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Slow Slip Following the 2003 Tokachi-oki M8 Earthquake off Hokkaido

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A Sacks-Evertson borehole strainmeter has operated since 1982 at Urakawa Seismological Observatory (KMU) of Hokkaido University in the southern part of the Hidaka Mountains. The site is 105 km NW of the epicenter of the 2003 Tokachi-oki earthquake (M8.0). We use State Space Modeling (Kitagawa et al., 2010) to remove strains due to earth tides, air pressure variations and precipitation. After the earthquake the data showed a clear episode of contraction for 4 days followed by expansion for 23 days. These signals correlate with increased aftershock seismicity for M>4 events. These strain changes, together with surface displacements detected by a temporary GPS network, are indicative of propagation of slow slip at depth (e.g. Geographical Survey Institute,2004). We use quasistatic calculations to generate synthetic waveforms for the measured quantities. Initial choices for source parameters are guided by the parameters of the main shock on the basis that the slow slip takes place on an extension of the same plane. We are able to satisfy the data with a rather simple 2 stage model of reverse slip propagation down an extension of the main shock rupture plane. In stage 1 slow slip of 44 cm propagates at 11cm/s on a surface extending 65 km along strike and 32 km downdip from 38 km depth; for stage 2 the corresponding parameters are 24 cm, 3 cm/s, 32.5 km, 66 km, 50.5 km depth. Both have strike of 241 degrees and dip of 23 degrees, essentially the same as in the GSI solution. The model is based primarily on the strain transient but is in good agreement with the GPS data. Note that the region we have identified as failing with slow slip is recognized as having low seismicity. This slow slip events occur in and down-dip extension of the fault plane of a major (M8.0) thrust earthquake, i.e. a significant area of the fault stores strain energy but fails as a slow event. This may partially explain the observation that only about 30% of the plate motion of this subduction zone is released by regular earthquakes.