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Extending permanent volcano monitoring networks into Iceland's ice caps

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The goals of the FUTUREVOLC project are the establishment of a volcano Supersite in Iceland to enable access to volcanological data from the country's many volcanoes and the development of a multiparametric volcano monitoring and early warning system. However, the location of some of Iceland's most active volcanoes inside the country's largest ice cap, Vatnajökull, makes these goals difficult to achieve as it hinders access and proper monitoring of seismic and deformation signals from the volcanoes. To overcome these obstacles, one of the developments in the project involves experimenting with extending the permanent real-time networks into the ice cap, including installation of stations in the glacier ice. At the onset of the project, only one permanent seismic and GPS site existed within Vatnajökull, on the caldera rim of the Grímsvötn volcano. Two years into the project both seismic and GPS stations have been successfully installed and operated inside the glacier; on rock outcrops as well as on the glacier surface.

The specific problems to overcome are (i) harsh weather conditions requiring sturdy and resilient equipment and site installations, (ii) darkness during winter months shutting down power generation for several weeks, (iii) high snow accumulation burying the instruments, solar panels and communication and GPS antennae, and in some locations (iv) extreme icing conditions blocking transmission signals and connection to GPS satellites, as well as excluding the possibility of power generation by wind generators.

In 2013, two permanent seismic stations and one GPS station were installed on rock outcrops within the ice cap in locations with 3G connections and powered by solar panels and enough battery storage to sustain operation during the darkest winter months. These sites have successfully operated for over a year with mostly regular maintenance requirements, transmitting data in real-time to IMO for analysis. Preparations for two permanent seismic sites in the ice started in early 2014, with the installation of windmills, solar panels and web camera to monitor snow accumulation and icing. The site locations were constrained by the availability of communication and locations of ice-divides to avoid significant lateral motion of the stations. At the onset of the Bárdarbunga dyke intrusion in August 2014, these sites were temporarily instrumented and transmitted real-time seismic data, important for tracking the dyke intrusion. In late 2014, a specially designed vault was installed at one of the sites and a Güralp broadband glacier seismometer installed.

Since 2013, three GPS stations powered by solar energy have been operated on the ice, to monitor the movement of the glacier during an expected subglacial flood, when accumulated melt water at the Eastern Skaftá cauldron sub-glacial geothermal area will drain. One of the sites, located in the depression above the subglacial lake to monitor the onset of the flood, transmits the data to a repeater just outside the depression, from where the signal is transmitted by 3G to IMO. Maintaining the transmission through the winter months has required considerable maintenance. The experience gained through this operation proved crucial for the successful installation and operation of a real-time transmitting GPS and strong motion seismometer inside the Bárdarbunga cauldron in October 2014 to monitor the ongoing caldera subsidence.