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Hydrological extremes in hyper-arid regions: A diagnostic characterization of intense precipitation over the Arabian Peninsula

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Aridity is typically associated with deep and dry daytime boundary layers, stable nighttime stratification, and divergent flows. All these factors are paramount in regulating the hydro-climatology of hyper-arid regions, resulting in extremely intermittent – and often intense – spatial and temporal precipitation patterns. If large-scale circulation has clearly a crucial role in advecting the atmospheric moisture necessary to the onset of extreme precipitation in arid regions, the understanding of how this synoptic-scale forcing contributes to local extremes under aridity still remains exceedingly limited. We present here a diagnostic study of intense precipitation in the Central Arabian Peninsula, based on the analysis of local extreme signatures embedded in synoptic patterns. Special emphasis is given to the genesis of winter extremes over the Peninsula, and to possible effects of synchronization between the atmospheric circulation over the Mediterranean and the Indian Ocean. Based on composites of tropospheric wind, precipitable water, meridional wind, vertically integrated moisture flux convergence and potential vorticity for a large ensemble of intense events, we show that moisture necessary to trigger winter extremes over the Peninsula starts to build up in average 8 days before heavy rainfall occurrence, mainly as a consequence of the interplay between the Mediterranean and the Monsoonal circulation. Moisture advection is in turn associated with an upper-troposphere cyclonic circulation and pronounced potential vorticity intrusions. Overall, our results show how large-scale precursors can be effectively used to improve the predictability of local rainfall extremes in hyper-arid regions.