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Aerosol Light Extinction Coefficient Closure - Comparison of Airborne In-situ Measurements with LIDAR measurements during JATAC/CAVA-AW 2021/2022 campaigns

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The JATAC campaign in September 2021 and September 2022 on and above Cape Verde Islands resulted in a large in-situ and remote measurement dataset. Its main objective was the calibration and validation of the ESA satellite Aeolus ALADIN Lidar. The campaign also featured secondary scientific objectives related to climate change. Constraining remote sensing measurements with those provided by in-situ instrumentation is crucial for proper characterization and accurate description of the 3-D structure of the atmosphere.

We present the results performed with an instrumented light aircraft (Advantic WT-10) set-up for in-situ aerosol measurements. Twenty-seven flights were conducted over the Atlantic Ocean at altitudes around and above 3000 m above sea level during intense dust transport events. Simultaneous measurements with PollyXT, and eVe ground-based lidars took place, determining the vertical profiles of aerosol optical properties, which were also used to plan the flights.

The aerosol light extinction coefficient was obtained at three different wavelengths as a combination of the absorption coefficients determined using Continuous Light Absorption Photometers (CLAP) and the scattering coefficients measured with an Ecotech Aurora 4000 nephelometer, which also measured the backscatter fraction. The particle size distributions above 0.3 µm diameter were measured with two Grimm 11-D Optical Particle Size Spectrometers (OPSS). Moreover, CO2 concentration, temperature, aircraft GPS position and altitude, air and ground speed were also measured.

We compare the in-situ aircraft measurements of the aerosol extinction coefficients with the AEOLUS lidar derived extinction coefficients, as well as with the ground-based eVe and PollyXT lidar extinction coefficients when measurements overlapped in space and time. The comparison was performed at the closest available wavelengths, with in-situ measurements inter/extrapolated to those of the lidar systems.

In general we find an underestimation of the extinction coefficient obtained by lidars compared to the in-situ extinction coefficient. The slopes of regression lines of ground-based lidars, PollyXT and eVe, against the in-situ measurements are characterised by values ranging from 0.61 to 0.7 and R^2 between 0.71 and 0.89. Comparison further suggests better agreement between Aeolus ALADIN lidar and the in-situ measurements. Relationship described by fitting the Aeolus to in-situ data is characterised by the slope value 0.76 and R^2 of 0.8.

The causes of better agreement of the in-situ measurements with the ALADIN lidar than with the surface based ones are being studied, with several reasons being considered: a) lower spatial and temporal resolution which homogenize the area of study in comparison with the very fine vertical variations of the aerosols, which can be detected with the surface-based measurements, impairing the comparison with highly vertically resolved ground-lidar measurements while not affecting averaged space-borne lidar; b) the effect of lower clouds/ Saharan air layers on the attenuation of the lidar signal.

The presented results show the importance of the comparison of the remote with in-situ measurements for the support of the research on evolution, dynamics, and predictability of tropical weather systems and provide input into and verification of the climate models.