Transient aseismic subduction deformation events jointly analyzed with geodetic and seismological recordings

In the simplest seismic cycle theory, tectonic loading at subduction zones is either released by large seismic earthquakes or by steady aseismic slip. Continuous geodetic measurements during the past two decades is however showing an increasing amount of transient aseismic deformation examples with various durations and spatial scales. Playing a key role in releasing part of the accumulated stress and in redistributing stresses on the plate interface, these transient deformation events are crucial to be analysed in details. When accompanied either by micro-seismicity or tectonic tremors, the seismic signals are providing important temporal and spatial information that should be accounted for in the modelling. In this presentation, I present two ways of reconciling the complementary observations given by geodetic and seismological recordings. The first example is a 5-year transient event occurring in Alaska. During this event, tectonic tremors are co-located with the inferred aseismic slip zone and occurred in weeks-long bursts of events. A decomposition of GPS time series relative to tremor times during the whole 5-year transient event shows that GPS site velocities are on average three to six times higher during tremor bursts than in between, suggesting that slip pulses are generally associated with tremor bursts. The dynamic modelling of a three-weeks subevent in September 2010 shows that both aseismic slip and the tremor front migrated along strike at speeds of ~8 km/day and with slip rates of ~3 mm/day. This particular slip pulse released 9% of the 5-year transient event total moment in 1.4% of its duration, proving the non-steadiness nature of slip rate during during the 5-year deformation event. The second example is a transient event occurring offshore the Boso peninsula in Japan, where slow slip events are happening every ~5 years since 1996, and are always accompanied by swarms of Mw 1 to 5 earthquakes on their northern and western flanks. Being located right beneath the Boso peninsula coastline, the dynamics of these slow slip events is particularly well imaged by dense GPS and tiltmeter networks. During the two-weeks-long June 2018 event, both geodetic slip inversions and double difference relocated seismicity indicate updip migrations, at a speed of a few km/day. We model the migrating mixed seismic-aseismic transient event as a single process. The interaction between aseismic slip and seismicity is modelled by Coulomb stress changes due to transient slow slip that explains the nucleation of seismic events in the surrounding volume of the transient slip. The nucleation of the earthquakes is governed by rate and state friction. These two examples show how combining geodetic and seismological recordings can help obtaining better temporal and spatial resolutions on transient aseismic slip models as well as understand the interactions between aseismic and seismic slip.