

HIGH TECHNOLOGY INFRASTRUCTURE FOR INTEGRATED CLIMATE AND ENVIRONMENTAL MONITORING

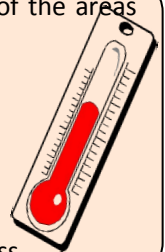


INFRASTRUTTURA DI ALTA TECNOLOGIA PER IL MONITORAGGIO INTEGRATO CLIMATICO-AMBIENTALE

The Mediterranean Basin, which encompasses 22 nations and about 1600 coastal cities, is home to more than 150 million people. The Mediterranean ecosystem is particularly sensitive to climate change: so its preservation is essential to ensure livability of people. The Mediterranean basin is also important for the economy: in 2014, Italian exports to this region reached almost 30 billion Euro (2.5-times the export to China, and as much as exports USA). It is to the Mediterranean and, in particular, to the Italian Convergence Regions, that PON **I-AMICA** has turned its attention.

The Mediterranean Region, as reported by the European Environment Agency (2012), is one of the areas subject to the greatest impacts of climate change in recent decades:

- Temperature **rises** larger than European average. **Increase** in mortality from heat waves.
- Decrease in annual precipitation. **Increasing** water demand for agriculture.
- **Decrease** in crop yields. **Expansion** of habitats for southern disease vectors.
- Increasing risk of forest fire. **Decrease** in hydropower potential.
- **Decrease** in summer tourism and potential increase in other seasons.
- Increasing risk of desertification. Decrease in annual river flow, increasing risk of biodiversity loss.



I-AMICA, has four developmental objectives (OR - Obiettivi Realizzativi): promoting the strengthening of atmospheric/ marine-coastal/agro-forestry Observing Systems, improving parallel computing infrastructure, and strengthening air-quality services (forecast, advanced observations and analysis). **I-AMICA** fosters technology transfer actions to develop and integrate productive activities. The **I-AMICA** Observing Systems were integrated into international programs. A strong integration between public and private activities allowed the development of innovative environmental devices and instrumentation, thus favouring promotion and support to regional businesses.



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OR1 Observing infrastructures for climate and environmental monitoring

The **I-AMICA** project has created or strengthened eleven **infrastructures** for the continuous monitoring of the **atmosphere, climate, agriculture and forestry systems**.

A **distributed platform for parallel computing** (inter-cloud) has been implemented to store and process large datasets; This platform is currently active for the fusion and interpretation of data and images from satellite sensors, from optical sensors for studying the biosphere/hydrosphere interactions, and from microwave remote sensing for analysis of ground deformation and sea currents.

The information system **GeoNetwork** (<http://sharegeonetwork.i-amica.it/>) enables the storage of information, data, images produced within the I-AMICA network, making them accessible to all potential users also through geographic web platforms.

The ongoing **144 measuring programs** provide continuous observations at different locations in the Convergence Regions related to:

- **Greenhouse gases** (CO₂, CH₄, H₂O) by using the advanced technique of cavity ring down spectroscopy.
- **Reactive gases** (O₃, CO, NO_x, VOC, SO₂), which play a major role on climate and atmospheric chemistry by influencing the atmospheric oxidation capacity and the formation of new particles.
- **In situ chemical, physical and optical properties of aerosols** (mass, number, size distribution, absorption and scattering coefficient, chemical composition), which have effects on climate, human health, visibility, ecosystems, air quality.
- **Vertical distribution of aerosols** to identify aerosol layers, vertical profiles of the optical prop-



erties, the aerosol types (desert dust, sea spray, smoke from fires, pollution) and the aerosol microphysical properties.

- **Carbon and water vapor budgets** exchange between atmosphere and agriculture/forestry ecosystems and the study of the vegetation physiological response to climatic variables and human activities.

- The contribution of **vegetation** to the **formation and removal of pollutants** in areas heavily inhabited and urbanized.

- The monitoring of **key hydrological parameters** (flow, transport) and water chemistry in a moun-

tain basin.

- The main **meteorological parameters**.

Thanks to advanced technological solutions, allowing near real time data delivery, the I-AMICA "supersites" constitute an opportunity for the early warning activities related to the monitoring and detection of episodes of pollutant transport in the atmosphere, also from natural origin, in agreement with the EU Directive 1999/30/CE, air quality matter, transposed at national level by DM 60 4/2/2002.

OR3 Climatic and environmental observational network linked to international infrastructures

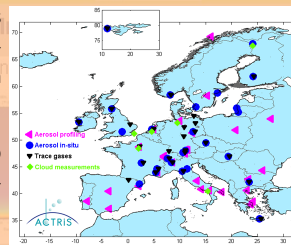
The research activity related to this task allowed the establishment, in the **Convergence Regions**, of an **infrastructure for climatic and environmental observations** both at European and international level. This has been achieved through infrastructural enhancement and networking, but also linking the infrastructure to the main European RI projects and to other international research programs.

Therefore, the benefits of this activity will be mainly related to the internationalization of the research system of the Convergence Regions in the climate and environment research field.

In particular, this research activity created the conditions to allow: (i) high level standard for the operability of the **I-AMICA** infrastructure; (ii) access to high quality information and services both for the scientific community and other end users (PA, SMEs, ...); (iii) opportunities for world-class research and international partnerships for the scientific community of the Convergence Regions; (iv) training of new users at international level, paying special attention to young researchers working in the atmospheric observation field; (v) enhancement of the competitiveness of the SMEs in the field of the new technologies development both at European and international level.

At European level, thanks to the compliance with the standards established within **EARLINET - European Aerosol Research Lidar NETwork**, the **I-AMICA** profiling measurement sites became part of this network, representing an important reference measurement infrastructure in the Mediterranean Basin. The networking of these climatic and environmental observation stations is accomplished through the implementation of a fully automatic

data processing system that provides both intermediate lidar products, with high space and time resolutions, and more advanced lidar products, with lower resolutions, ready to be uploaded to the **EARLINET** database and to be integrated, together with the **I-AMICA** in situ measurement stations, in the European Research Infrastructure **ACTRIS - Aerosol, Clouds and Trace gases Research InfraStructure**.



On a global scale: a network has been established between the **I-AMICA** in-situ and profiling stations through international programs and projects; data related both to reactive and greenhouse gases and to aerosol physical/chemical/optical properties have been included in the **GAW - Global Atmosphere Watch** program; data from **I-AMICA** station monitoring atmospheric mercury have been included in the **GMOS - Global Mercury Observation System** network.

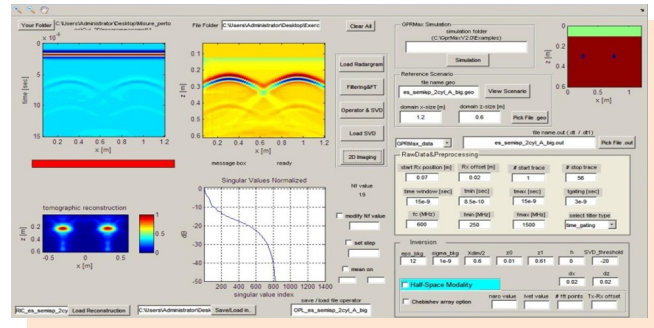
OR2 Innovation, technological development, industrial transfer

Examples of innovation and technological development in the laboratories CNR

- **Fiber optic system for monitoring fluids**, for control of the health of watersheds, river courses or marine waters and dedicated to **real-time surveillance of water quality in waterworks**: a useful application for the PON Smart City.
- Measurements of environmental interest and for the **monitoring of hydrological processes**.
- Production of a **prototype of a distributed fiber optic sensor** for the measurement of temperature and / or deformations along distances of kilometres and with 1 metre spatial resolution.
- Development of electromagnetic sensing methods, including the development and integration of a graphical interface, radar tomography algorithms for processing of GPR data, providing more easily interpretable **high-resolution images in 2D-3D**.
- Rapid Prototyping of **integrated optical sensors and microfluidics**.
- Development of spectroscopic analysis based methods for the **vegetation monitoring**.



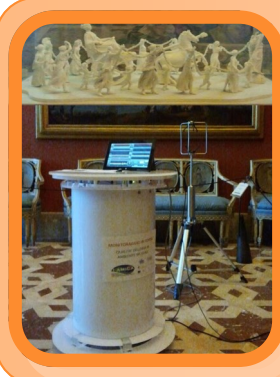
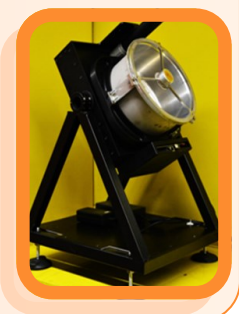
- **Development of sensors both for the measurement of the salt wedge intrusion in coastal areas** near the mouth of the River Volturno, and for the **study of desertification**, and **supporting coastal agricultural activities**.
- Prototyping of multi-parametric probe and software interface (Android, Apple iOS) to monitor in near-real-time water table temperature and salinity.
- Prototyping of a **multiple sensor for measuring the seismic waves speed and electric resistivity of the subsoil** and to define the geometry of an aquifer differentiating its properties in terms of salinity.



I-AMICA has supported the integration and strengthening of actions and structures for the development of equipment and services for environmental monitoring, through activities that promoted technology transfer and industrial development, thanks to the collaboration between public and private partners.

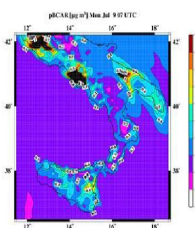
Developing **prototypes** of systems dedicated to atmospheric particulates measurements present on an optical path (horizontal or vertical) including **lidar systems portable and counterpropagating beams**. The innovative *Polaris*, *Hummingbird*, ... provide information on the properties of particles and were carried out by ALA srl., Advanced Lidar Application. These prototypes will be show-cased during the EXPO2015 in Milan.

A prototype for **indoor / outdoor air quality monitoring in museum environments** was developed by FAI Instruments srl. The prototype is in operation at the **Capodimonte Museum** and allows the monitoring of the concentration of CO₂, O₃, black carbon, PM₁, PM_{2.5} and PM₁₀, particulate size distribution, plus meteorological parameters and illumination.



OR4 Technological applications and services to the territory

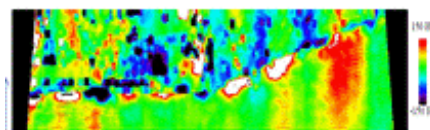
- Successful development of a **system for the air quality forecast** on "Convergence Regions" with a focus on natural sources: Saharan sand, sea aerosol, emissions from forest fires and volcanic eruptions. Available on the web in real time.



- Successful development of a tool for the **analysis of natural sources of pollutants**

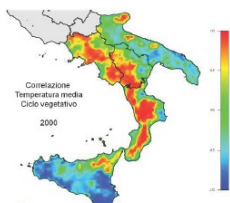
ronmental pollutants thanks to the realization of **optical microfluidic sensors and in optical fiber**.

- Successful development of a methodology for the monitoring of the **presence and diffusion of the liquid pollutants** based on the use of a georadar and a strategy to evaluate the water stress of plants



- Assistance with the development of a DOP for the **buffalo cheese farms** in Casertvolturno thanks to the development of monitoring systems of the soil quality and of the underground water, regarding the intrusion of the sea water in the coastal area.

- The monitoring site in **Capodimonte Park** (Naples) is the first example of **urban park** in Europe where the role of vegetation in **carbon sequestration**, the **emission of biogenic volatile organic compounds (BVOC)** and the **pollutants removal** it has been studied.



- Successful development of a **surface wind climatology** using observations from satellite and from monitoring sites in the "Convergence Regions"

- Studies of the **variations of vegetation activity** on a decadal basis for the following climatic regions: sub oceanic Mediterranean, sub-continental and mountain.

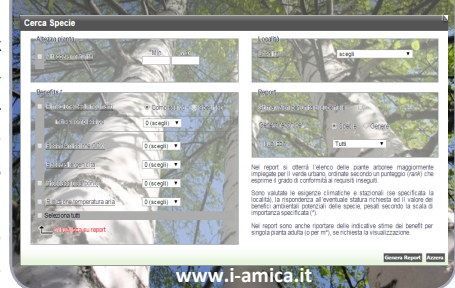
- Successful development of the **soil water content** on large scale and the **high sensitivity to the envi-**

ronment using new methodologies for a multi-disciplinary assessment, such as **bio-indicators**.

- The **geo-based database "I-AMICA db"** contains all the seasonal environmental data (water column and sediment) gathered in the period 2012-2014 during the oceanographic campaigns, the maps of the biogeophysical parameters both for terrestrial compartment and for the marine one and the surface speed at the mouth of the Volturno river obtained from SAR data.

- The compounds emitted during the different phases of a fire and their diffusion in the atmosphere have been successfully characterized.

SPECIFIND: Development of a IT tool to support the choice of urban tree species to be planted in order to improve air quality.





The **National Operational Programme for "Research and Competitiveness" 2007-2013 (NOP for R&C)** is Italy's means of contributing towards the development of a European Union Cohesion Policy for Italy's least-favoured regions. In this regard, Italy and the European Union have agreed that a significant part of European Structural Funds should be invested in research and innovation in the four Regions of the Convergence objective: **Apulia, Calabria, Sicily and Campania.**



The objective is to transform these regions into drivers of social and economic development.

EU Cohesion policy The 28 Member States

of the European Union form a community and an internal market of more than half a billion citizens. The economic and social disparities among these countries and their 272 regions are striking, and have grown in the wake of the enlargements and the economic and financial crisis. GDP per inhabitant is under 75% of the EU average in around 25% of the regions.

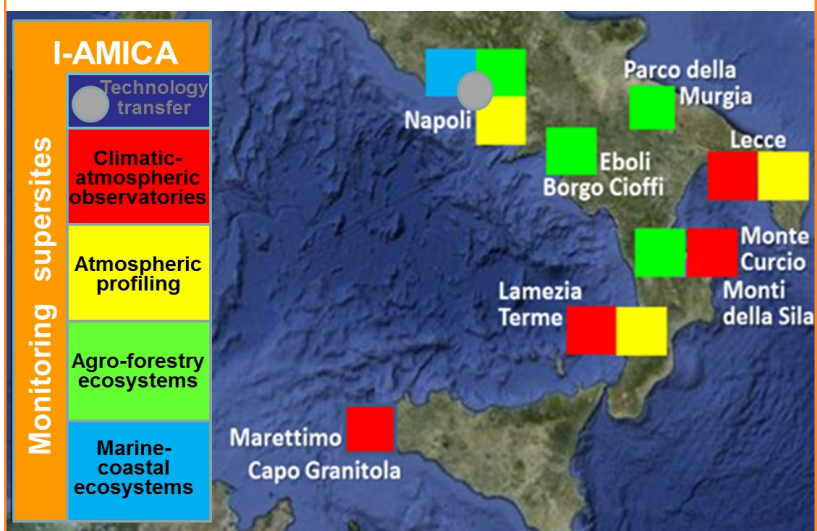
The I-AMICA Training Programme

The training programme allowed to develop several capability: in data analysis methodologies to understand measures and experimental data; and dialogue with: industries, financial institutions, local and regional government offices and citizens to transfer the acquired knowledge during the project. The main goal is to improve industrial capacity and enhance research results.



I-AMICA trained **19 researchers** jointly to **30 external researchers/technician/employees** of governmental offices (ARPA, INAIL, etc.) /University. In the classes were involved **70 internal** and about **20 external trainers** and **9 internal** and **4 external** unit in managing activities. About **4300 hours of lessons** were delivered in theory and practice/stage, **12 experimental videos** were realised on several arguments with the aims of promoting results, experiments and explain principle and use of instruments.

The stations for Integrated Climatic - Environmental monitoring



The **Italian National Research Council** promoted the I-AMICA project with 7 Institutes located in the Convergence Regions, and coordinated by **Department of Earth System Science and Environmental Technologies**:

Consiglio Nazionale delle Ricerche
Dip. Scienze del Sistema Terra e Tecnologie per l'Ambiente



CNR-IAMC: Istituto per l'Ambiente Marino Costiero Napoli, Capo Granitola
Institute for coastal marine environment <http://www.iamc.cnr.it>



CNR-IBAF: Istituto di biologia agro-ambientale e forestale Napoli
Institute of Agro-environmental and Forestry Biology <http://www.ibaf.cnr.it>



CNR-ICAR: Istituto di calcolo e reti ad alte prestazioni Rende
Institute for High-Performance Computing and Networking <http://www.icar.cnr.it>



CNR-IIA: Istituto sull'Inquinamento Atmosferico Rende
Institute of Atmospheric Pollution Research <http://www.iaa.cnr.it>



CNR-IREA: Istituto per il Rilevamento Elettromagnetico dell'Ambiente Napoli
Institute for Electromagnetic Sensing of the Environment <http://www.irea.cnr.it>



CNR-ISAFOM: Istituto per i sistemi agricoli e forestali del mediterraneo Rende
Institute for Agricultural and Forest Systems in the Mediterranean <http://www.isafom.cnr.it>



CNR-ISAC: Istituto di scienze dell'atmosfera e del clima Lamezia Terme, Lecce
Institute of atmospheric sciences and climate <http://www.isac.cnr.it>



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