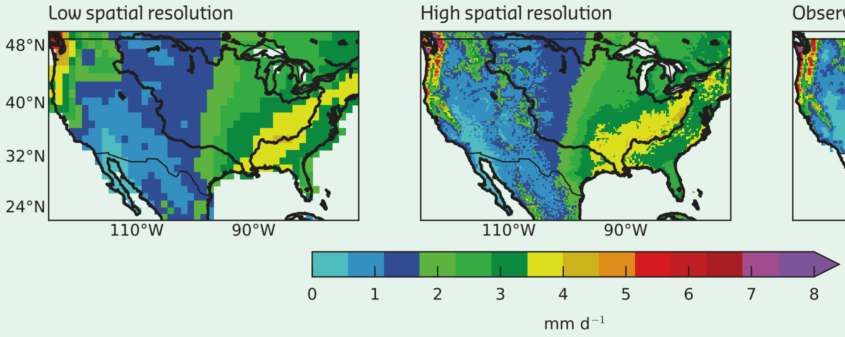
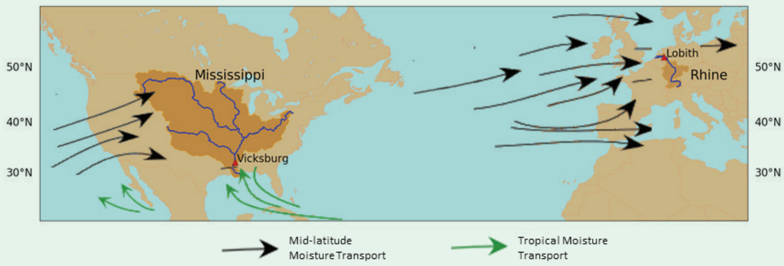


Thirty-year average of daily precipitation sums for the Mississippi basin

AN IMPROVED HYDROLOGICAL CYCLE WITH HIGH-RESOLUTION MODELS

Hydrological simulations on a global scale can generally be im-proved by enhancing the spatial resolution of climate and hydrological models. Higher resolutions also allow us to simulate extreme weather better. However, the spatial resolution of models is restricted by computational resources.



Climatological location of mid-latitude moisture transport (black arrows) and tropical moisture transport (green arrows) for the Rhine and Mississippi basins

During a PhD research project, Imme Benedict tested the benefits of global climate and hydrological models with exceptionally high horizontal resolution by analysing precipitation and discharge in two well-known basins: the Mississippi and Rhine deltas. The expectation was that large-scale meteorological processes would be better simulated and small-scale extremes would be more pronounced after spatial resolution was enhanced. In addition, river delineation and land use was expected to be represented better. Coarse- and high-resolution simulations of a state-of-the-art climate and hydrological model were compared for two very distinct river basins: the large Mississippi basin, where moisture input from the Pacific and the Caribbean is a major factor, and the Rhine basin, which is moderate in size and receives most of its precipitation from mid-latitude cyclones.

Higher horizontal resolution (~25 by 25 km instead of 125 by 125 km) led to a significant improvement in the representation of precipitation in the Rhine basin because large-scale circulation patterns were represented better. This improvement could not have been achieved by regional downscaling from coarse-resolution climate models and this conclusion underlines the need for high-resolution global models for the Rhine basin. By contrast, the precipitation budget for the Mississippi does not change with increased horizontal resolution, most likely because it is highly dependent on the representation of even smaller-scale convective processes. Downscaling is therefore more appropriate for the Mississippi basin.

We used precipitation, potential evaporation and temperature from the global climate model as input for our hydrological model in order to establish the discharges. We found that the precipitation signals were clearly reflected in the discharge and evaporation budgets for the two basins. Switching to a higher horizontal resolution in a hydrological model (~5 by 5 km instead of 50 by 50 km) is a complex task because it depends very much on the availability of the required input parameters. We remapped the parameters from the 50 km to the 5 km resolution – except for orography and vegetation – to raise resolution in the hydrological model. However, no significant changes in discharge were found in either basin with this higher resolution. Nevertheless, the improved precipitation obtained with the global climate model was reflected in improved actual evaporation and discharge with the hydrological model. Improvements in discharge are expected with high-resolution hydrological models if hydrological processes and parameters are better understood and described.

We conclude that raising resolution in the global climate model is the most straightforward way of obtaining better results for regions situated along the mid-latitude storm-track such as the Rhine basin. In the case of basins driven by convective processes, such as the Mississippi, improvements are expected with even higher-resolution models that include convection.

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Further reading:
https://www.hydrol-earth-syst-sci-discuss.net/hess-2017-473/