Abstract

In the context of the GEOS- Chattanooga support contract (ESA/ESRIN SPAP) and in the framework of the PANDONIA project (ESR), the Physics Department of “Sapienza” University of Rome and ESA/ESRIN EOD-MAG section have set up a joint instrumental suite for validating the atmospheric chemical and optical level 2 products retrieved from satellite, and for the studies about Planetary Boundary Layer (PBL). This instrumental set-up composed of in-situ instruments and passive remote sensing instruments are operating in synergy offering quantitative and qualitative information for a wide range of atmospheric parameters in a urban atmospheric boundary layer such as the Rome city centre (University of Rome), compared to a rural environment (ESA/ESRIN). The list of the BAQUNIN Super Site instrumentation comprises: Raman and elastic OMI (instruments operating day and night: aerosol, O3, NO2, O3DO3 and H2O (hydration profiles in 106)), MFRSR radiometer (aerosol, O3, NO2), POM 01 Probe sun-sky radiometer (aerosol, precipitable water content), Brewer spectrophotometer (O3, SO2, NO2, NOx), Pomp Pomp, CIMEL photometer (aerosol), YES broad-band UV radiometer, and meteorological sensors (for air temperature and relative humidity measurements). The atmospheric data acquired during BAQUNIN lifetime will be made available to the scientific community, and will contribute to the validation of the aerosol and tropospheric trace gases products produced by the Copernicus Sentinel-5p, Sentinel-4 and 5at and the ESA Third Party Missions (TPM), such as the ozone Monitoring Experiment (OMI). In this work, the BAQUNIN Super Site structure and operation strategies will be described in details.

The BAQUNIN super site instruments are located at Physics Department of “Sapienza” University of Rome and at the European Space Agency – European Space Research Centre ESA/ESRIN, as shown in Figure 1. In Figure 2, the University instruments are shown, the picture in Figure 3 shows the two additional instruments recently included in the BAQUNIN suite: a PANDONIA 25 spectrometer and a CIMEL.

The following instruments operated in the context of BAQUNIN are included in national/international networks:

- Brewer – European Brewer Network (EuBrewnet)
- PANDORA – PANDONIA network

In this work, some of the results obtained during the last measurements campaign carried out at the University of Rome, when the instruments have worked in synergy, are shown. The campaign took place from 20 June to 20 July of 2011, with the focus on the characterization of atmospheric aerosol in the urban environment of Rome (Urban: Sustainability Related to Observed and Monitored Aerosol, URBES-Roma). The results shown refer only to some instruments of the BAQUNIN super site: the elastic Lidar (1-2, 10), the Sodar (3, 4), the Pressure from POM 01 radiometer (5), the Multi Filter Rotating Shadowband (6) and the Brewer 01 radiometer (7).

The Figure 4 shows the aerosol backscatter ratio (BR) during the entire campaign as retrieved from elastic Lidar measurements. Values of BR in the range (0.15-2.5) reveal the presence of aerosols, values outside this range refer to clouds or “clear” atmosphere. According to the two days approach of 11 and 17 July, one of particular interest: in fact it is possible to appreciate that during the first day the enhanced presence of aerosol in the BR values in the 2-4 km altitude range respect the second day. This difference is also clearly visible in Figure 5, where the site distribution vs. radius of particles (as estimated from POM 01 sun sky radiometer instrument) is shown for the two days. A further confirmation comes from the results of the BSC-DREAM model displayed in Figure 6 where the different forecastial dust plumes and cloudiness for these two days are shown.

The aerosol optical depth (AOD) is also estimated with the POM 01 sun sky radiometer and the MYSTIC for several wavelengths in the range 415 to 1020 nm. In Figure 7 and 8 the AOD values obtained from the radiometer are reported during observation of 11 and 17 July. For these days, the sun elevation wind speed profiles are shown in Figure 5, in both days present a sudden change in wind direction and strength (10-15 m/s) due to the sea-breeze front movement. The columnar amount of O3 and NO2 are estimated from the Brewer measurements: The Figures 10 and 11 show the Brewer daily amount of O3 and NO2 (green dots) during the entire campaign, along with the collected Ozone Monitoring Experiment (OMI, red dots). At this stage, the OMI (270°-285°) daily fields are used, the use of satellite Level 3 products will be the baseline for the operational comparative/validation activities of BAQUNIN. For what concern O3, there is a good agreement between Brewer and OMI. For the NO2, the agreement between daily average Brewer data and OMI is poor (Figure 11). Selecting the Brewer NO2 values acquired in a range of two hours from the OMI overpass time (about 1:45pm, local time, the agreement with OMI improves significantly, as shown in Figure 12, demonstrating that diurnal variation on NO2 must be carefully considered when comparing ground based and satellite products. (Table 1)

Conclusions

The BAQUNIN site, with its scale of instrument of different types and application domains, is the ideal tool for the validation of satellite aerosol instruments in the characterization of atmospheric pollution. The synergistic use of rural (ESR/URBS) and urban (“Sapienza”) measurements will contribute to significantly improve the confidence on the validation results that will be carried out for Spa, Sp and Mimas.

References

[1] Böckl, F.B., et al., The role of urban boundary layer investigated by high resolution models and ground based observations in Rome area in a study for understanding parameterisations Atmospheric Environment, 62, 335-343, 2012.

Acknowledgments

This work was supported by a number of foundations and agencies, including the European Space Agency, European Union (Feder and ERDF), and the Federal Ministry of Education and Research of Germany. The measurements were made by the members of the University of Rome Sapienza - Sapienza Institute of Environmental Geophysics and Earth System Science.

Figures

Figure 1. BAQUNIN Super Site location: “Sapienza” University of Rome (in red), PAMO (in blue), ESA/ESRIN (in green), European Space Agency - European Space Research Centre ESA/ESRIN (in black). (a) The Italian capital at 31.41 ut, 1030, 2199 x 3702).

Figure 2. University of Rome BAQUNIN Super Site instrumentation: POM 01 sun-sky radiometer, MFRSR radiometer, Brewer, OMI, SODAR, CIMEL, PANDORA and Meteosat-2.

Figure 3. PANDONIA network instruments in operation at the University of Rome: Brewer (as EUBrewnet personnel), MFRSR, POM 01 sun-sky radiometer, Brewer, OMI, SODAR, CIMEL, PANDORA and Meteosat-2.

Figure 4. Aerosol backscatter ratio (BR) measured during the entire campaign as retrieved from elastic Lidar measurements with a relative error (Sdev) calculated for the sampling points at the wavelength 440 nm.

Figure 5. Daily evolution of aerosol volume size distributions is shown for a day with only aerosol presence (20 July 2011), displayed as the average value of the range size distributions (5-15 µm).

Figure 6. Daily evolution of aerosol volume size distributions are shown for a day with only aerosol presence (20 July 2011), displayed as the average value of the range size distributions (5-15 µm).

Figure 7. Aerosol Optical Depth (AOD) measured during the entire campaign as retrieved from POM 01 sun sky radiometer and the MYSTIC for several wavelengths in the range 415 to 1020 nm. In Figure 8 and 9 the AOD values obtained from the radiometer are reported during observation of 11 and 17 July. For these days, the sun elevation wind speed profiles are shown in Figure 5, in both days present a sudden change in wind direction and strength (10-15 m/s) due to the sea-breeze front movement. The columnar amount of O3 and NO2 are estimated from the Brewer measurements: The Figures 10 and 11 show the Brewer daily amount of O3 and NO2 (green dots) during the entire campaign, along with the collected Ozone Monitoring Experiment, OMI (red dots).

Figure 8. Aerosol Optical Depth (AOD) measured during the entire campaign as retrieved from POM 01 sun sky radiometer and the MYSTIC for several wavelengths in the range 415 to 1020 nm. In Figure 8 and 9 the AOD values obtained from the radiometer are reported during observation of 11 and 17 July. For these days, the sun elevation wind speed profiles are shown in Figure 5, in both days present a sudden change in wind direction and strength (10-15 m/s) due to the sea-breeze front movement. The columnar amount of O3 and NO2 are estimated from the Brewer measurements: The Figures 10 and 11 show the Brewer daily amount of O3 and NO2 (green dots) during the entire campaign, along with the collected Ozone Monitoring Experiment, OMI (red dots). At this stage, the OMI (270°-285°) daily fields are used, the use of satellite Level 3 products will be the baseline for the operational comparative/validation activities of BAQUNIN. For what concern O3, there is a good agreement between Brewer and OMI. For the NO2, the agreement between daily average Brewer data and OMI is poor (Figure 11). Selecting the Brewer NO2 values acquired in a range of two hours from the OMI overpass time (about 1:45pm, local time, the agreement with OMI improves significantly, as shown in Figure 12, demonstrating that diurnal variation on NO2 must be carefully considered when comparing ground based and satellite products. (Table 1).