The BAQUNIN project an overview

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ESA TO: P. Goryl

IDEAS+ WP

2015 Pandora #115 + CIMEL at ESRIN
2015 WRF Model at ESRIN
2016 Laser+chiller for MWL at Sapienza University
2016 Pandora #115 moved to CNR-ISAC, CIMEL moved to Sapienza University
2017 Second Pandora #117 at Sapienza
2018 Pyranometer + Sky-camera
2018 Third Pandora #138 at CNR-IIA (still under refurbishment!)

BAQUNIN Project

2019 (March) KO

BAQUNIN Project structure

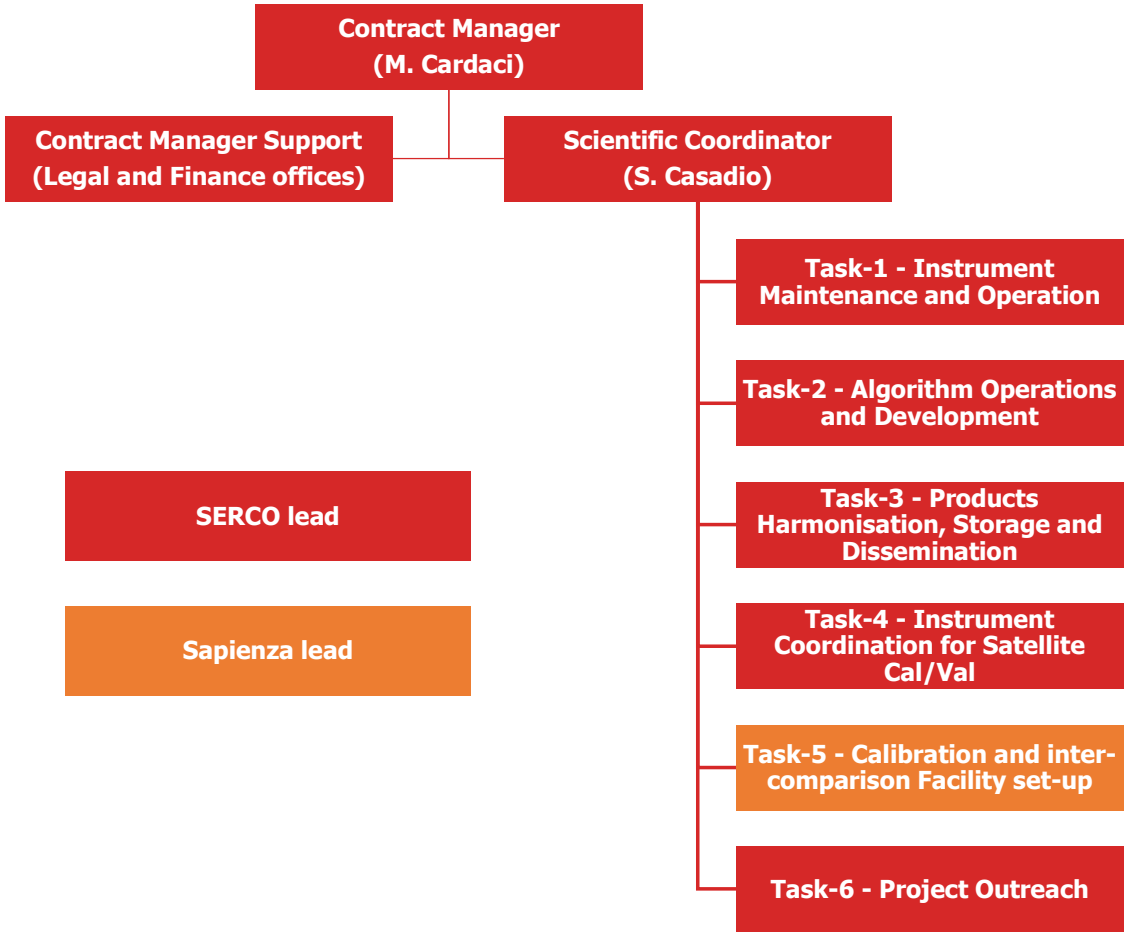
The project activities are structured into two phases, **Phase-1** and **Phase-2**.

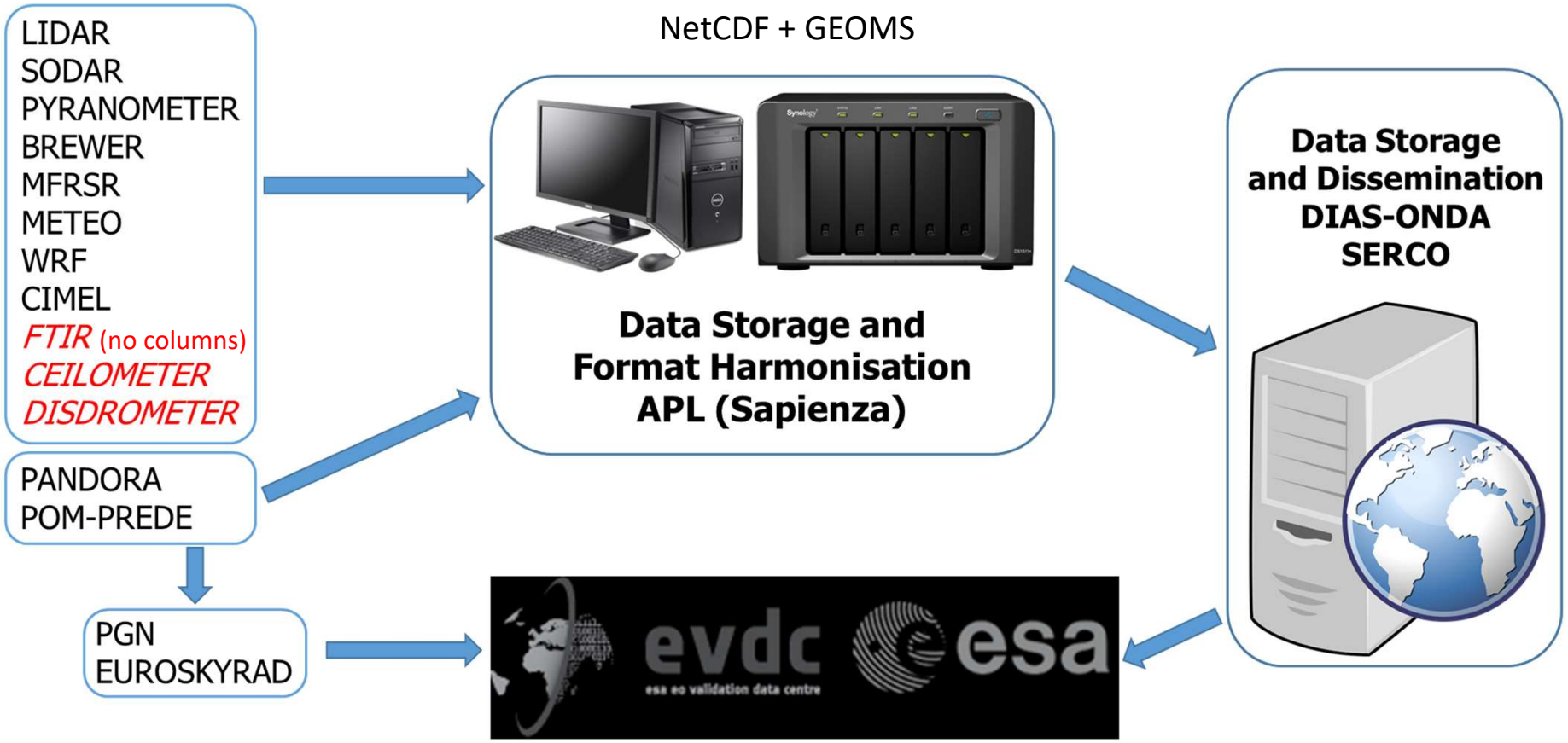
The time duration of the two phases is:

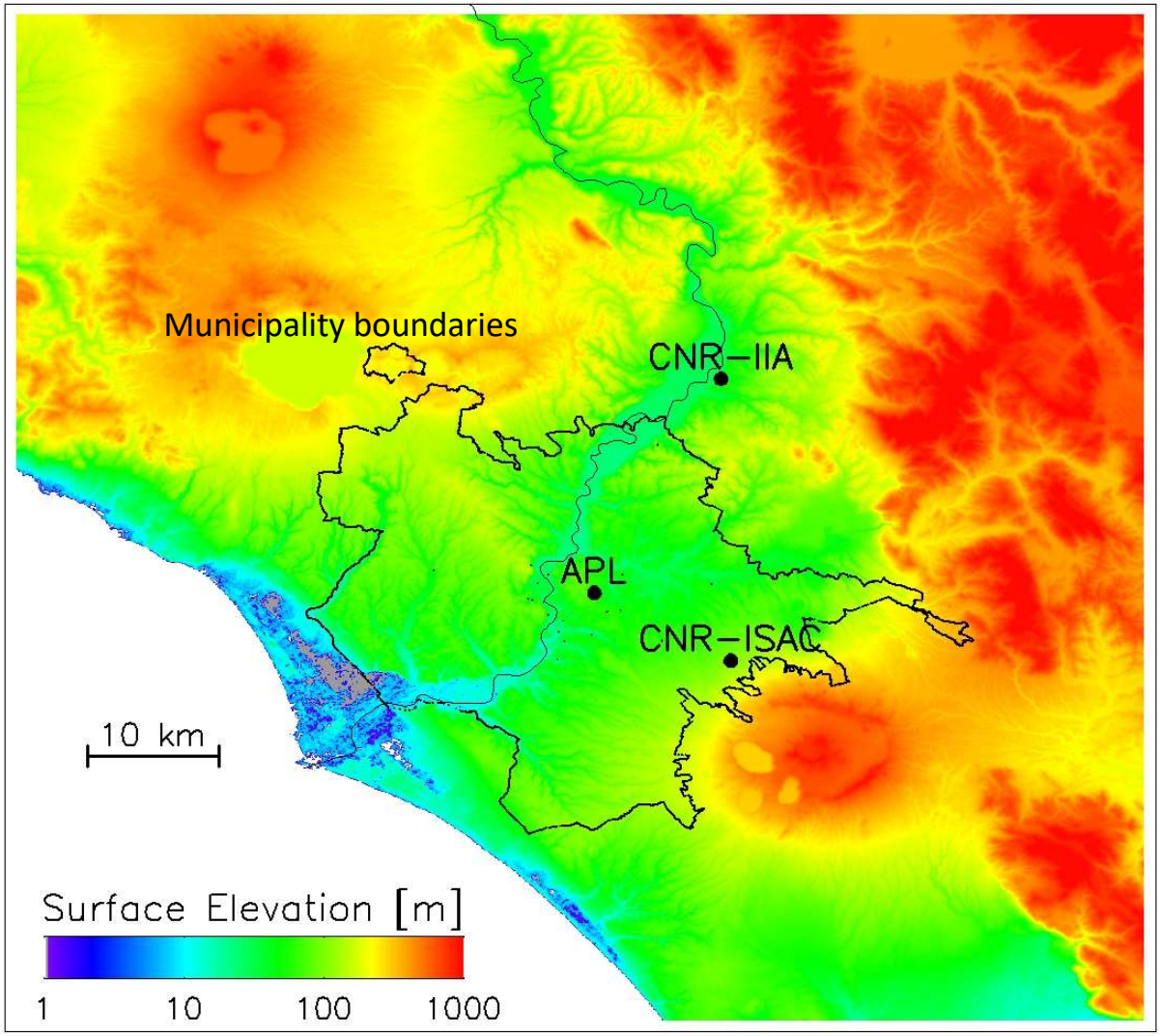
- **Phase-1**: from Mar-2019 to Feb-2020
- **Phase-2**: from Mar-2020 to Feb-2022

During **Phase-1**, only a subset of all potential activities will be activated, as this start-up period will be considered as a pilot and demonstrator.

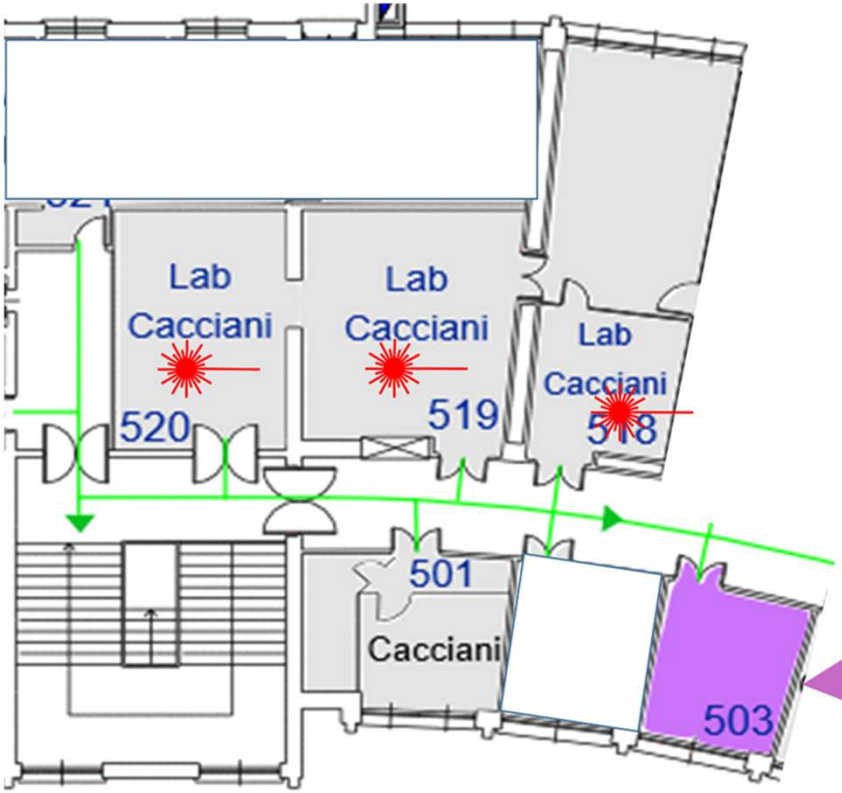
The full activity realisation will be achieved during **Phase-2** of the project.




LIDAR
SODAR
PYRANOMETER
BREWER
MFRSR
METEO
WRF
CIMEL
FTIR (no columns)
CEILOMETER
DISDROMETER
PANDORA
POM-PREDE
PGN
EUROSKYRAD
NetCDF + GEOMS
Data Storage and
Format Harmonisation
APL (Sapienza)
Data Storage
and Dissemination
DIAS-ONDA
SERCO
evdc
esa eo validation data centre
esa


Municipality boundaries
CNR–IIA
APL
CNR–ISAC
10 km
Surface Elevation [m]
1
10
100
1000

APL support instrumentation



1) HeNe Cw lasers
2) NdYag pulsed lasers (1064nm, 532 nm, 355 nm)
3) Jarrel Ash spectrometer (f=0.5 m)
4) Jobin Yvon U1000 double spectrometer (f=1 m)
5) Jobin Yvon LHT30 VUV spectrometer (f=0.3 m)
6) Optical tables
7) Spectral and Xenon lamps
8) Narrow- and large-band filters in the UV-Vis-NIR range
9) Set of mirrors, lenses, beam-splitters and dichroics
10) Optomechanics
11) Light sensors

Instrument	Owner	Site	Operation Conditions	Range (m.a.s.l.)	Dz (m)	Spectral Range / wavelengths	Observables	Since
SODAR	APL	APL	Day/Night	100 – 900	15	4450.75, 4650.75, 4840.75 Hz	PBL winds and turbulence	**1990**
Brewer MKIV	APL	APL	Day	Column	N/A	286.5 – 363 nm	Radiance, trace gases	**1992**
MFRSR	APL	APL	Day	Column	N/A	940, 870, 673, 615, 500, 415 nm	Radiance, aerosols, trace gases	**2004**
POM	CNR-ISAC	APL CNR-IIA	Day	Column	N/A	1600, 940, 870, 670, 500, 440, 380, 340 nm	Radiance, aerosols, water vapour	**2010**
Meteo station	Climate Consulting	APL	Day/Night	In situ	N/A	N/A	Air temperature and humidity	**2014**
LIDAR	APL ESA	APL	Day/Night	300 – 20000	7.5	Elastic: 1064, 532, 355 nm Polarised: 532 nm Raman: 407, 386 nm	Aerosols, water vapour, clouds	**2015**
WRF	Sard. Clim.	ESRIN	Day/Night	0-20000	39 levels	N/A	Meteorological variables	**2015**
Pandora-2S	ESA	APL CNR-ISAC CNR-IIA	Day/Night (Moon)	Column	N/A	290-520 and 400-900 nm	Radiance, trace gases, aerosols	**2016**
Sun-photometer	Univ. Lille	APL	Day	Column	N/A	1640, 1020, 870, 675, 500, 440, 388, 340 nm	Aerosols, water vapour	**2016**
All Sky Camera	ESA	APL	Day/Night	N/A	N/A	RGB	Clouds	**2018**
Pyranometer	ESA	APL	Day	Column	N/A	285 – 3000 nm	Radiance, clouds	**2018**
Ceilometer	APL	APL	Day/Night	100 – 6000	N/A	Elastic: 904 nm	Clouds, aerosols	**2019**
Disdrometer	APL	APL	Day/Night	In situ	N/A	N/A	Rain	**2019**
FTIR EM-27	CNR-ISAC	APL	Day/Night	Slant Column	N/A	700 – 2200 cm^{-1} (4.5 – 14 mm)	PBL GHG	**2019**

Example of **synergistic use** of different remote sensing instruments/products:

Pandora + SODAR

Pandora operated in MaxDOAS mode

SODAR provides wind profiles

SC = **Pandora** NO2 Surface Concentration (µg m^{-3})

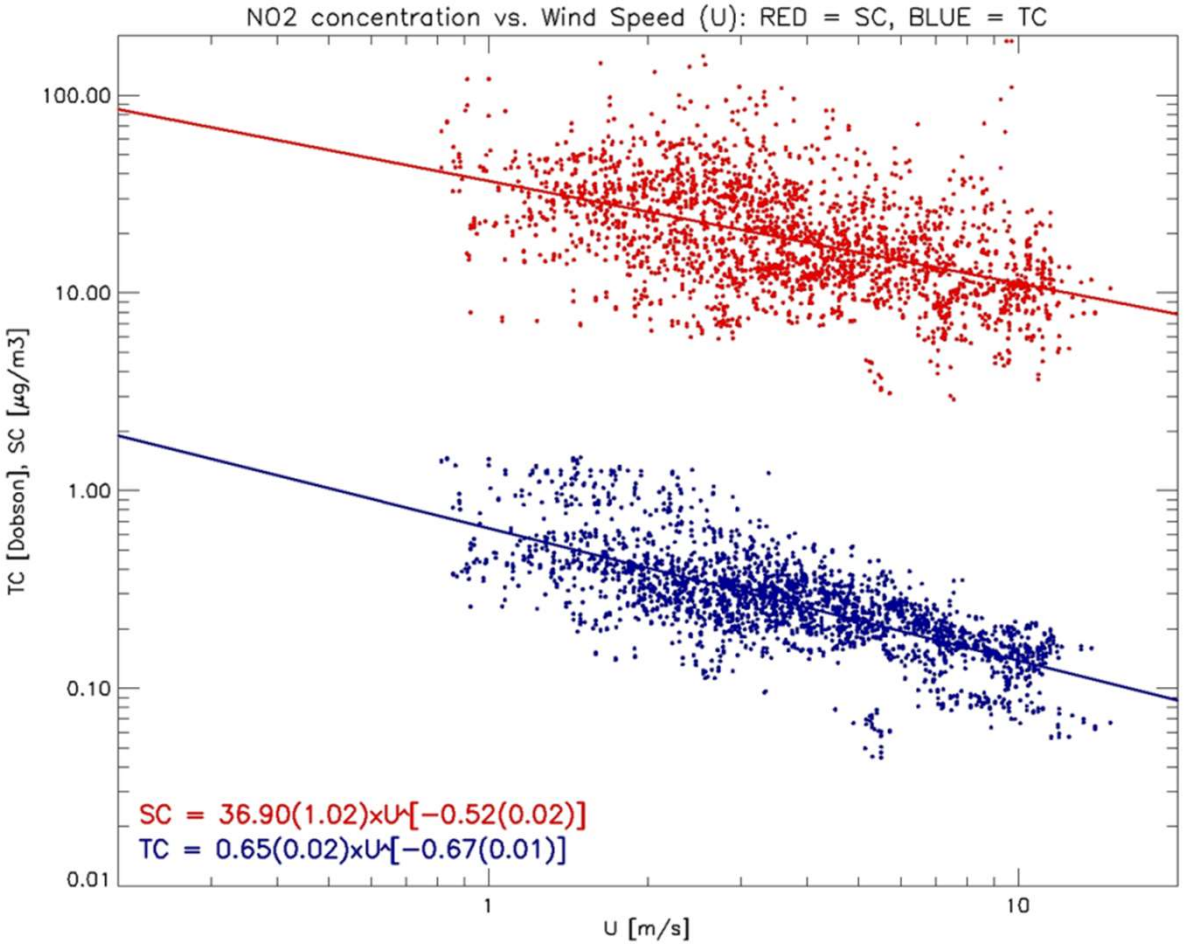
TC = **Pandora** NO2 Tropospheric Column (Dobson)

U = **SODAR** Inertial Sublayer wind speed (m s^{-1})

$$TC \propto U^{-2/3}$$

$$SC \propto U^{-1/2}$$

No significant dependency on wind direction

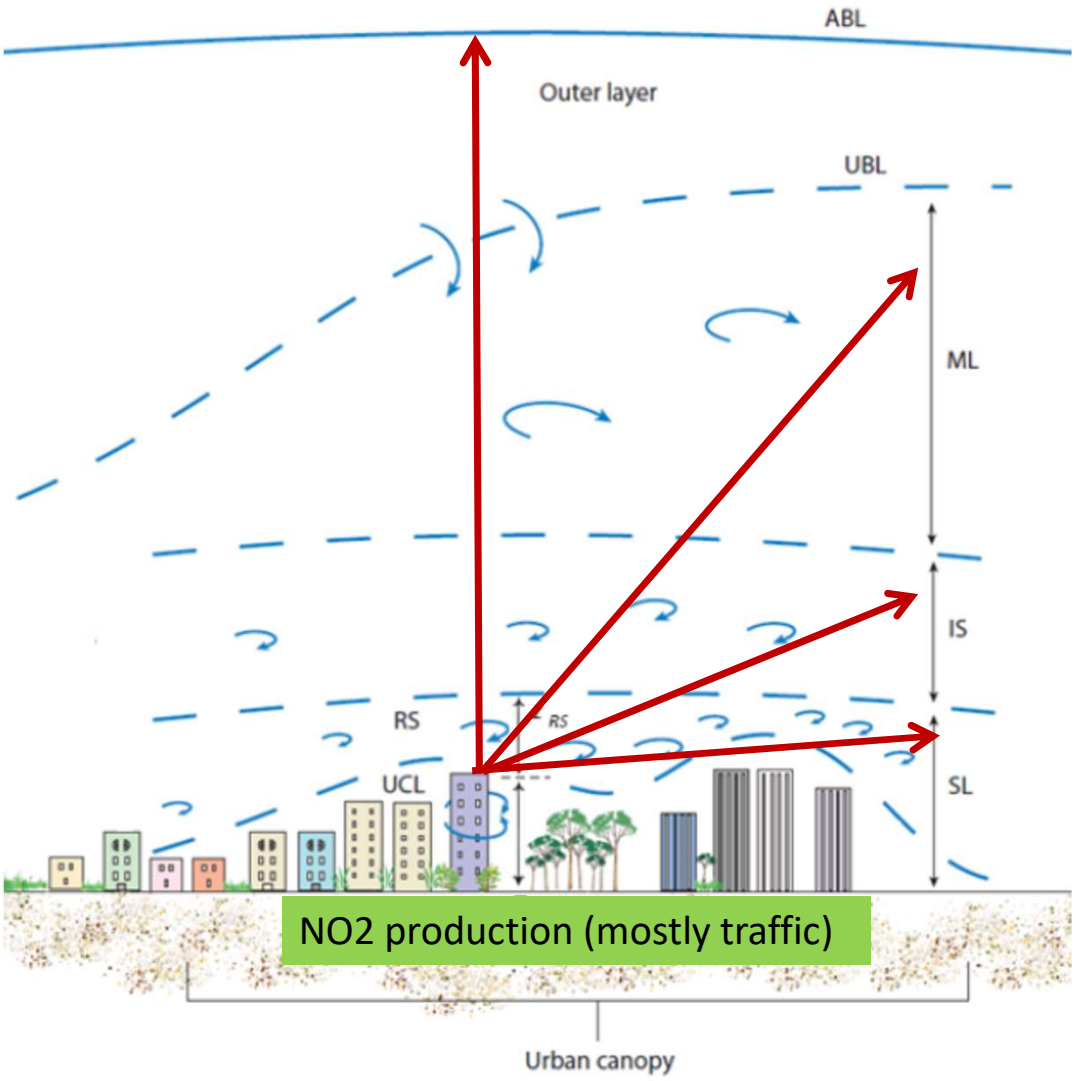


Urban Boundary Layer (UBL)
- Mixed Layer (ML)
- Inertial Sublayer (IS)
- Surface Layer (SL)
  - Roughness Sublayer (RS)
  - Urban Canopy Layer (UCL)

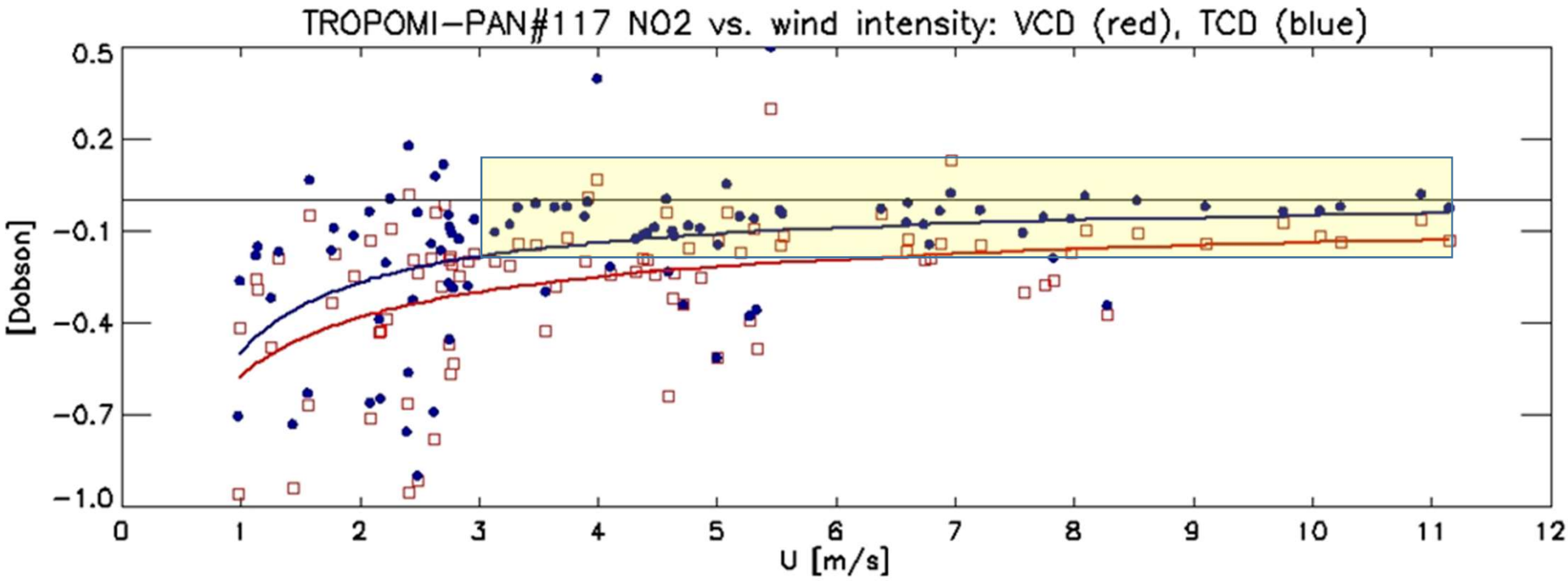
The Pandora TC does not include the SL contribution
The Pandora SC refers to the Roughness sublayer
NO2 production layer (UCL) is not probed

In low wind conditions, the NO2 produced in the UCL is lifted by turbulent updrafts and becomes detectable by Pandora.

In moderate to strong wind conditions (> 4 m/s) the NO2 bottom-up fluxes are suppressed and only a fraction of the NO2 profile is detectable.



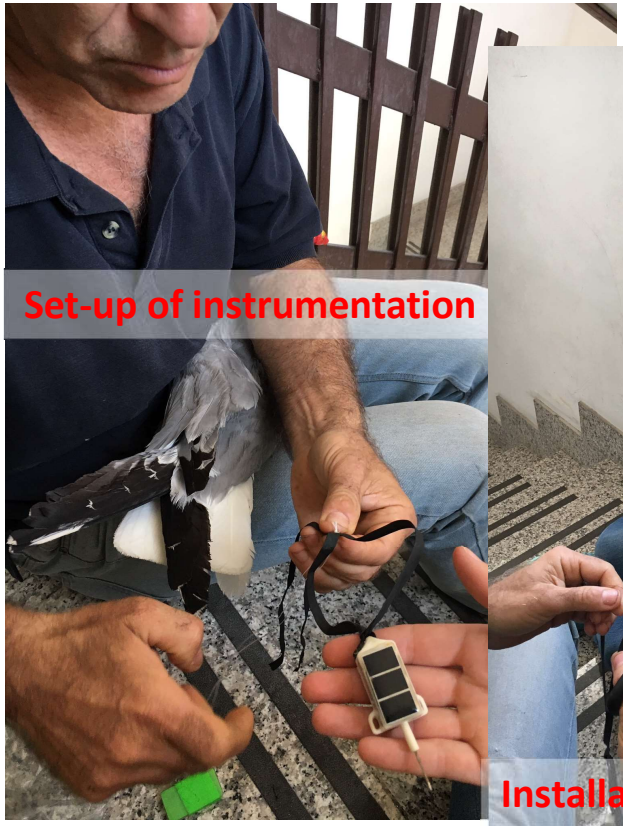
Significant impact on interpretation of TROPOMI NO2 validation



What is Pandora retrieving?
What is TROPOMI retrieving?

Creative approach to atmospheric monitoring

SBAM
Seagull Borne Atmospheric Monitoring



SBAM

A first test, a GPS was mounted on the platform, in order to follow its trajectory with sufficient accuracy.
The next phase of the experiment (if the platform survives and comes back in a reasonable time) we will install **P**, **T**, **CO2** and **CO** sensors on the platform in order to explore the Urban PBL in a 3D fashion!

The only applicable restriction is on the weight of the payload, which must not exceed 3% of the mass of the platform.

That is, Pterodactyls (250 kg) could fly 7.5 kg of instruments

The project is run in collaboration with **L**ega **I**taliana **P**rotezione **U**ccelli (LIPU)
Same as the **R**oyal **S**ociety for the **P**rotection of **B**irds (RSPB)

This means that

Seagulls are not physically offended (not sure about their pride)

We did not show how the platform has been convinced to collaborate

We cannot control the Seagull brain *yet* (research ongoing)

SBAM

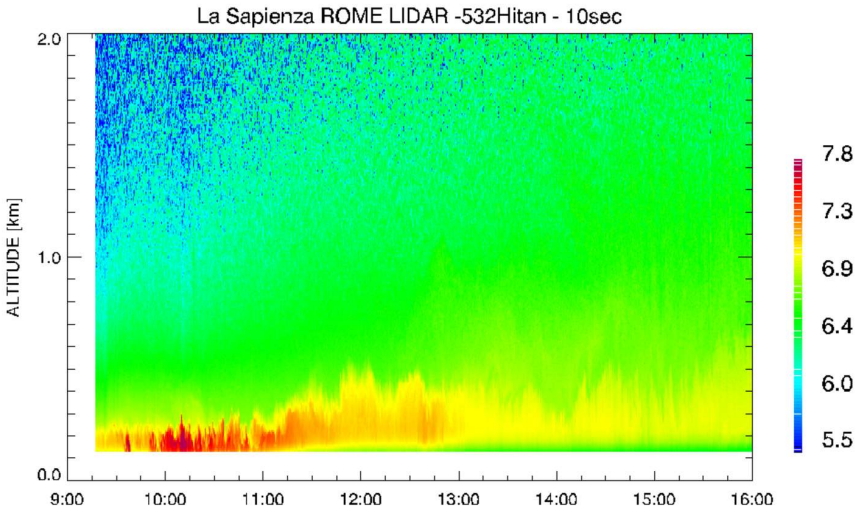
BAQUNIN Platform position from 3 to 9 May

TMB (waste facility) fire, 11 Dec 2018

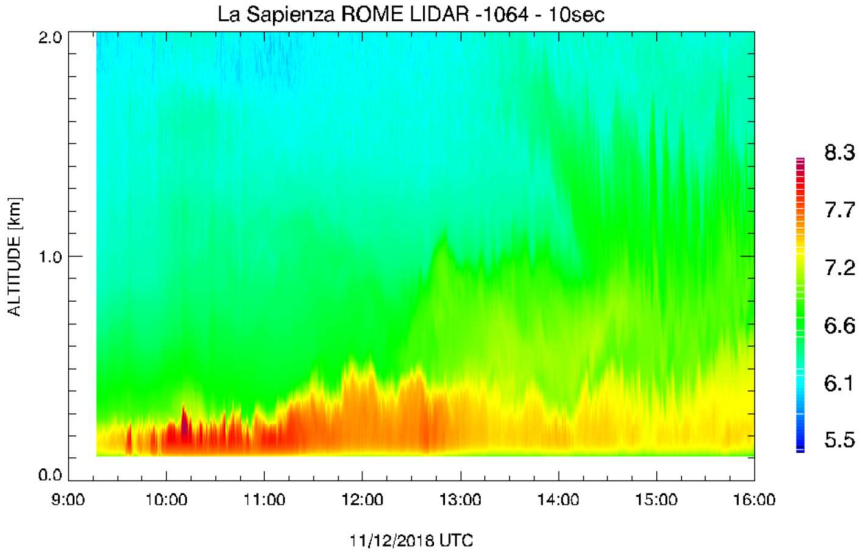
(ANSA) - Rome, December 11 2018 - A large fire broke overnight at a waste facility managed by Rome municipal trash company AMA. The fire at the 2,000-square-metre rubbish centre produced thick smoke on via Salaria, in the north of the historic capital, and the smell of smoke reached the centre. The city council has advised people in the area to keep their windows closed and refrain from outdoor activities.

The local authority said Lazio's ARPA environmental agency had not registered air-pollution levels outside the permitted parameters.

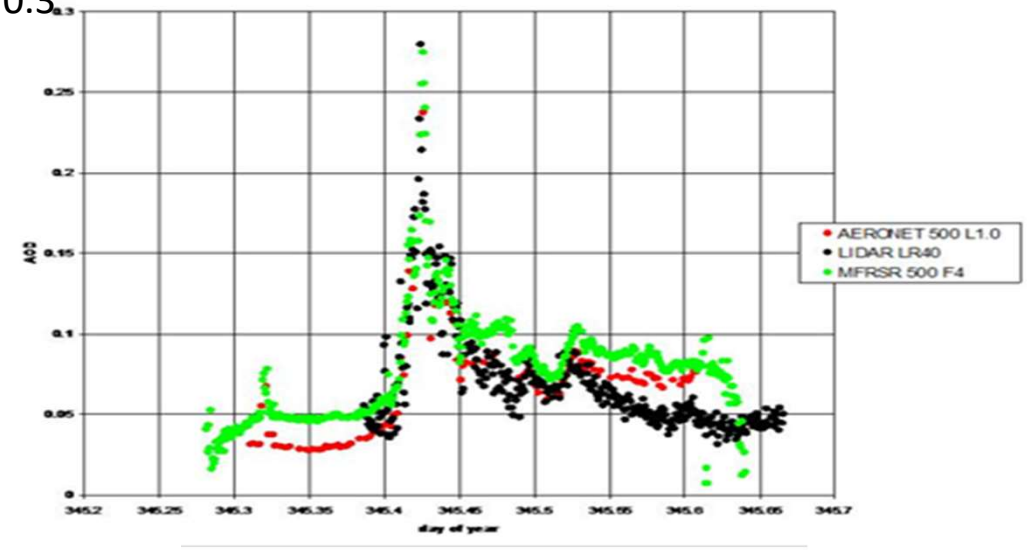
532 nm



1064 nm



0.3



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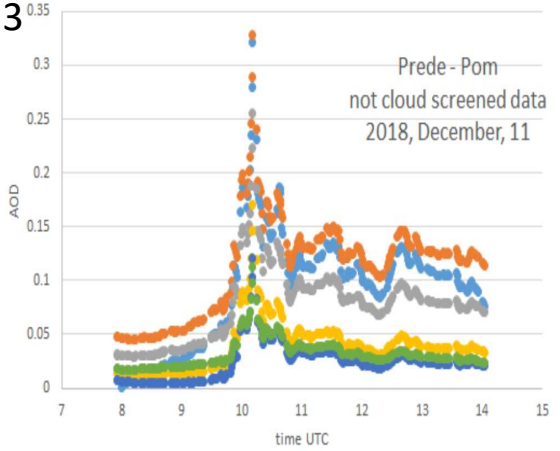


wvl (nm)

340

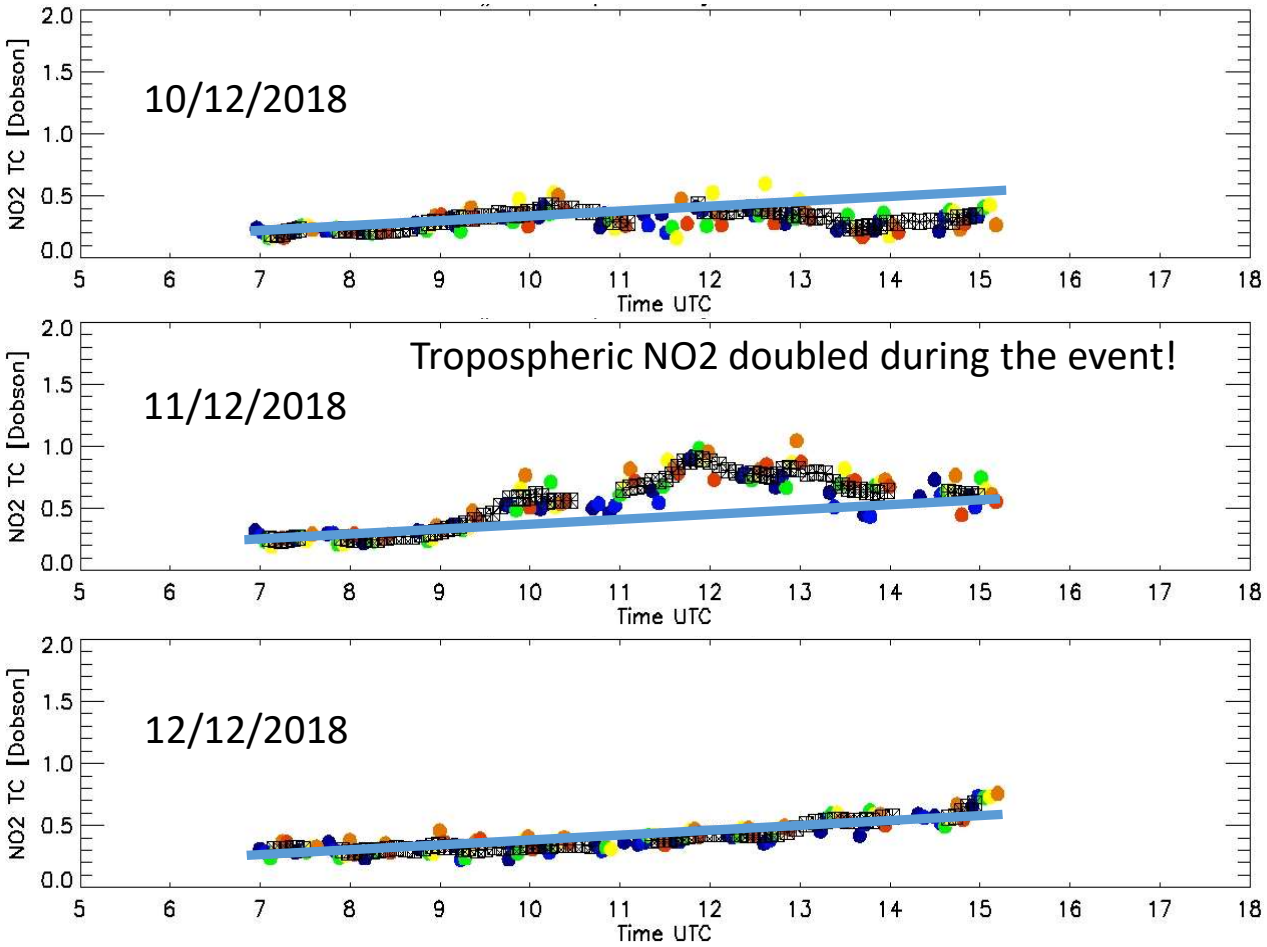
400

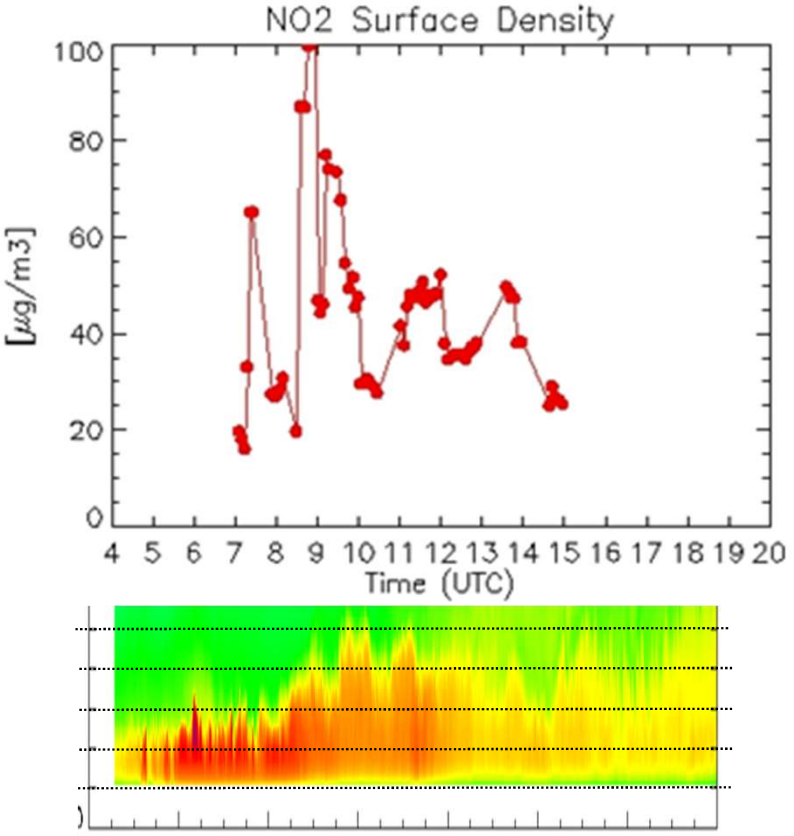
500

675

870

1020





Data analysis in progress
Pandora Formaldehyde
FTIR (horizontal measurements)
Sky-Camera images
WRF trajectories

What's still missing?

The Helios-100 brings a powerful compact spectrometer solution to the market. Its high SNR, large band and high spectral resolution allows to retrieve a large number of gas species including the main greenhouse gases and other trace gases. Instrument to instrument repeatability and response stability allows for network deployment to assess air quality over cities and other areas of concerns.

In the near future, development continues at ABB. A first activity will be to add a retrieval functionality to the instrument. Adaption to the TCCON GFIT retrieval algorithm will be done and run within the instrument. Retrieved gas concentrations will be saved and trend plotted in real-time on the HMI display. A second activity is to develop a variant of the instrument covering the mid infrared region.

(1) ABB inc, Space & Defense Systems
3400 Pierre-Ardouin, Quebec, CANADA
www.abb.com/spacedefence
gaetan.p.perron@ca.abb.com

Essential for GHG validation (e.g. EDAP => GOSAT, TANSAT)
Cost: *90 kUSD* (*0.89= *80* kEuro)

Tropospheric Profiling
of temperature, humidity and liquid water

Water Vapour Monitoring
e.g. at astronomical sites

Now-Casting
- atmospheric stability
- severe weather

Data Assimilation
input for weather and climate models

Boundary Layer Profiling
- high-resolution temperature profiles (better than balloons)
- 24/7 monitoring of temperature inversions
- fog detection
- air pollution applications

Absolute calibration of **Cloud Radars**

Satellite Tracking
- wet/dry delay
- humidity profiles along line of sight

- RPG-HATPRO
  - Humidity And Temperature PROfiler (standard profiling radiometer)
  - 7 channels: 22.24 GHz to 31.4 GHz
  - 7 channels 51 GHz to 58 GHz
  - over-sampling for redundancy
  - customized direct detection channels for precise Boundary Layer (BL) temperature profiles in elevation scanning mode

Essential for Tropospheric Species and aerosol validation (e.g. S5p, S4, S5, 3MI, IASI)
Cost: *130* kEuro

Conclusions

- Good example of IDEAS+ WP evolution into an ESA project
- Operate instruments, collect, harmonise and distribute data
- Support/perform validation of atmospheric composition satellite missions
- Synergistic use of active/passive atmospheric probes
- Lot of instruments => lot of data => lot of work

Outlook

- Phase 1 just started: web site to be launched before summer (data, docs)
- Participation in scientific campaigns: not limited to Tiber Valley (e.g. Etna)
- Attract other scientific institutions operating in Rome area (e.g. ENEA, INGV)
- Extend the instrumental suite => T&Q profiles, GHG columns