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Refraction seismics to explore subsurface architecture of a creeping alpine hillslope

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Assessing the human and economic threat introduced by sliding or creeping masses is of major importance in landslide hazard assessment and mitigation. Especially, in the densely populated alpine region unstable hillslopes represent a major hazard to men and infrastructure. Detailed knowledge, especially, of the dominant site-specific controlling factors such as subsurface architecture and geology is thereby key in assessing slope vulnerability. In order to evaluate the geological variations of a creeping hillslope in the Austrian Alps, we have collected six 2D refraction seismic profiles. We propose a layer-based inversion strategy to reconstruct P-wave velocity models using first arrival times. Considering the geological complexity at such sites, the selected inversion approach eases the interpretability of subsurface features given the optimization for a number of discrete user-defined layers.
Our study site Heumöser is located in the eastern Vorarlberg Alps (Austria), ∼25 km south of Bregenz. The slope has an extension of ∼1800 m in east-west and ∼500 m in north-south direction and elevations range from ∼900 to ∼1300 m above sea level. The geology is characterized by Cretaceous sediments (marls to limy marls) belonging to the Amden, Wang, and Leimern formations. Within the course of this study a total of ∼ 2.3 km densely sampled seismic refraction profiles have been acquired using a 5 kg sledge hammer as source and 14 Hz geophones to record the seismic wavefield. Inversion of the picked first arrival times is based on the generalized linear inversion approach originally introduced by Hampson and Russell (1984). As this layer-based inversion approach explains our travel time data equally well as a traditional smooth inversion approaches, it represents a feasible mean to summarize the structural complexity often found at such a site. Analysis of the inversion results illustrates that bedrock surface clearly deviates from a previously assumed planar surface and exhibits distinct topographic variation across the slope extension. Bedrock topography additionally impacts the intermediate geological units and, thus, this information is critical for further analyses such as geomechanical modeling.