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Impact of tropical waves on rainfall modulation and heavy rainfall event occurrence over western equatorial Africa

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Tropical waves, particularly convectively coupled equatorial waves (CCEWs), are known to modulate rainfall in tropical Africa on intraseasonal down to convective time scales, the latter of which includes the dynamics of heavy rainfall events. Data scarcity in large parts of Africa, especially in equatorial Africa, has long prevented a clearer picture on the regional variability of extreme rainfall. Thus, making use of globally gridded satellite data and a unique in-situ rainfall dataset for Cameroon, this study aims for a systematic comparison of the role of tropical waves on the occurrence and variability of intense rainfall over western equatorial Africa.

For the study period 2001-2019 in a selected domain over Cameroon, heavy daily rainfall (i.e. the 20% strongest and spatially most extensive) events are identified using both the satellite-based rainfall estimates of the Integrated Multi-satellite Retrievals for Global Precipitation Measurement (IMERG) and largely unique station data from the Karlsruhe African Surface Station-Database (KASS-D). The outgoing longwave radiation (OLR) dataset of the National Oceanic and Atmospheric Administration (NOAA) are then used (a) to support evidence of the occurrence of the intense rainfall events, and (b) to apply a wavenumber-frequency filtering in order to evaluate the co-occurrence of tropical waves around these events. These include the fast modes such as Kelvin waves and tropical disturbances (TD), in the study region commonly represented by African Easterly Waves (AEWs), as well as slow modes represented by equatorial Rossby waves and the Madden-Julian Oscillation (MJO). Finally, to account for regional differences in seasonal rainfall characteristics, the analysis is performed for a southern and northern sub-domain during the bi-modal (March–May/September–November) and unimodal (May–October) rainy seasons, respectively.

Results show that: 1) the passage of Kelvin waves and TDs have the strongest impact on daily rainfall rates in the two sub-regions, whereas the effect of the MJO is the weakest ; 2) the modulation by Kelvin waves is strongest in southern Cameroon whereas that of TDs is strongest in the north; 3) there is a shift between the wet wave phases in OLR and rainfall (IMERG, KASSD); 4) up to 78% of the cases with heavy rain coincide with the passage of a tropical wave; 5) Kelvin and TD are again the most likely to be associated with a heavy rainfall event, featuring an up to five

times higher local wave intensity as compared to the other waves.

To further test potential dependencies of results on the applied wave identification method, tropical waves have also been identified with a 2D spatial projection method based on parabolic cylinder functions (PCFs) using horizontal wind fields from ERA5. Here, first results suggest that the projection method overall yields less intense and slower Kelvin waves. Furthermore, the occurrence of a Kelvin wave appears to be related to heavy rainfall to a lesser degree compared to the wavenumber-frequency approach. This potentially stresses the importance of a careful choice of the suitable wave identification method for a given application, the details of which are currently evaluated.