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The development of a subglacial lake monitored with radio echo sounding and comparison with water volumes released during jökulhlaups: Case study from the Eastern Skaftá Cauldron in the Vatnajökull ice cap, Iceland

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We present a 6 year record of repeated radio echo sounding (RES) on a profile grid (200-400 m between profiles) surveyed over the Eastern Skaftá Cauldron (ESC). ESC is an ice cauldron produced and maintained by powerful geothermal activity (~1 GW) at the glacier bed. Beneath the cauldron and 200-400 m of ice, water accumulates in a lake and is regularly released in jökulhlaups. The maximum discharge in the river Skaftá exceeded 3000 m^3 s^{-1} in the most recent ones in 2015 and 2018. The record starts in 2014 and consists of annual measurements, obtained in June each year; the last on June 2019. Comparison of the repeated RES profiles (2D migrated) reveals the margin of the lake at different times and enables a classifying of traced reflections into lake and bedrock measurements. The bedrock measurements were obtained with the lake close to its minimum size in 2016, 2017 and 2019 (£~1 km^2 compared to 4.0 km^2 in 2015), hence it is possible to obtain fairly accurate digital elevation model (DEM) of the glacier/lake bed. This DEM is further constrained by two borehole measurements of the lake bed elevation at its centre. The traced lake reflections and comparison with the bedrock DEM enables creation of a lake thickness maps and an estimate of the lake volume for each survey. The lake thickness maps and volumes in June 2015 and 2018 are compared with the surface lowering pattern and water volumes drained in the jökulhlaups in October 2015 and August 2018. The drained water volume was derived by integrating the surface lowering during the jökulhlaups and adding estimated volume of crevasses formed in the events. The lowering in the 2015 jökulhlaup was obtained from TanDEM-X DEMs of September 23rd and October 10th, shortly before and after the jökulhlaup. The lowering in the 2018 jökulhlaup was derived from dense set of airborne altimetry profiles acquired on August 9th, a few days after the jökulhlaup, compared with a DEM in June 2018 (ArcticDEM in July 2017 corrected with dense GNSS profiles in June 2018). The lake volume estimate from the RES data is 240x10^6 m^3 in June 2015 but 320±20x10^6 m^3 drained from the cauldron in October. In June 2018 a relatively dense RES profile grid (~200 m between profiles) reveals a lake volume of 180x10^6 m^3 while 210±30x10^6 m^3 drained from the cauldron in August. This comparison demonstrates the

applicability of our survey approach to monitor the water accumulation in the lake and thus better constrain potential hazard in jökulhlaups.