Project of Strategic Interest NEXTDATA

Integrated observation system for environment and climate monitoring

WP 1.6 - Mountains criospheric resources
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WP1.6 -Task 1 - Deliverables 1.6A & 1.6B

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1. Planned activity and expected results

The activity conducted by WP 1.6 of the special project NEXTDATA includes: ì) monitoring data and quantitative inventory of Italian glaciers, considering both the entire Italian Alps and the Gran Sasso Group, Central Apennines (where the southernmost glacieret of the Italian Peninsula is located); ìì) collection of data on annual mass balance of the glaciers monitored by the Italian Glaciological Committee and Equilibrium Line Altitude (ELA) variation; ììì) collection of iconographic and photographic/photogrammetric material, in collaboration with the Italian Glaciological Committee. The expected results after this first phase of work are summarized here below.

1) Validation of the Italian glaciers limits derived from the interpretation of high-resolution orthophotographs that outlines a snapshot of the 2006-07 hydrological period (Salvatore et al., 2015).
2) Perimeter in the GIS environment of the glacial bodies of the Italian Alps in the time interval 1988-1989. All outlines of the glacial bodies were manually digitized using an open source GIS (Q-gis®), which allowed mapping glaciers' outlines as polygons in the vector domain as well as creating an alphanumeric attribute table associated with the glacier outlines (see Salvatore et al., 2015 for details on "Material and Methods").
3) Population of a database containing the quantitative glaciological parameters (number, location, extension, length, maximum and minimum dimensions, etc) of the Italian glaciers in 1988-1989 and in 2006-2007.
4) Construction and population of a database on measurements of frontal variations and annual mass balance of sample glaciers monitored by the Italian Glaciological Committee.

***Milestones**:*

1. Reconstruction of outlines of glacial bodies in the hydrological period 1988-'89.
2. Population of the glaciological dBase for the period 1988-'89.
3. Validation of the limits of Italian glaciers for the period 2006-2007.
4. Collection of glaciological data for reconstruction of time-distance curves (T-D).
5. Collection of data related to mass balances.

2. Deliverables expected for the reference period

- Database on the quantitative glaciological parameters (number, location, extension, length, maximum and minimum dimensions, etc.) of the Italian glaciers in 1988-1989 and in 2006-2007).
- Database on the measurements of the frontal variations and on the annual mass balance of sample glaciers monitored by the Italian Glaciological Committee.

3. Activity carried out during the reference period

3.1 Research activity

The activity carried out during the reference period reflects the project NEXTDATA WP 1.6 - Task 1. The following are the steps that have characterized the study to date.

- **Definition of the criteria for the collection and management of the glaciological data** of the Piemonte-Val d'Aosta, Lombardia and Triveneto sectors (with the addition of the Central Apennines for the Calderone Glacier), common and shared between the three Operative Units participating in the project (Padova Resp. Prof. Alberto Carton; Pisa Resp. Prof. Carlo Baroni; Torino: Resp. Prof. Marco Giardino). To guarantee the homogeneity of the glaciological data acquired for the three sectors of the Italian Alps (western, central and eastern), a basic documentation has been prepared for the three Operating Units that takes into account the criteria adopted for the creation of the Inventory of the Italian glaciers (CGI-CNR, 1957-1962) and the guidelines suggested by the World Glacier Monitoring Service. The criteria for the identification and for the interpretation of graciers limit as well as the methods of data acquisition have been defined; the database fields have been described and the models of the areal vector files (shape file templates) needed to store glaciological data in the GIS environment have been constructed. We adopted the *International Standardized Mountain Subdivision of the Alps (*ISMSA), better known by the acronym SOIUSA (Marazzi, 2005), which better allowed for connecting groups along the entire Alpine chain even if the Italian Alps were previously classified according to different criteria. ISMSA introduced the bipartition of the Alpine System (Western Alps and Eastern Alps) to replace the old tripartite division (Western Alps, Central Alps and Eastern Alps). The bipartite division follows a multilevel pyramidal hierarchy, accounting for the historical and geographical regions in the Alps, and provides higher level (5 major sectors SR; 36 sections SZ; 132 subsections STS) and lower level mountain groups (333 supergroups SPG; 870 groups GR; subgroups STG). The database fields follow the indications of the World Glacier Monitoring Service (WGMS), with the addition of specific fields that take into account the codes and names of Italian glaciers according to what is reported in the Cadastre of Italian Glaciers (CNR-CGI, 1961-1962) and the classification of mountainous groups, according to the ISMSA classification. Following the World Glacier Monitoring Service (WGMS) guidelines for the compilation of glacier inventory data from digital sources (Paul & *alii*, 2009), each table corresponding to a glacial body contains the main morphometric parameters (area, maximum length, width, slope, max and min elevation, aspect, latitude and longitude of the glacier centroid), the cadaster number

according to the previous Inventory of Italian Glacier (CGI-CNR, 1959, 1961a, 1961b, 1962), and the identification (ID) according to the hydrological coding suggested by the WGMS (1989). For solely operational purposes, additional punctual and linear vector files necessary for the measurement of some morphometric parameters were constructed. In this step the availability of orthophotographs in the years of interest was also verified through the Web Map Service (WMS) of the National Cartographic Portal and of the regional portals; specific requests were also sent to the competent Authorities in the case data were not available via WMS.

- **Monitoring and quantitative census of alpine glaciers** of the Piemonte-Val d'Aosta, Lombardia and Triveneto sectors (with the addition of the Central Apennines for the Calderone Glacier) for the period 1988-1989. This step has seen the interpretation of the images and the perimetration of the glacial bodies present (or resulting extinct with respect to the Inventory of the Italian Glaciers of CGI-CNR) in the three Sectors of the Italian Alps in 1988-89 (Fig. 1, 2 and 3); the attribute table was also populated with the morphometric and geographical parameters (area, length, width, slope, maximum and minimum altitude, exposure, glacier centroid coordinates, shape, etc; Fig. 4). At the same time, the database relating to the hydrological period 2006-2007 was also verified. Furthermore, the drawing of glacier outlines, the acquisition of the morphometric parameters and the population of the glacier attribute table of the three Alpine Sectors for the 2014-2015 hydrological period was also set out, applying the same criteria adopted previously. The geographic reference system adopted for all the time intervals analyzed is WGS84 UTM32, while the metadata, although still not totally defined, are oriented towards the INSPIRE standard. Dataset description is furnished in WP 2.3 - Archives of paleoclimatic data from mountain and continental regions (2.3.1 Monitoring and quantitative inventory of alpine glaciers – Task 1).

- **Database on measurements of frontal variations and annual mass balance of sample glaciers monitored by the Italian Glaciological Committee.** All the data relating to the measurements of the frontal variations recorded by CGI-coordinated annual glaciological campaigns were collected. The data were organized in tabular form within a spreadsheet to allow a verification of the data and a subsequent construction of the relative T-D curves (Fig. 5). The structure of the final DB

containing all the validated data is under review. Likewise, data on mass balances have been collected both from the annual glaciological campaigns and through the collection of scientific articles in which balance assessments are reported through indirect investigation techniques (Baroni et al., 2015, 2016, 2017; Carturan et al., 2016).

3.2 Application, Technologic, and Informatic developments

The data collected, for their structure and characteristics, will be merged into the Italian Glaciological Committee WEBGIS and be made accessible to those who request them.

3.3 Training activity

The training activity concerns in particular the activation within the project of 3 scholarships on the theme "Acquisition and processing of information related to the glaciers of the Alpine sectors: 1) Piemonte-Val d'Aosta, 2) Lombardia, 3) Triveneto".

3.4 Dissemination activity

The activity and preliminary results of the WP 1.6 task 1 project were presented in the following meetings:

- Meeting NextData Project, CNR, Rome, January 24th 2017;
- Annual meeting of SISC (Italian Society for Climate Sciences) -The NextData Side Event -Bologna 27 October 2017;
- Meeting "Paleoclimatic Meditations" at the CNR ISMAR, Venice, 12 -13 October 2017.

Further results are reported in three volumes illustrating glaciological itineraries on the Italian mountains published by the Italian Geological Society and edited by the Italian Glaciological Committeee (see list of publications here below, par 4.2).

3.5 Congresses and workshops

1. Cerrato R., Gunnarson B., Linderholm H.W., Salvatore M.C., Baroni C. [abstract] (2017). Pinus cembra L. maximum wood density records late summer maximum temperatures in the Ortles-Cevedale Group (Rhaetian Alps, Italy). In: Proceedings of the TRACE2017; 2017 May 16–21; Svetlosgorsk, Kaliningrad Region, Russia.
2. Cerrato R., Carturan L., Salvatore M.C., Baroni C. [abstract] (2017). Inferring Glacier Summer Mass Balance From Tree-Rings in Reathian Alps (Italy). In: Proceedings of the 9th International Conference of Geomorphology (9th ICG); 2017 Nov 6-11; New Delhi, India.

3. Cerrato R., Salvatore M.C., Linderholm H.W., Baroni C. [abstract] (2017). Tree-rings analysis for reconstructing alpine glaciers mass balance and climatic changes in the Raethian Alps during the last millennium. In: proceedings of the 1st International Summer School: Dendroecology, Quantitative wood Anatomy and Stable isotopes: from xylogenesis to tree-rings; 2017 Sep 25-29; Portici - Caserta, Italy.
4. Gennaro S., Salvatore M.C., Carturan L., De Blasi F., Cazorzi F., Baroni C. [abstract] (2017). *Recent Glaciers Variations in Alta Valtellina (Ortles-Cevedale Group, Italian Alps): Quantitative Analysis of an Accelerated Glacial Decline During the Last 60 Years.* In: Proceedings of the 9th International Conference of Geomorphology (9th ICG); 2017 Nov 6-11; New Delhi, India.

4. Results obtained during the reference period

4.1 Specific results (databases, measurement results, model output, etc)

The results obtained so far are consistent with those expected for the reference period, and include: 1) the outline of glacial bodies in the hydrological period 1988-'89; 2) the population of the glaciological dataBase for the period 1988-'89; 3) the validation of the limits of Italian glaciers for the period 2006-07; 4) the collection of glaciological data necessary for the realization of the time - distance curves (T-D); 5) the collection of data related to annual mass balance of the sample glaciers monitored by the CGI; 6) the start of the acquisition phase of the main morphometric parameters of the Italian glaciers related to the hydrological period 2014-2015.

4.2 Publications

ISI-WEB Journals

1. Baroni C., Bondesan A., Chiarle M. (Eds.) (2017). Report of the Glaciological Survey 2016. Relazioni della Campagna Glaciologica 2016. Geografia Fisica e Dinamica Quaternaria, 40 (2), 233-320. doi: 10.4461/GFDQ.2017.40.14
2. Baroni C., Bondesan A., Mortara G., Eds. (2016). Report of the Glaciological Survey 2015. Relazioni della Campagna Glaciologica 2015. Geografia Fisica e Dinamica Quaternaria, 39(2), 215-295. doi: 10.4461/ GFDQ 2016.39.20
3. Baroni C., Bondesan A., Mortara G., Eds. (2015). *Report of the Glaciological Survey 2014. Relazioni della Campagna Glaciologica 2014*. Geografia Fisica e Dinamica Quaternaria, 38(2), 229-304. doi: 10.4461/GFDQ.2017.38.18
4. Carturan L., Baroni C., Brunetti M., Carton A., Dalla Fontana G., Salvatore M.C., Zanoner T., Zuecco G. (2016). Analysis of the mass balance time series of glaciers in the Italian Alps. The Cryosphere, 10 (2), 695-712. doi:10.5194/tc-10-695-2016
5. Salvatore M.C., Zanoner T., Baroni C., Carton A., Banchieri F.A., Viani C., Giardino M., Perotti L. (2015). The state of Italian glaciers: A snapshot of the 2006-2007 hydrological period. Geografia Fisica e Dinamica Quaternaria, 38(2), 175-198. Doi: 10.4461/GFDQ.2015.38.16
6. Zemp M., Frey H., Gärtner-Roer I., Nussbaumer S.U., Hoelzle M., Paul F., Haeberli

W., Denzinger F., Ahlstrøm A.P., Anderson B., Bajracharya S., Baroni C., Braun L.N., Càceres B.E., Casassa G., Cobos G., Dàvila L.R., Delgado Granados H., Demuth M.N., Espizua L., Fischer A., Fujita K., Gadek B., Ghazanfar A., Hagen J.O., Holmlund P., Karimi N., Li Z., Pelto M., Pitte P., Popovnin V.V., Portocarrero C.A., Prinz R., Sangewar C.V., Severskiy I., Sigurdsson O., Soruco A., Usubaliev R., Vincent C. (2015). Historically unprecedented global glacier decline in the early 21st century. Journal of Glaciology, 61(228), 745-762. doi: 10.3189/2015JoG15J017

WGMS Database & Bullettin

WGMS (2017): Fluctuations of Glaciers Database. World Glacier Monitoring Service, Zurich, Switzerland. DOI:10.5904/wgms-fog-2017-10. Online access: http://dx.doi.org/10.5904/wgms-fog-2017-10

WGMS (2017): Global Glacier Change Bulletin No. 2 (2014-2015). Zemp, M., Nussbaumer, S.U., Gärtner-Roer, I., Huber, J., Machguth, H., Paul, F., and Hoelzle, M. (eds.), ICSU(WDS)/IUGG(IACS)/UNEP/UNESCO/WMO, World Glacier Monitoring Service, Zurich, Switzerland, 244 pp. Based on database version: doi: 10.5904/wgms-fog-2017-10.

WGMS (2015): Global Glacier Change Bulletin No. 1 (2012-2013). Zemp, M., Gärtner-Roer, I., Nussbaumer, S. U., H¸sler, F., Machguth, H., Mˆlg, N., Paul, F., and Hoelzle, M. (eds.), ICSU(WDS)/IUGG(IACS)/UNEP/UNESCO/WMO, World Glacier Monitoring Service, Zurich, Switzerland, 230 pp., publication based on database version: doi:10.5904/wgms-fog-2015-11.

Volumes

1. Comitato Glaciologico Italiano (2017). Itinerari Glaciologici sulle Alpi Italiane. Capitoli tematici. Società Geologica Italiana, Guide Geologiche. Vol. 1, 106 pp.
2. Comitato Glaciologico Italiano (2017). Itinerari Glaciologici sulle Alpi Italiane. Dalle Alpi Marittime all'Alpe Veglia. Società Geologica Italiana, Guide Geologiche. Vol. 2, 238 pp.
3. Comitato Glaciologico Italiano (2017). Itinerari Glaciologici sulle Alpi Italiane. Dal Ghiacciaio della Ventina al Calderone. Società Geologica Italiana, Guide Geologiche. Vol. 3, 286 pp.

4.3 Availability of data and modeling output (format, support, etc.)

The limits of the glacial bodies for the years 2006-2007 and 1988-1989 are available in * .shp file format. Glaciological parameters of glaciers for the years 2006-2007 and 1988-1989 are available in * .dbf, * .csv or other formats if required.

Data on the front glacier variations currently monitored by the CGI are available in * .csv format or other format if required. Consider that the data referring to the more distant time intervals are in course of validation.

Data on mass balances of glaciers monitored by the CGI are available in * .csv format or other formats if required.

4.4 Deliverables completed

-Outlines of glacial bodies in the hydrological periods 2006-2007 and 1988-1989. The data are collected in * .shp files.

- Database of the quantitative glaciological parameters (number, location, extension, length, maximum and minimum dimensions, etc) of the Italian glaciers in 1988-1989 and in 2006-2007. Data are collected in * .dbf files.

-Database on the measurements of the front variations of sample glaciers monitored annually by the Italian Glaciological Committee. The data are collected in * .xls and / or * .csv

-Database on the mass balance of sample glaciers monitored annually by the Italian Glaciological Committee. The data are collected in * .xls and / or * .csv

5. Comment on any deviations between planned / effectively performed activities / results / deliverables

No deviation to report.

6. Activities planned for the following period

The activities planned for the period 01/01/2018 - 31/12/2018 are:

i) completing the delimitation of Italian glaciers for the period 2014-2015;

ii) prosection of the activity of compiling datasets of the main morphometric parameters of Italian glaciers, for specific time steps (2014-2015);

iii) Complete multi-temporal database (2012-2014, 2006-2007, 1988- 1989, 1957-1958) of the quantitative glaciological parameters of Italian glaciers and related cartography.