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An extreme precipitation event in southern Morocco in spring 2002 and some hydrological implications

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ABSTRACT: This paper describes an extreme rain event in the semiarid to arid region south of the High Atlas in northwest Africa on 31 March and 01 April 2002. Apart from European Centre for Medium-Range Weather Forecasts analyses, satellite, radiosonde and synoptic weather station data, half-hourly observations from 12 climate stations that have been recently installed in the Drâa valley in southern Morocco as part of the IMPETUS project ('An Integrated Approach to the Efficient Management of Scarce Water Resources in West Africa') are considered. Precipitation totals (of up to 77 mm in 23 hours) range in the order of magnitude of more than half of an average annual sum and constitute the heaviest storm of the last 25 years in this region. The immediate run-off caused flooding and damage to buildings. Besides, a substantial filling of water reservoirs (+23.6% of the total capacity of the great storage lake Mansour Eddahbi) and a storage of water in the High Atlas snow cover (up to 1 m) and in the soil was observed, which positively impacted on the region's water supply until the summer.

The precipitation event was connected to a 'tropical plume' (TP) that formed on the eastern side of an quasi-stationary upper-level subtropical trough to the west of northwestern Africa during the previous days. The large positive potential vorticity (PV) anomaly associated with this trough suggests an intrusion of dry stratospheric air connected to an anticyclonic Rossby wave breaking event. This PV anomaly interacted with the low-level temperature front connected to the TP, initiating the development of a Mediterranean cyclone on the poleward side of the TP over the course of the following days. On 01 April, the merging of the TP with the cold air cloud feature resulted in the formation of a lambda-shaped cloud system, sometimes referred to as an "instant occlusion". A trajectory and integrated water vapour flux analysis reveals that on the equatorward side of the TP, mid-level moisture transports from tropical West Africa occurred, while the high clouds connected to the actual TP originated close to tropical South America. The strong dynamically induced upper-level divergence at the inflection point of the trough and the associated synoptic-scale uplift appear to be crucial factors for the formation of the extraordinarily heavy rainfalls. Orographic forcing might have played an additional role. In contrast to cases of tropical-extratropical interactions causing precipitation in the Atlas region in late summer/early autumn, large- scale dynamical and frontogenetic effects seem to dominate over local factors as for example the triggering of convection in the moist tropical air through the daytime heating of elevated terrain.

The results are contrasted to a simultaneous extreme event on the nearby Canary Island of Tenerife (up to 240 mm in three hours), which is identified as a localised thunderstorm in the unstable air underneath the axis of the upper-level cold trough that initiated the TP, potentially enhanced locally by the steep orography of the island.