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# Climate, glaciers and permafrost in the Swiss Alps during the first half of the 21st century: scenarios, consequences and recommendations

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In March 2007, the Advisory Body on Climate Change created in 1996 by the Swiss Academy of Sciences on behalf of the Swiss Federal Government published a report on climate change and Switzerland for the year 2050. Based on corresponding assessments for various sectors of the environment, the economy and the society, recommendations were prepared to the Swiss Federal Government. The present contribution summarizes the results concerning glaciers and permafrost in the Alps as an example of such analyses in cold high-mountain regions at lower latitudes. Scenarios of climatic conditions in 2050 as simulated using high-resolution ensemble modelling (16 model chains, 2 emission scenarios, 4 global and 8 regional climate models) for Europe from results of the EU-funded PRUDENCE project are based on the assumption that mitigation policies will only have a major influence in the second part of the 21st century and that the time horizon of 2050 could mark a transition to much more severe conditions at later stages. Mean temperature rise untill 2050 is estimated at + 2°C (uncertainty +1 to +5°C) in fall, winter and spring and +3°C (uncertainty +2 to +7°C) in summertime. Precipitation is assumed to rise by 10% in wintertime but to decrease by 20% in summertime. A trend towards more frequent and intense heat waves, probably also of droughts is expected in summertime. Cold waves in wintertime will probably decrease in number and intensity. As a consequence, about 75% of the glacier area may disappear and deep warming and degradation of permafrost on high-altitude slopes and within mountain peaks will take place. In contrast to the fast disapperance of surface ice, permafrost inside mountain peaks will continue to exist for time peri-

ods of many decades if not centuries or even millennia. This long-surviving permafrost will be warm and far out of equilibrium conditions. A special aspect to be treated is the widespread contact and interaction between surface and subsurface ice in complex high-mountain topography. Impacts primarily concern rather dramatic changes in landscape appearance, slope stability and the water cycle. The formation of lakes in the forefields of retreating and collapsing glaciers together with the decreasing stability of rock walls with warming permafrost leads to an increasing probability of major rock falls impacting onto water bodies and triggering dangerous floodwaves. A special recommendation was therefore provided to systematically assess the safety of natural, artificial and newly forming lakes in the Alps.