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GIS-aided permafrost mapping in the Brahmaputra river basin, Southern and Eastern Asia

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Permafrost occurrence, glacier distribution, and glacier changes are investigated for the area of the Upper Brahmaputra River Basin using remote sensing and GIS. The aim of the study is to determine the influence of degrading permafrost and melting glaciers on the long-term runoff of the Brahmaputra River. The work is embedded in the EU-project BrahmaTWinn which aims at quantifying climate change impacts on the Brahmaputra (Himalaya) and Inn (European Alps) river basins, and at investigating and comparing related water resources management strategies and policies.

Here we report about the assessment of the regional permafrost distribution. Little is known about the permafrost distribution in the Himalayan mountain ranges. The permafrost distribution in the Himalayan study region is estimated using regionally adapted versions of two empirical models, both originally developed to estimate the permafrost distribution on a regional scale in the Swiss Alps. One model (PERMAKART, Keller 1992) applies a topo-climatic key, established by Haeberli (1975), based on the relation between altitude above sea level, exposure, and permafrost probability. This model differentiates three permafrost categories: ‘probable permafrost’, ‘possible permafrost’ and ‘no permafrost’. A speciality of the model is its ability to consider the effects of long-lasting avalanche snow deposits in slope foot areas on the permafrost distribution. The second model (PERMAMAP, Hoelzle 1996) is based on a (linear) spatial relation between the bottom temperature of the winter snow cover (BTS), the mean annual air temperature (MAAT) and the potential direct solar radiation. In contrast to PERMKART, PERMAMAP allows the detection of permafrost occurrences at low altitudes (for instance, in extremely shaded areas) but does not take slope foot areas into account. The model distinguishes between two permafrost categories: ‘probable permafrost’ and ‘no permafrost’.

Adaptation of the models is done through the inclusion of ground based meteorological station measurements and validated using distribution patterns of periglacial landforms such as rock glaciers. The latter are mapped from high resolution satellite data such as CORONA and Quickbird imagery.

Due to inherent differences of the two models (empirical relationships in PERMAKART, statistical relationships in PERMAMAP) each model has certain advantages and disadvantages. These have to be taken into account when interpreting the results. PERMAKART represents the permafrost distribution in slope foot areas better than PERMAMAP. However, at the considered latitudes, the PERMAKART model tends to overestimate the permafrost occurrence. PERMAMAP, on the other hand, depicts the permafrost distribution more accurately in southerly exposed slopes and rock walls. However, this model cannot depict foot slope areas. Especially its results in northerly exposed foot of slope areas have, therefore, to be considered as too conservative.