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Rainfall regime across the Sahel band in the Gourma region, Mali

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SUMMARY

The Sahel is characterized by low and highly variable rainfall, which strongly affects the hydrology and the climate of the region and creates severe constraints for agriculture and water management. This study provides the first characterization of the rainfall regime for the Gourma region located in Mali, Central Sahel (14.5–17.5°N and 2–1°S). The rainfall regime is described using two datasets: the daily long term raingauge records covering the period 1950–2007, and the high frequency raingauge records collected under the African Monsoon Multidisciplinary Analysis (AMMA) project between 2005 and 2008. The first rainfall dataset was used to analyse the interannual variability and the spatial distribution of the precipitation. The second dataset is used to analyse the diurnal cycle of precipitation and the nature of the rainfall. This study is complementary to previous analyses conducted in Sahelian areas located further south, where the influence of the continental Sahara heat low is expected to be less pronounced in summer.

Rainfall regimes in the Gourma region present a succession of wet (1950–1969) and dry decades (1970–2007). The decrease of summer cumulative rainfall is explained by a reduction in the number of the rainy days in southern Gourma, and a decrease in both the number of rainy days and the daily rainfall in northern and central Gourma. This meridional difference may be related to the relative distances of the zones from the intertropical discontinuity, which is closer to the northern stations. 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 reveal that a large fraction of the rainfall is produced by intense rain events mostly occurring in late evenings and early mornings during the core of the rainy season (July–September). Conversely, rainfall amounts are less around noon, and this mid-day damping is more pronounced in northern Gourma. All these characteristics have strong implications for agriculture and water resources management.

Introduction

The arid and semi-arid regions of Africa are characterized by low and unreliable rainfall, which strongly affects water resources and food security (Nicholson, 1989). The largest of these regions, the Sahel, runs 3800 km from the Atlantic Ocean in the west to the Red Sea in the east, in a belt that varies from several 100–1000 km in width, covering an area of 3,053,200 km^2. This semi-arid area is bordered to the north by the Sahara Desert and to the south by Sudanian savannas. The Sahelian climate is characterized by a unimodal rainfall regime controlled by the west African Monsoon – WAM (Nicholson, 1981; Todorov, 1985; Morel, 1992; Hiernaux and Le Houérou, 2006). During the 20th century, the Sahel experienced a multidecennial drought that started at the end of 1960s, with two sequences of extremely dry years, in 1972–1974 and 1983–1985 (Hulme, 1992; Le Barbé and Lebel, 1997; D'Amato and Lebel, 1998; L'Hôte et al., 2002; Lebel et al., 2003). This is, indeed, the strongest measured climatic event of rainfall variability at these time and space scales (Hulme, 2001). The substantial changes in the climate conditions obliged Sahelian farmers and pastoralist communities to adapt to the decrease in water resources (Mortimore and Adams, 2001; Tarhule and Lamb, 2003; Pedersen and Benjaminsen, 2008).

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The few recent studies of Sahelian rainfall regimes using raingauge data were carried out over large areas located further south (Le Barbé et al., 2002; Lebel et al., 2003; Bell and Lamb, 2006), whereas the rainfall regimes of the drier central and northern Sahel, which experience a strong climatic influence of the Sahara heat low in summer, remain poorly described.

This study is the first to focus on the rainfall regime of the northern AMMA–CATCH (African Monsoon Multidisciplinary Analysis–Couplage de l'Atmosphère Tropical et du Cycle Hydrologique) mesoscale site (14.5–17.5°N, 1–2°W), located in the Gourma region, in Mali. Ground-based measurements covering a range of complementary scales are used.

This study focuses on an analysis of rainfall variability over the Gourma region during the years 1950–2007, using time series of daily precipitation data. The rainy season is characterized in terms of length, distribution of precipitation, and number and intensity of rainy days. Historical trends affecting West Africa and the Sahel over the past century are presented and discussed for the Gourma region specifically.

Smaller scale modes of rainfall variability are investigated using high frequency measurements collected by the AMMA–CATCH raingauge network during the AMMA Enhanced Observations Period (EOP), 2005–2008. Over the Sahel, and in the Gourma region, rainfall is of convective origin and organized Mesoscale Convective Systems (MCS), which accounts for most of the rainfall as shown by Mathon et al. (2002). Therefore, the distribution of rainfall rates associated with rainfall events over the Gourma region is analysed and compared with existing studies. The diurnal cycle, a major

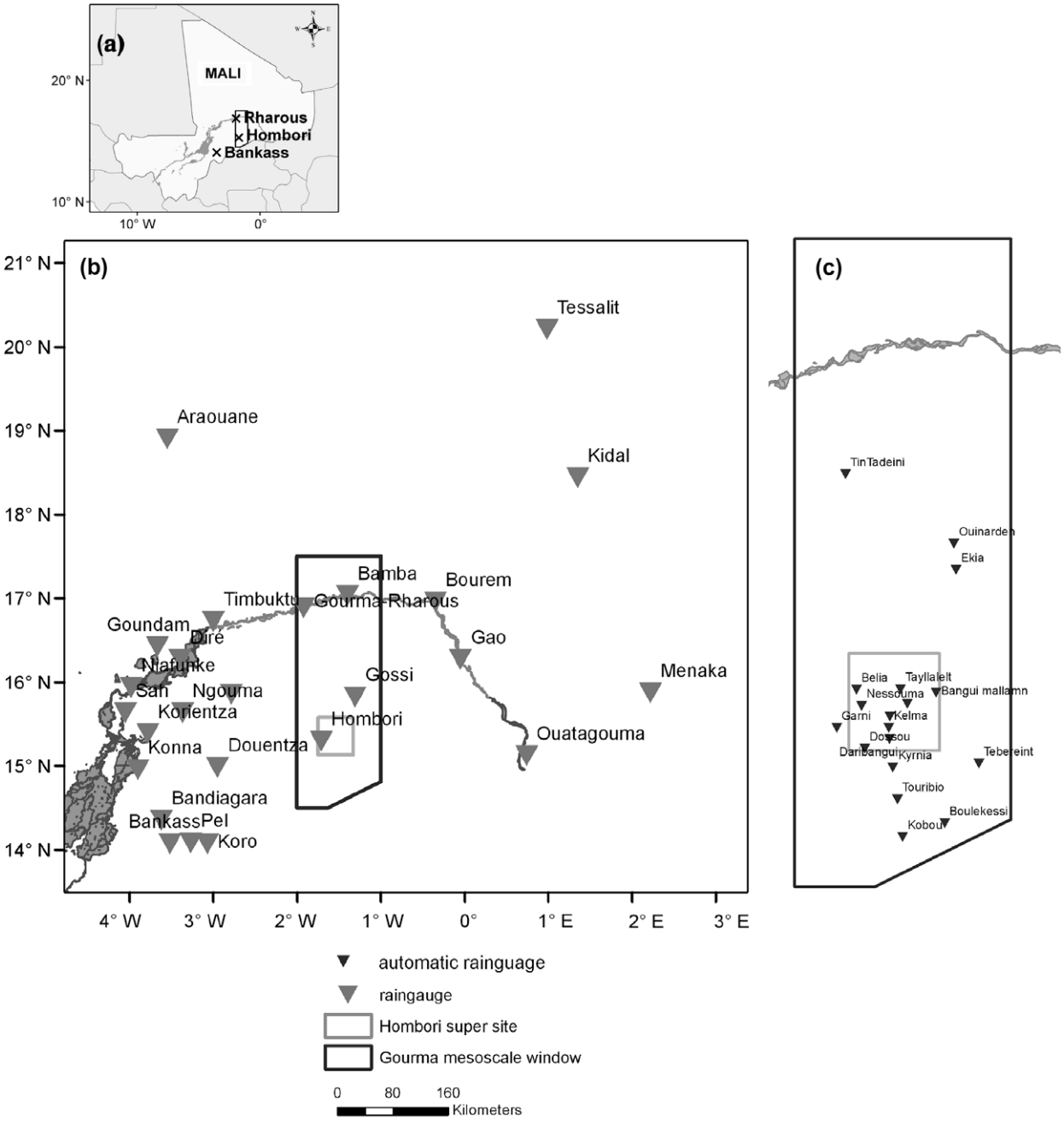

Fig. 1. (a) Location of the Gourma region, Mali, West Africa; (b) location of the historical rain gauges within and outside the Gourma region, Mali and (c) location of the automatic rain gauges in the AMMA mesoscale site.