

CESM3 and Paleoclimate Working Group Updates & Wrap-up Discussion

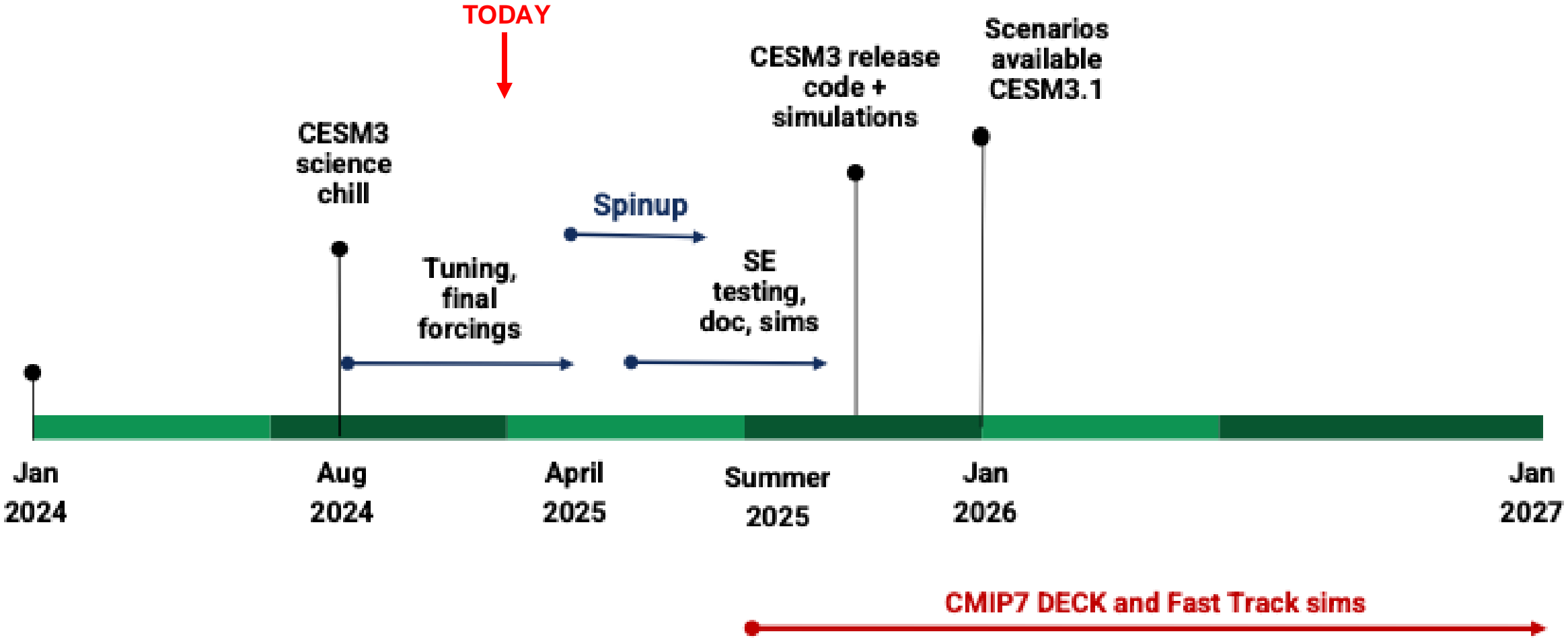
Jiang Zhu

Project Scientist II, NSF NCAR

Jan. 29, 2025



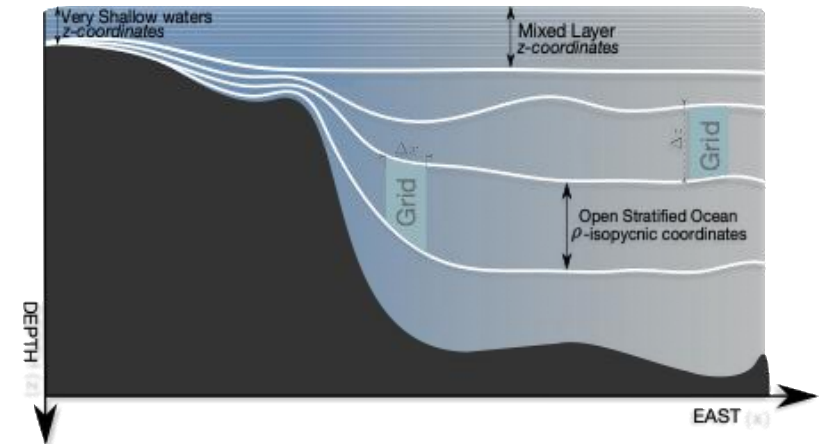
Get ready for CESM3! *(to be released this summer, exact date not yet decided)*



<https://www.cesm.ucar.edu/news/community-earth-system-model-3-cesm3-plans-progress-timelines>

New in CESM3 (a non-exhaustive list)

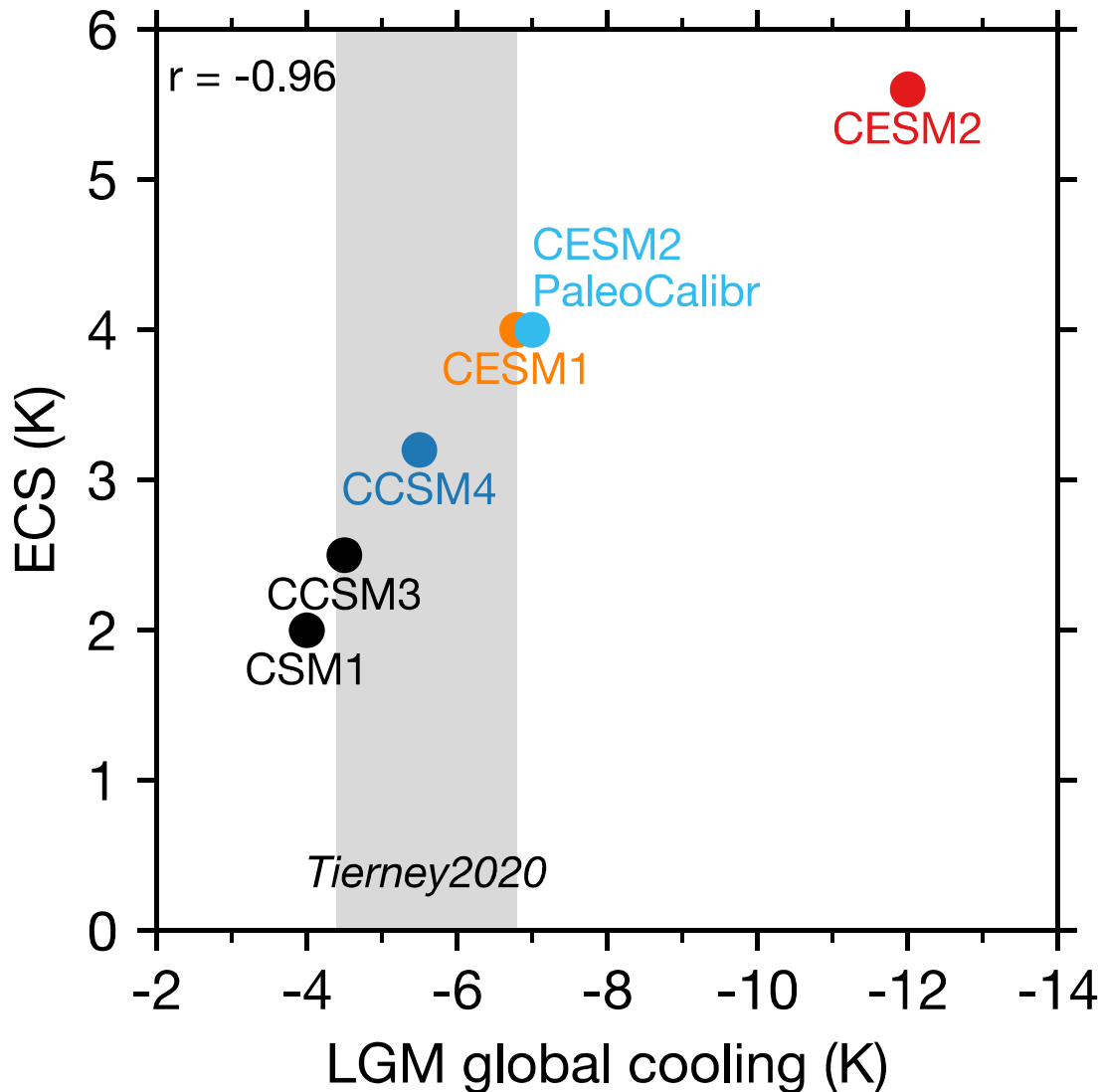
- **CAM7**
 - New dynamical core & unstructured grid
 - More vertical levels (93 vs 32; 58 levels used for development)
 - More accurate radiation (RTE+RRTMGP vs RRTMG)
- **MOM6**
 - Tri-pole grid with horizontal resolution of $\sim 2/3^\circ$
 - **Hybrid** or z^* vertical coordinate
 - Natural surface freshwater flux
 - Vertical mixing coupled to wave processes
- **New coupling infrastructure (CMEPS / NUOPC / ESMF)**
 - Much less mapping files
 - Domain files are replaced with mesh files (more modern & flexible than SCRIP files)



After Castaldi, 2018

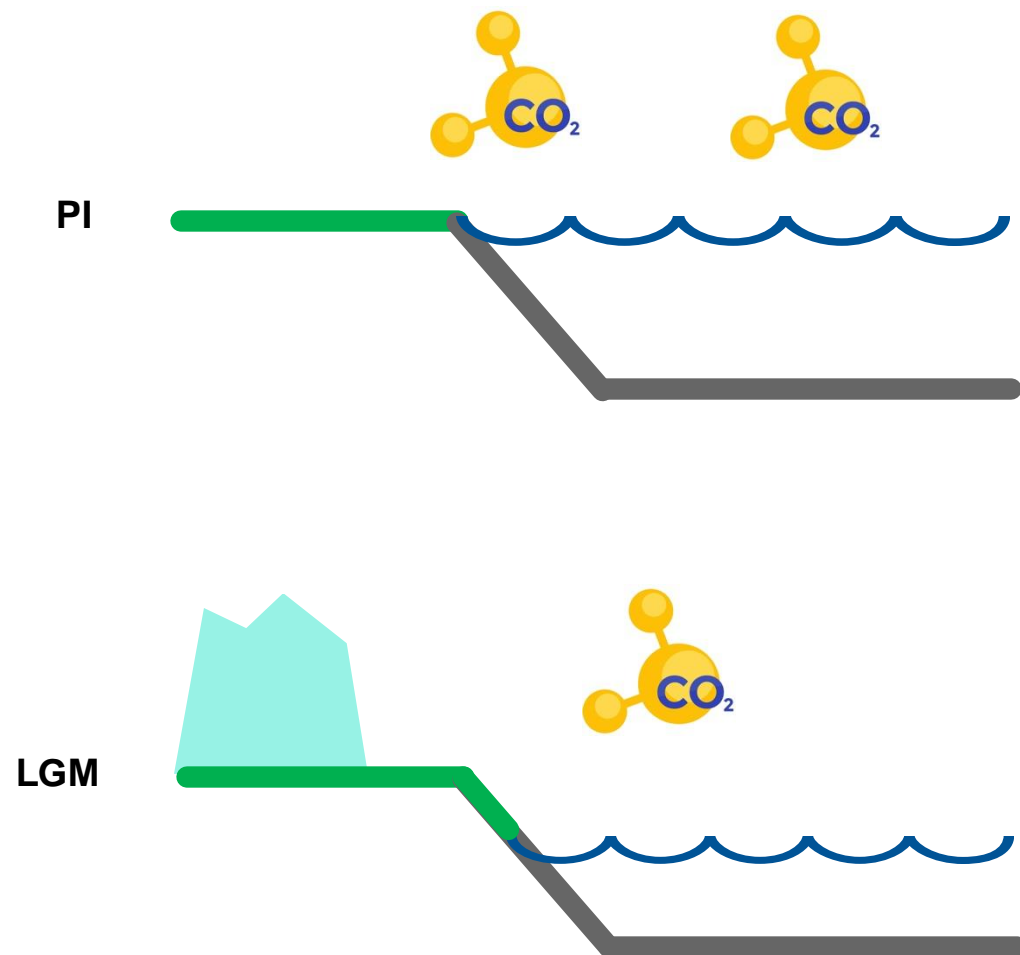
Cost/throughput: ~ 10 yrs/d & 13000+ pe-hrs/yr (vs CESM2's 28 yrs/d & 3800 pe-hrs/yr)

PaleoWG involvements — Evaluate CESM3's climate sensitivity with Last Glacial Maximum



Shin et al., 2003, CD
Otto-Bliesner et al., 2006, JC
Brady et al., 2013, JC
Zhu et al., 2017, 2020, GRL
Tierney et al., 2020, Nature
Zhu et al., 2022, JAMES

Setup of CESM3 LGM

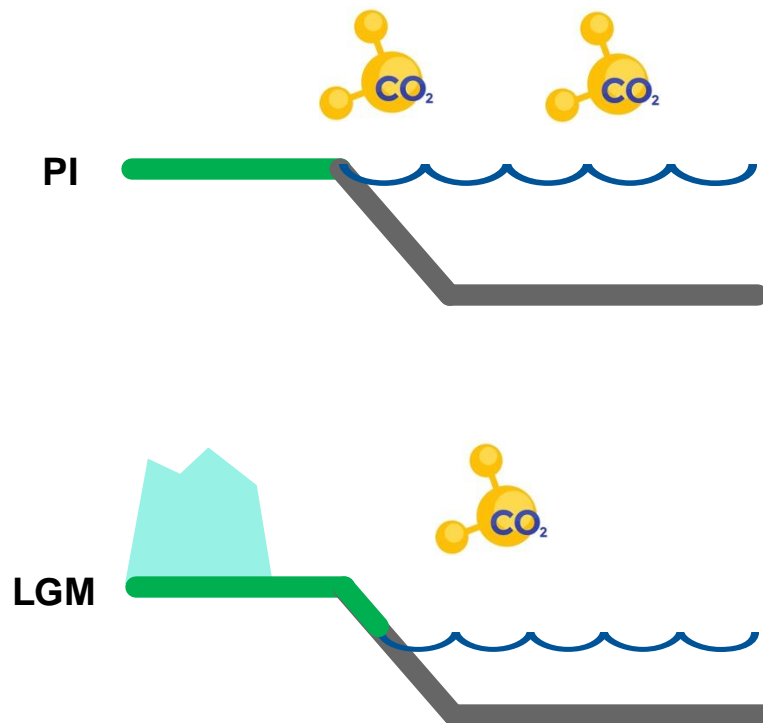


Climate forcings (*PMIP4; Kageyama et al., 2017, CP*)

- **Lower GHGs**
- **Land ice sheets (ICE-6G used)**
 - Albedo and surface properties
 - Topography
 - Sea level drop and shelf exposure
- PI conditions for others (e.g., vegetation type and phenology, aerosols, ozone, etc.)

Initial conditions: CESM2-PaleoCalibr LGM (*Zhu et al., 2022, JAMES*)

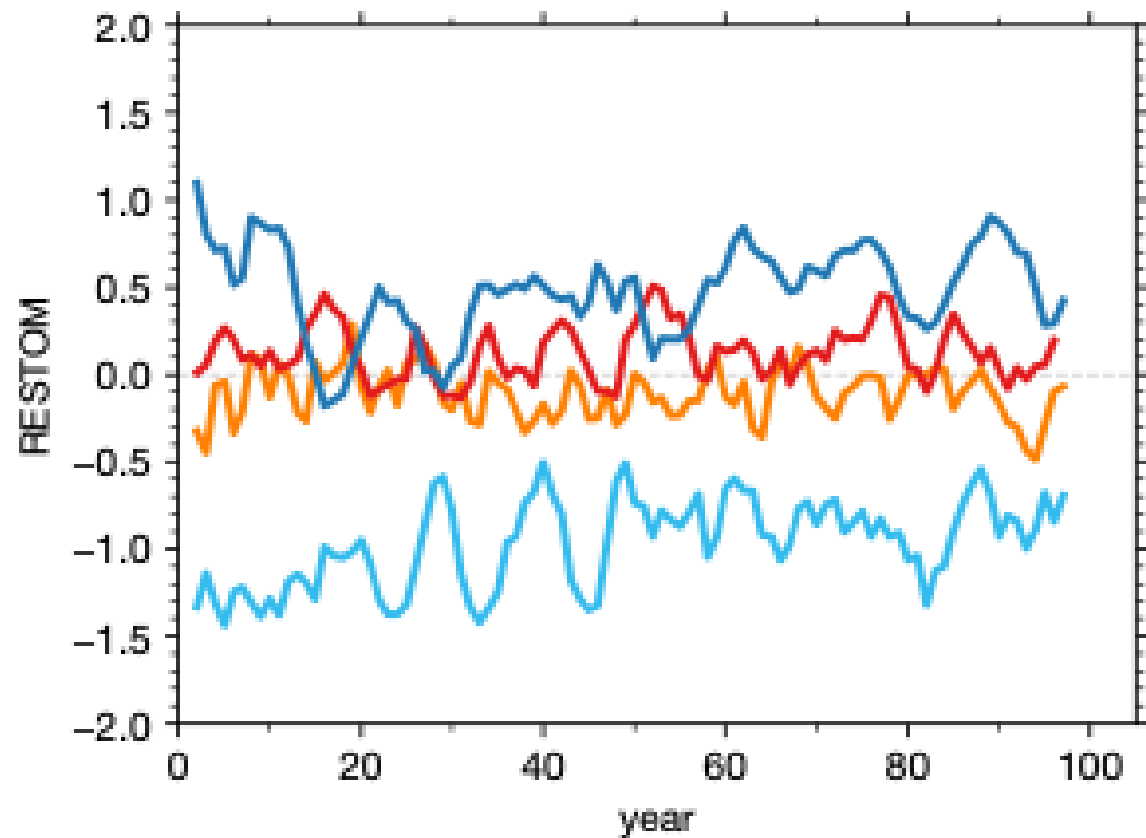
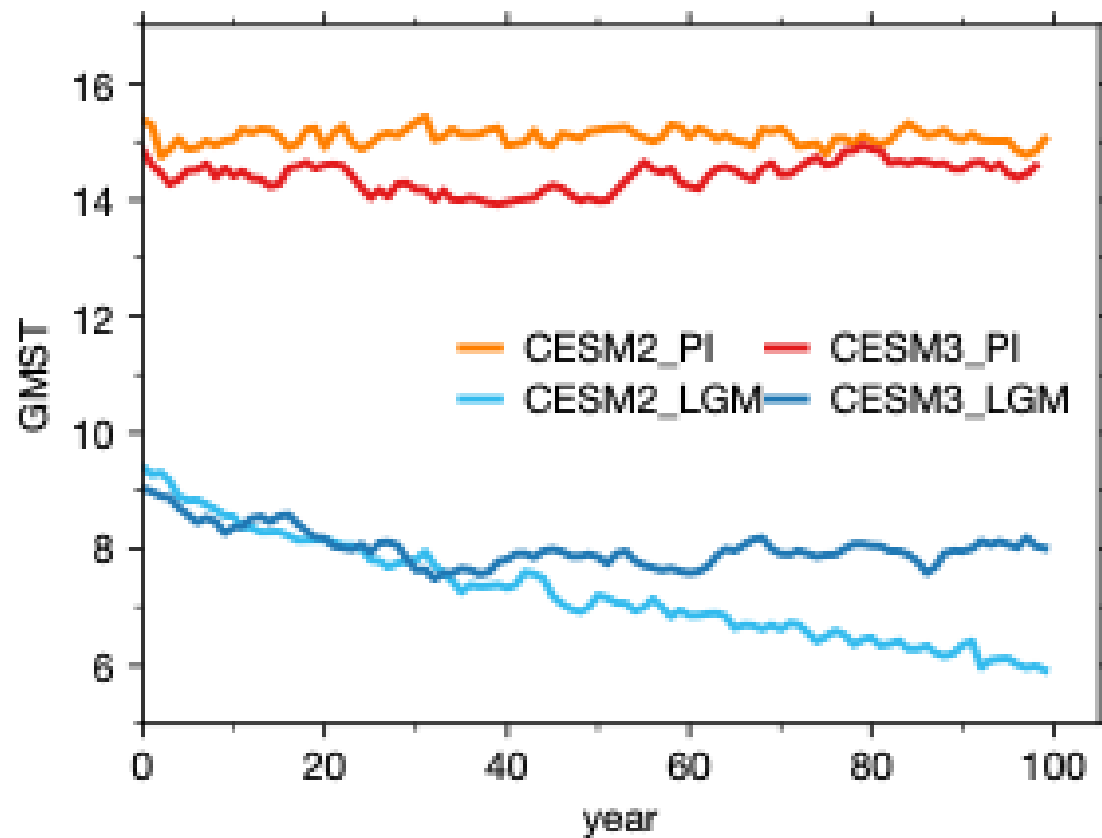
Setup of CESM3 LGM



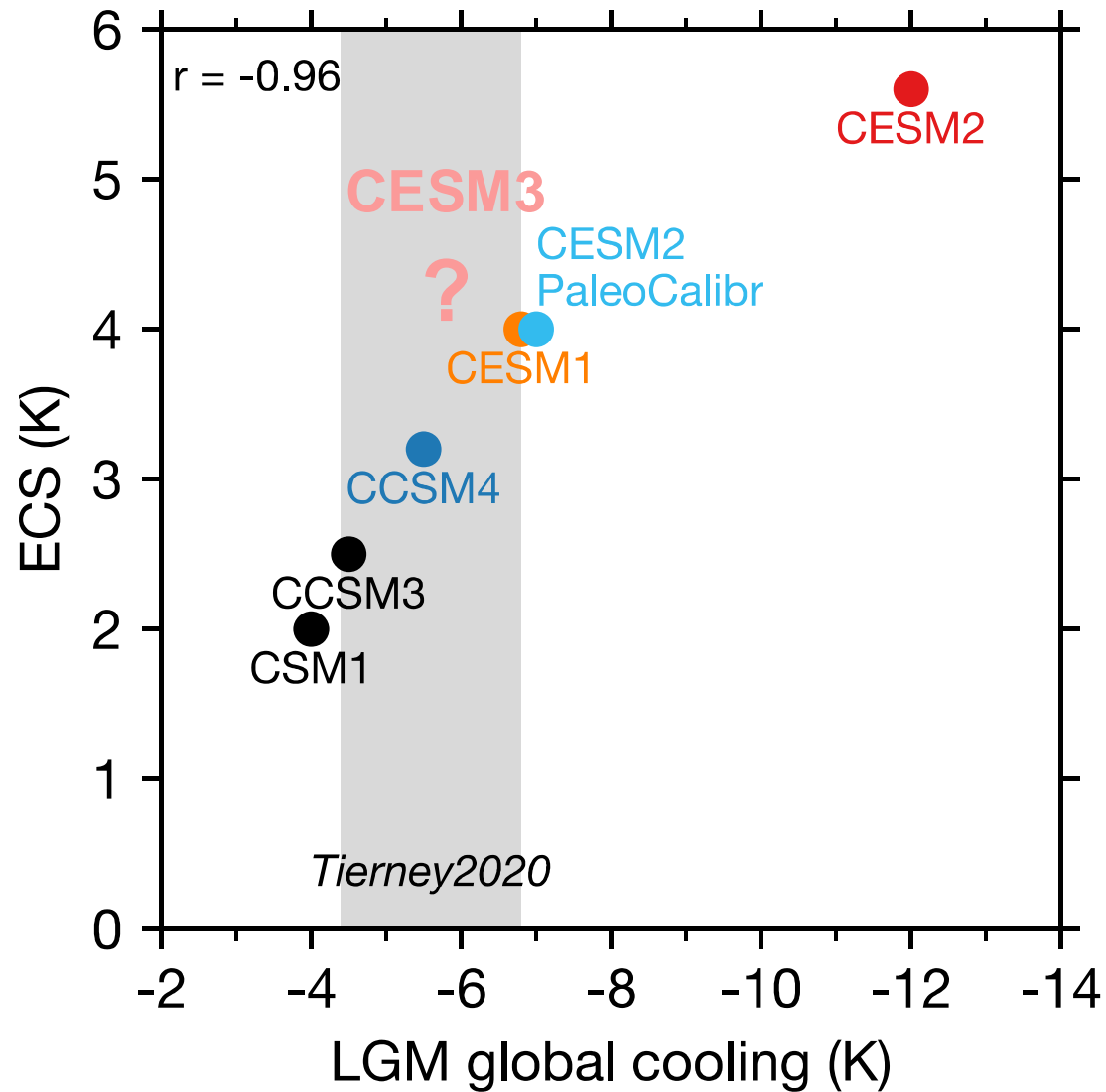
GHG • **Topography** • **Sea Level** • **Albedo/Land surface**

- **CAM7** (*low top with 58 level used*)
 - **GHG file with seasonal & latitudinal variations**
 - **Topography: mean elevation & SGS “roughness”**
- **MOM6**
 - **Bathymetry: sea level, straits/shelves, ice shelves, etc.**
- **Coupler**
 - **Mesh: MASK = OCN = ICE & WAV in gx3**
 - **Mapping: runoff to ocean**
- **CICE7**
 - *Grid file (likely temporary)*
- **CLM6**
 - **Land surface (new method & easier than CESM2)**
 - **No-Anthropogenic configuration & satellite phenology**
- **Use the old RTM for river routing**

Much warmer LGM in CESM3 than in CESM2

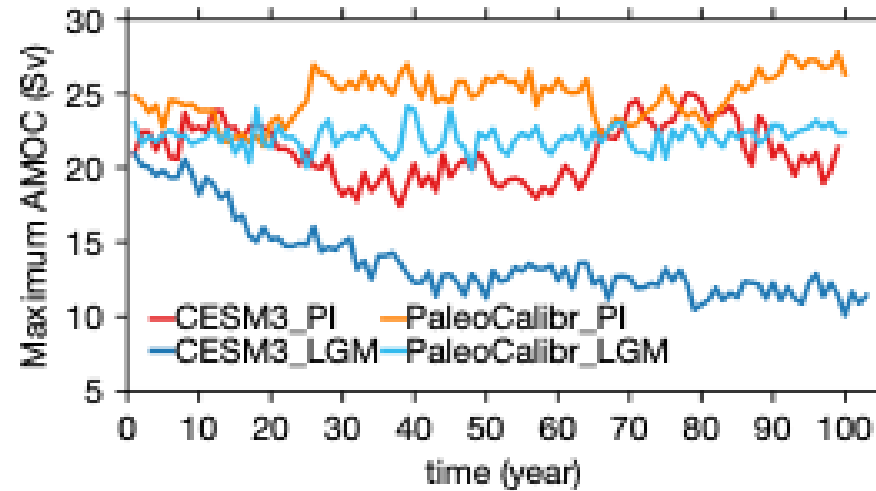


Very likely realistic LGM, supporting CESM3's climate sensitivity

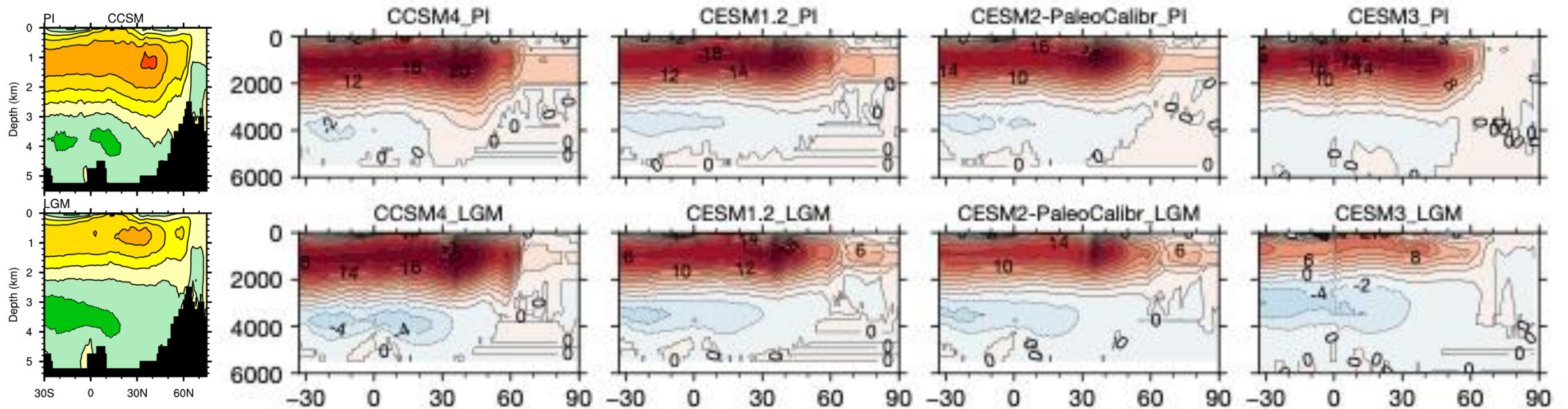


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Zhu et al., 2022, JAMES

Atlantic Meridional Overturning Circulation (AMOC) appears to be weak



Otto-Bliesner et al., 2006, JC
Brady et al., 2013, JC
Zhu et al., 2020, CP
Zhu et al., 2022, JAMES



- **Investigating the weak AMOC**
 - Run longer simulations
 - Test sensitivity to a slightly warmer initial condition (*CCSM4 from Brady et al., 2013, JC*)
 - Test role of more realistic LGM tidal energy (*Wilmes et al., 2019, P&P*)
- **Configuring Surface Mass Balance for LGM ice sheets**
 - Drive offline Community Ice Sheet Model (CISM3) ice sheets
 - Prepare for two-way ice sheet-climate coupling

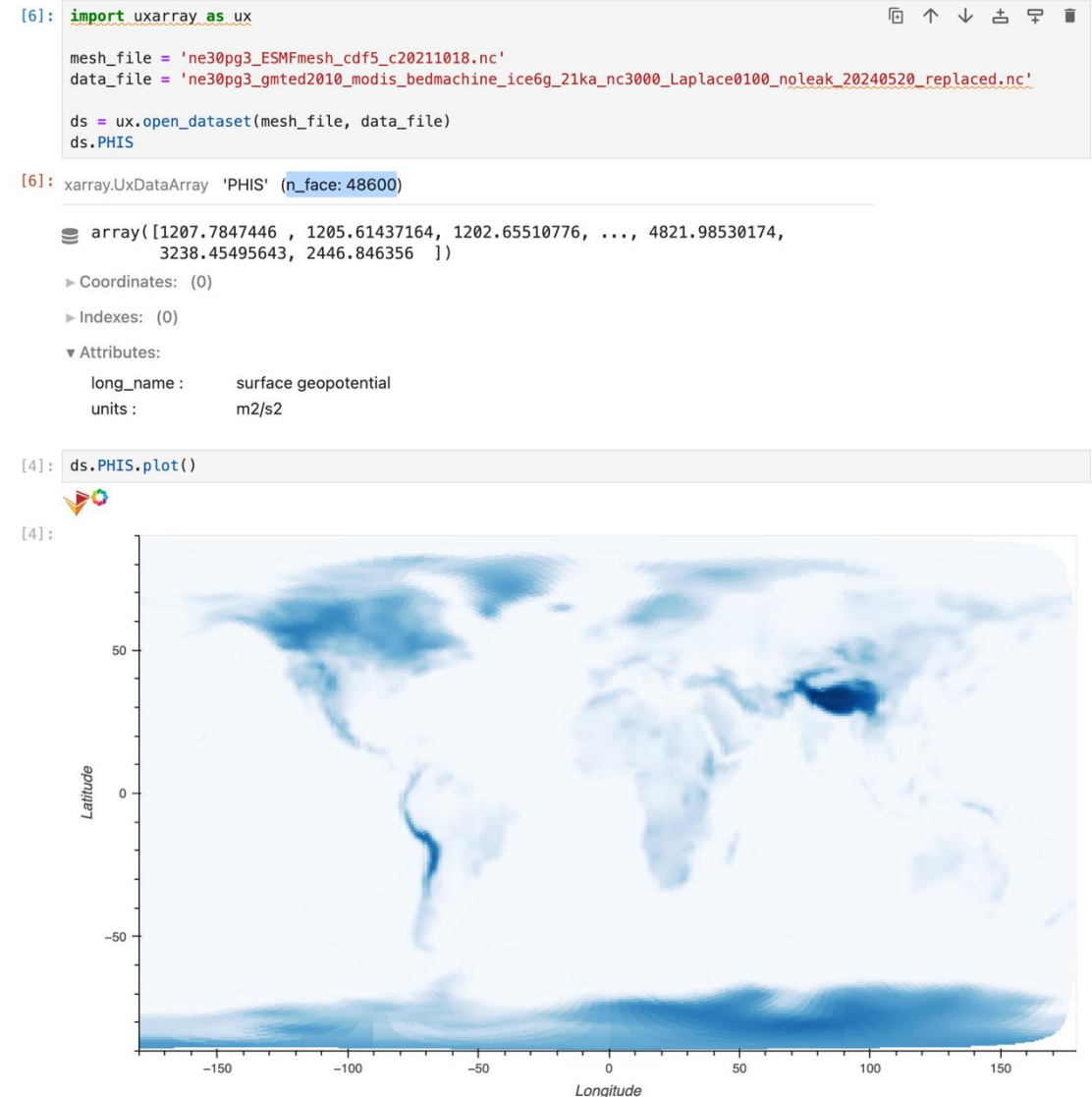
- **Goals**
 - *Document the setup of a challenging paleo simulation like LGM*
 - *Provide a streamlined, python-based workflow with good notes/references*
 - *Motivate and help you to create your own CESM3 simulations for your research*
- **Work in progress**
 - *For now: <https://github.com/jiang-zhu/paleowg-recipes>*
 - *Finalized version: <https://github.com/NCAR/paleowg-recipes>*
- **You can share your workflow and analysis code as well!**
 - *PaleoWG does not have a dedicated liaison, and it is on us to build community resources especially for early career researchers*

- **WG Website: landing pages for many simulations**
 - *e.g., Paleoclimate-Calibrated CESM2 simulation of LGM: <https://www.cesm.ucar.edu/working-groups/paleo/simulations/cesm2-paleocalibr>*
- **You can share your simulation data as well! We will ensure you are properly credited.**

A few notable efforts on Python-based diagnostic

- **CUPiD: CESM Unified Postprocessing and Diagnostics**
 - <https://github.com/NCAR/CUPiD>
- **ADF: AMWG Diagnostics Framework**
 - <https://github.com/NCAR/ADF>
 - *Successor of AMWG_diagnostics*
- **MOM6_tools**
 - <https://github.com/NCAR/mom6-tools>
 - *E.g., How do I compute the AMOC?*
- **XESMF for regridding**
 - <https://github.com/pangeo-data/xESMF>
- **UXarray for working with unstructured grid**
 - <https://github.com/UXARRAY/uxarray>
- **CVDP moving to Python?**
 - <https://github.com/NCAR/CVDP-ncf>

Use UXarray to visualize unstructured grid



Stay connected with more CESM activities

- **Survey — “Community input on future CESM OMWG development priorities”**
 - Submit responses by **Friday, Feb. 21, 2025**: <https://forms.gle/BxgFrS2SDwwniTGb8>
 - How can OMWG support your research?
 - Do you like a 2° ocean model? Regional modeling capability?
 - Need further info on designing new horizontal grid or vertical coordinates?
 - Would you like tutorials or example materials?
- **Many other working group meetings:** <https://www.cesm.ucar.edu/events/working-groups/2025>
- **CESM Tutorial (July 7–11, 2025) deadline: Feb. 7, 2025**
- **30th Annual CESM Workshop (June 9–11, 2025)**



CESM3

- **Public release is targeted for summer 2025**
- **Simulated LGM is reasonable, supporting its climate sensitivity**
- **AMOC is very weak and being investigated**

PaleoWG

- **New Python-based recipes are being developed and shared**
- **Check out the WG website for more resources**
- **New CESM diagnostics tools are being developed and available on GitHub**
- **Stay connected with upcoming CESM meetings/workshops/tutorials**

Thank you!
jiangzhu@ucar.edu