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Topographic precursors and geological structures of deep-seated catastrophic landslides caused by typhoon Talas, determined from the analysis of high-resolution DEMs

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Typhoon Talas crossed the Japanese Islands between 2 and 5 September 2011, causing more than 70 deep-seated catastrophic landslides in a Jurassic to Paleogene–Early Miocene accretion complex. Detailed examination of the topographic features of 10 large landslides before the event, recorded on DEMs with a resolution of 1 m (based on airborne laser scanner surveys), showed that all of the landslides had small scarplets near their future crowns prior to the slide, and one landslide had linear depressions along its future crown as precursor topographic features. These scarplets and linear depressions were caused by gravitational slope deformation that preceded the catastrophic failure. Strains, defined by the ratio of the length of a scarplet to the length of the whole slope (as measured along the slope line), ranged from 5% to 21%, and are the first reliable numerical data relating to the topographic precursor features of large and catastrophic landslides. Careful examination of aerial photographs from another four large landslides, for which no high-resolution DEMs were available, suggested that they also developed scarplets at their heads beforehand, which are not precisely quantified. Twelve of the 14 landslides we surveyed in the field had sliding surfaces with wedge-shaped discontinuities that consisted of faults, shear surfaces that formed during accretion, and bedding, suggesting that the buildup of pore pressure occurs readily in a gravitationally deformed rock body containing wedge-shaped discontinuities. Other types of gravitational deformation were also active; e.g., flexural toppling and buckling were each observed to have preceded one landslide.