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

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

WINTER 2015 REPORT

CNR - ISAC
National Research Council
Institute of Atmospheric Sciences and Climate
ITALY

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

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.6
Issued: June 2015, rev. 1
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 WINTER 2015 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. Then, an overview of the atmospheric and weather conditions during winter 2015 is provided, by considering:

- **surface ozone**
- **carbon monoxide**
- **nitrogen oxides**
- **sulphur dioxide**
- **black carbon**
- **aerosol scattering coefficient**
- **fine and coarse particles**
- **halogenated gases**
- **volatile organic compounds**
- **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 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 Winter mean values are calculated by averaging data from 2014, December 1st to 2015, February 28th.**

Premessa

Questo rapporto riassume i risultati relativi alle osservazioni atmosferiche effettuate durante l'INVERNO 2015 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.

Viene quindi fornita una panoramica delle condizioni atmosferiche e meteorologiche che hanno caratterizzato la stagione invernale 2015 considerando:

- **ozono superficiale**
- **monossido di carbonio**
- **ossidi di azoto**
- **anidride solforosa**
- **black carbon**
- **particolato fine e grossolano**
- **gas alogenati**
- **composti organici volatili**
- **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" dentificati con procedure opportunamente messe a punto e descritte.

- **trasporto 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 invernali sono calcolati come media dal 1 dicembre 2014 al 28 febbraio 2015.**

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.

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

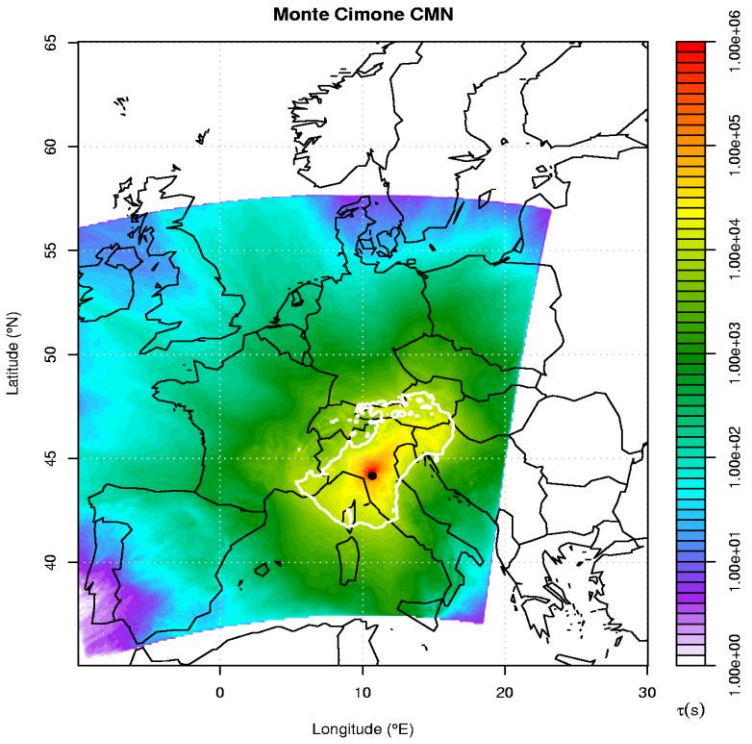
Lista delle stazioni globali GAW/WMO in aree di alta quota (for more information: http://gaw.empa.ch/gawsis/)

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).

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).

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.

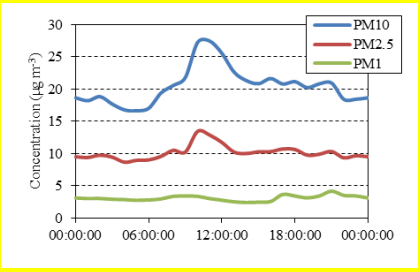
Monte Cimone è caratterizzato da un orizzonte completamente libero e quindi le masse d'aria possono raggiungere il sito di misura senza incontrare ostacoli orografici. Nella pagine precedente viene mostrata la media annuale del "bacino di raccolta" delle masse d'aria che nel giro di 48 ore sono arrivate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

NEWS

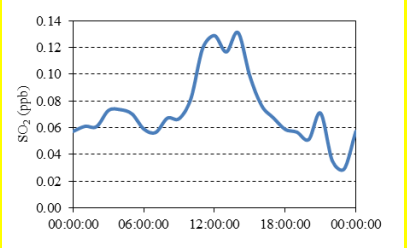
I-AMICA project new station at Capo Granitola (Sicily)
Nuova stazione di misura a Capo Granitola (Sicilia) per il progetto I-AMICA

A new station has been recently installed at Capo Granitola (Sicily) in the framework of the I-AMICO project, with the measurement programme starting on December 2014. This coastal station, located on the Sicily channel and abutting on the Mediterranean sea **is important to characterize the marine boundary layer background composition and to better asses the specific phenomenon that are responsible for its alteration** (e.g. mineral dust from North Africa, polluted air masses from landmass and sea-lanes).

Una nuova stazione è stata recentemente installata a Capo Granitola (TP) nell'ambito del progetto I-AMICA, con l'inizio delle misure a partire dal Dicembre 2014. Tale stazione costiera, posizionata sul Canale di Sicilia risulta essere di **particolare importanza sia nelle determinazione delle condizioni di "fondo" del boundary layer marino che nello studio dei processi** (ad esempio trasporto di aerosol minerale dal Nord Africa, inquinamento da traffico marino) **che contribuiscono ad alterarle**.



*Winter time diurnal variation of the PMs mass concentration, an **important aerosol parameter used to discriminate the many different contributions** to the aerosol composition of the marine boundary layer.*
*Variazione diurna della concentrazione di PM, impiegato nella **determinazione dei differenti contributi alla composizione dell'aerosol** atmosferico nel boundary layer marino.*



*Winter time diurnal variation of the SO_2 mixing ratio, an **important parameter used to identify passage of ships** along the major sea-lanes.*
*Variazione diurna della concentrazione di SO_2, un **importante tracciante dell'inquinamento da traffico marittimo**.*

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 *(Thermo Tei 49i)*
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)*
Sulphur dioxide	Primary pollutant, secondary aerosol precursor, volcanic tracer.	UV-fluorescence analyser (*Thermo 43i-TLE*)
Black carbon	Short-lived climate forcer, primary pollutant, combustion tracer. It contributes to PM_1	Multi-Angle Absorption Photometer *(Thermo MAAP 5012)*
Aerosol light scattering coefficient	Investigation of the aerosol climate direct forcing	3 –wavelenghts Integrating nephelometer *(TSI 3563)*
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)*
Halogenated gases	Stratospheric ozone depleting substances and climate forcer	Gas chromatography-Mass spectrometry. *(Agilent 6850–5975)*
Volatile organic compounds	Ozone and PM precursors	Gas chromatography-Mass spectrometry *(Agilent 6850–5975)*
Stratospheric nitrogen dioxide	Ozone destroying substance and buffer against halogen catalysed ozone loss	GASCOD-MTC: UV-Vis spectrometer
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 *(Thermo Tei 49i)*
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)*
Anidride solforosa	Inquinante primario, precursore dell'aerosol secondario, tracciante di eruzioni vulcaniche	Analizzatore a fluorescenza UV (*Thermo Tei43i-TLE)*
Black carbon	Forzante climatico a breve tempo di vita, inquinante primario, tracciante della combustione. Contribuisce al PM_1	Fotometro per l'assorbimento multi-angolare *(Thermo MAAP 5012)*
Coefficiente di scattering delle particelle	Studio della forzante climatica diretta degli aerosol	Nefelometro a 3 lunghezze d'onda*(TSI 3563)*
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)*
Gas alogenati	Distruggono l'ozono stratosferico, forzanti climatici	Gas cromatografia-Spettrometria di massa *(Agilent 6850–5975)*
Composti organici volatile	Precursori dell'ozono troposferico e del PM	Gas cromatografia-Spettrometria di massa *(Agilent 6850–5975)*
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

Winter 2015 did not present high average levels of short-lived climate forcers (SLCF): a value lower than the climatological mean was observed for black carbon, surface ozone and fine particles. While carbon monoxide showed an average value slightly higher than the climatological one, coarse particles average concentrations were on par with the usual winter values.

The 25.6% of the winter have been affected for a significant fraction of time by pollution events, with the majority of the events taking place on the December (especially at the end of the month) and February.

3 days (3.3%) were affected by mineral dust transport, with the event occurring from January 1st to January 3rd, the tail of the main event of the previous season that was associated with the presence of a through over western Europe.

The selection methodology allow the identification of 35 days related with air-mass transport from the stratosphere, with the highest O_3 average on December 23th.

Daily **surface ozone** peak was recorded on 20-02 (51.9 ppb). 30-minute average values ranged from a minimum of 8.5 ppb (31-12) to 57.0 ppb (08-02), with an average seasonal value of 41.8 ppb. This value is lower than the average climatological winter value obtained from the last 19 years (45.0 ppb).

Daily **carbon monoxide** peak was recorded on 05-02 (226.5 ppb). 30-minute average values ranged from a minimum of 56.6 ppb (31-12) to 286.5 ppb (24-02), with an average seasonal value of 134.8 ppb. This value is higher than the value obtained from the last 3 years (129.2 ppb).

Daily **nitric oxide** and **nitrogen dioxide** peaks were recorded on 06-02 (0.34 ppb) and 05-02 (2.00 ppb), respectively. 30-minute average values ranged from values below the detection limit to 1.78 ppb (for NO) and 9.20 ppb (for NO_2).

Daily **sulfur dioxide** peak was recorded on 31-12 (1.02 ppb). 30-minute average values ranged from values below the detection limit to 2.17 ppb (31-12), with an average seasonal value below the detection limit.

Sommario

VISIONE DI INSIEME

L' inverno del 2015 non ha presentato valori medi elevati di *short-lived climate forcers* (SLCF): il black carbon, le particelle fini e l'ozono hanno mostrato valori inferiori rispetto alle medie climatologiche. Mentre le concentrazioni di monossido di carbonio sono leggermente superiori a quelle climatologiche i valori delle particelle grossolane risultano essere in linea con quanto solitamente osservato durante la stagione invernale.

Il 25.6 % della stagione è stato influenzato da eventi significativi di inquinamento, con una prevalenza nei mesi di Dicembre (specialmente alla fine) e Febbraio (più distribuiti).

I primi 3 giorni della stagione sono stati caratterizzati da un notevole evento di trasporto di sabbia sahariana: questi giorni rappresentano tuttavia la coda dell'evento verificatorsi alla fine della stagione precedente ed originatosi a causa della presenza di una saccatura sopra l'Europa occidentale che ha favorito il trasporto dal Nord Africa.

La metodologia di selezione ha permesso di identificare 35 eventi di trasporto chiaramente associabile a masse d'aria provenienti dalla stratosfera, con la concentrazione di O_3 più elevata osservata il 23 di Dicembre.

Il valore massimo giornaliero della concentrazione di **ozono superficiale** è stato registrato il 20-02 (51.9 ppb). Le medie semi-orarie variano da 8.5 ppb (31-12) a 57.0 ppb (08-02), con un valore medio stagionale di 41.8 ppb. Tale valore è inferiore a quello climatologico relativo agli ultimi 19 anni (45.0 ppb).

Il valore massimo giornaliero della concentrazione di **monossido di carbonio** è stato registrato il 05-02 (226.5 ppb). Le medie semi-orarie variano da 56.6 ppb (31-12) a 286.5 ppb (24-02), con un valore medio stagionale pari a 134.8 ppb. Tale valore è superiore a quello delle ultime tre stagioni invernali (129.2 ppb).

I valori massimi giornalieri di **ossido d'azoto** e **biossido d'azoto** sono stati registrati rispettivamente il 06-02 (0.34 ppb) e il 05-02 (2.00 ppb). Le medie semi-orarie sono variate da valori inferiori al limite di rivelazione sino a 1.78 ppb (per NO) e 9.20 ppb (per NO_2).

Il valore massimo giornaliero di **biossido di zolfo** è stato registrato il 31-12 (1.02 ppb). Le medie semi-orarie sono variate da valori inferiori al limite di rilevabilità sino a 2.17 ppb (31-12), con un valore medio stagionale inferiore al limite di rilevabilità.

Daily **black carbon** peak was recorded on 20-02 (163.1 ng m^{-3}). 30-minute average values ranged from a minimum of 10.0 ng m^{-3} (07-01) to 520.7 ng m^{-3} (20-02), with an average seasonal value of 59.6 ng m^{-3}. This value is lower than the average climatological winter value obtained from the last 10 years (81.1 ng m^{-3}).

Daily **fine aerosol particles** peak was recorded on 20-02 (20.9 cm^{-3}). 30-minute average values ranged from a minimum of 0.01 cm^{-3} (21-02) to 50.5 cm^{-3} (28-02), with an average seasonal value of 2.9 cm^{-3}. This value is lower than the average climatological winter value obtained from the last 13 years (7.7 cm^{-3}).

Daily **coarse aerosol particles** peak was recorded on 02-12 (1.0 cm^{-3}). 30-minute average values ranged from a minimum of 0.002 cm^{-3} (07-02) to 2.7 cm^{-3} (01-12), with an average seasonal value of 0.06 cm^{-3}. This value is comparable to the average climatological winter value obtained from the last 13 years (0.07 cm^{-3}).

Daily **aerosol scattering coefficient at 550 nm** peak was recorded on 01-12 (9.9 Mm^{-1}). 30-minute average values ranged from below the detection limit to 140.9 Mm^{-1} (09-12), with an average seasonal value of 1.86 Mm^{-1}. This value is considerably lower than the average climatological summer value obtained from the last 8 years (7.25 Mm^{-1}).

Maximum **HFC-134a** peak was recorded on 24-02 (122.6 ppt). The lowest value (82.0 ppt) was recorded on 10-01 during a Stratospheric Intrusion event. Winter average of 90.2 ppt, this is the highest seasonal average observed in an increasing trend that is evidente since the start of the measurements in 2003.

Maximum **Benzene** peak was recorded on 07-12 (490.6 ppt), with the average of the non-background values (235 ppt) showing a slow descending trend of the climatologic winter values. The lowest value (9.7 ppt) was recorded on 19-02.

The maximum value of **nitrogen dioxide** columnar amount was recorded on 24-02 ($9.55 \cdot 10^{15}$ mol/cm^2) for the sunset and on 01-12 ($4.14 \cdot 10^{15}$ mol/cm^2) for the sunrise. The minimum value of the columnar amount of nitrogen dioxide was recorded on 7-01 ($2.09 \cdot 10^{15}$ mol/cm^2) for the sunset and on 09-01 ($1.15 \cdot 10^{15}$ mol/cm^2) for the sunrise. The trend of the two series follows the course of the annual cycle that involves a growth of the total column, with a maximum during summer months.

Il valore massimo giornaliero della concentrazione di **black carbon** è stato registrato il 20-02 (163.1 ng m^{-3}). Le medie semi-orarie variano da 10.0 ng m^{-3} (07-01) a 520.7 ng m^{-3} (20-02), con un valore medio stagionale pari a 59.6 ng m^{-3}. Tale valore è inferiore a quello climatologico relativo agli ultimi 10 anni (81.1 ng m^{-3}).

Il valore massimo giornaliero della concentrazione di **particelle fini** è stato registrato il 20-02 (20.9 cm^{-3}). Le medie semi-orarie variano da 0.01 cm^{-3} (21-02) a 50.5 cm^{-3} (28-02), con un valore medio stagionale pari a 2.9 cm^{-3}. Tale valore è inferiore a quello climatologico degli ultimi 10 anni (7.7 cm^{-3}).

Il valore massimo giornaliero della concentrazione di **particelle grossolane** è stato registrato il 02-12 (1.0 cm^{-3}). Le medie semi-orarie variano da 0.002 cm^{-3} (07-02) a 2.7 cm^{-3} (01-12), con un valore medio stagionale pari a 0.06 cm^{-3}. Tale valore è in linea con quello climatologico relativo agli ultimi 13 anni (0.07 cm^{-3}).

Il picco giornaliero del **coefficiente di scattering dell'aerosol a 550 nm** è stato osservato il 01-12 (9.9 Mm^{-1}). Le medie sui 30-minuti oscillano tra valori inferiori al limite di rilevabilità e 140.9 Mm^{-1} (09-12), con un valore medio stagionale di 1.86 Mm^{-1} che risulta essere considerevolmente inferiore al valore medio climatologico relativo agli ultimi 8 anni (7.25 Mm^{-1}).

Il massimo giornaliero di **HFC-134a** è stato registrato il 24-02 (122.6.2 ppt) mentre la concentrazione minima (82.0 ppt) è stata registrata il 10-01 in occasione di un episodio di intrusione stratosferica. Il valore medio invernale (90.2 ppt) è quello più elevato mai osservato, l'ultimo di una serie positiva di incrementi nelle concentrazioni medie osservati a partire dall'inizio delle msiure nel 2003.

Il massimo giornaliero di **benzene** è stato registrato il 07-12 (490.6 ppt), mentre il minimo (9.7 ppt) si è registrato il 19-02. Si osserva, nella serie annuale, un andamento in continuo calo dei valori medio stagionali di concentrazione (inverno 2015: 325.0 ppt) osservato in condizioni non di fondo.

Il valore massimo della quantità colonnare di **biossido di azoto** è stato registrato il 24-02 ($9.55 \cdot 10^{15}$ mol/cm2) per il tramonto ed il 01-12 ($4.14 \cdot 10^{15}$ mol/cm2) per l'alba. Il valore minimo della quantità colonnare di biossido di azoto è stato registrato il 07-01 ($2.09 \cdot 10^{15}$ mol/cm2) per il tramonto ed il 09-01 ($1.15 \cdot 10^{15}$ mol/cm2) per l'alba. La serie temporale segue l'andamento del ciclo annuale che prevede una crescita della colonna totale fino al raggiungimento della concentrazione massima durante i mesi estivi.

Daily **air temperature** peak was recorded on 10-01 (7.5°C), minimum on 31-12 (-12.5 °C). 30-minute average values ranged from a minimum of -15.4 °C (31-12) to 10.1 °C (10-01), with an average seasonal value of -2.5 °C, which is higher than the seasonal climatological value (-3.4 °C).

Daily **relative humidity** minimum was recorded on 23-12 (12.2%). 30-minute average values ranged from a minimum of 7.0 % (13-01) to a maximum of 100.0 % (observed on 13 days), with an average seasonal value of 78.0 %. This value is comparable to the average climatological winter value obtained from the last 19 years (77.5 %).

Daily **atmospheric pressure** peak was recorded on 02-01 (800.8 hPa), the lowest value on 30-01 (755.9 hPa). 30-minute average values ranged from a minimum of 751.8 hPa (30-01) to 802.3 hPa (02-01), with an average seasonal value of 786.6 hPa, comparable with the average climatological winter value obtained from the last 19 years (786.2 hPa).

Daily **wind speed** peak was recorded on 04-02 (25.6 m s^{-1}). 30-minute average values ranged from a minimum of 0.5 m s^{-1} (19-01) to a maximum of 67.3 m s^{-1} (04-02), with an average seasonal value of 11.0 m s^{-1}. This value is comparable with the climatological winter value (9.3 m s^{-1}).

Wind direction was prevalently from N (20.8 % of 30-minute data) and SW (23.5 % of 30-minute data), in line with the climatological analysis over the last 19 years showing a prevalence of SW winds.

Daily **solar radiation** highest average daily value was recorded on 20-02 (185.3 W m^{-2}). Generally clear sky conditions were observed during December and the first half of January. The lowest average daily value (0.9 W m^{-2}) was observed on 05-02, during a period (from 22-01 to 09-02)when cloud cover was present at the measurement site. Snow and ice over sensors could have affected measurements.

A similar trend was also observed for **UV-B radiation**, with the highest value observed on 20-02 (0.24 W m^{-2}). Snow and ice over sensors could have affected measurements.

Il valore massimo giornaliero della **temperatura** è stato registrato il 10-01 (7.5 °C), il valore minimo il 31-12 (-12.5 °C). Le medie semi-orarie variano da -15.4 °C (31-12) a 10.1 °C (10-01), con un valore medio stagionale pari a -2.5 °C, superiore a quello medio climatologico invernale (-3.4 °C).

Il valore minimo giornaliero dell'**umidità relativa** è stato registrato il 23-12 (12.2 %). Le medie semi-orarie variano da 7.0 % (13-01) a 100 % (osservato in 13 giornate), con un valore medio stagionale pari a 78.0 %. Tale valore è confrontabile con quello climatologico relativo agli ultimi 19 anni (77.5 %).

Il valore massimo giornaliero della **pressione atmosferica** è stato registrato il 02-01 (800.8 hPa), il valore minimo il 30-01 (755.9 hPa). Le medie semi-orarie variano da 751.8 hPa (30-01) a 802.3 hPa (02-01), con un valore medio stagionale pari a 786.6 hPa, simile a quello climatologico relativo agli ultimi 19 anni (786.2 hPa).

Il valore massimo giornaliero della **velocità del vento** è stato registrato il 04-02 (25.6 m s^{-1}). Le medie semi-orarie variano da 0.5 m s^{-1} (19-01) a 67.3 m s^{-1} (04-02), con un valore medio stagionale pari a 11.0 m s^{-1}. Tale valore è in linea con quello climatologico ottenuto dalle misure realizzate negli ultimi 19 anni (9.3 m s^{-1}).

La **direzione del vento** osservata nell' inverno 2015 è stata prevalentemente da Sud-Ovest (23.5 % dei dati semi-orari) e Nord (20.8 % dei dati). Diversamente da quanto osservato negli ultimi 19 anni si rileva quindi un cospicuo contributo di venti settentrionali, nonostante permanga la climatologica prevalenza di venti sudoccidentali.

La **radiazione solare** mostra il valore giornaliero massimo il 20-02 (185.3 W m^{-2}). Valori elevati, associati a condizioni di cielo libero da nubi vengono osservate per tutto il mese di dicembre e per la prima metà di Gennaio. Il minimo giornaliero (0.9 W m^{-2}) è stato osservato il 05-02, all'interno di un periodo compreso tra il 22-01 ed il 09-02, caratterizzato da copertura nuvolosa. Possibili accumuli di neve e ghiaccio possono aver indotto l'occorrenza di bassi valori di radiazione.

Analogo comportamento viene osservato per quanto riguarda la **radiazione UV**, con il massimo giornaliero, pari a 0.24 W m^{-2}, osservato il 20-02. Possibili accumuli di neve e ghiaccio possono aver indotto l'occorrenza di bassi valori di radiazione UVB.

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	December	January	February
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

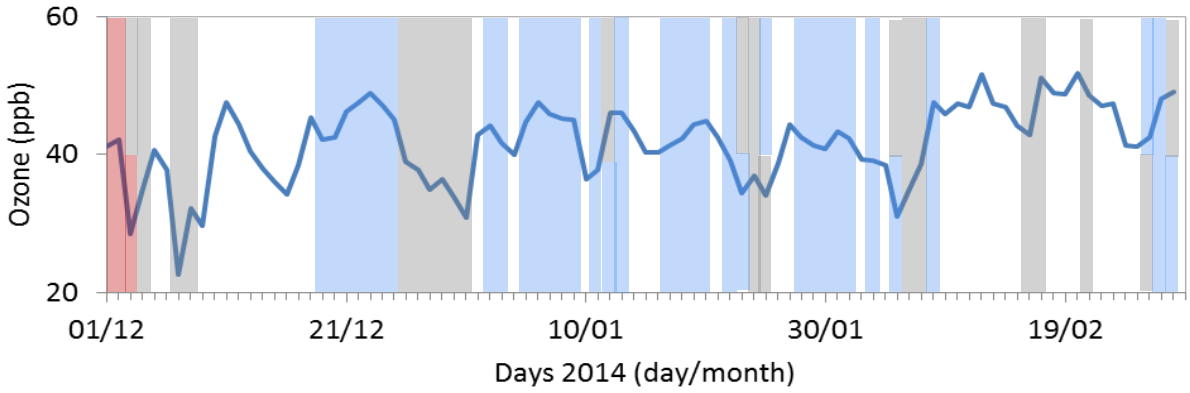
Mineral dust Stratospheric intrusions Pollution transport

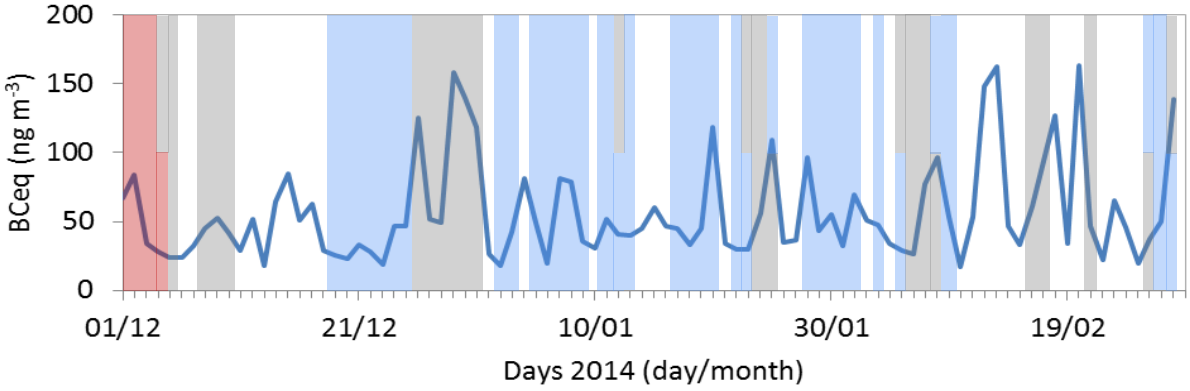
Eventi speciali

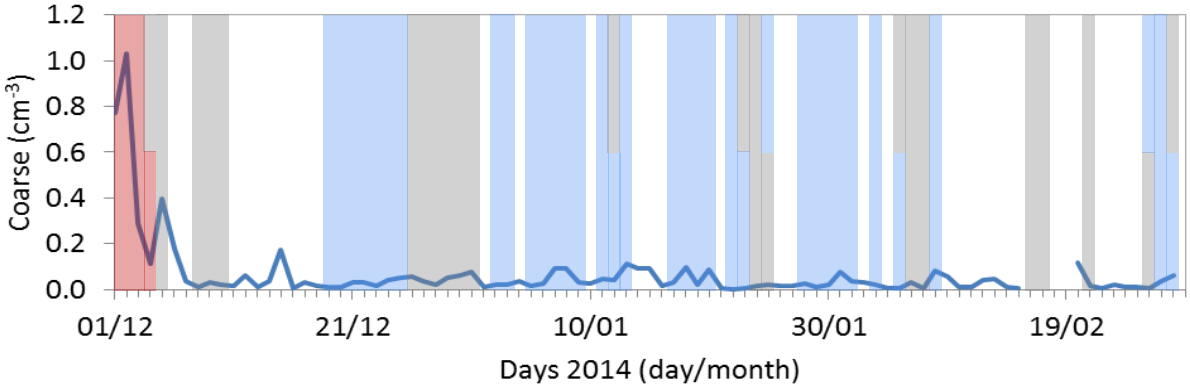
In questo paragrafo viene presentato l'elenco degli "eventi speciali" che sono stati registrati presso il sito di misura durante il periodo analizzato:

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

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.







LEGENDA

Mineral dust | Stratospheric intrusions | Pollution transport

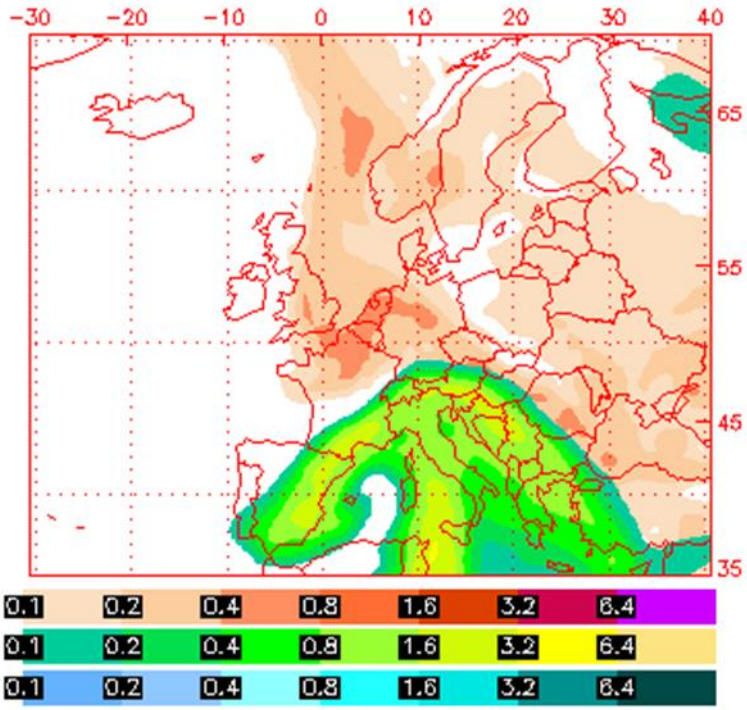
Mineral dust transport

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.

WINTER 2015:

- **3 days were characterized by the transport of mineral dust from northern Africa (3.3 % of the period). The identified event is the tail of the November 2014 transport.**
- **The Saharan dust event was associated to the presence of a pressure trough over west Europe.**
- **During the dust event the coarse particle peaked to 2.7 cm^{-3}, on 1st December 2014.**



Dust transport event simulation by NAAPS model (1st December 2014).

Simulazione dell'evento di trasporto di polveri minerali osservato il 01 Dicembre 2014 (modello NAAPS).

http://www.nrlmry.navy.mil/

Courtesy by NRL/Monterey Aerosol Modeling.

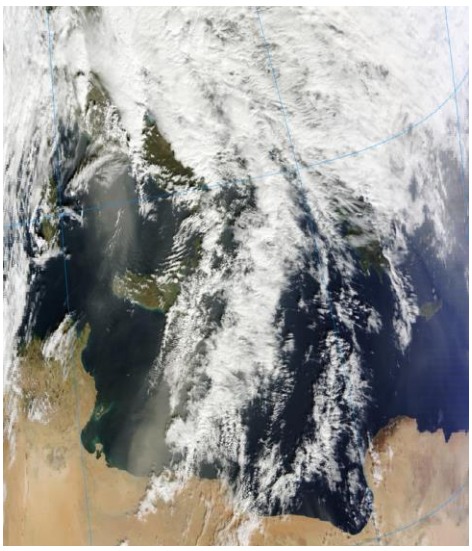
Trasporto di polveri minerali

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.

INVERNO 2015:

- **3 giorni sono stati caratterizzati dal trasporto di polveri minerali proveniente dal Nord Africa (3.3 % del periodo), tutti all'inizio di Dicembre come coda dell'evento di fine Novembre.**
- **L' evento di trasporto dal Sahara è stato favoriti dalla presenza di una saccatura sull'Europa occidentale.**
- **Il picco di concentrazione di particelle grossolane (2.7 cm-3) è stato osservato il 01 Dicembre.**



Dust transport observed by MODIS sensor on-board od AQUA and TERRA NASA satellite (1st December 2014). The brownish mineral dust clouds are clearly transported toward Monte Cimone.

Rappresentazione tramite immagine a colori dei satelliti Terra/Aqua dell'evento di trasporto di polveri minerali osservato il 01 Dicembre 2014. Sono evidenti le masse d'aria ricche di aerosol minerale che vengono trasportate verso Monte Cimone.

https://earthdata.nasa.gov
Courtesy by NASA - Worldview

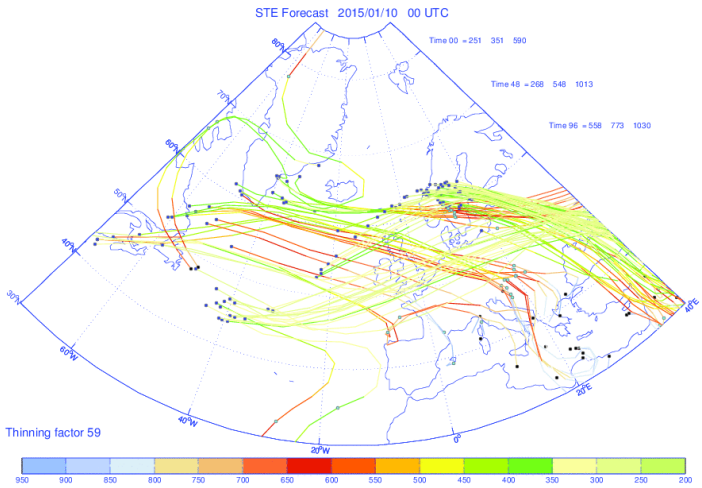
Stratospheric intrusions (SI)

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 6 hours of relatively dry conditions (RH<60%) during which RH also reached a value below 30 %, together with analysis of air-mass three-dimensional back-trajectories corroborating the origin of the air masses (daily potential vorticity maximum at least 1.6). **This methodology has been updated with regard to the last seasonal report, in a constant effort of better events detection**.

WINTER 2015:

- **During winter 2015, 35 days affected by the transport of air masses from the stratosphere were detected, representing the 38.9 % of the analysed period.**
- **The highest ozone concentration during a STE was observed on December 23th , with a daily average of 49.0 ppb.**
- **December 19th – 25th is a period continuously interested by the presence of Stratospheric Intrusions.**



Trajectories describing the path of stratospheric air-masses for the event of 10 January 2015. The color code represents the air-mass height (expressed as pressure level).
Courtesy by Michael Sprenger (ETH-Z, Switzerland)

Traiettorie che descrivono il moto in atmosfera di masse d'aria d'origine stratosferica per l'evento del 10 Gennaio 2015. Il colore rappresenta la quota (espressa come livello di pressione) delle masse d'aria.

Elaborazione: Michael Sprenger (ETH-Z, Switzerland)

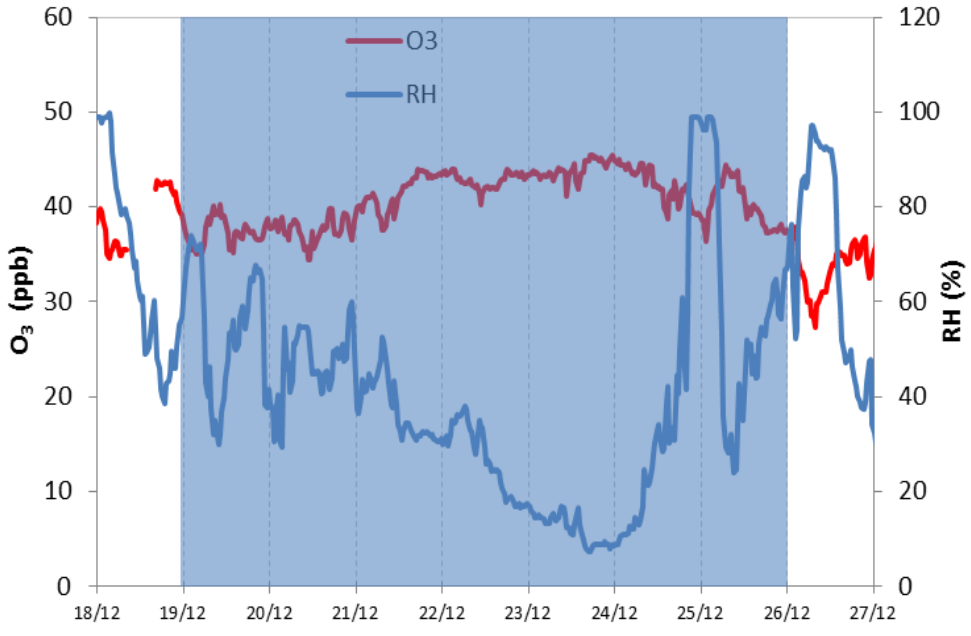
Intrusioni stratosferiche (SI)

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 6 ore dalla presenza di masse d'aria relativamente secche (RH<60%) durante le quali l'umidità rellativa scende anche al di sotto del 30%. Retro-traiettorie tridimensionali delle masse d'aria, sono state utilizzate per corroborare l'origine degli eventi (valore Massimo giornaliero della vorticità potenziale superior a 1.6). **La metodologia è cambiata rispetto all'ultimo rapporto stagionale, in una continua spinta al miglioramento della capacità di discernere eventi significativi.**

INVERNO 2015:

- **Durante l'inverno 2015 sono stati identificati 35 episodi di intrusione stratosferica, corrispondenti al 38.9 % del periodo analizzato.**
- **Il 23 Dicembre è stata osservata la concentrazione stagionale di ozono più elevata durante un evento di intrusione stratosferica (valore medio giornaliero: 49.0 ppb).**
- **Il periodo compreso tra il 19 ed il 25 Dicembre è stato caratterizzato dalla continua presenza di intrusioni stratosferiche.**



Relative humidity (blue) and ozone (red) behaviors at CMN during the 18th – 26th December2014. The blue bars indicates the days probably affected by SI.

Andamento dell'umidità relativa (azzurro) ed ozono (rosso) nel periodo 18 - 26 Dicembre 2014. Le barre azzurre indica il periodo probabilmente influenzato dagli eventi di SI.

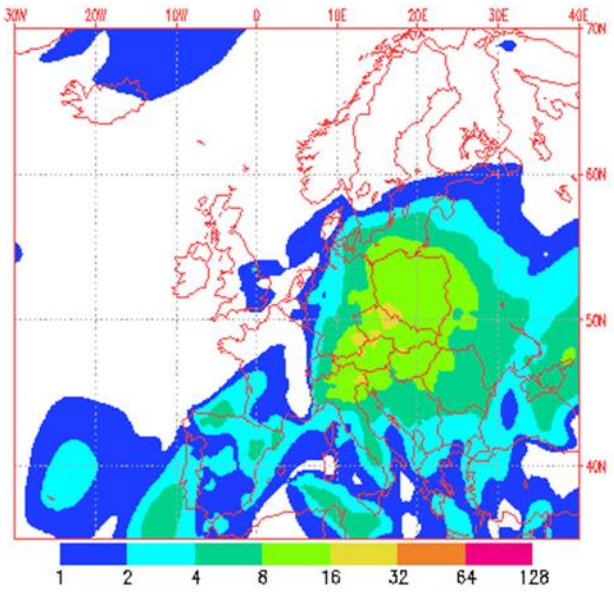
Pollution transport

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 18 hours of relatively high carbon monoxide concentrations (with the CO mixing ratio de-trended using the available climatic seasonal averages; high concentrations are those exceeding the seasonal average of the de-trended concentrations). **This methodology has been updated with regard to the last seasonal report, in a constant effort of better events detection**

WINTER 2015

- **23 days, related to nine different events, were characterized by significant transport of polluted air masses (25.6 % of the period).**
- **December was the month the most affected by pollution (11 days), while clean conditions prevailed during January, with the majority of SI and only 4 days characterizing this month.**



Pollution transport event simulation by NAAPS model (20th February 2015). The colored scale represents the sulfate aerosol concentration expressed as μg m^{-3}.

Simulazione dell'evento di trasporto di inquinamento osservato il 21 Febbraio 2015 (modello NAAPS). La scala colorata rappresenta la concentrazione dei solfati (aerosol) in μg m^{-3}.

http://www.nrlmry.navy.mil/

Courtesy by NRL/Monterey Aerosol Modeling

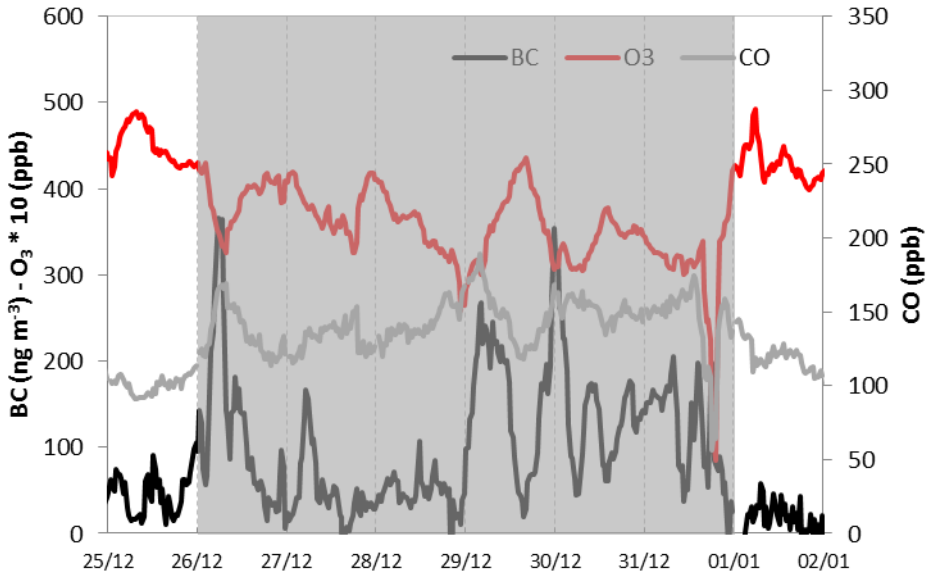
Trasporto di inquinanti

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 18 ore da concentrazioni elevate di monossido di carbonio (con le concentrazione di CO de-stagionalizzate considerando il valore medio stagionale climatologico; per concentrazioni elevate si intendono quelle superiori al valore medio stagionale della concentrazione de-stagionalizzata). **La metodologia è cambiata rispetto all'ultimo rapporto stagionale, in una continua spinta al miglioramento della capacità di discernere eventi significativi.**

AUTUNNO 2014

- **23 giorni (25.6 % della stagione), collegati a nove distinti eventi, sono stati caratterizzati da significativi episodi di trasporto di masse d'aria inquinate.**
- **Durante il mese di Dicembre si sono verificati 11 dei 23 episodi di trasporto di inquinanti individuati mentre il mese di Gennaio, con solo 4 giorni caratterizzati da trasporto di inquinanti e con la prevalenza di condizioni di fondo (evidenziata anche dalla presenza di oltre 20 giorni caratterizzati dalla presenza di intrusioni stratosferiche), rappresenta il mese più pulito.**



BC, ozone, and CO behaviours at Mt. Cimone from 25th December 2014 to 01st January 2015. Grey bars denote the presence of pollution at CMN.

Andamento delle concentrazioni di BC, ozono, e CO a Monte Cimone (25 Dicembre 2014 – 01 Gennaio 2015). Le barre grigie indicano la presenza di concentrazioni acute di inquinanti.

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 (Thermo Tei 49i). 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.

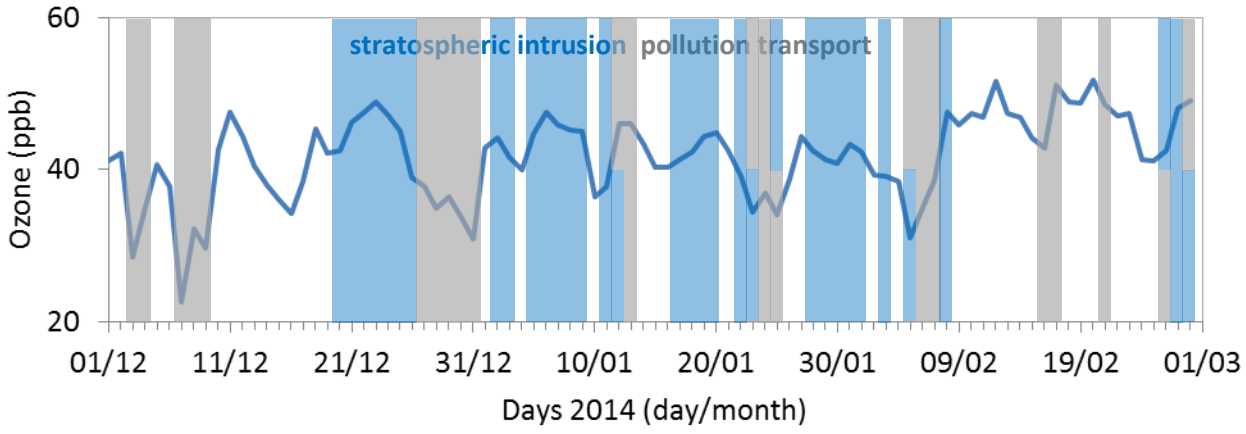
Basic statistical parameters

Statistical parameters are calculated basing on 30-minute aggregated values from December 2014 to February 2015.

Data availability (%)	Min value (ppb)	25th Percentile (ppb)	50th Percentile (ppb)	Average mean value (ppb)	75th percentile (ppb)	Max value (ppb)
99.4	8.5	38.2	42.7	41.8	46.3	57.0

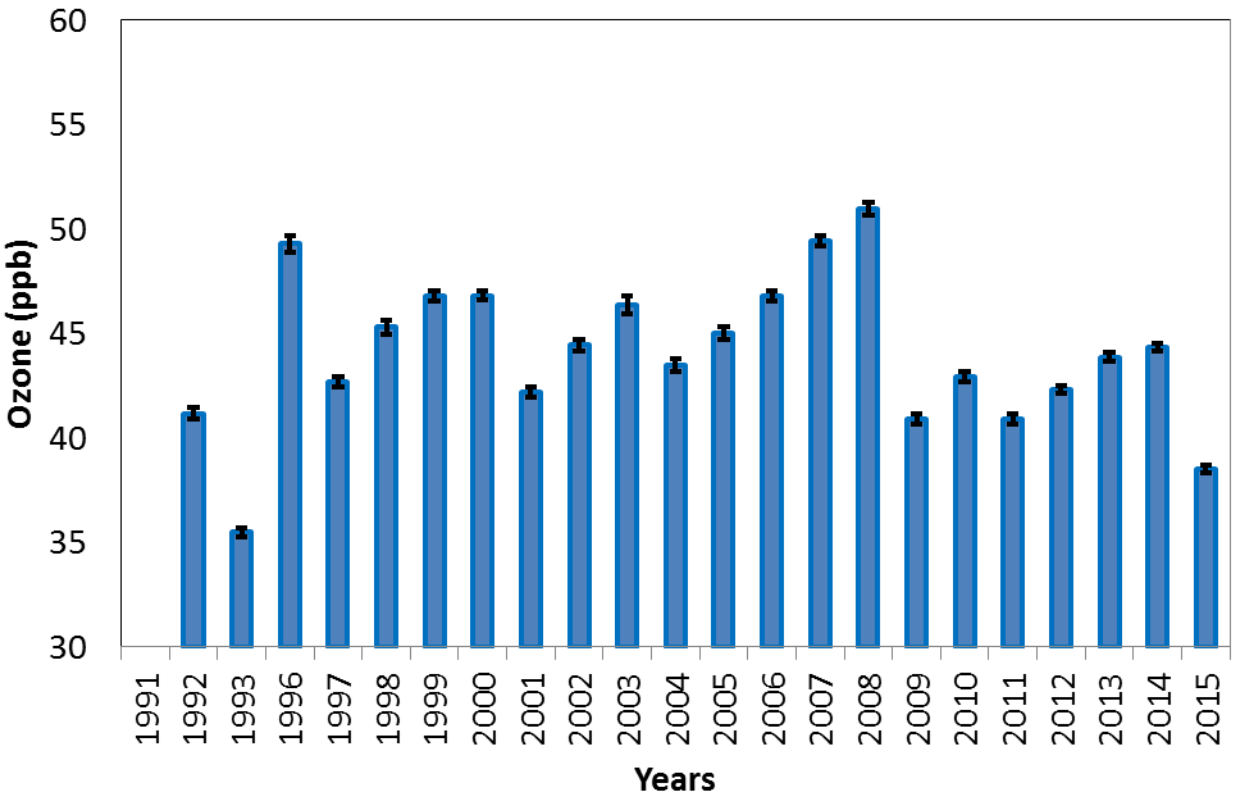
Time series of daily mean values

Relatively high values of ozone were observed after February the 8th, when **8 out of 23 pollution episodes** where observed at the measurement site, while low values were observed during the January episodes (11 out of 23), suggesting O_3 tritation and therefore “fresh" pollution. A general increase in ozone concentration is observed throughout the season, representing the natural transition from the winter minimum to the spring/summer maximum.



Comparison with historical data-set

The 2015 winter average mean value of O_3 is 41.8 ppb, **a slightly lower concentration than the climatological one (45.0 ppb)**, as result of lower than average concentrations for the first two thirds of the season, especially during the first 5 days of December when also air masses from north Africa (rich in mineral aerosol and coming from a natural ozone sink) reached the measurement site.



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). A CO working standard (approx. 10 ppm, synthetic air, Messer Italia) is used to calibrate the instrument with a dilution system. On a monthly basis, these working standards were compared against secondary standards from NOAA-CMDL.

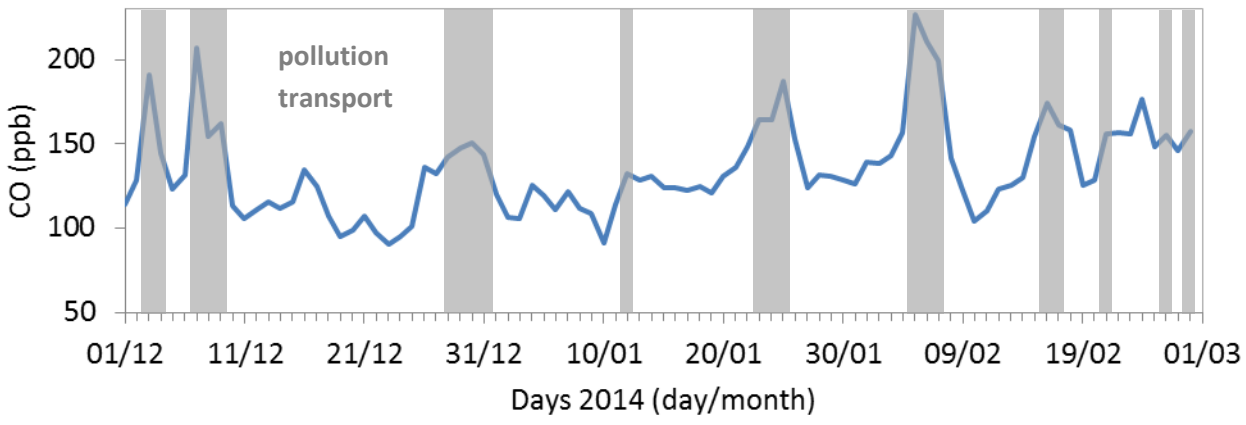
Basic statistical parameters

Statistical parameters are calculated basing on 30-minute aggregated values from December 2014 to February 2015.

Data availability (%)	Min value (ppb)	25th Percentile (ppb)	50th Percentile (ppb)	Average mean value (ppb)	75th percentile (ppb)	Max value (ppb)
97.7	56.6	113.6	129.4	134.8	149.3	286.5

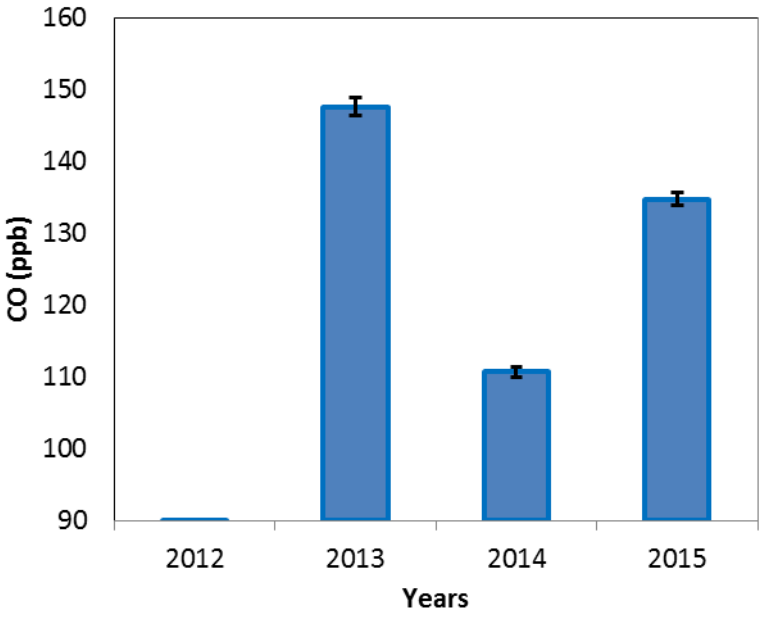
Time series of daily mean values

High CO daily average concentration were observed on December 3rd and 7th, together with high NO_2 concentrations and O_3 sink, suggesting the advection of air mass rich in fresh pollutants. In a similar vein the highest CO daily concentration was observed on February 5th, when also SO_2 and NO_2 peaked, suggesting the presence of air masses rich in pollutants but not in aerosols, probably due to wet scavenging.



Comparison with historical data-set

The 2015 winter average mean value of CO was 134.8 ppb, which is **higher than the average mean value of 129.2 ppb obtained from the last two winters**. This is the result of the occurrence of higher CO mixing ratios starting from the January 18th throughout the rest of the season, both during "major" pollution events and during "wet-scavenged" pollution event (like February 5th and 6th).



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 Chemioluminescence analyser (Thermo 42i-TL), equipped with a photolityc converter (Blue Light Converter) for NO_2 determination. Every 48 hours, zero and span checks are carried out for NO by using an external zero air source (dry compressed air scrubbed with active charcoal and Purafill) and dilution of certified NO standard (5 ppm +/- 2%). GPT is used to determine the conversion efficiency of the NO_2 converter.

Basic statistical parameters

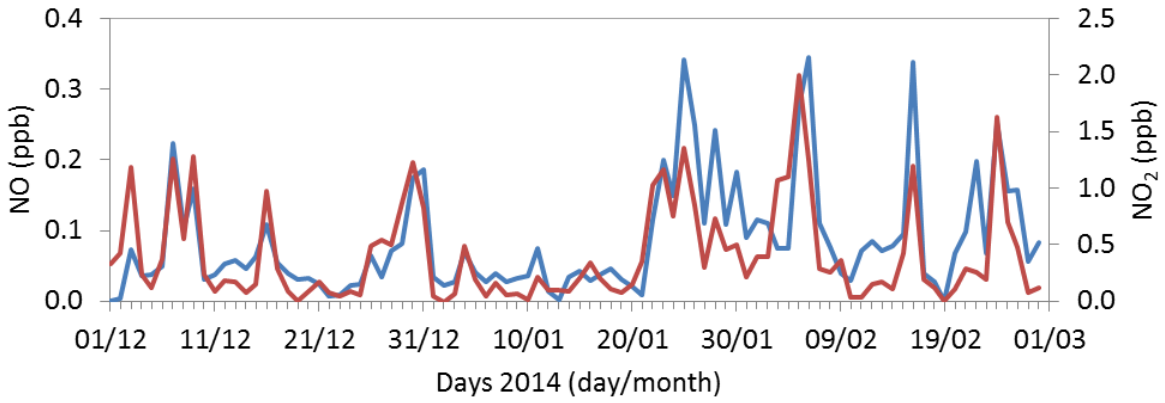
Statistical parameters are calculated basing on 30-minute aggregated values from December 2014 to February 2015.

Data availability (%)	Min value (ppb)	25th percentile (ppb)	50th percentile (ppb)	Average mean value (ppb)	75th percentile (ppb)	Max value (ppb)
NO 95.1	UDL	0.02	0.03	0.08	0.07	1.78
NO_2 95.1	UDL	0.05	0.17	0.41	0.47	9.20

UDL: under detection limit

Time series of daily mean values

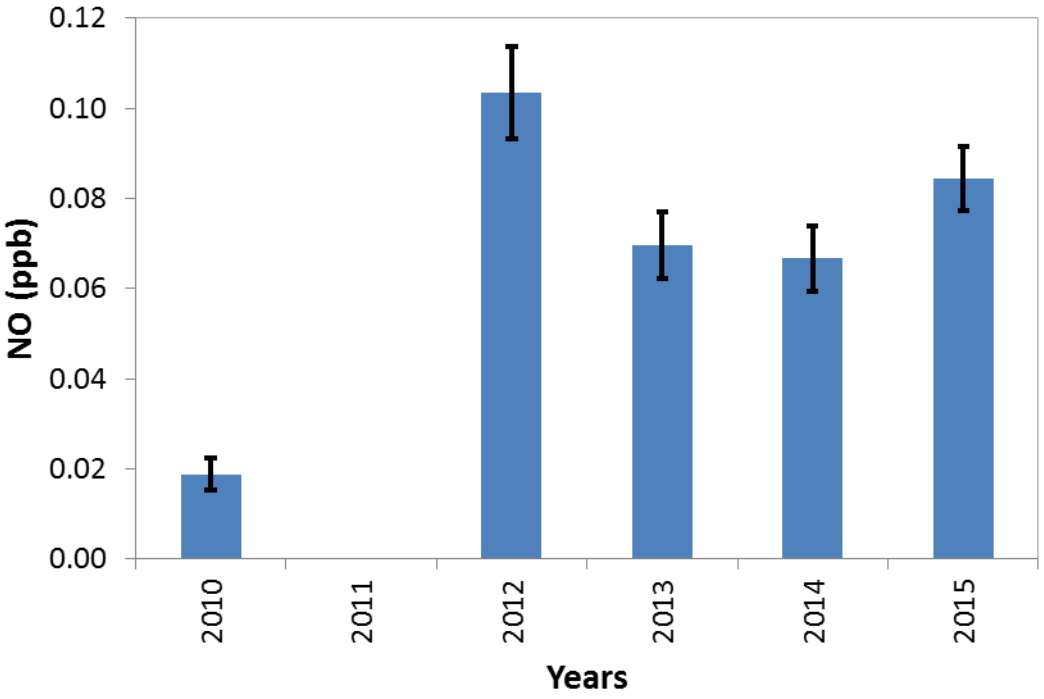
The highest NO value (blue line: 0.34 ppb) was observed on **February 6th** , while the highest NO_2 value (red line: 2.00 ppb) was observed on **February 5th**. This peak values are associated with elevated CO and SO_2 mixing ratios, but with low aerosol concentrations as a result of precipitation happening at the measurement site (wet scavenging) and are therefore not considered as "major" pollution events.

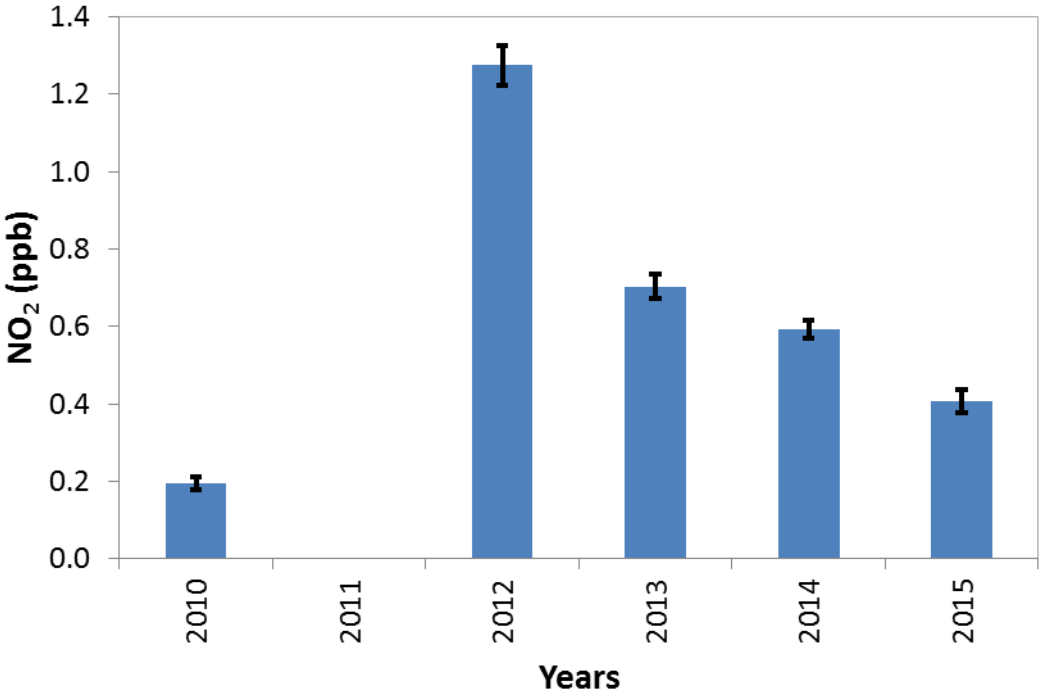


Comparison with historical data-set

The 2015 winter average mean value of NO (NO_2) was 0.08 ppb (0.41 ppb) which **is comparable (lower) with the average winter mean value of 0.06 ppb (0.69 ppb)**.

It should be noted that NO_2 data were obtained by analyzer equipped by Molybdenum during seasons 2012 - 2013. These data can be significantly overestimated in respect to the observations made by photolytic converter (year 2013) due to the interference of processed N-oxidised species (i.e. PAN) to the former data series.





Sulphur dioxide

Why is sulfur dioxide so important?

Sulfur dioxide (SO_2) is the main precursor to the sulphate aerosol which exerts a large influence on climate and air quality. It is a well know precursor for acid rains. SO_2 is also one of the main tracers for detecting the occurrence of ash plumes from volcanic eruption. In Europe, during the last years, SO_2 concentrations have been declining due to efficient restrictions on emissions.

Instrumentation and calibration

Sulphur dioxide is measured by using a UV-fluorescence analyser (Thermo 43i-TLE). Daily zero check are executed by using an external zero air source (scrubber with active charcoal), while daily span check are performed using a permeation tube with set point at 48 ppb. Detection limit for 1-minute average is estimated to be 0.11 ppb

Basic statistical parameters

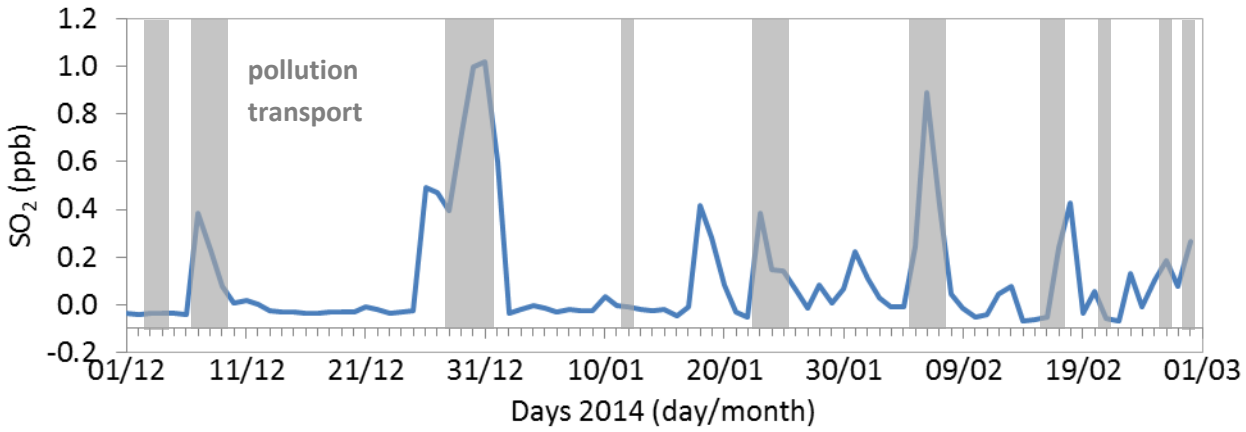
Statistical parameters are calculated basing on 30-minute aggregated values from December 2014 to February 2015.

Data availability (%)	Min value (ppb)	25th percentile (ppb)	50th percentile (ppb)	Average mean value (ppb)	75th percentile (ppb)	Max value (ppb)
99.6	UDL	UDL	UDL	UDL	UDL	2.17

UDL: under detection limit

Time series of daily mean values

During winter 2015 the average SO2 mixing ratio was lower than the detection limit, even though several SO2 peaks were observed throughout the season, especially after mid-January when many gaseous pollutants showed higher than average mixing ratios. The highest daily value (1.02 ppb) was observed on December 31st, with another high mixing ratio (0.89) on February 6th,togheter with NO and CO seasonal maxima.



NOTE: Negative values in the graph represent "under detection limit" conditions, common in a remote, high altitude, free troposphere measurement site.

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.

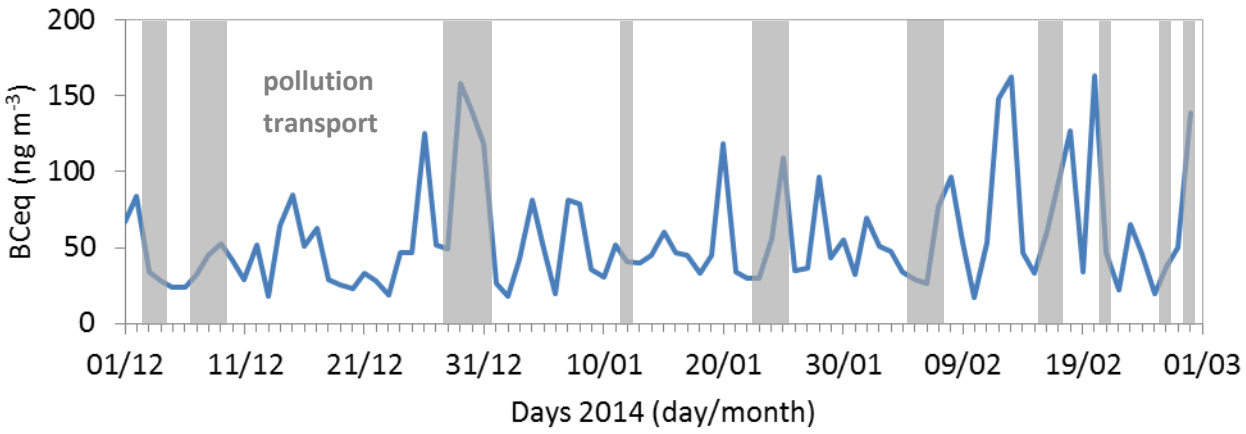
Basic statistical parameters

Statistical parameters are calculated basing on 30-minute aggregated values from December 2014 to February 2015.

Data availability (%)	Min value (ng m^{-3})	25th percentile (ng m^{-3})	50th percentile (ng m^{-3})	Average mean value (ng m^{-3})	75th percentile (ng m^{-3})	Max value (ng m^{-3})
82.7	10.0	22.1	39.5	59.6	76.3	520.7

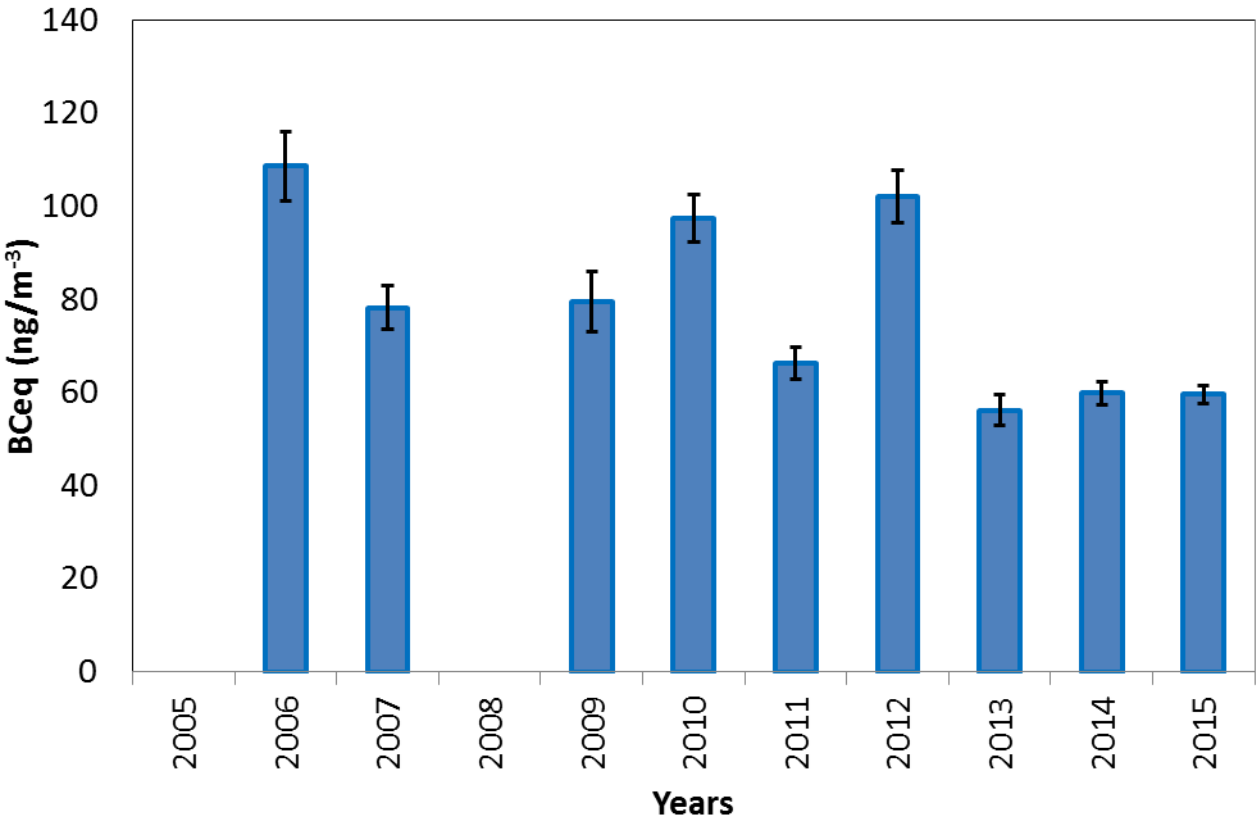
Time series of daily mean values

Similarly to other pollution tracers, the highest BC average concentrations were observed after mid-January. The seasonal daily average maximum (163.1 ng m^{-3})was observed on February 20th, with similarly high concentrations been observed on February 13th (162.1 ng m^{-3}) and December 29th (158.0 ng m^{-3}).



Comparison with historical data-set

The 2015 winter average mean value of BC is 59.6 ng m^{-3}, **which is lower than the climatological mean value (81.1 ng m^{-3}).** This behavior is the result of lower than average concentrations throughout the season (only the 20% of the day registered an average BC concentration higher than the climatological one), even though higher daily concentrations were observed starting from mid-January.



Aerosol light scattering coefficient

Why is aerosol light scattering coefficient so important?

Aerosol light scattering coefficient variability is an important parameter in deriving quantitative information on the optical properties of atmospheric aerosols, which are used to determine the direct effects of aerosols on the earth radiation balance (and therefore their impact on climate change). Moreover, information on the extinction coefficient, which is related to visibility in the atmosphere, is also an important parameter in many atmospheric applications.

Instrumentation and calibration

Starting from March 2014 a new three wavelength TSI Integrating nephelometer 3563 measures the aerosol light scattering coefficient at red (700 nm), green (550 nm), and blue (450 nm) wavelengths. A calibration on site with low span gas (filtered air) and high span gas (filtered carbon dioxide) is performed every 3 months.

Basic statistical parameters

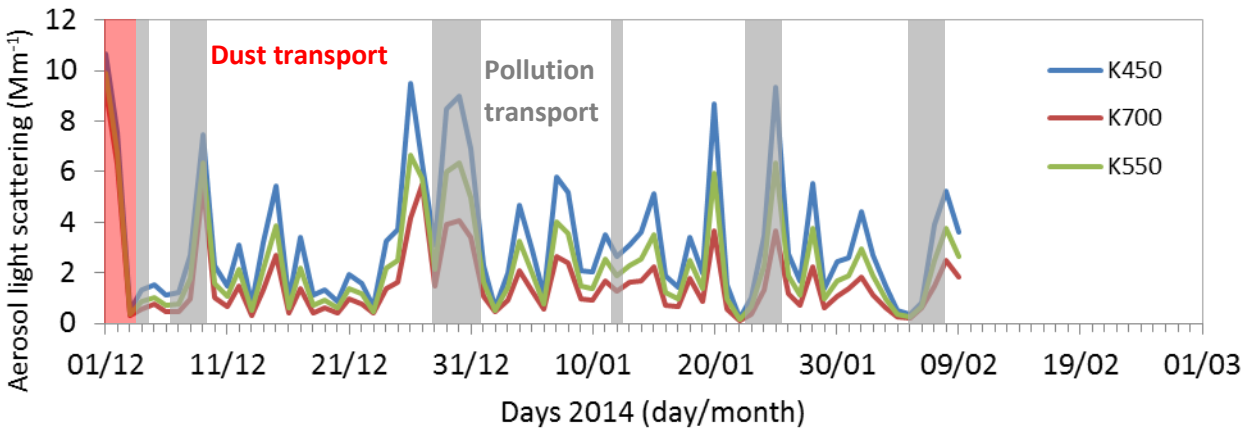
Statistical parameters are calculated basing on 30-minute aggregated values from December 2014 to February 2015.

Data availability (%)	Min value (Mm^{-1})	25th percentile (Mm^{-1})	50th percentile (Mm^{-1})	Average mean value (Mm^{-1})	75th percentile (Mm^{-1})	Max value (Mm^{-1})
700 nm 78.8	UDL	0.9	2.0	3.3	4.1	139.2
550 nm 78.8	UDL	0.6	1.4	2.4	2.9	140.9
450 nm 78.8	UDL	0.4	0.9	1.6	1.9	140.7

UDL: under detection limit

Time series of daily mean values

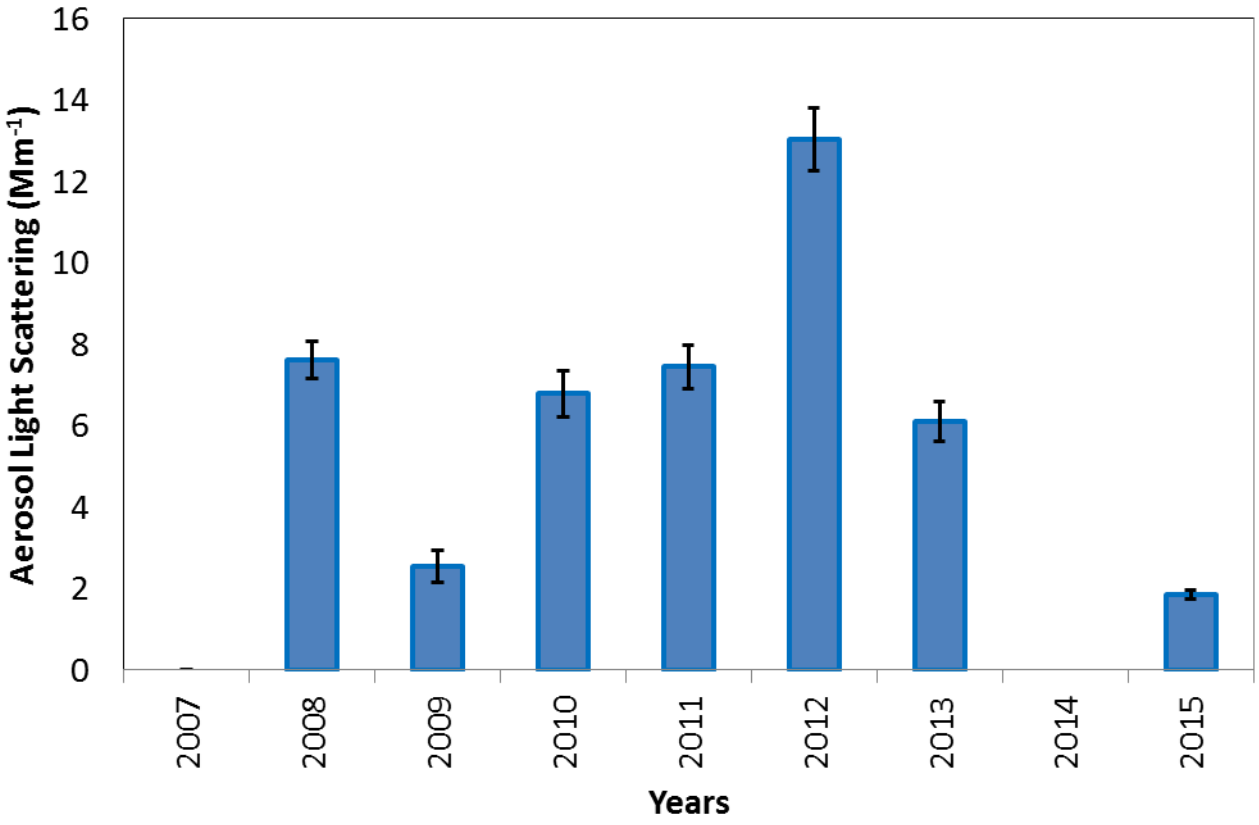
The highest daily mean value of the scattering coefficient at all three wavelength (450, 550, 700 nm) has been observed on **December 1st**, during the identified dust episode (respectively 10.7, 9.9 and 9.2 Mm^{-1}). High values were also observed together with BC peaks on December 26th and 31st , January 20th and 25th, during identified pollution events.



Comparison with historical data-set

The 2015 winter average mean value of scattering coefficient at 550 nm is 1.86 Mm^{-1}, which is **lower than the climatological mean value (7.25 Mm^{-1}).** The absence of the polluted end of the season could explain the low value observed.

It should be noted that aerosol scattering data were obtained by a M9003 integrating nephelometer (ECOTECH) during autumn seasons 2007 - 2013.



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

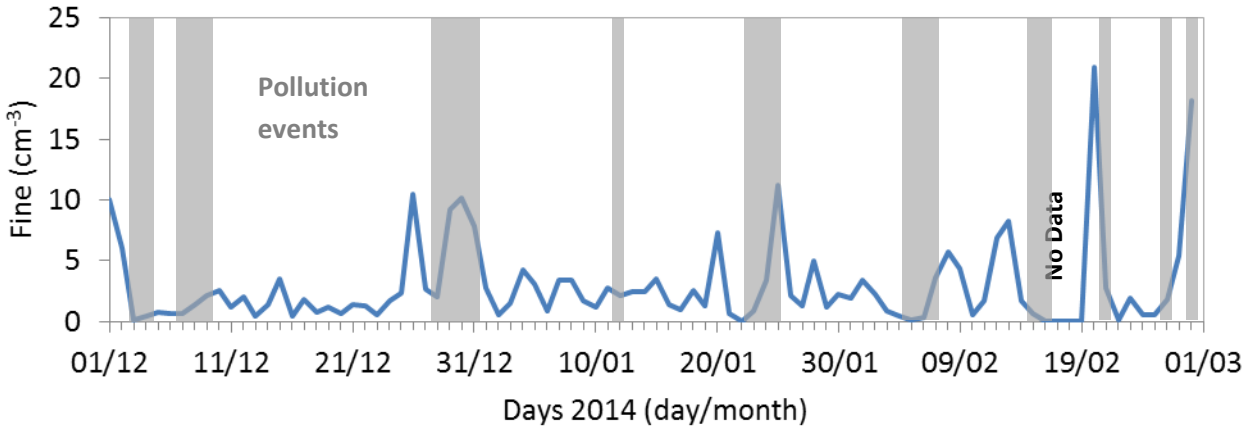
Basic statistical parameters

Statistical parameters are calculated basing on 30-minute aggregated values from December 2014 to February 2015.

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})
93.9	0.01	0.5	1.3	2.9	3.3	50.5

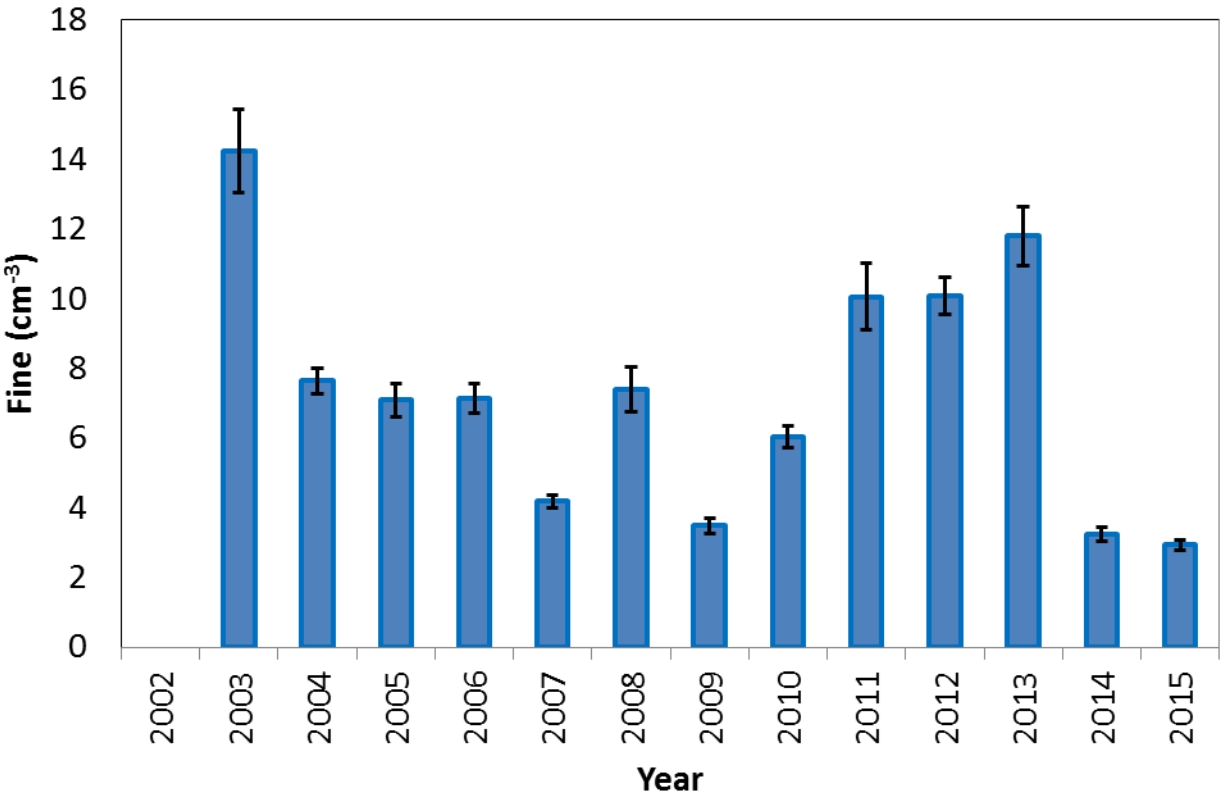
Time series of daily mean values

Fine particles daily mean values were generally quite low throughout the season with some exceptions at the start of December (dust event) and at the end of December (high concentration of many pollutants), with an increase in the number of peaks characterizing the end of the season, when the identified pollution events took place (highest concentration 50.5 cm^{-3} on February 28th).



Comparison with historical data-set

Winter 2015 fine particles average number concentration was 2.9 cm^{-3}, **lower than the seasonal climatological value (7.7 cm^{-3})**. This behavior is similar to what is observed for other pollution tracers and is the result of clean conditions in the first half of the season and the relatively low number of pollution events in the second half (of which 2 were missing).



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

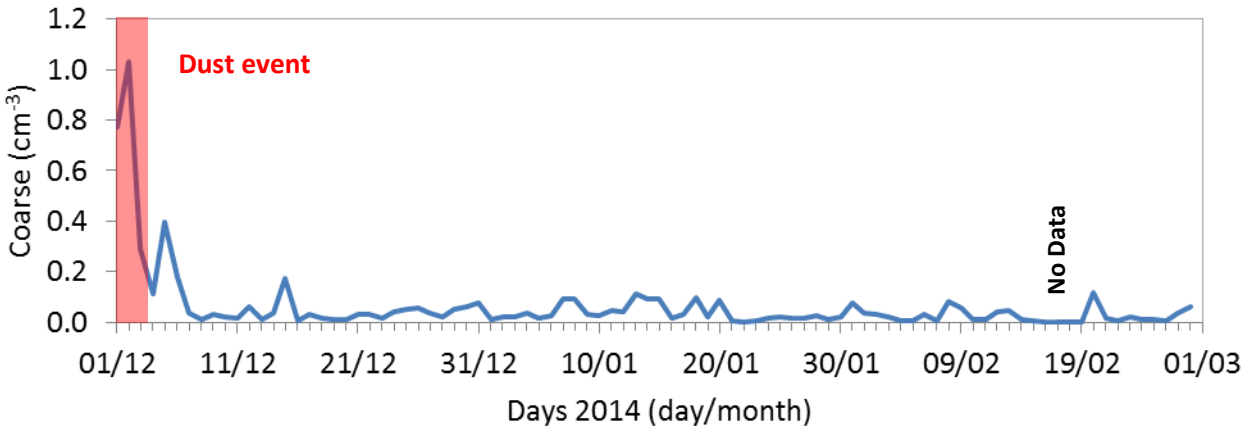
Statistical parameters are calculated basing on 30-minute aggregated values from December 2014 to February 2015.

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})
93.5	0.002	0.01	0.02	0.06	0.05	2.72

UDL: Under Detection Limit

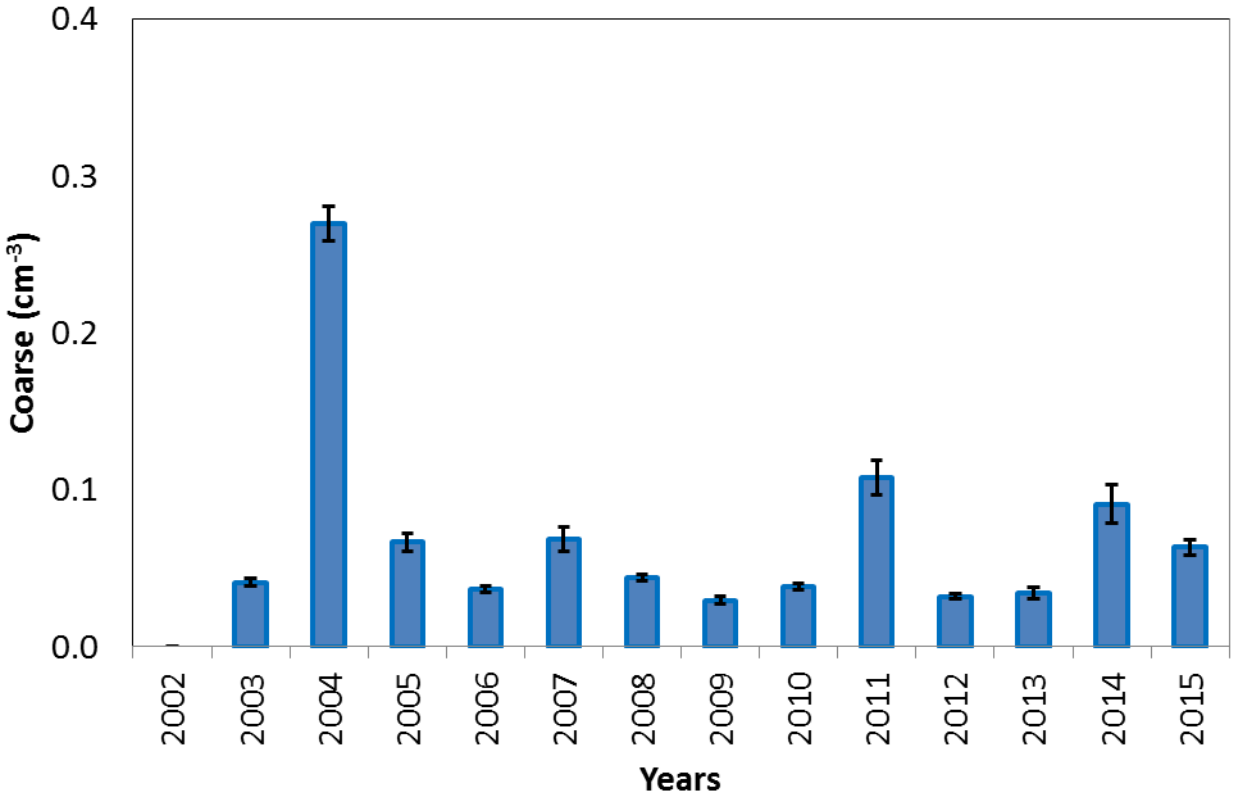
Time series of daily mean values

With the exception of the **high values observed at the start of the season** as the tail of the November dust transport event (highest daily average concentration of 1.0 cm^{-3} on December 2nd) low coarse particles concentrations were observed throughout the season.



Comparison with historical data-set

The winter 2015 average mean value of the coarse particles (0.06 cm^{-3}) is comparable to **the climatological value (0.07 cm^{-3}).**



Halogenated gases

Why is this research so important?

Halogenated gases are both stratospheric ozone depleting substances and powerful greenhouse gases and SLCF/P. High-frequency long-term measurements of halogenated gases are used in order to detect atmospheric trends and to verify emission inventories. The measurements conducted at Monte Cimone are used in order to ascertain the compliance to the International Protocols on a European scale.

Instrumentation and calibration

Thirty halogenated gases have been continuously measured (one sample every two hours) via gas chromatography-mass spectrometry since 2001. The GC-MS instrument (Agilent 6850–5975) is equipped with an auto-sampling/pre-concentration device (Markes International, UNITY2-Air Server2) to enrich the halocarbons on a focussing trap filled with four different adsorbing materials.

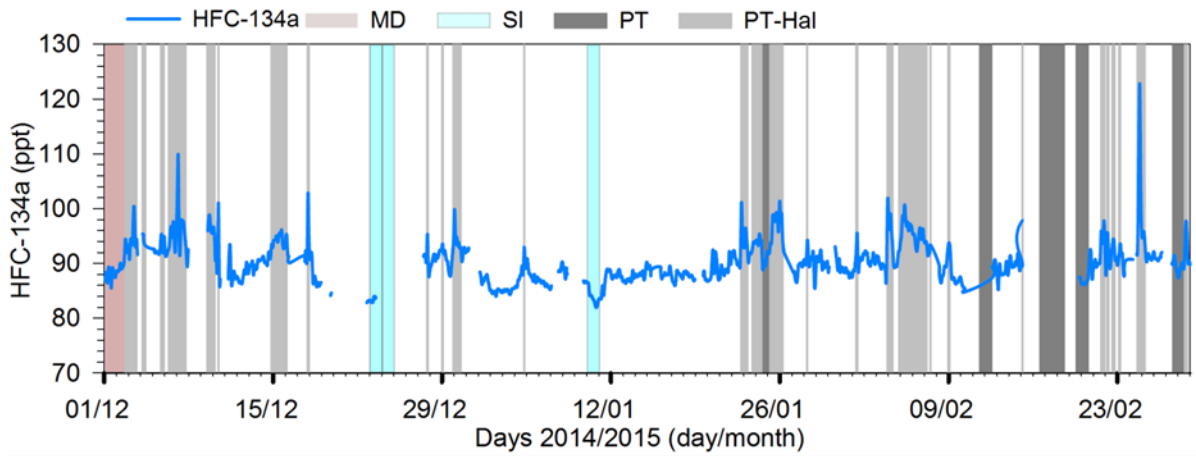
Basic statistical parameters

We report as an example** the basic statistical parameters of HFC-134a, a Kyoto gas mainly used in refrigeration sealed systems, such as industrial refrigeration, car and in-house air conditioners, domestic fridges. Statistical parameters are calculated based on bi-hourly measurements from September to November 2014.

Data availability %	Min value (ppt)	25th percentile (ppt)	50th percentile (ppt)	Average mean value (ppt)	75th percentile (ppt)	Max value (ppt)
72.8%	82.0	87.6	89.7	90.2	92.1	122.6

Time series of daily mean values

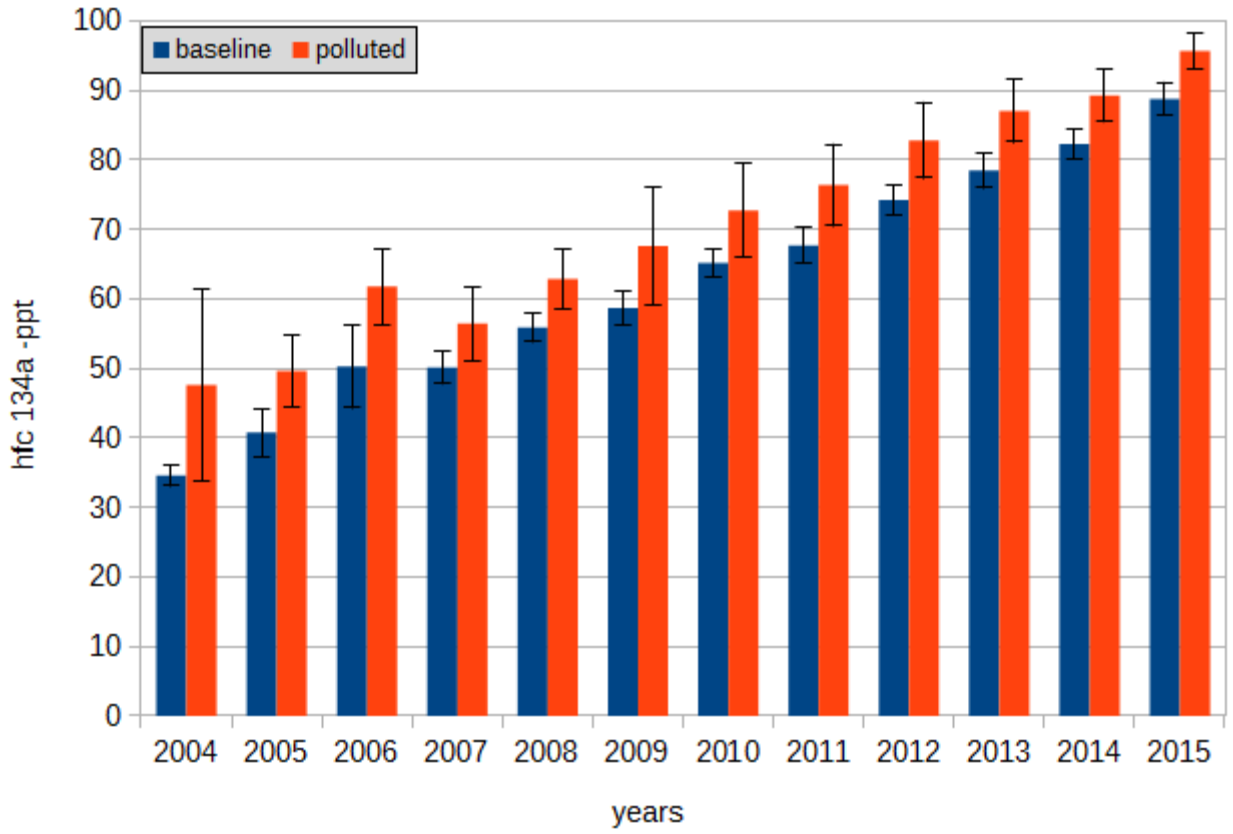
A high frequency of pollution events is observed in the second half of the winter, as was observed for the other tracers (CO, O_3, NO and BC). Interesting to note that the lowest values were observed at the occurrence of the Stratospheric Intrusion episodes, in the late December and mid-January, with the minimum recorder on January 10th.



Legend: MD –Mineral Dust; SI –Stratospheric Intrusion; PT –Pollution Transport; PT – Hai – Pollution Transport identified due to high HFC mixing ratio.

Comparison with historical data-set

Both Baseline (blue) and Polluted (orange) winter-averages show **a continuous and uninterrupted increase of atmospheric concentration**. Winter observations always show a reduced differences between the two dataset; furthermore the excursion range (1σ, dark bars), tend to minimize compared to the summer observations, as a consequence of the reduced emissions during coldest season.



** At CMN, the following halogenated gases are continuously monitored: CFC-11, CFC-12, CFC-114, CFC-115, H-1211, H-1301, HCFC-22, HCFC-142b, CH3Br, CH3CCl3, CCl4 (Montreal Gases); PFC-218, SO2F2, HFC-32, HFC-125, HFC-134a, HFC-143a, HFC-152a, HFC-227ea, HFC-236fa, HFC-245fa, HFC-365mfc; CH3Cl, CH3I, CH2Cl2, CHCl3, CH2Br2, CHBr3, TCE, PCE.

Volatile organic compounds (VOCs)

Why is this research so important?

Volatile organic compounds (VOCs) of anthropogenic origin play a significant role as precursors of both particular matter and tropospheric ozone. In situ continuous measurements of VOCs are used also for inferring the OH radical concentration. Furthermore, correlations among the different species are used In order to identify the main anthropogenic sources of these compounds.

Instrumentation and calibration

13 VOCs have been continuously measured (one sample every two hours) via gas chromatography-mass spectrometry since 2008. The GC-MS instrument (Agilent 6850–5975) is equipped with an auto-sampling/pre-concentration device (Markes International, UNITY2-Air Server2) to enrich the VOCs on a focussing trap filled with four different adsorbing materials.

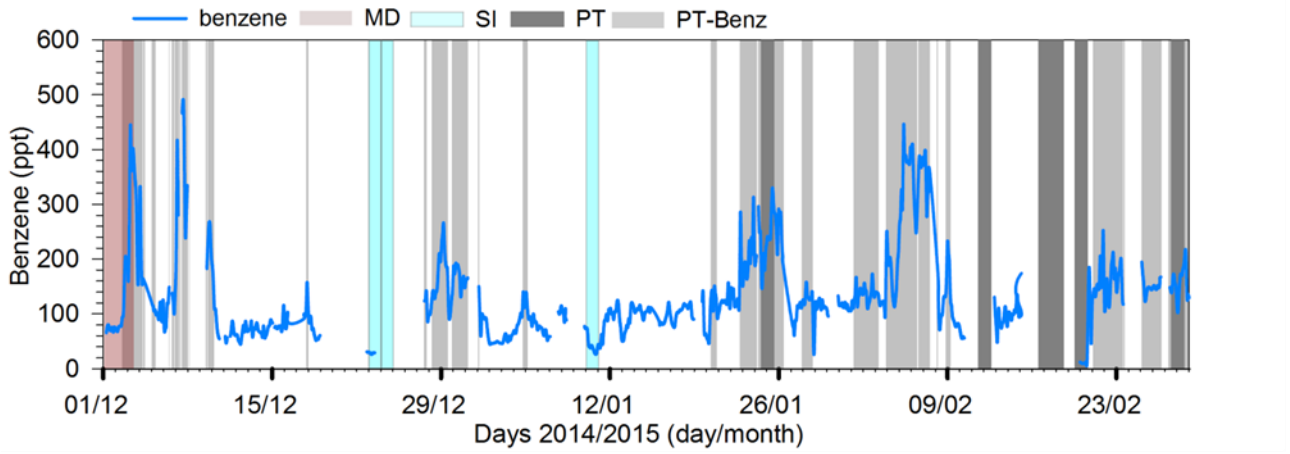
Basic statistical parameters

We report results for Benzene, as an example of all the VOCs measured. Benzene is a constituent of crude oil, is widely used worldwide in chemical industries as an intermediate and in the recent past was regularly added to gasoline to increase the octane number. The benzene atmospheric concentration is mainly due to exhausts from motor vehicles, from evaporative losses from petrol, incomplete combustions (wildfire) and industrial emissions/leakages. Statistical parameters are calculated based on bi-hourly measurements from September to November 2014.

Data availability %	Min value (ppt)	25th percentile (ppt)	50th percentile (ppt)	Average mean value (ppt)	75th percentile (ppt)	Max value (ppt)
70.3	9.7	79.1	112.0	131.0	152.1	490.6

Time series of daily mean values

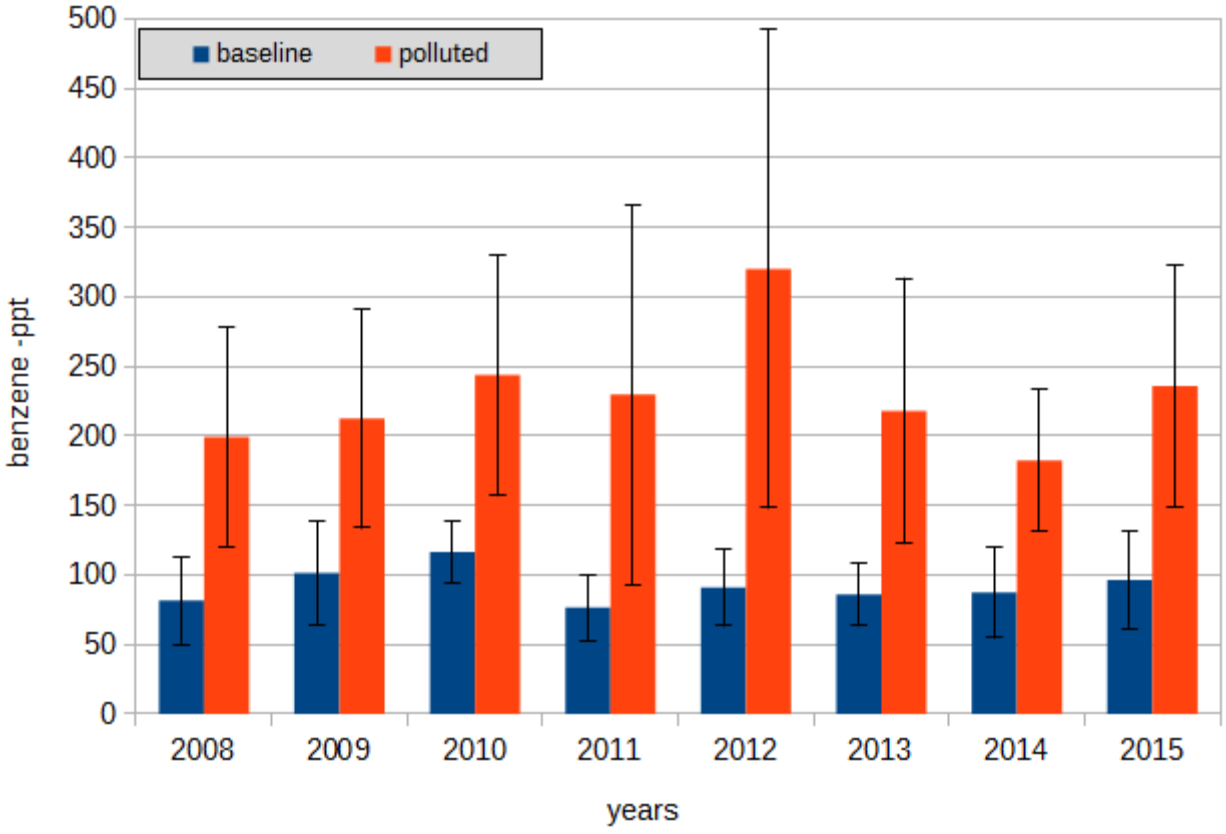
Winter observations of Benzene are characterized by larger pollution episodes, showing an increased frequency and an enhancement of max-min excursion, typical of the short-lived compounds. Several episodes of pollution transport are noticeable at the second half of the season, in common with other tracers (CO, BC etc.). Interesting to note that lowest values are observed during Stratospheric Intrusions events on December 24th and on January 10th, while the absolute minimum was observed late in February 19th.



Legend: MD –Mineral Dust; SI –Stratospheric Intrusion; PT –Pollution Transport; PT – Hai – Pollution Transport identified due to high Benzene mixing ratio.

Comparison with historical data-set

Benzene, as far as most of the VOCs, is characterized by a short atmospheric lifetime (10 days, year average). As a consequence, its concentration shows a large range of variation not only over the years –due to a change in emissions- but also within seasons because of different kinetics driven by thermal excursion among seasons. The discrepancy between baseline (blue) and polluted (orange) data, is enhanced during winter as a results of the increased emissions and a lower tropospheric reactivity. **Baseline data are comparable during the years and within seasons, whereas pollution events show a slow declining trend, as for other tracers (BC, CO etc.).**



** At CMN, the following VOC are continuously monitored: ethyne, propane, propene, i-butane, n-butane, i-pentane, n-pentane, c-propane, benzene, toluene, ethyl-benzene, m+p-xylene, o-xylene

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 (GASCOD) 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

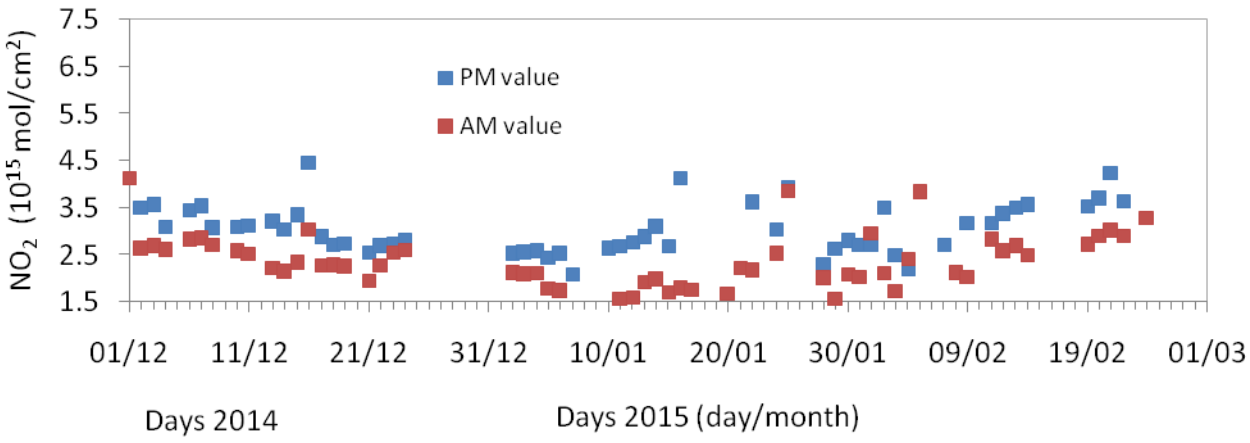
Statistical parameters are calculated basing on 1 data per day from December 2014 to February 2015.

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 (66.1)	1.15	1.96	2.26	2.33	2.67	4.14
PM (60.0)	2.09	2.68	3.05	3.17	3.51	9.55

UDL: under detection limit

Time series of AM and PM values

Data were available starting from December 1st 2014. During the entire period the GASCOD worked every day with some interruption due to bad weather conditions. The time series follows the typical climatologic trend reaching the minimum values of total column in January. This trend follows the annual cycle of stratospheric NO_2.



Comparison with historical data-set

The Autumn 2014 values of the nitrogen dioxide are comparable to the climatic ones characterized by its seasonal cycle: growing columns during the spring/summer periods and decreasing columnar values during the autumn/winter period. However no growing or decreasing trend over the years were found.

The NO2 annual cycle

The annual cycle of Stratospheric NO_2 is driven by photochemical reactions occurring in the stratosphere involving principally the ozone layer. Considering the ozone photolysis reaction $O_3 + hv = O + O_2$, where hv represents the sun radiation (here below 325nm), it is clear that the dissociation rate depends on the numbers of photons reaching the ozone layer, and implicitly, on the Zenith angle of the Sun which influences the absorption path of the photons. The shorter the path length, the lesser the absorption of UV photons. To this reaction also some heat releasing is associated. Both these facts contributes to the higher values measured during summer: the enhanced ozone photolysis rate, making even more oxygen disposable to the NO - NO_2 conversion; the associated enhancement of temperature, which favours the bimolecular chemical reactions like the $NO + O = NO_2$. Fig. 3 shows the annual cycle of stratospheric NO_2 while fig. 4 shows the 21 years of monthly averaged stratospheric NO_2 measurement at Mt. Cimone.

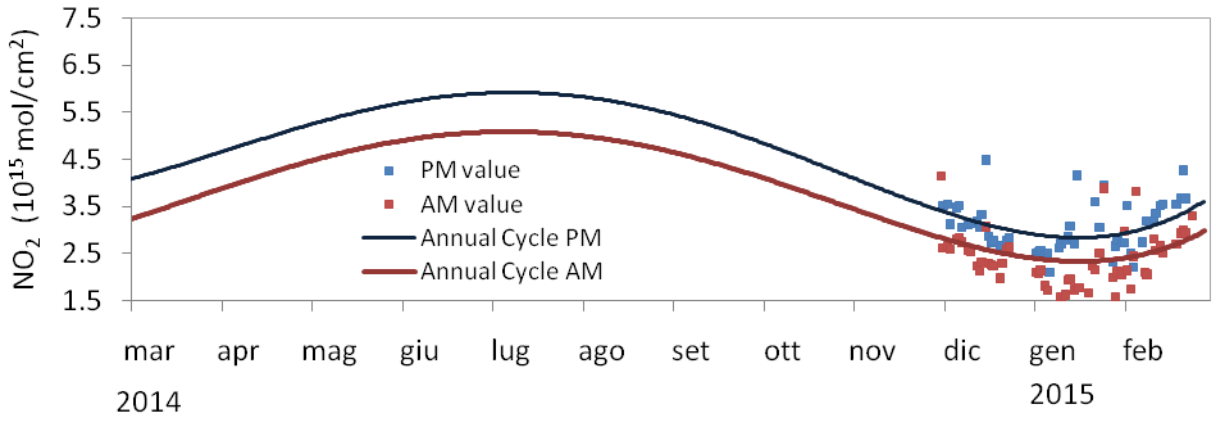


Figure A: annual theoretical cycle of NO_2 and ICO-OV winter observed data

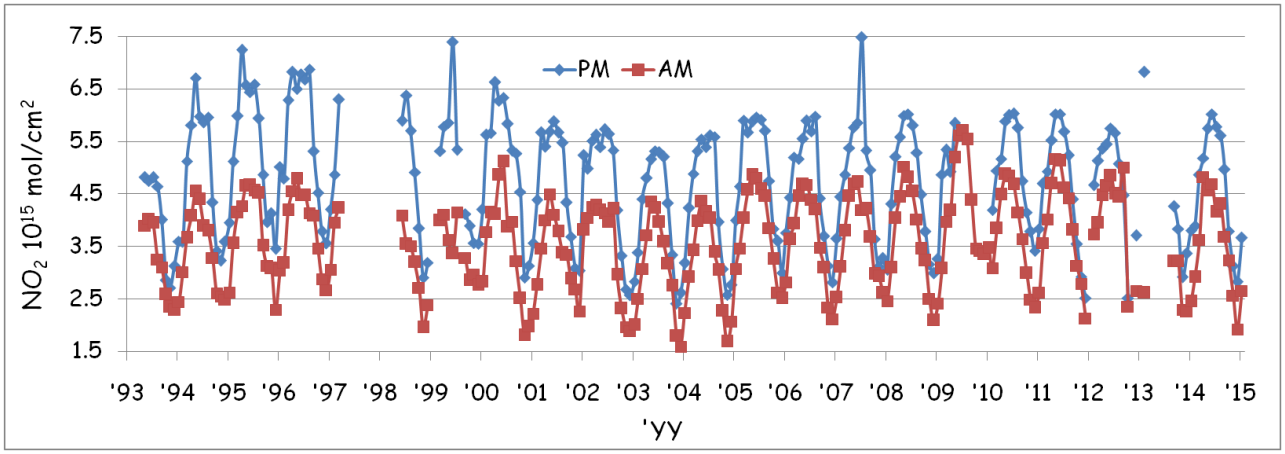


Figure B :21 years of NO_2 Vertical Column measurement at ICO-OV

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).

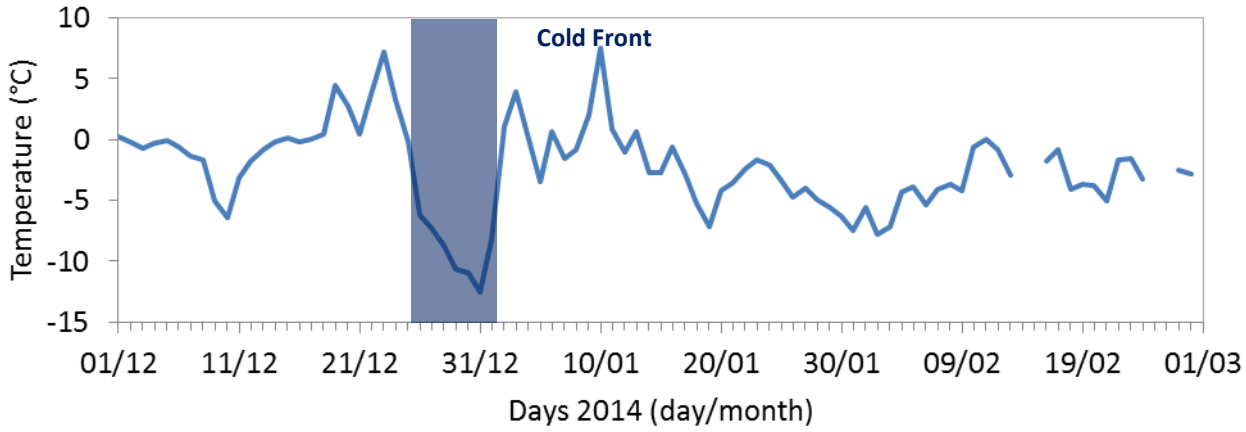
Basic statistical parameters

Statistical parameters are calculated basing on 30-minute aggregated values from December 2014 to February 2015.

Data availability %	Min value (°C)	25th percentile (°C)	50th percentile (°C)	Average mean value (°C)	75th percentile (°C)	Max value (°C)
92.0	-15.4	-4.7	-2.5	-2.5	-0.1	10.1

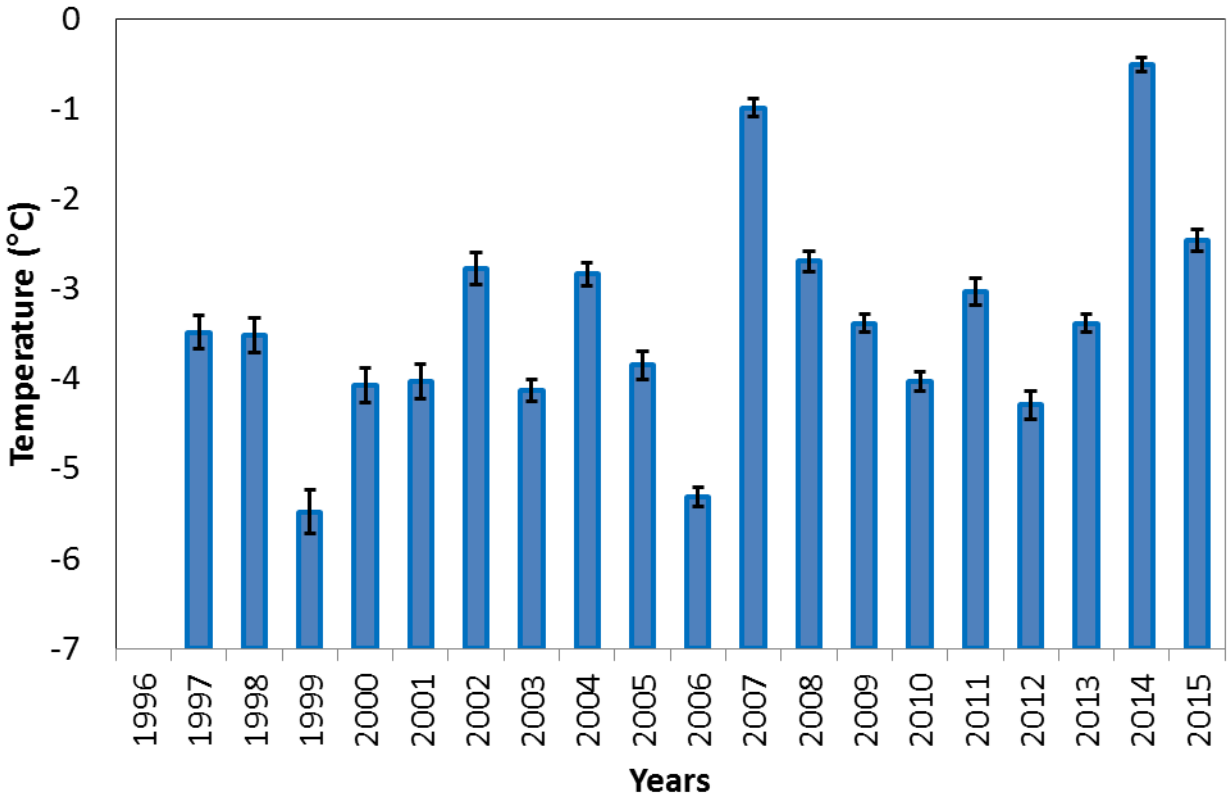
Time series of daily mean values

The highest daily mean value (7.5 °C) has been observed on **10th January**, during an STE event, while very low values (down to -12.5 °C) have been observed from **26th December till 1st January**, probably associated with the passage of a cold front. Despite this very low values however the season is characterized by relatively warm conditions, with 20 days (22%) showing an average positive temperature.



Comparison with historical data-set

The winter 2015 average temperature (-2.5 °C) is **higher than the seasonal climatological value (-3.4 °C):** it constitutes the 3rd higher seasonal value observed at ICO-OV from the beginning of the measurement programme. This is the result of a stable weather regime characterizing the first half of the season, resulting in the measurement site been interested by warmer temperature and clear sky conditions, albeit with the exception of the end of December cold front.



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).

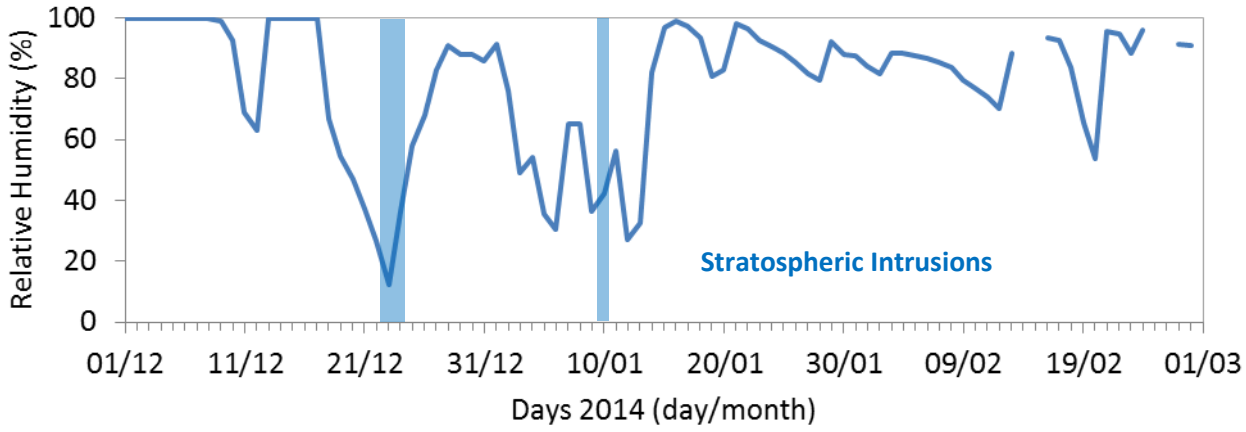
Basic statistical parameters

Statistical parameters are calculated basing on 30-minute aggregated values from December 2014 to February 2015.

Data availability (%)	Min value (%)	25th percentile (%)	50th percentile (%)	Average mean value (%)	75th percentile (%)	Max value (%)
92.0	7.0	67.1	87.8	78.0	96.9	100.0

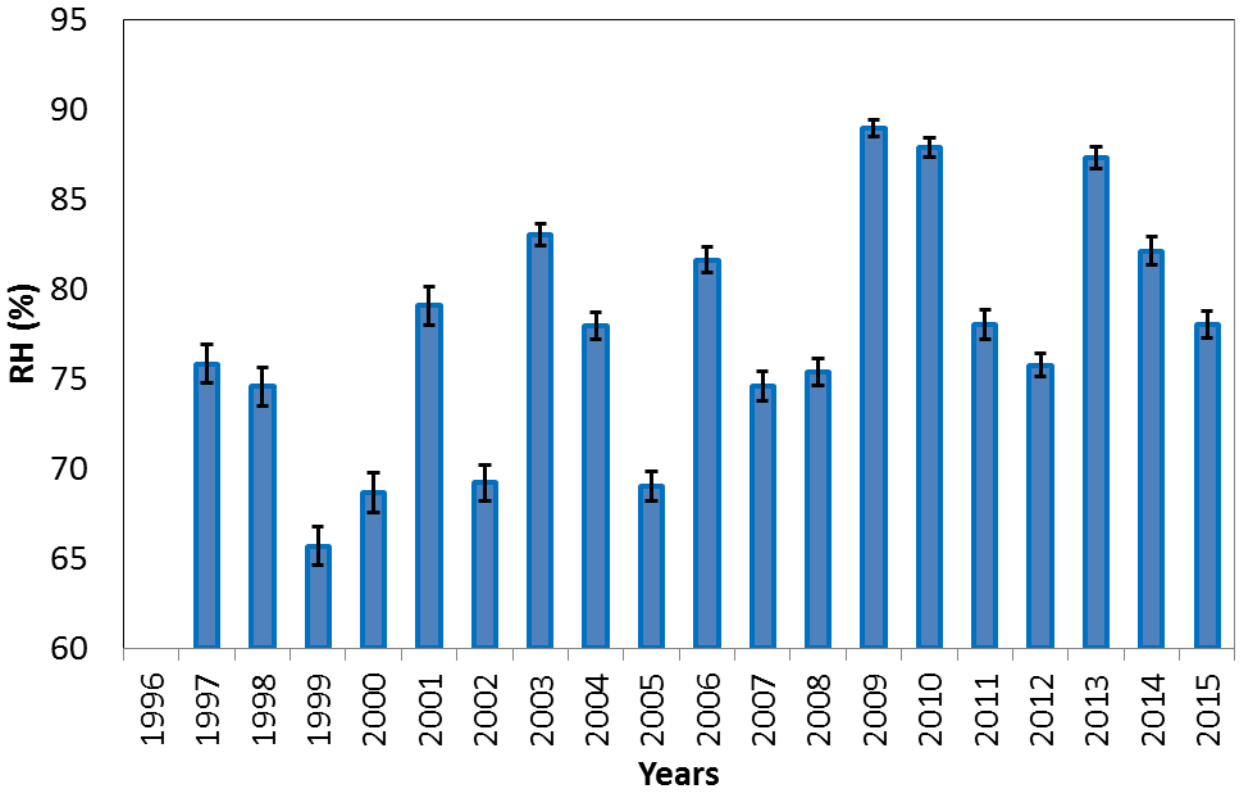
Time series of daily mean values

The daily mean RH values ranged from 100% to 12.2%. The 23.3% of days showed average value higher than 95%. Periods characterized by relatively dry conditions (mean daily values lower than 60%) were observed on 19th - 25th December and on 3rd – 13th January, during which the SI events were detected. In particular the 23-24th January SI episode is situated between the passage of a warm front and of the subsequent cold front (that caused very low temperature at ICO-OV).



Comparison with historical data-set

The Winter 2015 average relative humidity (78.0%) was **comparable to the seasonal climatological value (77.5%).**



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).

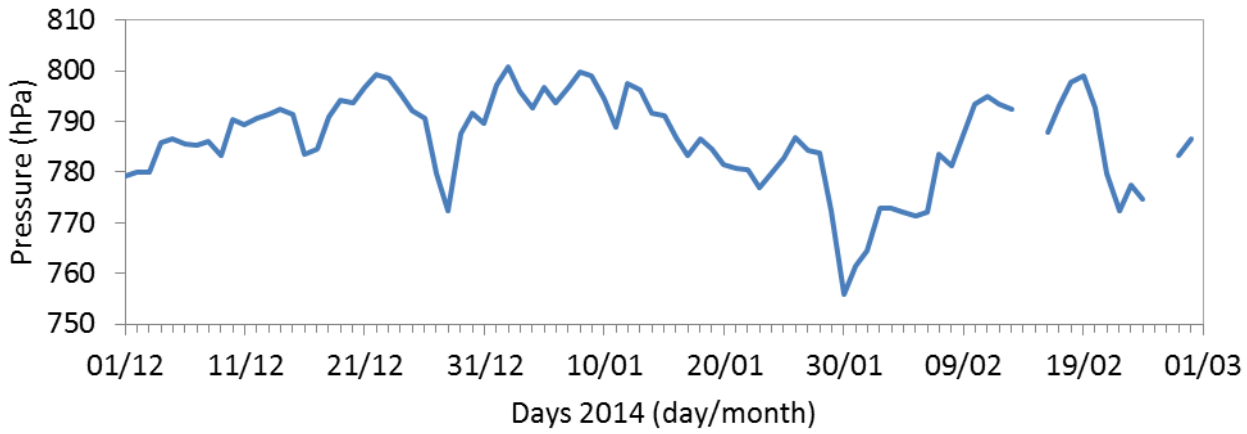
Basic statistical parameters

Statistical parameters are calculated basing on 30-minute aggregated values from December 2014 to February 2015.

Data availability (hPa)	Min value (hPa)	25th percentile (hPa)	50th percentile (hPa)	Average mean value (hPa)	75th percentile (hPa)	Max value (hPa)
92.0	751.8	781.3	787.7	786.6	793.7	802.3

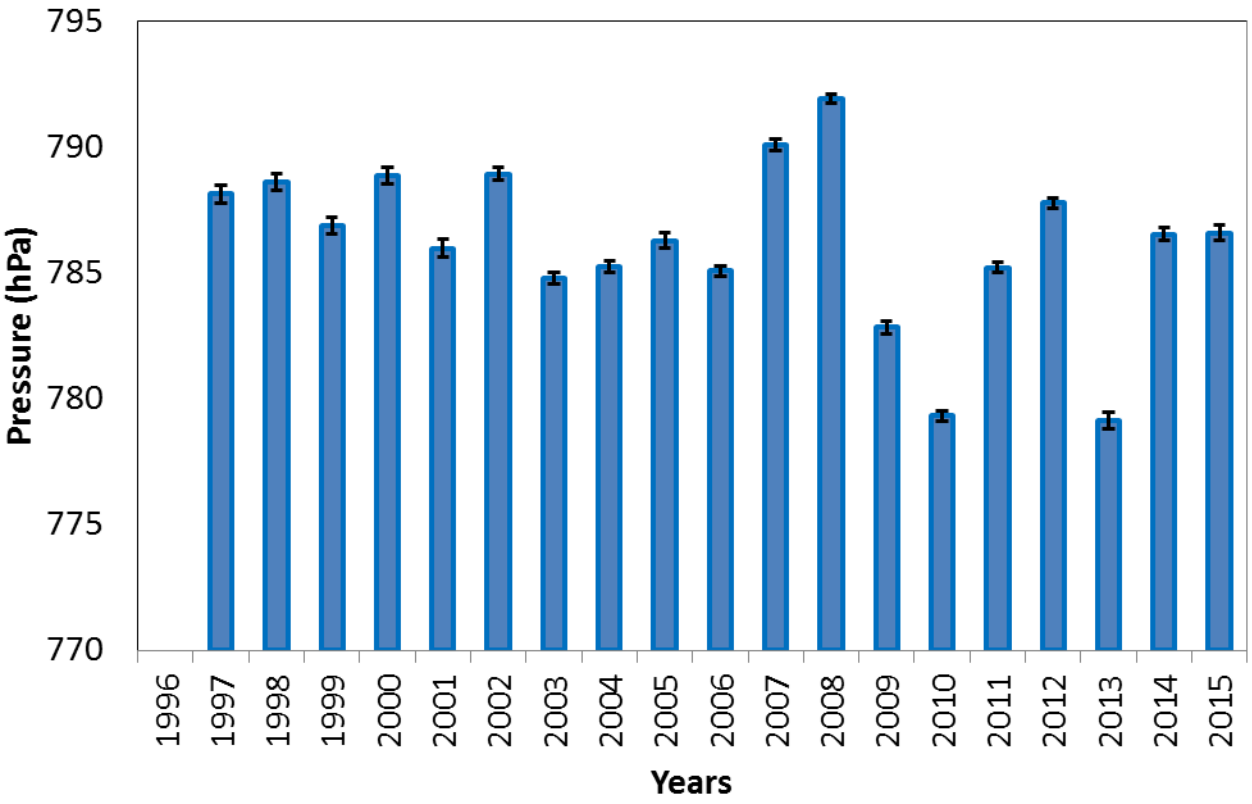
Time series of daily mean values

The first half of the season was characterized by the presence of stable conditions at ICO-OV, with high pressure values throughout the period (the highest daily value, 802.3 hPa, occurred on **2nd January)**. On the other hand the latter half was characterized by **high variability: pressure drops alternated with pressure increases**, indicating the passing of frontal systems over the measurement site, with the **lowest drop happening on 30th January** (751.8 hPa).



Comparison with historical data-set

The Winter 2015 averaged atmospheric pressure (786.6hPa) was **comparable with the Winter climatological value (786.2 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.

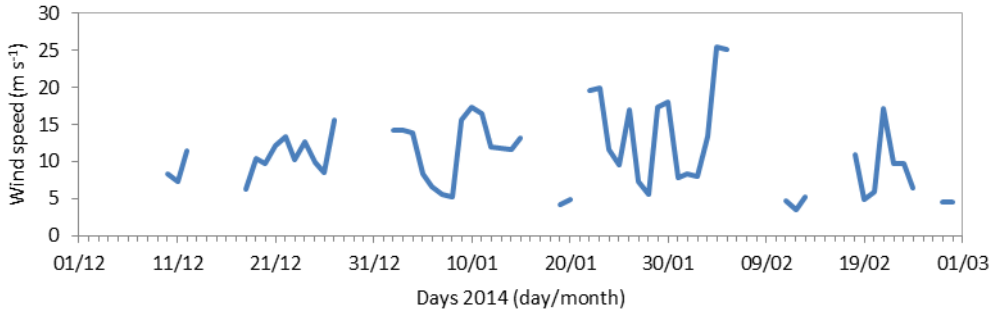
Basic statistical parameters of wind speed

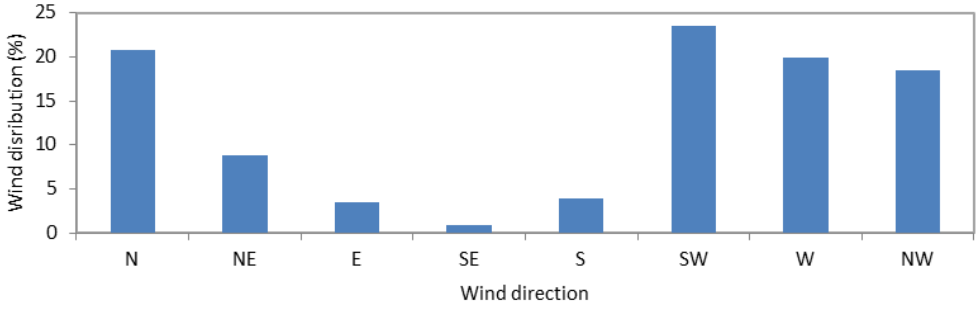
Statistical parameters are calculated basing on 30-minute aggregated values from December 2014 to February 2015. Due to technical problems affecting the primary anemometer (Vaisala 425), IRDAM WST700 data were used. Wind speed data recorded for RH>95% were not considered due to the large instrumental uncertainty during foggy conditions.

Data availability (%)	Min value (m/s)	25th Percentile (m/s)	50th Percentile (m/s)	Average mean value (m/s)	75th percentile (m/s)	Max value (m/s)
49.6	0.5	6.3	9.5	11.0	13.5	67.3

Time series of daily mean values

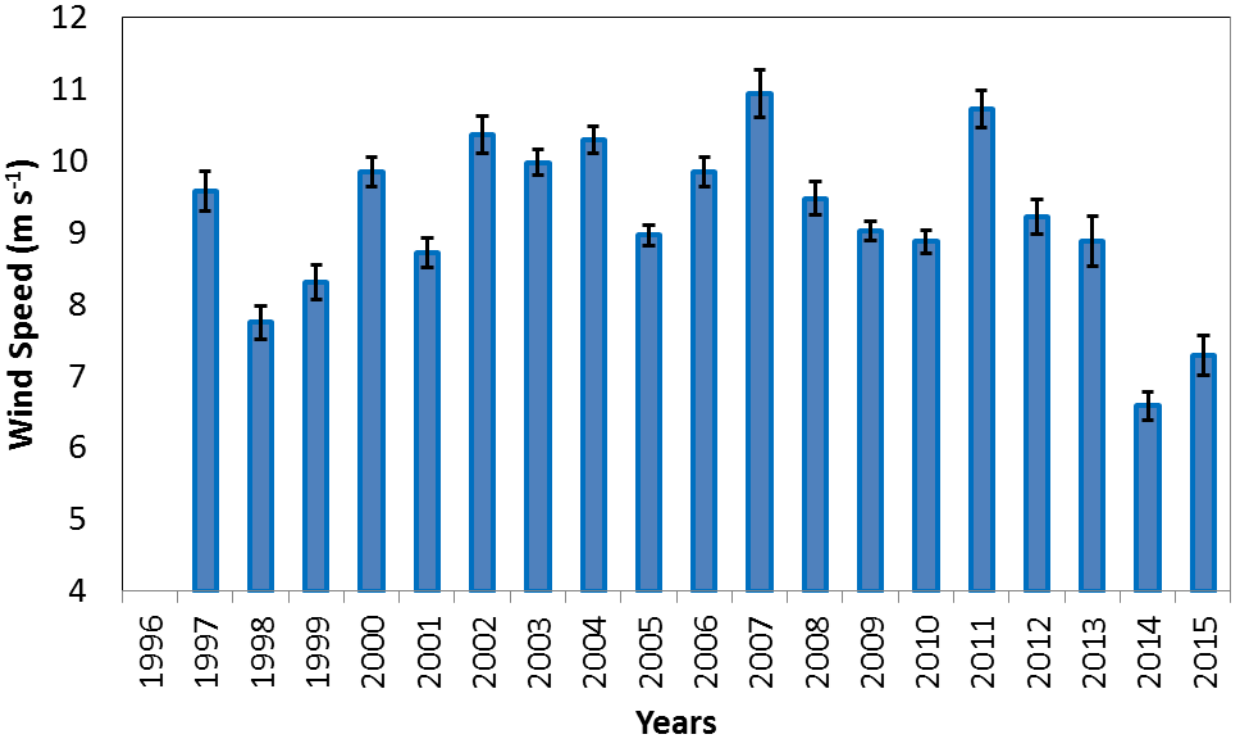
The availability of the wind direction and speed during Winter 2015 is low, due to instrument malfunctioning. In general the direction and intensity are in line with the climatological one however high NE winds were observed on the first few days of February.

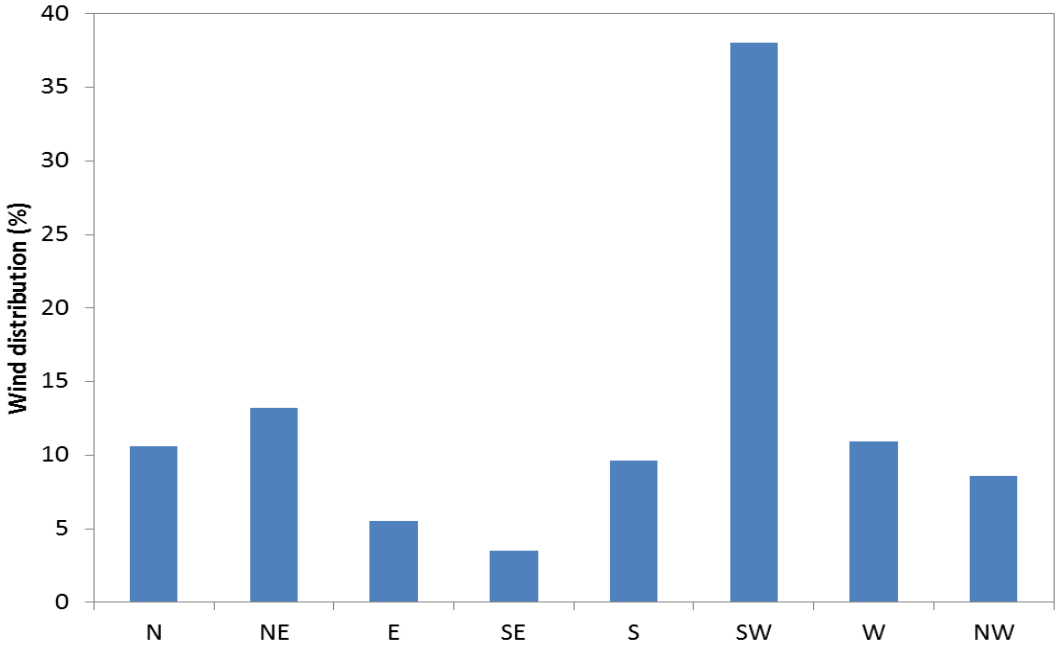




Comparison with historical data-set

The winter 2015 showed an average wind speed (11.0 m/s) **that is slightly higher thatn the climatological value** (9.3 m/s). The seasonal wind prevalent direction is SW (23.5), followed by W (20.0%), NW (18.5 %) and finally N (20.8 %), with the northerly contribution exceeding what is normally observed at the measurement site (10.4 %). However, these results could be influenced by the reduced number of available data and thus should be considered with caution.





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)

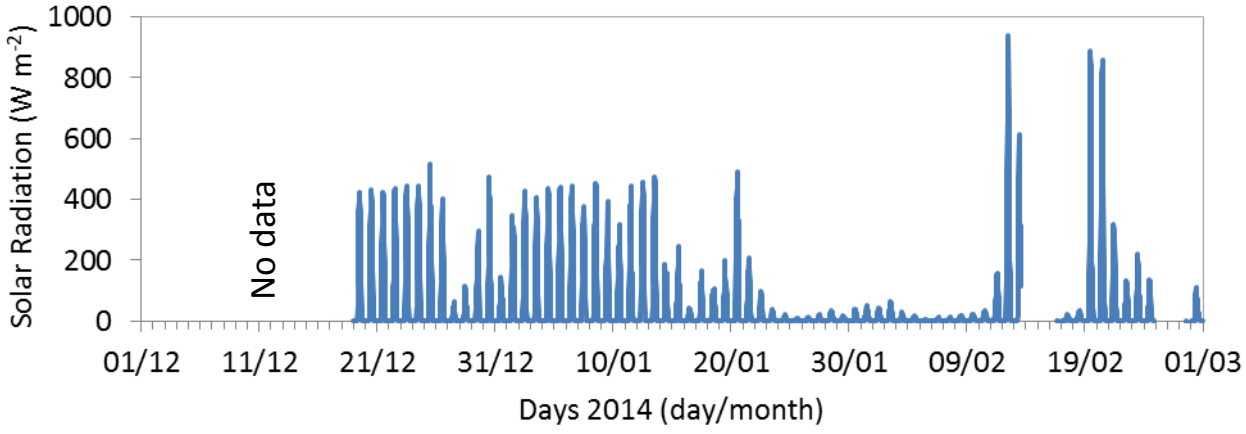
Statistical parameters are calculated basing on 30-minute aggregated values from December 2014 to February 2015.

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)
73.6	UDL	UDL	UDL	51.5	25.0	938.9

UDL: under detection limit

Time series (Solar radiation)

Despite the initial absence of available data, winter 2015 appear characterized by an initial presence of clear sky conditions at the measurements site, with the only exception been on 27th and 28th December 2015, when a cold front passed at ICO-OV causing a lot of snowing. On the other hand the latter half of the season showed many days whit significant cloud cover, related to the passage of many fronts as also underlined by the variability in the surface pressure values.



Basic statistical parameters (UV-B)

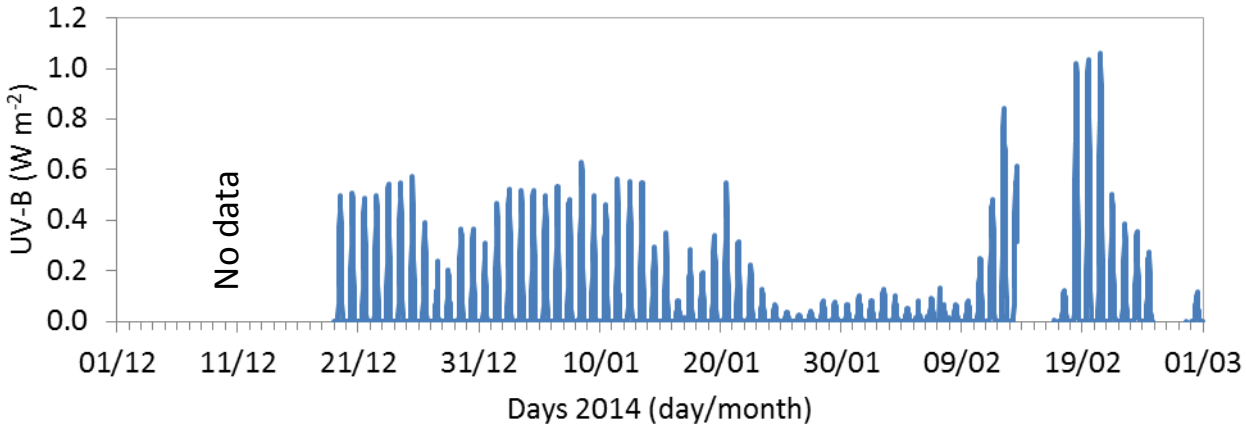
Statistical parameters are calculated basing on 30-minute aggregated values from December 2014 to February 2015.

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)
73.6	UDL	UDL	UDL	0.07	0.06	1.06

UDL: under detection limit

Time series (UV-B)

The UV-B solar fluxes day-to-day variability is almost the same of solar radiation. The highest daily average (0.24 W m^{-2}) value was observed on **February, 20th**.



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

Cristofanelli P, Scheel H-E, Steinbacher M, Saliba M., et al. Long-term surface ozone variability at Mt. Cimone WMO/GAW global station (2165 m a.s.l., Italy),. Atmospheric Environment. 101:23-33, 2014.

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.

Monitoring atmospheric composition & climate 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

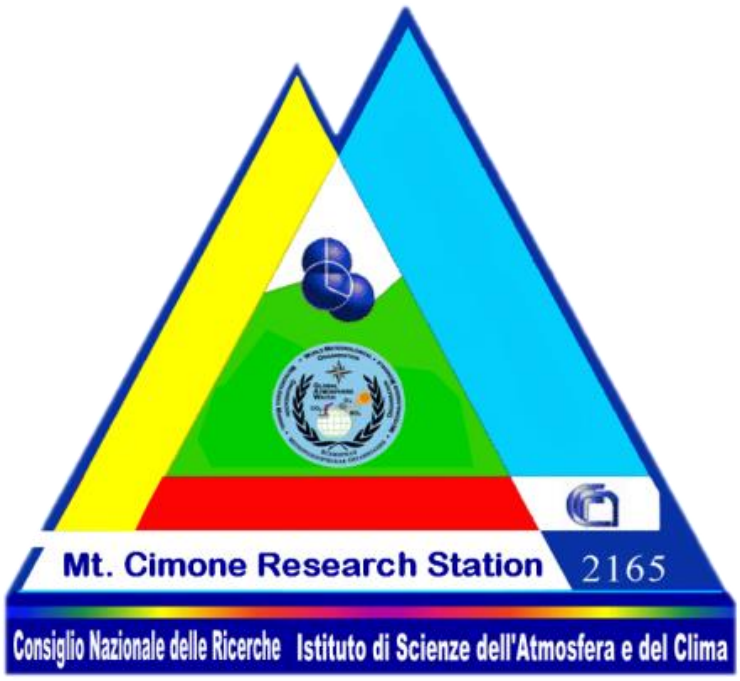
Maurizio Busetto - *Data acquisition and near-real time*
m.busetto@isac.cnr.it

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



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