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GPS and seismic data to highlight the interaction between deep and shallow deformation related to the 2013 Okhotsk earthquake, Kamchatka

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The 24/05/2013 Okhotsk earthquake (M=8.3) took place at 600 km depth on the Kamchatka subduction zone that accommodates 8 cm/yr of westward convergence of the Pacific plate with respect to the North American plate. The Okhotsk event has been preceded by several shallow earthquake swarms that stopped instantaneously at the time of the large and deep earthquake. This work aims at investigating the interaction between shallow and deep seismicity based on a detailed earthquake catalogue, and to search for related signals of transient surface displacements monitored by the Kamchatka permanent GPS network. The earthquake catalogue localizes the swarms before Okhotsk in depths between 40 and 80 km, and some notable activity of aftershocks between 500 and 700 km depth, with no events in the intermediate depths. The cumulative number of earthquakes from 2004 to 2016 reflects the occurrence of the shallow swarms by an increased rate before Okhotsk, while the earthquake rate of deep events (500-700 km) decreases simultaneously. Furthermore, an increase of earthquake rate is observed in 2009 in both depths. While it is difficult to extract a clear signal of surface deformation comparing the period before and after 2009 in the GPS data, the shallow swarms do have a surface expression, indicating purely co-seismic release of constraints during the last swarm just before Okhotsk, and co- and a-seismic release for the most energetic swarm with a cumulative magnitude of 7.1. In particular, during this swarm, a large scale transient motion is observed of $\sim$5mm toward the SE, covering the whole peninsula. Investigations are ongoing to identify possible sources, like hydrological loading (using GRACE data), stress transfer following the 2011 Tohoku event, or following the 2007 Kuril earthquakes that created large scale a-seismic creep over several years. Eventually, this transient is a first observation of a loading and unloading mechanism of the deep slab that could explain the simultaneous increase and decrease of seismic activity in shallow and large depths, respectively, before the Okhotsk event.