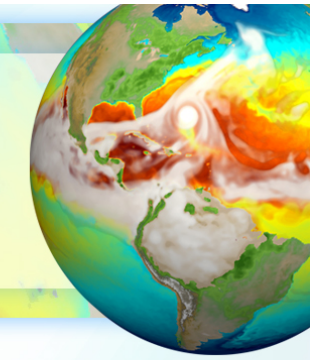
Energy Exascale Earth System Model Project



Dave Bader, E3SM Council Chair, Presenter

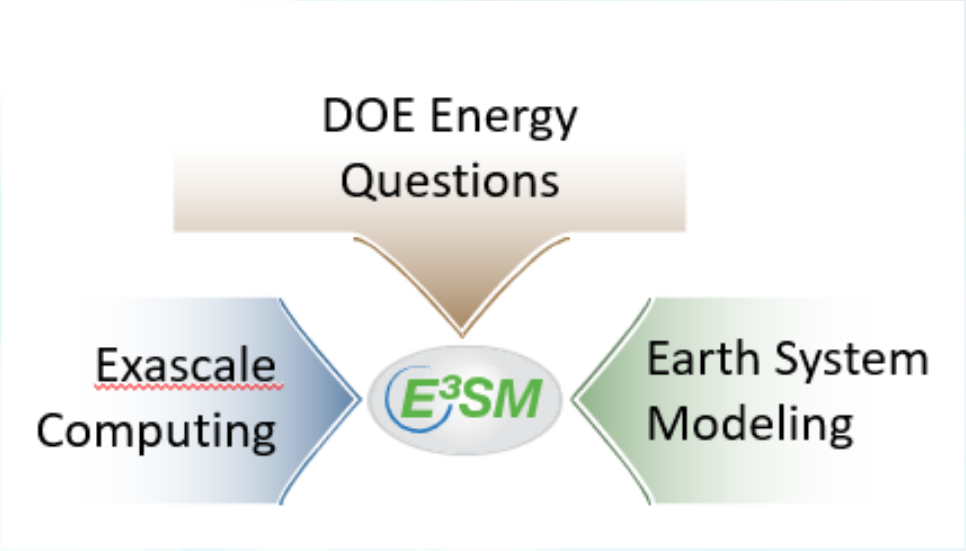
Ruby Leung, Renata McCoy, Mark Taylor, Chris Golaz, Luke Van Roekel, Steve Price, Mark Petersen, Wuyin Lin, Kate Calvin, Susannah Burrows, Rob Jacob, Jill Zhang, Phil Jones, Sarat Sreepathi, Peter Caldwell, Ben Bond-Lamberty, Shaocheng Xie, Andy Salinger and the E3SM Team from Eight DOE Laboratories and Many Universities

Earth System Model Development (PI) Virtual Meeting

October 26, 2020


Incredible Team
Ruby Leung, Renata McCoy, Mark Taylor, Chris Golaz,
Luke Van Roekel, Steve Price, Mark Petersen,
Wuyin Lin, Kate Calvin, Susannah Burrows,
Rob Jacob, Jill Zhang, Phil Jones, Sarat Sreepathi,
Peter Caldwell, Ben Bond-Lamberty, Shaocheng Xie,
Andy Salinger

"A DOE Model for the DOE Mission on DOE Computers"

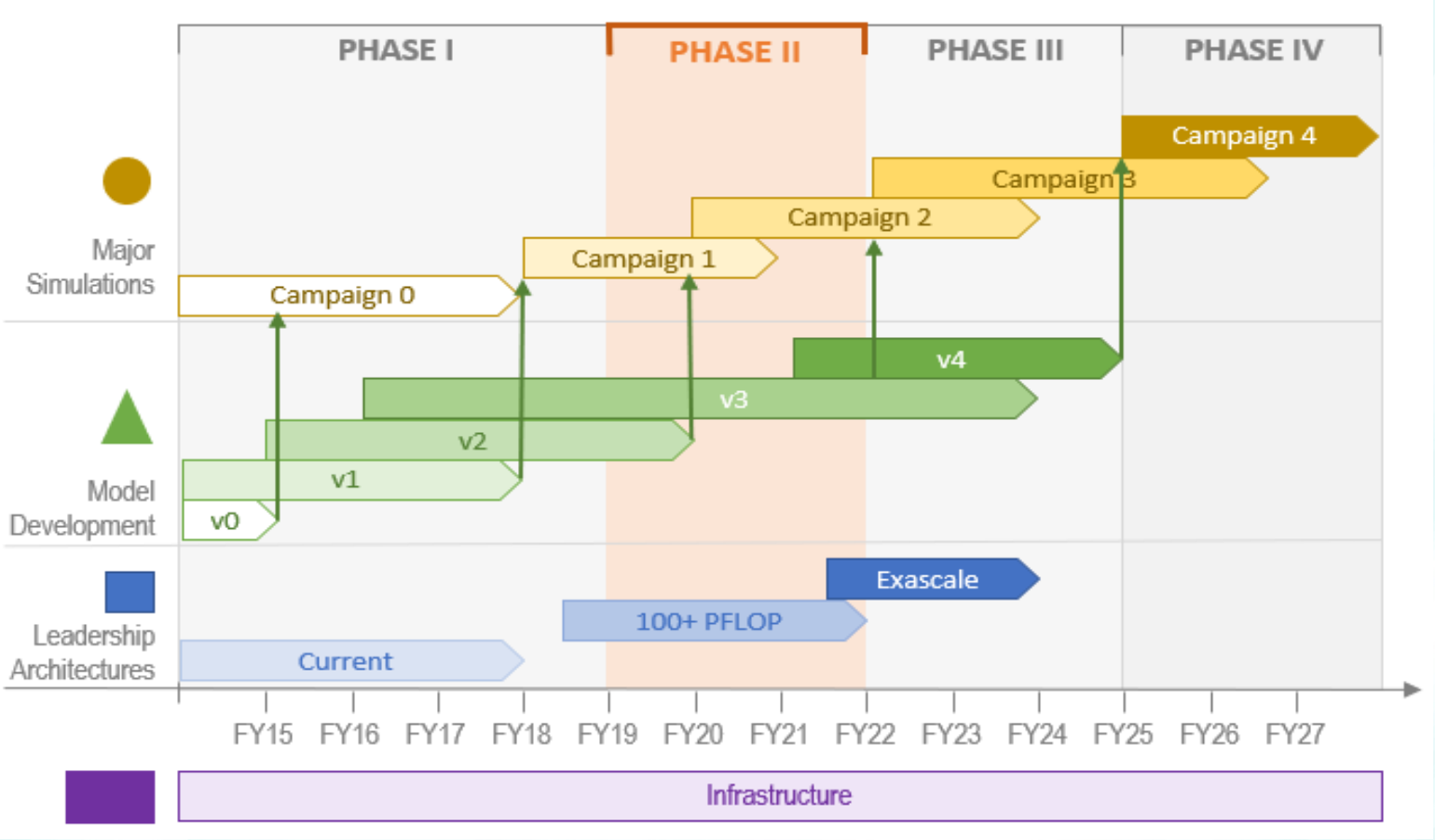


2017 E3SM Strategic Plan

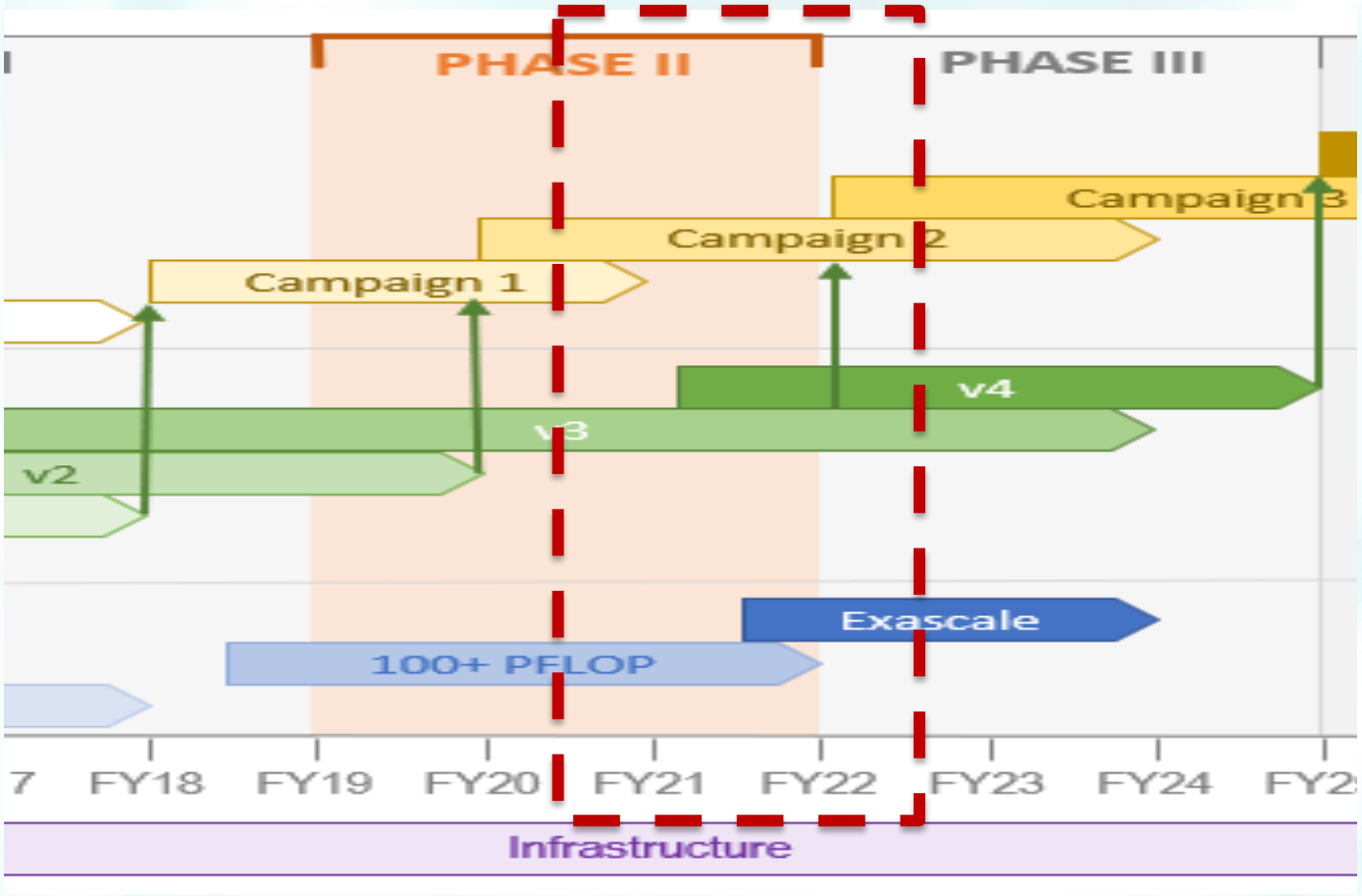
Four intersecting project elements:

- a series of **prediction and simulation experiments** addressing scientific questions and mission needs;
- a well documented and tested, continuously advancing, evolving, and improving **system of model codes that comprise the E3SM Earth system model**;
- the ability to use effectively **leading (and "bleeding") edge computational facilities** soon after their deployment at DOE national laboratories; and
- **an infrastructure** to support code development, hypothesis testing, simulation execution, and analysis of results.

Overlapping Development Cycle Paradigm Adopted from NWP Centers



We are nearing the end of Phase II and preparing for Phase III



Phase II Science and mission drivers for development and experimentation

- ***Resolution*** – weather-scale to convective scale-atmosphere and eddy-resolving ocean for simulation of multi-scale phenomena
- Utilize ***next-generation disruptive computing*** to enable high-throughput, high resolution simulations
- Extensive use of ***ensembles*** to quantify and bound uncertainty for ***actionable predictions.*** Even small reductions in uncertainty are useful in risk analysis.
- Coordinated efforts to ***reduce biases*** and ***address mission questions***

E3SM Model Versions

E3SMv1

Documented in AGU Special Collection

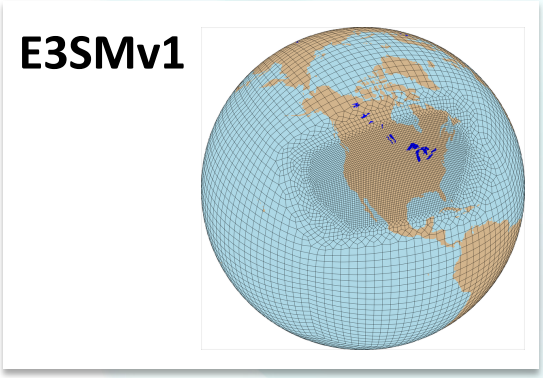
https://agupubs.onlinelibrary.wiley.com/doi/toc/10.1002/(ISSN)2169-8996.ENERGY1

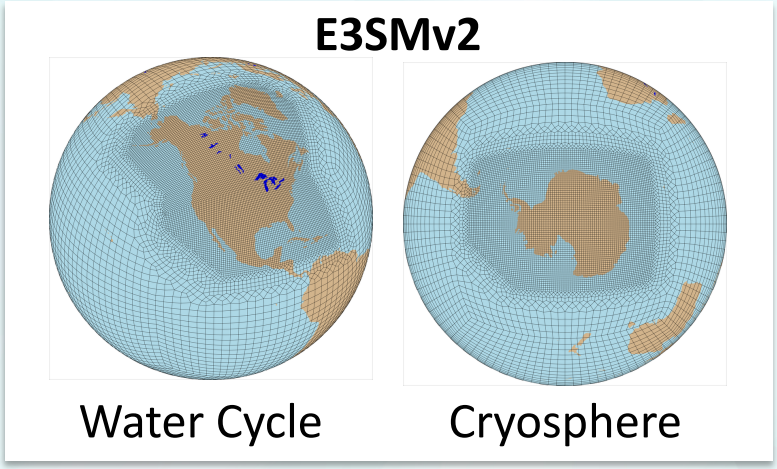
- **v1.0** Golaz et al. 2019
- **v1.1** Burrows, et al. 2020
- **V1.2** Jeong, et al. 2020 (JClim https://doi.org/10.1175/JCLI-D-19-0683.1)
- *Code available on https://github.com/E3SM-Project/E3SM/*
- *Model output available on ESGF and NERSC HPSS*

E3SMv2

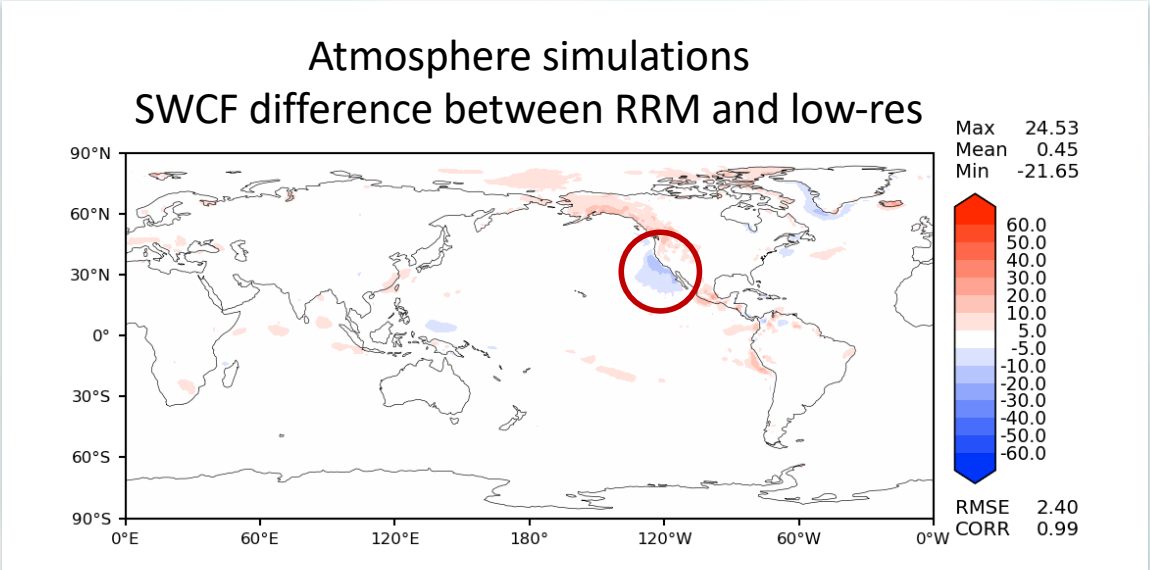
- Evolution from v1, but with many new features.
- Planning to freeze and start simulation campaign in **Fall 2020**.
- Compared to v1: "**faster and better**".

Regionally Refined Meshes Atmosphere

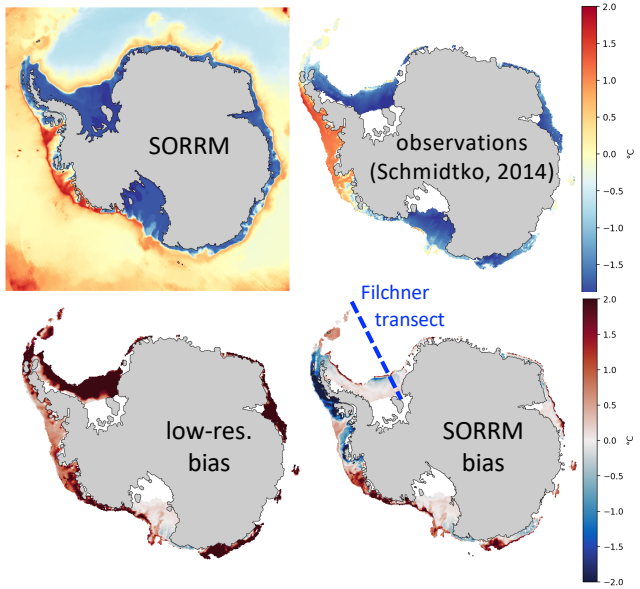


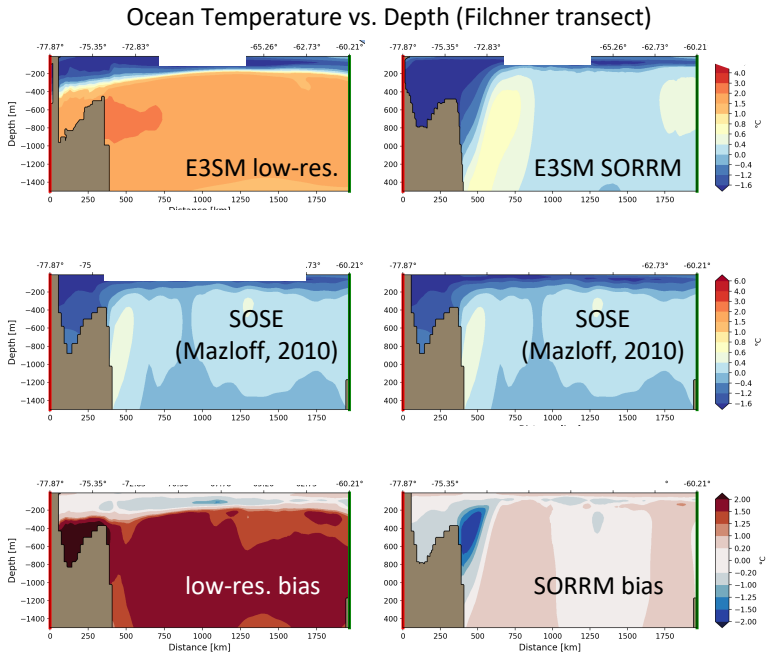


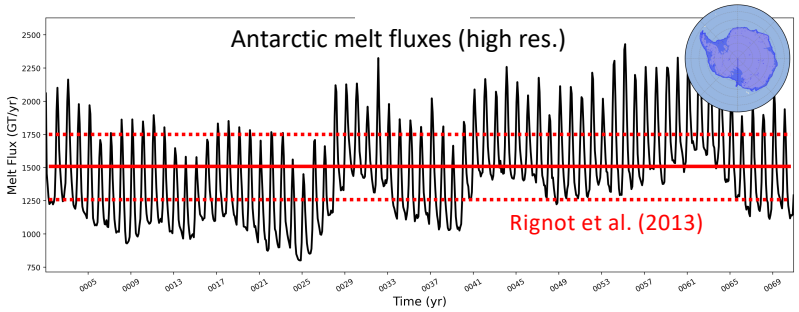
- With hybrid time step, no (or minimum) retuning is required for RRM compared to low-res atmosphere.
- RRM reduces shortwave cloud forcing bias over **stratocumulus** region



V2 Results: variable resolution configuration

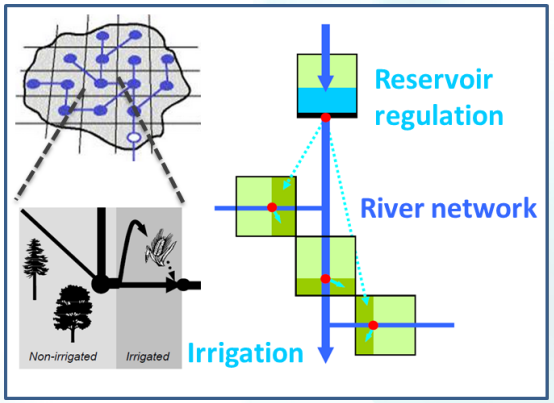




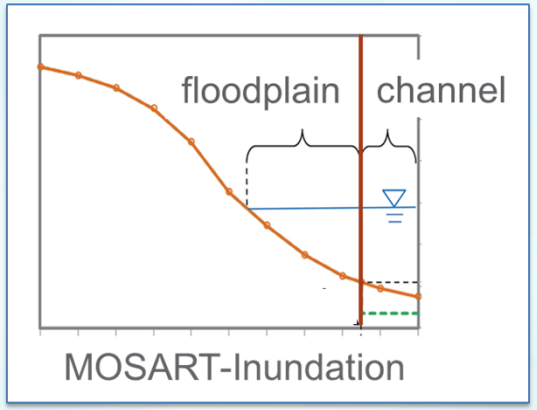


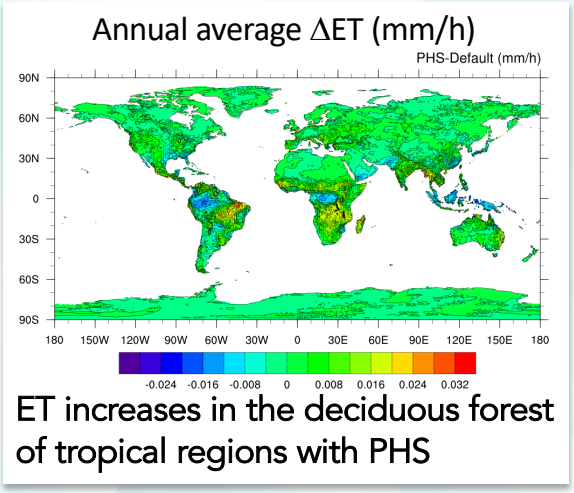
Higher ocean / ice res. around Antarctica improves on low-res. biases in regions with no GM closure

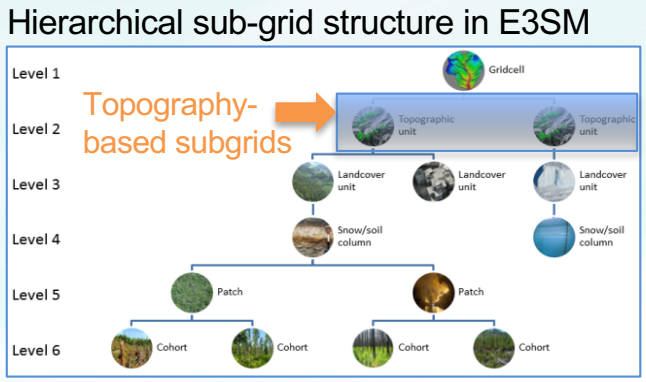
New land and river features

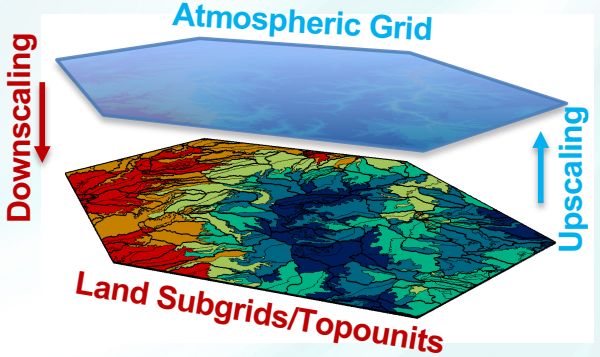


- **Land** and **river** models now on a **common grid** (1/2 or 1/8°), separate from atmosphere ("tri-grid").
- **Water management** and two-way coupled **irrigation** schemes.
- Flood **inundation** scheme.
- New **plant hydraulics** (PHS).
- **Sub-grid topographic units** with downscaling of atmospheric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



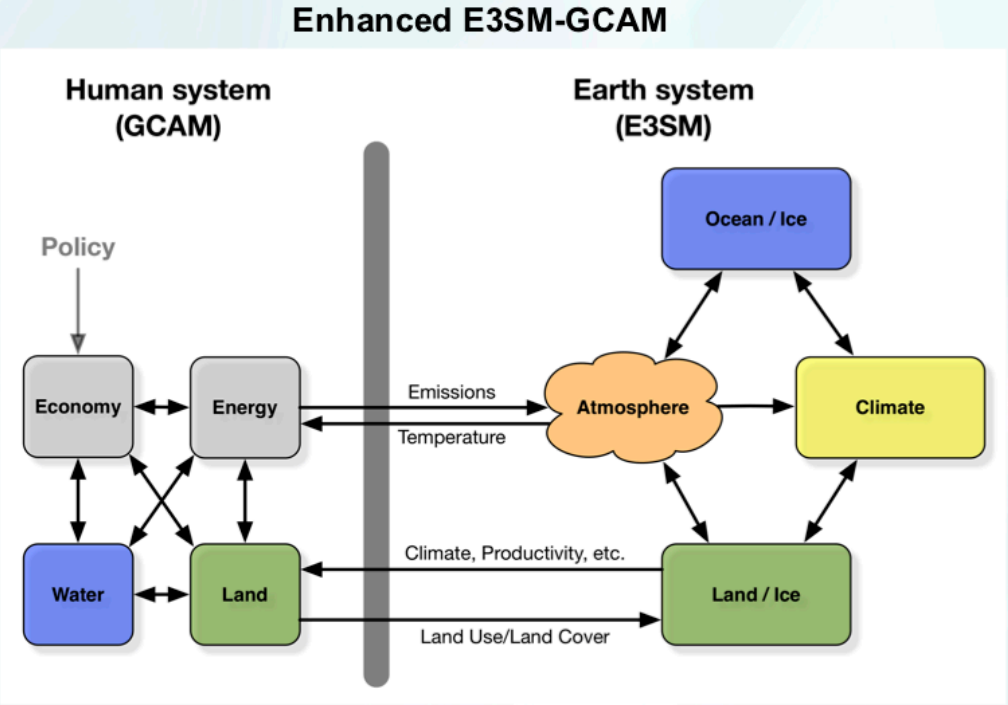






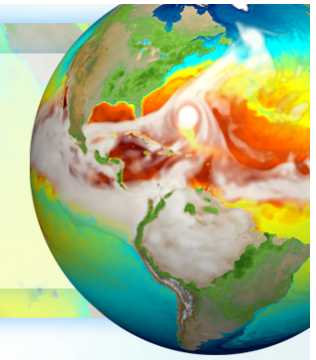
Energy Developments for v2

- Couple the Global Change Analysis Model (GCAM) with the E3SM
  - GCAM to E3SM: LULCC, CO_2 emissions, Non-CO_2 emissions/concentrations
  - E3SM to GCAM: changes in land productivity



● = Complete, ● = In Progress

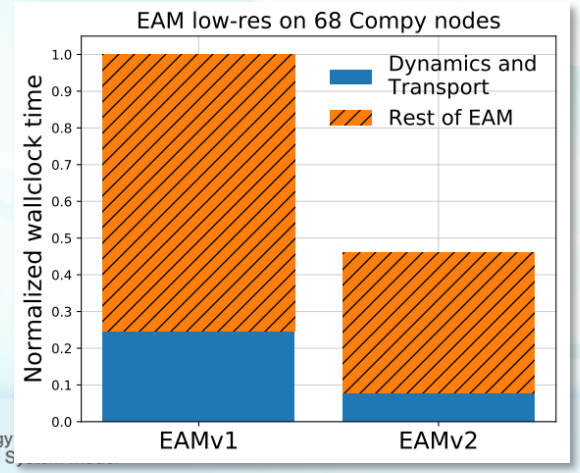
New computational improvements

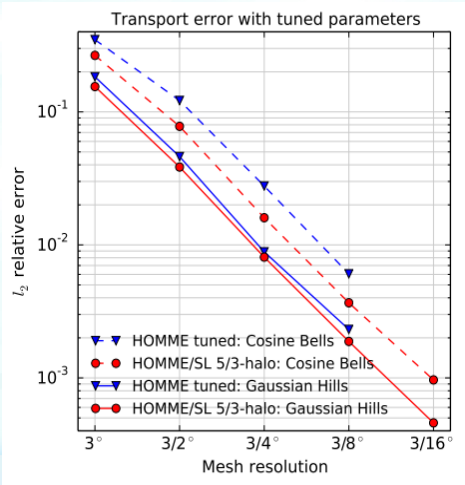


- New dynamical core (theta)
- Semi-Lagrangian (SL) tracer transport
- Physics grid (pg2)

✓ ~3-5x faster tracer transport
✓ ~2x faster atmosphere

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





E3SM Energy Earth S

U.S. DEPARTMENT OF ENERGY

Summary

- E3SMv1 Simulation Campaign (nearly) complete
- E3SMv1 Model available on GitHub and supported on NERSC and Compy
- Despite limited time for development, E3SMv2
  - is **faster** than E3SMv1 (~2x at standard-resolution)
  - has **better** climate (precipitation, SST, sea-ice, …)
- New **regionally refined** capabilities for **coupled simulations**.
- Simulation campaign to start before the end of the year.

Thank you for participating in the 2020 ESMD Meeting