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Istituto di Scienze dell'Atmosfera e del Clima



ITALIAN CLIMATE OBSERVATORY "O. VITTORI" Mt. CIMONE



GAW-WMO Global Station



WINTER 2013/2014 REPORT



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

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CNR
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DTA
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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 WINTER 2013/2014 at the Italian Climate Observatory “O. Vittori” (ICO-OV), managed by the Institute of Atmospheric Sciences and Climate (ISAC) of the National Research Council of Italy (CNR). This research infrastructure is part of the WMO/GAW global station of Monte Cimone together with the Meteorological Observatory of the Italian Air Force (GAW ID: CMN).

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

Then, an overview of the atmospheric and weather conditions during winter 2013/2014 considering:

- **surface ozone**
- **carbon monoxide**
- **nitrogen oxides**
- **black carbon**
- **fine and coarse particles**
- **halogenated gases**
- **stratospheric nitrogen dioxide**
- **volatile organic compounds**
- **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 winter is also presented, together with a description of the adopted selection methodologies:

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

For each observed parameter, a specific paragraph presents:

- **the time series of the daily mean values (calculated basing on 30-minute aggregated values, if the daily data coverage of 75% has been achieved)**
- **a table reporting the basic statistical parameters (on a 30-minute basis)**
- **a comparison with the seasonal historical mean values: for each year, the winter mean values are calculated by averaging data from 2013, December 1st to 2014, February 28th.**

Premessa

Questo rapporto riassume i risultati relativi alle osservazioni atmosferiche effettuate durante l'INVERNO 2013/2014 presso l'Osservatorio Climatico "O. Vittori" (ICO-OV) dell'Istituto di Scienze dell'Atmosfera e del Clima (ISAC) del Consiglio Nazionale delle Ricerche Italia (CNR). Questa stazione di ricerca è parte, insieme all'Osservatorio Meteorologico dell'Aeronautica Militare, della stazione globale WMO/GAW di Monte Cimone (GAW ID: CMN).

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

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

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

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

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

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

Per ogni parametro osservato uno specifico paragrafo presenta:

- **le serie storiche dei valori medi giornalieri (calcolati basandosi su valori mediati di 30 minuti, se la copertura dei dati giornaliera del 75% è stata raggiunta)**
- **una tabella con i parametri statistici di base (su un base di 30 minuti)**
- **Il confronto con i valori medi storici stagionali per ogni anno, considerando che i valori invernali sono calcolati come media dal 1 Dicembre 2013 al 28 Febbraio 2014.**

Monte Cimone GAW/WMO Global Station

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



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

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



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

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

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

*Managed by Italian Institutions

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

La Stazione Globale GAW/WMO di Monte Cimone

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



La spina dorsale del programma GAW è costituita dalla propria rete osservativa. Essa è formata da Stazioni Globali e Regionali, oltre che da Stazioni definite "Contributing" che forniscono informazioni aggiuntive. 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 |
| Jungfrauoch | 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

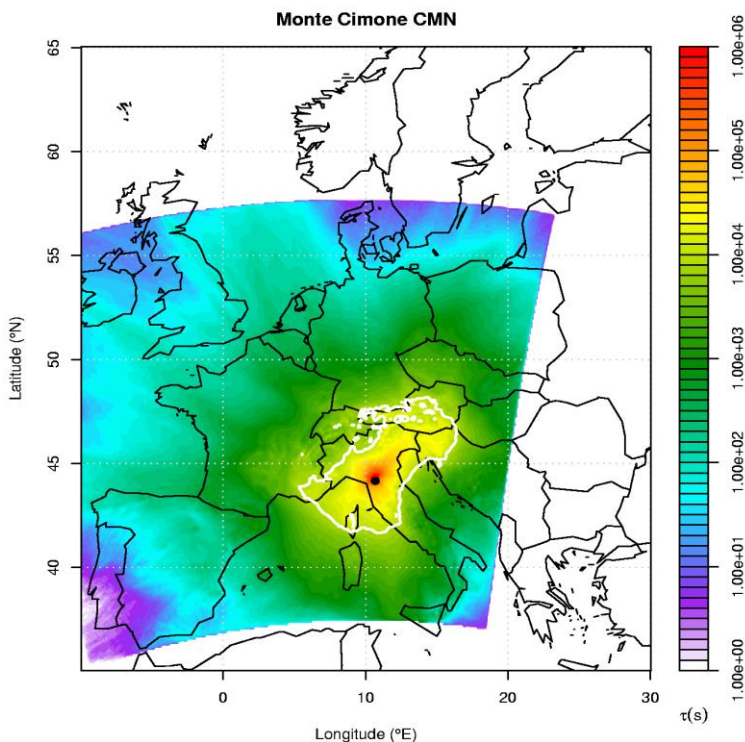
Lista delle stazioni globali GAW/WMO in aree di alta quota (for more information: <http://gaw.empa.ch/gawsis/>)

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 (<i>Dasibi 1108 W/GEN</i>) |
| Carbon monoxide | Primary pollutant, ozone precursor, combustion tracer | Non dispersive IR absorption (<i>Thermo Tei48c-TL</i>) |
| Nitrogen oxides | Primary (NO) and secondary (NO ₂) pollutants, ozone precursors, combustion tracers. | Chemiluminescence analyser (<i>Thermo Tei42</i>) |
| Black carbon | Short-lived climate forcer, primary pollutant, combustion tracer. It contributes to PM ₁ | Multi-Angle Absorption Photometer (<i>Thermo MAAP 5012</i>) |
| Aerosol number concentration (fine) | Short-lived climate forcer, primary and secondary aerosol, pollution tracer. It contributes to PM ₁ . | Optical particle counter (<i>GRIMM 1108</i>) |
| Aerosol number concentration (coarse) | Short-lived climate forcer, primary aerosol, mineral dust and sea salt tracer. It contributes to PM ₁₀ . | Optical particle counter (<i>GRIMM 1108</i>) |
| Halogenated gases | Stratospheric ozone depleting substances and climate forcer | Gas chromatography-Mass spectrometry. (<i>Agilent 6850–5975</i>) |
| Stratospheric nitrogen dioxide | Ozone destroying substance and buffer against halogen catalysed ozone loss | GASCOD-MTC: UV-Vis spectrometer (Since 1993) |
| Volatile organic compounds | Ozone and PM precursors | Gas chromatography-Mass spectrometry (<i>Agilent 6850–5975</i>) |
| Temperature and relative humidity | Meteorology and data interpretation | <i>Rotronic, IRDAM WS 7000</i> |
| Atmospheric pressure | Meteorology and data interpretation | <i>Technoel, IRDAM WS 7000</i> |
| Wind | Meteorology and data interpretation | <i>Vaisala WS425, IRDAM WST7000</i> |
| Solar radiation | Meteorology and data interpretation | Silicon cell pyranometer (<i>Skye SKS110</i>) |
| UV-B radiation | Meteorology and data interpretation | Silicon photodiode (<i>Skye SKU 430</i>) |

Lista dei parametri

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

| Parametri | Ruolo chiave clima – qualità dell'aria | Strumentazione |
|---|---|---|
| Ozono superficiale | Forzante climatico a breve tempo di vita, gas serra, inquinante secondario. | Analizzatore ad assorbimento UV (Dasibi 1108 W/GEN) |
| Monossido di carbonio | Inquinante primario, precursore dell'ozono, tracciante della combustione | Analizzatore ad assorbimento infra-rosso. (Thermo Tei48c-TL) |
| Ossidi d'azoto | Inquinanti primari (NO) e secondari (NO ₂), precursori dell'ozono, traccianti della combustione. In stratosfera NO ₂ influenza le concentrazioni di ozono. | Analizzatore a chemiluminescenza (Thermo 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) |
| Gas alogenati | Distrucono l'ozono stratosferico, forzanti climatici | Gas cromatografia-Spettrometria di massa (Agilent 6850-5975) |
| Biossido di azoto stratosferico | Distrugge l'ozono stratosferico e sostanza "tampone" per alogeni attivi nella deplezione dell'ozono stratosferico | Spettrometro UV/Vis GASCOD-MTC |
| Composti organici volatile | Precursori dell'ozono troposferico e del PM | Gas cromatografia-Spettrometria di massa (Agilent 6850-5975) |
| Temperatura ed umidità relativa | Meteorologia ed interpretazione dei dati | Rotronic, IRDAM WS 7000 |
| Pressione atmosferica | Meteorologia ed interpretazione dei dati | Technoel, IRDAM WS 7000 |
| Vento | Meteorologia ed interpretazione dei dati | Vaisala WS425, IRDAM WST7000 |
| Radiazione solare | Meteorologia ed interpretazione dei dati | Piranometro a celle di silicio (Skye SKS110) |
| Radiazione UV-B | Meteorologia ed interpretazione dei dati | Fotodiodo al silicio (Skye SKU 430) |

Summary

OVERWIEV

Winter 2014 did not present high average levels of **short-lived climate forcers (SLCF)**: a value lower than the climatological mean was observed for **carbon monoxide, black carbon** and **fine particles**. For **surface ozone** and **coarse particles** we reported an average value similar with previous winter seasons. The **halogenated gases** usually showed values lower than the northern hemispheric background, even if high concentration episodes were sporadically observed. The atmospheric and meteorological regime were well representative of the clean winter season. **However, winter 2013/2014 emerged as the warmest winter season even observed at ICO-OV since 1996.**

Only 4.4% of the winter days have been affected for a significant fraction of time by **transport of polluted air-masses**, with all of them taking place at the end of February.

11 days (12.2%) were affected by **mineral dust transport**, with a major event occurring from February 15th to 21st.

Air-mass **transport from the stratosphere** occurred for 16.6% of the period. No event was observed during February.

The winter 2013/2014 appeared to be the warmest winter ever observed at the ICO-OV since 1996

Sommario

VISIONE DI INSIEME

L'inverno del 2014 non ha presentato valori medi elevati di *short-lived climate forcers* (SLCF): il **black carbon**, il **monossido di carbonio** ed il **particolato fine** hanno mostrato valori inferiori rispetto alle medie climatologiche. Le **particelle grossolane** e l'**ozono** hanno mostrato valori in linea con quelli dei precedenti anni. I **gas alogenati** hanno mostrato valori generalmente al di sotto del fondo atmosferico, anche se sono stati evidenziati sporadicamente alcuni picchi di concentrazione. In generale gli andamenti sono ben rappresentativi del periodo invernale, caratterizzato da un minor numero di eventi di inquinamento e trasporto di polveri minerali rispetto alle altre stagioni. **Tuttavia l'inverno 2013/2014 è stato l'inverno più caldo mai osservato dall'anno 1996, quando sono state avviate le osservazioni presso l'ICO-OV.**

Solo 4.4% dei giorni sono stati influenzati da trasporti di **masse d'aria inquinate**, tutti osservati alla fine del mese di Febbraio.

11 giorni (12.2%) sono stati caratterizzati da **eventi di trasporto di sabbia sahariana**: l'episodio più intenso è stato osservato dal 15 al 21 di Febbraio.

Nel 16.6 % dei giorni sono stati identificati eventi di trasporto di **masse d'aria provenienti dalla stratosfera**, nessuno dei quali è stato osservato nel mese di Febbraio.

A Monte Cimone, l'inverno 2013/2014 è stato il più caldo a partire dal 1996.

Daily **surface ozone** peak was recorded on 25-02 (54.0 ppb). 30-minute average values ranged from a minimum of 21.9 ppb (26-12) to 58.7 ppb (25-02), with an average seasonal value of 44.5 ppb. This value is on par with the average climatological winter value obtained from the last 18 years (45.0 ppb).

Daily **carbon monoxide** peak was recorded on 28-01 (166.8 ppb). 30-minute average values ranged from a minimum of 36.0 ppb (26-12) to 268.0 ppb (02-02), with an average seasonal value of 110.7 ppb. This value is lower than the value of winter 2013 (147.6 ppb).

Daily **black carbon** peak was recorded on 18-02 (249.4 ng m⁻³). 30-minute average values ranged from a minimum of 10.0 ng m⁻³ (03-01) to 536.1 ng m⁻³ (19-02), with an average seasonal value of 60.0 ng m⁻³. This value is lower than the average climatological winter value obtained from the last 8 years (84.1 ng m⁻³).

Daily **fine aerosol particles** peak was recorded on 23-02 (21.8 cm⁻³). 30-minute average values ranged from a minimum of 0.01 cm⁻³ (02-02) to 89.2 cm⁻³ (23-02), with an average seasonal value of 3.2 cm⁻³. This value is lower than the average climatological winter value obtained from the last 12 years (8.1 cm⁻³).

Daily **nitric oxide** and **nitrogen dioxide** peaks were recorded on 24-01 (0.6 ppb) and (2.1 ppb), respectively. 30-minute average values ranged from values below the detection limit to 5.86 ppb (for NO) and 8.16 ppb (for NO₂).

Daily **coarse aerosol particles** peak was recorded on 19-02 (1.5 cm⁻³). 30-minute average values ranged from a minimum of 0.001 cm⁻³ (04-12) to 7.7 cm⁻³ (19-02), with an average seasonal value of 0.09 cm⁻³. This value is comparable to the average climatological winter value obtained from the last 12 years (0.07 cm⁻³).

Daily **HFC-134a** peak was recorded on 28-01 (103.9 ppt), and a minimum of 78.1 ppt was recorded on 09-01, with an average seasonal value of 83.9 ppt. These values are comparable to the average northern hemisphere values, and fit well with the global increasing trend of this compound.

The maximum value of **stratospheric nitrogen dioxide** columnar amount was recorded on 26-02 (5.29·10¹⁵ mol/cm²) for the sunset, and 18-01 (3.26·10¹⁵ mol/cm²) for the sunrise. The minimum value of the columnar amount of nitrogen dioxide was recorded on 21-12 (2.4·10¹⁵ mol/cm²) for the sunset, and 18-01 (1.69·10¹⁵ mol/cm²) for the sunrise. The trend of the series follows the course of the annual cycle that involves a lowering of the total column in winter.

Il valore massimo giornaliero della concentrazione di **ozono superficiale** è stato registrato il 25-02 (54.0 ppb). Le medie semi-orarie variano da 21.9 ppb (26-12) a 58.7 ppb (25-02), con un valore medio stagionale di 44.5 ppb. Tale è in linea con quello climatologico relativo agli ultimi 18 anni (45.0 ppb).

Il valore massimo giornaliero della concentrazione di **monossido di carbonio** è stato registrato il 28-01 (166.8 ppb). Le medie semi-orarie variano da 36.0 ppb (26-12) a 268.0 ppb (02-02), con un valore medio stagionale pari a 110.7 ppb. Tale valore è inferiore a quello dell'inverno 2013 (114.5 ppb).

Il valore massimo giornaliero della concentrazione di **black carbon** è stato registrato il 18-02 (249.4 ng m⁻³). Le medie semi-orarie variano da 10.0 ng m⁻³ (03-01) a 536.1 ng m⁻³ (19-02), con un valore medio stagionale pari a 60.0 ng m⁻³. Tale valore è inferiore a quello climatologico relativo agli ultimi 8 anni (84.1 ng m⁻³).

Il valore massimo giornaliero della concentrazione di **particelle fini** è stato registrato il 23-02 (21.8 cm⁻³). Le medie semi-orarie variano da 0.01 cm⁻³ (02-02) a 89.2 cm⁻³ (23-02), con un valore medio stagionale pari a 3.2 cm⁻³. Tale valore è inferiore a quello climatologico (8.1 cm⁻³).

I valori massimi giornalieri di **ossido d'azoto** e **biossido d'azoto** sono stati registrati il 24-01 (0.6 ppb e 2.1 ppb rispettivamente). Le medie semi-orarie sono variate da valori inferiori al limite di rivelazione sino a 5.86 ppb (per NO) e 8.16 ppb (per NO₂).

Il valore massimo giornaliero della concentrazione di **particelle grossolane** è stato registrato il 19-02 (1.5 cm⁻³). Le medie semi-orarie variano da 0.001 cm⁻³ (04-12) a 7.7 cm⁻³ (19-02), con un valore medio stagionale pari a 0.09 cm⁻³. Tale valore è confrontabile con quello climatologico relativo ultimi 12 anni (0.07 cm⁻³).

Il valore massimo giornaliero dell'**HFC-134a** è stato registrato il 28-01 (103.9 ppt), mentre un minimo di 78.1 ppt si è osservato il 09-01. La media stagionale è stata di 83.9 ppt. Questi valori sono in linea con i valori tipici dell'emisfero settentrionale e con il trend globale di crescita di questo composto.

Il valore massimo della quantità colonnare di **biossido di azoto stratosferico** è stato registrato il 26-02 (5.29·10¹⁵ mol/cm²) per il tramonto, e il 18-01 (3.26·10¹⁵ mol/cm²) per l'alba. Il valore minimo della quantità colonnare di biossido di azoto è stato registrato il 21-12 (2.4·10¹⁵ mol/cm²) per il tramonto, e il 18-01 (1.69·10¹⁵ mol/cm²) per l'alba. L'andamento della serie segue l'andamento del ciclo annuale che prevede un abbassamento della colonna totale nel periodo invernale.

Daily **Propane** peak was recorded on 15-01 (20 ppb), and a minimum of 193.1 ppt was recorded on 09-12, with an average seasonal value of 729.6 ppt. These values are comparable to the average continental Europe values, and fit well with the European decreasing trend of propane.

Daily **air temperature** peak was recorded on 17-12 (5.1°C), minimum on 01-12 (-6.1 °C). 30-minute average values ranged from a minimum of -7.8 °C (26-01) to 7.6 °C (17-12), with an average seasonal value of -0.5 °C. **This value is the highest winter seasonal record ever observed by ICO-OV since 1996.**

Daily **relative humidity** minimum was recorded on 17-12 (6.5%). 30-minute average values ranged from a minimum of 3.1 % (16-12) to a maximum of 100.0 % (observed on 3 days), with an average seasonal value of 82.1 %. This value is higher than the average climatological winter value obtained from the last 18 years (77.2 %).

Daily **atmospheric pressure** peak was recorded on 16-12 (803.4 hPa), the lowest value on 26-12 (765.5 hPa). 30-minute average values ranged from a minimum of 761.4 hPa (26-12) to 804.3 hPa (10-12), with an average seasonal value of 786.5 hPa. This value is on par with the average climatological winter value obtained from the last 18 years (786.1 hPa).

Daily **wind speed** peak was recorded on 25-12 (23.8 m s⁻¹). 30-minute average values ranged from a minimum of 0.2 m s⁻¹ (06-02) to a maximum of 50.5 m s⁻¹ (13-02), with an average seasonal value of 12.0 m s⁻¹. This value is higher than the average climatological winter value obtained from the last 18 years (9.4 m s⁻¹).

Wind direction was prevalently from SW (27.3 % of 30-minute data). This is similar to the climatological analysis over the last 18 years.

Daily **Solar radiation** showed a decreasing trend from December till the end of January, while it started to rise again during February: the highest average daily value was recorded on 25-02 (182.5 W m⁻²).

A similar trend was also observed for **UV-B radiation**: the highest value was observed on 25-02 (0.2 W m⁻²).

Il valore Massimo giornaliero del **Propano** è stato registrato il 15-01 (20 ppb), mentre il minimo di 193.1 ppt si è osservato il 09-12. La media stagionale è stata 729.6 ppt. Questi valori sono in linea coi valori tipici dell'Europa continentale e con il trend di diminuzione che si osserva per il propano su scala Europea.

Il valore massimo giornaliero della **temperatura** è stato registrato il 17-12 (5.1 °C), il valore minimo il 01-12 (-6.1 °C). Le medie semi-orarie variano da -7.8 °C (26-01) a 7.6 °C (17-12), con un valore medio stagionale pari a -0.5 °C. **Esso è il valore stagionale invernale più elevato osservato a partire dal 1996.**

Il valore minimo giornaliero dell'**umidità relativa** è stato registrato il 17-12 (6.5 %). Le medie semi-orarie variano da 3.1 % (16-12) a 100 % (osservato in 3 giornate), con un valore medio stagionale pari a 82.1 %. Tale valore è superiore a quello climatologico relativo agli ultimi 18 anni (77.2 %).

Il valore massimo giornaliero della **pressione atmosferica** è stato registrato il 16-12 (803.4 hPa), il valore minimo il 26-12 (765.5 hPa). Le medie semi-orarie variano da 761.4 hPa (26-12) a 804.3 hPa (10-12), con un valore medio stagionale pari a 786.5 hPa. Tale valore è confrontabile con quello climatologico relativo agli ultimi 18 anni (786.1 hPa).

Il valore massimo giornaliero della **velocità del vento** è stato registrato il 25-12 (23.8 m s⁻¹). Le medie semi-orarie variano da 0.2 m s⁻¹ (06-02) a 50.5 m s⁻¹ (13-02), con un valore medio stagionale pari a 12.0 m s⁻¹. Tale valore è superiore a quello climatologico ottenuto dalle misure realizzate negli ultimi 18 anni (9.4 ms⁻¹).

La **direzione del vento** osservata nell'autunno 2013 è stata prevalentemente da Sud-Ovest (27.3 % 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 nei mesi di Dicembre e Gennaio ed una risalita durante il mese di Febbraio: il valore giornaliero più elevato è stato registrato il 25-02 (182.5 W m⁻²).

Anche la **radiazione UV-B** mostra un simile trend nel corso della stagione: il valore massimo (0.2 W m⁻²) è stato osservato il 25-02.

Special events

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

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

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

| Day | December | January | February |
|-----|--------------------------|--------------------------|---------------------|
| 1 | | | |
| 2 | Mineral dust | | |
| 3 | | | |
| 4 | Stratospheric intrusions | | |
| 5 | | | |
| 6 | | | |
| 7 | | | |
| 8 | Stratospheric intrusions | Stratospheric intrusions | |
| 9 | Stratospheric intrusions | Stratospheric intrusions | Mineral dust |
| 10 | | | |
| 11 | Stratospheric intrusions | Stratospheric intrusions | |
| 12 | Stratospheric intrusions | Stratospheric intrusions | |
| 13 | Stratospheric intrusions | Stratospheric intrusions | |
| 14 | Stratospheric intrusions | | |
| 15 | Stratospheric intrusions | | Mineral dust |
| 16 | | | Mineral dust |
| 17 | | | Mineral dust |
| 18 | Stratospheric intrusions | | Mineral dust |
| 19 | | Mineral dust | Mineral dust |
| 20 | | | Mineral dust |
| 21 | Mineral dust | | Mineral dust |
| 22 | | | Pollution transport |
| 23 | Stratospheric intrusions | | Pollution transport |
| 24 | | | Pollution transport |
| 25 | | | Pollution transport |
| 26 | | | |
| 27 | | | |
| 28 | | | |
| 29 | | | |
| 30 | | | |
| 31 | | | |

LEGEND

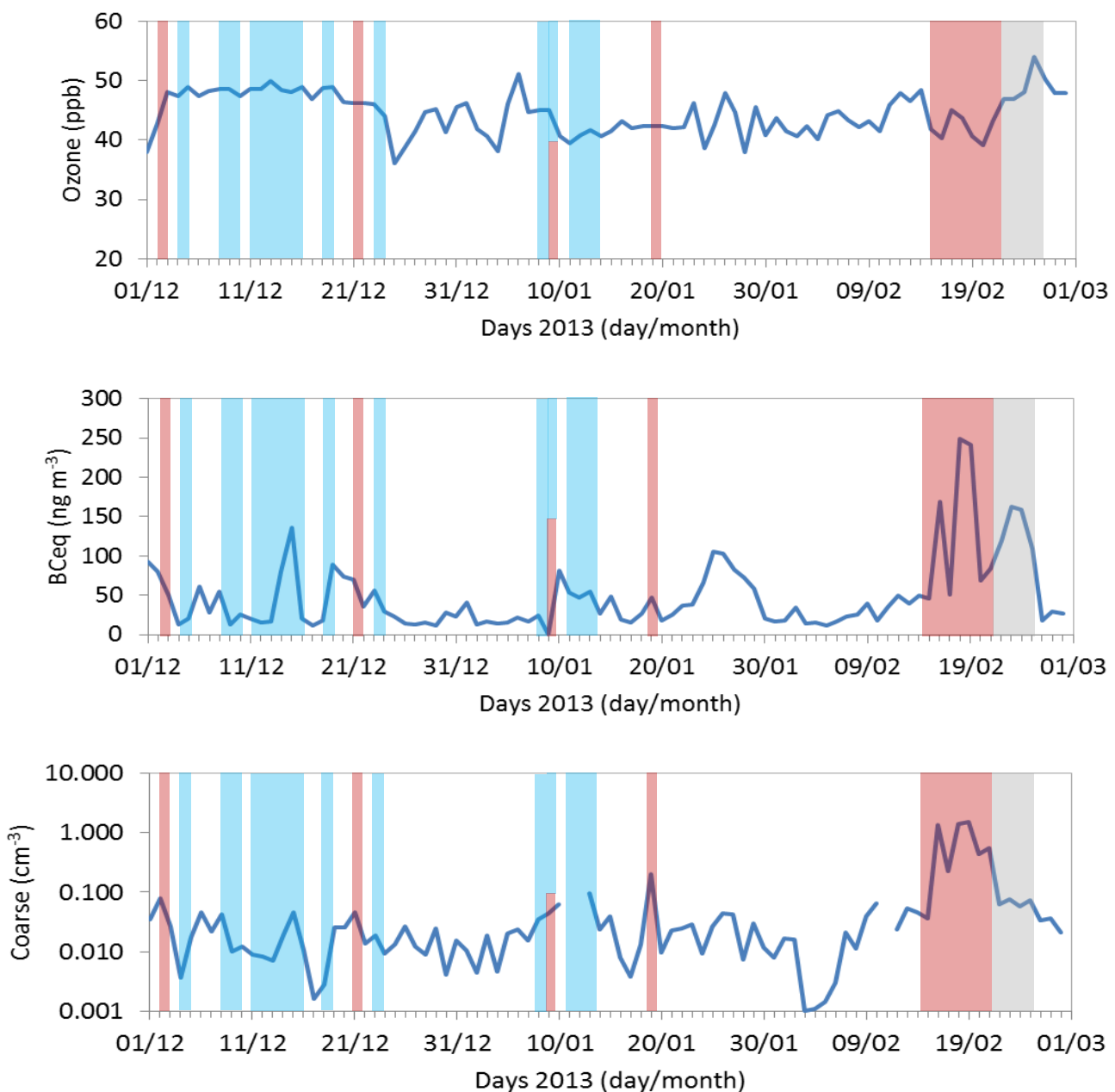
Mineral dust
 Stratospheric intrusions
 Pollution transport

Eventi speciali

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

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

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



LEGENDA

■ Polveri minerali ■ Intrusioni stratosferiche ■ Trasporto di inquinanti

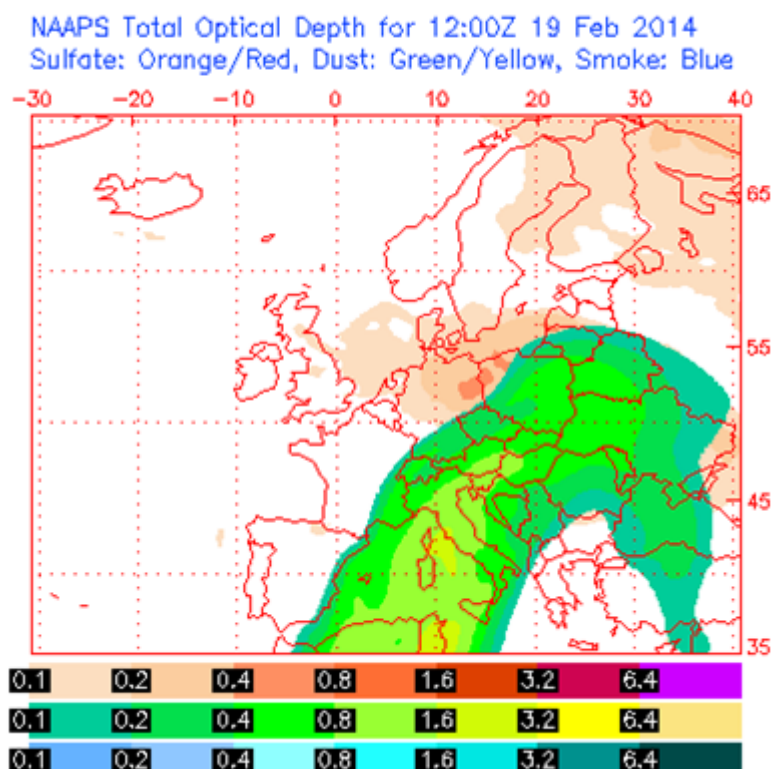
Mineral dust transport

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 PM₁₀ 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 $1 \mu\text{m} \leq D_p \leq 20 \mu\text{m}$) significantly increased with air-masses coming from North Africa, as deduced by three-dimensional air-mass back-trajectories and transport model outputs.

WINTER 2014:

- 11 days were characterized by the transport of mineral dust from northern Africa (12.2 % 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 February 15th to 21st, when the coarse particle reached the concentration of 1.5 cm^{-3} , on 19th February 2014.



Dust transport event simulation by NAAPS model (19th February 2014).

Simulazione dell'evento di trasporto di polveri minerali osservato il 19 Febbraio 2014 (modello NAAPS).

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

Courtesy by NRL/Monterey Aerosol Modeling.

Trasporto di polveri minerali

La presenza di aerosol (polveri) minerali nell'atmosfera può influenzare il clima attraverso effetti diretti ed indiretti. Esse possono inoltre alterare in modo significativo la qualità dell'aria in regioni prossime alle aree di emissione o soggette a fenomeni di trasporto, influenzando le concentrazioni di PM₁₀. 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 ($1 \mu\text{m} \leq D_p \leq 20 \mu\text{m}$) è aumentata in modo significativo con l'arrivo di masse d'aria provenienti dal nord Africa, come indicato da analisi di retro-traiettorie tri-dimensionali delle masse d'aria e da modelli di trasporto.

INVERNO 2014:

- **11 giorni sono stati caratterizzati dal trasporto di polveri minerali proveniente dal Nord Africa (12.2 % 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 15 al 21 Febbraio, quando è stata registrata la concentrazione massima di particelle grossolane per l'inverno 2014 (1.5 cm^{-3} , il 19 Febbraio 2014).**



Mt. Cimone (2014, March 19th). The brownish patches of snow denote the deposition of mineral dust during the winter season (Picture by P. Cristofanelli).

Monte Cimone (19 marzo 2014). Le macchie rossastre sulla neve, indicano la deposizione di sabbia avvenuta nel corso della stagione invernale (foto: P. Cristofanelli).

Stratospheric intrusions (SI)

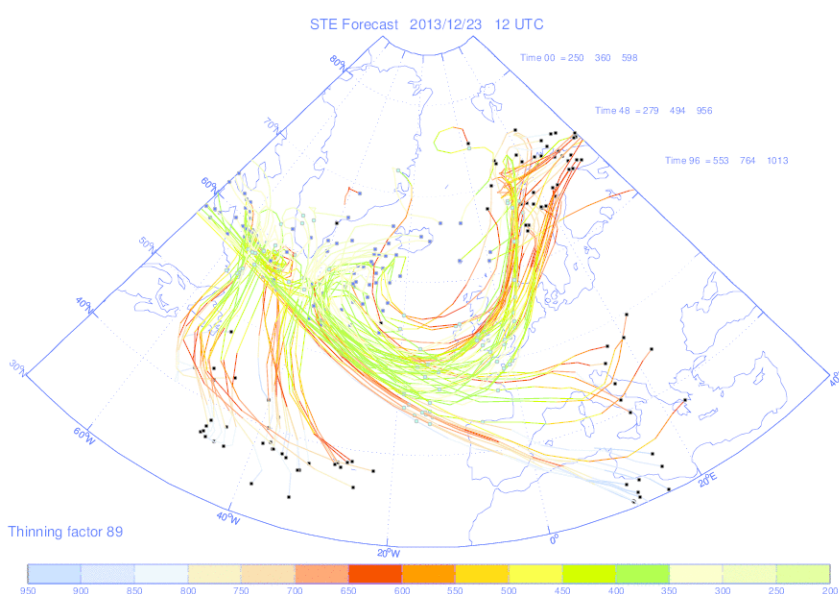
Stratospheric intrusions (SI) can be considered as a specific aspect of stratosphere–troposphere exchange (STE): the irreversible downward transport of stratospheric air relatively deep into the troposphere. Such phenomena are highly episodic and can be favored by a number of different mechanisms, acting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

WINTER 2014:

- 15 days were characterized by the transport of air masses from the stratosphere or the upper free troposphere (16.6 % of the period).
- These events were only observed on December and January.
- The highest daily ozone concentrations related to the STE occurred on 13th December (49.9 ppb).



Trajectories describing the path of stratospheric air-masses for the event of 23rd December 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 giorno 23 dicembre 2013. Il colore rappresenta la quota (espressa come livello di pressione) delle masse d'aria.

Elaborazione: Michael Sprenger (ETH-Z, Switzerland)

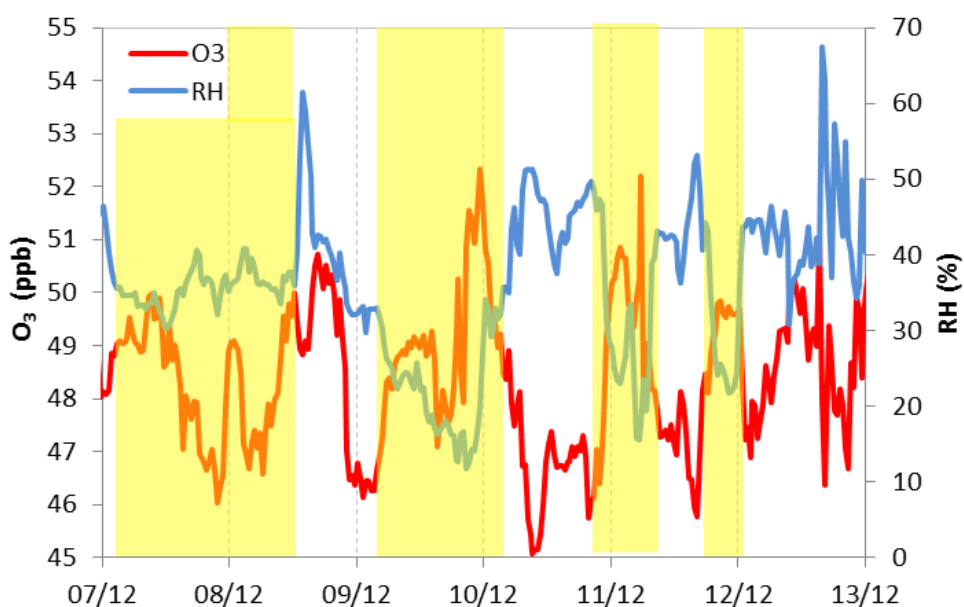
Intrusioni stratosferiche (SI)

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.

INVERNO 2014:

- 15 giorni sono stati caratterizzati dal trasporto di masse d'aria dalla stratosfera o dalla parte alta della libera troposfera (16.6 % del periodo).
- Gli eventi sono stati osservati nei mesi di Dicembre e Gennaio.
- Il picco giornaliero di ozono relativo a fenomeni di intrusioni stratosferiche è stato osservato il giorno 13 Dicembre (49.9 ppb).



Ozone (red) and relative humidity (blue) behavior at CMN during possible SI events (yellow) from 7th to 12th December 2013.

Andamento dell'ozono (rosso) e dell'umidità relativa (azzurro) durante possibili eventi di SI (in giallo) occorsi dal 7 al 12 Dicembre 2013.

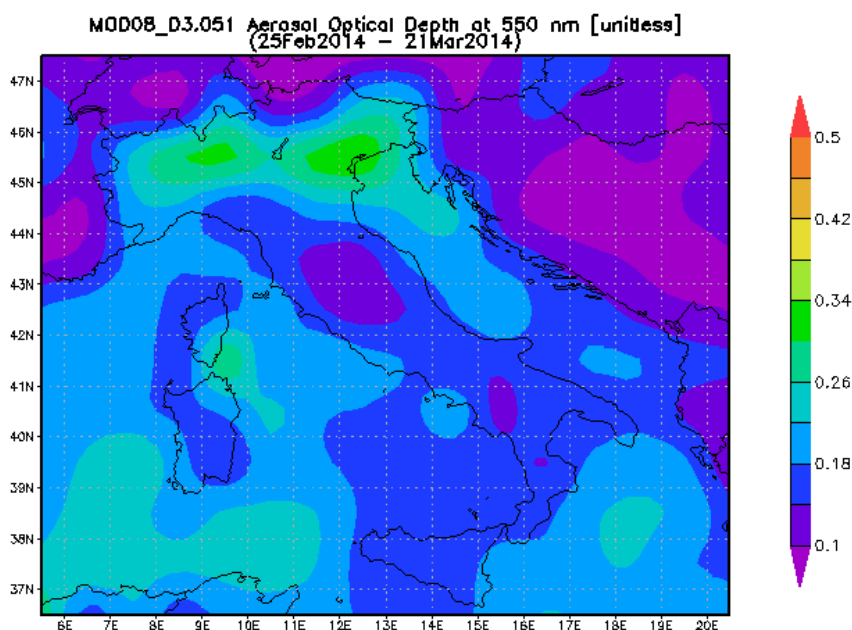
Pollution transport

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).

WINTER 2014

- 4 days were characterized by transport of polluted air masses (4.4% of the period).
- The detected events were mostly associated with the development of meteorological conditions which favored the transport of regional pollution.
- February was the only month interested by the presence of pollutions events.
- February 25th was the most polluted day for ozone (average value: 58.7 ppb) but not for carbon monoxide and black carbon (respectively 139.5 ppb and 109.7 ng m⁻³).



MODIS satellite Aerosol Optical Depth over Italy during the pollution episode detected at CMN from 22nd to 25th February 2014. Higher AOD value were present over the Po Basin.

Aerosol Optical Depth (AOD) dell'aerosol sull'Italia durante l'evento di inquinamento osservato a Monte Cimone dal 22 al 25 febbraio 2014. I valori più elevati di AOD si trovano sulla Pianura Padana.

<http://gdas1.sci.gsfc.nasa.gov>
AOD map was produced by the Giovanni online data system, developed and maintained by NASA GES DISC.

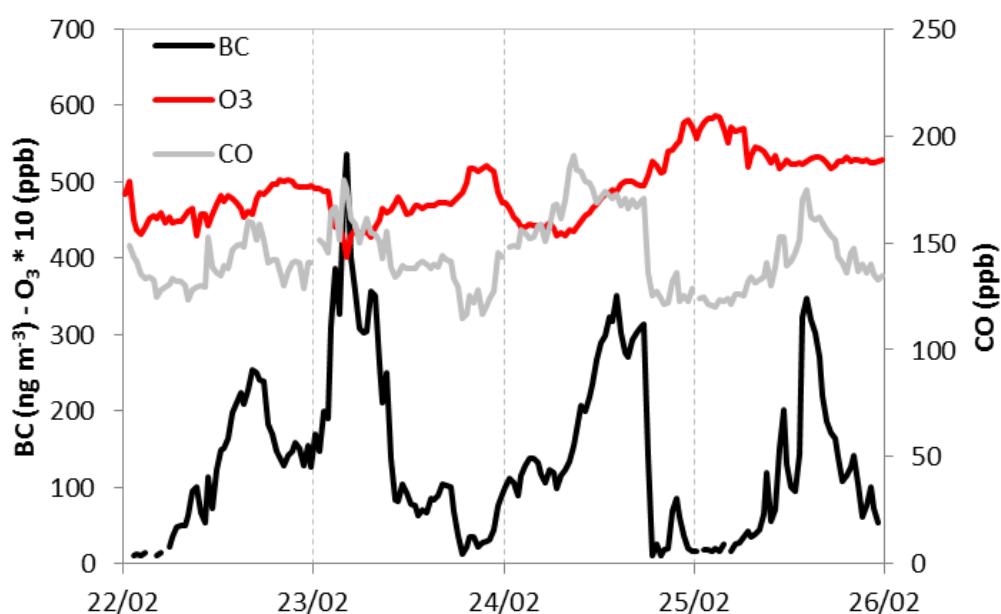
Trasporto di inquinanti

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).

INVERNO 2014

- 4 giorni sono stati caratterizzati dal trasporto di masse d’aria inquinate (4.4% del periodo).
- Gli eventi sono stati principalmente associati a condizioni meteorologiche che hanno favorito il trasporto di inquinamento a scala regionale.
- Gli eventi di inquinamento sono presenti solo durante il mese di Febbraio.
- Il 25 Febbraio è stato il giorno caratterizzato dal valore medio giornaliero di ozono più elevato (58.7) ma non per il monossido di carbonio e black carbon pari rispettivamente a 139.5 ppb e 109.7 ng m⁻³.



CO, ozono and BC behaviors at Mt. Cimone from 22nd to 26th February 2014.

Andamento delle concentrazioni di CO, ozono e BC a Monte Cimone (22 – 26 Febbraio 2014).

Surface ozone

Why is ozone so important?

Ozone (O₃) 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, O₃ 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 NO₃, O₃ 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.

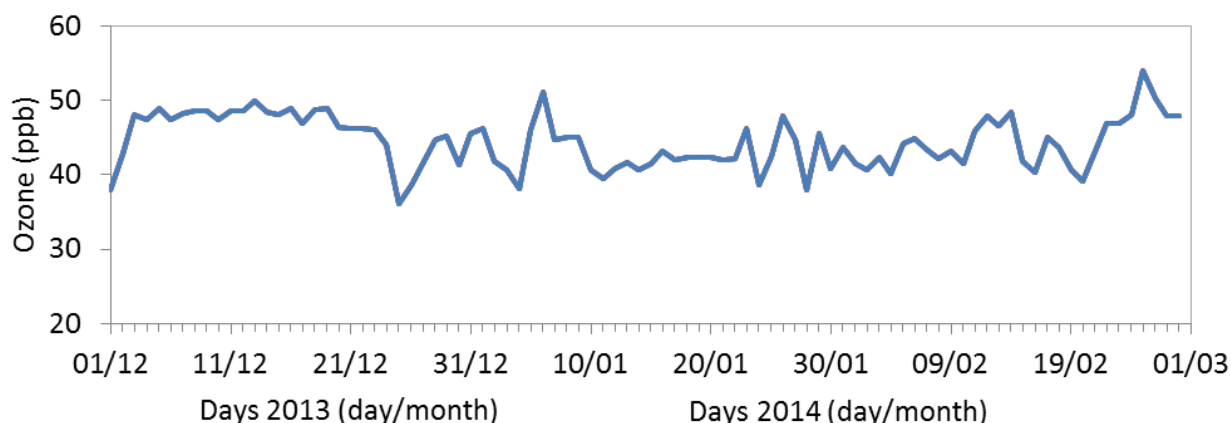
Basic statistical parameters

Statistical parameters are calculated basing on 30-minute aggregated values from December 2013 to February 2014.

| Data availability (%) | Min value (ppb) | 25 th Percentile (ppb) | 50 th Percentile (ppb) | Average mean value (ppb) | 75 th percentile (ppb) | Max value (ppb) |
|-----------------------|-----------------|-----------------------------------|-----------------------------------|--------------------------|-----------------------------------|-----------------|
| 99.7 | 21.9 | 41.6 | 45.0 | 44.5 | 47.7 | 58.7 |

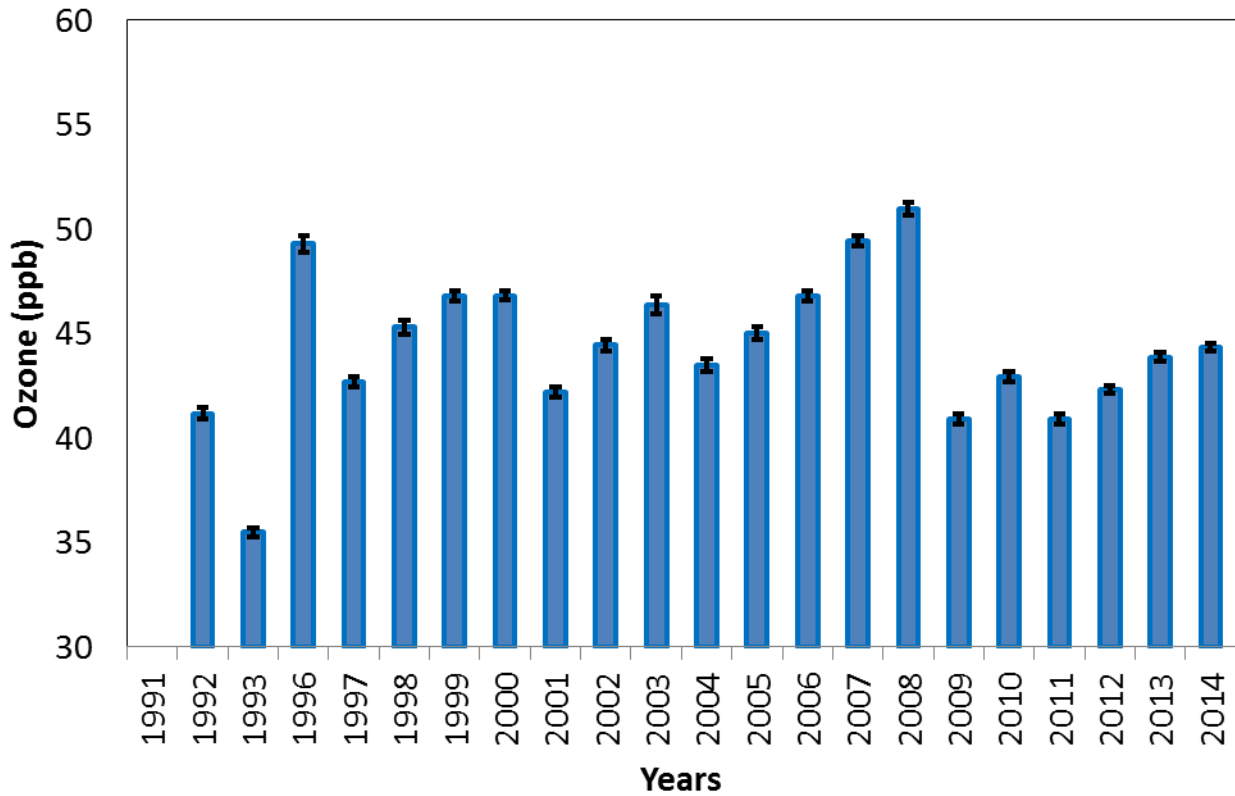
Time series of daily mean values

A period with relatively high O₃ has been recorded from February 22nd to 25th, with the highest daily mean value (54.0 ppb, corresponding to 108.0 µg/m³) being observed on February 25th 2014, together with high CO and BC levels (pollution). Relatively low O₃ values were instead observed on the preceding days, with the lowest on February 20th (39.2 ppb, daily average) during the major dust transport episode which has been observed on winter 2014.



Comparison with historical data-set

The **2014 winter average mean value of O₃ is 44.5 ppb, comparable to the climatological mean value (45.0 ppb)**. As deduced by the analysis of the daily time series, this is due to the occurrence of “background” conditions for the most part of the period.



Carbon monoxide (NDIR)

Why is carbon monoxide so important?

Carbon Monoxide (CO) plays an important role in the oxidation/reduction chemistry of the atmosphere and it participates in the reactions of photochemical O₃ production. CO has an indirect radiative forcing effect by influencing atmospheric mixing ratios of O₃ and methane. Through natural processes in the atmosphere, CO is eventually oxidized to CO₂. CO represents a tracer for combustion emissions (biomass burning, residential, traffic,...).

Instrumentation and calibration

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

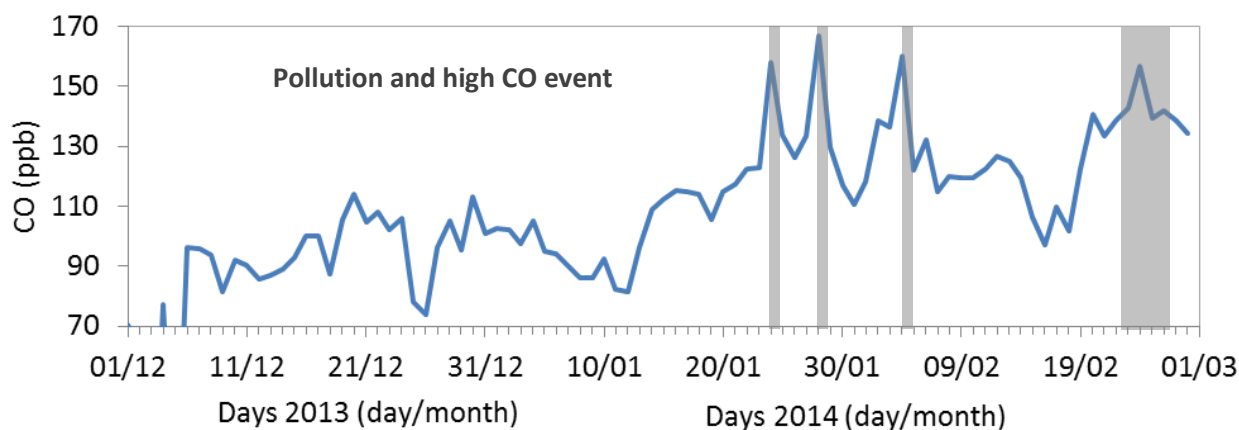
Basic statistical parameters

Statistical parameters are calculated basing on 30-minute aggregated values from December 2013 to February 2014.

| Data availability (%) | Min value (ppb) | 25 th Percentile (ppb) | 50 th Percentile (ppb) | Average mean value (ppb) | 75 th percentile (ppb) | Max value (ppb) |
|-----------------------|-----------------|-----------------------------------|-----------------------------------|--------------------------|-----------------------------------|-----------------|
| 93.9 | 36.0 | 94.2 | 108.0 | 110.7 | 124.4 | 268.0 |

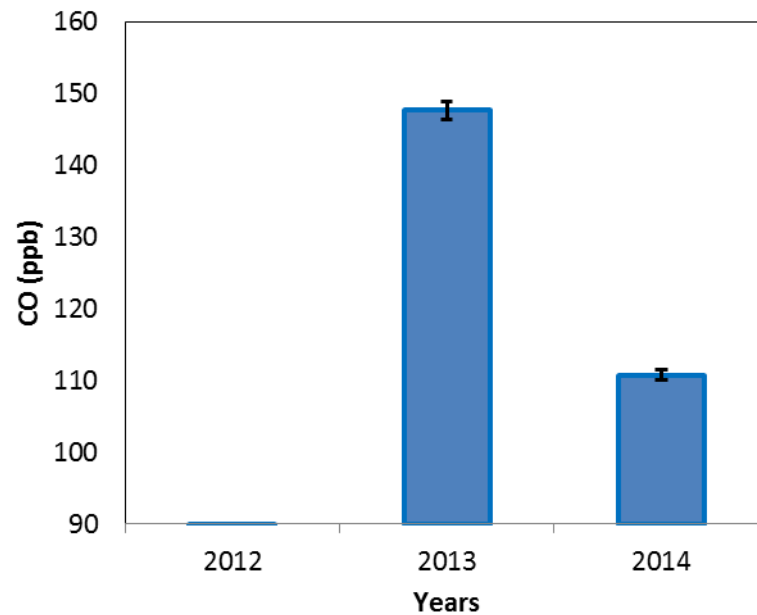
Time series of daily mean values

The highest daily CO value (166.8 ppb) has been recorded on January 28th 2014, together with high NO₂ (1.9 ppb) and low O₃ (37.9 ppb) and BC (72.6 ng m⁻³), possibly indicating the long range transport of aged air masses originally rich in atmospheric pollutants. In general an increasing trend in CO concentration is observable, in line with the large-scale background CO behavior.



Comparison with historical data-set

The **2014 winter average mean value of CO was 110.7 ppb which is lower than the average mean value of 147.6 ppb observed on winter 2013**. Low CO values (usually below 100 ppb) characterized the first half of the season: this behavior is also observed for BC and fine particles, suggesting that the first half of the season was characterized by “clean” conditions. This also ties with the high number of possible SI before January 13th.



Nitrogen oxides

Why are nitrogen oxides so important?

Nitrogen oxides (NO_x) encompasses nitric oxide (NO) and nitrogen dioxide (NO₂). 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 (NO_x=NO+NO₂) 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, HNO₃), the NO₂ reading can be significantly overestimated.

Basic statistical parameters

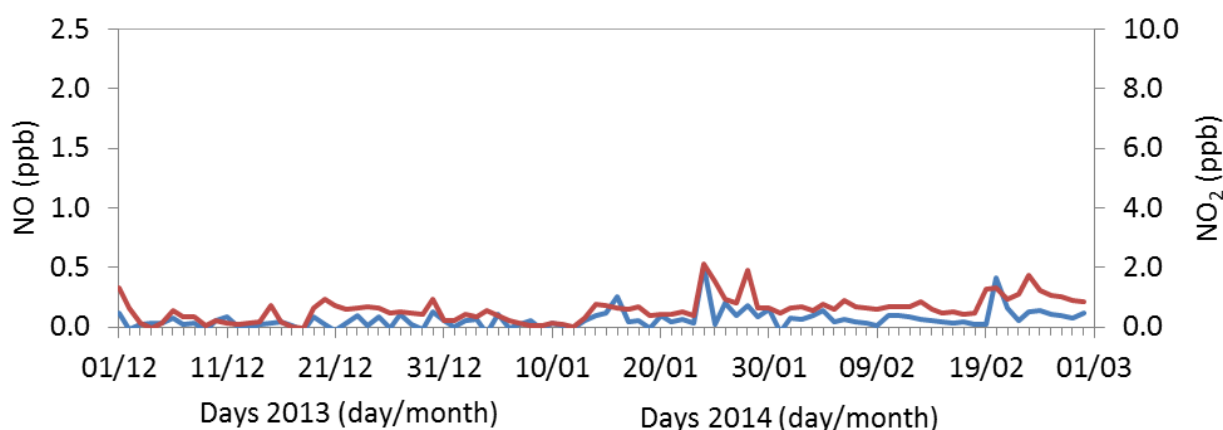
Statistical parameters are calculated basing on 30-minute aggregated values from December 2013 to February 2014.

| Data availability (%) | Min value (ppb) | 25 th percentile (ppb) | 50 th percentile (ppb) | Average mean value (ppb) | 75 th percentile (ppb) | Max value (ppb) |
|-----------------------|-----------------|-----------------------------------|-----------------------------------|--------------------------|-----------------------------------|-----------------|
| NO 99.9 | -0.49 | -0.02 | 0.06 | 0.05 | 0.15 | 5.86 |
| NO ₂ 99.9 | -0.05 | 0.39 | 0.58 | 0.71 | 0.91 | 8.16 |

UDL: under detection limit

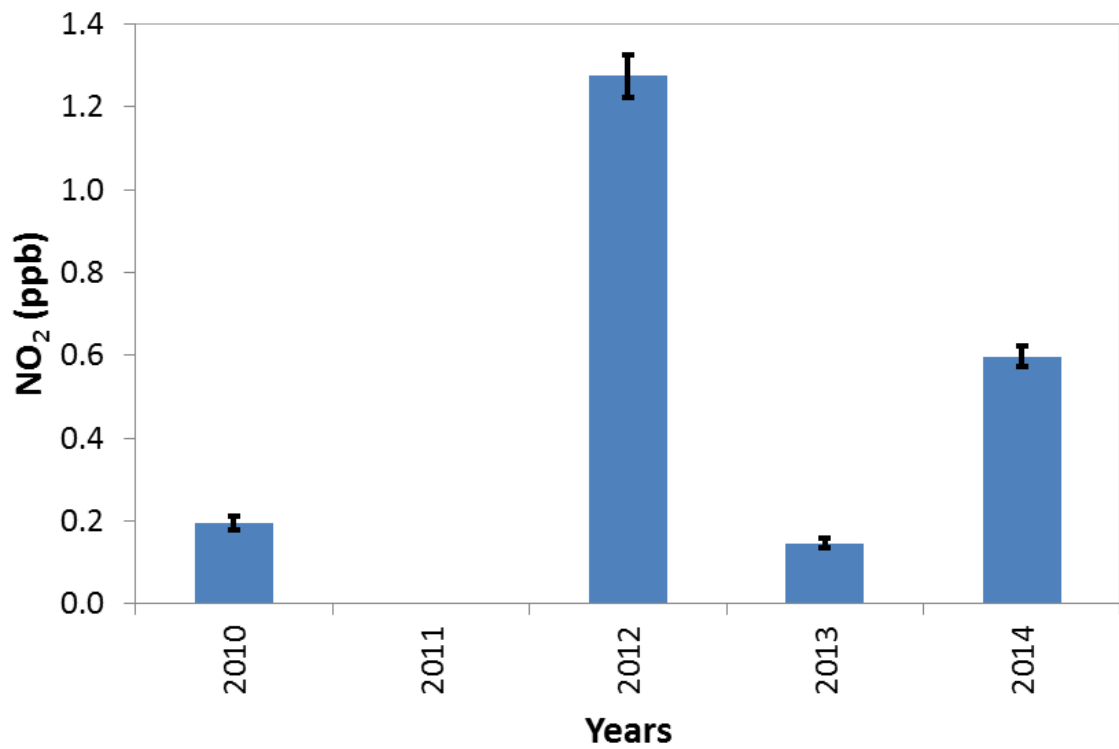
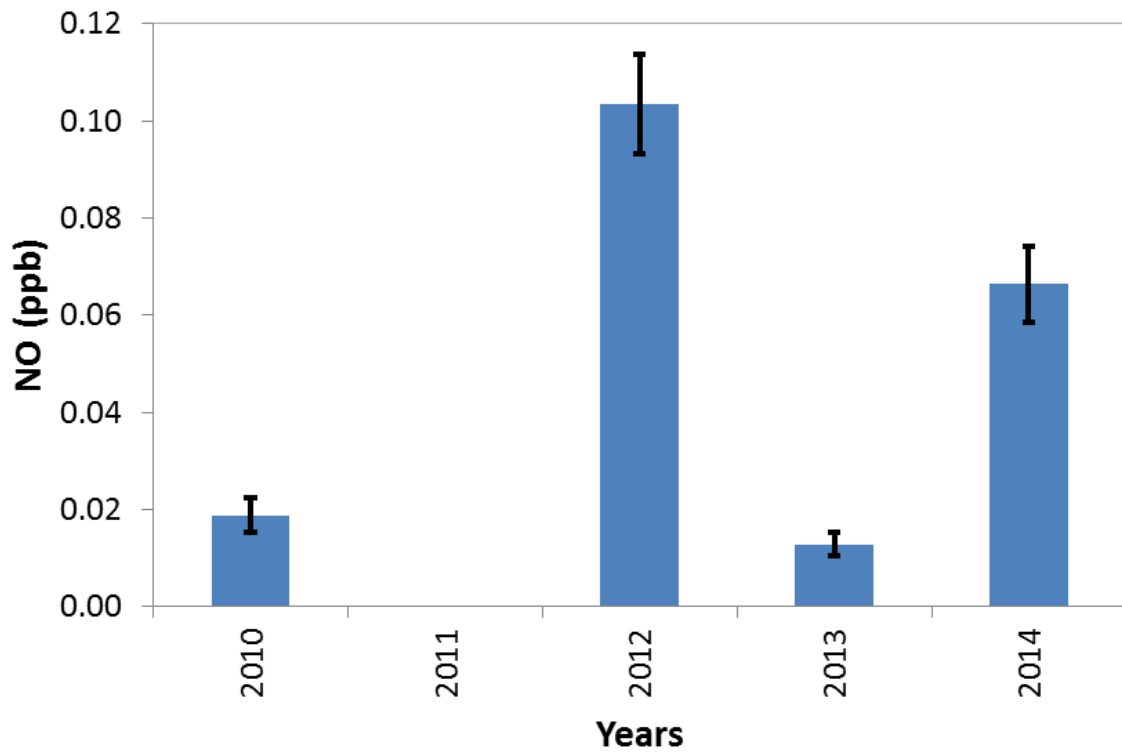
Time series of daily mean values

The highest NO value (both daily and 30 minute averages) was observed on January 24th. During the identified pollution event (22nd -25th February) high NO₂ was observed (the highest value on February 23rd: 4.34 ppb on 30-minute average).



Comparison with historical data-set

The 2014 winter average mean value of NO (NO₂) was 0.07 ppb (0.60 ppb) **which is comparable with the average climatological mean value** of 0.05 ppb (0.54 ppb).



Black carbon

Why is black carbon so important?

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

Instrumentation and calibration

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

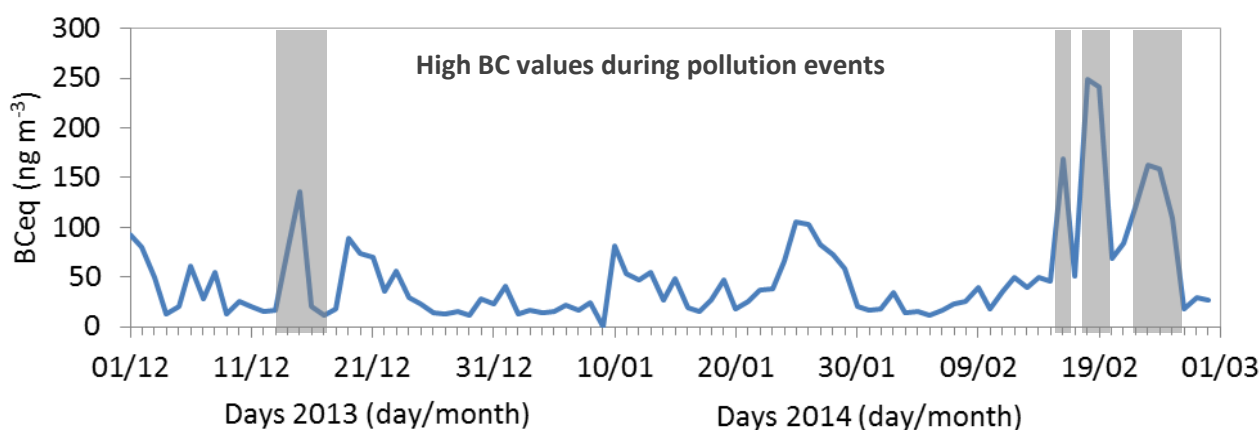
Basic statistical parameters

Statistical parameters are calculated basing on 30-minute aggregated values from December 2013 to February 2014.

| Data availability (%) | Min value (ng m^{-3}) | 25 th percentile (ng m^{-3}) | 50 th percentile (ng m^{-3}) | Average mean value (ng m^{-3}) | 75 th percentile (ng m^{-3}) | Max value (ng m^{-3}) |
|-----------------------|----------------------------------|--|--|---|--|----------------------------------|
| 68.5 | 10.0 | 17.5 | 34.3 | 60.0 | 71.7 | 536.1 |

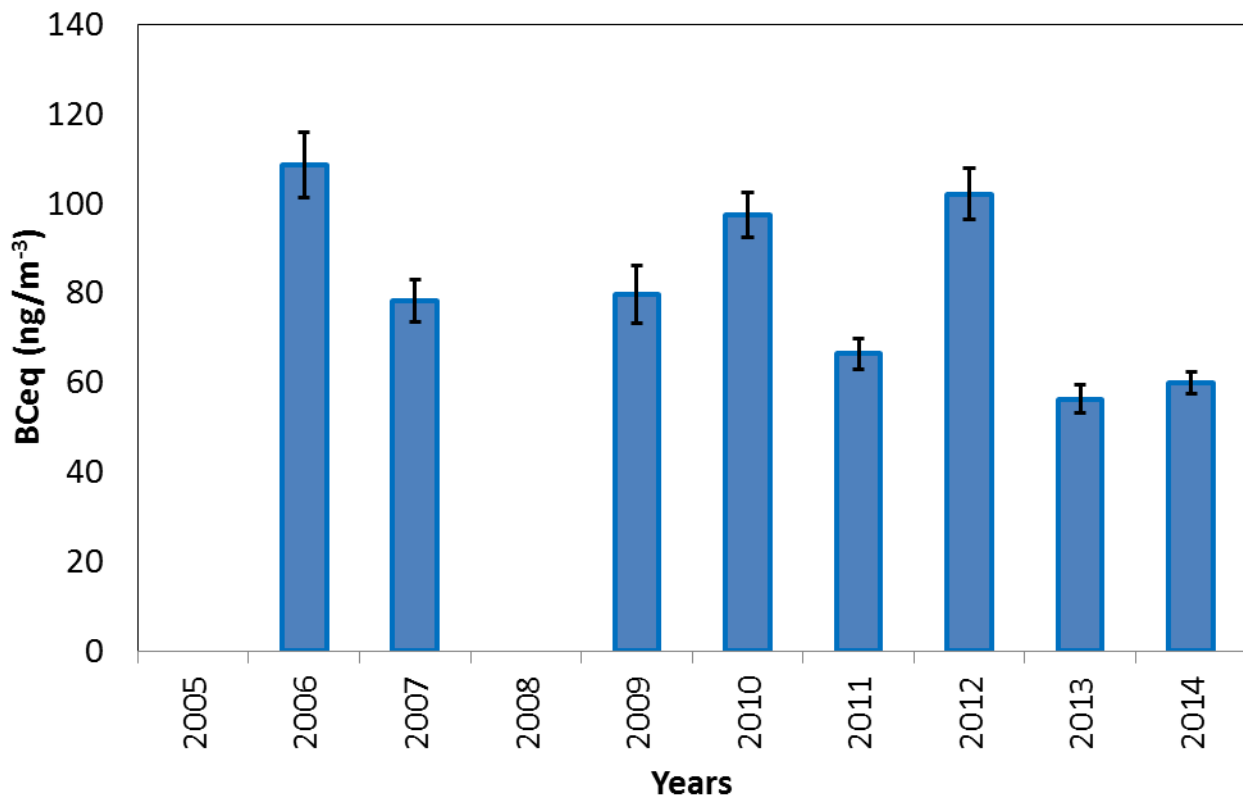
Time series of daily mean values

The highest daily mean value (249.4 ng m^{-3}) has been observed on February 18th 2014, during the transport of mineral dust from North Africa, **probably due to pollution emissions along the African coastlines**. However the analysis of the 30 minute average showed that the highest BC values were observed during afternoon (and early 19th night) when the coarse concentration decreased, suggesting the contribution of a different air mass.



Comparison with historical data-set

The 2014 winter average mean value of BC is 60.0 ng m^{-3} , which is lower than the climatological mean value (84.1 ng m^{-3}). The behavior is similar to that observed for CO and fine particles and can be explained by the occurrence of very unpolluted conditions during the first half of the season.



Aerosol number concentration (fine)

Why are fine particle so important?

Fine particles are highly effective in modifying the radiation field by absorbing and scattering solar and thermal radiation, thus impacting radiative transfer through the atmosphere. Additionally, aerosols act as cloud condensation and ice nuclei, thus influencing cloud properties. Aerosols also help to control the concentrations, lifetime and the physical as well as the chemical behavior of many important trace gases by providing reaction sites and serving as carrier and/or sink for many atmospheric species. Moreover, fine particles strongly contribute to air pollution, representing a main fraction of PM₁.

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 ≤ D_p ≤ 1 µm) particle number. The instrument is based on the quantification of the 90° scattering of light by aerosol particles

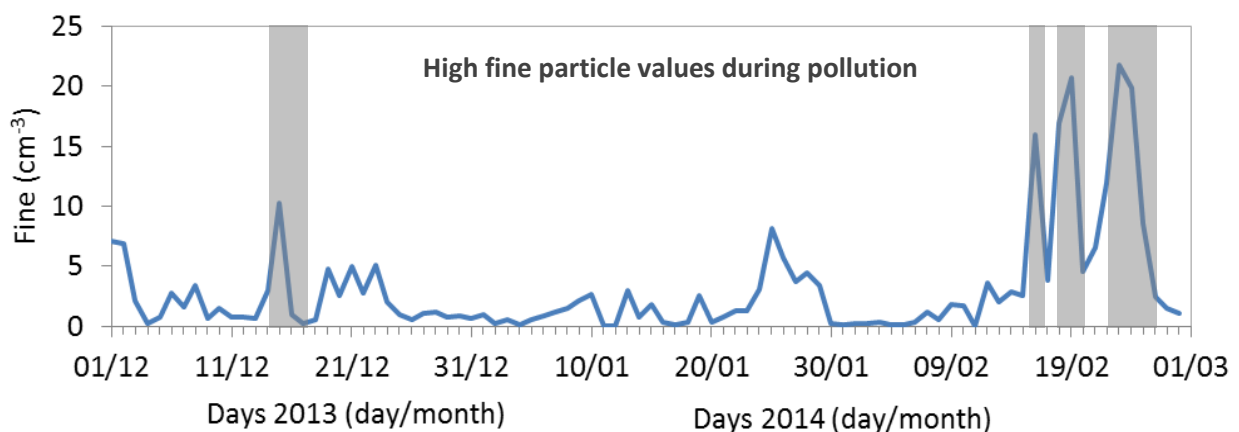
Basic statistical parameters

Statistical parameters are calculated basing on 30-minute aggregated values from December 2013 to February 2014.

| 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) |
|---------------------|-------------------------------|---|---|--|---|-------------------------------|
| 93.1 | 0.0 | 0.3 | 0.9 | 3.2 | 2.9 | 89.2 |

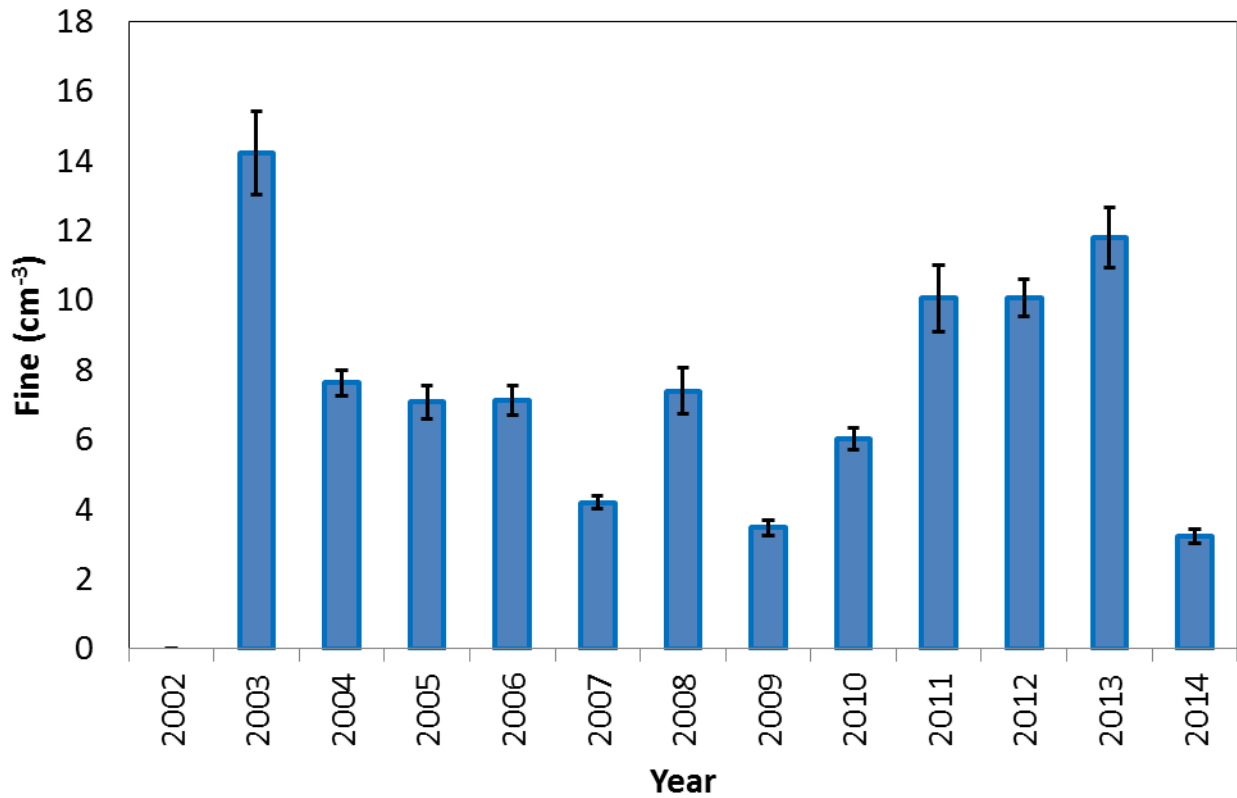
Time series of daily mean values

The highest daily mean value (21.8 cm⁻³) has been observed on 23rd February 2014 during a pollution event: high values also observed at the end of February, 2014 when high BC values were observed also.



Comparison with historical data-set

The 2014 winter average mean value of fine particles is 3.2 cm^{-3} , and is lower than the seasonal climatological value (8.1 cm^{-3}). This behavior is similar to that observed for CO and BC and is probably explained by an unpolluted first half of the season.



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 PM₁₀ 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 PM₁₀ 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 ($1 \mu\text{m} \leq D_p \leq 20 \mu\text{m}$) particle number. The instrument is based on the quantification of the 90° scattering of light by aerosol particles.

Basic statistical parameters

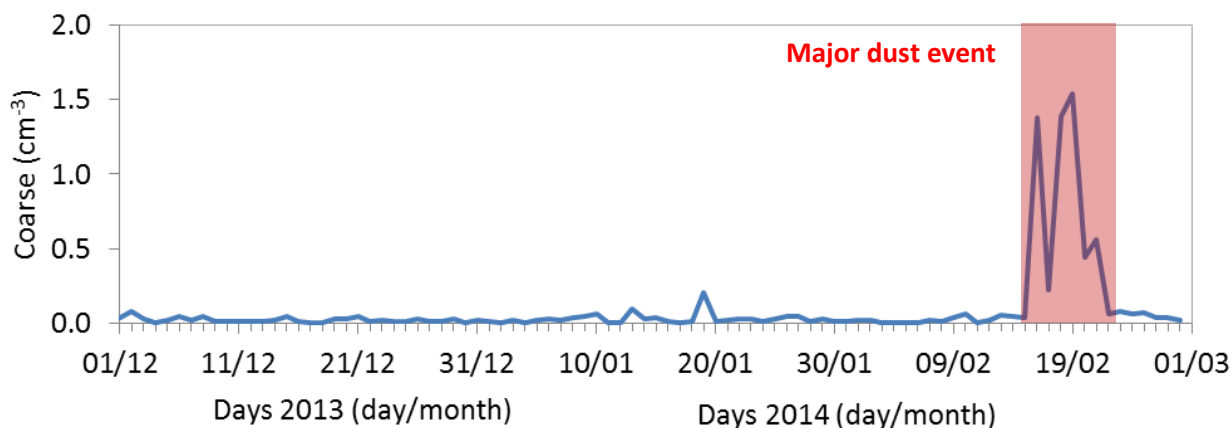
Statistical parameters are calculated basing on 30-minute aggregated values from December 2013 to February 2014.

| 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) |
|---------------------|-------------------------------|---|---|--|---|-------------------------------|
| 93.1 | UDL | UDL | 0.01 | 0.09 | 0.04 | 7.68 |

UDL: Under Detection Limit

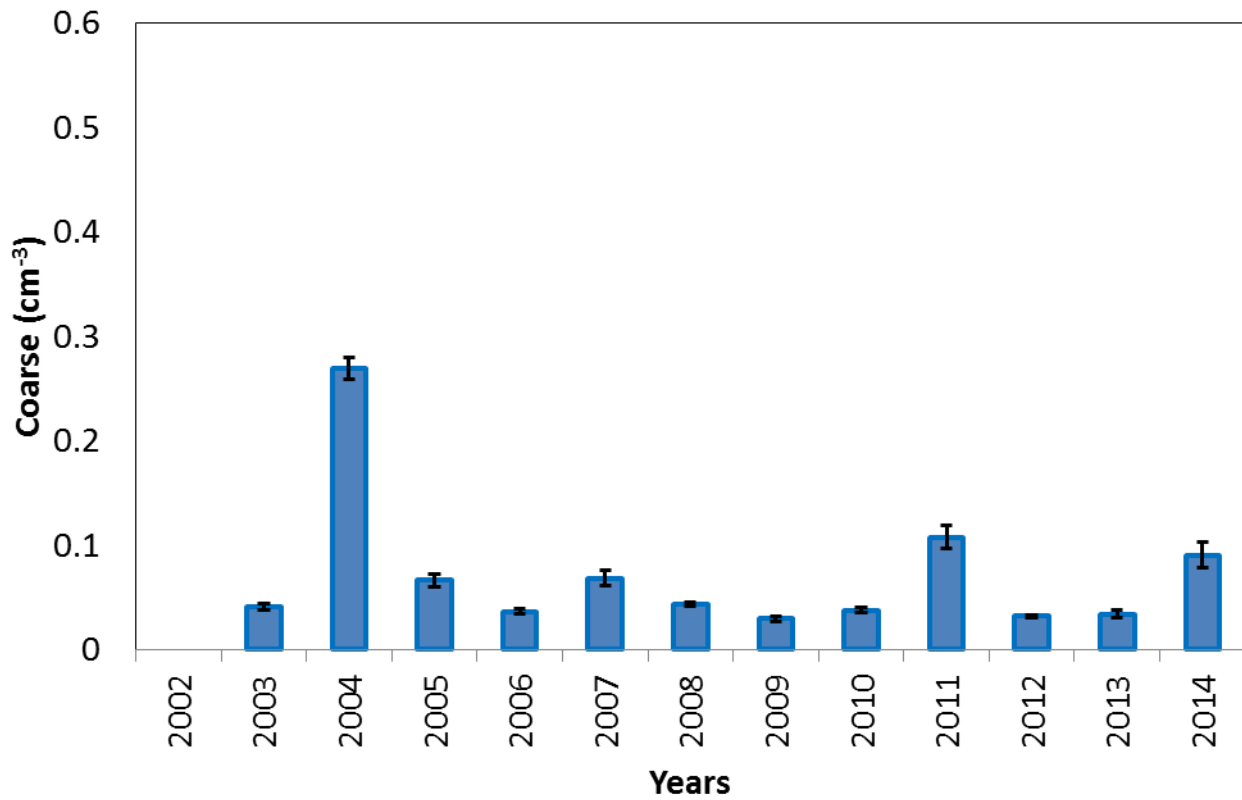
Time series of daily mean values

The highest daily mean value (1.5 cm⁻³) has been observed on February 19th 2014, when a major Saharan dust transport affected Mt. Cimone (from February 15th to 21th).



Comparison with historical data-set

The winter 2014 average mean value of the coarse particles (0.09 cm^{-3}) is well comparable with the winter climatological value (0.07 cm^{-3}). However the transport event observed on February 2014, represents the major winter episode observed at ICO-OV from the start of the measurement programme.



Halogenated gases

Why is this research so important?

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

Instrumentation and calibration

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

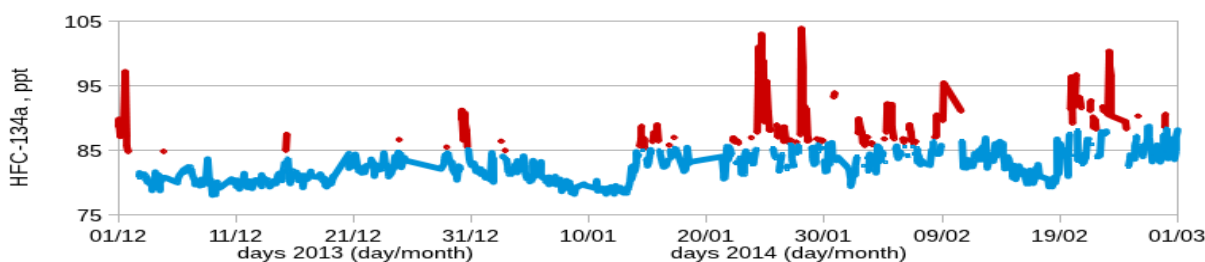
Basic statistical parameters

We report as an example** the basic statistical parameters of HFC-134a, a Kyoto gas mainly used in refrigeration sealed systems, such as industrial refrigeration, car and in-house air conditioners, domestic fridges. Statistical parameters are calculated based on bi-hourly measurements from December 2013 to February 2014.

| Data availability % | Min value (ppt) | 25 th percentile (ppt) | 50 th percentile (ppt) | Average mean value (ppt) | 75 th percentile (ppt) | Max value (ppt) |
|---------------------|-----------------|-----------------------------------|-----------------------------------|--------------------------|-----------------------------------|-----------------|
| 91 | 78.1 | 81.1 | 83.5 | 83.9 | 85.6 | 103.9 |

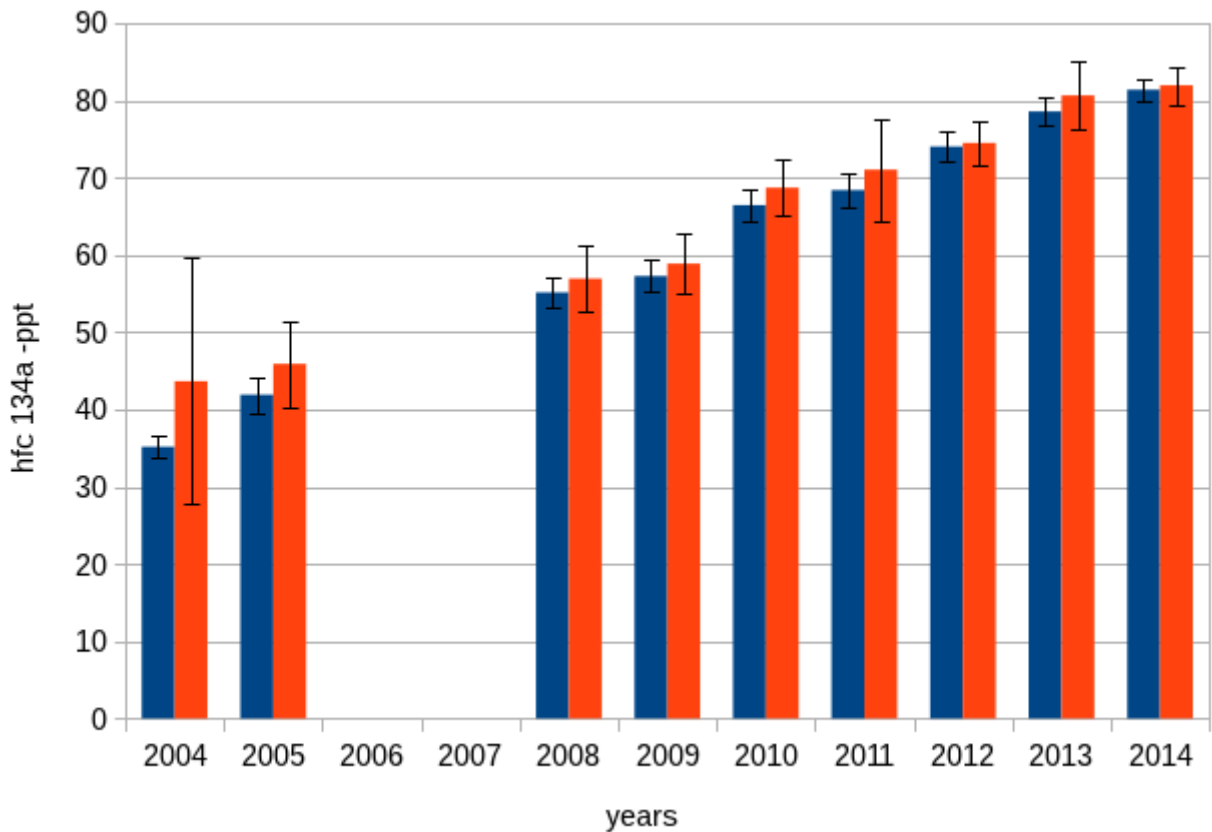
Time series of daily mean values

The first two weeks of December (from the 2nd to the 15th) and January from 9th to 12th were characterized by a low variability and mean value, indicating the **intrusion of clean air from the upper troposphere**. Sporadic increases (marked as polluted, in red in the graph) occurred in late January, in correspondence to an increase of CO and low O₃ values, indicating long range transport of aged **air masses originally rich in atmospheric pollutants**.



Comparison with historical data-set

The **winter 2014 baseline value of HFC-134a**** is in line with the **northern hemisphere background** as recorded at the European baseline station of Mace Head (IE). Both Baseline (in blue) and whole data-set (in red) averages show a continuous increase, due to large use of this gas; lower winter enhancements (discrepancy between blue and red values) than in summer, due to the low transport of polluted air masses.



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

Stratospheric nitrogen dioxide

Why is stratospheric nitrogen dioxide so important?

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

Instrumentation and calibration

NO_2 is measured by means of an UV-Vis spectrometer which collects diffuse solar radiation each day at sunset and sunrise. By means of the DOAS methodology its columnar value is measured each day at sunset and at sunrise, giving the two values called AM and PM.

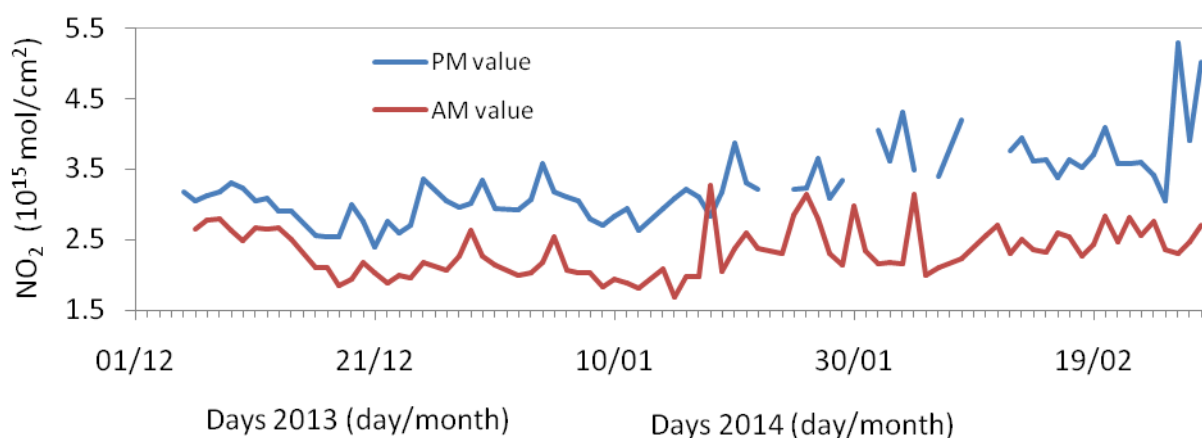
Basic statistical parameters

Statistical parameters are calculated basing on 1 data per day from December 2013 to February 2014.

| Data availability (%) | Min value (mol/cm ²) | 25 th percentile (mol/cm ²) | 50 th percentile (mol/cm ²) | Average mean value (mol/cm ²) | 75 th percentile (mol/cm ²) | Max value (mol/cm ²) |
|-----------------------|----------------------------------|--|--|---|--|----------------------------------|
| AM (86.6) | 1.69 | 2.07 | 2.31 | 2.34 | 2.60 | 3.26 |
| PM (81.1) | 2.40 | 2.94 | 3.17 | 3.28 | 3.58 | 5.29 |

Time series of daily mean values

The time series follows the typical climatologic trend which consists in a reduction of the total column of the gases during the winter period. Due to photochemical reaction PM value results always higher than the corresponding AM value.



Volatile organic compounds (VOCs)

Why is this research so important?

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

Instrumentation and calibration

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

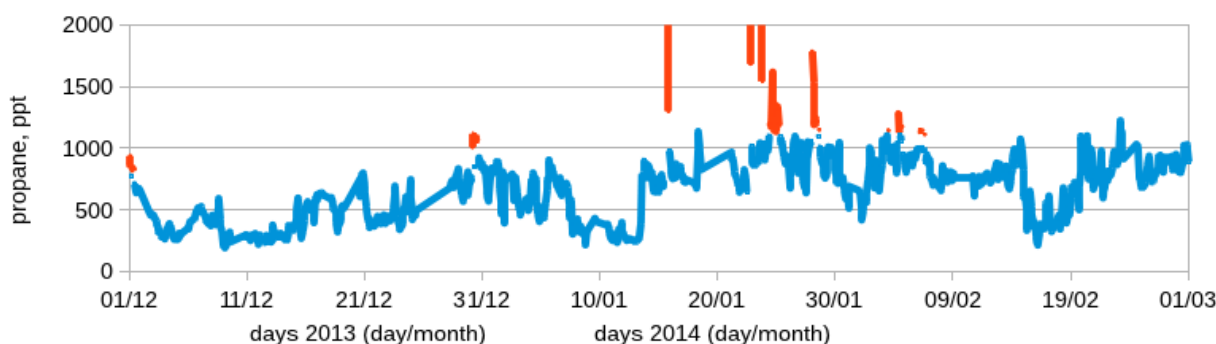
Basic statistical parameters

We report as an example the basic statistical parameters of propane (C₃H₈). Propane is one of the important components of LPG fuel and is a fingerprint species of leakages and unburned LPG. Statistical parameters are calculated based on bi-hourly measurements from December 2013 to February 2014.

| Data availability % | Min value (ppt) | 25 th percentile (ppt) | 50 th percentile (ppt) | Average mean value (ppt) | 75 th percentile (ppt) | Max value (ppt) |
|---------------------|-----------------|-----------------------------------|-----------------------------------|--------------------------|-----------------------------------|-----------------|
| 91 | 193.1 | 461.6 | 721.1 | 729.6 | 860.8 | 20,363.9 |

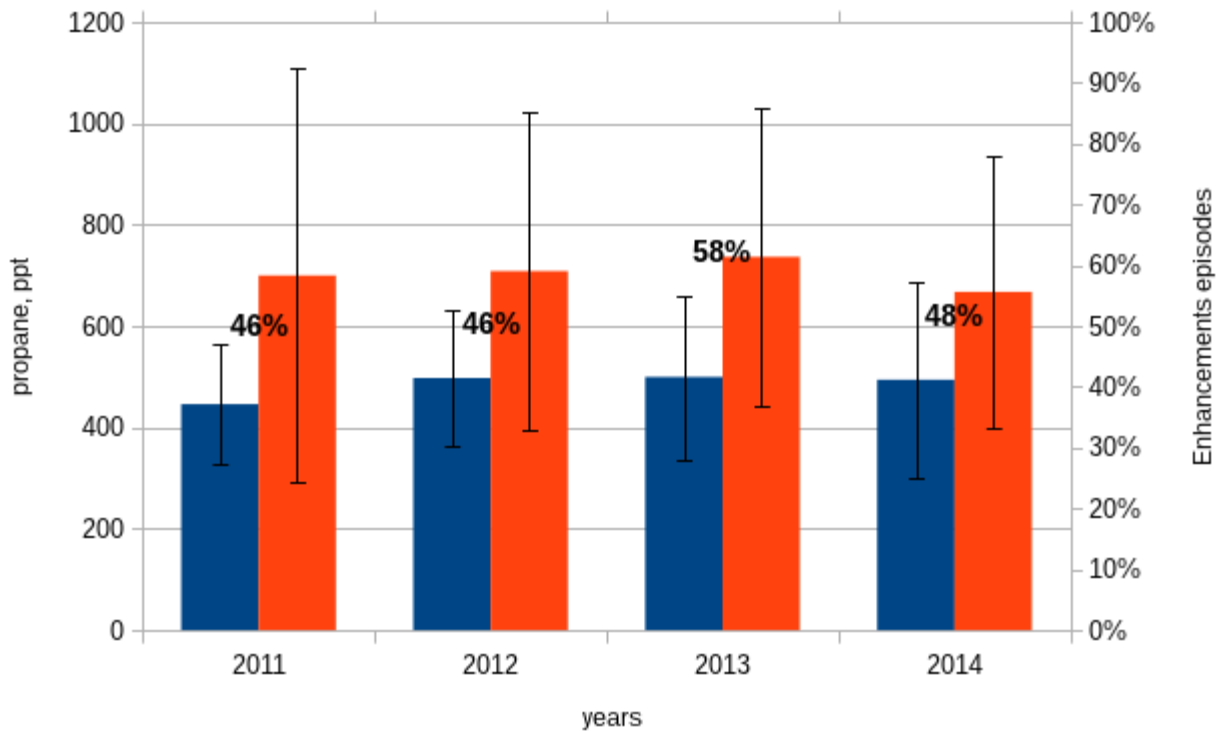
Time series of daily mean values

The high concentrations of propane (in red) observed during the study period are in line with the seasonal variation observed for this compound. The winter maxima are due both to an increase of emissions (linked to combustion processes) and to a decrease in the concentration of the OH radical that is the main sink for the VOCs.



Comparison with historical data-set

The winter 2014 average mean values of the baseline data (493 ppt, in blue) are well comparable with the winter values of previous years, as well as the number of enhancement episodes (in percentage over all observations).



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

Air Temperature

Why is air-temperature so important?

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

Instrumentation and calibration

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

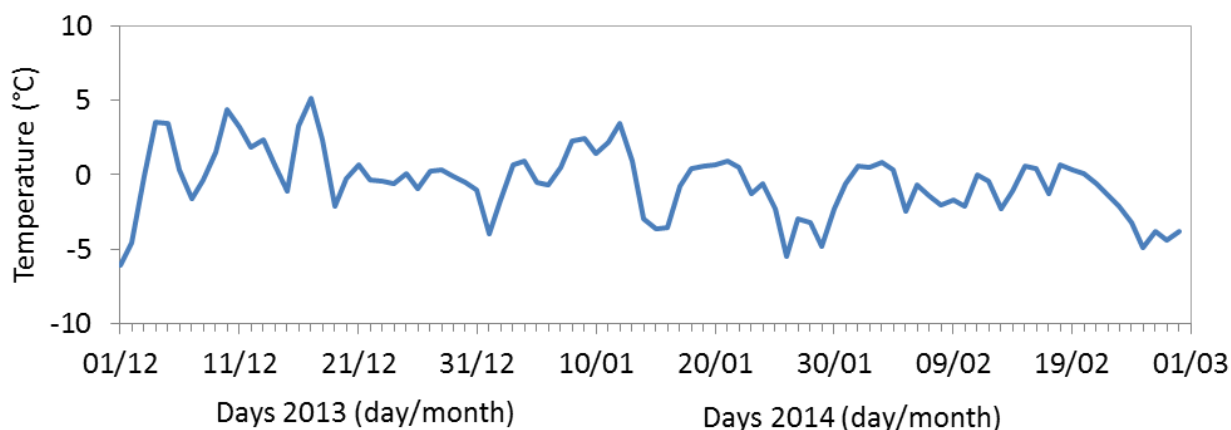
Basic statistical parameters

Statistical parameters are calculated basing on 30-minute aggregated values from December 2013 to February 2014.

| Data availability % | Min value (°C) | 25 th percentile (°C) | 50 th percentile (°C) | Average mean value (°C) | 75 th percentile (°C) | Max value (°C) |
|---------------------|----------------|----------------------------------|----------------------------------|-------------------------|----------------------------------|----------------|
| 100.0 | -7.8 | -2.0 | -0.2 | -0.5 | 0.8 | 7.6 |

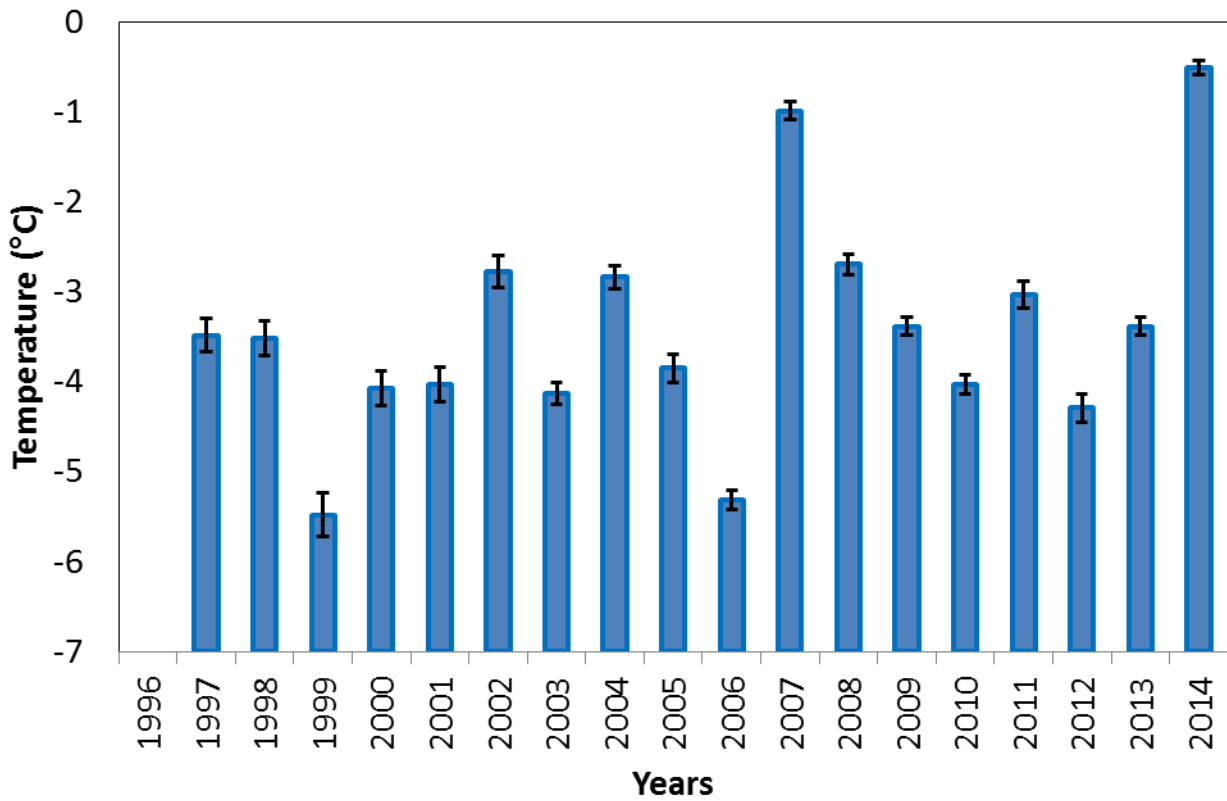
Time series of daily mean values

The highest daily mean value (5.1 °C) has been observed on 17th December 2013. High values (above 0°C) have been recorded before January 14th, especially during December (16 days).



Comparison with historical data-set

The **winter 2014 average temperature (-0.5 °C)** was higher than the seasonal climatological value (-3.6 °C): it represents the highest seasonal value ever observed at ICO-OV sine 1996. This results from anomalous high temperature observed for the greatest part of the season, especially during the first 40 days (when 24 days were characterized by daily average temperature greater than 0°C).



Relative humidity

Why is relative humidity so important?

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

Instrumentation and calibration

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

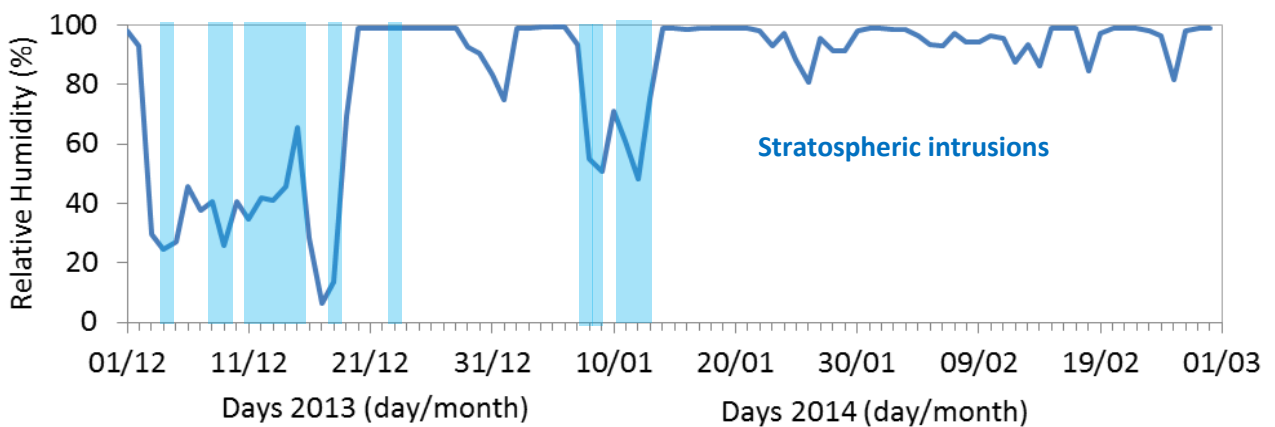
Basic statistical parameters

Statistical parameters are calculated basing on 30-minute aggregated values from December 2013 to February 2014.

| Data availability (%) | Min value (%) | 25 th percentile (%) | 50 th percentile (%) | Average mean value (%) | 75 th percentile (%) | Max value (%) |
|-----------------------|---------------|---------------------------------|---------------------------------|------------------------|---------------------------------|---------------|
| 100.0 | 3.1 | 75.2 | 97.9 | 82.1 | 99.0 | 100.0 |

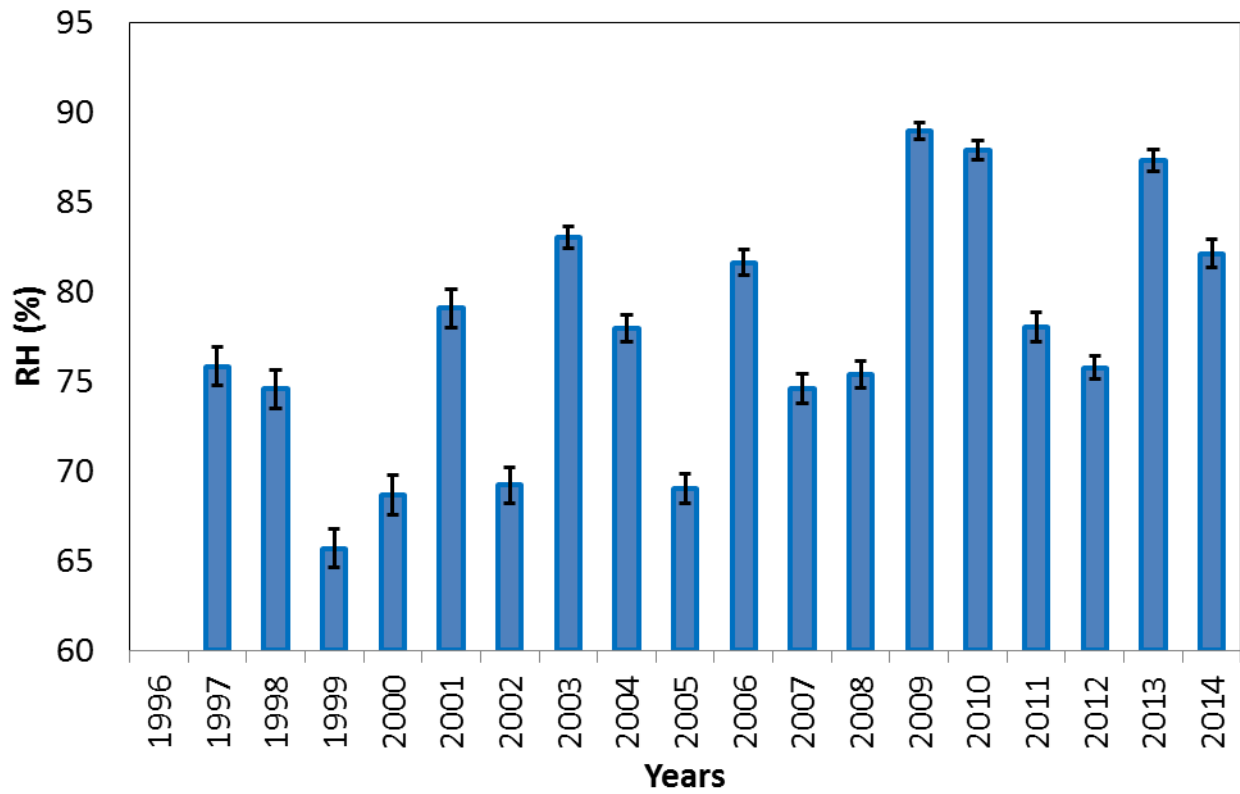
Time series of daily mean values

The daily mean RH values ranged from 100% to 6.5%. The driest period has been observed from December 3rd to 18th, when the majority of air-mass transport from stratospheric intrusions affected ICO-OV. Dry conditions also occurred from January 8th to 13th, also tracing air-mass transport from the free troposphere/stratosphere.



Comparison with historical data-set

The winter 2014 average relative humidity (82.1%) was higher than the seasonal climatological value (77.2%), with lower RH values being related mainly with stratospheric intrusion in the first half of December 2013.



Atmospheric pressure

Why is atmospheric pressure so important?

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

Instrumentation and calibration

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

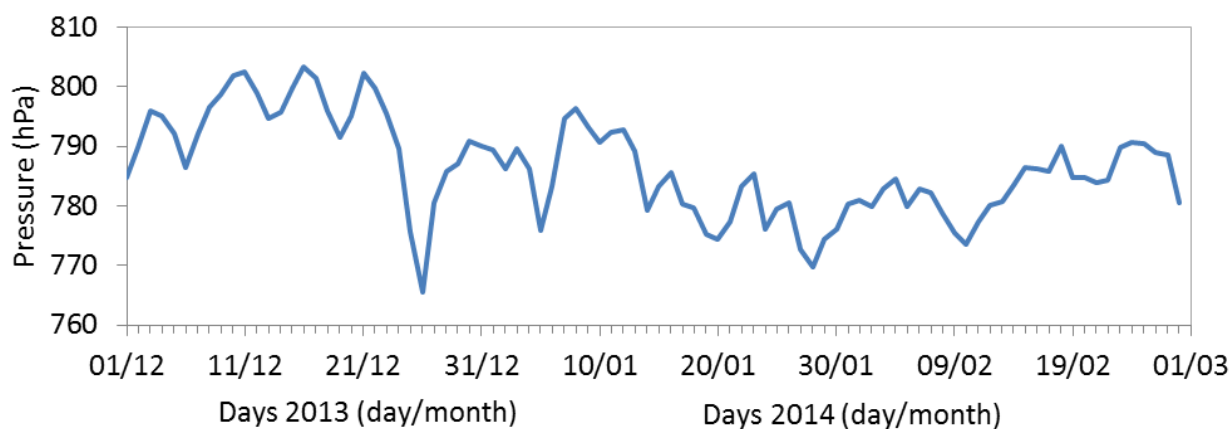
Basic statistical parameters

Statistical parameters are calculated basing on 30-minute aggregated values from December 2013 to February 2014.

| Data availability (hPa) | Min value (hPa) | 25 th percentile (hPa) | 50 th percentile (hPa) | Average mean value (hPa) | 75 th percentile (hPa) | Max value (hPa) |
|-------------------------|-----------------|-----------------------------------|-----------------------------------|--------------------------|-----------------------------------|-----------------|
| 100.0 | 761.4 | 780.6 | 786.3 | 786.5 | 792.3 | 804.3 |

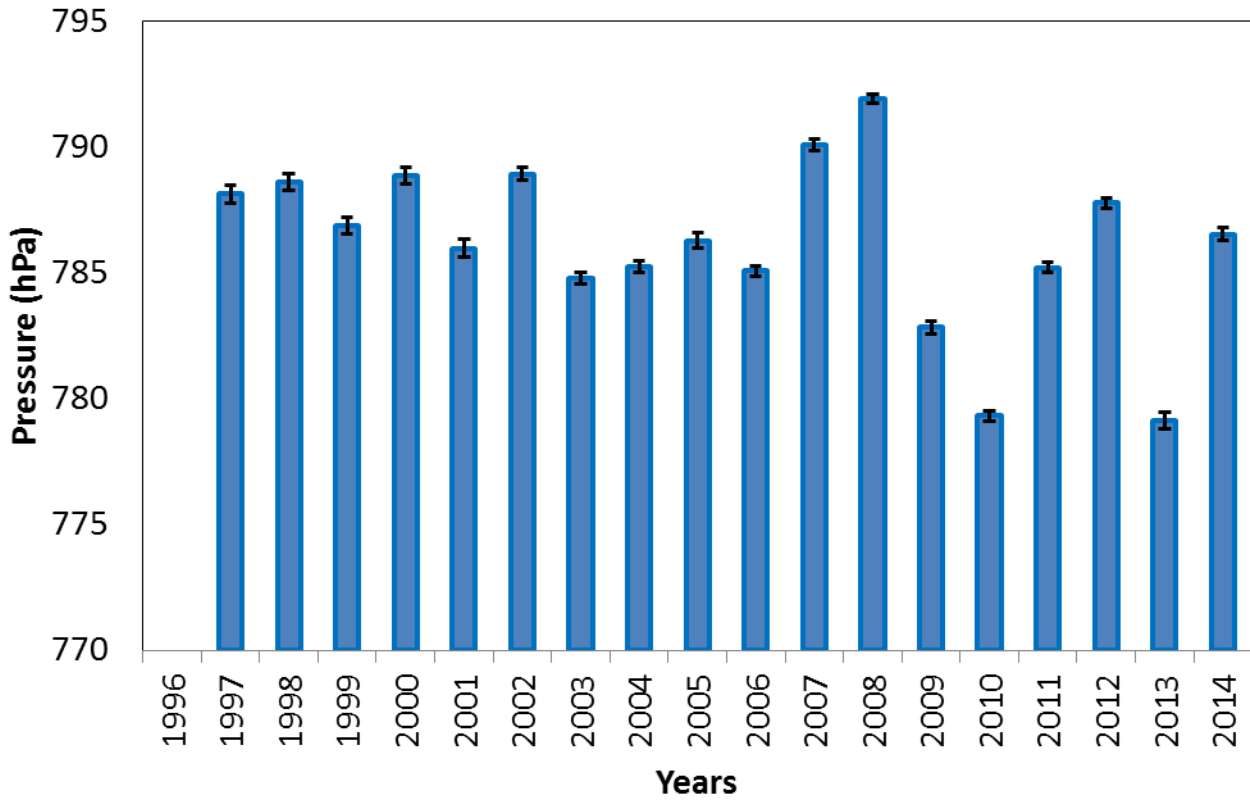
Time series of daily mean values

The daily mean pressure values showed **high values and low variability from December 1st to 24th 2013**, associated also with lower RH values and higher radiation (clear sky conditions), while a very large drops occurred on December 25th- 26th, indicating possible influence of synoptic-scale disturbances.



Comparison with historical data-set

The winter 2014 average atmospheric pressure (786.5hPa) was comparable with the winter climatological value (786.1 hPa).



Wind speed and direction

Why is wind so important?

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

Instrumentation and calibration

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

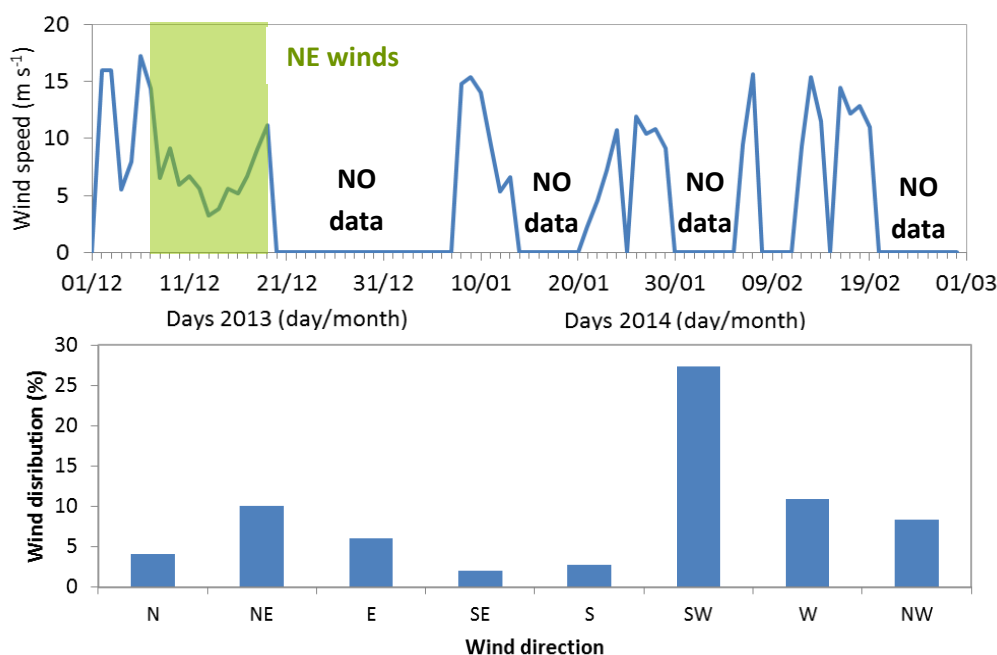
Basic statistical parameters of wind speed

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

| Data availability (%) | Min value (m/s) | 25 th Percentile (m/s) | 50 th Percentile (m/s) | Average mean value (m/s) | 75 th percentile (m/s) | Max value (m/s) |
|-----------------------|-----------------|-----------------------------------|-----------------------------------|--------------------------|-----------------------------------|-----------------|
| 32.9 | 0.9 | 5.7 | 8.1 | 9.2 | 12.5 | 28.0 |

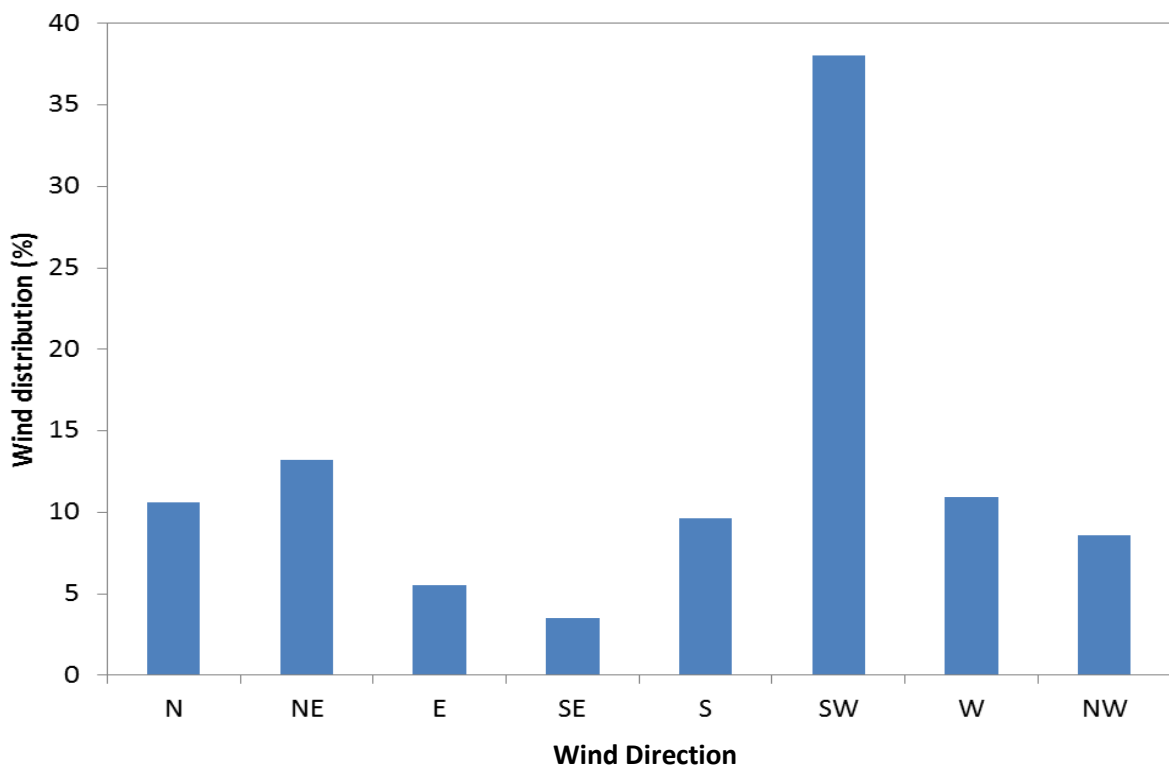
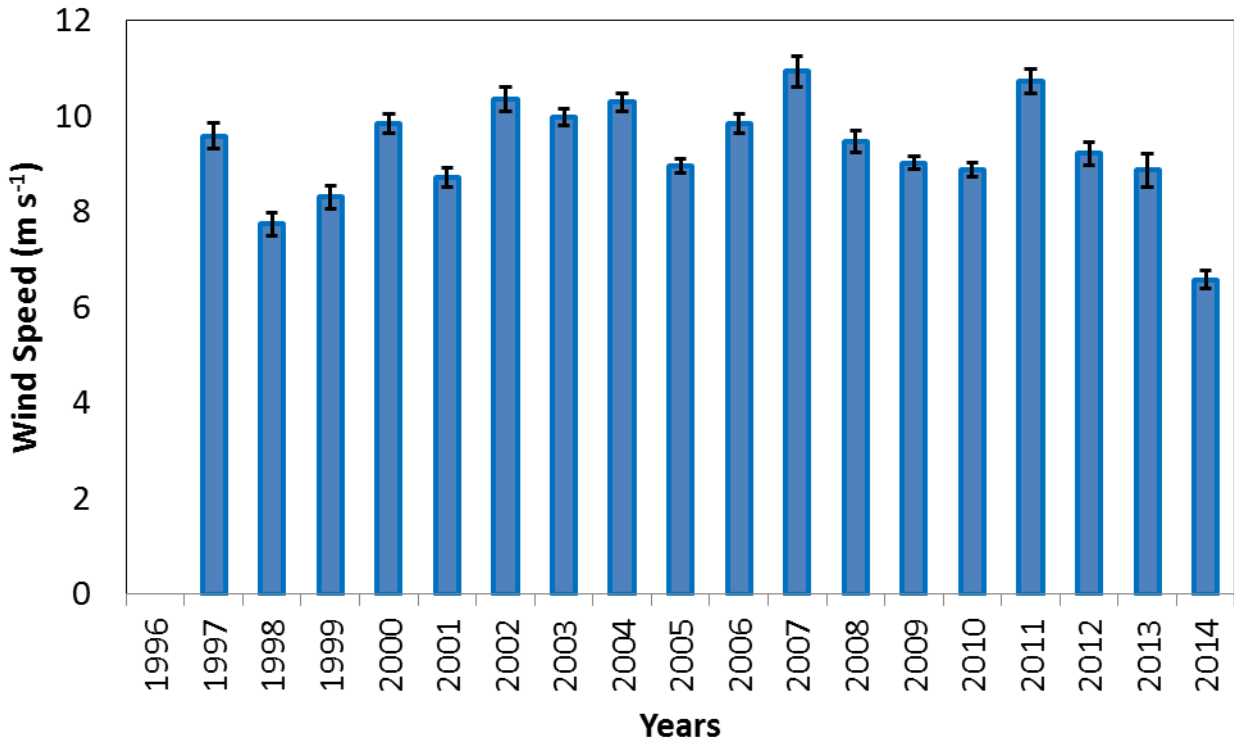
Time series of daily mean values

Although the winter 2014 is characterized by a predominance of SW winds, we observed the prevalence of NE winds of relatively low speed during the first half of December that are related with the high pressure and warm clear sky conditions.



Comparison with historical data-set

The winter 2014 showed an average wind speed (9.2 m/s) that is comparable to the climatological winter value (9.4 m/s). The seasonal wind direction is similar to the climatological one, with a prevalence of south-westerly winds (respectively 27.4 % and 38.0%). However, this information should be considered with caution due to the low data coverage.



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 O₃). Moreover, UV-B radiation is fundamental in determining the oxidative properties of the troposphere by leading O₃ photo-dissociation and thus determining OH levels.

Instrumentation and calibration

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

Basic statistical parameters (Solar radiation)

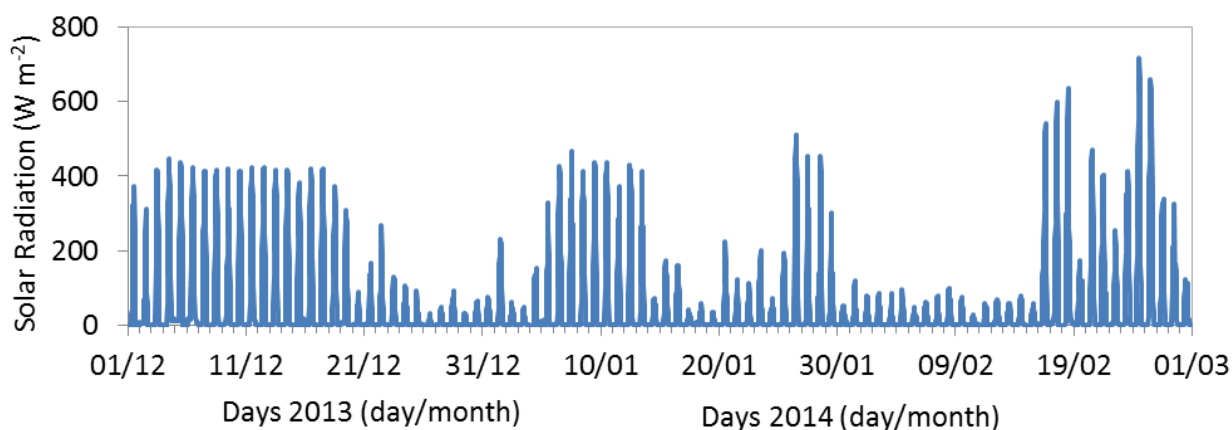
Statistical parameters are calculated basing on 30-minute aggregated values from December 2013 to February 2014.

| Data availability (%) | Min value (W/m ²) | 25 th Percentile (W/m ²) | 50 th Percentile (W/m ²) | Average mean value (W/m ²) | 75 th percentile (W/m ²) | Max value (W/m ²) |
|-----------------------|-------------------------------|---|---|--|---|-------------------------------|
| 100.0 | UDL | UDL | 0.4 | 52.2 | 40.5 | 719.4 |

UDL: under detection limit

Time series (Solar radiation)

During December and January, in clear sky conditions, the lowest daily maximum values were observed; these values started to raise during February. The highest daily value observed on February, 25th (182.5 W m⁻²) while the highest 30 minute mean value (719.4 W m⁻²) was observed on February, 24th. Please note that the presence of snow cover over the sensor could lead to a significant underestimation of the radiation values.



Basic statistical parameters (UV-B)

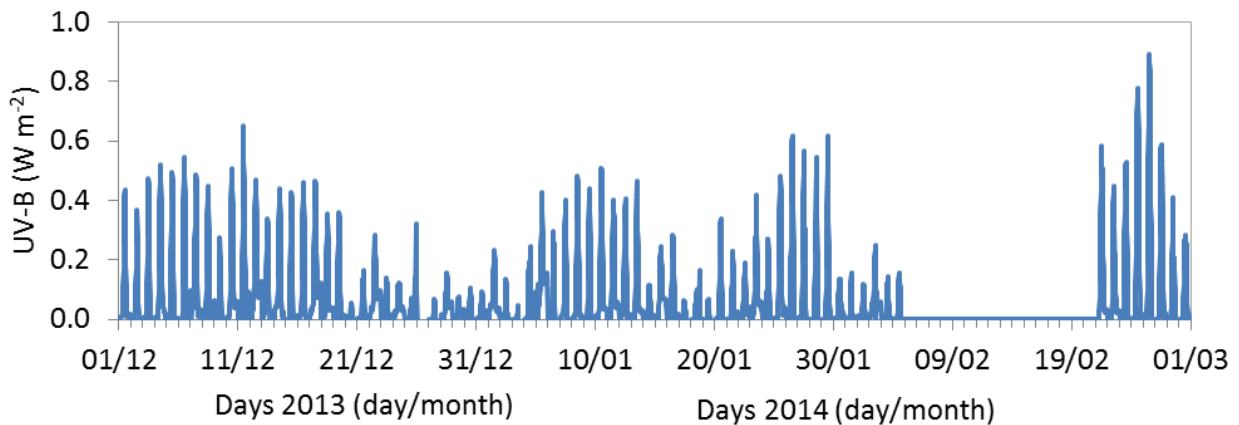
Statistical parameters are calculated basing on 30-minute aggregated values from December 2013 to February 2014.

| Data availability (%) | Min value (W/m ²) | 25 th Percentile (W/m ²) | 50 th Percentile (W/m ²) | Average mean value (W/m ²) | 75 th percentile (W/m ²) | Max value (W/m ²) |
|-----------------------|-------------------------------|---|---|--|---|-------------------------------|
| 81.6 | UDL | UDL | 0.01 | 0.06 | 0.08 | 0.89 |

UDL: under detection limit

Time series (UV-B)

A trend analogous to what have been observed for Solar radiation is also evident for the UV-B. The highest daily average (0.2 W m⁻²) and 30 minutes average (0.9 W m⁻²) values were observed on February, 25th. *Please note that the presence of snow cover over the sensor could lead to a significant underestimation of the radiation values.*



Bibliography

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

Bonasoni P, Stohl A, Cristofanelli P, Calzolari F, Colombo T, Evangelisti F: Background ozone variations at Mt. Cimone, *Atmos. Environ.*, 34 (29-30), 2000.

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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 meteorological 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 Committee comprising an international climate and atmospheric monitoring network, researches in environmental and geophysical sciences and new technology development for monitoring activity in high mountain regions. Working in synergy with projects run by UNEP and WMO, data from the SHARE initiative benefit the international scientific community as well as decision makers.



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



Monitoring atmospheric composition & climate

MACC-2 (Monitoring Atmospheric Composition and Climate - Interim

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



EUSAAR (European Supersites for Atmospheric Aerosol Research) The objective of EUSAAR

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



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



CIRCE (Climate Change and Impact Research: the Mediterranean 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.



SOGES (System for Observations of Halogenated Greenhouse Gases in Europe) SOGES 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 SOGES.



POLPO (Pollution Hot Spot Monitoring from GOME Applied to the Po-basin) POLPO investigated the feasibility 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 feasibility study.

QUILT

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 conducted to evaluate the influence of mineral dust on troposphere oxidizing 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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