The Future of Extremes

Redefining Coastal Extremes with an Impact Focus

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In a Nutshell

We are recommending that coastal extremes are redefined with a ***focus on impacts***.

This means moving away from focusing *only* on low probability, high magnitude events like tsunamis, earthquakes, super-storms, hurricanes, etc., and also include: 1) combinations of events like hurricanes and storm surge or wind/rain events; 2) multiple/sequential events like a number of smaller storms that result in flood events, dam overspills, etc.; and 3) events that are not extremes in and of themselves, but that may have major impacts on vulnerable populations and communities.

We recommend that Hubs are established that will facilitate the development of transdisciplinary teams that conduct research into these impact-focused extreme events.

We propose that this approach will not only change our understanding of the processes responsible for extreme impact events, it will also facilitate bringing scientists from different disciplines together and enable the training of future generations of scientists who perceive problems and solutions without the constraints of discipline.

Recommendations

We recommend the development of a ***transdisciplinary approach*** to characterize the complexity of coastal extreme events. Specifically, we recommend that we move from research projects that only focus on deterministic *worst case events* to research that also focus on the understanding and prediction of compounding processes over varying temporal-spatial scales that result in *extreme impact events.*

To enable the creation of this urgently-needed transdisciplinary approach, a list of research priorities are set as follows:

- Deep and fundamental understanding of the full distribution of key drivers and combined processes leading to extreme impact events
- Identifying adaptation solutions or interventions to minimize/mitigate the consequences of multivariate extreme events
- Downscaling and modeling large scale changes to local scale complexities
- Developing integrative methods and metrics for valuing “loss” beyond contents and damage
- Understanding the variability and uncertainty of how combined processes (sequential events with compounding impacts) of extreme events will change into the future, and the relative importance and contribution of each hazard process
- Recognizing the specific needs of diverse communities

- Integrating social and behavioral science into engineering and planning

Supporting Evidence

Millions of lives and properties are along the coastline, and the true risk to hazards is not necessarily represented in hazard maps. Globally, population explosions in coastline regions will only serve to place more communities in harm's way. In the US, the Atlantic coast as an example is a highly urbanized and densely populated region with ~33% of the population hosting one of the world's largest economies. Coastal regions also often experience some of the most damaging natural disasters.

For example, Hurricane Hugo (1989) was an intense slow-moving storm that created a massive 6 m storm surge along the South Carolina coast. Hurricane Sandy (2012) was a weaker, but large hurricane that make landfall during high tide and resulted in storm surge of between 3 and 4 m. More recent hurricanes Florence, Havey and Maria resulted in major flooding due to slow speeds and high precipitation rather than intensity or high storm surge. Furthermore, river discharge may interact nonlinearly with storm surge, which suggests that the magnitude of flooding may be underpredicted if both processes are not modeled integratively. January and February of 2017 brought small to moderate size storms to the San Francisco Bay Area, which saturated soils, filled regional dams, and created conditions for heavy runoff. Towards the end of February a larger storm bringing an approximately 5-year rainfall to the bay area, and due to antecedent conditions, generated the largest uncontrolled dam spill in the the south bay in the dam's history.

A large number of coastal communities are both highly populated and built around rivers, estuaries, island and waterways, making them especially vulnerable to the impacts of extreme events or combinations of events. For instance, it has been estimated that a future moderately intense hurricane could flood 30% of Manhattan. There is evidence that the pre-industrial 500-year return period for major flood events along our coastlines has already decreased to approximately a 25-year return period. Moreover, changes to the climate such as increases to sea level, precipitation, and the frequency and intensity of storms, increases the uncertainties in future flood risk.

What Impact does it Seek to Deliver?

As noted before, Hurricane Florence is just the latest major storm event following Superstorms Sandy, Harvey, and Maria. The insured loss for Hurricane Florence has been estimated to be between $2.8 and $5 billion[1]. The consequences of these catastrophic events demonstrate that there is a need to understand large complex systems as well as multiple/sequential events. This effort will deliver Hub(s) that will foster transdisciplinary collaboration to improve our understanding and the consequences and impacts of extreme events.

This impact and value of the Hub would be to:

- Advance the basic science associated with extreme events. For example, it would include efforts to understand the atmospheric drivers behind increases in the frequency and strength hurricanes likely to occur with climate change, as well as combinations of multiple

1 Estimates from RMS a global risk modeling and analytics firm.

processes and their evolving dependencies.

- Improve the understanding of uncertainty and variability of extreme events.
- Improve that characterization of the true risk to coastal communities
- Foster conversations that promote smarter, safer, resilient community and infrastructure design.
- Promote innovative, inclusive and effective communication around all aspect of extreme events and risk. This might include creative ways to promote an understanding of the physical processes, the risks associated with extreme events, and the anthropogenic influences of extreme events.
- Train future generations of scientists who perceive problems without the constraints of discipline.