

Project of strategic interest – PNR 2011-2013

NEXTDATA

**A national system for the retrieval, storage,
access and diffusion of environment and climate data
from mountain and marine areas**

CNR participating institutions:

URT EvK2-CNR, CNR-ISAC, CNR-DTA

External participating institutions:

**CMCC, DISAT-UNIMIB,
CASPUR, ENEA UTMEA, ICTP, INGV**

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EXECUTIVE PROJECT PLAN

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PARTICIPATING INSTITUTIONS

CNR institutions

For undertaking the NextData project activities, the CNR institutes have specific expertise, are centres of excellence and/or occupy a unique position in terms of the sector, facilities, international scientific joint ventures and international governmental agreements regulating the implementation of programmes.

URT Ev-K2-CNR: *CNR institution of research for Third Parties.* International excellence in the implementation of climate monitoring and measurement campaigns in remote high-mountain areas, the set up and management of experimental facilities in extreme environments, the running of and participation in international measurement programmes (SHARE, GAW-WMO, UNEP, bilateral programmes). It conducts activities in high-altitude areas in the Alps, Apennines, Hindu-Kush Himalaya Karakorum, Rwenzori, and the Andes. Participant in WPs 1.1, 1.2, 1.3, 1.4, 1.5, 2.1, 2.2, 2.3, 2.4 and 2.6.

CNR-ISAC: *State research institution.* International excellence in the field of climate observations in remote regions, measurement of atmospheric parameters and air quality, design, management and implementation of measurement campaigns, development of innovative technologies for data measurement and transmission, data analysis, numerical simulations of the global climate and high-mountain climates, *downscaling* techniques and analysis of climate change impacts on the mountain environment. It is involved in the management of European projects and participates in international programmes (GAW-WMO, UNEP, SHARE, ACTRIS, GEO/GEOSS, GEWEX, EC-Earth, ECRA). Participant in WPs 1.1, 1.2, 2.1, 2.5 and 2.6.

CNR-DTA: *State research institution.* International excellence in the running of experimental and observation programmes in remote areas, the drilling of cores in marine sediments and processing of sediment cores, data analysis and paleoclimate research activities. Participant in WPs 1.5, 2.4 and 2.6.

Non-CNR institutions

A number of scientific, data-processing and management institutions not affiliated to the the CNR, have been involved in the definition of project issues and in the undertaking of project activities. They have been identified on the basis of criteria of scientific excellence, and in view of their possession of essential expertise for the successful outcome of the project, thus assuring the attainment of the objectives envisaged by the project. There follows a brief description of the characteristics of excellence of the non-CNR institutions taking part in the project activities.

DISAT-UNIMIB: *State university.* Competence of international excellence in paleoclimate research based on ice cores, in ice drilling and data analysis, the development of techniques for the drilling and analysis of ice cores in extreme environments. Participant in WPs 1.4, 2.3 and 2.6.

ENEA UTMEA – Agenzia Nazionale per le nuove tecnologie, l'energia e lo sviluppo economico sostenibile: *Governmental research institution.* The ENEA UTMEA groups involved in the project have competences of international excellence in the measurement of atmospheric parameters in remote areas, the development and use of numerical regional-scale and climate models, Earth-atmosphere interactions in the Mediterranean area, paleoclimate studies by means of ice-core analysis, and participation in and running of international projects. Participant in WPs 2.1, 2.5 and 2.6.

CASPUR: *Non-profit inter-university consortium.* Competences of excellence in scientific numerical calculations on massively parallel computers, data processing and storage, the development of archives and data access portals and procedures of graphic visualization. Participant in WPs 2.5 and 2.6.

ICTP: *International institution funded by the Italian Government, UNESCO and IAEA.* Competences of international excellence in high-resolution numerical simulations of regional climate in the areas involved in the project, including the Himalayan zone. Participant in WPs 2.5 and 2.6.

INGV: *State research institution.* The INGV group involved in the project has competences of international excellence in the analysis of marine data and in reanalyses of the Mediterranean, based on the assimilation of historical data into high-resolution numerical models. Participant in WPs 1.3, 1.5, 2.2, 2.4 and 2.6.

CMCC: *Non-profit making limited consortium company.* Competences of international excellence in numerical simulations of the global and regional climate, the analysis of climate variability impacts, and participation in international research programmes on climate simulations (IPCC, CMIP5). Participant in WPs 2.5 and 2.6.

Public tenders

Starting from the second year, part of the project budget will be allocated through processes of public tender, aimed at identifying institutions and companies able to provide the expertise essential for the successful outcome of specific project activities. In particular, during the first year, the structure undertaking the development of the General Portal for data access will be identified. During the course of the project, public tenders will take place also to identify the organizations and institutions that will be involved in undertaking pilot studies regarding the use of the data and portals, those that will provide logistic support for core drilling outside Europe, and those that will furnish support in the construction and maintenance of the physical ice core archives. For this purpose, a two-stage procedure will be followed: firstly, in a fully disclosed manner, preliminary investigations will be undertaken to ascertain whether the required competences exist within the CNR, as priority choice. In the case of a negative outcome, open public tender processes will be conducted to identify the institutions with the required expertise.

DESCRIPTION OF PROJECT

Project motivations

An understanding of the climate and its changes, estimates of climate variability impacts and the development of measures of prevention, adaptation and mitigations, also in the light of the international commitments that Italy must fulfil over coming years, are predicated on the availability of reliable and continuous quantitative data on the state and evolution of the climatic and environmental systems, and on the availability of climate projections for the regions under consideration.

Over past years, an outstanding number of national research initiatives and projects, often carried out by the CNR and funded by the Framework Research Programmes of the European Union or linked to major international organizations (UNEP, WMO, WHO), have led to the creation of databases and repositories concerning the environment and climate, which greatly differ in size. In fact, the sizes of such archives vary from the information collected in single measurement campaigns for the study of specific processes, to the very large databases generated by satellite observation systems (foremost among them, COSMO-SkyMed), global measurement systems and numerical simulations of climatic variability. However, the currently available *in situ* measurements mainly refer to areas of easy access. By contrast, *in situ* data from remote areas of difficult access, such as high-altitude regions, are sparse, or even entirely lacking, in vast geographical areas that are hard to reach.

Access to quantitative information on remote regions is instead crucial in order to arrive at complete picture of the climatic and environmental situation. **Mountain regions, in particular, are considered to be the “sentinels of change” because they respond more rapidly, and more intensely, to the climatic and environmental changes in progress.** The resolution of the UN General Assembly in the 78th plenary session on Sustainable Mountain Development (UN, A/Res/62/196, 2008) states that: “mountains provide indications of global climate change through phenomena such as modifications of biological diversity, the retreat of mountain glaciers and changes in seasonal runoff that may impact major sources of freshwater in the world [...]” and that “sustainable mountain development is a key component in achieving the Millennium Development Goals in many regions of the world”. Detailed information on mountain regions permits us to determine in advance the type of evolution awaiting us in the coming decades, allowing the preparation of adequate measures of prevention, adaptation and mitigation. In addition, mountain areas are often the “water towers” of entire regions. Thus, climatic and environmental alterations in high mountains can have dramatic effects on the availability of water resources, the so-called “blue gold”, which has a determining influence on energy production, agriculture, the economy, urban settlements and societies living in the surrounding areas. It is therefore essential to increase the measurement network in high mountains, including the drilling of non-polar ice cores, which are capable of furnishing unique and irreplaceable information for determining climate variability in the recent past.

Open-sea areas are also difficult to access, yet are of great importance to climate systems. In particular, the information contained in marine sediments, retrievable by means of core drilling, provides essential data for the reconstruction of environmental and climatic conditions, allowing the comparison of current variability with that of the past, and the construction of databases for the validation of climate models. Similarly, high spatial and temporal resolution reconstructions of the Mediterranean “marine climate” during the past hundred years would allow a quantitative estimate of the climatic fluctuations of the recent past and the development of more reliable future projections.

The costs of maintaining and organising data from permanent monitoring networks and periodic measurement campaigns are very high, especially in the case of remote sites. For them to be truly useful both scientifically and in terms of application, **there has to be an adequate engagement with the critical issue of the organization and fruition of the data, through the creation of facilities working in close connection with international networks of measurement and climate research.** Modern science is progressing within a context when the process of scientific discovery increasingly depends on the capacity to analyse and manage extraordinary quantities of data. The pace of discovery and, hence, in the ultimate analysis, social and human productivity, is more and more dependent on how scientists manage to extract meaning from the mass of measurements, theories and experiments presented to them. This is especially true in the case of atmospheric sciences, like meteorology and climatology, which measure, study and analyses one of the most complex systems in existence, in terms of the parameters and variables on which scientists must operate. The knowledge embodied by a discipline is difficult to distil into few numbers and/or names, and the dispersion of the research process may lead to the loss of data, in the event of laboratory closures or the retirement of researchers themselves. It is therefore of crucial importance to build integrated archives of data and metadata, in an effort to pool information and permit its immediate and efficient utilization by all researchers, as well as public and private users, including the manufacturing and commercial sectors.

In tandem with measurement, data storage and dissemination activities, **it is essential for the researchers participating in the project and for representatives of the international scientific community, even those not participating directly in NextData, to be involved from the very outset in research activities based on the use of data and archives,** in order to improve and, where needed, modify, the project's observation strategies. Such research efforts, referred to here as "pilot studies", also have the purpose of responding to specific applicative requirements, employing the data within the archives, providing quantitative information and constituting an example for scientific research and applicative efforts based on the data obtained during the project.

NextData sets out to provide an answer to these requirements, by supporting and promoting the establishment of *in situ* measurement networks in remote mountain and marine areas, and developing the technology necessary to cope with the entire life-span of data, from their production to their validation through selection, management and analysis, and their permanent storage, guaranteeing their scientific and applicative exploitation by users by means of an efficient and user-friendly portal. The project also aims to develop a number of pilot studies, in collaboration with the international science community, to define "scientific questions" and provide quantitative estimates of the impacts of climatic and environmental changes.

The NextData project will develop technological and data-processing tools in harmony and collaboration with the international initiatives already in existence. They include the international projects and programmes SHARE GeoNetwork, GAW-WMO, ABC, GMES, GEO/GEOSS, GEWEX, SeaDataNet, EuroGOOS, MyOcean, specific European projects (FP7, Cost Actions, JRP and JPI), such as ACTRIS, MeteoMet and TERRABITES, the activities of ICOS, the International Glaciological Society (IGS), the European Climate Research Alliance (ECRA), the EC-Earth modelling consortium and the CMIP5 and CORDEX programmes for comparisons among climate projections. The project will also work in synergy with the research and monitoring activities of the CNR.

Parallel to the research activities, NextData will undertake **training and educational activities through the involvement of post-graduates and young researchers, the organization of Research Doctorate courses, the provision of university lectures and courses, as well as the activation of study bursaries and research grants. It also envisages the creation of an international school** devoted to research on mountain environments, pelecimatological studies, and analysis of the impacts of climatic and environmental variability in high-altitude regions. Additionally, it will disseminate and circulate the project results, through

a series of public lectures, the publication of articles and reports, and the development of multimedia products.

An important objective of the NextData project is the **establishment of a national “Network of Excellence” for the measurement, storage, analysis and interpretation of climate and environmental data, in order to make them available to the scientific community, management organizations and companies.** The Network will be set up during the first year, involving both CNR and non-CNR institutions identified on the basis of criteria of scientific and management excellence, and will be completed in subsequent years with the involvement of organizations selected by means of public tenders.

Scientific and technological objectives

Access to quantitative information on remote mountain and marine areas is fundamental for achieving a complete picture of the climatic and environmental system. Currently, however, information from remote regions is still scarce and often difficult to access. It is therefore of primary importance to increase the number of climate observation networks and measurement campaigns in mountains, complementing them with the drilling of non-polar ice cores, which provide essential information for determining climate variability in the recent past. Likewise, information from remote sea areas and sedimentary cores are crucial for obtaining a complete view of the changes which are in progress. In addition, the reconstruction of the climate in the Mediterranean area is essential for assessing climate change in coastal zones of major socio-economic interest to Italy. Finally, so that the measured data are truly useful from the scientific and applicative point of view, it is essential to undertake a careful planning of the organization and use of the data obtained.

The NextData project intends to respond to such needs by supporting and promoting *in situ* measurement networks in remote mountain and marine areas. Project activities will involve existing measurement stations, often part of international measurement networks, and data already available, permitting their integration and supporting the operative continuity of observations. Moreover, NextData will develop new measurement stations, performing further experimental field campaigns consonant with the project goals. The types of measurements undertaken will include meteorological data, air-quality data and data on climate-altering atmospheric compounds, data from cores of non-polar ice and marine sediments, collected for the purpose of reconstructing the climate of the past millennium, and environmental data, such as estimates of biological diversity and measurements of the hydrological cycle. A high-resolution reconstruction of the climate of the Mediterranean Sea in the last hundred years, will also be undertaken. A physical archive will be set up for the storage of non-polar ice cores, and support will be lent to the implementation of a marine sediment core repository, to allow the future analysis of the data according to new scientific requirements that may arise in future years. Finally, *ad hoc* numerical simulations will be performed to characterise climate variability in the regions of interest, the results of which will be made available to the scientific community.

The NextData project aims to create a system of Long Term Data Repositories, storing climatic and environmental data that build upon those already in existence, consolidating and strengthening efforts in progress, thus also safeguarding previous investments. The system includes both digital and non-conventional archives, such as ice cores, which call for specific maintenance techniques. Furthermore, the project envisages the technical up-dating of observation networks and processing systems to align them with the demands of the new mission. For each line of research, NextData will develop a specific access portal, as well as a General Portal, characterised by highly efficient processing and management technologies, which will constitute the access point to the system, also guaranteeing its extension to other institutions and/or

bodies that may subsequently wish to participate. The information made available by the project will be vital to the achievement of strategic scientific goal, to the planning of development and environmental safeguard interventions, and to the formulation of mitigation and adaptation measures, harmonizing data access and fruition policies, and strategies of technological adaptation, innovation and management.

NextData addresses, in particular, remote areas that are difficult to access and characterised by complex and extreme environmental conditions, such as high-mountain regions and specific sectors of research at sea. Especially at high altitudes, it is important to obtain information from the greatest possible number of measurement stations, well distributed in space and installed at different heights, due to the extreme orographic and climatic complexity of mountain terrains. The archives will also supply essential information on metadata, for example, the context in which an observation network has developed, the description of the instruments and methods employed. The datasets accepted by NextData will be certified, quality controlled, permanent, and accessible to the scientific community free of charge and without limitation, according to the INSPIRE directive. The data will concern environmental, climatic and paleoclimatic parameters from remote areas, as yet very sparsely available, although they are indispensable for estimating the future evolution of environmental systems and planning appropriate steps of adaptation and mitigation.

As well as the General Portal, physically located in Italy, the NextData project will develop **a centre for retrieval and analysis of data (including climate-altering emissions) and numerical simulations in mountain regions of complex orography for the region Hindu-Kush – Karakorum – Himalaya (HKKH).** The new centre will have an operational base in Kathmandu, Nepal, and, if possible, a second one in Pakistan. The centre should become a reference point for climate studies in the HKKH region, in synergy with international initiatives (UNEP, UE, ICIMOD, World Bank) and institutions of the countries in the region.

The definition of sites, measurement techniques and the specific climatic and environmental variables to be considered, as well as decisions on the type of climatic simulations to perform, will be addressed in the light of the requirements of the national and international scientific community. This will be based on a continuous dialogue with the researchers who will employ the data, and the needs linked to the validation and improvement of climate models, in order to best define the open questions that can be addressed through the implementation of new measurements and the integration of existing ones. The involvement of the scientific community will take the form of periodic workshops and the collaboration of research groups of excellence external to the project. Similarly, close collaboration is envisaged with national and international initiatives, including GAW-WMO programmes, UNEP, GMES, GEO/GEOSS, GEWEX, SHARE, SeaDataNet programmes, specific European projects (FP7, JRP and JPI), such as ACTRIS, MeteoMet and DRIHM, the GIIDA programme of the CNR, ICOS activities, the activities of the International Glaciological Society (IGS), the European Climate Research Alliance (ECRA) and the CMIP5 and CORDEX programme for comparison among climate projections. Many of the measurement stations included in the project already operate within these networks, and the NextData project will focus on strengthening the Italian presence within such international programmes. **The NextData archives will be open to collaboration with groups affiliated to universities and institutions not directly involved in the project, but who are able to contribute high-quality data relating to climate in remote mountain and marine areas.**

With regard to innovation, the project envisages the development of special methods for data measurement, transmission and storage, and for reducing the impact of scientific and sampling activities, which are appropriate in remote regions with difficult environmental conditions and poor accessibility. For example, tests are currently underway to allow the improvement and employment of a measurement system for atmospheric parameters and air quality, which can easily be transported to high-altitude regions, while special techniques for ice-core analysis are also planned. A further example is the development of a high-efficiency energy supply system, working off solar panels and high-powered

batteries, for use at high altitudes and in remote areas. The creation and management of the general data access portal will also allow the development of a data processing and analysis facility for private users (production companies, insurance companies, energy production companies). By its end, the project will make available **an integrated computerised system supplying technical-scientific support to decision-makers for the definition of appropriate knowledge-based environmental and climate policies**; in addition, a platform will be set up to provide support for existing initiatives and programmes, and to promote participation in new national and international projects.

Along with the definition of key issues, interaction with the scientific community will also take the form of participation in specific “pilot studies”, which constitute a central part of the project. The pilot studies will have the purpose of (i) defining the needs of researchers and data users, contributing to a constant improvement of the project strategies; (ii) employing acquired and historical data to respond to specific scientific and applicative questions concerning climate and environmental change impacts. The pilot studies will provide quantitative results on themes such as the estimation of hydrological resources, climate change impacts on health, ecosystems and biodiversity, the analysis and interpretation of paleoclimatic data from ice and sediment cores, analysis of uncertainties linked to climate reconstructions for the past hundred years in the Mediterranean area, and the possible geopolitical and social effects of climate and environment changes. The pilot studies are expected to begin generating results early on, offering hints as to possible improvements in the types of measurements and methods adopted and their integration. Such suggestions will be based on requirements emerging from scientific research, including, where appropriate, the high-profile expertise of other groups affiliated to universities and research institutions. The pilot studies envisaged in NextData will be based on the use of the General Portal and the data obtained in the course of the project, according to the following themes:

- Estimation of changes in the hydrological cycle in mountain areas (precipitation, snow cover, glaciers).
- Definition of direct and indirect aerosol effects in mountain areas.
- Assessment of changes in biodiversity and ecosystems in high-altitude areas.
- Assessment of climate and environment change effects on health in mountain regions.
- Climate reconstructions from ice and sediment cores and numerical simulations for the past millennium.
- Estimation of the response of the Mediterranean to climate forcings.
- Analysis of geopolitical effects of climate change in specific mountain regions of interest.

When the project is concluded, it will have supplied **innovative results linked to the availability of digital repositories of climatic and environmental data for remote mountain and sea regions and of a physical archive of non-polar ice cores**. These data will be available to international networks and will provide the scientific community and companies operating within the environmental field with **a unique and irreplaceable database for use in research, applications towards environmental protection, and assessment of climate change impacts**.

The project will include training and education activities aimed at young technicians and researchers, focusing on the development of skills in the planning and performance of measurements, as well as the analysis, interpretation and use of data. **The educational activities will take the form of doctoral research programmes, specialist and doctoral theses, the provision of study bursaries and research grants with the institutions participating in the project, and the organization of specialist residential courses on project issues**. The young researchers under training will participate in the phases of experimental activity, archive building and pilot studies.

An important objective of the NextData project is the **establishment of a national Network of Excellence for the measurement, storage, analysis and interpretation of climatic and environmental data and their availability to the scientific community, public authorities and companies**. This Network will be founded during the first year, with the participation of public research institutions, both affiliated to the CNR and external, selected on the basis of criteria of scientific and operational excellence. It will be completed in

subsequent years, also through the possible means of public tenders, for the involvement of partners not as yet identified.

Thus, the main objectives of the NextData project can be summarised as follows:

1. *OBSERVATION SYSTEMS*: Improvement and maintenance of high-altitude climate and environment observation systems in Italy and other geographic areas identified for intervention, according to recent European directives and developing efficient and up-dated strategies of ground measurement and storage.
2. *CLIMATIC AND DIGITAL ARCHIVES*: Setting up of climatic and digital archives into which all information produced by the high-altitude and marine observation networks, as well as numerical and modelling data, will be channelled, allowing the coherent and accessible storage also of information from new measurement stations and generated by other initiatives.
3. *LONG TERM CLIMATIC AND ENVIRONMENTAL ARCHIVES*: Setting up of (non-polar) ice and sediment core archives in order to ensure the conservation of the information derived from mountain glaciers at risk of extinction, and guarantee their future analyses in the presence of innovative techniques, archives of biological data (seed banks) of plants at risk of extinction in high-altitude areas, and contribution to the analysis of sediment and ice cores.
4. *CLIMATE RECONSTRUCTIONS FOR THE MEDITERRANEAN AREA*: Through the collection and processing of historical data relating to the Mediterranean basin, performance of a reanalysis at high spatial and temporal resolution addressing Mediterranean climate variability during the past hundred years.
5. *RECONSTRUCTION OF THE MEDITERRANEAN CLIMATE IN THE PAST THOUSAND YEARS*: Analysis of data obtained from non-polar ice and sediment cores, and numerical simulations of regional climate in the presence of different types of forcings, will allow for a quantitative estimate of climate variability in the Mediterranean and the Alpine regions for the past millennium, as a baseline against which future climate scenarios will be compared.
6. *INFORMATION SYSTEMS FOR CLIMATE AND ENVIRONMENT DATA*: Development of an intelligent information system for climatic and environmental data, based on the creation of a user-friendly General Portal of data access of easy consultation. Use of this system will allow the development of environmental analyses and forecasting models and their comparison with numerical models, in support of decision-makers, stakeholders, and available to the scientific community.
7. *SUPPORT SYSTEM FOR INTERMINISTERIAL AND INTERNATIONAL DECISION-MAKING*: Implementation of systems providing technical and scientific support to political decision-makers in the definition of knowledge-based environment and climate policies. Development of a platform supporting the activities of programmes already in progress and promoting response to announcements of new national and international projects.
8. *INDUSTRIAL DEVELOPMENT*: In synergy with manufacturers, development of advanced technical solutions in the field of sensors and instrumentation for environmental and climatic monitoring in mountains or remote areas of difficult access. Development of a data processing service for private end-users (insurance companies, manufacturers, energy supply companies).
9. *USE OF ARCHIVES FOR ENVIRONMENT PROJECTION AND IMPACT ASSESSMENT*: In the context of pilot studies based on the use of the experimental, observation and numerical data repositories, the NextData project envisages the development of methodologies for the use of data in environmental forecasting, assessment of impacts of climate variability on the environment, health and society, and the improvement of forecasting models. The archives will include the results of numerical simulations, focusing on the regions considered, capable of providing climate projections for the coming decades.

Strategic regions of intervention localization

The data obtained during the NextData project will refer to remote areas of special scientific, geographic and geopolitical interest, both nationally and globally. They include high-altitude mountain areas in Italy, with particular attention focusing on the Alps, Apennines and the Mediterranean basin, the Hindu-Kush – Karakorum – Himalaya mountains (Asia), the Rwenzori region (Africa) and the Cordillera Real (South America).

High-altitude zones in Italy, in both the Alps and Apennines, are essential for understanding climate and environment variability in this territory, both in the present and past, as well as for air-quality studies and the estimation of water resources today and in the future (for example, extension and evolution of glacial and snow-covered areas, precipitation regimes, evapotranspiration regimes), also with the goal of providing scientific support to the development of risk prevention, adaptation and mitigation measures. The Apennine area is host to the Monte Cimone station, part of the GAW-WMO global network, which represents a privileged point for collecting information and data for the NextData project. The setting up of measurement networks on the southern Alpine slopes is, moreover, an urgently felt need both nationally and internationally. In synergy with similar measurement networks on the northern side of the Alps, it will allow a complete characterization of climate and environment changes and the assessment of resources and risks in the Alpine region.

The Mediterranean basin is another strategic region for NextData, being particularly suited for climatic and paleoclimatic studies, as it is geographically confined and situated in an area of transition between the North African deserts and central and northern Europe. The basin is frequently subject to the transport of local and cross-border air pollutants, transport of particulate mineral mobilised from the Sahara desert, as well as being subject to the frequent forest fires which affect the nations that directly overlook the basin. The intense solar radiation that characterizes the Mediterranean means that these emissions can generate high concentrations of pollutants harmful to human health and damaging to the ecosystems of land and seas. The area is also subject to well-known continental stream flows, well-defined exchange balances and mechanisms with the open ocean. In addition, its close relationship with continental masses influenced by different climate processes allows documentation of global scale climate evolutionary phenomena. Finally, the retrieval of relatively high sedimentation rate values, documented for the late Quaternary, makes the Mediterranean basin a strategic place for the study of the past climate on the basis of high-resolution investigation of marine sediments, and the reconstruction, at high spatial and temporal resolution, of climate fluctuations over the past hundred years.

At the global level, other mountainous regions are extremely important from the climate and environment viewpoints. One of the most important regions is the mountain area of Hindu-Kush - Karakorum - Himalaya (HKKH). Extremely rich in glaciers, it constitutes the source of major rivers, such as the Yang-Tze, Yellow River, Brahmaputra, Ganges and Indus. They supply water to about a billion people in China, India and Pakistan, where changes in the availability of water resources are likely to generate strong political and social tensions. The HKKH region is therefore crucial from a geopolitical point of view and is of unique relevance to the global climate. Currently, the area is host to numerous international projects, such as the UNEP and ABC programmes, World Bank projects, ICIMOD initiatives, the European CEOP-AEGIS project, as well as the SHARE ABC and SHARE Paprika projects. The high Himalayas is the location of the Nepal Climate Observatory - Pyramid, part of the GAW-WMO global network, and a crucial point for enabling the collection of climate information and data for the archives of NextData. The NextData project will therefore lead to a significant increase in observational knowledge in the high-altitude areas of this region and will create a permanent archive of in situ data and data from numerical simulations, in close collaboration with research institutions and universities in Nepal, India and Pakistan.

In Africa, the Ugandan Rwenzori region hosts one of the most important African glacial systems, currently undergoing marked retreat, and running the risk of complete disappearance in the coming decades. This mountainous area is one of the areas closest to the equator able to sustain glaciers and was declared a UNESCO heritage site in 1994. The melting of ice in this region has given rise to course changes and fluvial erosion, triggering intense territorial disputes among the neighbouring countries. In terms of climate, the area is influenced by the seasonal variability of the Inter Tropical Convergence Zone (ITCZ) and can be influenced by changes in particulate loading (aerosols) in the atmosphere, particularly because equatorial Africa is one of the areas of the planet most affected by processes of biomass burning. The NextData project plans to acquire information for the database by integrating and providing support for the continuous monitoring efforts present in the area. This will take place by means of fixed networks of automated measurement stations (AWS) and specific campaigns, in collaboration with the Uganda Wildlife Authority and the Ugandan Meteorological Service. In addition to meteorological data, the monitoring of the area's glaciers will provide important information on current climate evolution.

In the region of the Bolivian Andes, in proximity to the Chacaltaya laboratory at 5230 meters a.s.l. (the world's highest research station for astrophysics and physics of cosmic rays), many glaciers have disappeared or have undergone significant retreat. For this reason, the study of climate change in this area is of particular interest, also in relation to changes in the chemical composition of the atmosphere and fine dust loading in the region. Such considerations prompted the creation of a new regional station for measuring atmospheric chemistry and aerosols in the GAW – Global Atmosphere Watch – programme of the WMO. The station is to be coordinated by Bolivian researchers of LFA-UMSA, thanks to an international collaboration that includes Italy, France, Switzerland, Germany and Sweden. The NextData project will facilitate the implementation and operation of this station, in synergy with other international initiatives, ensuring that the data, once obtained, are stored in user-friendly archives.

While the various mountain regions considered in the project possess similar characteristics (high altitude, extreme environment, strong daily and/or seasonal thermal excursions), they are located in areas with highly distinctive meteoroclimatic regimes. The creation of archives of high-quality data from all such regions will lead to enormous progress in the understanding and characterization of climate and environment change dynamics in high-altitude regions. The archives obtained by sediment coring in marine regions of the Mediterranean basin and ice coring on mountain glaciers, together with the results of multi-secular climate simulations focusing on this region, will allow a reliable quantitative characterisation of the climatic and paleoclimatic variability in Italy and the Mediterranean area over the past centuries.

Expected socio-economic results

As a research effort, the NextData project will have as its main outcome the availability of and easy access to quantitative data and numerical simulation results on climate and environmental variability in remote mountain and sea areas, the definition of the impacts of such changes on the environment, resources, and society, as well as the technological development of instruments suitable for remote areas with harsh environmental conditions. In addition to the scientific and technological achievements, NextData will also have a series of economic and social impacts. In particular, the expected results are:

1. Creation of data archives for use in procedures for evaluating climate-change and environment impacts, in synergy with the research and monitoring activities carried out by CNR. The archives will be available in real time for specific applications on the part of public institutions and private users, allowing rapid and easy access to the data necessary for obtaining quantitative answers to specific application requirements. In this way, the community of public and private decision makers and authorities responsible for land management will benefit from a single information collection centre, thus simplifying the work of data search and speeding up operating procedures.
2. Establishment of a General Portal for data access that is able to ensure the correct collection of data and an end-user-friendly diffusion of the system's information. It should also lead to the development of a rapid response system in scientific terms, functional to the requirements of environment planning, and a system for the estimation of long-term consequences and for intervention programming. The dissemination of data will be guaranteed through a multi-function, multi-targeting, multi-device, technological platform, which is cooperative, integrated, and capable of providing information to both public and private users.
3. Optimization and rationalization of procedures for obtaining climate information, environmental data and their inter-operative management, and of viewing, consultation and analysis methods. Availability of techniques for the analysis and evaluation of climate and environment change impacts, using the data made available by the General Portal.
4. Development of methodologies for using the stored data by means of evidence-based pilot studies on climate and environment variability impacts, the availability of water resources, health and society, as well as the undertaking of climate security analyses in support of decision making and planning. The results of the pilot studies conducted during the project will be made available on the General Portal, along with the analytical methodologies and instruments.
5. Establishment of systems suitable for the preservation and transmission of knowledge on climate to the scientific community, decision-makers, the public and private users, by encouraging the dissemination of the results of research carried out by the CNR and other participating institutions.
6. Strengthening of synergies among public research agencies, primarily the CNR, service and education providers, and private companies, as regards the development of instrumental and experimental measurement techniques in remote areas, and use of General Portal by private companies.
7. Creation of facilities for collecting and processing data in regions also outside Italy, such as the data collection and analysis centre envisaged in Nepal and Pakistan. The project will also favour the setting up of spin-off facilities for the analysis of climate and environment change impacts and for land management planning by private users (businesses, insurance companies etc.), as well as management bodies.

Pilot studies based on the use of the General Portal for estimating impacts and adaptation

The NextData project will allow for the creation of a General Portal of access to archives of the data obtained during the project. The Portal will be able to provide crucial information on the current situation and on climate and environment variability in remote mountain and marine areas. It will also constitute a database on which to construct models and techniques of forecasting, impact estimation and methodologies of adaptation.

In parallel, during the course of the project, pilot studies will be conducted, based on the use of the General Portal and data archives, with the dual purpose of (1) defining the requirements of researchers and data users, continually helping to improve the project strategies; and (2) respond to specific scientific and application-related issues concerning climate and environment changes. The pilot studies will be undertaken by the project participants, in collaboration with groups of scientific excellence also external to the project, who will be involved on specific issues. The pilot studies are an essential part of NextData and will serve to drive the project strategies in the course of the work, highlighting scientific requirements and suggesting possible changes in measurement and observation strategies and in the methods of data storage and usability. In addition, the pilot studies will constitute an example of how the General Portal and data archives can be used, even after the project termination, to answer specific scientific or applicative questions on the impacts of climate and environment change. In fact, the General Portal will make available both the results of the pilot studies and the methods of investigation and analytical techniques employed.

Thus, the observational and data collection component, on the one hand, and the archiving and dissemination part, on the other, will be complemented by activities of high-level research. Continuous contact with the scientific community and the involvement, on specific problems, of researchers or groups of excellence outside the project, will allow the correct scientific questions to be posed and the structuring of the project activities in the context of the priorities defined by the international scientific community.

Some of the specific pilot studies to be developed during the project are:

- Definition of the effects of aerosols in mountain areas, particularly considering the effects of dusts and black carbon. Analyses will focus on direct radiative effects, indirect thermodynamic effects, and microphysical effects of precipitation, as well as those linked to deposition of aerosols on snow surfaces. The work will be based on the analysis and interpretation of data provided by the measurement station networks and by specific campaigns carried out during the project, also using non-hydrostatic models adapted to the conditions of complex orography and able to represent aerosol dynamics. Particular attention will be paid to aerosol dynamics in the Himalaya-Karakorum region, where the strengthening of measurement networks envisaged by the NextData project will allow the attainment of the quantitative characterisation of aerosol impacts in the mountain environment.
- Use of meteoroclimatic data from mountain regions to validate non-hydrostatic models of atmospheric circulation in regions of complex orography. In particular, use will be made of the stations of the Khumbu valley in Nepal and of the Baltoro valley in Karakorum, Pakistan. Analyses will regard precipitation in high-altitude regions, its dependence on orography, and the partitioning between liquid and solid precipitation. Existing ground and satellite measurements will be analyzed, and new measurements obtained with instruments appropriate to high-altitude regions.
- Evaluation of changes in dynamics of the Indian monsoon, also associated with aerosol effects. Analysis of changes in interaction between monsoon-type tropical circulation and circulation at mid-latitudes (western weather patterns) in the Karakorum area. Data obtained during the project will be used to validate climate

models and obtain projections of changes in precipitation and atmospheric regimes in various future climate change scenarios.

- Estimation of changes in the hydrological cycle in mountain areas, with particular reference to the changes in snow cover and water resources, and the modelling of glacial areas in strategic regions of intervention localization. Existing data from ground-based measurement networks will be analyzed and interpreted, along with new data obtained during the project and stored in the General Portal. In particular, statistical and dynamic models of snow cover will be developed and implemented, to obtain estimates of recent changes in the persistence and depth of the snow pack in Italian mountain areas. Dynamic models of the response of Alpine glaciers to climate fluctuations will be developed. Glacial models will be validated against the available measurements and will be forced by meteorological variables obtained during the project and collected in the General Portal.
- Assessment of changes in biodiversity and ecosystems in mountain areas in strategic regions of intervention localisation, through statistical analysis and interpretation of data obtained during the project, and of pre-existing data, which will be made available on the General Portal.
- Assessment of effects on health in mountain regions in strategic regions of intervention localisation, with special attention focusing on the effects of aerosols on the indoor and outdoor environments in Himalayan region.
- Reconstructions of past climate from ice and marine cores and interpretation of climatic oscillations during the Quaternary, with a focus on the last millennium in the Mediterranean area, to obtain the most complete picture of climatic fluctuations in the Mediterranean basin over the last centuries. Data analysis will be completed by a series of global multi-secular simulations combined with a regional coupled sea-atmosphere model for the Mediterranean basin. To place Mediterranean variability in an appropriate context, results from coring in non-Mediterranean areas of particular interest will be also analyzed.
- Estimation of the response of the Mediterranean to climate forcing, by analyzing climate reconstructions for the past hundred years based on a high resolution re-analysis for the Mediterranean basin.
- Development and use of statistical downscaling and stochastic procedures to arrive at local statistical scenarios starting from global and regional modelling results. The use of downscaling procedures will allow a comparison between modelling results and ground-based measurements, in order to validate climate models and obtain climate projections with high spatial and temporal resolution for statistically estimating climate change effects on the mountain environment.
- Analysis of the geopolitical repercussions of climate change in specific sample areas considered by the project, including effects of changes in the hydrological cycle in the Hindu-Kush - Karakorum - Himalaya region and in some Middle-Eastern regions, and the geopolitical effects of climate change in particular African regions. Such analyses will allow the development of climate security skills for use in management and planning, also after project completion. These skills will permit the achievement of scenarios of social and political development and will suggest adaptation strategies appropriate to the various areas considered by the project.

In the course of the project, a special working group will be set up for each pilot study, which will be open to expertise external to the project.

Synergies with international research initiatives

Numerous national initiatives and research projects, funded by the European Union Framework Programs for research or linked to international organizations, have led to the creation of databases on the environment and climate. The NextData project will evolve in synergy with studies already in progress, making available to these programs the data collected and use of its archives. Their reliability is ensured by the fact that the data obtained during NextData will be certified, quality controlled, permanent, accessible and compatible with the INSPIRE directive.

In particular, the system created by NextData will collaborate with the following international initiatives:

1. **UNEP (United Nations Environmental Program):** Ev-K2-CNR will manage the archive of environmental and climate data relative to mountain ecosystems (SHARE) on behalf of UNEP. In line with the demands of the Chap. 13 of Agenda 21 and to support the resolution 62/196 of the UNGA, its role is to make available reliable scientific data and quantitative information to decision-makers and the international community. This will give decision-makers a continually updated and comprehensive picture, allowing them an adequate level of knowledge in the field, in order to promote environmental protection.
2. **WMO (World Meteorological Organization):** The WMO, through the Global Atmosphere Watch (GAW) programme, coordinates a network of stations for the study of the physico-chemical properties of the atmosphere. The stations of the GAW program must ensure the continuity of measurements performed according to well defined international standards and protocols. The participation of various countries in GAW constitutes a formal input to the Framework Convention on Climate Change (UNFCCC), signed also by Italy. NextData will assist in the continuous maintenance of operational stations, also in compliance with UNFCCC commitments, and the analysis of the data produced.
3. **GMES (Global Monitoring for Environment and Security):** NextData may qualify Italy to play a more active role in the GMES system, both at the marine project level (ECOMF, MyOcean), and in initiatives relating to atmospheric studies (MACC) and the management of environmental emergencies (SAFER). The NextData project will enable Italian research efforts to build some national climate databanks, thus making a coordinated contribution to the GMES Climate Service planned for the near future.
4. **GEO/GEOSS (Global Earth Observation System of Systems):** The results obtained by NextData could represent the Italian contribution to the GEO/GEOSS global Earth Observation System, particularly in relation to mountain ecosystems, in view of the role of the Ev-K2-CNR project SHARE within the 2011-2013 operational plan as leader of activities on mountain ecosystem vulnerability.
5. **GEWEX (Global Energy and Water Cycle Experiment):** The CNR is actively involved in the work of GEWEX, and the data collected by NextData will make an extremely useful contribution to the activities of this international initiative. Some of the pilot studies undertaken in the context of NextData are central to the GEWEX themes and a close collaboration between the two initiatives is therefore envisaged.
6. **HyMeX (Hydrological Cycle in Mediterranean Experiment):** The observational activities involved in HyMeX concern aspects of the hydrological cycle of extreme interest to NextData, such as the estimation of the intense precipitation in remote mountain areas. Integration between the activities of NextData and HyMeX is thus envisaged.

7. SeaDataNet: The CNR, ENEA and other Italian institutions are participants in SeaDataNet. The NextData project will interface with this venture, also in view of the projects that will be developed as part of the future Horizon Framework Programme 2020 and initiatives promoted by the JPI.
8. ECRA (European Climate Research Alliance): The CNR and ENEA participate in the initiative launched by the European Parliament "European Climate Research Alliance" (ECRA), with specific responsibility for coordinating the Collaborative Programme "Changes in the Hydrological Cycle". The activities undertaken during the NextData project are pivotal to the themes of this Collaborative Program and are set within a perspective of full integration with ECRA.
9. ICOS (Integrated Carbon Observation System): Some of the observation and monitoring activities planned for NextData are complementary to those performed by other measurement networks working in Europe, such as the ICOS project for the measurement of atmospheric greenhouse gases and the carbon cycle. A synergy with these measurement networks is therefore expected.
10. CMIP5 and CORDEX (Climate Model Intercomparison Project 5; Coordinated Regional Climate Downscaling Experiment): The results of some of the simulations performed or stored during the NextData will contribute to these international projects for intercomparison among modelling outcomes. Therefore, a close integration with such activities is therefore planned, also in terms of cross-linking of results.
11. EC-Earth: Some of the global climate modelling activities performed in the context of NextData will be part of the European EC-Earth Consortium, of which the CNR is a member. The purpose of the Consortium is to improve global climate models and its work is based on the atmospheric models of the European Centre in Reading, ECMWF.
12. FP7 projects: Close ties are envisaged with several FP7 European project focusing on issues considered by NextData, such as ACTRIS (Aerosols, Clouds, and Trace gases Research InfraStructure Network), MeteoMet (Metrology for Meteorology) and DRIHM (Distributed Research Infrastructure for Hydrometeorology). Specifically with the latter, a cross-link is proposed between the NextData General Portal archives and the hydrological and ground response models envisaged by DRIHM.
13. IGS (International Glaciological Society): NextData activities relating to the coring of non-polar ice will be undertaken in collaboration with international research programmes and in synergy with the IGS.
14. ILTER (International Long Term Ecological Research): Several of the ground-based monitoring activities carried out by NextData, relating to the assessment of biodiversity and its changes in high-altitude areas, will be integrated with the long-term ecological monitoring already performed as part of the ILTER programme.
15. Specifically in relation to the research activities undertaken in the Himalaya-Karakorum region, collaborative efforts are envisaged with the National Center for Earth Surface Dynamics of the NSF, USA, the National Center for Atmospheric Research (NCAR) of Boulder, Colorado, USA, and with the initiatives of ICIMOD (International Centre for Integrated Mountain Development).

Education and training activities

The NextData project provides for specific educational and training activities on topics relating to monitoring and measurement in remote mountain and sea regions, as well as data storage and usability. In particular, the pilot studies will see the involvement of students and young researchers engaged in periods of training and instruction.

Bursaries and research grants will be implemented, at the CNR, universities and other institutions involved, which will allow the training of young researchers on project issues. Doctoral degree bursaries will also be offered by agreement with universities and, where possible, by activating Research Doctorate specialist programmes at the CNR. Level II Specialist (Master) Degree courses and level III Doctoral courses will be set up, which will include some of the themes of the NextData project. Thus, work for Master and Doctoral Degree theses will be undertaken at the institutions participating in the project.

Particular importance will be attached to the organization of residential intensive courses on project-related issues for PhD students, post-graduates and young researchers. The courses will be held by researchers participating in the project, and by external lecturers of excellence in the issues considered by NextData. Specifically, an international school of research on the mountain environment will be set up, holding periodic residential courses on the scientific topics addressed in NextData. The school will be run by a board comprising a coordinator and a scientific council, whose members are researchers with expertise, both project participants or affiliated to external organizations and institutions of other countries.

Dissemination activities

Dissemination within the scientific community will take place through the publication of scientific articles in international journals and technical reports, as well as participation in national and international conferences and meetings with the scientific community. In addition, the NextData project intends to disclose and disseminate results towards the general public, schools and decision-makers of management bodies by realizing specifically targeted promotional material. They will include the organization of periodic meetings with schools and the public to explain project activities and results, as well as meetings with stakeholders and representatives of authorities. Articles will also be written for publication in the general and specialist press. The General Portal of access to data will include a website for public viewing, to illustrate the results of the project.

Also envisaged is the creation of video material illustrating the observational and experimental method employed during NextData, informing the public on innovative developments and the results obtained in the course of the project. In addition, at the end of the NextData activities, public conferences will be held to illustrate the results achieved, some intended for the scientific community, others for decision-makers, and others for the general public.

Project Duration

The duration of the project will be four years starting with project approval and the allocation of funding. Given the complexity of the planned activities, especially at the international level, an extension may be requested in the event that it is necessary to terminate some of the activities and for financial accounting requirements.

Continuation of activities after project conclusion

By its end, the NextData project will have strengthened the measurement network in remote areas and will have created a General Portal and a series of environmental and climatic digital archives to provide the necessary information for scientific research and application developments. In addition to the data and archives, NextData will also have developed pilot studies based on methods capable of making the best use of the data made available by the General Portal. On concluding the effort of creating networks, archives, General Portal for data access and collection and data processing centres, it will be necessary to maintain this system, updating it with new data from measurement stations and providing new analyses on the basis of scientific and applicative requirements.

Some of the products and scientific/technological services obtained during the NextData project will be related to the market for sensors and environmental monitoring instrumentation. In recent years, this market has increasingly expanded, both because it offers an excellent possibility of technological growth and because world economies are experiencing the need of managing the environmental impact of their activities in order to avoid repercussions bringing increased socio-economic damage.

A further essential aspect of NextData is the ability to provide innovative methods of analysing and interpreting data and numerical simulations, in response to specific application-related issues, some of which will be addressed in the context of the pilot studies. Once the data becomes available on the General Portal, their use and quantitative interpretation will often require specific skills not in the possession of all users. Thus, at the end of the project, technical and scientific support for the analysis and interpretation of data and results will be provided, based on skills acquired during the project, as a service to the scientific community, decision-makers, and private users.

During the course of the project, NextData will therefore favour the creation of streamlined facilities, both in Italy and in other regions of strategic interest, which are self-maintaining after the end of the project, ensuring the continuation of activities through national and international research programmes and interaction with companies. Accordingly, great attention will be paid to ensure that the project is of interest to industry and private companies, increasingly in need of reliable, accurate information for evaluations of climate impact and adaptation, as the basis for planning activities and future development. Hence, the facilities created during NextData will supply specific services to businesses, such as data analysis, processing and interpretation, using the techniques developed during the project, and ensuring the continuation of the functionality of the archives produced by NextData.

PROJECT STRUCTURE

Description of NextData project structure

The NextData project is subdivided into two Sub-projects (Sp), entitled

1. **Integrated observation system for environmental and climate monitoring**
2. **Long-term archives of digital data on environment and climate and pilot studies on data use**

The two Sub-projects represent the two specific methodological approaches of the NextData project: (i) the observation phase, involving the planning, observation and collection of data according to specific scientific and experimental requirements; (ii) the phase involving storage, analysis and interpretation, associated to specific computer science needs for visualization techniques and data analysis. The pilot studies included in this phase will permit a rapid focus on problems arising from the issues considered, to provide appropriate suggestions and solutions, and supplying answers to crucial questions on the impacts of climatic and environmental variability.

Sub-project 1. Integrated observation system for environment and climate monitoring

The first Sub-project aims to create an integrated observation system and is divided into five different Work Packages (WP) according to the type of data measured. They are associated with diverse requirements of research, and of climate, environmental, experimental, instrumental and technological applications:

WP 1.1 High-altitude climate observation system

WP 1.2 GAW-WMO climate observatories

WP 1.3 Marine observation systems and climate reconstructions

WP 1.4 Environment and climate data from ice cores

WP 1.5 Paleoclimate data from marine sediments

Sub-project 2. System of long-term environment and climate digital archives and pilot studies on data use

The second Sub-project is devoted to the creation of environmental and climatic archives, data analysis and interpretation and pilot studies. It covers the different types of archive corresponding to particular WPs:

WP 2.1 Archive of high-altitude observation networks

WP 2.2 Archive of marine observation networks and climate reconstructions

WP 2.3 Archive of data from non-polar ice cores and long-term biological data

WP 2.4 Archive of paleoclimatic data from sediment cores

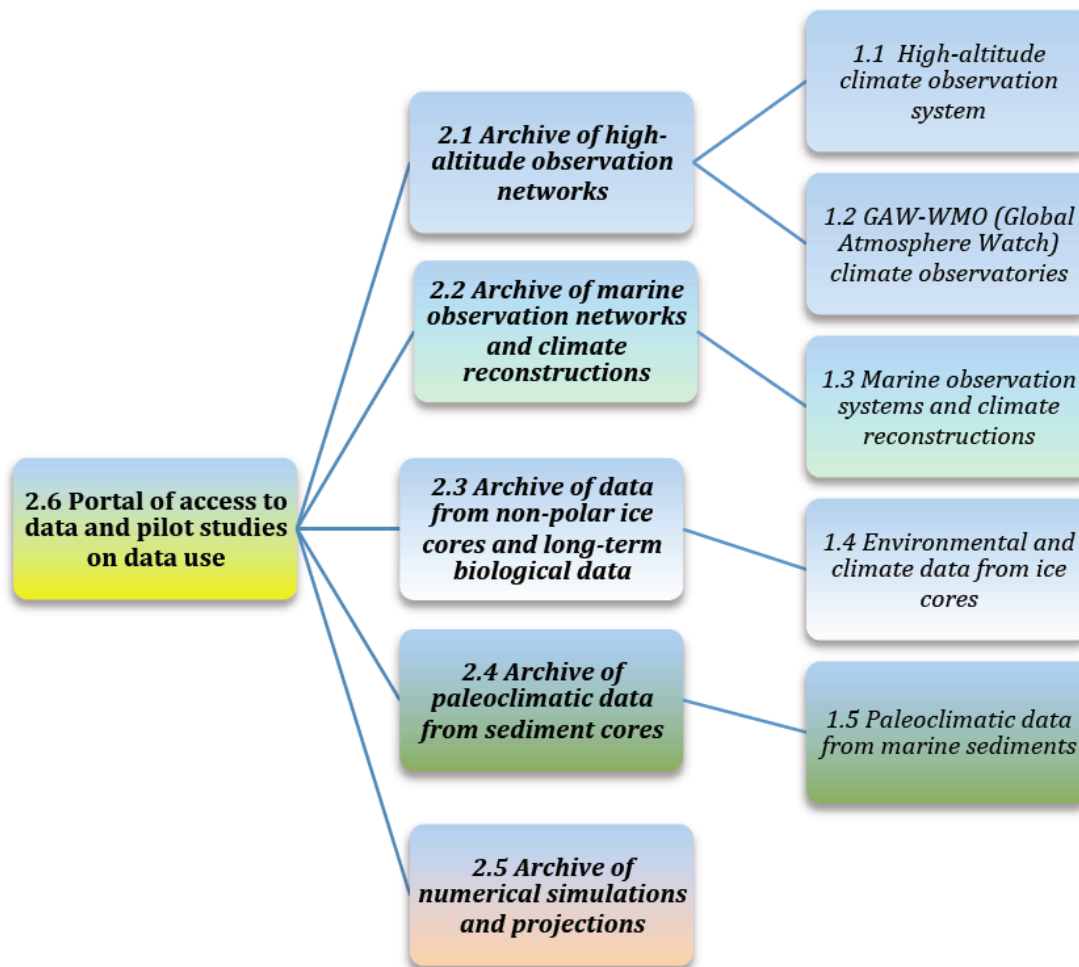
WP 2.5 Archive of numerical simulations and projections

WP 2.6 Portal for access to data and pilot studies on data use

Part of the collected data will be stored within a single distribution centre, while part will be made available at the computing centres of the participating institutions and bodies. The General Portal of access, developed in collaboration with the GeoNetwork of SHARE, will provide access to the entire series of archives in a clear, user-friendly way. The results and methods of the pilot studies will be made available on the General Portal.

The Pert diagram shown in Figure 1 highlights the relationships among the Work Packages into which NextData is divided. The observational Work Packages of Sub-project 1 are devoted to various types of measurement and communicate with the Work Packages on archive construction. The WP1.1 and WP1.2, regarding high-altitude measurements, communicate with WP 2.1, devoted to archives of high-altitude observational data. The WP 1.3, on marine observation systems, directly communicates with WP 2.2, devoted to marine archives. The WP 1.4 on non-polar ice cores communicates with WP 2.3, while WP 1.5, on climatic data from sediment cores, communicates with WP 2.4. The WP 2.5 collects the data of numerical simulations. Finally, WP 2.6 communicates with WPs 2.1-2.5 for the development of a General Portal of access to the data produced by NextData, in order to conduct pilot studies, and collate and disseminate their results.

FIGURE 1. Pert diagram for the NextData project



Means of project implementation

For the implementation of the project, the NextData Project Coordinator will supervise the coordination among the various project participants, in synergy with the DTA-CNR and URT EVK2-CNR, and assisted by an operative support group for day-to-day project management, and an Executive Committee with regard to strategic choices. He will organize regular meetings for verifying the progress of activities and the redefinition of strategies and project timelines, as required. The involvement of local stakeholders is ensured by activities of information exchange and verification of the results achieved, through conferences, workshops, seminars, technical reports and monographic publications. Doctoral courses, bursaries and research grants will be activated, and educational summer schools will be held focusing project on topics. With regard to the activities undertaken on the national level, a preferred channel of communication will be established with the Regional Administrations of research centres involved in NextData.

The URT EVK2-CNR will also support the research groups involved, in order to optimize the coordination of scientific activity, ensuring links and interactions with European and non-European research projects, agencies and institutions. For such purpose, specific activities will aim to strengthen the scientific and institutional partnerships in the organization and implementation of monitoring and research. In particular, contacts will be maintained with national and international efforts, including the GAW-WMO, UNEP, GMES, GEO/GEOSS, GEWEX, SHARE, and SeaDataNet programmes, specific European programmes (FP7, JRP and JPI) such as ACTRIS, MeteoMet and DRIHM, the CNR GIIDA programme, ICOS activities, International Glaciological Society (IGS) activities, the European Climate Research Alliance (ECRA) and CMIP5 and CORDEX programmes for comparing climate projections. The Project Coordinator, support group and participants, are responsible for ensuring that NextData activities are undertaken in synergy with these national and international programmes.

The partnership and ongoing collaboration with institutions participating in the project will ensure the proper conduct of activities and a correct flow of the data and information necessary for the implementation of the information systems envisaged by the project. For specific issues, collaboration is envisaged with individual research groups of excellence from institutions not participating in the project. More generally, such institutions will also be involved in pilot studies, with a view to enlarging the pool of skills included in the project, along with a broader involvement of the scientific community.

The CNR, in addition to the project implementation, will ensure the correct fulfilment of scientific activities and the results produced.

Finally, technological development activities envisage a close collaboration with the private sector for the development of sensors and environmental monitoring techniques.

The research results will be compiled and presented in scientific publications and monographic papers. In particular, they will be illustrated in both half-yearly reports produced by each Work Package and in the general Annual Reports on the project's progress. Meetings will be held twice a year for project participants, with regular meetings extended to the national and international scientific community. At the end of the project, there will be technical meetings and explanatory lectures on the archives and General Portal produced by the project and their use. The project will be concluded with an international meeting, to be held in a prestigious location, where the main results and products obtained by NextData will be presented and discussed.

Scientific management and administration

For the management of the project, the Project Coordinator will make use of the technical-administrative support already operative at the DTA-CNR for the URT EVK2-CNR, which is capable of taking care of the day-to-day running of the project, the management of funds and the practical implementation of documents and financial reports. This organizational set up will ensure the overall monitoring of project activities for their correct and effective performance. Its objective is to minimize problems and to constitute a reference point for the Central Administration with regard to the scientific network. It will also assist the Project Coordinator in relations between project participants and the offices of the Ministry for University and Research (MIUR). In the day-to-day running of the project, the Coordinator will be assisted by an operational support team, comprising researchers in relation to the scientific aspects, secretarial support and administrative support.

To support the Project Coordinator in the verification of the good progress of the project and in the implementation and eventual modification of project strategies, an Executive Committee (EC) will be set up, whose members will be appointed by the Project Coordinator. The purpose of the EC will be to assist the NextData Project Coordinator in the design, monitoring of activity implementation (including coordination among the participating institutions) and verification during the course of the work, also as regards the use of financial resources. A further objective of the EC will be to assist the Project Coordinator in monitoring the project objectives, as well as those emerging from the various actions of governance, ensuring that the model of governance is realised according to expectations. In addition, the EC will support the Project Coordinator in the periodic public reporting of results.

A technical-scientific manager will be appointed for each Sub-project, along with a coordinator for each Work Package. They will report to the Project Coordinator concerning the project's progress, its results, the use of financial resources and any problems that may arise. Work Package coordinators will be appointed annually, renewable until project conclusion.

Verification of project results

Within NextData, independent of the committee of external reviewers appointed by MIUR, a Peer Review committee will be set up, comprising both Italian and foreign experts, proposed by the Executive Committee for the purpose of periodically assessing the project's progress. The said committee will examine NextData documents and results once a year, suggesting possible modifications and integrations, and evaluating any critical points. In the event of scientific problems or strategic decisions, the Peer Review committee will be convened by the EC also at time intervals of less than a year. Ideally, some of the members of the Peer Review committee should be selected from among the potential users of the data archives, to ensure a direct, first-person check on the accessibility and completeness of the data bases produced by the project.

Dissemination of results and archive usability

The results obtained during the NextData project will be presented at national and international meetings, and will be reported in international journals and regular technical reports (half-yearly and annual) to be made available on the integrated portal, as well as in articles in the general web and print media. Results of the pilot studies on impact estimation will be available on the project web site, to assist researchers, policy-makers and private users. As well as providing specific information on different types of impact, they will constitute examples of how NextData archives can be used.

In the course of the project, meetings with the scientific community will be held, to guarantee the continuous verification of project strategies, and, if required, the re-definition of some scientific questions. Meetings will also be organized with the general public, institutes of further education and universities, to illustrate the project's progress and provide information on the availability and usability of the climate and environment data archives and the results of pilot studies. The project will culminate in a widely publicised event for the presentation of the results obtained. The main project results will be collected in a final volume, which will refer to technical reports for more specific information on different types of data and archives. A multimedia documentary will also be produced and distributed on DVD, providing explanations on how the data were retrieved and the possible uses of the NextData archives.

The integrated General Portal, true nodal point of the project, will be characterized by highly efficient information and management technology. It will constitute the access point to the system, guaranteeing its expandability to other institutions and/or bodies who wish to join at a later stage, and allowing easy and immediate use of the climatological, environmental and numerical data obtained during NextData. The portal will be located at a specially set up data collection and distribution centre. It will be provide straightforward and easy access both to the data physically present in the centre and those stored at other facilities affiliated to the project. All the data will be available to the scientific community, and national authorities and institutions. By means of special agreements, it will be possible to institute collaborations with private users to provide data analysis and interpretation services.

PROJECT COMPONENTS

The project is divided into two Sub-projects with a total of eleven Work Packages (WP), as described in detail below.

Sub-project 1: Integrated observation system for environment and climate monitoring

The Sub-project envisages the development of an integrated observation for environment and climate monitoring, able to promote measurement networks in remote mountain and sea areas and to deal with the entire lifetime of the data. It includes the development of measurement and data transmission technologies that are easy to transport, and dedicated for regions with extreme environmental conditions. The measurements will include meteorological and air quality data, the coring of non-polar ice and marine sediments, and environmental data (biodiversity, hydrological cycle). The activities will be undertaken in synergy with international programmes and projects (SHARE, GAW-WMO, UNEP, GMES, GEO/GEOSS, GEWEX, SeaDataNet, ICOS, ECRA).

SUB-PROJECT 1 – LIST OF WORK PACKAGES (WP)

Work package	Title	Participating research institutions
Sp1-WP1	High-altitude climate observation system	URT Ev-K2-CNR, ISAC
Sp1-WP2	GAW-WMO climate observatories	ISAC, URT Ev-K2-CNR
Sp1-WP3	Marine observation systems and climate reconstructions	INGV, URT Ev-K2-CNR
Sp1-WP4	Environment and climate data from ice cores	URT Ev-K2-CNR, DISAT
Sp1-WP5	Paleoclimate data from marine sediments	DTA, URT Ev-K2-CNR, INGV

WP 1.1 High-altitude climate observation system

The WP 1.1 aims to support the research system at high altitudes and in remote areas, providing Italy's specialized scientific and technological contribution. It will focus on strategic regions of intervention localisation, in close collaboration with the activities of the project Ev-K2-CNR SHARE, "Stations at High Altitude for Research in the Environment". For this purpose, WP 1.1 will make use of existing monitoring systems for the continuous collection of environmental data, while promoting innovative measurement systems to acquire new observations in areas still poorly monitored.

The central goal of the WP 1.1 monitoring system is to implement meteorological stations, both fixed and mobile, in key high-altitude sites for the study of climate change. Because of the complexity of mountain terrains and the marked orographic and climatic differences typical of high-altitude regions, it will be essential to establish measurement stations at different elevations and in a variety of environmental situations. The stations will be mainly located in protected areas, such as the Stelvio National Park and the Modena Regional Park of the High Apennines in Italy, the Sagarmatha in Nepal, the National Park of Central Karakorum in Pakistan and the Rwenzori National Park in Uganda. Activities for the establishment of a climate and environment monitoring system will also be undertaken in the area of the Cordillera Real in the Bolivian Andes and in the Mediterranean basin. This will allow the retrieval of continuous measurements of the main meteorological parameters, such as temperature, precipitation, humidity, radiation at the ground, wind intensity and direction, and, in some areas, snow cover. Particular interest will be taken in climate observations and measurements relating to the chemical and physical composition of the atmosphere (fine dusts and carbonaceous particulate, ozone, halogenated compounds) performed by both fixed and mobile stations. Generally, due to the often extreme environmental conditions and the lack of adequate technical and logistic infrastructure, meteorological measurements in remote and high-altitude areas require the development and use of specialized technologies, in terms of both measurement methods and data storage and transmission techniques. Such technologies, already developed and tested during the SHARE project, will be adopted and further refined in the course of the NextData project.

Other WP 1.1 activities will include measurements of environmental parameters and specific components of the hydrological cycle, and measurement campaigns for the assessment of biodiversity in mountain regions and the analysis of high-altitude ecosystem response to climatic and environmental changes.

The above activities will secure the availability of high quality long-term data, which will subsequently allow for a significant improvement in scientific knowledge on climate variability and climate change impacts at high altitudes. The monitoring activities carried out during the NextData project will constitute a contribution to international projects, namely UNEP-ABC, WMO-GAW, WCRP-CEOP, NASA-AERONET, ILTER, EU-EUSAAR, EU-ACCENT, EU-ACTRIS, and will be coordinated with the activities of ICOS, GIIDA, GMES, GEO/GEOSS, and ECRA.

WP 1.2 GAW-WMO climate observatories

The Global Atmosphere Watch (GAW) programme of the WMO (World Meteorological Organization), part of the GCOS (Global Climate Observing System), brings together 80 countries for the purpose of obtaining precise data and information on the chemical composition of the atmosphere and its variability (both natural and linked to anthropogenic influences), and helping to increase the understanding of processes involving the atmosphere, oceans and biosphere. The GAW programme sets out to establish a global coordination of observation activities on atmospheric composition in order to create a well-organized and harmonized observation system. The activities of GAW-WMO are based on an observation network of 410 regional

stations and 28 global stations, in addition to 81 associated stations. The stations are managed and funded by the individual countries participating in the programme, both by the respective national meteorological services and/or research bodies or agencies for environmental monitoring. A foremost challenge in monitoring atmospheric composition is to contribute efficiently to the detection and attribution of trends, as the basis for research and studies for projecting future scenarios, and thus propose appropriate measures of environmental mitigation. It is therefore essential to promote and establish continuous monitoring activities over long time periods.

In particular, Italy manages two Global Stations of the GAW-WMO network: the Monte Cimone climate station (2165 m a.s.l. in Northern Apennines) and the Nepal Climate Observatory - Pyramid (5079 m a.s.l. in Nepal). Thanks to their high-altitude locations, the measurements performed at these Global Stations have a high spatial representativeness, allowing a good characterization of atmospheric variability over vast geographic regions and over long time scales. The stations provide ongoing information about the variability of the atmospheric composition in two areas considered to be climate hot spots: the Mediterranean basin and Southern Asia. Thus, the data produced is crucial for increasing understanding and a more precise quantification of the influence that natural and anthropogenic processes have on the climate system and air quality.

The goal of this Work Package, carried out in close collaboration with WP 1.1, is first and foremost to ensure the continuation of observation and analysis activities currently being conducted at the GAW-WMO Global Stations under Italian management, providing for the implementation of observation programmes and technological resources. At the same time, it will be possible to provide support to specific GAW-WMO regional stations present in Italy and/or affiliated to the SHARE programme (in both high-altitude and remote areas). This will constitute a significant upgrade of the monitoring and study activities currently performed at these research and monitoring infrastructures, as well as a crucial support for the establishment of a national climate monitoring network. The monitoring activities implemented will involve in particular the measurement of climate-altering gaseous compounds and pollutants, physico-chemical properties of aerosol, short- and long-wave radiation fluxes, and meteorological parameters.

Through the said activities, the construction of increasingly exhaustive databases on variability in atmospheric composition, meteorological parameters and solar radiation fluxes, will supply extremely valuable information to policy-makers for the design of correct environmental policies. Their ultimate purpose is the adoption of measures to curb the effects of anthropogenic emissions on air quality and, hence, the climate, ecosystems and human health.

WP 1.3 Marine observation systems and climate reconstructions

In order to reconstruct the climate signal from all existing *in situ* and satellite measurements, recent years have seen the development of reanalysis techniques, which optimally combine models and observations. Such techniques take account of ground-based and satellite observations, integrating them with numerical models of general circulation, which function as "dynamic interpolators" with the observations, returning a homogeneous reconstruction of them, with the corresponding estimates of uncertainty. Thus, reanalysis represents a climate reconstruction for the recent past reflecting the best of existing scientific and technological knowledge: it provides dynamically consistent time series, on regular temporal-spatial grids, maintaining the information from measurements wherever available, while dynamically interpolating at time-space points where observational data are lacking. To date, very few oceanic reanalyses exist at the global level, and even fewer at the regional level, in the latter case because of the high digital resolution required and the need to dispose of a significant number of observations. For the Mediterranean Sea, the

Operational Group for Oceanography of the INGV has developed prototypes of reanalysis for the past twenty years.

Historical marine data for the Mediterranean Sea over the past hundred years are available in European databases, continuously updated by EU member countries, thanks to infrastructural projects such as SeaDataNet and EMODNET. Additionally, the GMES programme has developed a network of centres for the real time collection of data at the global and regional levels, which provide *in situ* observations from automated instruments (boe ARGOs, gliders, etc.) and satellites, which are employed to update the historical databases at fixed time intervals. These European consortia have developed the metadata standards for all marine measurements, both physical and biochemical, and have provided portals for accessing observations by harmonising procedures at the European level.

The historical series available for the Mediterranean Sea cover the past hundred years, and the reconstructions produced so far refer to a total period of the order of 20 years. The present WP aims to study the feasibility of and undertake the first high-resolution time-space climate reconstruction of the Mediterranean Sea for the past hundred years by means of reanalysis techniques. It also intends to design and build a computer system to make this reanalysis available to the scientific community, authorities and private stakeholders. The expected resolution of the reconstruction will be a few kilometres for the entire Mediterranean Sea and the adjacent areas of the Atlantic Ocean, while the temporal resolution will be of a few hours, thus representing the daylight cycle. The system of access to and retrieval of the reconstructed data must envisage the rapid recovery and analysis of massive amounts of data, of the order of tens of terabytes, similar to the size of the model data, thus posing a major challenge to current technology.

Research will focus on the updating and quality control of specific databases currently available at the international level (SeaDataNet, GMES) and on the improvement of circulation models and data assimilation techniques. Thus, NextData sets out to: 1) produce a reanalysis of the past hundred years of observations in the Mediterranean Sea, using both *in situ* and satellite measurements at a resolution of a few kilometres (approximately 5 km) in the horizontal and some tens of meters in the vertical for the first kilometre of the water column; 2) provide the reanalysis and atmospheric forcings used at the maximum temporal frequency (3-6 hours) in order to resolve the diurnal cycle; 3) analyze annual, interannual and interdecadal variability of sea level, temperature and salinity; 4) produce climatologies from raw data by means of alternative statistical techniques, e.g. objective variational analysis, comparing them with the reanalyses; 5) develop products derived from the reanalyses, which are able to provide indicators of climate change in the Mediterranean and its coastal areas.

This highly ambitious challenge could lead to a climate reconstruction that is unique of its kind, able to resolve the climate signal in the coastal areas of the Mediterranean Sea.

WP 1.4 Environment and climate data from ice cores

The international scientific community has been studying non-polar ice cores for over 25 years, as indicators of climate variability and environmental change. Ice cores have been extracted from the glaciers of the Andes in South America, Mt. Kilimanjaro in Africa, Tibet, in various sites in the Himalayas, Alaska, Russia, and also the Alps. Tropical, subtropical and mid-latitude glaciers offer unique information, with a high temporal resolution of recent climate variability in areas for which there is limited availability of data on past climate. They also supply information on the evolution of anthropogenic pollution processes and natural climate-altering processes in specific continental regions. In addition, thanks to their high-altitude locations (4,000 to 6,000 m), mountain ice cores provide information on the middle troposphere in relation to large-scale climate change.

Given the very strong likelihood that some glaciers, with their precious records of climate and environment information, are facing a dramatic retreat, leading to the loss of such information, this WP aims to collect and preserve non-polar ice cores to set up a permanent archive available to the international scientific community.

In the initial phase of the project, a careful investigation will be conducted to identify those sites where it is estimated that the damage caused by global warming will inevitably and rapidly lead to the melting of the glaciers, thus making ice coring impossible, and closing off access to this unique store of environmental and climate data. This is the case of the glaciers in the Alps, African mountains and the Andes. In preliminary field work, ice cores will be collected from sites which, according to past studies, have priority status in terms of environmental studies, but where the ice collected has been entirely used up during earlier analyses. At these sites several new cores need to be drilled: one for new studies, the others for preservation in a long-term store in order to guarantee the long-term availability of this environmental heritage. Thereafter, samples will be collected from glaciers where coring has not yet taken place, but are also expected to supply important climatic and environmental information. This is the case of many glaciers located at high altitudes, especially in the Himalayas, where the thicknesses of ice do not incur fear of glacier extinction in the short term, although the thermal conditions of the ice could change rapidly.

The Work Package also envisages the classification of different areas and types of glacier by integrating multi-time Landsat, Aster and Ikonos satellite images. Use will be made of image pre-processing and processing for the estimation of indicators of surface representativeness and for the selection of test areas in which to carry out *in situ* investigations. Maps will be produced of albedo, presence of rock outcrops and debris, of tributaries and proglacial lake formation, morphological perimeter situations, variations in epiglacial vegetation cover and surface variations and glacier thickness from ground- and satellite-based stereoscopic images.

Coring will be carried out with a electromechanical wire probe that reaches a depth of 400 m. Beyond this depth, drilling in liquid will be necessary, involving heavier logistics.

The ice measurements aim to determine the chronological extension of possible atmospheric records. In particular, non-destructive measurements, such as FTIR (infrared) and DEP (dielectric properties), aim to define horizons of historical reference (^{137}Cs , ^3H , volcanic tephra, insoluble powder levels), for determining seasonality and compositional trends (oxygen and hydrogen stable isotopes, ice chemistry, mineral powders contained, and others). Use will be made of CFA (continuous flow analysis) systems, mass spectrometry systems, ion chromatography and liquid counters, in the EuroCOLD Laboratory of the Bicocca University of Milan.

The WP 1.4 envisages an important phase of technological development to reduce the impact of the activities in ice on high-altitude glaciers, by developing an energy production system based on high-efficiency solar panels. Moreover, it aims to develop systems that allow measurements directly on ice, without sampling and melting. Two specific areas of development are foreseen: the measurement of dielectric properties of ice and infrared-based measurements. The purpose is therefore to minimize the consumption of a resource intended for preservation, while obtaining valuable information.

WP 1.5 Paleoclimatic data from marine sediments

The retrieval of series of proxy data on the past climate will serve to acquire a deeper understanding of the climate system and a more accurate prediction of its future development, as a priority task for the scientific community. In particular, the analysis of climate data of the past is an essential tool for studying the dynamics of the earth's climatic system in conditions different from present ones, and irreplaceable for testing the validity of medium- and long-term forecasting models.

The determination of the influence of anthropogenic impacts on the planet's environment is predicated on a clear understanding of the natural ways in which the earth's climate responds to the complex set of external forcings. Therefore, in recent decades, many national and international research groups have focused attention on the study of the climate evolution in late-Quaternary sediments from the Mediterranean area. By virtue of its close relationship with continental masses subject to different climatic processes, the Mediterranean basin permits the documentation of climate evolution both globally and in the Northern Hemisphere. Finally, it is worth noting that shallow sea (continental shelf) areas are natural repositories for the monitoring of short-term climate change and anthropogenic impacts on the marine system.

To make available information on climate history and environment yielded by marine sediments, this WP will be dedicated to analyzing and, where possible, collecting cores of marine sediments, especially those drilled in shallow sea environments, and focusing on climate dynamics in the Mediterranean over past centuries.

During its course, the project will analyse and, where possible, sample marine sediment cores in continental shelf environments and in different sectors of the Mediterranean basin. Previous studies have indicated them as key sites for the identification of major short-term climate fluctuations, due to global and local forces active during the Quaternary and particularly in the past thousand years. In fact, the possibility of enriching the databases referring to this time interval (to date, still limited to the Mediterranean) will provide new working hypotheses for the implementation of numerical models that attempt simulate how the Mediterranean, in particular the marine-coastal sector, has responded to past climate dynamics (Medieval Warm Period / Little Ice Age transition, Little Ice Age, the Industrial Age, and Modern Warming). The cores obtained will be the focus of multidisciplinary studies involving national and international research groups.

This WP also sets out to identify available data on coring in key areas of the Pacific, Atlantic and Indian Oceans, carrying out comparative analyses on materials and data stored in international core repositories, in order to compare the various effects of the main global events/climate changes in sedimentary records of areas localized in different paleogeographic settings.

Sub-project 2: Long-term system of digital data on climate and environment, and pilot studies on data use

Sub-project 2 will develop a system of repositories storing climatological and environmental data from measurements made during the project, pre-existing measurements, and numerical simulations. It will supervise the establishment of a physical archive of ice cores, and implement the archives of marine sediment cores. It also envisages setting up a General Portal providing access to the entire archive ensemble and a centre for data collection and analysis in the Himalaya-Karakorum region, in collaboration with major international research programmes. Sub-project 2 additionally foresees a number of pilot studies based on the use of the Portal, for the definition of the "scientific questions", and providing answers to applicative questions concerning climate and environment change impacts. It will cover, moreover, training and educational activities and implement the dissemination of NextData results.

Sub-project 2 is divided into six Work Packages, devoted to the construction of archives relating to the different types of data collected during the project, the construction of the General Portal of data access and the implementation of pilot studies based on the use of the data made available by the General Portal.

SUB-PROJECT 2 – LIST OF WORK PACKAGES (WP)

Work package	Title	Participating research institutions
Sp2-WP1	Archive of high- altitude observation networks	URT Ev-K2-CNR, ISAC, ENEA
Sp2-WP2	Archive of marine observation networks and climate reconstructions	INGV, URT Ev-K2-CNR
Sp2-WP3	Archive of data from non-polar ice cores and long-term biological data	DISAT, URT Ev-K2-CNR
Sp2-WP4	Archive of paleoclimate data from sediment cores	URT Ev-K2-CNR, DTA, INGV
Sp2-WP5	Archive of numerical simulations and projections	CMCC, CASPUR, ISAC, ICTP, ENEA
Sp2-WP6	Portal of access to data and pilot studies on data use	ISAC, CASPUR, URT Ev-K2-CNR, DTA, ICTP, CMCC, INGV, ENEA, DISAT

WP 2.1 Archive of high-altitude observation networks

Measurements carried out in high-altitude regions and remote sites (e.g. island areas) yield an improved knowledge of the overall/basic/background conditions of the Earth's atmosphere. When observations are continuously performed for long time periods, they provide useful data series both for defining climate variability in specific geographical regions and for characterizing the state of the atmosphere at the global level. Meteorological observations and measurements of atmospheric composition in high-altitude areas and sites in their proximity also constitute an effective tool for identifying the different contributions (linked to anthropogenic and natural processes) determining the chemical and physical properties of the troposphere and possible climate forcings.

Mountains and remote marine areas are also extremely vulnerable to anthropogenic pressures (air quality deterioration and climate change). The integration of an updated database making available, in a systematic and integrated manner, all the information gathered by air monitoring networks is crucially important in order to define adaptation and mitigation strategies for implementation in high-altitude areas and their surrounding regions.

The WP 2.1 has the task of building and making accessible the archives of atmospheric observational data (meteorological parameters, solar and infrared radiance fluxes, atmospheric composition) from meteorological stations and GAW-WMO stations in high-altitude and remote regions. This will be achieved by setting up a dedicated WebGIS, developed in collaboration with the SHARE project GeoNetwork system. A collection centre for meteorological data and those relating to anthropogenic emissions will be set up the Himalayan/Karakoram area, with bases in Nepal and Pakistan.

The archives constructed in WP 2.1 will constitute a platform providing data series relating to many climate parameters (e.g. gases, aerosols, solar radiance, meteorological parameters). They will be shared with the national and international scientific community to validate (or initialize) atmosphere simulation models, and to perform ground-truthing for validation and calibration in atmospheric measurements by sensors installed on satellites.

WP 2.2 Archive of marine observation networks and climate reconstructions

WP 2.2 sets out to build the archives of the observational data used to build and validate the reanalyses, of the atmospheric forcings and of the reanalysis of the Mediterranean Sea at high spatial and temporal resolution for the past hundred years (1912-2011). A portal will be specifically created for access to the enormous amount of reanalysis data. It will provide user-friendly access to essential climate data, indexes of data quality, and the derived physical and statistical products.

Time series for reanalysis and reconstructions are currently required by different research and institutional users (research institutions, ENI, NATO, meteorological centres, regional environmental agencies, etc.) and private companies (environmental consultancies, coastal engineering, and maritime transport companies, etc.) for the management of the marine environment, risk assessment and sustainable exploitation of marine resources. The reanalysis time series will consist of tens of terabytes of data, which will be made available to NextData at the maximum spatial-temporal resolution permitted by information technology, with an upgrade plan to continue over the years.

In the past, the INGV has developed various interfaces for direct data access, which allow catalogue consultation and immediate downloading through web access and ftp protocols. The temporal resolution of the reanalysis data has been necessarily restricted due to the lack of specific funding. The NextData

reanalysis archive will be organized through the development of specific metadata and data formats complying with international standards, and the data will be available at the highest possible spatial-temporal resolution. The archive will be simple to access, and can be sub-sampled and displayed interactively. The archive will be designed to conform to the latest guidelines of the European INSPIRE directive and the directive on Integrated Maritime Policy. In addition, interfaces and time series transformations will be developed in order to make available value-added products, such as trends and statistics on archived data.

WP 2.3 Archive of data from non-polar ice cores and long-term biological data

This WP will deal with the construction and usability of archives containing ice-core and biological data. With regard to the data from ice cores, a first step of WP 2.3 will be to establish a WebGIS dedicated to the non-polar glacial archive. For this purpose, archives and scientific literature will be thoroughly reviewed to identify all non-polar sites where cores have been retrieved. Subsequently, they will be used to extract all the necessary metadata for the characterization of the sites, particularly those linked to the analyses and processing undertaken. A Geodatabase will be developed, mapping the glacial mountain areas of the main alpine chains (Himalayas, Andes, Alps, etc.), based primarily on satellite and aerial images at various definitions. All the data obtained will be channelled into an upgradeable WebGIS, which will interact closely with the SHARE GeoNetwork portal, as support to the basic non-polar core archive.

A Decision Support System (DSS) will be applied to analyse all of the parameters underpinning the choice of glacial areas for potential coring work. Within this context, analyses will be made of glaciological issues, aspects of international research, and political and logistical questions. This will lead to the creation of a data bank of corings and of data acquired through radar systems. All data will be equipped with metadata compatible with the main European and international standards. Subsequently, all cartographic and other data, will be published on a web platform provided with Webmapping applications.

A further activity, central to this WP, concerns the establishment of a single storage (or better cryopreservation) centre housing the samples collected during NextData (WP 1.4), which can themselves become a UNESCO World Heritage. The samples with the respective basic information will become accessible online thanks to the WebGIS, for use by the scientific community in dedicated studies. The cryopreservation centre could then become a Museum of Ice and of paleoclimatological research in mountains.

A different type of archive is envisaged for seed banks of high-altitude plants, often in danger of extinction. An example is the archive storing seeds of flora typical of the Sagarmatha National Park in the area of Mount Everest. Such repositories will be used to preserve genetic information and, in many cases, the vital seeds of high-altitude plants. By comparing the data stored against those obtained in the future, they will permit research to assess the effects of climate and environment change on plant communities and biodiversity.

WP 2.4 Archive of paleoclimatic data from sediment cores

WP2.4 centres on the construction and usability of data archives relating to marine sediment cores, also associated with the respective chemical-biological data, where available.

As regards sediment core data, a preliminary activity will be the setting up of a WebGIS dedicated to the archive of marine sediment cores, from the Mediterranean areas considered in the project. This step will involve in-depth research work on repositories and scientific literature to identify all sites where marine

sediments have been cored (both continental shelf and basin environments). This preliminary WP activity will generate the metadata necessary for the characterization of the site, which will then be assimilated within the updatable WebGIS, thus constituting the basic archive of marine cores.

An archive will also store and make available information and analysis data for specific cores from certain extra-Mediterranean sectors. An information archive and portal will be set up, comprising data obtained from studies conducted on marine cores collected during the project, as well as those from the analysis and/or review of existing cores.

An important part of WP 2.4 will contribute to the implementation of a centre for the storage of marine sediment cores (WP 1.5), including those obtained during the project, which must be closely connected with other core repositories scattered around the Mediterranean, in order to create an integrated database for the Mediterranean Basin. All the data from analysis of cores considered in the NextData project will be accessible online thanks to the WebGIS, for use by the scientific community for specialised studies. Finally, the storage site of the marine sediment cores could be the basis for a Museum of the Sea, providing both specific facilities for proxy measurements, as well as valid technical support for dissemination.

WP 2.5 Archive of numerical simulations and projections

The availability of results from numerical climatic, paleoclimatic and environmental simulations, and data from oceanic reanalyses, is essential to integrate and interpret the information provided by measurements, and to develop methods for estimating future impacts. This WP will deal with the construction of the archives of results of global, regional, and local climate simulations, as well as those of oceanic reanalyses, both pre-existing and carried out during the project.

With regard to global climate patterns, archives will be constructed to store the results of simulations for the industrial period (1850-2005) and future projections (RCP 4.5, RCP 8.5, RCP 3-PD) for the 2006-2100 period, provided by different global climate models available at the participating institutions, namely, the CMCC model and the EC-Earth model used by CNR-ISAC. Some simulations will include results on aerosol distribution, essential in many strategic regions considered by NextData. These simulations will furnish an ensemble of modelling results, which will provide a global database for the characterization of large-scale climate conditions. The results of global models will be used as boundary conditions for local- and regional-scale simulations. The global simulations will be integrated with those made available by international programmes, such as CMIP5 and EC-Earth consortium simulations. The global ocean reanalyses at two different spatial resolutions (2° and 1/4 °) produced and archived at the CMCC processing centres will cover the 1960-2010 period and, possibly, a longer period on the basis of the availability of observational data for assimilation and atmospheric forcings. The CMCC will also provide a set of paleoclimatic simulations for understanding the key climate processes involved in the growth of continental ice.

The archive will make available the results of regional scale hydrostatic simulations for the strategic regions considered in the project (Mediterranean basin, Italy, Hindu-Kush - Karakorum - Himalaya, South-American Andes, and a region in the Rwenzori). It will include both the results of pure atmospheric simulations and coupled sea-atmosphere simulations for the Mediterranean basin. The regional hydrostatic simulations will be made available by the archives and numerical portals set up during the project. Statistical and stochastic downscaling procedures will also be developed for use with the outputs of global and regional models.

The archive will include case studies of results from non-hydrostatic high resolution (1-10 km) simulations in high-altitude areas, where the complex orography will impose the development of specific modelling

solutions. In these areas, the comparison between the numerical results and the data collected by the measurement networks will be essential for the calibration and validation of local scale models. Such models will be assimilated into global simulations to obtain an archive of future scenarios with high spatial resolution in the mountain regions considered. For the strategic area of the Hindu-Kush - Karakorum – Himalayas, a numerical modelling and Earth observation centre will be set up, with offices in Nepal and, possibly, Pakistan, manned by local researchers. The latter will have the task of providing and making available local-scale climate and environment simulations for the HKKH region, including aerosol dynamics and the response of snow cover and glaciers.

The numerical simulation archives will work in synergy with the archives to be developed by the EU FP7 DRIHM project, and some of the simulations will be proposed for European supercomputing initiatives.

WP 2.6 Portal of access to data and pilot studies on data use

The data obtained by the measurement networks during the project will be collected in thematic archives, associated with the specific Work Packages discussed above. Some archives will be physical ones (ice cores, sediment cores, seed bank) and will be housed in *ad hoc* facilities set up during the course of the project. The meteorological data produced by the measurement networks and stations, along with the results of numerical simulations and pilot studies, will be stored in appropriate digital archives.

Each WP, in coordination with the others, will produce a thematic archive specific to the type of data considered. Many of the archives will be located in a single collection centre, while others will be located at the premises of participating institutions. For the end-user, however, it is necessary to access a single integrated system that provides access to data wherever they are, in an easy and clear manner. This will allow for the efficient management and coordination of possible and desirable additions to the database by other institutions joining the project later.

The first part of WP 2.6 involves the design and implementation of an integrated information system allowing the sharing of data and metadata through specific web services from a single General Portal. This information system will be set up in close collaboration with the SHARE project, and will be formed by an integrated GIS database for the management of environmental data from high-altitude areas and those relating to the past climate. The web services platform pertaining to research developed in remote mountain and sea areas will be based on Open source GeoNetwork architecture, used to create a catalogue of international standard data and metadata at the disposal of the scientific community, also complementing other forms of access. It will permit an integration of initiatives for the collection and dissemination of environmental data from research in remote high-altitude and sea areas, by establishing a dedicated General Portal for access to various existing databases and to high-altitude stations. The web portal will allow users and stakeholders to identify and access information from a wide range number of local and global sources, facilitating the consultation and use of measured data, and making available results of numerical simulations and climate projection studies. A centre for data collection and processing and numerical simulations will be established in the Himalaya-Karakorum region, with offices in Nepal and, possibly, Pakistan, which will be integrated with the General Portal located in Italy.

The collection and use of information will be promoted in a synergistic and integrated way so as to ensure usability and accessibility to the various stakeholders, governments, consultants, policy makers, and to all those engaged in the promotion of sustainable development in mountain and sea environments. This will encourage a better understanding of the phenomena associated with climate change, and the development of adequate mitigation and adaptation strategies.

Parallel to the implementation of the General Portal, this WP will encourage pilot studies exploiting the data compiled during the project, through the use of thematic archives and General Portal. The purpose of the pilot studies is twofold: (1) to define the needs of research and data users, contributing to the continual improvement of project strategies; in this sense, the scientific studies serve to "pilot" the project and its measurement and storage strategies; (2) to respond to specific scientific and applicative issues concerning climate and environment change impacts; in this sense, the scientific studies conducted during the project will be "pilots" for future studies, providing examples of how the portals created during the project and the data contained therein can be used to address both scientific and application-related issues and requirements.

Some of the issues dealt with by pilot studies will be the following:

- Estimation of changes in the hydrological cycle in mountain areas, with particular reference to changes in snow cover and water resources, as well as the modelling of glacial areas. Data obtained during the project will be analyzed and interpreted, while the dynamic models will be developed and implemented for snow cover, the response of alpine glaciers to the climatic fluctuations, and response of the hydrological cycle.
- Definition of aerosol effects in mountain areas, including direct radiative effects, indirect thermodynamics and precipitation microphysics effects, as well as effects linked to the deposition of black carbon and dusts on snow-covered surfaces. This will be done through the analysis and interpretation of the data from measurement stations networks and from specific campaigns held during the project, and using non-hydrostatic models adapted to the conditions of complex orography.
- Assessment of changes in biodiversity and ecosystems in high-altitude mountain areas, by statistical analysis and interpretation of the data from monitoring performed during the project, and earlier data to be collected and made available in the course of the project.
- Evaluation of effects on human health in mountain regions, focusing special attention on aerosol effects in indoor and outdoor environments in the Himalayan region.
- Reconstructions of past climate from ice and marine sediment cores and interpretation of climate fluctuations over the last millennium in the Mediterranean area, in order to gain the most complete picture possible of climate fluctuations in the Mediterranean basin over past centuries. Data analysis will be complemented by a series of global multi-secular simulations including a coupled sea-atmosphere regional model for the Mediterranean basin. To set Mediterranean variability in an appropriate context, results from coring in non-Mediterranean areas of particular interest will also be analyzed.
- Estimation of the Mediterranean response to climate forcing, by means of climate reconstruction for the past hundred years based on a high resolution reanalysis for the Mediterranean basin.
- Use of statistical and stochastic downscaling procedures for the comparison of modelling results and *in situ* data, in order to validate climate models and obtain high spatial-temporal resolution climate projections, contributing to the statistical estimation of climate change effects on mountain environments.
- Analysis of the geopolitical effects of climate change in specific areas considered by the project, including the effects of changes in the hydrological cycle in the Hindu-Kush - Karakorum - Himalaya region and in some Middle-Eastern regions, and the geopolitical effects of climate change in specific regions of Africa.

In addition, other pilot studies may be identified and undertaken in the course of the project, according to changing scientific perspectives and application requirements. Furthermore, the project and related pilot studies aim to establish a system of services to scientific users and companies, based on the use of the General Portal and the available data, which will enable the continuation of activities after the conclusion of the project.

The WP 2.6 will supervise the tender procedures for selecting the organisation that is to realise the General Portal for data access, and will also activate tenders to identify some of the bodies to be involved in the conduct of the pilot studies on the use of data and portals.

The WP 2.6 will coordinate educational and dissemination activities. With regard to training and education, it will activate PhD grants, bursaries and research grants, hold courses as part of Specialised (Master) and Doctoral degree programmes, and supervise Master and Doctoral degree theses. It will coordinate the establishment of an international school on the mountain environment, organising residential courses for PhD students, post-graduates and young researchers, to focus on issues relating to the mountain environment and climate considered by the project. Dissemination activities will include the organization of public meetings, the publication of articles and the realization of video material.

APPENDIX

PROJECT MANAGEMENT ORGANIGRAM

Project Coordinator:

Antonello Provenzale (CNR-ISAC)

Executive Committee:

Antonello Provenzale (CNR-ISAC, project manager)

Agostino Da Polenza (URT Ev-K2-CNR)

Silvio Gualdi (CMCC)

Coordination operational support team:

Scientific coordination support:

Jost von Hardenberg (CNR-ISAC)

Elisa Palazzi (CNR-ISAC)

Roberta Toffolon (URT EvK2-CNR)

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Sub-project leaders:

Sp1: Paolo Cristofanelli (CNR-ISAC)

Sp2: Elisa Vuillermoz (URT EvK2-CNR)

Work Package coordinators:

WP1.1: Paolo Cristofanelli (CNR-ISAC)

WP1.2: Angela Marinoni (CNR-ISAC)

WP1.3: Nadia Pinardi (INGV)

WP1.4: Valter Maggi (DISAT-UNIMIB)

WP1.5: Fabrizio Lirer (CNR-IAMC)

WP2.1: Maria Teresa Melis (URT EvK2-CNR)

WP2.2: Marina Tonani (INGV)

WP2.3: Mattia De Amicis (DISAT-UNIMIB)

WP2.4: Luciana Ferraro (CNR-IAMC)

WP2.5: Silvio Gualdi (CMCC)

WP2.6: Antonello Provenzale (CNR-ISAC)

The Project Coordinator, Executive Committee members, sub-project leaders, WP coordinators, members of the scientific coordination support team and representatives of the institutions participating in the project who do not have a role in WP coordination (Vincenzo Artale for ENEA, Filippo Giorgi for ICTP and Piero Lanucara for CASPUR) will constitute the Scientific Committee (Steering Committee) providing consultation to the Project Coordinator and Executive Committee.