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GRACE gravitational signature of the 2011 Mw 9.0 Tohoku-oki earthquake

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We present a analysis of the 2011 Mw 9.0 Tohoku-oki earthquake gravity variations in a wide space-time window surrounding the event. We identify earthquake-related gravity signals by searching for transient variations near the time of the earthquake in GRACE-reconstructed time series of gravity gradients at different spatial scales. The gravity gradients are expressed in spherical frames rotated along the radial axis in order to enhance gravity variations according to different orientations. Applied to different sets of gravity field models, our analysis allows us to evidence anomalous gravity signals starting a few months before the rupture across the regional subduction system, which cannot be explained by mass redistributions from water cycle sources around Japan nor by GRACE striping. After the rupture, the gravity variations propagate far within the Pacific and the Philippine Sea plates interiors. We further test the presence of the pre-seismic signals by also applying a statistical analysis of the gravity gradient time series, without knowledge on the consecutive rupture. Our findings show that satellite gravity brings unique information to monitor major plate boundaries, which could be used in seismic hazard assessment.