

STATE OF CESM

THE 27th ANNUAL CESM WORKSHOP

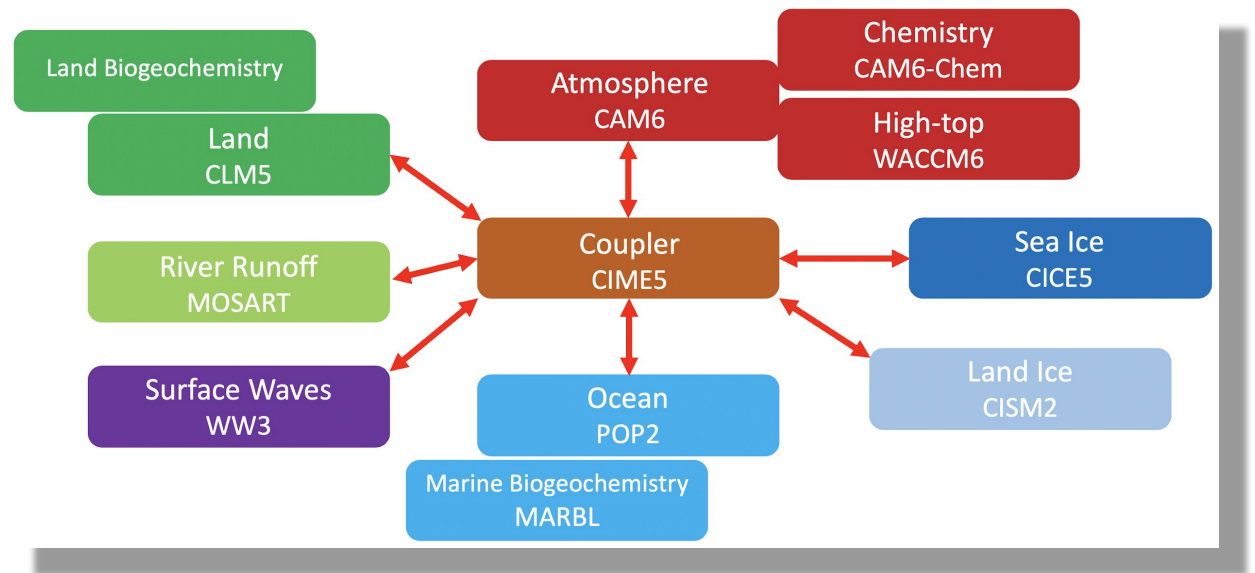
Gokhan Danabasoglu
NCAR/CGD CESM Chief Scientist

13 JUNE 2022



Highlighting diverse applications of the CESM

Versions of the CESM code base are publicly available on GitHub



CESM

Community Earth System Model



**Data Management and Data Distribution Plan for the
CESM Project**
January 2022

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Equilibrium Climate Sensitivity: A Paleoclimate Perspective

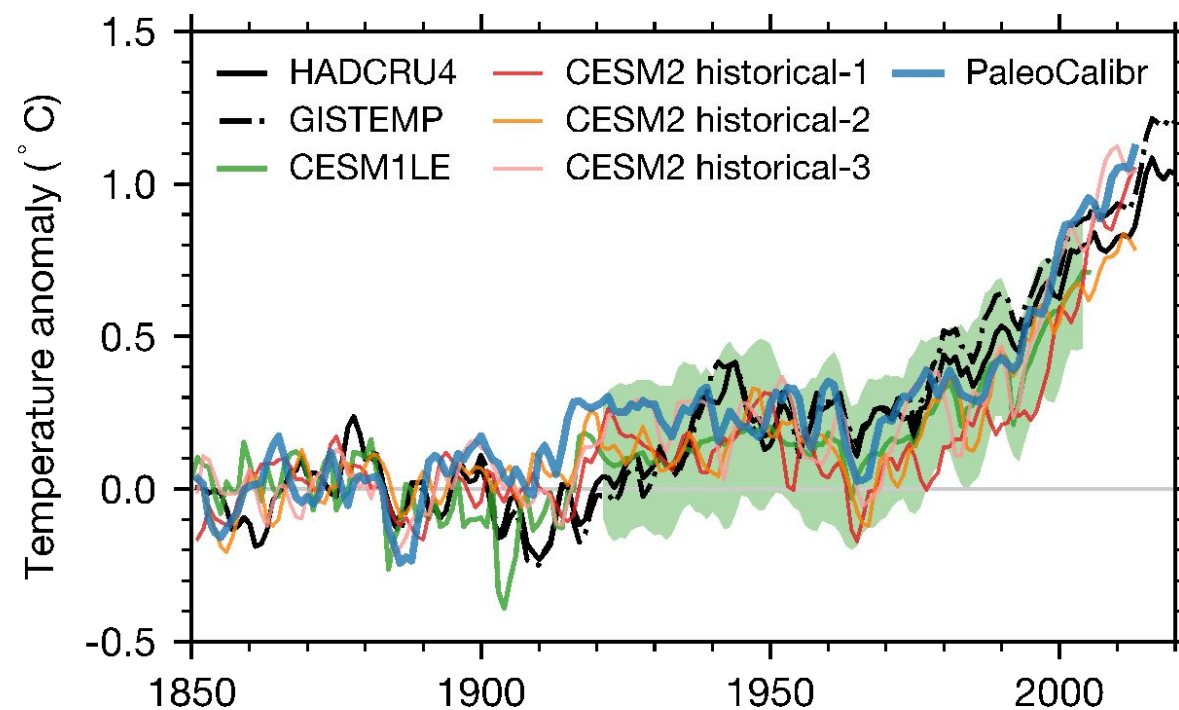
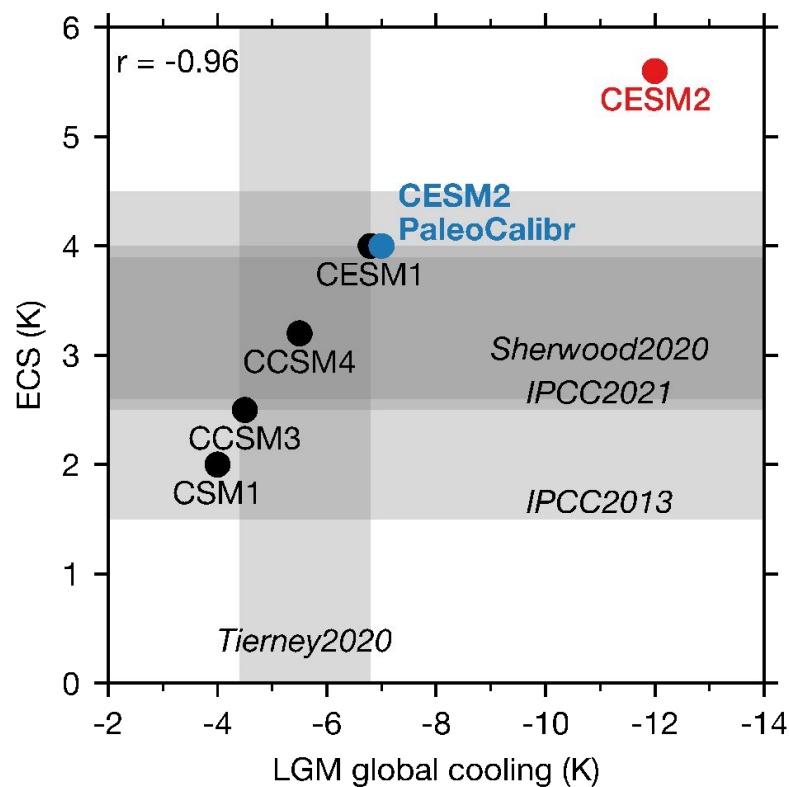
A critical consideration in Earth system model development

The standard **CESM2**

- High Equilibrium Climate Sensitivity (ECS)
- Simulates a too cold Last Glacial Maximum (LGM)

CESM2 (PaleoCalibr) with adjustments for clouds

- Lower ECS
- Matches the LGM and modern observations



Zhu et al. (2022, JAMES)

A partnership with the Institute for Basic Science (IBS) Center for Climate Physics (ICCP) in Busan, S. Korea

- A 100-member ensemble for the 1850-2100 period, using the SSP-3.70 scenario for the future extension;
- Uses a combination of macro and micro initialization approaches;
- 50 members use a smoothed biomass burning dataset for the 1990-2020 period;
- Datasets can be accessed via <https://www.cesm.ucar.edu/projects/community-projects/LENS2/>

Earth Syst. Dynam., 12, 1393–1411, 2021
<https://doi.org/10.5194/esd-12-1393-2021>
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Earth System Dynamics
 Open Access EGU

Research article

Ubiquity of human-induced changes in climate variability

Keith B. Rodgers^{1,2}, Sun-Seon Lee^{1,2}, Nan Rosenbloom³, Axel Timmermann^{1,2}, Gokhan Danabasoglu³, Clara Deser³, Jim Edwards³, Ji-Eun Kim^{1,2}, Isla R. Simpson³, Karl Stein^{1,2}, Malte F. Stuecker⁴, Ryohei Yamaguchi^{1,2}, Tamás Bódai^{1,2}, Eui-Seok Chung⁵, Lei Huang^{1,2}, Who M. Kim³, Jean-François Lamarque³, Danica L. Lombardozzi³, William R. Wieder^{3,6}, and Stephen G. Yeager³

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²Pusan National University, Busan, South Korea

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⁴Department of Oceanography and International Pacific Research Center, University of Hawai'i at Manoa

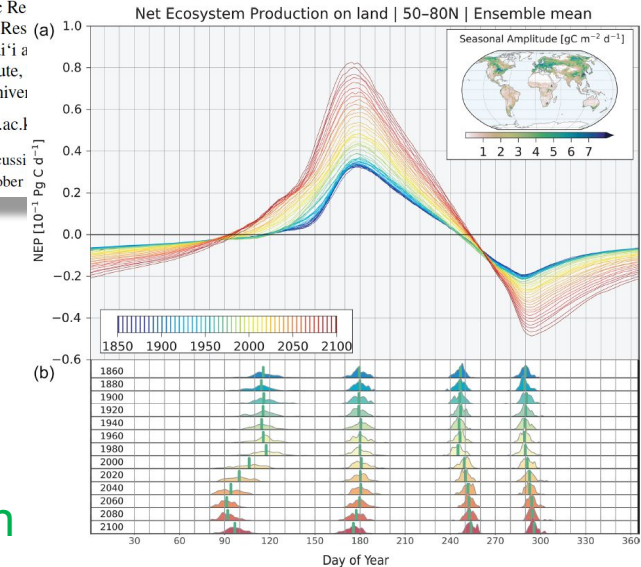
⁵Korea Polar Research Institute

⁶Institute of Arctic and Alpine Research, University of Colorado Boulder

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Received: 25 June 2021 – Discussion started: 2 July 2021

Revised: 5 October 2021 – Accepted: 9 October 2021



Expansion of the growing season length

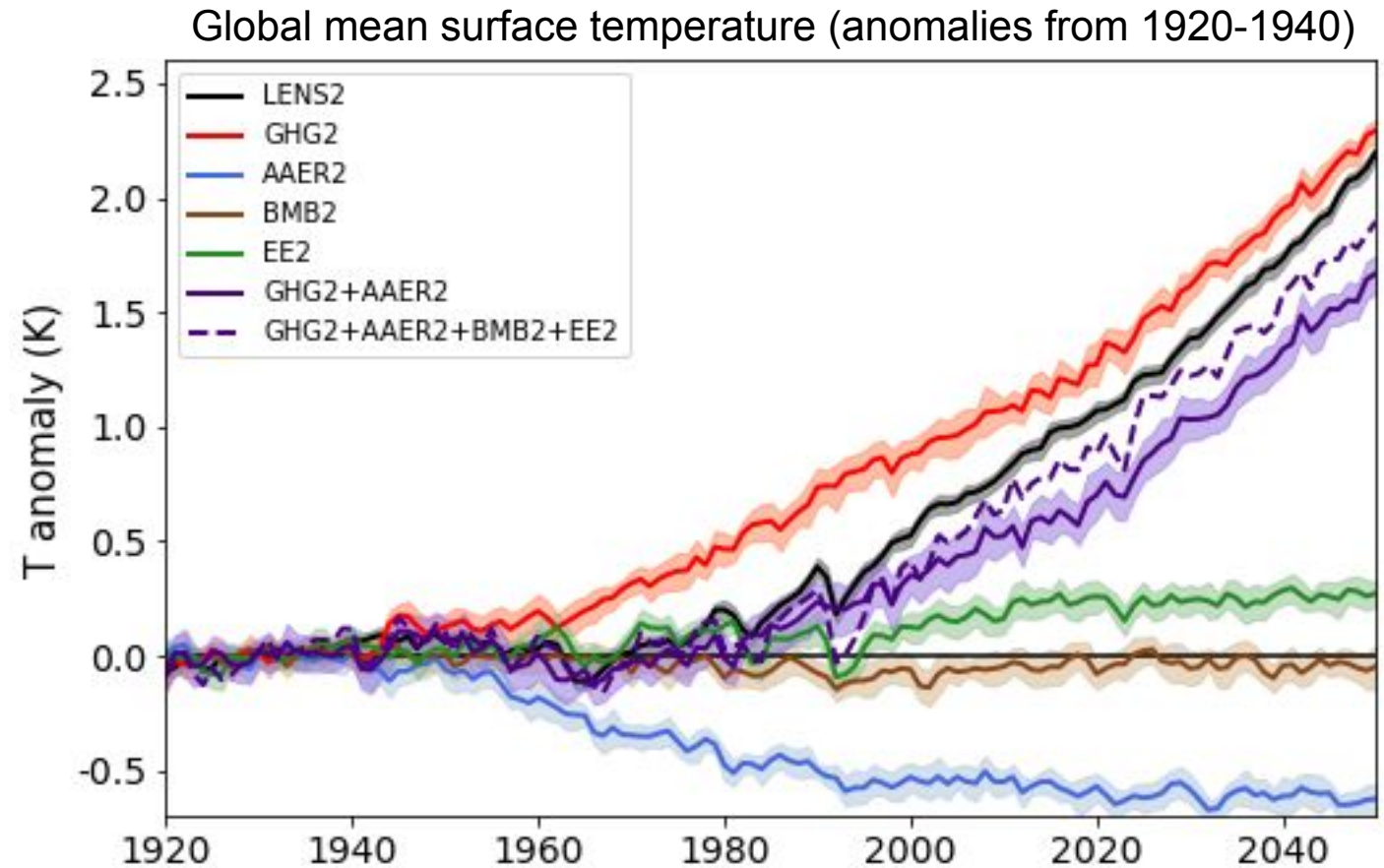
The Single Forcing Large Ensemble

- Complementary to the CESM2-LE set with smooth biomass burning
- Forcings held fixed at 1850's except those of interest

4 ensembles of 15 members
(1850-2050)

- GHG = Greenhouse gases
- AAER = Anthropogenic aerosols
- BMB = Biomass burning aerosols
- EE = Everything else

All the datasets will be available
following submission of an
introductory manuscript in July 2022



Simpson, Rosenbloom, Danabasoglu, Deser, Glanville

Reduced predictability of runoff and drought in the future

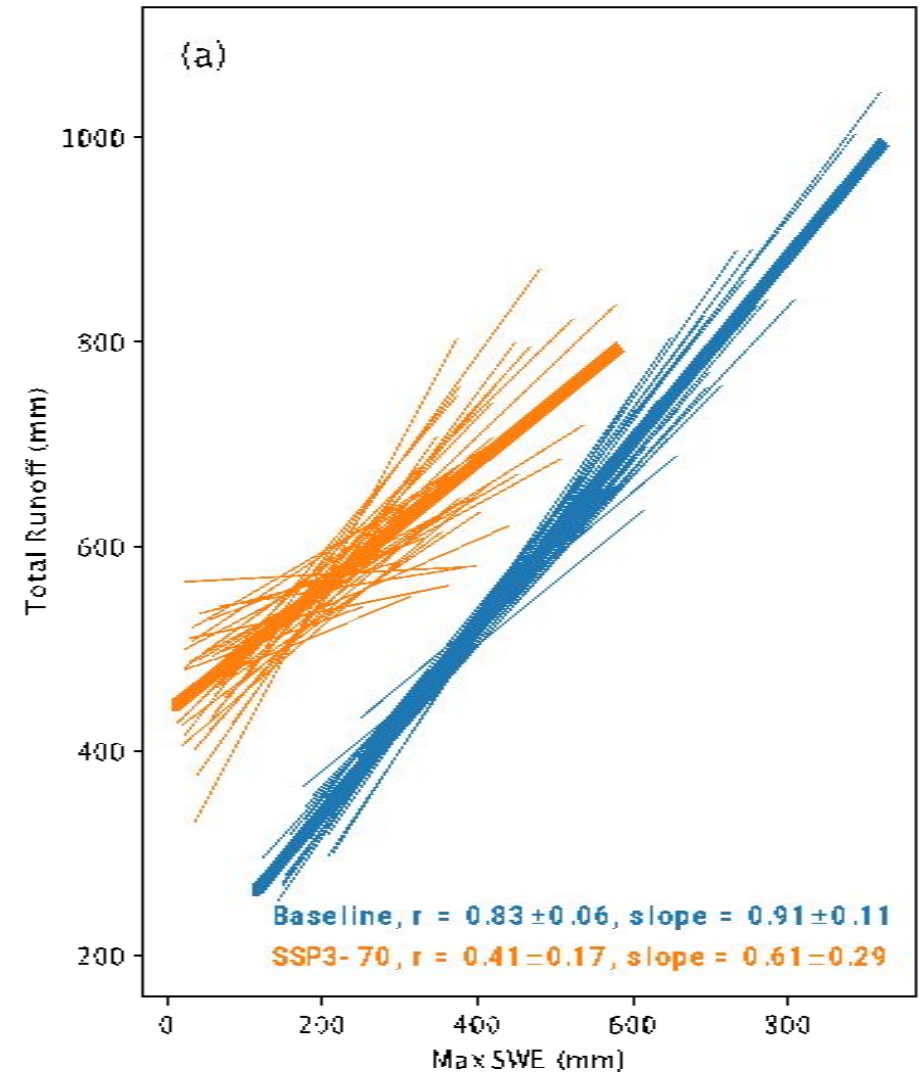
Relationship between the snow water equivalent (SWE) and runoff can be considered as a measure of predictability of runoff from SWE.

During 1940-1969, snow accumulation buffers the effects of stochastic precipitation events on runoff, leading to highly predictable runoff from SWE.

The loss of this snow buffer in the future means that runoff quantity and timing more closely reflect the stochastic character of precipitation, reducing the correlation between SWE and runoff.

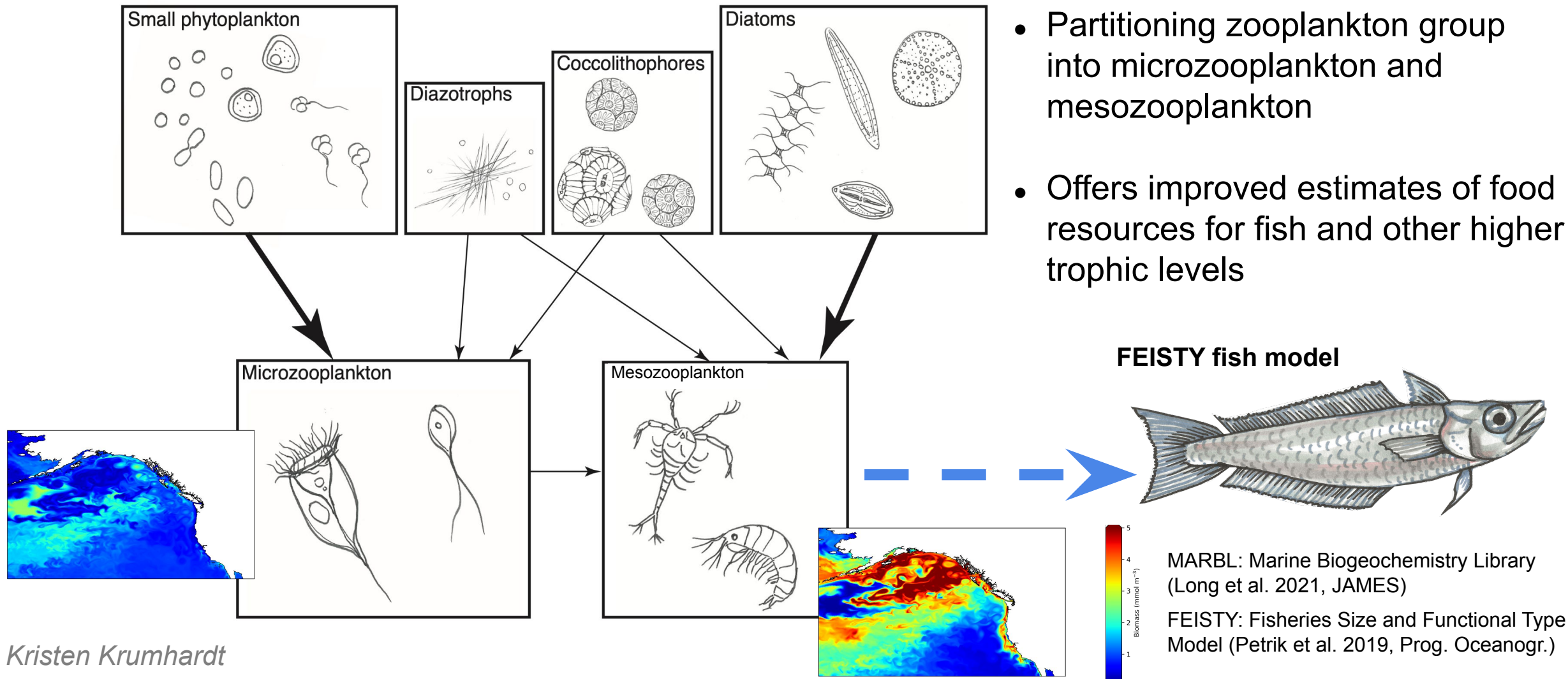
This suggests a reduced predictability of runoff and drought from seasonal snowpack in the future.

Northern Rocky Mountains of the US



Wieder et al. (2022, PNAS)

Expanding the MARBL Marine Ecosystem to Link to a Fisheries Model

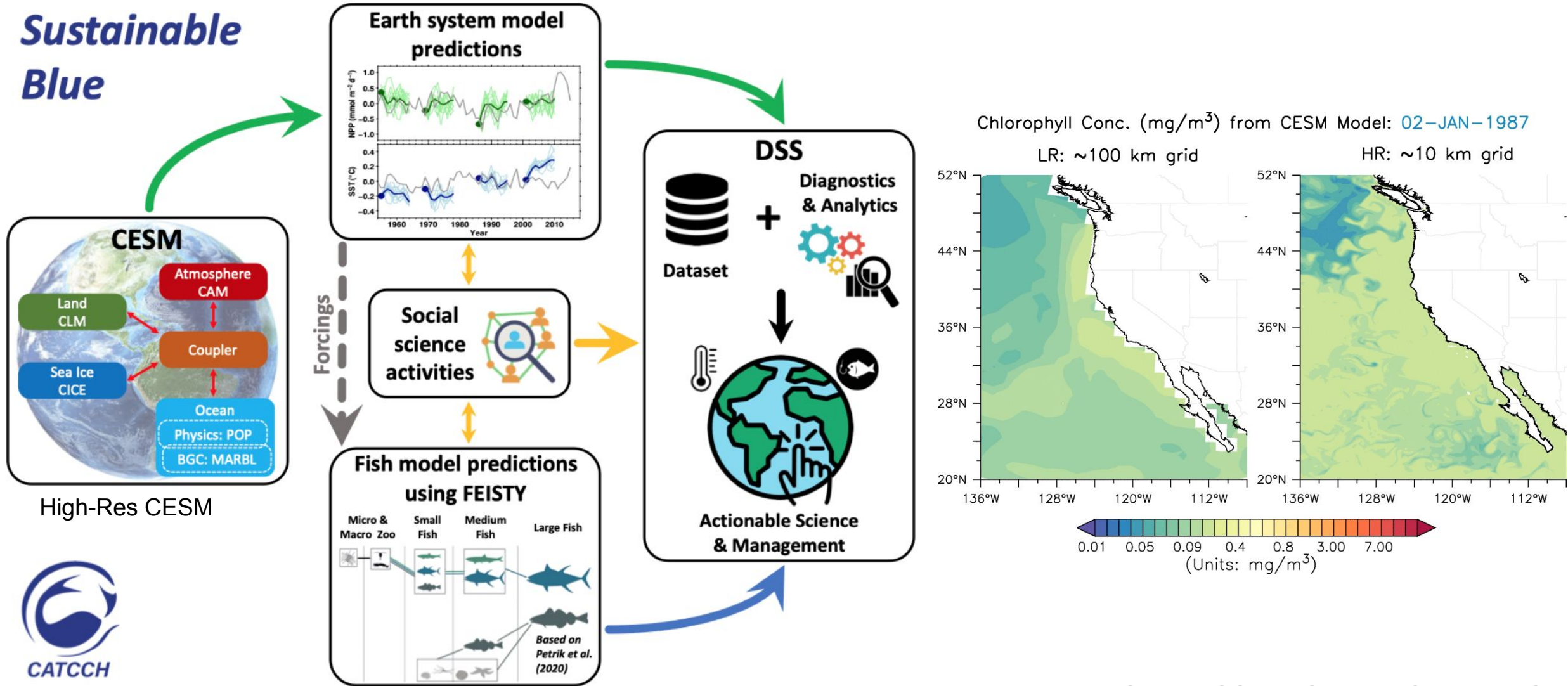


- Partitioning zooplankton group into microzooplankton and mesozooplankton
- Offers improved estimates of food resources for fish and other higher trophic levels

Kristen Krumhardt

Climate change Adaptation Tools for California Current fisheries

Sustainable Blue

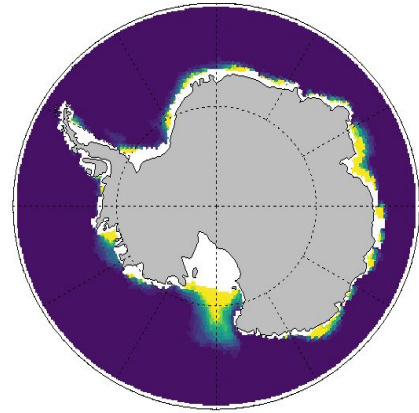


TAMU, U Texas Austin, NCAR, UCSD, PCFFA, NOAA NMFS

Antarctic Sea Ice – Biological Interactions

Variability/change of sea ice characteristics

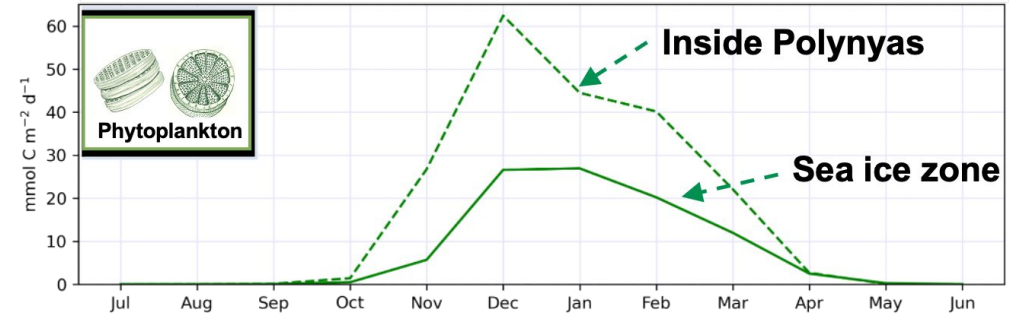
- Polynya metrics for models and satellite observations
- Exploring current and future polynya sizes, locations
- Other metrics (ice advance timing, etc.) being explored



ANN climatology
Fraction of days as a polynya

Connections between sea ice & biological activity

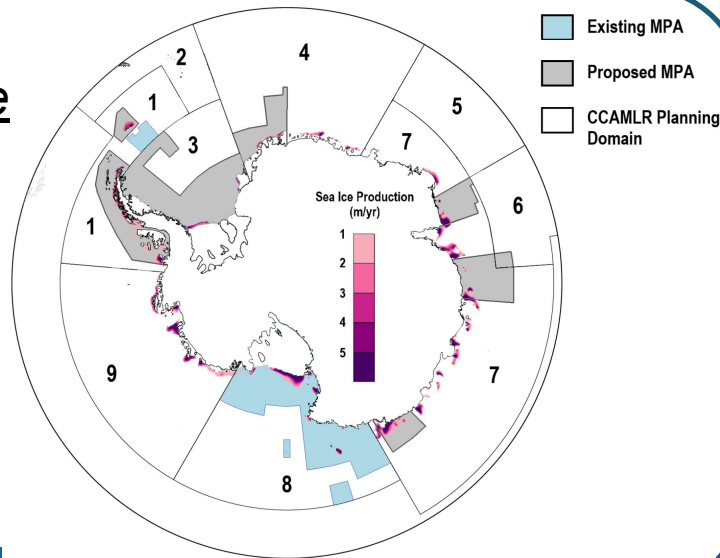
Net Primary Production (NPP)



- Gaining process understanding,
- Identifying biologically important regions

Actionable Information for Marine Protected Areas

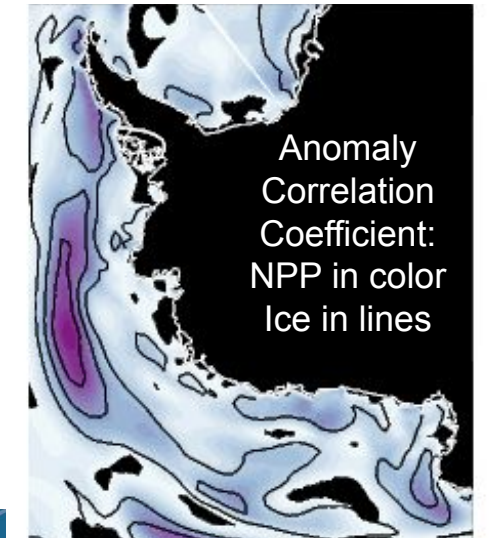
- Providing ice and biology projections to end-users and decision making bodies



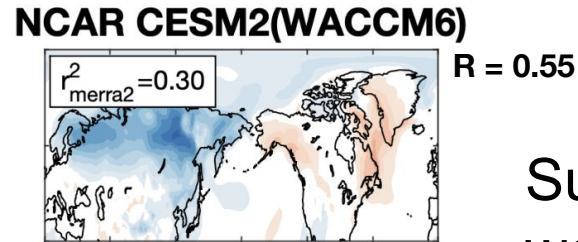
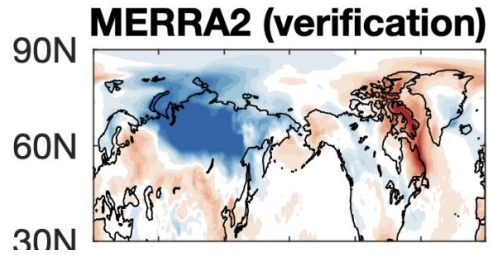
Predictability in sea ice, biology and links between them

- Seasonal to multi-decadal timescales
- Changing predictability in a warming climate

17-month December prediction



Predicting Impacts of Sudden Stratospheric Warmings (SSWs) on surface temperature

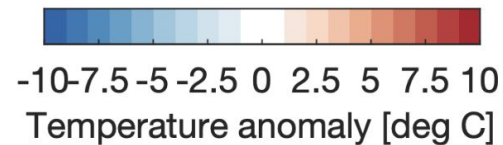


Surface temperature forecast for weeks 3-4 after 05 Jan 2021 SSW

CESM2(WACCM6) shows the highest skill among the SubX Models

SSWs have a limited impact!

The tropospheric circulation and coupling between the troposphere and stratosphere were dominant contributors to variability.

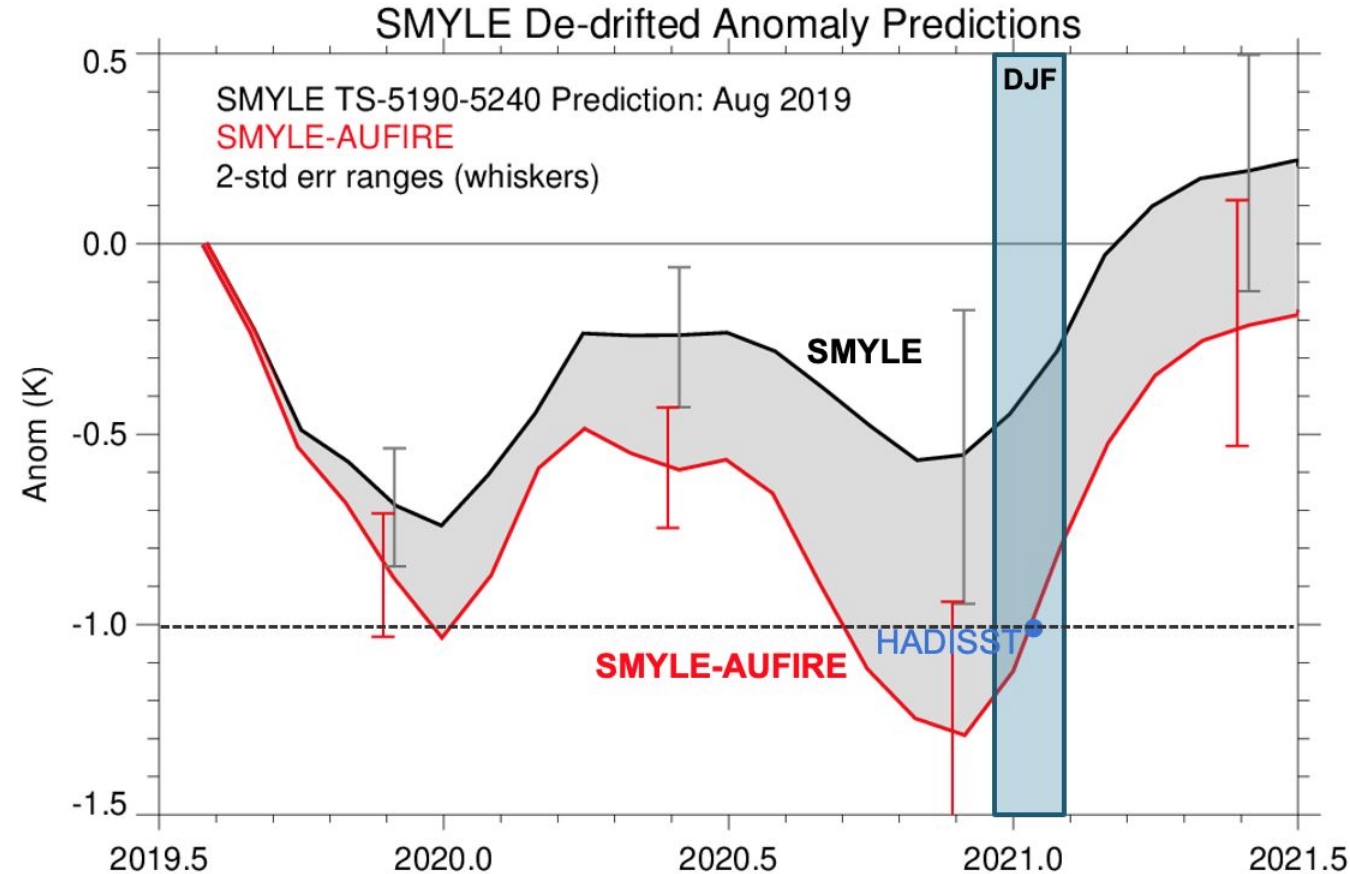


Davis et al. (2022, Nat. Comm.)

2019/20 Australian Wildfire Influences on Niño3.4 Predictions

In SMYLE, from the August 2019 prediction, there is a weak (-0.5 K) ensemble-mean prediction of La Niña in 2020/21.

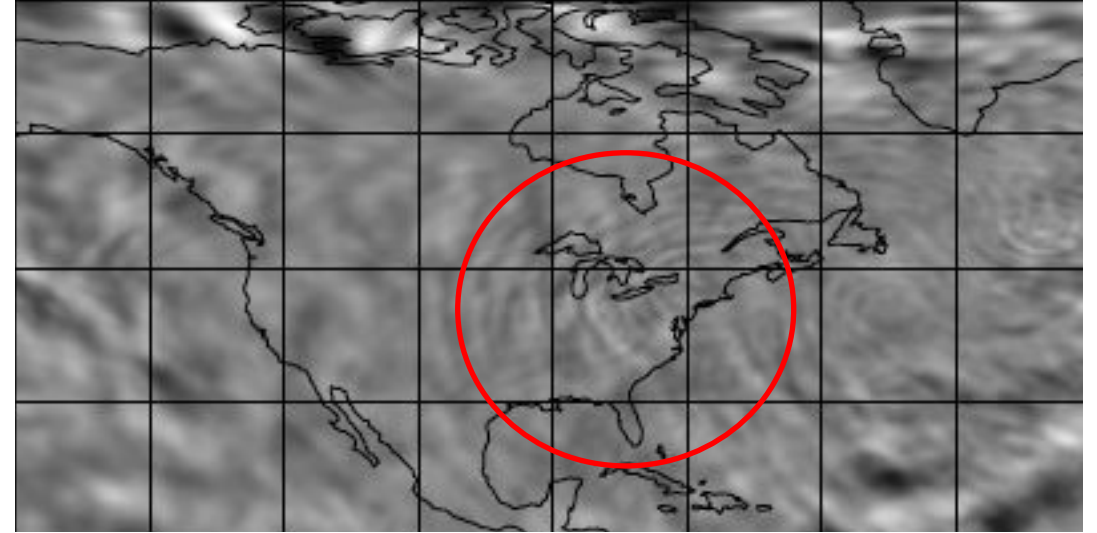
In the SMYLE-AUFIRE ensemble, these predictions shift to a considerably stronger event in 2020/21 and more closely match the -1 K anomaly reported in HADISST.



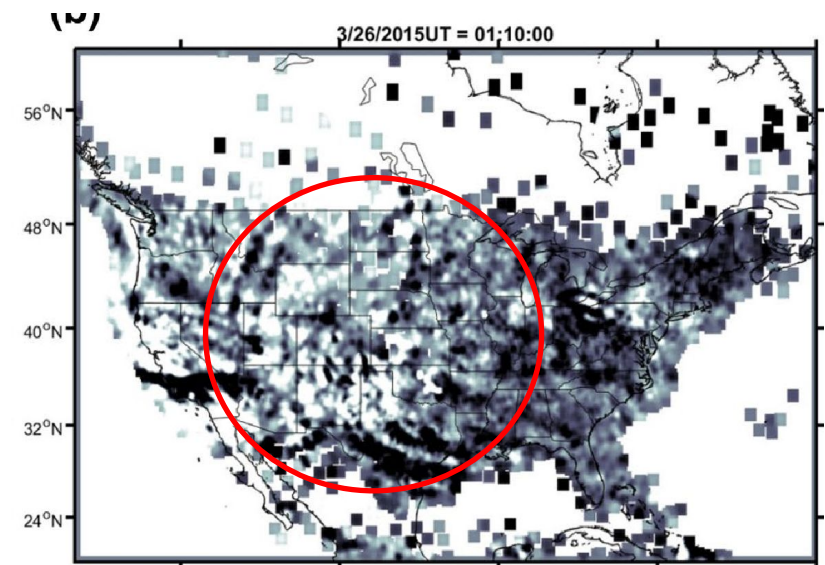
High Resolution Whole Atmosphere Modeling

- SE dycore modified to allow for extension into the upper atmosphere (SE-WACCM-X)
- Simulation with $\sim 0.25^\circ$ with 273 levels
- Resolved gravity waves agree with middle-upper atmosphere observations
- Resolved gravity wave forcing leads to better representation of the circulation and composition
- SE-WACCM-X reproduces small-scale concentric wave fluctuations in the ionosphere that are consistent with observations and important for understanding space weather

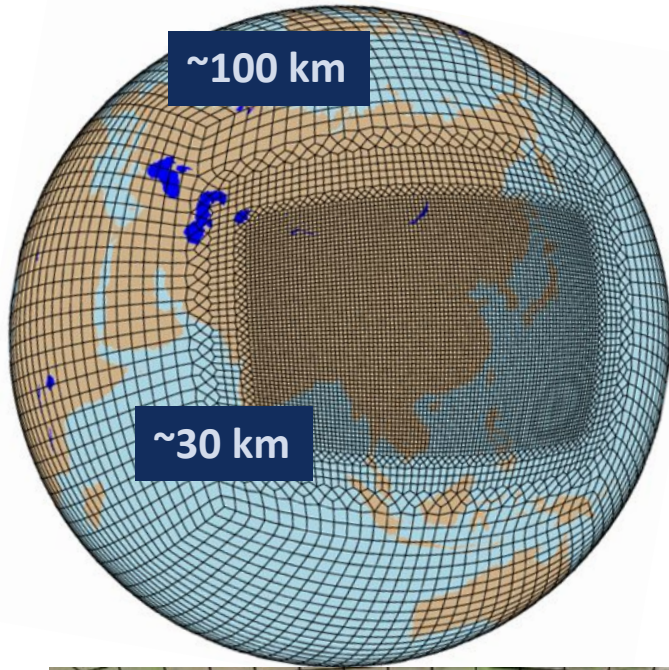
SE-WACCM-X Simulated Perturbations in Ionosphere Electron Density



Observations



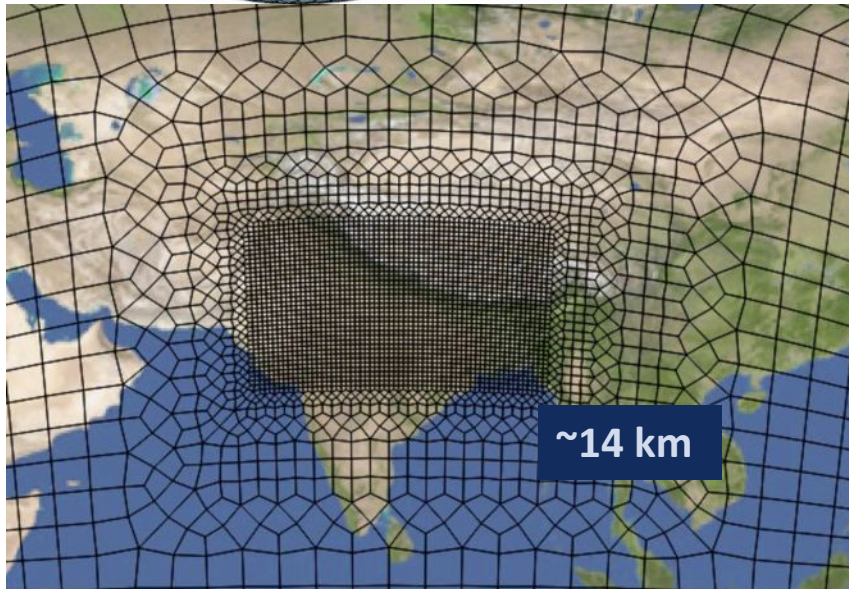
New grids for MUSICA-v0



Regional refinement for Asian Summer Monsoon

- Cover deep convection regions; anticyclone over the Tibetan Plateau; and eastward eddy shedding over the West Pacific region.
- Cover both natural and anthropogenic emission sources from South and East Asia.

Ren Smith, Jun Zhang



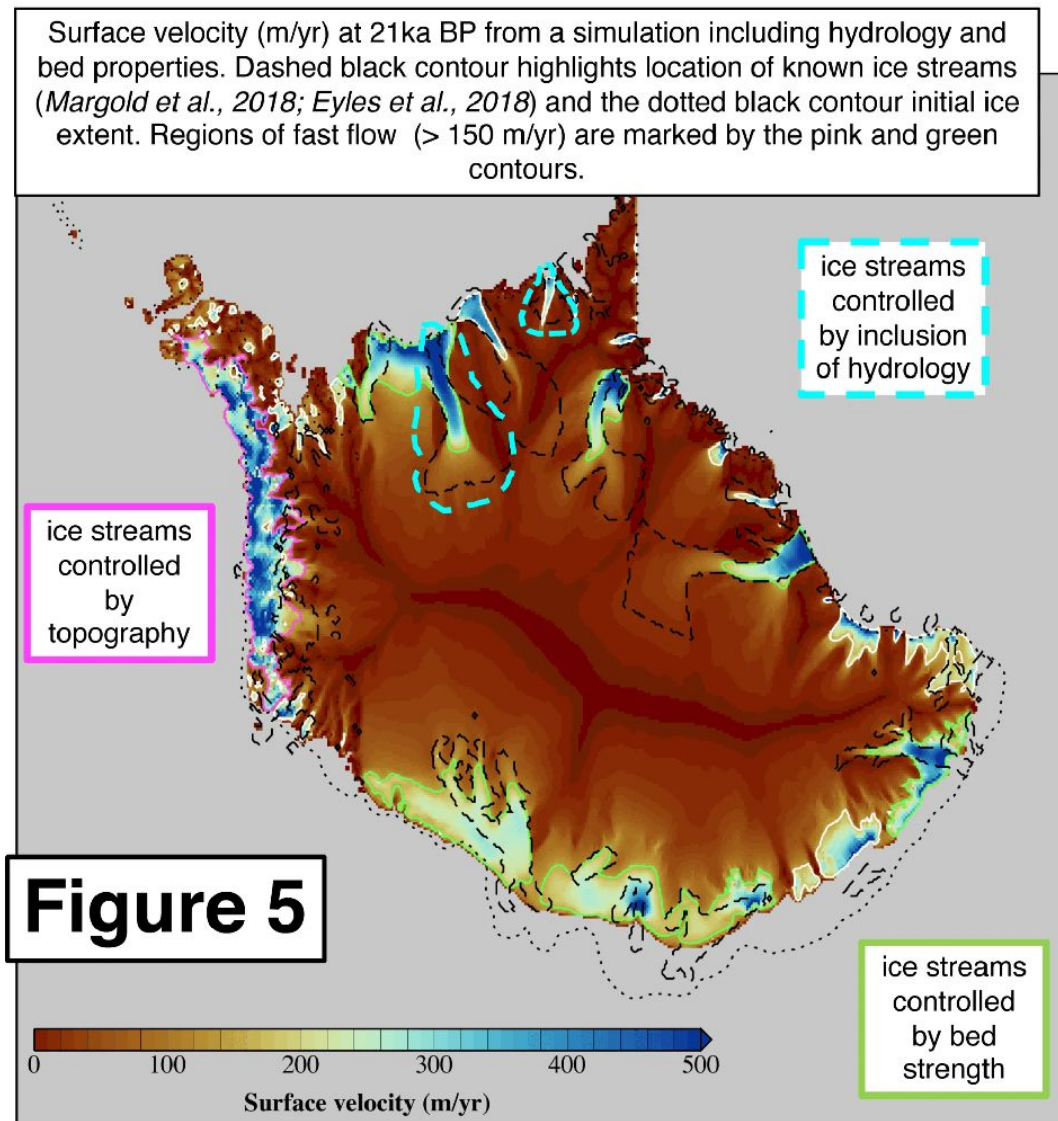
Air quality in India

- Long-range transport effects on regional air pollution
- Regional-scale chemistry and dynamic treatment effects on global modeling results

Behrooz Roozitalab

MUSICA: Multi-Scale Infrastructure for Chemistry and Aerosols

Paleo Ice Sheet Simulations



- CESM and CISM are being applied to the North American Ice Sheet complex at the time of the **Last Glacial Maximum, 21 ka**.
- CISM generates ice streams in good agreement with the paleoclimate record, as a result of **subglacial hydrology** (Arctic margin), **steep bed topography** (Pacific margin), and **weak basal till** (southern margin).
- These runs use offline coupling, but CESM-CISM is now enabled for **multiple coupled ice sheets**, including Antarctica.

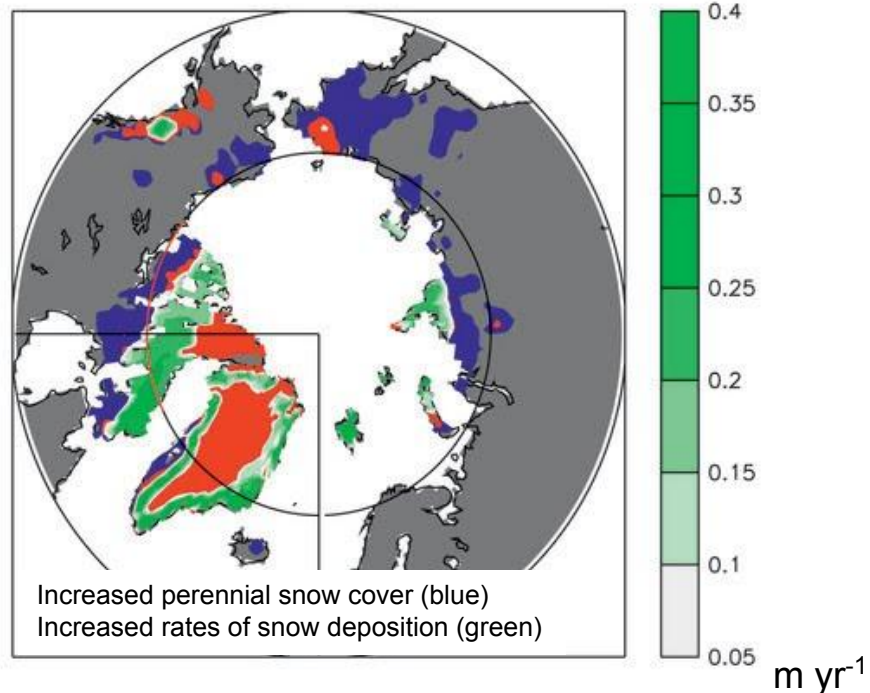
Sarah Bradley

Simulating Transitions into Ice Ages

A Key target for ESMs simulating climate change

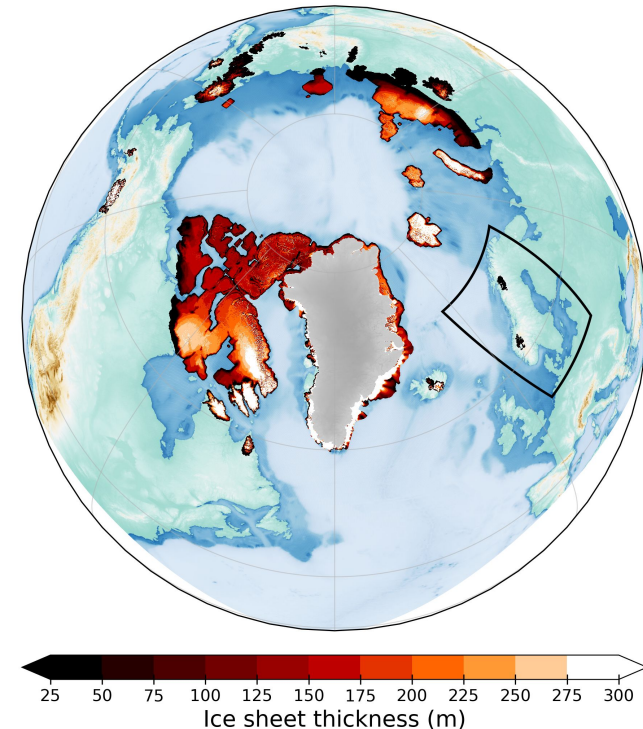
Jochum et al. (2012, J. Climate)

First step: CCSM4 simulates perennial snow cover in glacial inception sites due to improved orography representation



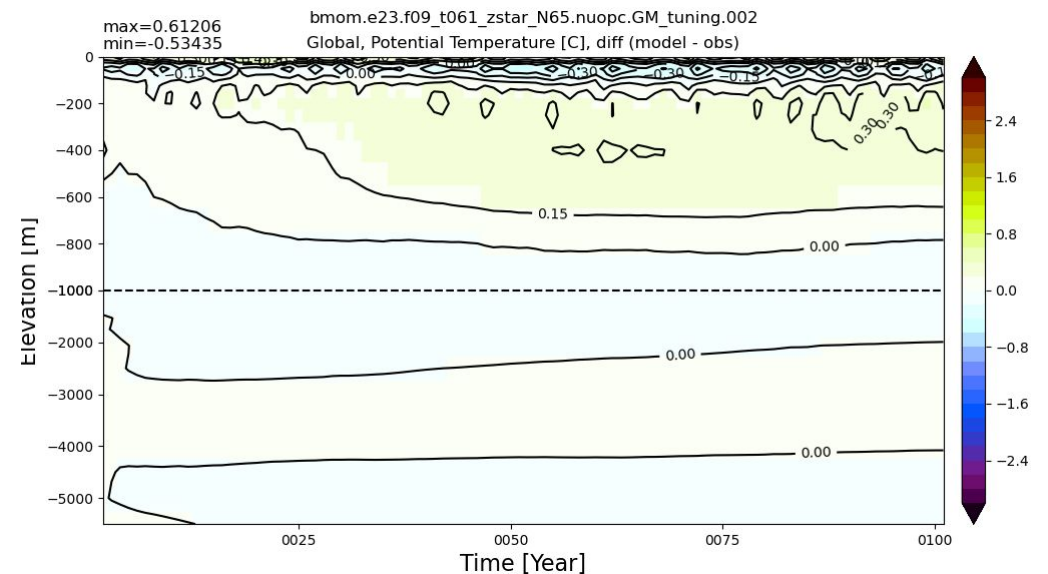
Lofverstrom et al. (2022, Nat. Geo., submitted)

CESM2 is the first-ever CMIP-class Earth system model with an interactive ice sheet model (CISM2), simulating the Northern Hemisphere glacial inception



Towards CESM3

- Preliminary coupled simulations that use the development versions of the component models have begun.
- These include MOM6, CICE6, and CAM6+ w/ 58 vertical levels.
- Nominal 1° horizontal resolution with MOM6 using a nominal 2/3° grid.
- Substantial technical and scientific effort, addressing challenges associated with realistic surface boundary conditions
- Opens up new research opportunities / science, e.g., sea level change, better represented near surface processes.



Marques, Hannay, Many many others

NEWS > COLORADO NEWS

Collapsed Breckenridge building's roof likely didn't meet modern snow standards

Ten Mile Room was built in 1972 when snow-loading standards weren't as sophisticated



The roof of the Ten Mile Room in Breckenridge collapsed from heavy snowfall Jan. 11, 2017.

Provided by Town of Breckenridge via Summit Daily News



Ten Mile Room at Village Hotel in Breckenridge

Photo Credit: Isla Simpson



Thank You!



CESM Distinguished Achievement Award



Steve Yeager
NCAR



CESM Graduate Student Awards

Abigail Bodner

Brown University

Courant Institute, NYU



CESM Graduate Student Awards

Inne Vanderkelen

Vrije Universiteit Brussel

