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The objective of this study was to document in situ the particle size distribution of desert dust particles during their long-range transport in the free troposphere, with a particular focus on the coarse size fraction that dominates the mass flux. The basic idea was to deploy a specifically designed optical particle counter/sizer named LOAC (Light Optical Aerosol Counter/sizer) under drifting balloons in order to minimize isokinetic sampling problems. Boundary-layer pressurized balloons (BLBPs) were launched on alert in the western Mediterranean basin in the framework of the Chemistry and Aerosol Mediterranean Experiment (ChArMEx) field campaigns, allowing us to perform original quasi-Lagrangian monitoring of desert dust aerosols over the sea.

We illustrate tests and validations of LOAC measurements performed to qualify the instrument that include comparisons with concurrent aircraft and tethered balloon measurements, and remote sensing measurements including an AERONET sun-photometer, and a ground-based and the CALIOP lidar systems. As many as 10 LOAC flights were successfully conducted, mainly from Minorca Isl., Spain, during 4 Saharan dust transport events, with BLPBs drifting at altitudes between 2.0 and 3.3 km above sea level. The longest flight exceeded 700 km and lasted more than 25 h. Aerosol optical depths in the balloon vicinity did not exceed about 0.4 but the presence of turbid dust layers was confirmed thanks to dual scattering angle measurements by LOAC allowing the identification of dust particles. LOAC data from BLBPs could generally be fitted by a 3-mode lognormal distribution at roughly 0.2, 4 and 30 μm in modal diameter. Up to about 0.0001 dust particles per cubic cm larger than 40 μm are reported and no significant evolution of the size distribution was observed during the flights whereas we were expecting to observe gravitational sedimentation of the largest particle size fraction.

We also flown LOAC under meteorological sounding balloons during those events to document the dust vertical distribution. Shorter integration time limits the sensitivity to large particles but their presence was confirmed in dust layers. Large particle were also occasionally observed during routine LOAC soundings at Aire-sur-l'Adour in southwestern France.

The presence and persistence of a 'giant' mode at about 30 μm in diameter even after several days of transport contradicts calculations of particles sedimentation velocity. From an indirect evidence of the presence of charged particles derived from the LOAC measurements, we speculate that electrical forces might counteract gravitational settling of the coarse particles.

More details can be found in the ChArMEx Special Issue (https://www.atmos-chem-phys.net/special_issue334.html; see Renard et al. papers).