Summary of Break-out Group Discussion for

Group 3: Tsunami Excitation by Seafloor Motion

Attendees:
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Summary:
We identified several relevant geologic processes for tsunami excitation: earthquakes, bolide impact, volcanic collapse, and landslides.

Earthquakes are reasonably understood as a source, at least for far-field impact where small changes in source parameters (location and slip) have little effect on the run-up and inundation. Near-source impact, from a modeling standpoint, requires greater understanding of slip distribution and location. Areas of improvement or future focus are:

1) Better knowledge of offshore faults (location, mapping, slip distribution) is one area of improvement, particularly as it relates to triggering landslides or EQs in non-subduction zone regions.

2) Strike slip faults do cause tsunamis (14% of all tsunamis); how does this occur? Is it the result of restraining bends -> uplift or some other process such as triggering a landslide?

Bolide impact is another excitation source, both from the displacement of water during impact with the ocean surface and the subsequent displacement caused by impact with the ocean floor.

1) Probabilistic framework required.

2) Requires knowledge of when impacts will occur; outside of the focus of this meeting.

Volcanic collapse was not discussed in our initial meeting, though we should have included it. It came up in later discussions. The process is likely similar to landslides though physics and constitutive relationships but will differ in many regards. Velocities are uncertain as well as the frequency/size distribution of events. Large uncertainties limit quantification of risk. Areas of possible focus include

1) Geodetic observations of pre-failure in response to volcanic activity.

2) Reach out to the volcanic community; there are likely realistic models of collapse and flow that could replace sliding block models for tsunami genesis.

Landslides are the least understood and most uncertain tsunami sources; they therefore dominated our discussion. Challenges are that they are infrequently observed in the marine environment (real time observations are practically non-existent with only a handful of examples, we mainly study historic failures) and that identified landslide features are often misinterpreted. A feature may not be a landslide or a landslide may in fact be a complex of many slides with many failure dates. As on land, submarine mass failures surely occur in a variety of forms (flows, translational slides, rock falls) and the failure mechanisms are not understood.

To properly address landslide tsunami potential, we need to understand the physics during

1) Pre-failure stage.

2) At the transition to failure.

3) Deformation of material during failure.

Most landslides do not cause tsunami but there are likely common physics between the infrequent large and fast moving slides that do and the more frequent small, non-tsunamagenic events. Appropriate action is therefore

1) Identification of past failures AND identification of possible future failures (from surface expressions such as fissures, crack, rills, and evidence of fluid/gas venting).

2) Geotechnical sediment analysis of those features (cohesion, residual shear strength, other properties).

3) Observation of possible future failures (geodetic techniques, in-situ sensors such as piezometers, repeat mapping).

4) Reach out to avalanche/volcano modelers and include them in our community.

5) Lab experiments of failure. Several tank experiments have been conducted on how sliding masses generate tsunami but such experiments should more appropriately examine how slides actually fail (initiation physics and internal deformation during failure).

6) ODP type mission through previous landslide complexes to obtain a deep enough core to examine the history of slides in the region.

In-situ observation of an actual slide is unlikely even in an area of possible failure given the infrequency of failure and large geographical areas. Observation during the pre-failure stage, however, may give insight into the later mechanics of failure as well as assign levels of hazard.

The above actions led to several additional questions.

1) Should we have a Parkfield like experiment for submarine landslides? It is unlikely that a landslide would be observed and there would be significant costs, though with proper identification of a possible slide area small deformation such as downslope creep may occur. We don't know. We would gain in technology development and would gain geotechnical information, but such an experiment really hinges on the location of interest.

2) To skirt the obvious problems of cost or a long-term Parkfield like experiment, the new Ocean Observatories should have a geohazards component if a nearby region of interest can be identified. If direct observations are not included, we should have the capability to respond to possible events adjacent to the observatories. This would require instrument pools such as OBS, piezometers, and AUVs. An actual failure should not be the prerequisite for response. A moderate earthquake, for example, may not trigger a landslide in the area of interest but understanding how the pore-fluid pressure changes may be critical to assess slope stability. A suite of instruments should be earmarked for campaign style measurements following possible geohazards relating to slope stability. It is a failure of the community, for example, to not be able to immediately deploy OBS around the epicenter of the Sumatra earthquake to record aftershocks and assess the area.

3) Should we re-consider the notion of a forced landslide in the marine environment? It has never been accepted in the United States; other nations have tried and largely failed. Can we learn what they did wrong and feasibly perform such an experiment while avoiding environmental and wildlife damage?

The forced triggering question is contentious, but the idea of an observatory is most promising, especially since such an experiment can be a component of a larger project such as the large-scale ocean observatories.