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Monitoring of geothermal signals through aircraft mapping of glacier surface during unrest in Öræfajökull, Iceland, in 2017-2018

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Öræfajökull is Iceland's highest volcano, located on the SE-coast, outside the main volcanic zones. It has extensive ice cover, and a 3-4 km wide ice-filled summit caldera. Öræfajökull has erupted twice in the last 1200 years, in 1362 and 1727. The 1362 eruption is considered to be the largest Plinian eruption in Europe since the 79 CE eruption of Vesuvius. It is considered to have led to the loss of many lives as it devastated the neighboring areas with pyroclastic density currents, tephra fall and jökulhlaups. The 1727 eruption was smaller but jökulhlaups caused damage and loss of life. After the 1727 eruption, no indications of unrest have been reported until the start of the current and ongoing unrest episode. Seismic activity and geodetic measurements indicate that the volcano entered a state of unrest in 2017 and that this activity has prevailed through 2018. In early November 2017, a geothermal smell was reported around the river that drains from the summit caldera of Öræfajökull. In mid-November, a clear depression was seen from aircraft in the center of the summit caldera. We started surface profiling of the glacier inside the caldera on 18 November 2017. The ice surface is mapped along profiles using an aircraft-based system, on board TF-FMS, the flight inspection aircraft of Isavia, the civil aviation service of Iceland. The system consists of a C-band ground clearance radar, linked with sub-meter DGPS is used, providing profiles of glacier surfaces with a spatial resolution of 15-20 m and elevation accuracy of 1-3 m. From late November, the cauldron grew in size, reaching a maximum depth of 24 m in January. The diameter of the cauldron was about 1 km and the ice thickness at this site was about 500 m before the onset of activity. During 2018, the cauldron has been declining. It was 12 m deep on 21 November 2018, and the volume had declined from 7 to 3 million m3. Radio-echo soundings done in the caldera in 2018 indicate no water accumulation under the cauldron. The observations indicates sudden onset of geothermal activity and subsequent rapid decline. This power required in November-December 2017 is several hundred megawatts, in a location were previous geothermal activity was very minor. Apparently, by January 2018 this injection of heat was mostly over and heat output at this site had declined to values if a few megawatts, similar to what they were prior to the unrest. A likely explanation is heat injection, probably by intrusion of magma, into the roots of an existing but not very active geothermal reservoir within the caldera. The causes and implications of these events is a subject of ongoing research.