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Coseismic Slip and Afterslip of the Great (M_w9.15) Sumatra-Andaman Earthquake of 2004

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We determine coseismic and the first-month postseismic deformation associated with the Sumatra-Andaman earthquake of December 26, 2004 from near-field Global Positioning System (GPS) surveys in northwestern Sumatra and along the Nicobar-Andaman islands, continuous and campaign GPS measurements from Thailand and Malaysia, and in-situ and remotely sensed observations of the vertical motion of coral reefs. The coseismic model is mainly constrained from displacement over the first day derived from daily solutions at 34 continuous GPS (cGPS) stations. It shows that the Sunda subduction megathrust ruptured over a distance of about 1500 km and a width of less than 150 km, releasing a total moment of 6.7-7.0 10^{22}Nm, equivalent to a magnitude M_w of about 9.15. This moment is slightly in excess of the 6.5 10^{22}Nm moment released over the first 500s as estimated from the inversion of seismic records (Model-III in Ammon et al. 2005). The latitudinal distribution of released moment in our model has three distinct peaks around 4˚N, 7˚ and 9˚N, which compares well to the latitudinal variations seen in the seismic inversion and of the analysis of radiated T-waves. Our coseismic model is also consistent with interpretation of normal modes and with the amplitude of very long period surface waves. The tsunami predicted from this model fits relatively well the altimetric measurements made by the JASON and TOPEX satellites. Neither slow nor delayed slip is needed to explain the normal modes and the tsunami wave. The geodetic data that encompass both coseismic deformation

and up to 40 days of postseismic deformation require that slip must have continued on the plate interface after the 500s long seismic rupture. The postseismic geodetic moment of about 2.5 10^{22}Nm (Mw$\sim$8.8) is equal to about 30$\pm$5% of the coseismic moment release. Constraints on the depth distribution of afterslip are loose, but it seems that it occurred on the plate interface both updip and downdip of the seismic rupture. Evolution of afterslip is consistent with rate-strengthening frictional afterslip. The proportion of aseismic slip is larger to the north, where it exceeds coseismic slip, possibly due to the subduction of thick sedimentary deposits of the Bengal fan there.