Catastrophic Geo-Events:
Instrument Arrays, Forecasting and Response

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The devastating tsunamis resulting from the 2004 Sumatra and 2011 Tohoku earthquakes are vivid examples of catastrophic geologically-driven events that affect coastal populations around the globe. These disasters could be a preview of what may happen if a large earthquake were to shake the Pacific Northwest. The next major eruption of Mt. Rainier has the potential to devastate major urban centers in the state of Washington. Submarine landslides, such as occur in the Gulf of Mexico or coastal Alaska, threaten coastal communities, habitats, and infrastructure. ***Despite the enormous social significance of these hazards to society, many of the basic physical and chemical processes controlling the occurrence and magnitude of these natural events remain poorly understood.*** Almost all tsunami, volcanic and landslide events are poorly forecast or occur with no apparent warning at all.

Advances in offshore and satellite observations now offer opportunities to record the run-up to earthquakes, eruptions, and the conditions that lead to landslides. New high rate datasets near faults and on volcanoes provide geochemical, hydrological, geophysical, and geological observations that, when assimilated, will lead to new dynamic, predictive models. The accurate forecasting of eruptions has been shown to improve dramatically with only a handful of instrumentation. New seafloor observations have captured migrating microseismicity and slip events that occurred in the weeks prior to the recent M 8.1 Iquique earthquake in Chile and the M 9.0 Tohoku event in Japan. These emergent phenomena provide new optimism that some large earthquakes and tsunami may be predictable. ***New technology and coastline-crossing instrument arrays are needed to capture the run-up to catastrophic events.***

Hand-in hand with the detection of events that anticipate catastrophic events is the development of new forecasting models that are physics-based. Volcanic eruptions are often preceded by a host of precursors that involve changes in the state of seismic, geodetic and gas activity. Most eruption forecasts are empirical and based on patterns recognized during previous eruptive episodes. The new goal, however, is to move past forecasts based on prior behavior, and develop ones based on near-real-time measurements and physics-based models, as for weather forecasting. ***Accurate, timely forecasts are clearly needed to provide the best mitigation strategies to affected populations.***

New approaches to catastrophe modeling and community resilience are also providing better risk management and mitigation solutions to tsunami, earthquake, volcano and landslides hazards. The USGS HayWired Scenario depicts a scientifically realistic earthquake scenario on the Hayward Fault in California’s Bay Area. The emphasis is on understanding impacts from modern society's lifeline interdependencies and reliance on the Internet. The hazard scenario provided event probabilities to catastrophic event models for financial risk assessment, which in turn, fed back to the USGS outcomes models. Novel engineering solutions, such as the tsunami vertical escape shelter at the Ocasta, WA elementary school, and future shelters planned for the Shoalwater Bay Indian Tribe in the Tokeland Area, provide life-saving hazard responses. Earthquake early warning systems use monitoring and models to alert devices and people seconds and minutes in advance of destructive shaking waves. Such linkages between government agencies, the reinsurance industry and engineering solutions feed back on each other to develop the best plans for community resilience to catastrophic events.

<u>Recommendations for Catastrophic Event Detection, Forecasting and Response</u>

• **New Coastline-Crossing Instrument Arrays For Near Real-time Data Before, During and After Catastrophic Events.** New instrumental arrays are needed on the seafloor near megathrusts, on active volcanoes, and on landslide-prone surfaces. Array data can be delivered via satellite telemetry in near real-time and open-access anywhere in the world. Such data are necessary for event early warning and developing short-term forecasts that inform life-and property-saving response.

• **Academic-Agency Partnerships**. In order to realize novel event detection infrastructure, new partnerships are necessary between government agencies, with a mission to monitor and inform, and academic laboratories, with a mission to develop new instrumentation and explore fundamental phenomena. Embedding graduate students within local agencies provides close ties with academia, and training for the next generation of students in both natural and social science.

• **Citizen Science**. Citizens are both interested in and useful to the science of catastrophic events. Crowdsourcing shaking data and sample collection are two examples of citizen scientists projects that add to data collection in a manner that may not be feasible for researchers. This type of participation also serves as public hazards education for citizens who may not otherwise learn about these hazards and their potential impacts. A well-informed citizenry is among the best forms of mitigating risk from tsunami, landslide and volcanic coastal hazards.

• **Science for Catastrophe Risk Management and Community Resiliency**. Assessing the financial risk to catastrophic events requires sustained and structured access to credible, synthesized scientific hazard probabilities. Building community resilience requires knowledge of the baseline states and validation of models from past catastrophic events and their impacts on populations and structures.

This White Paper borrows text from:

<u>ERUPT: Volcanic Eruptions and Their Repose, Unrest, Precursors, and Timing</u>.

National Academies of Sciences, Engineering, and Medicine. 2017. Washington, DC: The National Academies Press. doi: https://doi.org/10.17226/24650.

McGuire, J.J., T. Plank, et al. 2017. The SZ4D Initiative: Understanding the Processes that Underlie Subduction Zone Hazards in 4D. Vision Document Submitted to the National Science Foundation. The IRIS Consortium, 63 pp.

Other resources and reading:

HayWired Scenario, USGS, https://www.usgs.gov/natural-hazards/science-application-risk-reduction/science/haywired-scenario?qt-science_center_objects=0#qt-science_center_objects