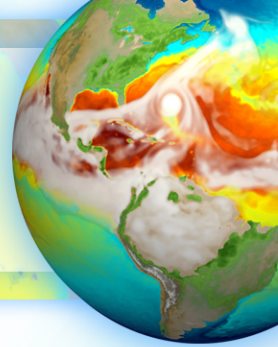


# E3SM Water Cycle Group v2 Update



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on behalf of the entire Water Cycle Group

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ESMD E3SM PI Meeting - October 2020

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# E3SM Water Cycle

## Overarching Science Question

How does the **hydrological cycle** interact with the rest of the human-Earth system on **local** to **global scales** to determine **water availability** and **water cycle** extremes?

# E3SM Water Cycle – brief history

## E3SMv1

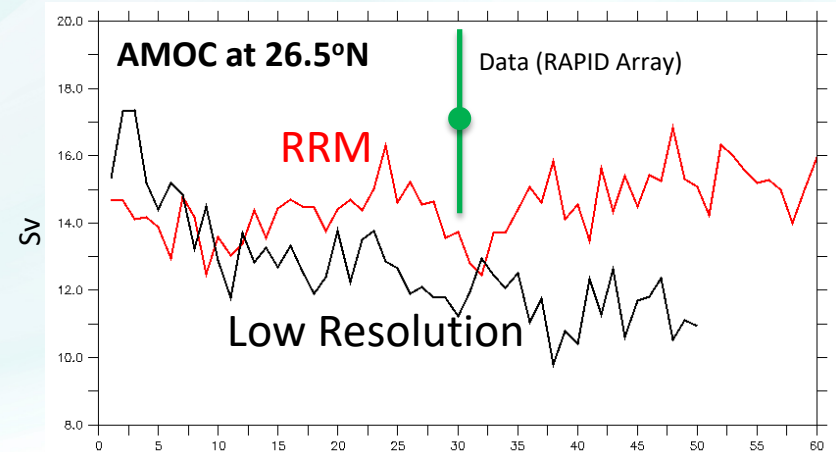
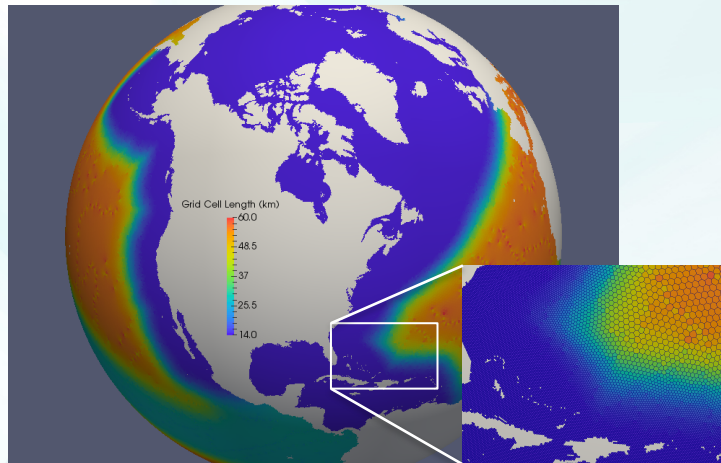
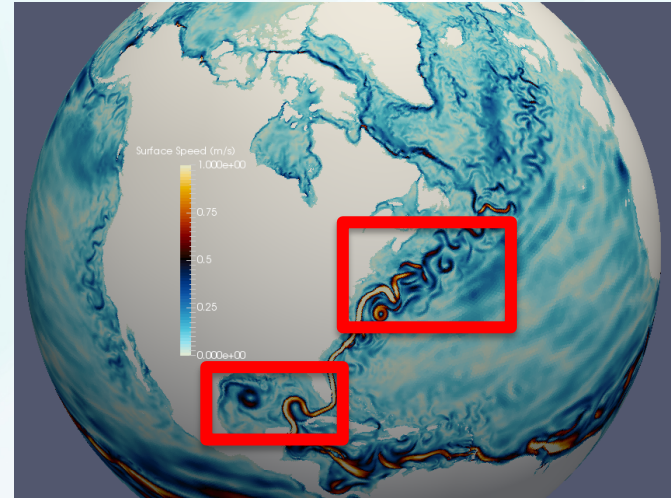
- **Jan 2018** Simulation campaign starts.
- **April 2019** Low-resolution paper accepted (Golaz et al. 2019).
- **Oct 2019** High-resolution paper accepted (Caldwell et al. 2019).
- **Since then** Many interesting analysis papers.

## E3SMv2

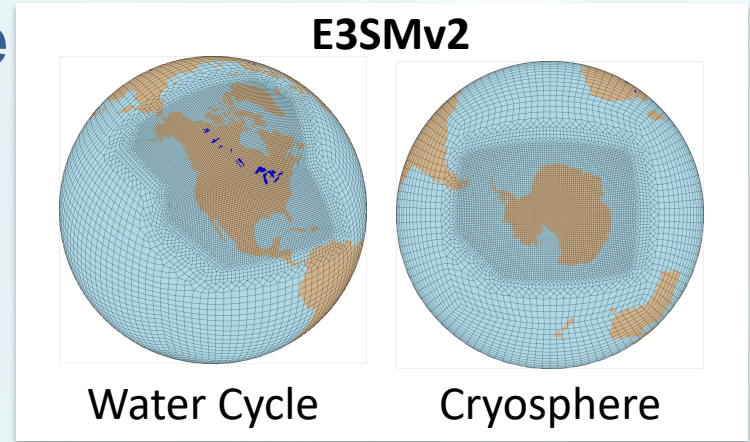
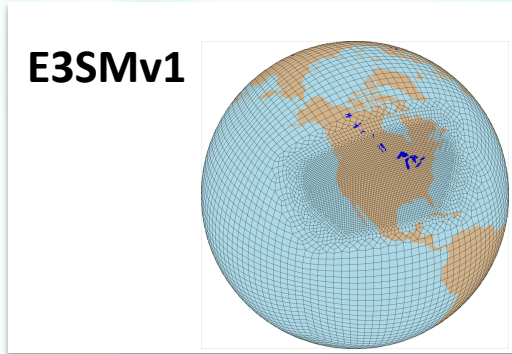
- Evolution from v1, but with many new features.
- Planning to freeze and start simulation campaign in **Fall 2020**.
- Compared to v1: “**faster and better**”.

# Regionally Refined Ocean

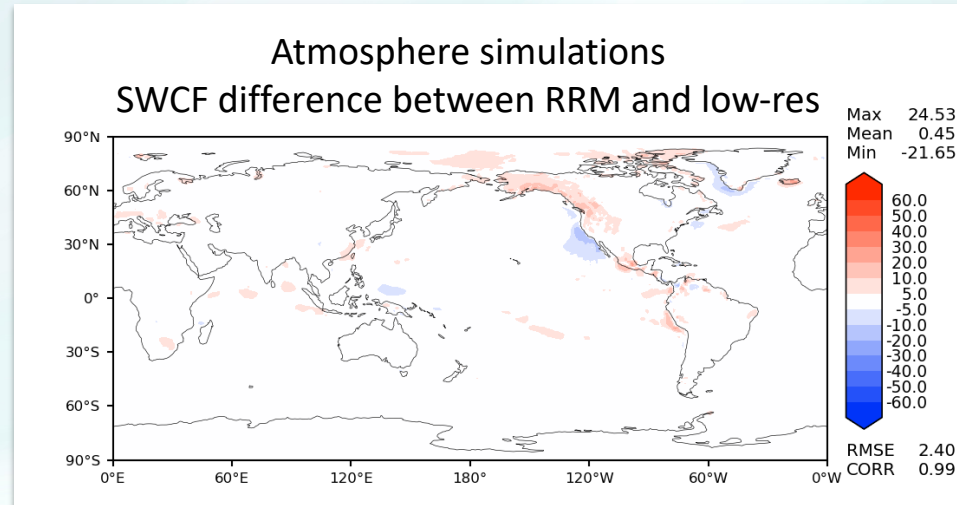
- **Key feature of v2 is a regionally refined capability**
- For Water Cycle (below):
  - Base is standard low-resolution mesh from v1
  - Resolution increased to 14 km in N. Atlantic and Arctic and near N. American Coast
- In forced ocean sea-ice cases, results are encouraging
  - Gulf stream: strength, separation, variability
  - AMOC ( $\sim 4\text{Sv}$  improvement)



# Regionally Refined Atmosphere

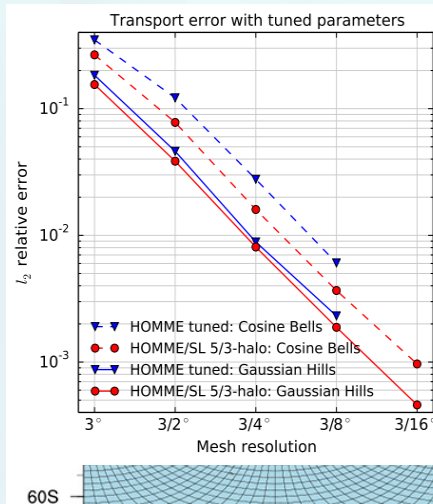
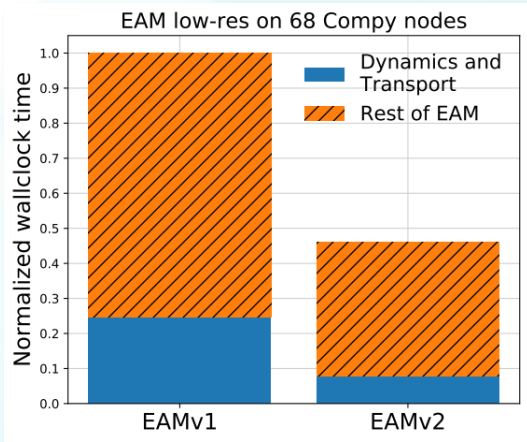


- With hybrid time step, **no (or minimum)** retuning is required for RRM compared to low-res atmosphere.
- Minimum differences **outside** refined region.
- High-resolution characteristics **inside**.

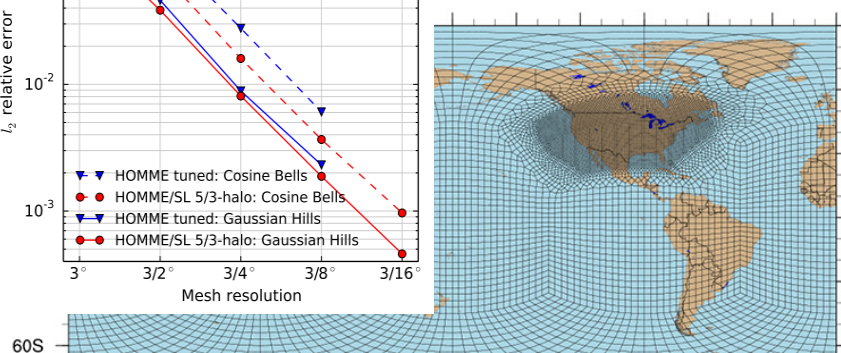


# New atmosphere capabilities

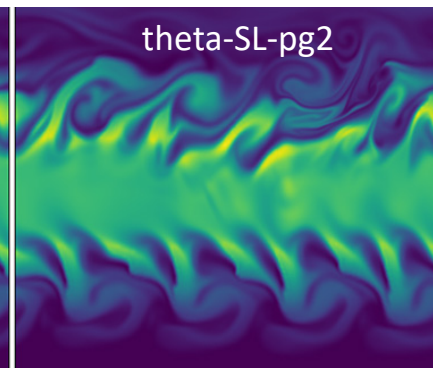
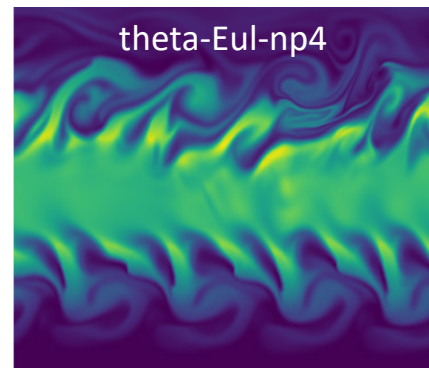
- New dynamical core (theta)
  - Semi-Lagrangian (SL) tracer transport
  - Physics grid (pg2)
- ✓ ~3-5x faster tracer transport
- ✓ ~2x faster atmosphere
- ✓ Reduced chemistry cost (30% -> 10%);  
for future versions



v2 tracer transport is faster than v1, with no loss of accuracy

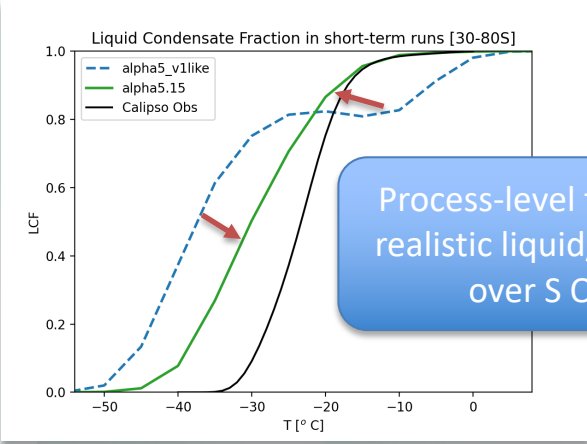


Specific humidity in moist baroclinic instability test on RRM grid.



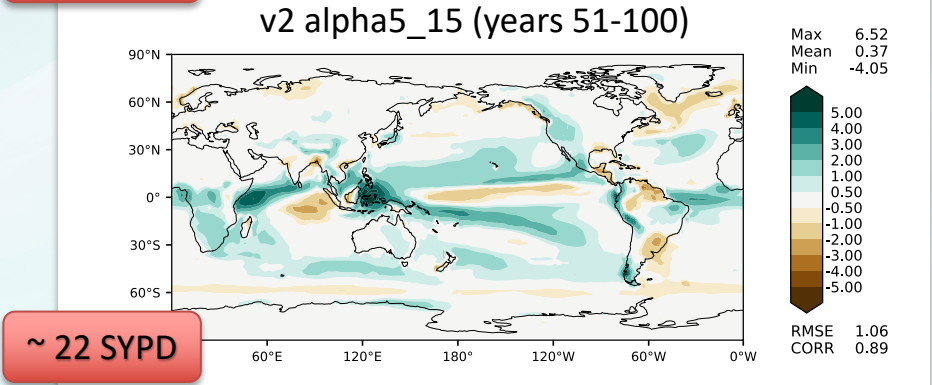
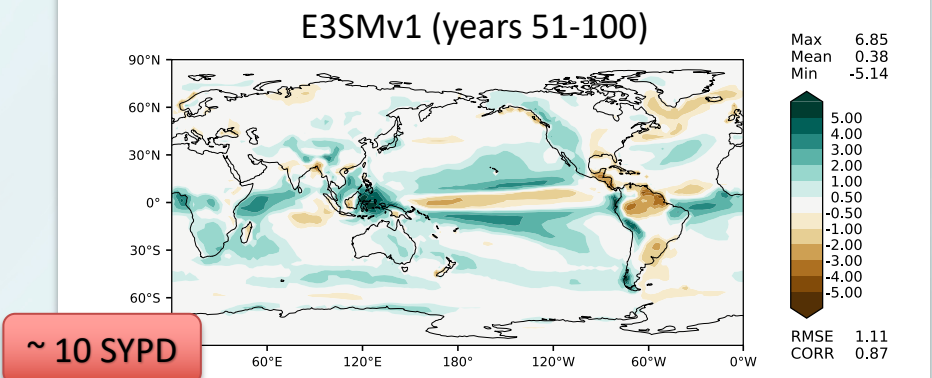
# Improved atmospheric physics with NGD-Atmosphere contributions

- Improved physics tunings.
  - Precipitation, clouds
  - Reduced aerosol-cloud forcing (min cloud number)
  - Reduced cloud feedback (?)
- New deep convection trigger (dCAPE+ULL)
- Improved QBO (retuning of GWD)
- Improved ozone chemistry, including troposphere
- More realistic dust
- ...and much more



Process-level tuning: more realistic liquid/ice partition over S Oceans.

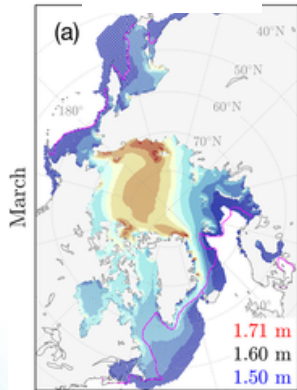
## Coupled piControl simulations: precipitation bias



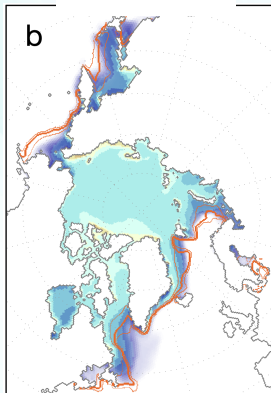
SYPD: simulated years per day

# New ocean and sea ice features

E3SMv1



E3SMv2



- **Ocean –**
  - Gent McWilliams
  - Redi Mixing
  - Critical Passages
  - Freezing Temperature
- **Sea Ice –**
  - Radiation scheme
  - Snow morphology
- **Discovered and addressed critical bugs**
  - Advection scheme
  - Snow melt on sea ice

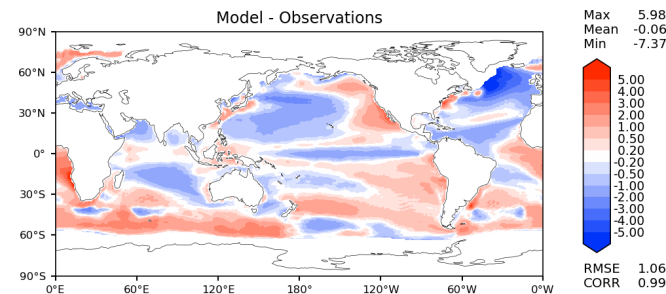
## Sea-ice (March, Northern Hemisphere)

**Contour:** thickness, truncated at 15% concentration.

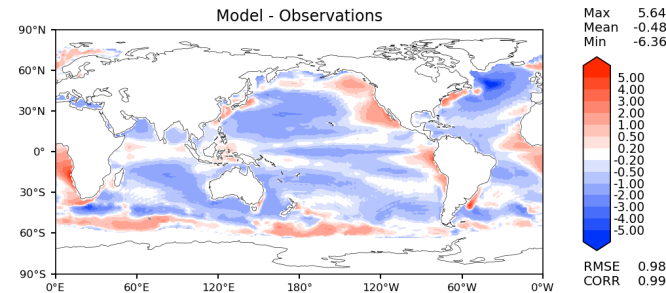
**Line:** observed sea-ice extent

## Sea-surface temperature biases (PI)

E3SMv1

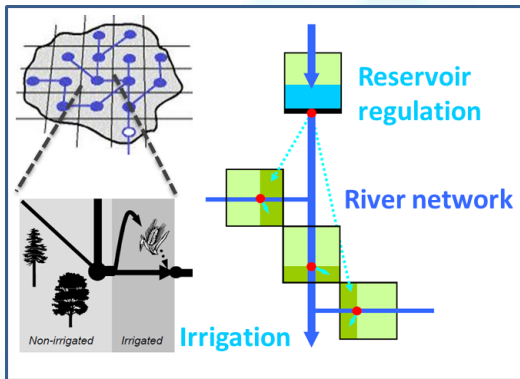


E3SMv2

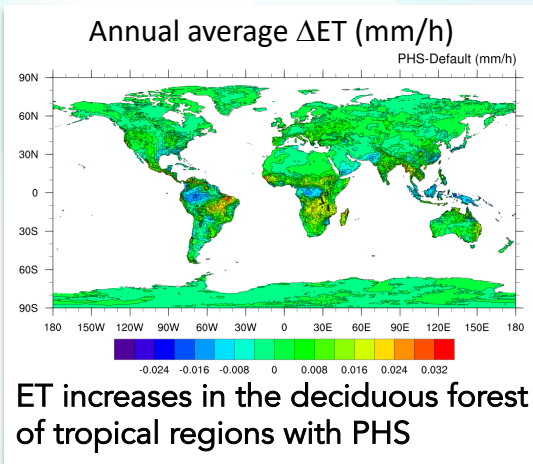
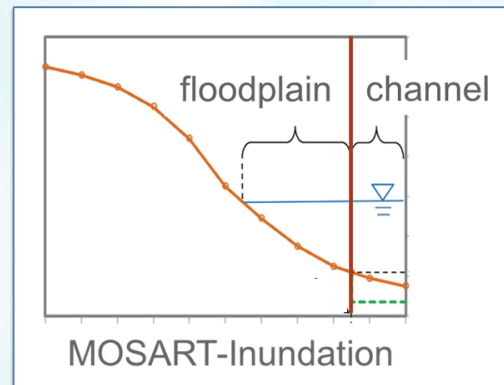




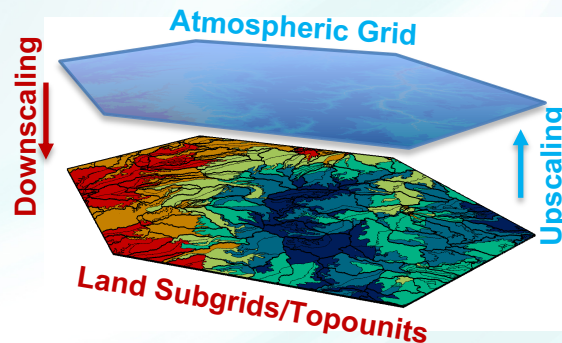
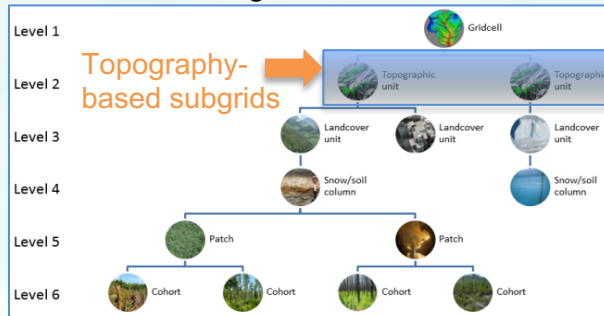
# New land and river features



- **Land and river models** now on a **common grid** ( $1/2$  or  $1/8^\circ$ ), separate from atmosphere (“tri-grid”).
- **Water management** and two-way coupled **irrigation** schemes.
- Flood **inundation** scheme.
- New **plant hydraulics** (PHS).
- **Sub-grid topographic units** with downscaling of atmospheric forcing.



## Hierarchical sub-grid structure in E3SM



# Summary

- Despite limited time for development, **E3SMv2**
  - **faster** than E3SMv1 (~2x at standard-resolution)
  - **better** climate (precipitation, SST, sea-ice, ...)
- New **regionally refined** capabilities for **coupled simulations**.
  - Considering DECK simulation campaign with RRM
- E3SMv2 Water Cycle configuration to be finalized in next few weeks.
- Simulation campaign to start before the end of the year.

**Questions?**