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Hydrological cycle in the Danube basin in present and projected future climate conditions: a models' intercomparison perspective

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We present an intercomparison and verification analysis of several GCMs and RCMs included in the 4th IPCC assessment report on their representation of the hydrological cycle on the Danube river basin for present and (in the case of the GCMs) projected future climate conditions. The basin-scale properties of the hydrological cycle are computed by spatially integrating the precipitation, evaporation, and runoff fields using the Voronoi-Thiessen tessellation formalism.

Large discrepancies exist among RCMs for the monthly climatology as well as for the mean and variability of the annual balances, and only few data sets are consistent with the observed discharge values of the Danube at its Delta. This occurs in spite of common nesting of the RCMs into the same run of the same AGCM, and even if the driving AGCM provides itself an excellent estimate. We find consistently that, for a given model, increases in the resolution do not alter the net water balance, while speeding up the hydrological cycle through the enhancement of both precipitation and evaporation by the same amount. We propose that the atmospheric components of RCMs still face difficulties in representing the water balance even on a relatively large scale. Moreover, since for some models the hydrological balance estimates obtained with the runoff fields do not agree with those obtained via precipitation and evaporation, some deficiencies of the land models are also apparent.

In the case of the GCMs, the span of the model- simulated mean annual water balances is of the same order of magnitude of the observed Danube discharge of the Delta; the true value is within the range simulated by the models. Some land components seem to have deficiencies since there are cases of violation of water conservation when annual means are considered. The overall performance and the degree of agreement of the GCMs are, surprisingly, comparable to those of the RCMs.

Both RCMs and GCMs greatly outperform the NCEP-NCAR and ERA-40 reanalyses in representing the present climate conditions. The reanalyses result to be largely inadequate for describing the hydrology of the Danube river basin, both for the reconstruction of the long-term averages and of the seasonal cycle. The reanalyses cannot in any sense be used as verification.

In global warming conditions, for basically all models the water balance decreases, whereas its interannual variability increases. Changes in the strength of the hydrological cycle are not consistent among models: it is confirmed that capturing the impact of climate change on the hydrological cycle is not an easy task over land areas. We note that for some of the diagnostics the ensemble mean does not represent any sort of "average" model, and it often falls between the models' clusters.

We suggest that these results should be carefully considered in the perspective of auditing climate models and assessing their ability to simulate future climate changes.