Multiple Source Analysis of the 2004 Sumatra Earthquake

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While it is agreed that the great Sumatra earthquake of December 26, 2004, was among the largest earthquakes of the past century, there has been disagreement on how large it was, which part of the fault ruptured, and how the rupture took place. We carried out a centroid-moment-tensor (CMT) analysis of the earthquake in which multiple point sources were used in the inversion to mimic a propagating slip pulse. Moment-tensor elements and centroid locations for a set of five sources were determined simultaneously. We used waveforms from the IRIS Global Seismographic Network (GSN) filtered in the pass band of 200 to 500 s in the inversion. The multiple-source inversion resulted in a 56% improvement in the fit to the waveforms compared with the original CMT analysis. The strong directivity towards the northwest observed in the data is successfully modeled by the five sources. The total moment for the five sources is $1.17*10^{30}$ dyne-cm, which corresponds to a moment magnitude Mw = 9.3, significantly larger than the Mw = 9.0 obtained in the standard single-source CMT analysis, but in agreement with reported long-period normal-mode amplitudes. The figure shows the locations and focal mechanisms of the five sources. The southernmost source ruptured first, and the remaining four sources ruptured in northward succession with a total duration for the earthquake of approximately 500 s. The focal mechanisms of the five sources change systematically from south to north. The strikes of the mechanisms (indicated by the needles) rotate clockwise, in agreement with the geometry of the subduction zone, and the slip vectors (indicated by black arrows) rotate from nearly pure thrust to oblique slip with a large strike-slip component. Most of the moment release occurred in the southern portion of the fault. The numbers in the figure give the individual seismic moments of each source in units of 10^{29} dyne-cm. The seismic data analyzed in this study do not appear to require a slow component of slip for the Sumatra earthquake.