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TITLE PAGE

Final Report

Description of the activities in the

**"International School on Satellites and Enviroment"
(2 - 13 december 1996).**

Organizer: International Center on Application of Mathematical Methods.

Location: Puebla, Pue. México.

Redactor: Andrés Fraguela Collar.

Puebla, pue. México, 22 december, 1996.

INTRODUCTION

The organization of this school was motivated by the necessity of showing different aspects related to the studies on conservation of the environment, territory planning, use and potentiality of the land and prevention of disasters.

Emphasis was placed on the observation of the earth and monitoring through remote sensing and the use of satellite images. The requirements of important multidisciplinary projects such as ECAPUEBLA (The study of the quality of the air in the Puebla city) were considered, too, as well as the role that a program of investigation of space would play in the design, development of technology and operation of systems capable of satisfying those demands.

For the universities and local centers of investigation, the realization of this type of projects would permit them to be in the "avante-garde" not only in México, but in all Latin America because of the character of the current multidisciplinary investigations that this includes as the reflection of this work in the educational and investigative activities of the regional professors and students involved.

For the state of Puebla, the development of multipisciplinary projects in the conservation of the environment will enable them to be at the front respecting the use of scientific systems for the making of decisions according to the short middle and long range development plans.

Great interest exists in the development of these projects by the government of the state of Puebla (México) wich was manifested by the participation and agreement of political leaders of the Departament of Urban and Ecological Development in the inauguration and other activities of the International School.

BODY OF THE REPORT.

The international school of satellites and environment was instructed primarily to provide a panorama of different aspects vinculated to the studies for the conservation of the environment, territorial planning, use and potenciality of the land and the prevention of disasters.

Despite the diversity of the areas considered, sight was not lost of regional needs and the importance of the development of multidisciplinary projects whose results would serve as a tool for the taking of decisions by the state government according to its developmental plans. This School is the first of this type wich is being developed in Mexico and that is why emphasis was placed on the importance of the design, development of technology and operation of systems for Mexico capable of providing the necessary infraestructure for the development of the above mentioned projects.

Taking into consideration these objetives during the scientific events, the following activities were realized:

I.- Short communications by specialists invited to describe the present state of the art in México and in particular in the State of Puebla in the utilization of the satellite information in studies for the conservation of the environment, territorial planning, use and potenciality of the land, and prevention of disasters.

Conferences took place on the development of spacial research programs in Mexico and respective objetives concerning monitoring and observation of the land.

These short conferences took place with the examples of software and results obtained by various mexican institutions. Given the extension of the subjects discussd and the limited time of the participants, it was not possible to record the conferences in writing. Material exists wich was published by institutions such as the National Institute of Statistics, Geography and Informatics (INEGI) and the Institute for the Study of the Use of the Land of the state of Puebla. Conferences were also realized by the representatives of Russia and Brasil in wich they spoke of their experiences and they made proposals for the development of mexican work plans.

II.- Cycle of minicourses.

During the first week, courses were given on different subjects relative to the construction of algorithms of navigation systems of control, stabilization, simulation and analysis of simplified models of satellite trajectories and application of the above to the design structural analysis and definition of the spacial mission of a microsatellite.

In the second week, courses were given on the methods and mathematical models of ecological systems and meteorological models for micro and mesoscale, reactivity and dispersion of

contaminants in the atmosphere, application of the geographical information systems and satellite images to agriculture and the processing of satellite images.

III.- Realization of a round table on the analysis of the perspectives for the use of advanced technology for the monitoring of the environment, territorial planning, the use and potenciality of the land and the prevention of disasters.

We will now continue with a description of each one of these activities.

I.- Short communications.

The following lectures took place:

1.- Program for the upgrading of the state of the use of the land in the state of Puebla, by Rafael Sosa Torres, Technical Director, of the Institute for the Study of the Use of the Land on the state of Puebla.

2.- Digital models of elevation by Ricardo Torres Carrete, Regional Subdirector for the Dissemination of Information of the National Institute of Statistics, Geography and Informatics.

3.- Program for the certification and deeding of community land rights by Ricardo Torres Carrete.

4.- Use of satellite information in the prevention of disasters (importance in the satellite monitoring of volcanic activity of Popocatepetl) by Alejandro Rivera, Director of the Center for the Prevention of Disasters of the Autonomous University of Puebla.

5.-Land station for the capture of AVHRR images by Augusto Moreno, Director, State Advisory Board of Science and Technology.

6.- Project ECAPUEBLA: Study via modelling of the quality of the air in the city of Puebla by Andrés Fraguera Collar, director, project ECAPUEBLA.

7.- Project SATEX by Alejandro Pedroza Meléndez, Technical Coordinator of project SATEX.

8.- Proposal for a universal microsatellite for remote sensing, communications and applications of new technologies by Mijail Ovchinnikov, Principal Constructor, Keldish Institute of Applied Mathematics, Russian Academy of Sciences.

9.- Project UNAMSAT by Gianfranco Bisacchi Giraldi, Director, University Program of Investigation and Spacial Development of the National Autonomous University of Mexico (UNAM).

10.- Artificial satellites and geographical information systems by Román Alvarez Bejar, Director, Institute of Geography, UNAM.

11.- Mexican satellite program : the Ibero American manisatellite project for the observation of the land, of the countries of Mexico, Argentina and Spain by Javier Roch, Director of Spacial projects, Mexican Institute of Communications.

12.- The brazilian program of monitoring of the environment (the Amazon project) by Ijar Milagre Da Fonseca, the Brazilian National Institute of Investigations of Space.

13.- The computer on board the SATEX by Esaú Vicente Vivas, UNAM Institute of Engineering.

II.- Minicourses.

A cycle of minicourses was developed whose main ideas may be found in the school program which is enclosed.

Because of unexpected developments, Dr. José M. Baldasano Recio from the Polytechnical University of Cataluña and Dr. Alfredo Altobelli from ICS-Unido could not participate in the School period; nevertheless the ideas of their courses were covered by the specialists, doctors: Juan Ruben Varela Ham, Rosa Maria Velazco, Maria Engracia Hernández Cerda, María Guadalupe Galindo and Vladimir Borovikov all of whom are of recognized prestige in the above mentioned areas and represent important mexican institutions of higher (learning) education.

For the month of march, 1997, Dr. J.M. Baldasano and Dr. Altolelli have been invited to continue the minicourses in the area of interest in the school and thus be able to contribute their valuable experiences.

The topics of the minicourses will be published in 1997 in two volumes by the State Advisory Board of Science and Technology of the state of Puebla and said volumes will be forwarded to UNIDO.

III.- Round table.

Several points were discussed in the round table relating to the needs of support for important projects dealing with the conservation of the environment and spacial studies .

- 1.- Requeriments for the deisgn and construction of a microsatellite for environmental monitoring and observation of the earth.
- 2.- Creation of a Center for the Studies of Space by the Autonomous University of Puebla.
- 3.- Dynamic simulation, design and construction of a controlable system from earth of environment monitoring.
- 4.- Needs for support of the ECAPUEBLA project.
- 5.- Creation of a laboratory for simulation and analysis of complex systems.

Regarding points 1,2 and 3 the importance of developing an aerospace program which would permit Mexico to adquire the capacity and experience necessary for the design, development, manufacture and operation of space systems was recognized. In order to reach this objeteve, it is important that the educational centers with the most scientific expertise in the nation in the disciplines related to the aerospace sector, such as schools and institutes of science and engineering, create programs, departments or centers that concentrate and coordinate the formation of human resources and efforts for the development of spacial technology. At the same time, it is of vital importance that communication and coordinations between the different instituitions that do work in this sector, as well as responsible parties in government, area supervisors and the private sector , cooperate with investments needs and their own projects in the aerospacial program.

Due to the late start of Mexico in this sector, it is important to establish obtainable goals wich will also permit access to competitive advanced technology in the area. Orientation toward a program of small satellites better known as microsatellites (5 to 50 Kg) and minisatellites (50 to 500 Kg), wich promise a great future because of the low cost, quick design and construction and orientation toward the solution of specifics problems has first priority. At present, almost all the countries with experience in the aerospacial area are developing minisatellite platforms to be used later in a multifunctional way that permits remote sensing and communications making scientific experiments and developing technology orientated toward the most important commerciable possibilities.

Thus, Mexico could profit from the recent and important experience obtained from the first mexican satellite in orbit (UNAMSAT,1996) and the one that is presently under construction (SATEX), as well as the participation in the recently established iberoamerican project for the design and construction of a trinational minisatellite by Spain, Argentina and Mexico.

It is agreed to participate actively in the iberoamerican project whose mission, among others is remote sensing.

It is also agreed to support a microsatellite project in the Autonomous University of Puebla involving a high students participation at the graduate and post graduate level, low costs and the experience of integrating human resources and demonstrate scientific and technological capacity.

Start the presentation of the program of development of dirigibles and sounding balloons, whose objective is to develop models and technology for the construction of stabilization and control systems and to make required applications at regional level as well as tests and use of monitoring equipment and remote sensing. It is agreed to integrate this program into the Program of Development in Science and Spacial Technology of the Autonomous University of Puebla.

Regarding point 4, it is agreed that the fundamental objective of the project ECAPUEBLA (study of the quality of the air in the city of Puebla) is the study of the principal factors that influence in the regional climates variety. They should make an inventory of emissions associated with a data base. model the process of transport and reactivity of contaminants in the city of Puebla, with the objective of simulating the present state of atmospheric contamination, determining the fundamental factors which cause contamination and the measures to be taken for its control, as well as to foresee the state of atmospheric contamination for the different corresponding actions relating to the regional development plans of the state government.

This way an interactive computerized system may be obtained resulting in a quick and efficient tool for the taking of decisions regarding the influence of this planning in the contamination of the atmosphere.

In the future this system can be amplified to include other risk factors in the taking of decisions.

It was agreed to request support from the Department of Urban Development and Ecology of the state of Puebla and to look for support from international institutions for the realization of this project regarding the contracting of specialists and technical personnel, the acquirement of equipment for meteorological monitoring and the measurement of solar radiation and the acquirement of software.

Regarding point 5, it was agreed to propose the creation of a modelling and simulation laboratory for the analysis of complex systems. This laboratory would support applied projects in the conservation of the environment, physiological processes and the determination of systemic risk parameters.

The needs are:

- i. A specialist in numerical methods, mathematical models, handling of simulation and data processing software.
- ii. A specialist in the processing of images and handling of geographic information (GIS).
- iii. A specialist in electronics working with interphase problems in measuring and computing equipment, capture of data, etc.
- iv. Two technicians in advanced programming that know MATLAB, MATHEMATICS, statistical processing of data and programming orientated to objects.

In order to comply with this objective certain computing equipment must be integrated for the creation of the laboratory. This was requested some time back. All of this should be located in one site and should be used for this end and should be enriched later with software and other equipment obtained through support funds for investigation projects.

The initial equipment that should be in this laboratory is:

One Sun work station
Two X- terminals
Two powerful PC's or Pentium
One laser printer.

TERMINAL SECTION

The international school on satellites and environment is the first of this nature held in Mexico especiality considering the amplitude of the scientific topics discussed as well as the complete discussion of the present state of the nation of Mexico with respect to the realization of a space program and the status of some important projects of investigation on the conservation of the environment.

Regarding these aspects, lectures that the school has given have satisfied the proposed objectives.

With a few exceptions the development of new technologies and systems applicable to the studies and programs on conservation of the environment is very limited in Mexico. The majority of the centers of investigation are located in Mexico city. One of the most important states of Mexico is the state of Puebla which is in in close proximity to Mexico city.

The establishment of a center in Puebla to carry out this activity is urgently required .This centershould be charged with all the coordination necessary to fulfill its obligations both in the interior as well as abroad.

We believe that the International Center for the Application of Mathematical Methods (CIAMM) is in condition to do this work with the help of the government and institutions of higher education and also those of international organizations such as UNIDO. There currently exists important agreements to colaborate between CIAMM and the M.V. Lomonosov University of Moscow. The support required should be directed fundamentally towards the stabilization of the CIAMM infraestructure (installations, adquisition of computer equipment and the contracting of qualified personnel) and the development of projects of investigation and the realization of scientific events.


Dr. Andrés Fraguela Collar.
General Director
CIAMM

SCHOOL PROGRAM

THE GENERATION AND EVOLUTION OF CONTAMINANTS

Lecturers: N. N. Smirnov, N. I. Zverev.
State University M. V. Lomonosov of Moscow

Lecture 1: Turbulence, vorticity and instability of the atmospheric flows.
Mathematical methods of turbulent flow modelling.

Lecture 2: Drift and sedimentation of clouds of particles in atmospheric flows.

Lecture 3: Physical and mathematical models of contaminants evolution in the atmosphere of big cities.

Lecture 4: Peculiarities of mathematical modelling of different sources of pollution: moving, stationary, continuous, incidental.

Lecture 5: Liquid contaminants evolution in soil. The importance of wettability effects and surface tension.

SHORT WAVE RADIATION IN THE TERRESTRIAL ATMOSPHERE

Lecturer: Dr. Agustín Muhlia Velázquez
Instituto de Geofísica, UNAM

Lecture 1: Optical characteristics of terrestrial atmosphere, as a medium for the propagation of solar short wave radiation

In this lecture, we will review the phenomenon of propagation and the process of solar radiation attenuation that take place in terrestrial atmosphere given their optical characteristics, to know the absorption and dispersion. We will talk about the principal absorption characteristics and atmospheric dispersion and the way to quantify their effects.

Lecture 2: An atmospheric model and the attenuation laws of each one of its constituents

In this lecture we will consider a simple model of atmosphere and the principal constituents that intervene in an important way in the solar radiation attenuation. Also we will speak about the theoretical experimental laws that rule absorption and/or dispersion of solar radiation for each one of the constituents considered in the model.

Lecture 3: Optical characteristics of atmospheric aerosol and their spectrum size

In this lecture we will talk about optical characteristics -absorption and dispersion- of individual particles that constitute the atmospheric aerosol, their spectral size and their integral effect as a system (denominated as aerosol) that attenuates solar radiation.

Lecture 4: Experimental methods in atmospheric optics

In this lecture we will describe some instruments that permit the study of optical phenomena that occur in the atmosphere, principally those that take place in the presence of aerosolic particles; in the same way, we will describe some inversion methods of experimentally obtained data to calculate some microphysical characteristics of aerosol particles.

Lecture 5: Radiation transference equation. A solution for the case of atmospheric parallel planes divided in layers.

In this lecture we will establish in a formal way the radiation transference equation that takes place in the atmosphere and the possibility of obtaining a solution for a particular case.

METEOROLOGICAL AND REACTIVITY MODELS FOR THE STUDY OF ATMOSPHERIC POLLUTION

Lecturer: Dr. José M. Baldasano Recio

Instituto de Tecnología y Modelización Ambiental (ITEMA)
Universidad Politécnica de Cataluña (UPC)

Lecture 1: Air Pollution Meteorology

The structure of the atmospheric boundary layer. Atmospheric flow scales. Atmospheric stabilities. Boundary layer processes and parameters.

Lecture 2: Air Quality Modelling

Air quality model components. Deterministic vs statistical models. Receptor models. Pollutant concentration variation. Short-range vs long-range. Short-term vs long-term. Plume rise. Model performance evaluation.

Lecture 3: Diagnostic and Prognostic meteorological models

Knowledge of the wind field. Mass-consistent diagnostic model. Linear diagnostic model (also named JH models). Fundamentals of prognostic models.

Lecture 4: Atmospheric emission source models

Main characteristics of an atmospheric emission source model. Road traffic emissions. Industrial emissions. Gas station emissions. Domestic heating emissions. Biogenic emissions. Airport emissions.

Lecture 5: Atmospheric dispersion and photochemical models

Eulerian vs Lagrangian approach. Eulerian models. Gaussian models. Lagrangian models. Atmospheric chemistry.

IMAGE PROCESSING OF MULTISPECTRAL DATA

Lecturer: Dr. Javier S. Salgado Pareja
Benemérita Universidad Autónoma de Puebla

Lecture 1: Solid surfaces sensing in the visible and near infrared

This lecture gives a general introduction to topics like: Sources spectral characteristics, wave surface interaction mechanism, signature of solid surface materials and the use of spectral radiometric signatures in surface studies.

Lecture 2: Hyperspectral analysis

This lecture will introduce the acquisition, analysis and application of the apparent reflectance data obtained by the Airborne Visible / Infrared Imaging Spectrometer (AVIRIS). These subsetted data cover the 2.0 to 4.0 micrometers range in 40 spectral bands approximately 10 nm wide. Calibration of data will be discussed in detail as well as radiance spectrum, and the spectral angle mapper classification technique.

Lecture 3: Satellite microwave imaging system

In this lecture, topics to be discussed deal with the principle of imaging RADAR system, imaging geometry, radar equation, signal fading, fading statistics, and geometry distortion.

Lecture 4: Satellite microwave imaging system

This second lecture on RADAR system introduces topics such as: Synthetic array approach, SAR Imaging coordinate system, point target response, description of SAR sensor, application of imaging radars for environmental studies and natural resources evaluation. We will stress on the processing, analysis and applications of recent data obtained in two microwave wavelengths, L-band (24 cm) and C-band (6 cm) by the Spaceborne Imaging Radar-C (SIR-C). The most important algorithms for image processing will be presented and practical examples discussed.

THE USE OF GIS AND SATELLITE IMAGE FOR TERRITORIAL ORGANIZATION IN THE AGRICULTURAL SECTOR

Lecturer: Dr. Alfredo altobelli

International Center for Science and High Technology, Italy, UNIDO

Lecture 1: Landscape modeling with GIS

Lecture 2: The use of GIS for the study of the environmental impact of land use with special emphasis to agriculture

Lecture 3: The use of GIS - GRASS 4.1 for the study of the agroecosystems

Lecture 4: Elaboration techniques of LANDSAT-TM data for crop monitoring

THE APPROXIMATE MATHEMATICAL AEROSPACE DYNAMIC MODELS

Lecturer: Dr. Igor V. Novozhilov
State University M. V. Lomonosov of Moscow

Lecture 1: The method of fractional analysis

The method of formalized construction of approximate mathematical models of dynamic systems is described. It combines both the methods of similitude and dimension theory and algorithm of asymptotic expansions in small parameters. The method of fractional analysis makes it possible to obtain approximation equations which describe big and small, fast and slow components of motion separately.

Lecture 2: The approximate models of flight dynamics

Small parameters are introduced in the equations of aircraft motions. Three groups of these parameters are introduced. They correspond to three classes of motion: In-flight, dynamical evolutions, and angular motion around the mass centre. Approximate mathematical models of these motion classes are obtained.

Lecture 3: The approximate models of angular motion of satellite controlled by gyrodyns

The models of slow and fast motions are obtained. The model of fast motions is investigated by means of the method that uses three-fold symmetry of the system.

Lecture 4: The angular motion model of a two-positional satellite controlled by jet-engines

The methods of definition solutions for systems with discontinuous characteristics is introduced. The equation of system has the same singular perturbed form. The system has intervals of sliding mode.

SPACE NAVIGATION AND ITS APPLICATION TO THE SATELLITE LOCATION

Lecturer: Dr. Nikolai. A. Parusnikov
State University M. V. Lomonosov of Moscow

Lecture 1: Problems of phase parameter determination for satellites

Model equations. Equations of errors in various systems of coordinates. Principal and additional information. Problem of correction for navigation algorithm as problem of orbital elements determination.

Lecture 2: Methods of solution for problem of correction

Kalman filter, its practical version based on Cholesky decomposition of covariance matrix. Observable and unobservable parameters. Regularization. Solution of navigation problem in post-processing mode (topographic positioning). Smoothing Kalman filters and their regularization. Examples.

Lecture 3: Methods for model reduction and decomposition

Parallel decomposition for stationary case. Decomposition in case of low eccentricity orbit. Measures of observability and reduction of navigation problem with regard to these measures. Measure-driven decomposition. Value of decomposition and reduction for modern on-board processing units.

Lecture 4: Satellite navigation systems

Satellite navigation systems GPS and Glonass. Use of these systems in airborne gravimetry (as applied to oil and gas recovery). Statement of a problem and description of its solution based on satellite navigation mode, two-component inertial navigation system with stabilized platform, and gravimeters. Different approaches to primary data smoothing (kernel smoothing, spline smoothing, Kalman smoothing). Three kinds of data processing algorithm structuring (differential, integral, and mixed). Example of partial realization of a system and results of flight tests.

MATHEMATICAL METHODS AND MODELLING

Lecturer: Dr. Andrés Fraguela Collar
Autonomous University of Puebla
State University M. V. Lomonosov of Moscow

Lecture 1: The mathematical modelling and differential equations

The fundamentals of mathematical modelling. The most important models with differential equations. The initial and boundary value problems.

Lecture 2: Methods to solve differential equations

A brief description of analytical, functional and numerical methods. The Fourier and filtering methods.

Lecture 3: The Problem of Optimization

Mathematical statement. Optimization methods. The role of optimization in the application.

Lecture 4: Mathematical methods for inverse problems

The direct and inverse problems. Regularization.

CONTROL THEORY OF MECHANICAL SYSTEMS

Lecturer: Dr. Vladimir V. Alexandrov
State University M. V. Lomonosov of Moscow
Autonomous University of Puebla

Lecture 1: Mathematical modelling of a controlled system

Ideal motion and the equation in variations. The resource of control and the information of sensor.

Lecture 2: Controllability and observability

Controllability and observability criteria. Decomposition. Discrete Kalman filtering.

Lecture 3: Stability and stabilization

Liapunov's theorems of asymptotic stability. Stabilization of closed-loop systems.

Lecture 4: Optimal control.

Lagrange's principle, maximum principle of Pontriaguin. Mathematical models of two-level closed-loop optimal controlled systems.

Lecture 5: Irregularity of optimal control in regular extreme problems

Special control. Sliding mode. Chattering control. Optimal control of aerospace flights. Dynamics simulation of optimal flights.