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Randomness of mega-thrust earthquakes implied by rapid stress recovery after the Japan M9 event

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Constraining the recurrence of mega-thrust earthquakes is genuinely important for hazard assessment and mitigation. The prevailing approach to model such events relies on subduction zone segmentation and quasi-periodic recurrence due to constant tectonic loading. Here we analyze earthquakes recorded along a 1,000-km-long section of the subducting Pacific Plate beneath Japan since 1998. We find that the relative frequency of small to large events varies spatially, closely mirroring the large-scale tectonic regimes, and suggesting a laterally unsegmented mega-thrust interface. Starting some years before it broke, the Tohoku source region is imaged as a region of high stress concentration. Following the 2011 M9 earthquake, the size distribution changes significantly and most dramatic in the areas of highest slip. However, we discover that it returns within just a few years to its longer-term characteristics as observed prior to the mega-thrust event. This indicates a rapid recovery of stress and implies that such large earthquakes may not have a characteristic location, size or recurrence interval, and might therefore occur more randomly distributed in time.