Earth System Prediction Working Group Update

Steve Yeager (NSF NCAR) & Kathy Pegion (U. Oklahoma), WG Co-chairs
Sasha Glanville (NSF NCAR), WG liaison
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February 3, 2026

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ESPWG:

The goal of the ESPWG is to **advance fundamental understanding of Earth system predictability** on time scales ranging from **subseasonal to decadal**. Towards that end, this working group will bring together a **multidisciplinary** group of researchers interested in **how initial conditions influence the near-term evolution of the Earth system**. A key focus will be the **generation and analysis of initialized ensemble simulations** that shed light on the predictability of different components of the Earth system.

- Web page & mailing list: https://www.cesm.ucar.edu/working-groups/earth-system
- Join the discussion!

ESPWG Initialized Prediction Production Datasets

- CESM1 **Subseasonal-to-Seasonal (S2S)** reforecasts
  - Data in IRI SubX library
- CESM1 **Decadal Prediction Large Ensemble (DPLE)** reforecasts
  - 40-member, 122-month ensembles initialized annually (Nov. 1st 1954-2017)
  - https://gdex.ucar.edu/datasets/d651028/
- CESM2 **S2S** reforecast sets
  - CAM: 11-member, 45-day ensembles initialized weekly (1999-2020)
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- CESM2 **Seasonal-to-MultiYear Large Ensemble (SMYLE)** reforecasts
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  - Upload to GDEX & CMIP6Plus underway
- CESM2 **MultiDecadal Prediction (CESM2-MDP)** reforecasts
  - 10-member, 20-year hindcasts initialized Nov. 1 1960,1965,...,2015)

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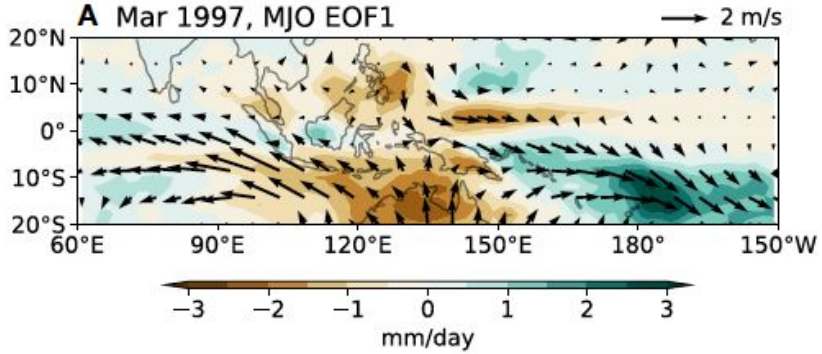
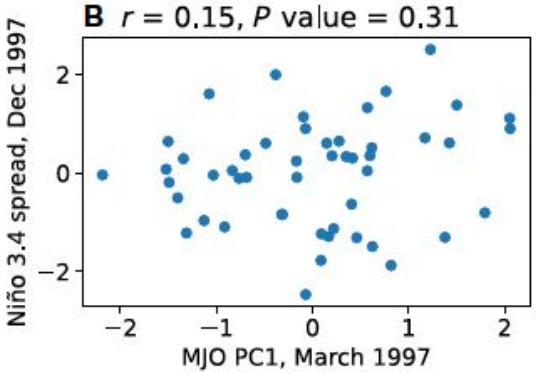
- CESM2 **SMYLE-TBIMIP** reforecasts
  - 10-member, 23-month hindcasts initialized Feb. 1 (1982-2021)
  - Restoring to observed SST anomalies in each of tropical Pacific, Indian, Atlantic
  - Upload to GDEX coming

Richter et al. (GMD, 2025)

Select Science Highlights

CESM2 SMYLE sheds light on relative role of seasonal El Niño precursors.



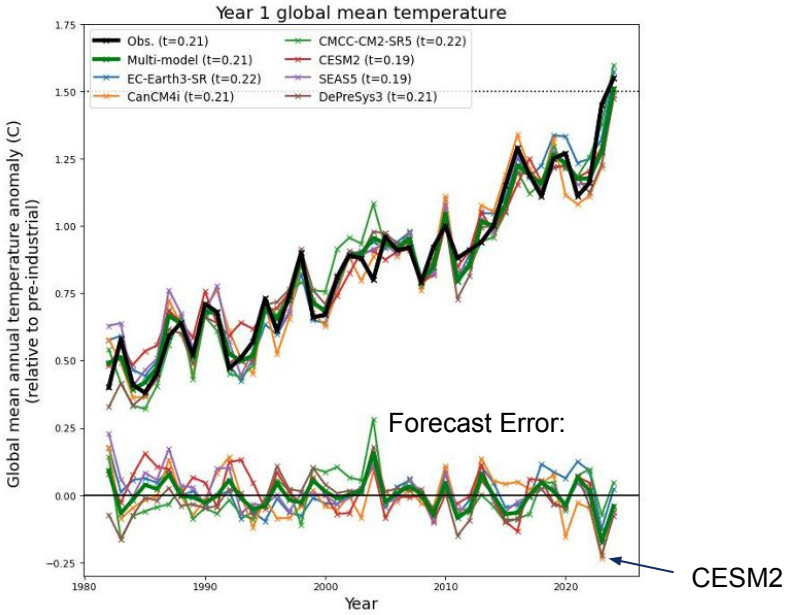


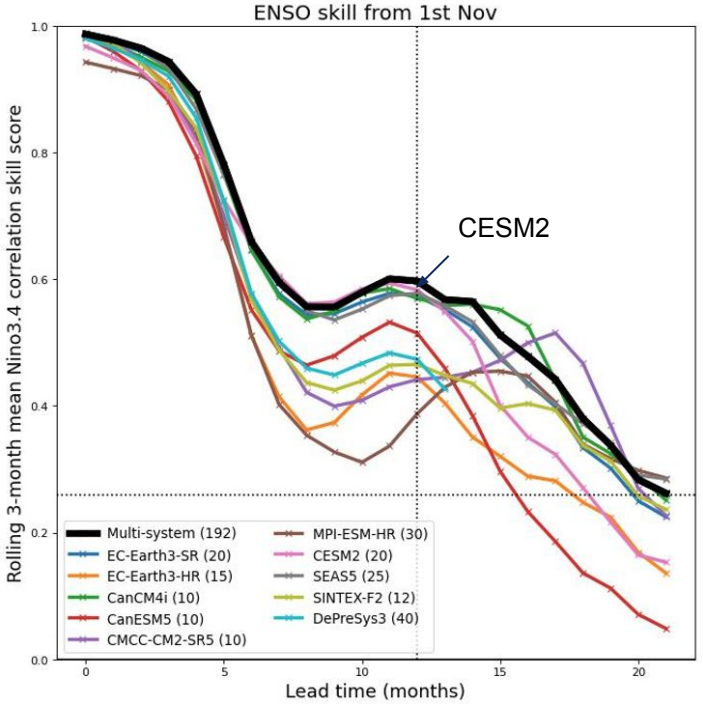
Liang et al., 2025: North Pacific meridional mode has larger impacts on El Niño evolution than the March Madden-Julian Oscillation, *Science Advances*, 11,eadv8621, DOI:10.1126/sciadv.adv8621.

Figure courtesy Yu Liang (Scripps/UCSD)

Select Science Highlights

CESM2 SMYLE multi-year ENSO skill is competitive, but it shows one of the poorest predictions of 2023 GMST…





Figures courtesy Nick Dunstone (UKMO)

Select Science Highlights

CESM1 and CESM2 decadal prediction systems outperform other DCPP systems in predicting Atlantic subpolar gyre heat content change.

What explains skill spread across systems?

(See talk by Dylan in ESPWG session Wednesday 2:45pm)

N. Atlantic ocean heat content skill:

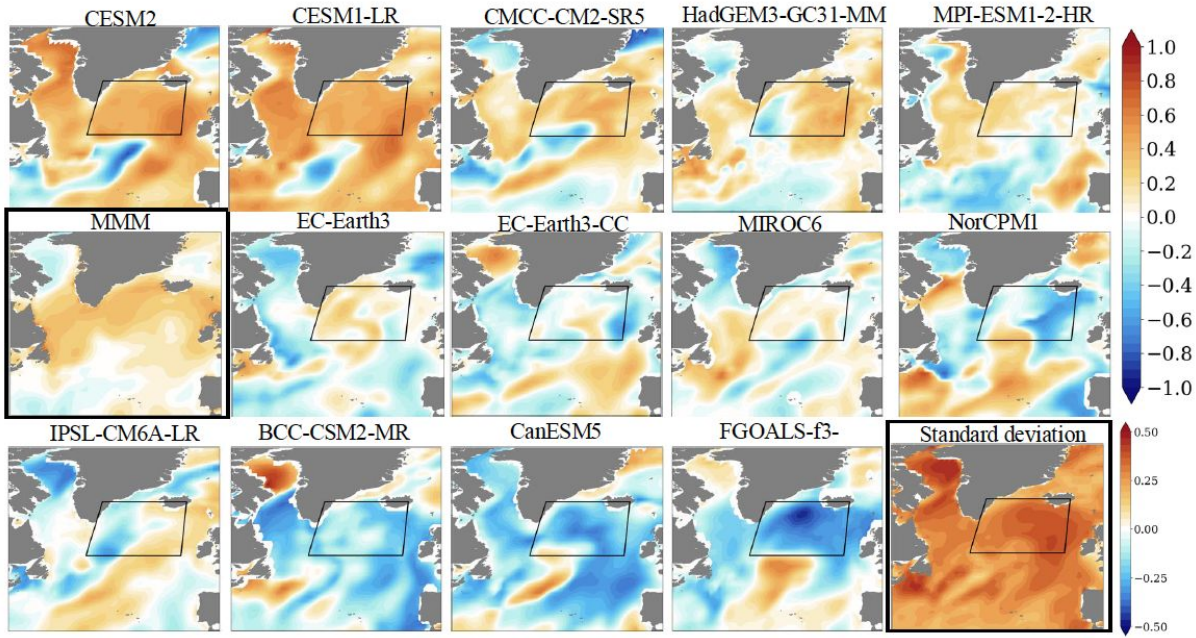


Figure courtesy Dylan Oldenburg (NCAR)

Select Science Highlights

Comparison of CESM prediction systems reveals high but variable skill over Africa.

Is skill actionable? What explains skill sensitivity?

(See talk by Nina Omani & Emily Riddle in ESPWG session Wednesday 3:20pm)

Country-level Precipitation Skill:

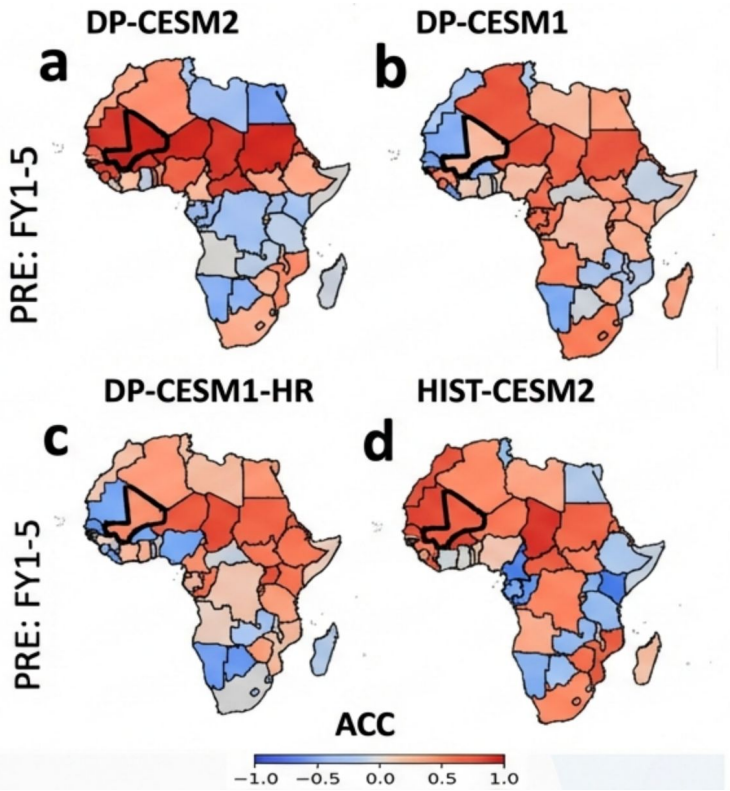


Figure courtesy Nina Omani (NCAR)

Recent Development Efforts

Supporting work to better understand the role of land-atmosphere interactions in S2S prediction.

CESM2 with stronger L-A coupling →

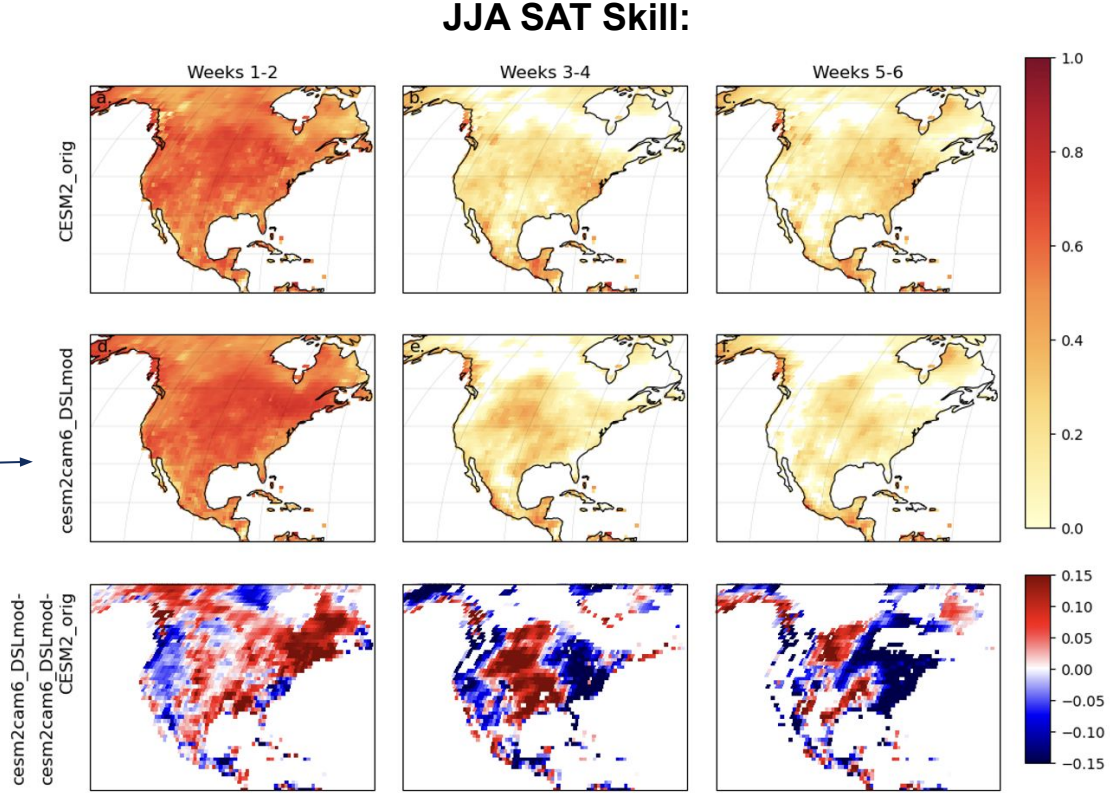


Figure courtesy Meg Fowler (NCAR)

Recent Development Efforts

Supporting work to better understand the role of model formulation/physics in S2S prediction.

(See talk by Abby in ESPWG session Wednesday 1:45pm)

DJF SAT Skill:

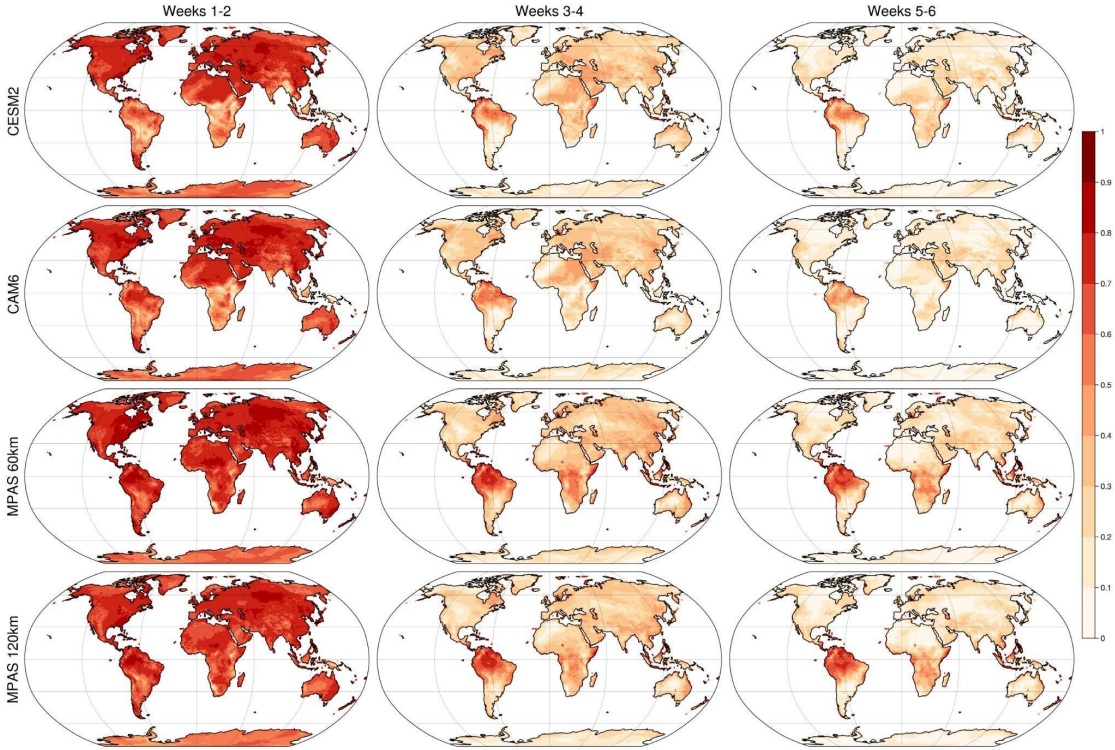


Figure courtesy Abby Jaye (NCAR)

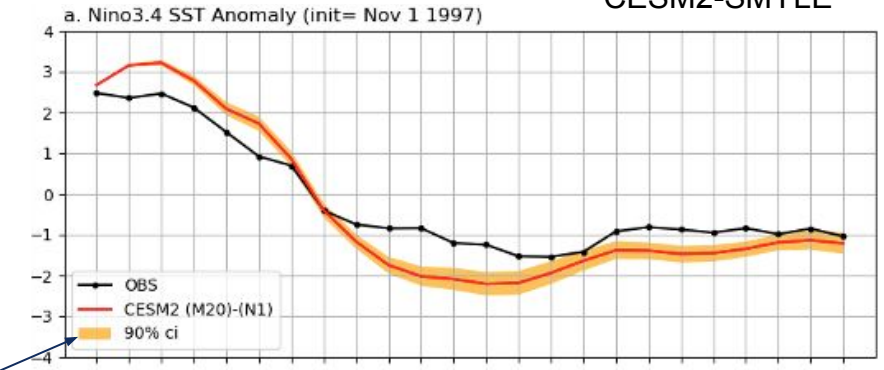
Recent Development Efforts

Supporting work to better understand prediction system drift.

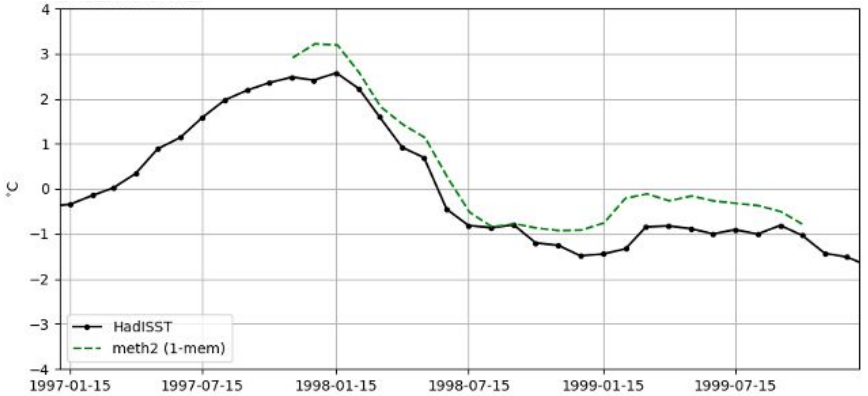
Uncertainty range when using 20x cheaper drift correction method

(See talk by Yeager in ESPWG session June 2025)

CESM2-SMYLE



CESM3



Recent Development Efforts

Supporting the development of the Decadal Climate Prediction Project (DCPP) protocol for CMIP7.

Coupled model (CESM2) response to idealized Aleutian Low forcing:

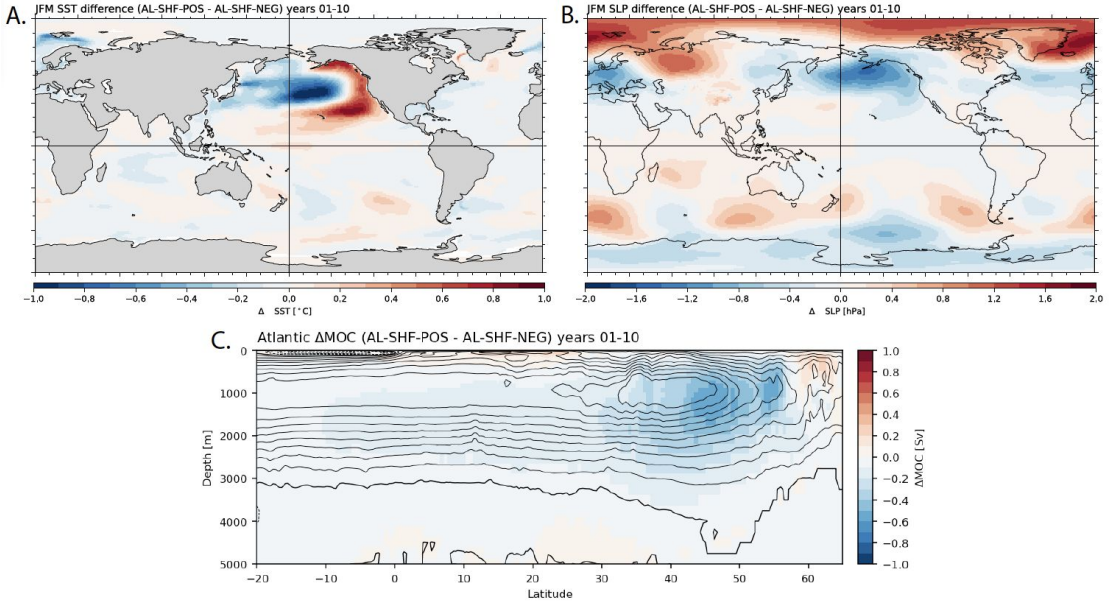


Figure courtesy Evan Meeker (U-Wisc Madison)

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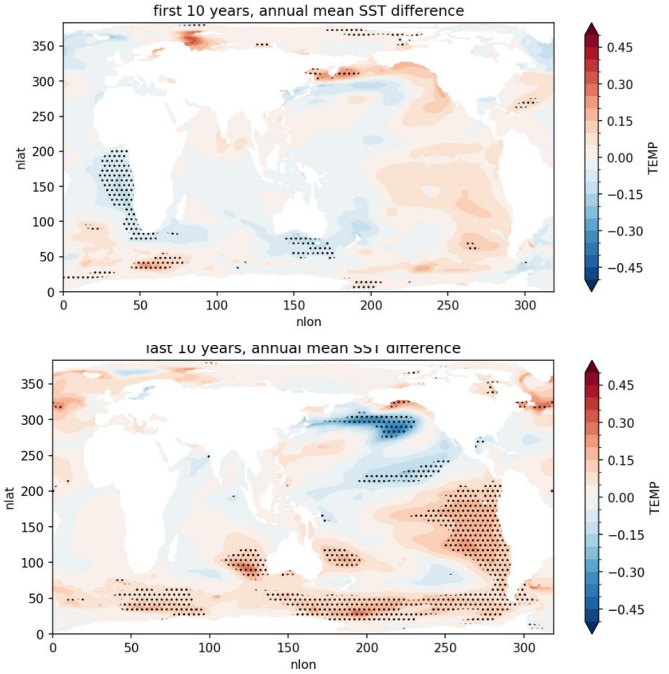


Figure courtesy Hui Li (NCAR)

DCPP in CMIP7

- Will follow CMIP6 in structure:
  - DCPP-A: retrospective forecasts
  - DCPP-B: real-time forecasts
  - DCPP-C: process experiments

- Key differences from CMIP6:
  - Lower barrier to entry (~1000 sim-year “DCPP DECK”) with option to choose multi-annual (28-month) or decadal (5+ year) forecast route
  - New real-time multi-annual predictions
  - Experiments to test impact of updated forcings on past forecasts
  - New coupled experiments to probe decadal mechanisms (cheaply) using standardized forcings
  - Open to AI/ML contributions

Looking Ahead

- Continued development exploration of sensitivities & novel experimental frameworks (using CESM2 baselines)

- CESM3 initialized prediction tests
  - Using similar methods as with CESM2 to facilitate direct comparison

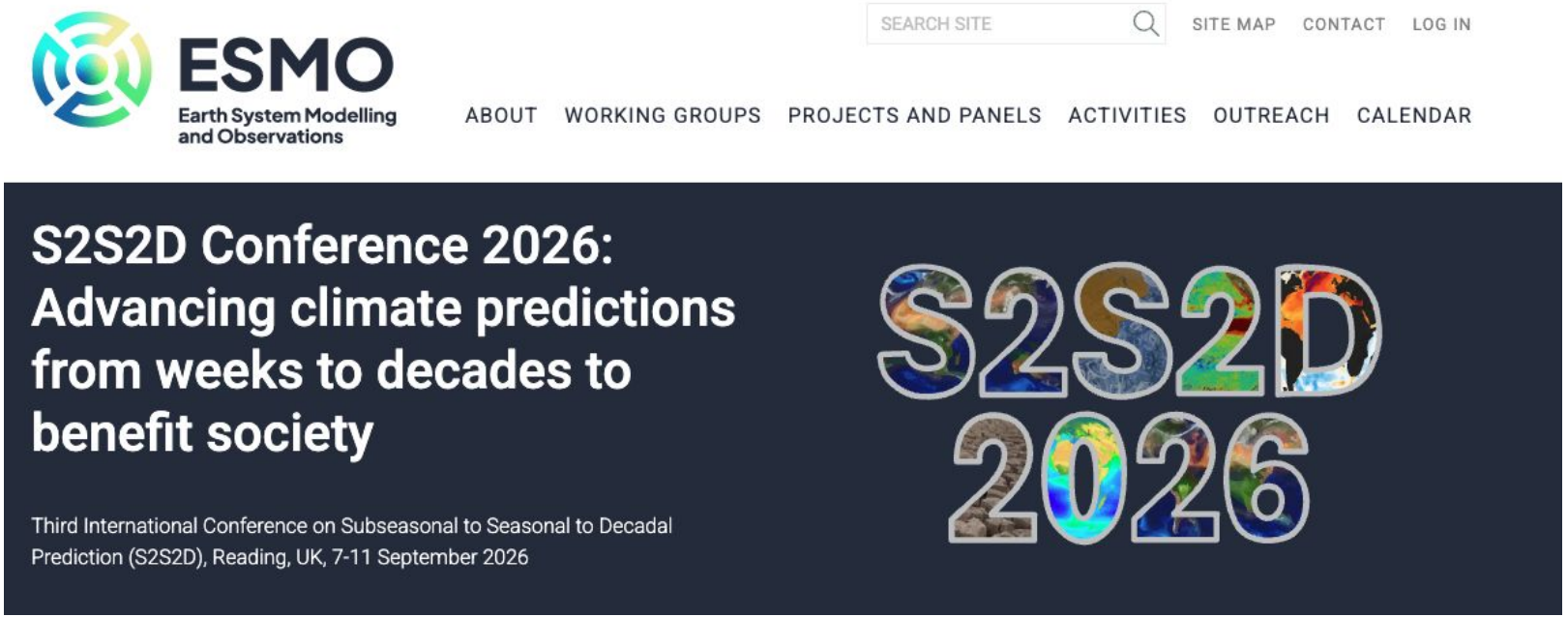
- CESM3 production contributions to SubC and DCPP-CMIP7
  - Best available methods

Challenges

- Strong demand for real-time capability ⇒ need for better initialization method

- Strong interest in high-resolution ⇒ need for well-designed, minimal experiments

Looking Ahead



- Abstract submission deadline: Feb. 15, 2026