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

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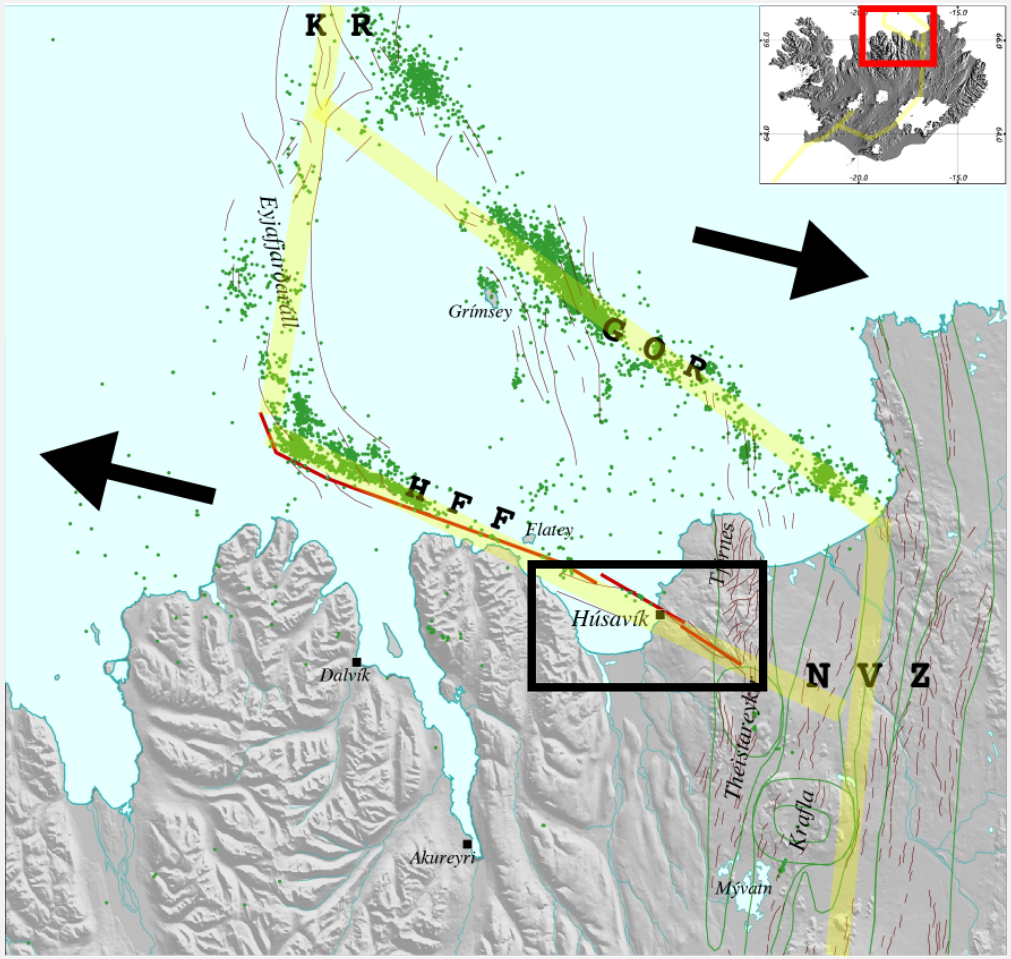

Figure 1. The Tjörnes Fracture Zone, formed by the Húsavík Flatey Fault (HFF) and the Grímsey Oblique Rift (GOR), accommodates the transform motion between the onshore Northern Volcanic Zone (NVZ) and the offshore Kolbeinsey Ridge (KR)

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Context

- Húsavík Flatey Fault (HFF) and Grímsey Oblique Rift (GOR) accommodate 18 mm/yr of transform motion

Motivations

- How much transform motion occurred on the HFF during the Holocene?
- How is the deformation distributed over the transform zone?

Drone Survey

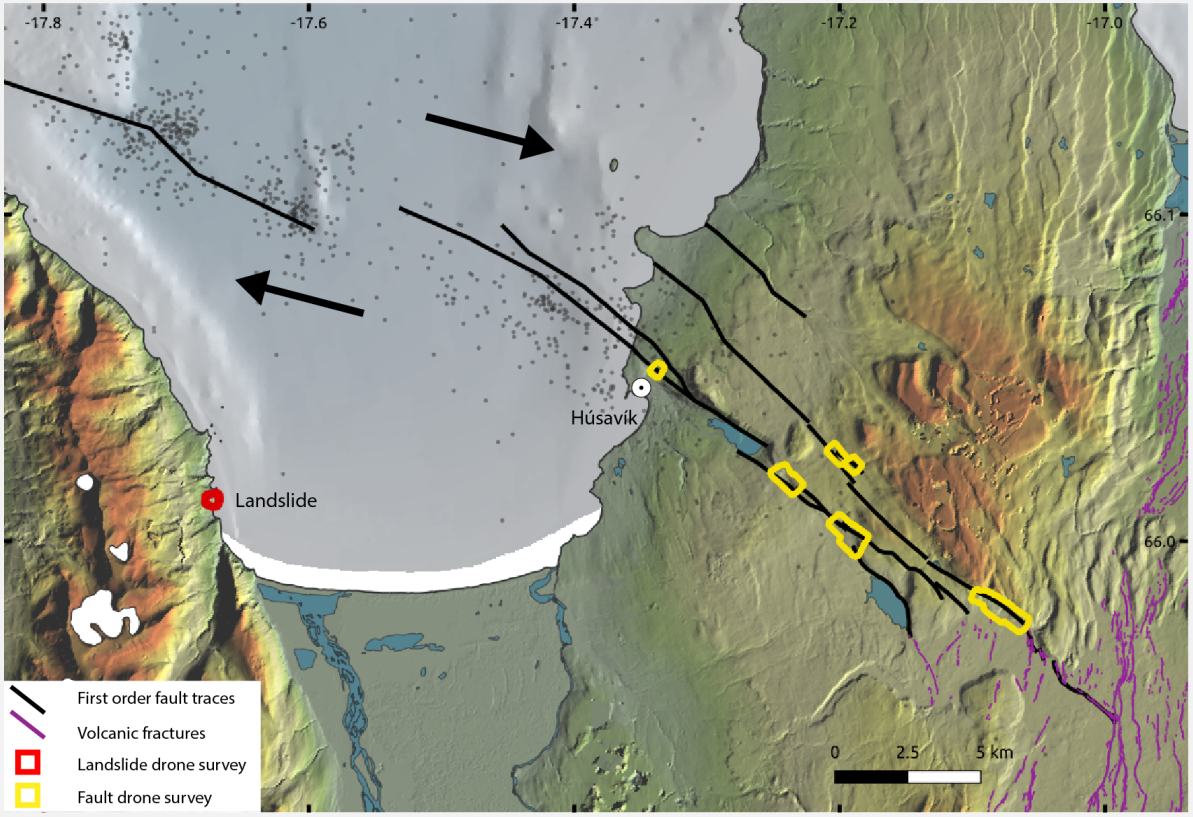

Figure 2. First order mapping of the HFF (black lines). The yellow boxes show the areas of the drone survey along the HFF.

- 6500 drone images
- Five survey areas (yellow boxes) covering 5.8 km of the fault system
- One landslide (red box)
- Five to ten Ground Control Points (GCP) per area, measured with differential GPS
- Down to 2.5 cm/px resolution

Figure 3. Left: Drone operators landing the UAV. Right: Operator measuring a GCP location with GPS

Mapping and offset measurements

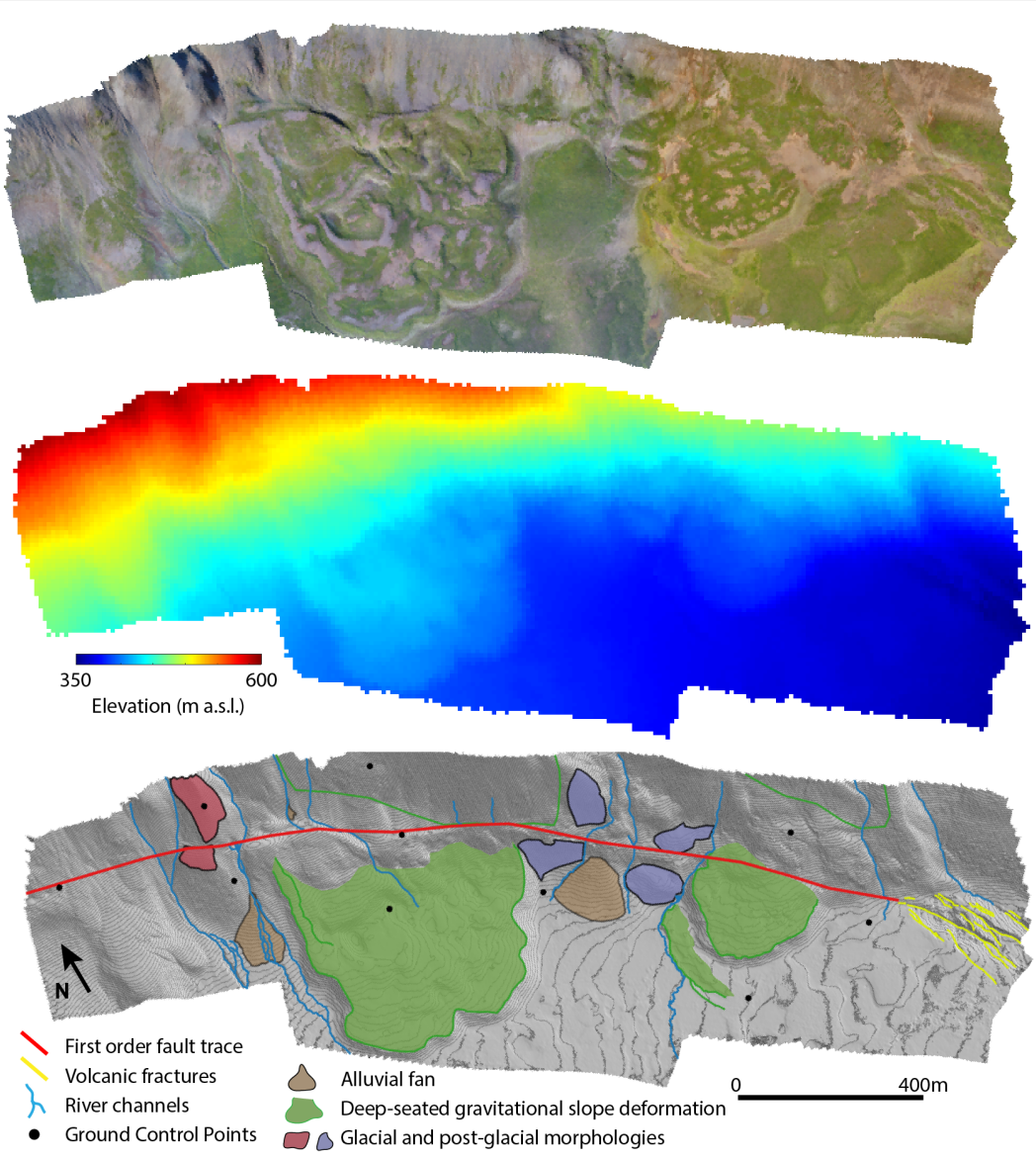

Figure 4. Example of one of the survey area with an orthomosaic (top) and DSM (middle) computed from the drone images using Agisoft PhotoScan Structure for Motion software. Interpreted map (bottom) from the orthomosaic and DSM

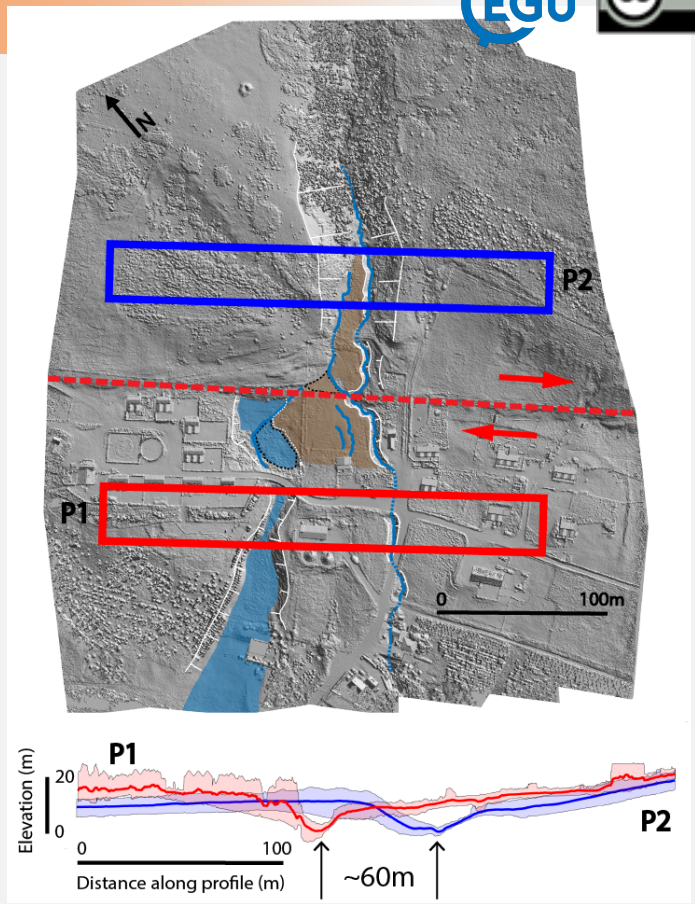

Figure 5. Top: Interpreted morphologies overlayed on a hillshade DSM. The blue and red rectangles show the topographic profiles used to measure fault offset (bottom)

- Drone images used to generate Digital Surface Models (DSM) and orthomosaics.
- Map of glacial and post-glacial morphologies used to measure cumulative offset along the HFF

Methodology: the use of Ground Control Points

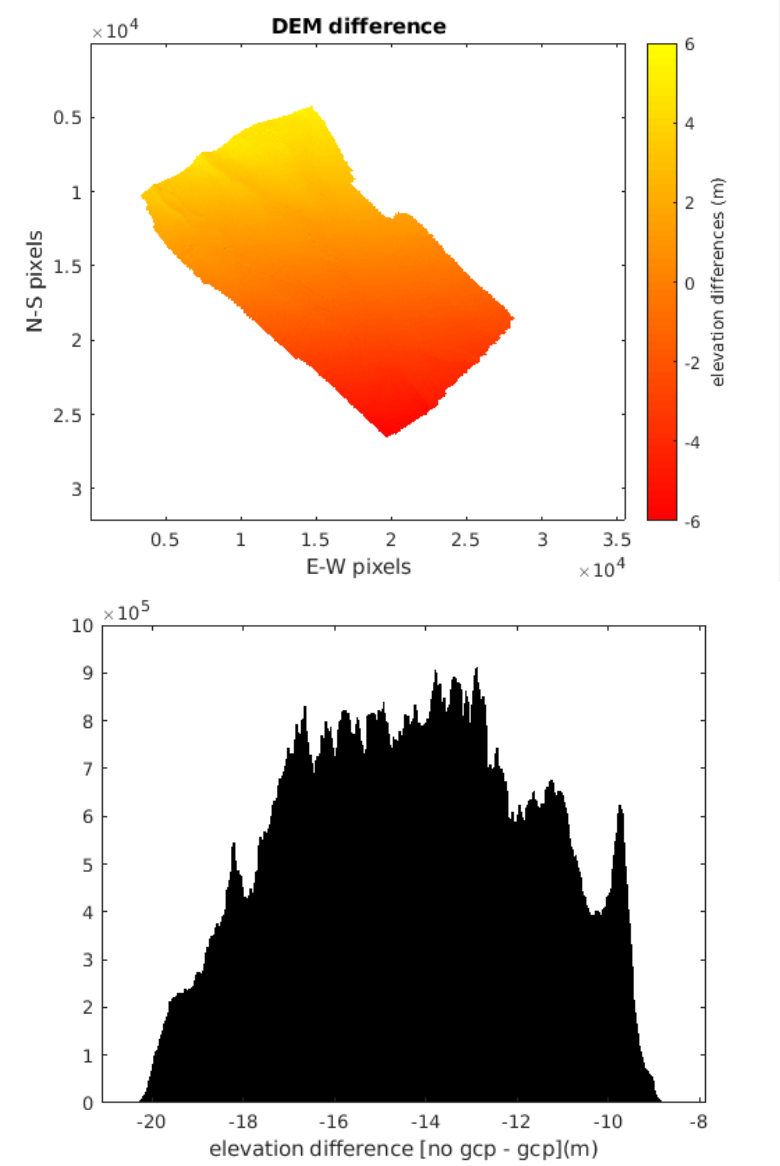

Figure 6. Example for one of the study area. Top: Relative vertical difference between DSM without GCP correction and DSM with GCP correction, corrected for absolute vertical difference. Bottom: Distribution of the relative vertical differences, corrected for absolute vertical difference. Relative vertical differences can be in the order of 10-15 m

- Ground Control Points (GCPs) used to improve image georeferencing and to minimize image distortions and reconstruction errors
- Comparison with and without GCPs:
  - Relative and absolute **horizontal** errors are minimal (a few pixels)
  - Absolute **vertical** errors can be large (tens of meters)
  - Relative **vertical** errors are not negligible (see Figure 6), up to 10-15 m and depend on the size of the area

⇒ GCPs are fundamental for minimizing vertical DSM errors that could lead to wrong measurements

Landslide survey

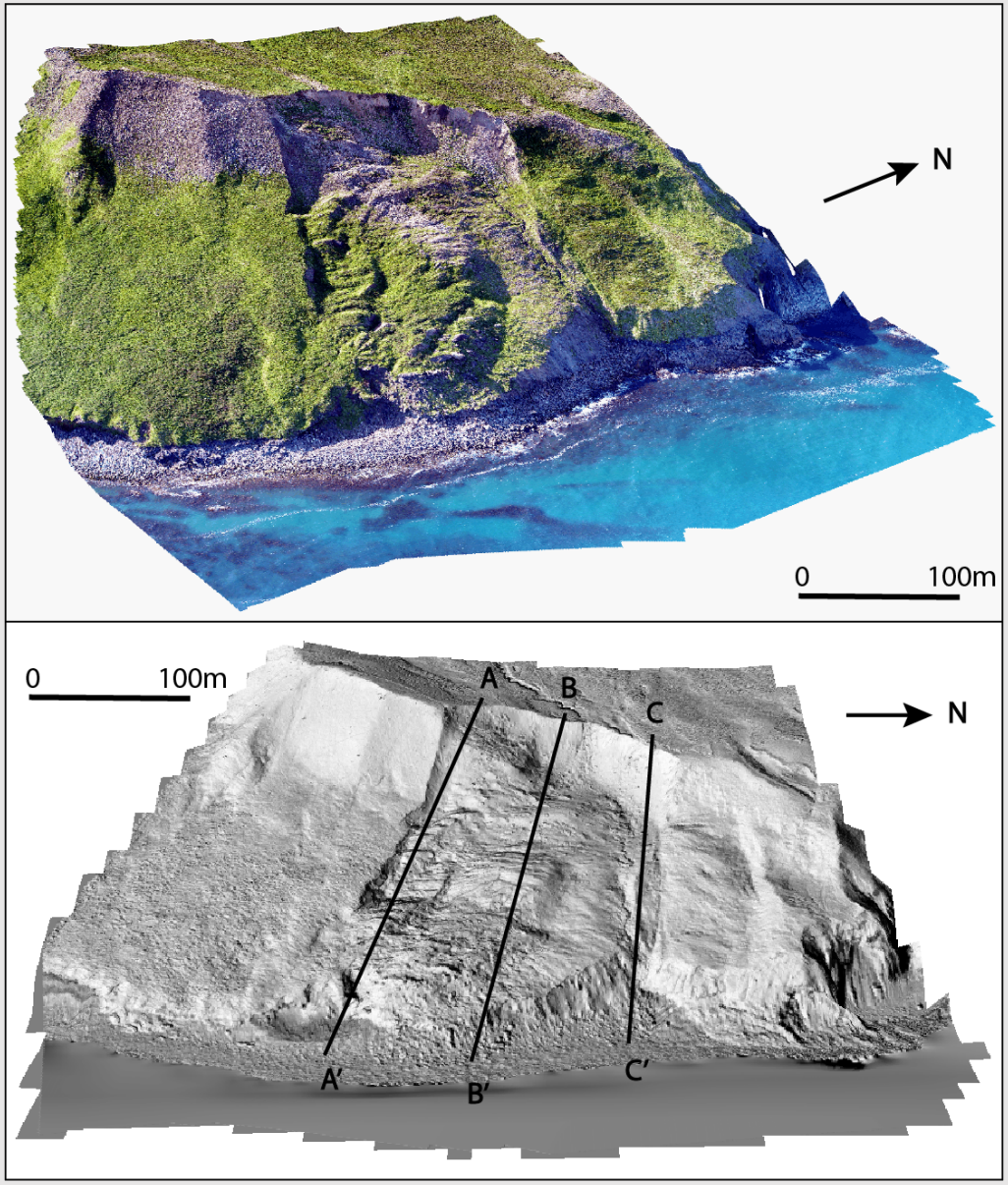

Figure 7. Top: 3D orthomosaic reconstruction of the landslide, overlayed on top of the DSM. Bottom: 3D reconstruction of the hillshade DSM, overlayed on top of the DSM, from a different perspective.

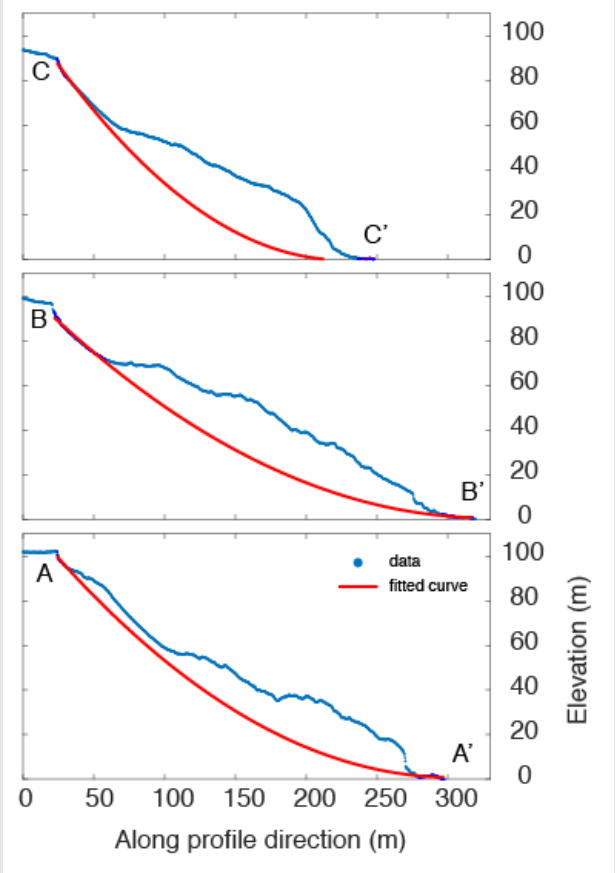

Figure 8. Topographic profiles across the DSM (in blue) and estimates of the slip surface along those three profiles (in red).

- Estimated landslide volume 4.3 x 10^5 m^3
- First drone survey to use as a benchmark to monitor the evolution of the landslide

Take home messages

- Drones are efficient for surveying ”intermediate”-scale areas (a few kilometers)
- Ground Control Points are critical to avoid errors on elevation measurements
- Our preliminary results suggest that the Holocene slip rate of the Húsavík Flatey Fault is slightly less than half of the 18 mm/yr transfer motion

- This is WORK IN PROGRESS, stay tuned for more!

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