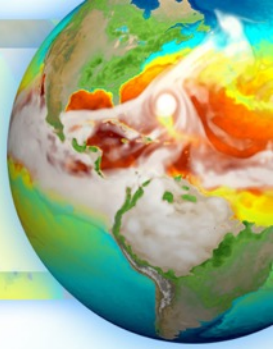


E3SM Science Goals for V3 and V4

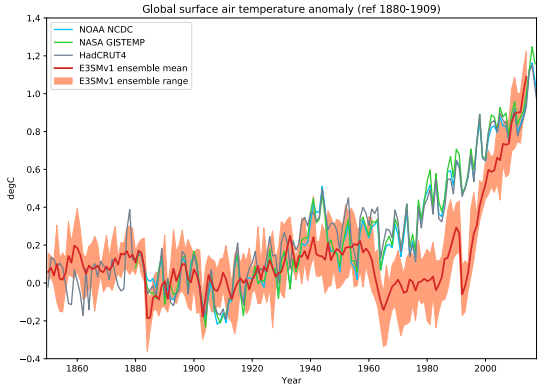
L. Ruby Leung

DOE E3SM Review, November 9-10, 2020

Water cycle: insights from v1

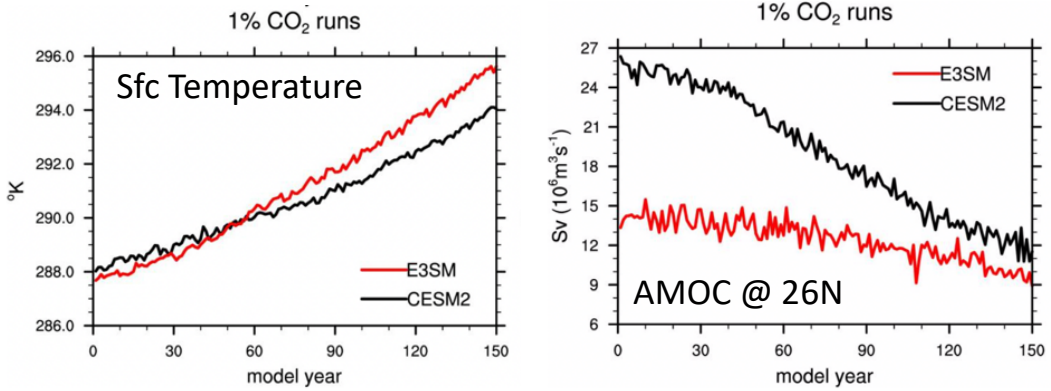
- E3SM v1 has high ECS partly due to large positive cloud feedback, with strong aerosol forcing
- E3SM v1 has high TCR, due partly to a weak AMOC
- These characteristics have important implications for projecting future water cycle changes
- Significant NGD development offers an opportunity to better constrain future projections of water cycle changes

E3SM v1 simulated historical temperature (ECS = 5.3 K)



(Golaz et al. 2019 JAMES)

E3SM v1 has a weak AMOC



(Hu et al 2020 J. Climate)

Water cycle: v3 science

Clouds, aerosols, ocean, sea ice, coupled processes, …

ECS and TCR

Energy flow in the earth system

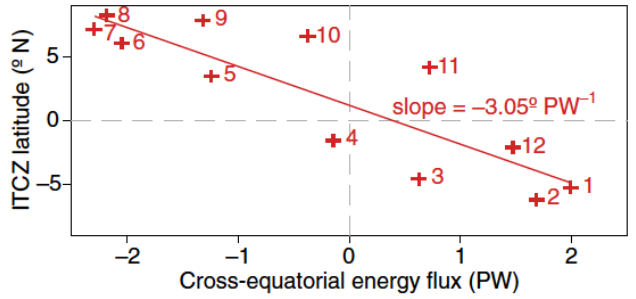
Precipitation and other water cycle processes

Historical climate

TCR — constrain? ↓

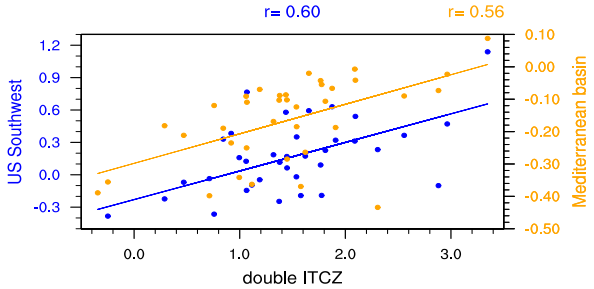
Future projection

Energetic constraint on tropical precipitation



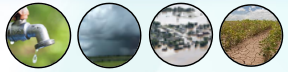
(Biasutti et al. 2018 NGEO)

Double ITCZ constraint on future precipitation changes



(Dong et al. in review)

Water cycle: v4 science



GPU-enabled

Storm-resolving to standard resolution

Resolution frontier

- Impacts of model resolution on water cycle processes (through impacts on cloud feedback, …)
- Impacts of air-sea interactions in cloud-resolving atmosphere and eddy-resolving ocean simulations on hydrological cycle

Quantify uncertainty through large ensemble simulations

- Relative contributions of uncertainties from internal variability, model physics, grid resolution to uncertainties in water cycle
- Relationships between uncertainties in present-day and future water cycle

Use of ML/AI: e.g., emulation for ensemble modeling

Biogeochemistry: v3 science

Land focused

V1: Impact of terrestrial CNP and nutrient competition on carbon-climate feedback

- Natural processes
- Diagnostic CO_2

Human and land focused

V2: Implications of different energy futures for BGC through LULC, water availability, and extreme events

- Human-earth interactions
- Prognostic CO_2

Coupled system

V3: Impacts of changes in carbon, methane, and other nutrients on climate and the coupled earth system

- Natural/anthropogenic sources (e.g., energy, LU) and sinks (e.g., CO_2 removal)
- Anoxia through land-river-coastal processes

Coastal capabilities (e.g., ICoM, InteRFACE)

Cryosphere: v3/v4 science

Ocean-ice shelf

V1: Impact of ocean-ice shelf interactions on melting of Antarctic Ice Sheet (AIS)

Atmosphere, ocean, and sea ice forcing

V2: Mediation of atmosphere, ocean, and sea-ice to sea level rise from AIS

Biases in processes driving ice shelf melting, tipping points, and implications for global climate and coastal vulnerability

V3: Key uncertainties in projecting regional sea level rise

Dynamic ice sheet (GIS and AIS)

Offline RSL modeling

V4: Impacts of sea level rise and extreme storms on coastal inundation

Online RSL modeling

Coastal modeling

Ice sheet/RSL capabilities (e.g., SciDAC, ECA)