Air quality measurements in Bucharest in the context of TROPOMI calibration / validation activities

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Abstract

In this paper, we present part of the results obtained from airborne measurements above Bucharest, Romania. The measurements are performed in the context of Sentinel 5P calibration/validation, and the strategy of these measurements is to have recurrent flights for the extense of one year. The idea behind this is to observe the variability of the city's pollution, as the sources change from one season to another. In a previous study from TROPOMI annual observation, was observed high variability of NO_2 values including between different days of the week. Measurements started in the Summer of 2021 and covered so far Summer and late Autumn days. The region of interest is Bucharest, capital of Romania, and its metropolitan surroundings, a region with a 112 km perimeter and 850 km^2 area. The city is subject to infringement from the EU regarding poor air quality. The main sources of pollution are represented by the city's power plants and the car traffic. Apart from airborne measurements, were performed ground-based, both from a fixed location and mobile (e.g., from a car). Fixed ground- based measurements are performed from a location 12 km distance from Bucharest city center, from the site MARS (Măgurele center for Atmosphere and Radiation Studies), a site equipped with lidars (e.g., for aerosols or wind profiling), cloud – radars, microwave radiometer, radiation station, and different in-situ instruments (for aerosols and gases), site part of ACTRIS research infrastructure. Airborne measurements were performed using research aircraft Britten-Norman BN-2 Islander, aircraft that went thru a certification by EASA. The modification consisted of an air inlet, mounted on top of the aircraft, and a nadir window for the remote sensing instrument. Georeferencing is done using an IMU, with a frequency of 1Hz. Now the aircraft can accommodate several instruments that can sample in situ, capable to measure aerosols (e.g., Aerosol Particle Sizer and Nephelometer) or trace gases (e.g., formaldehyde, methane, carbon monoxide and dioxide, water vapor, and nitrogen dioxide), and remote sensing (custom made DOAS whiskbroom imager for high-resolution mapping of SO_2 and NO_2 column concentration). For remote sensing measurements, the cruising altitude is 3.5 km, and the ground speed is around 200 km/h. The flight duration is about 3 hours, with less than 1h needed for the aircraft to enter the region of interest. It consists of approximately 10 flight – legs, and a sounding is performed above MARS, for vertical profiling of the atmosphere. Two hours are needed to sample the entire area and is being centred with the time of the S5P overpass on the region. In the case of two overpasses for TROPOMI in the study area during the daytime, it is targeted the closest to noon.

Measurement setups and Instrumentation

There will be presented preliminary results from one day of measurements (4 November 2021) performed with several platforms. The main platform is airborne, represented by the Britten-Norman 2 Islander aircraft operated by INCAS, shown in Fig. 1. On this platform, several instruments are implemented: two Picarro gas analyzers for CO, CO_2, CH_4, H_2O and H_2CO, an APS (Aerosol Particle sizer), a nephelometer, an AS32M for NO_2, all of which perform in-situ measurements and a custom DOAS whiskbroom imager (SWING+). Simultaneously with the airborne measurements, there were performed ground-based static and mobile measurements. Also, satellite data from ESA's Sentinel 5P TROPOMI was used.

Fig. 1: The Britten-Norman 2 Islander aircraft

Results and discussions

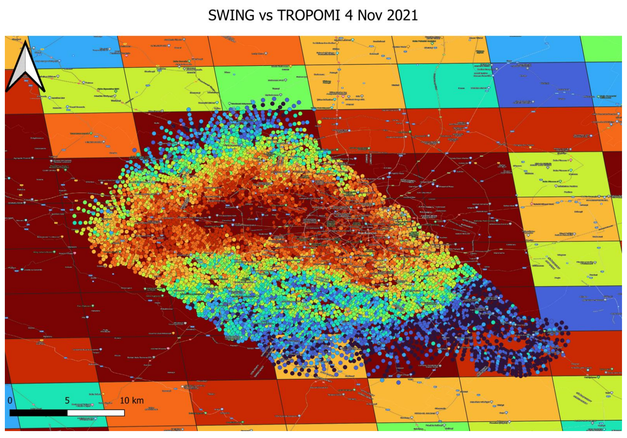

Fig. 2: Georeferenced NO_2 vertical column densities (molec/cm^2) from SWING+ on top of TROPOMI pixels

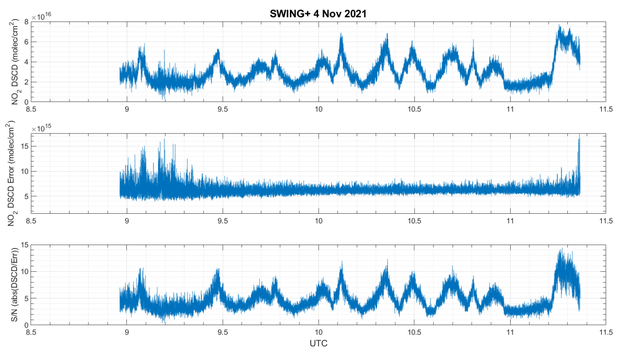

Fig. 3: Time series of NO_2 vertical column densities (molec/cm^2) from SWING+

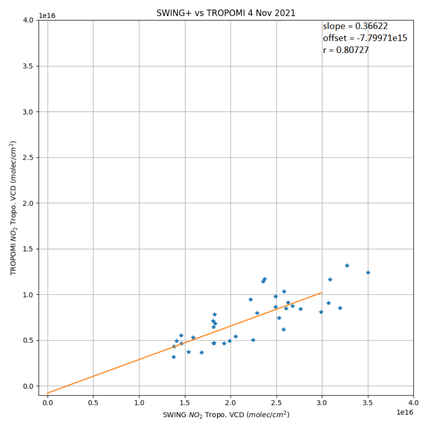

Fig. 4: Correlation plot of NO_2 vertical column densities (molec/cm^2) from SWING+ vs TROPOMI

In Fig. 2 are shown the NO_2 VCDs collected by the SWING+ represented on top of the tropospheric VCD pixels obtained from TROPOMI. The maximum concentrations recorded by the SWING+ are located on the W side of the city, decreasing rapidly on the NS direction, while slowly decreasing more slowly along the EW direction. There can be observed a good agreement between the two instruments in the areas where the concentrations are high, but in the areas where SWING+ records low concentrations, the TROPOMI still shows high values. Nevertheless, the correlation plot in Fig. 4 shows a very good overall agreement, with a correlation coefficient *r* of approx. 0.8. The Mobile DOAS data shown in Fig. 5 indicates high concentrations of NO_2 along the main road leading N from the city, a route prone to heavy traffic. The in situ data from the AS32M shows high NO_2 concentrations in the WSW part of the city, as seen in Fig. 2, as well.

Fig. 5: Georeferenced NO_2 differential slant column densities (in molec/cm^2) from the Mobile DOAS system

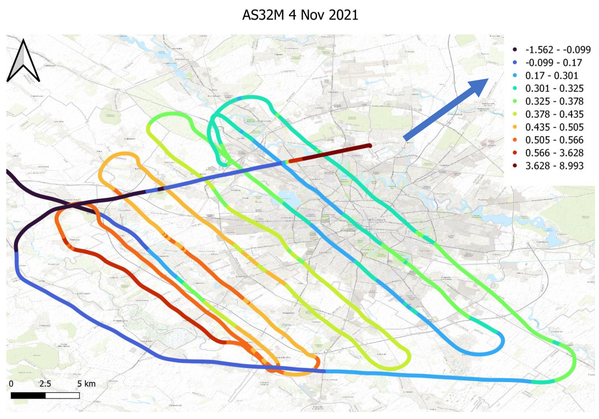

Fig. 6: Georeferenced NO_2 concentrations (in ppb) from AS32M. The arrow represents the general wind direction

Fig. 7: Georeferenced $PM_{2.5}$ concentration from APS. The arrow represents the general wind direction

Fig. 8: Georeferenced PM_{10} concentration from APS. The arrow represents the general wind direction

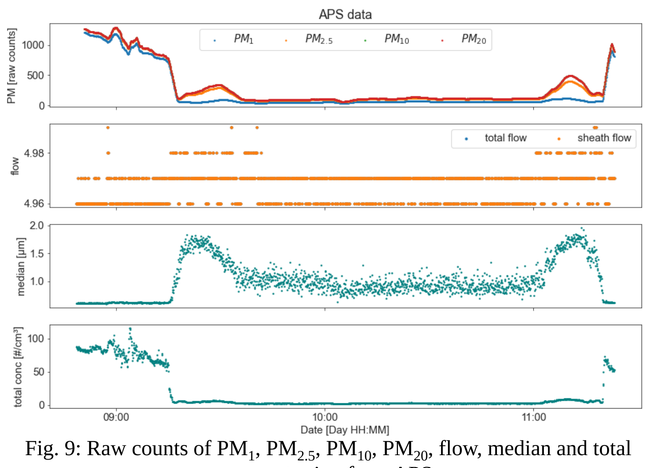

Fig. 9: Raw counts of PM_1, $PM_{2.5}$, PM_{10}, PM_{20}, flow, median and total concentration from APS

Fig. 7 and 8 show georeferenced $PM_{2.5}$ and PM_{10} data, respectively. IN both figures there can be observed relatively high aerosol concentrations in the lower altitude portions of the flight, where the influence of the city bellow has a greater effect. As seen in the first panel of Fig. 9, high concentrations of aerosol are noticed in the beginning and the end of the flight, but also in the first flight leg. The in-situ measurements show high concentrations of aerosol towards the end of the day, represented in Fig. 10.

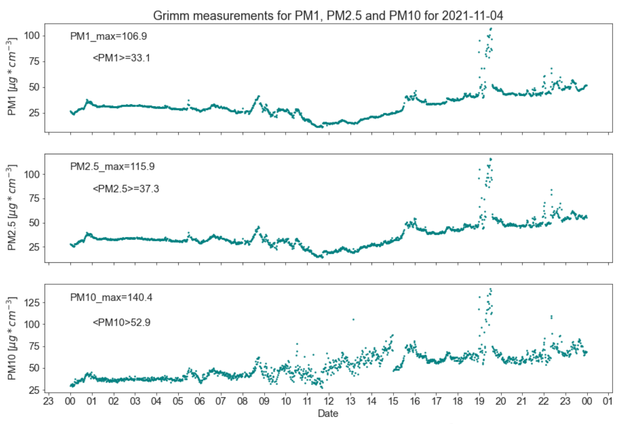

Fig. 10: PM_1, $PM_{2.5}$, PM_{10}, concentrations from GRIMM

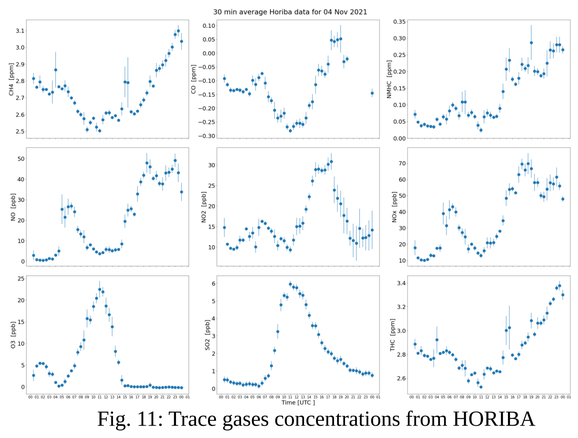

Fig. 11: Trace gases concentrations from HORIBA

The trace gas measurements represented in Fig. 11 show that most of the species presented high concentrations around noon, while other show the opposite, with a minimum concentration close to noon and a steady increase towards the end of the day.

Conclusions

There have been present preliminary results from one day of measurements, 4 November 2021. There has been observed a very good agreement between the data collected by the SWING+ and the satellite data form TROPOMI. The georeferenced data showed the spatial distribution of several atmospheric trace gases and aerosols, while the in-situ data shows the evolution of various species throughout a day. The results were highly positive showing good potential for future measurements and more focused data analysis for the purpose of calibration and validation activities of satellite products.

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