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Holocene deformation within the Húsavík-Flatey Fault zone in north Iceland from drone imagery and field investigations

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Drone imaging can be effective in determining earthquake fault offsets and landslide motion in areas where higher image resolution is needed than available in satellite data. Here we use drone mapping to study the Holocene tectonic activity along the Húsavík-Flatey Fault (HFF) in northern Iceland as well as a coastal landslide in the vicinity of the fault, which poses a tsunami threat. Together with the subparallel Grímsey Oblique Rift, the partially offshore HFF accommodates ~18 mm/yr transfer motion between two parts of the Mid-Atlantic Ridge. However, it remains unclear how much of that transfer motion has occurred on the HFF during Holocene. This is important to determine for seismic hazard assessments of North Iceland, as the HFF is located much closer to several coastal communities than the offshore Grímsey Oblique Rift.

We used a DJI Phantom 4 drone to survey 5.8 km of faults onshore in 5 separate areas that together cover 2.9 km². We processed ~6000 drone images using the photogrammetry software Agisoft PhotoScan to compute high resolution 3D Digital Surface Models (DSMs) and high resolution 2D ortho-mosaics. We placed 5 to 10 Ground Control Points (GCPs) in each survey area to reduce distortions and to apply corrections for the ortho-rectification. While errors on absolute horizontal positions (without the GCP corrections) are not large (sub-meter to a meter), errors on the absolute vertical positions can be substantial (several tens of meters). The GCP locations were determined using differential GPS and the open source package RTKLIB, and then later added in the 3D model reconstruction. Depending on the flight parameters (altitude, speed, camera rate...) and the reconstruction process, we obtained DSMs and ortho-mosaics with resolutions ranging from 2.5 to 10 cm. We used these high-resolution DSMs and ortho-mosaics to map postglacial morphologies and tectonic features along the HFF, and to measure offset structures along the fault segments, which we used to assess the Holocene slip rate of the HFF. We measured more than 30 offsets ranging from a few meters up to 80 m, which yields a minimum Holocene slip rate of 7.0 - 7.5 mm/yr, compatible with rates derived from modeling of present-day GPS observations.

In addition, we surveyed a coastal landslide that is 280 m x 130 m in size and located about 10 km south of the fault. A sudden movement of the landslide, e.g. triggered by earthquake shaking, would cause a tsunami and could threaten neighboring coastal areas, including the town of Húsavík. We aim at characterizing the volumetric and topographic evolution of the landslide to understand if the landslide is actively creeping and if it could be destabilized by an earthquake. To

do this, we compare our drone-image DSM with a DSM computed from older aerial images and will use this first drone survey as a benchmark to monitor the evolution of the landslide.