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Interseismic, postseismic and co-seismic strain on the Sumatra megathrust and their relation to the megathrust frictional properties

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The Sumatra Megathrust has recently produced a flurry of large interplate earthquakes starting with the giant Mw 9.15, Aceh earthquake of 2004. All of these earthquakes occurred within the area monitored by the Sumatra Geodetic Array (SuGAr), which provided exceptional records of near-field co-seismic and postseismic ground displacements. In addition, based on coral growth pattern, it has also been possible to estimate the pattern of interseismic strain in this area over the last few decades preceding 2004. This earthquake sequence provides an exceptional opportunity to understand the eventual relationship between large megathrust ruptures, interseismic coupling and the frictional properties of the megathrust. The emerging view is a megathrust with strong down-dip and lateral variations of frictional properties. The 2005, Mw 8.6 Nias earthquake ruptured nearly entirely a patch that had ruptured already during a similar earthquake in 1861 and that had remained well locked in the interseismic period allowing for stress to build up to an amount comparable to, or even larger than the stress released in 1861 or 2005. This patch is inferred to obey dominantly velocity-weakening friction and the pattern or interseismic coupling and afterslip suggests that it is surrounded by areas with velocity-strengthening friction. The 2007 Mw 8.4 and 7.9 earthquakes ruptured a fraction of a strongly coupled in the Mentawai area. They each consist of 2 sub-events which are 50 to 100 km apart from each other. On the other hand, the northernmost slip patch of 8.4 and southern slip patch of 7.9 earthquakes abut each other, but they ruptured 12 hours apart. They released a moment much smaller than the giant earthquakes known to have occurred in the Mentawai area in 1833 or in 1797. Also the moment released in 2007 amounts to only a fraction of the deficit of moment that had accumulated as a result of interseismic strain since these historical events, the potential for a large megathrust event in the Mentawai area remains large. We conclude that (1) seismic asperities are probably persistent features which arise form heterogeneous strain build up in the interseismic period; and (2) the same portion of a megathrust can rupture in different ways depending on whether asperities break as isolated events or cooperate to produce a larger rupture. The spatial distribution of frictional properties of the megathrust in the Mentawai area could be the cause for a more complex earthquakes sequence than what is observed along the Simelue-Nias segment.