Geophysical Research Abstracts
Vol. 20, EGU2018-8505, 2018
EGU General Assembly 2018

Very High Resolution Regional Climate Simulations for Germany and the Alpine Space: Optimized Model Setup, Performance in High Mountain Areas and Expected Future Climate

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Mountain regions are a particular challenge for regional climate simulations. The complex orography requires high spatial resolutions to account for the changing climate zones within short horizontal distances due to elevation differences. We present results from a new very high resolution regional climate simulation, based on RCP4.5 and dynamically downscaled with WRF for 1980-2009 (ERA-Interim reanalysis and MPI-ESM control run) and the future time slice 2020-2049. Horizontal resolution is 5 km and thereby close to convection permitting resolution. Before the regional climate simulations, we identified an optimized model configuration by evaluating an ensemble of combinations of microphysics-, radiation-, and PBL schemes. Significant differences in the quality of reproducing precipitation and temperature characteristics have been found. Averaged over Germany, annual mean temperature varies by 1.6°C, and annual precipitation by 120 mm depending on the model configuration. The regional and seasonal differences are even larger. The best combination of schemes shows a cold bias of approximately -1°C and a wet bias of 10 mm averaged over Germany on the annual scale.

The evaluation of our long term 5km resolution simulations focuses on the performance of the reanalysis- and control runs to reproduce temperature, precipitation, humidity, radiation and wind station observations in the region of the Berchtesgaden Alps, southern Germany, as well as to interpolated REGNIE precipitation observations in 1km spatial resolution. The station network, operated by the Nationalparkverwaltung Berchtesgaden, is unique in its density and allows evaluations particularly in high elevations. Depending on the elevation difference between station and grid cell, R2 values for hourly, daily and monthly air temperature are in the range of 0.8 to 0.95, with a RMSE of approximately 1°C for ten years of observations. R2 for monthly precipitation is 0.63 with a RMSE of 52 mm compared to 30 years of REGNIE observation data for the region of the Berchtesgaden Alps.

We show the elevation and season dependent expected climate change signals till 2050 and find particular effects. The mean warming in the study region Berchtesgaden Alps is shown to be between 0.95 und 1.03 °C. We find the strongest increase in temperature during winter and spring seasons, whereas warming is less distinct in summer and fall (around 1°C less warming in fall than in spring season). A clear increase in warming with elevation is found in summer and spring months, whereas this effect is abundant during winter. Annual precipitation is shown to increase between 104 and 275 mm in the study region, but is almost unchanged during summer and spring at high elevations. The increase in annual precipitation is mainly composed of a strong increase in fall and winter precipitation at all elevation levels.

We finally briefly report and conclude on current further use of the high resolution data set for the delineation of climate adaptation strategies in cooperation with climate managers of several administrative counties in southern Bavaria.