The role of CNR in national climate research

The most relevant activities of CNR in climate change research are part of the projects funded by the Ministry of University and Research. The main research topics are:

- the role of atmospheric particulate of anthropogenic origin on climate change (AEROCLOUDS Project, coordinated by CNR);
- the vulnerability of Italian coasts and marine ecosystems to climate change (VECTOR Project);
- the development of innovative instruments for the implementation of the Kyoto Protocol: creation and harmonization of the Italian measurement network for forest and agricultural sinks, and development of the national system for estimating and forecasting the absorption of greenhouse gases (CARBOITALY Project)

In addition, CNR coordinates 6 other projects, including the SHARE project (Stations at High Altitude for Research on the Environment), funded by Ministries and national Agencies, and participates in a further 15 projects.
Furthermore, CNR undertakes numerous activities on climate change developed in the framework of the National Programme of Research in the Antarctica (PNRA), covering a wide range of fields, including atmospheric and marine sciences, glaciology, and biodiversity.
CNR has also agreed with the recently founded Euromediterranean Centre for Climate Change, a framework program for joint research on chemical and physical processes of climate and the development of models for regional climate change.

The oceanographic vessel Urania (CNR Picture)

The role of CNR in international climate research

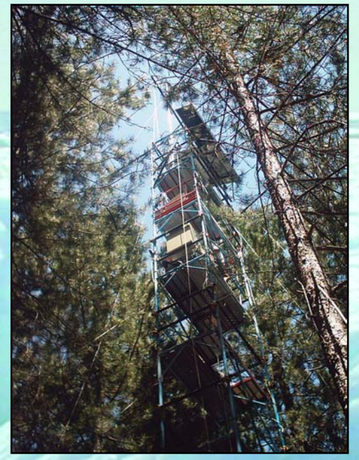
At the international level, the reference of CNR for climate change research are the large-scale projects promoted by IGBP (International Geosphere-Biosphere Project) and WCRP (World Climate Program), as well as the Framework Program for Research and Technological Development of the European Union. CNR currently participates in more than 40 international research projects on climate promoted by the European Commission (EC) and the European Science Foundation (ESF), with coordination responsibility for five of them, namely:

- ACCENT Network of Excellence (EC) which brings together all of the main European research institutions specialised in atmosphere composition change and its effects on environment and climate.
- AQUASTRESS Integrated Project (EC) on the mitigation of the effects of hydrological stress at the regional level, through integrated management of resources and technological innovation.
- EARLINET Infrastructural Project (EC), the first European-scale lidar measurement network for the study of atmospheric aerosol climatology.
- ISONET Marie Curie Network (EC) for the study of isoprenoids emitted by vegetation and their impact on environment and climate.
- VOCBAS project (ESF) on emissions into the atmosphere of volatile organic compounds of biogenic origin and their impact on environment and climate.

In the field of space research, CNR participates, and in some cases coordinates, projects of the European Space Agency (ESA) relevant to climate.
Finally, CNR is actively engaged in international climate research efforts set up in the framework of the International Polar Year, both in Antarctica and the Arctic.

CNR infrastructures for climate research

The instrumental infrastructure available for climate research in CNR Institutes include high-technology laboratories and computing facilities for development of models, as well as data storage and processing. The CNR Institutes also operate a number of experimental stations and equipment for both in situ and remote-sensing monitoring. These include stations for the study of atmospheric composition change, at the ground and at high altitude (Monte Cimone, S. Pietro Capofiume, Roma-Tor Vergata, Lecce, Lamezia Terme, Vigna di Valle), as well as over the sea (Venice Platform), in Antractica (Concordia, Zucchelli), in the Arctic (Dirigibile Italia) and in the Himalayan region (Piramide Laboratory). At these stations various technologies are integrated, including: lidar and sodar systems, radiometers, high-resolution interferometers, radars, and radiosonding systems. In the Arctic region, CNR is also a partner in the realization of the Ny-Ålesund Marine Laboratory. In addition, CNR operates the research vessels Urania and Dallaporta and several smaller vessels for investigations of the sea floor and of the physical and chemical properties of the oceans and the atmosphere, as well as some coastal and open-sea buoys for studies on physics, chemistry and biology of oceanic waters and coastal environments. This is the largest oceanographic fleet at national level. CNR also manages and runs several towers and some light aircraft Sky Arrow for the measurement of fluxes of CO_2 and other greenhouse gases.



Infrastructure located in the Sila National Park for measuring carbon, water vapour and energy fluxes between forest ecosystems and the atmosphere. (Courtesy of Giuseppe Scarascia Mugnozza)

Nighttime view of the Piramide laboratory located in the Himalayas at an elevation of 5050 m. (Courtesy of Ev-K -CNR)

CNR resources for climate research

Human Resources (man/year)	
CNR Scientists	201
Technical and Administration Personnel	124
Associate Scientists from Universities and other Institutions	52
Staff with training position	131

Financial Resources (M€/year)	
Institutional Funds	35
External Funds (European Union, Government, Local Authorities, Private Companies, etc.)	9

CNR Institutes engaged in research activities on climate	*Acronym*
Institute of Research on Firm and Development	CERIS
Institute of Acoustics "O.M. Corbino"	IA
Institute for Applied Mathematics "Mauro Picone"	IAC
Institute for Coastal Marine Environment	IAMC
Institute of Agro-Envinronmental and Forest Biology	IBAF
Institute of Biophysics	IBF
Institute for Biometeorology	IBIMET
Institute of Protein Biochemistry	IBP
Institute for the Dynamics of Environmental Processes	IDPA
Institute of Applied Physics "Nello Carrara"	IFAC
Institute of Environmental Geology and Geoengineering	IGAG
Institute of Geosciences and Earth Resources	IGG
Institute for Atmospheric Pollution	IIA
Institute of Methodologies for Environmental Analysis	IMAA
Methodological Chemistry Institute	IMC
Institute of Materials for Electronics and Magnetism	IMEM
Institute for Electromagnetic Sensing of the Environment	IREA
Research Institute for Geo-Hydrological Protection	IRPI
Water Research Institute	IRSA
Institute of Atmospheric Sciences and Climate	ISAC
Institute for Mediterranean Agriculture and Forest Systems	ISAFoM
Institute of Ecosystem Study	ISE
Marine Science Institute	ISMAR
Institute of Intelligent Systems for Automation	ISSIA

Consiglio Nazionale delle Ricerche

Clima e Cambiamenti Climatici
le attività di ricerca del CNR

A cura di
B. Carli, G. Cavarretta, M. Colacino, S. Fuzzi

Climate and Climate Change: the research activities of CNR

CNR has a long tradition of climate studies, dating back to the thirties, when, under the Presidency of Guglielmo Marconi, the project *Historical Research on Climate Variations in Italy* was started. CNR has steadily increased its commitment in this field through a strongly multidisciplinary approach developed within its Institutes, generating significant and internationally recognized expertise in physical-chemical processes and modelling of climate, reconstruction of past climates, Polar research, impacts of changes on terrestrial and aquatic ecosystems and the socio-economic risks of climate change. CNR also developed a wide range of skills and important infrastructures for observing the Earth both from the ground and from satellites, coordinating or collaborating in national and international observation programs that provide the data-bases crucial for the initialization and validation of climate models.

The results attained on several climate indicators, including: temperature increase, changes in precipitation regimes with an increase in extreme events, reduction in the extension of Alpine glaciers and sea-level rise, unequivocally attest that a change in climate is taking place and that it is a global phenomenon involving the entire planet.

A greater degree of uncertainty exists, instead, concerning the causes of the changes and the prediction of future climate trends. Some experts believe that that they can be explained by the natural variability of climate and the variations in the external forcing by solar radiation. However, the most probable explanation, according to the majority of the scientific community is that, alongside natural variability, the changes induced by internal forcing due to anthropogenic activities are becoming increasingly significant.

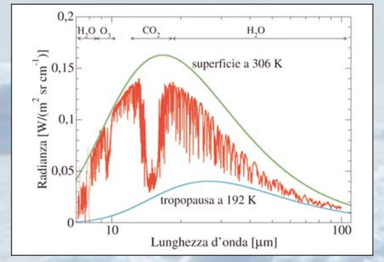
The Intergovernmental Panel on Climate Change (IPCC) established by the United Nations, has published in May 2007 the *Fourth Report on Climate and Climate Change*, to which CNR scientists provided a significant contribution. The Report states that global warming is a real fact and that most of the increase in the global mean temperature observed from the mid-20th century on is very likely (probability greater than 90%) due to the increase in the concentration of greenhouse gases caused by human activities.

A more certain assessment of the current situation and future evolution of climate at the global and regional scales, requires the availability of mathematical models capable of providing an accurate description of the physical, chemical and biological processes taking place within the climate system. This description is still fragmented, because of the extreme complexity of the system. Volcanic eruptions, the presence in the atmosphere of aerosols and dusts, the role of clouds, the changes in the chemical composition of the atmosphere, solar radiation, atmospheric and oceanic circulation, the hydrological cycle and precipitation balance, deforestation and, in general, land-use changes are just some of the players on the climate scene. The challenge of research is therefore to understand the processes operating within the climate system, and to evaluate correctly their role in the context of global climate variability.

Increasingly refined models are necessary to predict how the climate will evolve at the global and regional scales in response to different scenarios of intervention (or non-intervention) and to develop adaptation strategies to climate conditions different from those of the past.

These are the climate research issues in which CNR Institutes are engaged, and the results for the past few years of activity are published in the volume *Clima e Cambiamenti Climatici: le attività di ricerca del CNR*.

The patrimony of knowledge, research infrastructures and data presented here, has been built up by CNR as a service to the Country, also in collaboration with other research Institutions working in this field, above all to provide policymakers with the necessary knowledge with which to prepare measures of contrast, mitigation and adaptation to the changes already taking place and predicted in the future.



First spectrally resolved measurement of the up-welling radiance of the Earth towards space (red curve). The measurement, performed from a stratospheric balloon in the tropics, is compared with the black body emission of the Earth's surface (green curve) and of the tropopause (light blue curve). The observed spectral structure is due to the distribution and to the spectroscopic proprieties of the gases indicated in the figure. The difference between the red curve and the green curve is the quantification of the greenhouse effect. (Courtesy of Luca Palchetti)

Climate modeling and physico-chemical processes of climate

In recent years considerable progress has been made in climate models and interpretation of their results, even if the reliability of climate predictions remains subjected to scrutiny and discussion. Of paramount importance is the understanding of the physical-chemical processes characterizing the climate system and the feedbacks causing the non linearity of the cause-effect mechanisms within the system. CNR is engaged in numerous and extensive activities in the field of climate modeling: from global-scale to regional-scale models, from climate models of intermediate complexity to neural network models. The research issues addressed include climatic anomalies in tropical regions, teleconnections with the Mediterranean region, the climatic variability and predictability of atmospheric circulation regimes, and the description of marine and terrestrial ecosystems. Important research is also undertaken on the development of parameterization of processes involving atmospheric aerosol and clouds and the validation of models with experimental data. On the other hand, CNR studies on chemical and physical climate processes cover a wide range of topics relating to the changes in the chemical composition of the atmosphere and the consequent radiative effects, precipitating cloud systems and extreme events, the variability of the African monsoon and of the thermohaline circulation.

Reconstruction of past climates

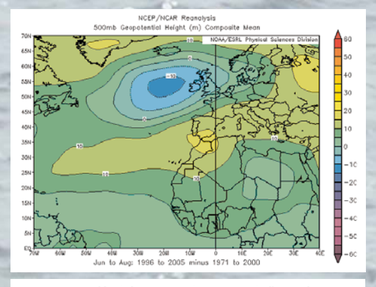
The reconstruction of past climates is of great importance to evaluate the natural climate variability. This research is performed with different methodologies: ice coring, sediment analysis, dendrochronology, pollen analysis, isotopic ratios for the study of paleoclimate, historical documents and series of instrumental data for the recent climate variations. The studies of CNR concern the paleoclimatic reconstruction through the analysis of long sediment records from continental areas and lake basins. A further line of research aims at the reconstruction of climate trends in Italy over the past 200 years, with attention focused on temperature and precipitations. These investigations are based on historical series of meteorological data, which have been gathered, harmonized and critically examined, so building a data-bank that is a unique heritage in the field. Other climate change indicators are also analyzed, including sea level, intense precipitations and heat waves.

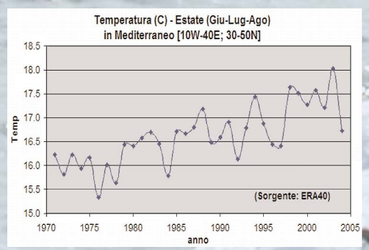
Polar research and climate change

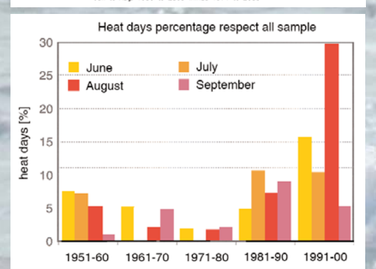
The Earth's climate variability is not limited to the geographical areas used for human activity. Hence, the study of extreme environments is a fundamental task for attaining a complete knowledge of the physical, chemical and biological processes determining global climate. CNR contributes to the study of extreme Polar environments with a significant participation in the National Research Program in Antarctica and the management of the station Dirigibile Italia in the Svalbard islands. The Polar areas are an ideal site for the study of hydrosphere-cryosphere-atmosphere interactions, the Antarctica, in particular, for paleoclimate investigations, analysing continental ice cores and marine sediments. Furthermore, extreme environments, thanks to their great distance from anthropogenic sources, constitute a unique test bed for the early identification of global perturbations (reduction in the extension of glaciers, change in dominant species, loss of biodiversity). Finally, CNR studies analyse the radiative, dynamic and biological processes through which the Polar areas and seas interact with climatic variables (aerosol-radiation interaction, marine segregation of carbon, teleconnections among remote processes).

Satellite observations, measurement networks and data-bases on climate change

CNR has a cogent activity in the development and implementation of new scientific instruments, measurement methodologies, and observation networks, as shown by the realization of instruments for atmospheric aerosol characterization, towers for the determination of CO_2 fluxes, different types of sea buoys, and by measurements of CO_2 along marine paths, and observations of climate indicators. Important are the results obtained thanks to the availability of some infrastructures, such as low-altitude aerial platforms for measuring surface exchange processes, a climate chamber for studying the effects of environmental changes on plants, and geographical information systems. CNR plays a major role in national and international observations networks. Of particular note is the Ev-K^2-CNR initiative, which manages the Piramide Laboratory located at 5050 meters in the Himalayas. Climate issues require observations on a global scale, which are most efficiently obtained by remote sensing from satellite. Alongside traditional ground-based measurements, recent years have seen an increase in the number of projects in which CNR employs satellite data to obtain operational precipitation fields, sea surface temperature, cloud properties, vegetation cover and response of vegetation to variations in exposure to sunlight and precipitations.







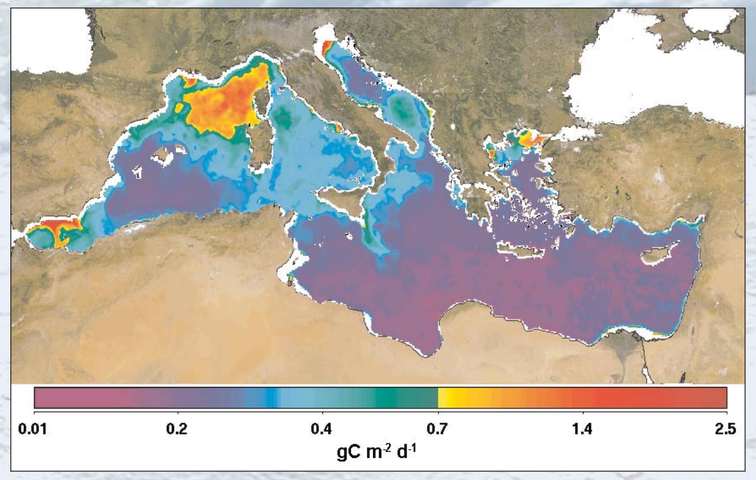
Changes of the atmospheric circulation affect the summer climate of the Mediterranean region. Upper left Figure shows the increase, relative to the reference mean in the period 1971-2000, of the mean atmospheric pressure at 5500 m level, recorded during the decade 1996-2005. As a consequence Atlantic perturbations shift northward and warm air from Africa enters the Mediterranean. These changes determine in Italy a climatic variation characterized in particular by dry spells and heat waves. Therefore during the summer, since the eighties, the trend of temperature (upper right Figure) in the Mediterranean region shows a relevant increase of the mean values, while the analysis of climate observations in Italy shows an increase in the number and intensity of heat waves (Figure on the left). (Courtesy of Marina Baldi)

Impacts of climate change

In the current panorama of climate research, the analysis of the impact of climate changes on the environment has assumed particular relevance. The increase in temperature, as well as causing the melting of Polar ice and a rise in sea level, directly influences ecosystems, which also undergo the stress due to changes in atmospheric composition and rainfall patterns. CNR performs numerous and diverse research activities in this area, focusing on the changes in the hydrological cycle, coastal erosion, the loss of biodiversity, the presence of alien fish species, phytoplankton communities and fish populations, especially in relation to fishing problems. A further area of investigation is the study of the physical, chemical and biological impacts of climate change on both Italian and Himalayan lakes. The data-bank, that is being assembled for the latter ones, is unique in its kind. Special attention is devoted to the impact of climate change on soils, vegetation, agricultural production, with studies on erosion, nutrients, drought, desertification, on the one hand, and Mediterranean crops, forest ecosystems, and the diffusion of insects and plant parasites, on the other. Considerable attention is devoted to the study of the responses of ecosystems to the increasing CO_2 concentrations and the sequestration capacity of vegetation, also with enrichment experiments in non-confined environments.

Mitigation of climate changes and adaptation

CNR is also engaged in numerous activities in the field of risk prevention and adaptation to climate change. Researches address various topics, from socio-economic issues, to the planning of safeguard and mitigation strategies. Worth to mention are studies on the impact of changes on agriculture, leading to an evaluation of the quantity and quality of products and soil deterioration, the classification of agricultural areas and infestations of parasites and insects. Further research concerns the analysis of environmental alteration, the planning and management of water resources, the problem of forest fires and landscape modification. Moving on from the natural environment to the human inhabited one, studies are being developed to express climate stresses in quantitative terms and to evaluate the impact of climate changes on recreation and the cultural heritage. From the technological point of view, research is directed towards the reduction of pollutant emissions, with studies addressing both the confinement of greenhouse gases and the development of energy saving technologies. Last but not least, effort is devoted to work of a socio-economic character for the purpose of analyzing and evaluating the risk mitigation instruments adopted so far, also at the international level.



A regional model has been developed to assess the impact of marine plankton on the carbon cycle and to study its variability over the last twenty years. The model, based on satellite remote sensing of ocean colour, allows the evaluation of the marine primary productivity (biomass available for higher trophic levels for surface unit and time). The figure shows the primary productivity of the Mediterranean sea (measured in grams of carbon/square meters/day) evaluated from SeaWiFS satellite observations for the month April 1999, during which maximum productivity was observed relative to the last decade. (Courtesy of Rosalia Santoleri)

All papers in the book
Clima e Cambiamenti climatici: le attività di ricerca del CNR
can be found in the web address: *www.dta.cnr.it*