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Numerical simulation of an observed Sahelian heat wave: surface energy budget and sensitivity to the representation of convection

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In the Sahel, the temperature is extremely high in spring, with typical monthly-mean values of daily minimum, maximum and mean temperature of respectively 30, 40 and 35°C (Guichard et al. J. Hydrology 2009). Therefore, heat waves occurring at this period of the year can have particularly severe repercussions. Furthermore, current climate projections suggest that their frequency and intensity may increase in the future.

Numerous heat-wave studies have focused on the mid-latitudes, but almost none on the Sahel. However, the specificities of the Sahelian climate imply that the mechanisms at play in this semi-arid region differ from those previously identified in the mid-latitudes. The influence of the Saharan Heat low is strong in this region; the soil is mostly dry in Spring, and soil-moisture feedbacks identified in mid-latitude studies are therefore unlikely to operate during Sahelian heat waves in spring. The present study is carried out within the ACASIS ANR project, which focuses on these Sahelian events.

Observations indicate that the months of April and May 2010 were the hottest of the last 35 years, and included several multi-day hot episodes (Fig. 1a). We selected a 10-day period in the early phase of this 2-month period, from 10 to 20 April, when the temperature was particularly high at night. This period is chosen to test the ability of models to simulate heat waves in the Sahel via comparisons with in-situ surface and boundary layer observations as well as gridded datasets. In particular here, we analyse the sensitivity of simulations to the representation of convection.

This is first analysed with the mesoscale model MesoNH using different domain and grid sizes, with and without parametrizing deep convection. We find a strong improvement of the simulation when the convection scheme is turned off, whatever the resolution, mainly because of the impact of precipitation on low-level temperature via changes in the surface energy budget.
This conclusion is further supported by an inter-comparison of the results obtained with 10 weather forecast models (TIGGE ensemble runs) and meteorological reanalyses (ERA-Interim, MERRA, NCEP2).

Our results also underline the major importance of the monsoon flow during the night, which induces dramatic changes in the surface-atmosphere couplings, namely a sharp increase of the net longwave flux involving water vapour radiative properties, accompanied by a strong night-time warming.

These processes are very diversely captured by models, which strongly affects their simulations of surface air temperature.