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Impacts and dynamics of volcanically-generated jökulhlaups, Eyjafjallajökull, Iceland

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Eyjafjallajökull, a 1666 m high, glacier-clad, stratovolcano in southern Iceland, is known to have erupted on four previous occasions historically: ∼500 AD, ∼920 AD, 1612 AD and 1821-23 AD. Each eruption caused rapid and large-scale glacier ice melt, culminating in the release of jökulhlaups (glacier outburst floods), with peak discharges of 10̂3-10̂4 m̂3ŝ-1 which inundated the surrounding populated lowlands.

The Icelandic Meteorological Office (IMO) identified a period of enhanced seismic activity under Eyjafjallajökull (since the beginning of January 2010). Based on the assumption that the exponential increase in both seismic activity and rates of ground deformation represented pre-eruption behaviour, we collected pre-eruption Terrestrial Laser Scanner and dGPS survey data from a number of probable jökulhlaup routeways in March, 2010. Five days after the end of this data acquisition period, the magma reached the surface along a newly formed 500 m-long fissure located north of Fimmvörðuháls pass and directly east of the Eyjafjallajökull ice cap. This phase of eruption was on a non-ice covered area and activity ceased on April 12. Only two days later (April 14 at 02:00 GMT) a large subglacial explosive eruption started beneath the 2.5 km-wide summit caldera of Eyjafjallajökull. Within hours the eruption melted through 200 m of the ice cap and became fully phreatic, producing a major 11 km-high volcanic plume. By 07:00 GMT on April 14, rapid melting of the Eyjafjallajökull ice cap generated jökulhlaups that cascaded from Gígjökull and down Núpakotsdalur on the northern and southern flanks of Eyjafjallajökull respectively. The initial jökulhlaup from Gígjökull reached peak discharge in the Markarfljót river system several hours later, damaging Iceland's main ring road near the Markarfljót bridge. Subsequent increases in eruption intensity generated repeated jökulhlaups that inundated the Markarfljót. An enormous jökulhlaup from Gígjökull was witnessed on an over flight at 18:55 GMT on April 15th, prompting the immediate evacuation of the population within the entire Markarfljót area. This jökulhlaup was 'ice-rich' and 'sediment-laden', characterised by a viscous, smooth-surfaced, lobate flow front followed by a more turbulent fluid flow body. These initial observations suggest that the frontal wave of this jökulhlaup was hyperconcentrated. Numerous flood barriers were destroyed by the impact of the ice –rich flow front.

In this project, we aim to improve understanding of the impacts of volcanically-generated jökulhlaup impacts and processes due to a subglacial volcanic eruption. In order to do this, we acquired post-jökulhlaup data for the Gígjökull proglacial area and the Markarfljót to compare against our directly pre-eruption, full 3D TLS topographic datasets. Our aims are to use this unprecedented and unique opportunity to (1) accurately quantify the geomorphological and sedimentary characteristics of a series of jökulhlaups and (2) to use these to inform and validate our reconstructions of the hydrodynamic characteristics of a series of volcanically-generated jökulhlaups capable of valley-scale geomorphological and sedimentary impact. A second and important phase of the project will use this data to model the impacts of the eruption on the proglacial outwash system. Quantification and modelling of jökulhlaup hydrograph characteristics will contribute to the better design of roads, bridges and flood defences as well as contributing to the revision of flood inundation maps.