Predicting Co-Seismic Deformation Following Intermediate and Deep Earthquakes

Sifang Chen* & Sunyoung Park

sfchen@uchicago.edu

Department of the Geophysical Sciences, The University of Chicago

In the past decades, remarkable advances have been achieved in understanding earthquake physics through the use of GNSS data. Currently, our framework of understanding the Earth's surface displacements mainly focuses on shallow (0-60 km) earthquakes, while ground displacements generated by deeper events are commonly assumed to be undetectable. However, recent detections of co-seismic deformation following intermediate and deep earthquakes show that this assumption may be unreliable. For instance, the 600-km deep 2013 M_W8.3 Okhotsk event has been reported to produce considerable (>1 cm) co-seismic displacements. This significant surface deformation suggests that failing to incorporate deep events can result in inaccuracies in GNSS break estimates, and hence, bias velocity estimates. Moreover, the considerable ground displacements imply that GNSS observations may bring new insights into the deep rupture processes that seismic observations cannot provide.

Therefore, to extend current geodetic framework to deeper earthquakes, in this study, we conduct systematic predictions of co-seismic deformation following intermediate and deep events. The predictions are made for a series of earthquakes with various depths, magnitudes, and focal mechanisms. In general, we find a relatively broad surface area experiences significant co-seismic deformation from intermediate and deep earthquakes. For example, an M_W 8.3, 45-degree dip-slip event at 600-km depth can generate deformation larger than 2 mm as far as 1500 km away from the epicenter. Based on these predictions, we come up with (1) an empirical equation that provide co-seismic deformation as a function of focal depth, magnitude, and epicentral distance and (2) threshold distances within which GNSS stations can record detectable co-seismic breaks. Using the empirical formula, we further find that deep events can produce larger surface deformation than shallow ones under certain conditions.

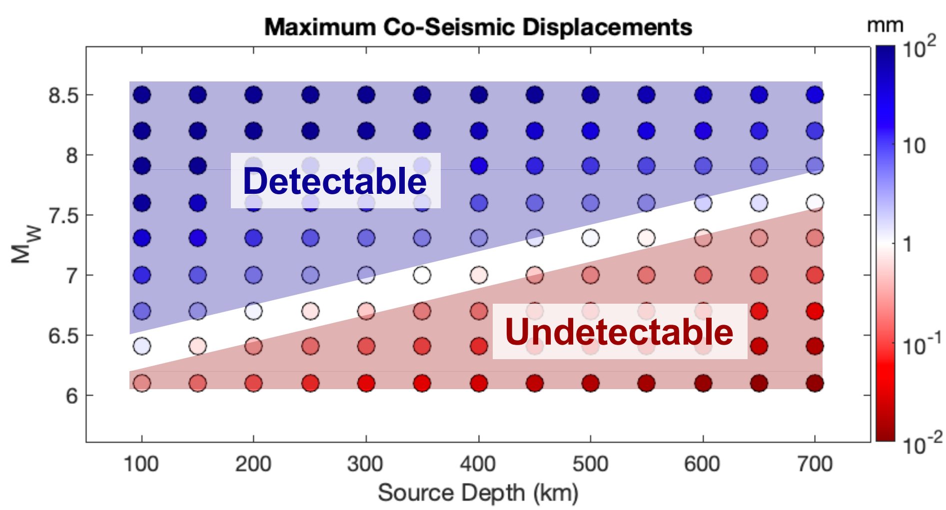

Figure: Maximum Co-Seismic Displacements Generated by Earthquakes (45° Dip Slip) with Various Moment Magnitudes and Source Depths

The blue and red shaded regions correspond to magnitude and source depth conditions that result in detectable (> 1 mm) and undetectable (< 1 mm) co-seismic deformation, respectively.