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The turbulence underside of the West African Monsoon

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We present an experimental analysis of the sahelian Planetary Boundary Layer (PBL) processes in the context of the AMMA (African Monsoon Multidisciplinary Analysis) program and its extensive observational deployment in 2006.

From May to October, two opposite flows are interacting in the first 5 thousands m over surface in Sahel: the moist southerly monsoon flow and the overlying northeasterly Saharan Air Layer (SAL) in which the African Easterly Jet (AEJ) is developing, generated by the contrast of surface moisture and temperature between Sahara and the Gulf of Guinea. Until the monsoon onset in mid-July, the low troposphere is slowly moistening through advection from the Guinea Gulf by the monsoon flow, especially during the night. During the day, the dry convection occurring within the PBL vertically redistributes part of the water vapour. After the onset, deep convection occurs much more frequently and the role played by the PBL completely changes. The relative position of the interface between monsoon and SAL and the PBL top inversion is crucial for the nature of the interaction and its impact on scalars, especially water vapour.

We consider the role of the PBL processes in this context, and focus on four main aspects:
(1) the diurnal cycle of the low troposphere,
(2) the interaction between the PBL and the AEJ,
(3) the entrainment at the PBL top
(4) the impact of the PBL processes at surface.

We base our analysis on long term profilers, radiosondes, and surface flux data, short term aircraft turbulence measurements made during the Special Observing Periods and Large Eddy Simulation.

The network of wind profilers enables us to study the large scale circulation and highlight the consistence and extent of the nocturnal jet, and the importance of the diurnal cycle of the low troposphere for the West African Monsoon.
During daytime, both the wind within the monsoon flow and the AEJ windspeed in the overlying SAL decrease, due to turbulent mixing within the PBL and momentum transfer across the inversion. The turbulence vertical structure is studied with aircraft measurements all along the monsoon setting, and estimates of entrainment at the PBL inversion were made. Entrainment rate decreases as the monsoon sets and are linked with the position of the inter tropical front.
At surface, the fluxes and scalar scales reveal the change of the predominant forcing PBL process from the start of the monsoon setting to the end of the active phase, in relation with the change of the mean vertical structure of the low troposphere along the wet season. This depends on the considered scalar and the possible sink or source at bottom or top. For example, entrainment at the PBL top has a specific signature on water vapour and can significantly impact on the spatial variability and the fluctuations of water vapour within the PBL down to the surface if the inversion reaches the monsoon/SAL interface.