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Annual cycle and interannual variability of surface thermodynamics and radiative fluxes in the semi-arid Sahel: an observational study

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This study builds upon the work of Guichard et al. (J. Hydrology 2009) who analysed the seasonal and diurnal cycles of surface radiation in the Sahel, and its couplings with the thermodynamics.
It makes use of a multi-year dataset collected in the Malian Gourma at 1.5°W-15.3°N with automated weather stations and a sunphotometer (AERONET), complemented by observations from the AMMA field campaign.

In this sub-tropical region, the strong dynamics associated with the transition from a drier hot Spring to a brief cooler wet tropical Summer climate involves very large transformations of the diurnal cycles and a large increase of surface net radiation Rnet; typically 10-day mean Rnet rises from about 30 W.m-2 in Winter to 150 W.m-2 in August. This increase is mostly driven by changes in the surface upwelling fluxes, shaped by rainfall events and vegetation phenology (surface cooling and darkening).

Observations also reveal astonishing radiative signatures of the monsoon on the surface incoming radiative flux which point to the significance of the atmospheric cooling during the monsoon season and of the heavy aerosol load in Spring. It also reveals that prior to the rainfall onset, the monsoon flow plays a major role on the diurnal cycle of the low-level temperature, due to its radiative properties.

Finally, beyond these Sahelian-specific features, and in agreement with some previous studies, strong links are found between the atmospheric humidity and the net longwave flux, LWnet at the surface all year long, even across the much lower humidity ranges encountered in this region. They highlight the major control of water vapour and water-related processes on the surface-atmosphere thermal coupling as measured by LWnet.

The large interannual variability of annual rainfall (less than 200 mm to more than 400 mm) is coupled with an equally significant variability of surface net radiation Rnet in Summer. More rainy monsoon seasons are characterized by higher Rnet; the difference can reach up to 30 W.m-2 on average over the month of August, and is mostly driven by changes in the surface longwave upwelling flux. By contrast, the short term (less than 10 years) inter-annual variability of the annual cycle is found to be the weakest in Spring; the implications of these peculiar features will be discussed.

Observational results such as presented here provide valuable ground truth for assessing models over a continental area displaying a challenging variety of surface-atmosphere regimes throughout the year, from a desert-like to a rainy tropical-like climate during the core of the monsoon. These will be shown in the companion studies of Bouniol et al. (2012) and Guichard et al. (2012) presented in this conference, for CMIP5 climate simulations and re-analyses (ERA-Interim, MERRA and NCEP-CFSR).