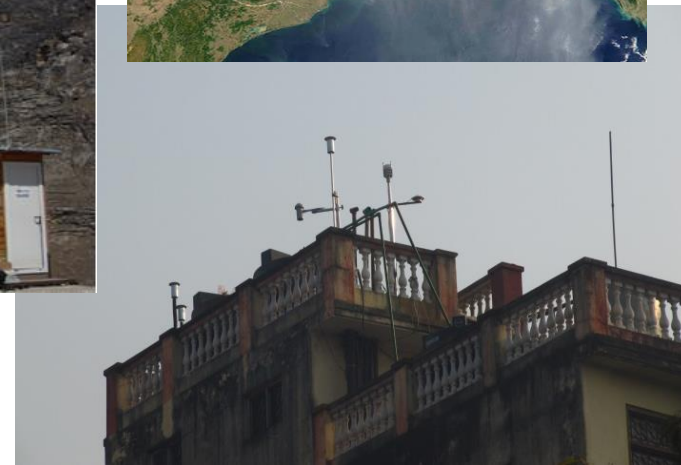
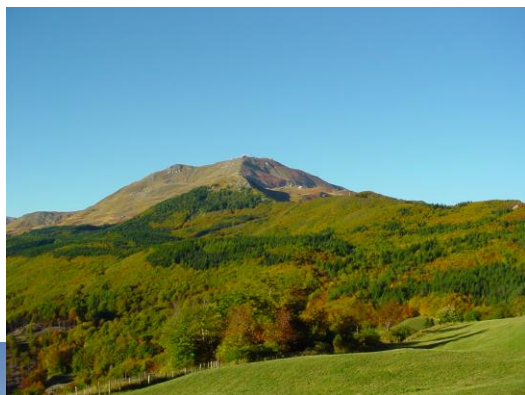


Studio della composizione dell'atmosfera in aree montane (WP1.1 e WP1.2)

Contact: P. Cristofanelli (ISAC-CNR)

URT Ev-K2-CNR, ISAC-CNR

Contributions by: IRSA-CNR, ENEA-UTMEA, Urbino University, RSE SpA, CETEMPS



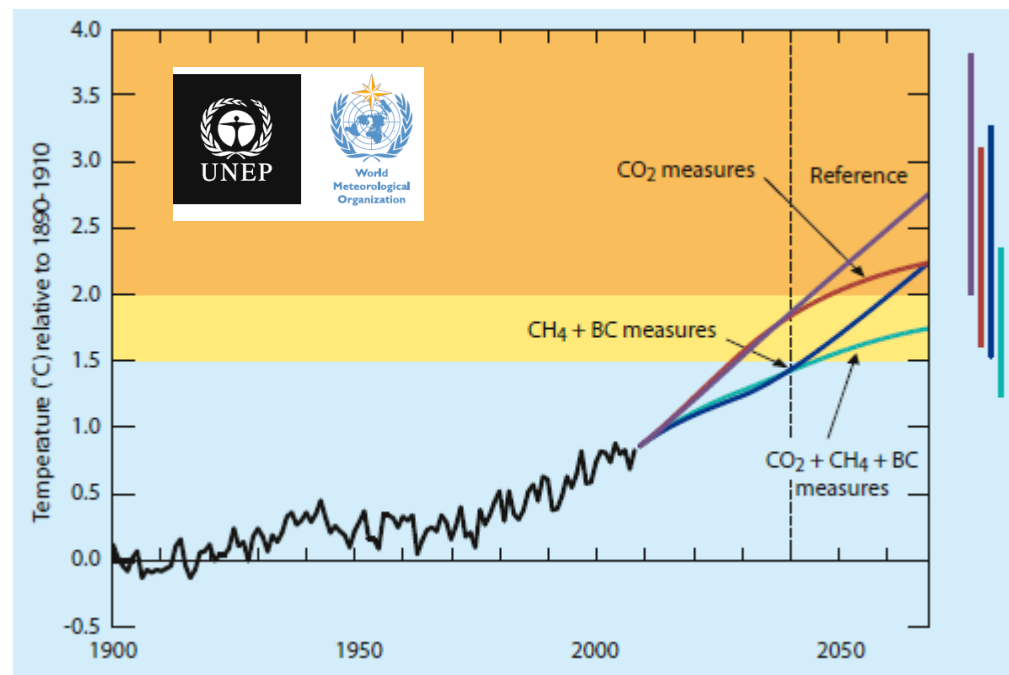
Motivazioni scientifiche:

- Misure in aree montane sono rappresentative di ampie aree spaziali e del «fondo» atmosferico (es. analisi dei trends di composti atmosferici e climalteranti) ma utili per valutare l'impatto delle emissioni antropiche nella libera troposfera
- Studio di hot-spot climatici (Mediterraneo e Asia meridionale/HKKH)
- Valutazione di processi (trasporto ed emissioni naturali/antropiche) sulla variabilità di composti clima-alteranti ed inquinanti (es. SLCF/P) a varie scale spaziali e temporali
- Definire solide basi scientifiche al fine di identificare corrette misure di mitigazione delle emissioni di composti inquinanti e clima-alteranti (es. ABC-Suskat) contribuendo alla quantificazione degli impatti.

Short-lived climate forcers (SLCF): composti quali CH_4 , BC, O_3 troposferico e HFCs che hanno un impatto climatico a breve termine e che hanno un tempo di vita in atmosfera più breve (da giorni a decenni) rispetto alla CO_2

Black Carbon (BC): si forma dalla combustione di carburanti fossili, legno e altra biomassa. Contribuisce al cambiamento climatico (**riscaldamento dell'atmosfera, influenza sulle proprietà delle nubi, albedo della neve**).

Ozono troposferico (O_3): gas serra clima-alterante, inquinante nocivo per la salute umana e gli ecosistemi.



Source: UNEP/WMO, 2011

Struttura della presentazione:

- Studio della composizione dell'atmosfera attraverso le osservazioni eseguite presso la **Stazione Globale WMO/GAW di Monte Cimone**
 - Studio dei long-term trends (ozono e proprietà fisico chimiche dell'aerosol)
 - Studio del trasporto di aerosol minerale
 - Studio dell'influenza delle emissioni di open biomass burning
 - Report trimestrali ed eventi speciali
 - NRT data delivery
- Studio della composizione dell'atmosfera attraverso le osservazioni eseguite presso la **Stazione Globale WMO/GAW Nepal Climate Observatory – Pyramid** e presso la **Stazione ABC-Suskat di Kathmandu**
 - Studio dell'impatto di open biomass burning sulla variabilità di ozono e black carbon
 - Processi di trasporto di inquinamento ed aerosol minerale durante il periodo di «onset» del monsone
 - Studio del trasporto di aerosol in Himalaya e sul Plateau Tibetano

“O. Vittori” Observatory – Monte Cimone

M. Cimone 44.0N, 10.7E, 2165 m a.s.l.

Vetta più elevata dell'Appennino settentrionale

Orizzonte libero a 360°

Usualmente oltre il PBL, eccetto nei mesi caldi

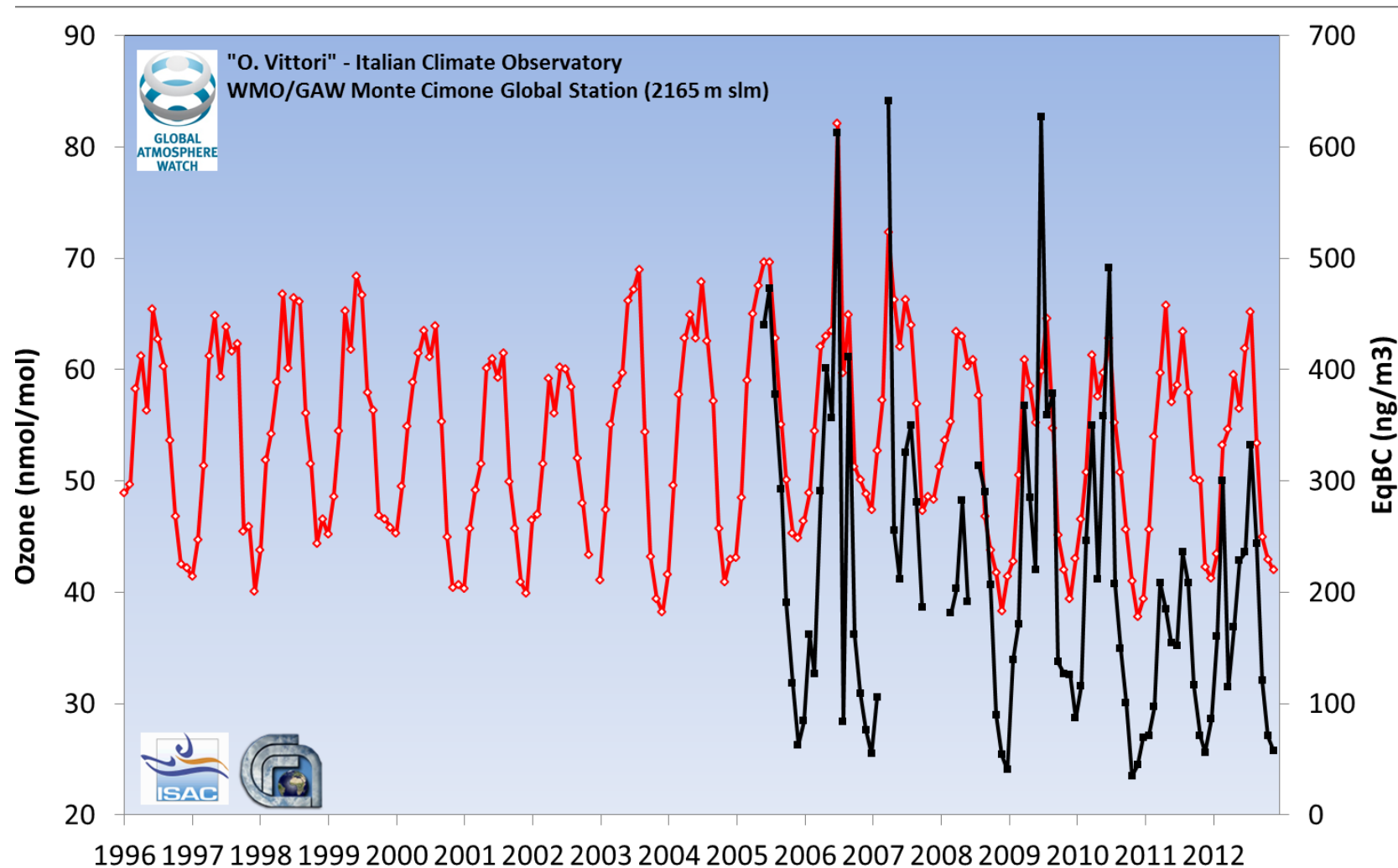
NRT data: www.isac.cnr.it/cimone/realtime

MACC-2 (O₃, CO), WMO SDS-WAS, ACTRIS

[illegible]

Osservazioni long-term di ozono e black carbon

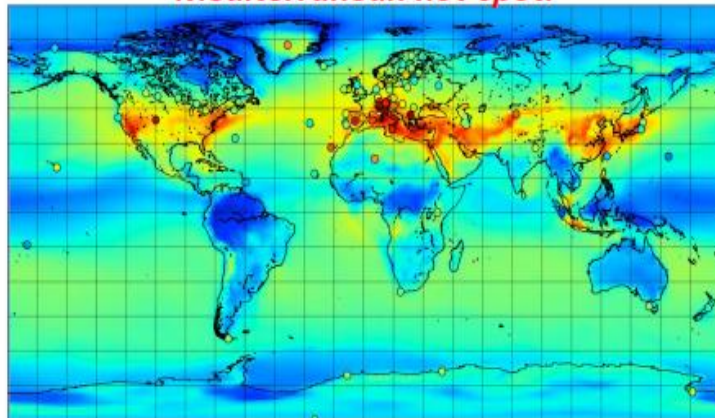
Valori più elevati nei mesi caldi (influenza dal PBL regionale/continentale) valori minimi nei mesi freddi
(più rappresentativi del fondo d'ampia scala spaziale)



Incontro Generale NextData - Roma, CNR, 3-4 giugno 2014

Tropospheric ozone (O_3) is a powerful greenhouse gas, influences the oxidation capacity of the troposphere and affects the population health as well as the ecosystem integrity and crop yields.

Mediterranean hot-spot.



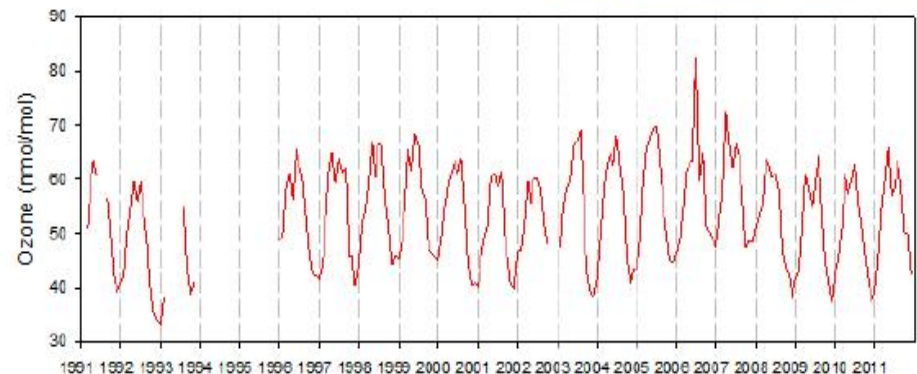
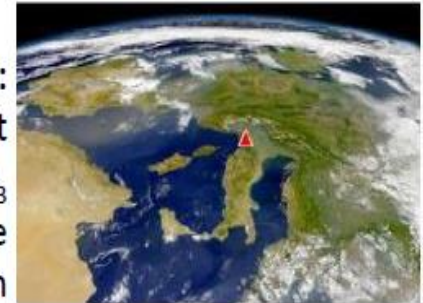
0 6 12 18 24 30 36 42 48 54 60 ppb

Global July distribution of near surface ozone mole fractions measured by the GAW network stations superimposed on model simulated mole fraction fields from the MACC (Monitoring Atmospheric Composition and Climate) reanalysis.

Several long-term studies at remote and rural locations of continental Europe **but no specific efforts have been conducted to evaluate the long-term O_3 trends in the Mediterranean basin.**

Aim of the work:

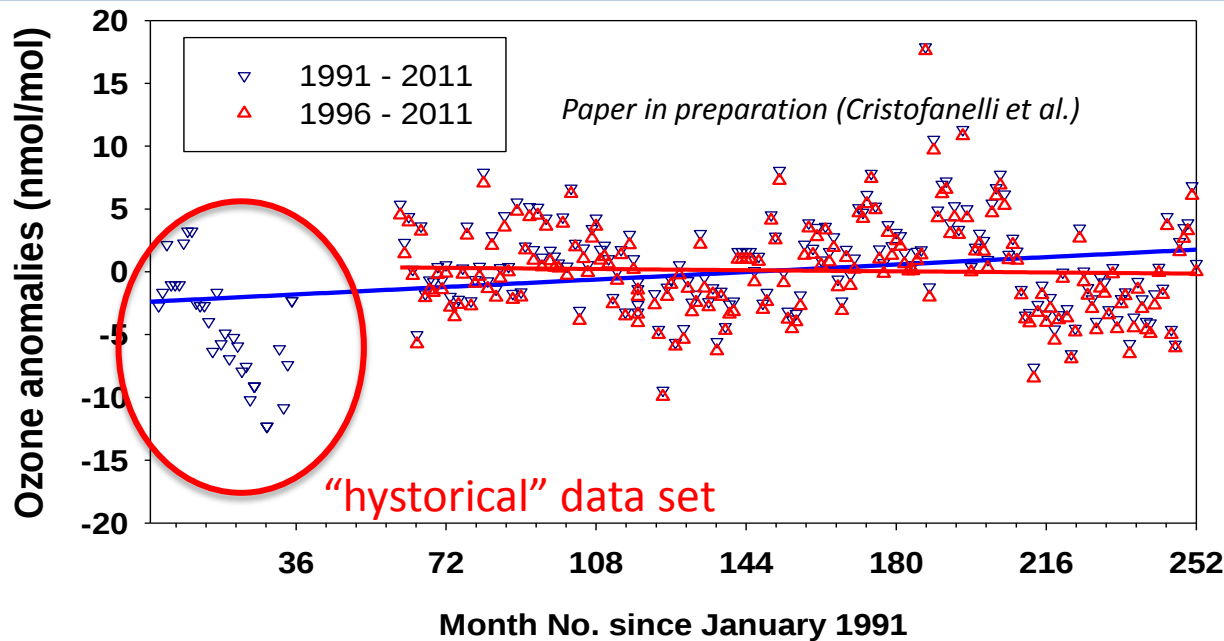
To provide information about long-term surface O_3 variability in the Mediterranean basin



The longest surface O_3 time series at a high-mountain location in the Med region

[Next](#)

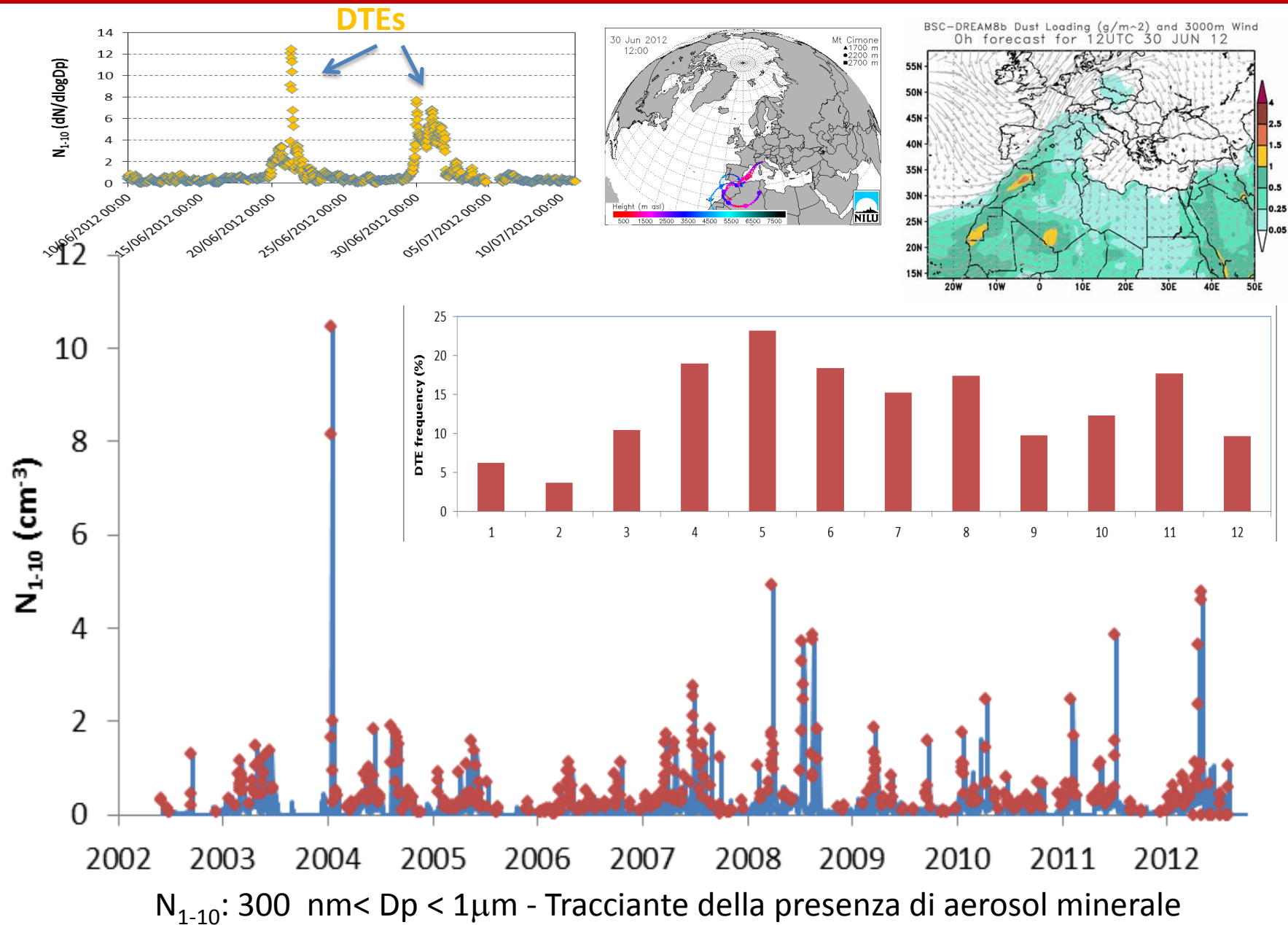
[Main menu](#)



Monthly O₃ anomalies and linear trend fitting.

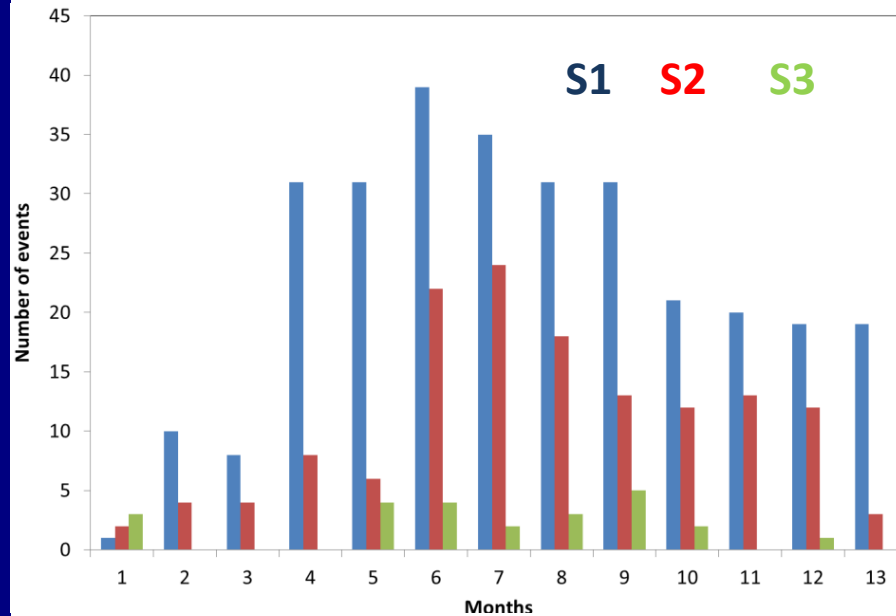
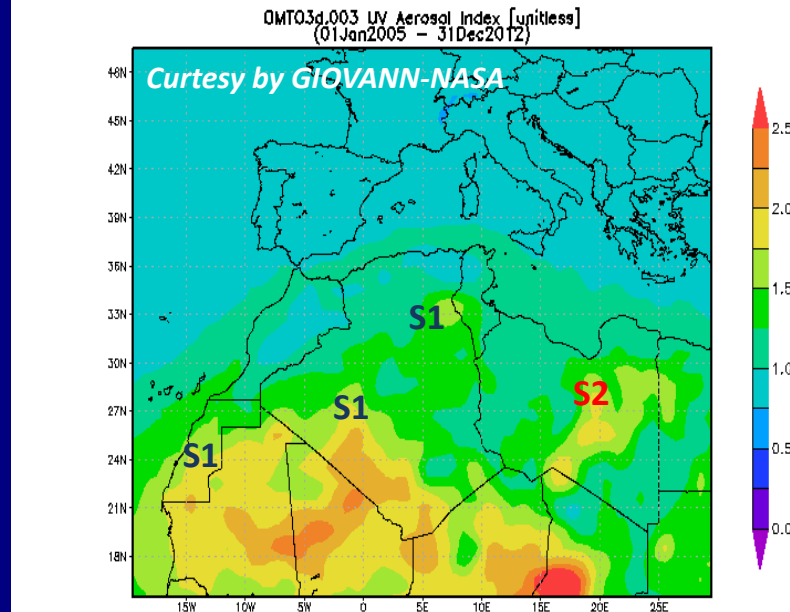
Long-term O₃ trends were evaluated over the entire measurement period (1991 – 2011) as well as over the specific time 1996 – 2011, for which a homogenous experimental set-up was available.

- For the period **1991 - 2011**, **significant (at the 95% confidence level) positive linear trends** have been calculated for monthly average values as well as for the 25th and 75th percentiles (0.21 ± 0.10 nmol/mol/yr).
- On a seasonal basis, only for **spring a positive trend (0.34 ± 0.32 nmol/mol/yr)** has been observed at CMN for **1991 – 2011**.
- For the shorter period 1996 -2011, which excludes the first 3 “hystorical” years, **no significant O₃ trends were detected at CMN**
- **For summer negative acceleration of the trend has been detected!**



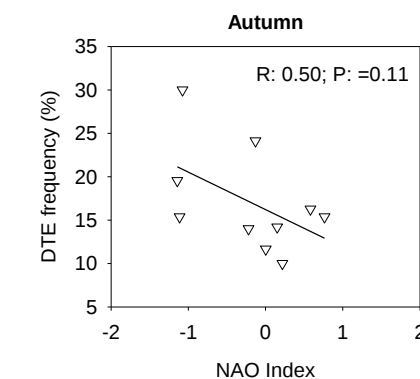
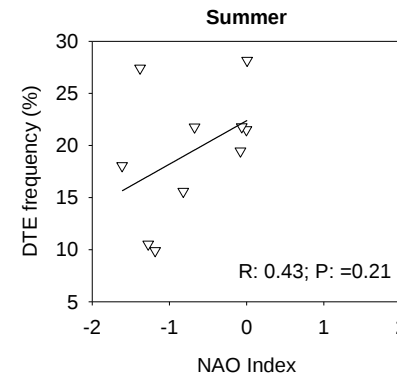
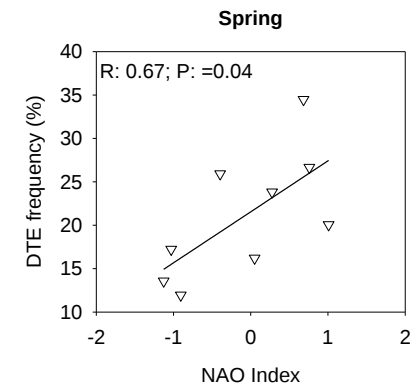
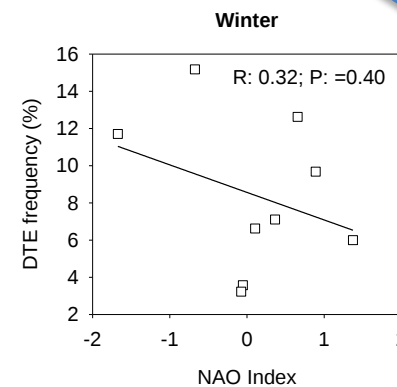
N_{1-10} : $300 \text{ nm} < D_p < 1 \mu\text{m}$ - Tracciante della presenza di aerosol minerale

Incontro Generale NextData - Roma, CNR, 3-4 giugno 2014



Analysis of dust source regions

Relationship of seasonal dust event frequency and NAO variability



Emissioni antropiche e regimi di CO-O3-BC

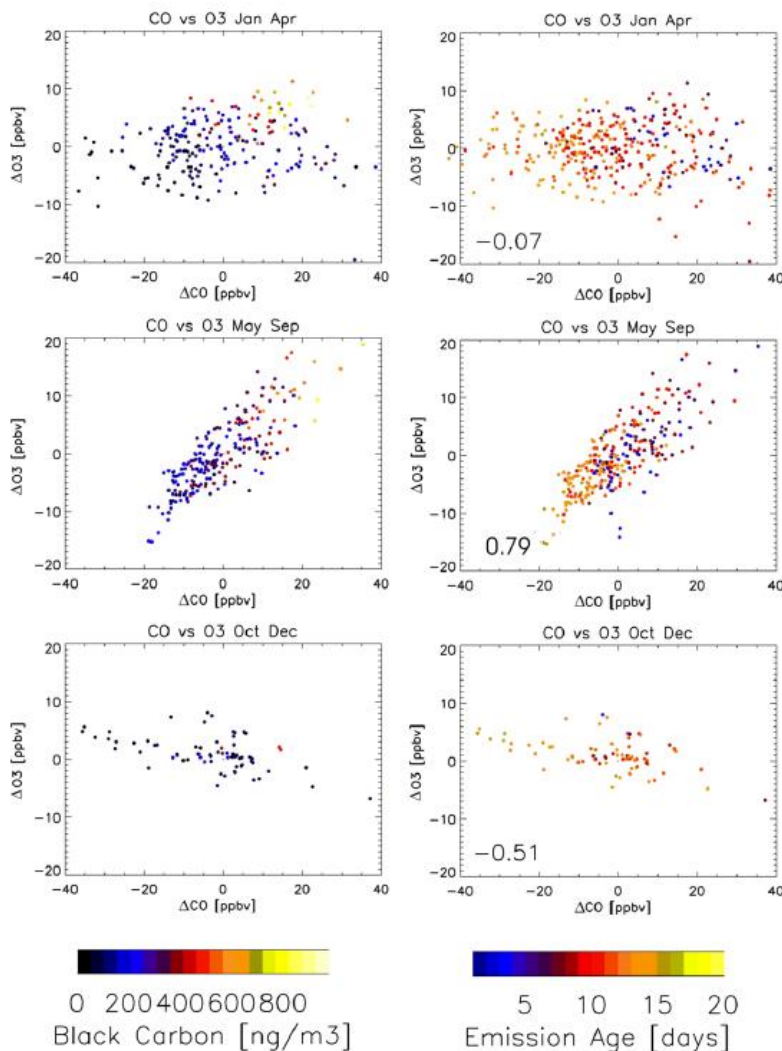
Per identificare la presenza di emissioni antropiche è stato utilizzato il modello di dispersione FLEXPART (CO_{ant}: tracciante antropogenico).

Atmos. Chem. Phys., 13, 15–30, 2013
www.atmos-chem-phys.net/13/15/2013/
 doi:10.5194/acp-13-15-2013
 © Author(s) 2013. CC Attribution 3.0 License.

Anomalie di CO e O₃ (Δ CO and Δ O₃) in funzione del BC (osservato) e dell'età di emissione del tracciante CO ant (simulato da FLEXPART)

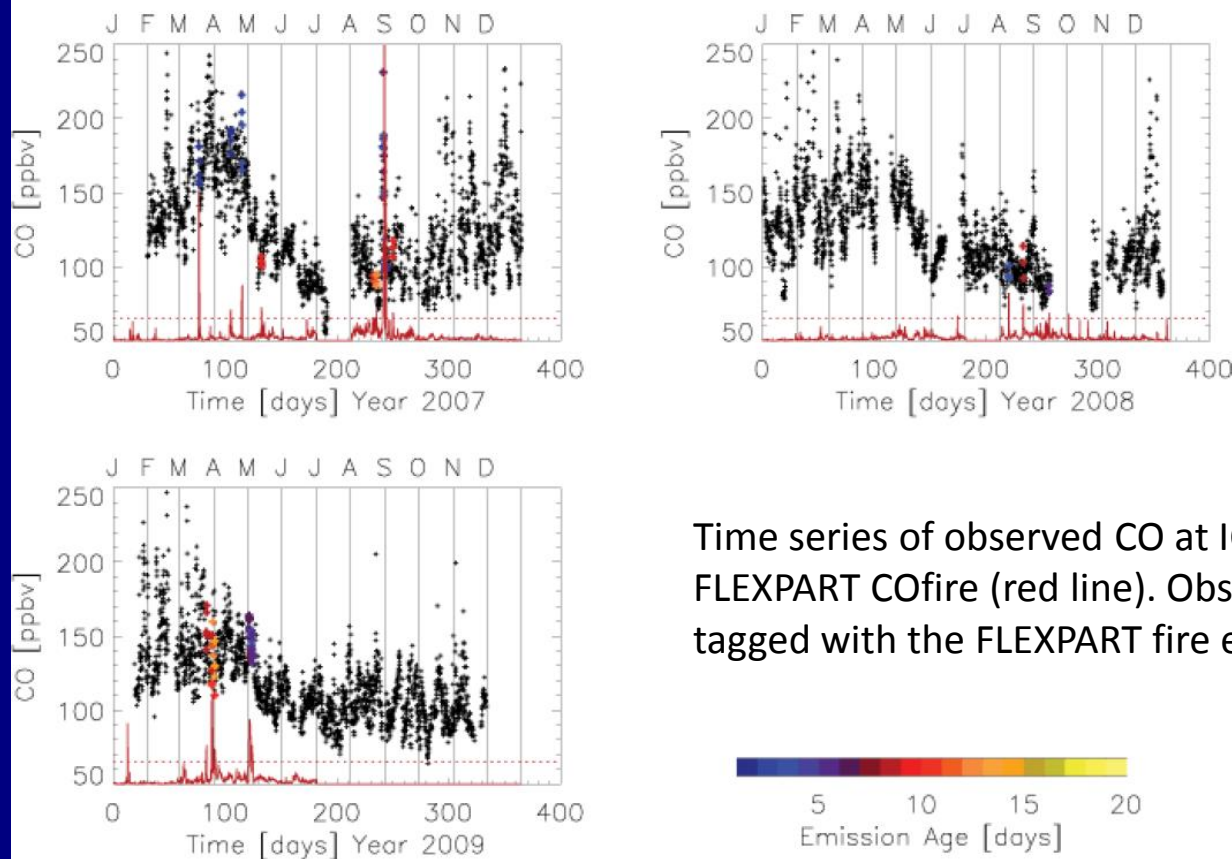
Three main regimes:

- 1) During May–September, **significant positive correlation (R : 0.79)** has been found for CO and O₃, with the highest CO and O₃ values observed in presence of high BC concentration (>400 ngm⁻³).
- 2) CO and O₃ were **negatively correlated (R : -0.51) during October–December**: ensemble of processes concurrent in enhancing O₃ with low CO (i.e upper troposphere/ lower stratosphere intrusions) and O₃ titration with NO in polluted air-masses along with low photochemical activity.
- 3) An intermediate situation occurs in January–April with CO and O₃ almost uncorrelated and BC enhancements mainly associated to relatively old (>7 days) anthropogenic emissions.



Open biomass burning impact to CO, O₃ and BC

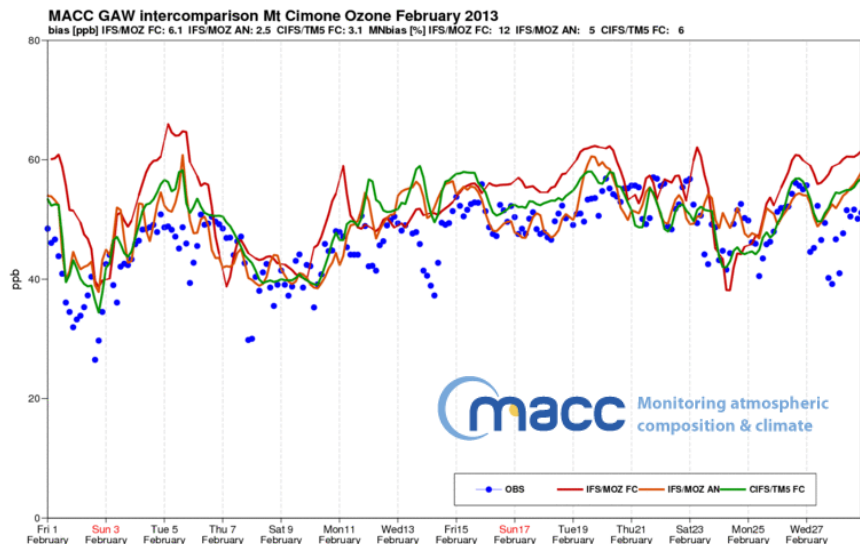
To identify the presence of BB plumes, we considered the time periods for which FLEXPART CO_{fire} continuously exceeded 10 ppbv for more than 12 h at CMN.



Time series of observed CO at ICO-OV (black dots) with FLEXPART CO_{fire} (red line). Observations at ICO-OV are tagged with the FLEXPART fire emission age

BB impact maximizes during the warm months (July to September) but appeared to have a significant contribution to the observed tracers only during 16 specific transport events.

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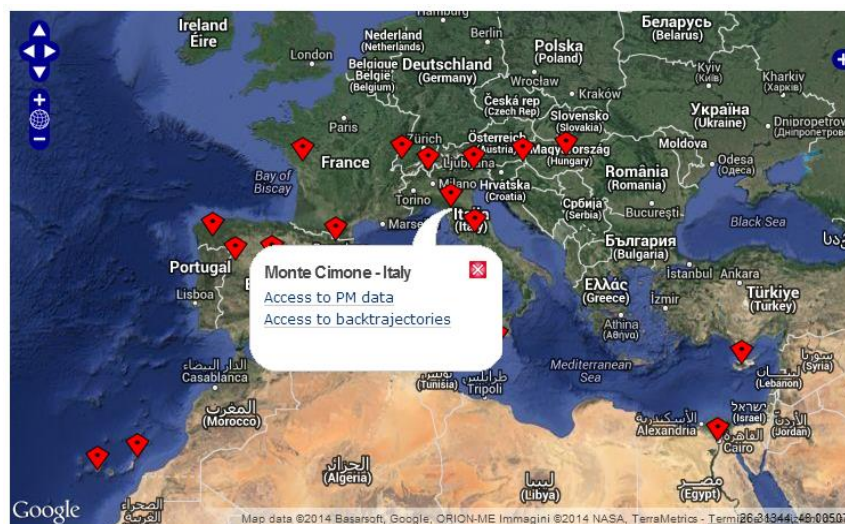
MACC-2

Scopo: validation and verification of numerical prediction models/data assimilation

Osservazioni: CO, Ozono

Risoluzione temporale: 1 h

In corso di attivazione anche per la stazione GAW/WMO di Plateau Rosa



SDS-WAS (WMO Sand and Dust Storm – Warning and Advisory System)

Scopo: early warning, validation and verification of numerical prediction models/data assimilation

Osservazioni: concentrazione in numero delle particelle fini e grossolane

Risoluzione temporale: 1 h

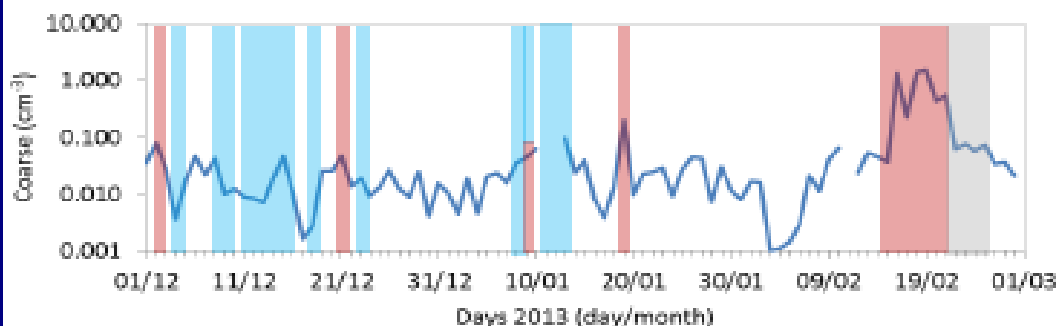
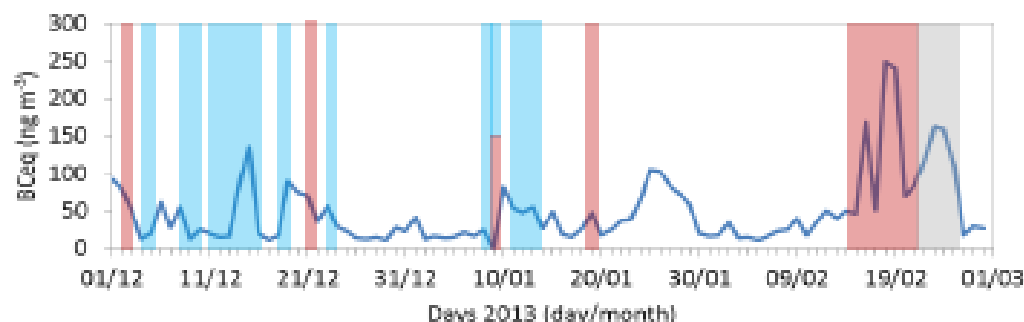
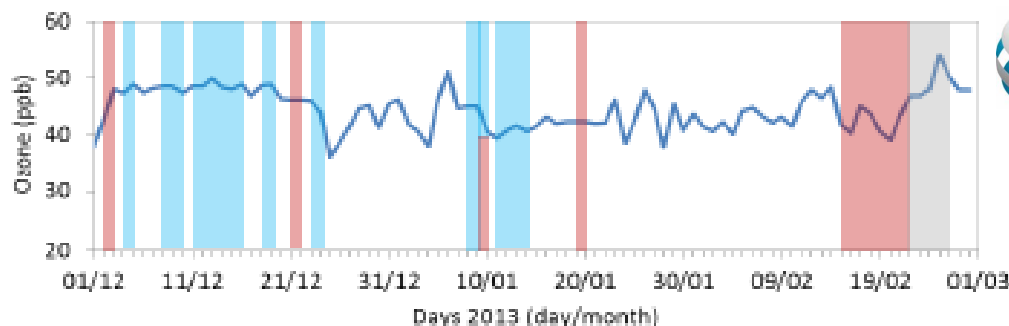
Identificazione di eventi speciali e variabilità degli SLCF/P



GAW Pubblicazione di Report
Trimestrali

<http://www.isac.cnr.it/cimone/reports>

http://www.wmo.int/pages/prog/arep/gaw/other_pub.html



LEGENDA

■ Polveri minerali ■ Intrusioni stratosferiche ■ Trasporto di inquinanti



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.

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 ($CO < 90 \text{ ppb}$). Retro-traiettorie tridimensionali delle masse d'aria, sono state utilizzate per corroborare l'origine degli eventi.

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).

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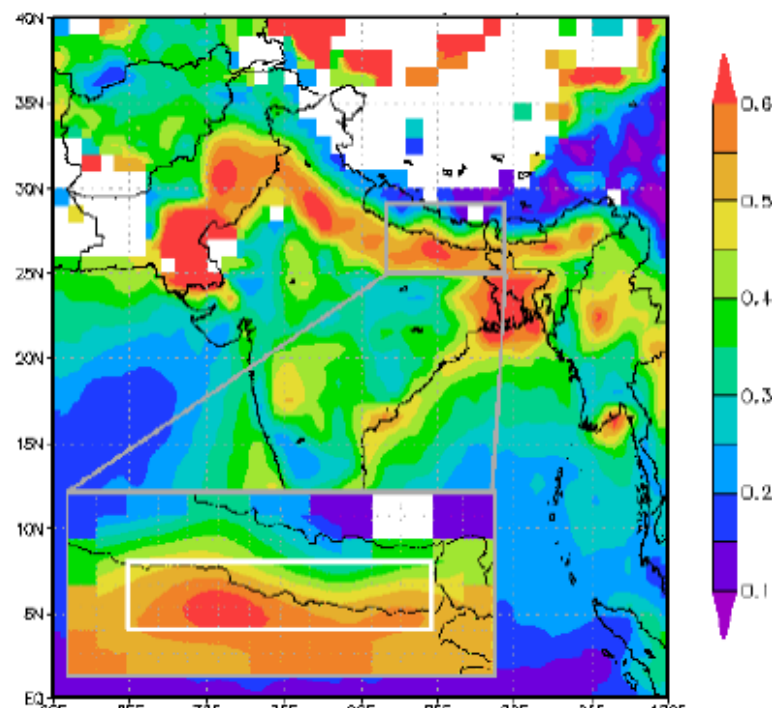
The Nepal Climate Observatory – Pyramid GAW Global Station

Lat: 27° 57'N, Lon: 86° 48'E; 5079 m asl



- Aerosol number concentration and size distribution (SMPS + OPC, CPC)
- Black carbon concentration (MAAP)
- Total and back scattering coefficient (Nephelometer)
- Aerosol optical depth (CIMEL)
- On-line PM₁₀-PM₁ (β absorption)
- Surface ozone (Thermo 49C)
- GHG concentration (flask sampling)
- Atmospheric Hg (IIA)
- Chemical mass closure of aerosol (filter sampling)
- Global solar irradiance (SW + IR)
- Meteo parameters

P. Bonasoni et al.: Atmospheric Brown Clouds in the Himalayas
Atmos. Chem. Phys., 10, 7515–7531, 2010



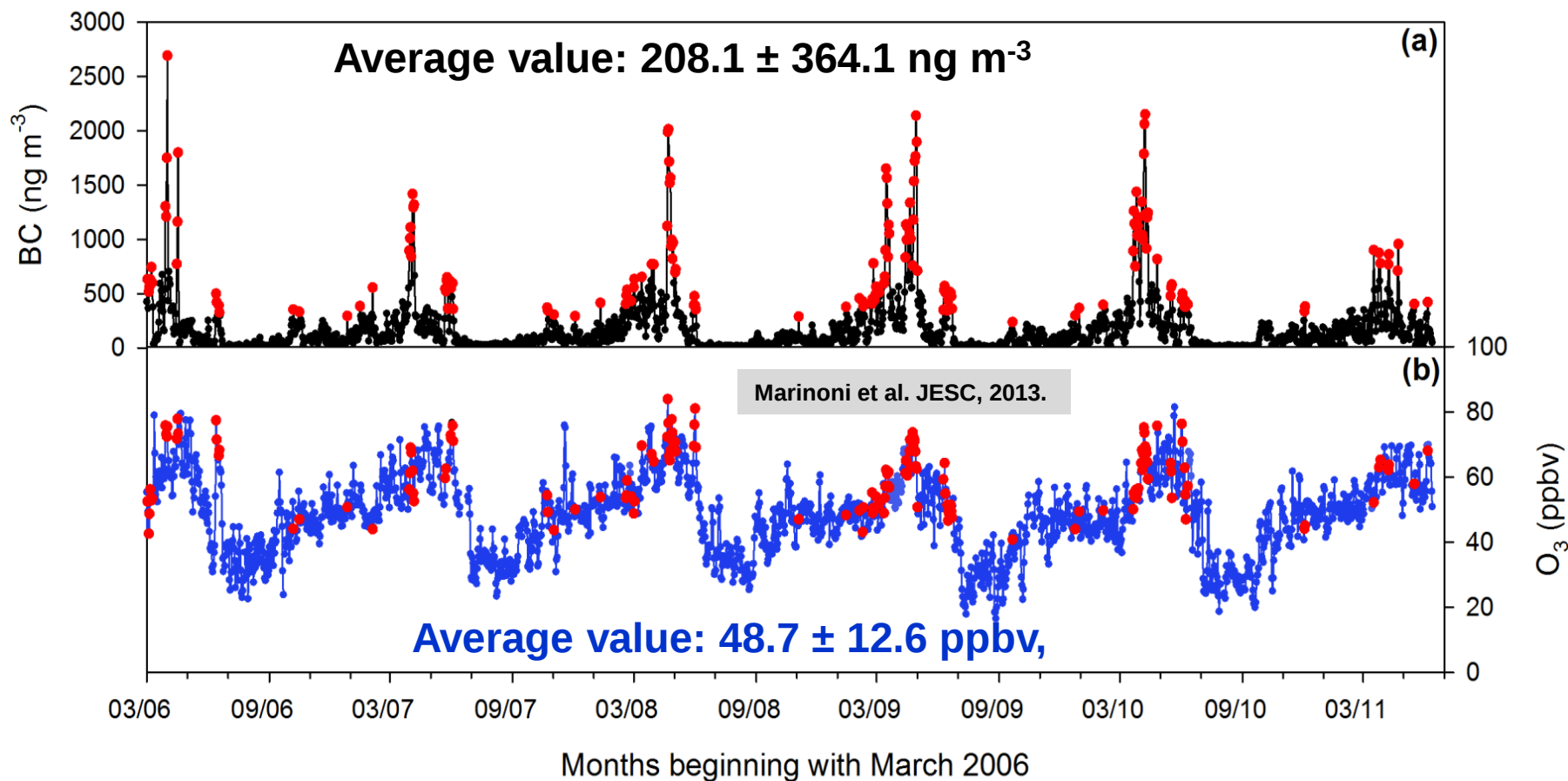
At NCO-P, a day was considered affected by ABC hot-spot if:

- (i) Upvalley wind ($V_y > 0 \text{ ms}^{-1}$) were well developed;
- (ii) BC, aerosol scattering coefficient and PM_{10} values significantly greater (at the 2σ confidence level) than seasonal background value;
- (iii) ABC hot-spots were present over Himalaya foothills (daily MODIS AOD @ 550 nm > 0.4).

50 days (7% of data-set) were identified as being influenced by direct ABC transport to NCO-P, 87% during pre-monsoon, 9% during the winter and 4% in post-monsoon.

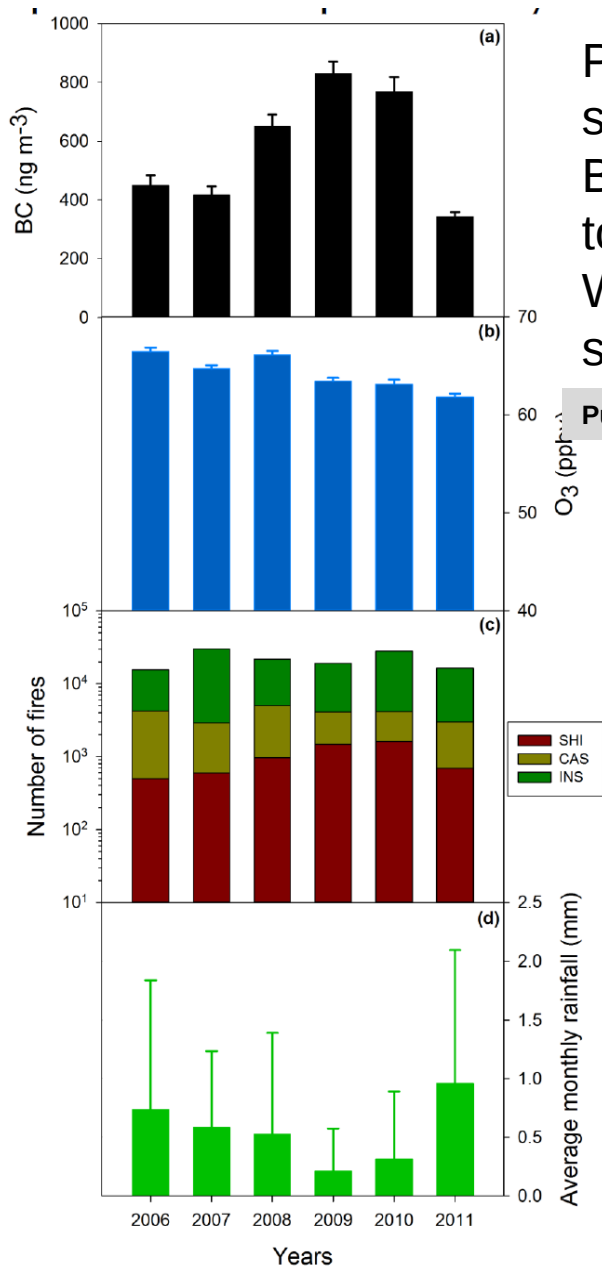
Table 2. Seasonal average (mean $\pm$ standard deviation) of BC, aerosol scattering coefficient, PM_{10} , coarse particle number and O_3 at NCO-P during the period March 2006–February 2008. Seasons are defined following Table 1. In the last column, means $\pm$ standard deviations are reported for the Atmospheric Brown Cloud hot-spot episodes identified at NCO-P during the pre-monsoon season (see Sect. 4.1).

	Pre-Monsoon	Monsoon	Post-Monsoon	Winter	ABC hotspots
BC (ng m^{-3})	316.9 ± 342.9	49.6 ± 60.9	135.3 ± 78.5	118.4 ± 80.9	1974.1 ± 1000.0 +522%
Scattering coefficient (Mm^{-1})	11.9 ± 10.5	2.2 ± 3.5	5.0 ± 2.9	3.4 ± 1.6	57.7 ± 28.2
PM_{10} ($\mu\text{g m}^{-3}$)	3.9 ± 4.0	0.6 ± 1.0	1.5 ± 0.8	1.3 ± 1.8	23.5 ± 10.2
Coarse (cm^{-3})	0.37 ± 0.37	0.09 ± 0.02	0.07 ± 0.05	0.16 ± 0.14	0.64 ± 0.32
O_3 (ppbv)	60.9 ± 8.4	38.9 ± 9.6	46.3 ± 5.0	51.2 ± 5.4	69.2 ± 10.4 +14%



- **Red dots: “acute” pollution events (156 days, 9.1% of the entire data-set)**
- The pre- monsoon is the season the most affected by these events
 - Dramatic BC increases and high O₃ enhancement
 - (+29% and +352% with respect to the remaining days).

Open fire influence on O₃ and BC at NCO-P (2006 – 2011)

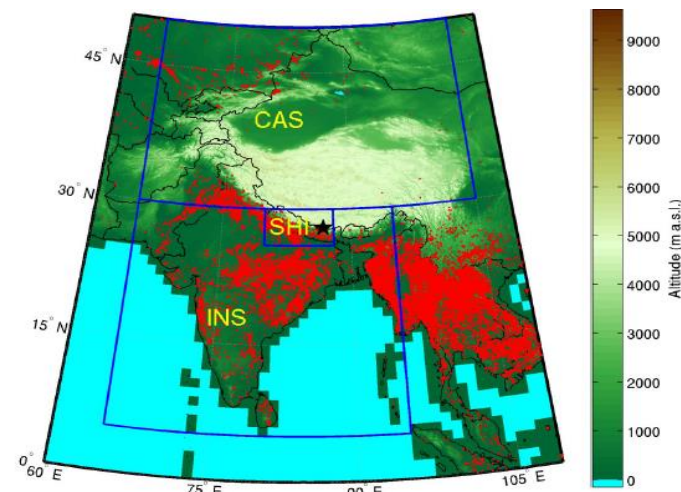


Pre-monsoon 2011 showed surprisingly low BC and ozone, compared to the previous years. What was the cause for such anomaly?

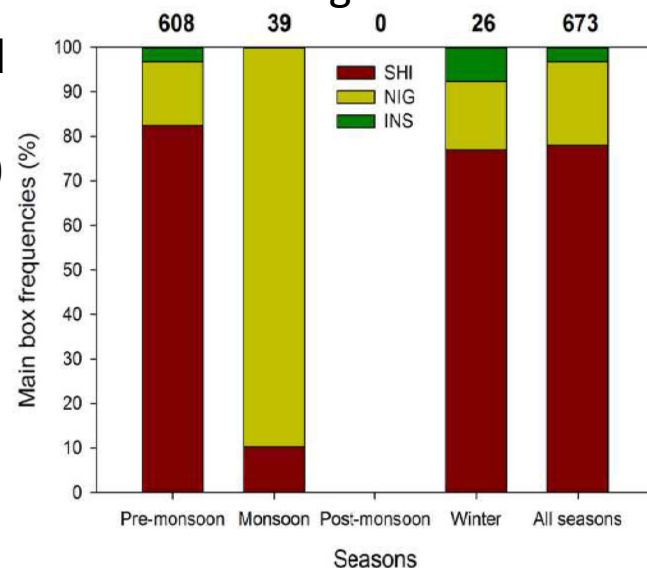
Puetro et al. Env. Poll 2014.

- Reduction of 60% for fires located in SHI and INS regions for 2011, compared to April 2010

- Increase of average monthly rainfall of 300% (2011 vs 2010) and 400% (2011 vs 2009)

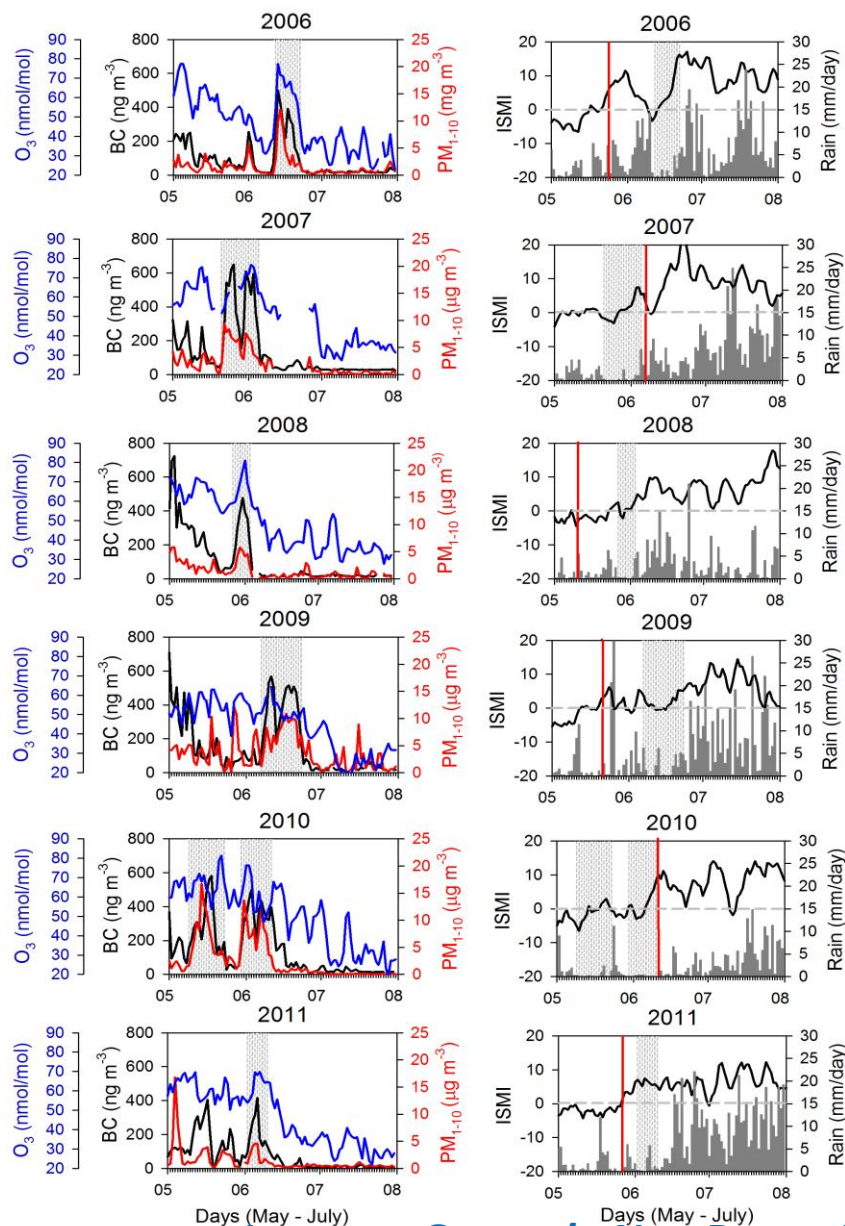


90 days (56% of the polluted days) showed air-masses crossing fire areas

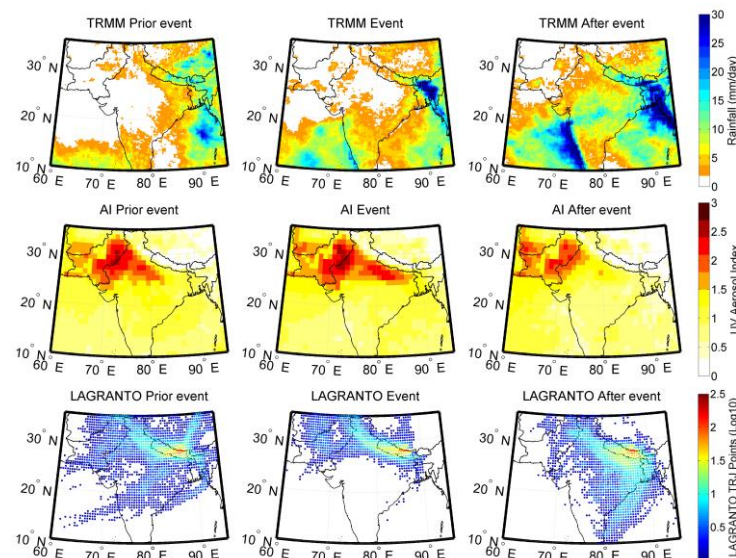


Pollution events during the summer monsoon onset period

NCOP Observations



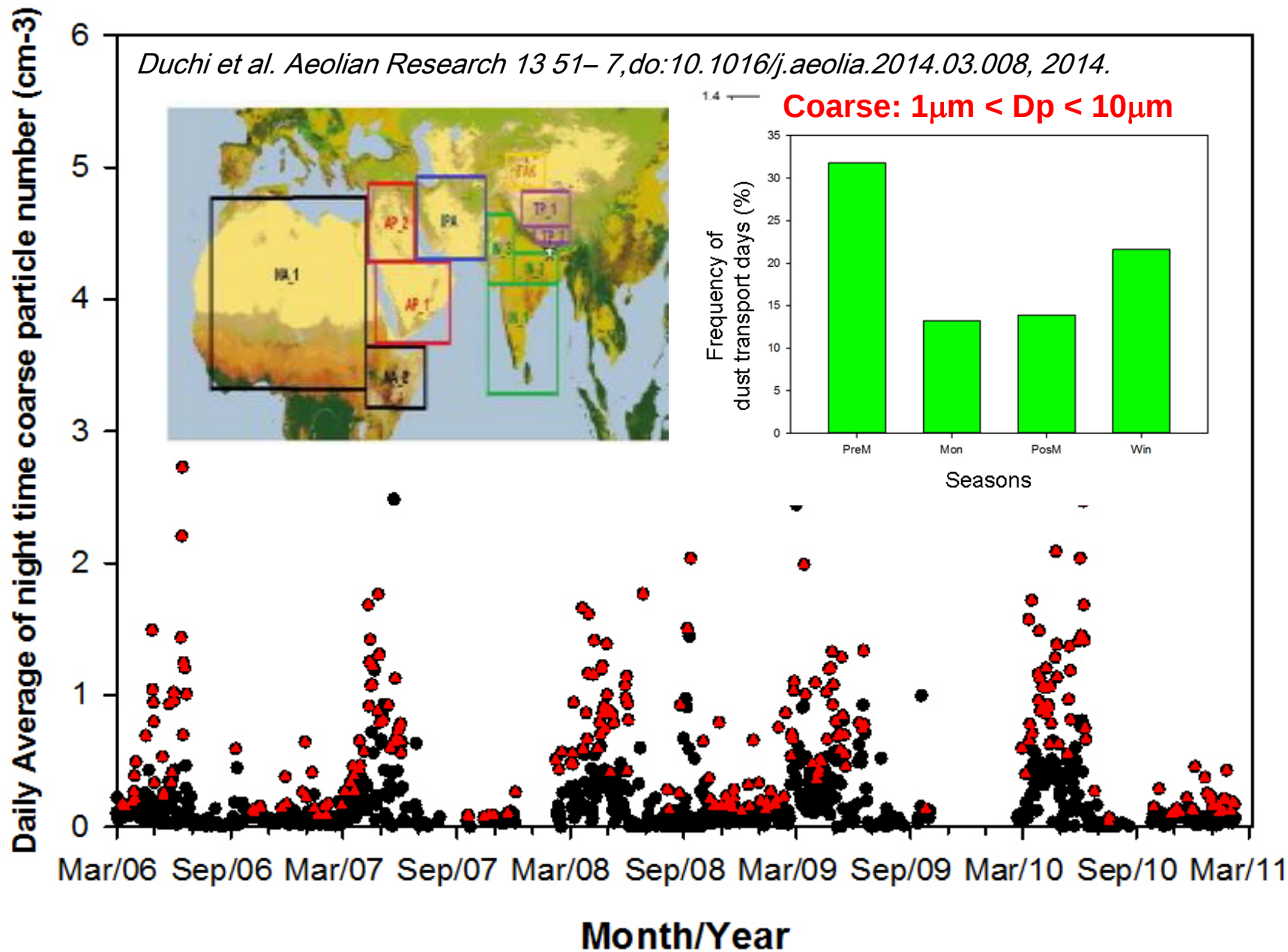
Satellite and model data composite



Mineral dust, black carbon and surface ozone reaching the NCO-P appeared to be related with emissions within the PBL of the central Pakistan (i.e. Thar desert) and north-western Indo-Genetic plain and Himalayas foothills.

Cristofanelli et al., ERL, accepted

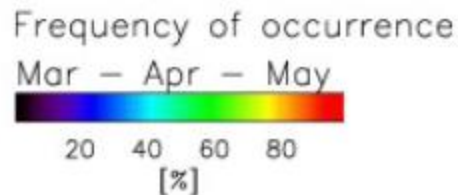
Synoptic-scale mineral dust transport (2006 – 2011)



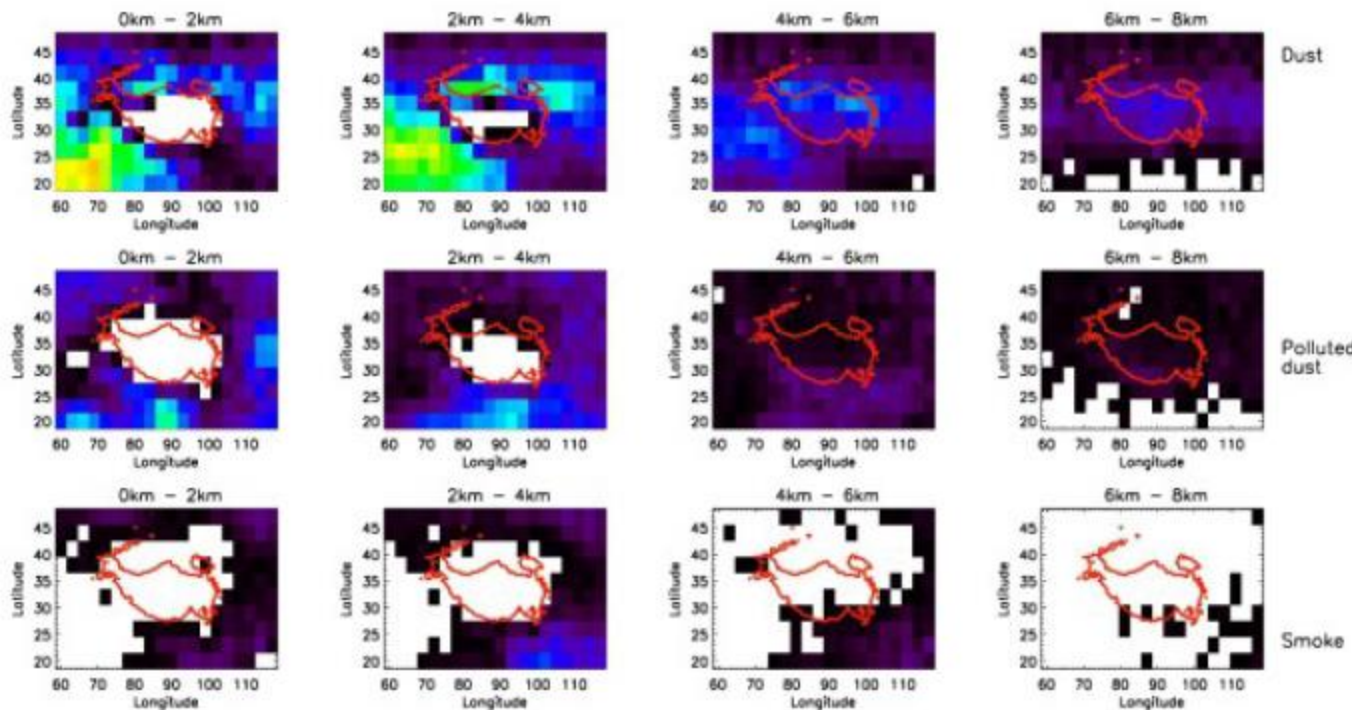
Incontro Generale NextData - Roma, CNR, 3-4 giugno 2014

CALIOP (Cloud Aerosol Lidar with Orthogonal Polarization) Aerosol Layer data (L2) analysis

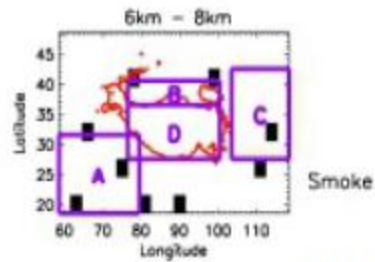
Seasonal frequencies of occurrence (from 2007 to 2010) of each class of aerosol (Dust, Polluted Dust and Smoke): # Layers of each class/# of satellite tracks on each bin.



Contact:
f.fierli@isac.cnr.it



Interannual Variability of Dust, Polluted Dust and Smoke



Monthly mean of frequency of occurrence for each aerosol class over 4 subregions of interest, at different height.

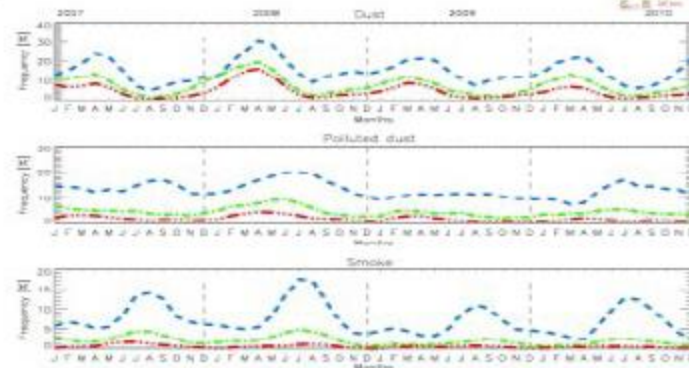
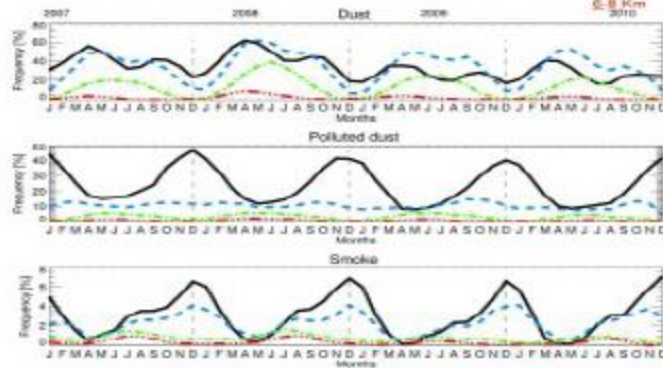
0-2 Km
2-4 Km
4-6 Km
6-8 Km

India

China

A)

B)

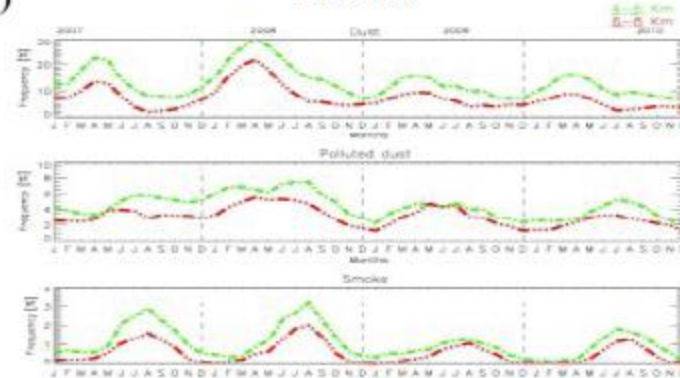
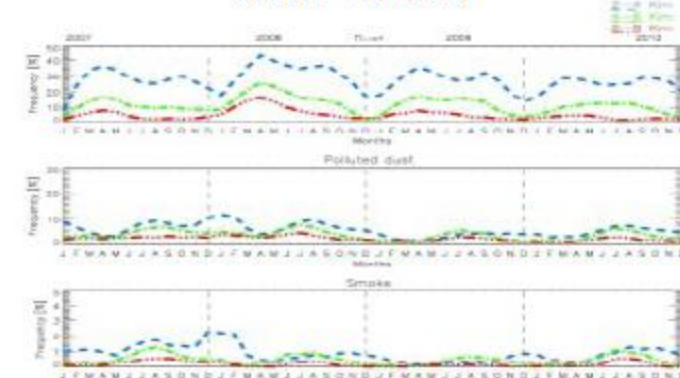


North Plateau

Plateau

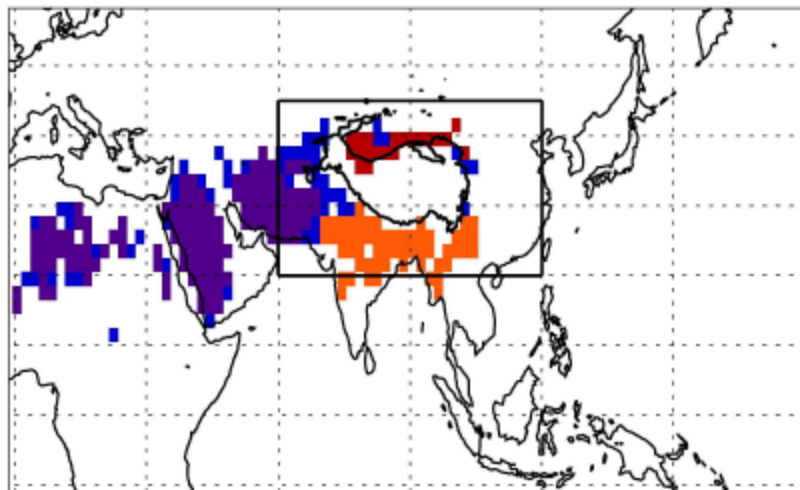
C)

D)



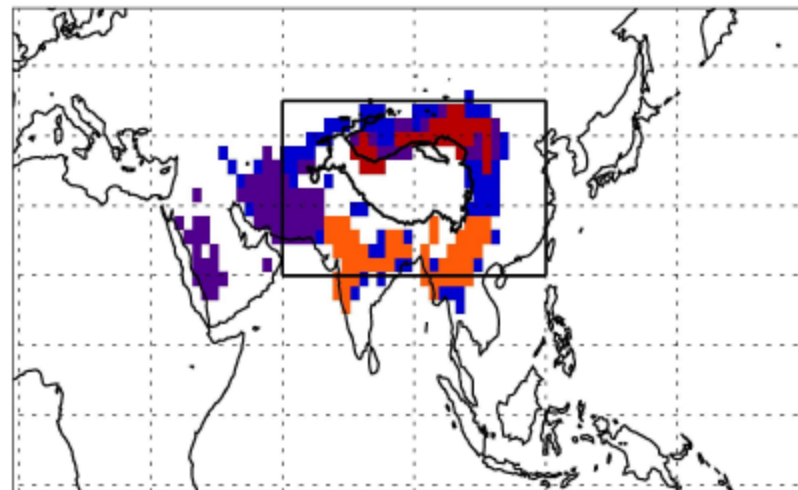
Air masses origin: back trajectories analysis for the Spring Seasons 2007-2010

500 hPa



PBL	23.1 %
Deserts	13.3 %
Gobi and Taklamakan	2.1 %
South East Asia	5.7 %

700 hPa

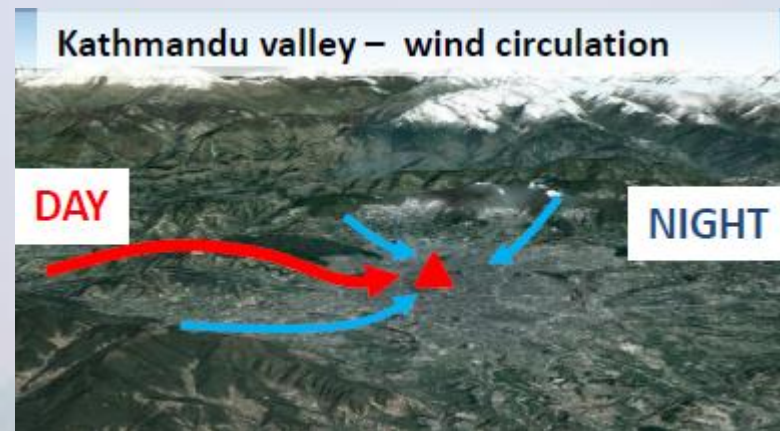
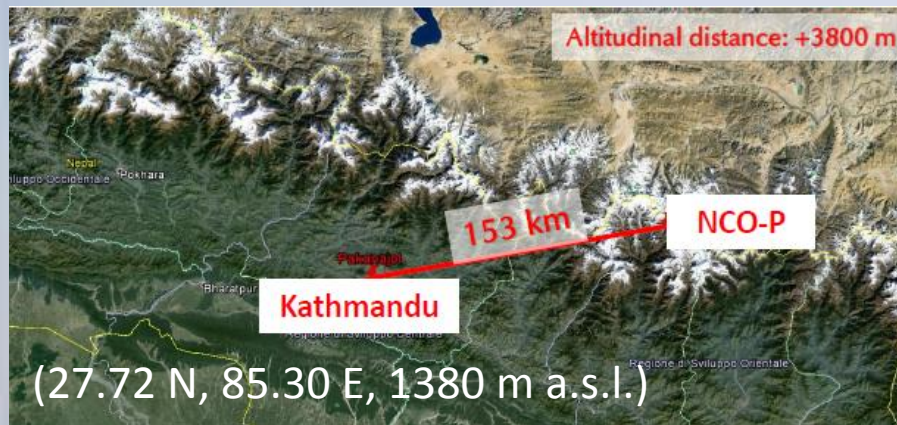


PBL	55.9 %
Deserts	23.7 %
Gobi and Taklamakan	8.3 %
South East Asia	18.1 %

The values above represents the percentages of Back-trajectories that, starting from a regular grid over the area highlighted by the black rectangle, cross respectively:

- the PBL
- the PBL over a desert
- the PBL over a local desert
- the PBL over the South East Asia region.

Suskat ABC – Station (Kathmandu, Nepal)



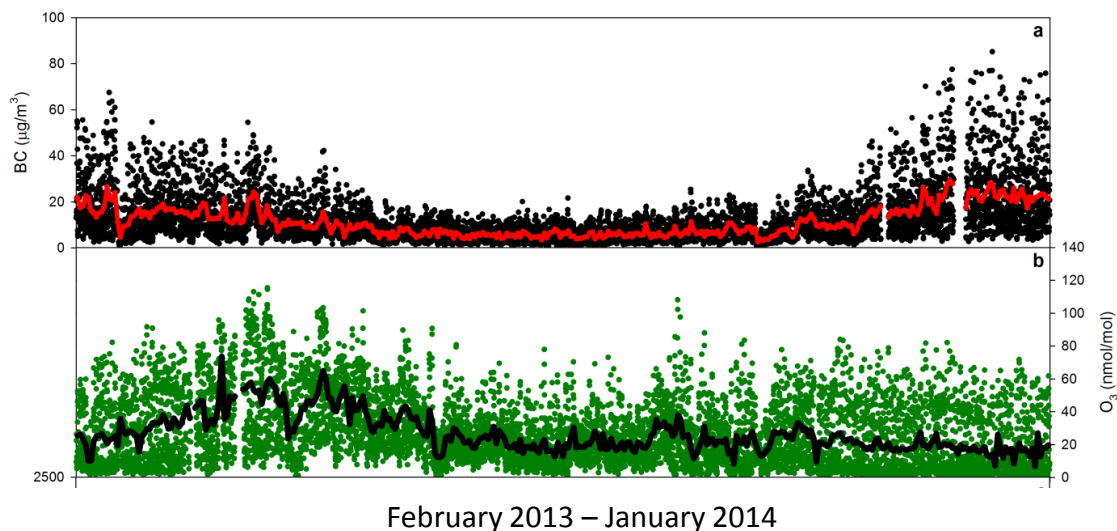
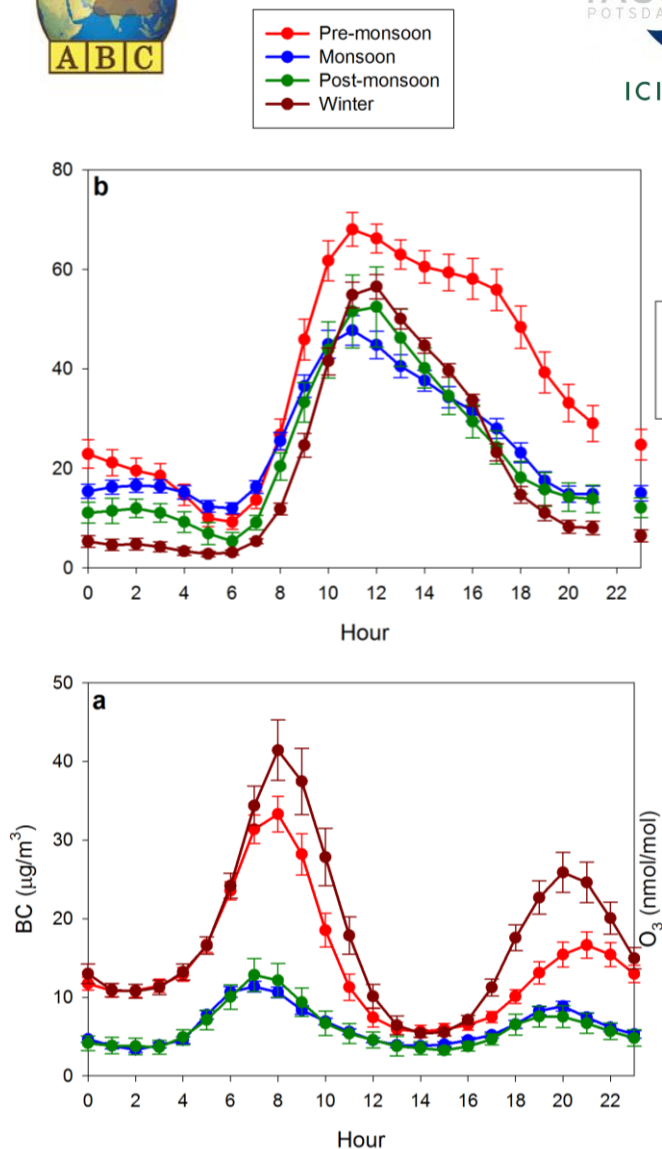
- Aerosol number concentration and size distribution (OPC, CPC)
- Black carbon equivalent concentration (MAAP)
- Aerosol absorption coefficient @ 635 nm (MAAP)
- On-line (24 h resolution) PM₁₀-PM₁ (β -absorption)
- Surface ozone (UV-absorption)
- Global solar irradiance (SW)
- Meteo parameters (Vaisala)

Suskat (A Sustainable Atmosphere for the Kathmandu Valley)



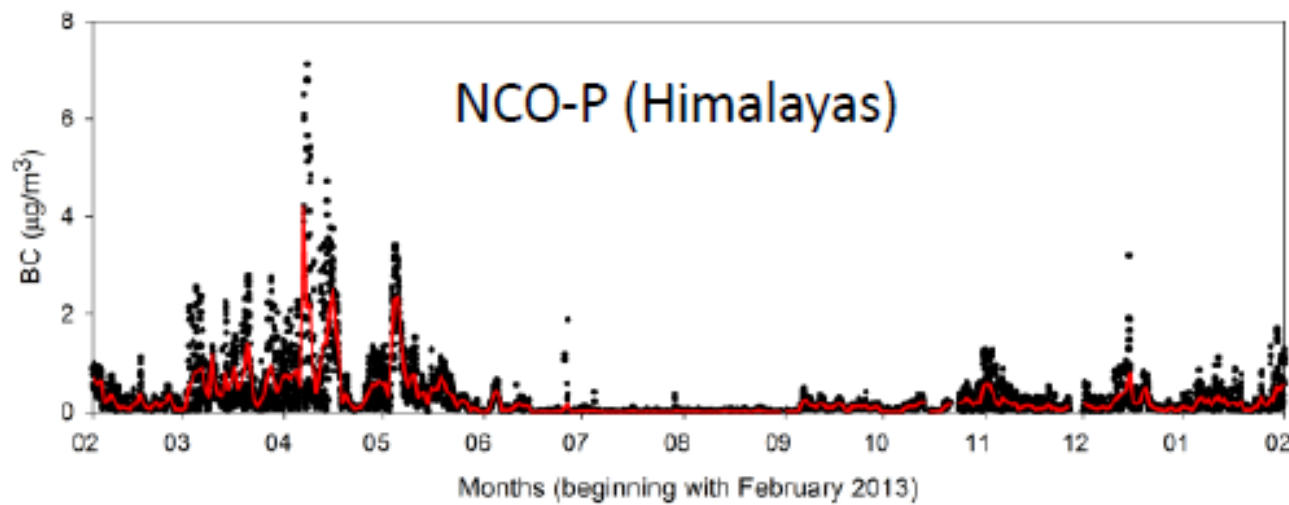
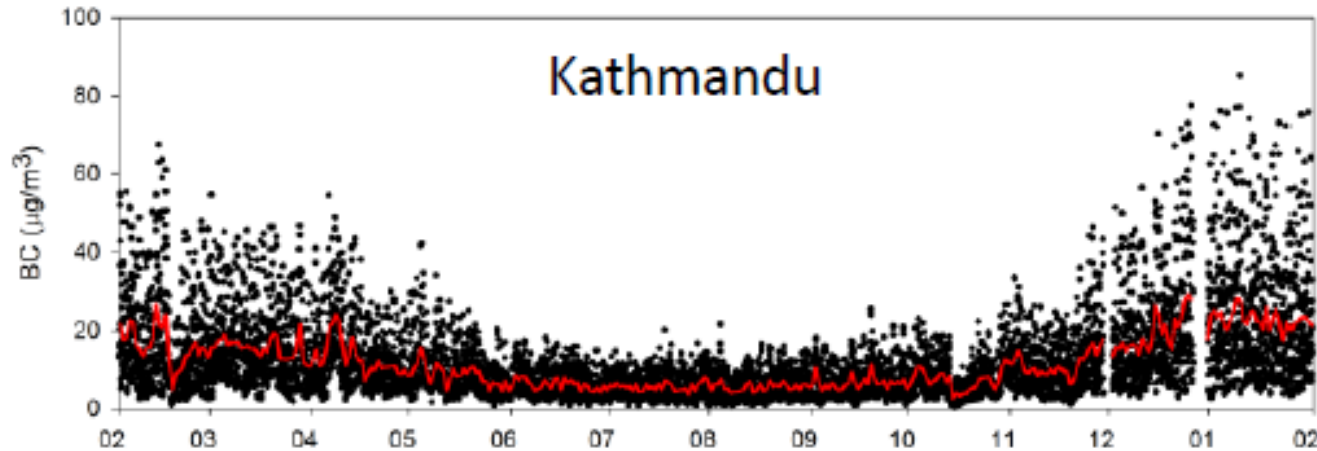
At present, the limited knowledge of emissions, transport, and removal of pollutants gained from previous studies hinders the quantification of air pollution impacts in the Kathmandu Valley and the broader region

SusKat is aimed at identifying the different contributions of several main sources of air pollutants in the Kathmandu valley, in order to design effective mitigation measures.



Differenti
prospettive del
fenomeno ABC

Emissioni locali >>
trasporto



Trasporto >>
Emissioni locali

Hourly (black) and daily (red) BC mean values

Trasmissione dei dati al Portale Generale

MONTE CIMONE

- Meteorology
- O₃ mixing ratio
- CO mixing ratio (NDIR)
- CO mixing ratio (GC-RGD and GC-FID)
- CH₄ mixing ratio (GC-FID):
- N₂O, SF₆ mixing ratio (GC-ECD):
- NO and NO₂ mixing ratio
(Chemiluminescence with Mo converter):
- Solar radiation (350 – 1100 nm and 280 – 315 nm)
- Size distribution of atmospheric aerosol in the 10 – 500 nm range
- Size distribution of atmospheric aerosol in the 300 – 20000 nm range
- Aerosol scattering coefficient at 525 nm:
- Aerosol number concentration
- Aerosol absorption coefficient at 635 nm
- Aerosol chemistry

NCOP

- Meteorology
- O₃ mixing ratio
- Greenhouse Gases mixing ratio (halogenated)
- Size distribution of atmospheric aerosol in the 10 – 800 nm range
- Size distribution of atmospheric aerosol in the 300 – 32000 nm range
- Aerosol scattering coefficient at 450, 525 and 700 nm
- Aerosol absorption coefficient at 635 nm
- Wet precipitation chemistry: Aerosol chemistry
- Solar irradiance (at 200 - 3600 nm)
- IR irradiance (at 3.5 μm to 50 \302\265m)

PLATEAU ROSA (RSE SpA)

- O₃ mixing ratio
- CH₄ mixing ratio
- CO₂ mixing ratio

Pubblicazioni

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- Cristofanelli, P, Putero, D, Adhikary, B, Landi, T, Marinoni, A, Duchi, R, Calzolari, F, Laj, P, Stocchi, P, Verza, G, Vuillermoz, E, Kang, S, Ming, J, and Bonasoni, P: Transport of short-lived climate forcers/pollutants (SLCF/P) to Himalaya during the South Asian Summer Monsoon onset, Submitted Paper to Environmental Research Letters (accepted).
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Prossime attività

- Mantenimento ed implementazione delle stazioni di misura (GAW, “SHARE”)
- Inserimento delle serie di dati validati nei data base di riferimento (GAW-WDCGG, GAW-WDCA, GAW-WDCPC, ABC) e nel data-base NextData
- Studio della variabilità su lungo termine dell’ozono nel Bacino del Mediterraneo (integrazione della serie di Monte Cimone con altri data-set): influenza dalla variabilità climatica
- Studio della variabilità interannuale dell’ozono in Himalaya (NCO-P) ed influenza dei processi STE (integrazione con data-set sul Plateau Tibetano).
- Analisi della variabilità di SLCF/SLCP presso l’altopiano del Deosai (Pakistan – Karakorum)
- Studio combinato della variabilità di ozono e black carbon in Himalaya attraverso le osservazioni NCO-P e Suskat
- Studio dell’impatto sulla salute della popolazione della variabilità dell’ozono in Himalaya
- Analisi dei trend di precipitazione, temperatura e di variabilità del monsone estivo in Himalaya attraverso lo studio delle reti di stazioni AWS – SHARE in Nepal

Grazie!

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Parco del Frignano
Ente di gestione per i parchi e la
biodiversità Emilia Centrale

arpa
agenzia
regionale
previsione e
controllo dell'ambiente

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

Servizio Meteorologico Aeronautica Militare

GLOBAL ATMOSPHERE WATCH

Monte Cimone

Il Sentiero della Atmosfera

2004
2014 *4 passi nel clima che cambia*

7 Giugno ore 10.00 Rocca di Sestola (Mo)
10 anni del Sentiero dell'Atmosfera
ricerca scientifica, didattica e turismo
ore 16.30 Piazza della Vittoria
Il Clima in una Piazza
esperimenti e laboratori per scoprire qualche cosa di più sul clima
ore 21.00 Cinema Belvedere
L'Alta Via dei Parchi: viaggio a piedi in Emilia Romagna
film documentario, un trekking nell'Appennino settentrionale e nel Parco del Frignano

8 Giugno ore 10.30 Pian Cavallaro
Escursione sul Sentiero dell'Atmosfera del Monte Cimone
percorrendo l'itinerario didattico-ambientale che conduce all'Osservatorio Meteo della Aeronautica Militare ed all'Osservatorio Climatico 'Vittori' del Consiglio Nazionale delle Ricerche
ore 15.15 Monte Cimone
Concerto per il Clima: Sofiya Shapiro, violoncello

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