

Background

Predicting the human impact on the present and future hydrologic cycle remains a significant scientific challenge. Anthropogenic impact includes water management practices like diverting water for irrigation, abstraction of groundwater, and reservoirs. Hydrologic extremes, in particular, are heavily affected by water management practices, due to the existing stress on the system during droughts and floods. Therefore, to prepare adaptation plans for hydrological extremes in the future, it is essential to account for water management and other human influences in Earth System Models. In this study we have implemented water management practices in the state-of-the-art GFDL land model, which includes terrestrial water, energy, and carbon balances. Both irrigation practices and reservoir operations have been added in the land surface model component of the model.

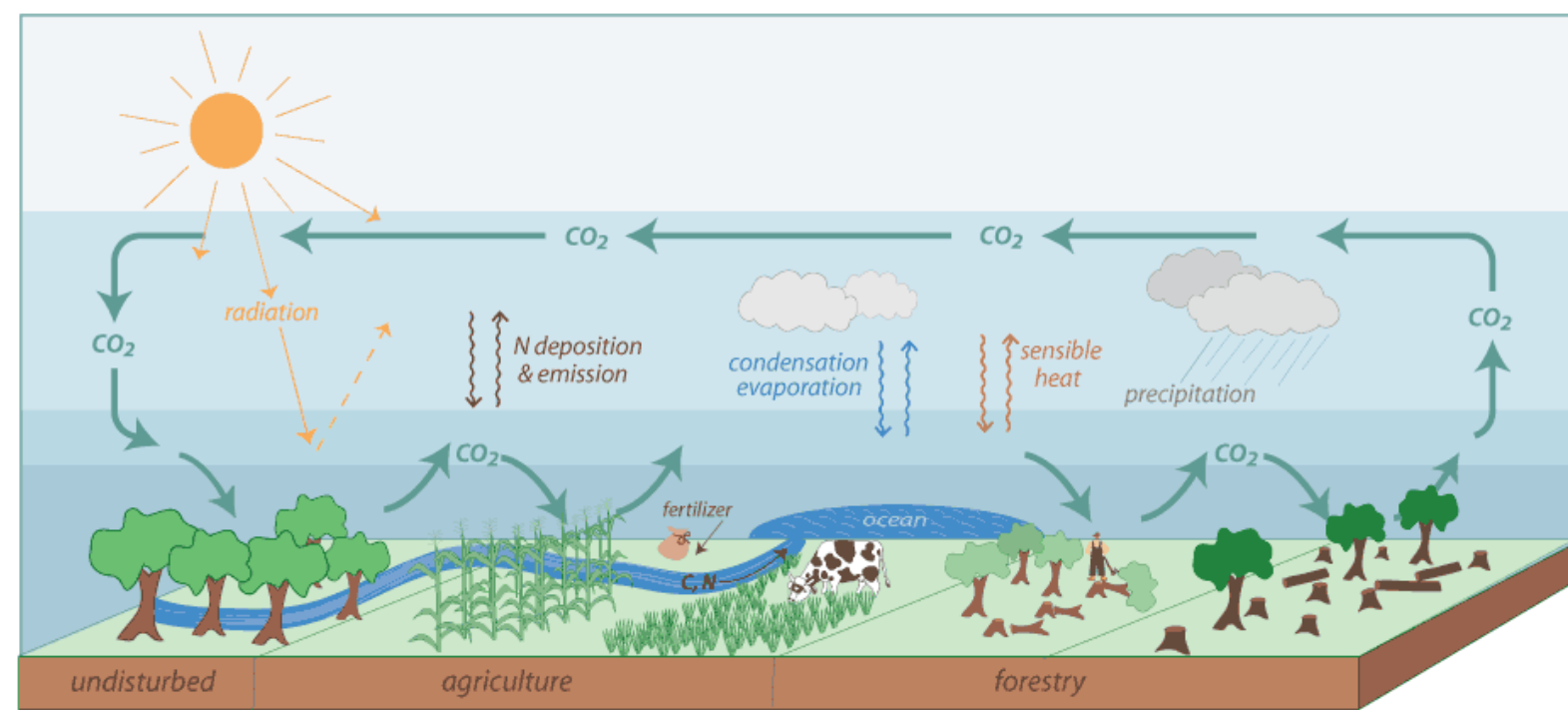


Fig. 1 Overview of the GFDL Land Model

Model setup

- 1 by 1 degree
- Spin-up for land use change from 1860-1960
- Offline land model with meteorological forcing from Princeton Global Forcing Dataset (Sheffield et al., 2006)
- Simulation with/without irrigation 1960-1999
- Model time step 30 minutes

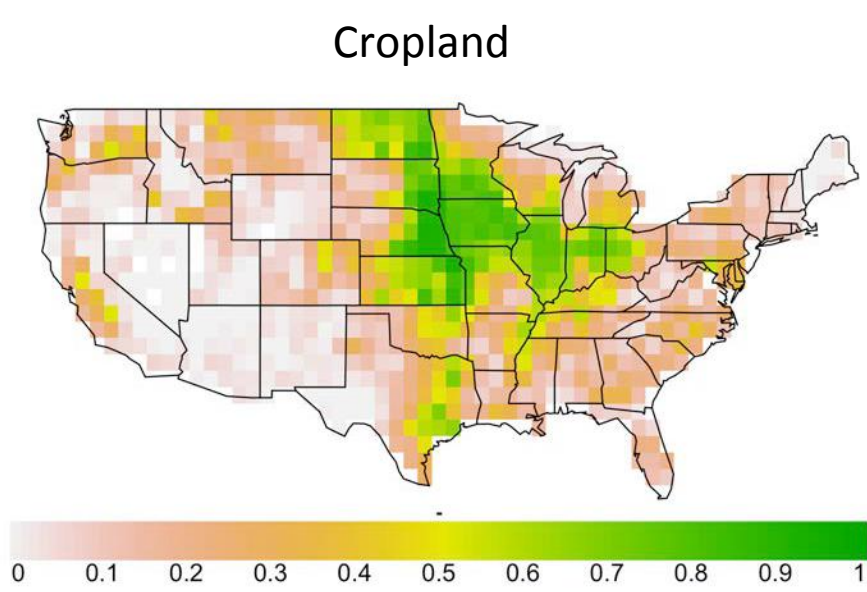


Fig. 2 Fraction of cropland in each grid cell (average 1960-2000)

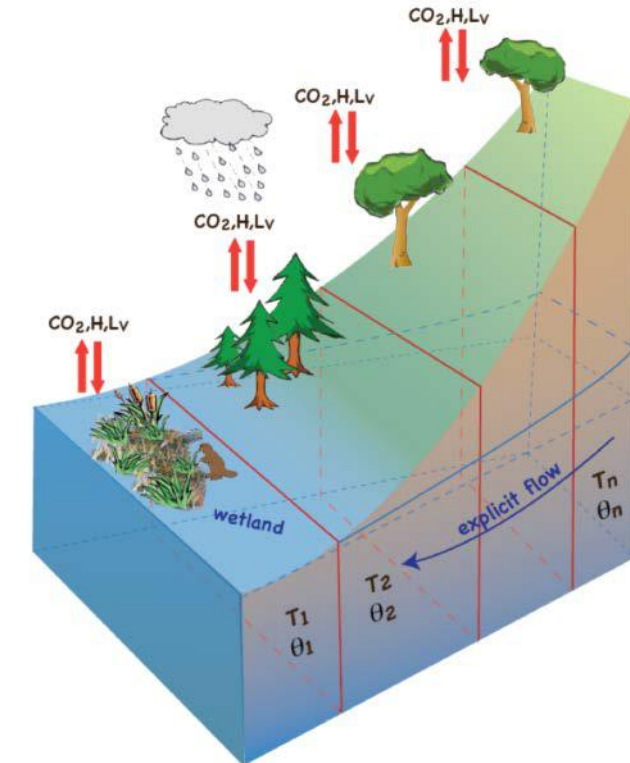


Fig. 3 Representation of hill slopes in the GFDL land model

Irrigation

- Irrigation demand = evaporation demand - soil water supply
- Only for tiles with crops
- Irrigated area taken from Global Map of Irrigation Areas (Siebert et al., 2013)
- Abstraction from surface water first, then groundwater

Differences between simulations with and without irrigations

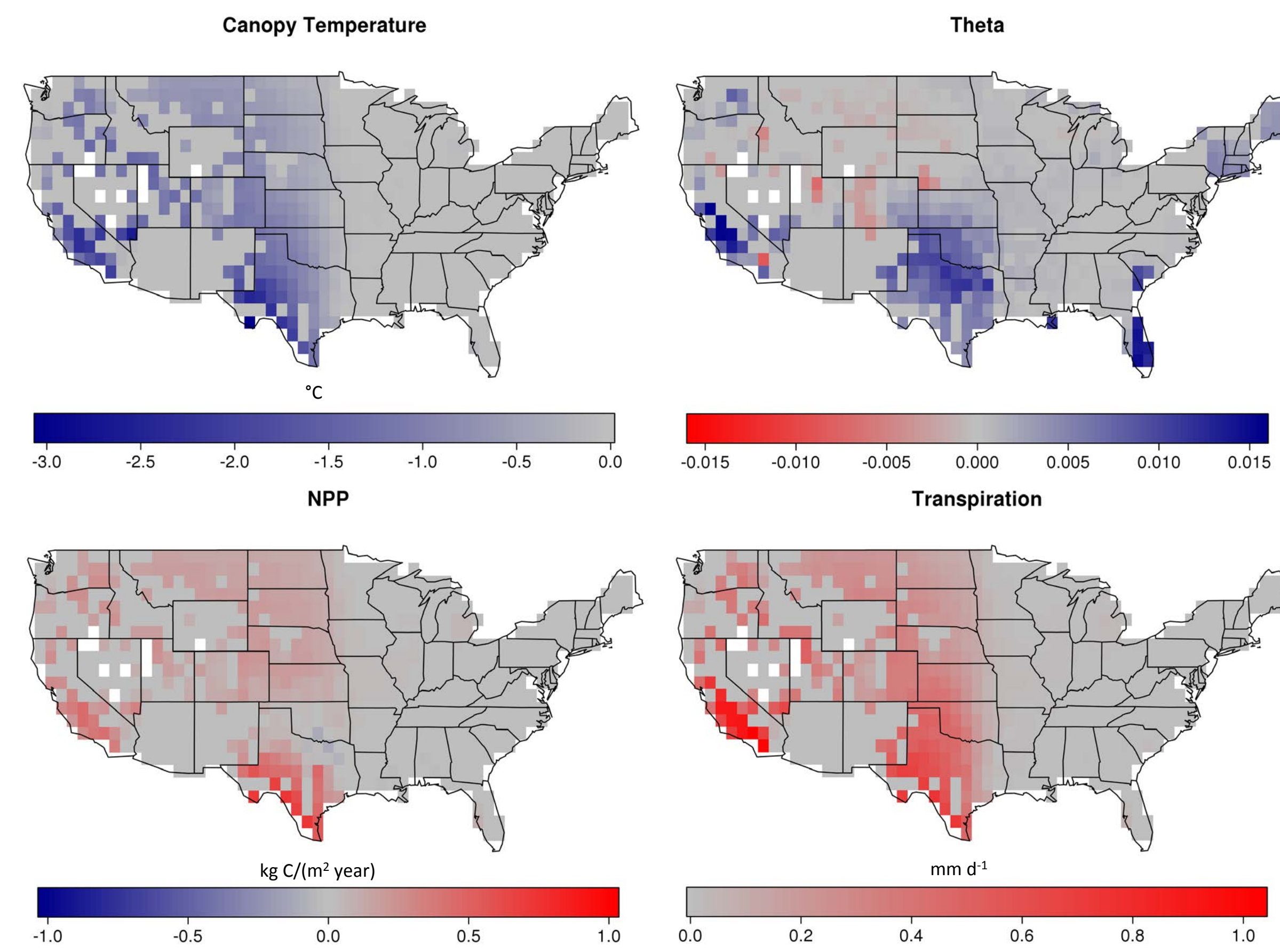


Fig. 5 Differences between model simulations with and without irrigation in canopy temperature, soil moisture, net primary productivity and transpiration

Model validation

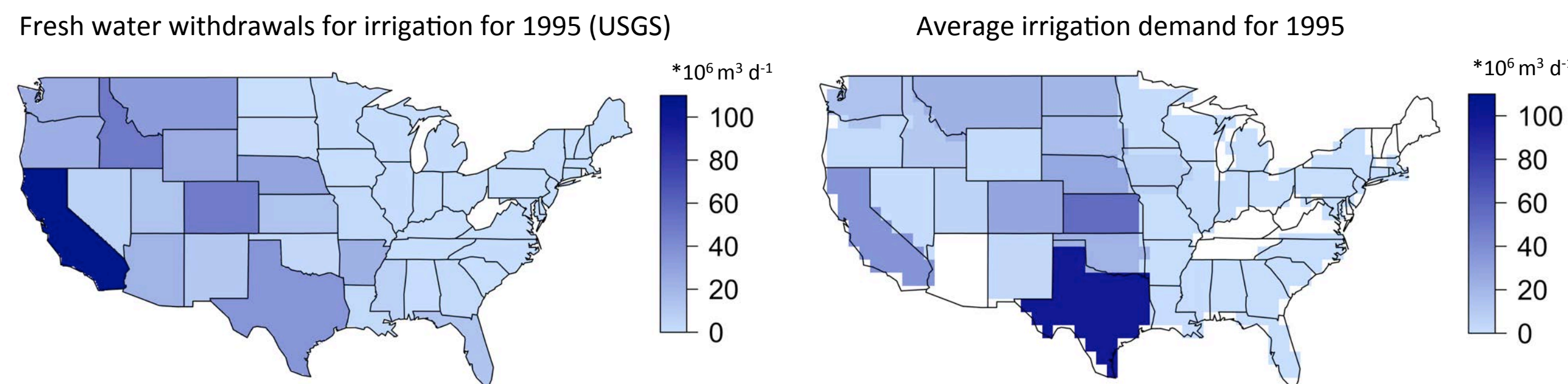


Fig. 6 Comparison between observed fresh water withdrawals (left) and simulated irrigation demand (right) over the year 1995

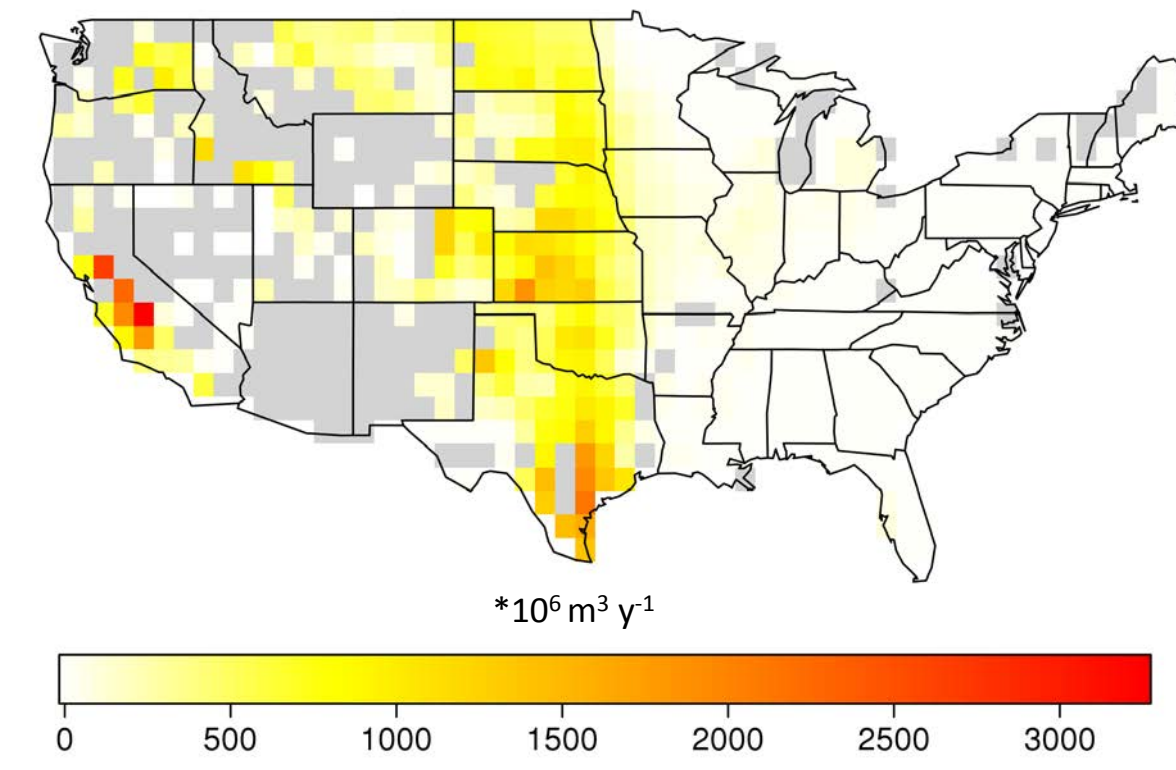


Fig. 4 Simulated average yearly irrigation demand for 1960-1999

Reservoir operations

- Outflow based on expected inflow and downstream water demand (Van Beek et al 2011, Hanasaki et al 2006)
- Location and information for reservoirs from the The Global Reservoir and Dam Database (GranD, Lehner et al 2008)

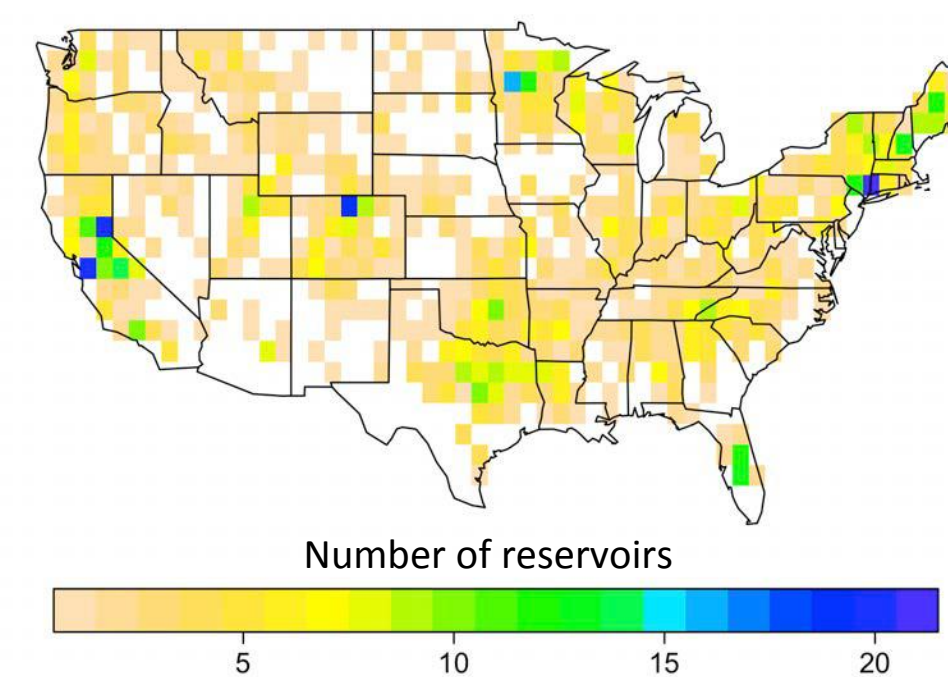


Fig. 7 Occurrence of reservoirs in the US given as number of reservoirs per grid cell

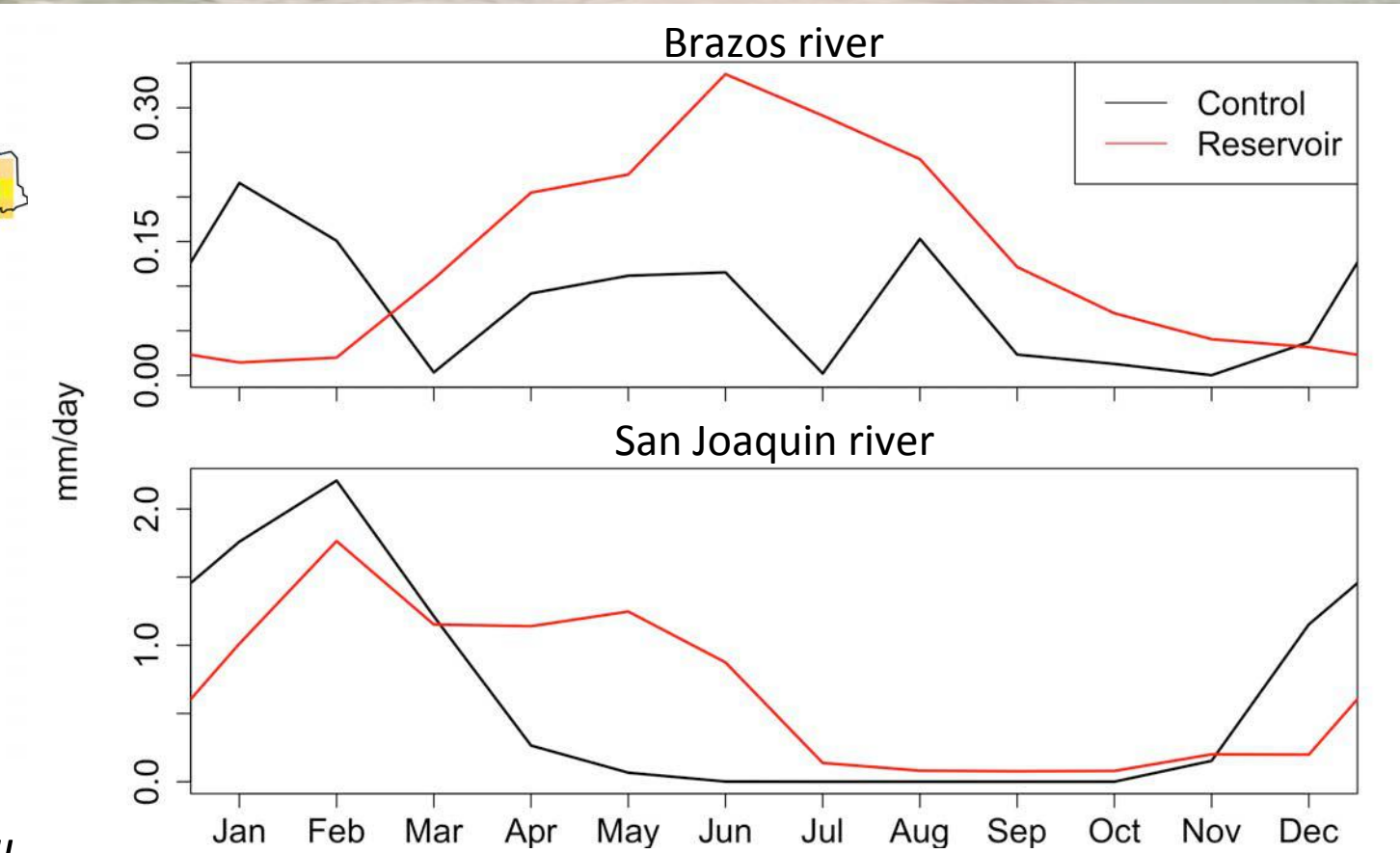


Fig. 8 Change in river outflow between simulations with (red line) and without (black line) reservoirs for two example grid cells

Conclusions

- Preliminary results show the importance of including water management into global scale models
- Irrigation has a large influence on crop growth, temperature and water availability
- Reservoirs can alleviate drought conditions in the stream, but this effect might be only temporary

Future work

The next steps in this research will focus on the implementation of water management at the global scale to be able to quantify the human impact on water availability.

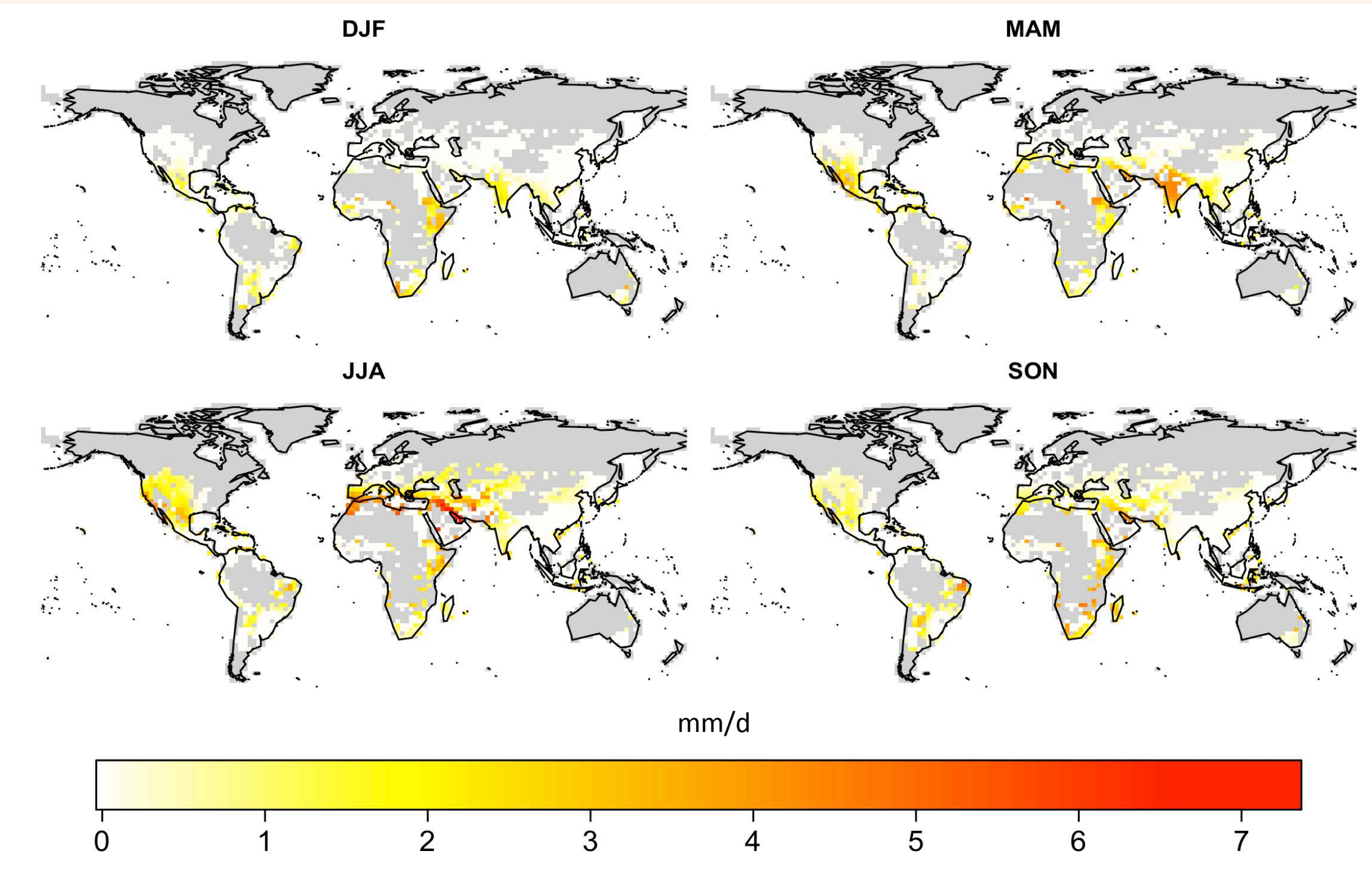


Fig. 9 Seasonal simulated average yearly irrigation demand for 1960-1999 at the global scale

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