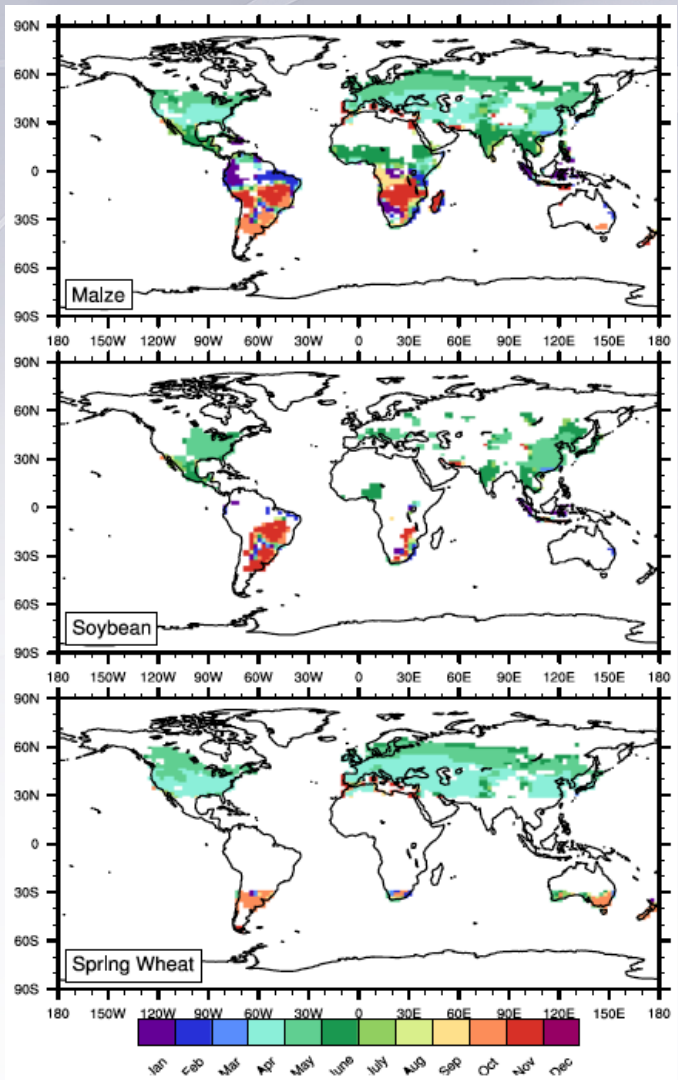
ACME land model development

- **Subgrid structure:**
  - Grid cell/subbasin; topography; land cover type with soil&snow column; patch; cohort
- **Biogeochemistry:**
  - A new coupled C, N, and P model (ALMv1-ECA-CNP) on nutrient competition using equilibrium chemistry approximation theory (Zhu et al. 2016a,b; 2017)
  - The ALMv1-CTC-CNP on nutrient competition based on relative demand (Yang et al. 2016; Metcalfe et al. 2017)
  - BeTR vertically-resolved reactive transport solver for soil biogeochemistry (Tang and Riley 2016; 2017)
  - ALM-PLOTRAN reactive transport solver for soil biogeochemistry and thermal hydrology
- **Soil hydrology and riverine processes:**
  - Variably saturated flow model (VSFM) (Bisht et al. 2017) and variable depth to bedrock (Brunke et al. 2016)
  - Model for Scale-Adaptive River Transport (MOSART) for streamflow (Li et al. 2013; 2015a), stream temperature (Li et al. 2015b), and floodplain inundation (Luo et al. 2017)
  - MOSART for river biogeochemistry (sediment, POC, DOC, DIC, and CO2 evasion)
- **Ecosystem demography:**
  - Functionally Assembled Terrestrial Ecosystem Simulator (FATES) coupled to ALM – plant hydraulics, fire, trait filtering, land use
- **Human activities:**
  - Crop modeling - dynamic roots, climate-driven planting dates, additional crop functional types
  - Irrigation and flow regulation - surface/groundwater irrigation (Leng et al. 2013; 2014), irrigation methods (Leng et al. 2017), coupling ALM-MOSART-WM
  - Coupling GCAM with ACME to represent human-earth system interactions

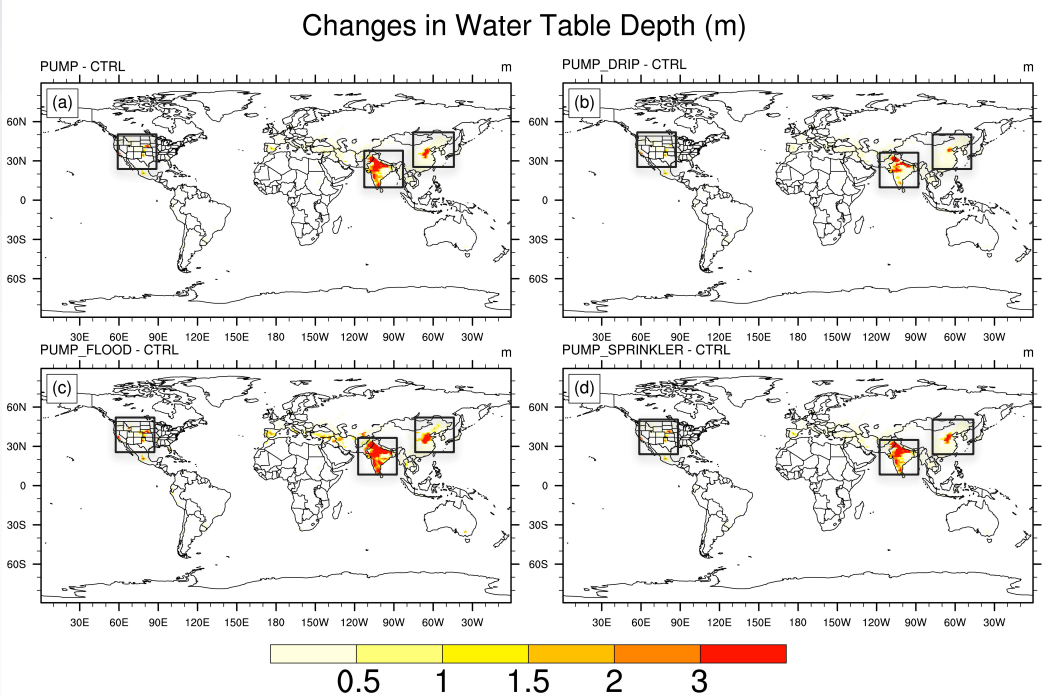
Modeling crops and irrigation

Month of planting

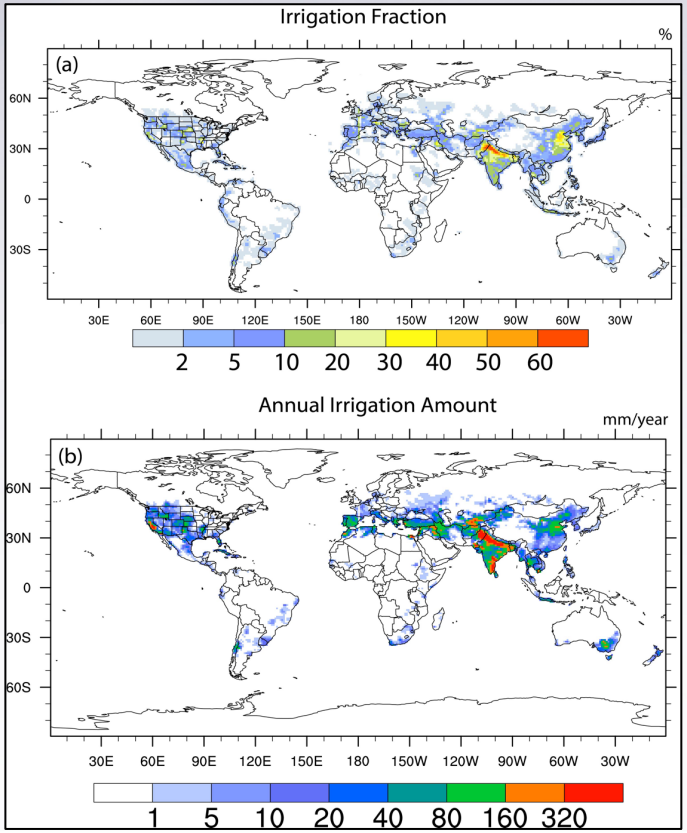


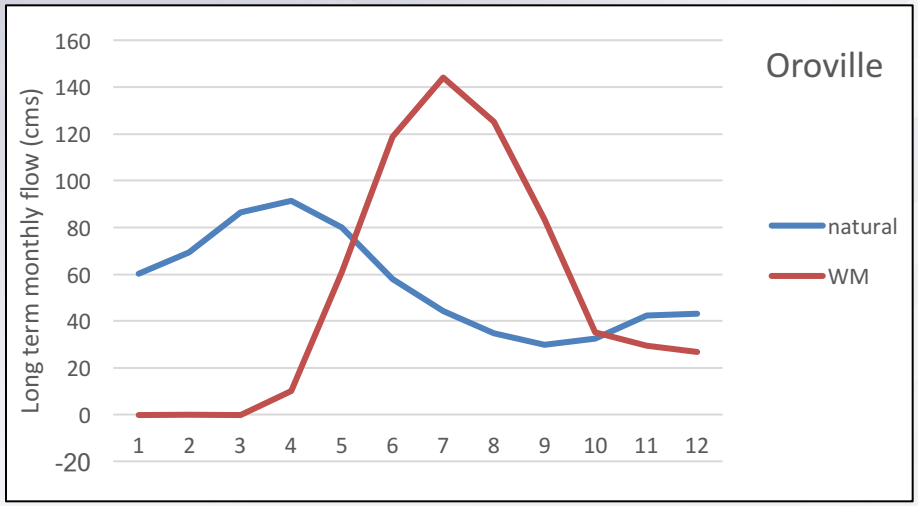
Irrigation method: drip, sprinkler, flood

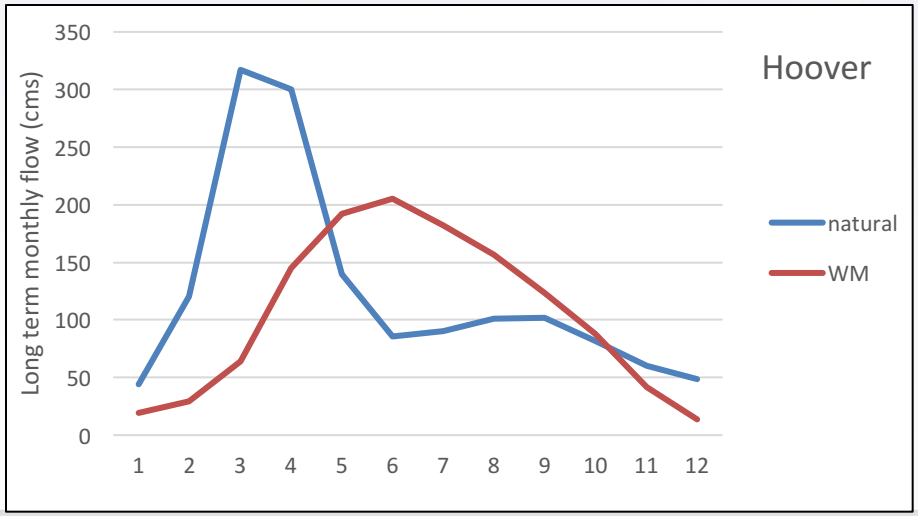
Impacts of different irrigation methods on water table depth



Coupled ALM-MOSART-WM to represent human impacts on water cycle

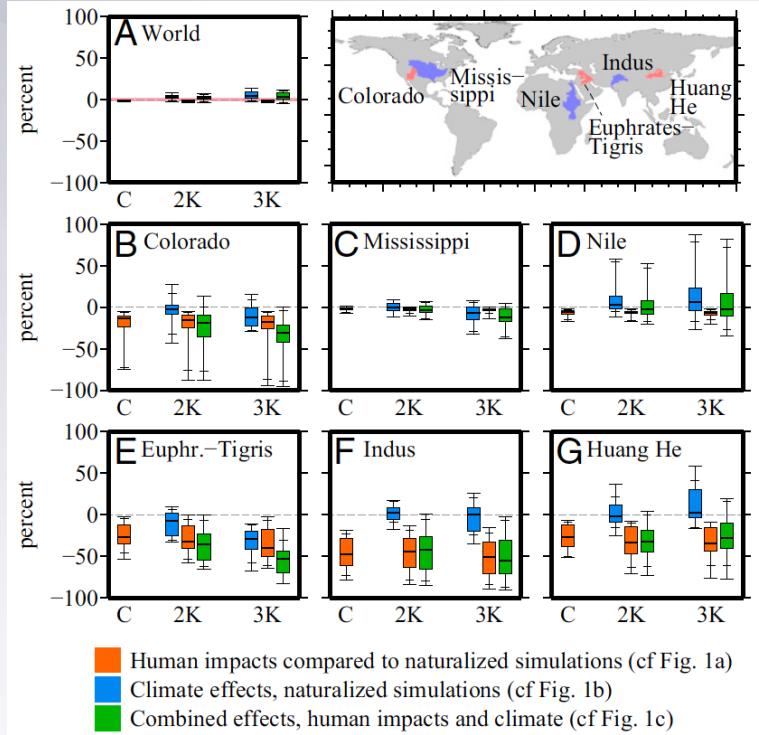


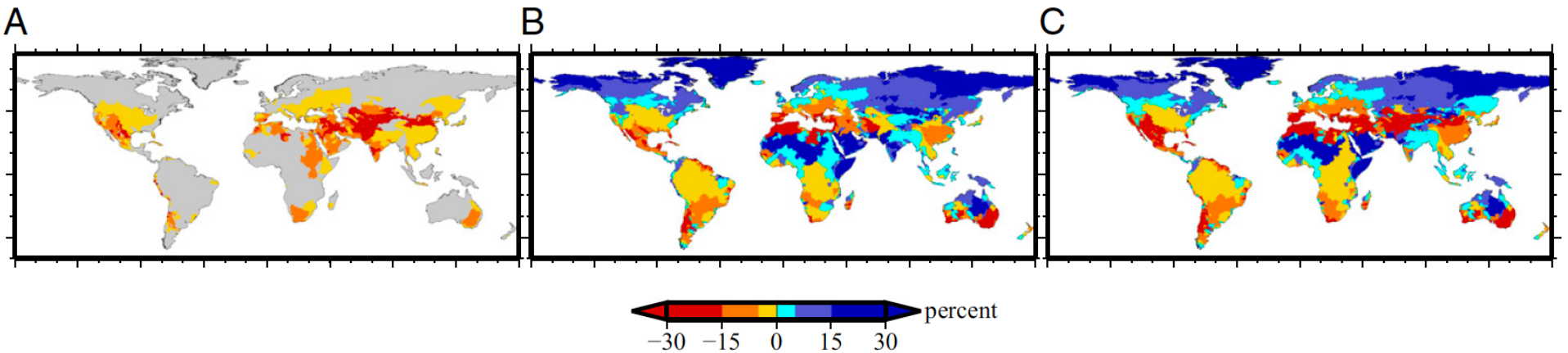


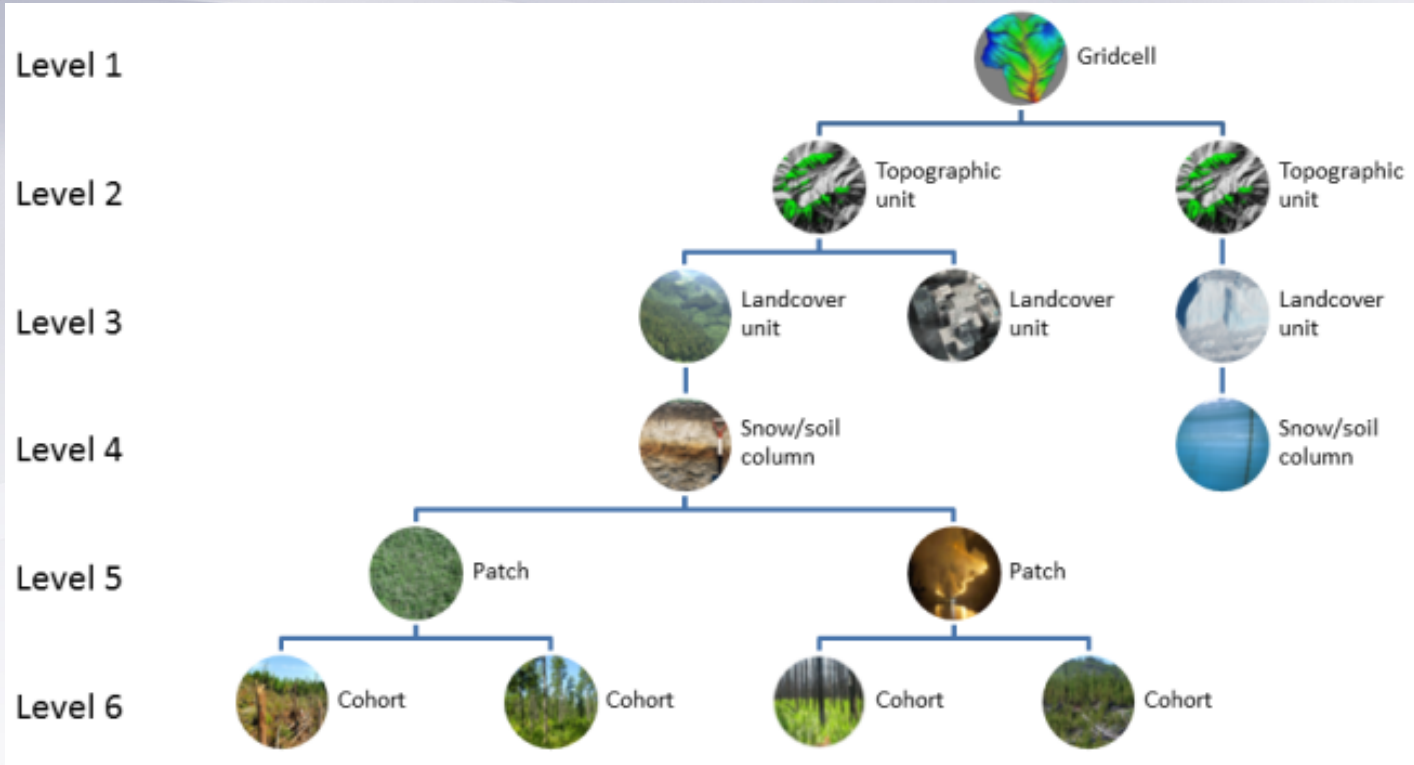


Climate change vs. human interventions

- At local scale, irrigation effects on groundwater storage and streamflow can be comparable to the changes induced by a 2.5 °C temperature rise (Ferguson and Maxwell, 2012; Haddeland et al. 2014)
- Irrigation impacts are expected to increase with the growing world population and food demand (Tilman et al., 2011)
- Increasing aridity from climate warming will also likely exacerbate irrigation water demand (Hanasaki et al., 2013; Wada et al., 2013; Leng et al., 2015)





(Haddeland et al. 2014 *PNAS*)

ALM subgrid structure