Performance and application of RCM results in high-mountain regions - Analyses for cryospheric process modeling

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The hydrological cycle is a major component of the climate system and a significant climate change impact driver. Freshwater availability and water management are among the biggest challenges facing mankind in the coming decades. Over 50% of the world's rivers have their source in mountain regions, with the cryosphere controlling a significant portion of the discharge rates and the timing of hydrological runoff. Therefore, the mountain cryosphere, a particular climate sensitive system due to its proximity to melting conditions, is a key factor affecting changes in the hydrological cycle.

Among the most promising tools to simulate climate variables in mountain areas for the past, the present and the future are Regional Climate Models (RCMs). Due to their higher horizontal resolution (10 – 50 km) compared to GCMs (~ 200 km), they are able to better resolve the atmospheric dynamics caused by the heterogeneous surfaces of mountain topography. Large projects such as the North American Regional Climate Change Program 'NARCCAP' (or PRUDENCE and ENSEMBLES in Europe), are now serving the climate impacts community with promising RCM results. However, for applications on local scales in mountain environments with complex topography, further downscaling is typically still required. Also, the performance of variables from RCM output must be proven previous to specific applications, because model performance is not simply transferable between variables and regions.

In a first part, I will discuss general challenges associated with the use of RCM results in mountain regions, such as spatial scale mismatch, model uncertainties or insufficient knowledge about climate sensitivities. I will then discuss possible approaches on how to cope with these constraints and present some application of RCM results for the simulation of mountain permafrost evolution at a site in the European Alps. In a second part, the focus will mainly be on analyses of NCEP-driven RCM simulations from NARCCAP. The results from five RCMs are analyzed regarding their performance to simulate the seasonal snow cover in the Upper Colorado River Basin (UCRB). The Colorado River is the major water resource for millions of people living in the surrounding areas. Some of the highest peaks of the Rocky Mountains gather in the UCRB and the high mountain seasonal snow pack contributes about 70% of the annual run off. On average, about 90% of the Colorado River's annual streamflow is generated in the relatively small area (about 500 km2) of the UCRB. Various variables from the RCMs are analyzed from a 'impacts perspective', including amongst others, the annual snow cycle (SWE), duration and dynamics of a significant snow cover, time of maximum snow cover, total accumulated precipitation and air temperature.