Climate Change and Runoff statistics: a process study for the Rhine basin using a coupled climate-runoff model

Jan Kleinn, Christoph Frei, Joachim Gurtz, Pier Luigi Vidale, Christoph Schär
Institute for Atmospheric and Climate Science, ETH Zurich

The consequences of extreme runoff and extreme water levels are within the most important weather induced natural hazards. The question about the impact of a global climate change on the runoff regime, especially on the frequency of floods, is of utmost importance.

In winter-time, two possible climate effects could influence the runoff statistis of large Central European rivers: the shift from snowfall to rain as a consequence of higher temperatures and the increase of heavy precipitation events due to an intensification of the hydrological cycle. The combined effect on the runoff statistics is examined in this study for the river Rhine. To this end, sensitivity experiments with a model chain including a regional climate model and a distributed runoff model are presented. The experiments are based on an idealized surrogate climate change scenario which stipulates a uniform increase in temperature by 2 Kelvin and an increase in atmospheric specific humidity by 15% (resulting from unchanged relative humidity) in the forcing fields for the regional climate model.

The regional climate model CHRM is based on the mesoscale weather prediction model HRM of the German Weather Service (DWD) and has been adapted for climate simulations. The model is being used in a nested mode with horizontal resolutions of 56 km and 14 km. The boundary conditions are taken from the original ECMWF reanalysis and from a modified version representing the surrogate scenario. The distributed runoff model (WaSiM) is used at a horizontal resolution of 1 km for the whole Rhine basin down to Cologne. The coupling of the models is provided by a downscaling of the climate model fields (precipitaion, temperature, radiation, humidity, and wind) to the resolution of the distributed runoff model. The simulations cover the five winter seasons 1989/90 till 1993/94, each from November until January.

A detailed validation of the control simulation shows a good correspondance of the precipitation fields from the regional climate model with measured fields regarding the distribution of precipitation at the scale of the Rhine basin. Systematic errors are visible at the scale of single subcatchements, in the altitudinal distribution and in the frequency distribution of precipitation. These errors only marginally affect the runoff simulations, which show good correspondance with runoff observations.

The presentation includes results from the scenario simulations for the whole basin as well as for Alpine and lowland subcatchements. The change in the runoff statistics is being analyzed with respect to the changes in snowfall and to the fequency distribution of precipitation.

Jan Kleinn
Institute for Atmospheric and Climate Science ETH
Winterthurerstr. 190
8057 Zürich1
Tel. +41-1-635 52 34
e-mail: kleinn@geo.umnw.ethz.ch