CAN EARTHQUAKE NUCLEATION AND RUPTURE EVOLUTION BE CONSTRAINED WITH EM DATA?

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Since electromagnetic (EM) signals generated by fault rupture travel at the speed of light, signals generated by initial preseismic fault rupture and subsequent rupture with associated seismic radiation arrive with negligible delay at surface observation sites. This contrasts with the inherent time delays plaguing observations of rupture and radiation recorded on near-surface seismic and strain instrumentation since these propagate more slowly at seismic wave speeds (Vp~5 km/s, Vs~2 km/s). Observation of EM during earthquake nucleation and rupture evolution could provide unique information about the earthquake source size and rupture evolution before the first P wave arrivals, if these EM signals can be detected. While clear observations of the magnetic offsets resulting from the total stress change with earthquakes have been frequently obtained, EM data showing rupture initiation before radiation starts (i.e. before the earthquake origin time) and during rupture evolution have been difficult to identify. Nevertheless, the magnetic offset data produced by the earthquake allow direct scaling to the largest allowable slip moment (modulus x area x slip) during both nucleation prior to rupture and rupture evolution after initiation. For the 2004 M6 Parkfield earthquake where 40 sample/sec EM observations were recorded through the earthquake at a point about 4 km above the final rupture and 15 km from the earthquake hypocenter, we observe less than 30 pT during the seconds prior to rupture initiation and 25 pT from rupture initiation to the first P wave arrival. This constrains the earthquake nucleation moment and rupture evolution moment to less than $2x10^{16}$ Nm (i.e. a moment magnitude less than that of a M5 earthquake).

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