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Does solving the energy balance improve Rhine streamflow simulations?

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Improving streamflow predictions in large river basins is a main research topic of land surface hydrology. Short (weeks) to medium-range (1-3 years) streamflow predictions are required for improving water management strategies, especially in a densely populated catchment such as the Rhine basin. To correctly estimate streamflow in a river basin hydrology model, it is essential to have realistic description of the most important land surface processes. Of particular interest in this presentation is the calculation of evapotranspiration. In simple water balance models evapotranspiration parameterization schemes are usually a function of temperature. In current day land surface models (LSM), evapotranspiration is derived from coupled water and energy balance computations. Therefore, LSMs carry the potential for a more realistic representation of evapotranspiration and thus surface runoff and streamflow. On the other hand, LSMs are usually more complex and more difficult to calibrate.

In this study we compare a water balance model, STREAM, with a widely used LSM, the Variable Infiltration Capacity (VIC) model for the Rhine catchment. Both models are forced with a downscaled version of ECMWF re-analysis data (ERA15) at a resolution of 0.088 degree. Forcing data is available between 1993 and 2003 at a 3-hourly time step. Both models are calibrated using streamflow data at the basin outlet from 1993 and validated using data from the remaining period. We evaluate the performance of both models by comparing simulated and observed streamflow from major tributaries and at several locations along the main branch of the Rhine river. From the resulting hydrographs, peak flow and low flow statistics are derived and analyzed. In addition, simulation of evapotranspiration is evaluated directly by comparison with lysimeter observations. Using these results we investigate the influence of a more physically-based representation of evapotranspiration and increased model complexity on streamflow simulation. We find that streamflow at the basin outlet is better simulated by STREAM, whereas at other locations in the basin VIC performs better. Also, evapotranspiration simulated by VIC yields a higher correlation with lysimeter observations than evapotranspiration simulated by STREAM.