Geophysical Research Abstracts
Vol. 20, EGU2018-10605, 2018
EGU General Assembly 2018

Quantifying ground ice content and its variability in permafrost bodies using geophysical techniques: implications for water release and future water availability

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The cryosphere in mountain regions undergoes currently strong changes due to climate change. Many studies confirm also the impact of enhanced glacier melt on the glacial water contribution during the 21st century. This effect will be strongest for comparatively dry regions, such as Central Asia and the Central Andes. Whereas the effect on glacial melt on long-term water availability and runoff is well investigated, little is known about the contribution of ground ice melt from permafrost regions to total runoff.

One reason is the sparseness of ground truth data (ice content) from permafrost regions, both regarding amount and spatial extent. Without this information, regional permafrost, hydrological, and/or hemispheric land-surface models can neither accurately estimate future permafrost extent and temperature, nor assess the impact of thawing permafrost on runoff. As permafrost and especially its ground ice content is invisible from the surface, remote sensing approaches can only be used for specific landforms, i.e. rock glaciers. However, also in this case the ground ice content, its thickness and its potentially heterogeneous spatial distribution within the rock glacier cannot be determined.

Geophysical surveying is the only alternative to costly and point-scale borehole information and is now widely used in permafrost research to detect and monitor frozen ground and to quantify the ground ice content. A combination of different methods, such as electric/electromagnetic and seismic methods, is hereby used for ground ice quantification over scales of 10 metres to a few kilometres.

In this contribution, we will present geophysical data and subsequently calculated ground ice contents from several survey sites in the Central Andes, where dry conditions increase the importance of thawing permafrost to future runoff. We will focus on the advantages but also the inherent uncertainties of our geophysical approach, including two measurement techniques (electrical resistivity tomography, refraction seismics) and the petrophysical model used to calculate the ice content (Hauck et al. 2011, Mewes et al. 2017). The effect of spatial variability and measurement uncertainty on estimations of future water release from permafrost regions will be discussed.

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Mewes, B., Hilbich, C., Delaloye, R., and Hauck, C. 2017. Resolution capacity of geophysical monitoring regarding permafrost degradation induced by hydrological processes, The Cryosphere, 11, 2957-2974, https://doi.org/10.5194/tc-11-2957-2017.