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Real-time monitoring of seismicity and deformation during the Bárdarbunga rifting event and associated caldera subsidence

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We present a monitoring overview of a rifting event and associated caldera subsidence in a glaciated environment during the Bárðarbunga volcanic crisis. Following a slight increase in seismicity and a weak deformation signal, noticed a few months before the unrest by the SIL monitoring team, an intense seismic swarm began in the subglacial Bárðarbunga caldera on August 16 2014. During the following two weeks, a dyke intruded into the crust beneath the Vatnajökull ice cap, propagating 48 km from the caldera to the east-north-east and north of the glacier where an effusive eruption started in Holuhraun. The eruption is still ongoing at the time of writing and has become the largest eruption in over 200 years in Iceland. The dyke propagation was episodic with a variable rate and on several occasions low frequency seismic tremor was observed. Four ice cauldrons, manifestations of small subglacial eruptions, were detected. Soon after the swarm began the 7x11 km wide caldera started to subside and is still subsiding (although at slower rates) and has in total subsided over 60 meters.
Unrest in subglacial volcanoes always calls for interdisciplinary efforts and teamwork plays a key role for efficient monitoring. Iceland has experienced six subglacial volcanic crises since modern digital monitoring started in the early 90s. With every crisis the monitoring capabilities, data interpretations, communication and information dissemination procedures have improved. The Civil Protection calls for a board of experts and scientists (Civil Protection Science Board, CPSB) to share their knowledge and provide up-to-date information on the current status of the volcano, the relevant hazards and most likely scenarios.
The evolution of the rifting was monitored in real-time by the joint interpretation of seismic and cGPS data. The dyke propagation could be tracked and new, updated models of the dyke volume were presented at the CPSB meetings, often daily. In addition, deformation data and models based on remote sensing were presented, further supporting the interpretations of lateral movements of magma. The rapid evolution of the dyke called for a quick response to install new seismic and GPS stations to improve constraints for the intrusion (seismic locations and deformation). The subsidence of the caldera called for innovative thinking, resulting in a high-rate cGPS instrument together with a strong motion sensor being installed on the ice surface. Moreover, specially designed broadband glacier seismometers have been installed. Surveillance flights continue to be carried out to monitor ice surface changes and provide important data on caldera deformation.
Monitoring information and interpretations of geophysical data have been made accessible to the public. Automated and manually checked earthquake locations are presented on web based maps and updated every five minutes. In addition cGPS time-series and maps showing GPS deformation vectors together with the color coded temporal evolution of the earthquake sequence are presented and updated regularly on IMO's webpage. Several examples of near-real-time data transfer, analysis and online visualization will be presented.