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The Sahara Troposphere – Simultaneous Aircraft Observations from Fennec

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The Saharan heat low (SHL) that develops over western Africa in Boreal summer has been recognised for its important role in the regional and continental scale climate system. It is co-located with the highest atmospheric dust loading and the deepest dry convective boundary layer in the world. As part of the Fennec 2011 Intensive Observation Period, two aircraft surveyed the SHL region in the morning and afternoon on 22 June 2011 along different tracks employing LIDAR instruments and dropsondes allowing the first characterisation of the structure and daytime evolution of atmospheric features in the central western Sahara including the SHL, the Saharan atmospheric boundary layer (SABL), the monsoon and atmospheric dust distributions within the system. The observations show a system that is more complex than previously thought. Characteristics include a) a NE-SW orientated SHL, b) a monsoon re-circulation around the SHL associated with dampened Convective Boundary Layer (CBL) growth and Saharan Residual Layer (SRL) top minimum, c) Harmattan winds associated with increased near-surface temperatures and enhanced CBL growth rate and CBL depth, d) near-surface inversions limiting CBL growth and vertical mixing of emitted dust, e) above SRL inversion strength linked to SRL top altitude, f) an aged dust layer close to the SABL top that shows a complex wave-like structure, and g) a potential tropospheric ventilation reducing SRL height and reducing dust concentration.

The NE-SW elongated SHL is located over northern Mauritania close to the Mali border in the morning and moves west by about 0.5 to 1.0° in the afternoon corresponding well with the ERA-Interim reanalysis. The CBL depth ranges from 0.45 to 2.01 km above mean sea level (aMSL) in the morning and from 1.75 to 6.02 km in the afternoon. Low-level inversions in the morning between 0.5 and 0.9 km aMSL are strongest (up to 0.83°C) where the CBL is most shallow and weakening with increasing CBL depth. Above SRL inversions tend to be strongest in the east (0.58°C) and west (0.81°C) of the flight domain where the SABL top is at a maximum altitude (up to 5.49 km aMSL) and weaken towards the centre of the flight domain (SHL region) where the SABL is at a minimum (4.89 km aMSL). Dry convection within the CBL is the primary process of vertical dust mixing, and the wave-like aged dust layer may be used as an indicator for large-eddy dry-convective structures. For the first time we show an observed 3-dimensional view of the central Saharan troposphere and its diurnal evolution. A conceptual model was developed for the case that the SHL is located far enough south to 'draw in' the monsoon: a) CBL dampening east of the SHL due to the southerly monsoon flow, b) CBL dampening northwest of SHL due to the re-circulated monsoon that may lead to a minimum in the SABL top surface, and c) enhanced CBL growth farther west where Harmattan winds increase near-surface temperatures leading to a maximum in the CBL top in the morning.