



Consiglio Nazionale delle Ricerche



Project of Interest “NextData”

Research project :

Database for reconstructing the spatial-temporal evolution of the Glacial Resource in the Italian ALPs over the last 100 years in the Framework of the NextData Project (DATAGRALP)

Coordination: Marta CHIARLE

CNR - IRPI - U.O.S. Torino

Work Package :
WP 2.1 ; WP 2.6

TITLE OF THE PROPOSED PROJECT:

DATABase for reconstructing the spatial-temporal evolution of the Glacial Resource in the Italian ALPs over the last 100 years in the framework of the NextData Project (DATAGRALP)

Project duration: 28 months

Presumed start date (in the first semester 2013): 01/06/2013

End date (in the second semester 2015, no later than 30 September 2015): 30/09/2015

Scientific coordinator of the proposed project:

Marta Chiarle

CNR Institute coordinating the proposed project:

IRPI - Istituto di Ricerca per la Protezione Idrogeologica (Institute of Research for Geo-Hydrological Protection)

Participating units, indicating the scientific responsible for each unit and the motivation for the inclusion in the proposal (in particular, illustrating whether and how the expertise of non-CNR partners is not available at CNR):

Unit 1 (CNR coordinating Institute): CNR-IRPI - Marta Chiarle

Unit 2 : CGI - Comitato Glaciologico Italiano (Italian Glaciological Committee) - Carlo Baroni

**Unit 1 (CNR coordinating Institute): CNR-IRPI -
Scientific responsible: Marta Chiarle (U.O.S. Torino)**

The CNR-IRPI, U.O.S. Torino, has a 20-years old experience of glaciological studies, in the Alps and in other mountain areas around the world, focusing on natural hazards related to glacier dynamics. A significant boost to the study of glacial environments has come in recent years from the issue of global climate change, as the dramatic changes experienced by glaciers are closely related to the increasing slope instability. Glaciers and recently deglaciated areas (since the end of the Little Ice Age, LIA) have proven to be some of the most sensitive areas to climate change. As a consequence, the studies carried out by CNR-IRPI Torino in recent years have increasingly focused on recent glacier dynamics in these areas: knowledge of glaciers change over time, as well as being a crucial terrestrial indicator of climate change, is essential to understand and forecast present and future occurrence of natural instability in such areas. This is the approach followed in the project GlaRiskAlp (“Glacial Hazard in the Western Alps”, Alcotra 2007-2013 project n. 56) just concluded, which has intensely involved CNR-IRPI in the last 3 years. During this project CNR-IRPI, as well as collecting a large amount of glaciological data, by exploiting its twenty years of experience has developed advanced methodological and technological tools for the collection, storage, management and analysis of glaciological data, which can now be made available to the NextData Project.

**Unit 2: CGI - Comitato Glaciologico Italiano (Italian Glaciological Committee)
Scientific responsible: Carlo Baroni**

Any activity concerning the analysis of the glacial resource on a national scale, and in particular with its recent evolution, cannot be comprehensive without the involvement of CGI (<http://www.glaciologia.it/>). CGI is a secular institution with few equals in the world, bringing together the foremost Italian experts on glaciology (from the academic world, but not only, <http://www.glaciologia.it/il-comitato/?lang=en>) with the aim of promoting and coordinating glaciological studies in a national and international context. The most important activity carried out by the CGI is definitely the coordination of the annual glaciological campaigns that since 1914 snap the condition of the main Italian glaciers, with the acquisition of photographs and data on the position of glacier fronts (<http://www.glaciologia.it/i-ghiacciai-italiani/le-campagne-glaciologiche/?lang=en>). The CGI realized the first and unique complete glacier inventory of the Italian Alps (<http://www.glaciologia.it/publicazioni/>), and is the referent for the initiatives of glacier inventory on an international scale (<http://www.glims.org/>). CGI also verifies and transfers data to the World Glacier Monitoring Service for the diffusion and dissemination of results to all stakeholders, also through websites

(www.glaciologia.it/; www.wgms.ch/). Based on its history, the CGI has an unparalleled wealth of glaciological data, which cannot be ignored for the reconstruction of the recent evolution of Italian glaciers, and which is not available in any other institution, included CNR institutes. In addition, the high scientific level of the CGI, guaranteed by the participation of the leading Italian scholars of glaciology, make it the scientific institution of reference for glaciological studies on a national scale. The CGI is an organization officially recognized by CNR.

Carlo Baroni, President of the Italian Glaciological Committee, is full professor of geomorphology at the University of Pisa. He is associated to the Institute for Geosciences and Georesources of CNR, Pisa. Since 1996 he is in charge of the coordination of annual glacier monitoring service in the Central Italian Alps. Since 2011 he is the national correspondent for Italy of the World Glacier Monitoring Service (WGMS-UNESCO). He is the national scientific coordinator of the research program of relevant national interest (MIUR, PRIN 2010-11) "Response of morphoclimatic system dynamics to global changes and related geomorphological hazards". He co-ordinated research projects of the Italian National Antarctic Program since 1993. His multidisciplinary activity was conducted and is still in progress with several international collaborations and is focused on investigating the glacial history of the Alps and paleoenvironmental and paleoclimatic evolution of cold regions (see attached CV and list of references).

1. GENERAL INFORMATION

Abstract of the proposed project

Glaciers are widely recognized as the best terrestrial indicator of climate change. Nevertheless, occurred changes, even in recent times, are often poorly known. Italy has a unique, secular history of glaciological documentation that, jointly with a rich wealth of spatial, multitemporal data, allows an accurate reconstruction of recent glacier evolution. Unfortunately, these data are dispersed and/or difficult to access.

The project focuses on the collection, validation, storage and analysis of glaciological data from the Italian Alps, referred to the last 100 years. A dedicated system will be realized for the management of these data, in line with the requirements of NextData Portal, and in agreement with the GeoNetwork architecture – like that of the SHARE Project.

The project aims to update and make easily available to the scientific community and to the stakeholders multitemporal data on the Italian glacial resource, through an integrated information management system made for this purpose.

Main goals of the project

The proposed project aims to:

- make available to the scientific community and disseminate to all stakeholders multitemporal data on the Italian glacial resource, by developing and populating a knowledge management system of validated glaciological data, made on purpose and accessible free on line through web portal;
- quantify glacial parameters, for specific time periods, needed by quantitative models aimed to simulate the response of glacial bodies to climatic scenarios;
- reconstruct the recent (last 100 years) spatial-temporal evolution of the Italian glaciers, as terrestrial indicators of climate fluctuations, in consideration of the extreme sensitiveness of glacial bodies to climatic parameters.

Expected results of the project

The expected results are listed below:

1. Development of an integrated information management system (database plus GIS in the framework of the Portal of the Nextdata Project, and in agreement with the GeoNetwork architecture – like that of the SHARE Project), for the storage, analysis and query of numerical, textual, iconographic and spatial data of the Italian glaciers; the system will represent a validated and reliable information base for quantitative modeling of glaciers response to climatic forcing, and can be a tool for further research projects on glacial/periglacial environments.
2. An updated picture of the glacial resource in the Italian Alps, through the acquisition of the most up to date available information on glaciers, including location, main geometric and morphologic parameters, also for their use in numerical simulations, and taking into account the existing international standards.
3. Reconstruction of the recent evolution of the Italian glaciers (last 100 years), mainly represented by changes in glacier length documented by the measures carried out in the framework of the annual glaciological surveys coordinated by the CGI. When available, numerical data on glacier extent in specific years, on mass balance, as well as the most relevant iconographic and textual documents will also be provided, in support of the reconstruction of glaciers evolution.
4. Promotion of a free, distributed use of the information on Italian glaciers, to be implemented within the NextData project but also in the future, encouraging the use of open source solutions.

Role of the different units

The role of Unit 1 (CNR-IRPI, coordinator) will be as follows:

1. To design, implement and administer a data management system related to the Italian glacial resource, in accordance to the indications of CGI, and providing the technical and informatics support required.
2. To input in the system the validated information provided by CGI, ensuring that data entry is in accordance with standards and protocols agreed with CGI. In addition, a bibliographic search will be carried, in order to complete the information provided.
3. To produce shape files of the glacier outlines and the related attribute tables of the basic glaciological parameters.
4. To provide trends relating to spatial-temporal variations of glacier fronts, based on the data of the glaciological campaigns, validated by CGI.
5. To provide information layers for the General Portal of the NextData Project, in the format requested by WP 2.6.
6. To carry out data analysis, in collaboration with CGI.
7. To produce the intermediate and final technical-economical and scientific reports and associated documents.

The role of Unit 2 (CGI) will be as follows:

1. To provide support to the creation of the system of management of the information related to the Italian glacial resource.
2. To provide unpublished data collected during the annual glaciological campaigns and during the glaciological investigations carried out on specific glaciers (measurements, cartography, iconography), in addition to those published in the Bulletin of the CGI, free accessible on the website (<http://www.glaciologia.it/>).
3. To validate the information to be entered in the management system.
4. To check project products (glacier outlines and related attribute table for different time steps, trends of spatial-temporal variations of glacier fronts).
5. To coordinate data analysis.
6. To produce intermediate and final technical-economical and scientific reports, related to the activity of Unit 2, to be included in the reports of the coordinating Unit.

2. DETAILED PROJECT DESCRIPTION

State of the art and motivations

The Intergovernmental Panel on Climate Change (IPCC) recognizes glaciers as the best terrestrial indicator of climate change, due both to their sensitivity to climatic variations and to the clear visibility of glacier growth and shrinkage to the public. In the Alps, general glacier retreat started at the end of the Little Ice Age (LIA): following the last temporary advance in the period 1970-1986, glacier shrinkage has been continuous, with a marked acceleration since 2003. In the last two decades, the attention towards glaciers has continuously grown, along with the awareness of ongoing climate change. In this context, researchers have highlighted the importance of glaciers as terrestrial indicators of climatic trends, and warned on the socio-economic and environmental impacts resulting from glaciers withdrawal: consequences on human life and nature through their crucial influences on the water cycle in cold mountains and their surrounding lowlands, on landscape evolution, tourism, and on natural hazards. International efforts have been made in the last decades to create worldwide datasets on glaciers: the World Glacier Inventory (WGI, http://nsidc.org/data/glacier_inventory/index.html) was launched in the '80s by WGMS, and contains information for over 130,000 glaciers. Inventory parameters include geographic location, area, length, orientation, elevation, and classification. The inventory entries are based on a single observation in time (from aerial photos, maps) and can be viewed as a 'snapshot' of the glacier at this time. Unfortunately, WGI data are generally not up to date and their retrieval and display aren't easy, as the information management system is now obsolete. The Global Land Ice Measurements from Space (GLIMS) project started in 2000 and was designed to continue this inventorying task with space-borne sensors. GLIMS maintains a geospatial database available via a website featuring interactive maps and an interoperability standard web mapping service (<http://www.glims.org>). GLIMS is an extremely interesting initiative on a global scale, particularly for glacier inventory in remote areas and/or in developing countries, where otherwise data would not be available. However, in the Alps and especially in Italy, field collection of glaciological data is rich and still actively in progress, while space-borne data resolution may be poor both in space (given the small size of glaciers and compared to the high resolution of other sources of information, such as aerial photos and field surveys), and time (space-borne data are not available before the early 70's).

In Italy, the history of glaciers over the past century is very well documented, thanks in particular to the efforts of CGI (established in 1914), which published in 1925 one of the first global initiatives of glacier inventory ("Catasto Porro-Labius"). This inventory, although synthetic and devoid of metric data, formed the basis for the subsequent work of updating and expansion made by CGI during the International Geophysical Year 1957-58. Every year since 1914, volunteer CGI surveyors visit the

glaciers, measure the terminus position and take pictures from fixed points; in addition, they write reports on the general conditions of the glaciers and on the main changes observed: all this information is sent to CGI and a synthesis is published yearly. In addition, CGI archives contain aerial and terrestrial photos, topographic surveys and maps, thematic maps, mass balances, journals, books, and unpublished studies. The CGI supplied the information to the WGI and is currently collaborating with the GLIMS project. In recent decades, local initiatives have been added to the activities of CGI. These works carry an undeniable contribution to the state of knowledge of the glaciation in Italy, however they have only partial coverage, and each of them has different standards for the collection, representation and analysis of data. Moreover, glacier evolution over time is usually not considered, or is treated only in a qualitative way, so that data cannot be used for purposes of numerical simulation of glacier in a context of climate change. In conclusion, Italy has a heritage of exceptional value, with few parallels in the world, which allows us to reconstruct the recent history of hundreds of glaciers. However, this wealth of data must be entered and managed in a database that meets international standards and, at the same time, allows a quick and easy retrieval and use of the data by the scientific community, the authorities concerned and the public (see also bibliographic references in attachment).

Detailed description of the project, including the work plan, deliverables and milestones (explicitly indicating the activities of the different years)

To attain the main goals declared, the project will be articulated in several activities, carried out according to the work plan described below: in order to meet the project deadlines, activities will be carried out in parallel for the three alpine sectors, western, central and eastern:

- In its first phase, the DATAGRALP project will mainly focus on the design and development of an integrated system for the management of numerical, textual, iconographic and geographic data related to the Italian glaciers. The system will consist of a server-side database (PostgreSQL+PostGIS), which will be connected to a web interface and to a GIS (QGIS). The system will be developed using open source applications according to the GeoNetwork architecture (like that of the SHARE Project), in coordination with the working group that will develop and manage the Portal of the NextData Project (Months: 1 to 3);
- Once the necessary documentation will have been acquired, we will proceed to draw glacier outlines in a GIS environment, in order to: a) set up an updated picture of the limits of the Italian glaciers, updated to 2006, according to the

date of the most recent ortophotos available free on line and covering the entire alpine area (Geoportale Nazionale, Ministero dell'Ambiente, www.pcn.minambiente.it/GN/); glacier outlines will be associated to an attribute table with the values of the main glacier parameters (area, length, width, slope, max and min elevation, exposure, latitude and longitude of the glacier centroid); b) reconstruct the characteristic data of glaciers corresponding to specific time steps (decades: '50s - from the glacier inventory of CGI, '80s from the World Glacier Inventory): where available, additional levels of information will be added. A particular attention will be paid to obtain the most relevant parameters (area, length, width, slope, max and min elevation, exposure) needed by quantitative models aimed to predict the future evolution of Italian glaciers. All the glaciers larger than 5 hectares will be considered for furnishing these multitemporal glaciological parameters. Glaciers of size ranging from 2 to 5 hectares will be considered if significant (Months: 4 to 24);

- Later on, we'll start the selection and acquisition of the relevant documentation, both iconographic and textual (reports and photos of the annual glaciological campaigns, historic photographs and maps, publications and unpublished reports) related to the glaciers of interest. Such material will be validated in order to be considered appropriate to the objectives of WP 2.1., and entered into the database. The information will be validated by mean of aerial photographs interpretation, and by mean of cross checking among different types of data (i.e. terrestrial photographs annually furnished by survey glaciological operators from the CGI archives – published and unpublished documents, topographic/thematic maps, multitemporal aerial photographs and/or satellite images, annual reports and related GPS data, etc...). In the meantime, the quantitative data contained in these documents will also be entered in the database and will represent the basis for further processing (Months: 8 to 18);
- Once completed the data entry in the database, trends relating to spatial-temporal variations of glacier fronts will be analyzed, based on the data of the glaciological campaigns, compared and integrated with the data acquired during the "GIS phase" of above. The number of glaciers annually surveyed by CGI operators changed during the time and today is about 150 glaciers. Data are anyway available for a larger number of glaciers, which are not anymore monitored (about 100 additional ones, with a different degree of continuity) (Months: 19 to 22);

- In addition, data of mass balances, annually surveyed with glaciological methods by CGI surveyors and/or local authorities will be provided. A list of these glaciers and the period of observation is reported below:

Glacier	Group	Measurement period	Source
Caresér	Ortles-Cevedale	1966-2012	CGI-TeSAF PD
Ciardoney	Gran Paradiso	1992-2012	SMI
Croce Rossa	Croce Rossa	2001-2012	SMI
Dell'Agola	Brenta	2001-2012	SAT-PAT
Fellaria Occidentale	Bernina	1992-2006	CGI
Fontana Bianca	Ortles-Cevedale	1983-1988 and 1991-2012	CGI - Prov.Aut.BZ
Grand Etrèt	Gran Paradiso	2000-2012	PNGP
La Mare	Ortles-Cevedale	2003-2012	CGI-TeSAF PD
Malavalle	Alpi Breonie	2001-2012	CGI - Prov.Aut.BZ
Marinelli	Bernina	1997-2006	CGI
Meridionale di Suretta	Tambò-Stella	2001-2011	SGL
Pizzo-Scalino	Bernina	1993-2009	CGI
Sforzellina	Ortles-Cevedale	1986-2012	CGI
Vedretta Lunga	Ortles-Cevedale	2003-2011	Prov Aut BZ
Vedretta Pendente	Alpi Breonie	1995-2012	CGI - Prov.Aut.BZ
Calderone	Gran Sasso	2000-2012	CGI-PresConsMin

Abbreviations: TeSAF PD: Dipartimento Territorio e Sistemi Agro-Forestali, Padova; SMI: Società Meteorologica Italiana; SAT-PAT: Società Alpinisti Tridentini-Provincia Autonoma di Trento; Prov.Aut.BZ: Provincia Autonoma di Bolzano; PNGP: Parco Nazionale Gran Paradiso; SGL: Servizio Glaciologico Lombardo; PresConsMin: Presidenza del Consiglio dei Ministri.

- At the end of the activities described above, the information levels for the Portal of the NextData Project and for the CGI and CNR-IRPI websites will be prepared, in the format requested by WP 2.6, and in agreement with the GeoNetwork architecture – like that of the SHARE Project (Months: 24 to 25);
- The work of collection and processing of glaciological data, performed in the previous steps, will be supplemented by their analysis, in order to reach a synthesis of the recent evolution of the glacial resource in the Italian Alps: special attention will be given, at this stage, to select and organize information in order to make it easily understandable and promptly available to the scientific community (Months: 26 to 28);
- The final stage of the project will be devoted to the preparation of the final report; in addition, scientific publications will be drafted. Moreover, a particular attention will be devoted to the creation of summary reports drawn up with a simple and direct language, and illustrated by maps, graphs and

tables easy to read and understand, intended for decision makers, stakeholders and the general public (Months: 26 to 28).

Deliverables

The deliverables associated to the different phases of the project, described above, will be available free on line on the Portal of the NextData Project, on the CGI and CNR-IRPI websites. The project deliverables will be the followings:

1. An integrated system for the management of numerical, textual, iconographic and geographic data related to the Italian glaciers, consisting of a server-side database (PostgreSQL+PostGIS) connected to a web interface and to a GIS (QGIS). The system will be developed using open source applications and in coordination with the working group that will develop and manage the Portal of the NextData Project, and in agreement with the GeoNetwork architecture – like that of the SHARE Project (Month: 3).
2. Thematic maps featuring the outlines of Italian glaciers updated to 2006, at a scale varying from 1:25.000 to 1:50.000, originally produced in the framework of this project (in two steps, Months: 12 and 24).
3. Data sets of the values of the basic parameters of the considered glaciers (area, length, width, slope, max and min elevation, exposure, latitude and longitude of the glacier centroid) for specific time periods (50s, 80s, 2006) (in 2 steps, Months: 12 and 24).
4. An integrated system for the management of the glacial resource (see deliverable # 1) populated with validated iconographic and textual documents related to the Italian glaciers, and with quantitative data obtained from these documents (Month: 18).
5. Data sets and graphs depicting trends in spatio-temporal variation of glacier front position, for the alpine glaciers subject to periodic surveys on occasion of the glaciological campaigns carried out by the CGI (Month: 24).
6. Information levels to be made available to the Portal of the NextData Project and to the CGI and CNR-IRPI websites (Month: 25).
7. The project final report, describing methods, activities and deliverables, including summary reports for decision makers, stakeholders and the general public, illustrating the recent (last 100 years) evolution of the glacial resource in the Italian Alps (Month: 28).
8. Scientific publications.

Milestones

- a. The on line of the integrated system for the management of numerical, textual, iconographic and geographic data related to the Italian glaciers, in order to make it available to the participants to the project in charge of data entry (end of Month 3).
- b. Completion of the list of multitemporal spatial data to be used by the participants to the project in charge of GIS activities (end of Month 3).
- c. End of the data entry in the informative system, of the relevant iconographic and textual documents, and of the quantitative data contained in these documents, referred to the Italian glaciers and to be used for the reconstruction of trends in spatio-temporal variation of glacier front position (end of Month 18).
- d. End of the activities of spatial analysis and delivery of the maps of outlines of Italian glaciers updated to 2006 , and of data sets of the values of the basic parameters of the considered glaciers for specific time periods (50s, 80s, 2006) (end of Month 24).
- e. Completion of the data sets and graphs of trends in spatio-temporal variation of glacier front position (end of Month 24).
- f. Extraction of the information levels to be made available to the Portal of the NextData Project (end of Month 25).
- g. Completion of the final report and of annexed documents (end of Month 28).