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Ground temperature monitoring of the Earth's highest mountain desert: thermal regime and ground ice on the Ojos del Salado (6893 m)

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The Ojos del Salado (27°06'35"S; 68°32'32"W) is situated on the Puna Plateau (Chile/Argentina) within the Andean Dry Diagonal. Due to the extremely arid climate, surface ice is almost absent on the high altitude mountains in the region. However, a significant amount of ice might be contained in the ground ice. The distribution of permafrost is relatively unknown in the region, especially in the area north of 30°S and outside of rock glaciers.

The high altitude periglacial environment of the Puna de Atacama has a continuous transition into the underlying Atacama Desert, which can be considered as the highest desert on the Earth. This transitional zone has a unique mixture of periglacial and aeolian landforms and processes which might even serve as a useful analogue for Mars.

This uninhabited high altitude extreme desert could be a great indicator of recent environmental processes. The possible future climate warming and the consequential ice melting might change the conditions of this environment substantially. These processes can be revealed by long-term field monitoring with a particular focus on the presence and changes of ground ice, debris permanently cemented by frozen water, and liquid water.

To constrain our knowledge on the periglacial conditions of the region, ground temperature have been recorded from 2012 by temperature loggers buried at six sites between 4200-6893 m a.s.l. in the region of Ojos del Salado. Physical and geoelectrical properties of the regolith, local geomorphology, snow coverage data derived from satellite imagery and micrometeorological conditions were surveyed to aid the interpretation of our ground temperature measurements – and to localize the areas with active layer and permafrost.

Our results represent the highest long-term in situ data of ground thermal regimes in the South American Andes. According to these, the widespread presence of ice-bearing permafrost is unlikely below 4600 m a.s.l., but likely above 5300 m a.s.l. on the Ojos del Salado, at 27°S. Continuous permafrost is present around 5800 m a.s.l. (for this environment a 3-phase thermal model for the active layer was created), while at higher altitudes continuous permafrost is present but the active layer is missing or it is very thin.

Our results are consistent with the modelling of Gruber (2012) and fit nicely into the trend of increasing elevation of ice-bearing permafrost towards the north in the Andes – and also consistent with increasing aridity – shown by previous in-situ investigations from the Central Andes at 33.5°S and the Norte Chico.