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

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

AUTUMN 2013 REPORT

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

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Summer report of the Italian Climate Observatory "O. Vittori" at Mt.Cimone – n.2
Issued: February 2014, rev. 1
The report is published quarterly. Download at: http://www.isac.cnr.it/cimone/reports
ISSN: 2283-9631

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

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

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

CNR
National Research Council of Italy
Consiglio Nazionale delle Ricerche

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

WDCGG
World Data Center for Greenhouse Gases
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http://ds.data.jma.go.jp/gmd/wdcgg/

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

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

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

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

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

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

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Foreword

This report summarizes the results concerning the atmospheric observations carried out during AUTUMN – September, October, November - 2013 at the Italian Climate Observatory "O. Vittori" (ICO-OV), managed by the Institute of Atmospheric Sciences and Climate (ISAC) of the National Research Council of Italy (CNR). This research infrastructure is part of the WMO/GAW global station of Monte Cimone together with the Meteorological Observatory of the Italian Air Force(GAW ID: CMN).

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

Then, an overview of the atmospheric and weather conditions during autumn 2013 considering:

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

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

Then, a list of special events which occurred during the period 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 September 1st to November 30th.**

Premessa

Questo rapporto riassume i risultati relativi alle osservazioni atmosferiche effettuate durante l'AUTUNNO – settembre, ottobre, novembre - 2013 presso l'Osservatorio Climatico "O. Vittori " (ICO-OV) dell'Istituto di Scienze dell'Atmosfera e del Clima (ISAC) del Consiglio Nazionale delle Ricerche Italia (CNR). Questa stazione di ricerca è parte, insieme all'Osservatorio Meteorologico dell'Aeronautica Militare, della stazione globale WMO/GAW di Monte Cimone (GAW ID: CMN).

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

Quindi viene data una panoramica delle condizioni atmosferiche e meteorologiche che hanno caratterizzato il periodo autunnale 2013, descrivendo gli andamenti di:

- **ozono superficiale**
- **monossido di carbonio**
- **ossidi di azoto**
- **black carbon**
- **particolato fine e grossolano**
- **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.

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

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

Per ogni parametro osservato uno specifico paragrafo presenta:

- **le serie storiche dei valori medi giornalieri (calcolati basandosi su valori mediati di 30 minuti, se la copertura dei dati giornaliera del 75% è stata raggiunta)**
- **una tabella con i parametri statistici fondamentali (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.**

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 29Global 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

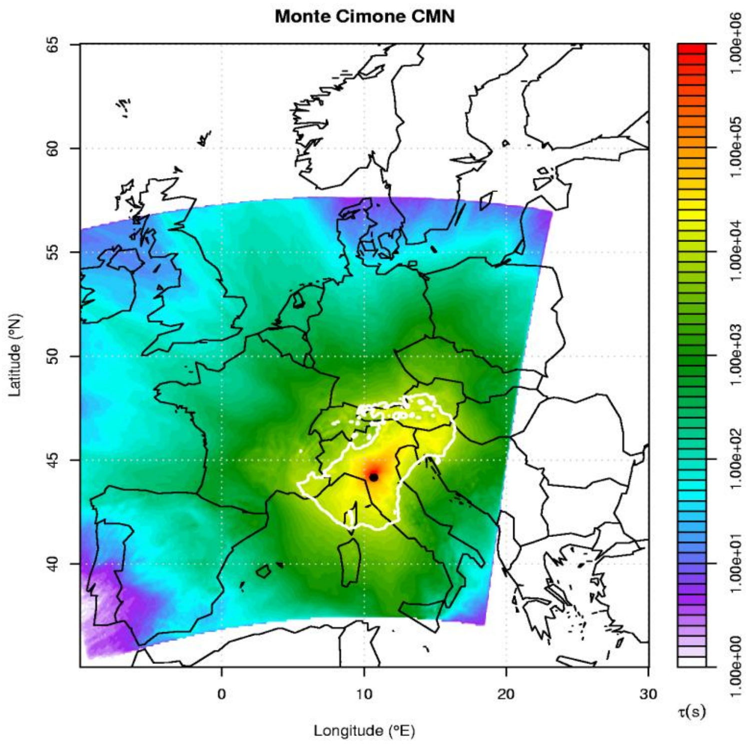
Lista delle stazioni globali GAW/WMO in aree di alta quota (for more information: http://gaw.empa.ch/gawsis/)

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).

Posizione geografica

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

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

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

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

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

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

List of parameters

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

Parameters	Key role	Instrumentation
Surface ozone	Short-lived climate forcer, greenhouse gas, secondary pollutant	UV-absorption analyser *(Dasibi 1108 W/GEN)*
Carbon monoxide	Primary pollutant, ozone precursor, combustion tracer	Non dispersive IR absorption *(Thermo Tei48c-TL)*
Nitrogen oxides	Primary (NO) and secondary (NO_2) pollutants, ozone precursors, combustion tracers	Chemiluminescence analyser (*Thermo Tei42)*
Black carbon	Short-lived climate forcer, primary pollutant, combustion tracer. It contributes to PM_1	Multi-Angle Absorption Photometer *(Thermo MAAP 5012)*
Aerosol number concentration (fine)	Short-lived climate forcer, primary and secondary aerosol, pollution tracer. It contributes to PM_1.	Optical particle counter *(GRIMM 1108)*
Aerosol number concentration (coarse)	Short-lived climate forcer, primary aerosol, mineral dust and sea salt tracer. It contributes to PM_{10}.	Optical particle counter *(GRIMM 1108)*
Temperature	Meteorology and data interpretation	*Rotronic, IRDAM WS 7000*
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 atmosferici presentati in questo report, assieme ad una breve descrizione dei loro ruoli nelle ricerche condotte ed il set up sperimentale utilizzato presso l'ICO-OV.

Parametri	**Ruolo chiave clima – qualità dell'aria**	**Strumentazione**
Ozono superficiale	Forzante climatico a breve tempo di vita, gas serra, inquinante secondario.	Analizzatore ad assorbimento UV *(Dasibi 1108 W/GEN)*
Monossido di carbonio	Inquinante primario, precursore dell'ozono, tracciante della combustione	Analizzatore ad assorbimento infra-rosso *(Thermo Tei48c-TL)*
Ossidi d'azoto	Inquinanti primari (NO) e secondari (NO_2), precursori dell'ozono, traccianti della combustione	Analizzatore a chemiluminescenza (*Thermo Tei42)*
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)*
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)*
Temperatura	Meteorologia ed interpretazione dei dati	*Rotronic, IRDAM WS 7000*
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 2013 did not present high average levels of short-lived climate forcers (SLCF): a value lower than the climatological mean was observed for surface ozone, carbon monoxide, black carbon and fine particles. For coarse particles we reported an average value similar with previous autumn seasons. The atmospheric and meteorological regime were well representative of the transition from Summer (more polluted and more affected by mineral dust transport) to Winter.

8.8% of the autumn days have been affected for a significant fraction of time by transport of polluted air-masses, with all of them taking place only on September.

11 days (12.1%) were affected by mineral dust transport, with a major event occurring from October 27th to 31st.

Air-mass transport from the stratosphere occurred for 9.9% of the period and have been observed mostly in September (66% of detected events).

Daily **surface ozone** peak was recorded on 04-09 (67.2 ppb). 30-minute average values ranged from a minimum of 8.4 ppb (12-11) to 83.7 ppb (05-09), with an average seasonal value of 46.0 ppb. This value is slightly lower than the average climatological autumn value obtained from the last 18 years (48.6 ppb).

Daily **carbon monoxide** peak was recorded on 15-11 (150.4 ppb). 30-minute average values ranged from a minimum of 45.4 ppb (23-09) to 212.7 ppb (15-09), with an average seasonal value of 100.7 ppb. This value is lower than the average value of autumn 2012 (114.5 ppb).

Daily **black carbon** peak was recorded on 04-09 (442.4 ng m^{-3}). 30-minute average values ranged from a minimum of 10.0 ng m^{-3} (16-10) to 1001.8 ng m^{-3} (20-09), with an average seasonal value of 135.4 ng m^{-3}. This value is lower than the average climatological autumn value obtained from the last 8 years (190.8 ng m^{-3}).

Daily **fine aerosol particles** peak was recorded on 02-09 (79.5 cm^{-3}). 30-minute average values ranged from a minimum of 0.01 cm^{-3} (24-11) to 152.4 cm^{-3} (20-09), with an average seasonal value of 13.3 cm^{-3}. This value is slightly lower than the average climatological autumn value obtained from the last 12 years (15.0 cm^{-3}).

Sommario

VISIONE DI INSIEME

L'autunno del 2013 non ha presentato valori medi elevati di *short-lived climate forcers* (SLCF): l'ozono, il black carbon, il monossido di carbonio ed il particolato fine hanno mostrato valori inferiori rispetto alle medie climatologiche. Le particelle grossolane hanno mostrato valori in linea con quelli dei precedenti anni. In generale appare evidente la transizione dal periodo estivo (tipicamente caratterizzato da più frequenti condizioni di inquinamento e trasporto di polveri minerali) a quello invernale.

Solo 8.8% dei giorni sono stati influenzati da trasporti di masse d'aria inquinate: tutti gli eventi sono stati osservati nel mese di Settembre.

11 giorni (12.1%) sono stati caratterizzati da eventi di trasporto di sabbia sahariana: l'episodio più intenso è stato osservato dal 27 al 31 di Ottobre.

Nel 9.9 % dei giorni sono stati identificati eventi di trasporto di masse d'aria provenienti dalla stratosfera. La maggior parte (66%) dei giorni influenzati da tali eventi è stata osservata nel mese di settembre.

Il valore massimo giornaliero della concentrazione di **ozono superficiale** è stato registrato il 04-09 (67.2 ppb). Le medie semi-orarie variano da 8.4 ppb (12-11) a 83.7 ppb (05-09), con un valore medio stagionale di 46.0 ppb, leggermente 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 15-11 (150.4 ppb). Le medie semi-orarie variano da 45.4 ppb (23-09) a 212.7 ppb (15-09), con un valore medio stagionale pari a 100.7 ppb. Tale valore è leggermente inferiore a quello dell'autunno 2012 (114.5 ppb).

Il valore massimo giornaliero della concentrazione di **black carbon** è stato registrato il 04-09 (442.4 ng m^{-3}). Le medie semi-orarie variano da 10.0 ng m^{-3} (16-10) a 1001.8 ng m^{-3} (20-09), con un valore medio stagionale pari a 135.4 ng m^{-3}. Tale valore è inferiore a quello climatologico relativo agli ultimi 8 anni (190.8 ng m^{-3}).

Il valore massimo giornaliero della concentrazione di **particelle fini** è stato registrato il 02-09 (79.5 cm^{-3}). Le medie semi-orarie variano da 0.01 cm^{-3} (24-11) a 152.4 cm^{-3} (20-09), con un valore medio stagionale pari a 13.3 cm^{-3}. Tale valore è leggermente inferiore a quello climatologico (15.0 cm^{-3}).

Daily **nitric oxide** and **nitrogen dioxide** peaks were recorded on 23-11 (0.46 ppb) and (2.7 ppb), respectively. 30-minute average values ranged from values below the detection limit to 2.06 ppb (for NO) and 5.77 ppb (for NO_2).

Daily **coarse aerosol particles** peak was recorded on 30-10 (0.8 cm^{-3}). 30-minute average values ranged from a minimum of 0.001 cm^{-3} (24-11) to 1.2 cm^{-3} (30-10), with an average seasonal value of 0.15 cm^{-3}. This value is comparable to the average climatological autumn value obtained from the last 12 years (0.17 cm^{-3})

Daily **air temperature** peak was recorded on 04-09 (13.7°C), minimum on 27-11 (-8.2 °C). 30-minute average values ranged from a minimum of -10.0 °C (27-11) to 19.0 °C (04-09), with an average seasonal value of 4.9 °C. This was the fourth highest autumn from the last 18 years.

Daily **relative humidity** minimum was recorded on 24-09 (41.0%). 30-minute average values ranged from a minimum of 22.7 % (24-09) to a maximum of 100.0 % (observed on 40 days), with an average seasonal value of 86.0 %. 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 03-09 (799.8 hPa), the lowest value on 23-11 (770.9 hPa). 30-minute average values ranged from a minimum of 768.3 hPa (21-11) to 801.0 hPa (03-09), with an average seasonal value of 789.8 hPa. This value is on par with the average climatological autumn value obtained from the last 18 years (789.5 hPa).

Daily **wind speed** peak was recorded on 12-11 (17.2 m s^{-1}). 30-minute average values ranged from a minimum of 0.6 m s^{-1} (20-09) to a maximum of 31.3 m s^{-1} (11-11), with an average seasonal value of 5.9 m s^{-1}. This value is lower than the average climatological autumn value obtained from the last 18 years (8.0 m s^{-1}).

Wind direction was prevalently from SW (27.4 % of 30-minute data). This is similar to the climatological analysis over the last 18 years.

Daily **Solar radiation** showed a decreasing trend from September to November: the highest average daily value was recorded on 04-09 (283.3 W m^{-2}), while the lowest was observed on 23-11 (6.2 W m^{-2}).

Also **UV-B radiation** showed a decreasing trend: the highest value was observed on 04-09 (1.8 W m^{-2}), while the lowest was observed during the last decade of November (0.003 W m^{-2} on 21-11).

I valori massimi giornalieri di **ossido d'azoto** e **biossido d'azoto** sono stati rispettivamente registrati il 23-11 (0.46 ppb e 2.7 rispettivamente). Le medie semi-orarie sono variate da valori inferiori al limite di rivelazione sino a 2.06 ppb (per NO) e 5.77 ppb (per NO_2).

Il valore massimo giornaliero della concentrazione di **particelle grossolane** è stato registrato il 30-10 (0.8 cm^{-3}). Le medie semi-orarie variano da 0.001 cm^{-3} (24-11) a 1.2 cm^{-3} (30-10), con un valore medio stagionale pari a 0.15 cm^{-3}. Tale valore è confrontabile con quello climatologico relativo ultimi 12 anni (0.17 cm^{-3}).

Il valore massimo giornaliero della **temperatura** è stato registrato il 04-09 (13.7 °C), il valore minimo il 27-11 (-8.2 °C). Le medie semi-orarie variano da -10.0 °C (27-11) a 19.0 °C (04-09), con un valore medio stagionale pari a 4.9 °C. Tale valore rappresenta il quarto più elevato registrato neglu ultimi 18 anni.

Il valore minimo giornaliero dell'**umidità relativa** è stato registrato il 24-09 (41.0 %). Le medie semi-orarie variano da 22.7 % (24-09) a 100 % (osservato in 40 giornate), con un valore medio stagionale pari a 86.0 %. 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 03-09 (799.8 hPa), il valore minimo il 23-11 (770.9 hPa). Le medie semi-orarie variano da 768.3 hPa (21-11) a 801.0 hPa (03-09), con un valore medio stagionale pari a 789.8 hPa. Tale valore è confrontabile con quello climatologico relativo agli ultimi 18 anni (789.5 hPa).

Il valore massimo giornaliero della **velocità del vento** è stato registrato il 12-11 (17.2 m s^{-1}). Le medie semi-orarie variano da 2.4 km h^{-1} (20-09) a 125.2 km h^{-1} (11-11), con un valore medio stagionale pari a 23.6 km h^{-1}. Tale valore è inferiore a quello climatologico ottenuto dalle misure realizzate negli ultimi 18 anni (32.0 kmh^{-1}).

La **direzione del vento** osservata nell'autunno 2013 è stata prevalentemente da Sud-Ovest (27.4 % dei dati semi-orari). Non vi sono differenze significative con l'andamento climatologico degli ultimi 18 anni.

La **radiazione solare** mostra un evidente trend decrescente da Settembre a Novembre: il valore giornaliero più elevato è stato registrato il 04-09 (283.3 W m^{-2}), quello più basso registrato il 23-11 (6.2 W m^{-2}).

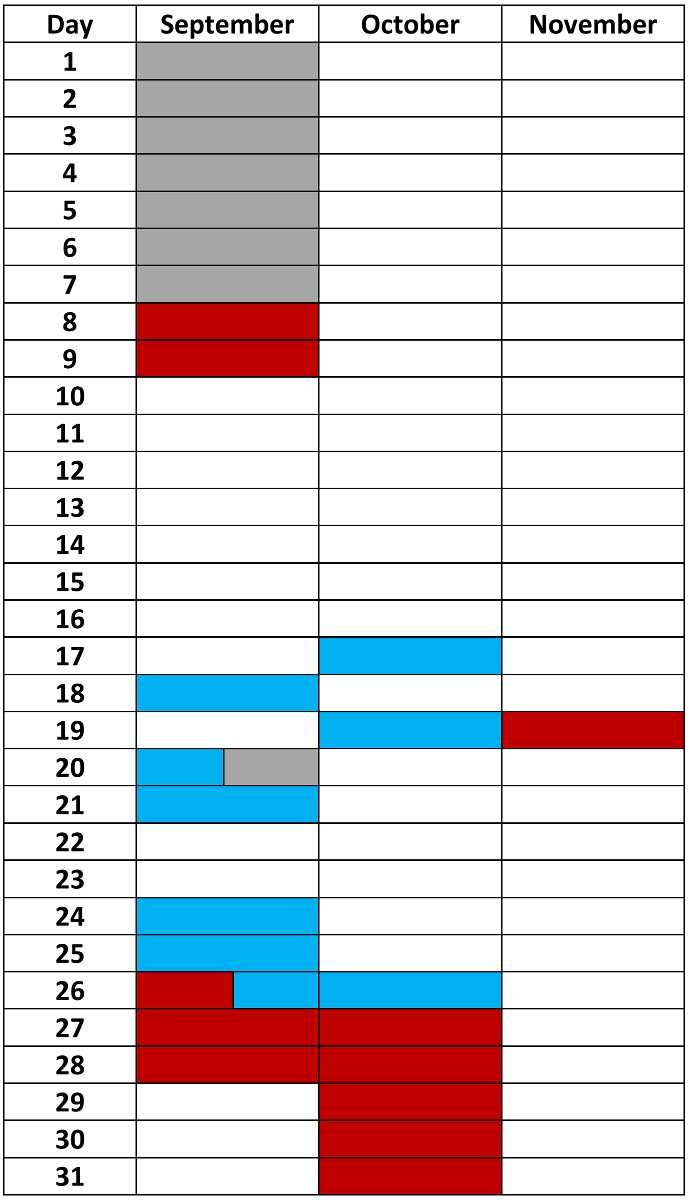
Anche la **radiazione UV-B** mostra un trend decrescente nel corso della stagione: il valore massimo (1.8 W m^{-2}) è stato osservato il 04-09, mentre il valore più basso (0.003 W m^{-2}) nell'ultima decade di novembre (il giorno 21-11).

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 (11 days);**
- **Stratospheric intrusions (9 days);**
- **Pollution transport (8 days).**

<u>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.</u>



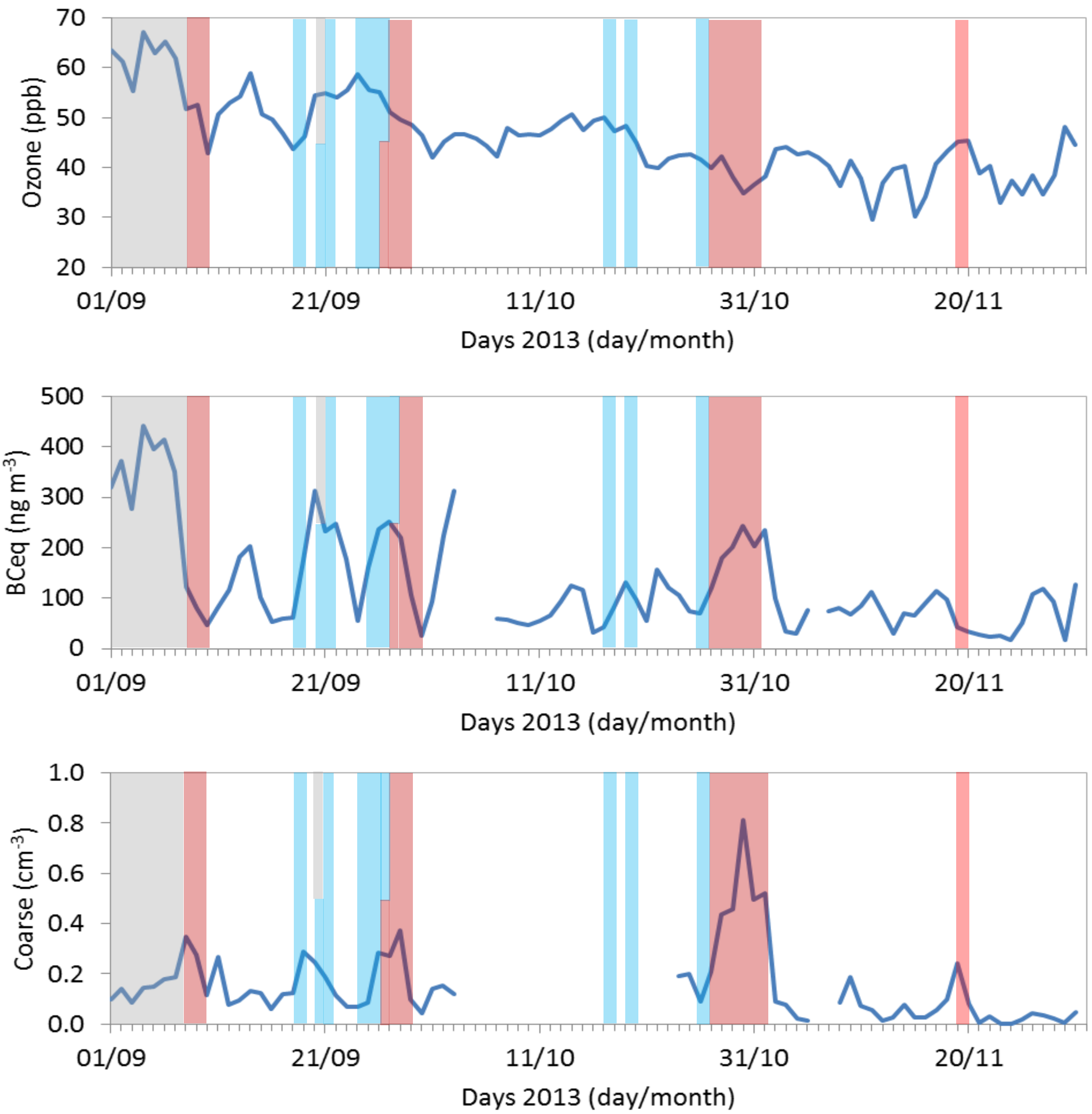
LEGEND

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 (11 giorni);**
- **Intrusioni stratosferiche (9 giorni);**
- **Trasporto di inquinanti (8 giorni).**

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

Polveri minerali | Intrusioni stratosferiche | Trasporto di inquinanti

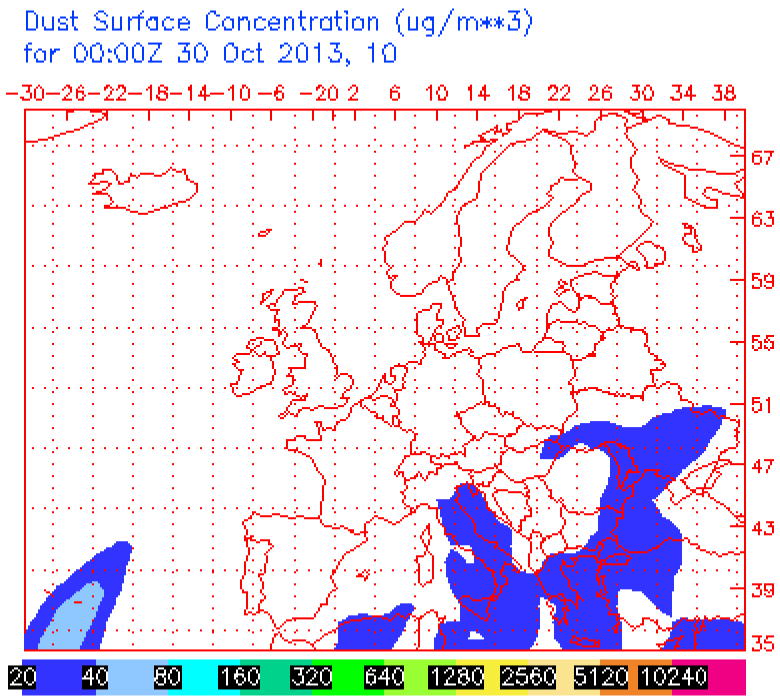
Mineral dust transport

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

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

AUTUMN 2013:

- **11 days were characterized by the transport of mineral dust from northern Africa (12.1 % of the period).**
- **The detected events were usually associated with the presence of a high pressure system over the central Mediterranean basin, triggering southwesterly winds over the Tyrrhenian Sea which favored the transport of mineral dust from western North Africa.**
- **The most important dust event occurred from October 27th to 31st, when the coarse particle reached the concentration of 1.2 cm^{-3}, on 30th October 2013.**



Dust transport event simulation by NAAPS model (30th October 2013).

Simulazione dell'evento di trasporto di polveri minerali osservato il 30 Ottobre 2013 (modello NAAPS).

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

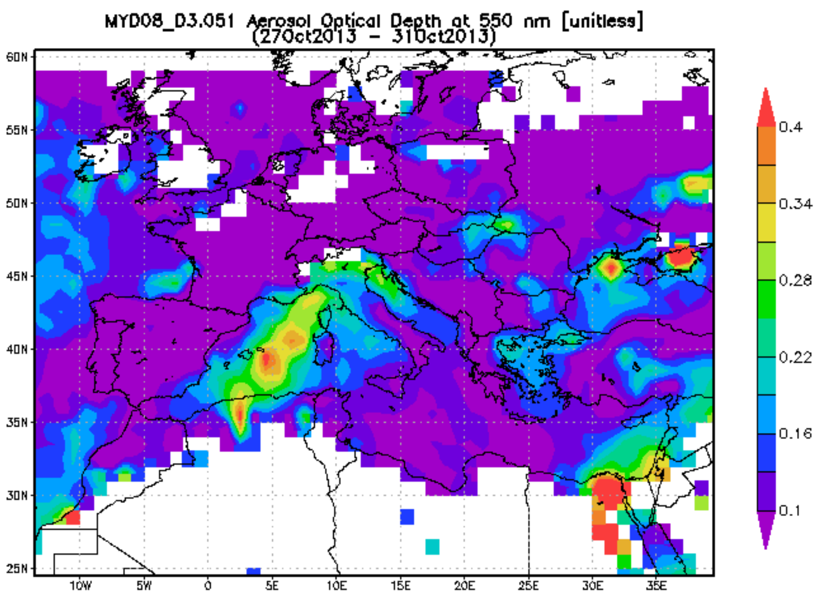
Trasporto di polveri minerali

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 2013:

- **11 giorni sono stati caratterizzati dal trasporto di polveri minerali proveniente dal Nord Africa (12.1 % del periodo).**
- **Gli eventi sono stati generalmente associati alla presenza di un'area di alta pressione sul Mediterraneo centrale, con la presenza di venti sud-occidentali sul mar Tirreno che hanno favorito il trasporto dal nord Africa.**
- **L'evento più significativo è stato osservato dal 27 al 31 Ottobre, quando è stata registrata la concentrazione massima di particelle grossolane per l'autunno 2013 (1.2 cm^{-3}, il 30 Ottobre 2013).**



MODIS satellite Aerosol Optical Depth over the Mediterranean basin for the mineral dust event detected at CMN on 27th – 31st October 2013.

Aerosol Optical Depth (AOD) dell'aerosol sul bacino del Mediterraneo durante l'evento del 27-31 Ottobre 2013 (dati MODIS da satellite). Valori elevati di AOD indicano la presenza di aerosol minerale in atmosfera.

http://gdata1.sci.gsfc.nasa.gov

The AOD map was produced with the Giovanni online data system, developed and maintained by the NASA GES DISC

Stratospheric intrusions (SI)

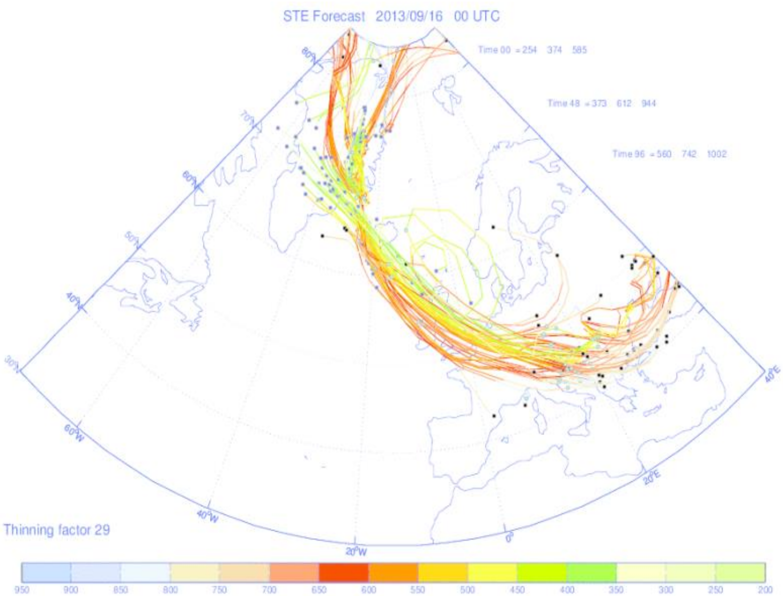
Stratospheric intrusions (SI) can be considered as a specific aspect of stratosphere–troposphere exchange (STE): the irreversible downward transport of stratospheric air relatively deep into the troposphere. Such phenomena are highly episodic and can be favored by a number of different mechanisms, acting 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 2013:

- **9 days were characterized by the transport of air masses from the stratosphere or the upper free troposphere (9.9 % of the period).**
- **These events are mainly concentrated on September (66%).**
- **The highest daily ozone concentrations related to the STE occurred on 24th September (58.8 ppb).**



Trajectories describing the path of stratospheric air-masses for the event of 20th September 2013. 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 Settembre 2013. Il colore rappresenta la quota (espressa come livello di pressione) delle masse d’aria.
Elaborazione: Michael Sprenger (ETH-Z, Switzerland)

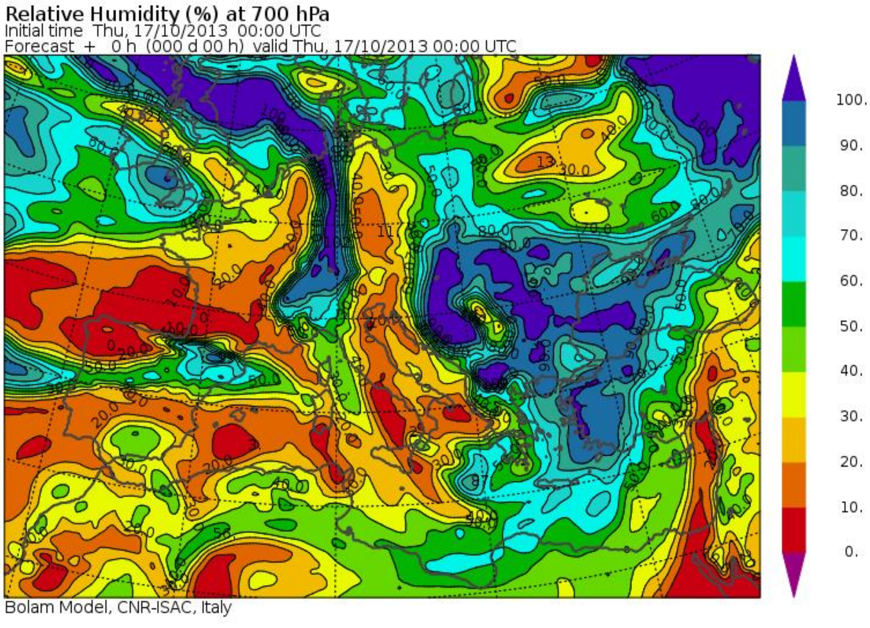
Intrusioni stratosferiche (SI)

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 alta della 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 2013:

- **9 giorni sono stati caratterizzati dal trasporto di masse d'aria dalla stratosfera o dalla parte alta della libera troposfera (9.9 % del periodo).**
- **Gli eventi sono stati principalmente osservati nel mese di settembre (66%).**
- **Il picco giornaliero di ozono relativo a fenomeni di intrusioni stratosferiche è stato osservato il giorno 24 Ottobre (58.8 ppb).**



Relative humidity at 700 hPa simulated by the ISAC BOLAM meteorological model on 17th October 2013. A stream of low RH is visible over Italy (orange-red colors), supporting the presence of dry stratospheric air-masses.

Umidità relativa a 700 hPa simulate dal modello meteorologico ISAC BOLAM per il 17 ottobre 2013. Una striscia di bassa RH è evidente sull'Italia (colori arancio-rosso), indicando la presenza di masse d'aria secche di origine stratosferica.
http://www.isac.cnr.it/dinamica/projects/forecasts/bolam/

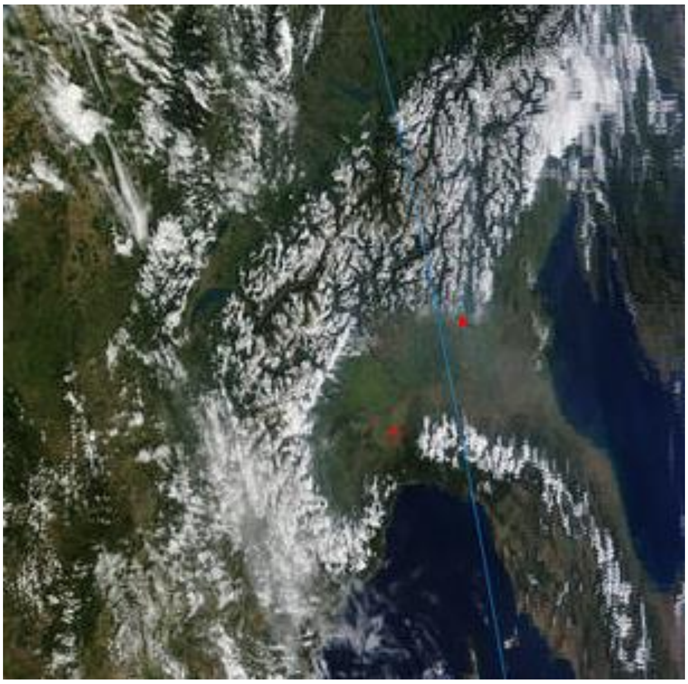
Pollution transport

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).

AUTUMN 2013

- **8 days were characterized by transport of polluted air masses (8.8% of the period).**
- **The detected events were mostly associated with the development of thermal winds or boundary layer growth during day-time, indicating a major influence of regional pollution emissions transported from Po valley.**
- **September was the only month interested by the presence of pollutions events.**
- **September 4th was the most polluted day for ozone (average value: 67.2 ppb), carbon monoxide (122.1 ppb) and black carbon (442.4 ng m^{-3}).**



Satellite image of the Po Basin on 6th September 2013 as seen by MODIS satellite sensor (onboard of "Terra" NASA satellite). The gray layer over northern Italy represent the pollution haze.

Immagine da satellite del nord Italia catturata il giorno 6 settembre 2013 dal sensore MODIS a bordo del satellite "Terra" della NASA. Lo strato di colore grigio, denota l'accumulo di inquinanti nello strato limite atmosferico.

http://rapidfire.sci.gsfc.nasa.gov/
Courtesy by NASA Earth Data

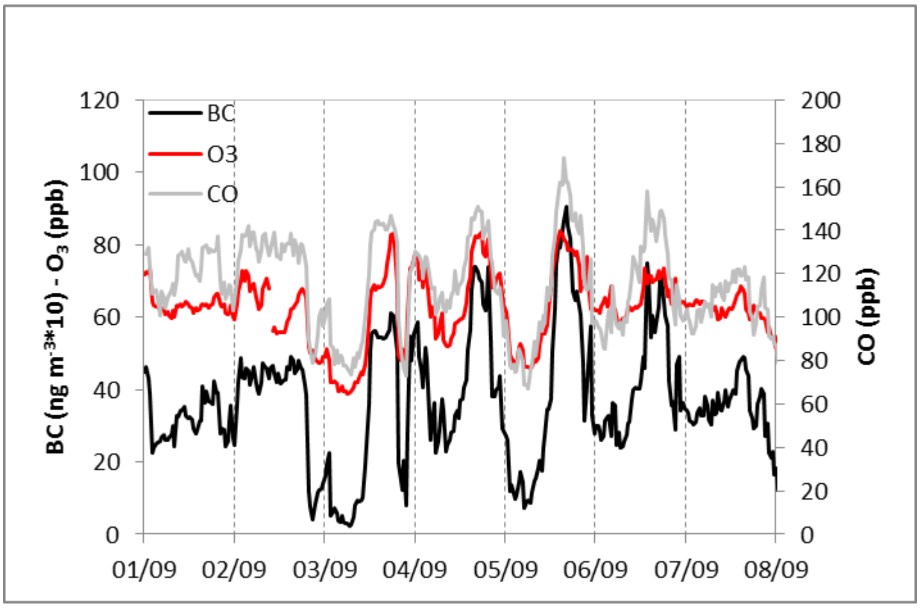
Trasporto di inquinanti

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).

AUTUNNO 2013

- **8 giorni sono stati caratterizzati dal trasporto di masse d’aria inquinate (8.8% del periodo).**
- **Gli eventi sono stati principalmente associati allo sviluppo di venti termici o alla crescita dell’altezza dello strato limite atmosferico durante il giorno, indicando una significativa influenza del trasporto dell’inquinamento a scala regionale sulle concentrazioni di fondo atmosferiche, normalmente rilevate.**
- **Gli eventi di inquinamento sono presenti solo durante il mese di Settembre.**
- **Il 4 Settembre è stato il giorno più inquinato, con valori medi di ozono, monossido di carbonio e black carbon pari a 67.2 ppb, 122.1 ppb e 442.4 ng m^{-3}.**



CO, ozone and BC behaviors at Mt. Cimone from 1st to 7th September 2013.

Andamento delle concentrazioni di CO, ozono e BC a Monte Cimone (01 – 07 Settembre 2013).

Surface ozone

Why is ozone so important?

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

Instrumentation and calibration

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

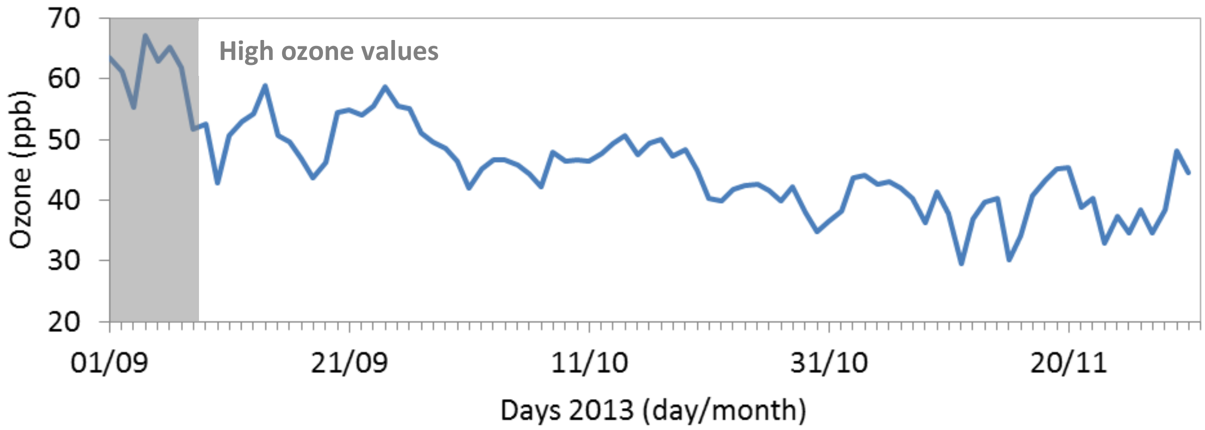
Basic statistical parameters

Statistical parameters are calculated basing on 30-minute aggregated values from Septmber to December 2013.

Data availability (%)	Min value (ppb)	25th Percentile (ppb)	50th Percentile (ppb)	Average mean value (ppb)	75th percentile (ppb)	Max value (ppb)
98.0	8.4	40.2	45.1	46.0	50.7	83.7

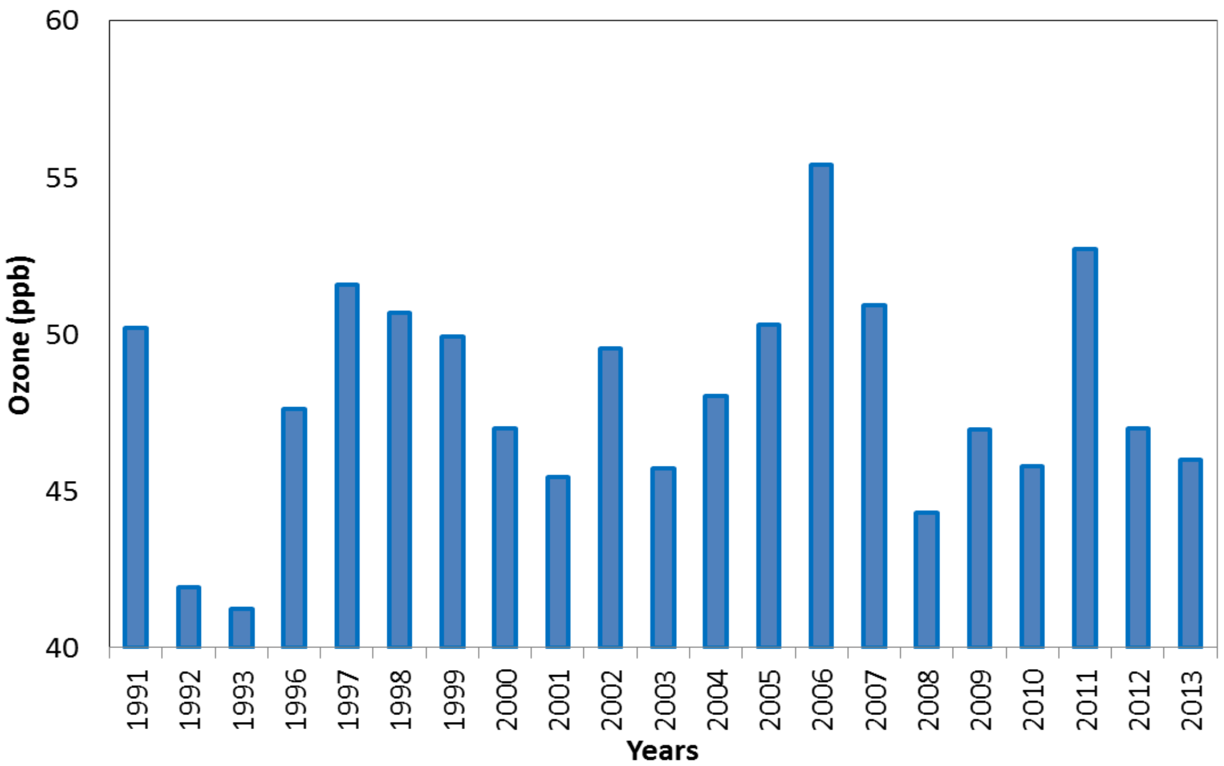
Time series of daily mean values

A period with **relatively high O_3 was recorded from September 1^{st} to 7^{th},** with the highest daily mean value (67.2 ppb, corresponding to 134.4 $\mu g/m^3$) being observed on September 4^{th} 2013. Low O_3 values have been observed on October 30^{th}, 11^{th} and 15^{th} November (during which high NO_2 and CO values were also observed).



Comparison with historical data-set

The **2013 autumn average mean value of O_3 was 46.0 ppb is slightly lower than the climatological mean value (48.6 ppb)**. As deduced by the analysis of daily time series, this is the result of lower-than-average O_3 starting from October 20th 2013, possibly related with a change in weather regime observed during the last third of the season.



Carbon monoxide (NDIR)

Why is carbon monoxide so important?

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

Instrumentation and calibration

Carbon monoxide is measured by using a non-Dispersive Infrared (NDIR) analyzer (Thermo Scientific TEI 48C-TL). Two CO standards (approx. 10 ppm, synthetic air, Messer Italia) are used to calibrate the instrument with a dilution system.

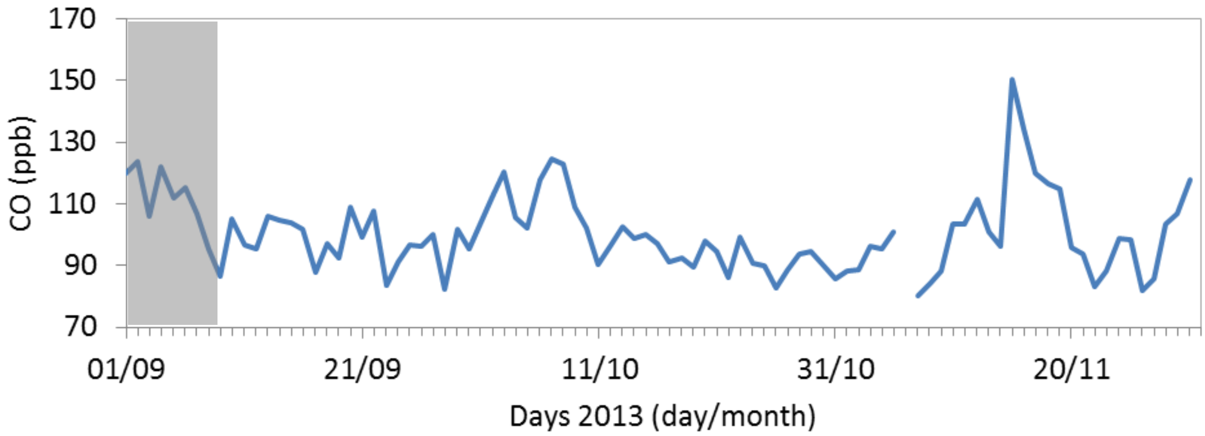
Basic statistical parameters

Statistical parameters are calculated basing on 30-minute aggregated values from September to December 2013.

Data availability (%)	Min value (ppb)	25th Percentile (ppb)	50th Percentile (ppb)	Average mean value (ppb)	75th percentile (ppb)	Max value (ppb)
94.1	45.4	88.9	97.8	100.7	110.3	212.7

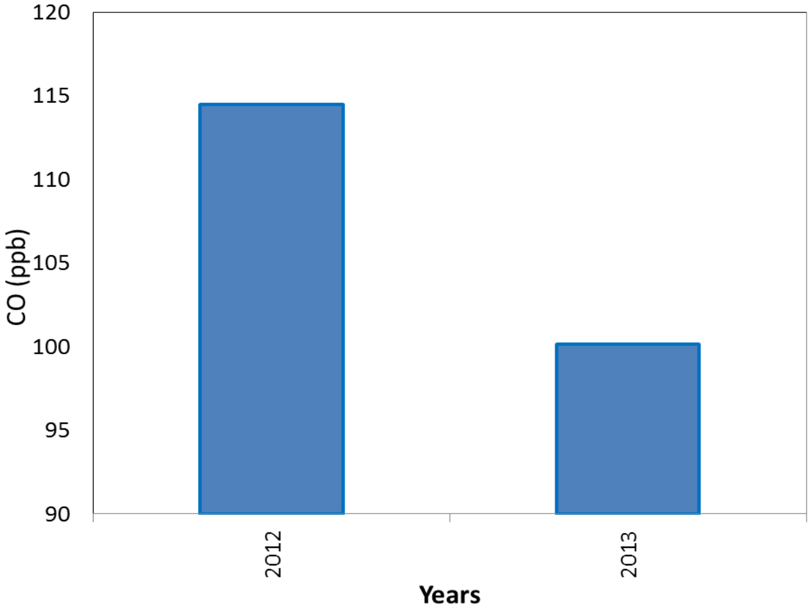
Time series of daily mean values

The highest daily CO value (150.4 ppb) was recorded on November 15th 2013, due to the possible long range transport of polluted air masses, even though the low black carbon and fine particles concentrations may suggest a rain scavenging effect on the aerosol particles.



Comparison with historical data-set

The **2013 autumn average mean value of CO was 100.7 ppb which is lower than the average mean value of 114.5 ppb observed on autumn 2012**. Low CO values (below 100 ppb) characterized the last two decades of September and October.



Nitrogen oxides

Why are nitrogen oxides so important?

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

Instrumentation and calibration

Nitrogen oxides ($NOx=NO+NO_2$) are measured by using a chemiluminescence analyser (Tei 42) equipped with Molybdenum converter. Manual zero checks are performed weekly. Due to the interference of other nitrogen compounds (e.g. PAN, HNO_3), the NO_2 reading can be significantly overestimated.

Basic statistical parameters

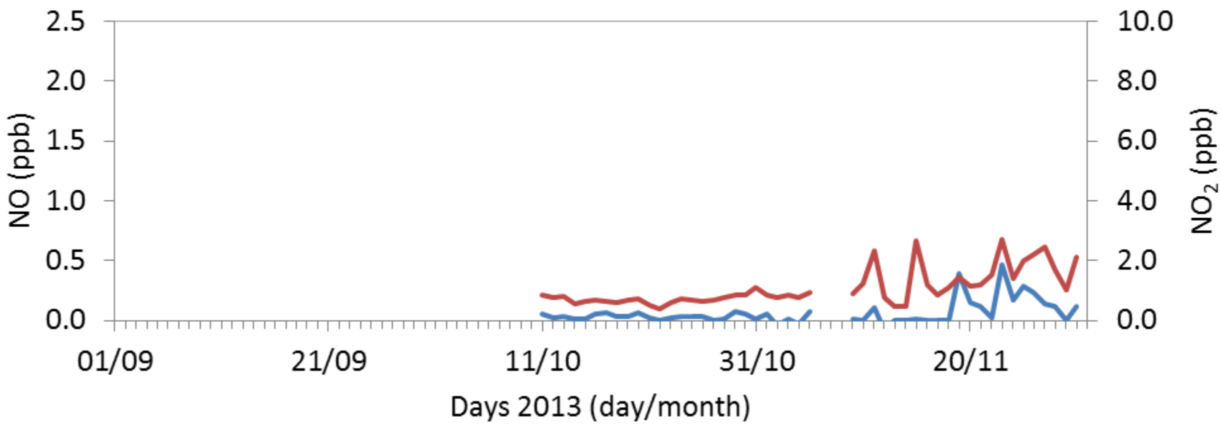
Statistical parameters are calculated basing on 30-minute aggregated values from September to December 2013.

Data availability (%)	Min value (ppb)	25th percentile (ppb)	50th percentile (ppb)	Average mean value (ppb)	75th percentile (ppb)	Max value (ppb)
NO 55.1	UDL	UDL	0.01	0.05	0.06	2.06
NO_2 55.1	0.2	0.6	0.8	1.0	1.1	5.8

UDL: under detection limit

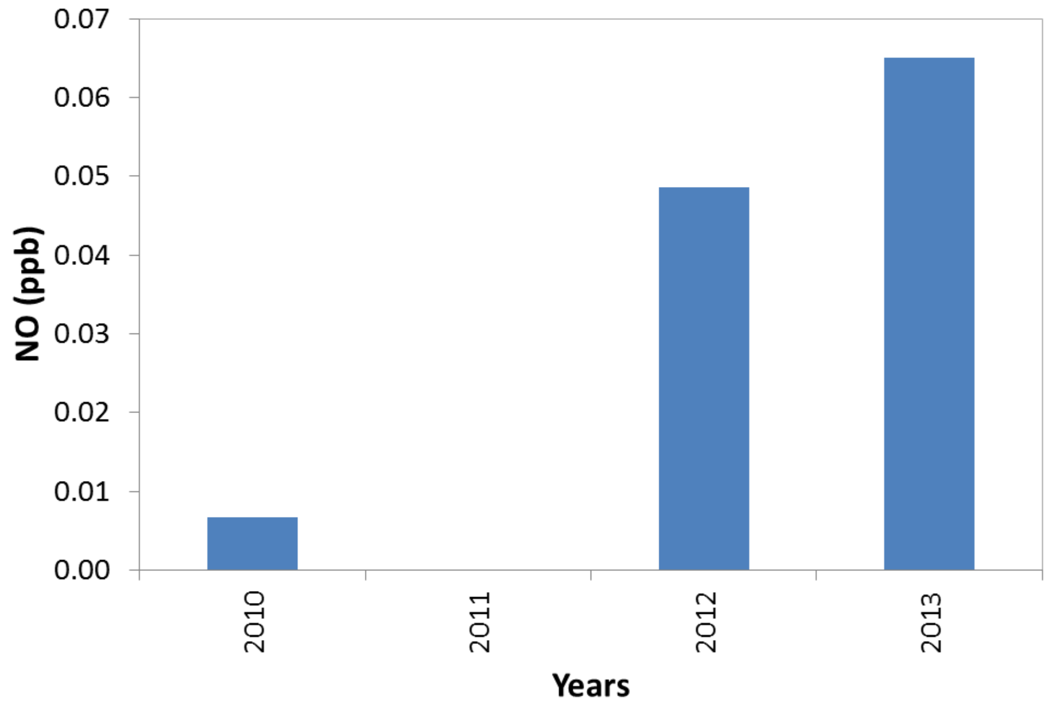
Time series of daily mean values

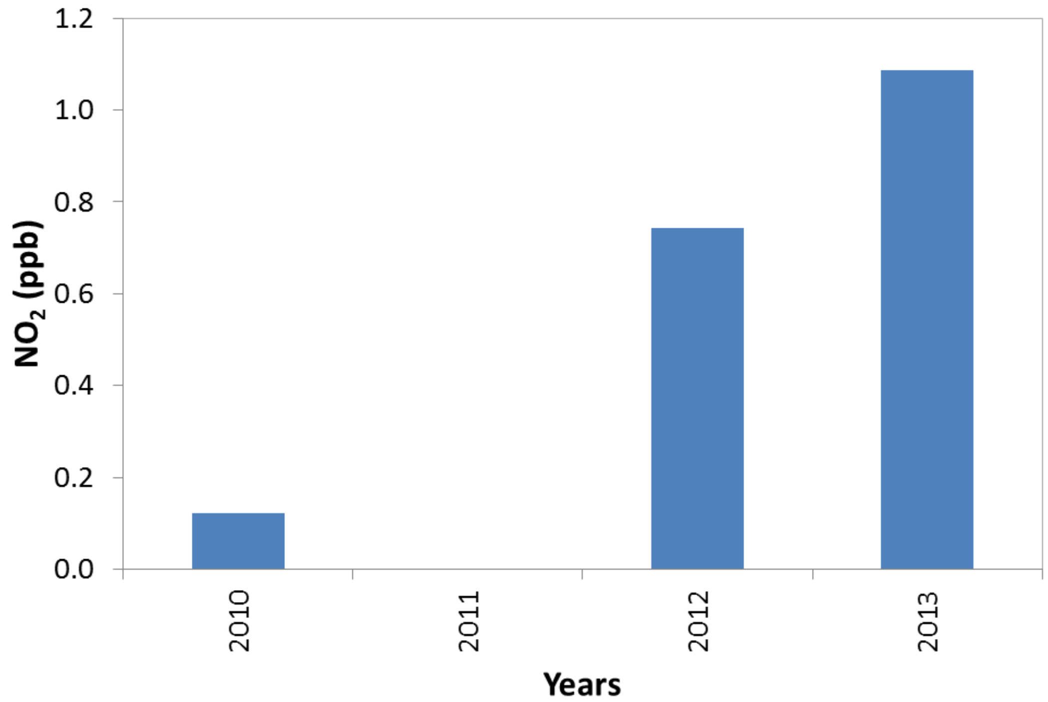
Data were available starting from October 11th 2013, when the instrument was re-installed at ICO-OV following maintenance. Very low NO values (blue lines) - below the detection limit - were recorded for almost half of this period. The highest NO and NO_2 daily values were observed on November 23th.



Comparison with historical data-set

The **2013 autumn average mean value of NO (NO_2) was 0.05 ppb (1.0 ppb) which is comparable with the average climatological mean value of 0.03 ppb (0.4 ppb)**. However it should be noted that due to the complete loss of data during September 2013 and the first decade of October 2013 the comparison with the previous years could be affected by notable uncertainty.





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.

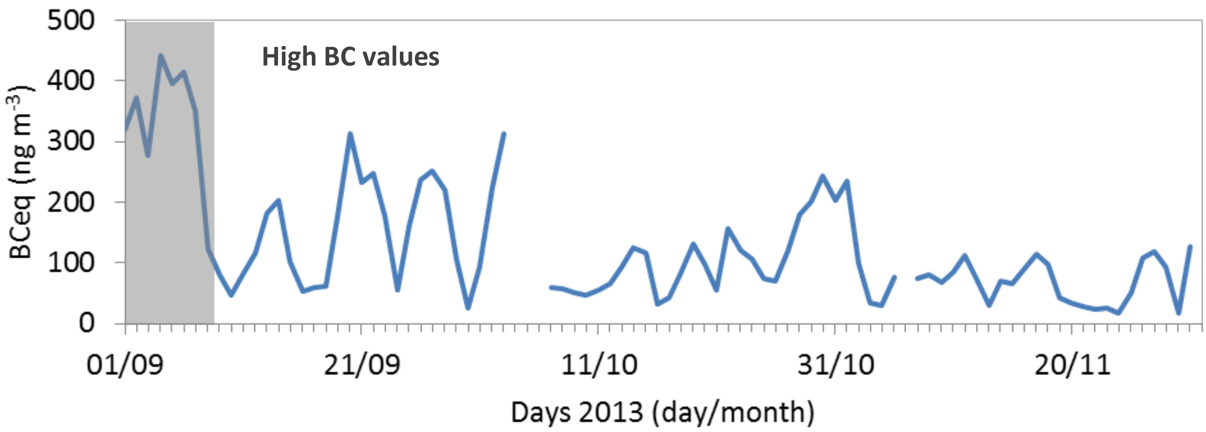
Basic statistical parameters

Statistical parameters are calculated basing on 30-minute aggregated values from September to December 2013.

Data availability (%)	Min value ($ng\ m^{-3}$)	25th percentile ($ng\ m^{-3}$)	50th percentile ($ng\ m^{-3}$)	Average mean value ($ng\ m^{-3}$)	75th percentile ($ng\ m^{-3}$)	Max value ($ng\ m^{-3}$)
82.8	10.0	45.4	88.7	135.4	181.1	1001.8

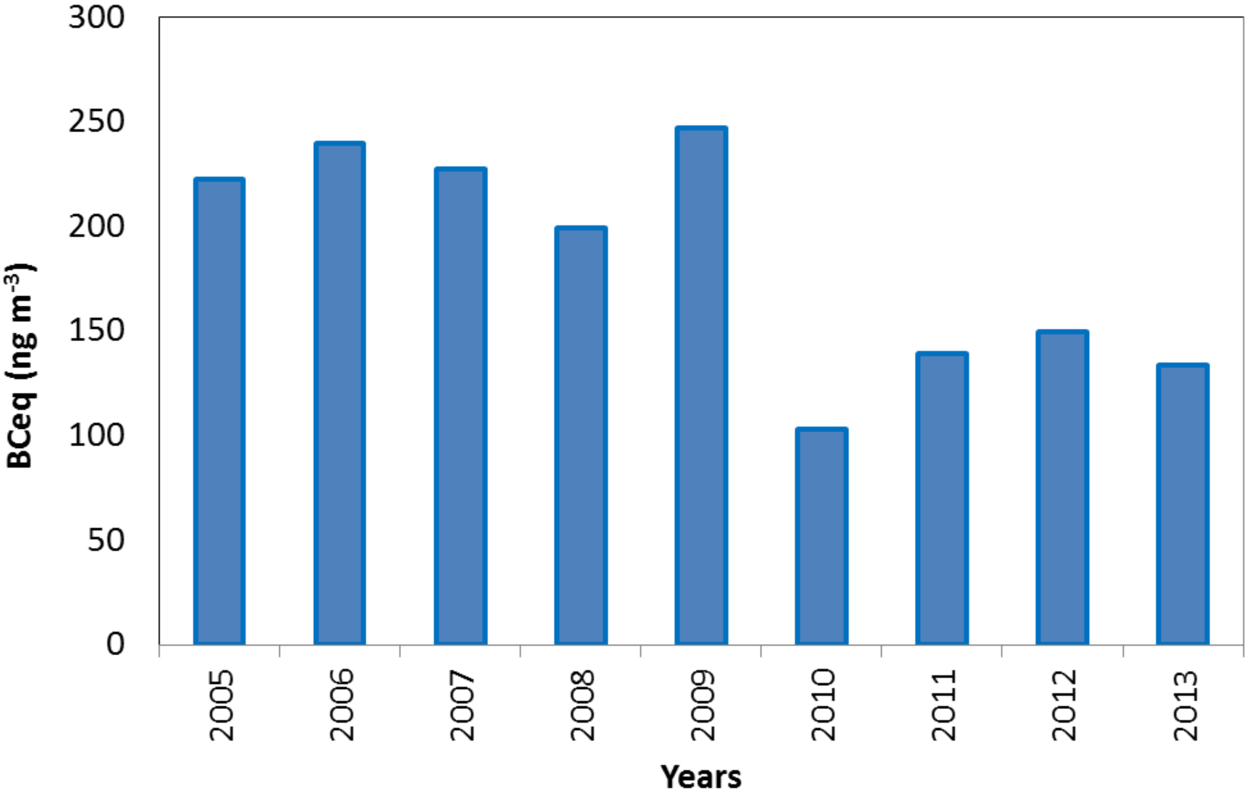
Time series of daily mean values

The highest daily mean value (442.4 $ng\ m^{-3}$) was observed on September 4th 2013, with high values characterizing the first week of September, supporting the presence of pollution at the measurement site. Very low values were observed starting from November 20th.



Comparison with historical data-set

The 2013 autumn average mean value of BC was 135.4 ng m^{-3}, which is lower than the climatological mean value (190.8 ng m^{-3}). During this period, September was the month characterized by the BC highest concentrations at Mt. Cimone (average value: 197.2 ng m^{-3}), thanks to the occurrence of one pollution transport events at the start of the month.



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

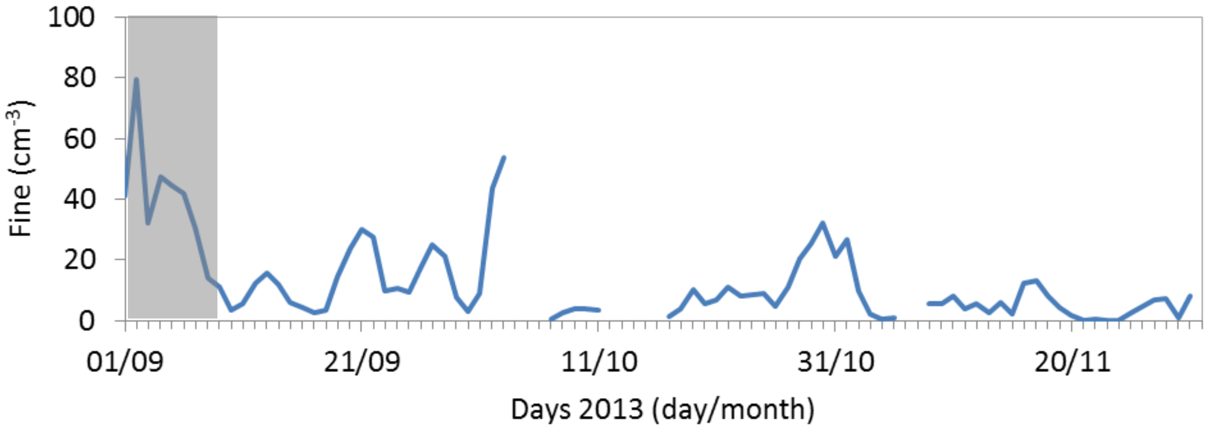
Basic statistical parameters

Statistical parameters are calculated basing on 30-minute aggregated values from September to December 2013.

Data availability %	Min value (cm^{-3})	25^{th} percentile (cm^{-3})	50^{th} percentile (cm^{-3})	Average mean value (cm^{-3})	75^{th} percentile (cm^{-3})	Max value (cm^{-3})
85.7	0.01	2.2	6.3	13.3	16.2	152.4

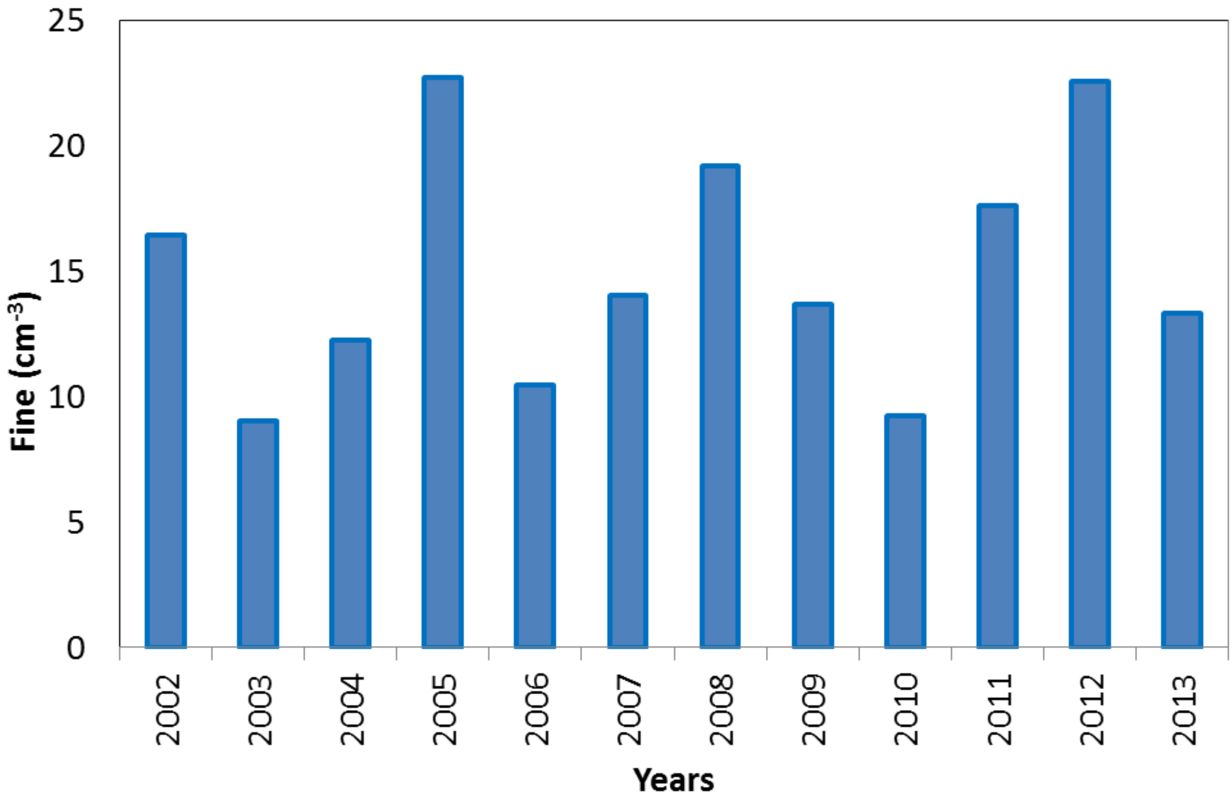
Time series of daily mean values

The highest daily mean value (79.5 cm^{-3}) was observed on 2^{nd} September 2013, indicating the presence of polluted air masses at the measurement site. Very low values were observed during November.



Comparison with historical data-set

The 2013 autumn average mean value of fine particles was 13.3 cm^{-3}: it is slightly lower than the seasonal climatological value (15.0 cm^{-3}). This behavior was mainly driven by the low values observed during November (5.5 cm^{-3}) even if relatively high values were still observed on September (20.3 cm^{-3}), especially during the pollution transport event which occurred during the first week.



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

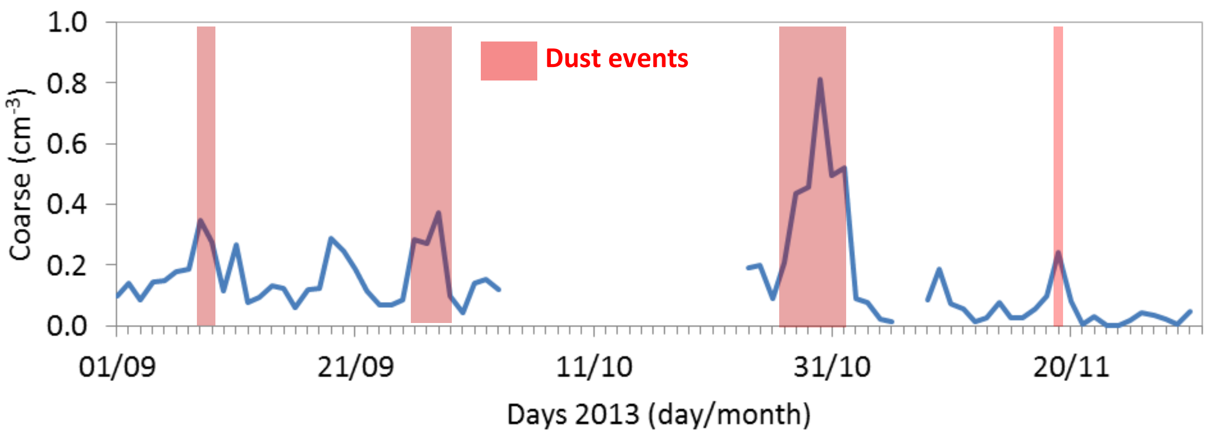
Statistical parameters are calculated basing on 30-minute aggregated values from September to December 2013.

Data availability %	Min value (cm^{-3})	25^{th} percentile (cm^{-3})	50^{th} percentile (cm^{-3})	Average mean value (cm^{-3})	75^{th} percentile (cm^{-3})	Max value (cm^{-3})
71.6	UDL	UDL	0.09	0.15	0.19	1.23

UDL: Under Detection Limit

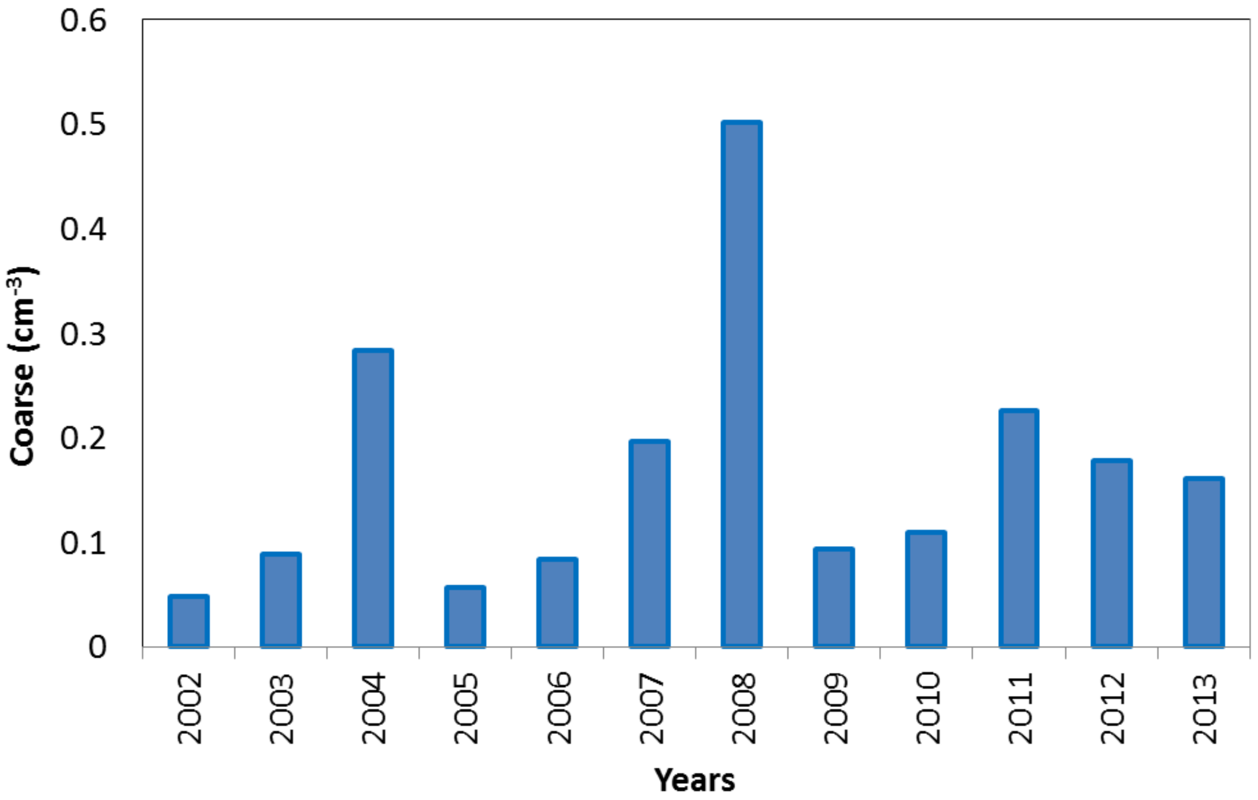
Time series of daily mean values

The highest daily mean value (0.8 cm^{-3}) was observed on October 30^{th} 2013, when a **Saharan dust transport affected Mt. Cimone** (from October 27^{th} to 31^{th}). The variability of coarse particle number concentrations was mainly determined by the occurrence of Saharan dust transport.



Comparison with historical data-set

The autumn 2013 average mean value of the coarse particles (0.15 cm^{-3}) was well comparable with the summer climatological value (0.17 cm^{-3}). Even though the concentrations are considerably lower than other years (e.g. 2004, 2008), the number of days affected by the transport of mineral dust is almost the same, possibly indicating the presence of less strong Saharan dust transport.



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).

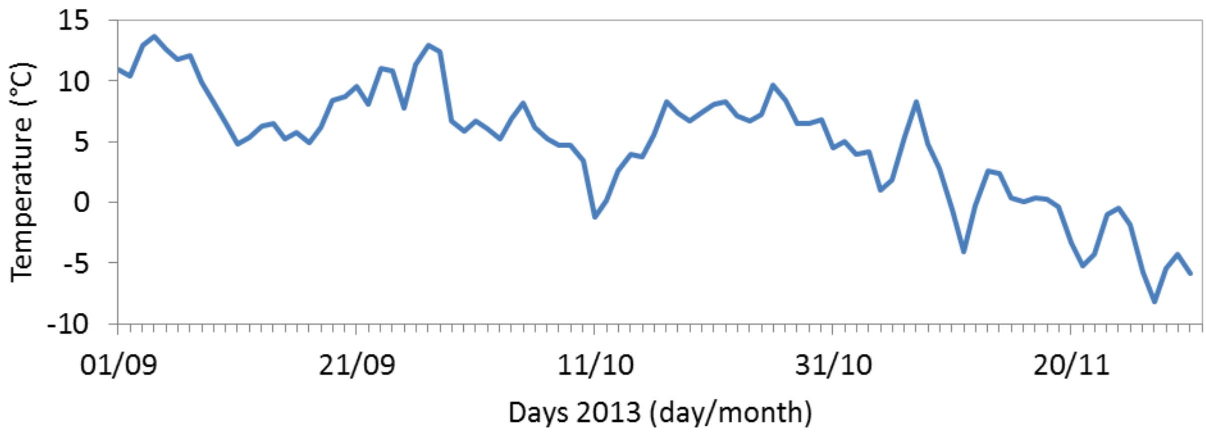
Basic statistical parameters

Statistical parameters are calculated basing on 30-minute aggregated values from September to December 2013.

Data availability %	Min value (°C)	25th percentile (°C)	50th percentile (°C)	Average mean value (°C)	75th percentile (°C)	Max value (°C)
98.8	-10.0	1.4	5.5	4.9	8.0	19.0

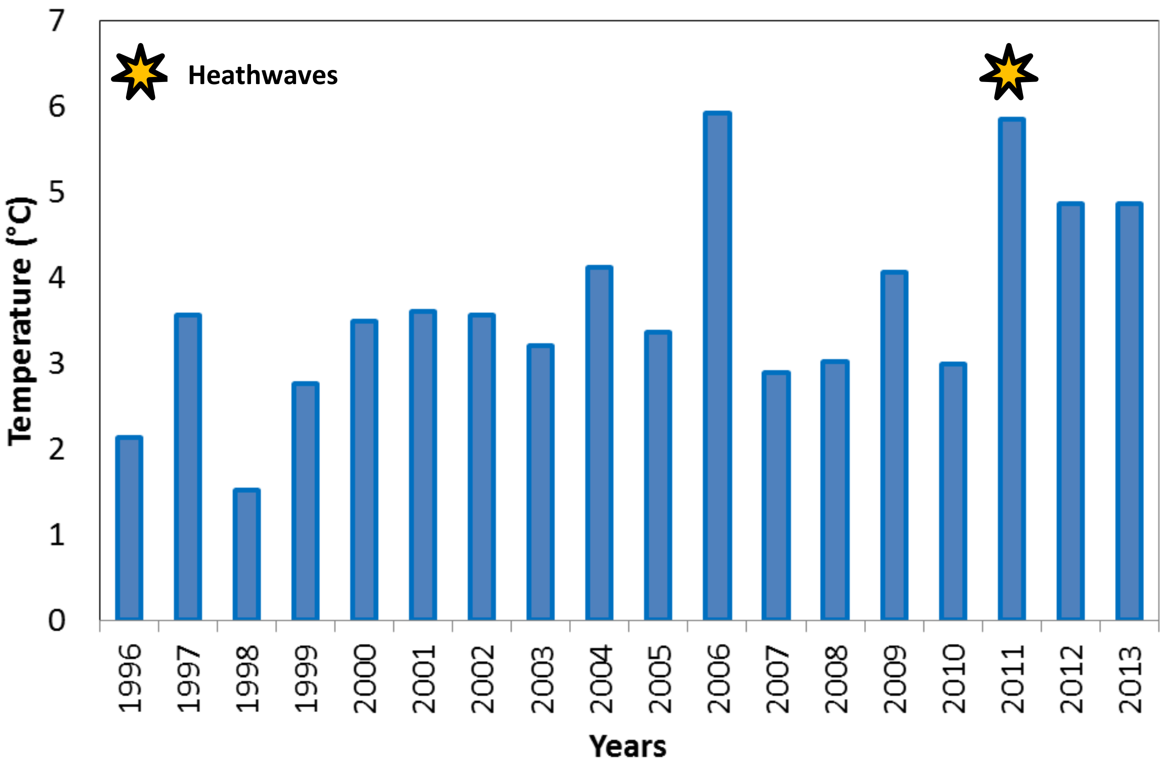
Time series of daily mean values

The highest daily mean value (13.7 °C) was observed on 4th September 2013, simultaneously with the occurrence of a pollution transport. An high air-temperature periods were also observed on September 18th - 30th (max: 16.8 °C). Low values (below 0°C) have been recorded from November 10th.



Comparison with historical data-set

The **autumn 2013 average temperature (4.9 °C) was higher than the seasonal climatological value (3.7 °C),** and the 4th highest seasonal value of all the time series. As deduced by the analysis of daily time series, higher-than-average temperatures were observed for the greatest part of September and October, while lower temperatures occurred after the first week of November.



Heathwaves identification

To unambiguously identify HWs which affected the north of Italy during **September** months, we analysed the time series of daily mean and maximum temperature at three low-land locations (Verona: 45°23'N 10°53'E; Milano: 45°26'N 9°17'E; Bologna: 44°32' 11°18'). In particular, we categorized as being influenced by HWs the warm periods (when simultaneously identified by the following WMO and ECA&D (European Climate Assessment and Dataset) selection methodologies:

(1) ECA&D: a period of at least 6 days with daily mean temperature above the upper tenth percentile of the temperature distribution for each of the calendar days;

(2) WMO: a period of at least 6 days with the daily maximum temperature greater than 5°C above the climate normal (CliNo) maximum temperature

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).

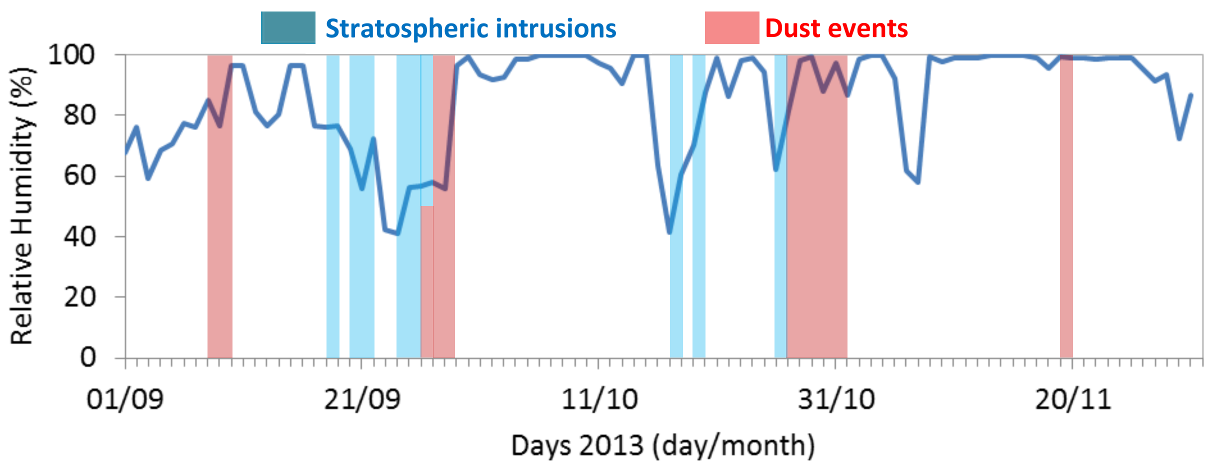
Basic statistical parameters

Statistical parameters are calculated basing on 30-minute aggregated values from September to December 2013.

Data availability (%)	Min value (%)	25th percentile (%)	50th percentile (%)	Average mean value (%)	75th percentile (%)	Max value (%)
98.8	22.7	73.0	99.0	86.0	99.7	100.0

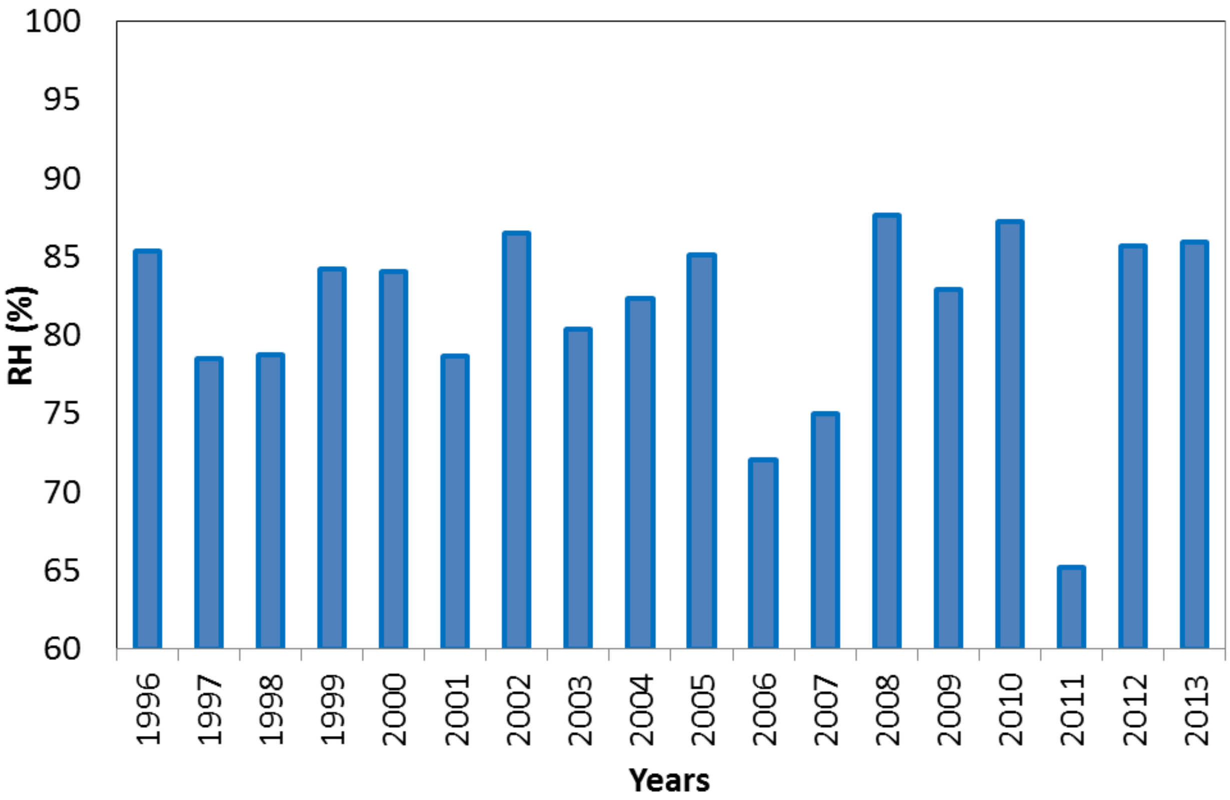
Time series of daily mean values

The daily mean RH values ranged from 100% to 23%. The driest period was observed from September 18th to 28th, when **air-mass transport from stratospheric intrusions and North Africa affected ICO-OV.** Relatively dry conditions also occurred during air-mass transport from free troposphere/stratosphere.



Comparison with historical data-set

The autumn 2013 average relative humidity (86.0%) was higher than the seasonal climatological value (81.4%), with lower RH values being concentrated mainly in the first two decades of September, apart for the two occurrences observed in October.



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).

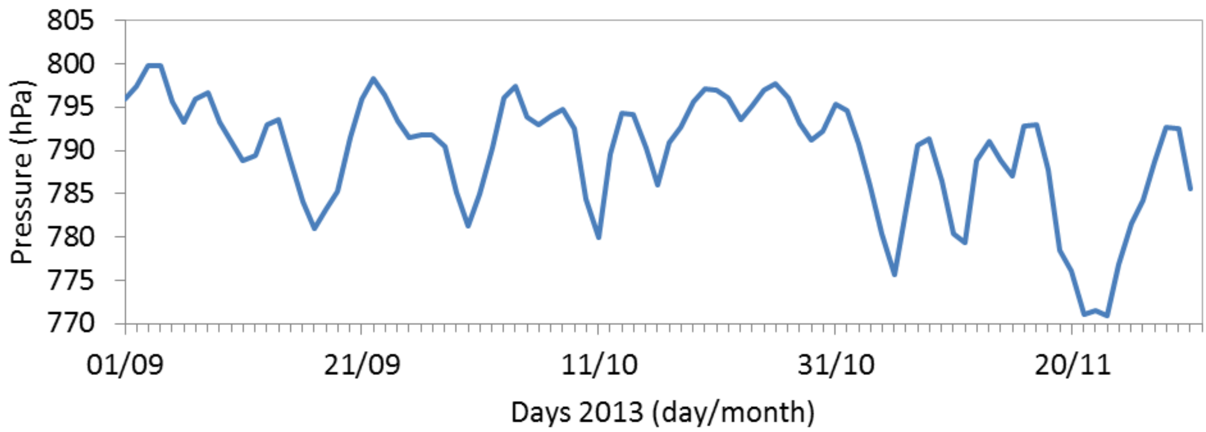
Basic statistical parameters

Statistical parameters are calculated basing on 30-minute aggregated values from September to December 2013.

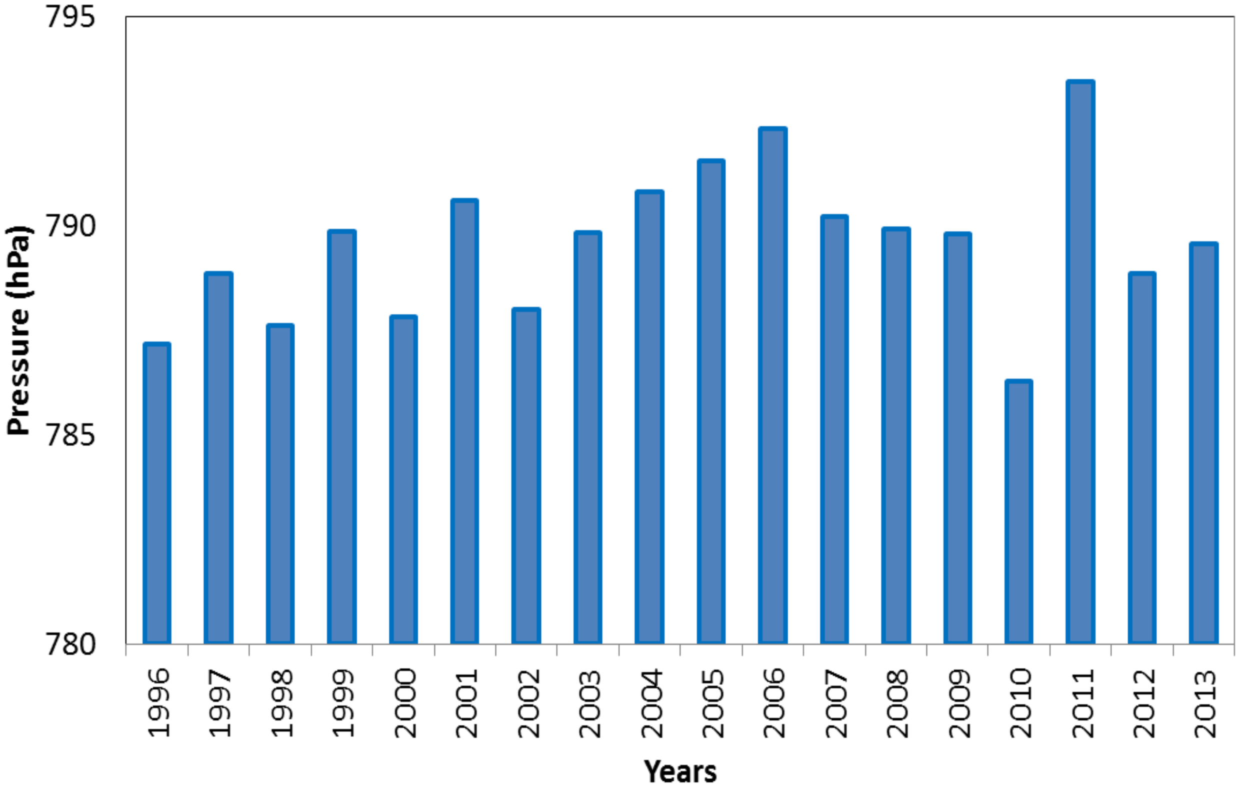
Data availability (hPa)	Min value (hPa)	25th percentile (hPa)	50th percentile (hPa)	Average mean value (hPa)	75th percentile (hPa)	Max value (hPa)
98.8	768.3	785.7	791.7	789.8	794.5	801.0

Time series of daily mean values

The daily mean pressure values showed **high values and low variability from October 17th to November 2nd 2013**, indicating the occurrence of typical summer conditions. A large drops occurred on November 21th- 23th, indicating possible influence of synoptic-scale disturbances. Low pressure values were also recorded on September 17th and 30th, on October 10th and on November 5th.



Comparison with historical data-set
The **autumn 2013 average atmospheric pressure (789.8hPa) 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.

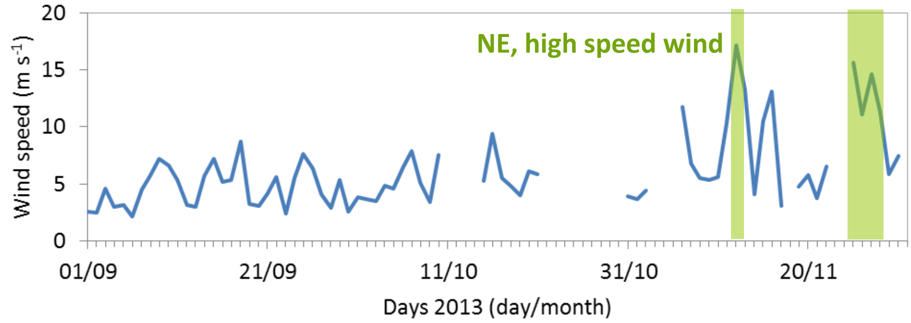
Basic statistical parameters of wind speed

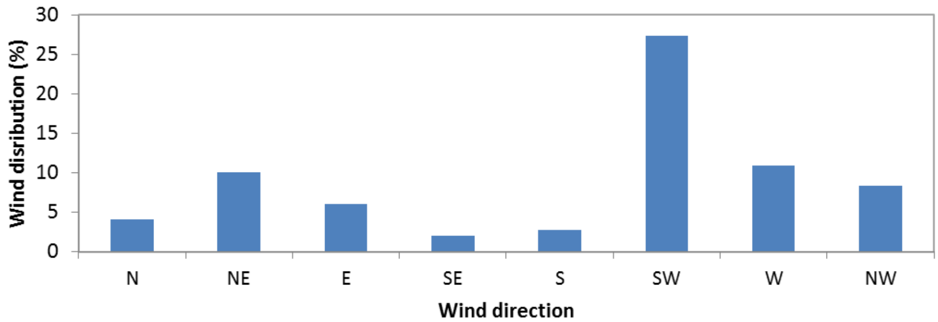
Statistical parameters are calculated basing on 30-minute aggregated values from September to December 2013.

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)
71.5	0.6	3.0	4.9	5.9	7.7	31.3

Time series of daily mean values

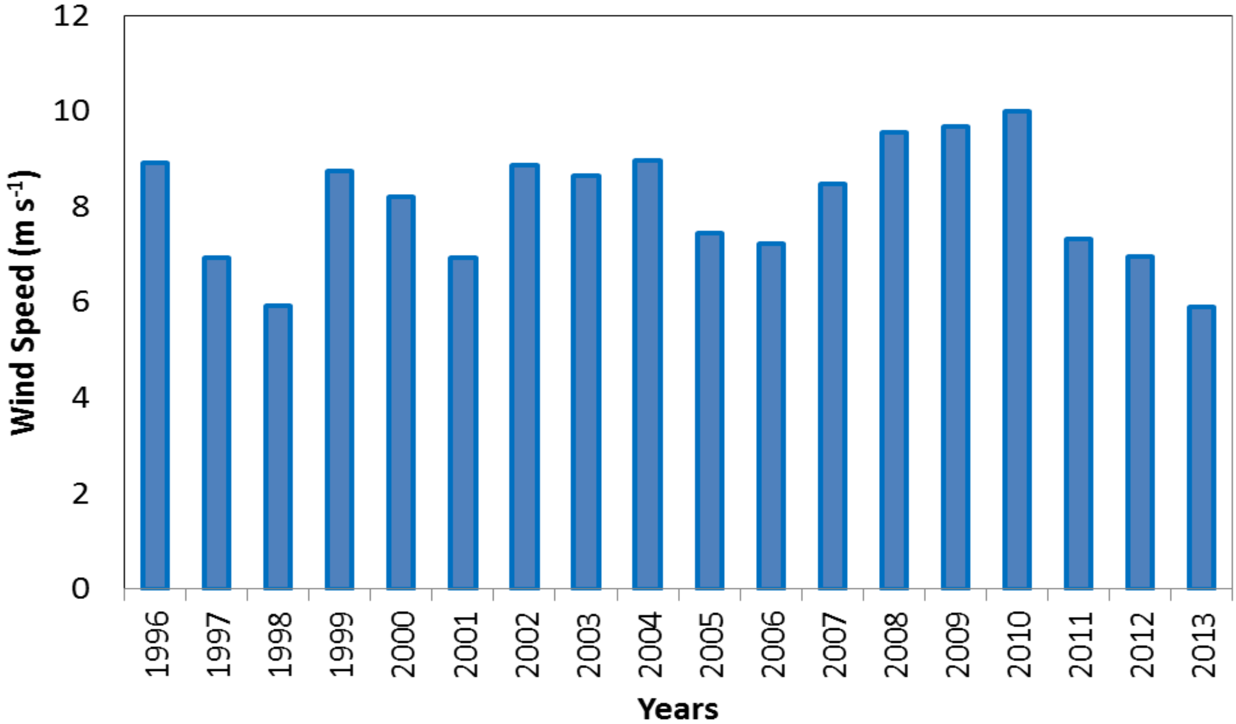
Although the autumn 2013 is characterized by a predominance of SW winds, on November 12th 2013 and on the period November 25th – 28th we observed prevalence of NE, high speed (>10 m s^{-1}) winds which were related with the passing of synoptic disturbances (pressure drops).

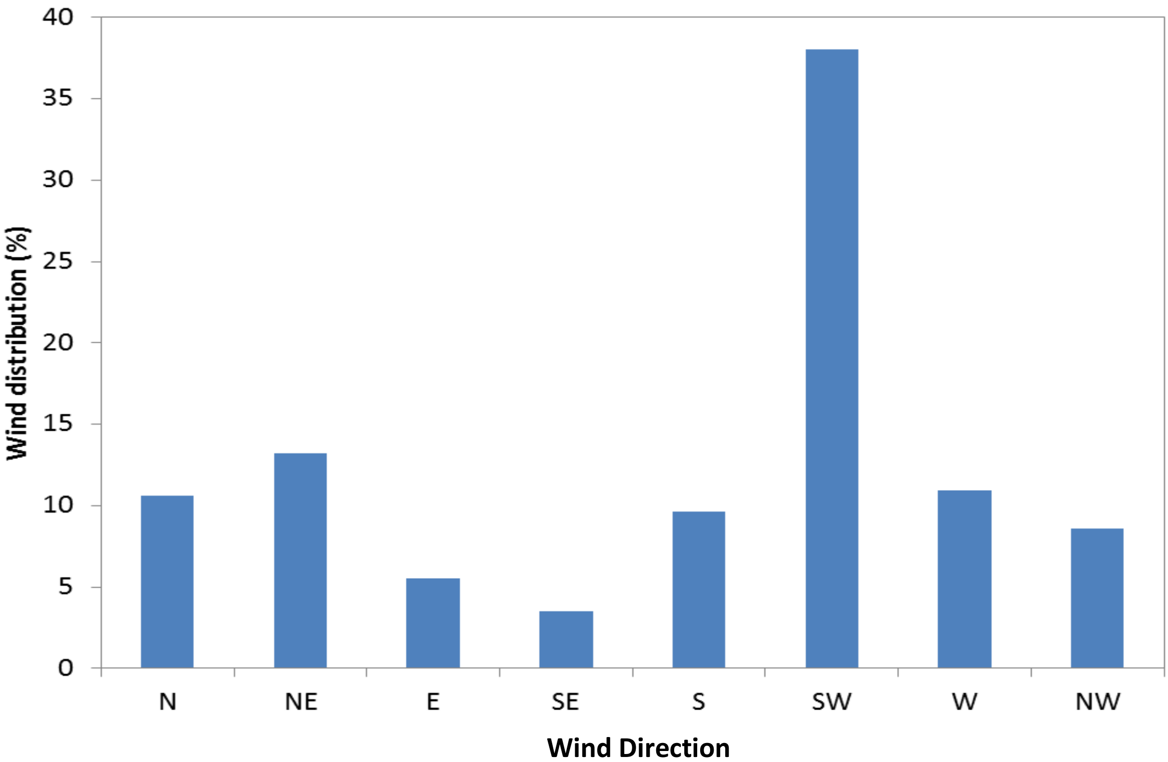




Comparison with historical data-set

The autumn 2013 showed an average wind speed (5.9 m/s) lower than the climatological value (8.0 m/s), however rather high wind speeds (> 10 m/s) were observed on a daily basis. The seasonal wind direction is similar to the climatological one, **with a prevalence of south-westerly winds (respectively 27.4 % and 38.0%).**





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). As a note, the presence of snow cover over the sensor could lead to an underestimation of the radiation values.

Basic statistical parameters (short-wave)

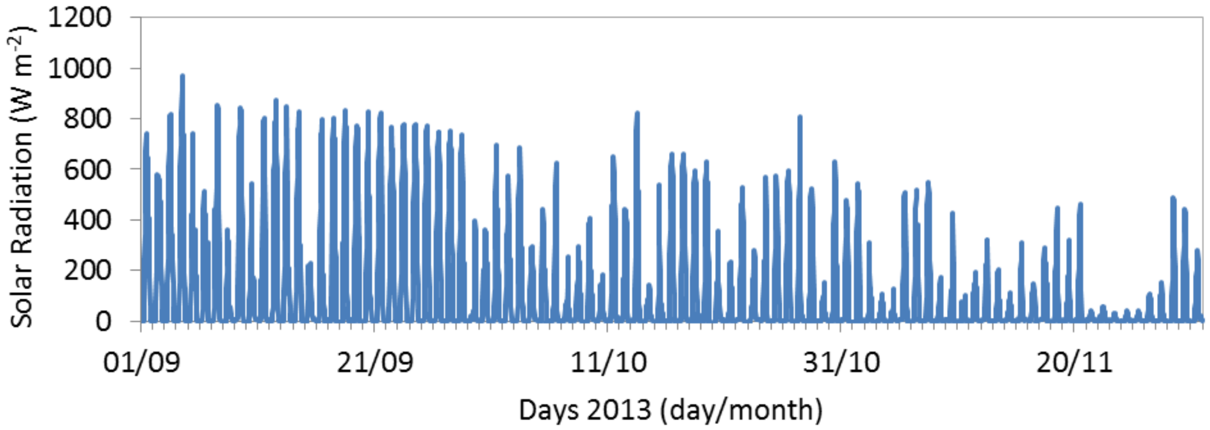
Statistical parameters are calculated basing on 30-minute aggregated values from September to December 2013.

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)
98.8	UDL	UDL	4.9	112.0	137.1	969.3

UDL: under detection limit

Time series (short-wave)

The highest 30 minute mean value (969.3W m^{-2}) was observed on September 4th, 2013. A period of low values was instead experienced between November 21st – 27th and November 1st – 11th, probably related to cloud cover. It is also evident a declining trend that points out a change in weather regime related to the shift from summer to autumn season.



Basic statistical parameters (UV-B)

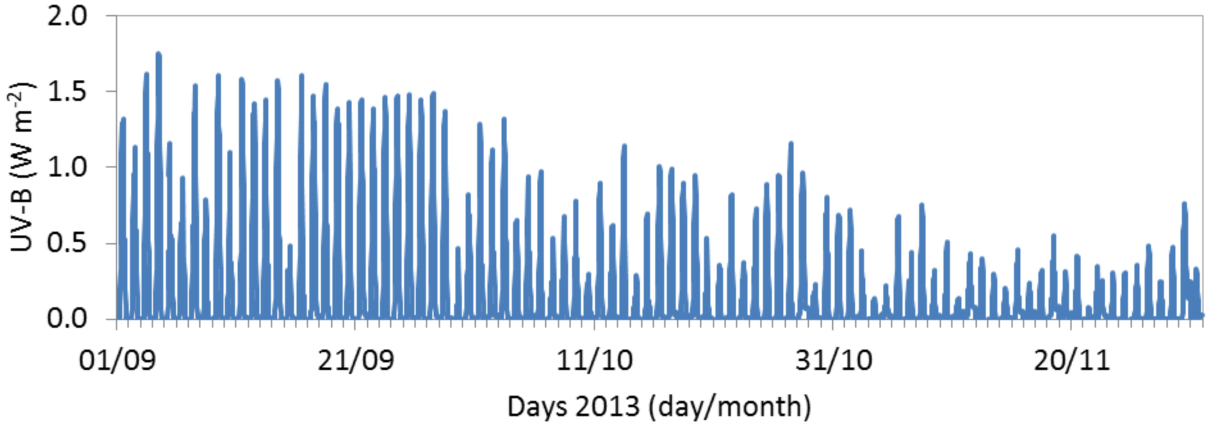
Statistical parameters are calculated basing on 30-minute aggregated values from September to December 2013.

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)
98.8	UDL	UDL	UDL	0.17	0.20	1.75

UDL: under detection limit

Time series (short-wave)

Similarly to what observed for the short wave solar radiation, a period of clear sky and high UV-B radiation affected Monte Cimone on September 16^{th} – 28^{th}, even though the highest seasonal value was observed on September 4^{th} 2013. Low values were recorded from November 11^{th} till November 27^{th}, related to a general attenuation of solar radiation as already observed for Solar Radiation.



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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-CO2 gases in the Kyoto Protocol (e.g. HFCs, methane, and nitrous oxide) to mitigate climate change.

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

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

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

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

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

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

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

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

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

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

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

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