Project of Strategic Interest NextData

Deliverable D1.2.1

Status of GAW-WMO stations managed by Italian Institutions or related to the SHARE project

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Report on the status of the GAW-WMO Global Station “O. Vittori” at Monte Cimone

1. Objectives and methods

The present document, drafted in the context of WP1.2 of the Project of National Interest NextData, provides a description of the current status of the atmospheric-climate monitoring activities at the GAW-WMO Global Station “O. Vittori” at Monte Cimone. The report also provides information on possible instrumental or infrastructural implementations targeted to support the competitiveness of the said facility in a national and international scientific context. In fact, to confront the climate challenges of our time, researchers and scientists require facilities capable of generating the data necessary for increasing the knowledge of basic atmospheric processes and supporting the development of forecasting models.

In particular, the report will give a detailed description of the research infrastructure, measurement programmes currently in progress, the number and type of personnel directly involved in running the activities, and participation in research initiatives or projects. The report is based on the results of numerous technical inspections of the station “O. Vittori” during the calendar year 2012 by the ISAC-BO, directly involved in the direction and management of the GAW-WMO station and the research programmes carried out there.

2. Infrastructure

The GAW-WMO Italian Climate Observatory “O. Vittori” is hosted by the facilities of the Italian Military Airforce (AMI) Observatory, on Monte Cimone (44.10N, 10.42E; 2165 m a.s.l.), the highest peak of the Northern Italian Apennines. It is situated in the building that formerly hosted the Italian Alpine Club (CAI) “Gino Romualdi” mountain shelter. The “O. Vittori” station is managed by the CNR Institute of Climate and Atmospheric Sciences (CNR-ISAC) in Bologna. As well as coordinating research activities in international and national contexts, CNR-ISAC directly performs most of the measurements and monitoring programmes undertaken there, also supplying technical, logistic and scientific support to organizations and institutions which perform, also as part of research campaigns, their own measurement activities at the station.

2.1 Station personnel

CNR – ISAC personnel supporting the GAW-WMO Global Station “O. Vittori” comprises 1 senior researcher, 2 researchers, and 1 technician. Monitoring and scientific research activities undertaken by CNR-ISAC at the “O. Vittori” station is also supported by 2 research fellows (one of whom was recently hired in the context of the project NextData) and 1 research assistant.

2.2 *Geographical location and site characteristics*

Situated on the highest peak of the Tuscan-Emilian Apennines, (Fig. 1), the station “O. Vittori” plays a strategic role in the study of tropospheric conditions in the central Mediterranean Basin, with particular reference to following themes:

Study of variability of greenhouse gases, reactive gases and aerosol physical-chemical properties on different time-scales (e.g. Giostra et al., 2011; Andrews et al., 2011; Marinoni et al., 2008);

Study of the influence of anthropogenic emissions during regional and trans-boundary pollution transport events (e.g. Cristofanelli et al., 2006; Cristofanelli et al., 2009; Marinoni et al., 2008; Maione et al., 2008).

Study of the influence of natural processes in regional- and long-range transport events, as well as those from the stratosphere (e.g. Zauli-Sajani et al., 2011; Cristofanelli et al., 2009; Cristofanelli et al., 2008; Bonasoni et al., 2000a).

Figure 1 shows the location of GAW-WMO (Regional and Global) stations in the European domain and the Mediterranean Basin, where measurements of greenhouse and reactive gases are performed (http://wdcgg.jpma.jp). It is evident that the Station of Monte Cimone is currently the only station of the GAW-WMO network located south of the Alps and the Po Valley. Together with the expertise of the personnel participating in research activities on measurements of atmospheric composition in high mountains, this has made the station a research infrastructure of international standing, of strategic interest to all studies concerning the physical and chemical processes in the Mediterranean Basin and southern Europe (Bonasoni et al., 2000; Fischer et al., 2003). Its role is testified by more than 60 articles published in ISI reviews, produced over a number of years, based on the data recorded at the "O. Vittori" station (http://www.isac.cnr.it/cimone/biblio).

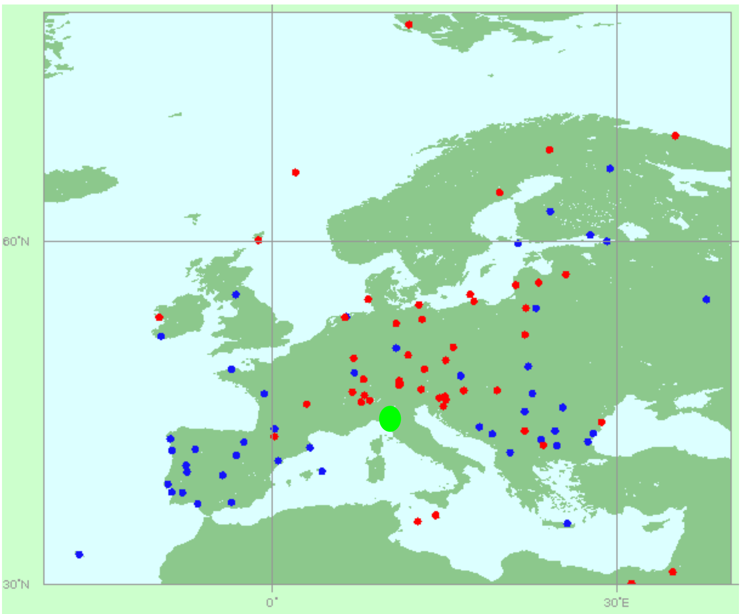

Figure 1. Locations of GAW-WMO stations affiliated to the World Data Center For Greenhouse Gases in the European domain (in red, stations sending data in the last calendar year). The large green circle indicates the position of the station "O. Vittori" of Monte Cimone.

Thanks to its altitude, Mt. Cimone is normally located above the height of the Atmospheric Boundary Layer (ABL). During the warm summer months, processes linked to the rise in ABL height or the mountain thermal wind regime can favour the direct transport of air masses rich in anthropogenic pollutants from the nearby Po Valley or Tuscany. This also allows the close study of the effects of pollutant transport of the chemical and physical characteristics on the "free troposphere".

The area in the immediate vicinity of the site is composed of terrain characterised by the presence of rocky outcrops (Fig. 2). The upper tree-line is positioned at around 1800 m a.s.l., even if grasslands extend above 2000 metres. Local sources of pollutants are entirely absent (the "O. Vittori" station and the nearby AMI Observatory only employ electrical energy). In the winter season only (December to March), an important skiing complex extends up to 300 m from the peak of Monte Cimone. The nearest settlement is Sestola (approximately 1500 inhabitants), situated some 15 km from the site at an altitude of 1400 m a.s.l.. The closest industrial and urban areas are those of Florence, Modena and Bologna, all within a radius of 50-60 km from the measurement site.

2.3 Access

Access to the Station, for the transport of personnel and materials, is guaranteed year round. During summer, a military road (managed and maintained by the Military Airforce – CAMM Monte Cimone) can be used to reach the locality of Pian Cavallaro (1850 m a.s.l.), immediately below the peak of Monte Cimone. From here, there is an internal cable car in operation, owned by the Military Airforce, by which it is possible to reach and transport materials to the Station "O. Vittori". Bulky materials can instead be transported, only during summer, by means of an externally operated cableway. In winter, Pian Cavallaro can be reached by the Cimone ski lifts (if running). If weather and snow cover conditions are favourable, it is possible to use a snow cat for the transport of bulky material. Accessibility is more problematic during transitional seasons, when the simultaneous closure of the military road and lifts can affect the ability to reach the measuring station or carry materials there.

2.4 Infrastructural facilties

The infrastructure hosting the GAW-WMO station occupies the premises of the former CAI shelter "G. Romualdi", completely renovated by the CNR in the period 1996-2000. Extending over 2 floors, they comprise: a laboratory for atmospheric aerosol measurements, a computer room, a laboratory for greenhouse gas measurements and one for the measurement of reactive gases. There is also a technical room, which houses high- and low-volume samplers for the study of atmospheric aerosol. To allow technical and research staff to stay at the station, there are two bedrooms providing 6 beds.

The Station "O. Vittori" also has an equipped terrace that can accommodate measurement instruments. It hosts the "weather hut", in addition to the centralized sampling system for the measurement of atmospheric aerosol, and antennas for the satellite internet connection. The following are located on the station's roof: the centralized inlet for the sampling of trace gases (greenhouse and reactive gases), 2 sampling heads for PM10 (for use coupled with two high-volume samplers), 2 sampling heads (PM1 and PM10) for use coupled with a low-volume sampler (recently installed as part of NextData activities).

In particular, the trace gas sampling system is designed to GAW guidelines, and is composed exclusively of Pyrex© and Teflon©. Externally heated, thanks to a high aspiration flow, it ensures the retrieval and air also in high wind conditions, reducing to a few second the residence time of air samples within the sampling system.

The centralized sampling system for studying the physical-chemical properties of atmospheric aerosol, has been designed according to the recommendations of the GAW/WMO and the EU project EUSAAR (European Supersites for Atmospheric Aerosol Research). The sampling system, made entirely in stainless steel, is equipped with laminar main flow (150 l/min) and an isokinetic separator of flows, which are subsequently distributed to the various instruments. An external pump with adjustable flow allows the maintenance of a constant total flow, also in the event variations in the general instrumental set-up. The shape of the sampling head allows sampling even in extreme conditions of wind and ice formation, since it extends up to about 6 m above ground level (3 m from the surface of the outdoor terrace).

The electrical power necessary to run the station's equipment is supplied by the commercial mains network, with a maximum capacity of 18 kW/h. The laboratories are all equipped with systems guaranteeing electrical continuity (UPS), surge protection systems and internet connection allowing remote access to the data acquisition and transfer systems (also in near real time/NRT).

Figure 2. Italian Climate Observatory "O. Vittori" part of the GAW-WMO Global Station at Monte Cimone during summer (above) and winter (below).

Figure 3. Detail of the laboratory for the study of atmospheric particulate.

Additionally, the laboratories contain special distribution lines linking the different analyzers to the centralized sampling systems and calibration systems (Figure 3). The reactive gas laboratory (first floor) is also equipped with two quartz windows in the roof, permitting the use of the remote sensing systems which work in the visible and infrared spectral field.
Over the years, the "O. Vittori" Station has also hosted supplementary instrumentation during measurement campaigns undertaken by various national and international projects (eg., MINATROC, PMTC2004, AEROCLOUDS, PEGASOS).

3. Instrumentation

Listed below is the instrumentation in use at the""O. Vittori" Station, indicating for each instrument, the measurement start date, the institution responsible for the measurements acquired and the status of measurements (active/inactive) at the times of inspection:

Meteorology

Automated weather station (atmospheric pressure, air temperature, relative humidity, wind direction and intensity). Manufacturer: IRDAM. Start date: 1996. Status: ACTIVE. Institution: CNR-ISAC.

Weather hut (atmospheric pressure, air temperature, relative humidity). Manufacturer of sensors: Rotronics, Tecnoel. Start date: 1996. Status: ACTIVE. Institution: CNR-ISAC.

2 sonic anemometers (wind speed and direction). Manufacturer: Vaisala. Start date: 2002. Status: ACTIVE. Institution: CNR-ISAC.

1 lightning detector (position and type of electrical charges in the atmosphere). Manufacturer: Boltek. Start date: 2003. Status: ACTIVE. Institution: CNR-ISAC.

Reactive gases

NDIR analyzer (CO mixing ratio). Manufacturer: Thermo Electron Corporation. Start date: 2012. Status: ACTIVE. Institution: CNR-ISAC.

UV absorption analyzer (O_3 mixing ratio). Manufacturer: DASIBI. Start date: 1996. Status: ACTIVE. Institution: CNR-ISAC.

UV absorption analyzer (O_3 mixing ratio). Manufacturer: Thermo Scientific. Start date: 2011. Status: ACTIVE. Institution: CNR-ISAC.

Calibrator for UV absorption analyzer (O_3). Manufacturer: Thermo Scientific. Start date: 2010. Status: ACTIVE. Institution: CNR-ISAC.

Gas chromatographic GC-FID modified system (mixing ratio CO). Manufacturer: AGILENT. Start date: 2007. Status: ACTIVE. Institution: University of Urbino/CNR-ISAC.

DOAS spectrometer (columnar O_3 and NO_2). Start date: 1993. Status: ACTIVE, Institution: CNR-ISAC.

Greenhouse gases

Gas chromatographic GC-FID modified system (CO, CH4, N_2O, SF_6 mixing ratio). Manufacturer: AGILENT. Start date: 2007-2008. Status: ACTIVE. Institution: University of Urbino/CNR-ISAC.

Gas chromatographic GC-MS modified system (mixing ratio CFC-11, CFC-12, CFC-113, CFC-114, CFC-115, HCFC-22, HCFC-141b, HCFC-142b, HCFC-124, H-1301, H-1211, CH_3Cl, CH_3Br, CH_3I, CH_2Cl_2, CH_2Br_2, $CHCl_3$, $CHBr_3$, CH_3,CCl_3, CCl_4, TCE, PCE, HFC-23, HFC-32, HFC-134a, HFC-152a, HFC-125, HFC-143a, HFC-365mfc, PFC-116, PFC-218, hydrocarbons C3 – C6). Manufacturer: AGILENT. Start date: 2003. Status: ACTIVE. Institution: University of Urbino/CNR-ISAC.

Radiometry and photometry

Pyranometer (solar radiation λ: 350 – 1100 nm). Manufacturer: Skye. Start date: 2004. Status: ACTIVE. Institution: CNR-ISAC.

UV-B radiometer (solar radiation λ: 280 – 315 nm). Manufacturer: Skye. Start date: 2004. Status: ACTIVE. Institution: CNR-ISAC.

Aerosol

Differential Mobility Particle Sizer (Size distribution of atmospheric aerosol in the 10 – 500 nm range). Start date: 2005. Status: ACTIVE. Institution: CNR-ISAC.

Optical particle counter (Size distribution of atmospheric aerosol in the 300 – 20000 nm range). Manufacturer: Grimm Gmbh. Start date: 2002. Status: ACTIVE. Institution: CNR-ISAC.

Optical particle counter (Size distribution of atmospheric aerosol in the 300 – 20000 nm range). Manufacturer: FAI. Start date: 2012. Status: ACTIVE. Institution: CNR-ISAC.

Nephelometer (Aerosol scattering coefficient at 525 nm). Manufacturer: Ecotech. Start date: 2007. Status: ACTIVE. Institution: CNR-ISAC.

Condensation Particle Counter (Numerical aerosol concentration). Manufacturer: TSI. Start date: 2008. Status: ACTIVE. Institution: CNR-ISAC.

Multi Angle Absorption Photometer (Aerosol absorption coefficient at 670 nm). Manufacturer: Thermo Electron Corporation. Start date: 2007. Status: ACTIVE. Institution: CNR-ISAC.

Virtual impactor (Aerosol chemical composition in fractions PM_1 and PM_{1-10}). Manufacturer: Universal Air Sampler TM. Start date: 2000. Status: ACTIVE. Institution: CNR-ISAC.

Two-channel PM1-PM10 sampler (On-line determination of particulate mass and sampling for off-line chemical analyses). Manufacturer: FAI. Start date: 2012. Status: ACTIVE. Institution: CNR-ISAC.

High-volume sampler (Concentration ^{7}Be, ^{210}Pb and PM10). Manufacturer: Thermo Electron. Start date: 1998. Status: INACTIVE. Institution: University of Bologna/CNR-ISAC.

Ancillary measurements

Radon Monitor (Concentration ^{222}Rn). Manufacturer: AlphaGuard. Start date: 2008. Status: ACTIVE. Institution: CNR-ISAC.

4. Affiliation to research projects/programmes

In addition to measurements performed in the framework of the GAW-WMO programme, monitoring activities carried out at the GAW-WMO station "O. Vittori" also regard the following national and international observation projects/programmes.

SHARE (Stations at High Altitude for Research on the Environment)

ACTRIS (Aerosols, Clouds, and Trace gases Research InfraStructure Network)

AGAGE (Advanced Global Atmospheric Gases Experiment)

MACC-2 (Monitoring Atmospheric Composition and Climate - Interim Implementation)

METEOMET (Metrology for Meteorology)

Supersito ARPA – Regione Emilia Romagna

5. Analysis of possible upgrades

As previously reported, the GAW-WMO Station "O. Vittori" presents an impressive instrumental set-up that guarantees the availability of one or more parameters for each of the seven GAW "focal areas", in line with the requirements set forth in the GAW-WMO programme for the status of "global" station (see Box 1). Although the station "O. Vittori" was found to be entirely satisfactory in terms of technical/instrumental facilities and performance of observation programmes, some areas of possible upgrade have been identified. They are reported below:

5.1 Greenhouse Gases

The surveys carried out took note of the absence of primary calibration standards directly derived from the reference scale adopted by the GAW programme for methane (CH4), sulphur hexaflouride (SF6), nitrous oxide (N2O) and carbon monoxide (CO, even if not a greenhouse gas, is considered in this context). The station is instead equipped with standard mixes referring indirectly to the NOAA2004 and NOAA 2006a calibration scales. Even though the calibration standards have been developed in compliance with the CMDL-NOAA directives at an approved laboratory (MPI-BJC, Jena, Germany) and are characterised by a high level of accuracy and stability, also in the light of indications provided by the GAW programme (see Box 1), it is recommended that the laboratory be equipped with a system of primary gas standards directly complying with the GAW reference scale, deposited at the GMDL-ERS of the NOAA.
Greenhouse gas measurements, in particular CH4 and N2O, are performed by gas chromatographic systems, until recently considered to be state of the art for this type of analysis (in terms of repeatability, reproducibility and measurement accuracy, GAW report N. 185, 2007). However, they involve considerable investment in terms of highly specialised man-hours, costs for the purchase of consumables, secondary and carrier calibration gas mixes, as well as expenditure on the maintenance of instrumentation. Today, there are commercially available systems based on the principle of Cavity Ring Down Spectroscopy (CRDS) or Off-axis technology (ICOS). As verified during a visit, in the context of the project NextData, to the EMPA laboratories (Switzerland) which host the GAW-WMO World Calibration Center for surface ozone, CO and CH4, such systems allow the performance of the same measurements with far higher accuracy levels and reproducibility, as well as lower costs in terms of man-time, maintenance and consumption. Although it must be taken into account that the implementation of this type of instrumentation involves a significant initial financial commitment for purchase, the implementation of these technologies is recommended at the Station “O. Vittori”. Also with the aim of better evaluating the feasibility of implementing CRDS systems at a high mountain site like the “O. Vittori” Station, a a feasibility study was carried out in 2012.
Measurement of halogenated greenhouse gases have been carried out for over 10 years in collaboration with the University of Urbino, Department of Basic Sciences and Fundamentals. The instrumentation employed and the protocols followed, fulfill the requirements of the AGAGE international measurement network, to which the station is affiliated. The resources currently available for this measurement programme are only just sufficient to cover maintenance and measurement continuity, in line with AGAGE measurement quality targets, the secondary calibration mixes and the propagation of the primary calibration scale (deposited at the SCRIPPS Institute of Oceanography, University of California-San Diego, Ca, USA) which is currently not directly available at the station. To this, one must add the considerable expenditure of consumables required for the sophisticated instrumentation employed (gas chromatography with mass spectrometry reader, automated sampler/pre-concentrator).

5.2 Reactive Gases

Concerning measurements of reactive gases and pollutants, the implementation of measurement systems for the determination of trace mixing ratio of nitrogen oxides (NOx and NOy), sulphur dioxide and formaldehyde (HCHO) is recommended. Such measurements are currently not performed at “O. Vittori”, although they are among the key variables cited in the GAW observation strategy (see Table 1). However, the implementation of these measurement activities calls for a considerable financial outlay in the start-up phase, also for the installation of the technical equipment necessary to ensure their correct execution (automated calibration systems, zero air generation systems, definition and implementation of calibration routines, monitoring of sampling conditions). Also with a view to

investigating such issues, in the framework of the NextData project, a feasibility study was carried out in 2012, focusing on the implementation of NOx (NO+NO2) measurements, in compliance with the guidelines defined by the GAW-WMO and the EU project ACTRIS (the latter being only preliminary at the time this report was drafted).
At the "O. Vittori" Station, measurements are active relating to some of the VOCs listed in the GAW Report 171 (2006), which are useful for the quantification of the contribution of emissions from man-made and natural sources, and the study of atmospheric background conditions. To date, however, it has not been possible to extended measurements to all of the GAW-WMO categories. They include, in particular, biogenic hydrocarbons and oxidized volatile organic compounds: both categories are of crucial importance for gaining information on short-term variations in atmospheric composition and the still little known relations/interactions leading to the formation secondary aerosol, whose various species/typologies are already being measured at the station. Therefore, it is recommended that the instrumentation necessary for such activities should be installed at "O. Vittori".

5.3 Aerosol

At the "O. Vittori" station, the particle size distribution between 300 nm to 10 μm is measured by optical particle counter (GRIMM 1108). The instrument is based on the principle of light scattering by aerosospese particles, allowing the inference of the particle number in 15 size channels. Thus, information can be obtained on the origin of aerosols and the transformation processes they undergo in the atmosphere. In particular, phenomena of mineral dust transport from the Sahara desert have been identified and monitored at Monte Cimone for over ten years. However, the diameter identified by an optical counter is the "optical diameter ", i.e. the diameter of a spherical particle with the same refraction index of the particle considered during the instrument calibration. The refractive index of atmospheric aerosol is unknown and is generally very different from that of the particles in Latex©, the only material of a size comparable to that of atmospheric aerosols of certified diameter, which are often used when calibrating instruments that measure particle size. Since size distribution observations are crucial for determining the characteristics of the air masses reaching Monte Cimone and the identification of their main sources, it is strongly recommended to implement parallel measurements of particle size distribution based on a different principle. They would be useful in validating the instrument's reliability and might even identify some correction factors to be applied to the historical data series. An optimal instrument for measuring particle size, also recommended by the GAW- WMO and the ACTRIS EU Project, is the one based on the measurement of particle time-of-flight, which allows the measurement of particle aerodynamic diameter, i.e. the diameter of a spherical particle of unit density that falls at the same speed as the particle considered. Particle density is a more easily identifiable parameter than the refractive index. In particular, at Monte Cimone, simultaneous measurements of volume (obtainable from the size distribution measurement) and mass (currently performed by a SWAM Dual Channel, in agreement with the feasibility study reported by D1.1.2) make it easy to obtain the measurement of particle density.
A further upgrade of the aerosol measurement programme can be related to the adoption of a three-wavelengths nephelometer. Currently, the measurement of the aerosol scattering coefficient is carried out by a one-wavelength nephelometer working with light source at 525 nm. The upgrade of the experimental set-up for the aerosol coefficient determination would allow a better characterization of atmospheric aerosol and a more accurate evaluation of its climate effects.

5.4 Radiometry

The maintenance and management of radiometric instrumentation involves a number of objective difficulties, because of the lack of personnel in constant attendance on-site and the harsh weather conditions, characterised by the formation of snow-banks and ice (especially in winter). Therefore, at the present time, the only radiometric measurements undertaken at "O. Vittori" on Monte Cimone (UVB and short-wave global solar radiation flux) are performed using two silicon micro-sensors (Silicon cell pyranometer Skye SKS110, silicon photodiode Skye SKU 430). Although calibrated in line with WMO guidelines, the available instrumentation is unsuitable for carrying out, for example, close studies of solar radiation flux variability as a function of atmospheric composition variability. It is therefore recommended to implement continuous radiometric measurements employing instruments based on termopiles, along with the installation of adequate data acquisition systems. Further necessary upgrading of measurement activities in the GAW context (Table 1) include the introduction of actinic flux measurements for the determination of quantities J(O1D) and J(NO2). The implementation of these measurement programmes would also be essential to investigate correctly photochemical processes and to quantify their influence on the variability of mixing ratios of greenhouse and reactive gases (O3, NOx, CO, CH4), and of secondary aerosol.

5.5 Profiling and remote sensing

Measurements relating to the columnar content of ozone and nitrogen dioxide are performed at "O. Vittori" employing a zenith-sky DOAS system developed at ISAC-BO (GASCOD - Gas Analyser Spectrometer Correlating Optical Differences). The system has been properly maintained over the years, and has been used in inter-comparison studies as part of the NDSC (Network for Detection of Stratospheric Change) programme. However, the instrument is now dated, and an upgrade is therefore recommended. In particular, the new-generation GASCOD systems are able to determine in continuous mode the columnar quantities of NO2, O3, SO2, HCHO, and glyoxal (OCHCHO). Coupled with suitable systems for spatial scanning in the vertical plane, these systems are also able to provide the temporal evolution of the vertical profiles of detected compounds.
The Station is entirely without columnar measurements or atmospheric profiles relating to atmospheric aerosol. This type of measurement could contribute to a better understanding of the influence of certain transport processes (eg. mineral dust, polluting aerosol transport) at the measurement site, also providing real-time information that is useful, for example, in the management of critical events (eg: volcanic ash transport). For this reason, too, in the course of the NextData project, a feasibility study was launched concerning the installation of a LIDAR system, able to provide data on the vertical profiles of backscatter and linear depolarization at 532 nm. Such data could supply information on cloud and atmospheric aerosol properties, in line with the GAW requirements for Global Stations (BOX 1, point 13). Currently, the site is without any specific space for the housing of LIDAR systems and profiling. However, the instrumentation could be located in a ground-floor room already provided with a roof-opening, which might be adapted to this use.

5.6 Ancillary measurements

At the Station "O. Vittori" on Monte Cimone, ^{222}Rn measurements are performed using the commercial system AlphaGuard "Radon monitor", based on the detection of radiation emitted by the decay of ^{222}Rn. ^{222}Rn forms from the decay of uranium, has a half-life of 3.8 days, and its fluxes from the ground are about 2-3 orders of magnitude greater than those at sea. For this reason, ^{222}Rn is an efficient tracer of air masses of the lower tropospheric layers and the ABL, in particular. The instrument currently used at Monte Cimone is adequate for obtaining qualitative information on the influence of air-mass transport from the regional ABL. However, it is unsuitable for making an accurate quantitative evaluation of atmospheric concentrations of ^{222}Rn and, therefore, of the presence of air masses directly transported from the regional ABL. At the present time, "O. Vittori" lacks an adequate sampling system (equipped with a buffer tank to favour Thoron decay) able to deliver accurate and continuous air samples for the determination of ^{222}Rn concentrations. It is therefore recommended that existing instrumentation should be upgraded and integrated with a suitable sampling system that is capable of accurately determining ^{222}Rn concentrations.

BOX1 – Characteristic of GAW-WMO Global Stations (from: GAW-WMO Strategic Plan 2008 – 2015)

1. The station location is chosen such that, for the variables measured, it is regionally representative and is normally free of the influence of significant local pollution sources.
2. There are adequate power, air conditioning, communication and building facilities to sustain long term observations with greater than 90% data capture (i.e. <10% missing data).
3. The technical support provided is trained in the operation of the equipment.
4. There is a commitment by the responsible agency to long term observations of at least one of the GAW variables in the GAW focal areas (cf. Section 7).
5. The GAW observation made is of known quality and linked to the GAW Primary Standard.
6. The data and associated metadata are submitted to one of the GAW World Data Centres no later than one year after the observation is made. Changes of metadata including instrumentation, traceability, observation procedures, are reported to the responsible WDC in a timely manner.
7. If required, data are submitted to a designated data distribution system in near-real-time.
8. Standard meteorological in situ observations, necessary for the accurate determination and interpretation of the GAW variables, are made with known accuracy and precision.
9. The station characteristics and observational programme are updated in the GAW Station Information System (GAWSIS) on a regular basis.
10. A station logbook (i.e. record of observations made and activities that may affect observations) is maintained and is used in the data validation process.
11. Measure variables in at least three of the six GAW focal areas (see item 4 above).
12. Have a strong scientific supporting programme with appropriate data analysis and interpretation within the country and, if possible, the support of more than one agency.
13. Make measurements of other atmospheric variables important to weather and climate including upper air radio sondes at the site or in the region.
14. Provide a facility at which intensive campaign research can augment the long term routine GAW observations

GAW focal area	**GAW Parameter**	**Interest**	**Availability at station dealt with in the present report**
Total Ozone *Reactive gases*	**O_3**	*Air Quality* *Oxidation Efficiency* *Climate Stratospheric Ozone Depletion*	X
Reactive gases	**CO**	*Air Quality* *Oxidation Efficiency*	X
Ancillary variable	$j(NO_2)$	*Air Quality* *Oxidation Efficiency*	-
Ancillary variable	$j(O_1D)$	*Air Quality* *Oxidation Efficiency*	-
Greenhouse gases	H_2O (water vapor)	*Air Quality* *Oxidation Efficiency* *Climate* *Stratospheric Ozone Depletion*	-
Reactive gases	HCHO	*Air Quality* *Oxidation Efficiency*	-
Reactive gases	**VOCs**	*Air Quality* *Oxidation Efficiency* *Climate*	X
Reactive gases	**$NO_x = NO+NO_2$** HNO_3	*Air Quality* *Oxidation Efficiency* *Climate* *Stratospheric Ozone Depletion*	-
Greenhouse gases	**N_2O**	*Climate* *Stratospheric Ozone Depletion*	X
Reactive gases	**SO_2**	*Air Quality* *Climate*	-
Greenhouse gases	BrO, ClO, OClO HCl, $ClONO_2$ CH_3Br, **CFC-12, HCFC-22**, halons	*Climate* *Stratospheric Ozone Depletion*	X
Aerosol	**Aerosol optical properties**	*Air Quality* *Oxidation Efficiency* *Climate* *Stratospheric Ozone Depletion*	X
Greenhouse gases	**CO_2**	*Climate*	X
Greenhouse gases	**CH_4**	*Oxidation Efficiency* *Climate* *Stratospheric Ozone Depletion*	X
UV radiation		*Air Quality* *Stratospheric Ozone Depletion*	X (UV-B)
Atmospheric wet deposition		*Air Quality* *Climate*	-

Table 1. List of atmospheric constituents and focal areas indicated in the GAW-WMO Strategic Plan 2008 – 2015. In bold, the GAW components of the WMO integrated global observation system. The fourth column indicates the state of execution of observations of the said compounds at GAW-WMO station "O. Vittori" on Monte Cimone.

6. Analysis of possible criticalities

We list below possible technical and logistic criticalities concerning monitoring activities carried out at the GAW-WMO station “O. Vittori” of Monte Cimone.

1) Monte Cimone is located at a short distance from the Tyrrhenian Sea. The wind regime (mainly western) favours the transport of humid air masses towards the measuring site. Particularly in winter, due to the low temperatures recorded, significant ice formation can occur (Fig. 4), which might pose a risk not only to the performance of sampling activities but also to the safety of external equipment. During the spring-summer period, the site is frequently affected by strong storms. Although the station is equipped with a series of surge protection devices, which require constant maintenance, such events can inflict damage on infrastructures and instrumentations (meteorological and radiometric) situated in the station’s external areas.

Figure 4. Ice and snow-bank formation at the Station “O. Vittori” of Monte Cimone

2) The “O. Vittori” laboratories are not provided with air-conditioning systems. Especially during summer, this could constitute a criticality with regard to the performance of measurements which need to take place in environments with limited temperature variations or specific temperature levels (eg., DMPS, NDIR, GC-FID).
3) Currently, in the test phase, the Station has a remote internet connection system based on WI-FI technology. The absence of a suitable back-up system could impede regular data transmission and remote control of instruments.
4) The currently available electrical capacity, while more than sufficient to guarantee present measurement activities, could be insufficient in the eventuality of measurement campaigns.

7. Conclusions

Based on evidence emerging during technical surveys and interventions, in order the guarantee the full functionality of the GAW-WMO Global Station “O. Vittori” and its upgrade, particular attention must be paid to the following actions:
a. Maintenance of technical/technological facilities and scientific instrumentation also as a function of the adverse weather and environmental conditions characterising the measuring site.

b. Providing the Station with adequate air-conditioning systems.
c. Providing the Station with a suitable back-up for the internet connection.
d. Increase of the electricity supply to ensure the possibility of accommodating new instrumentation, also in the course of measurement campaigns.
e. Upgrading the greenhouse gas measurement systems.
f. Upgrade of the experimental set-up for the measurement of the aerosol physical parameters.
g. Implementation of measurements of OVOC, SO2, NOxy, HCHO; measurements of solar radiation fluxes, actinic fluxes and atmospheric profiling (DOAS, LIDAR, ceilometer systems).

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Report on the status of the GAW-WMO Global Station "Nepal Climate Observatory-Pyramid"

1. Objectives and methods

The purpose of the present document, drafted in the context of WP1.2 of Project of National Interest NextData, is to provide a description of the current status of the atmospheric-climate monitoring activities at the GAW-WMO station "Nepal Climate Observatory-Pyramid", operative since March 2006 at 5079 m, in the Khumbu valley, at the foot of Mount Everest. The Report also provides information on possible instrumental or infrastructural implementations targeted to support the competitiveness of the said facility in a national and international scientific context.
It summarizes the measurements currently in progress, along with a detailed description of the research infrastructure and of the personnel involved in its technical and scientific management.
The report is based on the processing of information gathered during the annual inspection that took place on Spring 2012, during the campaign for the calibration of all instrumentation. It also draws upon numerous internal consultations with the Ev-K2-CNR technical staff continuously present at the Pyramid Observatory, who perform daily checks on the NCOP station and are responsible for ordinary maintenance of instrumentation.

2. Infrastructure

The "Nepal Climate Observatory – Pyramid" (NCO-P) GAW-WMO Global Station was installed in February 2006, in the high Khumbu valley (Nepal). The NCOP station is directly managed by EV-K2-CNR technical personnel, who are continuously present at the Pyramid Laboratory, making at least two daily ascents to perform routine checks. The technical staff is coordinated by the Ev-K2-CNR Committee of Bergamo and the Institute of Atmospheric Sciences and Climate of the CNR in Bologna (CNR-ISAC). In addition to coordinating the scientific research activities relating to the projects in which the station participates, they also perform directly most of the measurement and monitoring programme undertaken at the station.
The installation of this high-altitude monitoring station in the Himalayas as part of the Ev-K2-CNR "SHARE-Asia" (Stations at High Altitude for Research on the Environment) and UNEP "ABC" (Atmospheric Brown Clouds) projects, was deemed essential to fill the information gap on atmospheric background conditions in this region. The station is part of the Project ABC network, listed as a "Complementary Site", by the ABC Science Team (Bangkok, December 6, 2006). In 2007 the station became part of the GAW-WMO programme. In July 2010, the Nepal Climate Observatory - Pyramid was upgraded to GAW Global Station. As clearly shown by the map in Figure 1, N-COP is the only station providing information on background conditions in the Himalayan region, in particular on the Southern slope, directly overlooking one of the most polluted areas in the world: the Indo-Gangetic Plain.

2.1 Station personnel

The monitoring and scientific research activities undertaken by the Ev-K2-CNR Committee and CNR-ISAC at the GAW-WMO Global Station "NCOP" are supported by the work of 9 Nepalese technical staff members, who alternate to guarantee a continuous presence at the station, 2 Italian technical staff members, and 1 technical-scientific staff member. Their work is in turn supported by a scientific collaboration with CNR-ISAC and CRS-LGGE (Grenoble, France).

2.2 Geographical position and site characteristics

The Nepal Climate Observatory - Pyramid (NCO-P, 27.95 N, 86.82 E), is located at 5079m a.s.l., in the Sagarmatha National Park (eastern Nepal Himalaya), near the base camp of Mt. Everest and at the confluence of the secondary Lobuche valley (oriented NNW-SSE) and the main Khumbu valley (oriented NE-SW). The Observatory stands at the top of a hill, 100 m higher up and some 400m far from the Pyramid International Laboratory. The latter is a multidisciplinary high-altitude research centre founded by the Ev-K2-CNR Committee and the Nepal Academy of Science and Technology in 1990. The scientific information collected thanks to the NCOP observations are finalized to fulfill the following main purposes (see Bonasoni et al., 2008, 2010 as well as the Special Issue "Atmospheric Brown Cloud in Himalayas" on *Atmospheric Chemistry and Physics*):

- to obtain a chemical climatology of aerosol properties (optical, chemical and physical) at a high-altitude site in the Himalayas;
- to evaluate temporal trends of aerosol composition as a function of sources/transport;
- to evaluate the variations of radiative forcing produced by aerosols;
- to study the background ozone behavior and evaluate the contributions of stratospheric ozone intrusions as well as long range and regional transport of polluted air masses;
- to monitor the concentration trends of major halocarbons and greenhouse gases;
- to investigate the impact of Atmospheric Brown Cloud (ABC) in the Himalayas environment.

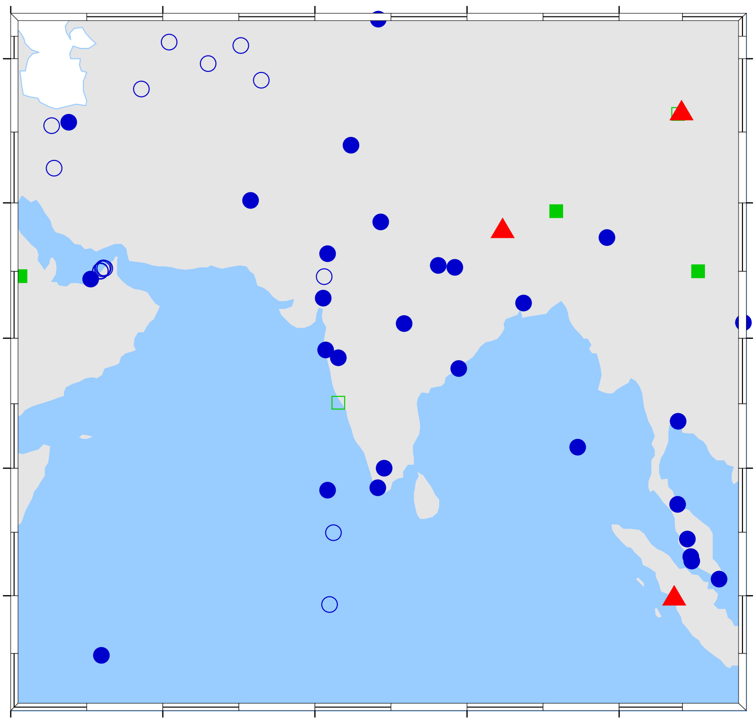

Figure 1. GAW network in the South Asia region. Clearly, NCOP is the only high-altitude station in the Himalayan region (courtesy by GAWSIS, http://gaw.empa.ch/gawsis).

Forests are encountered only in areas of the valley below 4 km a.s.l., while the landscape surrounding the measurement site is mostly rocky with patches of musk. The area is subject to short-lived snow cover periods, especially during the cold months and summer monsoon. NCO-P is located away from important anthropogenic sources of pollutants, and only small villages are present along the valley: Lobuche, Pheriche, Tyangboche, Namche Bazar (the largest village, with about 800 inhabitants), Phakding and Lukla. The closest major urban area is Kathmandu (about 1,000,000 inhabitants), situated in the valley of the same name (estimated population of the valley in 2009 was about 3 million). The city, located about 200 km South-West of the measurement site and more than 3.5km lower down, is characterised by high atmospheric pollution and poor air quality.

Figure 2. The Laboratory-Observatory Pyramid, situated in a lateral valley of the Khumbu Valley and the Nepal Climate Observatory – Pyramid, on the nearest hill overlooking the main valley.

2.3 Access

The Station can be accessed after a 5-6 day trekking from the city of Lukla which is connected to Kathmandu by a local airline(Figure 2). Materials and equipment necessary for running the station are transported either by local porters or animals (yak). Usually twice per year (during pre- and post-monsoon) maintenance campaigns are organized at the Station. In case of necessity bulkier materials can be transported up to the station by helicopters.

2.4 Infrastructural facilities

The instrumentation was initially housed in a small shelter built in wood and aluminum (L: 4 m, W: 2.4m, H: 2.4 m), part of which was also taken up by the batteries powered by 96 solar panels. In 2012 the Laboratory was extended to include a second building in brick, also used to house scientific instrumentation (Fig. 3). The laboratory shelter consists of two parts: the main hut is used to house the instrumentation for the scientific activities, while the part behind (a third of the shelter) houses the batteries for power supply. The aluminium roof has four holes employed as sampling inlets for: a PM1 Digital head for an integrating nephelometer and DMPS/SMPS instruments; a Total Particle Size for the Optical Particle Counters that has a specific head with probe and T and RH sensors; a PM10 head for the high volume discontinuous sampling of aerosol on quartz fiber filters; a second Total Particle Size head for ozone and black carbon measurements.

The monitoring activity in the laboratory-shelter is entirely realized using renewable energy from 112 photovoltaic panels, thus minimizing the possible influence of local emissions and guaranteeing air mass sampling in clean conditions. The energy produced by photovoltaic panels is stocked in 120 electric storage cells, placed on the shelf in the rear part of the shelter. Inverters guarantee current stabilization.
The data collection system is provided by two computers (K2-1 e K2-2) that provide regular functioning, diagnostics, data storage and transmission to the Pyramid. The special computers have an operative system suited to the remote, extreme environment, and have several technical features to ensure maximum reliability and low power consumption, e.g. solid state hard disks, redundant power supply and mobile processors.
A dedicated satellite connection permits near-real-time data transfer, as well as the remote control of instrumentation. Computers in the laboratory are connected to the server located at the Pyramid International Laboratory, using a coupled optical fiber and a wireless connection. The Himalaya server is linked to another server located at the CNR-ISAC Institute in Bologna (Italy). All the instrumentation is completely autonomous and remotely controlled. However, the employment of technicians is necessary for off-line measurements (aerosol sampling on filters; greenhouse gases sampling in flasks performed far from shelter in order to eliminate any possible local pollution sources) and for maintenance of the instrumentation.

Figure 3. The NCOP Observatory in 2006: the door on the right provides access the battery room, while the left part houses the instrumentation. Through the aluminium roof, four sampling lines allow the sampling of gas and aerosol particles. A live webcam imager is also visible, allowing the real-time image available on the website http://evk2.isac.cnr.it/

3. Instrumentation

The instrument set-up was defined in accordance with the "ABC" project standards (Ramanathan et al., 2006) and GAW-WMO recommendations. In particular, the instruments hosted at the NCI-P station are:

Aerosol

Multi-Angle Absorption Photometer (aerosol light absorption at 670 nm and black carbon equivalent concentration), Manufacturer: Thermo Electron Corporation, Start date: 2006, Status: ACTIVE, Institution: URT EV-K2-CNR/CNR-ISAC;

Differential/Scanning Mobility Particle Sizer (aerosol size distribution from 10 to 500 nm). Manufacturer: CNRS, Start date: 2006; Status: ACTIVE: Institution: URT EV-K2-CNR/CNR-ISAC/CNRS;

Optical particle counter (Size distribution of atmospheric aerosol in the 300 – 20000 nm range, PM1, PM2.5,PM10). Manufacturer: Grimm Gmbh. Start date: 2006. Status: ACTIVE. Institution: URT EV-K2-CNR/CNR-ISAC;

Integrating nephelometer (aerosol total and back scattering coefficients at three wavelengths 450, 550 and 700 nm), Start date: 2006, Manufacturer: TSI, Status: ACTIVE, Institution: URT EV-K2-CNR/CNR-ISAC/CNRS;

High volume aerosol sampler (aerosol chemical analyses), Start date: 2006, Status: ACTIVE, Institution: URT EV-K2-CNR/CNR-ISAC;

Two-channel PM1-PM10 sampler (On-line determination of particulate mass and sampling for off-line chemical analyses). Manufacturer: FAI. Start date: 2012. Status: TEST. Institution: CNR-ISAC/EVK2CNR.

Sun photometer (aerosol optical depth at 8 wavelengths between 340 and 1020 nm), Manufacturer: Cimel; Start date: 2006, Status: ACTIVE, Institution: EVK2-CNR/ISAC-CNR;

Wet precipitation chemistry (rain and snow sampling for off-line chemistry). Start date: June 2012; Status: ACTIVE; Institutions: EV-K2-CNR/ISE-CNR.

Trace gases

UV-absorption analyzer (Surface ozone), Manufacturer: Thermo Electron Corporation, Start date: 2006, Status: ACTIVE, Institutions: EVK2CNR/CNR-ISAC;

Ambient Air Mercury, Manufacturer: Tekran; Start date: 2012, Status: ACTIVE; Institutions: CNR-IIA/EVK2CNR;

Flask sampling (halogenated compounds: SF6, HFC-23, Halon 1301, CFC-115, HFC-125, HFC-143, CFC-12, HCFC-22, CH3Cl, HFC-134a, Halon 1211, HFC-152b, CFC-114, CH3Br, HCFC-142b, HCFC-124b, CFC-11, CH3I, CH2Cl2, HCFC-141b, CFC-113, CHCl3, CCl4, CHCCl3, CH3CCl3, C2Cl4), Start date: 2006, Status: ACTIVE; Institutions: University of Urbino/EVK2CNR.

Meteorology

Weather station (temperature, pressure, relative humidity, rain, wind intensity and direction), Manufacturer: Vaisala, Start date: 2006; Status: ACTIVE, Institutions: CNR-ISAC/EVK2CNR.

Radiometry

Pyrgeometer (downward component of longwave global irradiance). Manufacturer: Kipp and Zonen. Start date: 2006. Status: ACTIVE. Institution: EV-K2-CNR/ENEA-UTMEA-TER;

Pyranometer (downward component of shortwave global irradiance). Manufacturer: Kipp and Zonen. Start date: 2006. Status: ACTIVE. Institution: EV-K2-CNR/ENEA-UTMEA-TER.

4. Affiliation to research projects/programmes

In addition to measurements performed in the framework of the GAW-WMO programme, monitoring activities carried out at the GAW-WMO station NCO-P also regard the following national and international observation projects/programmes.

- SHARE (Stations at High Altitude for Research on the Environment)
- ABC (Atmospheric Brown Clouds)
- GMOS (Global Mercury Monitoring System)

5. Analysis of possible upgrades

NCOP significantly contributes to the GAW-WMO program, assuring at least one parameter among the main “focal areas” (GHGs, ozone, UV, aerosols).

5.1 Aerosol

During 2012, an additional Optical Particle Counter was installed (FAI OPC Monitor Multichannel), in order to validate the previous measurements performed with a GRIMM 190, which revealed a critical status during monsoon season, with persistent high relative humidity. The FAI Multichannel is coupled with a SWAM Dual Channel Monitor, providing the aerosol mass measurement every 12 hours, based on the β-attenuation technique. The simultaneous measurements of size distribution and mass (PM1 and PM10) allow the calculation of aerosol density in both submicron and supermicron fraction. Moreover, the filters used for mass determination are available for special chemical analyses.

NCOP represents a privileged point for observing the vertical distribution of the Indo-Gangetic Brown Clouds (ABC) and long range transport of air masses rich in pollutants and mineral dust. Surface measurements allow a detailed characterization of the air masses reaching the measurement site. In addition, a columnar aerosol investigation can be useful to achieve an advanced understanding of the processes that generate, redistribute, and remove aerosols in the atmosphere. The installation of a Light Detection and Ranging (LiDAR) near NCOP or in the lower Khumbu Valley could provide a quantitative description the vertical, horizontal, and temporal aerosol distribution. The unique columnar aerosol measurement currently performed at NCOP is the AOD, provided by the CIMEL Sun photometer, which can be used to better characterize the vertical aerosol profile obtained by a LiDAR, but is not sufficient to discriminate different levels of the atmosphere.

The formation of secondary particles by nucleation of their gaseous precursors is not well constrained, although it represents a potentially significant source in specific tropospheric regions. Thanks to recent advances in measurement techniques, new particle formation has now been observed in rural, marine, urban, and background environments. However, the spatial extent of new particle formation events, and in particular their occurrence at high altitudes, has rarely been documented. At NCOP, a very high number of new particle formation occurrences have been observed, especially during the summer monsoon season (Venzac et al., 2008). Measurements of aerosol-size distributions at NCO-P site were continuously performed using the scanning mobility particles sizer (SMPS) technique and a special campaign was held in spring 2007 with an aerosol ion spectrometer (AIS), yielding information on concentrations and size of ions down to 1 nm. The chemical composition of the nucleation mode is very scarcely documented, and it is extremely difficult to collect enough material on filters in order to perform classical chemical analyses. For these reasons, the employment of the new techniques providing single particle chemical composition are highly suited to this kind of investigation. In particular, the installation of an APiTOF - Atmospheric Pressure interface Time-of-Flight for a field campaign during the nucleation process can give information concerning chemical composition in the nucleation range, both for positive and negative ions.

5.2 Trace gases

The implementation of a monitoring program of reactive gases and greenhouse gases is highly recommended, because of the particular location of the NCOP Station. The aim is to study the influence of pollution and biomass burning plumes on the Himalayan range, which are poorly studied despite the important role they play in atmospheric composition and the Earth's radiative budget. One desirable measurement implementation is the installation of a Cavity ring-down spectroscope, such as the CRDS analyzer for CO, CO2, CH4 and H2O. In particular, measurements of carbon monoxide are important both in greenhouse gas monitoring, especially in distinguishing urban emissions. For these reasons, a feasibility study concerning the installation of a CRDS at high-mountain sites, has been performed in the framework of Nextdata project (see deliverable D1.2.2).

In compliance with GAW requirements (Tab. 1), the implementation of reactive gases (i.e. NOx and SO2) are also recommendable at the NCO-P. However, as shown by the feasibility study reported in

D1.2.2, accurate NOx measurements at a remote location like NCO-P can be very challenging and specific training of local staff appear as mandatory before any implementation. Due to the remoteness of the site, also the activation of reliable SO2 measurements appear to be critical. Due to the rather high detection limit of commercial available instrumentations, the execution of in-situ test are mandatory before any permanent installation.

5.3 Radiometry

Necessary upgrading of measurement activities in the GAW context (Tab. 1) include the introduction of UV measurements and actinic flux measurements for the determination of quantities J(O1D) and J(NO2). The implementation of these measurement programmes would also be essential for correctly investigating photochemical processes and quantifying their influence on the variability of mixing ratios of greenhouse and reactive gases and secondary aerosol.

BOX1 – Characteristic of GAW-WMO Global Stations (from: GAW-WMO Strategic Plan 2008 – 2015)

1. The station location is chosen such that, for the variables measured, it is regionally representative and is normally free of the influence of significant local pollution sources.
2. There are adequate power, air conditioning, communication and building facilities to sustain long term observations with greater than 90% data capture (i.e. <10% missing data).
3. The technical support provided is trained in the operation of the equipment.
4. There is a commitment by the responsible agency to long term observations of at least one of the GAW variables in the GAW focal areas (cf. Section 7).
5. The GAW observation made is of known quality and linked to the GAW Primary Standard.
6. The data and associated metadata are submitted to one of the GAW World Data Centres no later than one year after the observation is made. Changes of metadata including instrumentation, traceability, observation procedures, are reported to the responsible WDC in a timely manner.
7. If required, data are submitted to a designated data distribution system in near-real-time.
8. Standard meteorological in situ observations, necessary for the accurate determination and interpretation of the GAW variables, are made with known accuracy and precision.
9. The station characteristics and observational programme are updated in the GAW Station Information System (GAWSIS) on a regular basis.
10. A station logbook (i.e. record of observations made and activities that may affect observations) is maintained and is used in the data validation process.
11. Measure variables in at least three of the six GAW focal areas (see item 4 above).
12. Have a strong scientific supporting programme with appropriate data analysis and interpretation within the country and, if possible, the support of more than one agency.
13. Make measurements of other atmospheric variables important to weather and climate including upper air radio sondes at the site or in the region.
14. Provide a facility at which intensive campaign research can augment the long term routine GAW observations

GAW focal area	GAW Parameter	Interest	Availability at station dealt with in the present report
Total Ozone *Reactive gases*	**O_3**	*Air Quality* *Oxidation Efficiency* *Climate Stratospheric Ozone Depletion*	X
Reactive gases	**CO**	*Air Quality* *Oxidation Efficiency*	-
Ancillary variable	$j(NO_2)$	*Air Quality* *Oxidation Efficiency*	-
Ancillary variable	$j(O_1D)$	*Air Quality* *Oxidation Efficiency*	-
Greenhouse gases	H_2O (water vapor)	*Air Quality* *Oxidation Efficiency* *Climate* *Stratospheric Ozone Depletion*	-
Reactive gases	HCHO	*Air Quality* *Oxidation Efficiency*	-
Reactive gases	**VOCs**	*Air Quality* *Oxidation Efficiency* *Climate*	X
Reactive gases	**$NO_x = NO+NO_2$** HNO_3	*Air Quality* *Oxidation Efficiency* *Climate* *Stratospheric Ozone Depletion*	-
Greenhouse gases	**N_2O**	*Climate* *Stratospheric Ozone Depletion*	-
Reactive gases	**SO_2**	*Air Quality* *Climate*	-
Greenhouse gases	BrO, ClO, OClO HCl, $ClONO_2$ CH_3Br, **CFC-12, HCFC-22**, halons	*Climate* *Stratospheric Ozone Depletion*	X
Aerosol	**Aerosol optical properties**	*Air Quality* *Oxidation Efficiency* *Climate* *Stratospheric Ozone Depletion*	X
Greenhouse gases	**CO_2**	*Climate*	-
Greenhouse gases	**CH_4**	*Oxidation Efficiency* *Climate* *Stratospheric Ozone Depletion*	-
UV radiation		*Air Quality* *Stratospheric Ozone Depletion*	-
Atmospheric wet deposition		*Air Quality* *Climate*	X

Table 1. List of atmospheric constituents and focal areas indicated in the GAW-WMO Strategic Plan 2008 – 2015. In bold, the GAW components of the WMO integrated global observation system. The fourth column indicates the state of execution of observations of the said compounds at GAW-WMO station Nepal Climate Observatory-Pyramid (NCOP).

6. Analysis of possible criticalities

We list below possible technical and logistic criticalities concerning monitoring activities carried out at the GAW-WMO station Nepal Climate Observatory-Pyramid.

1) NCOP is located on the Southern Himalayan slope, directly exposed to the summer Indian monsoon, which brings the ocean humidity up to the high altitude of the Himalayas. The cold temperatures reached at this high altitude contributes to very high relative humidity, which in

this season never goes below 70%. Thus, there is an urgent need for systems for drying the aerosol sampling inlet lines, the necessity being particularly critical for measurements of aerosol size distribution, e.g. OPC, DMPS, nephelometer.

2) NCOP is very far from any road, and about a week-long trekking is necessary to reaching the site. Transportation of material is carried out by Sherpa porters or animals (yaks) and a preventive accurate organization is necessary for managing repairs, maintenance and for shipping spare parts.
3) No public electricity is available at NCOP, with only solar panel and batteries providing continuous power supply for the station's energy requirements. Every action has to consider this constraint and the upgrade of the station has to face this limitation, favoring new technologies at low energy consumption. The currently available electrical capacity is sufficient to guarantee present measurement activities, but could be insufficient in the eventuality of measurement campaigns.
4) Due to the remoteness of the station, the role of the local staff is very important for a successful monitoring activity. Thus, execution of high quality training activity is mandatory for the local staff.

7. Conclusions

Based on evidence emerging during technical surveys and interventions, in order the guarantee the full functionality of the GAW-WMO Global Station NCOP and its upgrade, particular attention must be paid to the following actions:

a. Maintenance of technical facilities and scientific instrumentation also as a function of the extreme environmental conditions characterizing the measuring site;
b. Increase in electricity supply to ensure the possibility of accommodating new instrumentation, also in the course of measurement campaigns,
c. Upgrade of measurements of aerosol physical parameters, trace gases and radiometry;
d. Implementation of measurements of vertical aerosol profile;
e. Execution of training for the local staff;
f. Performance of field campaign for instrumentation test.

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Report on the SHARE-Italy station of Campo Imperatore – Monte Portella

1. Objectives and methods

The present document, drafted in the context of WP1.2 of the Project of National Interest NextData, is to provide a description of the current status of the atmospheric-climate monitoring activities at the station of Monte Portella-Gran Sasso, part of the SHARE-Italia network. The Report also provides information on possible instrumental or infrastructural implementations targeted to support the competitiveness of the said facility in a national and international scientific context.
In particular, it gives a detailed description of the research infrastructure, measurement programmes currently in progress, the number and type of personnel directly involved in running the activities, and participation in research initiatives or projects. The report is based on the processing of the results of a technical inspection performed by the operative unit URT Ev-K2-CNR on July 20, 2012 and of a meeting with the research staff of the University of L'Aquila - CETEMPS directly involved in the direction and management of the station and of the research programmes carried out there.

2. Infrastructure

The station of Monte Portella is situated in the locality of the same name in the National Park of Abruzzo. The station is owned by CETEMPS which, in addition to coordinating the scientific research activities of projects to which the station is affiliated, also directly performs most of the measurement and monitoring programmes undertaken at the station.

2.1 Station personnel

Monitoring and scientific research activities at this observation station are supported by the work of 3 researchers (2 of whom are permanent staff), and 2 technicians (both of whom are permanent staff), as well as 2 research fellows and 1 grant-aided post-doctoral fellow.

2.2 Geographical location and site characteristics

Located at 2401 m altitude, on the crest of Monte Portella in the National Park of Abruzzo, the measurement station has a strategic role in the study of atmospheric conditions at high altitude in the Mediterranean Basin, with particular reference to following issues:

Variability of greenhouse and reactive gases in the atmosphere due to both natural and anthropogenic factors.

Variability of physical-chemical properties of aerosol in the atmosphere due to both natural and anthropogenic factors.

Figure 1 shows the location of GAW-WMO (Regional and Global) stations in the European area and the Mediterranean Basin, where measurements of greenhouse and reactive gases are performed (from http://wdcgg.jpma.jp). It is evident that the Station of Monte Portella (as yet not part of the GAW-WMO network) could fill the information gap still existing in the central part of the Italian peninsula. In particular, the station's position (at high altitude and at the heart of the Mediterranean Basin) is particularly strategic for the study of polluted air-mass transport of from mainland Europe to the Mediterranean Basin. Together with the high-altitude stations already existing in the Alps, the northern Italian Apennines and the southern Mediterranean Sea, it could become part of a "backbone" of observational stations, able to cover the entire latitudinal range extending from the Alps to the central Mediterranean Basin, an area identified as a hot-spot for global issues such as climate change, air quality, and atmospheric aerosol effects.

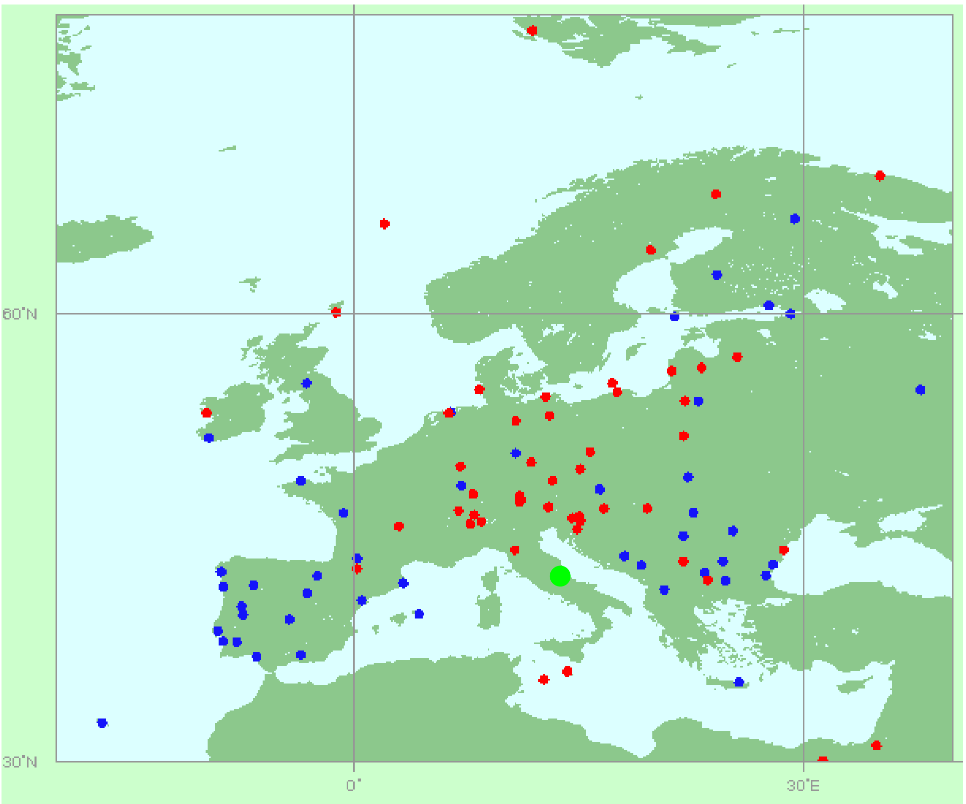

Figure 1. Locations of GAW-WMO stations affiliated to the World Data Center For Greenhouse Gases in the European domain (in red, stations sending data in the last calendar year). The large green circle indicates the position of Monte Portella station.

The area in the immediate vicinity of the measurement site is constituted by barren terrain, characterized in summer, by rocky outcrops and grasslands (Figure 2 and Figure 3), and in winter, by snow cover. With the exception of the mountain shelter "Duke of the Abruzzi", property of the Italian Alpine Club, located about 200 m to the east, there are no buildings within a radius of about 2 km of the measurement site. The village of Assergi, Italy, (approximate 500 inhabitants, at 1000 m altitude) is located 6 km south-east. The city of L'Aquila (approximately 60000 inhabitants) is located about 16 km to the south.

2.3 Infrastructural facilities

The experimental equipment is hosted inside an insulated shelter, provided with a sloping roof in order to avoid, in winter, an excessive accumulation of snow which poses a risk of damage to the equipment. The shelter houses approximately 3 m^2 for scientific instrumentation, in good part already occupied by the equipment in operation at the station. The station is powered by a 220 V 3kW electric line that originates from the nearby shelter "Duca degli Abruzzi". The station is equipped with a system to ensure continuity (UPS) of instruments for about 120 min in case of blackout. At the date of the inspection, the set up of a radio bridge was in progress, to ensure an internet link to the station, allowing remote access to systems for data acquisition and transfer (also in almost real time/NRT). Since last mid-November, the station has been connected via the radio bridge, so that basic control of instrumentation can be carried out from a remote location, along with real-time data transfer to a

CETEMPS server. The creation of a web page is currently underway to make the real-time data of the Monte Portella station directly available.
The laboratories also have special sampling leads for air sampling by the analyzers installed at the station. Currently, the provision of a roof opening device is in implementation (due next spring) with the installation of a 50 cm diameter quartz window (already available at CETEMPS) for remote sensing systems. In addition, a unified collection system has been installed, for air samples to use in the continuous analysis of greenhouse gas and reactive gas variability. The system, designed in collaboration with the CNR-ISAC Operational Unit in Bologna, complies with the guidelines of the Global Atmosphere Watch program of the WMO. In particular, the system consists of a Pyrex and Teflon© collection head, with a flow capacity of over 40l/s guaranteed by a turbine. The station is equipped with a collection head and inertial impact separator for PM10, as described in Annex VI of the Italian D. Lgs. 155/2010 (UNI EN 12341) for the measurement of particle size spectra via OPC.
The station is equipped with a server for the acquisition and near real-time transfer of data on ozone, NO and aerosol size distribution. There is also a data logger for the acquisition of meteorological data.
The Duca degli Abruzzi shelter, open every day from June 1 to September 30, has 2 rooms for a total of 22 beds, a restaurant and a bar. From October 1 to May 31, it is open at weekends subject to reservation. In winter the emergency area always remains open, with 3 bunks each with a mattress and blankets, and necessary facilities for meals. There is an agreement between CETEMPS and CAI (owner of the shelter) for the use of the facility for seminar meetings and the guesthouse. On the plain of Campo Imperatore (cable car access up to 2100 m, about 40 minute's walk from the station), a hotel is situated with several rooms, a meeting room and restaurant.

Figure 2. External view of the Portella station in the Gran Sasso Park at 2401 m. a.s.l.. In the background, Corno Grande (2912 m. a.s.l.), the highest peak of the Gran Sasso chain.

Figure 3. View from the north of the Portella station in the Gran Sasso Park. In the background, the plateau of Campo Imperatore.

3. Instrumentation

Listed below, the equipment in use at the Monte Portella station, indicating the status of measurements (active/inactive) at the date of inspection:

Meteorology

- Weather station (atmospheric pressure, air temperature, wind direction and intensity, precipitation). Manufacturer: Vaisala. Measurement start date: July 2102. Status: ACTIVE.
- Global Pyranometer. Manufacturer and model: Kipp&Zonen, CMP21. Start of measurements: July 2012. Status: ACTIVE.

Reactive gases

- UV-absorption analyzer (O3). Manufacturer: 2B technologies. Start of measurements: July 2012. Status: ACTIVE.
- Chemiluminescence (NOx) analyzer. Manufacturer: 2B technologies. Start of measurements:: July 2012. Status: ACTIVE.
- Ozone calibrator (ozone concentration). Manufacturer: 2B technologies. Start of measurements: July 2012. Status: ACTIVE.

Aerosol

- Optical particle counter (aerosol size distribution from accumulation to coarse mode). Manufacturer and model: FAI OPC MONITOR. Start of measurements: July 2012. Status: ACTIVE.

4. Affiliation to research projects/programmes

SHARE (Stations at High Altitudes for Environmental Researches)

5. Analysis of possible upgrades

The observation station of Monte Portella-Gran Sasso, although a very recent installation (July 2012), constitutes an important resource for studying variability and processes influencing the atmospheric composition in the Mediterranean Basin. This station is not part of the GAW-WMO programme. Also based on the inspection undertaken in the context of the NextData project, with regard to the requirements of the GAW-WMO programme for the status of "regional" station (see Box1), it should be noted that the station currently presents several criticalities, in particular, with regard to:

1) provision of adequate systems of power continuity, conditioning of laboratories and technological facilities capable of supporting long-term data coverage equal to 90% (< 10% missing data).

2) measurement tracking to primary GAW standards, with regard to surface ozone measurements.

In terms of the implementation of measurement programmes, the performance of measurements relating to the determination of atmospheric concentrations of black carbon/absorption coefficient of aerosol is recommended. This would favour a more accurate characterization of the contribution of combustion processes (natural and anthropogenic) to the variability of atmospheric composition, allowing also the combined definition of variability of the two most important "short living climate forcers" (i.e., ozone and black carbon). Also recommended, is the implementation of a CPC (Condensation Particle Counter) system, able to measure concentrations of particles in the size range from 4 nm diameter. Based on the electric power available, it should be carefully assessed whether to implement a measurement programme for the determination of aerosol chemical composition in different size fractions (PM10, PM2.5 or PM1)

From the point of view of trace gases, in accordance with the list of compounds included among the GAW "Focal areas" (Tab .1), observation of "well mixed" greenhouse gases is recommended, currently entirely absent at the Monte Portella station. In particular, carbon dioxide measurements could be carried out using low-energy-consumption commercial instrumentation of reduced size, based on the NDIR principle. Considering the current characteristics and features of the station, the implementation of continuous carbon monoxide measurements seem more complex, but would provide important qualitative and quantitative on the contribution of different emissions from combustion processes.

For the purpose of compliance with GAW-WMO guidelines, it is important to implement appropriate calibration systems and processes of the NOx measurement system.

BOX1 – Characteristics of GAW-WMO Regional Stations (from: GAW-WMO Strategic Plan 2008 – 2015)

1. The station location should be chosen so that, for the measurements performed, it ensures regional representativeness, and is normally free from local pollution sources.

2.The station must be equipped with adequate continuous energy systems, laboratory conditioning and technological support capable of supporting long-term observations for data coverage equal to 90% (< 10% of missing data).

3. The technical support provided is available during the running of instrumentation.

4. There must be a commitment of the respective Institution/agency to ensure the implementation of long-term observations for at least one of the GAW variables included among the GAW focal areas (see below).

5. Observations in the GAW context must be characterized by known quality levels and must comply with the GAW primary standards.

6. The data and respective metadata must be submitted to one of the GAW World Data Centres no later than one year from the implementation of the observations. Any change in the metadata, including instrumentation, traceability, and procedures for the execution of the observations, must be promptly communicated to the respective World Data Centre.

7. On request, the data will be submitted to specific distribution systems in "near real time" (NRT).

8. Standard meteorological observations are necessary for the precise determination and interpretation of GAW variables and must be carried out with known accuracy and precision.

9. The characteristics of the station and observational programmes must be updated on a regular basis by the GAWSIS information system

10. A station diary must be systematically updated, to be used for the purpose of data validation.

GAW focal area	GAW parameter	Interest	Availability at station dealt with in the present report
Total Ozone Reactive gases	**O_3**	*Air Quality Oxidation Efficiency Climate Stratospheric Ozone Depletion*	X (surface)
Reactive gases	**CO**	*Air Quality Oxidation Efficiency*	
Ancillary variable	$j(NO_2)$	*Air Quality Oxidation Efficiency*	
Ancillary variable	$j(O_1D)$	*Air Quality Oxidation Efficiency*	
Greenhouse gases	H_2O (water vapor)	*Air Quality Oxidation Efficiency Climate Stratospheric Ozone Depletion*	
Reactive gases	HCHO	*Air Quality Oxidation Efficiency*	
Reactive gases	**VOCs**	*Air Quality Oxidation Efficiency Climate*	
Reactive gases	**$NO_x = NO+NO_2$** HNO_3	*Air Quality Oxidation Efficiency Climate Stratospheric Ozone Depletion*	X
Greenhouse gases	**N_2O**	*Climate Stratospheric Ozone Depletion*	
Reactive gases	**SO_2**	*Air Quality Climate*	
Greenhouse gases	BrO, ClO, OClO HCl, $ClONO_2$ CH_3Br, **CFC-12, HCFC-22**, halons	*Climate Stratospheric Ozone Depletion*	
Aerosol	**Aerosol optical properties**	*Air Quality Oxidation Efficiency Climate Stratospheric Ozone Depletion*	X (size distribution)
Greenhouse gases	**CO_2**	*Climate*	
Greenhouse gases	**CH_4**	*Oxidation Efficiency Climate Stratospheric Ozone Depletion*	
UV Radiation		*Air Quality Stratospheric Ozone Depletion*	
Atmospheric wet deposition		*Air Quality Climate*	

Table 1. List of atmospheric constituents and focal areas indicated in the GAW-WMO Strategic Plan 2008 – 2015. In bold, the GAW components of the WMO integrated global observation system. The fourth column indicates the state of execution of observations of the said compounds at the Share-Italia station Campo Imperatore - Monte Portella.

6. Analysis of possible criticalities

In the implementation of any action aimed at experimental strengthening of the station (upgrade), special attention should be paid to the need for adequate maintenance of the infrastructure and instrumentation.
The mountain environment, where the station operates, poses a serious risk of damage to the infrastructure and laboratories. Care must be taken to take all necessary steps to counter the effect of strong wind, snow and ice formation, which can over time severely compromise the safety and integrity of the materials and, consequently the availability of the acquired data. During winter, although the cableway continues to operate, allowing personnel to reach 2100 m altitude at Campo Imperatore, access to the station itself is only possible on foot. Use of a helicopter would therefore be required for transporting heavy and bulky materials to the measurement site.
The limited space available to accommodate the instrumentation and technical equipment and the limited availability of electrical current, represent the main constraints in the implementation of observation and monitoring programmes, although in this first phase of start-up of station activities, the use of instrumentation with low power consumption and small size (e.g. probes for measuring CO_2, CPC) could overcome this criticality.

7. Conclusions

Evidence emerging during technical inspection and consultation with staff of the University of L'Aquila and CETEMPS has shown that in order to guarantee the full functionality of the station and its upgrade, particular attention must be paid to the following actions:

a. Maintenance of technical/technological facilities and scientific instrumentation also as a function of the adverse weather and environmental conditions characterising the measuring site.
b. Extension of the station's usable area and increase of the available electrical power supply;
c. Implementation of regular instrumentation calibrations, especially with regard to NOx instrumentation. Ensure the traceability of the ozone calibrator to the GAW reference standards;
d. Implementation of programmes for the on-line monitoring of atmospheric aerosol and reactive gases, if possible employing equipment with low-power consumption and small size.

Personnel participating in the inspection (20 July, 2012)

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Piero di Carlo (CETEMPS-Dipartimento di Scienze Fisiche e Chimiche Università dell'Aquila, piero.dicarlo@aquila.infn.it) – Station Manager

References

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.

Report on the state of GAW-WMO Regional Station “R. Sarao” on Lampedusa

1. Objectives and methods

The presents document, drafted in the context of WP1.2 of the Project of National Interest NextData, is to provide a description of the current status of the atmospheric-climate monitoring activities at the GAW-WMO station “R. Sarao” in Lampedusa. The report also provides information on possible instrumental or infrastructural implementations targeted to support the competitiveness of the said facility in a national and international scientific context.
In particular, it describes in detail the research infrastructure and the measurement programmes currently underway, the number and type of personnel directly involved in the running of activities, and participations in national and international research initiatives or projects.
The report is based on the processing of the results of a technical inspection at the “R. Sarao” station, performed by the operative unit CNR-ISAC on 18-19 October, 2012, and of a meeting with the ENEA-UTMEA research staff directly involved in the direction and management of the GAW-WMO station and the research programmes carried out there.

2. Infrastructure

The GAW-WMO "R. Sarao" station is situated in the locality of Punta Grecale in the municipality of Lampedusa, on the island with the same name. The station is the property of ENEA, and is managed by the UTMEA technical unit, which, in addition to coordinating the scientific research activities of the projects in which the station takes part, directly leads most of the measurement and monitoring programs undertaken there, also providing support to other bodies and institutions performing their own measures at the site.

2.1 Station personnel

Monitoring and scientific research activities at the GAW-WMO "R. Sarao" station are supported by the work of 6 researchers (5 of whom are permanent staff) and 3 technicians (all of whom are permanent staff).

2.2 Geographical location and site characteristics

Located on the Island of Lampedusa (Figure 1), the "R. Sarao" station plays a strategic role in the study of atmospheric conditions in the central part of Mediterranean Basin, with particular reference to following issues:

Evolution of greenhouse and reactive gases in the atmosphere and their influence on climate on diverse spatial and temporal scales, due to both natural and anthropogenic factors.

Studies on the radiative balance of the atmosphere and the role played by various atmospheric constituents (in particular, aerosol, ozone, water vapour and clouds), whose distribution can vary as a result of natural and anthropogenic factors.

Figure 1 shows the location of the GAW-WMO (Regional and Global) stations in the European domain and Mediterranean basin (taken from http://wdcgg.jpma.jp). Clearly, in addition to the GAW-WMO of station Malta - El Gozo, the Lampedusa site appears to be the only measurement point within a radius of some 900 km affiliated to this international measurement network. This measurement station is, therefore, a research infrastructure of unique and certain international interest, and is strategically important for all studies relating to the physical-chemical processes occurring in the Mediterranean basin, an area identified as a hot-spot for global issues such as climate change, air quality, and atmospheric aerosol effects.

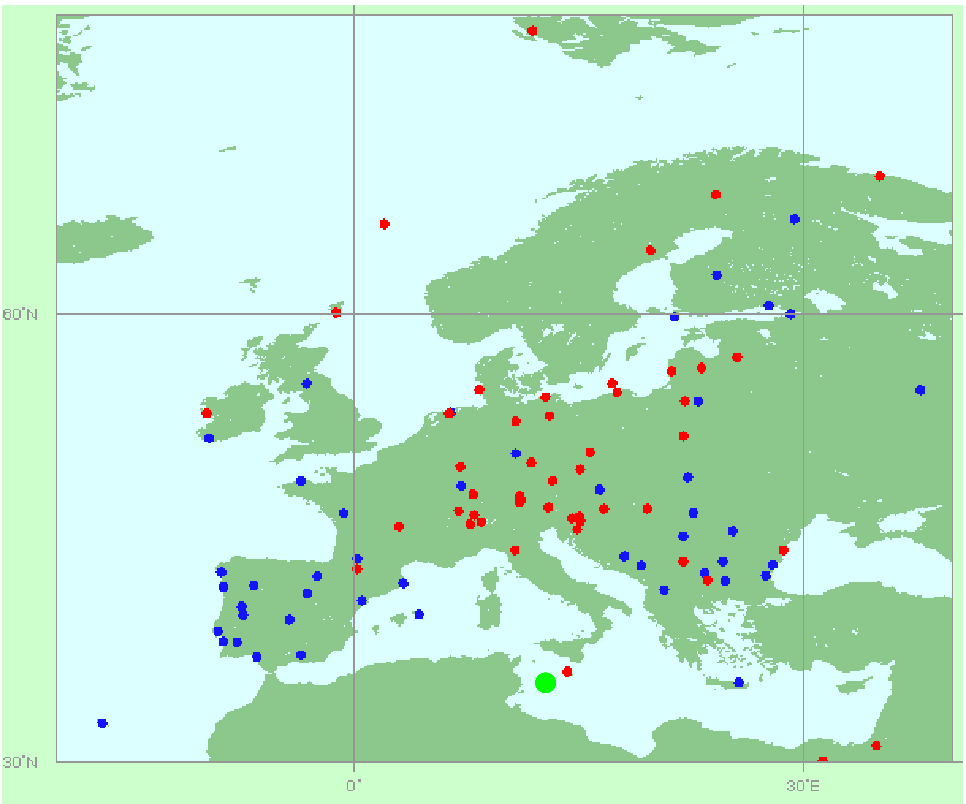

Figure 1. Locations of GAW-WMO stations affiliated to the World Data Center For Greenhouse Gases in the European domain (in red, stations sending data in the last calendar year). The large green circle indicates the position of the "R. Sarao" station on Lampedusa

The area in the immediate vicinity of the measurement site is characterised by barren terrain consisting of rocky outcrops and small shrubs (Figure 2 and Figure 3). Apart from the lighthouse located about 200 m to the east, there are no buildings within a radius of about 2 km surrounding the measurement site. The small town of Lampedusa (5000 inhabitants), with its own airport and the electricity production and distribution plant, is located 3 km south-east .

2.3 Infrastructural facilities

The infrastructure hosting the GAW-WMO station covers a surface area of 1000 m^2. It is equipped with a fenced off experimental field (about 850 m^2) and four buildings (the station's main building and three other transportable modules – two in masonry – housing laboratories, a small storage area and a "clean room" for the treatment of atmospheric aerosol samples). Both inside and on the roofs the buildings host an array of scientific instrumentation, technical installations and services for the staff.
The main building has a fully equipped terrace, where instruments for studying the atmospheric radiative budget are located. The experimental field accommodates the stations for the performance of flask sampling, a meteorological tower, a SODAR system (currently inoperative) and a system for studying dry and wet depositions. The roof of one of the two masonry blocks hosts the Cimel sun photometer. The laboratories are all equipped with systems to ensure electrical continuity (continuity groups and UPS) and an internet connection, which enable remote access to systems for data

acquisition and transfer (also in near real time/NRT). The electrical energy necessary for the supply of the station's apparatus is provided by the mains network, with a available capacity of 73kW.
The laboratories also have special sampling lines for air sampling by the analyzers installed at the station. Two laboratories are equipped with sky-lights on the roof to allow the possible installation of remote-sensing systems.
Recently, part of the lighthouse complex adjacent to the measurement station was renovated to create a meeting room, service room, a laboratory, a warehouse and service facilities (kitchen, toilets and guesthouse).

Figure 2. External view of the experimental field hosting the GAW-WMO "N. Sarao" station on Lampedusa, showing the main building, with its equipped terrace, and the weather tower.

Figure 3. Left: Weather tower in the experimental field of the "R. Sarao" station. Right: transportable modules housing laboratories for aerosol sampling, ozone analyzer, the PSAP, the Cimel, and a clean room for the treatment of aerosol samples for chemical analysis.

3. Instrumentation

Listed below, is the equipment in use at the "R. Sarao" station, indicating for each instrument, the institution responsible for the measurements acquired and the status of measurements (active/inactive) at the date of inspection:

Meteorology

a. Weather station (atmospheric pressure, air temperature, wind direction and intensity, precipitation and solar irradiance). Manufacturer: Vaisala, Kipp&Zonen. Start date: 1999. Status: ACTIVE. Institution: ENEA-UTMEA-TER.
b. Total sky imager (cloud cover). Manufacturer and model: Yankee Environmental Systems TSI 440. Start date: 2003. Status: ACTIVE. Institution: ENEA-UTMEA-TER.
c. Water vapour Raman lidar (Vertical profiles of water vapour, aerosol extinction). Start date: 2009. Status: INACTIVE. Institution: ENEA-UTMEA-TER /University of Rome.
d. Vaisala radio/ozone sonde (vertical profiles of temperature, pressure, humidity, wind direction and speed, ozone). Manufacturer and model: Vaisala Digicora III. Start date: 2004. Status: INACTIVE. Institution: ENEA-UTMEA-TER.
e. SODAR (vertical profiles of the three wind components). Start date: 2006. Status: INACTIVE. Institution: ERSE/ENEA-UTMEA-TER.
f. RPG Hat-Pro Microwave radiometer (vertical profiles of temperature and water vapour, columnar content of vapour and liquid water). Start date: 2009. Status: ACTIVE. Institution: ENEA-UTMEA.

Greenhouse gases

g. NDIR (CO2) Analyzer. Manufacturer: Siemens. Start date: 1998. Status: ACTIVE. Institution: ENEA-UTMEA-TER.
h. Automatic gas chromatography system (CH4, N2O, CFC-11, CFC-12). Manufacturer: HP. Start date: 1997. Status: ACTIVE. Institution: ENEA-UTMEA-TER.
i. Ozone analyzer (ozone concentration). Start date: 2003, 2006-2007, 2010. Status: ACTIVE. Institution: Provincial Authority of Agrigento
j. Air sampling system for greenhouse gas analyses (weekly samplings of CFC-113, HCFC-22, HCFC-141b, HCFC-142b, HFC-134a, SF6, CH3Cl, CH3Br, CH2Cl2, CCl4, CH3CCl3, Halon-1211, Halon-1301, CH2Br2, CH3I, CHCl3) Start date: 2004. Status: ACTIVE. Institution: ENEA-UTMEA
k. Air sampling system for greenhouse gas analyses (weekly samplings of CO2, CH4, SF6, CO, 13C, H2, 18O). Start date: 2006. Status: ACTIVE. Institution: ENEA-UTMEA-TER /NOAA.

Radiometry and photometry

l. Brewer MK III spectrophotometer (total ozone, UV spectral radiance, AOD). Start date: 1998. Status: ACTIVE. Institution: ENEA-UTMEA-TER.
m. Visible Multi Filter Rotating Shadowband Radiometer (AOD at different wavelengths, diffuse/direct radiation, columnar water vapour, SSA). Manufacturer and model: Yankee Environmental Systems MFR-7. Start date: 2001. Status: ACTIVE. Institution: ENEA-UTMEA-TER.
n. Ultraviolet Multi Filter Rotating Shadowband Radiometer (AOD at different wavelengths, diffuse/direct radiation, columnar water vapour, SSA). Manufacturer and model: Yankee Environmental Systems UV-MFR-7. Start date: 2004-2006/2010. Status: ACTIVE. Institution: ENEA-UTMEA-TER.
o. Cimel sun-photometer (AOD at various wavelengths, precipitable water). Start date: 2000-2005/2010. Status: ACTIVE. Institution: ENEA-UTMEA-TER /University of Modena and Reggio Emilia/NASA.
p. Precision Spectral Pyranometer (downward component of shortwave radiance). Manufacturer: Eppley. Start date: 2003. Status: ACTIVE. Institution: ENEA-UTMEA-TER.

q. Precision Infrared Radiometer (downward component of longwave radiance). Manufacturer: Eppley. Start date: 2003. Status: ACTIVE. Institution: ENEA-UTMEA-TER.
r. Shaded CGR4 pyrgeometer (downward component of longwave diffuse radiance). Manufacturer: Kipp and Zonen. Start date: 2007. Status: ACTIVE. Institution: ENEA-UTMEA-TER.
s. Shaded Precision Spectral Pyranometer (downward component of shortwave diffuse irradiance). Manufacturer: Eppley. Start date: 2006. Status: ACTIVE. Institution: ENEA-UTMEA-TER.
t. Radiometer for photosynthetic radiance (downward component of photosynthetic irradiance). Start date: 2004. Status: ACTIVE. Institution: ENEA-UTMEA-TER.
u. Actinic radiation spectrometer (actinic fluxes, photodissociation rates). Manufacturer: Metcon GmbH. Start date: 2004. Status: ACTIVE. Institution: ENEA-UTMEA-TER.

Aerosol

v. Aerosol lidar (aerosol backscattering and depolarization profile). Start date: 1999. Status: ACTIVE. Institution: ENEA-UTMEA-TER /University of Rome.
w. PM-10 sampler. Manufacturer and model: Tecora Skypost. Start date: 2004. Status: INACTIVE. Institution: ENEA-UTMEA-TER /University of Florence.
x. PM-10 Sampler (daily determination of EC/OC aerosol fractions). Manufacturer and model: Tecora Echo PM. Start date: 2010. Status: ACTIVE. Institution: ENEA-UTMEA-TER /University of Florence.
y. Particle Soot Absorption Photometer (aerosol absorption coefficient). Manufacturer: Radiance Research. Start date: 2010. Status: ACTIVE. Institution: LSCE/IPSL.

4. Affiliation to research projects/programmes

In addition to measurements pertaining to the GAW-WMO programme, monitoring activities at the GAW-WMO “R. Sarao” station are conducted as part of the following national and international research projects/programmes.

AERONET (Aerosol Robotic Network)
CHARMEX (Chemistry-Aerosol Mediterranean Experiement)
NOAA Cooperative Air Sampling Network
RAMCES (Reseau Atmospherique de Mesure des Composés à Effet de Serre)
InGOS (Integrated non-CO2 Gases Observing System)
GHG-Europe

5. Analysis of possible upgrades

Also on the basis of the inspection performed within the NextData project, it appears clear that the GAW-WMO "R. Sarao" station fully satisfies all of the requirements issued by the GAW-WMO programme for the status of a "Regional" station (see Box1). The GAW -WMO "R. Sarao" station has an impressive instrumental set-up in terms of photometry and radiometry, as well as greenhouse gas monitoring, both through on-line measurements (CO2, CH4, N2O, CFC-11, CFC-12) and off-line sampling and measurement programmes (implemented either autonomously by ENEA-UTMEA or in collaboration with the NOAA-CMDL). The station also carries out continuous measurements relating to aerosol chemical characteristics, through the performance of filter samplings (PM10). Information on boundary layer dynamics, meteorology and cloud characteristics, is obtained through the use of an automated weather station, a microwave radiometer, with the aid of a sky-camera. Therefore, a significant fraction of the variables listed in the 7 "focal areas" of the GAW-WMO Strategic Plan 2008 - 2015 are currently performed at the "R. Sarao" station (Tab. 1).

Although the "R. Sarao" station is equipped with a UV absorption ozone analyzer for the continuous in-situ determination of the ozone mixing ratio, managed by the Provincial Authority of Agrigento, at present, no information is available on QA/QC procedures and calibration scales adopted. Hence, there is a need to implement in-situ monitoring activities relating to reactive trace gases, with particular reference to ozone, sulphur dioxide, nitrogen oxides and VOC (Volatile Organic Compounds), i.e. the variables in the IGACO Integrated Global Observation System as yet not observed at the "R. Sarao" station (Tab. 1). In this context, it might be useful to implement a unified system for trace gas sampling (sampling head, ambient air intake system, and aspiration system) designed to GAW-WMO guidelines. Similarly recommended is the implementation of measurement programmes for the determination of the physical properties of atmospheric aerosol, with particular reference to size distribution (SMPS systems/DMPS, OPC or APS), the determination of scattering coefficients (nephelometers) and absorption (Multi Angle Absorption Photometer). As in the case of reactive gases, the "R. Sarao" station is currently not equipped with a single, integrated system for the sampling of atmospheric aerosol, designed to GAW-WMO/ACTRIS guidelines, to guarantee sampling in laminar flow and temperature- and relative humidity-controlled conditions. As well as continuing the measurement activities already established at the station, the implementation of monitoring programmes for reactive gases and aerosols is particularly recommended, also in the light of research on the influence of shipping traffic emissions in the Mediterranean Basin and their effect on the variability of atmospheric composition and radiative balance (Becagli et al. 2012)

BOX1 – Characteristics of GAW-WMO Regional Stations (from: GAW-WMO Strategic Plan 2008 – 2015)

1. The station location is chosen such that, for the variables measured, it is regionally representative and is normally free of the influence of significant local pollution sources.
2. There are adequate power, air conditioning, communication and building facilities to sustain long term observations with greater than 90% data capture (i.e. <10% missing data).
3. The technical support provided is trained in the operation of the equipment.
4. There is a commitment by the responsible agency to long term observations of at least one of the GAW variables in the GAW focal areas (cf. Section 7).
5. The GAW observation made is of known quality and linked to the GAW Primary Standard.
6. The data and associated metadata are submitted to one of the GAW World Data Centres no later than one year after the observation is made. Changes of metadata including instrumentation, traceability, observation procedures, are reported to the responsible WDC in a timely manner.
7. If required, data are submitted to a designated data distribution system in near-real-time.
8. Standard meteorological in situ observations, necessary for the accurate determination and interpretation of the GAW variables, are made with known accuracy and precision.
9. The station characteristics and observational programme are updated in the GAW Station Information System (GAWSIS) on a regular basis.
10. A station logbook (i.e. record of observations made and activities that may affect observations) is maintained and is used in the data validation process.

GAW focal area	GAW parameter	Interest	Availability at the station dealt with in the present report
Total ozone *Reactive gases*	**O_3**	*Air Quality* *Oxidation Efficiency* *Climate Stratospheric Ozone Depletion*	X (surface + columnar)
Reactive gases	**CO**	*Air Quality* *Oxidation Efficiency*	
Ancillary variable	$j(NO_2)$	*Air Quality* *Oxidation Efficiency*	X
Ancillary variable	$j(O_1D)$	*Air Quality* *Oxidation Efficiency*	X
Greenhouse gases	H_2O (water vapour)	*Air Quality* *Oxidation Efficiency* *Climate* *Stratospheric Ozone Depletion*	X (surface + columnar)
Reactive gases	HCHO	*Air Quality* *Oxidation Efficiency*	
Reactive gases	**VOCs**	*Air Quality* *Oxidation Efficiency* *Climate*	
Reactive gases	**$NO_x = NO+NO_2$** HNO_3	*Air Quality* *Oxidation Efficiency* *Climate* *Stratospheric Ozone Depletion*	
Reactive gases	**N_2O**	*Climate* *Stratospheric Ozone Depletion*	X
Reactive gases	**SO_2**	*Air Quality* *Climate*	
Reactive gases	BrO, ClO, OClO HCl, $ClONO_2$ CH_3Br, **CFC-12, HCFC-22**, halons	*Climate* *Stratospheric Ozone Depletion*	X
Aerosol	**Aerosol optical properties**	*Air Quality* *Oxidation Efficiency* *Climate* *Stratospheric Ozone Depletion*	X (absorption coefficients)
Reactive gases	**CO_2**	*Climate*	X
Greenhouse gases	**CH_4**	*Oxidation Efficiency* *Climate* *Stratospheric Ozone Depletion*	X
UV radiation		*Air Quality* *Stratospheric Ozone Depletion*	X
Atmospheric wet deposition		*Air Quality* *Climate*	X

Table 1. List of atmospheric constituents and focal areas indicated in the GAW-WMO Strategic Plan 2008 – 2015. In bold, the GAW components of the WMO integrated global observation system. The fourth column indicates the point of execution of observations of the said compounds at the GAW-WMO station "R. Sarao" at Lampedusa.

The "R. Sarao" station also has a system for the implementation of soundings/ozone soundings that is currently inactive, due to high operating costs. Should necessary funding become available, the resumption of these monitoring programmes is recommended, in view of the gap in this type of information for the central part of the Mediterranean Basin.
The "R. Sarao" station is equipped with a microwave radiometer for continuous observations of temperature and water vapour vertical profiles, also providing information on the vertical extension of the planetary boundary layer. Such advanced instrumentation provides parameters included among the GAW-WMO focal areas (ancillary variables), essential for studying the variability of atmospheric gases and aerosols. However, it requires high maintenance costs, which could be supported in the context of NextData activities (subject to available funding).
To evaluate the soundness of the surface ozone measurements carried out by the Provincial Authority of Agrigento, and to better define the methods of instrumental implementation at the GAW-WMO station "R. Sarao", an intercomparison with an instrument or calibrator is reccomended, complying with the standards of the World Calibration Center of the GAW-WMO.

6. Analysis of possible criticalities

In the implementation of any action aimed at the experimental strengthening (upgrade) of the GAW-WMO station "R. Sarao", special attention should be paid to the need for adequate maintenance of the infrastructure and instrumentation.
The station’s marine environment poses a serious risk of damage to the infrastructure and laboratories. For example, the meteorological tower situated in the station’s experimental field shows obvious signs of stress due to the action of sea salt, and is in urgent need of maintenance. Additionally, the external components of air conditioning systems, which maintain temperature and humidity of measurement laboratories at acceptable levels for instrumentation use and personnel activities, must undergo continuous maintenance or even complete substitution, due to the action of sea salt. Particular attention should therefore be paid to the implementation of actions to counter the effects of sea salt, which can, over time, seriously compromise the safety and integrity of materials.
In the course of the inspection, it was possible to verify the effects of an extreme weather event, which inflicted serious damage on the station’s facilities, as a result of strong wind and lightning (several doors and windows torn out, damage to external equipment, damage to the electrical system).

7. Conclusions

Evidence emerging during technical inspection and consultations with ENEA-UTMEA personnel, have shown that in order to ensure the full functionality of the GAW-WMO "R. Sarao" station, particular attention must be paid to the following actions:

a. Maintenance of technical/technological facilities and scientific instrumentation also as a function of the adverse weather and environmental conditions characterising the measuring site.
b. Execution of regular instrument calibrations with direct link to GAW-WMO standards, especially for surface ozone measurements;
c. Implementation of programmes for the on-line monitoring of atmospheric aerosol and reactive gases.
d. Execution of “ancillary” measurements (e.g., re-activation of vertical sounding monitoring programmes).

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Report on the state of GAW-WMO Regional Station Plateau Rosa

1. Purposes and methods

The purpose of the present document, drafted in the context of WP1.2 of the Project of National Interest NextData, is to provide a description of the current status of the atmospheric-climate monitoring activities at the GAW-WMO station of Plateau Rosa. The report also provides information on possible instrumental or infrastructural implementations targeted to support the competitiveness of the said facility in a national and international scientific context.
In particular, it provides full details on the research infrastructure and measurement programmes currently in progress, the number and type of personnel directly involved in the running of activities, and participations in national and international research initiatives or projects.
The report is based on a meeting with the research staff of RSE SpA - Ricerca sul Sistema Energetico directly involved in the direction and management of the GAW-WMO station and the research programmes carried out there. Unfortunately, due to adverse weather conditions, it was not possible to carry out a technical inspection of the station, which shall be conducted in the course of 2013.

2. Infrastructure

The GAW -WMO station Plateau Rosa (45.93 N, 7.70 E) is located in the Italian Alps of the Aosta Valley, on the southern ridge of Teodulo hill, in the municipality of Valtournenche. The atmospheric monitoring station is hosted by the "Testa Grigia" laboratory of the Turin Astrophysical Observatory (formerly, IFSI, Institute of Physics of Interplanetary Space) of the National Institute for Astrophysics (INAF). The atmospheric monitoring instrumentation is managed by RSE SpA personnel.

2.1 Station personnel

Monitoring and scientific research activities at the GAW-WMO station Plateau Rosa is supported by the work of a skilled technician, a laboratory/measurement station manager and a scientific officer.

2.2 Geographical location and site characteristics

Located at 3480 m altitude in western Italian Alps (Figure 1), the Plateau Rosa station is representative of the background conditions of southern Europe and is in a strategic position for studying the contribution of long-range western transport to variability in atmospheric composition. In particular, the Station of Plateau Rosa (Figures 2 and 3) is employed for studies and measurements relating to the analysis of long term atmospheric variability of greenhouse gases (see the Section “Reference”). To support the greenhouse gas measurements, continuous measurements of the main meteorological variables are carried out.
Figure 1 shows the location of GAW-WMO (Regional and Global) stations in the European domain and Mediterranean basin (taken from http://ds.data.jma.go.jp/gmd/wdcgg/). Although situated at a relatively short distance (about 75 km) from the GAW-WMO Global Station at Jungfraujoch (46.55 N, 7.99 E; 3580 m), Plateau Rosa is the only station in Italian in the Alpine region affiliated to the GAW-WMO network and, compared to Jungfraujoch, it has historical series of longer duration (for example, the first CO_2 measurements date from 1989). With a view to the possible establishment of a network of background climate stations in the Italian territory, the continuation of the monitoring activities at Plateau Rosa appears crucial. Finally, the possibility of having a number of similar stations within Europe is generally considered of great advantage, because this is likely to guarantee high quality

measurements and, above all, to provide the widest coverage possible of climate measurements of special interest.

Thanks to its unique geographical position south of the Alpine ridge, the station of Plateau Rosa constitutes a research infrastructure of special and certain international value and is strategically important for all studies relating to the physical-chemical processes occurring in the Mediterranean basin, an area identified as a hot-spot for global issues, such as climate change, air quality, and atmospheric aerosol effects.

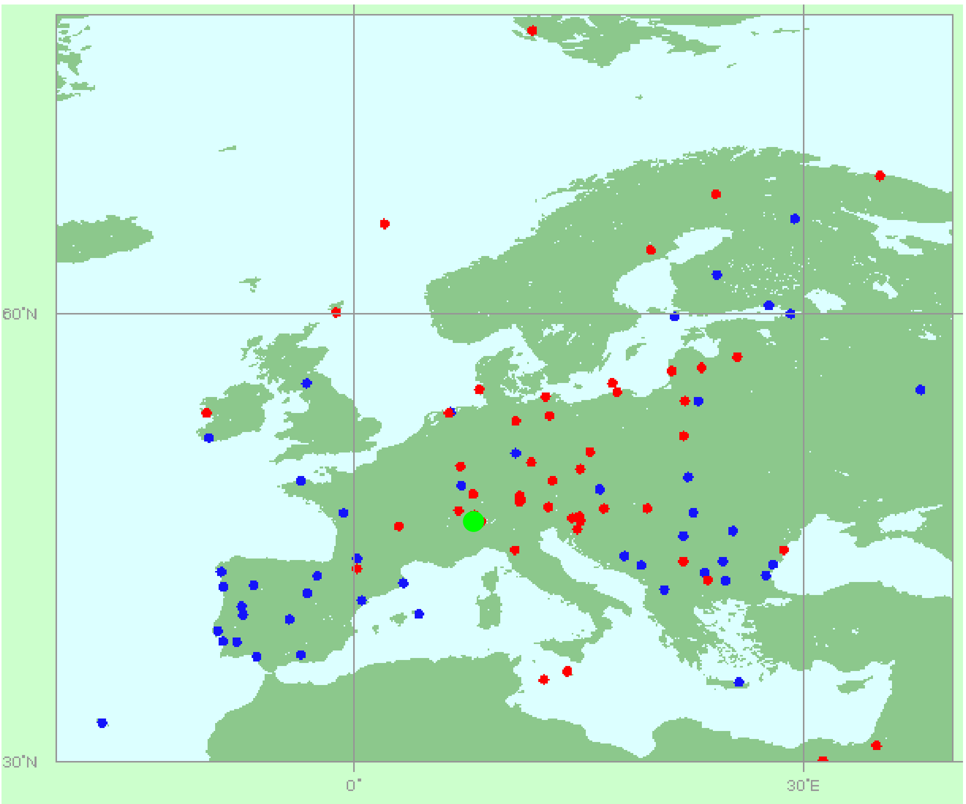

Figure 1. Positions of GAW-WMO stations affiliated to the World Data Centre for Greenhouse Gases in the European domain (in red, stations sending data in the last calendar year). Large green circle indicates the position of the GAW-WMO station of Plateau Rosa.

The area in the immediate vicinity of the measurement site is characterized by snowfields and glaciers and is far from urban and industrialised areas. In addition to the cable car arrival point, currently in immediate proximity to the measurement station at a distance of some 100 meters, there is a mountain shelter. The cable car installations are open for around 8 months a year, while in the remaining months, the station must be reached either by alternative means, or during climbing expeditions scheduled for inspections of facilities. The shelter is active mainly around mid-day (lunch hour), and the cable cars operate from 8 am to 4 pm (leaving approximately every 30 minutes). Often, although facilities are open, the cable cars cannot be used because of adverse weather conditions (usually characterized by strong winds). In addition to the cable car, the building of the previous funicular system is located about 400 m from the measurement site, today housing the meteorological instrumentation of RSE, the meteorological base of the Italian Air Force and radio antennas of the RAI (Italian Broadcasting Corporation).

The village of Breuil-Cervinia (about 2000 inhabitants, at 2000 m altitude) is situated a few kilometres south-west . The urban -industrial area closest to the measurement site is Aosta (35000 inhabitants), located 30 km away. The urban and industrial areas of Turin (900,000 inhabitants) and Milan (1,300,000 inhabitants) are located 100 km south-west and 132 km south-east, respectively.

2.3 Access

The easiest way to reach the monitoring station is by car (the normal route starts from the RSE Milan head-office to arrive at Cervinia), taking the cableway from Cervinia, and then using ski lifts (three sections), as far as Plateau Rosa, where the RSE Laboratory for the measurement of greenhouse gases is located.
Materials (gas pressurised cylinders containing standardised mixtures, consumables, etc.) and equipment necessary for running the station (verification tools, calibrators, data acquisition interfaces, etc.), are transported either by cable car, or using a local carrier, responsible for carrying bulkier deliveries (gas cylinders and heavy materials in general).

2.4 Infrastructural facilities

The laboratory hosting the GAW-WMO station has an area of 60m^2 within the premises of the "Testa Grigia" Research Station of the Turin Astrophysical Observatory, belonging to the National Astrophysics Institute (INAF). The station is also equipped with a outer deck and a 16m^2 dome housing astronomical instruments. The “Testa Grigia” Research Station of the Astrophysics Observatory in Turin, part of the National Astrophysics Institute (INAF), which hosts the GAW-WMO station, also has a small guesthouse of about 30m^2 (small rooms with bunk beds and a kitchenette). On request to the INAF, they are available to accommodate technical, and research personnel for brief periods.
The laboratory, where continuous measurements of atmospheric composition are performed, is equipped with systems to ensure electrical supply continuity (continuity groups and UPS), and a gsm connection for the daily transfer of acquired data.
The electricity supply and signal acquisition lines are provided with surge protection. The electrical energy necessary to power the station’s apparatus is provided by the commercial mains network.
Additionally, the laboratory is equipped with special lines for air sampling by the installed analyzers, including three collections lines, two in steel and one in heated Teflon for ozone analysis.
In particular, the air for continuous measurements of CO_2 is aspirated by an inert diaphragm pump connected to a stainless steel tube, terminating with the sampling probe mounted on the turret of the station (figure 4). For carbon dioxide (CO_2) measurements, the air passes through the cryogenic dehumidifier at -60 °C temperature, with three condensate separators mounted in parallel on three different lines, which operate alternately in the case of duct obstruction due to ice formation, thus avoiding air-flow blockage. The separators are controlled by the computerised acquisition system, which automatically switches from one to another, should the flow meter (mass flow controller) send a signal below a predetermined threshold value. The pressure within the air line is maintained constant, adjusted appropriately by a pressure reducer; prior to entering the analyzers, air samples are brought to a constant temperature by a heat regulator.

2.4.1 Calibration facilities

The station also has in operation equipment for calibrating the analyzers for the measurement of greenhouse gases. For CO_2 and CH_4, calibration is automatically carried out every 6 hours, while for ozone surface, calibration is performed manually by a span source inside the mod. THERMO ELECTRON 49i instrument. It is worth noting that the Laboratory of Environmental Metrology RSE in

Milan also houses an ozone calibrator. (THERMO ELECTRON 49 PS), which is traced back to the national standard hosted by INRIM in Turin.
Conversely, for calibrations of the CO_2 and CH_4 analyzers, two electronic control systems have been set up, based on the regulation of solenoid valves, to implement tertiary or working calibrations (2 standards for CO_2 and CH_4) and secondary calibrations (4 standards for CO_2). In addition to the workings standards, different calibration standards are available (at least 5 for CO_2 and 3 for CH_4) derived and/or purchased from the NOAA-CMDL laboratories, hosting the GAW-WMO reference scales for these compounds. The greenhouse gas measurement station of Plateau Rosa participates systematically in various inter-comparison campaigns both run by the GAW-WMO, and in the context of European research projects whose reference laboratory is the MPIG Jena (Germany). Secondary and working standards are generally reported every 6 months or, at most, yearly to the calibration bodies (in line with the WMO X2007 international measurement scale for CO_2, and NOAA2004 for CH_4).

Figure 2. External view of the "Testa Grigia" Research Station, which hosts the GAW-WMO station of Plateau Rosa.

Figure 3. Image of the station's location, seen from Cime Bianche (2960 m).

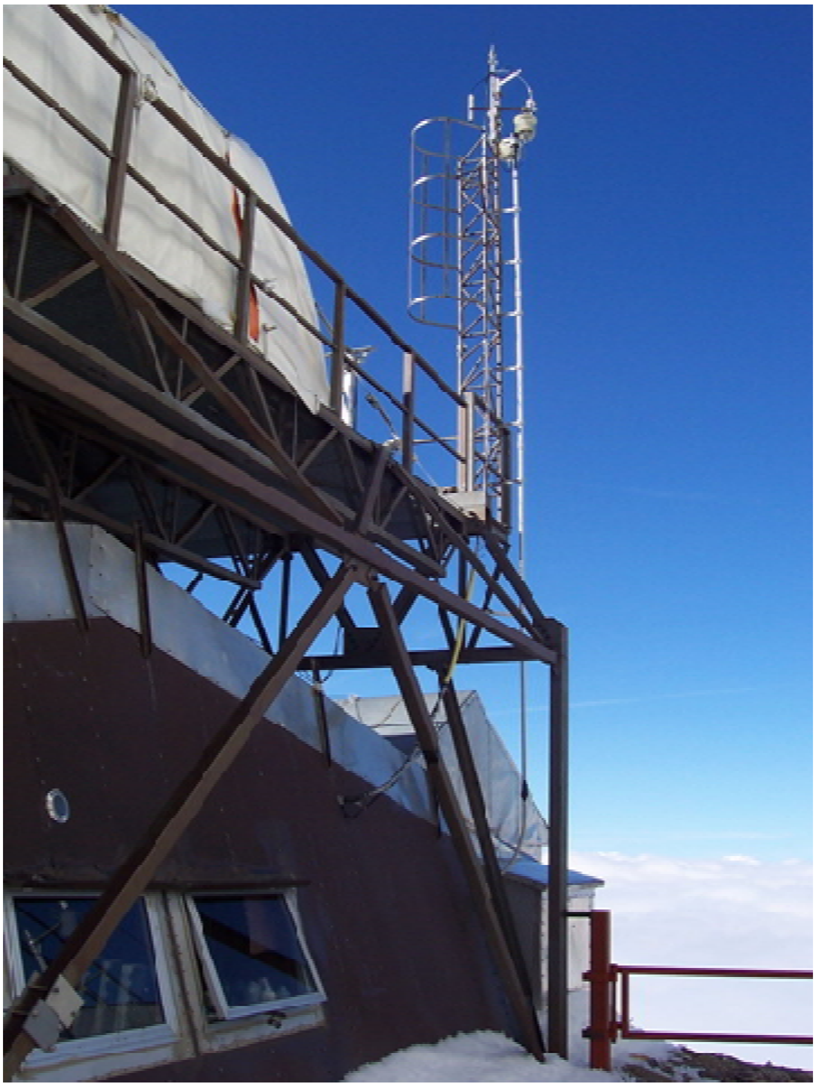

Figure 4. Image of the air sampling inlets

3. Instrumentation

Listed below, is the equipment in use at the Plateau Rosa station, indicating for each instrument, the institution responsible for the measurements acquired and the status of measurements (active/inactive) at the date of inspection:

Meteorological Instrumentation

1. Temperature: Temperature Sensor - model MICROS STEP (PT100 transducer). State: ACTIVE. Institution: RSE SpA.
2. Internal temperature sensor – model MICROS STEP (PT100 transducer). State: ACTIVE. Institution: RSE SpA.
3. Relative humidity: Relative humidity sensor - model MICROS SRHR (capacitive). State: ACTIVE. Institution: RSE SpA.
4. Relative humidity and Temperature: Combined Relative Humidity and Temperature sensor LSI – LASTEM. State: ACTIVE. Institution: RSE SpA.
5. Atmospheric Pressure: Barometer - model MICROS BAR (semi-conductor). State: ACTIVE. Institution: RSE SpA.
6. Absolute barometer - model LSI-LASTEM. State: ACTIVE. Ente: RSE SpA.
7. Wind speed and direction: GILL WindObserver II heated Sonic Anemometer. State: ACTIVE. Institution: RSE SpA.

8. Wind speed: Taco-anemometer – model LSI-LASTEM (Hall effect) heated. State: ACTIVE. Institution: RSE SpA.

Greenhouse gas Instrumentation

9. CO2 non-dispersive infrared (NDIR) analyzer - model SIEMENS ULTRAMAT 5E measurement range 350-400 ppm. State: ACTIVE. Institution: RSE SpA.
10. CO2 NDIR analyzer - model SIEMENS ULTRAMAT 6E measurement range 360-410 ppm. State: ACTIVE. Institution: RSE SpA.
11. Automated gas-chromatographic system for CH_4 measurements. Manufacturer and model: NIRA VENUS 301. State: ACTIVE. Institution: RSE SpA.
12. UV absorption O_3 analyzer Thermo Electron 49i. State: ACTIVE. Institution: RSE SpA.

4. Affiliation to research project/programmes

Research activities undertaken by RSE for the measurements performed at Plateau Rosa have so far been funded through the "Ricerca sul Sistema Elettrico" Programme Agreement financed entirely by MiSE (Italian Ministry for Economic Development). In the past, RSE has also participated in European research projects, providing measurement data from its monitoring station (see AEROCARB and CARBOEUROPE).

5. Analysis of possible upgrades

The GAW-WMO station at Plateau Rosa is equipped with an efficient instrumental set-up for greenhouse gas monitoring. For several years, continuous measurements have been performed, employing online procedures; they are visible almost in real time, both at the station itself and, for some quantities, on its institutional site OASi (http://oasi.rse-web.it/). Measurements currently performed relate to CO2, CH4 and surface ozone. The accurate execution of these measurements requires high costs of maintenance (both ordinary and extraordinary), purchase of supplies (including the rather expensive reference mixes), missions to the measuring station. Today, there are commercially available systems (e.g. Cavity Ring Down Spectroscopy - CRDS) which allow the performance of these measurements with high accuracy levels and reproducibility, as well as lower costs in terms of man-time, maintenance and consumption in respect with the "traditional" gas-chromatographic instrument currently used at Plateau Rosa. Although it must be taken into account that the implementation of this type of instrumentation involves a significant initial financial commitment for purchase, the implementation of these technologies can be recommended. Measurements of N_2O, CFC-11, CFC-12 and SF6 were also carried out in the past, but have now ceased to adapt the costs of activities to the reduced budget allocated to the activity. The re-starting of these measurement programmes would represent an important add-on to the observing capacities of the Plateu Rosa Station.

Referring to the GAW-WMO requirements for the status of "regional station" (see Box 1), it is noted that the Plateau Rosa station complies with the requirements set for the items 1, 3, 6, 7, 8, 9, and 10. In particular, the funding of monitoring activities is subject to approval, i.e. it can be reduced or withdrawn on an annual basis, and this leads to a "stop and go" situation in measurement continuity that is far from ideal in terms of producing quality data. Concerning the traceability of the executed measurements to the GAW-WMO standards, it should be noted that the surface ozone measurements do not comply with the GAW primary standard at the World Calibration Centre in Zurich (EMPA). Even if they do refer to a THERMO ELECTRON 49 PS primary calibrator in compliance with the national standard of INRIM in Turin, a direct link with the GAW-WMO standard is recommendable .

In addition to the ongoing measurement activities already present, the station could also gain a role of interest in the implementation of monitoring programmes concerning reactive gases and aerosols. In particular, the station of Plateau Rosa is entirely without activities for the study and monitoring of the physical-chemical characteristics of atmospheric aerosol. From this perspective, and also for the purpose of the interpretation of the variability of the greenhouse gases already monitored, it would be important to introduce measurement relating to aerosol size distribution (especially, in the accumulation and coarse fractions) and black carbon concentrations. The implementation of such additional measurement programmes could in fact provide important information on the impact on the variability of CO_2, CH_4 and O_3 due to air-mass transport from desert regions (evaluation of the "mineral dust" content) and from polluted regions or those influenced by forest and agricultural fire emissions.

With reference to trace gases, in view of the compounds listed in the GAW "Focal areas" (Tab. 1), it would be very useful to implement observation programmes for reactive gases (e.g. , NOx, CO). As well as contributing to better characterizing the variability of these compounds (also in the context of international initiatives, eg. the EU project ACTRIS), the implementation of such monitoring programs would allow a more accurate characterization of processes influencing the background variability of greenhouse gases.

It should also be pointed out that any extension of measurements has to be evaluated in the light of the willingness of INAF to allow RSE greater space to perform further measurements. Moreover, also a careful evaluation of available financial support should be assessed, since implementing new measurement activities would significantly increase the costs of the experimental activity and the technical/scientific resources involved.

BOX1 – Characteristics of GAW-WMO Regional Stations (from: GAW-WMO Strategic Plan 2008 – 2015)

1. The station location is chosen such that, for the variables measured, it is regionally representative and is normally free of the influence of significant local pollution sources.
2. There are adequate power, air conditioning, communication and building facilities to sustain long term observations with greater than 90% data capture (i.e. <10% missing data).
3. The technical support provided is trained in the operation of the equipment.
4. There is a commitment by the responsible agency to long term observations of at least one of the GAW variables in the GAW focal areas (cf. Section 7).
5. The GAW observation made is of known quality and linked to the GAW Primary Standard.
6. The data and associated metadata are submitted to one of the GAW World Data Centres no later than one year after the observation is made. Changes of metadata including instrumentation, traceability, observation procedures, are reported to the responsible WDC in a timely manner.
7. If required, data are submitted to a designated data distribution system in near-real-time.
8. Standard meteorological in situ observations, necessary for the accurate determination and interpretation of the GAW variables, are made with known accuracy and precision.
9. The station characteristics and observational programme are updated in the GAW Station Information System (GAWSIS) on a regular basis.
10. A station logbook (i.e. record of observations made and activities that may affect observations) is maintained and is used in the data validation process.

GAW focal area	**GAW Parameter**	**Interest**	**Availability at the station dealt with in the present report**
Total ozone *Reactive gases*	**O_3**	*Air Quality* *Oxidation Efficiency* *Climate Stratospheric Ozone Depletion*	X (surface)
Reactive gases	**CO**	*Air Quality* *Oxidation Efficiency*	
Ancillary variable	$j(NO_2)$	*Air Quality* *Oxidation Efficiency*	
Ancillary variable	$j(O_1D)$	*Air Quality* *Oxidation Efficiency*	
Greenhouse gases	H_2O (water vapour)	*Air Quality* *Oxidation Efficiency* *Climate* *Stratospheric Ozone Depletion*	
Reactive gases	HCHO	*Air Quality* *Oxidation Efficiency*	
Reactive gases	**VOCs**	*Air Quality* *Oxidation Efficiency* *Climate*	
Reactive gases	**$NO_x = NO+NO_2$** HNO_3	*Air Quality* *Oxidation Efficiency* *Climate* *Stratospheric Ozone Depletion*	
Greenhouse gases	**N_2O**	*Climate* *Stratospheric Ozone Depletion*	
Reactive gases	**SO_2**	*Air Quality* *Climate*	
Greenhouse gases	BrO, ClO, OClO HCl, $ClONO_2$ CH_3Br, **CFC-12, HCFC-22**, halons	*Climate* *Stratospheric Ozone Depletion*	
Aerosol	**Aerosol optical properties**	*Air Quality* *Oxidation Efficiency* *Climate* *Stratospheric Ozone Depletion*	
Greenhouse gases	**CO_2**	*Climate*	X
Greenhouse gases	**CH_4**	*Oxidation Efficiency* *Climate* *Stratospheric Ozone Depletion*	X
UV radiation		*Air Quality* *Stratospheric Ozone Depletion*	
Atmospheric wet deposition		*Air Quality* *Climate*	

Table 1. List of atmospheric constituents and focal areas indicated in the GAW-WMO Strategic Plan 2008 – 2015. In bold, the GAW components of the WMO integrated global observation system. The fourth column indicates the point of execution of observations of the said compounds at the GAW-WMO station of Plateau Rosa.

6. Analysis of possible criticalities

In the implementation of any action aimed at the experimental strengthening (upgrade) of the GAW-WMO station Plateau Rosa, special attention should be paid to the need for adequate maintenance of the infrastructure and instrumentation. At the present time, a substantial criticality is represented by the availability of long-term RSE funding for station management and for the running/implementation of the measurements performed there. Since this is a high quality experimental activity, the costs of maintenance (both ordinary and extraordinary), purchase of supplies (including the rather expensive reference mixes), missions to the measuring station, and the management activities at the RSE centre in Milan, constitute a considerable burden, giving rise to frequent demands to reduce the budget. This is likely to affect negatively the continuity and quality of the measurements performed. Continuity of funding and the commitment to cover the necessary costs of all activities, are essential requirements for continuing measurements and ensuring their quality and continuity.

The mountain environment, where the station is located, poses a serious risk to the safety of the infrastructure and laboratories. Care must be taken to ensure all necessary steps to counter the effects of strong wind, snow and ice formation, which can over time severely compromise the safety and integrity of the materials and, consequently, the availability of the acquired data.

On occasion, access to the station is obstructed by snowfalls often occurring at high altitudes. The transport of supplies, such as pressurised gas mixes (cylinders) and (although not always) instrumentation, is often undertaken by a local carrier. When the entrance is obstructed by snow and ice, some of the time allocated to station supervision is lost, in order to clear the access. Due to strong winds, it has been necessary to replace some meteorological sensors which have been irreversibly damaged. Missions to the station are required on average at least every three weeks. In view of the logistical problems, the type of work required, and, last but not least, the safety of respective personnel, missions must be carried out by two persons, skilled and/or trained for this type of activity.

7. Conclusions

Evidence emerging from consultations with RSE personnel, has shown that in order to ensure the full functionality of the GAW-WMO Plateau Rosa regional station, particular attention must be paid to the following actions:

a. Maintenance of technical/technological facilities and scientific instrumentation also as a function of the adverse weather and environmental conditions characterising the measuring site;
b. Execution of regular instrument calibrations with direct link to GAW-WMO standards, especially for surface ozone measurements;
c. Upgrade of greenhouse gas monitoring programmes (e.g. possible re-activation of halogenated gas measurements);
d. Implementation of programmes for the on-line monitoring of atmospheric aerosol and reactive gases (subject to approval INAF-IFSI).

A technical inspection of the Plateau Rosa station will be undertaken as early as possible, to confirm and possibly integrate the information provided in the present report.

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