Changes to Agenda:

TUESDAY, 19 February:

The Path to and Status of Released Models

1:00	Overview of CAM/CESM2 developments	Julio Bacmeister
1:20	CESM2 sensitivity	Cecile Hannay
1:40	Tuning NorESM at 1 and 2 degree resolution	Oeyvind Seland
2:00	Tuning the convection parametrization for climate integrations, and CESM2 variability and climate sensitivity in slab-aquaplanet mode	Thomas Toniazzo

Spectral Element development and evaluation

2:20	**A total energy error analysis of dynamical cores in the Community Atmosphere Model (CAM)**	Peter Lauritzen

WEDNESDAY, 20 February:

3:00	*Break*	
3:30	Implementing marine organic aerosol and ice nucleation in CESM2: Description, evaluation, and impacts on clouds	Xi Zhao
3:50	Competing roles of the fast and slow response in the total coupled West African precipitation response to anthropogenic aerosol forcing	Paul Kushner / Haruki Hirasawa
4:10	Discussion: Promising parameterizations? Critical biases to get to the bottom of?	
5:15	Adjourn	
5:30	*Reception (Damon Room)*	

Vertical resolution, model top?

Community Atmosphere Model *version 6*: Status update

Julio Bacmeister
NCAR/CGD, local AMWG co-chair

NCAR
NATIONAL CENTER FOR ATMOSPHERIC RESEARCH

AMWG Meeting, NCAR. February 19, 2019

Outline

- Developments since last February
  - Model versions 272-299
- CESM1 vs CESM2
- Other Developments
- Future
  - Dynamical cores (SE, MPAS, FV3)
  - Purpose of CAM/CESM

Since February 2018

- Model configurations 272 – 299(CESM2)
  - New WACCM forcing files
  - Minor bugfixes
- CESM2.0 frozen and released June 2018
- CESM2.1 released December 2018 (CMIP6 tag)

Since February 2018

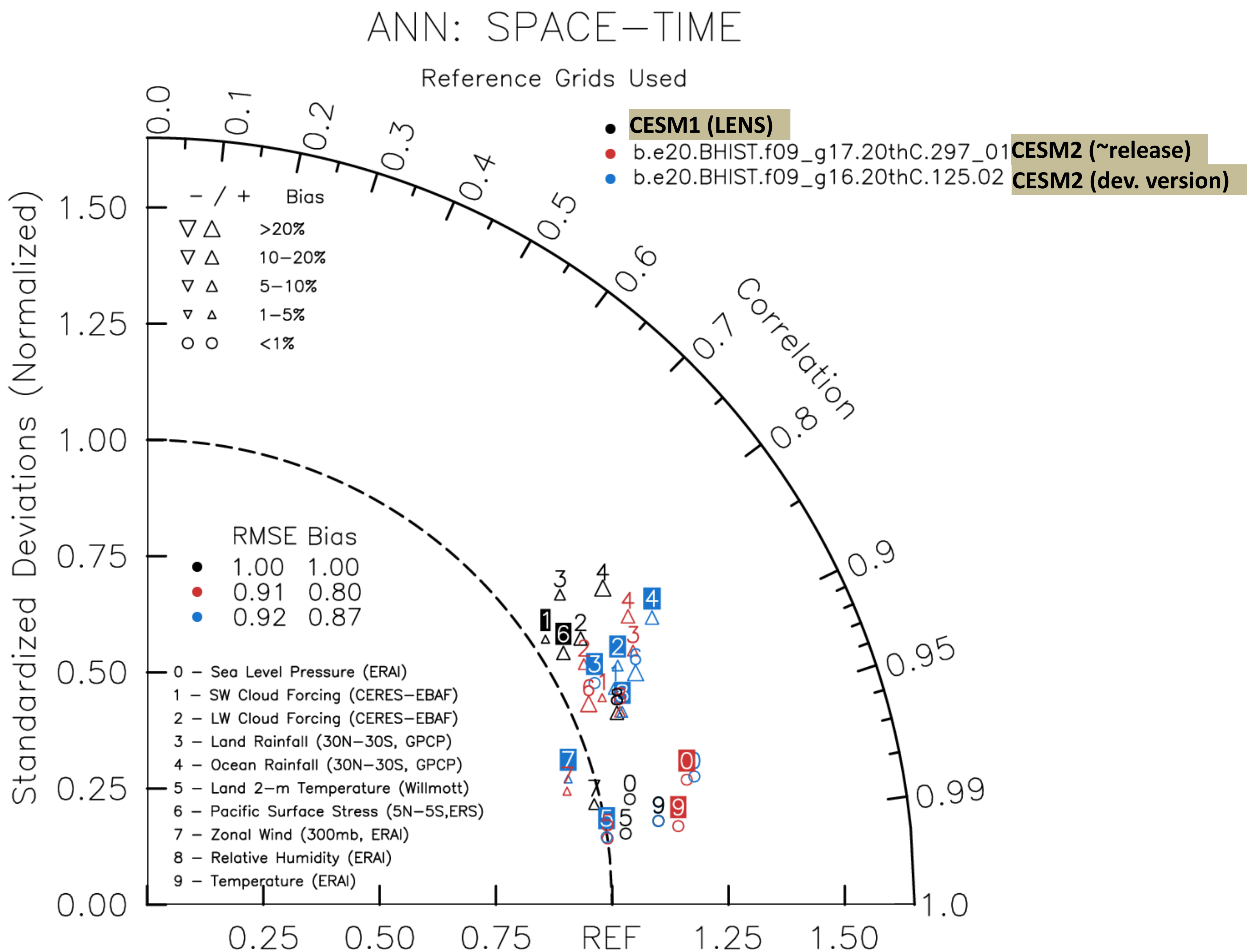
CMIP6 DECK runs well underway. First model results to be published soon

MIP name	Expt. Name	CMIP6 Exp Name	# years per ensemble member	#realizations	CESM2-BGC (1-degree)	CESM2 WACCM (1-degree)
DECK	Control	piControl	1000	1	1	0
	Control	esm-piControl	500	1	1	0
	Control WACCM	piControl	500	1	0	1
	Control high-res	piControl	175	1	0	0
	1% to 4x	1pctCO2	150	1	1	1
		1pctCO2				
	4xCO2	abrupt-4xCO2	150	1	1	1
		abrupt-4xCO2				
	AMIP (1979-2014)	amip	35	1	3	3
	AMIP (1979-2014), additional (	amip	35	7	7	
Historical	1850-2014	historical	165	10	9 of 10	0
	1850-2014	esm-hist	165	3	3	0
Historical WACCM	1850-2014	historical	165	3	0	3

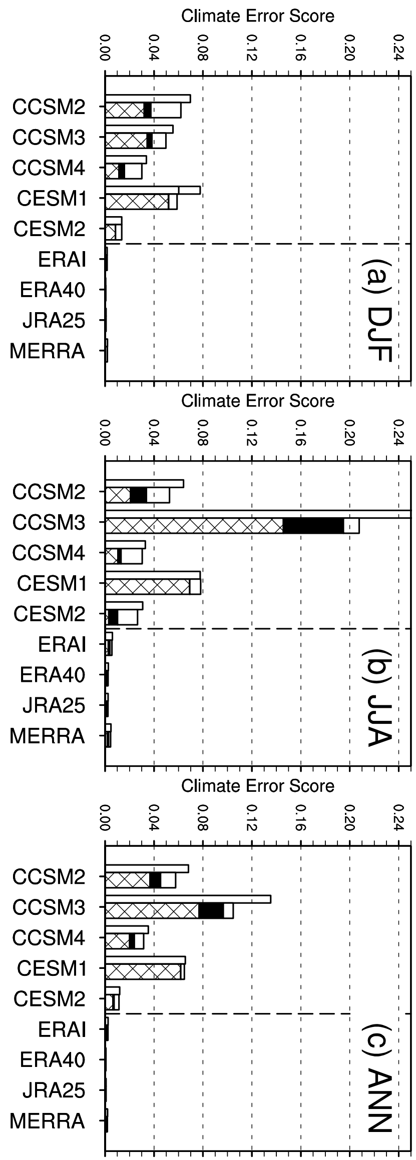
CESM2 vs CESM1 recap

Model	**CAM5** **CESM1.0**	**CAM6** **CESM2**
Release	**June 2010**	**June 2018**
PBL	Bretherton et al (2009)	CLUBB
Orographic form drag	Richter et al. (2010) "TMS"	Beljaars et al.2003
GW drag	McFarlane (1987) (non-orographic sources for WACCM)	Anisotropic/Low-level nonlinearities
Shallow Convection	Park et al. (2009)	CLUBB
Deep Convection	Neale et al. (2008)	Neale et al. (2008) Re-tuning
Microphysics	Morrison-Gettelman (2008)	Morrison-Gettelman v2 (2014)
Macrophysics	Park et al. (2011); Zhang et al (2003)	CLUBB
Radiation	Iacono et al. (2008)	Iacono et al. (2008)
Aerosols	Modal Aerosol Model (MAM3, Ghan et al., 2011)	Modal Aerosol Model (MAM4, Liu et al., 2016)

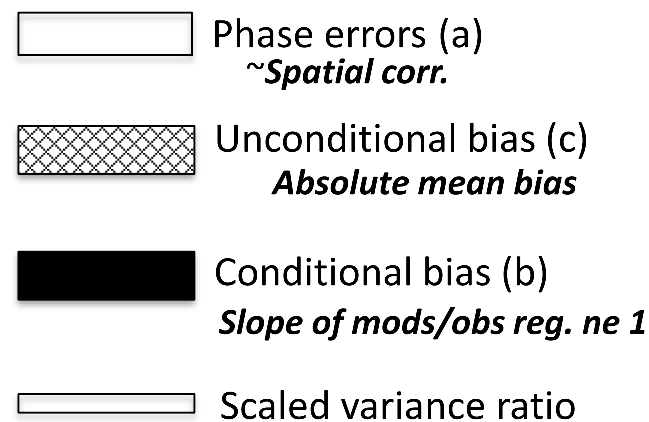
Evolution of Taylor Skill Score



Evolution of ***CESM*** Skill Score*



*Z500 20N-80N metric
(Collins et al. 2006, *J. Clim.*)

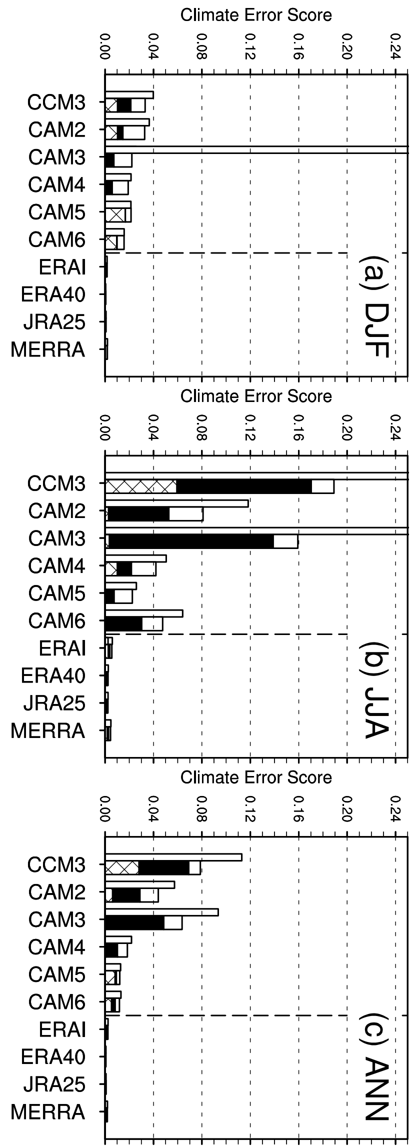


NMSE = (a)+(b)+(c)

- ***General improvement over CESM1***

(Courtesy: Rich Neale)

Evolution of *CAM* Skill Score*



*Z500 20N-80N metric
(Collins et al. 2006, *J. Clim*.)

Phase errors (a)
~Spatial corr.

Unconditional bias (c)
Absolute mean bias

Conditional bias (b)
Slope of mods/obs reg. ne 1

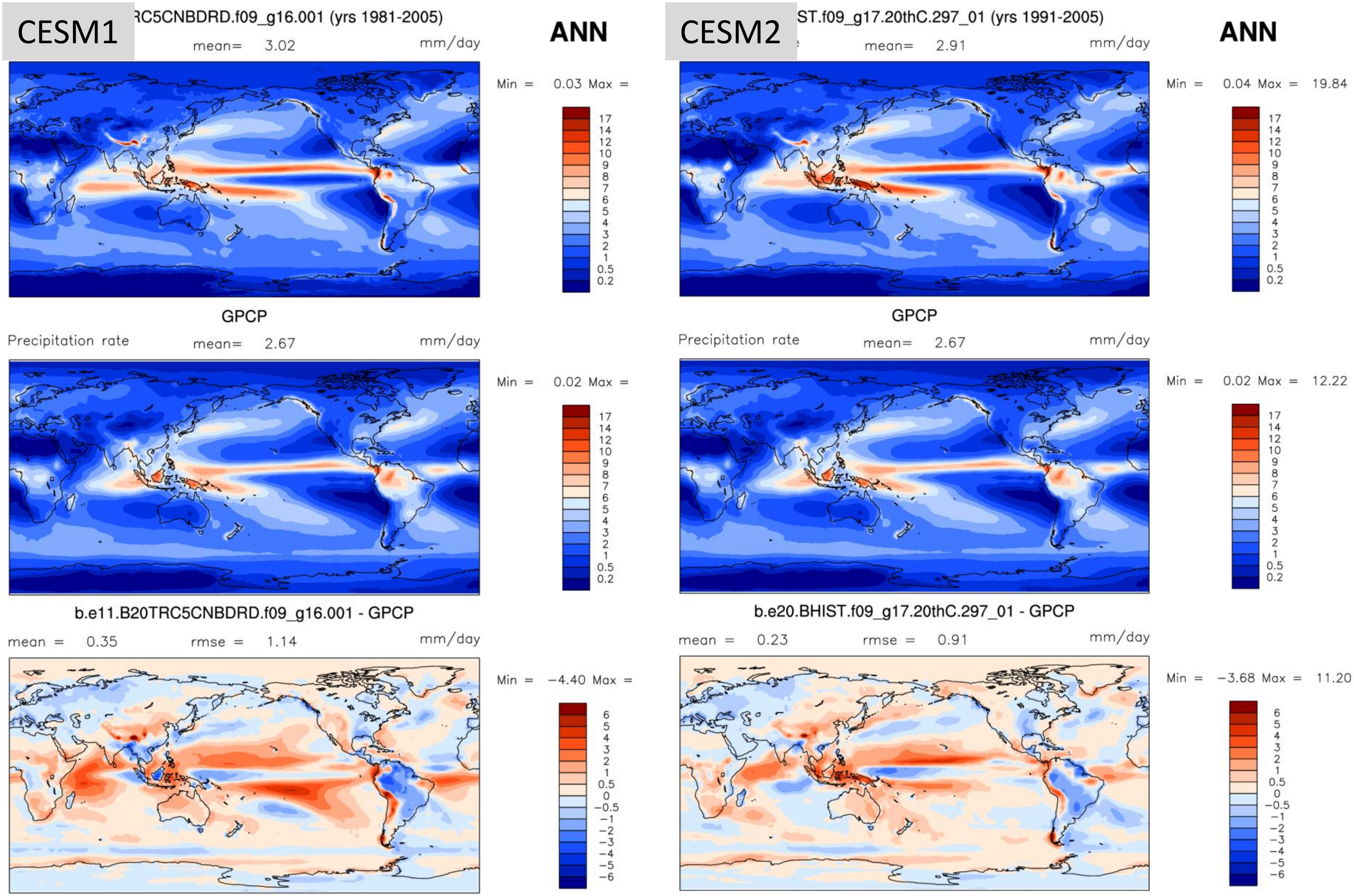
Scaled variance ratio

NMSE = (a)+(b)+(c)

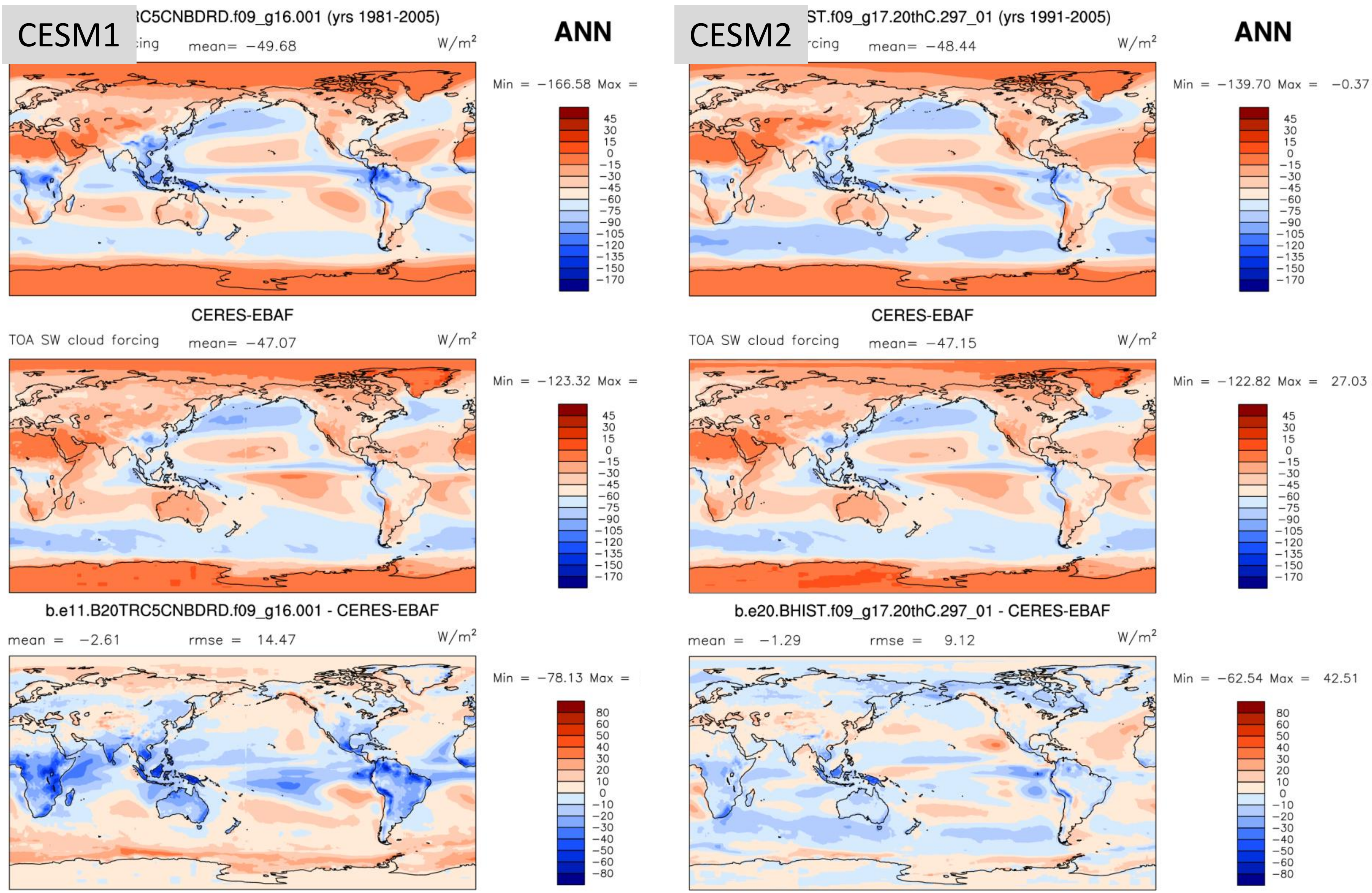
- ***Improvement in Annual, DJF means***
- ***Degradation in JJA (conditional bias, highs and lows over land)***

(Courtesy: Rich Neale)

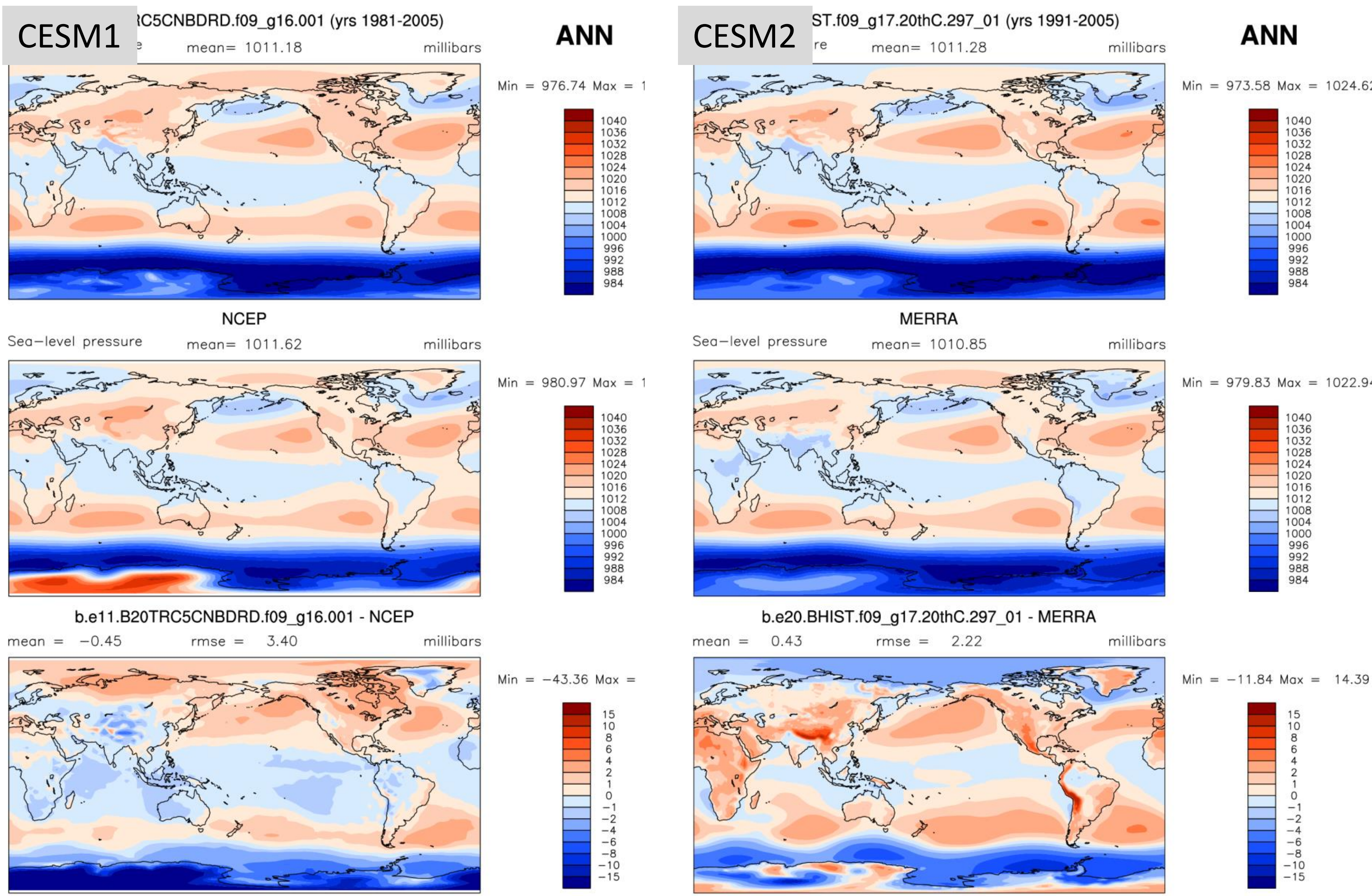
Precipitation simulation



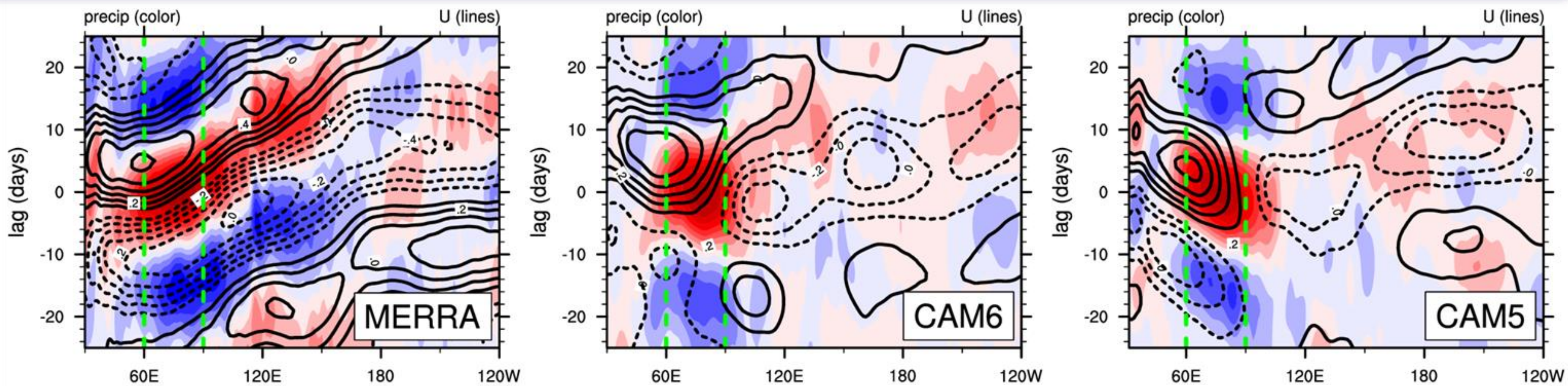
Shortwave cloud forcing



Sea-level pressure

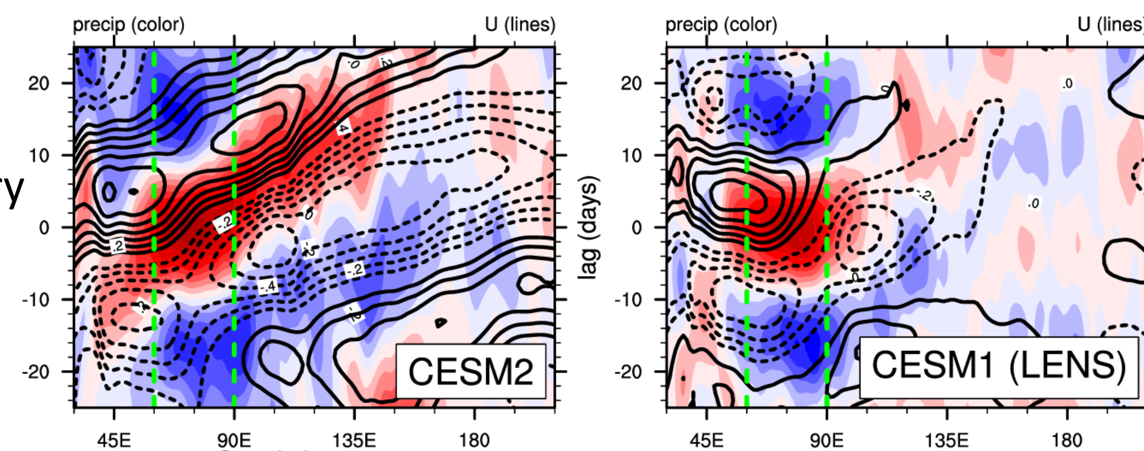


MJO



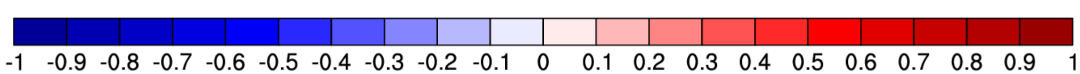
What Happened? – A lot!

- CLUBB (large-scale cloud, shallow convection, boundary layer)
- Deep convective retuning (stability sensitivity)
- Surface orography and drag (Beljaars scheme, GWD)
- Surface models (POP similar but with hourly coupling)



Precipitation

850-mb U



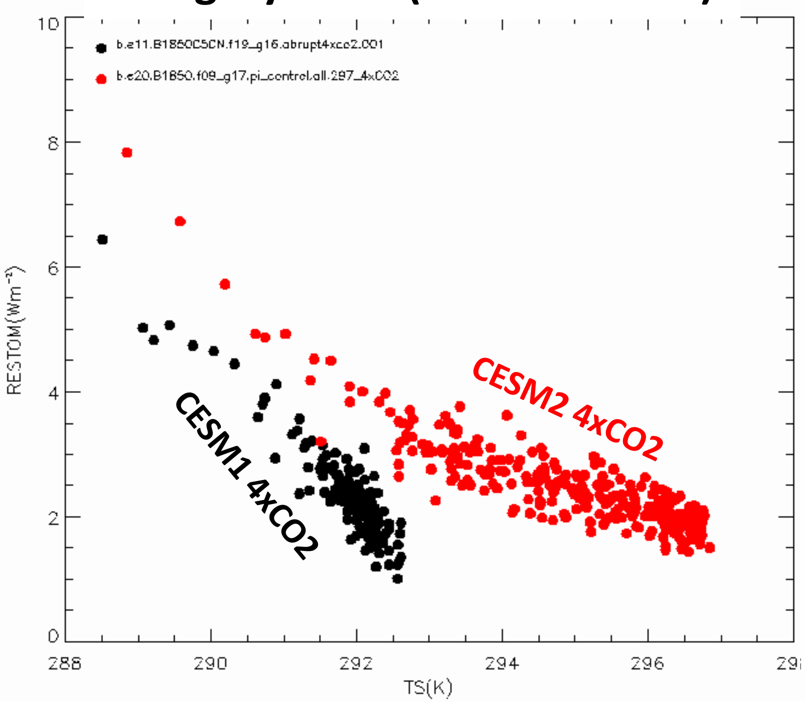
Courtesy *Rich Neale*

Sensitivity, 4x CO2 behavior

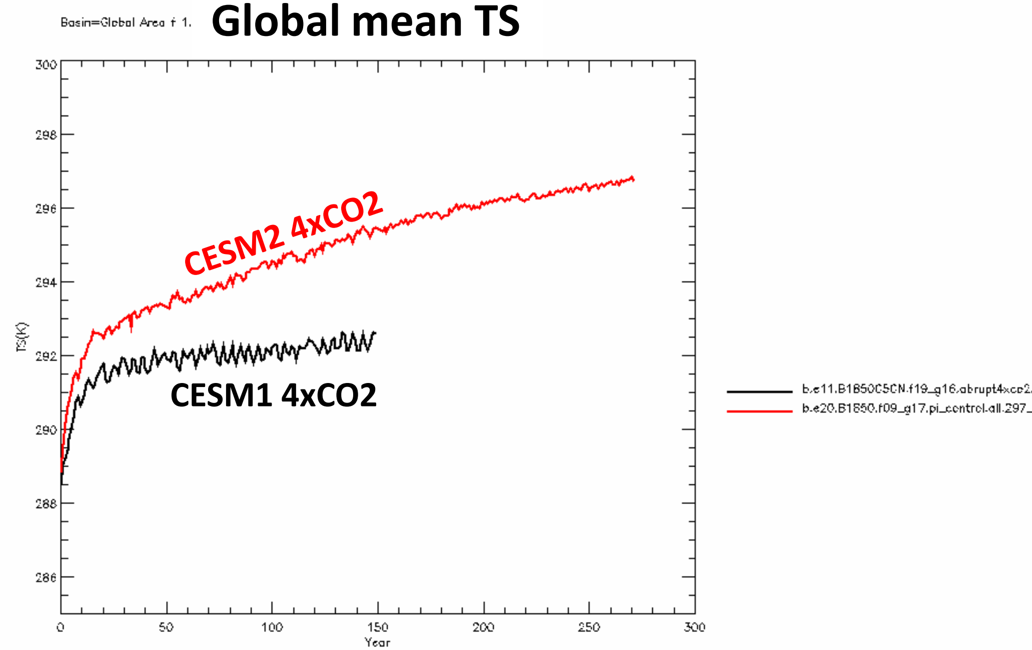
Increased climate sensitivity and Gregory plot nonlinearity

long-term, slow increase in TS

"Gregory Plot" (RESTOM vs TS)



Global mean TS



More on this in next talk by Cecile Hannay and in this afternoon's discussion

CESM1 to CESM2 AMIP investigations

https://docs.google.com/document/d/1WeGsE3vd6P3o_AanA34VgbMUv8OL-FUAo98C9PS-5b8/edit?usp=sharing

Model	CAM5 CESM1.0	CAM6 CESM2
Release	**Jun 2010**	**August 2018**
PBL	Bretherton et al (2009)	CLUBB
Orographic form drag	Richter et al. (2010) "TMS"	Beljaars et al.2003
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Proposed AMIP sensivity runs:

1) Full cam5 swap
2) CLUBB/UW-all
3) MG1/MG2
4) TMS/Beljaars
5) KK2000/SB2001
6) McFarlane/AOGW

Other development

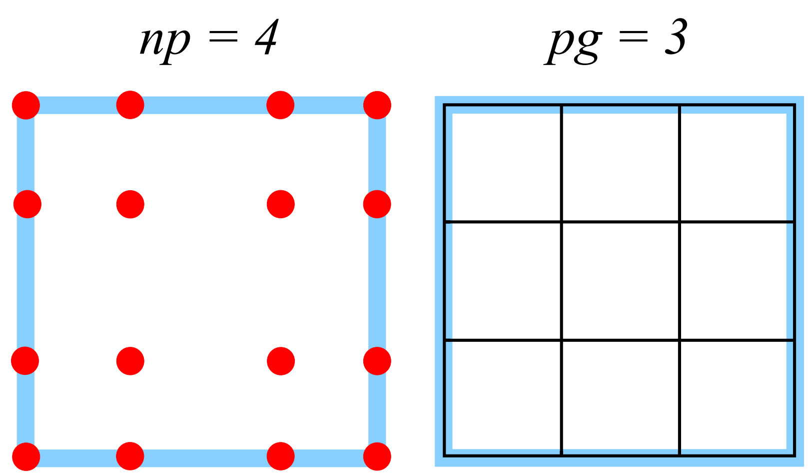
- SE development *(Lauritzen, Herrington, Callaghan)*
  - Dry-mass vertical coordinate (Lauritzen et al. 2018, *JAMES*)
  - Physgrid
  - Regional refinement
- MPAS and FV3 implementation *(Lauritzen, Goldhaber, Truesdale)*
- Aquaplanet/simpler models *(Simpson, Medeiros, Jablonowski, Gettelman, Truesdale, Callaghan)*
  - SCAM
  - Gray radiation
  - Aerosols
  - Simple moist physics
- Nudging/Specified dynamics *(Bardeen, Callaghan)*
- S2S forecasting *(Richter, Berner, Caron, Tribbia)*

Other development (cont.)

- 2-degree version of CESM2 *(Garcia, Otto-Bliessner, Mills, Gettelman, Neale, Bacmeister)*

Introducing an ~equal area physics grid*

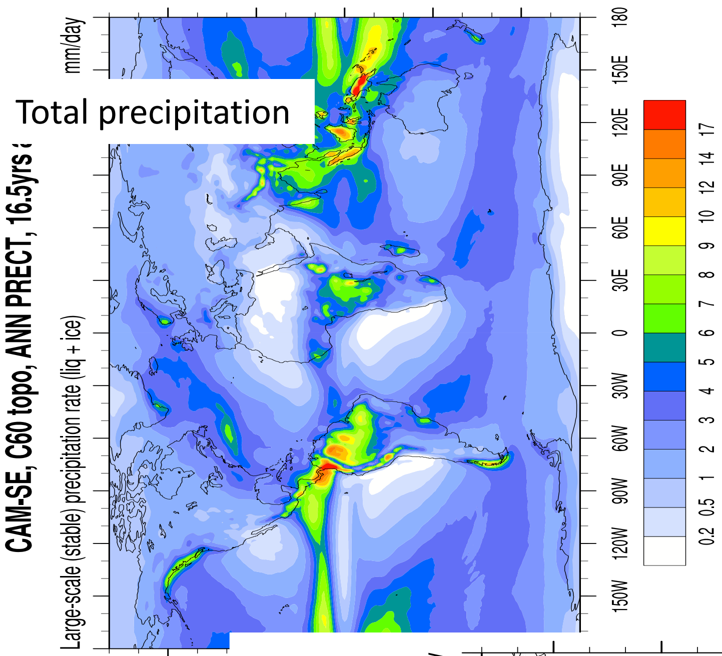
Lauritzen, Herrington …



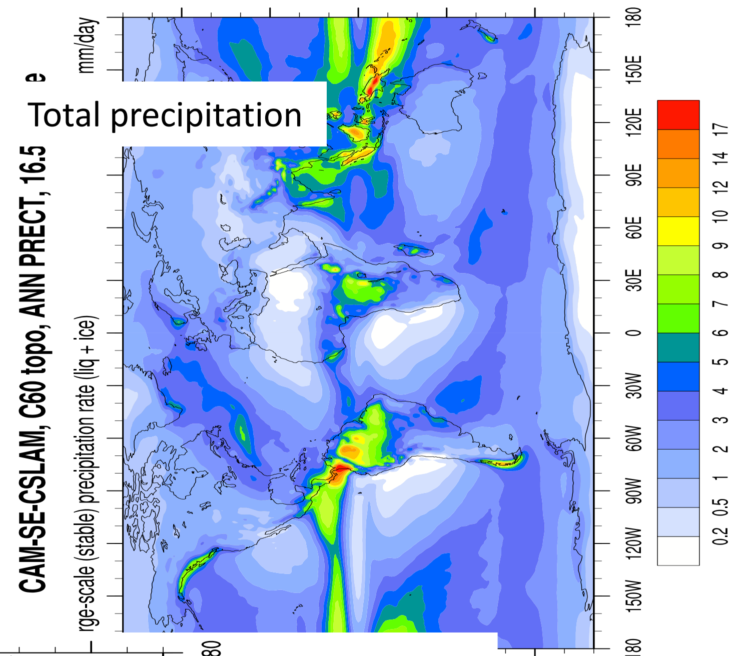
*Herrington, A. R. et al., 2019:** Physics–Dynamics Coupling with Element-Based High-Order Galerkin Methods: Quasi-Equal-Area Physics Grid. *Mon. Wea. Rev.,* 147, 69–84, https://doi.org/10.1175/MWR-D-18-0136.1)

Courtesy *Peter Lauritzen*

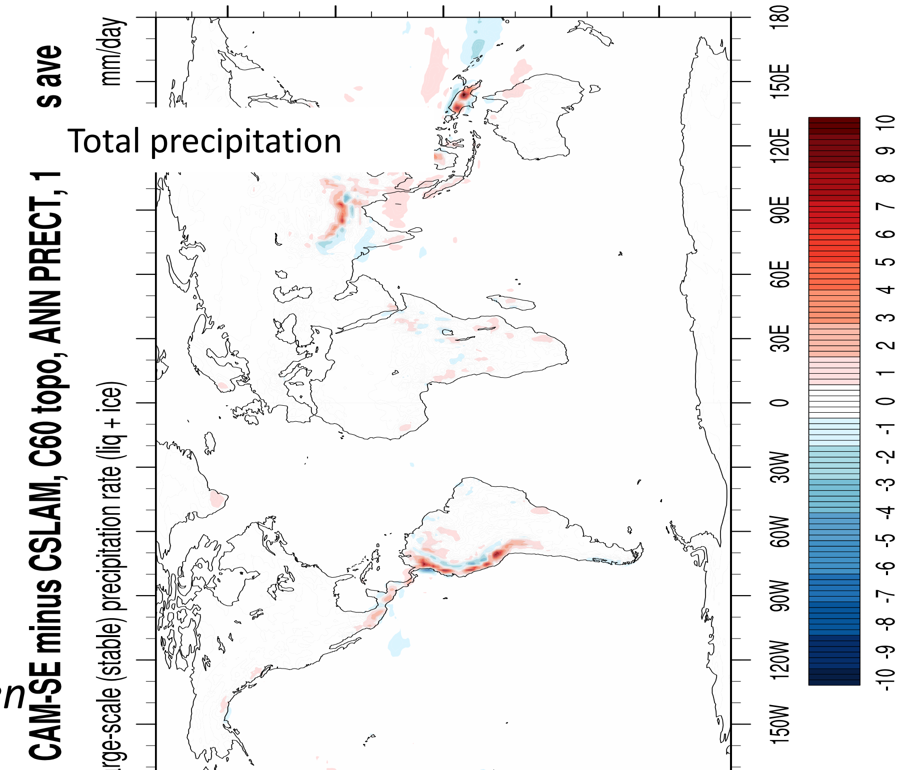
Total precipitation



Total precipitation



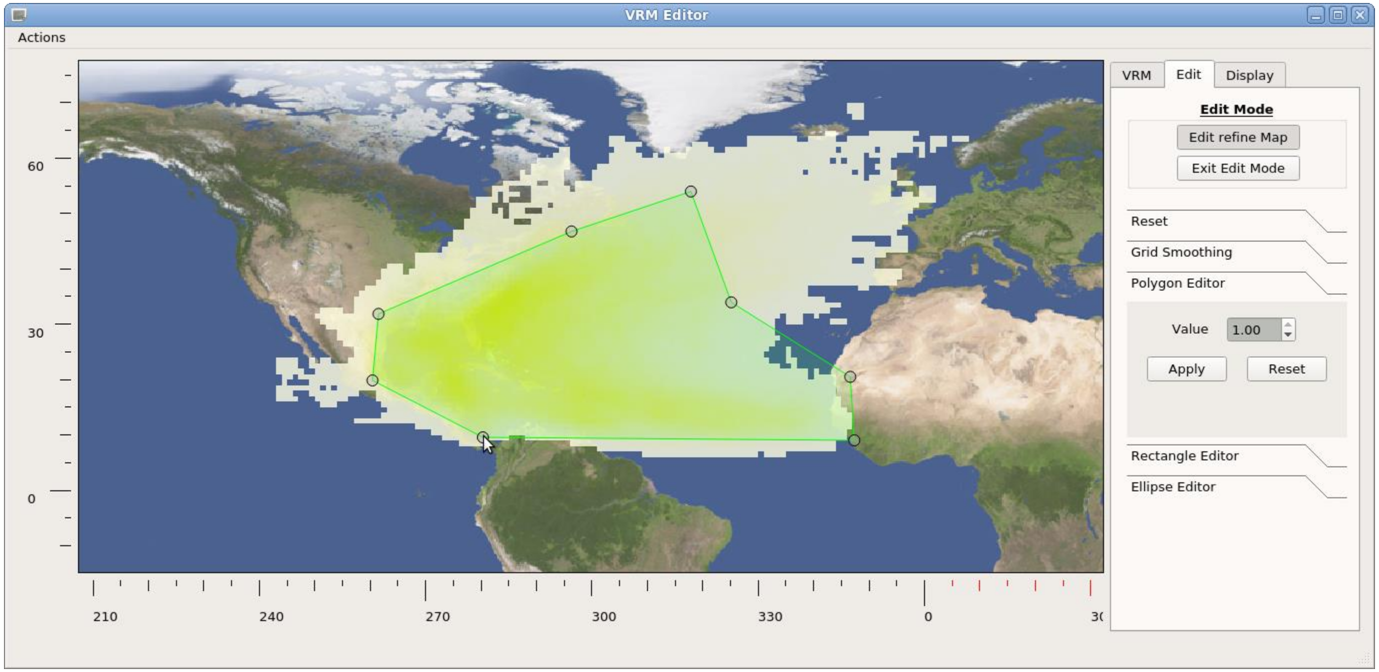
Total precipitation



Courtesy *Peter Lauritzen*

Regional refinement toolchain. P. Callaghan, C. Zarzycki, S. Goldhaber

VRM_Editor Usage Example: Refinement region for Atlantic Hurricanes



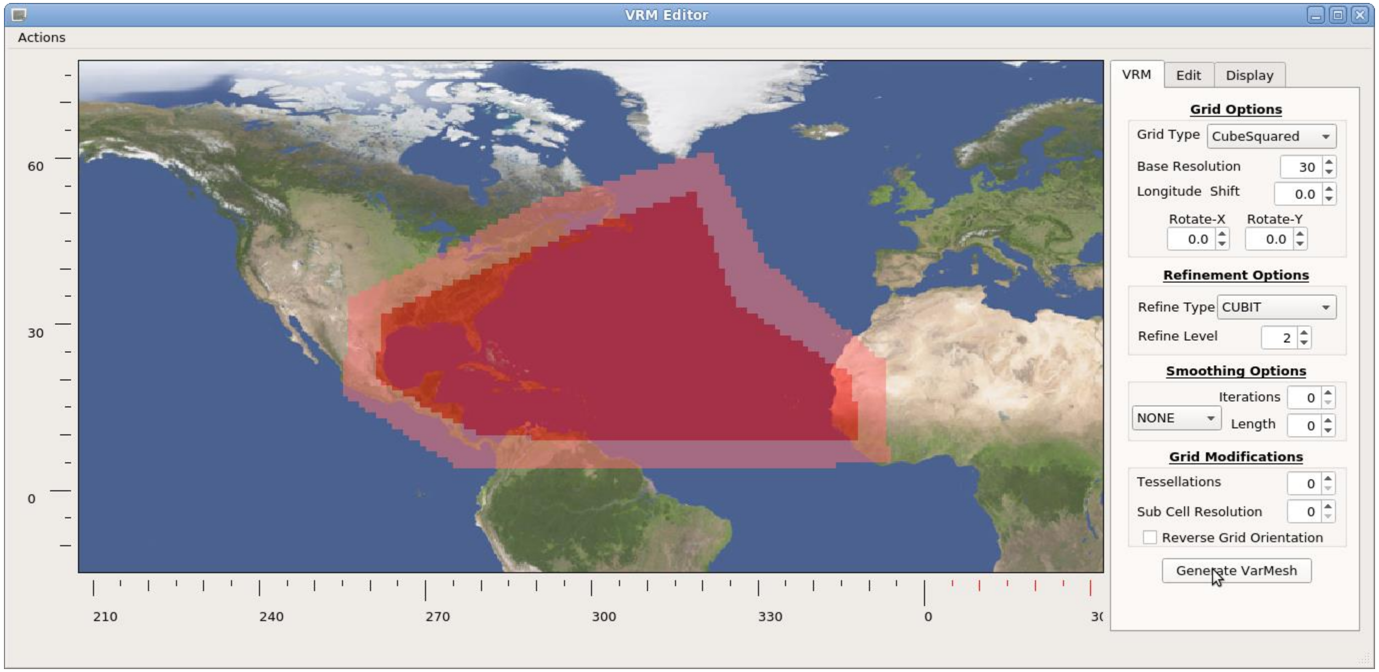
Create a Variable Resolution Grid

- There are editor options for and ellipse, a rectangle, and a general polygon.
- Use the polygon to map out a region encompassing the region.

Courtesy *Patrick Callaghan*

Regional refinement toolchain. P. Callaghan, C. Zarzycki, S. Goldhaber

VRM_Editor Usage Example: Refinement region for Atlantic Hurricanes



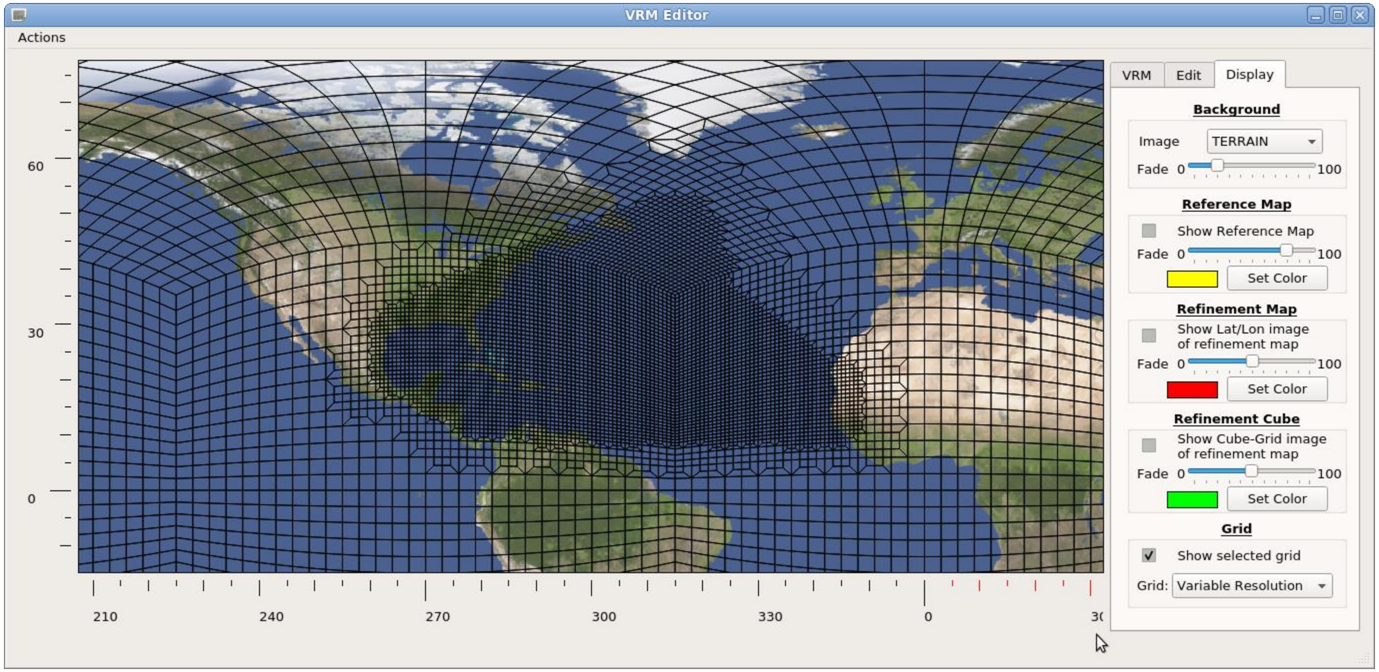
Create a Variable Resolution Grid

- On the VRM tab, set the base resolution to ne30, and set the refinement level to 2
- This will generate a ne30 grid with a refinement region of ne120.

Courtesy *Patrick Callaghan*

Regional refinement toolchain. P. Callaghan, C. Zarzycki, S. Goldhaber

VRM_Editor Usage Example: Refinement region for Atlantic Hurricanes



Create a Variable Resolution Grid

- Switch off the refinement map to view the grid alone.
- Note that if desired, the discrete refinement level values can be viewed in green by switch on the refinement cube display. (skip that for now).

Courtesy *Patrick Callaghan*

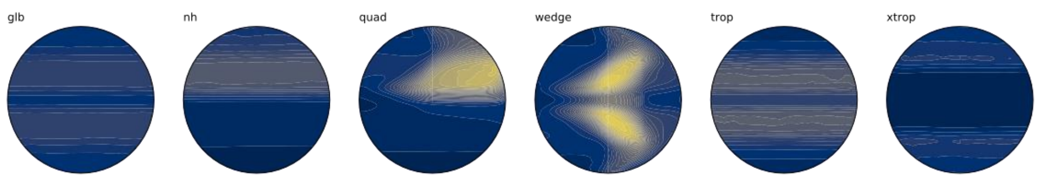
New aquaplanet compsets for aerosol studies. Brian Medeiros

Effective Radiative Forcing [W m^{-2}] w.r.t. only salt emission

-11.8	-8.3	-4.5	-5.8	-10.8	-7.7

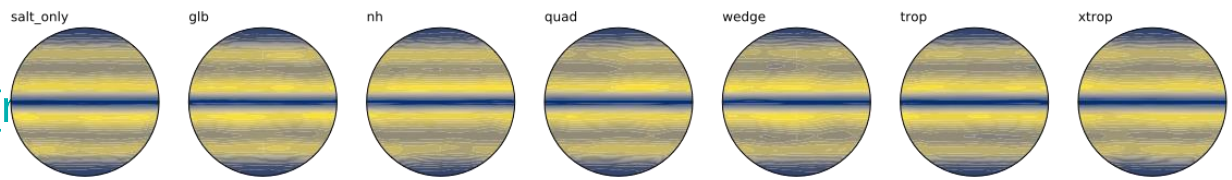
Same surface area of emissions, but different ERF

Sulfate burden [mg m^{-2}]



All have identical global average emissions.

Sea-salt burden [



Diagnostic salt only | global uniform | northern hemisphere | NH quadrant | wedge | tropics | extratropics

Courtesy *Brian Medeiros*

Future Directions

Dycore development

- SE in CESM is very mature and ready to go now
- MPAS, FV3 still need work
- How will we evaluate?
  - All dycores can produce good climate simulations. Any differences obtained in a “bake-off” likely the result of lucky tuning
  - Other considerations: speed, flexible regional refinement, deep atmosphere …
- Why can’t we support 3 dycores longer term - SE, MPAS, FV3? Scientific vs infrastructure support?

More in this afternoon’s discussion

Questions related to Future Directions

What is this model for?

1) Cutting edge US climate model? … S2S forecast model?
2) Easily built, economical Community model?

If 1), is more complexity, and increased resolution in both horizontal and vertical inevitable?

Who is our community and how do they use CAM and CESM? How can we find out?

Is a "cloud" version of CESM/CAM/SCAM useful?

This meeting

Is the current format, i.e., ~ 85% talks + 15% open discussion the most useful?

Tutorial/Workshop, June 2019

Tutorial and Workshop: Future Physics for Global Atmospheric Models
June 10-14, 2019
National Center for Atmospheric Research, Boulder, CO, USA
http://www.cgd.ucar.edu/events/2019/camtutorial/

Expressions of interest requested. Online application/registration form available soon.

Thank you

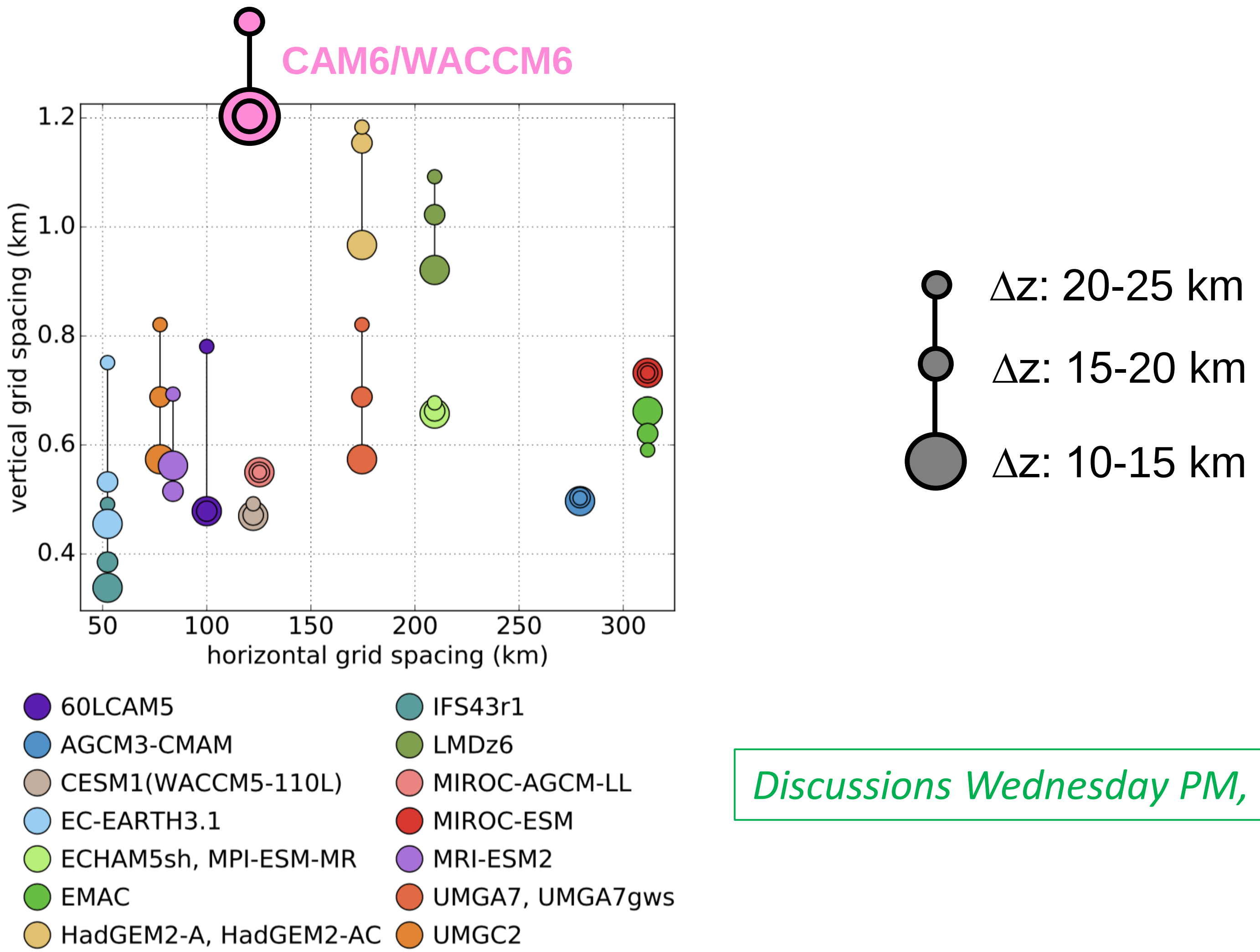
Extra Slides

WACCM-CAM Unification

- WACCM/CAM distinction has blurred (e.g. FHIST vs FW{sc}HIST)
  - Increased vertical resolution compset?
  - One, two or three vertical grids? How much support for each?

WACCM-CAM Unification

Vertical resolution



Adapted from Butchart et al. 2018, GMD

Discussions Wednesday PM, Thursday AM

Physics development

- CLUBB is a unified PBL/ShCu/Macrophysics scheme. How will further development proceed in CAM?
  - Only unified approaches considered from here on?
  - CAM5.x "alternate development platform"?
  - Development of CLUBB itself
    - New LES sims?
    - Developer access to CLUBB code?
  - Infrastructure for parallel physics calls (e.g. Grabowski) - passive and active? Regime dependent?
- MMM suites, NOAA GFS physics
- Other physics – microphysics, deep convection, drag, ***RTE+RRTMGP (Pincus&Mlawer)*** …
- *Infrastructure – Common Physics Driver*

Discussions Wednesday

Dynamical cores

- SE benchmark (idealized tests)
  - MPAS, FV3
  - Strat Plan, air/sea coupling

Discussions this afternoon

Development Methods

- Forecasts (CAPT)
- Assimilation
- Nudging
- Single-column configuration
- Simple models

Applications

- N-day/subseasonal/seasonal forecasting – to climate
- *Unified atmosphere modeling at NCAR - "Singletrack"*

Discussion Tuesday PM – Andrew Gettelman

“Usability”

- Is the model difficult to use?
- How can we make it easier?

Background/Timeline

- Challenges faced during development
  - Labrador Sea freezing
  - Cooling 20thC w/ CMIP6 aerosol forcing
  - Labrador Sea freezing again