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Assessment of adaptation measures to high-mountain risks in Switzerland under climate uncertainties

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The economic evaluation of different adaptation options is important to support policy-makers that need to set priorities in the decision-making process. However, the decision-making process faces considerable uncertainties regarding current and projected climate impacts. First, physical climate and related impact systems are highly complex and not fully understood. Second, the further we look into the future, the more important the emission pathways become, with effects on the frequency and severity of climate impacts. Decision on adaptation measures taken today and in the future must be able to adequately consider the uncertainties originating from the different sources. Decisions are not taken in a vacuum but always in the context of specific social, economic, institutional and political conditions. Decision finding processes strongly depend on the socio-political system and usually have evolved over some time. Finding and taking decisions in the respective socio-political and economic context multiplies the uncertainty challenge. Our presumption is that a sound assessment of the different adaptation options in Switzerland under uncertainty necessitates formulating and solving a dynamic, stochastic optimization problem. Economic optimization models in the field of climate change are not new. Typically, such models are applied for global-scale studies but barely for local-scale problems. In this analysis, we considered the case of the Guttannen-Grimsel Valley, situated in the Swiss Bernese Alps. The alpine community has been affected by high-magnitude, high-frequency debris flows that started in 2009 and were historically unprecendented. They were related to thaw of permafrost in the rock slopes of Ritzlihorn and repeated rock fall events that accumulated at the debris fan and formed a sediment source for debris flows and were transported downvalley. An important transit road, a trans-European gas pipeline and settlements were severely affected and partly destroyed. Several adaptation measures were discussed by the responsible authorities but decision making is particularly challenging under multiple uncertainties.

For this area, we developed a stochastic optimization model for concrete and real-case adaptation options and measures and use dynamic programming to explore the optimal adaptation decisions under uncertainty in face of uncertain impacts from climate change of debris flows and flooding. Even though simplification needed to be made the results produced were concrete and tangible, indicating that excavation is a preferable adaptation option based on our assumption and modeling in comparison to building a dam or relocation, which is not necessarily intuitive and adds an additional perspective to what has so far been sketched and evaluated by cantonal and communal authorities for Guttannen. Moreover, the building of an alternative cantonal road appears to be more expensive than costs incurring due to road closure.