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

A.M. Iannarelli (1), M. Cacciani (2), S. Casadio (1), G. Mevi (1), M. Campanelli (3), A.M. Siani (2), H. Diemoz (4), J. von Bismarck (5)

1) Serco SpA - 2) Physics Department, "Sapienza" University of Rome
3) CNR-ISAC - 4) ARPA Valle d'Aosta, Saint-Christophe, Aosta - 5) ESA/ESRIN

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

Inside the Physic Department of Sapienza University two research groups involved in atmospheric and climate studies are present since 30 years ago.
During the years, a lot of researchers were formed there, some of which still today work in these sectors.
Numerous are the international projects which involved these research groups, as international campaigns and studies, development of remote sensing instruments and retrieval algorithms.
The two research groups G24 and G-MET always collaborate combining their efforts, skills and instrumentation to give their contribute to scientific community.

In this context and thanks to the collaboration with ESA, in June 2016 the BAQUNIN Supersite is born.

In the last years, the suite of the instruments present in the Physics Department has expanded and so also the collaboration with other research agencies.

In the Supersite are present 12 ground based remote sensing instruments, operating in synergy, offering quantitative and qualitative informations for a wide range of atmospheric parameters for Planetary Boundary Layer (PBL) studies and for validating the satellite atmospheric composition and optical products (level 2).

BAQUNIN Super Site

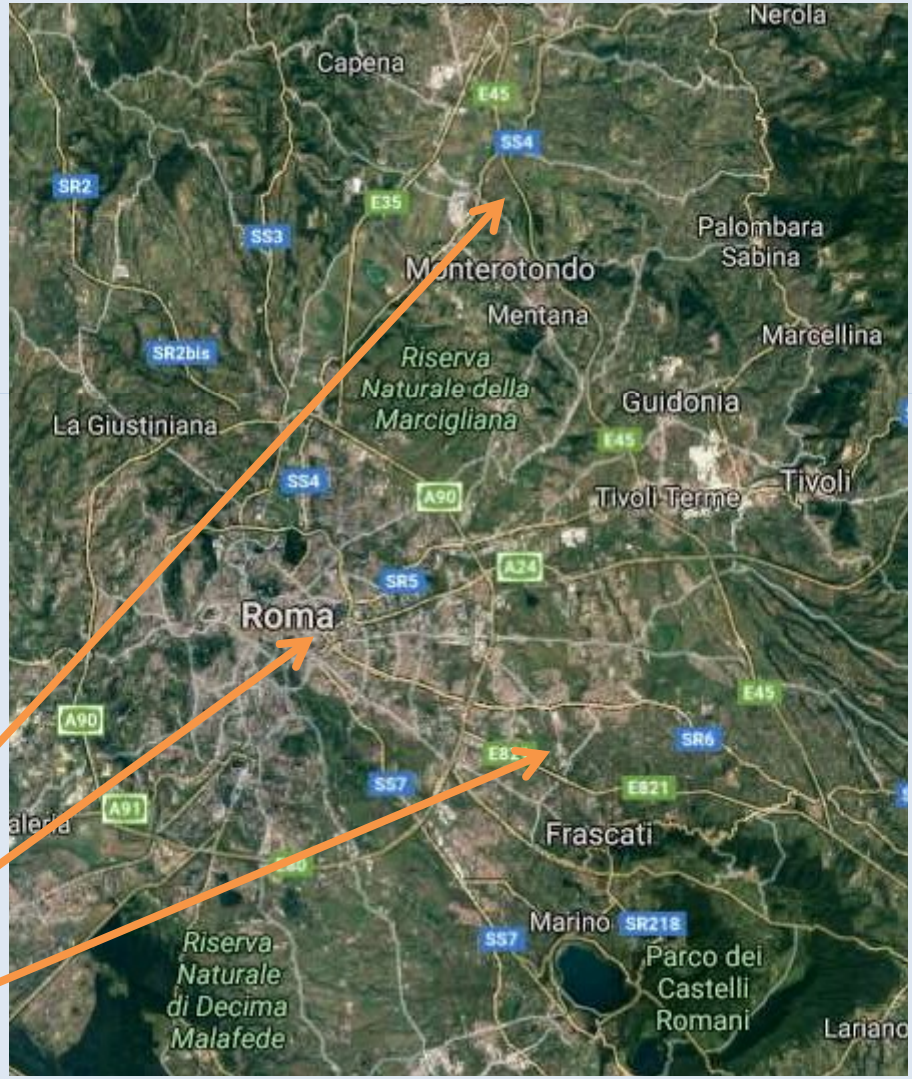
The great part of the BAQUNIN Super Site instrumentation is located at **Sapienza University**, in the city center.
Other two instruments (Pandora) are located in semi-rural areas:

- 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.

- 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

Locations

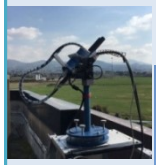


IIA-CNR Montelibretti

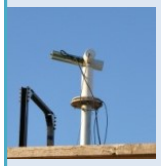
Sapienza University

ISAC-CNR Tor Vergata

BAQUNIN instruments



Pandora 2S #115
#117
#138



Cimel

Prede Pom 01

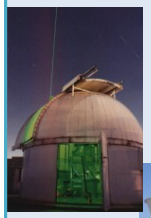
Brewer

Meteorological Sensors

MFRSR

Pyranometer

Skycam



LIDAR

SODAR

Networks and local data analysis

Pandonia

Aeronet

ESR/SKYNET

Eubrewnet

Local data analysis

Auxiliary meteo data

WRF THE WEATHER RESEARCH & FORECASTING MODEL

Meteo AERONAUTICA

BAQUNIN products

QC/QA & NETCDF GEOMS format

evdc esa

BAQUNIN Super-Site products & instruments

BAQUNIN PRODUCTS	INSTRUMENTS
O3 surface, tropospheric and total column	PANDORA 2S ‡, BREWER
NO2 surface, tropospheric and total column	PANDORA 2S ‡, BREWER
SO2 surface, tropospheric and total column	PANDORA 2S ‡
HCOH surface, tropospheric and total column	PANDORA 2S ‡
H2O total column, profile	CIMEL •, LIDAR (•), *PANDORA 2S ‡, PREDE ‡, MFRSR*
Aerosol Optical Depth (AOD)	CIMEL •, PREDE ‡, MFRSR, LIDAR (•), *PANDORA 2S ‡*
Aerosol backscattering and extinction profiles	LIDAR (•)
Scattering and Absorption Ångström Exponent (SAE & AAE)	CIMEL •
Angstrom Exponent (AE)	CIMEL •, PREDE ‡, PANDORA 2S ‡
Single Scattering Albedo (SSA), Volume size distribution (VSD), Real and imaginary part of Refractive Index (Refr. Indx), Phase Function (PF)	CIMEL •, PREDE ‡
Solar Irradiance	PYRANOMETER (•)
Spectral Radiance	PANDORA 2S ‡
UV Dose, UV Index	BREWER
Cloud top/bottom	LIDAR (•)
Cloud fraction	All Sky Camera
Thermal Turbulence, Wind Speed and Direction	SODAR (•)
Surface air temperature, humidity, pressure and wind	Meteorological sensors, WRF

• → "**twins**" or ‡ → "**triplets**"
Instrument operating in **urban** and **semi-rural** environment (brackets=>"possibly")

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)

Projects 2018

- DIVA ESA Project selected Lidar-CIMEL station (SERCO, SAPIENZA)

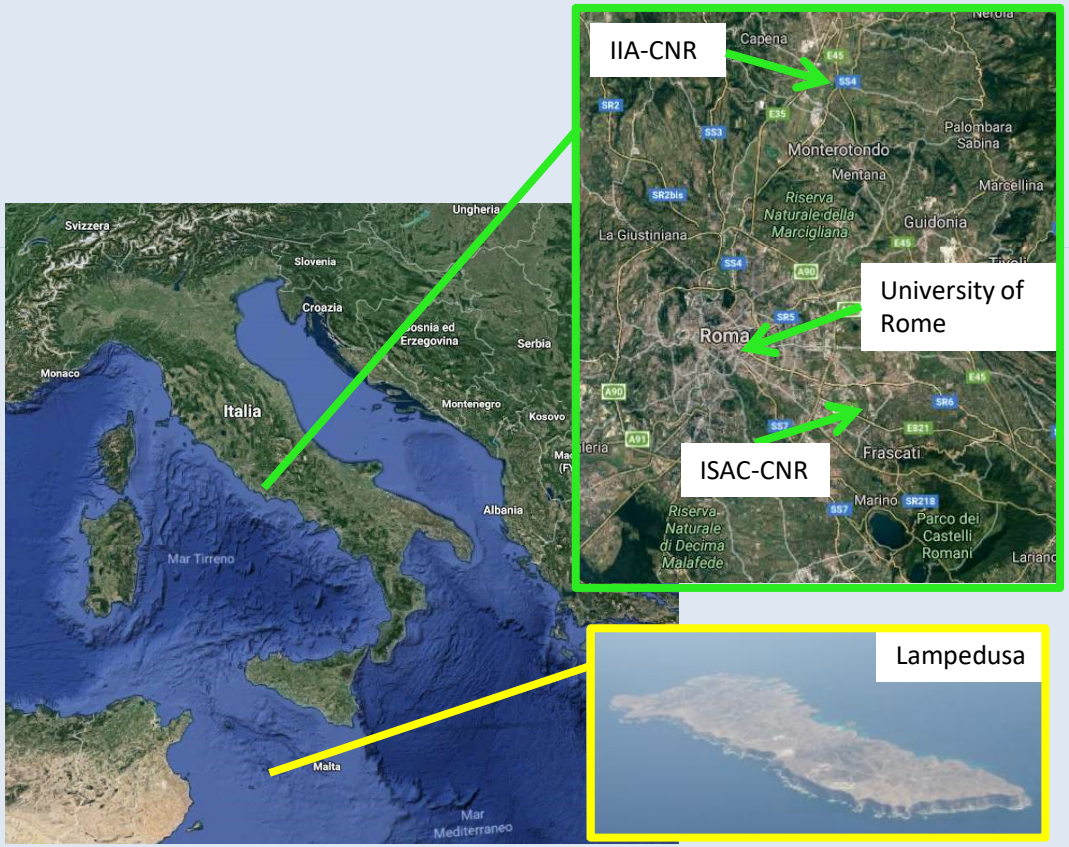
- PANDONIA ESA Project "POp" and "FRM4AQ" (SERCO, SAPIENZA ,CNR-ISAC/IIA)

- **EarthCare** Validation Proposal ID **38811** (SERCO, ENEA, CNR-ISAC, SAPIENZA)

- **S5p** Validation Proposal 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.



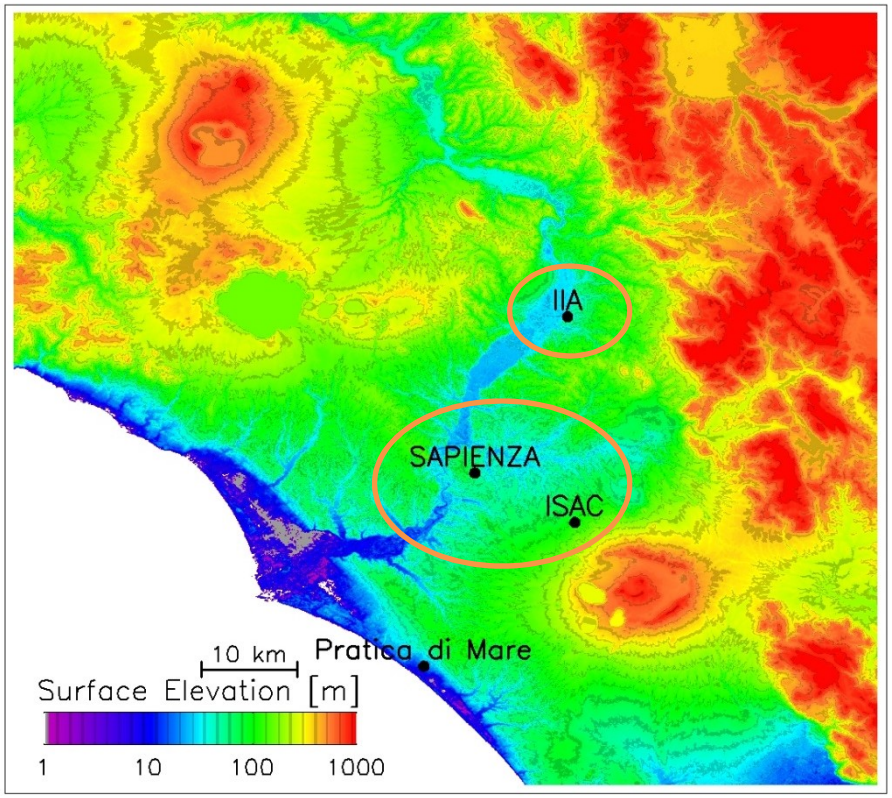
S5p Validation: BAQUNIN products for TROPOMI

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

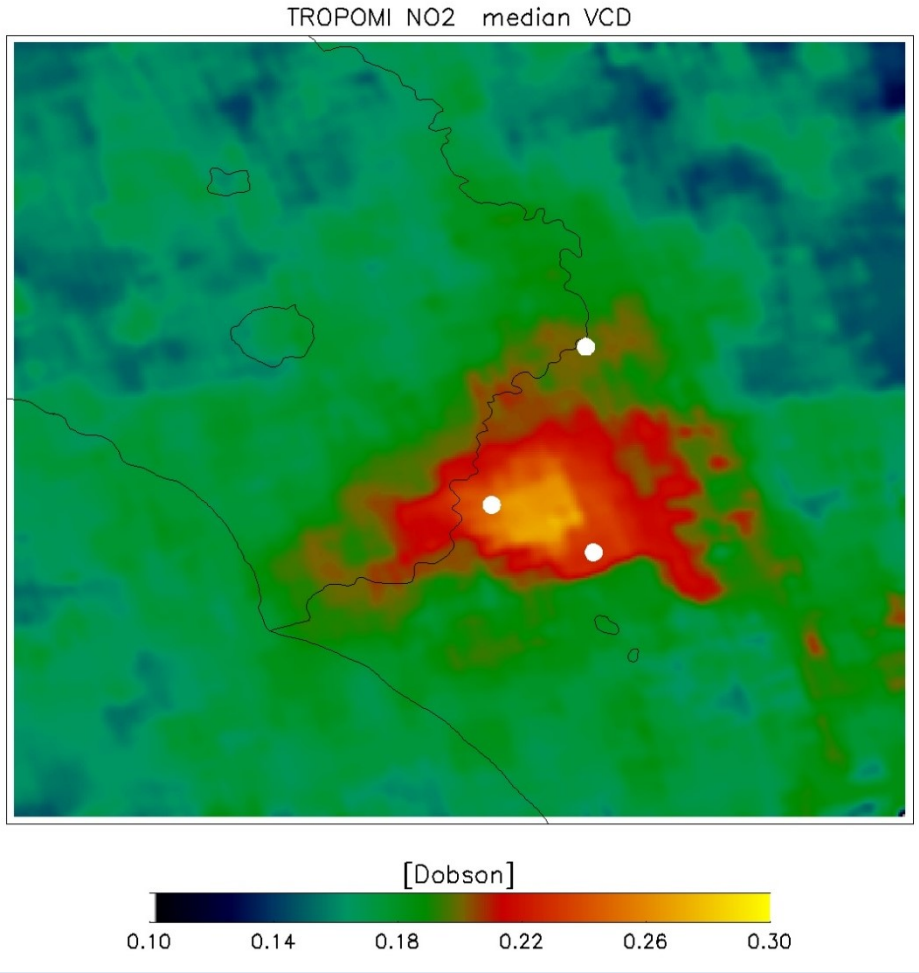
S5p Validation: First analysis of TROPOMI NO2 VCD in the Tiber Valley

The Sentinel 5p ground resolution (7 × 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



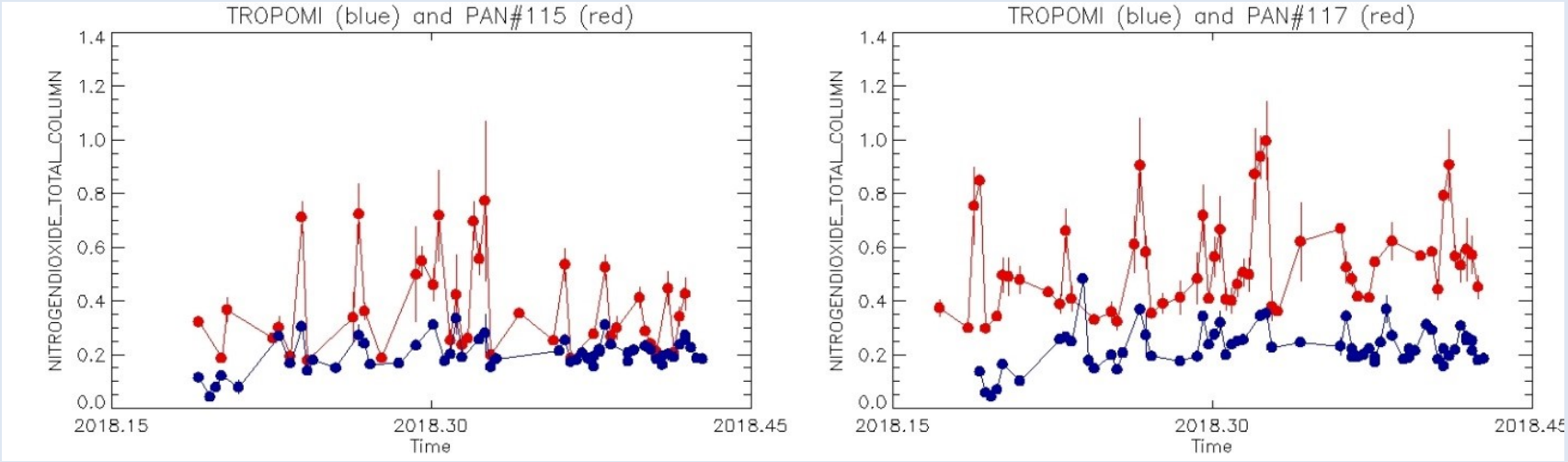
SRTM digital elevation model of Tiber Valley (log scale)

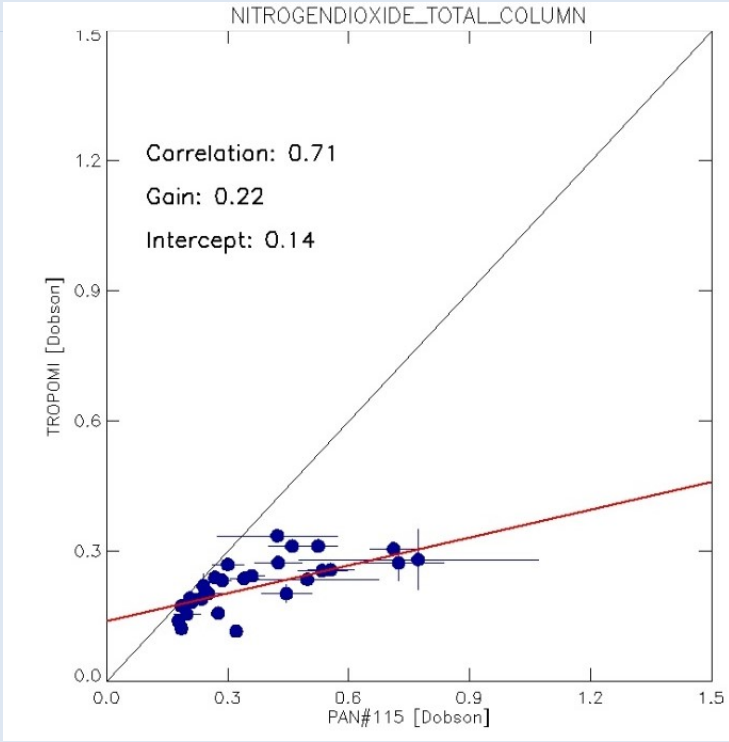


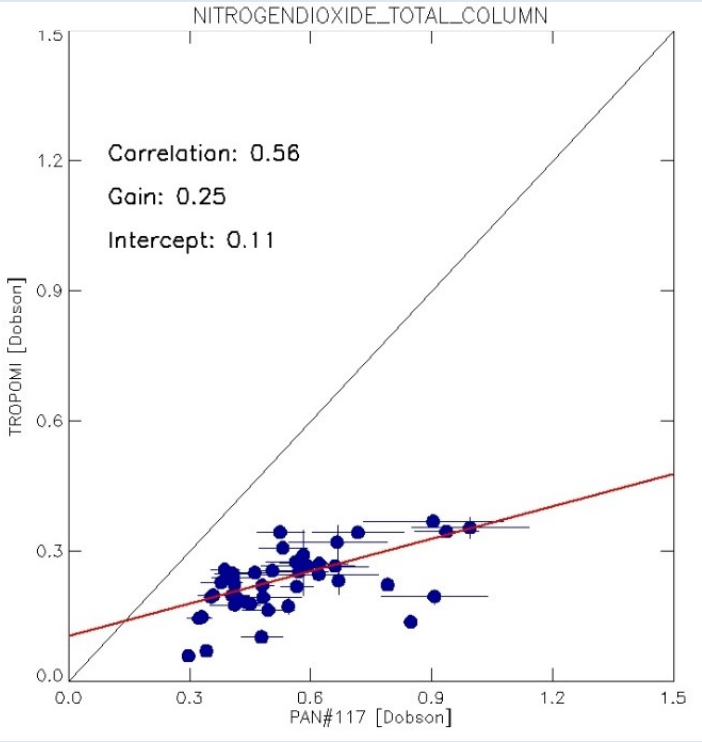
S5p Validation: NO2

9 March - 5 June

Total column



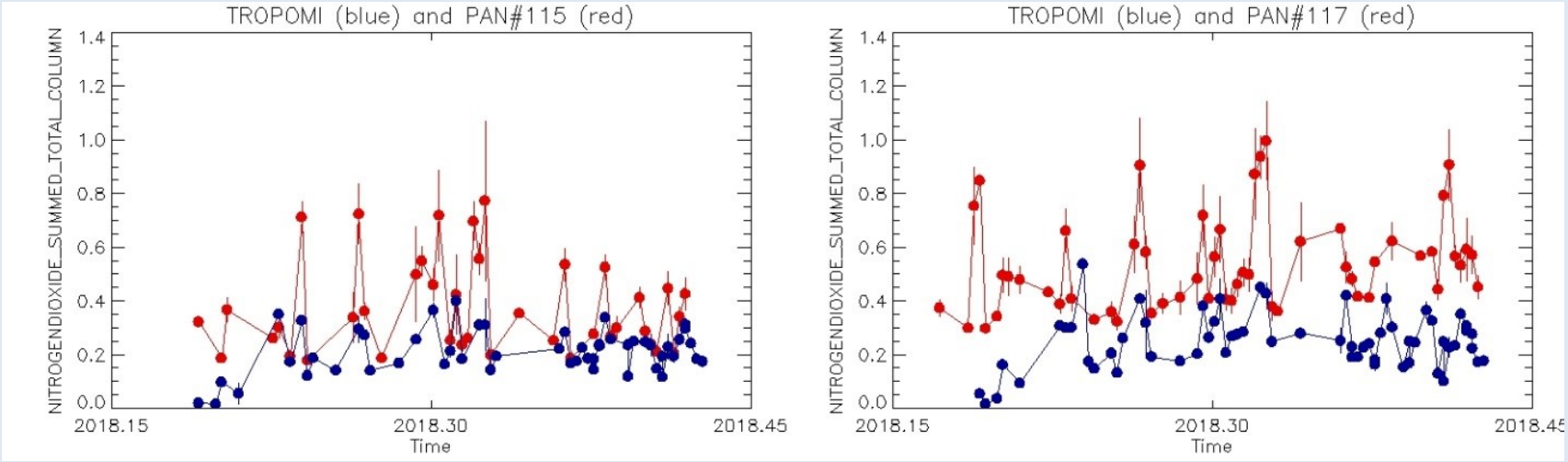


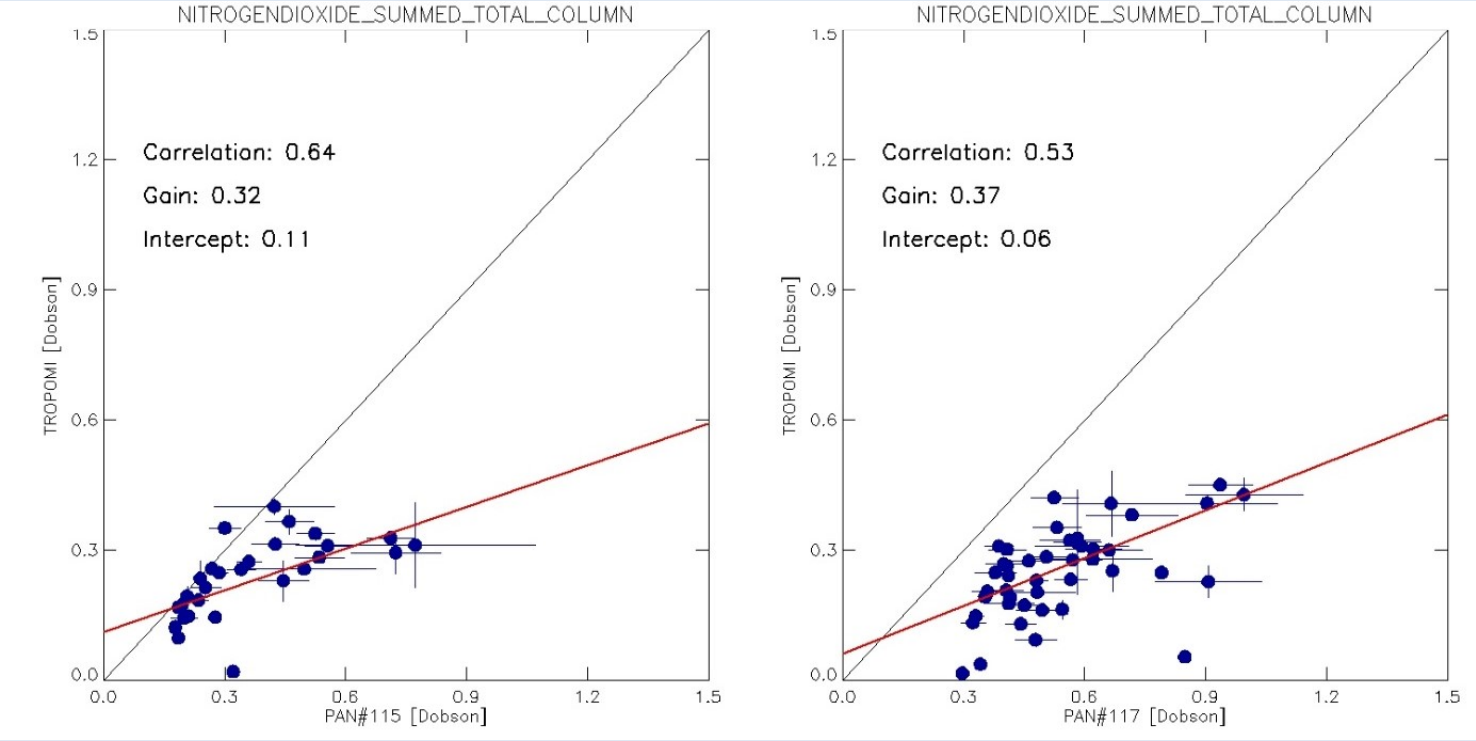


S5p Validation: NO2

9 March - 5 June

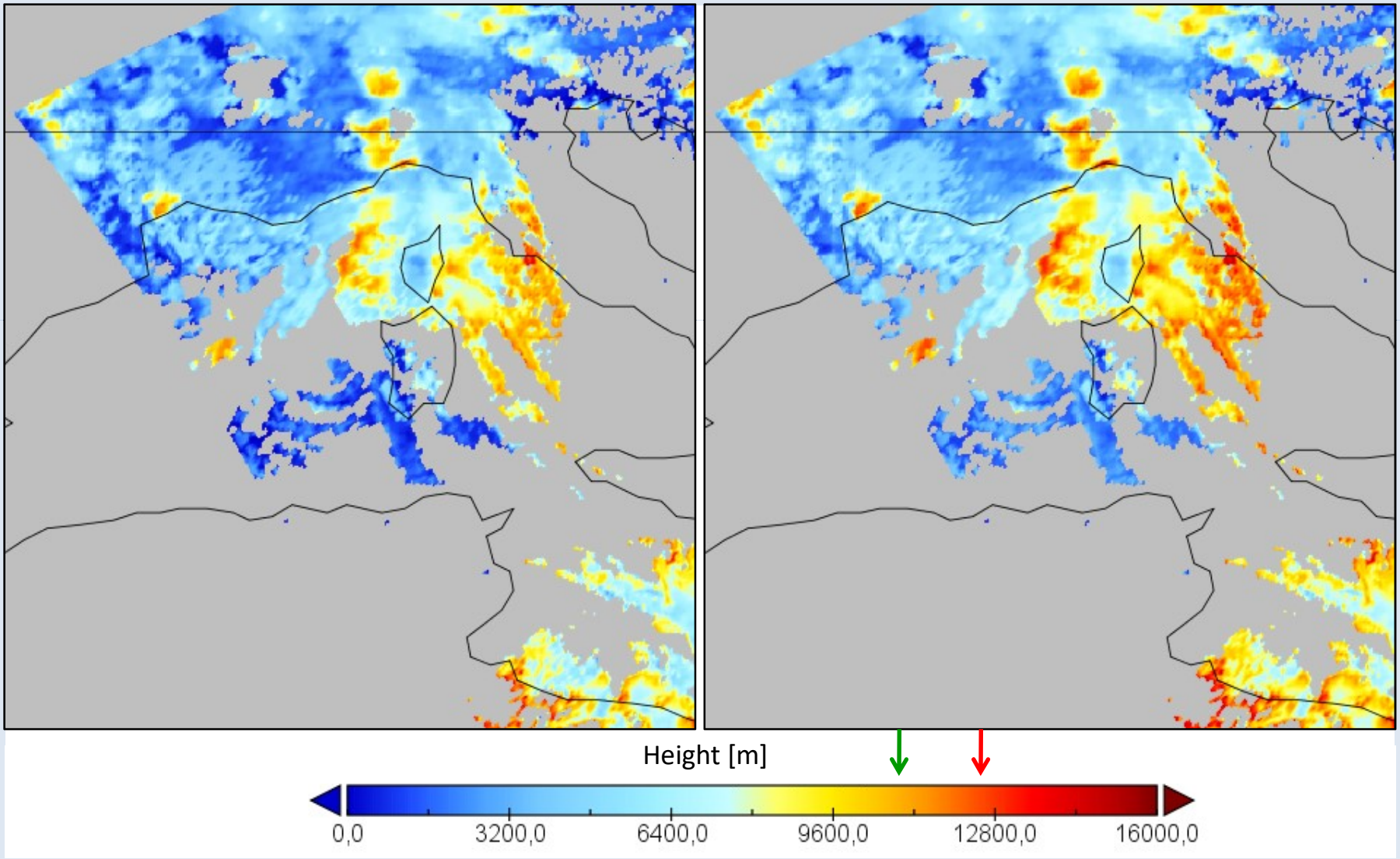
Summed total column





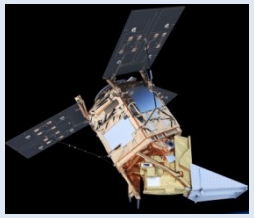
S5p Validation: First analysis of TROPOMI Sentinel 5P L2 cloud

Cloud base 11 / 06/ 2018 Cloud top

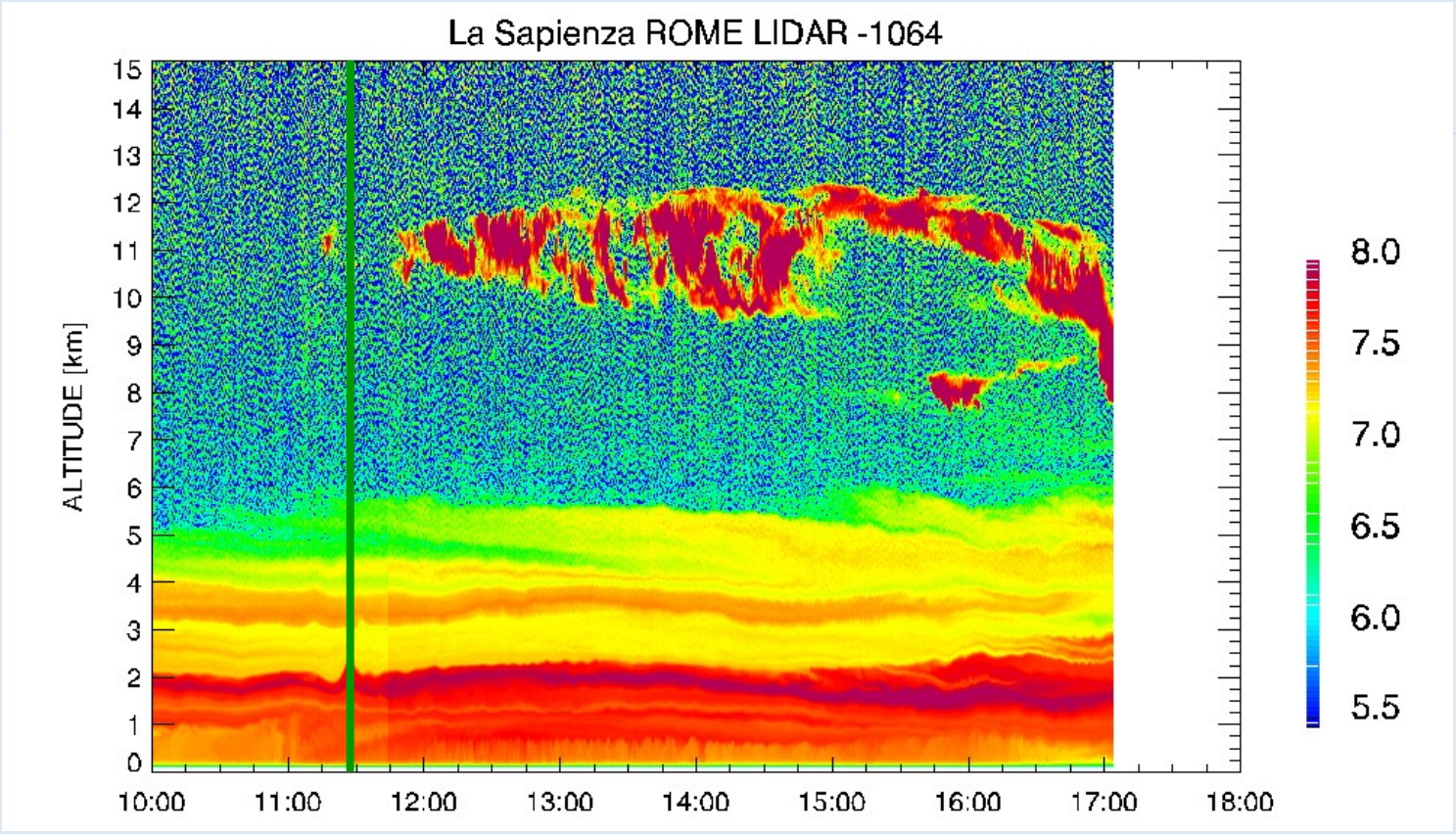


S5p Validation: First analysis of TROPOMI Sentinel 5P L2 cloud

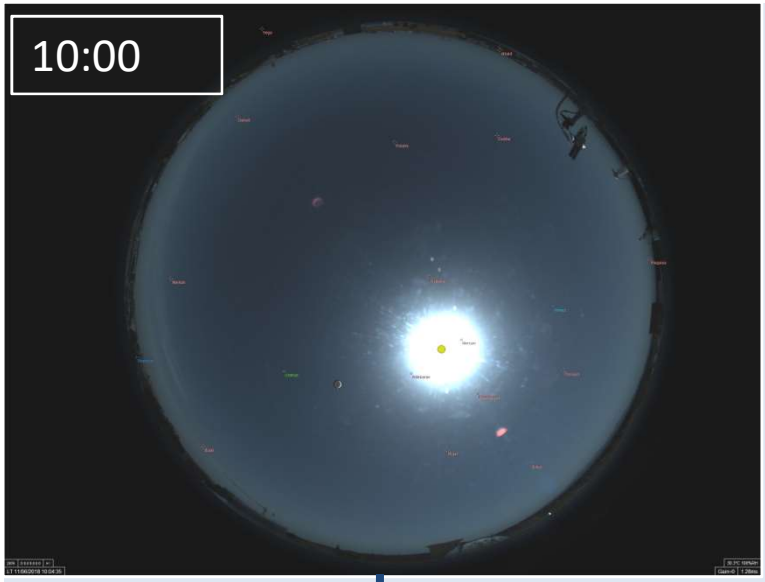
11 / 06/ 2018

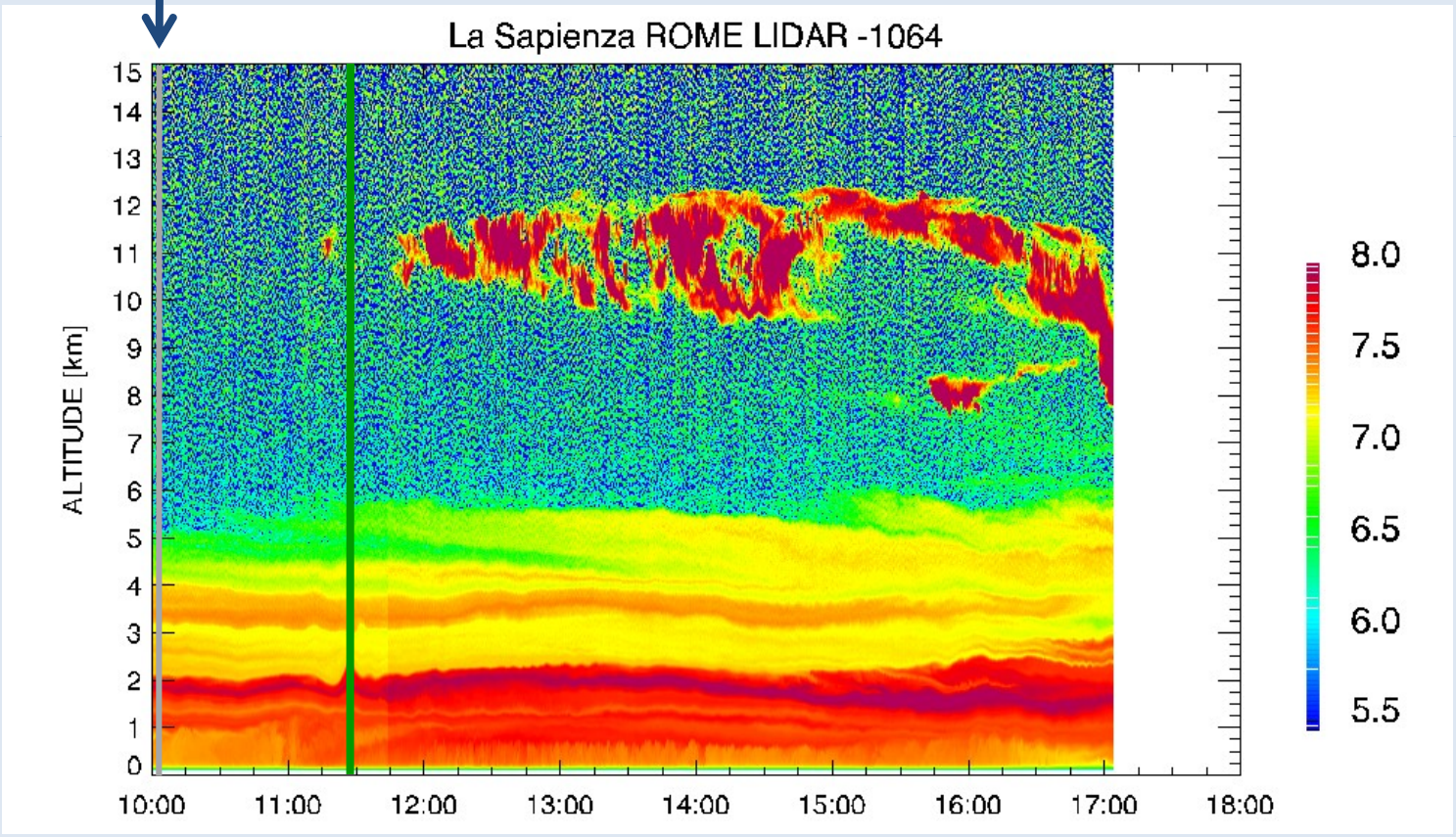


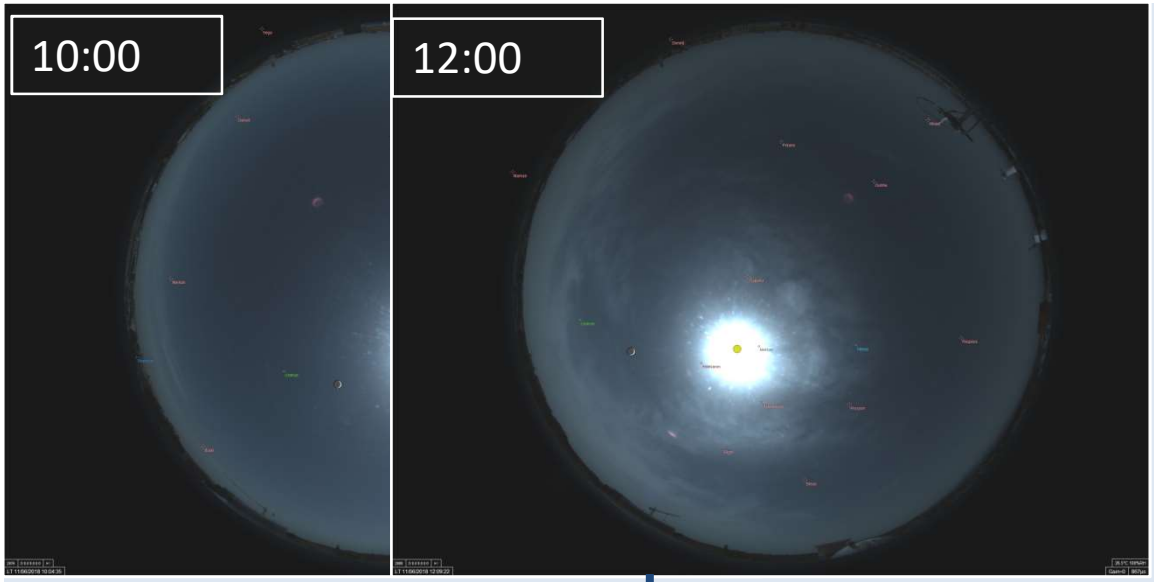
Sentinel 5P overpass

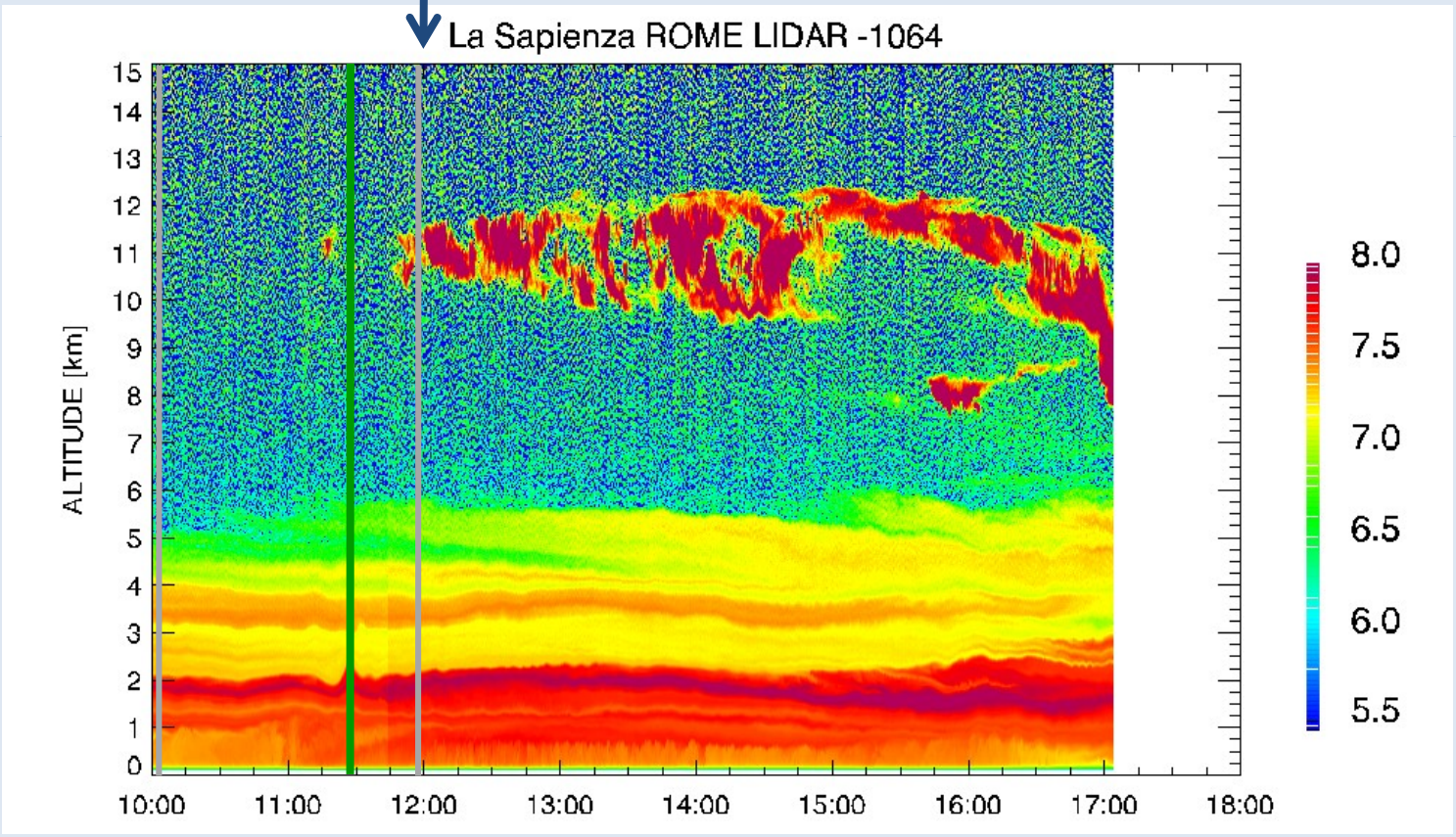


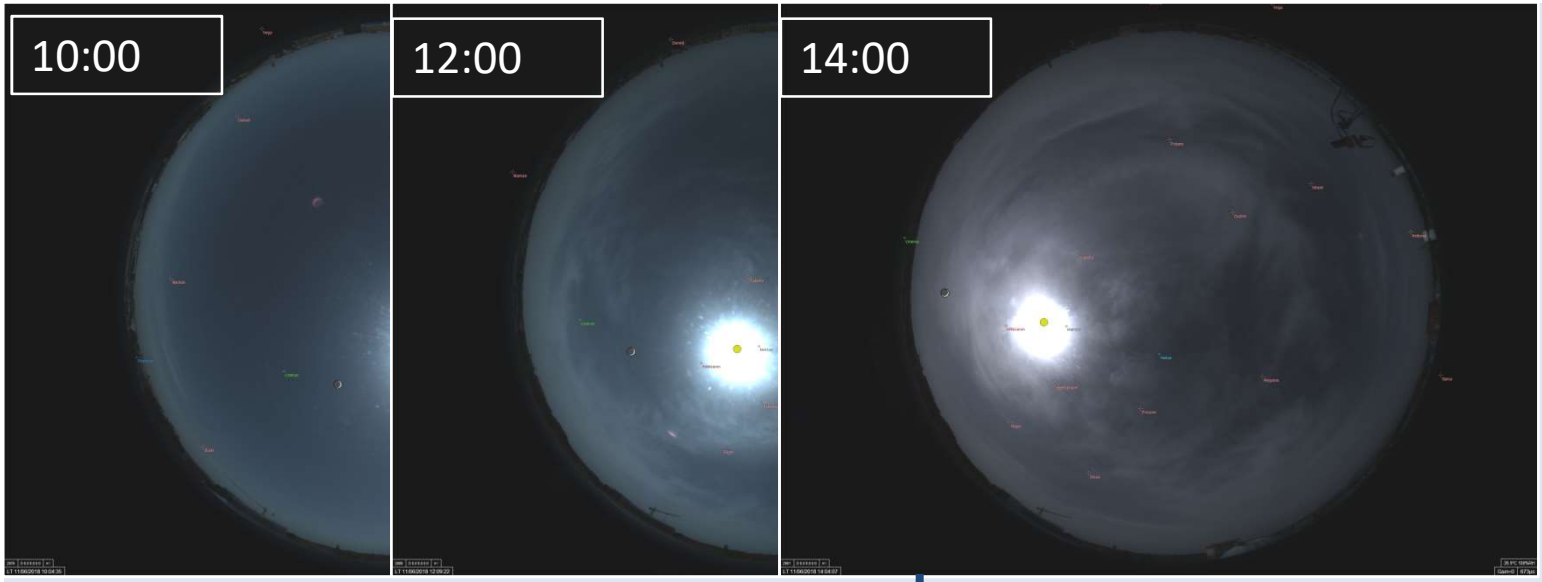
All Sky Camera images

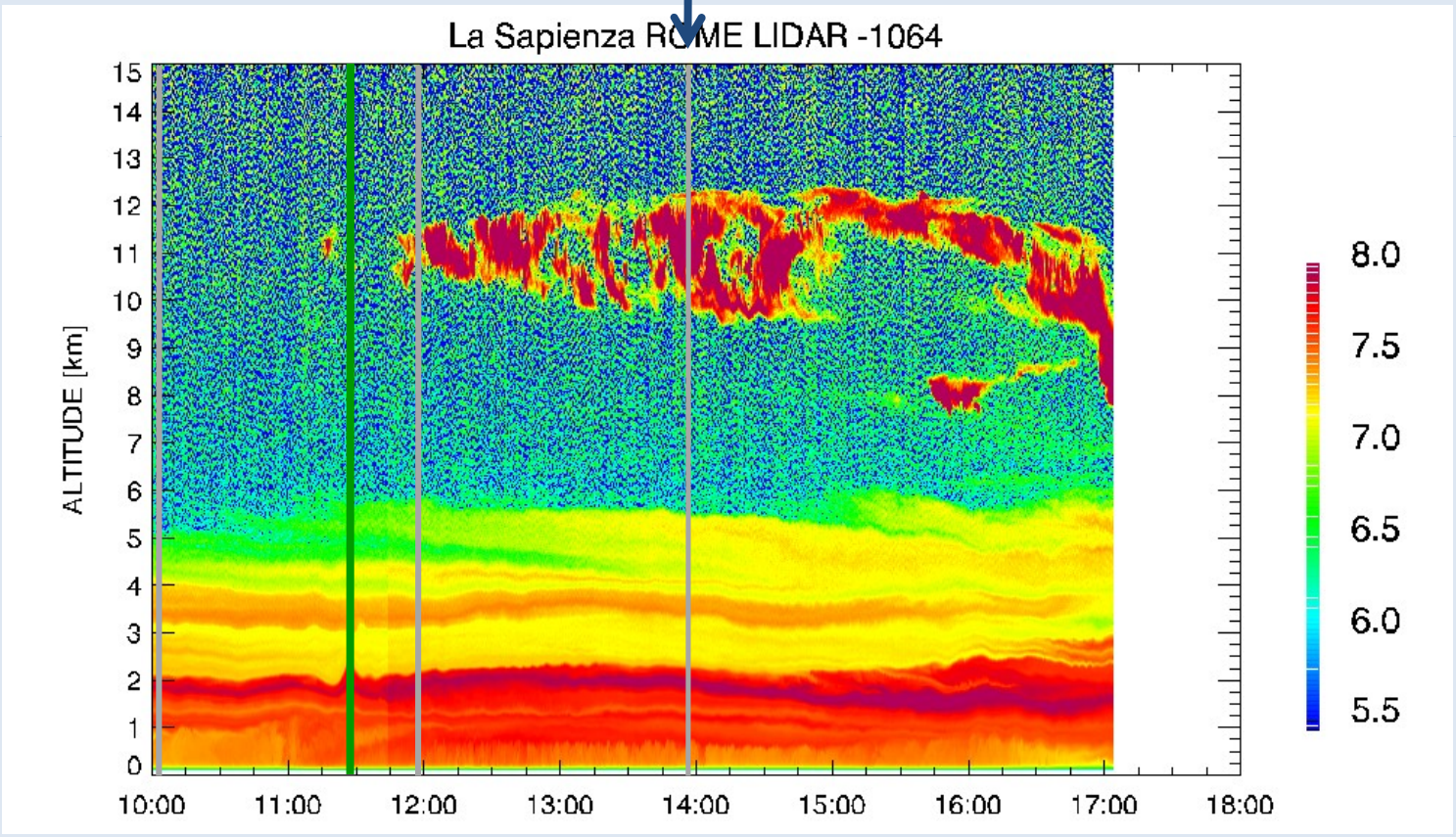


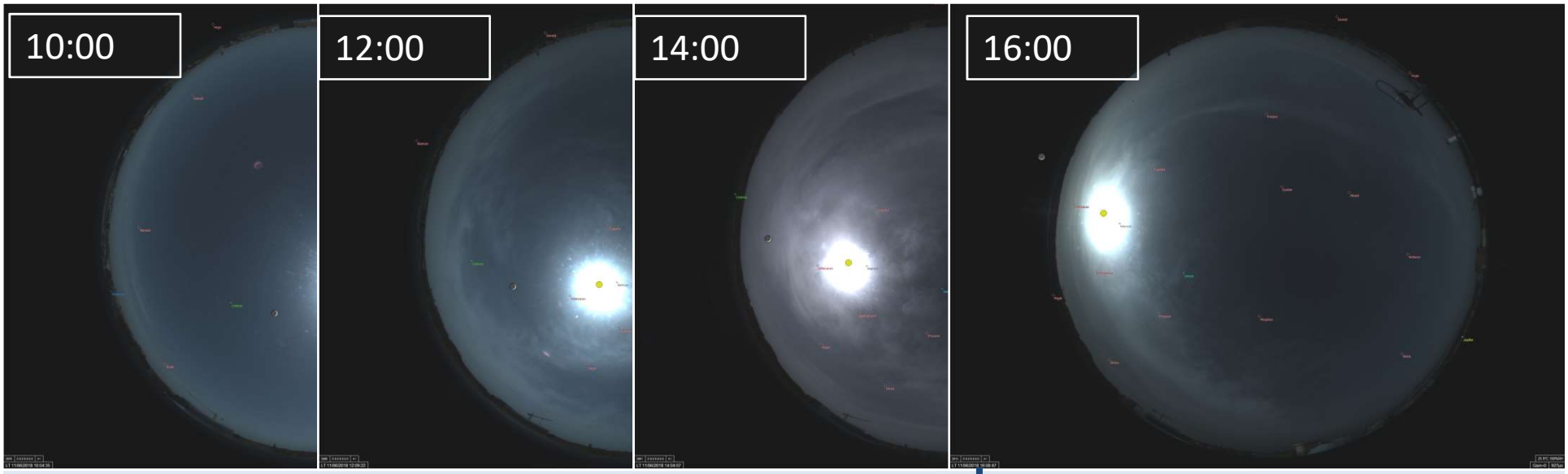


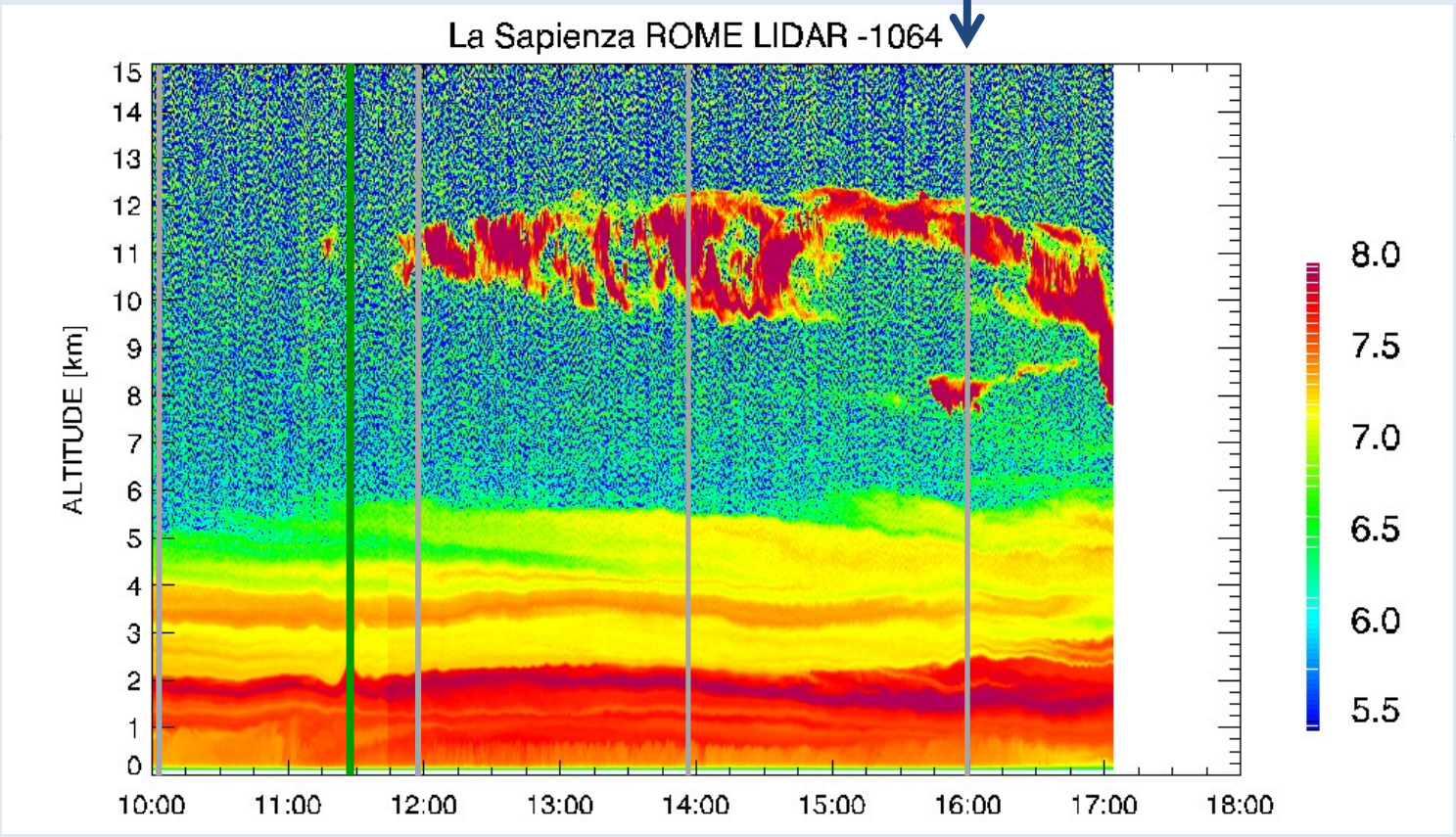

10:00
12:00

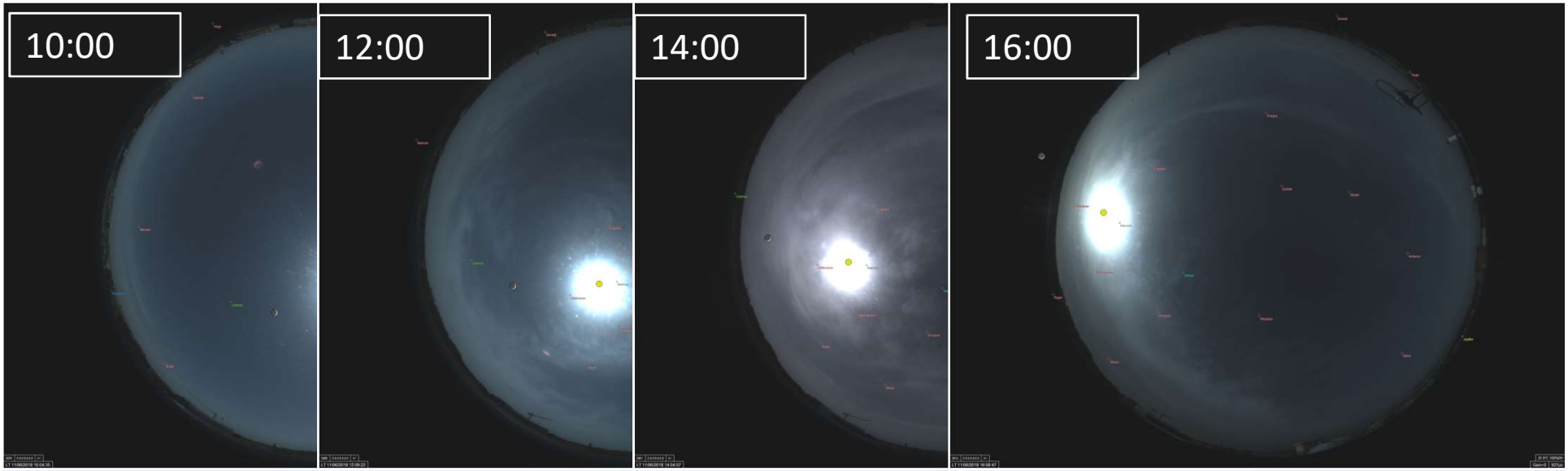

La Sapienza ROME LIDAR -1064
ALTITUDE [km]
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
10:00
11:00
12:00
13:00
14:00
15:00
16:00
17:00
18:00
8.0
7.5
7.0
6.5
6.0
5.5


10:00
12:00
14:00

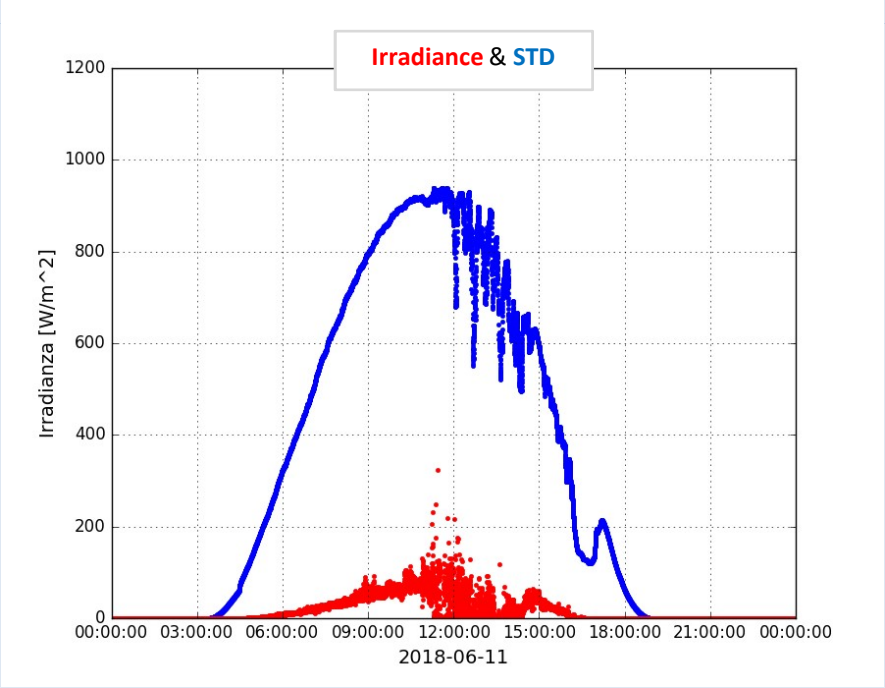

La Sapienza ROME LIDAR -1064
ALTITUDE [km]
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
10:00
11:00
12:00
13:00
14:00
15:00
16:00
17:00
18:00
8.0
7.5
7.0
6.5
6.0
5.5

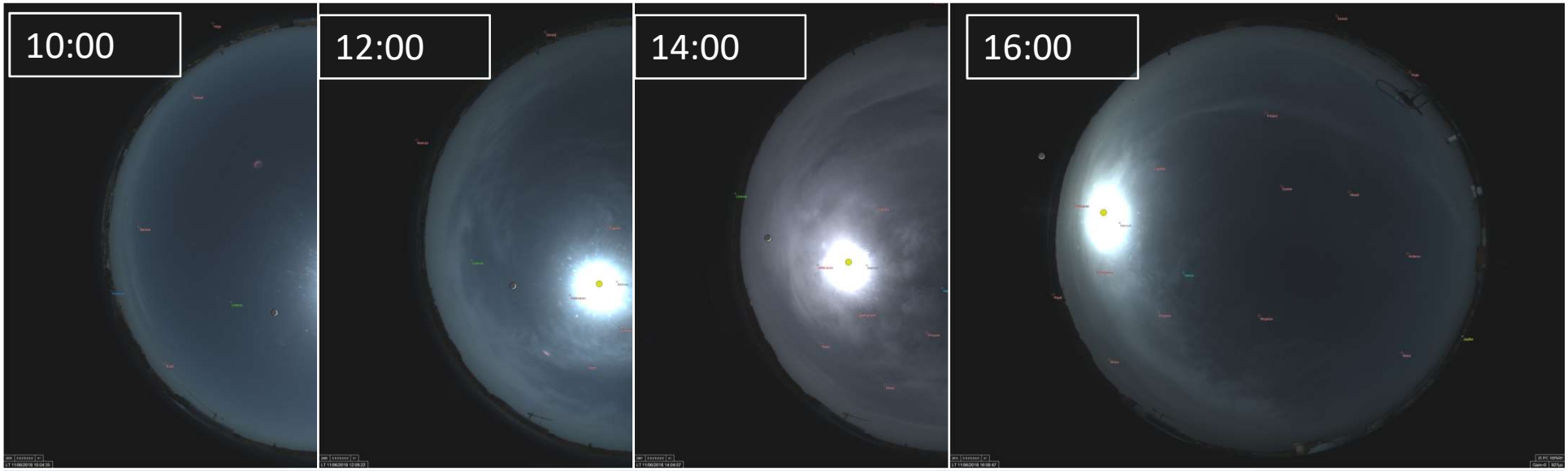

10:00
12:00
14:00
16:00


La Sapienza ROME LIDAR -1064
ALTITUDE [km]
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
10:00
11:00
12:00
13:00
14:00
15:00
16:00
17:00
18:00
8.0
7.5
7.0
6.5
6.0
5.5

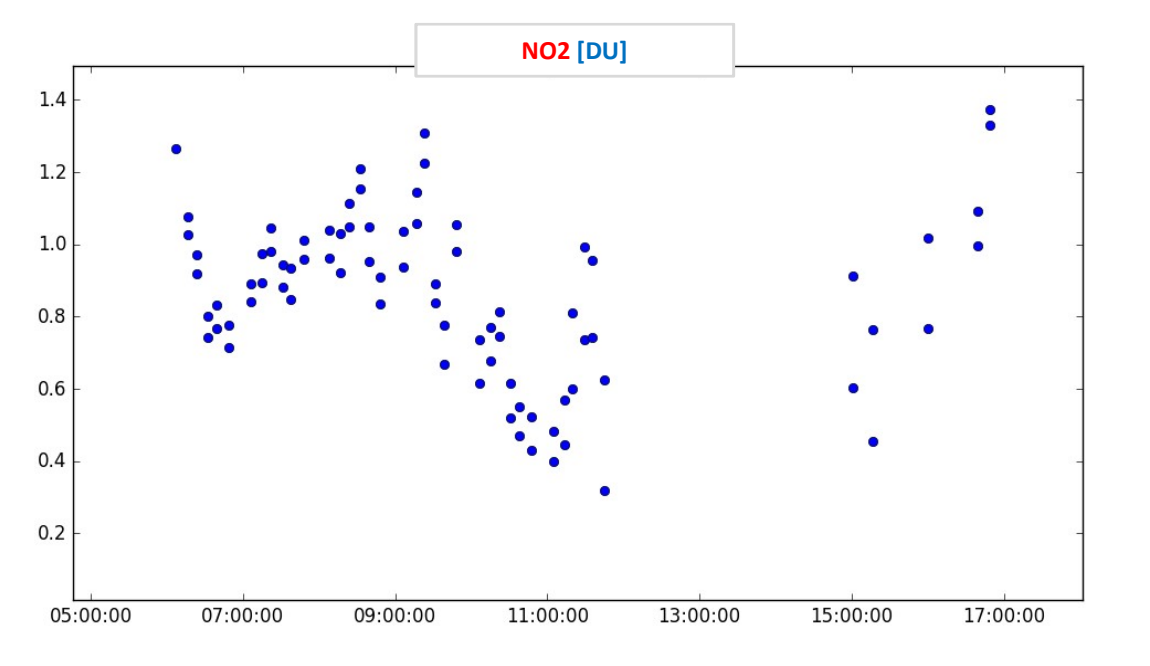


Pyranometer




10:00
12:00
14:00
16:00

Pandora 117


NO2 [DU]
1.4
1.2
1.0
0.8
0.6
0.4
0.2
05:00:00
07:00:00
09:00:00
11:00:00
13:00:00
15:00:00
17:00:00

BAQUNIN Staff		
Jonas von Bismarck	Jonas.Von.Bismarck@esa.int	ESA ESRIN
Stefano Casadio	Stefano.Casadio@esa.int	SERCO / ESA ESRIN
Anna Maria Iannarelli	Annamaria.Iannarelli@serco.com	SERCO / Univ. Sapienza
Marco Cacciani	Marco.Cacciani@uniroma1.it	Univ. Sapienza
Monica Campanelli	Campanellimonica@gmail.com	ISAC-CNR
Annamaria Siani	Annamaria.Siani@uniroma1.it	Univ. Sapienza
Daniele Di Erasmo	Daniele.dierasmo@serco.com	SERCO
Gabriele Mevi	gabriele.mevi@ingv.it	SERCO
Enrico Cadau	Enrico.Cadau@esa.int	Sardegna Clima ONLUS
Cristiana Bassani	cristiana.bassani@iia.cnr.it	IIA-CNR NEW

Thank you for your attention!

IDEAS+ esa serco Bringing service to life SAPIENZA UNIVERSITÀ DI ROMA