EGU2020-21325
https://doi.org/10.5194/egusphere-egu2020-21325
EGU General Assembly 2020

Assessing the impact of mass movements on alpine trails and huts using EO data

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The alpine infrastructure of trails and huts is an essential asset for summer tourism in the Austrian Alps. Every year, around five million people use the trail network for hiking and other mountaineering activities. Mass movements such as shallow landslides, debris flows and rockfalls cause significant damages to the alpine infrastructure and may block access to certain mountain areas for weeks or even months. Such damages require repair and increased maintenance activity or even rerouting of trails. Climate change will exacerbate the problem as more frequent and severe mass movements can be expected. Therefore, the Alpine associations have to take natural hazards into account for their trail and hut management.

A promising opportunity for assessing the impact of natural hazards on alpine infrastructure arises through the new generation of Earth observation (EO) satellites of the European Copernicus programme. The high spatial and temporal resolution allows the detection of mass movements with an impact on trails and huts.

Therefore, we initiated the project *MontEO* (*The impact of mass movements on alpine trails and huts assessed by EO data*) to investigate the opportunities for EO-based mass movement mapping and hazard impact assessment for alpine infrastructure. We start with a user requirements analysis that describes the demand for consistent and appropriate information on mass movements for alpine infrastructure management. We perform interviews with the Alpine associations and other relevant stakeholders. They help us to identify significant mass movements, their impact on the alpine infrastructure, and the actions that trail keepers and hut facility managers take to deal with the impacts. Based on this, we assess the suitability of EO-derived mass movement information for alpine infrastructure management, and define requirements for its production and delivery.

Based on the user requirements, we develop a multi-scale approach and combine optical and synthetic aperture radar (SAR) satellite data (e.g. Sentinel-1/2, Pléiades) to comprehensively map mass movements and to detect mass movement hotspots. Further, we integrate the EO-based mapping results with ancillary data for landslide susceptibility mapping, and for modelling and

simulating rockfalls and debris flows. Finally, we analyse the network of trails and huts in relation to the obtained mass movement information and thereby assess their impact on alpine infrastructure, i.e. identify the trails and huts that are (potentially) affected by mass movements.

We demonstrate the concept and methods for three study areas in the Austrian Alps: Großarl and Kleinarl Valley in Salzburg, Karwendel in Tyrol, and the Salzkammergut in central Austria. For these areas, we will create EO-based mass movement inventory maps, hotspot maps, and hazard impact maps. We validate our results in close collaboration with the users and analyse their usefulness for alpine infrastructure maintenance and management. The outcomes of *MontEO* will contribute to improved maintenance efficiency and will lead to a safer alpine infrastructure with an increased value for hikers, the tourism industry and the society.