Resolving the Trade-off between the Seismic Moment and Fault Dip of Large Subduction Earthquakes and Its Impact on Tsunami Excitation

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Abstract

Tsunami caused by 1992 Nicaragua and 1994 Java earthquakes were several times larger than the numerical simulations based on the slip distributions derived from seismic data. While such discrepancies could be explained with other mechanisms, the uncertainties of slip models need to be considered as well.

One of well known problems embedded in seismic results is the tradeoff between the inverted fault dip and seismic moment. Generally, observed amplitude of long period surface waves excited by large shallow subduction earthquakes is approximately proportional to $M_o \sin 2\delta$, where the $M_\circ$ and δ are earthquake scalar moment and fault dip angle, respectively. Even though this product is well constrained by seismic data, the dip angle δ cannot be determined very accurately for the events shallower than 30 km. The uncertainty in δ results in uncertainty in $M_\circ$ or fault slip [e.g., *Kanamori and Given*, 1981]. Here we report that above relationship isn't held for the long period Love waves observed along the fault strike direction. Their amplitude is approximated proportional to $M_o \cos 2\delta$, or just the scalar moment itself when the fault dip is small. Therefore this dataset could be used to resolve the tradeoff between the seismic moment and fault dip.

After testing such an idea with the observations of the 2005 Nias earthquake, whose slip distribution is well constrained with additional local GPS observations, we have revisited the 1992 Nicaragua and 1994 Java earthquakes by combined inverting the broadband teleseismic body waves and long period surface waves. For both events, our preliminary results show that the combined data sets favor fault models with smaller fault dip and larger seismic moment. Consequently, we find that the estimations of horizontal sea floor motion increase significantly, though the effect on predicted sea floor uplifts is not as pronounced. Further simulation will be preformed to test whether the enhanced horizontal motions as well as their spatial distributions could improve the explanations to these anomalous Tsunami observations.