



## **Extreme Precipitation Events in Saudi Arabia: Tropical-Extratropical Interactions in Autumn, Winter and Spring**

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The Middle East has a very dry climate, however, at times, extreme rainfall can cause flash floods with severe societal impacts. Using reanalysis (ERA-Interim) and observational precipitation (TRMM 3B42 and station) data, we study the underlying synoptic-scale atmospheric dynamics of three extreme precipitation events in Saudi Arabia occurring in autumn, winter and spring. All three cases involve strong tropical-extratropical interactions. A mid-latitude upper level trough, associated with Rossby wave breaking, intrudes into the subtropics and interacts with the (sub)tropical low level circulation, which triggers intensive poleward transport of tropical moisture and strong upward motions. The autumn case (November 2009) shows enhanced moisture transport over the Arabian and Red Seas together with the northward extension of the Red Sea trough, i.e. being an “Active Red Sea Trough” event. The winter case (January 2005) has characteristics of a tropical plume and involves the coupling of an equatorward penetrating cyclonic disturbance and the tropical low pressure zone over Equatorial Africa, significant moisture transport over central Africa and an intensified subtropical jet stream. The spring case (April-May 2013) demonstrates a prolonged period of intense convective activity, promoted by strong surface heating, a quasi-stationary upper level trough and associated cold air, and a persistent low level warm and moist air flow, partly originating from the southern hemispheric Indian Ocean through a cross-equatorial surge. The three events are strongly influenced by the seasonality of the climatological large-scale circulation.