Geophysical Research Abstracts
Vol. 20, EGU2018-16123, 2018
EGU General Assembly 2018

The evolution of ice cauldrons within the ice-covered Katla caldera, Iceland, since 2010, deduced from multi-temporal DEMs, elevation profiles and continuous GNSS stations

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The ice cauldrons of Mýrdalsjökull ice cap (S-Iceland, ~600 km^2) are depressions in the glacier surface created and maintained by melting at the glacier bed driven by local geothermal heat flux. Twenty-one ice cauldrons have been identified. Most of them are located near the rim of the ice-filled caldera (~100 km^2) of the subglacial volcano Katla. Jökulhlaups originate from beneath many of the cauldrons. They are of variable size ranging from minor events of few m^3 s^{-1} peak flow while the three largest jökulhlaups in the past decades reached peak discharge of a few thousand m^3 s^{-1}. The last jökulhlaup of that magnitude occurred in July 2011 and destroyed the bridge over the river Múlakvísl, closing the main highway for several days. Here the evolution of the ice cauldrons since 2010 is studied by use of 18 surface digital elevation models (DEMs) derived mostly from various remote sensing data. Three DEMs were obtained with airborne lidar survey in 2010–2012, 5 are from the ArcticDEM archive 2013–2015, 9 Pléiades derived DEMs 2014–2017 and 1 DEM from dense GNSS profiling in 2016. In addition, biannual surface profiles (GNSS and airborne radar) were surveyed. The most frequent DEMs are from last two summers, 3 in 2016 and 6 in 2017 (time between DEMs down to 15 days). Continuous GNSS stations were also operated in the summers of 2016 (1 station) and 2017 (5 stations) recording the surface motion at cauldron centres during few small jökulhlaups (10s of m^3 s^{-1} peak discharge or less). Our data set reveals variable pattern of elevation changes from one cauldron area (cluster of 2 or more cauldrons) to another. Some areas seem very stable during the study period, with only minor changes in cauldron depth and shape, indicating continuous leakage of geothermal meltwater as well as stable geothermal heat flux beneath the cauldrons in balance with ice dynamics and surface mass balance. Other cauldron areas show rather regular seasonal cycle of water accumulation and depletion resulting in a minor jökulhlaup near the mid-summer, typically increasing the depth of the cauldrons by ~10 m. An area of several cauldrons, which was the main source of the 2011 jökulhlaup, fits into neither of these categories. Jökulhlaups from there do not necessarily follow a seasonal pattern, the geothermal activity seems to vary substantially between years and the main geothermal heat outputs at the glacier bed seem to migrate between cauldrons. This typically results in a cauldron deepening during a period of one to a few years, while the neighbour cauldron becomes shallower. This is followed by a period of spatially mirrored pattern. Our study is ongoing, hence acquisitions of DEMs and deployment of continuous GNSS stations is planned for the summer 2018. We aim to identify the main causes of observed elevation changes at different times (water accumulation/depletion, subglacial melting without water accumulation, ice dynamics or surface mass balance) to enhance our understanding of the behaviour of underlying geothermal systems and the subglacial hydrological system and their interaction.