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Rainfall Types over Southern West Africa: Objective Identification, Climatology and Synoptic Environment

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Southern West Africa (SWA) is characterised by a wide range of precipitation systems reaching from short-lived warm rain showers to several hundred kilometre wide, highly organised and intense convective systems. Despite their importance for quantitative rainfall prediction, the relative importance of different rainfall types and the synoptic environments in which they occur have never been quantified on a regional level. Here we use 16 years (1998–2013) of three-dimensional reflectivity data from the Tropical Rainfall Measuring Mission-Precipitation Radar (TRMM-PR) to objectively distinguish between seven different rainfall types in three subregions of SWA (within 100 km from the Guinea Coast, inland up to 9°N and Soudan zone, i.e. 9–12°N; all 10°W–10°E).

Highly organised Mesoscale Convective System (MCS) –type events are the dominating rain-bearing systems in SWA. They tend to occur in environments with high low-level shear as a result of mid-level northeasterlies ahead of a cyclonic vortex. While the corresponding three TRMM-PR classes are reminiscent of Sahelian MCSs occurring ahead of African Easterly Wave troughs, their contribution to annual rainfall in SWA is lower decreasing from 71% in the Soudanian to 56% in the coastal zone. MCSs in SWA also propagate slower and are frequent only at the start of the first coastal rainy season. This also holds for the infrequent, yet rain-effective small and deep convective coastal systems. In terms of frequency of occurrence, about 90% of rainfall systems belong to weakly organised classes, among which small-sized, highly reflective (>40 dBZ) and moderately deep (<10 km) convective systems dominate in number and rainfall contribution (21–37%). The land-sea breeze along the Guinea coast strongly ties the occurrence of the less organised systems to the diurnal cycle, with isolated shallow echoes even before local noon. These warm rain systems are a coastal phenomenon between June and September and occur in a moist, low-shear, low-CAPE (convective available potential energy) environment with mid-level southwesterly anomalies to the east of a vortex. In general, the least organised systems occur in a deep westerly flow with a single mid-level cyclonic vortex and bear some resemblance to what has been termed “monsoon” or “vortex rainfall”. Combining TRMM-PR rainfall system identification with infrared-based cloud tracking reveals that organised convection over SWA typically lasts for more than 9h, whereas less intense rainfall types tend to be short-lived, diurnal phenomena.

This novel approach stresses the relevance of midlevel (wave) disturbances on type and lifetime of convective systems and thereby their regionally, seasonally and diurnally varying contribution to rainfall amount. The present study suggests further investigations into the character of the disturbances and possible implications for operational forecasting and the understanding of rainfall variability in the populous SWA region.