



## **Project of Strategic Interest NEXTDATA**

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

### **WP 1.2 - GAW-WMO climate observatories (Resp: Angela Marinoni, CNR-ISAC)**

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

#### **1. Planned activities and expected results**

Italian Institutions are managing two Global Stations belonging to the GAW-WMO programme: the Italian Climate Observatory "O. Vittori" at Monte Cimone (2165 m a.s.l., northern Apennines) and the Nepal Climate Observatory – Pyramid (5079 m a.s.l., Nepal). Thanks to their location at high altitudes, the measurements performed at these Global Stations are considered well representative of wide geographical areas, which allows an effective characterization of atmospheric variability over large regions and long time frames for two regions (the Mediterranean basin and the Himalayas) particularly affected by anthropogenic pressures and climate change.

During the first year, NextData supported the measurement programmes already in place at these GAW stations in the framework of the SHARE Project. Additionally, feasibility studies have been undertaken for the upgrade of (i) GAW-WMO stations, (ii) stations which operate within the SHARE Project. The measurement upgrade strategies have been defined according to national and international strategies (GAW-WMO, GMES, UE Projects).

M1 (PM8): Definition of the "scientific questions".

M2 (PM12): Definition of the measurement strategies. Feasibility studies for upgrading the Regional Stations GAW-WMO, in synergy with the SHARE-Italia network

#### **2. Deliverables expected for the reference period**

D1.2.1 (PM8): Report describing the status of GAW-WMO stations managed by Italian Institutions or participating in the SHARE project

D1.2.2 (PM12): Report describing the feasibility of upgrade actions for measurement stations within GAW-WMO.

D1.2.3 (PM12): Report describing the activities, data transfer to archives and to the General Portal

### 3. Activities actually carried out during the reference period

The observations and study activities at the GAW-WMO global station Monte Cimone (GAW ID: CMN) and Nepal Climate Observatory – Pyramid (GAW ID: PYR), already started within the SHARE project, have been continued. Within this framework, activities were carried out concerning instrument calibrations and data validation for trace gases (greenhouse and reactive), atmospheric aerosol (chemistry and physics), meteorological parameters and solar radiation fluxes (short-wave and long-wave) observations, according to the guidelines of the GAW-WMO programme.

During the reference period, data of atmospheric composition (until 31 dicembre 2011) were submitted to the GAW-WMO reference databases (<http://ds.data.jma.go.jp/gmd/wdogg/>, <http://ebas.nilu.no/Default.aspx>).

Data will be also shared with the NextData General Portal, once it is available. The status of data availability at the two global stations, is reported in Deliverable D1.2.3. To have a timely update of data behavior and availability at these stations, a near-real time (NRT) visualization system has been implemented at the CNR-ISAC Headquarters in Bologna.

In the framework of the activities described in deliverable D1.2.1, the group of CNR-ISAC at Bologna (ISAC-BO) and URT Ek-K2-CNR personnel, performed the inspections of the Global Station “O. Vittori” (Monte Cimone, Italy), Global Station NCO-P (Himalayas - Nepal), Regional Station “R. Sarao” (Lampedusa) and the high-mountain station Campo Imperatore – Monte Portella (Abruzzo). Due to adverse weather conditions, the inspection at Plateau Rosa (Valle d’Aosta) will be undertaken in 2013. However, the fruitful interaction with the station manager led anyway to the drafting of a report (in D1.2.1) on the current status of the station.

Moreover, a series of feasibility studies were carried out during the first year of NextData, to evaluate possible upgrades of the measurement programme at (i) GAW-WMO station managed by Italian Institutions, (ii) stations which operate within the SHARE Project. The following studies are reported in deliverable D1.2.2:

- *FEASIBILITY STUDY FOR THE INSTALLATION OF A WAVELENGTH-SCAN CAVITY RING DOWN SPECTROSCOPY (WS-CRDS) FOR GREENHOUSE GAS AND CARBON MONOXIDE MEASUREMENTS IN REMOTE MEASUREMENT STATIONS.*
- *FEASIBILITY STUDY FOR THE UPGRADE OF A COMMERCIAL CARBON MONOXIDE ANALYZER IN REMOTE MEASUREMENT STATIONS.*
- *FEASIBILITY STUDY FOR THE INSTALLATION OF NO<sub>x</sub> MEASUREMENT SYSTEMS IN REMOTE MEASUREMENT STATIONS.*
- *FEASIBILITY STUDY FOR THE UPGRADE OF THE SAMPLING SYSTEM OF A COMMERCIAL INSTRUMENT FOR THE ON-LINE MONITORING OF PM<sub>1</sub> AND PM<sub>10</sub>.*
- *FEASIBILITY STUDY FOR THE INSTALLATION OF AN AEROSOL LIDAR AT THE GAW-WMO GLOBAL STATION “O. VITTORI” AT MT. CIMONE.*

#### 3.1 Research Activities

At the **Nepal Climate Observatory – Pyramid (NCO-P)**, the technical upgrade of the power supply system was performed, as well as the enlargement of the station laboratories (a photovoltaic system for the production of 10.3 kW/h was built and a new set of batteries for energy storage was installed). The experimental set-up was

strengthened by installing a new system for the monitoring and on-line characterization of PM1, PM10, and the aerosol size distribution in the accumulation and coarse fraction ranges. Moreover, technical and logistic support was provided, as well as the electrical power for the installation of a Mercury analyzer working within the UE Project GMOS (Global Mercury Observation System).

In collaboration with ENEA-UTMEA, the Partners are redefining the strategy for the measurements of solar radiation fluxes at the GAW-WMO Global Station NCO-P by the acquisition of new instrumentation (pyranometer and pirgeometer).

During March – April 2012, a maintenance campaign was undertaken at NCO-P for the checking and calibration of the experimental set-up. Technicians and researchers from URT Ev-K2-CNR, ISAC-BO, LGGE-CNRS and the Pyramid personnel, participated in this campaign. Taking advantage of the scheduled inspection, ISAC-BO personnel also assessed the results of the major technical interventions carried out at NCO-P, as also reported in Deliverable D1.2.1.

To fulfill the recommendations of the GAW-WMO Joint Scientific Committee (JSC) to start measurements of precipitation chemistry at the GAW-WMO Global Station NCO-P, during June – July, the URT Ev-K2-CNR personnel implemented and upgraded the set-up for rainfall analysis (both sampling and storage systems). The sampling activity started on 18 June, 2012 on a daily basis until the middle of August and afterwards on a weekly basis until the end of October 2012. Starting from winter, a protocol for snow precipitation sampling has been activated (one sample/week).

In December 2012, the purchase of an aerosol LIDAR (Leosphere France) was discussed with the Irish Air Force. A study was performed for the installation of this system at the NCO-P also thanks to the collaboration with the National University of Ireland in Galway (Dr. Martucci). The adoption of a similar instrumentation at this measurement site would greatly upgrade the observing capacity of the station, with particular emphasis on the investigation of aerosol transport to the high Himalayas. It would also respond to the key priority, expressed by GAW-WMO, on the necessity of implementing a global network of aerosol and cloud lidars (see Deliverable D1.2.2).



**Figure 1.** The NCO-P GAW-WMO Global Station after the upgrade.

Also thanks to the interaction with WCC-EMPA personnel and according to the GAW-WMO guidelines and strategic plans (2008-2013), a feasibility study was performed to upgrade the greenhouse gas observations at the GAW-WMO Global Station NCO-P (and at other remote observatories) by installing a CRDS (cavity ring-down spectroscopy) system (see Deliverable D1.2.2). The system will allow simultaneous and continuous measurements of carbon dioxide, carbon monoxide, methane and water vapor. In December 2012, ISAC-BO personnel visited the WCC-EMPA laboratories to discuss the modality of implementation of this instrumentation at NCO-P and at other remote Observatories. Once available, the instrumentation will play an important role in defining the contribution of combustion processes related to biomass burning against those related to fossil fuels on the atmospheric composition properties in the Himalayas. This represents one of the major “scientific questions” in the Himalayan region, as defined in the framework of the ABC-UNEP project.

Also to support these observational activities, from November 2012 a fellowship (1 year) has been activated at CNR-ISAC Bologna.

At the GAW-WMO Global Station Monte Cimone, the first audit by the WCC (“World Calibration Center for Surface Ozone, Carbon Monoxide, Methane and Carbon Dioxide” of GAW) was hosted on 24-26 September, 2012. ISAC-BO, in collaboration with WCC personnel (hosted by EMPA), managed and coordinated both the preparation of the audit as well as the research activities carried out during the audit at the Italian Climate Observatory “O. Vittori”. This activity, which results will be made available in the coming months, focused on measurements of surface ozone, carbon monoxide, methane and nitrous oxide, with special emphasis on the instrumental set-up, calibration scales and QA/QC procedures at the station.

A Memorandum of Understanding has been signed with NOAA-GMD (National Oceanic and Atmospheric Administration - Global Monitoring Division) for the adoption of calibrated reference gas cylinders for CO<sub>2</sub>, CH<sub>4</sub>, CO and SF<sub>6</sub> (primary reference standards of GAW-WMO network), in collaboration with University of Urbino.

According to the “scientific questions” defined during the first project year (Deliverable D1.1.1), also thanks to the interaction with the EU Project ACTRIS, a project was defined for the realization of an advanced monitoring system for the measurement and investigation of NO<sub>x</sub> at the GAW-WMO Global Station Monte Cimone and at other remote Observatories (see deliverable D1.2.2). The installation of this instrumentation, based on the use of a chemiluminescence analyzer coupled with a photolytic converter, will represent a significant upgrade of the station. Currently, the procedures for the acquisition of some components of the system (chemiluminescence analyser, multicalibrator system, certified standard cylinders) are ongoing. Moreover, the implementation of SO<sub>2</sub> measurements has been planned. The acquisition of some components of the system (UV-fluorescence analyzer, permeation tubes for calibrations) is on going. Once tested at Mt. Cimone, the technical details will be shared with the other remote stations involved in the Project.

In July 2012, at the GAW-WMO global station Monte Cimone, the NDIR system for the continuous monitoring of carbon monoxide concentrations was upgraded. To adapt such instrumentation for working in a remote site like Monte Cimone, according to specific indications from the WCC-EMPA, a feasibility study was performed (see Deliverable D1.2.2), which led to the execution of several modifications to the instrumental set-up as well as to the measurement handling procedures. This significantly improved the measurement accuracy.

At the GAW-WMO Global Station Monte Cimone, the experimental set-up for monitoring atmospheric aerosol was upgraded by installing a new system for the online determination of PM<sub>1</sub> and PM<sub>10</sub> ( $\beta$ -absorption) offering the possibility of storing samples for offline chemical analysis. For this purpose, a study was carried out (see deliverable D1.2.2) to evaluate the feasibility of similar systems at remote Observatories characterized by adverse weather conditions. A series of technical inspections to the station were performed to define the modality of the system installation: this entailed the execution of infrastructural adaptation works by ISAC-BO personnel. The instrument (SWAM 5A MONITOR, FAI Instrument S.r.L), which provides 12-hour average values of PM<sub>1</sub> and PM<sub>10</sub>, was coupled with an optical particle counter (OPC monitor, FAI Instrument S.r.L), which provides the on-line aerosol size distribution in the accumulation and coarse ranges with 1-min resolution. Once connected by means of specific software, these instruments together will provide accurate Near Real Time (with 1-min resolution) information on PM<sub>1</sub> and PM<sub>10</sub> concentrations in the atmosphere. This allowed a significant upgrade of the capacity of atmospheric composition variability analysis on near-real time (NRT), in line with GAW-WMO recommendations concerning the adoption of technology for the provision of NRT data. Also with the aim of supporting the new experimental programmes with suitable manpower, a fellowship (duration: 1 year) was activated at CNR-ISAC Bologna in October 2012. In this framework, an automatic procedure for the validation of BC data has been developed and applied to the Mt. Cimone time series.

In September 2012, a new surface ozone analyzer (Thermo Tei 49i) was installed at the "O. Vittori" Station. After one year of intercomparison with this new instrument, the UV-absorption analyzer (Dasibi 1108) which has been working at this station from 1996, will be de-activated or used as a back-up instrument.

In October 2012, a LIDAR system (developed at the CNR-ISAC laboratories in Rome) with backscatter (BL) depolarization lidar (DL) with night-time Raman capabilities (RL) was installed at Monte Cimone, with the aim of evaluating the feasibility of use of this advanced instrumentation in remote high altitude observatories. It was positioned on the equipped terrace of the laboratory. Even if the system was already operative just after the installation, the beginning of experimental activity had to be postponed until 16 November, 2012, due to the delay in obtaining the permit to operate (NOTAM) from the National Aviation Authorities.

Recently, the atmospheric observatory located at Chacaltaya (La Paz University), joined GAW-WMO thanks to an international consortium (composed of CNRS, LGGE, IRD, LSCE, PSI, CNR-ISAC, Ev-K2-CNR), which supported the re-establishment of atmospheric observations in the Bolivian Andes. On 2-3 April, 2012, ISAC-BO personnel in collaboration with URT Ev-K2-CNR performed the maintenance and set-up of the surface ozone analyzer working at Chacaltaya. During the reference period, ISAC-BO personnel provided to the La Paz University personnel technical and scientific instructions on how to operate the surface ozone measurements correctly.

### **3.2 Applicative, technological and information developments**

- A feasibility study was compiled for the implementation of greenhouse gas measurements by CRDS systems at remote observatories.
- A feasibility study was compiled for the upgrade of a commercial system for the measurement of atmospheric carbon monoxide at remote sites.

- A feasibility study was completed for an advanced system for the measurement of NO<sub>x</sub> at remote observatories.
- A feasibility study was completed for upgrading the sampling system of a commercial instrument for the on-line monitoring of PM1 and PM10 at high mountain observatories.
- A feasibility study was completed for the implementation of aerosol LIDAR measurements at the GAW-WMO global station "O. Vittori".
- Software was developed for the automation of calibration procedures for surface ozone analyzers working at remote sites.
- Software was developed for the automatic validation of black carbon data by integrating despiking functions and QA/QC procedures (see the deliverable D1.2.2 for more details).

### **3.3 Training activities**

- Master Thesis (at University of Turin): "Ozone and black carbon variability in Southern Himalayas: influence of biomass burning emissions".
- PhD Thesis (at University of Urbino): "Analysis of synoptic-scale mineral dust transport to the Nepal climate Observatory – Pyramid GAW-WMO Global Station".
- During the maintenance campaign at NCO-P (Nepal), activities devoted to the training of local staff were continued with the aim of increasing their ability to manage and maintain the experimental instrumentation.
- Participation of 2 station operators in the "22nd GAWTEC Training Course" at the Zugspitze GAW-WMO Global Station (Germany).
- One training fellowship (Borsa di Studio) and one research fellowship (Assegno di Ricerca) were activated.

### **3.4 Dissemination**

None in this period.

### **3.5 Participation in conferences**

- Bonasoni P., Adhykari B., Inception Workshop: Reducing the Impacts of Black Carbon and other Short Lived Climate Forcers, 1-3 April, 2012, Kathmandu, Nepal.
- Bonasoni P., Impact of BC and Ozone at the Nepal Climate Observatory - Pyramid in Himalaya and on the Mountain ecosystems around the World, International Expert Consultation on Mountains and Climate Change, 4 April, 2012, Kathmandu, Nepal.
- Bonasoni P., Adhykari B., International Conference of Mountain Countries on Climate Change, 5-6 April, 2012, Kathmandu, Nepal.
- Bonasoni P., Scientific Research & Climate, SHARE General Assembly, 30 May 2012, Rome, Italy.
- A. Marinoni, ACTRIS General Assembly, 3-6 June 2012, Stresa, Italy.

- S. Fuzzi et al., SHARE contribution to ABC project, ABC Science Meeting, 13-14 September, 2012, Beijing, China.
- Bonasoni, P., A. Marinoni, P. Cristofanelli, P. Laj, R. Duchi, E. Vuillermoz, B. Adhikary, T.C. Landi & D. Putero. 2012. High level of pollution transported up to 5000 m a.s.l. in the Southern-Himalayas: continuous observations since 2006 at NCO-P GAW global Station. Sixth National Conference on Science and Technology – Economic, Growth through Science, Technology and Innovation, Kathmandu, Nepal, 25-27 September 2012.
- Adhikary, B., P. Bonasoni, P. Cristofanelli, A. Marinoni, R. Duchi, F. Calzolari, T. C. Landi, D. Putero, S. Fuzzi, S. Decesari, E. Vuillermoz, P. Stocchi, G.P. Verza, Sarika Kulkarni, South Asian Aerosols: Observations and regional scale modeling perspectives from the Nepal Himalayas. American Geophysical Union, Fall Meeting, December 1-7, 2012, San Francisco, USA.
- Cristofanelli, P., R. Duchi, B. Adhikary, P. Bonasoni, M.C. Facchini, F. Fierli, S. Fuzzi, F. Calzolari, S. Decesari, T. C. Landi, P. Laj, A. Marinoni, D. Putero, P. Stocchi, Mineral dust transport at the Nepal Climate Observatory – Pyramid" (27°57' N, 86°48' E, 5079 m a.s.l.). American Geophysical Union, Fall Meeting, December 1-7, 2012, San Francisco, USA.

#### 4. Results obtained during the reference period

##### 4.1 Specific results (databases, measurements results, model outputs, etc)

Activities at the GAW-WMO global station Monte Cimone and Nepal Climate Observatory – Pyramid, resulted in a database including meteorological parameters, trace gases mixing ratios and atmospheric aerosol. Data availability and validation status are

Additionally, the following scientific results have been achieved in the framework of the SHARE project:

- Assessment of the contribution of biomass burning emissions and anthropogenic pollution to the variability of BC, ozone and carbon monoxide observed at the global station GAW-WMO at Mt. Cimone;
- The influence of biomass burning emissions on inter-annual variability of ozone and black carbon concentrations in the Himalayas, identifying the main source areas and providing a preliminary assessment of their contribution;
- Characterization of the mineral aerosol transport to NCO-P extended to years 2006-2011;
- Analysis of long term surface ozone trend at the "O. Vittori" GAW-WMO Global Station at Monte Cimone.

##### 4.2 Publications

Bonasoni P., Cristofanelli P., Marinoni A., Vuillermoz E., Adhikary B. Atmospheric pollution in the Himdu Kush – Himalayan Region – Evidences and Implications for the Regional Climate. *Mountain Research Development*, 32(4):468-479. 2012.

Cristofanelli, P., F. Fierli, A. Marinoni, R. Duchi, J. Burkhart, A. Stohl, M. Maione, J. Arduini, and P. Bonasoni. Influence of biomass burning and anthropogenic emissions on

ozone, carbon monoxide and black carbon concentrations at the Mt. Cimone GAW-WMO global station (Italy, 2165 m a.s.l.). *Atmos. Chem. Phys. Discuss.*, 12, 21399-21435, 2012.

Cristofanelli, P., H.E. Scheel, F. Calzolari, R. Duchi, A. Marinoni and P. Bonasoni, Analysis of surface ozone trends at the Mt. Cimone GAW Global station (Italy), IGAC 2012, 17 -21 September 2012, Beijing, China.

Marinoni A., P. Bonasoni, P.Cristofanelli, P. Laj, R. Duchi, E. Vuillermoz, B. Adhikary, T. C. Landi, D. Putero and S. Fuzzi. High level of pollution transported up to 5000 m asl in the Southern-Himalayas: continuous observations since 2006 at NCO-P GAW global Station, IGAC 2012, 17 -21 September 2012, Beijing, China.

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

- The data Availability for the “O. Vittori” GAW-WMO Global Station at Monte Cimone is reported in the Deliverable D1.2.3 (part of the data series were obtained in the framework of SHARE and other Research Projects).
- The data Availability for the Nepal Climate Observatory - Pyramid GAW-WMO Global Station at Monte Cimone is reported in the Deliverable D1.2.3 (part of the data series were obtained in the framework of the SHARE Project).

#### **4.4 Completed deliverables**

D1.2.1: Report describing the status of GAW-WMO stations managed by Italian Institutions or related with the SHARE project

D1.2.2: Report describing the feasibility of upgrade actions for measurement stations within GAW-WMO.

D1.2.3: Report describing the activities, data transfer to archives and to the General Portal.

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

The technical inspections at the Plateau Rosa station were postponed to 2013. Some delays arose in the implementation/upgrade of the measurement programme at the GAW-WMO Global Station of Monte Cimone, due to administrative problems associated with the adoption of new purchase regulations by CNR.

### **6. Expected activities for the following reference periods**

- Continuation of observation and investigation activities at the GAW-WMO Global Station led by Italian Institutions (implementation of measurement programmes and technological facilities);
- Start of upgrade activities at remote GAW-WMO stations in Italy and at other SHARE stations;
- The scientific community will be informed about the upgrade/implementation activities at the stations by participation in meetings, workshops and conferences in



the framework of national and international initiatives (e.g. GAW-WMO, ACTRIS, GEO, Copernicus). The resulting data will be shared throughout the NextData General Portal and the other data-bases.