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A multi-scale analysis of in-situ precipitation data across the Sahelian Gourma

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Droughts and floods are recurrent features of the Sahelian climate, which is also characterized by a very large variability of rainfall, in both space and time. The present study focuses on the Malian Gourma (2°W-1°E, 14.5°N-17.5°N), located in the Central Sahel, where the very large majority of rainfall events occur between June and September, during the West African monsoon.

Rainfall is analysed with two complementary in-situ datasets: (i) daily rainfall series from 25 stations covering the period 1900–2007, and provided by the Direction Nationale de la Météorologie of Mali, and (ii) high-frequency rainfall data provided by a network of about 20 tipping bucket rain gauges, starting in 2005 - these rain gauges have been installed for the African Monsoon Multidisciplinary Analysis (AMMA), see Frappart et al. (2009) for additional information.

The Gourma displays a particularly marked meridional gradient, with annual rainfall decreasing from about 500 mm at 14°N to 150 mm at 17.5°N. In line with previous studies focused on the Sahel, the area also displays a strong decadal variability, with the same succession of wet (1950–1969) and dry decades (1970–2007).
The decrease of annual rainfall is explained by a reduction in the number of the rainy days in southern Gourma, but a decrease in both the number of rainy days and the daily rainfall in northern and central Gourma. This latter result contrasts with some studies focused on more southern areas. It may involves an influence of the distance from the inter-tropical discontinuity.
The length of the rainy season has varied since the 1950s with two episodes of shorter rainy seasons: during the drought of the 1980s and also since 2000. However, this second episode is characterized by an increase in the daily rainfall, which suggests an intensification of rainfall events in the more recent years.

High-frequency data show that most rainfall is produced by intense convective events whose characteristics are quantified at fine scale in a more statistical way. Rainfall amount also displays too peaks in the diurnal cycle, one in the evening and one in the early morning, but with distinct patterns in the early (June) and core (August) monsoon periods. Conversely, rainfall amounts are less around noon, and this mid-day damping is more pronounced in the northern Gourma. Links between this feature and the diurnal cycle of equivalent potential energy and CAPE will be discussed with the help of surface meteorological data and ECMWF full vertical resolution analyses (documenting the local vertical structure of the atmosphere). Late afternoon and evening maxima are consistent with the afternoon convective triggering, while the morning maximum involves the life cycle of mesoscale convective systems (MCSs). This second maximum is consistently less pronounced in June prior to the Sahelian monsoon onset and the more frequent development of MCSs. Finally, even though cumulative nighttime rainfall dominates total rainfall, rainfall rates appear overall lower during nighttime than daytime.

These results provide a necessary ground truth for satellite and radar rainfall products, as well as model evaluation over a region where rainfall has remained largely undocumented so far. This will be discussed briefly with results from commonly used satellite estimates (GPCP, CPC-RFE2, TRMM) and forecasts from NWP (numerical weather prediction) such as the ECMWF-IFS or NCEP reanalyses.

Frappart, F. P. Hiernaux, F. Guichard, E. Mougin, L. Kergoat, M. Arjounin, F. Lavenu, M. Koité, J.-E. Paturel and T. Lebel, 2009 : Rainfall regime over the Sahelian climate gradient in the Gourma, Mali, J. Hydrology, 375, 128-142. doi : 10.1016/j.jhydrol.2009.03.007