CONSIDERATION OF PERMAFROST AND PERMAFROST DEGRADATION IN NATURAL HAZARDS AND RISK ASSESSMENT

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INTRODUCTION

Permafrost is defined as soil or rock at or below the freezing point of water for two or more years. Due to this direct relation to temperature, permafrost is highly sensitive to climatic changes. Permafrost degradation and related natural hazards potentially affect traffic routes, tourism areas, infrastructures and settlements. So far, data on permafrost are spatially inconsistent and a map of the permafrost distribution in the entire Alpine Space does not exist. Furthermore, the relevance of subsurface ice content in rock glaciers and scree slopes for the hydrologic regime of alpine watersheds to be considered in water resources management is unknown.

Searching for an objective and scientifically sound way to consider permafrost in natural hazard management reasonably, the Autonomous Province of Bolzano/Bozen found that a commonly accepted strategy to tackle the emerging impacts of climate change in risk prevention and territorial development does not exist. In common natural hazards and risk management practice the effects of permafrost and permafrost degradation on the intensity and frequency of rockfall, landslides and debris flows are either neglected or overestimated. Especially the mass media and environmental organizations spread and force the assumption that permafrost degradation influences directly and in all cases on the intensity and frequency of natural hazards. But, decision makers and stakeholders need to be provided with objective and consolidated information about this topic to manage the consequences of climate change impacts on permafrost and the related natural hazards in a sustainable way. Due to the gap in objective data and the lack of a common strategy, the Autonomous Province of Bolzano/Bozen initiated an Alpine Space 2007-2013 project and set up a competent partnership. 14 project partners and more than 20 observers from governmental organizations, universities and research institutes are working together to reach the objectives of the project "PermaNET – Long-term permafrost monitoring".

The overall aim of the PermaNET project is to develop a common strategy for dealing with permafrost and related natural hazards under changing climatic conditions. The project aims to enforce good governance practices on the base of a common knowledge, of a jointly developed data base and of a commonly accepted strategy.

METHODS

The first step of the project was the setup of a network of permafrost monitoring stations in the Alps. All metadata of the key permafrost monitoring sites in the Alps were collected and compiled into a database. In regions without or with large gaps of monitoring sites new key monitoring sites were set up. The monitoring network consists of instrumented boreholes, repeated temperature measurements, repeated measurements of soil or slope movements and repeated geophysical measurements. The database has been published on the project website and is queryable. To ensure the comparability of the data from different monitoring stations, a handbook with guidelines, standards and technical requirements for setting up new monitoring stations has been elaborated. Furthermore, recommendations for building up permafrost monitoring networks have been compiled.

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In a second step, an inventory of all permafrost evidences has been compiled. All direct observations such as ice lenses, ice in rock fractures or ground ice are compiled into a single database for the whole Alps. Indirect evidences for permafrost like rock glaciers or perennial snow patches are also mapped and inserted into the inventory. The inventory contains much more than 4000 rock glaciers from nearly all parts of the Alps.
A new model for calculating the potential distribution of permafrost in the Alps has been developed and evaluated on the basis of the permafrost evidences inventory. This model provides the base to generate a map of the permafrost distribution of the whole Alpine Chain.
In further steps, different methods for monitoring slope movements and rock falls in permafrost areas are tested and evaluated. All the methods are examined in a SWOT analysis. The most promising techniques for permafrost detection and monitoring of related hazards are compiled in a handbook. A state of the art report on the effects of climate change to permafrost and related natural hazards has been elaborated. In this report, all possible effects of permafrost and permafrost degradation on natural hazards are pointed out, illustrated by a number of examples and well documented key events and sites. Based on the SWOT analysis and of the state of the art report, all the partners will formulate common recommendations for the consideration of the effects of climate change on permafrost and resultant natural hazards.

RESULTS AND DISCUSSION

So far, knowledge and awareness about permafrost and the effects of climate change on permafrost phenomena and related hazards is fragmented and differs throughout the Alps. The preliminary results of the project already show that different natural hazards such as debris flows, landslides and rock falls may be related to permafrost and especially to permafrost degradation. Indeed there is no common and simple relationship between permafrost and hazard scenarios; every case has to be analyzed singularly. But for all planning tasks in the high mountain environment the most important thing is to know if permafrost is absent or occurs actually or just probably. If there is permafrost, than the possible (negative) effects on the planned activity have to be taken into account. There are very different and more or less expensive ways to mitigate these effects: constructive measures, soil consolidation, or monitoring systems.
However, a raised awareness against the existence of mountain permafrost and the possible adverse effects to economic activities helps to calculate the efficiency and sustainability of investments. The outcome of the project, based on the experiences, measurements, common datasets and maps as well as compiled recommendations of 15 partners provides a well consolidated decision base.

Keywords: permafrost, climate change, risk assessment, rockfall, debris flows