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Impact analysis of climate change for an Alpine catchment using high resolution dynamic downscaling of ECHAM4 time slices

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Abstract. Global climate change affects spatial and temporal patterns of precipitation and so has a major impact on surface and subsurface water balances. While global climate models are designed to describe climate change on global or continental scales, their resolution is too coarse for them to be suitable for describing regional climate change. Therefore, regional climate models are applied to downscale the coarse meteorological fields to a much higher spatial resolution to take account of regional climate phenomena. The changes of atmospheric state due to regional climate change must be translated into surface and sub-surface water fluxes so that the impact on water balances in specific catchments can be investigated. This can be achieved by the coupled regional climatic/hydrological simulations presented here. The non-hydrostatic regional climate model *MCCM* was used for dynamic downscaling for two time slices of a global climate model simulation with the GCM *ECHAM4* (IPCC scenario *IS92a*, "business as usual") from $2.8^\circ \times 2.8^\circ$ to $4 \times 4 \text{ km}^2$ resolution for the years 1991–1999 and 2031–2039. This allowed derivation of detailed maps showing changes in precipitation and temperature in a region of southern Germany and the central Alps. The performance of the downscaled *ECHAM4* to reproduce the seasonality of precipitation in central Europe for the recent climate was investigated by comparison with dynamically downscaled *ECMWF* reanalyses in $20 \times 20 \text{ km}^2$ resolution. The downscaled *ECHAM4* fields underestimate precipitation significantly in summer. The ratio of mean monthly downscaled *ECHAM4* and *ECMWF* precipitation showed little variation, so it was used to adjust the course of precipitation for the *ECHAM4/MCCM* fields before it was applied in the hydrological model. The high resolution meteorological fields were aggregated to 8-hour time steps and applied to the distributed hydrological model *WaSiM* to simulate the water balance of the alpine catchment of the river Ammer (c. 700 km^2) at $100 \times 100 \text{ m}^2$ resolution. To check the reliability of the coupled regional climatic/hydrological simulation results for the recent climate, they were compared with those of a station-based hydrological simulation for the period 1991–1999. This study shows the changes in the temperature and precipitation distributions in the catchment from the recent climate to the future climate scenario and how these will affect the frequency distribution of runoff.

Keywords: coupled climate-hydrology simulations, dynamic downscaling,

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