Upscaling of geophysical measurements: A methodology for the estimation of the total ground ice content at two study sites in the dry Andes of Chile and Argentina

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With climate change and the associated continuing recession of glaciers, water security, especially in regions depending on the water supply from glaciers, is threatened. In this context, the understanding of permafrost distribution and its degradation is of increasing importance as it is currently debated whether ground ice can be considered as a significant water reservoir and as an alternative resource of fresh water that could potentially moderate water scarcity during dry seasons in the future. Thus, there is a pressing need to better understand how much water is stored as ground ice in areas with extensive permafrost occurrence and how meltwater from permafrost degradation may contribute to the hydrological cycle in the region.

Although permafrost and permafrost landforms in the Central Andes are considered to be abundant and well developed, the data is scarce and understanding of the Andean cryosphere lacking, especially in areas devoid of glaciers and rock glaciers.

In the absence of boreholes and test pits, geophysical investigations are a feasible and cost-effective technique to detect ground ice occurrences within a variety of landforms and substrates. In addition to the geophysical surveys themselves, upscaling techniques are needed to estimate ground ice content, and thereby future water resources, on larger spatial scales. To contribute to reducing the data scarcity regarding ground ice content in the Central Andes, this study focuses on the permafrost distribution and the ground ice content (and its water equivalent) of two catchments in the semi-arid Andes of Chile and Argentina. Geophysical methods (Electrical Resistivity Tomography, ERT and Refraction Seismic Tomography, RST) were used to detect and quantify ground ice in the study regions in the framework of environmental impact assessments in mining areas. Where available, ERT and RST measurements were quantitatively combined to estimate the volumetric ground ice content using the Four Phase Model (Hauck et al., 2011). Furthermore, we developed one of the first methodologies for the upscaling of these geophysical-based ground ice quantifications to an entire catchment in order to estimate the total ground ice volume in the study areas.

In this contribution we will present the geophysical data, the upscaling methodology used to
estimate total ground ice content (and water equivalent) of permafrost areas, and some first estimates of total ground ice content in rock glacier and rock glacier free areas and compare them to conventional estimates using remotely sensed data.