WP 1.6 - Mountain cryospheric resources
(WP leader: Carlo Baroni)

WP1.6 -Task 1
Deliverable 1.6E
Multi-temporal database of the quantitative glaciological parameters of the Italian Glaciers (2014-2015, 2006-2007, 1988-1989, 1957-1958) and related maps

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Introduction

Glaciers are among the most impressive elements of the Alpine landscape retaining a precious renewable freshwater resource. Furthermore, glaciers are among the most sensitive climatic indicators, and mountain glacier variations are considered one of the best natural proxies for investigating climate change and predicting future scenario (Zemp & *alii*, 2006; IPCC 2007, 2013; Haeberli & *alii*, 2007; Winkler & *alii*, 2010).

Since the end of the Little Ice Age (ca. 1850 AD), glaciers retreat was particularly significant in the Alps and dramatically accelerated during the last three decades.

Different variables of the alpine cryosphere such as glacier mass balance or permafrost ground temperatures are important indicators of climate change but also important to answer questions related to sea level rise, regional water cycles or natural hazards.

The knowledge of the entity of spatial and volumetric change of the glacial resource represents one of the most important tool for investigating environmental and climate changes. Monitoring alpine cryosphere is a key instrument for acquiring new data on past present and future change in high mountain environment and water resource avalilability. of relevant and indispensable Modern technologies represent a key tool for answering the question arising from stakeholders and policy makers.

The activity conducted within WP 1.6 (Task 1) of the special project NEXTDATA contributes to better understand the evolution of Italian glacial resources under warming climate. The main goals of WP 1.6 task were:

ì) monitoring data and quantitative inventory of Italian glaciers, considering both the entire Italian Alps and the Gran Sasso Group, Central Apennines (where is located the southernmost glacieret of the Italian Peninsula; Fig. 1);

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 data on measurements of frontal variations of sample glaciers monitored by the Italian Glaciological Committee.

ìììì) collection of iconographic and photographic/photogrammetric material, in collaboration with the Italian Glaciological Committee.

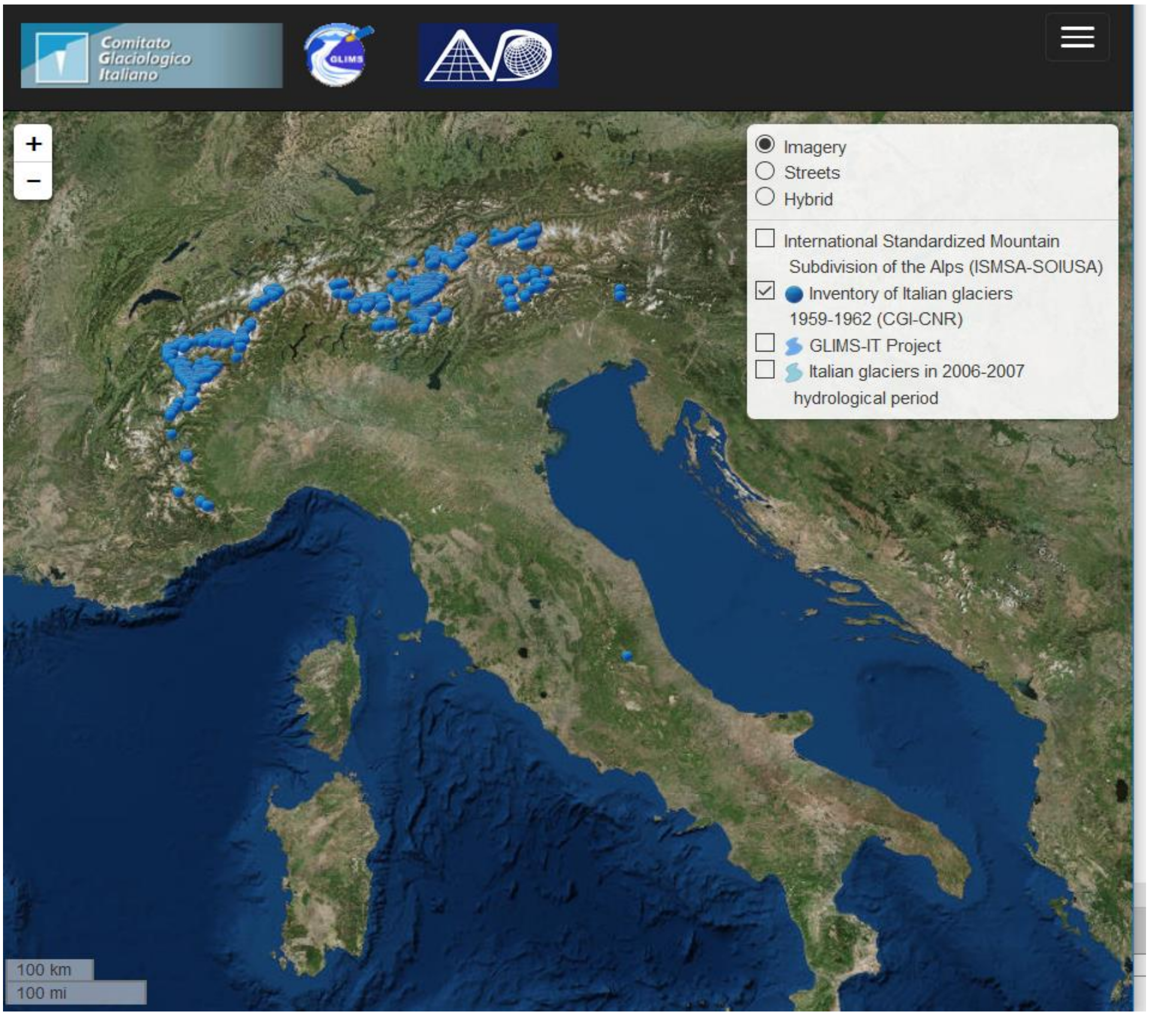

Fig. 1 – Location map of the Alpine Italian glaciers and the Calderone glacier in the Central Apennine (the most southern of the Italian Peninsula).

The work activity conducted for Deliverable 1.6 E “Multi-temporal database of the quantitative glaciological parameters of the Italian Glaciers (2014-2015, 2006-2007, 1988-1989, 1957-1958) and related maps “is summarized here below:

1a) outlines of the glacial bodies of the Italian Alps in the time interval 1988-1989, 2006-2007, 2014-2015 in GIS environment.

1b) Construction of a dBASE containing all the data of previous CGI inventory(1957-1958) associated with a vectorial shape file (point features) to identify the geographic location.

1c) 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, 2006-2007, 2014-2015 and in 1957-1958.

We considered five principal milestones to achive these goals:

- Reconstruction of outlines of glacial bodies in the hydrological periods 1988-1989, and 2014-2015.
- Validation of the limits of Italian glaciers for the period 2006-2007.
- Population of the glaciological dBase for the period 1957-1958, 1988-1989, 2006-2007and 2014-2015.

2. Research activity

In order to guarantee the homogeneity of the glaciological data acquired for the three sectors (western, central and eastern)of the Italian Alps, we compiled a basic documentation containing operational guidelines shared among the three Research Units involved in the project.

The criteria adopted took into account those of the Inventory of the Italian glaciers (CGI-CNR, 1957-1962) as well as the guidelines suggested by the World Glacier Monitoring Service.

To detecti and interpret glacier boundaries at different time steps, we used the orthorectified aerial photos at high geometric resolution provided by the National Geoportal of the Ministry of Environment and Protection of Land and Sea (available through the Web Map Service http://wms.pcn.minambiente.it/ogc?map=/ms_ogc/WMS_v1.3/raster/ortofoto_colore_06.map) or provided by the Regional cartographic server via WMS. In some cases, the Regional administration supported digital orthophotos in DVD (Valle d’Aosta for the 2014-2015 period). All outlines of the glacial bodies were manually digitized by an open source GIS (Q-gis®), which allowed to map glacier limits as polygons in the vector domain. It was also possible to create an alphanumeric attribute table associated with the glacier outlines (see Salvatore et al., 2015 for details in “Material and Methods”).

The inventory of the multitemporal glaciers dataset is provided in the form of vectorial files (shapefiles); the glacier features attributes are stored in the dBASE table.

The attribute tables for each time-step were populated with the morphometric and geographical parameters (area, length, width, slope, maximum and minimum altitude, exposure, glacier centroid coordinates, shape, etc.).

The geographic reference system adopted for all the time intervals was WGS84 UTM32, while the metadata followed 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).

The database provided the principal morphometric parameters of each glacial body (area, maximum length, width, slope, max and min elevation, aspect, latitude and longitude of the glacier centroid) and the glacier identification code (ID) as suggested by the WGMS (1989). In addition, the dBASE contains additional fields to supply codes and names of glacial bodies according to the previous Inventory of Italian Glaciers (CGI-CNR, 1959, 1961a, 1961b, 1962) as well as the geographic location, according with the International Standardized Mountain Subdivision of the Alps-ISMSA (SOIUSA, Marazzi, 2005; fig. 2).

The accuracy of glaciers outlines, assessed following Vögtle & Schilling (1999), gave an estimated error of less than ± 2%; the only exceptions were a few cases with continuous supraglacial debris coverage, for which we estimated a maximum value of approximately ± 5%. Moreover, following the standard adopted for the multitemporal inventory, we reorganized all the data contained in the CGI inventory in a dBASE jointed with a georeferenced vectorial shape file (point features) to identify the geographic location of both extinct and existing glaciers.

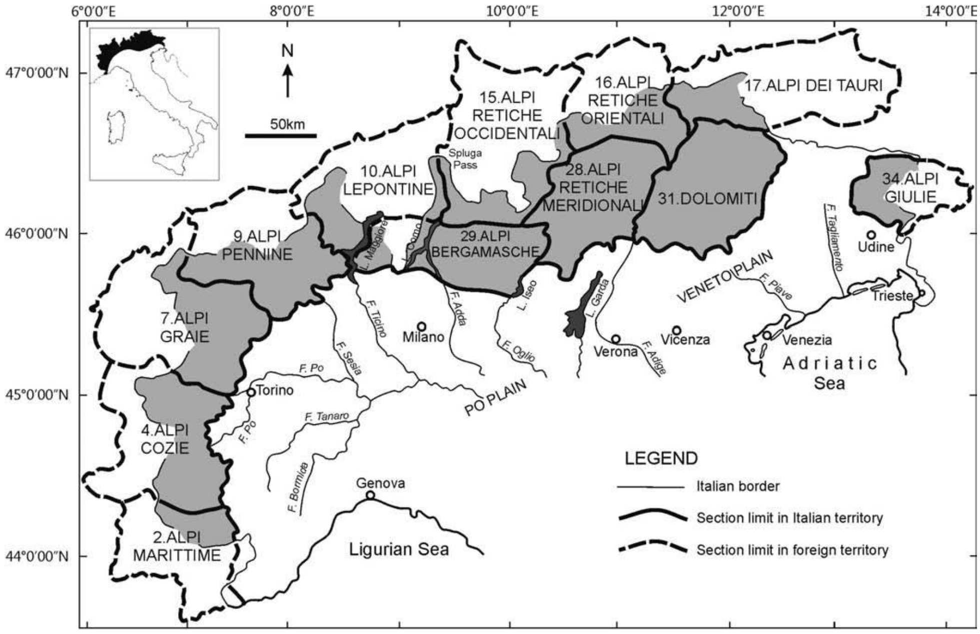

Fig. 2 - Geographical setting of the Alps according to the International Standardized Mountain Subdivision of the Alps (ISMSA). The division and toponymy of the reliefs are shown at the section level. Only sections with glaciers are represented. Light grey indicates sections partially or completely within the Italian territory (Salvatore et al., 2015).

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Results

We realized a multitemporal glaciers inventory of Italian Alps for 1988-1989, 2006-2007 and 2014-2015 hydrological periods. Moreover, we reorganized all the data contained in the previous inventory of the CGI as a dBASE jointed to vectorial shape file (point features) following the standard of the multitemporal inventory.

Outlines of glacial bodies are here presented at the scale of 1:500,000 in attached plates in appendix as listed here below:

- Plate 1_1988-1989: Piemonte S;
- Plate 2_1988-1989: Valle d'Aosta and Piemonte N;
- Plate 3_1988-1989: Lombardia;
- Plate 4_1988-1989: Trentino - Alto Adige;
- Plate 5_1988-1989: Veneto and Friuli Venezia Giulia;

- Plate 1_2006-2007: Piemonte S;
- Plate 2_2006-2007: Valle d'Aosta and Piemonte N;
- Plate 3_2006-2007: Lombardia;
- Plate 4_2006-2007: Trentino - Alto Adige;
- Plate 5_2006-2007: Veneto and Friuli Venezia Giulia
- Plate 1_2014-2015: Piemonte S;
- Plate 2_2014-2015: Valle d'Aosta and Piemonte N;
- Plate 3_2014-2015: Lombardia;
- Plate 4_2014-2015: Trentino - Alto Adige;
- Plate 5_2014-2015: Veneto and Friuli Venezia Giulia

Database of the quantitative glaciological parameters (number, location, extension, length, maximum and minimum dimensions, etc.) and shape files of the Italian glaciers in 1988-1989, 2006-2007, and 2014-2015 will be available on request after publication.

The dBASE of the multitemporal inventory allowed us to evaluate the total extent of Italian glaciers in four different time steps, including the previous inventory of CGI (1957-1958).

Here below, we report a synthesis of the quantitative data derived from multitemporal dBASE. Fig. 3 shows the total number of glacial bodies and their areal extent in the four time steps. In the most recent time step analysed (2014-2015), the Italian Alps hosted 857 glacial bodies, which covered a surface of ca. 344 km^2 ± 2% (fig. 3).

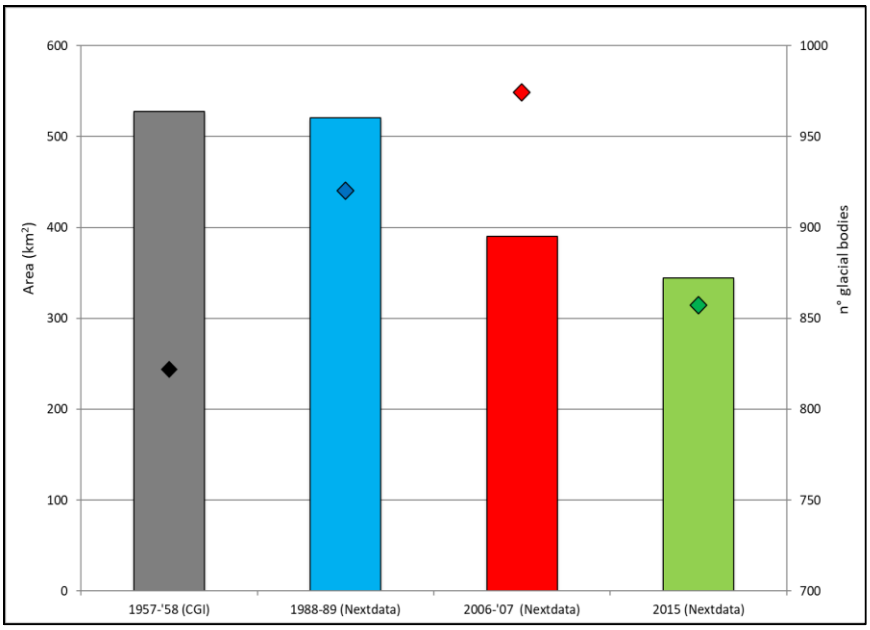

Fig. 3 – Areal extent (km^2) and number of glaciers (diamonds) in the different time steps.

Since 1957, Italian glaciers experienced a strong progressive reduction of their areal extension. The number of glacial bodies progressively increased from 1957-1958 to 2006-2007 due to the enduring withdrawal of glaciers and their consequent fragmentation in minor glacial bodies. Between 2006-2007 and 2015 the persistent areal reduction also induced considerable reduction also in term of number glacial bodies with a relevant increasing in number of extinct glaciers (fig. 4).

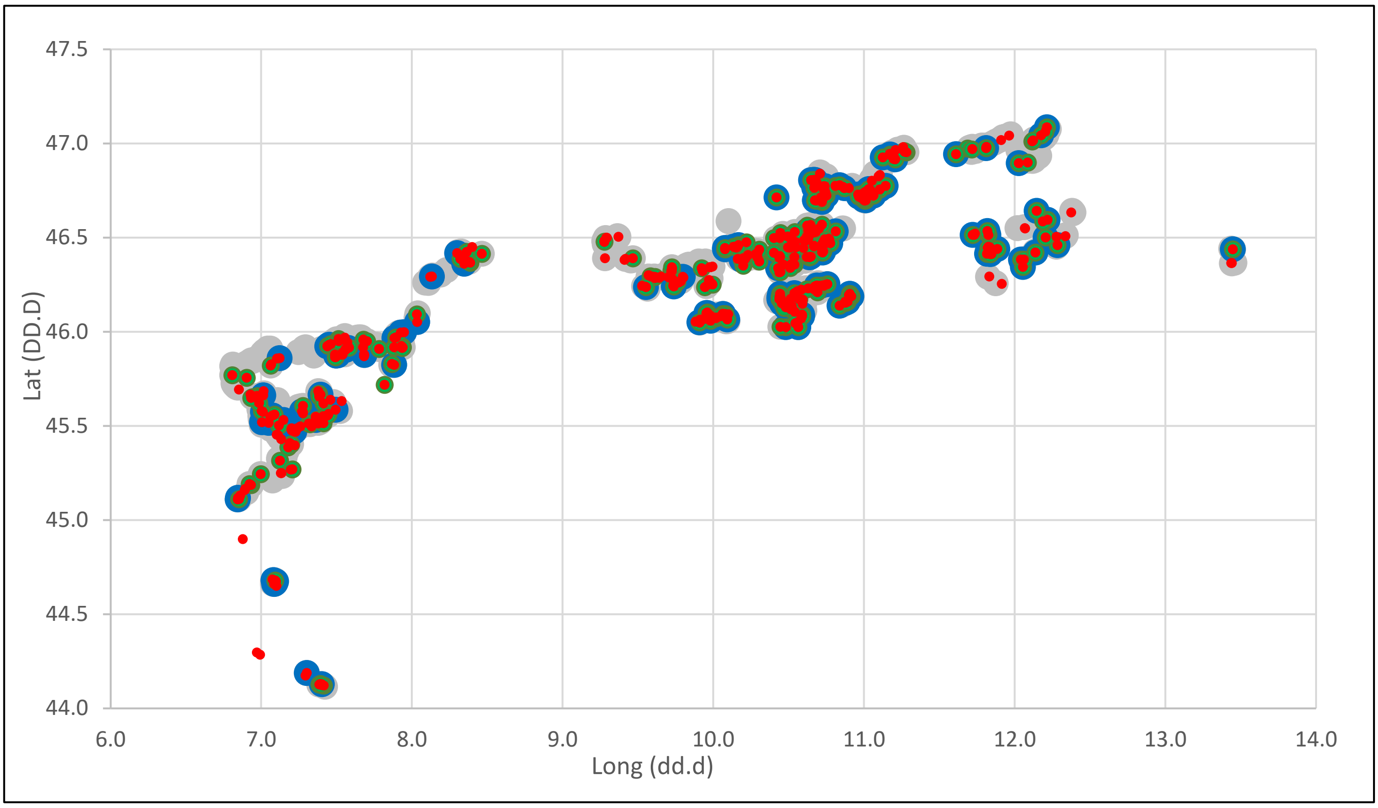

Fig. 4 – Exinct glaciers in the Italian Alps in the different time steps. In gray, existing glaciers in 1957 - 1958; blu, green and red circles indicate extinct glaciers in 1988-1989, 2996-2007 and 2014-2015, respectively.

The most glaciated mountain massifs are located in the Southern Rhaetian Alps, in particular in the Ortles Cevedale (ca. 66 km^2, fig. 5) and in the Adamello massifs (ca. 39 km^2) where are hosted 125 and 73 glaciers respectively. Pennine Alps and Graie Alps follows as glacial coverage with the Mt. Rosa (ca. 37 km2) and Mt. Bianco (ca. 36 km^2, fig. 6).

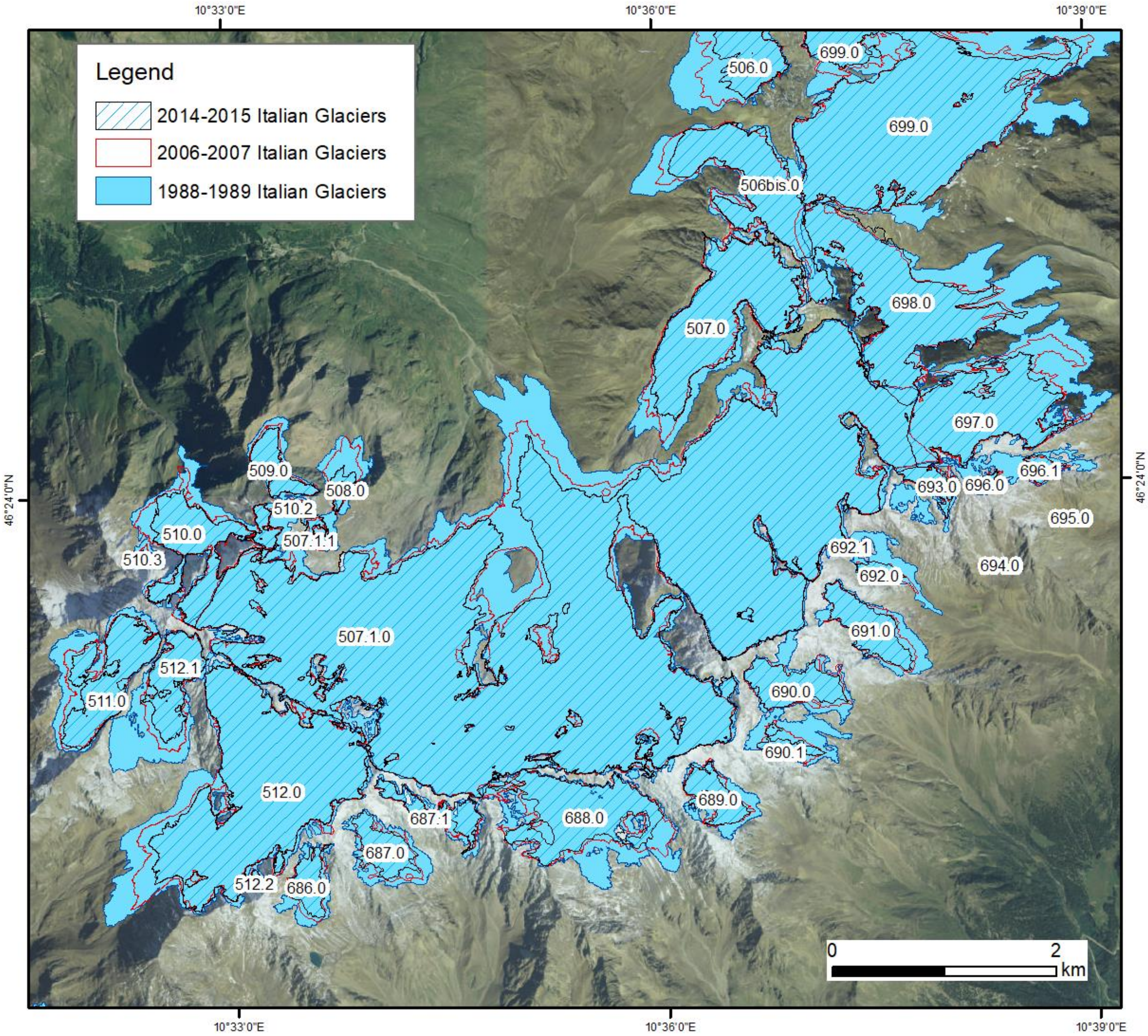

Fig. 5 – Forni glacier (code 507.1.0) and other glaciers of the southern Ortles Cevedale Gorup. Different time steps underlie the strong areal reduction and presence of enlarging rocky windows in the accumulation basin.

These mountain groups accounted for the about 52 % of the total glacierized area of the Italian Alps and ca. 32 % of the glacial bodies. the remaining 48 % in terms of glacierized area is distributed in all the other mountain groups. The southernmost glacier in the Italian Peninsula, the Calderone glacier in the Gran Sasso d'Italia, splitted in two small glacial bodies (debris covered) extending for about 0.04 km2. The three widest glaciers of the Italian Alps were the Adamello ice plateau (15.7 km2) and the Forni Glacier (10.7 km2), in the Alpi Retiche Meridionali together with the Miage Glacier (10.5 km2) in the Alpi Pennine. Altogether, these three ice bodies covered approximately 37 km2, representing approximately 10% of the total area.

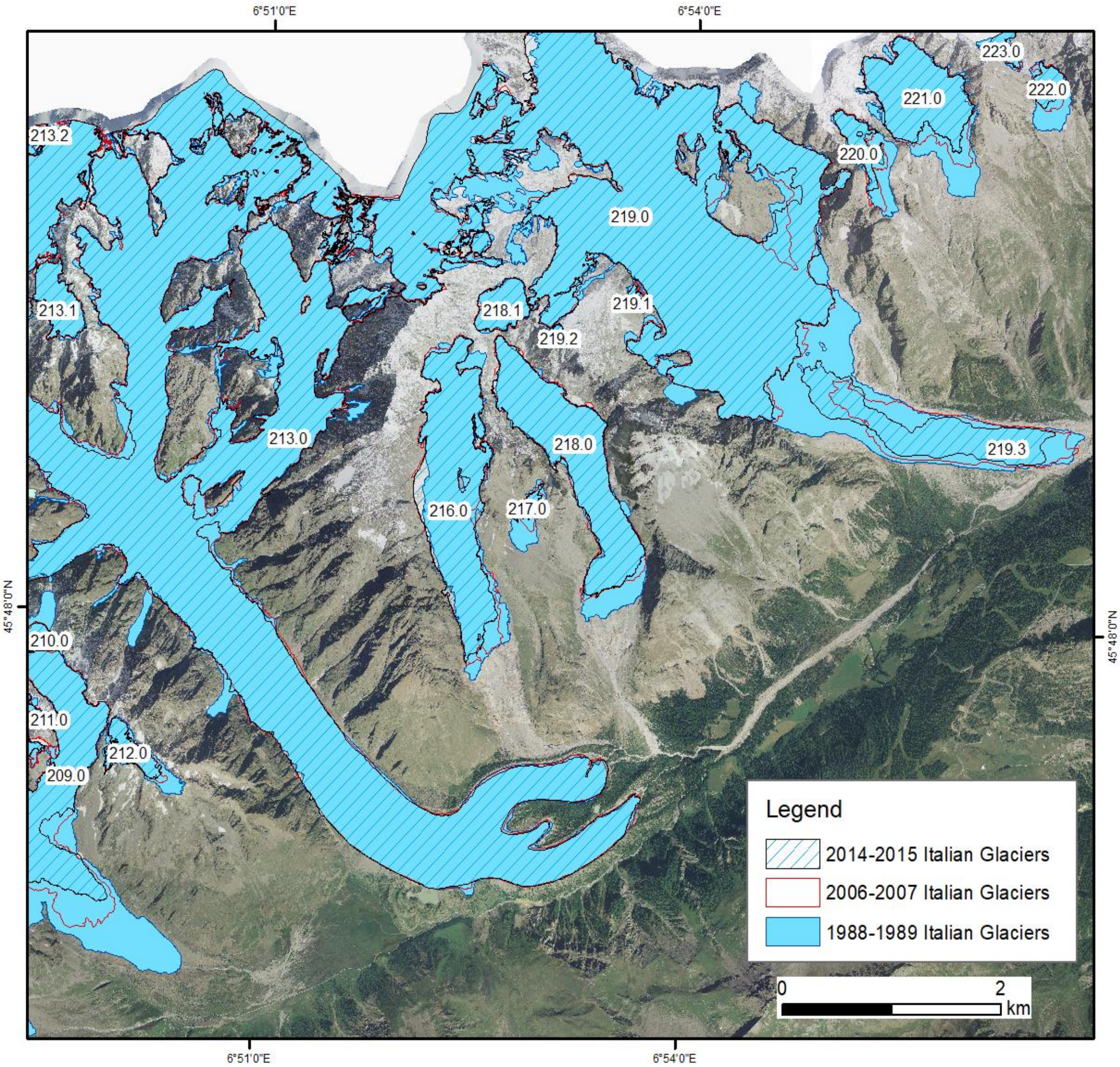

Fig. 6- Glaciers of the Val Veny, Monte Bianco Group.

Following Paul & *alii* (2004), we considered seven classes of glacier extension (fig. 7), which allowed for a comparison of our data with those of other national and international inventories. Considering the most recent time interval (2014-2015) the size of glaciers spanned from < 0.1 km^2 to 15.7 km^2 of the Adamello Glacier (Adamello-Presanella Group). Glaciers of the smaller size classes dominated the number of Italian glaciers in 2014-2015 as they represent ca. 55% of the total number (474 vs 857) but covering less then the 6% of the total area.

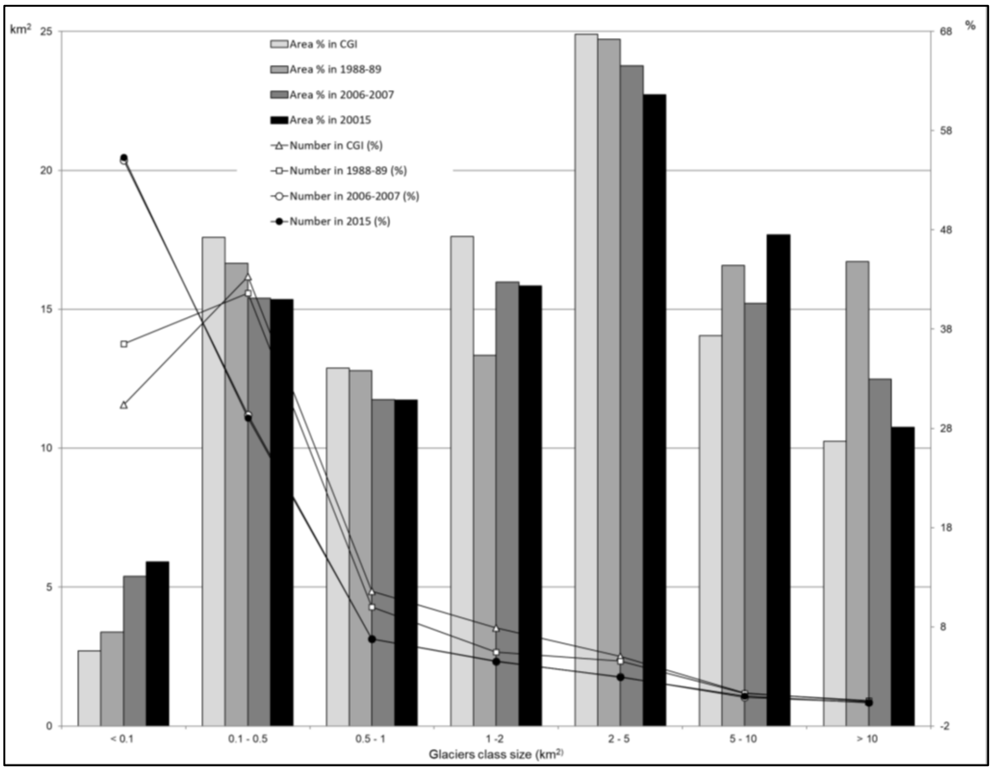

Fig. 7 - Comparison of areal frequency distribution and percentage of Italian glaciers in the time steps investigated, considering different size classes.

In all the time steps, the aspect of glacier bodies over the entire Italian Alps (fig.8) shows that the greatest glacierized area and number of glaciers were mainly concentrated in the northern sectors (NW, N and NE).

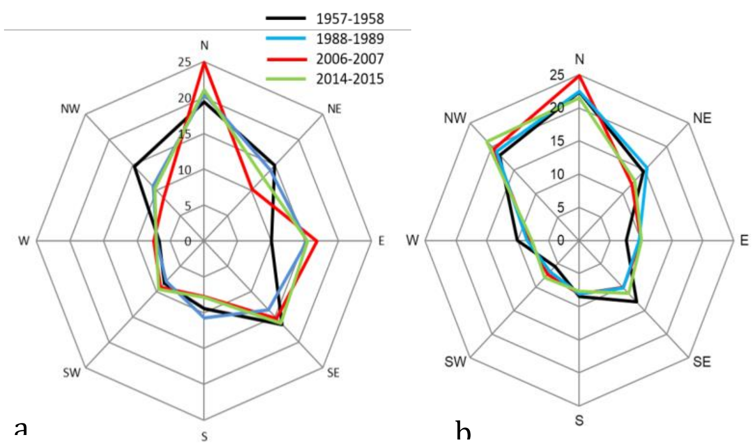

Fig. 8 - Frequency distribution of glacier areal extension (a) and number (b) in percent with respect to aspect in the Italian Alps, considering

Considering the entire Italian Alpine chain, average altitude of the glaciers and elevation of fronts change with respect to the longitude (fig. 9). The trend shows slight fluctuations from mean elevations in the West, stronger fluctuations from 8° to 13° E, and a minimum fluctuation at the easternmost margin. Alpi Giulie shows substantial stability despite the warming climate in recent years (Salvatore et al., 2015 and references therein).

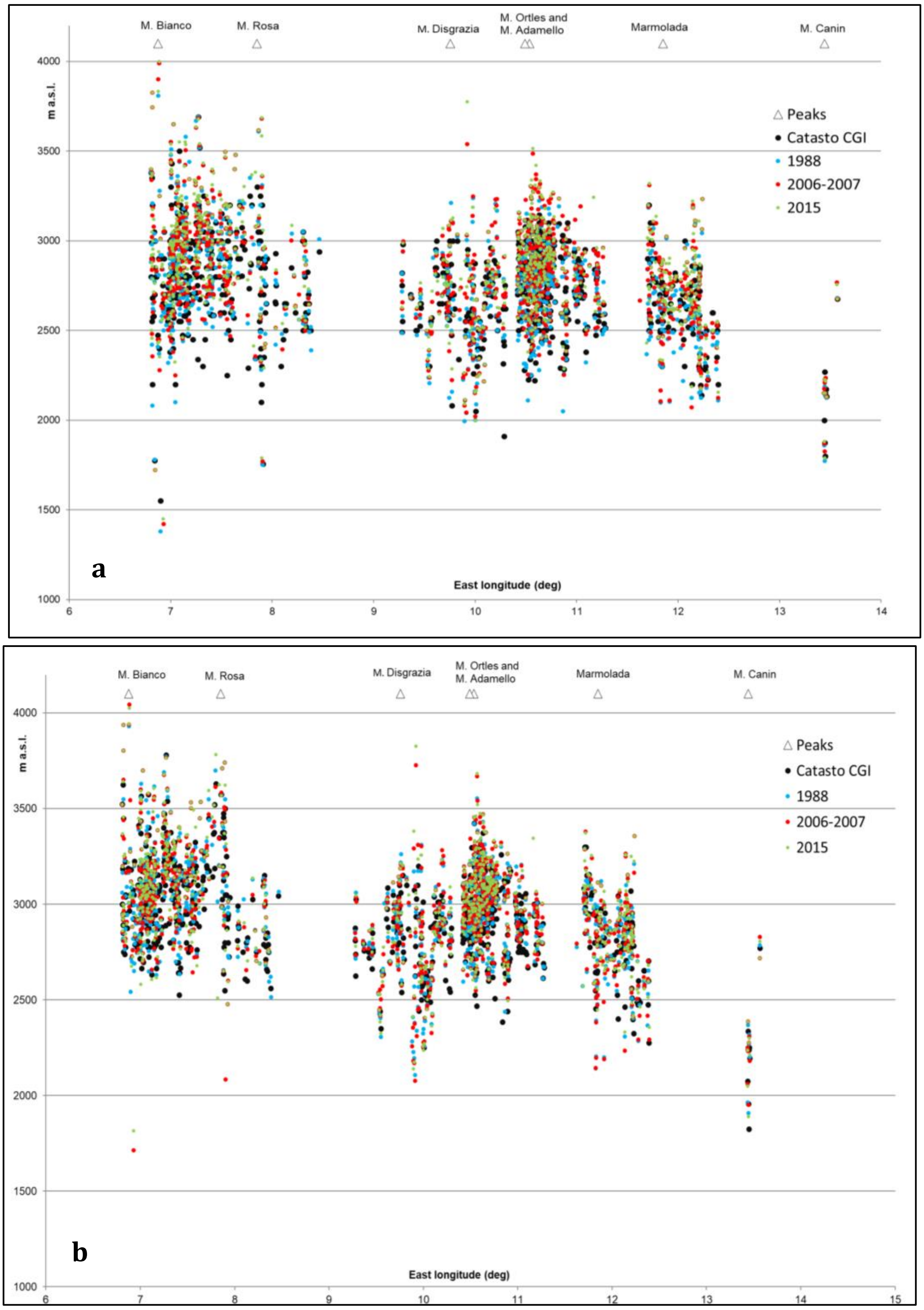

Fig. 9 – a) Altimetric distribution of Italian glacier fronts with respect to longitude in different time steps.; b) altimetric distribution of mean elevation of Italian glaciers with respect to longitude in different time steps. Triangles indicate the geographical position of the main peaks of the Italian Alps.

Due to their structure and characteristics, datasets will be merged into the Italian Glaciological Committee WEBGIS; all the data will be available after pubblication.

and they will be accessible to those who will request them, after their pubblication in scientific papers.

The outlines of the glacial bodies for 1988-1989, 2006-2007 and 2014-2015 hydrological periods are available in * .shp file format (poligonal features). Database containing glaciological parameters of glaciers (1988-1989, 2006-2007 and 2014-2015) are available in * .dbf, * .csv or other formats if required.

The activity and preliminary results of WP 1.6 task 1 project were presented in several meetings and congress (see list after Pubblications).

Publications

ISI-WEB Journals

Baroni C., Bondesan A., Carturan L., Chiarle M. (Eds.) (2018). Report of the Glaciological Survey 2017. Relazioni della Campagna Glaciologica 2017. Geografia Fisica e Dinamica Quaternaria, 41 (2), in press.

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

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

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

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.

Cerrato R., Salvatore M.C., Brunetti M., Coppola A., Baroni C. (2018) - Dendroclimatic relevance of Bosco Antico, the most ancient living European larch wood in Southern Rhaetian Alps (Italy). Geografia Fisica e Dinamica Quaternaria, 41, 35–49. DOI: 10.4461/GFDQ.2018.41.3

Cerrato R., Salvatore M.C., Gunnarson B., Linderholm H., Brunetti M., Carturan L., de Blasi F., Baroni C. (2019) - A Pinus cembra L. tree-ring record for late spring to late summer temperature in the Rhaetian Alps, Italy. Dendrochronologia 53, 22–31. DOI: 10.1016/j.dendro.2018.10.010

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

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 (2018): Fluctuations of Glaciers Database. World Glacier Monitoring Service, Zurich, Switzerland. DOI:10.5904/wgms-fog-2018-11. Online access: http://dx.doi.org/10.5904/wgms-fog-2018-11

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

Comitato Glaciologico Italiano (2017). Itinerari Glaciologici sulle Alpi Italiane. Capitoli tematici. Società Geologica Italiana, Guide Geologiche. Vol. 1, 106 pp.

Comitato Glaciologico Italiano (2017). Itinerari Glaciologici sulle Alpi Italiane. Dalle Alpi Marittime all'Alpe Veglia. Società Geologica Italiana, Guide Geologiche. Vol. 2, 238 pp.

Comitato Glaciologico Italiano (2017). Itinerari Glaciologici sulle Alpi Italiane. Dal Ghiacciaio della Ventina al Calderone. Società Geologica Italiana, Guide Geologiche. Vol. 3, 286 pp.

Congress and workshop

Baroni C., Gennaro S., Salvatore M.C., Zorzi M., Carton A., Carturan L., Zanoner T. (2018) - A new database for reconstructing the spatial-temporal evolution of the glacial resource in the Italian Alps. SISC, Sixth Annual Conference, Recent trends in climate sciences, adaptation

and mitigation. Parallel section 3 - NextData “Climate change in the Italian Mountains and Mediterranean Region”. Venezia Mestre, 17-19 October 2018. (oral communication)

Cerrato R., Salvatore M.C., Brunetti M., Coppola A., C. Baroni C. (2018) - Dendroclimatic temperature record derived from tree ring width of the oldest living wood in the Southern Rhaetian Alps (Ortles Cevedale Group, Italy). SISC, Sixth Annual Conference, Recent trends in climate sciences, adaptation and mitigation. Parallel section 3 - NextData “Climate change in the Italian Mountains and Mediterranean Region”. Venezia Mestre, 17-19 October 2018. (Best Poster Award)

Salvatore M.C., Baroni C., Carton A., Giardino M., Alderighi L., Bertotto S., Gennaro S., Perotti L., Zanoner T. (2018) - Multitemporal glacier inventory of the Italian Alps, a basic tool for reconstructing the ongoing climate change. SISC, Sixth Annual Conference, Recent trends in climate sciences, adaptation and mitigation. Parallel section 3 - NextData “Climate change in the Italian Mountains and Mediterranean Region”. Venezia Mestre, 17-19 October 2018. (oral communication)

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.

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.

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.

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.

Smiraglia C, Casarotto C., Baroni C. (2019) – For a better understanding of the glacier evolution and environment: glacier trails around the Italian Alps. Poster. 23rd Alpine Glaciology Meeting2019 Innsbruck (Austria), 28 Feb. – 1 March,2019.

Conferences and 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.

- SISC (Italian Society for Climate Sciences) Sixth Annual Conference, Rcent trends in climate sciences, adaptation and mitigation. Parallel section 3 - NextData “Climate change in the Italian Mountains and Mediterranean Region”. Venezia Mestre, 17-19 October 2018.

- SGI-CGI, presentazione ufficiale de “La guida degli itinerari glaciologici delle montagne italiane. Un contributo allo sviluppo del turismo sostenibile sulle Alpi”, Dipartimento di Scienze della Terra, Università di Milano, 5 novembre 2018 https://www.socgeol.it/323n1410/itinerari-glaciologici-sulle-montagne-italiane-un-contributo-allo-sviluppo-del-turismo-sostenibile-sulle-alpi.html).

http://www.loscarpone.cai.it/news/items/itinerari-glaciologici-sulle-montagne-italiane-un-contributo-allo-sviluppo-del-turismo-sostenibile-sulle-alpi.html.

- Baroni C., Itinerari glaciologici sulle montagne italiane: un paesaggio in rapida evoluzione. Ciclo di conferenze organizzato in occasione della mostra fotografica “Una Montagna di Vita” presso il Museo di Storia Naturale dell’Università di Pisa, 29 marzo 2019.

- Salvatore M.C., I Ghiacciai delle Alpi Italiane: un tema caldo di grande attualità. Ciclo di conferenze organizzato in occasione della mostra fotografica “Una Montagna di Vita” presso il Museo di Storia Naturale dell’Università di Pisa, 11 aprile 2019.

- Cerrato R., Gli alberi, testimoni silenti del clima che cambia. Ciclo di conferenze organizzato in occasione della mostra fotografica “Una Montagna di Vita” presso il Museo di Storia Naturale dell’Università di Pisa, 17 aprile 2019