AN ATMOSPHERIC INSTRUMENTAL SUPER SITE TO STUDY THE AEROSOLS AND THE TROPOSPHERIC TRACE GASES IN ROME

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Overview – Consolidated competences on atmospheric observation and their interpretation from *"Sapienza" University* and CNR-ISAC are exploited in a joint effort aimed to the investigation of the effect of a megacity on air quality, atmospheric composition and dynamics. Within this context, a joint instrumental Super Site, combining observation in urban ("Sapienza" University) and semi-rural (CNR-ISAC) environment, for atmospheric studies and satellites Cal/Val activities, has been set-up in the Rome area (Italy). Ground based active and passive remote sensing instruments located in both sites are operating in synergy, offering information for a wide range of atmospheric parameters. Preliminary results from an of H24 continuous measurement exercise are shown. The acquired data are currently under analysis to define actions, protocols and activities to produce useful information and common results to contribute to the foreseen scientific objectives of this joint instrumental super site.

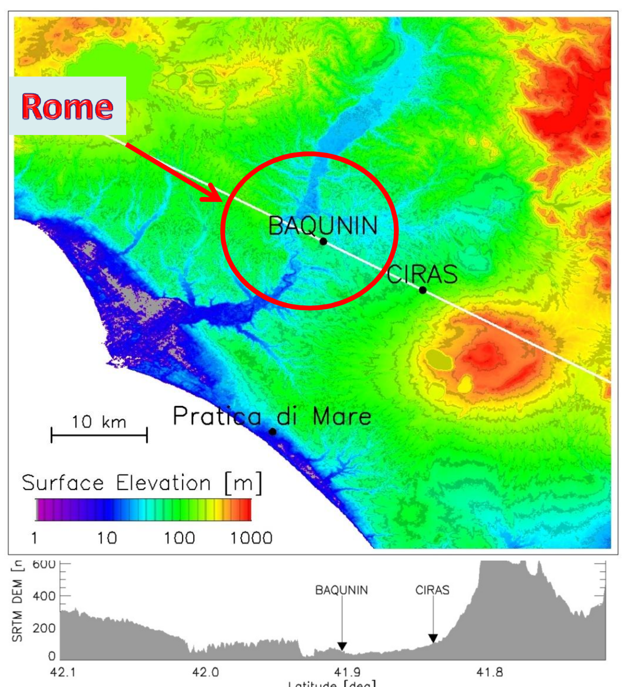

Figure 1. Upper panel: surface elevation a.s.l. of Tiber valley of the study area with the positions of BAQUNIN, CIRAS and the radio-sounding site of Pratica di Mare. Lower panel: elevation transect along with the location of two Super sites.

ROME JOINT INSTRUMENTAL SUPER SITE

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

The Boundary-layer Air Quality Using Network of Instruments (BAQUNIN) Super Site, is located at "Sapienza" University, in the city center (41.90° N, 12.51° E and 75 m ASL).

The CNR-ISAC Rome Atmospheric Supersite (CIRAS) is located in the semi-rural foot-hill area of Tor Vergata (41.88° N, 12.68° E, 107 m ASL).

The upper panel of Figure1 shows the surface elevation a.s.l. of the Tiber valley, with the position of BAQUNIN and CIRAS sites, instead the lower one is the elevation transect along with their location (distance ~13 km).

On the right side, the pictures of some available instruments for both sites, while the complete list is presented in Table1 with the available products.

The two sites have been set up so as to have as many pairs of equal instruments as possible, except for the two Lidar systems that have different characteristics as regards the design, optical and electronic components (Table 2).

CIRAS

BAQUNIN

H24 Experiment

During the 18th and the 19th of May 2017, a first test of continuous (H24) measurements using the instrument suite of both experimental sites has been performed. The objective was to set coordinated measurement procedures, to combine the different processing algorithms and to evaluate the possibility to characterize the temporal and spatial local variability scales of aerosol and water vapor through the RMR Lidars. Lidar acquisitions started on both sites between 03:00 UTC of 18/05/2017 and ended at 11 UTC of 19/05/2017.

Figure 2 refers to the image of the central Italy acquired by Sentinel 3 (visible channel) at 9:40 UTC of 18/05/2017. Figures 3 and 4 qualitatively depict the temporal evolution of the aerosol during the H24 experiment through the logarithm of the 1064 nm and 532 nm range corrected signal (RCS) of Baqunin and Ciras Lidar respectively. These figures also show the evolution of the mixing layer height (MLH) and the presence of a cirrus in both sites during the H24 measurements. Heights of bottom and top of the clouds are retrieved starting from the intensity of the elastic RCSs and shown in figure 5.

Instrument type	Products	BAQUNIN	CIRAS
Elastic & Raman lidars	Aerosol backscattering and extinction, H2O profiles, AOD, cloud boundaries	✖	✖
Ceilometer	Aerosol backscattering profile, cloud boundaries		✖
SODAR	Thermal turbulence, wind speed and direction profiles	✖	✖
RADAR	Precipitation		✖
MFRSR	Total column of AOD, O3, H2O	✖	
POM 01 L (PREDE)	AOD, SSA, AE, Refr. Indx, PF, VSD	✖	
Brewer	Total Column of O3, NO2 and SO2, UV Dose and UV Index	✖	
Pandora	Total Column of NO2, O3, HCHO, others	✖	✖
Meteorological sensors	Air temperature, RH, pressure, wind, SW and LW radiation	✖	✖
CIMEL	Total column of AOD and H2O, SAE, AAE, SSA, Refr. Indx, VSD	✖	✖

Table 1. List of the available instruments and products of both Super Sites.

	BAQUNIN				CIRAS		
Transmitter	Nd:YAG laser				Nd:YAG laser		
Wavelengths [nm]	1064, 532 and 355				532, 355 (1064 upgrade in 2018)		
Pulse frequency [Hz]	30				10		
Beam diameter [mm]	10				20		
Divergence [mrad]	0.5				0.4		
Receivers	I	II	III	IV	I	II	III
Type of telescopes	Cassegrain	Reflective	Cassegrain	Cassegrain	Newtonian array	Newtonian	Newtonian
Diam. [mm], f-num.	500, F9	50, F12	100, F9	100, F9	9*500, F3	300, F3	150, F3
FOV [mrad]	0.33	3.3	2.2	11	0.7	0.9	1.8
Data acquisition							
Channels [nm]	355 t, 387, 407	532 t	532 t, 532 p	1064	387, 407, 532 t	355, 387, 407	532 t
Sounding range [Km]	0.5 – 10	0.05 – 5 km	0.5 – 10	0.125-10	25 - 80 (elastic), 2 – 18 (Raman)	6-40 (elastic), 0.2-8 (Raman)	0.2 – 15 km
Vertical resolution [m]	7.5	7.5	7.5	7.5	75	75	75
Time resolution [sec]	10	10	10	10	600	600	600

Table 2. Instrumental characteristics of BAQUNIN and CIRAS RMR Lidar systems.

Figure 2. True colour composite from Sentinel3 OLCI. 18/05/2017 – 9.40 U-tc.

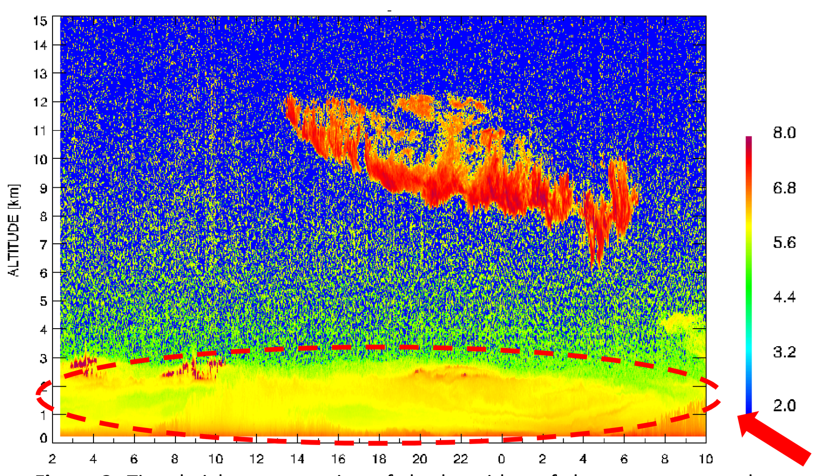

Figure 3. Time-height cross-section of the logarithm of the range corrected signal at 1064 nm derived by the BAQUNIN RMR Lidar during H24 experiment.

MLH

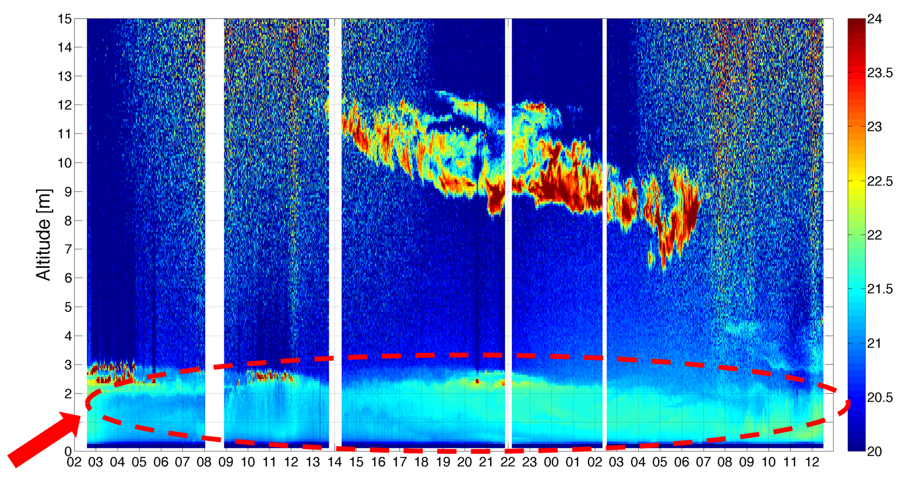

Figure 4. Time-height cross-section of the logarithm of the range corrected signal at 532 nm derived by CIRAS RMR lidar during H24 experiment.

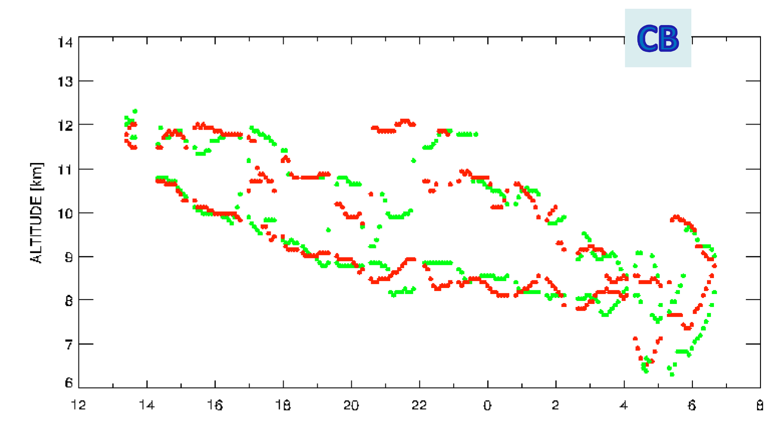

Figure 5. Temporal evolution of the cirrus boundaries heights observed by BAQUNIN (red) and CIRAS (green) lidars during H24 experiment.

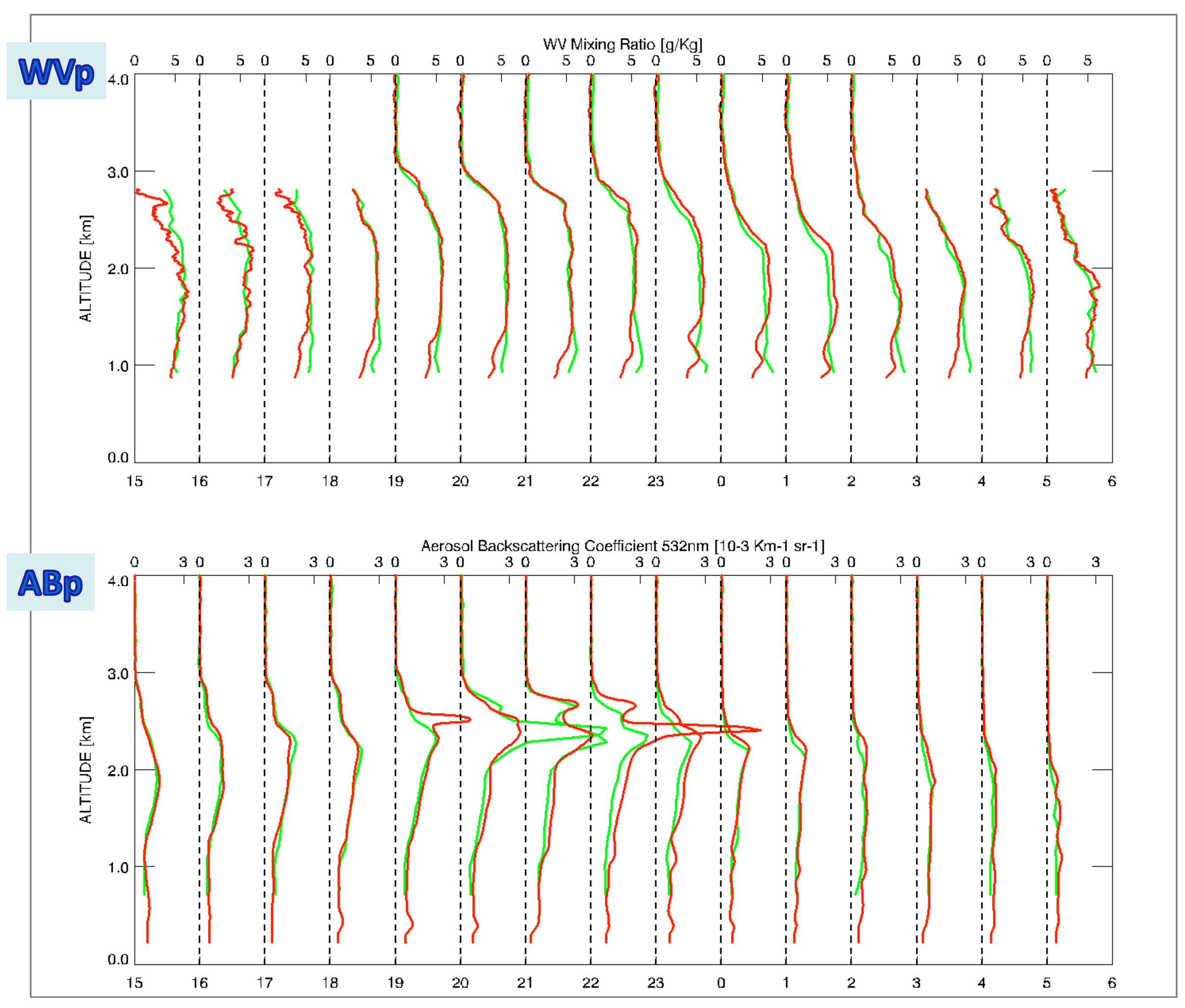

Figure 6. Temporal evolution of the 1-h integrated aerosol backscatter and WVMR profiles (upper and lower panel, respectively) derived by BAQUNIN and CIRAS lidars during H24 experiment. Time period is limited from 15:00 UTC of 18/05 to 06:00 UTC of 19/05 due to the high levels of background noise in the excluded hours.

Preliminary results

The (ongoing) analyses aim to compare the atmospheric temporal and spatial variability of the two sites in terms of:

- Evolution of the Mixing Layer Height (MLH)
- Water Vapor profiles (WVp)
- Aerosol Backscattering profiles (ABp) and Optical Depth (AOD)
- Cloud Boundaries (CB)
- Wind profiles (Wp)
- Trace gases (NO2 and 03)

In all figures, red and green colors refer to the measurements acquired by BAQUNIN and CIRAS instrumentation, respectively.

In figure 9, the results of the NATALI alghoritm applied to BAQUNIN Lidar data: the input data are the total backscattering profiles at 355, 532 and 1064 nm and extinction profiles at 355 and 532 nm. In the future also depolarization profiles will be available.

Perspectives and future activities

- Development of synergistic and coordinated ground-based measurement acquisition protocols and processing algorithms.
- Development of multi-instrumental -> multi-variable inversion algorithms
- Characterization of information content in the differential analysis.
- Providing independent and high-quality atmospheric composition ground-based data to accurately validate the upcoming European Earth Observation (EO) missions and payloads (e.g. S3, S5p, S5, S4, ADM-Aeolus, EarthCARE, METOP-SG, MTG).
- Characterization of the impact of the Rome environment on the atmospheric costituents, with a particular focus on the aerosols and water vapor variability.
- Investigate the use of the information obtained from the two sites for numerical atmospheric models at different scales.

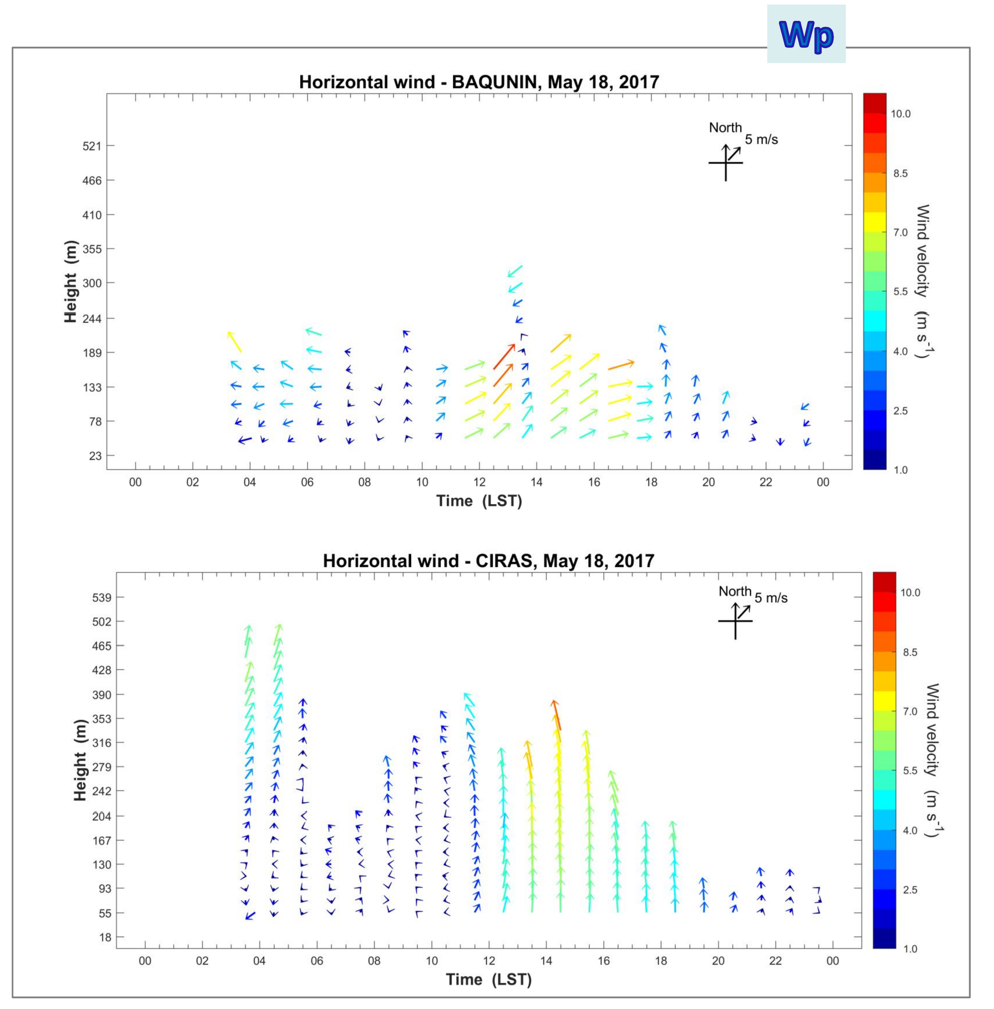

Figure 7. Temporal evolution of the horizontal direction an intensity wind profiles measured by the two sodars installed at BAQUNIN and CIRAS sites (upper and lower panel, respectively). Sea breeze activation can be observed at 11:00 UTC in BAQUNIN and 13:30 UTC in CIRAS.

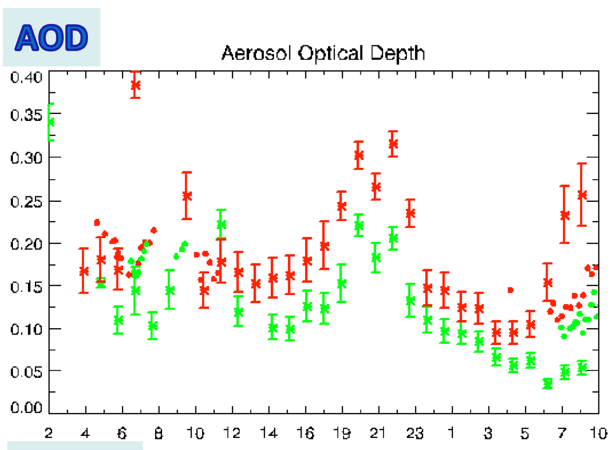

Figure 8. Comparison between the AODs measured by sun photometers at 500 nm and the ones derived by RMR Lidars at 532 nm. Circle points refers to the sun photometer values, CIMEL and PREDE Pom 01L in the BAQUININ and CIRAS respectively, instead the star points represent the value obtained from Lidars. Below 800 m, because of the Lidar overlap height, AOD values from CIRAS data are estimated using a linear interpolation. Highest Lidar AOD values are due to the presence of clouds.

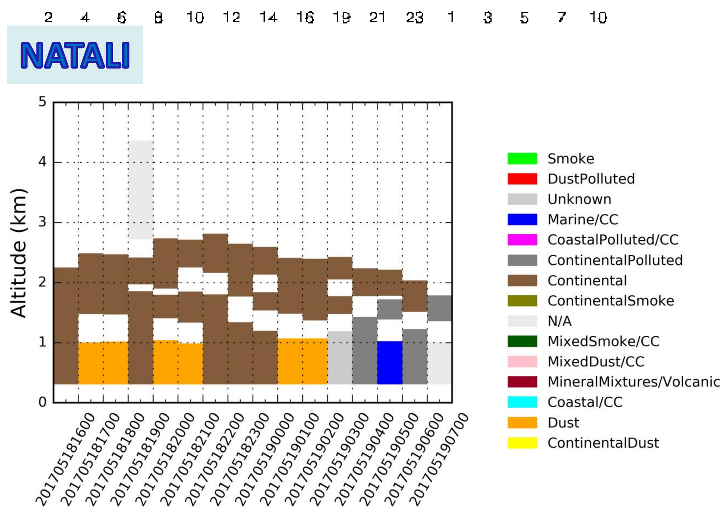

Figure 9. Example of the employment of the Neural network Aerosol Typing Algorithm based on LIdar data (NATALI) using BAQUNIN measurements.

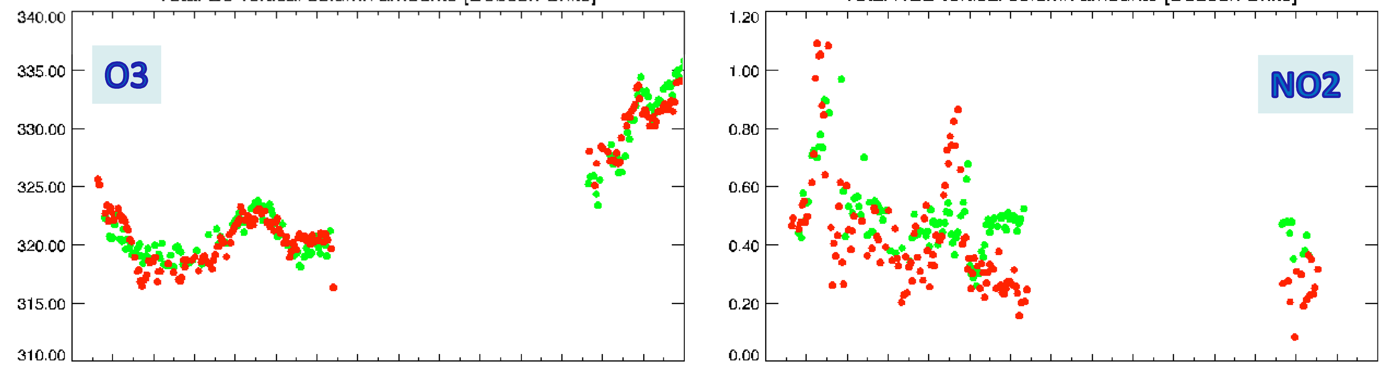

Figure 10. Daytime columnar levels of O_3 and NO_2 (left and right panel, respectively) measured by PANDORA instruments located at BAQUNIN and CIRAS lidars during H24 experiment. Rush hour peaks are distinguishable at 16 UTC of 18/05 and at 06 UTC of 19/05 in Ciras site.

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Links

CIRAS: http://www.isac.cnr.it/en/infrastructures/ciras-cnr-isac-rome-atmospheric-supersite
PANDONIA: http://pandonia.net/
AERONET: https://aeronet.gsfc.nasa.gov/new_web/index.html
EUROSKYRAD: http://www.euroskyrad.net/
EUBREWNET: http://www.eubrewnet.org/cost1207/
NATALI: http://natali.inoe.ro/
SENTINEL HUB: http://www.sentinel-hub.com/apps/eo_browser