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Remotely triggered seismicity in Yunnan, Southwestern China following the 2004 Mw9.3 Sumatra earthquake

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Following the 2004 Mw9.3 Sumatra earthquake, seismicity increased sharply over a wide area of up to ~2,500 km away in Yunnan province, southwestern China. Raised seismicity lasts for approximately 14 days. During this period, more than 800 events having a magnitude of ≥ 1.5 were observed, including at least 7 M4 class events and a M5.1 event. This is perhaps the most impressive example of remotely triggered seismicity yet observed. Major events were clustered at several sites that exhibit complex fault geometries, such as step-overs and junctures. We use statistic approaches including the Beta-statistics to examine the statistical significance of the seismic rate increases associated with the Sumatra mainshock and conclude that there is a reasonable probability that the raised seismicity was remotely triggered by the Sumatra earthquake.

Both rapid-onset dynamic triggering and delayed response were well established. During the first hour of event time (time from the origin time of the Sumatra earthquake), we can identify and locate at least 7 M1.5+ earthquakes. These events are embedded in the body waves and surface waves from the Sumatra earthquake. However, clear records at some stations are obtained by applying a high-pass filter to the original seismograms. The first identified event is a M4.6 earthquake occurred during the passage of the surface waves from the Sumatra earthquake. However, major clusters likely demonstrate significant delays in the onset of triggering seismicity, with the dominant energy releasing a few hours to a few days after the surface wave passed.

We use the epidemic-type aftershock sequence (ETAS) model to examine seismicity in the study in 2004 through 2005. Two major changing points and thus three phases (I through III) of activity pattern, are well determined. The second phase (II) corresponds to the period of seismic activity remotely triggered by the Sumatra earthquake. The ETAS models show great p_0 ($>30\%$) and small Alfa, which are 1.368, 0.804, and 1.328 for phases I, II, and III, respectively. Therefore, the triggered activities show earthquake swarm-like characteristics such as that indicated by the epidemic-type aftershock sequence (ETAS) modeling results (large percentage of random components and less magnitude dependence in Omori law type self triggering).

Multiple sources of evidence, including intensive hydrothermal activities, and low velocity and high V_p/V_s zones in the lower to middle crust suggests that magma/mantle-generated fluids have a role in the region. High fluid pressure in branched fault zones weakened the faults, making them sensitive to external disturbances and leading to fluid-driven seismicity.

Keywords: Remote triggering, ETAS, Fluid-driven seismicity, Yunnan, Sumatra Earthquake