Monitoring of geothermal activity in the ice-covered Katla caldera, Iceland, 1999-2012

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The upper parts of the Katla central volcano are covered by the 600 km2 Myrdalsjokull ice cap. The central part of Katla is a large (100 km2) ice-filled caldera. Eruptions in Katla occur about twice per century, typically phreatomagmatic explosive events of size VEI 3-4. The eruptions melt quickly through 400-600 m thick ice in the caldera before the onset of the subaerial explosive phase. During the typically 1-8 hour long subglacial phase large volumes of ice are melted, leading to catastrophic outbursts floods (jokulhlaups) with peak discharge of order 100,000 m3/s. Katla is located on the south coast, close to inhabited areas and because of the jokulhlaups it is regarded one of the most dangerous volcanoes in Iceland. As a consequence, Katla is monitored with a network of seismometers, continuously recording GPS and automated monitoring gauges are located in rivers that drain the ice cap. In addition, a monitoring program was set up in 1999 to survey ice surface profiles from low-flying aircraft across 17 depressions formed by geothermal activity under the ice. Although most depressions only have minor crevassing at the surface and lack vertical ice walls, it is customary to use the term ice cauldrons when referring to these depressions. On board the aircraft ground clearance radar coupled with kinematic GPS is used to map the surface profiles. The elevation accuracy from the surface profiles is 2-3 meters, allowing changes in ice surface between successive surveys in excess of 5 meters to be resolved. The surveying since 1999 covers two periods of enhanced unrest in Katla, 2001-2004 and 2011-2012. Both unrest periods were characterised by increased geothermal activity, manifested in increased depth and width of ice cauldrons. Some of the cauldrons have showed evidence of periodic accumulation of water at the bottom in winter and drainage in summer. Within the 13 year long survey period, two unusual jokulhlaups with discharge of a few thousand m3/s have occurred (1999 and 2011) when sudden increase in thermal activity lead to rapid growth of water bodies under cauldrons. The formation and size of such subglacial bodies is difficult to monitor with only ice surface profiling. Steps are being taken to supplement the airborne surveys with ground-based radio echo surveys. This will make it easier to detect cauldrons with unusual accumulation of water, as the ones that drained in the jokulhlaups of 1999 and 2011.