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Using a stochastic climate generator for simulating global warming effects on the water resources in a mountain basin

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To understand and predict the potential effects of climatic change on the water resources it is necessary to be aware of the nonlinearity and complexity of the interactions between the climate and the land surface, and to consider the dependency on the scale on which these interactions are investigated. Regional climate models can be utilized to provide the necessary meteorological input data for smaller scale hydrological models. However, in alpine areas the uncertainty in the downscaling increases with the relief gradient that has to be considered in the hydrological scale. We have developed a stochastical procedure to derive long time series of synthetical future climate from measured historical records. Therefor, discrete time slices of continuous meteorological datasets are re-arranged in such a way that a given IPCC temperature trend is represented: in our case, the B2 scenario which predicts a temperature increase of 2.7 K until 2100. To build together the future data set, the procedure applies a random variation of temperature, overlays the trend, and makes use of the statistical relation between mean temperatures and mean precipitations to select the appropriate time slice from the given basic population. The most important advantage of the described procedure is that the physical plausibility of the observations is conserved; furthermore, the model input is in the validated range, its spatial resolution is consistent, and the processing is computationally highly efficient. However, there are also some limitations: e.g., future extremes are limited to historical events, or the auto-correlation between the time slices is not preserved. The stochastic climate generator has been applied to weekly episodes of a 7 year meteorological dataset from a network of climate stations in the high alpine area of the Berchtesgaden National Park (Germany). Then an energy balance snow cover model was applied to continuously simulate the seasonal evolution of the snow cover under the B2 conditions until 2100. Results show that the increase of temperature and decrease of precipitation is accompanied by an increase of radiation, and both duration and height of the snow cover decrease significantly. The presented expert simulation scheme indicates that it is feasible to assess climate change effects with physically based models even for scenario durations according to the IPCC horizon. Limitations, mainly originating in the quality and features of the available data, are discussed.