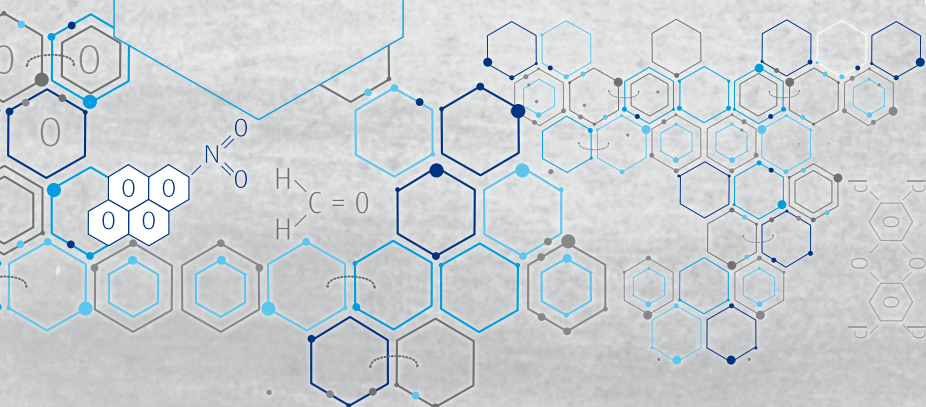
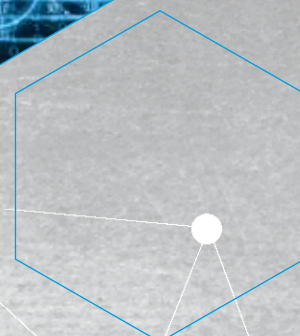
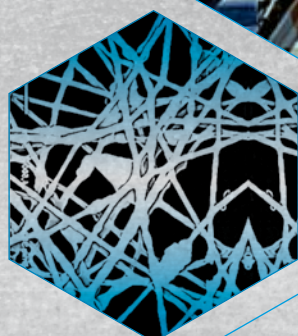


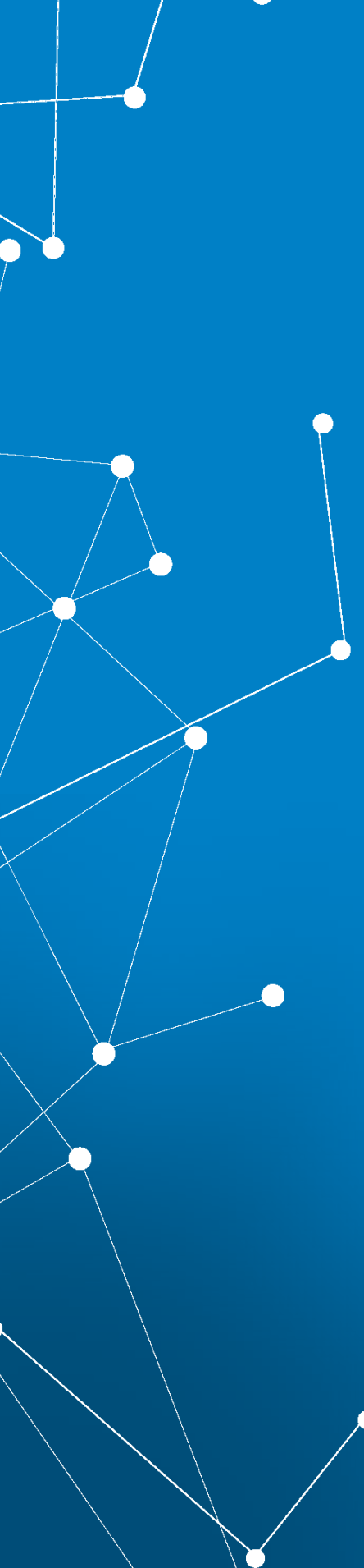
Institute
of Atmospheric
Pollution
Research

ari
our
natural
environ-
ment



National Research Council of Italy





Knowing about
and understanding
the quality of
the air we breathe
means believing
in sustainable
development and
acting to safeguard
future generations



Institute of
Atmospheric
Pollution Research

+130

members of staff:

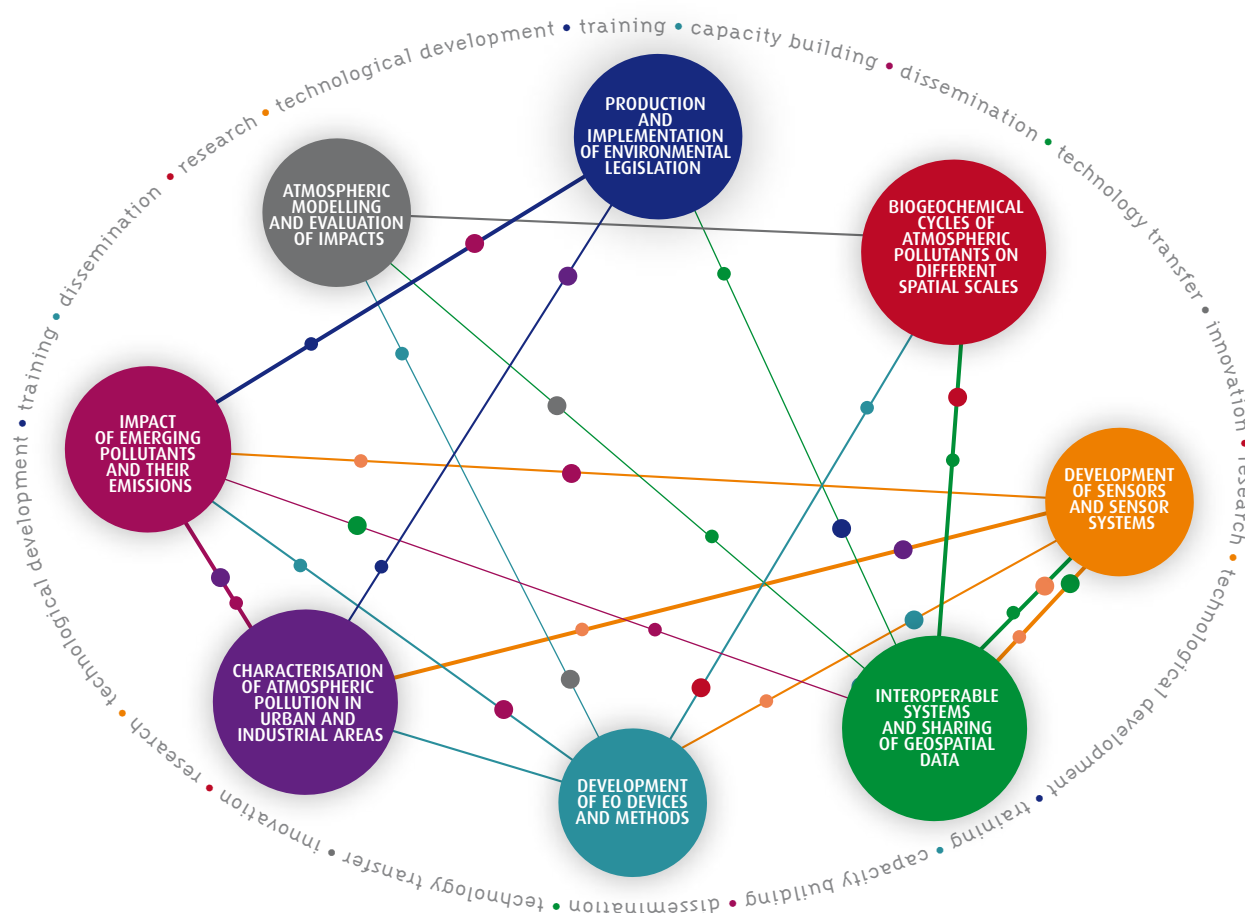
senior and junior researchers and technologists, engineers, clerks, graduates and post-graduates, post-doctoral students, scholarship holders in the institute's four sites; + 10 associated researchers and university lecturers from Italian and foreign universities and research centres. The Institutional Headquarter is located in the CNR Research Area Roma 1 in **Monterotondo (RM)**. The three **Divisions** are located in **Rende (CS)**, **Sesto Fiorentino (FI)** and **Rome c/o the Ministry of the Environment**. The Institute is part of the **Department of Earth System Science and Environmental Technologies of the CNR**.

TO IMPROVE KNOWLEDGE CONCERNING THE MULTIPLE MECHANISMS REGARDING THE EMISSION, CONVERSION AND CONVEYANCE OF ATMOSPHERIC POLLUTANTS, COMBINING MULTIDISCIPLINARY SKILLS FOR THE DEVELOPMENT OF NEW AND INNOVATIVE TECHNOLOGIES AND STUDY METHODS.

Relevant thematic areas:

- Atmospheric pollution in urban and industrial areas
- Industrial pollution and areas of high environmental risk
- Development of technologies and analytical methods in the laboratory and mobile units for the characterisation of environmental quality and sustainability
- Study of polar regions
- Cycles of atmospheric pollutants and their influence on global change
- Atmospheric pollution observation networks and systems in support of European directives and international agreements
- Development of interoperable systems and technologies for the sharing of geospatial information and knowledge of the environment.

Interdisciplinary activity of the Institute in the sphere of technological research and development



we, an interdisciplinary and dynamic reality

THE **INSTITUTE** STANDS OUT FOR ITS CONSIDERABLE CAPACITIES IN MULTIDISCIPLINARY SCIENTIFIC RESEARCH IN THE COMPLEX AND BROAD FIELD OF ATMOSPHERIC POLLUTION.

NOT ONLY DOES IT HAVE ITS RESEARCHERS AND TECHNOLOGISTS WITHIN THE MOST PRESTIGIOUS NATIONAL AND INTERNATIONAL NETWORKS, IT ALSO DEVELOPS PARTNERSHIPS WITH ENTERPRISES AND OTHER PUBLIC AND PRIVATE RESEARCH BODIES.

IT ALSO PROVIDES HIGH-QUALITY CONSULTANCY TO THE PUBLIC ADMINISTRATION.

SUPPORTS

the development of new technologies for the characterisation of atmospheric pollutants in urban and industrial areas, assessing pollutant concentrations in air and forecasting possible future scenarios.

COORDINATES

teams of Italian and foreign researchers performing scientific research activities, experimental development and the dissemination of research results.

PROMOTES

the values of environmental sustainability through scientific research as a driving force for local economic development.

SUPPORTS

initial and on-the-job training, with degree theses, doctorate scholarships and programmes for post-doc researchers.

areas of excellence

- Study of emissions to the atmosphere from industrial and natural sources; characterisation of impacts and of mechanisms for the conversion and transport of pollutants from the urban to the continental and global scale.
- Development of systems for the observation of atmospheric pollution;
- Design and creation of interoperable systems for the management of large databases (Big Data) and sharing of environment based knowledge;
- Design and creation of innovative technologies for the monitoring and characterisation of emissions and the quality of the air we breathe.
- Support to PAs for the drafting and implementation of national and Community environmental legislation.

MONITORS

the dynamics of exchange processes of gaseous pollutants in air/water/soil matrices present in extreme environments to verify the effects on human health of the concentration of pollutants caused by anthropogenic activity.

ACTS

alongside the Public Administration for the development of environmental legislation on a number of topics related to atmospheric pollution in European and International contexts and also their national implantation.

GUIDES

scientific research to attain a better quality of life.

PARTICIPATES

in national and international networks of excellence in the environment macro-area due to the presence of its researchers and technologists, and also because of a significant increase in funding from external European sources compared with the past.



areas

Technological research
and development
between earth and sky.

8 THEMATIC AREAS

THESE DESCRIBE AND HIGHLIGHT THE COMPLEXITY OF THE INSTITUTE'S NATIONAL AND INTERNATIONAL RESEARCH AND TECHNOLOGICAL DEVELOPMENT ACTIVITIES TO STUDY, MONITOR AND IMPROVE AIR QUALITY, AND TO SAFEGUARD ECOSYSTEMS AND HUMAN HEALTH. FROM THE EVALUATION OF ATMOSPHERIC POLLUTION IN URBAN AND INDUSTRIAL AREAS TO THE DEVELOPMENT OF EARTH OBSERVATION INSTRUMENTS AND THE TRANSFER OF TECHNICAL AND SCIENTIFIC KNOW-HOW TO DEVELOP AND IMPLEMENT LEGISLATION ON ATMOSPHERIC AND ENVIRONMENTAL POLLUTION.

Atmospheric pollution in urban and industrial areas

The focus of activity is the development and validation of advanced methods and instruments for the characterisation of pollutants present in the atmosphere and of their sources. This includes the study of physical and chemical processes that have an impact on ecosystems and on human health.

To understand atmospheric pollution phenomena, both local and widespread, **variation of the concentration of pollutants over time** (high temporal resolution, daily, seasonal, long-term) and the spatial distribution of pollutants (creation of concentration maps).

Results are interpreted in light of the meteorological situation, and in the **connection between air quality and atmospheric mixing conditions**, with the aid of natural radioactivity measurements.

In **urban areas** scientific interest ranges from an appraisal of the relative importance of combustion emissions from road traffic and residential heating, to an evaluation of air quality in confined environments (houses, offices, schools, means of transport). The quality of outdoor air and the role of natural sources, the study of the contribution to pollution on a regional scale and the impact of long-range transport.

Studies of industrial emissions from power generating plants (thermal plants powered by natural gas, biofuels, coal), waste-to-energy plants, refineries, steelworks and industrial plants in general are studied.

The **Institute's** activities form an integral part of national and international research programmes, and make an **important contribution to the action of decision-makers** at both a national and local level (Special Networks for the monitoring of Air Quality; integrated prevention and reduction of pollution from industrial activities – IPPC directive).

Emerging pollutants in emissions and in the air

The focus of this area is to identify the presence of new and emerging pollutants in both emissions and the air we breathe due to the use of new materials and chemical substances, production processes and the production of consumer goods.

The **aim** is to provide the community and legislators with knowledge in how to deal with various critical environmental areas; research activities are conducted in the following areas:

- development of **technologies for the monitoring** of pollutants – both regulated and non-regulated – in air and in emissions, and their application in the field;
- characterisation of **regulated and emerging pollutants** (VOC_y, PAH_y, OCP_y, POP_y, EOC, CVM, PM_x, HCHO, nanoparticles) in natural and man-made sources, with special reference to industrial processes and power generation (combustion of biofuels, biogases, bioethanol). Evaluation of their impact on environmental toxicity;
- identification of **pollution sources** based on the presence of environmental markers and emission footprints;
- characterisation of new pollutants that have short-term and long-term effects, such as endocrine disruptors and chemical substances subject to REACH regulations (phthalates, alkyl-phenols, chlorinated solvents, flame retardants, pharmaceutical products, personal care and hygiene products);
- analysis and monitoring of psychotropic substances and drugs (nicotine, cocaine, cannabinoids);
- study of **indoor environments**, domestic or occupational;
- studies of the **relationship between pollution and the chemistry of the atmosphere** (photochemical smog, transformation of the products of emissions) in urban environments, desert areas (Sahara), remote marine and mountain areas and in emerging nations.

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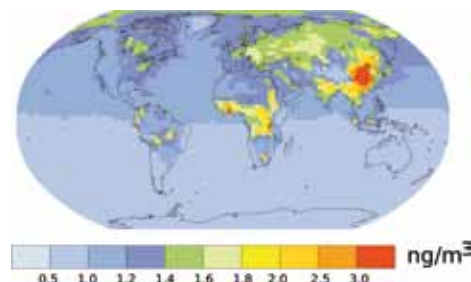
Cycle of pollutants at different spatial scales and in polar regions

Understanding how emissions of pollutants into the atmosphere from man-made and natural sources impact on the quality and sustainability of ecosystems and on the health of citizens requires understanding of the cycle of pollutants. Within the framework of European legislation and international treaties, an important priority is the study of the cycle of persistent pollutants (high residence times in the atmosphere) and toxic pollutants present in the atmosphere. These include POPs (persistent organic pollutants) and Hg (mercury), which can be distributed among the various ecosystems with changing meteorological and climatic conditions and man-made environmental pressures.

The general goal is to study the spatio-temporal variability of the various mechanisms that have the greatest influence on the cycle of pollutants among the various ecosystems, in particular:

- the variability of **residence times** in the atmosphere of inorganic and organic pollutants (i.e. Hg, O₃, BVOC, NO_x, HONO, halogens) and **relative (photo) chemical-physical processes** that have a bearing on the oxidative properties of the troposphere and depletion phenomena;
- **exchange** in the gaseous phase and mass balances at interfaces (air-water, air-snow, air-ice);
- dry and wet atmospheric deposition processes and the variability of the **vertical profiles** of concentrations of the most common pollutants in the troposphere at different latitudes.

A knowledge of these processes is indispensable for developing and validating atmospheric models used to analyse socio-economic-environmental scenarios adopted to reduce risks arising from the emission of pollutants on populations and on the quality of aquatic and terrestrial ecosystems. Within the framework of European and international programmes, innovative sampling systems and observation systems on a global scale are being developed for persistent pollutants such as Hg, as well as databases and interoperable systems in support of international agreements and programmes.

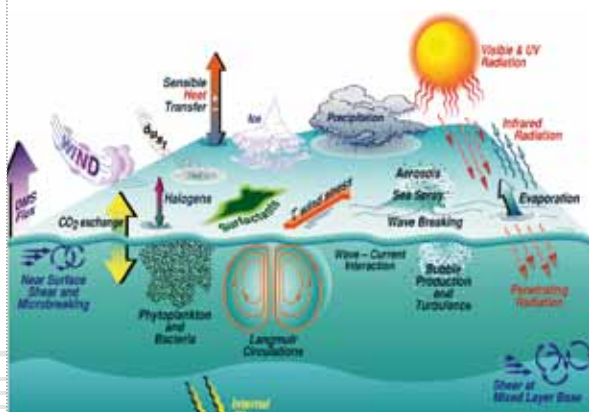


Atmospheric Modelling on a Regional and Global Scale

Development and use of computer **models** to help with the **reconstruction/interpretation, interpolation and forecasting** of parameters for the atmosphere and air quality, and to analyse future **scenarios** relating to climate change and pollutant emission patterns.

The modelling techniques used vary in terms of their temporal and spatial application. These pass from models used to analyse chemical processes in aerosols or in water droplets (including a very detailed description of the chemistry in the aqueous or gas phase), to global models used to study the **long-range transport of pollutants** (intercontinental) and of their precursors. Between these two extremes are models that perform simulations on a regional scale (from single Nations to Continents), and others that can be applied to specific areas, such as models on an urban scale. In addition to these more dynamic models, work is done to develop and apply **data-driven models: neural networks and models** for analysing Granger causality. They are used for:

- studying the causes (attribution) of recent climate changes and their impacts (with special reference to the influence of atmospheric pollutants on global warming),
- downscaling in order to obtain local future scenarios,
- forecasting physical parameters in the lower layers of the atmosphere (boundary layers).



Development of EO devices and methods

Earth Observation (EO) systems play a vital role in the study of environmental issues.

In keeping with the recommendations of the Group on Earth Observations Committee on Earth Observation Satellite (GEO/CEOS QA4EO, 2008) we propose **supplementing multiplatform and multisensory EO data in order to improve our knowledge of land-use** and facilitate the monitoring of phenomena of natural and man-made origins. Scientific interest is centred on environmental issues, analysis and monitoring of the land-use in the Mediterranean and in polar regions, where EO data make a substantial contribution to **studies on global changes**. Attention is focussed on the atmospheric component of EO data for the development of algorithms for the atmospheric correction of images and the study of radiative transfer.

The researchers involved have acquired skills in gathering field data to support and validate EO data and **studying the radiometric responses** of different surfaces, natural or otherwise. The spectral range of interest here is the visible and near infrared, most commonly used by EO systems; data from the various research programmes are collected in ad hoc geodatabases. The Institute manages the **hyperspectral sensor**, MIVIS, this too dedicated to the integrated management of the territory. In this area the Institute has acquired skills in analysing the territory which, based on remotely sensed images, make it possible to study the spatial distribution of atmospheric pollutants.



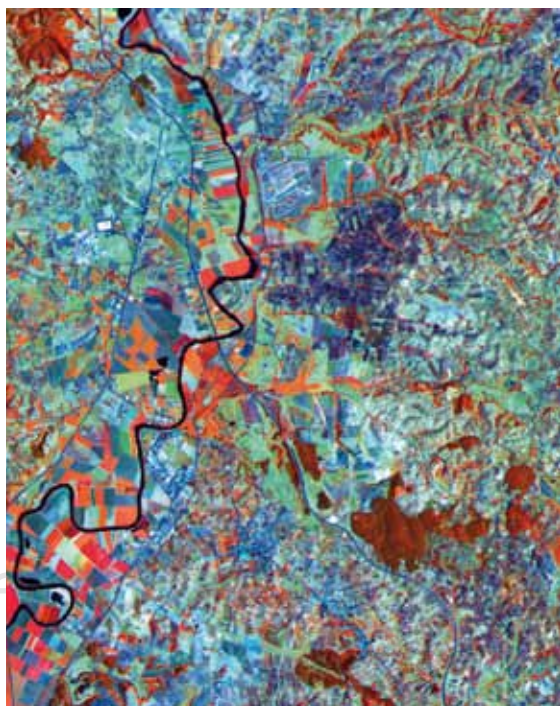
Sharing of Geospatial information and Environmental Knowledge

The **sharing of data** and knowledge, especially at an interdisciplinary level, is today acknowledged to be one of the keys for scientific progress and technological innovation.

The Institute deals with some of the main scientific and technological challenges relating to the sharing of such information and knowledge. The Institute has created new models of collaborative research and dissemination of information to a range of users (research, business, public administration, citizens), and possesses expertise recognised at an international level regarding technologies for the sharing of large quantities of heterogeneous data (big data) from simulations and remote sensing or in-situ systems.

A brokerage approach has been adopted for the discovery of and access to big data, adopted now in important initiatives at a national, European and global level, such as GEOSS (Global Earth Observation System of Systems).

Special attention is devoted to the **integration of networks of sensors**, in particular regarding air quality, and to support with the transition from data to knowledge, checking the quality of acquired data and developing **semantic tools** such as thesauri (e.g. EARTH), ontologies and the representation/execution of scientific models. The Institute's activities in the sector are performed in an international context, through participation in leading data-sharing programmes and initiatives (e.g. GEOSS, RDA, UNECE-EMEP, TF HTAP, UNEP), taking into due account the most relevant European directives (e.g. Air Quality, INSPIRE).



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Transfer of technical and scientific knowledge for drafting and implementing legislation on atmospheric and environmental pollution

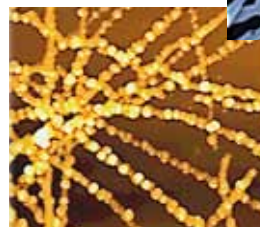
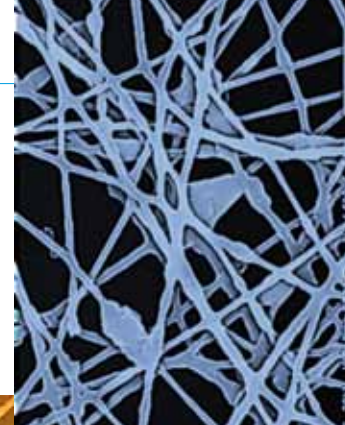
The aim is to transfer know-how to Public Administrations and Businesses and to support Organisations responsible for **environmental monitoring in preparing and implementing environmental legislation** at a national, Community and international level, in the following areas:

- **integrated prevention and control of pollution** (IPPC) from industrial activities (IED Directive) and on the subject of major accident hazards (Seveso Directive);
- air Quality, also with reference to **Special Networks for monitoring AQ**;
- analysis and definition of international, Community, national and regional **negotiating proposals**, with special reference to legislation on the subject of fluorinated gases, geological storage of CO₂, inventory of emissions, emission of greenhouse gases from fuels, quality of fuels and promoting the use of energy from renewable sources, CO₂ from motor vehicles, CO₂ from light commercial vehicles, metallic mercury and organic persistent pollutants;
- classification, labelling and packaging of chemical substances and their relative registration, appraisal, authorisation and restrictions (**CLP and REACH Regulations**); production and sustainable consumption of “green public procurement” (GPP);
- physical agents **such as noise and electromagnetic pollution**.



These activities make it possible to promote, enhance and make use of research findings, promote knowledge in society, partly through publishing initiatives, consultancy work and technical-scientific support.

The Institute is present and active in national and international bodies that develop cognitive tools and prepare documents, programmes and activities with a view to combating climate change, developing sources of renewable energies and promoting sustainable development in order to help implement relative standards and laws.



Development of high-performance Sensors and Sensor Systems for the monitoring of air quality and the environment

Studies to develop sensor devices based on composite and **nanostructured** materials consuming small amounts of energy for the **multiparametric monitoring** of complex environments have been rendered indispensable by the need to have data in support of European directives and international treaties and programmes on atmospheric and environmental pollution (i.e. UNECE-LRTAP, Minamata Convention, UNEP, GEOSS, Earth Cube) as well as the need to reduce the investment and operating costs of observation stations often located in places that are remote or hard to reach.

Innovative research activities include:

- the development and application of nanotechnologies for the controlled manufacturing of nanostructured materials for **highly sensitive sensors** (e.g., electrospinning, dipping, self-assembling, electrochemical growth and immobilisation) and **functionalisation systems in situ**;
- the design and manufacture of **chemical and biological sensors**, developed on both conventional and flexible substrates;
- the design and development of sensors in **bioinspired** platforms and networks for the monitoring of complex environmental matrices and definition of qualitative indexes;
- the design and development of **electronic interfaces for sensors**.

The progress made thanks to the development of nanotechnology and microelectronics has made it possible to study and develop high-performance sensors, in terms of sensitivity, response times and selectivity, for monitoring the quality of air (gases such as nitric oxide, sulphur dioxide, ozone, GHGs volatile and semi-volatile compounds, dust), soil and water (mercury, pesticides, IPA, POPs micro-organisms, etc.). The main activities of this thematic area are performed at an international level (i.e. European Cooperation in Science and Technology MP1206, MP1205, TD1105, Horizon 2020, ESA, UNEP, etc.) and nationally.



Where do knowledge and innovation come from?

THE INSTITUTE POSSESSES INNOVATIVE LABORATORIES AND RESEARCH INFRASTRUCTURE TO DEVELOP EXPERIMENTAL ACTIVITIES IN THE LABORATORY OR IN THE FIELD, DESIGNING AND BUILDING ADVANCED SENSOR SYSTEMS AND ANALYSING THE CAUSES AND EFFECTS OF ATMOSPHERIC POLLUTION IN ORDER TO DESIGN STRATEGIES TO REDUCE THE IMPACT ON ECOSYSTEMS AND ON HUMAN HEALTH.



Environmental chemistry laboratories

Solving the problem of pollution caused by emissions requires the expertise of researchers and engineers and the deployment of infrastructures (field measuring systems, chemistry and analysis laboratories equipped with low and high resolution GC-MSD, GC-multi-detection, HPLC-UVA/FD, HPLC/MSD systems), that collect, process and identify the chemical characterisation of samples. Special attention is devoted to organic toxic compounds (VOCs and carbonyls; dioxins, furans and chlorinated organic compounds; IPA and by-products; polar compounds), fractions of fine and ultrafine particulates, heavy metals, acid or oxidising species. Original procedures and instruments are developed for PAHs or new generation pollutants (endocrine disruptors).



Two mobile laboratories

Two mobile laboratories are available, one for monitoring air quality in urban and industrial areas, endowed with state-of-the-art instrumentation for the monitoring of pollutants in the gaseous and particle phases.

A second mobile laboratory unit is equipped with instrumentation for the monitoring of emissions from industrial plants, landfills, waste disposal units, plants producing biogases and biomass plants.

Laboratories for sensor applications

Sensor-related activities are performed in:

- laboratories dedicated to the development and deposition of nanostructured smart materials (chemical sensors), in particular by means of the electrospinning technology (**home-made electrospinning set-up**), and their morphological-topographic characterisation (atomic force microscope **Nanosurf Flex AFM**)
- laboratories for the development and characterisation of bio-materials (**biological sensors**) by means of electrochemical devices (**Palmsens**).

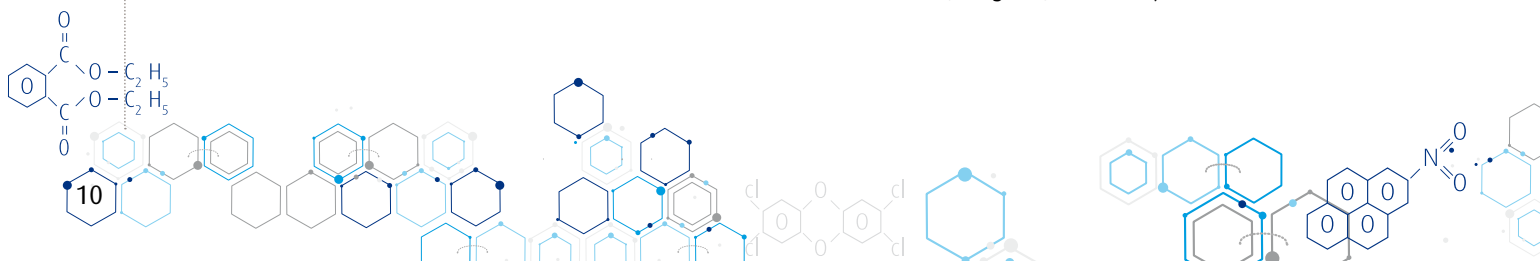
Miniaturised transducers are constructed in a clean-room (including **facilities** such as the molecular vacuum pump –Balzers 510 – fitted with electron gun, double-face mask aligner from **Electronic Vision**, etc.). Activities continue in laboratories that test and calibrate sensors using dynamic measuring systems in an aeriform environment (**EnviroNics**, **MKS**, **Tylan**) and liquid environment (**Gilson**) and through the use of interfaced electronic equipment.



Cyber Infrastructure and Atmospheric Modelling Laboratories

The Institute has developed Cyber(e)Infrastructures in support of European and international agreements on atmospheric and environmental pollution: these include infrastructures created for the Minamata Convention on global atmospheric pollution caused by mercury, as part of the GMOS network (www.gmos.eu) and for Task HE-02 "Tracking Pollutants as Hg and POPs" as part of the GEO-GEOSS programme.

The Institute has large databases and Eulerian and receptor models (e.g. ECHMERIT, WRF Chem) to define transport patterns and the impact on ecosystems and populations of the most common pollutants entering the atmosphere from natural and man-made sources, and to quantify the relative contributions of emissions from every emission source, both man-made (e.g. power plants, incinerators, steelworks) and natural (e.g. forest fires, biogenic, volcanoes).



Permanent observation stations

The Institute has built two experimental stations for the study of the temporal (seasonal) variability of the chemical composition of the atmosphere. One is situated at altitude on Mount Curcio (Alto Piano della Sila) and the other, Station "A. Liberti", situated in a suburban area. Both stations contribute to leading European and international programmes aimed at understanding the processes that have a bearing on the dynamics of atmospheric pollutants at different spatial scales.

• The High-Altitude Station of Mount Curcio

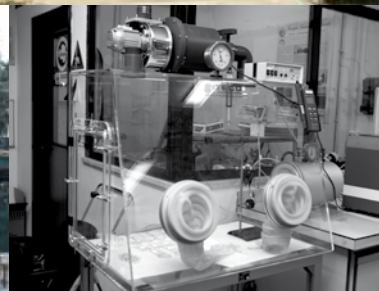
Situated on one of the highest peaks of the Sila mountain range in Calabria (1,768m asl), far from anthropogenic emissions, it is a strategic observation site for the chemical, physical and climatological study of the free troposphere, and for the analysis of air masses and the main pollutants involved in long-range transport. The station forms part of the GMOS (Global Mercury Observation System) international network and the GEO/GEOSS programme. The station has been enhanced with latest generation equipment to develop and integrate research activity that studies the chemistry of the atmosphere and support leading European and international Projects/Programmes, both ongoing and planned as part of the Horizon 2020 initiative. It will also reinforce the Institute's future participation in other international research programmes and infrastructures, including AERONET (AErosol RObotic NETwork), ESFRI (European Strategy Forum on Research Infrastructures) and GAW (Global Atmospheric Watch of the WMO).

> The High-Altitude Station of Mount Curcio

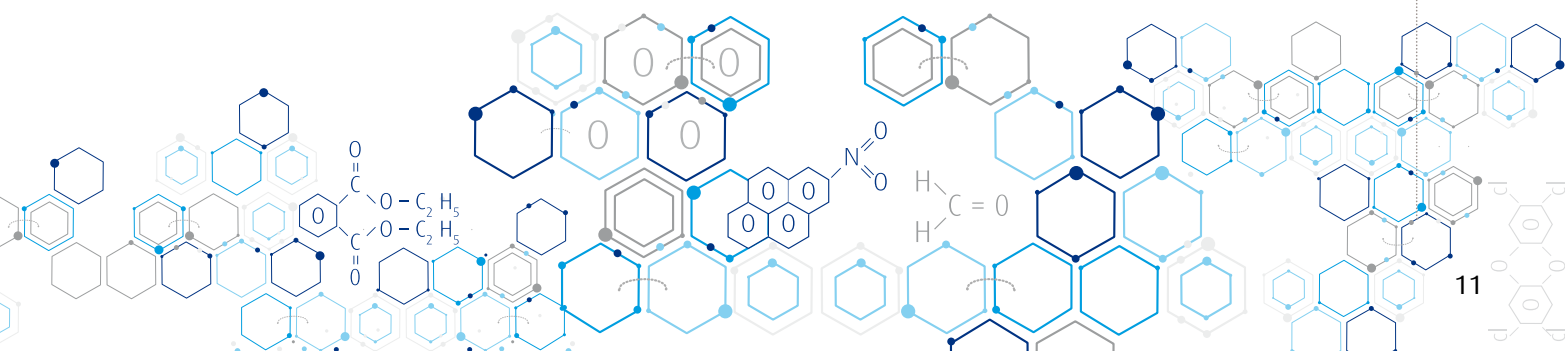


• The Station "A. Liberti" at Montelibretti

This site forms part of the network for the Cooperative Program for Monitoring and Evaluation of the Long-range Transmission of Air pollutants in Europe (EMEP). The programme, within the framework of the Convention for international cooperation on Long-range Transboundary Air Pollution (CLRTAP), is aimed at solving problems relating to the long-range conveyance of polluting species. It generates regular and continuous scientific information of use to Governments for the development and appraisal of international protocols to reduce emissions. The Station is equipped with state-of-the-art scientific equipment for the monitoring of air pollutants as part of national and international research projects. It also offers space and support for temporary equipment and for intercomparison exercises and intensive measuring campaigns.



> The Station "A. Liberti" at Montelibretti



international activities

The Institute is involved in many international programmes, also in its capacity as a national representative, in the sphere of atmospheric pollution and environmental sustainability, the development of strategies and technologies to curb and mitigate impacts and the transfer of knowledge to policy makers and stakeholders for the preparation and implementation of environmental legislation. As a national representative for European directives (e.g. IED-IPPC, REACH, GPP) and international treaties (e.g. UNECE-CLRTAP, Minamata, Stockholm, Basel) on atmospheric pollution, it handles, in part through the coordination of ad hoc working groups, the transfer of knowledge to political decision-makers on a number of subjects, such as emissions of pollutants from man-made and natural sources, technologies and methods to reduce emissions and monitoring air quality, development of innovative technologies to monitor the quality of data and share information.

With many researchers and technologists occupying leading positions in European and international programmes and projects, the Institute is able to play a part in steering future strategic choices in the various areas of environmental research. Within the framework of the Group on Earth Observation (GEO), which is seeking to develop the GEOSS (Global Earth Observation System of Systems), the Institute's researchers and technologists play a key role in the development of global observation systems and the definition of strategies and technologies designed to ensure the sharing of geospatial information on environmental quality and sustainability. The GMOS (Global Mercury Observation System – www.gmos.eu) project has been designed and built, as a global observation system for the monitoring of mercury pollution. GMOS is comprised of over 40 permanent observation stations in the north and south of the planet, with a programme of oceanographic measurements and also tropospheric measurements up to the UTLS. GMOS is coordinated by the Institute, and involves over 50 partners worldwide. It has been funded by the European Commission in FP7, and is currently supported by UNEP and GEF, to

supply data and forecasting models to be used for the implementation and enactment of the Minamata Convention. The GMOS system and coordination activities for the UNEP Mercury Fate and Transport Partnership Area is an integral part of the Centro Nazionale di Riferimento sul Mercurio (National Reference Centre for Mercury, CNRM) (www.cnrmerc.org), created by the CNR and the Ministry of the Environment in support of the Minamata Convention. In the INC6 (International Negotiation Committee) meeting held in Bangkok in November 2014 CNRM, together with GMOS and activities performed for UNEP, was recognised as reference partner for the future implementation of the Minamata Convention.

The Institute actively participates in leading international programmes to develop cyber(e)infrastructures for the sharing of environmental information, development of thesauri in the various Earth Observation domains, extraction of information in relation to the various issues of atmospheric and environmental pollution and the complex process of preparing and implementing environmental policies. These include programmes forming part of NSF-Earth Cube (BCube project), Research Data Alliance (Brokering Governance), Belmont Forum (e-Infrastructure and Data Management), INSPIRE (metadata), Open Geospatial Consortium (Earth System Science for netCDF). It also contributes to numerous European initiatives and projects centring on the design and development of digital infrastructures for inter- and cross-disciplinary research in the sphere of Earth and Space Sciences.

The general aim of the Institute is to make a contribution to scientific progress and technological innovation by taking an active part in the European Research area. The transfer the results of research to broad swathes of the Public Administration (domestic and overseas) and to Businesses in order to rewrite the paradigm of socio-economic development, combining the protection of environmental quality and sustainability with an advanced knowledge-sharing and green economy model that can benefit future generations is fundamental to the Institute.



The institute has been certified by **SGS** since **18/09/2006**
ISO 9001 / UNI EN ISO 9001: 2008 • Settore EA: 35, 37

Edited by **Laura Ragazzi** (IIA)

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