Residual topography and gravity anomalies reveal structural controls on co-seismic slip in the 2011 M_w 9.0 Tohoku-oki earthquake

*Dan Bassett[1], David T Sandwell[1], Yuri Fialko[1], Anthony B Watts[2]

1.Scripps Institution of Oceanography, 2.University of Oxford

The March 2011 Tohoku-oki earthquake was only the second giant (M_w ≥9.0) earthquake in the last 50 years and is the most recent to be recorded using modern geophysical techniques. Available data place high-resolution constraints on the kinematics of earthquake rupture, which have challenged prior knowledge about how much faults can slip in a single earthquake and the seismic potential of a partially coupled megathrust interface. But it is not clear what physical or structural characteristics have controlled either the rupture extent or the amplitude of slip. Here we use residual topography and gravity anomalies to constrain the geological structure of the overthrusting plate in NE Japan. These data reveal an abrupt SW-NE striking forearc segment boundary, across which gravity modelling indicates a south-to-north increase in the density of rocks overlying the megathrust of ~150-200 kg m^{-3}. We suggest this boundary represents the offshore continuation of the Median Tectonic Line (MTL), which onshore juxtaposes geological terranes composed of granite-batholiths (north) and accretionary complexes (south). The megathrust north of the MTL is strongly coupled, has a history of large earthquakes (18 with M_w ≥7 since 1896) and produced peak slip exceeding 40 m in the Tohoku-oki earthquake. In contrast, the megathrust south of this boundary is weakly coupled, has not generated an earthquake with M_j ≥7 since 1923, and experienced relatively minor (if any) co-seismic slip in 2011. We show that forearcs are not passive components of subduction zones and propose that the structure and frictional properties of the overthrusting plate are a key control on megathrust coupling and seismogenic behavior in NE Japan.

