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Modelling the thermal regime of a recently destabilised talus: the Eyjafirdi landslide (October 6th 2020, Iceland)

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In mountainous periglacial environments, permafrost degradation can be comprised among the triggering factors of landslides. Such hazards represent a threat for human lives and infrastructures (Geertsema et al., 2009). The extent of permafrost, and hence location of areas at risk of landslides, is estimated at the global scale using models based on air temperatures (e.g. Gruber, 2012). However, at the local scale, specific geological settings can allow the persistence of permafrost beyond its climate boundaries. In talus slopes specifically, peculiar air circulation named “chimney effect” can exist and favour permafrost formation and persistence at their foot, at location where it is not always predicted by models (Wicky and Hauck, 2017).

In Iceland, talus slopes can be destabilised and generate landslides (Morino et al., 2019). However, due to the complexity of their geological setting, the thermal regime of talus slopes is difficult to model. Hence, only few numerical studies were conducted (e.g. Wicky and Hauck, 2017; Tanaka et al., 2006). This makes challenging to understand the destabilisation mechanisms of talus slopes, when determining the triggering mechanisms associated with permafrost degradation remains a crucial challenge.

In that scope, we installed 16 temperature sensors within the talus (and close rockwall) where the Eyjafirdi landslide originated from (October 6th 2020, Iceland). They recorded temperature hourly from August 2021 to July 2022. The primary analysis of the dataset reveals that a chimney effect indeed occurs within the talus; therefore, we suspect that an ice lens could have persisted at the bottom of the talus – outside of the predicted extent of permafrost. This hypothesis is supported by the observation of molards within the landslide deposits – i.e. cones of loose debris formed by the degradation of ice-cemented blocks of sediment, transported by the landslide (Morino et al., 2019).

In order to better characterise the thermal regime of the Eyjafirdi talus slope, we first reconstruct the temperature back to 1881 at the level of our sensors. We base that reconstruction on the correlation between our measured temperatures and air temperature datasets from meteorological stations – that go back to 1881. The reconstructed temperatures will then be used as forcing data, to constrain a thermal numerical model of the Eyjafirdi talus slope.

Model runs will be performed using the commercial software FEFLOW. It uses the finite element method (i.e. a discretisation of the studied object as a mesh) to solve equations of heat transfer, taking into account freezing and thawing processes. These numerical models will allow us to determine whether the chimney effect indeed maintained an ice lens within the Eyjafirdi talus slope. Moreover, thanks to our unique temperature dataset, our study will represent the most accurate effort to model talus slopes so far.