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Extreme Precipitation Events in the Middle East: Dynamics of the Active Red Sea Trough

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Extreme precipitation events in the Middle East can cause flash floods with serious societal impacts. For example, in Egypt in November 1994, and in Jeddah (Saudi Arabia) in November 2009, flash floods caused almost 600 and more than 120 casualties, respectively. A major meteorological phenomenon involved is the Active Red Sea Trough (ARST), a midlatitude-tropical interaction. Previous ARST studies addressed the dynamics, however, do not provide a complete understanding of the mechanism, and moreover, focus only on the Levant. This study presents a generalized concept of the ARST dynamics and aims for an improved understanding of its geographical extent and seasonality. We used ERA-Interim data to analyze several ARST events affecting the Levant, the Jeddah flooding, and the seasonality of the ARST associated dynamics.

The synoptics around 25 November 2009 show a similar dynamical evolution as the ARST events over the Levant, revealing that the Jeddah flooding was in fact caused by an ARST. An ARST concept is defined, involving six important dynamical features: (1) a semi-permanent low-level trough (i.e. the Red Sea Trough), (2) a semi-permanent anticyclone at mid-levels over the Arabian Peninsula, (3) a mid-latitude upper level trough, (4) an intensified subtropical jet stream, (5) moisture transport and convergence, and (6) ascending motions resulting from the large scale forcing and tropospheric instability, leading to mesoscale convective systems and (local) extreme precipitation.

Our analysis emphasizes the significance of the semi-permanent anticyclone over the Arabian Peninsula, predominantly causing moisture transport from the Arabian and Red Seas. The seasonal cycle of these dynamical factors explains why the ARSTs over the Levant region occur primarily in autumn and to a lesser extent in spring, and suggests a temporal shift further to the south (e.g. around Jeddah), starting later in autumn, ending earlier in spring, and favorable conditions for ARSTs lasting throughout the winter.