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SELPER

REVISTA TÉCNICA, DE INTEGRACION IBEROAMERICANA Y MUNDIAL
REVISTA TÉCNICA, DE INTEGRAÇÃO IBERO-AMERICANA E MUNDIAL
TECHNICAL REVIEW FOR IBERO-AMERICAN AND WORLDWIDE INTEGRATION

24th International Symposium on Remote Sensing of Environment



Rio de Janeiro, Brazil

27-31 May 1991

• Bem-vindos •



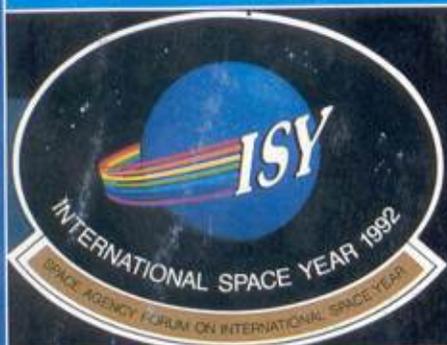
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UNA GRAN OPORTUNIDAD DE ACERCAMIENTO AL AÑO INTERNACIONAL DEL ESPACIO



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SOCIEDADE DE ESPECIALISTAS LATINO-AMERICANOS EM SENSORIAMENTO REMOTO
SOCIETY OF LATINAMERICAN SPECIALISTS ON REMOTE SENSING

SELPER

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PRESENTACION

Ing. MIGUEL SANCHEZ-PEÑA
Presidente SELPER

Con inmensa satisfacción dirijo estas breves palabras a la comunidad científica de socios, amigos, simpatizantes y colaboradores de SELPER, no solamente en América sino también de otras regiones en donde nuestra Sociedad Latinoamericana va siendo conocida cada vez más. Además de las actividades desarrolladas por el Directorio Ejecutivo y los Capítulos Nacionales, el año pasado firmamos una carta de intención para estrechar vínculos SELPER con la USACH, Universidad de Santiago de Chile. En Enero de 1991 firmamos un CONVENIO DE COOPERACION ENTRE SOCIEDADES, en el cual SELPER con la ASPRS (American Society of Photogrammetry and Remote Sensing) acuerdan un Convenio Magno a fin de desarrollar relaciones significativas y duraderas y potenciar una serie de actividades conjuntas entre ambas.

Entre el 27 y 31 de Mayo-91 se realizó en Río de Janeiro el 24th Symposium on Remote Sensing of Environment organizado por el ERIM de Michigan con el INPE de Brasil y una activa participación de nuestros asociados en condiciones ventajosas, en varias de las sesiones que se desarrollaron. En una sesión de posters se presentaron las actividades de SELPER y trabajos técnicos o actividades en la mayoría de los diferentes países de Iberoamérica. Durante el Simposio, los miembros de SELPER presentaron 22 trabajos y se realizó un FORUM presidido por el suscrito en donde colegas de varios países de la región presentaron las ideas predominantes en sus naciones en relación al Cambio Global. El Forum trató sobre "Contribuciones a los Requerimientos de Información por parte de Planificadores y Autoridades para alcanzar un Desarrollo Sostenido en esta Era del Cambio Global".

Las ponencias presentadas fueron de elevado nivel y junto con las discusiones posteriores permitieron obtener conclusiones importantes en donde se estima que SELPER, como asociación de profesionales altamente capacitados en percepción remota y sus aplicaciones, está llamada a desarrollar una decisiva labor en las actividades que se irán realizando en los próximos años con respecto al Cambio Global. Los trabajos presentados aparecerán en las Memorias del 22º Simposio ERIM y las conclusiones y recomendaciones del FORUM, serán publicadas en un anexo especial.

Durante este evento en Río de Janeiro y aprovechando que estaban presentes el Directorio Ejecutivo y varios de los Coordinadores Nacionales, se avanzó en la discusión de temas de interés para SELPER y se fijaron las condiciones para el otorgamiento del Premio EOSAT que será adjudicado al mejor proyecto que se presente. Está previsto otorgar este premio en oportunidad del V Simposio Latinoamericano en CUSCO. AGRADECEMOS a la Empresa EOSAT su constante ayuda a las actividades de SELPER.

Con el auspicio del CNES, GDTA y SPOT IMAGE de Francia se realizó entre el 17 y 21 de Junio un SEMINARIO y Curso Intensivo de Teledetección Aplicada al Uso de la Tierra, Planificación Urbana y Rural, organizado por SELPER, la Universidad Nacional de LUJAN y el CAPDIS en la ciudad de La Plata (Argentina). Reiteramos nuestro pedido de continuar promoviendo las acciones necesarias para la mayor participación en el V SIMPOSIO LATINOAMERICANO a realizarse en CUSCO, a fines de Octubre próximo.

NOTA DEL EDITOR

Ing. MAURICIO ARAYA-FIGUEROA
Director Editorial SELPER

Este número de la Revista SELPER también aparece con un retraso, menor pero importante, pues se pensó dedicarlo al XXIV Simposio Internacional de Percepción Remota del Medio Ambiente, organizado por el Environmental

Research Institute of Michigan (ERIM), en colaboración con INPE/Brasil y la especial participación de SELPER. Este suceso ocurrió entre el 27 y el 31 de Mayo de 1991, por lo que es natural la aparición de esta Revista de Junio durante el tercer trimestre de 1991.

Afortunadamente, los Boletines NOTICIAS y LATINISY de SELPER publicados en Enero y Mayo de este año, en conjunto con el Calendario Poster SELPER-91, han permitido llenar parcialmente el vacío producido por el retraso de los dos primeros números de la Revista SELPER durante 1991. Esto demuestra la gran utilidad de estas nuevas y ágiles publicaciones de nuestra Sociedad, iniciadas justamente durante este año y con el objetivo de editarse según necesidad, al menos cuatro veces al año cada una (NOTICIAS y LATINISY). En esta oportunidad se han incluido trabajos técnicos relacionados con las Actividades Canadienses de Percepción Remota, en particular CCRS y MDA. Se ha destacado en forma especial el Programa Técnico del Simposio ERIM, por su interés para la comunidad latinoamericana, dada la amplitud de los temas tratados y también como una forma de agradecer y estrechar vínculos con esta Institución, tan ligada desde el comienzo al nacimiento de SELPER.

Finalmente cabe resaltar la importante aproximación de SELPER a las actividades relacionadas con el Año Internacional del Espacio (ISY), donde el Simposio ERIM resultó una ocasión privilegiada, dadas las Sesiones Plenarias desarrolladas y el excelente nivel de los expertos invitados, como así la importante invitación extendida a SELPER para tener una activa participación en estos Paneles de Discusión. En este sentido, debe destacarse la amable colaboración del Dr. Alan K. Parker, Dr. Ric Cicone y Sra. Dorothy Humprey (ERIM); Dr. Ralph Brescia y Dra. Nancy Firestone (U.S. NASA); y la brillante participación del Instituto de Pesquisas Espaciais (INPE) de Brasil, en particular su Director Dr. Marcio Nogueira Barbosa, Dr. Roberto Pereira Da Cunha, Dr. Paulo Roberto Martini, Ing. Paulo César Gurgel de Albuquerque, Sra. Etelvina Renó Díaz Alves. Vayan también nuestros tradicionales reconocimientos especiales a la Dra. Valerie Hood (ES), Dr. Jean-Luc Devynck (CNES); Dr. Adigún Ade Abiodún y Dr. Sergio Camacho (ONU, OSAD); Dr. John MacDonald y Dr. Michael DeSandoli (MDA); Dr. Keith Raney (CCRS); Dr. Stephen Pruscia (INTERGRAPH); Dr. Pedro Rodríguez (INTERA); al Instituto Geográfico Militar (IGM) de Chile y a tantas personas e instituciones por su valioso e indispensable respaldo a nuestra labor editorial.

24th INTERNATIONAL SYMPOSIUM ON REMOTE SENSING OF ENVIRONMENT



27 - 31 May 1991
Rio de Janeiro, Brazil



ACTO INAUGURAL ERIM PALABRAS DEL PRESIDENTE DE SELPER

The Sociedad de ESPECIALISTAS LATINOAMERICANOS EN PERCEPCION REMOTA-SELPER, as a technical-scientific organization formed by a nucleus of specialists in our region, is proud to have an active role and to participate during this 24th International Symposium on Remote Sensing of Environment.

We are convinced that the technology of Remote Sensing is of vital importance for the development and welfare of our Nations.

"IberoAmerica" with its big extension and all kind of climates, soils and type of vegetation has very valuable renewables and non renewables resources that needs monitoring, management and better care.

Their exploitation must be made on such a way to avoid harmful changes on the environment. We must procure that future generations do not find our planet polluted and with scarce natural resources.

On the last decades the international scientific community has seen with preoccupation how the earth environment has been carelessly and harmfully managed; the greenhouse effect is one of the examples.

The indiscriminated forest destruction, the fishes depredation, the atmosphere pollution and the increasing desertification are just a few cases.

Today the mankind is aware of these problems and we are sure that space technology is a good help to solve them.

Earth observation from space began as a purely scientific exercise and it was much later that a commercial potential was seen. The Earth Observing System (EOS) is a U.S. effort involving many countries and will cost between 15 billion to 30 billion dollars. It will produce a wealth of data which will be used to evaluate Man's effort on our planet.

In Europe the ERS-1 Satellite and latter on in 1994 the ERS-2 will provide the data to study several environmental problems. They will contribute to a better understanding of the interaction between the oceans and atmosphere, the ocean circulation, the land use, etc. Both will be an important contribution to environmental studies. ie: the ERS-2 with the GOME instrument will allow to survey the Ozone at global scale.

The tremendous amount of available data must be transformed in useful information, reports, studies and recommendations on how to solve problems to improve the living conditions of mankind.

SELPER, a professional Society with specialists from all countries in America is an adequate organization to participate actively in this challenge that Man has for preserving their environmental.

We have demonstrated expertise to organize Symposia, Colloquium, Seminar, Training courses; to make special studies or to planify research programs on Remote Sensing. Besides we can receive and distribute information through our publications like REVISTA SELPER, LATINISY and others.

We offer all this to play an active role in the important task that we must overcome.

Last March in Buenos Aires during two days, a Group of Intergovernmental experts on climatic variations hold a seminar on Global Change.

On April 23-1991, it was held also there the Public Forum ECO-92 with the presence of Presidente Menem. Let me express some of the presidential words pronounced during this Forum;

"The conjunction of development and conservation of environment, not only must stop the present decay, but it must revert this process in such a way that our future generations find a better environment than the one they received from their ancestors. Finally I invite to the following meditation: If in the fifties the sentence was: tell me how much of natural resources you are using and I will tell you what degree of development you have. Today in the nineties the motto will be:

TELL ME HOW YOU TAKE CARE OF YOUR NATURAL RESOURCES AND I WILL TELL YOU WHAT DEGREE OF CIVILIZATION YOU HAVE".

Finally let me express in my name and in the name of my colleagues of SELPER many thanks to the local authorities, the local organizers, in the Environmental Research Institute of Michigan-ERIM- and the Consortium for Earth Science Information Network (CIESIN) of Ann Arbor and other sponsors.



24 TH INTERNATIONAL SYMPOSIUM OF REMOTE SENSING OF ENVIRONMENT



Summation of the SELPER Forum

Richard C. Cicone, Co-Chairman, Plenary Session 1 for Miguel Sánchez Peña, President, SELPER
31 May 1991

On Tuesday May 28, 1991, SELPER, the Society of Latin American Remote Sensing Specialists, conducted a forum on "An Assessment of the Information Required by Resource Managers and Policy Planners to Achieve Sustainable Development in an Era of Global Change".

The forum was held following the presentation of National Program papers during the morning poster session that included representatives from Argentina, Brazil, Chile, Columbia, Costa Rica, Ecuador, Mexico, Panama, Peru, Uruguay and Venezuela.

Miguel Sanchez Pena, President of SELPER, hosted the SELPER forum and five addresses were made: Domingo Antonio Gagliardini, SELPER Vice President, presented, "Global Change Program in Argentina: The Remote Sensing Contribution", Paolo Martini of INPE presented, "Brazilian Requirements of Environment Data for Policy and Decision Makers", Mauricio Araya, Editorial Director, SELPER, presented, "Expanding Chilean Capabilities Through International Cooperation in Remote Sensing and its Potential Contribution to Global Change Programs", Luis Carlos Molina, Columbia National SELPER representative, presented, "Data and Information Requirements for Policy and Decision Makers in Columbia", and Roman Alvarez, National Coordinator, Mexico, presented, "Mexican Contribution to the Mapping of Global Change".

The opportunity to discuss information requirements for Latin American response to global change was among the first conducted by SELPER as an organization, though each country is already contributing to the understanding of global change from national perspectives. A discussion, subsequent to the Tuesday forum, was held by the participants on Thursday to review the forum and summarize SELPER findings and recommendations. The principal findings of the forum are summarized as follows:

- 1) Through some Latin American countries are directly involved in global change research through IGBP programs, the primary focus of efforts is on regional issues. Yes, the regional issues tend to be local manifestations of global issues such as deforestation and depletion of arable land.
- 2) Remote sensing tools, particularly AVHRR, SPOT and TM play a prominent role in regional studies, but there is an increasing need for integration of other key physical and socio-economic data such as temperature, soil moisture, demographics, economics, and resource data, (e.g., agricultural). These data are often difficult to access for planning purposes. Explosive growth of new sources of information such as the 1991 Brazilian satellite create new challenges. An increasing emphasis is placed on regional resource planning in light of significant environmental change, and a basic need for sustainable development.
- 3) Though studies across Latin America are related to global change and extensive and innovative research is purposed, there is only modest coordination of global change research efforts among Latin American nations. A notable exception is the multinational Amazon region which, of course, receives worldwide

attention. But there are other notable issues: desertification in Argentina and Mexico, deforestation in the Atlantic forests, availability of fresh water resources for farming and human consumption in Chile and throughout Latin America. Issues related to the need for in situ data from Latin America are not fully addressed. Involvement in ISY activities discussed by Mauricio Araya in plenary 3 may increase opportunities for inter-regional cooperation.

Many notable research and resource planning activities are underway. Aside from the usual and universal concern for adequate financial resources to pursue the appropriate research tasks, the SELPER forum recommends that a new and special emphasis be placed on the following:

- 1) SELPER, an existing trans-Latino organization, with an eleven year history, can play an important role in raising the general level of recognition of global change related research activities in Latin America and the coordination of that activity throughout Latin America with worldwide interests.
- 2) SELPER will consider the development of an integrated Latin America data plan in response to global change issues that would include; a) the identification of key physical and socio-economic data requirements; b) the identification of in situ data collections that can be a contribution by Latin American countries to the worldwide global change program; and c) the identification of a Latin American wide digital data base of important global change data.
- 3) SELPER will undertake the analysis of needs and the development of a plan for the distribution and access to the Latin American global change data base by considering needs for integration with other data acquisition and information system plans and the need for enhancing access throughout Latin America, using telemetric and electronic network methods.

The results of this forum and the papers will be documented in a special addendum to the symposium proceedings. Summary papers will be placed in the SELPER Quarterly and in national circulars such as INPE's. The November SELPER symposium in Cuzco, Peru will be an opportunity for SELPER to continue to formulate this proposed technical agenda.

I extend my appreciation to Eng. Miguel Sanchez Pena for his extensive efforts in coordinating this worthwhile forum. I also thank all those SELPER members representing your respective nations for your contributions and participation both in the national papers poster session and in the forum.

Understanding global change is an effort that will require, in the long-term, astute local research activity as well as collaboration across national boundaries. SELPER has a unique opportunity, as a league of Latin American specialist expert in remote sensing, to make a significant contribution to this important international endeavor.



AUTORIDADES Y CIENTIFICOS EN SESIONES PLENARIAS DEL XXIV SIMPOSIO ERIM, BRASIL, MAYO 1991



24th INTERNATIONAL SYMPOSIUM ON REMOTE SENSING OF ENVIRONMENT



RIO DE JANEIRO, BRAZIL
27 - 31 MAY 1991



ORGANIZED AND CONDUCTED BY

Environmental Research Institute of Michigan
Ann Arbor, Michigan, USA

IN COOPERATION WITH

Consortium for International Earth Science Information
Network (CIESIN)

Ann Arbor, Michigan, **USA**

European Space Agency (ESA)

Paris, **France**

National Aeronautics and Space Administration (NASA)
Washington, DC, **USA**

National Institute for Space Research (INPE)

São José dos Campos, SP, **Brazil**

National Oceanic and Atmospheric Administration
(NOAA)

Washington, DC, **USA**

Society of Latin American Remote Sensing Specialists
(SELPER)

Buenos Aires, **Argentina**

United States Agency for International Development
(USAID)

Washington, DC, **USA**

The World Bank

Washington, DC, **USA**

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24th International Symposium
on Remote Sensing of Environment

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Brazil

On behalf of the International Remote Sensing
Community and particularly the participants in the 24th
International Symposium on Remote Sensing of
Environment, I would like to express our appreciation and
thanks to the above - named individuals and the staffs of
their respective organizations who have worked diligently
to make this Symposium possible.

Without their help and cooperation, it would be
impossible for us to meet in such an atmosphere of
international unity; to address the vital issues of Global
Change; and to determine how our common discipline,
remote sensing, can best be used to monitor that change
in a cost-effective, manner, thereby providing the
information needed to determine how we can modify or
control change.

The best repayment of our hosts' gracious hospitality
is for us to work together, using our technology to ensure
that Global Change produces a positive rather than a
negative impact on ourselves, our countries, and our
future generations who one day may transcend national
boundaries and make planet Earth a true Global
Community with an environment that is benevolent to all
people.

Alan K. Parker, Chairman

PROGRAM COMMITTEE

24th International Symposium on Remote Sensing of
Environment

Alan K. Parker, Chairman, Environmental Research
Institute of Michigan, Ann Arbor, Michigan, **USA**

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Research, São José dos Campos, SP, **Brazil**

Nancy Firestone, W. T. Chen and Company, Inc.,
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John W. Koehring, United States Agency for International

PROGRAM SCHEDULE

24th International Symposium on Remote Sensing • Rio de Janeiro, Brazil • 27-31 May 1991

	8:30	9:30	10:30	11:30	12:30	1:30	2:30	3:30	4:00	5:00	6:00	6:30	7:30	8:30	9:30
Mon 27	Secretariat					Registration									
	Gavea A Ballroom							Opening & Keynote							
	Gavea A/B Foyer									Exhibit Opening					
	Gavea B Ballroom										Reception				
Tues 28	Gavea A Ballroom		Poster A				Plenary 1		Plenary 1					Workshop I	
	Gavea A/B Foyer		Exhibits					Exhibits							
	Gavea B Ballroom				Buffet										
	Foyers								Coffe						
Wed 29	Gavea A Ballroom		Poster B				Plenary 2		Plenary 2					Workshop II	
	Gavea A/B Foyer		Exhibits					Exhibits							
	Gavea B Ballroom				Buffet										
	Foyers								Coffe						
Thur 30	Gavea A Ballroom		Poster C				Plenary 3		Plenary 3					Workshop I	
	Gavea A/B Foyer		Exhibits					Exhibits							
	Gavea B Ballroom				Buffet										
	Foyers								Coffe						
Fri 31	Gavea A Ballroom		Poster D				Closing								
	Gavea B Ballroom				Buffet										

Program Schedule

Development, Washington, DC, **USA**
B. Wayne Luscombe, The World Bank, Washington, DC,
USA

Miguel Sánchez Peña, Society of Latin American Remote
 Sensing Specialists, Buenos Aires, **Argentina**

John W. Sherman, III National Oceanic and Atmospheric
 Administration, Washington, DC, **USA**

MONDAY, MAY 27

8:30 a.m. – 6:00 p.m.

REGISTRATION

Secretariat

3:00 p.m. – 5:00 p.m.

OPENING CEREMONIES

Gavea A Ballroom

5:00 p.m. – 6:30 p.m.

OFFICIAL EXHIBIT OPENING

Gavea A/B Foyer

5:30 p.m. – 6:30 p.m.

OPENING RECEPTION

Gavea B Ballroom

OPENING CEREMONIES

INTRODUCTION OF GUESTS AND SPEAKERS

3:00 **Roberto Pereira da Cunha**, National Institute for
 Space Research, São José dos Campos, SP, **Brazil**

WELCOMING ADDRESSES

3:15 **Marcelo Nunes de Alencar**, The Mayor of the City of
 Rio de Janeiro, Rio de Janeiro, RJ, **Brazil**

3:30 **Roberto D'Ávila**, Secretary of the Environment for the
 State of Rio de Janeiro, Rio de Janeiro, RJ, **Brazil**

3:45 **Miguel Sánchez Peña**, President, Society of Latin
 American Remote Sensing Specialists, Buenos Aires,
Argentina

4:00 **Márcio Nogueira Barbosa**, Director, National Insti-
 tute for Space Research, São José dos Campo, SP, **Brazil**

4:15 **William M. Brown**, President, Environmental Re-
 search Institute of Michigan, Ann Arbor, Michigan, **USA**

KEYNOTE ADDRESS

4:30 **THE IMPORTANCE OF SPACE TECHNOLOGY
 FOR MONITORING OF ENVIRONMENTAL ACTIVITIES
 IN BRAZIL**

José Goldemberg, Secretary of Science and
 Technology, Brasília, DF, **Brazil**

TUESDAY, MAY 28

8:30 a.m. – 11:30 p.m.

POSTER SESSION A

Gavea A Ballroom

8:30 a.m. – 11:30 a.m.; 1:30 p.m. – 5:00 p.m.

EXHIBITS

Gavea A/B Foyer

11:30 a.m. – 1:30 p.m.

SYMPOSIUM BUFFET

Gavea A Ballroom

1:30 p.m. – 6:00 p.m.

PLENARY 1

Gavea A Ballroom

7:30 p.m. – 9:30 p.m.

WORKSHOP I

Gavea A Ballroom

POSTER SESSION A

NATIONAL PROGRAM PAPERS

Session Moderator

Miguel Sánchez Peña, President, Society of Latin
 American Remote Sensing Specialists, Buenos Aires,
Argentina.

National members of the Society of Latin American
 Remote Sensing Specialists will present papers on their
 countries' activities in remote sensing. Because of the
 publishing deadlines and the problems of international
 mail, we are unable to include the titles of papers to be
 presented. However, we have included a listing of
 scheduled presenters as of the Program publication date.

Starting promptly at 8:30 a.m., the Session Moderator
 will introduce each of the representatives in alphabetical
 order by country. Following the introductions, each
 representative will give a brief summary of the papers they
 will present during this session. At approximately 9:30 a.m.
 each representative will go to the poster locations
 indicated for individual discussion of their paper.

(A-1/2) **REMOTE SENSING ACTIVITIES IN ARGENTINA**
 - **Maria C. Serafini**, Buenos Aires, **Argentina**

(A-3/4) **REMOTE SENSING ACTIVITIES IN BRAZIL** -
Paulo Roberto Martini, São José dos Campos, SP, **Brazil**

(A-7/8) **REMOTE SENSING ACTIVITIES IN CHILE** -
Roberto Richardson, Santiago, **Chile**

(A-9/10) **REMOTE SENSING ACTIVITIES IN
 COLOMBIA** - **Luis Carlos Molina Marino**, Bogotá,
Colombia

(A-11/12) **REMOTE SENSING ACTIVITIES IN COSTA
 RICA** - **Sergio Benach Carro**, San José, **Costa Rica**

(A-13/14) **REMOTE SENSING ACTIVITIES IN
 ECUADOR** - **Fabían Durango V.**, Quito, **Ecuador**

(A-15/16) **REMOTE SENSING ACTIVITIES IN MEXICO** -
Román Alvarez Béjar, México City, DF, **México**

(A-17/18) **REMOTE SENSING ACTIVITIES IN PANAMA**
 - **Hernán Ortega Gonnell**, Panamá City, **Panamá**

(A-19/20) **REMOTE SENSING ACTIVITIES IN PERU** -
Walter Danjoy, Lima, **Perú**

(A-21/22) **REMOTE SENSING ACTIVITIES IN
 URUGUAY** - **Artigas Durán**, Montevideo, **Uruguay**

(A-23/24) **REMOTE SENSING ACTIVITIES IN
 VENEZUELA** - **Gustavo Ruiz**, Caracas, **Venezuela**

PLENARY SESSION 1

DATA AND INFORMATION REQUIREMENTS FOR POLICY AND DECISION MAKING IN RESPONSE TO GLOBAL ENVIRONMENTAL CHANGE

Program Co-Chairmen

Jack R. Lousma

Consortium for International Earth Science Information Network, Ann Arbor, Michigan, **USA**

Richard C. Cicone

Environmental Research Institute of Michigan Ann Arbor, Michigan, **USA**

Session Moderator

Jack R. Lousma

1:30 **AN INTRODUCTION TO THE CONSORTIUM FOR INTERNATIONAL EARTH SCIENCE INFORMATION NETWORK** - **Jack R. Lousma**, Consortium for Consortium for International Earth Science Information Network, Ann Arbor, Michigan, **USA**

1:45 **HUMAN DIMENSIONS OF GLOBAL ENVIRONMENTAL CHANGE** - **José Antonio Lutzenberger**, Special Secretary for Environment, Brasília, DF, **Brazil**

2:10 **THE EMERGENCE OF ECOLOGICAL AWARENESS IN SOCIETY** - **Conrad P. Kottak**, The University of Michigan, Ann Arbor, Michigan, **USA**

2:30 **INTEGRATING REMOTE SENSING AND RESOURCE MANAGEMENT FOR GLOBAL ENVIRONMENTAL CHANGE MITIGATION AND SUSTAINABLE DEVELOPMENT** - **Luiz Gylvan Meira Filho**, National Institute for Space Research, São José dos Campos, SP, **Brazil**

2:50 **INTEGRATING PHYSICAL SCIENCES, HUMAN SCIENCES AND REMOTE SENSING FOR UNDERSTANDING THE HUMAN DIMENSIONS OF GLOBAL ENVIRONMENTAL CHANGE** - **William R. Kuhn**, **Norman E. G. Roller**, Consortium for International Earth Science Information Network, Ann Arbor, Michigan, **USA**

3:10 **DATA AND INFORMATION ACCESS FOR ANALYSIS OF GLOBAL ENVIRONMENTAL CHANGE** - **Richard C. Cicone**, Environmental Research Institute of Michigan, Ann Arbor, Michigan, **USA**

3:30 **COFFEE**

4:00 **SELPER FORUM: AN ASSESSMENT OF THE INFORMATION REQUIRED BY RESOURCE MANAGERS AND POLICY PLANNERS TO ACHIEVE SUSTAINABLE DEVELOPMENT IN AN ERA OF GLOBAL CHANGE**

Session Moderator

Miguel Sánchez Peña

President

Society of Latin American Remote Sensing Specialists

Buenos Aires, **Argentina**

6:00 **ADJOURNMENT**

WEDNESDAY, MAY 29

8:30 a.m. - 11:30 p.m.

POSTER SESSION B

Gavea A Ballroom

8:30 a.m. - 11:30 a.m.; 1:30 p.m. - 5:00 p.m.

EXHIBITS

Gavea A/B Foyer

11:30 a.m. - 1:30 p.m.

SYMPOSIUM BUFFET

Gavea B Ballroom

1:30 p.m. - 6:00 p.m.

PLENARY 2

Gavea A Ballroom

7:30 p.m. - 9:30 p.m.

WORKSHOP II

Gavea A Ballroom

POSTER SESSION B

CONTRIBUTED PAPERS

(B-1) **SOME RESULTS ON CROP INVENTORY AND YIELD FORECASTING USING LANDSAT TM MULTITEMPORAL DATA IN NORTHERN ITALY** - **Mario A. Gomarasca**, **Eugenio Zilioli**, **Pietro A. Brivio** and **Francesca Pagnoni**, Institute of Geophysics of the Lithosphere - CNR, Milan, **Italy**

(B-2) **ACCESS TO GLOBAL ENVIRONMENTAL MODELING CAPABILITIES: INTEGRATED SATELLITE AND GROUND-BASED DATA WITH LOWCOST SOFTWARE ON PERSONAL COMPUTERS** - **D.A. Hastings**, NOAA National Geophysical Data Center, Boulder, Colorado, **USA**; **H. Karszenbaum** and **D. A. Gagliardini**, Centro Argentino de Estudios de Radio-comunicaciones y Compatibilidad Electromagnética (CAERCEM), Buenos Aires, **Argentina**.

(B-3) **DETERMINATION OF NORMAL BASELINES IN BRAZILIAN COASTS BY REMOTE SENSING TECHNIQUES** - **Wagner Santos De Almeida**, Directoria de Hidrografia e Navegação, Niterói, RJ, **Brazil**

(B-4) **RODIS-AN IMAGING SPECTROMETER FOR ENVIRONMENTAL MONITORING** - **B. Kunkel**, **F. Blechinger**, MBB Space Systems, Ottobrunn; **R. Doerffer**, GKSS; **J. Puls** and **H. van der Piepen**, DLR, Oberpfaffenhofen, **Germany**

(B-5) **ENVIRONMENTAL STUDY OF TROPICAL AFRICAN URBAN AREAS BY MULTITEMPORAL SATELLITE IMAGERIES (LUBUMBASHI IN ZAIRE, CENTRAL AFRICA)**, **M. Massart**, **N. Castiaux** and **J. Wilmet**, Université Catholique de Louvain, Louvain-la-Neuve, **Belgium**

(B-6) **APPLICATION OF CONTEXTUAL CLASSIFICATION TO LAND-COVER MAPPING IN WATERSHEDS** - **Jorge A. Silva Centeno** and **Vitor Haertel**, Federal University of Rio Grande do Sul, Porto Alegre, **Brazil**.

(B-7) **CHANGE ANALYSIS OF THE BIGGEST LONGSHORE SANDBAR ALONG THE TAIWAN COAST** - **Chin-an Wu** and **Miao-hsiang Peng**, Energy and Resources Laboratories, ITRI, Chutung Taiwan

(B-8) **BIO-CLIMATES OF SOUTH AMERICA AS DERIVED FROM MULTISPECTRAL AVHRR DATA** - **G. Garik Gutman**, National Oceanic and Atmospheric Administration/NESDIS/SRL, Washington, D.C., **USA**; **William T. Liu**, IAG/USP, São Paulo, **Brazil**

(B-9) **ORBITAL REMOTE SENSING APPLIED TO URBAN ENVIRONMENTAL IMPACT-A CASE STUDY** - **Sandra Maria Fonseca da Costa**, Universidade Federal de Minas Gerais, Belo Horizonte, MG, **Brazil**

(B-10) **TROPICAL RAIN FOREST NONDESTRUCTIVE INVENTORY AND TOPOGRAPHIC MAPPING** - **F. G.**

Bercha, D.H. Currie and **J. A. Dechka**, The Bercha Group, Calgary, Alberta, **Canadá**

(B-11) **AGRICULTURAL CROP AREA ESTIMATION IN SWEDEN** - **Karin Hall-Könyves** and **Stefan Pinzke**, University of Lund, Lund, **Sweden**

(B-12) **UTILIZATION OF SPOT DATA FOR LAND USE/COVER MAPPING AND SOIL/LAND CLASSIFICATION IN THE PIAUI STATE OF NORTHEASTERN BRAZIL** - **Harendra S. Teotia**, Federal University of Paraíba (UFPB), Areia, PB, **Brazil**; **Klaus A. Ulbricht**, DLR-Institut für Optoelektronik, Oberpfaffenhofen, Wessling, **Germany**; **Daniel L. Civco** and **William C. Kennard**, University of Connecticut, Storrs, Connecticut, **USA**

(B-13) **DIFFERENTIATE VEGETATION AND NON-VEGETATION IN ARIDLAND ENVIRONMENT USING (MOMS-1) VISIBLE AND INFRA-RED DATA** - **Sultan H. Al-Sultan**, Ministry of Municipality and Rural Affairs, Riyadh, **Saudi Arabia**

(B-14) **IDENTIFICATION OF TERRAIN CATEGORIES AND GEOLOGIC STRUCTURES USING SIR-B AND DIGITAL AEROMAGNETIC DATA IN THE RAIN FOREST COVERED GUIANA SHIELD, NORTHWESTERN BRAZIL** - **F. P. Miranda**, Petroleo Brasileiro S/A (Petrobras), Rio de Janeiro, RJ, **Brazil**; **J. V. Taranik**, Desert Research Institute/University of Nevada System, Reno, **Nevada**; **A. E. McCafferty**, U.S. Geological Survey, Denver, Colorado, **USA**

(B-15) **MONITORING THE GREEN AREAS AROUND TUCURUI (BRAZIL) USING "TASSELED CAP" TRANSFORMATION** - **Raul Edgard Germano Braga** and **Márcia Regina Labuto Fragoso da Silva**, IBM-Rio Scientific Center, Rio de Janeiro, **Brazil**

(B-16) **ESTIMATION OF BARE SOIL EVAPORATION FROM A MULTI-FREQUENCY AIRBORNE SAR** - **Joao Vianei Soares**, Jiancheng Shi and **Laura Hess**, University of California, Santa Barbara, California; **Edwin T. Engman**, National Aeronautics and Space Administration/GSFC, GSFC, Greenbelt, Maryland; **Jakob van Zyl**, NASA/JPL, Pasadena, California, **USA**

(B-17) **COMPARISON BETWEEN DIFFERENT METHODS OF REGIONAL STRATIFICATION, USING LANDSAT-TM AND EXOGENOUS DATA (FOUTA DJALLON-REPUBLIC OF GUINEA)** - **Eleonore Wolff**, Université Catholique de Louvain, Louvain la Neuve, **Belgium**

(B-18) **DETERMINATION OF "TASSELED CAP" TRANSFORMATION PARAMETERS FOR IMAGES OBTAINED BY THE SPOT SATELLITE** - **Márcia Regina Labuto Fragoso da Silva**, IBM- Rio Scientific Center, Rio de Janeiro, **Brazil**

(B-19) **ACCURATE ESTIMATION OF 1.5 M-HEIGHT AIR TEMPERATURE BY GMS IR DATA**

Ikou Horiguchi and **Hiroshi Tani**, Hokkaido University, Sapporo; **Toshihiro Motoki**, Japan Meteorological Agency, Tokyo, **Japan**

(B-20) **ASSESSMENT OF POTENTIAL MALARIA RISK IN CENTRAL AMERICA** - **Byron L. Wood**, Louisa R.

Beck and **Sheri L. Whitney**, TGS Technology, Inc./NASA Ames Research Center, Moffett Field, California, **USA**

(B-21) **DIFFERENTIATION OF GENUS OF AQUATIC MACROPHYTES THROUGH REMOTE SENSING IN THE TUCURUI RESERVOIR-PARA STATE-BRAZIL** - **Myrian de Moura Abdon**, Instituto Nacional de Pesquisas Espaciais (INPE); **Marion Meyer**, Fundação de Ciência, Aplicações e Tecnologia Espacial (FUNCATE), São José dos Campos, SP, **Brazil**

(B-22) **STUDY ON THE APPLICATION OF REMOTE SENSING TECHNIQUES IN SYSTEMATIC MAPPING OF NATURAL RESOURCES AND ENVIRONMENT** - **Ao He Hui**, **Guan Hai Yan**, **Han Tian Yun** and **Yang Ming Jun**, Shaanxi Remote Sensing Center, Xi'an, **China**

(B-23) **POLARIZACION MATRIX OF TWO-BOUNCE SCATTERING FROM OBJECTS LOCATED ABOVE A ROUGH GROUND SURFACE** - **Sune R. J. Axelsson**, Saab Missiles AB, Linköping, **Sweden**

(B-24) **REMOTE SENSING TECHNIQUES TO THE DETECTION AND MAPPING OF FLOODING DYNAMICS WITHIN THE PANTANAL, MATO GROSSO DO SUL STATE, BRAZIL; PRELIMINARY RESULTS** - **João dos Santos Vila da Silva**, Centro de Pesquisa Agropecuária do Pantanal (EMBRAPA/CPAP), Corumba, MS; **Hermann J.H. Kux**, Instituto Nacional de Pesquisas Espaciais (INPE), São José dos Campos, SP, **Brazil**

(B-25) **REMOTE SENSING OF TERRESTRIAL SURFACES IN A GLOBAL CHANGE PERSPECTIVE-A REVIEW OF THE CURRENT PROGRAMME OF THE INSTITUTE FOR REMOTE SENSING APPLICATIONS-CEC** - **R. Klersy**, **J. P. Malingreau** and **M. Verstraete**, Joint Research Center, Commission of the European Communities, Ispra, **Italy**

(B-26) **ENVIRONMENTAL CONDITIONS AND CHANGE ON THE AMAZON FLOODPLAIN: AN ANALYSIS WITH REMOTELY SENSED IMAGERY** - **John M. Melack**, **Suzanne J. Sippel** and **Dalton M. Valeriano**, University of California, Santa Barbara, California, **USA**; **Thomas R. Fisher**, University of Maryland, Cambridge, Maryland, **USA**

(B-27) **USE OF TM/LANDSAT DATA TO ESTIMATE CHLOROPHYLL CONCENTRATION AND TURBIDITY IN THE BARRA BONITA RESERVOIR** - **Evelyn Marcia Leão de Moraes Novo** and **Claudia Zuccari Fernandes Braga**, Instituto Nacional de Pesquisas Espaciais (INPE), São José dos Campos, PS, **Brazil**

(B-28) **NOISE REMOVAL IN MULTICHANNEL IMAGE DATA BY A PARAMETRIC MAXIMUM NOISE FRACTION ESTIMATOR** - **Knut Conradsen**, **Bjane Kjaer Ersbøll** and **Allan Aasbjerg Nielsen**, Technical University of Denmark, Lyngby, **Denmark**

(B-29) **MODELING SUSPENDED SOLIDS CONCENTRATIONS BASED ON TM/LANDSAT-5 IMAGES AT GUANABARA BAY, RJ, BRAZIL** - **Cláudia Zuccari Fernandes Braga** and **Alberto W. Setzer**, Instituto Nacional de Pesquisas Espaciais (INPE), São José dos Campos, SP, **Brazil**

(B-30) PRACTICAL APPLICATIONS OF AIRBORNE MULTISPECTRAL SCANNER DATA FOR FOREST, AGRICULTURE AND ENVIRONMENTAL MONITORING - **Peter T. Hick**, CSIRO, Remote Sensing Group, Floreat Park; **Michael D. W. Carlton**, Geoscan Pty. Ltd., West Perth, Western Australia, **Australia**

(B-31) REMOTE ASSESSMENT OF LEAF RUST OF WHEAT IN CULTIVAR MIXTURES AND COMPONENT PURELINES - **Tariq Mahmood**, Crop Diseases Research Institute, Islamabad, **Pakistan**; **David Marshall**, Texas A & M Research and Extension Centre, Dallas, Texas, **USA**

PLENARY SESSION 2

CURRENT SATELLITE SYSTEMS TO ADDRESS INTERNATIONAL CLIMATE AND GLOBAL CHANGE NEEDS

Program Co-Chairmen

Luis Gylvan Meira Filho, National Institute for Space Research Sao José dos Campos, SP, **Brazil**

John W. Sherman, III, National Oceanic and Atmospheric Administration Washington, DC, **USA**

Session Moderator

Luis Gylvan Meira Filho

1:30 THE NEAR-TERM SUITE OF SATELLITE SENSORS TO SUPPORT DEVELOPING COUNTRIES' CLIMATE AND GLOBAL CHANGE - **John W. Sherman, III**, National Oceanic and Atmospheric Administration, Washington, DC, **USA**

1:50 METHODOLOGY FOR ANALYZING ENVIRONMENTAL PROJECTS AND INSERTING OPERATIONAL REMOTE SENSING - **Laurent Martin**, SPOT Image, São José dos Campos, SP, **Brazil**

2:10 TWO DECADES OF LANDSAT DATA: A BASELINE FOR DETAILED GLOBAL CHANGE - **Victor Torres**, Earth Observation Satellite Company, Lanham, Maryland, **USA**

2:30 APPLICATION OF METEOROLOGICAL SATELLITE DATA TO GLOBAL CHANGE PROBLEMS - **Luis Gylvan Meira Filho**, National Institute for Space Research, Sao José dos Campos, SP, **Brazil**

2:50 ACCES TO GLOBAL ENVIRONMENTAL MODELING CAPABILITIES: INTEGRATED SATELLITE AND GROUND-BASED DATA WITH LOW-COST SOFTWARE ON PERSONAL COMPUTERS - **D.A. Gagliardini**, Argentine Center for Radio Communications Studies and Electromagnetic Compatibility, CAERCEM, Buenos Aires, **Argentina**

3:10 NEED FOR EXPANDED ENVIRONMENTAL MEASUREMENT CAPABILITIES IN GEOSYNCHRONOUS EARTH ORBIT - **Enrico P. Mercanti**, Mc Donnell Douglas Space Systems Company, Seabrook, Maryland, **USA**

3:30 COFFEE

4:00 SPEAKER PANEL DISCUSSION

5:00 AUDIENCE QUESTIONS FOR THE SPEAKER PANEL

6:00 ADJOURNMENT

THURSDAY, MAY 30

8:30 a.m. - 11:30 a.m.

POSTER SESSION C

Gavea A Ballroom

8:30 a.m. - 11:30 a.m.; 1:30 p.m. - 5:00 p.m.

EXHIBITS

Gavea A/B Foyer

11:30 a.m. - 1:30 p.m.

SYMPOSIUM BUFFET

Gavea B Ballroom

1:30 p.m. - 6:00 p.m.

PLENARY 3

Gavea A Ballroom

7:30 p.m. - 9:30 p.m.

WORKSHOP I

Gavea A Ballroom

POSTER SESSION C

CONTRIBUTED PAPERS

(C-1) MULTISPECTRAL SYNTHETIC IMAGES OF MOUNTAINOUS REGIONS - **Pietro A. Brivio**, **Paolo Furini**, **Massimo Righetti** and **Mario A. Gomarasca**, Institute of Geophysics of the Lithosphere-CNR; **Daniele Marini**, University of Milan, Milan, **Italy**

(C-2) ESTIMATION OF RESERVOIR SURFACE AREA USING DIFFERENT REMOTE SENSING IMAGES - **Abdalla Elsadig Ali**, King Saud University, Riyadh, **Saudi Arabia**

(C-3) MONITORING CROP PRODUCTION REGIONS IN THE SAO PAULO STATE OF BRAZIL USING NORMALIZED DIFFERENCE VEGETATION INDEX - **William T.H. Liu** and **Antonio A.V. Ferreira**, IAG/USP, Sao Paulo, **Brazil**

(C-4) ESTIMATION OF SOLAR RADIATION FROM IGMK MODEL AND SATELLITE DATA SET IN SANTA CATARINA STATE, BRAZIL - **M.E. Ferreira** and **E. C. Moraes**, Instituto Nacional de Pesquisas Espaciais (INPE), São José dos Campos; **E.C. Sucharov**, Universidade Federal do Rio de Janeiro (UFRJ), Rio de Janeiro, **Brazil**; **E. Raschke** and **R. Stuhlmann**, Institut für Physik, GKSS, Geesthacht; **M. Rieland**, Universität Hamburg, Hamburg, **Germany**

(C-5) HIGH-QUALITY SATELLITE IMAGES INTENDED FOR THE GENERAL PUBLIC - **Yves Baudot**, Université Catholique de Louvain, Louvain-la-Neuve, **Belgium**

(C-6) THE OPERATIONAL DETECTION OF FIRES IN BRAZIL WITH NOAA-AVHRR - **Alberto W. Setzer** and **Marcos C. Pereira**, Instituto Nacional de Pesquisas Espaciais (INPE), Sao José dos Campos, SP, **Brazil**

(C-7) CHANGE DETECTION MONITORING BY CLASSIFICATION OF COMBINED TEMPORAL-SPECTRAL REMOTELY SENSED DATA - **Chi-farn Chen** and **A. J. Chen**, National Central University, Chung-Li, **Taiwan**



DESTACADOS DELEGADOS SELPER EN EL XXIV SIMPOSIO ERIM, BRASIL, MAYO 1991

(C-8) **RETRIEVAL OF REFLECTANCE FROM 1989 AVIRIS RADIANCE DATA USING LOWTRAN 7 ATMOSPHERIC MODELS** - Frederick P. Portigal, Christopher D. Elvidge and James V. Taranik, Desert Research Institute, Reno, Nevada, **USA**

(C-9) **ILLUMINANCE AND ZENITH ANGLE INFLUENCE ON THE TRANSPARENCE OF A LENTIC LAGOON WATER** - Ronald Buss de Souza, Iara Musse Felix, Keity Corbani Ferraz and Viviane Testa, Instituto Nacional de Pesquisas Espaciais (INPE), São José dos Campos, SP, **Brazil**

(C-10) **USE OF REMOTE SENSING FOR FOREST RESOURCES MONITORING IN THAILAND** - Thongchai Charupatt, Royal Forest Department, Bangkok, **Thailand**

(C-11) **FIELD COVER ESTIMATION USING LANDAST MSS, LANDSAT TM AND SPOT DATA—A COMPARISON IN SEMI-ARID ENVIRONMENTS** - Peter Pilesjö and Helena Larsson, University of Lund, Lund, **Sweden**

(C-12) **OCEANOGRAPHIC APPLICATION OF LANDSAT/TM DATA IN CABO FRIO (BRAZIL)** - Renato Herz and Jarbas Bonetti, University of São Paulo, **Brazil**

(C-13) **CLASSIFICATION OF SABKHA DEPOSITS BY REMOTE SENSING: DISTINCTION OF SEASONABLE CHANGES IN SABKHA TERRAINS** - Abdulkader M. Al-Sari, Saudki Center for Remote Sensing (KACST), Riyadh; Adly Kh. Al-Saafin, Research Institute, KFUPM, Dhahran, **Saudi Arabia**

(C-14) **RADIOMETRIC MEASUREMENTS IN DIFFERENT SANDY SOIL PARTICLE SIZE TEXTURES (TERRIPSAMENT-HAPLUSTOL-ENTICO) OF LA PAMPA PROVINCE** - Mirta Raed, Comisión Nacional de Investigaciones Espaciales, Oscar Santanotoglia and Stella Navone, Cátedra de Manejo y Conservación de Suelos, Fac. Agronomía, U.B.A., Buenos Aires, **Argentina**

(C-15) **AN URBAN HEAT ISLAND IN TROPICAL AREA INVESTIGATED BY REMOTE SENSING: BELO HORIZONTE CITY** - Bernard C. R. J. Gastelois, Centro Tecnológico de Minas Gerais Foundation (CETEC), Belo Horizonte; Eleonora Sad de Assis, Architecture and Urban Planning University (FAUUSP), São Paulo, **Brazil**

(C-16) **SCALING OF VEGETATION INDICES FOR ENVIRONMENTAL CHANGE STUDIES** - J.Oi, A. Huete, and S. Sorooshian, University of Arizona, Tucson, Arizona, **USA**; A.Chehbouni and Y. Kerr, LERTS, Toulouse, **France**

(C-17) **THE INTEGRATION OF REMOTE SENSING AND GIS-TECHNIQUES FOR THE MAPPING OF LAND USE AND THE ASSESSMENT OF CROP ACREAGES** - M. De Goes Calmon, H. Eerens, B. Sapion and R. Gombeer, Katholieke Univesiteit Leuven (KUL), Heverlee, **Belgium**

(C-18) **A PROPOSAL TO INCREASE THE EFFICIENCY IN THE USE OF THE TECHNOLOGY OF REMOTE SENSING IN COUNTRIES OF THE THIRD WORLD** - Luiz Henrique Agular de Azevedo, Rio de Janeiro State University/SENSORIA Aerolevantamento S/A, Rio de Janeiro, **Brazil**

(C-19) **AN ATTEMPT TO LOCATE TSETSE-FLY HABITATS USING SPOT DATA** - G. Neuville, J. Baraza, F. Bleuzen and P. Lacanal, Regional Centre for Services

in Surveying, Mapping and Remote Sensing (RCSSMRS); B. Williams, R. Dransfield, R. Brightwell and O. Okello, International Centre of Insect Physiology and Ecology (ICIPE), Nairobi, **Kenya**

(C-20) **REMOTE SENSING OF THE BIOLOGICAL DYNAMICS OF LARGE-SCALE SALT EVAPORATION PONDS** - Laurie L. Richardson, Dave Bachoon, Vebbra Ingram-Wiley and Colin Chee Chow, Florida International University, Miami, Florida; Kenneth Weinstock, TGS Technology, Inc./NASA Ames Research Center, Moffett Field, California, **USA**

(C-21) **ALTIMETRIC RESTITUTION OF SPOT STEREO-PAIR: A SOLUTION FOR AUTOMATIC GENERATION OF DTM** - Antonio José Ferreira Machado e Silva and Raúl Edgard Germano Braga, Rio Scientific Center - IBM Brazil, Rio de Janeiro, RJ; Luiz Alberto Vieira Dias, National Institute of Space Research (INPE), São José dos Campos, SP, **Brazil**

(C-22) **APPLICATION OF AVHRR-LAC DATA IN SWEDISH AGRICULTURE** - Karin Hall-Könyves and Stefan Pinzke, Department of Physical Geography, University of Lund, Lund, **Sweden**

(C-23) **CHANGE DETECTION ON THE FRINGE OF THE INDIAN DESERT USING MULTI-DATE REMOTE SENSING DATA PRODUCTS** - S.S. Dhabriya, B. M. Birla Science and Technology Centre, Jaipur, **India**

(C-24) **AN OPERATIONAL GIS INTEGRATING SNOW-COVER AND GLACIER R. S. and F. D. FOR HYDRO-ELECTRIC MANAGEMENT PURPOSES** - Giancarlo Rossi, ENEL-CRIS Serv. Idrologico, Venezia Mestre; Carlo Caruso, Stefano Maran and Gianpaolo Penati, CISE, Milano, **Italy**

(C-25) **A GLOBAL CHANGE DATA BASE USING THEMATIC MAPPER DATA SCIENTIFIC RATIONALE AND TECHNICAL CONSIDERATIONS OF THE LANDSAT SYSTEM** - David L. Peterson and Keith C. Clarke, Hunter College, New York, New York, **USA**

(C-26) **THE USE OF INFORMATION SUPPLIED BY TEXTURAL CHARACTERISTICS OF ORBITAL IMAGES IN THE DETERMINATION OF URBAN LAND USE CLASSES** - Diana Sarita Hamburger and Celina Foresti, National Institute of Spatial Research (INPE), São José dos Campos, SP, **Brazil**

(C-27) **MONITORING WATERSHED DEGRADATION THROUGH CHANGES IN FLUVIAL MORPHOLOGY BY AERIAL PHOTOGRAPHS AND SATELLITE IMAGERY INTERPRETATION** - José Manuel Sayago and Elvira Yolanda Guido, Tucumán University, Tucumán, **Argentina**

(C-28) **BUSHFIRES MONITORING: A LOW - COST METHOD TO ASSESS AND MAP THE BURNED AREAS IN A TREE SAVANNA REGION (BURKINA FASO)** - Pierre Defourny and Marc Totte, Catholic University of Louvain, Louvain, Louvain-la-Neuve, **Belgium**

(C-29) **APPLICATION OF GIS TECHNIQUES TO MONITOR SEDIMENT YIELD IN WATERSHEDS** - Alfonso Rizzo and Vitor Haertel, Federal University of Rio Grande do Sul, Porto Alegre, **Brazil**

(C-30) **AUTOMATIC PREDICTION OF LOCAL REGION CHANGES, USING PATTERN RECOGNITION**

TECHNIQUES ON TEMPORAL DATA - R. Makwana and A. Barros Silva, The Open University, Milton Keynes, England

(C-31) "MEGAFANS" - SHUTTLE PHOTOGRAPHY AND MACROGEOMORPHOLOGY - M. Justin Wilkinson, Lockheed Engineering and Sciences Co., Houston, Texas, USA

PLENARY SESSION 3

INTERNATIONAL SPACE YEAR GLOBAL CHANGE RESEARCH PROGRAMS

Program Co-Chairmen

Ralph P. Brescia, National Aeronautics and Space Administration Washington, DC, USA

Nancy Firestone, W.T. Chen & Company, Arlington, Virginia, USA

Session Moderator

Nancy Firestone

1:30 SPACE AGENCY FORUM ON THE INTERNATIONAL SPACE YEAR (SAFISY): AN OVERVIEW/KEY 1992 EVENTS - Tasuku Tanaka, National Space Development Agency, Tokyo, Japan

1:50 SAFISY PANEL OF EXPERTS ON EDUCATION AND APPLICATIONS: COMMITTEE ON SPACE RESEARCH (COSPAR)/SAFISY PANEL OF EXPERTS ON SPACE SCIENCE: AN OVERVIEW - Ralph P. Brescia, National Aeronautics and Space Administration, Washington, DC, USA

2:10 SAFISY PANEL OF EXPERTS ON EARTH SCIENCE AND TECHNOLOGY: AN OVERVIEW

Burkhard K. Pfeiffer, European Space Agency/ ESTIC, Noordwijk, The Netherlands

2:30 SAFISY: THE WORLD FOREST WATCH PROJECT - Roberto Pereira da Cunha, National Institute for Space Research, São José dos Campos, SP, Brazil

2:50 SAFISY: THE GLOBAL CHANGE ENCYCLOPEDIA PROJECT - Marie-Claude Durand, Canadian Space Agency, Montreal, Quebec, Canada

3:10 SAFISY THE GLOBAL STUDENT VILLAGE - Buzz Sellman, Environmental Research Institute of Michigan, Ann Arbor, Michigan, USA

3:30 COFFEE

4:00 SPEAKER PANEL DISCUSSION

5:00 AUDIENCE QUESTIONS FOR THE SPEAKER PANEL

6:00 ADJOURNMENT

FRIDAY, MAY 31

8:30 a.m. - 11:30 a.m.

POSTER SESSION D

Gavea A Ballroom

11:30 a.m. - 1:30 a.m.

SYMPOSIUM BUFFET

Gavea B Ballroom

1:30 p.m. - 2:30 p.m.

CLOSING CEREMONIES

Gavea A Ballroom

POSTER SESSION D

CONTRIBUTED PAPERS

(D-1) MICROWAVE REMOTE SENSING FOR HYDROLOGICAL AND AGRICULTURAL MONITORING - C. Bechini, P. Canuti and S. Moretti, Department of Earth's Sciences; S. Paloscia, P. Pampaloni, I.R.O.E./C.N.R., Firenze, Italy

(D-2) MONITORING WINTER LEADS AND POLYNYAS IN BEAUFORT SEA WITH SPACE - BORNE TIR AND MICROWAVE DATA - B. Dey, Howard University, Washington, D.C., USA

(D-3) NORMALIZED DIFFERENCE VEGETATION INDEX FOR THE SOUTH AMERICAN CONTINENT USED AS CLIMATIC VARIABILITY INDICATOR - William T. H. Liu, Oswaldo Massambani and Mario Festa, IAG/USP, São Paulo, Brazil

(D-4) MIPAS - A HIGH-SPECTRAL RESOLUTION SPACEBORNE FOURIER TRANSFORM SPECTROMETER - W. Posselt and B. Kunkel, MBB Space Systems, Ottobrunn; H. Fischer, KIK, Karlsruhe, Germany; M. Endemann, ESTEC, Noordwijk, The Netherlands; J. Puls, DLR, Oberpfaffenhofen, Germany

(D-5) MULTISTAGE SAMPLING SURVEY TO ASSESS THE WOODY BIOMASS EVOLUTION IN A DRY TROPICAL REGION (BURKINA FASO) - Pierre Defourny, Catholic University of Louvain, Louvain-La-Neuve, Belgium

(D-6) DETERMINATION OF TANK DEPTH TO WATER RADIOMETRIC MEASUREMENTS

José Eduardo Mantovani and **Alexandre Pereira Cabral**, Instituto Nacional de Pesquisas Espaciais (INPE), São José dos Campos, SP, Brazil

(D-7) INTEGRATION OF REMOTELY SENSED DATA AND DEMs FOR RESERVOIR PLANNING - Peng Miao - Hsiang and Hsiao Kou-Hsing, Energy and Resources Laboratories, Chutung, Hsinchu, Taiwan

(D-8) THE USE OF SATELLITE REMOTE SENSING IN BUILDING LONGITUDINAL URBAN PLANNING DATABASES: THE CASE OF RIO DE JANEIRO - Thomas S. Lyons, Michigan State University, East Lansing, Michigan, Richard C. Cicone and William A. Tyler, Environmental Research Institute of Michigan, Ann Arbor, Michigan, USA

(D-9) UTILIZATION OF REMOTE SENSING TECHNOLOGIES FOR URBAN RECREATIONAL OPEN SPACE - Maria Isabel Sobral Escada and Maria de Lourdes N. de O. Kurkdjian, Instituto Nacional de Pesquisas Espaciais (INPE), São José dos Campos, SP, Brazil

(D-10) MULTISPECTRAL CORRELATIONS FOR VEGETATION SPACE ALONG IRRIGATED PROFILES: A CASE STUDY FOR THE CHOLISTAN DESERT - Gauhar Rehman, Iftikhar Ahmed and Anees Ahmad Iqbal, Space and Upper Atmosphere Research Commission (SUPARCO), Karachi, Pakistan

(D-11) LANDSAT TM BASED VOLUME ESTIMATIONS OF CONIFEROUS FOREST COMPARTMENTS IN SOUTHERN SWEDEN - Jonas Ardö, University of Lund, Lund, Sweden

(D-12) **FIRE ESTIMATES IN SAVANNAS OF CENTRAL BRAZIL WITH THERMAL AVHRR/NOAA CALIBRATED BY TM/LANDSAT** - Alfredo C. Pereira, Jr., Alberto W. Setzer nad João Roberto dos Santos, Instituto Nacional de Pesquisas Espaciais (INPE), São José dos Campos, SP, **Brazil**

(D-13) **FORESTRY VARIABLES ASSESSMENT USING LANDSAT TM DATA** - Marcos Leandro Kazmierczak, Instituto Nacional de Pesquisas Espaciais (INPE), São José dos Campos, SP, **Brazil**

(D-14) **REMOTE SENSING OF ILLICIT NARCOTIC CROPS FROM AIRCRAFT AND COMMERCIAL SATELLITE PLATFORMS** - Steven. A. Sader, University of Maine, Orono, Maine, **USA**

(D-15) **ON THE ORIGIN AND EVOLUTION OF CIRCULAR FORMS OBSERVED IN REMOTE SENSING IMAGES OF THE RIO DE JANEIRO STATE** - André Calixto Vieira, Universidade Federal Rural do Rio de Janeiro and Universidade Federal do Rio de Janeiro; Antonio Carlos J. de Castro and Edgar Hans Brauer, Universidade Federal do Rio de Janeiro, Rio de Janeiro, **Brazil**

(D-16) **INTERNATIONAL TRAINING COURSE ON REMOTE SENSING-BRAZIL: FIVE YEARS TRAINING SPECIALISTS IN REMOTE SENSING APPLIED TO NATURAL RESOURCES** - Tania Maria Sausen, Instituto Nacional de Pesquisas Espaciais (INPE), São José dos Campos, SP, **Brazil**

(D-17) **ABOUT ESTIMATES OF MEASURES OF THE CONVEX HULLS OF SETS OF POINTS RELATED TO THE PROBLEM OF SUPERVISED CLASSIFICATION** - J. P. Rasson, F. Orban - Ferauge, and V. Granville, University of Namur, F.U.N.D.P., Namur, **Belgium**

(D-18) **IMPLICATIONS IN REMOTE SENSING DOMAIN OF THE IMPROVEMENTS OF A CLASSIFICATION METHODS BASED ON THE CONVEX HULLS OF SETS OF POINTS** - F. Orban - Ferauge, J. P. Rasson, and V. Granville, University of Namur, F.U.N.D.P., Namur, **Belgium**

(D-19) **DUNE PATTERN IN THE UNITED ARAB EMIRATES USING LANDSAT TM DATA** - Nabil Sayed Embabl, U.A.E. University, Al - Ain, **United Arab Emirates**

(D-20) **NEED FOR EXPANDED ENVIRONMENTAL MEASUREMENT CAPABILITIES IN GEOSYNCHRONOUS EARTH ORBIT** - Enrico P. Mercanti, Mc Donnell Douglas Space Systems Company, Seabrook, Maryland, **USA**

(D-21) **A COMPARATIVE STUDY OF SPECKLE REDUCTION IN SAR IMAGES AND THEIR APPLICATION FOR CLASSIFICATION PERFORMANCE IMPROVEMENT** - Nelson D. A. Mascarenhas, Instituto Nacional de Pesquisas Espaciais (INPE), Sérgio E. Ono and David Fernandes, Instituto Tecnológico de Aeronáutica, Herman J. H. Kux, Instituto Nacional de Pesquisas Espaciais (INPE), São José dos Campos, SP, **Brazil**

(D-22) **A TEST OF GPS NAVIGATION FOR AERIAL PHOTOGRAPHY** - Li Shu Kai and Xu Chang, The Institute of Remote Sensing Application, Chinese Academy of Sciences, Beijing, **China**

(D-23) **QUANTIFICATION OF CHLOROPHYLL A IN**

COASTAL WATERS USING LANDSAT TM - Sam Ekstrand, Swedish Environmental Research Institute, Stockholm, **Sweden**

(D-24) **GLOBAL CHANGE EFFECTS ON EARLY HOLOCENE SEDIMENTATION OF THE BRAZILIAN CONTINENTAL SHELF DETERMINED FROM TM-LANDSAT 5 DATA OF THE SEAFLOOR** - Alexandre Pereira Cabral, Marcio Luiz Vianna and Douglas Francisco Marcolino Gherardi, Instituto Nacional de Pesquisas Espaciais (INPE), São José dos Campos, SP, **Brazil**

(D-25) **SUBMARINE RESOURCE DEVELOPMENT AND PRESERVATION IN THE BRAZILIAN CONTINENTAL SHELF: THE IMPACT OF TM-LANDSAT IMAGERY ON FORMULATION OF MANAGEMENT POLICIES** - Marcio Luiz Vianna, Alexandre Pereira Cabral and Viviane Testa, Instituto Nacional de Pesquisas Espaciais (INPE), São José dos Campos, SP, **Brazil**

(D-26) **A GLOBAL CHANGE DATA BASE USING THE-MATIC MAPPER DATA: EARTH MONITORING EDUCATIONAL SYSTEM (EMES)** - Hector L. D'Antoni and David L. Peterson, NASA/Ames Research Center, Moffett Field, California, **USA**

(D-27) **MULTISENSOR REMOTE SENSING DATA AND GIS TECHNIQUES FOR MONITORING PRESERVATION AREAS: A CASE STUDY** - Yosio Edemir Shimabukuro, David Chung Liang Lee and João Roberto dos Santos, Instituto Nacional de Pesquisas Espaciais (INPE), São José dos Campos, SP, **Brazil**

(D-28) **ADJUSTMENT OF SPOT IMAGERIES USING THE SPACE RESECTION** - Maarouf A.M. Diefallah, Qatar University, Doha, **Qatar**

(D-29) **VISIBLE AND NEAR INFRA - RED SPECTRA OF LATERITES OF ROCKS FROM CARAJAS MINERAL PROVINCE, IN BRAZIL** - Marco Rocio, Silvia B. A. Rolim, Ricardo Vedovello and Antonio Gomes Neto, Instituto Nacional de Pesquisas Espaciais (INPE), São José dos Campos, SP, **Brazil**

(D-30) **HIGH RESOLUTION REMOTE SENSING IN AGRICULTURE** - David J. Ward and Antonio Neves, Geonex do Brazil, Botafogo, RJ, **Brazil**

(D-31) **MULTITEMPORAL COMPOSITING OF SATELLITE DATA FOR IMPROVED GLOBAL CHANGE DETECTION** - Alfredo Huete, University of Arizona, Tucson, Arizona, **USA**; A. Chehbouni, LERTS, Toulouse, **France**; Jiaguo Qi, University of Arizona, Tucson, Arizona, **USA**

CLOSING CEREMONIES

INTRODUCTION OF GUESTS AND SPEAKERS

1:30 **Roberto Pereira da Cunha**, Co-Chairman, Regional Organizing Committee, National Institute for Space Research, São José dos Campos, SP, **Brazil**

CLOSING REMARKS

1:35 **SUMMATION OF THE SELPER FORUM: PLENARY SESSION 1** - **Richard C. Cicone**, Co-Chairman, Plenary Session 1, Environmental Research Institute of Michigan, Ann Arbor, Michigan, **USA**

1:45 **SUMMATION OF THE PANEL DISCUSSION: PLENARY SESSION 2 - John W. Sherman, III**, Co-Chairman, Plenary Session 2, National Oceanic and Atmospheric Administration, Washington, DC, **USA**

1:55 **SUMMATION OF THE PANEL DISCUSSION: PLENARY SESSION 3 - Ralph P. Brescia**, Co-Chairman, Plenary Session 3, National Aeronautics and Space Administration, Washington, DC, **USA**

2:05 **CLOSING REMARKS ON BEHALF OF THE SYMPOSIUM ORGANIZER - Alan K. Parker**, Chairman, International Symposia in Remote Sensing of Environment, Environmental Research Institute of Michigan, Ann Arbor, Michigan, **USA**

2:10 **CLOSING REMARKS ON BEHALF OF THE REGIONAL ORGANIZING COMMITTEE Miguel Sánchez Peña**, Honorary Co-Chairman, Regional Organizing Committee, Society of Latin American Remote Sensing Specialists, Buenos Aires, **Argentina**

ADJOURNMENT AND FAREWELL "ADEUS"

WORKSHOP I

APPLICATIONS OF REMOTE SENSING TO DIGITAL MAPPING

Location: Gavea A Ballroom
 Dates: Tuesday, May 28, and Thursday, May 30, 7:30 p.m. - 9:30 p.m.
 Fee: \$ 30.00 US
 Limit: 40 persons
 Instructor: **Dr. Lynnette Wood**, ERIM, Ann Arbor, Michigan, **USA**

WORKSHOP II

NEW VIEWS OF THE ENVIRONMENT USING SATELLITE DATA AND LOW COST PERSONAL COMPUTER TECHNOLOGY

Location: Gavea A Ballroom
 Date: Wednesday, May 29, 7:30 p.m. - 9:30 p.m.
 Fee: \$ 25.00 U.S.
 Limit: 40 persons
 Instructors: **Dr. D. A. Gagliardini**, CAERCEM, Buenos Aires, **Argentina**
Dr. D. A. Hastings, NOAA National Geophysical Data Center, Boulder, Colorado, **USA**

EXHIBITION

All attendees and their guests are invited to attend the Exhibition Opening at 5:00 p.m. on Monday, May 27. The exhibits will be located in the foyer of the Gavea A and B Ballroom. The Symposium Reception will begin at 5:30 p.m. in the Gavea B Ballroom and foyer area.

The exhibition will be open on Tuesday, Wednesday, and Thursday from 8:30 to 11:30 a.m. and from 1:30 to 5:00 p.m. Representatives from the most important international organizations will be available to discuss your needs for remote sensing products and services. In addition, several major publishers have sent publicity material and samples of their journals, for your information.

EXHIBITORS

Consortium for International Earth Science Information Network (CIESIN), Ann Arbor, Michigan, **USA**

Earth Observation and Satellite Company (EOSAT), Lanham, Maryland, **USA**

EIKON Tecnologia e Compugrafia Ltd., São Paulo, SP, **Brazil**

ERDAS, Atlanta, Georgia, **USA**

Environmental Research Institute of Michigan (ERIM), Ann Arbor, Michigan, **USA**

INTERA Technologies Ltd., Calgary, Alberta, **Canada**

Intergraph Corporation, Huntsville, Alabama, **USA**

National Institute for Space Research (INPE), São José dos Campos, SP, **Brazil**

Sisgraph, São Paulo, SP, **Brazil**

Society of Latin American Remote Sensing Specialists (SELPER), Buenos Aires, Argentina

Terra Mar Resource Information Services, Mountain View, California, **USA**

PUBLISHERS

Aster Publishing Corporation, Eugene, Oregon, **USA**

Blackwell Scientific Publications Ltd., Oxford, **United Kingdom**

Geocarto International, Hong Kong

Pergamon Press, Oxford, **United Kingdom**

Space Age Publishing, Honolulu, Hawaii, **USA**

VSP International Science Publishers, Zeist, **The Netherlands**

John Wiley & Sons, Ltd., Chichester, **United Kingdom**

SYMPOSIUM INFORMATION

1. REGISTRATION DESK-SERVICES AND HOURS

Services available: registration for the Symposium, distribution of Symposium documents, message center, other information as needed.

Hours:

Monday, May 27	8:30 a.m. - 12:00 (noon); 1:00 - 6:00 p.m.
Tuesday, May 28	8:00 a.m. - 12:00 (noon); 1:00 - 6:00 p.m.
Wednesday, May 29	8:00 a.m. - 12:00 (noon); 1:00 - 6:00 p.m.
Thursday, May 30	8:00 a.m. - 12:00 (noon); 1:00 - 6:00 p.m.
Friday, May 31	8:00 a.m. - 12:00 (noon); 1:00 - 6:00 p.m.

2. SYMPOSIUM MANAGEMENT PERSONNEL

The Symposium management personnel who will be available to serve you are: Alan K. Parker, Chairman
 Dorothy M. Humphrey, Symposium Coordinator
 Judith A. Steeh, Exhibits Coordinator

Other Environmental Research Institute of Michigan attendees who will be happy to assist you if possible include: William Brown, Ric Ciccone, Bob Rogers, Wilma Sedore, Buzz Sellman, Nancy Walman, and Lynnette Wood.

3. SECURITY ARRANGEMENTS

All Symposium participants will be issued an official Symposium badge at registration. A Symposium badge will be required to enter into the Symposium/Exhibition area and for all Symposium meals and events. The Symposium area will open 30 minutes before the first session and will close 30 minutes after the last session each day. Exhibitors may enter the Exhibit Area 30 minutes before the area opens to other participants and may remain 30 minutes after the area closes to participants.

SEMINARIO Y CURSO SOBRE TELEDETECCION APLICADA AL USO DE LA TIERRA: PLANIFICACION URBANA Y USO RURAL

La Plata, Bs. As., Argentina
11 - 21 Junio 1991



El Departamento de Ciencias Básicas de la Universidad Nacional de Luján (UNLu) y el Centro de Análisis y Procesamiento Digital de Información Satelitaria (CAPDIS) tienen el agrado de invitar a usted a participar en el SEMINARIO Y CURSO SOBRE TELEDETECCION APLICADA AL USO DE LA TIERRA: PLANIFICACION URBANA Y USO RURAL, a realizarse en la Ciudad de La Plata (Bs. As.) entre el 11 y 21 de Junio de 1991.

Estas actividades cuentan con el auspicio del Centre National D'Etudes Spatiales (CNES) y el Groupement pour le Developpement de la Teledetection Aerospaciale (GDTA) de Francia, de la Sociedad de Especialistas Latinoamericanos en Percepción Remota (SELPER) y de otras organizaciones gubernamentales.

OBJETIVO Y PARTICIPANTES

El objetivo principal de esta reunión es el de difundir las técnicas de percepción remota y su buena relación costo-beneficio entre funcionarios y profesionales relacionados con la planificación de áreas urbanas y rurales, a fin de incorporar esta tecnología como una eficaz herramienta para la toma de decisiones.

El SEMINARIO será de un día de duración, destinado a funcionarios del gobierno nacional, provincial y municipal, como así también a funcionarios de empresas privadas, en las áreas de catastro, planificación y decisión.

El Curso, de una semana de duración, estará destinado a funcionarios o especialistas en dichas áreas, interesados en la formulación o conducción de proyectos en los cuales la teledetección y los sistemas de información geográfica serán valiosas herramientas para la planificación urbana y las áreas rurales adyacentes.

Podrán participar ingenieros de varias orientaciones, arquitectos, geógrafos, biólogos, agrimensores y otros especialistas interesados en esta temática.

CUERPO DOCENTE

El Seminario y el Curso serán dictados por profesores de la Universidad Nacional de Luján (UNLu), el Centro de Análisis y Procesamiento Digital de Imágenes Satelitarias (CAPDIS) y el Groupement pour le Developpement de la Teledetection Aerospaciale (GDTA), con amplia experiencia en esta disciplina.

PROGRAMA GENERAL

SEMINARIO (21 de Junio de 1991)

Participarán en este Seminario funcionarios de nivel nacional, provincial, municipal, empresas privadas y alumnos participantes del curso.

- 9:00 a 9:45 hrs. Inscripción
- 10:00 a 13:00 hrs. Conferencias Especiales
- 13:00 a 14:30 hrs. Intervalo
- 14:30 a 16:00 hrs. Conferencias Especiales (*)

16:00 a 16:30 hrs. Intervalo
16:30 a 18:30 hrs. Mesa Redonda: Importancia de la Teledetección para la Planificación Urbana y Rural.

19:00 hrs. Vino de Honor

Capacidad máxima para el Seminario: 100 personas

(*) Las Conferencias especiales versarán sobre:

- Breve Introducción a la Percepción Remota
- Su importancia en la planificación rural y urbana
- Toma de decisión
- Sistemas de satélites para recursos naturales: Aspectos Económicos

CURSO (17 al 21 de Junio de 1991)

PROGRAMA ESQUEMATICO

- Introducción
- Sistemas Satelitales y Sensores
- Interpretación visual
- Aplicaciones a la planificación urbana
- Procesamiento digital de imágenes
- Aplicaciones a la planificación rural
- Equipamiento
- Utilización de Sistemas de Procesamiento.
- Discusión final y conclusiones

NOTA: El programa más detallado del Curso, se incluirá en una segunda circular que se enviará a las personas que completen y envíen el formulario de inscripción.

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NUMERO DE PARTICIPANTES: Máximo: 30 participantes

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UNIVERSIDAD DE MENDOZA

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CENTRO DE INVESTIGACIONES SUPERIORES

Programm für wissenschaftliche Forschungsarbeiten und technologische
Fortentwicklungen in bezug auf die Umwelt

Program of Scientific Investigations and Technological Developments on Environment

CRONICA

JORNADAS INTERNACIONALES
SOBRE MEDIO AMBIENTE

Mendoza, Argentina 25-30 Abril 1991

Concluyeron las Segundas Jornadas Internacionales Multidisciplinarias sobre Medio Ambiente que organizó la Universidad de Mendoza, con la participación de científicos, expertos, políticos, administradores y profesionales de Argentina, Alemania, Austria, Chile, Estados Unidos, España y Suiza. La actividad estuvo orientada a posibilitar el mejor desenvolvimiento del "Programa de Investigaciones Científicas y Desarrollos Tecnológicos Sobre Medio Ambiente" (PRIDEMA) que está cumpliendo la institución organizadora, por convenio suscrito con el Gobierno de Mendoza, quien lo aprobara por Decreto N° 972/88. Otro objetivo de estas Jornadas ha sido el de intensificar la cooperación internacional para mejorar la calidad de vida de nuestra provincia.

En el primer y segundo día del encuentro, se realizaron "workshops preliminares" (talleres de trabajo); el primero estuvo orientado al análisis y discusión de los proyectos de investigación científica y técnica que se desenvuelven en el marco de la cooperación científico-técnica, germano-argentina, relativos a la evolución del PRIDEMA. El segundo estuvo relacionado con los futuros proyectos del citado programa; uno está referido a un experimento ecológico en la zona árida de Mendoza (ecovilla); otro atiende a la educación ambiental y formación de recursos humanos. En esta área fue exhibido un programa de enseñanza desarrollado en Alemania; se trata de un sistema en el que los educandos pueden mostrar su destreza, en defensa del medio ambiente, usando una computadora con pantalla de color, programa "Ökolopoly", cuyo creador es el profesor, doctor Frederik Vester, director del S.B.U. (Grupo de Estudio para la Biología y el Medio Ambiente) de Munich (Alemania). El software de este programa ha sido traducido al castellano para ser utilizado en Mendoza.

En el rubro "Proyecto y Gestión Ambiental", fueron estudiados diversos temas relativos a la planificación, conducción gerencial y gestión de importantes proyectos que estudian esta problemática en Mendoza y en el país, habiéndosele prestado especial atención al riesgo sísmico, por el impacto ambiental que provoca en la zona afectada, y a los temas referidos al control y la sanidad ambiental.

Los aspectos legales conexos con la contaminación, también fueron materia de estudio en estos workshops, donde se incluyeron otros temas de interés para la región.

CONCEPTOS DEL GOBERNADOR
DE MENDOZA

En los días subsiguientes, en un ciclo de conferencias, que abarcó dos jornadas, fue tratada la temática ambiental y la cooperación institucional en nuestro país y en el ámbito internacional.

Este ciclo de conferencias fue inaugurado por el gobernador de la provincia, Licenciado José Octavio Bordón, quien destacó la importancia que el gobierno le ha dado a los temas del medio ambiente "habida cuenta de lo que significa para nuestra provincia, nuestro país y, con seguridad, para este hogar común de toda la humanidad que es el planeta Tierra". Luego recordó que el **acuerdo con la Universidad de Mendoza** "significaba", en el plano institucional un evento de importante trascendencia para nosotros" y que era el de "asumir" con toda decisión la necesidad de que las universidades, sus elementos de educación, de investigación, pudieran realizar una tarea conjunta, de apoyo mutuo, con las responsabilidades y actividades propias del Estado, tratando de poner, ambas contrapartes, un aporte a la necesidad y superación de compartimentos estancos, que implican fuerza y eficiencia en la búsqueda de respuestas, tratando de articular la actividad del Estado, los organismos de investigación, los sistemas educativos y la propia actividad privada". Luego se refirió a los cambios que se observan en distintos campos de la humanidad que han provocado "un achicamiento físico y, en términos de conciencia del planeta Tierra, nos pone frente al siglo 21" "ante dos desafíos excepcionales y explicó que uno de ellos es "la bofetada a nuestras conciencias de que en este mundo, que quiere libertad con igualdad, hay más gente que no accede a los mínimos bienes materiales y culturales que los que accedemos y el segundo, que el avance de la civilización, las tecnologías, que indudablemente han sido elementos muy positivos y que han logrado respuestas al mejoramiento en la calidad de vida, a veces, por no imaginar lo que sobrevendría junto con ellos, y otros, directamente por egoísmo y falta de responsabilidad, han puesto en peligro la sobrevivencia", señalando que las generaciones futuras tendrán esta tarea "de que la libertad y la igualdad" lleguen a nuestros hermanos y que tenemos "que defender la sobrevivencia de esta belleza, de este milagro que Dios le dio al hombre para realizarnos que es nuestra tierra". Después aludió a su participación en el Diálogo Interamericano donde se tomó conciencia del origen de algunos desastres ecológicos, entre ellos, ríos desaparecidos "que existían millones de años antes de que el hombre pisara la tierra".

Recordó al encuentro "Las Leñas" recientemente efectuado, con palabras de elogio para el doctor Guillermo Cano por su organización, y al encuentro del Rotary

Club Internacional que trataron estos temas, y agregó: "Y hoy estamos acá por **el esfuerzo notable de esta Universidad** para el desarrollo de estas Jornadas" señalando el recorrido de esta experiencia conjunta de cuyo diálogo "nació el Ministerio del Medio Ambiente, Vivienda y Urbanismo, tratando de avanzar y de ser una avanzada en la conciencia y en la ejecución del país" lo que nos lleva a evitar de cometer mayores agravios y agresiones a "nosotros mismos a través del medio ambiente", acotando que no es tarea fácil no obstante lo cual puso de manifiesto que "nosotros estamos orgullosos de cómo ha crecido en la provincia la conciencia" referida a la conservación del medio ambiente. Enseguida indicó algunas realizaciones que ha encarado el gobierno y mencionó el grave problema ante la amenaza del cólera y las medidas a tomar para evitarla, y expresó: "creo que esta enfermedad nos llama a la reflexión y a comprender que para la calidad de vida, la producción y la salud, la lucha por el medio ambiente, por la defensa de la calidad de nuestra tierra, de nuestro aire, de nuestra agua, es un instrumento fundamental para la salud, y también para la economía, porque los costos que puede implicar para nuestra producción, estas enfermedades, seguramente son mucho mayores que los costos que hubiese implicado tomar las medidas cuando habla que tomarlas" señalando a "aquellos que creen que hay que ahorrarse el dos o tres por ciento de los costos" lanzando irresponsablemente contaminantes al hábitat. Luego de otras reflexiones indicó que "la lucha por la justicia social también tiene que ver con el mejoramiento del medio ambiente porque, lamentablemente, los más golpeados son aquellos que menos tienen y que más necesidades padecen en su vida cotidiana.

Es indudable que nosotros —admitió— tenemos nuestras responsabilidades, y hay algo que me llena de esperanzas: que una universidad y un poder ejecutivo circunstancial, hayan efectuado una tarea, en un marco de amplio pluralismo, con tal alto grado de acuerdo" resaltando que las "cosas importantes son ampliamente compartidas por todo el espectro político de Mendoza y por el poder legislativo "lo cual da máximas garantías de cumplimiento".

Por último puso de relieve la necesidad de que las naciones desarrolladas colaboren con el resto del mundo para que todos podamos dar esta lucha, en favor del medio ambiente, de costos muy elevados.

LAS CONFERENCIAS

Con la introducción de una exposición donde el Ministro del Medio Ambiente, Vivienda y Urbanismo, arquitecto Pablo Márquez reseñó lo actuado por ese organismo en 16 meses de existencia, el Director de Saneamiento y Control Ambiental, ingeniero José Luis Puliafito, dentro del tema "Mendoza y la preservación del medio ambiente" dio detalles puntuales de la actividad de la dependencia, en el desarrollo de las tareas que le conciernen y aspectos de realizaciones futuras, en el marco de las conferencias previstas para el tercer y cuarto día de las II JIMMA.

Luego, el secretario ejecutivo del "Subprograma nacional del medio ambiente" de la SECYT, licenciado Eduardo Banús, trató el tema "Programa nacional de recursos naturales y medio ambiente" donde señaló el tratamiento prioritario que, el gobierno nacional, le está concediendo a estos temas, lo que se refleja en el número

de proyectos de investigación aprobados sobre el particular. Posteriormente el Rector de la Universidad de Mendoza, ingeniero Salvador Puliafito explicó qué es el PRIDEMA, reseñó los fines y objetivos de los distintos proyectos y puso énfasis en la posibilidad de su realización por la cooperación de la comunidad internacional, en especial el Max Planck Institut für Aeronomie de Alemania, y la del gobierno de la provincia según el convenio firmado con el mismo y que fuera aprobado por Decreto 972/88. La siguiente conferencia estuvo a cargo del Director del CRICYT, doctor Eduardo Rodríguez Echandía, quien habló sobre "El medio ambiente en proyectos nacionales de investigación".

El doctor Guillermo Cano, director ejecutivo de la Fundación Ambiente y Recursos Humanos inició el ciclo de la tarde con su tema "¿Qué debería hacer el gobierno nacional argentino en materia ambiental?. En la oportunidad, el doctor Cano resaltó la labor de la fundación que integra y dio detalles de la competencia que la misma tendrá en la próxima conferencia mundial denominada ECO'92.

El orador siguiente fue el presidente del Centro de Estudios y Proyectos del Ambiente (CEPA), arquitecto Rubén Pesci quien habló sobre "La opción latinoamericana para el desarrollo sustentable". Acto seguido tomó la palabra el doctor Joaquín López para referirse a la "Técnica legislativa en materia ambiental". El último conferenciante del día fue el doctor Miguel Mathus Esconhuela quien se refirió a la "Política Ambiental: concepto, contenido e instrumentos".

Las conferencias del día siguiente, estuvieron relacionadas con la cooperación interinstitucional, nacional y regional y fueron iniciadas por el director científico externo del flamante "Instituto para el estudio del medio ambiente", doctor Gerd Hartmann hablando sobre "Ciencia y medio ambiente". Hizo hincapié en su conocida teoría sobre el uso conservante del medio ambiente y sobre la necesidad de respetar al otro incluyendo algunos conceptos filosóficos. Después tomó la palabra el doctor John Olivero del Departamento de Meteorología de la Universidad Estatal de Pennsylvania (EE.UU.) para referirse al "Programa de cambio global del medio ambiente". A continuación, el doctor Reinhard Leitinger, habló sobre la "Influencia solar sobre el contenido de electrones en la ionósfera" del Instituto de Meteorología y Geofísica de la universidad austríaca de Graz. Continuó después exponiendo el doctor Erwin Schanda, del Instituto de Física Aplicada de la Universidad de Berna (Suiza). Le tocó exponer a continuación al ingeniero Carlos Mario Puliafito, investigador de la Universidad de Mendoza en colaboración con el doctor Alfred Loidl, del Max Planck Institut für Aeronomie de Alemania sobre "Medición de vapor de agua líquida en la atmósfera mediante radiometría-espectrometría de onda corta".

Después del intervalo dispuesto para la inauguración del IEMA, expuso el doctor Walter Kosmus, del Instituto de Química Analítica de la Universidad de Graz (Austria) y habló sobre "Depósitos terrestres y gases contaminantes de la atmósfera. Análisis químico del medio ambiente y de partículas simples". Por último, el doctor Erich Putz, del Instituto de Meteorología y Geofísica de la misma universidad que su antecesor, conferenció sobre "Mediciones ópticas verticales y horizontales de gases residuales en la atmósfera utilizando una Sonda Brewer".

En todos los casos hubo un servicio de traducción simultánea inglés-castellano, castellano-inglés lo que

facilitó la comprensión de los temas; además, todos los trabajos presentados serán publicados por la Editorial Idearium de la Universidad de Mendoza (EDIUM), la que, presentó una muestra de los libros publicados, con especial referencia a la serie PRIDEMA.

Paralelamente fueron exhibidos, también en la sede de la Universidad, los trabajos sobre medio ambiente realizados en el marco del citado programa, por distintas cátedras de la Facultad de Arquitectura y Urbanismo.

EL IEMA

Otro acto trascendente, lo constituyó la inauguración del "Instituto para el Medio Ambiente" (IEMA) y del "Campus Benegas", en el predio de Perito Moreno 2397 de Godoy Cruz, dependiente de la Universidad, donde fueron descubiertas placas recordatorias. En el mismo

acto fue designado el Director Científico Externo del IEMA, doctor Gerd Hartmann, del Max Planck Institut für Aeronomie, de Alemania; además se entregaron los respectivos diplomas a los diez profesionales y dos técnicos recientemente egresados del primer curso de posgrado de la Universidad, sobre "Proyecto y Gestión Ambiental" y a los miembros del Comité Internacional Científico Cultural de Asistencia al PRIDEMA que asistieron a las jornadas y un diploma al Intendente de Godoy Cruz, doctor Carlos de la Rosa por la colaboración de esa comuna en la remodelación de las nuevas instalaciones.

En la misma ocasión se habilitó una exposición de diversos anteproyectos para la construcción del futuro edificio del IEMA, realizados por una pluralidad de equipos compuestos por profesores de la Facultad de Arquitectura y Urbanismo de la Universidad de Mendoza.



**EL RECTOR DE LA
UNIVERSIDAD DE MENDOZA
ACOMPAÑADO POR LOS
CIENFICOS EUROPEOS
QUE ASISTIERON
A LAS II JIMMA**



**WORKSHOP SOBRE
"EDUCACION AMBIENTAL"
EN LAS II JIMMA,
EN LA CABECERA
EL RECTOR DE LA
UNIVERSIDAD DE MENDOZA**

Announcement



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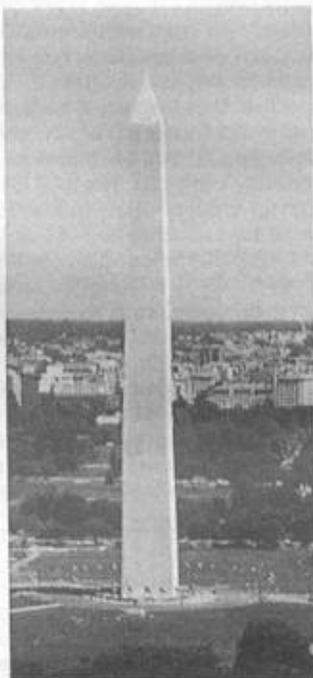
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CANADA'S RADARSAT PROGRAMME*

R. Keith Raney

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Introduction

RADARSAT (Figure 1) will carry one instrument, a multi-mode single polarization (HH) C-band SAR (synthetic aperture radar). It is capable of imaging swaths from 35 to 500, km wide, and with associated resolutions from 10 meters (one look) to 100 meters (8 looks). The incidence angles span (less than) 20° to (more than) 50°. The spacecraft is being designed for a five year lifetime, to be launched in December, 1994 by NASA. Nominal SAR on-time is up to 28 minutes per orbit which may consist of up to seven individual data takes. The orbit is planned for 800 km (nominal), sun-synchronous, dawn-dusk, and 24 day repeat with a three day sub-cycle. The SAR looks to the north, but the spacecraft may be yawed through 180° for short portions of the mission so as to obtain images of Antarctica. With the on-board tape recorders, C-band SAR imagery of the entire globe may be gathered by RADARSAT. The down-link is X-band, 100 Mhz.

RADARSAT is designed as an end-to-end system with operational users in mind. For perishable data, such as needed for navigation in the ice of the Arctic, SAR data will be gathered, relayed back to a processing centre, imaged, merged with ancillary data (such as bathymetry), Earth located, and relayed back to ships, all within four hours of satellite overflight. For other applications, the turn-around times are tailored to user needs, with a few days typical of agricultural work, for example. Precision products will be available. Costs for data are planned to be competitive with remote sensing products available from other remote sensing satellite systems. International data availability will be through RADARSAT International, headquartered in Ottawa (Suite 600, 1525 Carling Avenue).

1. MISSION

The original RADARSAT mission objectives were based primarily on Canadian national requirements for information to support domestic resource management and environmental monitoring. Studies in Canada have shown that an imaging radar satellite system would be the only acceptable sensor technology for reliable and timely information for Canada, frequently cloud covered or in the Arctic night. Radar data would provide a complementary data source to available optical data. Applications of importance to Canada include ice and Northern regions, agriculture, forestry, geologic resources, oceans and floating ice, coastal zones, and Arctic sovereignty.

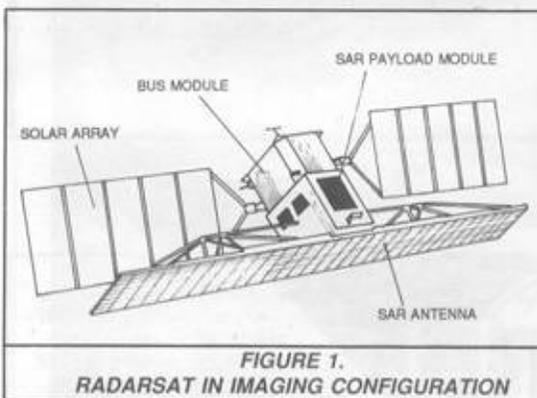


FIGURE 1.
RADARSAT IN IMAGING CONFIGURATION

Canada recognizes the potential importance of this system at the global level. Coverage of vast and environmentally sensitive areas (such as South as well as North Polar ice; the Earth's forests particularly in the tropics, large scale ocean features, and desert expansion) represents an important potentially significant use of radar satellite data. Whereas a C-Band SAR is not necessarily the ideal instrument for all such applications, it has the virtue that it can penetrate cloud cover, haze, smoke, and darkness, thus allowing reliable observations in all seasons, and under poor optical conditions. The resulting information would be useful in any information system designed to monitor these environmental regimes, and is a potential data source for studying global change. An Announcement of Opportunity for investigators and agencies worldwide to participate in these aspects of the RADARSAT Mission will be published before the launch.

Imaging swath widths and the spacecraft orbit have been chosen to satisfy both national and global coverage requirements. Using the 500 km swath, RADARSAT could provide daily imagery of the entire polar region above 79° north latitude (see Figure 2). With beam steering, any given point at Canadian latitudes can be observed within three days. Substantially complete coverage is available at the equator after only four days using the 500 km swath, although the orbit repeat period is 24 days.

For an Earth sensing radar satellite, solar illumination of the spacecraft is more important than a sunlit scene; RADARSAT will use a sun synchronous dawn-dusk orbit (Table I). Perhaps the greatest operational advantage of this orbit is that the SAR can be fully dependent on solar rather than battery power, which means that there is no

* Trabajo presentado en el Taller ONU/ESA de Microondas, INPE/Brasil, Noviembre 1990 y publicado con la gentil autorización de la División del Espacio Exterior de Naciones Unidas, Dr. Adigún Ade Abiodún.

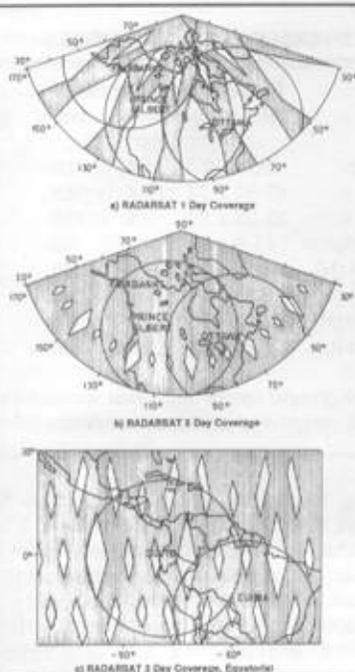


FIGURE 2. SAMPLE COVERAGE AVAILABLE FROM RADARSAT

limiting distinction between ascending and descending passes from an applications point of view. Thus, nearly twice as many viewing opportunities are available to the mission. Another operational advantage is that the ground station data downlink periods for RADARSAT will not conflict with other remote sensing satellites most of which use near mid-day orbit timing.

TABLE 1. ORBIT PARAMETERS

Altitude (local)	793-821 km.
Inclination	98.6°
Ascending node	1800 hours
Period	101 min.
Repeat cycle	24 days
Sub-cycles	7 & 17 days
Re-observation	3+ days

The nominal configuration of the spacecraft has the SAR pointing to the north providing for example regular Arctic coverage. However, twice during the first two years of the mission, the satellite will be rotated 180° about its yaw axis so as to direct the radar antenna beam to the south. Each such yaw manoeuvre is expected to be maintained for two weeks. The purpose of this manoeuvre is to obtain a complete SAR map of Antarctica at the times of maximum and minimum ice cover. This feature is in response to science requirements on RADARSAT as expressed by NASA.

RADARSAT will carry tape recorders with sufficient capacity for more than ten minutes of full quality SAR data. Thanks to the orbit yaw manoeuvre and the recorders, RADARSAT will be the first satellite system capable of complete global coverage.

Mission operations will be coordinated by a Mission Management Office (MMO) which will serve as the interface

between the user community, the Mission Control Facility for commanding the satellite, and the ground reception and processing facilities. In Canada, the ground facility now in place for ERS-1 will be upgraded to handle the increased throughput expected from RADARSAT. In addition to coordinating and scheduling request for SAR data acquisition, the MMO will monitor the entire data distribution system, and serve as the executive office for the mission.

Image products planned for RADARSAT may be grouped in three classes, generally available as both hard (photographic) copy and as digital files. *Georeferenced* products, the "standard" image, include systematic geometric correction with respect to the spacecraft Earth track based on satellite ephemeris data. *Geocoded* products are resampled and rotated to conform to a standard map projection. Ground correction points and correction for terrain elevation will be included, if available for the scene in question. *Special* products include unprocessed signal data, single look (full resolution) real or complex image files, and analysis of external calibration references.

Extensive data processing is required to form radar images from the data delivered by the spacecraft. For SAR systems this is often a lengthy and always a complex operation. Processing for RADARSAT, being operational and having several modes, presents its own set of challenges. In an earlier phase of the program, a demonstration processor was developed to verify the feasibility of maintaining processing speed and quality consistent with RADARSAT requirements. This processor is being used in Canada's ERS-1 ground station.

The main processing requirement is to produce high quality imagery in near real time. Data will be sent via satellite links to a central processing facility at 1/4 real rate, so that the image processor must handle an effective input rate of about 25 Mb/s. All data collected are to be processed, a "zero back-log" philosophy. Archives will be maintained for both the received signal, and the full resolution single look (complex) processed image files.

For highly perishable data, such as required by Canada's Ice Information Centre, an on-line data port is being implemented. The Ice Information Centre will be able to receive processed SAR data, integrate it with other data files in their information system, and relay derived user products to operators in the field within three hours of scene observation by the radar.

Unique amongst remote sensing initiatives worldwide, the RADARSAT project is supported through funding partnerships with U.S. agencies, Canadian provincial governments and the private sector. Canada is responsible for the design and integration of the overall system, for construction of the radar, for the provision of the satellite platform, for control and operation of the satellite in orbit and for operation of the data reception stations in Prince Albert, Saskatchewan and Gatineau, Quebec. The agreements are in the form of Memoranda of Understanding.

NASA will provide the launch services and operate a reception station in Fairbanks, Alaska in exchange for radar data for research programs. NOAA will facilitate the participation of the American private sector in the distribution of data.

All Canadian provinces have participated in planning the RADARSAT Program. Quebec, Ontario, British Columbia, and Saskatchewan share in the capital costs in proportion to technology development within their

industries. An agreement has also been developed with the other provinces for their participation in RADARSAT operations.

RADARSAT International (RSI) has been formed, a private sector corporation with headquarters in Ottawa. RSI has the right to distribute the data in excess of the international partner's governmental requirements. In return, they will invest in developing the international market and provide royalty payments to the Government from sales. Value added processing will be done in the private sector, as is the practice for most remote sensing satellite missions.

2. SAR PAYLOAD

RADARSAT has been designed in response to user requirements that demand a variety of incidence angles (from about 20° to 50°) in the standard imaging modes. An antenna with electronic beam steering is part of the baseline RADARSAT design. Whereas this meets user requirements, it adds further complexity to the entire system. In order to provide a (nominally) constant ground range resolution over the range of incidence angles, three different pulse bandwidths are needed. It also follows that very fine control of the transmitter pulse repetition frequency is required. Selected characteristics of the radar are listed in Table II.

TABLE 2. RADAR SYSTEM PARAMETERS

Frequency	5.3 GHz
Wavelength	5.6 cm.
Polarization	Horizontal
Pulse bandwidths	11.6, 17.3, or 30.0 MHz
Pulse length	42.0 µsec
PRF	1270 - 1390 Hz (2 Hz steps)
Peak power	5 kW
Average power	300 W (nominal)
Max. on time	28 min. per orbit
Antenna size	15 m. x 1.5 m.
Pointing	≤ 0.2°
Beams in RAM	20
Spacecraft mass	2750 kg.
Spacecraft power	2500 W
Attitude control	~ 0.05°
Solar array	3.4 kW

Having built in the flexibility (and complexity) to support standard mapping at a variety of incidence angles, several specialized modes become available at rather small marginal cost. The design philosophy for these extra modes has been to base the system specifications on the standard mapping modes, and to optimize the additional modes within the resulting constraints. The resulting imagery is predicted to be acceptable.

Radar operation time is constrained primarily by the spacecraft power system and thermal response of the high power transmitter. Typical continuous on time of the radar is baselined at 10-15 minutes per orbit out of 28 minutes maximum when in normal orientation, and 15 minutes is the maximum when in the Antarctic orientation. The minimum on-time is three minutes. Up to seven on/off cycles are available per orbit.

TABLE 3. IMAGING MODES

Mode	Resolution (R' x A, m)	Looks ²	Width (km)	Incidence (degrees)
Standard	25 x 28	4	100	20 - 49
Wide (1)	48-30 x 28	4	165	20 - 31
Wide (2)	32-25 x 28	4	150	31 - 39
Fine resolution	11-9 x 9	1	45	37 - 48
ScanSAR (N)	50 x 50	2-4	305	20 - 40
ScanSAR (W)	100 x 100	4-8	510	20 - 49
Extended (H)	22-19 x 28	4	75	50 - 60
Extended (L)	63-28 x 28	4	170	10 - 23

¹ Nominal; ground range resolution varies with range.

² Nominal; range and processor dependent.

Imaging modes for RADARSAT include Standard, Wide Swath, Fine Resolution, Extended, and ScanSAR. First order image characteristics of these modes are given in Table III. Image length, the dimension parallel to the sub-satellite track, is limited only by the duration of continuous radar operation, and may be thousands of kilometres long. Image widths and positions are determined by the elevation patterns (and the radar range gate control), and have been chosen for the standard modes so that there is at least 10% overlap between adjacent swaths. Range resolution when projected onto the Earth's surface varies with range, and has been specified for the standard beams for ground ranges of 400 km and 675 km from the sub-satellite locus. The geometry of the RADARSAT operating modes is illustrated in Figure 3. Image quality typical of a standard imaging mode is summarized in Table IV.

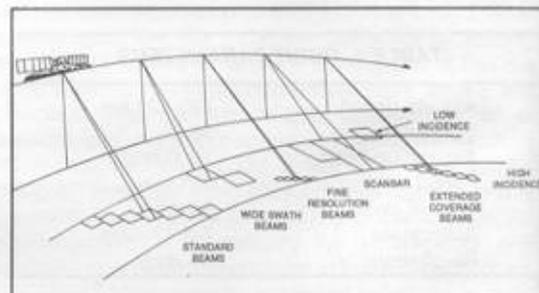


FIGURE 3.
GEOMETRY OF RADARSAT IMAGING MODES

Signal telemetry includes three systems (for redundancy), any two of which may be used in downlink operations, one for real time data, and one for recorded data. Telemetry signal and system parameters are listed in Table V. The telemetry sub-system is very similar to that being provided to the ERS-1 mission in which Canada is a contributing partner.

User requirements stipulate that RADARSAT provide calibrated data, for which purpose calibration has been included in the design from the outset in addition to the normally available engineering telemetry record of selected system performance parameters. RADARSAT calibration depends on both internal references, and on

TABLE 4. IMAGE QUALITY PARAMETERS

Noise equivalent (design)	< -23 dB
(beam edge, with margins)	< -18.5 dB
Total signal dependant noise ratio	< -10 dB
Azimuth ambiguity ratio	< -22 dB
Range ambiguity ratio	< -22 dB
Peak-sidelobe ratio	< -20 dB
Global dynamic range	> 30 dB
Relative radiometric accuracy	
w/in 100 km x 100 km scene	< 1 dB
w/in one orbit	< 1.5 dB
w/in 3 days	< 2 dB
satellite lifetime	< 3 dB
Absolute scene location ¹	< 1500 m
Geometric distortion ²	
w/in 100 km x 100 km scene	< 40 m

¹ As specified; better precision expected.

² Excluding terrain effects.

analysis based on radar data from an external calibration site. Most applications will be satisfied with relative calibration, for which the internal system is sufficient. Quantitative comparison of RADARSAT imagery with that from other (space) radars will require cross-calibration exercises using an external site. Verification of the antenna gain, beam shapes and steering for the various modes requires external calibration.

The standard form of image that the Radarsat SAR system is required to provide covers a 100 km swath positioned within an accessibility region² of over 500 km, spanning a range of incidence angles at the Earth's surface from 20° to nearly 50°. To achieve these swath widths at the larger incidence angles, it is necessary to operate with a lower pulse repetition frequency (PRF) than previous satellite systems. This, in turn, dictates the use of a longer antenna so as to provide the azimuth beamwidth of 0.2° (nominal) which is needed to avoid azimuth ambiguity problems.

The elevation beams required to illuminate the standard 100 km swaths decrease in angular width as incidence angle increases. The antenna therefore has to be capable of providing a variety of different elevation beamwidths, as well as variable beam directions. The

TABLE 5. SIGNAL TELEMETRY PARAMETERS

Carrier Frequencies	8,245 GHz, 8,370 GHz
Number of channels	2
Modulation	QPSK
Signal quantization	4 bits (I & Q)
Signal record capacity	> 10 min. / load
Data rates	105 MBPS (R / T)
	85 MBPS (Recorded)
RF power	22 Watts/channel
Bit error rate	10 ⁻⁵
Ground station G/T	31.9° dB/K
S/C antenna beamwidth	124°

resulting 15 m x 1.5 m array is about 50% larger in each dimension than the antenna on ERS-1.

In order to allow imaging of a swath much wider than ambiguity limits would normally allow, the Radarsat system has been designed to incorporate an alternative and less conventional mode known as ScanSAR. In this mode, for which rapid steering of the elevation beam pattern of the antenna is essential, extended range coverage can be obtained using a set of contiguous beams, enabling images of total swath width up to about 500 km to be produced. This is accomplished at no increase in mean data rate from the radar, but at the cost of degraded resolution of the resulting image.

3. CONCLUSIONS

RADARSAT is one of several civilian Earth observing imaging radar initiatives to become operational in this decade. It is planned to complement ERS-1 and 2 and J-ERS-1 which precede it, and to provide continuity with other Earth observing space radars that may follow at the turn of the century. It carries only one instrument, but one which has been designed to provide a variety of image products within the constraint of being a single frequency, single polarization radar. RADARSAT is intended primarily to serve a user community in need of Earth imagery for operational applications, and as such the data delivery infra-structure has been designed for rapid response, and for special circumstances, for on-line information transfer. Through RADARSAT, Canada is looking forward to significant contributions to both national and global requirements for Earth resource monitoring and management.

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IRLANDA.



A REVIEW OF RADAR REMOTE SENSING FOR TROPICAL FOREST MANAGEMENT*

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Abstract

Tropical forests are one of Earth's most valuable resources, from both economic and ecological perspectives. Their large areas and frequent cloud cover make them promising candidates for management strategies which incorporate satellite radar data. (Optical satellite data also should play an important role provided less frequent coverage is acceptable). In light of this situation, we have conducted an investigation into potential contributions radar satellite data may make toward wise management of tropical forests. We have reviewed previous satellite and airborne studies using radar, and, to a lesser extent, optical data in tropical forest. The results indicate for many tropical forestry applications, that radar satellite data should provide a valuable data source for reliable monitoring functions of use forest management.

The decade of the 1990s will see several significant satellite SAR systems in operation. All such systems are reviewed particularly with respect to coverage frequency, and image parameters. The predominant frequency is C-band. Although showing promise in tropical forest applications, quadrature polarimetric satellite systems will not be operational until after the turn of the century.

Satellite radar experience to date suggests that several monitoring objectives would be well met using such data. However, our investigations have identified two important problem areas which must be addressed urgently: 1) a dearth of C-band data of tropical forests upon which to base more critical assessments of satellite radar performance; and 2) the lack of a data pricing policy for radar remote sensing data products which would underwrite and support the need to acquire large amounts of wide data for global tropical forest monitoring as well as high resolution data for more detailed management information.

1. INTRODUCTION

The purpose of this paper is to consider typical information requirements for tropical forest monitoring, and to examine the contribution that microwave remote sensing systems (in conjunction with other readily available data sources) may make to the important issue of forest management.

Tropical forests are one of Earth's most valuable resources. From an ecological perspective, they play a major role in the hydrological cycle and recycling atmospheric carbon dioxide. They stabilize soil and prevent excess runoff of silt and dissolved substances into streams. Their effects on climate through energy and water exchange with the atmosphere are not well understood but are expected to be significant. Much of the Earth's species diversity is represented by the plants and animals which make up tropical forest biomes.

The rate of destruction of tropical forests has been widely documented and publicized (Myers, 1986, Nelson,

et al., 1987, Repetto, 1988 and 1990, Booth, 1989, Ellis et al., 1988, Wilson, 1989). For most tropical countries deforestation has become a drain of an increasingly valuable resource. Local and overseas interests alike have over-exploited forest resources. Failure to collect royalties, export taxes, and related fees has led to a chronic undervaluation of tropical forest resources (Repetto, 1990).

While it is apparent that improved management of tropical forests requires substantial economic, political, and institutional changes, it also requires additional information about the forests themselves and changes which are happening in and around them. Much of the additional information can be supplied by satellite and airborne remote sensing systems (with adequate field checking).

2. STUDIES WITH MICROWAVE DATA

The advantage of radar remote sensing to operate

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independently of solar illumination and in areas of persistent cloud cover, such as the tropics, was demonstrated in the successful completion of the first imaging radar mission over Darien Province of Panama in the late 1960s (Wing, 1970).

Numerous studies of the application of radar remote sensing in the tropics have been carried out since then. Most of the tropical experience with radar has been "on the job learning" as part of operational surveys, in contrast with temperate latitude studies, which have been generally of a formal research nature. A few reviews of the use of radar for forestry applications have been published, including those by Churchill *et al.*, 1985, Simonett *et al.*, 1987, and Werle, 1989b.

2.1 Airborne SAR and SLAR surveys

Airborne Synthetic Aperture Radar (SAR) and real aperture Side Looking Airborne Radar (SLAR) imagery of tropical areas around the globe have been acquired during more than 50 major commercial reconnaissance surveys, employing mainly X-band SLAR and SAR systems with HH polarization and to some extent a K_a -band SLAR system with HH and HV polarizations. Regional and nationwide surveys in Southeast Asia, and Africa as well as Central and South America to-date exceed more than 15 million km² in areal coverage. With the exception of more recent investigations employing digital SAR data, image analysis procedures have mainly relied on visual interpretation techniques. During the 1970s, most data sets were collected by the Westinghouse SLAR, the Motorola/MARS SLAR and the Goodyear/GEMS SAR systems. The data were optically correlated and processed on image film suitable for qualitative image analysis. The primary objective was the assessment of natural resource, terrain mapping and map revision, whereas in many instances the analysis of tropical vegetation was of secondary importance (Werle 1989a).

The development of digital SAR imaging and processing technology by Canadian industry and the Environmental Research Institute of Michigan (ERIM) during the early 1980s resulted in advanced operational systems. Digital SAR data with a spatial resolution as good as 6 meters and offering high geometric and radiometric fidelity were used in computer assisted image analysis procedures, for the construction of image mosaics, and in topographic mapping programs. Since the mid 1980s, Intra Technologies of Calgary has employed airborne SAR systems in the tropics for a variety of commercial forestry and land cover surveys including those with a focus on natural vegetation (Thompson and Dams, 1990).

Regional and nation-wide tropical vegetation surveys, primarily using X-HH data, have been reported by a number of investigators, e.g. Thompson and Dams, (1990). Major vegetation formations and to some extent zones experiencing ecological transition and stress within the tropics have been identified including savanna, dense and open tropical forest and woodland mosaics. Difficulties were encountered in identifying specific formations in hilly or mountainous terrain. De Molina and Molina (1989) were able to map thirty different vegetation cover types in Colombia at a scale of 1:40,000. Areas of selective logging and differing tree crown densities were also identified.

There is further evidence that mangrove forest

environments can be mapped accurately because of their generally strong radar backscatter compared to surrounding forest stands (Lewis 1977, MacDonald *et al.*, 1971). Thompson and Dams (1990) report success discriminating primary and secondary forests, and in mapping a variety of forest cover types, including mangrove/Nypa palm swamp, beach forest, peat swamp forest, hill dipterocarp forest, high scrub forest, tea tree and wallum cover, eucalyptus forest, and mimosoid legume and palm forests. Their data source was high quality black and white stereo prints made from X-Band HH digital SAR data with resolutions of 6 x 6 m and 6 x 12 m.

Plantation types which have been distinguished on airborne SAR imagery include palm and bananas (Dellwig *et al.* 1978, Thompson and Dams, 1990), and pine, eucalyptus, and rubber (Thompson and Dams, 1990).

Several studies indicate that forest disturbance can be detected and mapped (Dams *et al.* 1987, de Molina & Molina 1986, de Molina *et al.*, 1973, Sicco Smit 1978, Thompson and Dams, 1990).

To date there has been only one airborne SAR mission over tropical forests including C-band. The JPL aircraft, using C, L, and P-bands completed a series of flights over Belize in March, 1990, from which preliminary results are appearing (Zebker *et al.*, 1990). One value of this data is that it allows a direct comparison between these three wavelengths to tropical forest cover. Results show that image contrast in response to deforested/forested boundaries increases with wavelength, as expected. There is a decrease in mean reflectivity at C-band with increasing incidence over the range of angles expected from RADARSAT, a phenomenon that may prove to be useful. Change in reflectivity with incidence angle is progressively less pronounced as wavelength increases. C-band data is not the best frequency for tropical forest monitoring. Based on the very limited data now available, it shows little contrast between undisturbed tropical forest and older deforested areas or dense plantations. The limits and strengths of C-band in these and other applications requires further investigation.

The JPL experiment concentrated on the new dimension of quadrature polarimetry in tropical forest applications. Using this feature, scattering from the aerial foliage, the standing timber, and the surface beneath the forest may be differentiated (Zebker *et al.*, 1990, Ulaby and Elachi 1990). P-band shows the greatest power in expressing these three regimes through polarimetry. It holds promise for future missions that have radars capable of delivering quadrature polarimetric data. Likewise, the evidence to date shows that rarely does C-band penetrate through the foliage in closed moist forests.

Airborne radar data acquisition largely has been restricted to the dry season. Trevett (1986) noted that significant changes in radar backscatter were identified comparing dry and wet season imagery acquired during the Nigerian NIRAD survey. These changes were mainly attributed to moisture differences.

Very few multi-temporal data sets have been obtained, even within the same season. A major use of satellite radar imagery is expected to be detection of (man-made) changes in forest cover, so that there exists an urgent need for exploring this dimension.

2.2 Spaceborne SAR investigations

Spaceborne SAR imagery of tropical terrain has been

acquired during the experimental SEASAT (1978), SIR-A (1981) and SIR-B (1984) missions. These radars operated at L-band with horizontal transmit and receive polarization (L-HH). The spatial resolution achieved by each system varied between 25 meters, 40 meters and 18-60 meters, respectively. SIR-A and SIR-B provided only relatively narrow swath coverage of 50 km and 15-40 km, respectively. The combined total coverage in the humid and seasonally humid tropics exceeded a land area of 1.5 million km².

Multi-temporal SAR data is extremely limited and is restricted to some repeat coverage of the SEASAT SAR within the mask of the Merritt Island, Florida, receiving station, and to occasional overlap of SIR-A and SIR-B image swaths. With the exception of one study (Pope 1987), lack of data has virtually precluded the study of spaceborne SAR imagery for change detection within tropical forest environments. The few studies that have been carried to assess environmental conditions and dynamic land use phenomena have had to rely on single date spaceborne SAR data.

Both computer assisted and visual interpretation procedures have been employed in the analysis of spaceborne SAR data for tropical vegetation and land use investigations. In addition, most studies suffered from a lack of ground information and knowledge of specific environmental and target parameters at the time of data acquisition, thus limiting the reliability of interpretation results.

The imagery acquired during the SIR-A mission in November, 1981 provide a useful yet little known source of information representative of all major tropical forest regions of the globe. There is evidence that SIR-A imagery (L-HH) at a scale of 1:250,000 is suitable for identifying the nature and extent of tropical forest conversion such as commercial timber harvesting operations, man-made grasslands for cattle ranching projects as well as natural grassland successions, and, to a limited extent, settlement colonization and agricultural schemes (Werle 1986 and 1989a).

Stone & Woodwell (1987) and Stone *et al.* (1989) found evidence that clearings within the tropical forest of Amazonia may exhibit different radar backscattering behaviour as a function of age and clearing practices. They found that L-band would be helpful in determining primary forest composition, but their data were insufficient in areal coverage to determine exact rates of deforestation.

Hoffer & Lee (1989) evaluated the potential of multi-temporal SEASAT and SIR-B data for defining areas of forest change, different forest categories and reforestation sites in Florida. Primary categories of forest change such as deforestation and reforestation were identified with relatively high accuracy. Reforestation stages were detected with modest success.

Ford & Casey (1988) distinguished and mapped swamp and lowland forest, tidal forest, wetland and clearcut areas in the coastal rainforest of Borneo using SIR-B data at two different incidence angles. Radar backscatter values for swamp areas were noted to change as a function of incidence angle. The SIR-B data were not suited for discriminating between different forest types within the mountainous interior of Borneo.

Imhoff *et al.* (1986) have studied multi-incidence angle SIR-B data of Bangladesh in order to characterize forest canopy and assess radar penetration capabilities. They were able to map flood boundaries beneath mangrove vegetation canopies. Breaches and holes in the natural canopy structure were also easily detected.

De Molina & Molina (1986) examined SIR-A data as part of a multi-sensor study for forest classification in the Colombian Amazon. Although their forest typing exercise met with little success, a clear discrimination of forested and non-forested areas was noted. Boundaries between savanna vegetation, tropical forests, floodplain vegetation and clearings were delineated without difficulty.

Ford and Da Cunha (1985) examined the radar backscatter properties of floodplain vegetation using multi-frequency SAR data. Alluvial forest areas were

TABLE 1. SUMMARY OF SAR APPLICATIONS RESULTS IN TROPICAL FORESTS

Applications Area	Country	Band*	Resolution	Reference
Road detection	Sarawak	X	6 m	Thompson and Dams 1990
	Peninsular Malaysia	X	6 m	Ahmad <i>et al.</i> 1988
	(Cameroon)	L	40 m	Werle 1989 a)
	Belize	L, P, C ²	10 m	Zebker <i>et al.</i> 1990
Forest inventory informaton	Peninsular Malaysia	X	6 m	Ahmad <i>et al.</i> 1988
	(Nigeria)	X	> 30 m	Sicco Smit 1978)
	(Colombia)	Ka, X, L	10-22, 16, 40 m	de Molina and Molina 1986)
Clearcut detection	Cameroon	L	40 m	Werle 1986
	Venezuela	L	40 m	Werle 1986
	Indonesia	L	40 m	Werle 1986
	Brazil (?)	L	40 m	Stone & Woodwell 1987
	Colombia	Ka, X, L	10-22, 16, 40 m	de Molina & Molina 1986
	Costa Rica	X	6 m	Dams <i>et al.</i> 1987
	Belize	L, P, C ²	10 m	Zebker <i>et al.</i>

Continuación **TABLE 1**

Applications Area	Country	Band*	Resolution	Reference
Clearcut revegetation	Cameroon	L	40 m	Werle 1989a
	Venezuela	L	40 m	Werle 1989a
	Indonesia	L	40 m	Werle 1989a
	Costa Rica	X	6 m	Dams et al 1987
Settlements	Nigeria	X	30 m	Hunting, 1984
	Paraguay	L	40 m	Werle 1989a
	Indonesia	L	40 m	Werle 1989a
	Sarawak	X	6 m	Thompson and Dams 1990
	Colombia	X	6,12 m	de Molina and Molina 1989
Agricultural conversion	Paraguay	L	40 m	Werle 1986
	Sarawak	X	6 m	Thompson and Dams 1990
	Peninsular Malaysia	X	6 m	Thompson and Dams 1990
	Colombia	X	6,12	de Molina and Molina 1989
Tree plantations	Guatemala	Ka	10 - 22 m	Dellwig et al 1978
	Indonesia	L	40 m	Werle 1989a
	Australia	X	12 m	Lowry et al 1986
	Congo	X	6 m	Thompson and Dams, 1990
	Peninsular Malaysia	X	6 m	Ahmad et al 1988
	Belize	L,P,(C)	10 m	Zebker et al 1990
	Mangrove forests	Indonesia	X, L	40 m
Panama		Ka		Lewis & MacDonald 1973
Sarawak		X	6 m	Thompson and Dams 1990
Australia		X	12 m	Lowry et al. 1986
(Bangladesh)		L	=16 - 33 m	Imhoff et al. 1986)
(Florida)		L	25 m	MacDonald et al. 1981)
Flooding	Bangladesh	L	28 m	Imhoff et al. 1986
	Australia	L	40 m	Werle 1989a
	Indonesia	L	28 m	Ford & Sabins, 1985
	Guatemala	L	25 m	Pope 1987
	Colombia	X	6, 12 m	de Molina and Molina 1989
	Indonesia, Borneo	L	= 20 - 30 m	Ford & Casey 1988
	Drainage	Nigeria	X	> 30 m
Colombia		Ka,X,L	10-22,16,40 m	de Molina & Molina 1986
Brazil		X,L	16, 40 m	Ford & da Cunha 1985
Cameroon		L	40 m	Werle 1989a
Sarawak		X	6 m	Thompson and Dams 1990
Broad vegetation classes	Brazil	X	16 m	Furley, 1986
	Nicaragua	Ka	10-20 m	Trevett 1986
	Togo	Ka	> 20 m	Gelnett et al. 1978
	Nigeria	X	30 m	Hunting 1984
	Colombia	X	= 10 - 22 m	de Molina et al. 1973
	Colombia			Trevett 1986
	Colombia	Ka,X,L	10-22,16,40 m	de Molina & Molina 1986
	Colombia	X	6, 12 m	de Molina & Molina 1989
	Australia	X	6 m	Lowry et al. 1986
	Indonesia, Borneo	L	= 20 - 30 m	Ford & Casey 1988
	(Brazil)	X	= 16 m	Disperati and Keech 1978)

Notes:

1. Studies in parentheses () report negative findings for that application.
2. Partial success, depending on local conditions.

Wavelengths:

Ka = - 1 cm; X = 3 cm; C = 6 m; S = 10 cm; L = 23 cm; P = 68 cm

clearly identified on SIR-A L-band data, but could not be separated from surrounding forest areas on X-band airborne SAR data.

Pope (1987) was able to monitor seasonal flooding of lowland terrain in tropical forests of Guatemala using multi-temporal SEASAT SAR as well as airborne SAR data. Radar backscatter values of vegetated flooded terrain was found to be at a maximum under small incidence angle illumination.

These findings and others are summarized in Table 1, which shows that many different kinds of information useful for tropical forest management can be obtained from suitable radar data. With one exception, studies at C-band are noticeably absent from the tabulated results.

3. FORTHCOMING RADAR SATELLITES

The decade of the 1990s offers several satellite radar systems of interest for tropical forest monitoring. Civilian radar (SAR) satellites are summarized in Table 2. Several patterns emerge from the parameters tabulated.

Although the satellites span frequencies from C-band to L-band, the predominant frequency available will be C-band. When only the operational systems are considered, C-band is clearly the frequency of central interest. This is significant, in that C-band is the frequency for which there is the least amount of prior data available, and for which the most preparation is warranted.

Swath widths and resolutions are similar, except that RADARSAT offers a choice of coverage, ranging from 10 m resolution at 50 km swaths with width to 100 m resolution at 500 km swath width, using nominal specifications. Should incidence angle prove to be a parameter of value in scatterer discrimination, incidence angle selection is available on three of the operational systems. Additional information on RADARSAT may be found in Luscombe (1989), Langham *et al.* (1990), and Raney *et al.* (1990).

Quadrature polarization data will not be available until the middle of the decade, and only for experimental purposes from SIR-C/X-SAR. If the EOS SAR is approved operational quadrature polarimetry data will become available only after the end of the decade.

A major advantage of satellite SAR systems is the ability to provide repeat coverage for change detection analysis. It is expected that even at C-band, change in forest cover due to natural or human causes will be evident through multi-temporal analysis. All weather operation and the ability to co-register the data sets are essential elements of this method, both of which are supported by the operation systems listed in the table.

The Soviet Union has announced its intention to make imagery available from its Almaz radar satellite, due to be launched in November, 1990. The S-band frequency, and variable imaging parameters suggest that data from this system are of potential interest in the tropical context.

Two interesting initiatives are not shown on the table, due to the fact that they are in only conceptual stages. NASA proposed in 1988 that the Space Station should carry a P-band SAR whose main justification would be tropical forests. The proposal was not accepted at that time, although P-band forestry studies are continuing. These studies show considerable promise, and could influence wavelength selection of the EOS SAR during its final design and approval process.

A second initiative is developing through the International Space University. There is a Proposal (International Space University 1990) that would begin the process of design, build, launch, and operation of a "lightsat" SAR at P-band, conceived with tropical forest monitoring as the primary objective. Satellite data would be down-linked through existing low rate meteorological telemetry channels, and would be processed at centres distributed throughout the world. If approved—and it is a long way from maturity at this time—it could lead to

TABLE 2. SELECTED PARAMETERS OF ALL CIVILIAN SAR SATELLITES

	Seasat USA	ALMAZ USSR	ERS-1 ESA	J-ERS-1 Japan	(SIR-C) ³ USA	ERS-2 ¹ ESA	RADARSAT Canada	EOS ² USA
Operation	1978	90-93	91-93	92-94	93,4,5	94-96	94-99	99(?)
Radar Bands	L	S	C	L	C,L,X	C	C	C,L (X)
Polarimetry					yes			yes
Swath width (km)	100	30-300	80	75	15-90	80	50-500	50-500
Resolution (m)	25	15-300	30	18	~30	30	10-100	10-100
Incidence angle (°)	22	40-60	23	39	15-55	23	20-59	15-55
Máx. N. Latitude (°)	72	73	80	80	53	80	90	
o/b recorder		yes		yes	(yes)		yes	(yes)

¹For purposes of this discussion, ERS-2 parameters are assumed similar to those of ERS-1.

²Current NASA planning has deleted the SAR as a facility instrument on EOS, and is seeking approval for a separate but related SAR satellite. System parameters of the proposed SAR are not established, but are likely to be rather close to those listed above.

³Shuttle radar flights (SIR) each last about one week, as did SIR-A (1981) and SIR-B (1984).

relatively low-cost source of P-band satellite SAR data of medium resolution well before the end of the decade.

4. THE ROLE OF RADAR SATELLITE MISSIONS

In approaching the issue of satellite SAR, airborne SAR, and optical data for tropical forest management, it is very helpful to recognize a relationship between the area for which information is required, and the level of detail desired. There are also corresponding relationships between the area covered by a sensor and its spatial resolution (see Table 3), and between the spatial resolution of sensors and the level of detail available from them (Molina, 1981). These relationships result in natural groupings between the information requirements of various agencies, and the appropriate sensors to satisfy the information requirements. We have emphasized three such groupings in Table 4, where we match information requirements with the sensors which appear, at present, appropriate to satisfy the information requirements.

An important dimension not covered in either Table 3 or Table 4 is that of time. Spacecraft radars may be relied upon to provide repeat coverage of any given site, even if cloud covered. The time between coverage opportunities is a function of satellite orbit, swath width, and, indirectly, resolution. Revisit intervals for the systems listed in Table

3 range from 3 days to about 35 days, based on current knowledge of system parameters. Perhaps of more importance, the issue of establishing a requirement on "temporal resolution" (an entry that would be more suitable for Table 4) requires specific investigation, particularly in the light of system capabilities now projected. Temporal resolution would be dependent on season and anticipated levels of human activity in specific tropical forest regions. Whereas this dimension is not considered explicitly in the discussion that follows, it remains an important aspect of the forest monitoring issue. The change detection potential of composite pairs of images gathered at two different points in time should add considerably to the value of space borne radar data in tropical forest monitoring.

Numerous studies have shown microwave backscatter to provide information about vegetation which is complementary to the information provided by optical sensor (e.g. Ahern *et al.*, 1978, Guindon *et al.*, 1980, Brisco *et al.*, 1983, Wu, 1985). It is reasonable to expect, therefore, that microwave satellite data will also prove useful as a complement to optical data for mapping broad vegetation classes over wide areas.

The considerations noted above are based on the assumption that there is sufficient data available in order to perform both single pass and multi-temporal monitoring. Since large amounts of data are required, this

TABLE 3. BASIC CHARACTERISTICS OF TYPICAL OPTICAL AND MICROWAVE SENSORS

Sensor	Mode	Swath (km)	Resolution	Incidence
L-MSS	Standard	185	~ 80 m	- 11° to 11°
L-TM	Standard	185	30 m	- 11° to 11°
SPOT/HRV	Multispectral	60	20 m	- 31° to 31°
SPOT/HRV	Panchromatic	60	10 m	- 31° to 31°
AVHRR	Standard	~ 2000	~ 1100 m	- 45° to 45°
ERS-1	SAR	80	30 x 30 m (4 looks)	~ 23°
RS-SAR#	Standard	100	28 x 30 m (4 looks)	20° to 49°
RS-SAR	High Resolution	55	8 x 8 m (1 look)	20° to 49°
RS-SAR	Extended	100	28 x 30 m (4 looks)	49° to 60° and 10° to 20°
RS-SAR	ScanSAR	500	100 x 100 m (8 looks)	20° to 49°

#RS = RADARSAT

TABLE 4. SUMMARY OF INFORMATION REQUIREMENTS AND APPROPRIATE SENSORS¹

PART I: Broad Scale	
Global, continental, national	Agencies concerned:
Typical mapping scales: 1:10 ⁶ to 1:10 ⁷ Spatial resolution: 0.1 to 10 km	International organizations International development agencies Global environmental research groups
Information requirement	Appropriate sensor(s)
Broad vegetation classes	NOAA/AVHRR RADARSAT ScanSAR NOAA/AVHRR
Vegetation cover/vigour	
Length of growing season	NOAA/AVHRR
Large area vegetation change	RADARSAT ScanSAR NOAA/AVHRR
PART II: Medium Scale	
National, regional	Agencies concerned:
Typical mapping scales: 1:10 ⁴ to 1:10 ⁶ Spatial resolution: 10 to 1000 m	National, state, and provincial Natural Resource, Environment and Parks Departments
Information requirement	Appropriate sensor(s)
Topography	Air photo, SPOT/HRV (Radar) ²
Vegetation inventories	Air photo, Landsat/TM RADARSAT/Standard ERS-1, J-ERS-1
Mangrove forests	Landsat/TM, SPOT/HRV, RADARSAT/Standard ERS-1, J-ERS-1
Drainage networks, standing water	Landsat/TM, SPOT/HRV RADARSAT/Standard ERS-1, J-ERS-1
Standing water under canopy	(RADARSAT/Standard) (ERS-1) J-ERS-1
Roads and settlements	SPOT/HRV RADARSAT/High Resolution
Change detection	SPOT/HRV, Landsat TM RADARSAT Standard ERS-1, J-ERS-1
Forest damage	Air photo, Landsat/TM (based on temperate latitude studies)
Revegetation assessment	Landsat TM, SPOT/HRV (radar)
Plantation mapping	(RADARSAT/High Resolution) SPOT/HRV, Landsat TM

Continuación **TABLE 4. SUMMARY OF INFORMATION REQUIREMENTS AND APPROPRIATE SENSORS¹**

Agricultural conversion (vegetation change)	(RADARSAT/Standard) RADARSAT/High Resolution SPOT/HRV, Landsat TM (ERS-1)
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Fire detection	NOAA/AVHRR
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PART III: Small Scale**Local****Agencies concerned:**

Spatial resolution 1 to 10 m Typical mapping scales: 1:10 ³ to 1:10 ⁴	Resource companies, Municipalities, National and local parks administrations, engineering companies, non-governmental organizations
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Information requirement**Appropriate sensor(s)**

Vegetation species mix	Air photos, (airborne SAR)
Wildlife habitat	Air photos, Landsat TM, SPOT/HRV (airborne SAR)
Tree diameters and heights	Air photos, (airborne SAR)
Roads, trafficability	Air photos, SPOT/HRV, airborne SAR RADARSAT / High Resolution
Plantation mapping and assessment	Air photos, airborne SAR, SPOT/HRV Landsat TM (RADARSAT / High Resolution)

1. In this table we have indicated Landsat/TM and SPOT/HRV where studies have shown that Landsat/MSS is effective, because our experience with forestry applications at temperate latitudes has indicated that customers are usually willing to pay the extra cost for the additional information content of these sensors. We have **not** indicated aerial photography ("Air photo") for applications which can be done with satellite data because customers generally prefer the much lower cost per unit area of satellite data.

Radar sensor applicability for spacecraft is estimated based on the limited data available, and for aircraft is based on the extensive experience of Intera (Dams et al. 1987) using high resolution X-band SAR in various tropical applications.

2. Parentheses () indicate conditional applicability of the enclosed sensor.

is not a trivial condition, and cannot be taken for granted. If tropical nations were to be obliged to pay commercial rates for all of the data that they require, it is likely that they would acquire rather less data than is needed for full monitoring functions. The issue of data policy, its pricing and terms of availability, becomes of central importance in the context of tropical forest monitoring. It would be

constructive if this issue were to receive attention from the nations sponsoring these remote sensing spacecraft. There is an evident justification for such data to be made available through methods that are more enlightened than is the current commercial approach. Thoughts on this difficult topic are developed further in (Raney and Specter, 1990).

5. CONCLUSIONS

Radar data from satellites will be routinely available during the 1990s, and presumably for many years thereafter. One of the most significant applications for such data is tropical forest monitoring, as has been documented in numerous field reports. However, there is at present virtually no quantitative knowledge base upon which to build an operational capability to use such data, particularly at C-band data which is expected to be the most continuously maintained frequency throughout the decade. There is an urgent need to augment C-band experience over tropical forests, using both airborne systems in dedicated deployments, and with studies based on ERS-1 data, the first radar satellite to be operational. In parallel with the technical developments required, there needs to be studies towards enhancing the

infrastructure in tropical countries so that they are better prepared to use such data for active environmental management, and reconsideration of the remotely sensed data pricing policy so that sufficient data may be reliably acquired where it is needed at reasonable cost.

6. ACKNOWLEDGEMENTS

This paper is an outgrowth of a previous work (Ahern *et al.* 1990) that considered both optical and microwave sensing of tropical forests. The present text concentrates on the microwave aspect, and includes the most recent tropical forest microwave work in the Summary Table. The authors wish to thank L. Brown - Woods, L. Marcotte, T. Potter, and E. Storie of Horler Information Incorporated for their assistance in the literature review on which this paper is based.

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SPACEBORNE REMOTE SENSING AND THE MANAGEMENT OF PLANET EARTH: THE ROLE OF THE ECUADOR GROUND STATION*

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Abstract

The Cotopaxi Remote Sensing Ground Station is the first station conceived from the beginning to be able to receive and process data from three different spacecraft: LANDSAT, SPOT, and ERS-1. The reception and processing of data from multiple sensors carried on different spacecraft is fundamental to obtaining the maximum benefit from such a facility. Receiving such data is, however, only the beginning of the process of converting this data into useful information. Modern ground processing systems have as their principal objective the production of a set of output products which are designed to be used in operational applications. This paper is divided into two parts: The first part consists of a discussion of what might be called "the management of Planet Earth". The second part deals with a cursory description of the Cotopaxi station itself.**

MANAGEMENT OF PLANET EARTH

We have heard much in recent times about the need to change the way we treat our planet. We have become aware that if we are to survive as a species in the long term, we must manage the resources and environment of the Earth in a way which is fundamentally different from the way we have done things in the past. The prospect of global warming and the apparent depletion of the ozone layer as consequences of human activity are but two of the more well-known early manifestations of our ability to upset nature's equilibrium. It is generally accepted that human activity began to have significant effects on the environment at the time of the industrial revolution. If one examines the period since then, while there is evidence of some effect on environmental equilibrium due to human activity primarily in the industrial countries, there is no doubt that the quality of life for the average person in those countries has increased markedly during this period. These improvements have their roots in the very increase in economic activity which lies at the root of the negative effects we appear to be having on the environment. While it appears that our longterm survival as a species will depend on our

ability to act in ways which preserve the ecosystem of planet earth in its current state of natural equilibrium, none of us, whether we live in the industrialized countries or the so-called developing world, is anxious to accept significant curtailment of continuous improvement in our quality of life through what is commonly referred to as "economic development". The challenge then becomes one of achieving economic growth while at the same time sustaining the ability of our planet to continue to support our own and other species for the indefinite future. This is an exciting challenge for all of us. In the words of the World Commission on Environment and Development.

"Humanity has the ability to make development sustainable—to ensure that it meets the needs of the present without compromising the ability of future generations to meet their own needs. The concept of sustainable development does imply limits—not absolute limits but limitations imposed by the present state of technology and social organization on environmental resources and by the ability of the biosphere to absorb the effects of human activities. But technology and social organization can both be managed and improved to make way for a new era

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of economic growth". (World Commission on Environment and Development, Our Common Future, Oxford University Press, 1987)

Achieving the goal of sustainable development is a process which must be **managed**. In other words, if we are to achieve the goal of sustainable development, we must manage our activities toward that end. The essential first step in any management process is the acquisition of timely, reliable and accurate information. Because the problems of resource and environmental management are global, and the planetary systems we are attempting to describe are interdependent in as yet ill-understood ways, the information system for global environmental and resource management must be capable of encompassing the earth as a whole. This requirement points toward spacebased measurement of the earth as the basis for such a system. This is not to say that such a system would deal only with space-based measurements, it simply means that the system would be conceived around the idea of measuring the earth from space as a "backbone" concept which serves to define the framework within which all measurements including those from non-space sources are processed, stored, accessed and interpreted. Learning to understand what all these measurements mean in terms of the trends in the health of the planet will be facilitated by embedding them in a framework which, as an intrinsic characteristic, deals with the earth system as a whole. One cannot speak of environmental management and resource management separately. They are inextricably linked. Only when we approach the problem in this way, will we be able to objectively understand the trends in the health of the planet's biosphere and the effects we as a species are having on that health through our activities. The key concept here is that of management of the environment and the resources which we extract from this planet. This management process inevitably involves choices to be made between "economic progress" and "harming the environment". In recent times much confrontation has ensued between those who advocate one point of view or the other. Much of the argument has been emotional, and based in many cases on little or no knowledge of the real situation or the implications of one decision or the other. The beginning of good management in any discipline is accurate, objective and timely information. Remote sensing technology, which seeks to measure the parameters of our planetary system from a distance, will form the technological basis of the required information delivery system. It therefore follows that the systems we put in place today, such as Cotopaxi, should be looked on as the first steps in a larger enterprise which will be able ultimately to provide such information on a global scale.

It is important to emphasize that what we are dealing with here is **measurement**, not just observation. Remote sensing of the earth from space has, since its inception in the early 1970's, been regarded largely as an exercise in "picture taking". We have produced and visually interpreted magnificent pictures of the earth's surface and its atmosphere from spaceborne platforms. The instruments which we fly in space are however capable of far more than simple observation. They are precise measuring instruments which can be calibrated both spatially and radiometrically to high accuracy. The Ecuador Ground Station has been designed to exploit this capability, which is

necessary to be able to monitor trends over time in an objective way. It allows us to quantify changes in the Earth's system which can be related to physical processes in an objective and quantifiable way. Being able to deal with the data in this way is essential to being able to utilize spaceborne data successfully as inputs to earth system models. The use of these models will be fundamental in gaining the understanding necessary for the successful management of the resources and environment of our planet in the long term.

From the point of view of spaceborne measurement, the earth can be thought of as having four major components: the land, the ocean, the atmosphere, and the icecaps. When sensing these various components, it must be remembered that they are all interrelated. One cannot consider the atmosphere independently of the ocean or the land, and one certainly cannot sense the land without taking into account the effects of the atmosphere through which it must be observed.

For example, to one who is concerned with tracking atmospheric phenomena, the effects of the atmosphere on the observed radiation contains information (i.e. it is "signal"), while one who is interested in tracking phenomena on the surface, such as ocean surface temperature for example, would regard the effects of the atmosphere on the radiation as an interfering signal or "noise". An information system put in place to objectively monitor the planet must be capable of satisfying the needs imposed by many diverse requirements such as these.

In order to develop a consistent picture of trends in the earth system over time, the measurements made by satellite borne instruments must be reduced to calibrated physical variables which have meaning in terms of the processes and cycles being monitored. This process is

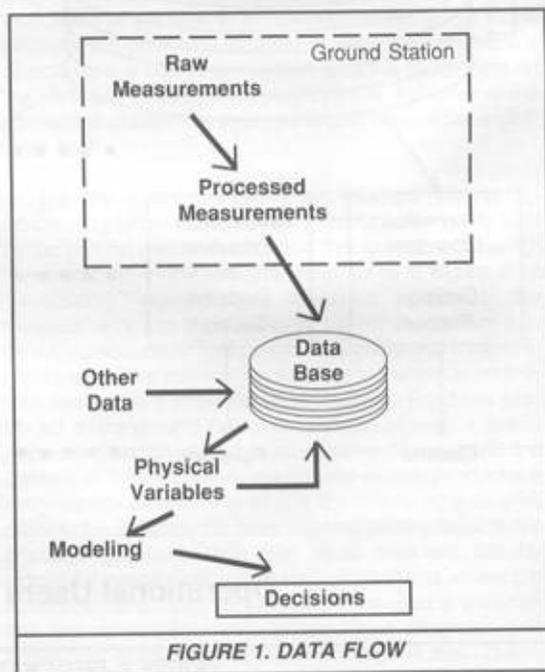


FIGURE 1. DATA FLOW

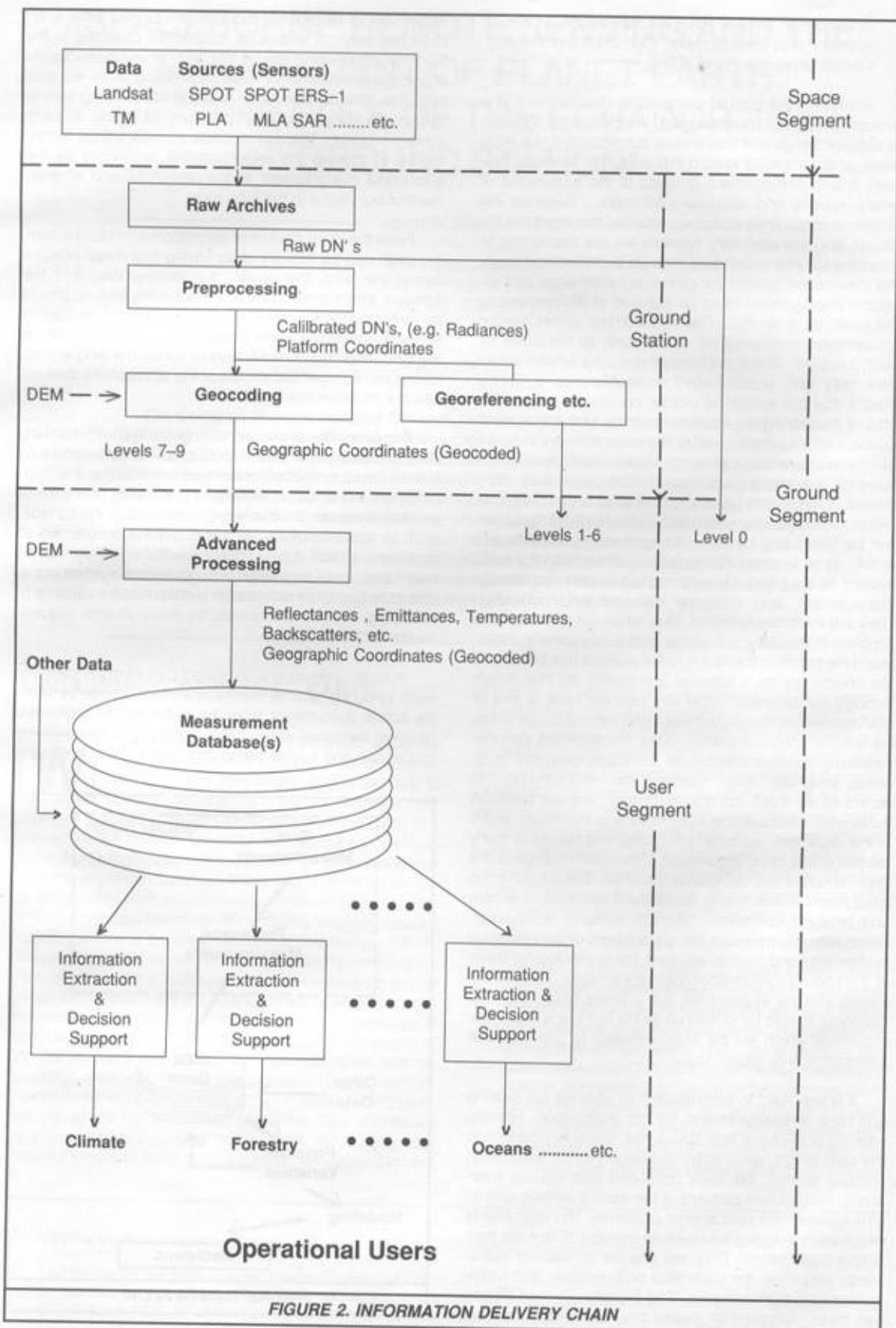


FIGURE 2. INFORMATION DELIVERY CHAIN

Level 0:	("Raw") Uncorrected. Radiometrically and geometrically raw. Detector offsets applied
Level 1:	Radiometrically corrected. Detector offsets applied
Level 4:	("Bulk") Radiometrically corrected. Across-track geometric corrections applied
Level 5:	("Systematic Georeferenced") Radiometrically and geometrically corrected. Two dimensional resampling to a map projection. No GCP's.
Level 6:	("Precision Georeferenced") Radiometrically and geometrically corrected. Two dimensional resampling to a map projection. GCP's used.
Level 8:	("Systematic Geocoded") Radiometrically and geometrically corrected. Two dimensional resampling. Geocoded (rotated and aligned to a map projection). No GCP's.
Level 9:	("Precision Geocoded") Radiometrically and geometrically corrected. Two dimensional resampling. Geocoded (rotated and aligned to a map projection). GCP's used.

TABLE 1. PROCESSING LEVELS

shown schematically in Figure 1. In the initial processing step, the raw sensor measurements are calibrated and precisely located on the earth's surface. These processed measurements (say radiance for example) are stored in a geocoded data base along with data from other sources. Physical variables (reflectance, for example), which are selves also stored in the database, are then derived from the processed measurements. The physical variables provide inputs to modeling processes which lead to an understading of the ecosystem being modeled.

In designing systems to make the measurements and perform to required processing tasks, we are led to ask three important questions:

1. What do we want to measure?
2. Why do we want to measure it?
3. How are we going to measure it?

The answers to these questions determine the type of system with which we end up, and they serve to remind us that the real objective of the system is to **deliver information**. They also emphasize the fact that the critical part of the system is the data handling subsystem, for it is this component of the overall system, together with the suite of sensors that are used on the spacecraft, which determines the type and quality of information we ultimately receive. Thus the answers to these three questions have a fundamental impact on all aspects of the system design beginning with the choice of sensors and orbit characteristics, and reaching all the way through the entire processing system. The role of the spacecraft and launch vehicle is simply to deliver the instrument(s) to ascertain point in space and time in order to make a set of measurements and send the resulting data to earth. Viewing the problem in this way changes one's perspective on the relative importance of various system components compared to that which has traditionally been held. It leads directly to the view that a remote sensing system is in reality an **information delivery system**, the *raison d'être* of which is to deliver information about the state of the planet

to those who require this information for the purposes of making decisions which affect management of the environment and resource development.

Figure 2 illustrates in schematic form, the basic structure of an information delivery system which uses remote sensing of the earth system as its major set of inputs. One can think of the information delivery system as consisting of a series of steps beginning with the acquisition of a measurement by a spaceborne sensor. This measurement is then transmitted to the ground where it is archived in its raw form at the ground station. Processing of a measurement takes place in several steps: A pre-processing step converts the raw digital number (DN) into a calibrated quantity which is proportional to the electromagnetic radiance entering the entrance aperture of the instrument at the time of acquisition. At this stage in the process, the positional location of each measurement is described in a coordinate system which is dependent on the particular ground track and dynamic behavior of the spacecraft platform as well as the geometry of the instrument itself.

(i.e. the spatial location of the measurements is described in platform coordinates.) Products are generated by the ground station which are at this level of processing. The next step in the process, referred to in Figure 2 as "Geocoding" converts the coordinate system of the measurements into a geographic coordinate system (i.e. they are geocoded). This permits fusion of these measurements with other information which is in the same coordinate system in a straightforward manner. Products produced by the ground station are defined at various levels, depending on the degree of processing. These levels are defined in Table 1. While the ground station produces a wide variety of products to suit the needs of a diverse community of users, the most sophisticated products are precision geocoded data sets. These data sets are designed for operational quantitative applications, where the remote sensing measurements are to be used in conjunction with other information, entered in a database, and applied to operational decision making. In this context "Advanced Processing", which is generally user -de-

pendent, converts the calibrated DN's into physically related quantities such as reflectance, emittance etc. in a geographic coordinate system (i.e. they are geocoded). By placing calibrated physical measurements in a geographic coordinate system we achieve two objectives:

1) The use of a common coordinate system which is independent of the particular geometry of the acquiring spacecraft allows measurements from various sources to be combined and compared, and 2) the use of a common **geographic** coordinate system permits easy integration of the measurements with other map-referenced data which are already in the same coordinate system.

Measurements which are geocoded in this way can be then entered into a Measurement Database, where they are integrated with information from other sources. Such a

database can be thought of as a generic description of a region of the Earth in space and time. Its contents describe that region. The final step in the information delivery system is to extract information from the data-base in support of resource and environmental management decisions. This is shown in Figure 2 by the many "Information Extraction & Decision Support" elements at the bottom of the delivery system. This final step in the process is very application dependent. The same physical measurements have different meanings and are interpreted in different contexts depending on the discipline of application. For example, the infrared reflectance profile over a forest has a different meaning and significance to a forester than it does to an exploration geologist. Thus we see that information drawn from the database is treated and interpreted differently by different application disciplines.

	Raw and Bulk Products	Georeferenced Products	Geocoded Products
Processing Levels:	0, 1, 4.	5, 6	8, 9
Quantization:	8 bits	8 bits	8 bits
Pixel Spacing:	30 m x 30 m	30 m x 30 m	30 m x 30 m
Nominal Dimensions:			
Full Scene:	6120 pixels x 5728 lines. 184 km x 172 km	6120 pixels x 5728 lines. 184 km x 172 km	2240 pixels x 2240 lines. 56 km x 56 km
Overlapping Quad:	3160 pixels x 2944 lines. 94 km x 88 km	3160 pixels x 2944 lines. 94 km x 88 km	N/A
Abutting Quad:	3060 pixels x 2864 lines. 92 km x 86 km	3060 pixels x 2864 lines. 92 km x 86 km	N/A
Location Specification:	LANSDAT World Reference System or latitude and longitude of scene centre.	LANSDAT World Reference System or latitude and longitude of scene centre.	Map sheet identification for the desired area with scale of 1:100,000
Map Projection:	Superficial Conic.	Lambert Conformal UTM	Lambert Conformal UTM
Output Media:			
CCT-	Full Scene or Quadrant Levels 0, 1, 4.	Full Scene or Quadrant Levels 5, 6	Subscene (mapsheet oriented) Levels 8, 9
Format:	CCRS DMD-TM 82-249 C, 1600 bpi or 6250 bpi BIL or BSQ.	CCRS DMD-TM 82-249 C, 1600 bpi or 6250 bpi BIL or BSQ.	CCRS DMD-TM 82-249 C, 1600 bpi or 6250 bpi BIL or BSQ.
Number of Bands	any combination of up to 7	any combination of up to 7.	any combination of up to 7.
Film	Full Scene or Quadrant Level 4	Full Scene or Quadrant Level 5, 6	Subscene (mapsheet oriented) Level 8, 9
Scale Full Scene:	1:1,000,000	1:1,000,000	1:500,000
Quadrant:	1:500,000	1:500,000	N/A
Number of Bands	any one of 7 for B/W any combination of 3 from 7 for colour.	any one of 7 for B/W any combination of 3 from 7 for colour.	any one of 7 for B/W any combination of 3 from 7 for colour.
Radiometric Enhancement	Histogram equalization or predefined custom enhancement.	Histogram equalization or predefined custom enhancement.	Histogram equalization or predefined custom enhancement.
Edge Annotation	Quality control/scale block, scale bar, 16 step colour step wedge and 16 step gray scale.	Quality control/scale block, scale bar, 16 step colour step wedge and 16 step gray scale.	Quality control/scale block, scale bar, 16 step colour step wedge and 16 step gray scale.

TABLE 2. LANDSAT THEMATIC MAPPER DATA PRODUCTS SPECIFICATIONS

	Raw and Bulk Products	Georeferenced Products	Geocoded Products
Processing Levels:	0, 1, 4.	5, 6	8, 9
Quantization:	8 bits	8 bits	8 bits
Pixel Spacing:	MLA: 20 m x 20 m PLA: 10 m x 10 m	MLA: 20 m x 20 m PLA: 10 m x 10 m	MLA: 12,5 m x 12,5 m PLA: 6,25 m x 6,25 m
Nominal Dimensions:			
MLA	3000 pixels x 3000 lines. 60 km to 81,5 km x 60 km	3000 pixels x 3000 lines. 60 km to 81,5 km x 60 km	2240 pixels x 3040 lines. 28 km x 38 km
PLA	6000 pixels x 6000 lines 60 km to 81,5 km x 60 km	6000 pixels x 6000 lines 60 km to 81,5 km x 60 km	4480 pixels x 6080 lines 28 km x 38 km
Location Specification:	GRS swath and row number or latitude and longitude of scene centre.	GRS swath and row number or latitude and longitude of scene centre.	Map sheet identification for the desired area with scale of 1:50,000
Map Projection:	Superficial Conic	Lambert Conformal UTM	Lambert Conformal UTM
Output Media:			
CCT- Format:	Full Scene: Levels 0, 1, 4. CRIS S-ST-73.1 CN (Level 0 only) 6250 bpi; BIL CCRS DMD-TM 85-428A (levels 0, 1, 4), 1600 bpi or 6250 bpi BIL or BSQ	Full Scene: Levels 5, 6. CCRS DMD-TM-85-428A, 1600 bpi or 6250 bpi BIL or BSQ	Full Scene: Levels 8, 9. CCRS DMD-TM-85-428A, 1600 bpi or 6225 bpi BIL or BSQ
Number of Bands	any combination of up to 3 for MLA 1 for PLA	any combination of up to 3 for MLA 1 for PLA	any combination of up to 3 for MLA 1 for PLA
Film	Full Scene: Level 0, 1, 4	Full Scene: Level 5, 6	Subscene (mapsheet o- riented), Levels 8, 9
Scale	1:500,000	1:500,000	1:250,000
Number of Bands	one for PLA B/W any one of 3 for MLA B/W any combination of up to 3 for MLA colour.	one for PLA B/W any one of 3 for MLA B/W any combination of up to 3 for MLA colour.	one for PLA B/W any one of 3 for MLA B/W any combination of up to 3 for MLA colour.
Radiometric Enhancement	Histogram equalization or predefined custom en- hancement.	Histogram equalization or predefined custom en- hancement.	Histogram equalization or predefined custom en- hancement.
Edge Annotation	Quality control/scale block, scale bar, 16 step colour step wedge and 16 step gray scale.	Quality control/scale block, scale bar, 16 step colour step wedge and 16 step gray scale	Quality control/scale block, scale bar, 16 step colour step wedge and 16 step gray scale.

TABLE 3. SPOT HRV DATA PRODUCTS SPECIFICATIONS

THE ECUADOR GROUND STATION

The design of the Ecuador ground station provides coverage of about 21 countries in the Caribbean basin and the northwest part of South America. Its design is based on the approach to information delivery outlined above, and depicted schematically in Figure 2. Since the details of the "User Segment" shown in Figure 2 are highly dependent on factors having to do with national standards and application disciplines, these functions of the information delivery chain are best allocated to processing facilities oriented around operational applications on a national

basis. This is depicted in Figure 3 which shows the ground station feeding level 0 and/or geocoded data sets to processing facilities in countries in the region of coverage.

The specifications of the LANDSAT data products available from the Ecuador Station are shown in Table 2, and specifications for the SPOT data products are shown in Table 3. These products are produced by a system which consists principally of three parts: a Data Acquisition subsystem, a Recording and Playback subsystem, and a Data Processing subsystem. The functional responsibilities of each of these subsystems are shown in Figure 4.

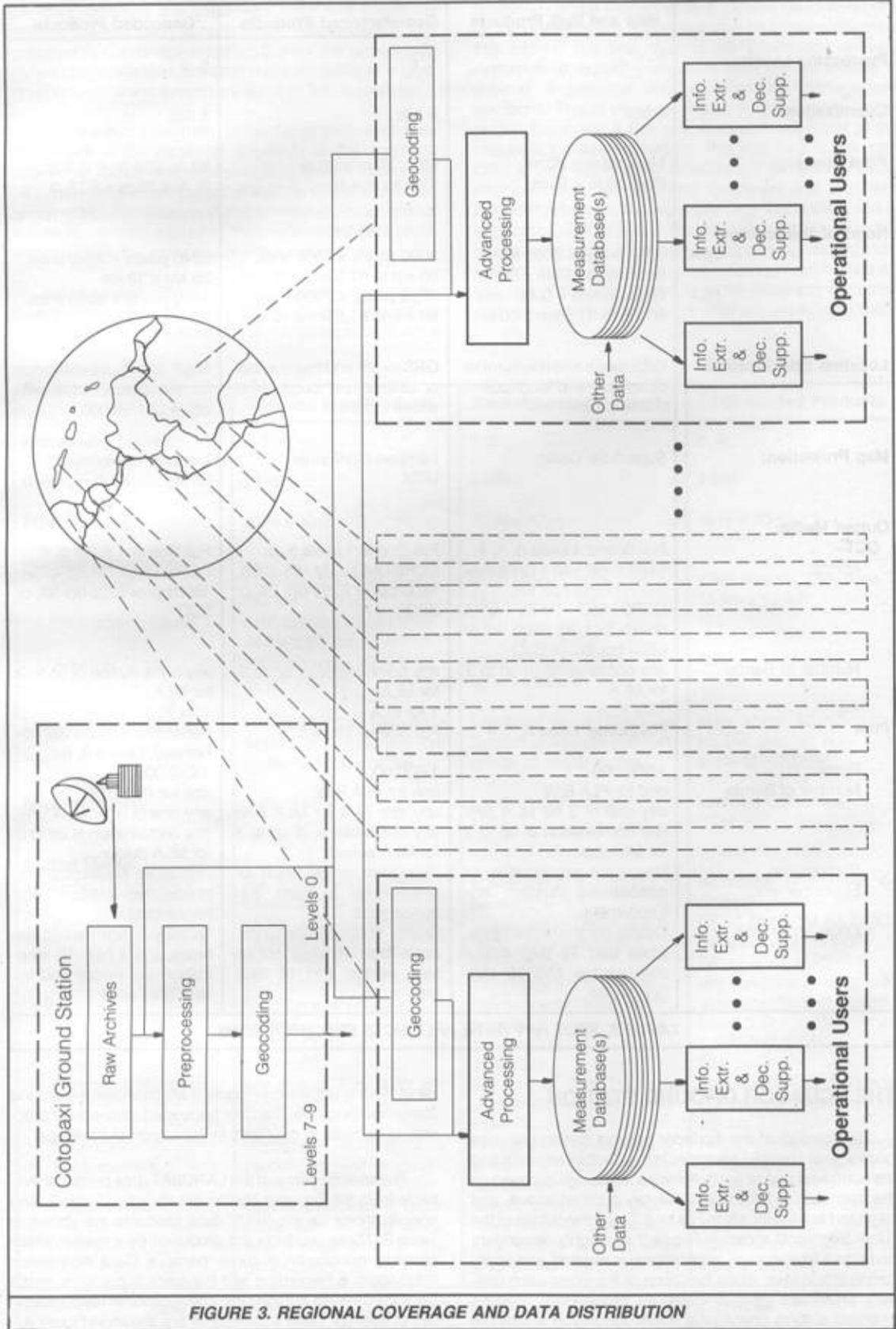


FIGURE 3. REGIONAL COVERAGE AND DATA DISTRIBUTION

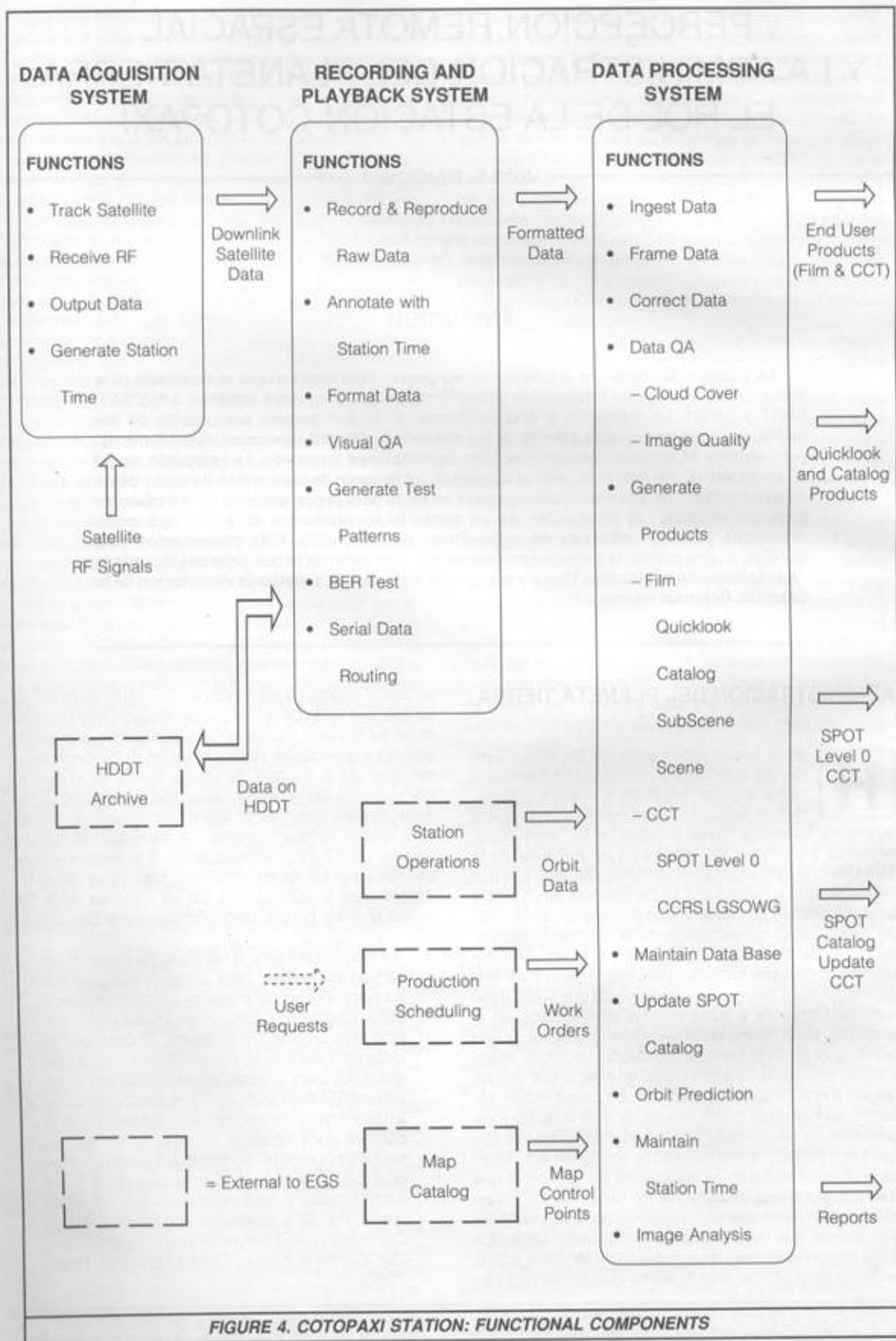


FIGURE 4. COTOPAXI STATION: FUNCTIONAL COMPONENTS

PERCEPCION REMOTA ESPACIAL Y LA ADMINISTRACION DEL PLANETA TIERRA: EL ROL DE LA ESTACION COTOPAXI

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Resumen

La Estación Cotopaxi es la primera en su género concebida desde el comienzo para poder recibir y procesar información proveniente de tres diferentes satélites: LANDSAT, SPOT y ERS-1. La recepción y procesamiento de la información proveniente de los múltiples sensores llevados a bordo de los diferentes aparatos espaciales es fundamental para obtener el máximo beneficio de tales instalaciones terrestres. La recepción de tal información es, sin embargo, sólo el comienzo del proceso de conversión de estos datos en información útil. Los modernos sistemas en tierra para procesamiento tienen como su principal objetivo, la producción de un conjunto de productos de salida que están diseñados para ser utilizados en aplicaciones operacionales. Esta presentación está dividida en dos partes: la primera consiste en una discusión de lo que debe ser llamado la "Administración del Planeta Tierra"; la segunda trata de una sintetizada descripción de la Estación Cotopaxi misma.

ADMINISTRACION DEL PLANETA TIERRA

Hemos escuchado mucho en los tiempos recientes acerca de la necesidad de cambiar la forma en que tratamos a nuestro planeta. Hemos llegado a tomar conciencia de que si queremos sobrevivir como especie en el largo plazo, debemos administrar los recursos y el ambiente de la Tierra de una forma fundamentalmente diferente a la que hemos llevado en el pasado. La perspectiva de un calentamiento global y de una aparente disminución de la capa de ozono como consecuencia de la actividad humana, son dos de las mejor conocidas recientes manifestaciones de nuestra habilidad para trastornar el equilibrio de la naturaleza. Generalmente se acepta que la actividad humana comienza a tener efectos significativos en el ambiente, en la época de la revolución industrial. Si uno examina el periodo transcurrido desde entonces, mientras hay evidencia de algún efecto en el equilibrio natural debido a la actividad en especial en los países industrializados, no hay duda que la calidad de vida de la persona promedio en esos países ha crecido marcadamente durante ese periodo. Estos mejoramientos tienen sus raíces en el drástico aumento de la actividad económica, la que a su vez representa las raíces de los negativos efectos en el medio ambiente, que ahora estamos observando. Mientras parece que nuestra sobrevivencia como especie a largo plazo dependerá de nuestra habilidad para actuar en forma de preservar el ecosistema del Planeta Tierra en

su actual estado de equilibrio natural, nadie de nosotros, ya sea que vivamos en los países industrializados como en el así llamado mundo en desarrollo, está ansioso de aceptar significativas reducciones en el continuo mejoramiento de la calidad de vida a través de lo que es comúnmente denominado "desarrollo económico". El desafío consiste entonces en lograr crecimiento económico y al mismo tiempo mantener la habilidad de nuestro planeta para continuar albergando a la nuestra y otras especies por un futuro indefinido. Este es un excitante desafío para todos nosotros. En las palabras de la Comisión Mundial para el Medio Ambiente y el Desarrollo:

"La Humanidad tiene la habilidad de lograr un desarrollo sostenible - para asegurar que satisfice las necesidades del presente sin comprometer la capacidad de las futuras generaciones para satisfacer sus propias necesidades. El concepto de desarrollo sostenible implica límites - no límites absolutos pero limitaciones impuestas por el actual estado de la tecnología y organización social sobre los recursos ambientales y la habilidad de la biósfera para observar los efectos de las actividades humanas. Sin embargo, tanto la tecnología como la organización social pueden ser administradas y mejoradas para abrir vía a una nueva era de crecimiento económico". (World Commission on Environment and Development, Our Common Future, Oxford University Press, 1987).

Lograr el objetivo de un crecimiento sostenible es un proceso que debe ser **administrado**. En otras palabras, si queremos lograr un desarrollo sostenible, debemos administrar nuestras actividades hasta el final. La primera etapa esencial en cualquier proceso de administración es la adquisición de información oportuna, confiable y precisa. Debido a que los problemas de administración de recursos y del ambiente son globales y que los sistemas planetarios que estamos intentando describir son interdependientes en forma aún incompletamente comprendida, los sistemas de información para administración global para el ambiente y recursos deben ser capaces de abarcar la tierra como un total. Este requerimiento apunta hacia mediciones logradas desde el espacio sobre la tierra, como la base de tales sistemas. Esto no quiere decir que un sistema como éste debería estar relacionado solamente con mediciones hechas desde el espacio, sino simplemente que el sistema debería estar concebido sobre la idea de medir la tierra desde el espacio como un concepto de "espina dorsal", que sirva para definir el rango de trabajo dentro del cual todas las medidas (incluyendo aquellas provenientes de fuentes no espaciales) puedan ser procesadas, almacenadas, utilizadas e interpretadas. Aprendiendo a comprender qué significan todas estas mediciones en términos de las tendencias para la salud del planeta, la labor será facilitada considerándolas como una propiedad característica, dentro de una franja de acción que trate con el sistema planetario como un total. Uno no puede hablar de administración del ambiente y administración de recursos naturales separadamente. Ellos están unidos indisolublemente. Solamente cuando nos aproximamos al problema de esta manera seremos capaces de entender objetivamente los rumbos necesarios para la salud de la biosfera del planeta y los efectos que nosotros como especie estamos teniendo en tal salud a través de nuestras actividades. El concepto clave aquí es el de administración del ambiente y los recursos que extraemos desde este planeta. Este proceso de administración inevitablemente involucra elecciones que deben ser hechas entre "Progreso Económico" y "Perjuicio del Medio Ambiente". En tiempos recientes se ha producido mucha confrontación entre aquellos que abogan por un punto de vista o el otro. Muchos de los argumentos han sido emocionales y basados en muchos casos en una incompleta o un total desconocimiento de la situación real o de las implicaciones de una decisión o de la otra. El comienzo de una buena administración en cualquier disciplina es contar con información precisa, objetiva y a tiempo. La tecnología de Percepción Remota, que está enfocada a medir los parámetros de nuestro sistema planetario desde la distancia, conformará la base tecnológica de los deseados sistemas de distribución de la información. Si además se logra que los sistemas que instalamos hoy en día, como la Estación Cotopaxi, estén enfocados como la primera etapa en una mas grande empresa, seremos capaces finalmente de proporcionar tal información en una escala global.

Es importante enfatizar que lo que estamos tratando aquí es con **mediciones**, no simplemente observaciones. La Percepción Remota de la Tierra desde el espacio ha sido mirada, desde sus inicios a comienzo de la década del 70, principalmente como un ejercicio de "toma de imágenes". Hemos producido e interpretado visualmente magnificas fotografías de la superficie de la Tierra y su atmósfera, desde plataformas espaciales. Los instrumentos que enviamos al espacio son, sin embargo, capaces

de conseguir mucho más que una simple observación. Ellos son instrumentos precisos de medición, que pueden ser calibrados tanto espacial como radiométricamente y con alta precisión. La Estación Ecuatoriana Cotopaxi ha sido diseñada para explotar esta capacidad, que es necesaria para poder estudiar y seguir tendencias a través del tiempo de una manera objetiva. Nos permite cuantificar cambios en el sistema terrestre que pueden estar relacionados con procesos físicos en una forma objetiva y confiable. Siendo capaces de tratar la información de esta manera es esencial poder utilizar la información espacial exitosamente como datos de entrada a modelos del sistema Tierra. El uso de estos modelos será fundamental para ganar la comprensión necesaria para la exitosa administración de los recursos y el ambiente de nuestro planeta en el largo plazo.

Desde el punto de vista de las mediciones espaciales, la Tierra puede ser concebida como formada por cuatro componentes básicos: la tierra, el océano, la atmósfera y las zonas de hielo. Cuando observamos estos componentes debe recordarse que todos ellos están estrechamente interrelacionados. Uno no puede considerar la atmósfera independientemente del océano o la tierra y tampoco uno puede medir la tierra sin tener en cuenta los efectos de la atmósfera a través de la cual ésta debe ser observada.

Por ejemplo, para alguien que está relacionado con rastreo de fenómenos atmosféricos, los efectos de la atmósfera en la radiación observada contiene información valiosa (representan una "señal"), mientras que para alguien que está interesado en el rastreo de fenómenos en superficie (tales como temperatura oceánica), los efectos de la atmósfera en la radiación representan una interferencia en la señal ("ruido"). Un sistema de información puesto en operación para rastrear objetivamente el planeta, debe ser capaz de satisfacer las necesidades impuestas por muy diversos requerimientos, tales como los mencionados.

En orden a desarrollar una imagen consistente de las tendencias del sistema planetario a través del tiempo, las mediciones hechas por instrumentos a bordo de los satélites deben ser reducidas a variables físicas calibradas que tienen significados en términos de los procesos y ciclos que están siendo rastreados. Este proceso es mostrado esquemáticamente en la figura 1. En la etapa inicial de procesamiento, las medidas primarias de los sensores son calibradas y ubicadas con precisión en la superficie terrestre. Estas mediciones procesadas (por ejemplo radiancia) son almacenadas en una base de datos geocodificadas en conjunto con la información proveniente de otras fuentes. Las variables físicas (reflextancia, por ejemplo), que son ellas mismas almacenadas en la base de datos, son luego derivadas de las mediciones procesadas. Las variables físicas proporcionan entradas a los procesos de modelamiento que conducen a una comprensión del ecosistema que está siendo modelado. Al diseñar sistemas para hacer las mediciones y ejecutar las tareas de procesamiento necesarias, estamos obligados a hacernos tres importantes preguntas:

1. ¿Qué queremos medir?
2. ¿Por qué lo queremos medir?
3. ¿Cómo lo vamos a medir?

Las respuestas a estas preguntas determinan el tipo de sistema que deberemos construir y ellas sirven para recordarnos que el objetivo real del sistema es **distribución de información**. Estas respuestas enfatizan el

hecho que la parte crítica del sistema es el subsistema de manejo de información porque es este componente del sistema total, en conjunto con la serie de sensores que son usados en el aparato espacial, los que determinan el tipo y calidad de la información que finalmente recibiremos. En consecuencia, las respuestas a estas tres preguntas tienen un impacto fundamental en todos los aspectos de diseño del sistema, comenzando con la elección de las características de los sensores y órbitas y así continuando a través de todo el sistema de procesamiento. El rol del aparato espacial y el vehículo lanzador es simplemente llevar los instrumentos o sensores a un cierto punto en el espacio y tiempo, de manera de confeccionar un conjunto de mediciones y enviar la información resultante a la tierra. Viendo el problema de esta manera, cambia nuestra perspectiva sobre la importancia relativa de varios componentes del sistema en relación a aquellos que tradicionalmente han sido tomados más en cuenta. Ello conduce directamente a la visión que un sistema de Percepción Remota es en realidad un **sistema de distribución de información**, cuya razón de ser es la de distribuir información acerca del estado del planeta hacia aquellos que requieren esta información para tomar decisiones que afecten la administración del ambiente y el desarrollo de los recursos.

La figura 2 ilustra en forma esquemática la estructura básica de un sistema de distribución de información, que utiliza percepción remota del sistema terrestre como su mayor conjunto de entradas. Uno puede pensar en el sistema de distribución de información como consistente de una serie de etapas, comenzando con la adquisición de una medición a través de un sensor instalado en un aparato espacial. Esta medición es luego transmitida a la tierra donde es archivada en su forma primaria en la estación receptora. El procesamiento de una medición tiene lugar en varias etapas: Una etapa de preprocesamiento convierte los números digitales primarios (DN) en una cantidad calibrada, que es proporcional a la radiancia electromagnética entrando al sistema de apertura del instrumento en el instante de la adquisición. En esta etapa del proceso, la ubicación posicional de cada medición es descrita en un sistema de coordenadas que depende del trazado orbital particular y la conducta dinámica de la plataforma espacial, así como de la geometría del instrumento mismo (es decir la ubicación espacial es descrita en coordenadas de la plataforma). Los productos son generados por la estación receptora cuando están a este nivel de procesamiento. La siguiente etapa en el proceso, referida en la figura 2 como "Geocodificación", convierte el sistema de coordenadas de las mediciones a un sistema de coordenadas geográficas (es decir, son geocodificadas). Esto permite la fusión de estas mediciones con otras informaciones que están en el mismo sistema de coordenadas, de una manera directa. Los productos producidos por la estación terrena son definidos en varios niveles, dependiendo del grado de procesamiento. Estos niveles son definidos en la tabla 1. Mientras la estación terrena produce una amplia variedad de productos para satisfacer las necesidades de la diversa comunidad de usuarios, los más sofisticados son los conjuntos de datos geocodificados con alta precisión. Estos conjuntos de datos están diseñados para aplicaciones cuantitativas operacionales, donde las mediciones de Percepción Remota deben ser usadas en conjunto con otra información, ingresadas a una base de datos y aplicadas a toma de decisiones operacionales. En este contexto, "El

Procesamiento Avanzado", que generalmente depende del usuario, convierte la información primaria (DN) en cantidades físicas relacionadas tales como reflectancia, emitancia, etc., en un sistema de coordenadas geográficas (es decir, son geocodificadas).

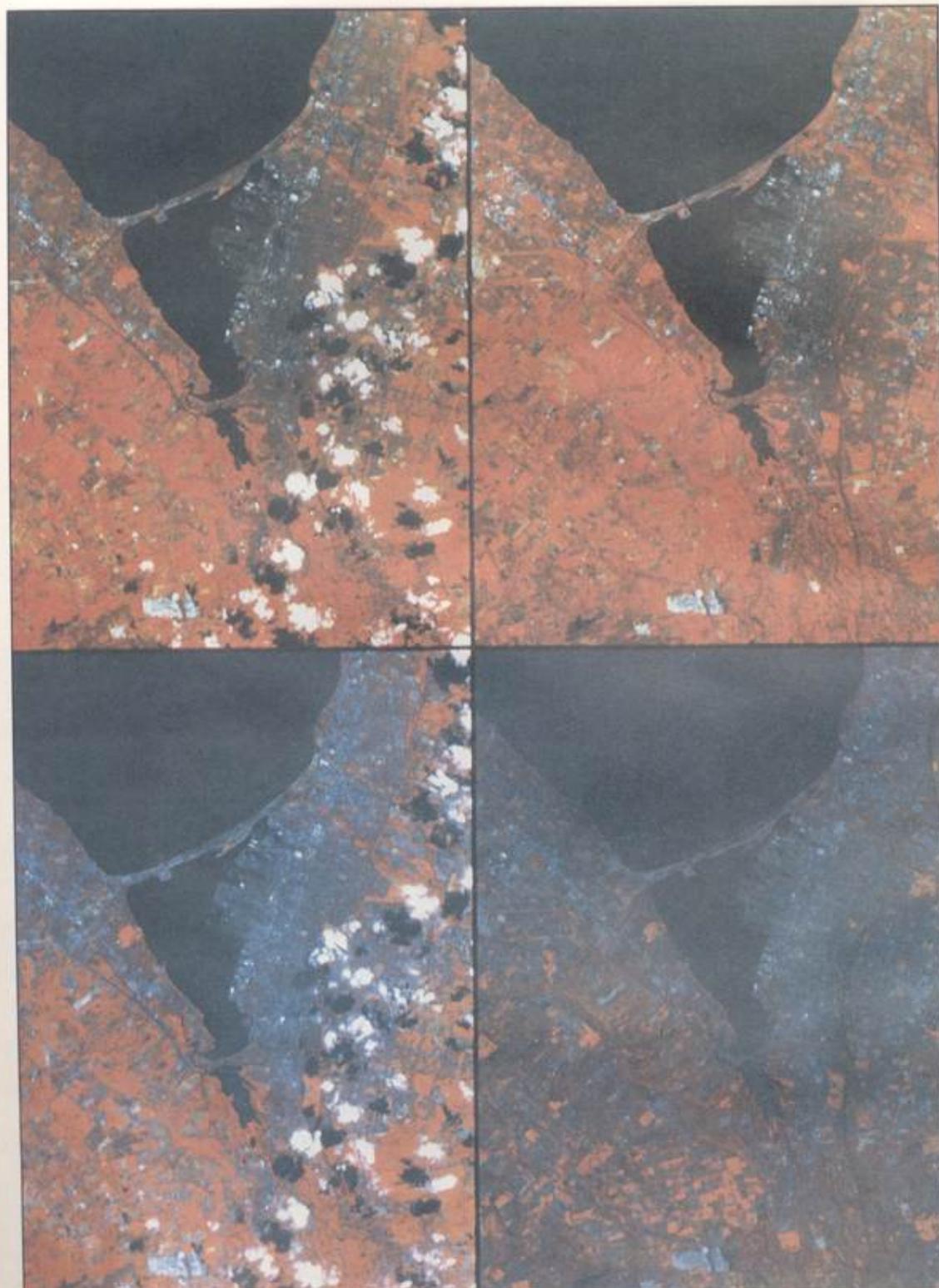
Poner las mediciones físicas calibradas en un sistema de coordenadas geográfico, permite lograr dos objetivos: 1) El uso de un sistema de coordenadas común, que es independiente de la geometría particular del aparato espacial utilizado, permite combinar y comparar mediciones provenientes de varias fuentes; 2) El uso de un sistema de coordenadas **geográficas** común, permite la fácil integración de las mediciones con otras informaciones mapa-referenciadas que ya están en el mismo sistema de coordenadas.

Las mediciones que están geocodificadas de esta manera pueden luego ser ingresadas a una Base de Datos de Mediciones, donde ellas son integradas con informaciones provenientes de otras fuentes. Tal sistema de base de datos puede ser concebido como una descripción genérica de una región de la Tierra en espacio y en tiempo. Su contenido describe tal región. La fase final en el sistema de distribución de información es la extracción de información de la Base de Datos como soporte para decisiones de administración ambiental y de recursos. Esto es mostrado en la figura 2, por los numerosos elementos de "Extracción de Información & Apoyo de Decisiones" al final del sistema de distribución. Esta etapa final en el proceso es muy dependiente de las aplicaciones. Las mismas mediciones físicas tiene diferentes significados y son interpretadas en distintos contextos, dependiendo de la disciplina de aplicación. Por ejemplo, el perfil de la reflectancia infrarroja sobre un bosque tiene sentido y significancia diferente para un Ingeniero Forestal que para un Geólogo. En consecuencia, apreciamos que la información obtenida en la Base de Datos es tratada e interpretada en forma distinta según las diversas disciplinas de aplicación.

LA ESTACION TERRENA DEL ECUADOR

El diseño de la Estación Ecuatoriana del Cotopaxi proporciona cobertura para unos 21 países en la Cuenca del Caribe y en la parte Noroeste de América del Sur. Su diseño está basado en la aproximación al sistema de distribución de información delineado recientemente y descrito esquemáticamente en la figura 2. Dado que los detalles del "Segmento de Usuarios" mostrado en la Figura 2 son altamente dependientes de factores relacionados con prioridades nacionales y disciplinas de aplicación, estas funciones de la cadena de distribución de información son mejor dirigidas a facilidades de procesamiento orientadas a aplicaciones operacionales según bases nacionales. Esto es delineado en la Figura 3, que muestra el nivel 0 de alimentación de la estación o conjunto de datos geocodificados a facilidades de procesamiento en países de la región de cobertura.

Las especificaciones de los productos LANDSAT disponibles en la Estación del Ecuador son mostrados en la Tabla 2 y las especificaciones para los productos SPOT, en la Tabla 3. Estos productos son confeccionados por un sistema que consiste principalmente de tres partes: un subsistema de Adquisición de Datos, un subsistema de Grabación y Reproducción y un subsistema de Procesamiento. Las responsabilidades funcionales de estos subsistemas son mostradas en la Figura 4.



ATMOSPHERIC CORRECTION: PROPER MODELLING OF THE ATMOSPHERE MAKES QUANTITATIVE REMOTE SENSING A REALITY. HERE LANDSAT TM SHOTS OF HAMILTON, ONTARIO APPEAR ALMOST IDENTICAL ONCE ATMOSPHERIC EFFECTS HAVE BEEN REMOVED.

CORRECCION ATMOSFERICA: EL ADECUADO MODELAMIENTO DE LA ATMOSFERA PERMITE HACER DE LA PERCEPCION REMOTA CUANTITATIVA UNA REALIDAD. EN ESTE EJEMPLO, VEMOS SUBESCENAS LANDSAT TM DE HAMILTON, ONTARIO, CANADA, QUE APARECEN CASI IDENTICAS UNA VEZ QUE LOS EFECTOS ATMOSFERICOS HAN SIDO REMOVIDOS.



THE SAME DATA DATA SET PROVIDES DIFFERENT INFORMATION TO DIFFERENT USERS. HERE A LANDSAT TM DATA SET OVER POINT GREY IN VANCOUVER, CANADA HAS BEEN USED TO DERIVE LAND COVER INFORMATION (UP) AS WELL AS ROAD PATTERNS (DOWN). EL MISMO CONJUNTO DE DATOS PROPORCIONA DIFERENTE INFORMACION SEGUN LOS USUARIOS QUE LO UTILICEN. AQUI, DATOS LANDSAT TM SOBRE POINT GREY VANCOUVER, CANADA, HA SIDO EMPLEADO PARA DERIVAR INFORMACION DE COBERTURA DE SUELO (ARRIBA) ASI COMO PATRONES DE CAMINOS O CARRETERAS (ABAJO)

PRODUCCION INDUSTRIAL DE ESPACIOMAPAS A PARTIR DE DATOS SPOT

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Resumen

L'Institut Géographique National (Instituto Geográfico Nacional: IGN) tiene la responsabilidad de la elaboración del mapa topográfico y de los mapas derivados de Francia. Presente desde el principio en el proyecto SPOT, el IGN, tiene también por finalidad el desarrollo de una técnica cartográfica de partir de datos de satélite. La implantación de IGN ESPACE en Toulouse (Francia) en 1989 responde a la necesidad de poner en producción estas técnicas en escala industrial.

El presente documento es una presentación de uno de los diferentes procesos desarrollados por IGN ESPECE: la producción industrial de espaciomapas a partir de datos SPOT.

Los espaciomapas SPOT están compuestos (vease reproducciones):
a) de un fondo imagen SPOT presentado en una proyección y un formato cartográfico de referencia elegidos por el usuario; b) de informaciones cartográficas y eventualmente toponimia

UTILIZACION

Un bajo costo y un ritmo rápido de producción (con un promedio de 100 hojas al mes) hacen atractivos los espaciomapas en los muchos casos en que no se necesita un auténtico mapa topográfico:

- * Cartografía de prospección, de proyecto, revisión de mapas básicos
- * Cubierta de áreas inaccesibles o muy nubladas cuando el mantenimiento de un avión fotógrafo resulta costoso
- * Estudios multitemporales

PROCESO DE PRODUCCION

Excepto la fase final de salida sobre película y sobre papel, se realizan todo el trabajo en computador a base de datos digitales.

El proceso consta de 4 etapas:

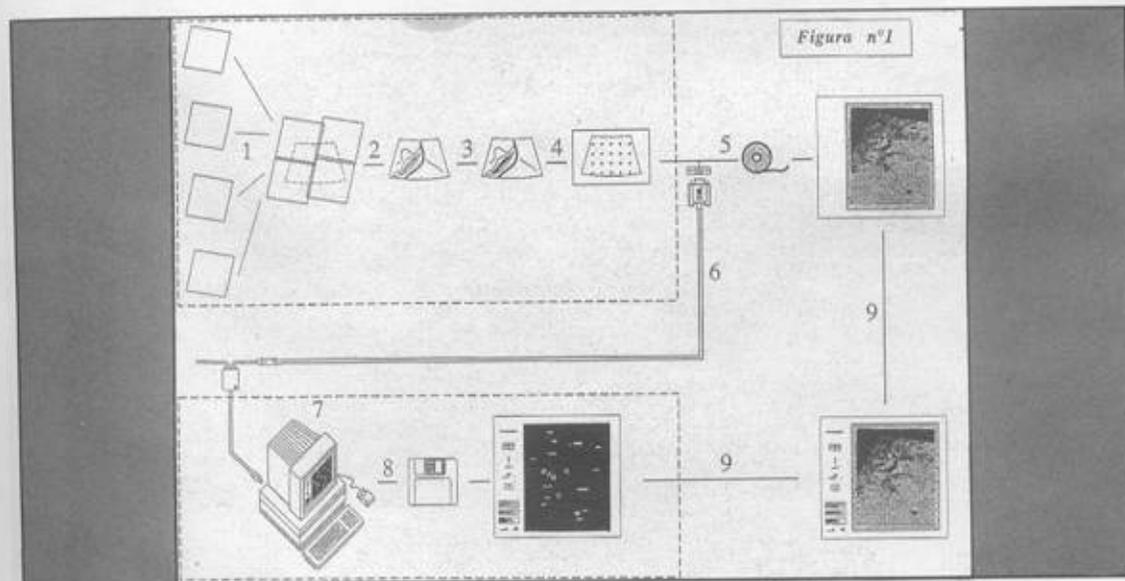
- * Rectificación de las imágenes en una proyección cartográfica
- * Mosaico de las escenas y confección del fondo imagen
- * Redacción de los nombres y de las informaciones marginales
- * Restitución sobre películas fotográficas
- * (eventualmente impresión de los mapas sobre papel)

A.-Corrección de las imágenes en Nivel 2 ó en Nivel 3 (ortoimagen)

En nivel 1, la geometría de las imágenes depende de las condiciones de toma (posición del satélite, ángulos de vista,...), por eso resulta imposible la confección del mosaico en cuanto cambia la fecha o la inclinación.

La finalidad de la rectificación en una proyección cartográfica (Mercator, Lambert o cualquier otra elegida por el usuario) es doble:

- * Hacer posible el mosaico de las escenas
- * Suministrar al usuario un documento de trabajo que le es familiar (los mapas que está acostumbrado a consultar)



Las escenas grabadas en cintas magnéticas, son leídas y almacenadas en el computador.

Para la corrección de nivel 2 ó 3 se toman puntos de apoyo y puntos de paso entre las fajas como en aerotriangulación clásica. Se procesan las imágenes conjuntamente. En cada faja (misma fecha, misma órbita, misma inclinación) 3 puntos de apoyo son necesarios, en cada extremo; luego se pueden tomar puntos de paso en el conjunto para asegurar la buena coherencia del mosaico.

* Los puntos de apoyo proceden de mapas existentes o de mediciones (GPS) en el terreno realizadas tras la adquisición de las imágenes (esto equivale a la estereopreparación). Este procedimiento largo y costoso queda poco utilizado: cuando no existen mapas fiables, sólo se toman en cuenta los datos satélite (Nivel 2A) la precisión de localización absoluta será de 400 metros.

* Los puntos de paso se eligen independientemente de los mapas: son detalles característicos muy puntuales que se pueden identificar sin ambigüedad de una imagen a otra.

Terminada la toma de puntos, se efectúa la rectificación de todas las escenas, sea en nivel 2, sea en nivel 3 (para

obtener una precisión cartográfica (de unos 20 m) en toda la imagen.

Por lo que se refiere al nivel 3, es necesario disponer de un MNT procedente sea del proceso automático de un par estereoscópico de escenas SPOT sea procedente de la digitalización de las curvas de nivel de una cartografía existente. En general se elige esta última opción (por su bajo costo) salvo en el caso de que las aplicaciones necesiten una precisión geométrica del orden de un pixel.

Al final de esta etapa, un conjunto de escenas de nivel 2 (u ortoimágenes) está listo en el computador. La etapa siguiente consiste en juntarlas y recortarlas.

B.- Formación del mosaico y confección del fondo imagen

Esta fase es muy automatizada. Se puede efectuar los procesos por ordenador, uno tras otro, la mayoría de las veces de noche. Se hace un control visual sólo al final, con el fin de comprobar si las juntas no quedan demasiado visibles.

En efecto, a pesar de la igualación previa de las imágenes, a veces ocurre que sea necesario "guiar" la línea de junta para evitar alguna zona de aspecto muy diferente

CONCEPCION



Escala 1:25.000
1 cm = 250 m

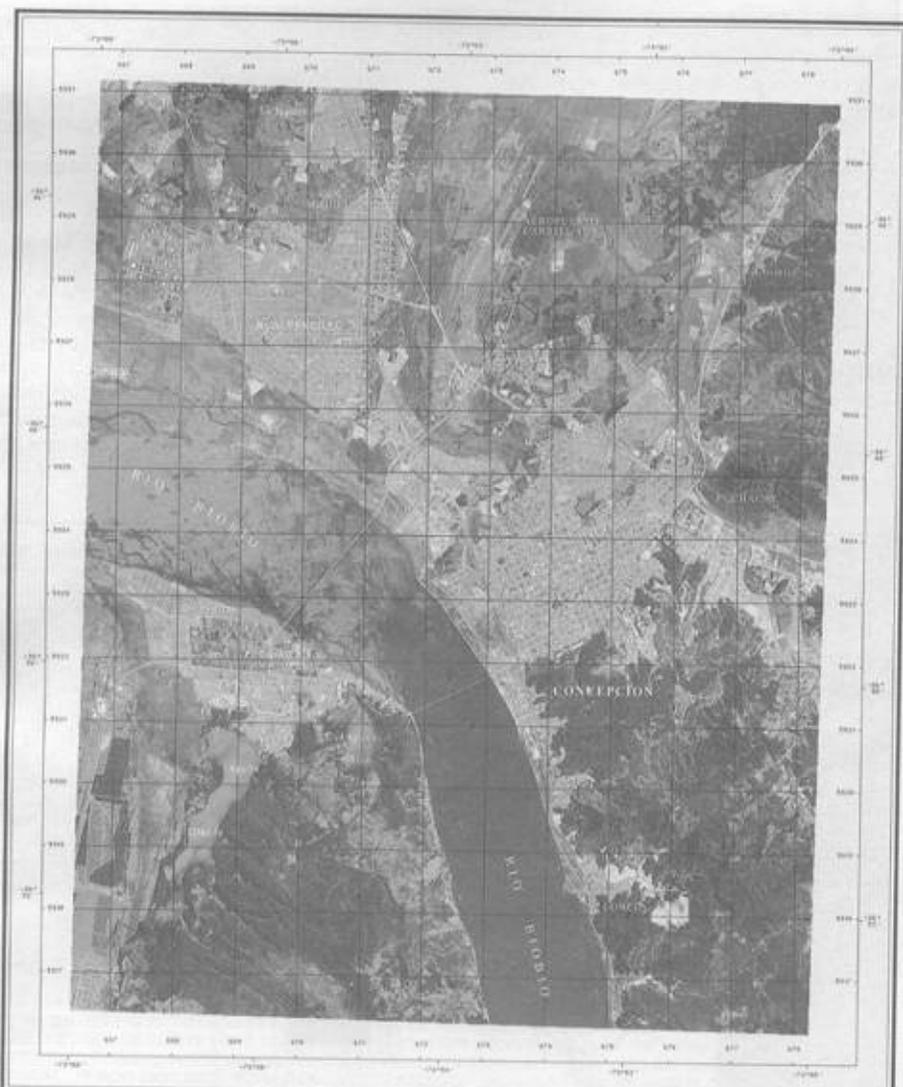


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redacción de las informaciones y de los topónimos es perfectamente equivalente al método convencional que utilizaba un papel de calcar transparente sobre una prueba fotográfica a escala del documento final.

Las ventajas de la redacción asistida por computador son numerosas: facilidad de manejo, rapidez de ejecución, ligereza de las modificaciones y correcciones, importante economía de soportes.

Cada operador puede redactar 5 mapas por día en vez de uno por el método convencional

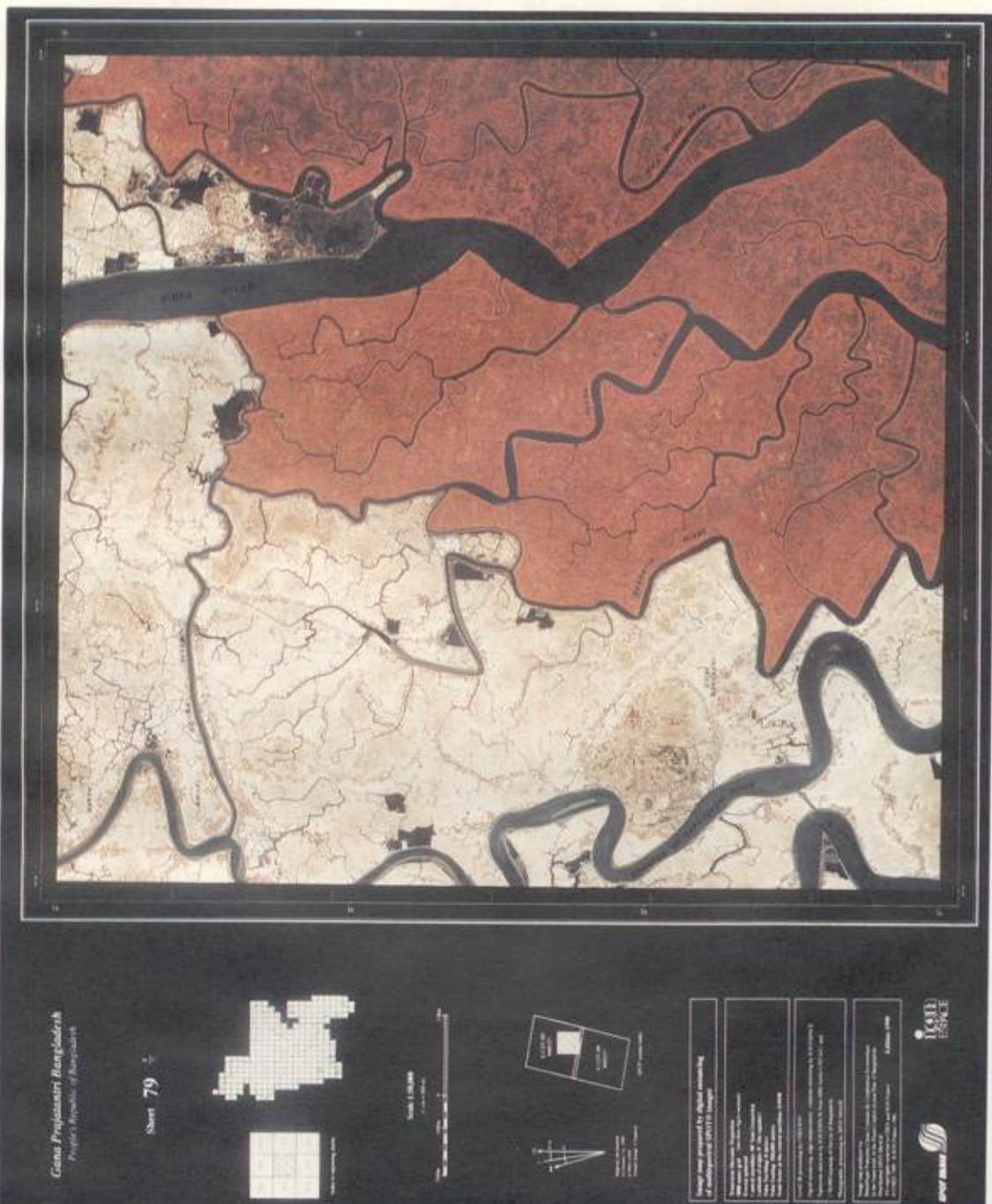
Al final del proceso, todas las informaciones reda-

ctadas, grabadas en una diskette (8) se transfieren a una película blanco y negro en una linotipia a misma escala que la película de la imagen.

Por fin, se reúnen las dos películas para formar una película única (9) a partir de la cual se pueden efectuar todas las operaciones corrientes (reproducción fotográfica, impresión sobre papel).

CONCLUSION

Con este proceso original y de uso cómodo IGN ESPACE dispone de un instrumento potente y eficaz de producción cartográfica.





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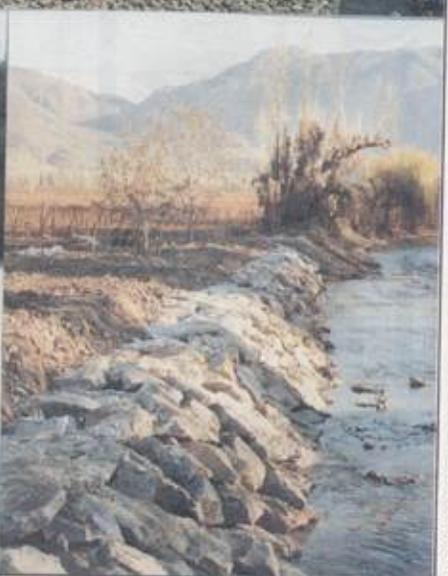
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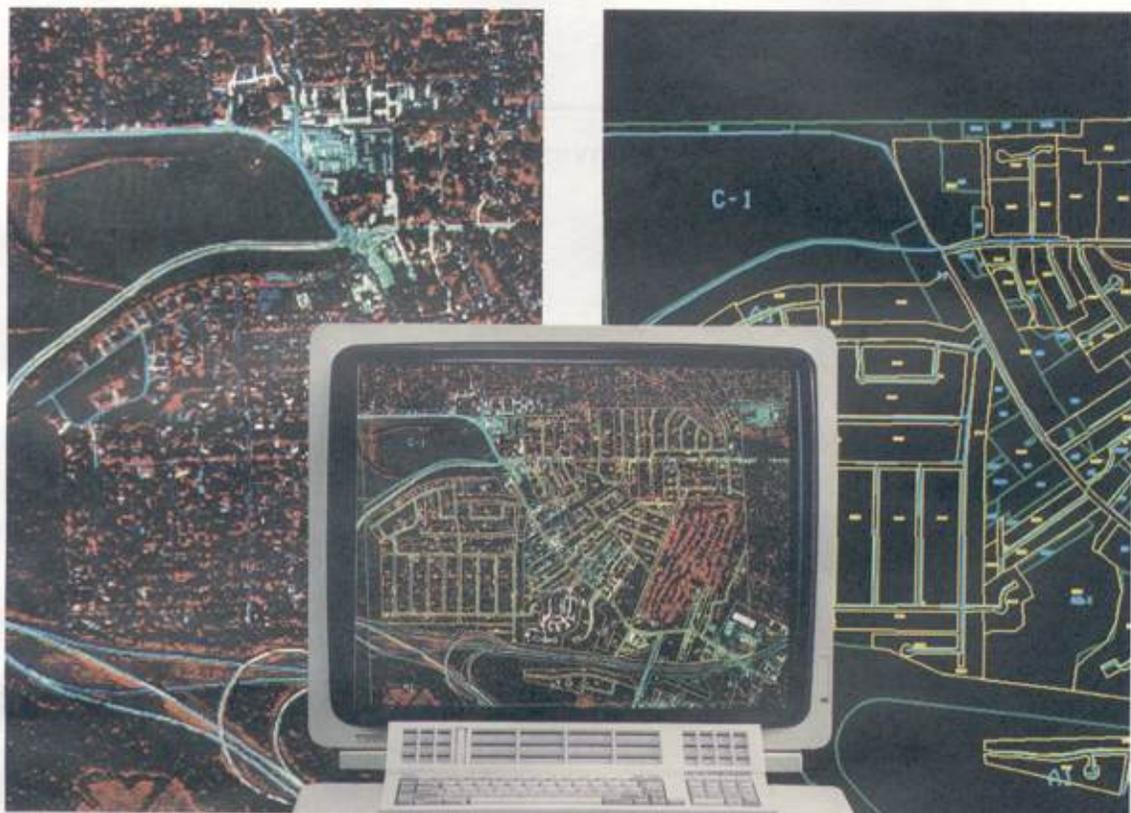
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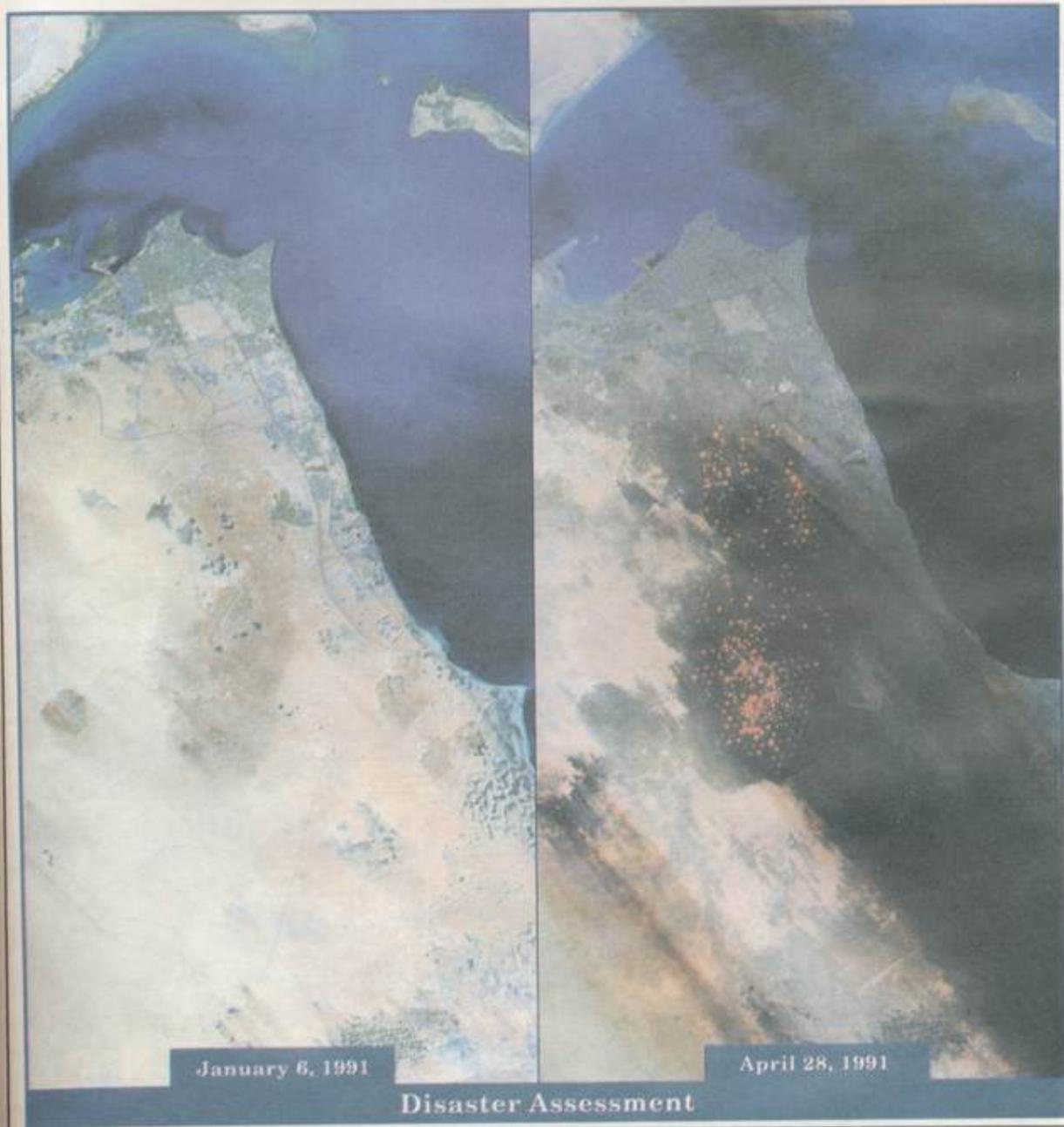
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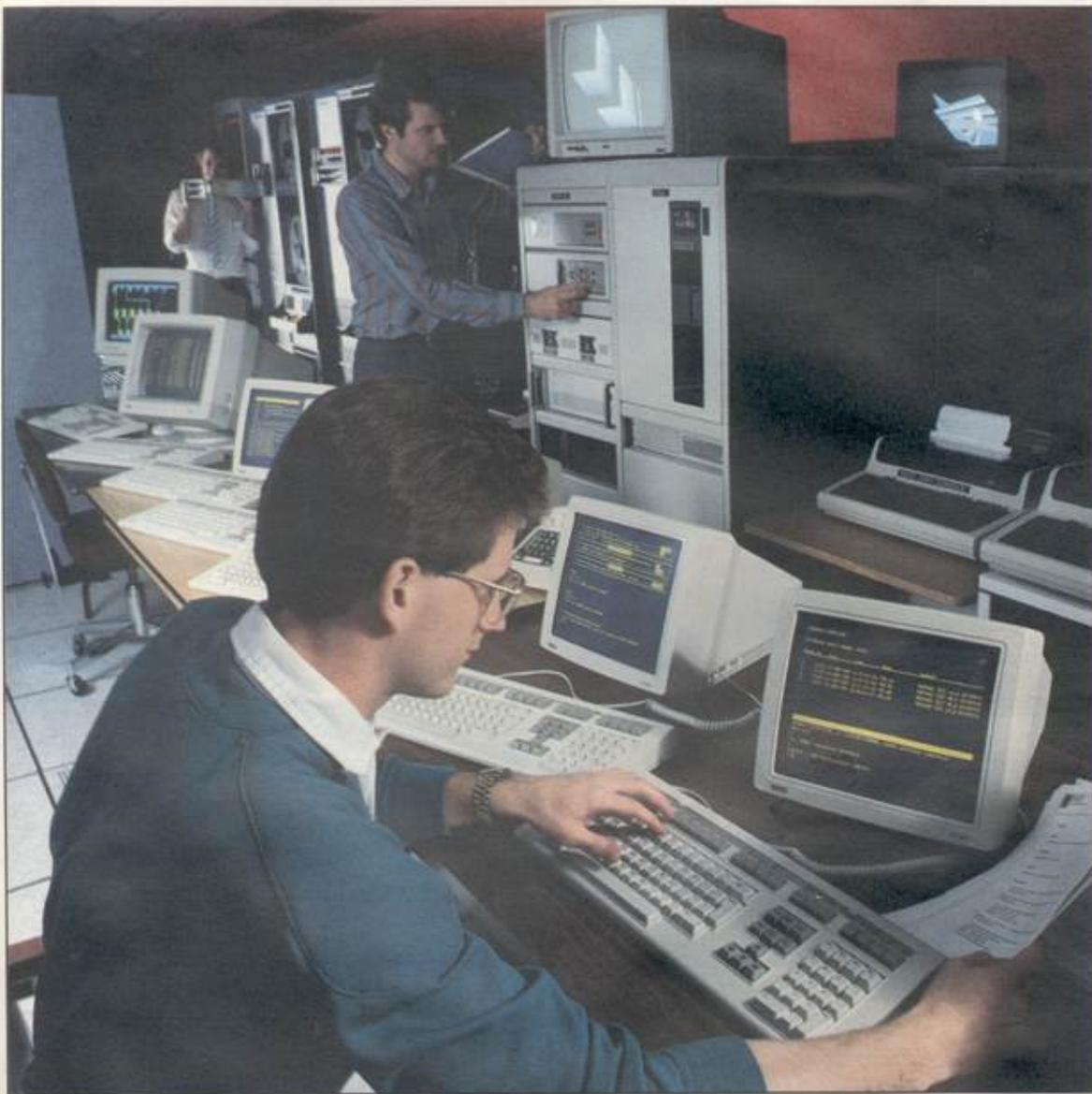
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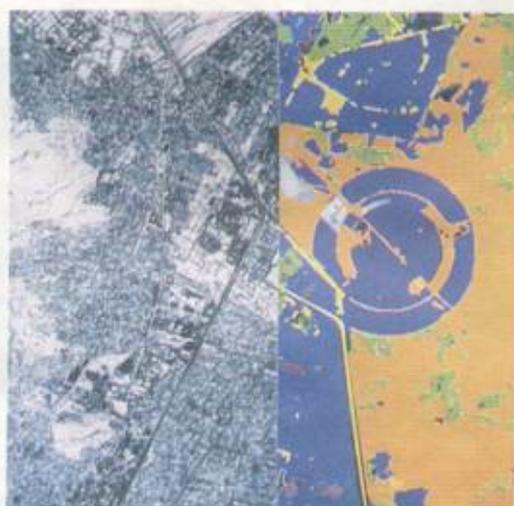


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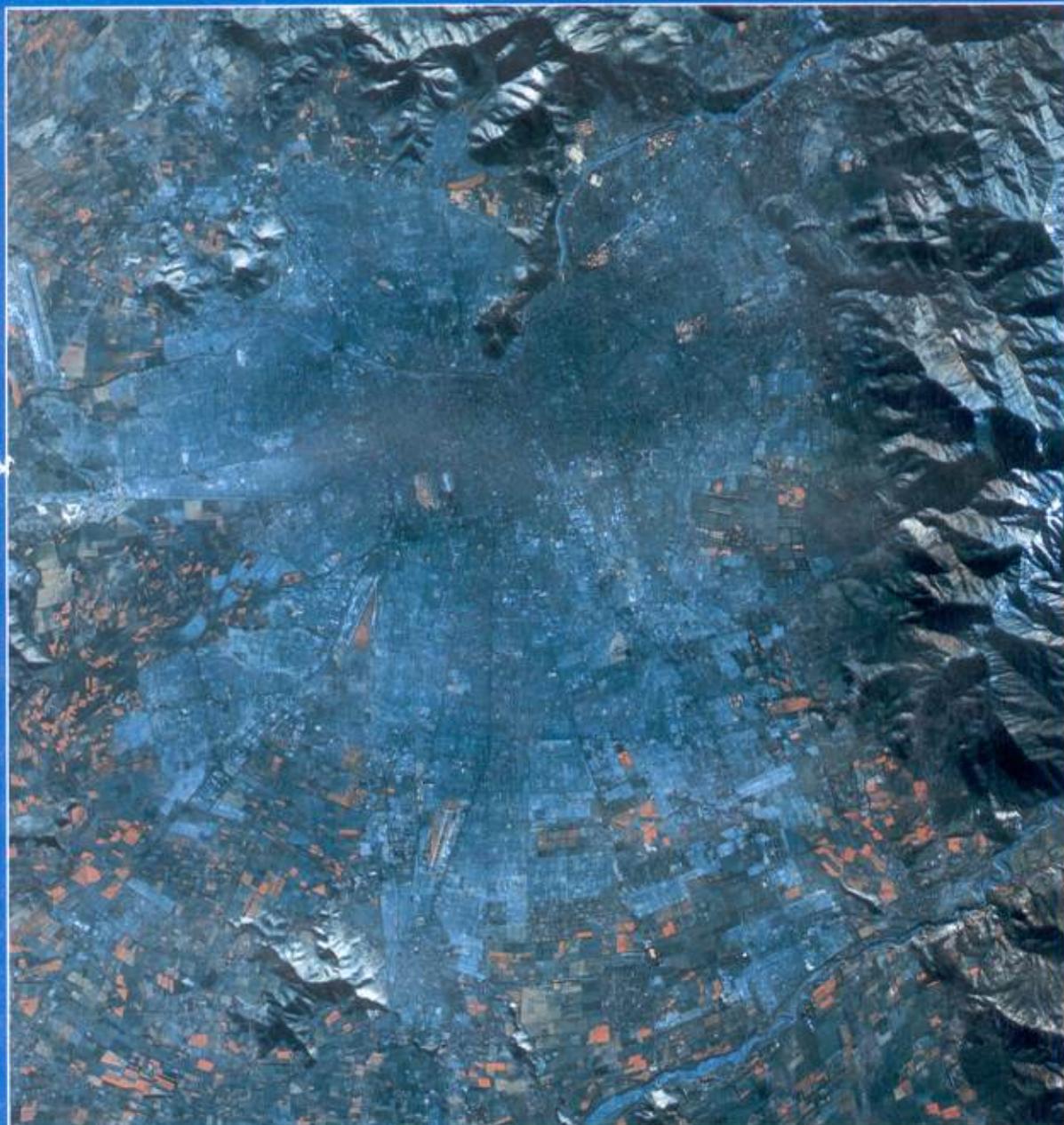
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