Consiglio Nazionale delle Ricerche
Istituto di Scienze dell'Atmosfera e del Clima

ITALIAN CLIMATE OBSERVATORY "O. VITTORI"
Mt. CIMONE
GAW-WMO Global Station

SPRING 2014 REPORT

CNR - ISAC

National Research Council

Institute of Atmospheric Sciences and Climate

ITALY

AUTHORS: Paolo Bonasoni, Paolo Cristofanelli, Angela Marinoni, Rocco Duchi, Francescopiero Calzolari, Fabrizio Roccato, Davide Putero, Tony Christian Landi, Maurizio Busetto, Laureline Bourcier, Samuele Masieri, Ubaldo Bonafè, Michela Maione, Jgor Arduini.

Institute of Atmospheric Science and Climate – National Research Council of Italy
Via Gobetti 101
40129 I-Bologna

Summer report of the Italian Climate Observatory "O. Vittori" at Mt.Cimone – n.4
Issued: May 2013, rev. 2
The report is published quarterly. Download at: http://www.isac.cnr.it/cimone/reports
ISSN: 2283-9631

The research activities and the measurement programmes carried out at the Italian Climate Observatory

"O. Vittori" at Mt. Cimone are supported by:

MIUR
Ministry of Education, University and Research
Ministero dell'Istruzione, dell'Università e Ricerca

CNR
National Research Council of Italy
Consiglio Nazionale delle Ricerche

DTA
Earth and Environment Department
Dipartimento di Scienze del Sistema Terra e Tecnologie per l'Ambiente

ACTRIS
Aerosol, clouds and trace gases research infrastructure network
Rete di infrastrutture per la ricerca su aerosol, nubi e gas in tracce

NEXTDATA
A national system for the retrieval, storage, access and diffusion of environmental and climate data from mountain and marine areas.
Un sistema nazionale per la raccolta, conservazione, accessibilità e diffusione dei dati ambientali e climatici in aree montane e marine.

SHARE
Stations at High Altitude for Research on the Environment
Stazioni di alta quota per la ricerca sull'ambiente

The research activities and the measurement programmes carried out at the Italian Climate Observatory "O. Vittori" at Mt. Cimone are an Italian contribute to:

WDCGG
World Data Center for Greenhouse Gases
Centro Dati Mondiale per i Gas Serra
http://ds.data.jma.go.jp/gmd/wdcgg/

WDCA
World Data Center for Aerosol
Centro Dati Mondiale per gli Aerosol
http://www.gaw-wdca.org/

MACC
Monitoring Atmospheric Composition & Climate
http://gmes-atmosphere.eu/

SDS-WAS
WMO Sand and Dust Storm Warning Advisory and Assessment System
http://sds-was.aemet.es/

AGAGE
Advanced Global Atmospheric Gases Experiment
http://agage.eas.gatech.edu/

ACKNOWLEDGEMENTS: ISAC-CNR gratefully acknowledges the Italian Air Force – CAMM Monte Cimone for the fundamental logistic support at Monte Cimone.

RINGRAZIAMENTI: l'ISAC-CNR ringrazia l'Aeronautica Militare Italiana – CAMM Monte Cimone per il fondamentale supporto logistico fornito.

List of contents

Foreword

This report summarizes the results concerning the atmospheric observations carried out during SPRING 2014 at the Italian Climate Observatory “O. Vittori” (ICO-OV), managed by the Institute of Atmospheric Sciences and Climate (ISAC) of the National Research Council of Italy (CNR). This research infrastructure is part of the WMO/GAW global station of Monte Cimone together with the Meteorological Observatory of the Italian Air Force(GAW ID: CMN).

Firstly, we provide a brief description of the measurement site and running experimental programmes is given.

Then, an overview of the atmospheric and weather conditions during Spring 2014 considering:

- **surface ozone**
- **carbon monoxide**
- **nitrogen oxides**
- **black carbon**
- **fine and coarse particles**
- **stratospheric nitrogen dioxide**
- **meteorological data (temperature, relative humidity, pressure, wind speed and direction)**
- **solar radiation and UV-B**

For each atmospheric parameter we provide basic statistical information (minimum, maximum and average values) together with a comparison with the climatological reference for Mt. Cimone.

Then, a list of special events which occurred during the spring is also presented, together with a description of the adopted selection methodologies:

- **pollution transport**
- **mineral dust transport**
- **transport of air-masses from the stratosphere**

For each observed parameter, a specific paragraph presents:

- **the time series of the daily mean values (calculated basing on 30-minute aggregated values, if the daily data coverage of 75% has been achieved)**
- **a table reporting the basic statistical parameters (on a 30-minute basis)**
- **a comparison with the seasonal historical mean values: for each year, the Spring mean values are calculated by averaging data from 2014, March 1st to May 26th.**

Premessa

Questo rapporto riassume i risultati relativi alle osservazioni atmosferiche effettuate durante la PRIMAVERA 2014 presso l'Osservatorio Climatico "O. Vittori " (ICO-OV) dell'Istituto di Scienze dell'Atmosfera e del Clima (ISAC) del Consiglio Nazionale delle Ricerche Italia (CNR). Questa stazione di ricerca è parte, insieme all'Osservatorio Meteorologico dell'Aeronautica Militare, della stazione globale WMO/GAW di Monte Cimone (GAW ID: CMN).

In questo Report viene innanzitutto fornita una breve descrizione del sito di misura e dei programmi di ricerca in atto.

Quindi viene data una panoramica delle condizioni atmosferiche e meteorologiche che hanno caratterizzato il periodo invernale 2014 considerando:

- **ozono superficiale**
- **monossido di carbonio**
- **ossidi di azoto**
- **black carbon**
- **particolato fine e grossolano**
- **biossido di azoto stratosferico**
- **dati meteorologici (temperatura , umidità relativa , pressione, velocità e direzione del vento)**
- **radiazione solare e UV- B**

Per ogni parametro atmosferico sono fornite informazioni statistiche di base (valori minimi, massimi e medi) ed un confronto con il riferimento climatologico dell'Osservatorio "O. Vittori" per Monte Cimone.

Successivamente viene presentata una lista di eventi "speciali" che si sono verificati durante il periodo ed identificati con procedure opportunamente messe a punto e descritte.

- **trasporti di masse d'aria inquinate**
- **trasporto di polvere minerale**
- **trasporto di masse d'aria dalla stratosfera**

Per ogni parametro osservato uno specifico paragrafo presenta:

- **le serie storiche dei valori medi giornalieri (calcolati basandosi su valori mediati di 30 minuti, se la copertura dei dati giornaliera del 75% è stata raggiunta)**
- **una tabella con i parametri statistici di base (su un base di 30 minuti)**
- **Il confronto con i valori medi storici stagionali per ogni anno, considerando che i valori primaverili sono calcolati come media dal 1 marzo al 26 maggio 2014.**

Monte Cimone GAW/WMO Global Station

The **Global Atmosphere Watch (GAW)** programme of WMO is a partnership involving the Members of WMO, contributing networks and collaborating organizations and bodies which provides reliable scientific data and information on the chemical composition of the atmosphere, its natural and anthropogenic change, and helps to improve the understanding of interactions between the atmosphere, the oceans and the biosphere.

A network of measurement stations is the backbone of the GAW programme. This network consists of GAW Global and Regional measurement stations with additional measurements from Contributing stations. Both Global and Regional stations are operated by their host countries, either by their National Meteorological Services or by other national scientific organizations. More than 80 countries actively host GAW stations.

Currently GAW coordinates activities and data from 29 Global stations, more than 400 Regional stations, and around 100 Contributing stations operated by Contributing networks

Location of the 29 Global Stations of the WMO/GAW programme

Mt. Cimone is the only WMO/GAW Global Station in Italy

Global station name	Altitude (a.s.l.)	Country
Assekrem/Tamanrasset	2710 m	Algeria
Izaña	2372 m	Spain
Jungfraujoch	3580 m	Switzerland
Mauna Loa,	3397 m	United States
Monte Cimone*	2165 m	Italy
Mt. Kenya	3678 m	Kenya
Mt. Waliguan	3810 m	China
Nepal Climate Observatory – Pyramid*	5079 m	Nepal
Zugspitze/ Hohenpeissenberg	2962 m	Germany

*Managed by Italian Institutions

List of GAW/WMO high altitude global station (for more information: http://gaw.empa.ch/gawsis/)

La Stazione Globale GAW/WMO di Monte Cimone

Il programma **Global Atmosphere Watch (GAW)** dell'OMM coinvolge gli Stati Membri della OMM e diverse reti osservative, organizzazioni ed Istituzioni con lo scopo di fornire dati scientifici ed informazioni attendibili sulla composizione dell'atmosfera, sui cambiamenti naturali e dovuti alle attività umane, contribuendo a migliorare la conoscenza delle interazioni fra atmosfera, oceani e biosfera.

GLOBAL ATMOSPHERE WATCH

La spina dorsale del programma GAW è costituita dalla propria rete osservativa. Essa è formata da Stazioni Globali e Regionali, oltre che da Stazioni definite "Contributing" che forniscono informazioni addizionali. Le Stazioni Globali e Regionali sono gestite dai Paesi di appartenenza, sia attraverso i Servizi Meteorologici Nazionali che gli Enti Pubblici di Ricerca. Le Stazioni GAW sono ospitate in oltre 80 Paesi del mondo.

Allo stato attuale il programma coordina 29 Stazioni Globali e oltre 400 Stazioni Regionali, oltre a 100 Stazioni "Contributing".

Dislocazione delle 29 Stazioni Globali del programma WMO/GAW

Monte Cimone è l'unica Stazione Globale WMO/GAW in Italia

Nome	Quota (s.l.m.)	Paese
Assekrem/Tamanrasset	2710 m	Algeria
Izaña	2372 m	Spagna
Jungfraujoch	3580 m	Svizzera
Mauna Loa	3397 m	USA
Monte Cimone*	2165 m	Italia
Mt. Kenya	3678 m	Kenya
Mt. Waliguan	3810 m	Cina
Nepal Climate Observatory – Pyramid*	5079 m	Nepal
Zugspitze/ Hohenpeissenberg	2962 m	Germania

*Stazioni gestite da Istituzioni Italiane

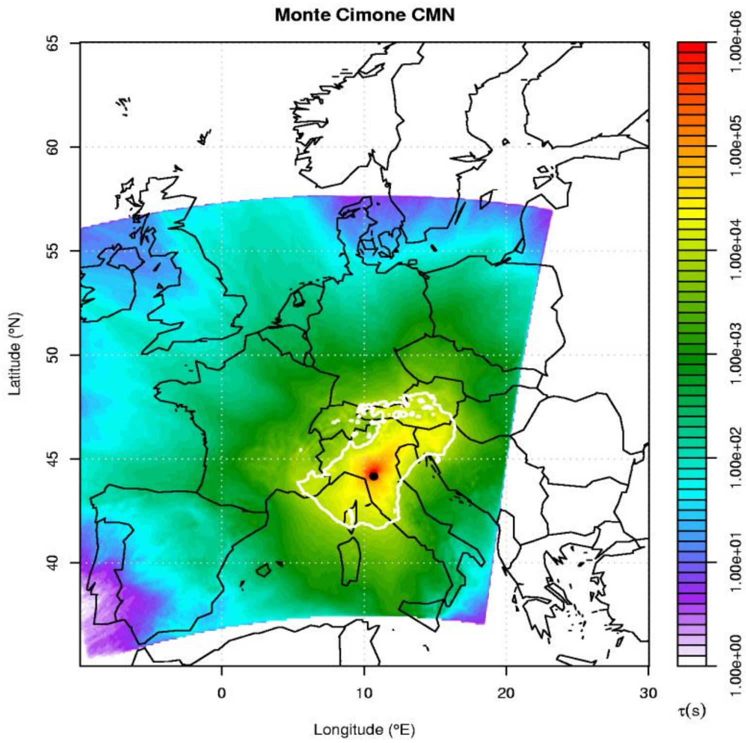
Lista delle stazioni globali GAW/WMO in aree di alta quota (for more information: http://gaw.empa.ch/gawsis/)

Geographical location

Mt. Cimone (44°12' N, 10°42' E, 2165 m a.s.l.) is the highest peak of the Northern Apennines, the border line of two different climatic regions: the continental Europe northwards and the Mediterranean Basin southwards.

The closest inhabited areas are small villages placed 15 km from and about 1100 m below the Observatory, whereas major towns (500000 inhabitants) are situated in the lowlands about 60 km away (Bologna, Firenze). The industrial areas are not closer than 40 km and 2 km lower. The closest roads with some traffic are 7 km far and 1 km lower. Forest of conifers and beech trees grow up to 1600 m, so that the Laboratory is above the timberline. Only some patches of vegetation are on the top of the mountain

Mt. Cimone is characterized by a completely free horizon for 360° and air masses originated in different areas can reach the station. In the following figure, the annual 48 hour catchment areas, (i.e. the areas from which the air masses come) is provided for ICO-OV (EU-Project GEOMON).



The catchment area of the site for the 48-hour integration time backwards in time is given by the intersection of the topography with the volume containing the largest residence time densities and comprises 50% of the total residence time.

Il "bacino di raccolta" delle masse d'aria a 48 ore è ottenuto considerando le aree geografiche sopra le quali si totalizza almeno il 50% del tempo di residenza totale delle masse d'aria durante il trasporto verso Monte Cimone.

For more information:
http://geomon.empa.ch/.

The atmospheric observations carried out at Monte Cimone can be considered representative of the free tropospheric conditions of the Mediterranean Basin/South Europe. Only during the warm periods of the year the measurement site can be affected by transport of air masses from PBL (planetary boundary layer).

Posizione geografica

Monte Cimone (44°12' N, 10°42' E, 2165 m s.l.m.) è la cima più alta dell'Appennino Settentrionale, la linea di confine tra due diverse regioni climatiche: l'Europa continentale a Nord ed il bacino del Mediterraneo a Sud.

Le zone abitate più vicine sono piccoli paesi a circa 15 km di distanza e 1100 m di più in basso rispetto all'Osservatorio, mentre le città più grandi (Bologna, Firenze) sono situate in pianura a circa 60 km di distanza. Non vi sono importanti aree industriali nel raggio di circa 40 km. Le strade trafficate più vicine distano circa 7 km (1 km di quota più in basso). Boschi di conifere e faggi crescono fino a 1600 m. Nei pressi della cima si trovano prati e zone rocciose.

Monte Cimone è caratterizzato da un orizzonte completamente libero e quindi le masse d'aria possono raggiungere il sito di misura senza incontrare ostacoli orografici. Nella pagine precedente viene mostrata la media annuale del "bacino di raccolta" delle masse d'aria che nel giro di 48 ore sono arrivate a Mt. Cimone (EU-Project GEOMON).

Mt. Cimone is located just over 50 km from the Tyrrhenian Sea and about 30 km from the Adriatic Sea. The GAW-WMO Global Station is composed by the **Meteorological Observatory of the Italian Air Force** and the **Italian Climate Observatory "O. Vittori" of the Italian National Research Council**.

Monte Cimone dista poco più di 50 Km dal Mar Tirreno e circa 130 dal Mare Adriatico. La Stazione Globale GAW/WMO è composta dall'**Osservatorio Meteorologico dell'Aeronautica Militare** e dall'**Osservatorio Climatico "O. Vittori" del Consiglio Nazionale delle Ricerche**.

Le osservazioni di composizione dell'atmosfera condotte a Monte Cimone possono essere considerate rappresentative delle condizioni di fondo della libera troposfera del bacino del Mediterraneo e del Sud Europa. Solo durante i mesi caldi, i processi convettivi possono favorire il trasporto di masse d'aria dallo strato limite planetario (PBL).

List of parameters

In the following table, we provide the list of the atmospheric parameters presented in this report, together with a brief description of their key roles in the atmospheric investigations and the experimental set-up at the ICO-OV.

Parameters	**Key role**	**Instrumentation**
Surface ozone	Short-lived climate forcer, greenhouse gas, secondary pollutant	UV-absorption analyser *(Dasibi 1108 W/GEN)*
Carbon monoxide	Primary pollutant, ozone precursor, combustion tracer	Non dispersive IR absorption *(Thermo Tei48c-TL)*
Nitrogen oxides	Primary (NO) and secondary (NO_2) pollutants, ozone precursors, combustion tracers.	Chemiluminescence analyser (*Thermo Tei42i - TL)*
Black carbon	Short-lived climate forcer, primary pollutant, combustion tracer. It contributes to PM_1	Multi-Angle Absorption Photometer *(Thermo MAAP 5012)*
Aerosol number concentration (fine)	Short-lived climate forcer, primary and secondary aerosol, pollution tracer. It contributes to PM_1.	Optical particle counter *(GRIMM 1108)*
Aerosol number concentration (coarse)	Short-lived climate forcer, primary aerosol, mineral dust and sea salt tracer. It contributes to PM_{10}.	Optical particle counter *(GRIMM 1108)*
Stratospheric nitrogen dioxide	Ozone destroying substance and buffer against halogen catalysed ozone loss	GASCOD-MTC: UV-Vis spectrometer (Since 1993)
Temperature and relative humidity	Meteorology and data interpretation	*Rotronic, IRDAM WS 7000*
Atmospheric pressure	Meteorology and data interpretation	*Technoel, IRDAM WS 7000*
Wind	Meteorology and data interpretation	*Vaisala WS425, IRDAM WST7000*
Solar radiation	Meteorology and data interpretation	Silicon cell pyranometer *(Skye SKS110)*
UV-B radiation	Meteorology and data interpretation	Silicon photodiode *(Skye SKU 430)*

Lista dei parametri

Nella tabella è presentata la lista dei parametri presentati in questo report, assieme ad una breve *descrizione dei ruoli nelle ricerche condotte ed il set up sperimentale utilizzato presso l'ICO-OV.*

Parametri	***Ruolo chiave clima – qualità dell'aria***	***Strumentazione***
Ozono superficiale	*Forzante climatico a breve tempo di vita, gas serra, inquinante secondario.*	*Analizzatore ad assorbimento UV (Dasibi 1108 W/GEN)*
Monossido di carbonio	*Inquinante primario, precursore dell'ozono, tracciante della combustione*	*Analizzatore ad assorbimento infra-rosso. (Thermo Tei48c-TL)*
Ossidi d'azoto	*Inquinanti primari (NO) e secondari (NO_2), precursori dell'ozono, traccianti della combustione. In stratosfera NO_2 influenza le concentrazioni di ozono.*	*Analizzatore a chemiluminescenza (Thermo Tei42i - TL)*
Black carbon	*Forzante climatico a breve tempo di vita, inquinante primario, tracciante della combustione. Contribuisce al PM_1*	*Fotometro per l'assorbimento con correzione sullo scattering a più angoli (Thermo MAAP 5012)*
Numero delle particelle fini	Forzante climatico a breve tempo di vita, aerosol primario e secondario, tracciante dell'inquinamento. Contribuisce al PM_1	Contatore ottico *(GRIMM 1108)*
Numero delle particelle grossolane	Forzante climatico a breve tempo di vita, aerosol primario, tracciante delle polveri minerali e del sale marino. Contribuisce al PM_{10}	Contatore ottico *(GRIMM 1108)*
Biossido di azoto stratosferico	Distrugge l'ozono stratosferico e sostanza "tampone" per alogeni attivi nella deplezione dell'ozono stratosferico	Spettrometro UV/Vis GASCOD-MTC
Temperatura ed umidità relativa	Meteorologia ed interpretazione dei dati	*Rotronic, IRDAM WS 7000*
Pressione atmosferica	Meteorologia ed interpretazione dei dati	*Technoel, IRDAM WS 7000*
Vento	Meteorologia ed interpretazione dei dati	*Vaisala WS425, IRDAM WST7000*
Radiazione solare	Meteorologia ed interpretazione dei dati	Piranometro a celle di silicio *(Skye SKS110)*
Radiazione UV-B	Meteorologia ed interpretazione dei dati	Fotodiodo al silicio *(Skye SKU 430)*

Summary

OVERWIEV

Spring 2014 did not present high average levels of short-lived climate forcers (SLCF): values lower than the climatological means were observed for black carbon, while for surface ozone and fine particles we reported average values similar with previous spring seasons. Carbon monoxide showed lower values in respect than the climatological reference. Only the coarse particles showed a high average value. The atmospheric and meteorological regime were well representative of the spring season.

Only 8.7% of the spring days have been affected for a significant fraction of time by transport of polluted air-masses, with none of them during May.

10 days (10.9%) were affected by mineral dust transport, with a major event occurring from May 22nd to 23rd.

Air-mass transport from the stratosphere were not present during this period, as deduced by our identification methodology.

Sommario

VISIONE DI INSIEME

La primavera del 2014 non ha presentato valori medi elevati degli *short-lived climate forcers* (SLCF): il black carbon ha mostrato valori inferiori alle medie climatologiche, mentre le particelle fini e l'ozono hanno mostrato valori in linea con quelli dei precedenti anni. Bassi valori si sono avuti anche per il monossido di carbonio. In generale gli andamenti sono ben rappresentativi del periodo primaverile. Solo le particelle grossolane hanno mostrato un valore medio stagionale elevato.

Solo l'8.7% dei giorni sono stati influenzati da trasporti di masse d'aria inquinate, nessuno dei quali verificatisi durante il mese di maggio.

10 giorni (10.7%) sono stati caratterizzati da eventi di trasporto di sabbia sahariana: l'episodio più intenso è stato osservato dal 22 al 23 di maggio.

Sulla base della nostra metodologia di identificazione, nessun evento di trasporto di masse d'aria provenienti dalla stratosfera è stato rilevato durante la primavera 2014.

Daily **surface ozone** peak was recorded on 18-05 (69.5 ppb). 30-minute average values ranged from a minimum of 33.4 ppb (05-03) to 78.0 ppb (04-04), with an average seasonal value of 56.3 ppb. This value is on par with the average climatological value obtained from the last 18 years (58.6 ppb).

Daily **carbon monoxide** peak was recorded on 06-03 (184.9 ppb). 30-minute average values ranged from a minimum of 77.2 ppb (24-05) to 208.0 ppb (06-03), with an average seasonal value of 130.6 ppb. This value is lower than the value of spring 2013 (140.0 ppb).

Daily **black carbon** peak was recorded on 12-03 (604.9 ng m^{-3}). 30-minute average values ranged from a minimum of 10.0 ng m^{-3} (27-03) to 924.9 ng m^{-3} (14-03), with an average seasonal value of 204.1 ng m^{-3}. This value is lower than the average climatological value obtained from the last 8 years (233.4 ng m^{-3}).

Daily **fine aerosol particles** peak was recorded on 13-04 (103.2 cm^{-3}). 30-minute average values ranged from a minimum of 0.02 cm^{-3} (23-03) to 239.4 cm^{-3} (13-04), with an average seasonal value of 28.7 cm^{-3}. This value is on par with the average climatological spring value obtained from the last 12 years (28.8 cm^{-3}).

Daily **nitric oxide** and **nitrogen dioxide** peaks were recorded on 06-03 (0.3 ppb) and (2.6 ppb), respectively. 30-minute average values ranged from values below the detection limit to 1.79 ppb (for NO) and 5.91 ppb (for NO_2).

Daily **coarse aerosol particles** peak was recorded on 22-05 (4.1 cm^{-3}). 30-minute average values ranged from a minimum of 0.001 cm^{-3} (13-04) to 17.8 cm^{-3} (23-05), with an average seasonal value of 0.37 cm^{-3}. This value is higher than the average climatological spring value obtained from the last 12 years (0.28 cm^{-3})

The maximum value of **nitrogen dioxide columnar** amount was recorded on 27-03 ($6.09 \cdot 10^{15}$ mol/cm^2) for the sunset, and 27-03 ($4.53 \cdot 10^{15}$ mol/cm^2) for the sunrise. The minimum value of the columnar amount of nitrogen dioxide was recorded on 18-03 ($2.99 \cdot 10^{15}$ mol/cm^2) for the sunset, and 20-03 ($2.31 \cdot 10^{15}$ mol/cm^2) for the sunrise. The seasonal trend is representative of the stratospheric annual cycles (growth of the total column during spring).

Il valore massimo giornaliero della concentrazione di **ozono superficiale** è stato registrato il 18-05 (69.5 ppb). Le medie semi-orarie variano da 33.4 ppb (05-03) a 78.0 ppb (04-04), con un valore medio stagionale di 56.3 ppb. Tale valore è in linea con quello climatologico relativo agli ultimi 18 anni (58.6 ppb).

Il valore massimo giornaliero della concentrazione di **monossido di carbonio** è stato registrato il 06-03 (184.9 ppb). Le medie semi-orarie variano da 77.2 ppb (24-05) a 208.0 ppb (06-03), con un valore medio stagionale pari a 130.6 ppb. Tale valore è inferiore a quello della primavera 2013 (140.0 ppb).

Il valore massimo giornaliero della concentrazione di **black carbon** è stato registrato il 12-03 (604.9 ng m^{-3}). Le medie semi-orarie variano da 10.0 ng m^{-3} (27-03) a 924.9 ng m^{-3} (14-03), con un valore medio stagionale pari a 204.1 ng m^{-3}. Tale valore è inferiore a quello climatologico relativo agli ultimi 8 anni (233.4 ng m^{-3}).

Il valore massimo giornaliero della concentrazione di **particelle fini** è stato registrato il 13-04 (103.2 cm^{-3}). Le medie semi-orarie variano da 0.02 cm^{-3} (23-03) a 239.4 cm^{-3} (13-04), con un valore medio stagionale pari a 28.7 cm^{-3}. Tale valore è in linea con quello climatologico (28.8 cm^{-3}).

I valori massimi giornalieri di **ossido d'azoto** e **biossido d'azoto** sono stati registrati il 06-03 (0.3 ppb e 2.6 ppb rispettivamente). Le medie semi-orarie sono variate da valori inferiori al limite di rivelazione sino a 1.79 ppb (per NO) e 5.91 ppb (per NO_2).

Il valore massimo giornaliero della concentrazione di **particelle grossolane** è stato registrato il 22-05 (4.1 cm^{-3}). Le medie semi-orarie variano da 0.001 cm^{-3} (13-04) a 17.8 cm^{-3} (23-05), con un valore medio stagionale pari a 0.37 cm^{-3}. Tale valore è superiore a quello climatologico relativo ultimi 12 anni (0.28 cm^{-3}).

Il valore massimo della **quantità colonnare di biossido di azoto** è stato registrato il 27-03 ($6.09\cdot10^{15}$ mol/cm^2) per il tramonto, e il 27-03 ($4.53\cdot10^{15}$ mol/cm^2) per l'alba. Il valore minimo della quantità colonnare di biossido di azoto è stato registrato il 18-03 ($2.99\cdot10^{15}$ mol/cm^2) per il tramonto, e il 20-03 ($2.31\cdot10^{15}$ mol/cm^2) per l'alba. La serie segue l'andamento del ciclo annuale che prevede un aumento del valore colonnare nel periodo primaverile.

Daily **air temperature** peak was recorded on 10-05 (8.9°C), minimum on 16-04 (-4.8 °C). 30-minute average values ranged from a minimum of -6.9 °C (16-04) to 12.0 °C (10-05), with an average seasonal value of 1.6 °C, which is higher than the seasonal climatological value (1.1 °C).

Daily **relative humidity** minimum was recorded on 17-03 (52.2%). 30-minute average values ranged from a minimum of 30.4 % (22-05) to a maximum of 100.0 % (observed on 32 days), with an average seasonal value of 85.3 %. This value is higher than the average climatological spring value obtained from the last 18 years (81.2 %).

Daily **atmospheric pressure** peak was recorded on 13-03 (798.6 hPa), the lowest value on 04-03 (766.1 hPa). 30-minute average values ranged from a minimum of 761.6 hPa (04-03) to 799.6 hPa (12-03), with an average seasonal value of 787.4 hPa. This value is on par with the average climatological spring value obtained from the last 18 years (787.3 hPa).

Daily **wind speed** peak was recorded on 18-03 (14.7 m s^{-1}). 30-minute average values ranged from a minimum of 1.0 m s^{-1} (01-04) to a maximum of 19.7 m s^{-1} (07-05), with an average seasonal value of 7.7 m s^{-1}. This value is comparable to the climatological spring value (8.0 m s^{-1}).

Wind direction was prevalently from SW (11.5 % of 30-minute data). However, differently from the climatological analysis over the last 18 years, there is also a significant contribution from N (8.6%).

Daily **Solar radiation** showed an increasing throughout the season, with the highest average daily value recorded on 15-05 (339.8 W m^{-2}).

A similar trend was also observed for **UV-B radiation**: the highest value was observed on 10-05 (0.6 W m^{-2}).

Il valore massimo giornaliero della **temperatura** è stato registrato il 10-05 (8.9 °C), il valore minimo il 16-04 (-4.8 °C). Le medie semi-orarie variano da -6.9 °C (16-04) a 12.0 °C (10-05), con un valore medio stagionale pari a 1.6 °C superiore a quello climatologico di 1.1 °C.

Il valore minimo giornaliero dell'**umidità relativa** è stato registrato il 17-03 (52.2 %). Le medie semi-orarie variano da 30.4 % (22-05) a 100 % (osservato in 32 giornate), con un valore medio stagionale pari a 85.3 %. Tale valore è superiore a quello climatologico relativo agli ultimi 18 anni (81.2 %).

Il valore massimo giornaliero della **pressione atmosferica** è stato registrato il 13-03 (798.6 hPa), il valore minimo il 04-03 (766.1 hPa). Le medie semi-orarie variano da 761.6 hPa (04-03) a 799.6 hPa (12-03), con un valore medio stagionale pari a 787.4 hPa. Tale valore è confrontabile con quello climatologico relativo agli ultimi 18 anni (787.3 hPa).

Il valore massimo giornaliero della **velocità del vento** è stato registrato il 18-03 (14.7 m s^{-1}). Le medie semi-orarie variano da 1.0 m s^{-1} (01-04) a 19.7 m s^{-1} (07-05), con un valore medio stagionale pari a 7.7 m s^{-1}. Tale valore è confrontabile con quello climatologico ottenuto dalle misure realizzate negli ultimi 18 anni (8.0 m s^{-1}).

La **direzione del vento** osservata nell'autunno 2013 è stata prevalentemente da Sud-Ovest (11.5 % dei dati semi-orari). Tuttavia è stato registrato un contributo consistente da parte dei venti settentrionali (8.6 %), differentemente da quanto solitamente osservato negli ultimi 18 anni.

La **radiazione solare** mostra un evidente trend crescente durante tutta la stagione, con il valore giornaliero più elevato registrato il 15-05 (339.8 W m^{-2}).

Anche la **radiazione UV-B** mostra un simile trend nel corso della stagione: il valore massimo (0.6 W m^{-2}) è stato osservato il 10-05.

Special events

In this paragraph, we present a detailed overview of “special events” which have been detected at the ICO-OV during the reference period, namely:

- **Mineral Dust transport**
- **Stratospheric intrusions;**
- **Pollution transport.**

It must be noted that the event selection methodologies are executed on 30-minute basis, thus, for the same day, different classes of special events can be observed.

Day	March	April	May
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			
16			
17			
18			
19			
20			
21			
22			
23			
24			
25			
26			
27			
28			
29			
30			
31			

LEGEND

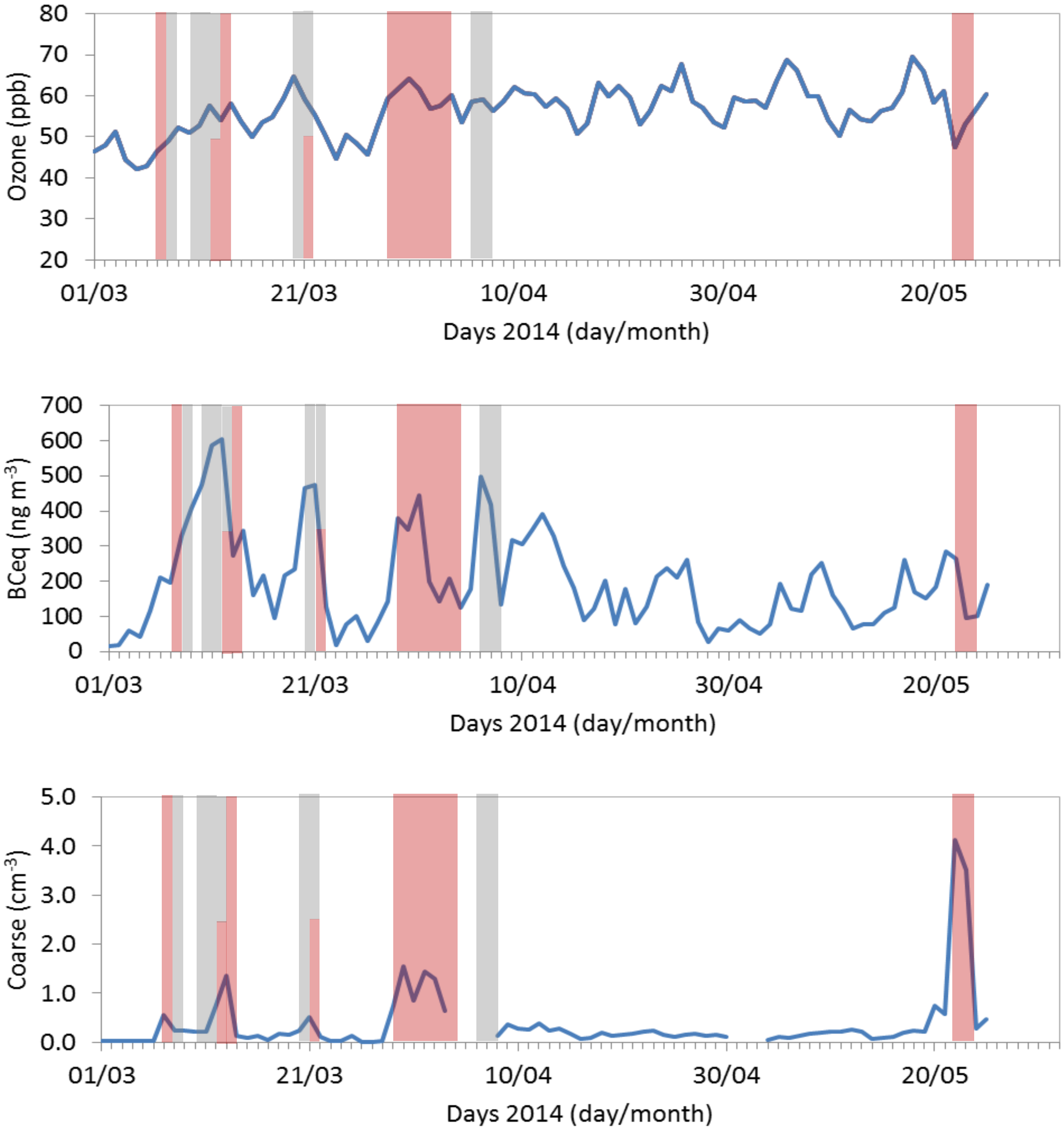
Mineral dust   Stratospheric intrusions   Pollution transport

Eventi speciali

In questo paragrafo viene presentato l'elenco degli "eventi speciali" che sono stati registrati presso il sito di misura durante il periodo analizzato:

- **Trasporto di polveri minerali;**
- **Intrusioni stratosferiche;**
- **Trasporto di inquinanti**

<u>Va notato che le metodologie di selezione degli eventi sono calcolate a partire dai dati a 30-minuti, quindi, per lo stesso giorno, possono essere osservate diverse tipologie di evento.</u>



LEGENDA

Polveri minerali | Intrusioni stratosferiche | Trasporto di inquinanti

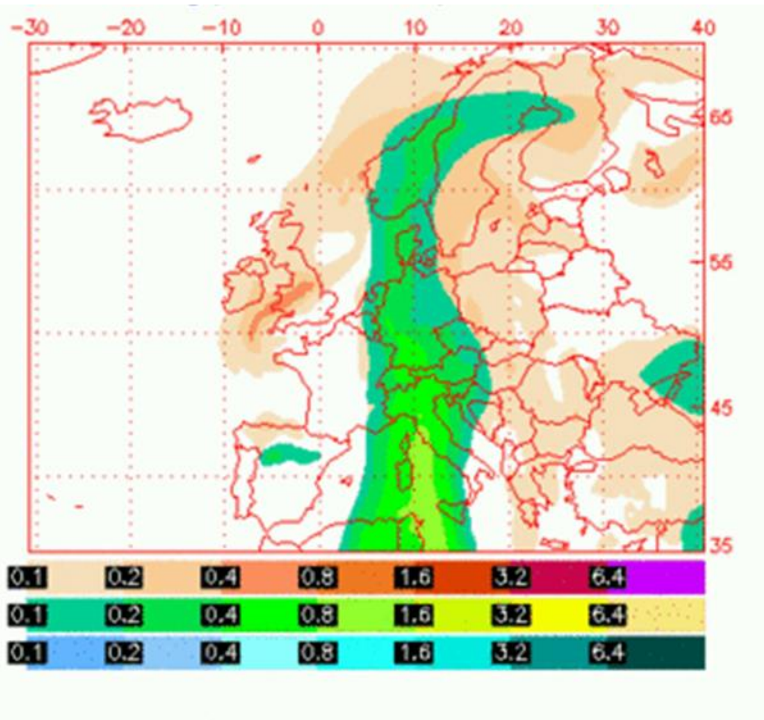
Mineral dust transport

The presence of mineral dust in the atmosphere plays direct and indirect role in affecting climate variations. Moreover, mineral dust can seriously affect air quality in regions downwind of desert areas, contributing to PM_{10} levels. Sahara desert exports more mineral dust than any other area of the world, injecting into the atmosphere millions of Tons of dust particles. Mt. Cimone represents one of the first mountain ridges that Saharan dust meet along their tracks towards Italy and Europe.

> *Selection methodology:* we detected a Saharan dust event when the atmospheric concentration of coarse particles (particles with diameter 1 µm ≤ Dp≤ 20 µm) significantly increased with air-masses coming from North Africa, as deduced by three-dimensional air-mass back-trajectories and transport model outputs.

SPRING 2014:

- **12 days were characterized by the transport of mineral dust from northern Africa (13.4 % of the period).**
- **The most important dust event occurred from May 22nd to May 23rd, when the coarse particle reached the concentration of 4.1 cm^{-3}, on 23rd May 2014.**



Dust transport event simulation by NAAPS model (22th May 2014).

Simulazione dell'evento di trasporto di polveri minerali osservato il 22 Maggio 2014 (modello NAAPS).

http://www.nrlmry.navy.mil/
Courtesy by NRL/Monterey Aerosol Modeling.

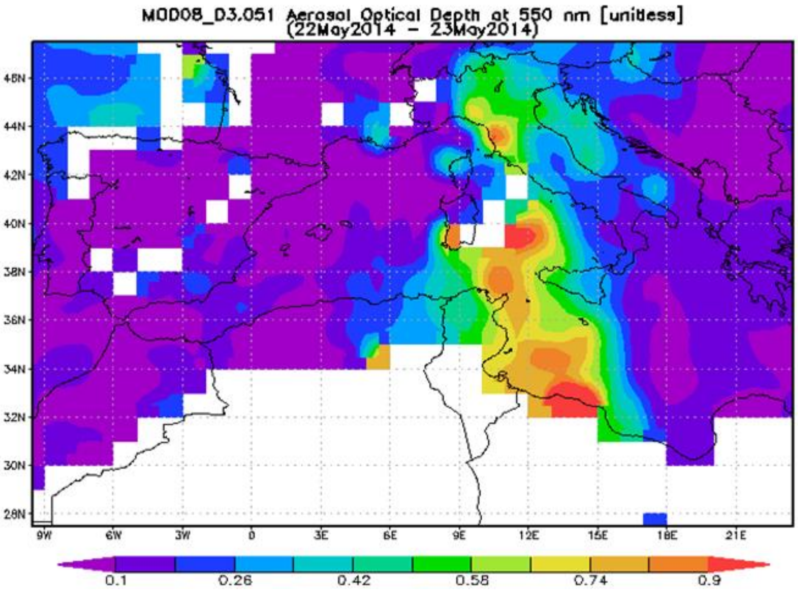
Trasporto di polveri minerali

La presenza di aerosol (polveri) minerali nell'atmosfera può influenzare il clima attraverso effetti diretti ed indiretti. Esse possono inoltre alterare in modo significativo la qualità dell'aria in regioni prossime alle aree di emissione o soggette a fenomeni di trasporto, influenzando le concentrazioni di PM_{10}. Masse d'aria ricche di polveri minerali possono essere trasportate dal deserto del Sahara, la più importante sorgente al mondo di polveri minerali, verso l'Italia e l'Europa. Mt. Cimone rappresenta uno dei primi rilievi montuosi che queste masse d'aria incontrano durante il loro movimento verso nord.

Metodologia di selezione: gli eventi di trasporto di polveri sahariane sono stati identificati quando la concentrazione delle particelle grossolane (1 µm ≤ Dp ≤ 20 µm) è aumentata in modo significativo con l'arrivo di masse d'aria provenienti dal nord Africa, come indicato da analisi di retro-traiettorie tri-dimensionali delle masse d'aria e da modelli di trasporto.

PRIMAVERA 2014:

- **12 giorni sono stati caratterizzati dal trasporto di polveri minerali proveniente dal Nord Africa (13.4 % del periodo).**
- **L'evento più significativo è stato osservato dal 22 al 23 di Maggio, quando è stata registrata la concentrazione massima di particelle grossolane per la primavera 2014 (4.1 cm^{-3}, il 23 Maggio 2014).**



MODIS satellite Aerosol Optical Depth over the Mediterranean basin for the mineral dust event detected at CMN on 22[th] May – 23[rd] May 2014.

Aerosol Optical Depth (AOD) dell'aerosol sul bacino del Mediterraneo durante l'evento del 22 - 23 Maggio 2014 (dati MODIS da satellite). Valori elevati di AOD indicano la presenza di aerosol minerale in atmosfera.

Stratospheric intrusions (SI)

Stratospheric intrusions (SI) can be considered as a specific aspect of stratosphere–troposphere exchange (STE): the irreversible downward transport of stratospheric air relatively deep into the troposphere. Such phenomena are highly episodic and can be favored by a number of different mechanisms, acting on different geographical and temporal scales: tropopause folding and cut-off lows at upper levels, and fronts or high-pressure systems at the surface.
Even though it has been assessed that nowadays the greatest contribution to tropospheric ozone concentrations comes from photochemical production, the contribution from STE is far from negligible, in particular in the free troposphere. For these reasons, at ICO-OV the frequency of SI and its contribution to ozone is assessed.

Selection methodology: at Mt. Cimone, we identified days probably affected by air-mass transport from the stratosphere or from the upper free troposphere by selecting the measurement periods characterized by at least 8 hours of relatively dry conditions (RH<60%) with low levels of anthropogenic pollution (CO<90 ppb) together with analysis of air-mass three-dimensional back-trajectories corroborating the origin of the air masses.

SPRING 2014:

- **Basing on the adopted selection methodology, no air mass transport from the stratosphere or the upper free troposphere have been identified.**

Intrusioni stratosferiche (SI)

Le intrusioni stratosferiche (SI) possono essere considerate un aspetto specifico degli scambi stratosfera-troposfera (STE). Tali fenomeni, che avvengono in maniera episodica, possono essere favoriti da processi dinamici e meteorologici caratteristici che agiscono su differenti scale spazio-temporali: ripiegamento della tropopausa, cut-off low, sistemi frontali o aree di alta pressione.
Sebbene il processo più importante che influenza la variabilità dell'ozono in troposfera sia oggi rappresentato dalla produzione fotochimica, il contributo dei processi STE è tutt'altro che trascurabile, in particolare nella libera troposfera. Per queste ragioni, presso l'ICO-OV viene effettuata l'identificazione e lo studio di questa classe di fenomeni.

Metodologia di selezione: a Mt. Cimone, sono stati identificati gli eventi di trasporto di masse d'aria dalla stratosfera o dalla parte superiore della libera troposfera come i periodi caratterizzati per almeno 8 ore dalla presenza di masse d'aria relativamente secche (RH<60%) e bassi livelli di inquinamento antropico (CO<90 ppb). Retro-traiettorie tridimensionali delle masse d'aria, sono state utilizzate per corroborare l'origine degli eventi.

PRIMAVERA 2014:

- **Durante l'intera stagione, sulla base dei criteri di selezione adottati, non si sono verificati fenomeni di trasporto di masse d'aria dalla stratosfera o dalla parte alta della libera troposfera.**

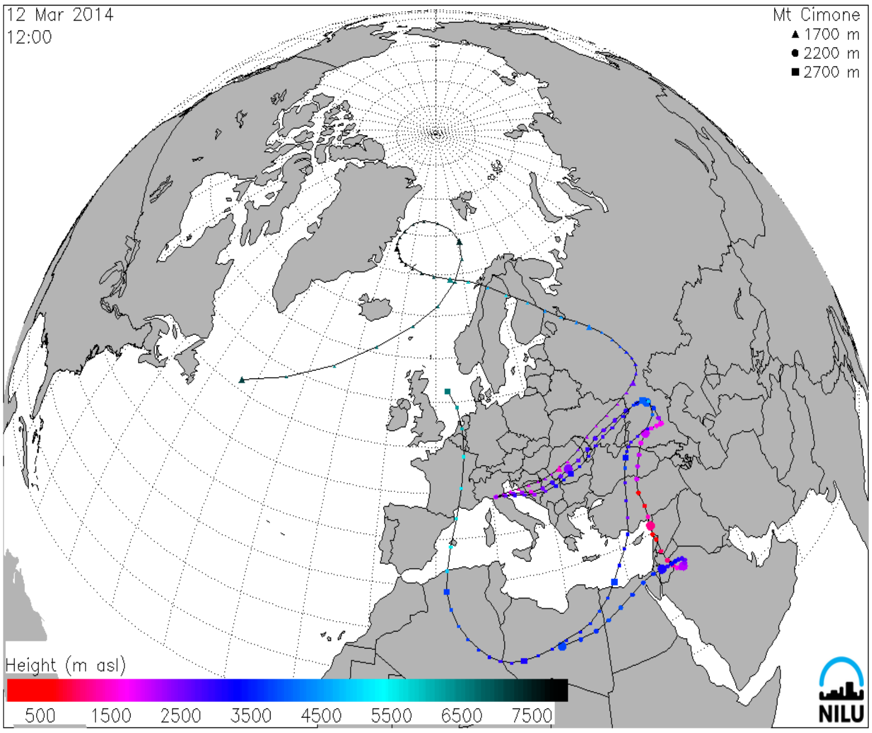
Pollution transport

The Mediterranean region represents a global hot-spot in terms of climate change and atmospheric composition variability while the Po Basin on which Mt. Cimone leans out, is considered one of the major polluted European regions. In particular during the summer seasons, when the high solar irradiance characterized these areas, many anthropogenic pollutants, including photochemically produced ozone can affect the lower troposphere. With the goal of better evaluating the influence of these processes on the atmospheric composition variability, polluted air-mass transport phenomena are systematically identified and investigated at ICO-OV.

Selection methodology: at Mt. Cimone, days possibly affected by polluted air-mass transport are identified by selecting periods characterized by at least 8 hours of relatively high ozone, black carbon and carbon monoxide concentrations (higher than the 75th percentile of the seasonal values observed from the start of the respective measurement programmes).

SPRING 2014

- **8 days were characterized by transport of polluted air masses (8.7% of the period).**
- **The detected events were mostly associated with persistent high concentrations of pollutants, thus suggesting an influence by long-range transport phenomena.**
- **March 12th was the most polluted day for black carbon (average value: 604.9 ng m^{-3}) with also relatively high carbon monoxide concentrations but not high ozone levels (respectively 141.0 ppb and 57.7 ppb).**



Retro-traiettorie tridimensionali delle masse d'aria calcolate per Monte Cimone per il 12 marzo 2014 alle ore 12:00, tramite il modello FLEXTRA (elaborato da NILU). Le analisi suggeriscono un possibile contributo di masse d'aria dall'Europa orientale all'episodio di inquinamento osservato a Monte Cimone.

3D air-mass back-trajectory calculated by the FLEXTRA model (courtesy by NILU): a long-range transport from eastern Europe was likely for the pollution event identified on 2014, 12th March.
http://www.nilu.no/projects/ccc/trajectories/

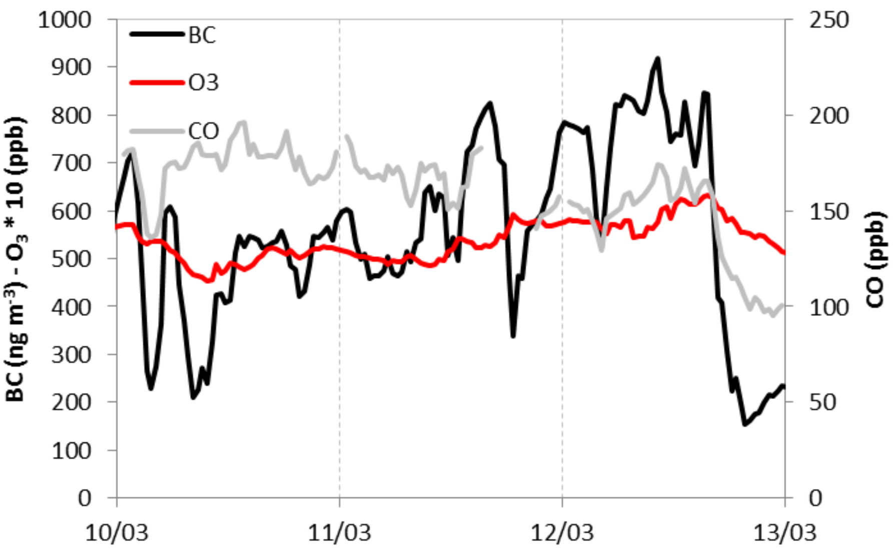
Trasporto di inquinanti

Il bacino del Mediterraneo rappresenta un “hot-spot” globale per quanto riguarda i cambiamenti del clima e della composizione dell’atmosfera, mentre la Pianura Padana rappresenta un’importante area sorgente di inquinamento antropico. In particolare durante l’estate, a causa dell’alto irraggiamento solare che caratterizza queste regioni, esse sono interessate da intensi eventi di produzione fotochimica e di ozono nella bassa troposfera. Con lo scopo di valutare l’influenza di tali eventi sulla composizione dell’atmosfera, i fenomeni di trasporto di masse d’aria inquinate sono sistematicamente identificati e studiati a Mt. Cimone

Metodologia di selezione: a Mt. Cimone, sono stati identificati i giorni possibilmente affetti da trasporto di masse d’aria inquinate selezionando i periodi caratterizzati per almeno 8 ore da concentrazioni elevate di ozono, black carbon e monossido di carbonio (maggiori del 75^{esimo} percentile dei valori osservati stagionalmente dall’inizio delle rispettive misure).

PRIMAVERA 2014

- **8 giorni sono stati caratterizzati dal trasporto di masse d’aria inquinate (8.7% del periodo).**
- **Gli eventi di inquinamento sono stati per lo più associati ad elevate concentrazioni di inquinanti nell’arco delle 24 ore, indicando una possibile influenza di fenomeni di trasporto di inquinamento a larga scala.**
- **Il 12 Marzo è stato il giorno caratterizzato dal valore medio giornaliero di black carbon più elevato (604.9 ng m^{-3}) con concentrazioni abbastanza alte di monossido di carbonio ma non di ozono (rispettivamente a 141.0 ppb e 57.7ppb).**



CO, ozone and BC behaviors at Mt. Cimone (2014, 10th to 13rd March).

Andamento delle concentrazioni di CO, ozono e BC a Monte Cimone (10 – 13 marzo 2014).

Surface ozone

Why is ozone so important?

Ozone (O_3) is one of the most important Short-Lived Climate Forcers and Pollutant (SLCF/P), being a powerful greenhouse gas at regional scale. Due to its chemical properties, O_3 is also a dangerous secondary pollutant in the lower troposphere. Its tropospheric mixing ratios are also affected by natural processes, e.g. stratospheric intrusions and lightning production. Being the precursor of oxidizing substances like OH radical and NO_3, O_3 is one of the key agents determining the oxidation capacity of the troposphere.

Instrumentation and calibration

Surface ozone is measured by using a UV-absorption analyser (Dasibi 1108 W-GEN). Intercomparisons with the laboratory standard (Dasibi 1008 PC #6506, traced back to SRP#15 at the World Calibration Centre for surface ozone at WCC-EMPA of Zürich) are carried out every 3-months.

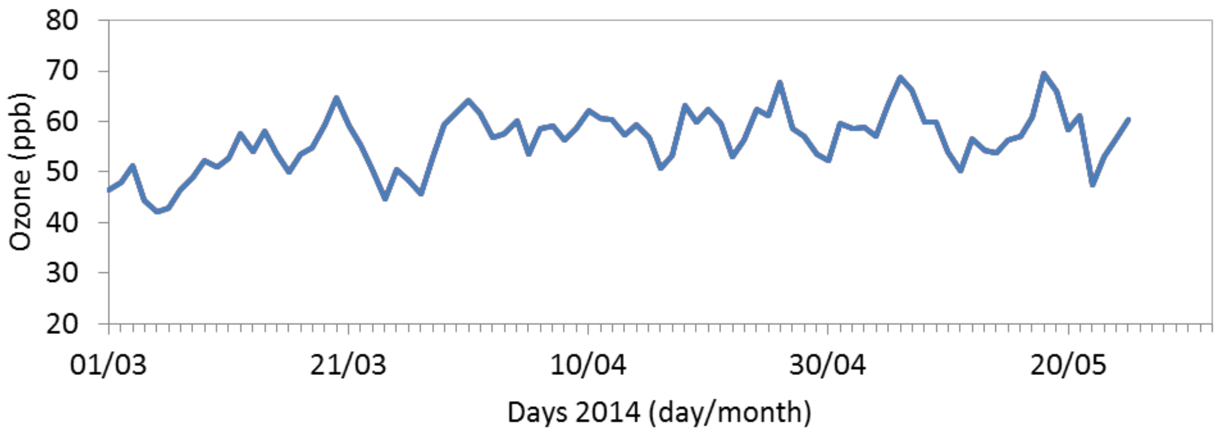
Basic statistical parameters

Statistical parameters are calculated basing on 30-minute aggregated values from March 2014 to May 2014.

Data availability (%)	Min value (ppb)	25th Percentile (ppb)	50th Percentile (ppb)	Average mean value (ppb)	75th percentile (ppb)	Max value (ppb)
94.2	33.4	51.7	56.9	56.3	60.8	78.0

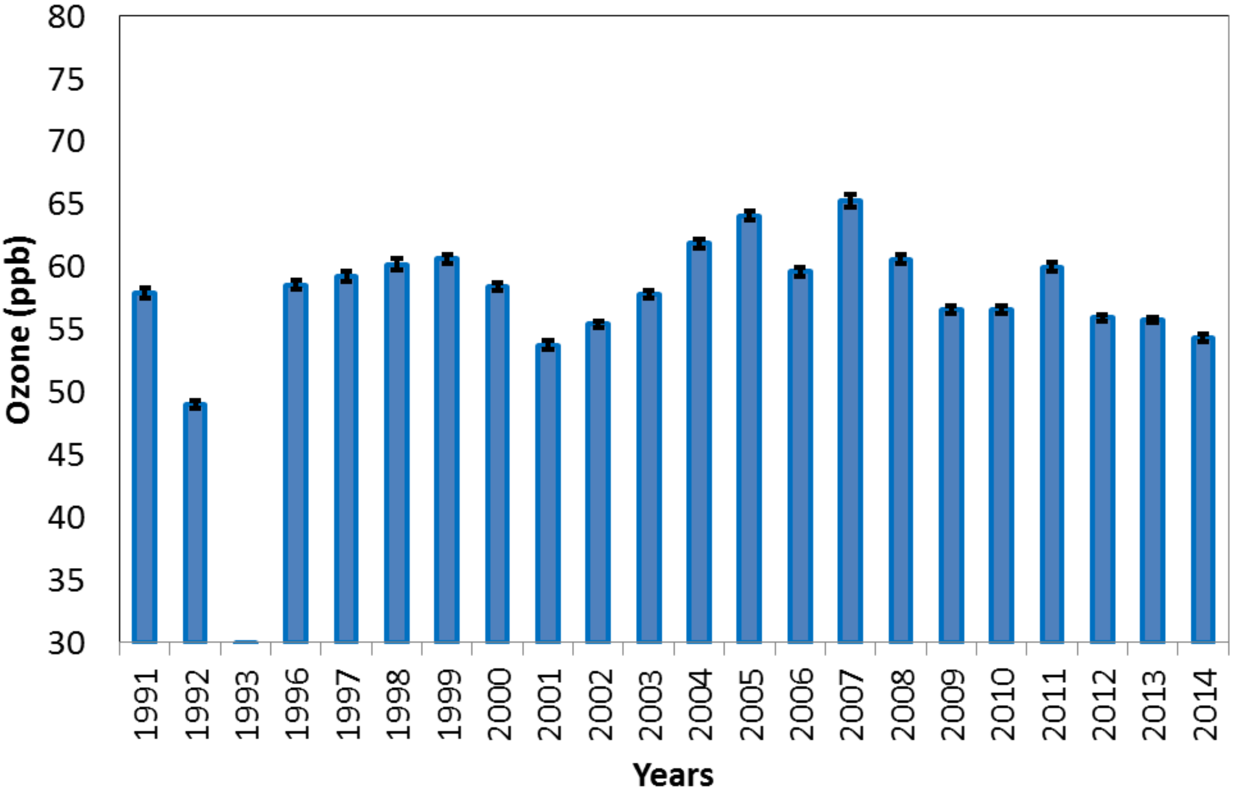
Time series of daily mean values

Relatively high ozone mixing ratios (above 60 ppb) were observed on 21st and 31st March, as well as on 26th April and 6th and 18th May. Lower mixing ratios were observed during the first days of March.



Comparison with historical data-set

The Spring 2014 average mean value of O_3 is 56.3 ppb**, similar to the climatological mean value of 58.6 ppb**. As deduced by the analysis of the daily time series, this is due to the occurrence of "background" conditions for the most part of the period.



Carbon monoxide (NDIR)

Why is carbon monoxide so important?

Carbon Monoxide (CO) plays an important role in the oxidation/reduction chemistry of the atmosphere and it participates in the reactions of photochemical O_3 production. CO has an indirect radiative forcing effect by influencing atmospheric mixing ratios of O_3 and methane. Through natural processes in the atmosphere, CO is eventually oxidized to CO_2. CO represents a tracer for combustion emissions (biomass burning, residential, traffic,...).

Instrumentation and calibration

Carbon monoxide is measured by using a non-Dispersive Infrared (NDIR) analyzer (Thermo Scientific TEI 48C-TL). Two CO working standards (approx. 10 ppm, synthetic air, Messer Italia) are used to calibrate the instrument with a dilution system. On a monthly basis, these working standards were compared against secondary standards from NOAA-CMDL.

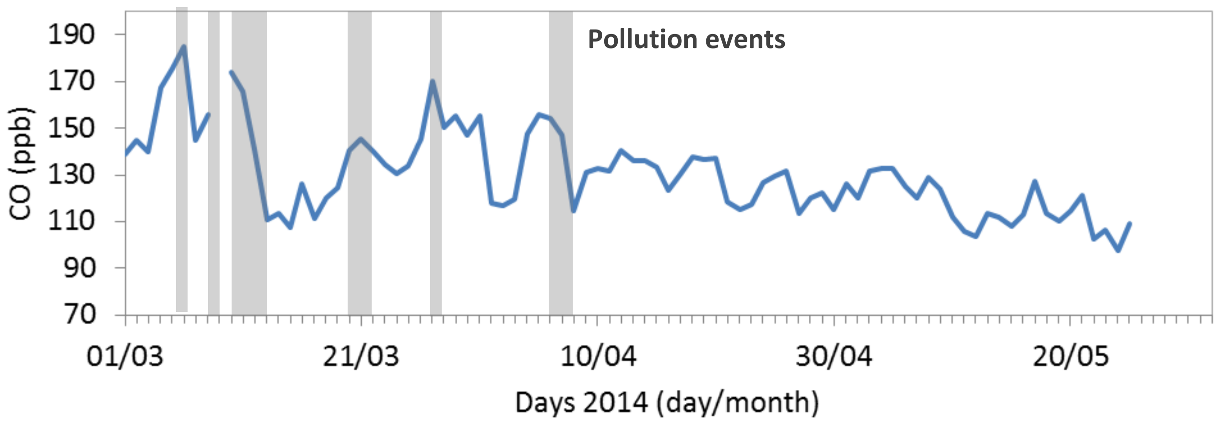
Basic statistical parameters

Statistical parameters are calculated basing on 30-minute aggregated values from March 2014 to May 2014.

Data availability (%)	Min value (ppb)	25th Percentile (ppb)	50th Percentile (ppb)	Average mean value (ppb)	75th percentile (ppb)	Max value (ppb)
91.5	77.2	115.5	128.3	130.6	141.6	208.0

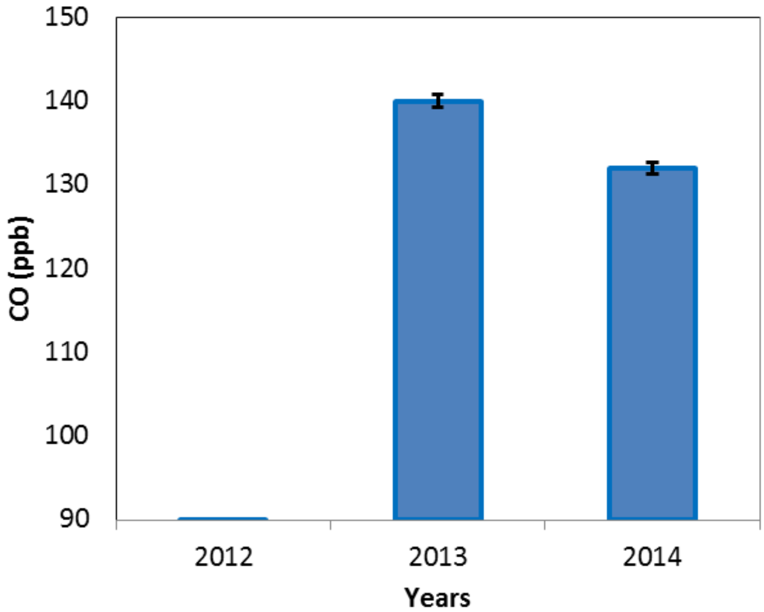
Time series of daily mean values

The highest daily CO value (184.9 ppb) has been recorded on March 6th, together with high NO_2 (2.6 ppb) and low O_3 (42.8 ppb), possibly indicating the long range transport of aged air masses originally rich in atmospheric pollutants. In general CO was characterized by higher concentration during the first part of the season (with the occurrence of pollution events), while cleaner conditions characterized the rest of the Spring 2014 .



Comparison with historical data-set

The Spring 2014 average mean value of CO was 130.6 ppb **which is slightly lower than the average mean value of 140.0 ppb observed on Spring 2013**, probably driven by the "clean" conditions which occurred during the second part of the season.



Nitrogen oxides

Why are nitrogen oxides so important?

Nitrogen oxides (NO_x) encompasses nitric oxide (NO) and nitrogen dioxide (NO_2). NO is naturally produced by lightning. Anthropogenic contributions are related to combustion processes and agricultural fertilization. NO_x are key elements of atmosphere chemistry influencing a number of atmospheric compounds with roles on climate, air-quality and ecosystem threats, e.g. sulphur dioxide, halocarbons, methane, tropospheric ozone, secondary aerosols.

Instrumentation and calibration

Nitrogen oxides ($NOx=NO+NO_2$) are measured by using a chemiluminescence analyser (Tei 42) equipped with Molybdenum converter. Manual zero checks are performed weekly. Due to the interference of other nitrogen compounds (e.g. PAN, HNO_3), the NO_2 reading can be significantly overestimated. Starting from 8th April, a new Tei42i-TL system has been installed at Mt. Cimone. This system is expressly designed for working at remote sites and it is equipped with photolytic converter. NO calibrations by dilution and NO_2 calibrations by GPT are performed every 48 hours.

Basic statistical parameters

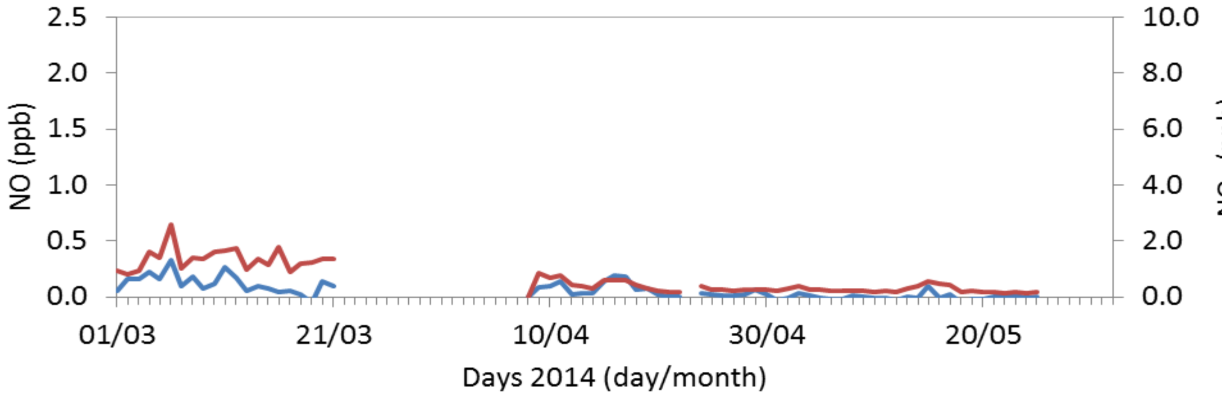
Statistical parameters are calculated basing on 30-minute aggregated values from March 2014 to May 2014.

Data availability (%)	Min value (ppb)	25th percentile (ppb)	50th percentile (ppb)	Average mean value (ppb)	75th percentile (ppb)	Max value (ppb)
NO 74.1	UDL	UDL	0.01	0.06	0.06	1.79
NO_2 74.1	UDL	0.21	0.36	0.65	0.87	5.91

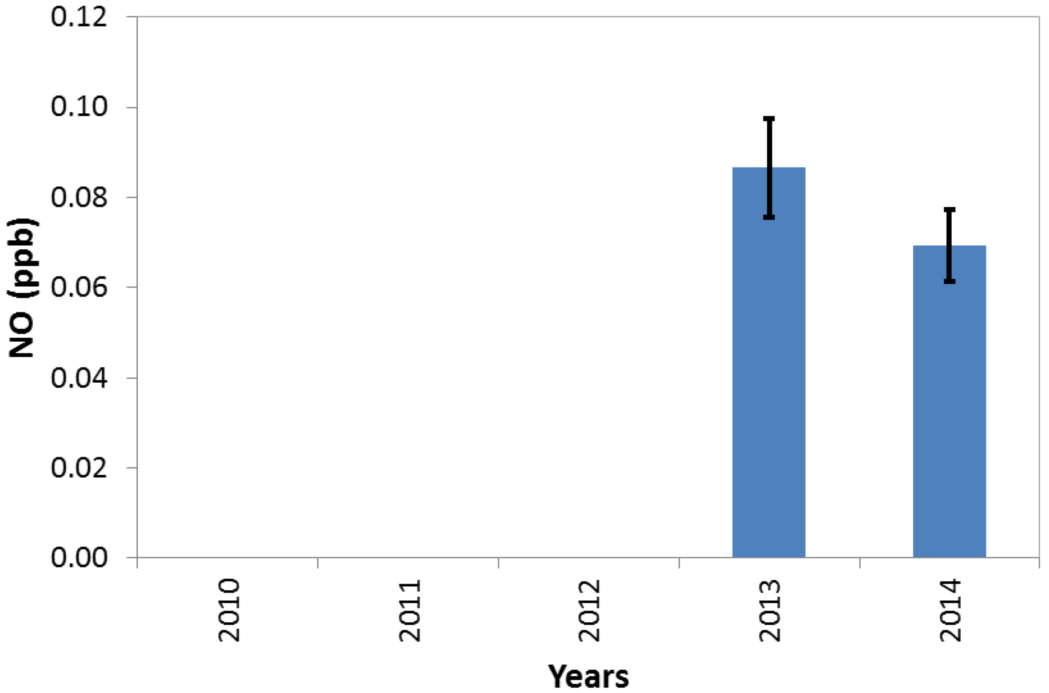
UDL: under detection limit

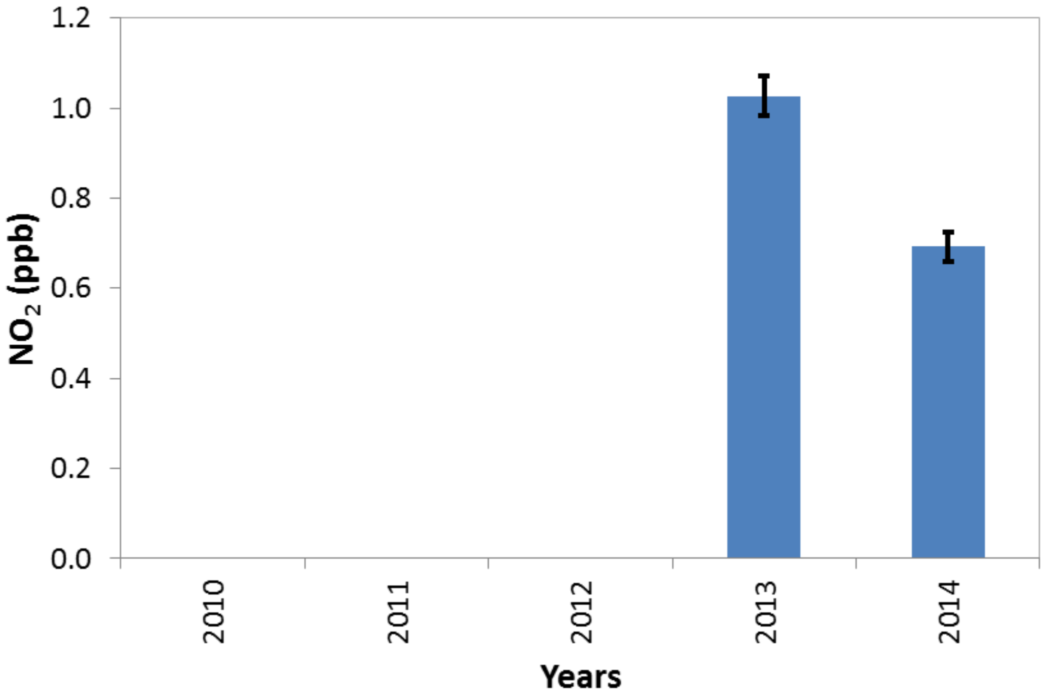
Time series of daily mean values

The highest NO value (1.79 ppb) was observed on March 11th , while the highest NO_2 value (2.6 ppb) was observed on March 6th, together with CO daily maximum. As for many other parameters, low values were observed on April-May.



Comparison with historical data-set
The Spring 2014 average mean value of NO (NO_2) was 0.06 ppb (0.65 ppb) **which is comparable (lower) with the Spring 2013 average mean value (0.08 ppb and 1.02 ppb)**.





Black carbon

Why is black carbon so important?

Black carbon (BC) is a primary aerosol resulting from incomplete combustion processes. Its main sources are fossil fuel combustion (anthropogenic) and biomass burning (natural and anthropogenic). BC, a Short Lived Climate Forcer and Pollutant, strongly absorbs solar radiation and it has been recognized as a driving factor of global warming: the magnitude of the direct radiative forcing due to BC can exceed that due to methane.

Instrumentation and calibration

Equivalent black carbon concentration is measured by a Multi Angle Absorption Photometer (MAAP, Model 5012 – Thermo Electron Corporation). Detection limit was measured as 3σ of 12 h measurement of free particle air. Calibration of sampling flow and internal temperature-pressure sensors are conducted every 6 months.

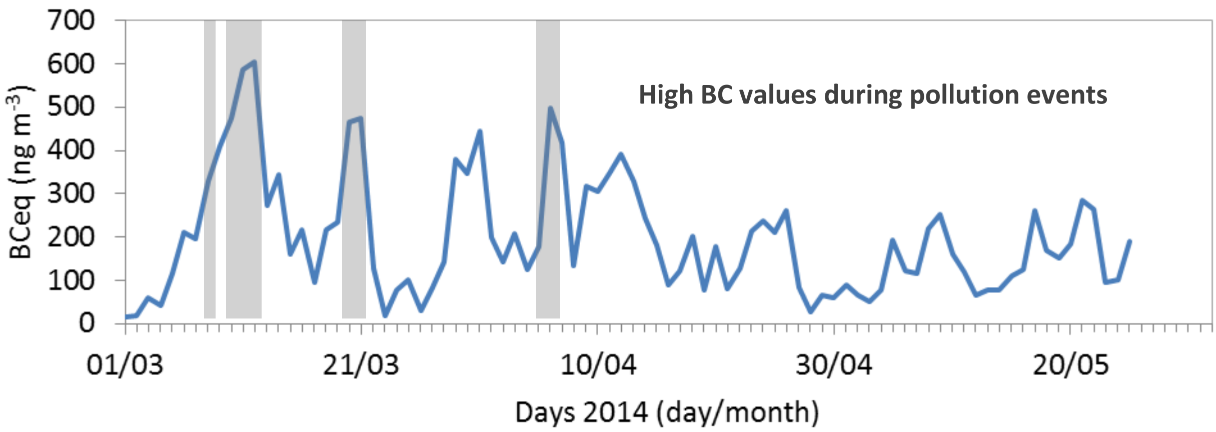
Basic statistical parameters

Statistical parameters are calculated basing on 30-minute aggregated values from March 2014 to May 2014.

Data availability (%)	Min value (ng m^{-3})	25^{th} percentile (ng m^{-3})	50^{th} percentile (ng m^{-3})	Average mean value (ng m^{-3})	75^{th} percentile (ng m^{-3})	Max value (ng m^{-3})
91.8	10.0	80.6	155.0	204.1	283.6	924.9

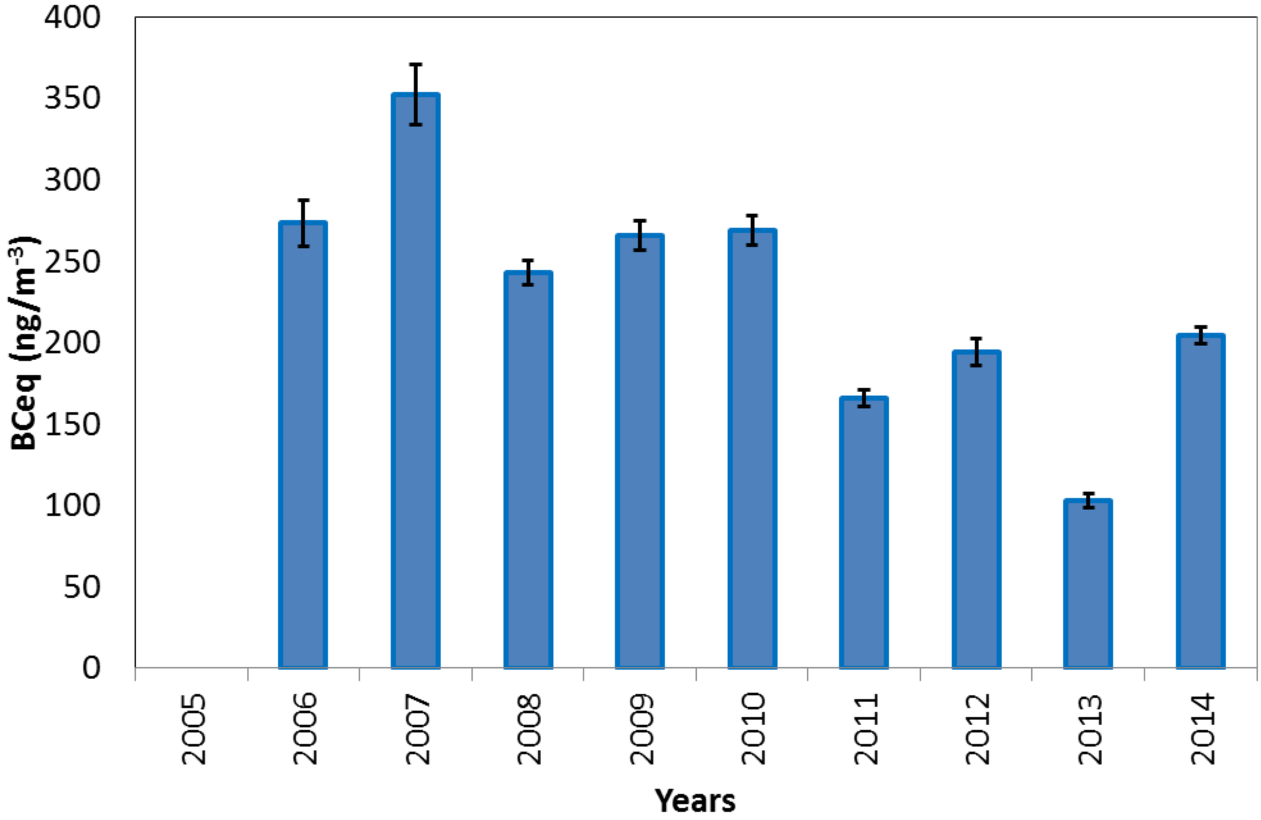
Time series of daily mean values

The highest daily mean value (604.9 ng m^{-3}) has been observed on March 12^{th} 2014, during a pollution episode. The 30 minute average time serie showed that BC concentration suddenly dropped as the air mass reach in mineral dust reached the measurement site, suggesting the contribution of a different air mass. The high BC concentrations observed during the first half of the season were mostly associated with air masses from North Africa.



Comparison with historical data-set

The 2014 spring average mean value of BC is 204.1 ng m^{-3}, **which is slightly lower than the climatological mean value (233.4 ng m^{-3}).** The behavior is similar to that observed for CO and fine particles and can be explained by the occurrence of very unpolluted conditions during the second half of the season.



Aerosol number concentration (fine)

Why are fine particle so important?

Fine particles are highly effective in modifying the radiation field by absorbing and scattering solar and thermal radiation, thus impacting radiative transfer through the atmosphere. Additionally, aerosols act as cloud condensation and ice nuclei, thus influencing cloud properties. Aerosols also help to control the concentrations, lifetime and the physical as well as the chemical behavior of many important trace gases by providing reaction sites and serving as carrier and/or sink for many atmospheric species. Moreover, fine particles strongly contribute to air pollution, representing a main fraction of PM_1.

Instrumentation and calibration

Aerosol concentration and size distribution of particles with optical diameter between 0.3 and 20 µm have been continuously recorded in 15-size channel by using an OPC Mod. GRIMM 1.108. These measurements allow the continuous measurement of the fine mode (0.3 µm ≤ Dp ≤ 1 µm) particle number. The instrument is based on the quantification of the 90° scattering of light by aerosol particles

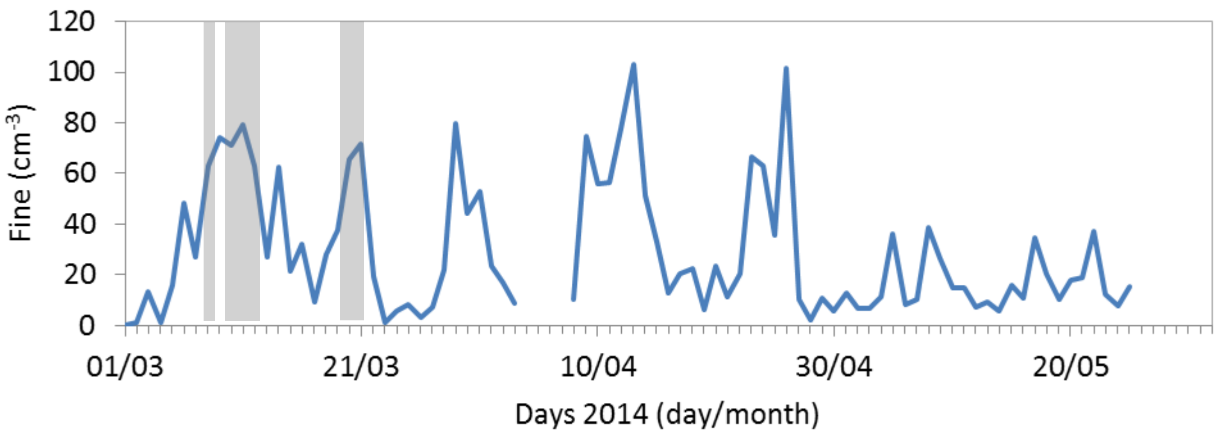
Basic statistical parameters

Statistical parameters are calculated basing on 30-minute aggregated values from March 2014 to May 2014.

Data availability %	Min value (cm^{-3})	25th percentile (cm^{-3})	50th percentile (cm^{-3})	Average mean value (cm^{-3})	75th percentile (cm^{-3})	Max value (cm^{-3})
87.6	0.0	6.7	16.7	28.7	39.5	239.4

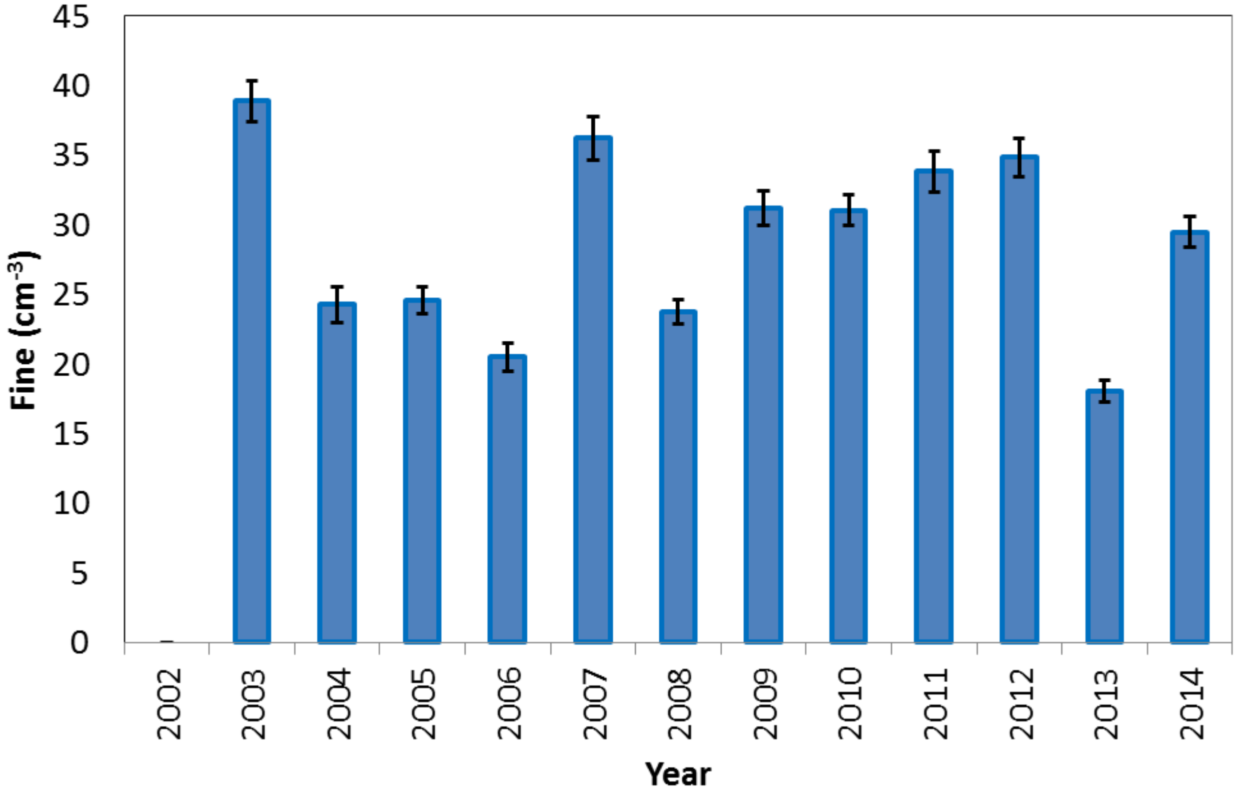
Time series of daily mean values

The highest daily mean value (103.4 cm^{-3}) has been observed on 13th April 2014. Events with high fine particle number concentrations have been also observed from March till the end of April, usually in association whit high BC values.



Comparison with historical data-set

The 2014 Spring average mean value of fine particles is 28.7 cm^{-3}, **and is comparable to the seasonal climatological value (28.8 cm^{-3})**. This behavior is the result of a balance between the higher than normal concentrations observed in March and April (usually associated with increases in BC concentrations) and "cleaner" conditions during May.



Aerosol number concentration (coarse)

Why is this research so important?

Coarse particles measured in background conditions represent a good tracer for mineral dust or marine aerosol transport. They play a significant role in radiation budget by absorbing and especially scattering solar radiation and can act as condensation and ice nuclei. Coarse particles can represent one of the major contributors to the overall PM_{10} variability. Moreover, mineral dust contributes in determining the chemical behavior of many important trace gases (e.g. ozone) by way of heterogeneous-phase chemistry. Coarse particles strongly influence PM_{10} concentrations.

Instrumentation and calibration

Aerosol concentration and size distribution of particles with optical diameter between 0.3 and 20 µm have been continuously measured in 15-size channel by using an OPC Mod. GRIMM 1.108. These measurements permit the determination of the coarse (1 µm ≤ Dp≤ 20 µm) particle number. The instrument is based on the quantification of the 90° scattering of light by aerosol particles.

Basic statistical parameters

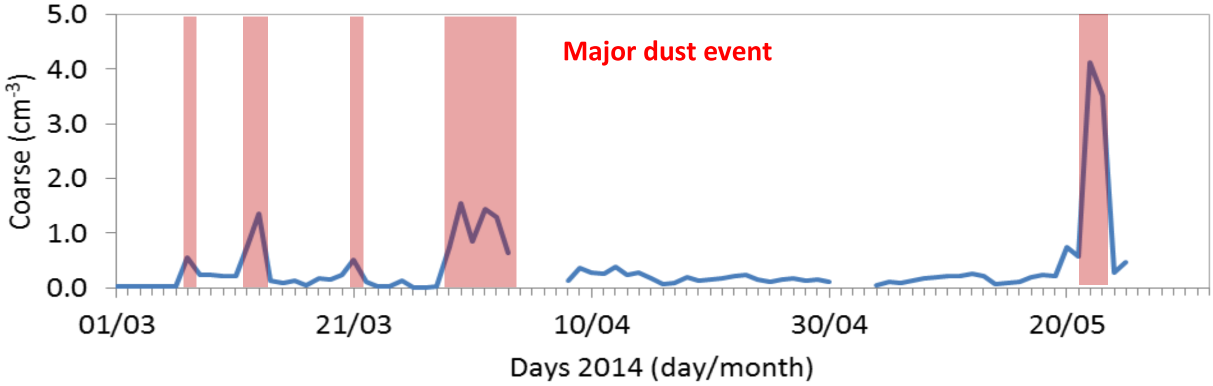
Statistical parameters are calculated basing on 30-minute aggregated values from March 2014 to May 2014.

Data availability %	Min value (cm^{-3})	25th percentile (cm^{-3})	50th percentile (cm^{-3})	Average mean value (cm^{-3})	75th percentile (cm^{-3})	Max value (cm^{-3})
82.4	UDL	0.06	0.15	0.37	0.31	17.77

UDL: Under Detection Limit

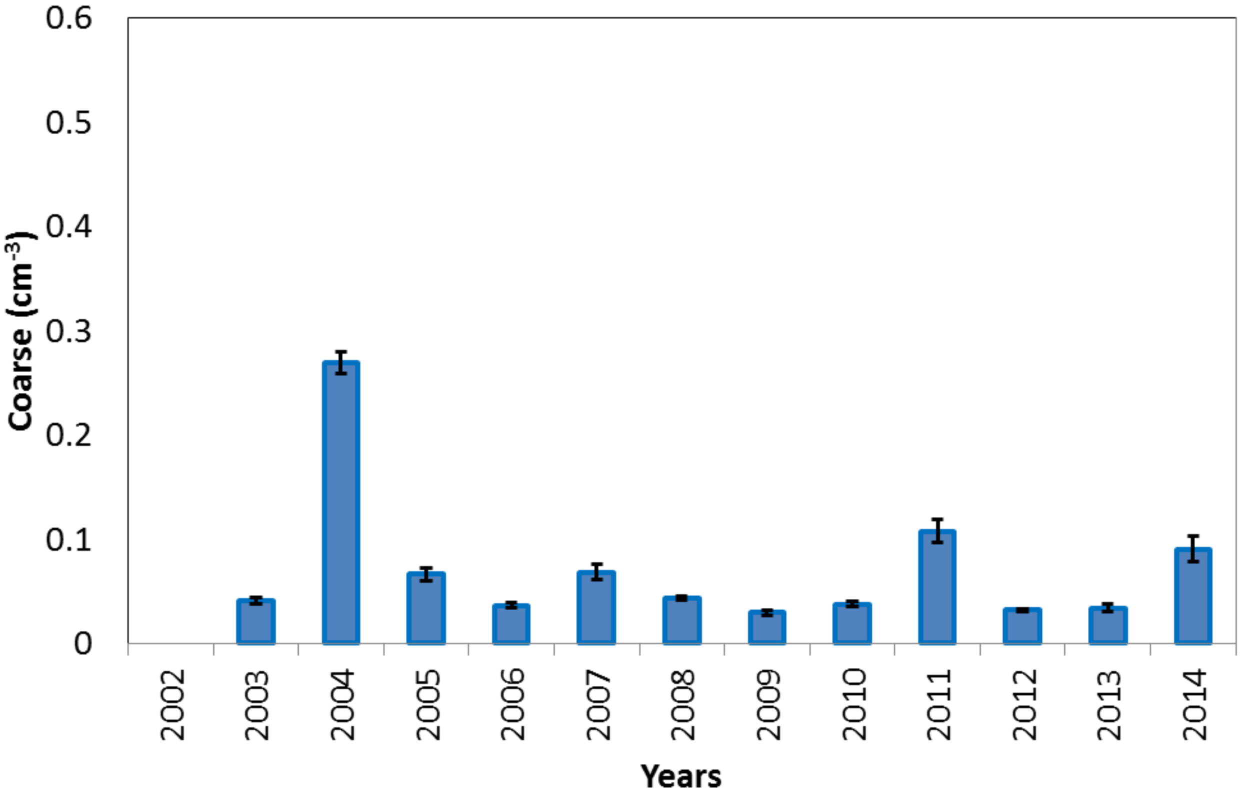
Time series of daily mean values

All the peaks in the number concentration of coarse aerosol particle have been observed during mineral dust transport events. The highest daily mean value (4.1 cm^{-3}) has been observed on May 23th when a major Saharan dust transport affected Mt. Cimone.



Comparison with historical data-set

The Spring 2014 average mean value of the coarse particles number concentration (0.37 cm^{-3}) **is higher than the climatological value (0.28 cm^{-3}).** This can be mostly attributed to the major event observed on May, which represents the fourth most important Saharan dust transport observed at ICO-OV during the Spring seasons.



Stratospheric nitrogen dioxide

Why is stratospheric nitrogen dioxide so important?

Nitrogen dioxide, in the stratosphere, acts both as an ozone destroying substance and as a buffer against halogen catalysed ozone loss (formation of chlorine and bromine nitrates). The main source of nitrogen oxides in the stratosphere is N_2O coming from soil emissions. The diurnal, seasonal, and latitudinal variation of NO_2 is dominated by the equilibrium between NO_x(NO_2+ NO) on one hand and the reservoir substances (mainly N_2O_5, HNO_3, $ClONO_2$) on the other hand.

Instrumentation and calibration

Nitrogen dioxide is measured by means of an UV-Vis spectrometer which collects diffuse solar radiation each day at sunset and sunrise. Its columnar value is measured each day at sunset and at sunrise, giving the two value called AM and PM.

Basic statistical parameters

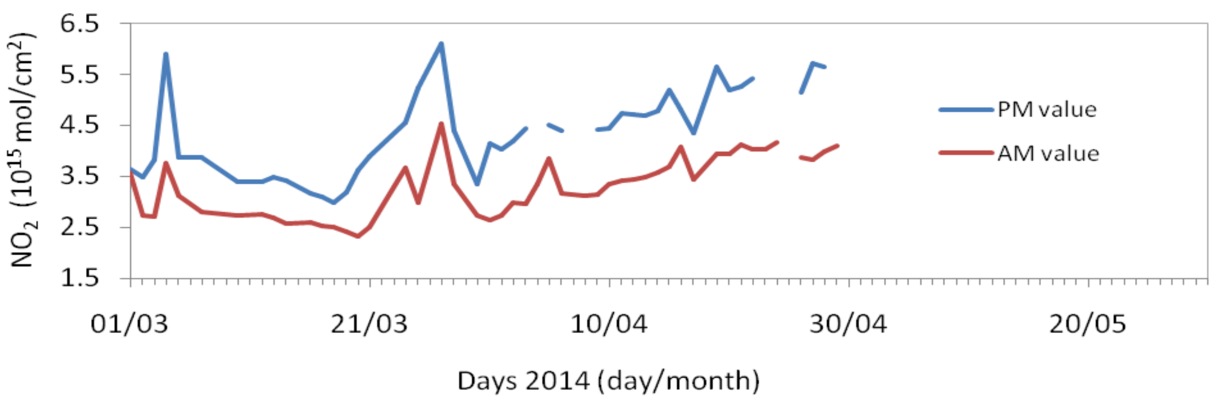
Statistical parameters are calculated basing on 1 data per day from March 2014 to May 2014.

Data availability (%)	Min value (mol/cm^2)	25thpercentile (mol/cm^2)	50thpercentile (mol/cm^2)	Average mean value (mol/cm^2)	75th percentile (mol/cm^2)	Max value (mol/cm^2)
AM (52.1)	2.31	2.74	3.35	3.29	3.83	4.53
PM (47.8)	2.99	3.63	4.40	4.37	5.09	6.09

UDL: under detection limit

Time series of daily mean values

During the month of May the GASCOD data were not available due to an instrumental failure. NO2 peaks were observed on 4th March and 24th – 26th March. Then, the NO_2 data started to increase following the typical climatologic trend (increasing of the NO_2 total column during the Spring period).



Air Temperature

Why is air-temperature so important?

Temperature data are useful to detect the occurrence of summer heat waves, during which photochemical smog episodes and transport of pollution from the boundary layer to the free troposphere can be favoured. The measurement of meteorological parameters at ICO-OV is a fundamental activity for the analysis of other measurements such as trace gases and aerosols.

Instrumentation and calibration

The basic meteorological data (temperature, relative humidity and atmospheric pressure) are measured above the ICO-OV terrace using instrumentation in compliance with WMO recommendations (IRDAM WST7000 and Rotronics thermo-hygrometer).

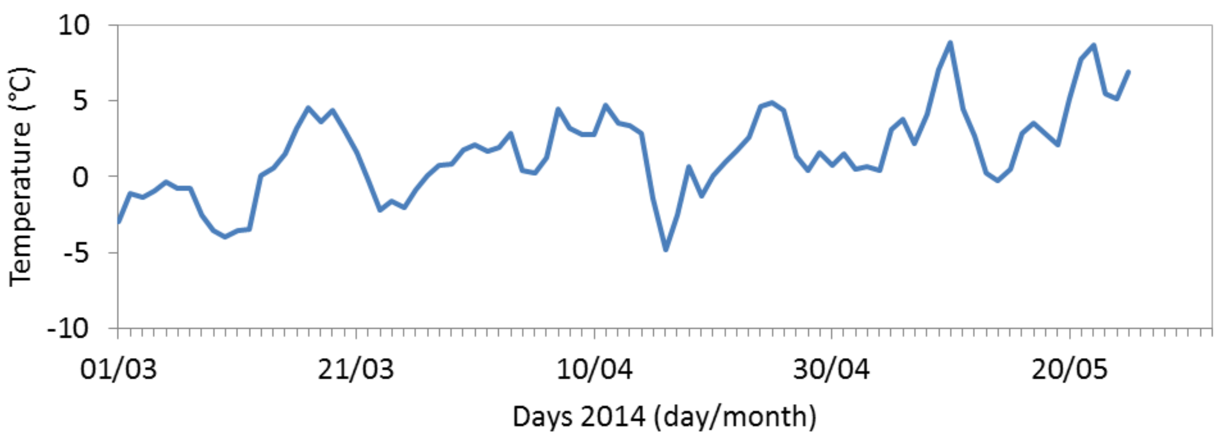
Basic statistical parameters

Statistical parameters are calculated basing on 30-minute aggregated values from March 2014 to May 2014.

Data availability %	Min value (°C)	25^{th} percentile (°C)	50^{th} percentile (°C)	Average mean value (°C)	75^{th} percentile (°C)	Max value (°C)
95.3	-6.9	-0.3	1.4	1.6	3.5	12.0

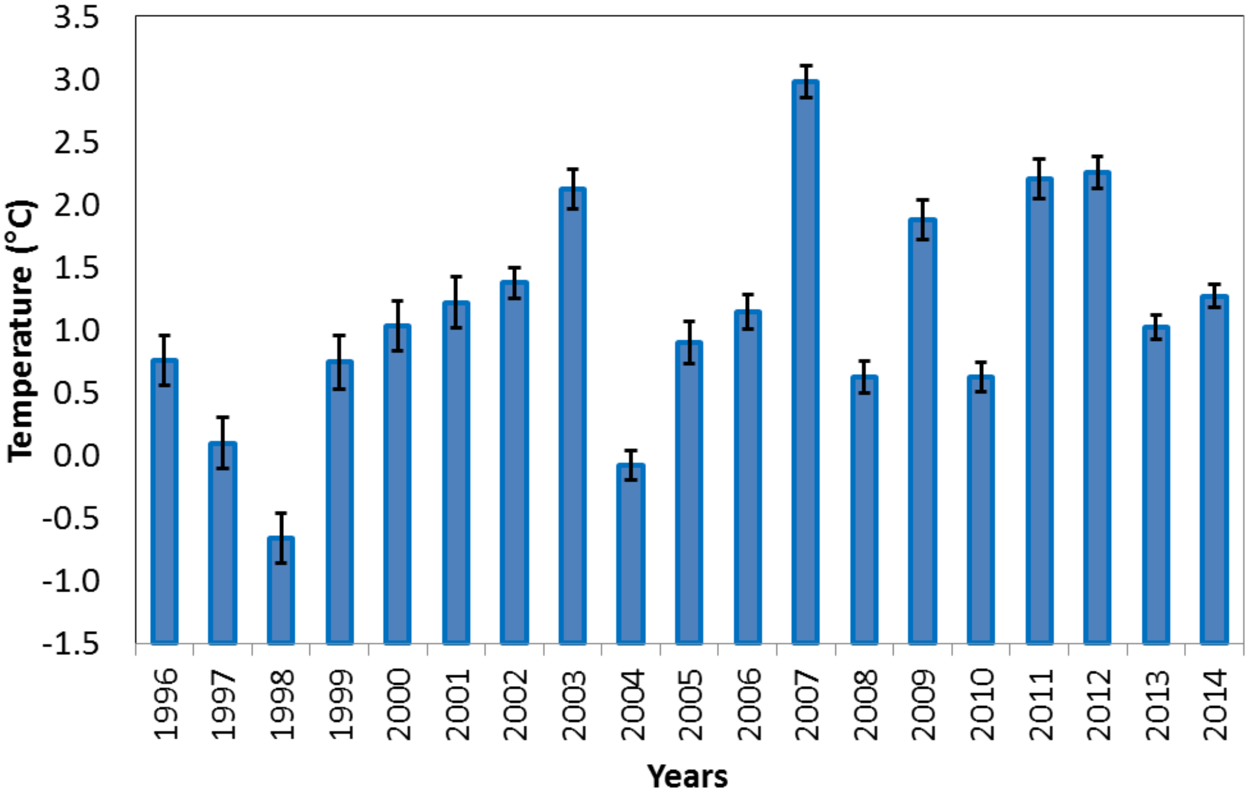
Time series of daily mean values

The highest daily mean value (8.9 °C) has been observed on 10^{th} May**.** High values have been recorded starting from the third decade of April. However, a period with relatively high air-temperature has been observed also from 15^{th} to 22^{nd} March, when high pressure conditions affected the measurement site.



Comparison with historical data-set

The Spring 2014 average temperature (1.6 °C) **is higher than the seasonal climatological value (1.1 °C).** This was due to the high temperature values observed starting from the 21st of April, when 24 days where characterized by daily average temperature greater than 1.5°C.



Relative humidity

Why is relative humidity so important?

Relative humidity is a key parameter to identify the occurrence of dry meteorological conditions (RH<60%), usually associated with stratospheric intrusions or air-mass transport from the free troposphere. During summer, afternoon-evening RH increases can trace transport of air-masses from the boundary layer.

Instrumentation and calibration

The basic meteorological data (temperature, relative humidity and atmospheric pressure) are measured above the ICO-OV terrace using instrumentation in compliance with WMO recommendations (IRDAM WST7000 and Rotronics thermo-hygrometer).

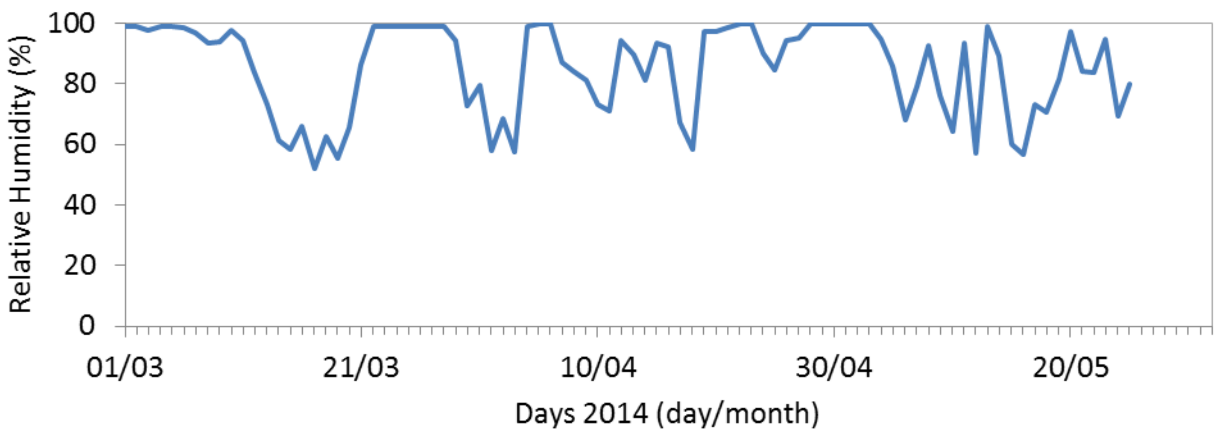
Basic statistical parameters

Statistical parameters are calculated basing on 30-minute aggregated values from March 2014 to May 2014.

Data availability (%)	Min value (%)	25th percentile (%)	50th percentile (%)	Average mean value (%)	75th percentile (%)	Max value (%)
95.3	30.4	72.0	96.1	85.3	99.0	100.0

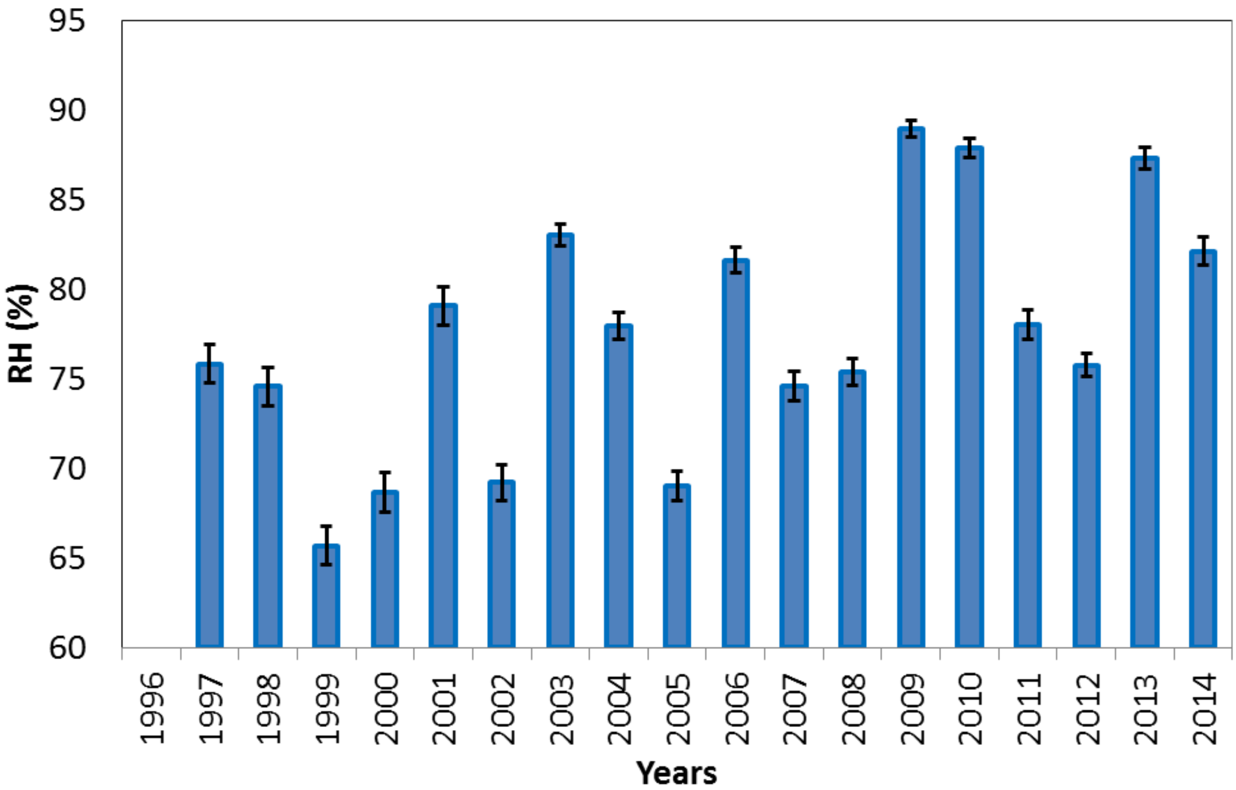
Time series of daily mean values

The daily mean RH values ranged from 100% to 52.2%. Relatively low RH values were observed from 11th to 22nd March, from 30th March to April 3rd, as well as on 16th – 17th April and on 12th May.



Comparison with historical data-set

The Spring 2014 average relative humidity (85.3%) **was similar than the seasonal climatological value (81.2%).**



Atmospheric pressure

Why is atmospheric pressure so important?

Pressure is a key parameter to investigate the variability of weather conditions at the ICO-OV. As an example, heat waves periods are characterized by the occurrence of high pressure values, while sudden pressure variability can be used to identify the passage of synoptic-scale disturbances possibly related to stratospheric intrusions.

Instrumentation and calibration

The basic meteorological data (temperature, relative humidity and atmospheric pressure) are measured above the ICO-OV terrace using instrumentation in compliance with WMO recommendations (IRDAM WST7000 and Tecnoel barometer).

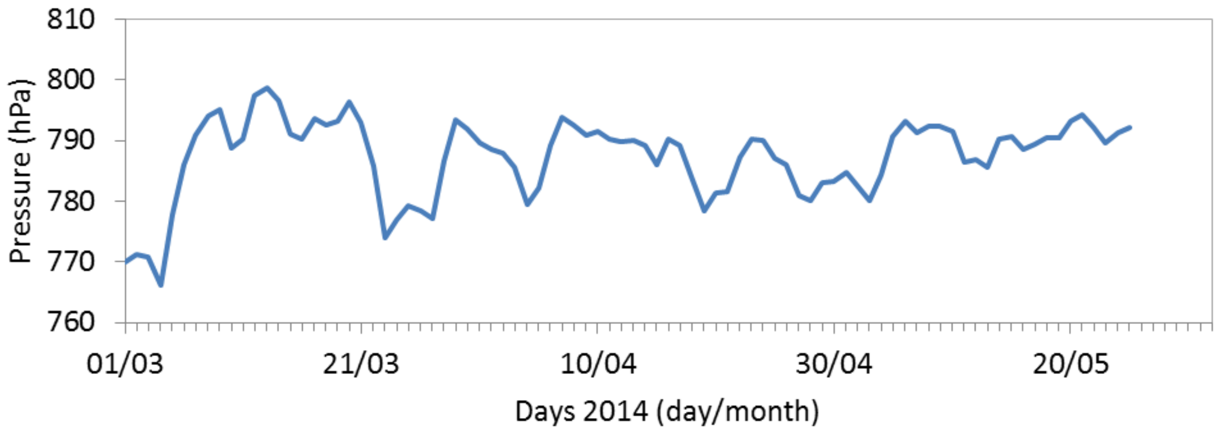
Basic statistical parameters

Statistical parameters are calculated basing on 30-minute aggregated values from March 2014 to May 2014.

Data availability (hPa)	Min value (hPa)	25^{th} percentile (hPa)	50^{th} percentile (hPa)	Average mean value (hPa)	75^{th} percentile (hPa)	Max value (hPa)
95.3	761.6	783.8	789.3	787.4	791.8	799.6

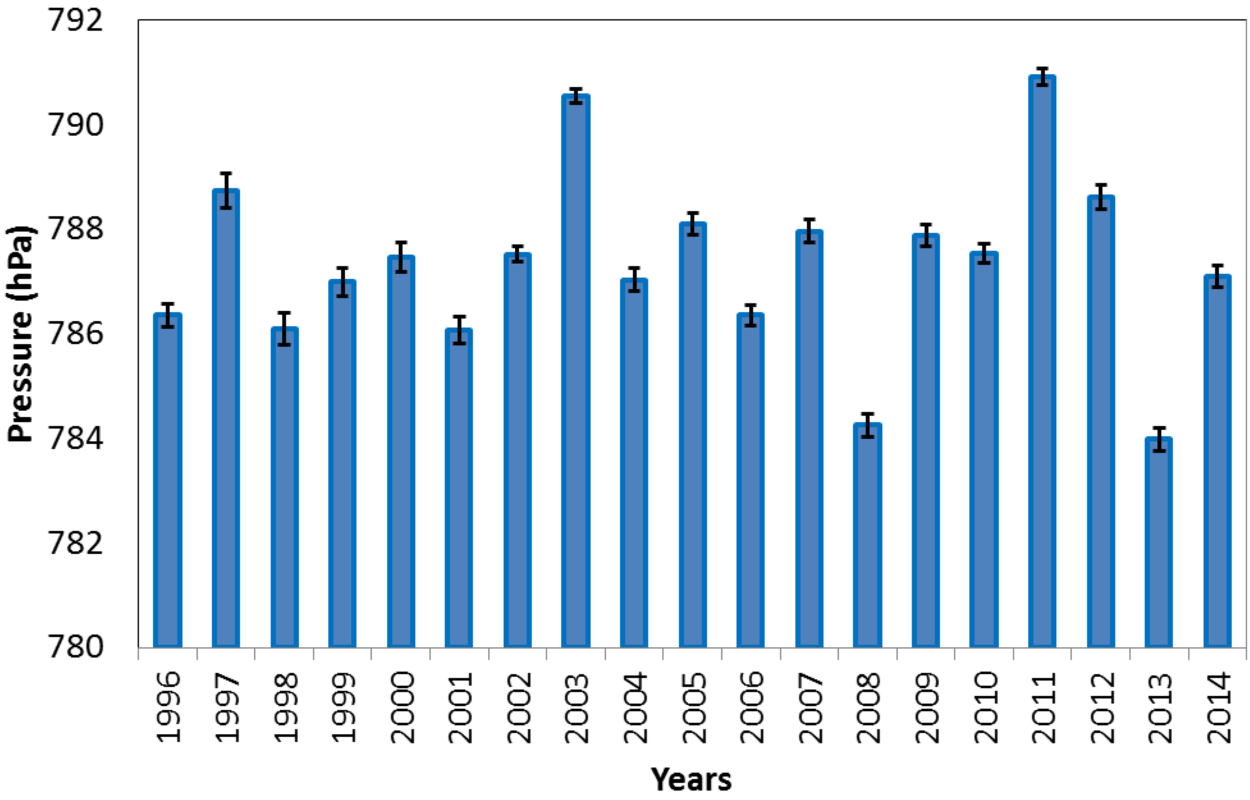
Time series of daily mean values

Large drops in the daily mean averages occurred on March 1^{st} - 4^{th} and on March 23^{rd} -27^{th} indicating possible influence of synoptic-scale disturbances. A period characterized by high pressure conditions has been observed on 11^{th} - 22^{nd} March, when rather low RH and high air temperature affected the measurement site.



Comparison with historical data-set

The Spring 2014 average atmospheric pressure (787.4hPa) **was comparable with the spring climatological value (787.3 hPa).**



Wind speed and direction

Why is wind so important?

Wind speed and direction are used to identify the air mass circulation and therefore the transport of polluted air-masses from the near Po basin, as well as to identify the passage of surface fronts and the development of thermal wind circulation.

Instrumentation and calibration

Wind measurements are carried out at 5 m and 3 m high above the roof of the station, by using an integrated weather station IRDAM WST7000 and a sonic anemometer Vaisala WS425, respectively.

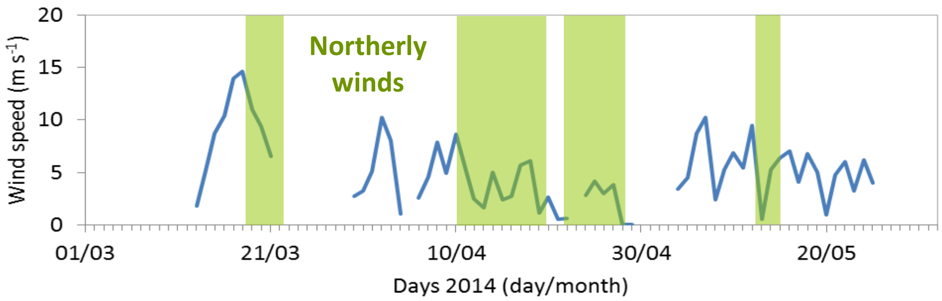
Basic statistical parameters of wind speed

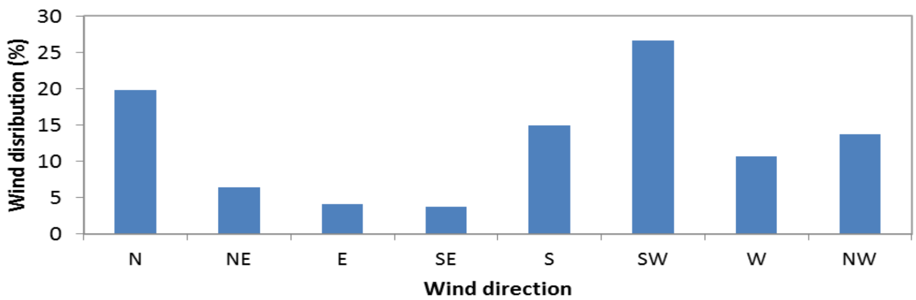
Statistical parameters are calculated basing on 30-minute aggregated values from December 2013 to February 2014. Due to technical problems affecting the primary anemometer (Vaisala 425), IRDAM WST700 data were used. Wind speed data recorded for RH>95% were not considered due to the large instrumental uncertainty during foggy conditions.

Data availability (%)	Min value (m/s)	25^{th} Percentile (m/s)	50^{th} Percentile (m/s)	Average mean value (m/s)	75^{th} percentile (m/s)	Max value (m/s)
46.2	1.0	4.6	6.9	7.7	10.5	19.7

Time series of daily mean values

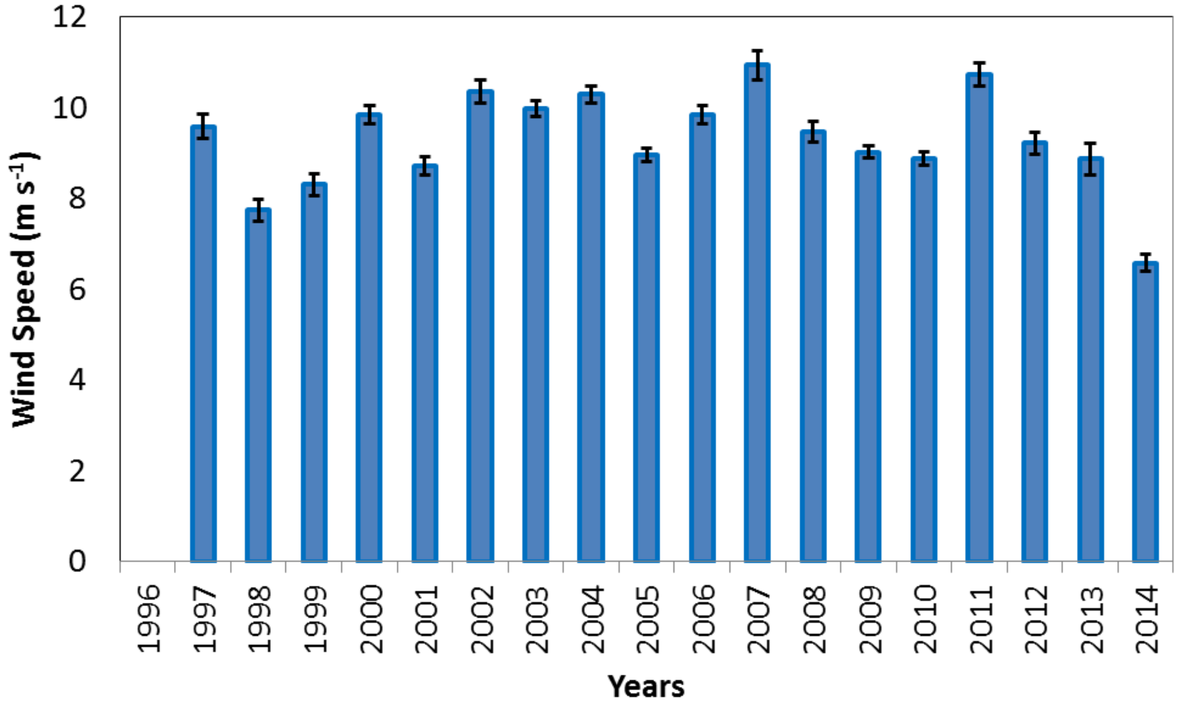
Although the Spring 2014 was characterized by a predominance of SW winds, we observed a significant contribution by N winds and rather low wind speed, especially during the last two decades of April.

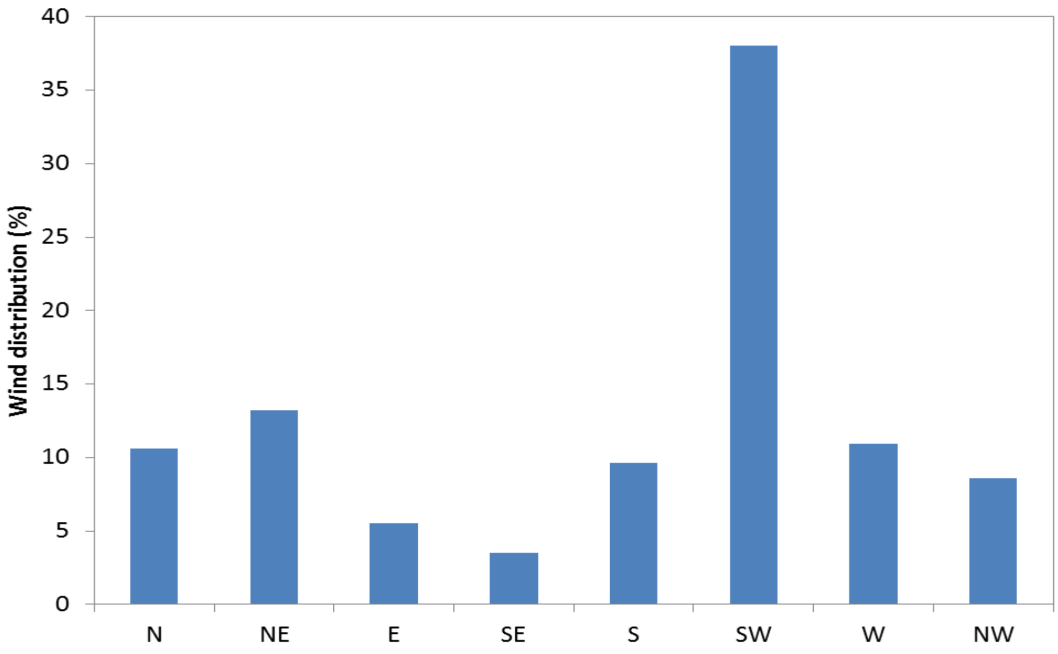




Comparison with historical data-set

The Spring 2014 showed an average wind speed (7.7 m/s) **that is comparable to the climatological winter value** (8.0 m/s). The seasonal wind direction frequency is similar to the climatological one, with a prevalence of south-westerly winds (26.6 % and 38.0%, respectively) **but also a considerable contribution of N winds (19.8 % and 10.6%, respectively).** However, this information should be considered with caution due to the rather low data coverage.





Wind Direction

Solar radiation (short-wave and UV-B)

Why is solar radiation so important?

Solar radiation is a key parameter in studying climate change and also play a role in defining the chemical properties of the troposphere, triggering photochemical reactions of important compounds (like O_3). Moreover, UV-B radiation is fundamental in determining the oxidative properties of the troposphere by leading O_3 photo-dissociation and thus determining OH levels.

Instrumentation and calibration

Solar radiation (wavelength: 350 – 1100 nm) and UV-B (wavelengths: 280-315 nm) are respectively measured by a commercial silicon cell pyranometer (Skye SKS110) and a silicon photodiode (Skye SKU 430). Calibrations were performed by factory against a WMO secondary standard pyranometer (for Skye SKS110) and against the National Physical Laboratory UK reference standard lamp (for Skye SKU 430).

Basic statistical parameters (Solar radiation)

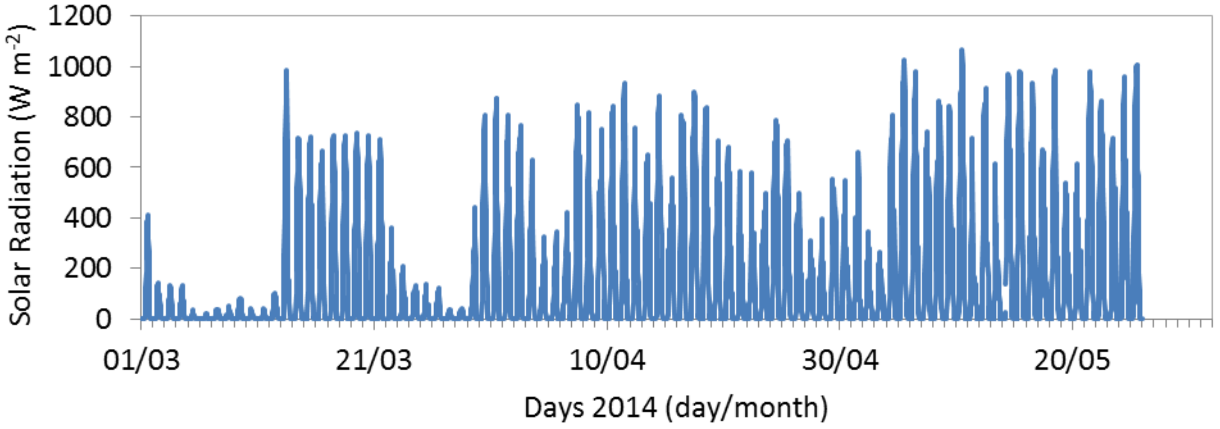
Statistical parameters are calculated basing on 30-minute aggregated values from March 2014 to May 2014.

Data availability (%)	Min value (W/m^2)	25^{th} Percentile (W/m^2)	50^{th} Percentile (W/m^2)	Average mean value (W/m^2)	75^{th} percentile (W/m^2)	Max value (W/m^2)
95.3	UDL	UDL	13.8	159.3	245.7	1066.4

UDL: under detection limit

Time series (Solar radiation)

Clear sky conditions mostly characterized Spring 2014. The highest daily value was observed on May, 15^{th} (339.8 W m^{-2}) while the highest 30 minute mean value (1066.4 W m^{-2}) was observed on May, 10^{th}. *Please note that the presence of snow cover over the sensor could lead to a significant underestimation of the radiation values.*



Basic statistical parameters (UV-B)

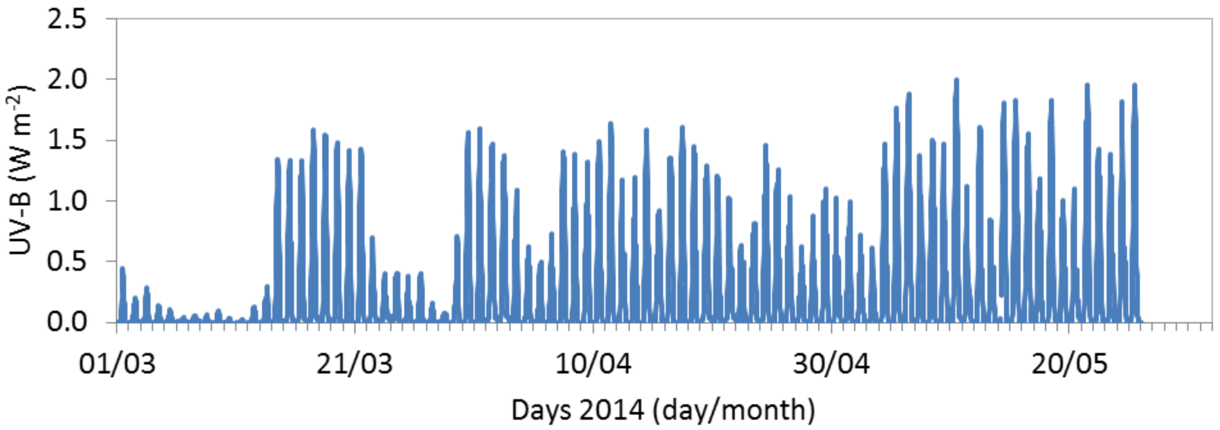
Statistical parameters are calculated basing on 30-minute aggregated values from March 2014 to May 2014.

Data availability (%)	Min value (W/m^2)	25th Percentile (W/m^2)	50th Percentile (W/m^2)	Average mean value (W/m^2)	75th percentile (W/m^2)	Max value (W/m^2)
95.3	UDL	UDL	0.02	0.25	0.35	2.00

UDL: under detection limit

Time series (UV-B)

A trend analogous to what have been observed for Solar radiation is also evident for the UV-B. The highest daily average (0.6 W m^{-2}) and 30 minutes average (2.0 W m^{-2}) values were observed on May, 10th. *Please note that the presence of snow cover over the sensor could lead to a significant underestimation of the radiation values.*



Bibliography

Here we present a list of the main scientific articles, from the year 2000 onward, resulted from the research activity conducted at ICO-OV:

Bonasoni P, Stohl A, Cristofanelli P, Calzolari F, Colombo T, Evangelisti F: Background ozone variations at Mt. Cimone, Atmos. Environ., 34 (29-30), 2000.
http://www.sciencedirect.com/science/article/pii/S1352231000002685

Wotawa G, Kroger H, Stohl A: Transport of ozone towards the Alps: results from trajectory analyses and photochemical model studies, Atmos. Environ., 34 (9), 2000.
http://www.sciencedirect.com/science/article/pii/S1352231099003635

Bonasoni P, Evangelisti F, Bonafè U, Ravegnani F, Calzolari F, Stohl A, Tositti L, Tubertini O, Colombo T: Stratospheric ozone intrusion episodes recorded at Mt.Cimone during the VOTALP project: case studies, Atmos. Environ., 34 (9), 2000.
http://www.sciencedirect.com/science/article/pii/S1352231099002800

Seibert P, Feldmann H, Neininger B, Baumle M, Trickl T: South foehn and ozone in the Eastern Alps: case study and climatological aspects, Atmos. Environ., 34 (9), 2000.
http://www.sciencedirect.com/science/article/pii/S1352231099004392

Balkanski Y, Schulz M, Bonasoni P, van Dingenen R, Hanke M, Gobbi G, Kormann R, Calzolari F: Measurements of Aerosol, Chemically Active Species Properties and Evidence for Their Interactions During the Mt Cimone (ITALY) Campaign: June 1st 2000 - July 6th 2000, F. Eos Trans, 81 (48), 2000.

Stohl A, Spichtinger-Rakowsky N, Bonasoni P, Feldmann H, Memmesheimer M, Scheel HE, Trickl T, Hübener SH: The influence of stratospheric intrusions on alpine ozone concentrations, Atmos. Environ., 34 (9), 2000.
http://www.sciencedirect.com/science/article/pii/S1352231099003209

Colombo T, Santaguida R, Capasso A, Calzolari F, Evangelist F, Bonasoni P: Biospheric influence on carbon dioxide measurements in Italy. Atmos. Environ., 34 (29-30), 2000.
http://www.sciencedirect.com/science/article/pii/S1352231000003666

Mangani F, Maione M, Lattanzi L, Arduini J: Atmospheric measurements of the halogenated hydrocarbons involved in global change phenomena, Atmos. Environ., 34 (29-30), 2000.
http://www.sciencedirect.com/science/article/pii/S1352231000002247

Gerasopoulos E, Zanis P, Stohl A, Zerefos CS, Papastefanou C, Ringerd W, Tobler L, Hubener S, Gaeggler HW, Kanter HJ, Tositti L, Sandrini S: A climatology of 7Be at four high-altitude stations at the Alps and the Northern Apennines, Atmos. Environ, 35, 2001.
http://www.sciencedirect.com/science/article/pii/S1352231001004009

Tomasi C, S. Marani, V. Vitale, Lupi A: Convective transport of particulate matter in an Apennine valley - 2. Time variations in the columnar aerosol mass content and vertical profiles of aerosol mass concentration, Atmos. Res., 63, 2002.
http://www.sciencedirect.com/science/article/pii/S0169809502000376

Marani S, Tomasi C, Vitale V: Convective transport of particulate matter in an Apennine valey 1. Sun-photometric measurements of aerosol optical depth time-variations at various altitudes, Atmos. Res., 61. 2002.
http://www.sciencedirect.com/science/article/pii/S016980950100103X

Hanke M, Uecker J, Reiner T, Arnold F: Atmospheric peroxy radicals: ROXMAS, a new massspectrometric methodology for speciated measurements of HO2 and SRO2 and first results, Int. J. Mass. Spectrum., 213, 2002.

Kormann R, Fischer H, Gurk C, Helleis F, Klupfel T, Kowalski K, Konigstedt R, Parchatka U, Wagner V: Application of a multi-laser tunable diode laser absorption spectrometer for atmospheric trace gas measurements at sub-ppbv levels, Spectrochim. Acta.,Part A, 58 (2489), 2002.
http://www.sciencedirect.com/science/article/pii/S1386142502000665

Stohl A, Bonasoni P, Cristofanelli P, Collins W, Feichter J, Frank A, Forster C, Gerasopoulos E, Gäggeler H, James P et al: Stratosphere-troposphere exchange - a review, and what we have learned from STACCATO, J. Geophys. Res., 108 (D12), 2003.
http://onlinelibrary.wiley.com/doi/10.1029/2002JD002490/pdf

Cristofanelli P, Bonasoni P, Collins W, Feichter J, Forster C, James P, Kentarchos A, Kubik PW, Land C, Meloen J: Stratosphere-to-troposphere transport: A model and method evaluation, J. Geophys. Res., 108 (D12), 2003.
http://onlinelibrary.wiley.com/doi/10.1029/2002JD002600/full

Fischer H, Kormann R, Klupfel T, Gurk C, Konigstedt R, Parchatka U, Muhle J, Rhee TS, Brenninkmeijer CAM, Bonasoni P, Stohl A: Ozone production and trace gas correlations during the June 2000 MINATROC intensive measurement campaign at Mt. Cimone., Atmos. Chem. Phys., 3, 2003.
http://www.atmos-chem-phys.net/3/725/2003/acp-3-725-2003.pdf

Balkanski Y, Bauer SE, van Dingenen R, Bonasoni P, Schulz M, Fischer H, Gobbi GP, Hanke M, Hauglustaine D, Putaud JP, Stohl A, Raes F: The Mt Cimone, Italy, free tropospheric campaign: principal characteristics of the gaseous and aerosol composition from European pollution, Mediterranean influences and during African dust events, Atmos. Chem. Phys. Disc., 3, 2003.
http://www.atmos-chem-phys-discuss.net/3/1753/2003/acpd-3-1753-2003.pdf

Putaud J-P, Dingenen VR, Dell'Acqua A, Raes F, Matta E, Decesari S, Facchini MC, Fuzzi S: Size-segregated aerosol mass closure and chemical composition in Monte Cimone (I) during MINATROC, Atmos. Chem. Phys., 3, 2003.
http://www.atmos-chem-phys.net/4/889/2004/acp-4-889-2004.pdf

Zanis P, Trickl T, Stohl A, Wernli H, Cooper O, Zerefos C, Gaeggeler H, Schnabel C, Tobler L, Kubik PW et al.: Forecast, observation and modelling of a deep stratospheric intrusion event over Europe, Atmos. Chem. Phys., 3, 2003.
http://www.atmos-chem-phys.net/3/763/2003/acp-3-763-2003.pdf

Hanke M, Umann B, Uecker J, Arnold F, Bunz H: Atmospheric measurements of gas-phase HNO 3 and SO 2 using chemical ionization mass spectrometry during the MINATROC field campaign 2000 on Monte Cimone, Atmos. Chem. Phys, 3, 417–436, 2003.
http://www.atmos-chem-phys.net/3/417/2003/acp-3-417-2003.pdf

A. Petritoli, Bonasoni P, Giovanelli G, Ravegnani F, Kostadinov I, Bortoli D, Weiss A, Schaub D, Richter A, Fortezza F: First Comparison Between ground-based and Sattelite-borne Measurements of Tropospheric Nitrogen Dioxide in the Po Basin, J. Geophys. Res., 109 (D15), 2004.
http://onlinelibrary.wiley.com/doi/10.1029/2004JD004547/full

Bonasoni P, Cristofanelli P, Calzolari F, U. Bonafe, Evangelisti F, Stohl A, Zauli Sajani S, van Dingenen R, Colombo T, Balkanski Y: Aerosol-ozone correlations during dust transport episodes, Atmos. Chem. Phys., 4, 2004.
http://www.atmos-chem-phys.net/4/1201/2004/acp-4-1201-2004.pdf

Van Dingenen R, Putaud JP, Martins-Dos Santos S, Raes F: Physical aerosol properties and their relation to air mass origin at Monte Cimone (Italy) during the first MINATROC campaign, Atmos. Chem. Phys., 5,2203–2226, 2005.
http://www.atmos-chem-phys.net/5/2203/2005/acp-5-2203-2005.pdf

Campana M, Li Y, Staehelin J, Prévôt ASH, Bonasoni P, Loetscher HP, Peter T: The influence of south Foehn on the ozone mixing ratios at the alpine site Arosa, Atmos. Environm., 39, 2005.
http://www.sciencedirect.com/science/article/pii/S1352231005000476

Beine HJ, Amoroso A, Esposito G, Sparapani R, Ianniello A, Georgiadis T, Nardino M, Bonasoni P, Cristofanelli P, Domine' F: Deposition of atmospheric nitrous acid on alkaline snow surfaces, Geophys. Res. Lett., 32 (L10808), 2005.
http://onlinelibrary.wiley.com/doi/10.1029/2005GL022589/full

Greally BR, Manning AJ, Reimann S, McCulloch A, Huang J, Dunse BL, Simmonds PG, Prinn RG, Fraser PJ, Cunnold DM et al.: Observation of 1,1-difluoroethane (HFC-152a) at AGAGE and SOGE monitoring stations 1994-2004 and derived Global and regional emission estimates, J. Geophys. Res., 112, 2006.
http://onlinelibrary.wiley.com/doi/10.1029/2006JD007527/pdf

Marenco F, Bonasoni P, Calzolari F, Ceriani M, Chiari M, Cristofanelli P, D'Alessandro A, Fermo P, Lucarelli F, Mazzei F et al.: Characterization of atmospheric aerosols at Monte Cimone, Italy, during summer 2004: source apportionment and transport mechanisms, J. Geophys. Res., 111 (D24202), 2006.
http://onlinelibrary.wiley.com/doi/10.1029/2006JD007145/full

Cristofanelli P, Bonasoni P, Tositti L, Bonafe' U, Calzolari F, Evangelisti F, Sandrini S, Stohl A: A 6-year analysis of stratospheric intrusions and their influence on ozone at Mt. Cimone (2165 m above sea level), J. Geophys. Res., 111 (D03306), 2006.
http://onlinelibrary.wiley.com/doi/10.1029/2005JD006553/full

Colombo T, Pelino V, Vergari S, Cristofanelli P, Bonasoni P: Study of temperature and precipitation variations in Italy based on surface instrumental observations, Global Planet. Change, 57 (3-4), 2007.
http://www.sciencedirect.com/science/article/pii/S0921818106003250

Cristofanelli P, Bonasoni P, Carboni G, Calzolari F, Casarola L, Sajani ZS, Santaguida R: Anomalous high ozone concentrations recorded at a high mountain station in Italy in Summer 2003.,Atmos. Env. 41, 2007.
http://www.sciencedirect.com/science/article/pii/S1352231006010326

Lee HN, Tositti L, Zheng XD, Bonasoni P: Analyses and comparisons of 7Be, 210Pb and activity ratio 7Be/210Pb with ozone observations at two GAW stations from high mountains, J. Geophys. Res., 112 (D05303), 2007.
http://onlinelibrary.wiley.com/doi/10.1029/2006JD007421/pdf

Cristofanelli P, Calzolari F, Bonafè U, R.Duchi, Marinoni A, Roccato F, Tositti L, Bonasoni P: Stratospheric Intrusion Index (SI2) from baseline measurement data, Theor. App. Clim., 2008.

http://link.springer.com/article/10.1007/s00704-008-0073-x

Maione M, Giostra U, Arduini J, Belfiore L, Furlani F, Geniali A, Mangani G, Vollmer MK, Reimann S: Localization of source regions of selected hydrofluorocarbons combining data collected at two European mountain Stations, Sci. Total Environ., 391, 232–240, 2008.
http://www.sciencedirect.com/science/article/pii/S0048969707010832

Marinoni A, Cristofanelli P, Calzolari F, Roccato F, Bonafe' U, Bonasoni. P.: Continuous measurements of aerosol physical parameters at the Mt. Cimone GAW Station (Italy - 2165 m a.s.l), Sci. Total Environ., 391, 2008.
http://www.sciencedirect.com/science/article/pii/S0048969707010844#

Cristofanelli P, Bonasoni P: Background ozone in the southern Europe and Mediterranean area: influence of the transport processes, Environ. Poll., 2008.
http://www.sciencedirect.com/science/article/pii/S026974910800451X

Cristofanelli P, Marinoni A, Arduini J, Bonafè U, Calzolari F, Colombo T, Decesari S, Duchi R, Facchini MC, Fierli F et al.: Significant variations of trace gas composition and aerosol properties at Mt. Cimone during air mass transport from North Africa – contributions from wildfire emissions and mineral dust, Atmos. Chem. Phys., 9, 2009.
http://www.atmos-chem-phys.net/9/4603/2009/acp-9-4603-2009.pdf

Stohl A, Seibert P, Arduini J, Eckhardt S, Fraser P, Greally BR, Maione M, O'Doherty S, Prinn RG, Reimann S et al.: A new analytical inversion method for determining regional and global emissions of greenhouse gases: sensitivity studies and application to halocarbons, Atmos. Chem. Phys., 9,1597–1620, 2009.
http://www.atmos-chem-phys.net/9/1597/2009/acp-9-1597-2009.pdf

Muller T, et al.: Angular Illumination and Truncation of Three Different Integrating Nephelometers: Implications for Empirical, Size-Based Corrections. Aerosol Sci. Tech., 43 (6), 2009.
http://www.tandfonline.com/doi/full/10.1080/02786820902798484#.UlfM41O9KuY

Carbone C, Decesari S, Mircea M, Giulianelli L, Finessi E, Rinaldi M, Fuzzi S, Marinoni A, Duchi R, Perrino C et al.: Size-resolved aerosol chemical composition over the Italian Peninsula during typical summer and winter conditions, Atmos. Environ., 44 (39), 5269-5278, 2010.
http://www.sciencedirect.com/science/article/pii/S1352231010006618

Sajani ZS, Miglio R, Bonasoni P, Cristofanelli P, Marinoni A, Sartini C, Goldoni CA, Girolamo DG, Lauriola P: Saharan dust and daily mortality in Emilia-Romagna (Italy), Occup Environ Med, 2010.
http://oem.bmj.com/content/68/6/446.full.pdf+html

Xiao X, Prinn RG, Fraser PJ, Simmonds PG, Weiss RF, O'Doherty S, Miller BR, Salameh PK, Harth CM, Krummel PB et al.: Optimal Estimation of the Surface Fluxes of Methyl Chloride using a 3-D Global Chemical Transport Model, Atmos. Chem. Phys., 10,5515-5533, 2010-
http://www.atmos-chem-phys.net/10/5515/2010/acp-10-5515-2010.pdf

Petkov B, Tomasi C, Vitale V, di Sarra A, Bonasoni P, Lanconelli C, Benedetti E, Sferlazzo D, Diemoz H, Agnesod G et al.: Ground-based observations of solar radiation at three Italian sites, during the eclipse of 29 March, 2006: Signs of the environment impact on incoming global irradiance, Atmos. Res., 96 (1), 2010.
http://www.sciencedirect.com/science/article/pii/S0169809509003457

Asmi A, et al. : Number size distributions and seasonality of submicron particles in Europe 2008–2009, Atmos. Chem. Phys., 11, 2011.
http://www.atmos-chem-phys.net/11/5505/2011/acp-11-5505-2011.pdf

Yver CE, et al. : A new estimation of the recent tropospheric molecular hydrogen budget using atmospheric observations and variational inversion, Atmos. Chem. Phys., 11, 2011.
http://www.atmos-chem-phys.net/11/3375/2011/acp-11-3375-2011.pdf

Keller CA, Hill M, Vollmer M. K., Henne S, Brunner D, Reimann S, O'Doherty S, Arduini J, Maione M, Ferenczi Z et al.: European Emissions of Halogenated Greenhouse Gases Inferred from Atmospheric Measurements, Environ. Sci and Technol., 46 (1),217-225, 2011.
http://pubs.acs.org/doi/ipdf/10.1021/es202453j

Yver CE et al.: A new estimation of the recent tropospheric molecular hydrogen budget using atmospheric observations and variational inversion, Atmos. Chem.and Phys., 11, 2011.
http://www.atmos-chem-phys.net/11/3375/2011/acp-11-3375-2011.html

Giostra U, Furlani F, Arduini J, Cava D, Manning AJ, O'Doherty SJ, Reimann S, Maione M: The determination of a regional atmospheric background mixing ratio for anthropogenic greenhouse gases: a comparison of two independent

methods, Atmos. Environ., 45, 2011.
http://www.sciencedirect.com/science/article/pii/S135223101100700X

Andrews E, et al. : Climatology of Aerosol Radiative Properties in the Free Troposphere, Atmos. Res., 102, 2011.
http://www.sciencedirect.com/science/article/pii/S0169809511002857

Muller T, et al.: Characterization and intercomparison of aerosol absorption photometers: result of two intercomparison workshops, Atmos. Meas. Tech., 4, 2011.
http://www.atmos-meas-tech.net/4/245/2011/amt-4-245-2011.pdf

Abeli T, Rossi G, Gentili R, Mondoni A, Cristofanelli P: Response of alpine plant flower production to temperature and snow cover fluctuation at the species range boundary, Plant Ecol., 213 (1 (2012)), 1-13, 2012.
http://link.springer.com/article/10.1007%2Fs11258-011-0001-5

Zauli-Sajani S, P.Bonasoni, Cristofanelli P, Marinoni A, Lauriola P: Only coarse particles from the Sahara?, Epidemiology, 4(23), 2012.
http://journals.lww.com/epidem/pages/results.aspx?txtKeywords=%22Sajani%22

Abeli T, Rossi G, Gentili R, Gandini M, Mondoni A, Cristofanelli P: Effect of the extreme summer heat waves on isolated populations of two orophitic plants in the north Apennines (Italy), Nordic J. Bot., 1 (30), 2012.
http://onlinelibrary.wiley.com/doi/10.1111/j.1756-1051.2011.01303.x/abstract

Saikawa E et al.: Global and regional emissions estimates for HCFC-22, Atmos. Chem. Phys., 12, 2012
http://www.atmos-chem-phys.net/12/10033/2012/acp-12-10033-2012.html

Brunner D, Henne S, Keller CA Reimann S, Vollmer MK, O'Doherty S, and Maione M: An extended Kalman-filter for regional scale inverse emission estimation, Atmos. Chem. Phys., 12, 3455-3478, doi:10.5194/acp-12-3455-2012, 2012
http://www.atmos-chem-phys.net/12/3455/2012/acp-12-3455-2012.html

Tositti L, Riccio A, Sandrini S, Brattich E, Baldacci D, Parmeggiani S, Cristofanelli P, Bonasoni P: Short–term climatology of PM10 at a high altitude background station in southern Europe, Atmos. Environ., 65, 2013.
http://www.sciencedirect.com/science/article/pii/S1352231012010333

Weaver C, Kiemle C, Kawa SR, Aalto T, Necki J, Steinbacher M, Arduini J, Apadula F, Berkhout H, Hatakka J et al.: Retrieval of methane source strengths in Europe using a simple modeling approach to assess the potential of space-borne lidar observations, Atmos. Chem. Phys. Discuss,. 13, 2013.
http://www.atmos-chem-phys-discuss.net/13/19559/2013/acpd-13-19559-2013.html

Cristofanelli P, Fierli F, Marinoni A, Calzolari F, Duchi R, Burkhart J, Stohl A, Maione M, Arduini J, Bonasoni P: Influence of biomass burning and anthropogenic emissions on ozone, carbon monoxide and black carbon at the Mt. Cimone GAW-WMO global station (Italy, 2165 m a.s.l.), Atmos. Chem. Phys, 13, 2013.
http://www.atmos-chem-phys.net/13/15/2013/acp-13-15-2013.pdf

Cristofanelli P, di Carlo P, Altorio AD, Salisburgo DC, Tuccella P, Biancofiore F, Stocchi P, Verza GP, Landi TC, Marinoni A et al.: Analysis of Summer Ozone Observations at a High Mountain Site in Central Italy (Campo Imperatore, 2388 m a.s.l.), Pure and Appl. Geophys., 2013.
http://link.springer.com/article/10.1007/s00024-012-0630-1

Maione M, Giostra U, Arduini J, Furlani F, Graziosi F, Lo Vullo E, and Bonasoni P: Ten years of continuous observations of stratospheric ozone depleting gases at Monte Cimone (Italy) - Comments on the effectiveness of the Montreal Protocol from a regional perspective, Sci. Tot. Environ., 445–446, 2013
http://www.sciencedirect.com/science/article/pii/S0048969712016130

Hall BD et al.: Results from the International Halocarbons in Air Comparison Experiment (IHALACE), Atmos. Meas. Tech., 6, 2013
http://www.atmos-meas-tech.net/7/469/2014/amt-7-469-2014.html

Beddows DCS et al. . Variations in tropospheric submicron particle size distributions across the European continent 2008–2009. Atmos. Chem. Phys.,14,4327-4348,2014
http://www.atmos-chem-phys.net/14/4327/2014/acp-14-4327-2014.pdf

Research Projects

GAW (Global Atmosphere Watch) The Global Atmosphere Watch (GAW) programme of WMO is a partnership involving 80 countries, which provides reliable scientific data and information on the chemical composition of the atmosphere, its natural and anthropogenic change, and helps to improve the understanding of interactions between the atmosphere, the oceans and the biosphere.

NextData The Project of Interest NextData will favour the implementation of measurement networks in remote mountain and marine areas and will develop efficient web portals to access meteoclimatic and atmospheric composition data, past climate information from ice and sediment cores, biodiversity and ecosystem data, measurements of the hydrological cycle, marine reanalyses and climate projections at global and regional scale.

SHARE (Station at High Altitude for Research on the Environment) Share is an integrated project funded by EV-K2-CNR Committe comprising an international climate and atmospheric monitoring network, researches in environmental and geophysical sciences and new technology development for monitoring activity in high mountain regions. Working in synergy with projects run by UNEP and WMO, data from the SHARE initiative benefit the international scientific community as well as decision makers.

ACTRIS (Aerosols, Clouds, and Trace gases Research InfraStructure Network) ACTRIS is a European Project aiming at integrating European ground-based stations equipped with advanced atmospheric probing instrumentation for aerosols, clouds, and short-lived gas-phase species. ACTRIS will have the essential role to support building of new knowledge as well as policy issues on climate change, air quality, and long-range transport of pollutants. ACTRIS is building the next generation of the ground-based component of the EU observing system by integrating three existing research infrastructures EUSAAR, EARLINET, CLOUDNET, and a new trace gas network component into a single coordinated framework. ACTRIS is funded within the EC 7th Framework Programme under "Research Infrastructures for Atmospheric Research" and started on 1 April 2011 for a period of 4 years.

MACC-2 (Monitoring Atmospheric Composition and Climate - Interim Implementation) is the current pre-operational atmospheric service of the European GMES programme. MACC provides data records on atmospheric composition for recent years, data for monitoring present conditions and forecasts of the distribution of key constituents for a few days ahead. MACC-II combines state-of-the-art atmospheric modelling with Earth observation data to provide information services covering European Air Quality, Global Atmospheric Composition, Climate, and UV and Solar Energy.

EUSAAR (European Supersites for Atmospheric Aerosol Research) The objective of EUSAAR UE-funded project is the integration of measurements of atmospheric aerosol properties performed in a distributed network of 20 high quality European ground-based stations. This integration contributes to a sustainable reliable operational service in support of policy issues on air quality, long-range transport of pollutants and climate change.

EUROHYDROS The aim of EUROHYDROS has been the initialisation of a European Network for observations of molecular Hydrogen based on 12 continuous measurements sites which allow a wide range of observation, from clean air stations for measurements of atmospheric background to moderately polluted and urban. This in order to improve the understanding of hydrogen in the global background atmosphere and of the impact of European emissions on the present day atmosphere.

CIRCE (Climate Change and Impact Reserach: the Mediterranenan Environment) The general project objectives are to predict and to quantify physical impacts of climate changes in the Mediterranean area; to evaluate the consequences of climate changes for the society and the economy of the populations located in the Mediterranean area; to develop an integrated approach to understand combined effects of climate change; to identify adaptation and mitigation strategies in collaboration with regional stakeholders.

AGAGE-Advanced Global Atmospheric Gases Experiment AGAGE and its predecessors (the Atmospheric Life Experiment, ALE, and the Global Atmospheric Gases Experiment, GAGE) have been measuring the composition of the global atmosphere continuously since 1978. The AGAGE is distinguished by its capability to measure over the globe at high frequency almost all of the important gases species in the Montreal Protocol (e.g. CFCs and HCFCs) to protect the ozone layer and almost all of the significant non-CO2 gases in the Kyoto Protocol (e.g. HFCs, methane, and nitrous oxide) to mitigate climate change.

CEOP HE (Coordinated Energy and Water Cycle Observation Project - High Elevation) CEOP HE is a component of 'regional focus' within the Coordinated Energy and Water Cycle Observation Project (CEOP) of the Global Energy and Water Cycle Experiment (GEWEX), under the WCRP of WMO. CEOP HE aims to further knowledge on physical and dynamic processes in high elevation areas, contributing to global climate and water cycle studies by providing rare but crucial information from high elevations. This initiative was launched and is coordinated by the Ev-K2-CNR Committee.

ACCENT (Atmospheric Composition Change - The European Network of Excellence) The overall goals of the UE-network ACCENT are to promote a common European strategy for research on atmospheric composition sustainability, to develop and maintain durable means of communication and collaboration within the European scientific community, to facilitate this research and to optimise the interactions with policy-makers and the general public.

AEROCLOUDS (Climatic Effects of Aerosol and Clouds) AEROCLOUDS is a project funded by the Italian Ministry for University and Research to improve our knowledge of the role of aerosol and clouds in the climate system. Four research lines have been investigated: 1) Radiative properties of aerosols ("direct" climatic effects); 2) Aerosol-Cloud interactions ("indirect" climatic effects); 3) Climatic effects of clouds and precipitation; 4) Regional and global modelling of the aerosol effects on climate.

SOGE (System for Observations of Halogenated Greenhouse Gases in Europe) SOGE is an integrated system for observation of halogenated greenhouse gases in Europe. The project was funded by UE and builds on a combination of observations and modelling. The observations are partly surface in situ data collected continuously at four background stations as a part of national or international measurement programs. For some species(PFC, SF6), for which high-frequency measurements are not yet fully developed, such capacity will be developed as a part of SOGE.

POLPO (Pollution Hot Spot Monitoring from GOME Applied to the Po-basin) POLPO investigated the feasability of applying satellite data for monitoring large pollution plumes. The prototype service demonstrated the application of GOME data for case studies. Users as, e.g., environmental agencies, who have to rely on ground-based measurements, found the added value satellited data provide together with its limitations in the feasability study.

QUILT (Quantification and Interpretation of Long-Term UV-Vis Observations of the Stratosphere)
The general aim was to use the existing ground-based, satellite and balloon borne UV-visible data as well as 3D atmospheric modelling tools for quantifying ozone loss in the past, to monitor its development in the present and to investigate its relation to active halogen and nitrogen species.

TOR-2 (Tropospheric Ozone Research - 2) The overall aim of TOR-2 was to quantify crucial processes in the atmosphere in order to improve the scientific background for the development of effect-based control strategies for photochemical oxidants over Europe.

STACCATO (Influence of Stratosphere-Troposphere Exchange in a Changing Climate on Atmospheric Transport and Oxidation Capacity) EU-project STACCATO is a comprehensive study of stratosphere-troposphere exchange (STE) processes and their effect on atmospheric chemistry. STE is a key factor controlling the budget of ozone, water vapour and other substances in both the troposphere and lower stratosphere.

MINATROC (Mineral Dust and Tropospheric Chemistry) Problems to be solved this EU-project focuses on the transformation of atmospheric pollutants from Europe in the presence of mineral dust over South Europe and Africa. Intensive field campaigns, experimental laboratory investigations and modeling studies were conducte dti evaluate the influence of mineral dust on troposphere oxidazing properties.

VOTALP-2 (Vertical Ozone Transport in the Alps - 2) The EU research project VOTALP II investigated the enhanced vertical exchange above the Alps as well as other processes which might be relevant for increased ozone concentrations. The role of stratospheric intrusions for mountain peaks and of horizontal advection of polluted air for the foothill area causing a high ozone abundance has been quantified for selected locations.

VOTALP (Vertical Ozone Transport in the Alps) The EU research project VOTALP investigated transport and formation of ozone in the Alps, focusing on processes which can cause increased ozone concentrations, namely stratospheric intrusions, horizontal advection of polluted air, and in-situ production of ozone due to emissions in Alpine valleys.

The ICO-OV staff

Paolo Bonasoni – *Station leader*
p.bonasoni@isac.cnr.it

Paolo Cristofanelli –*Trace gases and meteorology*
p.cristofanelli@isac.cnr.it

Angela Marinoni – *Atmospheric aerosol*
a.marinoni@isac.cnr.it

Francescopiero Calzolari – *Data acquisition and technical infrastructures*
f.calzolari@isac.cnr.it

Samuele Masieri – *Stratospheric nitrogen dioxide*
s.masieri@isac.cnr.it

MIchela Maione (Urbino University) - *VOC and Halogenated gases*
michela.maione@uniurb.it

Jgor Arduini (Urbino University) - *VOC and Halogenated gases*
jgor.arduini@uniurb.it

Fabrizio Roccato – *System manager*
*f.roccato@isac.cnr.*it

Rocco Duchi – *Data validation and analysis*
r.duchi@isac.cnr.it

Davide Putero – *Data analysis*
d.putero@isac.cnr.it

Tony Christian Landi – *Data analysis*
t.landi@isac.cnr.it

Maurizio Busetto - *Data acquisition and near-real time*
m.busetto@isac.cnr.it

Laureline Bourcier – *Aerosol studies*
l.bourcier@isac.cnr.it

Ubaldo Bonafè - *Technical infrastructures*
u.bonafe@isac.cnr.it

CONTACTS:

Italian Climate Observatory "O. Vittori" at Mt. Cimone
c/o Institute for Atmospheric Sciences and Climate – National Research Council of Italy
Via Gobetti 101
40129 Bologna (Italy)
www.isac.cnr.it/cimone

Follow @Cimone_CNR

Mt. Cimone Research Station

2165

Consiglio Nazionale delle Ricerche Istituto di Scienze dell'Atmosfera e del Clima

http://www.isac.cnr.it/cimone/