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Tohoku earthquake and tsunami focus of BSSA special issue

SAN FRANCISCO, May 3, 2013 – The 2011 Tohoku earthquake is the best recorded and most studied giant earthquake, resulting in a remarkable suite of observations. A special issue of the Bulletin of the Seismological Society of America (BSSA) captures the latest progress in understanding what happened when this massive M ≥9 earthquake struck offshore of Japan and produced a devastating tsunami that claimed almost 20,000 lives and precipitated the world's second worst nuclear power plant disaster.

"While not the final word, this special issue synthesizes the latest understanding of an extraordinary event that forced us to think more deeply about the processes at work and what can be expected from these large events," said Thorne Lay, one of seven guest editors of the special issue and professor of earth sciences at University of California, Santa Cruz.

The special BSSA issue contains a broad cross-section of 30 detailed investigations and syntheses of the rupture process, seismic radiation, geodetic deformations, tsunami waves, pre- and post-earthquake perturbations of the crustal medium, and regional and global aftershocks produced by the earthquake.

The 2011 Tohoku event is the fourth largest seismologically recorded earthquake and the largest known earthquake to have ever struck Japan, a country that has a several thousand year documented earthquake history. Expecting the region to produce no larger than about M 8.5 earthquake, the M 9.0 event caught most scientists by surprise and the ensuing tsunami overwhelmed many coastal tsunami defenses designed for smaller events like those of the past few centuries.

Highlights include:

- Yan Y. Kagan and David D. Jackson, researchers at University of California, Los Angeles, write that the Tohoku event actually "should not have been a surprise," suggesting that the previous subduction zone earthquakes of M 9 or larger around the globe should have served as a warning. Magnitude 9 earthquakes can be expected in any major subduction zone, even in regions with no seismological history of such large events, say Kagan and Jackson, who note a global average of five M ≥ 9 earthquakes every 100 years.

- This earthquake produced very large fault slip under the shallow sediments extending to the trench, as demonstrated by several papers in the special issue, whereas the slip for other great earthquake ruptures has commonly stopped short of the trench. The shallow slip helped to generate the huge tsunami as confirmed by other papers in the issue. Using dynamic rupture simulations of the Tohoku earthquake, Jeremy Kozdon and Eric Dunham of Stanford University, explored how the rupture broke to the seafloor at the Japan trench. They argue that slip propagated to the trench as a result of strong dynamic stresses overcoming the frictional behavior by which the sediments would normally deform without earthquakes. Large slip deeper on the fault produced the strong stress waves that drove the shallow rupture.

- Efthymios Lekkas of the National and Kapodistrian University of Athens, and colleagues suggest a new "Tsunami Intensity Scale" that reflects the intensity of the impact of tsunamis, taking into account the resulting damage to structures, infrastructures and people. Using observations and data collected from the study of the 2004 tsunami in the Indian Ocean and the 2011 tsunami in Japan, researchers suggest a scale that can address a diverse range of geographical areas, including areas under development as urban zones, rural areas with no residential cover, tourist areas and industrial zones. The 12-grade scale is comparable to similar scales that measure the impact of earthquakes.

- The global reach of the Tohoku quake, which generated a Pacific-wide tsunami and produced seismic vibrations throughout the planet, raised questions about the overall impact of the quake on Earth. Van der Elst et al. explore whether there is a causal connection among the 16 great earthquakes that have occurred between 1998 and 2011, finding that the data do not establish a compelling linkage between the great events but that may be due to limitations of the data. Hill et al. show that tremor in California was modulated by the passage of seismic waves from the Tohoku event, indicating that remote activation of events did occur in some places.

This BSSA special issue reflects the great societal impact and scientific importance of the 2011 Tohoku earthquake and tsunami. Published by the Seismological Society of America (SSA), BSSA is the premier journal of advanced research in earthquake seismology and related disciplines. SSA is an international scientific society devoted to the advancement of seismology and the understanding of earthquakes for the benefit of society.

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