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Multi-scale dynamic rupture modelling for the 2011 Tohoku earthquake: from foreshocks to mainshock

Hideo Aochi^{1*}, Satoshi Ide²

¹BRGM, Orleans, France, ²Graduate School of Science, Univ. Tokyo

We present conceptual dynamic rupture models for the 2011 Tohoku earthquake based on the multi-scale heterogeneity in fracture energy. Regardless of frequently occurring M7.5 events in this area, it is crucial that a large scale fault heterogeneity corresponding to a M9 event had not been clearly recognized until this earthquake. We show that the largest heterogeneity having high fracture energy is consistent with relatively slow rupture propagation of the Tokoku earthquake. The large gap in fracture energy explains the separation of two groups of waves clearly visible in observed ground motions. Our simulations prefer a cascading rupture that begins from a medium heterogeneity and then progresses over larger scale heterogeneity. We also find that the existence of foreshocks helps the rupture to grow up during the mainshock.

Keywords: dynamic rupture, multi-scale heterogeneity, Tohoku earthquake, fracture energy