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Modulation of precipitation over West Africa by equatorial waves

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Equatorial waves can couple with deep convection and thus modulate rainfall on the synoptic timescale throughout the tropics. Until now, however, no comparative study of the influence of all the different wave types on precipitation has been performed specifically for West Africa.

To fill this gap, the following wave types were analyzed for the pre-/post- and full monsoon season (April to October): (1) the Madden-Julian Oscillation (MJO), (2) Kelvin waves, (3) equatorial Rossby waves, (4) eastward-propagating inertia gravity waves, (5) mixed Rossby-gravity waves and (6) tropical disturbances/African Easterly Waves. The different wave types were filtered in the wavenumber-frequency spectrum of outgoing longwave radiation. Eight different wave phases were defined from a phase diagram that can be calculated from the time-derivative of the filtered wave signal. Subsequently, composites of dynamical and thermodynamical fields for each wave phase of the different wave types were plotted using the ERA Interim reanalysis from the European Centre for Medium-Range Weather Forecasts. This way the propagation of the wave can be depicted.

All aforementioned wave types, except the fast eastward-propagating inertia gravity wave, show consistent and significant influence on West African rainfall. The influence of the waves can be seen far into the subtropics for some wave types. The expected theoretical structure is confirmed by the analysis of upper- and lower-level divergence, wind and geopotential height. An interaction between the tropical and extratropical regime appears to occur for the MJO and equatorial Rossby waves. The mechanism involved in this interaction, however, is not fully understood. Composites of low-level wind shear, convective available potential energy and mid-level moisture are used to analyze whether waves create favorable conditions for the organization of convection. Additionally, the source regions of moisture were identified using moisture fields and moisture fluxes.

The results emphasize the importance of a correct representation of equatorial waves in numerical weather prediction (NWP) products for West Africa. Additionally, the statistical relationships found here indicate that statistical forecast models can be improved by including equatorial wave activity.