Geophysical Research Abstracts
Vol. 21, EGU2019-13443, 2019
EGU General Assembly 2019

Dante's peak: fiction or reality? Insightful conclusions for policy-makers, emergency responders and more.

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A dormant volcano suddenly awakens and bring chaos to a fictitious quiet town. Because of the delayed evacuation and poor emergency planning, inhabitants are left to themselves to survive through the unexpected series of consecutive events the volcanic eruption will generate: an earthquake, an avalanche (both prior to the eruption), the volcanic eruption and floods (lahars).

While this sensational plot was created for the blockbuster movie Dante's Peak (1997), recent examples show that these "black-swan" type of events do occur and as a result have the potential to cause devastating consequences. Last December, more than 400 people were killed in a volcano-triggered tsunami. While extremely rare, this tsunami event was actually the second one the country faced, after the earthquake-triggered tsunami causing around 2 200 casualties. The consequences of the Pinatubo eruption in 1991, one of the most important of the 20th century, were aggravated by the coincidence with typhoon Yunua, creating deadly lahars and displacing several communities.

Yet, spatial and temporal interactions from consecutive events are often neglected in regional or large-scale multi-hazard studies. Notwithstanding the large modeling complexity of such an endeavor, one might argue that the probability of occurrence of such series of events is extremely low and thus superfluous.

In this study, we build a statistical model and incrementally increase its complexity to take into account event duration and correlation within or between hazard types to investigate the likelihood of consecutive events. Starting with the assumption of a Poisson process, we later deviate from such an assumption to include changes in the inter-event time distribution and memory effects. For example, earthquakes can be followed by aftershock sequences, creating a series of dependent events. Similarly, we can expect a correlation between major flood events and typhoon occurrence, or tsunami generation and earthquake occurrence.

We collect and analyze occurrences of four hazard types in the Philippines from publicly available global databases for typhoons, earthquakes and volcanic eruptions and floods between 1980 to 2015 to calculate the parameters needed to force the model. We can therefore quantify the number of consecutive events that can be expected for an area exposed to multiple hazard types with such statistical characteristics. We also identify key challenges in the statistical modelling of consecutive events. Finally, our findings highlight the need to consider consecutive events in order to improve the resilience of emergency response plans or infrastructure in areas exposed to multiple hazards.