The Physics of Tsunami Generation: Recent Advances and Persistent Problems

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Understanding the details of how tsunamis are generated by geological processes is key to accurately assessing their severity and frequency of occurrence. Key problems in tsunami generation physics are reviewed and recent technological advances since the December 2004 Indian Ocean tsunami are highlighted. An important source of uncertainty in assessing the severity of a seismogenic tsunami is determining how tsunami source parameters, particularly coseismic slip, scale with seismic moment. Moreover, understanding the nature of maximum fluctuations in slip for a given earthquake is directly tied to estimating the maximum tsunami severity. Source inversions of the 2004 event, especially those based on satellite altimetry data of the tsunami, provide new insight with which to assess the average and statistical variation of slip and other source parameters for M~9 earthquakes. An enigmatic class of tsunamigenic earthquakes is termed "tsunami earthquakes", where the tsunami is much larger than expected relative to earthquake magnitude. Tsunami earthquakes, such as the recent M=7.7 July 2006 event off Java, most often occur in the shallow part of subduction zones near the trench. Whereas we can start to understand why the tsunami from these earthquakes is so large, there remains an open question as to the frictional stability conditions where tsunami earthquakes occur: seaward of the aseismic front. This contrasts with the case of submarine landslides where we have substantial knowledge of the stability conditions under which large landslides occur—the open question in this case is how tsunamis are generated from this geological process. Much of the uncertainty is related to a lack of instrumental data recording the dynamics of submarine landslides and the infrequent nature of their occurrence. Finally, many of these questions relate to a larger question: What is the chance of tsunami occurring at a particular coastal location? There are only a few locations around the world where tsunami probability can be determined from empirical data alone. A computational approach to determine tsunami probability, although a daunting task, is often the only method in which this question can be addressed. A particularly interesting aspect of tsunami probability, short-term clustering of events, is discussed in this context.

Eric Geist is a research geophysicist with the U.S. Geological Survey, where he has worked for over two decades. Throughout his career, he has focused on computer modeling of geophysical phenomena, including large-scale deformation of the earth in response to tectonic forces and the physics of tsunami generation. For the last ten years, he has investigated how details of earthquake rupture affect the tsunami waveform and runup. Eric has authored over 120 journal articles and abstracts, including a review paper on tsunamis published in the book "Tsunamigenic Earthquakes and their Consequences." Eric received his BS degree in Geophysics from the Colorado School of Mines and his MS degree in Geophysics from Stanford University.