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Developing tsunami scenarios in Alaska in the face of uncertainty

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The development of accurate tsunami hazard products requires the use of realistic earthquake rupture scenarios. Alaska presents a particular challenge in the regard because (1) the close distance and complexity of the coast frequently make tsunami impacts highly sensitive to small changes in the source, and (2) uncertainty about the history and likely geometry of ruptures, as well as submarine landslides, is larger than in many comparable regions of the world. For these reasons, tsunami hazard mitigation efforts in Alaska have had to develop approaches that explicitly recognize the breadth of rupture scenarios that are considered plausible, while adhering to the most up-to-date geophysical data and models.

The Alaska-Aleutian subduction zone is characterized by the strong along-strike variability of many parameters such as: the location of locked and creeping regions; the width of the locked zone during interseismic cycles; and the magnitude of any slip deficit. Limited historic records and spotty paleoseismic data further complicate these characterizations by limiting our knowledge of earthquake recurrence times and contributing to uncertainty about how seismic coupling changes with time along the arc.

To address these issues we have developed a number of strategies for generating credible tsunami scenarios for segments of the megathrust that have a short or nonexistent paleoseismic/paleotsunami record, and in some cases lack modern seismic and geodetic data. The potential tsunami scenarios are built based on a discretized plate interface model. We employ estimates of slip deficit along the Aleutian Megathrust from campaign GPS surveys, the slab surface, empirical magnitude-slip relationships, and numerical codes that distribute slip among the subfault elements, calculate coseismic deformations and solve the shallow water equations of tsunami propagation and runup. We define hypothetical asperities along the megathrust and in the down-dip direction, and perform a set of sensitivity model runs to identify the coseismic deformation patterns that result in the highest runup in the target community. Because we use a highly discretized plate interface, we can prescribe variable slip patterns using simple parameters that define slip variations in the along-strike and down-dip directions. We perform simulations for each scenario source using the numerical model of tsunami propagation and runup, which is validated through a set of analytical benchmarks and tested against laboratory and field data. The resulting numerical models are combined with historical observations and compiled into a variety of map-based tsunami hazard products to support planning and mitigation efforts at the community level.