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Analysing the bandwidths of hydrological change in small river catchments using an ensemble of high-resolution regional climate model projections

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Projections of the 21st century potential future climate evolution, especially for precipitation, are associated with high uncertainty and variability. Knowledge of the variability of the projected precipitation and resulting run-offs and the sources of uncertainties form the basis for analysis and assessment of future water-management options as well as potential risks related to droughts and flood events. The variabilities related to climate modelling can only be assessed by using a comparatively large number of climate projections.

In our research, we apply a large ensemble of regional climate model projections from the regional climate model REMO, driven by different global climate model simulations, at high temporal (hourly timestep) and high spatial (0.11 degree, or about 12.5 km) resolutions. Although the analysis of such big datasets involves considerable computational and storage capacities, this potentially helps to improve the simulation of future hydrological quantities in river catchments. For the analysis of the behaviour of small river catchments, we apply a semi-distributive hydrological model. Annual and winter average precipitation conditions show a robust and statistically significant increase especially for the RCP8.5 scenario. Precipitation ranges are compared with the ranges of runoff based on hydrological impact model runs driven by a set of simulated parameters from the regional climate model ensemble. The analyses are performed for a sub-catchment of the Lower Elbe system (Krückau catchment), which is a typical small basin (area < 200km^2) close to the city of Hamburg in northern Germany. The model runs cover a long simulation period of 150 years (1950-2100) with a temporal resolution of 1 day. Short term model runs with a temporal resolution of 1 hour were carried out for annual and seasonal (summer/winter) maximum runoff derived from the long-term simulations.

Average annual runoff shows an increase of 0 to 10 % for the RCP2.6 ensemble and an increase of 0 to 20 % for the RCP8.5 ensemble at the end of the 21st century. Annual and winter average conditions (precipitation sums and average runoff) of the RCP8.5 ensemble show a robust increase across different ensemble simulations. Extreme events however show high variability and no conclusive and robust trend. Analysis shows a good relation between average values of precipitation and average runoff (MQ). Future development of simulated annual maximum runoffs

shows only a weak relation with future simulated precipitation extremes. However, summer maximum runoffs tend to show a relation with summer precipitation extremes. The behaviour of winter runoffs might be explained by altered future conditions of snow aggregation and melt in combination with high soil moisture. With increasing average and extreme temperatures, snow fall, snow accumulation and concentrated runoff caused by snow melt in spring are less likely to occur.

One of the conclusions drawn is that especially for assessing extreme precipitation and its impacts on small hydrological catchments it is necessary to apply regional climate model projections with high spatial and temporal resolution where further improvement is expected by making use of the upcoming generation of climate simulations on convection permitting scale.