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Source regions and mobilisation processes for airborne Saharan dust during the Fennec campaign identified from a new Lagrangian method

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Knowledge of the source regions of airborne Saharan dust can provide important hints on the relevant mobilisation processes, radiative properties, and the potential as ice nuclei. The mineralogical composition of dust is difficult to assess at high time resolution from aircraft measurements, and may not give definitive answers on the source region due to the repeated suspension and sedimentation of dust across wide areas of the Saharan desert. Satellite imagery provides more detailed insight into mobilisation processes and source regions, but is restricted to a two-dimensional perspective.

Here we present a new method to identify the sources and mobilisation regions of dust based on backward calculations with the Lagrangian particle dispersion model FLEXPART. A large number of air parcels are traced backwards from a tropospheric column following the aircraft location at 60s intervals for all research flights of the Fennec campaign. Along the backward trajectories, dust uplift potential is integrated for a specified number of days and projected onto the atmospheric curtain along the aircraft location, along with further meteorological quantities extracted from operational ECMWF analysis data.

For a number of research flights leading through fresh and aged dust the Lagrangian integrated dust uplift potential along the flight route correlated well with in-situ nephelometer measurements of aerosol scattering. Well-reproduced horizontal gradients during two flights support the view that dust transport is simulated reasonably well, and that the Lagrangian dust identification is a useful tool for source region analysis. In one case a failed source region identification is due to dust mobilisation and transport by a haboob, a process that is not captured by the meteorological analysis nor the Lagrangian analysis. In a qualitative comparison to airborne LIDAR observations, the Lagrangian dust uplift potential is shown to provide a meaningful estimate of aerosol distribution and age in the convective boundary layer and residual layers above. The corresponding Lagrangian dust source maps are spatially different for these layers, underlining the importance of a three-dimensional dust transport analysis.