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On the nature of rainfall in dry climate: Space-time patterns of convective rain cells over the Dead Sea region and their relations with synoptic state and flash flood generation

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Space-time patterns of rainfall are important climatic characteristics that influence runoff generation and flash flood magnitude. Their derivation requires high-resolution measurements to adequately represent the rainfall distribution, and is best provided by remote sensing tools. This need is further emphasized in dry climate regions, where rainfall is scarce and, often, local and highly variable. Our research is focused on understanding the nature of rainfall events in the dry Dead Sea region (Eastern Mediterranean) by identifying and characterizing the spatial structure and the dynamics of convective storm cores (known as rain cells). To do so, we take advantage of 25 years of corrected and gauge-adjusted weather radar data. A statistical analysis of convective rain-cells spatial and temporal characteristics was performed with respect to synoptic pattern, geographical location, and flash flood generation. Rain cells were extracted from radar data using a cell segmentation method and a tracking algorithm and were divided into rain events. A total of 10,500 rain cells, 2650 cell tracks and 424 rain events were elicited. Rain cell properties, such as mean areal and maximal rain intensity, area, life span, direction and speed, were derived. Rain events were clustered, according to several ERA-Interim atmospheric parameters, and associated with three main synoptic patterns: Cyprus Low, Low to the East of the study region and Active Red Sea Trough. The first two originate from the Mediterranean Sea, while the third is an extension of the African monsoon. On average, the convective rain cells in the region are 90 km^2 in size, moving from West to East in 13 ms^{-1} and living 18 minutes. Several significant differences between rain cells of the various synoptic types were observed. In particular, Active Red Sea Trough rain cells are characterized by higher rain intensities and lower speeds, suggesting a higher flooding potential for small catchments. The north-south negative gradient of mean annual rainfall in the study region was found to be negatively correlated with rain cells intensity and positively correlated with rain cells area. Additional analysis was done for convective rain cells over two nearby catchments located in the central part of the study region, by ascribing some of the rain events to observed flash-flood events. It was found that rain events associated with flash-floods have higher maximal rain cell intensity and lower minimal cell speed than rain events that did not lead to a flash-flood in the watersheds. This information contributes to our understanding of rain patterns over the dry area of the Dead Sea and their connection to flash-floods. The statistical distributions of rain cells properties can be used for high space-time resolution stochastic simulations of rain storms that can serve as an input to hydrological models.