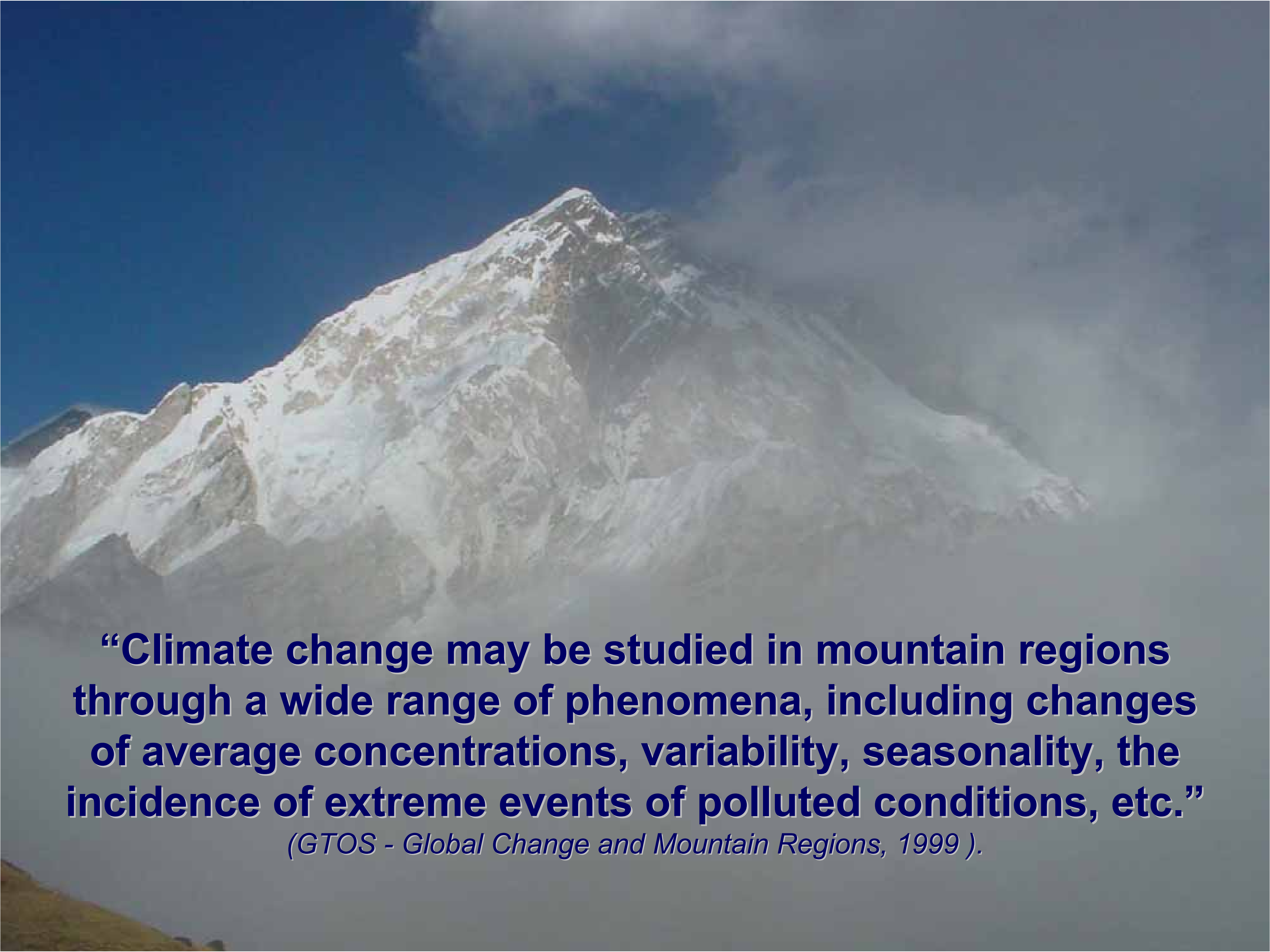
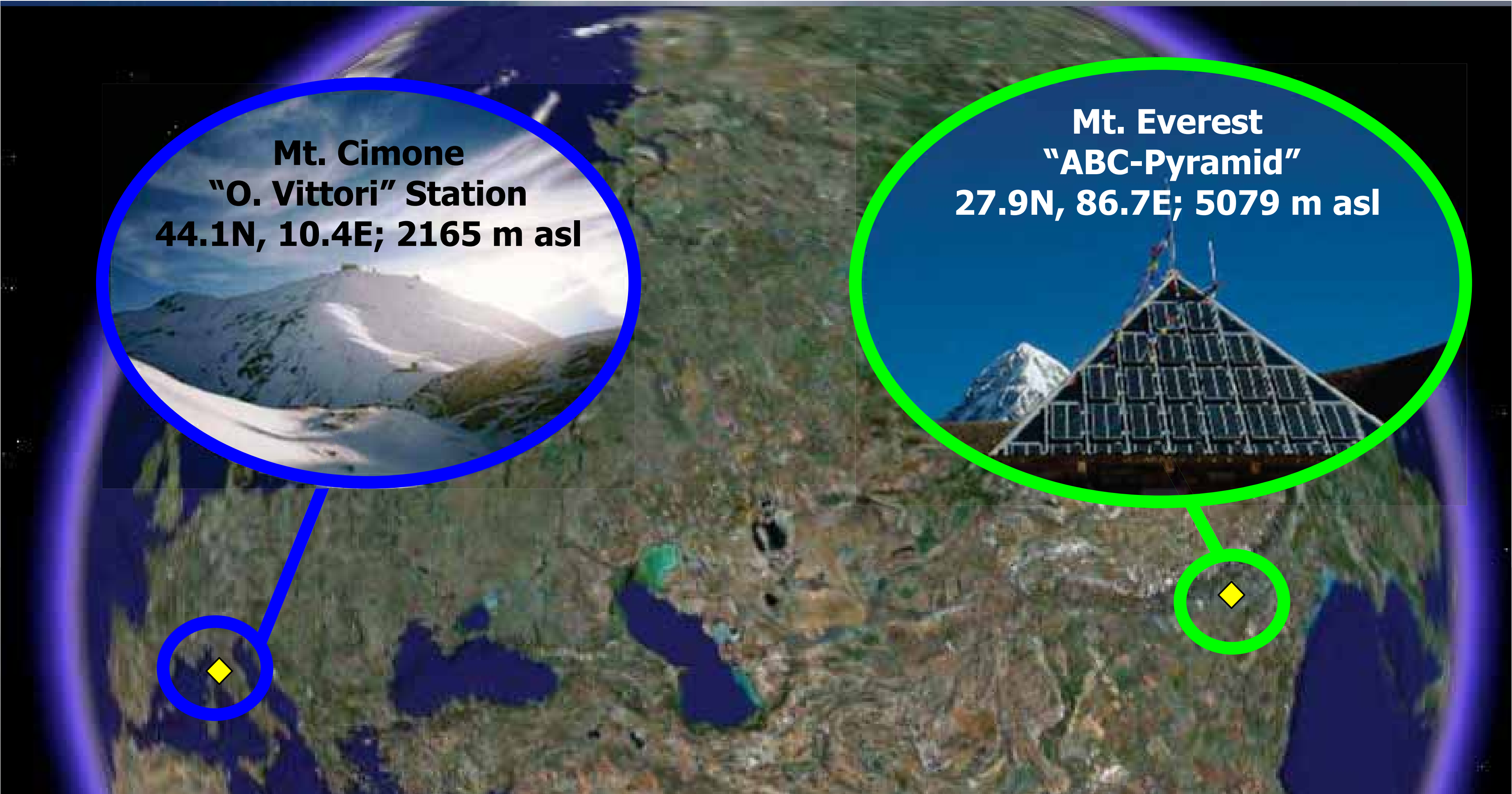
High Mountain Observatories for monitoring gases and aerosol properties in Himalaya and Apennine regions

Paolo Bonasoni

National Research Council
Institute for Atmospheric Sciences and Climate
Bologna - Italy
and
EV-K²-CNR
Bergamo - Italy

BEOBAL 2007


“Climate change may be studied in mountain regions through a wide range of phenomena, including changes of average concentrations, variability, seasonality, the incidence of extreme events of polluted conditions, etc.”
(GTOS - Global Change and Mountain Regions, 1999).

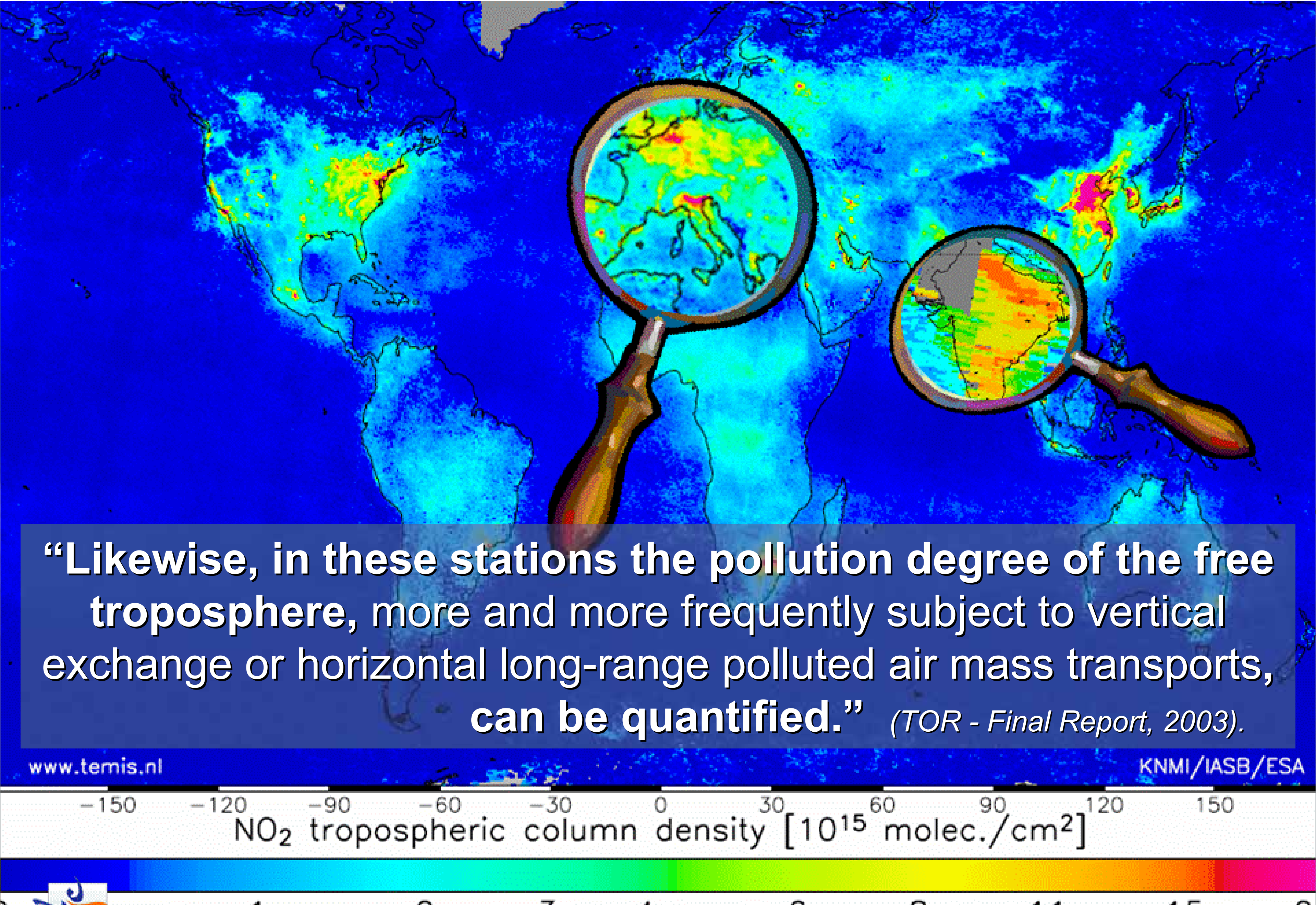


High Mountain Observatories are sites where atmospheric background conditions and environmental change processes can be studied thanks to continuous monitoring activities that constitute also an important aid to understand global change processes.

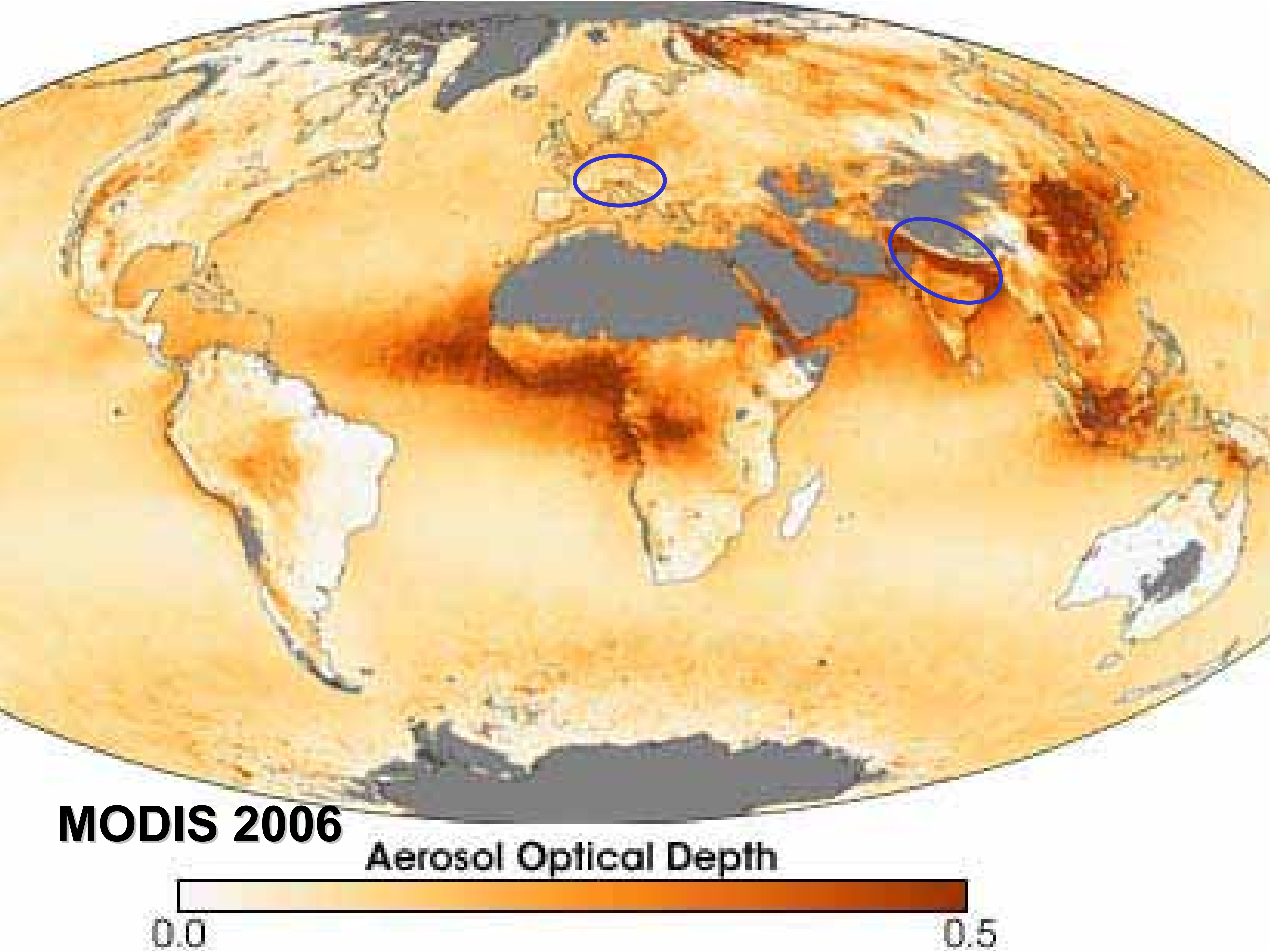
WHY
High Mountain Observatories ?

The HMO are above the atmospheric boundary layer
for most of the year
and can be considered representative of continental
free troposphere.

- **What is the role of atmospheric physical and chemical processes in amplifying or damping climate change?**
- **What effect do *regional emissions, long-range transports, stratosphere-troposphere exchanges and chemical transformations* have on the composition of the atmosphere?**



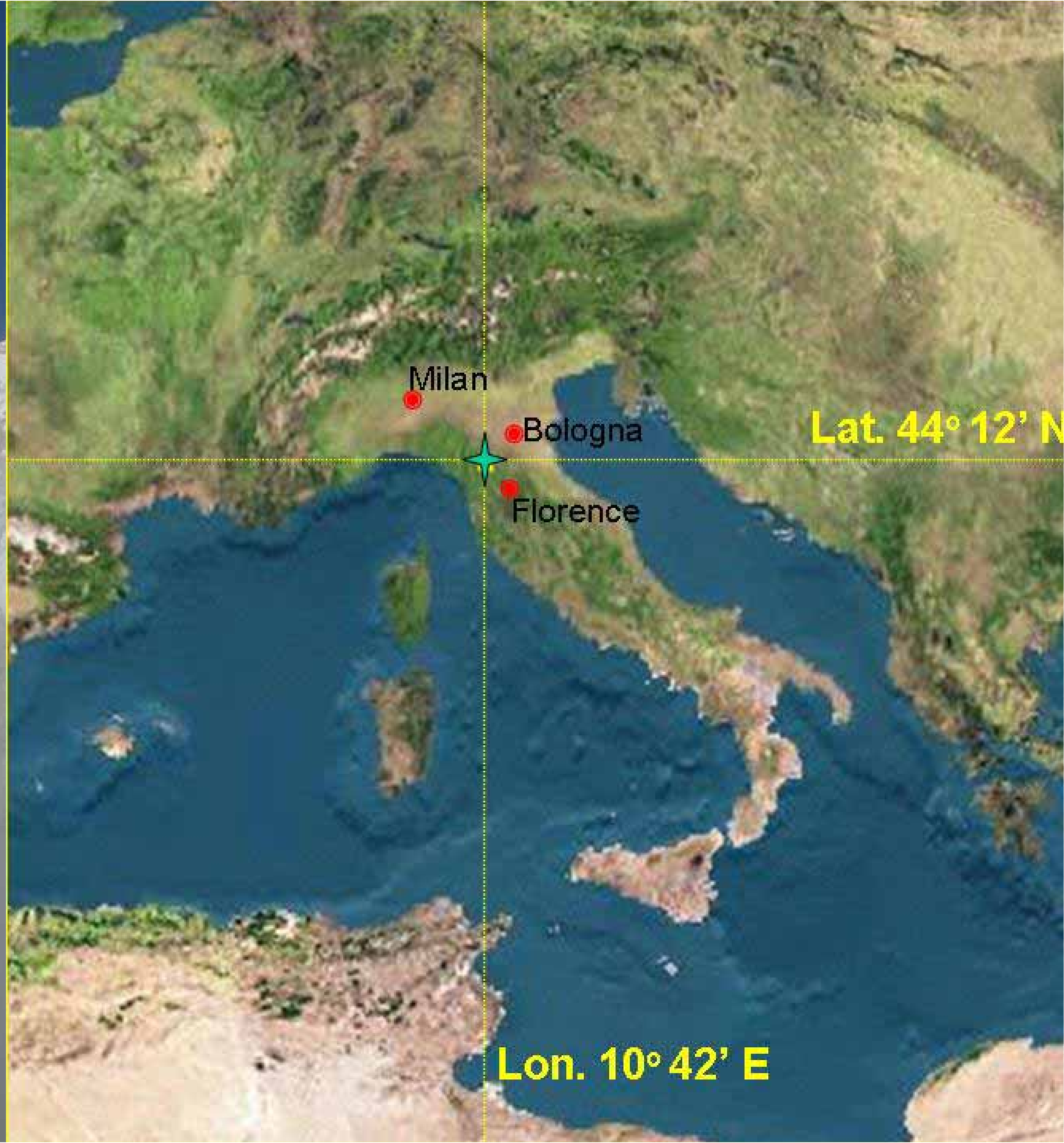
"Likewise, in these stations the pollution degree of the free troposphere, more and more frequently subject to vertical exchange or horizontal long-range polluted air mass transports, **can be quantified."** *(TOR - Final Report, 2003).*


MODIS 2006
Aerosol Optical Depth
0.0
0.5

Mt. Cimone (44°12' N, 10°42' E, **2165 m** asl) 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 major towns, Bologna and Florence (500000 inhabitants) are situated in the lowlands about 60 km away.

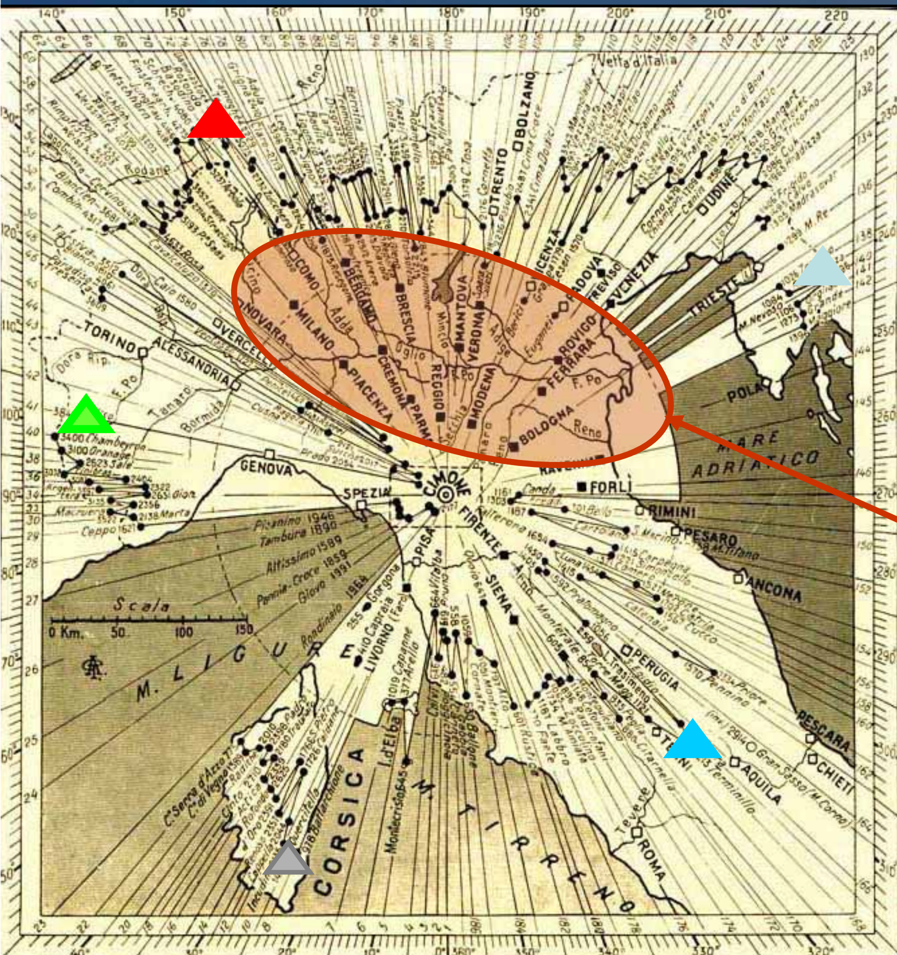
Industrial area are not closer than 40 km and 2 km lower



The Mt. Cimone GAW Station is a high mountain research station operating for measurement activities to study the physical and chemical aspects of the atmospheric environment.

The station is characterised by a completely free horizon for the whole 360° interval

In <u>very clear sky</u> conditions,
it is possible to see:



Thanks to its geographical position in South Europe and North Mediterranean, different aspects of the atmosphere can be studied at Mt. Cimone.

The Mt. Cimone activities are performed in two buildings:

1998, July 15:
the CNR Station was named to ***Ottavio Vittori*** one of the first Italian atmospheric scientists, the first Director of CNR FISBAT Institute in Bologna.

- *Observatory of the **Italian Air Force Meteorological Service***
- *"O. Vittori" Station of the **Italian National Research Council.***

The "*Ottavio Vittori*" CNR Station building

- two gas-sampling laboratories
- an aerosol HVS/LVS sampling laboratory
- a chemical/aerosol sampling laboratory
- a computer room with local network and satellite connection
- a meteorological station
- a terrace equipped for experimental activities

RegioneEmilia-Romagna

- ***1 small kitchen***
- ***2 bedrooms** for 6 people*
- ***2 bathrooms***

Measurements carried out at Mt. Cimone

O_3 and **CO** ***CNR and UniUrb***

CO_2 by ***Italian Air Force Meteorological Service***

Halocarbons: CFC-11 ,CFC-12, CFC-113, CFC-114, CFC-115, H-1211, H-1301, HCFC-22, HCFC-141b, HCFC-142b, HCFC-124, HFC-125, HCFC-152a, HFC-134a, HFC-143a, C_2F_6, SF_6, CH_3Cl, CH_3Br, $CHCl_3$, CH_2Cl_2
collaboration : ***Urbino University - CNR***

^{7}Be, ^{210}Pb, ^{222}Rn *collaboration:* ***Bologna University - CNR***

Aerosol: size distribution (OPC; DMPS)

black carbon, Nephelometer ***CNR***

PM10 collab. ***JRC Ispra - Bologna Univ.- CNR***

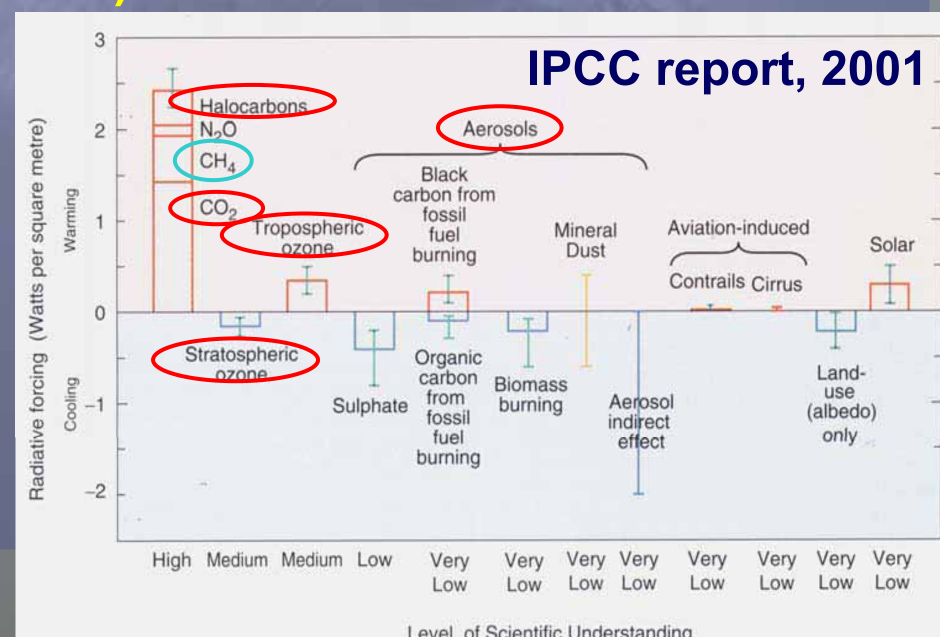
NO_2 *and* **O_3 total column** (DOAS) ***CNR***

Solar radiation ***CNR***

Bioaerosol (pollen and spore) ***CNR***

Meteorological parameters ***CNR***

and ***Italian Air Force Meteorological Service***

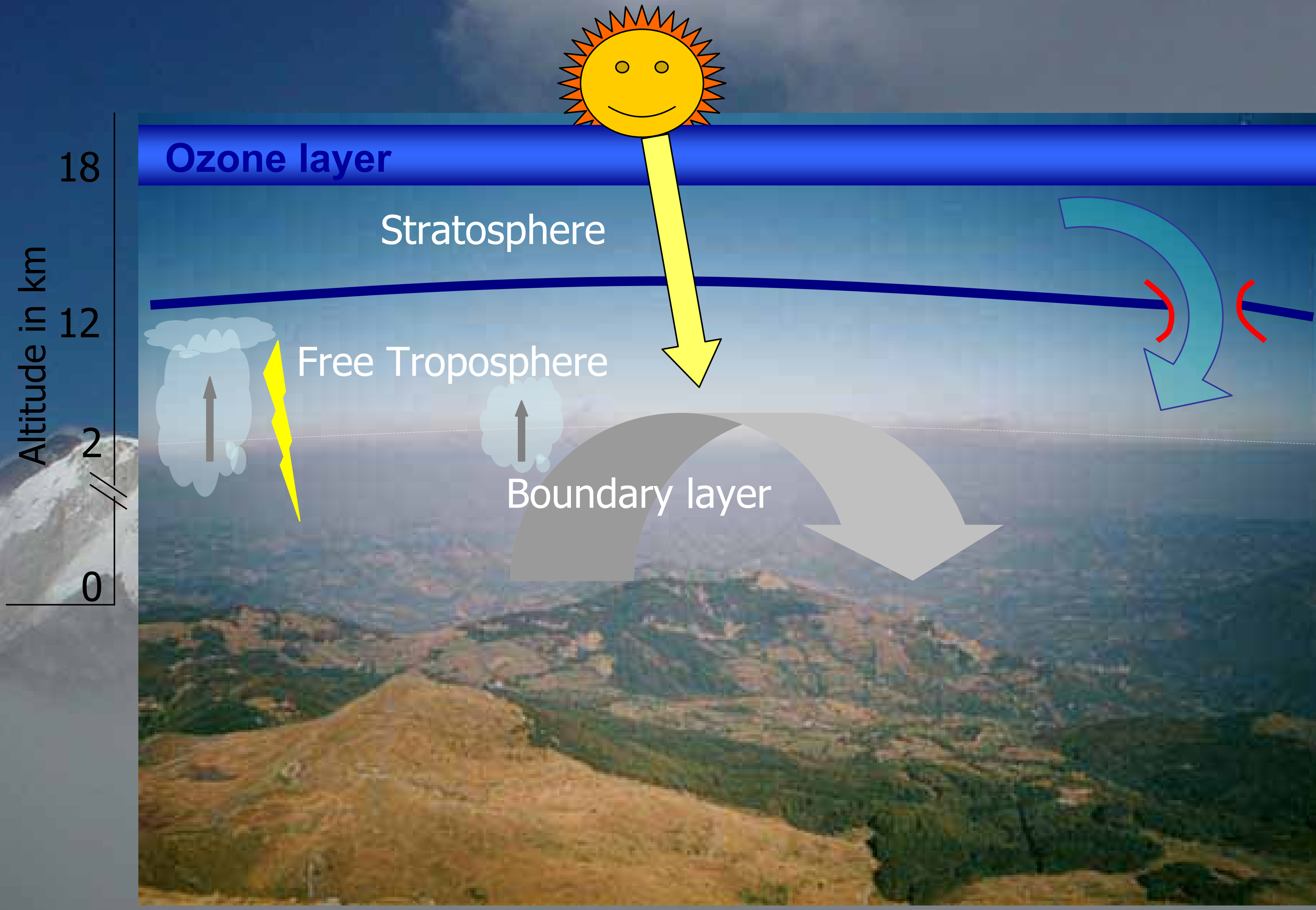


European atmospheric background conditions

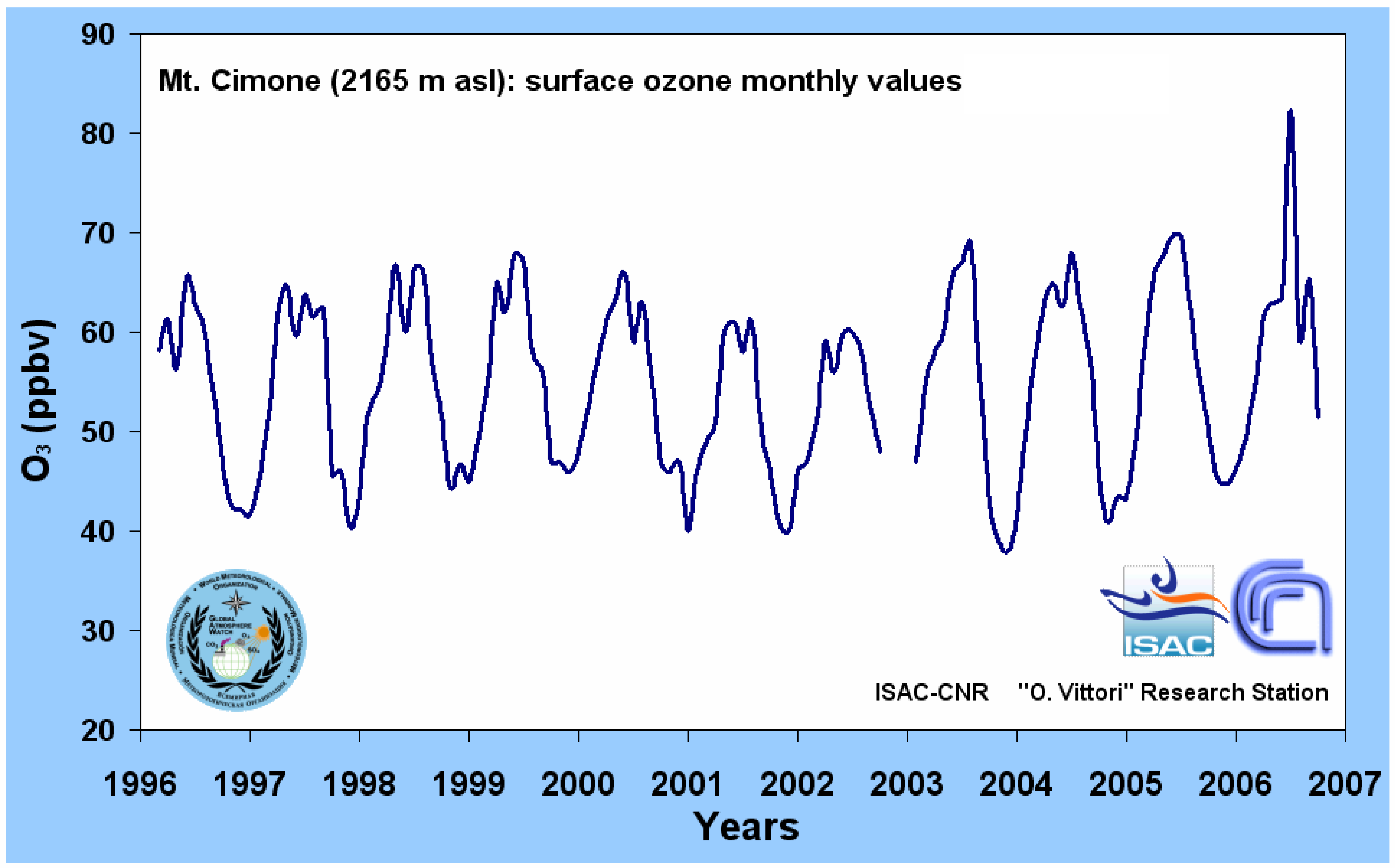
Comparison of trace levels (upslope/ downslope conditions) observed at Mt. Cimone (*MINATROC 2000, H. Fischer, MPI-Mainz*) with spring-summer observations at other remote mountain sites in Europe and the US.

	Mt. Cimone	*Mauna Loa* [1]	*Izana* [2]	*Jungfraujoch* [3]	*Idaho Hill* [4]
Lat./Long.	44.18°N / 10.7° E	19.38°N/155.36°W	28.18°N / 16.3°W	46.33°N / 7.59°W	39.5°N / 105.37°W
Altitude [m]	2165	3400	2370	3580	3070
Season	June 2000	July/Aug. 1992	July/August 1994	March/April 1998	Aug./Sept. 1993
O_3 [ppbv]	56 / 60	33.8 / 35.6	38 / 40	57.8 / 59.8	51
CO [ppbv]	119 / 118	64 / 66	92 / 89	193 / 184	92
NOx [pptv]	267 / 197	50 / 26	76 / 47	297 / 59	2221 / 393
NOy [pptv]	897 / 1027	223 / 188	519 / 392	956 / 625	4315 / 1340
HCHO [ppbv]	1.4 / 1.1	0.3 / 0.15	1.4 / 1.1	n.a.	1.4 / 0.9

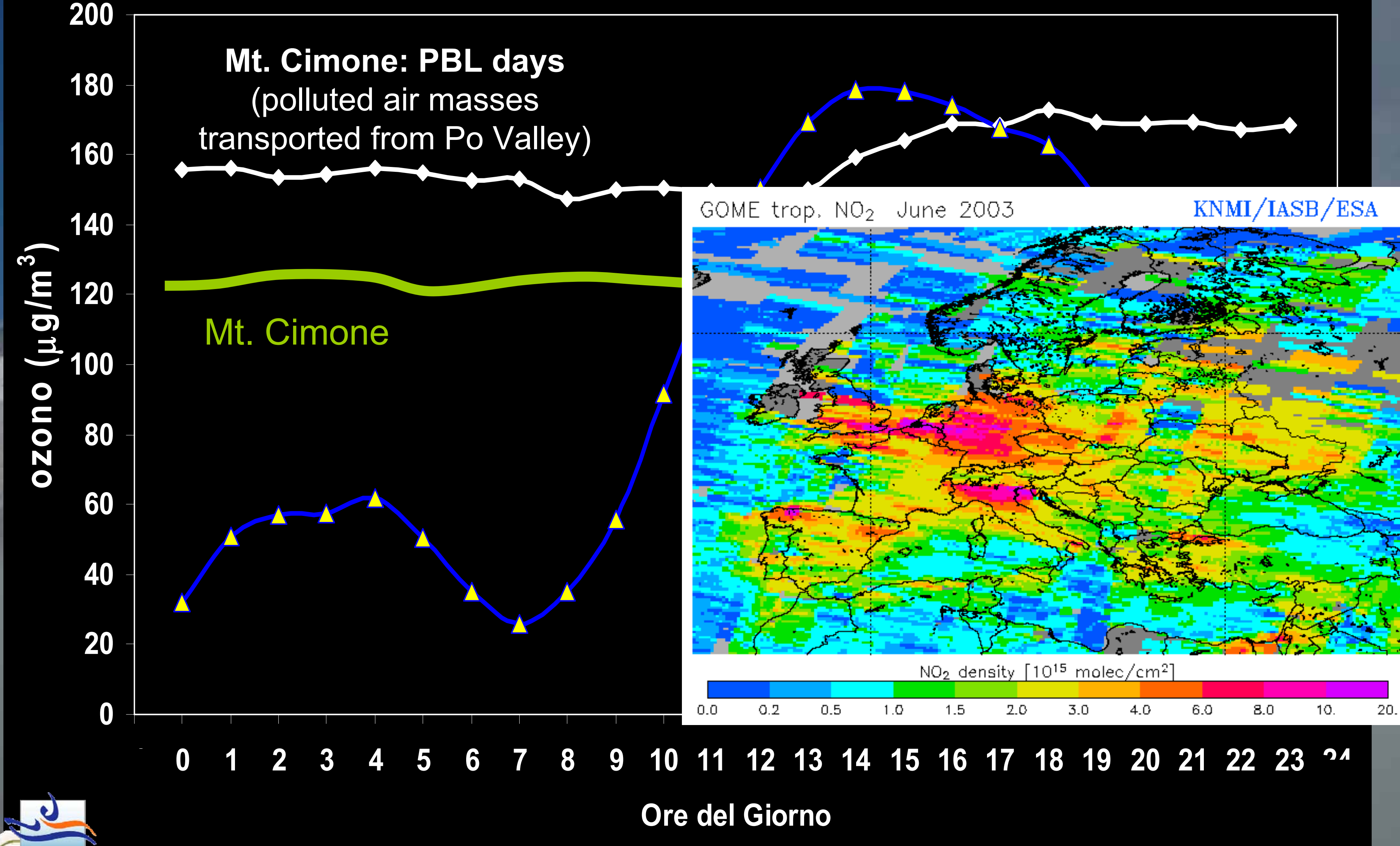
[1][Atlas and Ridley, 1996] [2][Fischer et al., 1998] [3][Zanis et al., 2000] [4][Centrell et al., 1997; Harder et al., 1997; Williams et al., 1997]



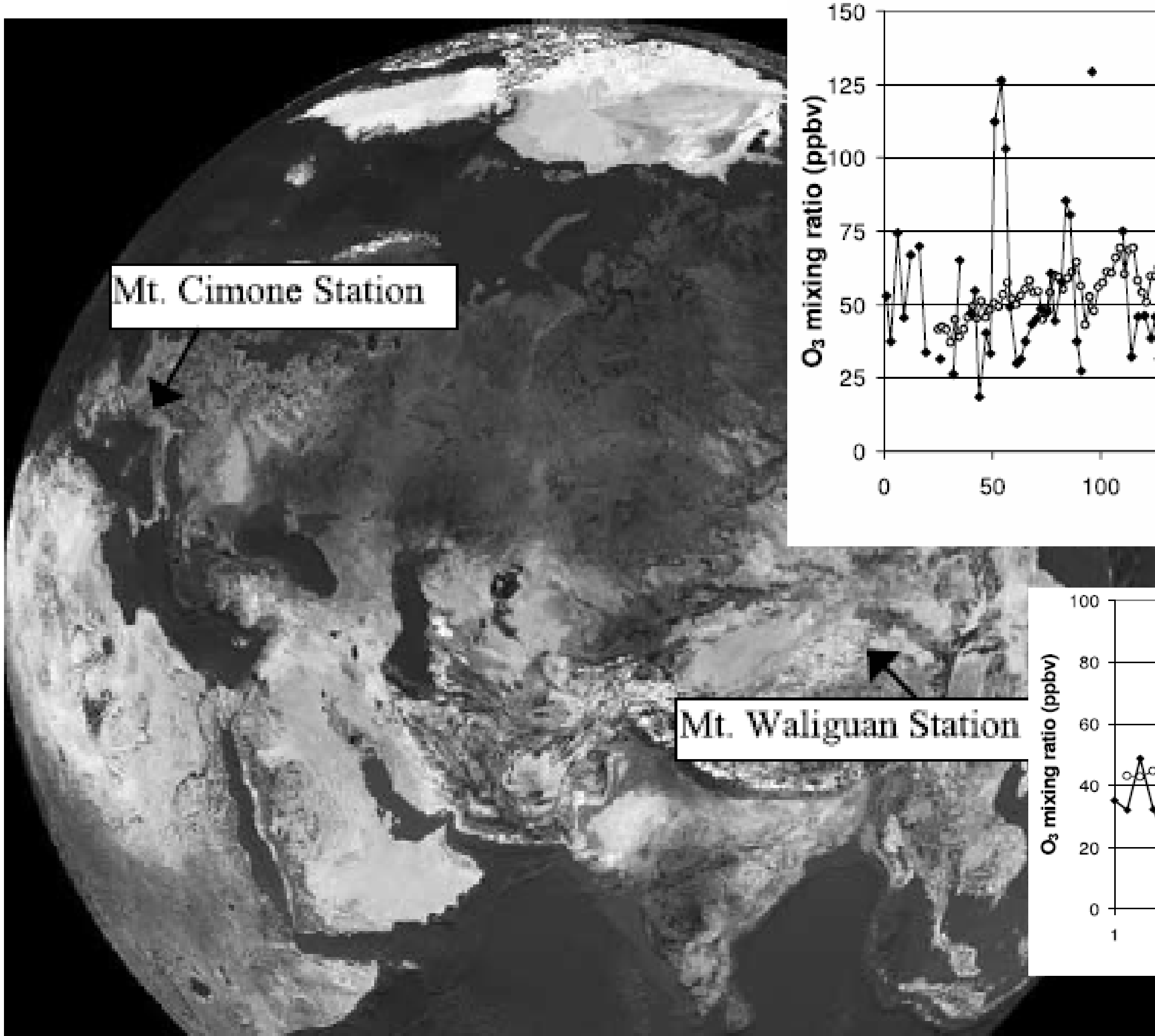
Summer view of the Po Valley from Mt. Cimone

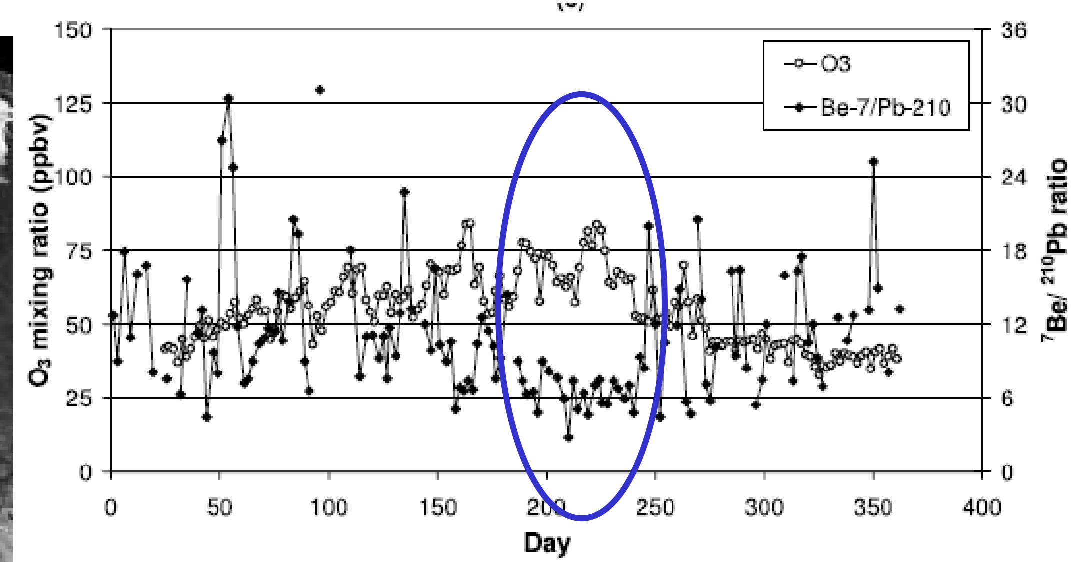

Mt. Cimone (2165 m asl): surface ozone monthly values
O_3 (ppbv)
90
80
70
60
50
40
30
20
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
Years
ISAC
ISAC-CNR
"O. Vittori" Research Station

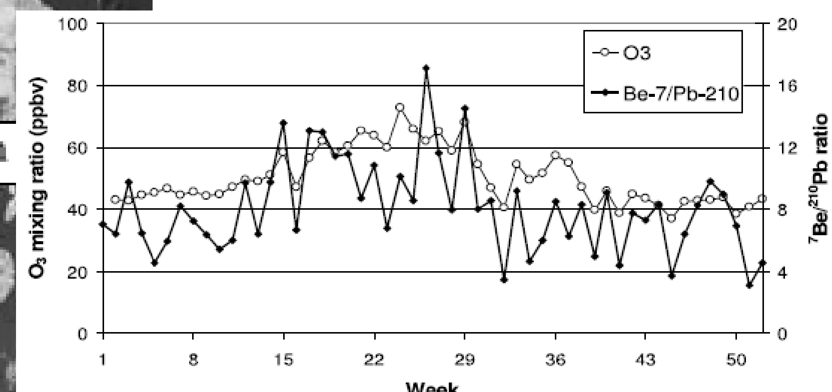
June 2003 - Ozone Concentrations Mt. Cimone - Modena



Mt. Cimone & Mt. Waliguam Stations 2003
Surface Ozone and behaviour Be7/Pb210







Analyses and comparisons of variations of ^{7}Be, ^{210}Pb, and ^{7}Be/^{210}Pb with ozone observations at two Global Atmosphere Watch stations from high mountains

H. N. Lee,[1] L. Tositti,[2] X. Zheng,[3] and P. Bonasoni[4]

JOURNAL OF GEOPHYSICAL RESEARCH, VOL. 112, D05303, doi:10.1029/2006JD007421, 2007

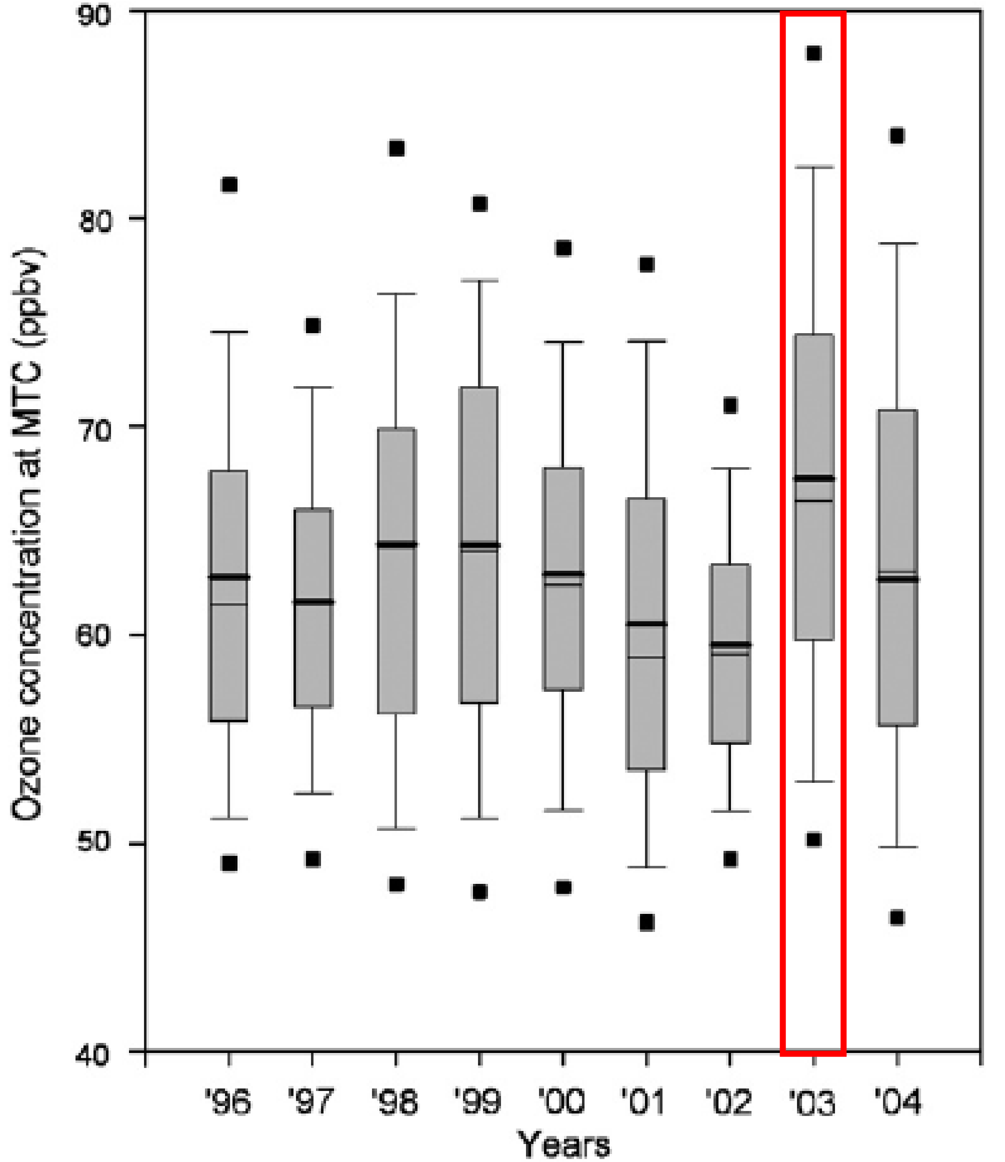


Fig. 1. Box-and-whiskers analysis of hourly O_3 concentrations for summers 1996–2004 at MTC. The box and whiskers denote the 10th, 25th, 50th, 75th and 90th percentiles, the outliers the 5th and 95th percentiles and the bold lines the mean values of summer O_3 concentrations.

MTC O3 concentrations

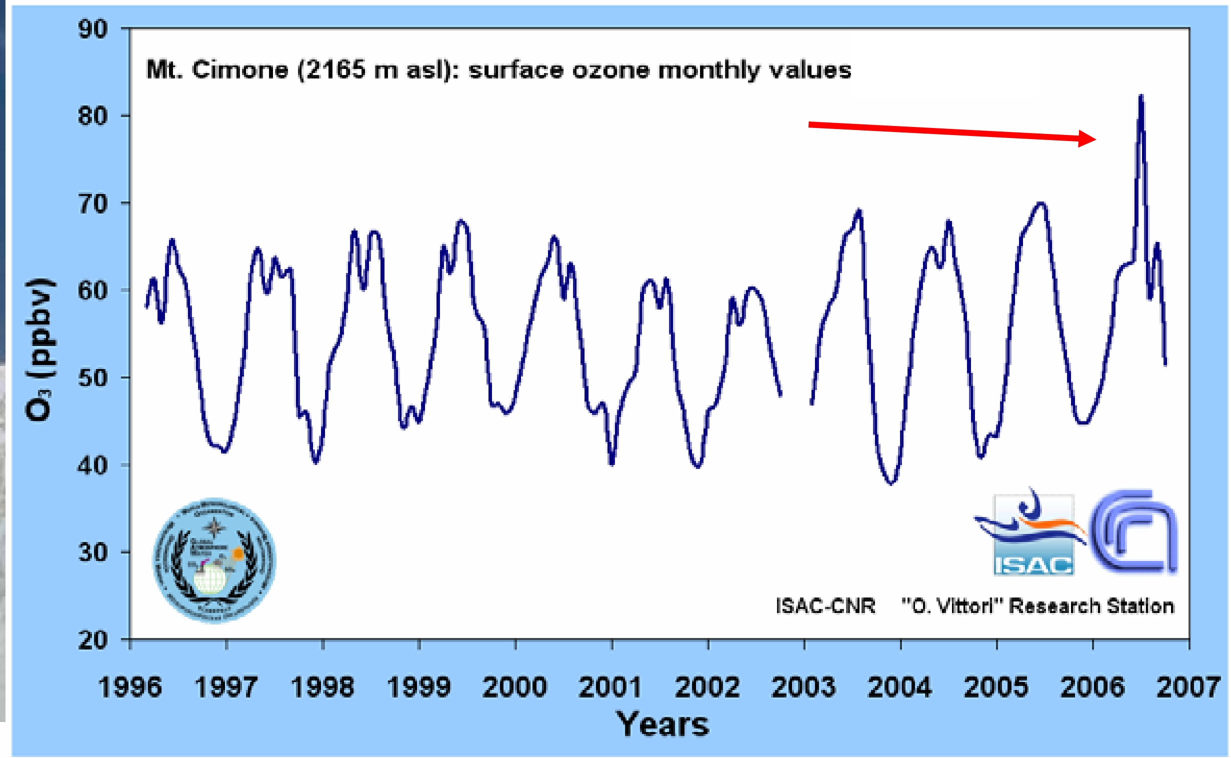
Summer 1996 – 2004

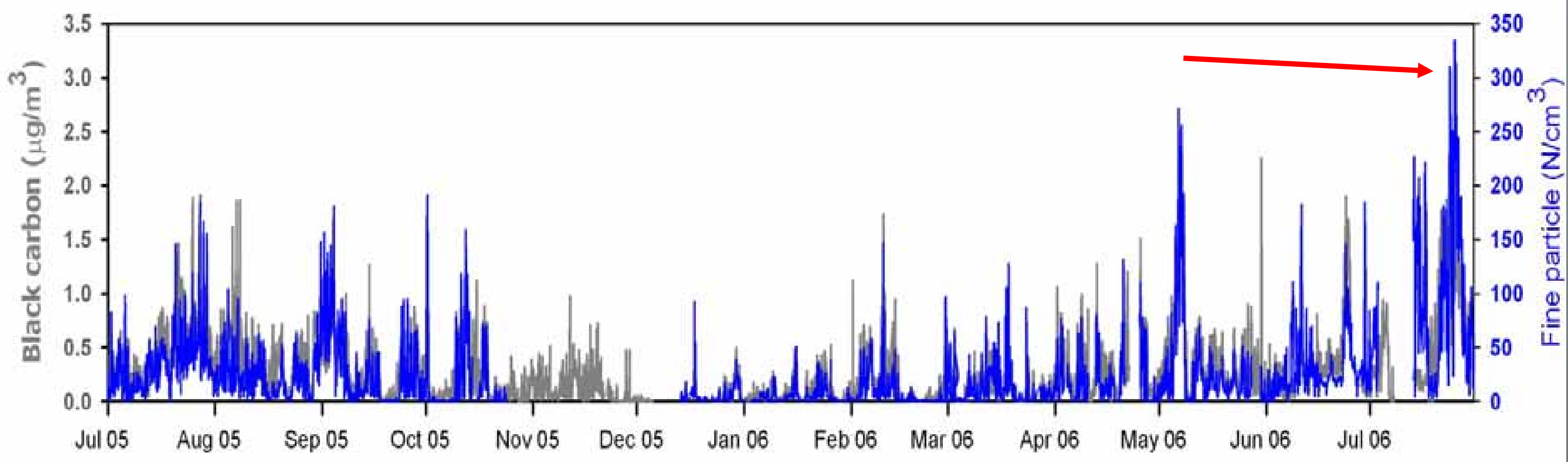
Anomalous high O3 concentrations recorded at a high mountain station in Italy in summer 2003

P. Cristofanelli et al.

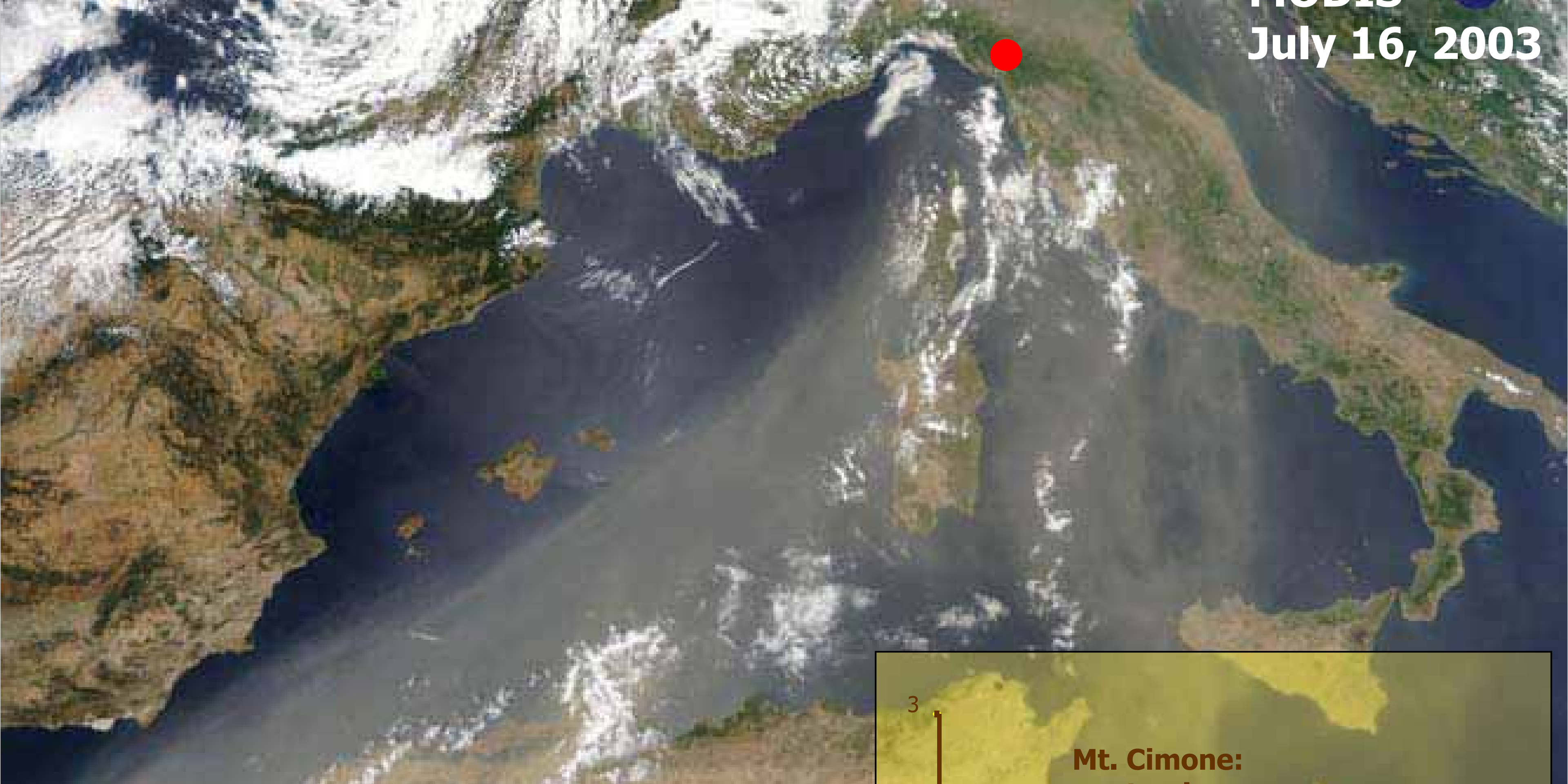
Atmos. Env. 41 (2007) 1383–1394

Po Basin PBL as viewed by Mt. Cimone camera



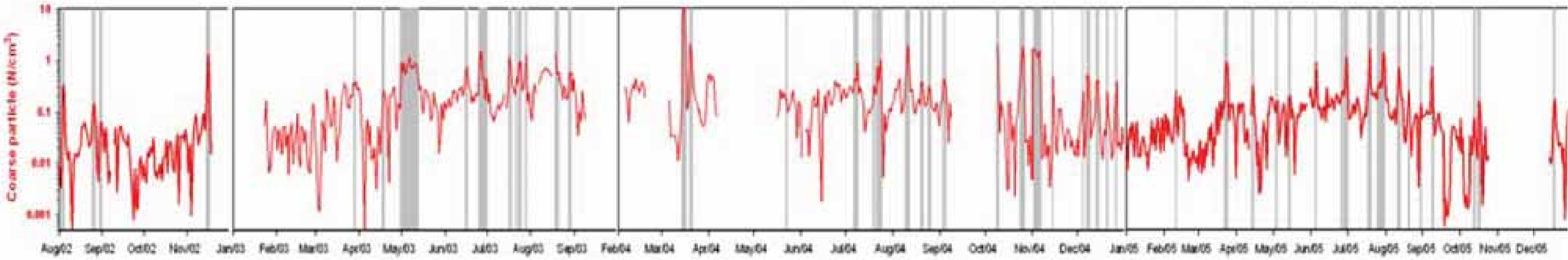


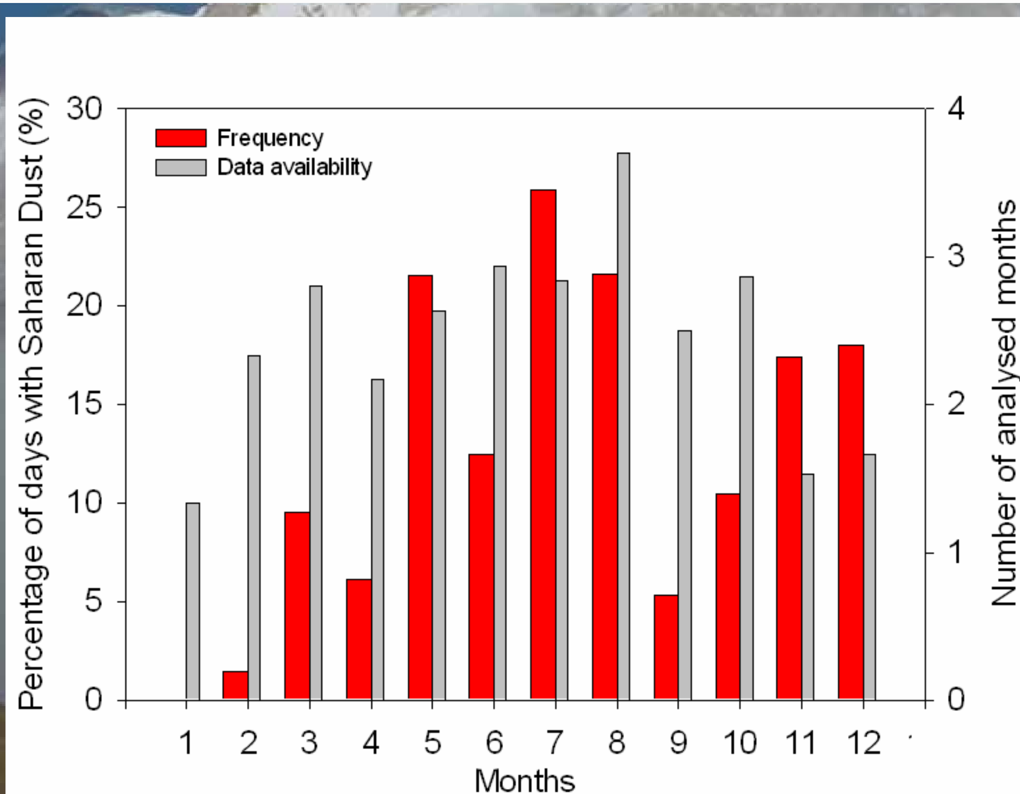
SAHARAN dust transports



Given its location in the Mediterranean region, Mt. Cimone is particularly suitable to study the transport of tropospheric air masses coming from the North Africa desert area.

Climatology of Saharan dust events from August 2002 to December 2005

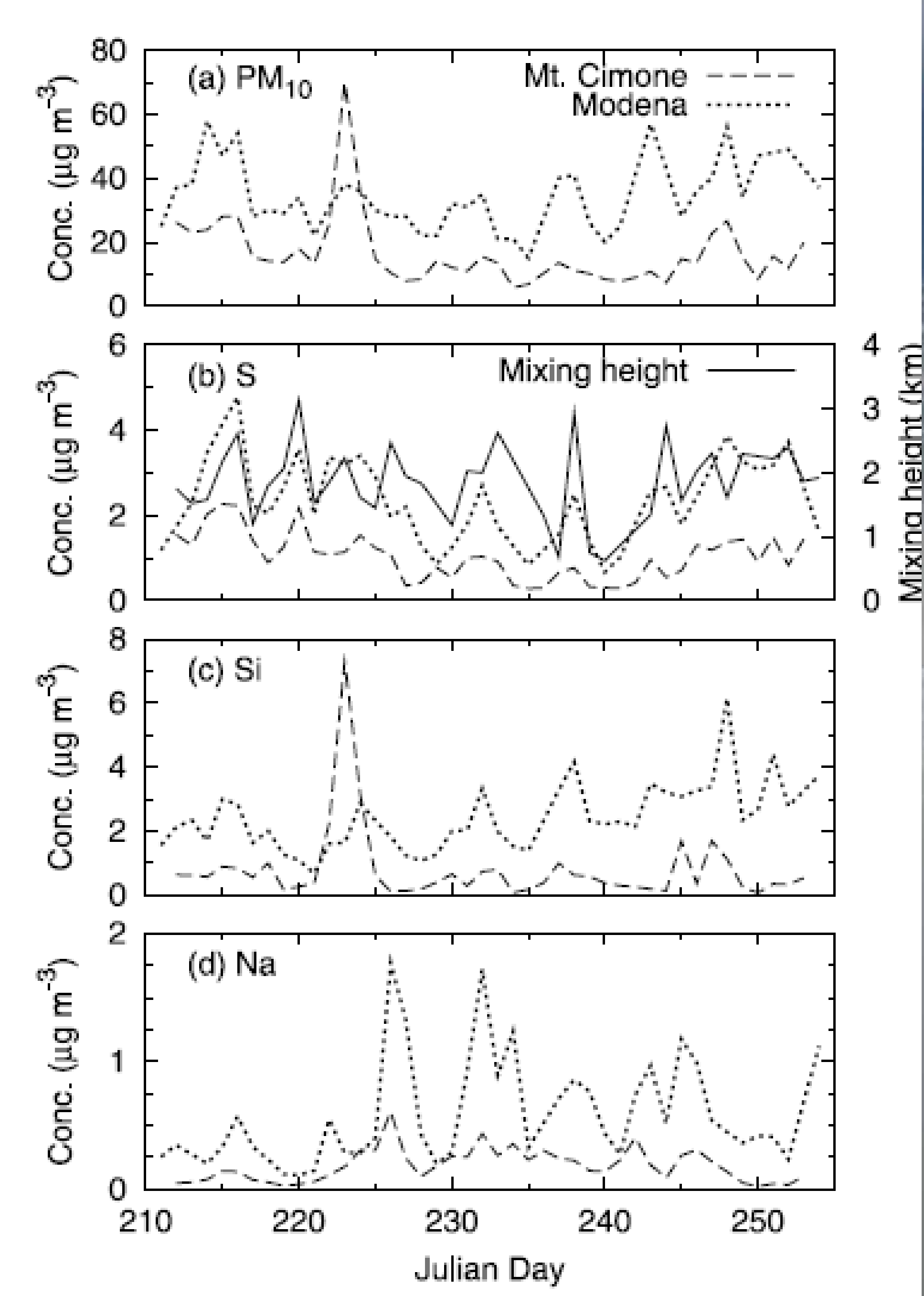




The percentage of day per month that Saharan dust was detected showed **2 main periods with high “dust activity”**:

from **May to August** and from **October to December**.

Saharan dust episodes: elemental concentrations



Concentrations of
(a) PM10,
(b) (b) S in PM10,
(c) Si in PM10, and
(d) Na
in PM10
at Mt Cimone (dashed lines)
and
in Modena (dotted lines).

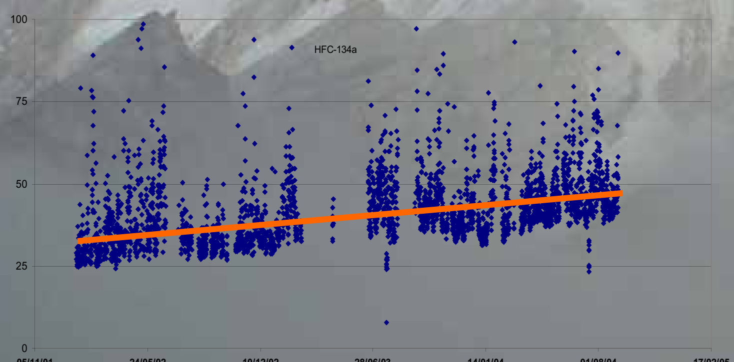
In Figure (b) the mixing height at San Pietro Capofiume (altitude above mean sea level) is also displayed (solid line).

"Characterization of atmospheric aerosols at Monte Cimone, Italy, during summer 2004: Source apportionment and transport mechanisms"

F. Marenco et al.
JOURNAL OF GEOPHYSICAL RESEARCH, VOL. 111, D24202, doi:10.1029/2006JD007145, 2006

SOGE

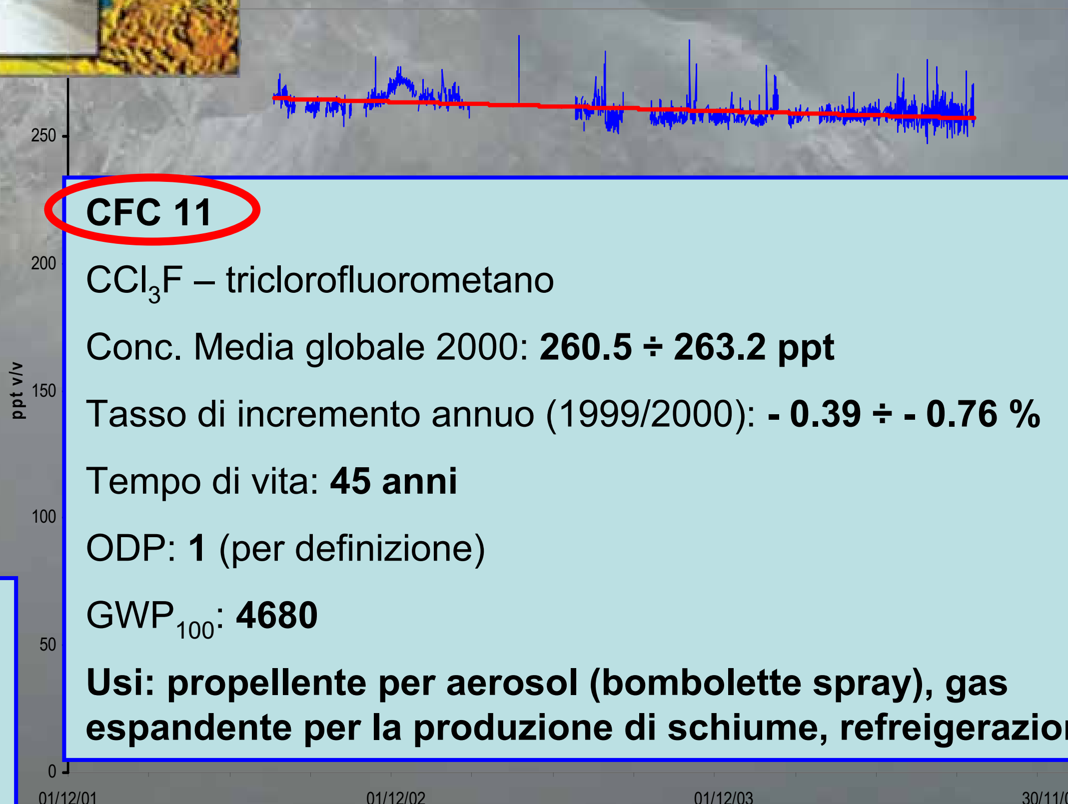
SYSTEM FOR OBSERVATION OF HALOGENATED GREENHOUSE GASES IN EUROPE



HFC 134a

CH_2FCF_3 1,2,2,2 tetrafluorometano

Usi: impianti di refrigerazione industriai e di uso domestico, condizionatori d'aria per autovetture e perambienti interni.



CFC 11

CCl_3F – triclorofluorometano

Conc. Media globale 2000: **260.5 ÷ 263.2 ppt**

Tasso di incremento annuo (1999/2000): **- 0.39 ÷ - 0.76 %**

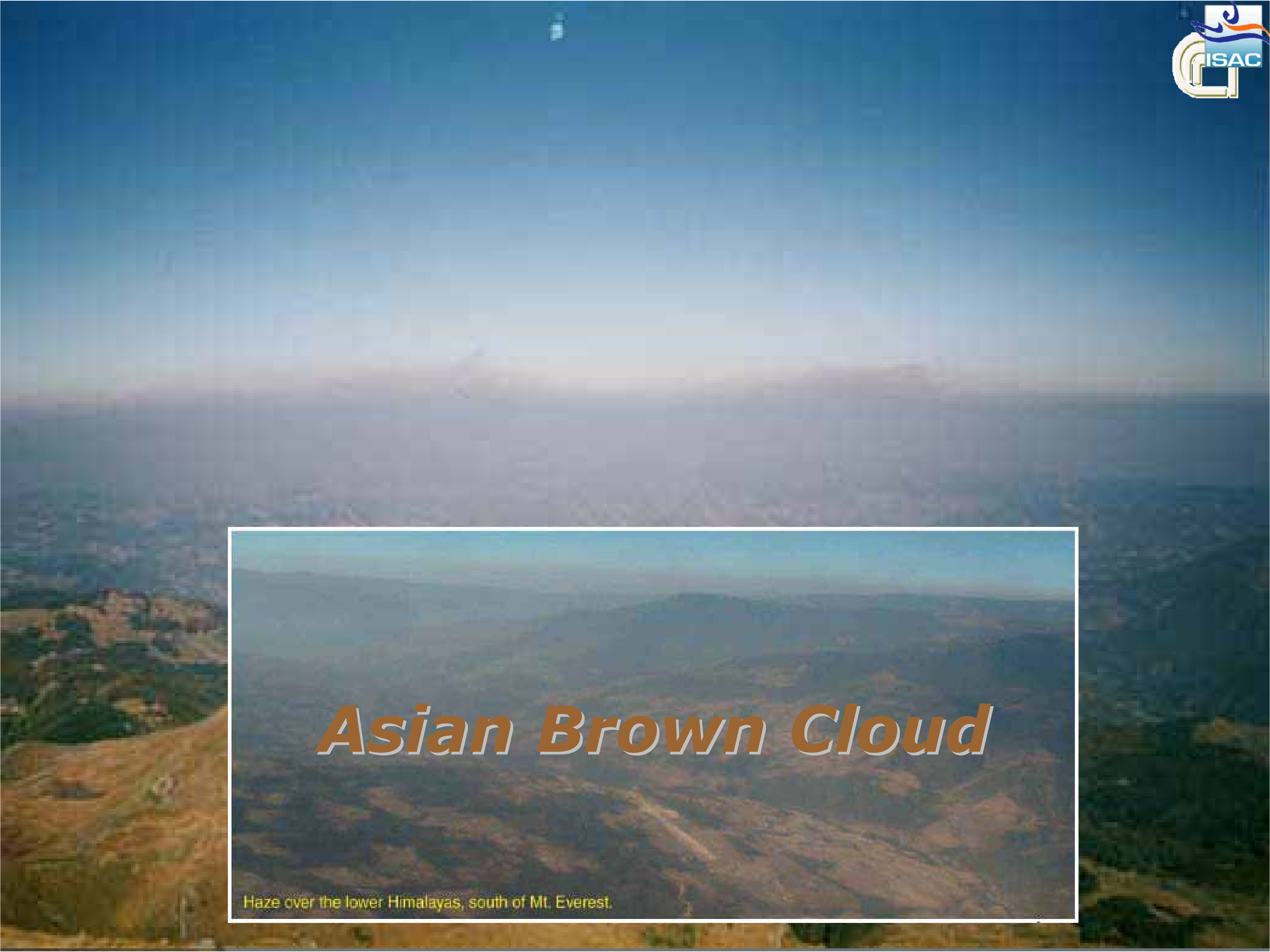
Tempo di vita: **45 anni**

ODP: **1** (per definizione)

GWP_{100}: **4680**

Usi: propellente per aerosol (bombolette spray), gas espandente per la produzione di schiume, refreigerazione.

Asian Brown Cloud



ASIA hosts more than 60% of the world's population live and is experiencing fast and rapid industrial growth

Asian haze, a 3 km thick brownish layer of pollutants
<u>hovering over most of tropical</u>
<u>Indian Ocean, South, Southeast and East Asia.</u>

Potential direct and indirect consequences of the haze involve regional and global climate change, impacts on ecosystem, the water cycle, agriculture and human health.

New programme to study atmospheric composition change in Himalaya and Karakorum mountain regions supported by Italian EV-K2-CNR committee with the specific aim of contributing to the ABC Project

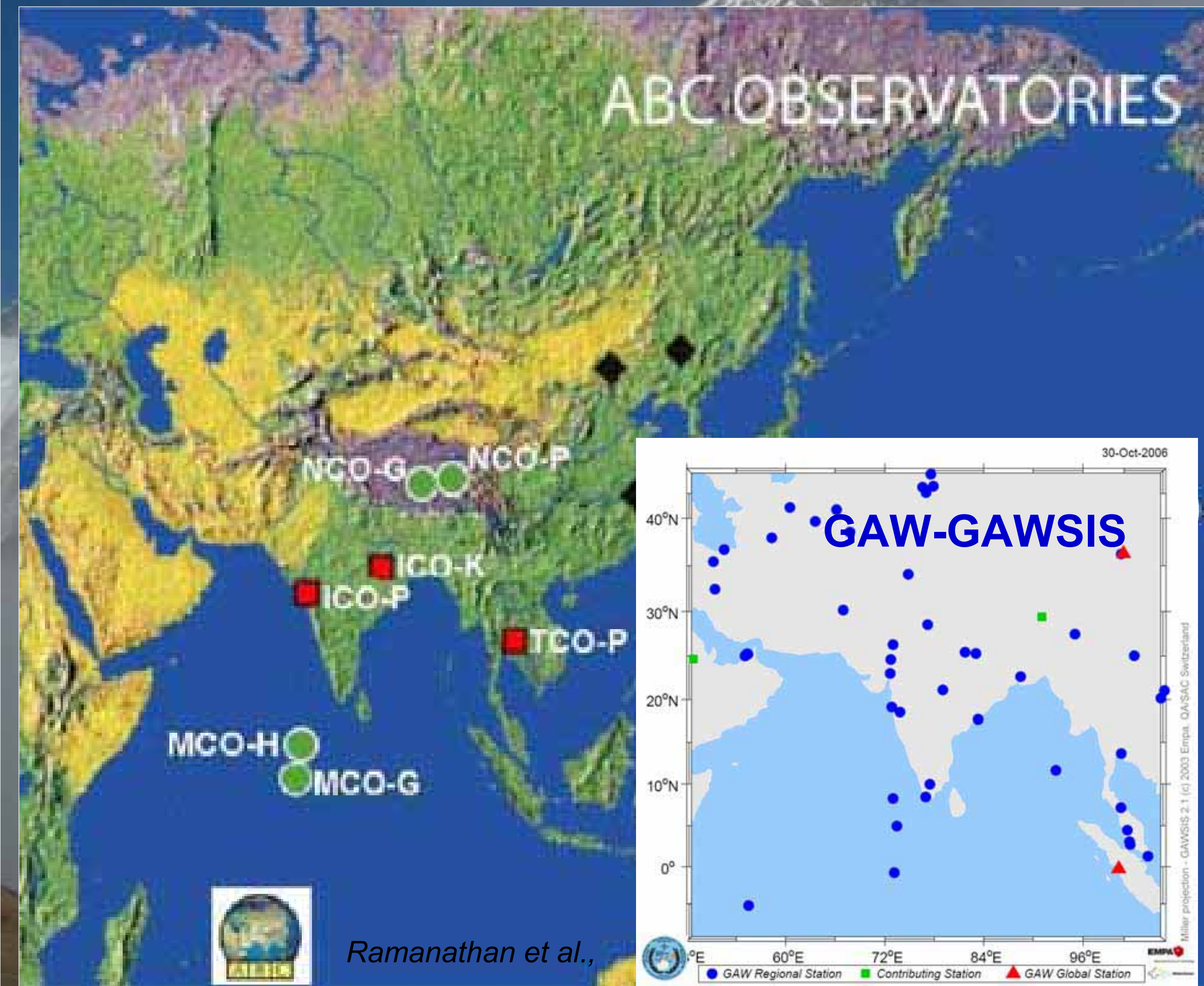
Asian Brown Clouds

A programme called **ABC** has been initiated jointly by UNEP – United Nations Environment Programme, and Center for Clouds, Chemistry and Climate (C4) at the Scripps Institution of Oceanography (C4/SIO).

Under Project ABC scientists plan to establish a network of ground-based monitoring stations throughout Asia to study the composition and seasonal pattern of the haze.

In the Himalayan area the continuous monitoring of atmospheric compounds represents a necessary action to well evaluate:

- ✓ the impact of the human activities on the environment
- ✓ the contribution of natural phenomena



However, due to technical and logistic difficulties to carry out continuous measurements at high altitude in Himalayas, no systematic observations of atmospheric constituents are available in this area till now.

SHARE – Asia Environmental Network

Ev-K^2-CNR

OPGC

ISAC

SHARE

Implementation Plan for the ABC-Pyramid Observatory

August 2002: EV-K2-CNR first contact with UNEP at Johannesburg World Summit

September 2003: Yokohama: ABC accept Pyramid as “exploratory site”

December 2004: definition of the team CNR - ISAC & OPCG - CNRS

April 2005: 3-years contract is signed between CNR-ISAC and EvK2CNR

May 2005: The ABC-Pyramid site in the Himalayas has been chosen, in order to carry out representative measurements of atmospheric compounds

May-September 2005: **Scientific discussions for the implementation plan among partners**

June- October 2005: Acquisition and Construction of instrumentation and inlets. Development of data acquisition and trasmission procedures

Sept.-Oct.-Nov. 2005: **ABC-Pyramid laboratory mounted and tested in Bologna with full instrumentation**

November 2005: ABC-Pyramid laboratory sent to Nepal (20m^3)

January-February 2006: **ABC-Pyramid laboratory mounted and first measurements performed: all OK!!**

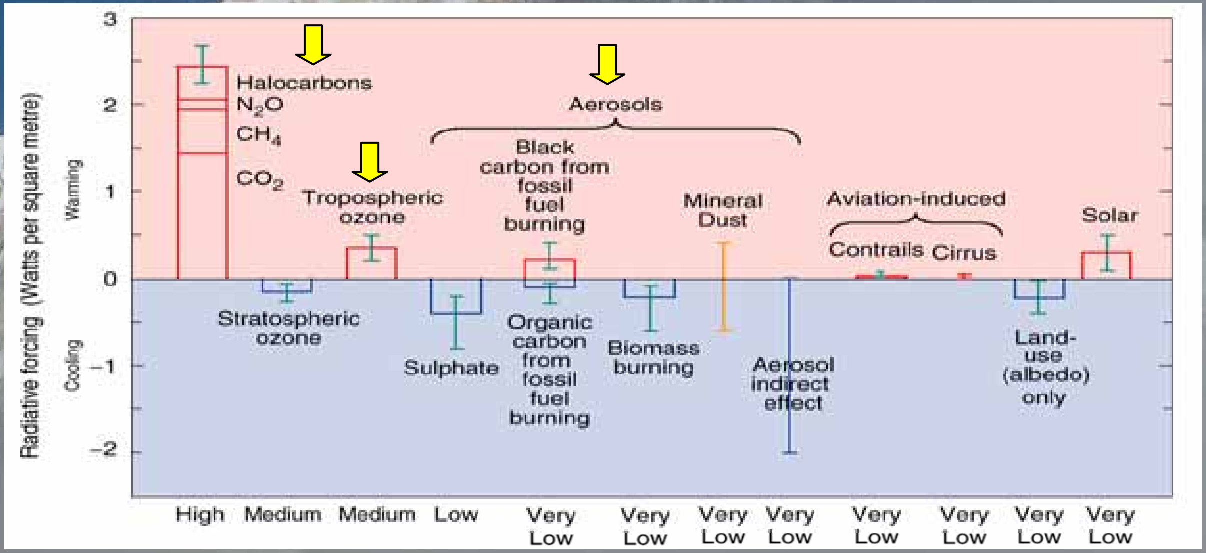
From March 2006: Continuous in situ measurements

February-March 2007: ABC-Pyramid instrument calibration and field campaign

2008 – 2xxx **…………………..**

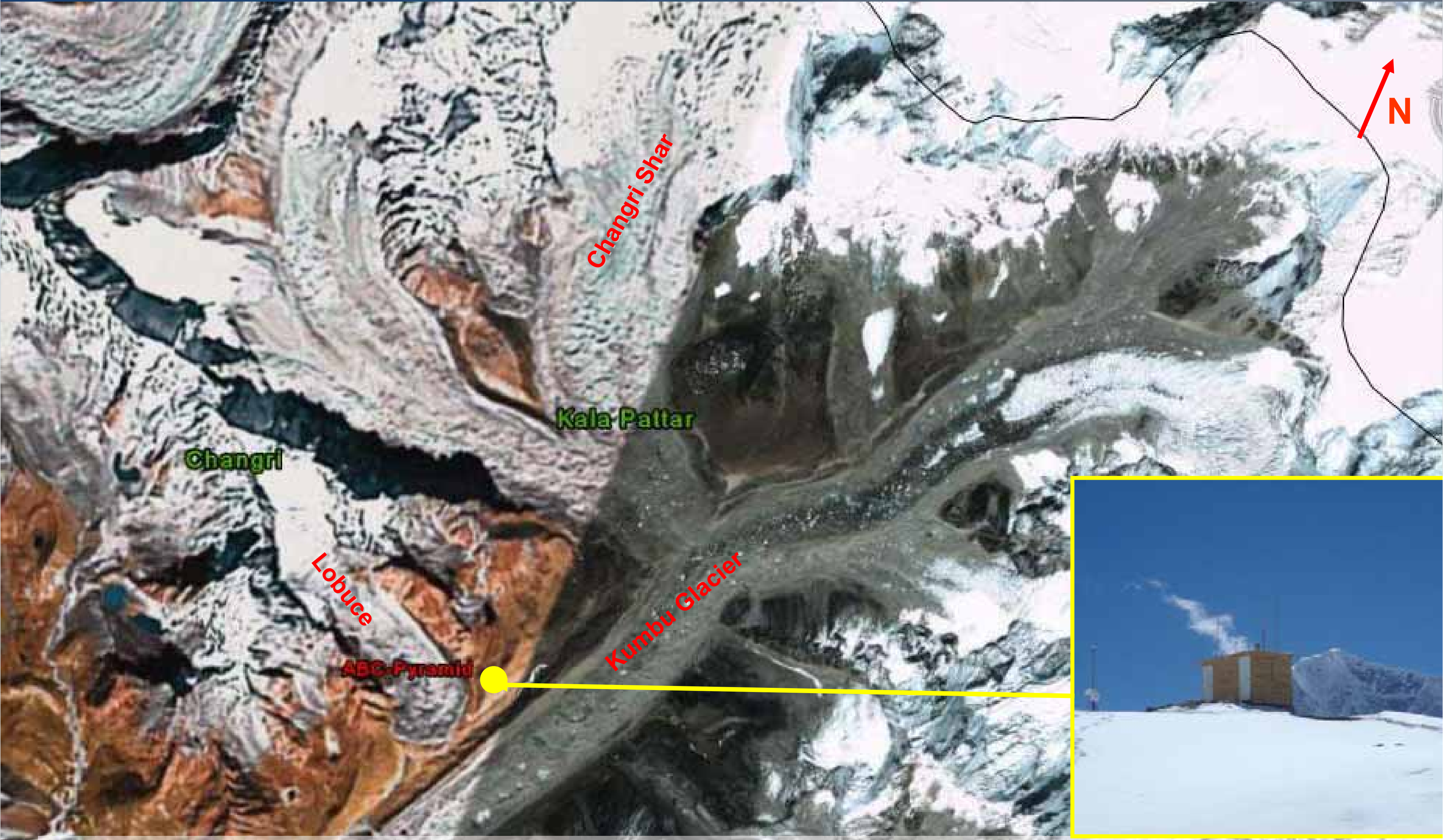
The ABC-Pyramid scientific goals:

To determine the physical, optical and chemical properties of <u>aerosol</u> and investigate the relationships between them.



Aerosol Forcings Cause the Largest Uncertainty in the Earth's Radiation Budget

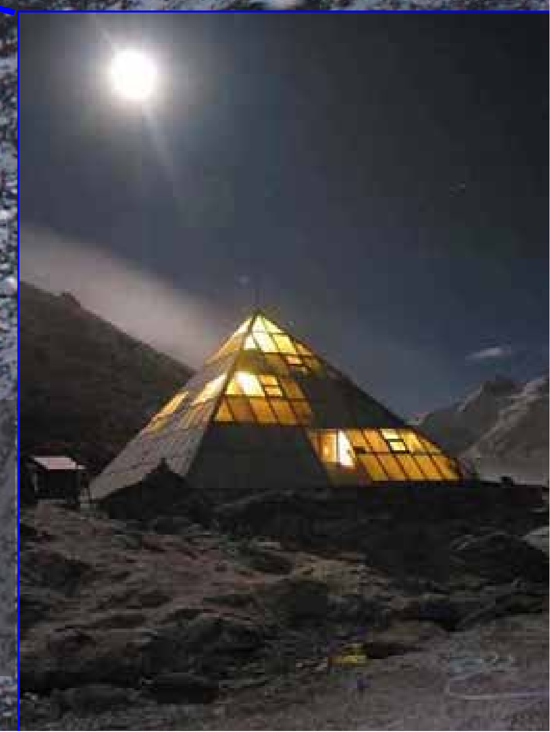
WHERE
the ABC-Pyramid observatory?



Lat. N 27°57' Lon. E 86°48` Altitude: 5079 m asl

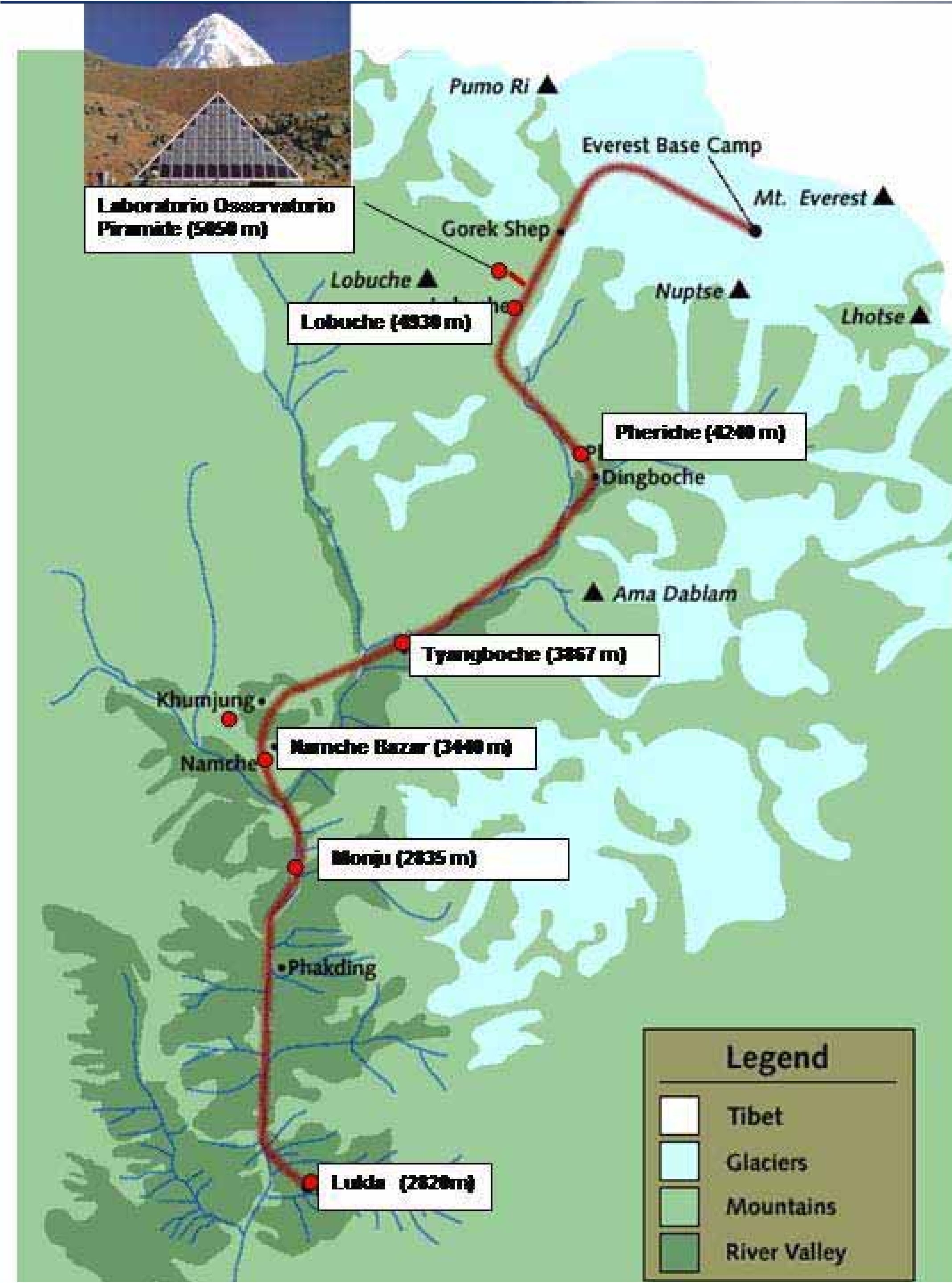
Khumbu Valley (Nepal), not far from the Pyramid

WHERE
the ABC-Pyramid observatory?

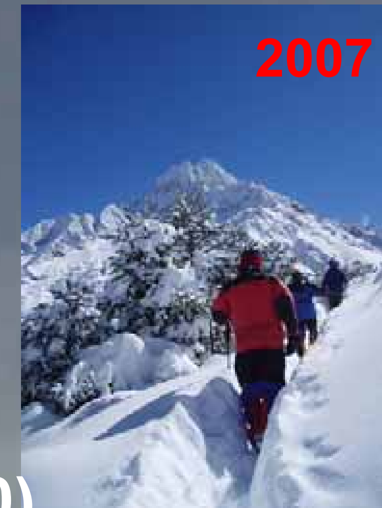


The Observatory is unique for investigating atmospheric composition changes

and providing the opportunity to look at both polluted and clean air masses depending upon the season.

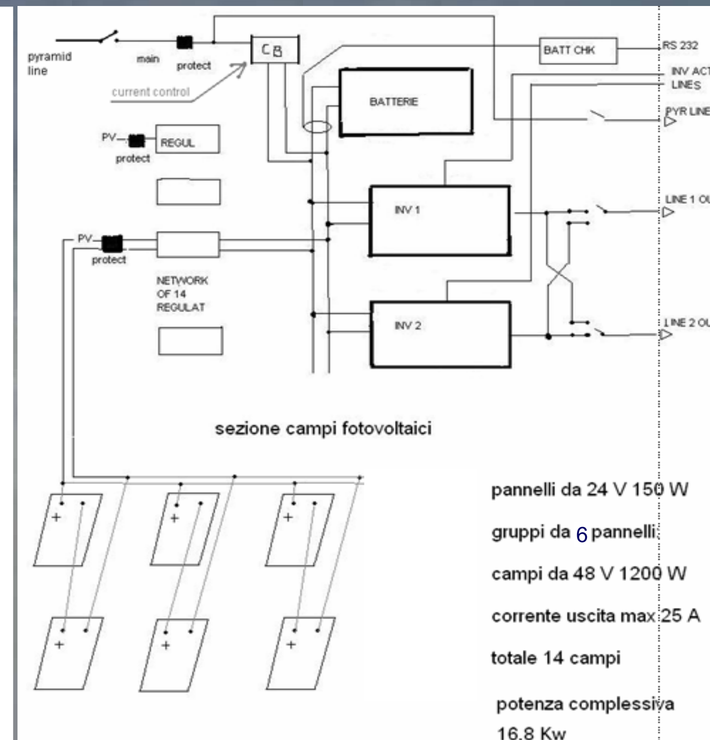


The tracking:



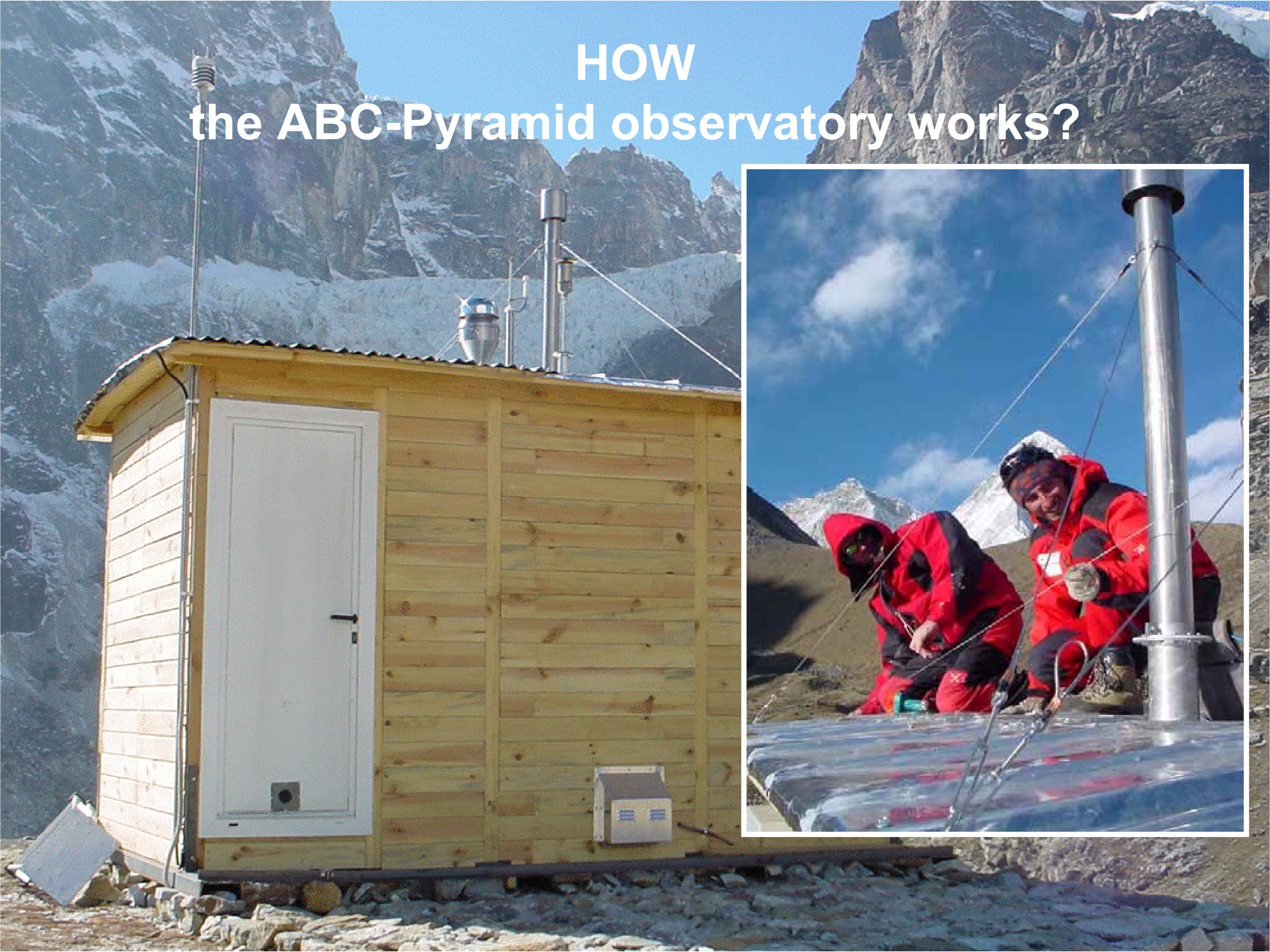
6 days from Lukla (2820) to Pyramid (5050), sleeping in Nepalese lodges

HOW
the ABC-Pyramid observatory works?



In the Himalayas the activity employ **renewable energy** from **96 photovoltaic panels and 120 electric storage cells.**

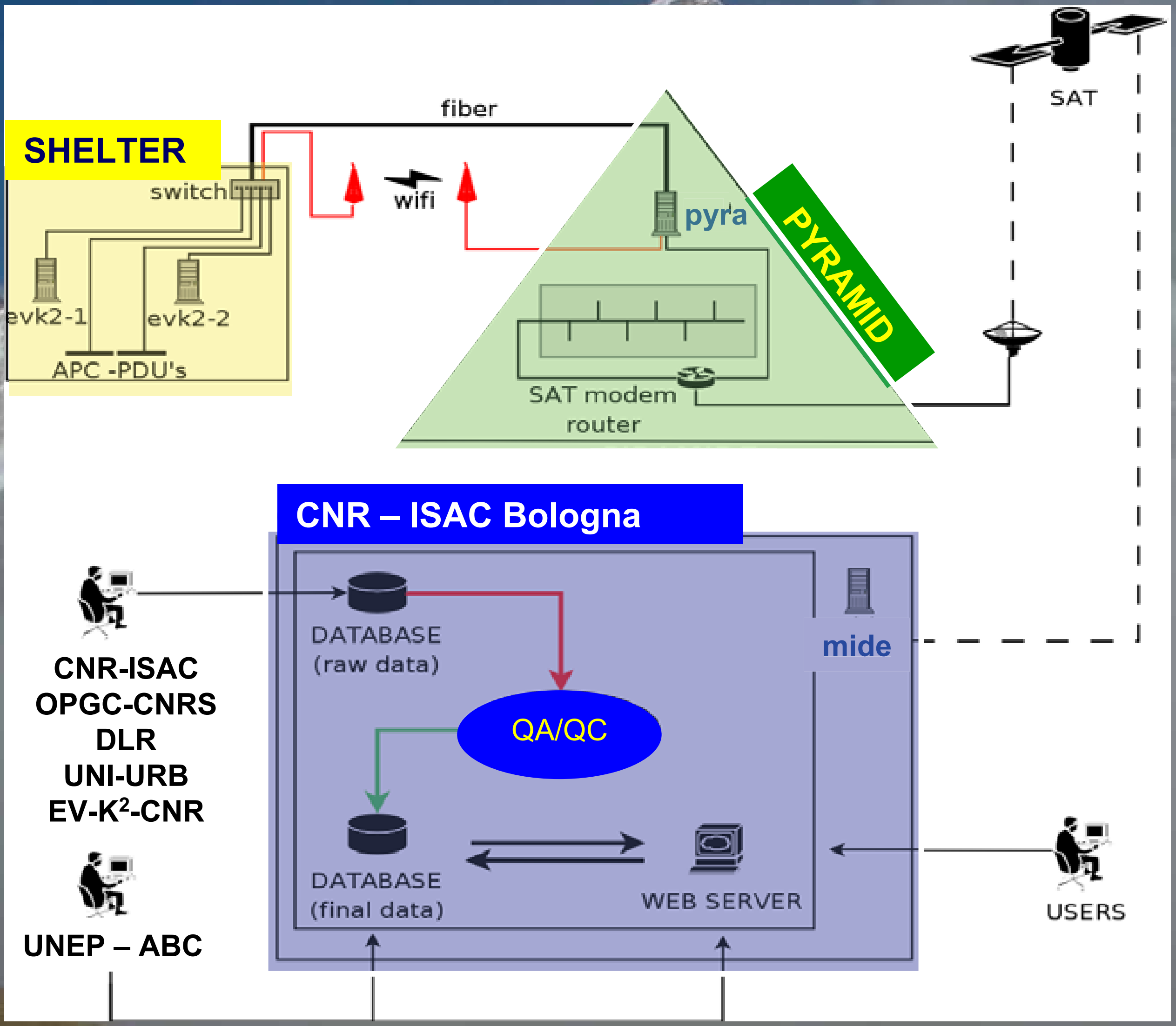
HOW
the ABC-Pyramid observatory works?




FIAMM
SMG 490

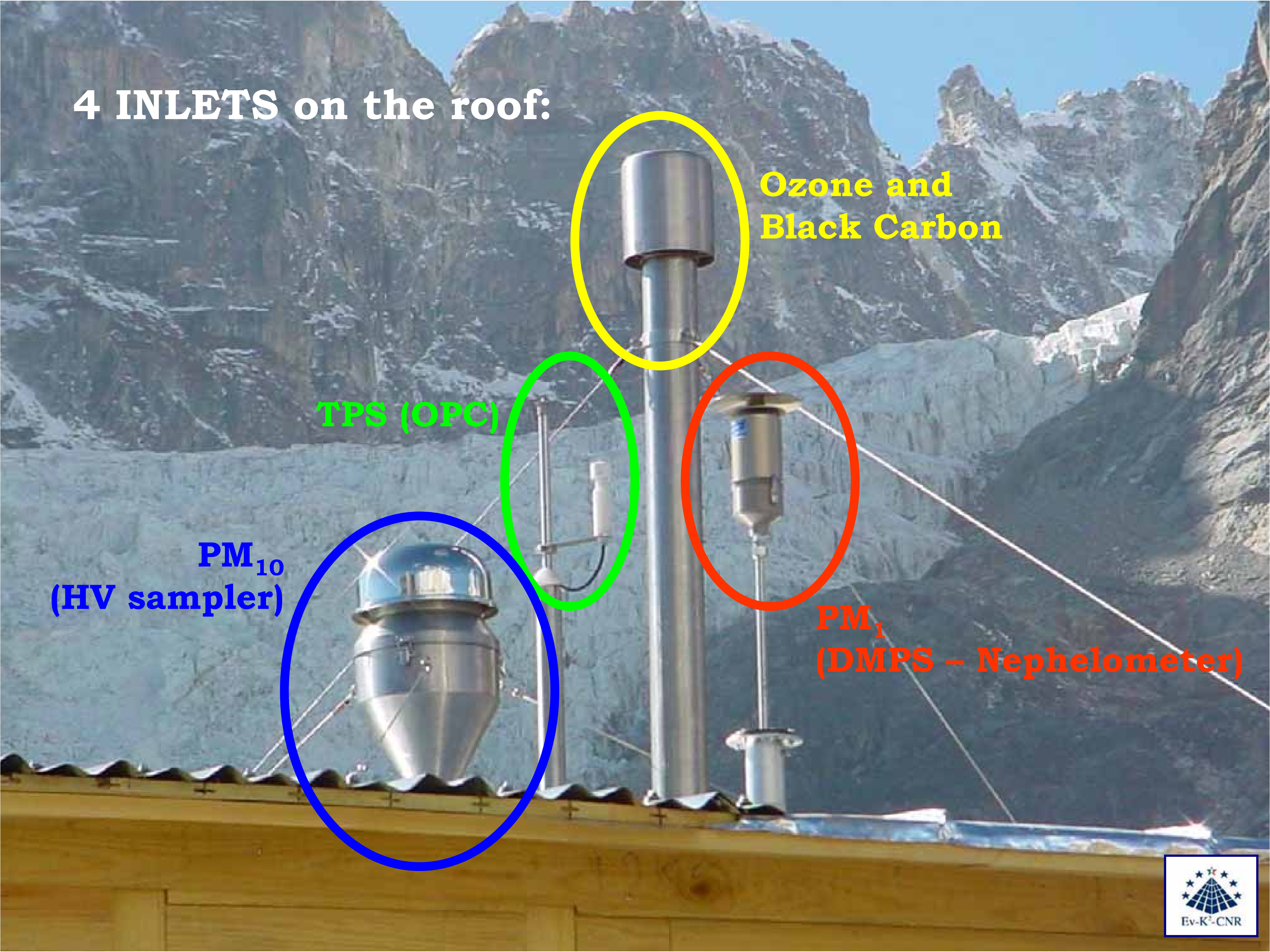
HOW the ABC-Pyramid observatory works?

Data acquisition and communication systems



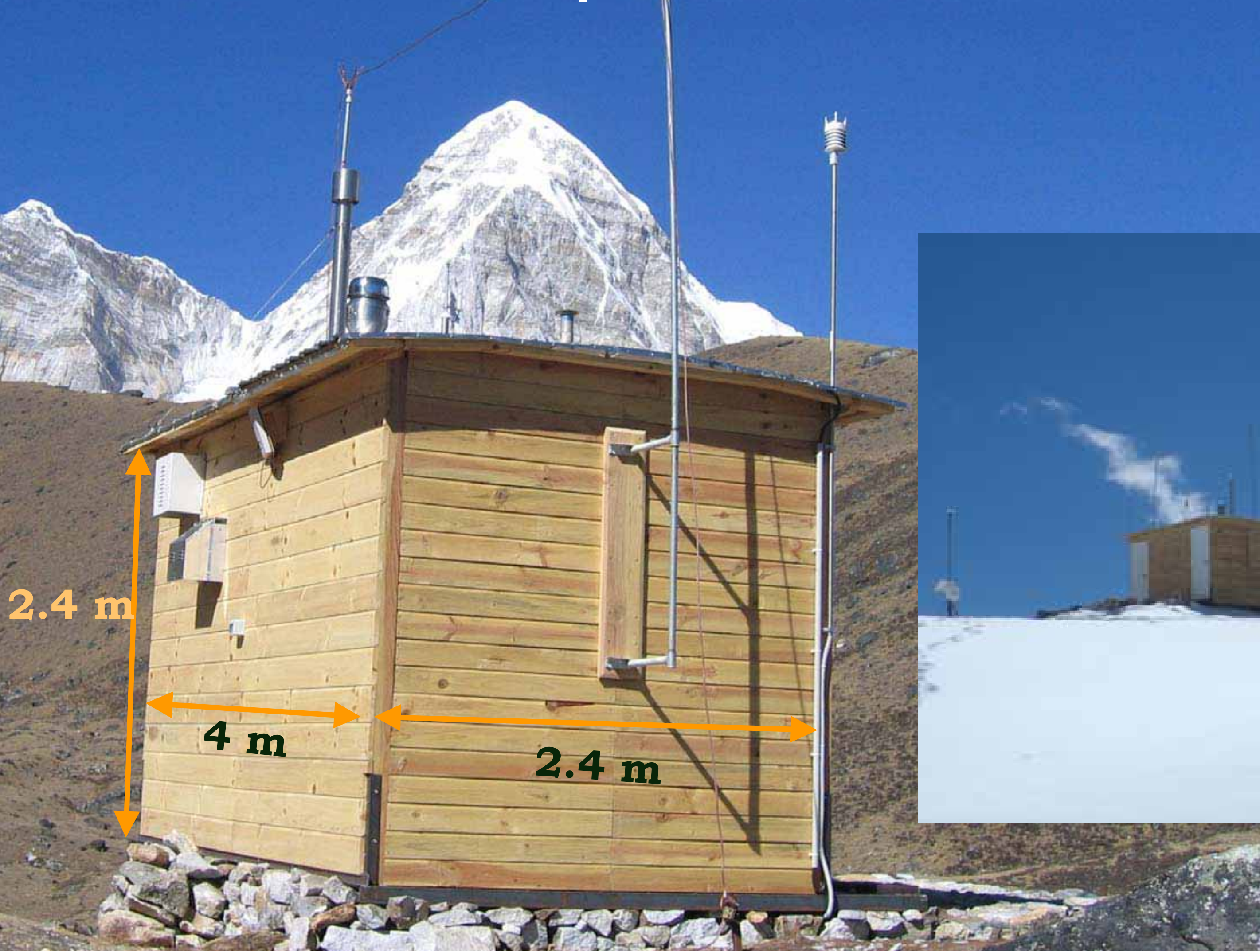
The data are sent to the CNR Institute where they can be accessed by different Institutions that provide QA/QC.

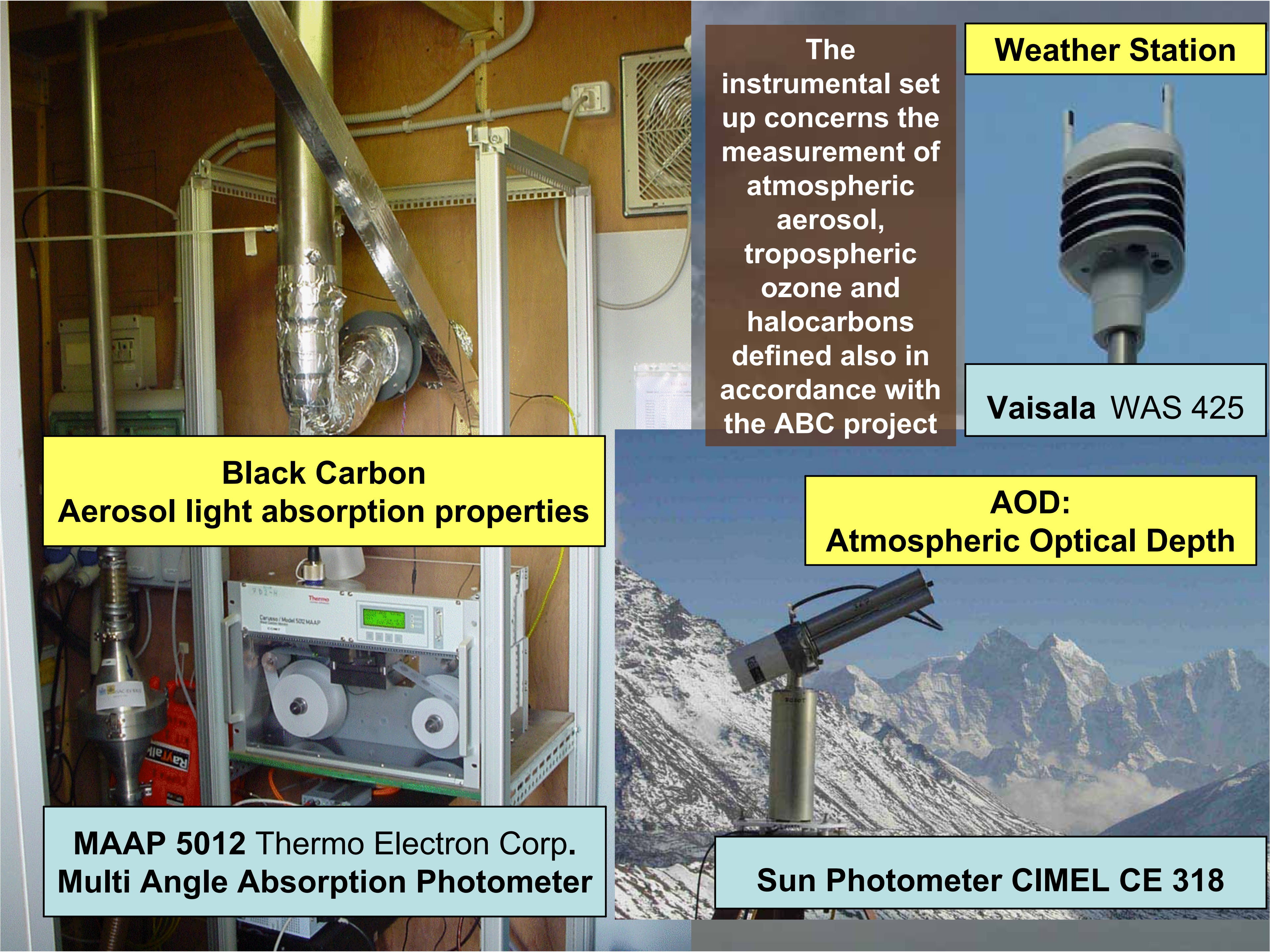
The remote control of the instruments is possible from CNR and CNRS Institutes.



4 INLETS on the roof:
Ozone and
Black Carbon
TPS (OPC)
PM10
(HV sampler)
PM1
(DMPS – Nephelometer)
Ev-K2-CNR

Continuous measurements of PM, CN, σabs, σdiff, dN/dLogD, O3, meteo, AOD, particle composition, GHG and Halogenated compounds



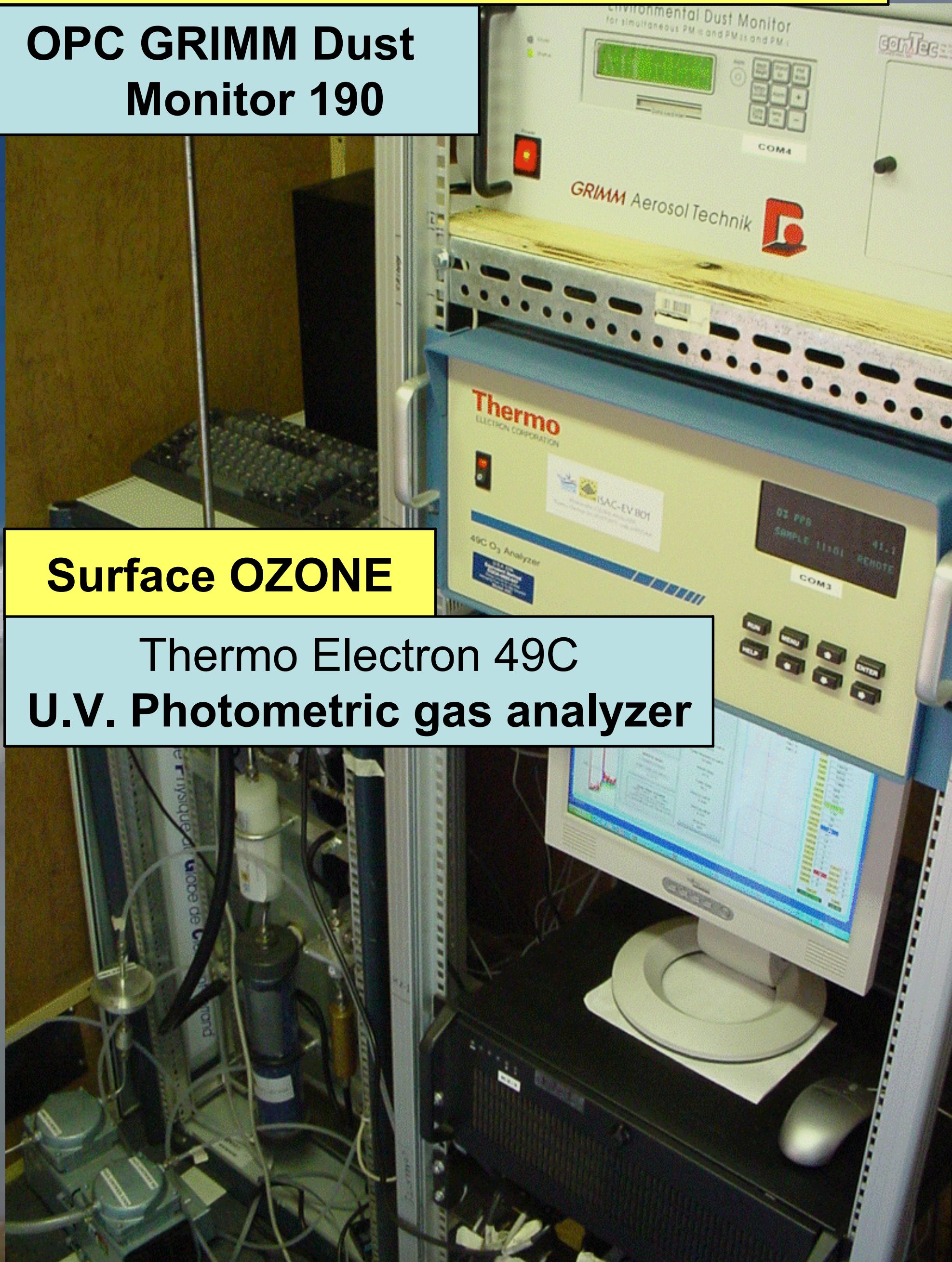

The instrumental set up concerns the measurement of atmospheric aerosol, tropospheric ozone and halocarbons defined also in accordance with the ABC project
Weather Station
Vaisala WAS 425
Black Carbon
Aerosol light absorption properties
AOD:
Atmospheric Optical Depth
MAAP 5012 Thermo Electron Corp.
Multi Angle Absorption Photometer
Sun Photometer CIMEL CE 318

Ev-K^2-CNR

Aerosol physical properties

Size Distribution 0.25-32 μm

OPC GRIMM Dust Monitor 190



Surface OZONE

Thermo Electron 49C
U.V. Photometric gas analyzer

Size distribution 15-500nm

SMPS / DMPS

Aerosol integral scattering coefficient

TSI 3563 Integrating Nephelometer

Halocarbon GHG compounds

Steel flask sampling (Nepal)
Gas analysis AGILENT GC-MS at Mt. Cimone CNR Station (Italy)

25 Halocarbons relevant for climate issues will be analysed in flask samples collected weekly

C2F6, SF6, HFC-23, Halon 1301, CFC-115, HFC-125, HFC-143, CFC-12, HCFC-22, CH3Cl, HFC-134a, Halon 1211, HFC-152b, CFC-114, CH3Br, HCFC-142b, HCFC-124b, CFC-11, CH3I, CH2Cl2, HCFC-141b, CFC-113, CHCl3, CCl4, CHCCl3, CH3CCl3, C2Cl4

Aerosol Chemistry
(Cl, WSOC, WIOC, metals…)

HV PM_{10} sampler (Nepal)
Analysis at ISAC (Bologna) and Urbino University

CALIBRATION AND QUALITY CONTROL

- The whole instrumentation has been pre-calibrated and tested in Bologna (Italy)
- In situ all the flow rates have been checked and regulated
- Routine maintenance is carried out by local Nepalese personnel; all instruments are accessed directly through satellite connection from ISAC in Italy and from OPGC in France
- Field campaign are planned for calibration, implementation and intensive studies
  (First field campaign occurred in Feb-March 2007)

Ev-K2-CNR

CALIBRATION AND QUALITY CONTROL

The instrumental set up,
quality control for the instrumentation and data reduction
has been defined and performed following the ABC project
recommendations,
EUSAAR/GAW/AGAGE procedures
concerning the measurement of atmospheric aerosol
properties, tropospheric ozone, halocarbons and other
greenhouse gases

(WMO/GAW, 2003; WMO, 1992; ABC, 2003)

Ev-K²-CNR

2000-2004 @ Pyramid EV-K2-CNR

WINTER (DRY SEASON)
December - February

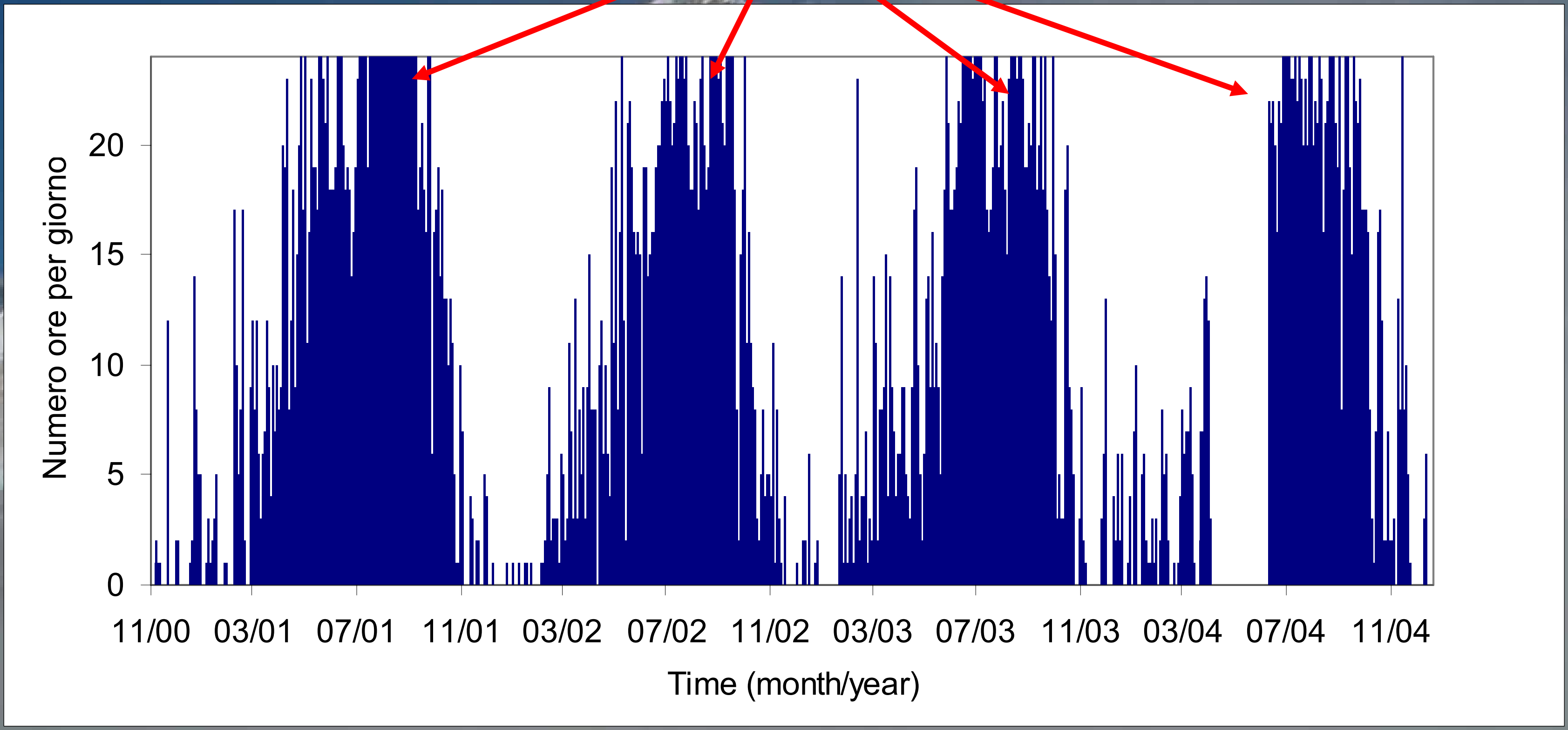
PRE-MONSOON
March - May

MONSOON
June - September

POST - MONSOON
November - December

2000-2004 @ Piramid EV-K2

MONSOON

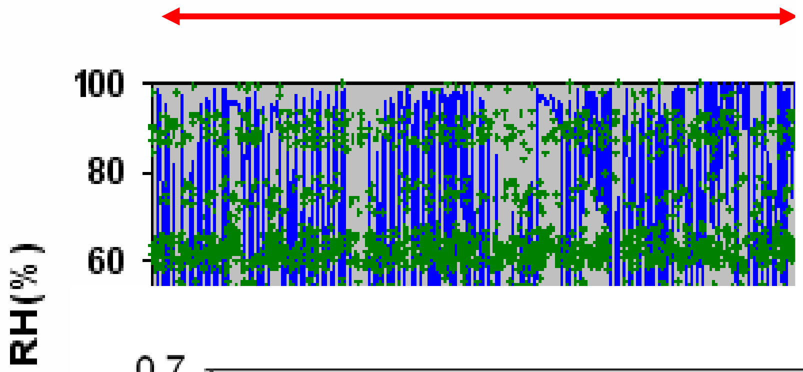


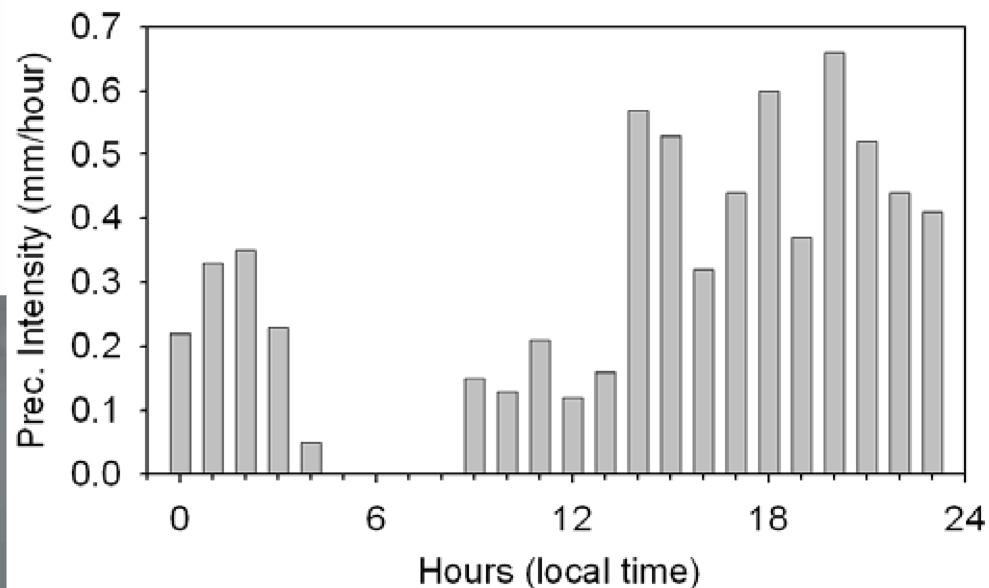
Number of hours per day with RH>95%

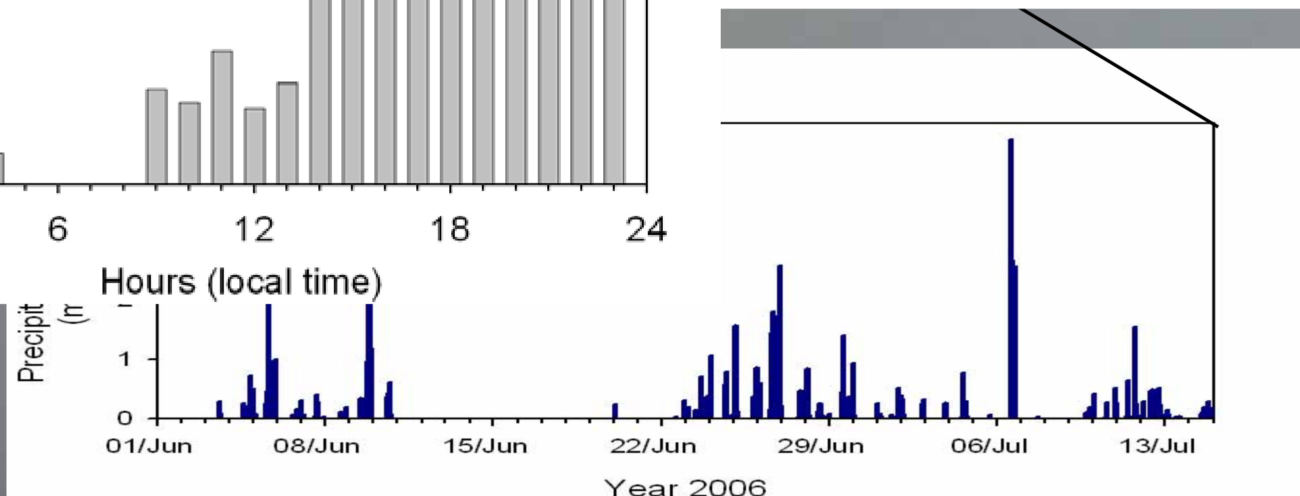
(26% of days with 24h/24)

2006

Pre-monsoon season before May 25 **Monsoon season after May 24**







Ev-K²-CNR

Main Results from Year 1

1- Differentiate 3 main periods Pre-Monsoon and Monsoon and post Monsoon

Large variability of atmospheric concentrations
Fairly high values of PM and BC.
Seen for O3 as well

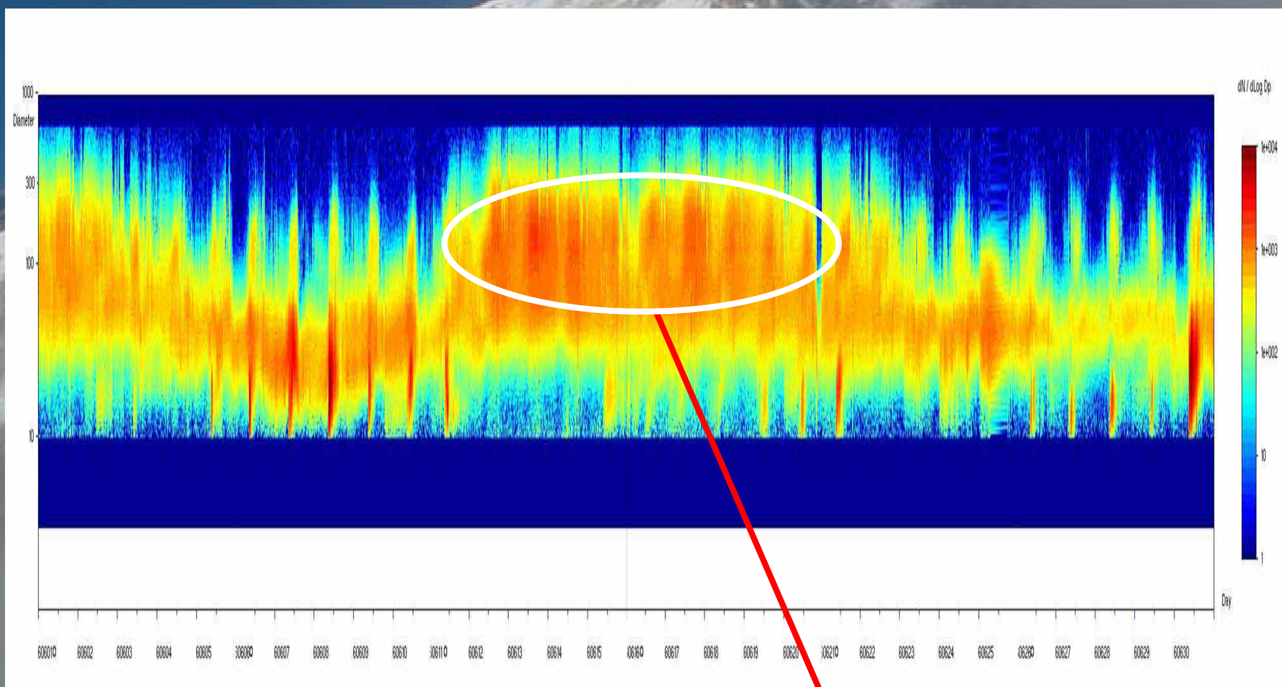
Main Results from Year 1

1- Differentiate 3 main periods Pre-Monsoon and Monsoon and post Monsoon

Lower concentrations close to FT background. Absorbing fraction decreases . O3 decreases

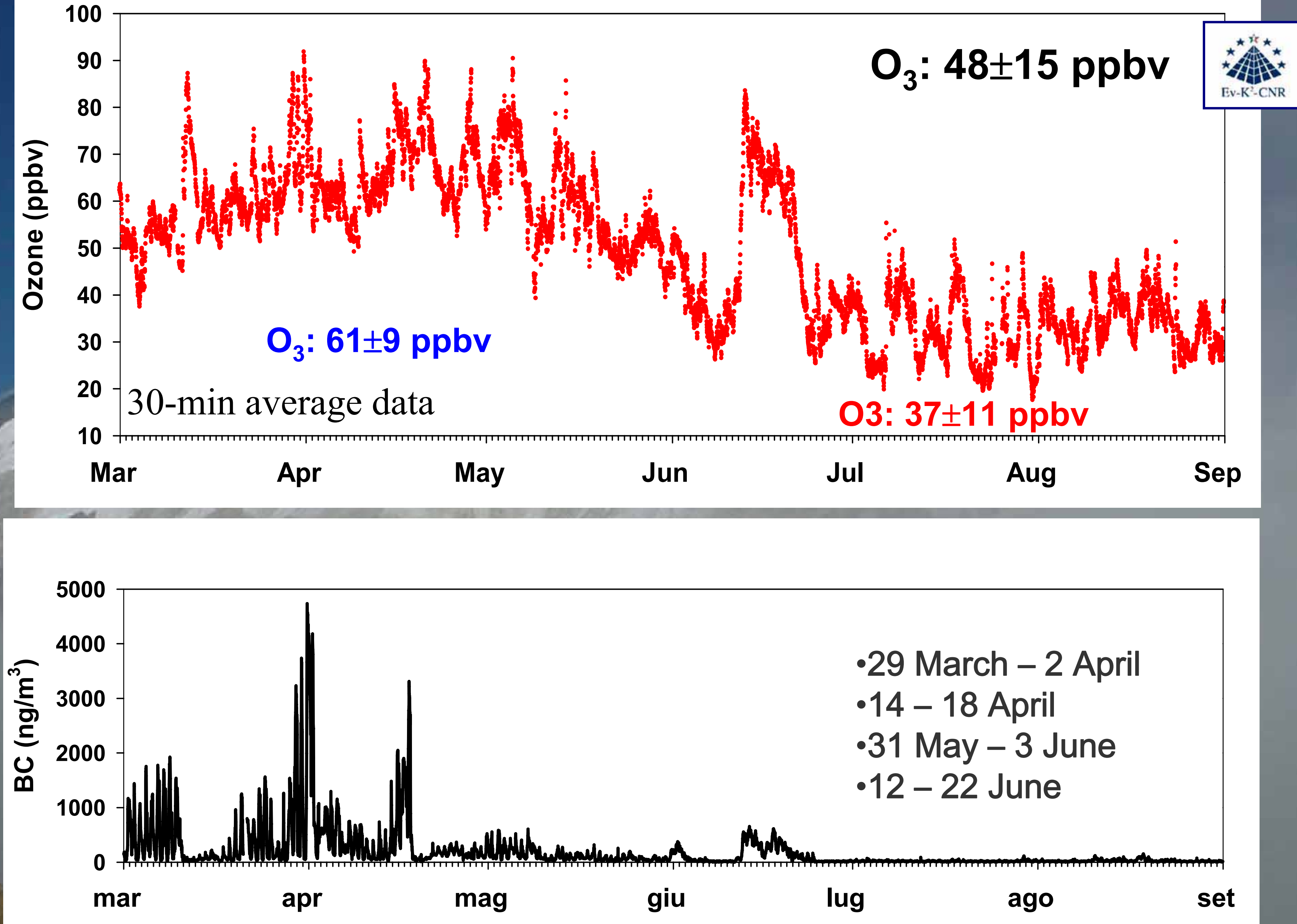
Main Results from Year 1

2- Identification of mesoscale-scale pollution episodes (from Pakistan)

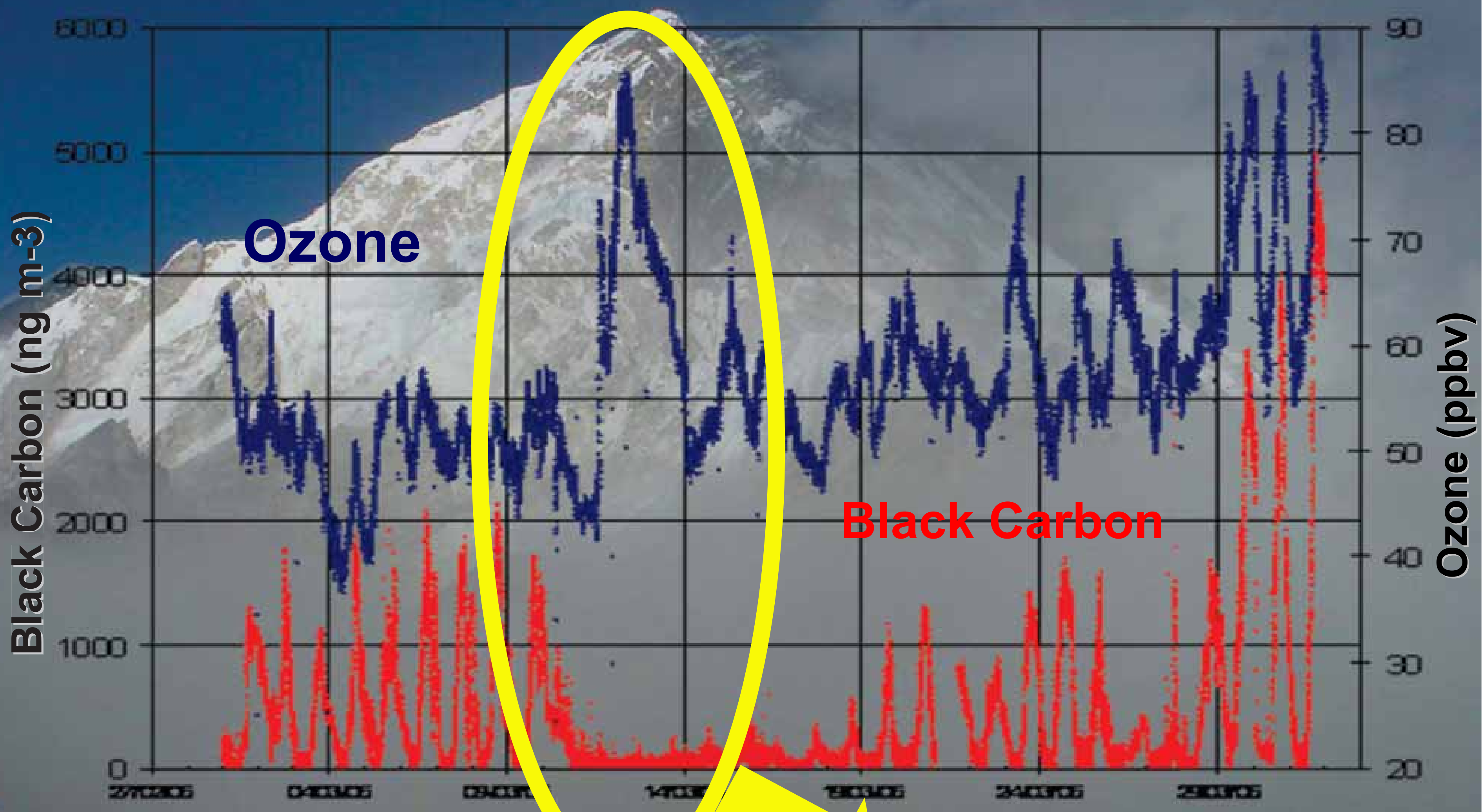


Episodes from long-range transport: mixed dust/carbonaceous aerosol (12-18 June, 28-29 April)

Surface ozone and BC behavior at ABC-PYR (March – August 2006)



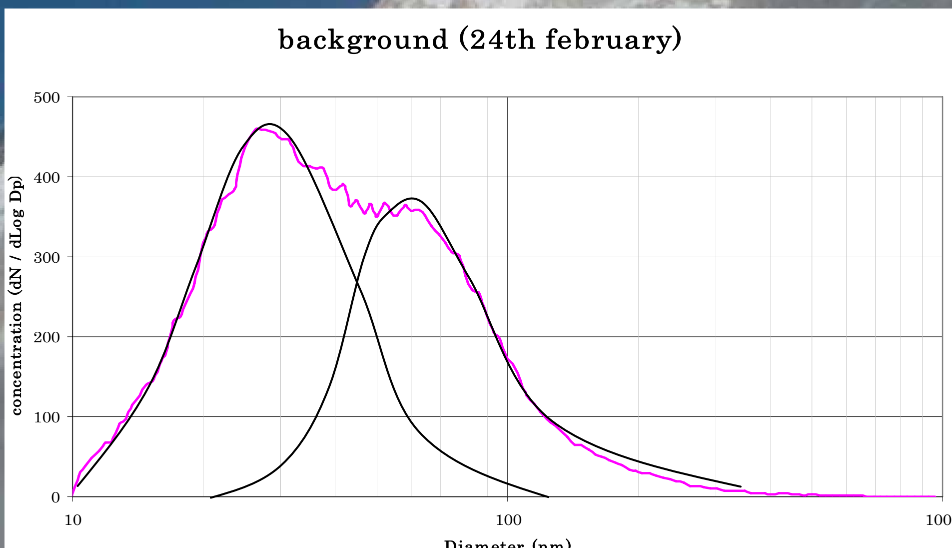
11th – 12th March 2006: POSSIBLE INTRUSION FROM UPPER TROPOSHERE – LOWER STRATOSPHERE



Total ozone column= 292 DU

Main Results from Year 1

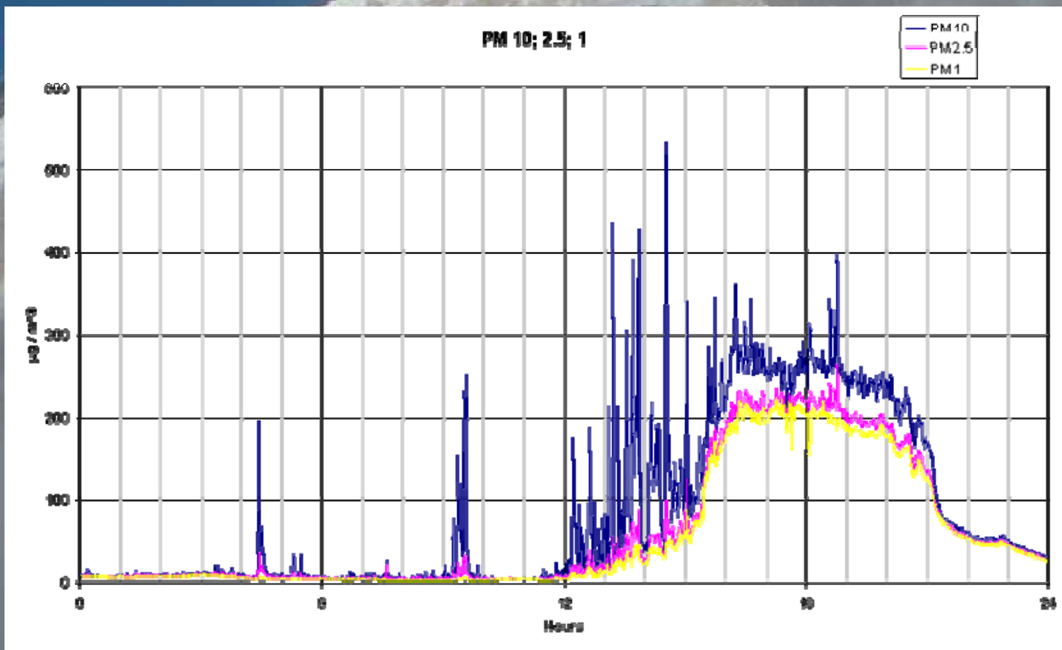
3- Identification of FT background



- Background period with modes at 30 nm and 60 nm
- Particle concentration down to 300 part. cm-3
- BC concentrations down to 20 ng/m3
- PM1 : < 1µg m-3
- Single scattering albedo : 0,98

Main Results from Year 1

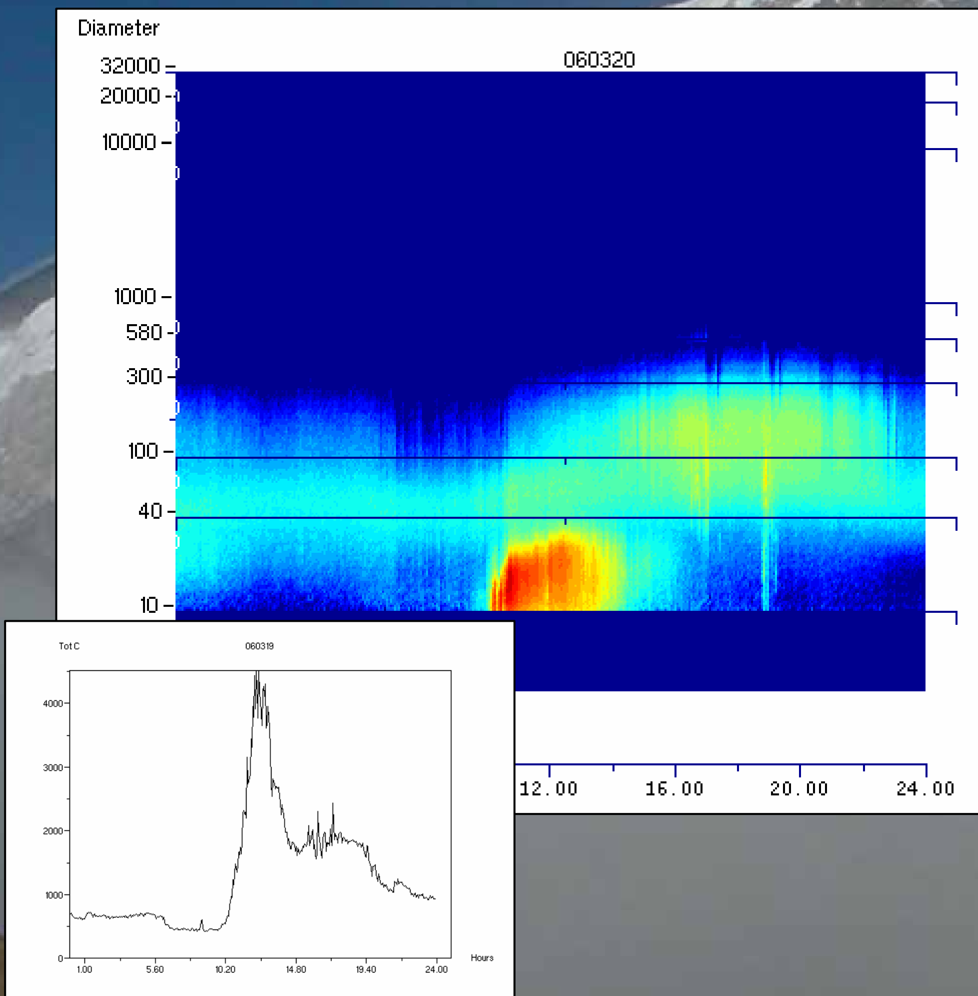
4- Ventilation from BL driven by upslope/downslope circulation



- Very high PM concentrations locally
- Mixture of local dust and combustion aerosols
- Resilience of BL aerosol in FT and regional impact ?

Main Results from Year 1

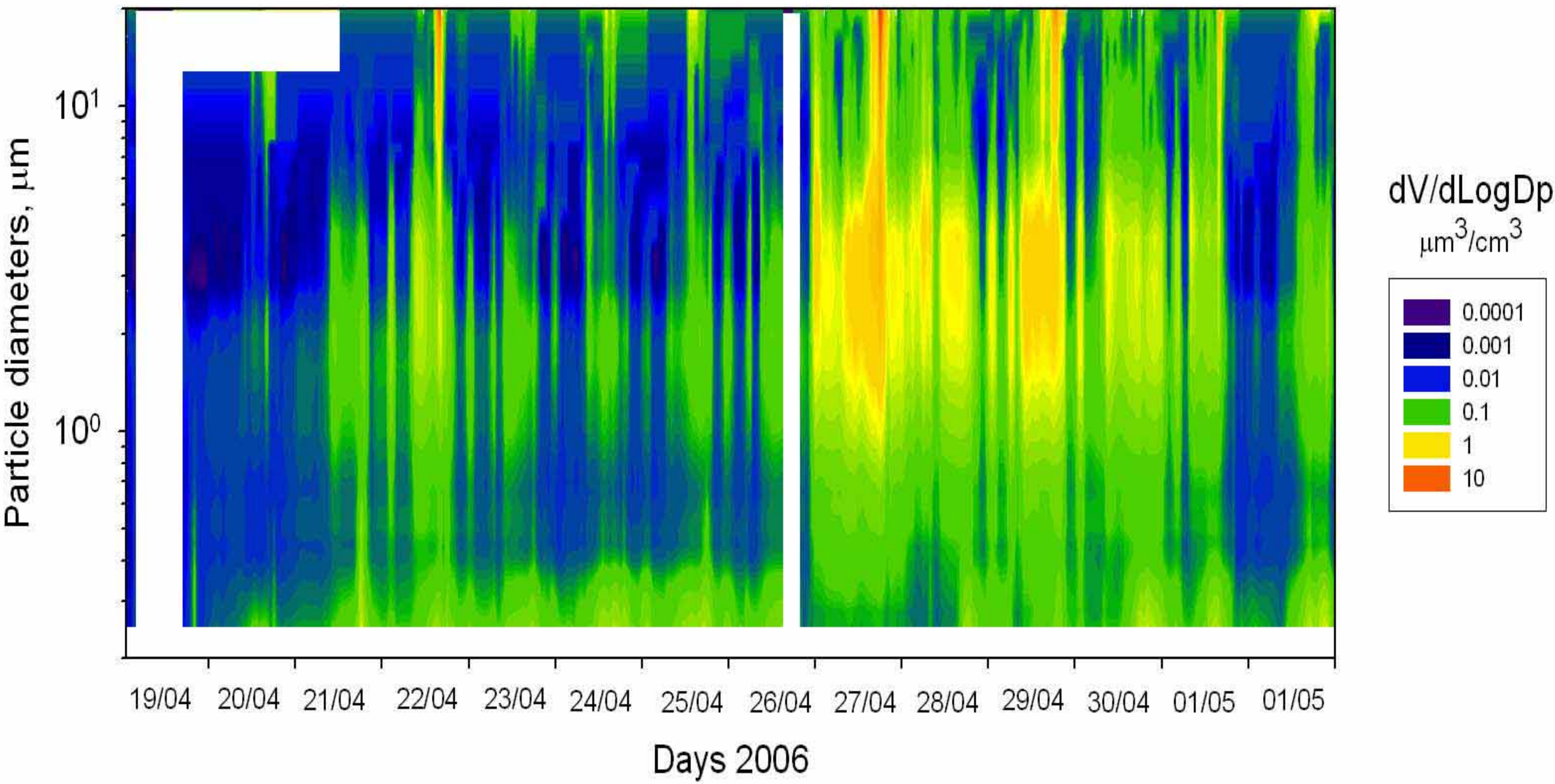
3- Particle formation at the BL/FT interface

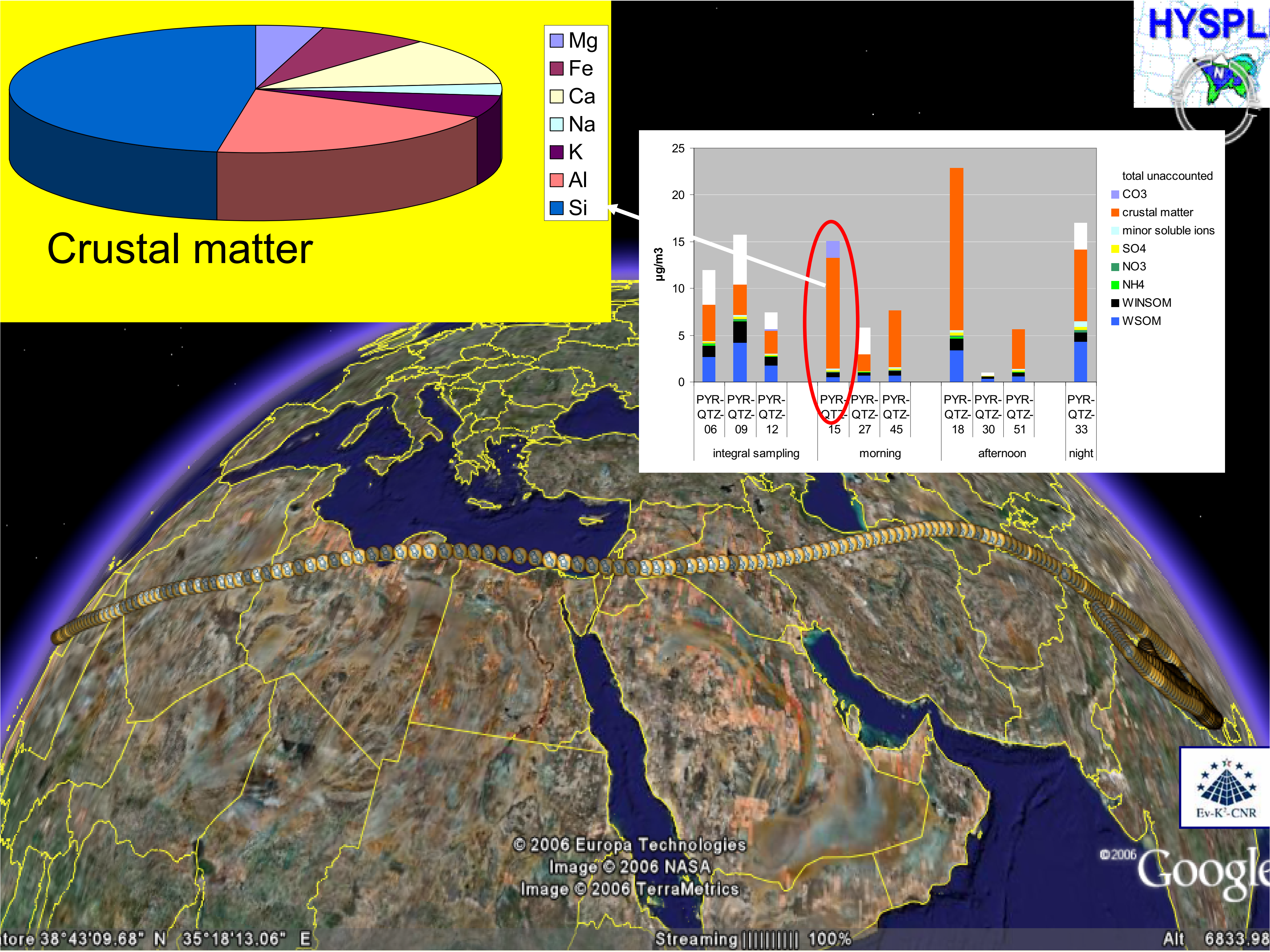


- Very high CN concentrations locally
- Role of Meteorological conditions and dynamics
- Next step: Identification of precursors

Dust transport event 26th – 30th April 2006

aerosol volume size distribution: 19 April - 1 May 2006

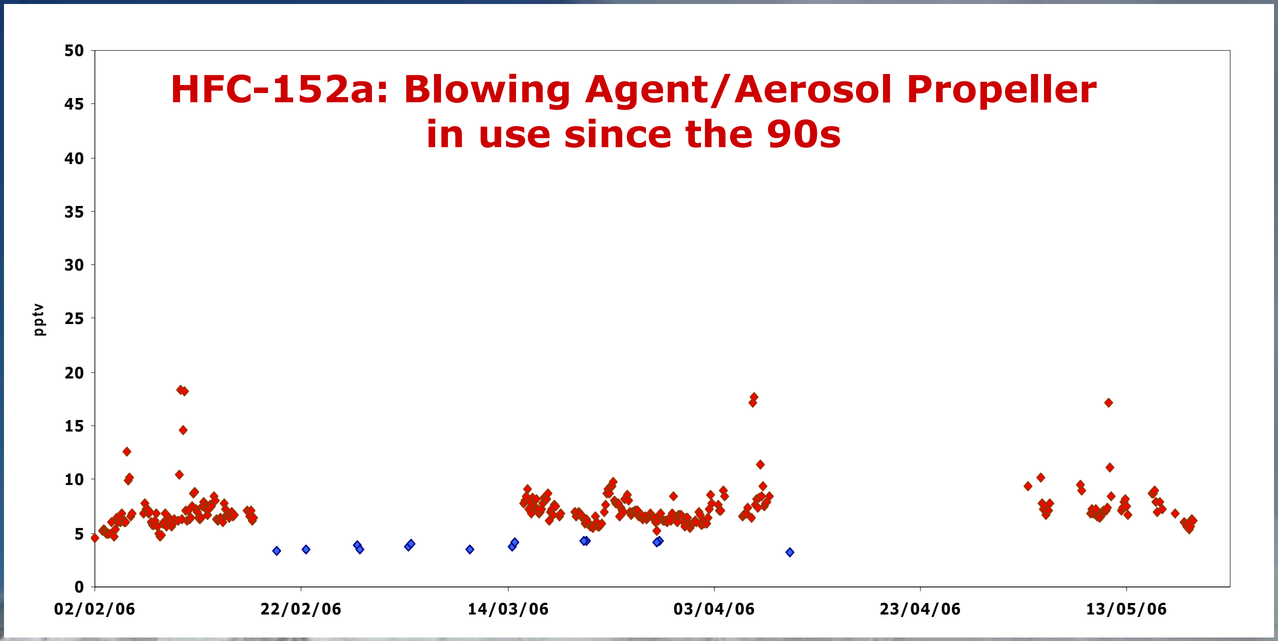


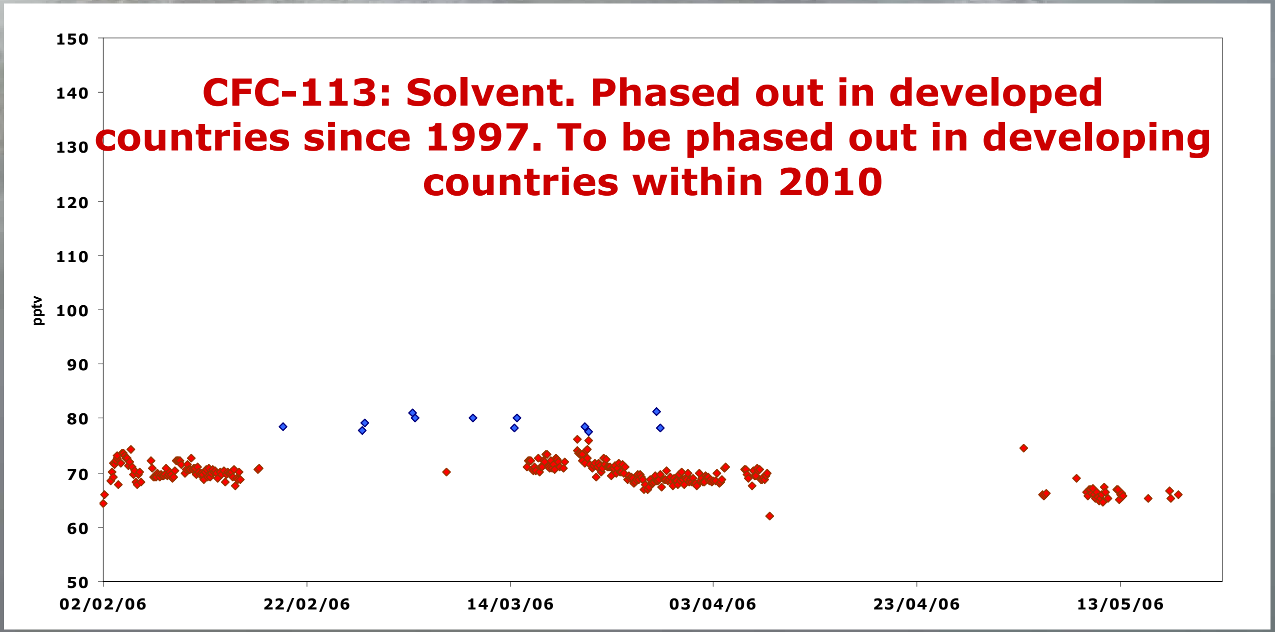

Mg
Fe
Ca
Na
K
Al
Si
Crustal matter
HYSPL
25
20
15
10
5
0
µg/m3
total unaccounted
CO3
crustal matter
minor soluble ions
SO4
NO3
NH4
WINSOM
WSOM
PYR-QTZ-06
PYR-QTZ-09
PYR-QTZ-12
PYR-QTZ-15
PYR-QTZ-27
PYR-QTZ-45
PYR-QTZ-18
PYR-QTZ-30
PYR-QTZ-51
PYR-QTZ-33
integral sampling
morning
afternoon
night
Ev-K²-CNR
© 2006 Europa Technologies
Image © 2006 NASA
Image © 2006 TerraMetrics
©2006 Google
tore 38°43'09.68" N 35°18'13.06" E
Streaming |||||||||| 100%
Alt 6833.98

Main Results from Year 1

4- Complex mixtures of aerosol material

- Absorbing material from BC and Dust.
- Elevated fraction of carbonaceous material in PM10.
- Dust events clearly identified
- Local versus long-range contributions to be determined
- Long-range transport of both dust and carbon material





- MTC
- ABC-Pyramid

The ABC-PYR laboratory - 5079 m asl
lat: 27.95N lon: 86.82E
A scientific laboratory for the study of atmospheric composition change and climate

Real-time data,
weather and satellite maps,
back-trajectories and STE forecasts (ETHZ)
available at:

http://evk2.isac.cnr.it/

Mt. Cimone → http://www.isac.cnr.it/cimone/

The ABC-Pyramid Observatory and the atmospheric research project

P. Bonasoni1, P. Laj2, U. Bonafè1, F. Calzolari1, P. Cristofanelli1, S. Decesari1, L.Emblico1, MC. Facchini1, S. Fuzzi1, GP. Gobbi1, F., Angelini1, V. Mancinelli1, M. Rinaldi1, A. Marinoni1, F. Roccato1, JM. Pichon2, K. Sellegri2, H. Venzac2, J. Arduini3, M. Maione3, M. Sprenger4, GP.Verza5 and E. Vuillermoz5

*1 - **CNR** - Institute for Atmospheric Sciences and Climate, Bologna, Italy*
*2 - **CNRS** - Université Blaise Pascal, Aubière Cedex, France*
*3 - **Urbino University**, Department of Environmental Science, Urbino, Italy*
*4- **ETHZ** - Swiss Federal Institute of Technology, Zurich, Switzerland*
*5 - **EV-K2-CNR** Committee, Bergamo, Italy*

ACKNOWLEDGEMENTS

Part of these studies were carried out within the framework of the Ev-K²-CNR Project in collaboration with the Nepal Academy of Science and Technology as foreseen by the Memorandum of Understanding between Nepal and Italy, and thanks to contributions from the Italian National Research Council and the Italian Ministry of Foreign Affairs.

Footpath of the Atmosphere

Since 2004, it is possible for school pupils to see **“where”** and **“how”** measurements concerning climate and atmosphere are carried out!

A footpath - the “**Trip of the Atmosphere**” - going up the north- western ridge of the mountain, brings the people to the Mt. Cimone top and to the <u>CNR Research Station</u> and the <u>Air Force Meteorological Observatory</u>

Along the **Trip of the Atmosphere**”, 10 panels introduce the trippers to the “secrets” of the atmosphere and climate change.

Info and booking:
http://www.isac.cnr.it/cimone/sa

Global warming, greenhouse gases, ozone hole, global and local pollution, aerosols…
Not only the ***Trip of the Atmosphere***, but also a **meeting point near to Mt. Cimone (Sestola)** to introduce and discuss the “secrets” of the atmosphere and climate change.


Thank you