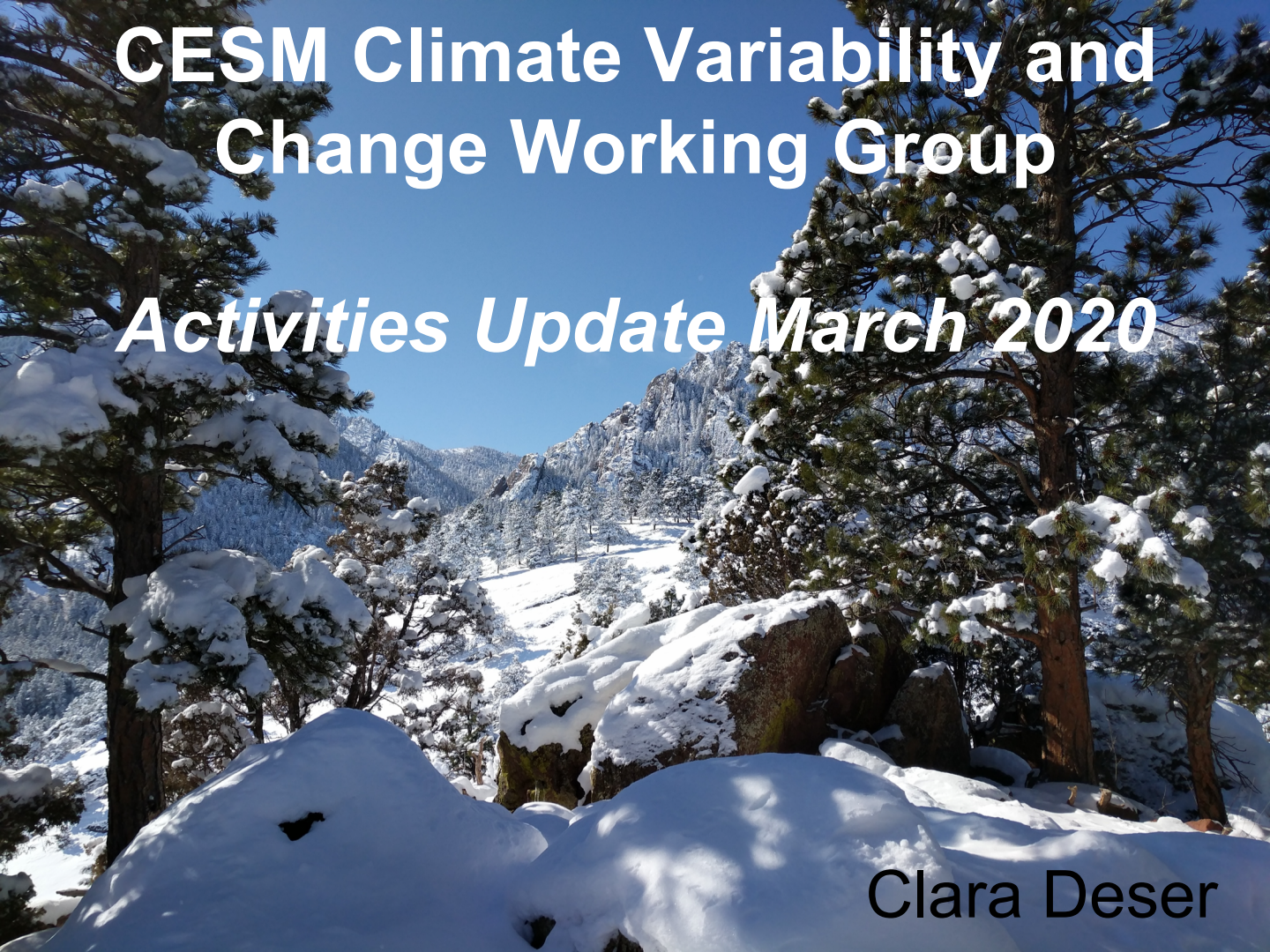
CESM Climate Variability and Change Working Group

Activities Update March 2020



Clara Deser

CVCWG Activities Update (March 2020)

- New easier-to-navigate webpages
- CESM2 Large Ensemble
- CESM2 Special Issue Papers
- New CMIP6 and other simulations
- Discussion of NCAR's role in CMIP
- Discussion of CAM vertical resolution
- Input for next CSL Proposal (2021-)

Welcome Isla Simpson as new co-chair

(along with Jerry Meehl, Peter Gleckler, Shang-Ping Xie)

Liaisons: Adam Phillips (science), Gary Strand (software)

New easier-to-navigate webpages (thanks to Adam Phillips)

http://www.cesm.ucar.edu/working_groups/CVC/

CLIMATE VARIABILITY & CHANGE WORKING GROUP CVCWG

Overview

The goals of the Climate Variability and Change Working Group (CVCWG) are to understand and quantify contributions of natural and anthropogenically-forced patterns of climate variability and change. Towards that end, the CVCWG coordinates, conducts and archives simulations with CESM that are of broad interest to the national and international climate research communities. These simulations are designed to enable researchers to evaluate and understand mechanisms of internal variability and externally-forced change due to natural and anthropogenic factors, detection and attribution of past climate change, and projections and predictions of future change. These simulations can also serve as baselines for users who wish to perform their own pertubation experiments using the same model version. A complete list of CVCWG simulations available for public download via the Climate Data Gateway at NCAR is available here.

Other CVCWG activities include development of the Climate Variability Diagnostics Package and Climate Data Guide, as well as contributions to the AGU CESM2 Virtual Special Issue and the CCSM4 and CESM1 Special Issues of the Journal of Climate.

Our Simulations

Recent / Notable

- CESM2 Large Ensemble Project
- CAM6 Prescribed SST Ensemble (forced with ERSSTv5)
- CAM5 Prescribed SST Ensembles (forced with ERSSTv3b, ERSSTv4 and ERSSTv5)
- CESM1.1 Large Ensemble Project
- CESM1.1 Single Forcing Large Ensemble Project
- CESM1.1 Tropical Pacific Pacemaker Ensemble

Past (organized by model version)

- CESM1.0 | CCSM4 | CCSM3

Other

- Multi-Model Large Ensemble Archive

CSL Proposals

2018-2020 Proposal / Experiments | 2016-2018 Proposal / Experiments | 2014-2016 | 2012-2014 | 2011-2012

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http://www.cesm.ucar.edu/working_groups/CVC/simulations/cesm1-single_forcing_le.html

CLIMATE VARIABILITY & CHANGE WORKING GROUP CVCWG

CESM1 "Single Forcing" Large Ensemble Project

The CESM1 "Single Forcing" Large Ensemble Project is a publicly available set of climate model simulations useful for addressing the individual roles of anthropogenic aerosols, greenhouse gases and land-use/land-cover in historical and future climate change. These simulations use the same model, forcing configuration and initialization protocol as the CESM1 Large Ensemble Project, but keep either industrial aerosols (AER), biomass burning aerosols (BMB), greenhouse gases (GHG) or land-use/land-cover (LULC) conditions fixed at 1920 while all other external anthropogenic and natural forcing factors evolve following historical and future (RCP8.5) scenarios. There are 4 sets of ensembles: XGHG (20 members, 1920-2080), XAER (20 members, 1920-2080), XBMB (15 members, 1920-2029) and XLULC (5 members, 1920-2029). All members are branched from the first member of the "all forcing" CESM1 Large Ensemble on January 1, 1920 by applying a small (order of 10-14 K) random noise perturbation to their initial atmospheric temperature fields. The impact of the withheld forcing factor can be deduced by subtracting the ensemble-mean of each "X" ensemble from the ensemble-mean of the original "all forcing" CESM1 Large Ensemble. Details are provided in the reference paper below.

We kindly ask that you acknowledge the CESM Project and CISL supercomputing resources (doi:10.5065/D6RX99HX) and reference Deser et al. (2020) when presenting results based on the CESM1 "Single Forcing" Large Ensembles in either oral or written form.

Deser, C., A.S. Phillips, I.R. Simpson, N. Rosenbloom, D. Coleman, F. Lehner, A. Pendergrass, P. DiNezio and S. Stevenson, 2020: Isolating the Evolving Contributions of Anthropogenic Aerosols and Greenhouse Gases: A New CESM1 Large Ensemble Community Resource, J. Climate, submitted.
[Article] [Supplemental Materials]

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Project Details

- **Simulation Names:**
  - XGHG: b.e11.B20TRLENS_RCP85.f09_g16.xghg.0XX, XX = 01-20
  - XAER: b.e11.B20TRLENS_RCP85.f09_g16.xaer.0XX, XX = 01-20
  - XBMB: b.e11.B20TRLENS_RCP85.f09_g16.xbmb.0XX, XX = 01-15
  - XLULC: b.e11.B20TRLENS_RCP85.f09_g16.xlulc.00X, X = 1-5
- **Model Version:** CESM1.1 Codebase | Documentation
- **Resolution:** 0.9x1.25_gx1v6 (CESM nominal 1° grid)
- **Years:** 1920-2080 (XGHG, XAER), 1920-2029 (XBMB, XLULC)
- **Ensemble Size:** 20 members (XGHG, XAER), 15 members (XBMB), 5 members (XLULC)
- **Time Frequencies Saved:** Monthly, Daily
- **Machine:** NCAR:Cheyenne
- **Compsets:** B20TRLENS / BRCP85LENS
- **Additional Notes:** All ensembles use the identical configuration as the CESM1 Large Ensemble but with the following differences:
  - The XGHG ensemble does not have time-evolving greenhouse gases.
  - The XAER ensemble does not have time-evolving aerosols.
  - The XBMB ensemble does not have time-evolving biomass burning.
  - The XLULC ensemble does not have time-evolving land use land cover changess.

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  - XBMB: b.e11.B20TRLENS_RCP85.f09_g16.xbmb.0XX, XX = 01-15
  - XLULC: b.e11.B20TRLENS_RCP85.f09_g16.xlulc.00X, X = 1-5
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[Article] [Supplemental Materials]

Data Acquisition

The data is available on the NCAR machine cheyenne (on the HPSS at /CCSM/csm/CESM-CAM5-BGC-LE) and from the Climate Data Gateway at NCAR.

The following are step by step directions on how to download CESM1 Single Forcing Project data from the Climate Data Gateway.

1. Proceed to the Climate Data Gateway CESM1 Large Ensemble page.
2. Scroll to the bottom of that page under *Child Datasets*, and click on the component and time frequency you are interested in.
3. The files are organized by variable, listed at the end of each link. Click on the variable you are interested in.
4. Click on the Download Options button. At this point, if you have not logged into the Climate Data Gateway you can do so now. If you have not registered before, registration is free and quick.
5. Upon logging in you will see a ridiculously long list of files. Scroll down until you see files that start with the simulation names identified above. (Alternatively, search on this page for the following string "b.e11.B20TRLENS_RCP85.f09_g16".) Once you have identified a file that you would like to download, click on the check box to the left of the file name. Note that you can select multiple files on this page at once. When you are finished selecting files, scroll to the top (or bottom) of the page and click on the *Download Options for Selection* box.
6. Click the *Request File Transfer from Archive* or choose an alternative method, and follow the status of the file transfer request

One unfortunately cannot select/download multiple files across variables at once from the Climate Data Gateway.

CESM2 Large Ensemble is underway!

- In partnership with IBS Center for Climate Physics, South Korea
- 1 degree spatial resolution
- 1850-2100 (historical and SSP370)
- 100 members
- Completion in ~ 7 months (Sep 2020)
- Data will become available in late 2020
- First 10 members are done.

Initialization protocol to create ensemble spread

- CESM1 used a single ocean initial state, with tiny (10^{-14} K) perturbations to the initial atmospheric temperatures (“pertlim”).

- CESM2 will use a combination of different ocean initial states (“macro perturbations”) and pertlim (“micro perturbations”).

CESM2 Large Ensemble Initialization Protocol

- 20 random ocean initial states
  (taken from restart files every 10 years of the long 1850 control simulation during model years 1001-1200 to avoid drift issues).
- 4 pre-selected ocean initial states based on AMOC phase (model years 1230-1301), with 20 “pertlim” members each.

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Allows assessment of AMOC initial condition memory, and ocean *vs.* atmosphere contributions to ensemble spread.

http://www.cesm.ucar.edu/projects/community-projects/LENS2/

THE CESM2 LARGE ENSEMBLE COMMUNITY PROJECT

We are pleased to announce the launch of the CESM2 Large Ensemble in partnership with the IBS Center for Climate Physics in South Korea. When completed, the CESM2 Large Ensemble will consist of 100 members at 1 degree spatial resolution covering the period 1850-2100 under CMIP6 historical and SSP370 future radiative forcing scenarios. The entire ensemble is expected to complete in Fall 2020, and the data should become available via the Climate Data Gateway by the end of 2020. A reference paper describing the ensemble will be posted by the end of 2020.

Unlike the CESM1 Large Ensemble, the CESM2 Large Ensemble will use a combination of different oceanic and atmospheric initial states to create ensemble spread as follows.

1. Members 1-10: These will begin from years 1001, 1021, 1041, 1061, 1081, 1101, 1121, 1141, 1161, and 1181 of the 1400-year pre-industrial control simulation. This segment of the control simulation was chosen to minimize drift.
2. Members 11-90: These begin from 4 pre-selected years of the pre-industrial control simulation based on the phase of the Atlantic Meridional Overturning Circulation (AMOC). For each of the 4 initial states, there will be 20 ensemble members created by randomly perturbing the atmospheric temperature field by order 10^-14K. The chosen start dates (model years 1231, 1251, 1281, and 1301) sample AMOC and Sea Surface Height (SSH) in the Labrador Sea at their maximum, minimum and transition states.
3. Members 91-100: These will begin from years 1011, 1031, 1051, 1071, 1091, 1111, 1131, 1151, 1171, and 1191 of the 1400-year pre-industrial control simulation. This set will include the extensive "MOAR" output, which can be used to drive regional climate models.

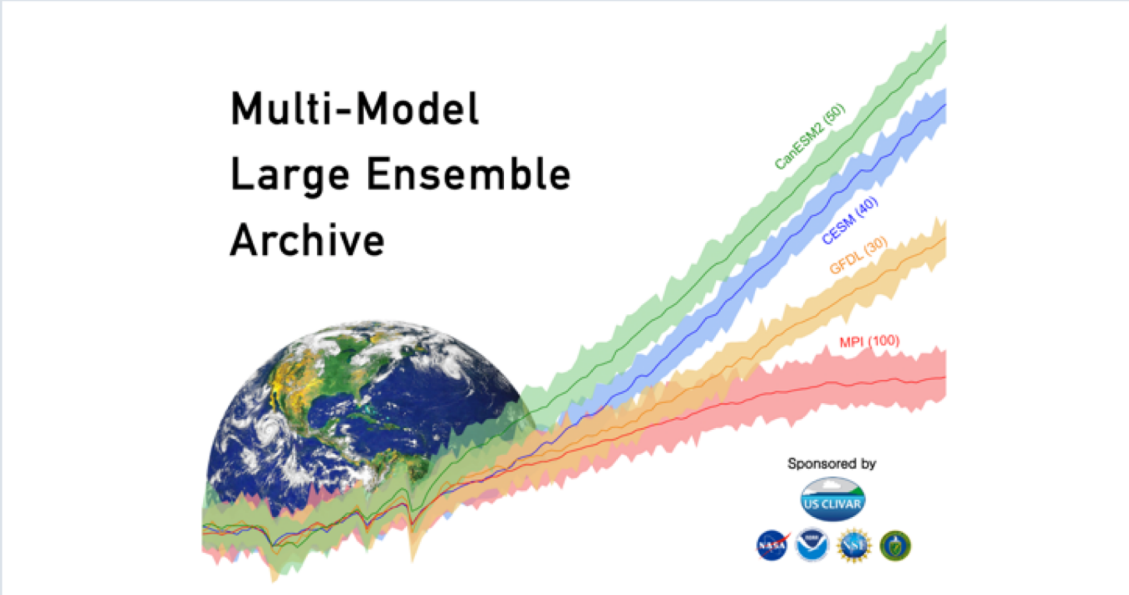
The initialization design will allow assessment of oceanic (AMOC) and atmospheric contributions to ensemble spread, and the impact of AMOC initial-condition memory on the global earth system.

List of output variables

http://www.cesm.ucar.edu/CESM2-LENS2/

http://www.cesm.ucar.edu/projects/community-projects/MMLEA/

MULTI-MODEL LARGE ENSEMBLE ARCHIVE



Courtesy of the US CLIVAR Working Group on Large Ensembles
(Deser, Lehner et al., 2020 *Nature Climate Change*)

New CVCWG Simulations

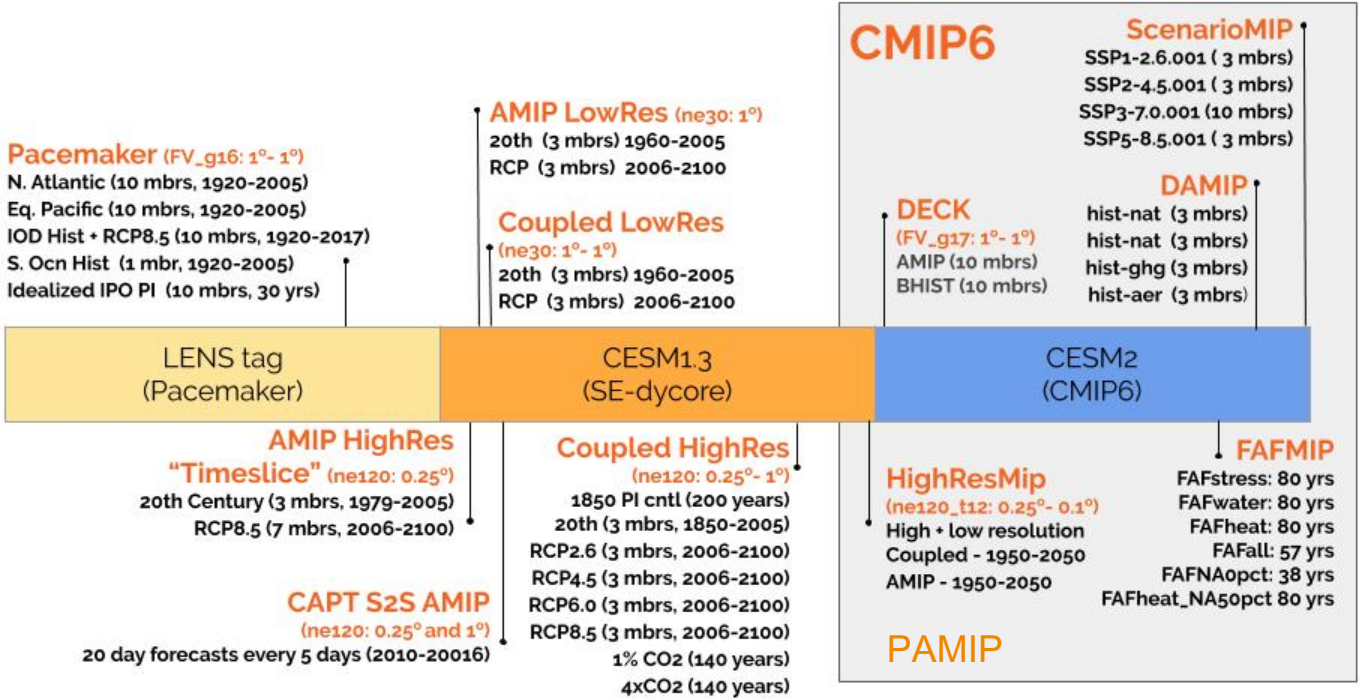
http://www.cesm.ucar.edu/working_groups/CVC/simulations/

- CESM1 Single-Forcing Ensembles (15-20 members each of XAER, XBMB, XGHG, XLULC)
  Deser et al. (2020, *J. Climate*)

- CAM6-1° Tropical AMIP Ensemble
  (10 members, ERSSTv5, 1880-2014)

- To be conducted (CAM6-1°)
  Global AMIP & Tropical Pacific Pacemaker
  CAM6-1° Control and CAM6-SOM* Control
  CESM2 control extension to 2000 years.

New CVCWG Simulations (cont')



Courtesy of Nan Rosenbloom (nanr@ucar.edu)

AGU CESM2 Virtual Special Issue Papers (33 total)

http://www.cesm.ucar.edu/publications/

Six led or co-authored by CVCWG co-chairs:

- Danabasoglu, G. et al (2020). The Community Earth System Model version 2 (CESM2). *JAMES,* in press.
- Capotondi, A., Deser, C., Phillips, A. S., Okumura, Y., Larson, S. M. (2020). ENSO and Pacific Decadal Variability in the Community Earth System Model Version 2. *JAMES, in revision.*
- Meehl, G. A. et al. (2020). Characteristics of Future Warmer Base States in CESM2. *JAMES, in revision.*
- Meehl, G. A., Shields, C., Arblaster, J. M., Annamalai, H., Neale, N. (2020). Seasonal mean monsoon simulations in CESM2.
- Simpson, I.R. et al. (2020). An evaluation of the large scale atmospheric circulation and its variability in the Community Earth System Model 2 (CESM2) and other CMIP models. *JGR-Atmos, in revision*.
- Gettelman, A., M. et al. (2020). The Whole Atmosphere Community Climate Model Version 6 (WACCM6), *JGR-Atmos*.

CESM Involvement in CMIP Discussion
(per NCAR leadership)

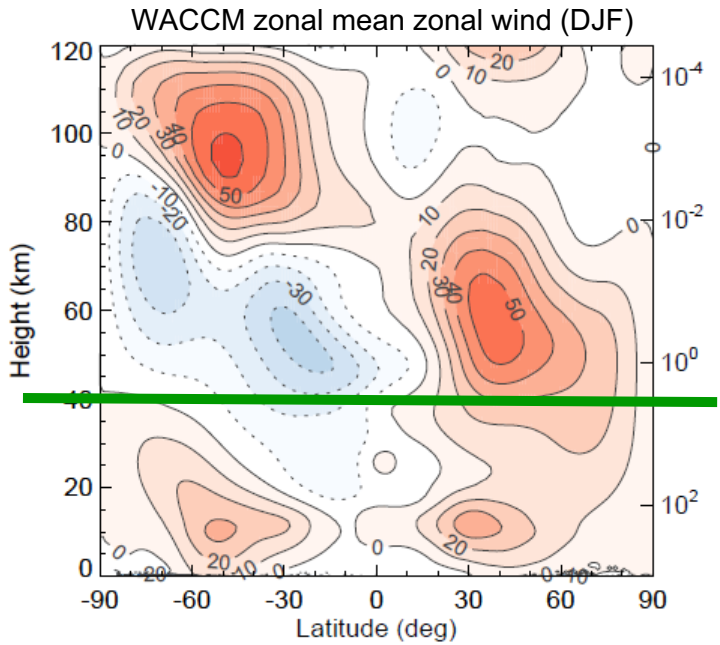
- What value do you see (or is there) in CESM's participation in the CMIP efforts?
- Relatedly, how have CESM CMIP simulations / experiments helped you advance your science?
- What fundamental science does the CESM's CMIP participation come at the expense of?

What are the CVCWG's views on vertical resolution?

What we currently have?

WACCM6 (70 layers)

Cost =
With chem ~28000 core-hours/yr
Without chem ~ 7500 core-hours/year



CAM6 (32 layers)

Cost = ~3500 core-hours/yr

CAM4	CAM5	CAM6	SC-WACCM6	WACCM6
~350	~1300	~3500	~7500	~23000
x1	x3.5	x10	x21	x65

Considerations

- Configuring and tuning multiple configurations is burdensome
- Many people want many different things…
  - Computational efficiency
  - Accurate representation of middle-atmosphere dynamics
  - Improved vertical resolution in the boundary layer
  - Optimum model top for seasonal forecasting (including a stratosphere but not going above initialization datasets as WACCM currently does)
- 300+ simulations were performed in the tuning process for CESM2
  - wouldn't have been feasible to do with WACCM
- We run CMIP with both CAM and WACCM → reduced computational cost if we converged on one model.
- There is evidence for the importance of the stratosphere
  - Well established influence of variability in the stratospheric polar vortices on the troposphere
  - QBO influences on the MJO (not yet captured even in WACCM)

Discussion points

- Should CAM and WACCM be unified? i.e., Could the CVCWG cope with a computational burden of a configuration that would meet the needs of WACCM users?
- Are we ok with not having a reasonable representation of the stratosphere? Could we take the computational hit of 1.5 or 2x CAM to have an improved representation of the polar vortices i.e., higher top but not as high as WACCM
- If you could have any model you want built for you, what would be on your wish list and why?

Your Input for next CSL Proposal
(more discussion at the CESM Summer Workshop)

Email input to:

Isla Simpson (islas@ucar.edu)
Jerry Meehl (meehl@ucar.edu)