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Geodesy Measurement Constrained Coseismic Slip of the 26 December 2004, Great Sumatra-Andaman Earthquake

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We ensemble a data set of coseismic displacements to invert for rupture distribution of the 26 December 2004 Sumatra-Andaman earthquake. These data include continuous GPS measurements from the IGS stations located in Indonesia, Singapore, the Philippines, India, Australia, and Guam, from the Crustal Motion Observation Network of China in mainland China and South China Sea, and from Caltech's SuGar network in central Sumatra. A month of data before and ten days of data after the quake are collected to derive the coseismic displacements. The data set also includes survey mode GPS measurements from a group of stations located in the Malay Peninsula reported by Vigny et al. (2005), from half-a-dozen stations in the India subcontinent derived by Banerjee et al. (2005), and from 5 survey mode stations located at the Andaman and Nicobar Islands deduced by scientists from the Center for Earth Science Studies, India (http://www. seires. net/content/view/122/52/). In addition to the GPS measurements we also use vertical displacement estimates derived from coral head emergence data and pivot line positions inferred from satellite remote sensing(Chlieh et al., 2005). All of the data are used to invert for fault rupture which is devised as dislocation in a layered elastic media. We adopt the "Earth flattening" method to accommodate the curvature effect of the Earth's surface, which is significant at the far field and should not be neglected. The fault model is composed of multiple tiles, meshing the interface of the subduction slab, with a first-order smoothing applied to enforce slip continuity. The degree of smoothing is optimally determined through balancing a trade-off between the data postfit residual chi-square and the number of parameters resolved in the inversion. We also search for the fault geometry to best fit the observed data. The fault dip angle is allowed to change linearly both along strike and downdip. Our result detects two local minima in the search with almost identical postfit chi-squares. The first one corresponds to a model with no lateral change of the dip angle which increases gradually up to 22° at the downdip end of the fault rupture. The second minimum corresponds to a model with dip angle increases linearly northward, and the dip angles at the north and south downdip corners are 21° and 35° respectively. The second model is more consistent with the plate geometry model outlined by Gudmundsson and Sambridge(1998). Both models show that the earthquake ruptured 200 km width of slab surface down to a depth of about 40 km.

Our result shows dominant thrust faulting for all the patches, ranging from $\sim$2.5 m to 8 m in amplitude, with the largest slip centered at the south central section of the rupture zone at $\sim$4°N latitude. Rupture becomes smaller and shallower going up north. It is also accompanied with about 1.5-meter right slip for the central and north sections, and also 1.5-meter left slip for the southernmost segment respectively. The total seismic moment accumulated over the entire rupture plane is $\sim 6.510^{22}$ N-m, equivalent to the energy release of an Mw 9.2 earthquake.