Contribution of hydrometeorological drivers to compound impacts of natural hazards: an impact-based methodology

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Abstract

Natural hazards such as floods, hurricanes, heatwaves, and wildfires cause significant economic losses (e.g., agricultural and property damage) as well as a high number of fatalities worldwide. Therefore, we need to understand what drives these extreme events and how different hydrometeorological drivers combine to contribute to the impacts of these events. While natural hazards are often considered to be caused by a single hydrometeorological driver (e.g., coastal flood from storm surge only), they can also be caused by the combined occurrence of multiple drivers (e.g., coastal flood driven by storm surge and precipitation). When multiple drivers are involved, traditional methods that focus on univariate extremes are insufficient to define and detect all relevant conditions that lead to a significant impact.

Based on historical socio-economic loss data, we developed an impact-based approach to assess the role of compounding effects between hydrometeorological drivers to create impacts of natural hazards. We use the SHELDUS database (CEMHS, 2020) to identify the historical hazard events that caused socio-economic losses (property and crop damage, injuries, and fatalities) across the U.S. Knowing the timing and location (i.e., county) of an impact we obtain time-series data from historical observations and reanalysis data for 13 hydrometeorological drivers linked with 9 different types of hazards. We then link all relevant hydrometeorological variables to each impact event to estimate if only one or multiple drivers were involved in creating the socio-economic impacts recorded in SHELDUS and how often the impacts result from a compound event. As a test case, we implemented this methodology in Miami-Dade County, Florida and our results show that hazards resulting in higher socio-economic impacts are all compound events caused by multiple hydrometeorological drivers. We find that around 80% of flooding events were compound events and a large portion of other hazards that caused significant impacts are also classified as compound events. For some hazards, such as hurricanes and wildfires, all the events that caused damages are classified as compound events in our framework. Our findings emphasize the benefit of including socioeconomic impact information when analyzing the compounding effects of natural disasters, as well as the importance of analyzing all relevant hydrometeorological drivers connected with natural hazards in order to better understand their impacts.