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

AUTUMN 2014 REPORT

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

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

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A national system for the retrieval, storage, access and diffusion of environmental and climate data from mountain and marine areas.
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SHARE
Stations at High Altitude for Research on the Environment
Stazioni di alta quota per la ricerca sull'ambiente

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/

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Foreword

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

Firstly, we provide a brief description of the measurement site and running experimental programmes. Then, an overview of the atmospheric and weather conditions during autumn 2014 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 Autumn mean values are calculated by averaging data from 2014, September 1st to November 30th.**

Premessa

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

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

Viene quindi fornita una panoramica delle condizioni atmosferiche e meteorologiche che hanno caratterizzato la stagione autunnale 2014 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 autunnali sono calcolati come media dal 1 settembre al 30 novembre 2014.**

Monte Cimone GAW/WMO Global Station

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

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

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

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

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

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

*Managed by Italian Institutions

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

La Stazione Globale GAW/WMO di Monte Cimone

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

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

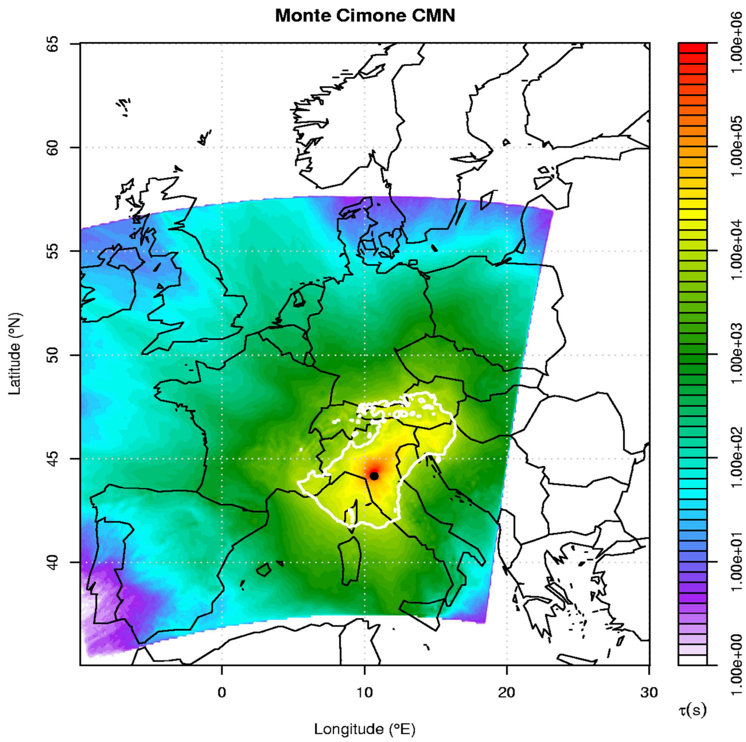
Lista delle stazioni globali GAW/WMO in aree di alta quota (for more information: http://gaw.empa.ch/gawsis/)

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).

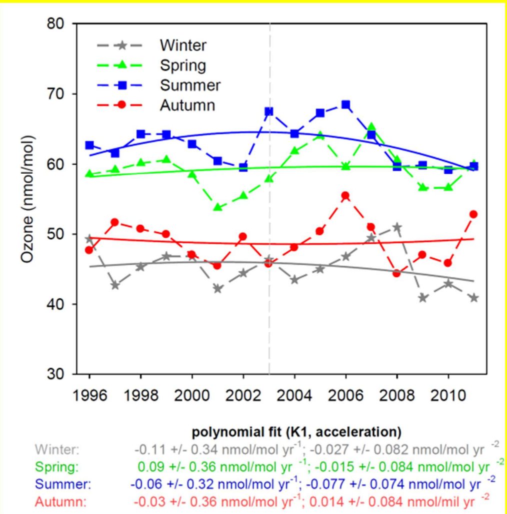
NEWS

Long-term ozone trend investigation

Studio del trend a lungo termine dell'ozono superficiale

A paper has been recently published by the international journal "Atmospheric Environment", where the long-term ozone trend at CMN were analyzed and discussed. **We detected a slowing down of the O_3 growth-rates in summer season at CMN and a lowering of mean O_3 during recent years** (i.e. from 2009 to 2011: 51.9 ± 8.3 nmol/mol), in agreement with other Alpine and Mediterranean baseline sites.

Sulla rivista internazionale "Atmospheric Environment "è stato recentemente analizzato e discusso il trend a lungo termine dell'ozono a Monte Cimone. **E' stato rilevata una decelerazione del trend nel periodo estivo ed un abbassamento dei valori di ozono negli anni più recenti** (dal 2009 al 2011: 51.9 ± 8.3 nmol/mol), in accordo con osservazioni simili condotte presso altri siti di fondo sulle Alpi e nel Mediterraneo.



Seasonal O_3 averages measured at CMN for 1996 – 2011. The lines indicate quadratic regressions over the data sets. ***The measurements performed at CMN represent the longest surface O_3 record at a baseline site in the Mediterranean basin.***

Valori medi stagionali dell'ozono a Monte Cimone nel periodo 1996 -2011. Le linee indicano il risultato di una regressione polinomiale. ***Le osservazioni di ozono a Monte Cimone, rappresentano la più lunga serie in condizioni di fondo nel bacino del Mediterraneo.***

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

Autumn 2014 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 only slightly higher than the climatological one, coarse particles average concentrations were higher than the autumn climatological one.

The 12.1% of the autumn have been affected for a significant fraction of time by acute pollution event, with 10/11 events on September 6th to 17th. September, 6th was the most polluted day, with an easterly circulation suggesting a contribution of fire emissions from eastern Europe. Unpolluted conditions were generally observed on October and November.

9 days (9.9%) were affected by mineral dust transport, with the most important dust event occurring from November 28th, associated with the presence of a through over western Europe.

The selection methodology allow the identification of 3 events distinctly related with air-mass transport from the stratosphere , with the highest O_3 average on November 2nd.

A volcanic plume was possibly detected on 22nd October, as traced by high SO_2 values at Mt. Cimone.

Daily **surface ozone** peak was recorded on 16-09 (58.5 ppb). 30-minute average values ranged from a minimum of 23.9 ppb (17-11) to 63.4 ppb (16-09), with an average seasonal value of 45.1 ppb. This value is lower than the average climatological autumn value obtained from the last 18 years (48.6 ppb).

Daily **carbon monoxide** peak was recorded on 04-09 (157.7 ppb). 30-minute average values ranged from a minimum of 55.7 ppb (20-10) to 176.2 ppb (04-09), with an average seasonal value of 113.2 ppb. This value is higher than the value obtained from the last 2 years (107.3 ppb).

Daily **nitric oxide** and **nitrogen dioxide** peaks were recorded on 18-11 (0.37 ppb) and 23-10 (1.20 ppb), respectively. 30-minute average values ranged from values below the detection limit to 1.64 ppb (for NO) and 3.18 ppb (for NO_2).

Daily **sulfur dioxide** peak was recorded on 23-09 (1.00 ppb). 30-minute average values ranged from values below the detection limit to 3.71 ppb (22-10), with an average seasonal value below the detection limit.

Sommario

VISIONE DI INSIEME

L' autunno del 2014 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 considerevolmente superiori alla media climatologica autunnale.

Il 12.1 % della stagione è stato influenzato da eventi significativi di inquinamento, con la maggioranza di essi (10/11) tra il 6 ed il 17 di Settembre. L'evento più importante è stato osservato il 6 settembre quando masse d'aria originatesi sull'Europa orientale, probabilmente ricche di emissioni da incendi, hanno raggiunto il sito di misura.

9 giorni (9.9%) sono stati caratterizzati da eventi di trasporto di sabbia sahariana: l'episodio più intenso è stato osservato a partire del 28 Novembre, associato alla presenza di una saccatura sopra l'Europa occidentale che ha favorito il trasporto dal Nord Africa.

La metodologia di selezione ha permesso di identificare 3 eventi di trasporto chiaramente associabile a masse d'aria provenienti dalla stratosfera: l'evento del 2 novembre è stato caratterizzato dalle concentrazioni di O_3 più elevate osservate per questa classe di eventi.

Il giorno 22 ottobre, è stata individuata a Mt. Cimone una nube vulcanica, come mostrato dagli elevati valori di SO_2.

Il valore massimo giornaliero della concentrazione di **ozono superficiale** è stato registrato il 16-09 (58.5 ppb). Le medie semi-orarie variano da 23.9 ppb (17-11) a 63.4 ppb (16-09), con un valore medio stagionale di 45.1 ppb. Tale valore è inferiore a quello climatologico relativo agli ultimi 18 anni (48.6 ppb).

Il valore massimo giornaliero della concentrazione di **monossido di carbonio** è stato registrato il 04-09 (157.7 ppb). Le medie semi-orarie variano da 55.7 ppb (20-10) a 176.2 ppb (04-09), con un valore medio stagionale pari a 113.2 ppb. Tale valore è superiore a quello delle ultime due stagioni autunnali (107.3 ppb).

I valori massimi giornalieri di **ossido d'azoto** e **biossido d'azoto** sono stati registrati rispettivamente il 18-11 (0.37 ppb) e il 23-10 (1.20 ppb). Le medie semi-orarie sono variate da valori inferiori al limite di rivelazione sino a 1.64 ppb (per NO) e 3.18 ppb (per NO_2).

Il valore massimo giornaliero di **biossido di zolfo** è stato registrato il 23-09 (1.00 ppb). Le medie semi-orarie sono variate da valori inferiori al limite di rilevabilità sino a 3.71 ppb (22-10), con un valore medio stagionale inferiore al limite di rilevabilità.

Daily **black carbon** peak was recorded on 06-09 (449.8 ng m^{-3}). 30-minute average values ranged from a minimum of 10.0 ng m^{-3} (06-11) to 368.2 ng m^{-3} (06-09), with an average seasonal value of 136.3 ng m^{-3}. This value is considerably lower than the average climatological autumn value obtained from the last 9 years (184.7 ng m^{-3}).

Daily **fine aerosol particles** peak was recorded on 30-11 (38.2 cm^{-3}). 30-minute average values ranged from a minimum of 0.01 cm^{-3} (17-11) to 172.5 cm^{-3} (30-11), with an average seasonal value of 7.7 cm^{-3}. This value is lower than the average climatological autumn value obtained from the last 12 years (15.0 cm^{-3}). However only the 18.3 % of the season was covered due to instrument failure.

Daily **coarse aerosol particles** peak was recorded on 30-11 (3.5 cm^{-3}). 30-minute average values ranged from a minimum of 0.001 cm^{-3} (17-11) to 16.7 cm^{-3} (30-11), with an average seasonal value of 0.41 cm^{-3}. This value is higher than the average climatological autumn value obtained from the last 12 years (0.17 cm^{-3}). However only the 17.0 % of the season was covered due to instrument failure.

Daily **aerosol scattering coefficient at 550 nm** peak was recorded on 30-11 (45.6 Mm^{-1}). 30-minute average values ranged from a minimum of 0.004 Mm^{-1} (11-09) to 230.6 Mm^{-1} (30-11), with an average seasonal value of 6.38 Mm^{-1}. This value is considerably lower than the average climatological summer value obtained from the last 7 years (20.03 Mm^{-1}).

Maximum **HFC-134a** peak was recorded on 01-10 (135.2 ppt). The lowest value (82.5 ppt) was recorded on 25-11 during a long period (since 24-11 to 30-11) of a relatively-background condition, occurred during a Saharan dust event.

Maximum **benzene** peak was recorded on 20-11 (164.3 ppt), with the average of the non-background values (78.3ppt) confirming the descending trend of the climatologic autumn values. The lowest value (22.2 ppt) was recorded on 29-09.

The maximum value of nitrogen dioxide columnar amount was recorded on 13-10 ($9.80 \bullet 10^{15}$ mol/cm^2) for the sunset, and 1-10 ($8.31 \bullet 10^{15}$ mol/cm^2) for the sunrise. The minimum value of the columnar amount of nitrogen dioxide was recorded on 26-11 ($2.99 \bullet 10^{15}$ mol/cm^2) for the sunset, and 25-11 ($2.48 \bullet 10^{15}$ mol/cm^2) for the sunrise.

Il valore massimo giornaliero della concentrazione di **black carbon** è stato registrato il 06-09 (449.8 ng m^{-3}). Le medie semi-orarie variano da 10.0 ng m^{-3} (06-11) a 368.2 ng m^{-3} (06-09), con un valore medio stagionale pari a 136.3 ng m^{-3}. Tale valore è considerevolmente inferiore a quello climatologico relativo agli ultimi 9 anni (184.7 ng m^{-3}).

Il valore massimo giornaliero della concentrazione di **particelle fini** è stato registrato il 30-11 (38.2 cm^{-3}). Le medie semi-orarie variano da 0.01 cm^{-3} (17-11) a 172.5 cm^{-3} (30-11), con un valore medio stagionale pari a 7.7 cm^{-3}. Tale valore è inferiore a quello climatologico (15.0 cm^{-3}). Tuttavia, la bassa copertura di dati (18.3 %) impedisce una robusta caratterizzazione stagionale.

Il valore massimo giornaliero della concentrazione di **particelle grossolane** è stato registrato il 30-11 (3.5 cm^{-3}). Le medie semi-orarie variano da 0.001 cm^{-3} (17-11) a 16.7 cm^{-3} (30-11), con un valore medio stagionale pari a 0.41 cm^{-3}. Tale valore è superiore a quello climatologico relativo agli ultimi 12 anni (0.17 cm^{-3}). Tuttavia, la bassa copertura di dati (17.0 %) impedisce una robusta caratterizzazione stagionale.

Il picco giornaliero del **coefficiente di scattering dell'aerosol a 550 nm** è stato osservato il 30-11 (45.6 Mm^{-1}). Le medie sui 30-minuti oscillano tra un minimo di 0.004 Mm^{-1} (11-09) e 230.6 Mm^{-1} (30-11), con un valore medio stagionale di 6.38 Mm^{-1} che risulta essere considerevolmente inferiore al valore medio climatologico relativo agli ultimi 7 anni (20-03 Mm^{-1}).

Il massimo giornaliero di **HFC-134a** è stato registrato il 01-10 (135.2 ppt) mentre la concentrazione minima (82.5 ppt) è stata registrata il 25-11, durante un periodo (dal 24-11 al 30-11) di condizioni di fondo durante un evento di trasporto di sabbia dal Sahara.

Il massimo giornaliero di **benzene** è stato registrato il 20-11 (164.3 ppt). L'analisi dei dati in condizioni di inquinamento, conferma il trend in diminuzione dei valori climatologici autunnali.

Il valore massimo della **quantità colonnare di biossido di azoto** è stato registrato il 13-10 ($9.80 \cdot 10^{15}$ mol/cm^2) per il tramonto, e il 1-10 ($8.31 \cdot 10^{15}$ mol/cm^2) per l'alba. Il valore minimo della quantità colonnare di biossido di azoto è stato registrato il 26-11 ($2.99 \cdot 10^{15}$ mol/cm^2) per il tramonto, e il 25-11 ($2.48 \cdot 10^{15}$ mol/cm^2) per l'alba.

Daily **air temperature** peak was recorded on 20-10 (11.7°C), minimum on 19-11 (-1.7 °C). 30-minute average values ranged from a minimum of -4.5 °C (22-10) to 14.6 °C (20-10), with an average seasonal value of 5.4 °C, which is higher than the seasonal climatological value (3.7 °C).

Daily **relative humidity** minimum was recorded on 02-11 (34.4%). 30-minute average values ranged from a minimum of 8.3 % (02-11) to a maximum of 100.0 % (observed on 38 days), with an average seasonal value of 85.3 %. This value is higher than the average climatological autumn value obtained from the last 18 years (81.4 %).

Daily **atmospheric pressure** peak was recorded on 28-09 (801.5 hPa), the lowest value on 19-11 (777.1 hPa). 30-minute average values ranged from a minimum of 772.3 hPa (20-11) to 801.9 hPa (28-09), with an average seasonal value of 790.8 hPa, comparable with the average climatological autumn value obtained from the last 18 years (789.5 hPa).

Daily **wind speed** peak was recorded on 22-10 (19.7 m s^{-1}). 30-minute average values ranged from a minimum of 1.3 m s^{-1} (26-09) to a maximum of 30.5 m s^{-1} (22-10), with an average seasonal value of 8.0 m s^{-1}. This value is comparable with the climatological autumn value (8.0 m s^{-1}), however it should be noted than only the 29.1 % of the season was covered due to instrumental failure.

Wind direction was prevalently from N (33.4 % of 30-minute data) and SW (32.4 % of 30-minute data). The climatological analysis over the last 18 years shows a clear predominance of SW winds, and the autumn 2014 behaviour could be the result of a reduced time coverage.

Daily **solar radiation** highest average daily value was recorded on 23-09 (239.6 W m^{-2}),during a period (from 8 to 30 September) characterized by clear sky condition. The lowest average value (5.2 W m^{-2}) was observed on 18-11, on the last day of the 4-18 November period 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 11-09 (0.34 W m^{-2}), even though a high value (0.32 W m^{-2}) was also observed during the solar radiation maximum. Snow and ice over sensors could have affected measurements.

Il valore massimo giornaliero della **temperatura** è stato registrato il 20-10 (11.7 °C), il valore minimo il 19-11 (-1.7 °C). Le medie semi-orarie variano da -4.5 °C (22-10) a 14.6 °C (20-10), con un valore medio stagionale pari a 5.4 °C, superiore a quello medio climatologico autunnale (3.7 °C).

Il valore minimo giornaliero dell'**umidità relativa** è stato registrato il 02-11 (34.4 %). Le medie semi-orarie variano da 8.3 % (02-11) a 100 % (osservato in 38 giornate), con un valore medio stagionale pari a 85.3 %. Tale valore è superiore a quello climatologico relativo agli ultimi 18 anni (81.4 %).

Il valore massimo giornaliero della **pressione atmosferica** è stato registrato il 28-09 (801.5 hPa), il valore minimo il 19-11 (777.1 hPa). Le medie semi-orarie variano da 772.3 hPa (20-11) a 801.9 hPa (28-09), con un valore medio stagionale pari a 790.8 hPa, simile a quello climatologico relativo agli ultimi 18 anni (789.5 hPa).

Il valore massimo giornaliero della **velocità del vento** è stato registrato il 22-10 (19.7 m s^{-1}). Le medie semi-orarie variano da 1.3 m s^{-1} (26-09) a 30.5 m s^{-1} (22-10), con un valore medio stagionale pari a 8.0 m s^{-1}. Tale valore è in linea con quello climatologico ottenuto dalle misure realizzate negli ultimi 18 anni (8.0 m s^{-1}). La bassa copertura dei dati (29.1%), limita tuttavia una robusta caratterizzazione stagionale.

La **direzione del vento** osservata nell' estate 2014 è stata prevalentemente da Sud-Ovest (32.4 % dei dati semi-orari) e Nord (33.4 % dei dati). Diversamente da quanto osservato negli ultimi 18 anni si rileva quindi un cospicuo contributo di venti settentrionali, tuttavia tale risultato potrebbe derivare dalla ridotta copertura stagionale dei dati.

La **radiazione solare**, i cui valori più elevati vengono osservati tra l' 8 ed il 30 di Settembre, mostra il valore giornaliero massimo il 23-09 (239.6 W m^{-2}), mentre il minimo giornaliero (5.2 W m^{-2}) è stato osservato il 18-11, all'interno di un periodo compreso tra il 4 ed il 18 di Novembre, 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**, tuttavia il massimo giornaliero, pari a 0.34 W m^{-2}, è stato osservato l' 11-09, sebbene un valore elevato sia stato osservato il 23-09 (0.32 W m^{-2}) in concomitanza con il massimo di radiazione solare. 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;**
- **Volcanic plume (see pag. 36).**

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	September	October	November
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			

LEGEND

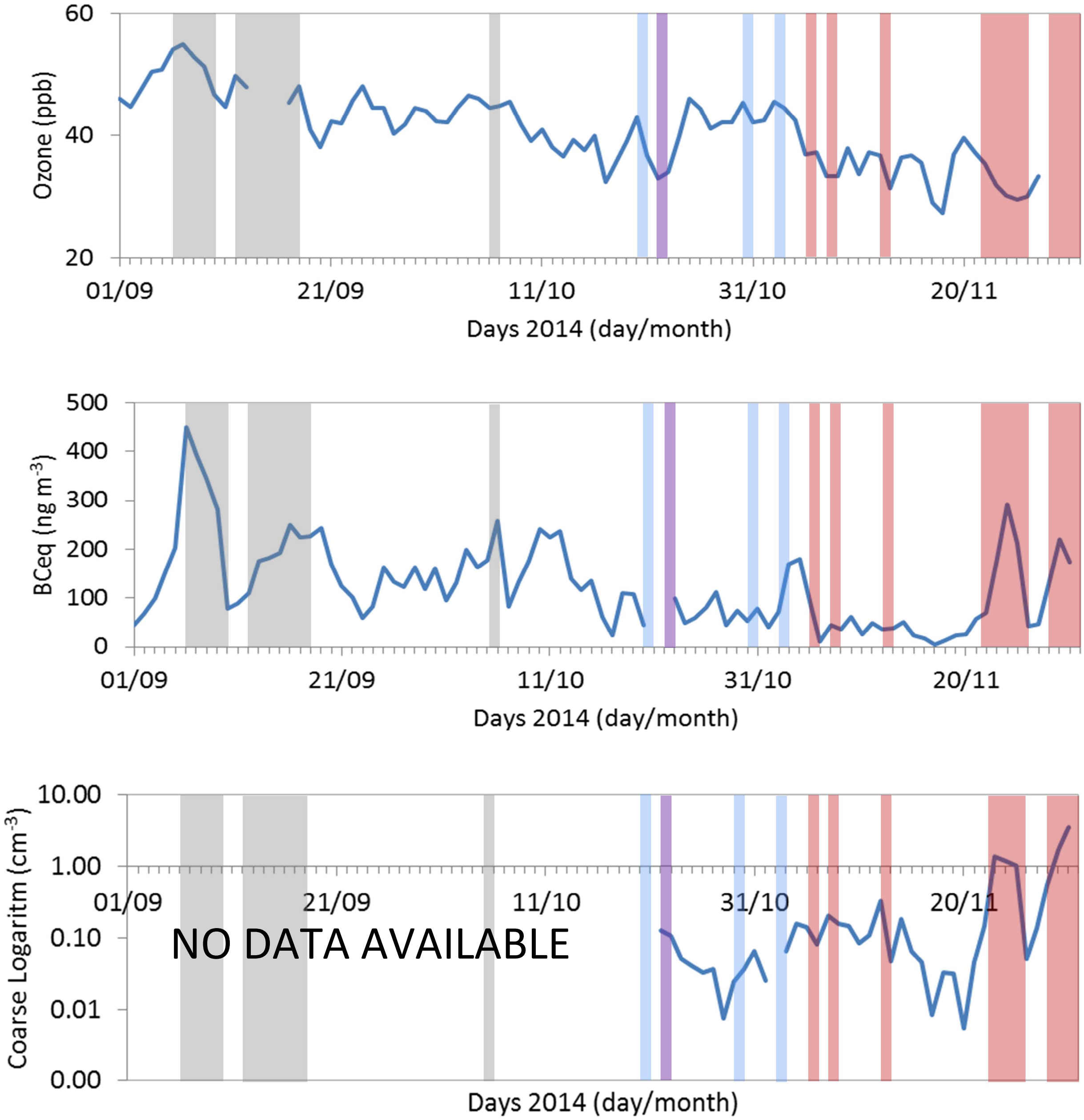
Mineral dust Stratospheric intrusions Pollution transport Volcanic emissions

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**
- **Trasporto di emission vulcaniche (si veda pag 36)**

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 | Volcanic emission

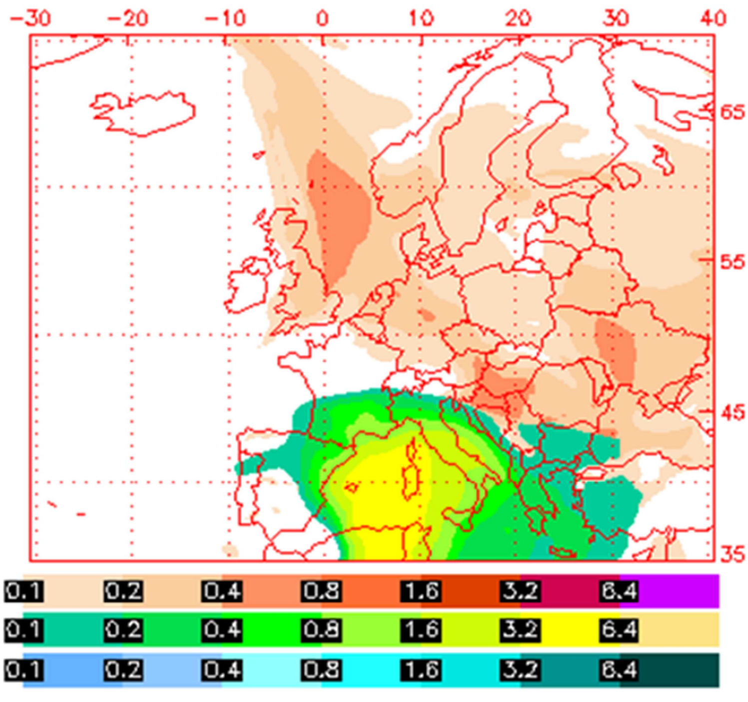
Mineral dust transport

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.

AUTUMN 2014:

- **9 days were characterized by the transport of mineral dust from northern Africa (9.9 % of the period). This number can be underestimated since no coarse particle data were available during September – October 2014.**
- **All the Saharan dust events were associated to the presence of a pressure trough over west Europe, with the exception of the 23rd-25th November event which was tagged to anticyclonic circulation over central Mediterranean basin.**
- **The most important dust event occurred from November 28th onward, when the coarse particle peaked to 2.5 cm^{-3}, on 30th November 2014.**



Dust transport event simulation by NAAPS model (30th November 2014).

Simulazione dell'evento di trasporto di polveri minerali osservato il 30 Novembre 2014 (modello NAAPS).

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

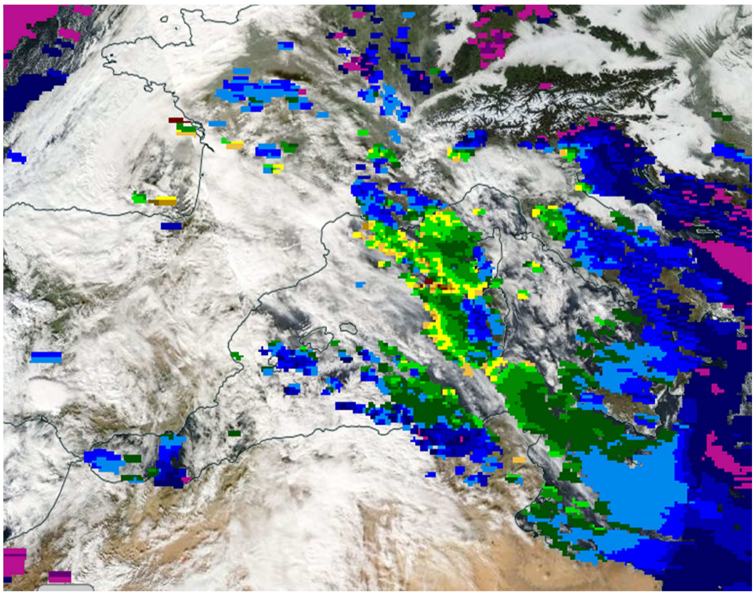
Trasporto di polveri minerali

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.

AUTUNNO 2014:

- **9 giorni sono stati caratterizzati dal trasporto di polveri minerali proveniente dal Nord Africa (9.9 % del periodo). Tuttavia questo dato può essere sottostimato poiché per i mesi di Settembre ed Ottobre non erano attive le misure di della concentrazione delle particelle grossolane.**
- **Tutti gli eventi stagionali di trasporto dal Sahara sono stati favoriti dalla presenza di saccature sull'Europa occidentale, con l'eccezione dell'evento del 23-25 Novembre che è stato associato a condizioni anticicloniche sul bacino del Mediterraneo.**
- **L'evento più significativo è stato osservato a partire dal 28 Novembre in avanti, quando è stata registrata la concentrazione massima di particelle grossolane per l'autunno 2014 (2.5 cm^{-3}, il 30 Novembre 2014).**



Dust transport observed by MODIS sensor on-board od AQUA and TERRA NASA satellite (25th November 2014). Colors represent the AOD (Terra) superimposed to Terra/Aqua true color image.

Rappresentazione dell'evento di trasporto di polveri minerali osservato il 25 Novembre 2014. I colori rappresentano le misure di AOD (MODIS su satellite Terra della NASA), sovraimposte alle immagini a colori dei satelliti Terra/Aqua.

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

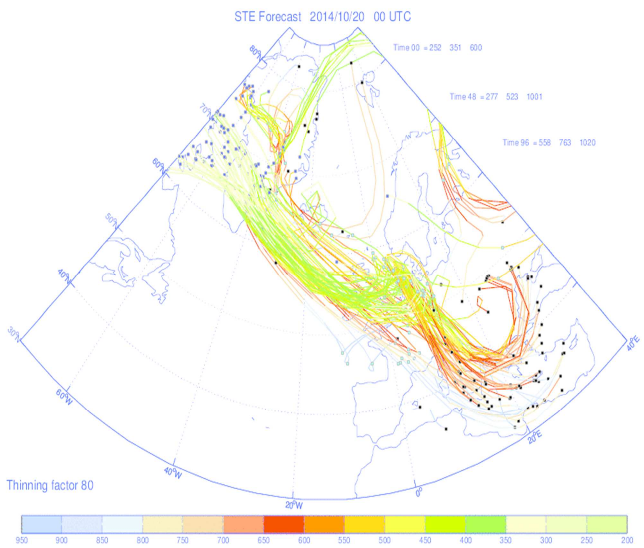
Stratospheric intrusions (SI)

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 8 hours of relatively dry conditions (RH<60%) with low levels of anthropogenic pollution (CO<90 ppb) together with analysis of air-mass three-dimensional back-trajectories corroborating the origin of the air masses.

AUTUMN 2014:

- **During autumn 2014, 3 events were detected, representing the 3.3 % of the analysed period.**
- **The highest ozone concentration during a STE was observed on November 2nd, with a daily average of 45.6 ppb.**



Trajectories describing the path of stratospheric air-masses for the event of 20 October 2014. 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 20 Ottobre 2014. Il colore rappresenta la quota (espressa come livello di pressione) delle masse d'aria.

Elaborazione: Michael Sprenger (ETH-Z, Switzerland)

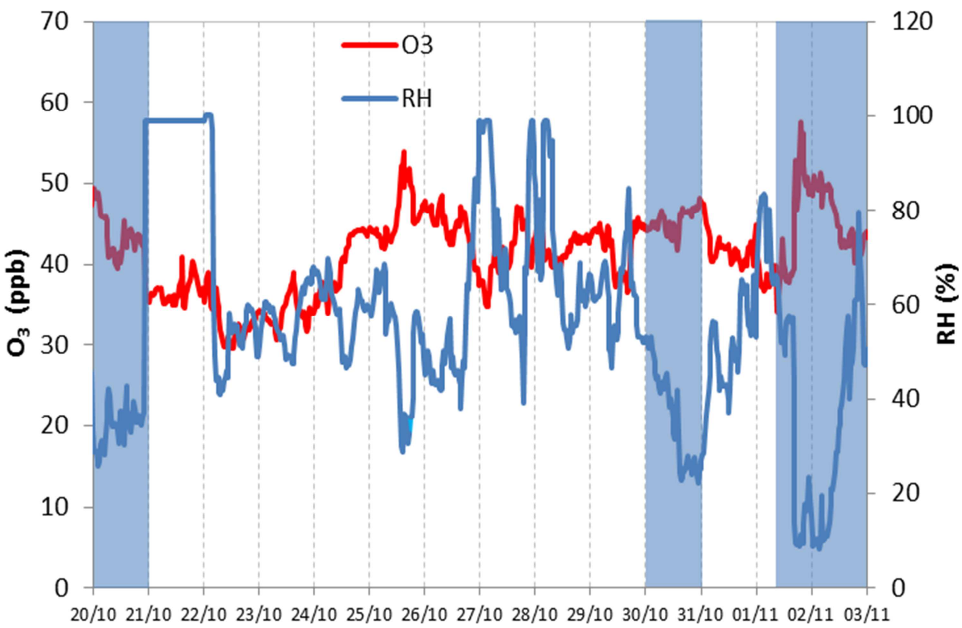
Intrusioni stratosferiche (SI)

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 8 ore dalla presenza di masse d'aria relativamente secche (RH<60%) e bassi livelli di inquinamento antropico (CO<90 ppb). Retro-traiettorie tridimensionali delle masse d'aria, sono state utilizzate per corroborare l'origine degli eventi.

AUTUNNO 2014:

- **Durante l'autunno 2014 sono stati identificati tre eventi di intrusione stratosferica, che rappresentano il 3.3 % del periodo analizzato.**
- **Il 2 Novembre è stata osservata la concentrazione stagionale di ozono più elevata durante un evento di intrusione stratosferica (valore medio durante l'evento: 45.6 ppb).**



Relative humidity (blue) and ozone (red) behaviors at CMN during October, 20th- November 3th 2014. The blue bars indicates the period probably affected by SI.

Andamento dell'umidità relativa (azzurro) ed ozono (rosso) nel periodo 20 Ottobre – 3 Novembre 2014. Le barre azzurre indica il periodo probabilmente influenzato dagli eventi di SI.

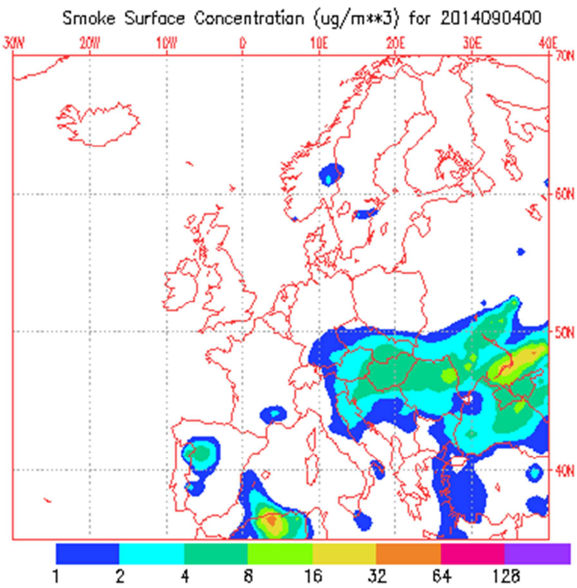
Pollution transport

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 8 hours of relatively high ozone, black carbon and carbon monoxide concentrations (higher than the 75th percentile of the seasonal values observed from the start of the respective measurement programmes). **This identification methodology leads to single out those "major" pollution events that significantly alter the usual seasonal behavior.**

AUTUMN 2014

- **11 days, related to three different events, were characterized by significant transport of polluted air masses (12.1% of the period).**
- **September was the month the most affected by pollution, with polluted conditions occurring almost continuously from September 6th to 9th and from September 12th to 17th. On 3rd – 5th September, air-masses affected by wildfire emissions from East Europe affected CMN;**
- **The most polluted day: September 6th (O_3: 52.9 ppb; CO: 153.5 ppb; BC:449.8 ng m^{-3}; aerosol scattering: 120.1 Mm^{-1}).**



Wildfire emission transport simulation by NAAPS model (4th September 2014). The colored scale represents the smoke aerosol concentration expressed as µg m^{-3}.

Simulazione dell'evento di trasporto di prodotti da incendi osservato il 4settembre giugno 2014 (modello NAAPS). La scala colorata rappresenta la concentrazione dell'aerosol associato alle emissioni degli incendi in µg m^{-3}.

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

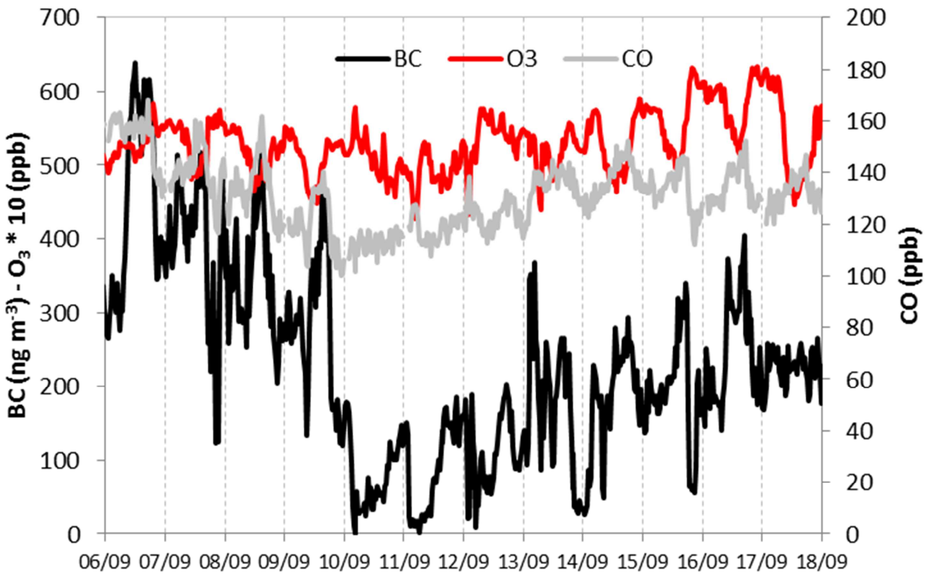
Trasporto di inquinanti

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 8 ore da concentrazioni elevate di ozono, black carbon e monossido di carbonio (maggiori del 75^{esimo} percentile dei valori osservati stagionalmente dall'inizio delle rispettive misure). **Questo metodo di identificazione permette di isolare quegli episodi "acuti" di inquinamento che alterano in maniera considerevole la normale composizione atmosferica stagionale.**

AUTUNNO 2014

- **11 giorni (12.1 % della stagione), collegati a tre distinti eventi, sono stati caratterizzati da significativi episodi di trasporto di masse d'aria inquinate.**
- **Settembre è stato il mese maggiormente influenzato dall'occorrenza di eventi di inquinamento, che hanno avuto luogo in modo quasi continuo dal 06 al 09 e dal 12 al 17 settembre. Nei giorni 3 – 5 settembre, sono state osservate masse d'aria ricche di composti emessi da incendi occorsi nell'Est Europa.**
- **Il 6 settembre è stato il giorno caratterizzato dalle concentrazioni più elevate di inquinanti (O_3: 52.9 ppb; CO: 153.5 ppb; BC:449.8 ng m^{-3}; aerosol scattering: 120.1 Mm^{-1})**



BC, ozone, and CO behaviors at Mt. Cimone from 6 to 17 September 2014.

Andamento delle concentrazioni di BC, ozono, e CO a Monte Cimone (6 – 17 Settembre 2014).

Surface ozone

Why is ozone so important?

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

Instrumentation and calibration

Surface ozone is measured by using a UV-absorption analyser (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.

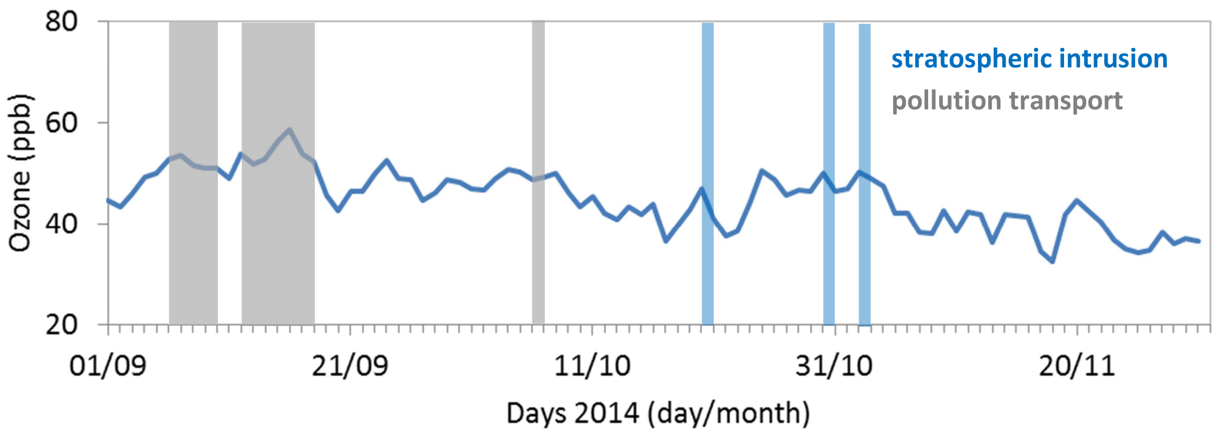
Basic statistical parameters

Statistical parameters are calculated basing on 30-minute aggregated values from September 2014 to November 2014.

Data availability (%)	Min value (ppb)	25^{th} Percentile (ppb)	50^{th} Percentile (ppb)	Average mean value (ppb)	75^{th} percentile (ppb)	Max value (ppb)
98.9	23.9	40.9	45.4	45.1	49.4	63.4

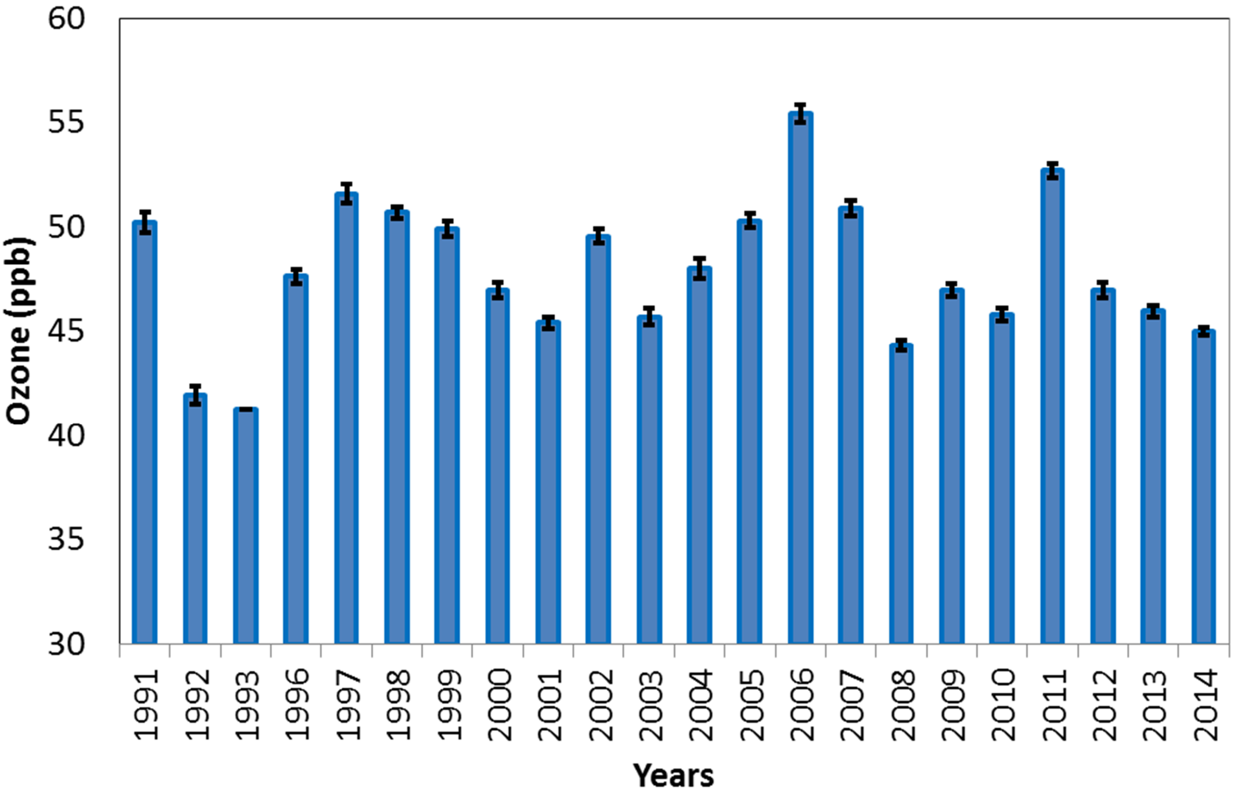
Time series of daily mean values

Relatively high values of ozone were observed during the first half of September, when **10 days were characterized by the occurrence of pollution transport** at the measurement site: the highest seasonal daily average (58.5 ppb) was observed on September 16^{th}. Lower, decreasing concentrations were observed starting from October 9^{th}, with the daily minimum on November 18^{th} (32.6 ppb).



Comparison with historical data-set

The 2014 autumn average mean value of O_3 is 45.1 ppb, **slightly lower than the climatological mean value of 48.6 ppb**, as result of lower than average concentrations from mid-October onward. This seasonal decreasing trend was also evident for CO and BC, which showed very low values on November during meteorological conditions not favorable to the accumulation of pollutants (passage of frontal systems favoring a "cleansing" the atmosphere).



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.

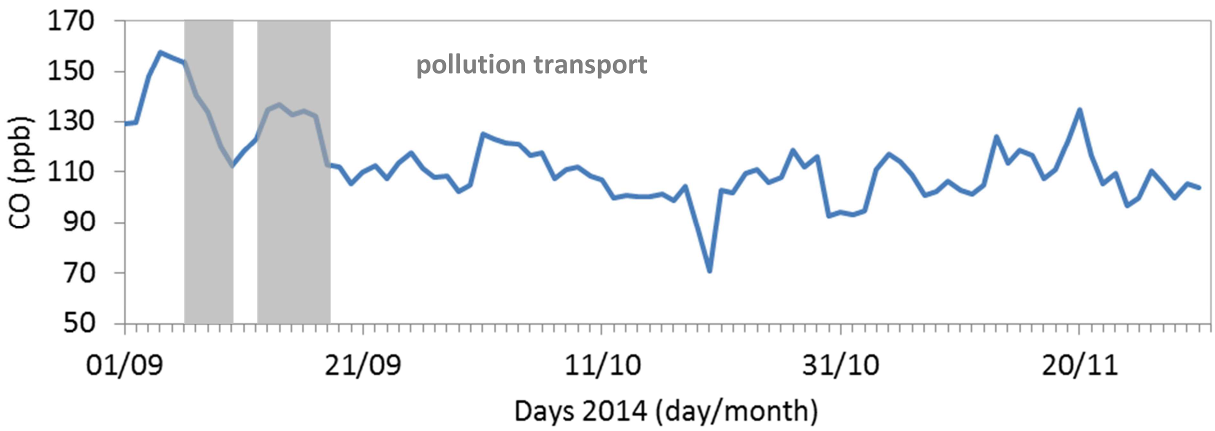
Basic statistical parameters

Statistical parameters are calculated basing on 30-minute aggregated values from September 2014 to November 2014.

Data availability (%)	Min value (ppb)	25th Percentile (ppb)	50th Percentile (ppb)	Average mean value (ppb)	75th percentile (ppb)	Max value (ppb)
94.1	55.7	102.4	110.6	113.2	121.7	176.2

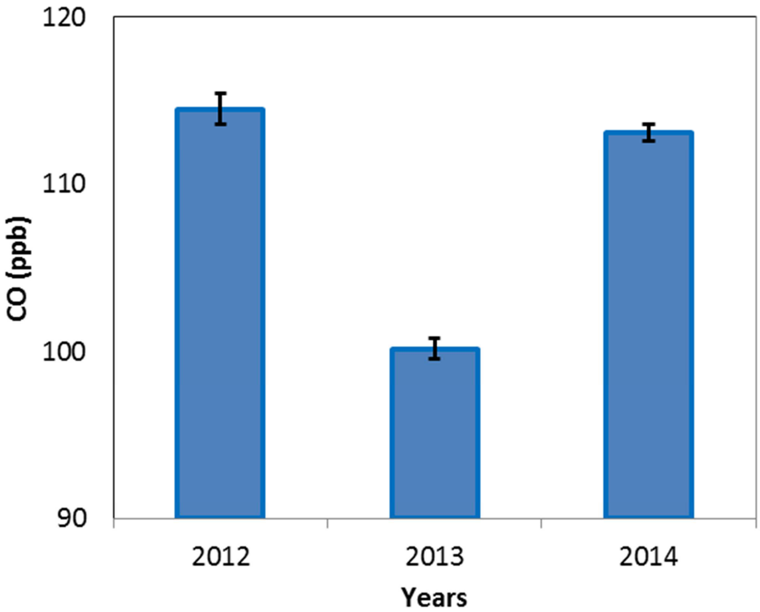
Time series of daily mean values

Similar to O_3 the highest CO concentrations were observed during the first half of September (maximum daily average concentration: 157.7 ppb on November 4th). Analogously to O_3 and BC, CO showed a declining trend starting from mid-October, with the lowest daily value observed on October 20th (70.7 ppb).



Comparison with historical data-set

The 2014 autumn average mean value of CO was 113.2 ppb, which is **higher than the average mean value of 107.3 ppb obtained from the last two autumns.** This is the result of the occurrence very high average values during the first half of September, especially in the first 5 days when eastern air masses reached the measurements after passing over wildfires in eastern Europe.



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

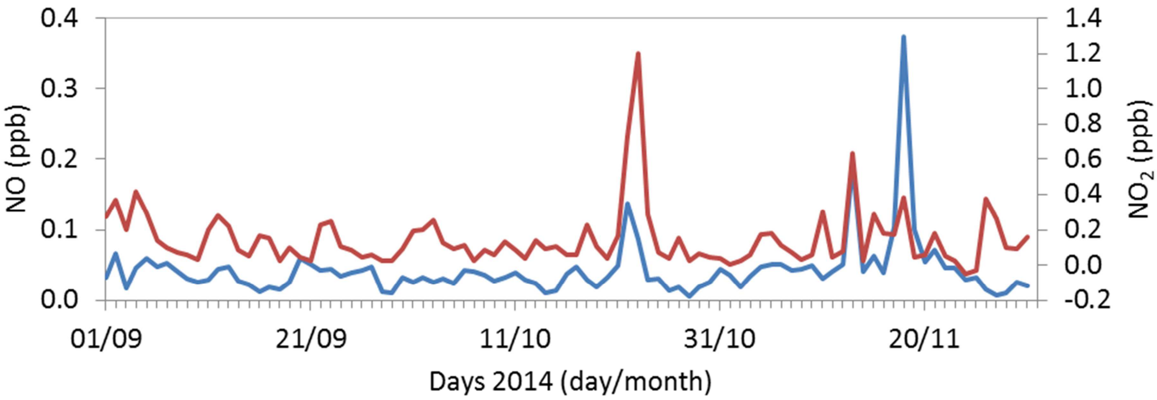
Statistical parameters are calculated basing on 30-minute aggregated values from September 2014 to November 2014.

Data availability (%)	Min value (ppb)	25^{th} percentile (ppb)	50^{th} percentile (ppb)	Average mean value (ppb)	75^{th} percentile (ppb)	Max value (ppb)
NO 94.4	UDL	0.02	0.03	0.04	0.05	1.64
NO_2 94.0	UDL	0.02	0.08	0.15	0.18	3.18

UDL: under detection limit

Time series of daily mean values

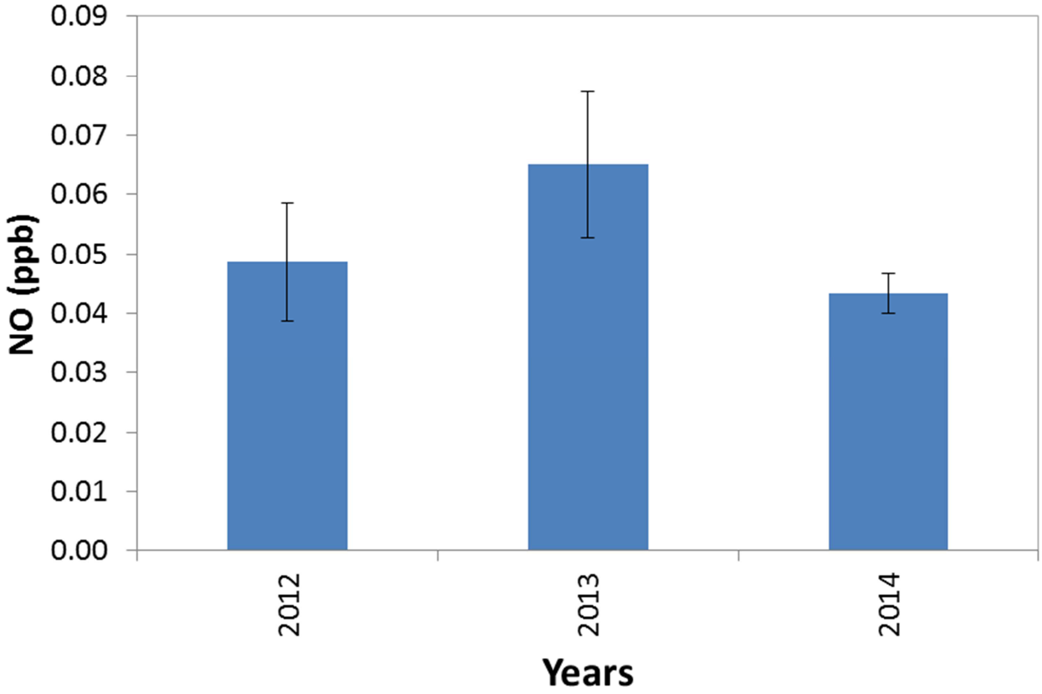
The highest NO value (blue line: 0.37 ppb) was observed on **November 18th**, while the highest NO_2 value (red line: 1.20 ppb) was observed on **October 23th**, due to the advection of PBL polluted air-masses from continental Europe to the measurement site.

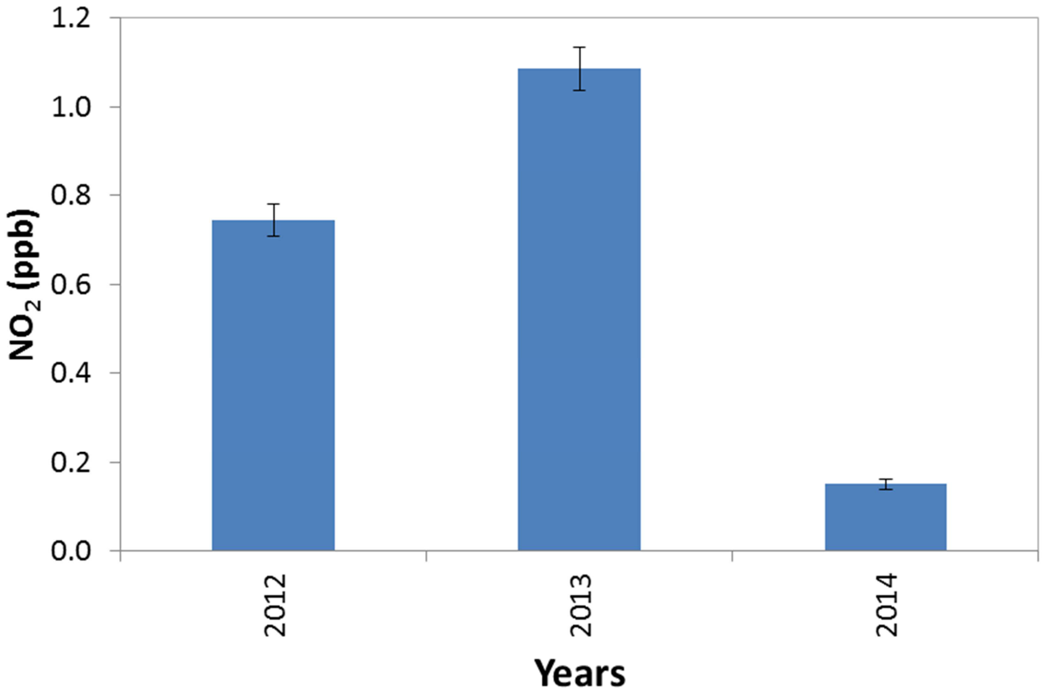


Comparison with historical data-set

The 2014 autumn average mean value of NO (NO_2) was 0.04 ppb (0.15 ppb) which **is comparable (lower) with the average autumn mean value of 0.06 ppb (0.92 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

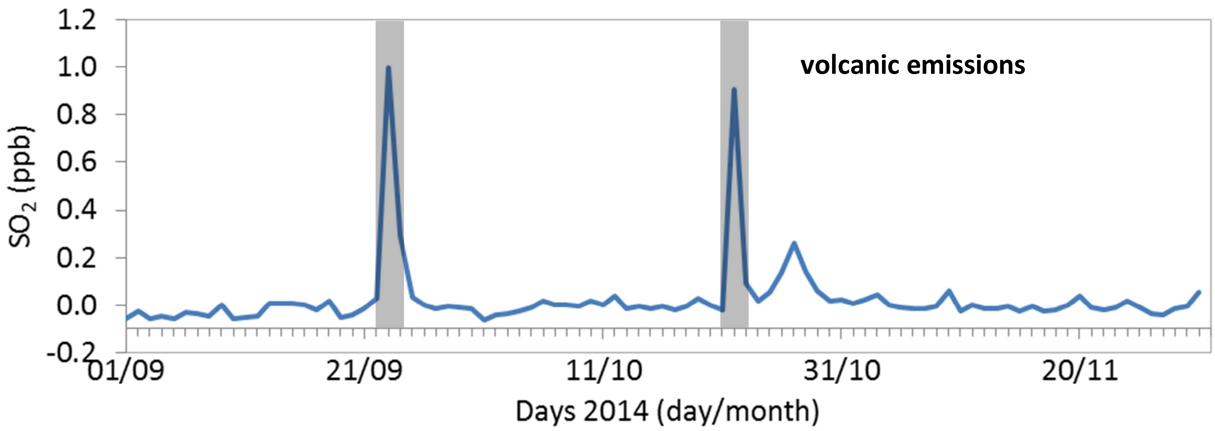
Statistical parameters are calculated basing on 30-minute aggregated values from September 2014 to November 2014.

Data availability (%)	Min value (ppb)	25^{th} percentile (ppb)	50^{th} percentile (ppb)	Average mean value (ppb)	75^{th} percentile (ppb)	Max value (ppb)
99.8	UDL	UDL	UDL	UDL	UDL	3.71

UDL: under detection limit

Time series of daily mean values

During autumn the average SO_2 concentration was lower than the detection limit. The highest SO_2 daily mean value (1.00 ppb) was observed on **September 23rd.- 24th**. The highest 30 minute average was instead observed on **October 22th**, when it reached 3.71 ppb, probably due to a volcanic plume transport.

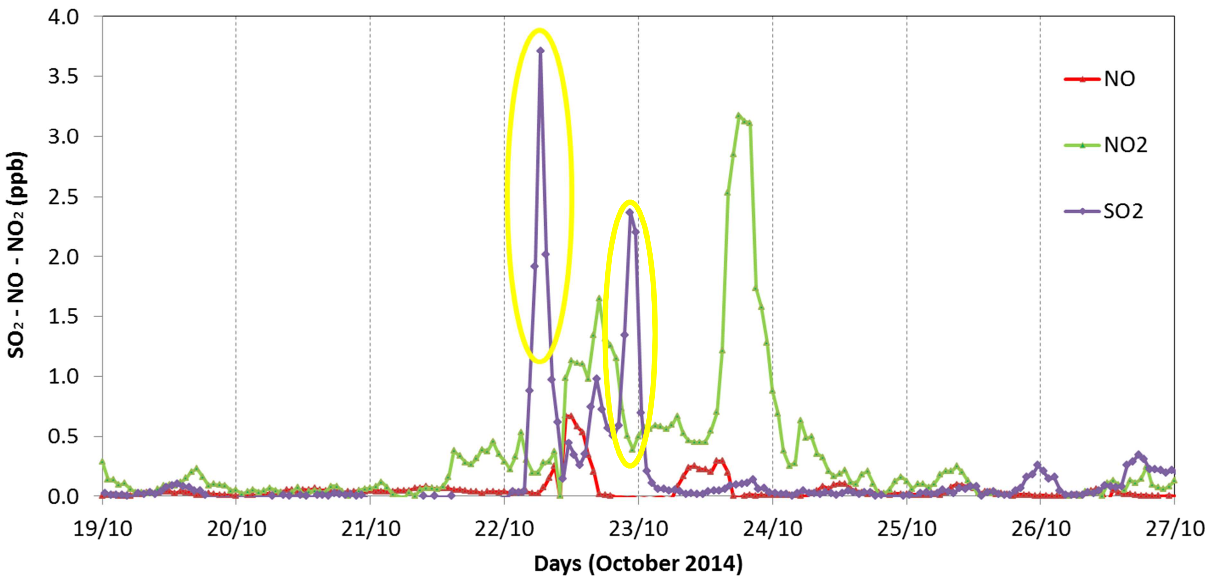


NOTE: Negative values in the graph represent "under detection limit" conditions, common in a remote, high altitude, free troposphere measurement site.

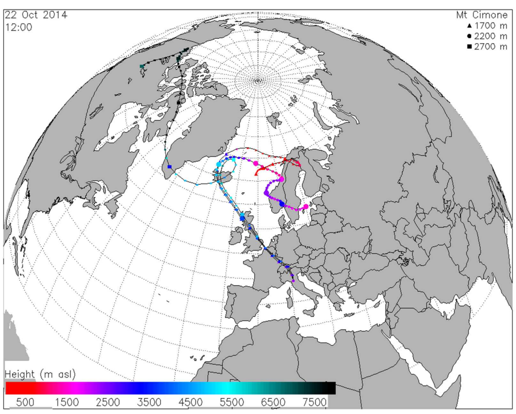
Highlight: volcanic plume

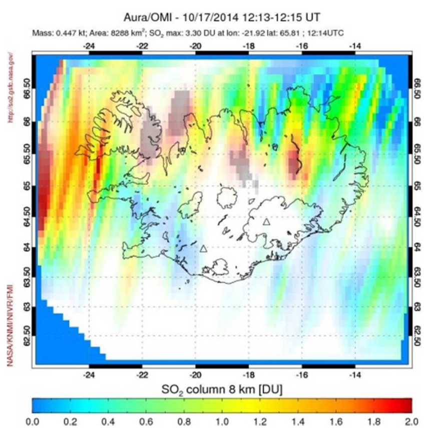
Volcanos are among the major natural source of sulfur dioxide (SO_2). Mixing ratios of SO_2 in continental background air range from 20 ppt to over 1 ppb (urban areas are characterized by higher SO_2 mixing ratios of several hundred parts per billion).The average SO_2 mixing ratio observed at Mt. Cimone is usually below the detection limit (10 ppt).

The autumn 2014 seasonal average SO_2 concentration did not deviated from these usual values. However, high SO_2 mixing ratios were observed, on October 22th. **The 30 minute averaged SO_2 values reached 3.7 ppb on October 22th at 6:00 and 2.4 ppb at 22:30**. These SO_2 peak were not related to increases in other anthropogenic pollutants (NO, NO_2, see yellow area below).



On August 16th the Icelandinc Bárðarbunga volcano started an intense eruption which is still active. FLEXTRA back-trajectories supported the transport of air-masses from Iceland, were high atmospheric SO_2 were detected by OMI satellite due to volcanic emissions.





On the left: 5-day air-mass back-trajectories calculated by FLEXTRA for October 22nd, 2014. Data and elaboration: NILU (curtesy By Andreas Stohl)

On the right: AURA/OMI SO_2 columnar integrated mixing ratio (expressed as Dobson Unit) on October 17th, 2014.

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.

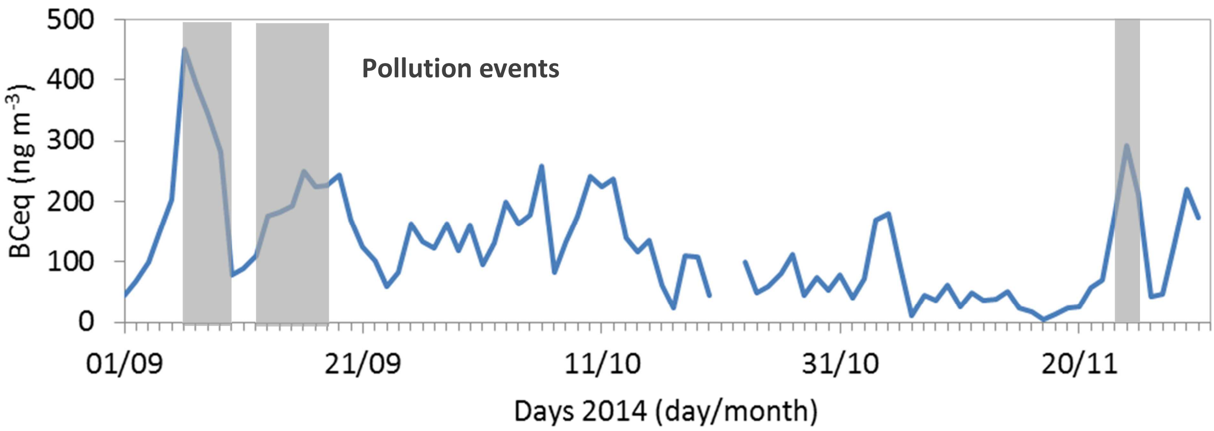
Basic statistical parameters

Statistical parameters are calculated basing on 30-minute aggregated values from September 2014 to November 2014.

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})
88.0	10.0	43.9	108.4	136.3	205.9	638.2

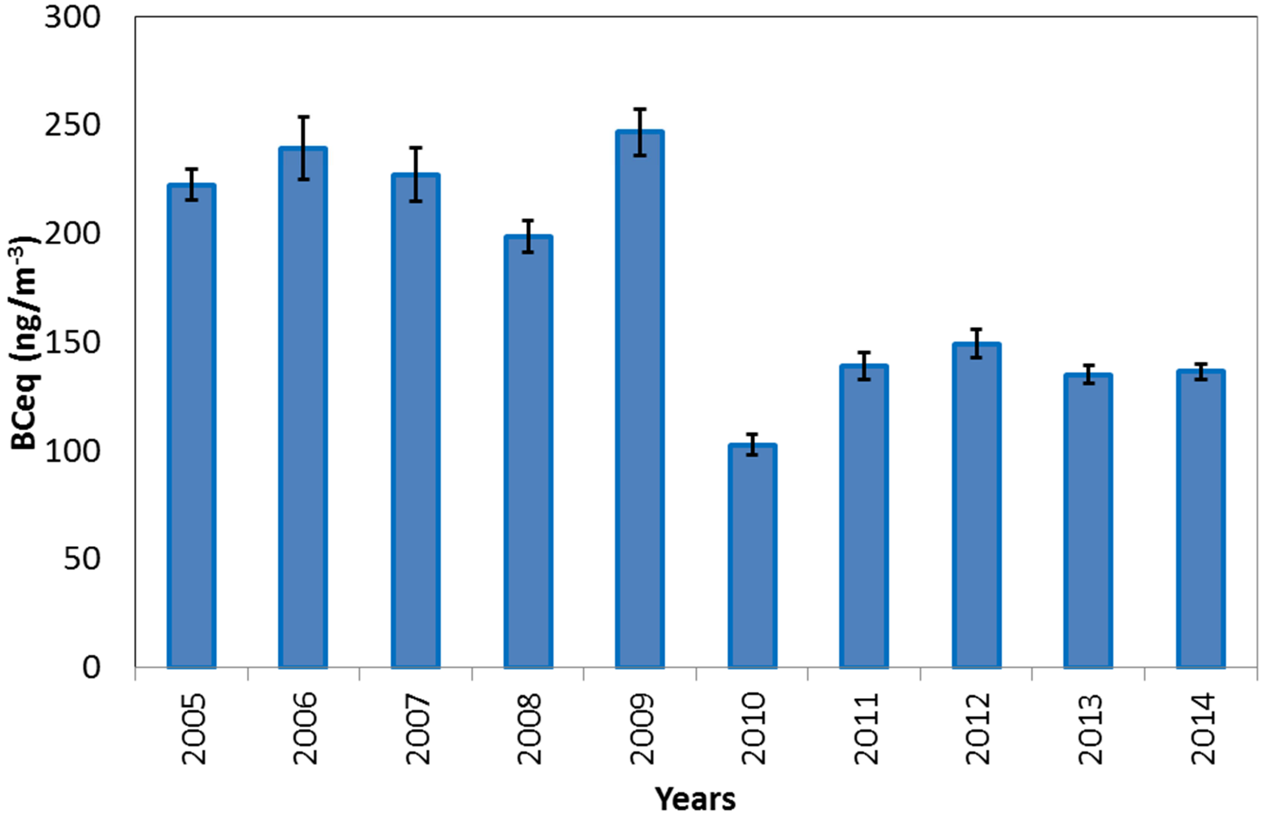
Time series of daily mean values

Similarly to other pollution tracers, the highest BC concentrations were observed during the first half of September, when the seasonal daily average maximum (449.8 ng m^{-3}) was observed on **September 6th** during a pollution event. A secondary daily maximum was also observed on **November 24th** when air masses from North Africa reached the measurements site.



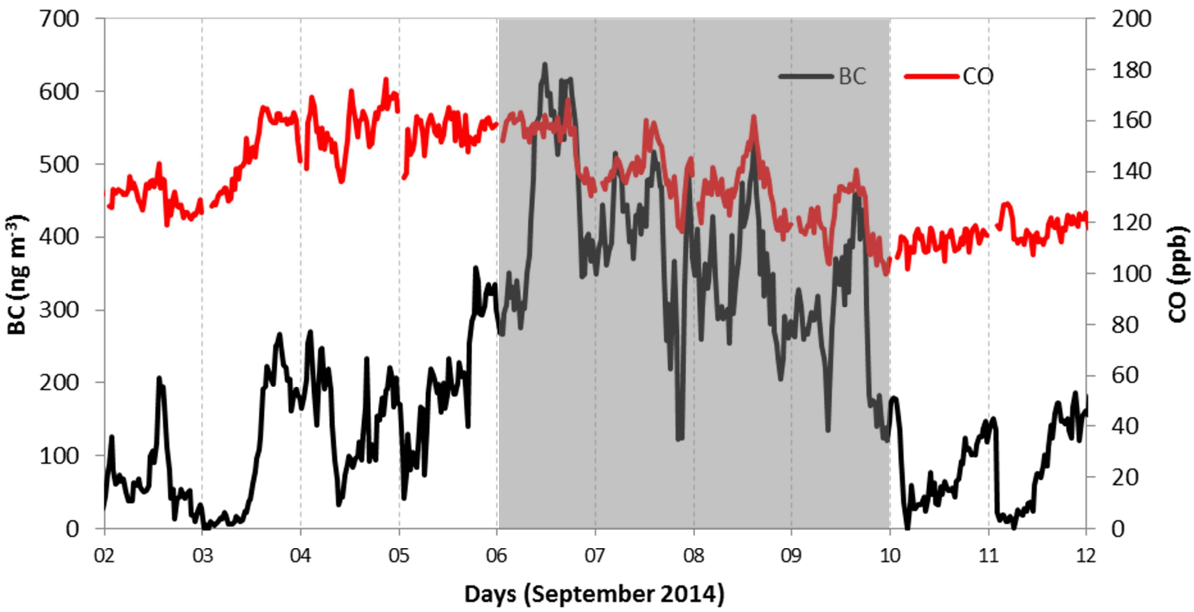
Comparison with historical data-set

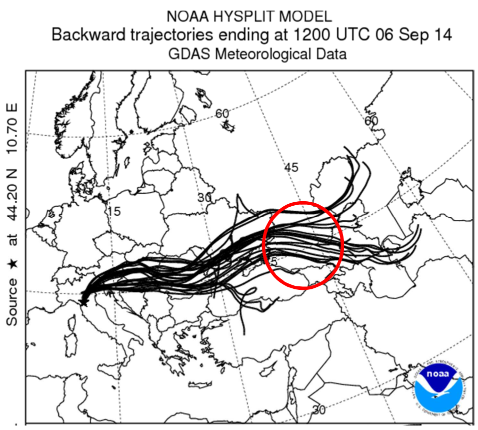
Despite the high BC value observed during the first 10 days in September, the 2014 autumn average mean value of BC is 136.3 ng m^{-3}, **which is lower than the climatological mean value (184.7 ng m^{-3}).** This behavior is the result of lower than average concentrations from mid-October onward.

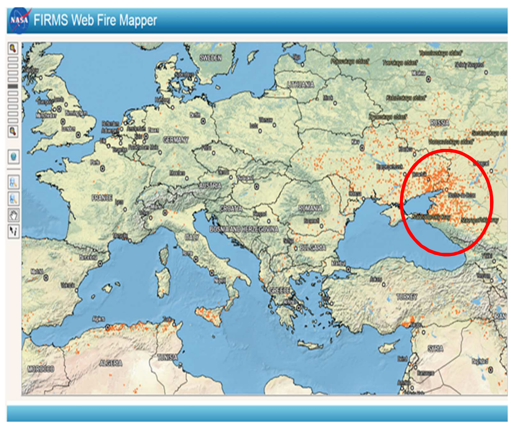


Wild fires represent a major contributor to trace gas and aerosol variability: BC produced by boreal wildfires accounts 10% of the annual anthropogenic BC emissions in the Northern Hemisphere. A dryer and warmer climate in the Mediterranean region, a possible result of the climate change, can lead to an increase in wildfire events and to an enhancement of the photochemical O_3 production, possibly *creating a positive feedback loop.*

The autumn 2014 season was characterized by the presence of 11 events of pollution. The first one (grey bar), from September 6th to 9th, was possibly driven by transport of open fire emissions from East Europe.







On the days preceding the pollution event, fires were detected mainly on the north eastern shores of the Black Seas (*MODIS Fire locations for the period September 1st to September 6th 2014.*).The analysis of the air masses path for this episode showed a clear easterly circulation (see the 5 *-day air-mass back-trajectories calculated by HYSPLIT for September 6th, 2014*), leading to the conclusion that the high levels of combustion by-products observed at ICO-OV are related to the transport of smoke-laden air masses.

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.

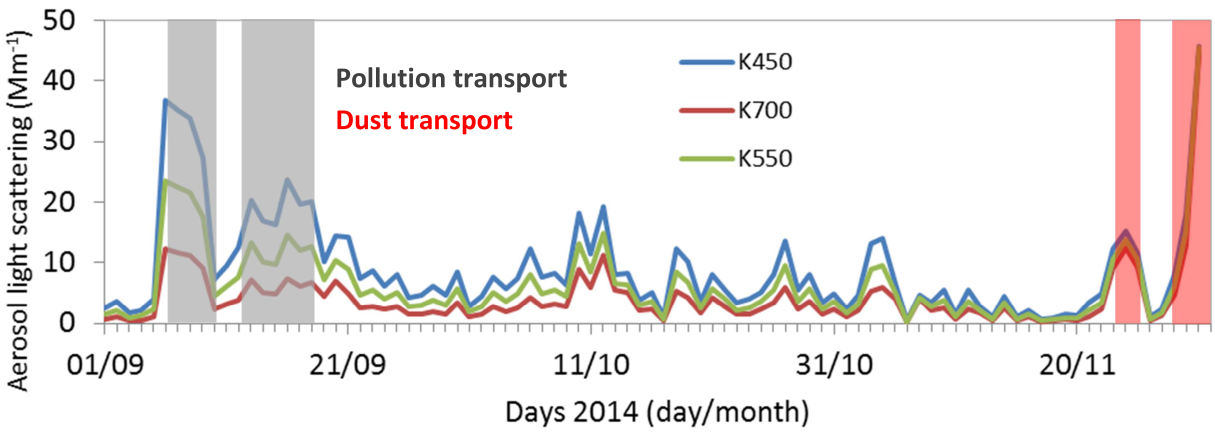
Basic statistical parameters

Statistical parameters are calculated basing on 30-minute aggregated values from September 2014 to November 2014.

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 99.7	UDL	1.8	5.0	9.1	12.9	224.7
550 nm 99.7	UDL	1.2	3.4	6.4	8.9	231.1
450 nm 99.7	UDL	0.7	2.1	4.2	5.3	232.4

Time series of daily mean values

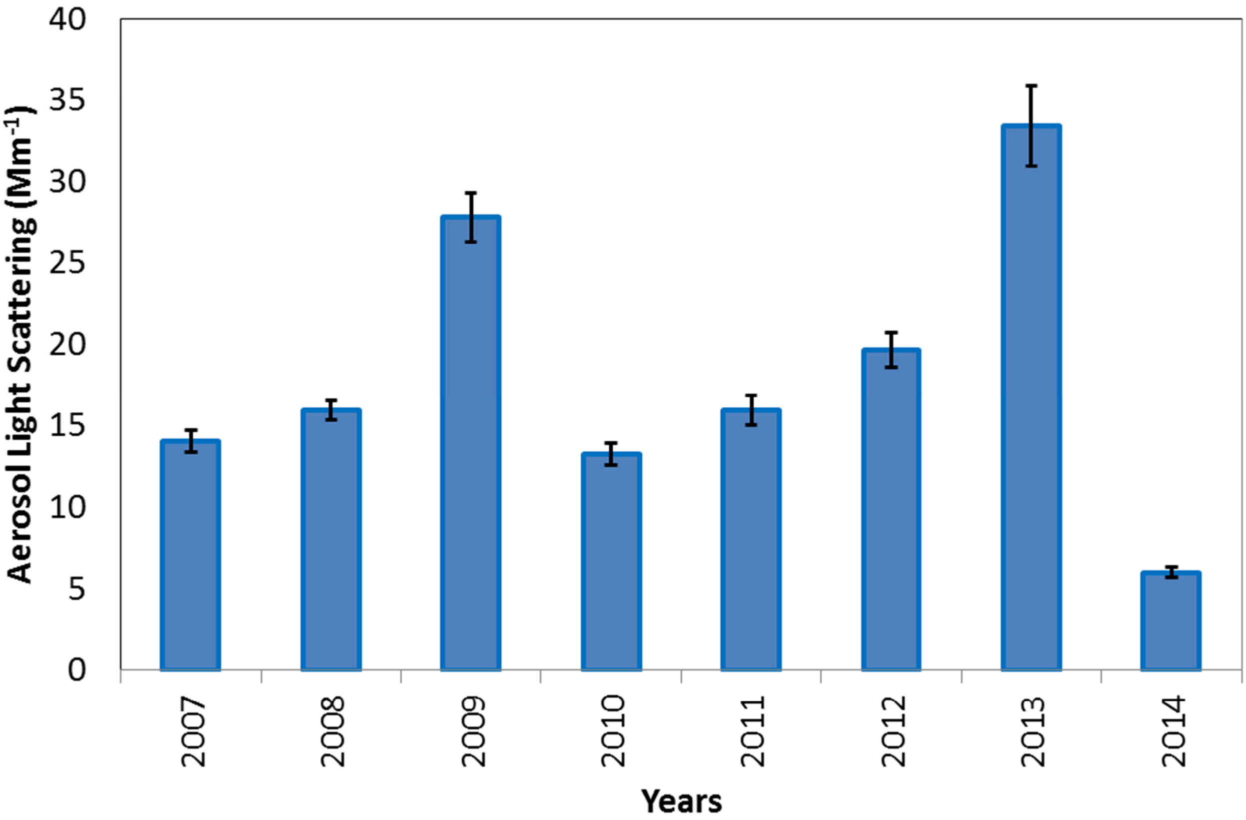
The highest daily mean value of the scattering coefficient at all three wavelength (450, 550, 700 nm) has been observed on **November 30th**, during the identified dust episode (respectively 45.7, 45.6 and 44.6 Mm^{-1}) even though high values were also observed for the pollution and wildfire episodes of September and November (but a with a different wavelength dependence).



Comparison with historical data-set

The 2014 autumn average mean value of scattering coefficient at 550 nm is 6.38 Mm^{-1}, which is **lower than the climatological mean value (20.03 Mm^{-1}).** The clean conditions observed at the measurement site after mid-October, related to the passing of frontal systems, could explain this lower than climatological seasonal scattering.

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

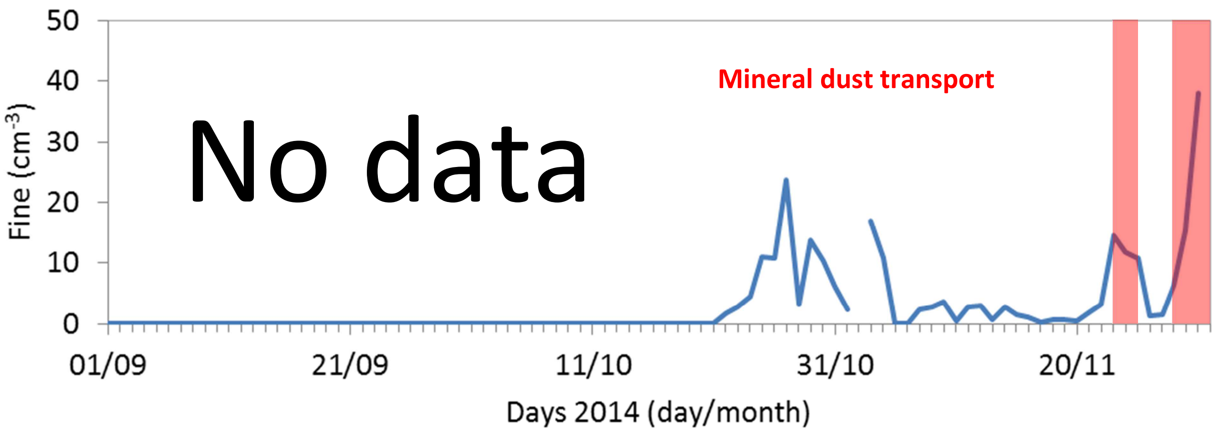
Basic statistical parameters

Statistical parameters are calculated basing on 30-minute aggregated values from September 2014 to November 2014.

Data availability %	Min value (cm^{-3})	25th percentile (cm^{-3})	50th percentile (cm^{-3})	Average mean value (cm^{-3})	75th percentile (cm^{-3})	Max value (cm^{-3})
18.3	0.01	1.0	3.1	7.7	11.3	172.5

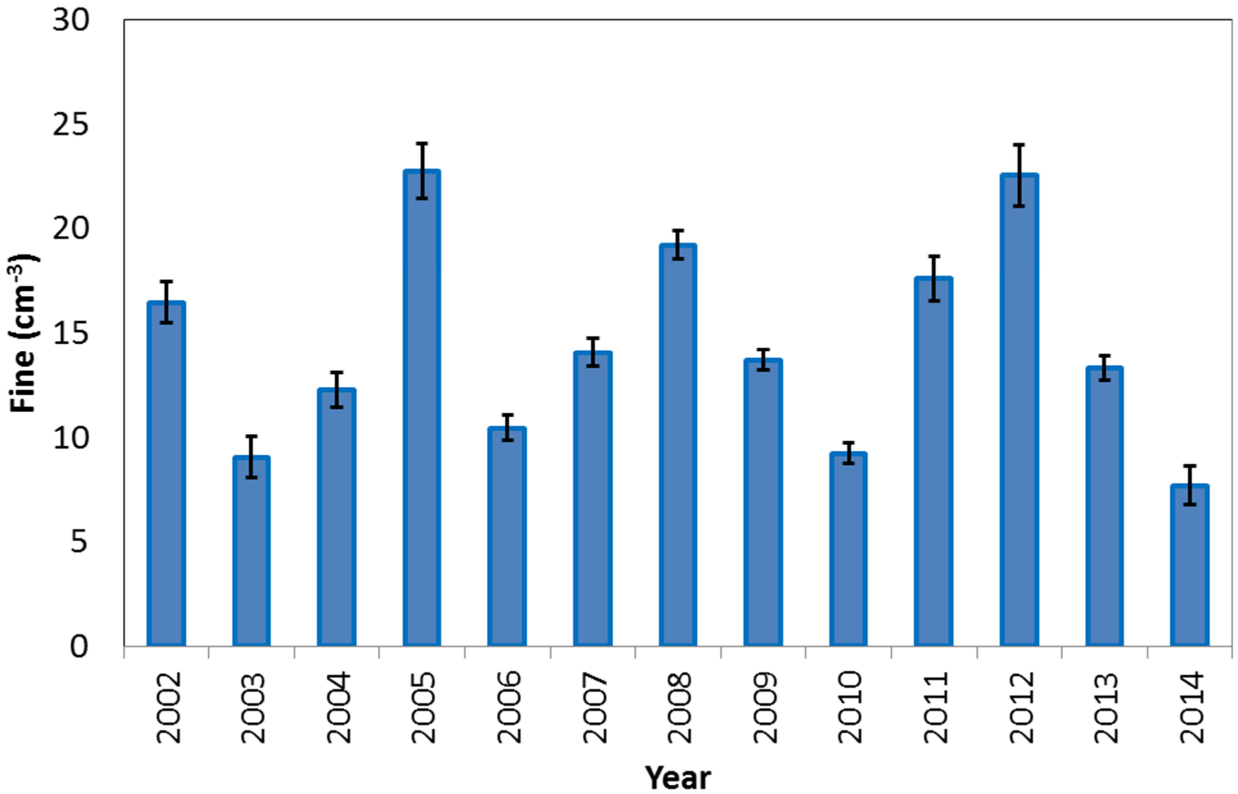
Time series of daily mean values

The highest fine particles daily mean value (38.2 cm^{-3}) has been observed on **30th November**, during the strongest seasonal dust event.



Comparison with historical data-set

Fine particle number 2014 autumn average mean value was 7.7 cm^{-3}: it was **lower than the seasonal climatological value (15.0 cm^{-3})**. However, the low number of available measurement during this period, due to the participation of CMN instrument to an international intercomparison exercise, cannot allow to draw robust comparison with previous years.



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

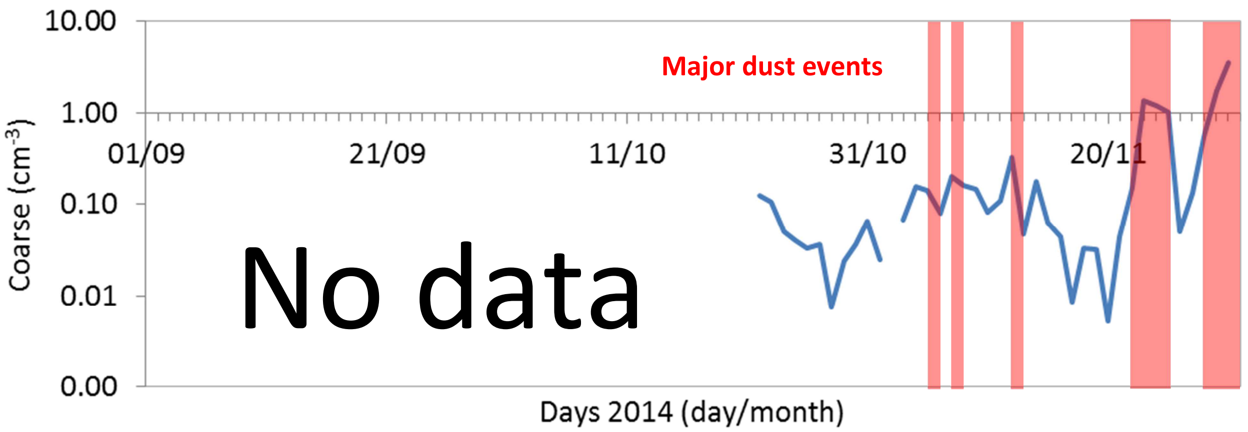
Statistical parameters are calculated basing on 30-minute aggregated values from September 2014 to November 2014.

Data availability %	Min value (cm^{-3})	25th percentile (cm^{-3})	50th percentile (cm^{-3})	Average mean value (cm^{-3})	75th percentile (cm^{-3})	Max value (cm^{-3})
17.0	0.001	0.04	0.08	0.41	0.27	16.69

UDL: Under Detection Limit

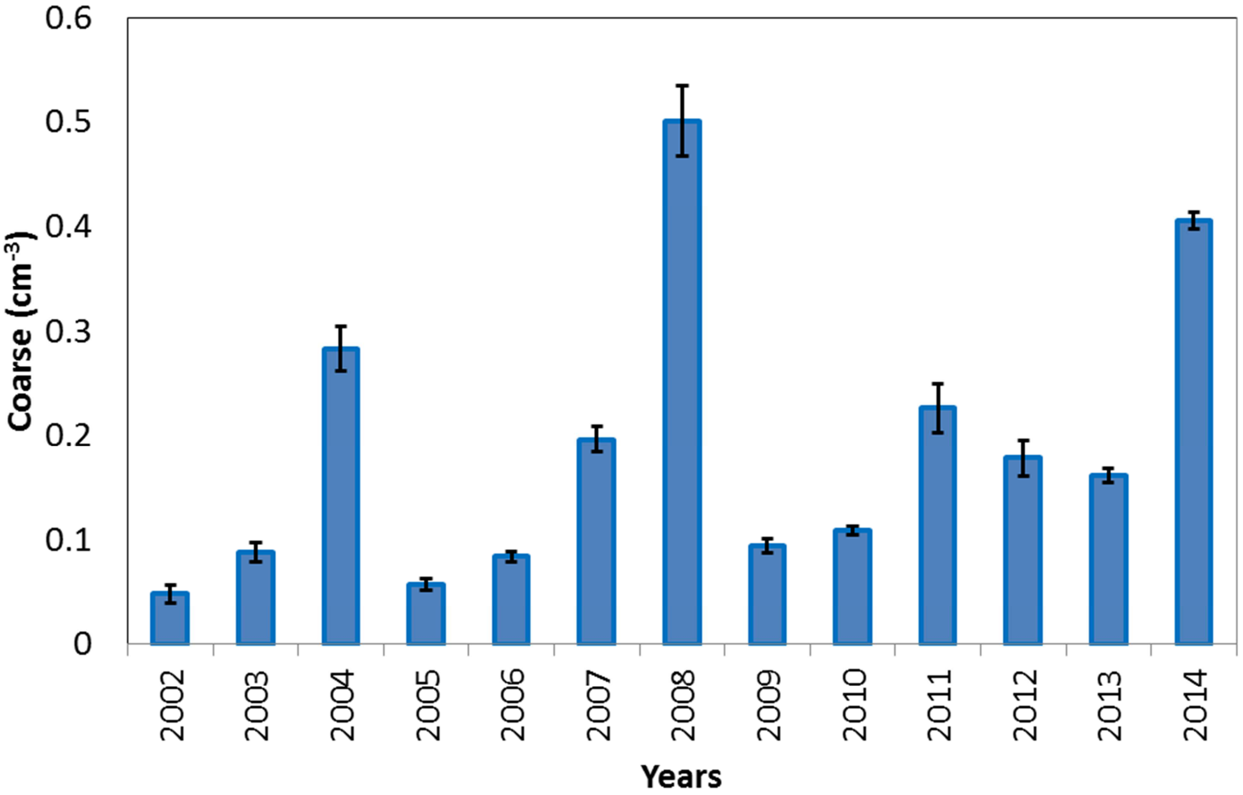
Time series of daily mean values

The highest daily mean value (3.5 cm^{-3}) has been observed on **November 30th** when a major Saharan dust transport affected the Mediterranean basin and Mt. Cimone. All the Saharan dust events during this season were associated to the presence of a pressure trough over west Europe.



Comparison with historical data-set

The autumn 2014 average mean value of the coarse particles (0.41 cm^{-3}) is higher **than the climatological value (0.17 cm^{-3}).** However, the low number of available measurement during this period, due to the participation of CMN instrument to an international intercomparison exercise, cannot allow to draw robust comparison with previous years.



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.

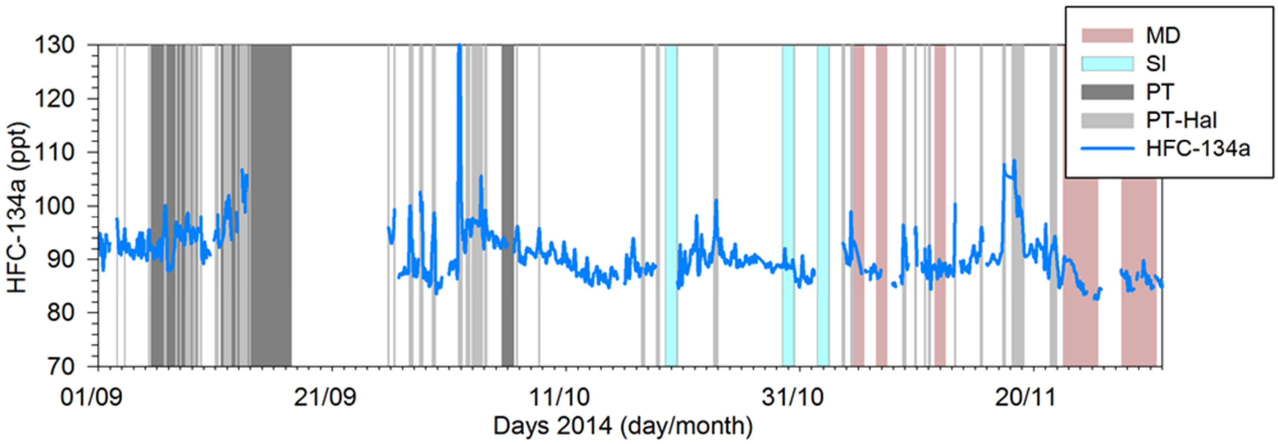
Basic statistical parameters

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)	25^{th} percentile (ppt)	50^{th} percentile (ppt)	Average mean value (ppt)	75^{th} percentile (ppt)	Max value (ppt)
79.1%	82.5	87.7	89.9	90.4	92.7	135.2

Time series of daily mean values

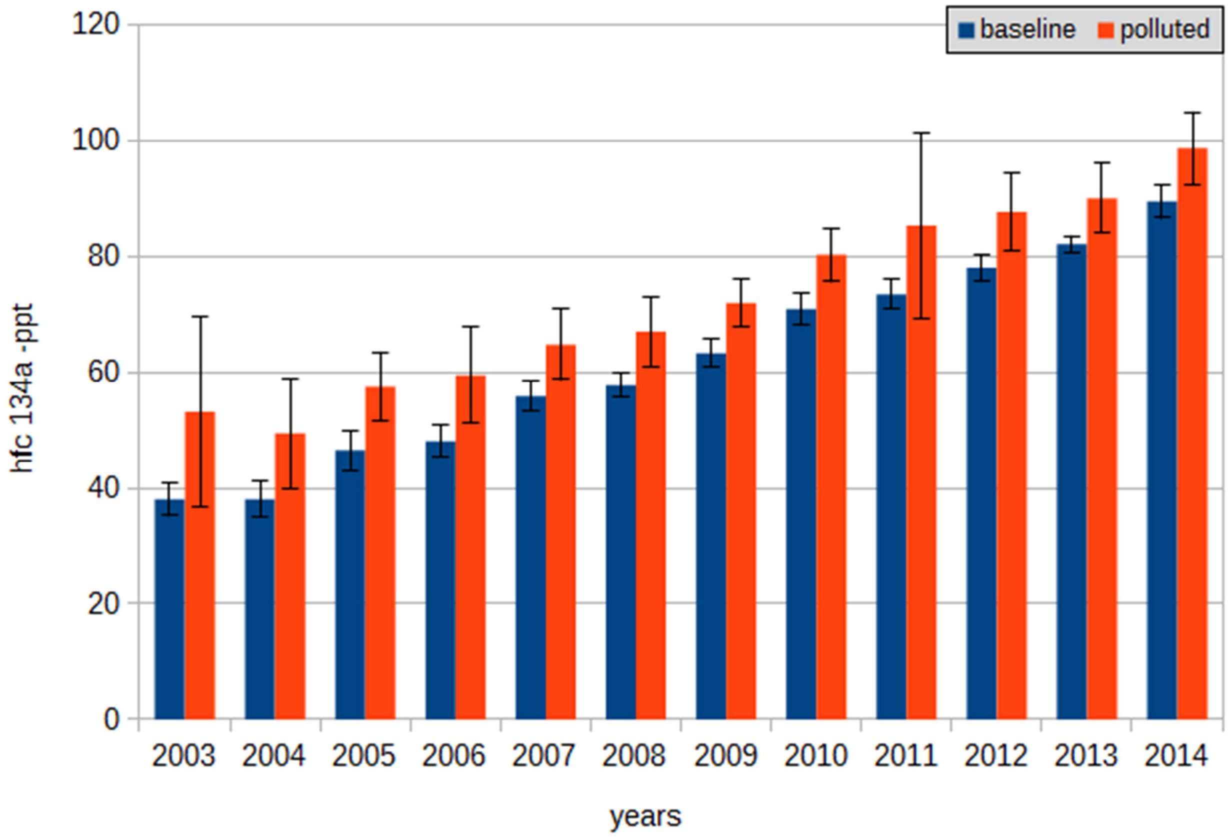
Higher HFC-134a values were observed in September (still influenced by typical summer emissions) with slightly lower concentration in the following months. A high frequency of pollution events is observed in the first half of September, as was observed for the other tracers (CO, O_3 and BC).



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) autumn-averages show **a continuous and uninterrupted increase of atmospheric concentration**. Autumn observations always show a significant differences between the two dataset, whereas the excursion range (1σ, dark bars), tend to lower, due to a modest reduction of the pollution events that are typical of the hot 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?

Voatile 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.

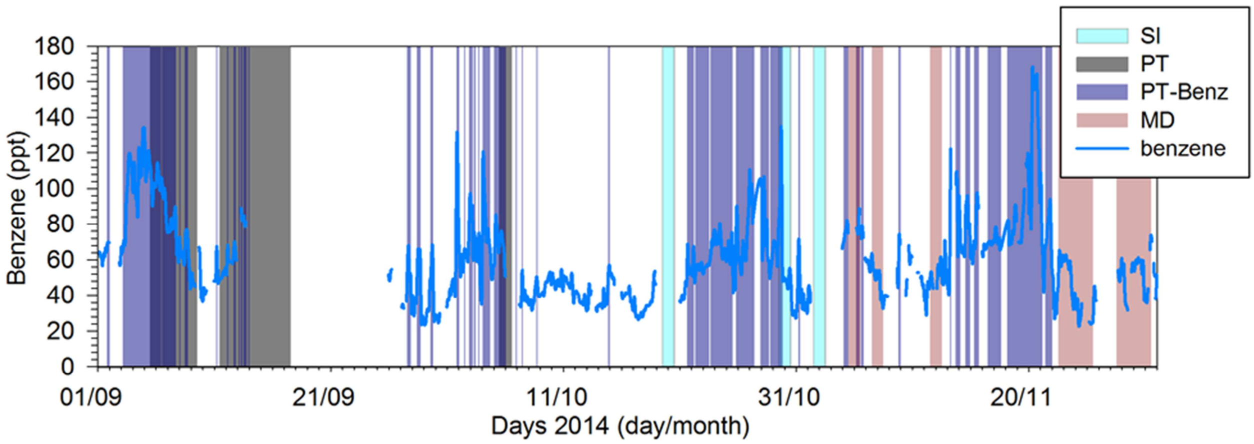
Basic statistical parameters

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)
79.1	22.2	41.3	55.6	59.14	69.3	164.1

Time series of daily mean values

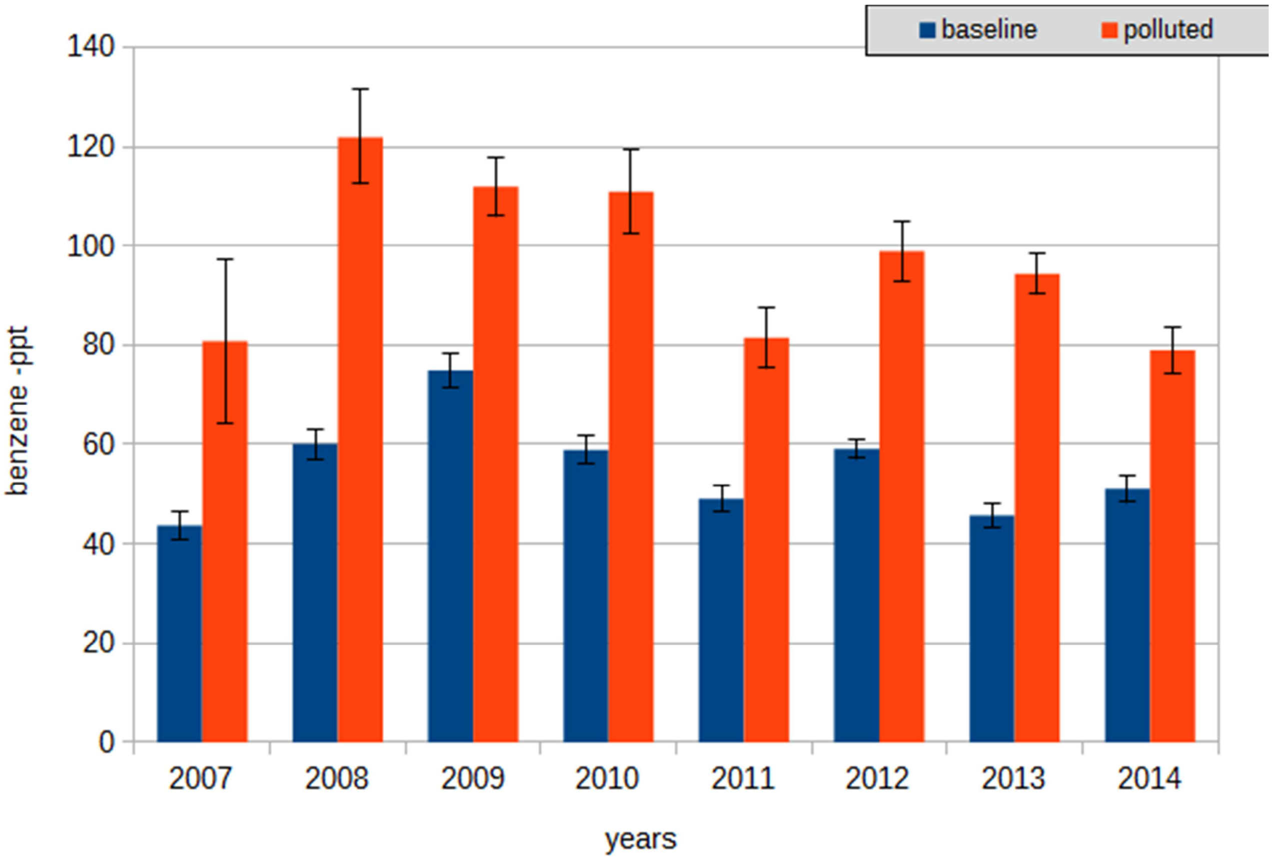
Unlike other pollutions tracers, the autumn observations of Benzene are characterized by an increasing trend after the summer minima, typical of the short-lived compounds. Several episodes of pollution transport are noticeable at the first half of September, in common with other tracers (CO, BC etc.).



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 over the years and within seasons. The discrepancy between baseline (blue) and polluted (orange) data, is an evidence of the transport of polluted air masses from local to mid-range source regions. **Baseline data are comparable during the years, whereas pollution events show a 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.

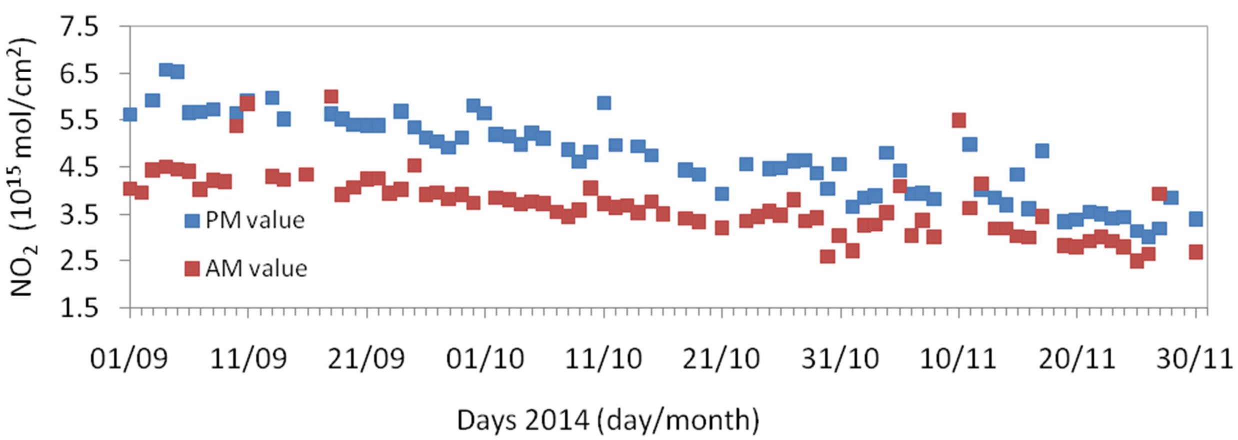
Statistical parameters are calculated basing on 1 data per day from September 2014 to November 2014.

Data availability (%)	Min value (mol/cm^2)	25thpercentile (mol/cm^2)	50thpercentile (mol/cm^2)	Average mean value (mol/cm^2)	75th percentile (mol/cm^2)	Max value (mol/cm^2)
AM (90.1)	2.48	3.28	3.70	3.75	4.05	8.31
PM (81.3)	2.99	3.92	4.81	4.76	5.40	9.8

UDL: under detection limit

Time series of AM and PM values

Data were available starting from September 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 annual trend which consists in a decreasing of the total column of the gases during the period.



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 values 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 NO_2 annual cycle

The annual cycle of Stratospheric NO_2 is driven by photochemical reactions occurring in the stratosphere. The ozone photolysis reaction O_3 + hv =O + O_2, where hv represents the sun radiation (here λ < 325nm), make available oxygen atoms for NO - NO_2 conversion. The O_3photolysis is maximized in summer (due to the shorter path length of solar radiation): together with the released heat it enhances NO_2 formation, leading to a stratospheric NO_2 peak on summer. Fig. A shows the annual cycle of stratospheric NO_2 while Fig. B shows the 21 years stratospheric NO_2 measurements at ICO-OV.

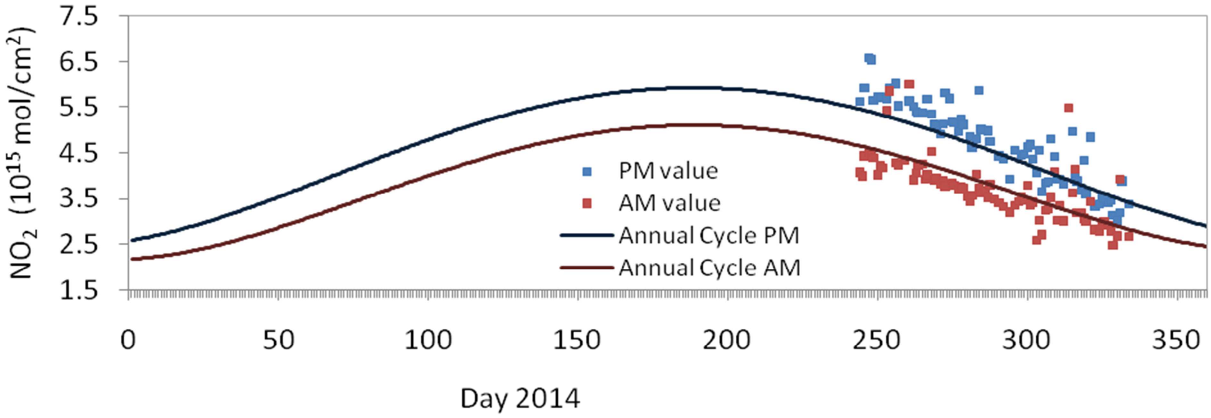


Figure A: annual theoretical cycle (lines) of NO_2 and ICO-OV autumn observed data (dots)

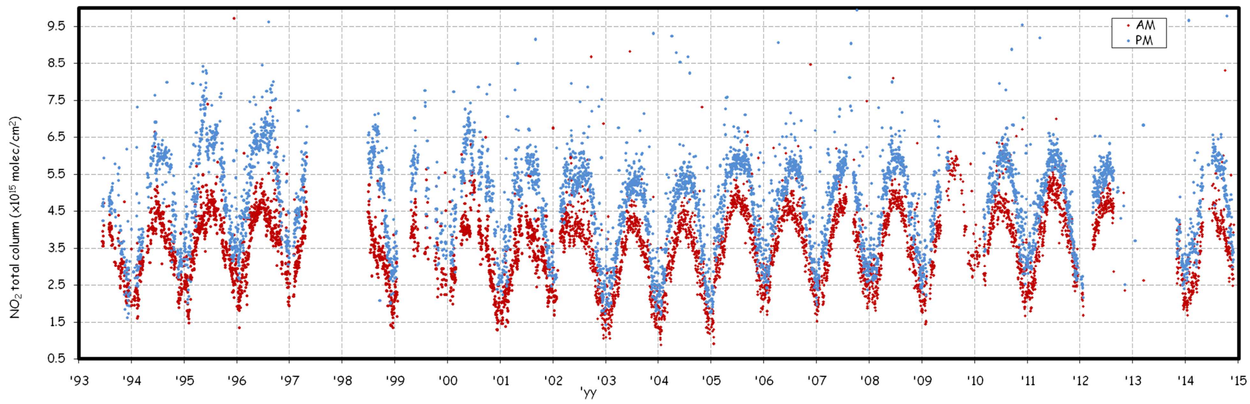


Figure B :21 years of NO_2 Vertical Column measurement at ICO-OV

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).

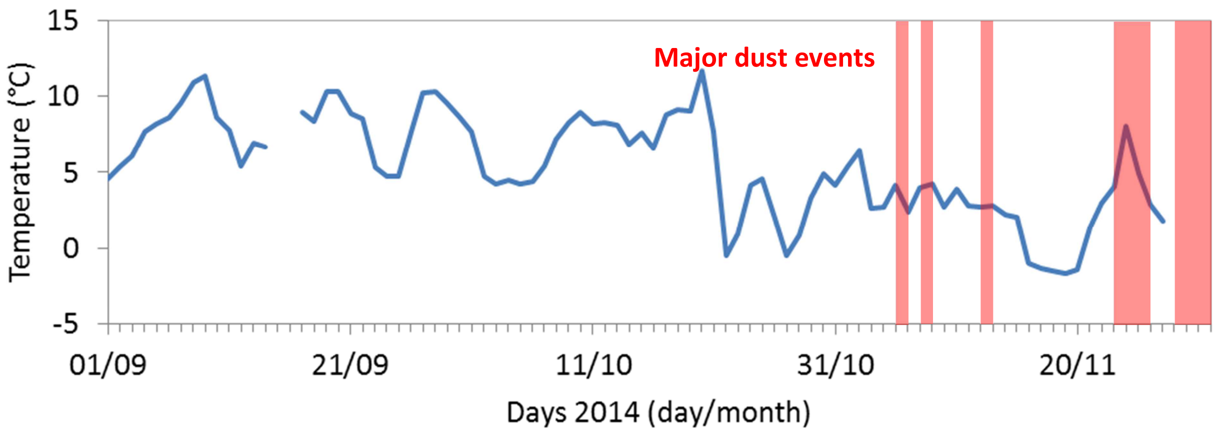
Basic statistical parameters

Statistical parameters are calculated basing on 30-minute aggregated values from September 2014 to November 2014.

Data availability %	Min value (°C)	25^{th} percentile (°C)	50^{th} percentile (°C)	Average mean value (°C)	75^{th} percentile (°C)	Max value (°C)
93.3	-4.5	2.9	5.5	5.4	8.2	14.6

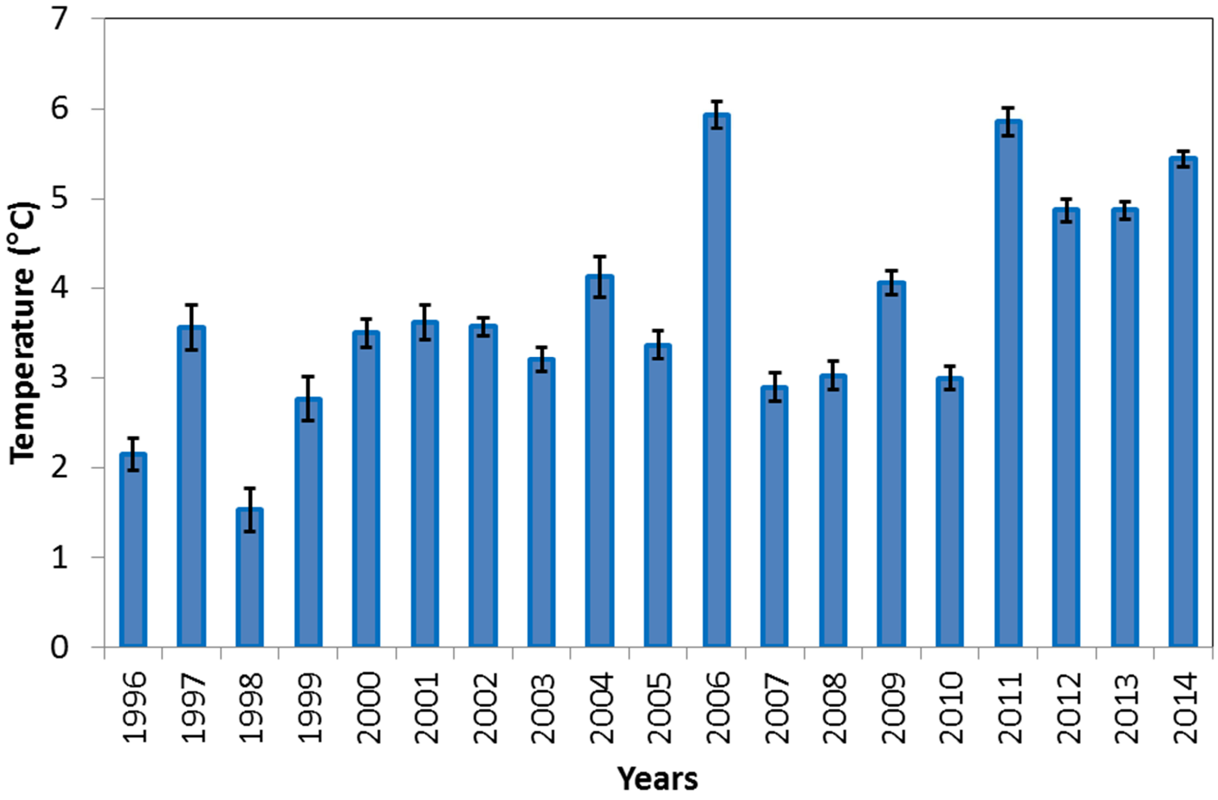
Time series of daily mean values

The highest daily mean value (11.7 °C) has been observed on **20^{th} October**, during an STE event. Even though the latter half of the season was characterized by lower temperature, associated with a general instability and the presence of frontal systems passing over the measurement site, a significant temperature increase was observed on 23-25^{th} November, during a mineral dust transport event from North Africa.



Comparison with historical data-set

The Autumn 2014 average temperature (5.4 °C) is **higher than the seasonal climatological value (3.7 °C):** it constitutes the 3rd higher seasonal value observed at ICO-OV from the beginning of the measurement programme. This is the result of an high pressure, stable weather regime characterizing the first half of the season, resulting in the measurement site been interested by warmer temperature and clear sky conditions.



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).

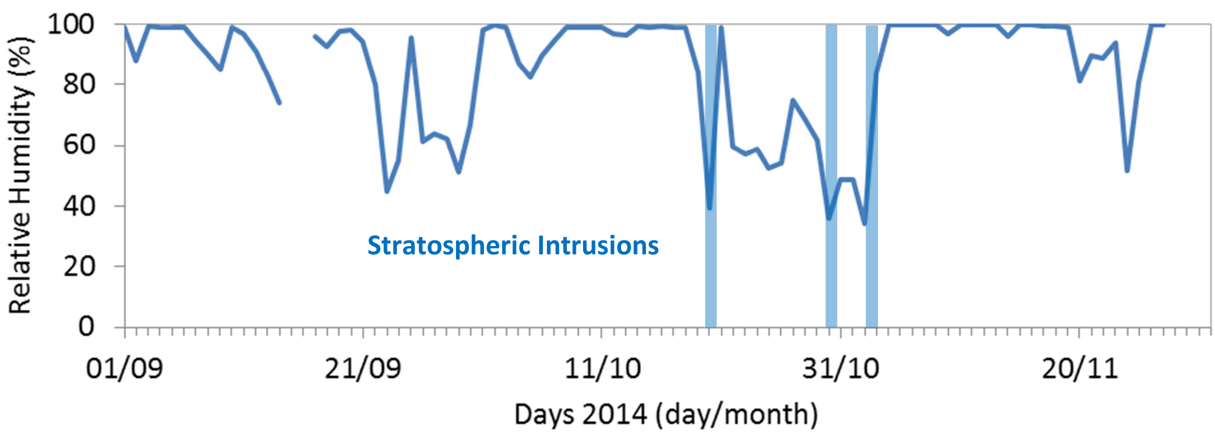
Basic statistical parameters

Statistical parameters are calculated basing on 30-minute aggregated values from September 2014 to November 2014.

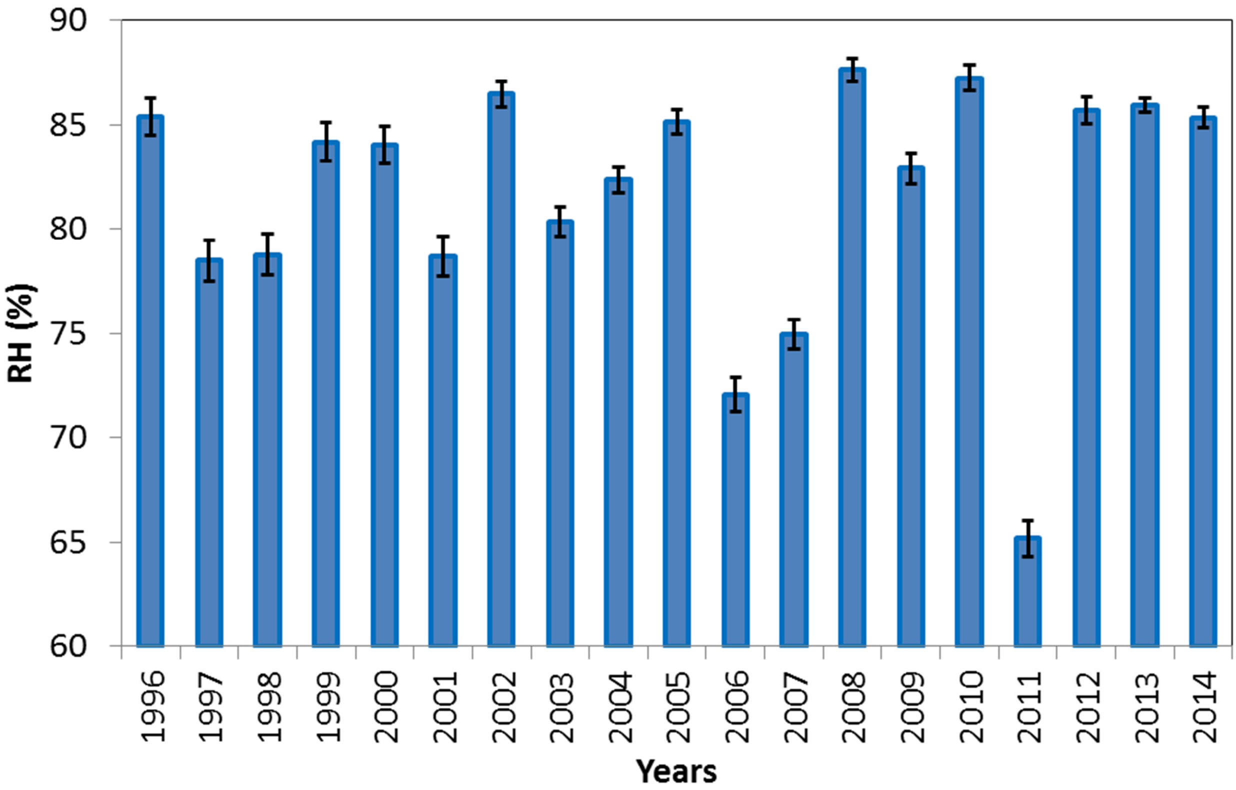
Data availability (%)	Min value (%)	25th percentile (%)	50th percentile (%)	Average mean value (%)	75th percentile (%)	Max value (%)
93.4	8.3	73.1	99.0	85.3	99.9	100.0

Time series of daily mean values

The daily mean RH values ranged from 100% to 34%. The 50% of days showed average value higher than 95%. Periods characterized by relatively dry conditions (mean daily values lower than 60%) were observed on 23rd - 29th September and on 20th October - 2nd November, during the SI events.



Comparison with historical data-set
The Autumn 2014 average relative humidity (85.3%) was **slightly higher than the seasonal climatological value (81.4%).**



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).

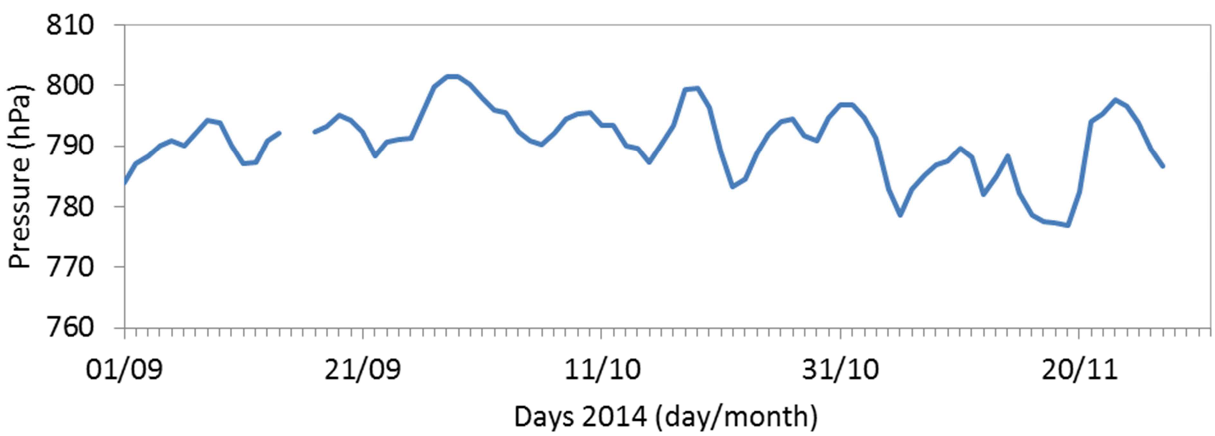
Basic statistical parameters

Statistical parameters are calculated basing on 30-minute aggregated values from September 2014 to November 2014.

Data availability (hPa)	Min value (hPa)	25th percentile (hPa)	50th percentile (hPa)	Average mean value (hPa)	75th percentile (hPa)	Max value (hPa)
93.4	772.3	787.5	791.4	790.8	794.7	801.9

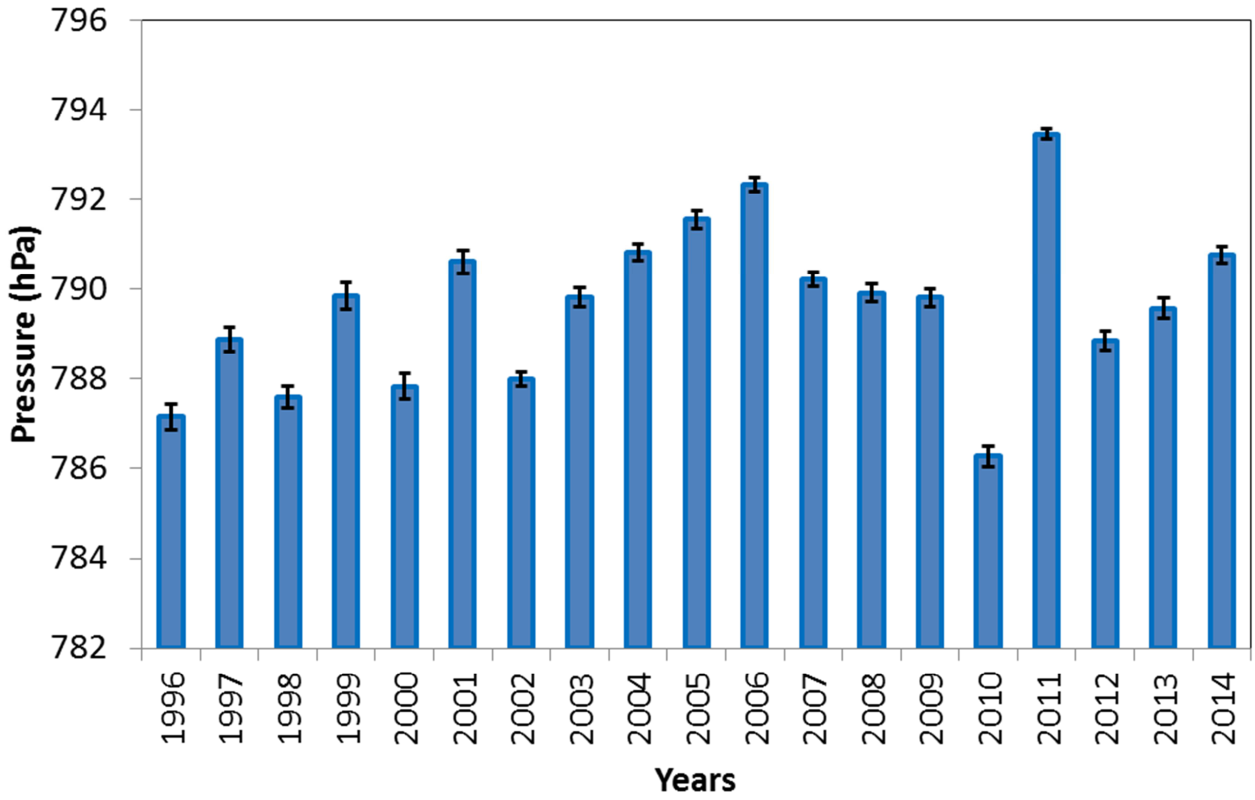
Time series of daily mean values

The seasonal latter half daily mean pressure values were characterized by **high variability: pressure drops alternated with pressure increases**, indicating the passing of frontal systems over the measurement site. The highest daily value (801.5 hPa) occurred on **28th** and **29th September**. A period of prolonged high pressure conditions was observed between the **24th October – 3rd November** when dry conditions also characterized ICO-OV conditions.



Comparison with historical data-set

The Autumn 2014 averaged atmospheric pressure (790.8hPa) was **comparable with the Autumn climatological value (789.5 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.

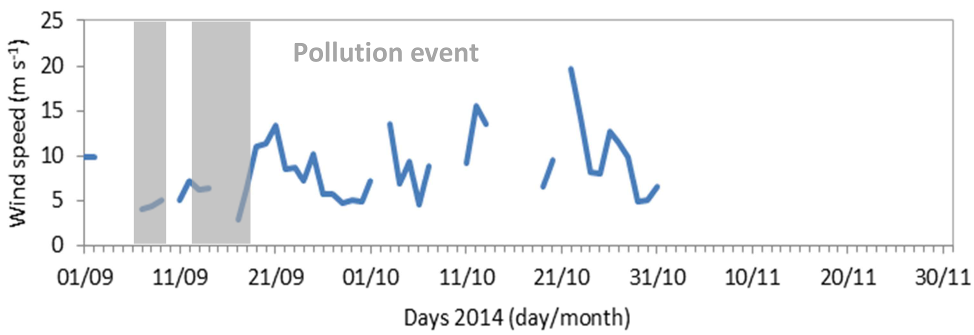
Basic statistical parameters of wind speed

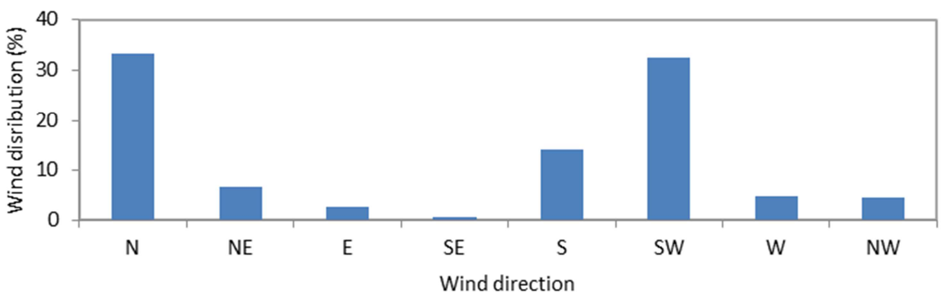
Statistical parameters are calculated basing on 30-minute aggregated values from September 2014 to November 2014. Due to technical problems affecting the primary anemometer (Vaisala 425), IRDAM WST700 data were used. Wind speed data recorded for RH>95% were not considered due to the large instrumental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

Data availability (%)	Min value (m/s)	25th Percentile (m/s)	50th Percentile (m/s)	Average mean value (m/s)	75th percentile (m/s)	Max value (m/s)
29.1	1.3	5.0	7.1	8.0	10.2	30.5

Time series of daily mean values

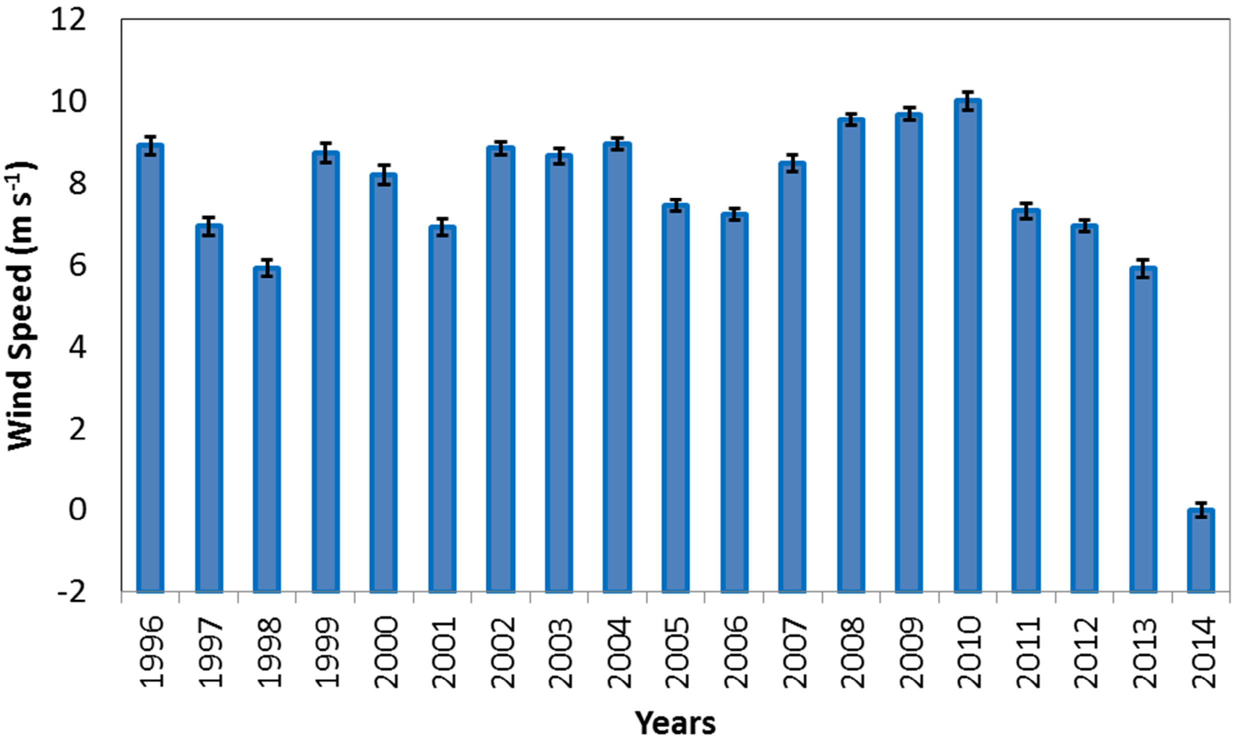
The availability of the wind direction and speed during Autumn 2014 is low, due to instrument malfunctioning. A period of low intensity, northerly winds characterized the first week of September, then W-SW prevailed (during the observed polluted conditions).

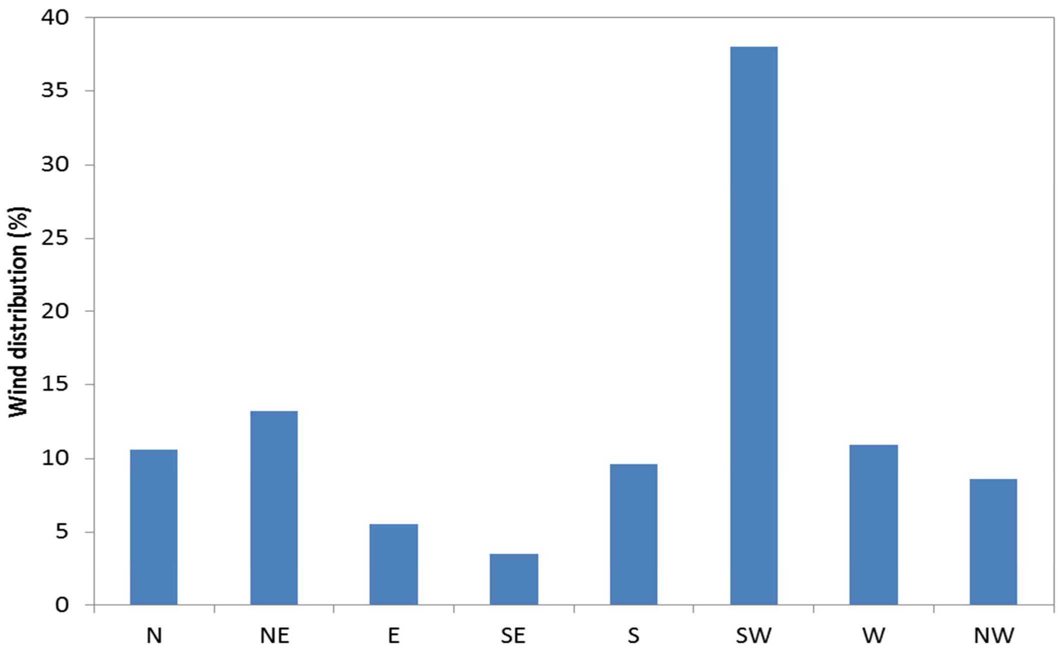




Comparison with historical data-set

The autumn 2014 showed an average wind speed (8.0 m/s) **that is comparable to the climatological value** (8.0 m/s). The seasonal wind direction is shows to prevalent directions, N (33.4 %) and SW (32.4%), with a northerly contribution that exceed what is normally observed at the measurement site (10.4 %). However, both these results are influenced by the reduced number of available data and thus should be considered with caution.





Wind Direction

Solar radiation (short-wave and UV-B)

Why is solar radiation so important?

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

Instrumentation and calibration

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

Basic statistical parameters (Solar radiation)

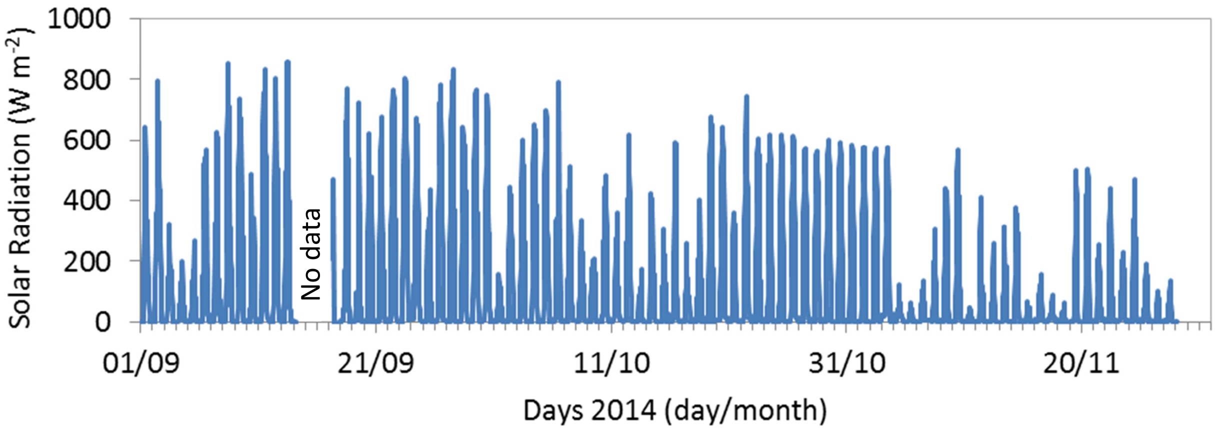
Statistical parameters are calculated basing on 30-minute aggregated values from September 2014 to November 2014.

Data availability (%)	Min value (W/m^2)	25^{th} Percentile (W/m^2)	50^{th} Percentile (W/m^2)	Average mean value (W/m^2)	75^{th} percentile (W/m^2)	Max value (W/m^2)
93.4	UDL	UDL	5.8	110.2	150.8	858.3

UDL: under detection limit

Time series (Solar radiation)

Autumn 2014 was characterized by clear sky condition for the majority of the first half, when the highest daily average value (239.6 W m^{-2}) was observed on **September 23th**. On the other hand, starting from October 9th, an increase in solar radiation variability was observed, related to the passage of cloud systems or deposition of snow/ice over the sensor. Clear sky condition (albeit with reduced intensity) were observed during the 23th – 25th November dust event.



Basic statistical parameters (UV-B)

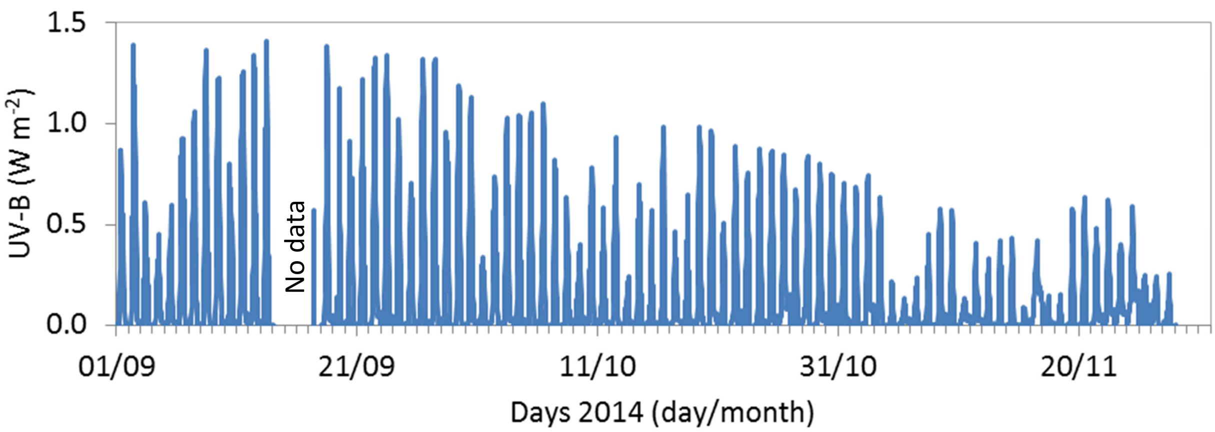
Statistical parameters are calculated basing on 30-minute aggregated values from September 2014 to November 2014.

Data availability (%)	Min value (W/m^2)	25th Percentile (W/m^2)	50th Percentile (W/m^2)	Average mean value (W/m^2)	75th percentile (W/m^2)	Max value (W/m^2)
93.4	UDL	UDL	0.02	0.15	0.19	1.41

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 (0.3 W m^{-2}) value was observed on **September, 11th**. Snow deposition an ice rimming could have influenced measurements during November.



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Research Projects

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

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

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

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

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

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

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

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

AGAGE-Advanced Global Atmospheric Gases Experiment AGAGE and its predecessors (the Atmospheric Life Experiment, ALE, and the Global Atmospheric Gases Experiment, GAGE) have been measuring the composition of the global atmosphere continuously since 1978. The AGAGE is distinguished by its capability to measure over the globe at high frequency almost all of the important gases species in the Montreal Protocol (e.g. CFCs and HCFCs) to protect the ozone layer and almost all of the significant non-CO_2 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, SF_6), 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.

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