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Quantifying global-warming-induced changes in spatial and temporal patterns of heavy precipitation events and the implications to flood properties in Mediterranean catchments

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Flood properties are known to be sensitive to spatial and temporal patterns of precipitation, which in turn are affected by global warming. In this study, we investigated the effect of global warming on properties of heavy precipitation events (HPEs) in the eastern Mediterranean, focusing on hydrologically-important characteristics, including total precipitation amount, coverage area, precipitation duration and the distribution of rain rates for different durations. Then, we quantified how changes in precipitation due to global warming affect resulting flood properties for small-medium catchments in the study region.

We used the weather research and forecasting (WRF) model to simulate 41 HPEsin present and future (end of 21st century; RCP 8.5 scenario) climate conditions and output the precipitation fields at high resolution (1 km^2, 10 min). The calibrated GB-HYDRA distributed hydrological model (<60 s, 100 m) was utilized to simulate floods from those HPEs in 4 small-medium-size basins (18–69 km^2). To account for the rainfall spatial uncertainty in the simulations, spatial shifts were applied to the simulated HPEs in a range of 20 km north and south.

We found a major decrease in precipitation accumulation (−30% averaged across events) in future HPEs. This decrease results from a substantial reduction of the rain area of storms (−40%) and occurs despite an increase in the mean conditional rain rate (+15%). In addition, the duration of the HPEs decreases (−9%) in future simulations. The above changes were consistent across events.

These changes have opposite directions, suggesting that flood properties changes are not trivial. Our simulations indicate a future decrease in both flood volume (-27%) and peak discharge (-20%, non-significant) at the outlet of the catchments. On the other hand, peak discharge is increasing in the future for small sub-catchments (< 5 km^2). We currently expand this research to account for expected changes in future antecedent soil moisture conditions and land-use.

To conclude: with global warming, HPEs in the eastern Mediterranean are becoming drier and more spatiotemporally concentrated. Consequently, small and larger catchments respond differently to this change, with the former reacting to the increase in rain rates and producing higher flood peak discharge, while the latter reacts more to the reduction in total rainfall, area and

duration, and results in lower flood volumes and peaks.