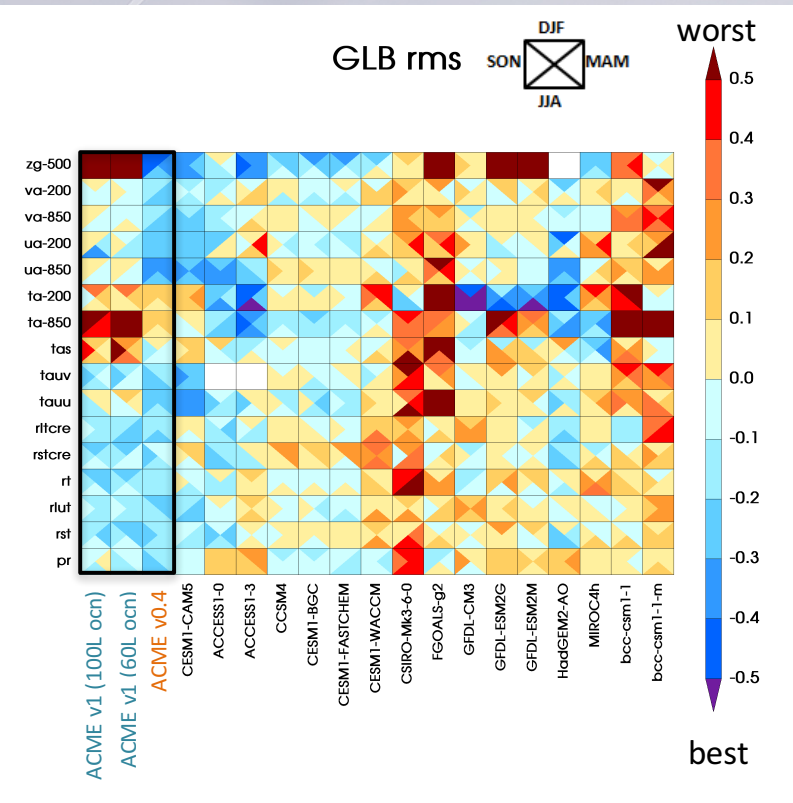
ACME system development

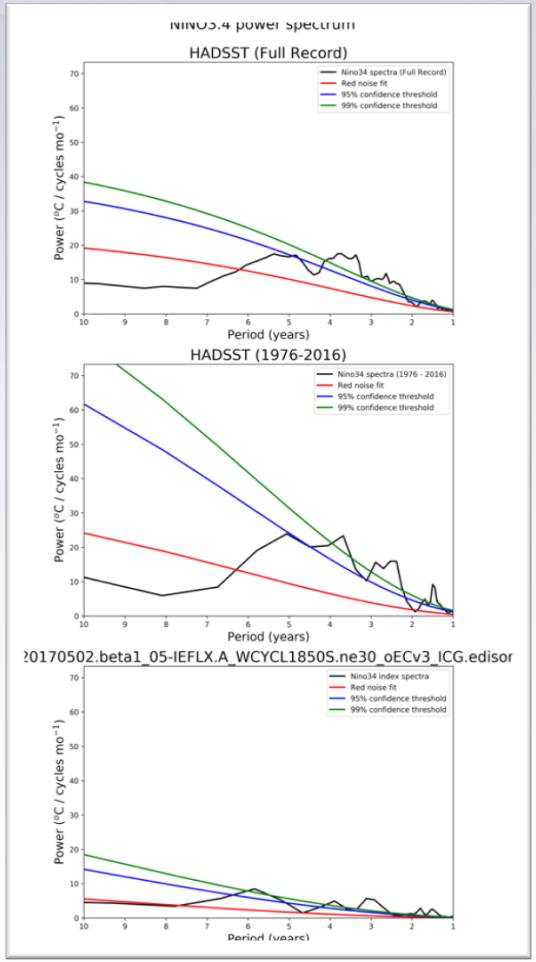
- **High resolution modeling:**
  - ACME v1
    - Atmosphere and land – 1/4° (L72 atmosphere)
    - Ocean/ice – 18 km - 6 km and ~1 km in regions (L100 and L60 ocean)
    - Land ice – 20 km to < 1 km in region
    - Atmosphere-land only simulations at 1/8° (Arctic and North America)
  - ACME v2
    - Exploit regional refinement in coupled simulations from 1° to 1/4° (e.g., Arctic, North America)
    - Ensemble simulations to characterize uncertainty
  - ACME v3
    - Nonhydrostatic atmosphere for convection permitting simulations
    - Superparameterized ACME-MMF – Exascale Computing Project (ECP)
  - Process representations
    - Scale-aware parameterizations for transitioning from ultra-high to convection permitting simulations
    - Hydrological processes, extreme events, cryosphere processes, BGC

Most urgent issue to be addressed

Reasonable climatological skill



Weak ENSO

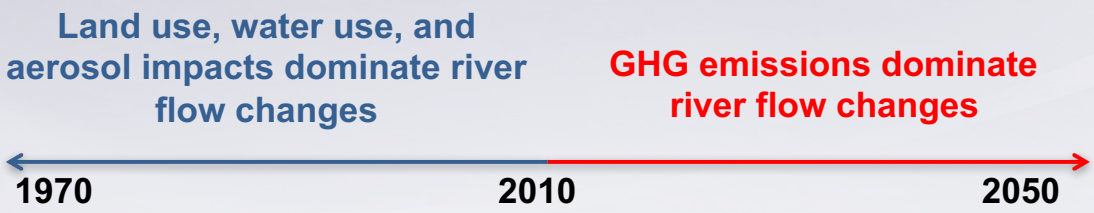


Ongoing diagnosis

- Few issues to iron out in the new ocean model (e.g., vertical diffusion and horizontal advection)
- Doubling vertical resolution in atmosphere model may benefit from further tuning
- Developing different configurations (e.g., coupling v0 and v1 atmosphere with POP vs. MPAS-O) is helpful for diagnosing coupled modeling issues
- Need lots of CPU and fast turnaround to test different hypotheses

Scientific research

- **ACME v1 water cycle and cryosphere experiments**
  - How will more realistic portrayals of earth system features affect the simulation of Earth's water cycle, including river flow and freshwater supplies at the watershed scale?
  - How do rapid changes in cryospheric systems interact with the climate system?
  - Hypothesis:

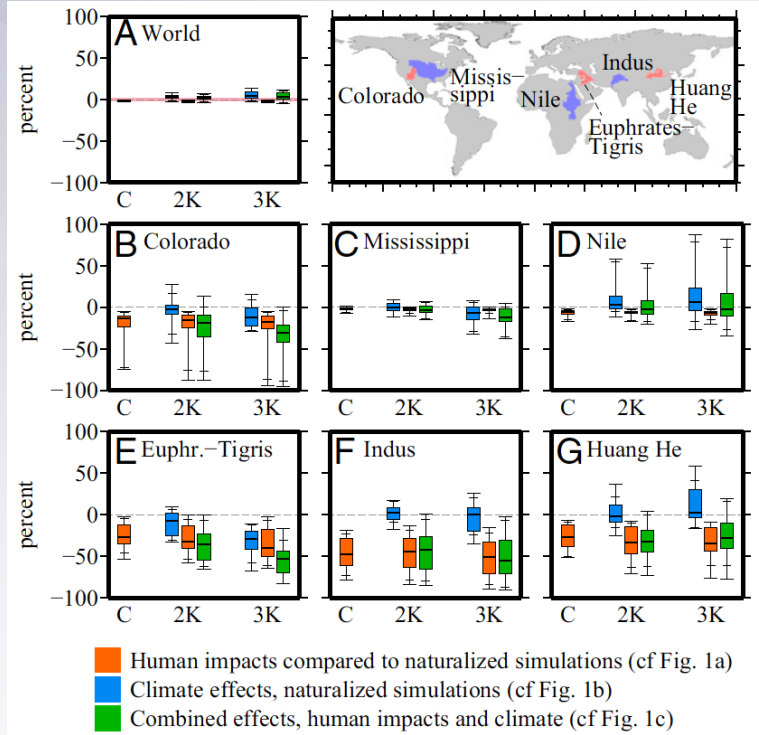


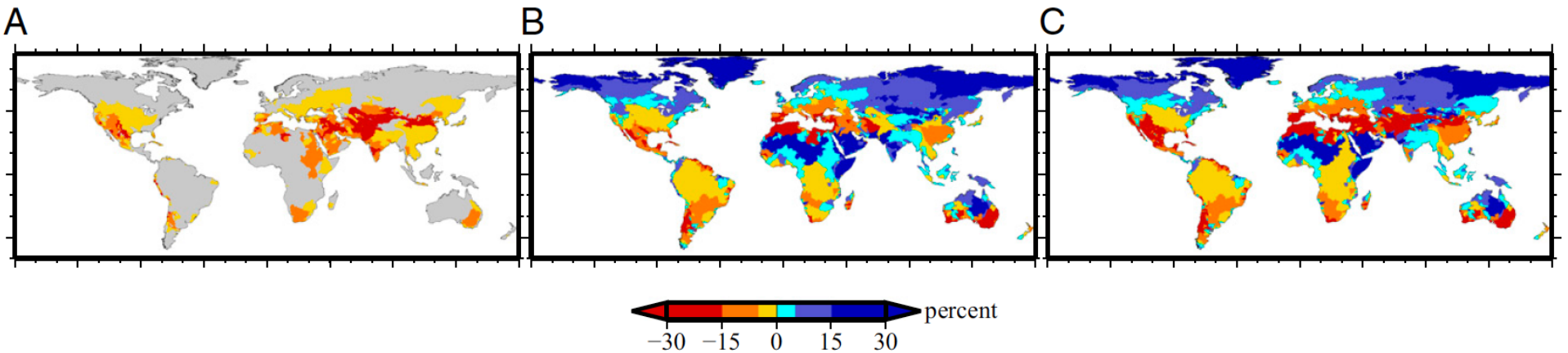
  - Challenges: Initialization of high resolution coupled decadal simulations; need for ensemble simulations for signal-to-noise

- **S2SD processes and predictability**
  - S2SD modes of variability (e.g., MJO, ENSO, NAO, PDO, AMO) and their influence on regional precipitation and extreme events
  - Decomposing decadal trends and signatures driven by individual and combined human activities (e.g., emissions, land use and water use)
  - Uncertainty in cryospheric processes that influence decadal SLR
  - Collaborations with other DOE projects on relevant processes/predictability (e.g., Arctic)

Climate change vs. human interventions

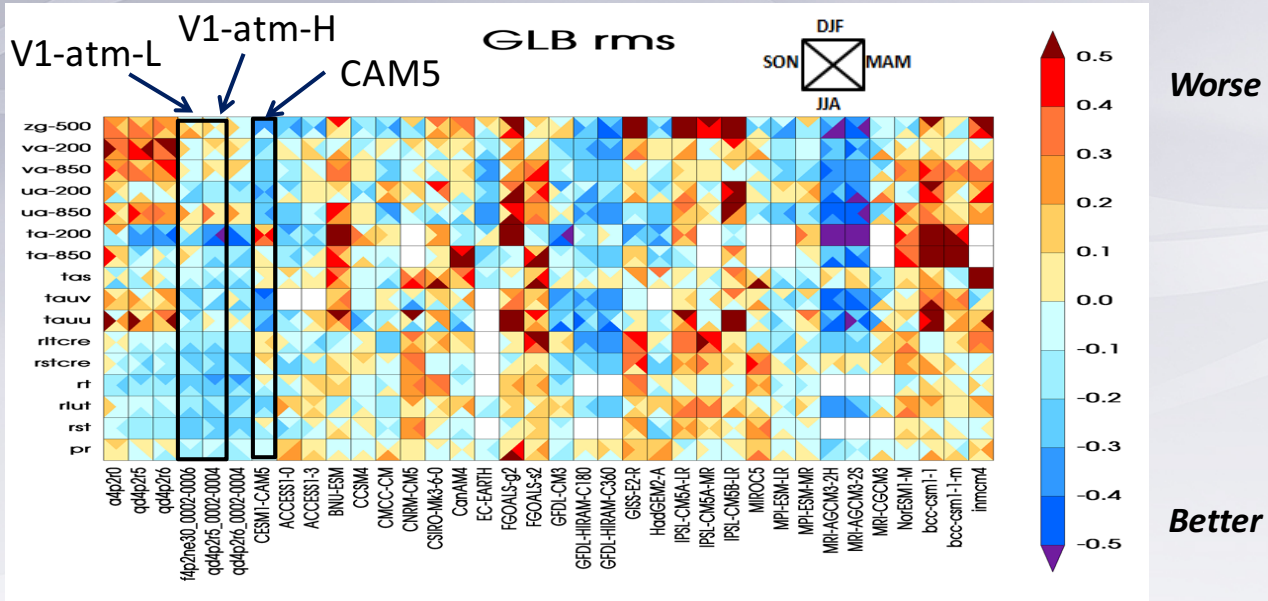
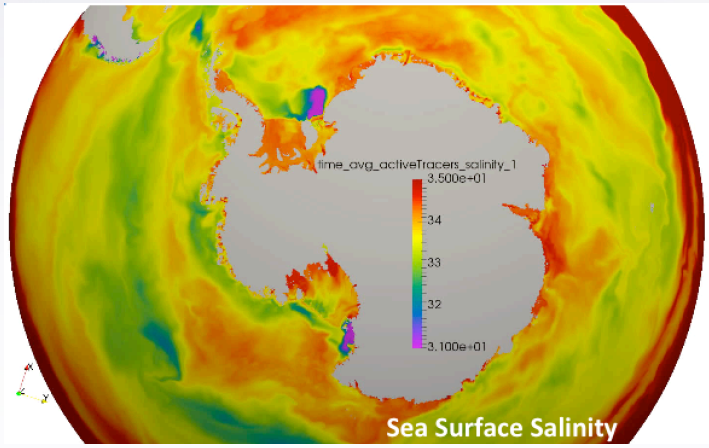
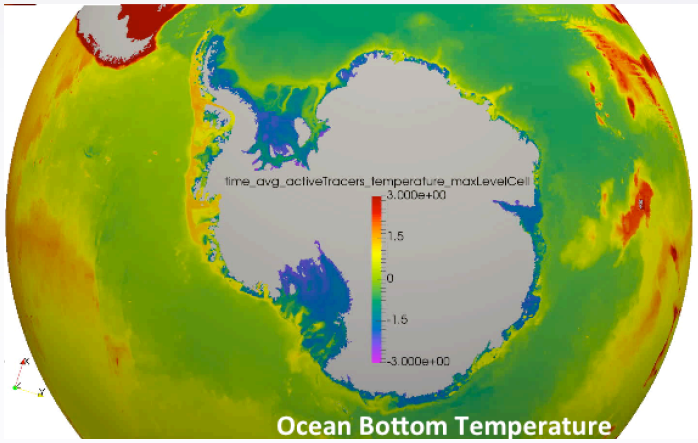
- At local scale, irrigation effects on groundwater storage and streamflow can be comparable to the changes induced by a 2.5 °C temperature rise (Ferguson and Maxwell, 2012; Haddeland et al. 2014)
- Irrigation impacts are expected to increase with the growing world population and food demand (Tilman 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*)

Preliminary results from high resolution simulations



MPAS-O: circulation beneath and coupling to Antarctic ice shelves