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The role of ENSO and Atlantic Niño on rainfall variability and extremes in West Africa

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The African monsoon is governed by the complex interplay of large-scale atmospheric and oceanic processes. Understanding how these drivers influence rainfall variability can improve the prediction of hydro-meteorological extremes (e.g. heavy rainfall, droughts) for this vulnerable region. This study examines the role of dominant climate modes, such as the El Niño–Southern Oscillation (ENSO) and the Atlantic Niño, in modulating rainfall variability and extremes over West Africa. Unlike previous studies, this investigation is conducted across seven objectively defined rainfall zones in West Africa, describing typical rainfall regimes (e.g. Sahelian) for the region. Moreover, the analysis builds on an advanced quality-controlled station-based rainfall dataset, namely the West African Historical Precipitation Database, compiled over the past decade to improve the coverage and quality of data from rain gauges in this region. To describe the state of ENSO, the Atlantic Niño and other climate modes, various state-of-the-art indices (e.g. MEIv2, ATL3, DMI, AMM, SOI) and indices specifically established for West African Monsoon (e.g. the African Southwesterly Index ASWI) are used. The statistical relationships between climate modes and rainfall variability are assessed for the seasonal rainfall amount and other rainfall statistics (e.g. onset, rainfall probability, mean-wet day amount) for the main monsoon phases over a period of 50 years (e.g. 1960 to 2010). Preliminary results show that JAS-rainfall for the Sahelian and Sudan savanna region is controlled by both, ENSO and Atlantic Niño, and low-level wind dynamics. The ASWI alone can explain up to 50% of the rainfall variability in this region compared to 20% for MEIv2 and ATL3. Moving southwards to the coastal regions with two monsoon peaks (MJJ and SON), ENSO becomes the dominant driver for MJJ-rainfall with lagged impacts between 1 to 3 months. Notably, ATL3 displays regime-dependent sign reversals, highlighting the contrasting impacts of Atlantic Niño across the region. Our findings indicate that WAM is strongly influenced by various drivers whose dependence structure with monsoonal rainfall varies in space and time. This reflects shifts in teleconnection dynamics and emphasizes the development of modelling approaches that can capture this non-stationarity in a suitable way.