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

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

SUMMER 2013 REPORT

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

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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
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 SUMMER 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 summer 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 summer 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 summer mean values are calculated by averaging data from June 1st to August 31st.**

Premessa

Questo rapporto riassume i risultati relativi alle osservazioni atmosferiche effettuate durante l'ESTATE 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 estivo 2013 considerando:

- **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" per Monte Cimone.

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 di base (su un base di 30 minuti)**
- **Il confronto con i valori medi storici stagionali per ogni anno, considerando che i valori estivi sono calcolati come media dal 1 giugno al 31 agosto.**

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
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Nepal Climate Observatory – Pyramid*	5079 m	Nepal
Zugspitze/ Hohenpeissenberg	2962 m	Germania

*Stazioni gestite da Istituzioni Italiane

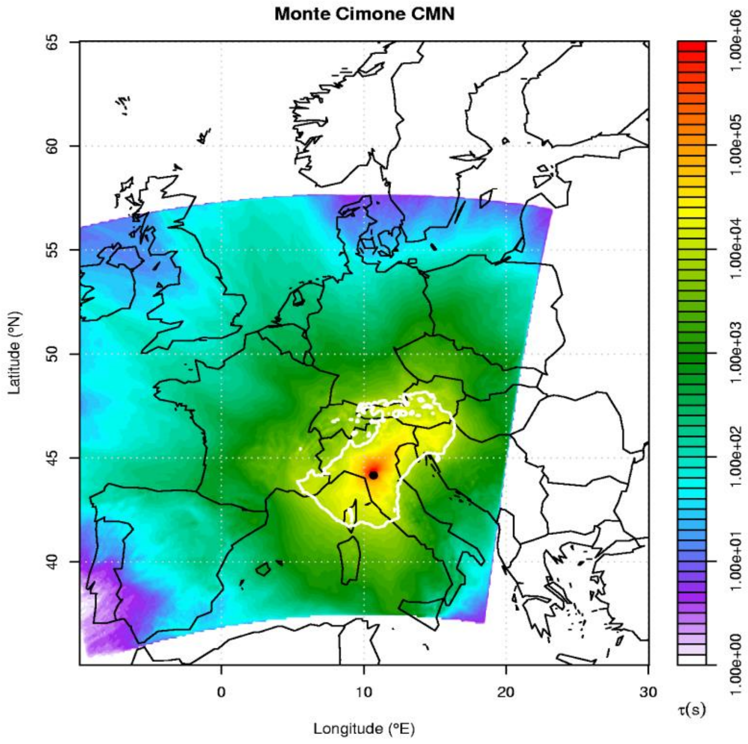
Lista delle stazioni globali GAW/WMO in aree di alta quota (for more information: http://gaw.empa.ch/gawsis/)

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)*

Short-lived climate forcers (SLCF)

Gases and aerosol particles that are emitted into or formed within the atmosphere remain there for longer or shorter times depending on their physical and chemical properties.

By the words "**short-lived climate forcers**" (SLCF), we refer to any atmospheric compound able to exert a climate forcing by modifying the energy budget of the atmosphere, but having a shorter lifetimes than carbon dioxide (100 years or more).

Black carbon, aerosol particles and ozone (having atmospheric life-time of the order of weeks) or methane, which has a lifetime of about 10 yr, are recognized as SLCFs.

Since some of the SLCFs are dangerous air-pollutants, **it has been assessed that reducing SLCF emissions can lead to immediate climate and social benefits, especially at regional scale**. This obviously does not mean that we are allowed to do not act to reduce the emissions of "long-lived" climate forcers like carbon dioxide.

To know more see: UNEP and WMO 2011 – Integrated Assessment of Black Carbon and Tropospheric Ozone.

Real time data: http://www.isac.cnr.it/cimone/realtime

The "O. Vittori" Climate Observatory during winter season with the view of a laboratory.

L'Osservatorio "O. Vittori" durante il periodo invernale con il particolare di un laboratorio.

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)*

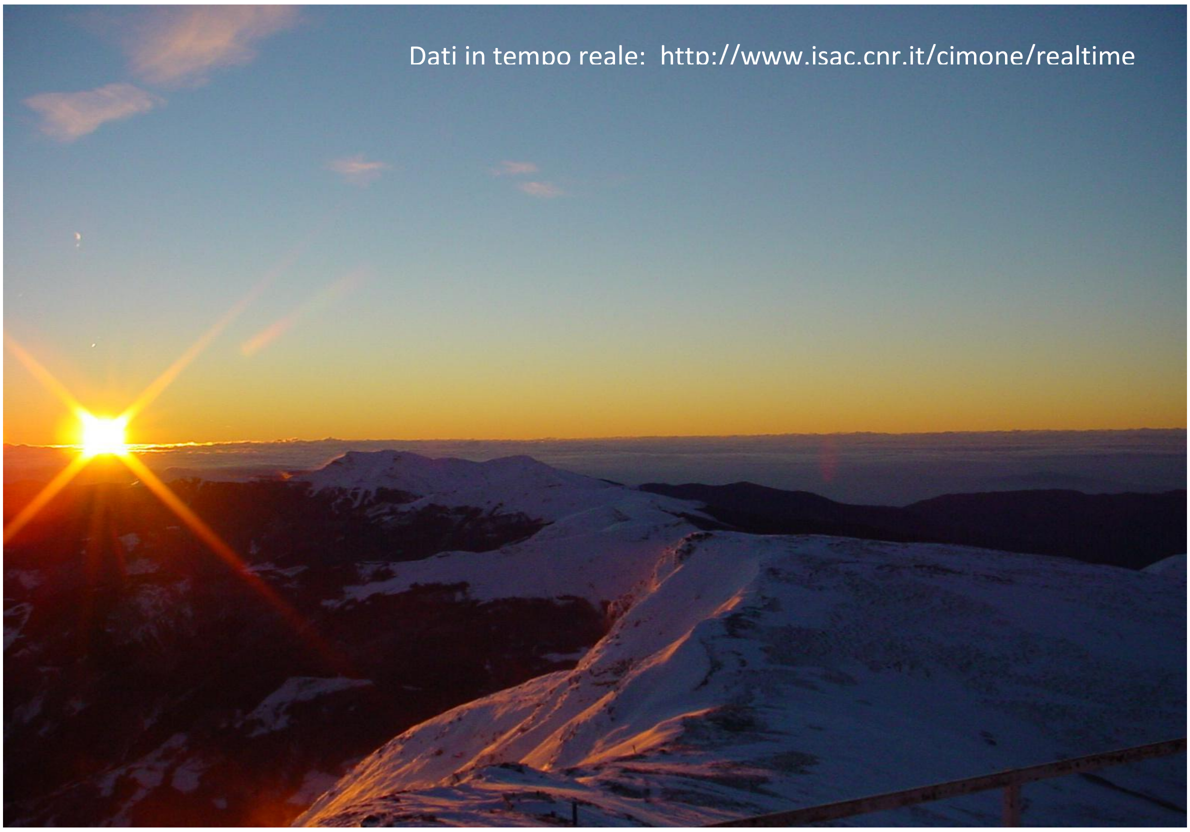
Forzanti climatici a breve tempo di vita (SLCF)

I gas e le particelle di aerosol che sono emessi o formati nell'atmosfera permangono in essa per periodi di tempo più o meno lunghi a seconda delle loro proprietà fisiche e chimiche. Con il termine "**forzante climatico a vita breve**" (SLCF), ci riferiamo ad ogni composto atmosferico in grado di esercitare un effetto sul clima modificando il bilancio energetico dell'atmosfera, ma che si caratterizza per avere tempi di vita molto più brevi di quelli della molecola dell'anidride carbonica (che è pari a circa 100 anni).

Il black carbon, l'aerosol, l'ozono (con un tempo di vita in atmosfera di poche settimane) o il metano, che ha un tempo di vita di circa 10 anni, sono importanti SLCF.

Alcuni SLCF sono anche importanti inquinanti. E' stato messo in luce che **riducendone le emissioni si potrebbero ottenere, soprattutto a livello regionale, immediati effetti positivi sul clima, sulla qualità dell'aria e quindi sulla salute della popolazione e della vegetazione**. Ciò, ovviamente, non implica che non si debba agire in modo efficace nel ridurre le emissioni dei forzanti climatici a lungo tempo di vita, quali l'anidride carbonica.

Per saperne di più: UNEP and WMO 2011 – Integrated Assessment of Black Carbon and Tropospheric Ozone



Dati in tempo reale: http://www.isac.cnr.it/cimone/realtime

Summary

OVERWIEV

Summer 2013 did not present particular high average levels of short-lived climate forcers (SLCF): a value similar to the climatological mean was observed for surface ozone while for black carbon, it was lower. Also coarse particles were comparable with the climatological value. Only for fine particles we reported higher average value in respect with previous summer seasons.

20.4% of the summer days have been affected for a significant fraction of time by transport of polluted air-masses. On a monthly basis, June and August 2013 appeared less polluted than July, which instead accounted for 79% of the polluted days, also showing the highest values of ozone, carbon monoxide, black carbon and fine particles.

13 days were affected by mineral dust transport, with a major event which occurred from August 4th to 10th, when very high air temperatures (19.1 °C) were also observed.

Air-mass transport from the stratosphere occurred for 21.7% of the period and have been almost equally distributed among the three months.

Daily **surface ozone** peak was recorded on 16-07 (80.0 ppb). 30-minute average values ranged from a minimum of 35.5 ppb (02-08) to 97.4 ppb (16-07), with an average seasonal value of 61.8 ppb. This value is similar to the average climatological summer value obtained from the last 18 years (62.5 ppb).

Daily **carbon monoxide** peak was recorded on 16-07 (158.9 ppb). 30-minute average values ranged from a minimum of 46.7 ppb (03-08) to 200.8 ppb (08-08), with an average seasonal value of 117.1 ppb. This value is slightly lower than the average value of summer 2012 (119.7 ppb), when this measurement programme was started.

Daily **black carbon** peak was recorded on 20-07 (583.1 ng m^{-3}). 30-minute average values ranged from a minimum of 11.0 ng m^{-3} (10-06) to 1945.5 ng m^{-3} (08-08), with an average seasonal value of 247.8 ng m^{-3}. This value is lower than the average climatological summer value obtained from the last 8 years (297.8 ng m^{-3}).

Daily **fine aerosol particles** peak was recorded on 20-07 (189.8 ng m^{-3}). 30-minute average values ranged from a minimum of 0.4 cm^{-3} (20-08) to 311.9 cm^{-3} (16-07), with an average seasonal value of 50.6 cm^{-3}. This value is higher than the average climatological summer value obtained from the last 12 years (36.9 cm^{-3}) and it represents the second highest summer value observed at ICO-OV from 2002.

Sommario

VISIONE DI INSIEME

L'estate del 2013 non ha presentato valori medi particolarmente elevati di *short-lived climate forcers* (SLCF): per l'ozono si è registrato un valore medio in linea con quelli climatologici, mentre il black carbon ha mostrato un valore inferiore. Anche per le particelle grossolane il valore medio è risultato confrontabile con quello climatologico. Solo il particolato fine ha mostrato un valore stagionale superiore a quelli osservati nelle precedenti estati.

Il 20.4% dei giorni sono stati significativamente influenzati da trasporti di masse d'aria inquinate: luglio è apparso come il mese maggiormente soggetto all'inquinamento, con il 79% degli eventi individuati ed i valori medi più elevati di ozono, black carbon, monossido di carbonio e particelle fini.

13 giorni sono stati caratterizzati da eventi di trasporto di sabbia sahariana: l'episodio più intenso è stato osservato dal 4 al 10 di Agosto, accompagnato da temperature molto elevate.

Nel 21.7 % dei giorni sono stati identificati eventi di trasporto di masse d'aria provenienti dalla stratosfera, distribuiti in modo quasi uniforme nei tre mesi considerati.

Il valore massimo giornaliero della concentrazione di **ozono superficiale** è stato registrato il 16-07 (80.0 ppb). Le medie semi-orarie variano da 35.5 ppb (02-08) a 97.4 ppb (16-07), con un valore medio stagionale di 61.8 ppb. Tale valore è confrontabile con quello climatologico relativo agli ultimi 18 anni (62.5 ppb).

Il valore massimo giornaliero della concentrazione di **monossido di carbonio** è stato registrato il 16-07 (158.9 ppb). Le medie semi-orarie variano da 46.7 ppb (03-08) a 200.8 ppb (08-08), con un valore medio stagionale pari a 117.1 ppb. Tale valore è leggermente inferiore a quello dell'estate 2012 (119.7 ppb), quando è stato avviato il programma di misura.

Il valore massimo giornaliero della concentrazione di **black carbon** è stato registrato il 20-07 (583.1 ng m^{-3}). Le medie semi-orarie variano da 11.0 ng m^{-3} (10-06) a 1945.5 ng m^{-3} (08-08), con un valore medio stagionale pari a 247.8 ng m^{-3}. Tale valore è inferiore a quello climatologico relativo agli ultimi 8 anni (297.8 ng m^{-3}).

Il valore massimo giornaliero della concentrazione di **particelle fini** è stato registrato il 20-07 (189.8 cm^{-3}). Le medie semi-orarie variano da 0.4 cm^{-3} (il 20-08) a 311.9 cm^{-3} (16-07), con un valore medio stagionale pari a 50.6 cm^{-3}. Esso è superiore a quello climatologico relativo agli ultimi 12 anni (36.9 cm^{-3}) ed è il secondo più elevato osservato a partire dal 2002.

Daily **nitric oxide** and **nitrogen dioxide** peaks were recorded on 01-06 (0.19 ppb) and 14-06 (2.6 ppb), respectively. 30-minute average values ranged from values below the detection limit to 0.64 ppb (for NO) and 4.81 ppb (for NO_2).

Daily **coarse aerosol particles** peak was recorded on 05-08 (1.22 cm^{-3}). 30-minute average values ranged from a minimum of 0.005 cm^{-3} (20-08) to 1.8 cm^{-3} (06-08), with an average seasonal value of 0.22 cm^{-3}. This value is comparable to the average climatological summer value obtained from the last 12 years (0.26 cm^{-3})

Daily **air temperature** peak was recorded on 04-08 (19.1°C). 30-minute average values ranged from a minimum of 0.3 °C (10-06) to 22.7 °C (04-08), with an average seasonal value of 10.8 °C. This value is on par with the average climatological summer value obtained from the last 18 years (10.6 °C).

Daily **relative humidity** minimum was recorded on 06-08 (37.9%). 30-minute average values ranged from a minimum of 11.1 % (04-08) to a maximum of 100.0 % (observed on 7 days), with an average seasonal value of 78.0 %. This value is slightly higher than the average climatological summer value obtained from the last 18 years (75.7 %).

Daily **atmospheric pressure** peak was recorded on 06-07 (799.4 hPa). 30-minute average values ranged from a minimum of 779.8 hPa (01-06) to 800.1 hPa (06-07), with an average seasonal value of 794.5 hPa. This value is higher than the average climatological summer value obtained from the last 18 years (792.7 hPa), and is similar to the one observed during summer 2003 (794.7 hPa), which was characterized by the presence of major “heatwaves”.

Daily **wind speed** peak was recorded on 20-08 (14.2 m s^{-1}). 30-minute average values ranged from a minimum of 0.4 m s^{-1} (11-07) to a maximum of 25.4 m s^{-1} (20-08), with an average seasonal value of 4.9 m s^{-1}. This value is slightly lower than the average climatological summer value obtained from the last 18 years (6.4 m s^{-1}).

Wind direction was prevalently from SW (30.0 % of 30-minute data) although a considerable amount was also coming from NE (23.6 %). This is similar to the climatological analysis over the last 18 years.

Daily **Solar radiation** peak was recorded on 17-06 (366.0 W m^{-2}). The longest period affected by the presence of cloud cover was from 04-06 to 10-06, although the lowest daily record was observed on 23-08 (102.5 W m^{-2}).

Daily **UV-B radiation** was characterized by the presence of high values from 17-06 till 21-06 (0.71 W m^{-2}), with the exception of 18-06 (0.41 W m^{-2}). A further period with high UV-B was recorded from 30-07 to 07-08. The lowest value was observed on 29-08 (0.16 W m^{-2}).

I valori massimi giornalieri di **ossido d'azoto** e **biossido d'azoto** sono stati rispettivamente registrati il 01-06 (0.19 ppb) ed il 14-06 (2.6 ppb). Le medie semi-orarie sono variate da valori inferiori al limite di rivelazione sino a 0.64 ppb (per NO) e 4.81 ppb (per NO_2).

Il valore massimo giornaliero della concentrazione di **particelle grossolane** è stato registrato il 05-08 (1.22 cm^{-3}). Le medie semi-orarie variano da 0.005 cm^{-3} (20-08) a 1.8 cm^{-3} (06-08), con un valore medio stagionale pari a 0.22 cm^{-3}. Tale valore è confrontabile con quello climatologico relativo ultimi 12 anni (0.26 cm^{-3}).

Il valore massimo giornaliero della **temperatura** è stato registrato il 04-08 (19.1 °C). Le medie semi-orarie variano da 0.3 °C (10-06) a 22.7 °C (04-08), con un valore medio stagionale pari a 10.8 °C. Tale valore è confrontabile con quello climatologico relativo agli ultimi 18 anni (10.6 °C).

Il valore minimo giornaliero dell'**umidità relativa** è stato registrato il 06-08 (37.9 %). Le medie semi-orarie variano da 11.1 % (04-08) a 100 % (osservato in 7 giornate), con un valore medio stagionale pari a 78.0 %. Tale valore è leggermente superiore a quello climatologico relativo agli ultimi 18 anni (75.7 %).

Il valore massimo giornaliero della **pressione atmosferica** è stato registrato il 06-07 (799.4 hPa). Le medie semi-orarie variano da 779.8 hPa (01-06) a 800.1 hPa (06-07), con un valore medio stagionale pari a 794.5 hPa. Tale valore è superiore a quello climatologico relativo agli ultimi 18 anni (792.7 hPa) ed è simile a quello osservato nell'estate 2003 (794.7 hPa) che fu caratterizzata dalla presenza di intense "ondate di calore".

Il valore massimo giornaliero della **velocità del vento** è stato registrato il 20-08 (14.2 m s^{-1}). Le medie semi-orarie variano da 0.4 m s^{-1} (11-07) a 25.4 m s^{-1} (20-08), con un valore medio stagionale pari a 4.9 m s^{-1}. Tale valore è leggermente inferiore a quello climatologico ottenuto dalle misure realizzate negli ultimi 18 anni (6.4 ms^{-1}).

La **direzione del vento** osservata nell'estate 2013 è stata prevalentemente da Sud-Ovest (30.0 % dei dati semi-orari), sebbene si evidenzi un presenza non trascurabile di venti da Nord-Est (23.6 % dei dati). Non vi sono differenze significative con l'andamento climatologico degli ultimi 18 anni.

Il valore massimo giornaliero della **radiazione solare** è stato registrato il 17-06 (366.0 W m^{-2}). Il periodo compreso tra il 04-06 ed il 10-06 è stato quello più interessato da copertura nuvolosa, sebbene il valore giornaliero più basso sia stato registrato il 23-08 (102.5 W m^{-2}).

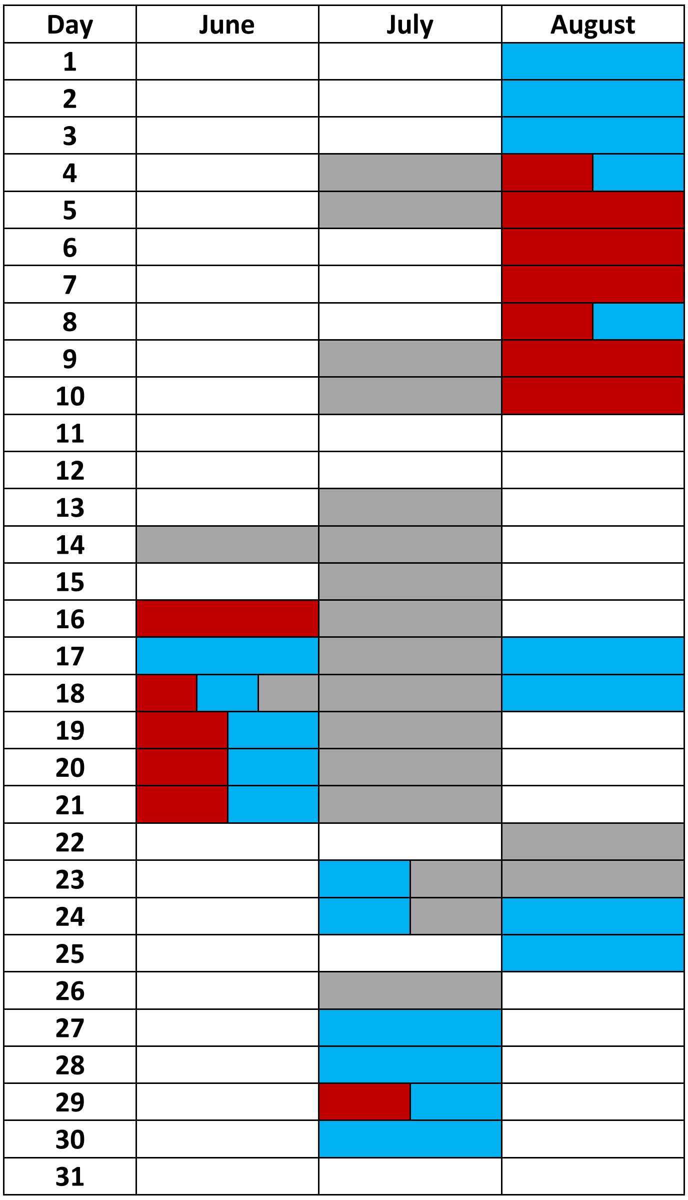
I valori giornalieri della **radiazione UV-B** osservati tra il 17 ed il 20 giugno, 0.71 W m^{-2}, sono i più alti del periodo (fa eccezione il 18-06 con 0.41 W m^{-2}). Elevati valori sono stati registrati anche dal 30-07 al 07-08. Il valore giornaliero più basso, 0.16 W m^{-2}, è stato registrato il 29-08.

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.**

<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>



Day	June	July	August
1			🟦
2			🟦
3			🟦
4		▨	🟥 🟦
5		▨	🟥
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29		🟥 🟦	
30		🟦	
31			

LEGEND

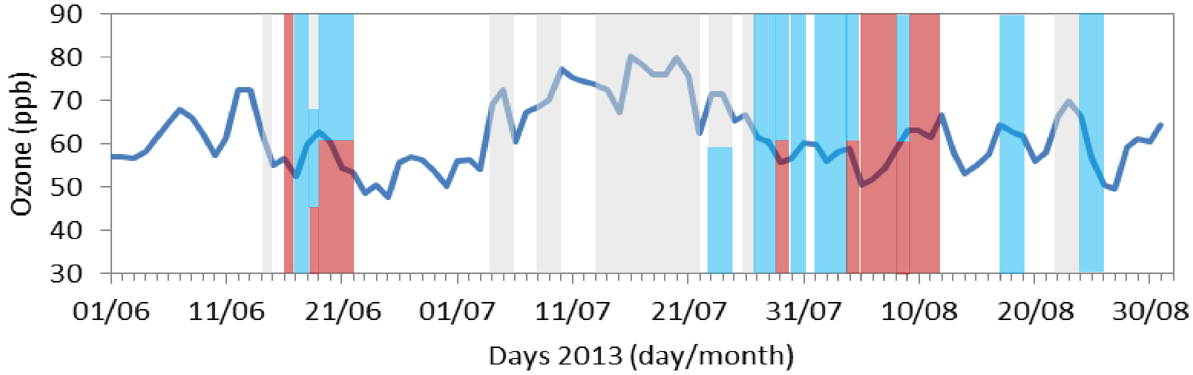
🟥 Mineral dust 🟦 Stratospheric intrusions ▨ Pollution transport

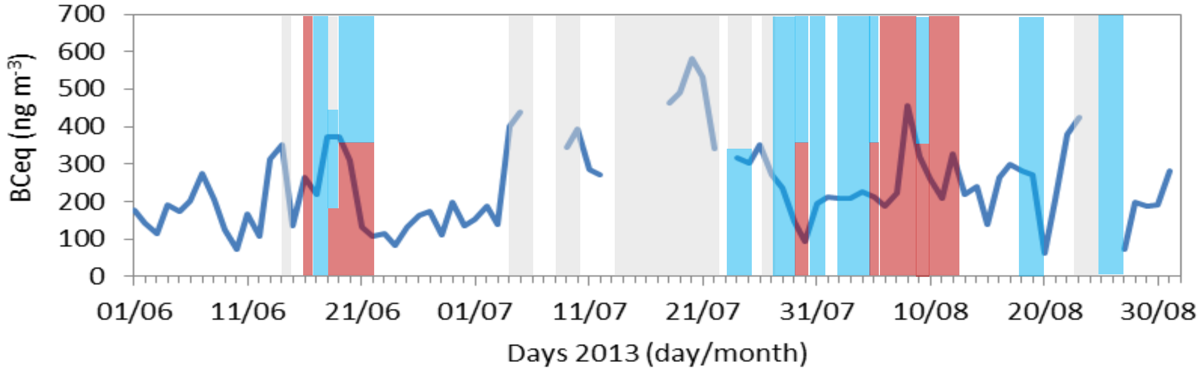
Eventi speciali

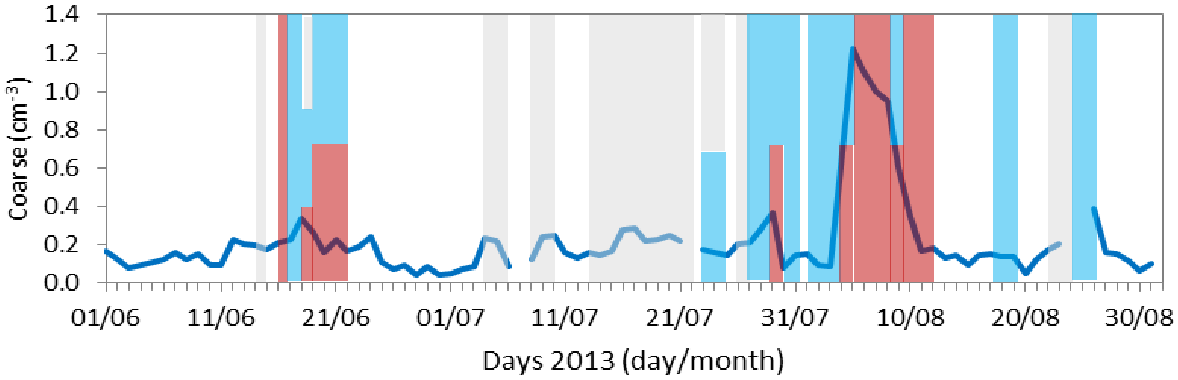
In questo paragrafo viene presentato l'elenco degli "eventi speciali" che sono stati registrati presso il sito di misura durante il periodo analizzato:

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

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







LEGENDA

🟥 Polveri minerali 🟦 Intrusioni stratosferiche ⬛ Trasporto di inquinanti

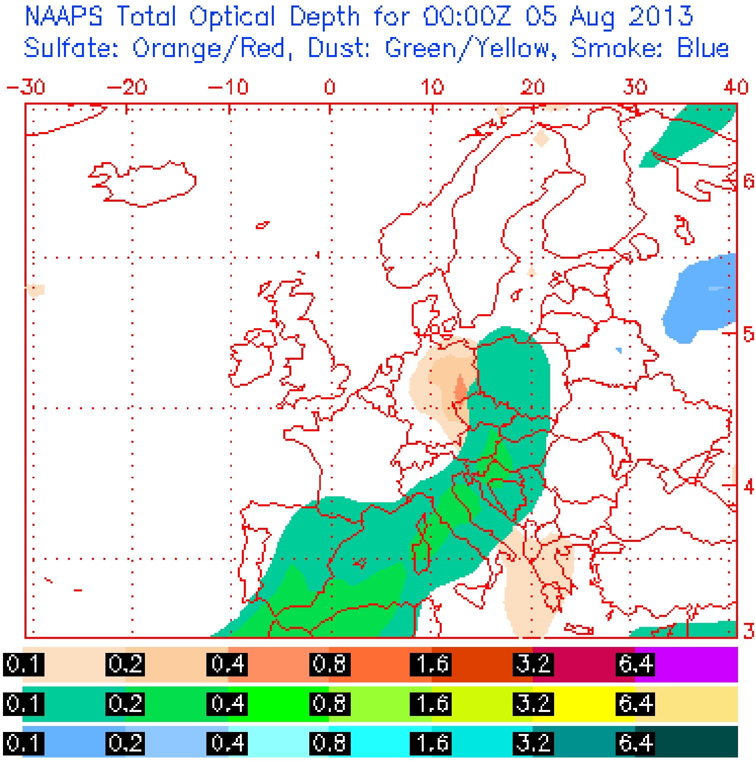
Mineral dust transport

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.

SUMMER 2013:

- **13 days were characterized by the transport of mineral dust from northern Africa (14.1 % of the period).**
- **The detected events were usually associated with the presence of a high pressure system over the central Mediterranean basin and a trough over western Europe, 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 August 4th to 10th, when the coarse particle reached the concentration of 1.22 cm^{-3}, on 5th August 2013.**



Dust transport event simulation by NAAPS model (5th August 2013).

Simulazione dell'evento di trasporto di polveri minerali osservato il 5 Agosto 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.

ESTATE 2013:

- **13 giorni sono stati caratterizzati dal trasporto di polveri minerali proveniente dal Nord Africa (14.1 % del periodo).**
- **Gli eventi sono stati generalmente associati alla presenza di un'area di alta pressione sul Mediterraneo centrale ed una depressione sull'Europa occidentale, che hanno innescato venti sud-occidentali sul mar Tirreno che favoriscono il trasporto dal nord Africa.**
- **L'evento più significativo è stato osservato dal 4 al 10 Agosto, quando è stata registrata la concentrazione massima di particelle grossolane per l'estate 2013 (1.22 cm^{-3}, il 5 Agosto 2013).**

Satellite image (Terra/MODIS) showing the mineral dust crossing the west Mediterranean basin on 3rd August 2013, one day before the detection at Mt. Cimone.

Immagine satellitare (Terra/MODIS) che mostra la presenza di aerosol minerale sul bacino occidentale del Mediterraneo il 3 agosto 2013, il giorno precedente l'osservazione a Monte Cimone.

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

Stratospheric intrusions (SI)

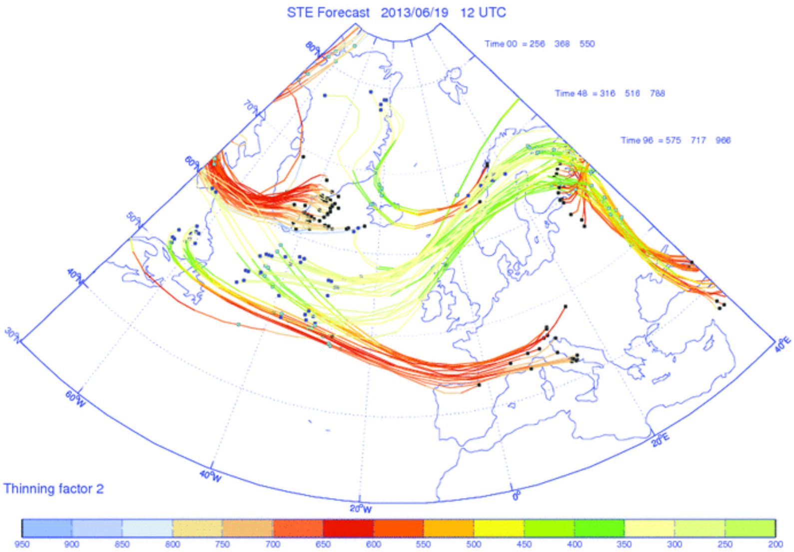
Stratospheric intrusions (SI) can be considered as a specific aspect of stratosphere–troposphere exchange (STE): the irreversible downward transport of stratospheric air relatively deep into the troposphere. Such phenomena are highly episodic and can be favored by a number of different mechanisms, acting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

SUMMER 2013:

- **20 days were characterized by the transport of air masses from the stratosphere or the upper free troposphere (21.7 % of the period).**
- **These events appeared to be almost equally distributed among June, July and August.**
- **The highest daily ozone concentrations related to the STE occurred on 23th - 24th July (71.5 and 71.6 ppb)**.



Trajectories describing the path of stratospheric air-masses for the event of 18-19 June 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 18-19 giugno 2013. Il colore rappresenta la quota (espressa come livello di pressione) delle masse d'aria. *Elaborazione: Michael Sprenger (ETH-Z, Switzerland)*

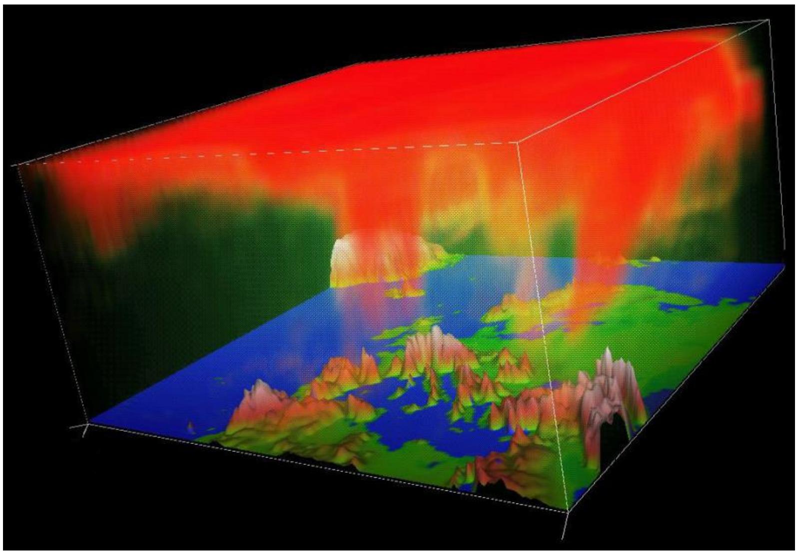
Intrusioni stratosferiche (SI)

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 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.

ESTATE 2013:

- **20 giorni sono stati caratterizzati dal trasporto di masse d'aria dalla stratosfera o dalla parte alta della libera troposfera (21.7 % del periodo).**
- **La frequenza di tali eventi è stata simile nei tre mesi di giugno, luglio ed agosto.**
- **Il picco giornaliero di ozono relativo a fenomeni di intrusioni stratosferiche è stato osservato nei giorni 23 - 24 luglio (71.5 and 71.6 ppb)**.



3-D visualization of an intrusion of stratospheric air (red) into the troposphere, resulting from a FLEXPART simulation (from Andreas Stohl's home page, http://zardoz.nilu.no/~andreas/)

Visualizzazione 3D di un evento di instrusione di aria stratosferica (in rosso), sulla base di simulazioni condotte con il modello FLEXPART (elaborazione Dr. Andreas Stohl, http://zardoz.nilu.no/~andreas/)

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).

SUMMER 2013

- **19 days were characterized by transport of polluted air masses (20.4% 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.**
- **July was the most polluted month, with elevated concentrations of ozone, carbon monoxide, black carbon and fine particles almost continuously from July 13th to 23rd.**
- **July 16th was the most polluted day for ozone (80.0 ppb) and carbon monoxide (158.9 ppb), while 20th was the most polluted day for black carbon (583.1 ng m^{-3}) and fine particle (189.8 cm^{-3}).**

Picture of the Po Basin as seen from Mt. Cimone. The gray layer represents the polluted boundary layer.

Immagine della Pianura Padana vista da Monte Cimone in una giornata estiva. Lo strato di colore grigio, denota l'accumulo di inquinanti nello strato limite atmosferico.

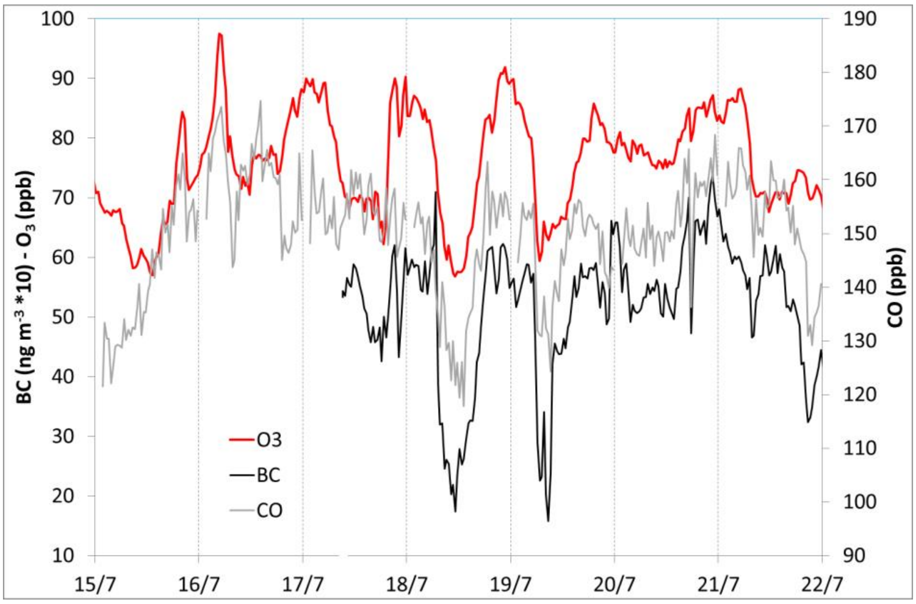
Trasporto di inquinanti

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).

ESTATE 2013

- **19 giorni sono stati caratterizzati dal trasporto di masse d'aria inquinate (20.4% 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.**
- **Luglio è stato il mese più inquinato, con elevate concentrazioni di ozono, monossido di carbonio, black carbon e particelle fini, in particolare fra tra il 13 ed il 23 luglio.**
- **Il 16 luglio è stato il giorno più inquinato per l'ozono (80.0 ppb) ed il monossido di carbonio (158.9 ppb), mentre il 20 Luglio è quello con le più alte concentrazioni di black carbon (583.1 ng m^{-3}) e particelle fini (189.8 cm^{-3}).**



CO, ozone and BC behaviors at Mt. Cimone from 15 to 21 July 2013.

Andamento delle concentrazioni di CO, ozono e BC a Monte Cimone (15 – 21 luglio 2013).

Surface ozone

Why is ozone so important?

O**zone** (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.

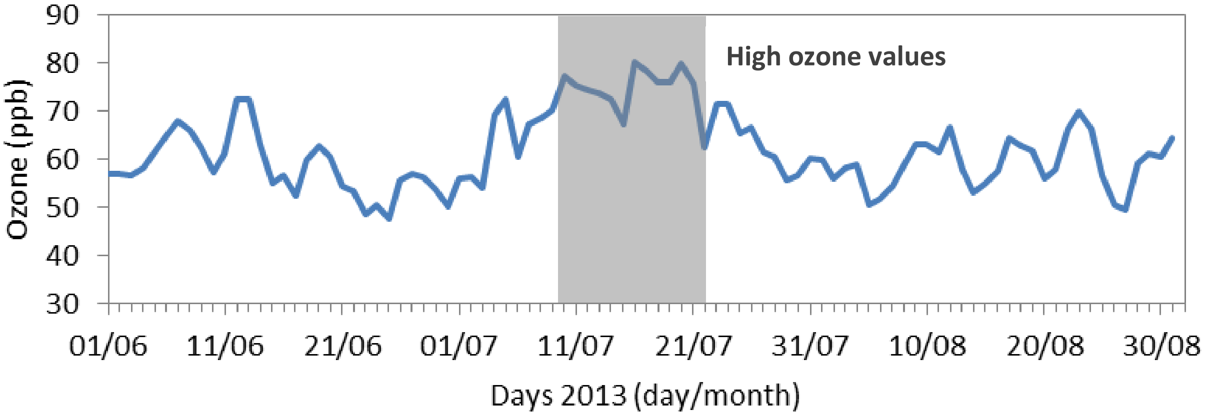
Basic statistical parameters

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

Data availability (%)	Min value (ppb)	25th Percentile (ppb)	50th Percentile (ppb)	Average mean value (ppb)	75th percentile (ppb)	Max value (ppb)
98.9	35.5	55.0	60.6	61.8	67.6	97.4

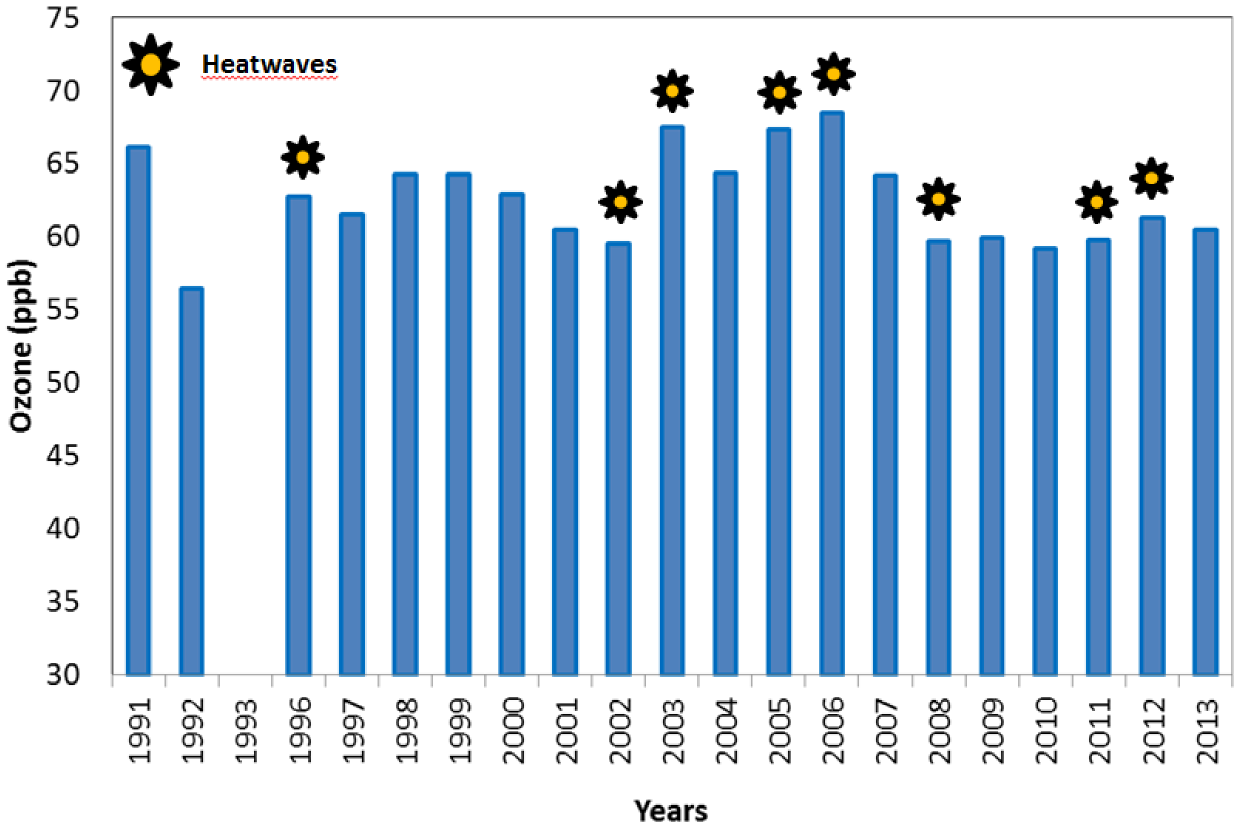
Time series of daily mean values

A long-lasting period with **relatively high O_3 has been recorded from July 9th to 21st, when several pollution agents** have been observed at ICO-OV. The highest daily mean value (80.0 ppb, corresponding to 160 $\mu g/m^3$) has been observed on July 16th 2013.



Comparison with historical data-set

The **2013 summer average mean value of O_3 is 61.8 ppb which is slightly lower than the climatological mean value (62.5 ppb) but significantly lower than average values observed during years 2003, 2005 and 2006**, when major heat waves have been observed at Mt. Cimone. As deduced by the analysis of daily time series, this is the result of higher-than-average O_3 during July and lower-than-average O_3 during June and August 2013.



Heathwaves identification

To unambiguously identify HWs which affected the north of Italy, 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.

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.

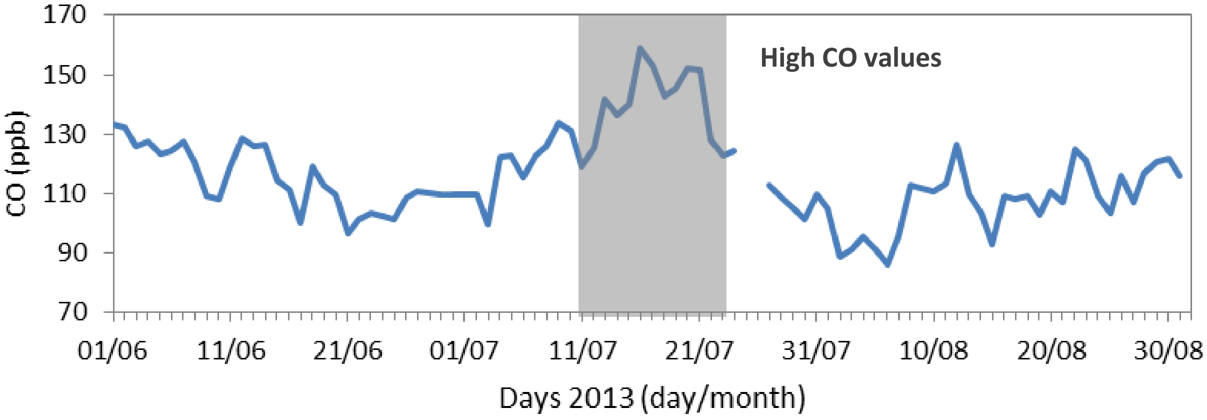
Basic statistical parameters

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

Data availability (%)	Min value (ppb)	25th Percentile (ppb)	50th Percentile (ppb)	Average mean value (ppb)	75th percentile (ppb)	Max value (ppb)
92.8	46.7	105.2	117.1	117.1	129.1	200.8

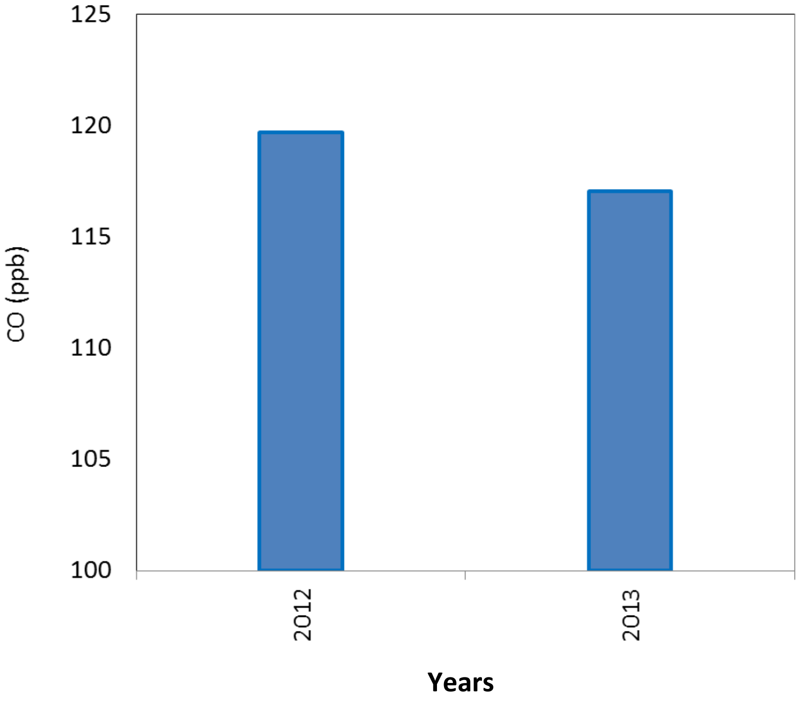
Time series of daily mean values

Similarly to $O_{3,}$ **a period with relatively high CO has been recorded from July 9th to 21st**, supporting the occurrence of pollution events at ICO-OV. The highest daily mean value (158.9 ppb) has been observed on July 16th 2013.



Comparison with historical data-set

The **2013 summer average mean value of CO is 117.1 ppb which is very similar to the average mean value of 119.7 ppb observed on summer 2012**, when the measurements by the NDIR system started at ICO-OV. The last decade of June and the first week of August 2013, have been characterized by values lower than average, while the first two weeks of June and the central part of July 2013 showed higher CO values.



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

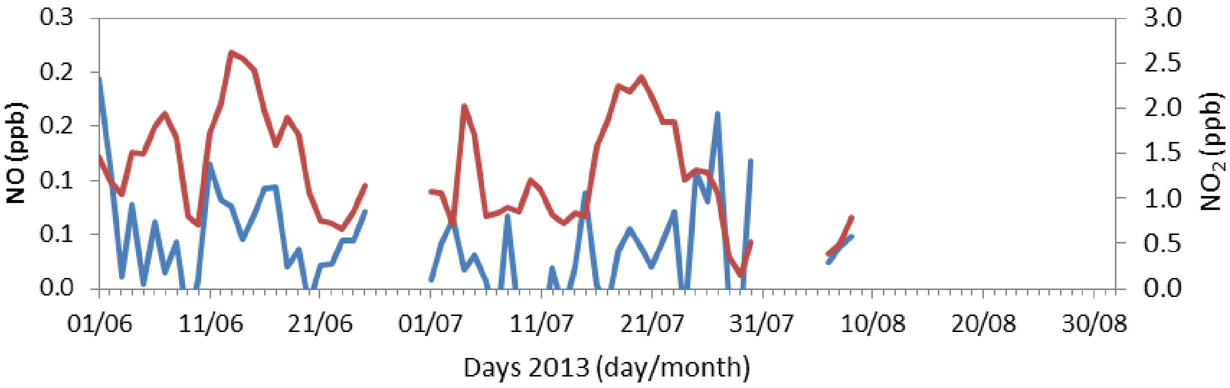
Statistical parameters are calculated basing on 30-minute aggregated values from June to September 2013.

Data availability (%)	Min value (ppb)	25th percentile (ppb)	50th percentile (ppb)	Average mean value (ppb)	75th percentile (ppb)	Max value (ppb)
NO 64.2	UDL	UDL	0.03	0.04	0.08	0.64
NO_2 64.2	UDL	0.73	1.20	1.31	1.82	4.81

UDL: under detection limit

Time series of daily mean values

Data were available until 8th August 2013, when an instrumental failure prevented the execution of further measurements. Very low NO values (blue lines) were recorded. NO_2 increases (red lines) were observed on June 11th -19th and on July 17th -24th 2001. The highest NO and NO_2 daily values were observed on June 1st and 14th, respectively.



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.

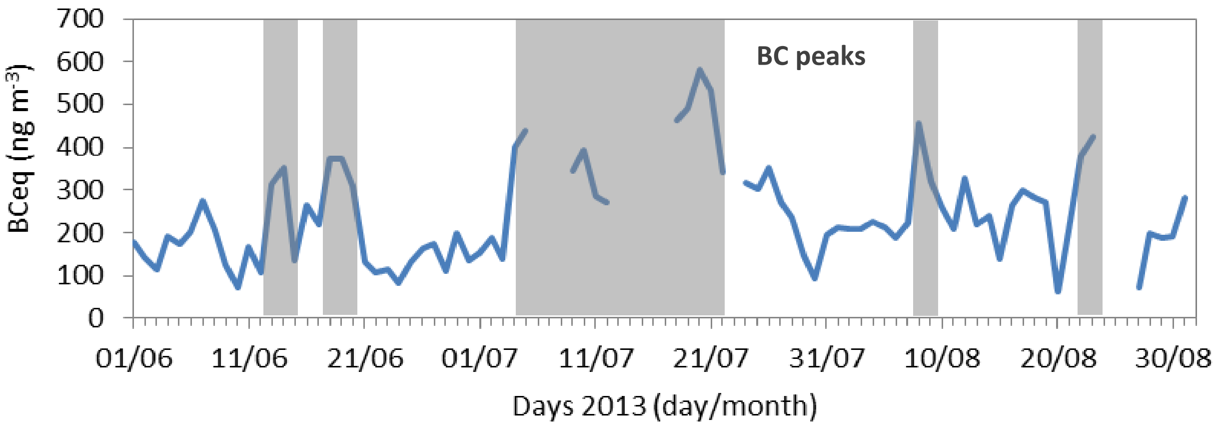
Basic statistical parameters

Statistical parameters are calculated basing on 30-minute aggregated values from June to September 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})
88.6	11.0	136.5	228.3	247.8	334.6	1945.5

Time series of daily mean values

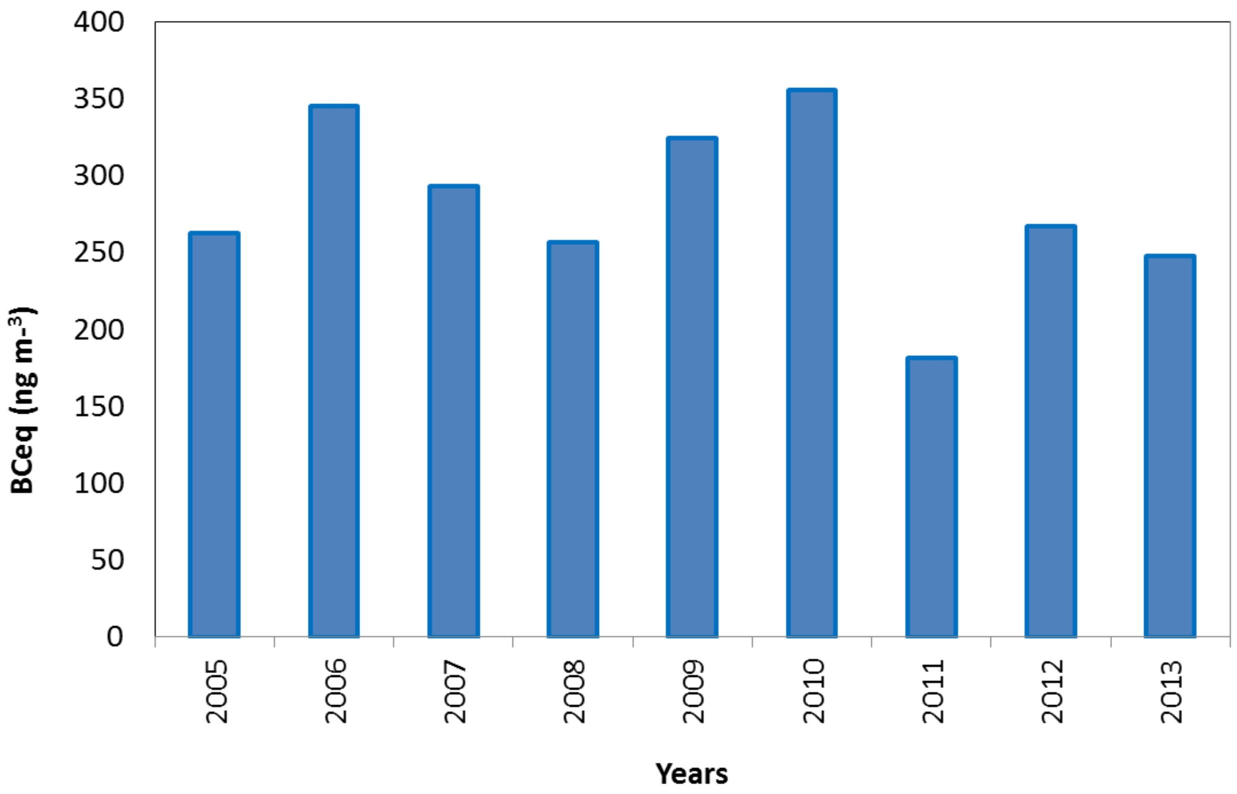
The highest daily mean value (583.1 ng m^{-3}) has been observed on 20th July 2013. **High values have been observed also on June 14th and 18th - 19th, from July 4th to 21st, on August 8th -9th and 22nd - 23rd**, supporting the presence of pollution at the measurement site (see grey bars).



Comparison with historical data-set

The 2013 summer average mean value of BC is 247.8 ng m^{-3}, which is lower than the climatological mean value (297.8 ng m^{-3}). During this period, July was the month characterized by the BC highest concentrations at Mt. Cimone (average value: 318.2 ng m^{-3}), thanks to the occurrence of several pollution transport events also triggered by the favorable fair weather conditions.

It should be noted that BC was measured from July 2005 till February 2007 by using a Particle Soot Absorption Photometer (PSAP). Thus, possible biases arising from the different experimental set-up cannot be completely ruled out in respect to the more recent MAAP measurements. However, both PSAP and MAAP participated in the first NA4 Aethalometer-Nephelometer Intercomparison (Leipzig, Germany - March 2007) in the framework of EUSAAR project. MAAP participated also in the 2nd NA4 Absorption Photometer Workshop (Leipzig, Germany - July 2009).



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

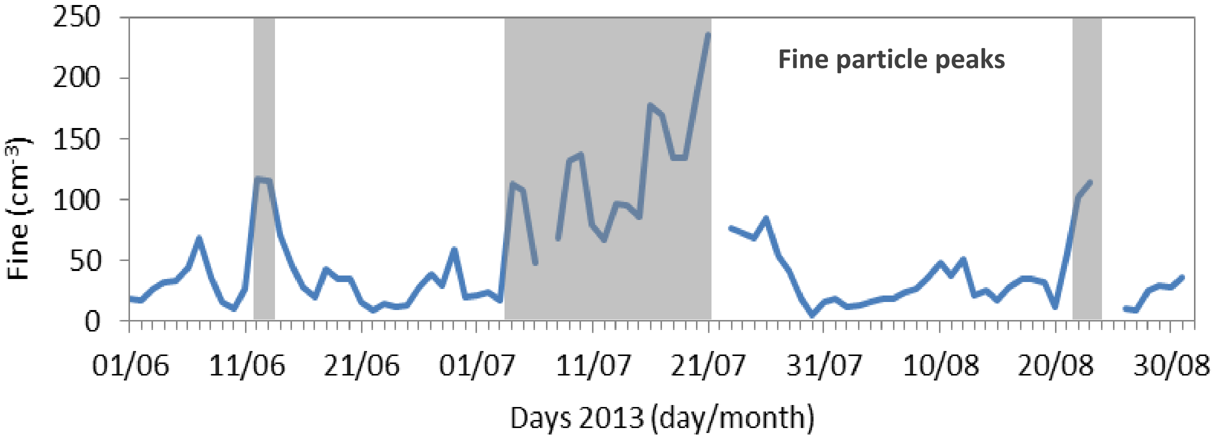
Basic statistical parameters

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

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})
92.0	0.4	15.5	31.4	50.6	68.9	311.9

Time series of daily mean values

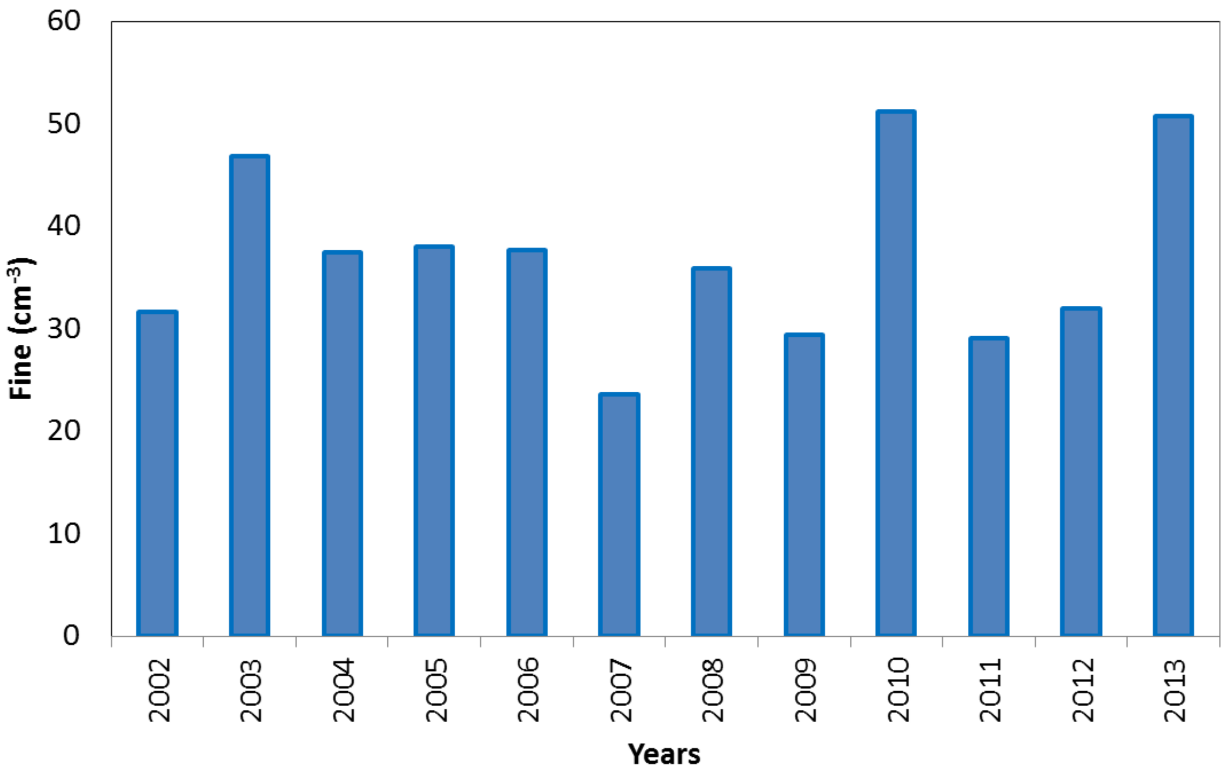
The highest daily mean value (189.8 cm^{-3}) has been observed on 20th July 2013. Daily peaks have been observed on **June 12th -13th**, from **July 4th to 21st** and **August 22nd -23rd**.



Comparison with historical data-set

The 2013 summer average mean value of fine particles is 50.6 cm^{-3}, which represents the second highest values observed at Mt. Cimone after summer 2010 (51.2 cm^{-3}).

While June (35.9 cm^{-3}) and August (33.2 cm^{-3}) were characterized by average values comparable with the climatological ones, July 2013 (average value: 85.5 cm^{-3}) doubled the climatological value (36.9 cm^{-3}). This behavior is different from that of other secondary (i.e. ozone) or primary (i.e. black carbon) pollutants which showed, for summer 2013, lower values than the climatology. This point deserves more investigation, but the contribution of secondary aerosol during polluted events in July can play a not negligible role.



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.

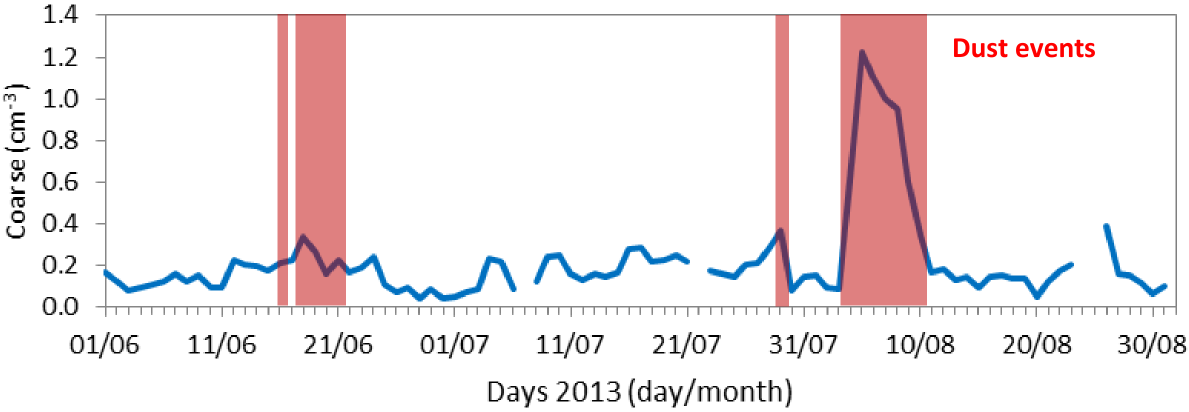
Basic statistical parameters

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

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})
90.8	0.005	0.1	0.2	0.2	0.2	1.8

Time series of daily mean values

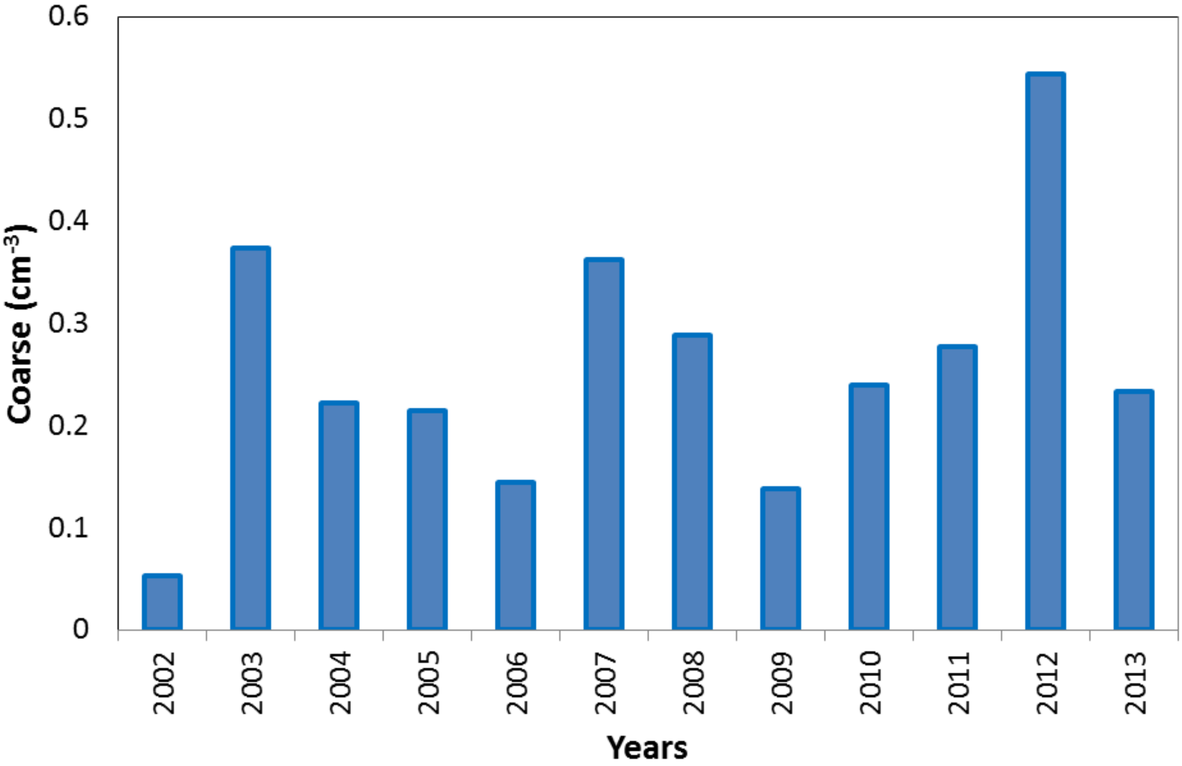
The highest daily mean value (1.22 cm^{-3}) has been observed on August 5th 2013, when a **strong Saharan dust transport affected Mediterranean basin and Mt. Cimone** (from August 4th to 10th).



Comparison with historical data-set

The summer 2013 average mean value of the coarse particles (0.22 cm^{-3}) is well comparable with the summer climatological value (0.26 cm^{-3}).

In respect to other years (e.g. 2003, 2007, 2012) the 2013 summer period was characterized by relative low number of Saharan dust transport events.



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).

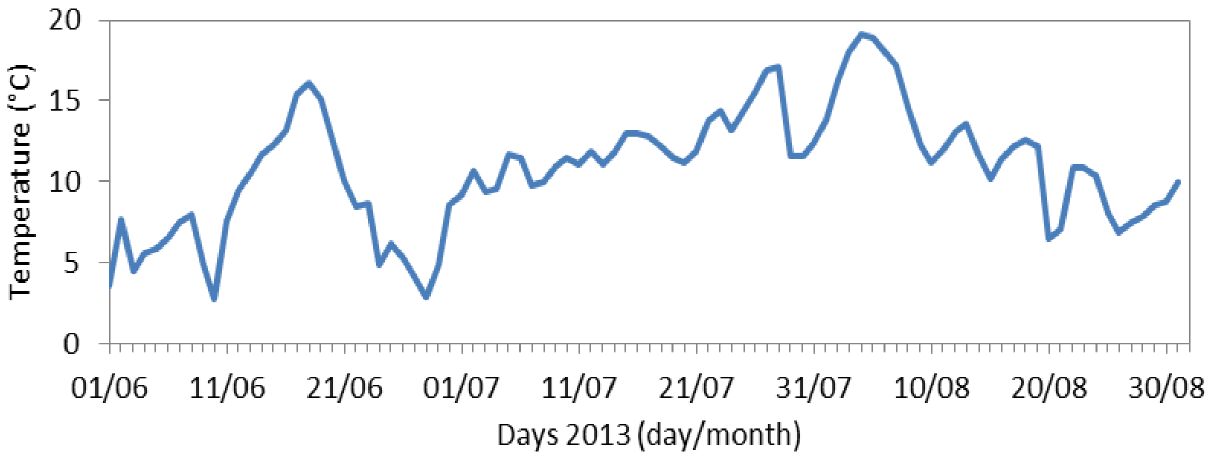
Basic statistical parameters

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

Data availability %	Min value (°C)	25th percentile (°C)	50th percentile (°C)	Average mean value (°C)	75th percentile (°C)	Max value (°C)
100.0	0.3	8.0	10.7	10.8	13.5	22.7

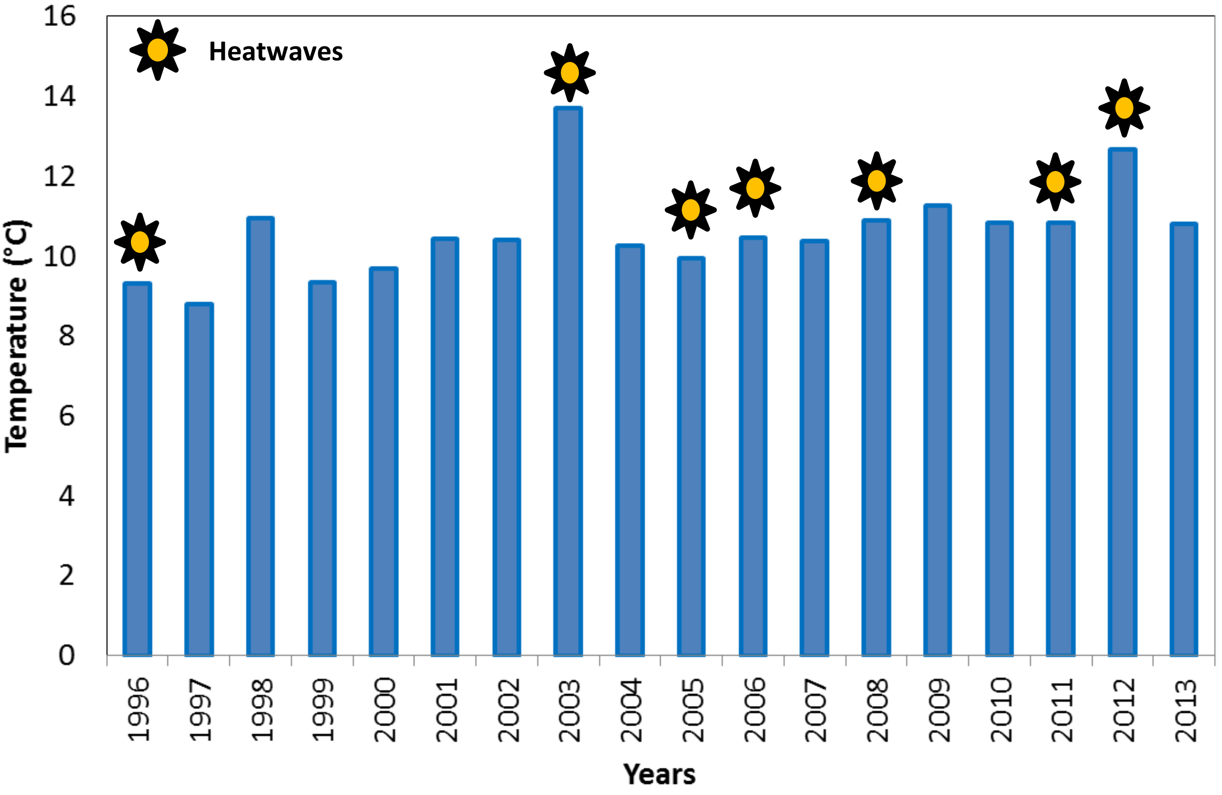
Time series of daily mean values

The highest daily mean value (19.1 °C) has been observed on 4th August 2013, simultaneously with the occurrence of a Saharan dust transport. High air-temperature periods have also been observed on June 16th - 20th (max: 16.1 °C) and July 21st – 29th (max: 17.1 °C).



Comparison with historical data-set

The **summer 2013 average temperature (10.8 °C) was comparable with the summer climatological value (10.6 °C),** and much lower than those recorded during summer 2003 (13.7 °C) and 2012 (12.6°C), when strong heat waves affected Europe, northern Italy and Mt. Cimone. However, as deduced by the analysis of daily time series, a large variability in air-temperature was observed at Mt. Cimone during summer 2013: higher-than-average temperatures have been observed in the central part of June, during the last 10 days of July and at the beginning of August, while lower temperatures occurred on the remaining days of June and during the last decade of August**.**



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).

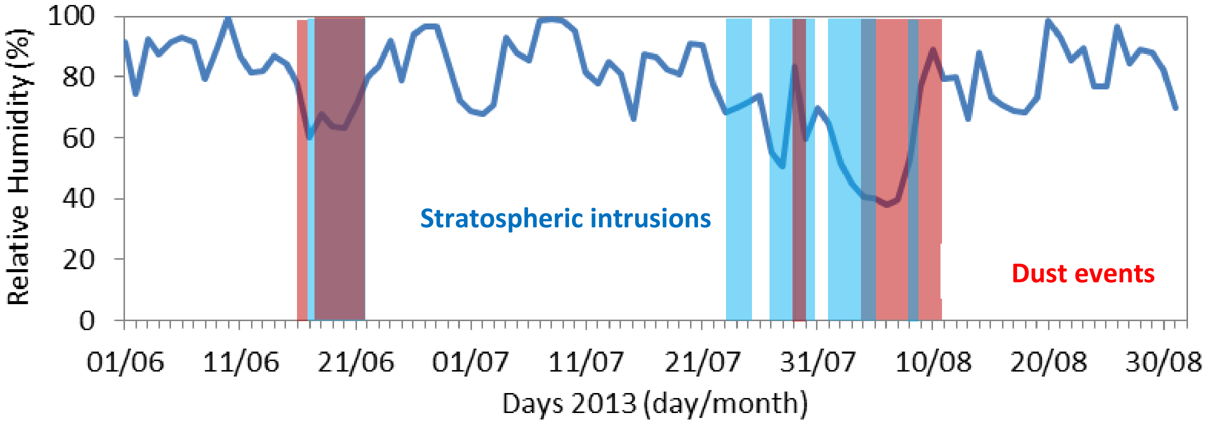
Basic statistical parameters

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

Data availability (%)	Min value (%)	25th percentile (%)	50th percentile (%)	Average mean value (%)	75th percentile (%)	Max value (%)
100.0	11.1	67.0	80.3	78.0	94.3	100.0

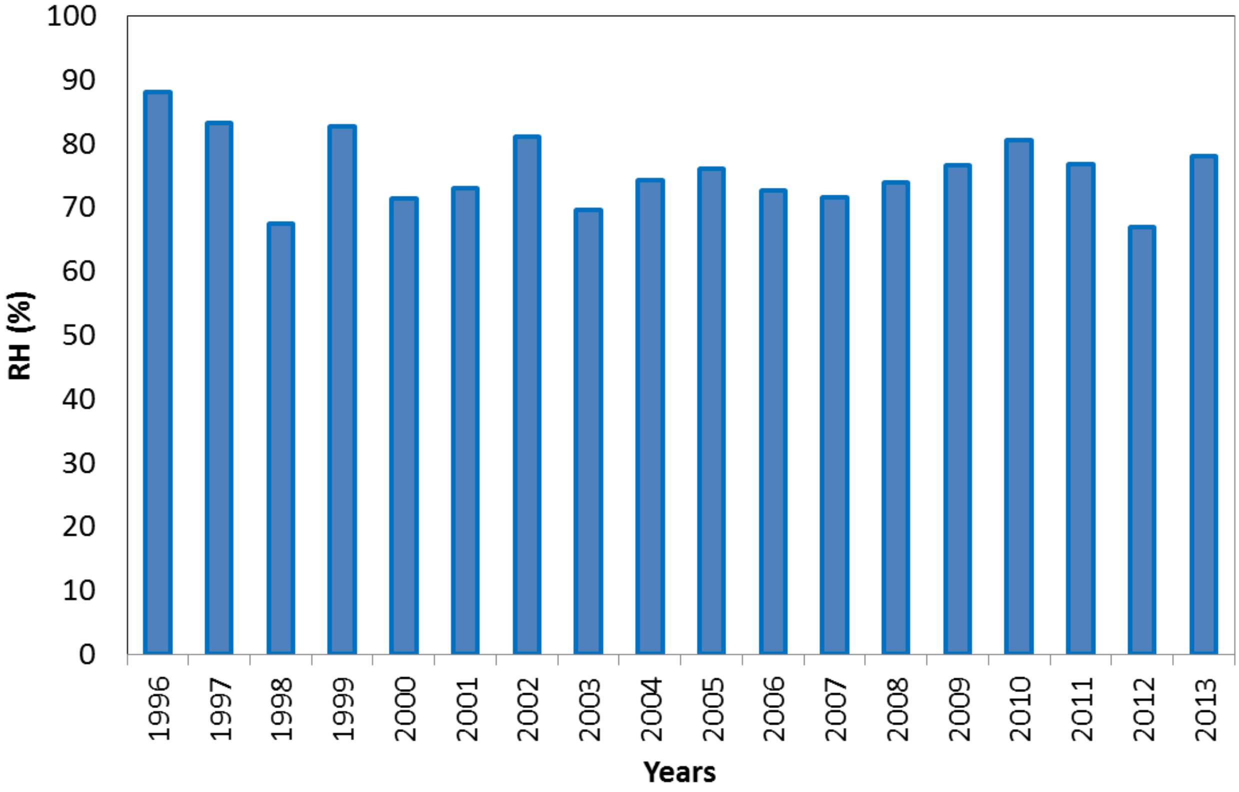
Time series of daily mean values

The daily mean RH values ranged from 100% to 40%. The driest period has been observed from August 1st to 8th, when **air-mass transport from North Africa and stratospheric intrusions affected ICO-OV.** Dry conditions also occurred on June 17th – 21st, simultaneously with an O_3 increase, thus possibly tracing air-mass transport from free troposphere/stratosphere.



Comparison with historical data-set

The summer 2013 average relative humidity (78.0%) was comparable with the summer climatological value (75.7%). Nevertheless, it should be noted the occurrence of extremely dry conditions at the beginning of August 2013, with daily mean RH values well below 60%, as deduced by the analysis of the daily values time series.



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).

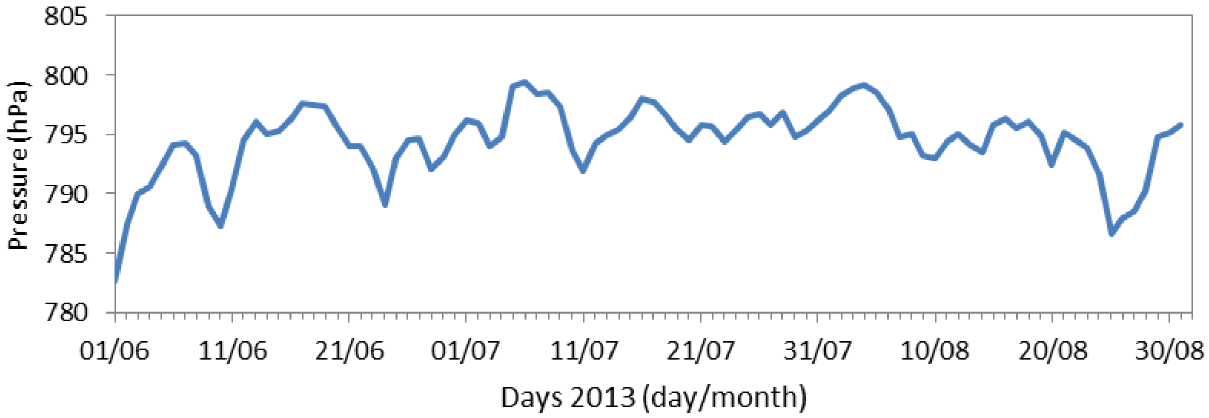
Basic statistical parameters

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

Data availability (hPa)	Min value (hPa)	25th percentile (hPa)	50th percentile (hPa)	Average mean value (hPa)	75th percentile (hPa)	Max value (hPa)
100.0	779.8	793.4	795.0	794.5	796.4	800.1

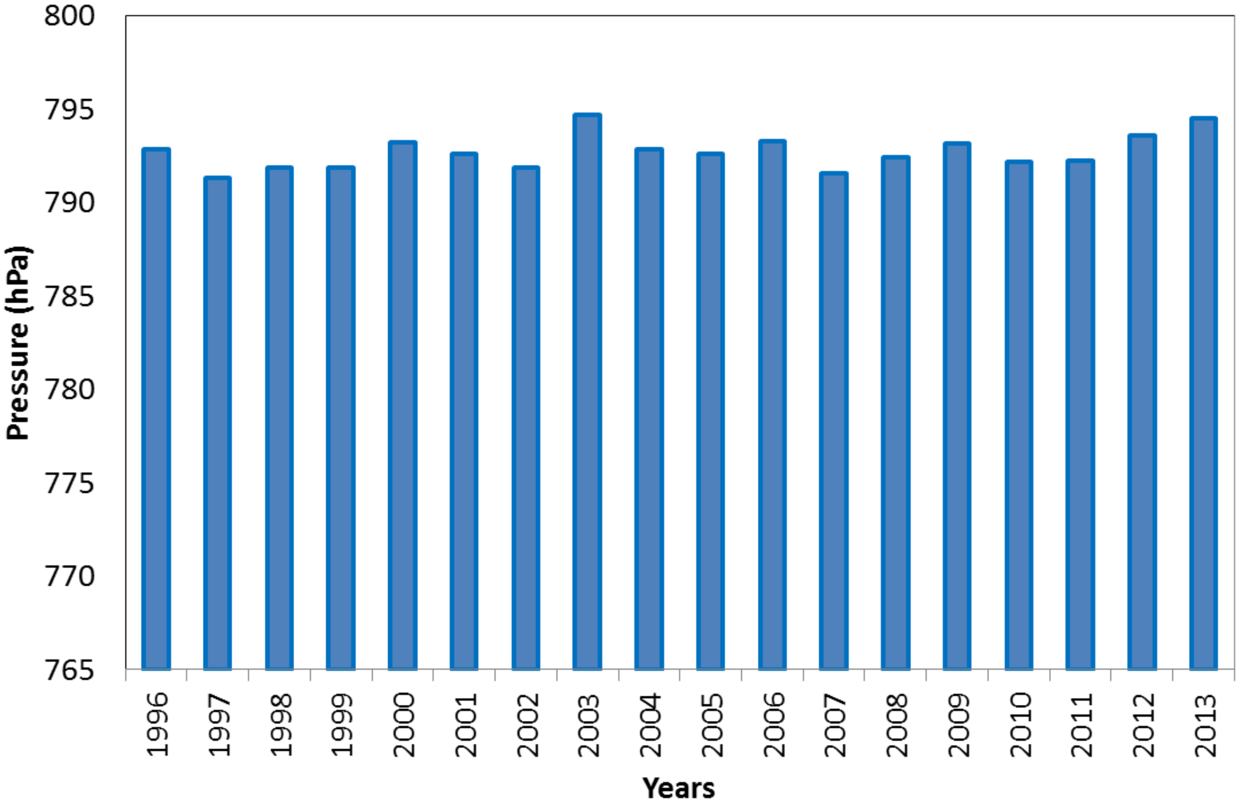
Time series of daily mean values

The daily mean pressure values showed **high values and low variability from July 16th to August 8th 2013**, indicating the occurrence of typical summer conditions. Large drops occurred on June 10th, June 24th, July 11th and August 25th, indicating possible influence of synoptic-scale disturbances.



Comparison with historical data-set

The **summer 2013 average atmospheric pressure (794.5 hPa) was slightly higher than the summer climatological value (792.7 hPa).** As deduced by the analysis of the time series of daily values, this can reflect the occurrence of high pressure conditions on middle June, during the first decade of July, from the end of July until the beginning of August 2013.



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.

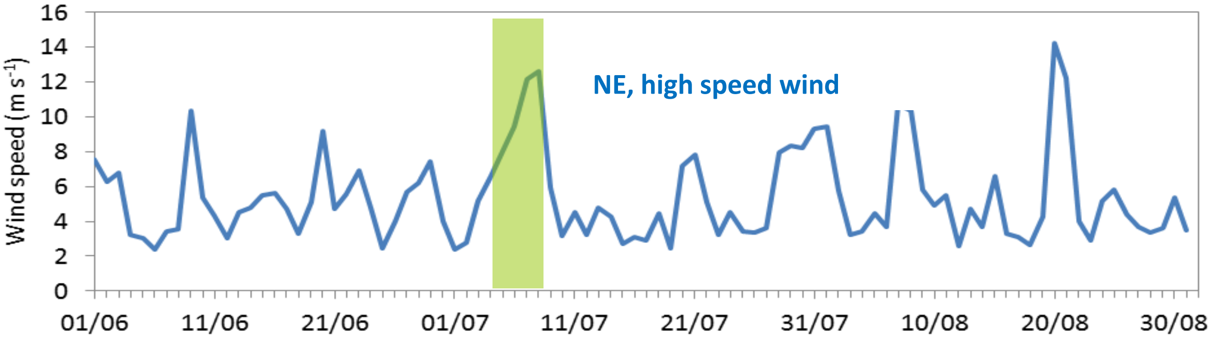
Basic statistical parameters of wind speed

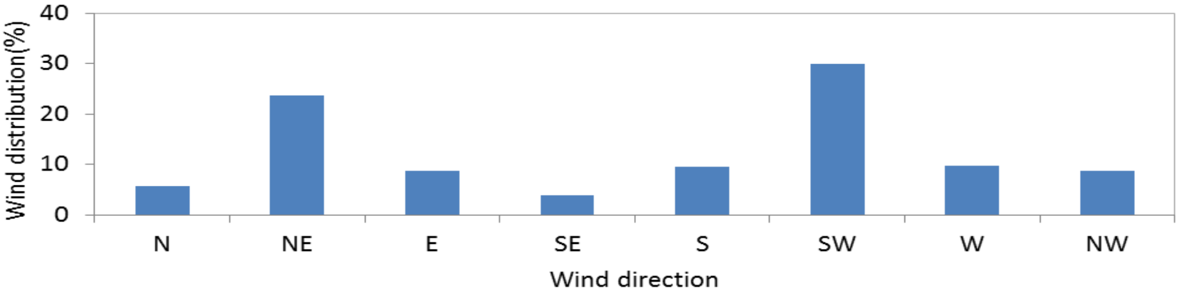
Statistical parameters are calculated basing on 30-minute aggregated values from June to September 2013.

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)
100.0	0.4	2.2	3.8	4.9	6.4	25.4

Time series of daily mean values

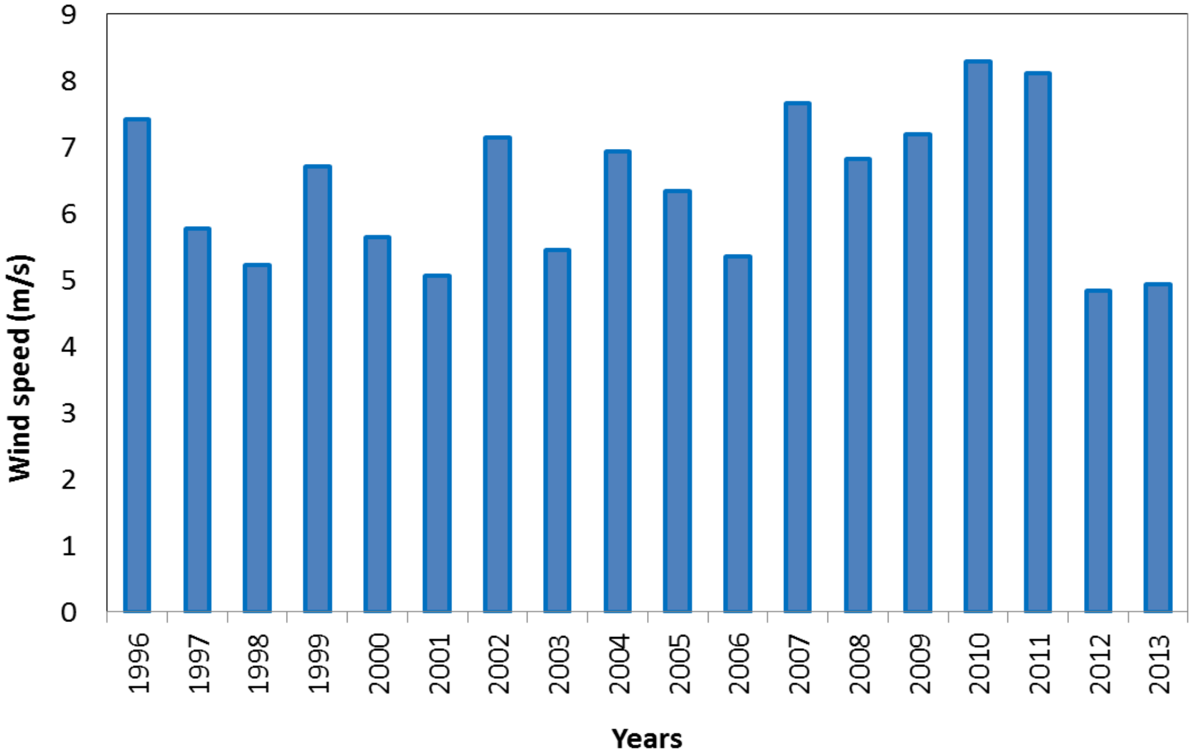
Although the summer 2013 is characterized by a predominance of SW winds, during the period July 4th – 9th 2013 we observed the prevalence of NE, high speed (>10 m s^{-1}). High wind speed were also observed on June 9th, 7th and August 20th – 21st.

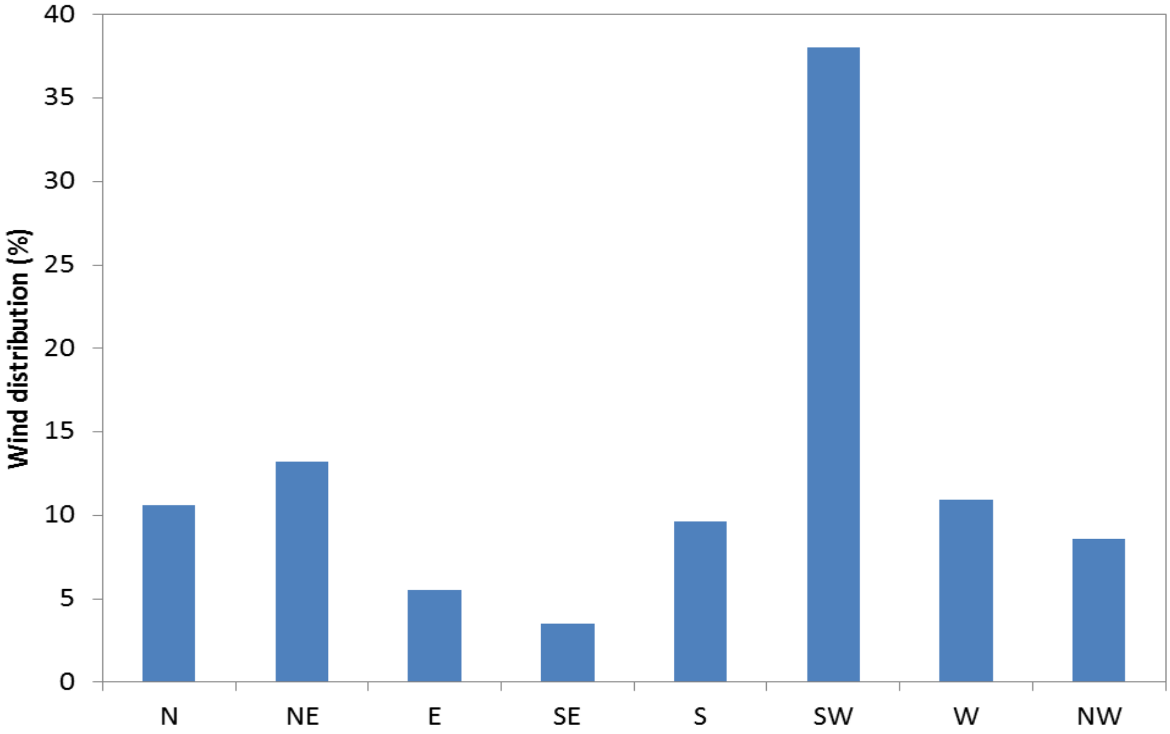




Comparison with historical data-set

The summer 2013 showed an average wind speed (4.9 m/s) slightly lower than the climatological value (6.4 m/s), however rather high wind speeds (> 10 m/s) have been observed on a daily basis. The seasonal wind direction is similar to the climatological one, **with a prevalence of south-westerly winds (respectively 30.0 % and 38.0 %)**, although during summer 2013 a strong contribution from NE winds was also present (23.6 %).





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 (short-wave)

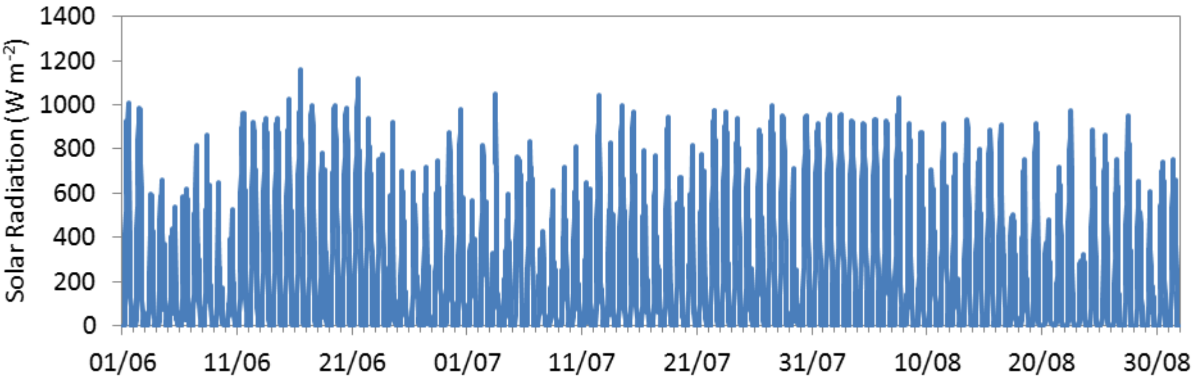
Statistical parameters are calculated basing on 30-minute aggregated values from June to September 2013.

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)
99.8	UDL	UDL	85.3	234.6	421.5	1160.3

UDL: under detection limit

Time series (short-wave)

The highest 30 minute mean value (1160.3 W m^{-2}) has been observed on June 16th 2013, during a period (June 13th – 22nd 2013) mostly characterized by clear sky and high air-temperature. A significant period of cloud cover was instead experienced between June 4th – 10th and July 1st – 11th 2013.



Basic statistical parameters (UV-B)

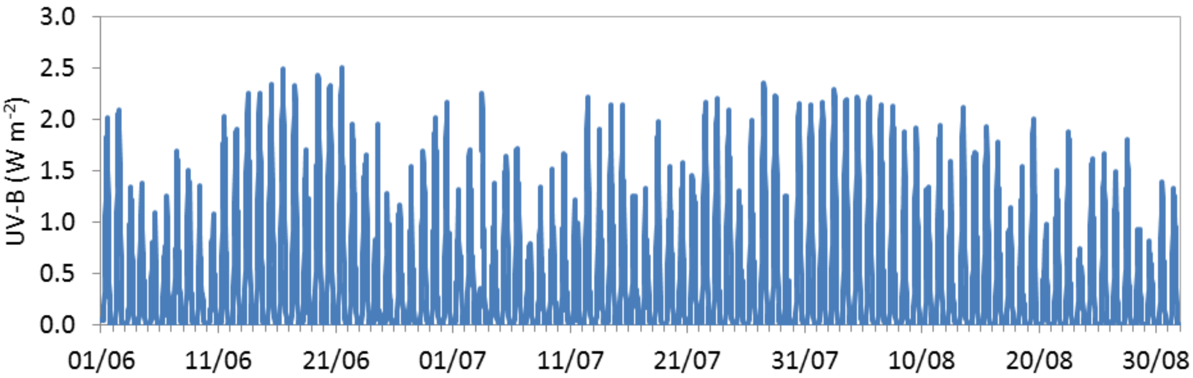
Statistical parameters are calculated basing on 30-minute aggregated values from June to September 2013.

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)
99.8	UDL	UDL	UDL	0.44	0.72	2.51

UDL: under detection limit

Time series (short-wave)

Similarly to what have been observed for the short wave solar radiation, a period of clear sky and high UV-B radiation (including the seasonal maximum 2.51 W m^{-2}) has been observed on June 17th – 21st and 30th July- 7th August 2013.



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Research Projects

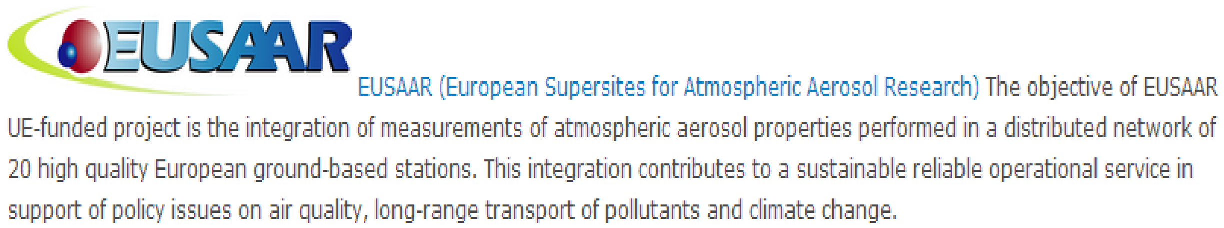
GAW (Global Atmosphere Watch) The Global Atmosphere Watch (GAW) programme of WMO is a partnership involving 80 countries, which provides reliable scientific data and information on the chemical composition of the atmosphere, its natural and anthropogenic change, and helps to improve the understanding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