

# REMOTE SENSING IN ITALY FROM 2000 TO 2004

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## ABSTRACT

This paper summarises the activity performed by the Italian scientific community in the field of remote sensing in the last four years. It is particularly referred to the community that is represented by the Italian Remote Sensing Association (AIT) that includes people operating in different sectors concerning scientific (public and private) and academic institutions, and industry. According to the guidelines provided by the international community, techniques focused on improving the scientific knowledge of the environment, on operational applications devoted to provide innovation, added-value to services and, globally, enhancement of quality of life were developed. The more relevant initiatives of the Italian Remote Sensing community are reported, as they are testified by the scientific workshop and conferences organised on specific topics.

## 1. INTRODUCTION

In the last four years the remote sensing Italian community has been particularly active, besides restriction occurred in terms of financial support to public structures and institutions including research centres and universities. Also for the year 2003 the trend of the reduction of the budget for research in Earth Observation has strongly characterised the scientific activities in Italy. The freezing of the employment at the University and Institutions like the National Research Council of Italy (CNR), and many others, joint with the nomination of commissaries at CNR and [Italian Space Agency \(ASI\)](#), reduced significantly the opportunities to carry on research activities in the field of remote sensing. However, many groups have been working in international projects, both devoted to analysis of data produced by new sensors and to the design of new instruments. Also project devoted to education in the use of remote sensing data and techniques were carried out, involving in particular the universities that organised master courses in Remote Sensing and GIS.

In recent years the main feature that has characterised Remote Sensing in Italy is a new approach to environmental applications driven by the availability of a new satellite sensor generation, both in the optical and in the microwave range. Very high resolution optical data, such as those provided by IKONOS and Quickbird satellites had profound effects on expanding remote sensing applications in terms of stimulating a major request from public administration of products derived from these satellites to study, monitor and manage the environment. In particular these data, along with those provided by digital cameras, favoured the development of applications on agricultural (precision farming) and urban areas as well as on areas of small extension, which are often of major concern to public administration. In microwave range, the multi-polarization and multi-angle SAR of ENVISAT represented a considerable improvement with respect of ERS satellites for land applications. On the other hand, for a large scale monitoring, which is useful for the study of the dynamics of climate changes, the new multi-channel microwave radiometers AMSR and AMSR-E onboard ADEOS-II and AQUA satellites, respectively, guarantee a very large Earth's coverage with a frequency spectrum able to give information on the whole water cycle.

Studies are also being conducted on the integration of optical remote sensing data and ecosystem modelling functions for evaluating the carbon budget of natural and semi-natural vegetated surfaces.

Following the more relevant initiatives of the Italian Remote Sensing community are reported, as they are testified by the scientific workshop and conferences organised on specific topics. Reference is also made to the activity of the Remote Sensing Association and of ASI.

## 2. THE SPECTRA MISSION

The goal of the SPECTRA mission is to investigate the role of terrestrial vegetation in the carbon cycle and its response to climate variability. Dedicated research has demonstrated that accuracy of biophysical variables, as used in ecosystem models can be improved with retrievals from multi-angular, hyperspectral remotely sensed data. The SPECTRA mission will provide such data sets for all global biomes. Biome-specific parameters can then be assimilated into ecosystem models at local, regional and global scales, resulting in improved monitoring and understanding of the dynamics of the global carbon cycle.

The mission is conceived as a single satellite that will carry a space-borne imaging spectrometer. This instrument will be able to view targets on the Earth from different angles in order to analyse directional reflectance and emission of thermal radiance by soil and vegetation. SPECTRA will focus on systematically obtaining data over an ensemble of regions that are representative of all the major terrestrial biomes, such as boreal forest, deciduous woodland, tropical forest and savannah. The data acquired by SPECTRA will help derive measurements of important plant properties, such as chlorophyll and water content, temperature and leaf area. This information can then be used in larger scale models for accurate assessment of the current and future role that terrestrial vegetation plays in the global carbon cycle.

The 2nd SPECTRA Workshop, was held on 28-30 October 2003, provided the forum for a wide range of interesting discussions covering all aspects of the SPECTRA mission concept. The mission, which has just finished undergoing feasibility study, aims to address areas of uncertainty in the

terrestrial carbon cycle balance by describing, understanding and modelling the role that terrestrial vegetation plays in the carbon cycle and how it responds to climate change. The work presented at the event demonstrated that the preparation of the SPECTRA mission concept has focussed a wide community on the scientific exploitation of the data that can be achieved from this mission.

Next spring the mission will undergo the Earth Explorer selection process. If selected for further development, the SPECTRA mission will offer a better understanding of the role that vegetation plays in the carbon cycle, and this is vital for improving capabilities to analyse processes related to climate change and to further our understanding of the impact that increasing human activity is having on terrestrial ecosystems. As an additional product of the long optical remote sensing development effort in Europe, SPECTRA will extend and consolidate European expertise in the area of hyper-spectral instrumentation. It will provide the knowledge base needed to develop space-based tools for long-term observations of the state and mechanisms of the biosphere, as required for the European GMES effort.

### **3. HYPERSPETRAL OBSERVATIONS OF TERRESTRIAL ENVIRONMENTS**

Airborne imaging spectroscopy in Europe has a long history, including the Italian spectrometer MIVIS (Multispectral Infrared and Visible Imaging Spectrometer) of the CNR and the German spectrometers ROSIS and DAIS. In the last years MIVIS supported several projects aimed at urban areas monitoring, forest mapping and analysis, environmental hazard and monitoring. A major concern on the applications that can be carried out by hyperspectral data is also expressed by departments of the Italian Ministry of Defence to fight illegal activities all over the Italian Territory.

Hyperspectral instruments have already been launched into space; Hyperion on EO1 by NASA and CHRIS on the PROBA platform by ESA. Contemporaneously, ASI has financed some studies on the technology and application potential of hyperspectral sensors. In the next few years, ASI plans to develop a technological demonstrator of hyperspectral observations in the VIS through SWIR region. These instruments are prototypes that are designed to validate new technological solutions and concepts. They are associated with low and uncertain revisiting capacity, limited swath, and often limited radiometric performances. Furthermore, they will also have a relatively short lifetime and give limited access to the data. Nevertheless, they offer a very interesting opportunity to evaluate and develop retrieval algorithms based on their improved spectral sampling capacity.

A workshop concerning hyperspectral observations was held in Florence, in March 2004. The workshop was intended to be a forum to report recent advances on instrument development, processing and calibration, new methods and algorithms as well thematic applications with focus on different terrestrial environments. It was therefore an opportunity to present and discuss the last advances in these fields, with particular relevance to the integrated use of hyper-spectral observations and ground data for simulating and modeling the main processes occurring through the land-atmosphere interface, such as evapo-transpiration, photosynthesis and productivity. The event was sponsored by the National Research Council, the Italian Remote Sensing Association and the Italian Space Agency, and it was hosted by the Accademia dei Georgofili of Florence.

### **4. MONITORING AND INDICATORS OF FOREST BIODIVERSITY**

The biological diversity of European forests is the result of the evolution of the communities under ecological forces such as climate, fire and competition, as well as a long history of human influence. A key issue for a strategy to preserve forest biodiversity is to find principles based upon an optimal mixture of designated areas and production forests managed with considerations of biodiversity. In both categories the objectives and management to reach the aims must be based upon scientifically sound knowledge of the biological diversity and ecosystem processes. To be successful this strategy should be developed and locally adapted in close interaction with policy makers, forest owners and other stakeholders. On a pan-European scale there is a need to further develop biodiversity assessment tools; i.e. indicators of biodiversity and preferred methodologies to collect data. Validation and further definition of biodiversity indicators and/or inventory methodologies are crucial for the progress. A pan-European forest stratification, i.e. forest type classification, is needed both for a successful implementation of indicators and to facilitate the assessment to be carried out. In this context Remote Sensing plays a major role as demonstrated by the IUFRO (International Union of Forest Research Organisation) conference organised in Florence, Italy, November 2003. The conference, organised by Italian (University of Florence, Italian Academy of forest Sciences, Italian Ministry of Agriculture) and European (EEA, JRC) institutions provided a forum for discussions between experts with field experience, the wider scientific community and policymakers related to forests and the environment on how to successfully implement biodiversity indicators, e.g. with respect to adaptation to forest types and methods for inventory.

### **5. MULTI-TEMPORAL STUDIES**

The development of effective methodologies for the analysis of multi-temporal data is one of the most important and challenging issues that the remote sensing community will face in the coming years. Its importance and timeliness are directly related to the ever-increasing quantity of multi-temporal data provided by the numerous remote sensing satellites that orbit our planet. The synergistic use of multi-temporal remote sensing data and advanced analysis methodologies results in the possibility of solving complex problems related to the monitoring of the Earth's surface and atmosphere at different scales. However, the advances in the methodologies for the analysis of multi-temporal data have been significantly under-illuminated with respect to other remote sensing data analysis topics. In addition, the link between the end-users' needs and the scientific community needs to be strengthened. The second International Workshop "Analysis of Multi-Temporal Remote Sensing Images" was successfully held at Joint Research Centre, Ispra, Italy on July 2003. The proceedings volume is now available and contains several contributions from researchers representing academic and research institutions, industry and governmental organizations. It is organized into three thematic sections: Image Analysis and Algorithms; Analysis of Synthetic Aperture Radar Data; Monitoring and Management of Resources. The workshop was organised by the Remote Sensing Laboratory, Dept. of Information and Communication Technologies, University of Trento, Italy

## 6. ITALIAN SPACE AGENCY

In 2003 the Italian Government appointed Prof. Sergio Vetrella (for several years EARSeL Chairman) as Commissary of the Italian Space Agency (ASI). The necessity to reorganise the Agency restricted tremendously the financial support to the Research Community. ASI, on the basis of the Italian Government Directives, has already started joint activities with ESA programs and other International Space Agencies (i.e., NASA, CNES, DLR, CONAE).

Italy has a fundamental role in the following projects:

- *Vega*: the strategic ESA small-medium launcher;
- *Galileo*: the Europe's own global navigation satellite system;
- *Cosmo-SkyMed*: the first dual satellites constellation for high resolution Earth Observation (ORFEO program) jointly with the Pleiades program defined by CNES; in its final configuration Cosmo-SkyMed should provide a constellation of about seven satellites equipped with SAR and hyperspectral sensors, designed to provide data in the fields of risk management, geology, agriculture and forest systems, land management and ecology, monitoring of coastal zones and law enforcement.

The Italian Space Program 2003-2005 is the first that derives from the guidelines included in the Research National Program proposed by the Instruction and Research Ministry. The central focus of the Program is the application oriented approach, where the research and the innovation are important to reach well defined product-objectives. There are five main thematic areas: Earth Observation, Telecommunication, Navigation, Medicine and Biotechnology, Astronomy and Astrophysics.

Concerning Earth Observation, strong relevance has been focused on four main arguments: oil spill, landslides, floods and forest fires. Activities on this topics are planned to start in 2004. ASI also supported a project proposed by AIT devoted to validation of satellite-derived thematic products, and to satellite data calibration and validation.

## 7. ASSOCIATIONS

The Italian Remote Sensing Association (AIT) was particularly active in promoting the use of remote sensing data at different level of expertise through the organisation of thematic seminars and workshop. AIT is member of the Federation of the Scientific Societies for the Geographic and Environmental Information (ASITA) since 1997 that includes also the Scientific Associations SIFET, AIC and AM/FM GIS Italy; all these associations are involved with different aspects of Geomatics. In particular:

*SIFET* is the Society for Topography and Photogrammetry, representing Italy within the International Society for Photogrammetry and Remote Sensing (ISPRS);

*AIC* is the Cartography Association, representing Italy in the International Cartography Association (ICA);

*AM/FM/GIS Italia* - Automated Mapping/Facilities Management/ Geographic Information System/Italia;

The 7<sup>th</sup> National Conference of ASITA was held in Verona, 27-31 October 2003. About 1.300 participants attended the Conference, 350 papers were published in the Proceedings, and more than 60 exhibitors presented their technical solutions in the field of the Geographic Information. Eberhard Parlow, EARSeL Chairman presented an invited paper in the introductory plenary session of the Conference. Further information about the several activities promoted by ASITA can be found at the Web site: [www.asita.it](http://www.asita.it).

Since 1996 AIT is also Associate Member of ISPRS and has about 450 Members. Each year AIT publishes three issues of the Italian reviewed Remote Sensing Journal (Rivista Italiana di Telerilevamento), and supports and organises several training courses concerning EO and GIS, as well as National and International thematic workshops.

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## 8. LABORATORIES

*CNR- Institute for the Electromagnetic Detection of the Environment (IREA), Milan*

The activities of the Institute have concerned with: Geomatics, optical passive remote sensing; active remote sensing in the microwave band; electromagnetic diagnostics; modelling of the electromagnetic interaction processes; integration of multisource spatial data for environment monitoring; evaluation of exposure and of biological effects related to electromagnetic fields. Simulation of optical Cosmo-SkyMed imagery is among the major activities.

The Institute has strong interest and activities concerning Education and Training.

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*CNR-Institute for Atmospheric Pollution (IIA), Monterotondo (Rome)*

This Institute manages the hyperspectral airborne MIVIS sensor in cooperation with CGR (Compagnia Generale Riprese aeree, Parma, Italy). In the last four years several initiatives were focused on the deployment of the MIVIS sensor over the Italian territory and relevant environmental issues were studied by MIVIS data, particularly referred to vegetated areas, and to urban areas to detect asbestos and to monitor the impact of waste disposal. MIVIS data were also acquired during the Etna eruption occurred in July-August, thus providing valuable data for volcanologic research and to support ASTER data validation.

A special issue of the Italian Remote Sensing Journal (edited by the Italian Remote Sensing Association) was devoted to the results of the MIVIS workshop held at Colorno (Parma), on June 2000. This issue contains 17 papers spanning a wide range of applications including urban, marine and lagoon environments analysis and investigations, lake monitoring, and archaeological investigation. Many of the papers discussed the results obtained in studying active volcanic areas of southern Italy, and in performing atmospheric correction and calibration of the MIVIS sensor. A relevant feature, common to all the papers, was the contribution provided by field spectral signatures acquired in the 350-2500 nm wavelength range to support MIVIS data calibration and validation.

Among the major research activities of IIA is the analysis of the relationship between reflectance and physical characteristics of the snow cover in polar regions. Several field surveys were carried out at Ny-Ålesund, Svalbard and at Terra Nova Bay, Victoria Land, Antarctica, to acquire spectroradiometric and ancillary data of different snow and ice surfaces. Field reflectance was measured in the spectral range 350-2500 nm, and snow data including temperature, grain size and shape, density and water content, surface layer morphology, vertical profile of the snow pack were also collected. A detailed analysis of reflectance based on snow physical structure was performed. Field reflectance data were also re-sampled at the spectral intervals of Landsat TM to compare the ability of identifying different snow targets at discrete wavelength intervals.

Field data were all organised into a relational data base called SISpec.

*Department of Electronics and Information (DEI) of the Politecnico di Milan*

The Permanent Scatterers Technique (PST) applied to ERS SAR data for monitoring ground deformation has become fully operational. Ground deformation monitoring by means of the PST is now offered as a service through Telerilevamento Europa (T.R.E.) base in Milan.

Ground based parasitic SAR studies are currently in progress at POLIMI. A second prototypal receiving station has been completed. It consists of two synchronized satellite digital TV receivers that cross-correlate the direct TV signal with that backscattered by the terrain. The system will generate X-band SAR images of the observed area every 12 hours. They will be exploited to analyse X-band backscattering and interferometric possibilities, in order to evaluate atmospheric effects and the availability of PS.

*CNR-IBIMET, Institute of Bio-meteorology, Florence*

The institute is active in several fields of environmental monitoring, and particularly in the evaluation of the effects of climate changes on natural and artificially controlled ecosystems. The remote sensing sector mainly deals with the integration of conventional and remote sensing data within a modelling approach for estimating and monitoring vegetation processes. Specific efforts are presently devoted in order to operationally evaluate the main bio-geo-chemical fluxes through vegetated surfaces whose knowledge is essential for the correct management of environmental resources at both local and global scales.

*CNR- Earth Observation Dept. Institute of Applied Physics (IFAc), Florence*

Several activities were carried out during 2003 at IFAc, mainly within the framework of the ENVISAT projects.

Atmosphere: The processor for the near real time level 2 analysis of the MIPAS instrument, operating on the ENVISAT satellite, was successfully implemented and for the first time global maps of atmospheric temperature and composition are daily acquired in a tri-dimensional field (latitude, longitude and altitude).

Microwave activity: Experiments on snow with microwave sensors (radiometers and SAR), within the framework of both Envisnow and ASI projects, were concluded in summer 2003. Snow parameters were measured and used as inputs in hydrological models. Soil moisture mapping from multitemporal ENVISAT images for the monitoring of areas at risk of flooding (EC Floodman project).

Ionospheric activity: Total Electron Content (TEC) and electron density determinations (tomography) from: 1- measurements by a chain of four NIMS receivers, 2-Analysis of downloaded GPS data; 3- downloaded occultation and ionosonde data.

Investigation and modelling of ionospheric scintillation  
Lidar: reconstruction of 3-D fluorescence images of phytoplanktonic cells carried out by using fluorescence microscopy. Participation in the EC SERQUA regional project for the use of different remote sensing instruments devoted to the monitoring of air and water quality in industrial sites.

*IPRS Image Processing and Pattern Recognition for Remote Sensing Laboratory, University of Genoa*

The Laboratory is involved in the development of image analysis and pattern recognition methodologies for several applications related to the EO. The activity of this year has been focused mainly on the following methodologies applied in particular to natural disaster management and environmental monitoring: Multi-temporal classification and partially supervised and unsupervised analysis for change detection;

Supervised classification with unknown classes based on Support Vector Machines (SVM) for non-parametric probability density function estimation; hierarchical clustering and hybrid supervised/unsupervised classification; texture analysis in high spatial resolution images; feature reduction, Expectation-Maximization, use of semi-labelled samples for hyperspectral data analysis. In addition we have considered: water quality analysis from hyperspectral images, coastline extraction from satellite SAR images based on the fusion of intensity and coherence information extracted from an interferometric couple.

## 9. EDUCATIONAL PROJECTS FOR DEVELOPING COUNTRIES

An adequate knowledge of available natural resources is a basic step before any rural development initiative. Problems very often arise in developing countries, due to lack or inadequacy of environmental information. 'Geomatics' is a modern scientific term referring to the integrated approach of collection, analysis, and management of Earth-based data. Such data can come from many sources, including earth observation satellites, airborne sensors and ground observations. In this context, Remote Sensing and Geographical Information Systems (GIS) are outstanding data collection and management tools.

In this context The Istituto Agronomico per l'Oltremare (IAO – Florence) has organised and managed training activities for Developing Countries by means of the Professional Master on "Geomatics and natural resources evaluation".

The IAO approach is based upon a pragmatic and interdisciplinary integration of field survey and remote sensing, both aerial photographs and satellite imagery, by mean of GIS techniques, in varying proportions according to the scale of the study. The aim of the Course is to provide participants, having different academic qualifications, with a common background on Remote Sensing data processing and interpretation as well as on GIS set up and use, in order to carry out natural resources inventories and their evaluation, with special emphasis on the rural sector in developing countries.

The Course is divided into two basic modules: the first one is a series of lectures and seminars, followed by practical exercises. Topics covers fundamentals of Remote Sensing, GIS and related disciplines, as well as Remote Sensing applications in various environmental fields. Visits to government departments and private companies are also included. The second module is a complete case study including one month of fieldwork in a developing country. Previous case studies have been set in Tunisia, Morocco, Eritrea, Bolivia and Senegal.

In the past IAO has developed several bi-lateral development co-operation projects and contracts with international agencies. The most important concern with the Africover project. IAO has carried out the final phase of the building of the digital land cover database for the Democratic Republic of Congo (1:200,000), now available on line at the following address:

Bi-lateral development co-operation projects include:

- Training project on Natural Resources Management and Food Security in the Sahel (in collaboration with the Agrhyet Regional Centre),
- Strengthening the Centre de Suivi Ecologique (CSE) in Dakar-Senegal for the production and management of information on natural and environmental resources.

Multilateral and multi-bilateral initiatives

- FAO project "Soil and Water Conservation in the Governorates of Kairouan, Siliana and Zaghwan" (GCP/TUN/028/ITA) in Tunisia, IAO is assisting the Regional Centres for Agricultural Development

(CRDA) and the DG/ACTA in strengthening and developing their GIS units

- FAO/UNEP Global Land Cover Network initiative; the IAO will host a topic centre for land cover mapping methodological development (based upon the FAO/UNEP Land Cover Classification System).

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