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Hyper-resolution hydrological modelling over Europe: results and emerging challenges

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Performing hydrological simulations at 'hyper-resolution', that is at or below a spatial resolution of 1 km, was and still is a major challenge in hydrological sciences. However, as computational power and the number of readily available and open datasets at useful spatial resolutions increase, several hyper-resolution modelling efforts have been taken. Here, we present a first continental-scale application of the global hydrological model PCR-GLOBWB over Europe at 1 km spatial resolution. To isolate the effect of resolution refinement, results are compared with runs at the thus far 'default' resolutions of 10 km and 50 km, respectively. A range of modelled states and fluxes was evaluated against observations: discharge, evaporation, soil moisture, and terrestrial water storage. Evaluation metrics indicate increased accuracy with finer spatial resolutions for simulated discharge. For the other variables, results are mixed possibly due to the coarse resolution of the validation products: while the used validation products have the advantage of long observational records which helps establishing a robust baseline understanding, their spatial resolution may be too coarse to fully assess the accuracy of models at hyper-resolution. At that scale, more recent satellite products can be of more use but at the cost of only short observation record. We thus additionally validated 1 km model output against additional validation products at finer spatial resolution. Furthermore, 1 km output of PCR-GLOBWB is benchmarked against 1 km output over the UK indicating that additional emphasis needs to be put on model parameterization. Despite these outstanding challenges, our findings shows that large-scale hyper-resolution modelling is now feasible and that further pursuing these efforts can eventually lead to more locally-relevant hydrological information and process understanding.