Project of Strategic Interest NEXTDATA

Deliverable D2.3.4
Collection of available palynological studies in Northern Italy and Alpine area from different chronological context.

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Pollen analysis is applied since decades on sediments from marine and continental settings to reconstruct the history of environments and climate over short to very long time periods. The potential of pollen as a proxy for quantitative estimations of climate parameters (temperature, precipitation) has not yet been fully understood and explored. The basic biological assumptions for pollen as paleoclimate proxy are the followings: (i) pollen is a function of regional vegetation; (ii) regional vegetation is a function of climate; (iii) then pollen is an indirect function of climate and can be used to reconstruct past climates on a regional scale.

The NextData group working on palynological data in Milano is developing research activities aiming at: 1) checking the availability of pollen data from limnic sedimentary environments covering the last 3 kyr; 2) preparing a database/data repository and tools to address future researches, 3) reconstructing the pattern of plant species distribution and past ecosystems structure through pollen data (in collaboration with the NextData group in Rome; the first outcome of this research is presented in Magri et al., in press); 4) providing quantitative paleoclimate estimations to be used for the multiproxy "Italy 2k" reconstructions (as a contribution to the NextData Italy-2k grand challenge). First objective has been achieved. The other three are "work in progress".

The survey of existing data revealed a huge number of palynological records available in Italy and covering the Holocene (last ~11,7 kyr). 211 sites (199 continental and 12 marine sites) were counted, from both published or unpublished data. The geographical distribution of these sites guarantees the representation of all altitudinal belts though not evenly spaced within the country. In order to select sites documenting the past 3 kyr (or part of this interval) we evaluated the chronological robustness (available 14C ages), the chronostratigraphic resolution (less than one hundred years) and the comparability with the regional biostratigraphic model of each pollen record available. Following this procedure, 23 pollen records obtained from lacustrine and palustrine successions were selected to constitute the best N-Italy pollen datasets which will be part of the larger Italian NextData database for last 3 kyr (Fig. 1).

Past distribution and dynamics of nine tree taxa (*Picea*, *Abies*, *Betula*, *Fagus*, *Carpinus betulus*, *Corylus*, deciduous and evergreen, *Quercus* and *Olea*) during the last 11 ka have been reconstructed from fossil pollen data (Magri et al., in press).

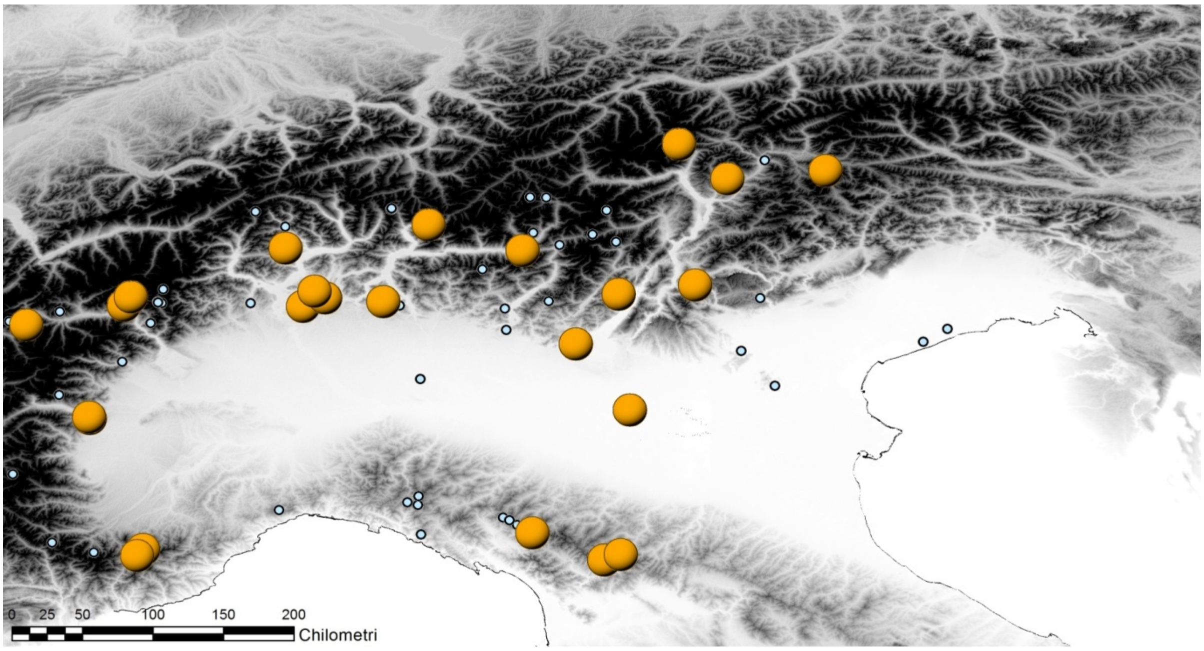

Fig. 1. N-Italy best pollen datasets. Big yellow circles represent the 23 sites selected as best fossil pollen record.

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D2.3.5
Revision and harmonization from data from EMPD (European Modern Pollen Database), for pollen data quantitative reconstruction

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A wide literature is available on the state-of-the-art of quantitative climate reconstructions from pollen data. A three steps approach is required (Fig. 2). The first necessary step is to acquire a modern training set which is used to develop the transfer functions to reconstruct the paleoclimate variables. The NextData group used the whole European Modern Pollen Database (EMPD) (Davis et al., 2013) as modern training set. This database includes modern pollen samples and related climate data from nearly 4800 sites across Europe and part of N-Africa. Statistical multivariate analysis (Detrended Corresponce Analysis, DCA) was applied on the EMPD dataset to explore the sites distribution taking into account the climate parameters available for each site. The second step was the application of numerical techniques to develop the transfer functions used to model numerically the relationship between the modern pollen data and the modern climate data (temperatures and precipitations). Three numerical techniques were used to this aim:

- wMAT = weighted Modern Analogue Technique. Using similarity/dissimilarity coefficients, this method is able to find k- analogues of each fossil pollen sample in the modern training set. Values of environmental variables are then calculated as weighted means from the K-analogues.
- LWWA = Locally Weighted Averaging. Similar to MAT, but larger number of analogues is taken into account (30-40). Environmental optima and tolerances are then estimated by weighted mean of the values expressed by the k analogues. This method is based on dynamic training sets: for each pollen sample, calibration methods are applied to the nearest k analogues.
- LWWA-PLS = Locally Weighted Averaging Partial Least Square. Similar to LWWA but principal components are searched for to reduce collinearity effects.

The third step consisted on testing the model we developed in step 2 on fossil series covering the last 200 years.

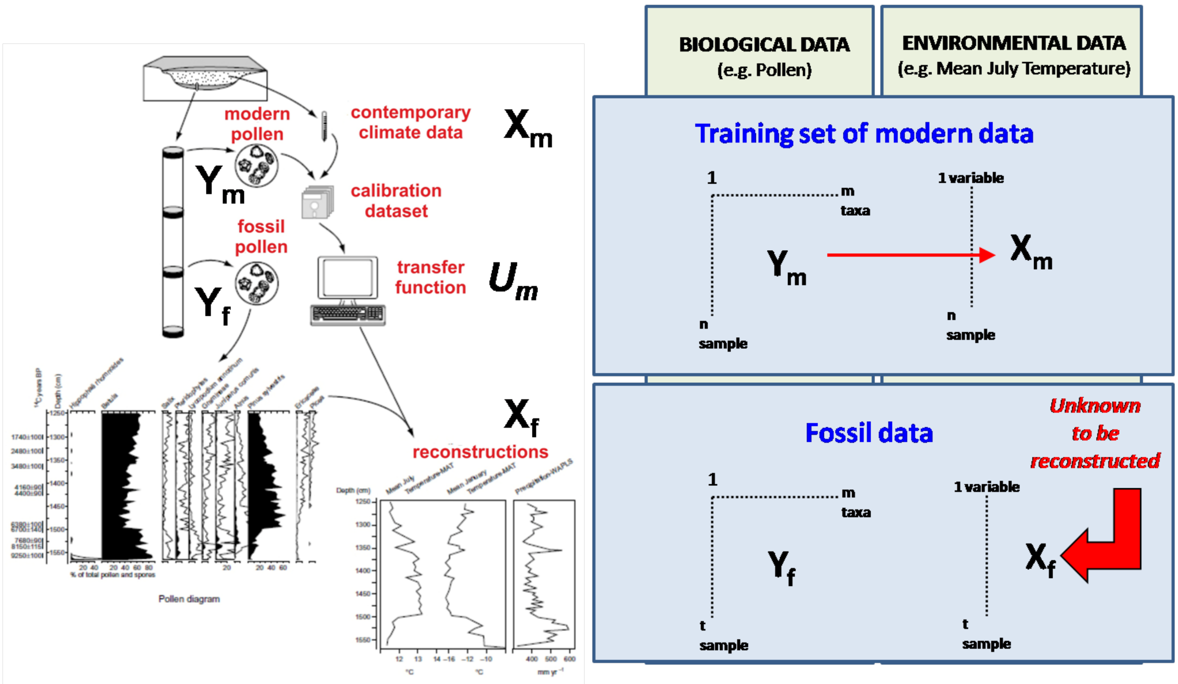

Fig. 2. Scheme illustrating the recostrunction of past environmental data "Xf" (e.g. past temperature) from fossil pollen data "Yf". The calibration is done by using transfer function "Um" which are based on relationship between modern pollen data "Ym" and modern climate data "Xm".

First tests and obtained results

a) Testing pollen transfer function for the last 200 years:

Pollen - climate transfer functions were tested on pollen sequences covering the last 200 years in order to compare reconstructed temperature series with centuries-long instrumental records available for the same sites and kindly provided by M. Brunetti (CNR-ISAC). A good correspondence is observed between instrumental series and pollen-inferred temperatures (Fig. 3).

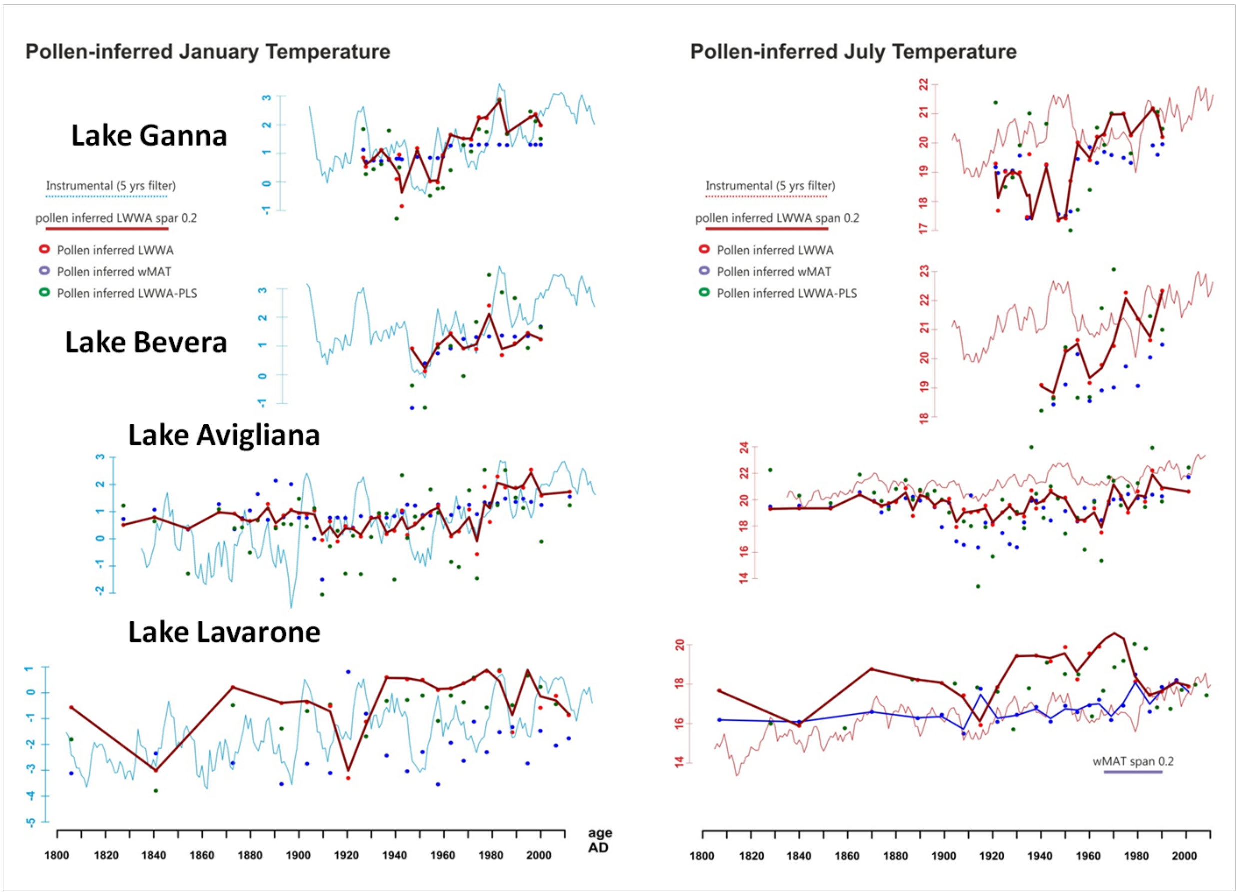

Fig. 3. Comparison between pollen-inferred temperatures (January and July) obtained with transfer functions for four N-Italy sites, Lake Ganna, Lake Bevera, Lake Avigliana and Lake Lavarone over the last 200 years and instrumental climate data (kindly provided by M. Brunetti, ISAC-CNR).

b) Testing pollen transfer function over the Holocene:

Pollen - climate transfer functions were then applied on longer Holocene series to retrieve the signal of climate variability along a longer time interval (Fig. 4). First comparisons between our pollen-inferred temperatures and other Temperature proxy records show that pollen-inferred temperatures can reconstruct strong climate events (e.g. at 8.2 kyr cold event).

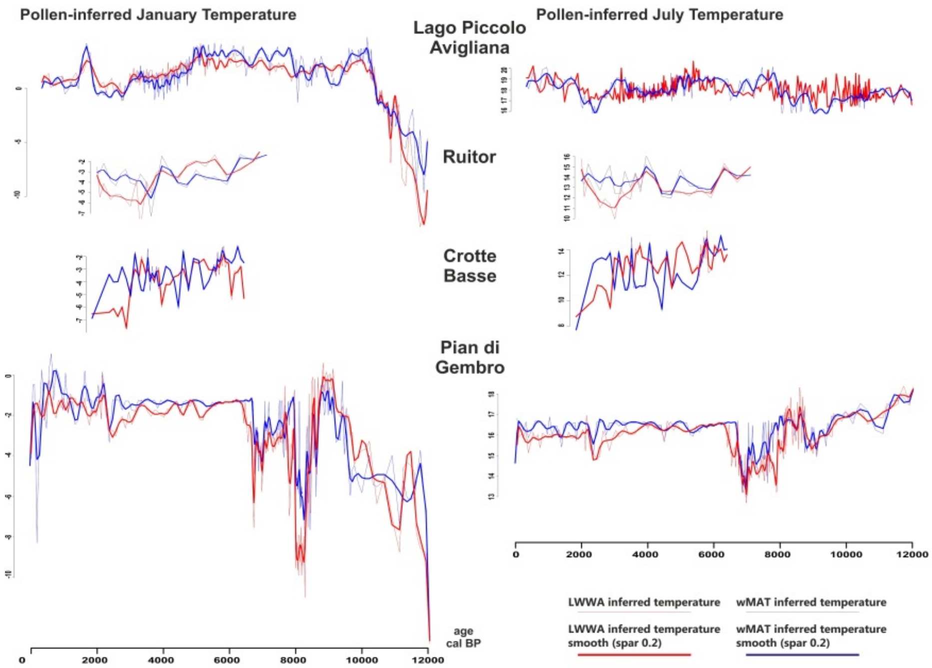

Fig. 4. Pollen-inferred temperatures (January and July) obtained for four N-Italy sites, covering the whole Holocene (Lago Piccolo di Avigliana, Pian di Gembro) or a shorter section (Ruitor and Crotte Basse).

The first results of the climate reconstructions highlighted the main issues in reconstructing climate variables for N-Italian sites, especially for high altitude pollen records keeping track of a pollen component coming from long-range transport. The main problems are related to the availability of modern training set and to the difficulty of defining the transfer functions to find analogues which could well represent the past conditions. Thus, we are currently improving the available training set by creating local training set especially designed for mountain regions.

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D2.3.6
Dendrochronological data provided by University and Research Centres will be structured and organized according to the requirements of NextData and then incorporated in to Project database.

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The dendrochronology activities developed within the NextData Project are comprised under four main topics: data analysis, creation of a database for collecting dendrochronological metadata and data at the national level, publications, communication.
As for the data analysis, the activities were mainly focused on the definition of a methodology for increasing the temperature signal in tree-ring chronologies from high-altitude Alpine sites. High-resolution land surface temperature from these environments, primarily impacted by variations in climatic regimes, may be derived from the trees growing there, that may record century-long climatic information with annual resolution. Indeed, most of the annually-resolved climatic reconstructions performed for periods prior to instrumental records are largely based on tree-ring information.
One of the main challenges when dealing with tree-ring series for past climate reconstructions is the selection of chronologies with a stable signal in the low-frequency domain and especially the selection of only those chronologies holding a strong climatic signal, thus discarding less sensitive chronologies from sites that are also likely impacted by non-climatic factors.
For this purpose, the analyses were focused on the 1° x 1° grid point lat. 46°N long. 10°E, a portion of the Central Alps region comprising Italy, Switzerland and Austria, particularly rich in tree-ring data. Overall 42 chronologies from high-altitude sites (>1800 m a.s.l.) were collected for a total of 1259 tree-ring series of three conifers species:

- LADE (*Larix decidua*) 11 sites: presena (2160 m a.s.l.), val d'avio, sils-maria gr blais dal fö, valfurva, val solda, bergün gr val tuors, obergurgl, val di fumo, presanella, sils maria gr resgia, rabins (1850 m a.s.l.);
- PCAB (*Picea abies*) 5 sites: bergün gr val tuors (2065 m a.s.l.), val trafoi, obergurgl, davos gr dischma-fluela, davos gr sertig (1800 m a.s.l.);
- PICE (*Pinus cembra*) 26 sites: valfurva cune (2250 m a.s.l.), val di pejo verdignana, val d'ultimo lago verde, val martello colle cirmoli, val di pejo pian venezia, muottas da schlarigna, tamagur, mt confinale, valle forni losseda, celerina, val martello lago gioveretto, val zebru mt. forccellino, valle forni stella alpina, val trafoi trafoi, val d'ultimo lago pesce, val martello paradiso di cevedale, sils-maria gr blais dal fö, silvaplana, val solda, passo gavia, val trafoi borletti, obergurgl tyrol architectural timbers, lawiner grant, obergurgl, engadin, sils maria, gr resgia (1850 m a.s.l.).

These chronologies were obtained from the database of the University of Milan, the University of Pisa and from the ITRDB (http://www.ncdc.noaa.gov/) database. For each site, a quality check on all individual series was applied in order to keep only those series showing growth patterns that were compatible with patterns of other series within each site. The subsequent method applied for the selection of Highly Sensitive To Temperature (HSTT) series was based on the comparison of each indexed series against the summer temperature series in the first step, and against the growing reference series in the pre-instrumental period. Only the series showing a high and statistically significant synchronicity (given by a Glk index at $p<0.001$) and a minimum correlation of $r>0.3$ with the reference series were saved and included in the pool for the construction of the regional chronology HSTT. In this specific approach the HISTALP dataset (high-altitude series; Auer et al., 2007) was used.
This is a multi species approach whose aim is the construction of a regional chronology holding the strongest possible signal of summer temperature (JJA) for the longest possible period: the obtained chronology spans from AD 1388 to 2007, with a good stability of the signal (EPS>0.85) from AD 1480 up to 2007. This approach has also the advantage of checking

and potentially using any individual series from trees growing in a determined region, thus opening the possibility of fully using all the information available in large dataset.

Parallel to this approach, a regional chronology for each species was constructed by means of the Regional Curve Standardization (RCS), a type of chronology that can hold low-frequency signals of climate variations (Esper et al., 2007). For each species, only the site chronologies showing a correlation r>0.3 with the JJA temperature series over the period 1780-2007 were kept for constructing the final regional chronology: for LADE, therefore, only 6 site chronologies out of the initial 11 were kept, for PICE only 5 out of the initial 26 were kept.

For PCAB, only 1 chronology satisfied the required restriction, however all the 5 chronologies were kept in order to have datasets of similar consistency, but the different quality signal of the PCAB chronology was taken into consideration in the subsequent elaborations.

This classical approach leads to the construction of species chronologies that have shorter time extension than the HSTT over the domain of an EPS>0.85: LADE from (1675-2008), PCAB (1654-2005) and PICE (1650-2004).

Regression approaches as well as simple scaling (Esper et al., 2005) were applied to the HSTT, avgALL (average of all species) and avgLADE-PICE (average of LADE and PICE) chronologies for reconstructing annually-resolved summer temperatures for periods not covered by instrumental records, reaching AD 1580, 1675 and 1725 respectively.

Understanding past climatic variability in the Alps and providing century-long high-resolution temperature reconstructions may be extremely useful for modelling past climatic variability in remote sites and for correctly predicting the future impacts of ongoing climate change on the Alpine environment and its resources. Therefore the proposed approach will be replicated in other grid points comprising the Italian territory, starting from those rich of long series of dendrochronological data. For the Alps the temperature reconstructions should be generally easier than in the Apennines and in the Mediterranean regions, given the higher number of chronologies available and the strongest signal of temperature recorded in the tree-ring chronologies. Going south, less data are available, the recorded signal is more related to drought periods and it is generally a mixed signal of temperature and precipitation.

The data collection has been strategic for depicting the spatial distribution of data currently available in Italy and potentially available for reaching the Italy-2k grand challenge objective of climate reconstruction.

By directly contacting the various groups operating in Italy, the NextData Project objectives have been circulated also to other research groups or entities external to the Project, thus widening and fostering the possibility of new collaborations. Overall, up to December 31st, 6 groups have sent their metadata, other information on Italian sites where derived from the ITRDB database and other groups (University of Pavia and University of Padua) have promised their incoming participation.

In particular it was possible to collect metadata of 89 sites: University of Milan (24 sites), ITRDB (17 sites), University of Molise (13), Second University of Naples (13), University of Basilicata (12), University of Pisa (5), Civic Museum of Rovereto - former Italian Institute of Dendrochronology - (5). Overall data of 25 site chronologies were collected: ITRDB (17 chronologies), University of Milan (4), University of Pisa (4). Both metadata and data have been periodically elaborated, ordered and sent to the Project partners for further elaborations. In particular, a quality check was performed on each chronology before entering it in the NextData database.

For enhancing the visibility of the dendrochronological information collected from the various groups, a web site has been set up (http://geomatic.disat.unimib.it/dendro), from which the metadata relative to each chronology can be downloaded by clicking over any of the points on the map. In particular,it is possible to gain information on the Chronology name, Site name, Coordinates, Altitude, Cores extraction date, Chronology time span, Measured parameter,

Species, Author (or group), Institution owner of the data, Address of the Institution, Contact name, e-mail, Bibliographic reference and Abstract (when available) for each site.
The system is organised to receive new information at any time, so that if new data are sent by some of the groups, it is possible to easily update the information by adding the new points on the map. The collection of all metadata and data available in the ITRDB for Italian sites was started last December, so that within a few months all information in this open database will be checked for quality and then transferred to the NextData Project.
Concerning the publications, some elaborations in GIS environment were undertaken to be included in a paper dealing with the tree recolonization patterns in the Forni Glacier forefield (the largest Italian valley glacier) according to active geomorphological processes and glacier retreat phases since the end of the Little Ice Age (about AD 1850).
The estimation of the lag time between surface exposure after glacier retreat and the successful tree establishment (ecesis interval) has been assessed along a transect in the forefield and in the proglacial area. As we could demonstrate, tree ecesis intervals along the valley bottom linearly dropped from a mean of 64 years at about 2540 m from the glacier front position of 2011 (post Little Ice Age period), to a mean of 7 years at about 420 m. The spatial distribution of the ecesis anomalies has highlighted that where geomorphological processes are present or where unstable till and rock deposits characterize the substrate, tree establishment and growth after glacier retreat are delayed with respect to the predicted values of ecesis. Showing linearly decreasing ecesis intervals, the study suggests a climate-driven dynamics which poses important implications in dating minimum ages of landform surfaces within glacier forefields with unknown glacier front retreat patterns. It also demonstrates that ecesis anomalies may be used in glacier fore fields also for detecting portions of territory where the study of the impacts of active geomorphologic processes would be important. In November the manuscript has been submitted to *Arctic Antarctic and Alpine Research* for the peer review process.
Since December the publication activities dealt with the data organisation for the paper of dendroclimatic reconstruction of summer temperature for the grid point 46°N 10°E.
Two main events took place for what concerns the communication activities. The first oral communication was given at the SGI-SIMP (Società Geologica Italiana & Società Italiana di Mineralogia e Petrologia) congress *The future of the Italian Geosciences of the future* at University of Milan, session Climate change and the Earth System: understanding the past, analysing the present and predicting future scenarios. The communication entitled 'An innovative approach to high-resolution summer-temperature reconstructions for the last centuries using large tree-ring datasets from the Central Alps' (by Leonelli G., Coppola A., Baroni C., Salvatore M.C., Pelfini M.) dealt with the presentation of the HSTT approach for constructing chronologies holding a strong temperature signal. The dataset initially comprised only chronologies from the Ortles-Cevedale and the Adamello-Presanella Groups plus another 9 chronologies added from the ITRDB for a total of about 800 individual series of tree-ring growth series covering the period from nearly AD 1300 up to 2008.
The second oral communication entitled 'Tree-ring climate reconstructions in the Italian Alps' (by Pelfini M. and Leonelli G.) took place at the *Italy 2k - NextData congress* at Accademia Nazionale dei Lincei, in Rome. The presentation dealt with the several approaches that may be undertaken for reconstructing past climatic information using a dendrochronological approach: from the spot retrieval of subfossil logs included in till and moraines o some glaciers of the Central Alps (dendroglaciological approcah) to the reconstruction of past climate variability by analyzing long tree-ring series from large datasets. A particular attention was given to the need of starting a systematic approach for constructing century- to millennia-long tree-ring chronologies also in the Italian side of the Alps, following what

already done in Austria and France, moving a step forward from the spot retrieval of subfossil logs.

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