Geophysical Research Abstracts
Vol. 18, EGU2016-7256, 2016
EGU General Assembly 2016

Assessing the geomorphological sensitivity of cold climate mountains to climate-driven permafrost degradation: the case of the Russian Altai Mountains

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In cold regions, climate change related permafrost thawing is causing geomorphic processes to intensify. This is especially the case in mountain regions, where several studies indicate increased geomorphic activity with the recent thawing of permafrost bodies. In addition to the effect on geomorphic processes, permafrost degradation also results in increased CO_2 and CH4 emissions. This causes a positive feedback mechanism on climate change processes. For both the intensity of geomorphic processes and rate of greenhouse gas (GHG) emissions, little information exists for mountain areas in the permafrost belt worldwide. The Russian Altai Mountains are marginally glaciated and house sporadic and discontinuous permafrost. Due to global warming, temperature and precipitation are changing rapidly in the area, at rates higher than the global average. This result in highly dynamic environmental processes, making the Altai Mountains a potential area to understand the interrelations between geomorphology and permafrost, as influenced by climate change. Due to its marginal nature, permafrost degradation is rapid in the Russian Altai Mountains, and related geomorphological processes (e.g. landslides) are therefore accelerating. Therefore, a geomorphological time-depth analysis will be done focusing on geomorphic permafrost indicators such as rock glaciers, solifluction, permafrost creep, polygon patterned ground, palsas and thermokarst. Mapping the present day situation will be based on fieldwork, existing maps, satellite imagery and ASTER Digital Elevation Models. A specific geomorphological map representing the (peri)glacial geomorphology of the 1960s based on CORONA images will be prepared. In addition, 3D-photomodelling of rock glaciers and solifluction lobes will reveal short-term geomorphic dynamics. To understand the permafrost dynamics (1960s-2100) of the area, a statistical-empirical permafrost model will be used, using topo-climatic factors and temperature data from remote sensing. This will be validated with geomorphologocal and climatological field data and result in permafrost probability maps. Spatio-temporal geomorphic dynamics will be linked to permafrost state and distribution using these regional permafrost probability maps. Quantifying the magnitude of greenhouse gas emissions from thawing permafrost will be done for different permafrost environments. By doing so, this study expects to contribute to the understanding of the geomorphological sensitivity of cold climate mountains to climate-driven permafrost degradation, and to assess the potential of such mountains to greenhouse gas emissions.