Two sprouting researches to characterize postseismic deformation: Neural network learning and modified Omori-law

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Spatiotemporal evolution of "postseismic deformation" in which the earth's surface continues to move after a large earthquake can be explained to some extent by physical mechanisms such as afterslip and viscoelastic relaxation of asthenosphere. On the other hand, physical models that assume constitutive laws and parameter distributions differ greatly between previous studies. As an example, viscosity of the subduction zone mantle wedge in the Tohoku region varies by 1 order of magnitude in the range of about 10^{18}-10^{19} [Pa s]. This suggests that there is a large trade-off between model parameters to explain the observation data. Therefore, focusing on the explanation and prediction of time-series data of surface displacement, characterization of postseismic deformation by regression analysis assuming simple logarithmic and exponential functions (Nishimura, 2014; Tobita, 2016) is also an important research.

In this presentation, we introduce two different approaches to characterizing the postseismic deformation. As a test case, we use GNSS time-series data from Geospatial Information Authority of Japan, GEONET, for the 2011 Tohoku earthquake. One approach (Yamagata and Mitsui, 2019) used a recurrent neural network (RNN), a method of machine learning. RNN was made to learn the postseismic time-series data 1 year after the mainshock, and predict the postseismic deformation by the end of 2018 at observation points which was not used for the learning, to compare with the actual data. In the other approach, we converted the displacement of the postseismic deformation to the velocity, and tried its characterization by a power law similar to the improved Omori law of aftershocks (Ingleby and Wright, 2018). Using the high-rate data of 30-second sampling, we regressed the time decay of the postseismic deformation rate from just after the Tohoku earthquake to 2018, and obtained a small estimated value of the power index p of about 0.7. Both approaches suggested that the dominant physical mechanism of the postseismic deformation changed around 2013.

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