



EARTH VENTURE 1 DISCOVER – AQ

Possible Italian collaborations

Contributions: **CNR (ISAC, IFAC)**

Carlo Gavazzi Space

University of L'Aquila

University of Brescia

University of Milan-Bicocca

Presented by: **Ivan Kostadinov**

ISAC, Bologna

i.kostadinov@isac.cnr.it



The Italian National Research Council (CNR) is the largest public research institution in Italy, the only one under the University and Research Ministry (MiUR) performing multidisciplinary activities.

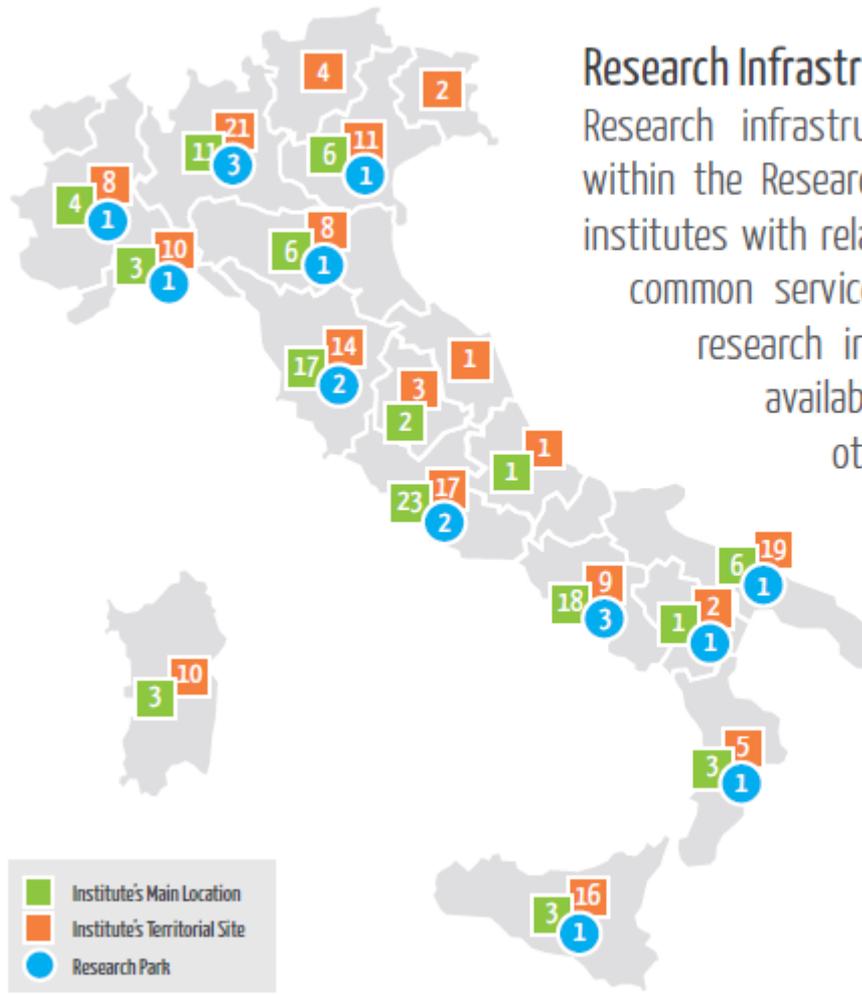
The Mission is to perform research in its own Institutes, to promote innovation and competitiveness of the national industrial system, to promote the internationalization of the national research system, to provide technologies and solutions to emerging public and private needs, to advice Government and other public bodies, and to contribute to the qualification of human resources.

The 11 Departments are:

- Agrifood
- Cultural Heritage
- **Earth and Environment**
- Energy and Transport
- Information and Communication
- Technologies
- Life sciences
- Materials and Devices
- Medicine
- Molecular Design
- Production Systems



The Scientific Network localization



Research Infrastructures

Research infrastructures are mainly located within the Research Parks, grouping together institutes with related scientific tasks, sharing common services. The use of some large research infrastructures is also made available to researchers belonging to other scientific institutions in Italy and abroad, such as marine vessels, or other facilities settled in remote locations (i.e. Svalbard islands and Himalaya region) for environmental research.



ISAC is a national institute of CNR whose headquarters are located in Bologna.

Over 200 staff members, postdoctoral researchers, and students.



A wide range of experimental and modelling expertises are present in ISAC, which can be summarised in the following headlines:

- Climate modelling, climate historical reconstruction and its variation, impacts of climate change on environment and society
- Meteorology: theory, observations and models
- Atmospheric composition: observations and processes from the local to the global scale and their effects on air quality, climate, ecosystems and human health
 - Theory and models of atmospheric transport processes at different scales and their connections to air quality and climate
- Polar atmospheric studies, both in the Arctic and in Antarctica
- Satellite observations of sea surface and system development for the sustainable use of marine resources
- Natural, environmental and anthropic risks of cultural heritage

ISAC obtained a score of excellence in the evaluation process just concluded within the National Research Council (March 2010)

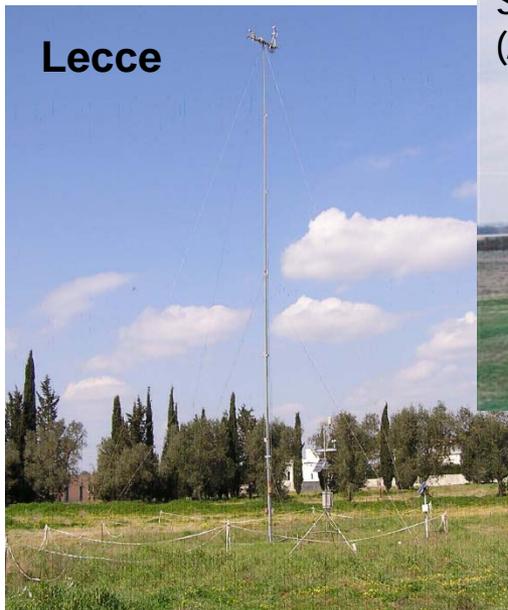
Roma Torvergata



Italian Climate Observatory "Ottavio Vittori" @ Monte Cimone



Lecce



San Pietro Capofiume (ARPA Emilia-Romagna, Servizio IdroMeteorologico)

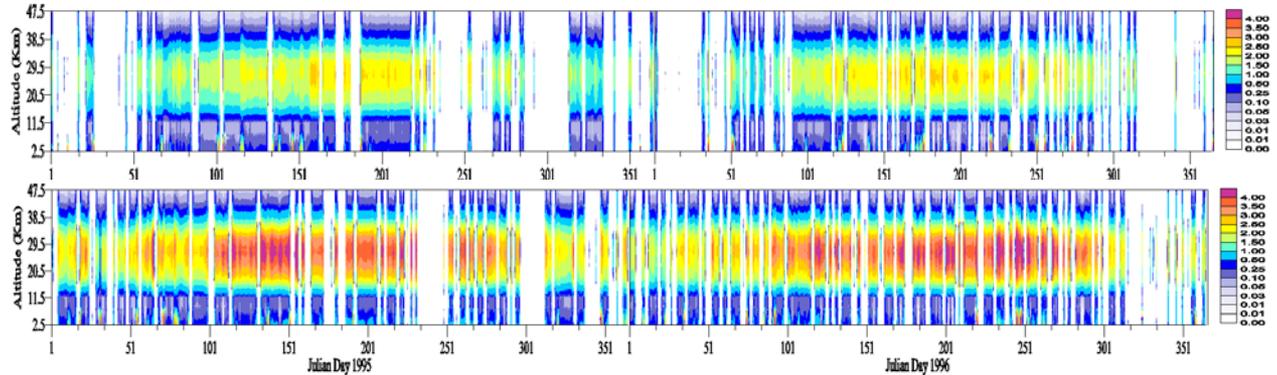


Antarctic Station Terra Nova Bay

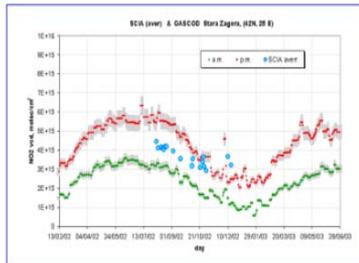
UV-Vis DOAS Ground – based instruments: / 1



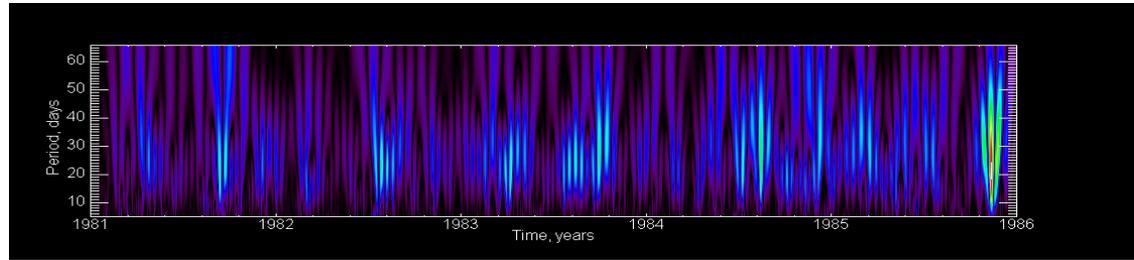
Since August 1993
@ Cimone, Italy



Stratospheric NO₂ a.m. and p.m. profiles

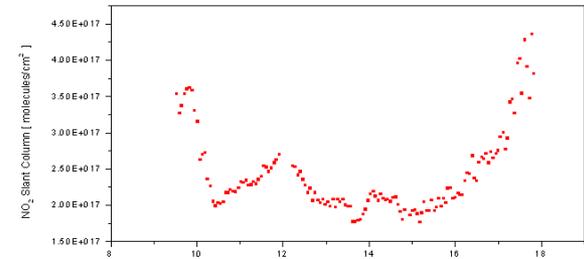


Since August 1999
@ Stara Zagora,
Bulgaria



Stratospheric NO₂ response to 27-day solar rotational cycle

Since Oct 2005
@ Accra/Tema,
Ghana



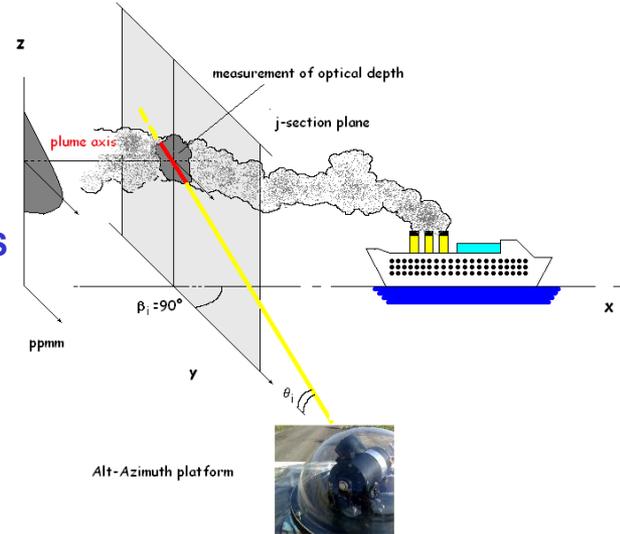
UV-Vis DOAS Ground – based instruments: / 2



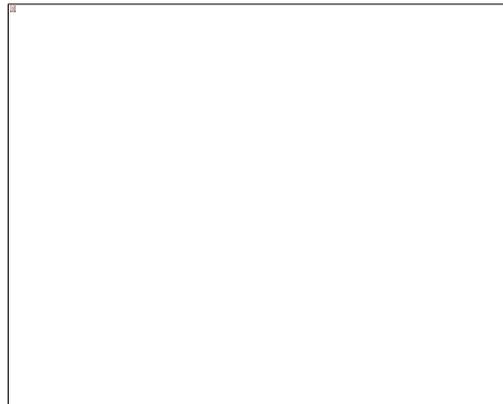
GASCOD @ TNB



Cruise Ships flow rate emission evaluated by means of passive DOAS instrument placed at the end of the Giudecca channel



GASCOD multi-input 295-700 nm ;
TEC CCD ; SR 0.5 nm;
Both active and passive mode

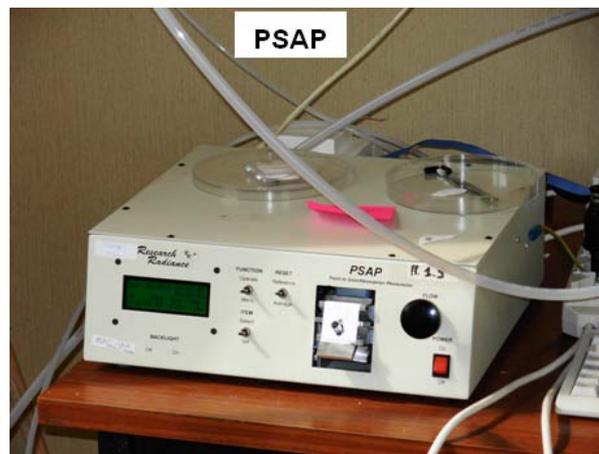


1-m gas cell for validation of DOAS instruments

Study and monitoring of radiative transfer processes in the atmosphere devoted to investigate processes in polar areas as well as in the Mediterranean region.

Measurements as well as radiative transfer code suitably modified and constrained by experimental results are used to deepen our knowledge on radiative processes, role played by aerosols, clouds, trace gases and surface characteristics, and forcing on the Earth's climatic system arising at local and regional scale by changes in concentration, distribution and physico-chemical characteristics of these atmospheric constituents.

- CH1 Kipp & Zonen Normal Incidence Pyrheliometer
- Radiance Research M903 nephelometer
- Radiance Research particle/soot abs. photom. (PSAP)
- UVISIR sun-photometer
- PREDE SkyRadiometer POM-02
- MFR-7 multi-filter rotating shadow band radiometer
- CG4 Kipp & Zonen Pyrgeometer



**Multi Filter Rotating Shadowband Radiometers
(MFRSR-7)**



UV-RAD Radiometer



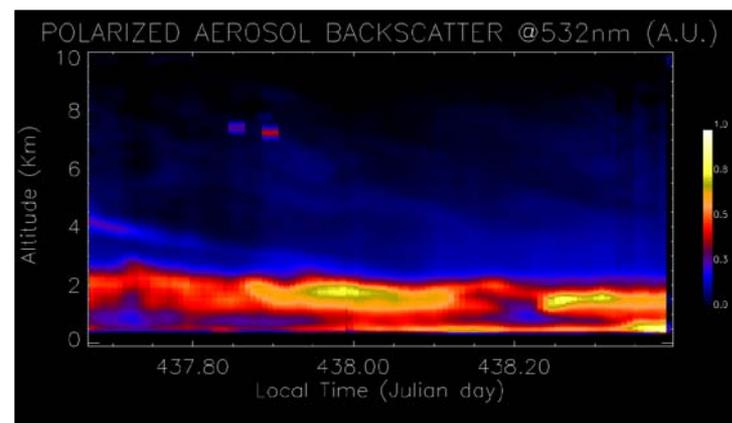
- Remote sensing of aerosol and thin clouds physical properties;
- Interaction Aerosol-Radiation-Atmosphere;
- Microphysics of aerosols and clouds;
- Development and use of lidar systems;
- Validation of satellite observations of aerosol and thin clouds;
- Saharan dust and Mediterranean aerosol;
- Impact of natural aerosols on air quality (PM_x);
- Polar Stratospheric Clouds and the Ozone Hole;
- Volcanic eruptions, aerosols and climate;



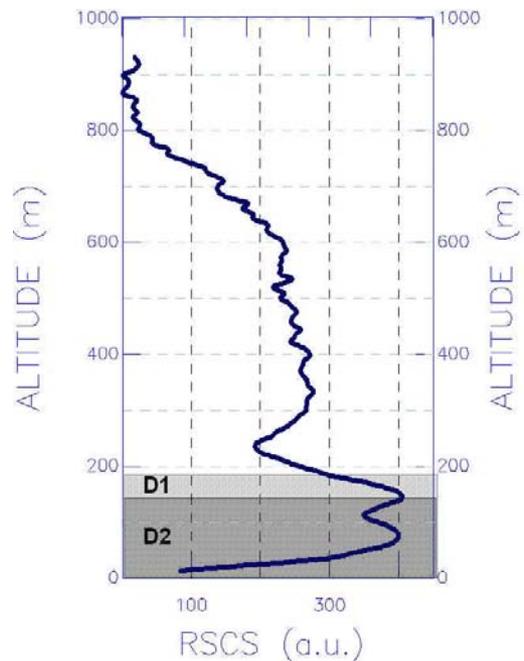
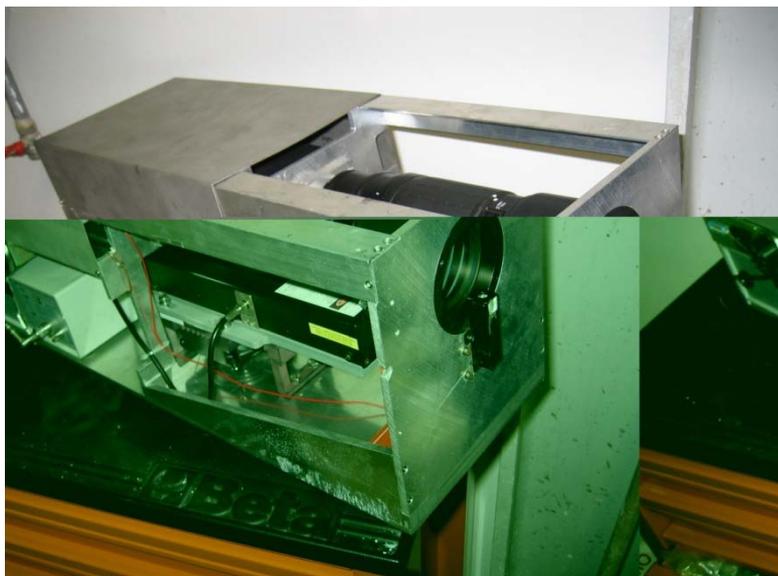
A view of the photometer and the transmitting antenna on the institute roof



Automatic mobile lidar of ENEA/ISAC-Rome operating at the San Pietro Capofiume station.

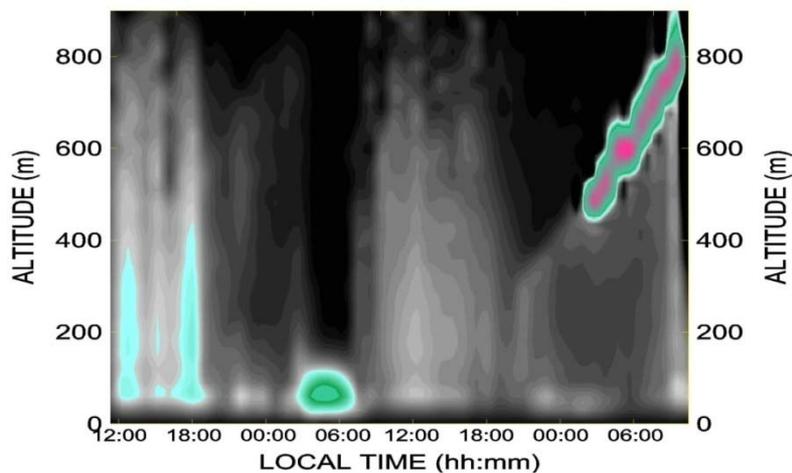


Time-patterns of the vertical profile of the polarized aerosol back-scattering ratio at 532 nm wavelength, measured on March 1, 2009

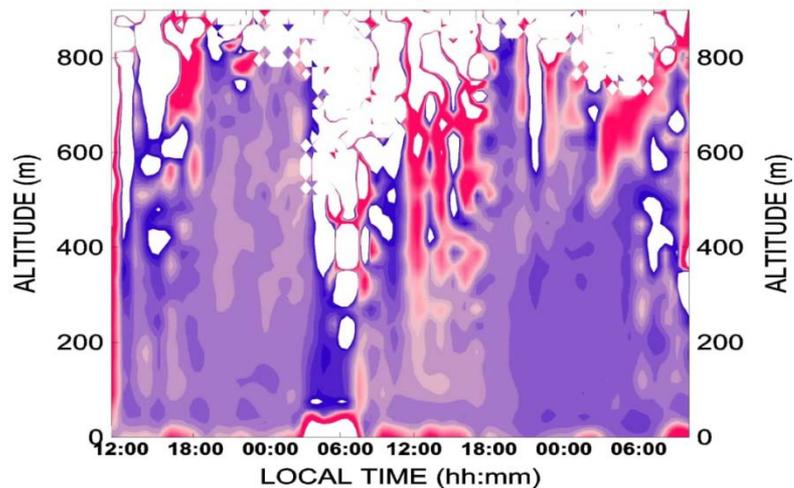


MICROLidar-LECCE
26/03/03 LT 21:00
Averaged time = 10 min

MAIN POLARIZATION SIGNAL
LECCE March, 26-28, 2003



VOLUME DEPOLARIZATION
LECCE March, 26-28, 2003



RTM

- **PROMSAR** MC model (**PRO**cessing of **Mu**lti**S**cattered **Atm.** **R**adiation)
(Palazzi, E. et al. , 2005)
- **MOCRA**: a **MO**nTe Carlo **C**ode for the simulation of **R**adiative Transfer in terrestrial **At**mosphere. (Premuda, M. et al. , 2010, submitted)

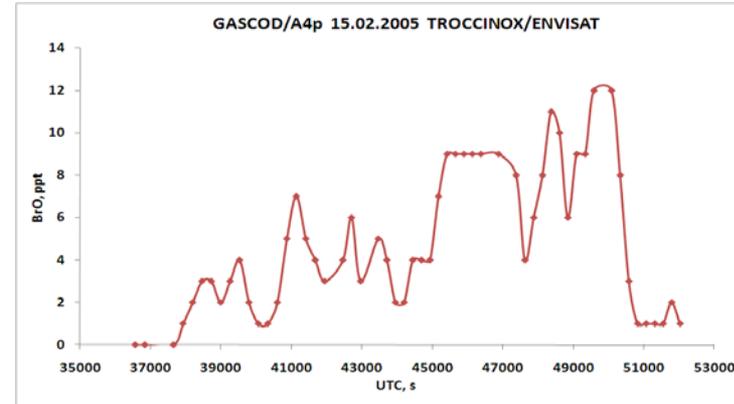
BOLCHEM (BOLam + CHEMistry)

is a coupled meteorological-chemistry model. Meteorological model is the hydrostatic mesoscale model BOLAM (Bologna Limited Area Model) (Buzzi et al., *Quart. J. Roy. Meteor. Soc.*, 2003) and chemical mechanisms are SAPRC90 and CB4 (SAPRC90 and CB-IV), (Mircea et al., 2008, *Atm. Env.*)

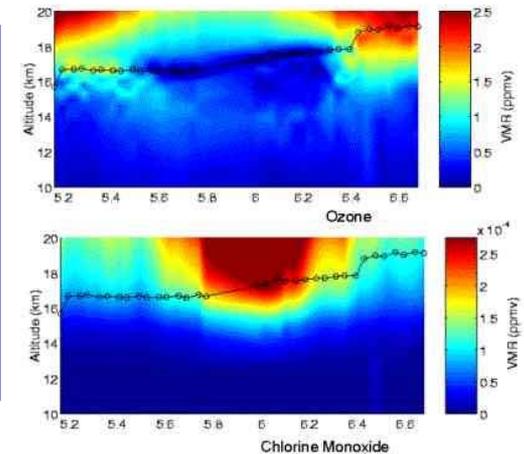
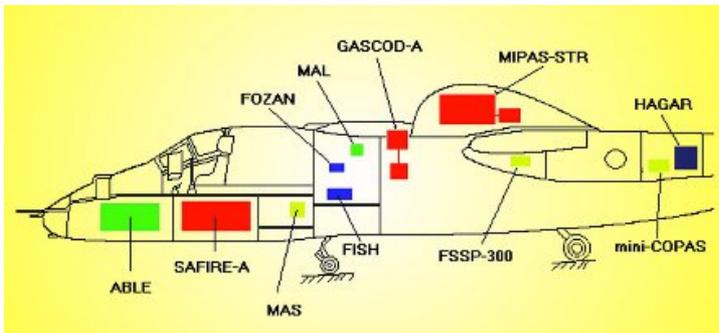
CHIMERE

is a 3D Eulerian chemistry-transport model. The meteorological fields are provided by the hydrostatic mesoscale model BOLAM
(Schmidt et al. *J. Geophys. Res*, 2001; Beekmann & Derognat, *J. Geophys. Res*, 2003).

..... and other models.



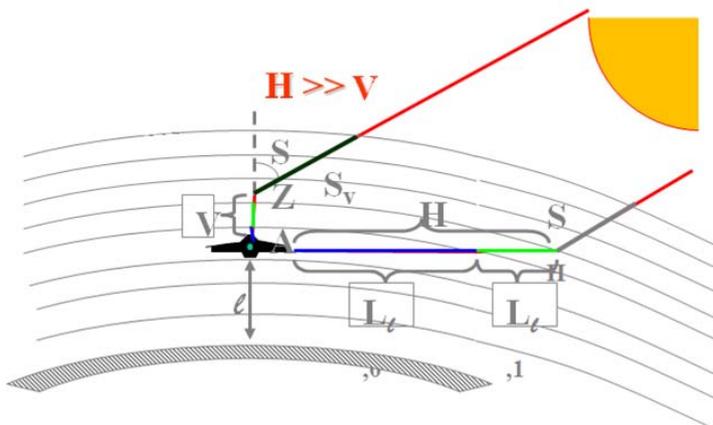
BrO derived by GASCOD-A4pi measurements
TROCINOX / Envisat campaign, Brasil, 15.02.2005



2D distributions of O₃ (upper panel) and ClO (lower panel) volume mixing ratio (in ppmv) measured by SAFIRE-A as a function of altitude and time (UTC) during the 990923 flight of the APE-GAIA campaign.



MAS aboard M55
Geophysics



ACILA Retrieval Methodology,
Petritoli et al, 2002



GASCOD-A/4π

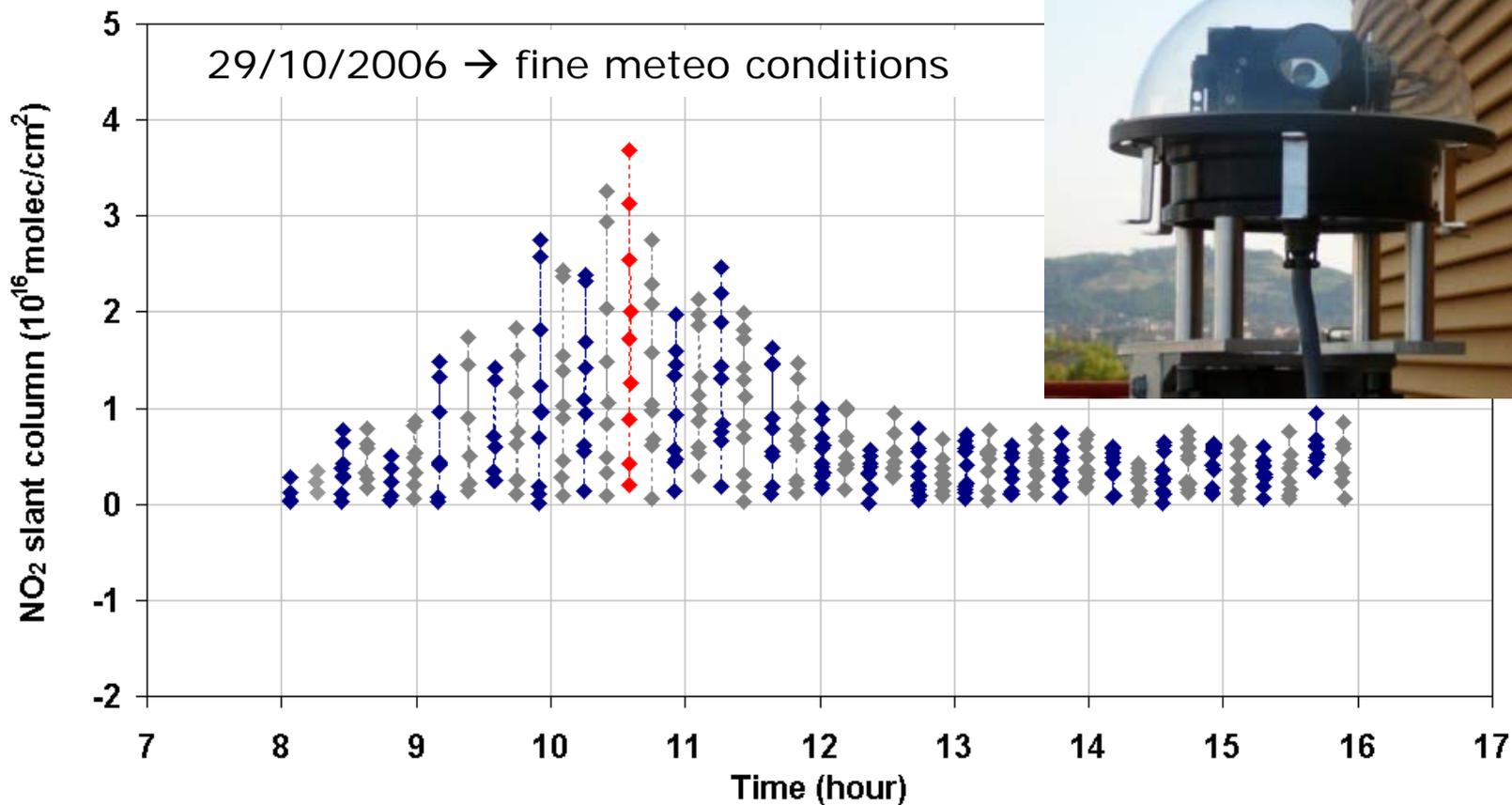


- Spectrally resolved actinic flux
- J(NO₂) evaluation

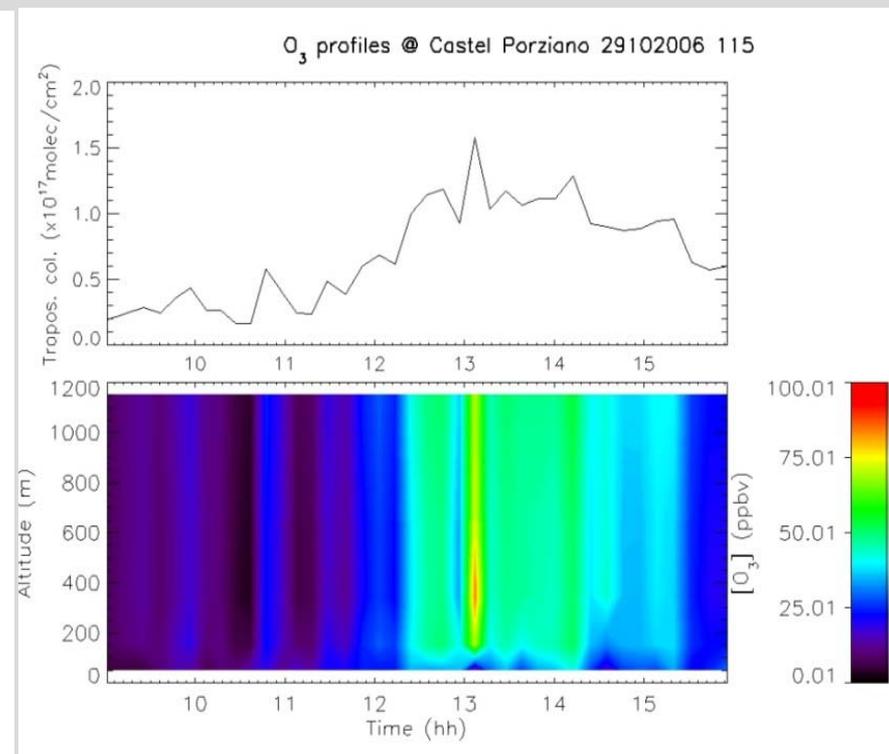
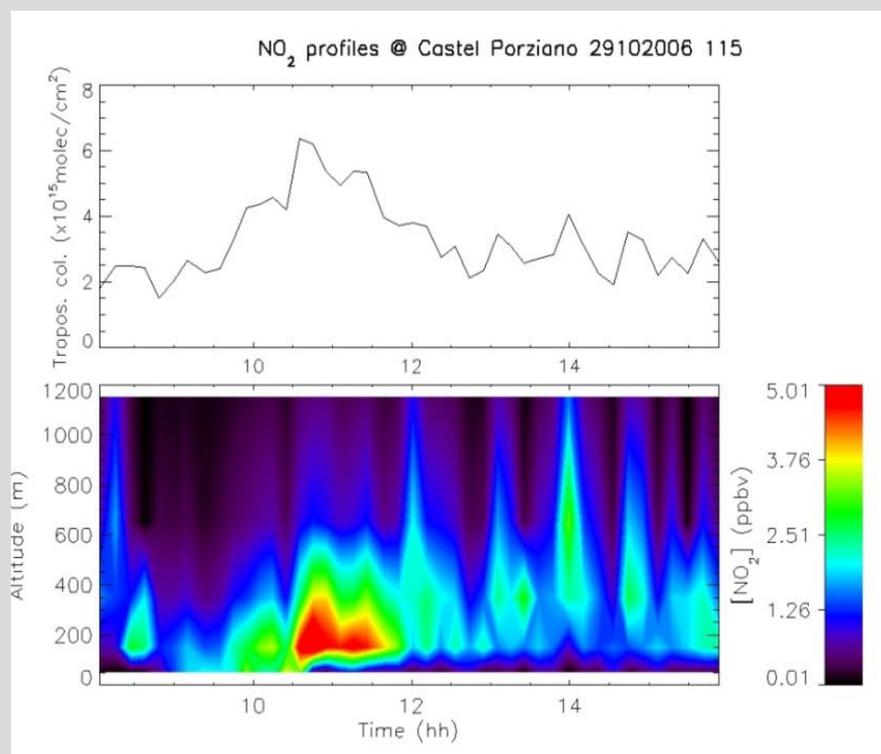
Kostadinov et al, 2009



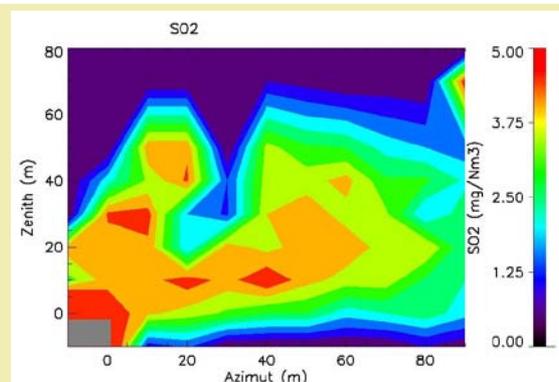
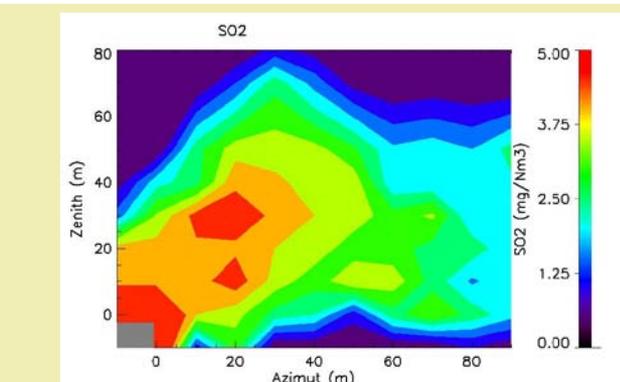
Example: Slant column measurements for vertical columns and profiles



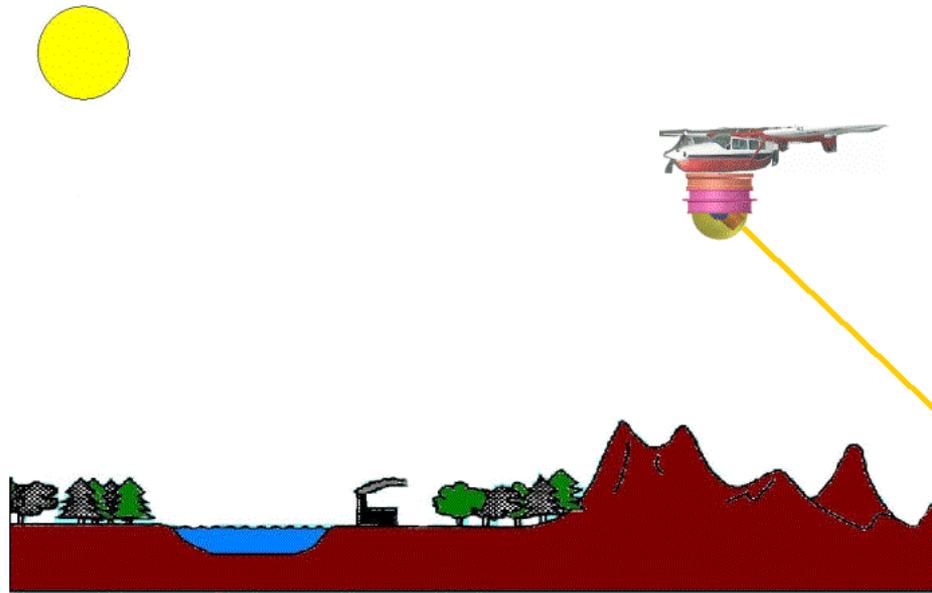
LOS: 60°, 70°, 75°, 80°, 84°, 87°, 88°, 89° (sza



NO₂ and O₃ vertical columns are anticorrelated (photochemistry)



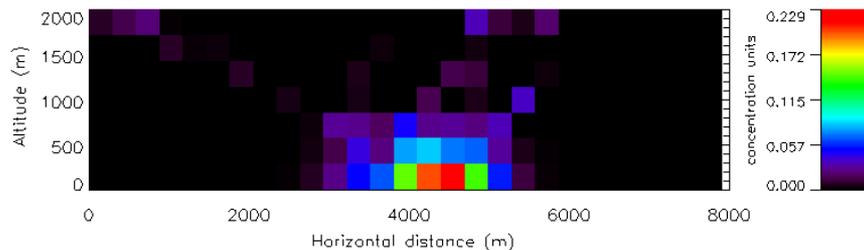
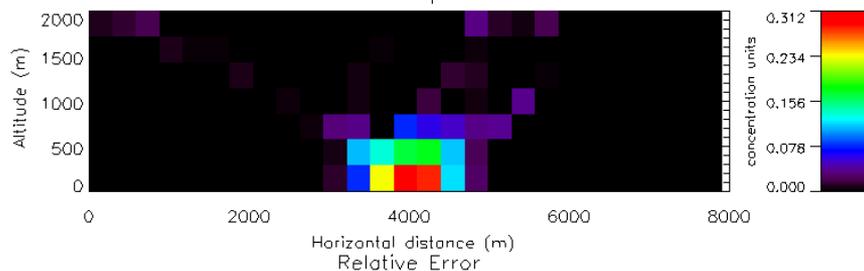
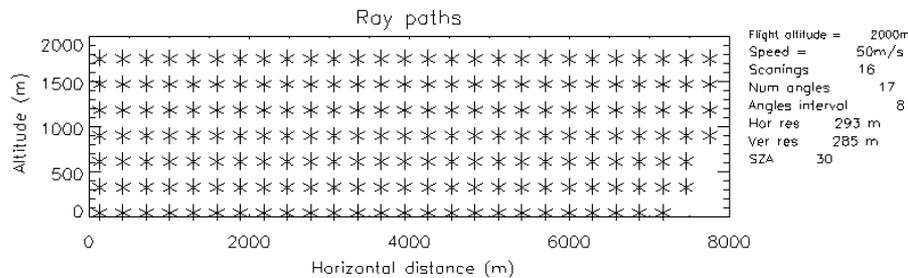
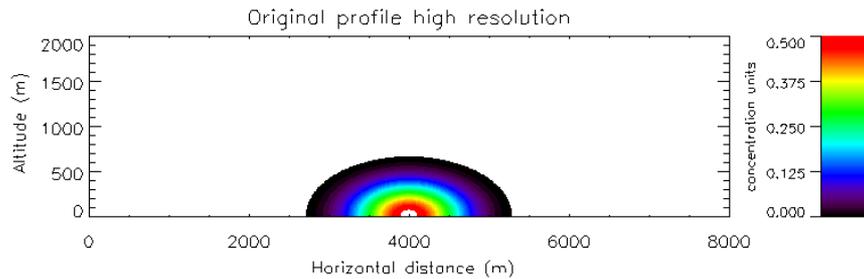
Maps of SO₂ around a target chimney derived by means of 2D scanning (30.06.2008).



Measurements for 2D and 3D reconstructions of pollutants distribution

TOGART model

(Tomographic retrieval of GASOCD observations based on the Algebraic Reconstruction Technique)



SIMULATIONS

Flight altitude:	2000 m
Aircraft velocity:	50 m/s
Scanning angles:	16
Scans:	17
Angle between 2 scans:	8°
Hor:	293 m
Vert:	285 m
SZA:	30°

DOAS measurements 2D mapping, tomography

Developed @ CNR-ISAC (Bologna, Italy)

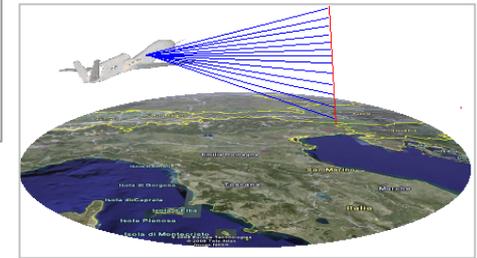
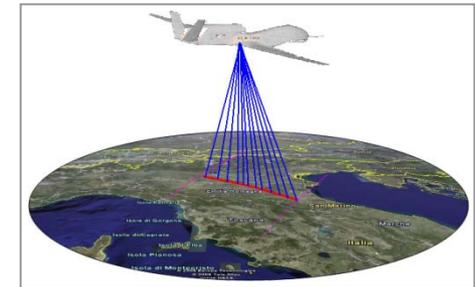
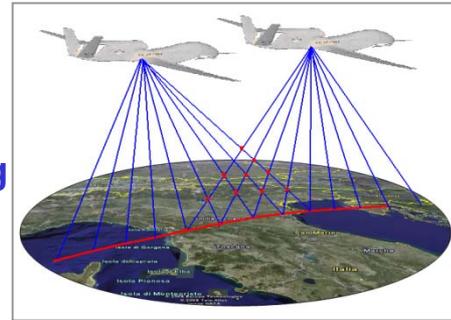
Weight: ~ Opt.Unit < 5kg ~ Elect Unit < 5kg

Volume: ~ 0.08 m³

Power consumption: < 350 W

n.b. all parameters To Be Confirmed

Gas concentration profiling Air Quality



Satellite data validation

Imaging UV-VIS spectrometer

- **Passive DOAS** (Differential Optical Absorption Spectroscopy)
- **Inversion methods**
- **Tomography**

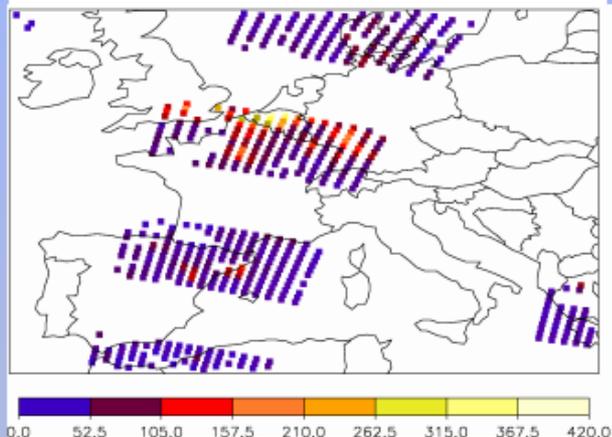
Spectral range: 295 ÷ 485nm (*simultaneously examined*), Spectral resolution: 0.6 ÷ 0.8 nm

Spatial cannels: 32

Scientific Products: column content of NO₂, O₃, BrO, SO₃ etc., 2D mapping, tomography, etc

Status: **In development, laboratory tests of the diffraction grating**

NO₂ tropospheric columns

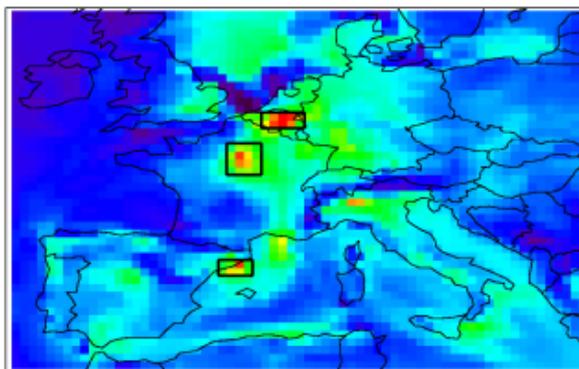
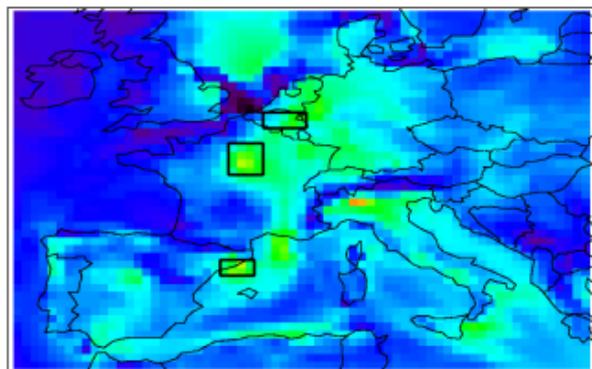


Case study 29th July 2004 - 4th August 2004

Horizontal resolution
of $0.50^\circ \times 0.50^\circ$ for
CHIMERE and
 $0.40^\circ \times 0.40^\circ$ for
meteorological model

In general the model
underestimates ozone
concentration, in particular
in polluted areas.
Assimilation can correct
these discrepancies

Ozone concentration at the ground level of model ($\mu\text{g}/\text{m}^3$) 30 July 2007 15 UTC



Assimilation
improves O₃ at the
ground level
mainly in the
polluted areas:
Paris area from 60-
100 $\mu\text{g}/\text{m}^3$ to 70-130
 $\mu\text{g}/\text{m}^3$, in **Belgium**
from 50-80 $\mu\text{g}/\text{m}^3$ to 90-
130 $\mu\text{g}/\text{m}^3$, in
Barcelona area from
70-90 to 80-130 $\mu\text{g}/\text{m}^3$

Atmospheric Group

Atmospheric Group of IFAC is part of the Development and deployment of passive and active techniques for atmospheric sounding project the Earth and Environment Department of CNR.

The scientific objectives are the study of the atmospheric composition and of the Earth radiation budget. The field of activity is climate change and atmospheric chemistry.

Framework

The research is performed within the framework of international programmes promoted by the European Community and the European Space agency (ESA), but also through bilateral collaborations with NASA and NASDA and with the support of the National Agencies, such as the Italian Space Agency (ASI) and the National Antarctic Research Programme (PNRA).





Activities

The "Atmospheric Group" of IFAC develops instruments, observation methods, forward models and retrieval techniques for the measurement of geophysical parameters for the study of the Earth's atmosphere.

The observations are made from high mountain sites, stratospheric balloons and aircrafts, and satellite using passive instrumentation operating at the different wavelengths (from the visible to radio).

Fourier transform spectroscopy is a specific competence of the group.

Important projects performed in the past are: IBEX, SAFIRE, APEGAIA, in which the group had the leadership and ASSETT, AMIL2DA and ICT-ONE in which the group participated. On going projects are: MIPAS, MARSCHALS, REFIR, KLIMA, CTOTUS and GOSAT.





The experience of Italian research groups regarding air quality and satellite observations were focalized into

QITSAT

agenzia spaziale italiana

An Italian Space Agency Pilot Project for Monitoring, Forecasting and Planning the Air Quality

CARLO GAVAZZI
Carlo Gavazzi Space SpA

ISAC

UNIVERSITÀ STATALE DI BREZICE

UNIVERSITÀ DEGLI STUDI DI MILANO
BICOCCA

SISTEMAS

MERLINO
TECHNOLOGY

arpa
agenzia regionale
prevenzione e
ambiente dell'emilia romagna

Arpa
PIEMONTE
Agenzia Regionale
per la Protezione dell'Ambiente



QUITSAT is an Italian pilot project funded by the Italian Space Agency (ASI) and led by Carlo Gavazzi Space (*Prime Contractor*) from 2006 to 2009, for developing a system devoted to Air Quality (AQ) assessment through the fusion of observations coming from polar and geostationary satellite sensors, ground-based data and CTM models

Project domain: Po valley area (Northern Italy)

The strategic objectives of QUITSAT Project were twofold:

- to promote in Italy the development of Earth Observation (EO) applications (*i.e. products and services based on satellite data*)
- to study and implement application missions of pre-operational or operational type.

Therefore, the QUITSAT system was designed to:

- Explore the potential use of Earth Observation (EO) data.
- Fuse satellite data with ground-based remote sensing data from traditional technologies.
- Set up operational tools for Air Quality (AQ) management useful for decision makers.
- Take into account the Users role for priorities and requirements definition on AQ.



Satellite Observations

- MODIS/EOS-Terra
- EOS-Aqua
- SCIAMACHY/Envisat
- SEVIR/MSG
- MOPITT/EOS/-Aura

Modelling

- Chem. Transp. 3D models (TCAM and CHIMERE)
- Stochastic and Deterministic Forecasting
- Integrated Assessment Mod. for AQ policies

QUITSAT

Ground-Based Measurements

- Gas and PM in-situ sampling
- Sun-photometry and radiometry
- DOAS
- LIDAR

End User

- Requirements and System Assessment provided by Regional Italian EPA



The QUITSAT system consists of the 3 following sub-systems:

(1) PM and Gas monitoring, which is subdivided into Part A (for PM) and Part B (for gases): it provides estimates of the ground concentration of Particulate Matter (PM_{2.5} and PM₁₀) and gaseous pollutants (NO₂, O₃, SO₂ and HCHO) through the fusion of Earth Observation data, ground-based measurements and chemical transport models (CTM).

(2) PM and Gas forecasting over short-term periods.

(3) AQ planning is a stand-alone tool dedicated to the Air Quality planning support and aimed at evaluating the impact of sustainable emission scenarios and the costs of emission reductions.



PM Monitoring sub-system provides estimates of ground-level PM mass concentrations $PM_{2.5}$ and PM_{10} through the integration of the PM columnar content data derived from satellite observations (mainly MODIS/Terra and MODIS/Aqua) with

a) PM concentration data given by ground-level measurements taken at the EPA sites;

b) continuous measurements of the aerosol scattering and absorption extinction coefficients at ground-level performed with nephelometers and Particle Soot Absorption Photometers (PSAP) at some Po valley sites;

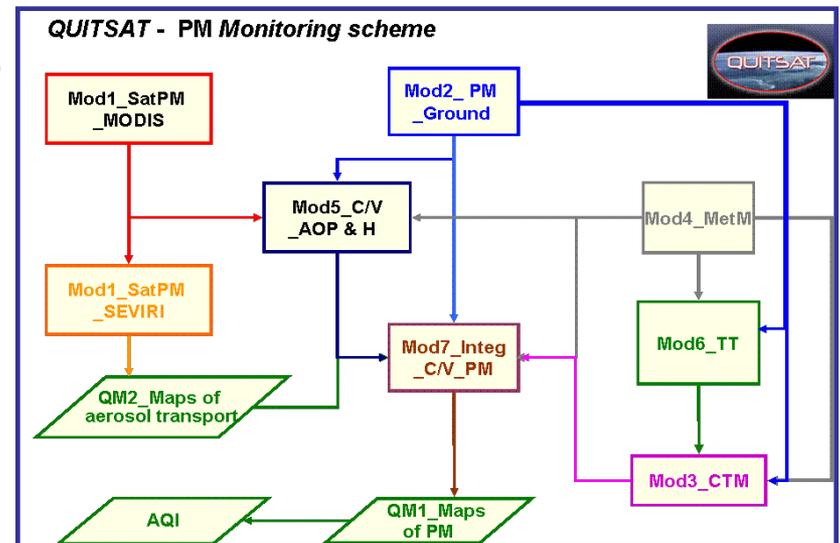
c) ground-based measurements of aerosol optical depth using multi-wavelength sun-photometers;

d) ground based measurements of the vertical profile of aerosol extinction coefficient with lidar techniques to determine the time-patterns of aerosol scale height H_a (H-type parameters)

(see Tomasi (1981) in the Po Valley, and Kaufmann and Fraser (1982) in the United States);

e) evaluations of the mixing layer height H_{mix} from meteorological models;

f) evaluations of mixing layer height H_{mix} from CTM modelling.





The philosophy of the PM sub-system is based on the following equations:

$$\tau_{a,\lambda} = \int_0^{z_t} dz \int_{r_m}^{r_a} dr \int_{i_n}^{i_x} Q_{\lambda}^e(r, m) \pi r^2 n(r)$$

where $\tau_{a,\lambda}$ is the aerosol optical depth at wavelength λ , $Q_{\lambda}^{ext}(r, m)$ is the Mie extinction efficiency factor of an aerosol particle having radius r , $n(r)$ is the size-distribution of the aerosol number concentration for real conditions of air relative humidity RH , dell'aria, and m is the particulate complex refractive index.

$$\tau_{a,\lambda} = \int_0^{z_t} \rho(z) \sigma_{\lambda}^{ext}(z) dz$$

where $\rho(z)$ is the aerosol mass concentration measured in $[mg/m^3]$ at altitude z , and $\sigma_{\lambda}^{ext}(z)$ is aerosol extinction cross-section measured per aerosol unit mass measured at altitude z in m^2/mg .

$$\rho(0) = \frac{\tau_{a,\lambda}}{\sigma_{\lambda}^{ext}(0) H_a}$$

where use is made of the concept of aerosol scale height H_a defined by Kaufmann and Fraser (1982) and calculated as the ratio between the aerosol optical depth measured at a visible wavelength and the ground-level volume extinction coefficient in the visible. Parameter H_a serves to “scale” the optical depth $\tau_{a,\lambda}$ down to the ground-level aerosol mass concentration $\rho(0)$.

$$P_{2.5} = \frac{\tau_{a,2.5}}{\sigma_{e,dx,2.5}(0) F(R; \gamma) H_M}$$

which allows to derive the value of the dry particle $PM_{2.5}$ from the value of $\rho(0)$ by **i)** reducing the aerosol optical depth $\tau_{a,\lambda}$ to the fraction due to fine particles (with radius $r < 1.25 \mu m$), **ii)** correcting the extinction effects produced by the particle growth as a function of RH , and **iii)** representing H_a in terms of parameter H_{mix} , as defined by well-known meteorological models (MM5, WRF).

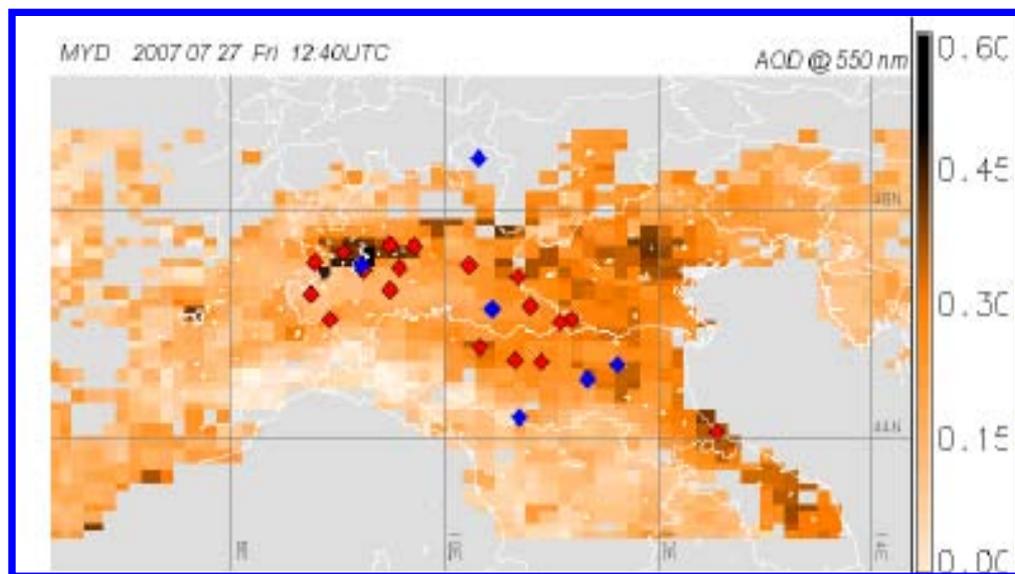
$$P_{2.5} = \frac{A_{i,j} \eta \tau_a}{F_h (R; \gamma) H_M} + B_{i,j}$$

where aerosol optical depth $\tau_{a,2.5} = \eta \tau_a$ due to fine particles only and quantities H_{mix} and F_{hyg} can be defined in a space-temporal coincidence in such a way to define parameters $A_{i,j}$ $[mg/m^2]$ and $B_{i,j}$ $[mg/m^3]$ relative to the i -th pixel and j -th month.



PM measurements have been routinely performed at the numerous particulate matter (PM) stations of the ARPA Lombardy, ARPA Emilia-Romagna and ARPA Piedmont networks, together with those taken at the 6 QUITSAT super-sites during some seasonal campaigns, when supplemental field measurements of aerosol optical depth (AOD), aerosol optical properties (AOP) and H-type parameters were performed.

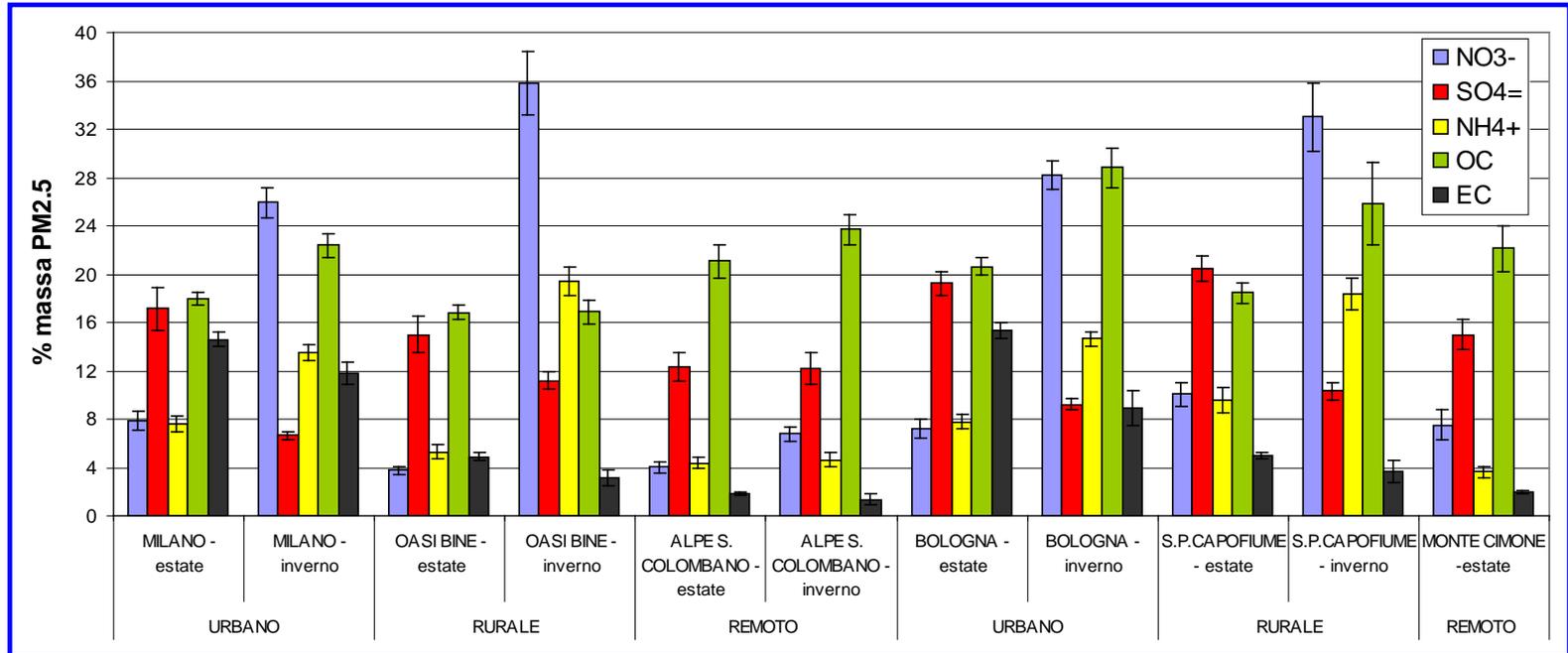
The use of the 3D fields of PM given by CTM models contributes to improve the coverage of the QUITSAT domain in both space and time.



Northern Italy map of aerosol optical depth $\tau_a(550\text{ nm})$ defined on July 27, 2007, from MODIS/Aqua data, indicating the PM measurement ARPA sites used to calibrate the satellite data (\blacklozenge) and the chemical analysis sites (\blacklozenge), where simultaneous measurements of $\text{PM}_{2.5}$ chemical composition with 24-h samplings, $\tau_a(550\text{ nm})$ with sun-photometers, vertical profiles of particle extinction coefficient with lidar techniques were performed.



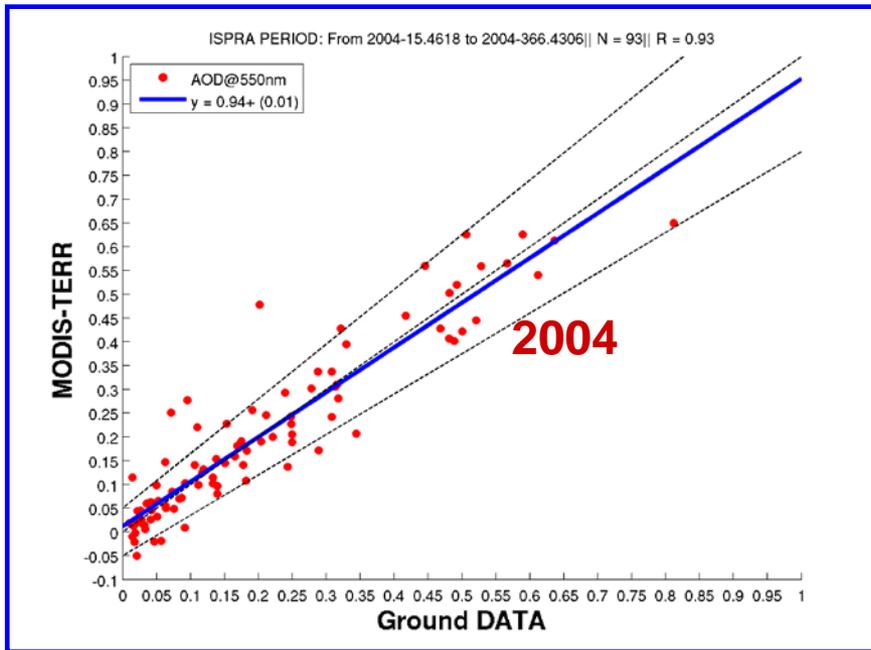
In-situ PM sampling measurements



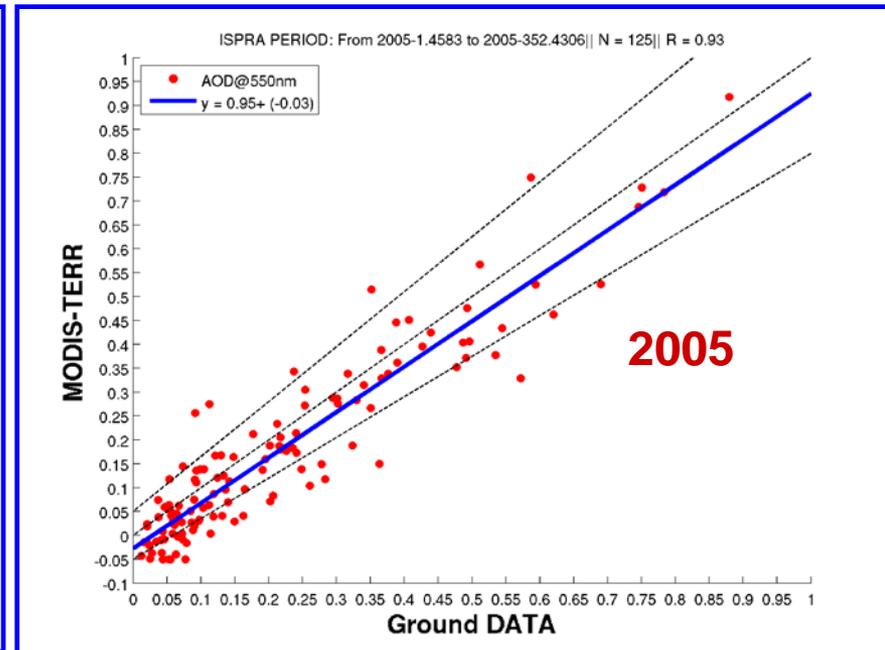
The chemical composition of particulate matter sampled in summer and winter periods at the urban sites of Milan and Bologna, rural sites of Oasi Bine and San Pietro Capofiume, and high-altitude mountain sites of Alpe San Colombano and Monte Cimone (both at altitude of more than 2000 m a.m.s.l.) presents mass percentages of nitrate ions, sulfate ions, ammonium, organic carbon and elemental carbon which are similar to those of the Atlantic Ocean coastal region in the United States. Therefore, the algorithms defined in the Po Valley area could find a good application also in such an area of the United States.

Here two examples are shown, relative to MODIS/Terra data taken in the years **2004** (left) and **2005** (right) and presenting high regression coefficients.

τ_a (550 nm) measured by the Cimel CE-318 at the AERONET Ispra



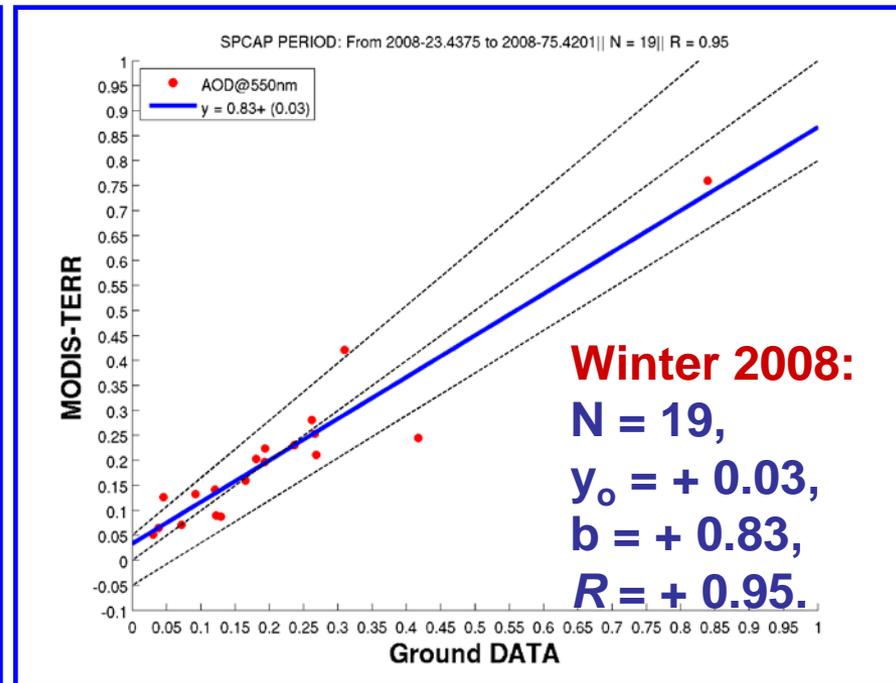
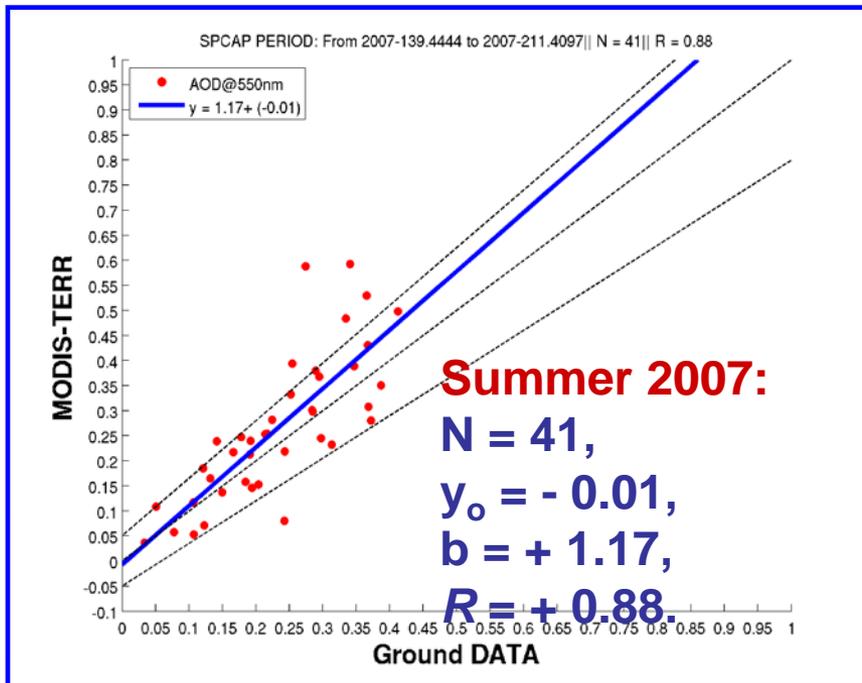
N = 93,
Intercept = + 0.01,
Slope coeff. = + 0.94,
Regression coeff. R = + 0.93.



N = 125,
Intercept = - 0.03,
Slope coeff. = + 0.95,
Regression coeff. R = + 0.93.



Module Mod5_C/V_AOP & H serves to intercompare the various PM data provided by module Mod2_PM_Ground and compare them with the τ_a and AOP data derived from MODIS and SEVIRI satellite. In particular the **validation** of the satellite-borne τ_a data was made through comparison with τ_a data simultaneously recorded using the CIMEL sun-photometers at the AERONET sites of Ispra and Venezia A.A. the PREDE POM02L sun/sky-radiometer at San Pietro Capofiume, and the MFRSR-7 shadow-band radiometer at Bologna.

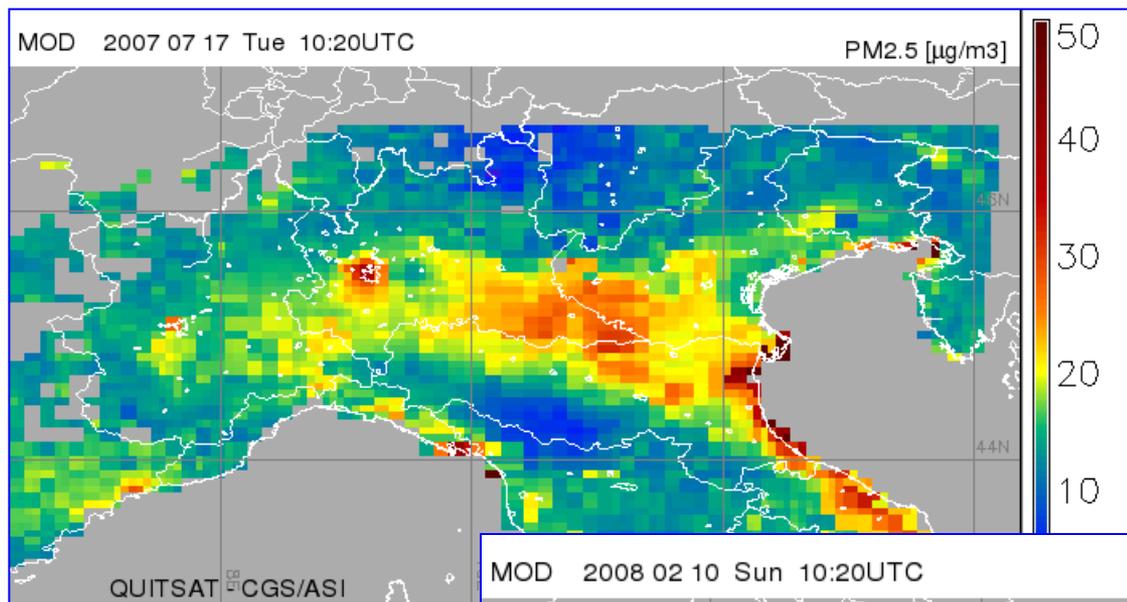


τ_a (550 nm) retrieved from MODIS/Terra during the summer 2007 (left) and winter 2008 (right) campaigns at **San Pietro Capofiume** versus τ_a (550 nm) measured with the PREDE sun/sky-radiometer.

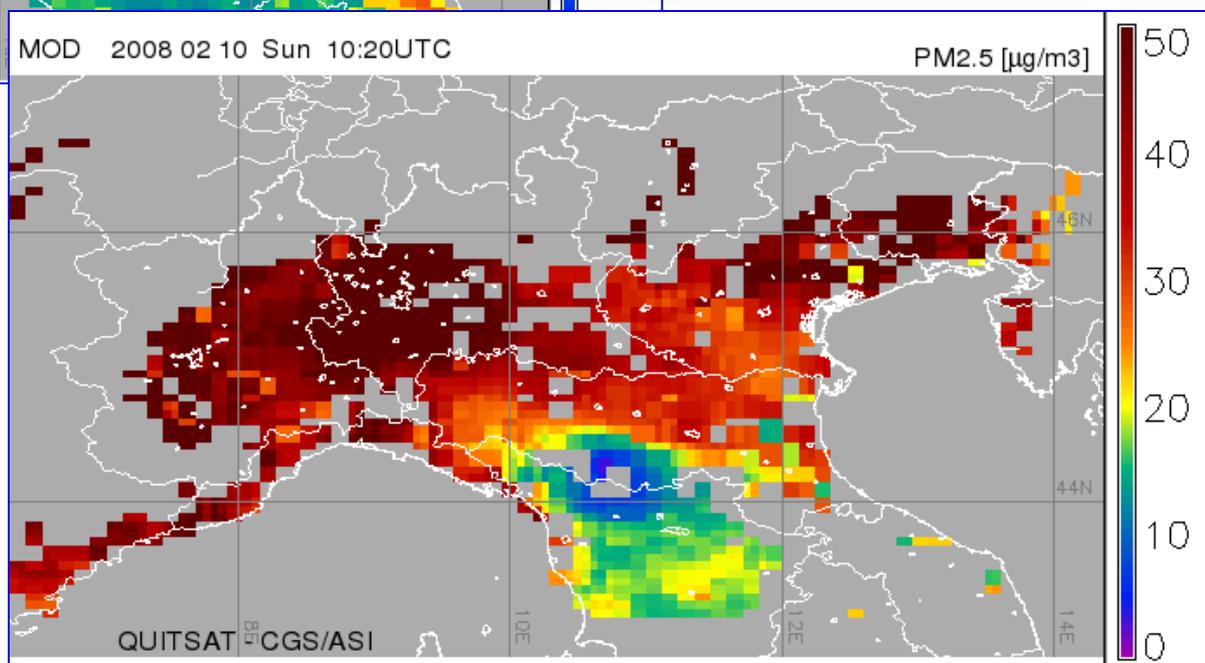


QM1 product

MODIS/Terra-based PM2.5 ground level maps



July 17th, 2007



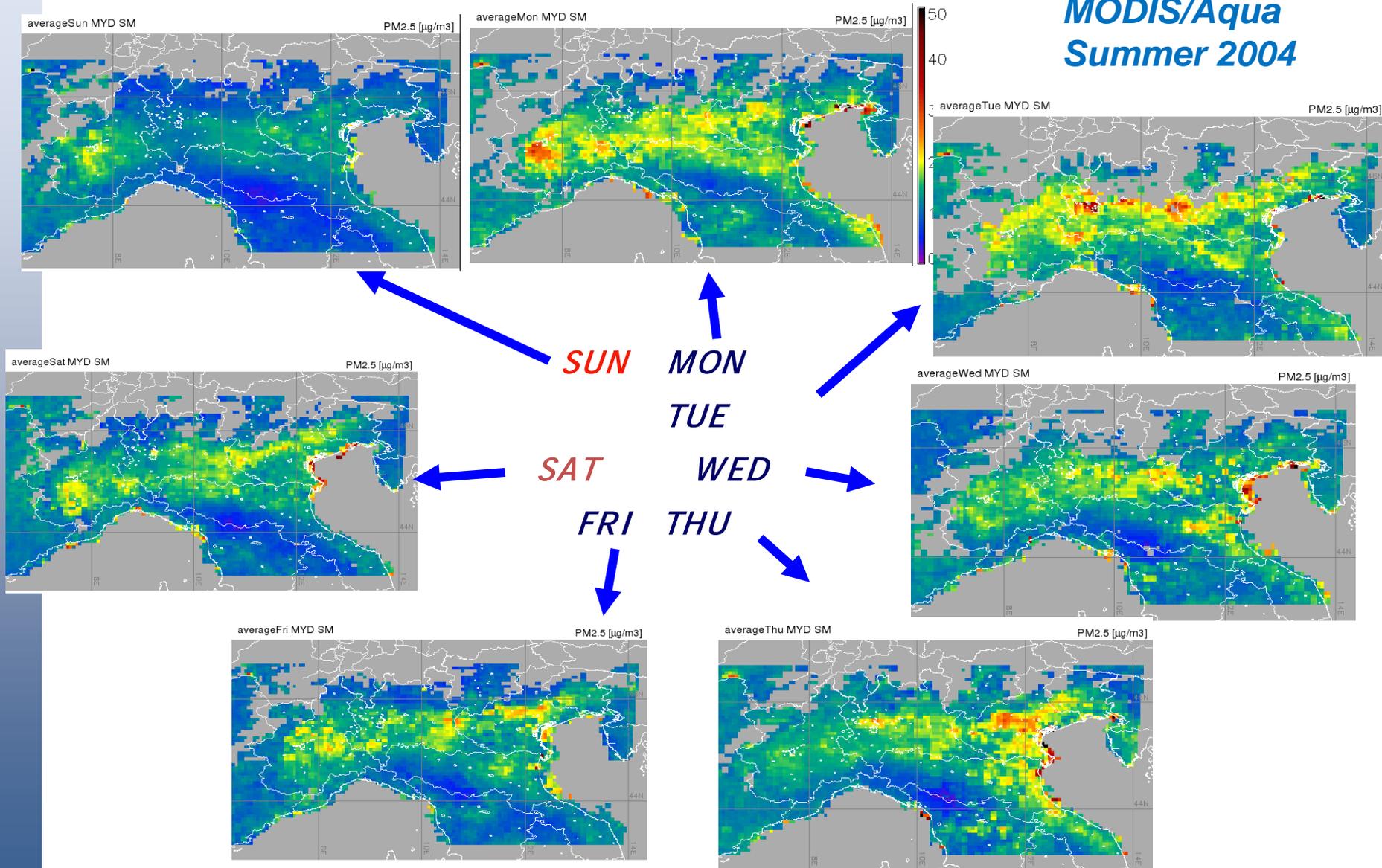
Feb, 10th 2008



QM1 product

MODIS-derived PM2.5: Weekly cycle maps

MODIS/Aqua Summer 2004

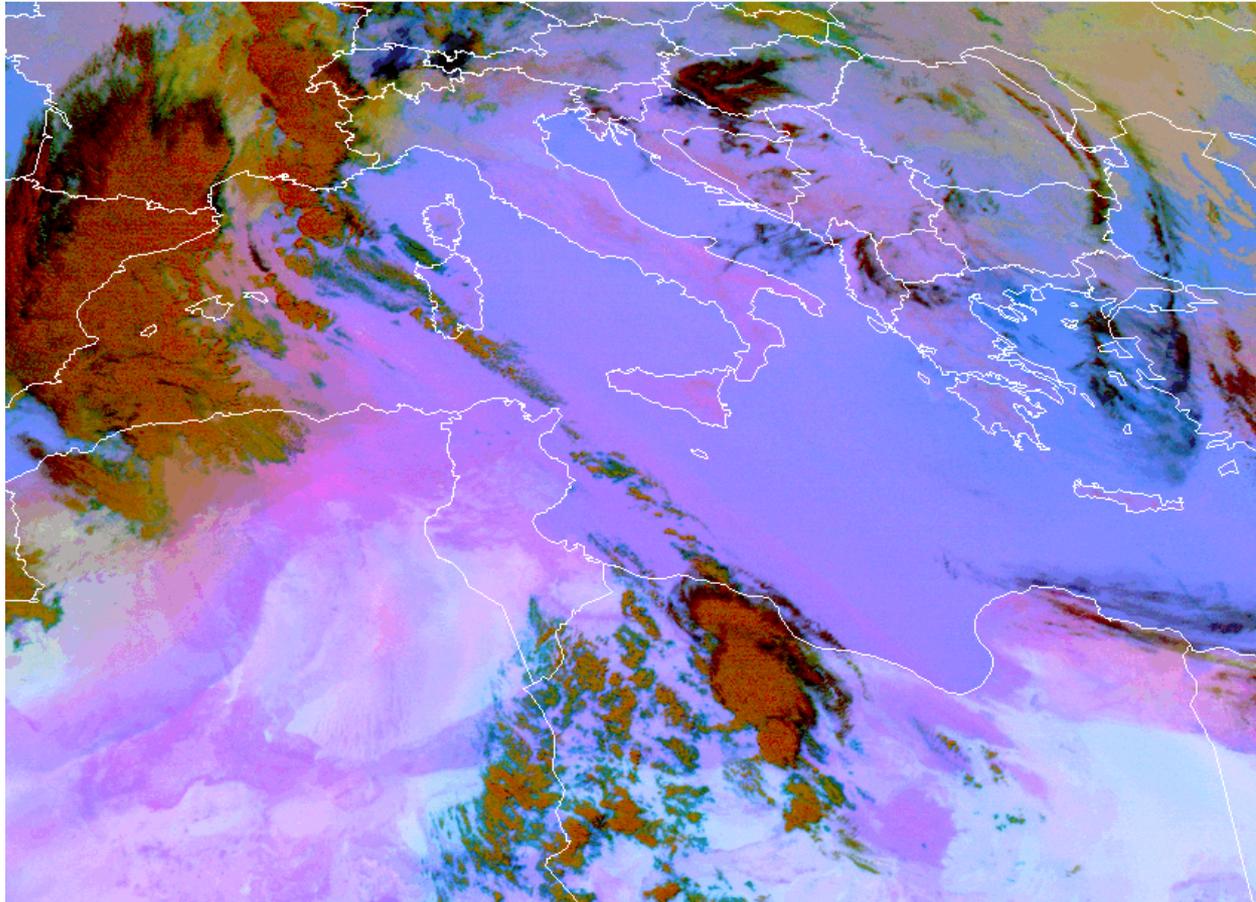




Maps of aerosol transport

SEVIRI/MSG DDI-BTD

2008-05-27 00:15 UTC



cold, thick, high level clouds	thick mid-level cloud	low-level cloud (cold atm, Europe)	thin cirrus clouds contrails	thin, mid-level cloud	low-level cloud (warm atm, Africa)	dust storm
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QITSAT - CGS/ASI

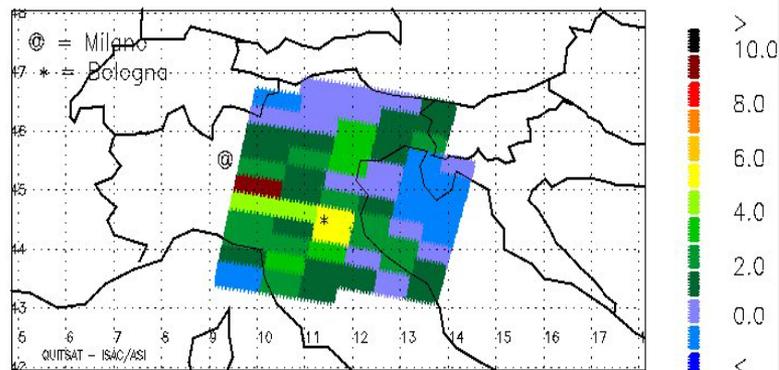
Sequence of SEVIRI/MSG images describing a transport episode of desert dust from Sahara toward Mediterranean Sea.



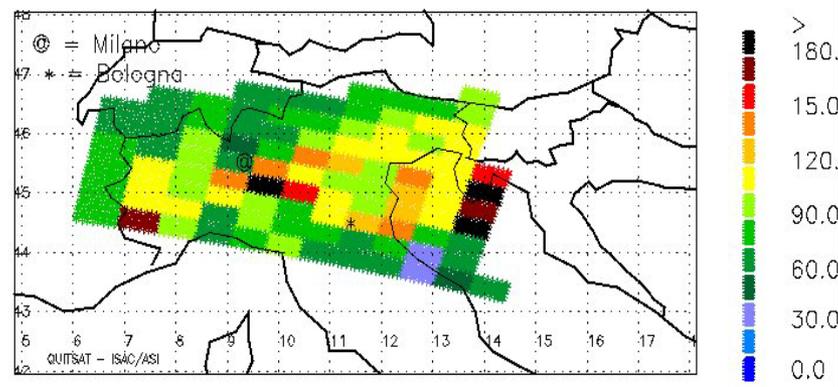
QM3 Product

Estimation of near-surface NO₂, HCHO, SO₂, O₃ concentrations considering satellite and model data validated by means of ground-based measurements

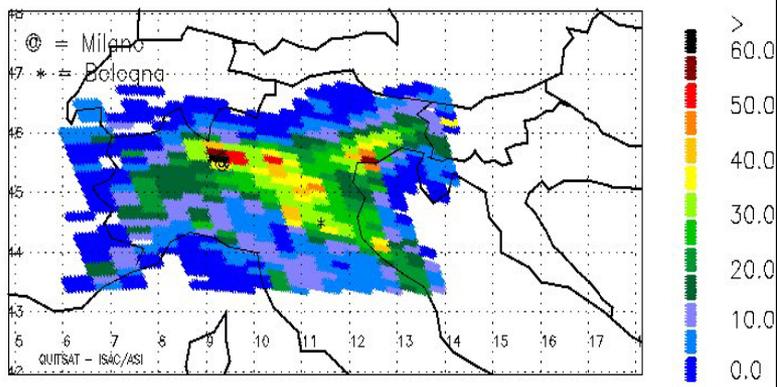
19072004 HCHO concentration



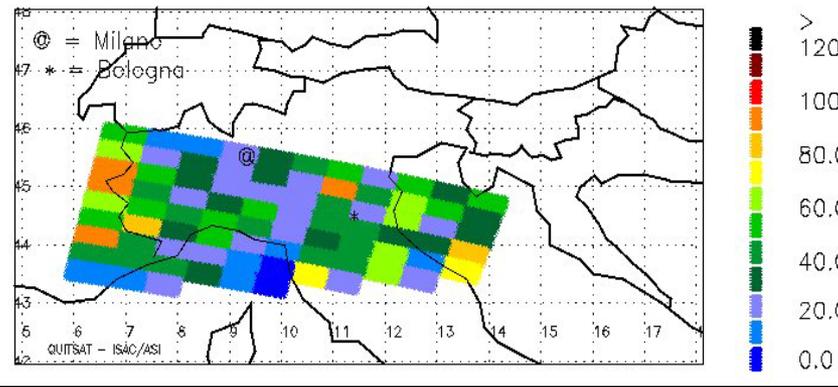
01092004 O₃ concentration



13032008 NO₂ concentration

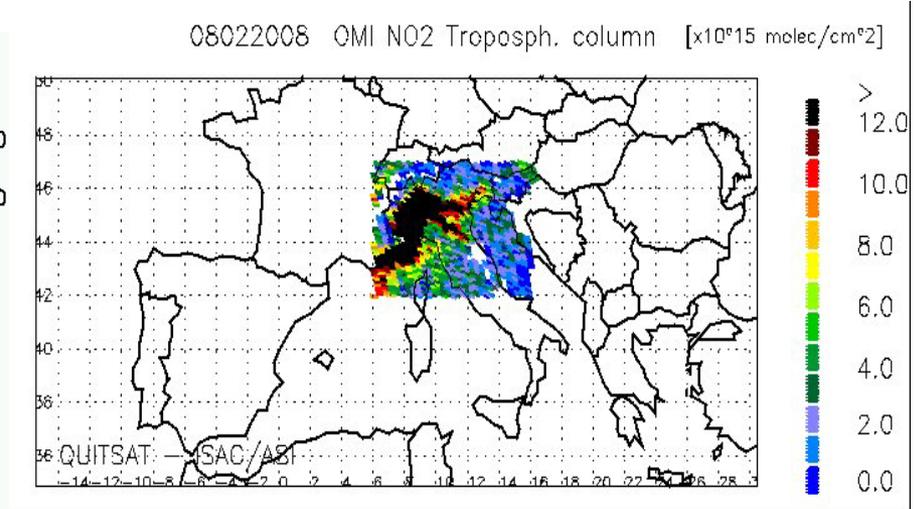
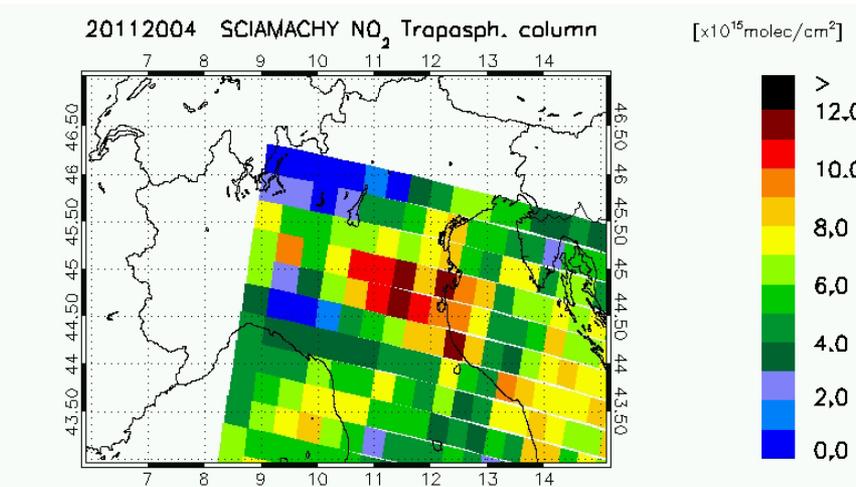


28052007 SO₂ concentration





Earth Observations (EO)



SCIAMACHY/ENVISAT

[DOAS processor @ ISAC-CNR
(Petrìoli et al., 2006)]

- NO₂, O₃, HCHO, SO₂ (tropospheric column)
- resolution: 30km x 60km
- 1 overpass / 3-6 days
- period: 2004

OMI/AURA

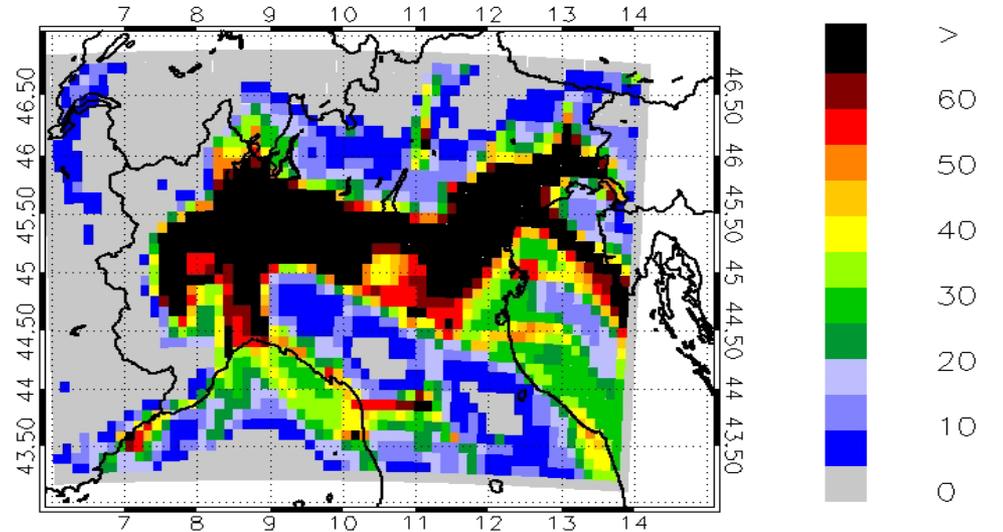
provided by KNMI www.temis.nl

- NO₂ (tropospheric column)
- resolution: 13km x 12km
- 1-2 overpass* / day
- period: field campaigns 2007-2008



CTM

20080206 TCAM surface NO2 @ 10



GAMES (*Volta et al., 2006*)

- vertical profiles of NO₂, O₃, HCHO, SO₂ etc.
- spatial grid: 10km x 10km
- hourly average
- photochemical model TCAM (*Carnevale et al., 2008*); meteo preprocessor PROMETEO; emission processor POEMPM (*Carnevale et al., 2008*)



EO/CTM integration

Model profile

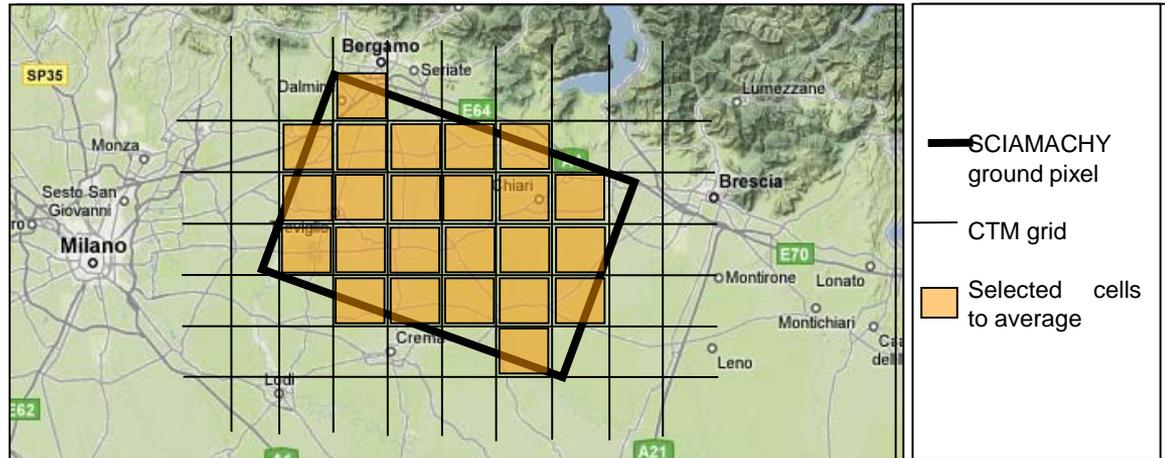


Column



Satellite column (C_s) and its error (ΔC_s)

Averaged model column (C_M) within satellite pixel and its standard deviation (ΔC_M)





QM3 Product

The merging between satellite values and CTM simulations to get an improved ground level NO₂ concentration, is done according to the following steps:

i) the NO₂ tropospheric column from satellite (C_S) and its error (ΔC_S) are estimated using DOAS technique;

ii) similar quantities are obtained from the GAMES model (C_M and ΔC_M) by integrating the vertical profile to get the tropospheric columns (the model vertical extension is up to 4km). All the C_M whose central latitude and longitude match the satellite ground pixel area are then averaged to get the final C_M and ΔC_M is its variance.

iii) a corrected column (C_C) is thus calculated using C_M and C_S according to the following formula

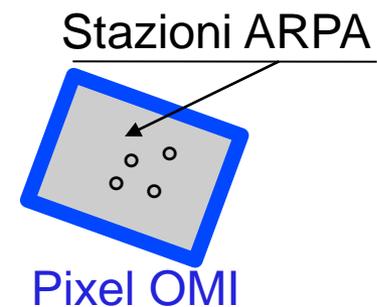
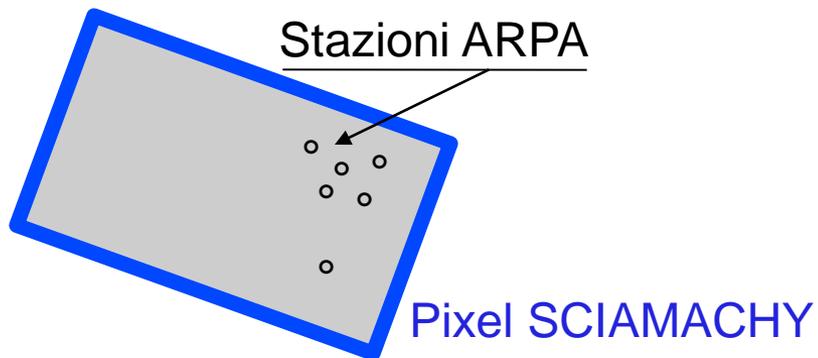
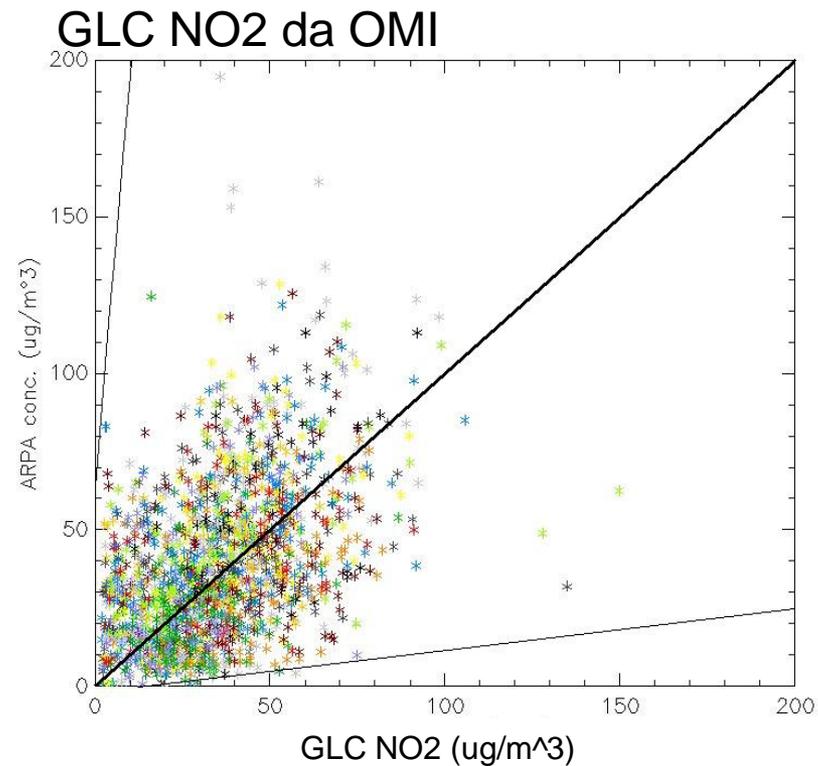
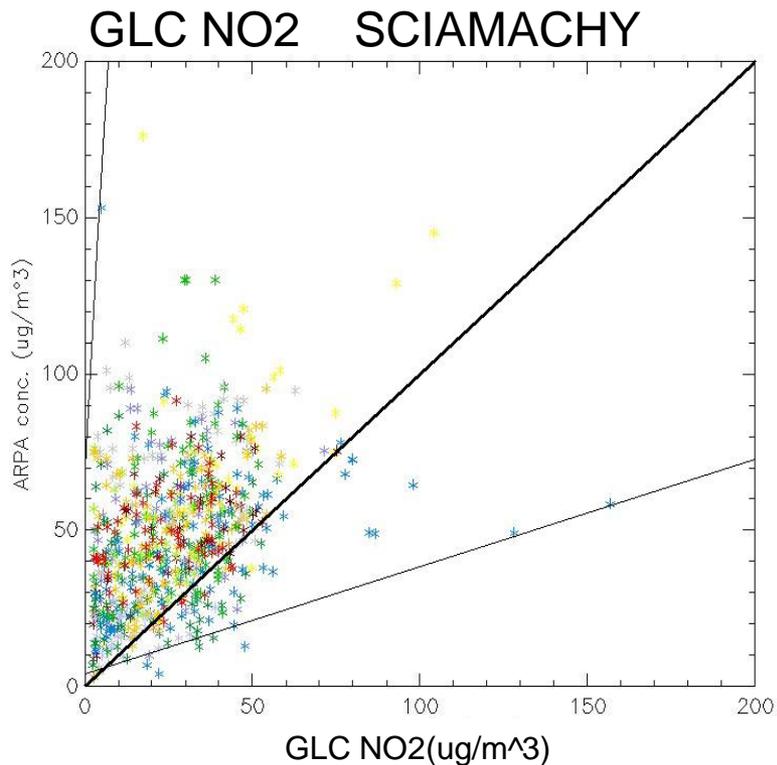
$$C_C = \frac{\left[\left(\frac{C_S^2}{\Delta C_S} + \frac{C_M^2}{\Delta C_M} \right) \right]}{\left[\left(\frac{C_S}{\Delta C_S} + \frac{C_M}{\Delta C_M} \right) \right]} \xrightarrow[V3]{V2} C_C = \frac{a \cdot C_M + b^2 \cdot C_S}{a + b^2} = \frac{\frac{1}{b} \cdot C_M + \frac{b}{a} \cdot C_S}{\frac{1}{b} + \frac{b}{a}}$$

C_C is a weighted average between C_M and C_S where the respective errors are the weights; $a = 1/\Delta C_M$, $b = 1/\Delta C_S$

iv) an average NO₂ profile corresponding to the satellite ground pixel is calculated from the model simulations and the respective column is scaled so to be equal to C_C obtaining then a corrected profile. The Ground Level concentration, thus Corrected, is considered the final product (GLC_{NO2}).



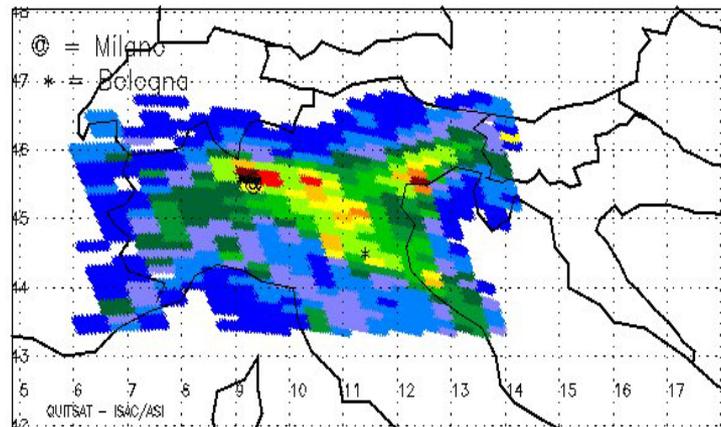
QM3 Product





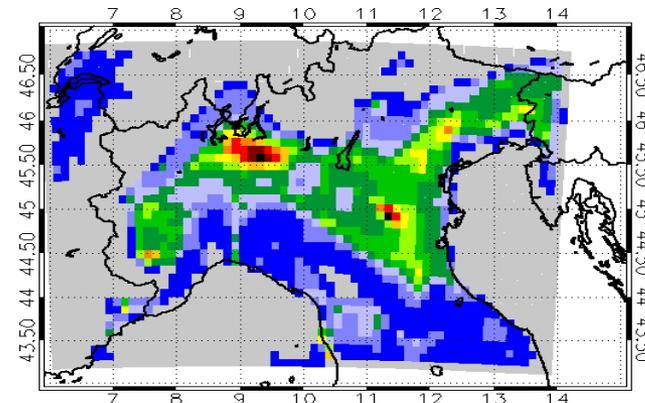
QM3 products, maps of ground-level gaseous concentrations

13032008 NO2 concentration



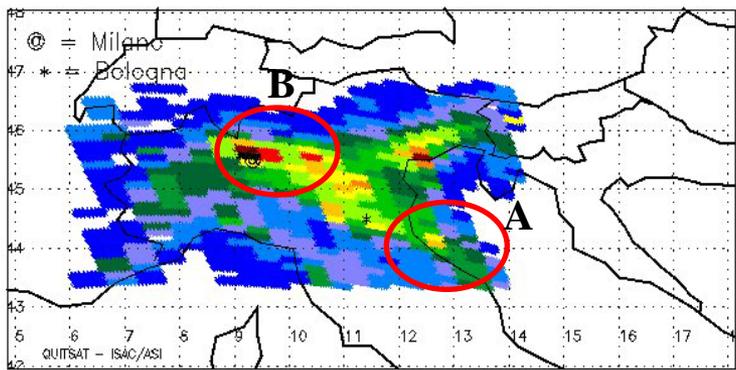
[ug/m³]

20080313 TCAM 0 NO2 @ 13



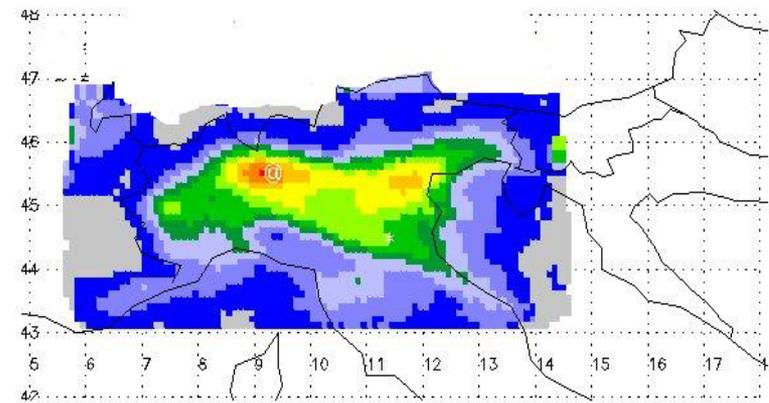
[ug/m³]

13032008 NO2 concentration



[ug/m³]

average NO2 OMI QM3 product



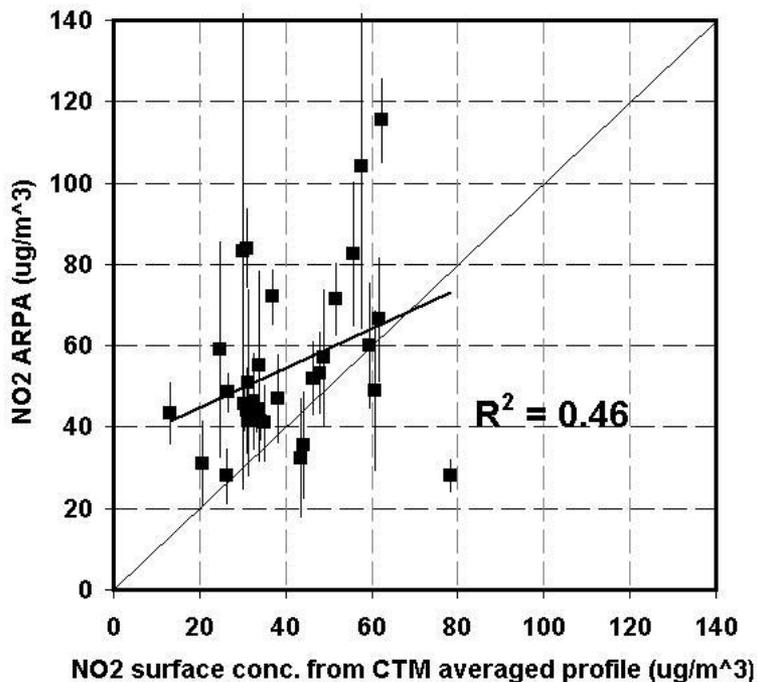
[ug/m³]

Maps of (a) OMI NO₂ tropospheric column amount; (b) GAMES NO₂ ground level concentration; (c) QM3 NO₂ on March 13th 2008; and (d) QM3 NO₂ averaged field in the period from May 2007 to March 2008.

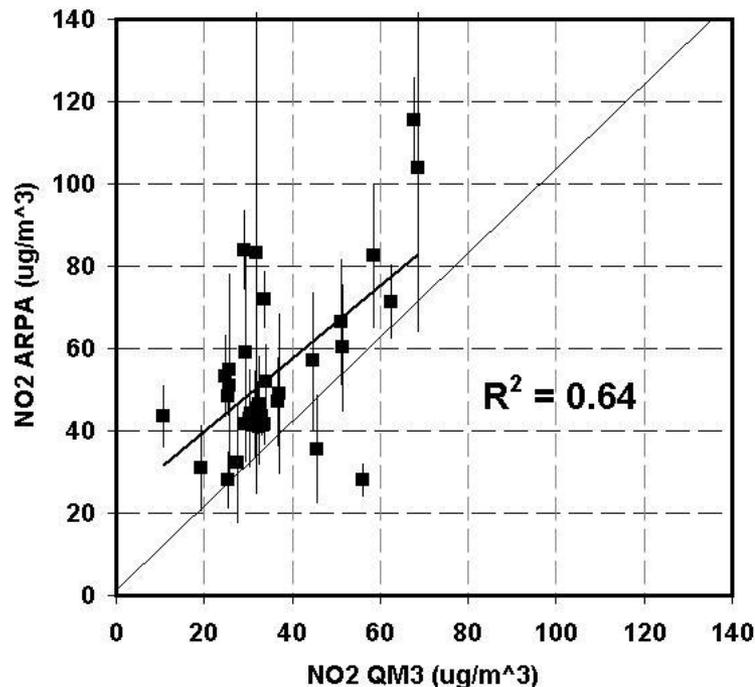


QM3 Product

19 Feb 2008



NO2 ARPA vs. TCAM

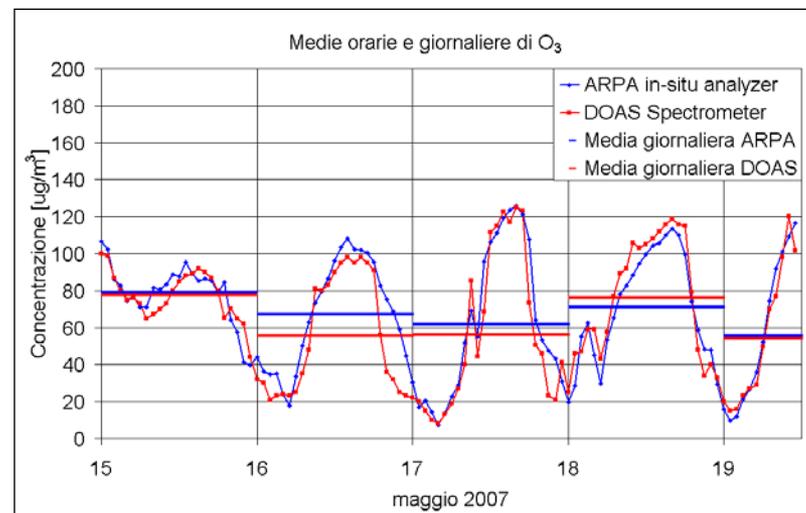
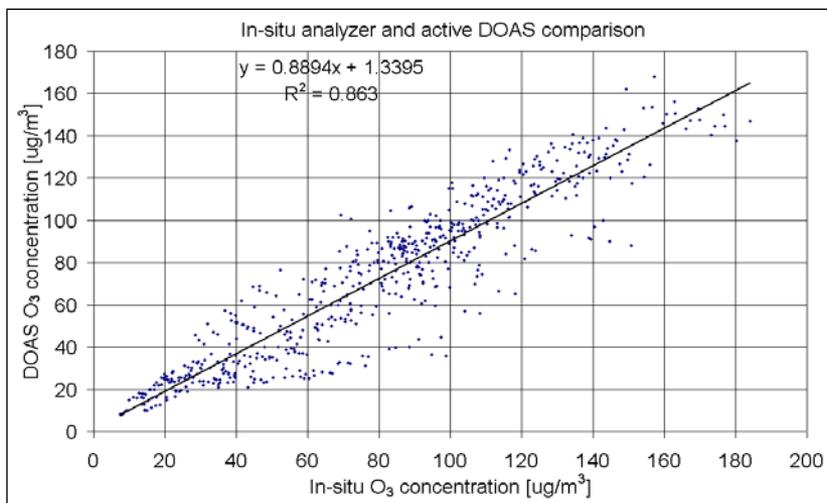
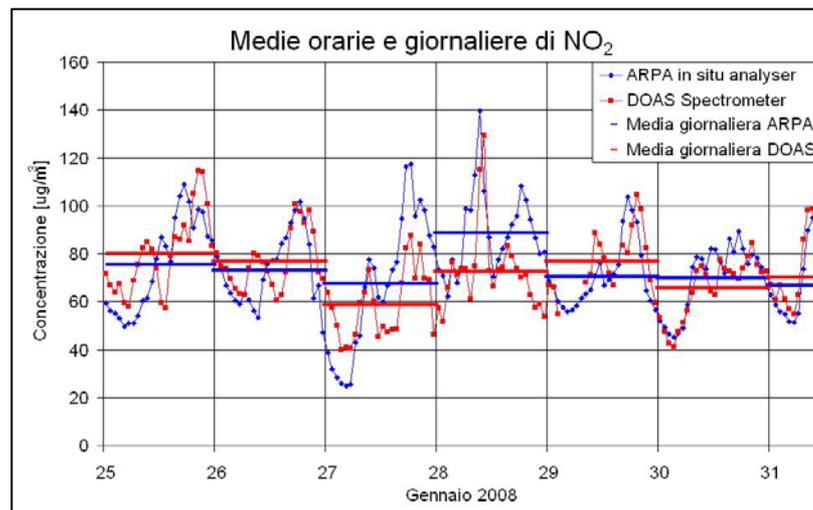
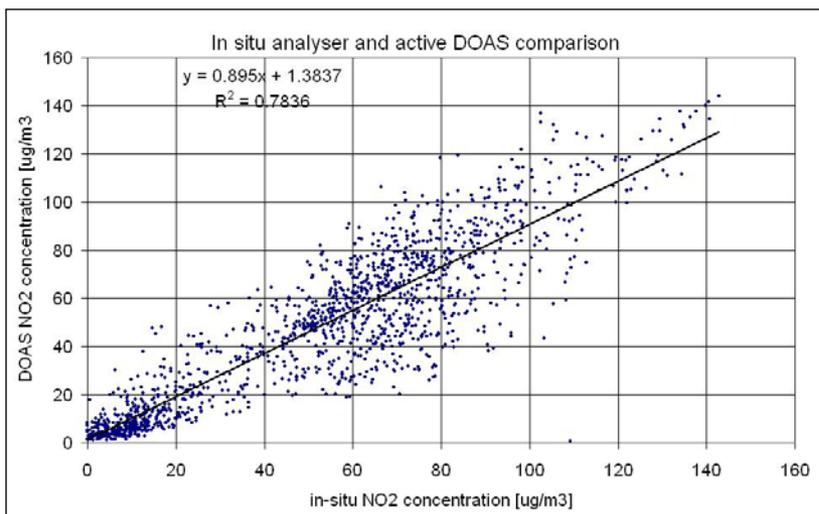


NO2 ARPA vs. QM3

Improvement of the correlation (0.46 → 0.64) using QM3 product (*integrated satellite and model data*) instead model data.



Comparison DOAS-Long Path vs ARPA

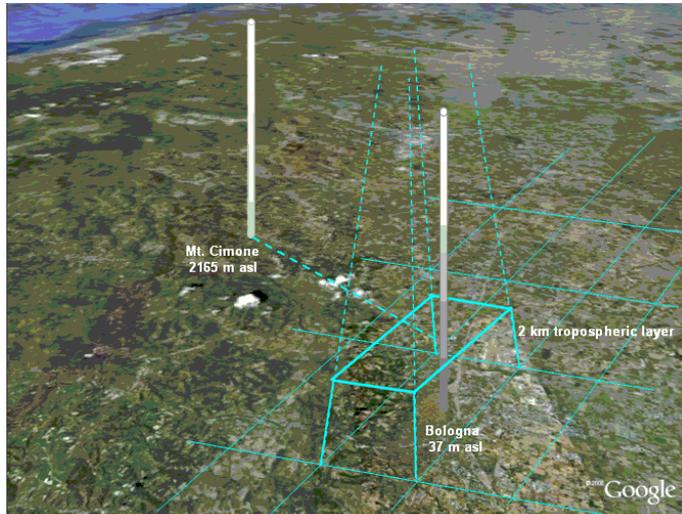




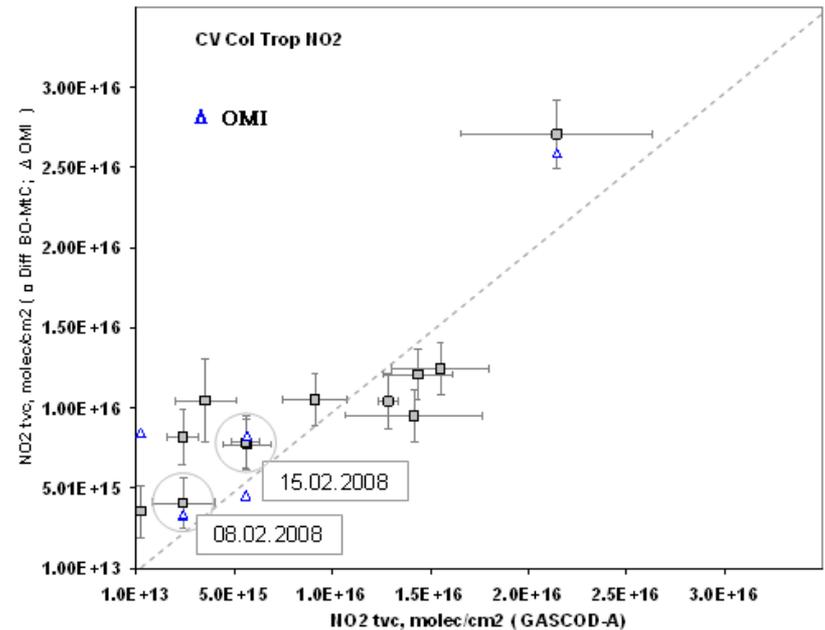
NO2 (0-2 km) tropospheric column as a difference between two DOAS measurements taken at different altitude.

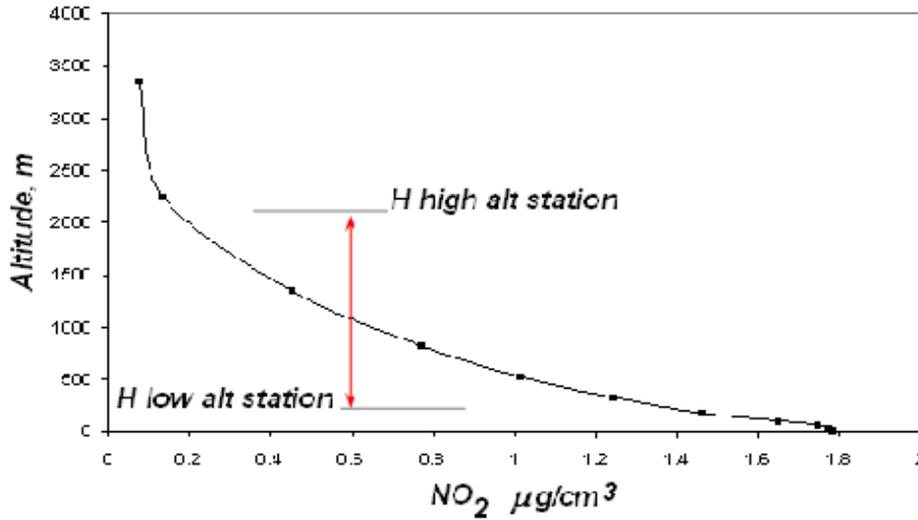
Calculated partial tropospheric column is used to validate:

- modelled column over the stations.
- Satellite tropospheric column (*assumption: the main impact due to PBL, usually below 2 km in the stations area*)



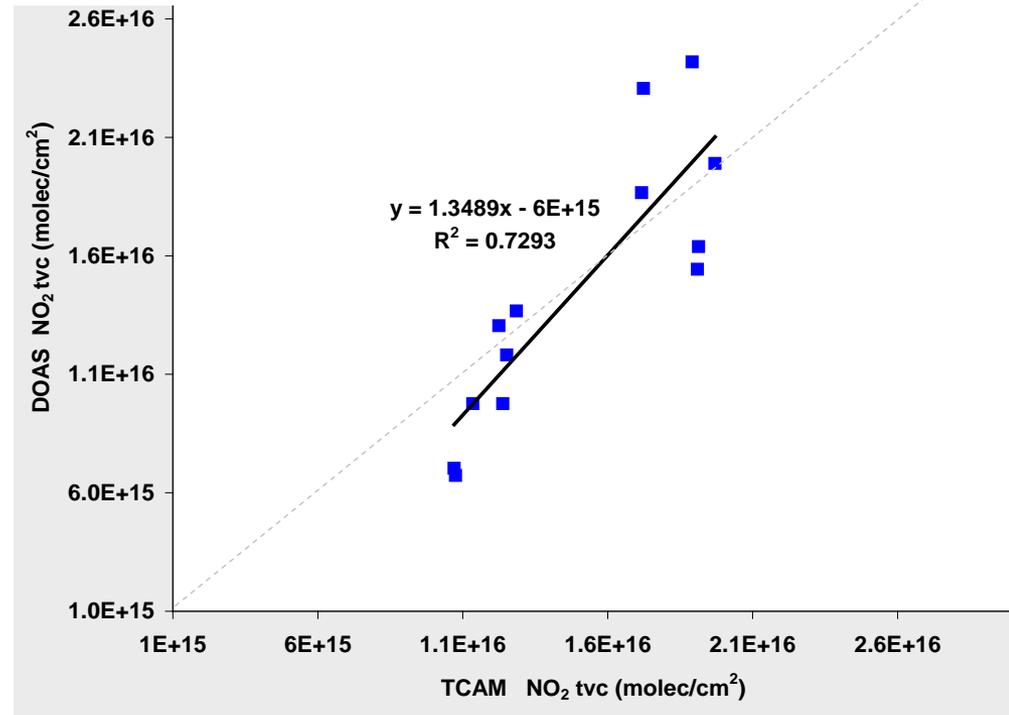
Mt. Cimone 44N, 10E, 2165 m a.s.l.
Bologna 44 N, 11E, 42 m a.s.l. - urban area
S.P.Capofiume 44 N, 11E, 10 m a.s.l. - rural area

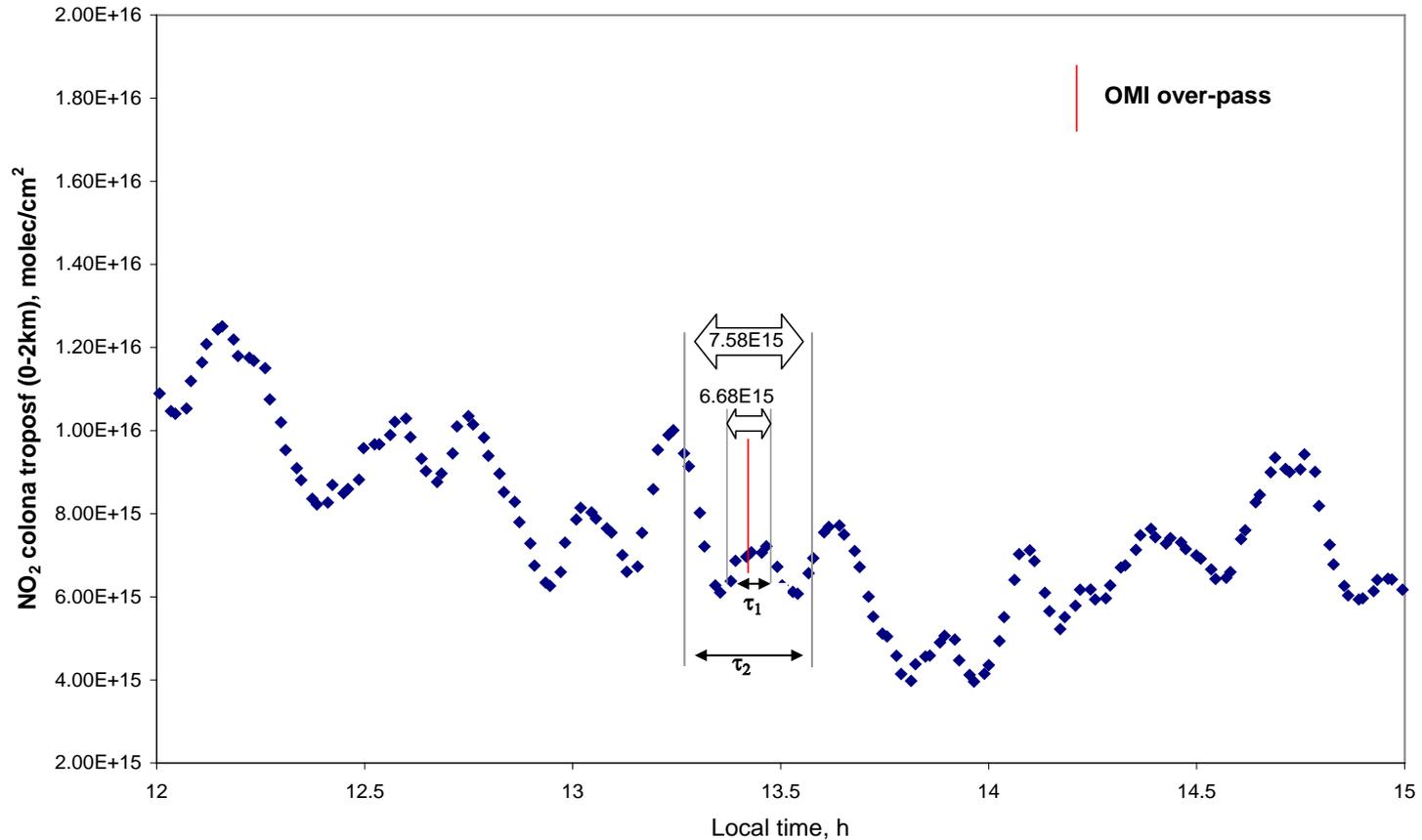




GAMES/TCAM profile is integrated within the layer defined by the difference of altitudes of both DOAS stations ⇒ this results in partial (0-2 km) NO₂ vertical column

Tropospheric NO₂ vc (0-2 km) derived from DOASV and GAMES/TCAM February 2008. Further improvements are foreseen:
 e.g. 2D interpolation in order to account NO₂ horizontal gradients (*displacement of DOAS station in respect the center of the model pixel*)





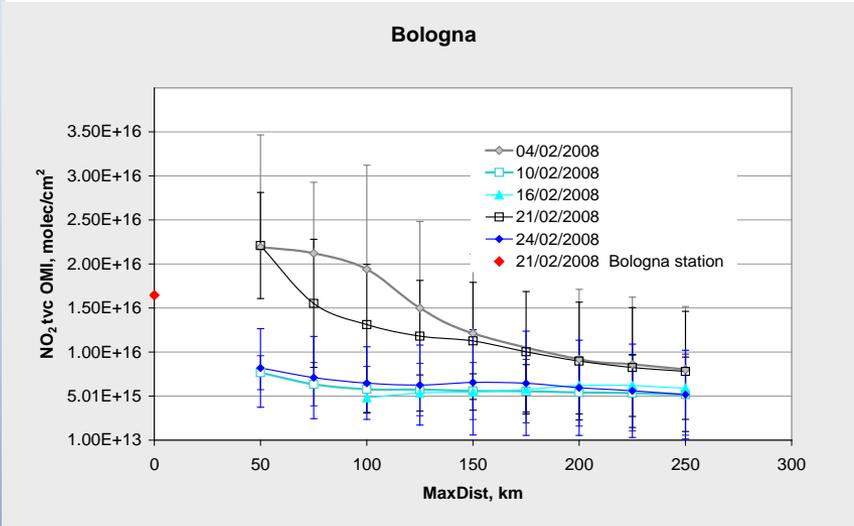
Averagging of the ground-based data:

- $t_0 \pm \tau_1, t_0 \pm \tau_2, \dots ?$
- Symetry of the variations in respect to the satellite over-pass

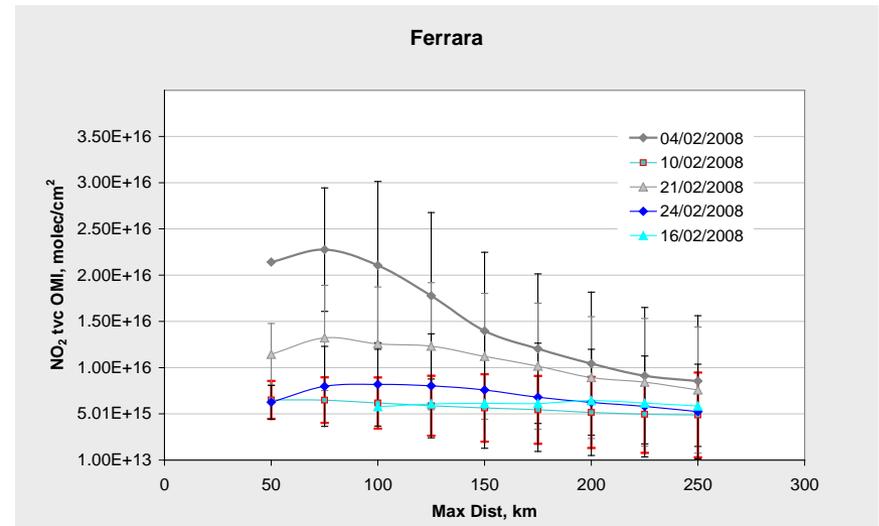


OMI

NO₂ (0-2 km) in function of the max distance (*D_{max}*) between selected DOAS station and the most distant corner of the satellite pixels for given range.



Decreasing of *D_{max}* leads to bad statistics: only very few high resolution pixels remain available.





Laser Induce Fluorescence system for NO_2 , Peroxy Nitrates (PNs), Alkyl Nitrates (ANs) and HNO_3 aircraft and groundbase observations

P. Di Carlo
University of L'Aquila (Italy)



The Technique

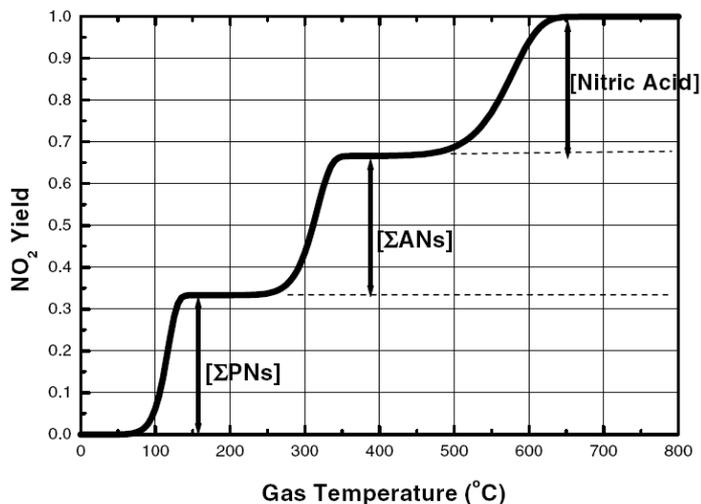
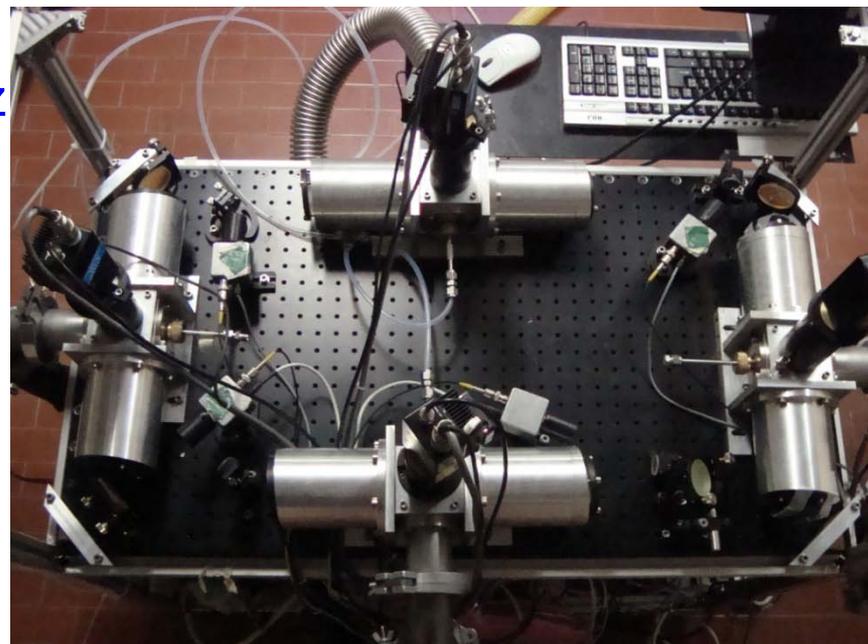
NO₂ measured directly exciting with a pulse Yag laser at 532nm, the fluorescence is detected at wavelength longer than 600nm.

High selectivity

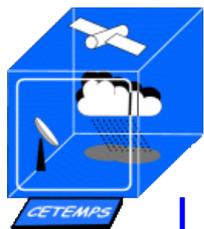
detection limit: 3.6 pptv

high frequency: observations at 10Hz

PNs, ANs, HNO₃ are detected after thermal conversion into NO₂.



We know technique pioneered by Ron Cohen (U. Berkeley). The advantage of our system is the use of 4 cells that allows simultaneous observations of the 4 species without gaps



Aircraft Installation of the L'Aquila LIF

Last June the LIF was certified by the British Aerospace (BAE system) to fly and was installed on the BAe 146 aircraft of the FAAM (*Facility for Airborne Atmospheric Measurements*)



LIF inlet

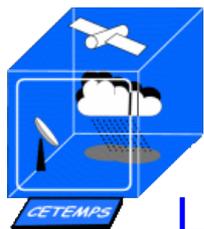


BAe146

LIF on the
BAe146

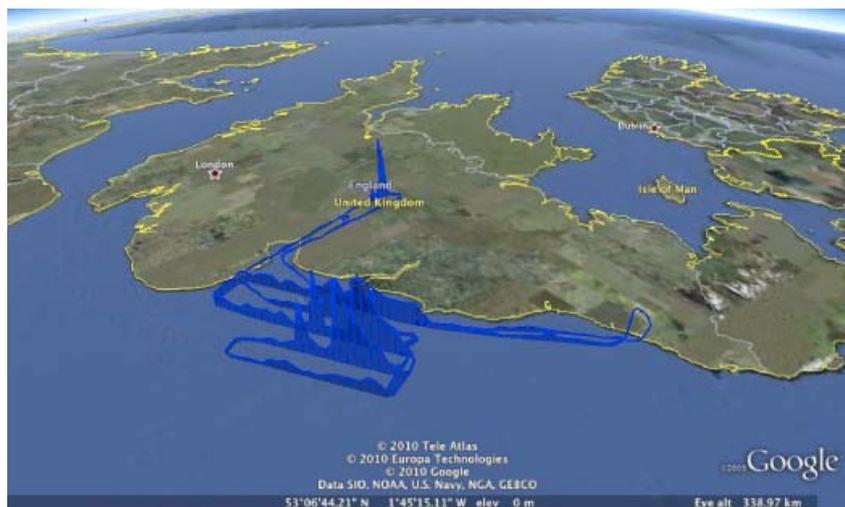


Instrument weight 227kg in the rack plus 90 kg for the pumps
(installed in the rack beside the LIF)
Dimension of the LIF rack: 112x90x56 cm

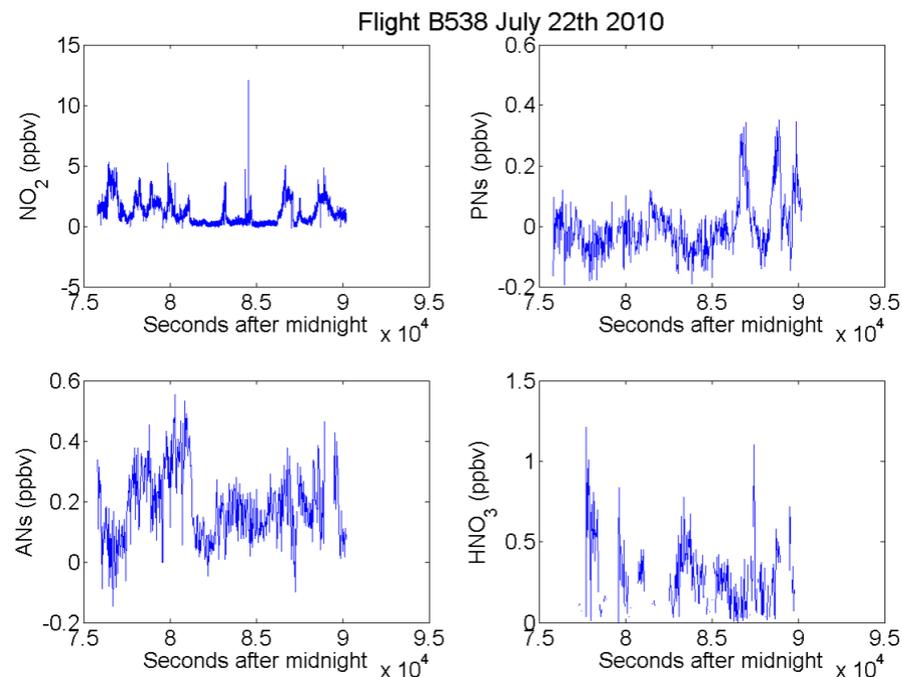


Aircraft Campaigns so far

Last July the LIF was successfully used during the RONOCO campaign (East Midlands airport, UK) and during the SeptEX campaign in the same airport in September.



Example of the NO₂ concentrations along flight track of the 16th/17th July (Flight 534). Pollution plumes moving into the North sea from the Humberside region are clearly visible



Example of the NO₂, PNs, ANs and HNO₃ observations



Groundbase campaign

During June and July 2008 the LIF was deployed in the Borneo forest (Malaysia) for observations of NO_2 , PNs and ANs (OP3 campaign).

NO_2 was observed at 8 m and at 75 m on the Bukin Atur tower

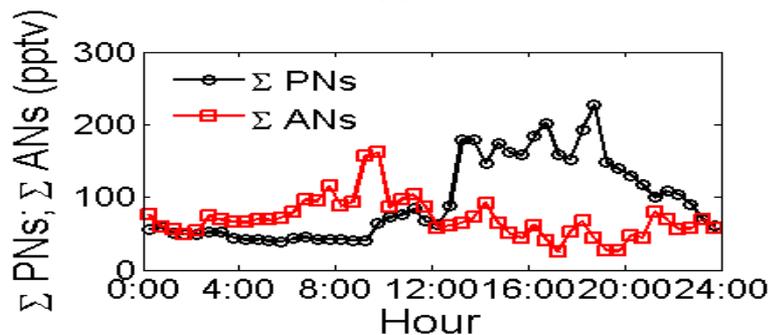
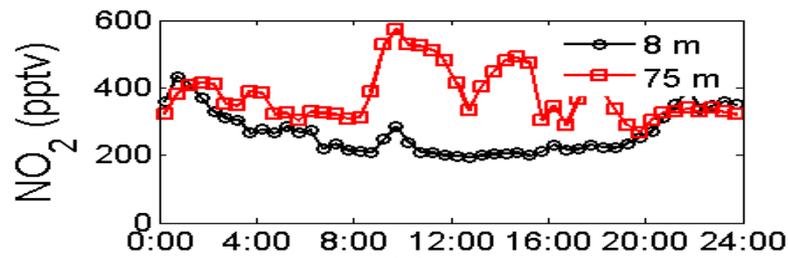
PNs, and ANs observed at 8m

Measurements at 10Hz allowed the calculation of NO_2 Flux at 75m using the Eddy covariance technique

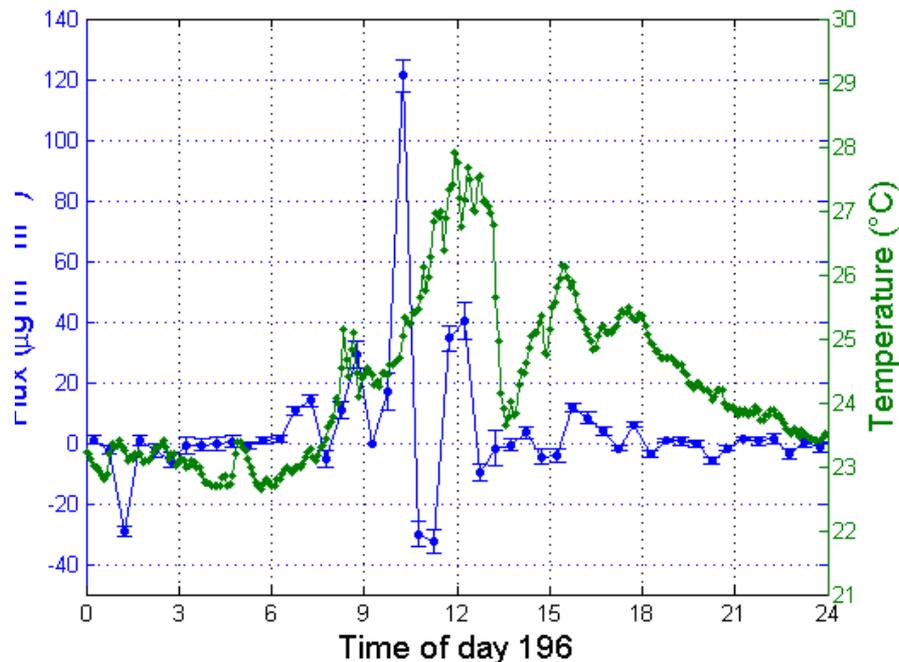




LIF observations during OP3 campaign in Malaysia



Diurnal variation of NO₂ at different altitude, PNs and ANs at 8 m



Flux observations of NO₂ at 75 m



Conclusions

- **Valuable expertise in the field of atmospheric studies:**
 - theory
 - instrumentation (ground-based, aircraft and balloon deployments)
 - field facilities
 - data processing
 - modeling and data assimilation
- **Satellite data validation** (ground-based, aircraft)
- **Environmental monitoring**

Italian research groups are interesting in to establish large collaborations devoted to cutting-edge technologies and methods for AQ evaluation by means of integration of satellite, aircraft, ground-based and model data.



Many thanks for your kind attention

For details contact:

Aerosols:	<i>c.tomasi@isac.cnr.it</i>
DOAS:	<i>i.kostadinov@isac.cnr.it</i>
LIDAR:	<i>f.cairo@isac.cnr.it</i>
FTIR:	<i>b.carli@ifac.cnr.it</i>
QUITSAT PM:	<i>w.dinicolantonio@isac.cnr.it</i>

