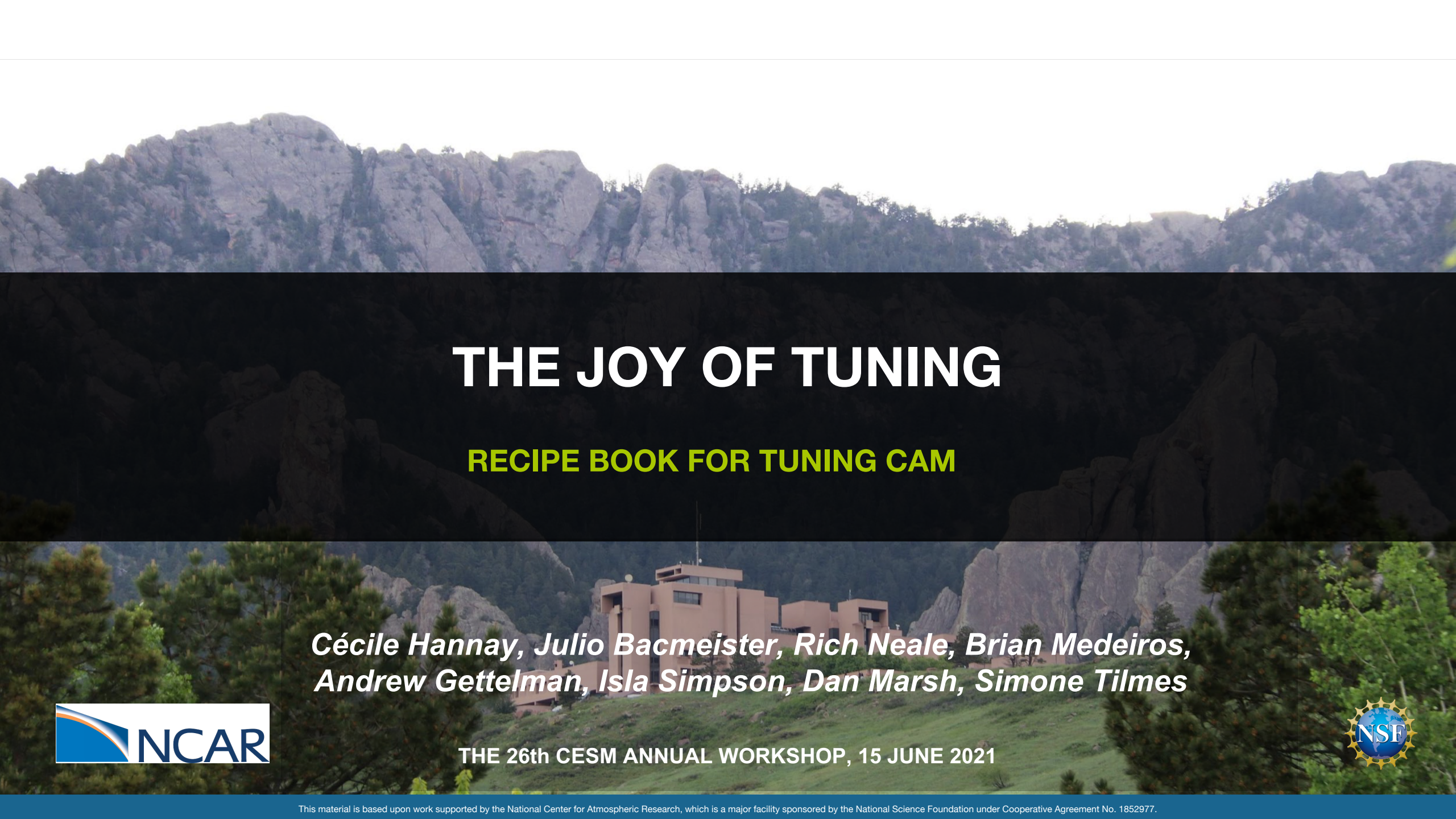

THE JOY OF TUNING

RECIPE BOOK FOR TUNING CAM

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NCAR

THE 26th CESM ANNUAL WORKSHOP, 15 JUNE 2021

NSF

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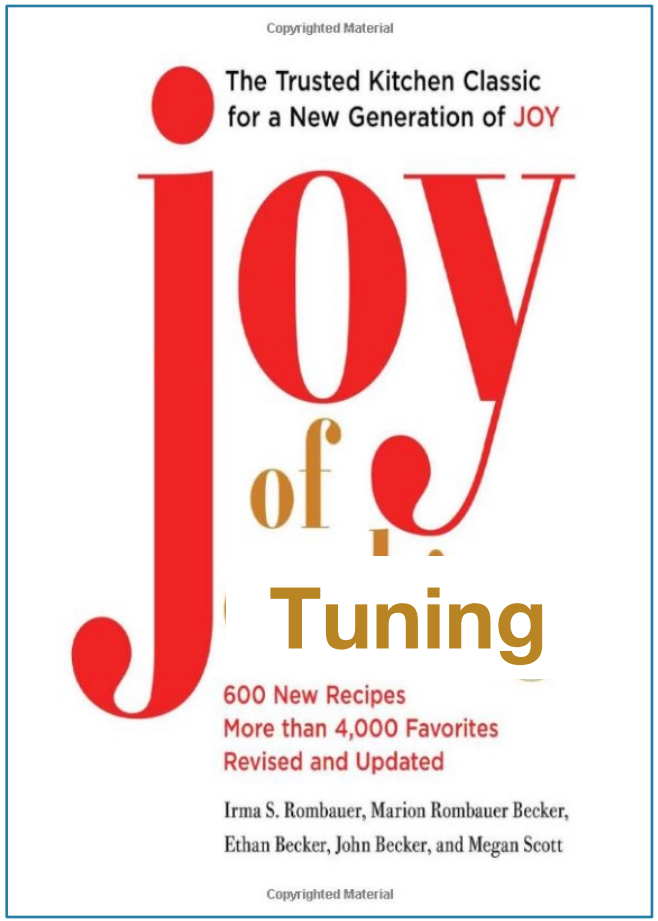
Motivation

Tuning is a fundamental step during model development...

... but nitty-gritty details are not fully documented

"The Joy of Tuning"

- CAM tuning recipes
- make CAM tuning process more explicit and more transparent
- living document (feedback welcome)



Definition of Climate Modeling Tuning

Tuning = adjusting parameters (“tuning knobs”) to achieve best agreement with observations.

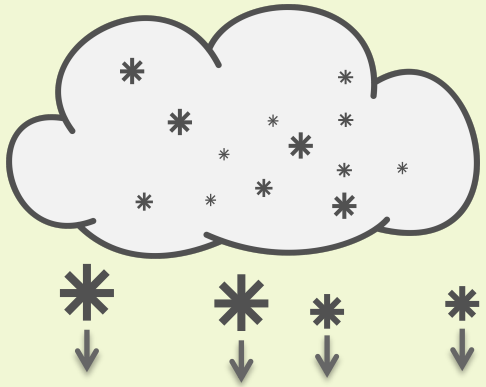
Definition of Climate Modeling Tuning

Tuning = adjusting parameters ("tuning knobs") to achieve best agreement with observations.

Tuning knob = parameter weakly constrained by observations

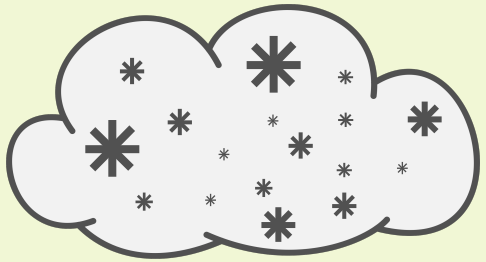
Dcs = Threshold diameter to convert cloud ice particles to snow

Smaller Dcs



Less cloud ice
Less LWCF

Larger Dcs



More cloud ice
More LWCF

Definition of Climate Modeling Tuning

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Definition of Climate Modeling Tuning

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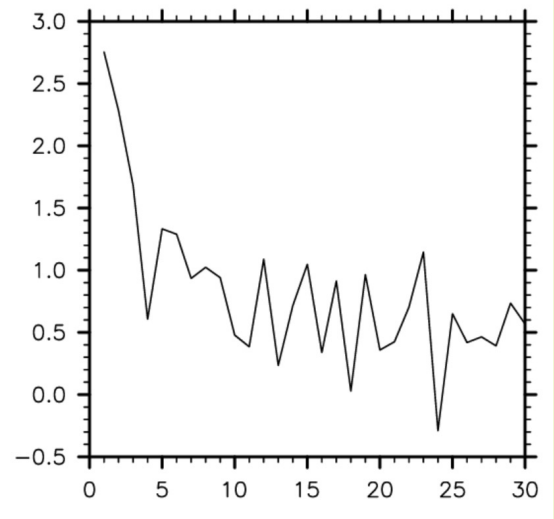
Top of atmosphere radiative balance (RESTOM should be small)

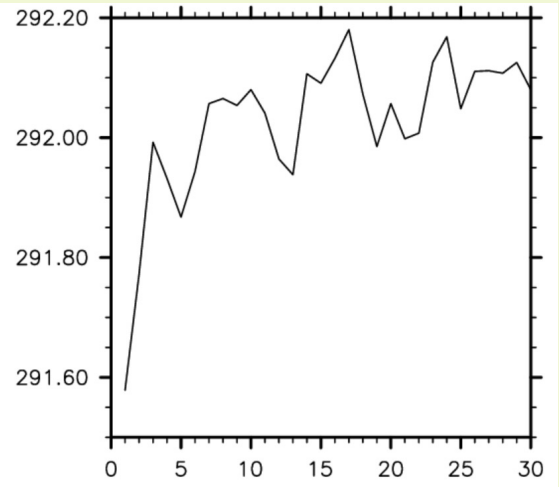
RESTOM in pi-control simulation < 0.1 W/m2

RESTOM > 0.1 W/m2



=>

SST increases



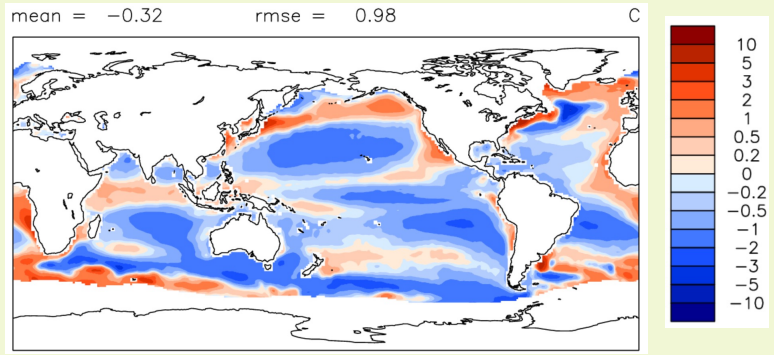
Other Key Variables: SST, SWCF, LWCF, PRECT, PSL, TAU

Variables are typically evaluated against observations using the AMWG diagnostics package
Some datasets are being updated in the AMWG Diagnostics Framework (ADF)

SST bias

HadISST/OI.v2

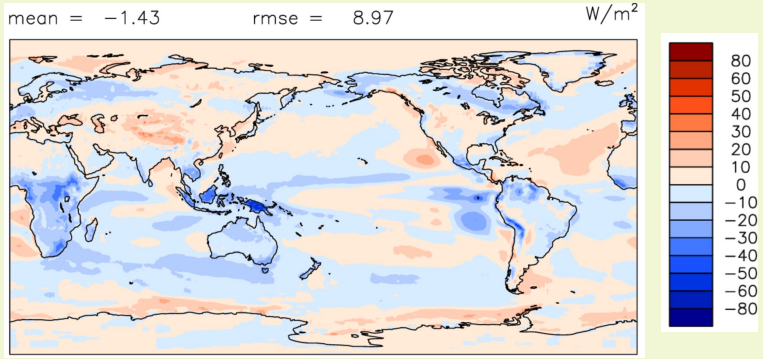
Bias < 0.3 K
RMSE < 1.2



SWCF bias

CERES-EBAF

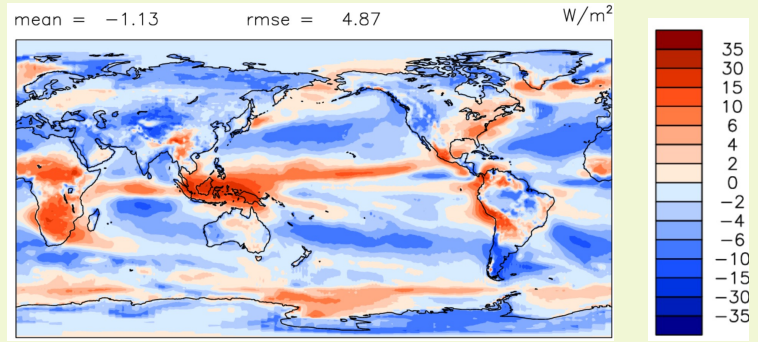
Globally: ± 2 W/m2
+ Local biases



LWCF bias

CERES-EBAF

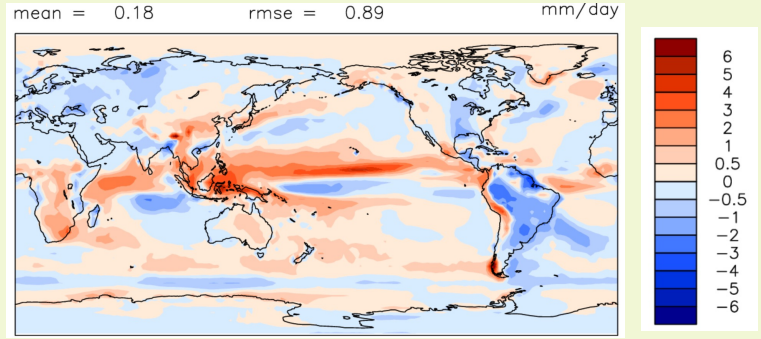
Globally: ± 2 W/m2
+ Local biases



PRECT bias

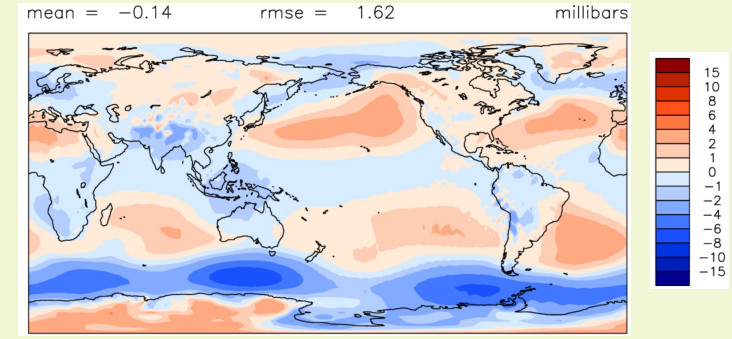
GPCP

Bias < 20%
RMSE < 1.2



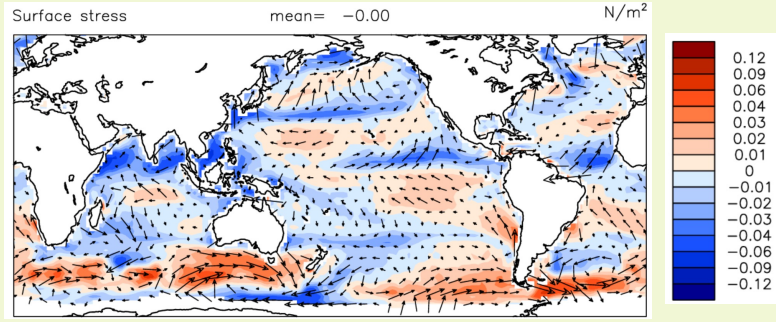
PSL bias

JRA25



Surface stress bias

Large-Yeager



Tuning steps

Step 1
CAM-only simulations

F2000climo: 5-10 yrs

FHIST: 10-30 yrs

Tuning

Key variables:
SWCF, LWCF,
PRECT, PSL, ...

Step 2
Fully coupled pre-industrial

Initialization spunup state

B1850: 10-20 yrs

Tuning

RESTOM < 0.1 W/m^2
+ Key variables

B1850: 50-100 yrs

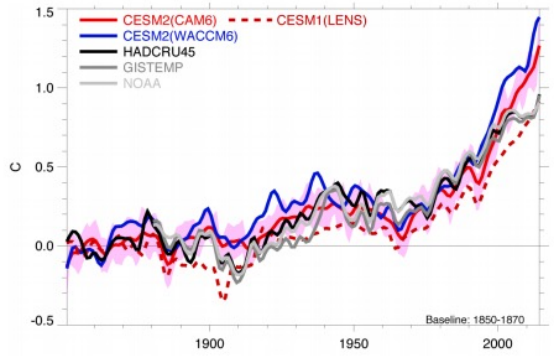
Tuning

RESTOM and TS drift
+ Key variables
+ ENSO, AMOC, sea-ice

Step 3
Fully coupled historical runs

BHIST: 1850-2014

Historical warning



No Tuning

Dilemmas while tuning

- **Subjectivity of tuning targets**

  Tuning involves choices and compromises
  Overall, tuning has limited effect on model skills

- **Tuning for pre-industrial ⇔ Tuning for present day**

  Pre-industrial: Radiative equilibrium
  Present day: Available observations

- **Tuning individual components ⇔ Tuning coupled model**

  Tuning individual components is fast
  But no guarantee that results transfer to coupled model

- **Tuning exercise is very educative**

  We learn a lot about the model during the tuning phase.

Where does “The Joy of Tuning” live?

NCAR UCAR | COMMUNITY EARTH SYSTEM MODEL CESM ®

PUBLICATIONS ABOUT HELP SEARCH ...

ADMINISTRATION WORKING GROUPS MODELS EVENTS

/ CESM Working Groups / Atmosphere Model Working Group

Atmosphere Model Working Group AMWG

The Atmosphere Model Working Group (AMWG) is a broad collection of researchers across university and federal institutions engaged in atmospheric science research using the Community Earth System Model (CESM). The overarching goal is to continually develop the Community Atmosphere Model (CAM) in order to periodically provide new versions for use by the wider CESM community.

We set short and long term development targets to guide community research. Ultimately, we aim to deliver the best representation of the atmosphere to be used in multiple applications for climate, climate variability and climate change research.

ATMOSPHERE MODEL WORKING GROUP
- Overview
- Featured Highlights
- Contact Info

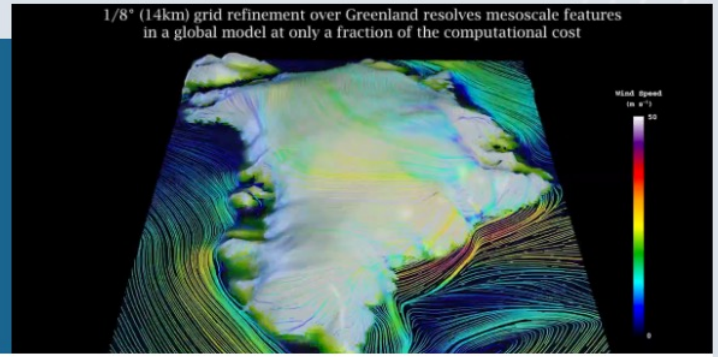
CAM DEVELOPMENT
- Dycores & Resolution
- Parameterizations
- Simulations

MODELS AND TOOLS
- Atmosphere Models
- Diagnostics Packages
- Developer's corner

Featured Highlights

05/28/2021

New visualization illustrating the benefits of variable-resolution grids for use in ice sheet research



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Developer's Corner

Information and tools for developers of the Community Atmosphere Model

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Community Atmosphere Model

The CAM source code (including both release and development code) is located in a Github repository. See the README file in the CAM Github repository for instructions on downloading the correct version of CAM and view the CAM documentation which includes the user's guide.

Contributing to CAM

If you have already developed a solution for a particular bug, or if you are working with an NCAR scientist or engineer to bring in new science or a new model feature, then first create a fork of the CAM repo, and add/test your code changes there. Instructions for how to do this properly can be found here.

Once you have your own personal version with all of the working code modifications, then open a pull request to the main CAM repo. Instructions for how to do this properly (including how to push to the correct CAM branch) can be found here.

Finally, CAM coding standards for Python and Fortran (the two main programming languages used in CAM) can be found here.

Tuning CAM

Model tuning is a necessary of part of climate models development. We provide here a living document that describe the tuning process of CAM.

Debugging CAM

Helpful techniques which are useful when the model is crashing can be found here.

Reporting Bugs & Issues

If you are having trouble with CAM, or if you believe there is a bug or problem with the model, then please make a post on the CAM forum.

If the problem is indeed a real bug, then you will be notified by an NCAR scientist or engineer, and an official Github Issue will be created and added to the work list.

Git & Github

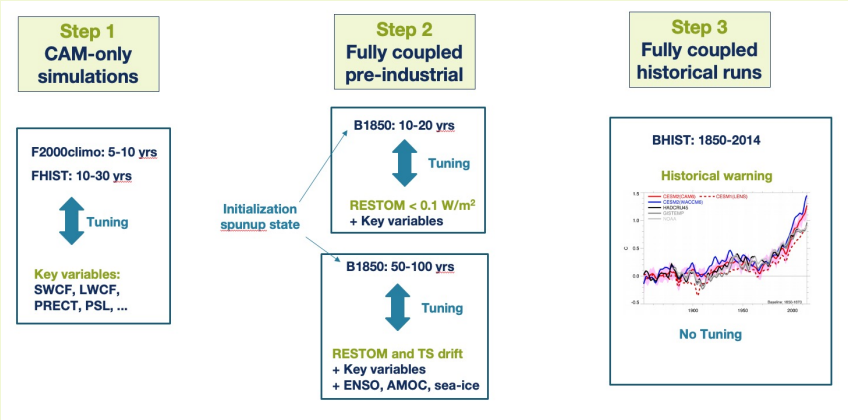
If you need any help with either Git or Github, or would like to know some possibly helpful tips, you can view them here.

https://www.cesm.ucar.edu/working_groups/Atmosphere/

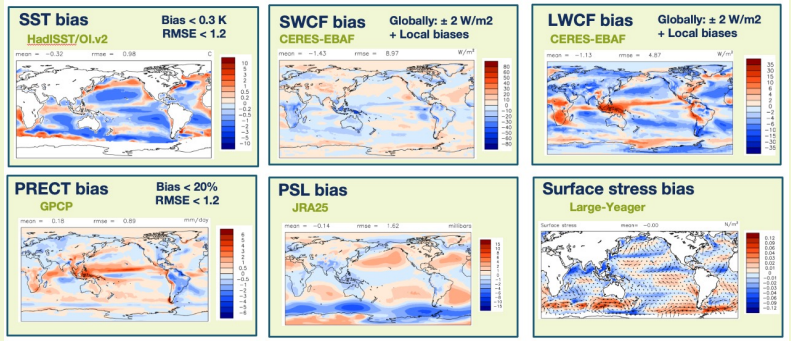
What does “The Joy of Tuning” provide?

CAM tuning recipe in living document

Overall process



Key variables



Coming soon: Stratosphere tuning document

Tuning parameters

Parameters	Description	Default value and range	Diags
micro_mg_dcs	Threshold diameter to convert cloud ice particles to snow	Default = 500.D-6 Range = [300.,600.] D-6	N/A
clubb_gamma_coef	Controls the skewness of vertical velocity (larger values produce larger skewness)	Default = 0.308 Range = [0.25, 0.35]	N/A
clubb_c_K10	Ratio of eddy diffusivity of wind to heat	Default = 0.5 Range = [0.2, 0.6]	N/A

Coming soon: Results from CAM-PPE

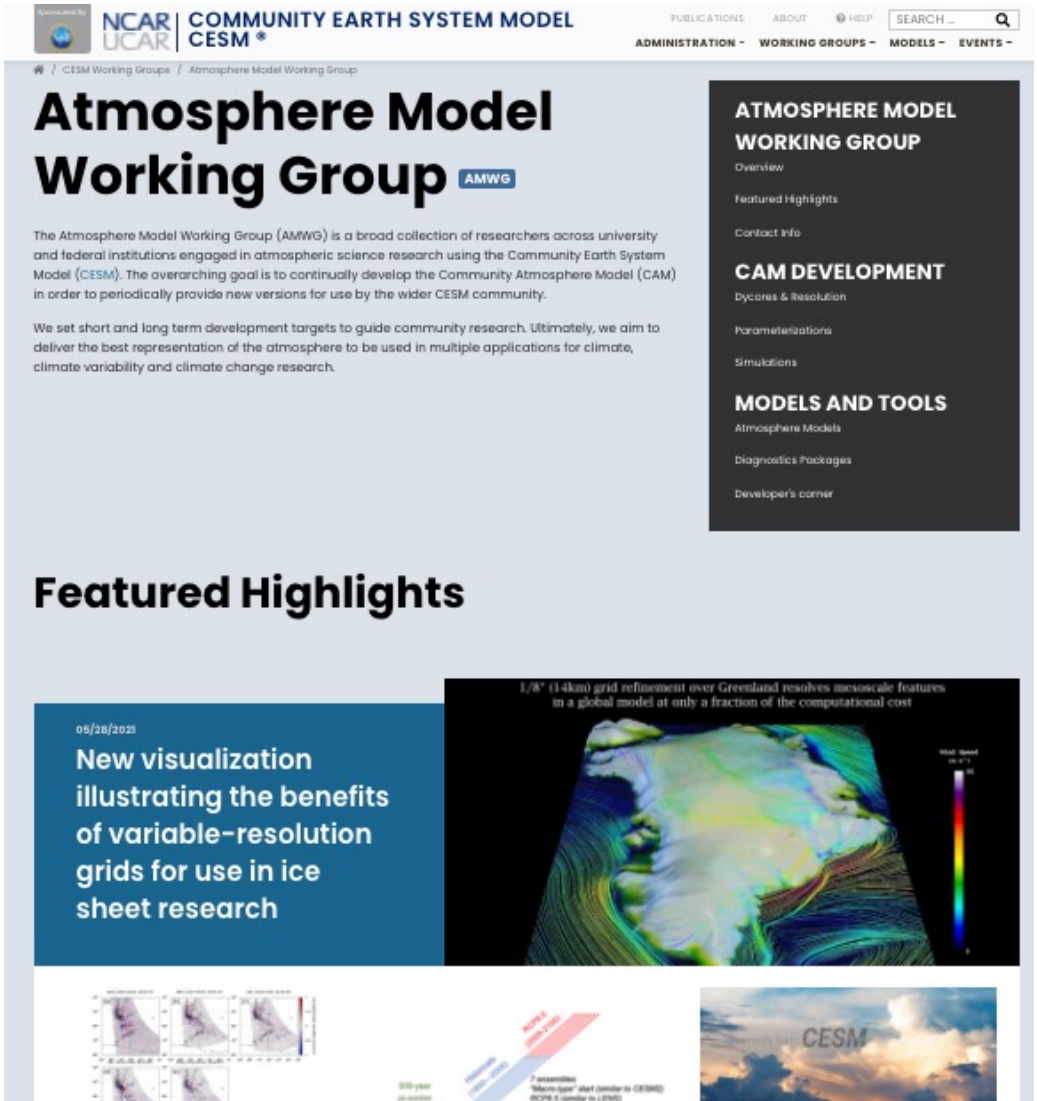
Datasets

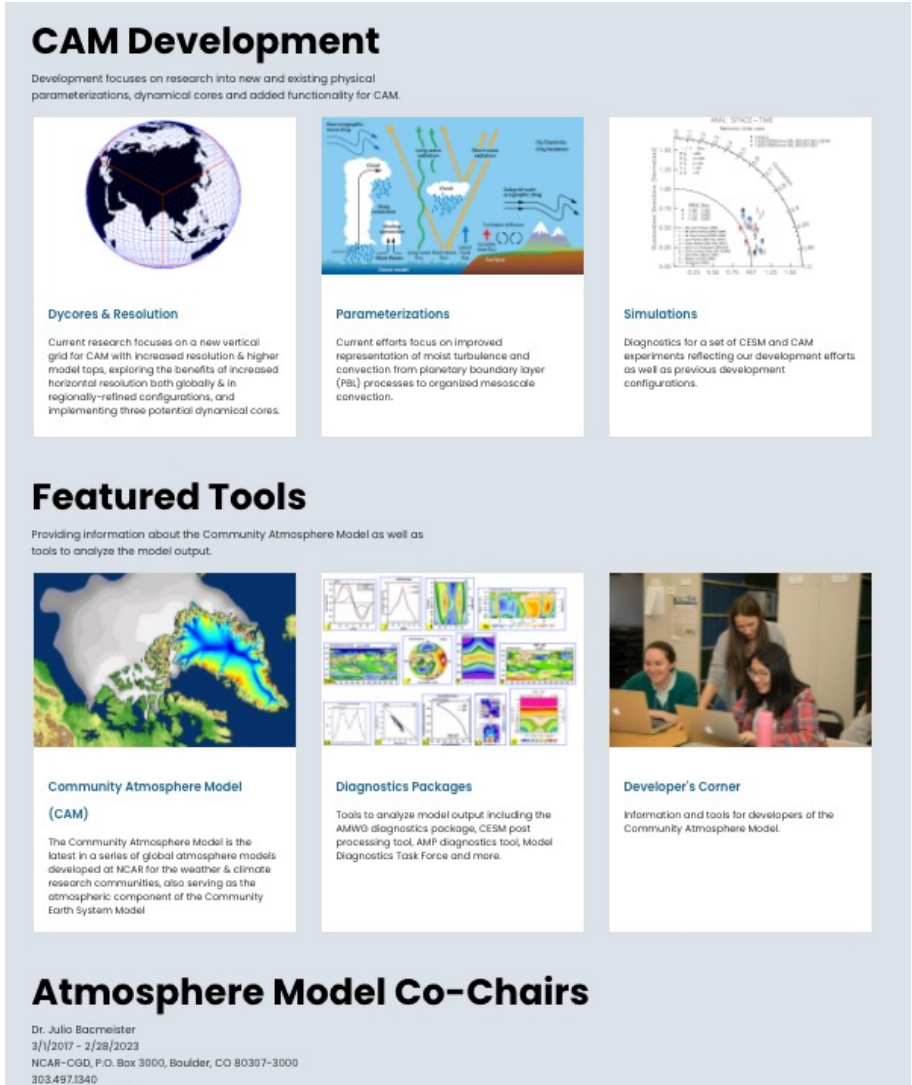
Quantities	Datasets	Guidance
SST	HadISST	We use HadISST/OI.v2 (Pre-Industrial) 1870-1900 A mean SST bias compared to pre-industrial HadISST of between [-0.3, 0.3] K A RMSE below 1.2 is acceptable, below 1.0 is ideal to be comparable with CESM release versions.
SWCF	CERES-EBAF Ed4.1 (2001-2020)	The present day global annual mean SWCF in the CERES-EBAF Ed4.1 dataset is -45.3 W/m2 For B1850, we target a global SWCF between -44.5 and -47.5 W/m2
LWCF	CERES-EBAF Ed4.1 (2001-2020)	The present day global annual mean LWCF in the CERES-EBAF Ed4.1 dataset is 25.8 W/m2 W/m2. The LWCF is typically underestimated in CAM. For B1850, we target a global annual LWCF > 24 W/m2

Coming soon: Some datasets are updated

And while you are there...

Take a tour of the AMWG website: https://www.cesm.ucar.edu/working_groups/Atmosphere/





Thank You!