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Impact of the viscoelastic postseismic deformation following megathrust earthquake on seismic hazard in subduction zones : the case of the Maule and Illapel earthquakes in Chile

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On 16th September 2015, the Mw8,3 Illapel earthquake occurred in the region of Coquimbo, Central Chile. In this area, similar size (Mw 8+) megathrust earthquakes had occurred in 1943 and 1880 and GPS measurements conducted over the last 15 years revealed an apparent coupling of more than 60 %. Therefore, this segment seems to be a clear application of the seismic gap theory with recurrent earthquakes of similar size. However, the precise timing and extension of the 2015 rupture are quite unsettling : it occurred about 6 years after the Maule Mw 8,8 earthquake, why not sooner ? Also, it did not connect to the 2010 rupture area, leaving an even more coupled 200km-long section unbroken in front of Valparaiso. The analysis of 5 years of GPS data following the 2010 event highlights a propagation of the postseismic deformation at very large scale, that we attributed mostly to viscoelastic relaxation in the asthenosphere and in a low viscosity channel along the slab. Orientated trenchward in the Maule rupture zone, the postseismic displacements are rotating northward at the edge of the 2010 rupture, reaching a Northeastern direction in the Coquimbo region. There, we observe an increase of about 10 % of the horizontal surface velocity, roughly aligned with the pre-seismic direction. Between these two sections of the subduction (Maule where strain is highly decreased by post-seismic relaxation and Illapel where strain is increased) lies the Valparaiso section. The latitude where strain starts to increase significantly is located at 32°S (Los Vilos), approximately where the 2015 rupture started.

In this study, we take advantage of the very dense GPS data sets to quantify precisely the stress transfer due to viscous relaxation using 3D FE models. We show that the amplitude and orientation of the postseismic deformation in the Valparaiso area contributes to release strain in the upper plate, when on the contrary, it induces a significant stress increase of about 0,3 bar, precisely where the Illapel earthquake occurred. Therefore, we suggest that post-seismic relaxation after the Maule Earthquake has been instrumental (along with geometrical particularities of the slab geometry in this area) in triggering the 2015 rupture and forbidding (for now) a similar earthquake in front of Valparaiso. We suggest the same mechanism has been active along the Sumatran trench where a similar highly coupled and mature seismic gap remains unbroken between the Banda-Aceh and Nias earthquakes of 2004 and 2005 on one side and the Bengkulu earthquake of 2007 on the other side : the Padang gap.