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22745



Training Course on:

**INDUSTRY AND AND DEVELOPMENT
RELATED TO
MEDITERRANEAN BASIN**

Rabat, Morocco 29 Octobre – 03 Novembre 2001



Schedule, Conferences and Contribution of participants



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Conferences

- 1- Coastal Environment Engineering (**Prof. A.Nejjar**, Ecole Mohammadia d'Ingénieurs E.M.I., Rabat, Morocco).
 - Technologies pour le Contrôle de la Pollution du Milieu Marin.
 - Focus On the Impacts of the Industrial Development in the Mediterranean Basin.
 - Nutrients Impact: Eutrophication .
- 2- An Overview of Knowledge Based Expert Systems and Object Concepts (**Prof. D.Ouazar**, E.M.I., LASH, Rabat, Morocco).
- 3- Numerical Modelling and simulation aspects: Esimeau Integrated Information System for Modelling and Management of Water resources Concept and Architecture (**Prof. F.Dabaghi** Institut National de Recherche en Informatique et Automatique INRIA, Paris, France).
- 4- Coastal Environmental Impact Assessment (**Prof. D.Bensari**, E.M.I., Rabat, Morocco).
- 5- GPS Measurement and Applications (**Prof. D.Bensari**, E.M.I., Rabat, Morocco).
- 6- Spatial Decision Support for Integrated Coastal Area Management (**Prof. E.Feoli**, ICS Trieste, Italy).
- 7- Multidimensional Spaces of Landscape System (**Prof. E.Feoli**, ICS Trieste, Italy).
- 8- Industrial Ecology (**Prof. E.Feoli**, ICS Trieste, Italy).
- 9- Use of GIS, Remote Sensing and Spatial Decision Support Systems (SDSS) for the environmental management of coastal areas:
- 10- Basic Concepts of Remote Sensing (RS), Geographic Information System (GIS) and Decision Support (DSS) (**Dr. M.Ghribi**, ICS Trieste, Italy)
- 11- Case study in Monfalcone, Italy (**Prof. A.Altobelli - M.Ghribi** ICS Trieste, Italy)
- 12- Case study for the coastal areas of the region of Tunis – Bizerte, Tunisia (**Dr. M.Ghribi**, ICS Trieste, Italy)
- 13- Case study in India (**Dr. S.Betapudi - M.Ghribi**, ICS Trieste, Italy)
- 14- Exercices (**Dr. M.Ghribi**, ICS Trieste, Italy)
- 15- Strategic Action Programme To Address Pollution From Land- Based Activities (SAP) United Nations Environment Programme-Mediterranean Action Plan (**Prof. F.Abousamra**, UNEP/MAP Greece).

Contribution of participants

- 1- Industrial Activities in Algeria (**Ms N.Kacimi & A.Loukriz**, Ministry of Environment Algeria).
- 2- Utilisation du Système d'Information Géographique en domaine des Ressources Halieutiques en Méditerranée Marocaine (**Dr. Rachidia Houssa** from: Institut National de Recherche Halieutique Centre Régional de Nador).
- 3- Les Systèmes d'Informations Géographique Pour les Pêcheries En Afrique de l'Ouest 1995-1997 (**Mr A.Srairi** Coordinateur National du projet F.A.O- S.I.G, Institut National de Recherche Halieutique de Casa).
- 4- Etude Hydrodynamique dans la baie de M'DIQ ; Impact des apports Terrigènes sur l'activité aquacole (**Mr. L.Idrissi** from: Institut National de Recherche Halieutique de Casa).
- 5- Diversification and Evolution of the sedimentary system tracts on the Moroccan Atlantic Margin from the Middle Cretaceous to the Present (**Dr. Nadia Mhammdi** from: Institut Scientifique Rabat Maroc).
- 6- Country Report on Fisheries and Aquaculture in Turkey (**Dr. Hayri Deniz** from: Ministry of Agriculture and Rural Affairs, General Directorate of Agricultural Production and Development in Turkey).
- 7- Environmental Auditing Manuel for Hotels and the Green Hotel Guidelines. (**Ms Sarah Kouzi** from: Ministry of Environment, Lebanon).

COASTAL ENVIRONMENTAL ENGINEERING

**TECHNOLOGIES POUR LE CONTROLE DE
LA POLLUTION DU MILIEU MARIN**

A. NEJJAR

En 1985, la population des régions côtières méditerranéennes a été estimée à plus de 133 millions d'habitants, autrement dit 38% de la population totale des pays bordant la Méditerranée habitaient 15% environ de la superficie de ces pays. Il a été estimé qu'en 2025 la population habitant les régions côtières pourrait atteindre environ 200 millions de personnes et représenter à peu près 55% de la population totale des pays riverains de la Méditerranée.

Le littoral est le lieu d'implantation privilégié pour de nombreuses activités économiques et pour l'urbanisation. Le programme d'action pour la Méditerranée (PAM) a identifié 103 " hot spots " (sites critiques de pollution urbaine et industrielle).

La mer Méditerranée constitue un milieu récepteur de toutes sortes de substances dangereuses . Ainsi de vastes zones côtières ont été gravement endommagées par des rejets excessifs de déchets industriels, de produits chimiques utilisés en agriculture et d'eaux Usées (Tableaux 1a à 1c).

D'après les estimations, si l'on compare la quantité de polluants d'origine terrestre,

77% environ de la charge de pollution sont imputables à des sources terrestres : (44% provenant des eaux de ruissellement et des décharges directes terrestres, 33% provenant de l'atmosphère).

I- LES REJETS LIQUIDES

Classification des eaux résiduaires industrielles:

On peut classer les eaux résiduaires industrielles en quatre catégories :

- Première catégorie : cette catégorie comprend les eaux résiduaires contenant des matières solides en suspension ou des émulsions ayant plus ou moins tendance à décanter ou à flotter.

Ces eaux peuvent être traitées par **floculation, décantation, filtration** avec ou sans dégrillage et dessablage préalable.

- La deuxième catégorie comprend les eaux résiduaires contenant en solution des substances toxiques ou susceptibles de troubler l'évolution biologique du milieu récepteur. Il faut alors des traitements spécifiques pour la destruction des substances indésirables (cyanures, etc.).

- La troisième catégorie comprend les eaux résiduaires contenant des substances fermentescibles, essentiellement de nature organique. Ces eaux peuvent être épurées par voie biologique d'une façon similaire à une eau usée domestique.

- La quatrième catégorie comprend les eaux résiduaires contenant des substances radioactives ou des produits (détergents, etc. ...) responsables de pollutions collectives.

Classification des eaux résiduaires industrielles selon leurs caractères :

- Eaux résiduaires à caractère minéral dominant :

Les industries de traitement de minerais, les industries métallurgiques, les industries chimiques minérales...

- Eaux résiduaires à caractère organique dominant :

Les abattoirs, les ateliers de traitement des déchets animaux, les industries alimentaires (laiteries, fromageries, sucreries, brasseries, distilleries, fabriques de conserves, etc.)

- Eaux résiduaires à caractère mixte :

Les industries textiles, les industries de la cellulose (papier, carton), les industries du cuir, caoutchouc, du bois etc.

Autres classification : le degré de biodégradabilité (Tableau 2)

Classe I : Facilement biodégradables (sucreries , abattoirs , pharmaceutiques)

Classe II : Lentement biodégradables (tanneries , blanchisseries , ateliers mécaniques)

Classe III :Très lentement biodégradables (textiles, papier, chimiques et parachimiques
etc...).

Dans cette classe , les effluents ont une carence en N et P et renferment des substances toxiques .

LES PRINCIPALES ETAPES DU TRAITEMENT DES EAUX RESIDUAIRES INDUSTRIELLES :

Toutes les eaux résiduaires industrielles contiennent des matières en suspension et des matières colloïdales .

Les premières opérations sont donc le dégrillage , le dessablage , la décantation . Cette dernière peut être accélérée par des flocculants et des adjuvants de floculation .

- Prétraitement (moyens physiques ou mécaniques)

But : séparer les gros éléments
dégrillage, tamisage, dessablage, déshuilage.

- Traitement primaire

(Pour l'élimination des M.E.S)
la sédimentation, la centrifugation , la flottation , l'électroflottation.

- Traitement secondaire(moyens biologiques ou physico-chimiques)

traitement biologique :

Le traitement biologique des eaux résiduaires industrielles , quand il est possible , peut être réalisé avec des eaux résiduaires industrielles brutes , ou bien mélangées avec des eaux usées urbaines (épuration mixte).

Boues activées

Lits bactériens

Disques biologiques

Traitements physico-chimiques :

Coagulation- floculation

La floculation permet de récupérer , dans certain cas , les produits en suspension présentant un intérêt économique .

réactifs utilisés (minéraux ou organiques) : la chaux , le sulfate d'Alumine , le chlorure ferrique , le sulfate ferreux, utilisation de polyélectrolytes.

Filtration sur charbon actif.

- Les procédés de traitement chimique

Les traitements chimiques s'appliquent essentiellement aux eaux résiduaires industrielles contenant des matières non organiques sur lesquelles un traitement biologique serait sans effet.

Les traitements chimiques comprennent :

La neutralisation des effluents(ajustement du pH)

La précipitation des matières dissoutes

L'oxydation ou la réduction

L'échange d'ions

- Neutralisation des effluents.

Effluents acides :

- Opération de décapage de métaux
- Conserveries de fruits
- Teinture de laine
- Fabrication de acides

Réactifs utilisés : NaOH, Na₂ CO₃, CaCO₃, Ca(OH)₂

Effluents basiques :

- Tanneries
- Dégraissage des textiles
- Blanchisseries
- Fabrication de l'acétylène
- Diverses opérations de lavage industrielles.

Réactifs utilisés : tout acide fort

Appareillages utilisés : "les réacteurs chimiques à circulation accélérée"(Fig.1)

Traitement de précipitation – clarification

Utilisé pour les eaux résiduaires des industries sidérurgiques, chimiques, traitement de surface...

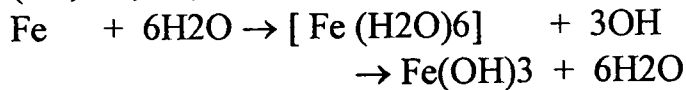
Ce procédé consiste à faire précipiter ,au moyen de réactifs chimiques, les substances polluantes dissoutes, parfois toxiques, avec formation de nouveaux composés chimiques insolubles, séparés par décantation ou flottation.

Substances chimiques polluantes dissoutes ——— réactifs chimiques ———>

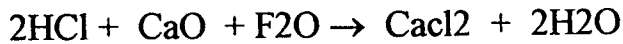
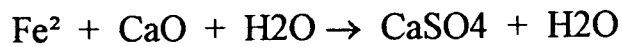
composés chimiques insolubles→décantation / flottation

- Elimination d'éléments métalliques :

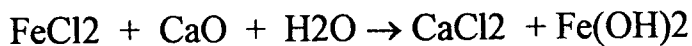
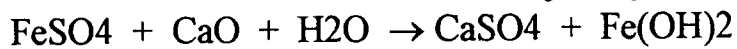
(Fe, Cu, Zn, Ni, Al, Pb, Cr ...)



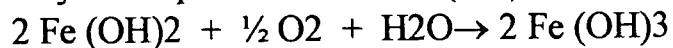
Neutralisation de l'acidité :



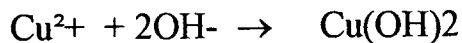
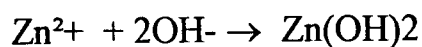
Transformation des sels ferreux en hydroxyde ferreux (colloïdal)



Oxydation par aération en $\text{Fe}(\text{OH})_3$ décantable :

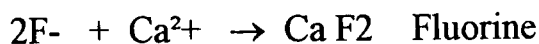


Il en est de même du Zinc et du cuivre(à pH = 9 – 9,5)

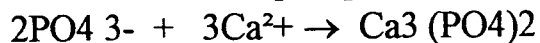


(si pH ↑ ⇒ $\text{Zn}(\text{OH})_2 + 2\text{OH}^- \rightarrow [\text{Zn}(\text{OH})_4]^{2-}$ soluble)

- Elimination des Fluorures :



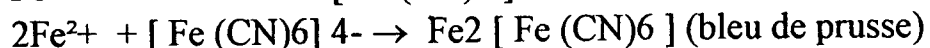
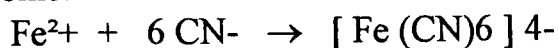
- Elimination des phosphates



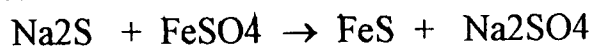
- Précipitation des composés cyanurés et sulfurés

(Galvanoplastie, cokerie, tannerie, lavage de gaz de hauts fourneaux)

Complexation des cyanures par le sulfate ferreux sous forme de combinaisons insolubles :



- Sulfures : élimination des sulfures à l'état de sulfure de fer, noir, précipité par réaction avec le sulfate ferreux



Traitement par oxydation chimique :

Effluents de l'industrie organique de synthèse
industrie minérale renfermant des CN métalliques

- Procédés d'oxydation par les composés chlorés
 $CN^- + OCl^- \rightarrow CNO^- + \frac{1}{2} Cl_2$
 $2CNO^- + 3Cl^- + H_2O \rightarrow N_2 \text{ (azote)} + CO_2$
- Oxydation par O_3 :
 $CN^- + O_3 \rightarrow CNO^- + O_2$
- Cas des dérivés soufrés (sulfites et sulfures)
(pâte papier, tanneries, industries chimique, organique)

Sulfures: 3 procédés :

chlore et dérivés,

les gaz de fumées (SO_2 , CO_2).

L'aération : $Na_2S \rightarrow NaSH$

Sulfites : aération + catalyseur

- Cas des substances phénoliques :

Effluents d'industrie chimique (industrie matières plastiques, colorants, cellulose)

- par oxydation ($KMnO_4$, H_2O_2 , Cl_2 et dérivés).
- voie biologique : bactéries aérobies sélectionnées.

Traitement de réduction

- la déchromatation :

Le but du traitement est de réduire le chrome hexavalent, très toxique, en chrome trivalent de toxicité moindre, par précipitation en milieu alcalin (pH # 8,5), puis décantation.

- Réduction du chrome hexavalent par le sulfate ferreux :

Le processus de traitement peut s'effectuer soit en milieu acide, soit en milieu alcalin.

- Réduction du chrome hexavalent en chrome trivalent à l'aide des ions sulfites.

- **L'épuration thermique**

On peut envisager l'épuration thermique de certaines eaux résiduaires par la combustion de leurs composants organiques .

On peut citer par exemple le cas des eaux résiduaires d'une usine de fibres synthétiques :

ces eaux contiennent de l'alcool méthylique , de l'acide acétique , de l'acide formique etc., et présentent une DBO5 élevée (de l'ordre de 100.000 mg O2 /l).

Rejets industriels par le biais d'un émissaire en mer

POUVOIR DISPERSIF DU MILIEU MARIN

Lorsqu'un effluent est rejeté en mer , généralement à l'aide d'un émissaire ancré sur le fond , il subit une dilution dans ce milieu à trois effets principaux ; Dans un premier temps , les effluents ayants une densité inférieure à celle de l'eau de mer remontent à la surface sous forme d'un panache . Ce phénomène , appelé effet de jet est relativement bien connu et la dilution obtenue en surface est principalement fonction de la hauteur d'eau au dessus de l'émissaire, du débit rejeté et de la différence relative entre les densités des effluents et de la mer . Les effluents sont ensuite entraînés par les courants et soumis à une dilution produite par le pouvoir dispersif du milieu marin et à une disparition de certains polluants (assimilable à une dilution) par effet de biodégradation.

ETUDE DE LA BIODEGRADATION

Le milieu marin n'est pas chimiquement neutre vis-à-vis de certains polluants , en particulier pour les bactéries . On observe généralement une disparition par biodégradation plus ou moins rapide suivant les conditions du milieu : lumière , salinité , présence de phytoplancton , température , etc. Dans le cas de bactéries coliformes , cette biodégradation peut être interprétée comme une dilution supplémentaire de la forme :

$$D_2 = 10 \ t / T_{90}$$

où t est le temps de présence de bactéries dans le milieu marin
 T_{90} est le temps au bout duquel 90%des bactéries ont disparu ,
cette valeur étant obtenue par expérimentation.

La mesure du paramètre T_{90} est relativement délicate , cependant de nombreuses expériences permettent d'estimer que T_{90} est voisin de 4 heures pour des bactéries coliformes.

II- CARACTERISATION ET TRAITEMENT DES REJETS INDUSTRIELS ATMOSPHERIQUES

1 - Introduction

Parmi les sources de pollution atmosphérique les activités industrielles occupent une place notable dans cette pollution.

2 - Principaux polluants émis par l'industrie :

- **Les poussières (MPS)**

Des particules très fines de compositions chimiques diverses sont émises par certains procédés industriels (les cimenteries, l'industrie métallurgique, les installations de combustion au charbon ou au fuel, les carrières, ...).

L'industrie y contribue à plus de 60%.

Les poussières les plus fines se retrouvent dans les bronches, pouvant y apporter des altérations.

- **Le dioxyde de soufre (SO₂)**

Il a pour origine essentielle la combustion du gaz et du charbon. En brûlant, ces combustibles libèrent du soufre qui se combine avec l'oxygène de l'air pour former du SO₂. Les principales sources de SO₂ sont les installations de chauffage industrielles, les raffineries de pétrole ainsi que certains procédés de fabrication (sidérurgie, chimie, production de pâte à papier) l'industrie y contribue pour plus de 65%.

- **Les oxydes d'azote (NO_x)**

Ils résultent principalement de la combinaison à haute température entre l'oxygène de l'air et l'azote présent dans l'air ou dans les combustibles.

Ils sont émis par les installations de combustion industrielles, les centrales énergétiques et par certains procédés de fabrication.

L'industrie y contribue à plus de 25%.

- **Les COV :**

Sous ce nom générique, on regroupe des milliers de composés aux caractéristiques très variables. Ce sont notamment les vapeurs d'hydrocarbures des moteurs et des stockages de produits pétroliers et chimiques, les solvants de peinture et de nettoyage. L'industrie y contribue à hauteur de 35%.

- **Les produits fluorés :**

Les principales sources de pollution fluorée sont les industries des tuiles et briques, des céramiques (utilisation d'argiles contenant du fluor), du verre (emploi d'acide fluorhydrique pour la gravure) et des engrais.

- **Les métaux lourds**

Ils sont émis lors de la combustion du charbon, de l'incinération des déchets et par de nombreux processus industriels (sidérurgie, fabrication du cristal, ...).

- **HCl**

Il est produit principalement lors de l'incinération de déchets industriels (et ménagers) ainsi que pendant la combustion de certains charbons.

3 – Techniques de dépollution

Les dépollueurs peuvent être classés suivant le mode de séparation mis en jeu.

Dépollueurs mécaniques

Ce sont des séparateurs qui font appel essentiellement à des champs de forces mécaniques, comme la pesanteur, l'inertie et la force centrifuge.

- **Dans une chambre de sédimentation**

Ce sont des séparateurs dans lesquels la vitesse du gaz porteur est réduite de manière à permettre la sédimentation des MPS sous l'action de la pesanteur. Le rendement de ces séparateurs dépend essentiellement de la vitesse de chute des particules, ce qui rend leur efficacité limitée à la captation de particules grosses ($\Phi > 50$ à 100μ).

Ce système est utilisé souvent comme prétraitement d'une unité industrielle, en amont d'un dépollueur plus efficace.

- **Dans une chambre à inertie**

De brusques variations de direction du gaz permettent de séparer les plus grosses particules ($\Phi > 20\mu$).

- **Dans les dépollueurs à cyclone**

Les particules les plus lourdes subissent la force centrifuge et se trouvent écartées du flux gazeux.

Les cyclones sont efficaces pour des particules supérieures à 5μ . Ils sont d'autant plus efficaces que leur diamètre interne est faible ; mais en diminuant le diamètre, le débit du gaz à traiter est réduit. Pour cette raison, un système composé de plusieurs cyclones de faible diamètre (moins de 300mm) a été conçu : ce sont les multicyclones (ils permettent d'augmenter le rendement de captage par rapport aux cyclones).

Dépoussiéreurs hydrauliques : **(Les tours de lavage, à garnissage ou à pulvérisation, les laveurs venturi)**

Aux dépoussiéreurs mécaniques, on peut ajouter une pulvérisation hydraulique. La poussière, s'associant à l'eau, s'agglomère. En plus de la poussière, l'eau peut capter certains constituants gazeux.

L'inconvénient de cette technique est la consommation d'énergie, sachant que la pollution se transfère de l'air vers l'eau.

Dépoussiéreurs à couche poreuse : les filtres à manches

Dans ces appareils, les gaz sont dépoussiérés par passage à travers une couche fibreuse sous forme de manches ou de poches rassemblées dans des cellules . Les poussières retenues sur la couche fibreuse forment un gâteau de filtration qui augmente la résistance au passage des gaz ; il doit donc être détaché périodiquement par secouage, passage de gaz à contre- courant ou injection d'air comprimé.

Dépoussiéreurs électriques : les électrofiltres

Le principe de fonctionnement de l'électrofiltre consiste à soumettre les particules en suspension dans le gaz à l'action d'un champ électrique ionisé. Le gaz circule à faible vitesse entre deux séries d'électrodes émettrices et collectrices d'électrons . La différence de potentiels peut être de 40 000 volts. Un tel champ s'établit lorsque l'on porte à un potentiel négatif supérieur au seuil d'ionisation un fil tendu entre deux plaques reliées à la terre.

Les particules soumises au bombardement ionique se chargent et se dirigent vers l'électrode collectrice sous l'action du champ électrique régnant entre fil et plaques. Les poussières s'agglomèrent , tombent par gravité ou par effet mécanique sur les plaques et sont recueillies par les trémies :

4 étapes : ionisation du gaz

charge des particules

migration des particules vers l'électrode collectrice

décharge des particules sur la plaque collectrice

Le rendement d'un électrofiltre est très élevé ; il peut atteindre 99,9%. Mais il est affecté par les caractéristiques des poussières à traiter et par leur résistivité électrique.

4 – Traitement des effluents gazeux

- Procédés de désulfuration des fumées industrielles

a- Élimination de SO₂ par adsorption

- procédé BF (Bergbau-Forschung) :
 - utilisation du charbon actif
 - régénération thermique par mélange avec du sable
 - SO₂ recueilli
- Procédé Lurgi-Sulfacid
 - utilisation du charbon actif
 - régénération par lavage à l'eau
 - Obtention de H₂SO₄ à 20%
- Oxydation catalytique de SO₂ en SO₃ : Procédé Monsanto Cat-Ox
 - Fumées dépoussiérées
 - Conversion de SO₂ en SO₃ à 500° C (rendement de 90%)
 - SO₃ transformé en H₂SO₄ à 70%

b - Absorption par voie humide

- Procédé au CaCO₃
 - La solution alcaline obtenue élimine SO₂ du mélange gazeux.
 - Il se forme du sulfite et du sulfate de calcium.

- Procédé à l'ammoniaque (Walther)

Le courant gazeux mélangé à l'ammoniaque et à l'eau est introduit dans un premier réacteur.

Par addition d'ammoniaque, tout le liquide est transformé en sulfite, puis en sulfate d'ammonium par contact avec l'air dans un deuxième réacteur.

Ce procédé élimine en même temps HCl et HF.

- Procédé au carbonate de sodium

SO₂ est absorbé par passage du mélange gazeux à travers une solution de Na₂CO₃. On obtient du sulfite de sodium.

(procédé bien adapté à l'industrie du papier)

3 - Absorption à sec

- Procédé à la dolomite et au CaCO₃

La dolomite est partiellement calcinée avant son emploi. L'absorbant (CaCO₃, MgO) ainsi obtenu est très poreux.

Produits de la réaction : sulfate de calcium et cendres des fumées.

- Procédé à l'alumine alcalinisée
- Procédé au MnO₂, Mg(OH)₂ et la coke en poudre
- Procédé au CuO

- PROCÉDÉS D'ÉLIMINATION DES NO_x

a- Procédés par voie humide

- Procédé EDTA (Lurgi, SHL)

Absorption de NO_x par le complexe Fe(II) EDTA(sel) et utilisation de SO₂ pour la réduction des NO_x en N₂.

- Procédé Walther

Dans un premier réacteur NO est oxydé par l'ozone en NO₂.

Dans un deuxième réacteur NH₃ en solution est ajouté

Produit final : fertilisant composé de sulfate et de nitrate d'ammonium.

b - Procédés à sec

- Procédé SCR

Ce procédé repose sur la réaction des NO_x avec NH₃ (catalyseur : TiO₂ et autres oxydes). On obtient N₂ et vapeur d'eau.

- **Procédé Desonox (Degussa, Lurgi, Lentjes)**

Réacteur à deux étages :

D'abord réduction sélective catalytique en présence de NH_3 .

Ensuite, oxydation catalytique du SO_2 : H_2SO_4 à 70%.

- PROCÉDÉS D'ÉLIMINATION SIMULTANÉE DE SO_2 ET NO_x

a - Procédés à sec

- Procédé BF-UHDE

1ere étape : dans un adsorber(charbon actif) SO_2 est transformé en H_2SO_4 .

2ème étape : réduction catalytique de NO_x par NH_3 .

- D'autre part, le SO_2 résiduel est aussi transformé.

- régénération thermique du charbon actif à 300°C et récupération de SO_2 jusqu'à 30%.

- Procédé Desonox(Degussa, Lurgi, Lentjes)
- Procédé à courant d'électrons(AEG/Lurgi)

b - Procédés à voie humide

- Procédé à l'ammoniaque(Walther)
- Procédé à l'EDTA(Saarberg, Hoelter, Lurgi)
- Procédé Ciba-Geigy(Acide sulfurique/nitrique)

III – CONCLUSION :

La prévention de la pollution, une nouvelle façon de procéder.

Plutôt que de réagir à la pollution, chercher à la prévenir à la source.

Industrie	poll. physique	poll. chimique
Accumulateurs et piles		Acides Cadmium Mercure plomb
Agricoles (produits fertilisants et pesticides)		Cadmium Cuivre Mercure Pesticides Plomb Nitrates Phosphates Sulfates Silicates
Blanchiment		Chrome Hypochlorite
Blanchisserie	Turbidité Tension-superficielle	Phosphates (silicates) Tensio-actifs
Boissons et alimentaires	Tension superficielle	Phosphates Sulfates Tensio-actifs Nitrites Acides organiques
Teinturerie	Tension superficielle Couleur	Eaux calcifiantes Tensio-actifs Tannin
Verreries		sélénium, silice Fer, cobalt Chrome, Al

Tableau 40: industries et types de pollutions possibles induites

Caoutchouc	Température	Sélénium Soufre Prod. organiques
Electrolyse de l'aluminium	Température	Aluminium Arsenic Sulfates Chlorures Fluorures
Electrolyse du chlore		Sodium Chlorures Mercure
Electronique		Arsenic Sélénium Mercure
Fours à coke	Température	Cyanures Phénols
Galvanoplastie traitement des sulfates		Acides Chrome Cyanures Métaux (trait. suf.)
Incinérateurs d'ordures ménagères	Température	Chlorures Sulfates Sodium
Mécanique		Essences Graisses Huiles Détergents Sels métalliques
Métallurgie du cuivre	Température	Cuivre Arsenic Sélénium Sulfate Chrome

Métallurgie du zinc	Température	Zinc Cadmium Arsenic Sulfate Chlorure
Métallurgie du fer	Température	Fer Sulfate Chlorure
Métallurgie du plomb	Température	Plomb Arsenic Sulfates Chlorures
Métallurgie- presses lami- nage		Huiles Graisses
Nucléaire	Température radioactivité	
Papeterie	Turbidité	Mercuré Chrome
Peintures	Couleur Turbidité	Solvants Plastifiants Cadmium Chrome Plomb Zinc
Plastiques		Cadmium Silice Mercuré
Photographie	Couleur	Argent Sulfites Acides Composés organiques Sélénium
Tannerie	Couleur Turbidité	Chrome

Traitement préférentiel	Nature du rejet	Industries concernées
Voie biologique	Eaux résiduaires renfermant uniquement des matières organiques biodégradables	Sucreries - Distilleries Féculeries Malteries Conserveries Abattoirs Elevage intensif Laiteries - Fromageries Industrie pharmaceutique (antibiotiques) Tanneries
Voie chimique et physico-chimique	Eaux résiduaires renfermant des substances toxiques minérales et ou organiques avec des molécules organiques non biodégradables Eaux résiduaires renfermant des constituants inorganiques - milieu carence en éléments nutritifs (N, P)	Industrie de revêtement et traitement de surface Industrie chimique (élastomères) - plastiques Sidérurgie (laminage - décapage) Industrie mécanique Mines et installations de traitement (minerais - charbons - ardoisières etc...)
Association obligatoire du traitement chimique en pré ou post traitement et du traitement biologique	Eaux résiduaires renfermant des molécules organiques plus ou moins biodégradables et des substances minérales et ou organiques toxiques - milieu généralement carencé	Industrie photographique - Tanneries Fabriques de colle et gélatine Fabrique de pâte à papier Papeteries - cartonneries Textile (teintureries) Laveries de laine Industrie pharmaceutique Fondoirs de suif - margarinerie Industrie chimique (engrais) Pétro-chimie - raffineries Usines à gaz - cookerries
Possibilités d'utiliser indifféremment la voie chimique ou la voie biologique	Les toxiques considérés comportant principalement des substances réductrices ou oxydantes	Blanchisseries Féculeries

Tableau 2: divers types d'eaux résiduaires industrielles

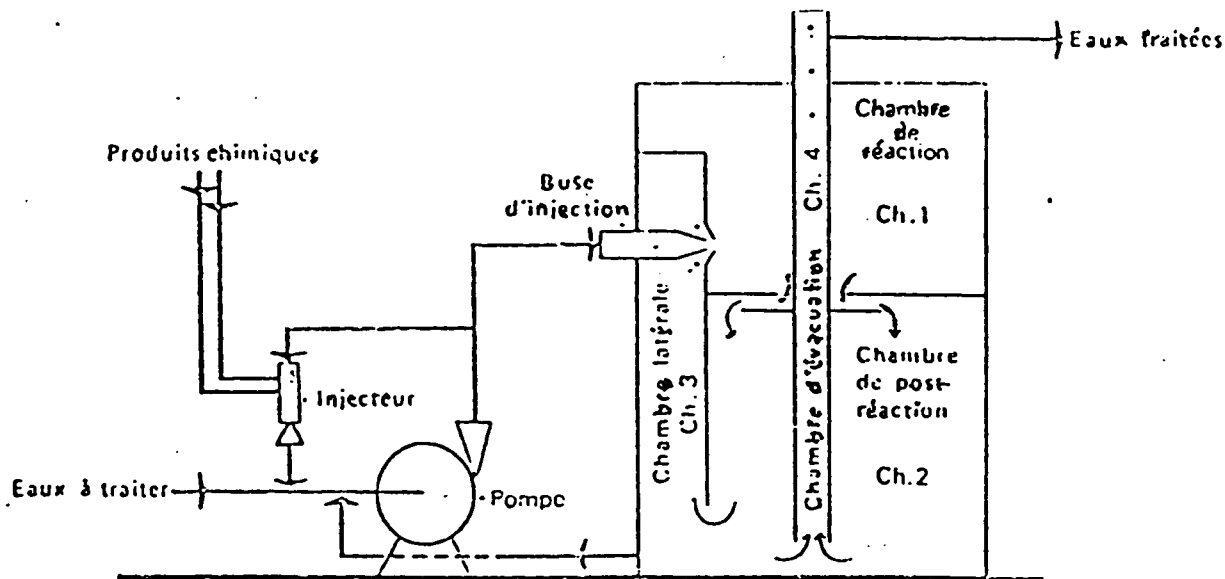
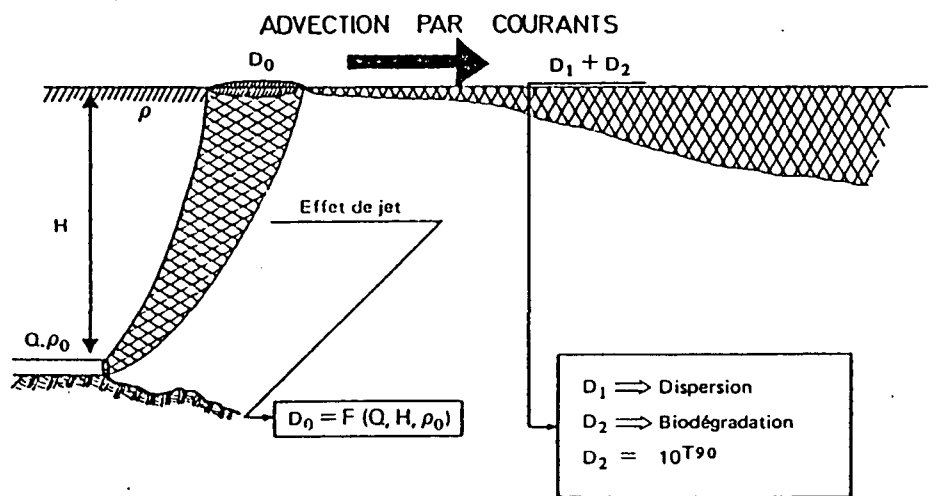


Fig. 1 : les réacteurs chimiques à circulation accélérée.



Schema 1.

Tableau 3

Différentes industries et leurs émissions

groupe	aérosols	gaz et vapeurs	taux d'émission caractéristiques
Combustion	Poussières fumées	NO ₂ , SO ₂ , CO, acides, matières plastiques	0.05 à 1.5% du poids du combustible
Industrie du pétrole	Poussières buées	SO ₂ , H ₂ S, NH ₃ , CO, hydrocarbures, mercaptans	0.25 à 1.5% du poids de substance traitée
Industrie chimique	Poussières buées fumées pulvérisations	Selon procédé: SO ₂ , CO, NH ₃ , acides, matières organiques, solvants, odeurs, sulfures	0.5 à 2% "
Thermo et électro métallurgie	Poussières fumées	SO ₂ , CO, fluorures, matières organiques	0.5 à 2% "
Traitement des minerais	Poussières fumées	Selon procédé: SO ₂ , CO, fluorures, matières organiques	1 à 3% "

Tableau 4
Industrie chimique

Industrie	Principaux polluants émis
Acide sulfurique	-SO ₂
Acide nitrique	-Oxydes d'azote
Chlore	-Faible pollution
Fertilisants	-HF, SiF ₄
Papier	-SO ₂ , H ₂ S, mercaptans, poussières
Matières plastiques	-Pollution très faible mais fort diversifiée

**Focus on the impacts of the industrial development in the
Mediterranean Basin**

**IMPACTS DU DEVELOPPEMENT INDUSTRIEL
DANS LE BASSIN MEDITERRANEEN
A . NEJJAR**

La mer Méditerranée est une mer semi-fermée d'une superficie de 2,5 Km², bordée par deux détroits (Tableau 1)

L'ensemble de la population des pays riverains du bassin méditerranéen , compte aujourd'hui un peu plus de 400 Millions d'habitants. En 2025 (autrement dit, le très proche avenir) elle atteindra entre 520 et 570 Millions d'habitants.

Mais le fait important que fait ressortir la figure 1 est que , sur ce chiffre , les deux tiers seront constitués par les pays du Sud et de l'Est du bassin (contre environ la moitié aujourd'hui). Autrement dit , l'écart démographique croissant entre la rive Nord et la rive Sud ne fera qu'aggraver les disparités dans d'autres domaines : emploi , productivité , ressources , terres agricoles , qualité de vie , etc.

Le taux d'urbanisation actuellement de 64,3% atteindra 74,4 % en 2025 du fait de la croissance urbaine dans les pays du Sud et de l'Est de la Méditerranée .

Cette croissance concernera notamment les régions côtières Méditerranéennes de ces pays dont les villes gagneront encore 30 Millions d'habitants supplémentaires (schéma 1).

Les pressions exercées par la population sur l'environnement et les ressources naturelles (eau , sols , littoral) s'accroîtront donc encore fortement .

Le littoral est le lieu d'implantation privilégié pour de nombreuses activités économiques et pour l'urbanisation. (Fig.2) Le programme d'action pour la Méditerranée (PAM) a identifié 103 " hot spots " (sites critiques de pollution urbaine et industrielle).

Le tourisme représente en Méditerranée un enjeu considérable de par son importance économique et sociale et ses impacts positifs et négatifs sur l'environnement. C'est aussi une question décisive pour l'avenir de la Méditerranée , puisque les 150 Millions de touristes internationaux et nationaux fréquentant ses régions côtières pourraient devenir 300 Millions en 2025 .

La mer Méditerranée constitue en outre un milieu récepteur de toutes sortes de substances dangereuses . Ainsi de vastes zones côtières ont été gravement endommagées par des rejets excessifs de déchets industriels, de produits chimiques utilisés en agriculture et d'eaux usées.

Activité humaines affectant l'environnement marin

- Le développement des zones littorales

La région du littoral est généralement une région complexe comprenant des baies, estuaires et de grandes aires semi- enclavées où les populations humaines et le développement industriel sont concentrés.(Fig.3)

Les activités humaines se manifestent surtout par une dégradation physique résultant de la concentration croissante de nombreuses activités.

A commencer par l'urbanisation côtière, à laquelle s'ajoutent les activités touristiques, les implantations industrielles et énergétiques (raffineries, centrales thermiques, ports de chargement et de déchargement d'hydrocarbures ou de charbon), les développements agro-alimentaires, les activités de pêche ou d'aquaculture, les infrastructures de transport, etc...

Or, cette zone littorale et infra-littorale est vitale pour le développement de nombreuses espèces et sa dégradation est une menace grave sur la vie même de la Méditerranée.

- **L'érosion du littoral (Fig.4)**

Si l'érosion est due à des facteurs naturels tels que le vent, les courants, la houle, l'élévation ou la baisse du niveau de la mer , elle est amplifiée par l'exploitation du milieu marin et du littoral : extractions de granulats, construction de barrages sur les rivières et même ouvrages installés pour stabiliser les traits de côte .

Les fluctuations du trait de côte sont parfois considérables. Dans certaines zones le linéaire côtier est en recul.

- **le développement et l'exploitation des ports**

Les pétroliers et les navires rejettent quotidiennement dans la mer des tonnes de déchets et d'hydrocarbures. On a calculé qu'un huitième à un quart de la pollution mondiale due aux hydrocarbures aboutit en Méditerranée.

En plus des activités dans le port lui-même, la plupart des grands ports disposent d'une infrastructure considérable incluant routes, voies ferrées, centrales thermiques, décharges, traitements des déchets.

- **Trafic et pollution du milieu marin : activités des navires, déversements et forages pétroliers (Fig.5)**

Mises à part les marées noires , la circulation des navires est à l'origine de déversements accidentels de substances chimiques , de pertes de conteneurs ou de fûts parfois remplis de matières dangereuses ainsi que de rejets illicites d'hydrocarbures et autres résidus de ballast difficiles à évaluer avec précision .

Au niveau mondial, grâce aux effets positifs des conventions internationales, les pollutions accidentelles par hydrocarbures ont significativement diminué (de 60%) depuis les années 70, où une moyenne de près de 320 000 t/an se déversait dans la mer .De 1990 à 1997 , ces déversements sont estimés à 130 000 t/an.

La fréquence des accidents majeurs est passée de 24 déversements par an (année 70) à 9 (années 80), puis 8 (1990-97). De 1988 à 1997 , seuls 10 accidents sur 360 (soit moins de 3% du total des déversements supérieurs à 7 t) sont responsables de 70% des quantités d'hydrocarbures déversées dans le milieu marin .

Il faut citer également les pollutions occasionnées par l'expansion spectaculaire de la navigation de plaisance et par le déballastage frauduleux (goudrons, détritux).

- **Les rejets urbains et industriels**

La pollution marine d'origine terrestre est la principale composante de la pollution de l'environnement marin :

70% des eaux usées dans environ une centaine de villes du littoral sont rejetées dans la mer sans aucun traitement préalable approprié. (Tableau 2a)

D'après les estimations, si l'on compare la quantité de polluants d'origine terrestre, 77% environ de la charge de pollution sont imputables à des sources terrestres :

(44% provenant des eaux de ruissellement et des décharges directes terrestres, 33% provenant de l'atmosphère).

Le reste provient du transport maritime (12%), des décharges en mer (10%), de l'exploration et de l'exploitation off-shore des ressources minérales, en particulier du pétrole (1%).

De nombreuses zones littorales sont endommagées et même dangereusement polluées. Les contaminants des sources peuvent être groupés comme suit :

- les micro-organismes
- la matière organique affectant le taux d'O₂
- les nutriments (éléments nutritifs)
- les composés organiques synthétiques
- les hydrocarbures pétroliers
- les matières particulaires / sédiments

Un composé (paramètre) de chacun de ces groupes peut avoir un impact à différents degrés sur l'environnement marin.

L'ordre de grandeur de cet impact est une fonction des caractéristiques chimiques et biologiques du composé, sa forme chimique, sa concentration, son pouvoir de bioaccumulation, et des caractéristiques du milieu récepteur.

Les rejets urbains affectent toutes les composantes de l'environnement marin.

Principaux effets :

- les risques sanitaires (présence de pathogènes)
- l'eutrophisation et / ou déficit en O₂ (dû à la présence de nutriments et de matière organique)
- les effets toxiques sur les organismes marins
- les risques pour la santé humaine dus à la présence de composés chimiques multiples et plus ou moins nocifs dans les ressources nutritives des organismes marins. Les polluants chimiques peuvent suivre la chaîne alimentaire jusqu'à l'homme .

Les principales sources de rejets industriels sont :

Les usines de pâte à papier, cellulose, usines d'engrais, aciéries, usines métallurgiques, raffineries de pétrole, tanneries et autres industries de fabrication de produits chimiques incluant l'industrie pharmaceutique.

Par conséquent, quand les effluents toxiques de ces usines (notamment métaux lourds) et des raffineries de pétrole sont rejeté en mer, ils ne détruisent pas seulement la vie marine au moment de leur rejet, mais dans certains cas (le Mercure), ils peuvent se concentrer en remontant la chaîne alimentaire, passant du plancton, aux poissons, aux être humains, mettant ainsi en danger la santé humaine et l'équilibre précaire des écosystèmes marins.

La plupart des polluants et substances ayant des effets biologiques sont rejetés en grandes quantités en mer (en zone littorale), souvent sans traitement adéquat .

Les produits de la mer sont ainsi très fréquemment impropres à la consommation, étant pollués par les hydrocarbures et autres produits chimiques ou bien contaminés par des microbes pathogènes provenant des eaux usées .

En outre dans le bassin méditerranéen le développement de centres urbains, de l'agriculture et de l'industrie a souvent été géographiquement interdépendant. Les polluants généralement rejetés par les rivières sont concentrés le long de zones littorales limitées, aggravant ainsi les conséquences négatives. Pour cette raison, il est souvent difficile de faire la distinction entre les rejets domestiques d'eaux usées, les rejets industriels et agricoles et la pollution diffuse caractérisée par des effets synergiques.

Les paramètres devant être pris en compte pour caractériser les différents types de pollutions (selon le milieu récepteur) ont été définis (Tableau 2b à 2d).

La vulnérabilité de la mer Méditerranée

La Méditerranée couvre une superficie de 2,5 millions de Km². C'est un système semi-fermé, caractérisé par une grande surface du plateau continental (20%), une profondeur moyenne faible (≈ 1400 m).

On distingue un certain nombre de points critiques pour l'évaluation d'un impact potentiel des polluants sur les systèmes côtiers méditerranéens :

- Des températures élevées :
minimum annuel 12°C (atteignant jusqu'à 25°C pendant l'été)
Ceci implique des vitesses de réactions biochimiques (métaboliques) élevées, ce qui va affecter la production et l'activité des communautés vivantes.
- Un régime de marées inférieur à 50 cm, donc une réduction de la capacité de diffusion et de dispersion des solutés et des polluants particuliers, surtout dans des baies fermées où les courants générés par le vent sont faibles.
- Oligotrophie :
 - teneur faible en nutriments
 - faible production primaire
 - et biomasse phytoplanctonique faible

Ce sont des caractéristiques typiques de la plupart des écosystèmes marins en Méditerranée (surtout dans le bassin Est - Méditerranéen)

La faible biomasse de phytoplancton induit une transparence élevée et une profonde pénétration de la lumière, ce qui permet la photosynthèse dans des eaux plus profondes.

- La production primaire (PP) :
Le facteur limitant de la PP est le phosphore, contrairement aux autres océans. Dans ces conditions, l'eutrophisation n'aura lieu, que dans le cas où les phosphores sont rejetés en quantité notable.
- Apports fluviaux :
La Méditerranée est caractérisée par un échange d'eau limité à travers le détroit de Gibraltar et des apports fluviaux limités.
- Morphologie côtière :
La morphologie des baies est très spécifique aux côtes Méditerranéennes : elles ne sont pas alimentées en permanence par des apports fluviaux.

- Biodiversité :
L'écosystème dispose d'une biodiversité élevée (faune et flore) surtout dans les zones littorales et consiste en grande partie en espèces endémiques (taux élevé d'endémisme dû à la grande quantité d'espèces vivant uniquement dans ses eaux). Ceci est le résultat du passé géologique dynamique de la Méditerranée. Cette importante biodiversité peut être affectée par certaines activités de pêche, la mariculture et l'invasion de poissons tropicaux.
- Le benthos est caractérisé par une faible abondance, à cause des conditions oligotrophes prédominantes.
- Pression anthropogénique :
Environ 400 millions d'habitants vivent dans le bassin méditerranéen. Ils déversent tous leurs déchets dans la Méditerranée et environ 150 millions de touristes fréquentent la Méditerranée.

Tous ces facteurs font de la Méditerranée un écosystème fragile, particulièrement vulnérable et sensible aux impacts de la plupart des polluants provenant des activités anthropiques.

Le taux de pollution croissant sur son littoral est lié à des produits résiduels (500 million de tonnes par an), des métaux lourds (7500 tonnes par an), des pollutions industrielles et agricoles (200 000 tonnes de produits chimiques par an et jusqu'à 1 million de tonnes de pétrole brut issu de déversements accidentels et des superpétroliers).

Les apports de polluants vers l'environnement marin

L'état de l'environnement marin concernant les apports de contaminants anthropiques est probablement mieux décrit en évaluant les variations de flux à travers les principales voies d'acheminement des polluants plutôt qu'en caractérisant systématiquement les eaux des océans (schéma 2).

- Les fleuves transportent tous genres de polluants - municipaux, agricoles et industriels - et les déposent dans la mer à un rythme qui dépasse de loin celui des versements directs d'origine tellurique.
- On estime à plusieurs milliers de tonnes les polluants chimiques (pesticides) transportés loin par le vent et retombant dans la mer avec la pluie. Ajouter à cela l'apport considérable drainé par le sol.
- Les matières toxiques se déposent dans les sédiments où elles détruisent les communautés vitales pour les organismes marins. Plusieurs contaminants qui s'associent aux sédiments resteront piégés jusqu'à ce qu'ils soient remis en suspension par les vagues et les courants.

Les divers apports naturels et anthropiques à la Méditerranée transitent par des interfaces-frontières.

Ces interfaces sont des zones de transition de dimensions variables et sont toutes caractérisées par l'existence de forts gradients énergétiques et chimiques susceptibles de modifier la concentration et la forme chimique des éléments et composés chimiques introduits dans la masse d'eau.

Concernant ces apports, on peut poser un certain nombre de questions relatives :

- aux ressources en nutriments de la Méditerranée et à leur taux de renouvellement,
- à l'interaction de l'activité humaine avec le milieu marin,
- aux modifications réelles des concentrations et du fonctionnement naturel engendrées par cette activité,
- aux perturbations du milieu naturel qui en résultent et les risques effectifs qu'elles font courir aux ressources vivantes que recèle la Méditerranée.

Dans ce cadre, on peut définir une approche méthodologique rigoureuse à quatre niveaux :

- La description chimique (la concentration totale de la forme chimique)

- Mesures des flux d'éléments chimiques aux interfaces et l'étude des relations (c'est à dire des mécanismes de transfert et du flux net de polluant) entre zone côtières et zone hauturière.
- L'étude des processus chimiques et des cycles biogéochimiques des métaux et des composés organiques.
- La réalisation de modèles conceptuels puis prédictifs du devenir des éléments et composés chimiques, modèles devant intégrer les données physiques et biologiques

Les contaminants marins : niveaux de distribution

Les deux principales voies à travers lesquelles les polluants sont transférés du continent vers la mer sont les rivières et l'atmosphère. (Tableau 3)

Alors que les décharges directes et apports des fleuves affectent principalement les eaux côtières, les apports de polluants de source terrestre transportés par l'atmosphère affectent des régions marines très éloignées de la source dont ils proviennent.

	Tous les polluants	Hydrocarbures pétroliers	
		Tous les océans	Mer du Nord
Sources naturelles	8	8	2
Production offshore	0.5	2	28
Transport maritime	11	45	3
Atmosphère	30	10	12
Continent	40	34	43
Autres	10	1	12

Tableau 3 : Apports de polluants vers l'océan (en %)

	Pb	cd	Cu	Zn
Apport par l'atmosphère				
Dissous	79	1.9 - 3.3	14 - 45	33 - 173
partic.	9	0.4 - 0.7	2 - 7	11 - 55
Apport par les rivières				
Dissous	2	0.3	10	6
partic.	1600	15	1500	3900

Tableau 4 : Dépôts globaux de Métaux dans les océans (109 gy⁻¹)

D'après le tableau 4, il semble que les rivières constituent la source principale de la pollution particulaire d'éléments trace pour les océans.

Cependant, il faut souligner que les apports particuliers des rivières se déposent près des zones côtières, alors que les apports atmosphériques sont transportés en haute mer. Sous forme dissoute l'apport atmosphérique semble prédominer pour le Zn et le Cd.

En ce qui concerne la Méditerranée le tableau 5 donne une comparaison des apports par l'atmosphère et par les rivières pour les éléments de trace.

	Atmosphère	Rivières
Pb	5000 – 30000	2200 - 3100
Zn	4000 - 25000	11000 - 17000
Cr	200 - 1000	350 - 1900
Hg	20 - 100	30 - 150

Tableau 5 : Apports atmosphère / rivières de métaux à la Méditerranée (en $\text{t} \text{y}^{-1}$)

Le tableau 6 résume les valeurs de flux atmosphérique de certains éléments trace vers la Méditerranée (en $\text{mg} \text{m}^{-2} \text{y}^{-1}$)

Pb	Cd	Hg	Zn	Cu	Références
7.3	0.3	0.024	6.0	-	WMO , 1985
29	1.0	-	34	4.2	Bergametti et al.1989
4.6	0.13	-	9.8	1.6	LPA / EMI, 1991

Tableau 6 : Les flux atmosphériques ($\text{mg}/\text{m}^2/\text{y}$) vers la Méditerranée

Les différents impacts dans le bassin Méditerranéen :

Impact des métaux lourds

A l'échelle mondiale, les fleuves et cours d'eau sont en général la principale source de métaux se présentant sous forme de particules non dissoutes, bien qu'une fraction importante de ces matériaux soit retenue dans les sédiments des zones littorales.

Pour les métaux dissous, les quantités apportées par l'atmosphère et par les fleuves sont grosso modo égales quand il s'agit de métaux tels que le cuivre et le nickel, alors que pour le zinc, le cadmium et en particulier le plomb les apports atmosphériques semblent l'emporter.

Il semble, que 90% environ du plomb pénètre dans les océans par voie atmosphérique;

pour certains polluants organiques que l'on trouve dans les eaux du grand large, les apports atmosphériques sont de l'ordre de 80 à 90% (par exemple PCBs (diphényles polychlorés), DDT, HCB (hexachlorobenzène), et HCH (hexachlorohexane); l'apport atmosphérique d'azote est considérablement plus grand que l'apport net par les fleuves ; et l'apport atmosphérique de substances phosphorées est sensiblement le même que celui qui pénètre dans la mer par voie fluviale. Environ 90% des émissions de plomb dans l'atmosphère ont lieu dans l'hémisphère nord.

Dans la plupart des mers du globe, on observe une faible concentration de polluants métalliques à la surface de l'eau et une concentration plus importante dans les couches inférieures.

En Méditerranée en revanche, ces polluants ou métaux-traces sont plus concentrés dans les couches supérieures que dans les couches inférieures où ils restent en quantité relativement stable.

Les apports de métaux lourds à la Méditerranée sont généralement dus aux rivières et rejets industriels . Les métaux lourds s'accumulent dans les sédiments côtiers, particulièrement près des centres urbains , des exutoires naturels (rivières) et des émissaires de rejets industriels.

Dans la mer Méditerranée , la distribution de la forme dissoute du Zn , Cu , Pb , et Cd est principalement contrôlée par la circulation marine et la production géologique .

Actuellement, on constate une teneur en métaux lourds relativement élevée dans la couche de surface, à cause de l'état stationnaire des cycles suite à une augmentation des sources due au développement des activités agricoles et industrielles et à l'urbanisation dans le pourtour méditerranéen depuis les années 60 .

En général , la pollution par les métaux lourds est très élevée, avec des concentrations jusqu'à 15 fois celles d'autres océans:

Les eaux côtières Egyptiennes sont considérées comme parmi les plus polluées en métaux lourds dans la Méditerranée : environ 5 à 14 tonnes de Hg et Pb sont déversés annuellement. Hg et Pb sont accumulés par certains micro-organismes marins . Les côtes Grecques et Espagnoles présentent également des teneurs élevées en métaux lourds dans les sédiments .

D'autre part , les derniers rapports scientifiques ont montré que la contamination par les métaux lourds a augmenté ces dernières années dans la Méditerranée Occidentale (NW) , à l'exception du plomb . Les concentrations de Pb ont en effet diminué de manière importante durant les 10 dernières années .

Impact des hydrocarbures

Chaque année environ 600 à 800 x 10⁶ tonnes d'hydrocarbures sont transportées en mer Méditerranée . (équivalent à environ 30% du transport maritime mondial de pétrole brut) .

Les raffineries de pétrole constituent la 2^{ème} source importante de pollution chronique. Les activités off-shore contribuent également à cette pollution (300 000 tonnes par an de pétrole brut déversé en Méditerranée).

Le benthos est le domaine optimal d'étude des effets du pétrole sur l'environnement.

La première conséquence de déversement de pétrole en mer est la création d'une émulsion couplée à une absorption de pétrole sur les particules en suspension avec dépôt au fond de l'océan. Le pétrole brut s'accumule dans les sédiments atteignant des concentrations élevées.

Les principaux effets de la présence de pétrole dans les sédiments sont la réduction de l'O₂ et les changements dans les propriétés des sédiments (réduction des échanges à l'interface sédiment/eau).

L'utilisation des dispersants pour la décontamination peut augmenter la toxicité des hydrocarbures avec des conséquences sur les communautés benthiques.

Les effets à long terme peuvent avoir des conséquences différentes.

Impact des éléments nutritifs

La vie marine, repose presque entièrement sur la photosynthèse. Le phytoplancton, algues microscopiques qui flottent librement dans l'eau, est la forme de vie végétale la plus importante dans les océans. C'est le premier producteur de matières organiques. Toutes les formes de vie animale dépendent en fin de compte de la matière organique fournie par cette production initiale.

L'emploi de plus en plus large d'engrais dans l'agriculture, les eaux usées déversées par les égouts et certains types de déchets industriels entraînent une concentration croissante d'éléments nutritifs dans les eaux littorales et sont cause de leur eutrophisation. Les niveaux élevés d'éléments nutritifs dans les eaux littorales et les estuaires favorisent la prolifération des algues marines, laquelle entraîne la turbidité des eaux et une pénétration réduite de la lumière.

Pour finir, les algues meurent et se décomposent, entraînant, entre autres résultats, une raréfaction de l'oxygène, des hécatombes de poissons et des odeurs nauséabondes. Ce schéma se reproduit partout où les eaux littorales reçoivent des apports croissants d'éléments nutritifs d'origine terrestre. L'apparition de plus en plus fréquente de floraisons algales toxiques peut être mise en relation avec l'eutrophisation. Ces algues sont ingérées par les coquillages et les crustacés, les substances toxiques s'accumulent dans leur corps et peuvent entraîner de très graves répercussions sur la santé humaine.

Les zones méditerranéennes menacées :

- La mer Adriatique :

Elle reçoit presque 30% du total des apports fluviaux de la Méditerranée qui déverse la charge organique de 25 millions d'habitants. Ces conditions permettent le développement de l'eutrophisation.

La densité du phytoplancton varie de 1000 à 600 000 /litre avec des pointes de plusieurs centaines de millions par litre.

- Entre 1975 et 1979, chaque été le phénomène d'eutrophisation des côtes du nord de l'Adriatique (jusqu'à 21 M/litre) ainsi que dans la partie est, et dans une moindre mesure, dans le golfe de Trieste et le long des côtes Slovènes.

- Dans certaines côtes Italiennes (le golfe de Naples, estuaires de rivières)

l'eutrophisation est due essentiellement aux rejets d'activités humaines.

- La côte Française est surtout affectée par les déversements du Rhône (5 millions de tonnes de Mes, 76 000 tonnes de N inorganique et 8 400 tonnes de P par an).

- La côte Espagnole est affecté également par l'eutrophisation (zone littorale de Valence).

- La Méditerranée méridionale est généralement caractérisée par des conditions oligotrophes élevées : les eaux des côtes Grecques (baies, estuaires) semblent très menacées.

- De même, les côtes Libanaises, alors qu'en Egypte l'eutrophisation a été très souvent observée, suite à des déversements importants de nutriments (Alexandrie et d'autres zones).

-Impact des changements climatiques

Données générales sur le réchauffement de la planète

Le réchauffement global de la terre prévu au cours du siècle constitue désormais une des préoccupations climatiques majeures actuelles. Le mécanisme de ce réchauffement résulte d'une augmentation de la concentration en gaz carbonique (CO₂), et en d'autres gaz comme le méthane (CH₄), l'oxyde nitreux (N₂O), l'ozone (O₃), et les chlorofluorocarbones (CFCs) (Tableau 7).

Dans l'ensemble, plus de la moitié de la perturbation du bilan radiatif de la terre est attribuée au CO₂.

La concentration du CO₂ est passée de 280 ppmv (1750-1800) à 353 ppmv (1990), soit 25% d'augmentation.

Au rythme actuel, le CO₂ augmente à raison de 1,8 ppmv par an (+ 0,5%) et on prévoit que sa concentration sera entre 415 et 480 ppmv à l'horizon 2050 et entre 460 et 560 ppmv vers la fin du siècle.

Si aucune action n'est entreprise en vue de réduire ces émissions, la communauté scientifique, en se basant sur des modèles, prévoit un réchauffement de l'ordre de 2 à 5%.

En outre, les chutes de pluie sont souvent favorisées par les contrastes de température entre la terre et la mer. Comme la terre et la mer ont des inerties thermiques effectives différentes, un échauffement à grande échelle pourrait retentir sur ce contraste, conduisant ainsi à une réduction des pluies et des épisodes orageux, en particulier dans le bassin oriental.

En revanche des températures plus élevées de la surface de la mer, tant en Méditerranée que dans l'Atlantique Nord, pourraient conduire à augmenter l'humidité atmosphérique et par conséquent les précipitations.

Un réchauffement de l'atmosphère a pour autre répercussion majeure un relèvement accéléré du niveau des mers en raison de la fonte des glaciers alpins et polaires et de l'expansion thermique des eaux océaniques. L'analyse des données jaugées de marée, la principale source indicatrice pour détecter les tendances du niveau de la mer relativement à court terme, autorise à penser qu'au niveau mondial le relèvement a été d'environ 10-15 cm au cours des 100 dernières années.

Selon l'ampleur de l'expansion thermique océanique et le comportement des calottes glaciaires polaires, la gamme des estimations, prudentes à modérées, du relèvement du niveau des mers est de 13-39 cm (d'ici 2025), 24-52 cm (d'ici 2050), et 35-100 cm (d'ici 2100).

Les effets du compactage tectonique et sédimentaire local se superposeront au relèvement du niveau des mers. Des mouvements terrestres verticaux se produisent couramment en Méditerranée à un taux de 3 à 20 mm.a⁻¹ (moyenne sur 15-20 ans). La subsidence locale peut dépasser 5 mm.a⁻¹.

Il s'ensuit qu'à l'avenir le coût économique de la protection ou de l'abandon d'ouvrages ou de terres sur le littoral méditerranéen dépendra grandement des mouvements terrestres locaux associés à la hausse du niveau des mers.

Les variations du niveau de la mer en Méditerranée, telles qu'observées par altimétrie satellitale ont un impact important sur les activités socio-économiques du bassin Méditerranéen.

Les différentes techniques utilisées pour mesurer les variations du niveau de la mer sont les marégraphes et l'altimétrie.

Les marégraphes ont été utilisés depuis plusieurs décennies pour surveiller les variations du niveau de la mer dans le bassin méditerranéen.

Mais les données jaugées de marée ne permettent pas de distinguer la part due à des mouvements terrestres et/ou aux activités anthropiques d'une variation absolue du niveau de la mer. Avec l'avènement des techniques spatiales, ceci est maintenant possible (systèmes GPS, DORIS). On peut déterminer la part due aux mouvements terrestres avec une précision de quelques mm/an.

L'altimétrie satellitale permet donc d'observer les variations du niveau de mer à partir de l'espace, avec des précisions de l'ordre du mm/an.

Une mission franco-américaine (TOPEX / POSEIDON) a utilisé récemment cette technique pour observer les variations du niveau de mer de la Méditerranée. (Fig. 6)

Résultats obtenus à partir des modèles généraux de circulation (MGC)

Il est généralement convenu que les résultats obtenus à partir des modèles généraux de circulation (MGC) fournissent les meilleures possibilités d'obtention des scénarios sur les changements climatiques régionaux.

Changement climatique global : (Tableau 8)

- Augmentation de la température de 2.5°C et du niveau moyen de la mer de 65cm ± 35cm d'ici la fin du 21^{ème} siècle.
- Augmentation du niveau de mer en 2030 : 18cm ± 12cm, température : 1.8°C
- Des scénarios du changement climatique (pour la température et la pluie) pour la Méditerranée ont été développés par une université anglaise (University of East Anglia climate research unit).

MALTE (UEA) :

- Température : le changement annuel devrait être un peu moins important que le changement global : 0.8 à 0.9°C
- Pluies : peu de changement à aucun.

SFAX (UEA) : 2030

- Température : + 0.8% à 0.9°C
- Pluies : + 6% à 9% / °C de réchauffement global

SUD de L'EUROPE et TURQUIE (prévisions du groupe de travail IPCC pour 2030)

- Température : + 2°C (Hiver) +2 à 3°C (Eté)
- Pluies : + 10% (Hiver) entre - 5% et + 15% (Eté)

Les résultats varient d'un modèle à l'autre (quelquefois d'un facteur de 2) à cause des difficultés à prévoir de manière assez précise les futures émissions de CO2 et à cause des différentes stratégies possibles concernant la consommation d'énergie.

La question est encore plus cruciale pour les pays en développement.

- L'intrusion saline

Dans les aquifères des zones côtières, un fragile équilibre maintient l'eau douce au dessus de l'eau salée, plus dense. Une fois envahis par l'eau salée, les aquifères sont alors très difficiles à dépolluer et deviennent impropres pour de nombreuses utilisations (Fig. 7).

Concernant les régions côtières méditerranéennes, on trouve une grande différence entre les parties Nord et les parties Sud en termes de rapport entre l'eau souterraine extraite et le potentiel d'eau existant. Dans le Sud ce rapport s'élève à 74,5 tandis qu'au Nord il baisse (13,5).

On devra donc s'attendre à ce que, lors de l'augmentation du niveau de la mer et de l'accroissement de la pression humaine sur les côtes, l'intrusion saline dans les aquifères s'accroisse et s'étende sur une dizaine de kilomètres du linéaire côtier, jusqu'aux colonnes d'eau des rivières.

La pollution transférée par voie atmosphérique

Il est maintenant bien reconnu qu'une fraction significative de contamination des océans et des mers est transférée à partir des sources basées sur le continent par voies atmosphériques.

Les principaux polluants concernés sont
les métaux lourds et métalloïdes (Pb, Cd, Hg, As, Sn, Cu, Zn),
les hydrocarbures pétroliers,
les hydrocarbures halogénés et
les microorganismes pathogènes.

Les processus de transport :

- Transport horizontal :

Le transport atmosphérique vers la Méditerranée peut se produire à deux échelles différentes :

- Echelle off-shore
- Echelle longue distance

• Dans le mode off-shore, une fraction importante de contaminants se dépose près des principales sources côtières (< 100 Km). Le transport des polluants (parcelle d'air pollué) a lieu dans ce cas dans la couche limite qui est bien mélangée dans le plan vertical (hauteur de mélange < 1000 m).

• Le mode longue distance (100-1000 Km et plus) au contraire, inclut des mécanismes qui transportent les substances chimiques dans la haute troposphère
L'une des méthodes les plus utilisées pour interpréter le transport à longue distance et l'utilisation des modèles basés sur les trajectoires d'air (en utilisant des champs de pression, de température et de vents). Combinée à des mesures chimiques, cette méthode constitue un outil pour identifier la source du polluant étudié.

- Le dépôt :

Il y a deux processus de base par lesquels les polluants sont transférés de l'atmosphère vers la mer :

- Le dépôt humide (Dh)
- Le dépôt sec (Ds)

• Le dépôt humide :

Pour le calcul de Dh , la quantité totale de pluie est nécessaire.

L'échantillonnage de pluie inclut à la fois les phénomènes de lavage dans les nuages (rainout, within-cloud scavenging) et ceux sous les nuages (washout, below-cloud scavenging) : ils constituent les deux composantes du dépôt humide.

L'analyse chimique fournit la concentration Cr du polluant étudié : C(mg/l)

A partir de la quantité de pluie P(mm) (1 mm \cong 1 l/m²/j) et la concentration Cr.

On peut estimer le dépôt humide Dh :

$$Dh = Cr \cdot P \cdot [\text{mg} / \text{m}^2 / \text{j}]$$

Le flux de dépôt humide (Fr) est alors donné par :

$$Fr = P \cdot S \cdot Ca \cdot \rho^{-1}$$

ρ : densité de l'air

S : coefficient de lavage (scavenging ratio)

(S = 200-2000)

Ca = concentration du polluant dans l'atmosphère

• Le dépôt sec :

- Aérosols

Pendant les périodes sans pluie, les constituants particulaires sont entraînés vers le sol l'effet de processus différents :

- La sédimentation due à la gravitation
- La diffusion turbulente

Le dépôt sec des particules est estimé à partir de la vitesse de dépôt v_d :

$$v_d = F_p / C_a$$

v_d : vitesse de dépôt sec

F_p : flux des particules à la surface

C_a : concentration atmosphérique

On mesure le dépôt sec D' sur une surface donnée (pendant 1 mois) et on détermine la concentration C_a : $D' \approx v_d \cdot C_a$

A partir de D' et de C_a on calcule v_d .

$$F_p = C_a \cdot v_d \quad (\text{g/m}^2/\text{an})$$

- Gaz :

Les flux de gaz à travers l'interface air/mer ne peuvent être mesurés directement.

Ils doivent être estimés à partir de modèles d'échanges gazeux.

Dans un système de double couches limite à l'interface air/eau le flux d'un gaz à travers chaque couche limite est donné par :

$$F_g = k \Delta C$$

F_g : flux du gaz

ΔC : différence de concentration à travers la couche particulière

k : la vitesse de transfert correspondante

k dépend de plusieurs facteurs (degré de mélange de l'eau et de l'air, la réactivité chimique du gaz).

La réciproque de k ($1/k$) appelée la résistance r , est la mesure de la résistance de transfert du gaz (sec/cm).

La résistance totale de l'échange du gaz sera la somme de la résistance dans la phase gazeuse et dans la phase liquide :

L'échange de gaz qui ne sont pas solubles dans l'eau (N_2 , O_2 , CO_2 , gaz inertes et un grand nombre de composés organiques synthétiques) est contrôlé par la résistance dans la phase liquide.

L'échange de gaz très solubles dans l'eau (H_2O , SO_2 , HNO_3 , HCL ...) est contrôlé par la résistance dans la phase gazeuse.

Transfert de métaux lourds (aérosols, pluies) par voie atmosphérique vers la Méditerranée : étude de cas(LPA /EMI)

Introduction

In the framework of our contribution to the monitoring of the transport of pollutants to the Mediterranean Sea through the atmosphere , a monitoring programme is running since 1989. This study deals particularly with the input of heavy metals from the atmosphere into the Mediterranean sea , dry and wet deposition have been considered.

Using Atomic Absorption Spectrometry the trace element (Zn , Cd , Pb and Cu). Composition of aerosols and rain waters collected at two cities in Morocco was estimated , and dry and wet deposition fluxes calculated . The results are presented in this paper.

Sample collection and Analysis

The aerosol samples were collected during a period of eighteen months (Septembre 1989 - February 1991) at two cities , Tangiers and Beni-Mellal .

Tangiers (Latitude : 35 43' N , Longitude : 05 54' W) , is situated on the coast of the Mediterranean Sea , in the Northern Morocco .

Tangiers is moderately industrialized; while a few industries are situated along the coast, several mid-size industries are spread throughout the city and in nearby areas . The sampling site (elevation : 20,52 m) was located about 13 km NW of the city centre at the meteorological station.

Beni-mellal (Latitude : 32 22' N , Longitude : 06 24' W) as a reference monitoring station, is not directly influenced by identifiable local sources of air pollution . Sampling was done at the meteorological station (Altitude : 468 m).

A first study has started September 1989 in the two sampling stations (both for aerosol and precipitations) .

Besides the sampling , the common meteorological parameters (precipitation amount, wind speed and direction , Air temperature , relative humidity and barometric pressure) were measured at the sampling sites.

Airborne particles were collected using high-volume samplers , on at least a monthly basis (Twenty-one samples in Tangier and eighteen in Beni-Mellal) .

Rain water has been collected on an event basis in preacidified rain-collecting bottles (twelve samples in Tangiers and seven in Beni-Mellal). All trace elements could be measured by AAS, equipped with a graphic furnace.

Results and Discussions

The mean concentrations and the maximum to minimum concentration ratio of the studied trace elements (Zn , Cd , Pb and Cu) in the atmospheric aerosols are given for both sampling sites in table 1 , while the same parameters in precipitations are presented in table 2.

ELEMENT	TANGIERS		BENI-MELLAL	
	Mean	Ratio	Mean	Ratio
Zn	45	12	63	24
Cd	0,6	11	0,3	30
Pb	28	5	10	4
Cu	7,2	14	4,7	6

Table 1. Mean concentration (ngm-3) of trace metals in aerosols.

It is seen from Table 1 that the element levels in air in both cities are found to be lower than those reported for urban and rural areas . This is probably due to the poorer collection efficiency of our filters for the fine particles.

The concentrations of Cu , Pb and Cd are higher for the urban area , while the levels of Zn are more important for the rural area . This higher Zn could be related to the soil rather than increased industrial emission . (The TSPM levels were generally higher for Beni-Mellal compared to Tangiers) .

In Table 2 are presented the level concentrations of the same anthropogenic elements (Zinc, Lead and Copper) in rain waters , the element cadmium couldn't be detected .

ELEMENT	TANGIER		BENI-MELLAL	
	Mean	Ratio	Mean	Ratio
Zn	13	32	9	17
Cd	n.d	-	n.d	-
Pb	12	3	8	7
Cu	2,5	9	1	19

Table 2 . Mean concentrations ($\mu\text{g} / \text{l}$) of trace metals in precipitations

If we consider the maximum to minimum concentration ratio, it was found to be between 3 and 32 at the urban area while it was between 7 and 19 at the rural zone . The variations in all cases were generally larger for precipitations than for the aerosols .

Deposition Flux Calculations

Using the reported data dry (F_p) and wet (F_r) deposition flux calculations have been done. The dry deposition velocity average to 1,0 cm/s has been taken , while a mean scavenging ratio (S) of 500 has been assumed for the pollutant aerosols (recommended values for coastal and near shore areas).

The mean annual rainfall at Tangier and Beni-Mellal are respectively 737,3 and 392,3 mm .

ELEMENT	TANGIERS			BENI - MELLAL		
	F_p	F_r	F	F_p	F_r	F
Zn	14.2	13.8	28	19.8	10.2	30
Cd	0.18	0.18	0.36	0.09	0.05	0.14
Pb	3.8	8.6	12.4	3.15	1.68	4.7
Cu	2.27	2.2	4.47	1.49	0.78	2.27

Table 3 : . Dry, wet and total atmospheric depositions flux ($\text{mgm}^{-2} \text{ yr}^{-1}$) calculations ($v_d = 1 \text{ cm s}^{-1}$, $S = 500$) .

Table 3 provides an order of magnitude estimate of the elemental deposition . The observed results are generally lower than literature values for the North Western Mediterranean . From the data it is seen that dry deposition fluxes are in most cases more important than wet deposition particularly in the rural area , while most literature works for the input of trace metals are reporting the predominant significance of wet deposition . This is probably due to the relatively low rain amount and changes in airflow and precipitation patterns . From the table , it is estimated that dry deposition represents 15 - 50 % of the total deposition flux for the urban region , while it represents 50 - 70 % for the rural zone .

Conclusion

The reported data about the level concentrations of the trace metal elements (Zn , Cd , Pb , Cu) represent a good preliminary description of the principle constituents in atmospheric aerosols and rain waters. A refinement should be possible as more data becomes available . To determine the contribution of sea-salt , mineral and anthropogenic aerosols , indicator elements such as Na and Al will also be included in our future work. The partitioning of trace elements between soluble and insoluble form and the particle-size dependance of solubility is also an important area for our future research. Consequently , future effort will be made on wet deposition , aerosol composition and particle-size distribution , to contribute and get a clear description of all the problems involved in estimating trace metals contribution to the Mediterranean sea from the atmosphere. .

Accords et Programmes concernant la protection du milieu marin

Les principales mesures prises récemment reflètent le souci croissant pour l'environnement marin dans le monde.

En 1992, la conférence des Nations Unies sur l'environnement et le développement (CNUED) a adopté le programme d'action pour un développement durable (Agenda 21).

Le chapitre 17 de l'Agenda est consacré à la protection des océans, de tous les types de mers, y compris les mers fermées et semi-fermées et les zones côtières, et la protection, exploitation et développement nationaux de leurs ressources vivantes.

Une définition de la « pollution du milieu marin » a été adoptée dans la convention des Nations Unies sur le droit de la mer et dans la convention de Barcelone (modifiée en 1995) : « On entend par pollution du milieu marin, l'introduction directe ou indirecte par l'homme de Substances ou d'énergie dans le milieu marin, y compris les estuaires, lorsqu'elle a ou peut avoir des effets nuisibles tels que dommages aux ressources biologiques et à la faune et la flore marines, risques pour la santé de l'homme, entrave aux activités maritimes, y compris la pêche et les autres utilisations légitimes de la mer, altération de la qualité de l'eau de mer du point de vue de son utilisation et dégradation des valeurs d'agrément ».

Au niveau régional (bassin Méditerranéen), une série de programmes et de plans d'actions ont été mis en place, notamment un programme de surveillance et de lutte contre la pollution en Mer Méditerranée, le programme MED-POL.

Objectifs du programme MED-POL

En 1975, seize (16) pays méditerranéens ont approuvé un plan d'action pour la protection de la Méditerranée. Ce plan comportait notamment la mise en œuvre d'un programme de surveillance continue et de recherche en matière de pollution en mer Méditerranée (MED-POL).

Première phase : MED-POL I (1976 – 1980) la phase I avait pour but d'étudier les sources, l'étendue, le degré, les parcours, les tendances et les effets des polluants affectant la Méditerranée et de mettre en place des structures capables d'exécuter le programme de surveillance.

L'objectif général de la phase II du MED-POL (1981 – 1990) était de concourir à la réalisation des objectifs de la convention de Barcelone en aidant les parties contractantes à prévenir, réduire et combattre la pollution dans la zone de la Méditerranée ainsi qu'à protéger et améliorer le milieu marin dans cette zone.

L'objectif général de la phase III de MED-POL (1996-2005) est l'élimination de la pollution dans la mer Méditerranée par toutes les activités occasionnant cette pollution, notamment les activités basées à terre.

Depuis la dernière réunion des parties contractantes en 1989, il a été décidé de mettre l'accent sur le transfert de la pollution par voie atmosphérique vers la Méditerranée.

Le laboratoire de pollution atmosphérique et marine (LPA) de l'EMI, pour sa part, après avoir participé à la phase II du MED-POL, notamment l'étude des sources (effluents des agglomérations urbaines et des effluents industriels en zone littorale), participe actuellement à l'estimation de la pollution transférée par voie atmosphérique vers la Méditerranée, notamment les éléments trace dans les aérosols et les pluies.

CONCLUSION GENERALE

L'état de pollution de la mer Méditerranée a atteint donc un degré alarmant, à quelques exceptions près.

Nul doute sur la nécessité impérieuse d'envisager sérieusement l'adoption de critères relatifs à la qualité de l'environnement en ce qui concerne un certain nombre de polluants, la qualité microbiologique de certaines stations balnéaires, de coquillages et de leurs zones d'élevage.

Un certain nombre de conventions et protocoles ont été signés :

- La convention pour la protection de la mer Méditerranée contre la pollution (Barcelone, 1976).
- Le protocole relatif à la prévention de la pollution de la mer Méditerranée par les opérations d'immersions effectuées par les navires et aéronefs (Barcelone , 1976).
- Le protocole relatif à la coopération en matière de lutte contre la pollution de la mer Méditerranée par les H.C et autres substances en cas de situation critique (Barcelone , 1976).
- Le protocole relatif à la protection de la mer Méditerranée contre la pollution d'origine tellurique (Athènes , 1980).
- Le protocole relatif aux aires spécialement protégées de la Méditerranée (Genève , 1982).

La gestion intégrée des zones côtières : un outil pour lutter contre la pollution ?

Le littoral, interface entre la terre et la mer, est milieu complexe, riche sur le plan écologique, et très convoité. Actuellement, 60% de la population vit à moins de 60 km des côtes et l'urbanisation littorale risque de s'amplifier, puisqu'on attend 75% de la population mondiale sur les côtes en 2025. L'aménagement intégré des zones côtières, mentionné au chapitre 17 de l'agenda 21 adopté à Rio en 1992, veut prendre en compte tous les paramètres terrestres (urbanisation, agriculture, assainissement des eaux, industries, infrastructures ...) et marins (pêche, déballastage, protection des écosystèmes marins...) pour protéger le littoral sans nuire aux activités économiques, imposer des réglementations sans nuire à la vie des populations locales, élaborer des programmes d'aide qui soient pilotés au niveau local. Des expériences sont déjà en cours dans une cinquantaine de pays du monde.

Les problèmes émergents

- Les changements climatiques
- Les nouvelles classes de contaminants du milieu marin
- L'accumulation de composés organiques persistants dans les sédiments des fonds marins
- L'océan en tant que dépôt potentiel de dioxyde de carbone

<i>Features</i>	<i>Unit</i>	<i>Data</i>
sea surface	million km ² /million sq m	2.5/0.965
East—west extent	miles/km	2,500/4,000
North—south extent	miles/km	500/800
average water depth	km/yd	1.5/1,640
water depth, Strait of Gibraltar	meters/feet	97/320
water depth, Bosphorus	meters/feet	70/200
coastline total length	thousand km	45.0
coastline island length	thousand km	17.7
Mediterranean coastal region, surface	million km ² /million sq m	1.5/0,579
countries (*)	no.	21
autonomous territory	no.	1 (**)
urbanisation	% of the coastline	65
coastal population, total Mediterranean, 1980	million inhabitants	84.5
coastal population, total Mediterranean, 2000	million inhabitants	123.7
coastal population, total Mediterranean, 1980/2000 increase	percent	46
population pressure, 2000 (residents and tourists)	thousands per km of coastline	5,700 to 6,600
population pressure, 2025 (residents and tourists)	thousands per km of coastline	11,000 to 12,200
power plants: existing/planned/total - Mediterranean	no.	112/43/155
power plants, existing/planned/total - northern side	no.	60/4/64
power plants, existing/planned/total - southern side	no.	52/39/91

* Albania, Algeria, Bosnia and Herzegovina, Croatia, Cyprus, Egypt, France, Greece, Israel, Italy, Lebanon, Libya, Malta, Monaco, Morocco, Slovenia, Spain, Syria, Tunisia, Turkey, Federation of Yugoslavia (Serbia and Montenegro).

** Gaza Cis-Jordan entity.

Tableau 1 :
The Mediterranean. Main Data

POPULATION DES PAYS MÉDITERRANÉENS

Évolution 1950-1985; scénario moyen 1985-2025

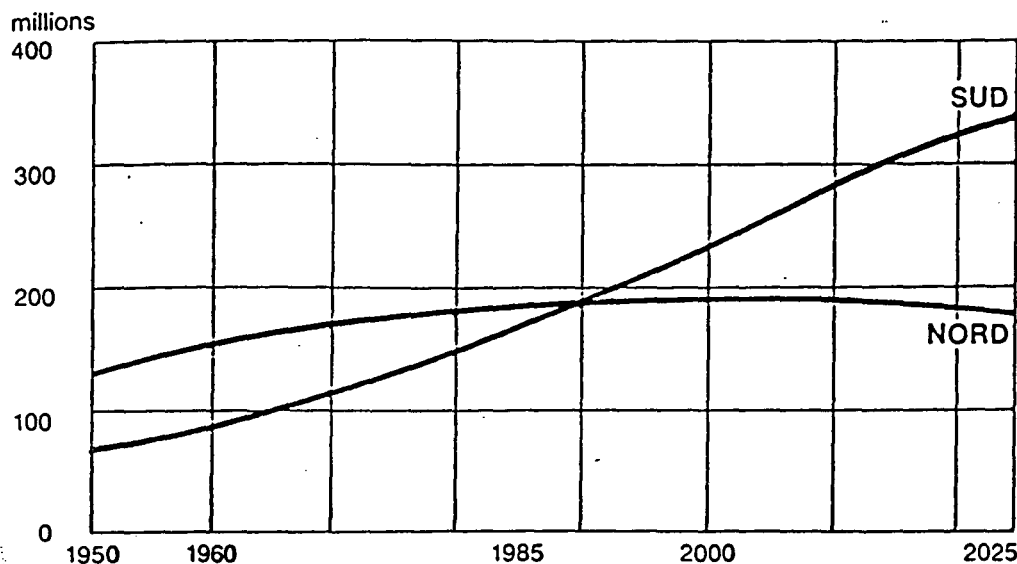


Schéma: Evolution des populations du bassin Méditerranéen

EVOLUTION DES POPULATIONS DES VILLES DE PLUS DE 10000 HABITANTS DANS LES REGIONS COTIERES MEDITERRANEENNES, 1995 - 2025

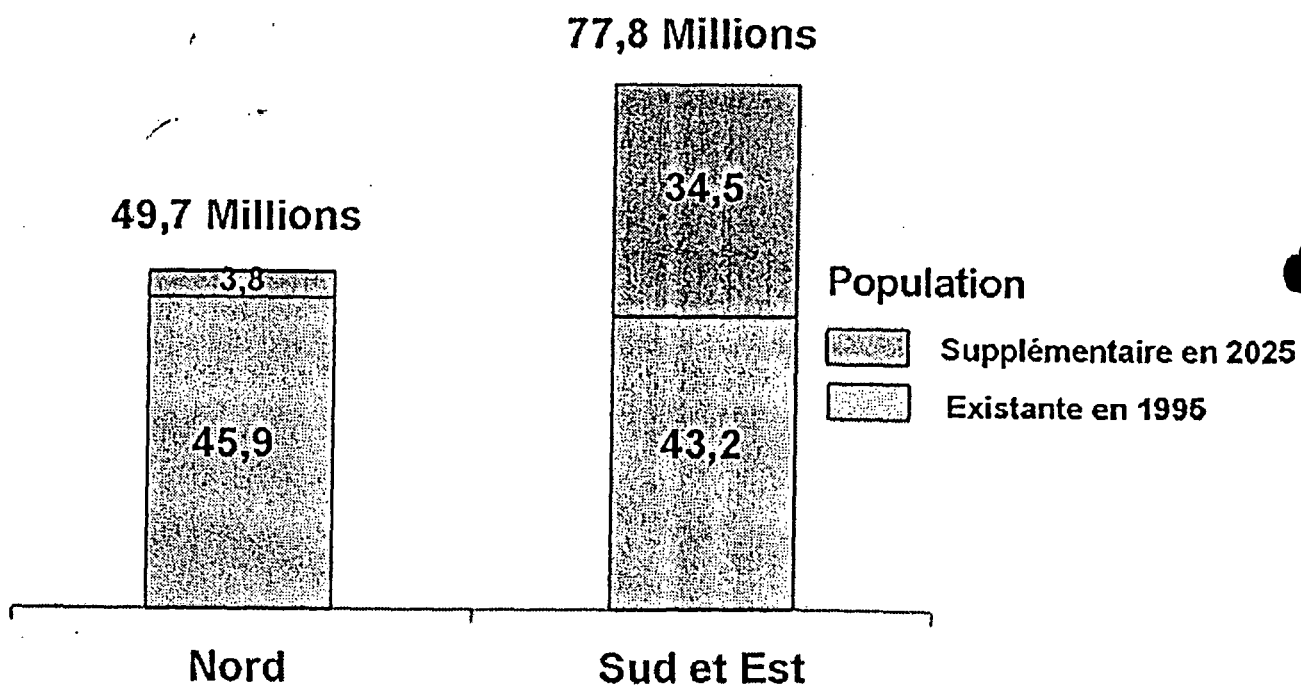


Figure 1 : Evolution démographique du bassin Méditerranéen

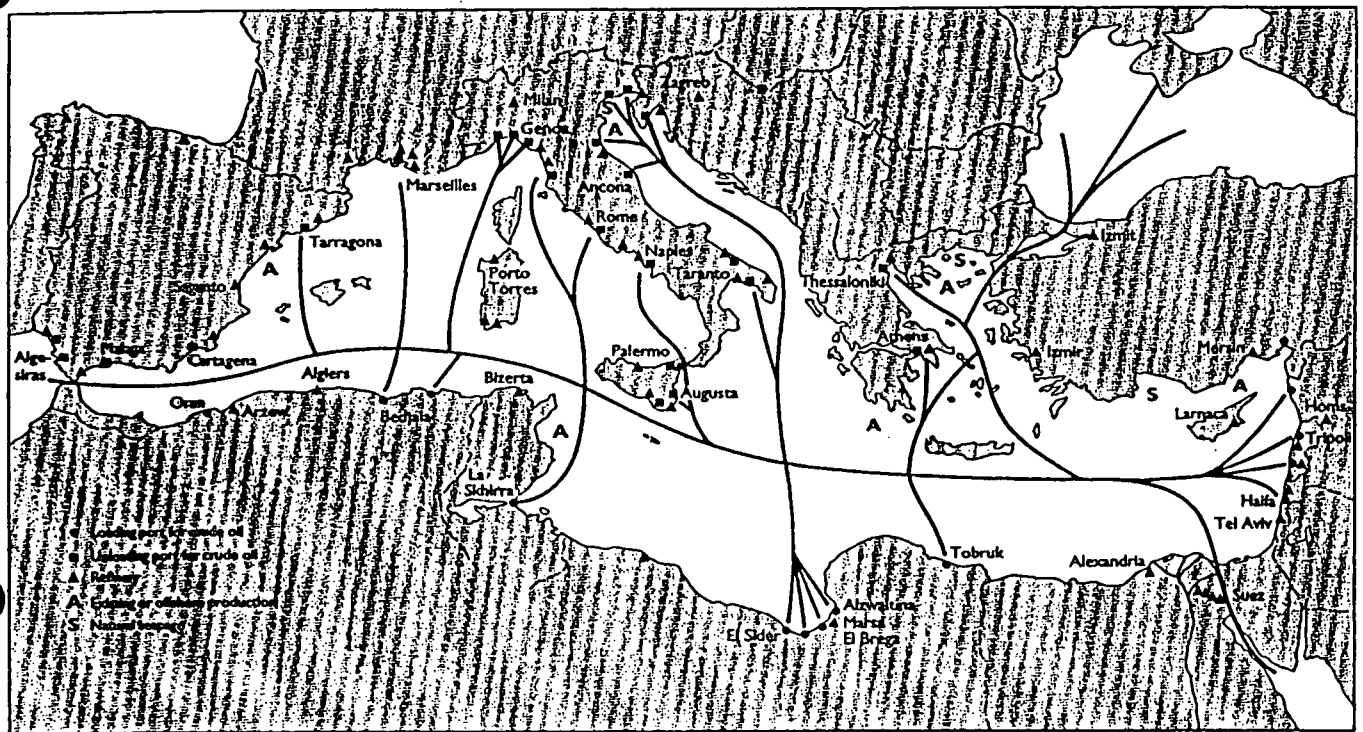


Fig 5: Loading ports, refineries, natural seepage and traffic routes in the Mediterranean

Area	Depth	Organic carbon flux	Lipid flux	Amino acid flux	Carbohydrate flux	Source
	(m)	MgC m ⁻² d ⁻¹	mg m ⁻² d ⁻¹	mg m ⁻² d ⁻¹	mg m ⁻² d ⁻¹	
Tropical Atlantic	North 732	nd	0.45	nd	nd	De Baar et al. 1983
Panama	890	5.5 - 17.3	nd	2.6 - 9.9	0.6 - 7.6	Ittekkot et al. 1984
Panama Basin	1267	5 - 14	0.4 - 2.5	2.4 - 7.3	nd	Lee et al. 1983
Central Sea	Arabian 2914	nd	0.085	nd	nd	Reemtsma et al. 1990
NW Mediterranean Sea	645	92.7	nd	68.2	11.8	"
NW Mediterranean Sea	2000	3.4 - 5.7	0.04 - 0.13	nd	nd	"
Cretan Sea	1515	2.46-6.25*	0.53-2.85	0 - 3.23°	2.1 - 8.9	Danovaro et al. 1999a
Northern Aegean	799-1248	3.0-249.2	0.3-3.7	0.7-33.5	6.2 - 575.8	Danovaro et al. 1999b
Southern Aegean	1450-1690	3.3 - 7.5	1.1 - 3.1	1.3 - 2.6	18.1 - 27.3	

* expressed as BPC flux

° expressed as protein flux.

Tableau 2a:
Fluxes of labile organic compounds in different areas of the Mediterranean and comparison with available information worldwide.

Tableau 2b:

Les paramètres à déterminer dans les effluents :

Paramètres prioritaires

- Mercure total (Hg)
- Cadmium total (Cd)
- Hydrocarbures de pétrole (HDP)

Autres paramètres (non par ordre de priorité)

- Hydrocarbures chlorés à poids moléculaire élevé (HH)
- Demande biochimique d'oxygène (DBO5)
- Demande chimique en oxygène (DCO)
- Matières en suspension totales (MEST)
- Phosphore total (P)
- Azote total (N)
- Coliformes fécaux (CF)
- Détergents anioniques (DET)
- Phénols (indice) (PHE)
- Plomb total (Pb)
- Chrome total (Cr)
- Zinc total (Zn)
- Radionucléides sélectionnés (RAD)

Tableau 2C

LIST OF RECOMMENDED PARAMETERS

PRECIPITATION

pH
Conductivity
Acidity
Alkalinity
SO₄-S
NH₄
NO₃-N
Na, K, Mg, Ca
Cl
Cd
Pb
Cu
Zn
Radionuclides
Organic compounds
Precipitation amount

PARTICLES

SO₄⁻²-S
Na
Al
Cd
Pb
Cu
Zn
Radionuclides
Organic compounds
Total SPM
Air volume

GASES

O₃ *)

METEOROLOGICAL parameters

Wind speed
Wind direction
Air temperature
Sea surface temperature **)
Dew point
Relative humidity
Barometric pressure

*) at impact station

**) when applicable

TOPEX/POSEIDON, from October 1992 to September 1997

Mediterranean Mean Sea Level Variations

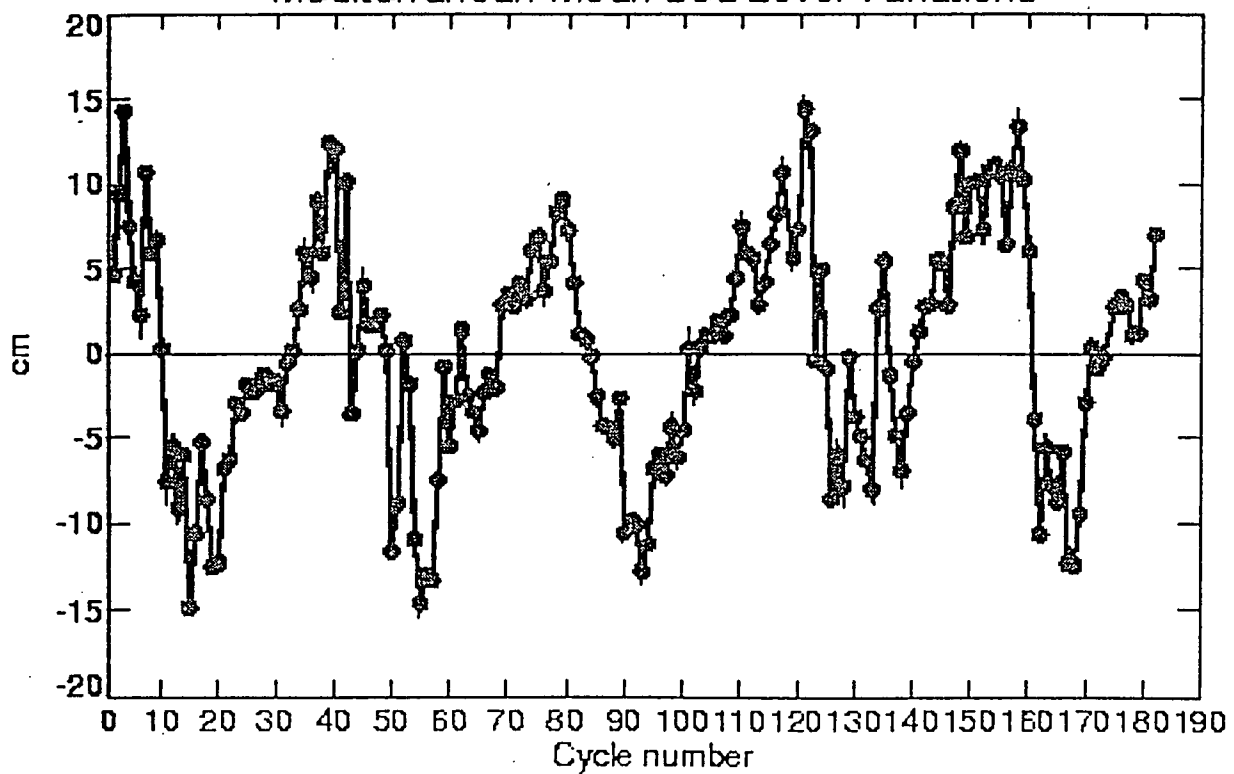


Fig. 6 : Mediterranean mean sea level variations calculated from almost five years of TOPEX/POSEIDON data

Tableau 7: Concentration increases and effects of trace gases

Gas	Rate of Increase % per yr	Effects	Sources	Lifetime (years)
Carbon dioxide	0.4 (0.2-0.7)	Added greenhouse effect	Natural; combustion	10-15
Methane	1.3 (1-2)	Added greenhouse effect; OH cycle; ozone (tropospheric and stratospheric)	Natural; food production	7-10
Nitrous oxide	0.3	Added greenhouse effect; ozone depletion (stratosphere)	Natural; combustion; agriculture	100
Carbon monoxide	5	Indirect effects, OH depletion (troposphere)	Natural; combustion; automobiles	0.2
F-11 and F-12	5	Added greenhouse effect; ozone depletion (stratosphere)	Anthropogenic	50-100
Others				
F-113	10	Ozone depletion (stratosphere)	Anthropogenic	Long
F-22	11			15
Methylchloroform	5	Added greenhouse effect		6
Carbontetra-chloride	3			50

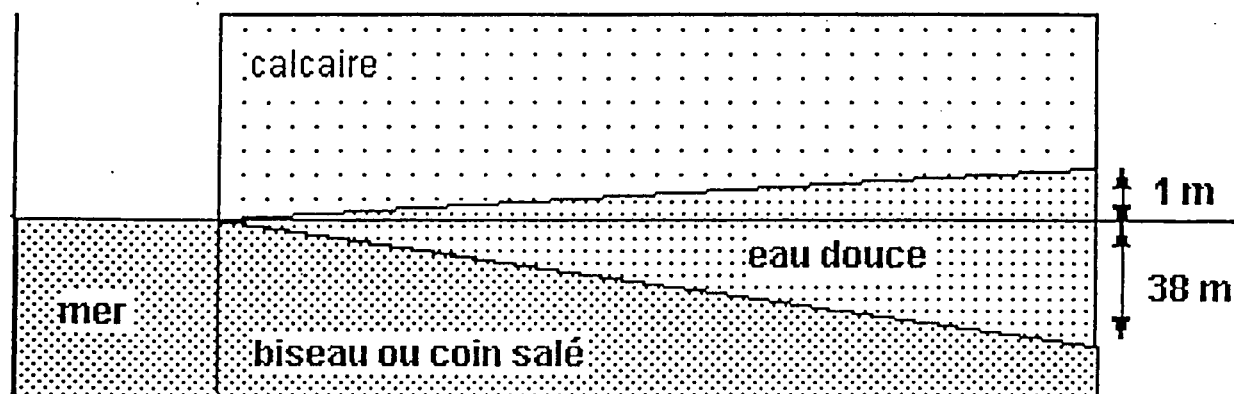


Figure 7: position théorique de l'interface eau douce eau de mer dans un aquifère littoral.

SCENARIO	HORIZON		
	2030	2050	2100
<u>IPCC GLOBAL</u>			
Temperature	+1.8°C	-	+2 to +5°C
Mean sea level	+18cm ±12cm	-	+65cm ±35cm
<u>IPCC Southern Europe</u>			
Temperature	+2°C in winter +2 to +3°C in summer	-	-
Rainfall	+0 to +10% in winter -15 to -25% in summer	-	-
Soil humidity	-15 to -25% in summer	-	-
<u>UEA: Mediterranean</u>	For each °C of global increase		
Rainfall	+3% in winter -3% in summer	-	-
<u>UNEP Task Teams</u>			
Temperature	-	+1.5 to +3°C	-
Mean sea level	-	+38cm ±14cm	-
<u>Sfax. derived from UEA Maita model</u>	For each °C global increase		
Temperature			
Annual	+0.8 to 0.9°C	As for 2030	As for 2030
Winter	+0.8 to 0.9°C		
Spring	+0.7 to 0.8°C		
Summer	+0.8°C		
Autumn	+0.8 to 0.9°C		
Rainfall*			
Annual	+6 to +9%		
Winter	+8 to 12%		
Spring	0 to -6%		
Summer	Not forecast		
Autumn	+5 to +10%		

* Rainfall changes are expressed as a percentage relative to current values

Tableau 8 :

Future climate scenarios derived from scenarios established by IPCC and the university of East Anglia.

Focus on the impacts of the industrial development in the Mediterranean Basin

The monitoring of pollutants affecting the Mediterranean marine environment reflect primarily the immediate and long-term requirements of the Barcelona Convention and its protocols, but also take into account those factors needed for the understanding of the relationship between the socio-economic development of the region and the pollution of the Mediterranean Sea.

NUTRIENTS IMPACT :Eutrophication

1. Introduction

Increases in the availability of nutrients due to anthropogenic activities (nutrient inputs via sewage, agriculture, industry and the natural load, carried by rivers) affect plant production in the sea.

This may have the consequences upon man's interests and the environment.

Nutrients in this context can be defined as those substances which are required for growth of primary producers such as benthic algae and phytoplankton all of which are autotrophic organisms using light as their energy source.

This process of primary production also involves nutrients being taken up mainly from the surrounding water.

The major nutrients in a marine context are compounds of nitrogen and phosphorus and, to a lesser extent, silicate.

It is, however, worth noting that a wide variety of elements, e.g. iron, manganese, zinc, copper and cobalt, are known to be essential for the process of algal production to proceed, as these elements are incorporated into organic molecules which enter into photosynthesis reactions. It has also been shown that at least some algal species require the presence of organic compounds such as Vitamin B12, thiamine and biotin.

The term often used to describe these effects is eutrophication.

The important issue is the actual effects the nutrient enrichment can have on the marine environment and the extent to which these are regarded as harmful i.e. constitute pollution.

Activities affects either the rate of primary production or the composition of the species involved in primary production.

2. Forms of nutrients in chemical terms : concept of most limiting nutrients.

The rate of primary production of new organic matter in the marine environment is generally limited either by nutrient availability or by one of two physical factors : light intensity and temperature. Even in the latter case the final maximum size of the crop is, however, usually limited by the availability of either combined phosphorus or nitrogen. Other micronutrients may, under certain circumstances also be important in this respect. The actual growth rate will be a function of more complex biological factors such as grazing pressure and the presence of a seed population of the species concerned. The stability of the water column will also influence both the level of production and whether the full maximum potential crop yield is achieved.

In natural as well as moderately polluted coastal sea water, phosphorus usually appears in the following forms : particulate, colloidal, inorganic phosphate and dissolved organic. Orthophosphate is the form preferred by unicellular algae, but on the basis of results obtained through algal monocultures, an ability to utilize other forms such as polyphosphates and organic phosphorus, seems to be widespread. It is generally agreed that combined inorganic nitrogen is usually the most limiting nutrients in the sea.

The principal forms of inorganic nitrogen in the marine environment are dissolved molecular nitrogen, which is usable by blue-green algae (cyanobacteria), nitrate, nitrite and ammonia ; organic forms of nitrogen also occur in both particulate and dissolved forms, for example as urea and amino acids .

The chemistry of nitrogen in the sea is quite complex

In its most oxidized combined form, nitrogen exists as the nitrate ion and this constitutes the most important reservoir of combined nitrogen in the deep ocean. In highly productive marine ecosystems, phytoplankton production is usually driven by the availability of nitrate.

In less productive systems, however, ammonia may be the more important form. Phytoplankton are also able to utilize other forms of nitrogen, notably nitrite, urea and some amino acids, particularly where more readily assimilable forms have become exhausted.

Nitrogen nutrients are introduced to the sea by terrestrial weathering and plant decomposition, oceanic mixing processes, regeneration from decomposing marine primary and secondary producers (in the water column and sediments) and by air-sea exchange processes (including dry deposition and rainfall). Human activities may influence all of this processes.

The most common land-based sources of nutrients arise from :

domestic wastes (principally sewage and detergents),
agricultural run-off (either of fertilizers or through increased erosion and weathering), animal wastes from intensive livestock units (industrial farming),
industrial effluents and
atmospheric discharges from fuel combustion and agriculture.

These sources supply nitrogen and phosphorus in a wide variety of chemical forms, not all of which are immediately taken up by marine plants but require further remineralization by heterotrophic processes. Depending on the composition of the discharge, a wide geographic area may thus become nutrient enriched. The ecological impact of a given nutrient source will vary with the depth and flushing characteristics of receiving water body.

3. THE MEDITERRANEAN SEA

Euphotic layers of the major part of the Mediterranean Sea have unusually poor natural supplies of nutrients, typical concentrations being below 0.05 mol./ Liter P-P04 and 0.5 mol. /Liter N-N03 , hence it is known as one of the most oligotrophic regions of the World Ocean.

Except for some areas, the Mediterranean shelf is rather narrow and land-borne nutrient inputs are generally very modest except in a few northern areas.

Therefore, a widespread offshore eutrophication is unlikely ever to appear, except in the areas directly affected by discharges from rivers most of which are quite polluted.

In fact, two areas already show indications of a large-scale anthropogenic eutrophication : Golfe de Lion and the Northern Adriatic.

The last presents an example of fast developing processes that clearly have a destabilising effect on both ecosystems and the economy (fisheries and tourism).

A combination of river-borne and densely scattered point-sources supply this shallow area with unusually high levels of nutrients.

In response, the productivity as a rule rises quite steadily all over the area. but with the maximum rise in the western coastal zone which, in the summer season, is affected by persistent heavy blooms such as « red tides » which cause anoxic conditions and mass mortalities of fish and benthic invertebrates. Under particular hydrological and weather conditions, summer blooms such as catastrophic « red tide » of 1977, extend all over the North Adriatic and, there seems to be an increase in the frequency of these phenomena and a consequent decrease in oxygen levels. As a consequence, mass mortalities of benthic fauna have occurred.

In addition an increasing number of lagoons, semi-enclosed bays and maritime ports are subject to inputs of nutrients at levels that induce heavy eutrophication and associated adverse effects, the most drastic example being the lake of Tunis.

This shallow 48 km² lagoon receives sewage of 0.5 million population equivalents that result in massive additions of nutrients (median levels in mol.liter-1 : 2 – 8 P-P04, 4 – 16 N-NH₄ and 2 – 12 N-N0₃) and extremely high standing crops of phytoplankton (50-400 g/liter of chlorophyll-a).

In spite of intensive consumption of this plant material, there is a substantial surplus of dead organic matter which decomposes during the summer seasons and takes up all available oxygen. The resulting anoxia causes mass mortality of fish and less tolerant invertebrates.

Coastal Mediterranean Waters of Egypt :

Along the coast of Egypt are several relatively enclosed sea water areas that receive considerable amounts of untreated sewage discharges .

The BOD₅ value of the wastes discharged into the Eastern Harbour of Alexandria is equivalent to 5 tonnes of oxygen day. Eutrophication in this semi-closed area increased to the point where it became unsuitable for recreation and fishing. Depletion of dissolved oxygen and liberation of H₂S occurs at the eastern side, due to the limited exchange of its water with the open sea.

In the Western Harbour, dissolved oxygen is depleted in summer and H₂S is liberated. The maximum average phosphate value and the minimum average oxygen concentrations are found near waste-outfalls. The average values of nutrients are 2.5 for NO₃ and 0.57 g/l.

The coastal delta lakes, as well as the Nile estuaries are important land-based sources of nutrient inputs to the southern Mediterranean.

4. ENVIRONMENTAL CHANGES DUE TO EUTROPHICATION AND THEIR EFFECTS ON MAN'S INTEREST

As the foregoing examples indicate, there is now ample evidence from a wide variety of situations around the world that addition of nutrients to the marine environment can affect phytoplankton production and in turn lead to other adverse effects. All of the affected environments have a common characteristic that of restricted water exchange with the open sea; they range in scale however, from small to large bays, lagoons or inlets to entire enclosed seas. The extent of effect which is considered adverse or critical varies markedly, from area to area.

The following paragraphs give some of the symptoms of eutrophication and are graded in an approximate order of progression of the development of the phenomenon.

Effects of eutrophication, particularly in coastal areas might interact (synergistically or antagonistically) with other impacts of human activity on the marine environment. Most of the possible interaction will be of an adverse nature. Thus disposal of organic material will obviously increase oxygen demand in addition to the secondary effects of eutrophication.

In many areas, especially those which are oligotrophic or in which phytoplankton production is seasonally limited by nutrient supply, the first signs of effects of additional nutrient availability will be enhanced phytoplankton activity. This may discolour the water, increase its turbidity and reduce light penetration.

As a consequence of reduced light penetration the zone in which fixed macroalgae can flourish may be reduced, resulting in either a restricted habitat or a total loss of that habitat . Thus, if phytoplankton production leads to demise of the algae more phytoplankton production may result.

A number of phytoplankton species produce substances which may be toxic to man or animals or to fish species or birds. Blooms of both toxic and non-toxic algal species are known to occur in open waters where anthropogenic influences are unlikely.

As primary productivity is increased the rain out of organic matter from dying primary and secondary producers is enhanced and the sediments become enriched with organic carbon and phosphates. This is likely to lead initially to enrichment of benthic animals in terms of both species, numbers and diversity. As organic enrichment of the bottom sediments progresses, species diversity will suffer and, if the conditions become so overloaded that anoxia occurs, near total loss of benthic animals may result.

This latter phase may be associated with severe depletion of oxygen levels in the water, especially in the deeper bottom waters. Thus the water column species diversity and intensity may also be depressed.

Impact on Fisheries

Initially the increase in primary production may be used to advantage by secondary producers and yields of fish or shellfish may actually increase.

However, as habitats become changed or lost fish and shellfish production is likely to be reduced, either in overall terms or in species diversity terms, usually with consequent loss of income to commercial fishermen, and decrease in the attractiveness of the area to sport or leisure fishermen.

Impact on Amenities

In naturally oligotrophic waters tourism is often a major source of economic well being. Among the main attractions of such areas are swimming and diving in the normally clear waters. Eutrophication may cause discolouration of waters rendering them far less attractive.

Impact on Man's Health

As has clearly been mentioned, there is some evidence that blooms of certain species of algae, which are toxic to man, animals, fish or birds, may be more frequent in areas subjected to anthropogenically increased inputs of nutrients.

5. REMEDIAL ACTIONS

In coastal waters which are widely open to the sea, particularly when human settlements are small and/or scattered, there is in principle no risk of a considerable anthropogenic eutrophication, provided that the sewage and similar effluents are adequately disposed and dispersed away from the immediate inshore zones. Disposal of mechanically pretreated effluents via submarine pipelines with diffuser outlets at an appropriate distance from the shore and in a depth below the thermocline, wherever applicable, can be proposed as an adequate control measure, and most economic one.

However, it should be stressed that this strategy of course does not apply to stagnant marine environments such as lagoons, semi-enclosed bays and inlets and many types of estuaries whose receiving capacity is very restricted.

In such circumstances the strategy of direct discharge is obviously not a solution. In this case, it is of crucial importance to reduce levels of nutrients, entering the coastal sea wherever this is feasible ; unfortunately, even so a substantial part of loads that cannot be at present controlled by technical measures will contribute to the enrichment of the coastal sea. From an engineering and management stand point this means very definite and advanced treatment of any substantial effluents discharged into rivers and of those from larger settlements and industries along the shores.

SUMMARY

1. In order for phytoplankton growth to occur, nutrients must be present. The elements most commonly considered essential are the combined forms of phosphorus and nitrogen, but it is increasingly apparent that the presence or absence of other substances, albeit in trace amounts, may limit growth in some circumstances. It is also now generally recognized that if the readily available inorganic forms of nitrogen and phosphorus are exhausted, phytoplankton can continue to grow by utilizing internal reserves and/or other forms of nitrogen and phosphorus.
2. Blooms of phytoplankton occur when conditions favour rapid growth. Other factors, apart from nutrient availability, are important in this respect, light, temperature and water column stability being especially so.
3. Inputs to marine environment of nitrogen and phosphorus have increased, mainly as a consequence of wide scale use of fertilizers, the adoption intensive animal husbandry techniques, the discharge of sewage and industrial waste water, and at least in some areas, nitrogen oxide emissions to the atmosphere from combustion processes.
4. In some coastal waters and enclosed seas, increased inputs of nitrogen and phosphorus compounds have led to clearly detectable increases in the concentrations of such compounds in the water. The areas so affected are numerous and geographically widespread. A common feature of all the areas so affected is a limited water exchange with the open sea.
5. The main concern from a human health stand point in relation to changes in phytoplankton blooms is the fact that certain species give rise to toxins which are accumulated by filter-feeding molluscs such as mussels and clams and cause poisoning in man. Blue-green algal blooms may also be toxic and cause illness in man and the death of animals.
6. In many areas of the Mediterranean Sea which are potentially threatened by eutrophication, there is a need for a marked improvement in observational monitoring efforts in order to establish time series data on which to base identification of eutrophication events or trends.
7. It is possible, on the basis of experience in areas which are recognizably eutrophied, to identify the types of changes which characterize the progressive stages of eutrophication from early onset to criticality.

8. There is ample evidence, from action taken in local situations, that is possible to control the eutrophication process and improve the environmental quality by reducing the scale of nutrient inputs to an affected area . The extent of reduction required and the time taken for environment to recover will depend both on the degree of eutrophication and the characteristics of the area.
9. It can be extremely difficult to identify the early stages of eutrophication with the desired scientific exactitude. Consequently, it may be hard to persuade the policy makers and pollution prevention authorities to take remedial or preventative action .
10. However, since eutrophication seems to occur only in areas with restricted water exchange, it is possible, on a local scale, to identify areas which may be at risk. Thus, for example, any lagoon, inlet, fjord or enclosed bay which receives anthropogenically enhanced nutrient inputs is liable to show signs of eutrophication in time.

Sea - Surface Microlayer

The sea-surface microlayer represents the thin water layer at the air-sea interface, where accumulations of material, living and dead, can occur. The microlayer is the site of accumulation of oil films, both natural and man-made . Oil films are capable of concentrating various lipophilic organic substances, such as organohalogen compounds, as well as concebrating metals . Thus, in the context of air-sea exchange of contaminants, the microlayer represents the location where there is a holdup, or discontinuity, in the transfer process. The extent of this holdup is determined by the residence time of a particular material in the microlayer.

In comparison with the other marine interfaces, the transit time for most contaminants across the air-sea boundary is relatively short.

Various forms of microorganisms , plants and animals , are associated with the microlayer and are collectively termed neuston. They consist of bacterioneuston , phytoneuston and zooneuston. Like the non-living organic and inorganic matter , neuston organisms concentrate in and near the microlayer.

These organisms are enriched in the microlayer, compared to the seawater only a few cm below , by factors of $10^2 - 10^4$ for bacterioneuston , $1 - 10^2$ for phytoneuston and $1 - 10$ for zooneuston (Hardy , 1982) .

Neuston organisms engage in various processes, which undoubtedly affect the transfer of substances between the atmosphere and the sea. These include biodegradation , biotransformation , bioaccumulation , exudate release , defecation , photosynthesis, predation and diurnal vertical migration . There are few quantitative data on the effects of the foregoing processes on air-sea exchange of pollutants and other substances. These effects probably vary with the physical and chemical characteristics of a particular marine area.

2.3 Studies In The Mediterranean Area

The Long-term Programme for Pollution Monitoring and Research (MED POL - Phase II) of UNEP's Mediterranean Action Plan includes monitoring of the transport pollutants into the Mediterranean Sea through the atmosphere and research and studies on pollutant-transfer processes at air / sea interface . The purpose of the monitoring is to establish the input (flux) of pollutants into the Mediterranean Sea through the atmosphere and thus to provide additional information on the pollution load reaching the Mediterranean Sea . The monitoring includes :

- areas directly influenced by identifiable sources of air pollution and
- reference areas not directly influenced by identifiable sources of air pollution .

LIST OF RECOMMENDED PARAMETERS

PRECIPITATION

pH
Conductivity
Acidity
Alkalinity
SO₄-S
NH₄
NO₃-N
Na, K, Mg, Ca
Cl
Cd
Pb
Cu
Zn
Radionuclides
Organic compounds
Precipitation amount

PARTICLES

SO₄⁻²-S
Na
Al
Cd
Pb
Cu
Zn
Radionuclides
Organic compounds
Total SPM
Air volume

GASES

O₃ *)

METEOROLOGICAL parameters

Wind speed

Wind direction

Air temperature

Sea surface temperature **)

Dew point

Relative humidity

Barometric pressure

*) at impact station

**) when applicable

ATMOSPHERIC TRANSPORT OF CONTAMINANTS INTO THE MEDITERRANEAN REGION

Introduction

It is now recognized that a substantial fraction of the contamination entering the ocean derives from sources located on land via atmospheric inputs. Contaminants of major concern are heavy metals and metalloids such as Pb, Cd, Hg, As, and Sn, petroleum hydrocarbons, chlorinated hydrocarbons and pathogenic microorganisms. Such elements or substances are present in the air in the particulate form and / or in the gaseous form. The atmospheric lifetime of such materials is generally long enough (greater than 1 day) to allow them to be transported far from their sources (greater than 1000 km). On the other hand, these lifetimes are often too short (less than one year) to allow uniform horizontal and vertical mixing of contaminant material in the global atmosphere.

1.1 Transport Processes

1) Horizontal Transport

Atmospheric transport to the ocean can be regarded as occurring in two different scales : off-shore and long range.

In the off-shore mode, it may be assumed that a considerable fraction of contaminant deposition will occur on waters relatively close to the major coastal sources (less than 100 km). In this mode, the transport of contaminated air parcels takes place in the turbulent, relatively shallow boundary layer which is well- mixed in the vertical plane (height less than 1000 m).

In contrast to off-shore transport, long range transport (100 – 1000 km and greater) involves mechanisms that incorporate chemical substances into the upper troposphere. The air parcel eventually undergoes large scale descent and again becomes incorporated into the boundary layer. During ascent, interactions with cloud and rain droplets can chemically and physically alter, effectively remove and vertically displace some of the trace constituents.

Such interactions are extremely complex and still little understood, and models capable of describing the complete three-dimensional picture of emission / deposition have not been developed

The method for interpreting long-range transport is the use of air trajectory models.

Computer techniques permit the routine computation of numerous trajectories to relate pollution movement forward in time from sources of emissions and also backward in time from sampling arrays. They can be constructed using several techniques based on pressure and temperature fields and observed wind fields. When calculated over a period of a number of years, trajectories are extremely useful to describe long-range flow climatology and to characterize year to year variations.

When combined with chemical measurements, the use of trajectories provides a means to identify the source of materials being investigated.

2) Deposition

There are two basic processes by which contaminants enter the ocean from the atmosphere: dry deposition and wet deposition.

a- Wet Deposition

Collection of precipitation samples which are representative of trace quantities of contaminants over the ocean is often quite difficult. To distinguish wet from dry deposition,

wet-only sampling is required, i.e. sampling only when rain is actually falling. Wet-only sampling includes both the rainout (within-cloud scavenging) and washout (below-cloud scavenging) components of wet deposition.

Washout factors, or scavenging ratios, are often used to relate atmospheric concentrations of substances present in aerosols or in the gas phase to their concentrations in rain. Washout factors have been defined in several ways, but all involve a ratio of the rain concentration to the atmospheric concentration of the substance of interest.

The use of washout factors to calculate deposition rates of substances implicitly assumes that the concentrations in rain and air are linearly related.

b) Dry Deposition

(i) Aerosols

The dry deposition of aerosol particles to the ocean surface refers to all deposition processes except precipitation . It is often estimated by utilizing the dry deposition velocity, v_d , given by :

$$v_d = F / M$$

where

v_d is the dry deposition velocity

F is the flux of particles to the surface , and

M is the atmospheric concentration.

(ii) Gases

Unfortunately techniques are not yet available to measure directly gas fluxes across the air / sea interface. Fluxes must be estimated by use of gas exchange models. In a two-layer boundary system at an air / water interface the flux of any gas through each boundary layer is given by :

$$F = k c$$

Where

F is the flux

c is the concentration difference across the particular layer

k is the corresponding transfer velocity

k depend on many factors, including the degree of mixing of the water and air and the chemical reactivity of the gas. The reciprocal of k is often called the resistance, r, and is a measure of the 'resistance' of the gas to transfer. It has units of sec / cm. The total resistance to the exchange of any gas will be the sum of the resistance in the gas and the liquid phase laminar layers.

The exchange of gases which are not particularly soluble in water, e.g. N₂, O₂, CO₂, and the inert gases is largely controlled by the resistance in the liquid phase. This group includes a number of synthetic organic compounds. On the other hand, the exchange of such very soluble gases as H₂O, SO₂, HNO₃, HCl, etc. is controlled by resistance in the gas-phase laminar layer. This class of compound is often quite reactive in the aqueous phase.

c) Complications in Wet and Dry Flux Determinations

An accurate measurement of the concentration in rain and dry deposition is a necessary first step in evaluating fluxes of substances to the ocean. The total amount of rainfall in the period of interest, per year for example, must be known.



INTERNATIONAL CENTRE FOR SCIENCE AND
HIGH TECHNOLOGY



UNITED NATIONS INDUSTRIAL
DEVELOPMENT ORGANIZATION

ECOLE MOHAMMADIA D'INGENIEURS



An Overview of Knowledge Based Expert Systems and Object Concepts

Driss ^{ou}OUAZAR
Professor of Civil Engineering
Ecole Mohammadia d'Ingenieurs
B.P. 765, Agdal, Rabat, Morocco
Phone: 0021237670579; Fax 0021237778853
Email: ouazar@emi.ac.ma



Outline

- Engineering Problems Features
 - Well-posed
 - Ill - structured
 - problem statement

- Problem Solving Techniques
- Artificial Intelligence
- What is an Expert System
- Types and Applications Area
 - Derivation
 - Formation
- Examples of developed E.S.



- Appropriateness of a KBES approach
- K.B.E.S main components
 - Desirable components
- Development process
- Conventional Programs vs KBES
- Inference mechanism
 - Forward chaining
 - Backward chaining
- Search techniques
 - Brute force search
 - Depth first
 - Breadth first
 - Heuristic search
 - Hill climbing (Best-First)



- Knowledge representation
 - Engineering Knowledge
 - Structures and Reasoning
 - Mechanisms
 - Knowledge representation
 - Rule-based
 - Logic
 - Semantic Networks
 - Frames
 - ...
- Expert System Shells
 - Shell Selection for Engineering Purposes
 - Available commercial shells

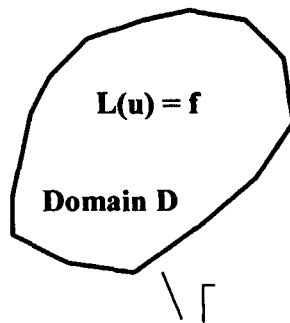


Biography

1. Computer Aided Engineering. The Knowledge Frontier. (Vol.1. Fundamentals), Ed. D. Sriram, M.I.T Cambridge, 1990.
2. Knowledge Engineering, Ed. H. Adeli, He Graw Hill 1990.
3. Lecture notes on Expert Systems in Civil and Mining Engineering V.U. Nguyen, University of Wollongout, 1990.
- 4 Object Oriented Methodology, Rumbaugh et all, Addison Wisley 1993
- 5 Object Oriented Approachy, Brooch et all, Addison Wisley 1995

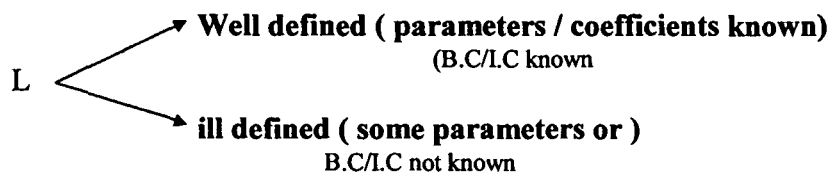


Engineering Problems Features



$L(u) = f$
Subject to
Boundary Conditions (B.C)
and to
Initial Conditions (I.C)

L is usually an operator involving Partial
Differential Equations



Engineering problems

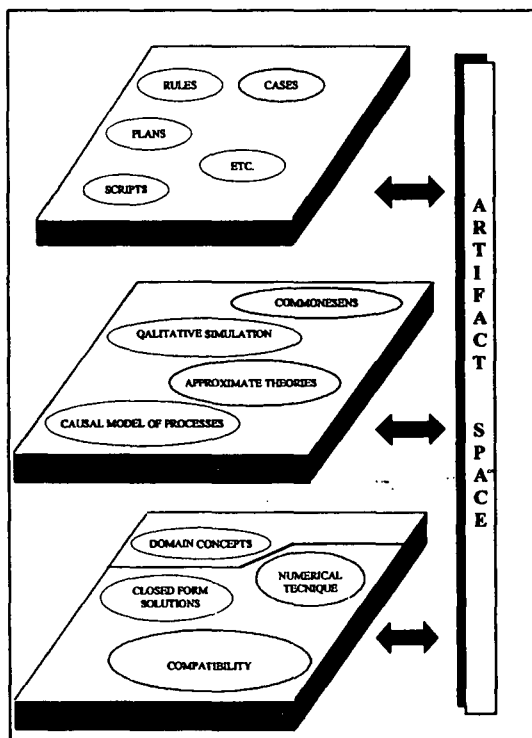
Highly complex

- Data
- Models
- Knowledge
- Expertise

Require

- Calibration
- Validation
- Experiments
 - Laboratory
 - Field/in-situ

For accurate
Modelling and
possible simulation



Knowledge

Public Knowledge

- Documentation
- Books
- Private Knowledge



INTELLIGENCE ?

- *Capital :*
 - Reasoning
 - Acquire and apply knowledge and know how
 - Perceive and manipulate things
 - Constituted by many talents of representing information and its treatment



Artificial Intelligence

Definition : Development of computer programs that emulate human intelligence in problem solving :

- computer vision
- pattern recognition
- human-language comprehension and processing
- robotics
- KBES or ES



KBES (Expert System)

- An Expert System is a computer programme in a specific field (domain) that can mimic the manner and methodology of a human expert in developing a solution and providing advices or answers to a problem in that field, usually through a highly interactive process (like an interview).



Objective

- Solve engineering problems not amenable to a purely algorithmic solutions i.e.
 - Ill-structured problems



Implications

- Users
- Designers
- Knowledge Engineers



MECHANISMS

Knowledge Base

Facts
Rules
Information about
the Subject

Inference Engine

General
Knowledge
about How to
draw
Conclusions



Categories of KBES Applications

- **Interpretation:** Inferring data describing a situation, using sensors and other input devices
- **Prediction:** Inferring likely consequences of given combinations of circumstances and situations
- **Diagnosis:** Inferring malfunctions in various kinds of systems based on observable and recorded data



Categories of KBES Applications Continued

- **Design:** Designing and configuring systems subject to constraints
- **Planning:** Creating plans of action from goals to be achieved
- **Monitoring:** Following up and comparing observations to expected scenarios and values



Categories of KBES Applications Continued

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- **Control:** Governing the behaviour of a total system



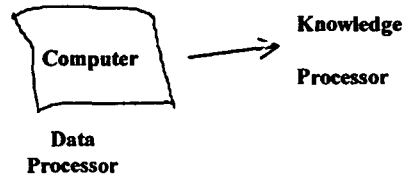
Intensive Use of the computer

Computers are mainly used :

Storage and data treatment
Databases, Scientific computation

A.I. Revolution

Conventional



Possibility of Reasoning
INFERENCE



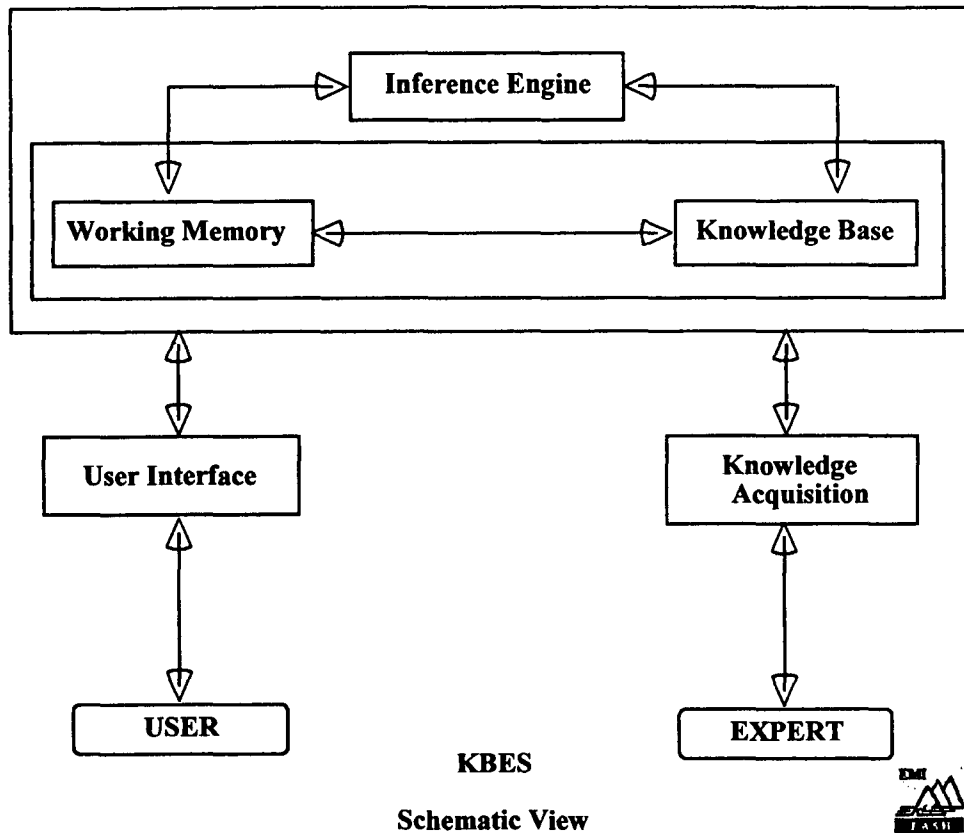
Why E.S. and K.B.E.S

Human expert : respect
long time experience
and practice
do well their job

but Trouble : Scarcity
not always reliable
require payment
can die taking their knowledge and experience

Human expert are :
scarce
expensive service
always in demand and busy
can die (Loss of all their knowledge)





KBES MAIN COMPONENTS

- **Knowledge Base**

Contains the domain knowledge stored in the form of facts and heuristics

Information and data are supplied by a domain expert
 Knowledge is embodied by a knowledge engineer using one
 or a combination of the many existing knowledge representation schemes.

- . Production rules
- . Frame - based
- . Object oriented

- **Context**

Is the workspace for the solution constructed by the inference mechanisms from
 the information provided by the user and the knowledge base.

Inference mechanism (engine)

Module used for monitoring the execution of the program by interpreting the
 knowledge base contents in order to modify context.



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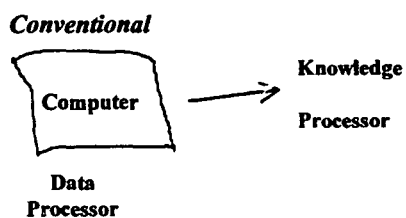


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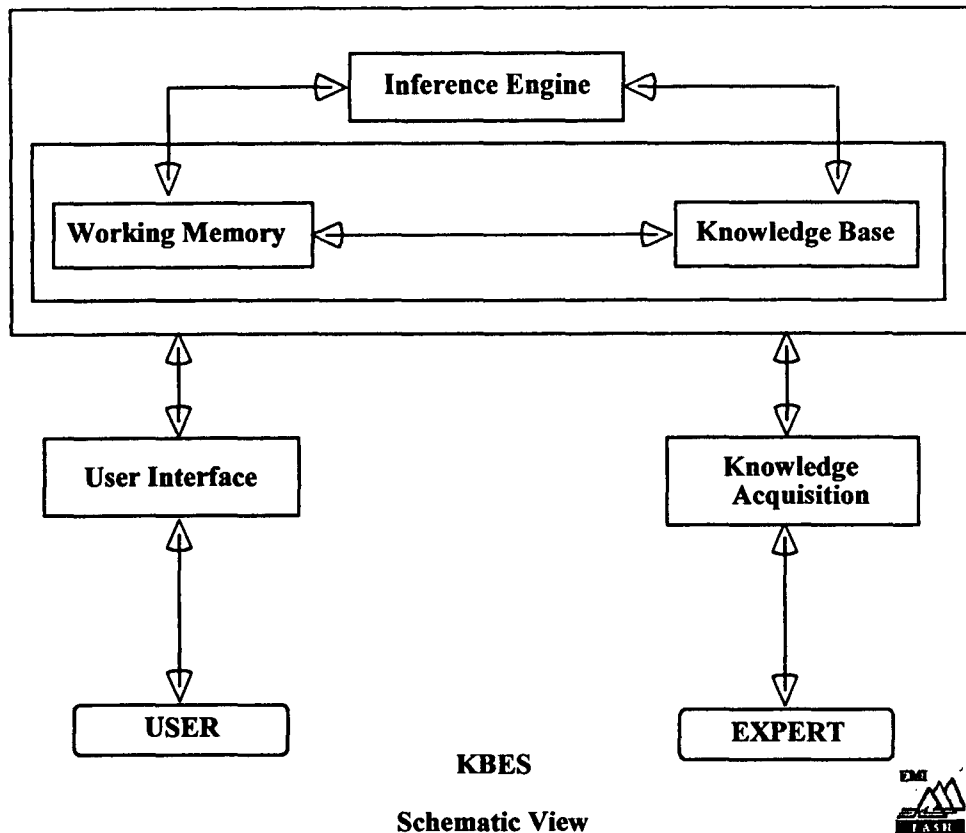
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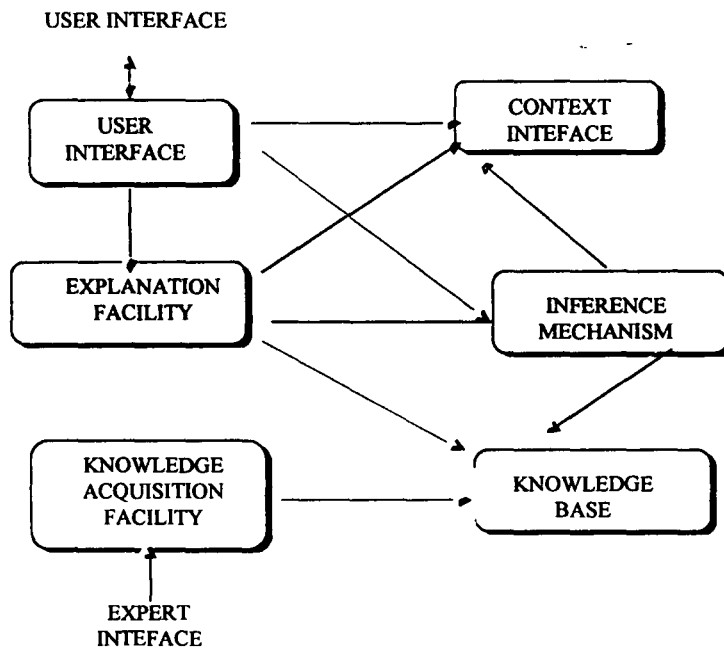
Inference mechanism (engine)

Module used for monitoring the execution of the program by interpreting the knowledge base contents in order to modify context.



• Other desirable components

- Explanation facility
Help the user understanding the reasoning process
- Knowledge acquisition facility
Serves generating the knowledge base resulting from the interaction between the domain expert and the knowledge engineer
- User interface
Receives information and data from the user and supplies explanation for the reasoning behind inferencing and deduction.



Schematic View of a Complete Knowledge-Based Expert System [25]



Explanation Facility

The inference mechanism acts on the rules in the knowledge-base depending on the type of information in the context and then takes the appropriate action. This can be thought of as reasoning. A KBES should be capable of explaining its reasoning process, i.e., it should be capable of showing how it used the rules and the information provided by the user. This explanation is achieved by an explanation facility. An ideal explanation facility should :



1. Be able to handle questions about all relevant aspects of the system's knowledge and actions. It should be able to answer the following questions :

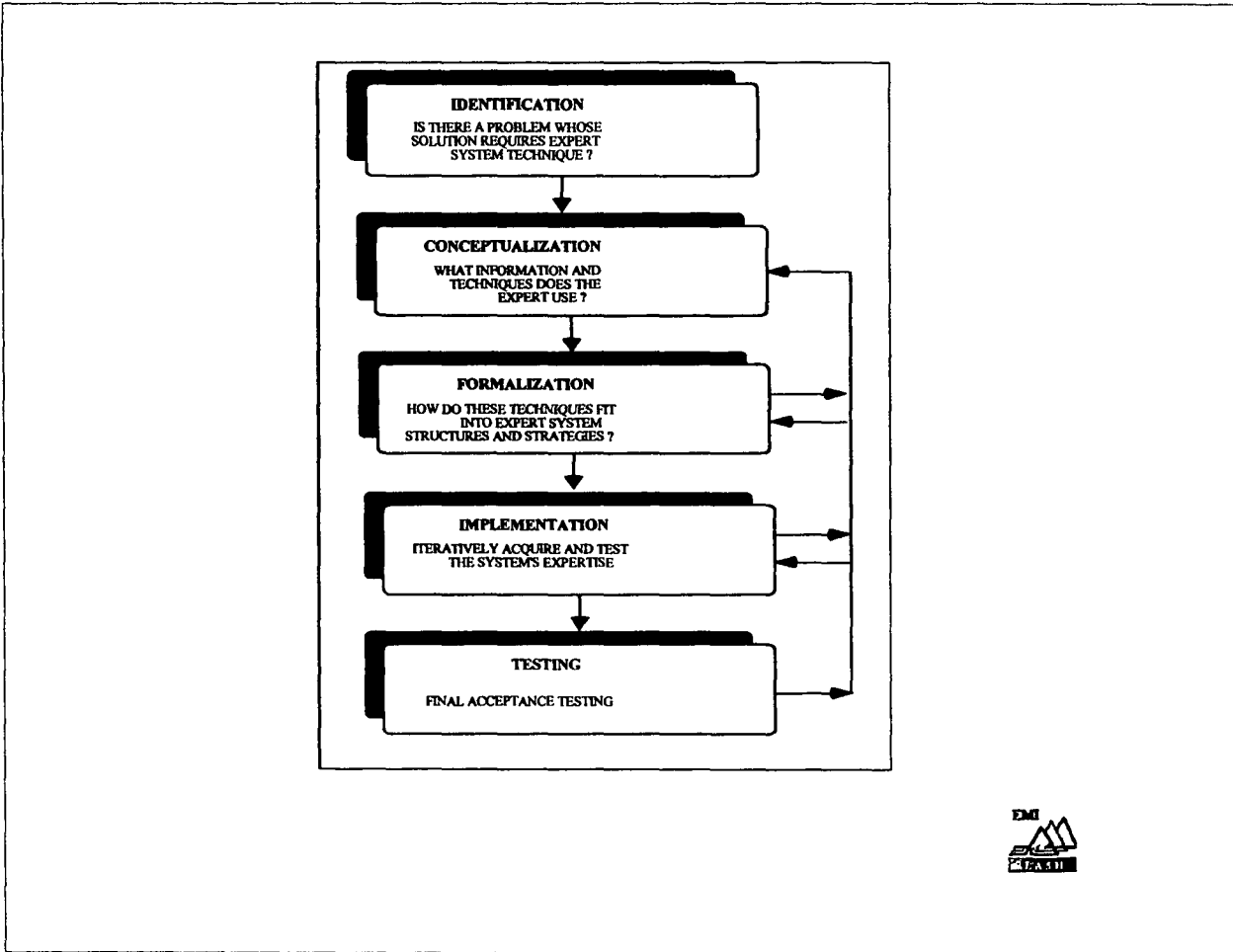
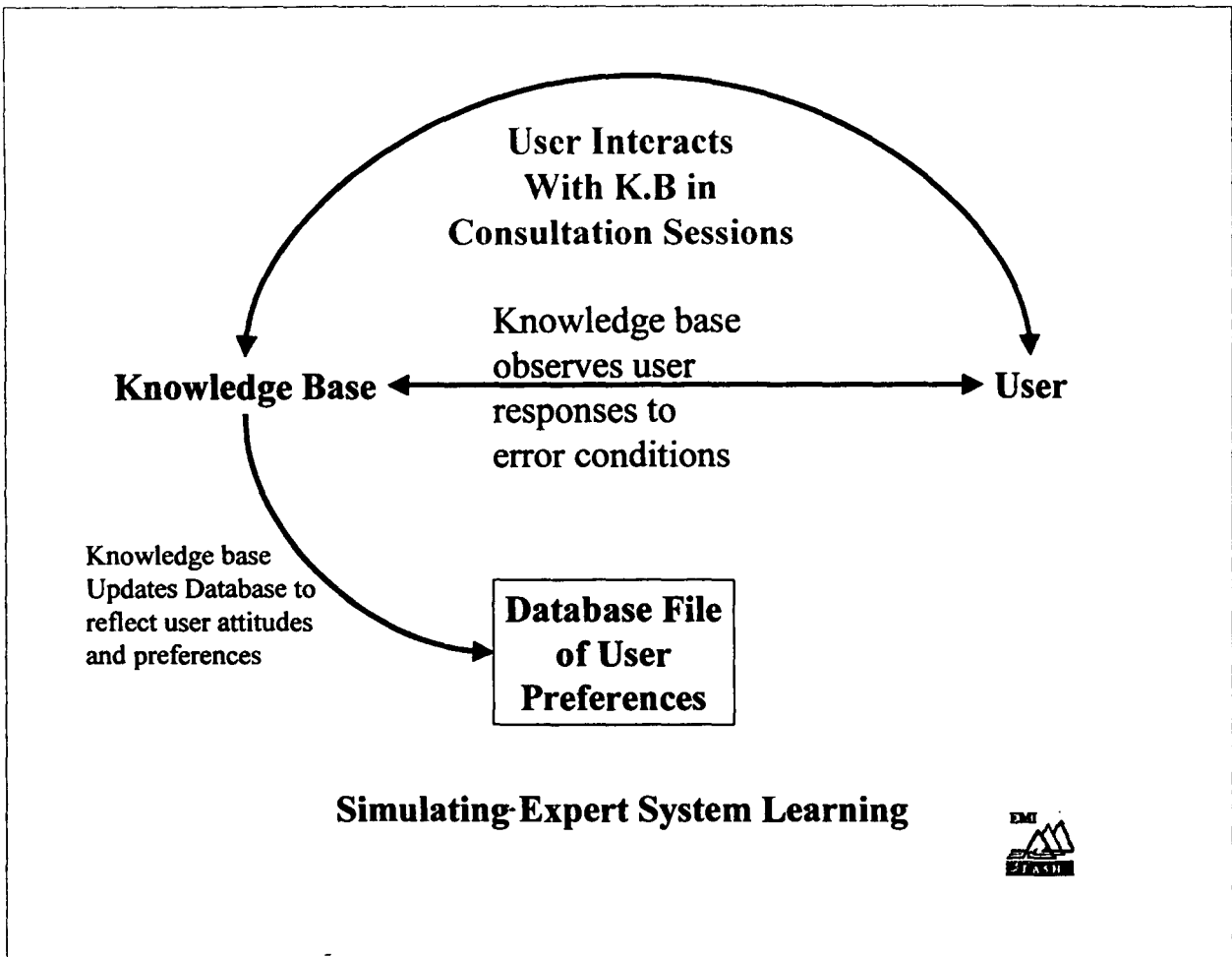
- how it made a certain decision
- how it used a piece of information
- what decision it made about some subproblem
- why it did not use a certain piece of information
- why it failed to make a certain decision
- why it did or did not require a certain piece of information
- how it will use a certain piece of information while the consultation is in progress
- what the system is currently doing.

2. Be easy to use

3. Give answers comprehensively and completely"

The explanation facility of one of the expert systems has been discussed in detail by Scott et al. ; similar techniques can be applied to other rule-based systems.





Development Process

Inference Engine

Inference in E.S. involves comparison of the data and information Supplied by the user and the rules or facts contained in the knowledge base, followed by deduction to arrive at a solution.

Inference techniques depend strongly on the structure of the knowledge base.

Forward chaining

Strategy of reasoning that works from initial state of known facts to goal state.

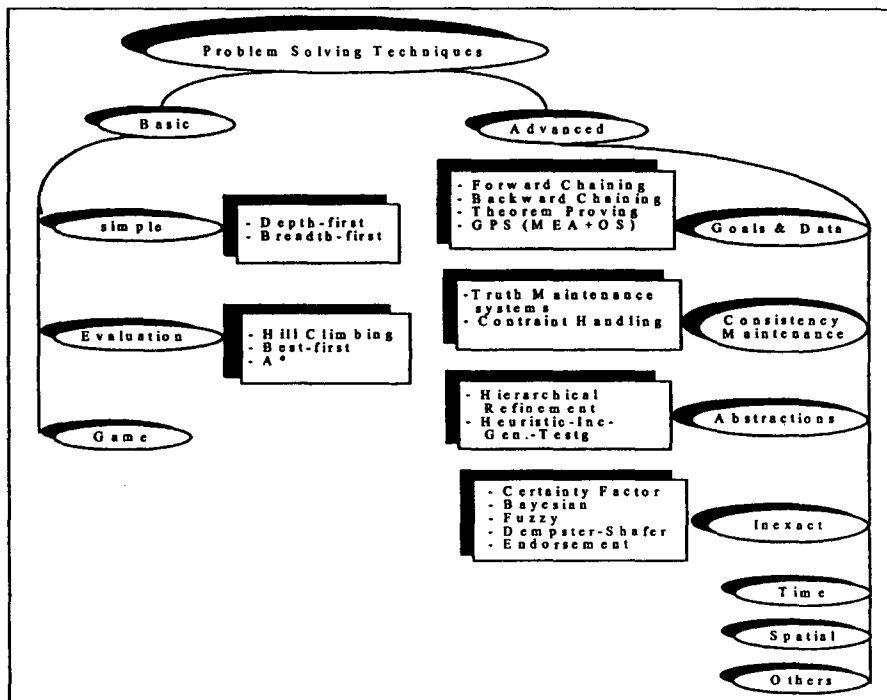
. many hypotheses

goal

. few input data

Backward chaining

Strategy that tries to support a known goal state or hypothesis by checking known facts.



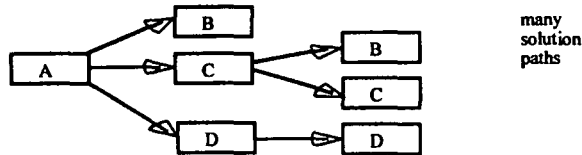
Search techniques

Search is ubiquitous to human problem solving

A. Newell

To simulate human problem solving in a computer, we need search algorithms.

Consider a typical graph providing a solution path to identify some goal (cause) A.



Goal : objective of the search

Node : A point on the graph and possible goal

Terminal node : A node at the end of a search path

Search space : Complete set of nodes in the graph



Brute Force Search

Try every possible path at every possible node in the state space graph until it reaches a solution

Depth-First Search

The solution path explores right to a terminal node on every branch before coming to the next.

Breadth-First Search

Check all the nodes at the same level first for a solution before proceeding to the next deeper level

Heuristic Search

Some kind of philosophy is embodied in the search. The search is selective on the number of possibilities available at each node.

Hill Climbing Search (Best-First Search)

Choose only one direction that is towards the top.



LOGIC

Propositional logic

TRUE	FALSE
\wedge	And
\vee	or
\neg	Not
\Rightarrow	implies
\Leftrightarrow	equivalent

ex $(P \wedge Q) \text{ or } R \Rightarrow S$



Rule-based representation

IF CONDITIONS THEN ACTIONS

Heuristic and control knowledge

\Rightarrow Introduction of confidence factors

Action involving two conditions

Fact 1 CF 1

Fact 2 CF 2

Combination $CF = (CF1 + CF2) / 2$

$CF = (1 - (1 - CF1) (1 - CF2))$



Semantic Networks

(nodes and arcs (associative links))

Frames

IN ORDER TO KNOW AN OBJECT, I MUST KNOW NOT ITS EXTERNAL
BUT ALL ITS INTERNAL QUALITIES.

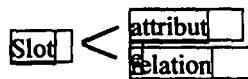
- Cit-

Frames deal with

- . epistemological
- . conceptual
- . linguistic

LEVELS

Support objects which have names a number of slots, and each slot
may have a number of facets. Slots and facets store values.



Frame also viewed as a collections of semantic networks and links.



Design Issues

- Define the problem domain
 - The narrower, the better
 - Concentrate the effort on the critical parts
 - Be sure there is enough expertise
 - Budget and time constraints



The Expert ?

- Ego involvement
- Sublimation of knowledge
- Commitments
- Proprietary secretiveness



Knowledge Acquisition

- Skilful interviewing
- Effective tool utilization
- Good pupil



AI / KBES Tools

- AI Language

Pros:
Adapted to special use Efficient
design process Rapid
prototyping

Cons:Difficult to interface
Not a lot of talented
programmers Often slow,
memory intensive Mostly
interpreted



AI / KBES Tools --Continued

- Conventional Language

Pros:
.Large pool of programmers
.Often compiled, fast
.Interfaces possible

Cons:
.Useful data types absent
.Inference engine to be
rewritten
.Few possible links



AI / KBES Tools --Continued

- Expert System Shell

Pros:

- .Easier programming
- .Integration
- .Interfaces
- .Incremental

Cons:

- .Relatively new technology
- .Validation not obvious
- .Selection difficult



Robustness / Tools

- Variety of knowledge representation approaches
- Interface to the outside world
- Graphics Capabilities
- Ability to deal with large and complex knowledge bases



Additional Criteria / Tools

Continued

- **Experience**
- **Platform support**
- **Execution Speed**
- **Customer Support**
- **Price**



EARLY RESEARCH TOOLS

EMYCIN
KAS

LARGE SHELLS

EXPERT
ROSIES
S.1
KEE
ART
EST / ESCE + ESDE

MICROCOMPUTER - BASED

EXPERT-EASE
M.1
The Deciding Factor
Rule Master
Insight 2+
1st Class
VP-EXPERT
KAPPA
NEXPERT



AVAILABLE OOP LANGUAGES

- Smalltalk
- Object Pascal
- Neon
- Expert Commonlrsp
- Objective C
- Object Assembler
- Object Logo hardware
- C ++ dependant
- Flavers
- Loops
- KEE
- STROBE



Object-Oriented Design

Software controls

- . enormous systems of great complexity
to understand
- . model in sufficient details
- . pass the information to other equally complex systems.

⇒

- . ongoing maintenance of large applications becomes a true headache.
- . software development is time-consuming ⇒ expensive



Abstraction

We understand the world by CONSTRUCTING MENTAL MODELS OF PORTIONS OF IT.

We try to understand things so we can interact with them.

MODEL BUILDING ⇔ DESIGNING
SOFTWARE

Difference : the model is manipulated by a computer

key : simplicity of mental models



MENTAL MODELS abstract out those features of a system required for our understanding, while ignoring irrelevant features.

Abstraction is essential to the functioning of a normal human mind and is an immensely powerful tool for dealing with complexity.

ex. : maps, telephone numbers, software abstraction.

Objects

OO approach attempts to manage the complexity inherent in real world problems by abstracting out knowledge, and encapsulating it within objects.

Finding or creating these objects is a problem of structuring KNOWLEDGE and ACTIVITIES.

INFORMATION = FUNCTIONS AND DATA



OO Paradigm

Tello [12]

OO is a type of programming that provides a way of modularising programs by establishing partitioned memory areas for both Data and Procedures that can be used as templates for spawning copies of such modules on demand.

⇒ . Functional Independence

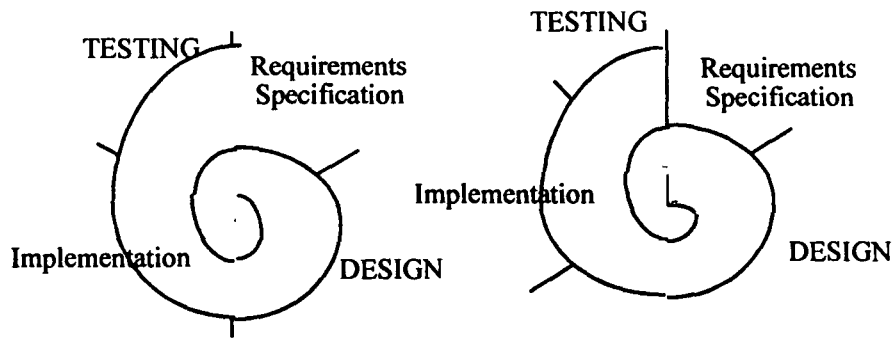
. Memory partitions may be used in a variety of different programs without modification and with complete assurance that none of the memory locations will be overwritten.

i.e. . Efficiency in code writing

. Ease of extension and maintenance

← Active entities that know how to perform various operation on themselves.





Conventional

OOP



Software Life Cycle

Traditional

Object-oriented

- Robust software
- Easily
 - . reused
 - . refined
 - . tested
 - . maintained

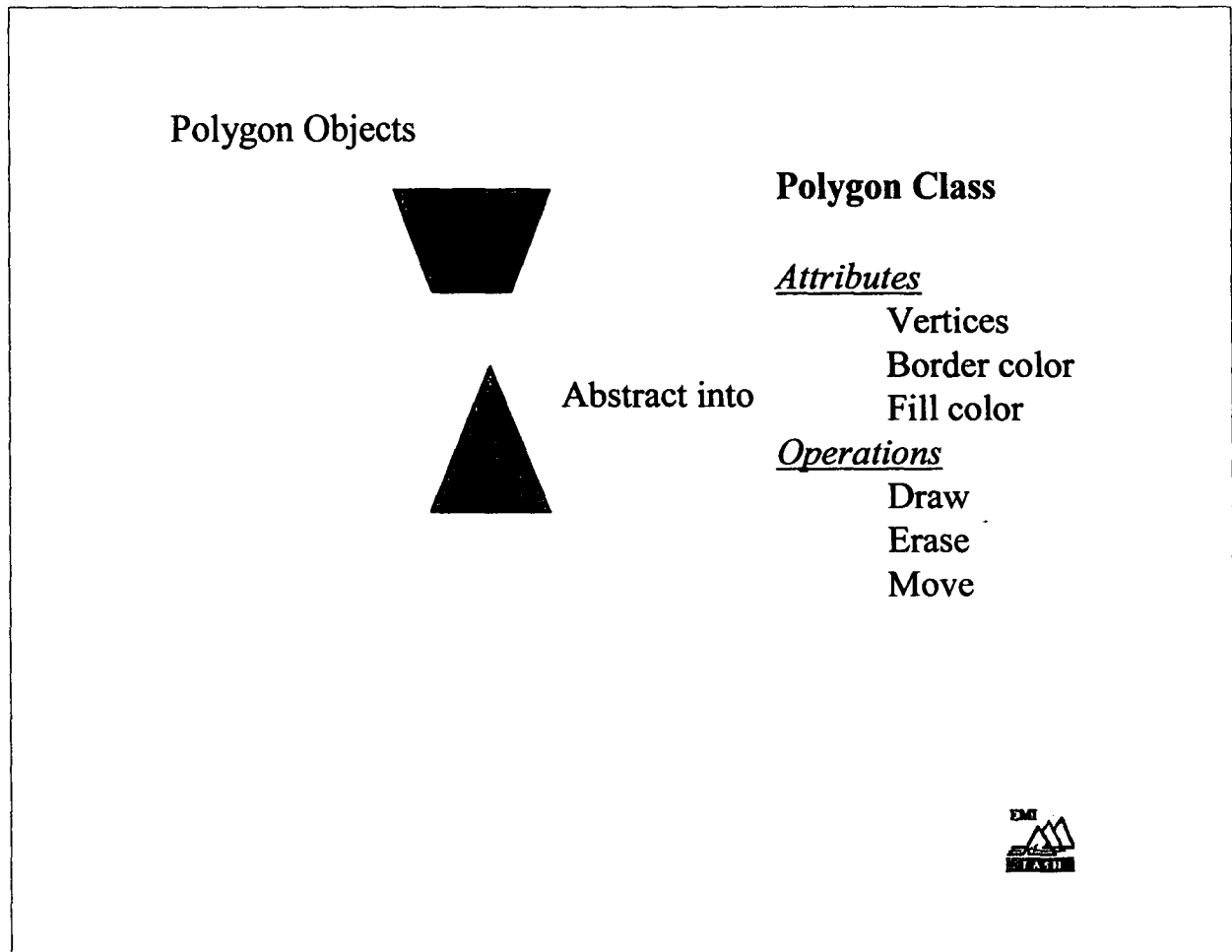
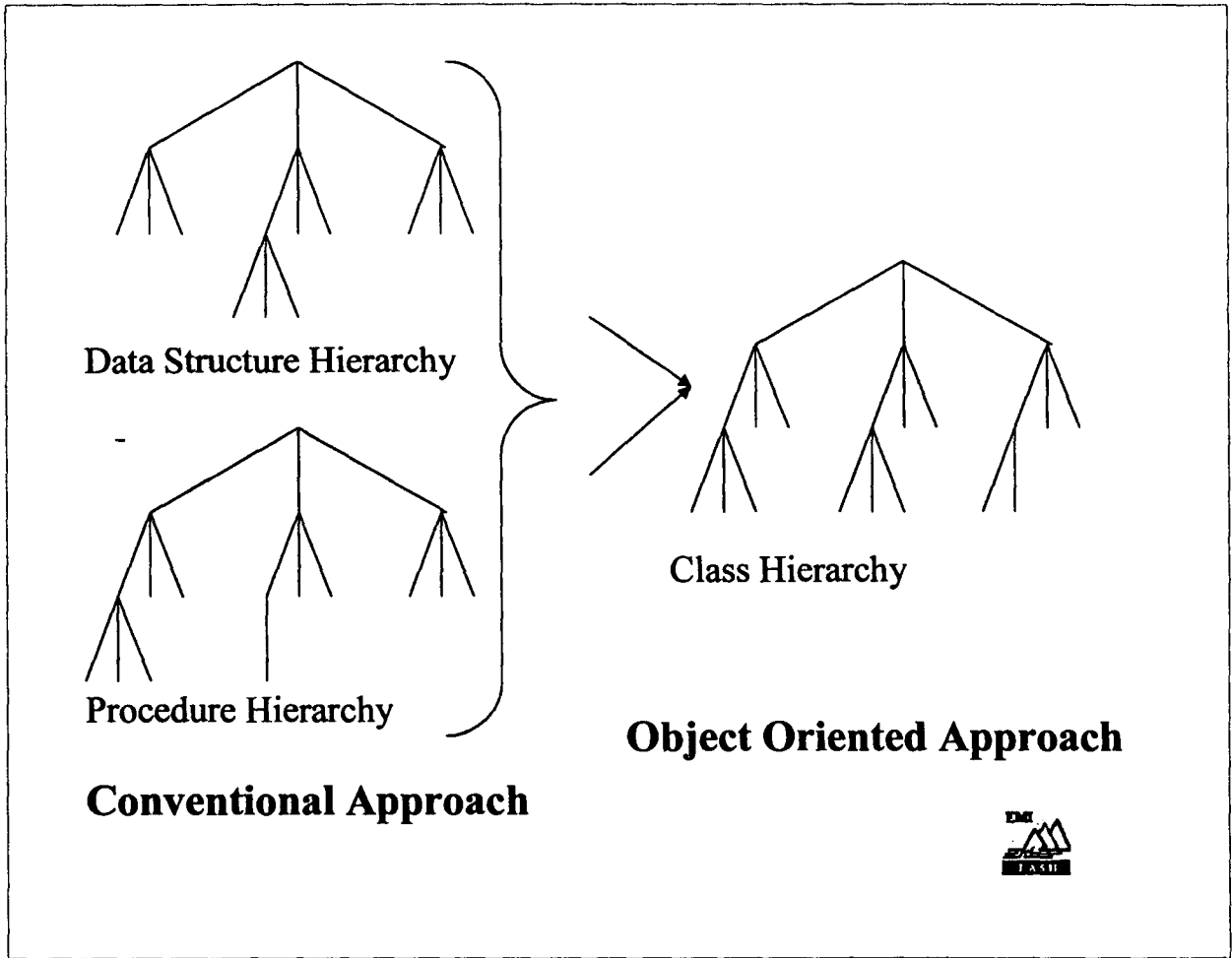


PRODUCTIVITY

DESIGN consists in :

- a system of objects that fulfill requirements
- a description of the public behaviour of those objects and
- the patterns of communications between the objects.





Publicly, an object declares :

I can do those things

I can tell those things

but it does not tell how it knows or does them, nor need other objects concern themselves with that.

ANTHROPOMORPHISM

OOP : A view of the world as a system of co-operating and collaborating agents the work is accomplished by :

One object sending a request to another to perform one of its operations, reveal some of its information or both.

Software : living thing

BORN
LIVES ITS LIFE
DIES



ACCESS TO OBJECTS

	message	
SENDER	name and arguments	RECEIVER

MESSAGE SEND

Only through their public interface by message sending.

The set of messages to which an object can respond is known as the behaviour of the object.
(including to itself)

METHOD

When an object receives a message it performs the requested operation by executing a method.

A method is always part of the private representation of the object. Never out of the public interface.

A method is the step by step algorithm executed in response to receiving a message whose name matches the name of the method.



ENCAPSULATION - INFORMATION HIDING

An object knows how to be itself but not to be anything also.
Some of the data in a system resides within certain of its objects and other data resides within other objects.

ENCAPSULATION : Act of grouping into a single object both data and the operations that affect that data.

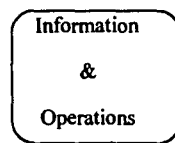
The knowledge encapsulated within an object can be hidden from external view

Public face : what it can do and tell
other entities know only how they can interact with it.

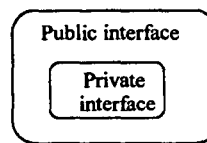
Private side : how it does these things (information hiding)



capsule around some collection of things



Encapsulation



Information hiding



CLASS

Object sharing the same behaviour are said to belong to the same class (factory)

INSTANCE

Objects that behave in a manner specified by a class are called instances of that class. All object are instances of some class.

POLYMORPHISM

Ability of two or more classes to respond to the same message, each in its own way.

INHERITANCE

Ability of one class to define the behaviour and data structures of its instances as a superset of the definition of another class or classes.

allows

conceive a new class of objects as a refinement of another, to abstract out similarities between classes, and to design and specify only the differences for the new class.

⇒ **quickly create class**



CLASSES

- Extract noun phrases from the specification and build a list.
- Look for nouns that may be hidden, and add them to the list.
- Identify candidate classes from the noun phrases by applying the following guideline :
 - Model physical objects
 - Model conceptual entities
 - Use a single term for each concept
 - Be wary of the use of adjectives
 - Model categories of objects
 - Model external interfaces
 - Model the values of an object's attributes.
- Identify candidate for abstract superclasses by grouping classes that share common attributes.
- Use categories to look for classes that may be missing.
- Write a short statement of the purpose of the class.



CLASS : ClassName (Abstract / concrete)	
Superclass Names (List)	
Subclasses Names (List)	
Responsibility	Collaboration

SUBSYSTEM : SubsystemName	
Contract	Delegation



Classes that inherits from other classes can inherit behaviour.

If a class can use some or all the code it inherits, it need not reimplement those methods.

⇒ code can be reused over and over

SUBCLASS

Is a class that inherits behaviour from another class. adds its own behaviour to define its own unique kind of object.

SUPERCLASS

Is a class from which specific behaviour is inherited.



Class Specification

Class	:	class name
Superclasses	:	class names
Subclasses	:	class names
Hierarchy Graphs	:	page page number
Collaboration Graphs	:	page page number
Description	:	Description of the class
Contracts		
#. Contract name		
Responsibility		
Signature		Uses list of collaborations
		Description of the signature
Private Responsibilities		
Responsibility		
Signature		Uses list of collaborations
		Description of the signature

-page # -



Subsystem Specification

Subsystem	:	Subsystem name
Classes	:	List of classes and subsystems
Collaboration Graphs	:	page page number
Description	:	Description of the subsystem
Contracts		
#. Contract name		
Server	:	class or subsystem name

-page # -

Contract Specification

Contract #.	:	contact name
Server	:	class name
Clients	:	class or subsystem
Description	:	Description of the contract

-page # -



Steps (Exploratory)

- ❑ Find the classes
- ❑ Determine what operations each class is responsible for performing, and what knowledge it should maintain.
- ❑ Determine the ways in which objects collaborate with other objects in order to discharge their responsibilities.

Steps (Detailed Analysis)

- . Examine the inheritance relationships between classes. Take a closer look at the behaviour of each class. Identify classes sharing certain responsibilities.
- . Analyse the collaboration between the classes in an effort to streamline them.
 - . message traffic
 - . collaboration degree
 - . class groups



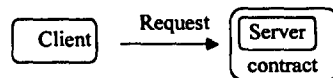
Subsystem of classes

A subsystem is a set of classes (and possibly other subsystems) collaborating to fulfil a set of responsibilities.

Useful conceptual entities.

Clients and servers

One object requests a service of another object.



Object that makes the request

Object that receives the request and provides the service

A contract : List of requests that a client can make of a server.

Model the design as clients and servers who collaborate in ways specified by contracts.



□ Find responsibilities using the following guidelines :

- Recall the purpose of each class, as implied by its name and specified in the statement of purpose.
- Extract responsibilities from the specification by looking for actions and information.
- Identify responsibilities implied by the relationships between classes

□ Assign responsibilities to classes using the following guidelines :

- Evenly distribute system intelligence
- State responsibilities as generally as possible
- Keep behaviour with related information
- Keep information about one thing in one place
- Share responsibilities among related classes



□ Find additional responsibilities by looking for relationships between classes :

- Use "is-kind-of" relationship to find inheritance relationships
- Use "is-analogous-to" relationship to find missing superclasses
- Use "is-part-of" relationship to find other missing classes.

□ Find the objects :(primary abstraction)

modelling process i.e
logical objects in the problem space
mapping to the actual object in the program



OBA steps

OBA : 5 steps are summarised in the following table :

Step	Action	Result
①	Understand the application ; identity behaviour	Initial behaviours of the system
②	Derive objects using the behavioural perspective	Objects and objects behaviour
③	Start classifying objects	Objects classified with behaviours and visible properties.
④	Identity relationships among objects	Object relations and coordination
⑤	Model processes	Requirement specification and possible analysis prototyping.



Script Components :

Agent Action Recipient Result

The output of this step should lead to a list of behaviour expected of the system, a list of its *visible properties* and the *scripts*.

Next, we have to define the exhibitors or agents of behaviour.

OBA steps

Who or what is responsible for particular behaviour ? is the answer.

Technical forms or *modelling cards* are useful in this step.

Modelling cards are *small index cards* with the terms name, *responsibilities* and *collaborators* written on them.



ESIMEAU INTEGRATED INFORMATION SYSTEM FOR MODELING AND
MANAGEMENT OF WATER RESOURCES:
CONCEPT AND ARCHITECTURE

F. EL DABAGHI¹, D. OUAZAR², P. PRASTACOS³

¹ INRIA Rocquencourt, Domaine de Voluceau, 78153 Le Chesnay Cedex, France,
dabaghi@squatina.inria.fr

² Ecole Mohammadia d'Ingénieurs (EMI), B.P. 765, Agdal, Rabat, Morocco,
ouazar@emi.ac.ma

³ Regional Analysis Division, Institute of Applied and Computational Mathematics
(IACM), Foundation for Research and Technology-Hellas (FORTH), P.O. Box 1527,
711 10 Heraklion, Greece,
poulicos@iacm.forth.gr

This paper addresses the concept and architecture of ESIMEAU, an integrated information system that can be used for modeling and managing water resources. ESIMEAU has been designed to provide a framework that permits users to implement it in various water modeling issues. It brings together a variety of information technology tools including advanced numerical models, database management systems, geographic information technology. In this paper the general framework of ESIMEAU is discussed as well the application of this framework to study the eutrophication problem in the Bouregreg lake in Morocco.

Keywords: integrated information systems, water resources, eutrophication, aeration, GIS, architecture.

1. Introduction

The increasing water demand worldwide associated to the overall trend of decrease in water resources due to extensive use of water in intensive agriculture and industry and the resulting pollution are calling for better assessment and design. The complexity of water resources problems are characterized by the interaction of several physico-chemical phenomena. Water problems include preservation of water for irrigation, watershed management, dam construction for mitigating floods and/or conservation purposes, river management, pollution control, to cite a few examples.

The difficulties and issues associated when attempting to provide an answer to a water resources problem are numerous. Some of the most significant include:

- Models can be ill posed either because of coefficients/parameters uncertainty or knowledge or boundary conditions are not well known,
- Hybrid Modeling involving validation and calibration,
- Limited know-how on some phenomenologies related to turbulence and low generalization level due to the existence of variety of closure models and parameterization
- Digital elevation models (DEM) and data characteristics for representing an area,
- Large heterogeneous data bases,

- Highly advanced information technologies as opposed to water resources and infrastructures
- Multidisciplinary actions and know how involving water resources, environment, engineering, computer sciences and end users,.
- Integration of domains traditionally ill-linked.

Though water resources modeling is often perceived as a low technology issue and is usually accomplished with relatively simple hydrology/hydraulics/hydrodynamics models, there are many similarities with the highly advanced engineering and science areas like aerospace, involving computational fluid dynamics, electromagnetism field, etc... This is illustrated in Table 1 where the low technology field of water resources is compared to the so called high technology engineering. It is clear that both are governed by partial differential equations (PDE), involve complex domain geometry and have many common features. However, paradoxically water applications are by far more complicated to deal with due to uncertainties, multi-disciplinarity, and validation/calibration aspects.

Table 1: Low technology versus High technology applications

Thematic	Low technology	So-called High technology
Disciplines	Fluid Mechanics, hydraulics, Geology, Meteo, Tools	Fluid Mechanics, Aero-Mechanics, Tools
Technology /Know-how	Transferable	Classified
Domain	Complex, Heterogeneous	Simple to complex
Governing Equations	P.D.E.	P.D.E.
Parameters	Unknown, stochastic. (Historical nature)	Established
Validation/Calibration	Scale effects	Handled Wind Tunnel.

They require highly advanced numerical tools and optimization schemes for better design and operating policies including the estimate of benefits. Similarly to any engineering or science problem, water resources are featured by:

- Partial differential based governing equations (PDEs) involving parameters and/or coefficients that might be known or need laboratory or in situ experimental information for their evaluation,
- Phenomena that occur in a geometric domain that can be a watershed, a lake, a river, etc...,
- Well posedness is required (boundary and initial conditions are needed),

- Computer code for numerically computing the unknown variables using a numerical method (finite difference, finite element, finite volume based) therefore involving the so-called discretization or meshing of the domain through a pre-processor,
- Post processing facilities,
- High performance computing networks (HPCN) facilities since large scale problems are concerned.

Once a computer model is built, one can then proceed to further simulations of scenarios that represent the user's requirement and exploitation. However, the end user has to go through all the process, i.e. i) data analysis and data preparation for a model, ii) domain meshing, iii) computer simulation, iv) post processing, v) decisions. This is a bit cumbersome. Another problem that arises is related to parameter identification and so-called inverse problems which are also required for any model calibration. Optimization techniques are needed to take care of these. They might also involve heavy computations.

The ESIMEAU framework is an attempt to model water resources problems by employing some of the tools used in high technology engineering (Dabaghi, 1999; Dabaghi, 1998; Ouazar, 1999). In this paper the ESIMEAU concept will be illustrated through the aeration process related to the oxygenation of a lake for eliminating eutrophication problems.

In the next section of this paper we provide an overview of the ESIMEAU concept and in the following sections we discuss the components of the information system and the overall architecture.. In the last section an application of ESIMEAU to study the eutrophication problem in the Bouregreg dam in Morocco is provided.

2. The ESIMEAU concept

In the last few years spatial decision support systems (SDSS) have emerged as the leading paradigm for addressing complex decision support systems. SDSS have been used for tackling complex environmental problems, as well as, business decisions -- location, allocation problems—(Densham and Goodchild, 1989; Malczewski, 1998). SDSS are defined "as computer based systems designed to support a user or group of users in achieving higher effectiveness of decision making with solving spatial decision problems" (Malczewski, 1998). The components of a SDSS are the database management system, the models and the user interface that permits users to interact with the system in a user-friendly manner.

Efforts to develop such systems for water resources problems have been carried mainly on the PC environment (Goodchild et. al., 1993; Watkins and McKinney, 1996) by integrating geographic information systems (GIS) and various hydrological models. One of the main limitations of these efforts is that the PC environment is not amenable to the solution of a set of partial differential equations, the solution of which often require excessive computational time (Prastacos, 2000). The other problem with these approaches is that they have been designed to address one particular water resources problem. As a result, the information systems developed are not easily reusable to solve problems other than the ones that have been developed for.

The ESIMEAU framework attempts to overcome most of these limitations. It provides a “container” that permits the integration of databases, tools and models, which takes advantage of numerical solvers / meshers that might exist and which can be used for handling various water resources problems. Mathematical models for water resources problems have been developed for some time but their use is not widespread, because they are cumbersome to use and difficult to comprehend by people without extensive computational mathematics and computer background. For their use, these models need domain meshing that constitute also another difficulty for possible end users. It has been designed in such a way that can be used as stand alone platform independent system or as a distributed system with the databases and the solvers residing in different systems.

ESIMEAU aims to develop an open and modular architecture that can aid decision-makers to arrive to intelligent decisions with respect to various selected problems of water resources. The architecture of the system and related component is depicted in Figure 1 embodying and linking various information technology tools, meshers, numerical models including HPCN implementation.

The strategy adopted in ESIMEAU was to develop a system that:

- Is modular and reusable; this was considered a very important aspect since it was felt that the infrastructure developed should be capable to handle a variety of models and databases. This necessitated the adoption of an object oriented analysis and implementation,
- Can handle a variety of heterogeneous databases and also includes tools for handling the pre and post processing of datasets and can be used also for improving the data quality,
- Provides access to existing numerical solvers. The objective of using existing numerical solvers (or solvers that can be improved with some additional development) was a key consideration since it was felt that such solvers have been developed in the last twenty years to solve numerical problems in other sciences such as aerospace, electromagnetism and others and there is not any need to “reinvent the wheel”. The development of such solvers require extensive resources.
- Represents topography through detailed Digital Elevation Models (DEMs) that can be used for providing the necessary inputs to the numerical solvers, thus improving characterization of hydrometeorological parameters.
- Use meshing tools, GIS and other third part software for efficient graphics representation. For specific use and exploitation however, other tools that are compatible with huge and heterogeneous databases, are required, especially for results provided by numerical models which are closely dependent on spatial meshing techniques.
- Use image analysis and interpretation to give more insight on some hydraulic parameters that are required for modeling purposes.
- Can handle efficiently both vector and raster databases by employing geographic information systems technology. Although GIS have not been used traditionally in conjunction with numerical models; they are the only tools for handling spatial data.
- Provides access to the databases and models and solvers in a way which is transparent to the end user. This was a key consideration since end users of such systems are not expected to be familiar with advanced computational mathematics or

the latest tools of information technology. An issue here was to provide visualization capabilities that would permit users to display the inputs and the outputs of the models on their screen using maps.

- Can be used in a variety of computer platforms and stand alone or distributed architectures. Although there is a proliferation of PC environments; the numerical solvers needed for handling real-world flow problems often may require powerful computing facilities such as workstations and/or HPCN platforms. Additionally, since the numerical solvers might exist in remote systems, the architecture should be able to handle a distributed system.
- Access to / Sharing of databases, data sets, computer codes via Internet/Intranet protocols
- Use HPCN facilities to extend the numerical simulation to large size problems.

The overall framework of ESIMEAU is shown in Figure 1.

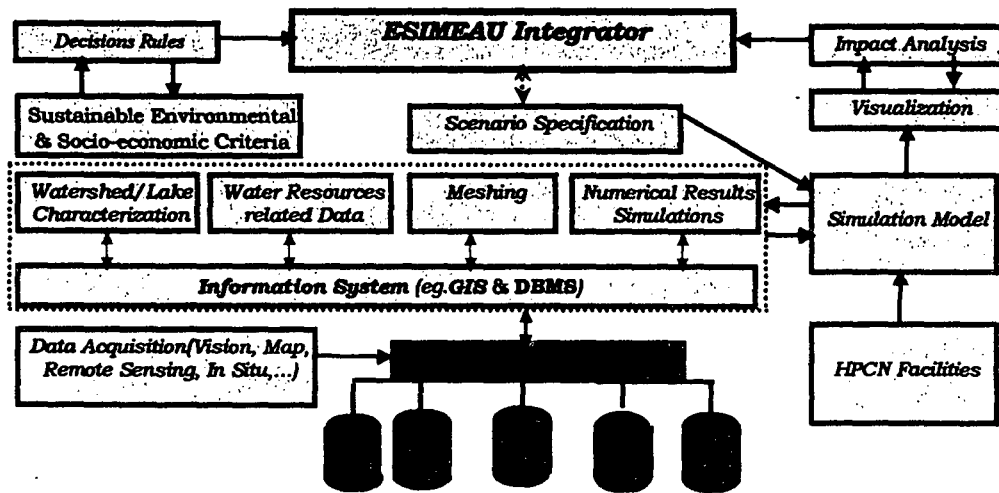


Figure 1 The ESIMEAU framework

The physical models as described in detail in Dabaghi, 1999 and include:

- One-phase flow based
- Two-phase flow
- Mixing model

A discussion of these models is beyond the scope of this paper. They differ by the assumptions on the fluids, number of unknowns, and turbulence closure models adopted, etc... For the sake of illustration, the one phase flow model has been selected and implemented.

3. The Information System Components

The information system of ESIMEAU has been designed in such a way so that it can be implemented as both a stand alone system, as well as, a distributed system. This was deemed necessary since a stand alone system running on the PC can be used to solve relatively small 2-dimension problems, whereas for the solution of 3-D problems there is a need for powerful computing facilities and HPCN implementation. Although the two systems are different they use the same components with the most important difference being that the numerical codes on the distributed system residing on a remote powerful computing system rather than the same system

The information system of ESIMEAU consists mainly of three components; the

- GIS system for storing and visualizing all databases ,
- Meshing module for preparing the inputs for the models
- Numerical solvers.

Each of these systems is independent of each other and they are connected through appropriate interfaces so that outputs from one component are passed as inputs to the other in a transparent way.

3.1 The Geographic Information System

A Geographic Information System is often defined as a *system for capturing, storing, checking, integrating, manipulating, analyzing and displaying data which are spatially referenced to the Earth*. GIS technology integrates common database operations such as query and statistical analysis with the unique visualization and geographic analysis benefits offered by maps. These abilities distinguish GIS from other information systems and make it valuable to a wide range of public and private enterprises for explaining events, predicting outcomes, and planning strategies.

A GIS stores information about the world as a collection of coverages linked together through some type of geographic/spatial reference. The geographic reference can be spherical coordinates (longitude and latitude) or Cartesian resulting from the projection system adopted. GIS draws its power from this common geographic referencing system. Unrelated information can be combined to derive new, more complex information. For example, queries of the type "how far away are the population centers from a pollutant site", or "what are the soil characteristics near the stream" can be answered easily from a GIS.

The GIS system used in ESIMEAU is the ArcView™ software from ESRI (ESRI, 1998). ArcView is a widely used GIS commercial software which is available for the PC and UNIX environments. ArcView is a menu driven software that can be used to store both vector and raster databases. Associated with ArcView is the script language Avenue™ which permits the development of procedures so that tasks can be automated.

The GIS databases in ESIMEAU and the procedures for accessing them have been designed in such a way so that they can handle a variety of layers that might be needed when addressing watershed problems. The list of layers include among others:

- Coastline,
- Road network,

- Rivers, streams and lakes,
- Drainage basin,
- Soil,
- Land cover,
- Digital terrain model (DTM) (altitude-topography)

Most of these are vector layers (points, lines, polygons), whereas the DTM is a raster layer, that is a geo-referenced image in which each pixel (or grid cell) there is an associated value which represents the elevation at that specific point. A DTM can be shown as a real world 3-D model using the ArcView 3-D extension of the ArcView software.

3.2 The Mesher software

Any numerical solver requires the discretization of the domain to be studied beforehand. The purpose is to approximate the continuous domain into a set of small finite elements constituted by nodes where the values of variables are to be found. For 2D calculations, these elements are of triangular and/or quadrilateral shape.

The EMC2 mesher used, was developed at INRIA (F.Hecht and E. Saltel, 1990) and run on Unix platform. The sources codes are in C and Fortran. A Windows version was developed within the ESIMEAU framework using primitive graphic routines.

3.3 The Solvers

The physics as described in detail in Dabaghi, 1999 is complicated in that the governing equations are partial differential equations for one or two fluids depending on the approximations and model idealization used. Whatever the model used, a numerical approximation is required. Within the ESIMEAU framework, the approximation is built on a discrete variational formulation technique of Galerkin-type associated mainly to finite element context. In this paper a one-phase flow model based on Navier-Stokes equations with a turbulence correction is used for illustration purpose. The numerical approach is based on a combination of the finite element method and the method of characteristics. A straight Fortran implementation has been carried out. The solver will permit simulations of the aeration process to treat the eutrophication phenomena.

3.4 The viewers

Third part software viewers have been used for the visualization of results including the Arcview GIS.

4. The Architecture of the Information System

The architecture of the ESIMEAU information system has been designed in such a way so that the complete system can be implemented as a standalone system and a distributed system. The various components discussed above communicate through the main application which calls the appropriate module and passes inputs and outputs among the GIS databases the mesher and the numerical solvers (Figure 2).

In general terms the main application calls the GIS software which displays the various layers and which prepares an appropriate ASCII file that is then the input to the mesher. Users can visualize the mesher to add more points and then the mesher output is sent to the solvers for estimation. The results are passed back to the mesher and then to the GIS for storage, visualization and further analysis. A special effort has been done on the standardization of the input/output (topography data and related numerical results) of numerical modeling solvers in order to be attacked easily by any graphic or analysis software via basic and elementary interfaces.

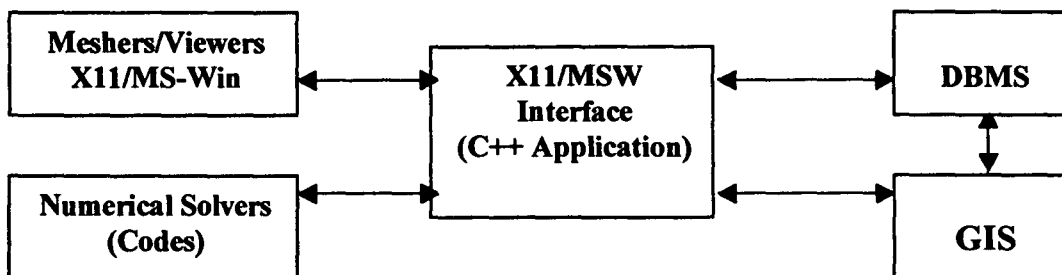


Fig. 2: Architecture of the ESIMEAU information system

A key concern when developing the system was to be platform independent. This was an important consideration since it was felt that although the PC environment is the platform of choice nowadays, most numerical solvers can be executed in reasonable time only on workstations. To achieve platform independence the main application has been developed in C (Unix version) and Visual C++ (Windows environment) with some elements of the user interface developed in Java. This approach was followed since although Microsoft Visual C++ offers a development environment that permits quick prototyping of menus etc. the code can not run in UNIX.

Some components of the main interface have been written in Java. Java is a computer language extensively used nowadays for web development. One of the main features of Java is that it is platform independent and therefore code written in Java can run on both Unix and Windows. Java was used to diminish some of the effort needed for developing code for two different environments.

On the PC environment the Access database is used for storing all datasets, whereas in UNIX the database has a simple ASCII format and is accessed through simple scripts written in C simulating the Access commands. Another DBMS system such as Oracle could be used instead. It was felt however, that the development effort needed was excessive and the data structures were relatively simple, and also the potential exploitation of the system would be hindered if its implementation required the Oracle DBMS which is not widely used in scientific and/or environmental management areas.

The mesh generator (EMC2) has been written in FORTRAN and C. For graphics generation for Windows the Microsoft Graphic Software Development Kit (SDK) has been used. For the Unix environment the graphics calls follow the X11 library. The vast majority of the numerical solvers were already available, some additional development was done to adapt them to the problems discussed earlier.

4.1. Stand Alone System

In the PC stand alone system the ESIMEAU integrated system, communicates between the main interface (the Visual C++ application), ArcView, Database (stored in Microsoft Access DBMS), mesh generator (EMC2) and numerical models codes using DDE (Dynamic Data Exchange and ODBC (Open Database Connectivity) protocols.

The DDE is client/server mechanism, that allows data exchange between two applications. Both ArcView and Visual C++ support this protocol. Using DDE protocol, the interface can ask ArcView to run one of its scripts. The disadvantage of DDE protocol is that it requires the existence of the client and server run in the same computer. DDE does not support network.

The ODBC protocol is an interface between the client application and the DBMS, it allows the client application to access database data. ODBC supports all DBMS. This protocol was used to circulate data between the interface (Visual C++ application) or ArcView and DBMS. Firstly the boundary of the domain is input, then physical data are introduced, meshing is launched for the domain defined by the boundary, the simulation can then be ran. With ArcView, many aspects and results can be visualized (attributes, spatial information, mesh, etc..)

The "Stand Alone System" platform architecture is depicted in the figure below showing the communication between various software components

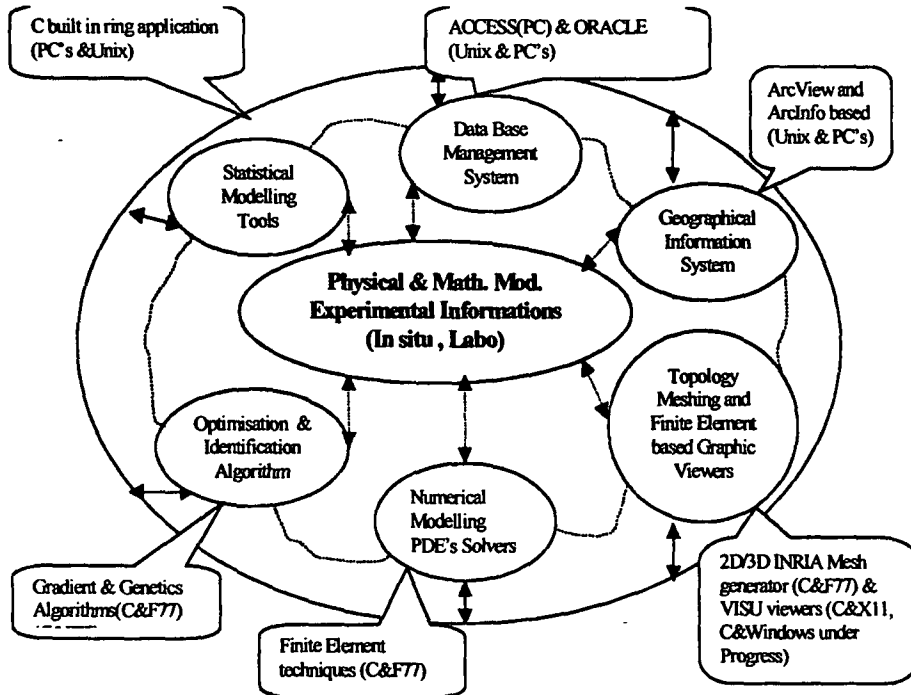


Fig. 3: Standalone System Architecture

4.2 Distributed information system

The architecture of the distributed system separates the stand alone system into two main components, the GIS and mesher component which can run on the client computer and the numerical solvers which are executed on the powerful remote system, the server, where the numerical codes reside. With this architecture data are stored in databases in the client organized under a GIS. The process is initiated locally by the main application of ESIMEAU that calls ArcView and prepares the files for the mesher and the numerical solvers.

The mesher is executed locally and then the appropriate data are transferred to the remote system for code execution. The server is accessed through a web interface that permits the transfer of data and eventual execution of the codes. Output files are then sent to the local system for storage and visualization.

As discussed in detail in Prastacos (2000), this architecture has significant advantages. Namely:

- The computational load is appropriately allocated among the client and the server; the client is used for storing the databases and performing the visualization, whereas the server is used for heavy number crunching
- Data security is maintained since the complete databases are not transferred to the remote system and are available only on the user's system
- The server is used only for model execution and therefore there is less need for maintenance etc.
- Provides the user with the opportunity to use other software (spreadsheets, statistical packages, specialized software etc.) for further processing or analysis of the results on his own system
- Through the use of web technology issues related to transmission problems are avoided
- It is an extensible architecture that can easily handle different models and datasets, while at the same time offering ease of use and efficiency.

5. Application for the eutrophication problem

Eutrophication in water supply reservoirs is a complex phenomena involving many physico-chemical parameters. It is a result of solar radiation penetrating the surface during summer. It is characterized by a specific temperature/density structure followed by a deterioration of water quality in the hypolimnion layer in the form of odor, color, deoxygenation, or in other parameters.

In semi-arid areas, it is well known that thermal factors combined to biological and to the biochemical processes play an important role in the overall behavior of ecosystems. Such bio-climatology variations generate in reservoirs an unsteady dynamic process making that water quality decreases progressively. The reservoir is considered as

eutrophic when the dissolved oxygen concentration becomes less than 3 mg/l (Klapper 1991; Hunt et al, Phelippot 1975).

Aeration is considered as the cheapest best remedial and/or preventive action against eutrophication. A source of compressed air is pumped to the reservoir bottom and released. The resulting buoyant plume causes local mixing dismantling the density structure (Figure 4).

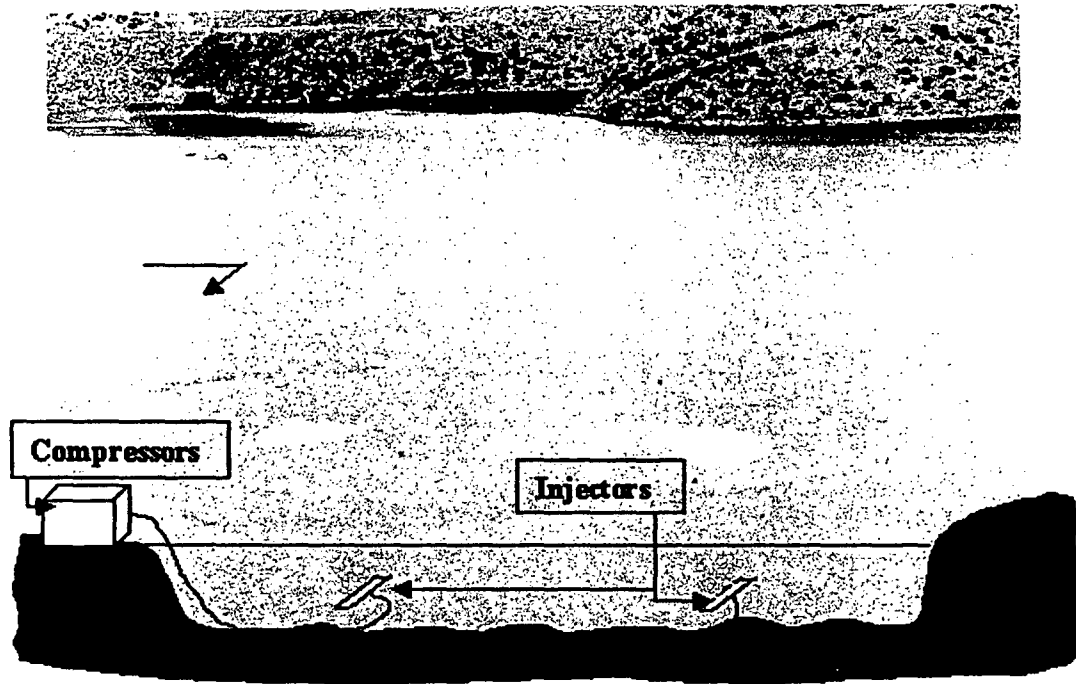


Fig. 4: SMBA lake and injectors.

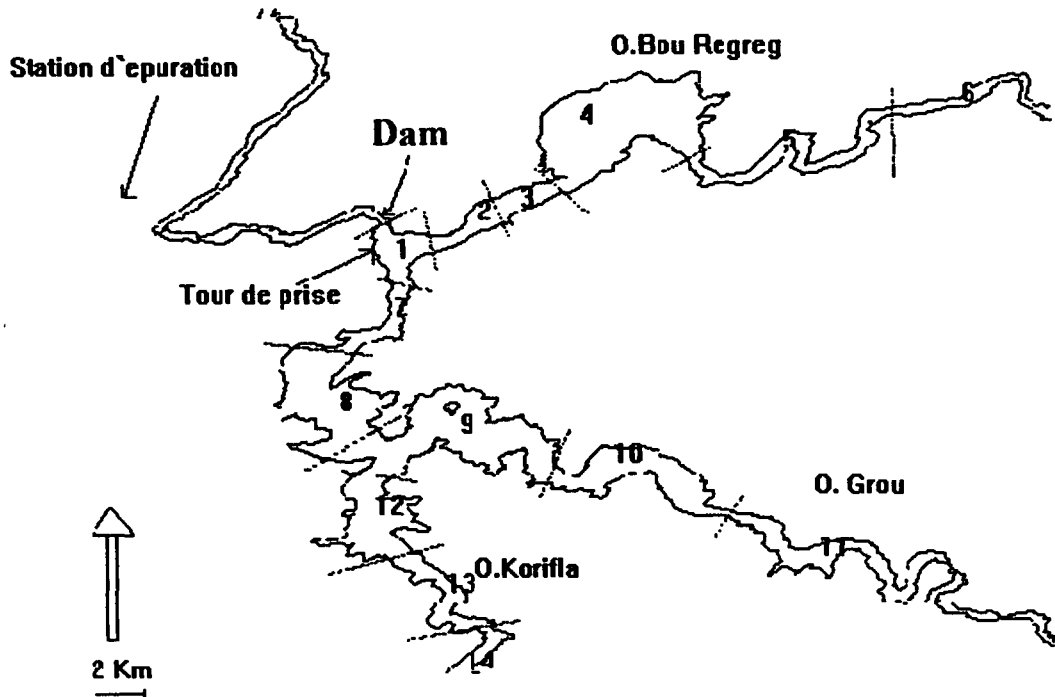
The Bouregreg dam is located in the area of Rabat. The Sidi Mohammed Ben Abdellah (SMBA) dam has been built and is under exploitation since 1974. The main purpose is water supply of the coastal zone between Salé and Casablanca, i.e. about 20% of the total population of Morocco. At 50 MGN (Moroccan Geographic North), its volume amounts 480 millions of m³, the wetted surface is estimated to 32 Km², the average depth is 17 m, and the maximum depth is 42m.

The water supply production capacity from the dam is 9 m³/s. The lake is supplied by three rivers with an average total annual mean flow of 21.4 m³/s.

For SMBA, we observe an average of 60 µm / l of phosphorus and 54 60 µm / l of maximum concentration of chlorophyll A. According to the OCDE (Office de Coopération et de Développement Economique) standards, the dam is eutrophic. Since 1975, the central water quality laboratory of ONEP the National Agency of Water Supply has observed dissolved oxygen depletion at the hypolimnion with a thermal stratification during summer. The ONEP has tested many procedures to combat eutrophication. Among the best, the aeration process has proved to be by far efficient

and economical and has been installed in 1992. The solution consists simply in injecting oxygen through a source of compressed air as depicted in fig. 1.

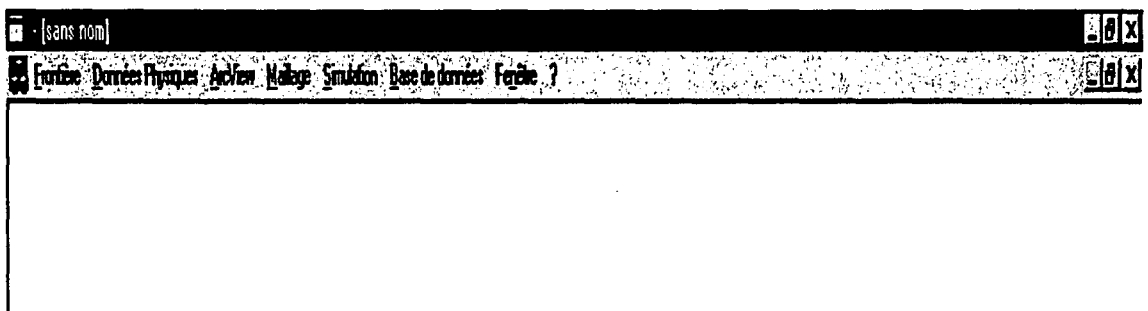
A map of the Bouregreg dam is shown in Figure 5.



BOUREGREG SMBA DAM - MOROCCO

Fig. 5: Bouregreg Domain Area

The first screen shows the main features of the application linking items such as Boundary, Physical data, Arcview, Meshing, Simulation, Data Base, Windows, Help. The boundary can be introduced through the keyboard, mouse click or via a digitized file to define the domain to be studied (i.e. lake, watershed, river, etc..). Data are then introduced. The meshing is then done through invoking a mesher, simulation proceeds then. All the input/output data can be visualized through Arcview. In the second screen we illustrate the water quality data base within a lake. The last screens illustrate the visualization one of the Bouregreg cross sections through Arcview including the refinement near the injectors, the attributes of the aerators, etc...



Microsoft Access

Fichier Edition Affichage Insertion Outils Fenêtre ?

AspectChimiqueEauxAnnuel : Table

Nom du champ	Type de données
Code	Numérique
CodeA	Numérique
Cote	Numérique
OxygeneDissous	Numérique
PH	Numérique
MnTotal	Numérique
NTotal	Numérique
Nitrates	Numérique
PTotal	Numérique
Orthophosphate	Numérique
Couleur	Texte
FeTotal	Numérique

AspectBiologiqueEauxHebdo : Table

Nom du champ	Type de données
Code	Numérique
CodeH	Numérique
ZooPlancton	Numérique
DBOS	Numérique
Chlorophyllea	Numérique
Odeur	Texte

Propriétés du champ

PressionInstantanee : Table

Nom du champ	Type de données
Code	NuméroAuto
N JRE	Numérique
Annee	Numérique
Mois	Numérique
Jour	Numérique
Heure	Numérique
Minute	Numérique
Pression	Numérique

Propriétés du champ

Général

Taille du champ: Entier long
Nouvelles valeurs: Incrément

AspectPhysiqueEauxMensuel : Table

Nom du champ	Type de données
Code	Numérique
CodeJ	Numérique
Temperature	Numérique
Pression	Numérique
Densite	Numérique
Nebulosite	Numérique
Turbidite	Numérique
VitesseEaux	Texte
Salinite	Numérique

Base de données : Base de données

Tables Requêtes Formulaires États Macros Modules

Pluieheure	QualiteEauHebdo
PluieInterAnnuelle	qualiteEauInstantane
PluieJournaliere	QualiteEauJournalier
PluieMensuelle	QualiteEauMensuel
PressionHebdo	RayonnementHebdo
PressionInstantanee	RayonnementInstarv
PressionInterAnnuelle	RayonnementInterAu
PressionJournaliere	RayonnementJourna
PriseEau	RayonnementMensu
QualiteEauAnnuel	SectionDeControle

Ouvrir
Modifier
Nouveau

Microsoft Ac... ArcView GIS Ve... nov1998 Microsoft Word

ESRI ArcView Version 3.0a

File Edit View Data Display Windows Help

ESRI

Attributes of Domain (1)

Point	X	Y
Point 1	375141.000000	371463.000000
Point 2	375123.750000	371463.000000
Point 3	375105.500000	371463.000000
Point 4	375087.250000	371463.000000
Point 5	375072.000000	371463.000000
Point 6	375054.750000	371463.000000
Point 7	375039.500000	371463.000000
Point 8	375020.250000	371463.000000
Point 9	375000.000000	371463.000000
Point 10	375000.000000	371451.500000
Point 11	375000.000000	371438.187500
Point 12	375000.000000	371422.750000
Point 13	375000.000000	371407.312500
Point 14	375000.000000	371392.875000
Point 15	375000.000000	371377.437500
Point 16	375000.000000	371362.000000
Point 17	375000.000000	371346.562500
Point 18	375000.000000	371331.125000
Point 19	375000.000000	371315.687500
Point 20	375000.000000	371300.250000
Point 21	375000.000000	371284.812500
Point 22	375000.000000	371269.375000
Point 23	375000.000000	371253.937500
Point 24	375000.000000	371238.500000
Point 25	375000.000000	371223.062500
Point 26	375000.000000	371207.625000
Point 27	375000.000000	371192.187500
Point 28	375000.000000	371176.750000
Point 29	375000.000000	371161.312500
Point 30	375000.000000	371145.875000
Point 31	375000.000000	371130.437500
Point 32	375000.000000	371115.000000
Point 33	375000.000000	371100.562500
Point 34	375000.000000	371085.125000
Point 35	375000.000000	371069.687500
Point 36	375000.000000	371054.250000

ESRI ArcView Version 3.0a

File Edit View Data Display Windows Help

ESRI

Attributes of Domain (1)

Point 1

Point 2

Point 3

Point 4

Point 5

Point 6

Point 7

Point 8

Point 9

Point 10

Point 11

Point 12

Point 13

Point 14

Point 15

Point 16

Point 17

Point 18

Point 19

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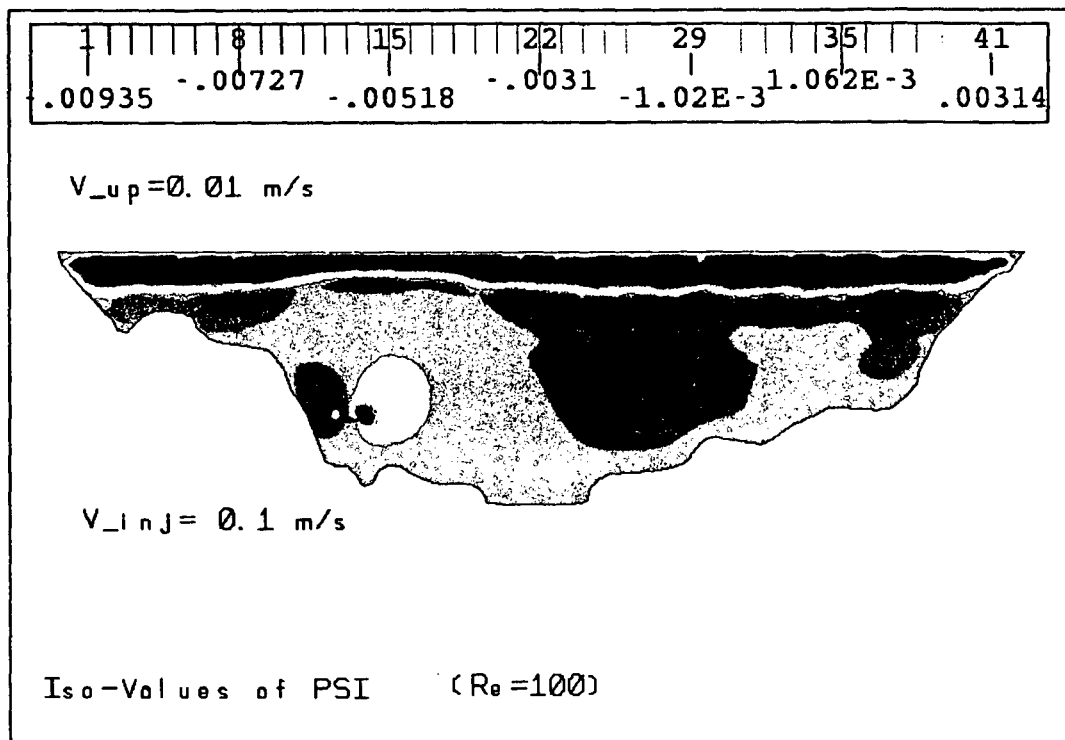
ESRI ArcView Version 3.0a

File Edit View Data Display Windows Help

ESRI

Attributes of Domain (1)

As mentioned earlier, one has to consider a two-phase flow model in order to simulate numerically the aeration process. However, we use in this work an *equivalent* model based on a monophasic Navier-Stokes equations with a turbulence correction term representing the injection effect of the air bubbles in the water. We present a typical numerical simulation result showing the stream line distribution as reported in the figure below.



6. Conclusion

The objective of this paper is to present the framework of the ESIMEAU integrator. ESIMEAU has been developed to handle various water resources problems. The information system proposed has the advantage that it can be implemented on both Windows and UNIX platforms and also it can run as stand alone, as well as, distributed system.

The application of the system for studying the eutrophication problem has demonstrated that systems with advanced numerical codes can be used for studying real world problems. Future work now that the information system is developed will concentrate on extending the family of numerical solvers currently accessible to the system and also applying ESIMEAU in other watershed problems.

Acknowledgements. The European Union sponsorship is gratefully acknowledged. The ESIMEAU project is funded through the INCO-DC/ESPRIT programme of DG-III.

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**International Training Course on
"Industry and Development Related to the Mediterranean Basin"**

**Rabat, Morocco
29 Oct.-03 Nov. 2001**

**COASTAL ENVIRONMENTAL IMPACT
ASSESSMENT**

By Prof. Driss BEN SARI

SUMMARY

- INTRODUCTION
- COASTAL ZONE : C.Z.
- PHYSICAL PROCESSES IN THE COASTAL ZONE.
- MEDITERRANEAN COASTAL ECOSYSTEMS
- SOME COASTAL IMPACTS IN THE MEDITERRANEAN
- ENVIRONMENTAL IMPACT ASSESSMENT E.I.A.
- MONITORING : IN SITU AND R.S.TECHNIQUES
- IN SITU MONITORING
- REMOTE SENSING TECHNIQUES
- REMOTE SENSORS – SPECTRAL DOMAINS AND FUNCTIONS
- R.S. AND IN SITU MEASUREMENTS INTEGRATION
- SPECIFICITIES ON COASTAL MONITORING
- LOICZ OF IGBP

INTRODUCTION

Industrial pollution reaches water, soil and air.

Growing economic importance of the coast.

Necessity of objective assessment of coastal problems.

Balance between Industry, Environment and Development.

The industrial development requires a knowledge based management of natural resources (raw material) and environment.

Data and knowledge on the state of the environment and on the level of its degradation.

Integrated pollution monitoring by combination of different data from R.S. and from in-situ measurements is fundamental for the environmental impact monitoring.

Controls at different scale levels and establishment of protocols for risk assessment, plans for response to emergency and also for early warning systems.

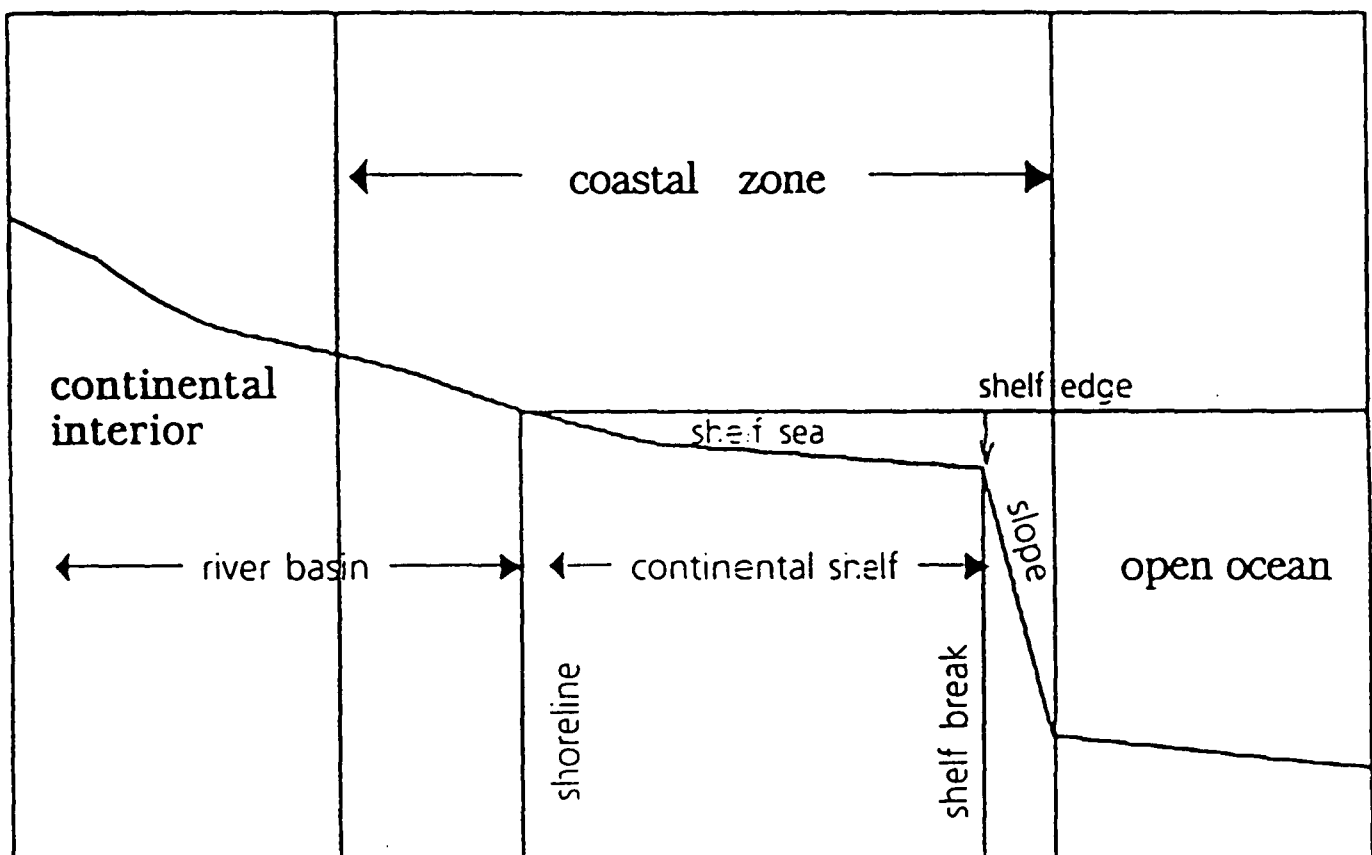
COASTAL ZONE : C.Z.

The C.Z. is the transitional area between land and sea and is determined by the interaction of marine and terrestrial coastal processes.

Ecologically, in the C.Z., the marine environment influences the terrestrial environment, and vice versa. It extends from the region of terrestrial maritime vegetation to the edge of the continental shelf (200 meters of depth).

The C.Z. is subject to various natural processes, which may be of a physical, chemical or biological nature. Gradual, seasonal or stochastic changes in these processes may lead to a variety of impacts on the appearance, functions and (potential) uses of the C.Z..

Figure 1. Coastal zone



PHYSICAL PROCESSES IN THE C.Z.

Variable natural processes involving adverse environmental effects :

- Coastal currents and sediment flows leading to coastal erosion or accretion,
- Storm and wave conditions affecting coastal profiles,
- Dispersion, degradation, absorption and sedimentation processes affecting water and sediment quality,
- Ecological succession leading to changes in habitat types and biodiversity,
- Energy and material cycles affecting biological productivity.

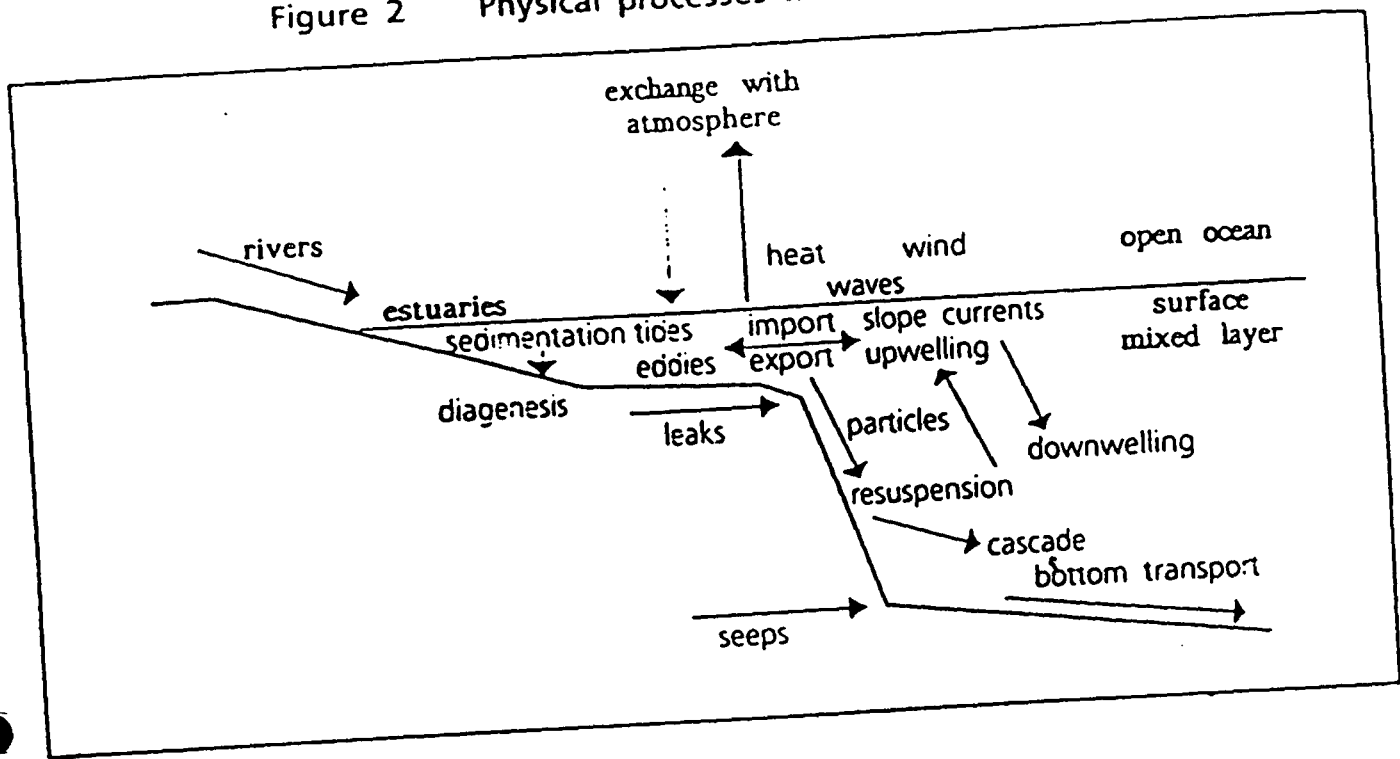
PHYSICAL PROCESSES IN THE C.Z. (continue)

Physical processes in the C.Z. -

The perturbations induced by these activities are :

- Eutrophication,
- Marine contamination,
- Increased sediment transport,
- Off-site generation of coastal pollution (use of agro-chemicals, farming practices, waste disposals,...)

Figure 2 Physical processes in the coastal zone



MEDITERRANEAN COASTAL ECOSYSTEMS

Variety of ecosystems, unique in diversity and richness in Mediterranean basin. Biodiversity is also very rich.

Mediterranean coastal ecosystems are of special interest both biologically and economically

● Biological reasons include :

● The Mediterranean basin features many unique ecosystems, supporting some 25,000 species, half of which are endemic. Mediterranean coastal ecosystems are considered transitional between tropical ecosystem and boreal ecosystems.

Components, which the human agency, and can thus provide baseline data to determine the impact on biodiversity. Such information is important in understanding and managing biodiversity.

MEDITERRANEAN COASTAL ECOSYSTEMS

(continue)

Major marine organism :

Plankton (phytoplankton and zooplankton), Nekton, Benthos and Demersal are the marine organisms affected by the pollution.

The factors affecting coastal organisms are :

- **Abiotic** : such as temperature, salinity, light, waves, currents and tides, oxygen, ... These physical features interact with organisms to produce both constraints and opportunities .
- **Biotic** : biological features, of the environment including predators, competitors, symbiots and pathogen.

SOME COASTAL IMPACTS IN THE MEDITERRANEAN

Sea pollution by : untreated urban waste, industrial pollution, agriculture run-off, marine transport...

Beach erosion : wide spread phenomenon (especially in southern and eastern shores) with negative implication for human health, properties and life.

Water shortage and land pollution : Southern and eastern shores of Mediterranean suffer particularly from water shortages. Pollution and salinization further aggravate the lack of water.

ENVIRONMENTAL COASTAL IMPACTS IN THE MEDITERRANEAN

Some coastal industries

Ports and port industries,

Tourism/Siting of recreational facilities,

Drinking water extraction facilities, desalinization,

Oil and gas exploration, refineries,

Power stations/other industries,

Capture fisheries/mariculture....

Etc.

The industrial pollution reaches water, soil and air.

ENVIRONMENTAL COASTAL IMPACTS IN THE MEDITERRANEAN (continue)

Habitat loss : In the last 50 years the Mediterranean has lost 1 million hectares of wet lands.

Forest loss : The Mediterranean forests today are mostly endangered by human activities such as massive logging, overexploitation for firewood or degradation by grazing. Fire is an important problem due to the hot and dry climate. Forest losses contribute to flooding, erosion, desertification, dam siltation, microclimatic changes, etc.

ENVIRONMENTAL IMPACT ASSESSMENT

E.I.A.

Many human activities produce potentially adverse environmental effects.

The principal biophysical effects of human activity on the environment include :

- Changes in physical processes in the C.Z.
- Changes in water turbidity, suspended load, and temperature,
- Increases in chemical pollutants such as salt, heavy metals and insecticides...
- Changes in vegetation caused by site clearing and alteration to site conditions, and
- Changes in wild life population and distribution.

E.I.A. (continue)

Necessity of :

- To establish monitoring systems offering data and knowledge on state of environment and level of its degradation.
- Control at different levels and different scales
- Observance and modelization of spatio temporal evolution of many indicators.

E.I.A. (continue)

Environmental impact statements are required to contain specific information on the magnitude and characteristics of environmental impact.

An assessment of physical site characteristics involves an inventory of physiographic, geologic, soil, vegetative, wild life, watershed, airshed conditions.

The assessment will draw an expertise persons from many fields like landscape architecture, civil engineering, forestry, geography, geology, seismology, botany, biology, environmental engineering, hydrology, chemistry,...).

Environmental indicators

Table 1 : Battelle environmental evaluation system

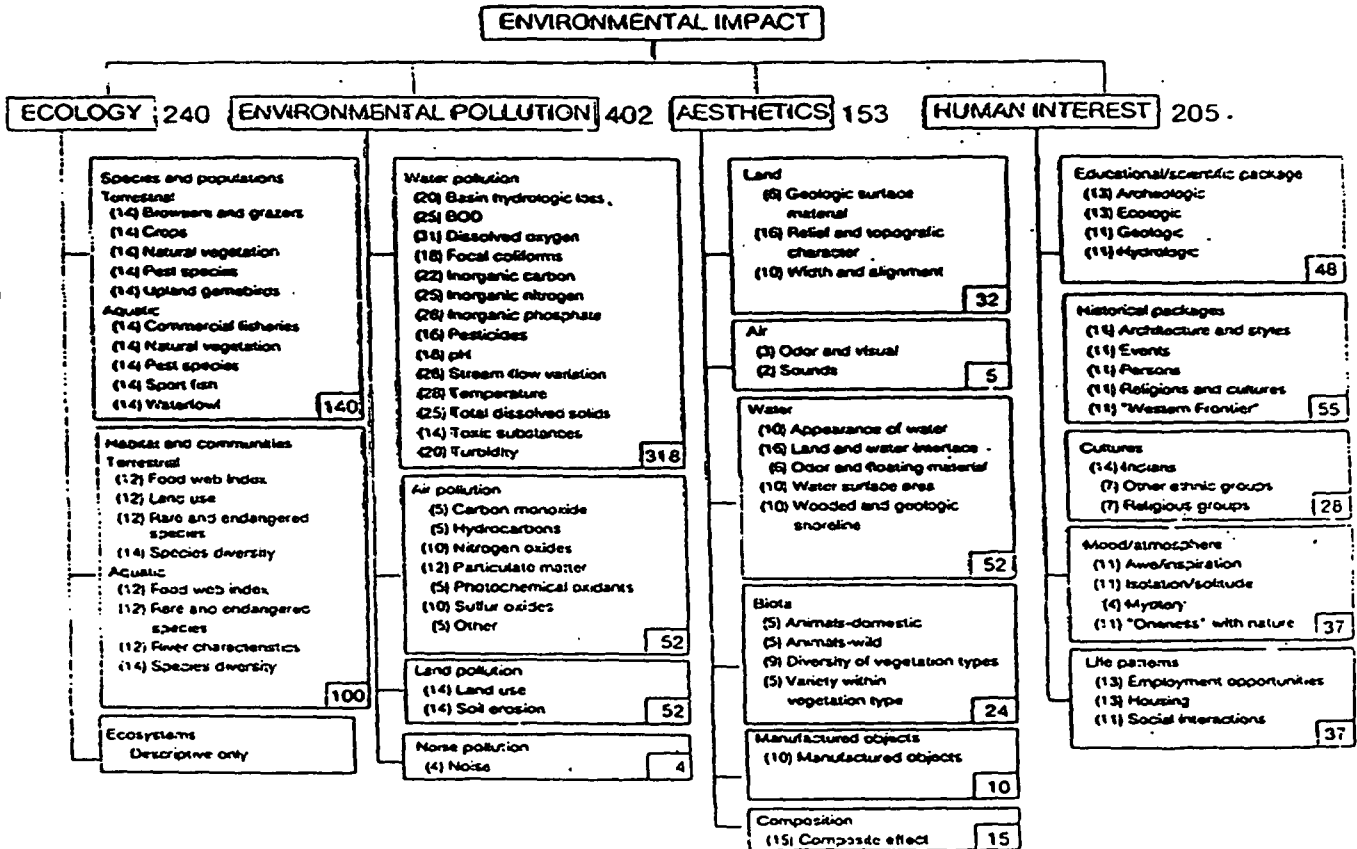


FIGURE 2 The Battelle environmental evaluation system, EES

MONITORING : IN SITU AND R.S. TECHNIQUES

In situ and R.S. Monitoring techniques are essential to support E.I.A. and planning remediation of industrial pollution.

Monitoring system requires technologies related to captors, technologies and techniques for data acquisition and transmission (optical fibers, satellite transmission, etc.), physics, biology, analytical chemistry, data integration (S.I.G.).

MONITORING : IN SITU AND R.S TECHNIQUES (continue)

Data collection is needed to assess and control the state of the environment from the chemical-physical point of view. These data are used for the development of models concerning the distribution and diffusion of pollutants in the environment. Results of data analysis and models can be extended at landscape level by integrating them by G.I.S. with remotely sensed data.

IN SITU MONITORING

The available technology and techniques for in situ monitoring are : automated fixed stations (river courses, etc.) mobile stations, sample collection, sample preparation and preservation, measuring and sampling plans ; measurement parameters at time and space scales, etc.

The structure of a monitoring system includes in-situ monitoring sites for the detection of several chemical-physical parameters, mobile laboratories and a central laboratory.

Additional investigations and experiments on samples would be performed and that will serve as a collecting point of information of various sources.

REMOTE SENSING TECHNIQUES

R.S. is the science and art for obtaining information about an object, area, or phenomenon through the analysis of data acquired by a device that is not in contact with the object, area, or phenomenon under investigation.

R.S. is one of the most efficient techniques that can be applied at macro scale (i.e. for the description of landscape-level parameters).

Figure 3 : Principle of R.S.

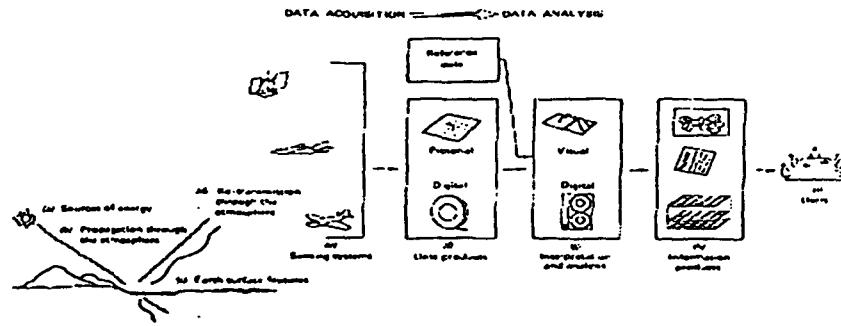


Figure 1.1 Electromagnetic remote sensing of earth resources.

CHAPTER 1 CONCEPTS AND FUNDAMENTALS OF REMOTE SENSING

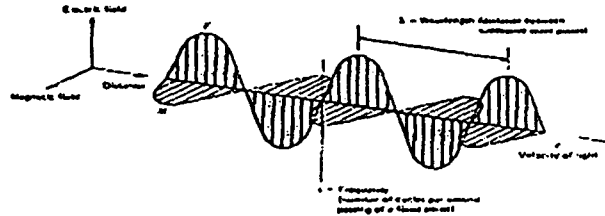


Figure 1.2 An electromagnetic wave. Components include a sinusoidal electric wave (E) and a similar magnetic wave (H) at right angles, both being perpendicular to the direction of propagation.

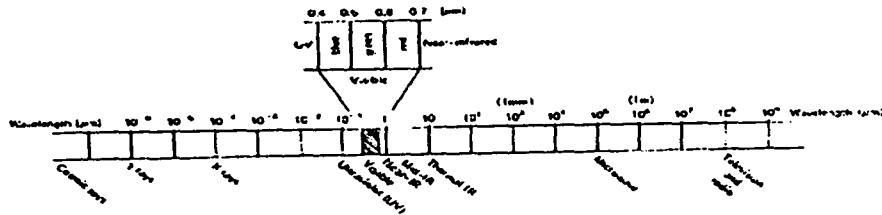


Figure 1.3 The electromagnetic spectrum

REMOTE SENSING TECHNIQUES (continue)

R.S. techniques are relevant for :

- Planning the monitoring system (assessment of industrial landscape patterns) ;
- Monitoring industrial development and its effects on the environment.

R.S. is able to detect large scale pollution both in urban and coastal areas. The use of indexes, derived from the combination of different spectral bands, is widespread to assess some environmental parameters such as vegetation indexes as an indicator of vegetation health, or indexes of water color and turbidity applied in marine and coastal areas.

REMOTE SENSING TECHNIQUES (continue)

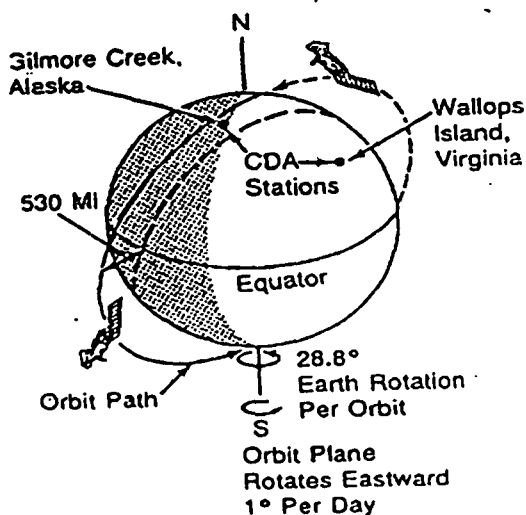
Overview on satellite Earth R.S.

Several satellites launched in recent years provide various types of data with applications at a general scale (global earth survey) or in a specific contest (marine areas, coastal areas, desert landscapes, etc).

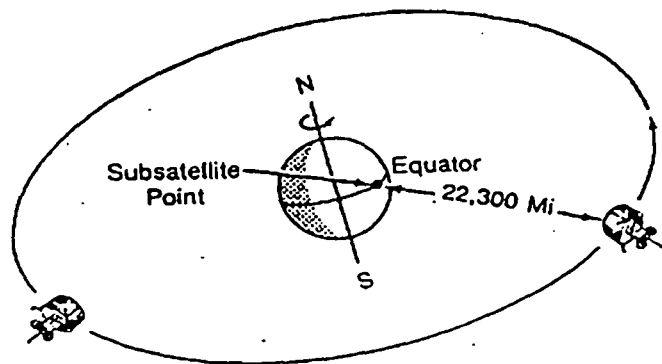
NOAA currently operates three types of environmental satellites.

Environmental satellites of the GOES series are in equatorial geosynchronous orbit and provide the repetitive earth views needed to improve U.S. severe weather warning capabilities.

Polar Orbiting Satellites



Geostationary Satellites



REMOTE SENSING TECHNIQUES (continue)

Environmental satellites of the NOAA series are in sun-synchronous, near-polar orbits and provide the whole earth information needed for monitoring and prediction programs.

Satellites of the LANDSAT series provide sun-synchronous views of the globe for the monitoring of land resources.

Table 2: Recent and current missions for land application satellites.

Mission	Sensor	Waveband location VIS NIR SWIR TIR MW	Spatial resolution	Operational dates	Application
Landsat 4	MSS TM	* * * *	80m 30 (120m TIR)	off since 1994	Earth survey
Landsat 5	MSS TM	* * * *	80m 30 (120m TIR)	July 1984 - present	Earth survey
NOAA - 11	AVHRR / 2	* * * *	1.1 km	Sep: 1988 - present	Global Earth survey
SPOT - 2	HRV	* * * *	20m (10m panchromatic)	Jan 1990 - present	Earth survey
MOS 1b	MESRR VTIR	* *	50m 0.9km(VIS) 2.7km(TIR)	Feb 1990 - present	Marine observation
NOAA - 12	AVHRR / 2	* * * *	1.1 km	May 1991 - present	Global Earth survey
ERS - 1/2	AM SAR ATSR	* * * *	30m 1.1 km	July 1991 - present	Ocean observation and ice monitoring
IRS - 1b	LISS - I LISS - II	* *	72.5m	1993 - present	Earth survey
ERS - 1	OPS SAR	* * * *	18x24m 15m	Feb 1992 - present	Earth survey
IRS - 1c	LISS I MEOSS	* *	72.5m	1993 - present	Earth survey
SPOT - 3	HRV	* * * *	20m (10m panchromatic)	Sept 1993 - present	Earth survey
RadarSat	SAR	* * * *	10-100m	1995 - present	Earth survey, coastal monitoring, ice reconnaissance

Waveband location: VIS, Visible; NIR, Near infrared; SWIR, Shortwave infrared; TIR, Thermal infrared MW, Microwave.

Table 2. Recent and current missions for land application satellites.

REMOTE SENSORS – SPECTRAL DOMAINS AND FUNCTIONS

Using various sensors, we remotely collect data that may be analyzed to obtain information about the objects, areas, or phenomena being investigated.

Remotely, collected data can be of many forms, including variations in force distributions, acoustic wave distributions, or electromagnetic energy distributions.

REMOTE SENSORS – SPECTRAL DOMAINS AND FUNCTIONS (continue)

Electromagnetic energy sensors are currently being operated from airborne and spaceborne platforms to assist in inventorying mapping, and monitoring earth resources environment.

These sensors acquire data on the way, various earth surface features emit and reflect electromagnetic energy, and these data are analyzed to provide information about the resources under investigation.

REMOTE SENSORS – SPECTRAL DOMAINS AND FUNCTIONS

1. For geostationary satellites

Visible and infrared Spin Scan Radiometer (VISSR)
Visible Atmospheric Sounder (VAS) : The VAS is a visible and infrared radiometer capable of providing both multi-spectral imaging and dwell sounding data. It possesses eight visible and six infrared detectors. Positioning a filter wheel allows selections from among 12 spectral bands with central wavelengths between 3.9 and 15m.

REMOTE SENSORS – SPECTRAL DOMAINS AND FUNCTIONS (continue)

2. For Landsat satellites

Multi-spectral Scanner (MSS) is the specified operational sensor Swath width is 185 km, resolution is 80m.

Thematic Mapper (TM) : The TM is a NASA experimental sensor. It is designed to provide 30m resolution, except for 120m resolution in the thermal infrared band.

Sensor MSS

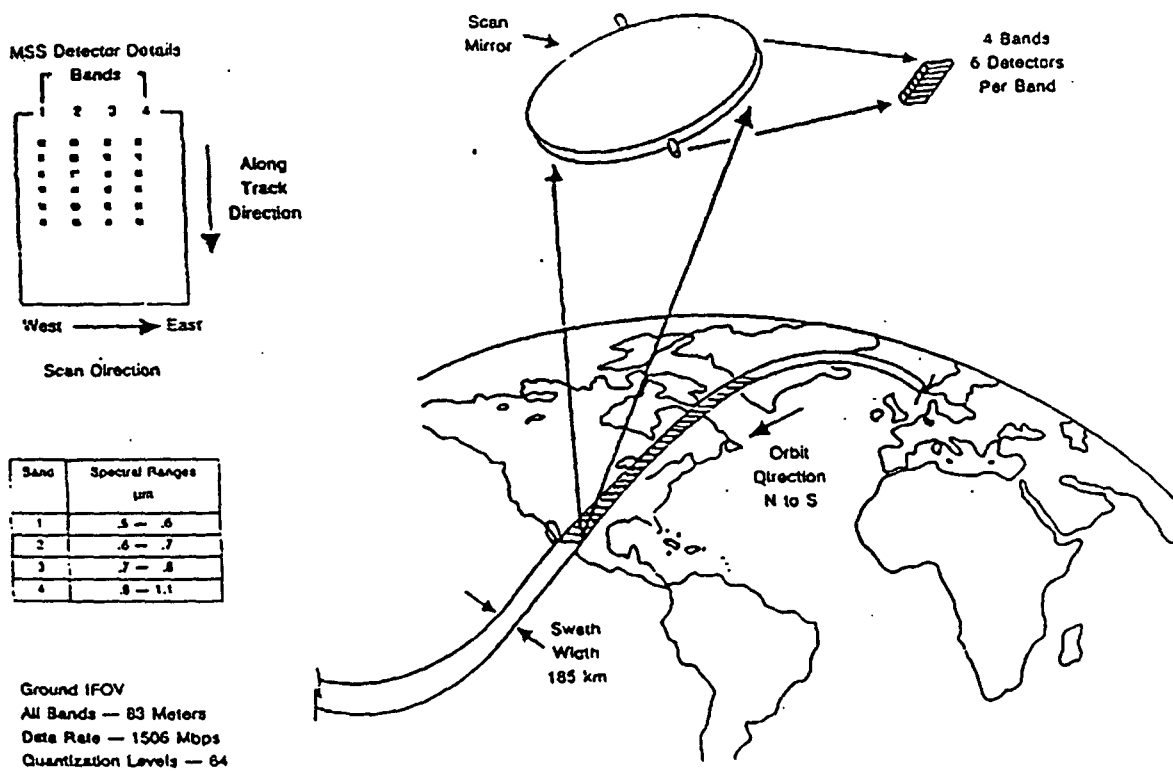
Wavelengths

(μm)

Primary uses of MSS

- 0.5-0.6 Movement on sediment laden water, delineation of shallow water areas
- 0.6-0.7 Cultural features
- 0.7-0.8 Vegetation, boundary between land and water, landforms
- 0.8-1.1 Penetration of atmospheric haze, vegetation, boundary between land and water landforms.

Figure 5 Multispectral Scanner (MSS) Sensor



Sensor T.M

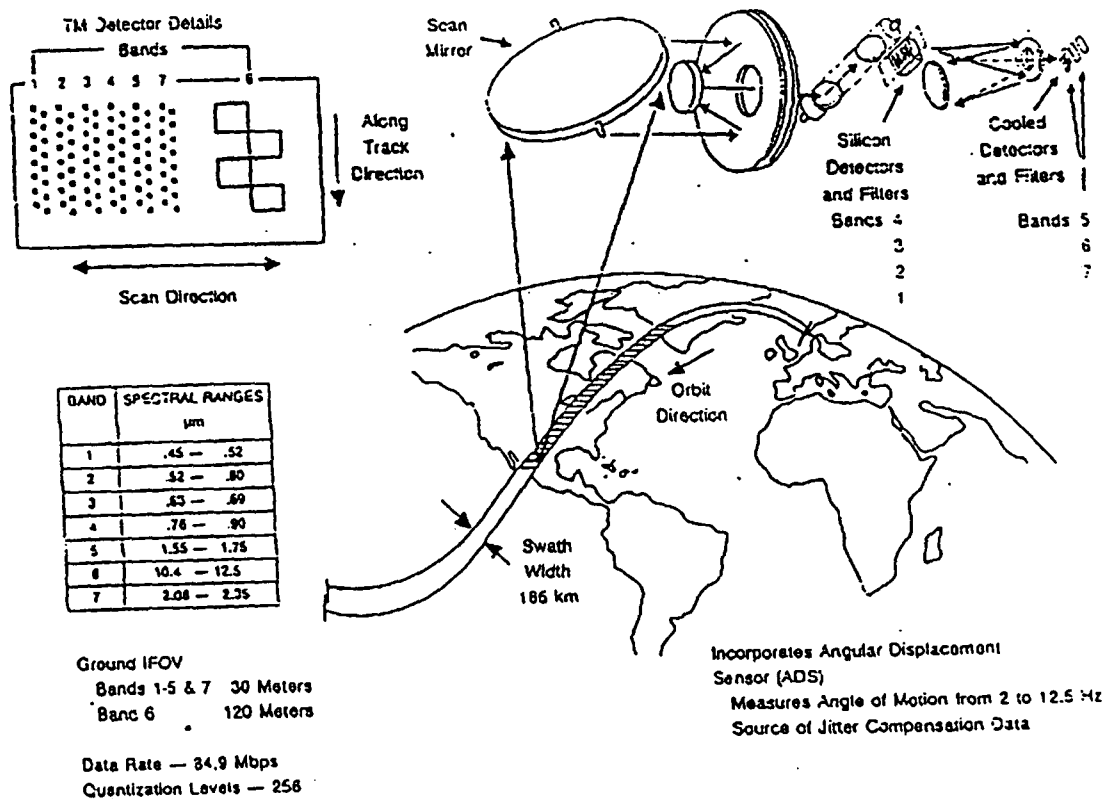
Wavelengths Primary uses of T.M.

(μm)

0.45-0.52	Coastal water mapping, soil/vegetation differentiation, deciduous/coniferous differentiation
0.52-0.60	Green reflectance by healthy vegetation
0.63-0.69	Chlorophyll absorption for plant species differentiation
0.76-0.90	Biomass surveys, water bod
1.55-1.75	Vegetation moisture measurement
10.40-12.50	Plant heat stress management, other thermal mapping
2.08-2.35	Hydrothermal mapping

Figure 6

Thematic Mapper (TM) Sensor



R.S. AND IN SITU MEASUREMENTS INTEGRATION

Data collection is needed to assess and control the state of the environment from the chemical-physical point of view.

These data are used for the development of models concerning the distribution and diffusion of pollutants in the environment.

Results of data analysis and models can be extended at landscape level by integrating them with remotely sensed data.

- This integration can be done by G.I.S.
-

R.S. AND IN SITU MEASUREMENTS INTEGRATION (continue)

- All the information collected are transferred to a central data base where the phases of analysis, integration and data processing take place.
-

The central laboratory is foreseen to be supported by an Information System with a G.I.S. where in situ measurements can be integrated with and related to other types of spatial data (i.e., remotely sensed data, thematic, maps, etc.).

Table 3 : Parameters detected with different monitoring techniques for land and marine environments

Indicators	Remote sensing	In-Situ Monitoring	
		Sample analysis	Measures
Vegetation Dynamic	X		X
Water quality <small>ECR2, CCR2 Microbiology ICOM</small>	X	X X X	X
Eutrophication <small>temperature nutrients chlorophyll turbidity O2 ICOM</small>	X X X X	(X) (X) X X	X X X X X Models
Soil <small>roughness temperature coarse</small>	X X X		
Coastal dynamics	X		X Models

Parameters detected with different monitoring techniques for land and marine environments

SPECIFICITIES ON COASTAL MONITORING

Phenomena and parameters to be monitored – Available technologies and techniques

Fixed stations (buoys, profilers) ;

Underway measurements by automated packages (Blue Box, etc.) ;

Measures and sample collection, probes calibration ;

Sample preparation and preservation.

Measuring and sampling plans ; parameters at time and space scales.

Accuracy and reliability of measurements, data quality assessment, statistical approach to data acquisition quality.

SPECIFICITIES ON COASTAL MONITORING

(continue)

Parameters continuously measured

Conductivity/salinity (accuracy 0.02%, by CTD probe into the bubble trap ;

Temperature :

a) by CTD probe into the bubble trap,

b) by AD 590 at the sampling point.

SST : by thermal infrared radiometers (8-11 micron, accuracy 0.5 C and sensibility of 0.1C) in the bow of ship

SPECIFICITIES ON COASTAL MONITORING

(continue)

Fluorescence :

a) Chlorophyll a "in vivo" (450 nm Ex. And 670 nm Ex.) ;

b) D.O.M. (340 nm Ex. And 450 nm Em.).

Turbidity in FTU (accuracy 2%)

pH (resolution 0.1%)

Ship's positioning by Loran C/GPS system

Continuous water pumping for discrete samples.

SPECIFICITIES ON COASTAL MONITORING

(continue)

In-situ investigation can be further divided in two different activities :

- Monitoring campaigns where routine measurements and sample collection and analysis can be performed.
- Two types : land campaigns and sea campaign (with the use of ships, vessels or other platforms).
- On-line measurements at fixed and mobile stations where chemical-physical parameters are detected by suitable sensors.

Atmospheric chemistry

The chemical compounds are important for the evolution of the all earth system.

Important processes related to the formation of an pollutants in urban areas.

In the early 1970's, it became evident that the stratospheric ozone layer could be substantially altered as a result of human activities.

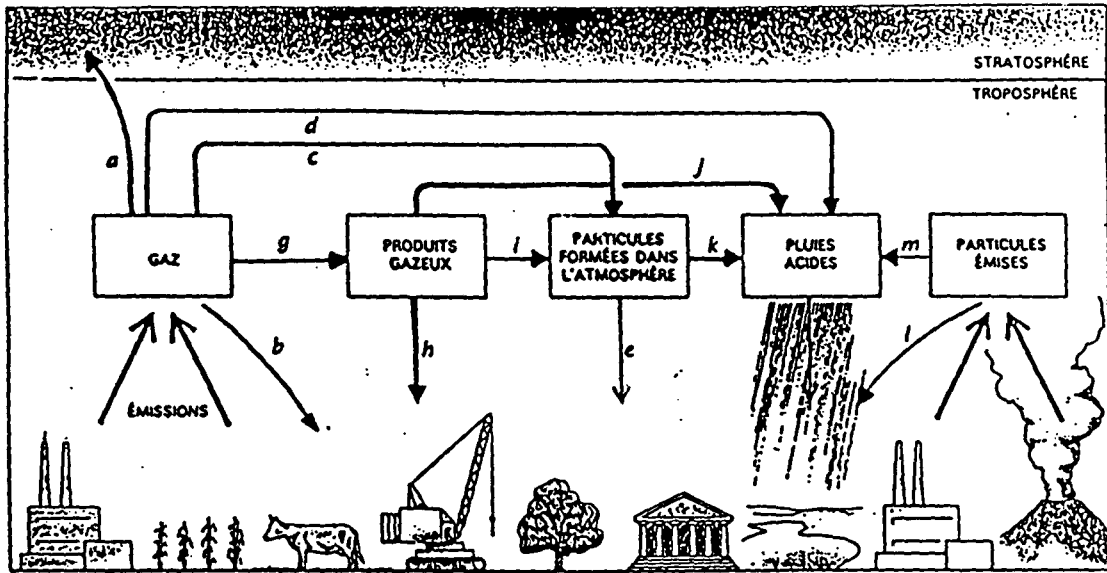
Nitrogen oxides exhausted by the engines of a projected fleet of high altitude supersonic air craft would have the potential to destroy large quantities of ozone above the tropopause.

Chlorine released from the industry manufactured chlorofluocarbons would become a major threat to stratospheric ozone.

In the mid-1980's an ozone hole was indeed discovered over the Antarctic continent during springtime and is expected to the present each year for the next 50 years.

FP/1997

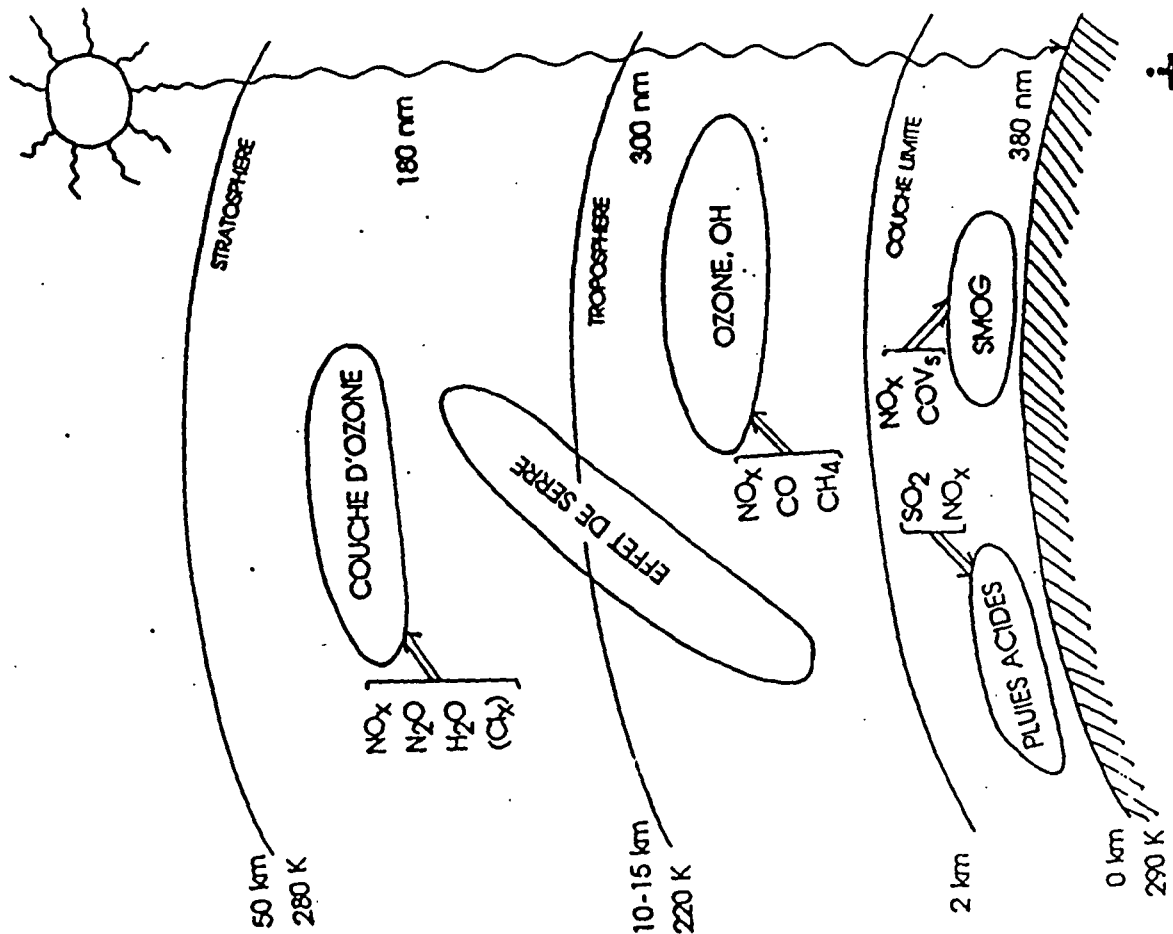
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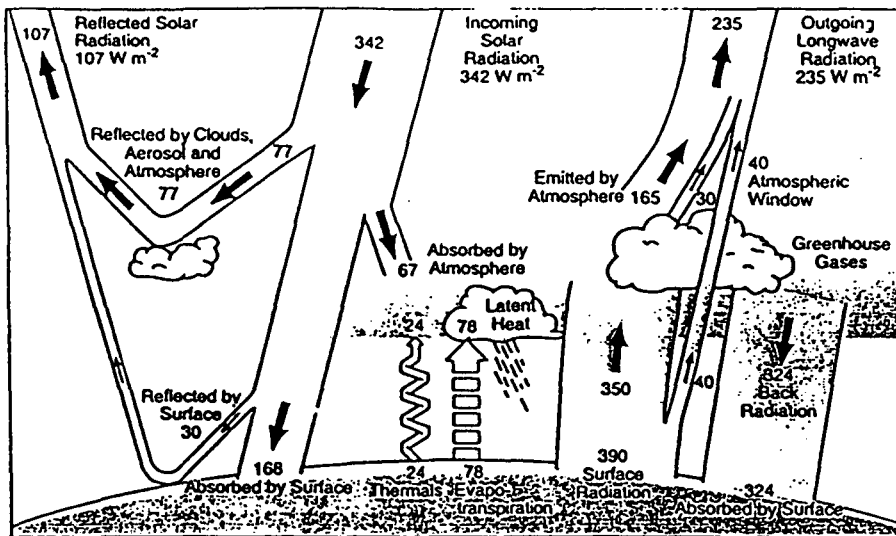


FP

FP

EFFETS DES POLLUANTS





53
 Figure 1.2: The Earth's annual and global mean energy balance. Of the incoming solar radiation, 49% (168 W/m²) is absorbed by the surface. That heat is returned to the atmosphere as sensible heat, as evapotranspiration (latent heat) and as thermal infrared radiation. Most of this radiation is absorbed by the atmosphere, which in turn emits radiation both up and down. The radiation lost to space comes from cloud tops and atmospheric regions much colder than the surface. This causes a greenhouse effect. Source: Kiehl and Trenberth, 1996.

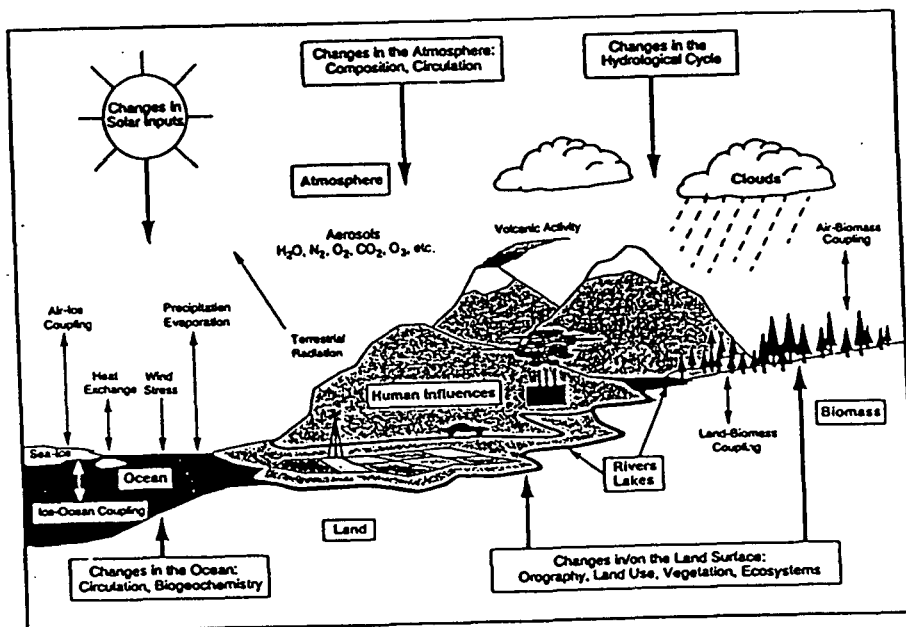


Figure 1.1: Schematic view of the components of the global climate system (bold), their processes and interactions (thin arrows) and some aspects that may change (bold arrows). Source: IPCC, 1996.

LOICZ OF IGBP

Land Ocean Interactions in the Coastal Zone (LOICZ) is one of International Geosphere-Biosphere-Programme (I.G.B.P.) Core Projects. Each one of the Core Projects, dealing with different aspects of Earth System Research, contributes to the expanding knowledge base about our planetary life support system and the changes that are occurring to it.

The Core Projects cover the wide spectrum of earth System studies, from the land, the oceans, the atmosphere, to rivers and coasts and the water and biochemical cycles that are part of them all.

IGBP

IGBP is built on interdisciplinarity, networking and integration. The programme addresses scientific questions where an international approach is the best or the only way to provide an answer. Based on the voluntary contributions of thousands of scientists working on all continents and in all ocean basins of the planet, the programme adds value to this large number of research projects through integrating activities aimed at achieving enhanced scientific understanding.

LOICZ : Land-Ocean

A rapidly growing proportion of the world's population lives in the coastal zone, with enormous impacts on this narrow but valuable strip. The Land-Ocean Interactions in the Coastal Zone (LOICZ) Core Project looks at the transfer of matter across the interface between the land and the ocean and the vulnerability of coastal zone ecosystems to global change. What do the accelerating changes to the coastal zone mean for its ability to transmit, filter or store materials from land areas upstream ? How will systemic changes in the Earth System impact the coastal zone, especially the most vulnerable areas ? What are the implications of a changing Earth for management strategies in the coastal zone ?

LOICZ (continue)

Typology : Low budget R.S.

From off the shelf parts of the coasts sensitive signal to the fluxes of :

- Carbon,
- Nitrogen
- Phosphorus
- In the various parts of the world coastal zone.
- Shades of Red. Green, blue and various combinations.

Once we have measured what is represented by the various colors and combinations, we can construct algorithms to interpolate and extrapolate the images to the times and places where we have not made measurements.

LOICZ (continue)

Good analogy for LOICZ approach to determining the global biochemical function of the coastal zone.

The biogeochemical modeling activity is the ground-truth acquisition process, collecting, interpreting, and comparing CNP Budgets from coastal sites around the world.

The typology effort is the satellite equivalent –viewing the world from a conceptual distance, on the bases of lands of information represented by globally available environmental databases.

LOICZ (continue)

To extend the analogy even further, the interpretative algorithms are to be provided in large part by the LOICZ View Clustering Software.

To devise an image generator that will produce a generalizable context for the available ground truth.

The strategy of LOICZ is to use available data and to search for the patterns and connections within.

LOICZ (continue)

“Typology” will divide the world coastal zone into land, coast and sea cells (0,5 x 0,5%) and will populate those cells with data on dozens of variables ranging from air temperature to population density and from bathymetry to soil texture.

Then various populations of cells will be statistically clustered to identify similarities and differences which will in turn be examined for their ability to explain or describe the distribution of types of biochemical budgets in the coastal database.

LOICZ (continue)

Start process of extrapolating to regional and global coast zone function, once data selection, weighting and tuning have resulted in a set of topologies that are robustly predictive of the budget.

A tool for the Job : LOICZ View

There are many possible ways, both conceptually and methodologically, to classify and explore coastal characteristics.

LOICZ View a consistent methods for achieving the LOICZ goals, a credible time scale.

Table 4 : Test of Australian classification by LOICZ View clustering

Table 1: Test of Australian Coastal Classification by LoiczView Clustering

Test	Clusters / n	Distance	Variable	Values
1	12	Mean scaled	Temperature	Annual mean
			Precipitation	Annual mean
			Runoff	Annual mean
2	12	Mean Scaled	Air temperature	Seasonal maximum and minimum
			Precipitation	Seasonal maximum and minimum
			Runoff	Annual mean
			Soil moisture	Seasonal maximum and minimum
			Evaporation	Proxy index (see note 1)
			Elevation	Standard deviation of cell mean
			Sea surface temperature	Seasonal maximum and minimum
			Salinity	Seasonal maximum and minimum
			CS Color Scanner	Seasonal maximum and minimum
			Wave height	Annual mean
			Tidal Mixing	Proxy index (see note 2)
3	12	Maximum scaled	Same as Test 2	[Note: 12 clusters is suboptimal for the maximum distance method]
Note 1: Evaporation Proxy = (wind speed)x(vapor pressure)x10				
Note 2: Tidal mixing = (tide range)x(F), where F = 1 if diurnal, 2 if mixed, 3 if semidiurnal				

Results

The strong similarities among the expert typologies and the various clustering approaches indicate that there is robust, distinguishable structure in the nature of coastal environments – classification is both reasonable and feasible with manageable numbers of classes.

The significant and generally understandable differences among the approaches means that we have the tools to tune and calibrate the classification approach

A tour present budget data density, most of the major classes are represented by at least one budget site, and some have enough for statistical comparisons of the budget – coast relationship.

**International Training Course on
“Industry and Development Related to the Mediterranean
Basin”**

**Rabat, Morocco
29 Oct.-03 Nov. 2001**

GPS MEASUREMENTS AND APPLICATIONS

By Prof. D. Ben Sari

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1. INTRODUCTION

The Global Positioning System (GPS) consists of a constellation of 24 satellites tracking at 20.200 km above the Earth's surface.

The GPS satellites have quasi-circular orbits with period of 12 sidereal hours.

The orbits have an inclination of about 55° and all satellites are distributed in six orbital plans.

With this constellation, the satellites provide global coverage with 4 to 8 observable satellites above 15° at any time of day and in any place in the world.

The GPS equipment works in all weather conditions, is easy to carry and don't need the mutually visibility between receivers.

The GPS technique presents a lot of advantages for applications in geodesy and geodynamics.

The most important advantage is the great accuracy which makes the technique very useful for geodesy, geodynamics, global changes monitor over time.

Obtaining such good accuracy require the correction of errors affecting GPS measurements. The errors can be instrumental, environmental or originated from orbital and tidal models.

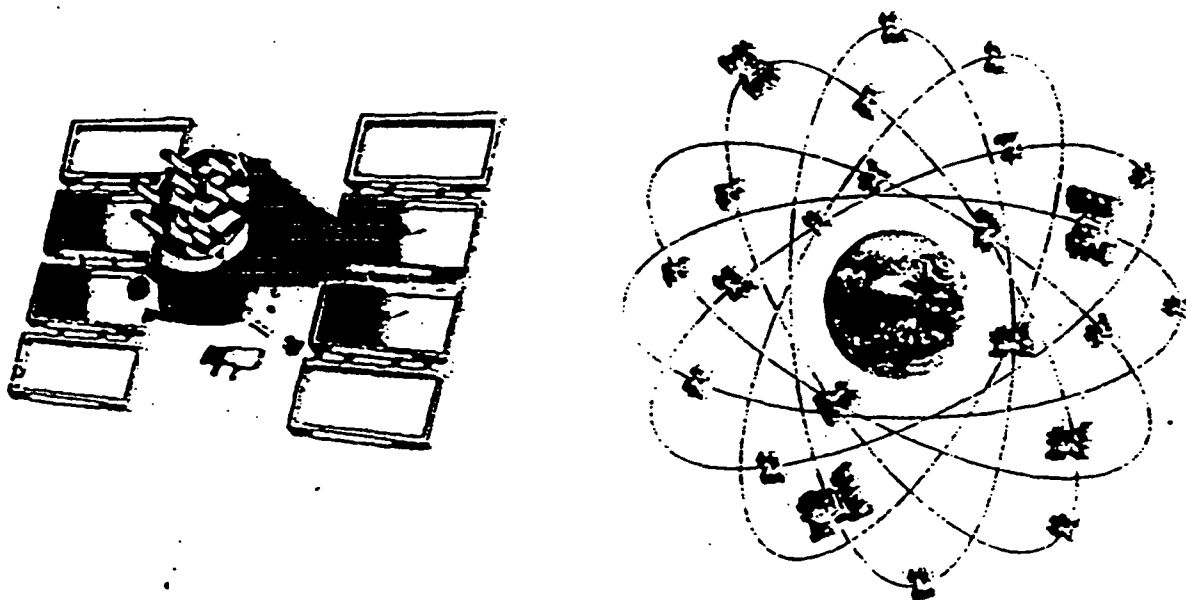


Fig. 1 : Constellation and satellite GPS

2. THE GPS SYSTEM

2.1. Structure of GPS Message

The GPS signal has a fundamental frequency $f_0 = 10.23 \text{ MHz}$.

Two signals are coherently derived from this fundamental frequency, the L1 and the L2 carrier waves generated by multiplying the fundamental frequency by 154 and 120 : we obtain :

$$L1 = 1575,42 \text{ MHz and } L2 = 1227,60 \text{ MHz}$$

Two codes by which the carrier signals are modulated :

- C/A code (Coarse Acquisition) = $f_0/10$ available for civilian use and is modulated on L1 signal only.
- P code (Precision Code) reserved for US military and authorized users. It is modulated on both L1 and L2 carriers.

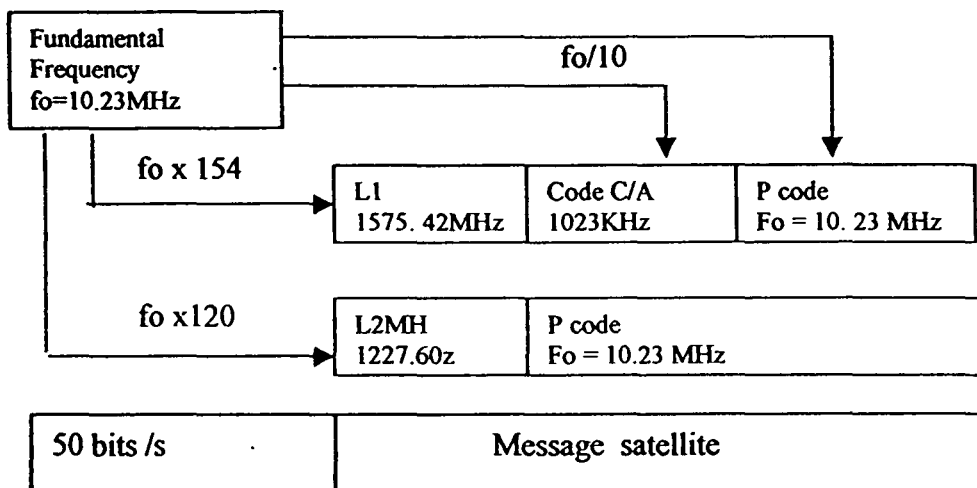


Fig.2 : Structure of GPS Message

2.2. Components of the satellite's message :

- Satellite's ephemeris factors,
- Fundamental frequency : $f_0 = 10.23 \text{ MHz}$
- Carrier L1 = $154f_0 = 1575.42 \text{ MHz}$
- Carrier L2 = $120f_0 = 1227.60 \text{ MHz}$
- 3 Pseudo Random Noise (P.R.N.) :
 - C/A = $(f_0/10), 10^6 \text{ bits/s}$ under L1
 - P = $(f_0), 10^7 \text{ bits/s}$ under L1 & L2
 - W : $(f_0/20)$
- Ionospheric coef. Model

⇒ Signal emitted by the satellite (Maxwell Law) is represented by :

$$L1(t) = a_1(P(t) D(t) \cos.2\pi f_1(t) + a_1 \text{ C/A } D(t) \sin.2\pi f_1(t))$$

$$L2(t) = a_2 P(t) D(t) \cos 2\pi f_2(t)$$

3.RECEIVER TYPE

GPS receiver is a hand held device powered by flash light batteries (fig.3)

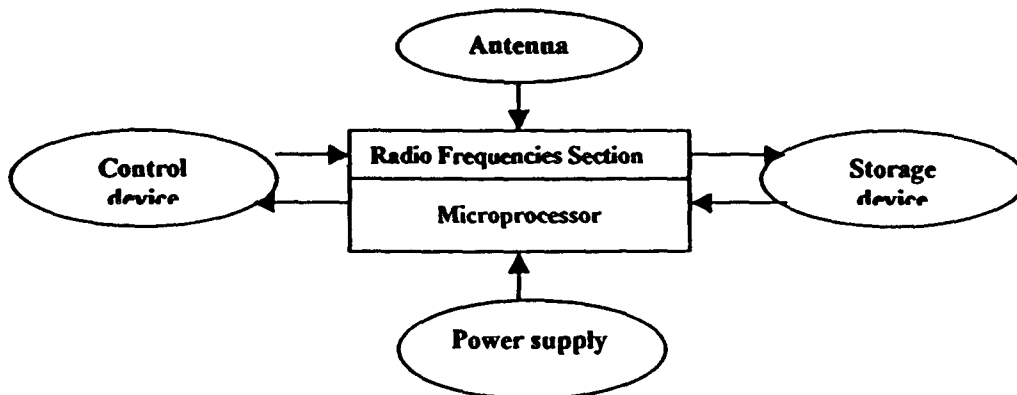


Fig.3 : Components of the receiver unit.

The antenna receives the signals from the satellites, amplifies them and transmits them to R.F. section.

Interactive communications with the receiver are provided by the control device.

The storage device is necessary for storage a huge amount of data collected by the receiver.

The R.F. section is the most important part of the receiver because it processes the incoming signals using separate channels (1 to 6).

The entire system is controlled by the micro processor.

The receivers have output the three-dimensional position (latitude, longitude and height).

For Kinematic GPS applications, four or more channels receivers are required in order to track simultaneous satellites ranges for an accurate position determination.

If the receiver is at a fixed location, the use of one channel device is more appropriate.

There are 3 types of GPS receivers : C/A code receivers, P code receivers and Y code receivers.

3.1. C/A Code receivers

This receiver observe the carrier phase and pseudo-range from L1 carrier. It has at least 4 channels (12 max.)

3.2. P-code receivers

This kind of receivers use P code on L1 and L2 carriers.

The Anti Spoofing (AS) consists on adding W code to the P code in both L1&L2 carriers

The W code (or the Y code) is a classified code.

If the A/S is off, the observable are derived by correlating the signals by a replica of the P code and then after removing this code, the phases are obtained.

Two main advantages for the P code receivers measurement of a long baseline (100 km) with an accuracy of few cm² measurement of a moderate baselines length (20 km) with the same accuracy and within short time of observation using linear combination of the measured L1&L2 phases.

If A/S is on, P code is replaced by the Y code.

However, the P code receivers can work in a codeless mode providing the phase and pseudo ranges for the L2 frequency without knowing the Y code.

This is made possible by performing the techniques : signal squaring, cross correlation, code correlation with squaring and the Z-tracking techniques :

3.2.1. Squaring technique : This technique is based on autocorrelating the received signal. This received signal is mixed with its self and thus all modulations are moved. With this technique there is 180° shift during the modulation.

$$[L_2(t)]^2 = a^2 Y(t)^2 D(t)^2 \cos^2 2p f_2(t) \&$$

$$a^2 \cos^2 2p f_2 t = a^2 / 2 (1 + \cos^2 (2 p f_2 t))$$

3.2.2. Cross correlation technique : This technique is based on the fact that the Y code is identical in both L1 & L2 carriers. Through the ionosphere the wave propagation velocity depends on the frequency. Thus, Y code on L2 is slower than the Y code in L1. The delay of the L2 signal is variable and must be adjusted to complete the correlation between L1&L2 signals.

$$L_1(t) = a_1 C/A(t) Y(t) D(t) \cos^2 p f_1 t$$

$$p L_1(t) \times L_2(t) = a_1 a^2 C/A(t) \cos^2 p f_1 t \cos^2 f_2 t$$

$$L_2(t) = a^2 Y(t) D(t) \cos^2 p f_2 t$$

3.2.3. Correlation plus squaring technique : In this method the received Y code on L2 is correlated with a locally generated replica of the P code.

3.2.4. Z-tracking techniques : The received Y code on both L1&L2 is correlated separately with a locally generated replica of the P code.

3.3. Y-code receivers

With this kind of receivers, the user can access to the P code even it the A-S is on.

4. DATA ANALYSIS

4.1. Tool of analysis

The tool of our analysis is GAMIT/GLOBK software (King et Bock, 1998 ; Herring 1998). This software is developed at MIT (Massachusetts Institute of Technology) to estimate the site position components for GPS stations and the orbits of the satellites. The software is operational under UNIX operating system.

The processing strategy in the software necessitate the use of certain types of data such as :

- The approximate station coordinates for all processed GPS stations.
- The broadcast ephemeris for the observed satellites
- The observation data : phase and pseudo-range measurements
- Specific information about the antenna height and meteorological data

The software includes several modules, each module has a specific function and can be run individually.

The analysis approach follow numerous steps : The steps of analysis approach

- Preparing the data : generating an approximate set of stations coordinates and information about antennas and receivers used in the GPS campaign. The software need also the use of the broadcast ephemeris generated by the satellites.
- Execute the batch processing : follow the different modules to generate the final solution
- Data editing : the software allows numerous methods of data editing.

4.2. GPS observables

The GPS observable are :

4.2.1. Pseudo ranges/Absolute positioning : distance between GPS antenna and the satellites, obtained by measuring the period of time necessary for the signal to travel between the satellite (using the satellite clock) and the receiver (using the receiver clock).

The pseudo ranges measurement is obtained by using the 300m wavelength C/A code or 30m wavelength P code transmitted by the satellites. Pseudo ranges provide the primary GPS observation for navigation but are not precise enough to be used along in geodetic surveys. However, they are useful for synchronizing receiver clocks, resolving ambiguities and repairing cycle slips in phase observations and as an adjunct to phase observation in estimating satellite orbits.

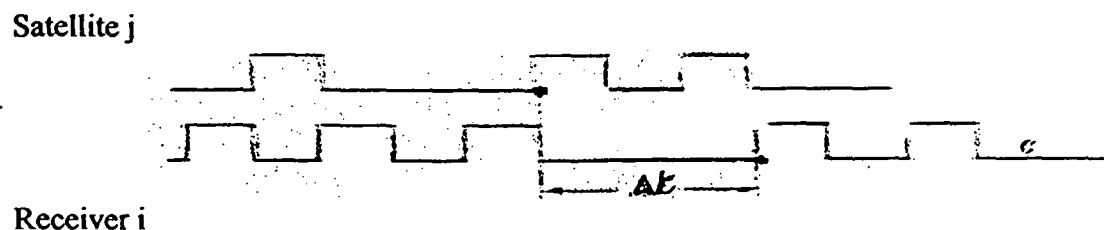


Fig. 4 : Comparison between the received signal from the satellite j and the proper signal of the receiver i

$$\Delta t_i^j = t_{Ri} - t_E^j \quad (1) \quad \text{The two clocks are not synchronous}$$

$$t_{Ri} + dt_i = t_R \quad (2) \quad t_{Ri}^j = \text{time of signal's receipt at time scale of receiver}$$

$$t_E^j = \text{time of signal's emission at time scale of satellite}$$

$$t_E^j + dt_i^j = t_E \quad (3) \quad t_E = \text{time of emission at GPS time}$$

$$t_R = \text{time of receipt at GPS time}$$

$$\Delta t_i^j = t_R - dt_i - t_E + dt_i^j = t_R - t_E + (dt_i^j - dt_i) \quad (4)$$

$$dt_i = \text{difference between receiver's time and GPS time}$$

$$dt_i^j = \text{difference between satellite's time and GPS time}$$

$$R_i^j = c \Delta t_i^j = c(t_R - t_E) + c(dt_i^j - dt_i)$$

$$= \rho_i^j + c(dt_i^j - dt_i) \quad (5)$$

In absolute positioning :

$$R_i^j = \rho_i^j + c(dt_i^j - dt_i) + \Delta \rho^{\text{iono},j} + \Delta \rho^{\text{tropo},j}$$

$$\rho_i^j = \sqrt{(X^j - X_i)^2 + (Y^j - Y_i)^2 + (Z^j - Z_i)^2}$$

R_i^j = pseudo range in m

ρ_i^j = geometrical distance between satellite j at t_E and receiver i at t_R .

(X_i, Y_i, Z_i) = unknown coordinates of i station

(X^j, Y^j, Z^j) = known coordinates of satellite j

$\Delta \rho^{\text{iono},j}$ and $\Delta \rho^{\text{tropo},j}$ = calculated by models and eliminated by bifrequency measurement.

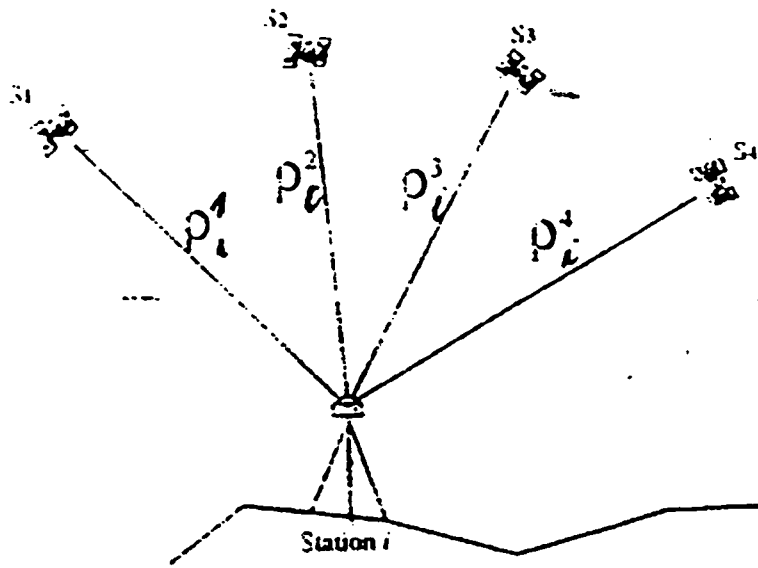


fig. 5 : Absolute positioning by pseudo distance measurement

- The geometric dilution of precision GDOP

The precision of positioning depends on geometrical distribution of satellites and factors of precision's dilution (KDOP)

IF Q_x is Matrix of variance/covariance

Q_L is transformed Matrix in local geodetic referential

VDOP = σ_h/σ_0 for the heights

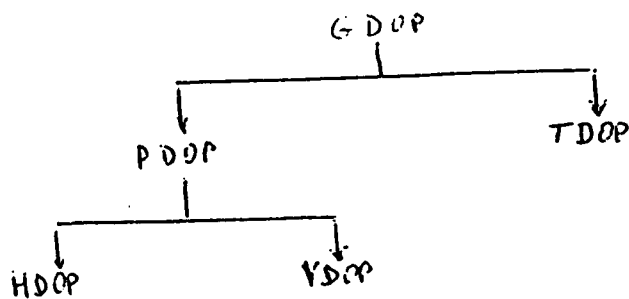
HDOP = $1/\sigma_0 \sqrt{\sigma_x^2 + \sigma_E^2}$ for horizontal positioning

PDOP = $1/\sigma_0 \sqrt{\sigma_n^2 + \sigma_R^2 + \sigma_h^2}$ for 3D

TDOP = σ_t/σ_0 for the time

GDOP = $1/\sigma_0 \sqrt{\sigma_x^2 + \sigma_c^2 + \sigma_h^2 + c^2 \times \sigma_t^2}$

vertical DOP
horizontal DOP
Position DOP
time DOP
geometric DOP



4.2.2. Phase observable : difference between the transmitted signal and the generated signal inside the receiver

(2) High precision geodetic – differency standards

Phase measurement by carrier L1 ($\lambda = 19,0$ cm) and carrier L2 ($\lambda = 24,4$ cm)

Rappel :

Sine wave $X(t)$ with A , amplitude and f = frequency

$$X = A \cos(x(t-t_0) + \varphi_0)$$

$$\omega = 2 \pi f \text{ (rd/s)}$$

φ_0 = phase in rd. at t_0

$$\varphi_{\text{rad}} = 2 \pi f x (t-t_0) + \varphi_0$$

$$\varphi_{\text{Cycles}} = f(t-t_0) + \varphi_0/2\pi$$

$$\lambda = c/f \quad \text{Satellite } j$$

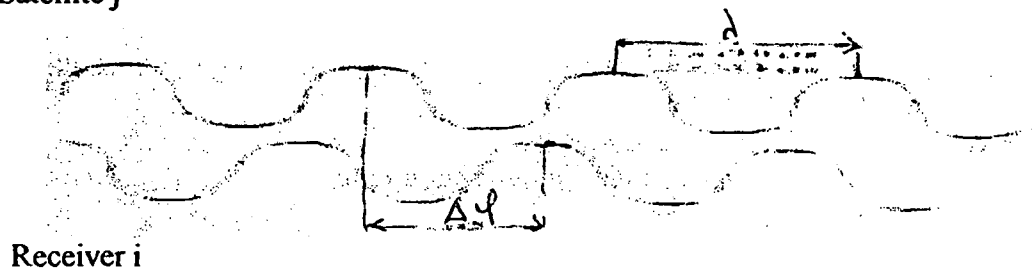


Fig. 6 : Comparison between signal received and signal generated by the receiver

High-precision geodetic measurements with GPS are performed using the carrier beat phase and the output from a single phase tracking channel of a GPS receiver. The carrier beat phase can be measured with sufficient precision that the instrumental resolution is a millimeter or less in equivalent path length.

The distance ρ_i^j between satellite and receiver is obtained by comparison between the phase at (t_R) and the phase at (t_E).

$$\Phi(t_R) - \Phi(t_E) = f(t_R - t_E) \text{ in cycles} \quad (6)$$

$$\text{and } (t_R - t_E) = \rho_i^j/c \quad (7)$$

$$\Rightarrow \Phi(t_R) - \Phi(t_E) = f \rho_i^j/c \quad (8)$$

$$\varphi_i(t_R) - \rho_i^j(t_E) = \Delta\varphi(t_R) + N_i^j(t_R) \quad (9) \quad \text{with } 0 < \Delta\varphi < 1 \text{ cycle}$$

$N_i^j(t_R)$ = integer number of cycles

$$N_i^j(t_R) = N_i^j(t_1) + n(t_R) \quad (10) \quad \text{with } t_1 = \text{initial epoch}$$

$n(t_R)$ = number of cycles given by counter at t_R .

$$\Delta\phi(t_E) = \phi^i(t_R) - \phi^j(t_E) - [N_i^j(t_1) + n_{t_R}] \quad (11) \quad N_i^j(t_1) = \text{ambiguity is the same for one satellite } j \text{ and one receiver } i$$

The phase measurement is :

$$\Delta\phi(t_R) + n(t_R) = \phi^i(t_R) - \phi^j(t_1) - N_i^j \quad (12)$$

$$(8) \Rightarrow \phi^j(t_E) = \phi^j(t_R) - f\rho_i^j/c \quad (13)$$

$$\Delta\phi(t_R) + n(t_R) = \phi^i(t_R) + f\rho_i^j/c - N_i^j \quad (14)$$

If the 2 clocks are synchronized

$$\phi^i(t_R) = \phi^j(t_R)$$

But

$$t_{Ri} = t_R - dt_i$$

$$t_{Rj} = t_R - dt^j$$

dt_i and dt^j are the differences between GPS time and clocks times

$$\phi^i(t_{Ri}) - \phi^j(t_{Rj}) = f_x(t_R - dt^j) - f_x(t_R - dt_i) \quad (15)$$

$$\phi^i(t_{Ri}) = \phi^j(t_{Rj}) = f \times dt^j - dt_i$$

$$\lambda\Phi = t(dt^j - dt_i) + \rho_i^j - \lambda N_i^j \quad (16)$$

with $\Phi = \Delta\phi(t_E) + n(t_E)$

Also between satellites to cancel completely the effects of variations in the stations clocks.

Since the phase biases of the satellite and receiver oscillators at the the initial epoch are eliminated in doubly differenced observations. The doubly-differenced range (in phase units) is the measured phase plus an integer number of cycles (one cycle has a wavelength of 19 cm at L1 and 24 cm at L2 for code correlating receivers, half these values for squaring type receiver channels). If the measurement errors, arising from errors in the models for the orbits and propagation medium as well as receiver noise, are small compared to a cycle, there is the possibility of determining the integer values of the biases, thereby obtaining from the initially ambiguous doubly differenced phase an unambiguous measure of doubly differenced range resolution of the phase ambiguities allows a more precise measure of the relative positions of the station.

Noise of measurements

GPS signal	λ	Noise < 1% of λ
C/A code	300 m	1 to 3 m
P code	30 m	10 to 30 cm
Phase L1 or L2	20 cm	1 to 2 mm

4.2.3. Combination of measurements Dual band processing :

For the highest relative positioning accuracies, carrier beat phase observations must be obtained simultaneously at each epoch from several stations for several satellites and at both L1 = 1575.42 MHz (= 19cm) and L2 = 1227.60 MHz (= 24.9cm) GPS frequencies precise measure of the relative position of the stations.

Some linear combinations of GPS observations phases are known to improve the position accuracy as they eliminate certain type of errors.

$$\begin{aligned} \Phi &= n_1 \Phi_{L_1} + n_2 \Phi_{L_2} & f &= n_1 f_1 + n_2 f_2 \\ \Rightarrow \\ M\Phi &= n_1 f_1 t + n_2 f_2 t = ft & \lambda &= c/n_1 f_1 + n_2 f_2 \end{aligned}$$

The "single difference", which is the difference of observations issued from two receivers eliminate the effects of bias or instabilities in the satellite clock.

$$\begin{aligned} \text{For } n_1 = n_2 = 1 &\Rightarrow \Phi_{L_1+L_2} = \Phi_{L_1} + \Phi_{L_2} \Rightarrow \lambda_{L_1+L_2} = 10.7 \text{ cm} \\ n_1 = 1, n_2 = -1 &\Rightarrow \Phi_{L_1-L_2} = \Phi_{L_1} - \Phi_{L_2} \Rightarrow \lambda_{L_1-L_2} = 86.2 \text{ cm} \end{aligned}$$

The single difference between satellites eliminate the clock receiver errors and also is used for the determination of ambiguities.

We use also another combination $\Phi_{L_1} = 2,541\Phi_{L_1} - 1,984\Phi_{L_2}$ or $\Phi_{L_{\text{eff}}} = \Phi_{L_2} - 0.779\Phi_{L_1}$
For the same satellite and the same receiver, differencing the observations are used to eliminate the satellites and the receivers clock at the same time and also the ionospheric errors

$$\begin{aligned} J_{ik} &= j_k - j_i \\ J_{ik} &= f(dt_i - dt_k) + f_j \\ F &= c(j_k - j_i) - (N_{jk} - N_{ji}) \end{aligned}$$

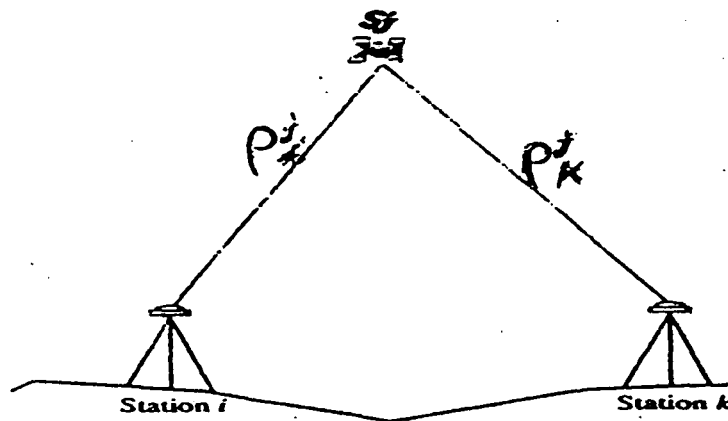


Fig 7.1: Single difference

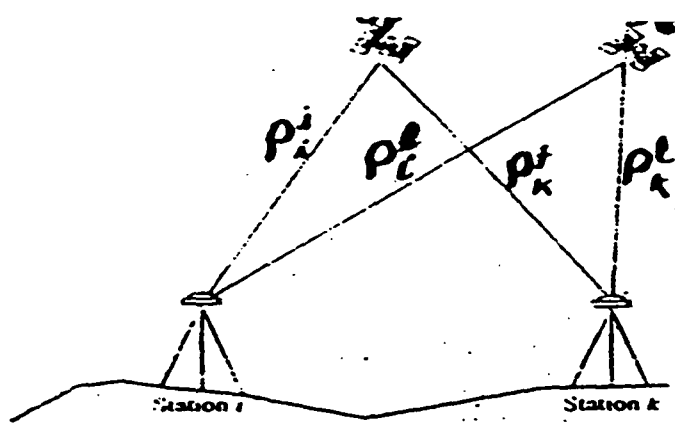
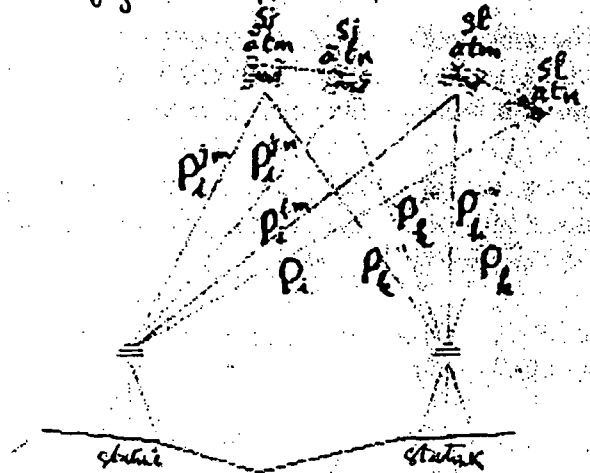


fig7.2:Double difference

$$J_{tik} = tik - jik$$

$$J_{fik} = f \cdot c(tk - jk + ji - ti) - (N_{tk} - N_{jk} + N_{ji} - N_{ti})$$

fig 7.3 Triple difference



“Decalage” of receivers clocks are eliminated by this difference.

For a single satellite, differencing the phases (or pseudo ranges) of signals received simultaneously at each of two ground stations eliminates the effect of bias or instabilities in the satellite clock. This measurement is commonly called the between-stations difference or single difference observable. If the stations are closely spaced, differencing between stations also reduces the effects of tropospheric and ionospheric refraction on the propagation of radio signals.

Another useful combination is the difference between L2 and L1

$$\Phi_{LG} = \Phi_{L2} - 0,779 \Phi_{L1}$$

called “LG” because the L2 phase is scaled by the “gear” ratio ($f_2/f_1 = 60/77$).

In the LG phase we have a direct measure of the ionospheric variations.

If precise (P-code) pseudorange is available for both GPS frequencies, “wide-lane” (WL) combination of L1, L2 and P2 can be formed which is free of both ionospheric and geometric effects.

$$WL = n_2 - n_1 = L_2 - L_1 + (P_1 + P_2)(f_1 - f_2)/(f_1 + f_2)$$

The WL observable can be used to fix cycle slips in one-way data but should be combined with LG and doubly differenced LC to rule out slips of an equal number of cycles at L1 and L2.

To provide a check the algorithm used by GAMIT employs both the pseudoranges and the “phase wide-lane” with ionospheric constraints to resolve the wide-lane ambiguities.

4.3. Modeling the Satellite Motion

A first requirement of any GPS geodetic experiment is an accurate model of the satellites motion. The (3-dimensional) accuracy of the estimated baseline, as a fraction of its length, is roughly equal to the fractional accuracy of the orbital ephemerides used in the analysis.

By using phase measurements from a global network of over 50 stations, however, the International GPS Service for Geodynamics (IGS) is able to determine the satellites' motion with an accuracy of ~~5-10 parts in 10⁹~~ (10-20 cm).

10 mm uncertainty in the relative position of sites 2500 km apart introduces an (approximate) uncertainty of only 1 mm in the components of a 250 km baseline.

The motion of a satellite can be described, in general, by a set of six initial conditions (Cartesian position and velocity, or osculating Keplerian elements, for example) and a model for the forces acting on the satellite over the span of its trajectory.

In principle, a trajectory can be generated either by analytical expression or by numerical integration of the equations of motion ; in practice, numerical integration is almost always used, for both accuracy and convenience.

The position of the satellite as a function of time is then read from a table (ephemeris) generated by the numerical integration.

In modeling the phase and pseudorange observations, we must take into account not only the motion center of mass of the satellite but also meter-level offsets between the center of mass and the phase-center of the transmitting antenna.

4.4. Estimation by Least Squares

GAMIT incorporates a weighted least squares algorithm to estimate the relative positions of a set of stations, orbital and Earth-rotation parameters, zenith delays, and phase ambiguities by fitting to doubly differenced phase observations.

Data can be viewed and edited interactively without iteration since CVIEW uses the pre-fit residuals, partial derivatives, and parameter adjustments to compute and display "predicted" post-fit residuals. Automatic editing is more effective near convergence, however, since AUTCLN uses pre-fit residuals.

In current practice, the GAMIT solution is not usually used directly to obtain the final estimates of station positions from a survey. Rather, we use GAMIT to produce estimates and an associated covariance matrix of station positions and (optionally) orbital and Earth-rotation parameters which are then input to GLOBK or other similar programs to combine the data with those from other networks and times to estimate positions and velocities.

5. ERRORS IN GPS MEASUREMENTS

The observed phase is affected by a number of error sources.

Correction of these errors is very important because high measurement accuracy is required.

The error sources affecting GPS measurements are classified into 3 classes :

- Instrumental errors
- Environmental errors
- Modeling errors.

5.1. Instrumental errors :

Related to the GPS equipments : (antenna and GPS receiver) including : antenna phase center, signal scattering, thermal noise, interchannel biases and clock drifts.

5.1.1. Antenna phase errors : The phase center of the antenna is the point which the phase measurements are referenced. It is different from the geometric antenna center. The offset depends on the elevation, the azimuth and the intensity of the GPS signal. This offset is different for L1&L2 observable (systematic variation can reach 1 to 2 cm). Each antenna model has its own phase center variation. If the same type of antenna is used within the same network, the phase error contribution will in general cancel out while differencing the observable, but it strongly depends on the lengths of the baselines.

5.1.2. Signal scattering :

Caused by the edges of the antenna and structures in the near field zone, the signal scattering is a site dependent error (electronic coupling between antenna and near field environmental)

Reducing the effect of signal scattering by measuring the characteristics of the antenna including all elements in the vicinity of the antenna (numerical methods, physical and geometrical optics).

5.2. Environmental errors

The environmental errors are errors related to the environment of the GPS antenna, such as multipath errors, propagation errors and the monument instability.

5.2.1. Multipath errors :

The multipath phenomena occur when the signal emitted by the satellite is reflected by reflecting surfaces in the neighborhood of the antenna .Multipath is a dangerous phenomena (interference between the direct and the reflected signal).

Thus, it is implicit that the geometry of the antenna location is as important on determining the multipath effects as the nature of the reflecting surfaces and the weather conditions. The weather can modify the multipath effect because it modifies the propagation medium properties and then the signal propagation.

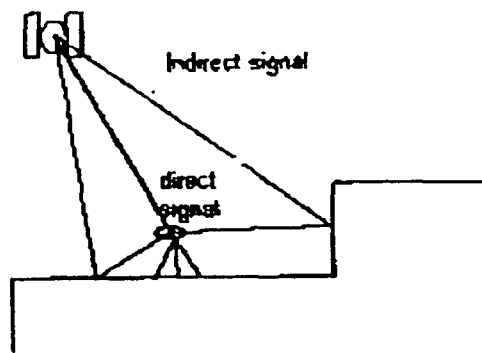


Fig.8 : Illustration of the multipath phenomena

The GPS signal is reflected by the ground or by obstacles in the vicinity of the antenna.

We need the antenna to reject reflected signals but also to receive signals at low elevation angles with a reduced gain in the same time.

5.2.2. Propagation errors

The atmosphere is divided into two areas : the ionosphere (50 to 500 km altitude), dispersive medium for which the effect is largely eliminated by using dual frequency observations, and the neutral atmosphere (0 to 10 km altitude) especially the troposphere, non dispersive medium, for which the delay must be inferred from a profile of the medium refractivity of estimated from the GPS measurements themselves.

The most efficient method to eliminate the ionospheric refraction is to use two signals with different frequencies. A linear combination of the two observations eliminate the ionospheric effect.

The propagation delay is directly related to the refractive index of the medium. The path is given by : $I = \int n ds = 10 \int N ds$, where n refers to the refractive index of the medium and N is the refractivity. In order to model the propagation delay we need to integrate the refractivity along the line of sight to the satellite.

We can however divide the quantity N into N_{dry} and N_{wet} , corresponding respectively to the dry refractivity and the wet refractivity. The terms wet and dry are directly related to the presence or the absence of water vapor in the air.

One of the major sources of error in GPS measurements and especially in height measurements is the signal propagation delay due to the atmospheric water vapor. Many studies were conducted to clarify, the correlation between water vapor and GPS height estimates.

The tropospheric dry zenith delay : I_{dry} (value of the dry tropospheric delay in the zenith), is related to the total air mass in the vertical column above the station. The accuracy of this quantity is greatly dependent of the accuracy of pressure measurements. A pressure reading error of 1 mbar causes a 23 mm error in the dry zenith delay (Dodson et al, 1996). The wet zenith delay is smaller than the dry one (about 3-30 cm compared to 200-300 cm for the dry delay (Jaldehyag, 1995), but much more difficult to model. The difficulty of such a model is

due to the variability of water vapor pressure in the atmosphere and also to its poor correlation with the surface meteorology data.

The zenith delay can vary from 190 to 240 cm (GAMIT documentation, 1998). The atmospheric delay increases with decreasing elevation angle, an approximation of this relationship is the cosecant formula of the elevation angle. So the atmospheric delay at 30° of elevation is about $1/\sin(30^\circ) \times$ (error at the zenith). The result varies from 380 and 480 cm.

5.3. Monument instability

An important issue in regards to site dependent errors, is the control of monument stability. The site stability can be monitored by remeasuring the local network at the same time as the regional one.

5.4. Modeling errors

The modeling errors include : satellite and receiver clock errors, satellite orbits, ocean tides and atmospheric pressure loading effects.

5.4.1. Satellite orbits

Precise orbits are available from the IGS with an accuracy of 5cm. So for a baseline of 1000 km the error introduced by the satellites orbits is 2 mm.

5.4.2. Ocean tides

The gradient in the attraction of the moon and the sun deform the solid Earth, oceans and atmosphere creating tides. The largest effect on GPS observations is the diurnal movement of the crust at the station (about 10 cm), but this effect can be modeled within a few millimeters. Ocean tides are larger but act on the station indirectly by loading the crust, creating motions up to a few centimeters. The ocean tides phenomena are complex, they depend on the geometry of the basins and therefore the loading effects are location-dependant. The loading effect is complicated by the different responses of the oceans and land. It can reach 25 mm in vertical and 8 mm in horizontal.

5.4.3. Atmospheric pressure loading effects

The atmospheric pressure variations are loading the Earth surface and induce quasi-periodic surface deformation. VanDam et al, 1994, demonstrated that 24% of the total variance of the GPS height estimates is due to atmospheric pressure loading effects. That was possible by comparing daily GPS geodetic positions using an atmospheric pressure loading model over 300 days of observation. For all the studied sites, the predicted variance of the loading displacements varies between 0 and 25 mm².

Such results confirm that the atmospheric pressure loading is an important source of error for GPS measurements. The total influence induced varies between 20 and 30 mm for a 50 mbar of regional pressure change (Sun et al., 1995).

For observations used in geophysics and geodesy, which require a high level of accuracy, it's important to correct the effect of atmospheric pressure loading by adopting an adequate model.

6. ANALYSIS APPROACH

6.1. GAMIT/GLOBK software

GAMIT/GLOBK is a software (Bock et al. 1997) to estimate the stations position for each day of observation.

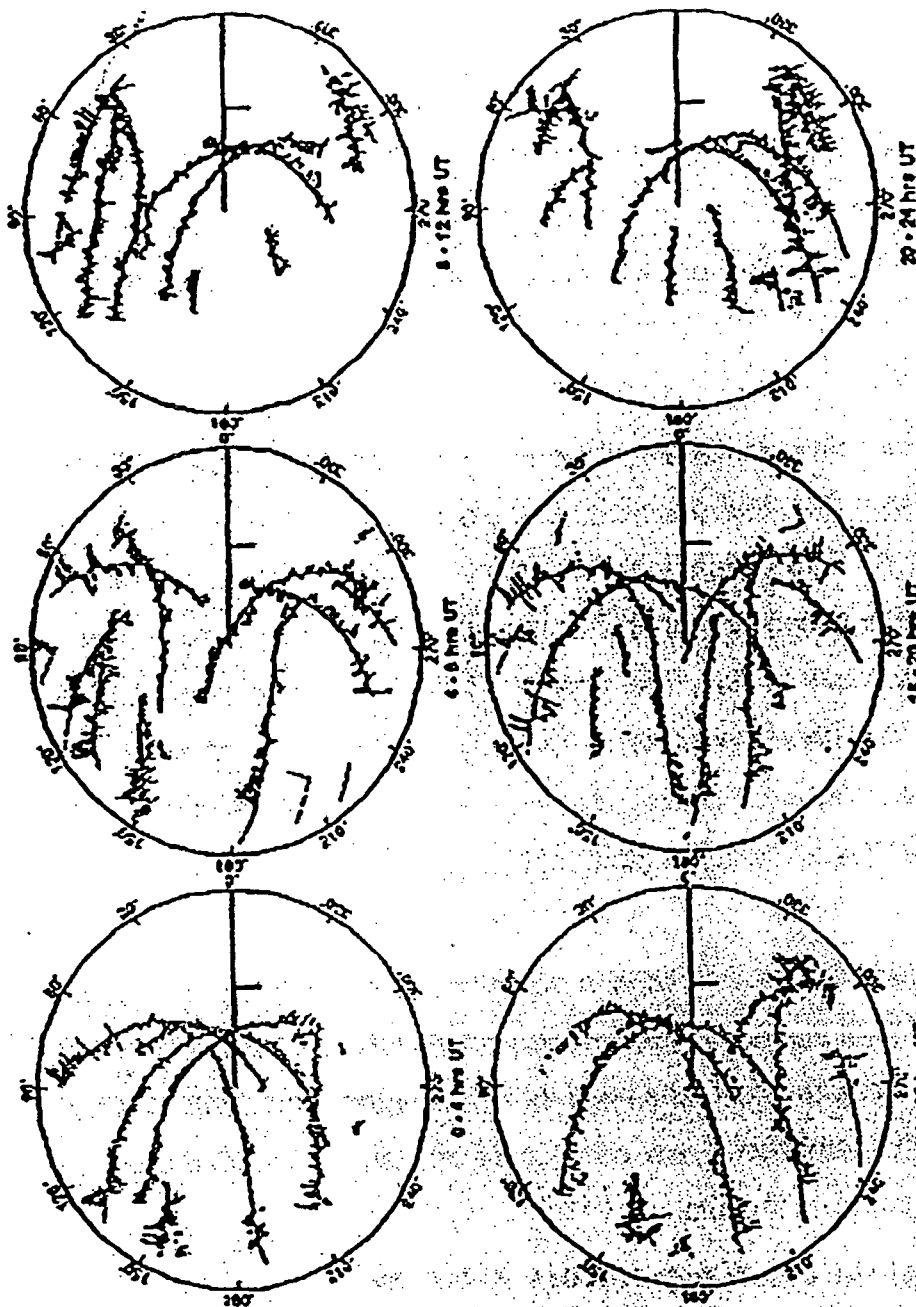
Three steps :

The first step is to obtain a loosely constrained estimation of station coordinates, zenith delay and Earth orientation parameters using the GAMIT software. The second step is to use the loosely constrained estimates of those parameters and their covariances for each day as quasi-observations in order to combine data from different days and different networks.

GAMIT incorporates different operator algorithms that map the carrier beat phases into singly and doubly differenced phases. These algorithms extract the maximum relative positioning information from the phase data regardless of data outages, and take into account the correlations that are introduced in the differencing process.

6.2. Error model for the phase analysis

We can notice that the phase scatter larger by a factor of two at low elevation angles. That can be explained by unmodeled errors at low elevation angles due to multipath and tropospheric delay. To minimize those errors, we downweighted data at low elevation angles (Constant weighting, site independent elevation-dependent weighting or site -dependent elevation dependent weighting. The multipath errors and the tropospheric delay related with the water vapor are much more important when the satellite is near the horizon.



The phase residuals of the IAVH site plotted as a function of the satellites azimuths during the day 206

Fig 9 :

6.3. Characterizing station noise

The model is defined by given values of two parameters a and b and is a function of the elevation angle : $a^2 + b^2 / (\sin(\text{elev}))^2$. Where elev is the elevation of the satellite

The elevation model curve is an approximate fit of the phase it provides a method for day to day comparison for a given station. The goal is to compare the daily GAMIT solutions for each day and for each site.

The RMS (solid line) and scaled formal uncertainty (dashed line) for GRAS site as a function of the cutoff angle, the scale factor is 0.35

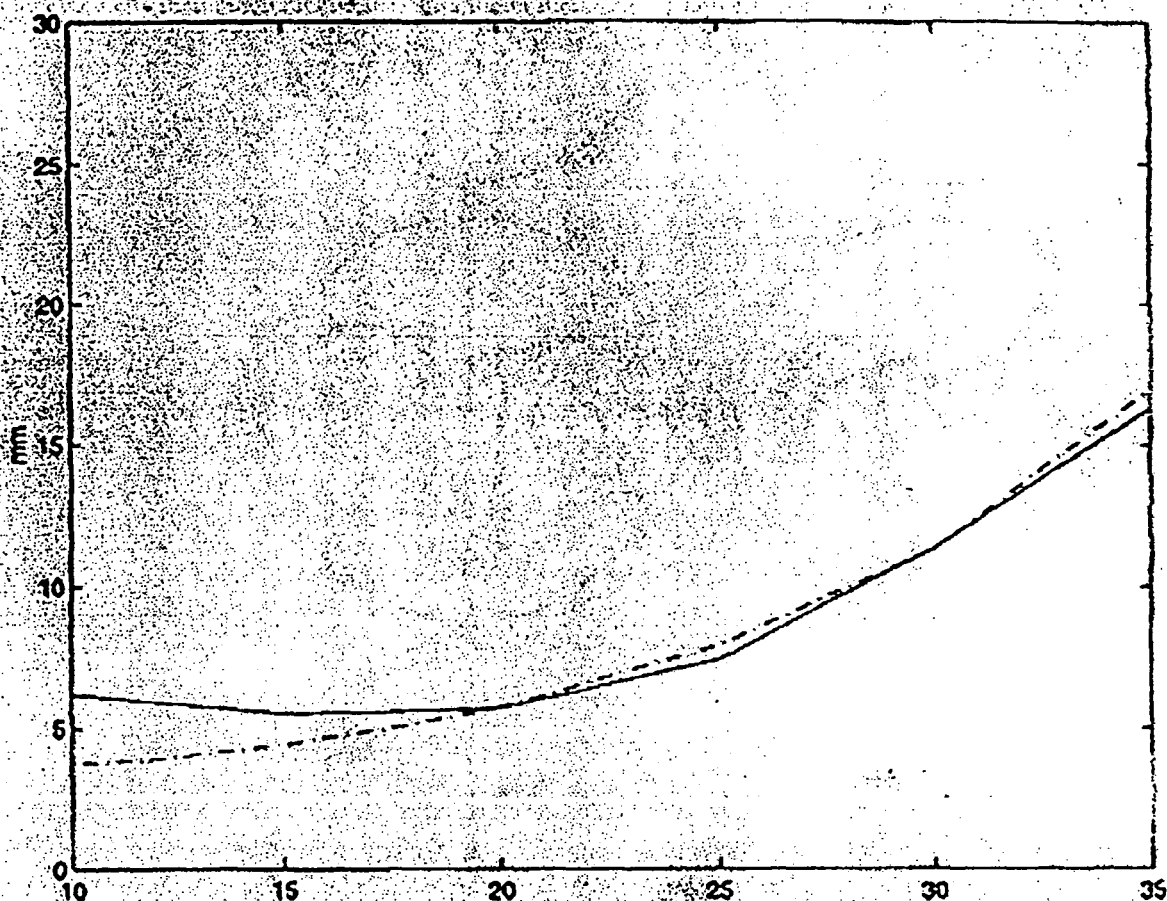


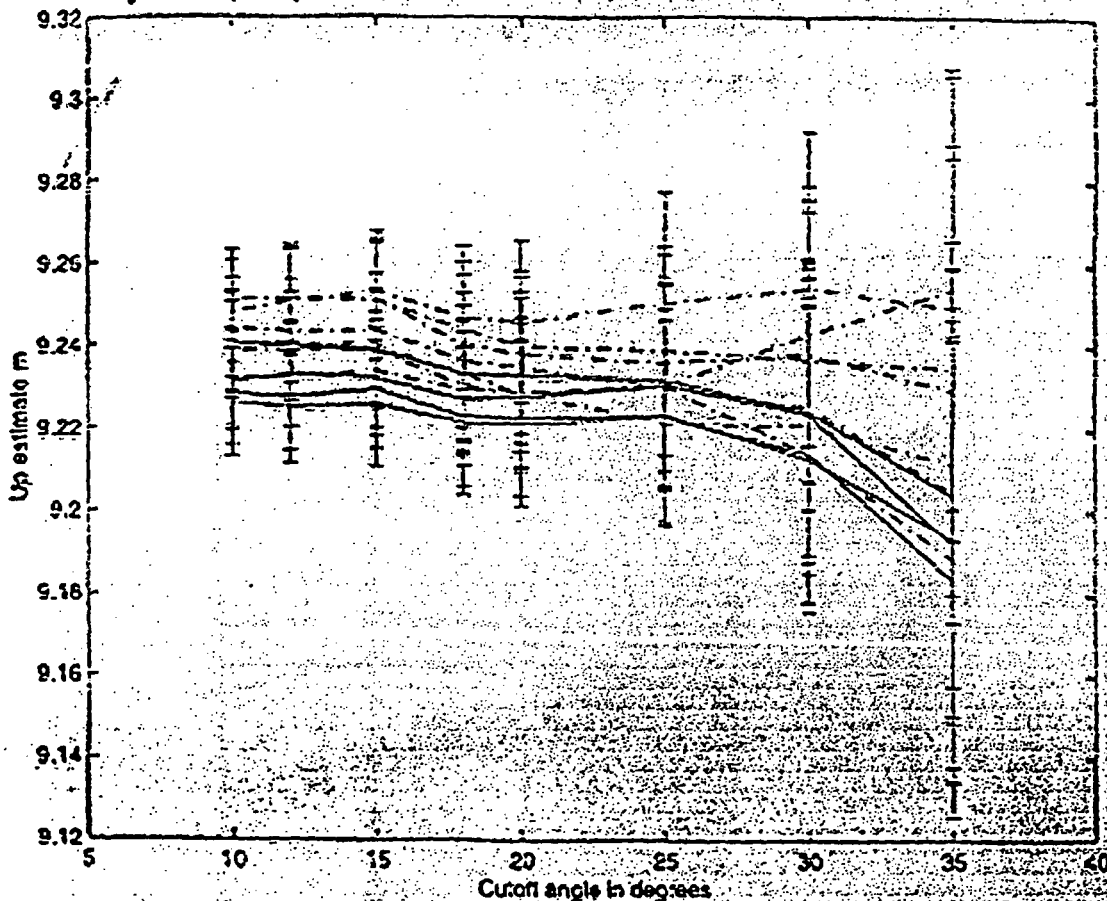
Fig. 10

6.4. Illustration of the cutoff dependency in the results

The results obtained from the software are estimates of station position and baseline. For each site, the software gives the north, east and vertical component estimate and their formal uncertainties for stations position and baseline. And for each baseline, it gives the north, east and vertical components and their formal uncertainties. The formal uncertainty is quite arbitrary as it is based on an arbitrary choice of the phase measurement precision. The change observed in the formal uncertainty for different values of the cutoff angle is useful. However it is directly related to the strength and amount of data used in the analysis.

6.5. Use of phase residuals to map water vapor and multipath

We saw the contribution of the water vapor in the phase residuals as one of the major source of error affecting the GPS observations. We are also interested in the contribution of the multipath in the phase residuals. This contribution is shown by viewing the phase residuals as a function of the satellites azimuths



The vertical component of the IAVH site plotted as a function of the cutoff angle over 11 days: 4 days in February (solid lines) and 7 days in July (dashed lines)

FIG. 10

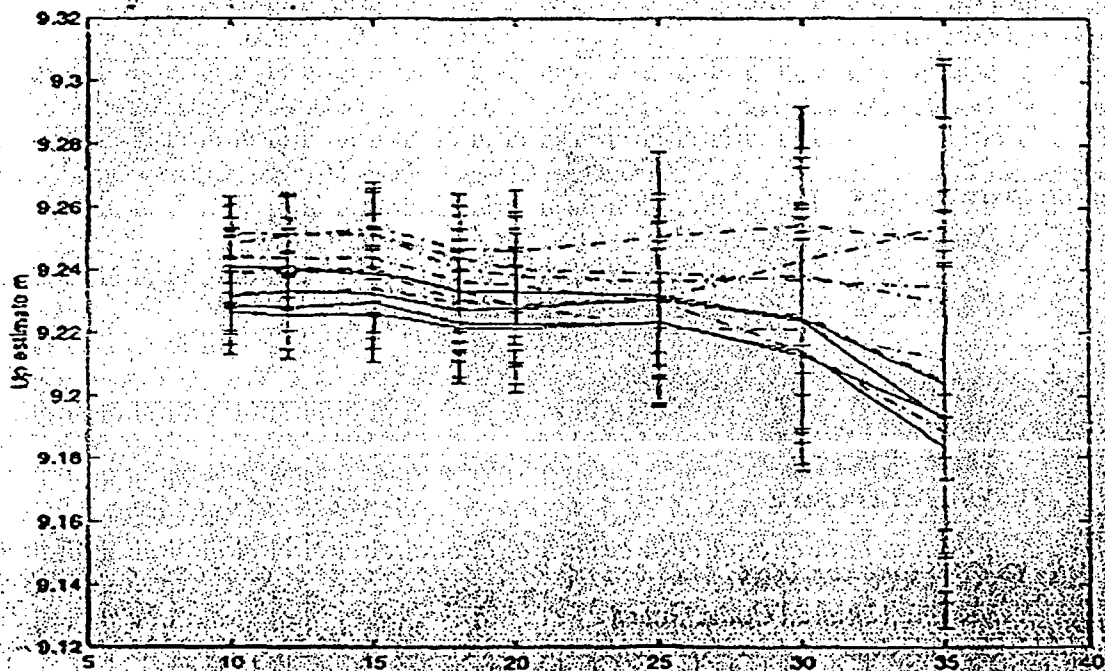
6

6.5. Use of phase residuals to map water vapor and multipath

We saw the contribution of the water vapor in the phase residuals as one of the major source of error affecting the GPS observations. We are also interested in the contribution of the multipath in the phase residuals. This contribution is shown by viewing the phase residuals as a function of the satellites azimuths

Fig. 11

The vertical component of the IAVH site plotted as a function of the cutoff angle over 11 days: 4 days in February (solid lines) and 7 days in July (dashed lines)



7.APPLICATIONS

7.1. Surveying and construction

National geological survey
National geodetic survey

7.2. GIS Field Asset management

Maintenance gas and electric
Navy, railway, etc.

7.3. Agriculture and mining

Tyler industries
Automatic Flagman ?
Fording coal
Modula mining
Benchmark materials

7.4. Navigation

Avionics
Navy
Car navigation (graphical map-based navigation system)

7.5. Tracking

Vehicle Tracking
Vessel Tracking
Aircraft Tracking

7.6. Reference stations

Marine :National Coast Guard
Geophysical

7.7. GPS and plate tectonics :

The Global Positioning System (GPS) in Hellenic arc;

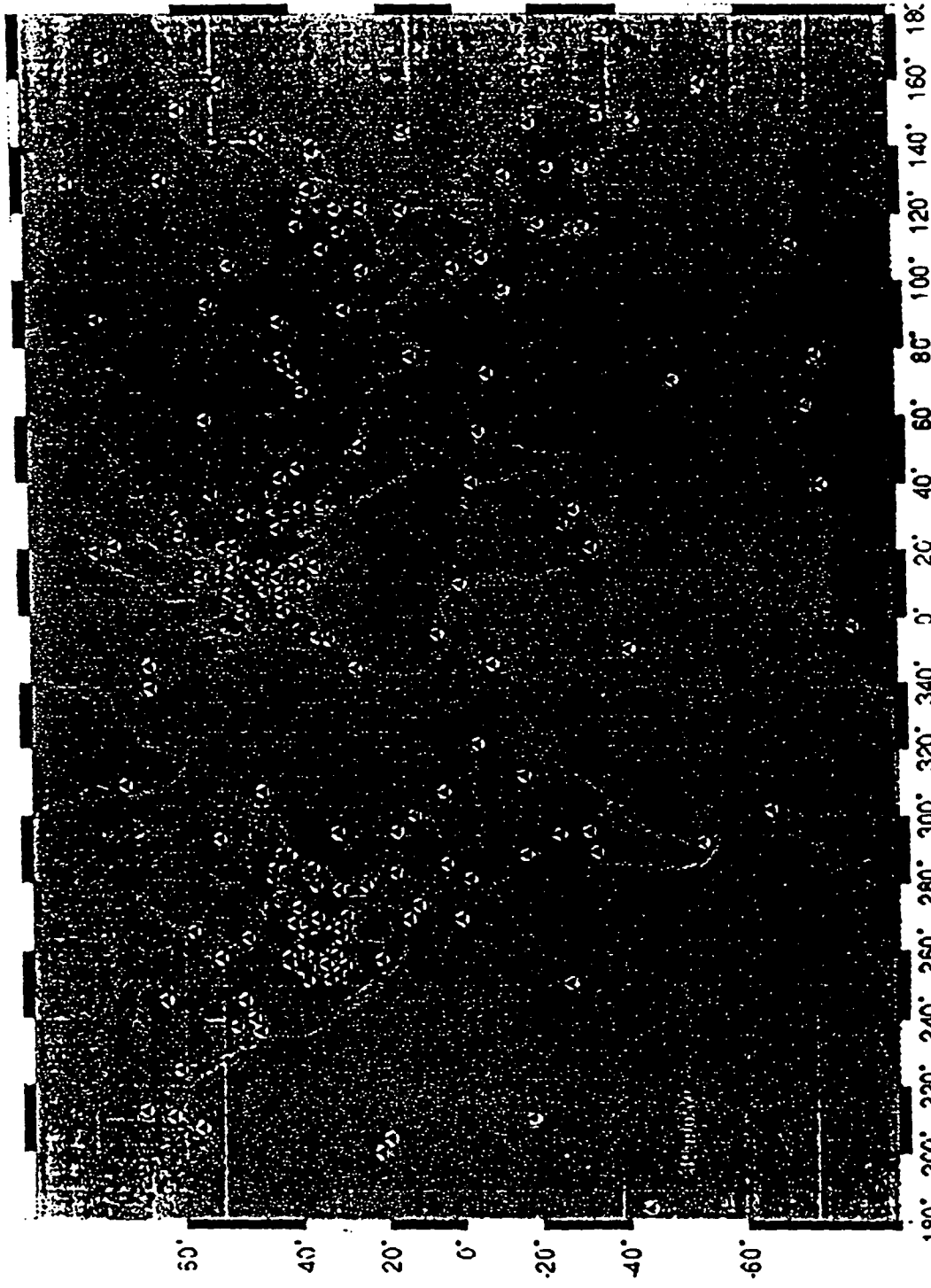
The Global Positioning System (GPS) is providing an important new tool to quantify continental deformation to a precision and on a scale unprecedented in the Earth sciences. These new constraints on the kinematics of continental deformation are, in turn, providing constraints on rheological models of the continental lithosphere and the forces responsible for active deformation.

GPS observations collected over the past 9 years (1988-1997) for a large part of the eastern Mediterranean region in the zone of interaction of the Arabian, African, and Eurasian plates and consider the implications for the nature of contemporary tectonic processes in this plate collision zone. The present paper extends the work of Reilinger et al. (1997a) by including GPS results for the Aegean and North Africa are includes as well as new data from 1996 and

1997 surveys in Turkey and the Caucasus, which more tightly constrain velocity estimates and provide denser spatial coverage throughout this region.

Fig.12 is a schematic tectonic map of the eastern Mediterranean/Middle East region. This region has been identified as an ideal natural laboratory for studying the kinematics and dynamics of plate interactions (e.g., Plag et al, 1998) because of the wide variety of tectonic processes encompassed, including various stages of continental collision (Zagros/Caucasus/Black Sea), subduction of oceanic lithosphere and associated back arc spreading (Cyprus/Hellenic/Carabrian arcs, Aegean and Tyrrhenian Seas), continental extension (western Turkey/Marmara Sea/Gulf of Corinth), continental "escape" (Anatolia), major continental strike-slip faults (North and East Anatolian and Dead Sea faults), and a variety of smaller-scale processes associated with African-Arabian-Eurasian plate interactions. All of these processes are contained within an area with linear dimensions of roughly 2000 km. Furthermore, the eastern Mediterranean region has a remarkably long historic record of major earthquakes.

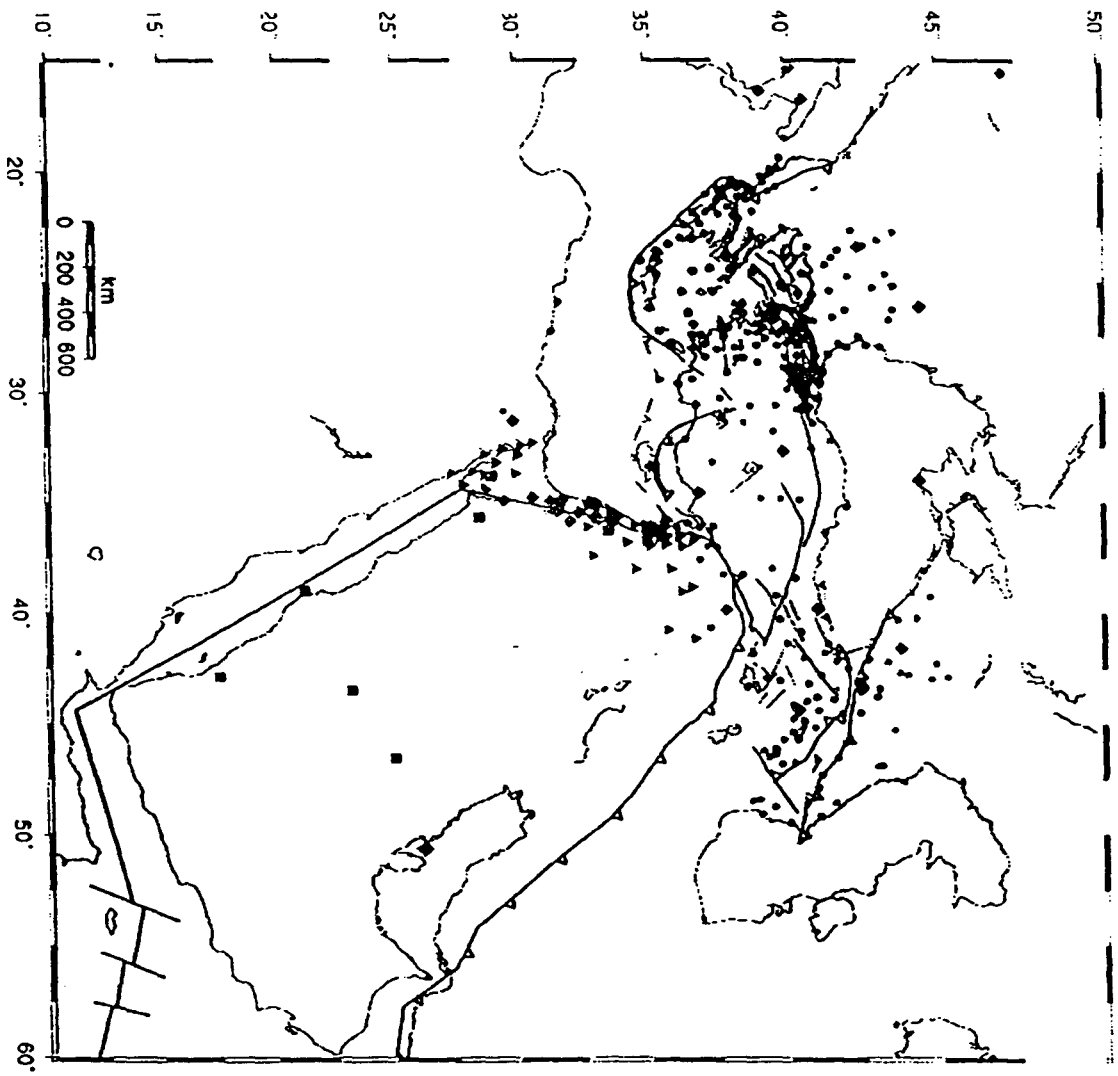
The tectonic framework of the eastern Mediterranean is dominated by the collision of the Arabian and African plates with Eurasia (McKenzie, 1970, Jackson and McKenzie, 1984, 1988). Plate tectonic models (DeMets et al, 1990, Jestin et al, 1994) based on analysis of global seafloor spreading, fault systems, and earthquake slip vectors indicate that the Arabian plate is moving in a north-northwest direction relative to Eurasia at a rate of about 18-25mm/yr, averaged over about 3 Myr. These models also indicate that the African plate is moving in a northerly direction relative to Eurasia at a rate of about 10mm/yr (at 30°N, 31°E). Differential motion between Africa and Arabia (10 to 15mm/yr) is thought to be taken up predominantly by left-lateral motion along the Dead Sea transform fault. This northward motion results in continental collision along the Bitlis-Zagros fold and thrust belt, intense earthquake activity and high topography in eastern Turkey and the Caucasus mountains, and westward extrusion of the Anatolian plate (McKenzie, 1970 (Anatolia is here defined as the region of Turkey west of the Karloiva triple junction and lying between the East Anatolian and North Anatolian faults. The leading edge of the African plate is being subducted along the Hellenic arc at a higher rate than the relative northward motion of the African plate itself, requiring that the arc moves southward relative to Eurasia proper (e.g., Sonder and England, 1989, Royden, 1993). Subduction of the African plate is also thought to occur along the Cyprean arc and/or the Florence rise south of Turkey, although it is less well defined in these regions than along the Hellenic arc.(fig.13,14).

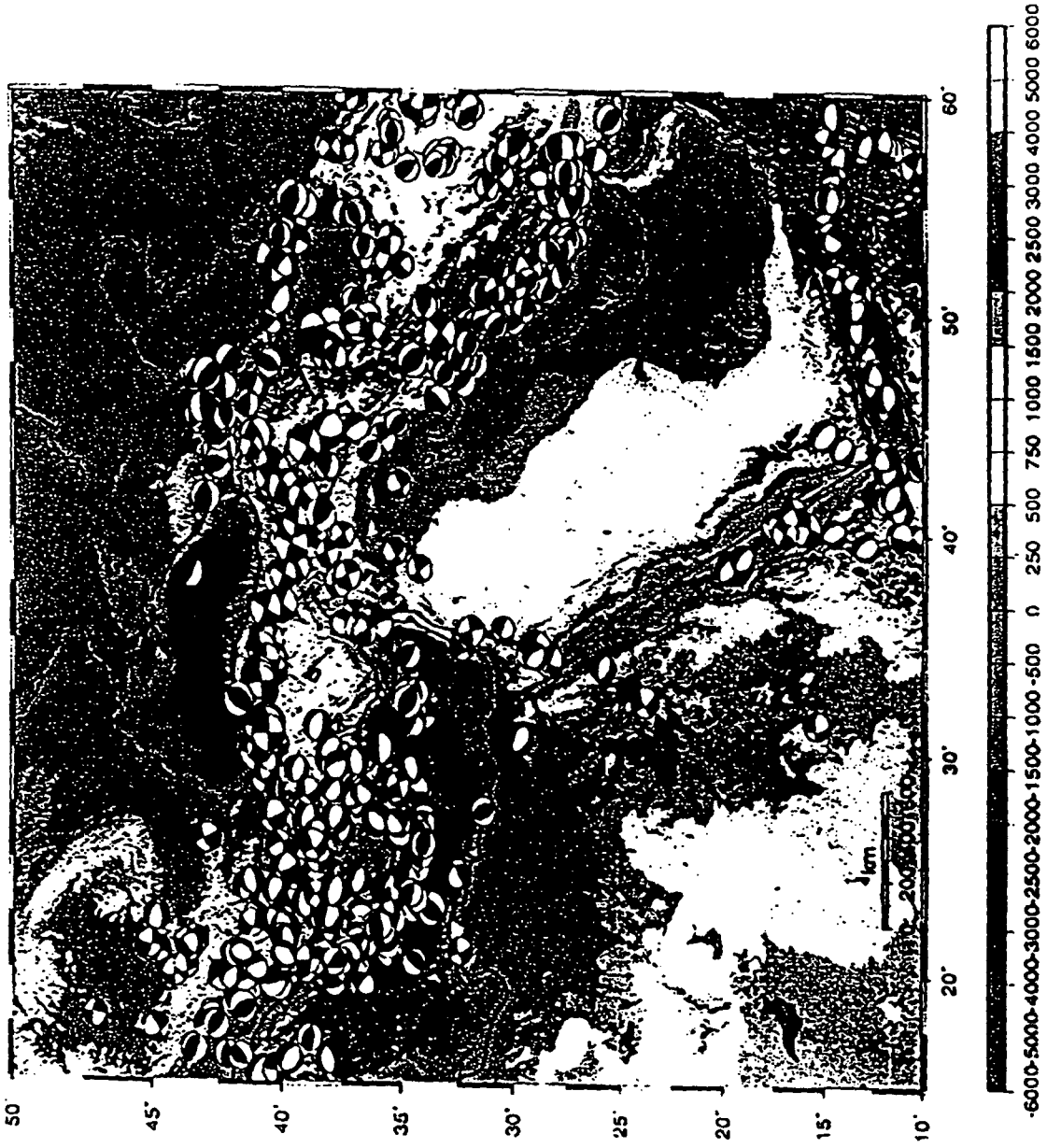


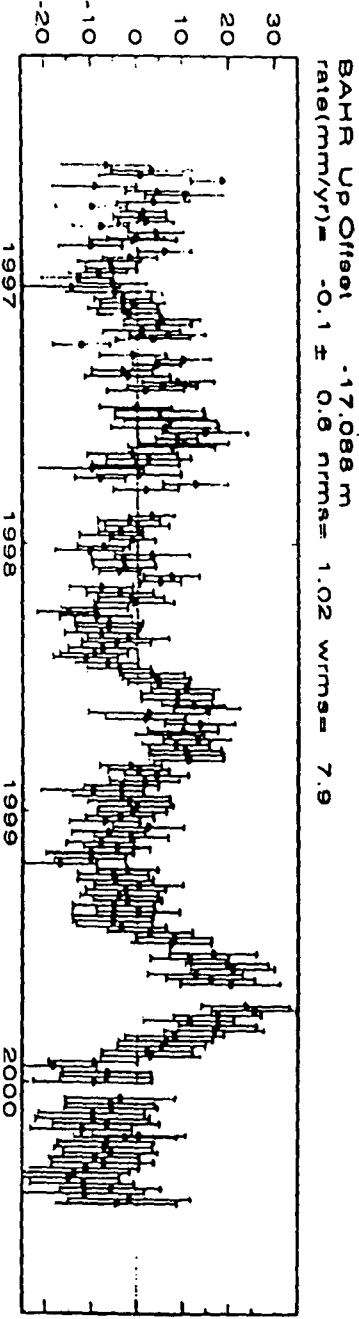
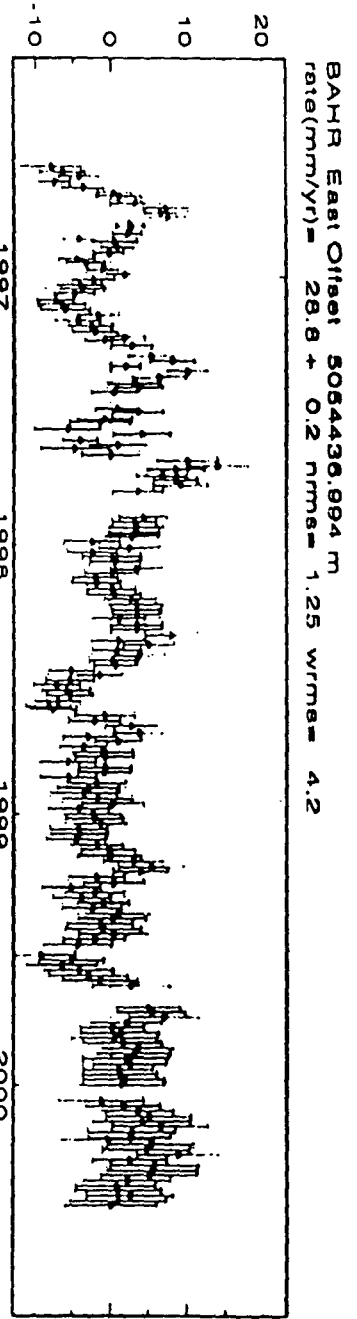
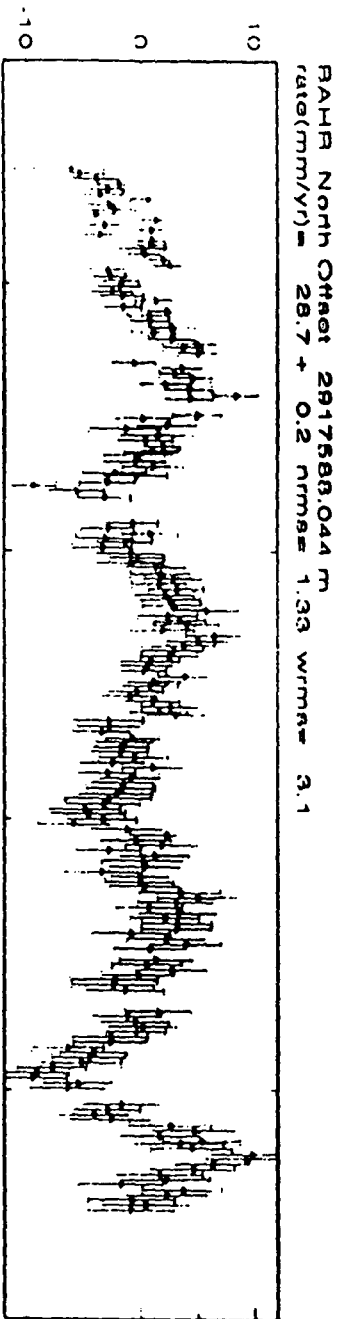
CAT: 00114 13 00 09 27 AREA: GLOBAL CRUISE NAME: NAVY 1981 DATE: 08 08 1981 MORE: NOBIL: WHITE



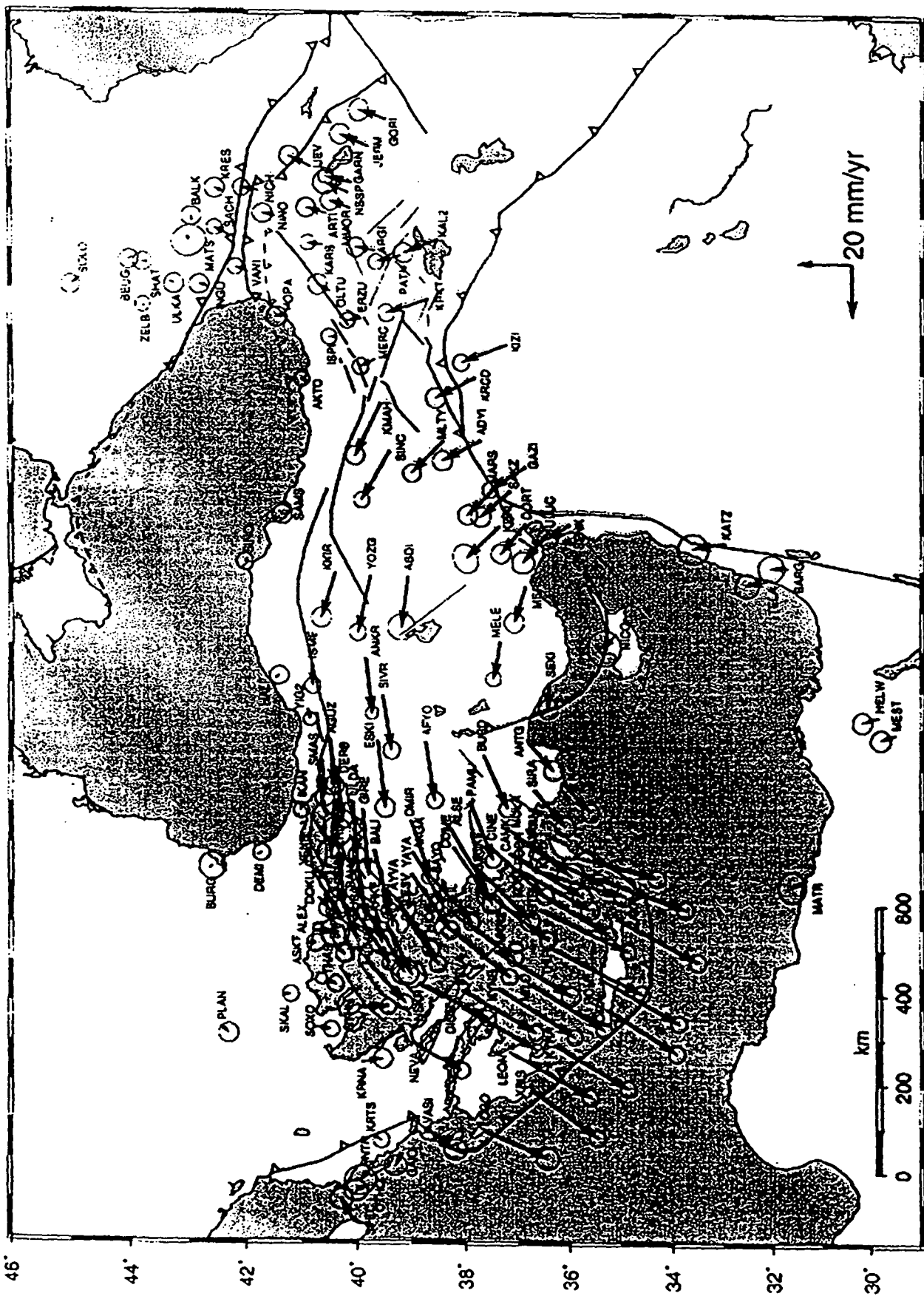


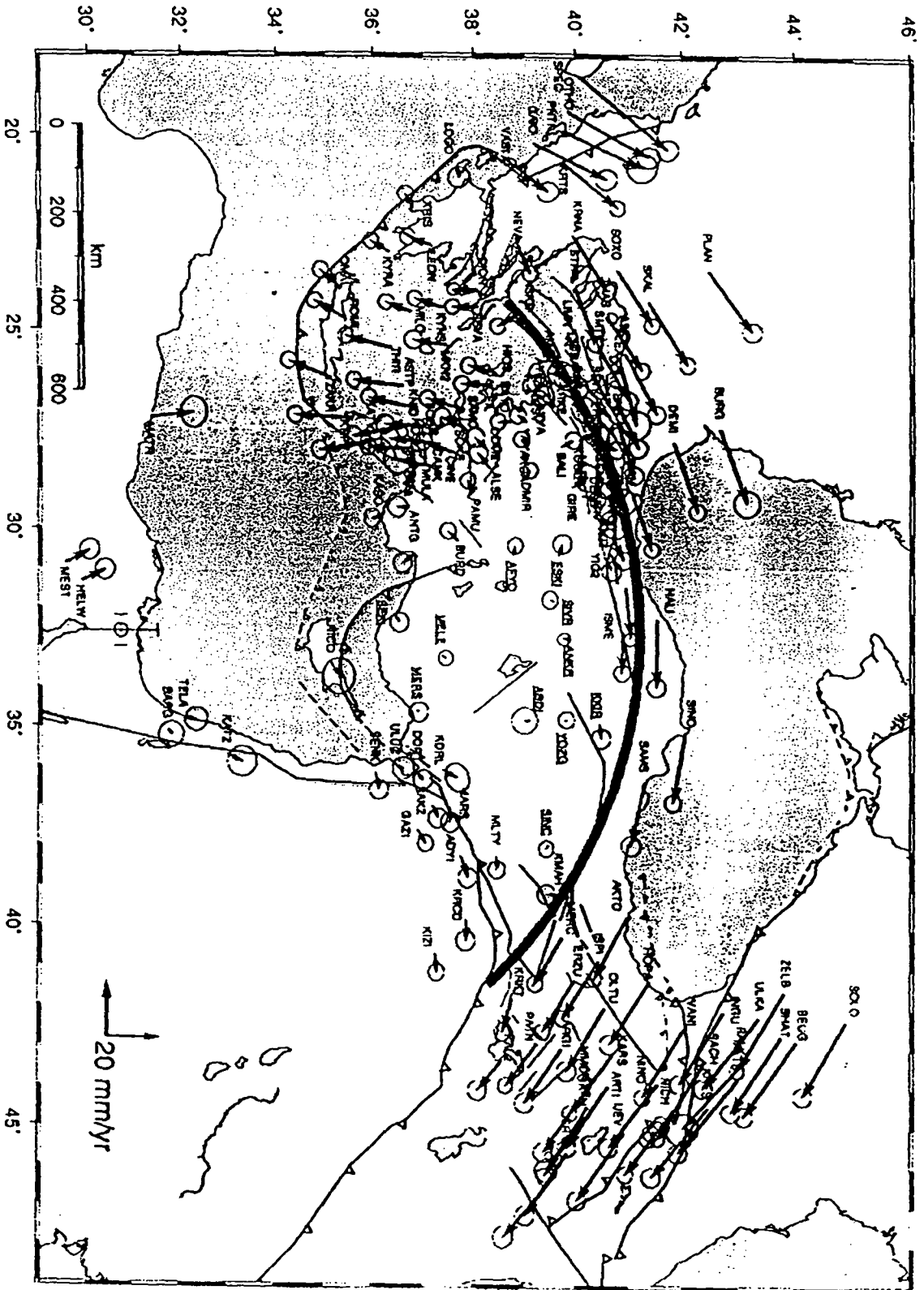


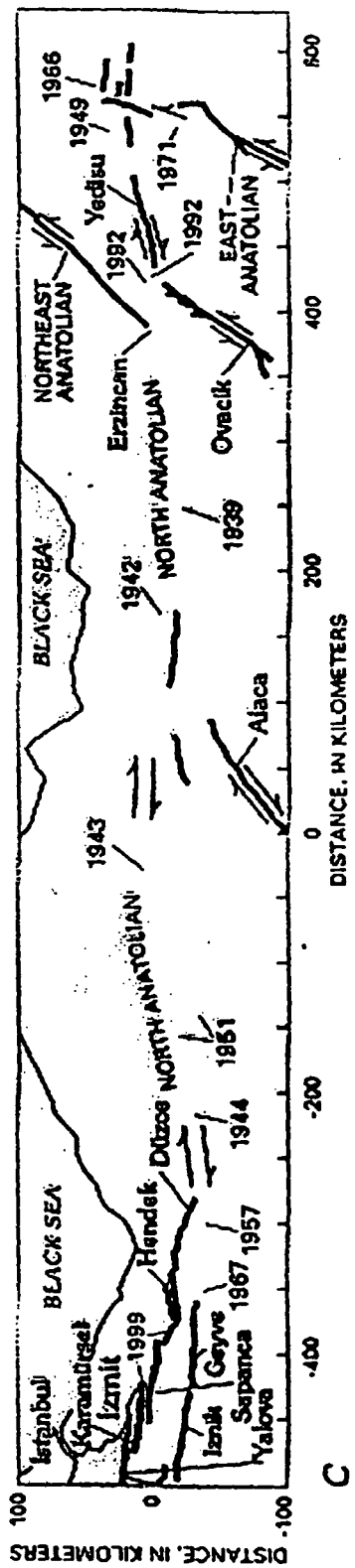


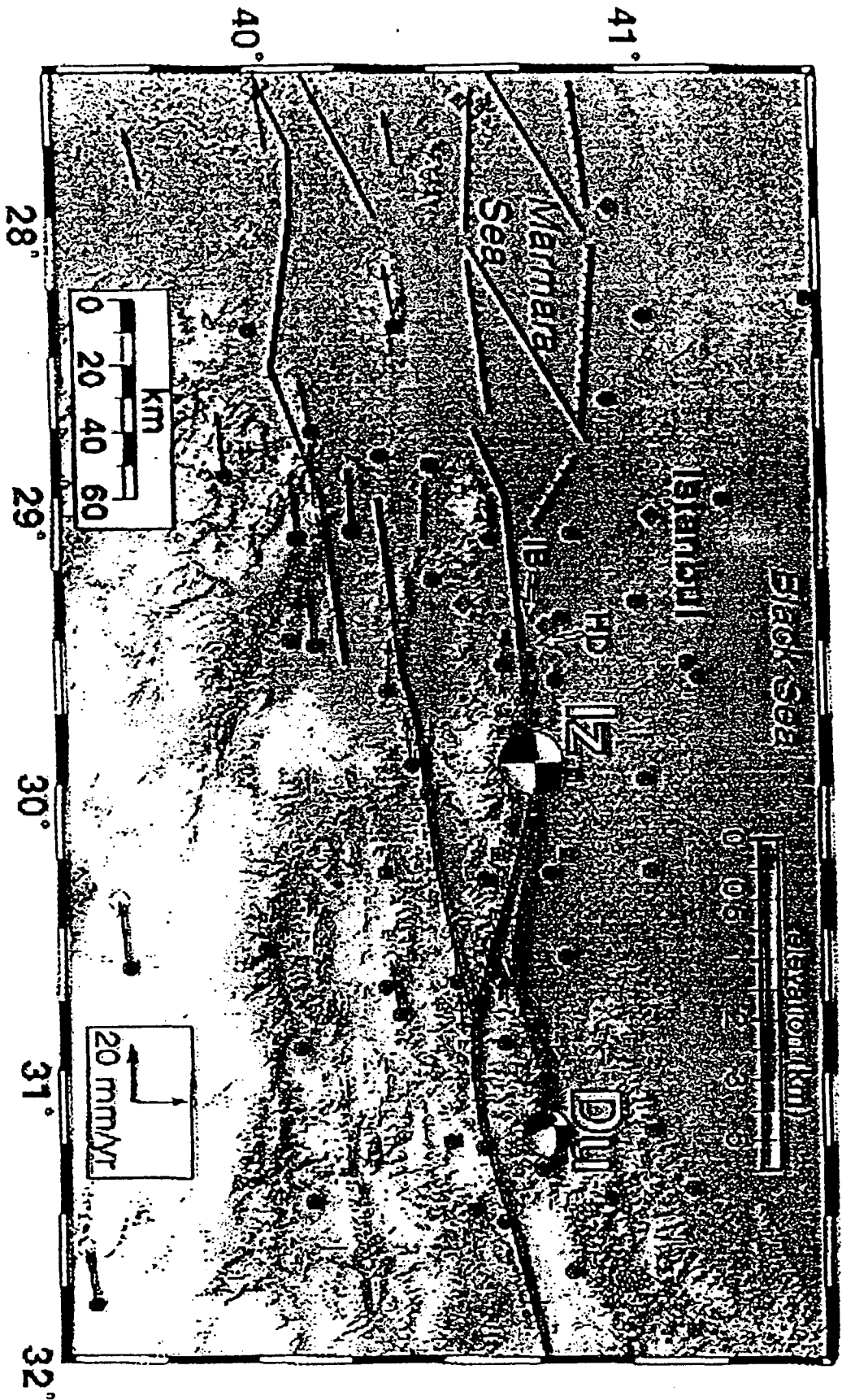


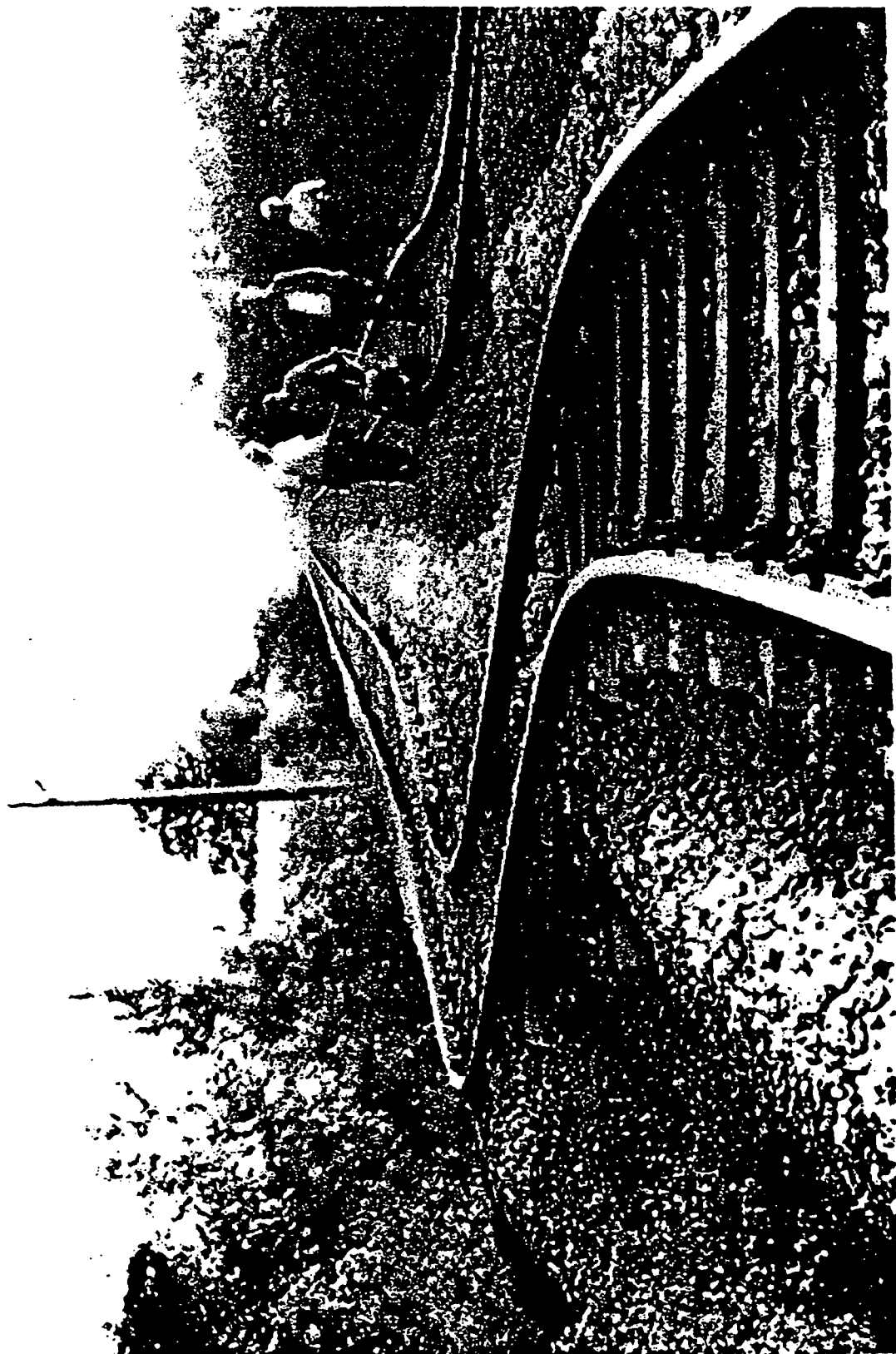
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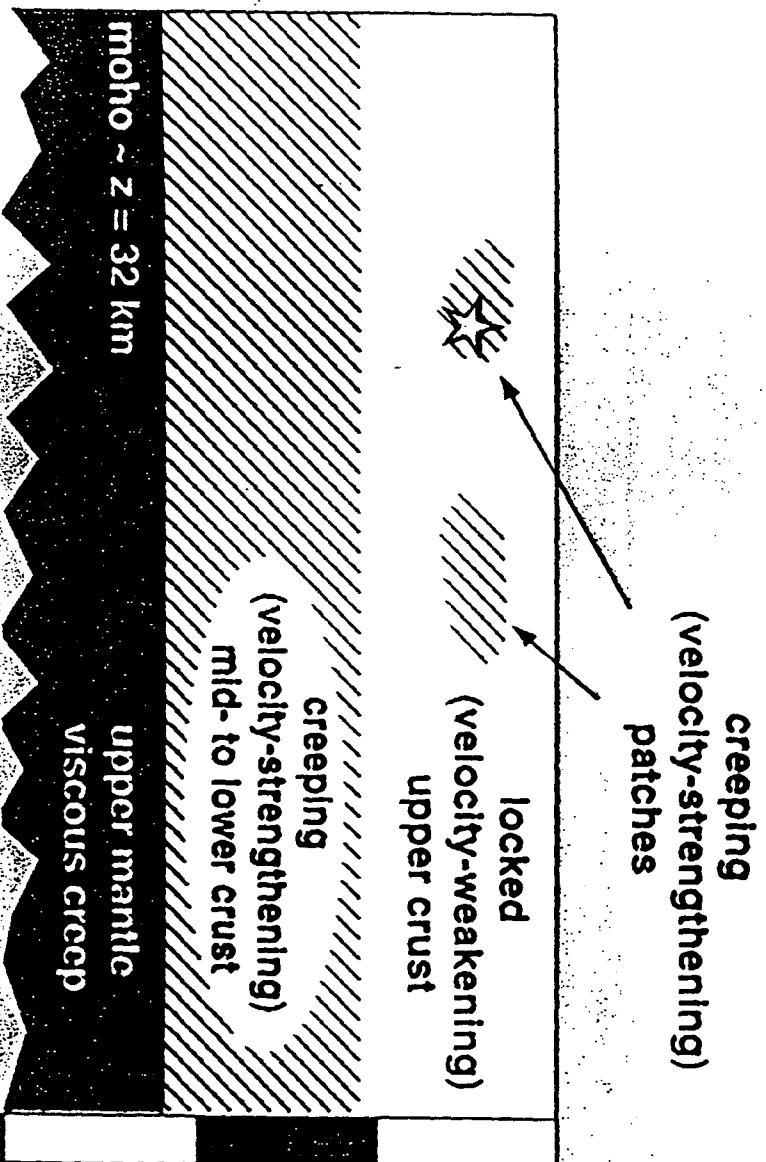


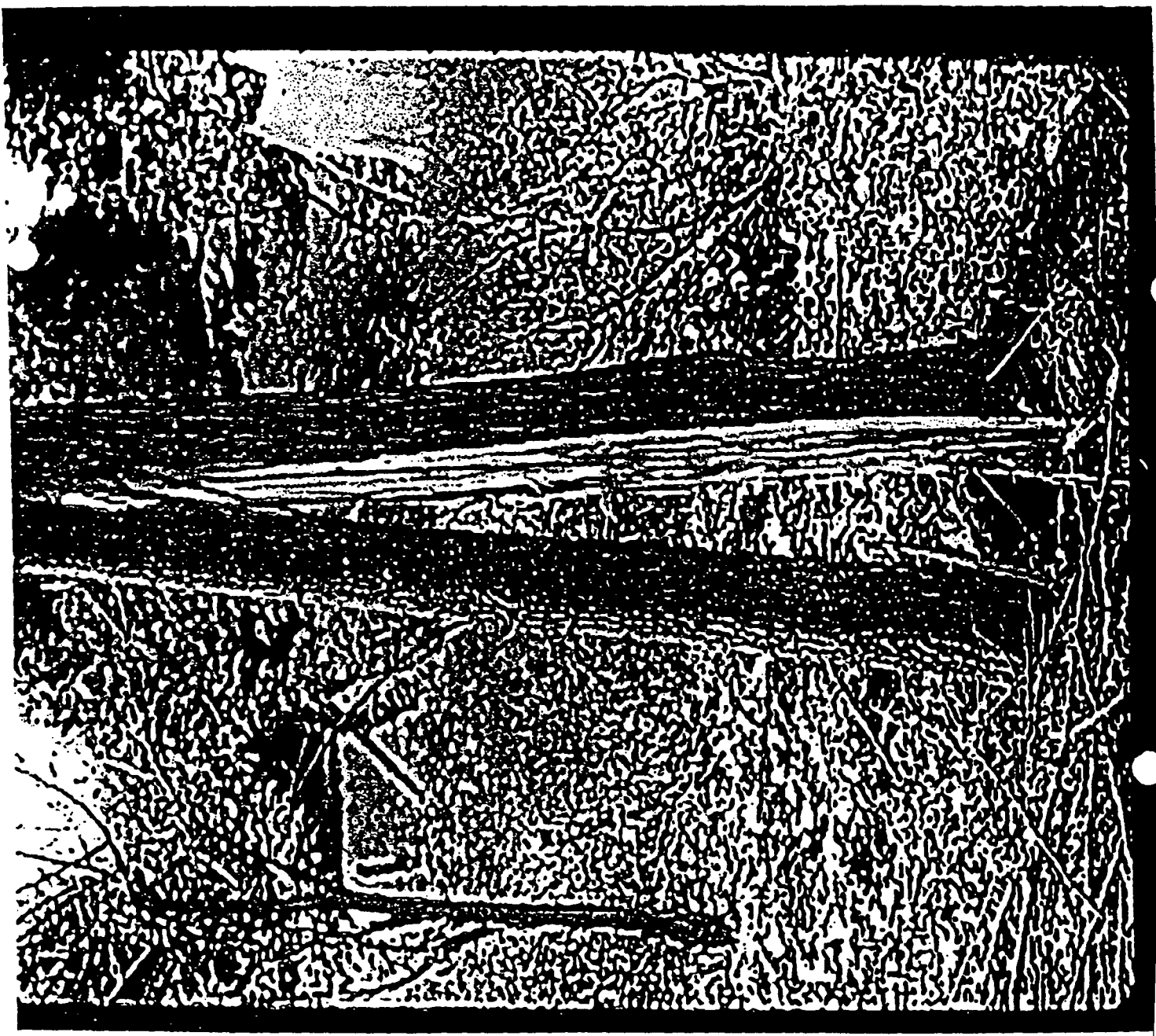






Preferred Izmit fault model





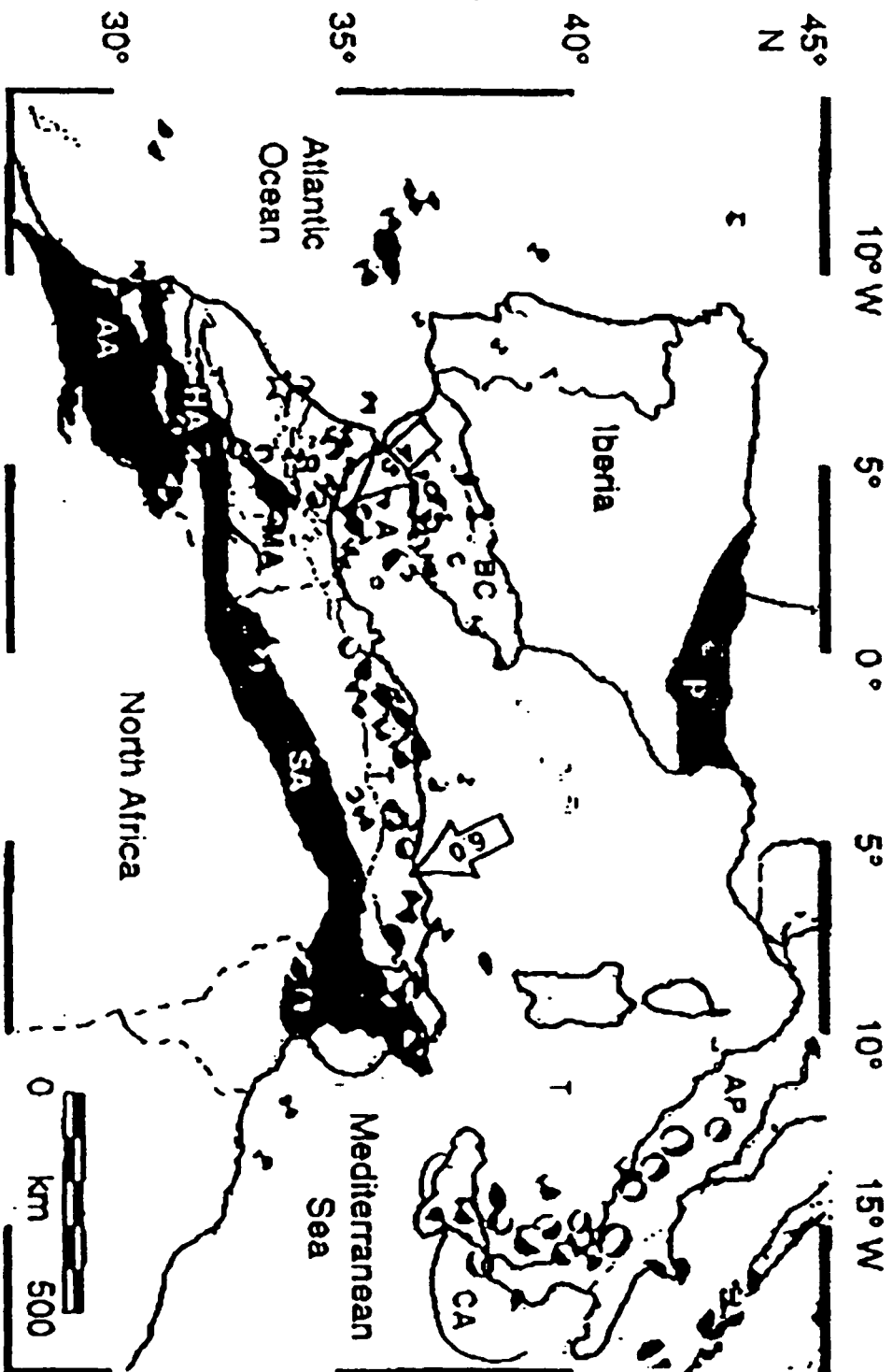


Figure 1 Seismotectonic map of the western Mediterranean region. Mountain belts are shaded gray: R = Rif, BC = Betic Cordillera, HA = High Atlas, MA = Middle Atlas, SA = Saharan Atlas, AA = Anti Atlas, T = Tell Mountains, AP = Apennines, P = Pyrenees. A = Alboran Sea, T = Tyrrhenian Sea, CA = Calabrian Arc. White star denotes Rabet. Focal mechanisms are shown for crustal earthquakes with magnitudes from 4 to 7 (1980 - 1985, compiled from numerous sources). White arrows indicate the direction and rate (mm/yr) of convergence between Eurasia and Africa (fixed) predicted by NUVEL-1A.

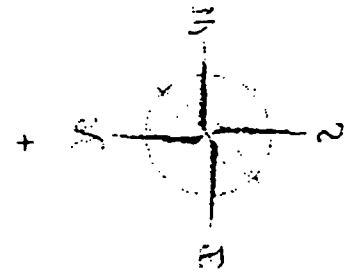


Figure 2

Appendix 1. Summary of GAMIT Processing

A.1.1. Data Preparation

Create an experiment directory with subdirectories for tables and each session (day)

Execute `links.tables` in the tables subdirectory

Assemble RINEX (or FICA) files from diskettes, tape, and/or ftp

Prepare an L-file -- see Section 4.2

Enter antenna heights and receiver software versions in `station.info`

Enter scenarios in `session.info` (optional if running MAKEXP)

For each day:

Execute `links.day`

Run MAKEXP, or

 Create `[day].makex.batch`

Execute MAKEJ to get a J-file

Execute MAKEX to get X- and K-files

Create a G-file and T-file from IGS or broadcast information -- see Section 4.10

A.1.2. Obtaining an approximate solution for each day

(may be skipped if good a priori coordinates and orbits)

Create a D-file `d[expt][y].[day]` (created by MAKEXP)

Execute FIXDRV to get an I-file and batch files for a "quick" plus regular solution

 Type of Analysis = i-ITERATION

 Choice of Observable = LC_HELP

 Constrain coordinates of 3 or 4 fiducial sites

Possibly comment out regular-solution part of .bat file (after first SOLVE)

Execute `b[expt].bat`

 (If starting from G-file only, ARC creates a T-file of satellite orbits and partials)

 (MODEL creates an "0" series [i. e., last digit of year] C-file for each site)

 (AUTCLN cleans the "0" series C-files and creates "a" series C-files)

 (CFMRG creates an M-file `m[expt]1.[day]`)

 (SOLVE estimates site and orbital parameters, updating `m[expt]1.[day]` and creating `l[expt]a.[day]`, `g[expt]a.[day]`, `q[expt]1.day`, and `o[expt]1.day`.

 (Optional: ARC creates a new T-file using the adjusted initial conditions

If regular solution not executed,

 Check `q[expt]1.[day]` to assure reasonable `nrms` (< 0.5) and orbital adjustments (< 100 m)

 Use SCANDD, sortv, sorter, and/or CVIEW to detect problematic data. Use `sh_autedt` to modify `autdn.cmd` to delete data flagged by CVIEW.

 Comment out quick solution and uncomment regular solution; execute `b[expt].bat`.

If regular solution executed,

 (ARC creates an "a" T-file using improved initial conditions from quick solution)

 (MODEL creates a "b" series C-file for each site)

 (AUTCLN cleans the "b" series C-files and creates "c" series C-files)

 (CFMRG creates an M-file `m[expt]a.[day]`)

 (SOLVE estimates site and orbital parameters, updating `m[expt]a.[day]` and creating `l[expt]b.[day]`, `g[expt]b.[day]`, `q[expt]a.day`, and `o[expt]a.day`.

Check `q[expt]a.[day]` to assure reasonable `nrms` (< 0.5) and orbital adjustments (< 100 m)

Use CVIEW, SCANRMS, SCANDD and/or SCANM with `m[expt]a.[day]` to edit the data and write

out clean "c" series C-files, or execute the second iteration with a second pass of AUTCLN after modifying the autcln.cmd file to correctly edit problematic data.

A.1.3. Obtaining a high-accuracy solution with good a priori coordinates and orbits

Execute FIXDRV with Type of Analysis = 0-ITERATION

Execute b[expt].bat

(MODEL creates a "0" series C-file for each site)

(AUTCLN cleans the "0" series C-files and creates "a" series C-files)

(CFMRG creates an M-file m[expt]a.[day])

(SOLVE estimates site and orbital parameters, updating m[expt]a.[day] and creating g[expt]b.[day], l[expt]a.[day], q[expt]a.[day], o[expt]a.[day], and h[expt]a.[day])

Check q[expt]a.[day] for good nrms (<0.3), small site and orbital parameter adjustments, and good ambiguity resolution

Verify quality of fit with CVIEW (using m[expt]a.[day]) and/or SCANM, SCANRMS, SCANDD (Optional: use CTOX to create clean "c" (or "year") series X-files)

Delete the C-files to save disk space; backup the original (and cleaned) X-files to tape.

A.1.4. File-naming conventions

A - file: ASCII version of the T-file (tabular ephemeris)

B - file: controls the batch mode of data processing

C - file: observed - computed (O-C's), partial derivatives

D - file: driver file of sessions and receivers

E - file: broadcast ephemeris, in FICA Blk 9 or RINEX navigation file format

G - file: orbital initial conditions and non-gravitational parameter values

H - file: adjustments and full variance-covariance matrix for input to GLOBK

I - file: receiver clock polynomial input

J - file: satellite clock polynomial coefficients

K - file: values of receiver clock offset during observation span, from pseudorange

L - file: station coordinates

M - file: controls merging of data (C-) files for SOLVE and editing programs

N - file: data-weight overrides for SOLVE created from autcln.sum.postfit

O - file: record of the analysis (reduced form of Q-file) for post-processing analysis

P - file: record of a MODEL run

Q - file: record of the analysis (SOLVE run)

S - file: station coordinates and antenna offsets — *no longer used*

T - file: tabular ephemeris

V - file: editing output of SINCLN, DBLCLN, and SCANRMS

W - file: meteorological data

X - file: input observations

Y - file: satellite yaw parameters

Z - file: water-vapor radiometer data

A.1.5. Summary of input and output files

INPUT	OUTPUT
MAKEXP	- RINEX (or X-) files - station.info - session.info - D-file - session.info (optional) - Input batch files for MAKEX, MAKEJ, BCTOT
MAKEJ	- E-file (RINEX nav file) - C-file (optional--See 4.6) - J-file (satellite clock file)

MAKEX - raw observations (RINEX or FICA) - station.info (ant hts, rcvr software) -
 session.info (scenario file) - E-file (RINEX nav file) - J-file (satellite clock file) - L-file (coordinates of
 stations) - K-file (receiver clock) - X-file (input observations)
ARC - arc.bat (batch input file) - G-file (orbital initial conditions) - arcout.ddd (output print file) - T-
 file (tabular ephemeris for all sat. ses.)
FIXDRV - D-file (defines the input and output) - sestbl. (session control) - .sittbl. (site control)
 - T, J, L, X (or C) input - B-file (bexpy.bat : primary batch file) - B-file (bexpy.nnn : secondary
 batch files) - I-file (rcvr clock polynomials)
MODEL - L-file (site coordinates) - station.info (ant heights) - X-file or C-file - T-file - I-file - J-file
 - C-file (upgrade if input C-file)
AUTCLN - C-file - - C-file (cleaned)
CFMRG - C-file - M-file (points to the C-files)
SOLVE - C-file - M-file - Q-file - G-file - H-file - L-file
CVIEW SCANDD - M-file and C-files - C-files (CVIEW only)

MAKEK - E-file - J-file - L-file - X-file - K-file
BCTOT - E-file - G-file - T-file

B. INTERESTS IN GEODETIC ACTIVITIES

One can classify as follows the various fields of interest linked to geodesy.

- 1. Global references
 - . Reference systems
 - . 3-D references, vertical references
 - . Precise/accurate orbits
 - . Gravity fields
 - . Time/Frequency
- 2. Observing systems
 - . Integrated geodesy-geodynamics observing systems
 - . Monitoring of geodetic networks
 - . High precision horizontal and vertical networks
- 3. Modelling
 - . General mathematical models for geodesy
 - . Theories of the gravity field
 - . Orbital computations
 - . Atmospheric and geophysical effects in geodesy
- 4. Data analysis techniques
 - . Statistical and numerical analysis
 - . Optimization methods, least squares methods, filtering
 - . Data processing and management
- 5. Gravity field and geoid
 - . Determination of the external gravity field
 - . Determination of the geoid
 - . Non tidal gravity variations
- 6. Geodesy and Earth sciences
 - . Crustal deformations
 - . Sea surface topography and mean sea level
 - . Atmospheric sounding
 - . Potential field variations incl. tides
 - . Earth-Atmosphere-Ocean interactions
 - . Earth rotation and internal structure
 - . Planetary and lunar dynamics
- 7. Space missions
 - . JASON, ENVISAT
 - . CHAMP, GRACE, GOCE
 - . ICESAT, CRYOSAT
- 8. Applied geodesy
 - . Control networks
 - . Gravity networks
 - . Geographic Information Systems
 - . Engineering surveying
 - . Civil engineering construction
 - . Stability monitoring
 - . Machine guidance

06 Quantify your interest in these fields:
Marginally (M), Slightly (S), Very (V), Highly (H) interested

	M	S	V	H
# 06.1 Global references	[]	[]	[]	[]
# 06.2 Observing systems	[]	[]	[]	[]
# 06.3 Modelling	[]	[]	[]	[]
# 06.4 Data analysis techniques	[]	[]	[]	[]
# 06.5 Gravity field and geoid	[]	[]	[]	[]
# 06.6 Earth sciences	[]	[]	[]	[]
# 06.7 Space missions	[]	[]	[]	[]
# 06.8 Applications to engineering	[]	[]	[]	[]

07 Quantify the role you think IAG should play in these fields:
Marginal (M), Secondary (S), Strong (V), Crucial (H).

	M	S	V	H
# 07.1 Global references	[]	[]	[]	[]
# 07.2 Observing systems	[]	[]	[]	[]
# 07.3 Modelling	[]	[]	[]	[]
# 07.4 Data analysis techniques	[]	[]	[]	[]
# 07.5 Gravity field and geoid	[]	[]	[]	[]
# 07.6 Earth sciences	[]	[]	[]	[]
# 07.7 Space missions	[]	[]	[]	[]
# 07.8 Applications to engineering	[]	[]	[]	[]

Spatial decision support systems for integrated coastal area management
Draft for the Training Course on "Industry and Development Related to the Mediterranean Basin"
Rabat, Morocco
29 October to 3 November 2001

Enrico Feoli and Mounir Ghribi
Area of Earth, Environmental and Marine Sciences and Technologies
International Centre for Science and High Technology
United Nations Industrial Development Organization
ICS-UNIDO, AREA Science Park, Padriciano 99
34012 Trieste, Italy
Tel.: 0039-040-9228108
Fax: 0039-040-9228136
<http://www.ics.trieste.it>

Abstract

This paper presents an overview of methods and tools of spatial data analysis useful for establishing computer based decision support systems (DSS) for an integrated coastal area management. The spatial DSS refer to those systems based on the use of GIS (Geographic Information Systems) technology, remote sensing technique and decision support methodology. The integration of those information technologies provides an important source of methods that are usefully incorporated in a decision-support system and make use of geographically referenced data.

After a brief introduction on the peculiarities and unique management problems of coastal areas, the paper first describes the meaning and role of decision analysis (DA) and then the major tools and components for constructing a Spatial Decision Support Systems (SDSS) for coastal zone management.

1. Introduction

This paper is based on ICS-UNIDO experience in developing advanced information technologies for integrated coastal area management.

According to Fedra and Feoli (1998), the definition of coastal zone, for the purpose of this paper, is "the area, on both sides of the actual land-water interface, where the influences of land and water on each other are still a determining factor - climatically, physically, ecologically and economically".

The characteristics of the coastal zone are therefore related both to the landside and the waterside.

In the first case the coastal zone shows a high population density with a large number of urban conglomerations, and as consequence, in most countries, a fast population growth.

In the water side there are fisheries and aquaculture, exploiting a generally highly productive ecosystem, that is not only productive in its own right, but plays an important role in the aquatic ecology as a breeding and nursing ground for many commercially important fish species. Very specific, and valuable as well as vulnerable typical coastal ecosystem include estuaries, salt marshes, mangroves, sea grass meadows and coral reefs.

The Environmental problems of coastal zones are both anthropological and natural. Anthropological problems Vallega (1993) offers a systematic classification of coastal zone uses, they include: Seaports, Shipping (carriers, routes, navigational aides), Sea pipeline, Cables, Air transportation, Biological resources, Hydrocarbons, Metallurgic resources, Renewable energy, Defence, Recreation, Waste disposal, Research, Archaeology, Environmental preservation and protection. These are further subdivided into a total of 250 kinds of uses, all focussing more or less on the aquatic part of the coastal zone. A similar classification can be found, for land-based activities, with urban development, industry (ranging from mining to manufacturing) and commerce, agriculture, and recreation as the main elements in Ajjour and Drabih (1997). All these uses are causes of pollution and environmental changes.

The set of natural problems is related to the exposure of the terrestrial zone to marine impacts, and on the other terrestrial impacts on the coastal waters.

These include such phenomena as storms, tides, and surges, the occasional tsunamis, and the prospect of sea level rise, coastal erosion, salt water intrusion in rivers and aquifers caused by (often man made) low-flow and excessive withdrawal.

Since all of the activities in coastal zone compete, for space, for resources, and for the waste absorption capacity of the coastal ecosystems, it follows that there is an obvious and often dominating spatial aspect, which makes coastal zone management a spatial problem.

2. Spatial Decision Support Systems and Coastal Zone Management

Definitions

Definitions of decision support systems range from: "interactive computer based systems that decision makers utilize data and models to solve unstructured problems" (Gorry & Morton, 1971) to "Any system that makes some contribution to decision making" (Sprague & Watson, 1986).

A *decision* is a choice between alternatives. The *alternatives* may represent different courses of action or different hypotheses and rational human behaviour involves the evaluation of choice alternatives based on some criteria. A *criterion* is some basis for a decision that can be measured and evaluated. It is the evidence upon which a decision is based. Criteria can be of two kinds: Constraints, serve to limit the alternatives under consideration and factors that enhance or detract from the suitability of specific alternative for the activity under consideration

A *decision rule* is the procedure by which criteria are combined to arrive at particular. Decision rules are structured in the context of a specific objective, for example, to determine which area is suitable for a given activity. To meet a specific objective it is frequently the case that several criteria will need to be evaluated (Multi-Criteria Evaluation).

The *decision support field* is the "development of approaches for applying information systems technology to increase the effectiveness of decision makers in situations where the computer can support and enhance human judgement in the performance of tasks that have elements which cannot be specified in advance" (Sol, 1983).

Decision process

According to Sol (1983), the decision support field is a development of approaches for applying information systems technology to increase the effectiveness of decision-making, in particular, in situations where PC-aided support can enhance human judgement in the performance of tasks that have elements, which cannot be specified in advance.

Decision support systems must provide integration of information and feedback loops to support investigations and further research of information. The intangible factors in the decision making process may be accounted for through information supplied and choices made by a decision-maker who operates the DSS interactively. The above suggest that spatial decision support systems may be developed as general-purpose tools for decision-making when spatial elements are involved (Goodchild & Densham, 1990).

Spatial Decision Support Systems

The spatial decision support systems have been extensively and adequately covered in the literature (Craig & David, 1991, Densham, 1991, Goodchild & Densham, 1990, Moon, 1992, NCGIA, 1992). According to Densham (1991) and Geoffrion (1983), Decision Support Systems has six characteristics:

- Explicit design to solve problems;
- Powerful and easy-to-handle user interface;
- Ability to flexibly combine analytical models with data;
- Ability to explore the space analysis solution by building alternatives;
- Capability of supporting a variety of decision-making styles; and
- Allowing interactive and recursive problem solving.

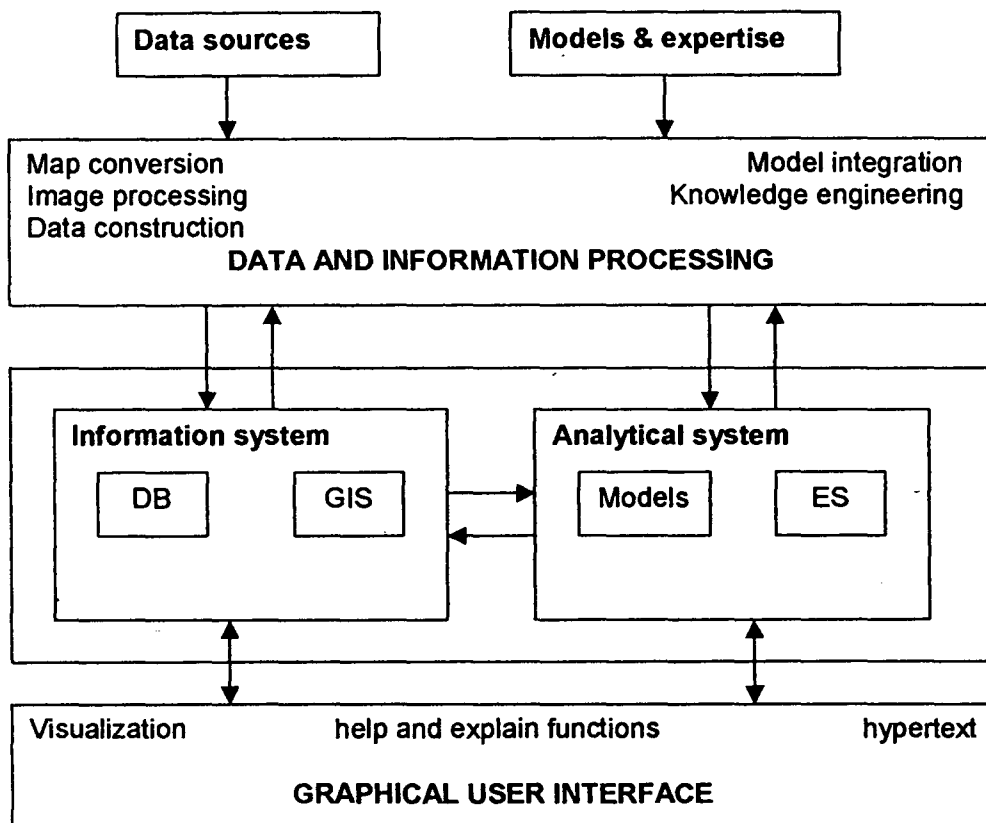
The distinguishing capabilities and functions of Spatial Decision Support Systems are to:

- Provide mechanisms for the input of spatial data
- Allow representation of the spatial relations and structures
- Include the analytical techniques of spatial and geographical analysis
- Provide output in a variety of spatial forms, including maps

Notwithstanding, in the specialised literature (Holsapple and Whinston, 1991) DSS is mainly viewed as a mathematical technique or a set of techniques for decision making by optimising something under some specific constraints, we consider SDSS in its broad meaning as an information system that can be used to support decisions at spatial level. By SDSS we mean the integration of all the methods and tools that can be useful to build up a decision support system for spatially related problems. The system needs the following components: GIS, Data analysis and Image processing, modelling and Expert systems, Simulation and Optimisation, Multi-Criteria Decision Analysis and a suitable User Interface. These components are discussed mainly following Fedra and Feoli (1998). The relationships between them are explained in Fig. 1.

The ultimate objective of a computer based spatial decision support system for coastal zone resources management is, or should be, to improve planning and decision making processes by providing useful and scientifically sound information to the actors involved in these processes, including public officials, planners and scientists, and the general public.

Fig 1.



3. The components of SDSS

- *Geographic Information System (GIS)*

A Geographic Information System (GIS) is designed as a computer tool to efficiently capture, store, update, manipulate, analyse, and display all forms of geographically referenced. GIS typically links data from different sets, using geo-referencing, i.e., spatial co-ordinates, as a common key between the data sets. The power of a GIS stems from its ability to combine many data sets and display them in a common framework as thematic maps. To obtain thematic maps the GIS may have internal software tools for database and data analysis and image processing, or may be easily interfaced with external software. There are many GIS on the market, commercial and public domain GIS and they are all different each other. They may answer more or less easily and completely to the following typical questions depending on how they have been designed:

- *Spatial identification*: find locations where certain conditions are satisfied, including the logical (Boolean) or arithmetic combination of multiple layers (overlay analysis);
- *Trends*: find the differences within an area over time or along spatial dimensions;
- *Patterns*: find correspondences between distributions of different attributes; calculate similarity between patches, fractal index, indices of fragmentation, and so on.
- *Modelling*: answer "What if" questions.

However to answer more complex questions we need to combine (static) geographic data layers with dynamic and spatially distributed models. A progress toward this integration may be achieved by the object-oriented approach (Malczewski 1999). This can be considered as an alternative or a complement of the layer data base approach common in most of the GIS.

- *Data Analysis and Image processing*

The maps obtained by GIS may be seen not only as cartographic representations of a classification of the landscape at the end of an analytical process, but mainly as data sources for the landscape spatial pattern

analysis through the many different indices of the landscape structure such as shape, fragmentation, fractal, diversity, etc. (Turner 1989, Fabbri and Chung 1996). Many GIS have internal data analysis and image processing systems that can calculate different pattern indices. Some GIS such as IDRISI, ILWIS, GRASS (see Malczewski 1999 for a comparison between different GIS) have the possibility to treat remote sensing data (Image processing) coming from LANDSAT, SPOT, NOAA, etc. however there aren't GIS including data analytical and statistical techniques that are able to classify specific Operational Geographic Units (OGU) described by different data sets as suggested by Feoli and Zuccarello (1996). The classification may be obtained by applying the clustering algorithms or other multivariate techniques. The probabilistic similarity functions proposed by Goodall (1964) that have been suggested and that have been included in the information system developed in ICS/UNIDO (Feoli 1995) would improve the interpretation by introducing the probabilistic aspect in the prediction.

- Modelling and expert systems

In GIS, the basic concept is one of location, of spatial distribution and relationship; basic elements are spatial objects. In environmental modelling, by contrast, the basic concept is one of state, expressed in terms of numbers, mass, or energy, of interaction and dynamics; the basic elements are state variables, which may be biological, chemical, and environmental media such as air, water or sediments, etc.

Simulation and optimisation modelling is a powerful tool of analysis, and forecasting. Modelling of marine systems has a considerable tradition in both physical and biological oceanography. For summary treatments, more recent model comparisons, and some classics in the field see, for example: Nihoul, (1975); Goldberg et al., (1977); Kremer and Nixon, (1978); Falconer et al., (1989); Fránsz et al., (1991). Management oriented and model based studies of marine systems include the RAND Corporation classic on the Oosterschelde (Bigelow et al., 1977) or the study of the North Sea MANS, Management Analysis North Sea (Klomp, 1990). Other important recent models for coastal zone management are ECOPATH, ECOSIM and ECOSPACE (Pauly et al. 2000) that are offering a set of tools for evaluating ecosystem impact of fisheries based on modelling the mass balance fluxes in the fish food-webs both in homogeneous and heterogeneous space conditions.

Expert systems can be used just as any other model to assign a value to an output variable given a set of input variables; they do this, however, by using rules and logical inference rather than numerical algorithms. In the context of models, expert systems are often used to help configure models (implementing an experienced modellers know-how to support the less experienced user) and estimate parameters. A number of these "intelligent front end systems" or model advisors have been developed in the environmental domain (e.g. Fedra 1993).

The flexibility to use, alternatively or conjunctively, both symbolic and numerical methods in one and the same application allows the system to be responsive to the information at hand, and the user's requirements and constraints. This combination and possible substitution of methods of analysis, and the integration of data bases, geographical information systems, and hypertext, allows to efficiently exploit whatever information, data and expertise is available in a given problem situation.

- Multi-Criteria Evaluation

To meet a specific objective, it is frequently the case that several criteria will need to be evaluated. Such procedures are called Multi-Criteria Evaluations (MCE) (Eastman et al., 1995). Two of the most common procedures for multi-criteria evaluation are weighted linear combination and concordance-discordance analysis (Carver, 1991). Weighted linear combination is very straightforward in a raster GIS. Indeed, it is the derivation of the weights, within the context of the decision objective that provides the major challenge. The weights are developed by providing a series of PAIRWISE comparisons of the relative importance of factors to the suitability of pixels for the activity being evaluated (Saaty 1980, Eastman, 1997).

Decisions about the allocation of land typically involve the evaluation of multiple criteria according to several, often conflicting-objectives (Eastman et al., 1995). Making-decisions about the allocation of land, is one of the most fundamental activities of resource development (FAO, 1976). With the development of GIS, we now have the opportunity, for a more explicitly reasoned process of land-use evaluation.

The advantage of MCE is that it provides a flexible way of dealing with qualitative multi-dimensional environmental effects of decisions (Munda, 1995).

- Multi-Objective Evaluation

While many decisions we make are prompted by a single objective, it also happens that we need to make decisions that satisfy several objectives. These objectives may be complementary or conflicting in nature (Carver, 1991).

a) *Complementary Objectives*

With complementary or non-conflicting objectives, land areas may satisfy more than one objective. Desirable areas will thus be those, which serve these objectives together in some specified manner. For example, we might wish to allocate a certain amount of land for combined recreation and wildlife preservation uses. Optimal areas would thus be those that satisfy both of these objectives to the maximum degree possible.

b) *Conflicting Objectives*

With conflicting objectives, objectives compete for the available land since it can be used for one or the other, but not both. For example, we may need to resolve the problem of allocating land for timber harvesting and wildlife preservation. Clearly the two cannot coexist. Exactly how they compete, and on what basis one will win out over the other will depend upon the nature of the decision rule that is developed.

In case of complementary objectives, multi-objective decisions can often be solved through a hierarchical extension of the multi-criteria evaluation process. For example, we might assign a weight to each of the objectives and use these along with the suitability maps developed for each to combine them into a single suitability map indicating the degree to which areas meet all of the objectives considered (see Voogd, 1983). However, with conflicting objectives the procedure is more involved.

With conflicting objectives, it is sometimes possible to rank order to objectives and reach a *prioritised* solution (Rosenthal, 1985). In these cases, the needs of higher ranked objectives are satisfied before those of lower ranked objectives are dealt with. However, this is often not possible, and the most common solution to conflicting objectives is the development of a *compromise* solution. Undoubtedly the most commonly employed techniques for resolving conflicting objectives are those involving optimisation of a choice function such as mathematical programming (e.g. Fiering, 1986). In both, the concern is to develop an allocation of the land that maximises or minimises an objective function subject to a series of constraints.

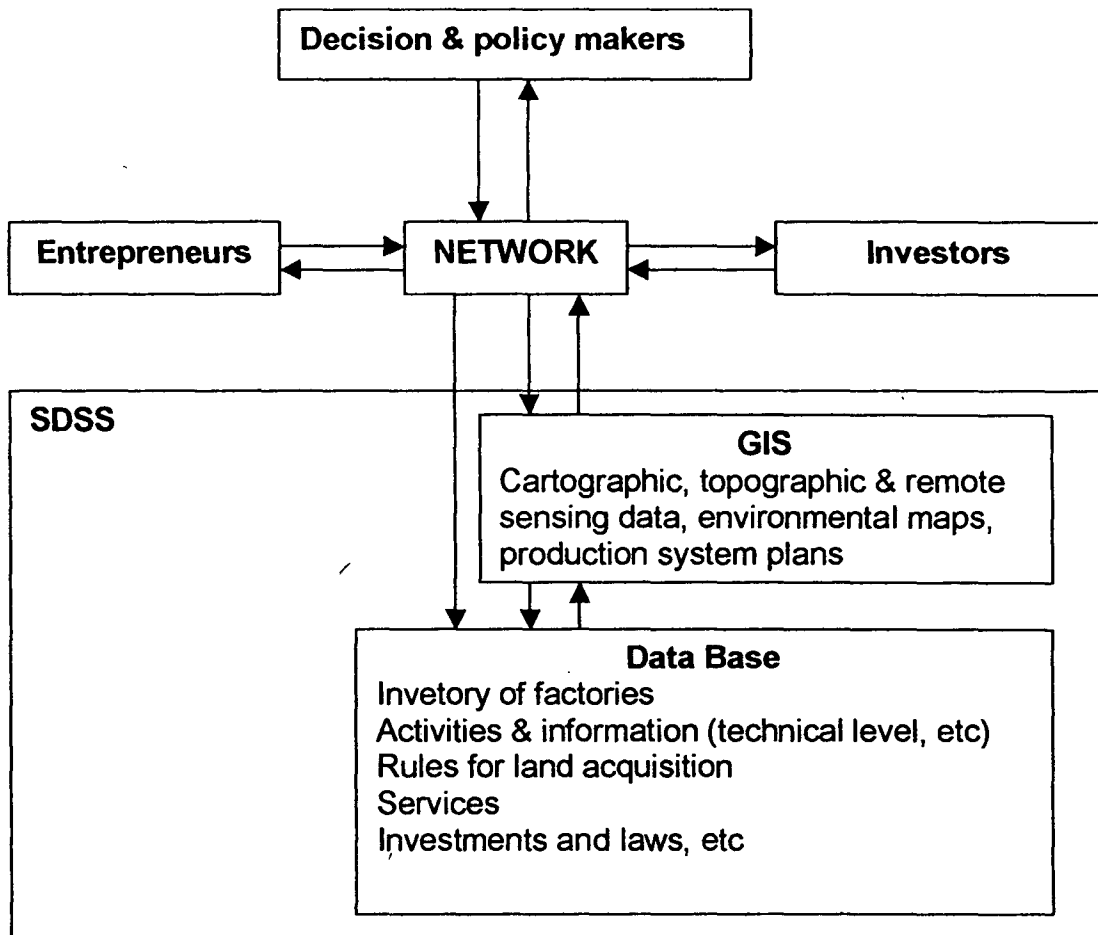
- *The user interface*

According to Fedra and Feoli (1998) for having an efficient user interface we need:

- An interactive, menu-driven user interface that guides the user with prompts and explains messages through the application.
- Dynamic colour graphics for the model output and a symbolic representation of major problem components that allow easy and immediate understanding of basic patterns and relationships.
- Embedded Artificial Intelligence (AI) components such as specific knowledge bases allowing the user specifications to be checked and constrained, and ensuring the consistency of an interactively defined scenario.

Interaction is a central feature of any effective man-machine interface: a real-time dialogue, including explanation, allows the user to define and explore a problem incrementally in response to immediate answers from the system. An efficient user interface is essential to introduce the Spatial Decision Support System, with all its components, into the network that links Decision and Policy makers, Entrepreneurs and Investors in an operational way (Fig. 2). Fast and powerful systems with modern processor technology can offer the possibility to simulate dynamic processes with animated output, and they can provide a high degree of responsiveness that is essential to maintain a successful dialogue and direct control over the software. The user interface plays a very important role in visualisation of possible scenarios coming from different decision alternatives, providing the band-width necessary to communicate and understand large amounts of highly structured information, and permitting the development of an intuitive understanding of processes and interdependencies of spatial and temporal patterns. Also, many of the problem components in a real-world planning or management situation, such as risk or reliability, are rather abstract: a graphical representation of such concepts makes them tangible objects that can literally be manipulated and understood intuitively.

Fig 2.



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Multidimensional Spaces of Landscape System

*Draft for ICS-UNIDO Training Course on "GIS & DSS for Industrial Development"
Trieste, Italy, 20-24 November 2000*

by

Enrico Feoli

ICS Senior Scientific Consultant

Earth, Environmental and Marine Sciences and Technologies

ICS-UNIDO

AREA Science Park, Bldg. L2

Padriciano 99, Trieste, Italy

Tel.: +39-040-9228109

Fax: +39-040-9228136

Abstract

The data describing the landscape system in terms of pattern and/or landscape elements are giving rise to multidimensional spaces. For understanding pattern and processes in the landscape and to model them it is necessary to represent in efficient way such multidimensional spaces by few dimensions. Exploring multidimensional spaces on the basis of spectral and singular value decomposition theorems (SVD) and eigenanalysis (EA) is an exercise that can be useful to get information on landscape patterns and can be used for modeling complex systems in iterative way without feeling too much restricted to precision problems. The idea of modeling clusters of points, rather than lines is suggested. Fuzzy set theory can be used as a useful data interpolation method and data transformation before EA.

1. Introduction

Some definitions are necessary before to start to discuss on the application of singular value and spectral decomposition theorems (SVD) and eigenanalysis (EA) that are used and could be used to explore the multidimensional spaces generated by matrices describing the landscape system:

- 1) *Landscape* is a complex system with states determined by all the interactions between man, plants, other living organisms and the chemical-physical environmental factors.
- 2) *Landscape ecology* is the discipline aimed to understand all the aspects of landscape system concerning its composition (diversity), structure (spatial pattern and spatial relationships), functions and dynamics (the ways and the the causes of landscape changes in space and time). It uses the concept of multidimensional space (*ecological space*) defined by all the ecological factors influencing the human life and the life of the other organisms.
- 3) Landscape is sampled and described by Operational Geographic Units (OGU). They are sampling units, which are supposed to represent in a satisfactory way a

landscape at a given time in a given place. These sampling units may be defined by the user in a GIS procedure, or defined automatically by remote sensing techniques (pixels). The variables that are sampled and described in each OGU may be of different nature such as spectral bands, environmental chemical-physical factors and/or human and other biological factors that are supposed to influence the landscape states. OGUs can be sampled following some sample design or by preferential sampling as it may happen in vegetation science (Orloci 1991a,c; Orloci and De Patta Pillar 1991). It must be clear that an OGU is an operational concept, which is useful to integrate in a GIS the remotely sensed data with other multisource data.

The concept of Operational Geographic Unit (OGU) was defined as the basic cartographic element for understanding biogeographical patterns by classification and ordination techniques (Crovello 1981). It is analogous to the concept of Operational Taxonomic Unit in numerical taxonomy (Sneath and Sokal 1973), with the only difference that OGU is a georeferenced unit. The concept of OGU has been already introduced in GIS context by Feoli and Zuccarello (1996), to describe ecological processes in space and time. OGUs may be used to store information in data bases following what Peuquet (1984) calls geographical data models, however we prefer to use the concept to integrate and extract georeferenced data already stored in GIS data bases. The data integration is achieved when each OGU is described by remotely sensed data (average values, class frequencies, min-max values, etc. of bands) and by other landscape multisource data not directly attributable to the single pixels (e.g. population density, urbanisation density, yield production, biodiversity, etc.), usually called ancillary data. OGUs can be obtained by a GIS in a very flexible way. They, as adjacent or non adjacent polygons (or points), may be easily defined by administrative boundaries or by superimposing to the maps regular or irregular tessellated structures (grids, triangulated networks, quadtree patterns, hexagonal mesh, Thiessen polygons, etc., see Peuquet, 1984; Skole et Al. 1993).

4) OGUs that are considered similar enough are grouped into the same land cover type or class, which is used for cartographic purposes. A GIS can easily show the results of OGUs classifications by maps showing the spatial distribution of the classes of OGUs. Since these classes may be characterized by the character states, used for the OGUs classification, the maps show the spatial pattern of those character states in the landscape. In this sense OGUs are useful tools of the Dobson's "macroscope".

5) In a given landscape a land cover type is spread within the geographic ranges of the combination of characters that are characterising it (Characteristic variables) as a different type from other land cover types present in the landscape. The extension and the shape of the area occupied by a land cover type depend on the extension of the environment favourable to the combination of its characteristic variables in the geographical space. The environment hosting a land cover type defines, in analogy with the community niche concept (Feoli, Ganis and Zerihun 1988), the land cover type niche. However the concept of niche is not only related to environmental variables, if socio-economic variables are only used the multidimensional space will represent a socio-economic multidimensional space and the niche of a land cover type will be a socio-economic niche. The niches may be wide or narrow in the multidimensional space irrespective its extension in the geographic space, the niche width depends on the heterogeneity of the land cover type.

6) Once defined the land cover types on the basis of a set of characters (variables), landscape can be studied on the basis of other sets of variables. The classification of landscape based on a set of land cover types can be used as a reference system on which to overimpose other kind of classifications or other information.

7) Land cover type niches are partially or completely represented in a matrix X given by a set of OGUs (almost always disposed as column vectors). Matrix X represents partially the multidimensional ecological space (it is just a sample of it). In this each variable has a number of co-ordinates equal to the number of OGUs and each OGU has a number of co-ordinates equal to the variables that are describing it. Variables and OGUs may be seen as vectors with a common origin, namely the origin of the space. Their length and direction are determined by their co-ordinates in X . The dimensionality of the space represented by X is, however, equal or lower than the minimum number among the number of OGUs and the number of variables. The dimensionality (rank of the matrix) is, in fact, the minimum number of orthogonal axes that are able to get the projections of all the OGUs and all the variables. Only the variable or OGU with all the co-ordinates equal to the co-ordinates of the origin of the space do not have axes where to be projected. These orthogonal axes are the reference system for variables and OGUs. They give the minimum number of co-ordinates necessary to correctly positioning variable and OGUs in the multidimensional space. These axes are also used to represent the space by a reduced number of dimensions. Their efficiency in doing this is measurable. X may be divided into sub-matrices on the basis of the kind of variables used to describe the OGUs: e.g. $X(1)$ matrix of biological variables, $X(2)$ matrix of environmental variables, $X(3)$ matrix of socio-economic variables, $X(4)$ matrix of human impacts, etc. Each matrix X is the matrix representing the states of landscape system according to some set of variables. To study the correlation between different matrices is possible by many mathematical methods.

2. Spectral and Singular value decomposition theorems.

The spectral and singular value decomposition theorems of matrix algebra are generally mentioned in the Appendix of multivariate data analysis textbooks addressed to applications (Jongman, Ter Braak and Van Tongeren 1995). However it would be more appropriate to present them at the beginning of these books since they are essential for understanding why multidimensional space of a given matrix X may be represented by few orthogonal dimensions.

The theorem of spectral decomposition says that a symmetric matrix S of rank p can be decomposed by the following three matrices:

$$S = T \Lambda T' \quad (1)$$

where T is an orthogonal matrix ($m \times p$), i.e. $T_i' T_h = 0$, Λ is a diagonal matrix ($p \times p$) and T' is the transposed of T . Λ is the matrix of the p positive eigenvalues of S that are disposed in decreasing order. T is the matrix of standardized eigenvectors of S .

Λ may be calculated by the characteristic equation of eigenvalues:

$$\det (S - \lambda I) = 0$$

where *det* means the determinant of the matrix $(S - \lambda I)$, λ is a scalar and I is the identity matrix (i.e. a matrix with ones along the diagonal and zeros outside). Out of this equation only the positive p solutions are considered in the diagonal matrix Λ . Once calculated the p positive eigenvalues ($\lambda_i, i=1, \dots, p$), T may be obtained by solving p times the system of equations:

$$(S - \lambda_i I)T_i = 0 \quad (2)$$

The singular value decomposition theorem says that given a rectangular matrix X of m rows and n columns ($m \times n$) of rank p it can be decomposed in the following product of three matrices:

$$X = U \Lambda V' \quad (3)$$

where U is an orthonormal matrix ($m \times p$) ($U'U = I_p$, identity matrix), V is an orthonormal matrix ($n \times p$) ($V'V = VV' = I_p$) and Λ is a diagonal matrix ($p \times p$) with positive elements.

If we consider that:

$$X'X = (U \Lambda V')' U \Lambda V'$$

it follows that

$$X'X = V \Lambda' (U'U) \Lambda V'$$

and since $U'U = I_p$ it follows that

$$X'X = V \Lambda^2 V'$$

on the other hand

$$XX' = U \Lambda^2 U'$$

and since both $X'X$ and XX' are symmetric matrices (S) the theorem of spectral decomposition holds true. From this it follows that the eigenvalues of the two symmetric matrices are the same.

The relevant implications of these two theorems for exploring multidimensional spaces of X (or $X(1)$, $X(2)$, $X(3)$, etc.) are the following:

1) each numeric matrix X , i.e. a matrix for which it is possible to apply the product matrix $(X'X)$ or (XX') , may be represented by two sets of orthogonal axes that may be used to order column vectors (objects) and the row vectors (variables) simultaneously

by biplot graphs (Gabriel 1971; ter Braak 1995). The efficiency of the representation is given by the ratio between the sum of the eigenvalues corresponding to the eigenvectors used for ordination and the total sum of eigenvalues;

2) for any numeric symmetric matrix S obtained in some way from X it is possible to compute its eigenvalues and eigenvectors by equation 2). T_i may be adjusted in several ways, e.g. $T_i' T_i = 1$ or $T_i' T_i = \lambda_i$ or $T_i' T_i = \lambda_i^{1/2}$;

3) if S is the symmetric matrix for the rows, T_i is an axis of ordination for the elements in rows. If S is a symmetric matrix for the columns, T_i is an axis of ordination for the elements in columns. For better clarity we can indicate with R the symmetric matrix for rows and with Q the symmetric matrix for columns (in analogy with the well known terminology R-mode and Q-mode algorithms, ter Braak 1995), and respectively we can indicate by α_i the eigenvectors of R and by β_i the eigenvectors of Q . Only in some circumstances the matrix of the β_i can be computed by multiplying the matrix of the α_i by X . This happens when R is obtained by XX' . When Q is obtained by $X'X$, α_i can be obtained by multiplying X by β_i (Orloci 1967, 1978). Not always the R and Q matrices can be obtained by scalar products between row or column vectors. If the matrix X is ordinal or alphanumeric, other measures of similarity or correlation (association) rather scalar products should be applied, e.g. Gower's and/or Goodall's and Burnaby's indices (Goodall 1964; Dale 1991; Carranza et Al. 1998). In this case only the SVD of the symmetric matrix makes sense.

3. Ordination methods and gradient analysis

In landscape analysis, as in ecology, the methods able of positioning objects (OGUs, or variables) in a reference system of orthogonal or obliques axes are called ordination methods (Orloci 1966, 1967, 1978, ter Braak, 1995). Ordination methods are used to display the relationships between variables and objects with the aim to discover clusters, trends of variation (gradients) and/or trajectories. More in general they are used to study patterns (spatial, temporal, structural) of landscape and gradients, i.e. the way in which landscape is changing in function of environmental factors. Gradient analysis is playing an important role in landscape ecology. Its primarily aim is to reconstruct the sequence of response curves of variables along single environmental variables (primary or secondary ecological factors), or combination (linear or non-linear) of them. Two methods of gradient analysis have been so far distinguished: direct gradient analysis and indirect gradient analysis (Whittaker 1967, Whittaker 1978, Prentice and ter Braak 1988).

- *Direct gradient analysis*

In direct gradient analysis two matrices of data are considered: the matrix of independent variables (causal or explanatory variables, e.g. chemical-physical variables in ecology) $X(2)$, and the matrix of dependent variables of our interest that have been used to describe landscape features $X(1)$. Direct gradient analysis may be

done by two approaches: one considers only $X(2)$ and uses it to order $X(1)$ the other considers both the matrices simultaneously.

Let us consider the first approach. The following procedures are used:

- 1) $X(1)$ is rearranged (ordered) according to environmental axes given by the single environmental variables or according to some combination (linear or non-linear) of all of them or only some of them. $X(2)$ is subjected to SVD after having standardized the variables. The T axis are used to rearrange $X(1)$. If according to the scattergram of T axes, a curvilinear pattern of points is evident, than the curve interpolating the points, or an angular seriation, can give the non-linear combination of the variables in $X(2)$ (Feoli and Orloci 1991). The new axis so obtained is used to plot the response values of the variable.
- 2) Graphs are produced by simply plotting the variable scores against the environmental axis, and/or by curves fitting the scores by regression analysis (ter Braak 1995).
- 3) A model of response curves is described and used for predicting landscape composition all along the gradient.

In the second approach $X(2)$ and $X(1)$ are used simultaneously following two main procedures. In the first one the two matrices may be fused in one with $m+s$ rows and n columns, where m (number of environmental variables) are the rows of $X(2)$ and s (number of variable) the rows of $X(1)$. This matrix (X) after standardization of row vectors may be decomposed according to SVD. This gives the simultaneous ordination of variable, environmental variables and OGU's. This procedure includes the methods known as Principal Component Analysis (PCA) and Correspondence analysis (CA). They differ only because in PCA the variables are centered and/or standardized ($z_{ij} = (x_{ij} - \xi_j) / \sigma_j$), where ξ_j is the mean of i -th variable and σ_j is its standard deviation, while in CA the variables are transformed according to the deviation of the scores from the expected scores calculated as the product of the marginals (row totals and column totals) divided by the grand total of the matrix X .

In the second procedure the two matrices are kept together by multiplying $X(2)$ by $X'(1)$ in order to obtain a matrix of scalar products $C(m \times s)$. When the s variable and the m variables are standardized by the z variable this matrix is a non symmetric correlation matrix. $C(m \times s)$ can be decomposed by SVD. The resulting matrix U' of p eigenvectors corresponding to the p positive eigenvalues may be multiplied by $X(2)$ (standardized by rows) in order to obtain $\beta(2)$, namely the p ordination axes for the n OGU's. This gives ordinations based on the m variables under the constraint of their correlation with the s variable. The multiplication of matrix of V' by $X(1)$ (standardized by rows) gives $\beta(1)$, namely the p ordination axes of the n OGU's based on the s variable under constraint of their correlation with the m variables. Scattergrams can be obtained by using $\beta(2)$ or $\beta(1)$ and also by using $\beta_j(2)$ against $\beta_j(1)$, i.e. j -th axis of $\beta(2)$ against j -th axis of $\beta(1)$. This type of scattergrams show the pattern of correlation between $X(2)$ and $X(1)$. The methods of multivariate data analysis known as canonical correlation analysis, canonical correspondence analysis and redundancy analysis are based on this procedure. They differ only by the way in which the variables are transformed or combined into the two matrices before the

multiplication in order to get C. In terms of equation $(S - \lambda I)p)T_i = 0$ they differ only by the way in which S is computed based on C. In canonical correlation analysis:

$$S = R_{11}^{-1} R_{12} R_{22}^{-1} R_{21}$$

for obtaining $\beta(1)$, $\beta_1(1) = T_1' X(1)$

or

$$S = R_{22}^{-1} R_{21} R_{11}^{-1} R_{12}$$

for obtaining $\beta(2)$, $\beta_1(2) = T_1' X(2)$

where R_{11} is the correlation matrix between the variable in X (1), R_{22} between the variables in X(2) and R_{12} or R_{21} is the C matrix. R_{11}^{-1} and R_{22}^{-1} are respectively the inverse matrices of R_{11} and R_{22} .

In redundancy analysis R_{11} is the identity matrix. In Canonical correspondence analysis the data are transformed as in correspondence analysis and centered, then the equation for getting $\beta(2)$ is equal to that of canonical correlation analysis (ter Braak 1995).

If the variables cannot be standardized, because measured in different scales (e.g. variable in ordinal scale and environmental variables in ratio scale), the two matrices have to be both transformed in symmetric matrices (resemblance matrices), namely $Q(1)$ and $Q(2)$, by suitable resemblance functions (Dale 1991, Podani 1991a). Both the matrices can be decomposed by SVD. $\beta(1)$ and $\beta(2)$ are respectively the matrices of eigenvectors of $Q(1)$ and $Q(2)$. $X(1)$ can be ordered and response curves of variables detected by using $\beta(2)$ as ordination axes (first procedure above). In order to get the second procedure, i.e. constrained ordination, $\beta(1)$ is multiplied by $\beta(2)$ and the resulting matrix decomposed by SVD. In this case the constrained ordination axes are obtained respectively by multiplying U' by $Q(1)$ and V' by $Q(2)$.

The proper direct ordination is always the one based on X(2). To constrain the ordination by matrix X(1) it means to keep into consideration all the factors that have determined the matrix X(1) included those in X(2). The constrained ordination axes of X(2) obtained based on matrix C (mxs) are always axes that in some way maximize their linear correlation with the axes obtained from X(1), irrespective the type of relationship between the variables. Scattergrams obtained by plotting $\beta(1)$ axes versus $\beta(2)$ axes may show linear correlation between X(1) and X(2) notwithstanding the correlation between variable, between environmental variables and between variable and environmental variables may be non-linear.

In direct gradient analysis constrained ordination axes can be obtained by Procrustes analysis (see Podani 1991b and Feoli, Podani and Sun 1993, for applications and for references). By it, given k axes of $\beta(2)$, in a matrix called for convenience X(kxn), and k axes of $\beta(1)$, in a matrix Y(kxn), the k axes of $\beta(2)$ are transformed in such a way to fit as much as possible the configuration of OGUs in the space defined by Y. This

means that the new axes of X are adjusted in such a way to "absorb" the effects that other environmental factors have and/or have had in defining the ordination of n OGUs in $\beta(1)$.

The required rotation of X is obtained by its multiplication with the $n \times n$ (n =number of OGUs) orthogonal transformation matrix:

$$H(n \times n) = V(n \times p)U'(p \times n)$$

where U and V result from SVD of

$$Y'X(n \times n) = U(n \times p) \Lambda(p \times p) V'(p \times n)$$

Rescaling parameters should be necessary for measures the goodness of fit of the rotation (Podani 1991b). This would be useful to measure what variables in $X(2)$ are better related to $X(1)$ in a step-wise process followed according to some suitable criterion.

- Indirect gradient analysis

Indirect gradient analysis is based on the assumption that the variables describing the landscape are good indicators of the landscape states. It is assumed that the landscape pattern is determined by all the environmental and historical factors that can be and that cannot be measured and that the pattern is indicating both the environmental situation and the environmental impact of human activities.

Indirect gradient analysis uses only the matrix $X(1)$ to get ordination axes. The explanatory matrix $X(2)$ is only used to try to explain the pattern of $X(1)$. Indirect gradient analysis does not require that the explanatory matrices have the same number of columns of $X(1)$. Their number of columns can be less than the number of columns in $X(1)$. The ordination axes obtained by SVD of $X(1)$, or of Q matrices obtained by different resemblance functions applied to $X(1)$, are used for detecting gradients and for what ter Braak (1995) calls calibration, i.e. the prediction of scores of explanatory variables. In this case $X(2)$ is rearranged according the ordination axes obtained by $X(1)$. Along these axes, or along non-linear combination of them (projections of OGUs to curves or angular seriations) the scores of variable and/or those of environmental variables are plotted (Feoli and Feoli Chiapella 1980).

4. Ordination based on classification and fuzzy set theory

The ordination methods based on SVD and eigenanalysis of a matrix X (or of its submatrices obtained by separating groups of variables) are generally maximizing dispersion or correlation. When the OGUs are classified into groups by explanatory variables, a direct ordination can be obtained by Discriminant Analysis. In terms of equation 2), Discriminant Analysis (DA) is:

$$(W^{-1}B - \lambda_i I_p)T_i = 0$$

where W^{-1} is the inverse of the matrix of covariance of the variables within the sets of OGUs and B is the matrix of covariance of the same variables between the sets of OGUs.

$\beta(2)$ ordination axes are obtained by $\beta(2) = T'X(2)$. These axes maximize the separation between the sets of OGUs. Discriminant analysis allows to find what are the variables that better discriminate the OGUs sets and also gives the probability of each OGU to belong to the sets under the assumption of normal distribution, linear correlation and equality of variance-covariance of the variables within the clusters. All these limitations are rarely met in data matrices, however they can be tested and the tests can be useful to understand landscape patterns rather than to prove hypothesis (Feoli and Lagonegro 1991). Discriminant analysis (DA) can be also used as an indirect ordination method when W^{-1} and B are obtained by the dependent variables. To avoid singularity problems, the number of variable should be always less the number of OGUs in the sets. This is rarely met. A way to overcome this problem is to group variable in sets before DA. In this way OGUs are described by variable groups (average scores of the variable in each group).

Another method of ordination based on classification is the one proposed by Feoli and Zuccarello (1986, 1988). This is based on fuzzy set theory since the ordination axes are given by the degree of belonging of OGUs to sets of OGUs. According to fuzzy set theory a fuzzy set is given by a set of elements with their degrees of belonging to the set (see Feoli and Orloci 1991 for references). In this method the similarity matrix Q is considered a fuzzy matrix, where each OGU represents a set. The similarity measures (ranging between 0 and 1, with 0 no similarity, 1 identity) in the i -th row or j -th column ($i=j$, being the matrix symmetric) are the degree of belonging of all the OGUs to the set represented by i -th OGUs. On the other way, they are also the degrees of belonging of the i -th OGU to all the sets represented by all the other OGUs. Fuzzy axes can be obtained by averaging the values of similarity in a matrix of similarity after having rearranged its rows and columns according to some classification. The Q matrix becomes a rearranged $Q\rho(n \times n)$ that is transformed in a $Q\rho(n \times c)$ matrix where c is the number of clusters (sets). The c clusters can be obtained by any classification method, provided, and this is essential for fuzzy set theory, they are well characterized, i.e. "conceptualized". Each set has to be described by variables that have been used for classification or that have been added later. For doing this it is essential to rearrange the original data matrix X according to $Q\rho(n \times n)$ and discovering what are the discriminating variables. Once discriminat variables have been defined the sets are characterized according to them. In this way each j -th vector of the c vectors in $Q\rho(n \times c)$ is associated to a variable or to a set of variables highly correlated and represent the degree of belonging of all the OGUs to that set, each j is a fuzzy set. If the values in $Q\rho(n \times c)$ are adjusted to the row totals in order to get $\sum_j \xi_{ij} = 1$ (with ξ_{ij} = degree of belonging of i -th OGU to j -th fuzzy set) $Q\rho(n \times c)$ represent a fuzzy partition, let call it $F\rho(n \times c)$. SVD of $F\rho(n \times c)$ gives the representation of the fuzzy system space where the n OGUs and the c fuzzy sets find their mutual position. This method of ordination can be applied to any kind of matrices and it is not confined, as DA, to variables measured in ratio scale. When the data are mixed (alfanumeric, ordinal, etc.) Q matrices can be obtained by suitable similarity measures that are not based on scalar product, such as Gower, Burnaby or Goodall's similarity indices. Direct gradient analysis can be done using the matrix $\Phi(n \times m)$ obtained, as was

suggested by Feoli and Zuccarello (1988) by multiplication $F\rho(nxc)E'(cxm)$. $\Phi(nxm)$ is a matrix that describes the OGUs by the variables in $E(mxc)$. There are many ways to put values in $E(mxc)$: average values, maximum values, the most probable value, etc. The result in $\Phi(nxm)$ depend on the way chosen. $\Phi(nxm)$ represents a new description of all the n OGUs, (notwithstanding data were not collected for all the OGUs in E) in this sense fuzzy set ordination can be considered an interpolation method in the fuzzy system space. If the values in $\Phi(nxm)$ are adjusted in such a way that the row totals are equal to 1, than $\Phi(nxm)$ is a fuzzy partition with m environmental fuzzy sets. Each column represents the degree of belonging of OGUs to the sets defined by the j -th environmental variable. The SVD of $\Phi(nxm)$ represents the fuzzy system space where OGUs and environmental variables find mutual position. Once defined a fuzzy partition, let say $F\rho(nxc)$, many other fuzzy partitions can be obtained by matrix multiplication. Keeping the c fuzzy sets as axes all the objects that may belong to the c sets (environmental variable, morphological characters, chorological, etc.) can be overimposed into a single ordination, examples are given by Feoli and Zuccarello (1988, 1992, 1994) and Banykwa, Feoli and Zuccarello (1990).

5. Conclusions

Mapping multidimensional spaces described by X matrices is a good exercise to study niches of land cover types and to study relationships between variables or sets of variables and between them and land cover types. Data analysis is often criticised for not being enough explanatory: elements of deductive approach are considered missing and the methods are considered not predictive. This criticism is not realistic. It is true that the mechanistic element in landscape studies is weak, but it is also true that cannot be stronger owing to the complex nature of landscape. Landscape is a self-organizing system, objects or entities that can be described by several variables (characters) are in a certain area for historical and ecological reasons that cannot be modelled in a mechanistic way. Shapes of features are the results of many interactions. Based on SVD we are able to model clusters in multidimensional space by creating new data by interpolations or extrapolations in the space defined by V in $X = UAV'$. Iterative calibrations according to ter Braak (1995) can be done accordingly. The space defined by V based both on real or fuzzy data, can be used to find the position and width of the ecological niches of variable and communities in the ecological space (Zerihun et Al. 1989) and can be used for detect or simulating gradients by direct or indirect methods.

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Case study in Monfalcone, Italy

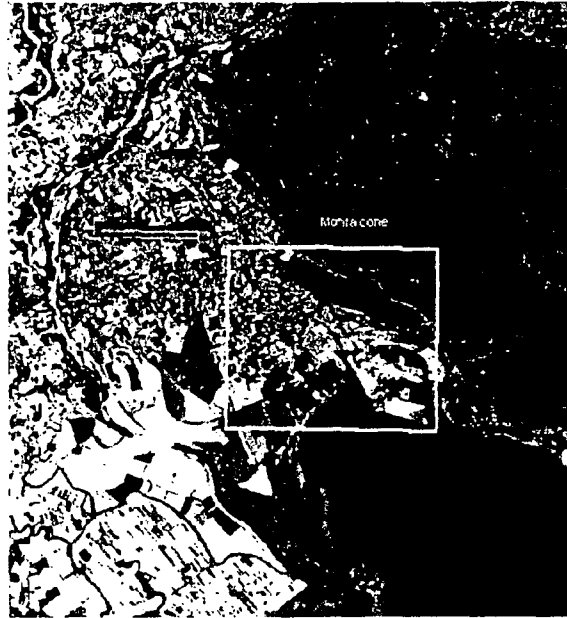
A. Altobelli

A GIS application for Monitoring Optimization and Risk Assessment

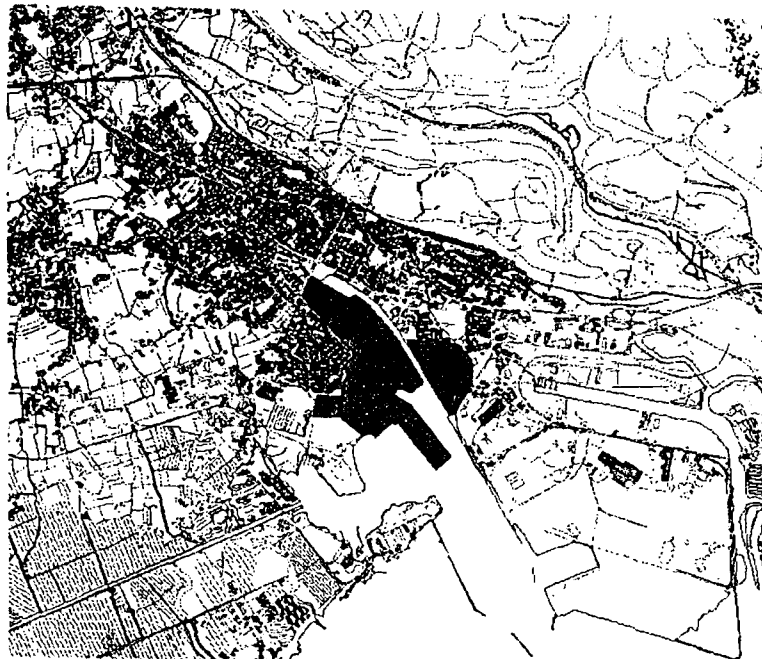
GIS and spatial pattern analysis methods can be used for facilitating industrial planning and environmental control.

The study area is located in Monfalcone (GO). A highly industrialized municipality in North East Italy. Central to the industrial development of the area are: an important shipyard, an engineering company specialized in the manufacture of electric motors and an oil and coal-fired power station. A considerable number of other factories contribute to the creation of a substantial source of potential pollution.

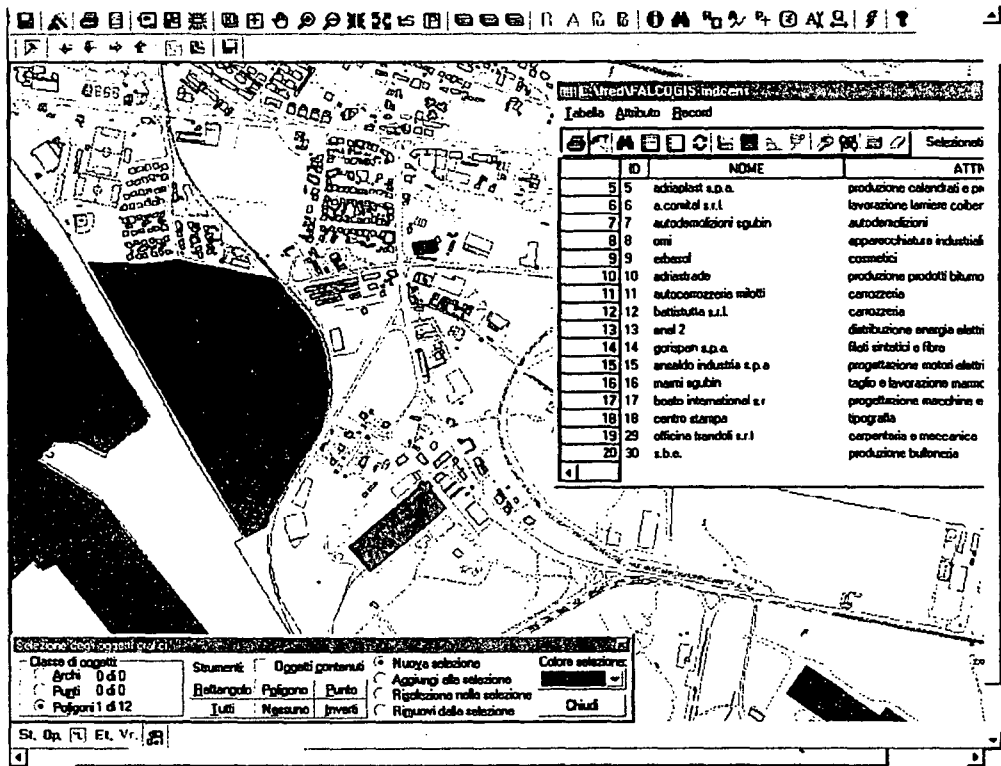
Study Area Presentation



Industrial Area of Monfalcone



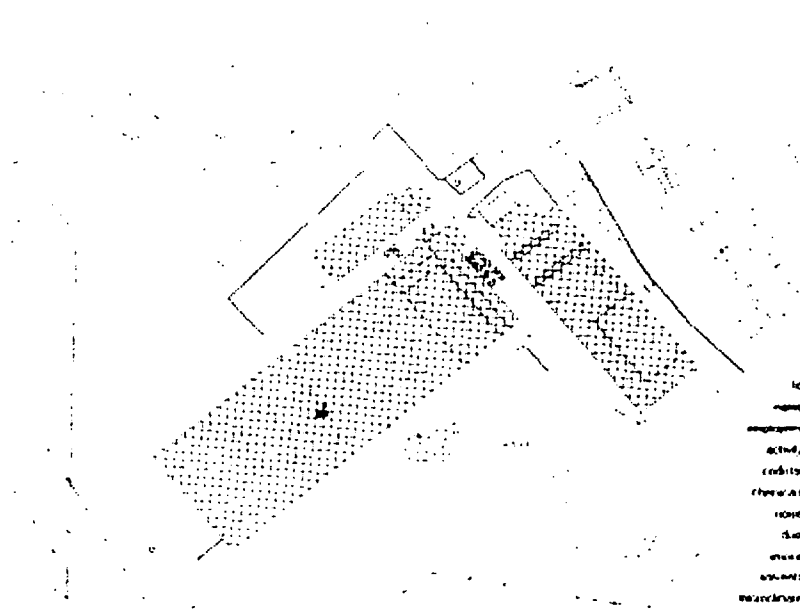
Relational Data base construction for the Industrial Area



Each industry is mapped and described with a database containing information about the activity, number of employees and type of internal risk (chemicals, noise, dust and fibre, smoke and steam, solvents, temperature and electrical fields).

The spatial pattern of the industries is carried out by clustering their positions based on Euclidean distance and average linkage method. Four main clusters are identified:

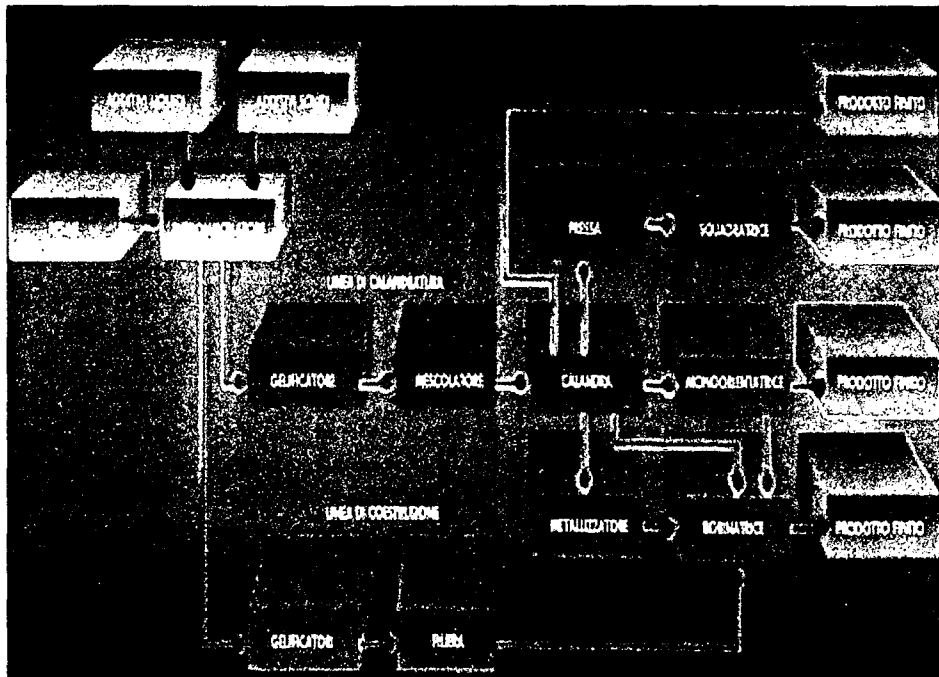
- 1: small enterprises located in the residential area
- 2: engineering and metalworking companies
- 3: shipyard related activities
- 4: port, oil and coal-fired power station and plastic manufacture



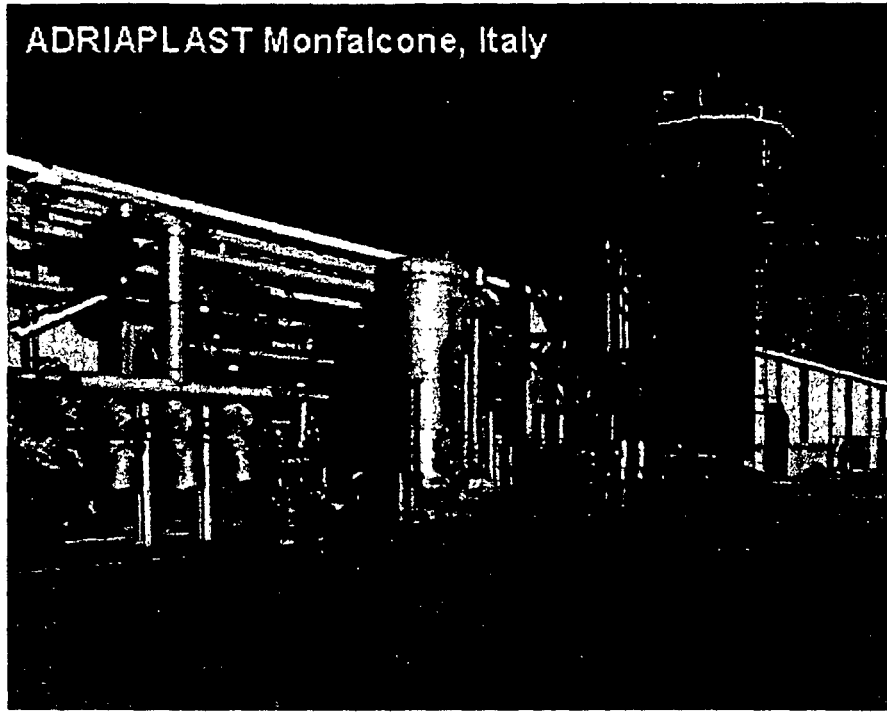
IS	11
region	ACRIAPLAST
employee	200
activity	PVC MANUFACTS
country	IR S
country alt	
name	
date	
value	
value alt	
value alt2	
value alt3	
value alt4	
value alt5	

Database query for a plastic manufacturing industry

ADRIAPLAST Production System Plan



ADRIAPLAST Monfalcone, Italy



**Case Study for the municipality of
Koper, Slovenia**

M. Russi

INTRODUCTION

•Slovenia is mainly a continental state. The total length of **the coastline**, all facing the Bay of Trieste, **is only 46 km**. This small coastal area is of strategic economic and political importance for the whole country.

•Along this coastal area Three towns have developed there: Koper (administrative center of the area, industry and harbour activities), Izola (tradition in the fishing industry (cannery)), Piran and neighbouring Portorož (highly developed tourist center) and smaller settlements and tourist facilities between them, so the entire coast is one large urban area.

•For this reasons competition for the land use among housing, marine activities, tourism and industry is strenuous. However, close to this large urban area, environmentally valuable - unique - locations are located (ex. the Valley of Dragonja).

•As a result of these conflicts **seven hot spots** have been identified in the Slovenian coastal zone in the frame of the Mediterranean Action Plan (MED POL programme) survey. They are located in all the three municipalities.

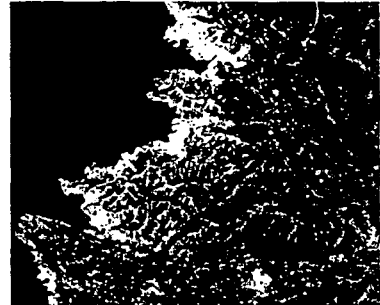
•Surface flows, numerous urban wastewater outlets and one submarine outfall are the main sources of pollution of the coastal sea. Untreated industrial (three hot spots) and urban wastewater in the rivers are among the biggest problems.

•The contribution of land-based sources of pollution situated on the Slovenian coastal zone is much smaller than the overall value for the entire Bay of Trieste. The Italian side contribution must be -also- considered.

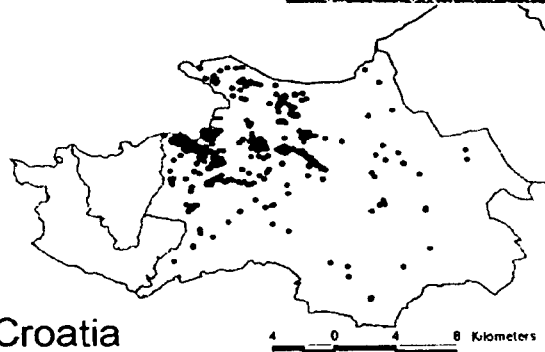


Industrial Area

Industrial activities in the municipality of Koper (Slovenia)



Italy



• industrial activities

Croatia

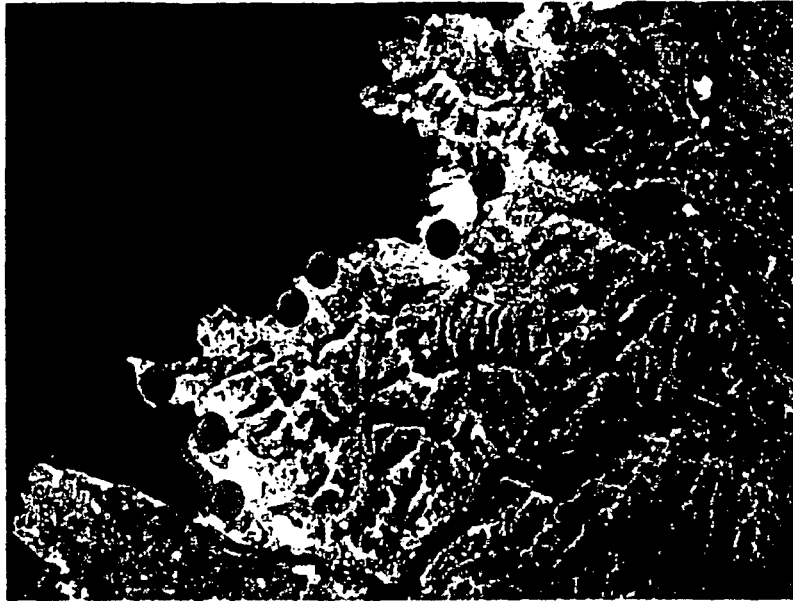
— administrative borders

4 0 4 8 Kilometers

The Study Area is opened to the northern Adriatic Sea in the west, connected with the inland Slovenia in the east and bordering with Italy and Croatia respectively in the north and in the south.



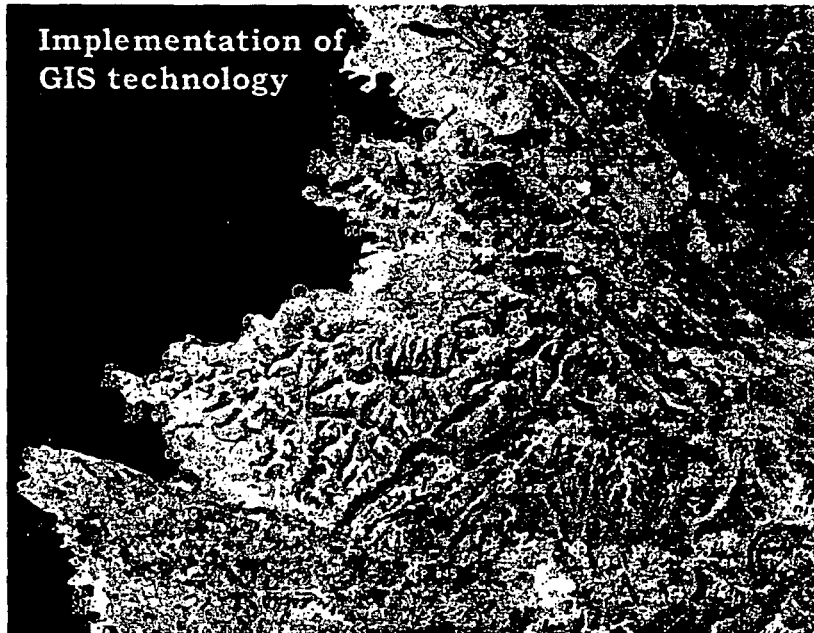
7 hot spots/ 46 Km of coastline



Hot spots in the Slovenian coastal areas
(source MAP/UNEP, 1999)

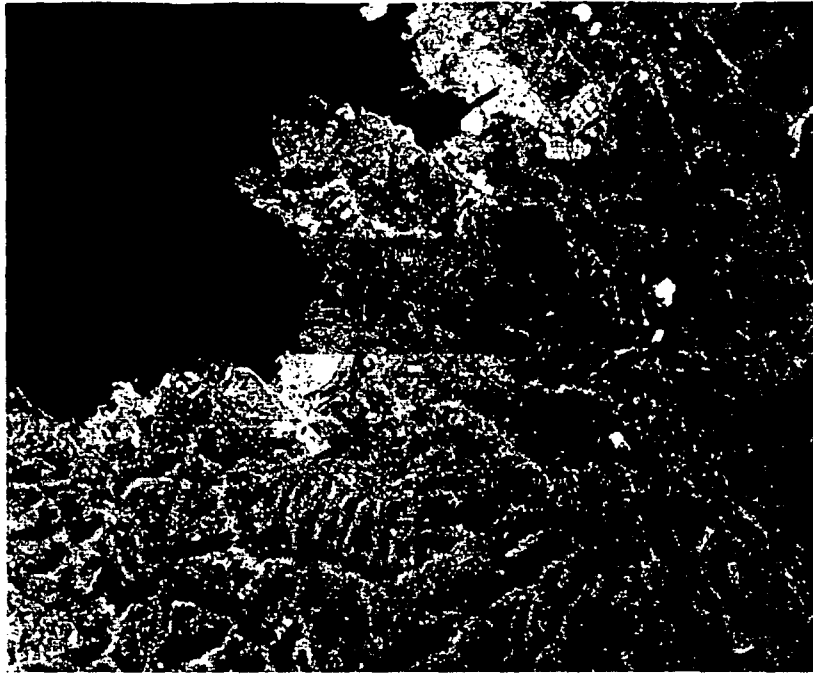
  International Centre
for Science and High Technology

Implementation of
GIS technology

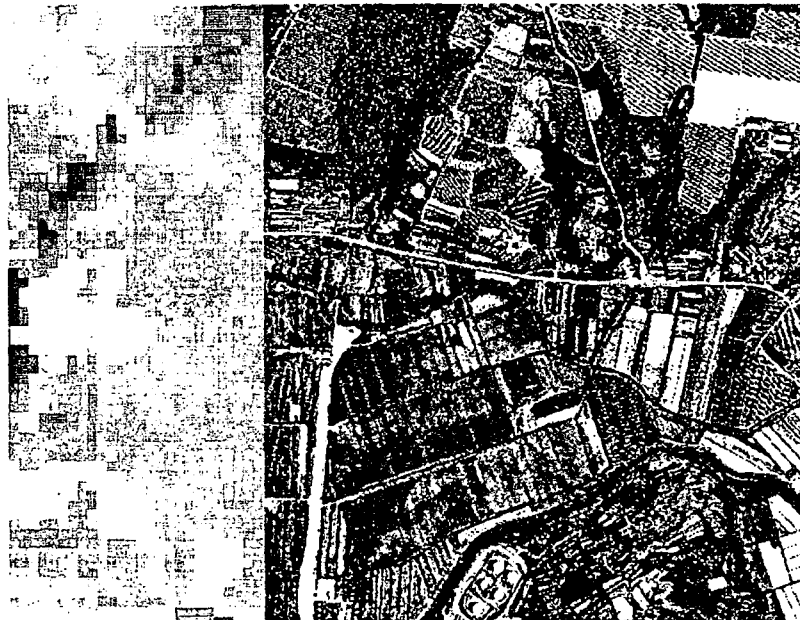


False color composite image of the Slovenian coastal zone
with ground control points (Landsat 5-TM image, summer 1997)

  International Centre
for Science and High Technology



Layer 1: color composite image, Layer 2: orthophoto
(Georeferenced Landsat 5-TM, summer 1997)



Layer 1: false color composite image, Layer 2: orthophoto
(Georeferenced Landsat 5-TM, summer 1997)

Industrial Ecology

Draft for

Industry and Development Related to Mediterranean Basin
Rabat, Morocco 29 October - 3 November

Enrico Feoli
ICS-UNIDO Trieste

Industrial Ecology

1.1 Industrial ecosystem and ecological foot print

Industrial Ecology (IE) has been defined by White (1994) as: "the study of the flows of materials and energy in industrial and consumer activities, of the effects of these flows on the environment, and of the influences of economic, political, regulatory, and social factors on the flow, use and transformation of resources. The objective of industrial ecology is to understand better how we can integrate environmental concerns into our economic activities".

Furthermore:

"IE seeks to optimise the total industrial materials cycle from virgin material to finished product to ultimate disposal of wastes" (Gradel, 1994). According to Frosch (1992) IE is based: "upon a straightforward analogy with natural ecological systems... The system structure of a natural ecology and the structure of an industrial system, or an economic system, are extremely similar".

IE opens a well-defined perspective of looking at the biosphere, it focuses on the industrial production and therefore it offers a clear framework of interactions between industry, economy and the basic environmental variables (in particular what we call resources) of the environmental systems. **IE deals with a multidimensional space in which all kinds of ecosystems are developing their trajectories. This is an ecological space (Feoli and Orloci 1991) that includes the space defined by Tewolde (1982) as technological space.**

IE is analysing the environment within the industrial plants and outside the industrial plants by using a system approach that "can help illuminate useful directions in which the system might be changed" (Richards et al. 1994). As the natural ecosystems the industrial systems should develop in such a way to minimize the sink of waste. For this man has to find technological solutions for using the wastes as resources and/or to change the technology as to minimize the energy and material consumption, i.e. by developing the so-called clean technology (Ehrenfeld 1997). **The overall industrial system of the biosphere is given by all the industrial plants (including mines) that are placed in different states for different historical, political, economical and environmental reasons (resource availability).**

All the industrial plants have strict links with the areas from where raw material, energy, water, labour, information are coming and also with the areas where the products and pollutants are "going". In particular mining has a strict link with the area where the raw material is available. The message of IE is that today we have to deal with the sustainability of industrial systems by integrating the different human systems with environmental system in a very practical context. It means, according to Ehrenfeld (1995) to study "how we humans can continue rearranging Earth, but in such a way as to protect our own health, the health of our natural ecosystems, and the health of future generations of plants and animals and humans".

In this respect Tibbs (1992) proposed seven practical objectives of IE, these are:

- (1) Improving the metabolic pathways of industrial processes and material use**
- (2) Creating loop-closing industrial ecosystems**
- (3) Dematerialising industrial output**
- (4) Systematizing patterns of energy use**
- (5) Balancing industrial input and output to natural ecosystem capacity**
- (6) Aligning policy to conform with long-term industrial system evolution**
- (7) Creating new action-coordinating structures, communicative linkages, and information.**

Ehrenfeld (1995) considers the Tibbs's practical framework a convenient way to organize a complex set of notions into two categories, one strictly containing the

technological elements (objectives (1) to (4)) and the other including the organizational and strategic elements (objectives (5) to (7)). Ehrenfeld focuses its discussion on IE under the perspectives of developing a product policy and suggests guidelines to develop such a policy accordingly. It is obvious that the achievements of the seven objectives will have a strong effects on mining activities. According to **Allenby and Richards (1994)** the production system should be planned in such a way that it would most closely resemble to the natural mature ecosystems (climax ecosystem). In these ecosystems all the materials enter into functional cycles maintaining their structures and functions in such a way that the total production is equal to the total consumption and only heat is dispersed (Richards et Al. 1994, Gradel 1994). If the concept of the industrial system would be consistent with the concept of natural ecosystem it should be self-sustainable also for what the environmental variables are concerned. These are, besides the necessary raw materials on which the products are based, energy, man power, air, water and biodiversity.

Folke (1992) has an approach consistent with IE. He cites a statement of Ulanowicz (1989) written in the review of the Odum's book (1989) "despite all the advances in modern technology, society remains irrevocably dependent upon natural systems for life-support a condition that is unlikely to change in the foreseeable future".

This brings to the concept of industrial ecosystem as the system including all the components that are ensuring the ecological sustainability of the industrial system. For this reason the boundaries between the industrial systems and the other ecosystems (urban, agricultural, natural) are very difficult to be drawn. All the industrial ecosystems are more or less functionally interconnected in the biosphere notwithstanding they may belong to different states, nations, and economies.

The definition of industrial ecosystems has to be done at different

hierarchical levels as it happen for ecosystems. Following the analogy: as in Ecology the definition of the ecosystems is based on the biological structures and functions, in IE the definition of industrial ecosystems must be based on structures and functions of the industrial systems. An industrial system may be defined at the level of a single factory, at the level of a set of factories of the same typology (i.e. food factories, or refineries, etc.), or at the level of set of different factories that are sited in specific industrial settlements (industrial areas, industrial parks, etc.), or sets

of industrial settlements belonging to small administrative units (e.g. municipality), or to administrative units of higher level such as the province or the state. An industrial system may be defined also at the level of set of states, provided interconnections and links are present between the components (e.g. the industrial system of the European Union). In order to plan the so called sustainable development it is necessary to evaluate the self-sustainability of industrial systems defined at different hierarchical levels. Since the concept of self-sustainability is implicit in the concept of ecosystem the definition of any industrial ecosystem is not complete if we do not define the area (portion of the biosphere) sustaining the industrial system under all the ecological point of views. This area is considered by many Authors the ecological foot print of the industrial system (see Wacknagel and Yount 2001). It is analogous to the concept of minimal area in ecology, i.e. the area necessary to support one ecosystem in its complete functionality. We can say that given an industrial system, an industrial ecosystem is automatically defined by the industrial system and by the portion of biosphere necessary to ensure its self-sustainability.

1.2 Ecological industrial carrying capacity and eco-efficiency

The industrial ecosystem is a dynamical entity, it changes according to the market demand and according to technological changes. Similar industrial systems may give origin to different industrial ecosystems. This depends on the type of ecosystems they impact: a refinery in the Gulf of Trieste (North Adriatic Sea) defines a different industrial ecosystem of that defined by a refinery in the Persic Gulf; a mine in the African desert defines a different industrial ecosystem of a mine in the Alps.

The sustainability of a given industrial system by a given area is achieved only if the rate of depletion of renewable resources of the area utilized by the industrial system is lower or equal than the rate of

their renovation. This statement suggests to introduce the concept of ecological industrial carrying capacity of the biosphere as a global concept since the atmosphere and the hydrosphere have not clear boundaries.

To be operative it is necessary to develop an information system capable to evaluate the ecological foot print of all the industrial systems. If the ecological foot print of the total industrial system of the Earth is higher than the area of the biosphere it is logic that the global industrial system is not ecological sustainable. It should be clear that the concept of ecological sustainability is different from the concept of sustainability.

Many argue that mining is by definition a non sustainable activity because the raw material is worked out soon or later. The concept of sustainable development does not consider the product itself it considers its functionality and the possibility of the future generation of utilising such a product in a health environment.

Grubler (1994) conceptualises the industrialization as a "succession of phases, characterized by the pervasive adoption of technology clusters". In this respect he rediscovers the technological space of Tewolde (1982). The cluster is defined as "a set of (interrelated) technological, organizational and institutional innovations driving industrial output and productivity growth". The analogy with the ecological succession is very strict and it is more evident in the following Grubler's statements: "Such a succession is, however not a rigid temporal sequence as various clusters coexist (with changing weights) at any given time. Older technological and infrastructural

combinations coexist with the dominant technology cluster, and in some cases previous clusters (compared to the dominant technology base in the leading industrialized countries) are perpetuated, as was largely the case in the post-World War II industrial policy of the former USSR".

The technology clusters are analogous to the species clusters (species associations) in ecology. In the natural succession the changes of clusters of species is gradual and, in some case of isolation, the succession does not proceed in the same way as in other places. In analogy of what happens in ecology, trajectories of industrial ecosystems can be defined in the multidimensional space given by the variables describing their components. In natural successions the trajectories end in the hyper-volume of equilibrium. This happens when the carrying capacity of the environment is reached, i.e. when the environment is not able to sustain more biomass of what is sustaining.

In analogy with Ecology, where the life cycle of the species and turnover of materials is fundamental to predict the trajectories of ecosystems, in IE it has been introduced the concept of "life cycle" (LC) as the history of products and all the parts of the industrial system (that are also products of the same or other industrial systems) and the system itself, from their "born" to their "death".

In each stage of its life (raw material collection, manufacturing, primary use, secondary use, ..., disposal) a product has a more or less intense and direct or indirect impact on the environment since it occupies space and/or consumes the environmental resources. The reason to study the LC is to get information on how to produce a product by a process design that minimizes the overall environmental impact of the industrial system. It is therefore necessary to integrate the so called **Life-Cycle Assessment (LCA) with the industrial Design For the Environment (DFE)**. This will lead to the development of clean technology application to industrial production processes. There are some examples of applications in Braungart (1994) with the perspective to replace as much as possible the waste management by the product life-cycle management. According to Ehrenfeld (1995) both LCA and DFE require normative inputs to permit weighting and aggregation of impacts along diverse environmental axes that "address" the trajectories of the industrial systems in the direction of a higher eco-efficiency.

The concept of eco-efficiency can have only a relative meaning in the sense that we can only say that one industrial system, out of a set of systems considered equivalent (for technological or economical reasons), is more eco-efficient than the others. This eco-efficiency can be measured by the amount of resources of any kind consumed for the sustainability of the corresponding industrial ecosystem. On such a basis a parameter of the eco-efficiency is the minimal area of the industrial ecosystem (its ecological foot print). It follows that the ecological efficiency of an industrial system is improving when the minimal area for its self-sustainability is decreasing.

Reducing the minimal areas of industrial ecosystem should be the target of international and national environmental policy. According to Ehrenfeld (1994,1995) the product policy should play an important role in the implementation of industrial ecology by creating favourable framework of institutions supporting the sustainable industrial development.

A major policy challenge should be "to discover ways to get beyond price as the only means of coordinating actions in the market. Green consumerism is claimed to be a powerful new force for bringing about changes in corporate strategies and forcing product innovation. ... Individual choice can be transformed, in a broad cultural sense, through education about the relationship of environment to our survival and through the development of increased competence in taking a more critical stance toward the way we value nature".

The life-cycle assessment is one of the applications of IE that would help the industrial enterprises within an industrial system to conform their standards with ISO14000 (Marcus and Willig 1997). The ISO 14000 are a set of evolving guidelines that are supposed to help the industrial systems to improve their ecological efficiency. However other perspectives have to be introduced from IE. These need education and new research directions. Stahel (1994) suggests a shift to an economy that sells the functionality of products rather the products themselves to decelerate materials flow. Another practice that should be used in this direction is the reuse of the product as much as possible before recycling. These suggestions require to introduce strategies into the economy that demand a change in "the mind-set of corporations and government. However, these strategies are themselves long term and

are here to stay, once established. For strategic reasons, dynamic companies should therefore try to be the first in their field of activity to change" (Stahel 1994).

Notwithstanding ISO 14000, the 1992 UNCED conference, the 1997 Kyoto conference, etc., the application of clean technology to the industrial system is still a slow process. It is particularly slow in mining activities where there is not clear what are the actions that can be substitute by cleaner technology. As a consequence of this slowness, today we are still pressed to find solutions that are related to end-of-pipe pollution treatment and waste management.

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**Use of GIS, RS and DSS for the
environmental management
of coastal areas**

(CASE STUDIES PRESENTATION)

**Case Study for the coastal areas of the region
of Tunis- Bizerte, Tunisia**

M. Ghribi

INTRODUCTION



The Tunisian coastline has for years seemed infinite in its capacity to support human pressures, hosting a variety of activities including habitation, recreation, industrialization, tourism and shipping among others.

This concentration of resource-use, stemming from activities of socio-economic nature, is giving rise to a series of environmental problems linked to the extreme fragility of coastal ecosystems and non-rational resource use that are the main causes of environmental degradation.

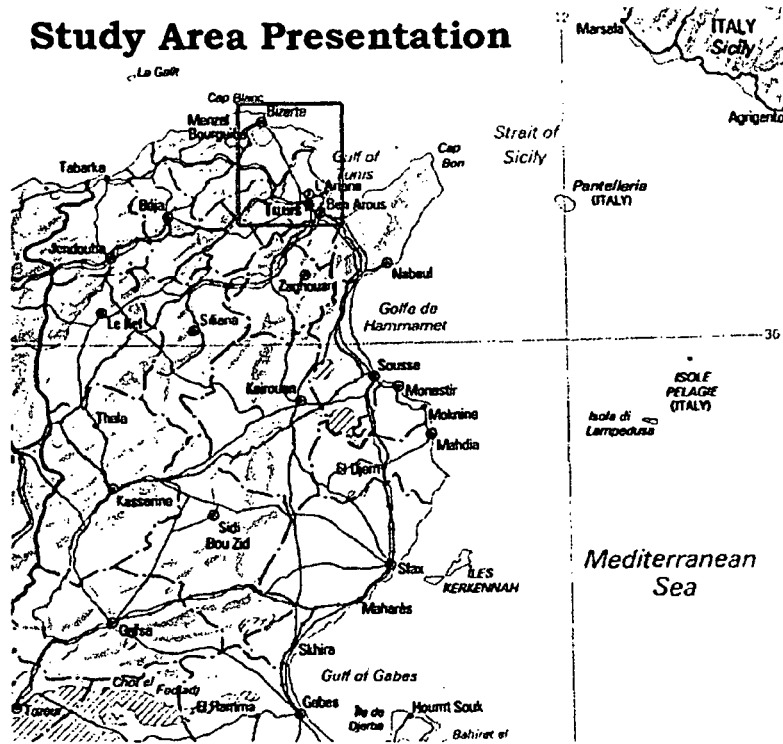


High expectations are now required of an Integrated Information Technology (IT) including Geographic Information Systems (GIS), Remote Sensing, Networking and Internet facilities for developing a planning system, which aims to accommodate multiple and often conflicting activities on the coast.

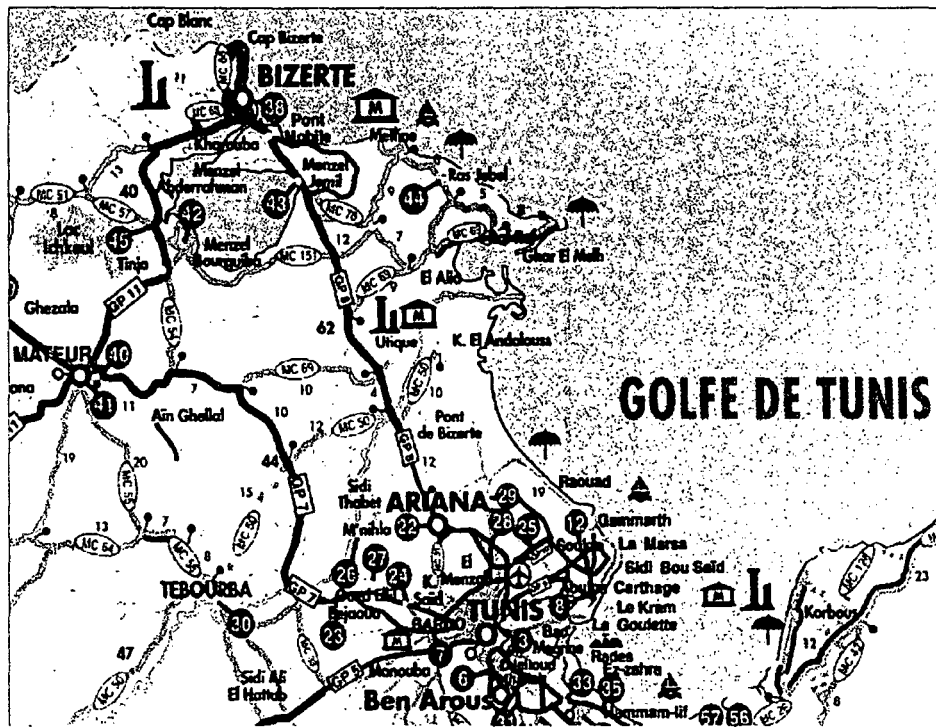
As a contribution to decision-making, the present work provides a Multi-Criteria Evaluation for Urban Management and Industrial Siting in Tunisia.

Study Area Presentation

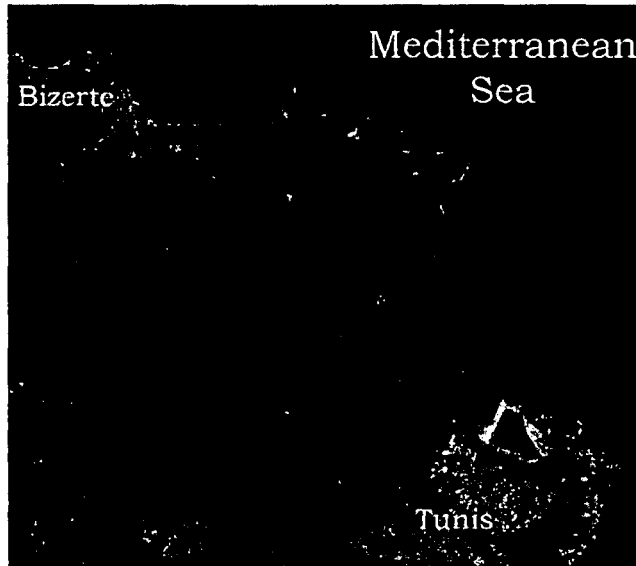
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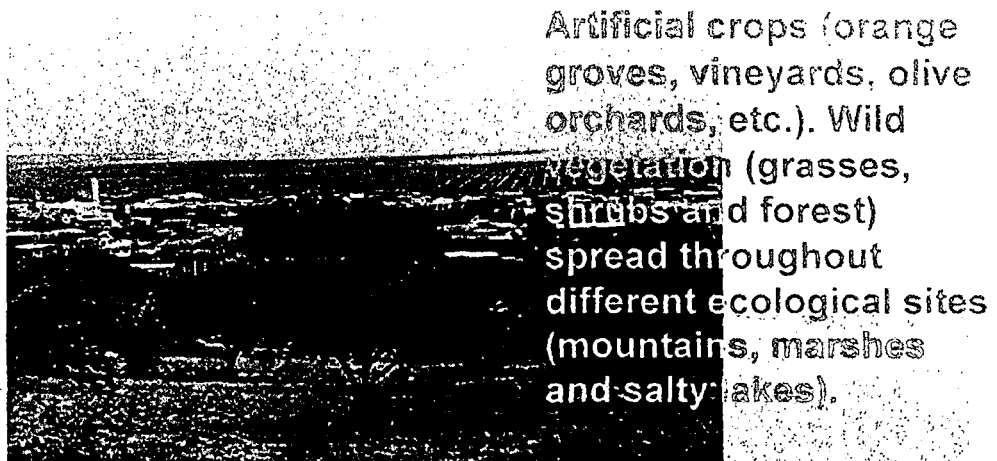



Selection Criteria



Landset Thematic Mapper (Sep-97)

1. It is a Mediterranean Coastal Area



2. The Area encompasses multiple patterns of vegetation biodiversity





3. A continuous and frequently spontaneous Urban settlement



4. A large set of Industrial activities

Multi-Criteria Evaluation for Industrial Siting

Concept

Decisions about the siting of industries typically involve the application of Multi-Criteria Algorithm based on logical PAIRWISE comparison.

GIS offers the opportunity to apply decision-making processes in a more enhanced and integrated context.

Aim

To design suitability map of industrial sensitivity of the coastal zone of the region Tunis-Bizerte.

Methodology

Investigation of interactive effects by contributing factors and constraints that may enhance or decrease industrial susceptibility.

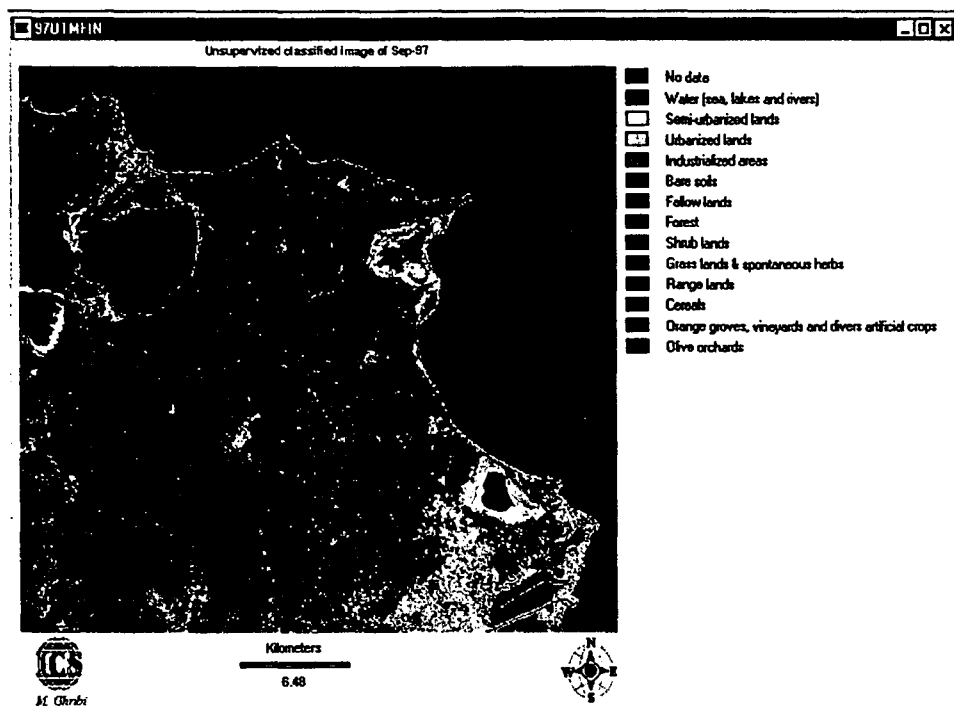


Factors contributing to the change of industrial susceptibility include:

- Proximity to main industrial sites
- Proximity to main residential sites
- Proximity to main roads
- Proximity to water (sea, lakes and rivers)
- Proximity to protected forest & national parks
- Proximity to bares lands

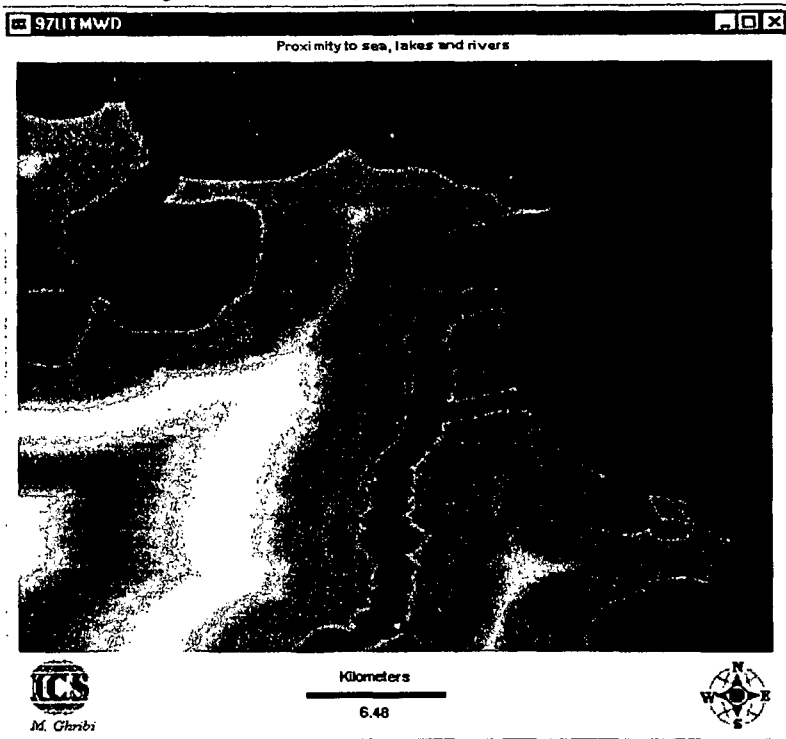
The output will consist of a number of categories, each reflecting its susceptibility to the installation of new industries.

Classified Landsat image of Sep-97



Proximity to water (sea, lakes and rivers)

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Summary information from Weight

The eigenvector of weights is :

97UTMUDS : 0.2809
 97UTMIDB : 0.2809
 97UTMRDB : 0.1029
 97UTMWD : 0.0385
 97UTMFD : 0.0463
 97UTMBDB : 0.2505

Consistency ratio = 0.02
 Consistency is acceptable.

The principal eigenvector of weights resulting from PAIRWISE comparison between factors

WEIGHT - AHP Weight Derivation

Pairwise Comparison 9 Point Continuum Scale

1/9 1/7 1/5 1/3 1 3 5 7 9

Extremely Less Important Moderately Equally Moderately Strongly Extremely More Important

	Urban	Industry	Roads	Water	Forest	Bare Soil
97UTMUC:1						
97UTMID:1	1					
97UTMR:1/3	1/3	1				
97UTMW:1/7	1/7	1/3	1			
97UTMF:1/7	1/7	1/3	1	1		
97UTMB:1	1	3	7	3	1	

Compare the relative importance of 97UTMIDB to 97UTMUDS

Calculate weights...

The continuous rating scale used for the PAIRWISE comparison between factors

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 for Science and High Technology


Multi-Criteria Evaluation procedure

MCE - Multi-Criteria Evaluation

MCE procedure to be used:

Boolean Intersection
 Weighted Linear Combination
 Ordered Weighted Averaging

Number of constraints:

Number of factors:

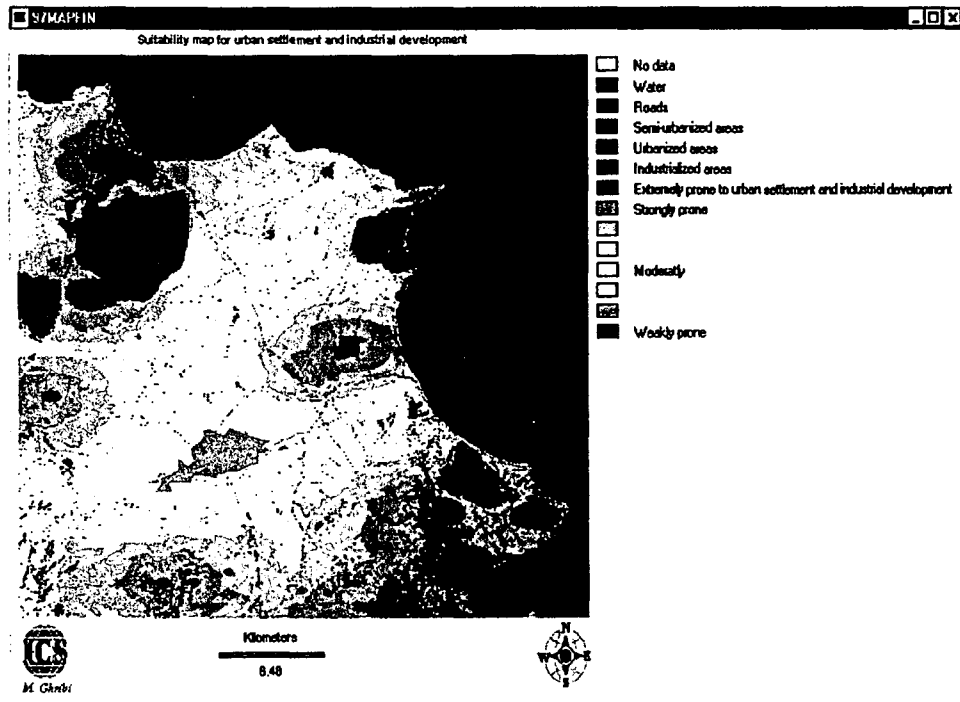
Factor 1:	S7UTMUD8	Factor weight 1:	0.2809
Factor 2:	S7UTMID8	Factor weight 2:	0.2809
Factor 3:	S7UTMRD8	Factor weight 3:	0.1029
Factor 4:	S7UTMWD8	Factor weight 4:	0.0365
Factor 5:	S7UTMFD8	Factor weight 5:	0.0463

Output image:

Output image title:

Buttons: OK, Save parameters, Retrieve parameters, Cancel, Help

Industrial siting suitability map



Multi-Criteria Evaluation for Urban settlement

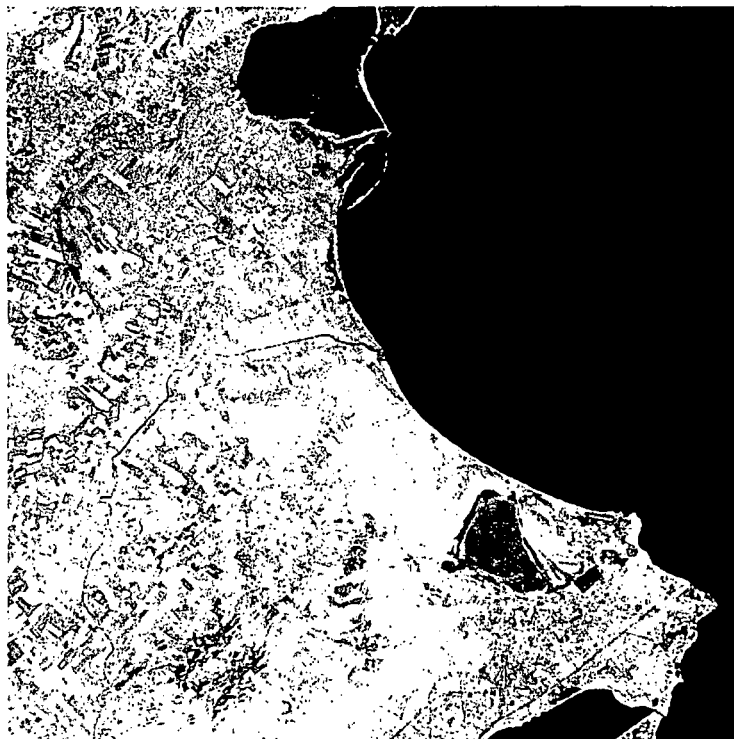
The aim is to allocate prone lands for urbanization according to:

*** Some factors;**

1. Proximity to Residential sites (urban areas and commercial centers...)
2. Proximity to Industrial zones
3. Proximity to Main roads
4. Proximity to Rivers
5. Proximity to water points (lakes and sea)
6. Elevation

*** Some constraints;**

Reserved lands (Urban, beaches, Water and Salty lake) are excluded



LANDSAT Thematic Mapper, September 1997

Proximity to Coast Areas

International Centre
for Science and High Technology



M. Oterbi

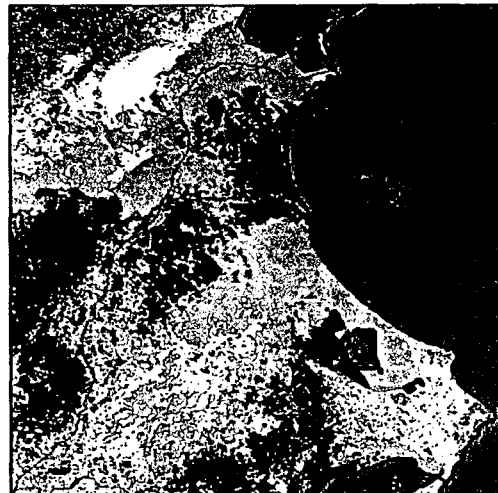
Kilometers

8.76



Preliminary Suitability Map

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M. Oterbi

Kilometers

8.76

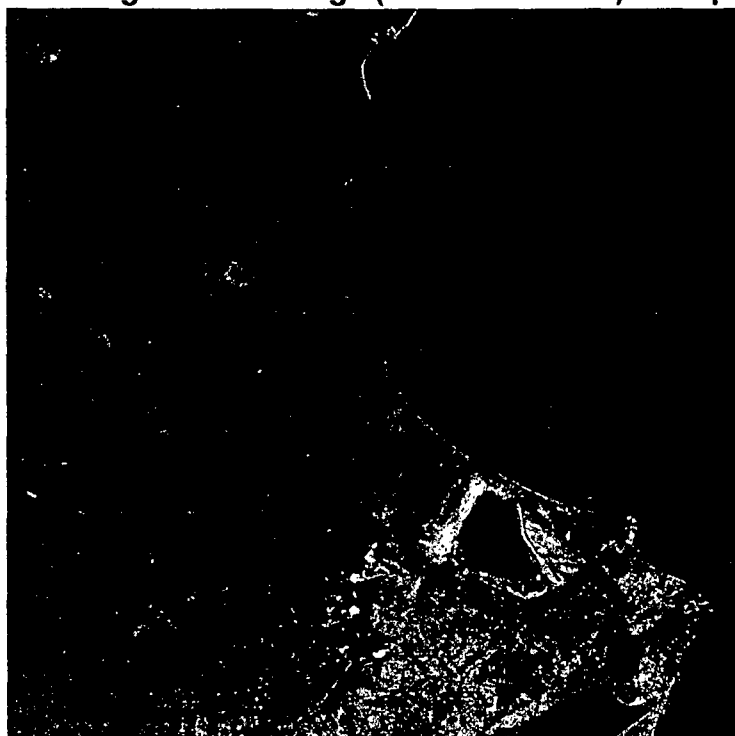


Hazardous waste analysis

Purpose

The aim is to improve the decisions concerning prioritization of sites for a remedial response to hazardous waste. In course to achieve this goal a cluster analysis was made to reflect the degree of similarity between the main industrial sites.

Identification of Main Industrial Sites using satellite image (LANDSAT 5 TM) of September 1997

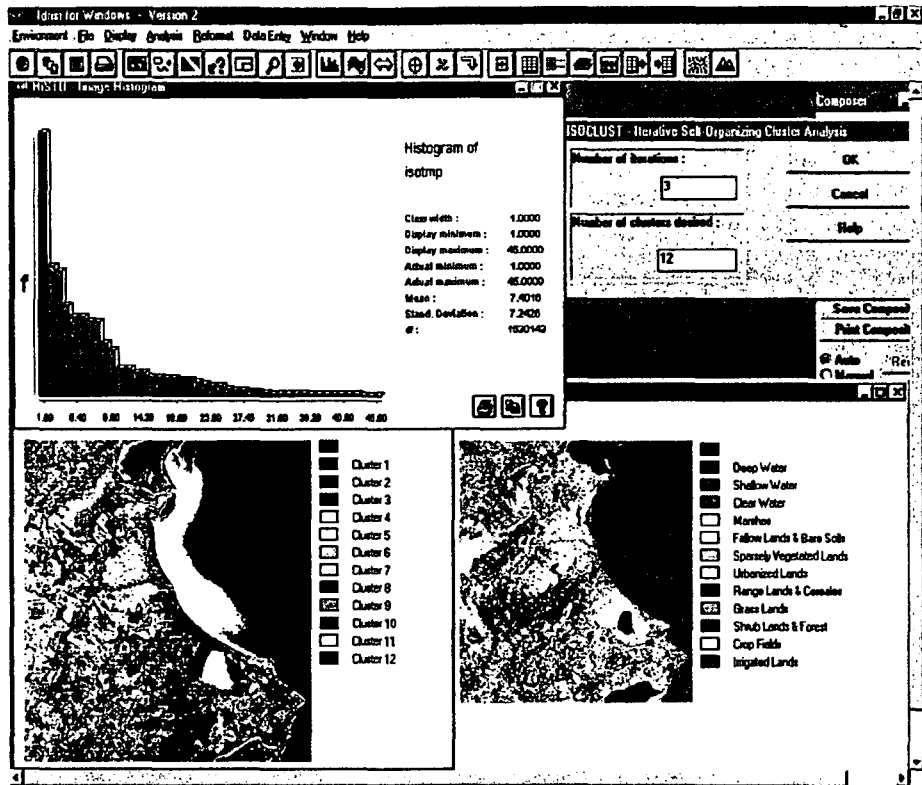


- 1: Ariane
- 2: Echerguia
- 3: Mannouba
- 4: Ettadhamen
- 5: Douer Hicher
- 6: El Mnhle
- 7: Kalaat Andalous

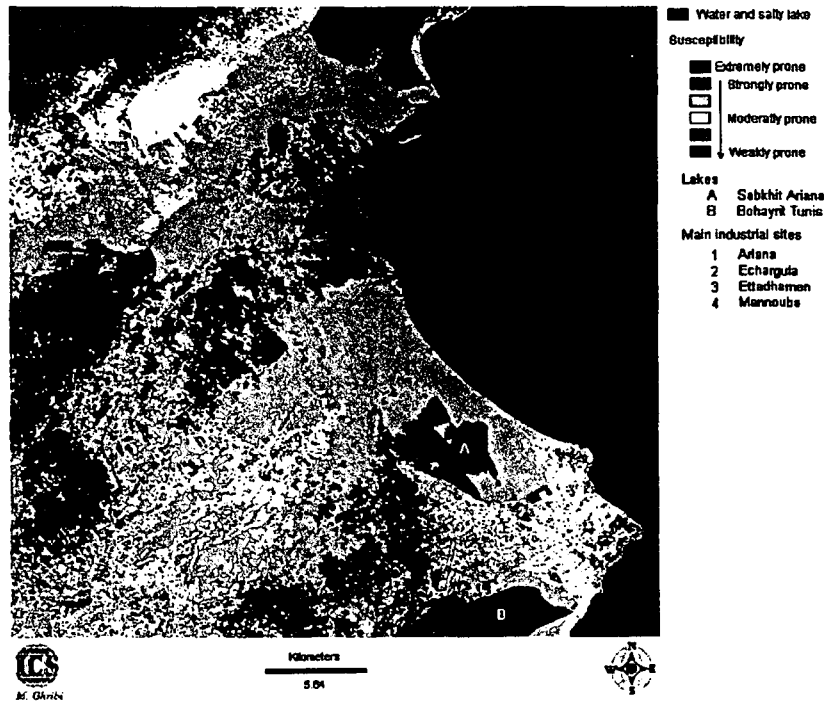


100meters

5.04



Final Suitability Map



Matrix B (Activity, Potential Impact)

	Sludge containing heavy metals	Pesticides & manure / contaminated filters	Building and soil material	Solvents/hydrocarbons/residues/sludge/leakage aqueous waste	Wide range of hazardous materials usually in relatively small quantities Domestic or industrial										
Textile & Garment / Leather & shoes	1	0	0	0	0	1	0	1	0	0	1	0	0	1	0
Agro-alimentary	0	1	0	0	0	1	1	0	0	0	1	1	0	0	1
Mechanical & Electrical	1	0	0	0	0	1	0	0	0	1	1	0	0	1	0
Construction materials / Glass & ceramics	0	0	1	0	0	1	0	1	0	0	1	0	0	1	0
Chemical	1	0	0	1	0	1	0	1	1	0	1	0	1	0	1
Miscellaneous	0	0	0	1	1	1	1	1	1	1	1	0	1	1	1

Matrix AB = Matrix A x Matrix B (Industrial Sites, Potential Impact)

	Sludge containing heavy metals	Pesticides & manure / contaminated filters	Building and soil material	Solvents/hydrocarbons/residues/sludge/leakage aqueous waste	Wide range of hazardous materials usually in relatively small quantities Domestic or industrial										
Ariana	41	16	3	44	13	73	29	47	15	23	73	16	15	55	31
Echarguia	180	73	13	189	53	319	126	202	64	97	319	73	64	235	137
Marnouba	44	17	4	46	13	78	30	50	16	24	78	17	16	58	33
Ettadhamen	26	12	3	28	8	49	20	31	9	14	49	12	9	36	21
Douar Hicher	62	26	5	66	19	112	45	71	23	34	112	26	23	82	49
El Mrihla	14	6	1	16	5	26	11	17	6	8	26	6	6	19	12
Kalaat Andalous	8	3	1	9	3	15	6	10	4	5	15	3	4	11	7

Existing activities per main industrial sites

	Activity									
	Textile & Garment / Leather & shoes	Agro-alimentary	Mechanical & Electrical	Construction materials / Glass & ceramics	Chemical	Miscellaneous	Pharmaceutical works	Hospital and medical clinics	Municipal or industrial landfills	Scientific laboratories etc...
Industrial sites										
Ariana	29	16	10	3	2			13		
Echarguia	125	73	44	13	11			53		
Mannouba	30	17	11	4	3			13		
Ettadhamen	19	12	6	3	1			8		
Douar Hicher	43	26	15	5	4			19		
El Mnihla	10	6	3	1	1			5		
Kalaat Andalous	5	3	2	1	1			3		
Typical hazardous waste	Sludge containing heavy metals	Pesticides & manure / contaminated filters	Sludge containing heavy metals	Building and soil material	Solvents/halogenated residues/sludge/tars aqueous waste	Halogenous & halogen free solvents	Infectious waste, radioactive material	Domestic or industrial wastes	Wide range of hazardous materials usually in relatively small quantities	
Nature of hazards	Pollution by toxic	Pollution by toxic/infection	Pollution by toxic	Pollution by toxic & odorous substances	Fire/ explosion/ pollution by toxic	Pollution by toxic	Pollution by toxic/micro-organisms/radiation	Fire/explosion/ pollution by toxic	Pollution by toxic/infection/radiation	
Potential impact	Soil and water contamination	Soil and water contamination, bio-accumulation & persistence in environment	Soil and water contamination	Soil and water contamination	Soil, water & air contamination	Soil, water & air contamination	Soil and water contamination	Soil, water & air contamination	Soil, water & air contamination	
Potential health impacts	Chronic & acute illnesses through intake of pollutants through water supply and food chain	Chronic & acute illnesses through inhalation and intake of pollutants through water supply and food chain	Chronic & acute illnesses through intake of pollutants through water supply and food chain	Chronic & acute illnesses through intake of pollutants through water supply and food chain	Chronic & acute illnesses through inhalation and intake of pollutants through water supply and food chain	Chronic & acute illnesses through intake of pollutants through water supply and food chain	acute illnesses through inhalation and intake of pollutants through water supply and food chain	Chronic & acute illnesses through inhalation and intake of pollutants through water supply and food chain	Chronic & acute illnesses through inhalation and intake of pollutants through water supply and food chain	

Tunisian Ministry of International Cooperation and External Investment (1998) Inventory.

IAEA (1996) Manual for the classification and prioritization of risks due to major accidents in process and related industries, International Atomic Energy Agency (IAEA).

Matrix A (Industrial sites, Activity)

	Activity					
	Textile & Garment / Leather & shoes	Agro-alimentary	Mechanical & Electrical	Construction materials / Glass & ceramics	Chemical	Miscellaneous
Industrial Sites						
Ariana	29	16	10	3	2	13
Echarguia	125	73	44	13	11	53
Mannouba	30	17	11	4	3	13
Ettadhamen	19	12	6	3	1	8
Douar Hicher	43	26	15	5	4	19
El Mnihla	10	6	3	1	1	5
Kalaat Andalous	5	3	2	1	1	3

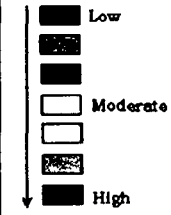
Potential impact for each industrial site



Industrial Sites

- 1: Ariana
- 2: Echerguia
- 3: Mannouba
- 4: Ettadhemen
- 5: Douar Hicher
- 6: El Mnihla
- 7: Kalaat Andalous

Potential Impact

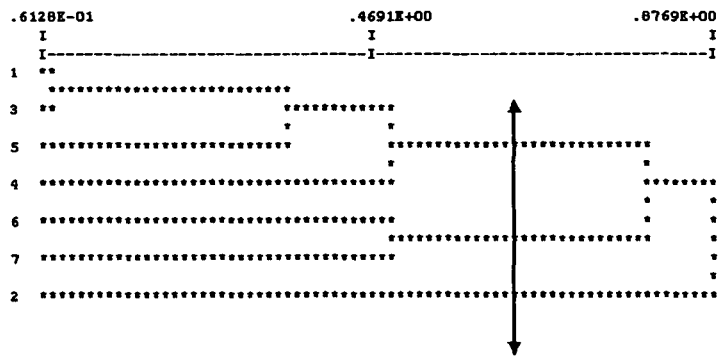


Kilometers

5.84

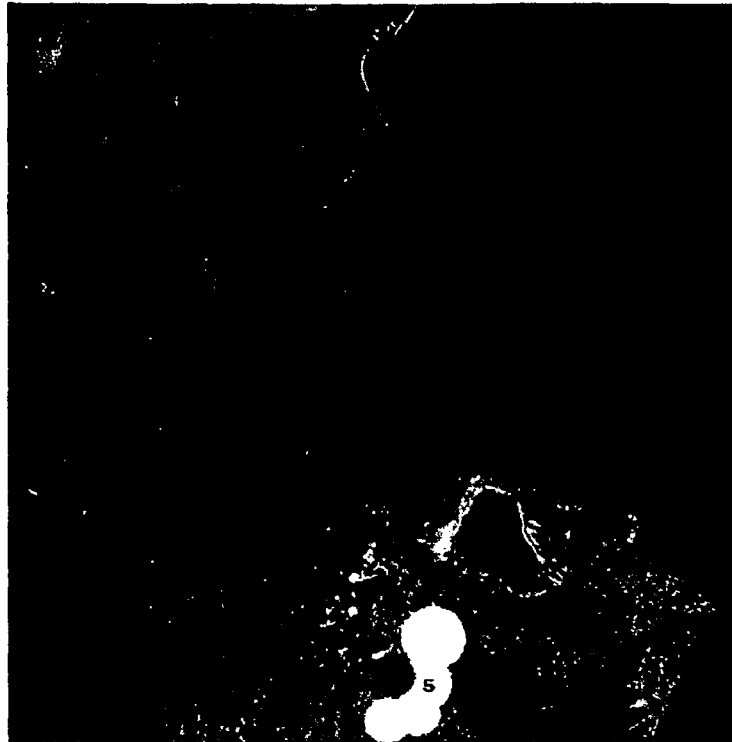
Hierarchical clustering classification

Dendrogram of objects



1. Ariana
2. Echerguia
3. Mannouba
4. Douar Hicher
5. Ettadhemen
6. El Mnihla
7. Kalaat Andalous

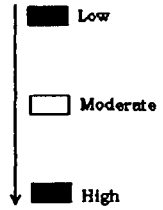
Potential impact per each cluster



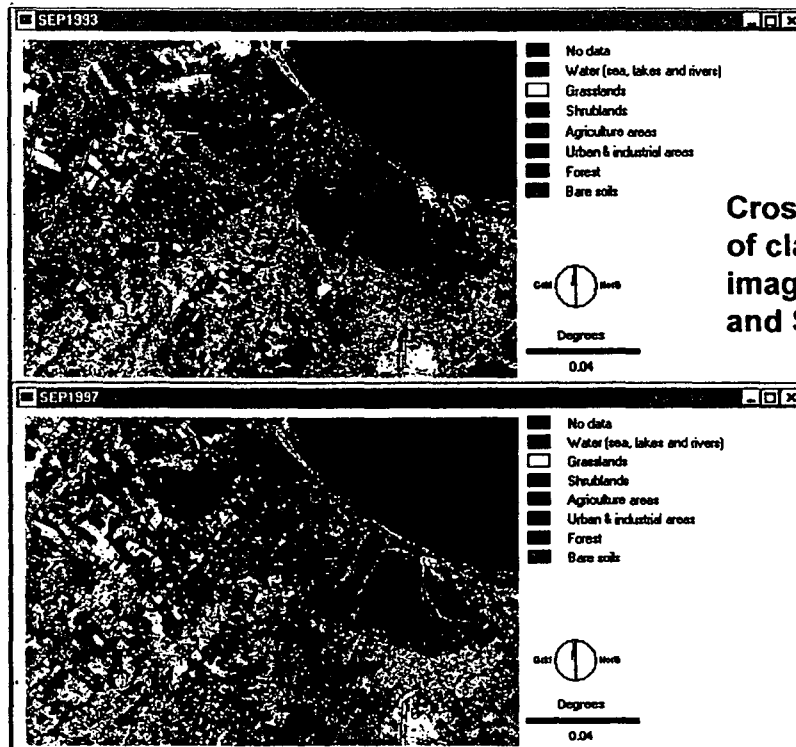
Industrial Sites

- 1: Ariana
- 2: Echerguia
- 3: Mannouba
- 4: Ettadhemem
- 5: Douar Hicher
- 6: El Mnhla
- 7: Kalat Andalous

Potential Impact



Kilometers
5.84



Cross Tabulation of classified images of Sep93 and Sep97

Crosstabulation of Sep1993 (columns) against Sep1997 (rows)

	1	2	3	4	5	6	7	Total
1	93835	178	240	4	0	358	2241	96856
2	295	37062	14339	14542	0	13002	591	79831
3	262	31067	53305	38635	0	5888	4123	133279
4	43	6681	7082	42180	0	3787	110	59883
5	2	2025	7268	21878	43757	716	436	76032
6	1733	9962	1992	2111	0	17207	892	33897
7	868	4883	4824	403	0	1704	9484	22156
Total	97028	91858	89050	119753	43757	42662	17876	501864

- Legend**
- 1 Water (sea lakes and rivers)
 - 2 Grasslands
 - 3 Shrublands
 - 4 Agriculture lands
 - 5 Urban & industrial areas
 - 6 Forest
 - 7 Bare soils

Chi Square = 1032103.75
df = 36
Cramer's V = 0.5854

Proportional Crosstabulation

	1	2	3	4	5	6	7	Total
1	0.1889	0.0004	0.0005	0	0	0.0037	0.0045	0.1929
2	0.0006	0.0738	0.0286	0.029	0	0.0259	0.0012	0.159
3	0.0005	0.0619	0.1062	0.077	0	0.0117	0.0082	0.2855
4	0.0001	0.0133	0.0141	0.084	0	0.0075	0.0002	0.1193
5	0	0.004	0.0145	0.0436	0.0872	0.0014	0.0009	0.1516
6	0.0035	0.0198	0.004	0.0042	0	0.0343	0.0018	0.0675
7	0.0017	0.0097	0.0096	0.0008	0	0.0034	0.0189	0.0441
Total	0.1933	0.183	0.1774	0.2386	0.0872	0.085	0.0356	1

Multi-Objective Decision Making in GIS

Aim

Solving a multi-objective land allocation problem with conflicting objectives.

Procedure

Based on the information from two suitability maps, we attempt to maximize the suitability of lands for each objective given the weights assigned.

Objectives

- .To find lands that are best for industrial development
- .To protect lands for forestation

Conflict

Since lands can be allocated to only one of these two uses, the objectives are viewed as conflicting.

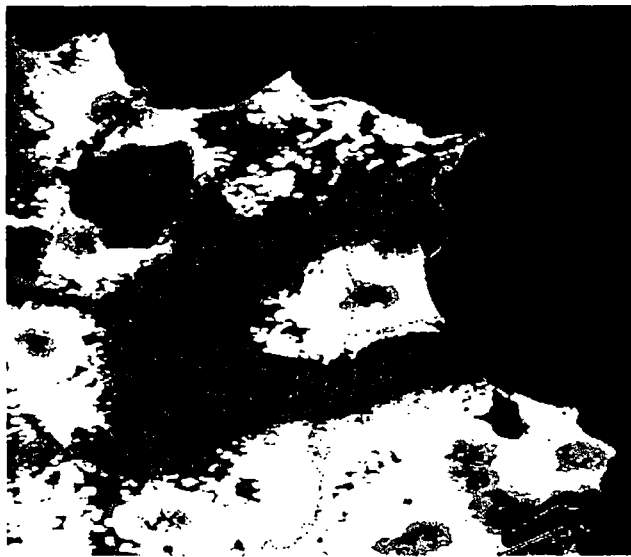
Data Requirements

2 ranked suitability maps for each objective that have been produced by means of the multi-criteria evaluation.

Objective 1: To find lands that are best suited for industrial development

International Centre
for Science and High Technology





- Water (sea, lakes and rivers)
- Extremely prone to industrial development
- Strongly prone
- Moderately prone
- Weakly prone



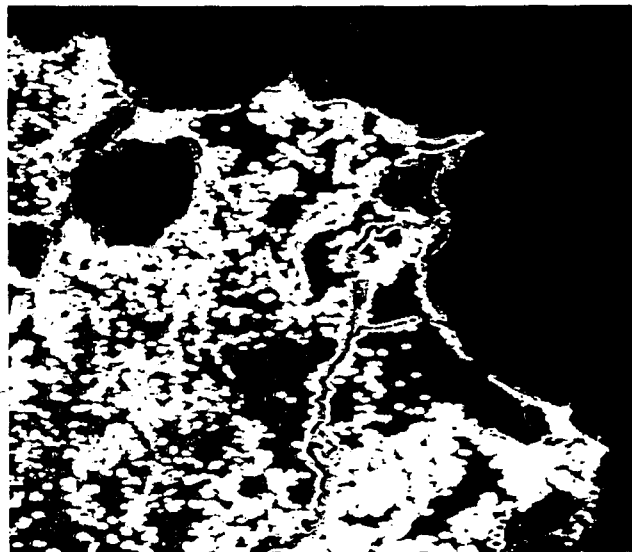
Industrial suitability map

Kilometers
6.48

Objective 2: To protect lands that are best for forest

International Centre
for Science and High Technology





- Water (sea, lakes and rivers)
- Extremely prone to forestation
- Strongly prone
- Moderately prone
- Weakly prone



Suitability map for forestation

Kilometers
6.48

Solving the Multi-Objective Land Allocation problem

International Centre
for Science and High Technology



Best allocated lands for forestation

Kilometers

6.48

Case study in India

S. Betapudi

Study Area

South India

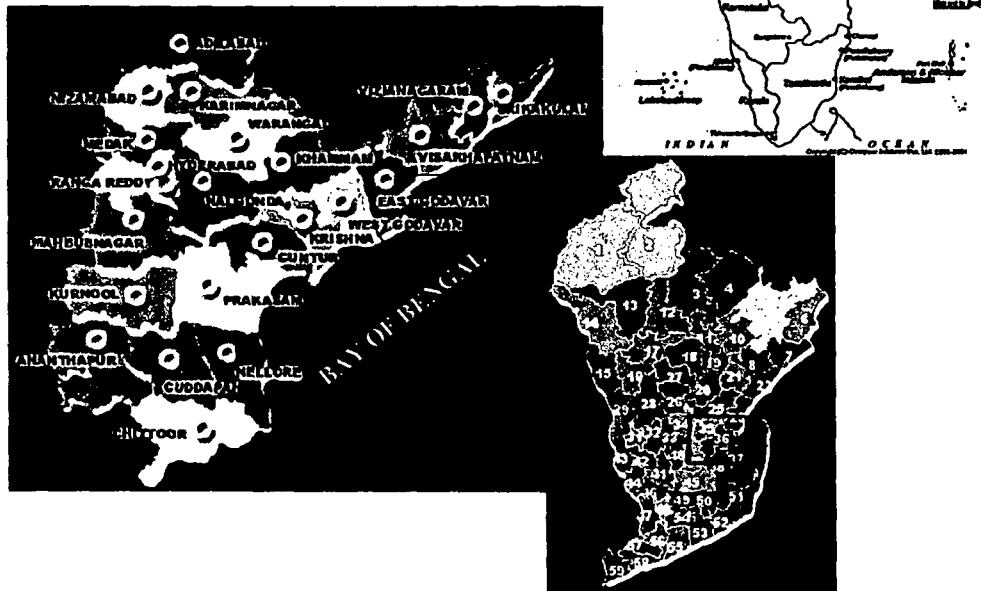


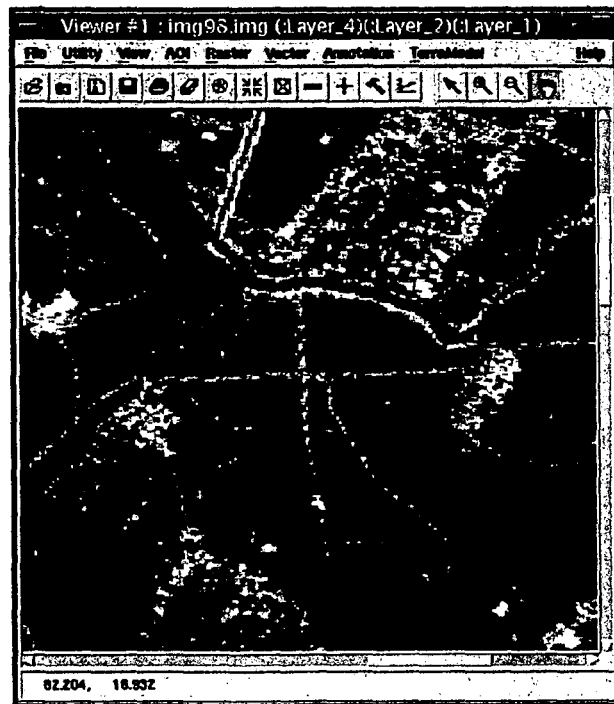
Image Processing



- Image processing
 - Geometric correction
 - Image enhancement
 - » Spectral
 - » Spatial
 - » Fourier analysis
- Image classification
 - Unsupervised
 - Supervised
 - NDVI Classification

Contd.....

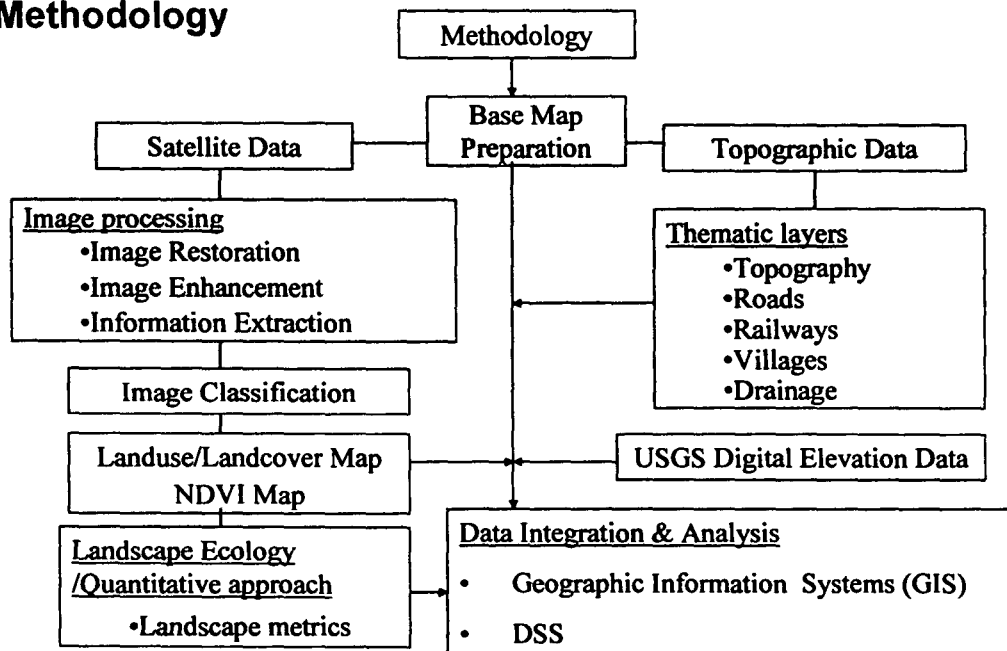
IRS 1C LISS-III image of 17th Feb. 1998



The Data

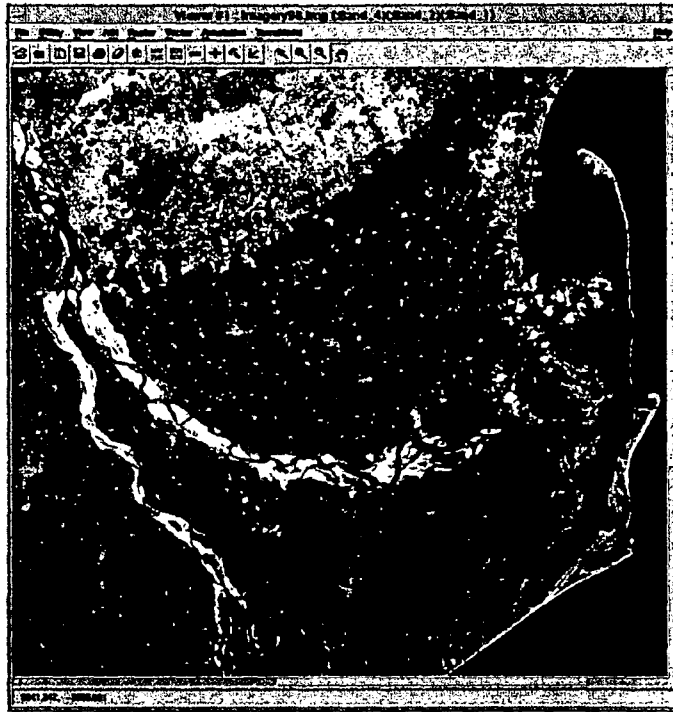
- Indian Remote Sensing Satellite (IRS 1-C) Linear Imaging Self-Scanner (LISS-III) 23.5m resolution 4 bands image data
 - 12th February 1999 image
 - 17th February 1998 image
 - 03rd January 1997 image
- NOAA-AVHRR NDVI 1.1KM data
 - 1992 to 1996
- USGS Digital Elevation data
- Survey of India toposheet No: 65L/5
- Ancillary data

Methodology



Cond.....

The Godavari Delta -IRS LISS-III imagery



Objectives

- To study the land use and land cover dynamics over the years
- A quantitative study of landscape ecology/metrics
- Assessing the land use and land cover variations using landscape metrics
- To study the impact of anthropogenic activities on the LUCC dynamics

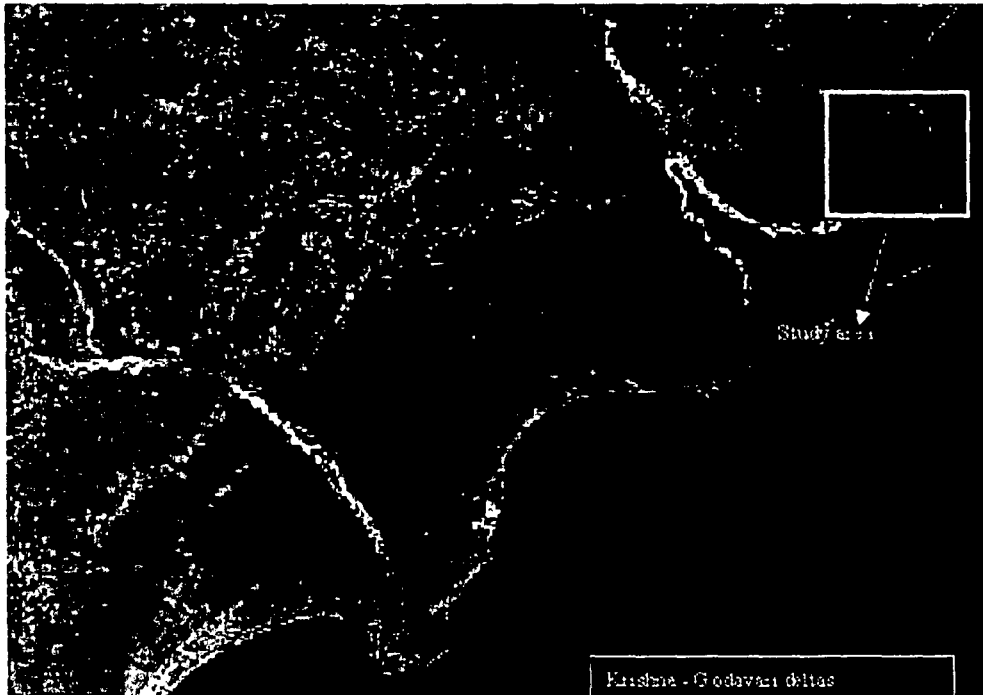
Godavari delta

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Krishna - Godavari Deltas

UNIDO
International Centre
for Science and High Technology



Rectified image

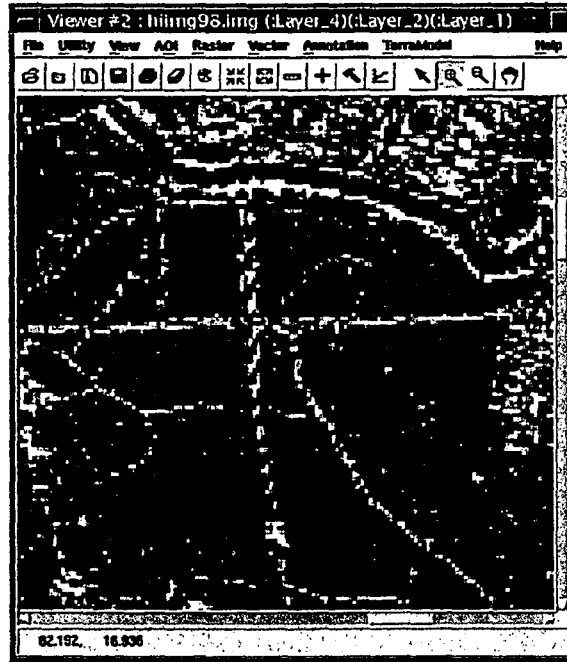








Image Classification - Training sites

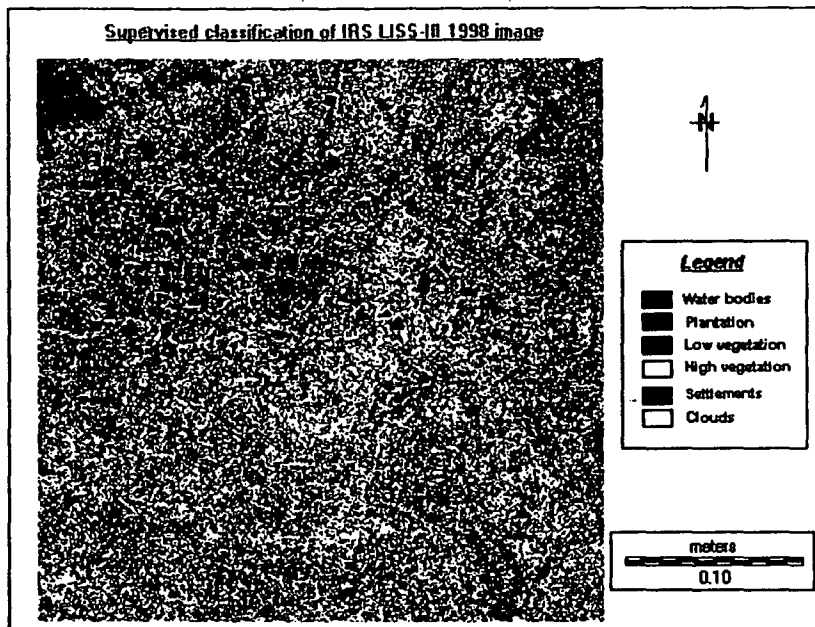
Signature Editor (98sig.sig)

File Edit View Evaluate Feature Classify Help

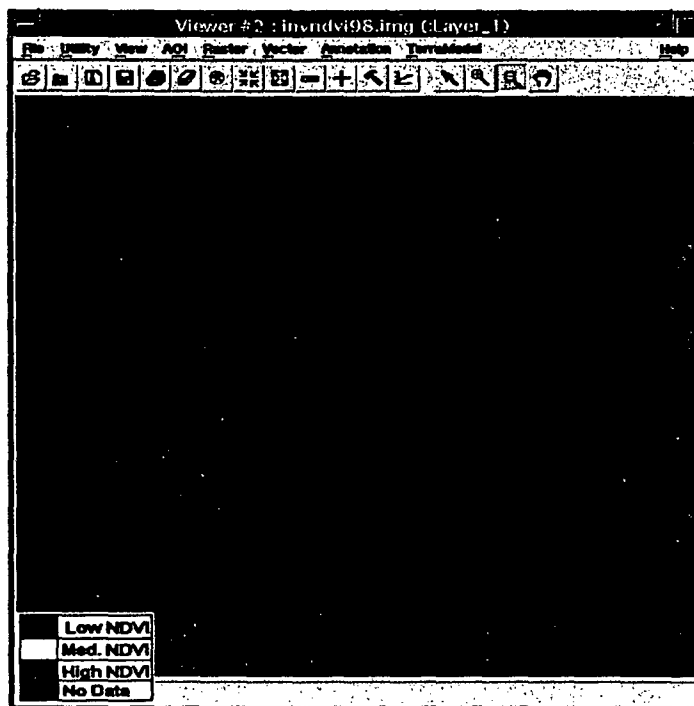
Class #	>	Signature Name	Color	Red	Green	Blue
1	>	water		0.000	0.000	1.000
2		settlements		0.000	1.000	1.000
3		plantation		1.000	0.000	0.000
4		high vegetation		0.000	0.392	0.000
5		low vegetation		0.000	1.000	0.000
6		clouds		1.000	1.000	1.000

The Signature Editor Cellarray

Supervised Classification

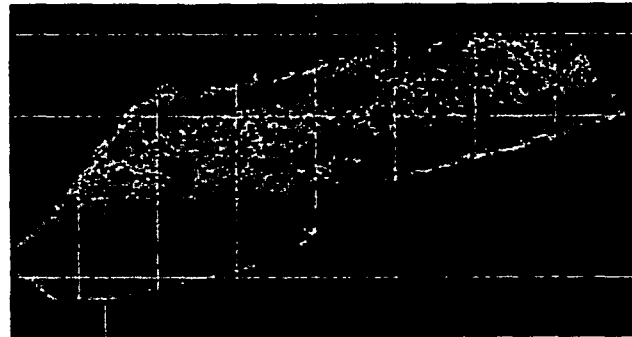


NDVI Classification



DEM Generation

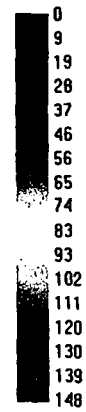
Orthoimage generated by using DEM (USGS)



meters
100.56



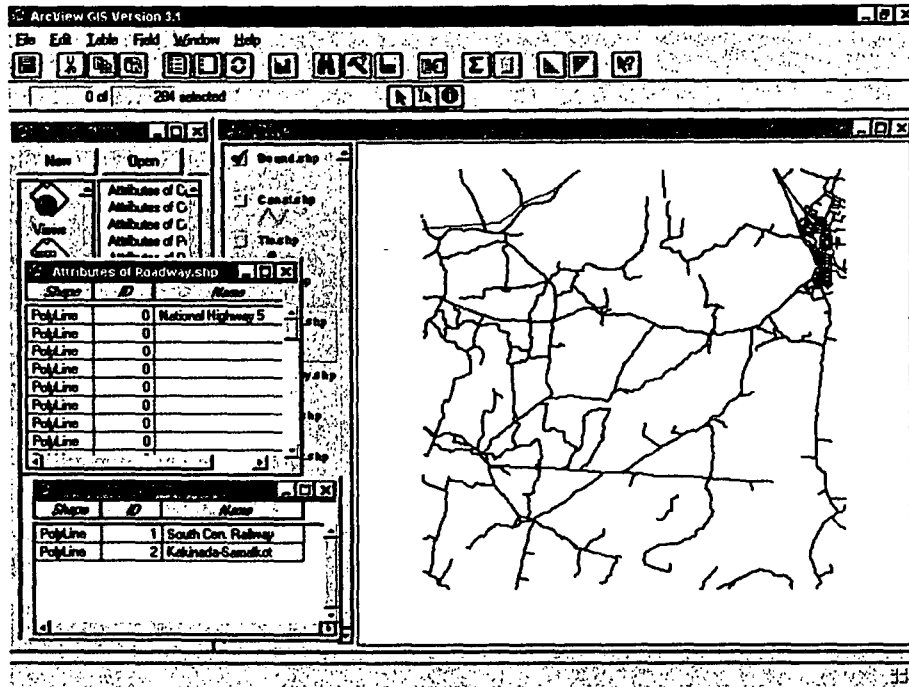
NDVI



Geographic Information Systems(GIS)

- Data base generation
 - Base map preparation
 - Scanning
 - Rectification & mosaicing
 - On Screen digitization
 - » Arcview
- Topology
 - Error rectification
 - Building
 - Attribute assignment

Railway and Road map

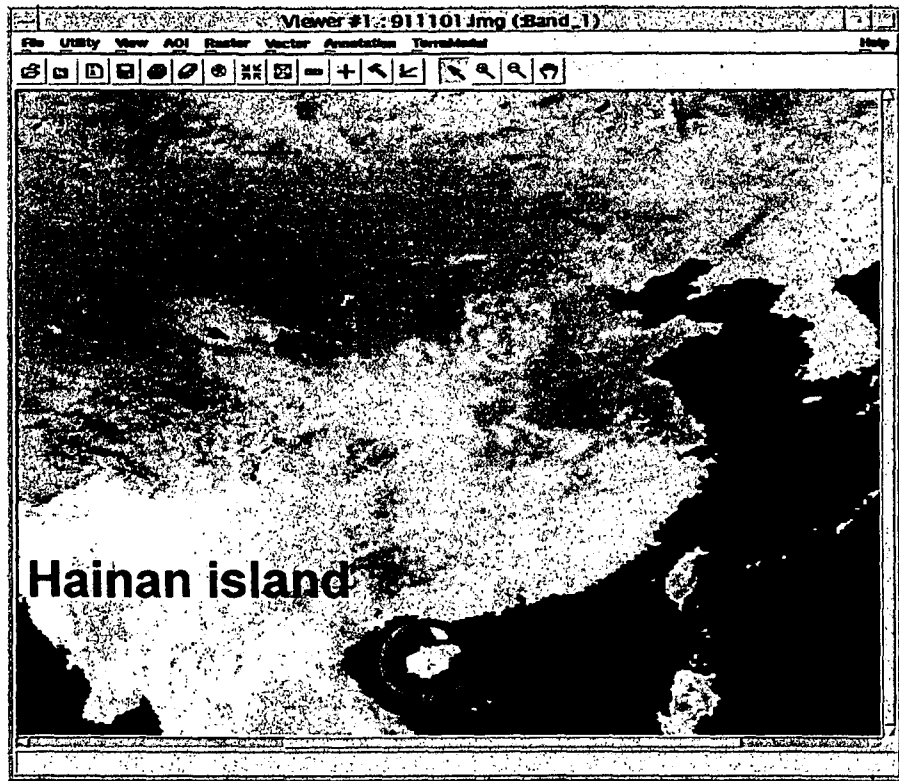


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Case study in Hainan island, China

Xiaobo Wu

UNIDO
International Centre
for Science and High Technology



Study Area: Hainan Island

- Location: N 18 ° 10 ' 04 " -- 20 ° 09 ' 40 "
E 108 ° 36 ' 43 " -- 111 ° 02 ' 31 "
- Area: 34,000 km²
- Population: 7,245,289 (end of 1997)
- Temperature: year average 23 °C - 25 °C
 - yearly sunshine time 1750 - 2750 hours
 - coldest month temperature average 17 °C - 20 °C
- Wind: typhoon season is from May to November.
- Rainfall: eastern 2000 – 2500 mm/year
western <1000 mm/year
- Geo-morphological feature: multi level circular structure. Upheaval in center and gradually lower in surrounding.

- The highest peak: 1867.1m
- From center outward is middle mountain - low mountain - high hill - low hill - terrace - plain.
- Vegetation

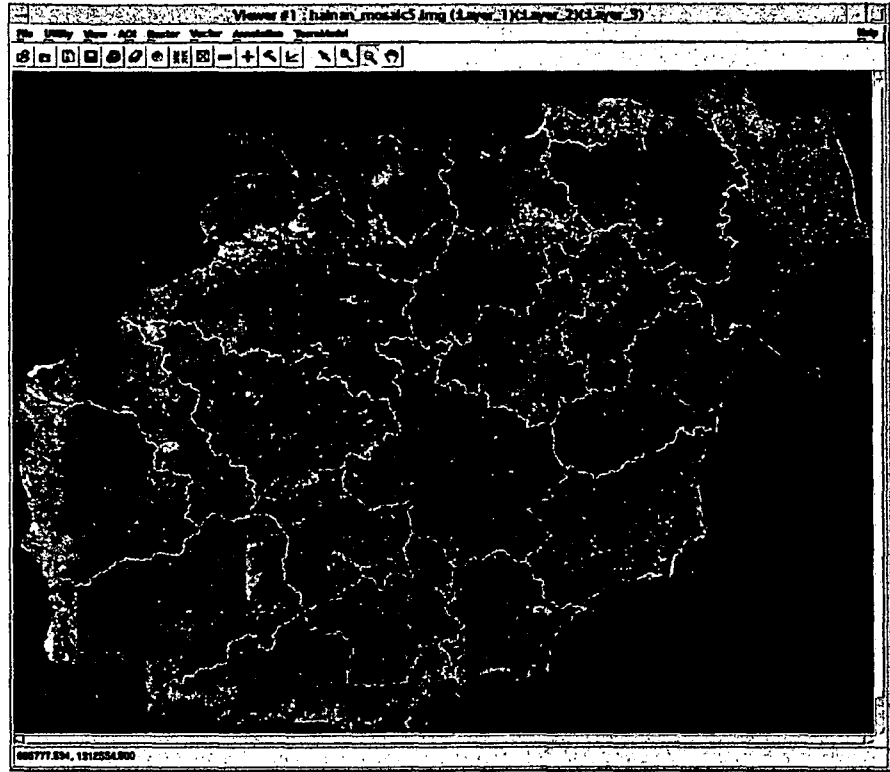
- tropical evergreen monsoon rain forest
- defoliate monsoon rain forest
- valley rain forest
- mountain rain forest
- mountain evergreen broadleaf forest
- tropical coniferous forest
- coastal mangrove
- tropical tree-scattered shrubs
- tree-scattered steppe
- damp steppe
- low hill and tableland steppe
- hill and mountain steppe



Vegetation

1	Tropical evergreen monsoon rain forest
2	Defoliate monsoon rain forest
3	Valley rain forest
4	Mountain rain forest
5	Mountain evergreen forest
6	Coastal mangrove forest
7	Tropical tree-scattered shrubs
8	Tree-scattered steppe
9	Damp steppe
10	Low hill and tableland steppe
11	Hill and mountain steppe
12	Agro-ecological forest
13	Wetland forest
14	Coastal mangrove forest
15	Coastal mangrove forest
16	Coastal mangrove forest
17	Coastal mangrove forest
18	Coastal mangrove forest
19	Coastal mangrove forest

vegetation in Hainan



Objective of my study

- find out the relationship between land cover change and socio-economic development
- establish a system to monitor the ecosystem change, make warning to prevent from human activity damaging the ecosystem balance

Data

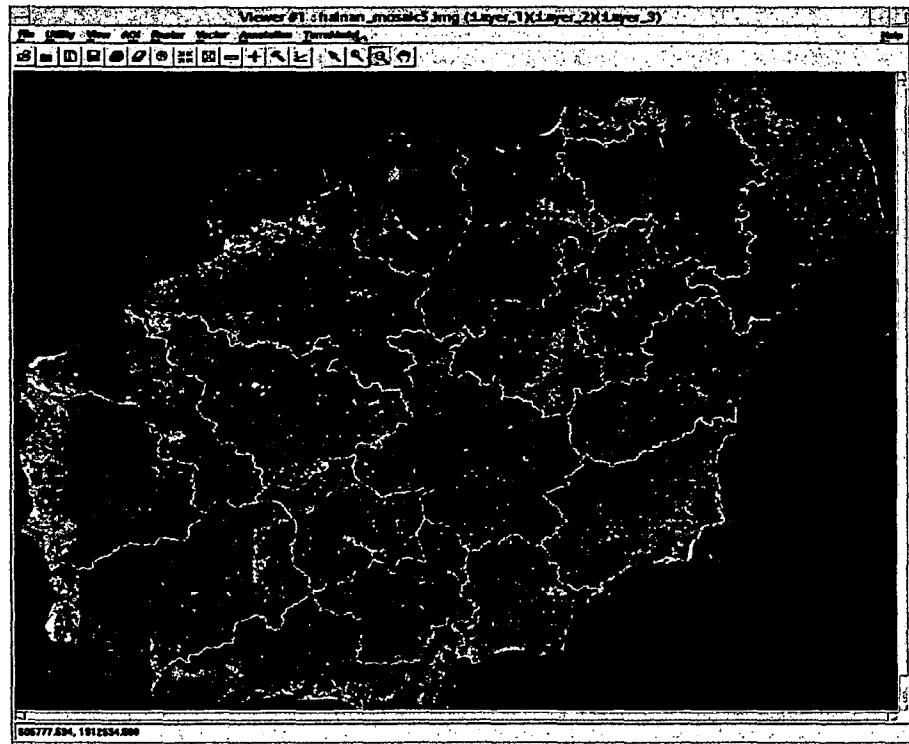
NOAA/AVHRR

- time period: 92,93,95 and 96
- resolution: 1.1 km
- range: whole island

TM

- range: whole island
- time period: 1996
- band: 2,3,4

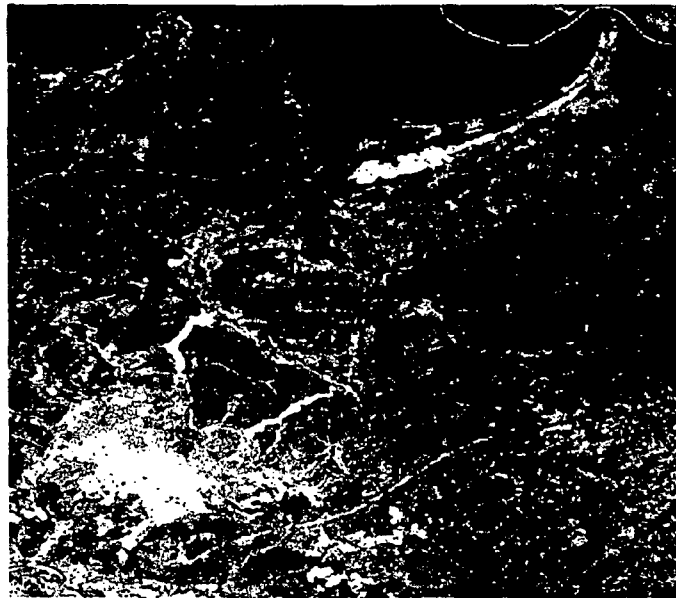




ancillary data (Chinese)

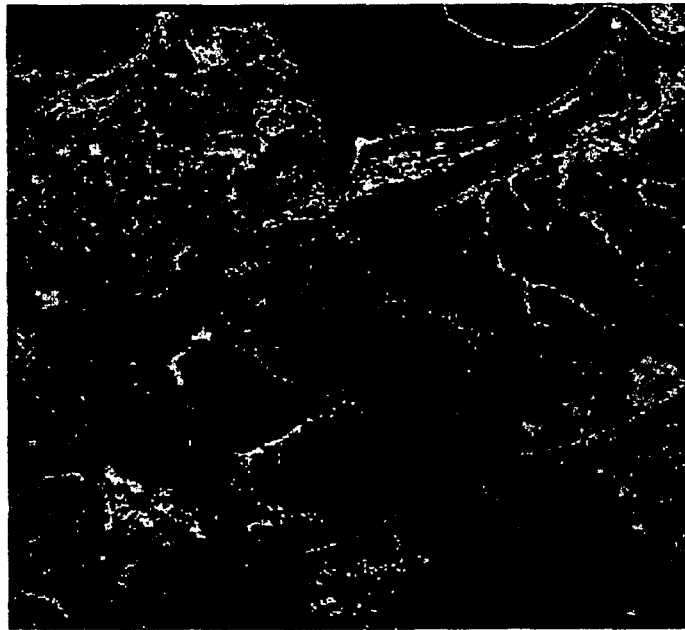


- some published papers and books on soil, landscape, geological structure, geomorphologic feature, climate etc in Hainan Island.
- forest distribution map of Dan Zhou and Tong Zha (scale: 1: 50,000 1:100,000)
- DTM of Nan Du River Basin
- forest distribution of Nan Du River Basin in digital format
- socio-economic data on county level from 1987 - 1999

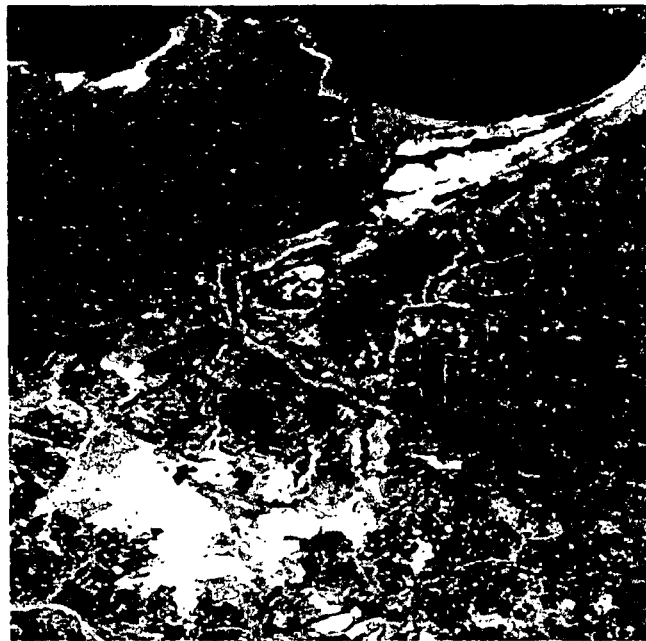


natural color image of pilot1 in 1996

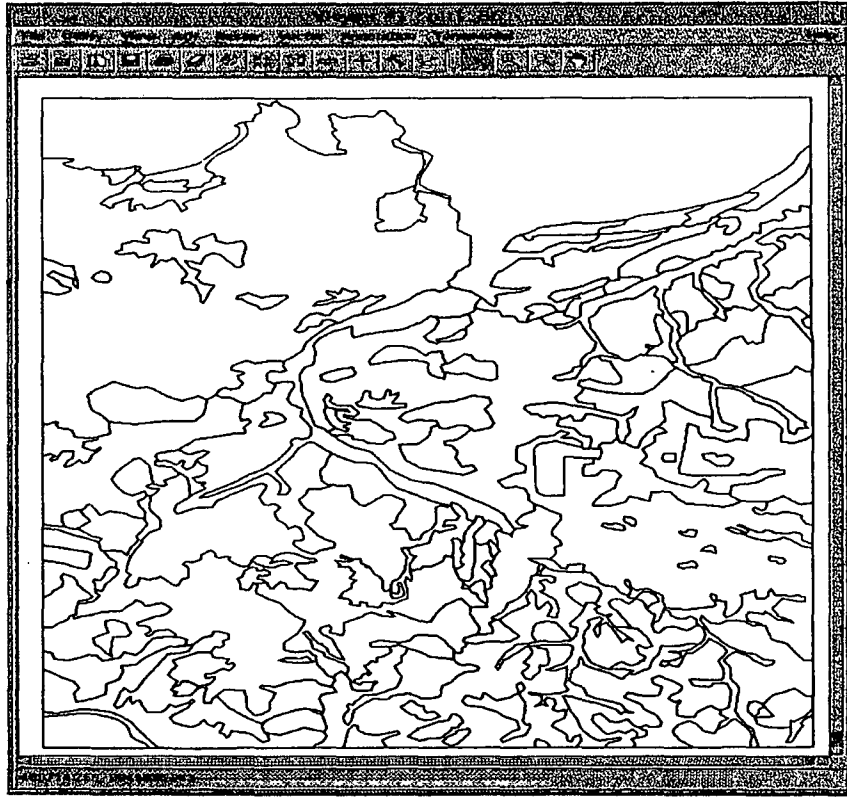














unsupervised classification
on PCA image of pilot1 in 1996



interpreting on screen



The unsupervised classification of pilot1 in 1986

- | | | | |
|---|--------------|---|------------|
|  | shrub, marsh |  | sandy land |
|  | river |  | bare land, |
|  | water |  | forest |
|  | rubber |  | farm land |
| | |  | mangrove |
| | |  | trees |



Further environmental applications of GIS:

- Monitoring of areas that are sustained by the industrial activities; risk assessment and pollution control;
- industrial site planning and land allocation;
- Evaluation of the expansion of different industrial zones, their spatial distribution, their number, their infrastructure, their additional activities, etc;
- Definition of the homogenous areas to which specific concessions are assigned like degraded industrial areas;
- Evaluation of different degraded industrial areas and comparative analysis of industrial sites in alternative environments;
- Planning based on complete database of industrial plants (concentration and distribution, labor density and specialization) for each industrial zone and area at regional and national levels.

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Thank you for your attention

Merci pour votre attention

Exercises

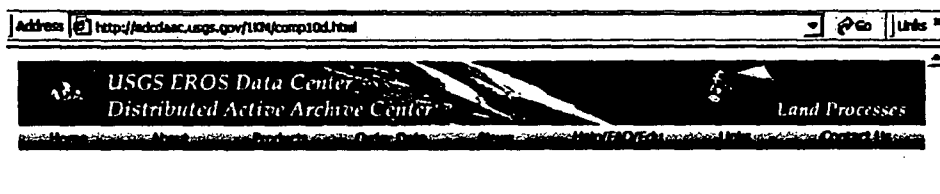
- Data extraction from Internet public domain
- Multi-Criteria Decision Making in GIS
- Industry and Sustainable development

Data extraction from Internet public domain

Purpose: This exercise emphasizes the utilities of the Worldwide Web as a source for data. It explains the steps involved in selecting the desired data and how to import it to GIS software.

Procedure: Using an Internet browser, access the following URL site:

<http://edcdaac.usgs.gov/1KM/comp10d.html>



FTP access to Global AVHRR 10-day composite data

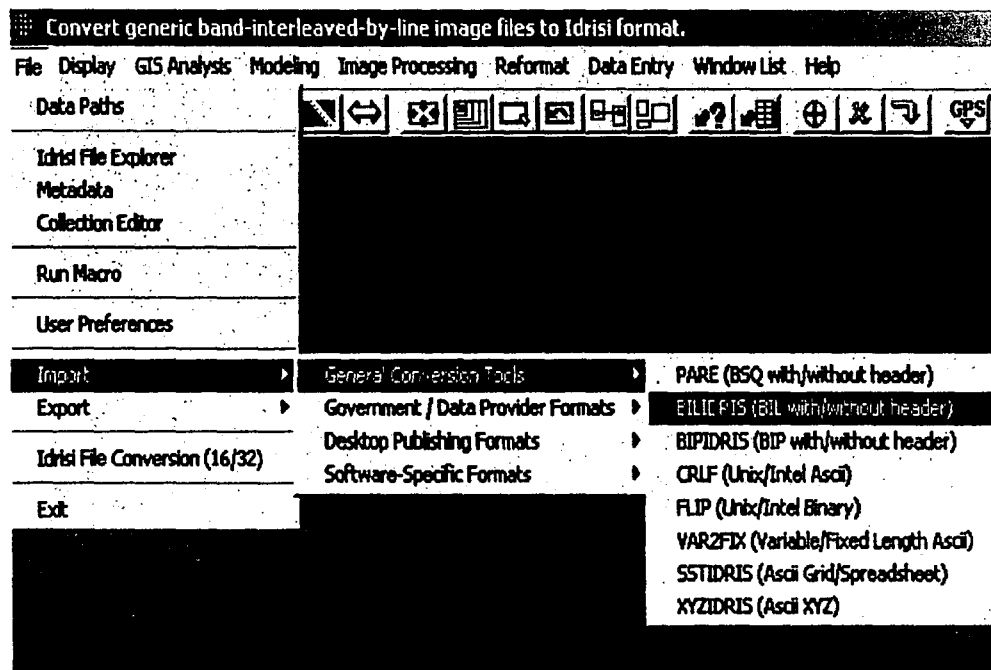
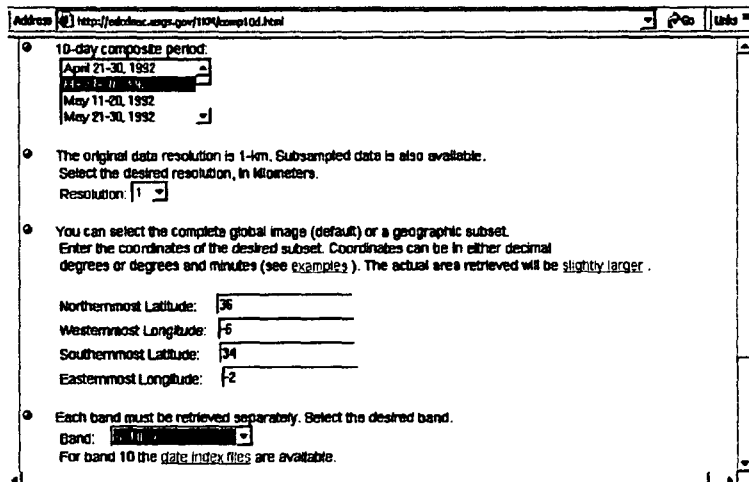


New Notice to Global 1-km AVHRR Data Users

Select the following criteria for this specific exercise (case study for Morocco):

- 10-day composite period: May 1-10, 1992
- Resolution: 1.1Km
- Latitude/Longitude geographical coordinates: Northernmost Latitude 36, Westernmost Longitude -6, Southernmost Latitude 34, Easternmost Longitude -2.
- Bands to be retrieved: NDVI

Press Retrieve data icon, and the research is launched. The output gives the size of the extracted image, specifying the number of lines (rows) and samples (columns). Select Retrieve data again and the data will be downloaded.



The image data can be arranged inside the files in many ways. Most common ones are:

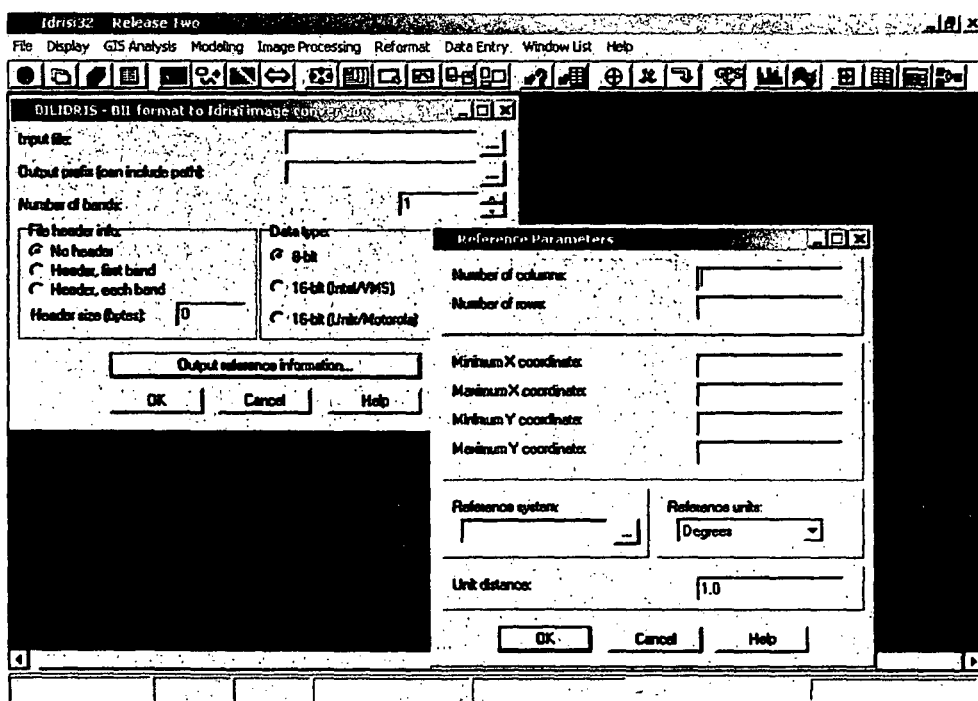
- BIP, Band Interleaved by Pixel
- BIL, Band Interleaved by Line
- BSQ, Band SeQUential

If the pixels of the bands A, B, C and D are denoted a, b, c and d respectively then:

BIP is organized like abcdabcdabcdabcdabcdabcdabcdabcdabcd... line 1/
 abcdabcdabcdabcdabcdabcdabcdabcdabcd... line 2/
 abcdabcdabcdabcdabcdabcdabcdabcdabcd... line 3/ ...
 abcdabcdabcdabcdabcdabcdabcdabcdabcd...
 abcdabcdabcdabcdabcdabcdabcdabcdabcd...

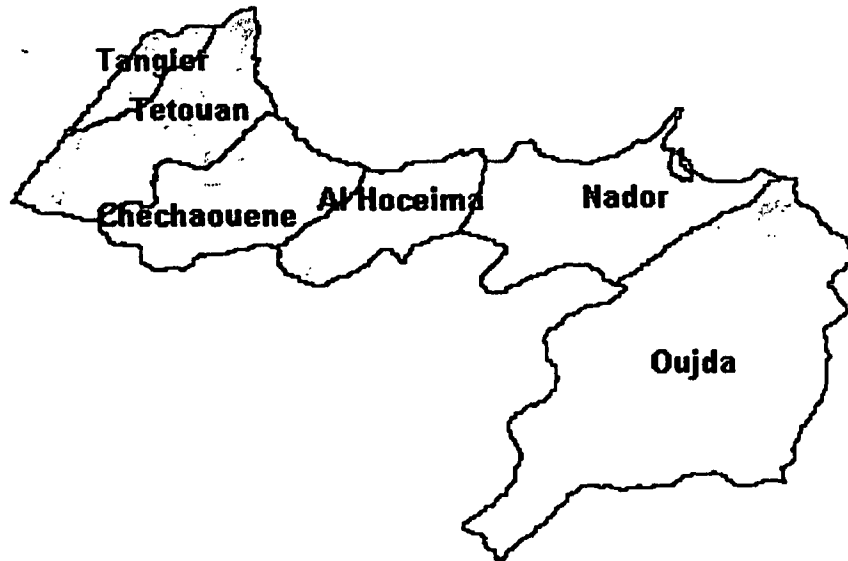
BIL looks like aaaaaaaaaa... band 1, line 1 bbbbbbbbbbbb... band 2
 cccccccccc... band 3 dddddddddddd... band 4 aaaaaaaaaa... band 1, line 2
 ...

BSQ shows aaaaaaaaaa... line 1, band 1 aaaaaaaaaa... line 2
 aaaaaaaaaa... line 3 ... bbbbbbbbbbbb... line 1, band 2 bbbbbbbbbbbb... line 2
 bbbbbbbbbbbb... line 3 ... cccccccccc... line 1, band 3 cccccccccc... line 2
 cccccccccc... line 3 ... dddddddddddd... line 1, band 4 dddddddddddd... line 2
 dddddddddddd... line 3 ...



Band 1 extracted from may1092





Multi-Criteria Decision Making in GIS

The **MCE mathematical procedure** is concerned with how to combine the information from several criteria to form a single index of evaluation.

With a weighted linear combination, factors are combined by applying a weight to each followed by summation of results to yield a suitability map.

$S = \sum W_i X_i$ where S: suitability

W_i : weight of factor i

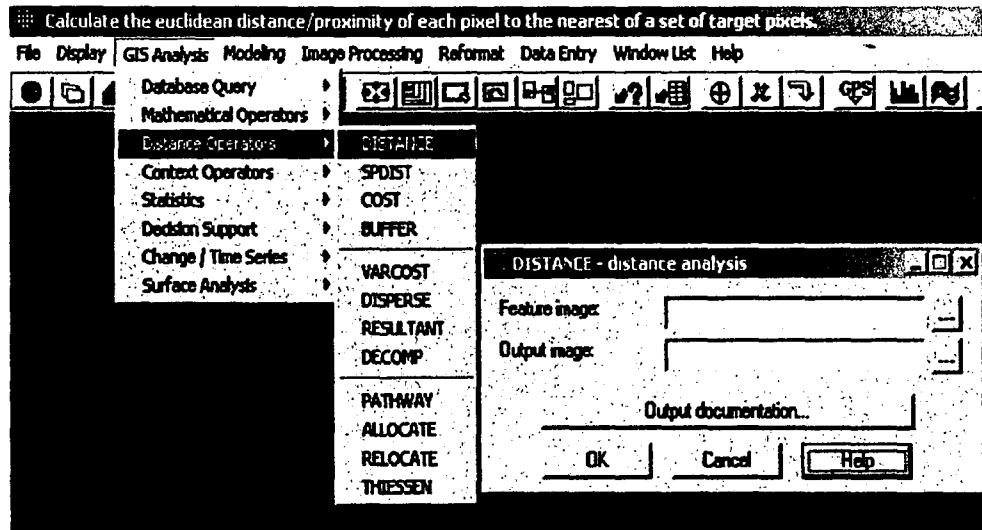
X_i : criterion score of factor i

\sum : summation

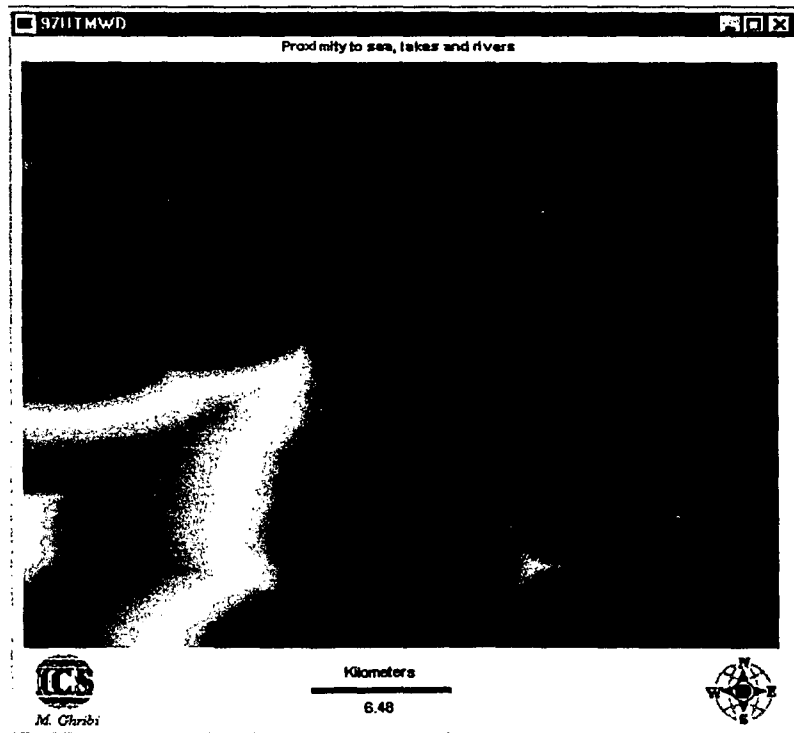
In case where Boolean constraints are also taken in consideration the suitability is:

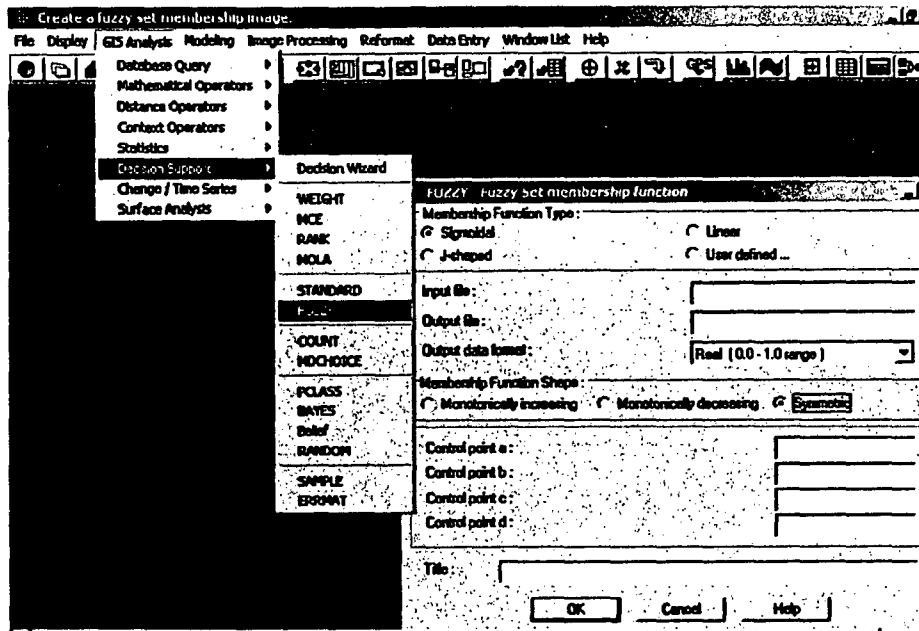
$S = \sum W_i X_i \prod C_j$ where C_j : criterion score of constraint j

\prod : product

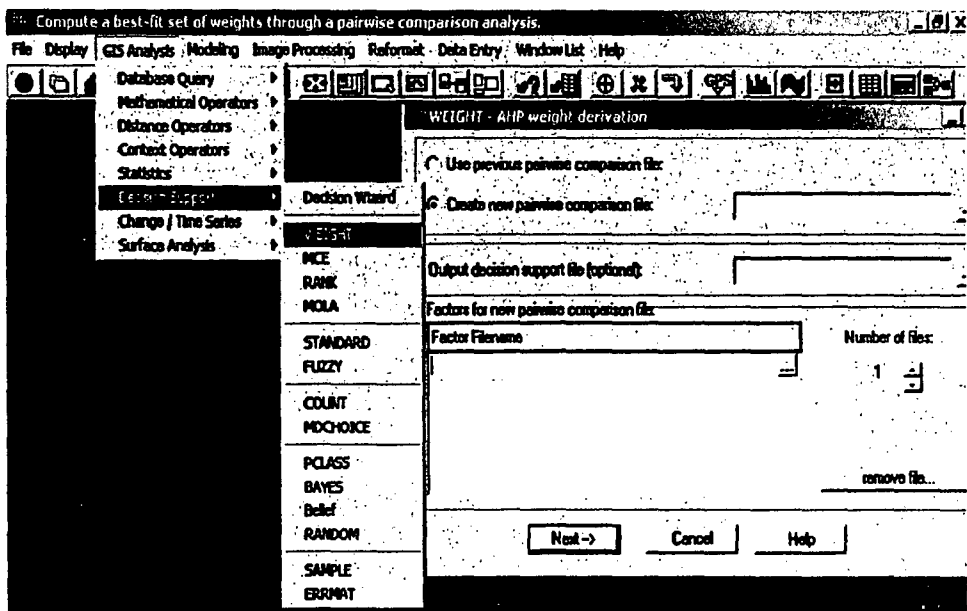


Proximity to water (sea, lakes and rivers)





In Multi-Criteria Evaluation, fuzzy set membership is used in the standardization of criteria. Exactly which function should be used will depend on the understanding of the relationship between the criterion and the decision set, and on the availability of information to infer fuzzy membership. In most cases, either the sigmoidal or linear functions will be sufficient.



WEIGHT - AHP weight derivation

Pairwise Comparison 9 Point Continuous Rating Scale

1/9	1/7	1/5	1/3	1	3	5	7	9
extremely	very strongly	strongly	moderately	equally	moderately	strongly	very strongly	extremely
Less Important					More Important			

Pairwise comparison file to be saved: D:\ghrib\97UTMDSS.PCF

	97UTMUDB	97UTMDB	97UTMRDB	97UTMWDB	97UTMFDB	97UTMBDB
97UTMUDB	1					
97UTMDB	1/3	1				
97UTMRDB	1/7	1/3	1			
97UTMWDB	1/7	1/7	1/3	1		
97UTMFDB	1/7	1/7	1/3	1	1	
97UTMBDB	1	1	3	7	3	1

D:\ghrib\97UTMPW.PCF

File Edit View Help

6

97UTMUDB Urban

97UTMDB Industry

97UTMRDB Roads

97UTMWDB Water

97UTMFDB Forest

97UTMBDB BareSoil

1

1 1

1/3 1/3 1

1/7 1/7 1/3 1 1

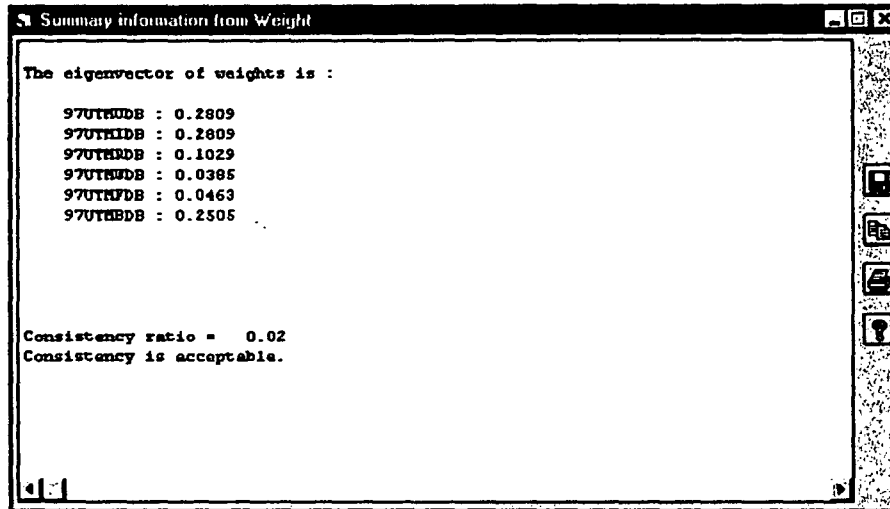
1/7 1/7 1/3 1 1

1 1 3 7 3 1

cursor position: 10,2

- 9: relative to the column variable, the row variable is extremely more important
- 8
- 7
- 6: relative to the column variable, the row variable is strongly more important
- 5
- 4: relative to the column variable, the row variable is moderately more important
- 3
- 2
- 1: relative to the column variable, the row variable is equally important
- 1/2
- 1/3
- 1/4: relative to the column variable, the row variable is moderately less important
- 1/5
- 1/6: relative to the column variable, the row variable is strongly less important
- 1/7
- 1/8
- 1/9: relative to the column variable, the row variable is extremely less important

The principal eigenvector of weights resulting from PAIRWISE comparison between factors



MCE - multi-criteria evaluation

MCE procedure to be used:

Boolean intersection Ordered weighted average

Weighted linear combination

Constraints:

Constraint filename: [] Number of constraints: 0

[Remove file ...]

Factors:

Factor filename	Factor weight	Number of factors:
[]	[]	1

[Remove file ...]

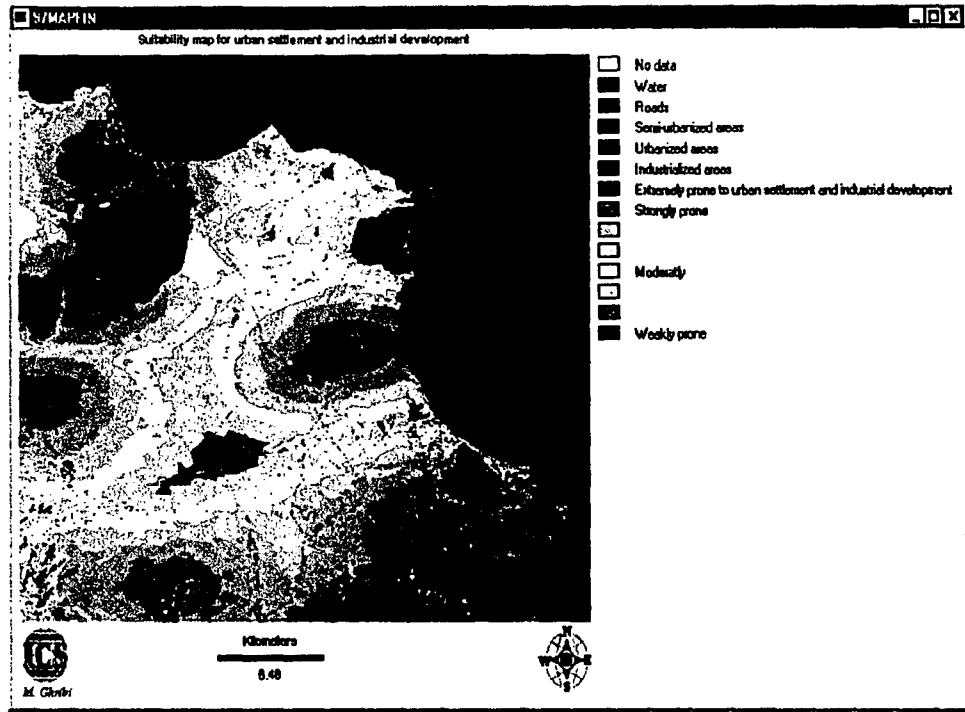
Output image: []

Title: []

[Retrieve parameters] [Save parameters]

[OK] [Cancel] [Help]

Industrial siting suitability map




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Industry and Sustainable development

Industrial component

Social component

Existing
Extension
New

Education
Job creation
Social development

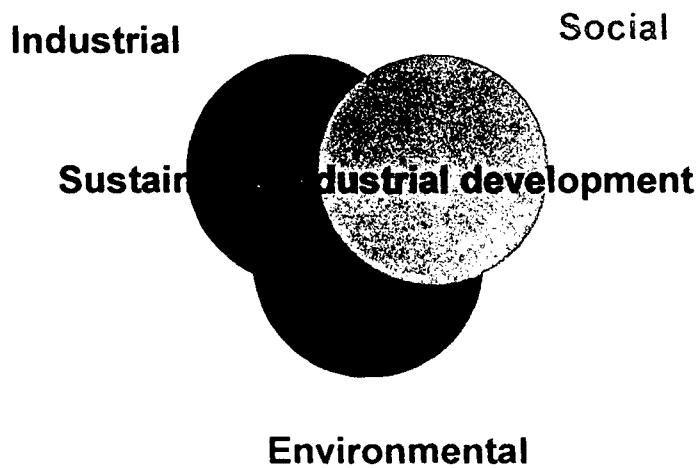
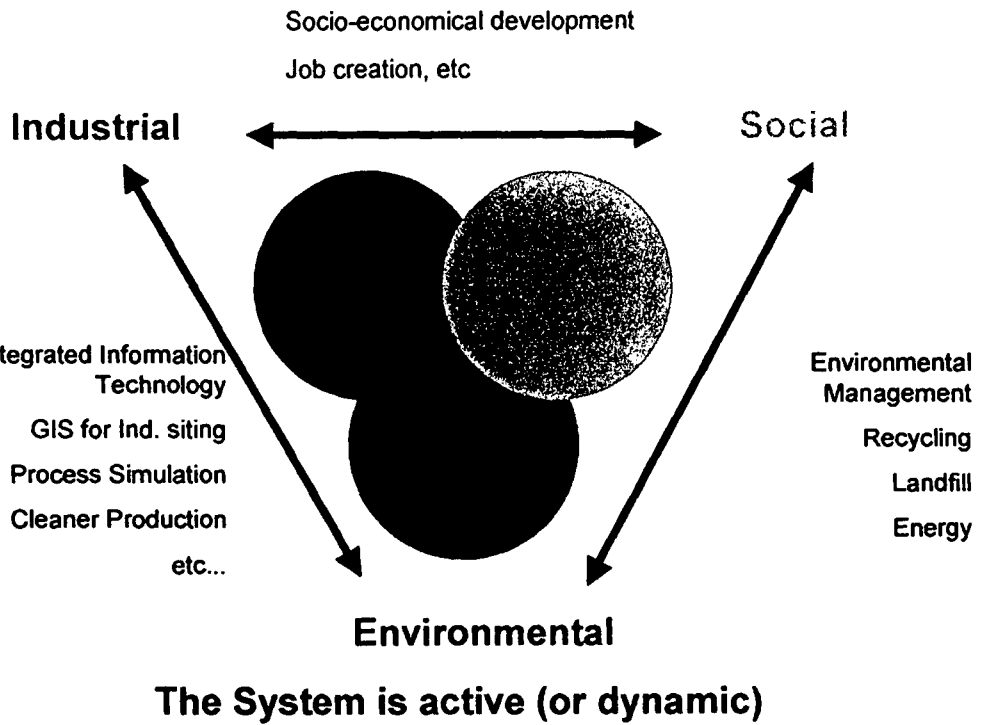
Place
Number
Activity
Technology

Environmental component

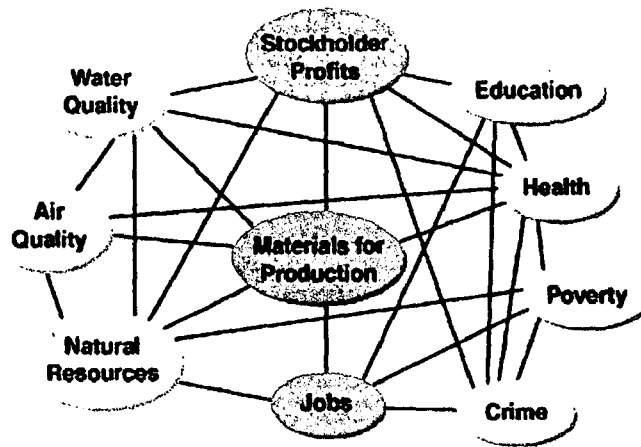
Land degradation
Pollution (water, air and soil)
Over use of coastal areas
etc.

The System is inactive (or passive)


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Sustainability requires...



...interactions among multidimensional indicators that show the links among the environment, the economy (industry) and society.

As the figure illustrates, the natural resource base provides the materials for production on which jobs and stockholder profits depend.

Jobs affect the poverty rate and the poverty rate is related to crime.

Air quality, water quality and materials used for production have an effect on health. They may also have an effect on stockholder profits: if a process requires clean water as an input, cleaning up poor quality water prior to processing is an extra expense, which reduces profits.

Likewise, health problems, whether due to general air quality problems or exposure to toxic materials, have an effect on worker productivity and contribute to the rising costs of health insurance.



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An autonomous body of the United Nations Industrial Development Organization

**GIS, remote sensing and spatial
decision support systems
(SDSS) for costal zone
management**

Mounir GHRIBI
Environmental Technologies Engineer
ICS-UNIDO
AREA Science Park, Padriciano 99
34012 Trieste, Italy
Tel. 0039-040-9228105, Fax. 0039-040-9228136
Mounir.ghribi@ics.trieste.it
<http://www.ics.trieste.it>

ICS-UNIDO is supported by the Italian Ministry of Foreign Affairs

**International Centre
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**Basic concepts of Remote Sensing (RS),
geographic information system(GIS) and
decision support system (DSS)**

La télédétection, le traitement d'image, les
systèmes d'information géographique (SIG) et
les systèmes interactifs d'aide à la décision:
concepts de base

Remote Sensing (Télédétection):

RS is the science (set of knowledge and techniques) of acquiring information about the earth's surface and its environment without actually being in direct contact with it.

This refers to a process of gathering data by sensing and recording electromagnetic energy.

Examples range from aerial photography to multi-spectral scanning and radar, usually by aircraft and satellite sensors.

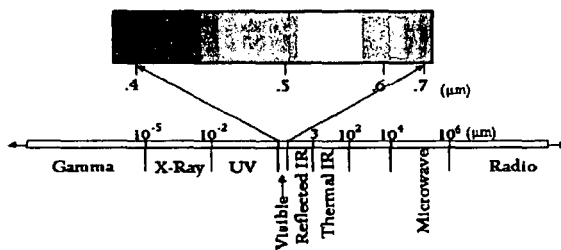
Télédétection

La télédétection est la détection d'un objet à distance. Ce terme correspond plus spécifiquement à une technique qui utilise les ondes électromagnétiques (rayonnement) pour obtenir des informations concernant la Terre et l'atmosphère.

Le spectre électromagnétique comporte plusieurs parties distinctes, dont le rayonnement ultraviolet (UV), la lumière visible, le rayonnement infrarouge (IR) thermique, les rayons X, les micro-ondes, etc...

The Electromagnetic Spectrum:

- The electromagnetic spectrum ranges from the shorter wavelengths (including gamma and x-rays) to the longer wavelengths (including microwaves and broadcast radio waves)
- Ultraviolet or UV portion of the spectrum has the shortest wavelengths
- The visible wavelengths cover a range from approximately 0.4 to 0.7 μm

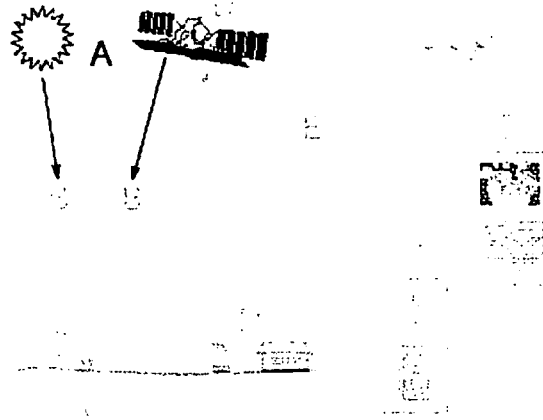


Violet: 0.4 - 0.446 μm
 Blue: 0.446 - 0.500 μm
 Green: 0.500 - 0.578 μm
 Yellow: 0.578 - 0.592 μm
 Orange: 0.592 - 0.620 μm
 Red: 0.620 - 0.7 μm

Characteristics of Electro Magnetic Radiation:

- Wave length
 - The wavelength is the length of one wave cycle, which can be measured as the distance between successive wave crests
 - Wavelength is measured in meters (m)
- Frequency
 - Frequency refers to the number of cycles of a wave passing a fixed point per unit of time
 - Frequency is normally measured in hertz (Hz)

Interactions with the Atmosphere:



Particles and gases in the atmosphere can affect the incoming light and radiation. These effects are caused by the mechanisms of

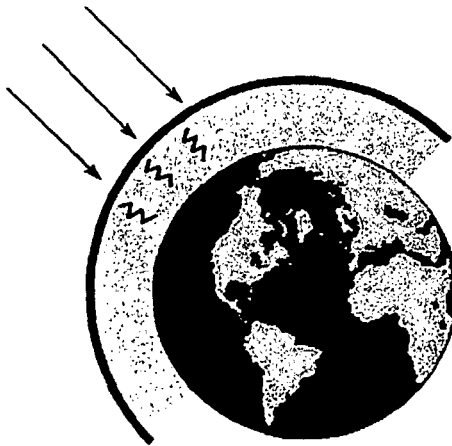
- ✓ Scattering
- ✓ Absorption

Scattering (Dispersion):



- Rayleigh scattering
The particles are very small compared to the wavelength of the radiation
 - Blue light scatters
- Mie scattering
The particles are just about the same size as the wavelength of the radiation
 - Dust, pollen, smoke
 - water vapour
- Non selective scattering
The particles are much larger than the wavelength of the radiation
 - Water droplets and
 - large dust particles

Absorption (Absorption):

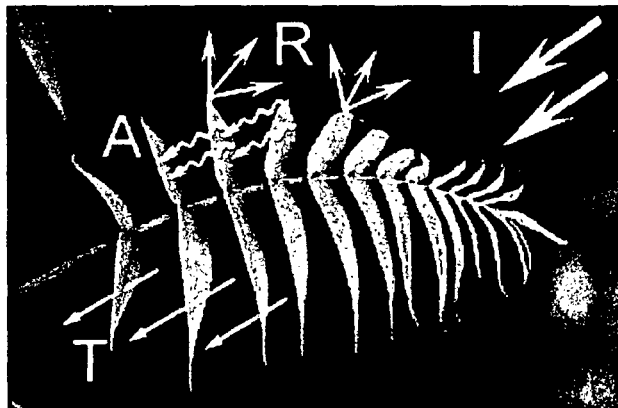


This phenomenon causes molecules in the atmosphere to absorb energy at various wavelengths.

- Ozone (UV absorber)
- Carbon dioxide (IR absorber)
- Water vapour (long wave infrared and short wave microwave radiation)

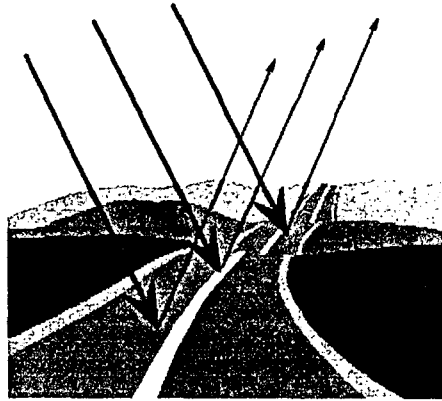
Radiation/ Target Interactions:

- Absorption (A)
(Absorption)
- Transmission (T)
(Transmission)
- Reflection (R)
(Réflexion)

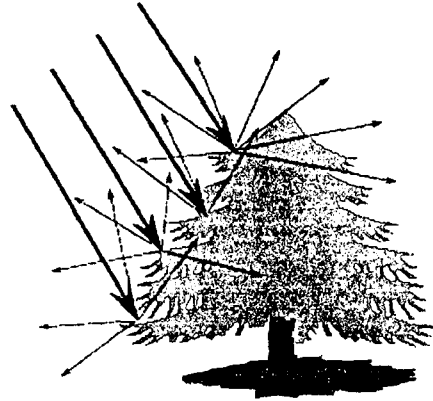


Reflection (Réflexion):

Specular reflection
(Réflexion Spéculaire)

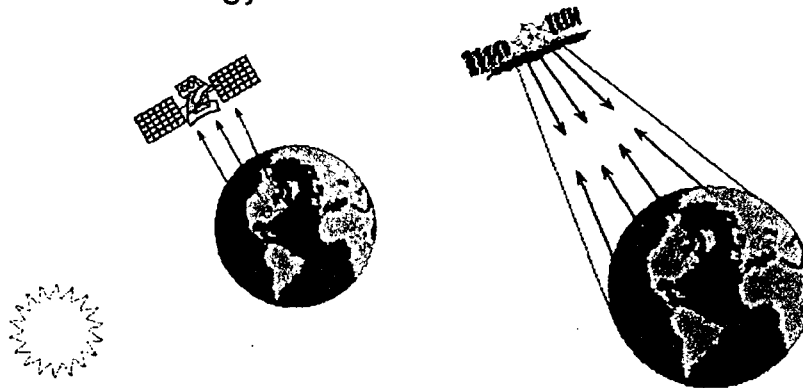


Diffuse reflection
(Réflexion Diffuse)

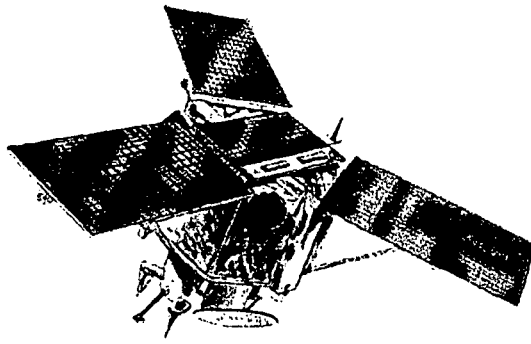


Passive & Active Sensing:

- Passive sensors can only be used to detect energy when the naturally occurring energy is available
- The Active sensor emits radiation which is directed toward the target to be investigated and receive the reflected energy



Earth Remote Sensing (Téledétection De la Terre)



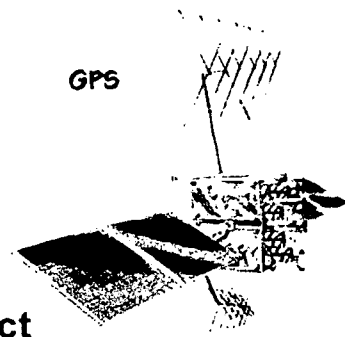
Remote-sensing satellites, like the one shown above, study Earth's surface. From 300 miles (480 km) up, this satellite uses powerful cameras to scan the planet. The satellite then sends back valuable data about global environments.

How we use Satellite Imaging?

(Comment utilisons-nous l'information obtenue?)

- The instruments on remote-sensing satellites study earth's plant cover and surface water, among many other features.
- People who work in farming, fishing, mining, and many other activities find this information very useful.
- We can also use remote sensing satellites to study changes in the earth's surface that are caused by people.

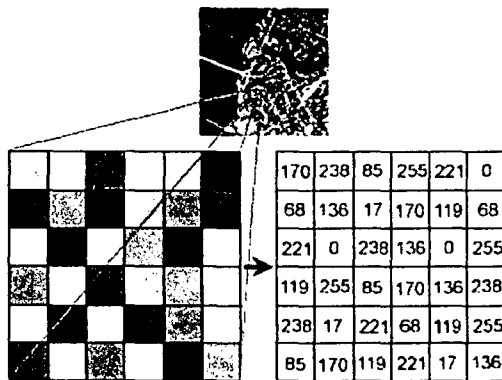
Global Positioning System (GPS) (Le système de positionnement global)



This satellite is part of a group of satellites that can tell you your exact spatial coordinates (latitude, longitude and altitude).

The Global Positioning System (GPS) was developed for military purposes, but now people everywhere can use these satellites to determine geo-referenced control points.

Characteristics of a remotely sensed image (Caractéristiques d'une image):



- A digital format by subdividing an image into small equal-sized and shaped areas, called 'picture elements' or 'pixels'
- Pixel represents the brightness of each area with a numeric value or digital number (DN)

Image interpretation and analysis:

Interpretation and analysis of remote sensing imagery involves the identification and /or measurement of various targets in an image in order to extract useful information about them

» Manual interpretation

» Digital interpretation

- Manual interpretation is a subjective process, meaning that the results will vary with different interpreters
- Digital analysis is based on the manipulation of digital numbers in a computer and is thus more objective, generally resulting in more consistent results

Elements of Visual Interpretation:

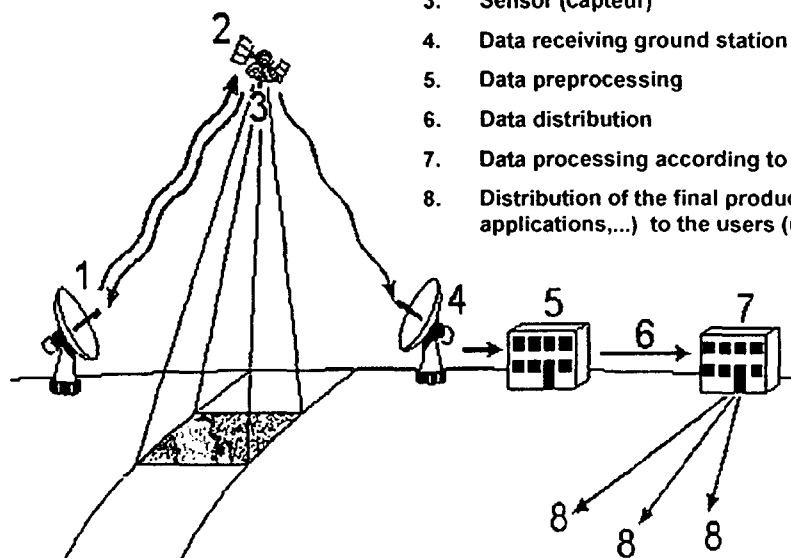
Recognizing targets is the key to interpretation and information extraction

- Tone
- Shape
- Size
- Pattern
- Texture
- Shadow
- Association

Digital Image Processing (Traitement d'Image):

- **Preprocessing (Prétraitement)**
 - Correct for sensor and platform-specific radiometric and geometric distortions of data. The geometric correction is performed by giving each pixel of the image the correct place on the earth (geocoding).
- **Image Enhancement (Perfectionnement d'Image)**
 - Enhancements are used to make it easier for visual interpretation and understanding of imagery
- **Image Transformation (Transformation d'Image)**
 - Basic image transformations apply simple arithmetic operations to the image data
- **Image Classification and Analysis (Classification et Analyse)**
 - To identify homogeneous groups of pixels which represent various features or land cover classes of interest

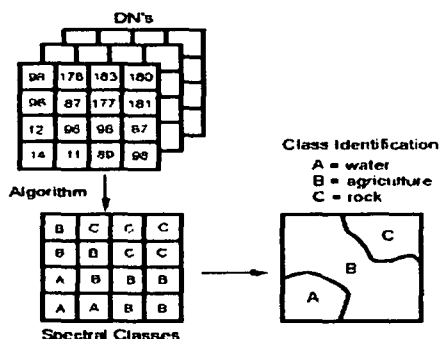
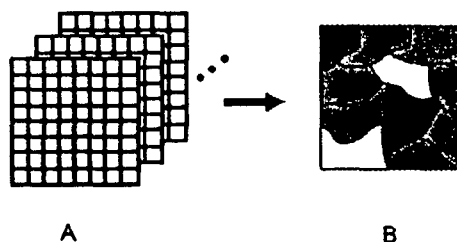
Processing of satellite data



1. Satellite control ground station: programming & remote control of the flight of the satellite
2. Satellite
3. Sensor (capteur)
4. Data receiving ground station
5. Data preprocessing
6. Data distribution
7. Data processing according to the user's needs
8. Distribution of the final products (maps, GIS applications,...) to the users (utilisateur)

Image Classification and Analysis:

Unsupervised classification
 Supervised classification



Unsupervised Classification

Unsupervised Classification is a technique for the computer-assisted interpretation of remotely sensed imagery. The computer routine does this by identifying typical patterns in the reflectance data. These patterns are then identified by undertaking site visits to a few selected examples to determine their interpretation. Because of the mathematical technique used in this process, the patterns are usually referred to as clusters.

Supervised Classification

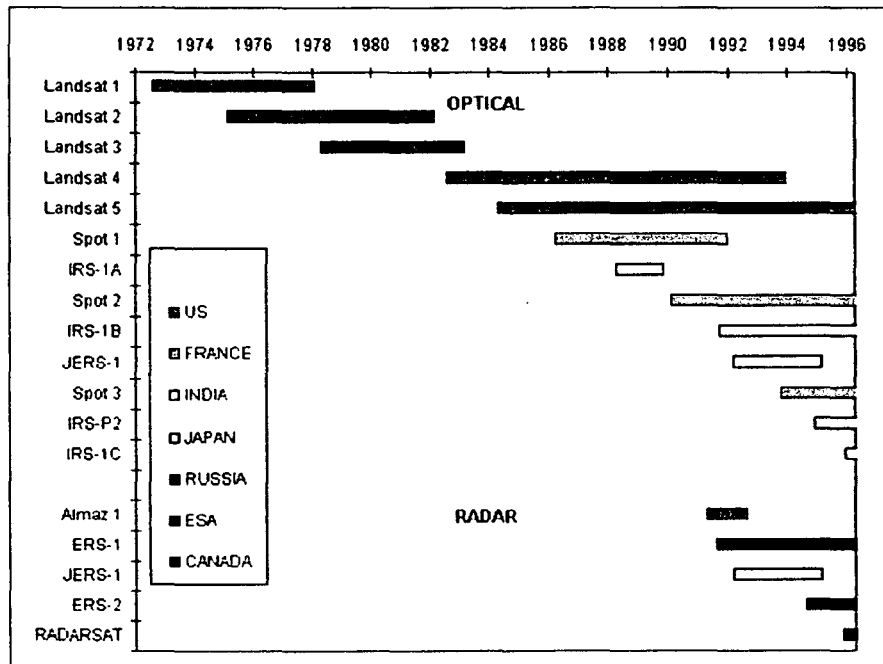
Supervised Classification is a technique for the computer-assisted interpretation of remotely sensed imagery. The operator trains the computer to look for surface features with similar reflectance characteristics to a set of examples of known interpretation within the image. These areas are known as training sites.

Data Integration and Analysis:

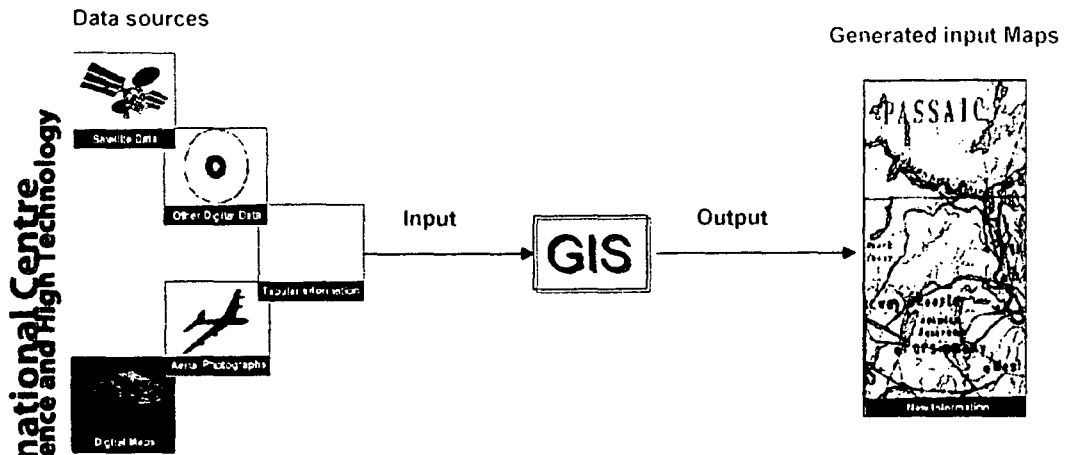
Data integration fundamentally involves the combining or merging of data from multiple sources in an effort to extract better and/or more information. This may include data that are:

- multi-temporal
- multi-resolution
- multi-sensor
- multi-data type in nature

Satellite missions:

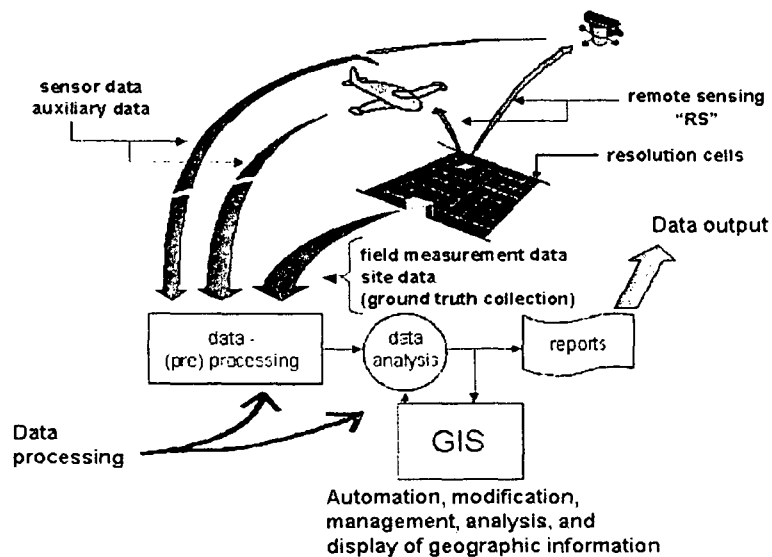


Spatial data management and information extraction



Relating information from different sources
 Data capture and integration
 Projection, geo-referencing and registration
 Data processing, modeling and presentation

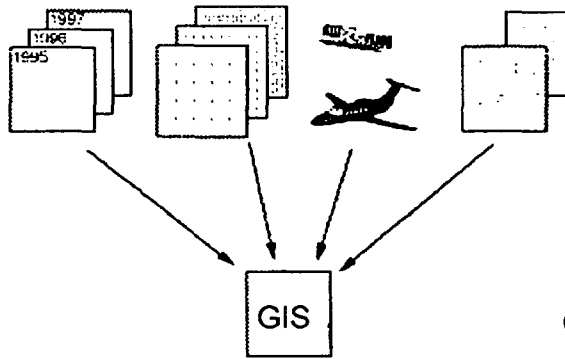
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Geographic Information Systems (GIS)

(Les systèmes d'information géographique)



GIS are computer based systems capable of assembling, storing, manipulating and displaying geographically referenced information.

Les systèmes d'information géographique

Les systèmes d'information géographique (SIG) permettent de gérer sous forme numérique des couches d'information (rues, routes, trait de cote, etc.).

Ces données peuvent ensuite être analysées, combinées et visualisées pour produire des cartes.

Geographic Information Systems

Map making and
cartography

Spatial data management

Management of different sources
of geographically referenced
data



Spatial Decision Support Systems (SDSS)

Multi-Criteria Analysis (MCA)

Site planning and industrial siting

Site selection and Land allocation

Emergency response planning

Simulating environmental effects

How does GIS work?

- Relating information from different sources
- Data capture
- Data integration
- Projection and registration
- Data structures
- Data modeling
- Data presentation

Map Projection



Projection refers to the representation of one surface onto another.

In the mapping sciences it is understood to refer to the representation of a **spherical** earth onto a **flat** medium such as paper or a computer screen.

Since it is physically impossible to flatten a globe without distortion, scale will vary across the projection surface with consequent distortions in **distance, area, and angular** relationships.

Geo-referencing

Geo-referencing refers to the location of an image or vector file in space as defined by a known coordinate referencing system.

With raster images, a common form of geo-referencing is to indicate the reference system (e.g., latitude/longitude), the reference units (e.g., degrees), and the coordinate positions of the left, right, top and bottom edges of the image.

The same is true of vector data files, although the left, right, top and bottom edges now refer to what is commonly called the bounding rectangle of the coverage -- a rectangle which defines the limits of the study area.



Some examples of reference system

These include the geodetic coordinates **LATLONG** (latitude/longitude) using the decimal degrees as unit of measure, the **UTM** system (Universal Transverse Mercator) and **SPC** (State Plane Coordinate) systems based on the Lambert Conformal Conic and Transverse Mercator projections.

The UTM grid referencing system is frequently used for map projection. The unit of measure is meters or kilometres (m or km). It is usually necessary to know the UTM zone and datum used by the reference system.

What can GIS offer?



- Information retrieval
- Data input
- Data base construction
- Data manipulation
- Topological modeling
- Overlay operation
- Data analysis
- Data output
- Data exchange and Networks



GIS Applications:

- Mapmaking and cartography
- Site selection and land allocation
- Emergency response planning
- Simulating environmental effects

Applications:

- **Agriculture & Soil** (cropping pattern and soil occupation, biomass and crop yield...)
- **Archaeology** (site prediction and identification, database management...)
- **Biodiversity & Ecology** (wildlife management, conservation and planning...)
- **Business & Economy** (industrial site planning and tourism...)
- **Environment** (survey and monitoring...)
- **Forestry** (harvesting and foliage cover monitoring...)
- **Geology** (geological mapping...)
- **Geomorphology** (slope, fluvial and morphological analysis)
- **Health** (impact analysis...)
- **Military** (image resolutions...)
- **Natural Hazards** (earthquakes, floods, storms, drought, fire and landslides...)
- **Oceanography** (sea-level change and marine pollution...)
- **Urban Planning** (urban agglomeration and cultural resource management...)
- **Water Resources** (ground water assessment, water quality, watershed management, surface water management and water pollution)
- **Utility** (telecommunications, power, transport...)

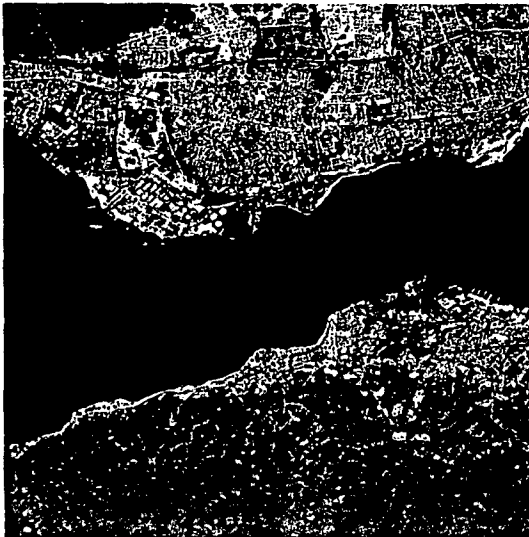
Significant images... Worldwide

...Chosen from the SPOT on-line satellite image catalog



www.spot.com
www.spotimage.fr

Earthquake in Turkey

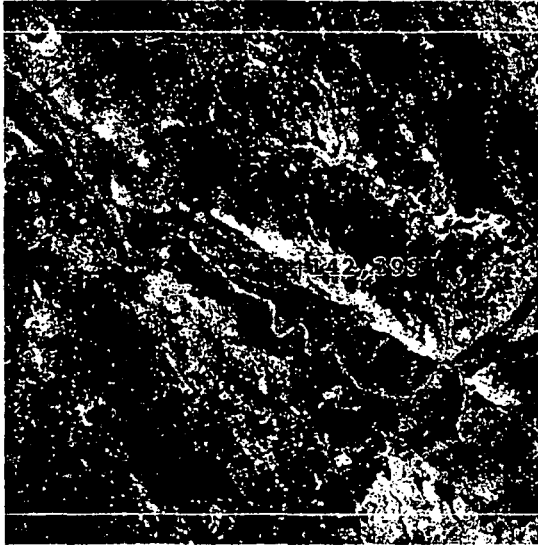


Izmit, Turkey on July 9, 1999



Izmit, Turkey on August 20, 1999
(smoke from oil refinery fire creates haze visible in this image)

Mozambique Floods

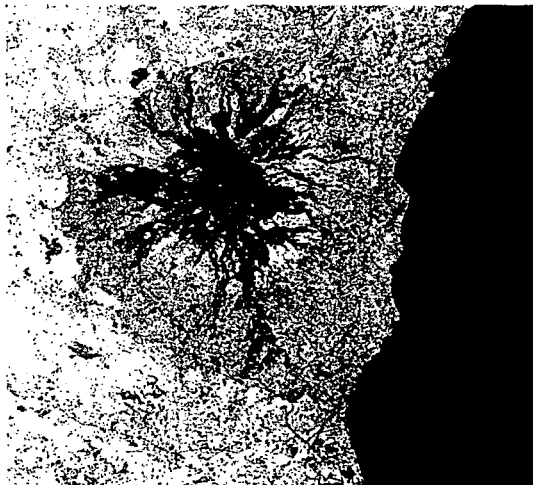


November 15, 1998 – Although the rainy season of Mozambique begins November 1, the bed of the Limpopo River is clearly visible as it snakes diagonally across the northern image (142, 399).

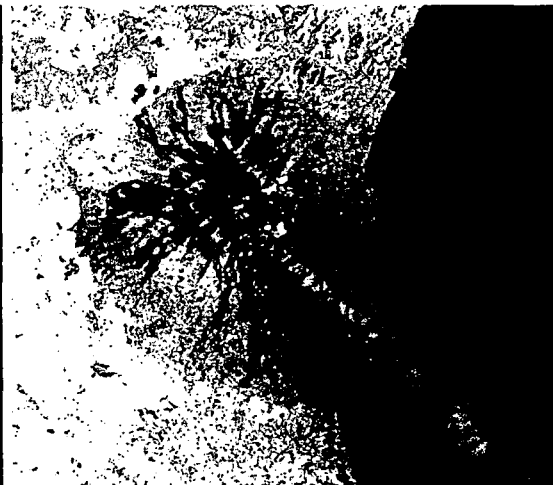


March 4, 2000 – After torrential rains in late February and early March, the Limpopo River has greatly overrun its banks and engulfed the lakes to the northeast. The river has also merged with the lake to the south.

Etna explosion, Italy

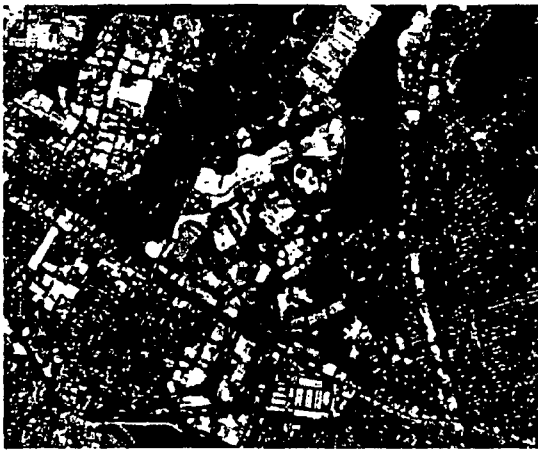


On this image acquired on July 19th, 2001 by SPOT 4, old lava flows can be seen in dark shades while the most recent lava flows stand out in red (image processing using the SWIR band).

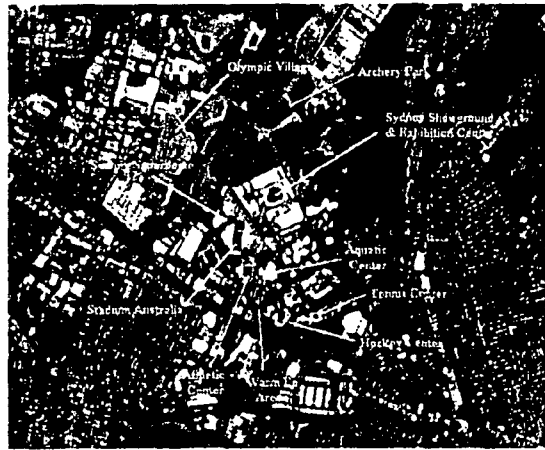


SPOT Satellite Image acquired on July 23rd, 2001. Sicily's Mount Etna continued to spew lava and ash, forcing the international airport in Catania to shut.

Olympic Games 2000, Sydney from space



An image of Sydney captured on November 8, 1994 illustrates bare ground and undeveloped land surrounding the location for the Olympic Village and the Sydney Showground & Exhibition Center.



Six years later, on July 25, 2000, Sydney has added a number of venues for the 2000 Olympic Games. A waterway has been expanded and a bridge built between the Olympic Village and the athletic stadiums.

Manhattan, New York (World Trade Center Side by Side comparison) September 15, 2001 - IKONOS 1-meter



Decision Support Systems (DSS) (systèmes interactifs d'aide à la décision)

- A decision is a choice between alternatives.
- The alternatives may represent different courses of action or different hypotheses.
- Rational human behaviour involves the evaluation of choice alternatives based on some criteria.
- A criterion is some basis for a decision that can be measured and evaluated.

Criteria can be of two kinds:

- Factors that enhance or detract from the suitability of specific alternative for the activity under consideration
- Constraints which serve to limit the alternatives under consideration

What is DSS?

Definitions of decision support systems range from:

“Interactive computer based systems that decision makers utilize data and models to solve unstructured problems” (Gorry & Morton, 1971)

to

“Any system that makes some contribution to decision making” (Sprague & Watson, 1986)

‘The decision support field is the development of approaches for applying information systems technology to increase the effectiveness of decision makers in situations where the computer can support and enhance human judgment in the performance of tasks that have elements which cannot be specified in advance’

Multi-Criteria Evaluation:

- To meet a specific objective, it is frequently the case that several criteria will need to be evaluated. Such procedure is called Multi-Criteria Evaluation (MCE)
- In a MCE, an attempt is made to combine a set of criteria to achieve a single composite basis for a decision according to a specific objective
- The advantage of MCE is that it provides a flexible way of dealing with qualitative multi-dimensional environmental effects of decisions

Decision Support Systems (DSS) has six characteristics:

- Explicit design to solve problems;
- powerful and easy-to-handle user interface;
- ability to flexibly combine analytical models with data;
- ability to explore the space analysis solution by building alternatives;
- capability of supporting a variety of decision-making styles; and
- allowing interactive and recursive problem-solving

The distinguishing capabilities and functions of Spatial Decision Support Systems (SDSS) are to:

- provide mechanisms for the input of spatial data ;
- allow representation of the spatial relations and structures ;
- include the analytical techniques of spatial and geographical analysis ; and
- provide output in a variety of spatial forms, including maps

Example: Multi-Criteria Evaluation for industrial siting

- Decisions about the siting of industries on certain land areas typically involve the application of Multi-Criteria Algorithm based on logical PAIRWISE comparison.
- With the advent of GIS, we now have the opportunity to apply decision-making processes, in more enhanced and integrated context

Mise en place d'un système d'information géographique (SIG)

Objectif

L'objectif est de donner aux ingénieurs, techniciens et cadres en charge, les bases nécessaires à:

- la saisie des données localisées ou géographiques (scannerisation, digitalisation, GPS...);
- la structuration de l'information (modèle et équation);
- la mise en œuvre des applications informatiques de gestion de l'information géographique;
- le traitement des données (requêtes, analyse, traitement d'image...);
- l'édition des données (cartes, tableaux...)

Procédure

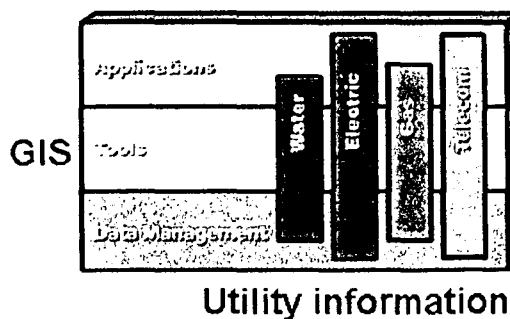
La mise en œuvre d'un système d'information géographique ne saurait se limiter au simple apprentissage de l'outil logiciel qui n'en constitue que l'interface d'accès et de manipulation des données. Il faut replacer le sujet dans une vision globale du système d'information alliant la représentation cartographique à une véritable banque de données.

GIS Application for utility information Management

GIS are powerful tools for the integration, maintenance, modelling and data management of utility information. GIS are used:

- to support the vertically integrated utilities (electric, gas, water and telecommunications networks);
- to view, design, map, manage and maintain spatial data in a multi-utility context.

GIS can be applied to share common data models and user interfaces to create an integrated solution across utilities.



Telecommunication GIS & Information data management



- Land Base Created from Geographically Correct Sources
- GPS tracking compatible Land Base
- Land Base Built on the Applicable Coordinate System
- Data Management and marketing Information Interface Utilizing Network Schematics and Base Maps

Example: GIS and database of wireless locations

Database contents: Site Name, Latitude/ Longitude location (decimal degrees), AGL (Above Ground Level) Height, AMSL (Above Mean Sea Level) Height, Ground Elevation, Site ID, Owner/Manager Name, Leasing Agent Telephone, Type of Structure, Street Address, etc.

GIS and Mapping for Mobile Systems



GIS technology and GPS functionality may play an important role for:

- mobile mapping and field data collection;
- data accuracy and real time information;
- immediate data availability and validation;
- data access via Wireless Technology (to download images or map layers via wireless technology using a TCP/IP connection, such as a wireless LAN, cellular phone, or a wireless modem).



STRATEGIC ACTION PROGRAMME TO ADDRESS POLLUTION FROM LAND-BASED ACTIVITIES (SAP)

THE STRATEGIC ACTION PROGRAMME (SAP)

- Specifies the main land based pollution issues in the Mediterranean
- Indicates the desired targets to be reached to resolve these issues.
- Indicates the possible control measures that could be taken at the national and regional level, including their costs
- Establishes a general schedule and timeframe for their implementation.



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United Nations Environment Programme - Mediterranean Action Plan

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Strategic Action Programme



STRATEGIC ACTION PROGRAMME TO ADDRESS POLLUTION FROM LAND-BASED ACTIVITIES (SAP)

TARGETS AND ACTIVITIES:

The agreed targets and activities are identified at the national and the regional level and are of legal, institutional or technical nature.

THEY COVER:

- ▶ Urban environment
- ▶ Industrial development
- ▶ Physical alterations and destruction of habitats
- ▶ Monitoring
- ▶ Capacity Building
- ▶ Public Participation
- ▶ Reporting

The SAP also contains Guidelines for the preparation of National Action Plans and an Investment portfolio.

STRATEGIC ACTION PROGRAMME TO ADDRESS POLLUTION FROM LAND-BASED ACTIVITIES (SAP)

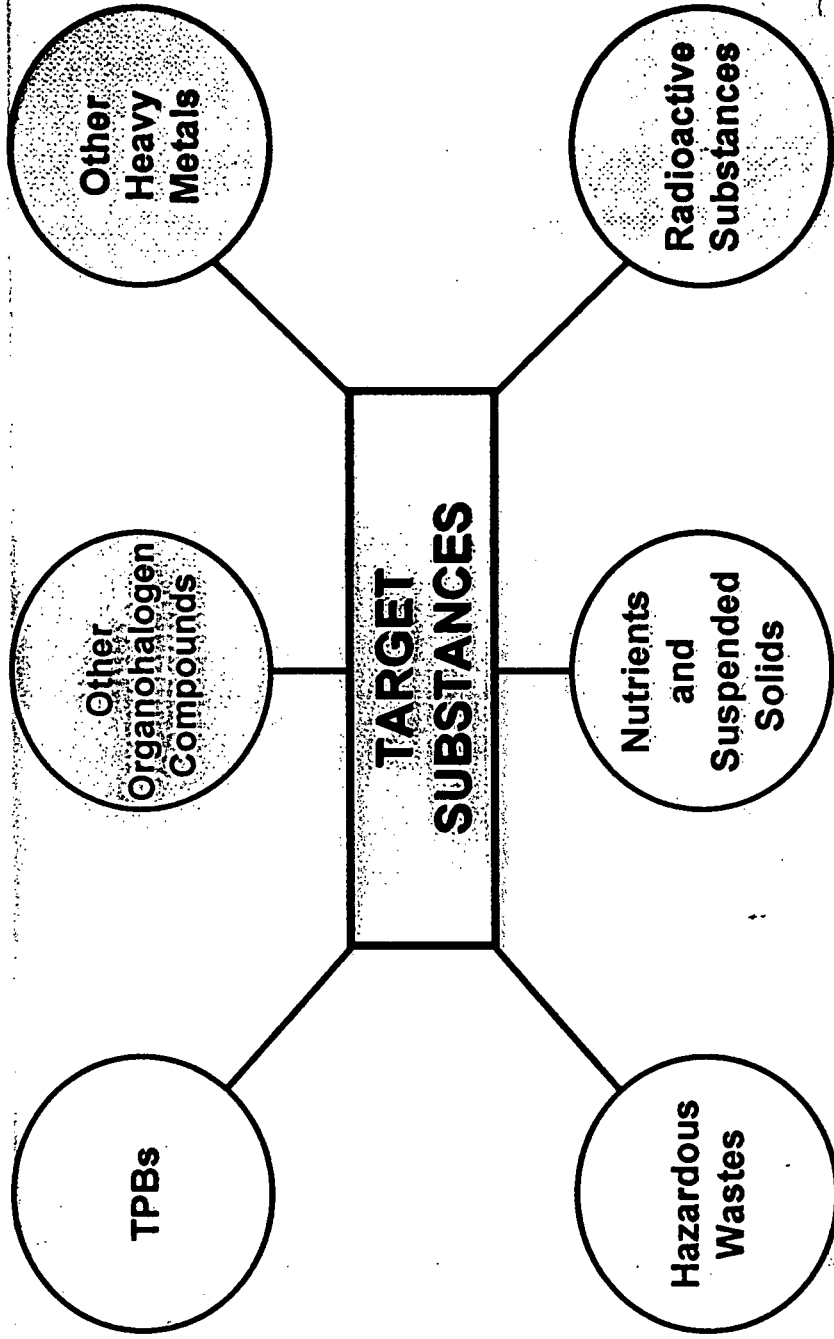
URBAN ENVIRONMENT

- ▶ Municipal sewage
- ▶ Urban solid waste
- ▶ Air pollution

INDUSTRIAL DEVELOPMENT

- ▶ TPBs
- ▶ Other Organohalogen Compounds
- ▶ Other Heavy Metals
- ▶ Radioactive substances
- ▶ Nutrients and suspended solids
- ▶ Hazardous wastes

STRATEGIC ACTION PROGRAMME - INDUSTRIAL DEVELOPMENT



UNEP

in Plan

UNEP MAP

United Nations Environment Programme

TPBS are:

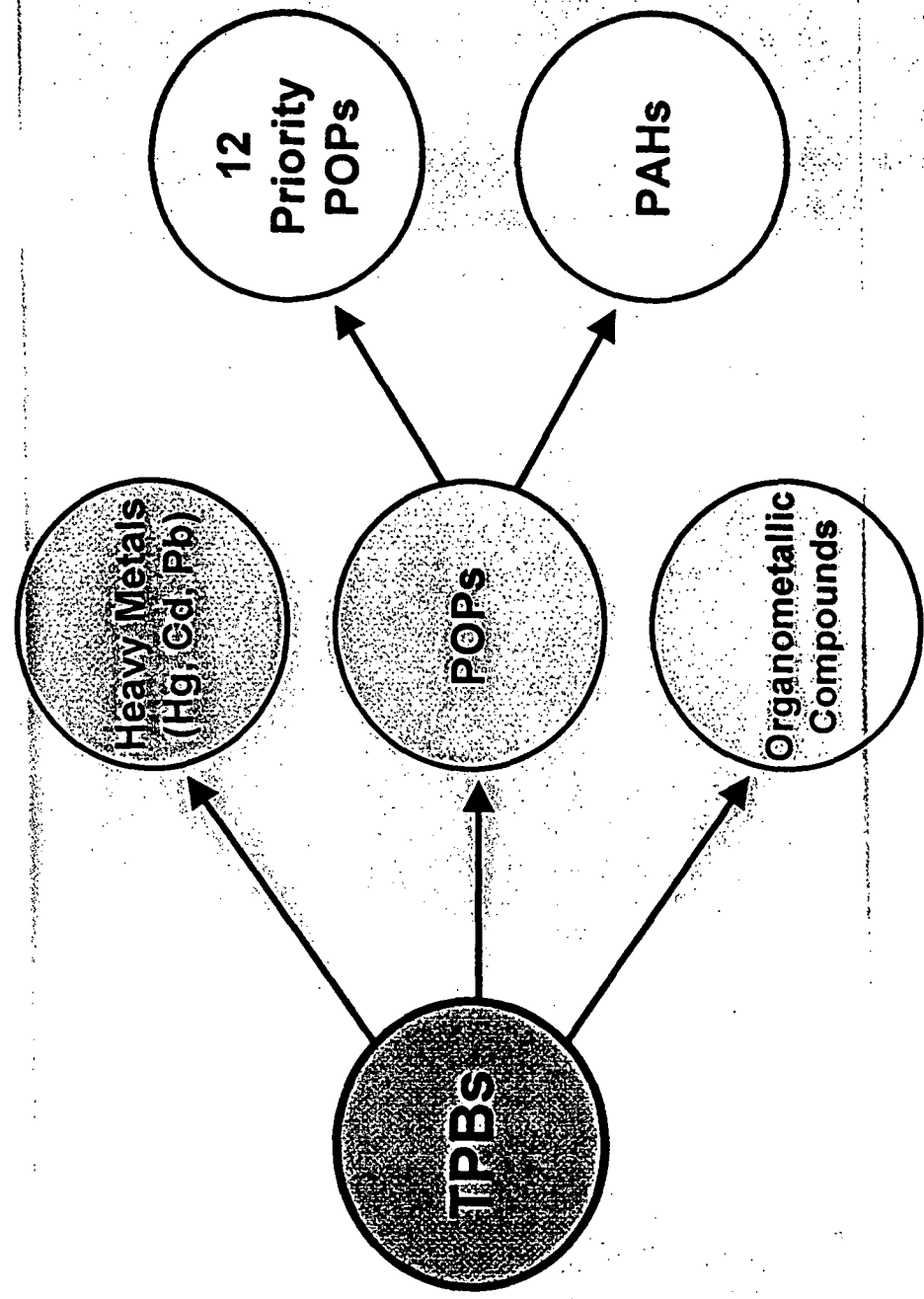
- ▶ Toxic
- ▶ Persistent
- ▶ Liable to Bioaccumulate

and they include:

- ▶ Persistent Organic Pollutants (POPs)
- ▶ Some heavy metals (Hg, Cd, Pb)
- ▶ Some organo-metallic compounds (organo-mercuric, organo-lead and organo-tin compounds)

SAP - INDUSTRIAL DEVELOPMENT

BREAKDOWN OF TPBS



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Issue	Targets			Regional activities	National activities
	2005	2010	2025		
1) Industrial pollution		50% reduction of TPB	Point sources discharge and emissions conformity with LBS & standards	<ul style="list-style-type: none"> - guidelines for WWT - EQO for point sources - information programme - research programme - guidelines for BEP, BAT - environmental management 	<ul style="list-style-type: none"> - inventory of point sources - national regulations - priority to SME - environmental management
		50% reduce of inputs	Phase out inputs of POPs	<ul style="list-style-type: none"> - provide technical information - guidelines for BEP and BAT - emission values for point source discharges for PAH 	<ul style="list-style-type: none"> - inventory of POPs and PAHs - phase out use of pesticides - safe disposal of PCBs and pesticides - reduce emissions of HCB, dioxins, furans
2) TPB-POPs	collect and dispose all PCBs	Phase out inputs of POPs	phase out inputs of PAH		<ul style="list-style-type: none"> - apply BEP & BAT
		25% reduction of PAH inputs			

Issue	Targets			Regional activities	National activities
	2005	2010	2025		
3) Heavy metals (Hg, Cd, Pb)	85% reduction	50% reduction	phase out discharges emissions & losses		<ul style="list-style-type: none"> - apply BAT & BEP - national programmes - adopt emissions of 0.5 g Hg/t of chlorine or 5 g Hg/t depending on process - 2 g Hg total releases
organo Hg, Pb, Tin compounds	phase out organo Hg	50% reduction of discharges	phase out organo Pb, organo Sn	<ul style="list-style-type: none"> - guidelines for BAT & BEP - EQO and standards 	<ul style="list-style-type: none"> - inventory of organometallic - phase out the use of organotin as antifouling and cooling systems - apply BAT & BEP and environmental management
zinc, copper, chromium		reduce discharges	eliminate discharges	<ul style="list-style-type: none"> - guidelines for BAT & BEP - EQO and standards 	<ul style="list-style-type: none"> - adopt 1 mg/l of zinc - 0.5 mg/l of copper releases into the sea - apply BAT, BEP and environmental management

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United Nations Environment Programme - Mediterranean Action Plan



Issue	Targets			Regional activities	National activities
	2005	2010	2025		
4) - Organoha- logen compounds - Haloge- nated aliphatic hydrocar- bons - Chlorinated phenolic compounds - Organoha- logen pesticides		reduce dischar- ges	eliminate discharges	- guidelines for BAT & BEP - EQO and standards	- apply BAT, BEP and environmental management - adopt 1 kg/t of pulp of AOX release - inventory of pesticides - adopt national programmes for reduction - reduce uses of chlorinated solvent - reduce and control use of 2,4D and 2,5T and chlorophenols - participate in regional and international related programmes
5) Radio- active substances			eliminate inputs	- information system	- environmental management of radioactive waste - apply BAT, BEP to reduce input - reporting

Issue	Targets			Regional activities	National activities
	2005	2010	2025		
6) Nutrients and suspended solids - Urban and industrial waste water		50% reduction from industry	all waste disposed according to LBS protocol	- guidelines for BAT & BEP - EQO and standards	- reduce discharge - environmental management of waste water - apply tertiary treatment - good housekeeping - reuse of treated waste water - environmental management of sludges
- Agriculture			reduce inputs	- guidelines for rational use of fertilizers and losses of nutrients - participate to FAO related programmes	- assess fertilizers - assess quantities of ma... - rational use of fertilizers - good agriculture practices - participate to FAO related programmes - Implementation of convention on desertification

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Issue	Targets			Regional activities	National activities
	2005	2010	2025		
- Atmospheric emissions - Hazardous wastes		20% reduction of generation of hazardous waste 50% safely disposed	dispose in safe environmental sound manner	- prepare Mediterranean strategy for management of hazardous wastes - adopt common antipollution measures	- national strategy for the management of hazardous wastes - national plans for management of hazardous wastes - envir. sound disposal of hazardous wastes - ratify hazardous wastes protocol
- Obsolete chemicals	collect and dispose in a safe environmental manner			- programmes for information exchange	- training programmes for recycling, collection treatment, disposal - inventories
- Luboil	50% collect and dispose in a safe environmental manner			- adopt standards for PCB content (50 mg/kg)	- inventories - pilot programmes for recycling, collection treatment, disposal
- Batteries		20% reduction of generation 50% disposed in an environmental manner	dispose all batteries in an environmental manner		- nation inventories - pilot programmes for recycling, collection treatment, disposal - special programmes for public and military sectors



IMPLEMENTATION OF SAP TARGETS

REDUCTION OF RELEASES OF INDUSTRIAL POLLUTANTS INTO THE SEA

The National Budget approach

Applying a **national** budget approach will mean that "each Mediterranean country shall reduce by (x%) their aggregate releases of a targeted pollutant by the year (y) with a reference to a national baseline budget of releases for each SAP targeted pollutant"

Cont...



Cont...

IMPLEMENTATION OF SAP TARGETS
REDUCTION OF RELEASES OF
INDUSTRIAL POLLUTANTS INTO THE SEA

In order to apply the **national budget** approach:

1. each country should set up its own national "baseline budget" for each targeted pollutant, with the assistance of the Secretariat as needed;
2. the "national baseline budget" for a SAP targeted pollutant will be the sum of the individual releases;
3. any country may transfer internally release reduction targets between different activities generating the same pollutant according to the socioeconomic and environmental priorities prevailing in the country.

The National Coordinators adopted the year 2003 as the year for calculating the budget of releases of each SAP targeted pollutant to be able to start the agreed reductions and monitor changes in subsequent years.

Table 1

Phasing of the MAP implementation process

Phase	Milestone activities	Note
<u>Prerequisites</u>	<ul style="list-style-type: none"> - (MED POL Phase III) - LBS Protocol - National Reports on Hot Spots and Sensitive areas - SAP 	<ul style="list-style-type: none"> (Adopted) (Signed, not yet entered into force) (Prepared) (Prepared, approved)
1. <u>Initiation</u>	<ul style="list-style-type: none"> - Operational Document, draft - Operational Document, revised draft - Approved Operational Document 	<ul style="list-style-type: none"> MED POL MED POL Coords., MAP NFPs CPs
2. <u>Formulation of the</u>		
<u>Preparation of inputs</u>	<ul style="list-style-type: none"> - Updating of National reports on Hot Spots and Sensitive areas - Preparation of NDAs - Preparation of sectoral programmes 	<ul style="list-style-type: none"> (National authorities) and MED POL) " "

Preparation of NAPS

- Preparation of NAPS
- Adoption of NAPS

"
(to be defined by national authorities)

- Adoption of list of priorities
- Adoption of workplan and timetable

(national authorities)

- Gradual implementation of NAPS according to list of priorities

(According to NAP and targets defined by SAP and NAP)

- Provision of assistance and support (National support, MED POL and international sources)

(MED POL and international sources)

4. Reporting and Update

- fifth year review of SAP implementation process
- fifth year update of the SAP according to the development international conventions

(MED POL and national authorities)

5. Implementation and Monitoring

- Participatory activities
- Monitoring, evaluation, reporting
- Readjustment of NAP, if needed

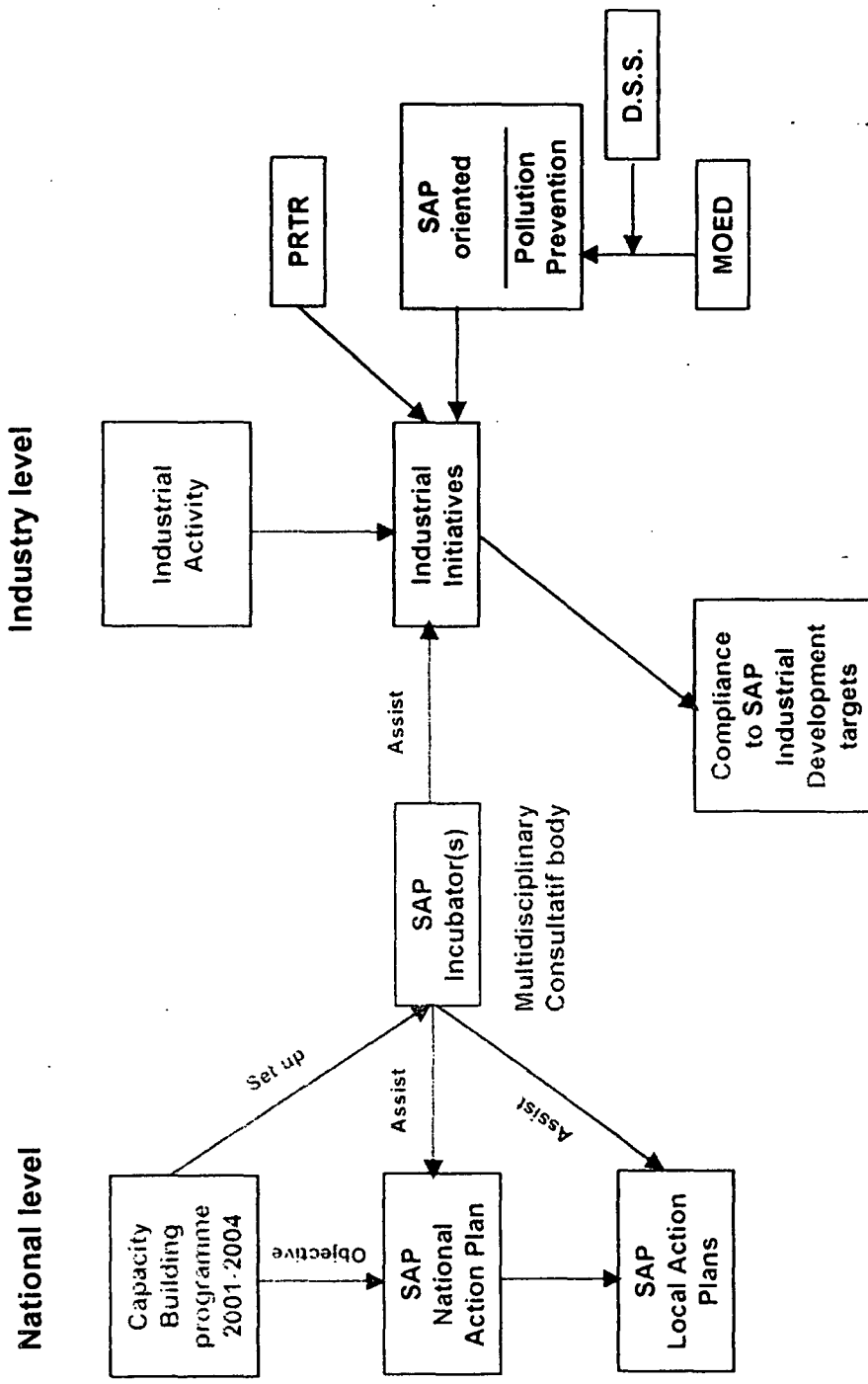
(Following SAP and NAP provisions)

(Targets identified by SAP and NAP)

(According evaluation of results and reports)



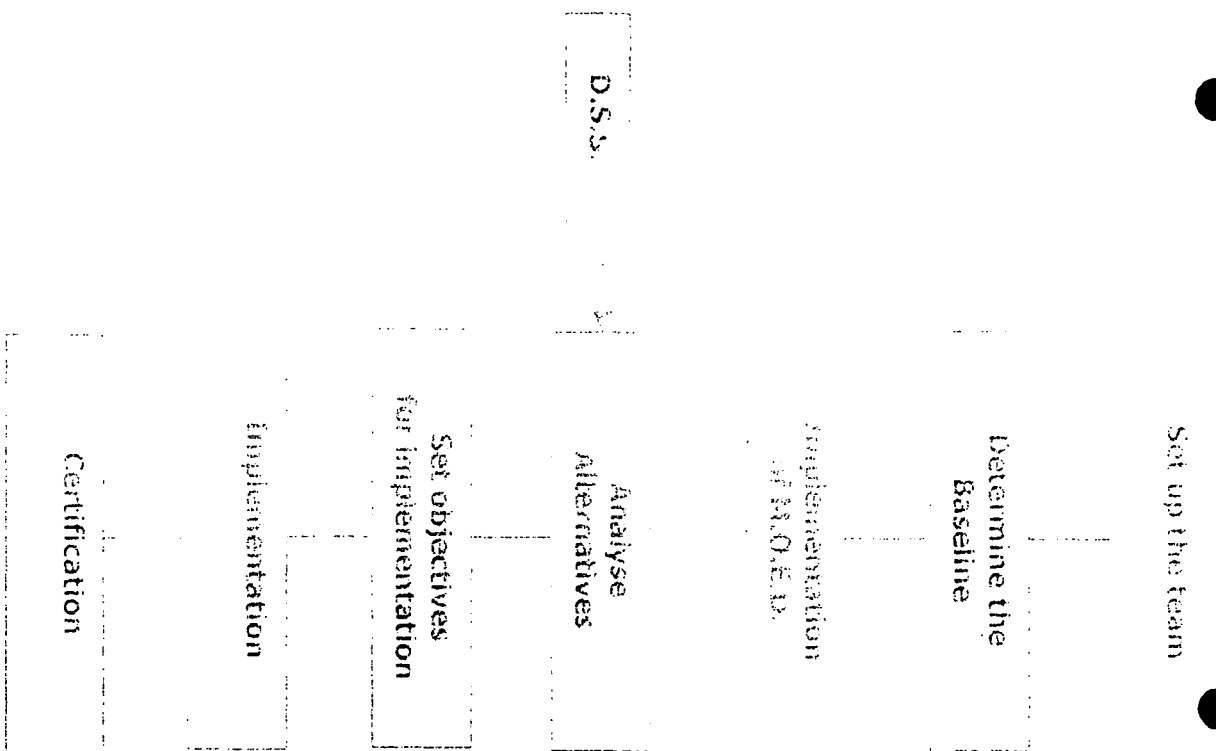
Proposed SAP Industrial Development Implementation Strategy





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Description of the Major Steps of the Implementation of P.P.P.



situation at t_0
 $B.B.A = \square R_1, R_2, R_3$

N.A.P. set up targets to reach by individual projects
 R_1', R_2', R_3'

Implementation of
Pollution Prevention Plan

Individual certified release reductions
 R_1'', R_2'', R_3''

$O.B.B.A = \square R_1'', R_2'', R_3''$

Three possibilities
 $O.B.B.A < B.B.A$ certification
 $O.B.B.A = B.B.A$ no certification
 $O.B.B.A > B.B.A$ no certification

Flow Chart Indicating the Certification Process

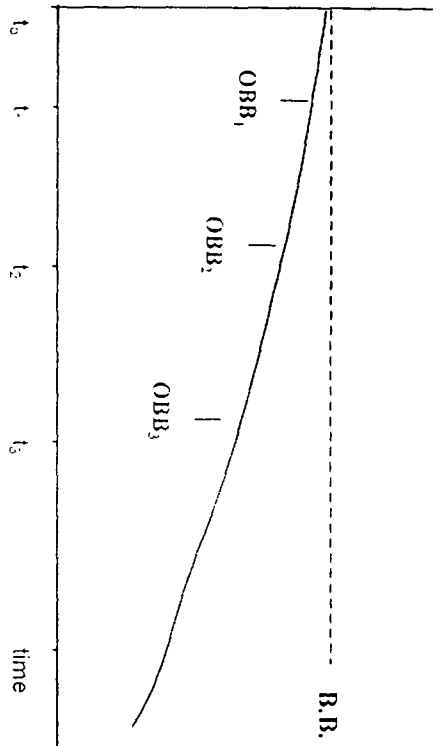


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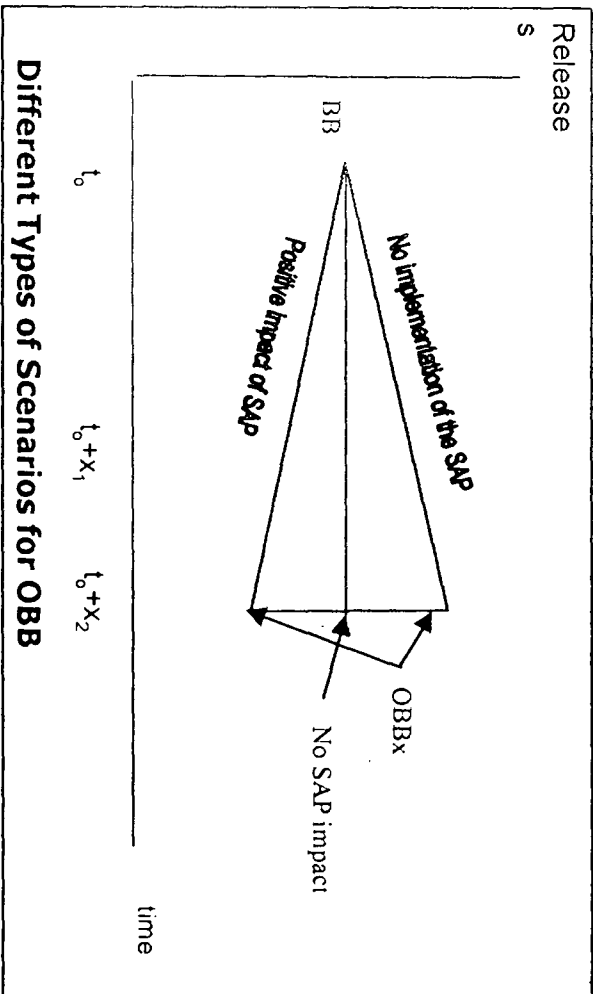
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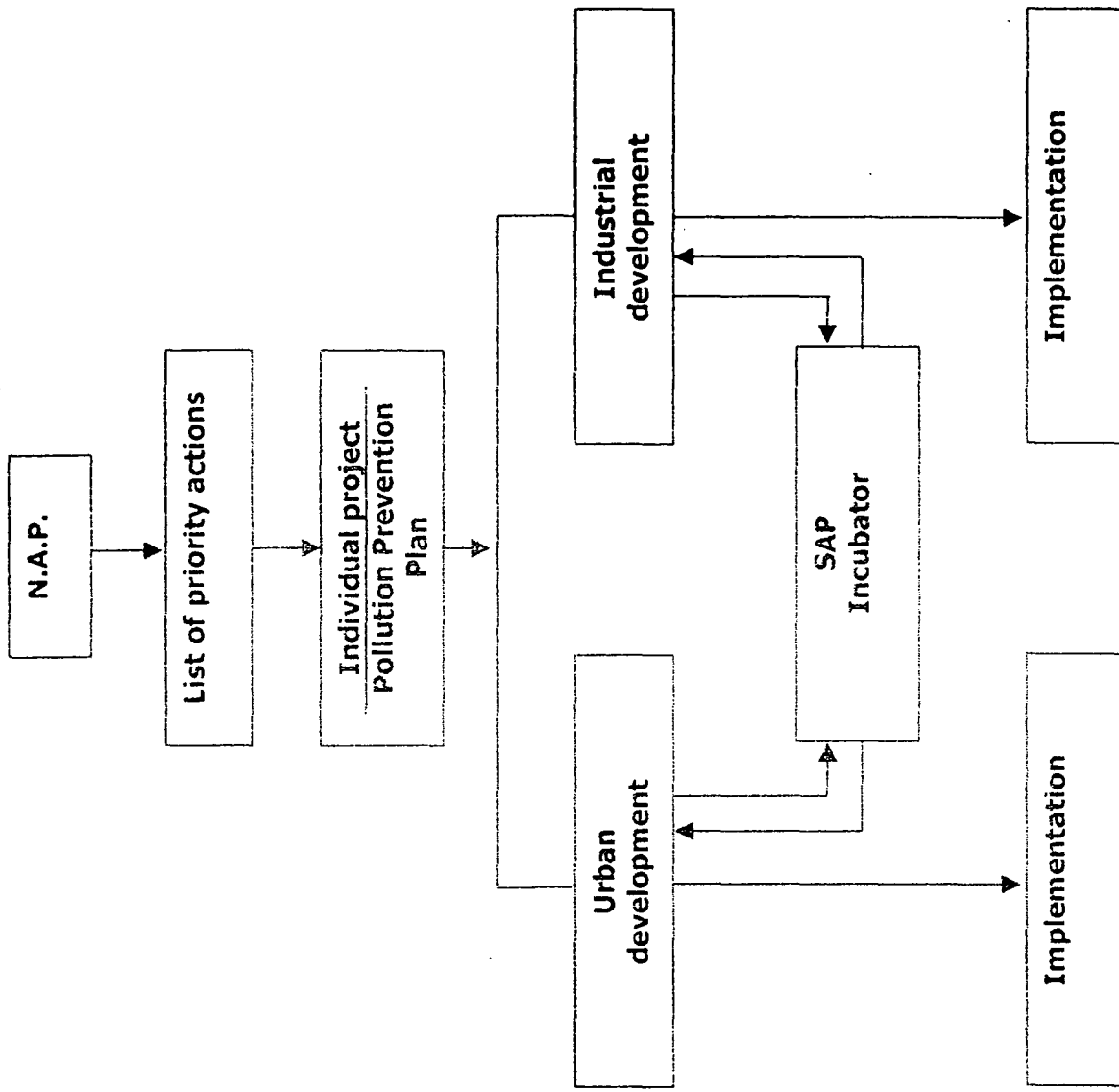
Releases



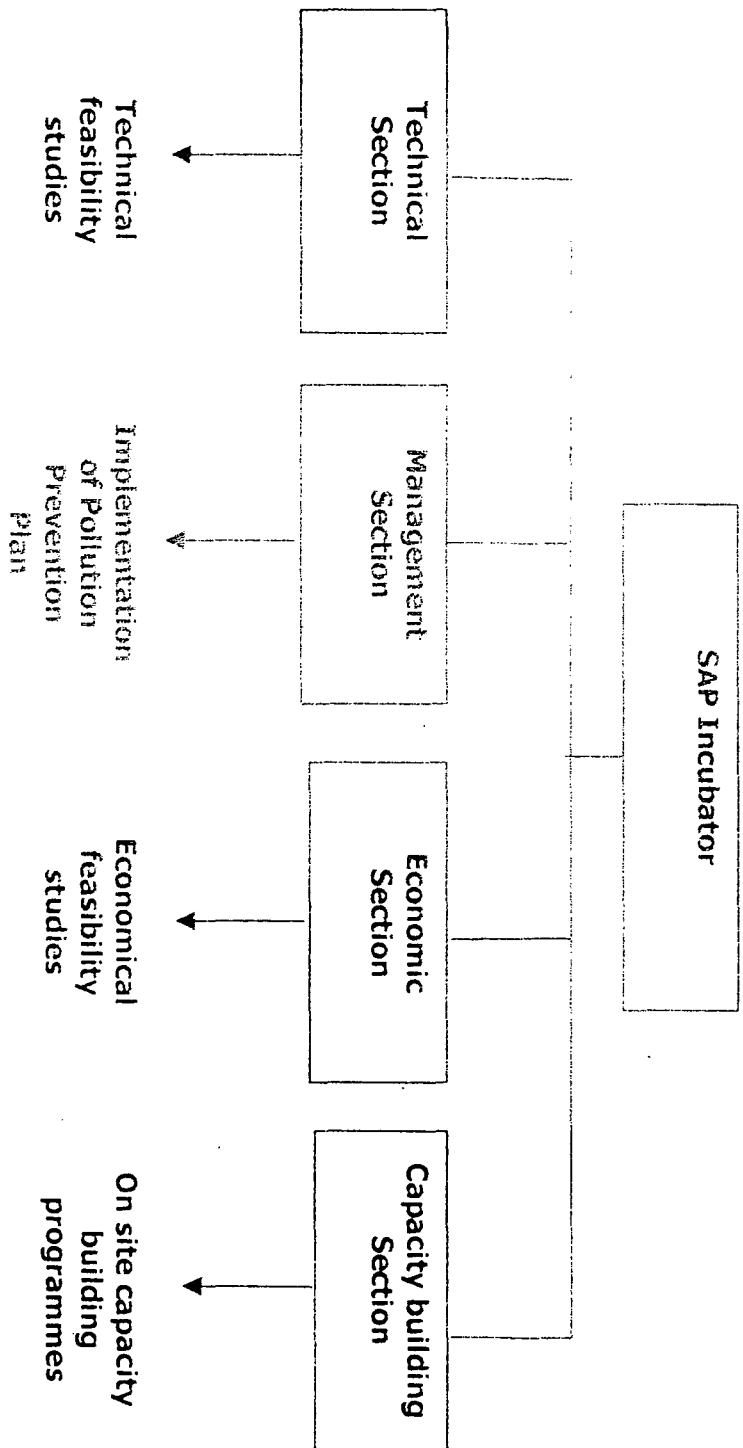
Schematic figure describing the BB and OBBS concepts



Different Types of Scenarios for OBB



Integration of SAP Incubator in the Process of Implementation of SAP-NAP



Institutional Set Up and Duties of the SAP Incubator

REPUBLIQUE ALGERIENNE DEMOCRATIQUE ET POPULAIRE

MINISTERE DE L'AMENAGEMENT DU TERRITOIRE

ET DE L'ENVIRONNEMENT

Industrial activities in Algeria

**Training course on "INDUSTRY AND DEVELOPMENT
RELATED TO THE MEDITERRANEAN" Rabat , Morocco, 29
October – 03 November 2001**

By Ms N.Kacimi & A.Loukriz

Industrial activities

Before the promulgation of the frame-law related to the environmental protection dated in 05 February 1983, all the projects was realized without providing the Environmental Impact Assessment (EIA).

In 27 February 1990 a national decree number 90-78 related to the Environmental Impact Assessment was appeared, it shows us the kind of projects not submitted to an EIS, in 1998 an other decree was created respecting the nomenclature of classified plants, it notes that each projects needs the wali's or minister's authorization should provide an EIA.

The target from the EIA is to prevent all the negative and positive impacts of the project on the environment, then to try to find the measures in order to reduce, eliminate or to mitigate the significant potentials impacts on the environment.

It has been register that the industrial projects which was implemented without elaboration of EIA, has affected the environment and human health by rejecting its wastes in the nature and gas emissions in the air.

For example some of rivers has been polluted by the liquid wastes, such as Moulah, Tafna, El-Mabtoul Sarno, Mina et Cheliff in the West, El-Harrach in the Center, and Rhumel, Kebir-rhumel and Seybouse in the East.

In the center of Algeria, more than 100 factories have thrown their liquid wastes loading with organic and mineral matters and heavy metal inside the El-Harrach River. The last has reached a high level of pollution

Concerning the atmospheric pollution caused by the industrial activities, we can hold as example the cement plants existed in different regions of the country, has rejected: 4569 T of NO_x, 1269T of CO and 1020.000 of SO₂ per year.

Industrial activities generate also an important quantity of solid wastes, some of its are taken towards the public discharge, the other are stored on the land within the factories in waiting on a final solution. The following table gives the production's quantity of wastes per sector :

Sector	Percentage
Steel-making, metallurgic, mechanic, and electric	50%
Building material, ceramic, glass,	5%
Chemistry, rubber, plastic	2%
Food's industry , tobacco, matches	29%
Textiles, hosiery trade, clothing industry	10%
Leather and shoes	1%
Wood, paper, printing works	3%

To confront this problem of pollution, the administration of the environment has ordered to elaborate the environmental audit for the industries started to work before 1990, and which is source of pollution.

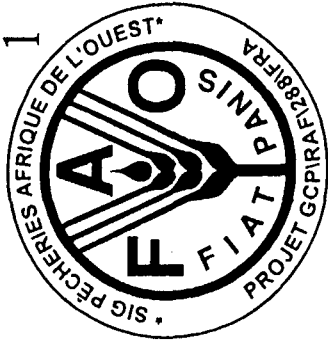
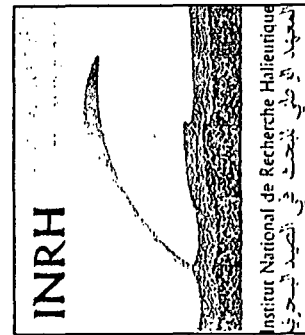
By the way two audits are established, one is for Rais hamidou cement plant situated in Algiers (capital), the other is for the painting complex of Souk ahras in the East of Algeria.

The environmental audit of Rais Hamidou estimates that 3063 T of dust particles pollutes every year the surrounding of the industry.

To avoid this kind of pollution and increase the production with 3100 T, the audit has suggested to put in the filters.

Concerning the measures taken by the audit of the painting complex, we note the followings:

- The ecological management of hazardous wastes
- Put in of the monitoring system of gas emission
- The installation of smokes washing system at the chimney.

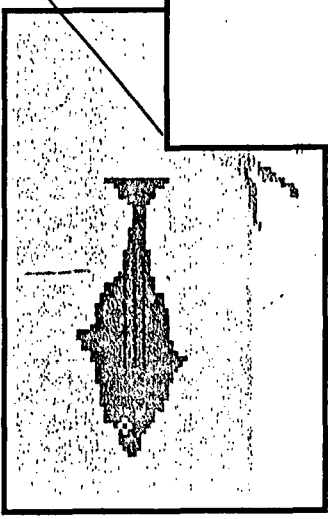


**LES SYSTEMES D'INFORMATION GEOGRAPHIQUE POUR
LES PECHERIES EN AFRIQUE DE L'OUEST
1995-1997**

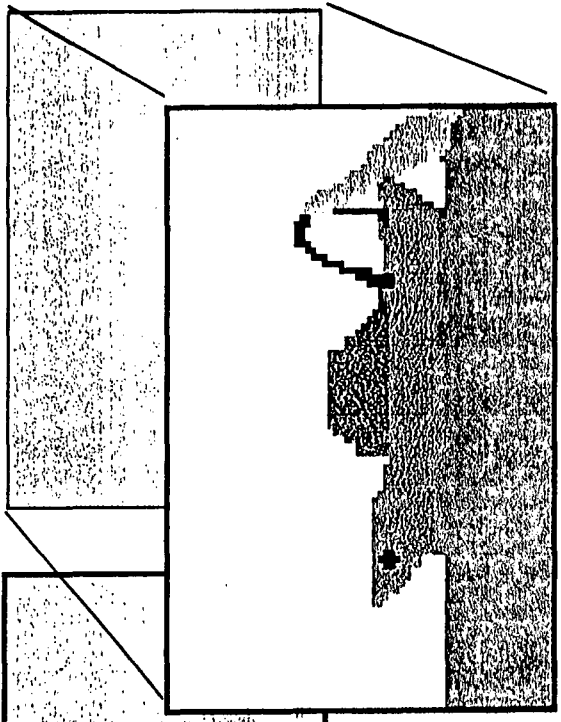
PAR

**ALI SRAIRI
COORDINATEUR NATIONAL DU
PROJET F.A.O.-S.I.G**

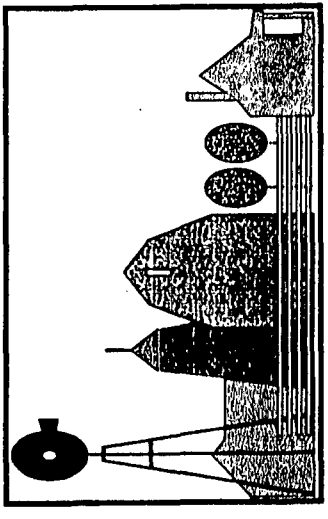
RESSOURCES



FLOTTILLES



INFRASTRUCTURES



Le Projet

GIS for fisheries in West Africa

First part

- Introduction : Project approach
- users needs
- tools developed
- Perspectives

Second part

- Demonstration on developed tools

The Project

Context

- Marine GIS = virgin field
- large regional geographical dimension

● Objectives

- improve fisheries management through the use of modern GIS technologies
- improve national capacities
- reinforce regional collaboration

● Strategy

- pilot project
- national applications
- participative approach
- regional coordination

Principales phases du Projet

Faisability

- sensibilisation
- evaluation of state of the art (data inventory)
- preparation of a demonstration

Assesment of users needs

- decision makers
- information producers

Development of tools / training

- data base structuration
- user interface development
- Maps elaboration

Presentation of results

Needs expressed by users

- **Decision makers needs**

- 1) **multi thematic descriptive cartography**
 - resources
 - fleets activity / means of production
 - infrastructures
- 2) **structure data on demand**
 - information system
- 3) **impact studies / fisheries management scénariis**
 - multi critèrion spatial modelisation
 - quantitative simulations

- **information prducers needs**

- **data base structuration**
 - models
 - concepts
- **dispose of work autonomy**
 - friendly user tools : user interfaces
 - references to methods
- **information exchange**
 - standard marine data bases
 - data exchange protocoles

Computer TOOLS

développé in the frame of the Project

OPERATIONNAL OBJECTIVES

- regional scale standards tools
- GIS as research tool :
 - user friendly tool to make easier spatial exploration of data by scientists
- GIS as management tool :
 - articulation with ATLAS type use forecasted

PROPERTIES

- extensible and supple tools

The TOOLS

- 3 standard models : resources, fleets, infrastructures
- 3 complementary softwares

GIS Perspectives

Success of geographical Approach

- scientist level
 - funny to use
 - understanding of phenomenons
- decision maker level
 - concrete support of exchanges and communication
 - descriptive approach is fundamental
- constraint : importance of a cartographer

multi-thématique approach

- GIS = real support of pluri-disciplinary approach
- institutionnal aspect very important

geographical quantitative Modélisation

- delicate because of fluid phenomenons
- prerequisite :
 - undertake indeep exploration of phenomenons
 - strong coordination and animation

Perspectives système d'information offertes par ces nouveaux outils

thematic Aspects :

- audit / available data inventory
- tools training sessions

opérationnal Aspects :

- network necessity
- information system team

institutionnal Aspects :

--> to allow exchanges

- intra organisms : IS departement function
 - needs definition
 - data quality assesment
- inter institutions : steering comitees role
 - define data quality protocoles
 - define exchange protocoles



Institut National de Recherche Halieutique
المعهد الوطني للبحث في الصيد البحري

FORMATION DES CADRES DU MINISTERE
DES PECHEES MARITIMES
03/04/2000 au 21/04/2000

COURS D'OCEANOGRAPHIE LITTORALE

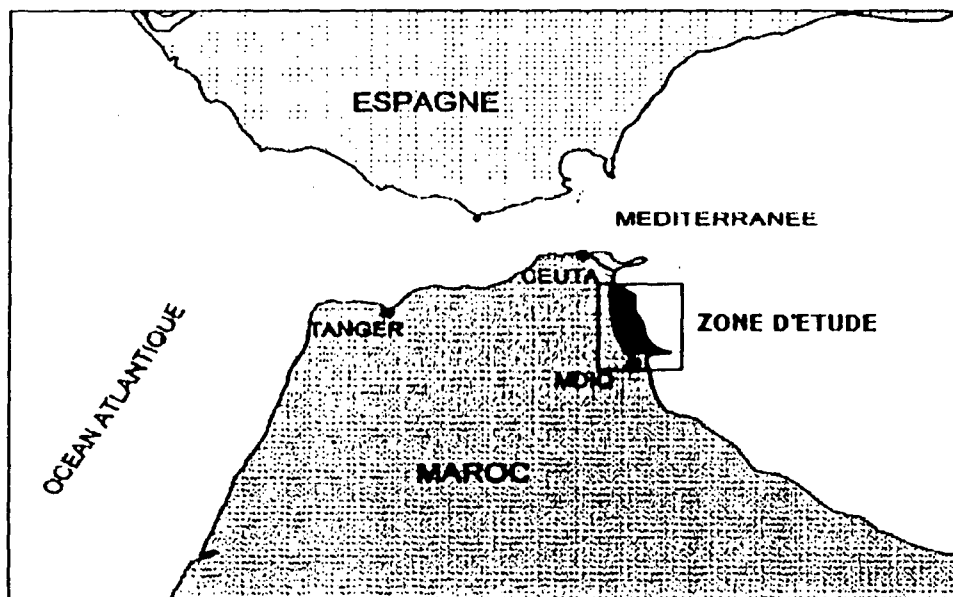
Par : Jaouad LAKHDAR IDRISSE (*)
E-mail : jlakhdar@yahoo.com

Département d'Océanographie et d'Aquaculture (I.N.R.H)
Unité de Recherche et Développement Océanographie (URDO)
(*) Laboratoire d'Océanographie Biologique (LOB)

ETUDE HYDRODYNAMIQUE DANS LA BAIE DE M'DIQ IMPACT DES APPORTS TERRIGENES SUR L'ACTIVITE AQUACOLE

Par : J. LAKHDAR I(1), A. ORBI(1), F. ZIDANE(2), K. HILIM(1) et F. SARF(1)

(1) : INSTITUT NATIONAL DE RECHERCHE HALIEUTIQUE (I.N.R.H)
(2) : FACULTE DES SCIENCES AÏN CHOCK- CASA I



XXVI^{ième} Colloque de L'UOF :
Zones Littorales et Anthropisation
Gestion et Nuisances
La Rochelle (France), 4 - 6 Juillet 2000

PLAN

□ PROBLEMATIQUE DU SUJET

- ORIGINE DE LA MORTALITE
- CHOIX DU NOUVEAU SITE

□ PRESENTATION GENERALE DE LA BAIE DE M'DIQ

- CARACTERISTIQUES SPECIFIQUES DE LA BAIE
- CONTRAINTES NATURELLES

□ METHODOLOGIE DE TRAVAIL

- RESEAUX D'ECHANTILLONNAGE
- PARAMETRES ETUDIES

□ RESULTATS

- ETUDE SEDIMENTAIRE
- ETUDE PHYSICO-CHIMIQUE AU NIVEAU DES DEUX SITES D'ELEVAGE
- ETUDE COURANTOLOGIQUE

□ CONCLUSION

- SCHEMA DE CIRCULATION DES EAUX :
 - ⇒ SITUATION NORMALE (ETE)
 - ⇒ SITUATION EXCEPTIONNELLE (HIVER)
- CHOIX DU NOUVEAU SITE

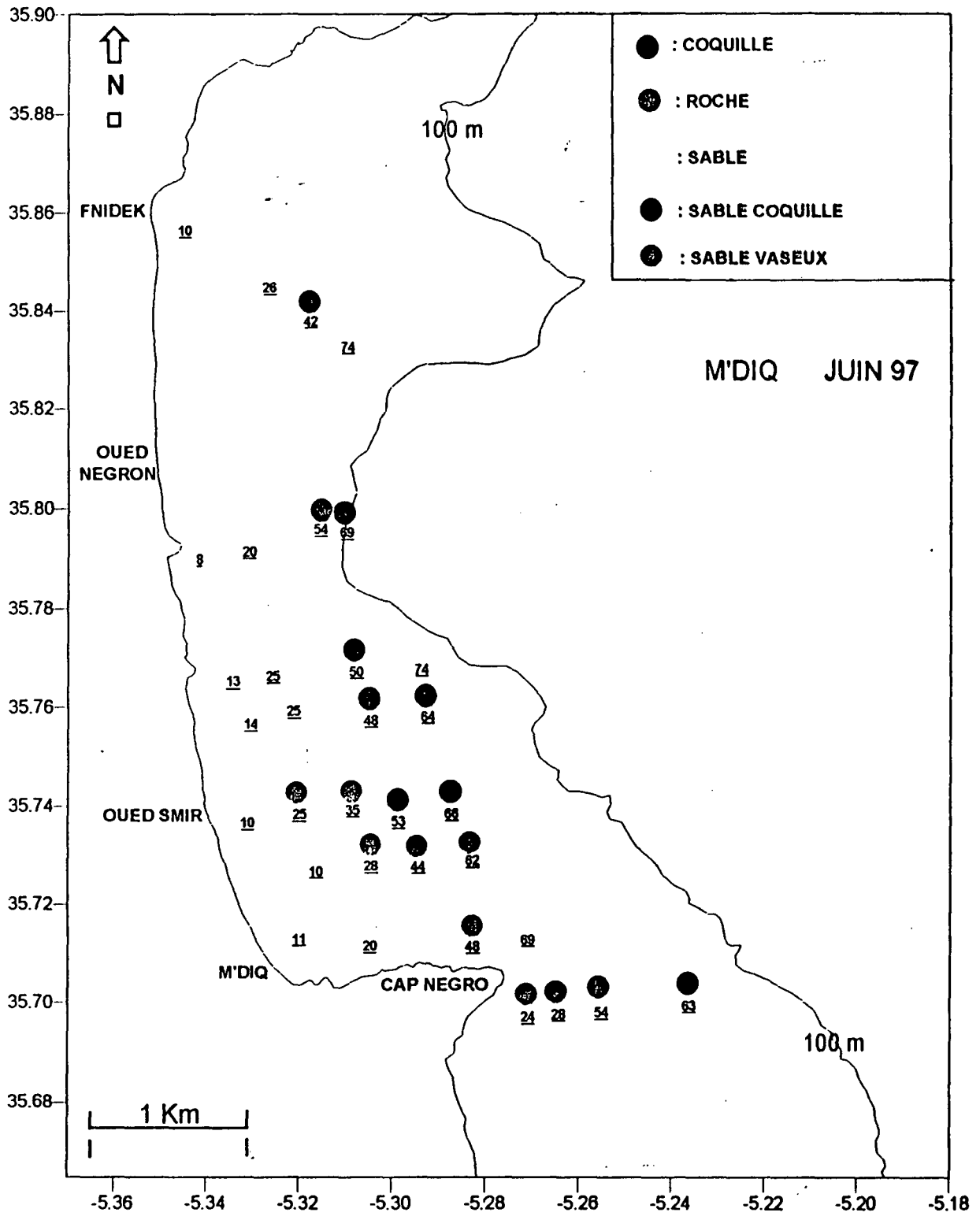
PRESENTATION GENERALE DE LA BAIE

1- CARACTERISTIQUES SPECIFIQUES DE LA BAIE

SITUATION GEOGRAPHIQUE	CEBTA (NORD) – CAP NEGRO (SUD)
LONGUEUR	23 KM DANS UNE DIRECTION NORD-SUD
CARACTERISTIQUES TOPOGRAPHIQUES	<ul style="list-style-type: none"> - COTE AVEC UNE PENTE FAIBLE - COTE ROCHEUSE - FONDS SEDIMENTAIRES - GRAND BASSIN VERSANT
EXISTENCE DE 2 OUEDS	OUED RIO NEGRON AU NORD (HIVER) OUED RIO SMIR AU SUD (ETE HIVER)

2- CONTRAINTES NATURELLES

CLIMAT	TYPE MEDITERRANEEN <ul style="list-style-type: none"> - ETE : CHAUD ET SEC - HIVER : PRECIPITATIONS BRUTALES (800 A 100MM/AN SUR TROIS 3 MOIS) 		
VENTS DOMINANTS (VIOLENTS)	MAI-OCTOBRE : EST "CHERGUI" OCTOBRE-FEVRIER : OUEST "GHARBI"		
TYPE DE HOULES - HOULES DOMINANTES - HOULES EXCEPTIONNELLES (ENGENDRE UN TRANSIT SEDIMENTAIRE DU S VERS LE N, PENDANT UN LAPS DE TEMPS)	<u>DIR</u>	<u>HAUTEUR</u>	<u>PERIODE</u>
	<ul style="list-style-type: none"> - E A E-N-E - E 	0,5M-2M 4M – 5M	5 A 6 S 2 A 3 S



Carte n° 3 : Nature du fond et profondeurs des stations d'échantillonnage
(JUN 1997)

RESULTATS DE L'ETUDE SEDIMENTOLOGIQUE

LE REPERAGE DES FACIES SEDIMENTAIRES DANS LA BAIE PERMET DE LOCALISER TROIS ZONES HYDRODYNAMIQUES :

» **ZONE ROCHEUSE** : SITUEE EN FACE DE KABILA ET EN FACE DE CAP NEGRO ET CARACTERISEE PAR UNE FORTE DYNAMIQUE ;

» **ZONE DE SABLES COQUILLERS** : SITUEE ENTRE KABILA ET RESTINGA ET CARACTERISEE PAR UNE FORTE AGITATION PERMANENTE QUI PERMET UN TRI DU SEDIMENT ;

» **ZONE DE SABLES VASEUX ET DE VASES SABLEUSES** : REPEREE AU NIVEAU DU CAP NEGRO ET AU SUD DE L'OUED SMIR ET CARACTERISEE PAR DE FAIBLES TURBULENCE DES COURANTS (CALME).

STATION n°1 " Site d'élevage "

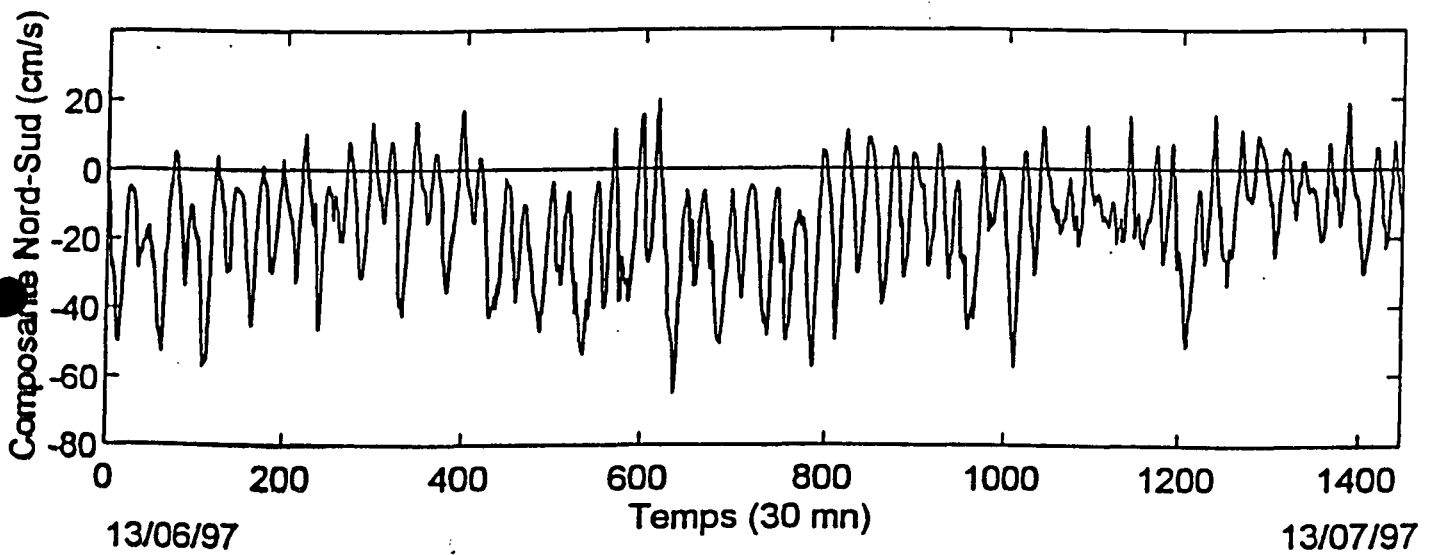
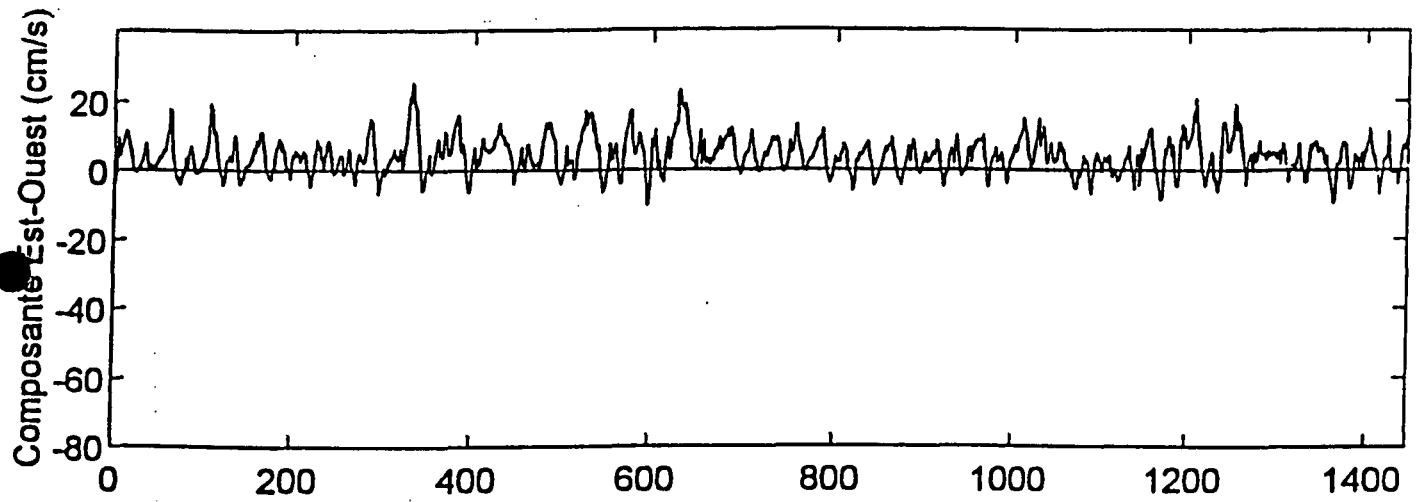


Fig. : Variation temporelle des composantes U (Est-Ouest) et V (Nord-Sud) du courant à la station n°1 du 13 Juin au 13 Juillet 1997

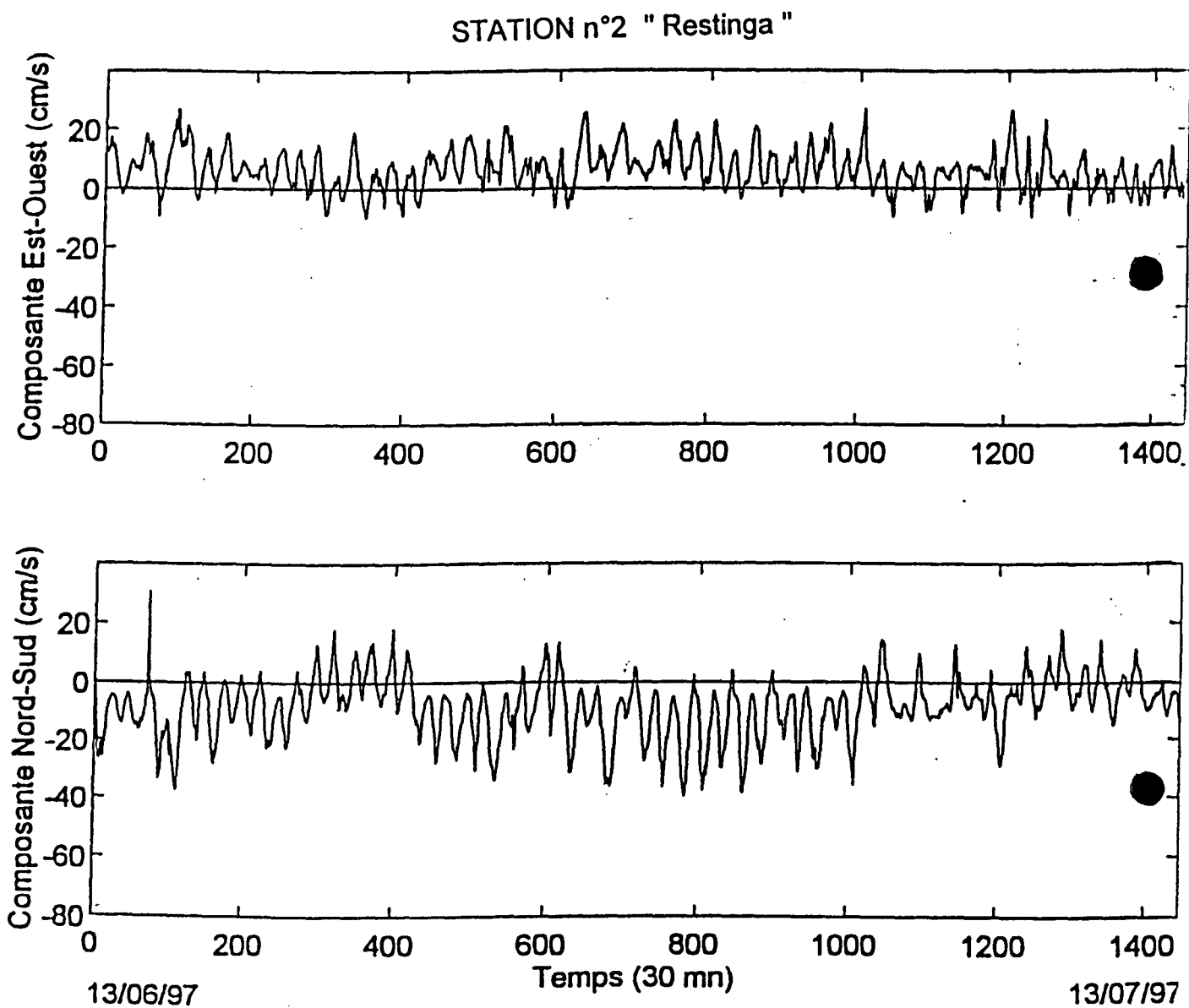


Fig. : Variation temporelle des composantes U (Est-Ouest) et V (Nord-Sud) du courant à la station n°2 du 13 Juin au 13 Juillet 1997

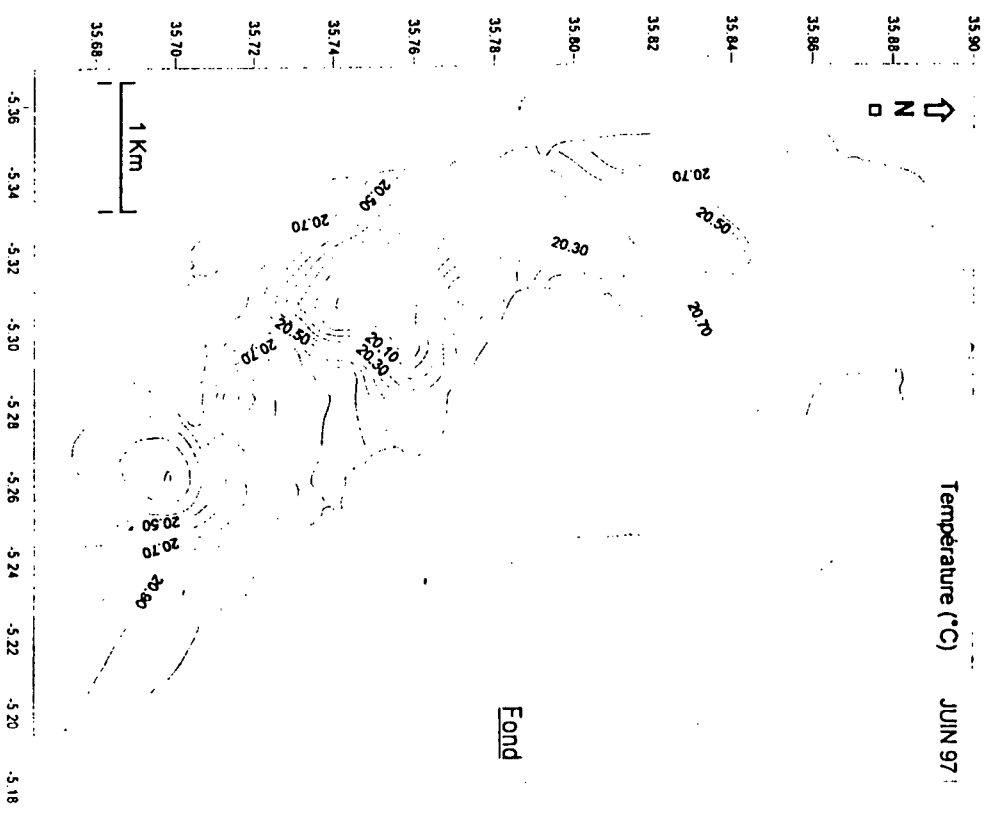
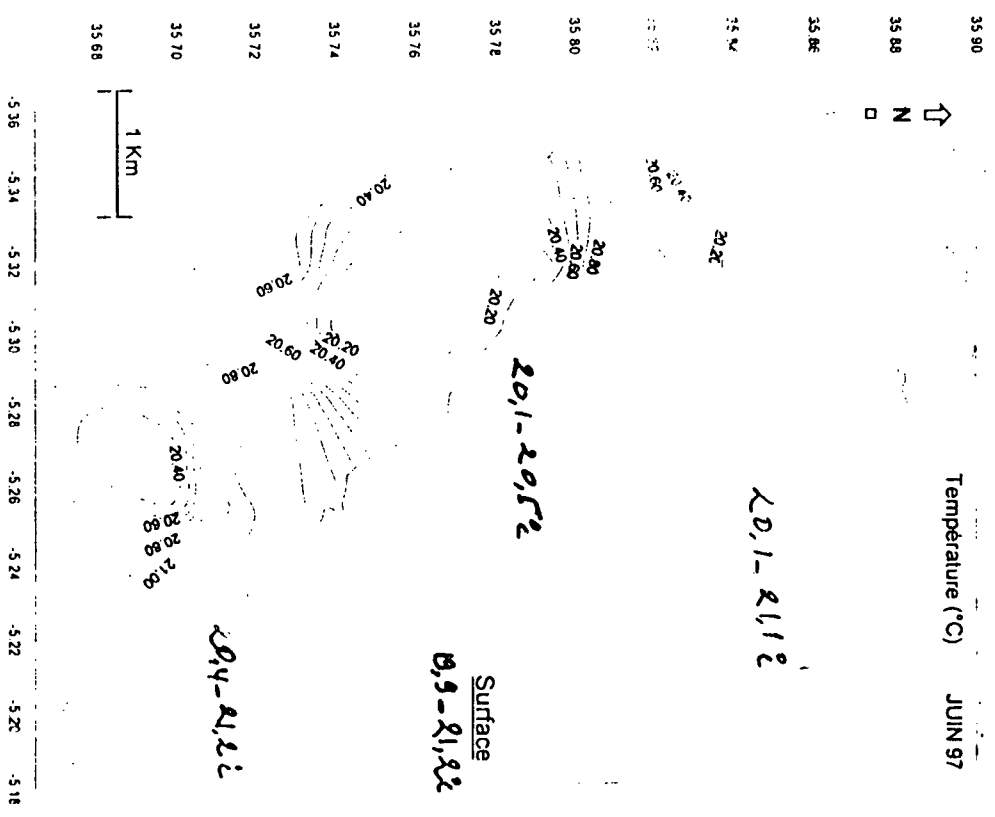
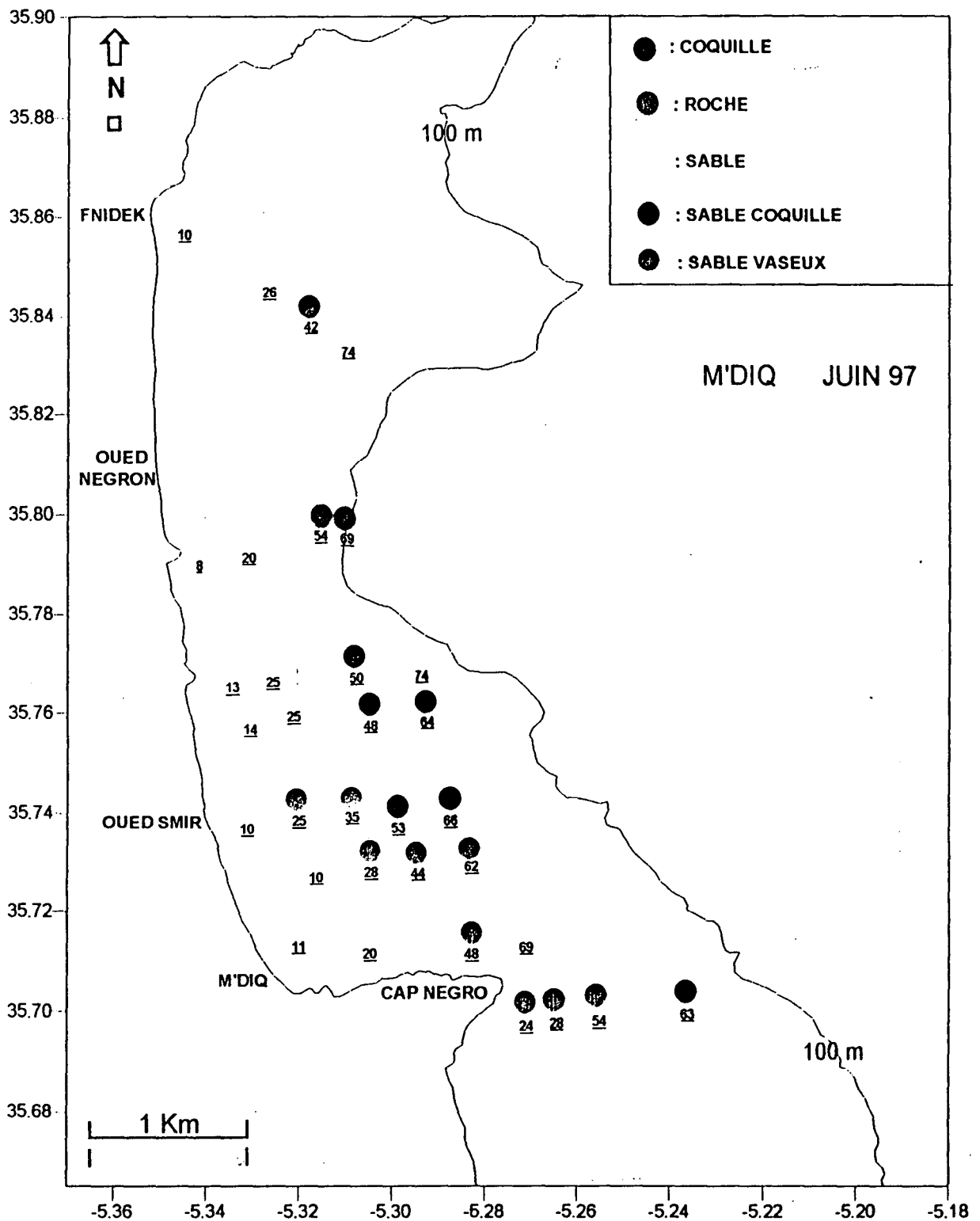


Fig.4 : Isothermes des eaux de la baie de Midj



Carte n° 3 : Nature du fond et profondeurs des stations d'échantillonnage
(JUN 1997)

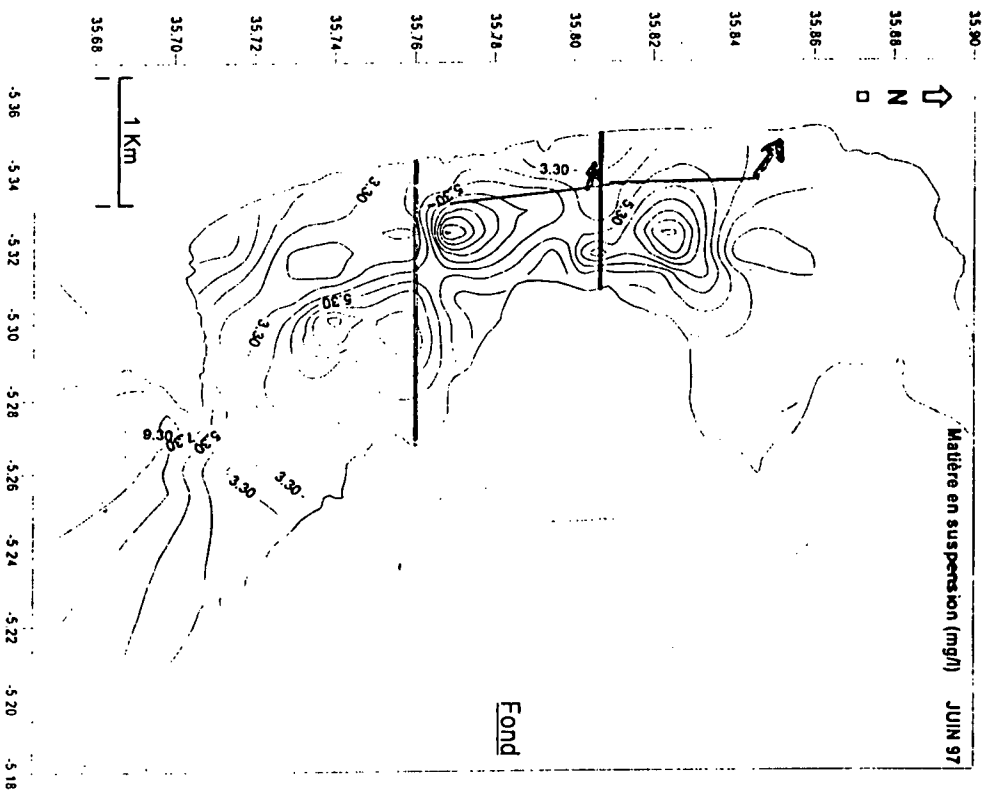
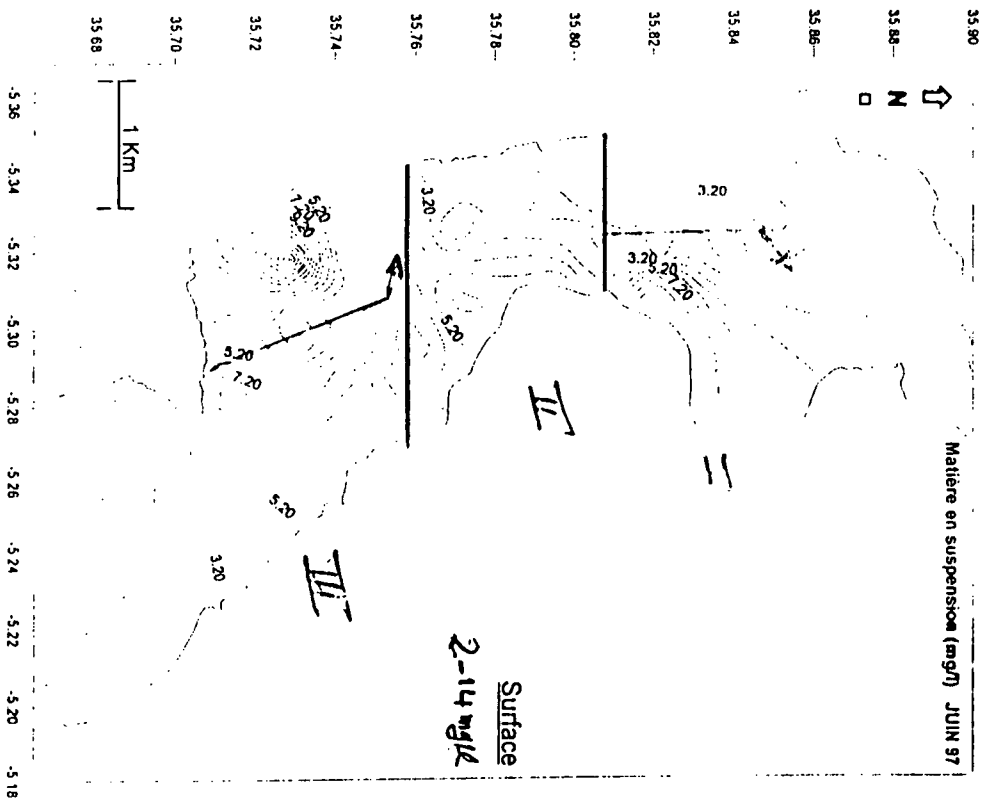


Fig. 6: Répartition de la matière en suspension des eaux de la baie de M'diq

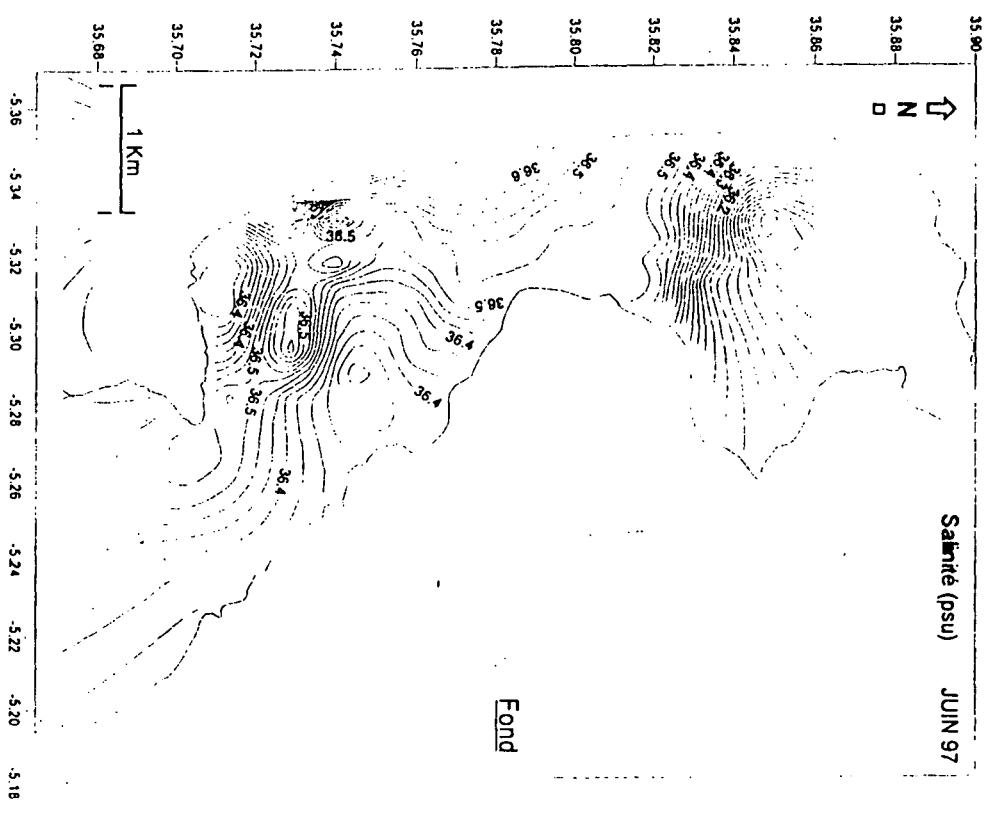
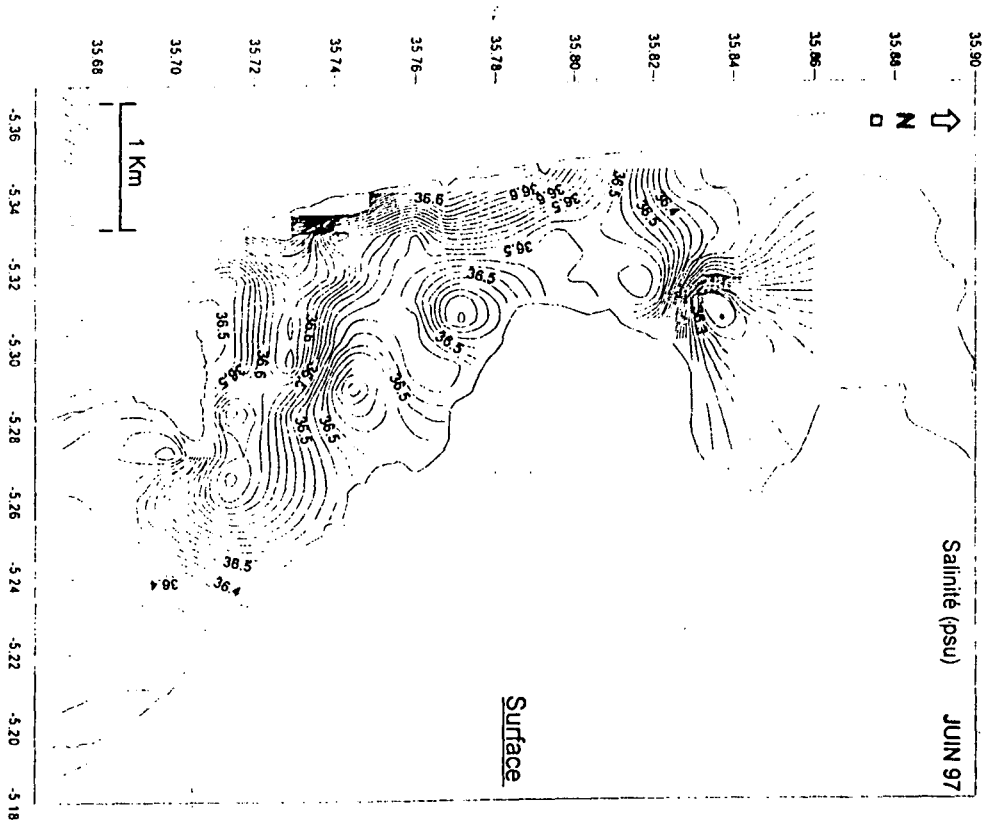


Fig.5 : Isohalines des eaux de la baie de M'idiq



BAIES

DEFINITION

Baie : partie rentrante d'une côte occupée par la mer (Golf).

BAIES DU LITTORAL NATIONAL

En Méditerranée :

Caractéristiques spécifiques : petites, protection partielle et potentiel limité.

- Baie de M'diq
- Baie de CALA IRIS
- Baie de Djebha

En atlantique

Caractéristiques spécifiques :

- 1- protégées, vastes, profondes, stables
- 2- manque d'infrastructures, éloignement

- Baie d'IMMESSOUANE
- Baie d'AGADIR
- Baie de DAKILA
- Baie de CINTRA

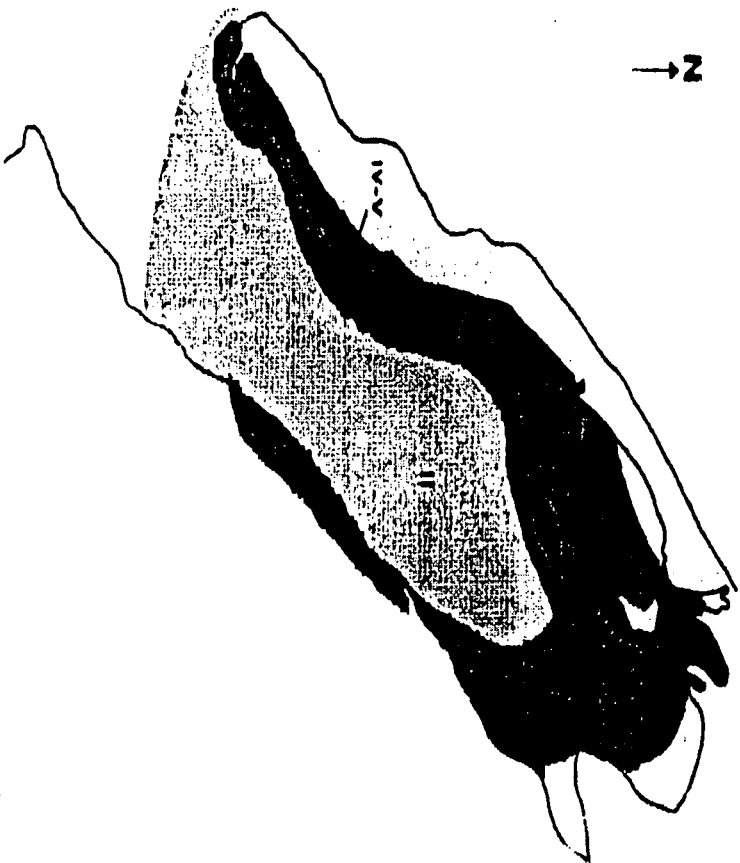
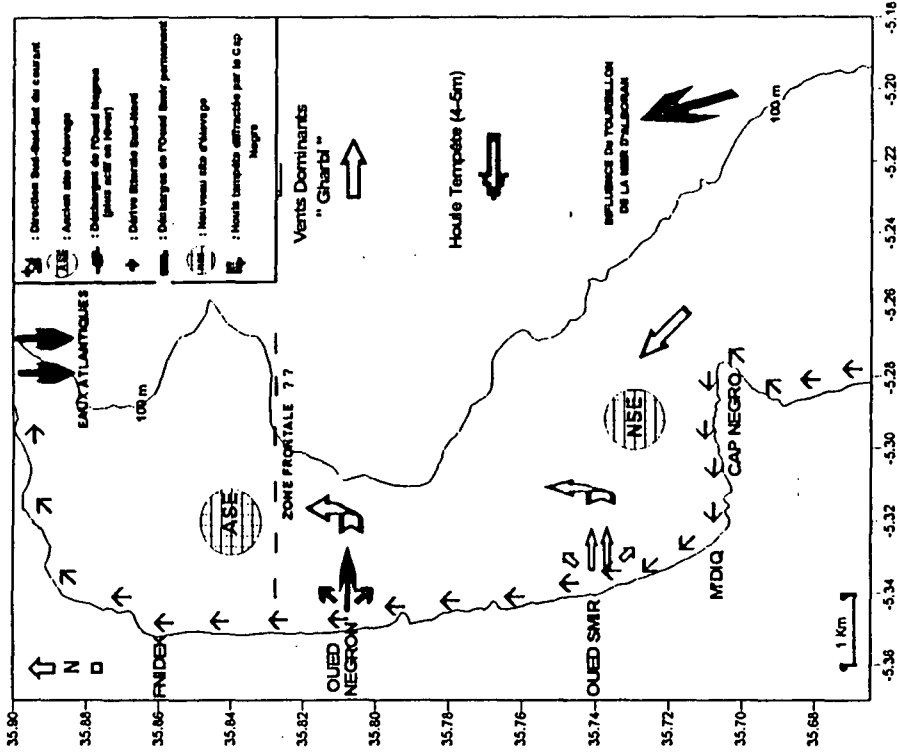
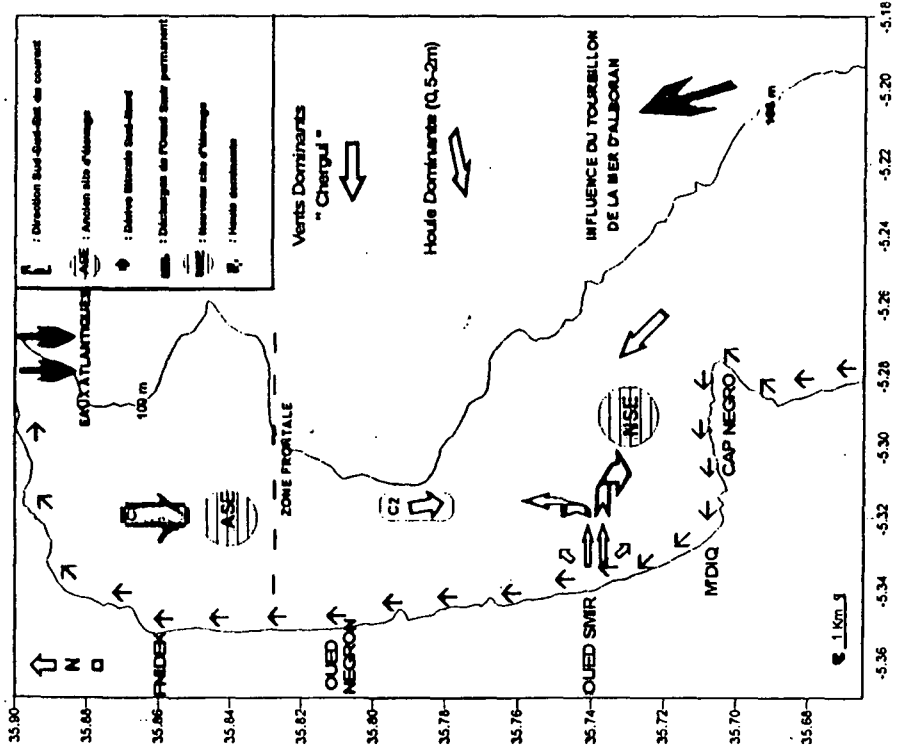


Fig 1: Zonation biologique de la Baie de Dakhla

BAIE DE DAKHLA (Atlantique Sud)



(a): "Situation Exceptionnelle (cas de tempête)"



(b): "Situation Normale"

Carte n°4 : Schéma de circulation des eaux dans la baie de M'diq en période normale (a) et en période de tempête (b).

CONCLUSION

⇒ LES RESULTATS AU NIVEAU DE L'ASE, MONTRENT :

- ◆ CE SITE SE TROUVE DANS UNE ZONE INSTABLE.
- ◆ LES EAUX SONT GÉNÉRALEMENT FROIDES ET PRÉSENTENT DES ÉCARTS THERMIQUES ET HALINS SURFACE-FOND IMPORTANTS.
- ◆ LES EAUX DU FOND SONT MOINS OXYGÉNÉES, RICHES EN NITRATES D'ORIGINE ANTHROPIQUE. LES EAUX DE SURFACE SONT RICHES EN CHLOROPHYLLE "A" ET EN MATIÈRES EN SUSPENSION.

CES RESULTATS COMBINÉS A LA NATURE DU FOND, CARACTÉRISÉE PAR DES SABLES COQUILLERS, TÉMOIGNENT D'UNE ZONE TURBIDE, DUE AU BRASSAGE DES EAUX PAR L'ACTION DES VENTS

⇒ LES RESULTATS AU NIVEAU DU NSE, MONTRENT :

- ◆ CE SITE SE SITUE DANS UNE ZONE CALME.
- ◆ LES EAUX, RELATIVEMENT PLUS CHAUDES, PRÉSENTENT DES CONCENTRATIONS IMPORTANTES EN NITRATES, EN PHOSPHATES ET PARTICULIÈREMENT UN TAUX ÉLEVÉ EN AMMONIUM.
- ◆ LE FOND SEDIMENTAIRE PRÉSENTE UN FACIÈS VASEUX-SABLEUX

IL APPARAÎT DONC QUE LA QUALITÉ DE L'EAU AU NIVEAU DE CETTE ZONE SE TROUVE SOUS L'INFLUENCE COMBINÉE DES APPORTS TERRIGÈNES DE L'OUED SMIR ET LES DÉCHARGES DE L'EFFLUENT DE LA VILLE DE M'DIQ.

CAUSE DE LA MORTALITÉ DES GENITEURS DANS LE SITE D'ÉLEVAGE " CAS DE TEMPÊTE "

EN SE BASANT SUR CES RESULTATS, IL APPARAÎT QUE :

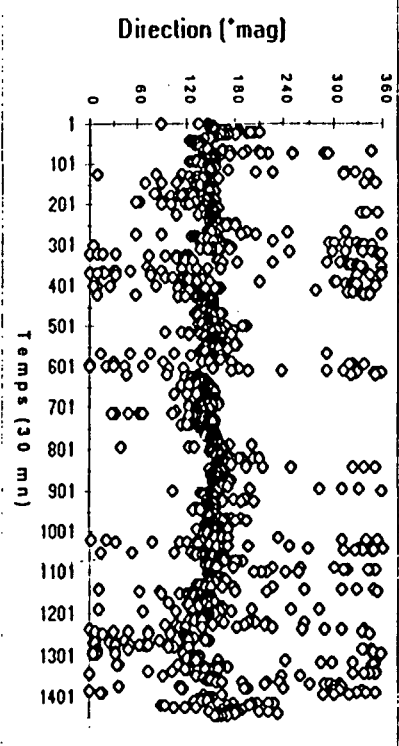
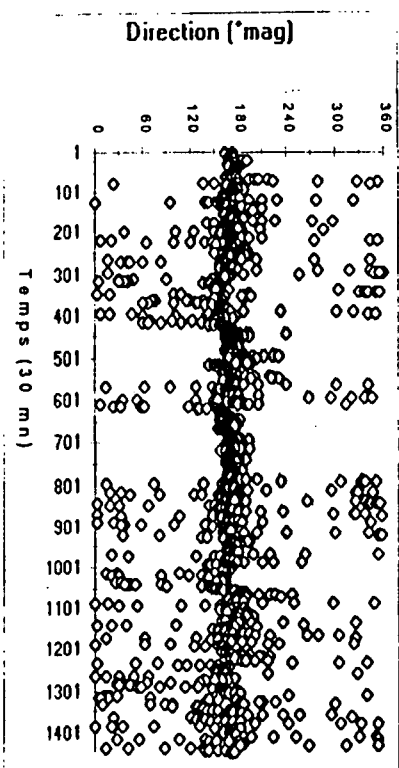
- ◆ L'AGITATION QUI A PROVOQUÉ LA MORTALITÉ DES GENITEURS DE THON ROUGE, PEUT ÊTRE RELIÉE AUX DÉCHARGES EN PROVENANCE DU CONTINENT PAR L'OUED NEGRON.
- ◆ LA POSITION DE L'ANCIEN SITE, SITUE AU NORD PAR RAPPORT A L'OUED NEGRON, LAISSE SUPPOSER QUE LES DÉCHARGES DE L'OUED NE PEUVENT INFLUENCER LES SITES D'ÉLEVAGE QUE SI LES COURANTS DE HOÛLES (N-E), COMBINÉS AUX TEMPÊTES PARTICULIÈRES, DOMINENT SUR LES COURANTS DE MAREE QUI SONT DE DIRECTION S-S-E.
- ◆ LE NOUVEAU SITE D'ÉLEVAGE SE TROUVE DANS UNE ZONE STABLE, MAIS PRÉSENTE DES TAUX ASSEZ ÉLEVÉS EN MÈS EN ÉTÉ ET QUI PEUT S'ACCENTUER EN HIVER : ON CONSEILLE UN DÉPLACEMENT DU NOUVEAU SITE VERS LE LARGE.

RESULTATS DE L'ETUDE COURANTOLOGIQUE

LES PRINCIPAUX RESULTATS DE L'ETUDE COURANTOLOGIQUE DANS LA BAIE DE M'DIQ DURANT LA PERIODE D'OBSERVATIONS SONT LES SUIVANTS :

- » LE COURANT POINTE DANS LA DIRECTION SUD-SUD-EST. IL EST PLUS INTENSE DANS LA ZONE NORD QUE DANS LA ZONE CENTRALE ;
- » LA COMPOSANTE V (NORD-SUD) DU COURANT DOMINE LARGEMENT SUR LA COMPOSANTE U (EST-OUEST), CE QUI VEUT DIRE QUE LE COURANT LATERAL DOMINE SUR LE COURANT TRANSVERSAL ;
- » LA COMPOSANTE V (NORD-SUD) DU COURANT PRESENTE DE FORTES FLUCTUATIONS A LA ZONE NORD QU'A LA ZONE CENTRALE ; PAR CONTRE, LES FLUCTUATIONS DE LA COMPOSANTE U (EST-OUEST) SONT QUASIMENT SIMILAIRES ;
- » LA MAREE DANS LA BAIE DE M'DIQ EST SEMI-DIURNE ET LE MARNAGE EST DE L'ORDRE DE 20 CM EN PERIODE DE MORTE-EAU, DE 80 CM EN PERIODE VIVE-EAU ET INTERMEDIAIRE ENTRE LES DEUX PERIODES.

STATION 1 " ANCIEN SITE D'ELEVAGE "



STATION 2 " RESTINGA "

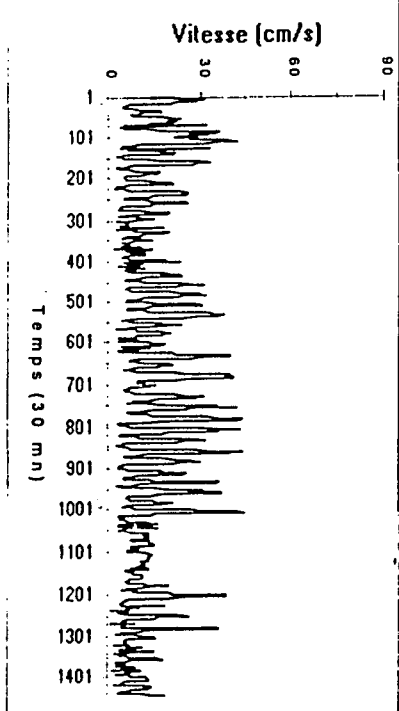
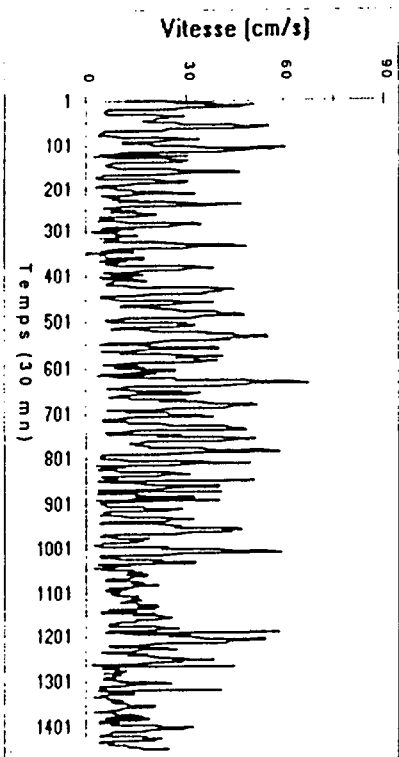
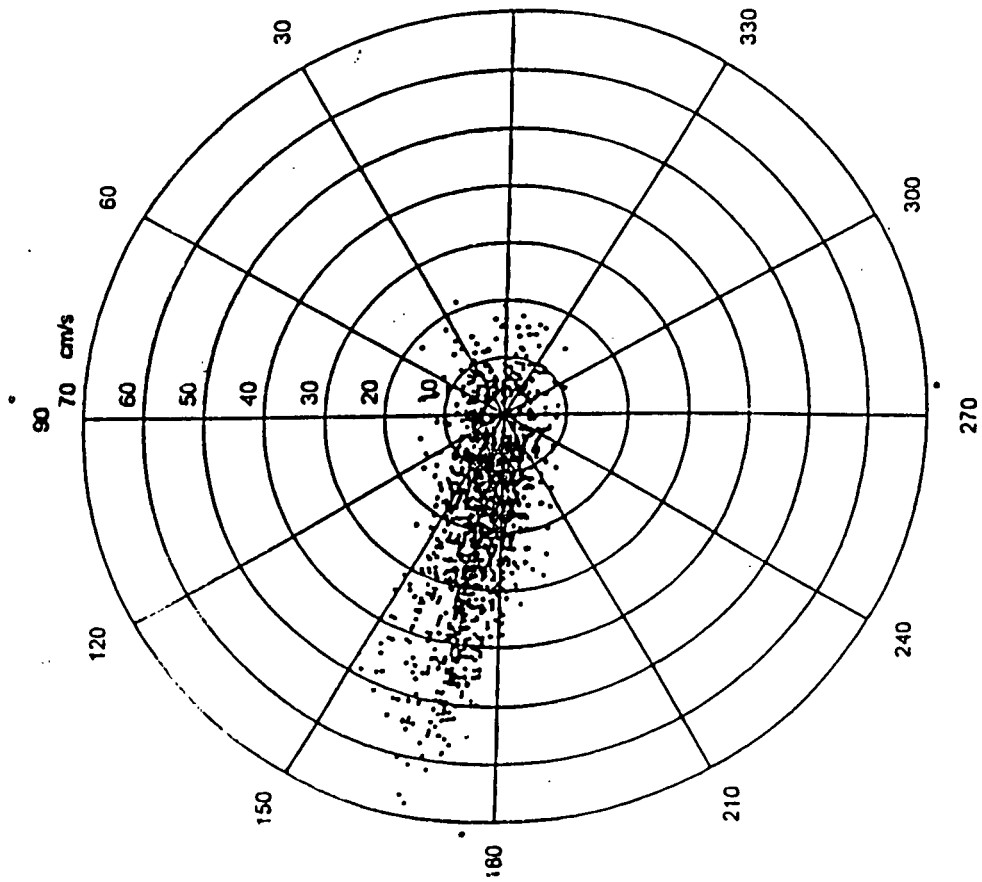


Fig. 4: Variation temporelle de la direction magnétique et de l'intensité du courant aux deux stations 1 et 2 du 13 juin au 13 juillet 1997.

STATION n°1 " Site d'élevage "



STATION n°2 " Restinga "

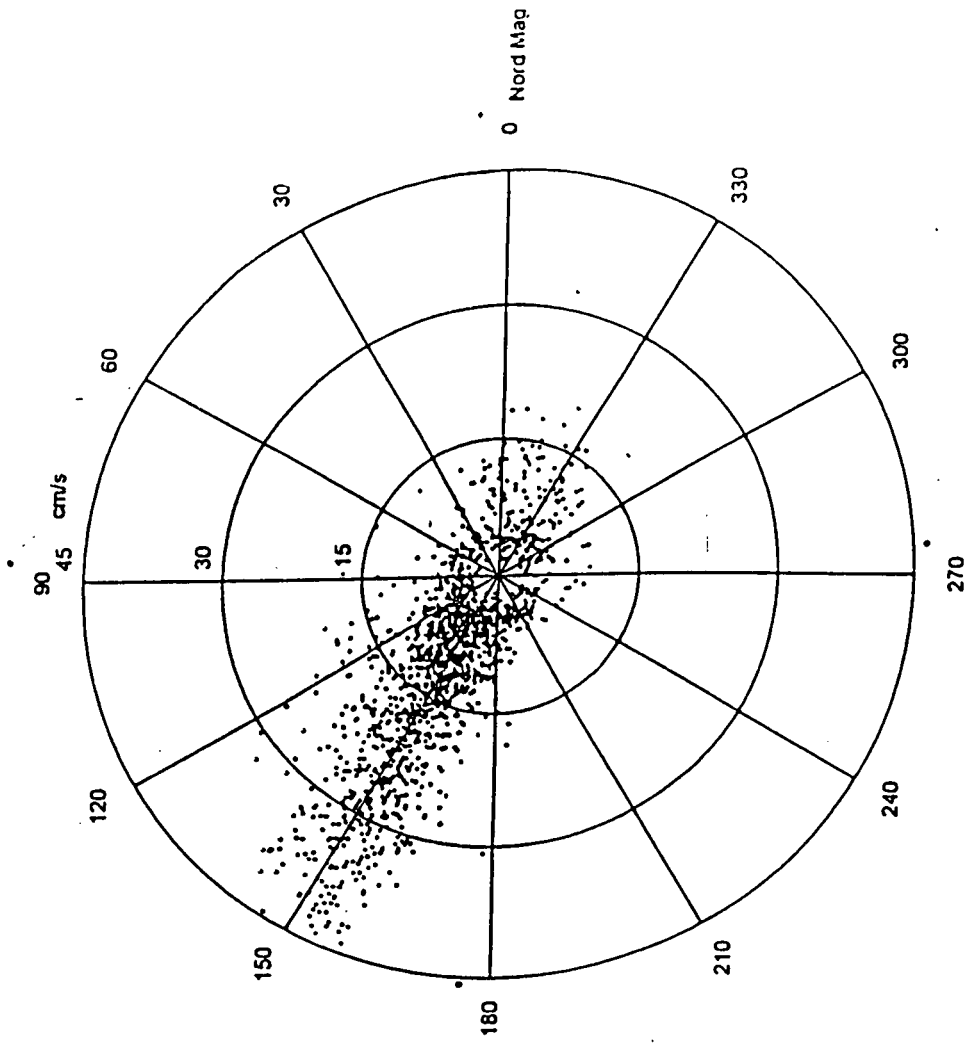
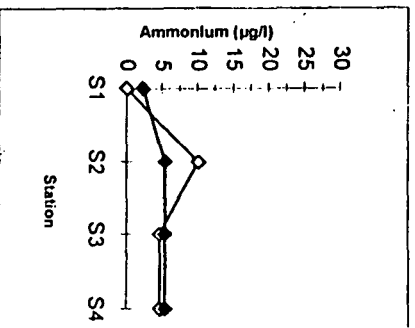
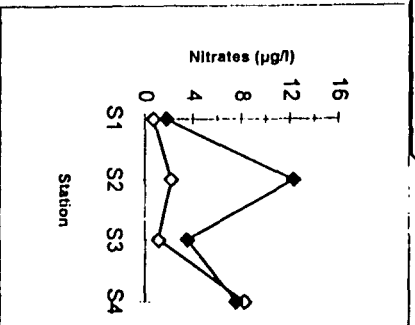
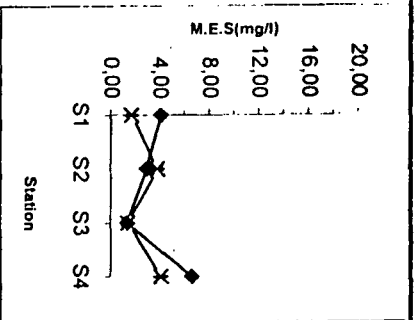
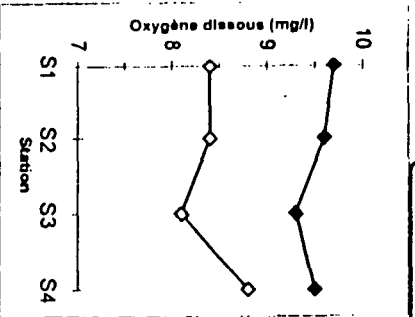
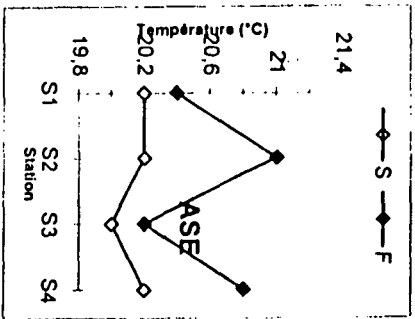


Fig. 6 : Roses du courant aux stations n°1 et 2 du 13 Juin au 13 Juillet 1997

Radiale I (Ancien site d'élevage: ASE)



Radiale VIII (Nouveau site d'élevage: NSE)

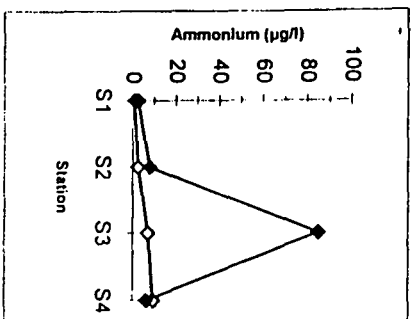
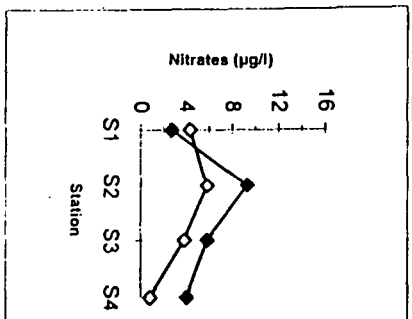
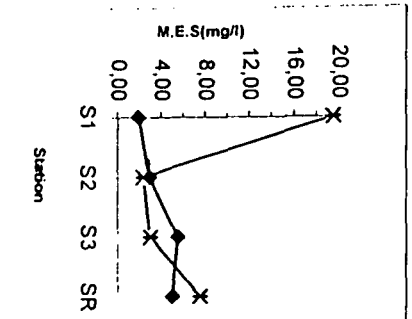
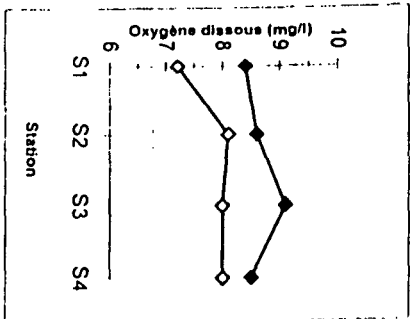
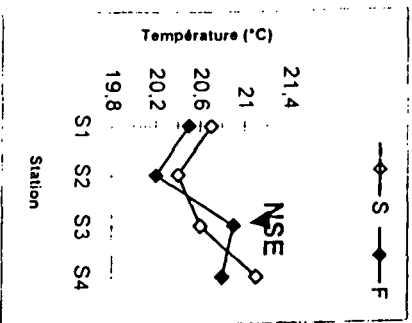


Fig.3: Variation des paramètres de la qualité de l'eau au niveau des deux radiales I (ASE) et VIII (NSE) (D'après Orbi et al., 1997).

Utilisation du Système d'Information Géographique en domaine des Ressources Halieutiques en Méditerranée Marocaine

Par : Rachida HOUSSA

Institut National de Recherche Halieutique
Centre Régional de Nador

B.P. 493 – Nador – Maroc ; tél. & fax : (212) 56 60 38 28 ;
C.E. rhoussa@nadomet.net.ma

L'utilisation du Système d'Information Géographique (SIG) constitue une nouvelle approche pour la spatialisation de l'information et la mise à jour des travaux de cartographie, en vue d'aide à la prise de décision, notamment en matière de gestion et d'aménagement des pêches.

Dans le domaine de recherche halieutique, les efforts nécessaires à la cartographie combinés au besoin croissant en données numériques mises à jour fréquemment ont amené l'Institut National de Recherche Halieutique (INRH) a donné un intérêt particulier pour le développement de son expertise local dans l'utilisation des techniques SIG.

Cet intérêt s'inscrit également dans le cadre de besoin en cartes récentes et à précision fine, de façon qu'elles soient opérationnelles dans de nombreux secteurs d'envergure : domaine de recherche, professionnel ou d'aménagement.

Le but du présent travail est de présenter l'apport du système d'information géographique pour :

- l'élaboration d'une carte de bathymétrie de la Méditerranée marocaine avec des isobathes détaillés, notamment dans les zones de faibles profondeurs où se concentrent la plus grande partie de l'activité de la pêche côtière ;
- l'étude de la distribution spatio-temporelle des ressources démersales à partir des données de campagnes de chalutage expérimentale.

Dr. M'HAMMDI NADIA

Enseignant Chercheur à l'Institut Scientifique

"Département Physique du Globe (DPG)"

☎ 212-7-77-45-43, ☎ 212-7-77-45-40,

☒ : Institut scientifique, DPG, B.P. 703 Charia Ibn Batouta Rabat, Agdal

E-Mail : mhammdi@israbat.ac.ma

Activities Of Research

➤ Two themes of research :

- **Theme 1** consists in the study of a tidal sand bank (Sark Bank), its edification, its internal architecture and relationship between sedimentary and hydrodynamic conditions

The tidal sand bodies on continental shelves remains a matter of debate. They result from complex interactions between relative sea level change and hydrodynamic processes. The dynamics of their building up, of their evolution and their internal structure are not still very known.

- The genetic interpretation and the building up of this big sedimentary bodies is one of axes of the oil research.

- Their proximity of coasts makes some of the potential zones for the exploitation of sand or concentration of minerals and the important zones for halieutic activities

- The mobility of these bodies in of the relatively short times can modify the depth of navigation ways dangerously and embarrass the circulation of boats.

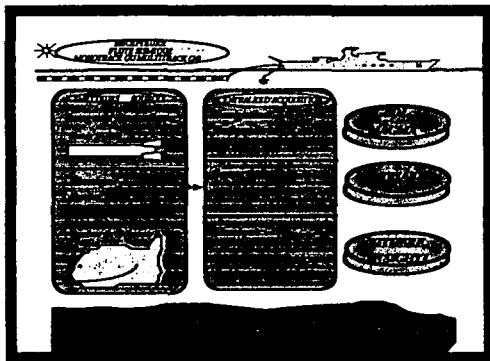
The objective of this survey was to specify the internal architecture of this sedimentary body and to understand the existing report between the dynamic agents and these bodies. This survey required an approach pluridisciplinaire by the utilization of varied complementary techniques.

- Morphology : Bathymetry, acoustic Imagery (side scan Sonar)

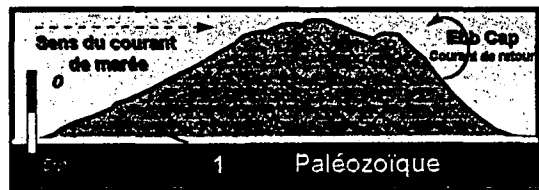
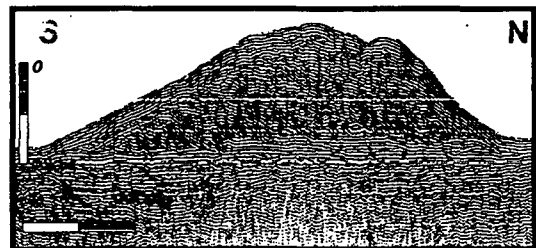
- internal Structure: Seismic Very High Resolution,

- Dynamic Measures, Numerical Models,

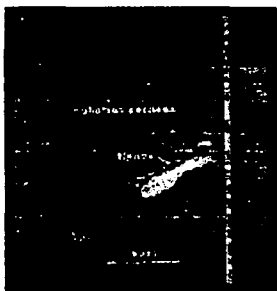
- Sedimentology : Cores and Grab samples



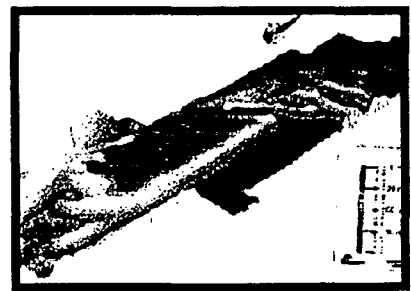
Principe des investigations par géophysique marine très haute résolution



Profil sismique THR d'une dune tidale actuelle et son interprétation. Localisation Banc de Seroq. (Mhammdi, 1994)



Sonogramme d'une épave de navire, abri privilégié pour les poissons. Localisation Nord Pas de Calais (Augris 1990)



Bloc diagramme 3D du banc de Seroq réalisé à partir des données de bathymétrie (Mhammdi, 1994)

- **Theme 2** (see the poster) consists en study of 'Diversification and evolution of the sedimentary system tracts on the Moroccan Atlantic Margin from the trias to the Present' .

The Moroccan Atlantic continental margin constitutes an example of passive margin due to the Atlantic opening between African and North American Plates. Schematically the evolution of this Moroccan Atlantic margin can be subdivided in 5 main steps well identified on the margin of El Jadida (Ruellen and Auzande,1985; Ruellen and al., 1984, Von Rad and al.,1965). To every step of this evolution, crustal discontinuities of the basement have been rejuvenated giving strike slipe faults playing in transtension or transpression (LeRoy, 1997, Mehdi & Bobier 1999) Such tectonic heredity processes induced the appearence of shearing corridors and a segmentation of the margin. We try to show how the segmentation of the margin drives to a North-South diversification of the system tracts according the degree of interaction between Tectonics-Eustacy-Climatic variations from Triassic to Present Time.

Diversification and evolution of the sedimentary system tracts on the Moroccan Atlantic Margin from the Middle Cretaceous to the Present

Mhammdi N. (1); Bobier C. (2); Hamoumi N.(3) ; Dakki M. (4) , Mehdi K. (5);Chennouf T. (6)

1)Scientific Institute B.P.703.Charia Ibn Batouta ,Rabat Agdal, Morocco. E-mail. nmhammdi@israbat.ac.ma

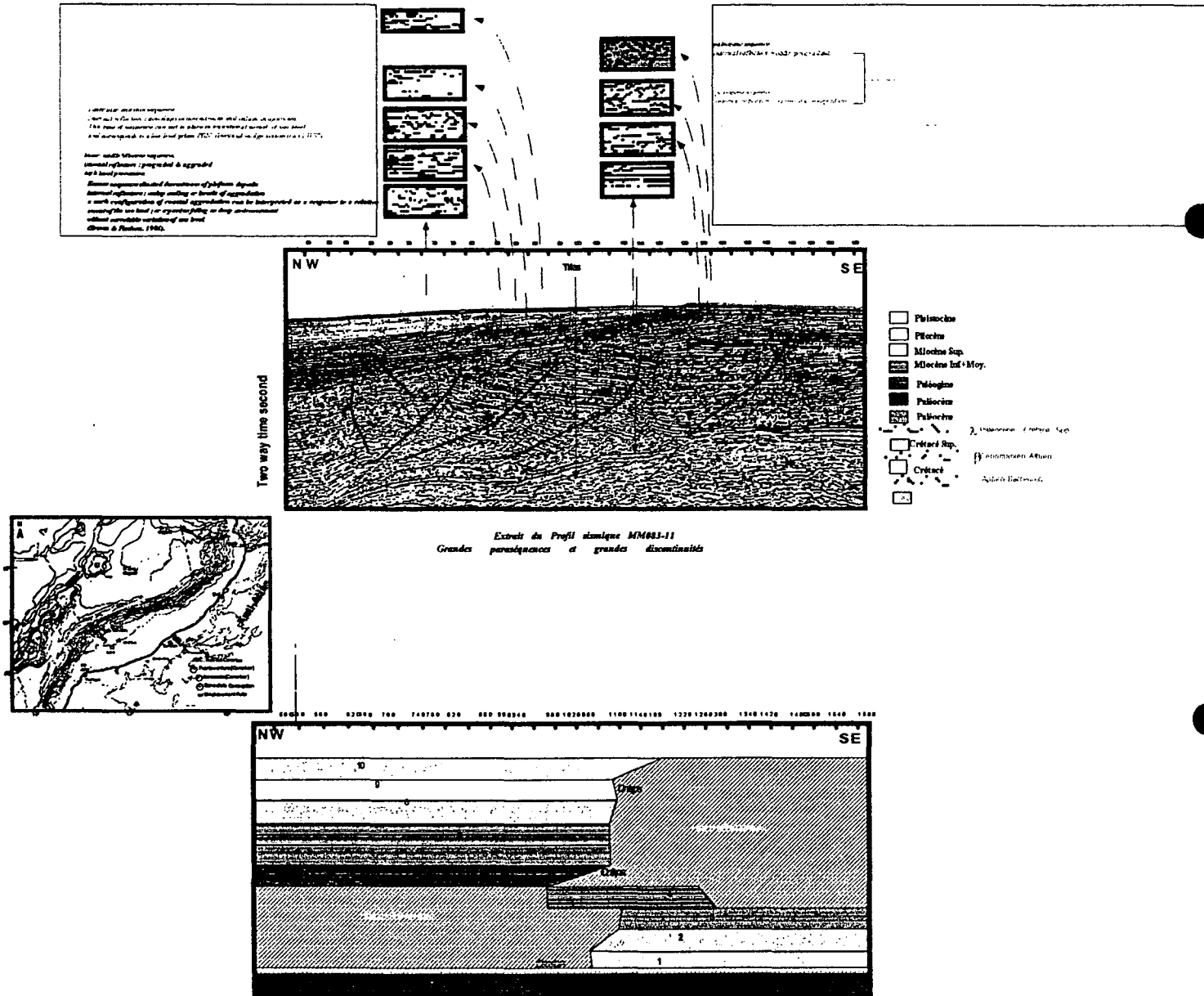
2)Dept Géologie et Océanographie,UMR CNRS 5805 ;University Bordeaux I , Avenue des Facultés ,F33405 Talence Cedex France.

3)Departement of Earth Sciences, University Mohamed V, Rabat Agdal, Morocco.

4)Office National de recherches et d'Exploitations Pétrolières.

5)Departement of Earth Sciences ,Marine geosciences Laboratory , University Chouaib Doukali ,Sciences Faculty El Jedida , Morocco ;

6) Departement of Earth Sciences , Applied Geology " Environment and Hydrogeology " Laboratory , University Mohamed Ith , Sciences Faculty ,Oujda Morocco;



Superposition of a upper sequences resting on the lower sequences by erosional discordance. This discordance is a limit of sequence of type 1 (Vail & al. ,1987). It is characterized by a subaerial discordance in the continental shelf and submarine beyond the slope. Eocene deposits are the most ancient sequences knew indrilling (Le Roy, 1997). The erosion Cretaceous/Tertiary is between the Senonian and the Eocene. The evaluation of the column eroded is of about 2000 m.

ACKNOWLEDGMENTS
*We thank ONAREP for providing seismic profiles.
 This study is done under the project STU/051/97.*

EVOLUTION OF THE SEDIMENTARY SYSTEM TRACTS ON THE MOROCCAN ATLANTIC MARGIN FROM TRIASSIC TO LOWER CRETACEOUS

N. Hammad ¹, E.H. Boumaggard ², M. Bakdi ³, T. Chennouf ⁴, N. Hammad ⁵, C. Rabier ⁶

¹Scientific Institute B.P.763,Cherif Ibn Batouta ,Rabat Agdal, Morocco. E-mail:hammadnadi@unrabat.ac.ma

²Departement of Geology, Oueliz Sciences and Technical Faculty, Marrakech : Morocco

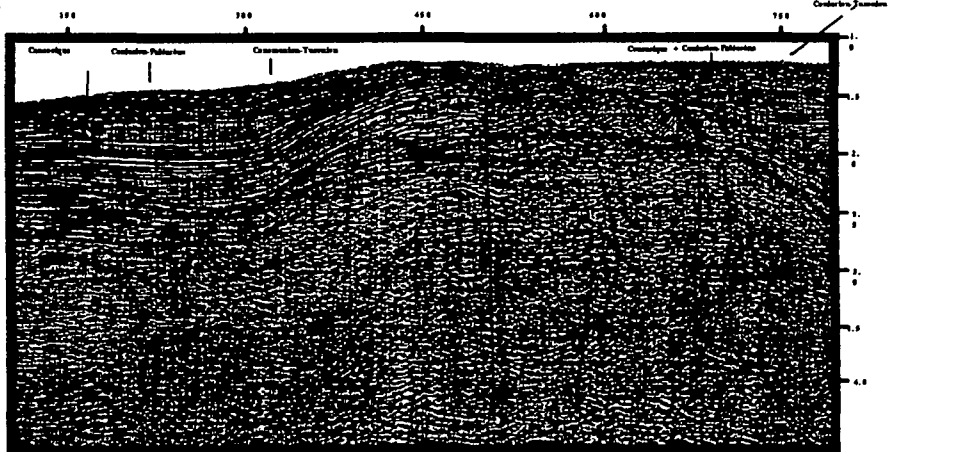
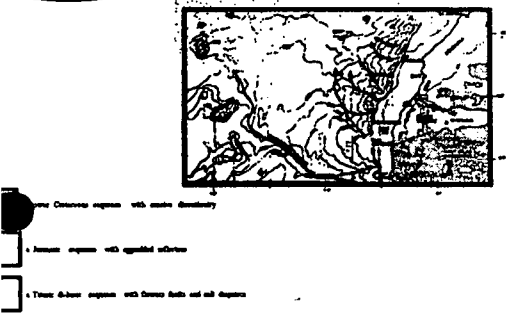
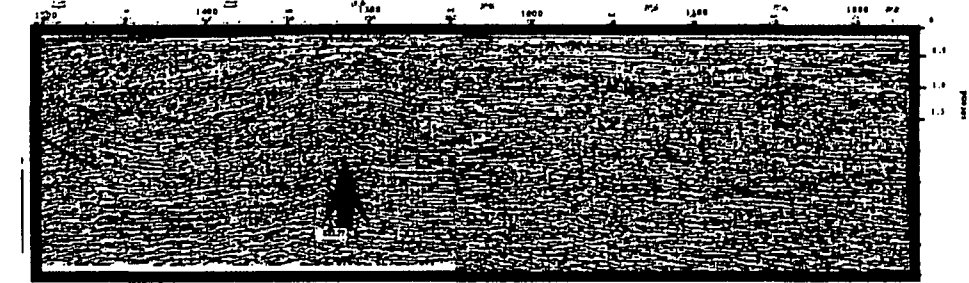
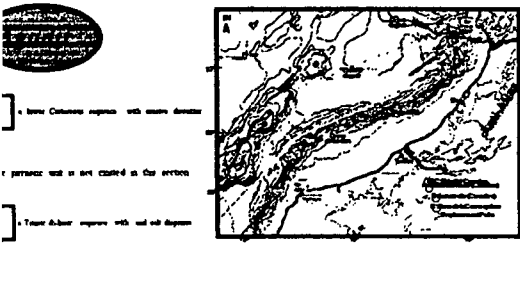
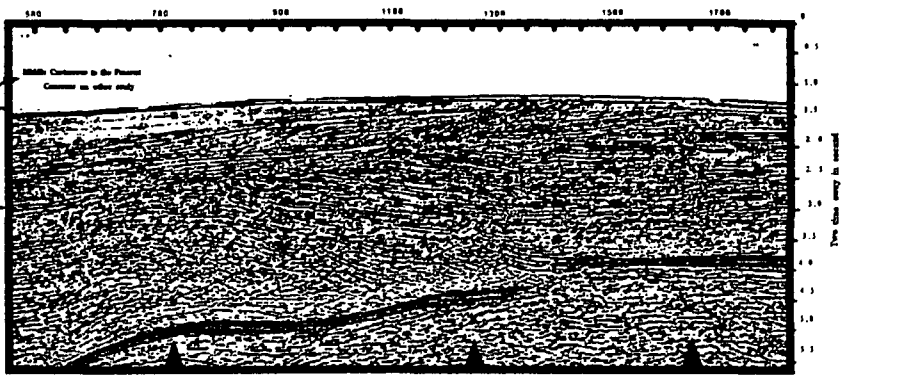
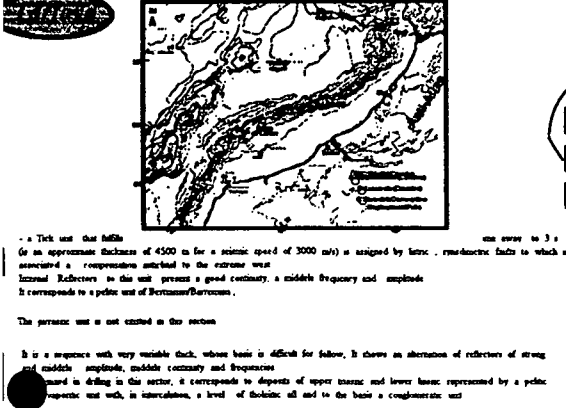
³Office National de recherches et d'Exploitation Pétrolières

⁴Departement of Earth Sciences, Sciences Faculty, Oujda Morocco;

⁵Departement of Earth Sciences, University Mohamed V, Rabat, Morocco.

⁶Dept Géologie et Océanographie,UMR CNRS 5805 (University Bordeaux I, E-mail: c.rabier@geocema.bordeaux.fr

Moroccan Margin is a part of the African Margin made up of many coastal and offshore basins filled by sedimentary tracts starting with ane rift Triassic continental red beds. In present paper we try to show how segmentation of the margin has induced a North-South diversification of the sedimentary system tracts from Triassic to Lower Cretaceous according to the degree of interaction between Tectonics-Eustasy and Climatic variations. During the Triassic to Liassic rifting step, as the central Atlantic Ocean was opened as a pull-apart basin in a mega shear zone, its margin have been affected by shear processes due to rejuvenation of the Cambrian to hereynian discontinuities. Such an evolution has induced a segmentation of the margin with variations in the coefficient of extension between each rhomb-grabens inducing important variations in thickness of the synrift and post rift deposits. So we can observe first a differentiation between eastern areas more or less continental covered by continental deposits with basaltic traps and western tilted blocks filled by evaporates accumulated in and land locked settings with various thickness. So the western areas will be marked later by salt tectonics. During the Middle to Upper Jurassic continental drifting step distribution of sedimentary system tracts is dominated by the existence of carbonated platforms often bounded by structures due to salt tectonics. Such structures induced differential subsidence processes which, combined with subsidence of the margin due to sedimentary loading, are responsible for variations in thickness and facies of the limestones. During the Lower Cretaceous thermal subsidence step thick sedimentary prisms of progradation accumulated in many segments.



- 1) First step corresponding to the Triassic to Liassic rifting step: aperture of rhomb grabens induced a differentiation between continental more or less eastern areas covered by continental deposits and basaltic traps and tilted blocks and grabens filled by evaporates accumulated in arid land locked settings.
- 2) During the second step, which corresponds to the continental drift stage ending with the Jurassic Neocomian bound, system tracts are dominated by the development on the high zones of carbonated platforms bounded in many places by structures due to halokinesis (salt pillow and rime synclines) responsible for inversion of subsidence or differential subsidence. Such processes associated with subsidence due to sedimentary loading of the margin induced important variations in facies and thickness of the limestones.
- 3) The third step, Lower Cretaceous, is characterized by the accumulation of thick sedimentary prisms of progradation in many segments.



Dr. M'HAMMDI NADIA

Enseignant Chercheur à l'Institut Scientifique

"Département Physique du Globe (DPG)"

☎ 212-7-77-45-43, 📠 212-7-77-45-40,

✉ : Institut scientifique, DPG, B.P. 703 Charia Ibn Batouta Rabat, Agdal

E-Mail : mhammdi@israbat.ac.ma

Activities Of Research

➤ Two themes of research :

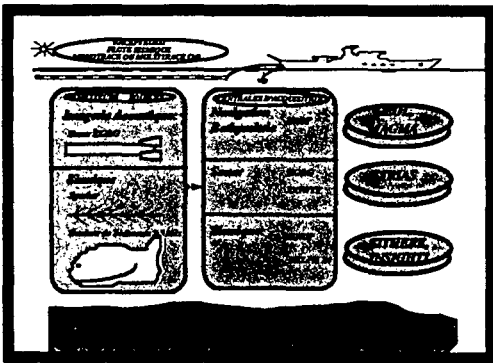
- **Theme 1** consists in the study of a tidal sand bank (Sark Bank), its edification, its internal architecture and relationship between sedimentary and hydrodynamic conditions

The tidal sand bodies on continental shelves remains a matter of debate. They result from complex interactions between relative sea level change and hydrodynamic processes. The dynamics of their building up, of their evolution and their internal structure are not still very known.

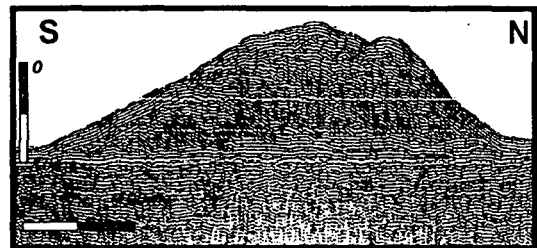
- The genetic interpretation and the bulding up of this big sedimentary bodies is one of axes of the oil research.
- Their proximity of coasts makes some of the potential zones for the exploitation of sand or concentration of minerals and the important zones for halieutic activities
- The mobility of these bodies in of the relatively short times can modify the depth of navigation ways dangerously and embarrass the circulation of boats.

The objective of this survey was to specify the internal architecture of this sedimentary body and to understand the existing report between the dynamic agents and these bodies. This survey required an approach pluridisciplinaire by the utilization of varied complementary techniques.

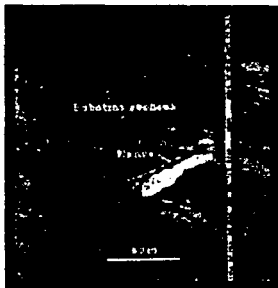
- Morphology : Bathymetry, acoustic Imagery (side scan Sonar)
- internal Structure: Seismic Very High Resolution,
- Dynamic Measures, Numerical Models,
- Sedimentology : Cores and Grab samples



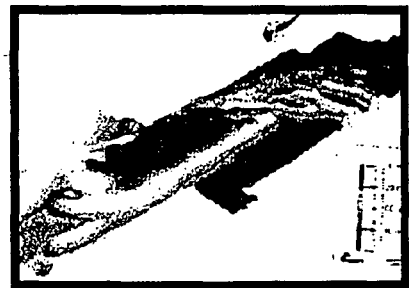
Principe des investigations par géophysique marine très haute résolution



Profil sismique THR d'une dune tidale actuelle et son interprétation. Localisation Banc de Sercq. (Mhammdi, 1994)



Sonnogramme d'une épave de navire, abri privilégié pour les poissons. Localisation Nord Pas de Calais (Augris 1990)



Bloc diagramme 3D du banc de Sercq réalisé à partir des données de bathymétrie (Mhammdi, 1994)

- **Theme 2** (see the poster) consists en study of 'Diversification and evolution of the sedimentary system tracts on the Moroccan Atlantic Margin from the trias to the Present' .

The Moroccan Atlantic continental margin constitutes an example of passive margin due to the Atlantic opening between African and North American Plates. Schematically the evolution of this Moroccan Atlantic margin can be subdivided in 5 main steps well identified on the margin of El Jadida (Ruellen and Auzande,1985; Ruellen and al., 1984, Von Rad and al.,1965). To every step of this evolution, crustal discontinuities of the basement have been rejuvenated giving strike slipe faults playing in transtension or transpression (LeRoy, 1997, Mehdi & Bobier 1999) Such tectonic heredity processes induced the appearence of shearing corridors and a segmentation of the margin. We try to show how the segmentation of the margin drives to a North-South diversification of the system tracts according the degree of interaction between Tectonics-Eustacy-Climatic variations from Triassic to Present Time.

**TRAINING COURSE
ON
INDUSTRY AND DEVELOPMENT RELATED
TO THE MEDITERRANEAN BASIN**

**COUNTRY REPORT
ON
FISHERIES AND AQUACULTURE
IN TURKEY**

Dr. Hayri DENIZ

**MINISTRY OF AGRICULTURE AND RURAL AFFAIRS
General Directorate of Agricultural Production and Development**

29 October – 2 November 2001

Rabat - MOROCCO

1. TURKISH FISHERIES

1.1. General Overview

Fisheries being one of the four sub-sectors of the agricultural sector in Turkey has importance in contribution for human nutrition, providing raw material for the industrial sector, creating employment possibilities and potential for export.

Turkey, with its favourable geographic position between the Black Sea and Mediterranean Sea, has access to the fish resources of both of these water bodies. The country is also endowed with rich inland waters and river systems with significant capture fishery and aquaculture potential. The estimated fish landings, including aquaculture production, show Turkey, with its annual production of 582,376 tonnes in 2000 as one of the important fishing country in the region. However, fisheries Sector has not reached to the adequate level in agricultural and in National Economy yet. Fisheries have a share of 0,3 % in GNI (Gross National Income) and 2.7 % in the agricultural sector.

1.2. Natural Condition

Turkey, with 8333 km of coast line, many rivers with 177,714 km total length, nearly 900 thousand ha of natural lakes, some 300 000 ha of dam lakes has rich marine and inland resource potential (Table 1-2). Turkey's fisheries resources area is larger than its forest area and as large as its agricultural areas.

Being in half closed position, these seas have different characteristics in respect of biological, physical, chemical and ecological points. Turkish fisheries have the characteristics of small-scale fisheries and in general it can be considered as coastal fisheries. There is also great potential for inland fisheries and aquaculture.

Table 1. Marine Resources of Turkey.

The Seas	Coastal Line Length (Km.)	Surface Area (Hectare)
Black Sea, Aegean sea and Mediterranean	7.144	23.475.000
Sea of Marmara , Istanbul and Dardanelle	1.189	1.132.200
TOTAL	8.333	24.607.200

Source: The Ministry of Agriculture and Rural Affairs.

Table 2. Freshwater Resources of Turkey.

Fish Producing Sources	Numbers	Surface Area (Ha)	Length (Km)
Natural Lakes	200	906.118	-
Dam Lakes	159	342.377	-
Ponds	750	15.500	-
Rivers	33	-	177.714

Source: The Ministry of Agriculture and Rural Affairs

1.3. Production Figures

Fisheries production figures are prepared by the State Institute of Statistics in collaboration with Ministry of Agriculture and Rural Affairs.

Total fish production from domestic sources in Turkey was 582,376 tonnes in 2000. This total in 2000 was made up 75.8 % from marine fishes 7.3 % freshwater fishes, 13.6 % aquaculture (Table 3).

Grey mullet, common carp, cray fish, pikeperch and snail are among the important freshwater species caught.

Trout, sea bass and bream are the main species cultured and small amount of carp, mussel and shrimp are also farmed.

Table 3. Total Fisheries Production of Turkey, 1982-2000 (Tonnes).

Years	Freshwater Fish (t)	Marine Fish (Inc.shellfish crustacean, molluscs) (t)	Aquaculture (t)	Total (t)
+++++1982	33,616	470,171	N/A	503,787
1988	44,535	627,369	4,100	676,004
1989	42,833	409,959	4,354	457,116
1990	37,315	342,017	5,782	385,114
1991	39,401	317,425	7,835	364,661
1992	40,370	404,766	9,210	454,346
1993	41,575	502,031	12,438	556,044
1994	42,328	542,328	15,998	601,104
1995	44,983	582,610	21,607	649,200
1996	42,202	474,243	33,201	549,646
1997	50,460	404,350	45,450	500,260
1998	54,500	432,700	56,700	544,900
1999	50,190	523,634	63,000	636,824
2000	42,824	460,521	79,031	582,376

Source: State Institute of Statistics (SIS)

1.4. Marine Fisheries

Despite marine capture fisheries historically contributing over 90% of total catch, this has slowed down in the late 1980's, and in 2000 it accounted for 441,690 t, representing 75.8 % of total fish supplies. Marine fish production increased until 1988, reaching a peak point of 623,404 t then declined sharply to 317,425 t in 1991. The sharp decrease between 1988 and 1991 have been mainly attributed to the fall of anchovy, which is related to a combination of over fishing and the accidentally introduction of a jellyfish (*Mnemiopsis leidyi*). Of marine fisheries, anchovy is the most important species, accounting for % 48 of the total catch (280,000 t). Grey Mullet (27,000 t), Hake (18,180 t), whiting (18,000 t), sardine (16,500 t) are also significant.

1.5. Freshwater Fisheries

Despite Turkey has vast resources for freshwater fisheries, it accounted for 7.3 % of the total fish supply in 2000. The most important species are grey mullet (*Chalcarburnus tarichi*) (15,654 t), common carp (14,137 t) to a lesser extend cray fish (1,681 t), pike perch (1,633 t) and snail (1,592 t). Common carp distributed throughout the country, but grey mullet is found only in the Van lake. Stocking activities have been carried out to enhance freshwater resources by Ministry of Agriculture and Rural Affairs (MARA), Ministry of Forestry (MF) and General Directorate of State Hydraulic Works, Ministry of Energy and Natural Resources (MNER). The main species used for stocking are common carp and mirror carp to a lesser extend grass carp, trout, wels and perch. Though the contribution of fresh water catch to total fishery production is relatively small, its contribution to the rural areas in terms of fish supply and employment is significant.

The freshwater sources, in connection with the irrigation and energy production purposes, are increasing steadily. Southeastern region is an important area in this regard. A number of big dams on Euphrates, Tigris and other rivers of the region have been constructed within the framework of special regional project of Southeast Anatolian Project called "GAP Project". This project will provide 220.000 ha of water surface and the total freshwater fish production will increase by 10,000 tons with the completion of the Project. The dam lakes in this area and other water sources create possibilities many different fish species to be grown.

1.6. Fishing Fleet

There are four basic types of fishing in Turkey, small scale, a typical two men operation uses an 8 m open boat with a 10-25 HP inboard diesel engine, by far the largest employer, trawling, purse seining and beach seining. The larger units may use 10 m boats with three fishermen. Some are equipped with depth recorder/fish finders. Most fishermen use basic

gears, trammel nets and long lines. After 1980, some developments have been observed in the fishing fleets in terms of the capacities and engine powers, but still there is no fishing fleet into the open seas and oceans. However, this positive development has brought problem to problems of over fishing, therefore additional licensing of over 12 m fishing boats was stopped in 1991. In 1997 all licensing were stopped for new fishing vessels. Fishing vessels have also been registered according to the FAO standards. According to 1999 statistics, there were 17,475 boats and vessels of which some 40 % operates in the Black sea.

1.7. Financial Support

To support the fisheries and aquaculture sectors, credits are available through Agricultural Bank of Republic of Turkey and Under-secretariat of the Treasury provides also incentives and subsidies.

1.8. Consumption

The per capita consumption of fishery products in Turkey is primarily dependent on the marine fisheries catch. From 5.4 kg in 1991, the lowest level, this reached a record high level in 1995, exceeding 9.5 kg for the first time but falling to 7.8 kg in 1999.

The per capita consumption of fishery products in Turkey is almost similar with central African (8 kg) and Near-East (African) countries (7 kg). This is also quite low compared to the world average about 15.7 kg in 1999, and with consumption within the European Community at an average of 23.3 kg per annum.

2. Aquaculture

Until recently, the aquaculture industry in Turkey was almost entirely confined to the production of rainbow trout in fresh water. Commercial-scale utilisation of country's coastal waters for fish farming began only in the late 1980s, and has grown rapidly into an important activity, which is considered by industry and government to have potential for increasing both regular domestic fish supply and export earnings. The production reached 79,031 tonnes in 2000 what was 3,075 tonnes in 1986, a more than 25 fold increase in the last two decades (Table 4).

The contribution of aquaculture production to the total fish supply has also rapidly increased from 0.5 % in 1986 to nearly 13,6 % in 2000. As with increases of total aquaculture production, the number of licensed fish farms has also steadily increased in the last decade, reaching 1,719 in 2000, of which most are small with less than 50 tonnes production per annum (Table 5). Out of 81 provinces, commercial fish farming takes place in 66.

Main species cultured are rainbow trout, sea bass, sea bream and to lesser extent, sea trout, mussel and shrimp. Though marine aquaculture production has been expanded faster than freshwater, rainbow trout is the most cultured fish in the country, representing 56,3 % of the total aquaculture production (including sea trout, 1,961 tons) in 2000. The production of Atlantic salmon has gradually decreased due to the unsuitable environmental conditions. Carp culture also has declined since 1989 due to low demand and market price and its share in total aquaculture production has dropped dramatically from 66 % in 1986 to 1 % in 2000.

Trout farms are widely dispersed across the country, and out of the 65 provinces where fish farms are established; trout has been cultured in 63.

Trout culture in cages has become an attractive and expanding activity in recent years. Some reservoirs have been opened to aquaculture activity 1994, an important stage in utilizing freshwater bodies. In order to limit the environmental impact of aquaculture activities only 1 % of the surface (circa 300.000 ha) of the selected reservoirs is allocated for use in aquaculture.

Most sea bream and sea bass farms are located in the southern Aegean coast, which provides many sheltered sites suitable for mooring conventional floating cages. In 2000, 94% of the total sea bass and sea bream production was reported to come from Aegean region with a total production of 31,415 t. There are also sea bass and bream farms using earthen ponds. Trout are also produced in the marine environment in the Black Sea at both portion and large size. Black sea turbot has successfully produced at an experimental level in the Black Sea. First tuna farm is about to establish in the Mediterranean region with a production capacity of 840 tonnes per annum. The culture of other species has also been practised in the recent years to diversify aquaculture production such as red sea bream, thick-lip mullet, stripped grey mullet, white grouper, and dentex.

Though most farms are small in Turkey, there have been increasing trend to establish larger marine farms and to enlarge the existing ones. In this regard, 8 offshore farms are licenced with a capacity of about 500 tonnes per annum for each and 9 are pre-licensed. This is due to not only economies of scale but also the conflict of interest to use the coastal zone.

In parallel with the development of the marine aquaculture in the country, the number of hatcheries has also increased over the last decade. Since the first marine hatchery was established in 1986, the number of hatcheries operated by the private sector had reached 16,

with a total production of about 80 million fry per annum by 2000. Additionally, two public hatcheries are also producing sea bass and bream fry, with a total production of 2 million per annum. To provide a sustainable development the collection of fry from the wild has prohibited since 2000. Trout farms have their own hatchery and propagating their own fingerlings. Most rely on resources purchased from government hatcheries and/or private hatcheries in the country, or the import of certified disease-free fertilised eggs from overseas.

Table 4. Freshwater and Marine Aquaculture Production by Species, 1986-2000 (Tonnes).

Species	Years							
	1986	1994	1995	1996	1997	1998	1999	2000
Common carp	2,050	288	424	780	800	950	900	813
Rainbow trout (Ponds and Cages)	990	6,977	12,689	17,180	26,500	32,340	36,870	42,572
Trout (marine&cages)	-	N/A	N/A	1,330	2,000	2,290	1,700	1,961
Atlantic salmon	-	434	654	193	50	40	0	0
Sea bass	-	2,229	4,847	5,210	6,300	8,660	12,000	17,877
Sea bream	34	6,070	2,773	6,320	7,500	10,150	11,000	15,460
Mussels	-	0	180	1,918	2,000	2,000	500	321
Shrimp	-	0	40	270	300	270	30	27
Others	1	0	0	0	0	0	0	0
Total	3,075	15,998	21,607	33,201	45,450	56,700	63,000	79,031

Source: State Institute of Statistics (SIS)

Table 5. The Number of Licensed Aquaculture Farms, Capacities and Production by 2000

SPECIES	NO.OF LICENCED FARMS	LICENCED FARMS CAPACITY (t/year)	PRODUCTION (t)
TROUT (Ponds & Cages)	1,288	39,823	42,572
TROUT (marine&cages)	14	1,610	1,961
CARP	66	9,794	813
MUSSEL	4	2,211	321
SHRIMP	1	320	27
SEA BASS& BREAM	346	25,332	33,337
TOTAL	1,719	79,090	79,031

Source: Ministry of Agriculture and Rural Affairs.

2.1. Production Systems

Different production systems have been developed in the country by technology transfer such as earthen ponds, concrete ponds, Fiberglas tanks and cages. Most freshwater aquaculture enterprises in Turkey are simple grow-out operations using both semi-intensive and intensive systems. The most common practice is the use of concrete raceways, particularly for freshwater trout.

Freshwater aquaculture

The use of semi – intensive earthen ponds is the most common practice for carps. Earthen ponds are also used for intensive rearing of trout. The most common practice is the uses of concrete raceways, particularly for trout in freshwater and some larger farms have modern circular concrete tanks. Cages used in reservoirs for trout culture are generally of simple wooden type.

Marine aquaculture

A few semi-intensive marine farms using earthen ponds exist in Turkey, with some 19 farms with an annual production of 3-10 t per annum in the Aegean Region. Semi-intensive culture has also been practiced in some lagoons using larger earth ponds in Turkey. The most popular intensive system farming practice for sea bream and sea bass is the floating cage, measuring from 5*5* 5m deep to 12-20m diameter HDPE circular, hexagon or octagon cages.

2.2. Regulations for the establishment and operation of fish farms

Since aquaculture was considered as part of the field of fishing, there is no law or by-law specific to aquaculture. Fisheries Law No.1380 of 1971 as amended by Law 3288 of 1986 includes aquaculture activities. Licenses to establish and operate fish farms are issued by the Ministry of Agriculture and Rural affairs. To provide a sustainable development, licensing, establishment and control of fish farms have been ruled by a ministerial decree, which regulates aquaculture activities. To maintain an environmentally sound development an EIA (Environmental Impact Assessment) should be provided on individual sites where fish farmers applied for licence. There are currently 10 institutes involved in the decision-making process regarding licence for farms and leases for particular sites to be used for aquaculture.

To maintain more effective licensing and control mechanism, new aquaculture legislation, in line with a draft report prepared by international consultants is under preparation.

3. Research Activities

To obtain a sustainable development in fisheries and aquaculture sector, special attention has been given to research activities

At present moment there are 4 research institutes of the Ministry dealing with the fisheries and aquaculture research. Two of them are in charge of marine fisheries located in the Black sea (Trabzon) and Aegean regions (Bodrum/Mugla) and two of them are in charge of inland fisheries, located in central (Egirdir/Isparta) and eastern Anatolia regions (Elazig). Besides that Universities are also carrying out research on fisheries.

As a part of the Turkish-Japanese bilateral cooperation activities, a project named "The fish culture development project in the Black Sea" commenced and Turbot has been produced successfully and many released to enhance the turbot stocks in the Black Sea. Turbot culture is expected to expand from pilot scale to commercial scale in the region.

4. Education

Until 1982 fisheries education had been part of other related sciences such as biology and animal husbandry. There are currently 16 universities in Turkey, which have faculties of fisheries, fisheries department or fisheries Institutes. Four universities have fisheries departments offering two years training for technicians. In addition two fisheries vocational school provide training for master fishermen, fish processors and more technical aspects of the fishing industry. A study showed that there was 525 technical staff in fisheries and aquaculture. About 3500 students were undergoing fisheries and aquaculture education and 3800 students graduated from these universities.

5. Producer Organization

There are 312 fisheries co-operatives organised with a membership of around 15,000. None are associated with aquaculture in Turkey. About 40 % of these are for freshwater fisheries; they are involved in production, storage, processing as well as marketing. Cooperatives have certain advantages in leasing water resources and to obtain incentives and credit.

Recognising the importance of non-governmental organisations in decision-making and to adopt the production activities to the needs of the market, two foundations and three societies have been established with the encouragement of the government. Most recently, to promote and increase the consumption of fish in the country, " Fish Promotion Group" has been established with the participation of the government and Non-Governmental organisations and private companies.

In order to make the NGOs efficient to manage the agriculture sector, including fisheries and aquaculture a law has been approved by the parliament, which will force the farmers to establish producer union.

6. Post Harvest and Processing

Handling of landed fish has been improving in Turkey. Since the concerns of governments, public and consumers are growing and the market values of fish are increasing, Municipalities of various cities are construction new wholesale markets for fisheries products. And main importer countries are demanding high quality and safety standards for the products. In recent years, smoked and canned fish production has been developing. An important portion of cultured trout now is smoked for foreign markets. The Ministry of Agriculture is giving grate consideration to Quality Control and HACCP and companies which are exporting are under tough supervision.

In order to meet the EU requirements, the number of companies which are granted approval number to export fishery products is 72 of which 11 has HACCP approval.

7. Markets and Trade

In Turkey fish is mainly consumed in fresh form. Fish landing of Turkey is mainly between late autumn and early spring. So it provides a favourable condition for transport and fresh marketing. During the rest of the year the cold chain is available and improving. Most Turkish consumer does still not prefer frozen products. Consumption of processed products, due to high prices and consumption habits of the people is also low and requires promotion.

Main export products are live crustaceans, molluscs, mussel, oyster (very small amount of them are consumed in Turkey) and frozen, chilled, canned high valued pelagic and cultured fish species. Some 80 % of the sea bass and sea bream productions go to the EU market. The import ban which was introduced by EU in 1998 made grate damage on mussel fishermen and especially sea bass and bream farmers.

Main import products of Turkey are frozen tuna fishes and molluscs for processing, canning and partly re-exporting.

Total Export quantity and value of Turkey in 2000 were 33,519 tonnes and US \$ 87.6 millions respectively, while the import for the same year 44,502 tonnes and US \$ 37.9 millions. The foreign trade figures between 1994-2000 are presented in Tables 6 and 7. Under-secretariat of Foreign Trade is the Government organisation regulating fisheries export and import regime. Export Promotion Center (IGEME) assists the exporting companies.

Table 6. Fishery Exports of Turkey 1993-2000, (Q= t, V= Value US\$ 1000)

Products	1993		1996		1997		1998		1999		2000	
	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V
Live fish *	112	379	12	101	40	224	9	63	4	35	8	37
Fish, chilled	2881	11669	4642	18184	6307	25004	3590	11977	8728	33557	7143	20812
Fish, frozen	791	2329	684	1976	1115	2667	766	2117	929	2077	731	1860
Fish, fillets	582	3218	1038	4747	1890	8469	1349	7251	1819	8162	1795	7790
Fish dried, salted, smoked	119	3128	251	1753	291	1831	182	950	431	2068	275	1278
Crustacean	798	4129	812	6122	1558	7733	1299	4260	1130	5911	988	4091
Molluscs	8435	18356	5349	22313	7210	22280	4329	13264	2910	9737	3272	9646
Fish, canned	4042	1180	12889	39490	14187	45642	13436	42746	12868	29079	15092	26367
Crustacean, Molluscs canned	2243	9980	2424	12972	3233	14151	3254	13848	1860	8589	4219	15730
Total		61646		107658		128001		96477		99251		87611

Source: Under-secretariat of Foreign Trade of Prime Ministry

* 1000 x (numbers)

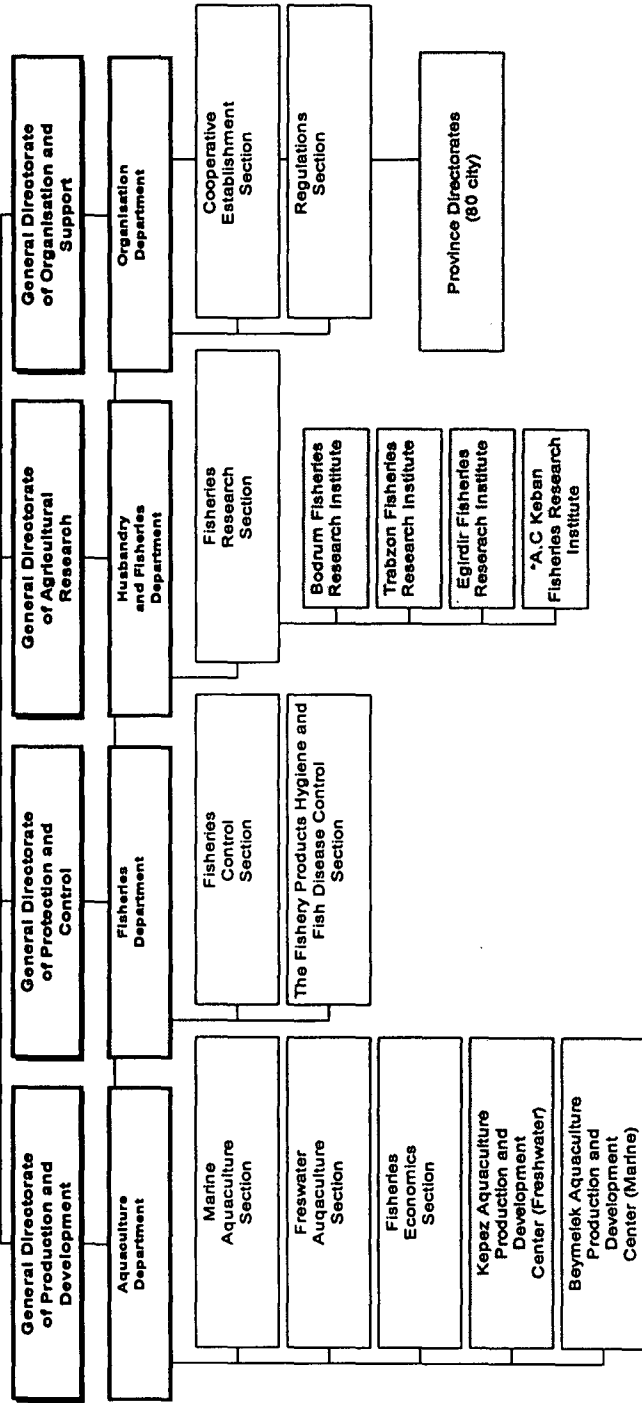
Table 7. Fishery Imports of Turkey 1993-2000, (Q= t, V= Value US\$ 1000)

Products	1993		1996		1997		1998		1999		2000	
	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V
Live fish *	3191	686	65	494	89	647	69	450	65	394	122	804
Fish, chilled	42	105	20	106	185	165	104	133	2353	256	325	157
Fish, frozen	31228	19020	26945	27898	36191	44038	27607	33857	33923	25252	40300	31343
Fish, fillets	382	555	1318	1883	1418	2178	1479	2457	956	1514	1351	1981
Fish dried, salted, smoked	141	502	353	792	673	1407	721	1234	1321	504	60	436
Crustacean	53	241	110	449	100	36	90	30	67	234	56	91
Mollusc	1728	2095	899	1898	1259	2040	1398	2127	932	1254	2005	2206
Fish, canned	40	248	224	639	1259	562	508	1527	147	556	140	348
Crustacean, Mollusc canned	33	95	276	1054	274	995	347	1287	140	537	143	503
Total		23547		35213		52394		43373		30501		37869

Source: Under-secretariat of Foreign Trade of Prime Ministry

* 1000 x (numbers)

MINISTRY OF AGRICULTURE AND RURAL AFFAIRS



SPASI- BRIEF OVERVIEW-1

BACKGROUND INFORMATION

Financed by the:



European Union

Managed by the:

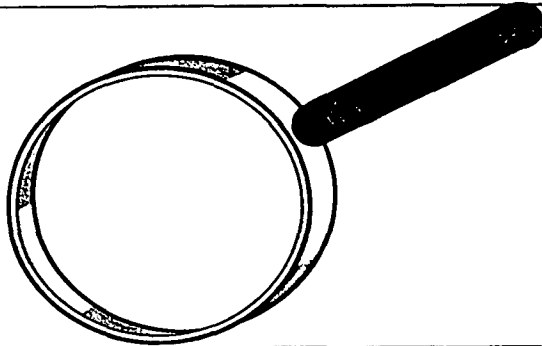


UNDP

Executed by the:



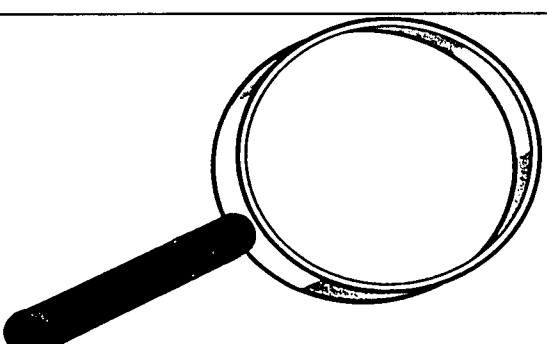
MoE



SPAST- BRIEF OVERVIEW-2

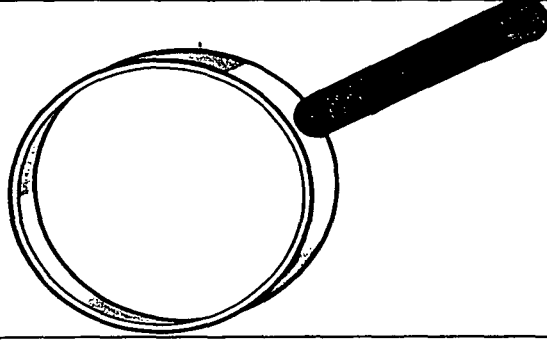
GOALS

To strengthen the permitting, monitoring and auditing system for industries through the development of necessary legislation and the introduction of adequate tools.

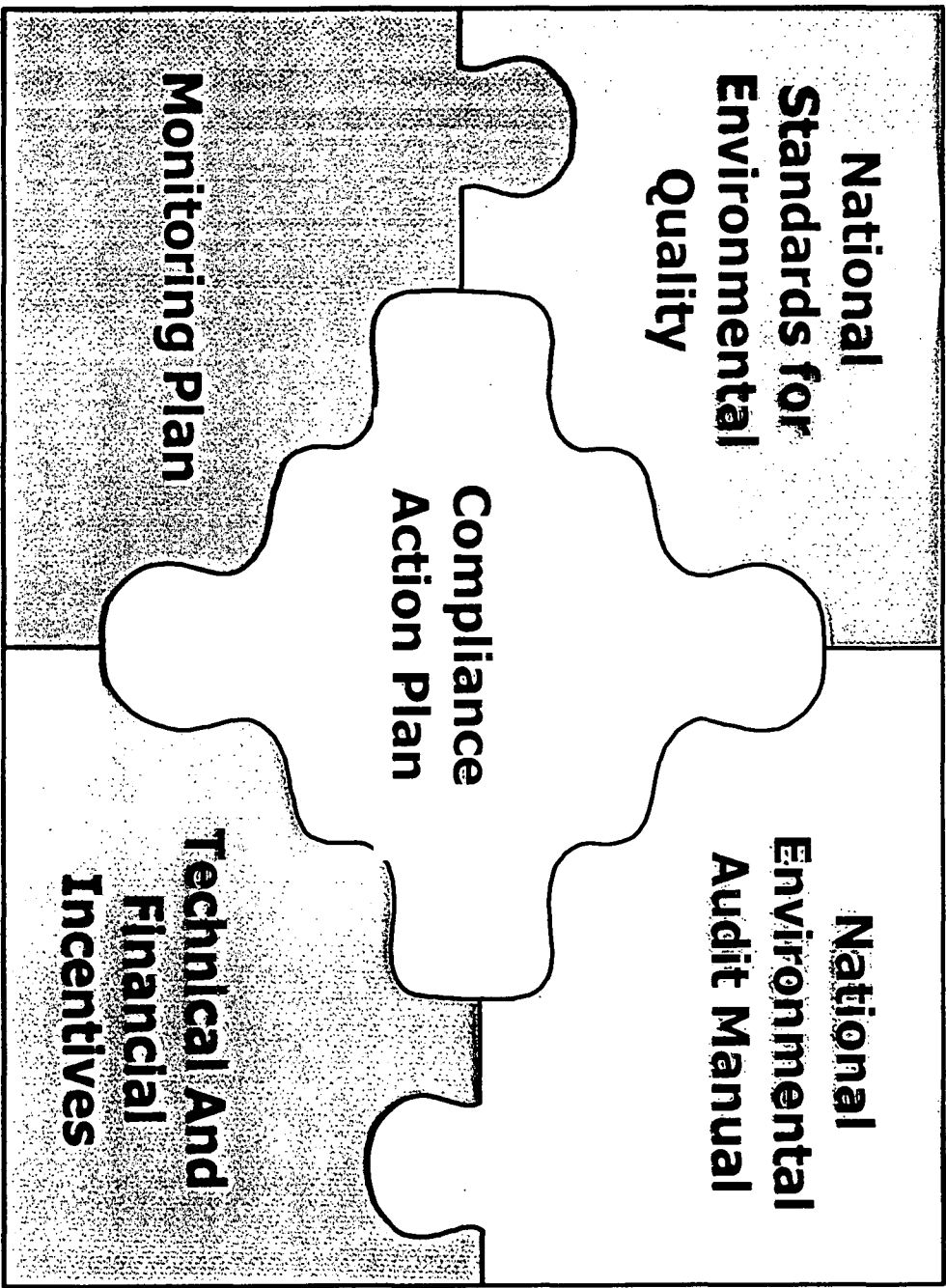


OBJECTIVES

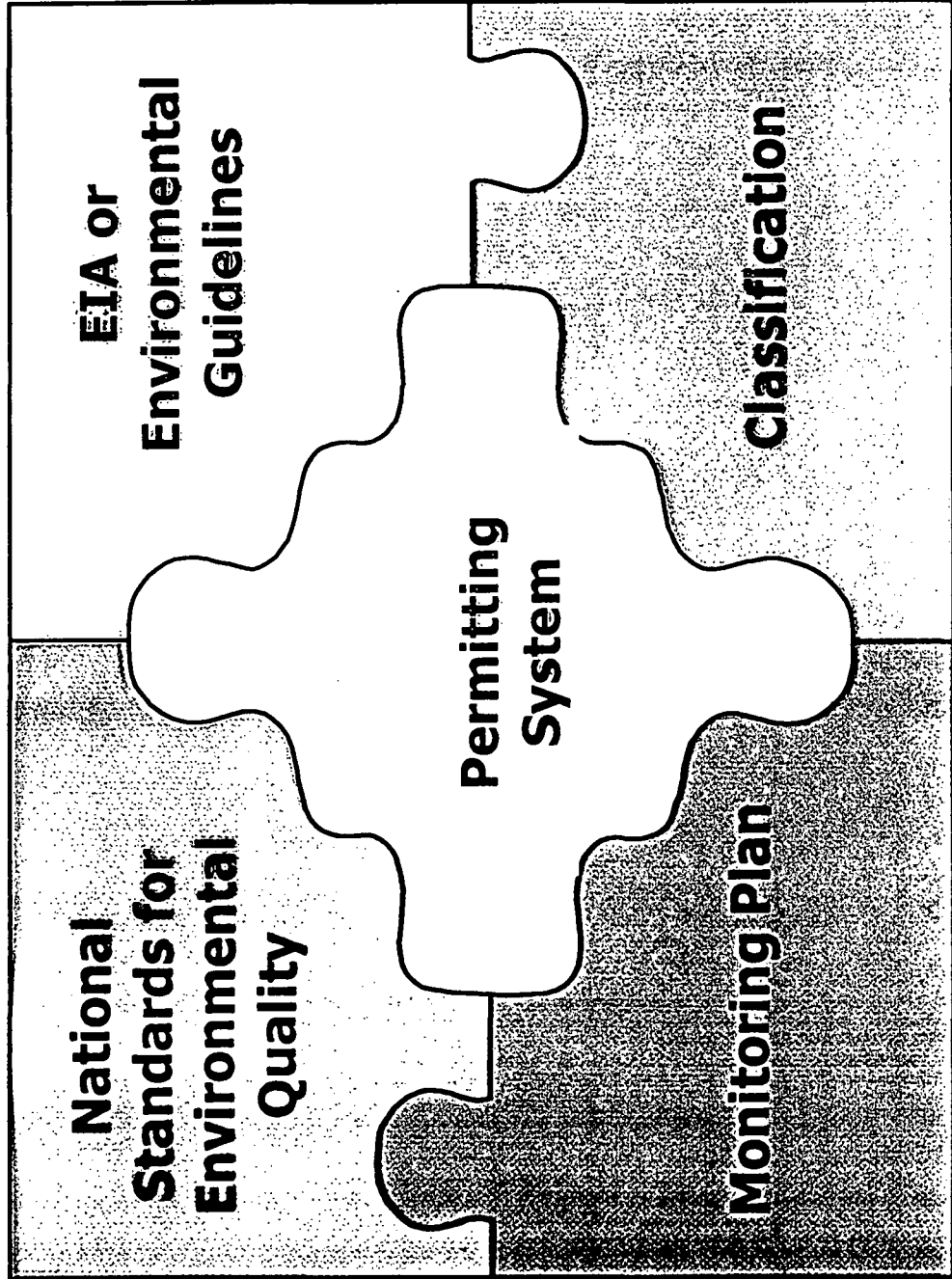
- Set/update decrees for classified establishments
- Set/update standards for environmental quality
- Design the national environmental auditing manual;
- Strengthen the capacity for environmental monitoring procedures;
- Develop a Compliance Action Plan;
- Spread awareness concerning environmental compliance;
- Build the capacity of concerned parties to conduct CAP, environmental audits and monitoring;
- Facilitate environmental compliance in selected industries;
- Respond to MoE needs.



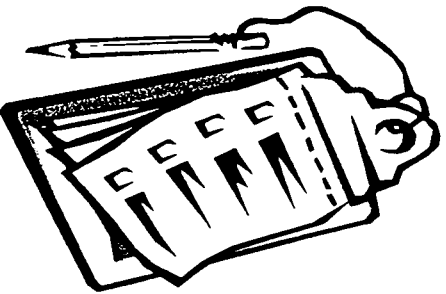
SPASIS STRATEGY FOR EXISTING FACILITIES



SPAS'S STRATEGY FOR NEW FACILITIES



ENVIRONMENTAL AUDITING MANUAL



OBJECTIVE

The main objective of the audit manual is to facilitate and unify the environmental auditing procedures in industrial facilities. The final audit findings will provide an exact idea about the environmental performance and overall situation of the plants visited, enabling the environmental experts to adopt the necessary measures for achieving compliance.

ENVIRONMENTAL STANDARDS

OBJECTIVE

The National Standards for Environmental Quality were developed and finalized in a form of Ministerial Decision numbered 8/1 published in the official newspaper on the 1st of March 2001.

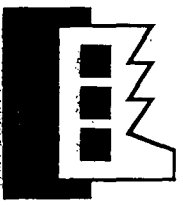
The standards cover:

1. Wastewater discharges in the **Sea, Surface water** and **Sewerage systems**.
2. Air pollution: **Generic or specific** standards for the energy sector, power generators, cement industry, glass industry, battery manufacturing, electroplating, aluminum industry, food industry, MSW incinerators.

INCENTIVES/ENFORCEMENT MEASURES FOR INDUSTRIES

Incentives & enforcement measures are used in parallel to help industries achieve compliance

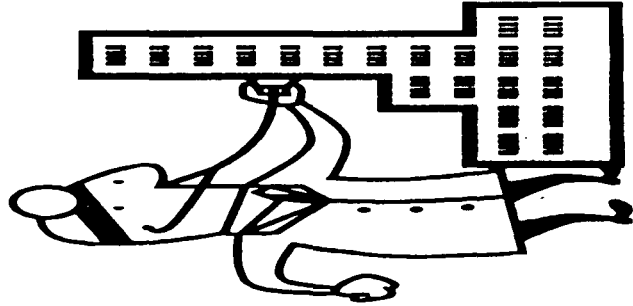
**Direct/Indirect
Enforcement
measures**



**Direct/Indirect
Incentives**

**Better Environmental
Performance/Compliance**

ENVIRONMENTAL MONITORING



OBJECTIVE

SPASI is presently developing a monitoring software capable of selecting randomly the future industrial facilities to be visited.

Having a sound monitoring strategy represents a major step towards ensuring the continuous sustainability of industrial compliance.

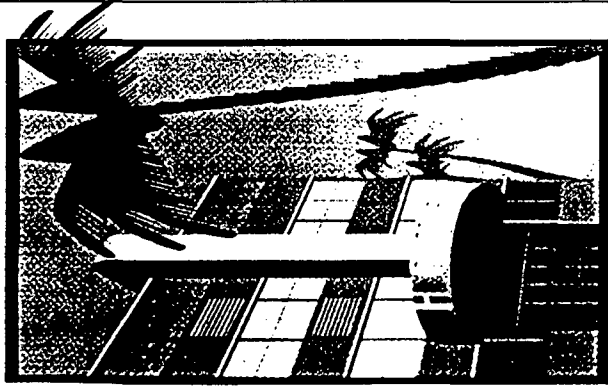
Ministerial Decisions



OBJECTIVE

10 ministerial decisions related to the environmental guidelines required for permitting the construction and operation of 10 types of classified establishments have been developed and published in the official gazette.

Environmental Auditing Manual for Hotels and The Green Hotel Guidelines



OBJECTIVE

SPASI has developed the Environmental Auditing Manual for Hotels and the Green Hotel Guidelines to serve as tools in improving the environmental management and overall environmental performance of the hotels in Lebanon

NOVEMBER