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The elastic rebound process of the 2011 great Tohoku-Oki earthquake

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The 2011 Tohoku-Oki earthquake was an anomalously large elastic rebound of the upper-plate wedge against basal drag by the Pacific plate. The wedge consists of two parts, the seismically active inner (landward) segment and the inactive outer (oceanward) segment. A unique feature of this earthquake is the unexpectedly large rebound of the usually inactive outer segment. Here, we develop an elastic rebound model predicting a drastic change in stress state within the outer segment of the wedge characterized by a relatively steep seafloor and a very gentle plate interface. The model predicts, as the basal friction is reduced, the stress difference decreases in a horizontally compressional state, reaches a minimum (to which the stress state be referred) and then increases in a horizontally tensional state. The observed low seismic activity and normal fault-dominated seismic structure imply that the outer segment is in general marginally in a horizontally tensional state and decoupled from the compression-dominated inner segment by a strongly locked segment-segment boundary. The 2011 event started with unlocking of this boundary which shifted the area of stress concentration from the segment-segment boundary to the outer segment to place transiently the outer segment in a horizontally compressional state. The consequent large stress drop, accompanied by a drastic change of stress state within the outer segment, was transmitted to the inner segment through their already unlocked boundary. The unique role of the outer segment is a key to understand the whole rebound process of the Tohoku-Oki earthquake.