Project of Strategic Interest NEXTDATA

Scientific Report for the reference period **01/01/2012-31/12/2012**

WP 1.1 – High altitude climate observation system (Resp: Paolo Cristofanelli)

Partners: URT Ev-K2-CNR, CNR-ISAC

1. Planned activities and expected results

Within WP1.1, the *in-situ* measurement activities of meteo-climatic parameters and atmospheric composition started in the framework of the SHARE Programme, will be continued in the mountain regions considered by the Project (Alps, Italian Apennines, Hindu-Kush Karakorum Himalaya, Rwenzori, Andes), also favoring the technical and scientific implementation of the measurement progammes already activated. Moreover, the following activities are planned:

- feasibility studies concerning the installation of new infrastructures for the execution of climate and environmental monitoring;
- survey to define the current status of technologies for the implementation of transportable systems suitable for use in regions where the installation of standard measurement stations is impossible, unfeasible or unaffordable;
- definition, in a national and international framework, of the scientific questions that will benefit from the execution of measurement activities in mountain areas.

M1 (PM8): Definition of the relevant "Scientific questions".
M2 (PM12): Results of first year measurements, feasibility studies for new infrastructures and survey concerning the technology for transportable and energetically autonomous measurement systems.

2. Deliverables expected for the reference period

D1.1.1 (PM8): Report on the "scientific questions".
D1.1.2 (PM12): Report describing the activities, data transfer to archives and to the General Portal.
D1.1.3 (PM12): Report on the technology for transportable and energetically autonomous measurement systems.

3. Activities actually carried out during the reference period

Within WP1.1, some of the in-situ activities of mountain meteo-climatic measurements in the regions of interest (Alps, Italian Apennines, Hindu-Kush Karakoram Himalayas, Rwenzori, Andes), originally conducted in the framework of the SHARE project, have been continued in the framework of the NextData project, favoring and extending the technical and scientific implementation of the measurement activities which are already active (Tab. 1). The SHARE activities at the GAW-WMO Global Station "Ottavio Vittori" -Monte Cimone and "Nepal Climate Observatory – Pyramid", are now carried out under the NextData WP1.2.

Measurement site	Country/Continent		Class	Elevation (m a.s.l.)
Forni glacier (Central Alps,)	Italy	Europe	AWS	2,669
Dosdè Glacier (Central Alps,)	Italy	Europe	AWS	2,740
Gigante Glacier (Western Alps)	Italy	Europe	AWS	3,500
Italian Climate Observatory "O. Vittori" (northern Apennines)	Italy	Europe	ATM	2,165
Osservatorio Portella del Gran Sasso (central Apennines)	Italy	Europe	ATM	
Nepal Climate Observatory – Pyramid (Khumbu valley, Himalayas)	Nepal	Asia	ATM	5,079
Pyramid Laboratory Observatory (Khumbu valley, Himalayas)	Nepal	Asia	AWS	5,050
Pheriche (Khumbu valley, Himalayas)	Nepal	Asia	AWS	4,258
Namche Bazaar (Khumbu valley, Himalayas)	Nepal	Asia	AWS	3,560
Lukla (Khumbu valley, Himalayas)	Nepal	Asia	AWS	2,660
Kala Patthar (Khumbu valley, Himalayas)	Nepal	Asia	AWS	5,600
Changri Nup Station (Khumbu valley, Himalayas)	Nepal	Asia	AWS	5,700
South Col (Mt. Everest, Himalayas)	Nepal	Asia	AWS	8,000
Urdukas (Baltoro glacier, Karakorum)	Pakistan	Asia	AWS	3,926
Askole (Baltoro glacier, Karakorum)	Pakistan	Asia	AWS	3,015
Concordia (Baltoro glacier, Karakorum)	Pakistan	Asia	AWS	4,700
Chacaltaya (Cordillera Real, Ande)	Bolivia	South America	ATM	5,200
Mt. Stanley (Elena glacier, Rwenzori)	Uganda	Africa	AWS	4,700

Table 1. Measurement stations (AWS: automatic weather stations, ATM: observatories for atmospheric composition measurements) installed in the framework of the SHARE Project and now supported by NextData.

3.1 Research activities

During the first year of the project, CNR-ISAC coordinated the activity within WP1.1, while the URT Ev-K2-CNR was directly in charge of the station management and of data handling for the Automatic Weather Stations (AWS) listed in Table 1 and Figure 1. These data are gathered in the archive of the SHARE monitoring network , currently hosted at URT Ev-K2-CNR, and will be shared with the General Portal (WP 2.6), as soon as it becomes operational during the second year. Deliverable D1.1.2 reports, for each AWS,

the current status of the available measurements together with the availability of validated data.

CNR-ISAC also provided scientific and technological indications to support the execution of the scheduled actions, also based on the inputs from the national and international scientific community. In particular, thanks to participation in major national and international Projects/Programmes concerning the investigation of atmospheric composition and the environment in mountain areas (SHARE, ACTRIS, UNEP-ABC, WMO-GAW, GEO), in collaboration with URT Ev-K2-CNR, the following "scientific questions" (SQ) have been defined:

- *SQ1: How to obtain more accurate operational atmospheric composition monitoring and forecasting using near real-time data from remote atmospheric observatories?*
- *SQ2: How to obtain a more comprehensive understanding of the atmospheric role of nitrogen oxides using in situ data from remote atmospheric observatories?*
- *SQ3: What is the role of light absorbing aerosol in regulating the earth's climate and in affecting mountain environments?*
- *SQ4: How reliable are precipitation measurements in high-altitude regions and what strategy should be used to achieve the best information from the available observations?*

The ensemble of SQ, which is described in the Deliverable D1.1.1, will represent one of the reference points for the definition of future implementation of the activities within WP1.1 and WP1.2.

In the following, for each mountain regions covered by the Project, a summary of the activities is provided.

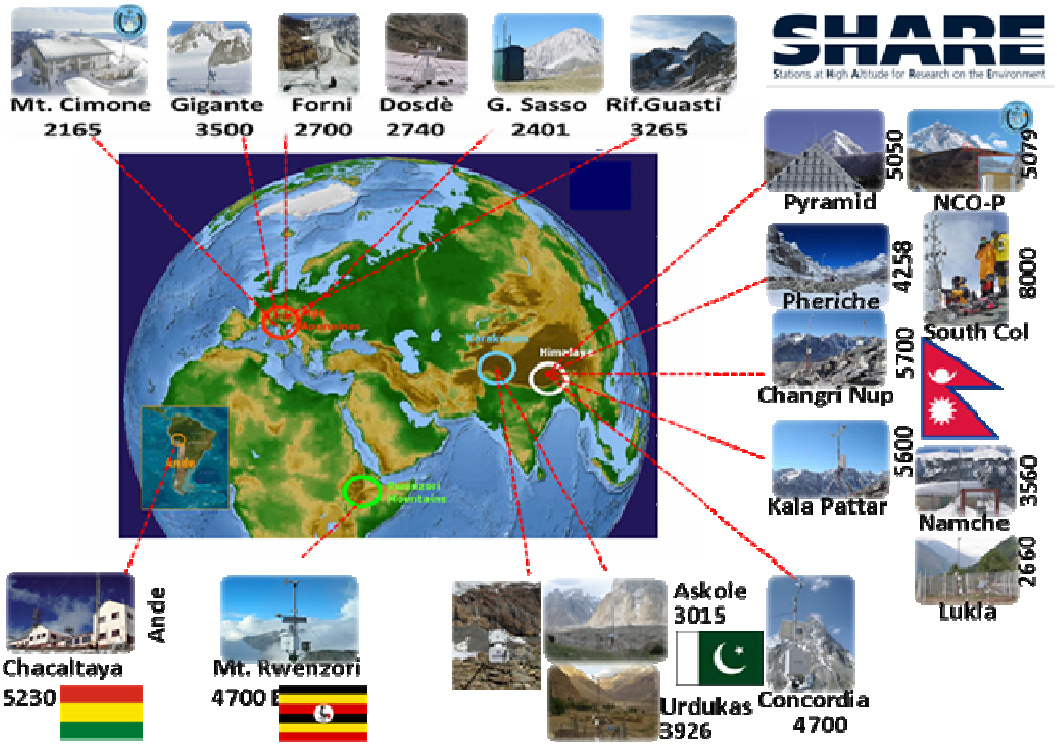

Figure 1. Overview of the measurement stations operating in the framework of the SHARE Project and now supported by NextData.

3.1.1 Himalayas

Activities carried out in the Himalayan areas are concentrated mainly in ***Nepal***, at the International Pyramid Laboratory-Observatory, installed by Ev-K2-CNR in 1990, at 5,050 m asl in the Sagarmatha National Park, in collaboration with the Nepal Academy of Science and Technology. This facility represents a strategic logistic base for supporting monitoring activities carried out along the Khumbu Valley, in the region of Mt. Everest, where a network of meteo-climate monitoring stations and the GAW-WMO Nepal Climate Observatory Pyramid are installed (Tab. 1). The meteorology and atmospheric composition data collected through this programme are extremely important for NextData, since they represent key variables in the Himalayas region (WP 1.1 and WP 1.2). The observation sites require daily checks, as well as periodical technical interventions, also concerning the management of the data transmission systems both in Nepal and in Italy.

The Laboratory, which is able to host up to 20 persons, is used as scientific/operational base for researchers and technicians involved in research activities and research projects carried out in the Sagarmatha National Park region. During the reference period, about 80 researchers and technicians involved in several international projects were hosted.

Moreover, thanks to its satellite communication systems, the Pyramid is able to transmit in real time data collected by the monitoring stations located in the Khumbu valley. Environmental conditions in the remote Khumbu valley demand a regular supervision, careful maintenance and periodic upgrade in order to guarantee a correct operation of this facility as a unique resource for the international scientific community. The management of the Pyramid Laboratory-Observatory is entrusted to URT Ev-K2-CNR. It makes use of Nepalese technicians at the field site. The team is currently composed of eight members, who daily manage the facility and all the 8 monitoring stations. The staff's duty is to identify possible anomalies in the operation of instruments, in order to permit timely interventions of restoration, which are often coordinated by remote intervention from Italian technicians, thank to the use of technology for remote checking. This operation has a fundamental importance in order to fulfill the commitments taken with national and international organizations (UNEP, WMO, NASA, ecc), supplying them with continuous and high level data. For this reason, periodically courses on site and in Italy were organized for the local technician staff, about the management of equipments, data processing, data transmission systems, etc…

During 2012, the ordinary maintenance activity of the AWSs along the Khumbu Valley was guaranteed, thanks to the intervention of the local technical staff, who works in close collaboration with the Italian staff. Moreover, the calibration and checking activities were performed by using a "travelling standard", which was set-up in 2011 in the framework of the SHARE activities. In particular, during 2012 intercomparison exercises have been carried out at the AWS Periche, Kala-Patthar and Lukla, allowing the identification of possible sensor malfunctioning. URT Ev-K2-CNR, in close collaboration with CNR-ISAC, was in charge of the analysis of the intercomparison results, also performing the necessary actions to re-establish the correct operation of the AWSs (e.g. by changing sensors not working properly) or to improve the AWS functionality (e.g. by modifying data acquisition procedures). For this purpose, collaboration with ENEA-UTMEA was also undertaken in order to define the correct methodology for checking and calibrating the broadband short-wave and long-wave radiation sensors working at the AWSs. During 2013, the "reference" AWS will be sent to Italy for performing the scheduled maintenance activity and to recalibrate the sensor. The methodologies and

guidelines for the validation of meteorological data have been defined. Moreover, in compliance with the recommendations of the Department of Earth Sciences of the University of Milan (Italy), methods were implemented for validating surface albedo data recorded in the high Khumbu valley (on the Changri Nup Glacier). Thanks to the collaboration with the METEOMET EMRP-funded Joint Research Project, a preliminary study was carried out for the definition of the requirements for the traceability to international metrological standards of air temperature and atmospheric pressure measurements in Himalaya. To this end, the installation of a specifically-designed device for calibrating meteorological sensors (especially for air-temperature and atmospheric pressure) in "controlled" working conditions is planned for 2013 at the Pyramid International Laboratory. This device, representing a real traveling standard, will be then used to link directly the measurements carried out in the high Khumbu valley to well-defined national metrological standards for meteorological measurements, thus significantly increasing the reliability of meteorological measurements undertaken by the AWS network.

In 2012, Italian researchers from ISE-CNR carried out a mission in Nepal in order to collect samples of water from lakes in mountain regions and to study the effects of climate change on these ecosystems. Moreover, personnel from IRSA-CNR collected hydrological data and water samples of the main streams and tributaries along Khumbu Valley in order to investigate the presence of issues related to water quality.

In the framework of collaborations with local Institutions (ICIMOD - International Centre for Integrated Mountain Development) and the UNEP-ABC and SHARE-EvK2CNR Projects, CNR-ISAC and URT Ev-K2-CNR participated in the setting-up of the SusKat (Sustainable Atmosphere for the Kathmandu Valley) ABC field campaign. The aim of this international initiative (to be held in Kathmandu from January to March 2013) is to increase basic knowledge on air pollution in the Kathmandu valley and its possible recirculation to the Himalayas and the free troposphere. In this framework, in January 2013, a new measurement station will be installed at the URT Ev-K2-CNR building in Kathmandu (Fig. 2). This new air quality and climatic urban station will provide complementary information to that of the NCO-P GAW-WMO Global Station, thus representing a reliable reference point for typical urban (and polluted) conditions in the Himalaya foothills. A study has been carried out in 2012, to assess the feasibility of this new installation. In particular, the station will be equipped with:

- meteorological sensors;
- global pyranometer for downward solar short-wave radiation;
- surface ozone analyzer;
- optical particle counter for aerosol size distribution from 0.3 to 10 μm;
- on-line PM1/PM10 mass determination (for spot measurements during special events);
- multi-angle absorption photometer for equivalent black carbon mass measurement.

Moreover, passive sensors for the determination of average NOx mixing ratios operated by ICIMOD will be installed.

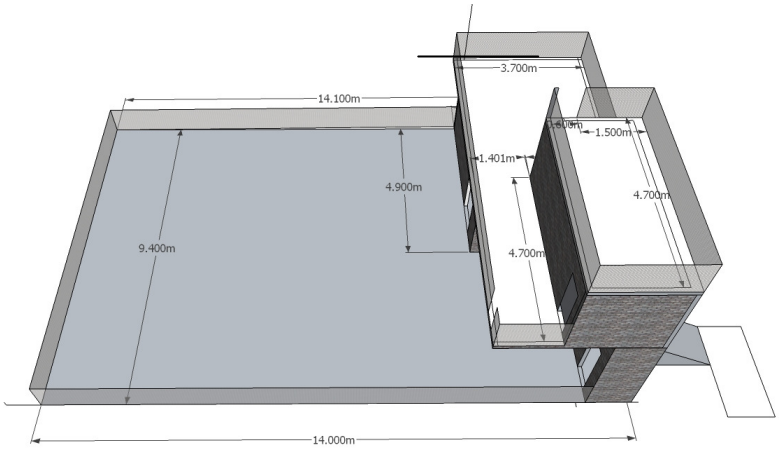

Figure 2. Technical scheme of the URT Ev-K2-CNR building roof at Kathmandu, where the new atmospheric air quality and climatic station will be located.

3.1.2 Karakorum

In ***Pakistan***, in collaboration with the Pakistan Meteorological Department (PMD), the URT Ev-K2-CNR continued the operation of the AWS network already existing in the Baltoro region: Askole, Urdukas and Concordia (Tab. 1).

During summer 2012, the URT Ev-K2-CNR re-established and upgraded the Urdukas AWS by repairing the power supply system, upgrading the data acquisition and by replacing sensors not working properly.

In the framework of the activities related to the feasibility study for the installation of a new climatic observatory in Pakistan, scheduled during the second year of the project, CNR-ISAC analysed the data from the NANO-SHARE system that operated at Askole from August to October 2012. Thanks to this system (further information on the NANO-SHARE is provided in the deliverables D1.1.1 and D1.1.3), simultaneous measurements of surface ozone, carbon dioxide, aerosol particle number concentration (with 10 nm < Dp < 3 μm) and meteorological parameters were carried out. The resulting information was shared with URT Ev-K2-CNR in order to contribute to the Deliverable D1.1.3. Moreover, preliminary actions to develop contacts with private companies and/or industries to define applicative questions for business have been pursued by URT EV-K2-CNR.

3.1.3 Rweznori

In ***Uganda,*** the Automatic Weather Station installed at 4.700 m a.s.l on Rwenzori in the framework of SHARE project, has been periodically checked by local technicians from the Uganda Meteorological Department, trained to manage the equipment. At present, this station is not operational due to technical problems related to failures of the power system (using photovoltaic panels) and of the data storage systems.

Based on the results of a feasibility study, URT Ev-K2-CNR has planned an experimental campaign (to be held in Spring 2013) to upgrade the AWS and re-start meteorological observations. In addition to monitoring standard meteorological parameters (air temperature, atmospheric pressure, relative humidity, wind speed and direction, rain precipitation), the new AWS will be equipped with sensors for measuring broadband long-wave and short-wave albedo as well as the snow level. Moreover, an upgraded acquisition system will allow the near real-time data delivery to Ev-K2-CNR

headquarters. This campaign, will represent an advanced feasibility study for evaluating the possibility of starting in a near future atmospheric composition measurements.

The importance of this site has been pointed out also in the framework of the UNEP-ABC project in which the Rwenzori National Park area is recognized as a key area for the study of the Atmospheric Brown Cloud (ABC) phenomenon in Africa, as reported in the report on the relevant "Scientific questions" (D1.1.1). In this context, the possibility of realizing and installing a station devoted to atmospheric monitoring is also being evaluated. In addition to measurements of basic meteorological parameters, information on average levels and variability of short-lived climate forcers (SLCF) like surface ozone, black carbon or particulate matter would represent an important set of data, still lacking in this area.

3.1.4 Alps and Apennines

In ***Italy***, analysis of data collected by the stations on Forni, Dosdè and Gigante-Mt. Bianco Glaciers continued, allowing an advancement of knowledge on the micrometeorology of Alpine glaciers.

The retrieval of data collected at the SHARE glacial stations is regularly managed by the URT Ev-K2-CNR staff. In June and October 2012, two missions on the Forni Glacier were organized and on these occasions technical interventions were carried out in order to restore the AWS operation and the data delivery service to Ev-K2-CNR HQs. During 2012, a study has been carried out in collaboration with ARPA Valle d'Aosta to evaluate the feasibility of the installation of a new AWS on the Mont Blanc at an elevation of 4180 m. An experimental set-up similar to the new Rwenzori AWS was defined, allowing observations of air temperature, atmospheric pressure, relative humidity, wind speed and direction, rain precipitation, broadband long-wave and short-wave albedo and snow level. In the framework of this activity, a new mechanical system will be used, specifically designed for the harsh glacier environment and able to guarantee the AWS stability over ice surface.

CNR-ISAC, in close synergy with WP1.2, shared technical information with CETEMPS – University of L'Aquila for the implementation of a new mountain measurement station at Campo Imperatore – Monte Portella, which operates in the framework of the SHARE-Italia network (Gran Sasso d'Italia, Abruzzo). In particular, based on the Monte Cimone and NCO-P know-how, the technical design of the air intake for trace gas sampling was shared and indications were provided on the wind sensors and instrumentation for monitoring atmospheric aerosol number size distribution, thus contributing to the feasibility study for the station installation. At the current stage, this station, which was already (partially) supported by the SHARE Project, is continuously measuring meteorological parameters, ozone and NOx mixing ratios, and aerosol size distribution (with diameters from 0.3 μm to 10 μm, using an optical particle counter). A sub-set of these data is also transmitted in near real-time and plotted at http://cetemps.aquila.infn.it/Cetemps/it/portella.html. A detailed analysis of the summer ozone variability at Campo Imperatore – Monte Portella, as deduced from preliminary measurements carried out in August 2009 in the framework of the SHARE Project, has been performed and it is currently in press (Cristofanelli et al., Analysis of summer ozone observations at a high mountain site in central Italy (Campo Imperatore - 2388 m a.s.l., Pure and Applied Geophysics, in press).

3.2 Applicative, technological and information developments

- Algorithms for the implementation of semi-automatic routines for AWS data validation.
- Prototype for a portable and energetically autonomous system for the measurement of meteorological variables (atmospheric pressure, air temperature, relative humidity) in high elevation mountain sites.
- Execution of in-situ tests for the evaluation of the performance of a transportable system for atmospheric composition measurements.

3.3 Training activities

- The training of the local staff involved in managing and maintaining the AWS in Nepal and Pakistan was continued. The training activities were carried out by Italian personnel both in-situ (during the maintenance campaigns) and remotely (during tele-controlled activities).
- PhD Thesis on "Contribution to the comprehension of climate change towards cryosphere and atmospheric analysis: the cases study of Changri Nup Glacier, Nepal Himalayas and of Forni Glacier, Italian Alps".

3.4 Dissemination

Participation of URT Ev-K2-CNR personnel in the "Festival della Scienza 2012" (Genova) for presenting the SHARE activities carried out in the mountain regions considered by the Project (Alps, Italian Apennines, HKKH, Rwenzori, Andes).

3.5 Participation in conference

- *International Symposium on Cryosphere & Climate Change – 2012*, 2-4 April 2012, Manali, India.
- *GEO (Group on Earth Observations) Work Plan Symposium*, 30 March – 2 April 2012, Ginevra, Switzerland.
- *GEO (Group on Earth Observations) European Project's Workshop*, 7-8 May 2012, Rome, Italy.
- *Conference on Cryosphere of the Hindu Kush Himalayas: State of the Knowledge,* 14 – 16 May, 2012, Kathmandu, Nepal.
- *NASA SERVIR MINX Workshop*, 11-13 June 2012, Kathmandu, Nepal.
- *Congresso della Società Italiana di Ecologia,* 10 - 13 September 2012, Alessandria, Italy.
- *Sixth National Conference on Science and Technology – Economic, Growth through Science, Technology and Innovation*, 25-27 September 2012, Kathmandu, Nepal.
- *IV Convegno Nazionale AIGEO, 2* - 5 October 2012, Palermo, Italy.
- *Comitato di Coordinamento LTER, 13* November 2012, Rome, Italia.

- *Plenary IX – GEO (Group on Earth Observations)*, 22-23 November 2012, Foz do Iguaçu, Brazile.
- *American Geophysical Union, Fall Meeting*, 1-7 December 2012, San Francisco, USA.

4. Results obtained during the reference period

4.1 Specific results (databases, measurements results, models output, etc)

- Database of measurements and meteo-climatic variables recorded at the AWS stations reported in Table 1.
- Database of surface ozone, carbon dioxide, total particle number, meteorological parameters at Askole from August to October, 2012.
- Database of surface ozone, NOx, aerosol size distribution (0.3 – 10μm), meteorological parameters, global short-wave solar radiation at Campo Imperatore – Monte Portella (July – December 2012);
- Database LTER of meteorological, water chemistry (P, N, main anions and cations, metals) and water biology (Phytoplankton, Zooplankton, Benthos) at two Pyramid Lakes (Superior and Inferior) from 1992 to 2012.
- Database of river discharge measurement (flow rate) at Pheriche and at Pyramid Lake superior emissary (June 2012-ongoing)

Moreover, the following measurement results have been achieved in the framework of the SHARE project:

- The summer variability of the surface ozone at Campo Imperatore station- Monte Portella (Central Apennines).
- Preliminary assessment of the atmospheric composition variability in the Karakorum regions.
- Investigation of the surface albedo variability at the Chungri Nup glacier.

4.2 Publications

Adhikary, B., E. Vuillermoz, R. Toffolon, P. Cristofanelli, A. Marinoni, R. Duchi & P. Bonasoni. 2012. SHARE Project: climate observations for environmental monitoring in the Himalayas. *ISCCC – 2012*, Manali, India, 2-4 April 2012.

Adhikary, B., E. Vuillermoz, A. Marinoni, P. Cristofanelli & P. Bonasoni. 2012. Chemical Transport Modeling: a decision support a tool for policy makers for sustainable development planning. *Sixth National Conference on Science and Technology – Economic, Growth through Science, Technology and Innovation*, Kathmandu, Nepal, 25-27 September 2012.

Cristofanelli P., Di Carlo P., et al.: Analysis of summer ozone observations at a high mountain site in central Italy (Campo Imperatore - 2388 m a.s.l.), *Pure and Applied Geophysics*, in press.

Rogora, M., A. Lami, A. Marchetto, G. A. Tartari, G. Tartari, F. Salerno A. Boggero, La ricerca a lungo termine sui laghi in aree remote: effetti del cambiamento climatico sulla chimica dei Laghi Paione (Alpi Centrali, Italia) e dei laghi della Piramide (Himalaya, Nepal). *Congresso della Società Italiana di Ecologia*, 10 - 13 September 2012, Alessandria, Italia.

Senese, A., R.S. Azzoni, A. Zerboni, G. Diolaiuti, M. Maugeri & C. Smiraglia. 2012. Proposta di metodologia per lo studio delle relazioni tra albedo e detrito sopraglaciale su un ghiacciaio alpino, il Ghiacciaio dei Forni (Alpi centrali, Lombardia). *IV Convegno Nazionale AIGEO*, Palermo, Italy, 2-5 Ottobre 2012.

Vuillermoz, E., A. Marinoni, P. Bonasoni, GP. Verza, G. Diolaiuti, A. Senese, C. Smiraglia,D. Bocchiola, A. Soncini & U. Minora. 2012. Studying Himalayan glaciers to understand atmospheric dynamic and ongoing climate variations. Data and findings from the Changri Nup Glacier (Nepal, Himalaya). *Conference on Cryosphere of the Hindu Kush Himalayas: State of the Knowledge*, Kathmandu, Nepal, 14 – 16 May, 2012.

Vuillermoz, E., A. Marinoni, P. Bonasoni , GP. Verza, G. Diolaiuti, A. Senese , C. Smiraglia , D. Bocchiola, A. Soncini & U. Minora. 2012. Studying Himalayan glaciers to understand atmospheric dynamics and ongoing climate variations. Data and findings from the Changri Nup Glacier (Nepal, Himalaya). *Sixth National Conference on Science and Technology – Economic, Growth through Science, Technology and Innovation*, Kathmandu, Nepal, 25-27 September 2012.

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

- SHARE network AWS: described in the Deliverable D1.1.2.
- Asokle (August - October 2012): surface ozone, carbon dioxide, total particle number, meteorological parameters (format: Excel; status: preliminary validation; data provider: URT EVK2CNR; data accessibility of validated data: upon request);
- Campo Imperatore – Monte Portella (July – December 2012); surface ozone, NOx, aerosol size distribution (0.3 – 10μm), meteorological parameters, global short-wave solar radiation (format: ascii; status: raw data; data provider: CETEMPS, URT EV-K2-CNR; data accessibility of validated: upon request)
- Superior and Inferior Lakes at Pyramid (1992-2012): meteorological, chemical and biological parameters (format: Excel, DBMS format only for Phytoplankton; status: validated data; data provider: ISE-CNR, URT EV-K2-CNR; data accessibility of validated: upon request)
- Pheriche and Pyramid Lake superior emissary (2012 – ongoing): database of river discharge measurement (format: ascii; status: raw data; sata provider: IRSA-CNR, URT Ev-K2-CNR; data accessibility of validated data: upon request).

4.4 Completed deliverables

D1.1.1 (PM8): Report on the “scientific questions”.

D1.1.2 (PM12): Report describing the activities, data transfer to archives and to the General Portal

D1.1.3 (PM12): Report on the technology for transportable and energetically autonomous measurement systems.

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

No significant deviations have occurred during the first year between the planned activities and those actually performed.

6. Expected activities for the following reference period

- Continuation and upgrade of the in-situ measurement programmes in the regions considered by the Project;
- Activation of new infrastructures for the execution of measurements to support climate and environmental studies in the regions considered by the Project;
- Development of specific procedures for acquisition of information, measurement protocols, data acquisition and transmission.
- Use of transportable systems for the measurements of atmospheric compounds and climate-environmental parameters.
- Integration and exchange of data with other international initiatives on measurement networks (e.g. GMES, GEO, SUSKAT).