Project of Strategic Interest NEXTDATA

Scientific Report
for the reference period 01-01-2014 / 31-12-2014

WP2.6 Pilot studies on data use

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Authors are indicated in the description of the individual Pilot Studies

1. Scheduled activities, expected results and Milestones

WP 2.6 is devoted to carry out Pilot Studies based on the data collected and made available during the Project. The planned activities for this WP concern the following aspects and they will be described in detail in the Appendix:

- Estimate of the changes in the hydrological cycle in mountain areas, with particular attention to the changes in snow cover, snow depth, precipitation and water resources availability in current conditions and future scenarios. Focus regions are the Greater Alpine Region and the Karakoram-Himalaya-Tibetan plateau region.
- Investigation of the effects of aerosol particles in mountain areas, both direct and indirect effects.
- Reconstruction of the high resolution normal values of temperature and precipitation over the Italian Alpine area.
- Past climate reconstructions from ice cores and sedimentary cores, pollen data and dendroclimatology and other paleoclimatic proxy data, and interpretation of the climatic fluctuations over the last 2000 years in the Italian territory. The analysis will be complemented by multi-secular simulations with global climate models and eventually regional climate models over specific periods of interest. **These activities represent the WP6 contribution to the Italy-2k Grand Challenge of the NextData Project, focused on the characterisation of the Italian climate over the last 2000 years.**

2. Deliverables expected for the reference period

D2.6.3: Report on the results of the Pilot Studies in the third year.

3. Activities which have been actually conducted during the reference period

3.1 Research activities

Continuation of the ongoing Pilot Studies on (a) analysis of changes in water resources in the Himalaya-Karakorum and of the interaction between monsoon and mid-latitude perturbations, (c) estimation of the changes in snow cover and the hydrological cycle of the Alps and the Apennines, and (e) multi-secular historical climate simulation for the Mediterranean area and comparison with paleoclimatic proxy data, to obtain a climatological history of Italy in the last one thousand years. The activities of the Pilot Study (d) “effect of aerosols in high altitude areas” started in the first year have been concluded during the third year.

Continuation of the Pilot Studies related to the Special Projects activated during the second year: (f) measurement and analysis of precipitation in high-elevation regions; (g) response of Alpine glaciers to climate change; (h) high-resolution climatological information for mountain areas for a 30-yr reference period. Five new Pilot Studies have been activated.

3.2 Applications; technological and computational aspects

There have been several technological and numerical developments during the third year, mostly documented in the WP2.5 report and Deliverable, a fundamental pre-requisite for carrying out the activities foreseen in the Pilot Studies and for the fulfilment of the specific Pilot Study objectives. In fact, the research performed within each Pilot Study has exploited the availability of a great amount of numerical data produced during the Project as a result of the global and regional climate model simulations. The Pilot Studies are based on datasets other than the model simulation outputs as well. For example the gridded observation-based datasets and reanalysis data have been widely employed for the study of precipitation and snow pack in the Hindu-Kush Karakoram Himalaya region.

3.3 Formation

Post-Doc research fellowships and Boursaries were continued on themes related to the Pilot Studies of the NextData Project. One PhD Thesis on the topics of Pilot Study (a) and one Master Thesis on the topics of Pilot Study (e) are being performed under the supervision of ISAC-CNR researchers in Turin. One Master Thesis on the topics of Pilot Study (c) was completed.

3.4 Dissemination

The Project of Interest NextData was presented at various scientific meetings and to the general public.

Elevation Dependent Warming EXPERT MEETING, Payerbach, Austria, April 22-25, 2014.

Scoping Workshop of the Belmont Collaborative Research Action (CRA) "*Mountains as Sentinels of Change*", Ceresole Reale, Italy, June 2014

IGFA-Belmont Forum, Beijing, October 2014.

3.5 Participation in conferences, workshops, meetings

The activities of the Pilot Studies were presented at different scientific meetings as discussed in the individual reports for the individual Pilot Studies.

4. Results obtained during the reference period

4.1 Specific results (Data libraries, Measurements, Numerical simulations, etc))

The results of the Pilot Studies are detailed in the individual reports.

4.2 Publications

The results in terms of peer-reviewed publications are detailed in the individual reports (Appendix).

4.3 Availability of data and model outputs (format, type of library, etc)
Described in the individual reports for the Pilot Studies.

4.4 Completed Deliverables
Deliverable D2.6.3, due at the end of the third year, has been completed.

5. Comment on differences between expected activities/results/Deliverables and those which have been actually performed.

We have not met specific problems or had significant delays from the activities initially foreseen for the third year.

6. Expected activities for the following reference period

Continuation of the Pilot Studies a), c) and e) and of the Pilot Studies related to the special projects, as described in the Appendix.

Appendix
Results of the Pilot Studies

Pilot Studies and authors:

2.6a: Analysis of water resources in the Himalaya-Karakoram and interaction between monsoon and mid-latitude perturbations
Lead Author: Elisa Palazzi (CNR-ISAC, Torino).
Contributors: S. Terzago, L. Filippi, J. von Hardenberg (CNR-ISAC); A. Provenzale (CNR-IGG).

2.6c: Estimation of the changes in the hydrological cycle, snow cover and water availability in high altitude areas.
Lead Author: Silvia Terzago (CNR-ISAC, Torino).
Contributors: E. Palazzi, J. von Hardenberg (CNR-ISAC); A. Provenzale (CNR-IGG); C. Cassardo (Univ. Torino, Dip. Fisica); U. Morra di Cella, E. Cremonese (ARPA-VdA).

2.6d: Effects of aerosols in high-altitude regions
Lead Author: Jost von Hardenberg (CNR-ISAC, Torino).
Contributors: E. Palazzi (CNR-ISAC), S. Terzago (CNR-ISAC).

2.6e: Multi-secular historical climate simulation for the Mediterranean area and comparison with paleoclimatic proxy data, to obtain a climatological history of Italy in the last one thousand years
Lead Author: Elisa Palazzi (CNR-ISAC Torino).
Contributors: J. von Hardenberg (CNR-ISAC); A. Cuccu (University of Torino).

2.6f (Special Project P2): NextSnow - Measurement and analysis of precipitation in high-elevation regions
Lead Author: Vincenzo Levizzani (CNR-ISAC Bologna).
Contributors: S. Laviola, E. Cattani (CNR-ISAC); U. Morra Di Cella, E. Cremonese (ARPA-VdA); R. Rudari, S. Gabellani (CIMA Foundation); P. Claps, F. Laio, P. Allamano, A. Libertino (Politecnico di Torino – DIATI); S. Ferraris, D. Canone, M. Previati (Politecnico e Università di Torino – DIST); C. Cassardo, S. Ferrarese (Università di Torino – Dip. Fisica); S. Fratianni, F. Acquaotta, D. Garzena, L. Perotti (Università di Torino – Dip. Scienze della Terra).

2.6g (Special Project P3): 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)
Lead Author: Marta Chiarle (CNR-IRPI, Torino).
Contributors: C. Baroni, A. Carton, M. Chiarle, M. Giardino, G.Mortara, G. Nigrelli, L. Perotti, M. C. Salvatore (CNR-IRPI, CGI).

2.6h (Special Project P7): High Resolution Climate Information for Mountain Areas (HR-CIMA)
Lead Author: Michele Brunetti (CNR-ISAC, Bologna).
Contributors: A. Bertolini, M.Brunetti, C. Simolo (CNR-ISAC); M. Maugeri (Dipartimento di Fisica – Università di Milano).

2.6j: (Special Project / Studio Pilota): RelationsHips between meteo-climAtic paraMeters and ground surface deforMation time sEries in mountain enviRonments (HAMMER)
Autore: Francesca Ardizzone (CNR-IRPI).

2.6a: Analysis of water resources in the Himalaya-Karakoram and interaction between monsoon and mid-latitude perturbations

Coordinator: Elisa Palazzi
CNR-ISAC

1. Scheduled activities, expected results and Milestones

The third year of this Pilot Study has been dedicated to the investigation of the synoptic origin of winter precipitation in the Karakoram area (western portion of the Hindu-Kush Karakoram Himalaya region), making use of both observations and reanalysis data. We have analysed the relationship between winter precipitation and the North Atlantic Oscillation (NAO) focusing on the variability during the last century of the NAO-precipitation correlation in the HKK.

2. Deliverables expected for the reference period

Contribution to the Project Deliverable D2.6.3 with the results obtained during the third year of this Pilot Study (D2.6.3a).

3. Activities which have been actually conducted during the reference period

3.1 Research activities

This section resumes the research activities performed during the third year of this Pilot Study. We refer to the Deliverable 2.6.3a for the details and for the bibliography reported in the text and in Table 1.

The Hindu-Kush Karakoram (HKK) is located at the western edge of the Himalayan range, and it is exposed to two main circulation patterns - the Indian monsoon and the mid-latitude westerlies, mainly known as Western Weather Patterns (WWPs). The various circulation patterns lead to a different precipitation climatology in the western and eastern portions of the mountain chain. The HKK in the west, in particular, receives precipitation both in winter, carried on WWPs originating from the Mediterranean/Atlantic regions, and in summer due to the monsoon. As a result, precipitation in HKK is characterized by a bimodal annual cycle (Palazzi et al., 2013). WWPs are primarily responsible for the build-up of seasonal snow cover in the Karakoram, constituting an essential water reserve and source for several river basins (Archer and Fowler, 2004).

The North Atlantic Oscillation (NAO) has been indicated as an important factor affecting winter/spring precipitation in the Karakoram region (Syed et al., 2006; Yadav et al., 2009). Previous studies have indicated that winter precipitation and NAO are correlated with above (below) than normal precipitation over the HKK area during the positive (negative) NAO phase. This can be clearly seen in Figure 1 (Filippi et al., 2014) showing the spatial distribution of the statistically significant correlations (at the 95% confidence level) between DJFM precipitation and DJFM NAOI time series; precipitation data come from three gridded archives based on the interpolation of in-situ rain gauge measurements (GPCC, CRU and APHRODITE), and the ERA40 reanalysis data. The strongest signal emerging from these plots is a European precipitation dipole in which strong positive NAO phases tend to be associated with above-average precipitation over northern Europe in winter and below-average precipitation over southern and central Europe, whereas opposite patterns of precipitation anomalies are observed during strong negative NAO phases. Another area displaying statistically significant positive correlations is located at the border between northeastern Pakistan and northwestern India, corresponding to the HKK region, although differences in the spatial extent arise between the datasets. All datasets show a positive (negative)

precipitation anomaly during the positive (negative) NAO phase, but with differences both in the spatial extent and intensity of the anomaly. Compared to the observational data, the ERA-40 reanalyses show significant positive correlations over a broader area encompassing central and northern Afghanistan and Pakistan, and the greater Himalayan chain. The lower correlation signal in station-based datasets, compared to ERA40, may be associated with the underestimation of total precipitation in the observations (Palazzi et al., 2013) where winter snowfall is not ade- quately captured. However, we note that reanalysis precipitation outputs should be treated with care, as they are susceptible to model errors and inhomogeneities in the data used in the assimilation procedure.

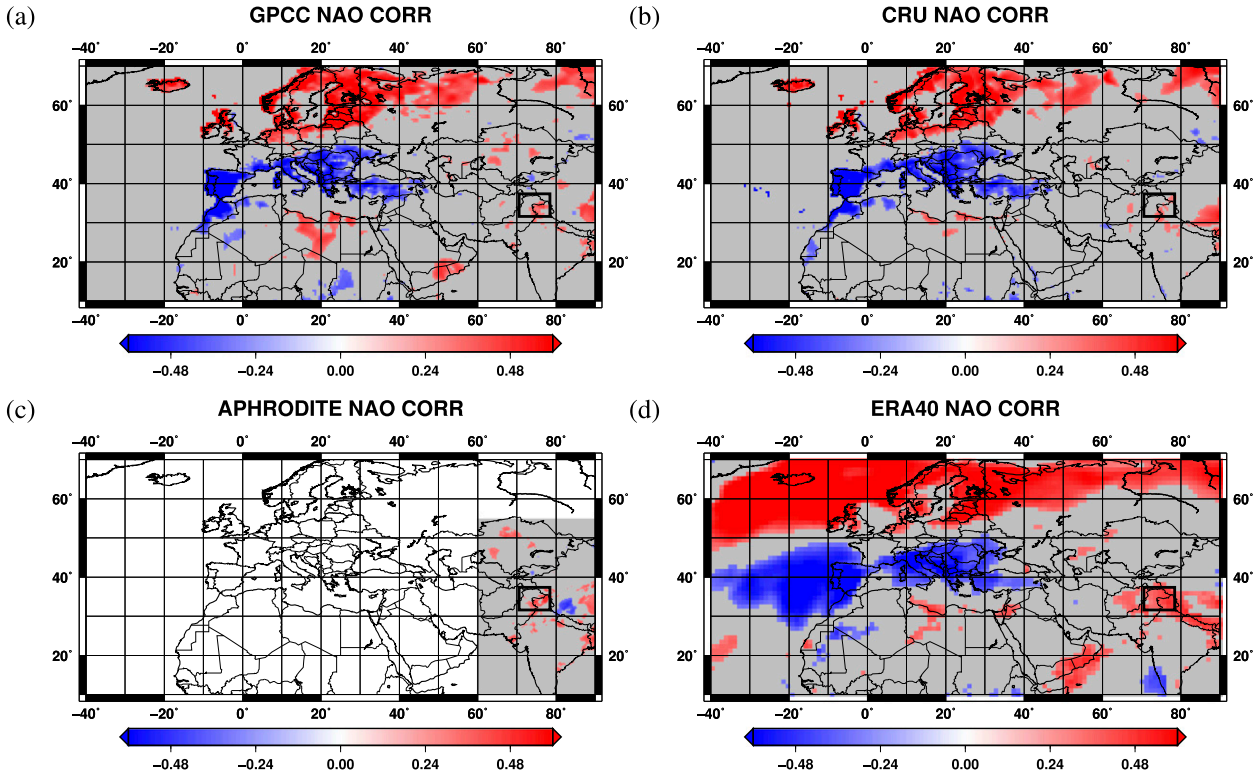

Fig. 1. Correlation coefficients between the NAO and winter precipitation from (a) GPCC, (b) CRU, (c) APHRODITE, and (d) ERA-40 during the period 1958–2002. Colors indicate statistically significant correlations at the 95% confidence level; nonsignificant correlations are marked in gray. The black rectangle highlights the HKK region (Filippi et al., 2014)

The main aim of the research peformed during the third year has been to identify and better understand the synoptic-scale mechanisms behind the relationship between the NAO and winter precipitation in the Karakoram. In particular we have addressed the secular variations that occurred in the NAO–precipitation signal and investigated whether the spatial shifts in the NAO variability (i.e., the spatial shifts of the NAO Centres of Action, COA) help us to understand the observed changes, using Twentieth Century Reanalysis (20CR) data (Compo et al. 2011) to reconstruct the atmospheric variability from 1871 to the present.

To this aim we have used an index already introduced by other authors called Angle Index (AI) to quantify the relative position of the COAs and provide a measure of the spatial displacement of the NAO pattern in the North Atlantic; the AI provides additional information that cannot be represented by a standard, fixed-in-space NAO index.

Figure 2 shows the time series of the angle index and of the correlation between the NAO and precipitation, and the two seem to evolve in antiphase: in the two periods with non-significant correlations (1920–1940 and 1980 onward) the AI shows the highest values (i.e., the NAO has a positive tilt). Conversely, the period with significant correlations (1940–1980) is characterized by lower values of the AI, which was strongly negative before the mid-1950s

(when GPCC shows its highest correlations) and approximately zero afterward. At the beginning of the twentieth century, when CRU and GPCC suggest a weakening of the NAO–precipitation relationship, the AI is moving from negative to positive values. There are sources of variability other than the NAO for precipitation in this area and these factors add noise to the record of sliding correlations, potentially worsening the synchronization with the time series of the AI. However, our results support the view that the position of the NAO COAs regulates the strength of the NAO–precipitation relationship in the HKK region. In particular, Fig. 2 suggests that, when the NAO has a positive tilt, the NAO–precipitation correlation is weaker, whereas suitable conditions for the NAO–precipitation correlation are found when the NAO shows a negative - or at least very small – tilt (Filippi et al., 2014).

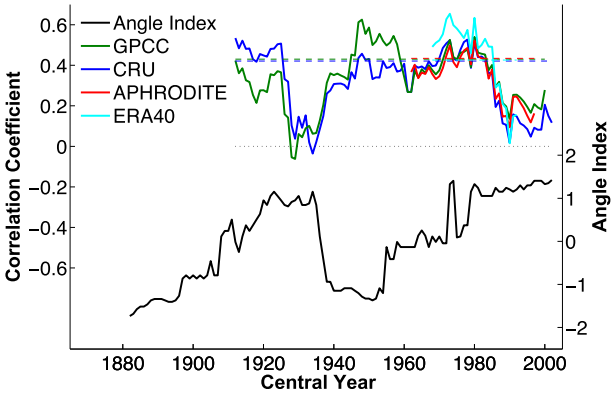

Fig. 2. Sliding correlations on 21-yr moving windows between the NAO and the time series of precipitation averaged in the HKK domain (718–788N, 328–378E) from GPCC (green), CRU (blue), APHRODITE (red), and ERA-40 (cyan). Dashed lines indicate the 95% significance level and the dotted line indicates zero correlation. The black line is the time series of the AI. Sliding correlations and the AI have different y axes on the left and right side respectively. Values are plotted at the 11th year of each 21-yr window (Filippi et al., 2014).

3.2 Applications; technological and computational aspects

During the third year, we did not produced new model simulations for the HKKH region with the EC-Earth Model. We used instead gridded datasets from the reanalysis products ERA40 and 20CR.

3.3 Formation

We are supervising the research program of a PhD student (Dr. Luca Filippi) working on the role of mid-latitude disturbances on winter precipitation in the Karakoram and the relationship between precipitation in the Karakoram and teleconnection patterns.

We are co-supervising the Master Thesis of Dr. Samreen Abdul Hakeem on water resources in the Karakoram river basins, in collaboration with Prof Adnan Tahir from Pakistan.

3.4 Dissemination

No dissemination activities in the reference period for this Pilot Study.

3.5 Participation in conferences, workshops, meetings

The results of the research activities performed during the third year were presented at the following scientific workshops, conferences and other meetings:

PALAZZI E., VON HARDENBERG J., TERZAGO S., PROVENZALE A.: The CMIP5 picture of current and future precipitation in the Karakoram-Himalaya (poster presentation). *EGU General Assembly Conference 2014*, Vienna, 27 April - 02 May 2014.

FILIPPI L., PALAZZI E., VON HARDENBERG J., PROVENZALE A.: NAO effect on winter precipitation in the Hindu-Kush Karakoram and its secular variations (Talk). *29th Himalaya-Karakoram-Tibet Workshop*, Lucca, Italy, September 2-4, 2014.

PALAZZI E., TAHIR A. A, CRISTOFANELLI P., VUILLERMOZ E., PROVENZALE A.: Climatic Characterization of Baltoro Glacier (Karakoram) and Northern Pakistan from in-situ Stations. *IAEG XII Congress Torino 2014 Engineering Geology for Society and Territory*, Torino, September 15-19, 2014.

PALAZZI E., TERZAGO S., FILIPPI L., VON HARDENBERG J., PROVENZALE A.: Precipitation, snow and atmospheric circulation in the Hindu-Kush Karakoram Himalaya: uncertainties and strengths in observations and global models. *HKH Workshop***,** Kathmandu, November 7, 2014.

4. Results obtained during the reference period

4.1 Specific results (Data libraries, Measurements, Numerical simulations, etc)

We did not perform specific new simualtions during the third year, but anlaysed the outputs of observational datsets and reanalysis data as described in section 3.1. We also calculated the NAO index using dofferent methodologies and verified their consistency.

4.2 Publications

FILIPPI L., PALAZZI E., VON HARDENBERG J., PROVENZALE A., (2014): Multidecadal variations in the relationship between the NAO and winter precipitation in the Hindu Kush-Karakoram. *Journal of climate*, 27 (20), 7890-7902. doi: 10.1175/JCLI-D-14-00286.1.

PALAZZI E., VON HARDENBERG J., TERZAGO S., PROVENZALE A., (2014): Precipitation in the Karakoram-Himalaya: a CMIP5 view. *Climate dynamics*, doi: 10.1007/s00382-014-2341-z.

4.3 Availability of data and model outputs (format, type of library, etc)
None in the reference period

4.4 Completed Deliverables
The contribution to the Deliverable D2.6.3 has been completed (D2.6.3a).

5. Comment on differences between expected activities/results/Deliverables and those which have been actually performed

We have not identified particular problems or significant deviations from the activities planned for the third year.

6. Expected activities for the following reference period

Next activities foreseen for this Pilot Study concern another topic which is strictly related to water resources in high-altitude areas: the Elevation Dependent Warming. There is growing evidence, in fact, that the rate of warming is amplified with elevation, such that high-mountain environments experience more rapid changes in temperature than environments at lower elevations. Elevation-dependent warming (EDW) can accelerate the rate of change in mountain ecosystems, cryospheric systems, hydrological regimes and biodiversity. We will analyse the Elevation Dependent Warming in the Karakoram-Himalaya and Tibetan plateau

region using an ensemble of CMIP5 models and possibly in higher resolution regional climate models.

2.6c: Changes in snow cover and hydrological cycle in mountain areas

Coordinator: Silvia Terzago
CNR-ISAC

1. Scheduled activities, expected results and Milestones

The activity scheduled for the reference period consists in the evaluation of two land-surface models for the simulation of the snowpack characteristics in terms of snow water equivalent, snow depth and density. The objective is to verify which model performs better in relation to the spatial/temporal characteristics of the meteorological forcing.

2. Deliverables expected for the reference period

Deliverable D2.6.3c with the results of the analyses.

3. Activities which have been actually conducted during the reference period

3.1 Research activities

The long-term objective of this Pilot Study is to provide information on the recent and future expected changes in snow resources and in the hydrological cycle in high altitude areas, with a focus on the Alps and Apennines.
The evaluation of the temporal and spatial changes of snow pack requires a highly resolved representation of the atmospheric and surface dynamics in mountain regions, which at present can't be achieved with Global and Regional Climate Models (GCM, RCM). Recent studies suggest to use the atmospheric variables produced by global or regional climate models appropriately downscaled to drive land surface models able to simulate the temporal variability of snowpack characteristics at very local scale (e.g. Schmucki et al., 2014; Steger et al., 2013).
We investigated this approach, considering two land surface models: the European Centre for Medium-Range Weather Forecasts (ECMWF) Hydrology-Tiled ECMWF Scheme for Surface Exchange over Land (HTESSEL) and the University of TOrino land Process Interaction in Atmosphere (UTOPIA).
The first aim is the validation of the two models, to determine how reliable they are in representing the temporal evolution of the snow pack, in terms of snow water equivalent, snow depth and snow density, in optimal condition, i.e. when they are forced with high-quality and high frequency measurements. Secondly, as our focus is on reproducing snow variability on regional scale, both over the historical period and in future scenarios, we explore the possibility of driving the land-surface models with climate models simulations, properly downscaled. To this objective, we investigated how the accuracy of the models drops when they are forced with low temporal resolution measurements and model data (reanalysis) with spatial resolution comparable to that of global/regional climate models.
All simulations are performed over the area of Torgnon weather station. This station, in fact, provides high quality measurements of both meteorological variables to force the models and snow variables (snow water equivalent, snow depth and snow density) to validate the models output.

3.2 Applications; technological and computational aspects

- Two land-surface models, UTOPIA from the University of Torino and HTESSEL from ECMWF, have been made available at ISAC-CNR to perform simulations of snowpack charteristics.

- Two meteorological datasets have been collected and adapted to satisfy the models requirements on the input data. The datasets are:

  - Meteorological measurements of the high elevation station of Torgnon (45°N, 34°W, 2160 m a.s.l, Aosta Valley, Western Italian Alps), including all the input variables needed to force the models available at high frequency and with a high level of accuracy. Period June 1st 2012 - July 31st 2014.
  - ERA-Interim reanalysis, a global gridded data product providing 3-hourly surface parameters at 0.75° resolution, extracted in the grid-point nearest to Torgnon weather station.

3.3 Formation

Participation in the summer school: "Dynamics, stochastics and predictability of the climate system", held in Valsavarenche, Valle d'Aosta, June 9-18, 2014 (50 hours of lectures).

3.4 Dissemination
None in the reference period.

3.5 Participation in conferences, workshops, meetings

The results of the pilot study have been presented at the following conferences and workshops:

TERZAGO S., PALAZZI E., VON HARDENBERG J., PROVENZALE A.: Perspectives on snow in the Third Pole and the Alps" (presentazione orale). *Arctic Science Committee workshop. Arctic snow cover changes and their consequences*, Copenhagen, October 16-17, 2014.

TERZAGO S., PALAZZI E., VON HARDENBERG J., PROVENZALE A.: Precipitation and snow resources in the Hindu-Kush Karakoram Himalaya mountains: current picture and expected changes (presentazione orale). *29th Himalaya, Karakoram and Tibet Workshop*, Lucca, September 2-4, 2014**.**

TERZAGO S., VON HARDENBERG J., PALAZZI E., PROVENZALE A.: Current status and future projections of the snow depth in the Third Pole from CMIP5 Global Climate Models (poster presentation). *IAEG XII Congress Torino 2014 Engineering Geology for Society and Territory*, Torino, September 15-19 2014.

TERZAGO S., VON HARDENBERG J., PALAZZI E. & PROVENZALE, A.: Present conditions and future projections of the Alpine snow cover (poster presentation). *87° Congresso della Società Geologica Italiana e 90° Congresso della Società Italiana di Mineralogia e Petrologia*, Milano, September, 10-12 2014.

TERZAGO S., VON HARDENBERG J., PALAZZI E., CASSARDO C., BALSAMO G. and PROVENZALE A.: Sensitivity of snow models to the spatial and temporal resolution of meteorological forcing (poster presentation). *European Geosciences Union General Assembly 2014*, Vienna, Austria, April 27 – May 02, 2014.

4. Results obtained during the reference period

4.1 Specific results (Data libraries, Measurements, Numerical simulations, etc)

The following simulations have been performed to test the models sensitivity to changes in the spatial and temporal resolution of input data. They refer to the period June 1st 2012 - July 31st 2014:

- OBS: The first control runs are performed to validate UTOPIA and HTESSEL models, thus using "optimal" high quality meteorological forcing measured at the Torgnon weather station, at high (30 minutes) temporal resolution.
- OBS3, OBS6, OBS12: These experiments are performed using the meteorological measurements at intervals of 3, 6 or 12 hours. The data were interpolated to the time step of the land surface models, using linear interpolation for all variables except for precipitation, for which a constant precipitation rate is assumed over the 3, 6 or 12 hours time interval.
- ERA: The third experiment is performed forcing the models with the ERA-Interim reanalysis extracted on the grid-point nearest to Torgnon weather station interpolated in time to the land surface models integration time step of 30 minutes.
- ERA-LR, ERA-BIAS: These experiments are similar to the previous one but we corrected the ERA-Interim temperature using the local elevation at the site and the adiabatic lapse rate. ERA-Interim grid-point nearest to the Torgnon weather station is 1480 m a.s.l., that is, 680 m lower than the true station altitude. In experiment ERA-LR we corrected the temperature data for the elevation, assuming a fixed moist lapse rate of 6.5°C/km. In experiment ERA-BIAS, we corrected the temperatures using the difference in the climatological averages between the temperatures reported by ERA and those measured at the Torgnon station. This bias was subtracted from the ERA-Interim temperature and was assumed to be constant in time.

All outputs, together with the R codes to elaborate the results, are available on request.

4.2 Publications

TERZAGO, S., VON HARDENBERG, J., PALAZZI, E., & PROVENZALE, A., (2014): Snowpack Changes in the Hindu Kush–Karakoram–Himalaya from CMIP5 Global Climate Models. *Journal of Hydrometeorology*, 15(6), 2293-2313.

In preparation:

TERZAGO S., VON HARDENBERG J., CASSARDO C., BALSAMO G., MORRA DI CELLA U. and PROVENZALE A.: Sensitivity of snow models to the spatial and temporal resolution of meteorological forcing.

TERZAGO S., VON HARDENBERG J., PALAZZI E. AND PROVENZALE A.: Uncertainty in the representation of snowpack over the Alps in CMIP5 global climate models.

4.3 Availability of data and model outputs (format, type of library, etc)

Full availability of the model simulations (ascii or netcdf format), on request.

4.4 Completed Deliverables

Deliverable D2.6.3c.

5. Comment on differences between expected activities/results/Deliverables and those which have been actually performed

No deviations from the scheduled activity.

6. Expected activities for the following reference period

Analysis of the changes of the temporal and spatial variability of snow depth over the Alps, with observational data, reanalyses and CMIP5 model simulations. The analysis will include the projected changes in snow distribution for the 21st century in several climate change scenarios.

2.6d: Effects of aerosols in high-altitude regions

Coordinator: Jost von Hardenberg
CNR-ISAC

1. Scheduled activities, expected results and Milestones

The third and last year of this Pilot Study has been devoted to review previous acitvities and results related to this Pilot Study in order to create an overall picture of the effect of aerosols in the high altitude regions of the Hindu-Kush Karakoram and Himalaya (HKKH). To this aim we considered satellite observations (from MODIS), reanalysis data (from MACC) and model data (regional and global climate model simulations). The employed regional climate model (RCM) is the ICTP RegCM4 model run with and without the aerosol interactive component. In addition, we analysed the outputs of an ensemble of CMIP5 global climate model (GCM) simulations. Our analyses have been mainly conducted on a seasonal time scale and distinguishing between western and eastern stretches of the HKKH region.

2. Deliverables expected for the reference period

Contribution to the Deliverable D2.6.3 with the results of this Pilot Study (D2.6.3d).

3. Activities which have been actually conducted during the reference period

3.1 Research activities

In the framework of this Pilot Study, the aerosol optical depth (AOD) reproduced in the HKKH region by a regional climate model (the RegCM4 model run by ICTP) has been compared with satellite observations (MODIS-Terra) and with an aerosol reanalysis product provided by the MACC project (Monitoring Atmospheric Composition and Climate). The model was run for a regional domain including the Indian subcontinent defined for the CORDEX Project. Two present-day simulations (2000-2009) are available with boundary conditions provided by ERA-Interim reanalyses and by the global model EC-Earth run created for CMIP5 by CNR-ISAC. A future scenario timeslice in the period 2040-2050 has been created using EC-Earth boundary conditions for the RCP 4.5 emission scenario.
The ability of the model in reproducing AOD distributions and their seasonality has been assessed by comparing climatological averages over the HKKH region with the MODIS and MACC spatial climatological distributions, considering the years 2003-2009, common to all datasets. We used the ERA-Interim boundary conditions for running RegCM in these simulations. The analysis has confirmed that in winter RegCM is capable of reproducing to a large extent the amplitude and the spatial distribution of the optical depth of aerosols in this area, with a good reproduction of a low over the Tibetan plateau and of a higher AOD at the southern feet of the Himalayas, mainly associated with anthropic pollution. In summer we found a good reproduction of a severe maximum of AOD centered over the border between Pakistan and India, even if with an offset in the position of the maximum which is located farther east.
Experimentation with a dynamical dust scheme used in the model has allowed to assess the role of an accurate representation of dust emissions from the local desert areas (mainly the Thar desert) in order to represent correctly this maximum during the monsoon season.
In addition to the analysis of the regional climate model simulations, we have analysed the output of the historical (1870-2005) and scenario (2600-2100) simulations of thirty-two CMIP5 global climate models (GCMs) participating in the CMIP5 effort, in order to understand what model features, particulalrly those related to the aerosol properties, may affect the

representation of seasonal precipitation in the HKKH region. The models have different spatial (horizontal) resolution, number of vertical levels in the atmosphere, and representation of the aerosol effects. It is worth underlying that some of these climate models share a common lineage and are not really independent of each other, either because they share a common dynamical core (in particular the same atmospheric model) or they are developed in the same centre.

A great source of uncertainty in the model representation of precipitation in the mountain areas is given by the coarse model resolution. However, especially in the monsoon-dominated regions, precipitation is also influenced by aerosol particles that act in both direct and indirect ways as climate drivers.

The mean annual cycle of precipitation, averaged over the years 1901-2005 (2006-2100) for the historical (future) climate, is shown in Figure 1 for the Himalaya (a) and HKK (b) regions. Each grey line indicates the output of a single model member, the multi-model mean (MMM) is shown with the black solid line, while CRU and GPCC observations are shown with the pink and green lines, respectively. With respect to CRU, the CMIP5 MMM indicates an overestimation of the simulated precipitation all over the year in both the HKK and Himalayan regions, a positive bias which is commonly found in the precipitation simulated by the state-of-the-art GCMs over high-elevated terrains. The same model bias is found with respect to GPCC data, except for July and August precipitation in the HKK region. In both regions, the model spread relative to the multi-model mean is large, indicating that the models do not converge in their representation of the historical precipitation annual cycle. Despite this, all models reproduce one-modal precipitation annual cycles in the Himalayan region, even if the various distributions are differently wide and have different amplitudes, while the model disagreement is much more serious in the HKK region, where annual cycles with very different characteristics are simulated (Palazzi et al., 2014).

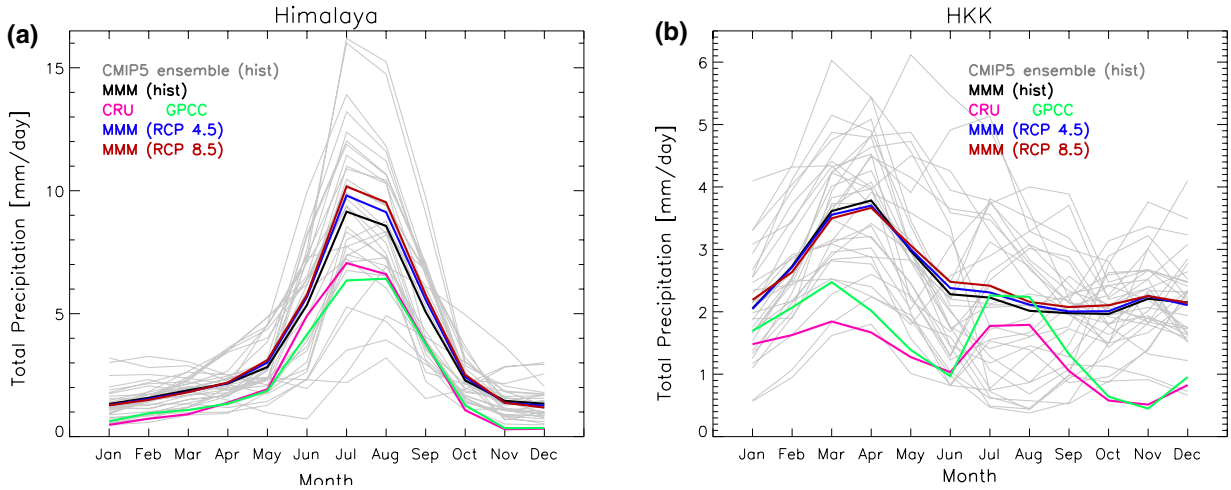

Fig. 1. Mean annual cycle of precipitation in the Himalaya (a) and HKK (b), obtained as a multi-annual average over the years 1901– 2005 (historical period) for each CMIP5 model (grey lines) and for their multi-model mean (MMM, black line). The solid blue and red lines represent the mean annual cycle of precipitation over the years 2006–2100 in the RCP 4.5 and the RCP 8.5 future scenarios, respectively, for the CMIP5 MMM.

A hierarchical clustering analysis, using a standard Euclidean distance as a distance metric, has been applied to group the various models based on their output in terms of precipitation annual cycle in the HKK and Himalaya region, so assuming no a priori knowledge about the features of any model. Using the simplest rule of thumb to set the number of clusters, the procedure allowed to determine four model clusters in both regions and to identify the better performing models in the the HKK and Himalaya domains (not shown gere, see Palazzi et al., 2014).

An important outcome of the performed cluster analysis is that no feature of the better-performing models in the Himalaya or in the HKK region has clearly emerged as one playing a pivotal role for providing the best results in terms of precipitation annual cycle in the two regions. To better explore this issue, a further imposed "a priori" clustering was applied, based on the known characteristics of the models. Figure 2 shows, for the Himalaya and for the HKK sub-region, the precipitation annual cycles simulated by the models (grey area) and by their MMM (black line), grouped using the following criteria: models that do not/do include the indirect effects of sulfate aerosols (panels a/b); models that do not/do include fully-interactive aerosols (c/d); models with low/high horizontal resolution along longitudes (e/f; the models with a resolution coarser than 1.40625° longitude have been considered low-reso- lution models); models with low/high vertical resolution (g/h; the models with less then 47 vertical levels have been classified as low vertical resolution models). The division of models into high/low vertical and horizontal resolutions was made arbitrarily.

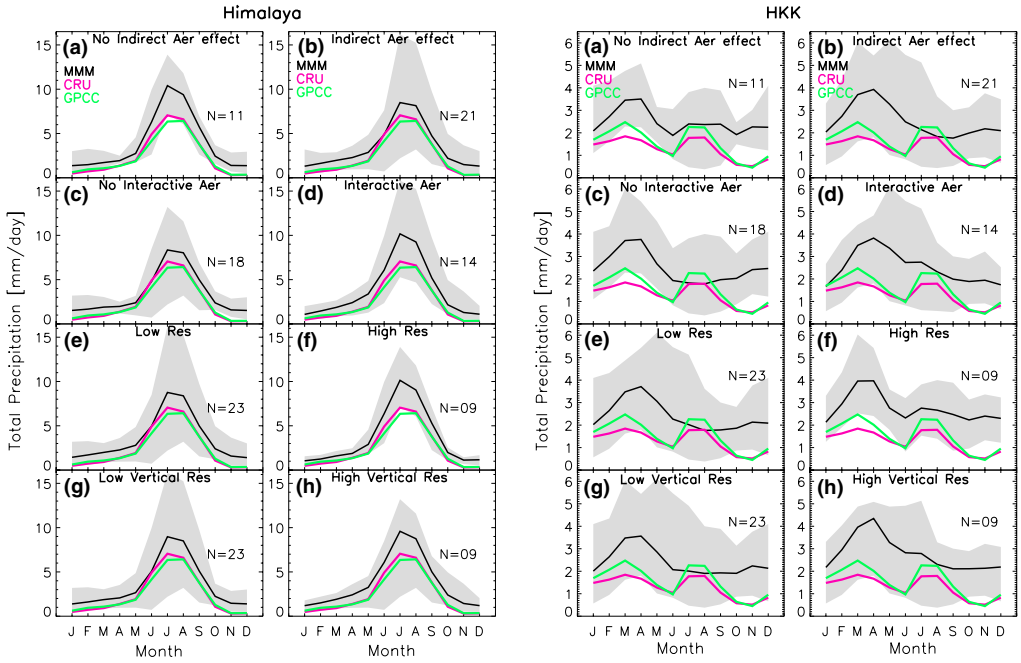

Fig. 2. Mean annual cycle of precipitation in the Himalaya (left panels) and in the HKK (right panels) simulated by all models which do not (a)/do (b) include the indirect effect of sulfate aerosols; have not (c)/have (d) fully-interactive aerosols; have low (e)/high (f) horizontal resolution; have low (g)/high (h) vertical resolution. The grey shaded areas indicate the variability range of the models; the MMM is shown with the black line while CRU and GPCC observations with pink and green lines, respectively. The number of models within each cluster is indicated in the plots.

Just focusing on aerosols, this further analysis shows that, in the Himalaya region, the models including the indirect effects of sulfate aerosols reproduce a precipitation annual cycle, which is closer to the observations than the models incorporating the direct effect of sulfate aerosol only. The same is found for the models with prescribed aerosols with respect to those incorporating a fully-interactive aerosol. In the HKK sub-region, the best performing models are those which do not include the indirect effect of sulfate aerosols.

3.2 Applications; technological and computational aspects

3.3 Formation

None in the reference period.

3.4 Dissemination
None in the reference period.

3.5 Participation in conferences, workshops, meetings

None in the reference period. See also the pilot study 2.6.3a (section 3.5)

4. Results obtained during the reference period

4.1 Specific results (Data libraries, Measurements, Numerical simulations, etc)

We did not peform new regional simulations with the RegCM4 model. Instead, we analysed the output of the CMIP5 models to understand what aerosol-related features affect the representation of precipitation in these models.

4.2 Publications

None in the reference period.

4.3 Availability of data and model outputs (format, type of library, etc)

4.4 Completed Deliverables

Contribution to the Deliverable D2.6.3 with the results of the Pilot Study during the third year (D2.6.3d).

5. Comment on differences between expected activities/results/Deliverables and those which have been actually performed

No deviations from the scheduled activity.

6. Expected activities for the following reference period

Third year was the last year of activity for this Pilot Study.

2.6e: Multi-secular historical climate simulation for the Mediterranean area and comparison with paleoclimatic proxy data, to obtain a climatological history of Italy in the last one thousand years

Coordinator: Elisa Palazzi
CNR-ISAC

1. Scheduled activities, expected results and Milestones

This report describes the second year of activities of the Pilot Study dedicated to the paleoclimate simulations and comparisons with proxy data, to obtain a climatological history of Italy in the last one thousand/two thousands years. The activities of this Pilot Study have been focused, on the one hand, on the identification and retrieval of observational datasets that will be used to validate and calibrate paleoclimate data. On the other hand, we have performed modeling studies using an Earth System Model of Intermediate Complexity called PlaSim. The model has been used to test changes in the earth climate due to changes in orbital parameters (eccentricity and tilt) and the input of energy from the sun.

2. Deliverables expected for the reference period

Contribution to the Deliverable D2.6.3 with the results of this Pilot Study (D2.6.3e).

3. Activities which have been actually conducted during the reference period

The two main activities carried out during this pilot study have been focused on 1) performing climate simualtions with an Earth System Model of Intermediate Complexity, and 2) collecting and analysing the available climate datasets, mainly precipitation and temperature data, useful for paloeoclimate data calibration and validation and supporting the activities of WP1.4 and WP1.6.
Climate simulations have been performed with the PlaSim (Planet Simulator) model that has been run testing different options and configurations. In particular, during the reference period of the model, we made experiment with the PlaSIm model in order to perform paleoclimate simulations. We refer to the Deliverable D2.6.3e for a detailed description of the activities that are only resumed here below.

3.1 Research activities

a) Paleoclimate simulations with the Intermediate Complexity model PlaSim
The Planet Simulator (PlaSim) is an Earth System Model of Intermediate Complexity (EMIC) that was developed at the Meteorological Institute of the University of Hamburg and can be used to run climate and paleoclimate simulations for time scales up to 10 thousand years, due to its medium complexity and associated less intensive computing requirements.
Compared to other state-of-the-art EMICs (Claussen, 2002), PlaSim has a more complex atmospheric model (the Portable University Model of the Atmosphere, PUMA) based on the moist primitive equations conserving momentum, mass, energy and moisture and including, as in the most comprehensive general circulation models (GCMs), all atmospheric processes, but with the limitation of less sophisticated parameterizations (Fraedrich et al., 2005).
The atmospheric model in PlaSim can be coupled to different ocean models besides using climatological sea surface temperatures (SST). These ocean models can be a mixed-layer ocean or the large-scale geostrophic ocean (LSG, Maier-Reimer et al., 1993). Besides the atmospheric and oceanic parts, a land surface model with biosphere and a module

representing sea ice can also be included. A complete description of how the coupling between the various components is realized can be found in the PlaSim User Guide (http://www.mi.uni- hamburg.de/fileadmin/files/forschung/theomet/planet_simulator/downloads/PS_UsersGuid e.pdf).

In the first experiments performed with PlaSim, the atmospheric component, PUMA, has been coupled with the dynamical ocean (LSG) and ice modules. We have performed pluri-secular simulations by changing the solar constant using fractions of the actual value. We have analysed the PlaSim outputs in terms of surface temperature, precipitation, ocean temperature, snow/ice cover and albedo.

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3.2 Applications; technological and computational aspects

The intermediate complexity model PlaSim was installed and run at ISAC-TO and the generated outputs made available on dedicated archives for further post-processing.

3.3 Formation

Supervision of a Master thesis entitled “Sensitivity of an Earth System Model of Intermediate Complexity to Climate Forcing Parameters”, University of Turin.

3.4 Dissemination

None in the reference period.

3.5 Participation in conferences, workshops, meetings

Conference *Climate variability in Italy during the last two millennia – Italy2k*, Rome, December, 1-2, 2014.

4. Results obtained during the reference period

4.1 Specific results (Data libraries, Measurements, Numerical simulations, etc)

Numerical simulations with the Earth System Model of Intermediate Complexity, PlaSim, run at different spatial resolution and different Ocean and ice module configurations. Perpetual

simulations have been performed varying the solar constant value to explor the equilibrium states of the system.

4.2 Publications
None in the reference period.

4.3 Availability of data and model outputs (format, type of library, etc)
Outputs of the PlaSim simulations in NetCDF format.

4.4 Completed Deliverables
Our contribution to the Deliverable D2.6.2 has been completed (D2.6.3e).

5. Comment on differences between expected activities/results/Deliverables and those which have been actually performed.

We have not identified particular problems for the execution of the activities described in the Executive Plan for this Pilot Study

6. Expected activities for the following reference period

PlaSim will be used in the following period to perform paleoclimate simulations representing the modelling support to the Italy-2k Grand Challenge of NextData.

2.6f: Estimate of snow resources and their changes on the Alps (NextSnow)

Coordinator: Vincenzo Levizzani
CNR-ISAC

Report with essential contribution of:

S. Laviola, E. Cattani, S. Terzago (CNR-ISAC)
U. Morra Di Cella, E. Cremonese (ARPA-VdA)
R. Rudari, S. Gabellani (CIMA Foundation)
P. Claps, F. Laio, P. Allamano, A. Libertino (Politecnico di Torino – DIATI)
S. Ferraris, D. Canone, M. Previati (Politecnico e Università di Torino – DIST)
C. Cassardo, S. Ferrarese (Università di Torino – Dipartimento di Fisica)
S. Fratianni, F. Acquaotta, D. Garzena, L. Perotti (Università di Torino – Dipartimento di Scienze della Terra)

1. Scheduled activities, expected results and Milestones

1.1 UR1-CNR-ISAC. Development of the satellite-based algorithm for the estimation of snow cover and snowfall using cross-track passive microwave sensors on board NOAA and EUMETSAT satellites. Milestone: 31 December 2014.
Dataset of snowfall and snow cover. Milestone: continuous production, 31/12/2014.

1.2 UR2–ARPA-VdA. Production of a) regional database of station measurements of snow depth (HS), b) regional maps of Snow Water Equivalent (SWE, Nov-May, from 2007), and c) satellite maps of MODIS MOD10A2 product reprojected on the Valle d'Aosta (since 2000). Milestone: 01 January 2014.

1.3 UR3–CIMA Foundation. Satellite data of snow cover and SWE. MODIS products of Snow Cover Area (SCA) with georeferencing over the entire Alpine area from 2009 and over Valle d'Aosta from 2000:

- MOD10A2 produced by UR2;
- MODIS SCA produced over Italy (2009-present) with the algorithm Decision Tree Classifier–Optimum Threshold (DTC-OT).

H-SAF Snow product SN-OBS1 over the region of interest from 2009.
Milestone: 31 December 2014.

1.4 UR4-Politecnico di Torino–DIATI. Processing and validation of manual measurements of snow depth and density of fresh snow. Mathematical modeling of the relationship between SWE of fresh snow and ancillary variables (with uncertainties). First reconstruction of SWE from automatic station and setup of the database of historical measurements of fresh snow SWE for the Western Alps.
Milestone: 31 December 2014.

1.5 UR5–Politecnico and Università di Torino–DIST – Continuous production of ground data in the measurement areas over the entire duration of the Project:

- SWE and soil moisture along the 12 km transect centered over Aosta: 31 December 2014.
- Flux monitoring at the eddy covariance site of Cogne Gimillan (2011-2012). Milestone: 31 December 2014.
- Verification of SCA at basin scale from 2007 till the end of the Project. Milestone:

31 December 2014 for the data collected before the start of the Project.

1.6 UR6–Università di Torino–Department of Phisics – Setup of the database of input products for the UTOPIA model runs.
Input dataset for the physical snow cover simulation model. Milestone: 31 December 2014.

1.7 UR7–Università di Torino–Department of Earth Sciences – Collection and analysis of long term (1961-2010) homogeneous snow data from manual and automatic stations. Collection of meteorological datasets from high altitude manual and automatic stations of the ARPA Piemonte monitoring network. Snow cover measurements also from satellite data. Milestone: several during the Project.

2. Deliverables expected for the reference period

UR1. Quasi real time production of a satellite-based snow cover and snowfall dataset to be used by the other URs.

UR2. Various SWE and HS datasets over Valle d'Aosta.

UR3. Satellite-based datasets of snow cover and SWE.

UR4. Reconstruction of SWE for automatic stations and construction of the database of historic measurements of fresh snow SWE over the Western Alps.

UR5. SWE and soil moisture dataset along the 12 km transect centered over Aosta; dataset of fluxes at the eddy covariance site of Cogne Gimillan (2011-2012); verification of the snow cover at basin scale from 2007 to the inception of the Project.

UR6. Input database for the snow mantle physical model UTOPIA.

UR7. Collection of long term snow data over the Piedmont region.

3. Activities which have been actually conducted during the reference period

3.1 Research activity

The research activities belong to the various aspects of the demonstration project: dataset production, improvement of retrieval algorithms and tuning of numerical models.

UR1 has concentrated on the improvement of the Water vapour Strong Lines at 183 GHz (183-WSL) satellite retrieval algorithm for the estimation of snowfall and snow cover. The work has focused on the calibration of sensitivity thresholds of the actual version of the algorithm over snow covered terrain in conditions of complex orography. To this aim, the 183-WSLSF module, specifically developed for the snowfall retrieval, was applied to several snowstorm cases over the US using as ground truth the US national radar network NMQ, whose data include a flag for the identification of snowfall. As a further reference parameter, the NOAA snowfall retrieval algorithm was used, which is validated over the US. The second phase of the study, still in progress, concerns the validation of the performance of the 183-WSLSF over the European continent using the NIMROD ground radar network data. In this latter case no snowfall flag is available and thus several intense snowfall events were selected from Northern Europe to the Central Mediterranean basin. The final results of this study and the successive recalibrations of the sensitivity thresholds of the algorithm will allow for the application of the 183-WSLSF over the Alpine region targeted by the Project using the databases made available by UR3 and UR4.
UR1 has coordinated the intercomparison experiment of snow models; in particular, several datasets were prepared and made available for UR2, UR3 and UR6 containing the atmospheric

forcing variables for the models and the results of the first simulations were collected and analyzed.

UR2 has made available the datasets (with metadata) as described in 1.2. In particular, the following datasets were published in a project-accessible area of the NextData data repository: 1) snow depth, mean weighted density and SWE over Valle d'Aosta (5057 records, 2005-2013), 2) meteorological data and data from the eddy covariance station used to drive and validate the experiment of comparison with the models of snow accumulation and melting, 3) the "SWE gold" dataset containing the estimates of the distributed value of SWE over the region over the November-May 2002-2013 period.
On the basis of the released datasets a few analyses were conducted whose scope is to evaluate i) the spatio-temporal variability of the snow mantle and its relationship with SWE and snow depth at the ground, and ii) the climatology of SWE at regional scale over the 2002-2013 decade.
During 2014 UR2 has started the validation activity of the MODIS Maximum Snow Extent data (MOD10A2) product using station measurements of HS.
Moreover, the analysis of the effects of the progressive degradation of input data on the performance of a selection of empirical and physically-based models has started; more specifically, ARPA VdA is responsible for the simulations with the Amundsen and GEOtop models. The activity, planned for 2015, will allow for completing the comparison and draw conclusions on the behaviour of the main models that are operationally run over the areas of interest of the Project.
The coordination and advancement of the Project, guaranteed by the Project Coordinator, were examined during the meeting (organized by UR2) in Saint-Christophe (AO) on 21 February 2014.

UR3 has produced the simulations of the evolution of the snow mantle using the S3M and ACHABSnow models over the Torgnon station using different configurations. Such configurations (decided with UR2 and UR6 and named experiment 0, 0.5, 1, 1.5, 2 and 2.5) aim at evaluating the influence of the description of the processes, in the parameterizations and of the spatial and temporal resolution of the inputs on the performance of the models used in the Project.
UR3 has used the manual measurements of snow depth, density and SWE from the UR2 "SWE Gold" dataset for the evaluation of the S3M model evidencing the skill of the model in effectively reproducing the snow mantle depth and its tendency to overestimate the observed snow density. Moreover, the S3M simulations were compared over the entire Valle d'Aosta region with the 15-day estimates of SWE made available by UR2 with the flow rate at the outlet of the Dora Baltea basin at Tavagnasco; such an analysis points out an overall good skill of the model in reproducing the available water quantity at the end of the accumulation season.

UR4 has started the definition of the relationships for the reconstruction of fresh snow SWE starting from the meteorological conditions as measured during the snowfall. Their application to measurement points where the nivometric and thermometric data are available is in progress. The lack of funding for 2014 has inevitably induced a slow down in the production of the databases as well as in the definition of the analysis procedure.

UR5 has improved the high altitude site of Cogne (AO) where the measurements are still ongoing during the 2014-2015 winter season. A four-component radiometer was added starting August 2014 and calibration of the net radiometer already in operation was conducted both in presence or absence of snow. A Doppler sensor of snow depth and a series of sensors at the terrain/snow mantle interface were installed. UR5 is continuing the measurements with TDR (time domain reflectometry, soil moisture and snow density), TIR (thermal infrared, soil and snow temperature) and eddy covariance (sensible heat and vapor

fluxes). For this latter instrument the exact direction of the katabatic winds was determined so as to optimize the sonic anemometer measurements.

UR6 has devised the procedures for the extraction of a special dataset from the Global Land Data Assimilation System (GLDAS) database in order to acquire the necessary inputs for the UTOPIA model (and for the other similar physical models, such as H-Tessel) that will be used for the runs on the Project target areas in Valle d'Aosta. In particular, for the time being, the data for the Torgnon station were extracted and made available to the community. Since the GLDAS database contains also the outputs of the NOAH model, these latter were extracted as well. The data extraction procedure from the database will allow for verifying the discrepancies of the dataset with respect to the station data and comparing the model outputs with another physical model largely used in the literature. At the same time, the verification of the parameterizations of the snow mantle with UTOPIA was continued leading to the update of a few parameterizations. However, the verification at this stage is not finished and thus a complete and improved version of the UTOPIA model is not available yet.

UR7 has worked on the collection and climatological analysis of snow data from the long term manual and automatic stations (1961-2010) over Piemonte and Valle d'Aosta. In particular, the main activity was focused on quality control and homogeneization of data so as to obtain reliable series to correctly compute trends, climatic indexes and extreme events.

3.2 Applications, technological and computational aspects

UR1 has made available on a page dedicated to the NextSnow Project on the NextData portal the archives of snow depth, density and SWE (observations and spatial maps) over Valle d'Aosta and the dataset of the Torgnon measurements, used to force and validate the experiment of intercomparison of snow models. Such datasets at the moment are accessible only to the project participants, but in the future the access will be completely free to the public.

UR2 has completed the implementation of the model for the "regional and local estimation of HS and SWE" now operational in its final and stable version with the 4 simulation chains that are activated automatically as a result of the relative availability of near real time density data.

3.3 Formation
Nothing to report.

3.4 Dissemination

The NextSnow Project was inserted into the Regional Hydroclimatology Project (RHP) MOUNTerrain (GEWEX Mountainous Terrain Rainfall project) of the Global Energy and Water Exchanges (GEWEX) project. The project will include various experiments studying the water cycle in mountainous regions: Himalaya, New Zealand, Colombian Andes, etc.

NextSnow will represent a Pilot Project in this context bringing forward the scientific issues typical of the European Alpine environment.

3.5 Participation in conferences, workshops, meetings

AIC (Association Internationale de Climatologie), Dijon, 1-4 July 2014.

IAEG (Enginering Geology for Society and Territory), Torino, 15-19 September, 2014

TERZAGO S., VON HARDENBERG J., PALAZZI E., CASSARDO C., BALSAMO G., and PROVENZALE A.: Sensitivity of snow models to the spatial and temporal resolution of meteorological forcing (poster

presentation). *European Geosciences Union General Assembly 2014*, Vienna-Austria, 27 April–02 May 2014.

4. Results obtained during the reference period

4.1 Specific results (Data libraries, Measurements, Numerical simulations, etc)

UR3 has delivered the results of the S3M and ACHABSnow models over the Torgnon site.

UR6 has produced the GLDAS input dataset for the UTOPIA and H-Tessel models and the output of the NOAh model over the same input data for the snow and soil variables.

UR7 has extended the collection of snow and meteorological data to the Valle d'Aosta region. The quality control and the homogeneization over the climatic series were conducted.

4.2 Publications

ACQUAOTTA F., FRATIANNI S., GARZENA D., (2014): Temperature changes in the North-Western Italian Alps from 1961 to 2010. *Theoretical And Applied Climatology*. DOI:10.1007/s00704-014-1316-7.

ACQUAOTTA F., COLOMBO N., FRATIANNI S., ROMEO V., BARBERO S., (2014): Preliminary Results of a Comparison Study Between Two Independent Snow Networks in North-Western Italian Alps (Piemonte Region). *Engineering Geology for Society and Territory*, 1. DOI 10.1007/978-3-319-09300-0, pp. 113- 116.

BROCCA L., TARPANELLI A., MORAMARCO T., MELONE F., RATTO S.M., CAUDURO M., FERRARIS S., BERNI N., PONZIANI F., WAGNER W., MELZER T., (2013): Soil Moisture Estimation in Alpine Catchments through Modeling and Satellite *Observations Vadose Zone Journal*, vol. 8-2, 1-10. DOI:10.2136/vzj2012.0102.

FRATIANNI S., TERZAGO S., ACQUAOTTA F., FALETTO M., GARZENA D., PROLA M.C., BARBERO S., (2014): How Snow and Its Physical Properties Change in a Changing Climate Alpine Context? *Engineering Geology for Society and Territor*,. 1,. 57- 60. DOI 10.1007/978-3-319-09300-0.

FRATIANNI S., ACQUAOTTA F., GARZEAN D., (2014): Analyse de températures dans les Alpes occidentales italiennes: interactions entre les variablesclimatiques à l'échelle locale et globale pour l'évaluation du changement climatique. In: *Climat: Systéme & Interactions*, Camberlin P., Richard Y., ISBN: 978-2-907696-20-3, Dijon, pp. 144-150.

GARZENA D., FRATIANNI S., ACQUAOTTA F., (2014): Temperature Analysis on the North-Western Italian Alps Through the Use of Satellite Images and Ground-Based Meteorological Stations. *Engineering Geology for Society and Territory,* 1, 77- 80. DOI 10.1007/978-3-319-09300-0.

GIACCONE E., COLOMBO N., FRATIANNI S., BUFFA G., PARO L., (2014): Les impacts du changement climatique sur géosphére, cryosphére et biosphére dans un bassin alpin de haute altitude (bassin du Sabbione, Alpes Lepontines, Italie). In: *Climat: Systéme & Interactions*, Camberlin P., Richard Y., ISBN: 978-2-907696-20-3, Dijon, pp. 369- 375.

4.3 Availability of data and model outputs (format, type of library, etc)

UR3 has delivered:

- The dataset of MODIS satellite images for the SCA identification.
- The input datasets for the snow mantle models obtained from the interpolation of meteorological variables over the Valle d'Aosta region.

UR6 has produced the GLDAS input database for the snow cover physical models UTOPIA and H-Tessel.

4.4 Completed Deliverables

UR1. Report on the retrieval of snow cover from satellite passive microwave radiometers (31/12/2013). 183-WSL dataset relative to snowstorms over US and Europe (31 December 2014).

UR2. Regional database of SWE point measurements (since 2005).
UR2. Regional database of SWE maps distributed over the Valle d'Aosta regional territory for the Nov-May period (2002-2013).
UR2. Intensive SWE measures (manual and GPR) for the estimation of maximum snow accumulation in specific mountain basins (since 2009). Dataset organized and metadated. Available to the various URs upon request.
UR2. Analysis of the spatio-temporal variability of snow density at regional scale and testing of predictive models.

UR5. Dataset of high quality meteorological data for a high altitude station (Cogne, Valle d'Aosta, 1730 m a.s.l.).

UR7: Dataset of snow and meteorological data in the Piedmont region.

5. Comment on discrepancies between expected and actually performed activities (results/Deliverables, etc…)

The NextSnow Project has carried out the activities foreseen for the 2014 period regardless of the unavailability of fundings for the entire year. The coordinator wants to express his deep gratitude and appreciation to all participating colleagues for their availability and high level of responsibility. However, he also needs to express the urgency to make available the necessary fundings so as to guarantee the completion of the Project.
The Deliverable "Regional database of punctual HS measures (since 2004)" was canceled because it was agreed (cfr. meeting 2014) not to carry out a specific data collection at the Centro Funzionale Regionale della Valle d'Aosta since such a collection was not instrumental to the activities of the project.
The Deliverable "Daily, cropped and reprojected MODIS-derived (MOD10A2) SCA maps (from 2000)" does not imply the creation of a specific dataset since the SCA data is directly assimilated in the SWE maps and autonomously used by the various URs.
The creation of the database of meteo-hydrological data at the Pian dei Corsi station is in progress due to problems with the installation of a few instruments, problems that are now being solved.

6. Expected activities for the following reference period

The main 2015 activity sees the continuation of ground data collection (automatic stations and specific measurement campaigns) and from satellite to construct the Project database. The utilization of the datasets produced during 2013 and 2014 and their integration with other measurements that become available in the mean time are another important point. Finally, the models will be tuned and run to finalize the intercomparison over the Western Alps.
A Project meeting is foreseen in spring 2015 at the UR2 premises to coordinate the activities of the URs, both experimental and model based.
Among others, the following activities of the URs are planned for 2015:
UR1. A calibration and validation activity of the 183-WSLSF retrieval model will be carried out within a collaboration between UR1 and NOAA.

UR3. Over the next months the activity will be focused on the improvement of the models of snow mantle evolution ACHABSnow and S3M as suggested by the results of the comparison between the models over the Torgnon site and by the validation conducted using the database made available by UR2.
UR4. The planned activities concern the reconstruction of SWE for automatic measuring stations (those equipped with a nivometer) and the production of a database of fresh snow SWE over the Western Alps.
UR6. The procedures of optimization of the UTOPIA model snow cover parameterizations will be finalized (multi-layer cover, slope, wind effects,…) together with verification of the available station data.
UR7. The collection and analysis activity of the time series and of the datasets of snow cover and snowfall over the Western Alps will be continued.

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2.6g: 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)

Partners: CNR-IRPI, CGI

Coordinator: Marta Chiarle
CNR-IRPI

Contributors:
Carlo Baroni, Alberto Carton, Marta Chiarle, Marco Giardino, Giovanni Mortara, Guido Nigrelli, Luigi Perotti, Maria Cristina Salvatore, Francesca Alberta Banchieri, Stefania Lucchesi, Cristina Viani, Thomas Zanoner

1. Scheduled activities, expected results and Milestones (as indicated in the Executive Plan)

The **scheduled activities** of the DATAGRALP Special Project, for the reporting period, consisted in: **a)** continuation of the digitization in GIS of the outlines of the Italian glaciers updated to 2006-07, 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/) and compilation of the related attribute table containing the main quantitative morphometric parameters of the outlined glaciers; **b)** beginning of the phase of reconstruction of the characteristic data of Italian glaciers for the specific considered time steps (decades: '50s - from the glacier inventory of CGI, '80s from the World Glacier Inventory); **c)** beginning of the phase of selection and acquisition of the relevant documentation, both iconographic and textual, related to the glaciers of interest (reports and photos of the annual glaciological campaigns, historic photographs and maps, publications and unpublished reports, unpublished data available to CGI). Such material will be validated in order to be considered appropriate to the objectives of WP 2.6, and entered into the database DATAGRALP/NextData. 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.

The **expected results** at the end of the reference period were as follows: **i)** completion of the first two tranches of digitization in GIS of the outlines of the Italian glaciers updated to 2006-07, in shapefile format, and of the related attribute table containing the main quantitative morphometric parameters of the outlined glaciers; **ii)** completion of the first two tranches of acquisition of the values of the main quantitative morphometric parameters of the Italian glaciers, for the specific considered time steps ('50s and '80s); **iii)** beginning of the phase of selection and acquisition of the relevant documentation, both iconographic and textual, related to the glaciers of interest.

Milestones:

There were no planned Milestones for the period considered.

2. Deliverables expected for the reference period

First two tranches of delivery of digitization in GIS of the outlines of the Italian glaciers, corrected and validated, updated to 2006-07, in vector format (shapefile), and of the related

attribute table containing the main quantitative morphometric parameters of the considered glaciers.

First two tranches of delivery of the validated datasets of the main glaciological parameters, related to specific time steps ('50s and '80s).

3. Activities which have been actually conducted during the reference period

3.1 Research activities

The activities actually carried out during the reference period in the framework of the DATAGRALP Project correspond to the activities scheduled for the same period, and in some cases have overcome them; more precisely they were as follows:

- **a)** Completion of the digitization of the outlines of the Italian glaciers related to the 2006-07 time step, carried out with a GIS (QGIS), open source and able to connect to the general portal of the NextData Project and to SHARE-GeoNetwork; in addition, debris-covered glacial areas have been outlined; compilation of the related attribute table, containing the main quantitative morphometric parameters of the outlined glaciers (area, length, slope, max and min elevation, exposure, latitude and longitude of the glacier centroid); verification and validation of the vector files (*.shp) and of the associated data sets.
- **b)** Location of the Italian glaciers included in the CNR-CGI inventory (1959-1962) in a GIS (QGIS), through the elaboration of shape files provided by CGI and the completion of the associated attribute table containing the main quantitative morphometric parameters of the considered glaciers (area, length, width, slope, maximum and minimum altitude, exposure, latitude and longitude). As the above data, the numerical and geographical information resulting from this activity can interface with the general portal of the NextData Project and with SHARE-GeoNetwork. –GeoNetwork; verification and validation of the vector files (*.shp) and of the associated data sets.
- **c)** Start of the phase of acquisition and of data enter into the database DATAGRALP of the qualitative glaciological information concerning the Italian glaciers (codes and names, geographical location, morphological characteristics as specified by the World Glacier Inventory).
- **d)** Start of the phase of selection, acquisition, and data enter into the database DATAGRALP of the relevant documentation, both iconographic and textual, relating to the glaciers of interest.
- **e)** Compilation of metadata relating to DATAGRALP Project and data, for publication on the GeoNetwork/Nextdata website (http://geonetwork.nextdataproject.it/);
- **f)** Preliminary analysis of data produced in the framework of the Project.

3.2 Applications; technological and computational aspects

Development and testing of the information management system, available, following a request of authentication, at the address http://dbirpi.to.cnr.it/datagralp/index.php.

3.3 Formation

During the reporting period, activities of formation at the university level were carried out: in this context, two projects of formation and orientation (curriculum stages) have been continued, that involved two students enrolled in the BSc in Computer Science (Systems and Networks) for an overall duration of 4 months/person. The training project was titled "Design and implementation of a server-side database for an integrated and interoperable management system of information related to the alpine glaciers".

With regards to glaciological themes, the formation activity was related in particular to 3 scholarships of 12 months each on the topic "Acquisition and processing of information relating to the glaciers of the Alpine sector: 1) Piedmont-Aosta Valley, 2) Lombard, 3) Triveneto" and 1 research grant on the topic "Tools and methods for the treatment of multi-temporal glaciological data in digital format".
Finally, during the reference period activities of university education were carried out through the activation of traineeships at the University of Pisa for students of the BSc in Geological Sciences and the Master of Geological Sciences and technologies, aimed to skill acquisition in the photo-interpretation of glacial bodies, in digitizing glaciological data in GIS environment, and in the development of geo-referenced databases. At the headquarters of the Italian Glaciology Committee in Turin, continued traineeships for university students (in the framework of scientific agreements with the universities of Torino, Pisa, Milano Statale, Milano Bicocca, Padova) aimed to digitizing the documentary heritage (maps and photographs) of the CGI and to the creation of a database containing information relating to the archive documentation of CGI.

3.4 Dissemination

The activities of the DATAGRALP Project have been presented in the following occasions:

General Meeting of the NextData Project, held at CNR, Rome, on 3-4 june 2014 (www.nextdataproject.it/sites/default/files/docs/P3_0.pdf).

Annual Meeting of the Italian Glaciological Committee, Padova, 19 December 2014.

Interviews of newspapers and of local and national television networks during the International Symposium on *The Future of the Glaciers: from the past to the next 100 years* held in Turin on 18-21 september 2014: part of the activities carried out in the framework of the Project will also be illustrated within a television service that will be presented in the program Leonardo (RAI 3).

Annual Meeting of the Cabina di Regia dei Ghiacciai Valdostani,Courmayeur, AO, 03 December 2014.

3.5 Participation in conferences, workshops, meetings

The activities and results obtained within the Project were presented at the International Symposium on *The Future of the Glaciers: from the past to the next 100 years* held in Turin on 18-21 september 2014 under the patronage of the Ministry for the Environment, Land and Sea protection, of the Presidencies of CNR and CAI, of the Piedmont Region and of AIGEO. About one hundred people attended the symposium, including researchers, fellows and students, many of them foreigners. The DATAGRALP and NextData Projects, and the research outcomes were presented through oral communications (C. Baroni) and in 4 distinct posters, illustrating the results obtained by the participants to the DATAGRALP Project. The abstracts submitted to the conference can be downloaded from the CGI website (http://www.glaciologia.it/turin2014/).

4. Results obtained during the reference period

4.1 Specific results (Data libraries, Measurements, Numerical simulations, etc)

The results achieved during the reporting period agree and sometimes exceed those expected and consist specifically in:

- Test and validation of the information management system, realized for the DATAGRALP Project.

- Implementation of the DATAGRALP database with the vector data (*.shp) and the related attribute table (main quantitative morphometric data of glaciers), validated, relating to the time steps '50s (punctual data) and 2006-07 (areal data).
- Updated picture of the glacial resource in the whole Italian Alps, divided by sector (Western, Central, Eastern Alps) through the validation of existing glaciological data and digitizing (according to international standards) current glaciological data (time step 2006-07).

A first analysis of the obtained data indicates a general trend of withdrawal of glaciated areas between the '50s of the 20th century and 2006-2007, but with different signals in the different alpine sectors.
With regard to the Western Alps, the CGI-CNR inventory (1959-1962) included 322 glaciers (363 including extinct ones) covering an area of 238 km^2. 34% of the glaciers existing in the '50s are extinct in 2006-2007, and nearly a quarter of the glaciers dismembered in smaller glacial bodies. The total number of glaciers recognized in 2006-2007 is therefore of 313 units, covering an area of about 160 km^2. It has therefore been a reduction of over 30% of the glaciated area.
With regard to the Lombard sector of the Central Alps, during the '50s there were 185 glaciers (Italian Glacier Inventory, CGI-CNR, 1959-1962), with a total area of over 100 km^2. The preliminary data for 2006-2007, indicate the existence of about 245 glacial bodies covering an area of about 88 km^2. Overall, the glaciers of the Central Alps show an areal reduction of about 24%. The extent of the areal reduction is not homogeneous for the different mountain ranges and varies from 7% in the Orobie Alps to 54% in the Tambò-Star Group. The highest glacial retreat took place in the Ortles-Cevedale Group, where the comparison with the data of the '50s shows a loss of about 13.5 km^2 in the considered period.
The Eastern Alps and the Gran Sasso of Italy in the '50s hosted 330 glaciers (342 considering extinct ones) that covered an area of about 175 km^2. Preliminary data for the 2006-2007 time step indicate the existence of 411 glacial bodies, covering an area of about 134 km^2. The increase in the number of glaciers depends on the withdrawal and on the consequent fragmentation of glaciers in smaller glacial bodies. Compared to the '50s there was an average reduction of the glaciated area of 23%, with a considerable variability between the Julian Alps, which underwent minimal reductions, and the Dolomite Alps, where an average areal reduction of 37% has been recorded. The maximum values of areal reduction have been recorded in the Ötztal, Passirie, and Breonie Alps, where about 17 km^2 of ice got lost.
In summary, for the entire Italian Alpine chain, 969 glaciers are inventoried in 2006-2007 (over 1000 if you count also glacierets), covering an area of over 380 km^2, with a reduction of about 25% compared to the '50s.

4.2 Publications

BARONI C., CHIARLE M., CARTON A., GIARDINO M., SALVATORE M.C., MORTARA G., NIGRELLI G., PEROTTI L., BANCHIERI F., BONDESAN A., LUCCHESI S., PERONA S., VIANI C. and ZANONER T., (2014): DATAGRALP – A new 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. *International Symposium 'The Future of the Glaciers: From the past to the next 100 years*, Torino (ITALY), 18th - 21st september 2014, p. 4, doi: 10.4461/GFDQ.2014.37.15.

CARTURAN L., BARONI C., BRUNETTI M., CARTON A., DALLA FONTANA G., SALVATORE M.C., ZANONER T., (2014): Analysis of long-term mass balance series of the glaciers in the Italian Alps. *International Symposium 'The Future of the Glaciers: From the past to the next 100 years*, Torino (ITALY), 18th - 21st september 2014, p. 6, doi: 10.4461/GFDQ.2014.37.15.

GIARDINO M., MORTARA G., LUIGI PEROTTI L., PERONA S., VIANI C., (2014): DATAGRALP - A new 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 - The Western Italian Alps. *International Symposium "The Future of the Glaciers: From the past to the next 100 years*, Torino (ITALY), 18th - 21st September 2014, p. 29, doi: 10.4461/GFDQ.2014.37.15.

Salvatore M.C., Baroni C., Banchieri F.A., (2014): DATAGRALP - A new 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 - The Central Italian Alps. *International Symposium 'The Future of the Glaciers: From the past to the next 100 years,* Torino (ITALY), 18th - 21st September 2014, p. 57, doi: 10.4461/GFDQ.2014.37.15.

ZANONER T. and CARTON A. (2014): DATAGRALP - A new 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 - The Eastern Italian Alps. *International Symposium 'The Future of the Glaciers: From the past to the next 100 years'* Torino (ITALY), 18th - 21st September 2014, p. 68, doi: 10.4461/GFDQ.2014.37.15

4.3 Availability of data and model outputs (format, type of library, etc)

- georeferenced vector files (*.shp), validated, containing glacier bodies outlines during the time step 2006-07;
- georeferenced vector files (*.shp), validated, relating to the location of the Italian glaciers inventoried in the CGI Glacier Inventory (1959-1962);
- validated datasets relating to the main quantitative glaciological parameters, associated as attribute tables to the above mentioned shapefiles;
- DATAGRALP database, containing the datasets of the main glaciological parameters, validated, ready to be tranferred to the general portal of the NextData Project and to SHARE-GeoNetwork;
- Metadata for publication on the Geonetwork/Nextdata website (http://geonetwork.nextdataproject.it/.

4.4 Completed Deliverables

Outlines of the Italian glaciers, verified and validated, updated to 2006-07, in vector format.

Location of the Italian glaciers inventoried in the CGI-CNR Glacier Inventory (1959-1962);

Validated datasets of the main quantitative glaciological parameters relating to specific time steps ('50s and 2006-07).

5. Comment on differences between expected activities/results/Deliverables and those which have been actually performed

We report a positive difference between the scheduled activities and those that have been actually realized: in fact, in addition to having complied with the planned activities, the digitization of the outlines of the Italian glacier referring to the time step 2006-2007 was completed sooner than expected, as the end of this activity was planned in 2016. Again with reference to the period 2006-2007, the digitization was performed also for the debris-covered glacial areas, that have been digitized distinctly from those of uncovered ice: this activity was beyond the planned activities, but it has been considered of fundamental importance for the understanding of glacial dynamics in response to climate change.

6. Expected activities for the following reference period

The activities planned for the period 01 January 2015 – 31 December 2015 are as follows:

i) compilation of the dataset of the values of the main quantitative morphometric parameters of the Italian glaciers, referring to the time step ‘80s;
ii) continuation of the population of the information management system DATAGRALP, in particular with the qualitative information on the Italian glaciers and with the most significant documentation, both iconographic and textual, relating to the glaciers of interest;
iii) transfer of the validated information to the portal GeoNetwork/Nextdata;
iv) start of the phase of analysis of trends relating to spatial-temporal variations of glacier fronts, based on the data of the glaciological campaigns, compared and integrated with the data acquired during the “GIS phase”;
v) start of the data acquisition on mass balances.

2.6h: High Resolution Climate Information for Mountain Areas (HR-CIMA)

Coordinator: Michele Brunetti
CNR-ISAC

Contributors:
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1. Scheduled activities, expected results and Milestones

In spite of the non-payment of planned funding for this second year, the research activity proceeded as scheduled thanks to the co-funding of the ECLISE Project. However, the ECLISE Project is now closed and the HR-CIMA activity will not be guaranteed for the next future if the planned financial resources will not be provided.

The activity planned for the second reporting period of the Project is aimed at the conclusion of the inventory of monthly precipitation and temperature data available in digital form for the Italian Alpine region and surroundings. Among these data will be chosen and rescued (according to series length and completeness) the stations' series which will constitute the base for the realization of a 1961-1990 climatology at 30 arc-second of resolution for the Italian Alpine territory above 1500 m of elevation and for the construction of monthly data sets (at the same spatial resolution) for three case study areas (Gran Paradiso National Park, Stelvio National Park, Paneveggio and Pale di San Martino National Park) spanning the last decades.
Within this second year we also planned to conclude the digitalization of "nivo-pluviometric totalizer" data measured by the former National Hydrographic Service between 1920s and 1970s.
Particular care will be given to the recovery of long temporal series that will be used for the construction of the temporal component, merging the former Hydrographic Service network (unfortunately abandoned in most regions) with the new regional networks to get long series with the possibility to periodically update them in the future.
Within this second year the homogenization of the long temporal series that will be used for the three case studies will start.

2. Deliverables expected for the reference period

D1.1: Inventory of monthly temperature and precipitation data available in digital form for the Italian Alpine area and surroundings" has been completed within this second year.

3. Activities which have been actually conducted during the reference period

3.1 Research activities

The research activity during the second year focused on the conclusion of the inventory of monthly temperature and precipitation data already available in digital form for the Alpine region. These data will constitute the bases for the construction of the 1961-1990 30 arc-second climatology and the monthly data sets for the three study areas.

1930 temperature stations and 2910 precipitation stations do exist in the examined area (for some regions the stations with less than 10 years of data were already excluded).

Once the inventory has been completed, the data rescue activity started, focused on the rescue of the series with at least 10 years of available data, and with particular attention to long temporal series for the three case study areas.
The data rescue activity is encountering some difficulties because of the low cooperation of some data providers.
While data rescue proceeds, the already acquired data undergoes quality checks (as far as the meteorological data are concerned) and consistency as far as their geographical location is concerned. Such checks are performed by comparing each site's elevation with that of a 30-arc-second digital elevation model. This detailed data verification, though extremely time consuming, is very important to enhance the reliability of the stations elevation, as incorrect elevation values can introduce significant errors in the estimation of the relation between the meteorological variable and elevation, which represents the key-point of the model for the construction of climatologies.
As far as the long-term series are concerned, a homogeneity procedure has been started on the data series already acquired. This procedure is aimed at the correction of the data from those non-climatic signals due to stations and instruments relocations, changes in measurement equipment and rules, and so on. All these problems can produce a long-term signal whose entity is similar or even larger than the climatic signal we want to study.

3.2 Applications; technological and computational aspects

This research activity will lead to the realization of a database which will constitute the base for the application of the algorithm we realized for the construction of the high-resolution climatologies for the Italian Alpine area that, together with the interpolation of the anomalies of the longest temporal series that will be recovered (and that will be preventively homogenized), will permit the realization of the high-resolution data sets for the three study areas.

3.3 Formation

A research assistant contract (started on 20 november 2013) has been concluded on 19 November 2014 and renewed exploiting the co-funding of the ECLISE Project, because no NextData funding arrived for 2014. The grant holder concluded in 2014 his first year of the doctorate school in Models and Methods for Material and Environmental Sciences (XXIX cycle) at the Modena and Reggio Emilia University.

A student of the Master Degree in Physics of the Earth System started his thesis work taking in charge a piece of the data set.

3.4 Dissemination

For the time, being the activities carried out so far concentrated on data rescue and partially on quality check, the only activities of dissemination were those of presentation of the objectives of the Project to the meeting of NextData (Rome, 3-4 June 2014; Milan 11 April), moreover the methodologies for the high resolution data sets were solicited to the Italy2k Conference at the Accademia dei Lincei (Rome, 1-2 December 2014).

3.5 Participation in conferences, workshops, meetings

NextData Paleodata meeting, Milan 11 April 2014.

NextData meeting, Rome 3-4 June 2014.
Italy-2k Conference, Rome 1-2 December 2014.

4. Results obtained during the reference period

4.1 Specific results (Data libraries, Measurements, Numerical simulations, etc)

Data rescue is still in progress and will be concluded in March 2015 (month 22) as planned in Deliverable 2.1. However, any new data that will become available after the conclusion of the Deliverable, will be incorporated in the data set the same. In this sense the data rescue will continue until the end on the Project.

4.2 Publications

Activities planned until now are purely reconnaissance and data rescue, and did not produce any scientific publication.

4.3 Availability of data and model outputs (format, type of library, etc)
None in the reference period

4.4 Completed Deliverables
D1.1: Inventory of monthly temperature and precipitation data available in digital form for the Italian Alpine area and surroundings.
This Deliverable is provided as appendix of the present report.

5. Comment on differences between expected activities/results/Deliverables and those which have been actually performed.

Due to the non-payment of planned funding for this second year, it was not possible to renew the research assistant grant on the NextData Project but, thanks to the co-funding of the ECLISE Project, it was renewed on this Project. However the ECLISE Project closed in 2014 and it will not be possible to rely on this co-funding also for the next year.

6. Expected activities for the following reference period

Within the next reporting period the whole task 2 will be completed.
The recovered stations data will be organized into two data sets: one comprising all stations series at least 10 years long and one constituted by longest series (at least 30 years, but hopefully half century long) for the areas centered on the three case studies. For the first one, climate normal referred to the 1961-1990 period will be estimated. The second data set will be homogenized and neighbouring series merged to produce longer and potentially updatable time series. This merging will permit to update the former Hydrographic Service network with the modern regional networks. All the stations coordinates will be quality checked by comparing their elevation with that of a 30 arc-second resolution digital elevation model. Finally, for each station the associated geomorphological parameters will be estimated from the USGS GTOPO 30 digital elevation model.
Deliverables D2.1. and D2.2. will be completed.

2.6.j: RelationsHips between meteo-climAtic paraMeters and ground surface deforMation time sEries in mountain enviRonments (HAMMER)

Coordinator: Francesca Ardizzone
CNR-IRPI

1. Scheduled activities, expected results and Milestones (as indicated in the Executive Plan)

HAMMER aims to reconstruct ground surface deformation time series in test areas located in mountain environments, and to analyse the correlation between the ground deformation and meteo-climatic time series. HAMMER aims also to implement data and results in digital archives compatible with the NextData Project archives. The Project focuses on the following study areas: (i) Italian Western Alps, (ii) Apennines, (iii) Pyrenees, and (iv) Atacama desert, Andes.

The scheduled activities of the HAMMER Special Project, for the reference period, consisted in:

- collection and organization of surface and sub-surface deformation provided by in-situ monitoring systems available for test sites in the Alps and the Apennines.
- Collection and organization of ground deformation DInSAR time series already processed for test sites in the Apennines, the Andes and Pyrenees.
- Systematic search of the surface deformation information available through the *Piano Straordinario di Telerilevamento Ambientale* (http://www.pcn.minambiente.it/viewer/) for selected study areas in the Alps and the Apennines.
- Systematic search of the surface deformation information available through a literature review.
- Collection of meteorological/climate time series for relevant meteorological stations in the study areas.

The expected results in relation to reference period were as follows:

- analysis of the scientific and technical literature to determine where quantitative information on ground deformations in landslide areas is available, and for which periods.
- Organization of time series of surface and/or sub-surface ground deformations and of meteorological data, for selected test sites in Europe. This includes time series obtained processing SAR images, and by surface and/or sub-surface topographical and inclinometric measurements.

The expected Milestone in relation to reference period was: no milestone was scheduled in the reference period.

2. Deliverables expected for the reference period:

The expected Deliverables in relation to reference period were as follows:

- collection and organization of surface and sub-surface deformation available for test sites in the Alps and the Apennines, including the results of the systematic search of the surface deformation, information available through a literature review.
- Collection and organization of ground deformation DInSAR time series already processed for test sites in the Apennines, the Andes and Pyrenees and of the meteorological/climatic data.

3. Activities which have been actually conducted during the reference period

3.1 Research activities

The activities carried out during the reference period correspond to the activities scheduled and focused on:

- collecting and organizing in-situ monitoring ground deformation time series already available for the study areas located in the Alps and Apennines territory. The study areas included Gardiola, Grange Orgiera and Montaldo di Cosola landslides in Piemonte region and Ivancich landslide in Umbria region. For each area, in-situ monitoring data were considered, including total stations and inclinometers. These technologies are essential to provide ground deformation time series with very high temporal sampling and reconstruct temporal evolution of single landslide phenomena over time.
- Collecting and organizing ground deformation DInSAR time series already processed for test sites in the Apennines, and Pyrenees. In particular, HAMMER collected the ground deformation and velocity map and associated time series for the Ivancich landslide (Central Apennines), and Portalet landslide in the Tena Valley (Central Spanish Pyrenees). The data set of Tena Valley was acquired in the framework of the "Framework agreement between NxtData and TERRAFIRMA for exchange of data and information" (GEMS ESRIN/Contract No. 4000109669/13/I-AM).
- Surveying and gathering meteorological data from meteorological stations close to each test site. In particular, for Piedmont test sites the meteorological data are available for free download by Arpa Piemonte website (http://www.regione.piemonte.it/ambiente/aria/rilev/ariaday/annali/meteorologici) and for test site located in Umbria, the data are available on Umbria Region website (http://www.idrografico.regione.umbria.it/annali/default.aspx). For Tena Valley test site, the meteorological data are available by SAIH Ebro Confederación Hidrográfica del Ebro (Hispagua, Sistema Español de Informacíon sobre el Agua: http://hispagua.cedex.es/).
- Processing of SAR images by using the ESA service named Grid Processing On-Demand G-POD (http://gpod.eo.esa.int/) to obtain ground deformation and velocity maps and associated time series for two test sites opportunely selected: Grange Orgiera (Sampeyre municipality, Piedmont, Northern Italy), and the Valle d'Aosta Region (Northern Italy). The results have been compared to the Envisat data available on the *Piano di Telerilevamento Straordinario*, (http://www.pcn.minambiente.it/viewer/) elaborated with the PSInSAR technique. The ground deformation time series and the mean velocity values were comparable.
- Analysis of the scientific and technical literature to determine where quantitative surface and sub-surface information on ground deformations in landslide areas is available, and for which periods. For the purpose we compiled a database of scientific and technical papers consisting in an Excel file that lists 110 records. The items (i.e. bibliographic documents) were classified based on different criteria.

3.2 Applications; technological and computational aspects

The implementation of a database to store the collected time series is one of the objectives of HAMMER, as well as the preparation and delivery of the collected information for the NextData main portal. For this purpose during the first year the following actions were set up:

- a metadata schema was prepared as excel file according to European directive INSPIRE (http://essi-lab.eu/do/view/GIcat/InspireMetadata) and according to the different data type (in-situ, SAR, meteorological/climate data), in order to make available the data to the NextData Project (http://geonetwork.evk2cnr.org). For each dataset we compiled a corresponding metadata form that describes the dataset.

- an FTP site (host: s1irpito.to.cnr.it, following authentication) was implemented to store and share data and metadata. The FTP structure, for each test site, is organized as follows:
    - DATA: the folder contains "*in situ* data" and the corresponding "metadata".
    - METEOROLOGICAL DATA: the folder contains meteorological/climate data available for free download on regional website. A specific criteria was adopted to store and share this type of information; the meteorological data will be uploaded in case of data processing, otherwise up to this phase, will be uploaded only the information relate to the type of data available and the website link.
    - ORTOPHOTO: the folder contains the orthophoto maps as tiff files where available, or the link to the regional portal providing the Web Map Service (WMS).
    - PROJECT: the folder contains the project files prepared for the production of digital map using QGIS software (http://www2.qgis.org/it/site/).
    - SAR: the folder collects the results of Differential Interferometric Synthetic Aperture Radar (DinSAR) processing already available for the test sites.
    - SHP: the folder contains punctual, linear and polygonal shape files of available data for each test sites.
    - TOPOGRAPHY: the folder contains topographic map as tiff files where available, or the link to the regional portal providing the Web Map Service (WMS).

During the first year the ESA service named Grid Processing On-Demand G-POD (http://gpod.eo.esa.int/) was tested to obtain additional data. This service implements the Parallel-SBAS processing chain and exploits SAR images stored on the Virtual Archive 4 (http://eo-virtual-archive4.esa.int/, in the framework of Supersite initiative). G-POD is accessible through a user-friendly web-interface, and allows setting easily some useful input parameter for processing (e.g., selection of temporal range, baseline, coherence threshold, reference point).

3.3 Formation

During the reference period no formation activity was developed in the contest of HAMMER Project.

3.4 Dissemination

During the reference period no dissemination activity was developed in the contest of HAMMER Project.

3.5 Participation in conferences, workshops, meetings

HAMMER internal kick-off meeting, 7 March 2014.

NextData general meeting, CNR, Roma, 3-4 June 2014.

ALLASIA P., ARDIZZONE F., CIGNETTI M., GIORDANO D., GUZZETTI F., MANCONI A. & MANUNTA M. (2014): Ground deformation analysis exploiting surface and sub-surface displacement measurements (abstract & poster). .*Congresso della Società Geologica Italiana – Società Italiana di Mineralogia e Petrologia (SGI-SIMP)*, sessione S5: Climate change and the Earth System: understanding the past, analysing the present and predicting future scenarios. Milano 10-12 September 2014.

4. Results obtained during the reference period

4.1 Specific results (Data libraries, Measurements, Numerical simulations, etc.)

The results obtained correspond to those expected for the reference period, as listed below:

- analysis of the scientific and technical literature to determine where quantitative surface and sub-surface information on ground deformations in landslide areas was carried out.
- Collection and organization of the time series of surface and/or sub-surface ground deformations and of meteorological parameters, for the test sites in Europe.
- Production of a new ground deformation and velocity map and associated time series for the Valle d'Aosta region by exploitation of SAR satellite images using the G-POD ESA service.

4.2 Publications

No publications in the reference period.

4.3 Availability of data and model outputs (format, type of library, etc.)

No data available, because the data are being acquired and validated.

4.4 Completed Deliverables

The Deliverable includes: (i) collection and organization of surface and sub-surface deformation available for test sites in the Alps and the Apennines, including the results of the systematic search of the surface deformation information available through a literature review; (ii) collection and organization of ground deformation DInSAR time series already processed for test sites in the Apennines, and Tena Valley (Pyrenees), and (iii) collection of meteorological data for the study areas located in Piemonte, Umbria.

5. Comment on differences between expected activities/results/Deliverables and those, which have been actually performed.

The expected activity for the reference period was completed and the expected results were achieved. The exploitation of the G-POD ESA service not included in the scheduled activities of HAMMER Project was carried out in order to collect new ground deformation data at regional scale in a mountain territory such as Valle d'Aosta Region.

6. Expected activities for the following reference period

The activities planned for the period 01-01-2014 / 31-12-2014 are:

- upgrade of the systematic search of the available surface deformation information through the *Piano Straordinario di Telerilevamento Ambientale* (http://www.pcn.minambiente.it/viewer/) for areas in the Alps and Apennines and through a literature review.
- Upgrade of the collection and organization of the meteorological/climate data.
- Processing of new satellite images to produce new ground deformation and velocity maps and associated time series.
- Implementation of a database for the storage of the collected datasets. It includes the design and implementation of a database and the preparation and delivery of the collected information for the NextData main portal.

Correlation of the two types of time series. It consists of the statistical analysis of the correlation (or lack of correlation) between ground deformation and meteorological/climatic data, and their interpretation.