EMS Annual Meeting Abstracts,
Vol. 6, EMS2009-272, 2009
9th EMS / 9th ECAM

9TH EUROPEAN CONFERENCE ON Applications of Meteorology
9th EMS Annual Meeting
High resolution meteorology - applications and services

Roles of low-level thermodynamics on surface-convection interactions over West-Africa

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This study aims to characterize the thermodynamics of the atmospheric low levels across West Africa (WA), on the basis of observations provided by the AMMA project. A dataset made of several thousands of high-resolution soundings is used for this purpose. Moist-convection related indexes, boundary layer (BL) parameters, and a combination of two indexes proposed by Findell and Eltahir (2003) (FE03) are compted for each sounding. These latter indexes are well suited for distinguishing between aspects of surface-atmosphere interactions involving atmospheric vertical structures.

The variability of the low levels is found to be stronger in the Sahelian zone than in the Soudanian zone, from daily scale up to the monsoon season (JJAS). FE03 indexes suggest that surface-atmosphere feedbacks are actually significantly operating over West-Africa, but that the feedback loops change sign with latitude and season. Thus, thermodynamic environment at low level is broadly consistent with the idea of daytime convection being either suppressed or favoured over wet surface versus dry ones, depending on latitude and seasonal variations. This finding is consistent with observations that daytime convection is not always favoured over wet land surfaces. It remains to assess the scale down to which the local thermodynamic environment is actually playing a role, and how it combines with other factors, such as turbulence, clouds and mesoscale circulations, to explain observations.

Variations of the lifting condensation level (LCL) and level of free convection (LFC) are further consistent with the previous analysis. For instance, in Niamey (Sahelian), a strong diurnal cycle of LCL is found, especially early in the season, while the LFC does not fluctuates much with the hour in the day, but shifts downwards from June to August. The LCL is however not such a good indicator of BL height when the low levels are the driest. This is particularly true in June in the Sahel, on days when none of the daytime BL convective plumes reach their LCL. In that case, moist convective development is limited by high convective inhibition (CIN) rather than convective available potential energy (CAPE). Indeed, no clear seasonal trend of CAPE is found in Niamey, while, it actually decreases in Parakou during the core of the monsoon season. Consistently with the differences found for the LFC in Niamey and Parakou, the diurnal cycle of CAPE is less pronounced in Niamey than in Parakou.

Finally, relationships between convective indexes and low-level properties are presented. CAPE is found to be strongly linked to the low-level equivalent potential temperature (thetae) across West Africa. Above a value of the low-level thetae of approximately 340K, CAPE increases steadily with thetae (by about 200 J.kg-1.K-1). Thus, the low levels appear as the dominant driver framing atmospheric stability well beyond their diurnal fluctuations.