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From synoptic conditions to precipitation structure and extreme flash flood generation

Efrat Morin (1), Idit Belachsen (1), Moshe Armon (1), Francesco Marra (1), Davide Zocatelli (1), Yair Rinat (1), and Nadav Peleg (2)

(1) Institute of Earth Sciences, Hebrew University of Jerusalem, Jerusalem, Israel, (2) Institute of Environmental Engineering (IfU), ETH, Zurich, Switzerland

Flash flood magnitude is highly sensitive to the space-time patterns of precipitation, which, in turn, depend on the meteorological conditions. To better understand the chain of processes leading to extreme flash floods, we put the focus on precipitation patterns as the main hydrological forcing, and examined what precipitation patterns favor extreme flash flood generation and under what synoptic conditions such patterns typically evolve. We focused on arid and Mediterranean climates, where convective rain is the main source of runoff, and based our analyses on a long-term, high resolution, corrected and adjusted radar-based rainfall database. We identified convective rain cells, tracked them in time, and examined the probability distributions of their space-time properties under different synoptic conditions. Their linkage to flash flood magnitude was analyzed both statistically and by means of hydrological models. We identified several key factors driving flash floods magnitude, including cells velocity and direction and rain intensity-duration-area relations, among others. These properties are found to depend on the generating synoptic conditions and to affect the type of activated catchments. A detailed analysis of several extreme events highlighted the importance of synoptic scale processes, such as moisture transport, versus meso-scale processes, affecting precipitation triggering and efficiency.