Slip pattern along the northern Sumatran fault, Indonesia revealed by geodetic and geomorphic observations

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We have conducted geodetic and geomorphic observations in Aceh province, northern Sumatra, Indonesia to clarify slip history and current strain accumulation along the northernmost segments of the Sumatran fault. Evaluation of the earthquake generation potential in Aceh province is highly urgent because of the largest slip rate along the 1900-km long Sumatran fault, absence of major earthquakes for more than 120 years, and local Coulomb stress increase due to two recent interplate megathrust events at the Sunda Trench, the 2004 Sumatra-Andaman (Mw 9.2) and 2005 Simeulue-Nias (Mw 8.7) earthquakes.
We have deployed continuous and campaign GPS network since 2005 called AGNeSS (Aceh GPS Network for the Sumatran Fault System). Using horizontal and vertical displacements spanning over five years with different relaxation times, we have proposed multiple physical mechanisms (afterslip and viscoelastic relaxation) that control postseismic deformation (Gunawan et al., 2014). Moreover we have inferred shallow creep/locking distribution along the Aceh segment of the Sumatran fault (Ito et al., 2012). The result shows the segment is capable of producing a M 7 event in the future. In 2013 two M 6.1 earthquakes occurred successively in the network and we detected clear coseismic displacements.
Tectonic geomorphic features are also investigated to reveal long-term slip history of the fault. We used high-resolution stereo-paired ALOS/PRISM satellite images to map the surface trace and conducted field observations to ensure it. The trace is well-defined by fault scarps, pressure ridges, linear troughs and deflected streams. In addition, we set up alignment arrays at four locations to directly determine surface creep rates by repeated geodetic surveys. In 2015 we revealed the evidence of at least three slip events from one paleoseismic trenching site. We will conduct carbon dating of samples to estimate the timing of the most recent event and a recurrence interval.
InSAR analysis of ALOS/PALSAR images has supplemented limited coverage of GPS stations and geomorphic observation sites. Stacked images spanning approximately three years from 2007 to 2009 shows a clear contrast of LOS (line-of-sight) contraction in one side of the fault and extension in another side. Profile of the LOS change across the fault is characterized by a step-like offset of about 10-15 mm/yr at the location of the surface fault trace. The pattern of the LOS change is consistent to the right-lateral slip motion of the Sumatran fault though the offset seems too large compared with the expected slip rate of the fault. We will develop the interpretation of the LOS change including GPS displacement rates and geomorphic information.

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