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Precursors and processes culminating in the Krakatau 2018 tsunami

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For the second time in documented history, Krakatau became the site for volcano-triggered tsunami. The 1883 Krakatau eruption was associated with a major tsunami, causing 36,000 fatalities. Long debate still exists whether this 1883 tsunami was a result of caldera collapse, volcano landslide, the explosion that was heard across the oceans, or a combination thereof. In december 2018, volcanism at Anak Krakatau, once more, was associated with a deadly tsunami; for the first time the preparation processes of a volcano sector collapse could be monitored in high level of detail. Here we use multi-sensor geophysical and remote sensing approaches to identify precursors that culminated in the 22 december 2018 disaster.

Anak Krakatau was in an elevated stage of activity throughout the year 2018, producing moderate explosive eruptions, lava flows and pyroclastic density currents. Optical and spectral satellite imagery (Sentinel-2) reveal an increase of the island area, and coastline shift on the southwest of Anak Krakatau. Satellite thermal data (MODIS) suggest persistent thermal anomalies, punctuated by pulses exceeding > 100 MW, associated to flow deposition. Interferometric synthetic aperture radar (InSAR) analysis of both moderate-resolution Sentinel-1 and high-resolution TerraSAR-X data reveal flank motion at the southwestern flank. Deformation is maximum in the southwestern sector which collapsed into the ocean on 22 december 2018. The resulting landslide was well recorded by broadband seismic data from regional as well as teleseismic stations that show clear signatures of the landslide itself, with an origin time at 13:55:49 UTC. High-frequency, tremor-like signals follow, possibly associated with water-magma interaction and phreatomagmatic explosions. Results of a landslide-triggered tsunami are consistent with tsunami backtracking simulations we performed using a regional bathymetry model. The landslide and tsunami source was followed by a 15 minute phreatic explosion episode gradually declining, indicating re-equilibration of the volcano-magma system. This study therefore sheds light on the chronology of events at Krakatau and elsewhere, suggesting that landslide generated tsunamis may in fact show precursory deformation and seismic signatures that may be utilized in future for early warning systems.