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Geomorphometric analysis of the 2014-2015 Bárðarbunga volcanic unrest, Iceland, using multi-temporal TanDEM-X DEMs

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Topographical information is of major interest when assessing material flows throughout active volcanic systems. In order to obtain accurate estimates of temporal elevation changes at volcanic edifices, time sequences of digital elevation models (DEMs) are required. DEM time series from the TanDEM-X mission provide records of topography at remarkably high temporal and spatial resolution and were applied to monitor topographical change during the 2014-2015 Bárðarbunga volcanic eruption in Iceland.
The 2014-2015 Bárðarbunga volcanic event was associated with lateral dyke growth in direction of the Holuhraun plain and the effusion of large volumes of lava approximately 10 km north of the Vatnajökull glacier. Moreover, the deflation of the subsurface magma chamber resulted in the collapse of the ice-covered Bárðarbunga caldera, located in the northwestern corner of Vatnajökull, and minor subglacial volcanic eruptions and increased geothermal activity led to the formation of new ice cauldrons around the caldera. In order to reliably quantify topographical change at both, the Bárðarbunga caldera and the Holuhraun lava field, a DEM uncertainty investigation was conducted and the impact of the local environment, the SAR processing and the radar system parameters on TanDEM-X DEM quality was analysed. For the study area of the snow-covered Bárðarbunga caldera, microwave penetration into snow was the main factor to affect DEM quality and acquisitions over the Holuhraun lava field were mainly impacted by dynamic lava flows and outwash plain.
The topographical analysis over the Bárðarbunga caldera and the Holuhraun lava field raised a total subsidence and dense-rock equivalent (DRE) effusion volume of -1.40 $\pm$ 0.13 km^3 and +1.36 $\pm$ 0.07 km^3 respectively. The maximum vertical displacement was computed at approximately -65 m for the Bárðarbunga caldera and at +43 m for the Holuhraun lava field. The computation of subsidence and effusion volumes allowed the deduction of rates and showed the near-exponential decrease of the two processes over time. Moreover, the ratio between caldera subsidence and DRE lava effusion volume suggested the coupling between piston collapse and dyke intrusion.