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Crustal gravitational potential energy change induced by the Great Sumatra-Andaman earthquake of 26 December 2004

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The Mw 9.3 Great Sumatra-Andaman earthquake of 26 December 2004 was the second largest earthquake recorded during the past century. The rupture propagated approximately 1300 km northward, and the maximum co-seismic slip was nearly 20 m offshore of northwestern Sumatra. The earthquake triggered a massive uplift of the seafloor, and changes in the geometry of the region were detected by GPS measurements from the area. In this study, we examined the changes in crustal gravitational potential energy in the Sumatra area since the Mw 9.3 Sumatra-Andaman earthquake of 26 December 2004. The epicenter of the mainshock was located in the area where the ÄGPE was highest (∼95.5°E; 3°N) during the interseismic period. The areas with the next highest ÄGPE were concentrated along the interplate after-slip area beneath the Aceh Basin (∼94°-95.5°E; 4°-6°N) and near the trench along the subduction system (∼92°-93°E; 6°-8°N). Before the mainshock, a pattern of GPE loss was observed along the slab at depths between 35 and 70 km, suggesting that the down-dip extension mechanism was caused by the slab gravity effect. We propose that the shallow portion of the slab was locked before the mainshock. The right-lateral strike-slip Sumatra fault had a pattern of GPE gain prior to the mainshock and a pattern of ÄGPE loss immediately after, indicating a stress release associated with stress partitioning along the Sumatra Fault and/or an intraplate stress decrease caused by the unlocking of the asperities. Beneath the subduction zone, the left-lateral strike-slip oceanic fracture zone is separated into several tectonic units with different crustal GPE change distribution patterns. After the 2004 mainshock, almost no trenchward seismicity was observed in the northern Sumatra area. The presence of active N-S fracture ridges associated with major regions of high gravity could block the subduction system and prevent energy transfer along the interplate boundary. However, the south to north propagation of thrusting type earthquakes along the trench approximately 4 months after the mainshock indicates that energy was slowly transferred northward. The consistency of our study with GPS and coral data suggests that GPE change estimation may serve as an additional method for studying the surface deformation produced by large events.