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Chronicle of a disaster foretold: The Storm Daniel dam-breaching flood at Derna, Libya

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Storm Daniel, the deadliest recorded Mediterranean tropical-like (medicane) storm, led to severe floods in large parts of the eastern-central Mediterranean, including Greece and northern Libya. Extreme rainfall, reaching more than 400 mm day^{-1}, triggered a flash flood in Wadi Derna (Libya)– an ephemeral river with a drainage area of 575 km^2 that crosses the city of Derna at its outlet to the Mediterranean Sea. In the 1970s, dams were built in Wadi Derna basin to mitigate flood risks. However, during Storm Daniel, at least two dams were breached by a flash flood that inundated much of the city of Derna and resulted in over 5,000 casualties, thousands of missing persons, and tens of thousands of displaced people. The devastating event was the focus of media coverage for a long time, but many questions with implications for other dammed Mediterranean regions are still open. Here, we focus on three main research questions: (a) How unique and extreme were the storm and meteorological conditions of Storm Daniel? (b) How extreme was the flood? And (c) What could have been the flood outcome if dams hadn't been built upstream in the first place?

To analyze the characteristics of Storm Daniel over Wadi Derna, the catchment's hydrological response, and the impact of the flood on the city of Derna, we integrate various datasets and models. Satellite-based precipitation estimations (IMERG) were used to quantify spatiotemporal storm properties and the catchment-scale rainfall, which were fed into the KINEROS2-RHEM hydrological model to quantify surface runoff. The modeled flood hydrograph is then fed into a 2D hydraulic model (HEC-RAS) to test three end-member scenarios: (a) dam filling, overflow, and collapse, (b) dam overflow but no collapse, and (c) no dams exist in the wadi. This combination of methods reveals that the peak discharge during the flood was ~1,400 m^3 s^{-1}, falling below the expected maximum extreme flood for this region. Based on the total discharge volume, we estimated the return period of the flood as 33-50 years. In the dam-collapse scenario, the populated flooded area is 40% larger and ten-fold more destructive than the no-dam scenario. Given the high variability of precipitation in the Mediterranean and the projected increase in extreme precipitation intensity under climate change, the Wadi Derna flood should serve as a warning sign for other populated areas downstream of dams in similar environments.