Earthquake Swarms Occur at the Edges of Great Earthquake Rupture

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A key question in seismology and earth science is why certain subduction zones appear to have a characteristic size for the largest earthquake possible at that margin. A manual search for earthquake swarms by Holtkamp and Brudzinski (2011) documented 180 megathrust earthquake swarms at Circum-Pacific subduction zones and found that regions of the megathrust with large along strike gaps in swarm activity experience larger magnitude earthquakes. Consistent with this, Holtkamp et al. (2011) show that the 2010 Chile earthquake rupture was bracketed to the north and south by previous megathrust earthquake swarms. Subsequently, we have found evidence for similar relationships in Sumatra, Peru, Alaska, Kamchatka, and Japan. Holtkamp and Brudzinski (2011) found 10 earthquake swarms in the Sendai region on or near the subduction margin that ruptured during the 2011 Tōhoku earthquake. The swarms occurred exclusively in two regions which appear to closely bound the northern and southern extent of the Tōhoku rupture, with the Tōhoku earthquake and the Mw 7.9 aftershock occupying the ~400 km gap between swarms. In this study, we examine the relationships between earthquake swarm occurrence from 1973 to 2010, interseismic coupling, and co-seismic moment release for recent great earthquakes. The two swarm regions in Sendai Japan occur at zones of reduced plate coupling, determined by Loveless and Meade (2010), while the gap between the swarm regions, which ruptured during the Tōhoku earthquake, was determined to be a region of high interseismic coupling. We suggest that earthquake swarms can be used as a proxy for either subduction zone coupling or stress heterogeneity, both of which have been hypothesized to influence the size to which an earthquake can grow. If aseismic slip is a driving mechanism for megathrust earthquake swarms and is releasing a large percentage of the overall convergence, the lack of long term (earthquake cycle scale) stress accumulation in these regions may explain why rupture termination seems to occur in earthquake swarm regions.