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Rapidly Decaying Afterslip Following the 2011 Mw9.0 Tohoku Earthquake

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It is well known that viscoelastic relaxation of the upper mantle and aseismic afterslip of the fault play important roles in controlling postseismic crustal deformation of giant earthquakes. Thanks to modern geodetic observations, postseismic deformation at timescales of months to a few decades has been well studied. However, how the deformation hours to days following the earthquake evolves into longer-term processes remains poorly understood. To investigate this problem, we processed the GPS data of the GeoNET in Japan after the 2011 Mw9.0 Tohoku earthquake. The data include high-rate 5-minute time series for the first two days after the earthquake and daily solutions afterwards. Some GPS stations moved more than 20 cm during the first day after the earthquake. In this work, we have developed three-dimensional viscoelastic finite element models to study the transient viscoelastic relaxation and evolution of the afterslip at scales from hours to years. In our model, the viscoelastic relaxation is represented by the bi-viscous Burgers rheology. Steady-state Maxwell viscosities are based on previously published studies. Afterslip on the fault is modeled by a narrow weak shear zone. Our preliminary tests indicate that the transient Kelvin viscosity is about two orders of magnitude lower than that of the steady-state Maxwell viscosity. Afterslip of the fault decays exponentially with time. In the first day after the earthquake, the megathrust slipped aseismically for up to more than 50 cm.