Implementation of irrigation practices in a global scale land model

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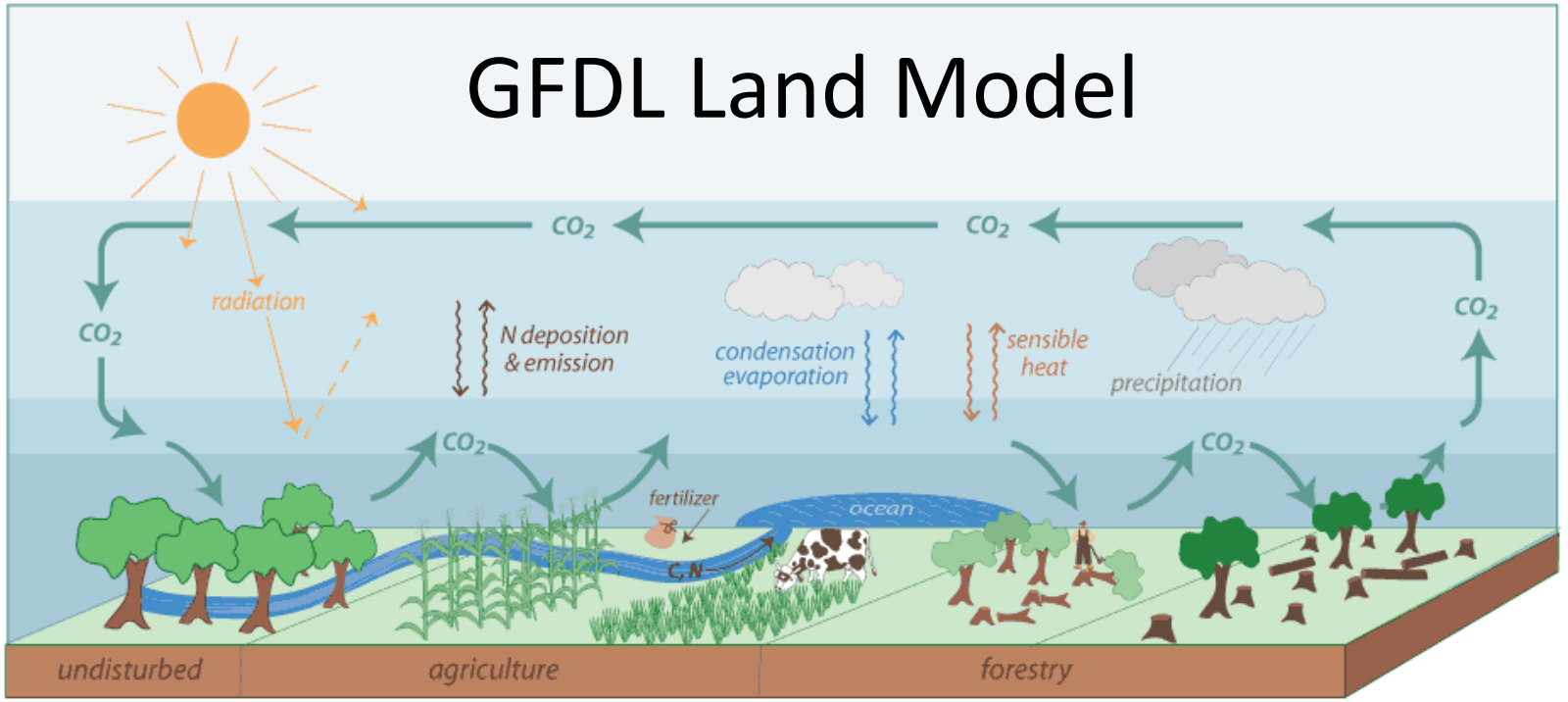
Introduction

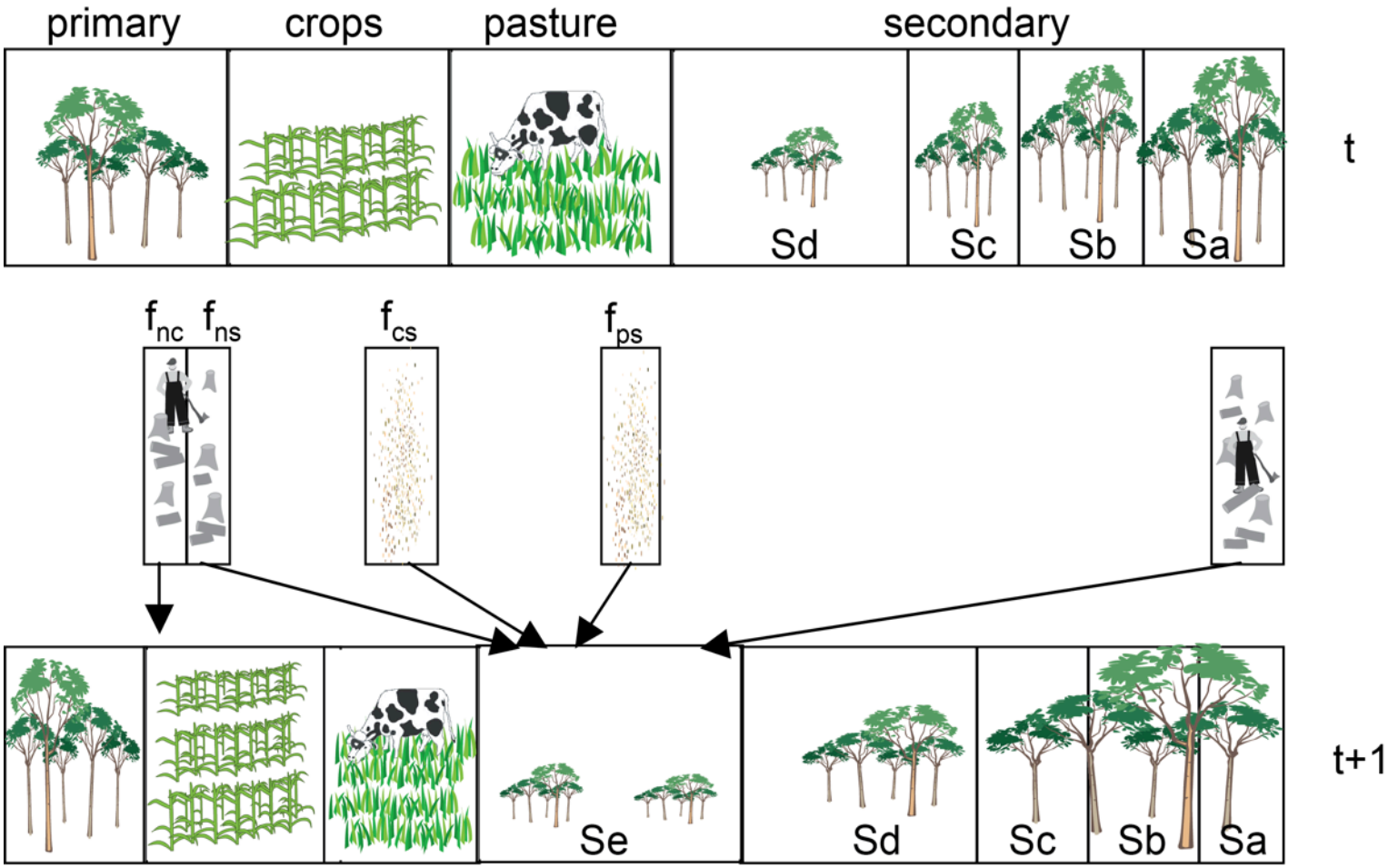
- Humans significantly alter the hydrologic cycle
- Water management practices need to be included in earth system models to more adequately understand changes towards the future
- Humans will impact future water availability, water scarcity, and drought

GFDL Land Model

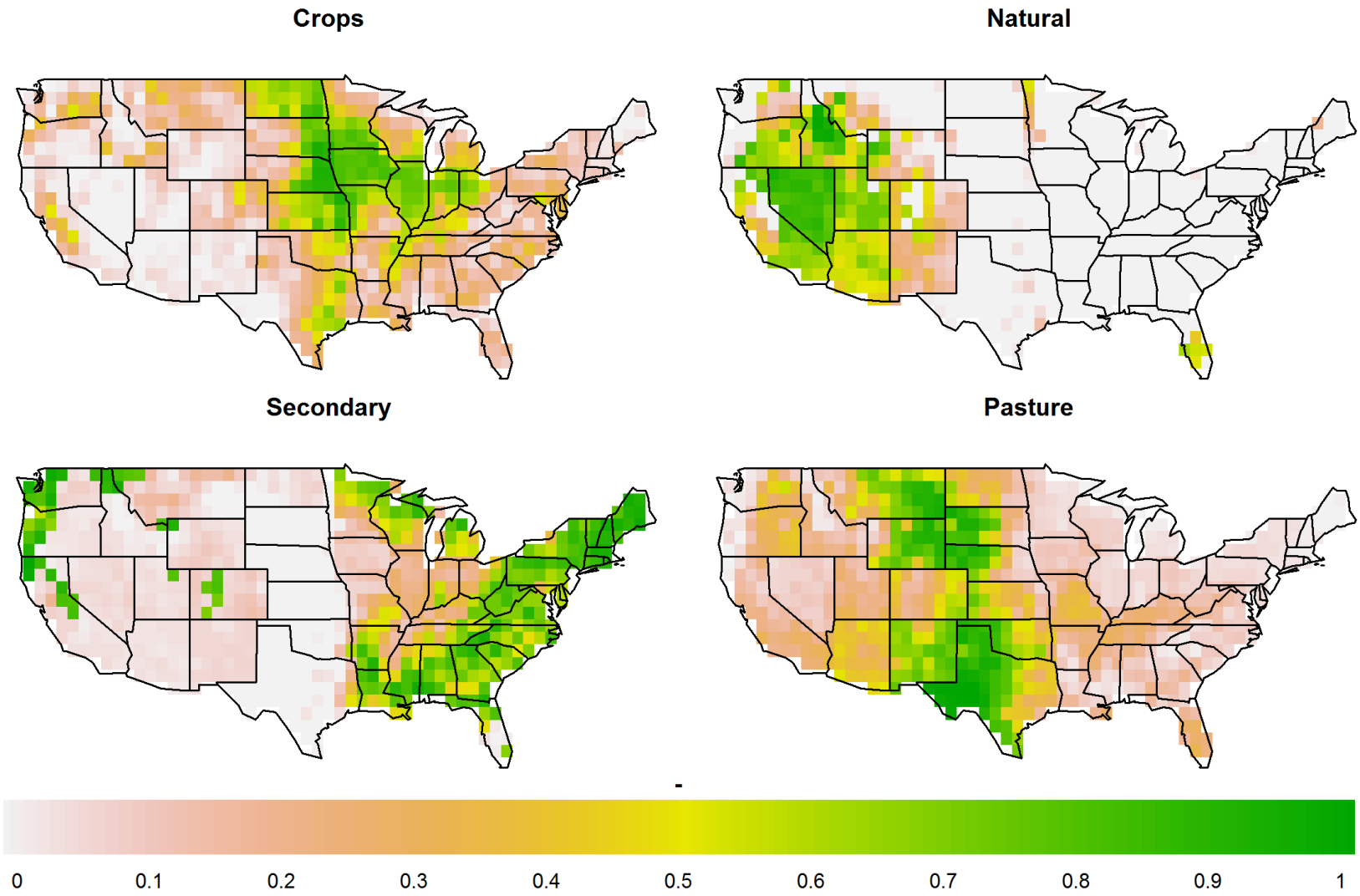


- Land surface parameterization and hydrological processes
  - Energy and water exchange between land, atmosphere and ocean
  - Liquid/frozen water dynamics, rivers and lakes
- Ecological processes
  - Vegetation succession and growth
  - Carbon and Nitrogen cycles
- Land use and management
  - Deforestation, wood harvesting and re-growth
  - Changes in surface characteristics (e.g. albedo and roughness)

GFDL LM4: Land-use tiling



GFDL LM4: Land use



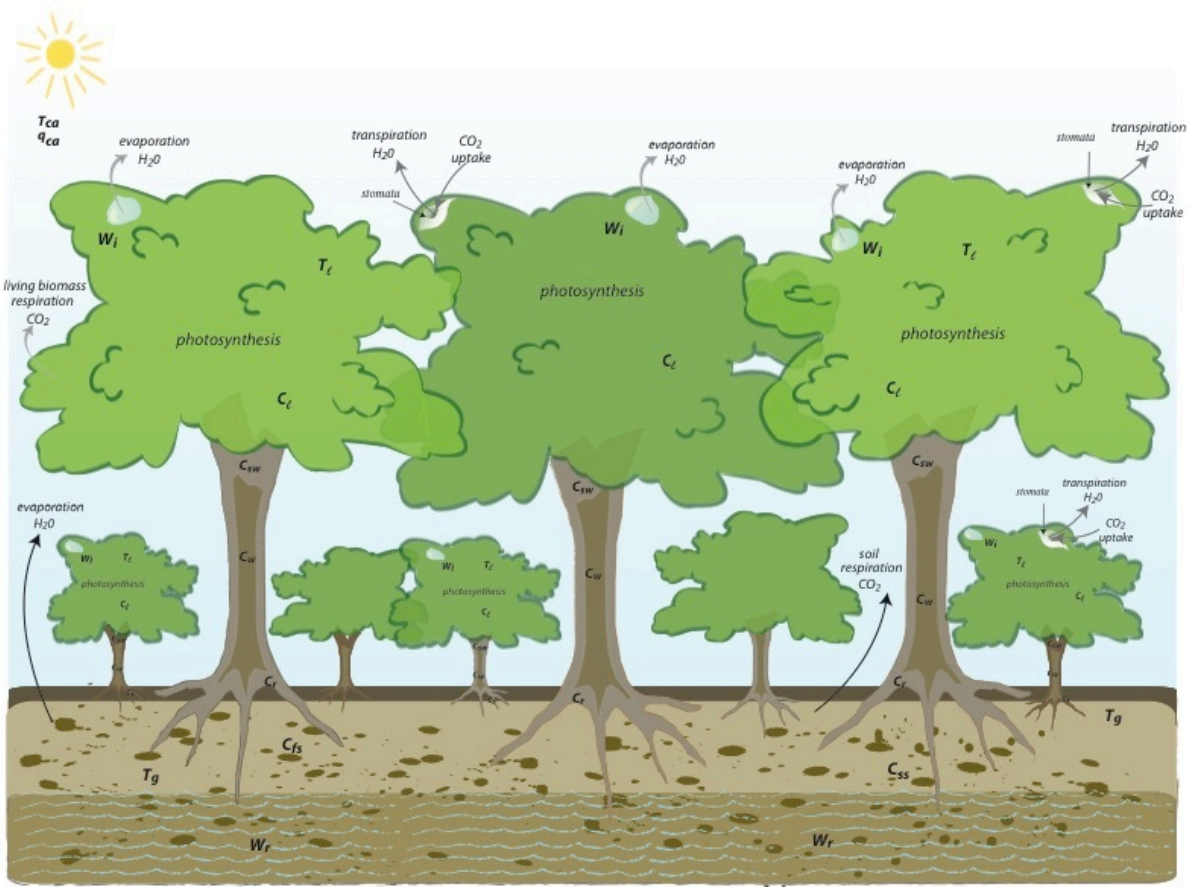
Fraction of grid cell area for 4 land use types (average 1960-2000)

Perfect Plasticity Approximation (PPA) Vegetation Dynamics

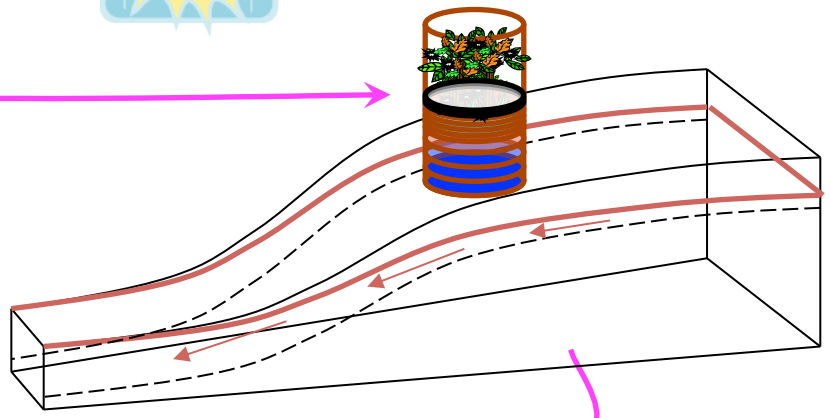
Challenges for global PPA

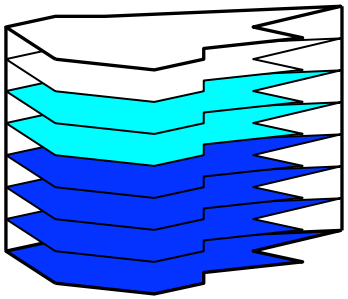
- capturing plant diversity
- phenology and mortality
- evaluating succession

Tree cohorts with multiple individuals (stems)

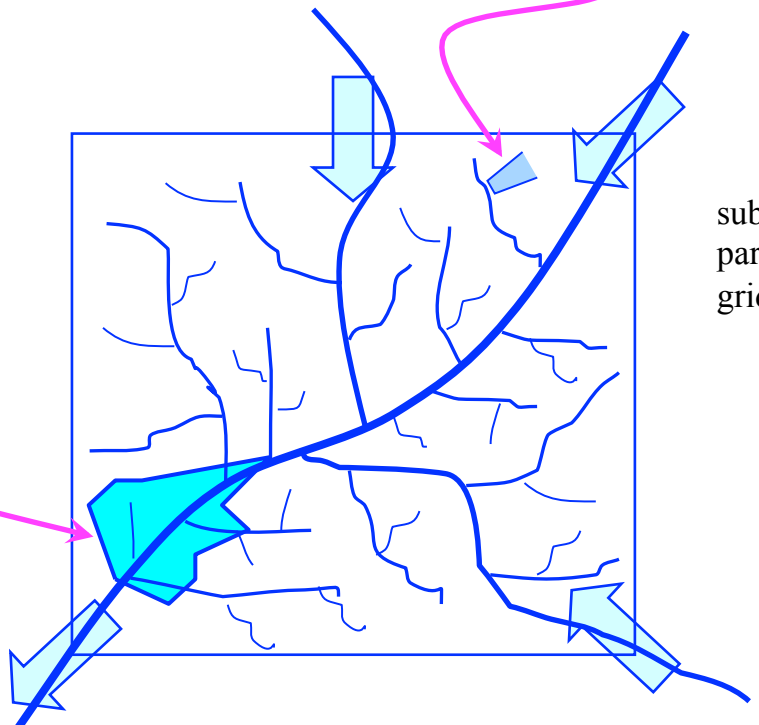


GFDL LM4: Hydrology





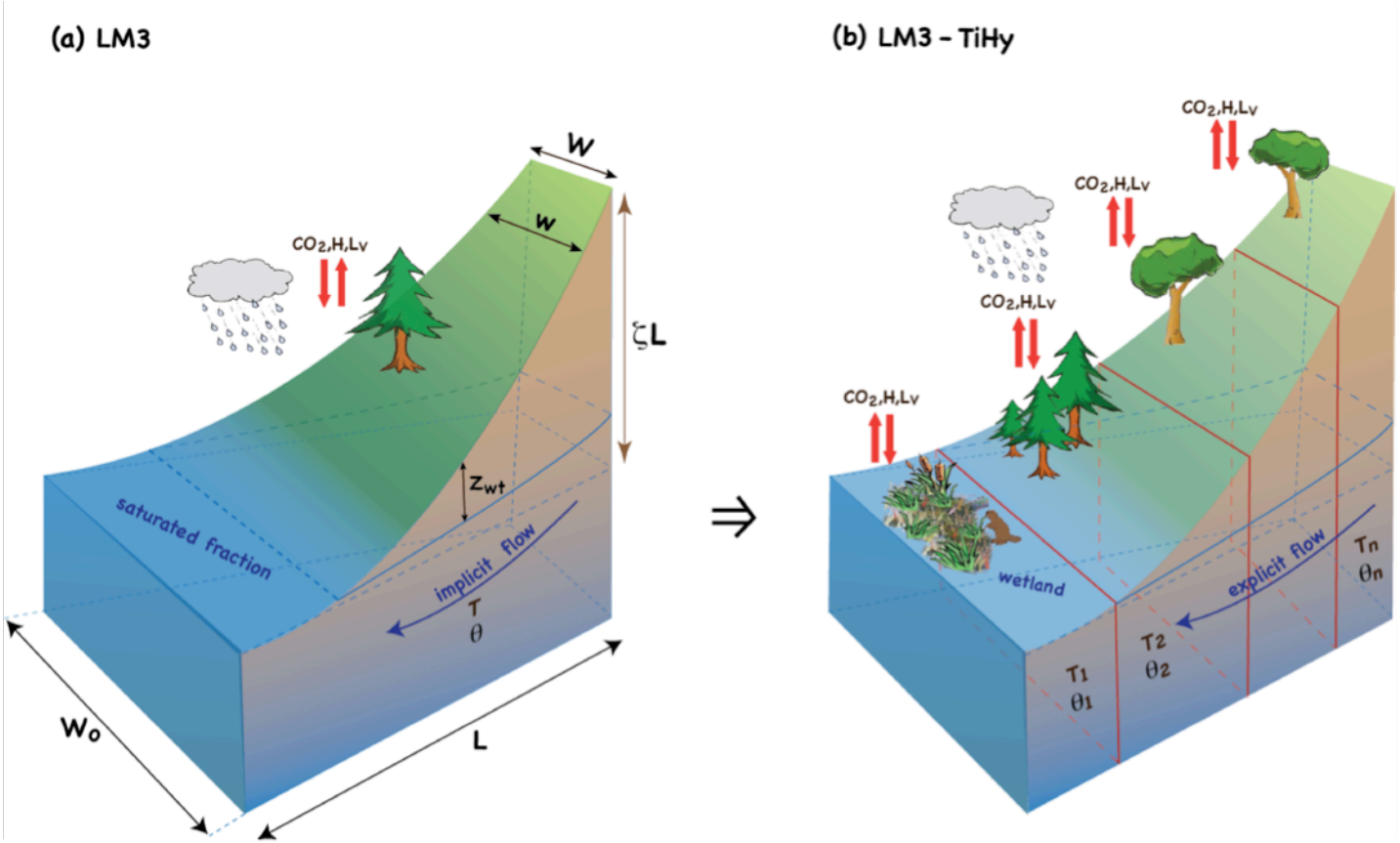
~20-layer lake,
with ice cover,
snow pack



sub-grid
partitioning of
grid area

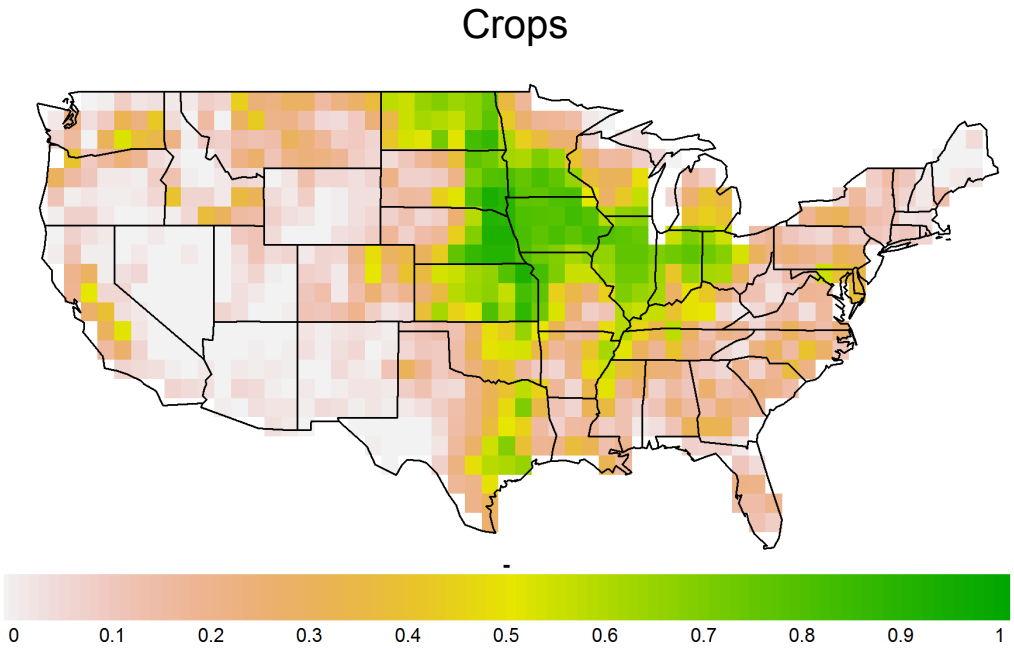
GFDL LM4: Hydrology

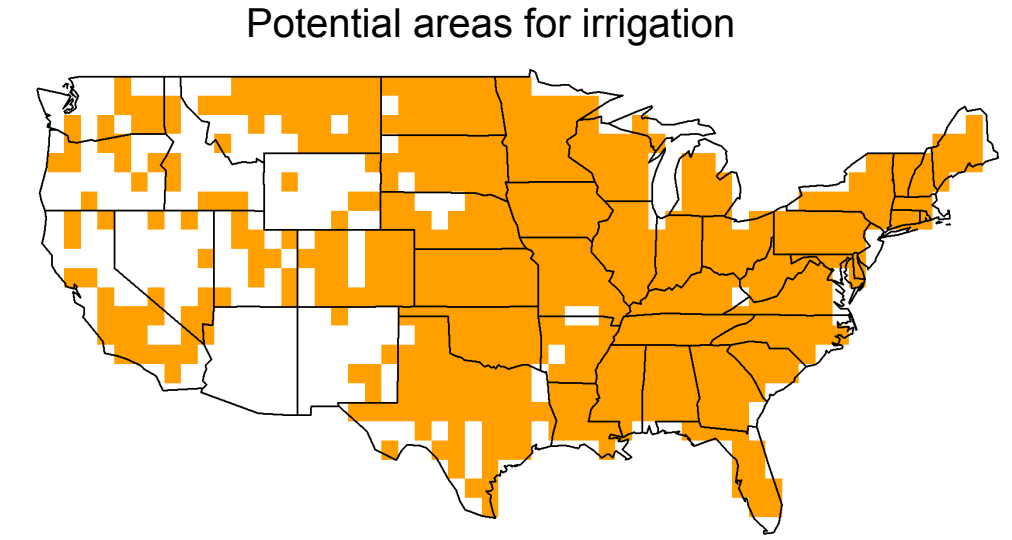
- Tiles extended with representation of subgrid heterogeneity of hillslopes and soils
- Resulted in field-scale coupling of the water, energy, and biogeochemical cycles



Implementing 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

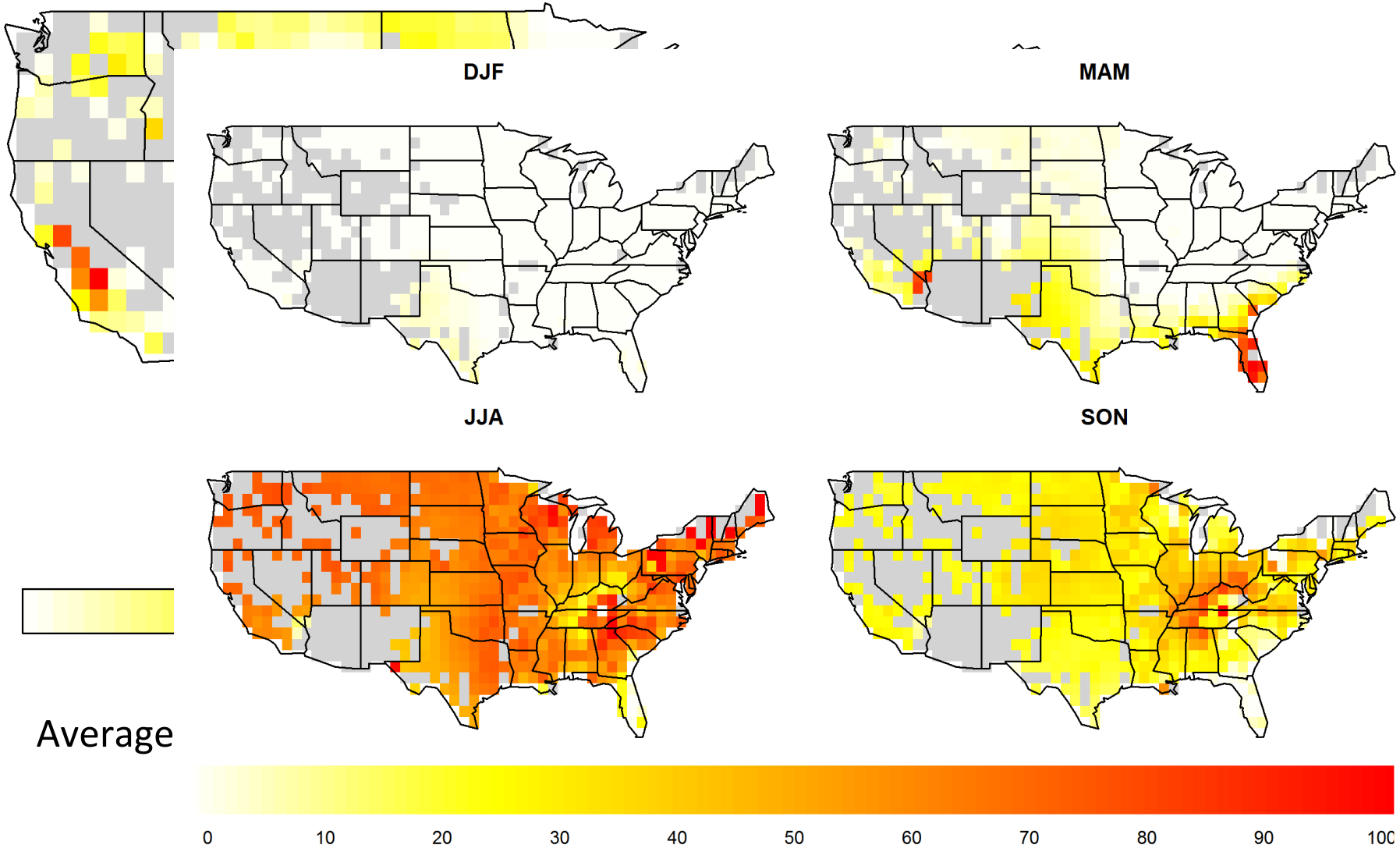




Model simulations US

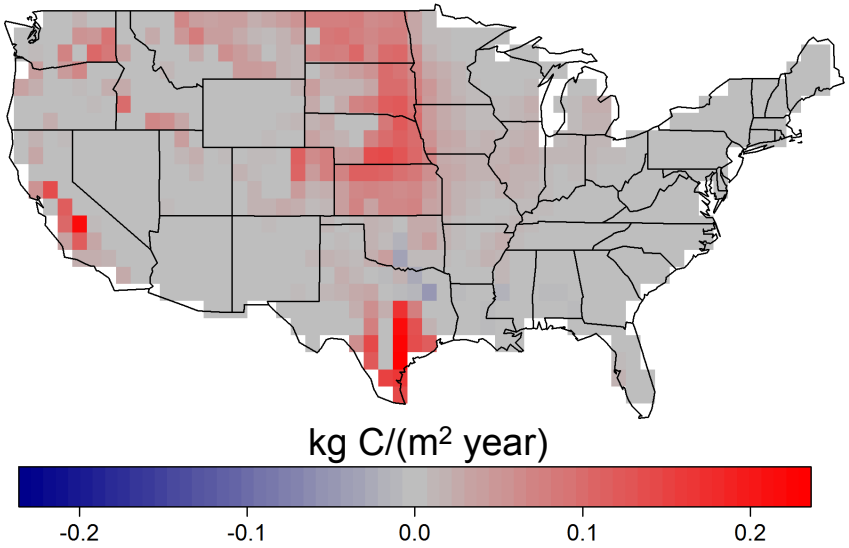
- 1 by 1 degree
- Spin-up for landuse change from 1860-1950
- Offline land model with meteorological forcing from Global Meteorological Forcing Dataset (Sheffield et al., 2006)
- Simulation with/without irrigation 1950-1998

Irrigation demand

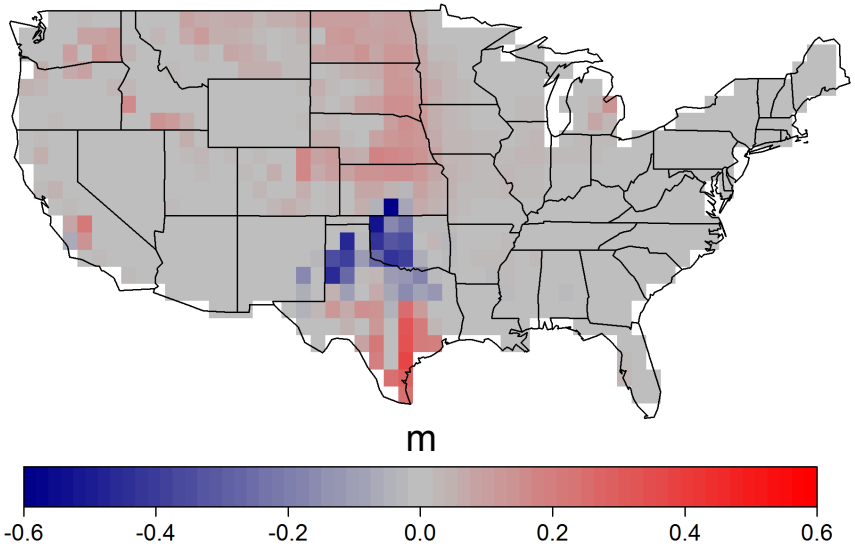


Control versus Irrigation

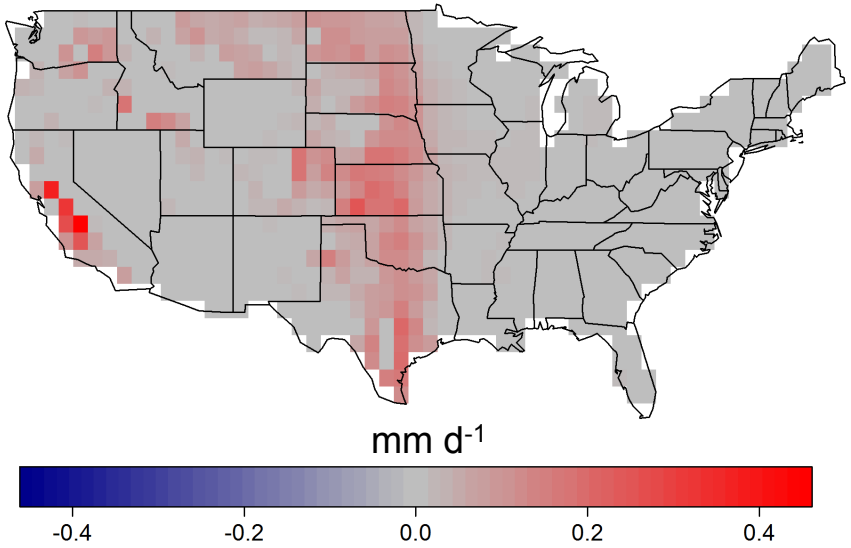
NPP



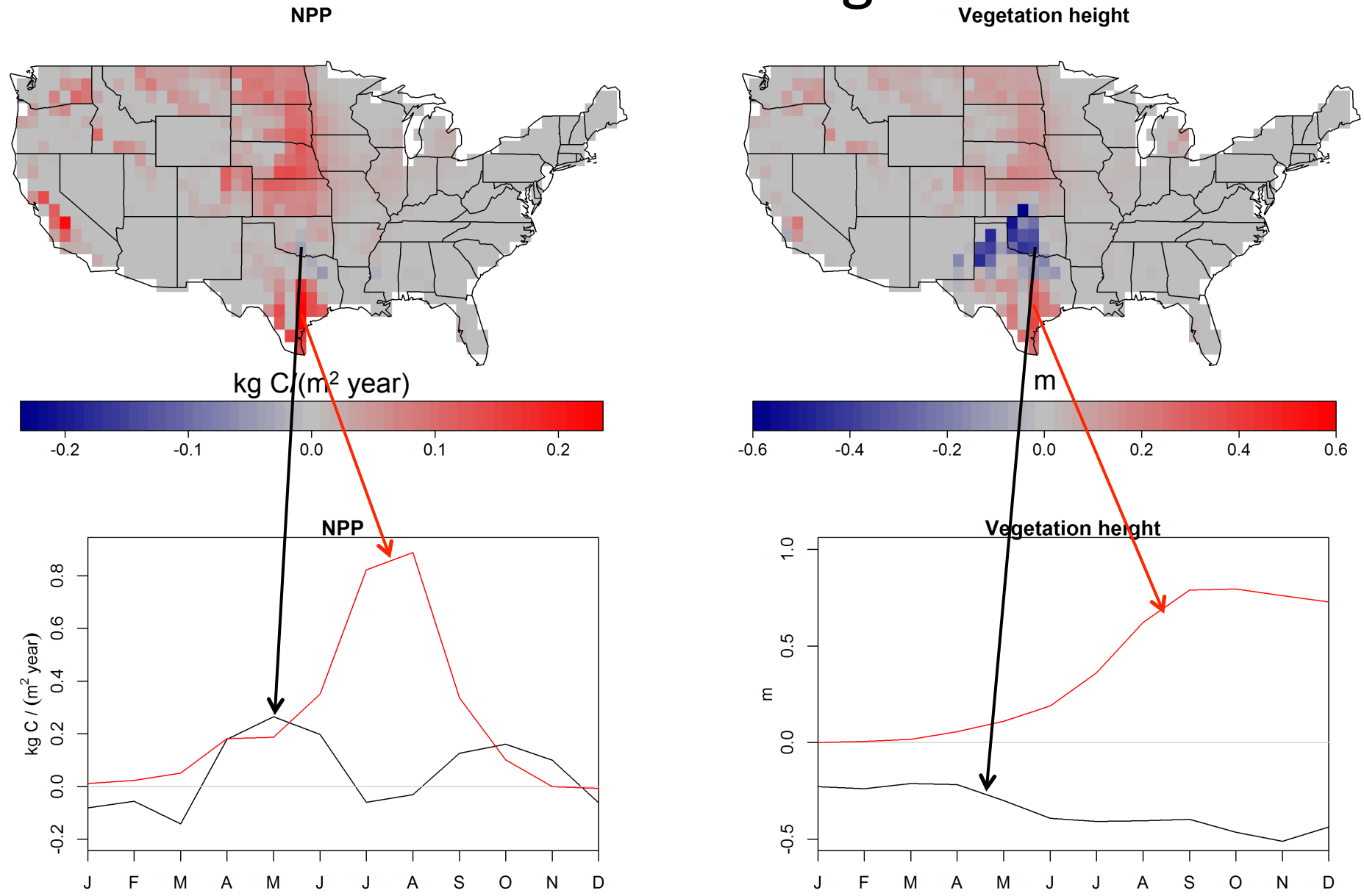
Vegetation height



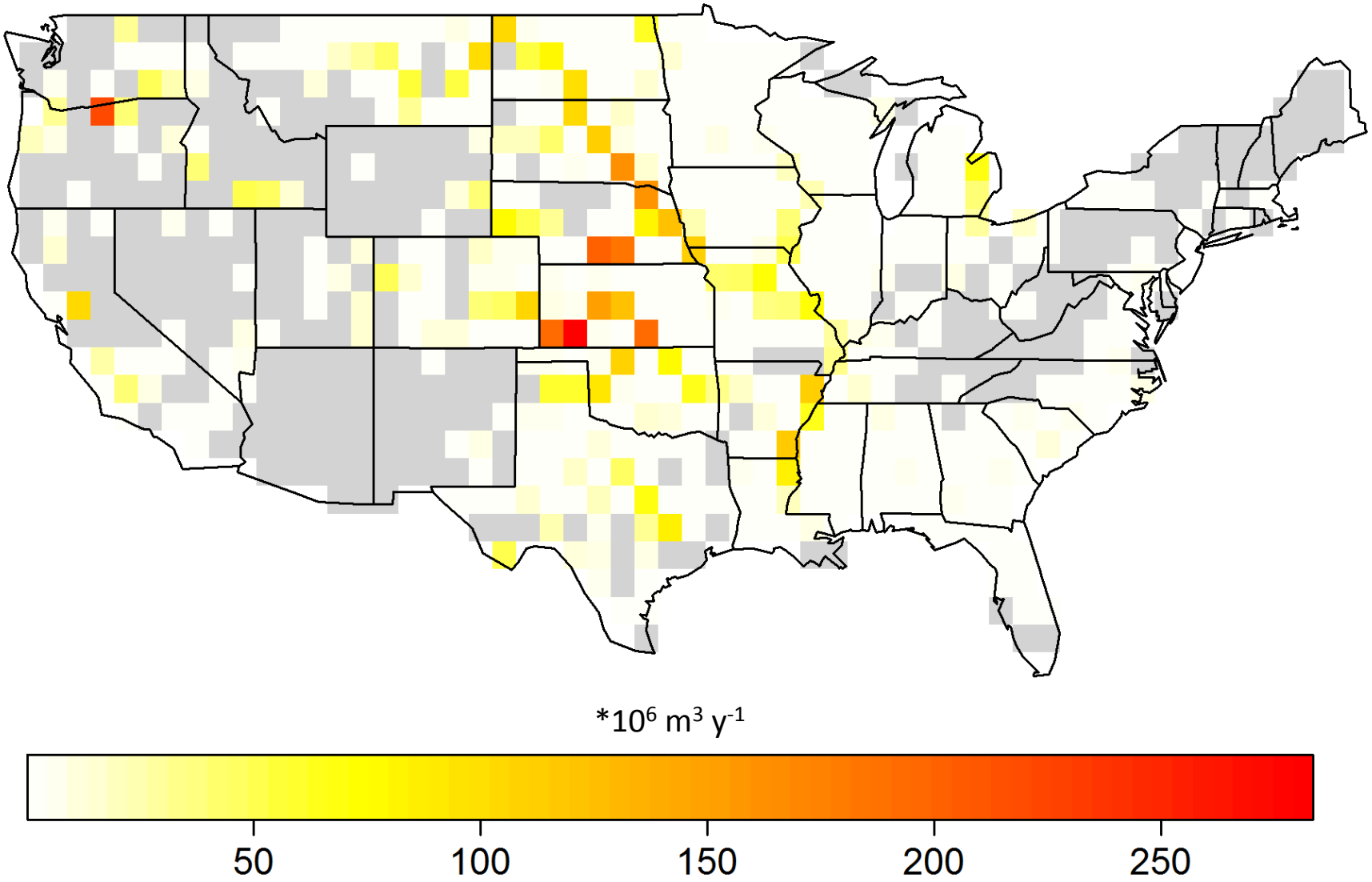
Transpiration



Control versus Irrigation

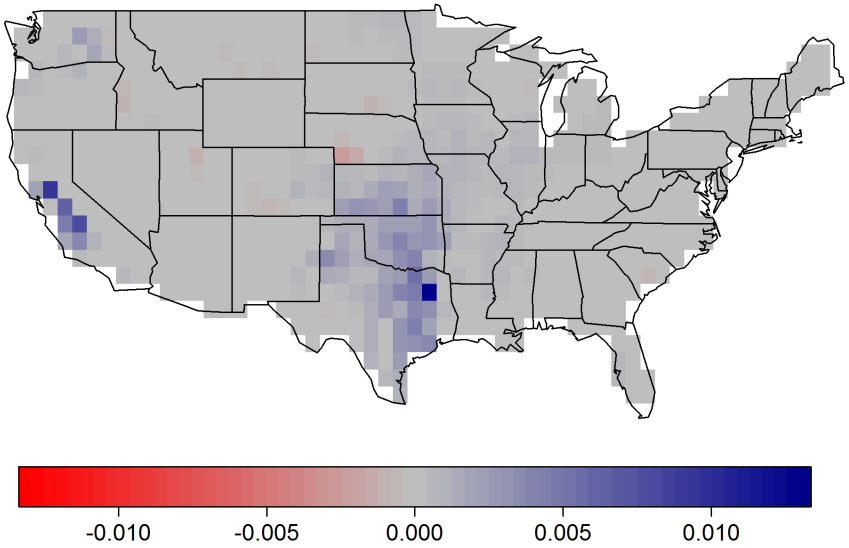


Surface water abstraction

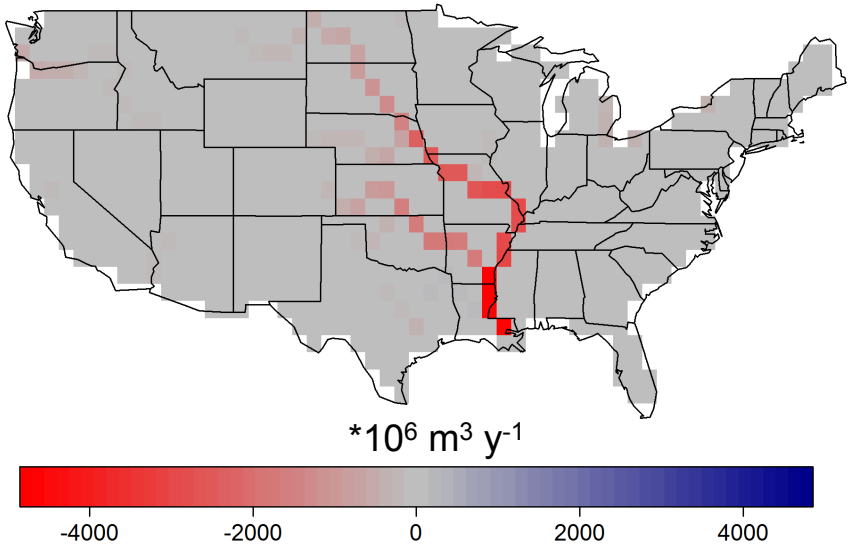


Water scarcity and drought

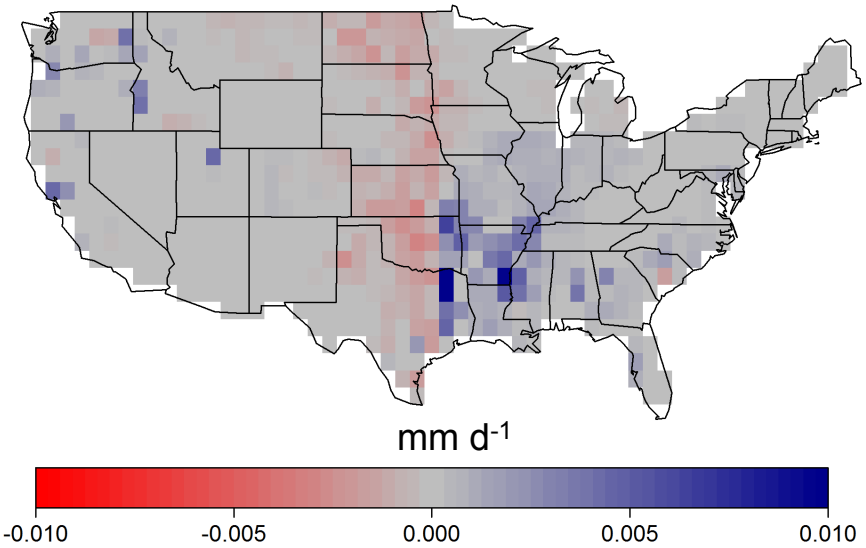
Theta



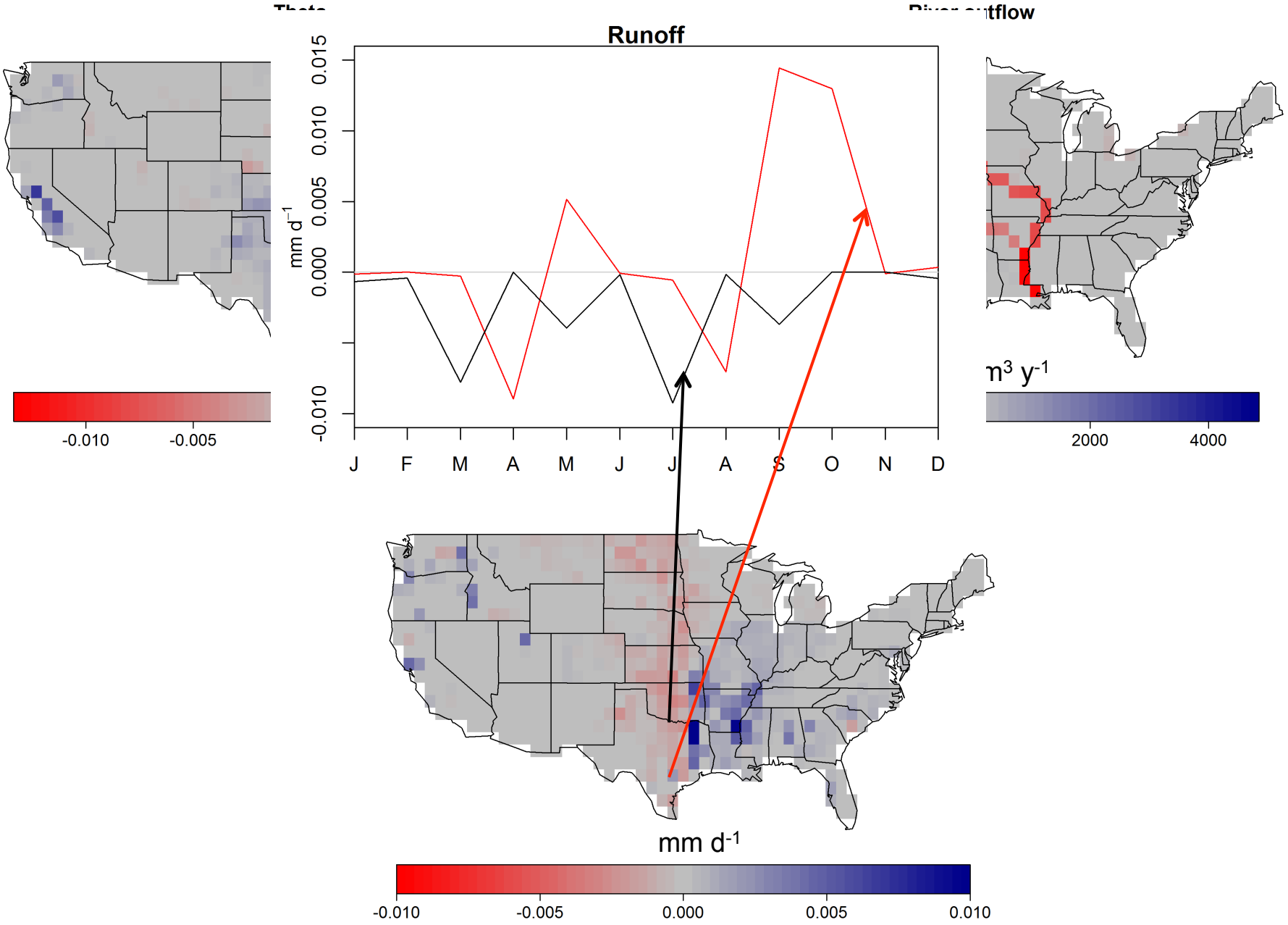
River outflow



Runoff

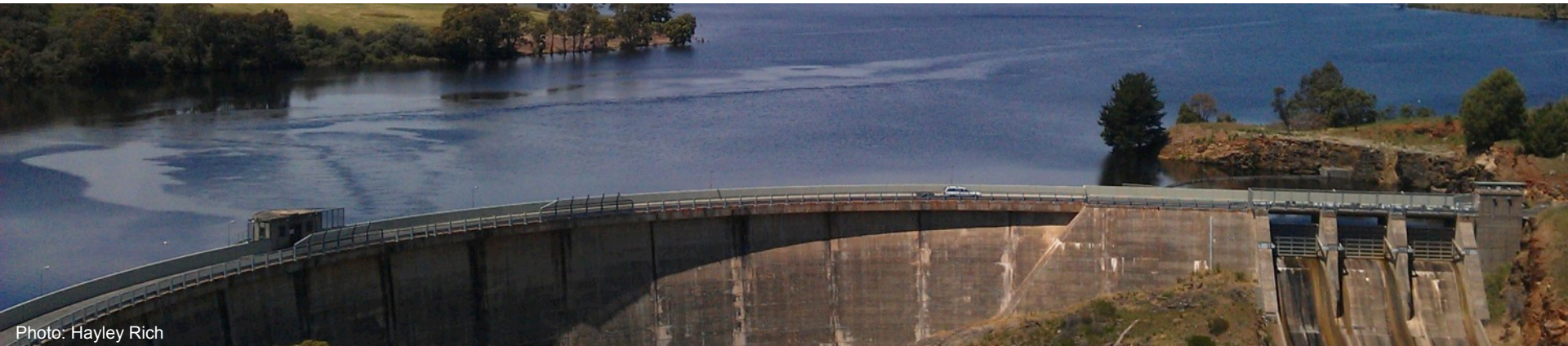


Water scarcity and drought

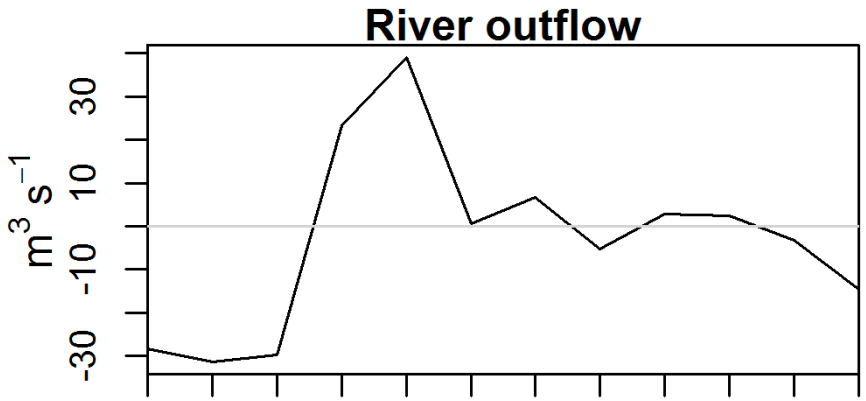


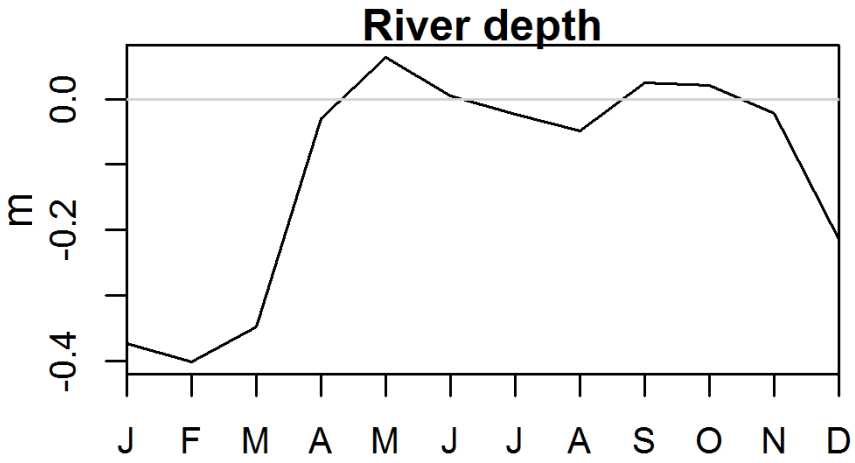
Implementing Reservoirs

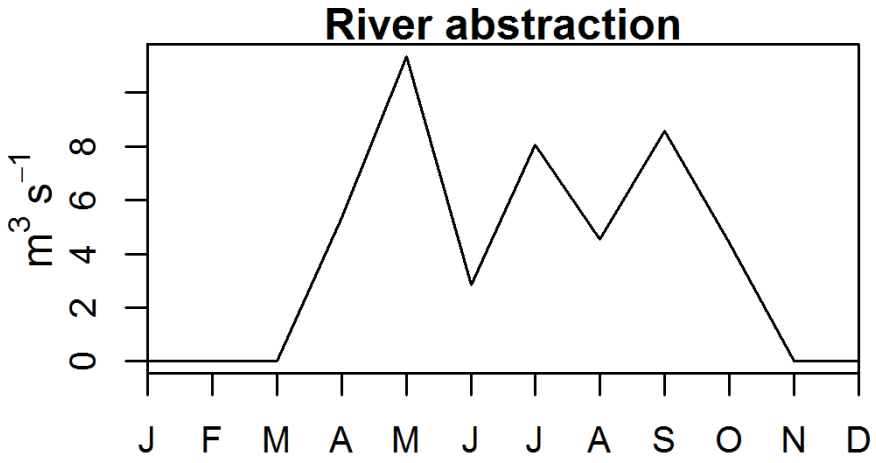
- Outflow based on expected inflow and downstream water demand (Van Beek et al 2011, Hanasaki et al 2006)
- Location and information for reservoirs from the The Global Reservoir and Dam Database (GranD) (Lehner et al 2008)



Impact reservoir







Reservoir in Nebraska,
max depth 27m

Next steps

- Implementing groundwater abstraction
- Implementing reservoir scheme at continental and global scale
- Testing different irrigation demand calculations e.g. soil moisture threshold
- Simulate water demand at the global scale (1degree resolution)
- Study human influence on drought

- Far future: Fully coupled model runs to investigate feedbacks