



## The Boundary-layer Air Quality-analysis Using Network of Instruments (BAQUNIN) Super-Site for Satellite Atmospheric Chemistry Products Validation



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A.M. Siani (2), H. Diemoz (4), C. Bassani (5), E. Cadau (6)

1) Serco SpA - 2) Physics Department, “Sapienza” University of Rome  
3) CNR-ISAC - 4) ARPA Valle d'Aosta, Saint-Christophe, Aosta - 5) IIA-CNR – 6) Sardegna Clima ONLUS

# BAQUNIN Super Site

## Locations

The great part of the BAQUNIN Super Site instrumentation is located at **Sapienza University**, in the city center. Other two instruments (Pandora) are located in semi-rural and rural areas:

- The **ISAC-CNR** Rome Atmospheric Supersite, southeast of the city (Tor Vergata) , 10 Km from the city center
- The **IIA-CNR** Institute for Atmospheric Pollution, northeast of the city (Montelibretti), 20 Km from the city center.

These three experimental sites located in the metropolitan area of Rome (4.3 Million residents) , offer a unique possibility to study the effects of a megacity on different trace atmospheric constituents, combining an ensemble of remote sensing and in-situ measurements in both urban and semi-rural context.

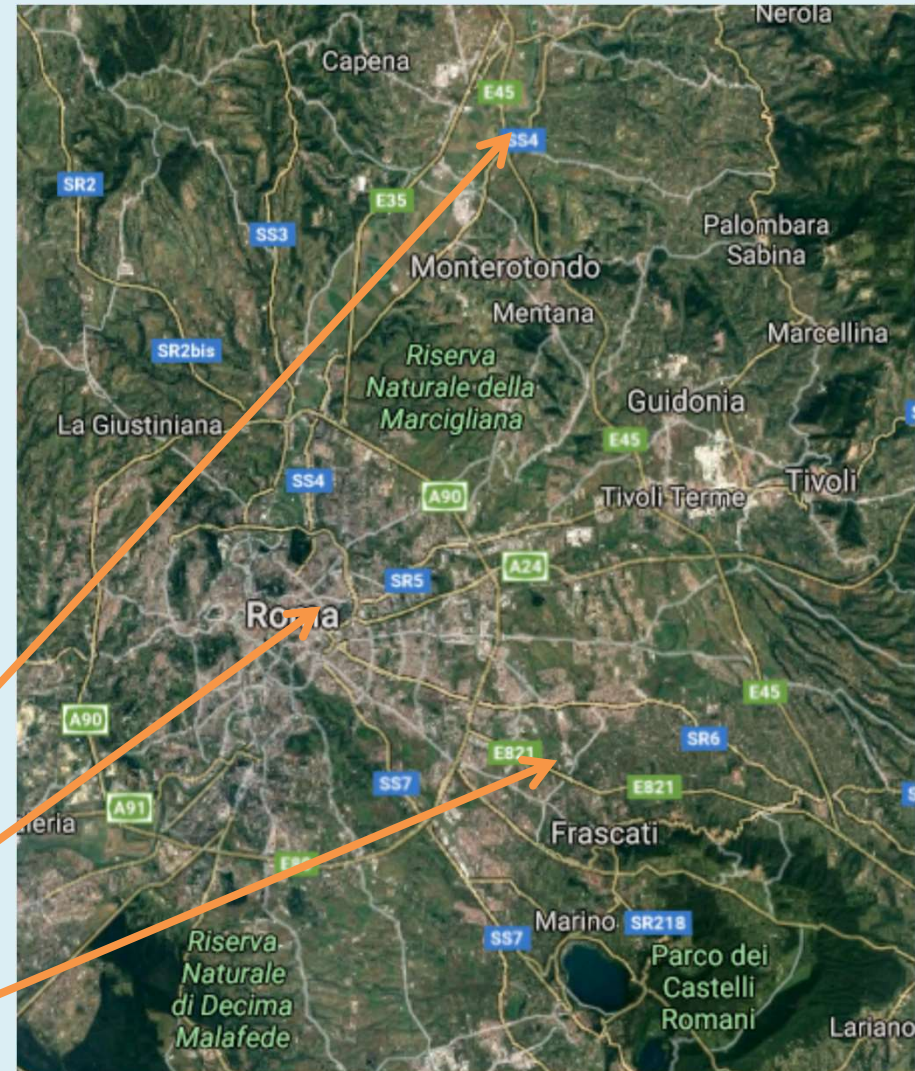


IIA-CNR Montelibretti



Sapienza University

ISAC-CNR Tor Vergata





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❖ In the two sites Sapienza and ISAC-CNR, many pairs of equal instruments are available

→ data comparison/variability

❖ In the IIA-CNR Site several instruments for in-situ measurement of trace gases are located

→ data integration

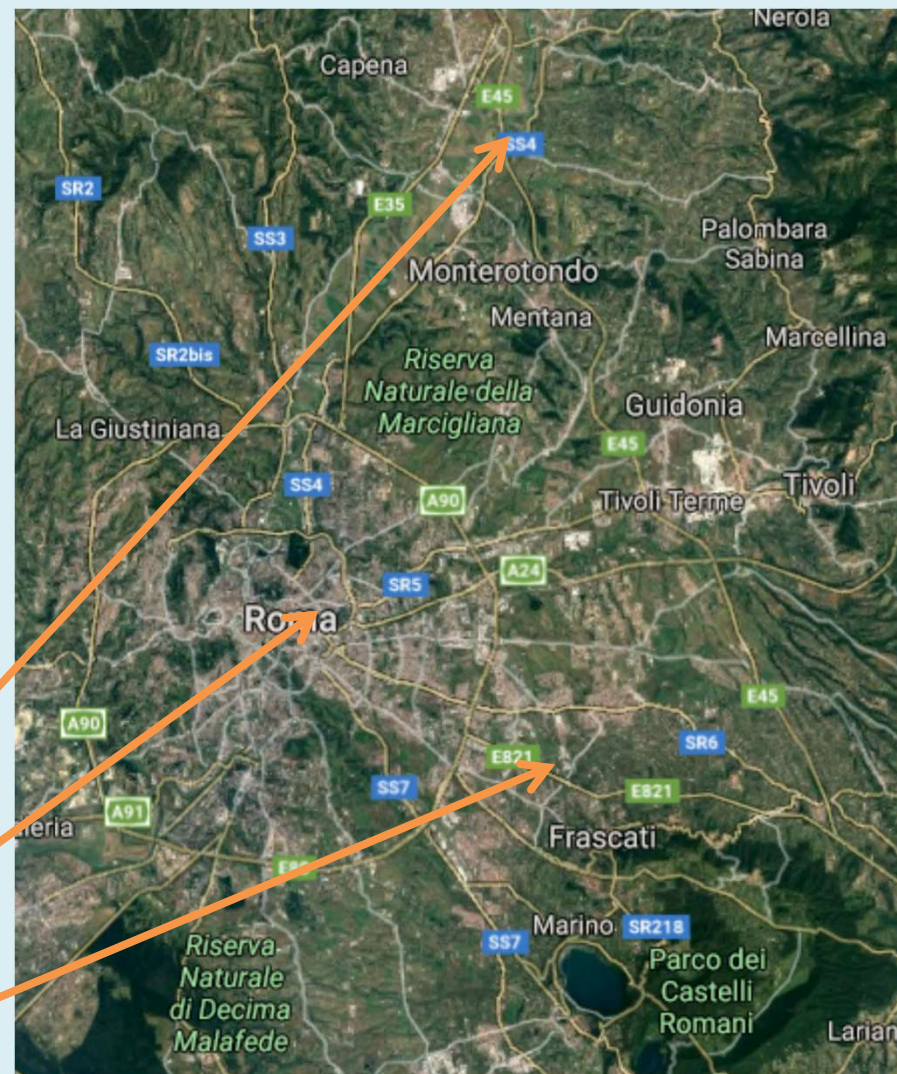


IIA-CNR Montelibretti



Sapienza University

ISAC-CNR Tor Vergata



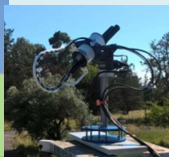
## BAQUNIN instruments



Pandora 2S #115

#117

#138



Cimel



Prede Pom 01



Brewer

Meteorological

Sensors

MFRSR



Pyranometer



Skycam



LIDAR



SODAR

## ...coming soon

FTIR (Fourier Transform Infra-Red spectrometer )

→ In situ trace gases (CO<sub>2</sub>, CH<sub>4</sub>, N<sub>2</sub>O)



ISAC – CNR Bologna/Rome (IT)

Ceilmeter

→ Cloud base/top height and backscatter profiles



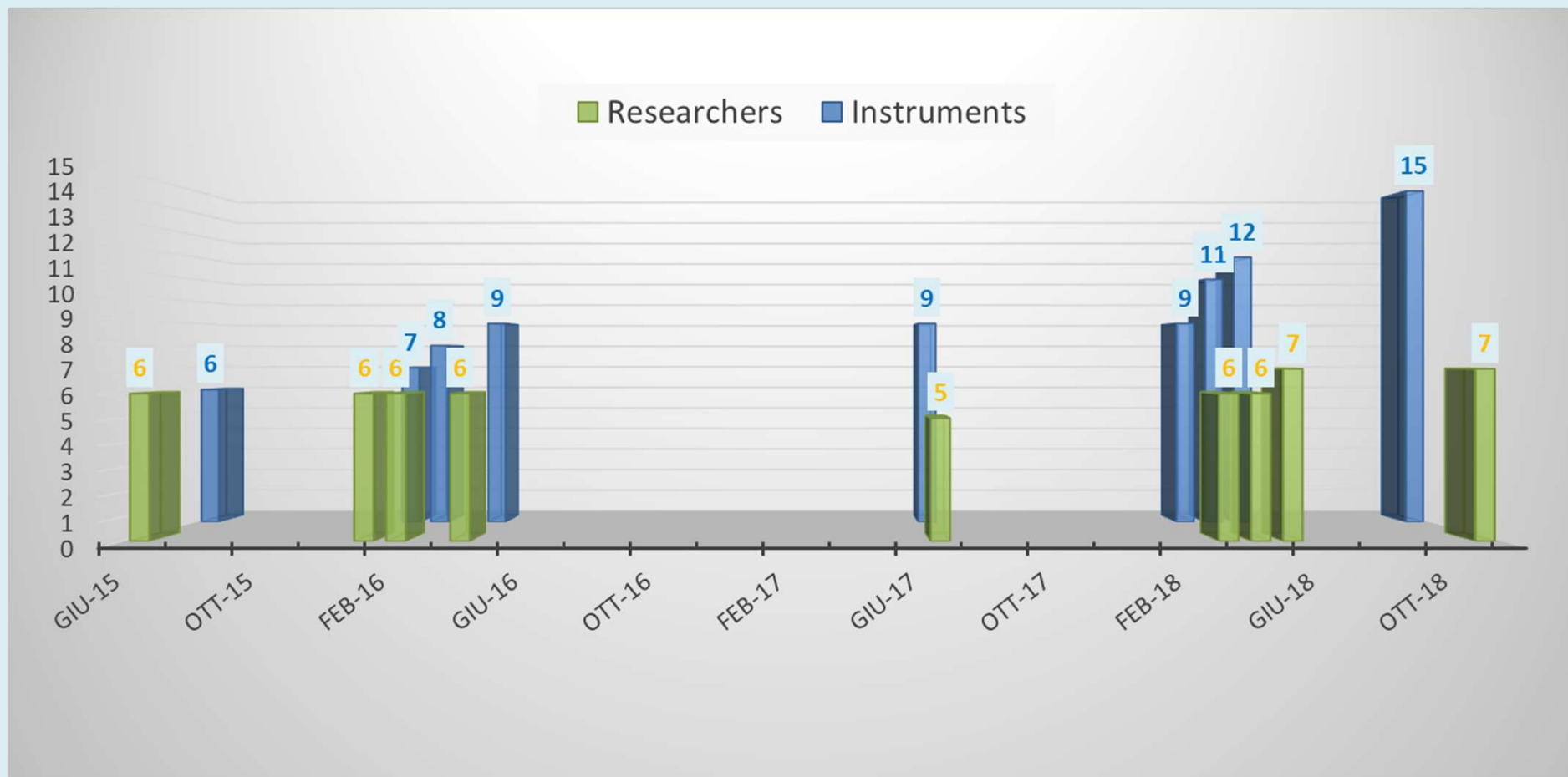
Rain gauge

→ Rainfall rates



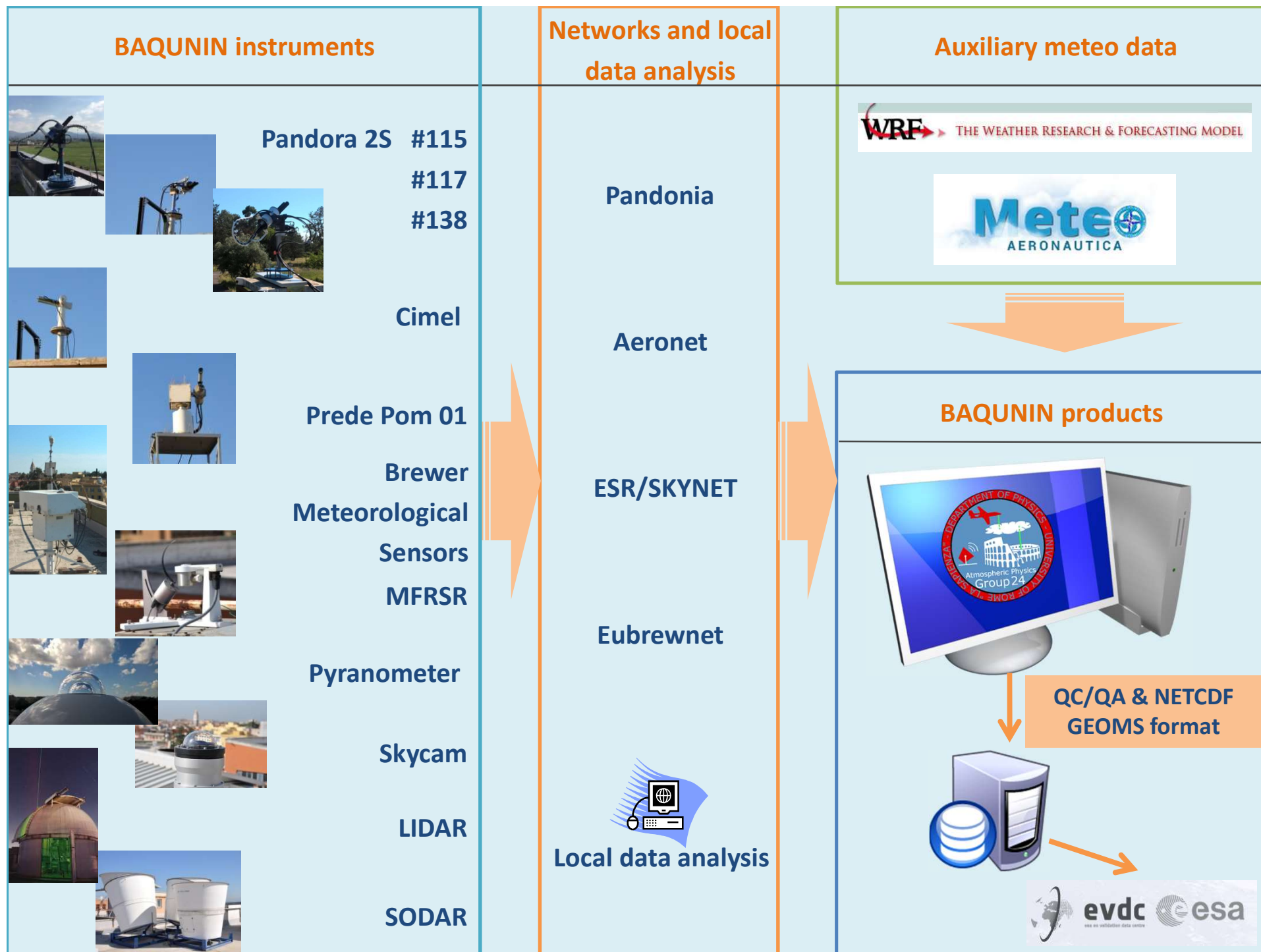
Sapienza University of Rome

## BAQUNIN trends



| BAQUNIN instruments   |  | Principal Investigator & Local Operator |   |
|---|--|---|---|
|    | <b>Pandora 2S #115</b><br><b>#117</b><br><b>#138</b> | <b>S. Casadio</b>                       | <b>M. Campanelli</b><br><b>A.M. Iannarelli</b><br><b>C. Bassani</b> |
|    | <b>Cimel</b>   | <b>M. Campanelli</b>                    |   |
|    | <b>Prede Pom 01</b>                                  |   |   |
|    | <b>Brewer Meteorological Sensors</b>                 | <b>A.M. Siani</b>                       |   |
|   | <b>MFRSR</b>   | <b>M. Cacciani</b>                      | <b>A.M. Iannarelli</b>  |
|    | <b>Pyranometer</b>                                   | <b>A.M. Iannarelli</b>                  |   |
|    | <b>Skycam</b>  |   |   |
|    | <b>LIDAR</b>   | <b>M. Cacciani</b>                      | <b>A.M. Iannarelli</b><br><b>S.Casadio, G. Mevi</b>                 |
|    | <b>SODAR</b>   | <b>M. Cacciani</b>                      |   |





## BAQUNIN Super-Site products & instruments

| BAQUNIN PRODUCTS  |
|---|
| O3 surface, tropospheric and total column   |
| NO2 surface, tropospheric and total column  |
| SO2 surface, tropospheric and total column  |
| HCOH surface, tropospheric and total column   |
| H2O total column, profile   |
| Aerosol Optical Depth (AOD)   |
| Aerosol backscattering and extinction profiles  |
| Scattering and Absorption Ångström Exponent (SAE & AAE)   |
| Angstrom Exponent (AE)  |
| Single Scattering Albedo (SSA), Volume size distribution (VSD), Real and imaginary part of Refractive Index (Refr. Indx), Phase Function (PF) |
| Solar Irradiance  |
| Spectral Radiance   |
| UV Dose, UV Index   |
| Cloud top/bottom  |
| Cloud mask and fraction   |
| Thermal Turbulence, Wind Speed and Direction  |
| Surface air temperature, humidity, pressure and wind  |



# BAQUNIN Activities

## Campaigns 2017/2018

- Lidar&Radiometer Measurement Campaign (LRMC-2017 - ACTRIS)  
Lidar + CIMEL (at CALIPSO overpass)
- Effect of Megacities on the Transport and Transformation of Pollutants on the Regional to Global Scales (EMeRGe, <http://www.iup.uni-bremen.de/emerge/home/home.html>)  
All instruments (two overpasses, low-thick clouds in both cases!)
- QUALity and TRaceabiliy of Atmospheric aerosol Measurements (QUATRAM, <http://www.isac.cnr.it/en/tags/quatram> )  
POM-PREDE, Pandora, Middleton, PFR, CIMEL + Lidar(4 weeks intense operations)
- Valutazione Integrata dell'Esposizione a Particolato in ambiente indoor (VIEPI)  
All instruments (continuous operations, ongoing)

# The QUATRAM Campaign: QUALity and TRaceability of Atmospheric aerosol Measurements

M. Campanelli [1], A.M. Iannarelli [2], S. Kazadzis [3], S. Vergari [4], V. Estelles [5], H. Diemoz [6], A. di Sarra [7], A. Cede [8]

[1] ISAC/CNR, Rome, Italy; [2] SERCO SPA; [3] WRC/WORCC; [4] Italian Air Force; [5] University of Valencia; [6] ARPA Valle d'Aosta; [7] ENEA (Italy); [8] LuftBlick, Austria

<http://www.euroskyrad.net/quatram.html>



**ESR/SKYNET:** 4 PREDE/POM sun-sky photometers

**AERONET:** CIMEL 646 photometer

**PANDONIA:** Pandora spectrometer

**WMO:** Precision Filter Radiometer (PFR)

**BAQUNIN:** Multi Filter Rotating Shadowband Radiometers (MFRSR)

**ENEA:** Middleton photometers

**AIMS:**

- Evaluate homogeneity and comparability among measurements performed by equipment of different International Networks and/or manufactures
- Evaluate the accuracy of new "on site" calibration procedures that allow frequent traceability of measurements and avoid internal inevitable changes of the equipment due to their shipping

# BAQUNIN Activities

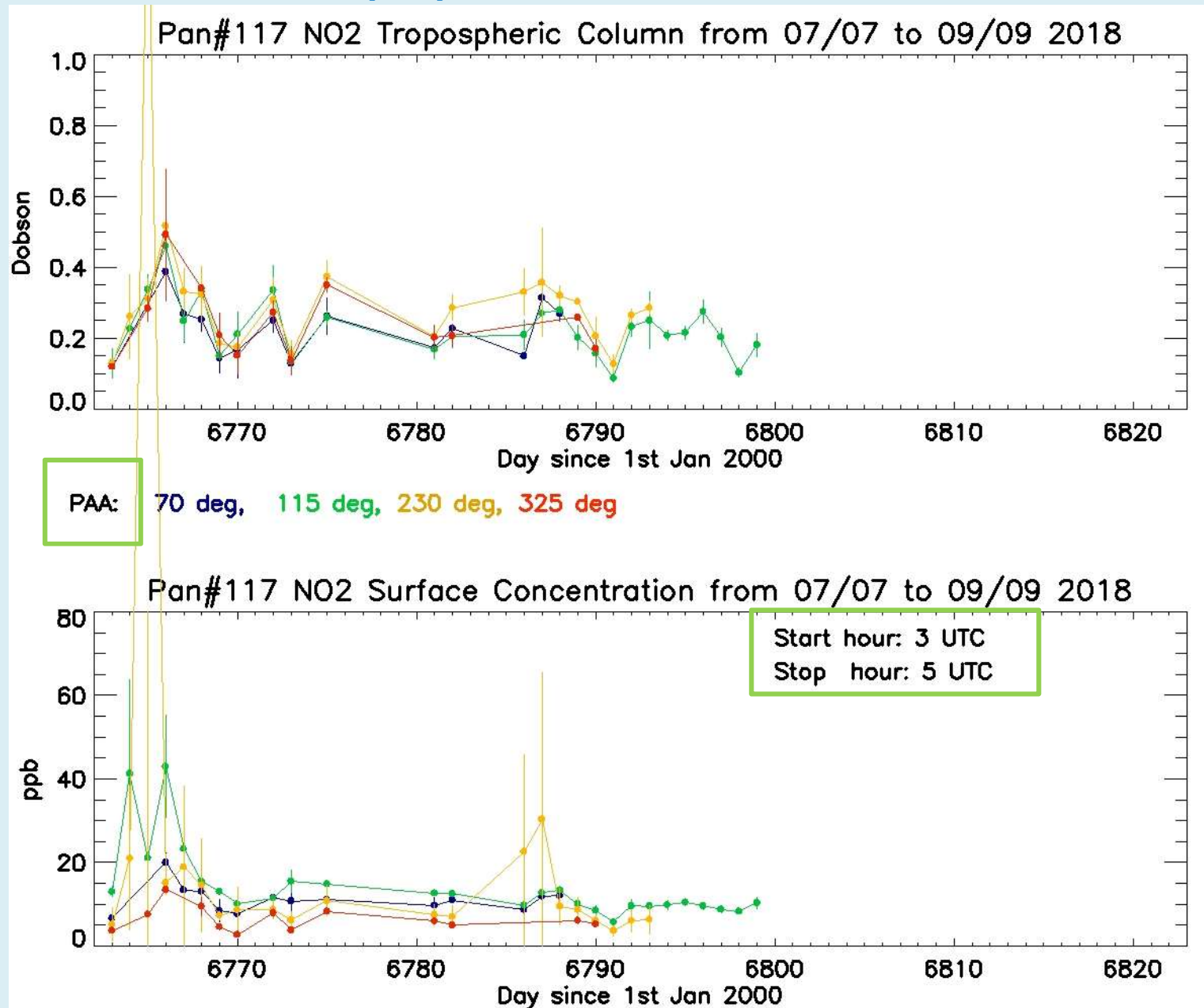
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- Valutazione Integrata dell'Esposizione a Particolato in ambiente indoor (VIEPI)

## Projects 2018

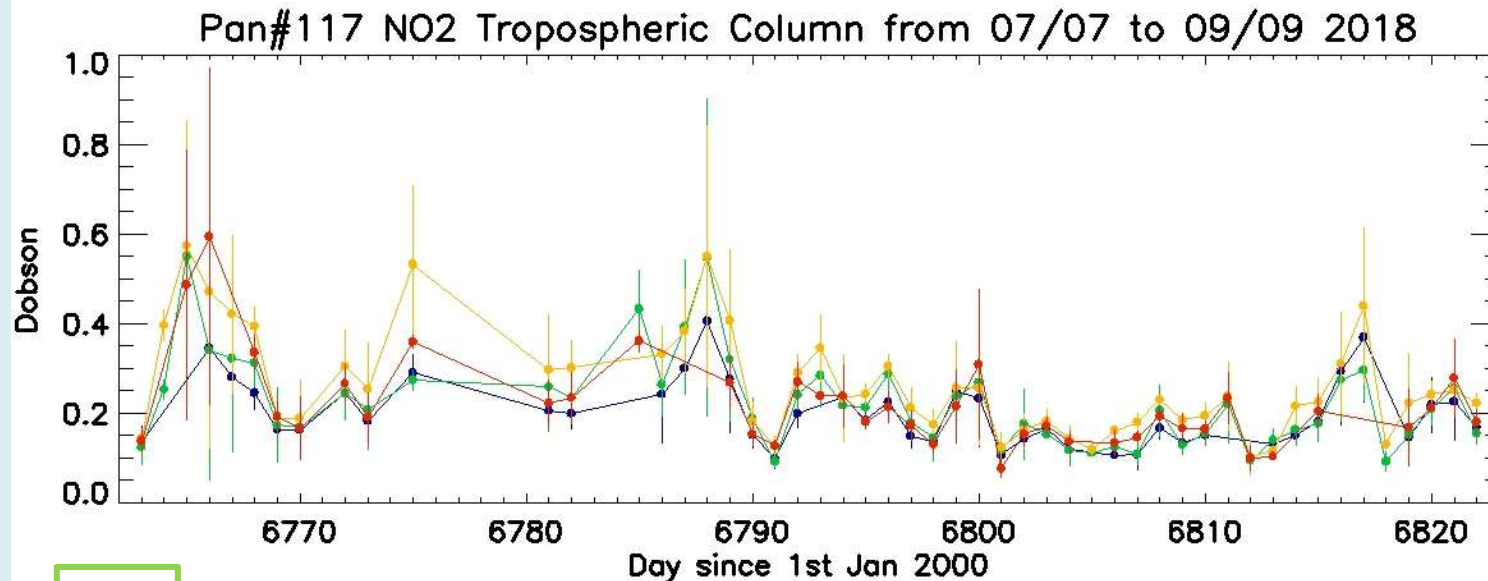
- DIVA ESA Project selected Lidar-CIMEL station (SERCO, SAPIENZA)
- PANDONIA ESA Project “POp” and “FRM4AQ” (SERCO, SAPIENZA ,CNR-ISAC/IIA)

## Pandora #117 NO<sub>2</sub> Tropospheric Column & Surface Values

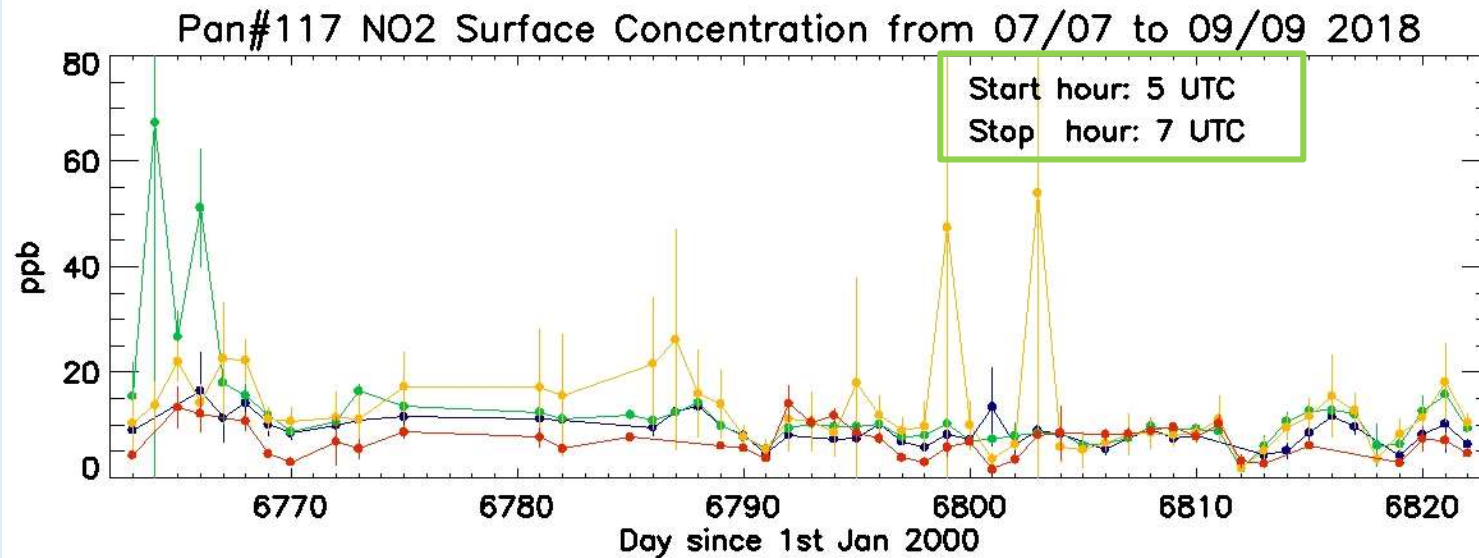




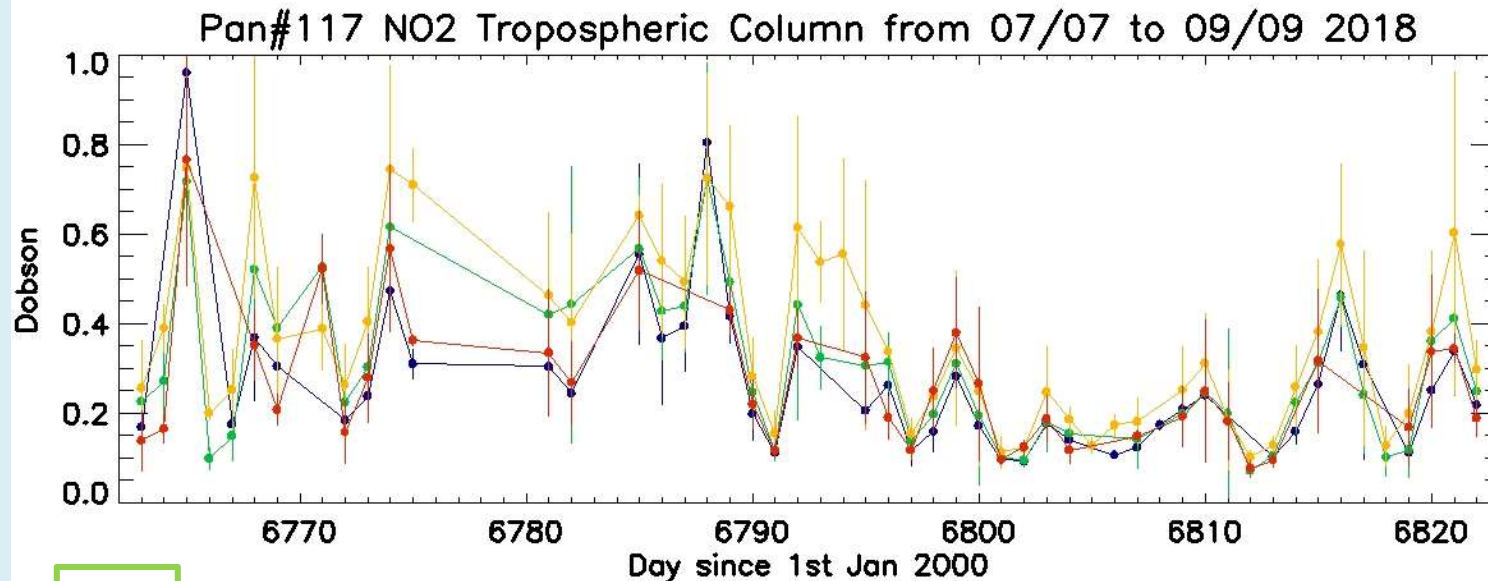
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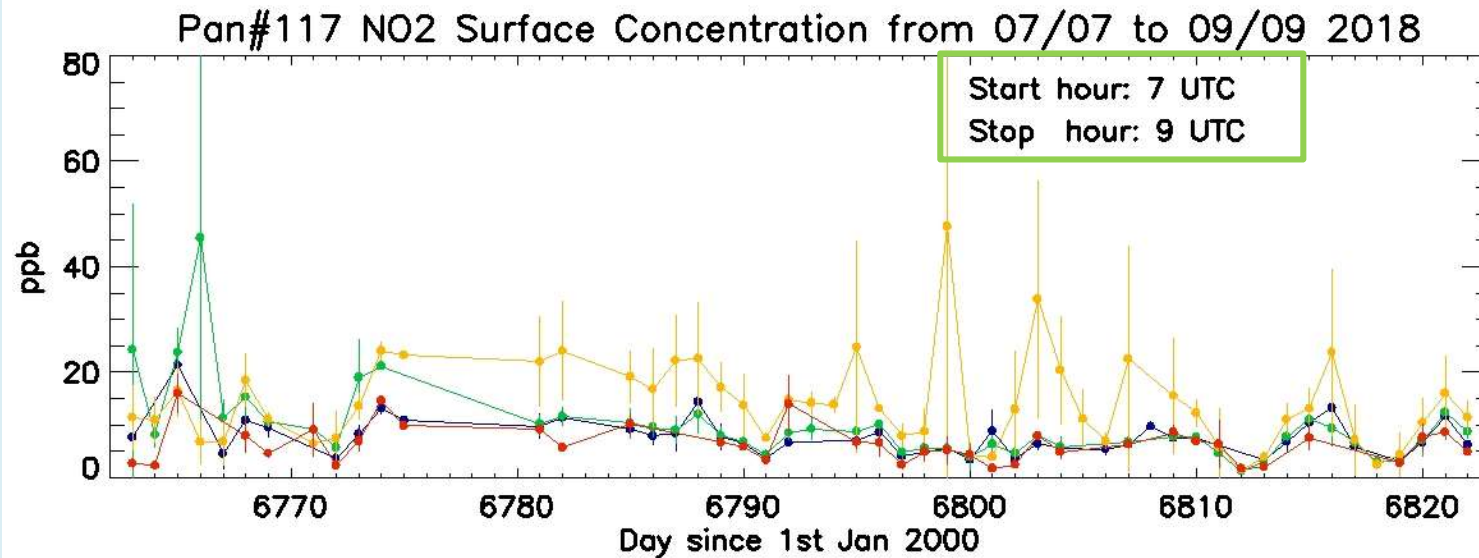
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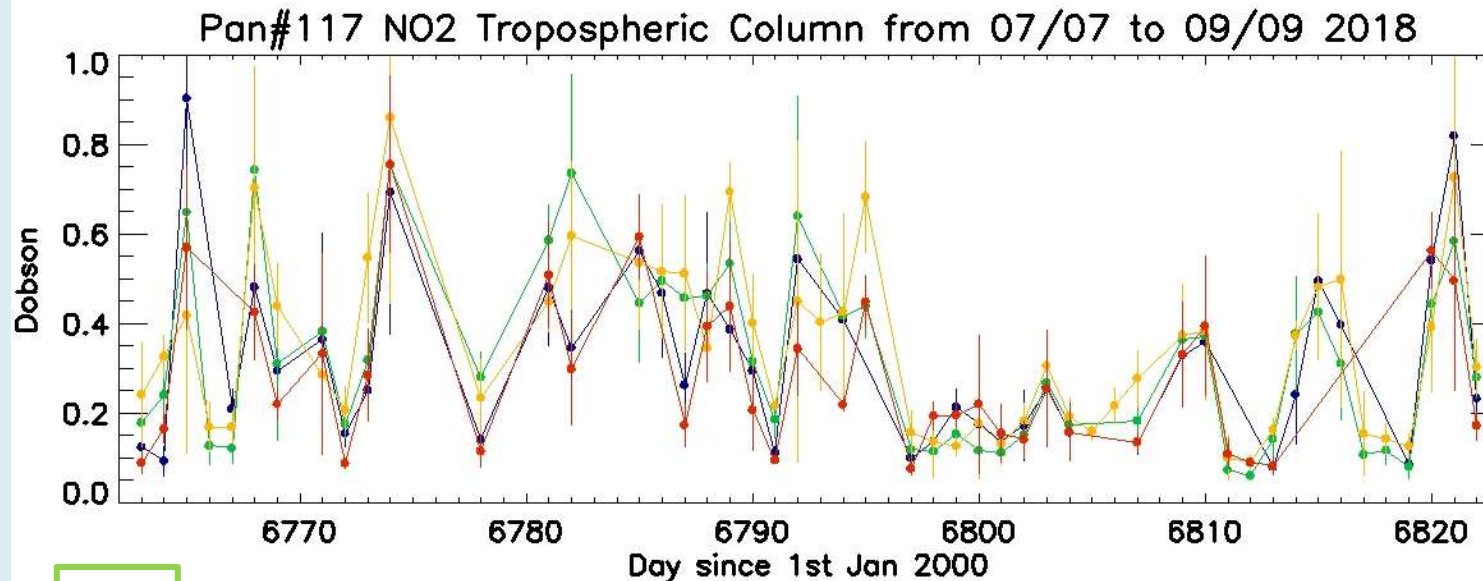
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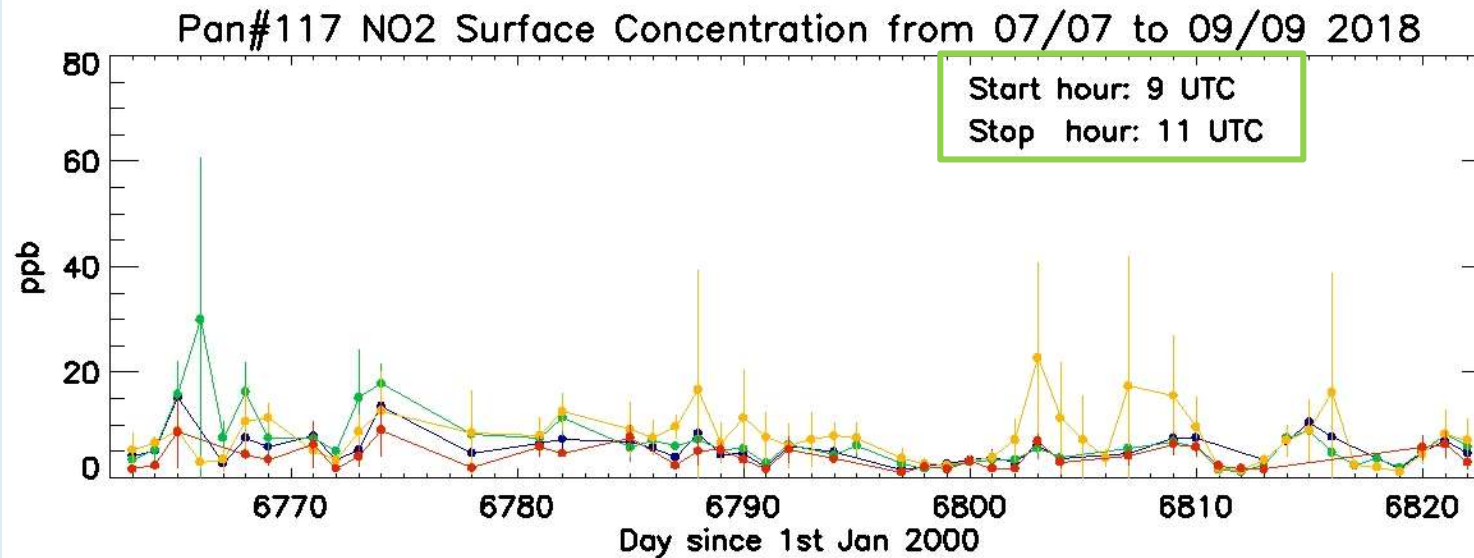
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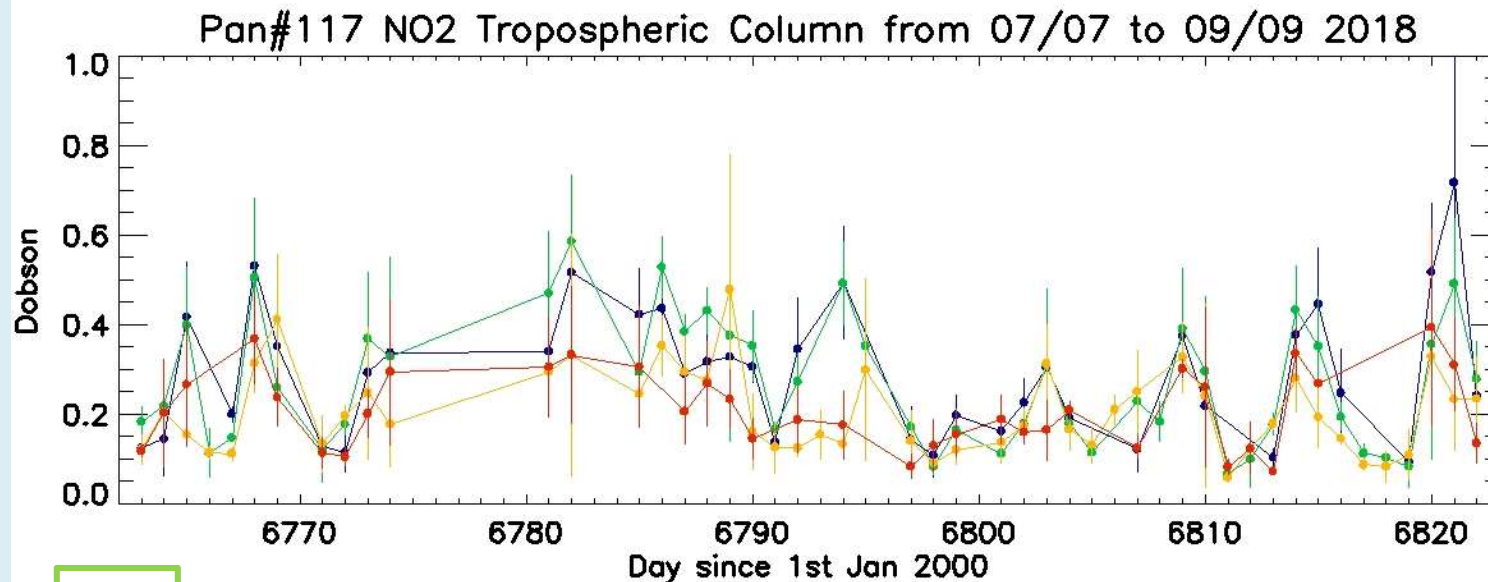
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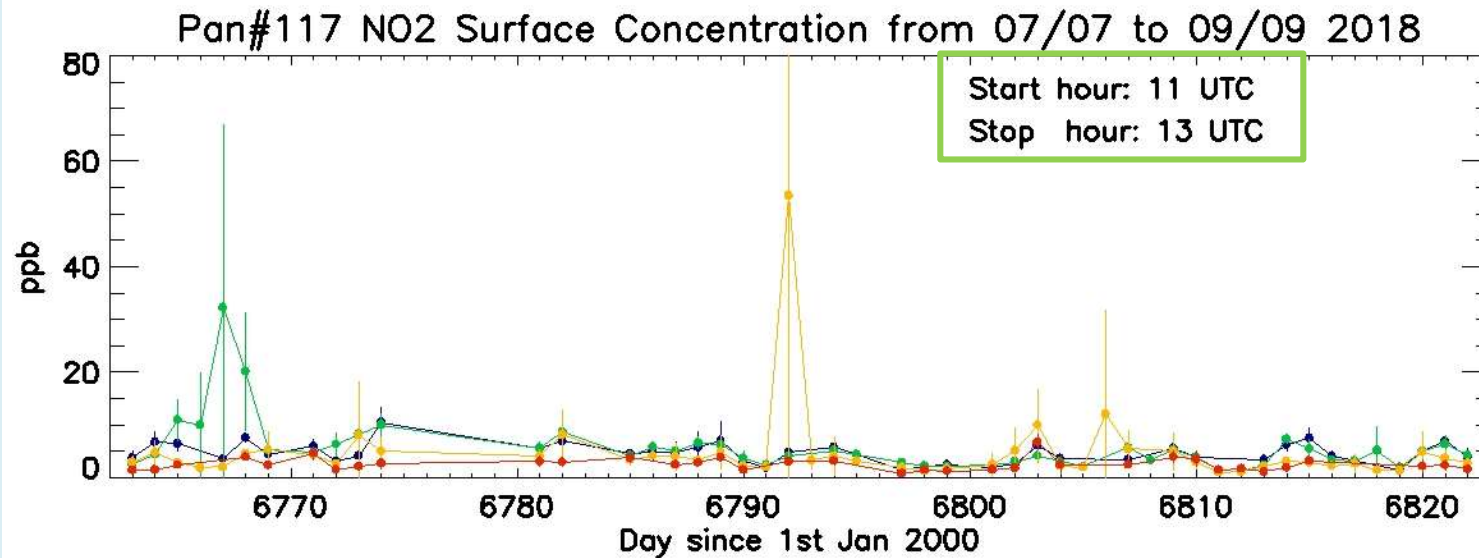
PAA: 70 deg, 115 deg, 230 deg, 325 deg



## Pandora #117 NO<sub>2</sub> Tropospheric Column & Surface Values

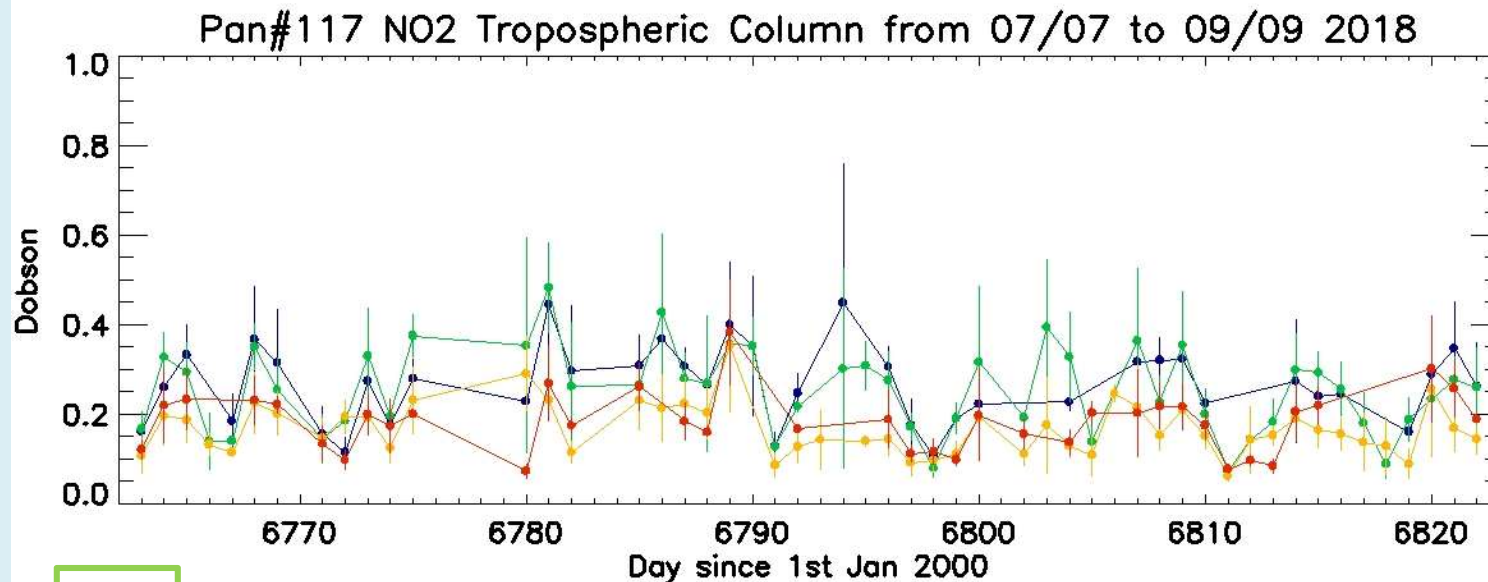


PAA: 70 deg, 115 deg, 230 deg, 325 deg

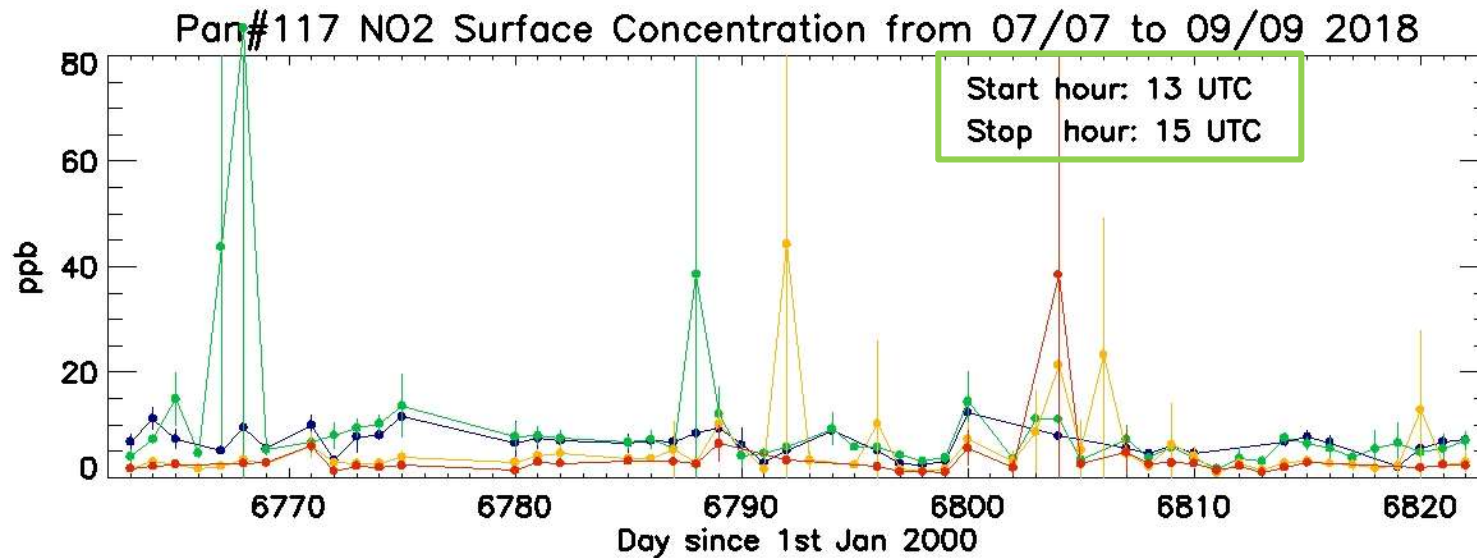




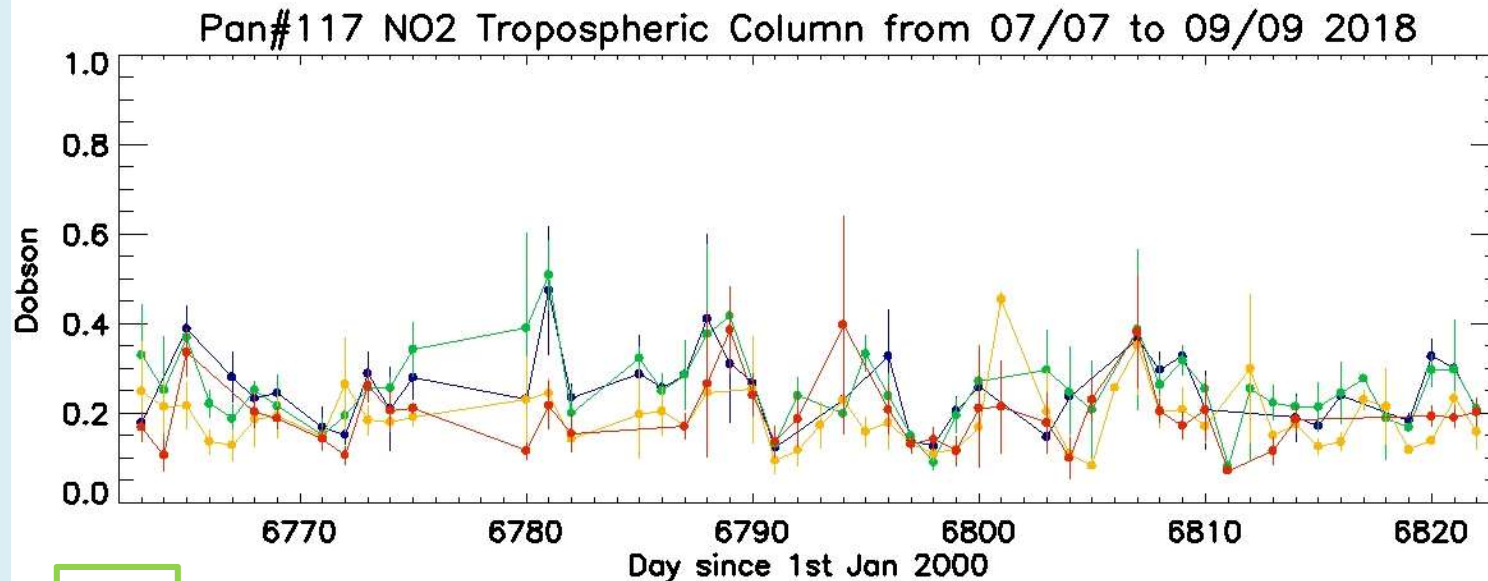
## Pandora #117 NO<sub>2</sub> Tropospheric Column & Surface Values



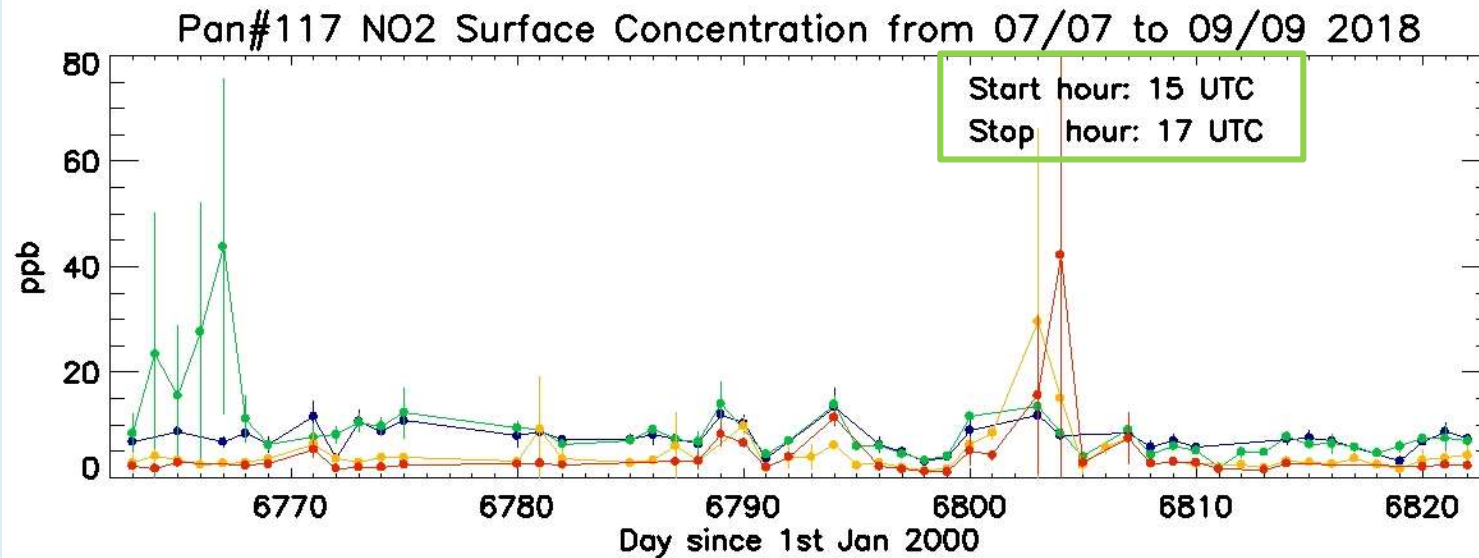
PAA: 70 deg, 115 deg, 230 deg, 325 deg



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PAA: 70 deg, 115 deg, 230 deg, 325 deg



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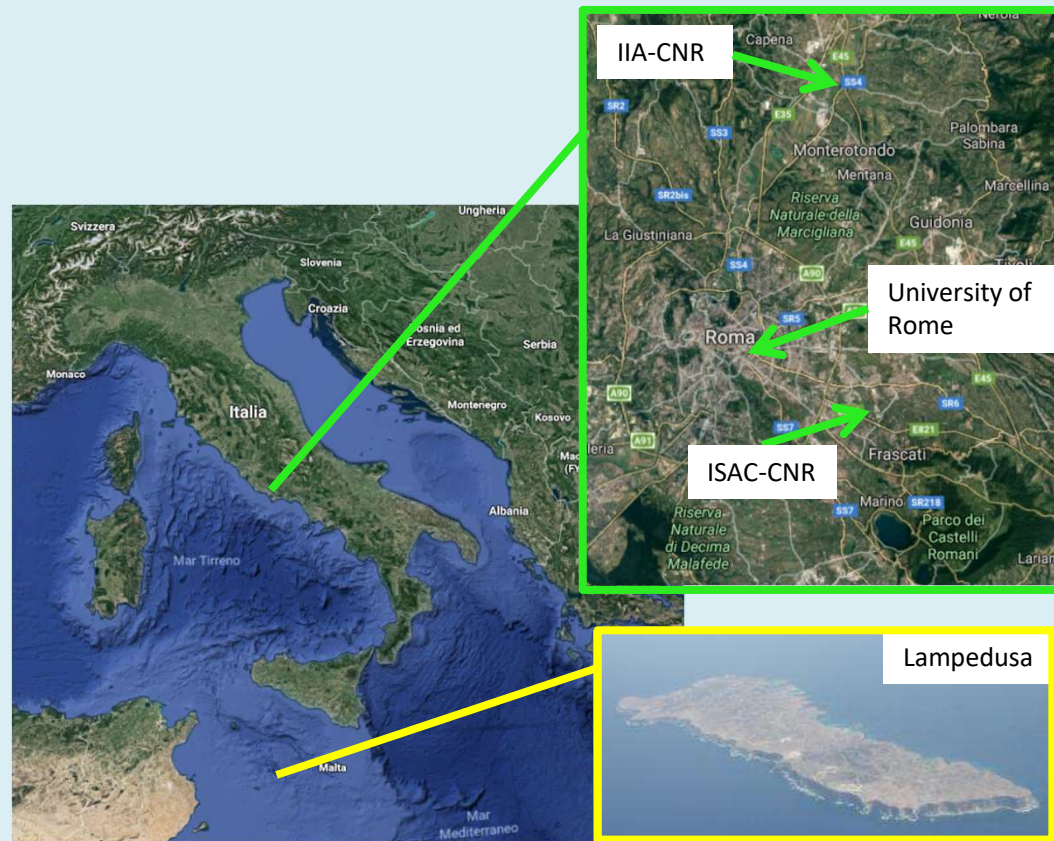
## Projects 2018

- DIVA ESA Project selected Lidar-CIMEL station (SERCO, SAPIENZA)
- PANDONIA ESA Project “POp” and “FRM4AQ” (SERCO, SAPIENZA ,CNR-ISAC/IIA)
- **EarthCare** Validation Project ID **38811** (SERCO, ENEA, CNR-ISAC, SAPIENZA)
- **S5p** Validation Project ID **42807** (SERCO, ENEA, CNR-ISAC/IIA, SAPIENZA, Sard. Clim.)

## S5p Validation

The **BAQUNIN** Supersite, in collaboration with **ENEA**, **CNR-ISAC/IIA**, will take part to the validation of Sentinel 5p products. The objective of our proposal is to take full advantage of available instrumentation and knowhow from 4 Italian atmospheric observatories in Central Mediterranean to provide high quality correlative data for Sentinel-5p L2 products validation.

The observatories are located in the Island of Lampedusa, in the Rome city center (BAQUNIN), in two semi-rural (CNR-ISAC CIRAS) and (CNR-IIA) sites allowing the sampling of different regimes/processes of interest for TROPOMI validation.

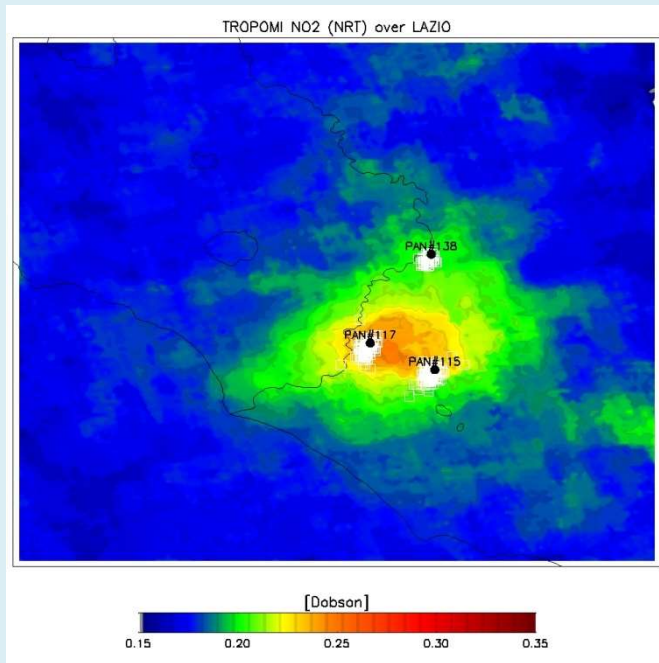




## S5p Validation: BAQUNIN products for TROPOMI

| BAQUNIN PRODUCTS  | TROPOMI  |
|---|----------|
| O3 surface, tropospheric and total column   | YES      |
| NO2 surface, tropospheric and total column  | YES      |
| SO2 surface, tropospheric and total column  | YES      |
| HCOH surface, tropospheric and total column   | YES      |
| H2O total column, profile   | FUTURE!  |
| Aerosol Optical Depth (AOD)   | Indirect |
| Aerosol backscattering and extinction profiles  | Indirect |
| Scattering and Absorption Ångström Exponent (SAE & AAE)   | Indirect |
| Angstrom Exponent (AE)  | Indirect |
| Single Scattering Albedo (SSA), Volume size distribution (VSD), Real and imaginary part of Refractive Index (Refr. Indx), Phase Function (PF) | Indirect |
| Solar Irradiance  | Indirect |
| Spectral Radiance   | Indirect |
| UV Dose, UV Index   | Indirect |
| Cloud top/bottom  | YES      |
| Cloud fraction  | YES      |
| Thermal Turbulence, Wind Speed and Direction  | Support  |
| Surface air temperature, humidity, pressure and wind  | Support  |

# Satellite S5p validation

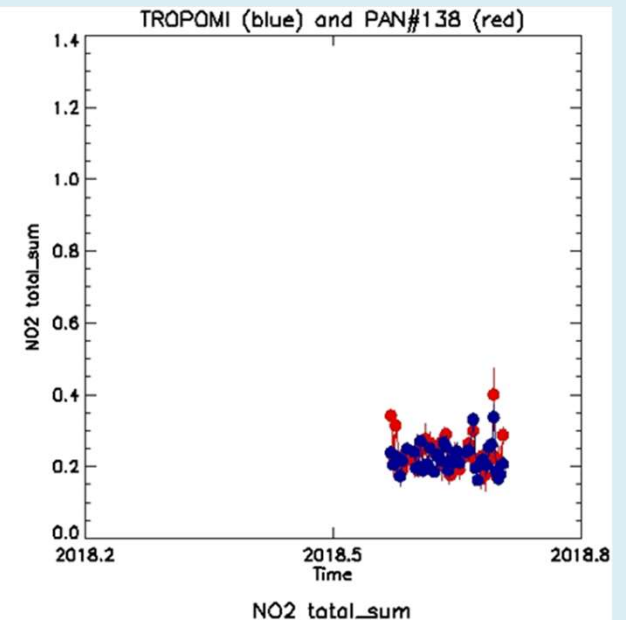
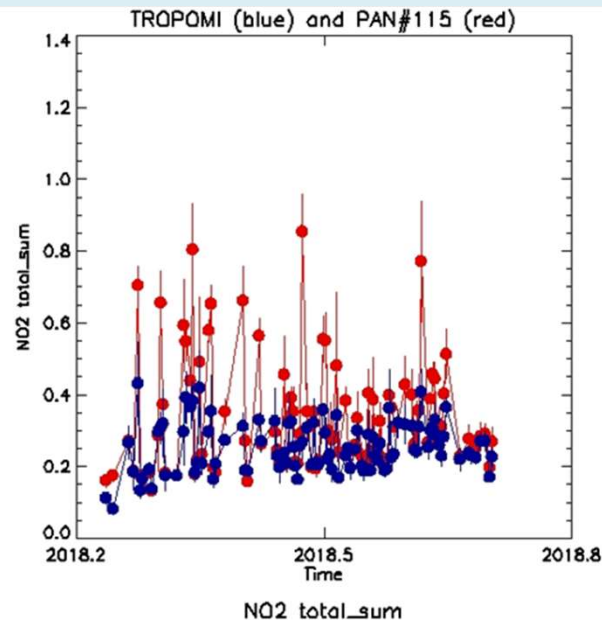
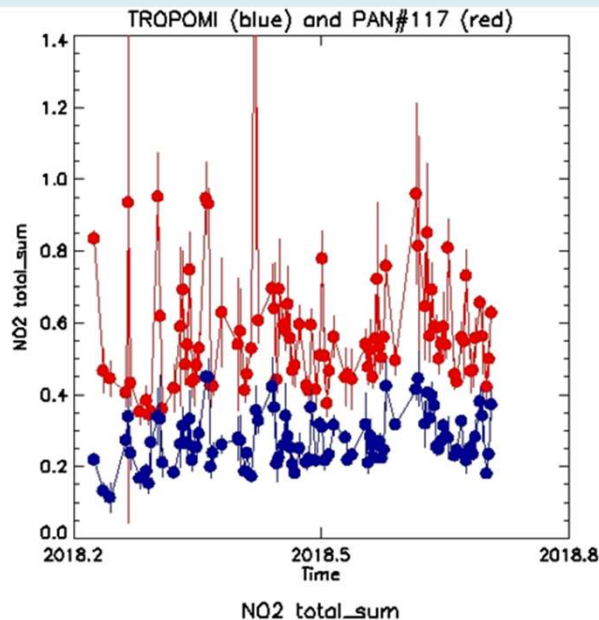


The Sentinel 5p ground resolution ( $7 \times 3.5$  km) is so high that validation of tropospheric species for inhomogeneous environment (e.g. urban) requires a “dense” network in order to investigate the role of:


- Highly variable surface reflectance on retrieval algorithms
- Seasonal changes of probed atmosphere/surface from satellite and ground based instruments
- Possibility to validate the “background” NO2

The comparison between NO2 values from TROPOMI (blue) and each Pandora instrument (red):

- TROPOMI agrees with Pandora in semi-rural and rural environments
- TROPOMI significantly underestimates Pandora in urban environment



# S5P SVA validation pass for camp EVDC



evdc esa  
esa validation data centre

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☐ METOP-B

☐ NOAA 15

☐ OCO2 (FS)

☐ ODIN

☐ PROBA-V

☐ QUIKSCAT

☐ SENTINEL-1A

☐ SENTINEL-1B

☐ SENTINEL-2A

☐ SENTINEL-2B

☐ SENTINEL-3A

☐ SENTINEL-3B

☒ SENTINEL-5P

☐ SMAP

☐ SMOS

☐ SPOT 6

☐ SPOT 7

☐ SUOMI NPP

☐ TERRA

☐ NAOMI

☐ OCO-2

☐ OLCI

☐ OLI

☐ OMI

☐ OMPS

☐ Optical

☐ Radar

☐ SCIAMACHY (Limb)

☐ SCIAMACHY (Nadir)

☐ SeaWinds Scatterometer

☐ SLSTR (Nadir)

☐ SLSTR (Oblique)

☐ SMR

☐ TANSO-ETS

☒ TROPOMI

☐ VGT-P

☐ VIIRS

☐ WVC

Info


Full Screen

Select Location

Select Polygon

Show Footprint

Reset



CESIUM bing © 2018 Microsoft Corporation • Earthstar

Oct 9 2018 21:42:51 UTC

Oct 10 2018 00:00:00 UTC

Oct 12 2018 00:00:00 UTC

Start: 2018-10-11 02:03:57Z - TROPOMI

Start: 2018-10-11 00:23:30Z - TROPOMI

Start: 2018-10-10 12:05:20Z - TROPOMI

Start: 2018-10-10 00:42:03Z - TROPOMI

Start: 2018-10-09 12:24:13Z - TROPOMI

Longitude: 12.515773 Latitude: 41.901695 Format: DDD.DDDD

Start: 08/10/2018 06:31

End: 12/10/2018 20:31

☐ Joint Overpass 20 Max Time Difference (minutes)

Predict Orbits

Get Spatial Overpasses

Get Temporal Overpasses

Add Satellite

Search Satellite Data

Choose Data File

Upload

Show Overpass

Download Results

## S5p overpass from EVDC: example

|                           |                           |
|---------------------------|---------------------------|
| id query                  | 111672                    |
| satellite                 | 3553                      |
| instrument                | SENTINEL5P TROPOMI        |
| pass_number               | 10                        |
| rise_time                 | 2018-10-10 12:05:20+00:00 |
| set_time                  | 2018-10-10 12:16:11+00:00 |
| rise_longitude            | 17.6012222222222          |
| set_longitude             | 2.92066666666667          |
| rise_latitude             | 22.7923055555556          |
| set_latitude              | 60.4171388888889          |
| rise_azimuth              | 2.89303684234619          |
| set azimuth               | 6.03523540496826          |
| max_time                  | 2018-10-10 12:10:44+00:00 |
| max_alt                   | 1.52344810962677          |
| elevation                 | 832213.5                  |
| sun_alt                   | 0.672763228416443         |
| duration                  | 650                       |
| visible                   | False                     |
| query_start_time          | 2018-10-08 06:31:00+00:00 |
| query_end_time            | 2018-10-12 20:31:00+00:00 |
| meters_to_ground_location | 6365.24033815485          |

Requirements for  
validation cloud  
products from  
*First Sentinel-5  
Precursor Products  
Release Workshop*  
25 - 26 June 2018

<10°

<160Km

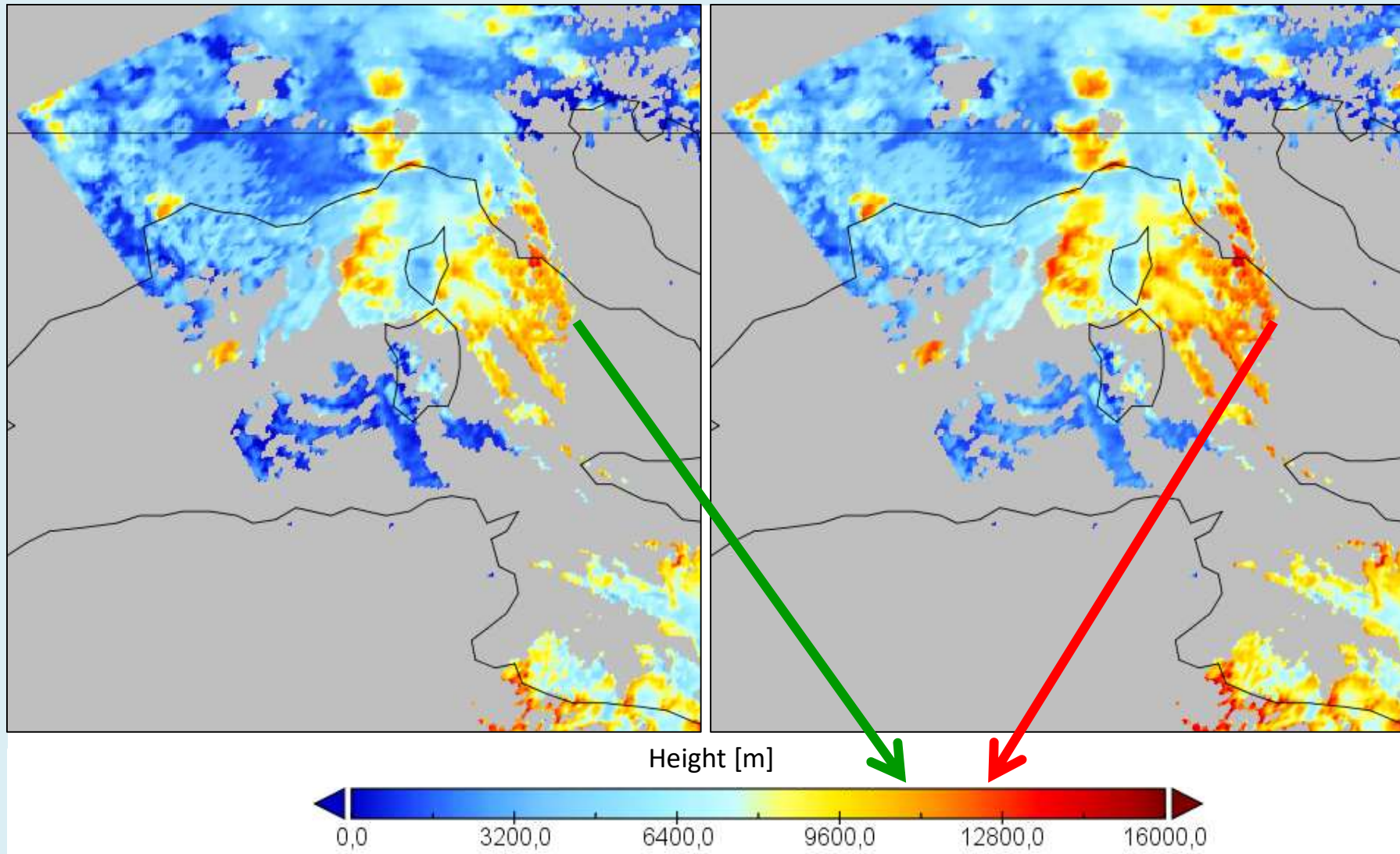


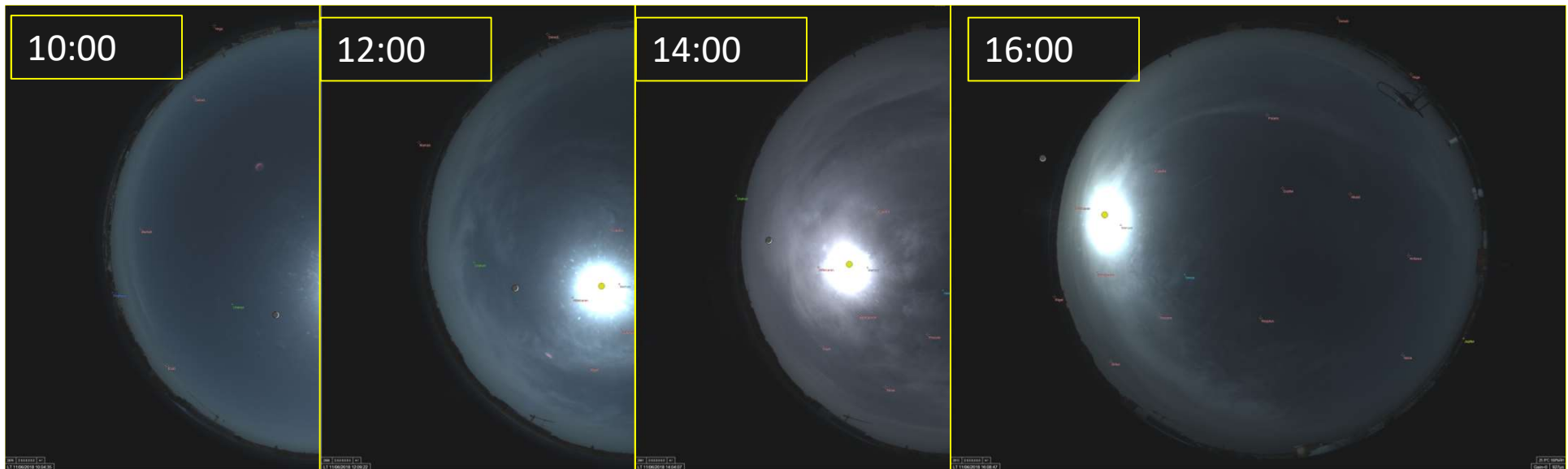
# S5p Validation: L2 cloud

11 / 06 / 2018

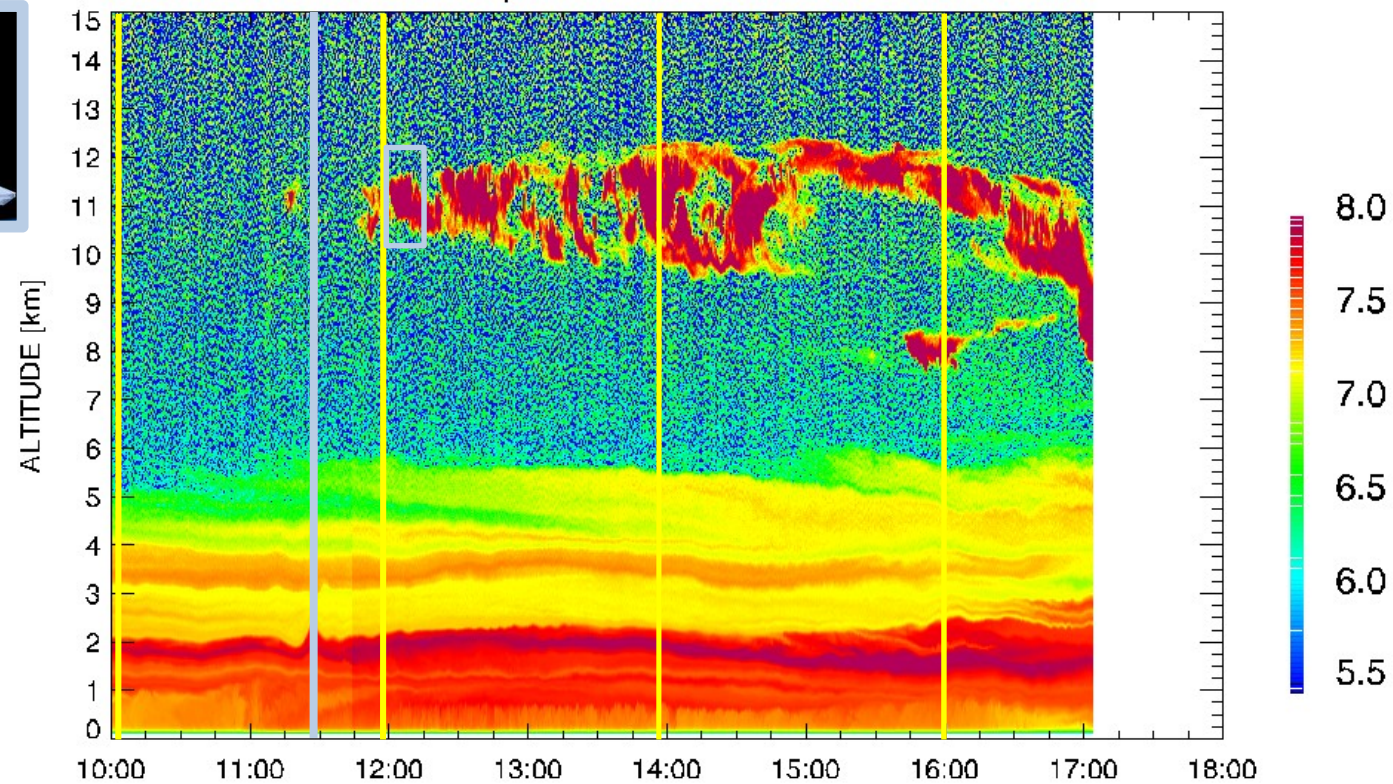
Cloud **base**

Cloud **top**





La Sapienza ROME LIDAR -1064



# BAQUININ Activities

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## Summer school 2018

- SORBETTO Summer School, 2-6 July 2018





# ***SORBETTO***

## ***Solar Radiation Based Established Techniques for aTmospheric Observations***

<http://sorbetto2018.artov.isac.cnr.it/>

Organized by ISAC-CNR, Sapienza University of Rome, ESA. Funded by SERCO within the IDEAS project



**SAPIENZA**  
UNIVERSITÀ DI ROMA



**serco**





# **SORBETTO** summer school

**2-6 July 2018**

**CNR Headquarter and Sapienza University, Rome, Italy**

## **Aims**

- **Forming young scientists** providing them an overview of the current status of solar radiation based techniques, a solid theoretical base, and hands-on experimental activities
- Building a bridge among International communities involved in atmospheric science for establishing and reinforcing future cooperation.

## **Topics**

- Radiometry (theory, networks, calibration)
- Photometry (theory, networks, calibration)
- Spectrometry (theory, networks, calibration)
- Inter-comparison campaigns
- Calibration and Validation of satellite Missions
- Laboratories

**Invited 18 Speakers** from the main Institutions in Europe and Japan

**35 Students** from Europe, Africa and Asia attended the courses, valued with a good approval rating



# LMAST

## Laurea Magistrale in Atmospheric Science and Technology

<http://www.dsfc.univaq.it/it/corso-magistrale-lmast.html>

**LMAST PROGRAMME.** The Laurea Magistrale in Atmospheric Science and Technology (LMAST) is a Master of Science (MSc) degree in the Physics class (LM-17), organized as an international inter-university programme, jointly proposed by the ***Sapienza University of Rome and University of L'Aquila***. The unique feature of LMAST programme is to educate master students with solid knowledge and specific skills in the domain of atmospheric science from a physics and an engineering perspective.

**LMAST ORGANIZATION.** The Laurea Magistrale in Atmospheric Science and Technology (LMAST) is held entirely in English and provides students with advanced concepts, professional training and specific physics and engineering skills, enabling them to address complex issues requiring analysis, development, simulation and application in a wide range of atmospheric science topics.

# BAQUNIN Staff

## *Instrument Technical Support, Maintenance, Calibration, and Engineering*

|                       |                                |       |
|-----------------------|--------------------------------|-------|
| Stefano Casadio       | Stefano.Casadio@esa.int        | SERCO |
| Anna Maria Iannarelli | Annamaria.Iannarelli@serco.com | SERCO |
| Gabriele Mevi         | gabriele.mevi@ingv.it          | SERCO |

## *Site management, Scientific Analysis, Instrument (co-)PI*

|                   |                              |                |
|-------------------|------------------------------|----------------|
| Marco Cacciani    | Marco.Cacciani@uniroma1.it   | Univ. Sapienza |
| Annamaria Siani   | Annamaria.Siani@uniroma1.it  | Univ. Sapienza |
| Monica Campanelli | Campanellimonica@gmail.com   | ISAC-CNR       |
| Cristiana Bassani | cristiana.bassani@iia.cnr.it | IIA-CNR        |

## *WRF Model Simulations, Trajectories*

|              |                      |                |
|--------------|----------------------|----------------|
| Enrico Cadau | Enrico.Cadau@esa.int | Sardegna Clima |
|--------------|----------------------|----------------|

*Thank you for your attention!!!*