

Introduction

The **Institute for Electromagnetic Sensing of the Environment (IREA)** is part of the largest Italian public scientific and technological research institution, the National Research Council (CNR). IREA is committed to the "Engineering – ICT and technology for Energy and Transports" Department and participates in the activities of the "Earth System Science and Technologies for the Environment" Department. In addition, the Institute is involved in research projects in collaboration with the Department of "Social and Human Sciences - Cultural Heritage". The **research activities** respond to important needs of scientific and technological development of the country in the fields of remote sensing and electromagnetic monitoring of the environment aimed at territory surveillance and management, security and risk assessment, including the one resulting from exposure to electromagnetic fields. The activities focus on the study of methodologies and technologies for acquisition, processing, fusion and interpretation of images and data achieved through electromagnetic sensors operating on satellites, aircraft and in situ, and for dissemination of the extracted information. In addition, methodologies and technologies are developed for the realization of infrastructures for geospatial data and biomedical applications of electromagnetic fields.

Founded in 2001, IREA has become in few years one of the institutes of excellence of CNR. It can be regarded as a reference point within the research fields in which it operates. It is capable of exploiting its multi-disciplinary characteristics and to effectively interact with the scientific and socio-economic reality at a national and international level. The results of the research activities have given rise not only to a high scientific production, characterized by publications in the most prestigious journals in the fields of reference, but also to important initiatives of technological transfer and to the creation of a new company.

IREA is a growing reality. The analysis of the last three year records related to the research staff, the technical and administrative staff and the temporary staff, in fact, shows an increasing trend. The structured **personnel** is composed of 55 units, distributed between the headquarters in Naples and the Support Unit in Milan. It includes 42 researchers and technologists and 13 technical and administrative assistants. Furthermore, 28 unstructured researchers, 8 associate researchers and many young people in training through scholarships, PhDs, traineeships, and students who carry out their thesis at the Institute, contribute to the Institute development.

The research activities focus on 5 main topics: Microwave Remote Sensing, Optical Remote Sensing, Electromagnetic Diagnostics, Bioelectromagnetics, Geographic Information Systems. In addition, activities in the field of public communication of science are also carried out.

Research Infrastructures

At the headquarters in Naples, there are four main infrastructures: a cluster for SAR data processing, an electromagnetic diagnostics laboratory, an optical and optoelectronic sensing laboratory, and a bioelectromagnetics laboratory.



The **cluster for Synthetic Aperture Radar (SAR) data processing** was designed and implemented at IREA with the aim of optimizing the performance according to the particular application type. The architecture is composed of two front end nodes in heartbeat and 22 processing nodes at 64-bit. The total disk space available is about 1 PB.

The **electromagnetic diagnostics laboratory** is equipped with a georadar system for the survey of sub-soils and vertical structures; a holographic radar capable to obtain, in real time, two-dimensional images of the subsurface layers of the structure under test; a last generation system operating at THz frequencies for high resolution (millimeter) spectroscopy and imaging; a bio-radar prototype for the detection of vital signs; an X-band radar system for the characterization of the sea state.



The **optical and optoelectronic sensing laboratory** is equipped with instruments necessary to the making, the development, and the characterization of planar opto-fluidic and optoelectronic integrated sensors and fiber optic sensors, including a direct laser writing lithographic system and a small clean room.

The **Bioelectromagnetics laboratory** is fully equipped with the instrumentation for cell culture exposure to low and high frequency electromagnetic fields and to pulsed electric fields, as well as for the evaluation of the biological effects related to the genotoxic and non-genotoxic carcinogenesis in cell cultures.



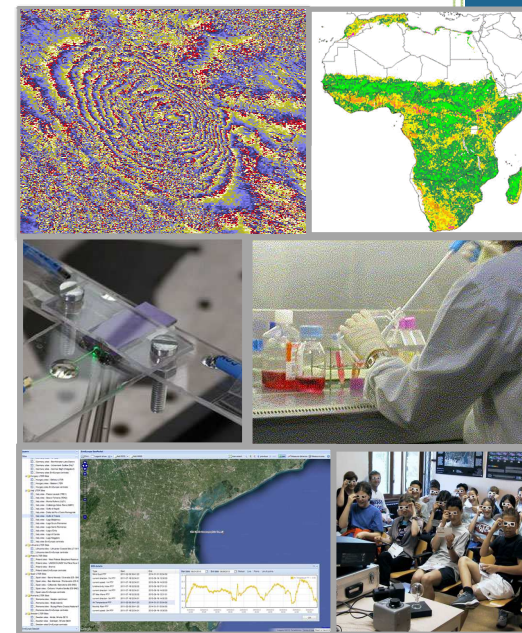
The Support Unit in Milan has an **optical-electronic laboratory** that serves as a collection center for the scientific instrumentation necessary for the activities of calibration / validation of remote sensing data. The laboratory is also equipped with an optical bench to be used for laboratory measurements.

The **Experimental Station "Eugenio Zilioli"**, located at Sirmione (Garda Lake, Italy), carries out constant measurements of environmental parameters. It has a sun photometer, which is part of the international network 'AERONET', and a didactic laboratory for the analysis of the waters. The Station hosts the Environmental Sensing Center (CRA) which promotes environmental education activities for schools and the local population.



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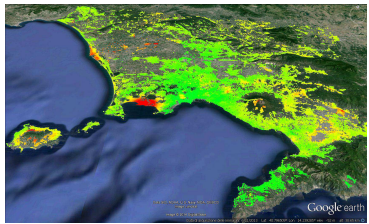
Support Unit

www.irea.cnr.it



Main research themes

MICROWAVE REMOTE SENSING

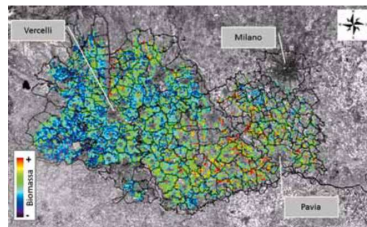


The activities in this field focus mainly on the development of innovative methodologies and techniques of processing and interpretation of data acquired from sensors operating in the microwave portion of the electromagnetic spectrum. In particular, great importance

have the differential SAR interferometry techniques that allow the measurement of the Earth's surface deformations with an accuracy of few centimeters (in some cases millimeters) and are, therefore, of great interest for the study of natural (earthquakes, volcanic activity, landslides) and anthropogenic (subsidence) phenomena. In this context, IREA has developed an innovative technique widely used internationally, called SBAS, which allows to study the temporal evolution of the detected deformation phenomena, with obvious implications in the prevention of risk and decision support in crisis scenarios. Moreover, IREA is engaged in the development of research activities in the area of geophysical modeling of remote sensed and geodetic data related to the sources cause of the deformation. The skills acquired in these fields led IREA to become Centre of Competence for the Italian Department of Civil Protection. As far as the new technologies of SAR data and signal processing, IREA researchers have developed tomographic techniques that allow to make 3D reconstructions and to monitor the deformations of individual buildings and infrastructures. In addition, activities in this area have contributed to the extension of SAR interferometric techniques to airborne sensors for the reconstruction of digital maps of terrain elevation at very high resolution. Recently, researchers have also focused on the study, development and implementation of distributed systems for satellite data processing, with particular reference to cloud platforms capable of storing large archives of satellite radar data and providing significant resources to process them.

OPTICAL REMOTE SENSING

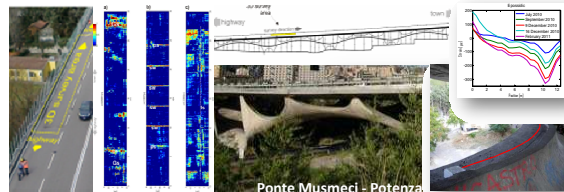
In the field of optical remote sensing the activities are focused on the analysis of information related to the territory and the environment, obtained thanks to the measures of the electromagnetic energy reflected and / or emitted by the Earth's surface using optical-electronic sensors installed on airplanes or satellites. The principal applications are: monitoring of water quality;



monitoring of agricultural resources and natural vegetation; identification of fires; assessment of water availability; census of

alpine glaciers and analysis of changes in land use. The research ranges from the local scale (e.g. water quality of Lake Garda) to the continental scale (e.g. study of desertification phenomena in sub-Saharan Africa). In particular, the activities aim at the production of thematic maps of the territory by means of automatic image interpretation techniques, and the characterization of the environment state through the extraction of bio-geophysical parameters descriptors of the state of natural surfaces. The availability of thematic maps is crucial for both the management of the environment and the territory resources and in case of natural disasters (damage assessment, early intervention programming, preparation of recovery plans). Thematic mapping also plays an essential role for territorial and urban planning, identification of hazardous materials, such as asbestos cement or oil spills and soil sealing caused by overbuilding. Equally important are the research activities dedicated to the territory and the environment monitoring by means of time series of satellite data, as well as those oriented to the acquisition of field measures for the interpretation and processing of remote sensing signals. The analysis of long time series of data available today over a thirty-year period allows the identification of geographic regions where present conditions are significantly different from the long time trends and thus need further and detailed analysis.

ELECTROMAGNETIC DIAGNOSTICS



The research activities in this field aim to develop technologies able to obtain information on structures and areas not directly accessible, in a non-destructive and non-invasive way. These diagnostic technologies are based on the interaction between electromagnetic waves and materials. By using the portion of the electromagnetic spectrum from microwaves to Terahertz up to the optical frequencies, they have applications in many fields such as the monitoring of civil structures, critical infrastructures and the state of the sea, the medical and cultural heritage diagnostics, the detection of pollutants, the issues related to physical security, such as the localization of explosive devices, the detection of hidden objects on people and the remote detection of vital signs. The activities involve methodological and technological aspects. They concern the development of strategies for microwave tomographic imaging and radar data processing in close sensing, in order to obtain high-resolution and reduced ambiguity images of static or moving objects, hidden or buried in complex scenarios; the development of fiber optic distributed sensors to measure temperature and / or deformation of the structure investigated on distances up to tens of kilometers; the development and realization of microwave and optofluidic sensors for environmental, chemical and biological analysis. Recently, the research has been extended to the study of the potential use of microwaves for the early diagnosis of breast cancer and the development of X-band radar systems for monitoring the state of the sea. The latter activity led to the birth of the company Remoceen Srl, a spin-off of the CNR.

BIOELECTROMAGNETICS



Main aim of the research activities is the study of the interaction between non ionizing electromagnetic fields (EMF) and biological systems, in order to assess both the possible risks to the health of the population and the applications in the medical field. The research activities are carried through in vitro experiments mainly on mammalian cell cultures

exposed to electromagnetic fields of low and high frequency, with particular reference to the frequencies in use for mobile phones. After exposure, cell samples are treated for the analysis of the possible effects related to carcinogenesis. Moreover, due to the high degree of environmental pollutions and the large diffusion of electromagnetic field sources, the effects of combined exposures to EMF and environmental pollutants or drugs exhibiting well known action mechanism are also evaluated. Recently, interactions are also studied in the presence of nanoparticles which, by selectively binding to tumor cells, on the one hand increase the detection, on the other hand facilitates the localization of the therapeutic treatment. In this field it is also evaluated cytotoxicity of nanoparticles in human cell lines of both healthy and cancer tissues. The mechanisms of interaction between pulsed electric fields and cellular structures are also studied in order to expand the applications in oncology. Finally, a monitoring activity of electric, magnetic and electromagnetic field levels in urban and working environment is also carried out in order to characterize the exposure conditions of the population and to verify the compliance with exposure limits defined by national and international regulations.

GEOGRAPHIC INFORMATION SYSTEMS

IREA activities in this area come from the need to use the Internet to spread and process geospatial products of the research, mainly maps from Earth Observation, as well as in-situ observations. It concerns the study of techniques for integrating multisource geographic information and the development of infrastructures for sharing on the web the geographic data that largely IREA itself produces. Keywords are interoperability of data and systems, independence of delivery tools with respect to accessing and viewing clients, storage and maintenance of data where they are produced. The research activities make direct reference to the European Directive INSPIRE, which aims to make spatial information of the various European countries compatible and usable in a cross-border context, and takes place in the framework of other important international initiatives, such as the European Commission Programme "Copernicus" and initiatives related to the development of OGC standards and Digital Earth.

