Results from CAM-SE
AMIP and coupled simulations

Cécile Hannay (AMP)

Rich Neale, Peter Lauritzen, Mark Taylor,

Julio Bacmeister, Joe Tribbia, Sungsu Park,

Andy Mai, Gokhan Danabasoglu, and many others.

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Andy Mai, Adam Phillips, Mariana Vertenstein, Gokhan Danabasoglu,
Sam Levis, Dave Bailey, Keith Olesson, and Jack Chen.

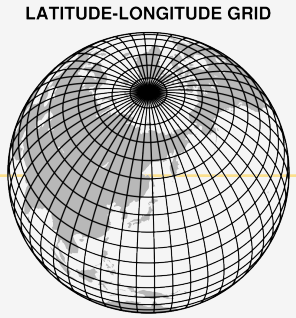
Outline

- What's new in the CAM5 family ?
- AMIP simulations
- Coupled simulations
- A few words about timing

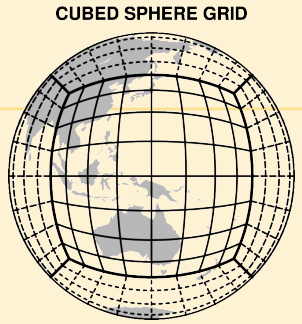
The CAM5 family

Version	Release	Description
CAM5 (CESM1.0)	June 2010	Physics: New set of parameterizations in CAM (representation of aerosol indirect effect) Dynamics: Finite Volume dycore (CAM-FV)
CAM5.1 (CESM1.0.3)	June 2011	Minor changes in the physics Bug fix + tuning improvements Used for CMIP5 runs
CAM5.2 (CESM1.1)	Nov 2012	Dynamics: Spectral element dycore (CAM-SE) Improves scalability of CAM (no polar filter)
CAM5.3 (CESM1.2.0)	June 2013	New vertical advective scheme (Lagrangian) Options: - Prescribed MAM aerosols - MG1.5 microphysics

"CAM-FV"



"CAM-SE"



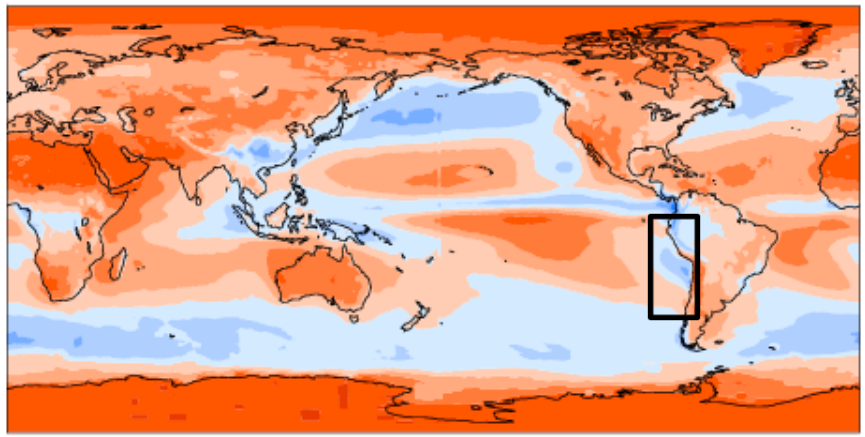
"CAM-FV" means CAM with the Finite Volume dycore
"CAM-SE" means CAM with the Spectral Element dycore
Resolution: CAM-FV (1 degree) ⇔ CAM-SE (ne30)

Why do we need CAM5.3 ?

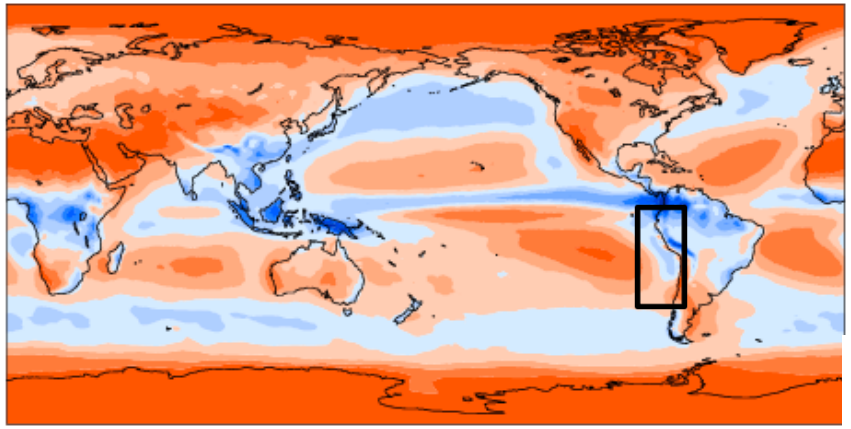
CAM5.2: Stratocumulus are degraded with SE dycore

SWCF (W/m2)

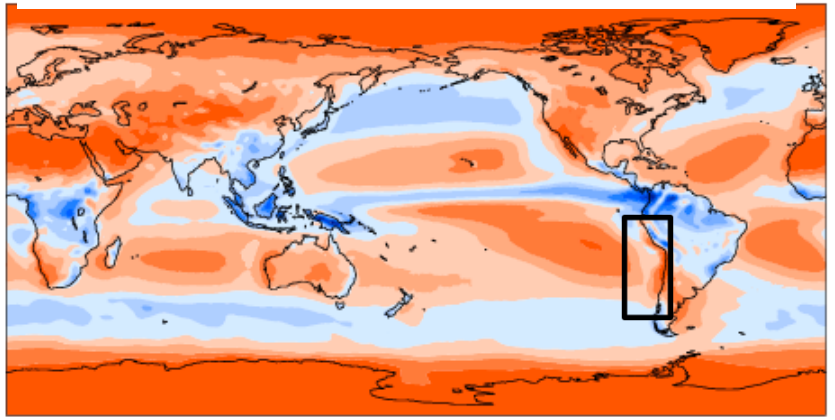
CERES-EBAF
mean = -47.1 W/m^2

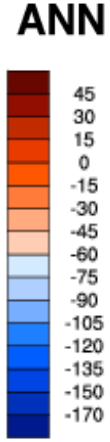


CAM-FV
mean = -48.9 W/m^2



CAM-SE
mean = -47.7 W/m^2





Vertical transport in CAM-SE

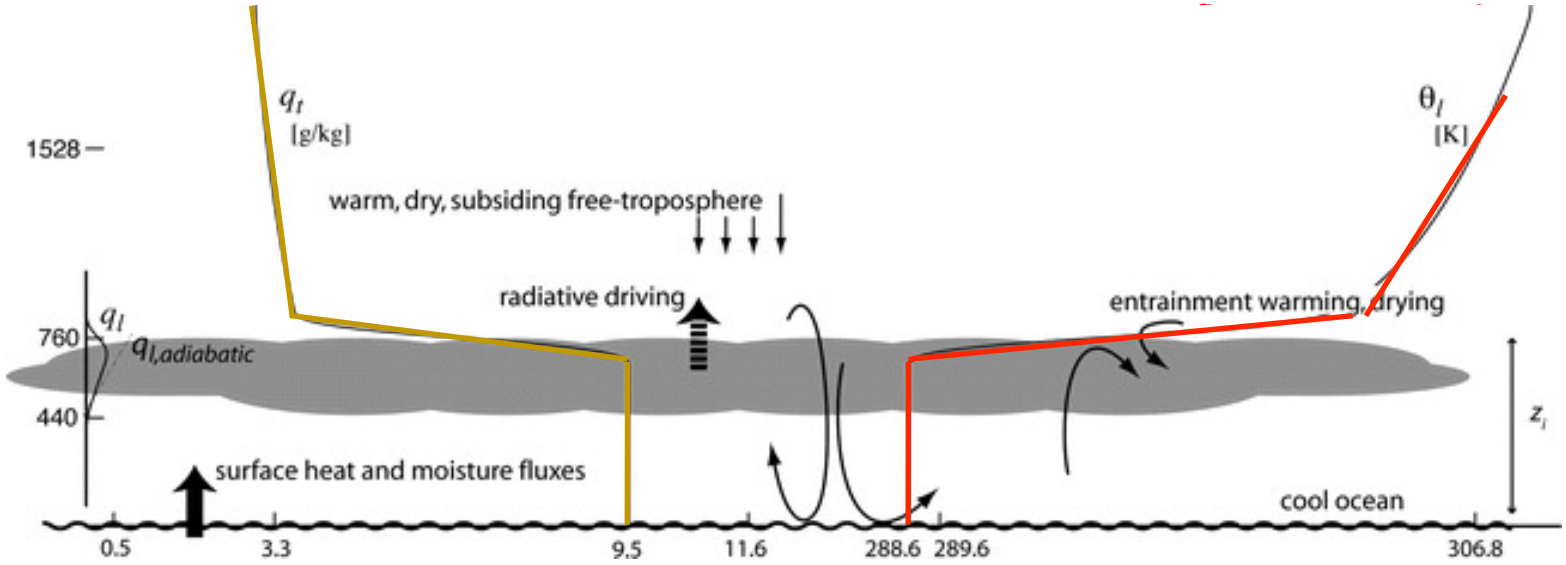
CAM-SE

Vertical advection of tracers (q, …)
(Lagrangian method)

Vertical advection of T

CAM5.2 → ~~(Eulerian method)~~

CAM5.3 → (Lagrangian method)



Processes maintaining stratocumulus deck

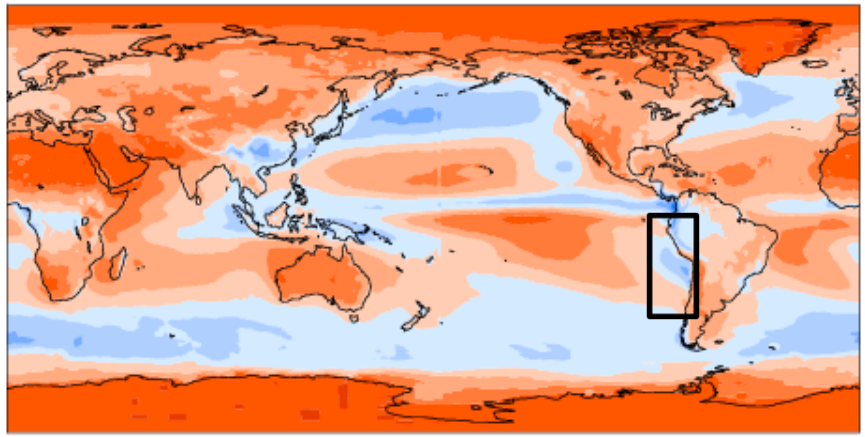
Lagrangian code improves stratocumulus deck

Stratocumulus in CAM5.3

SWCF (W/m2)

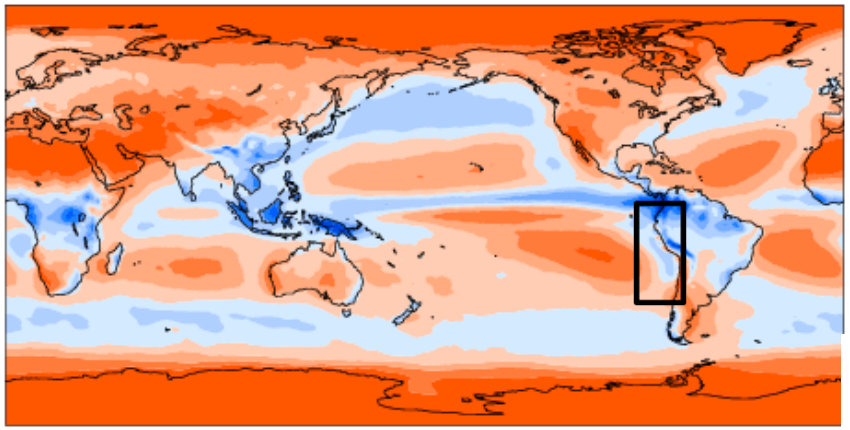
CERES-EBAF

mean = -47.1 W/m^2



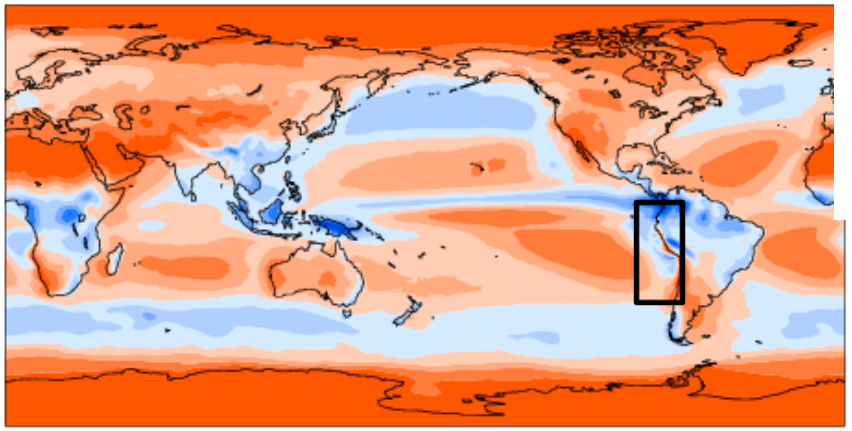
CAM-FV

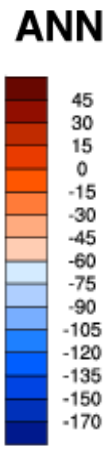
mean = -48.9 W/m^2



CAM-SE + Lagrangian code

mean = -48.1 W/m^2





CAM5.3: released last week !

Changes in CAM5.3 (for reference)

Dynamics

- Use floating Lagrangian vertical coordinate also for non-mass variables (T,u,v).
- Change vertical remapping algorithm

  Piecewise Spline Method (PSM) is replaced by Piecewise Parabolic Method (PPM)
  PPM is also used used in CAM-FV and is courtesy of Matt Norman (ORNL, Oakridge)
  => significant speed up of vertical remapping.
  (CPU and GPU version of cam are the same)
- Shape-preserving filters on vertical remapping of velocity components
- Energy-fixer turned on
- Remap T instead of total energy
- Bugfix in hyperviscosity code (important only for variable resolution grids)

Physics

- Prescribed MAM aerosol (PNNL) as an "option"
- MG1.5 microphysics as an "option"
- Reduced size history files (namelist flags for extra output)

Slide: courtesy of Peter Lauritzen

Outline

- What's new in the CAM5 family ?

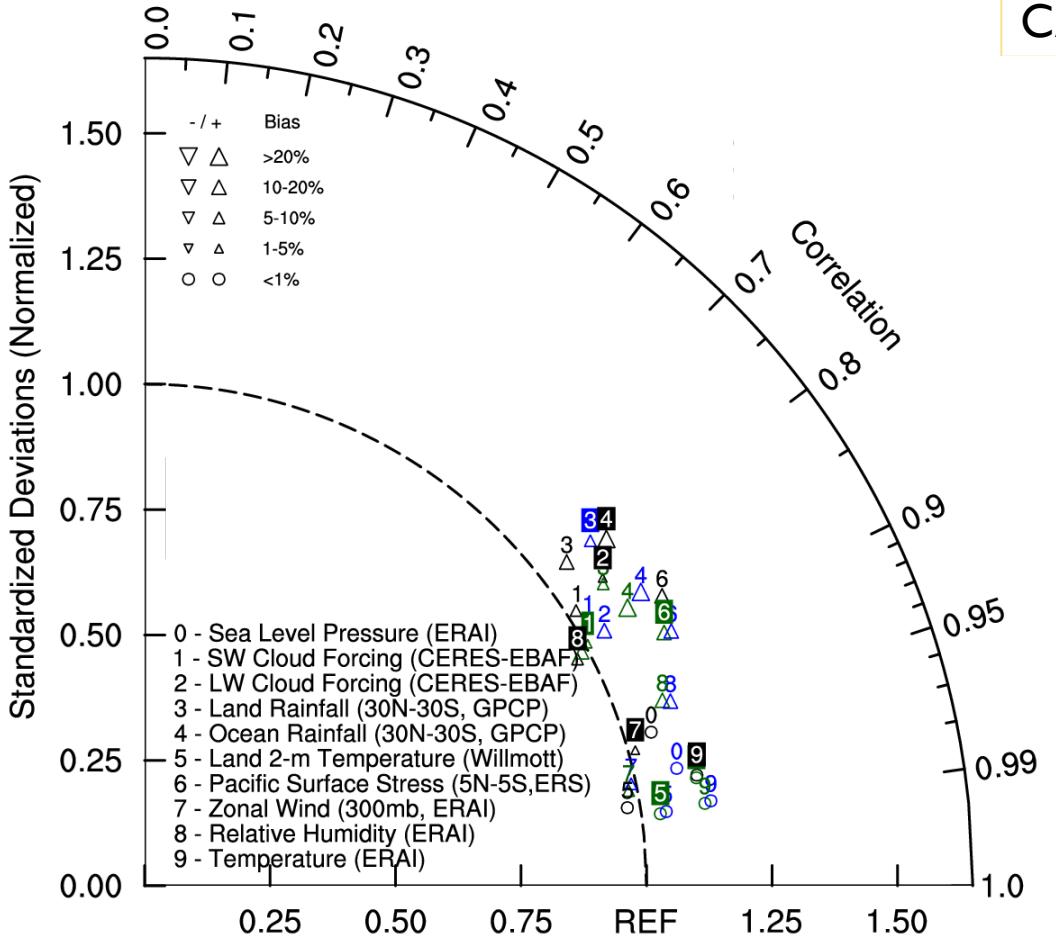
- **AMIP simulations** CAM-FV ⇔ CAM-SE
  (50 years) (50 years)

- Coupled simulations

- A few words about timing

AMIP runs: Taylor diagram

	RMSE	Bias
CAM-FV	0.88	1.21
CAM-SE	0.83	1.19



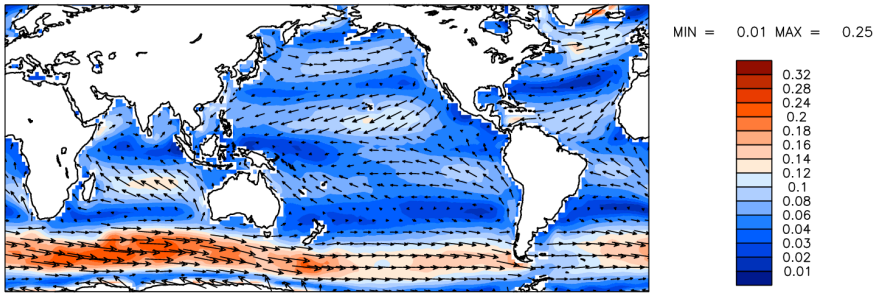
CAM-SE is competitive with CAM-FV

- CCSM3.5
- CAM-FV (1deg)
- CAM-SE (ne30)

AMIP runs: Surface stress

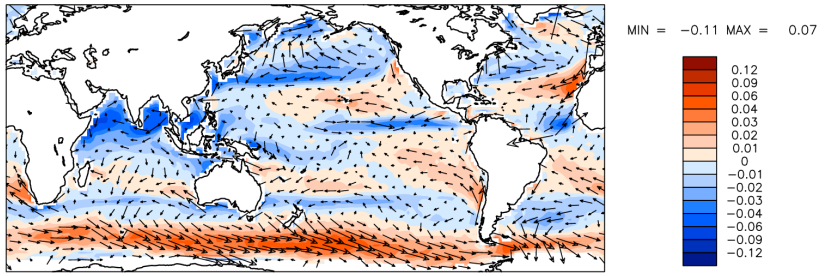
Observed surface stress

Large-Yeager (2009)

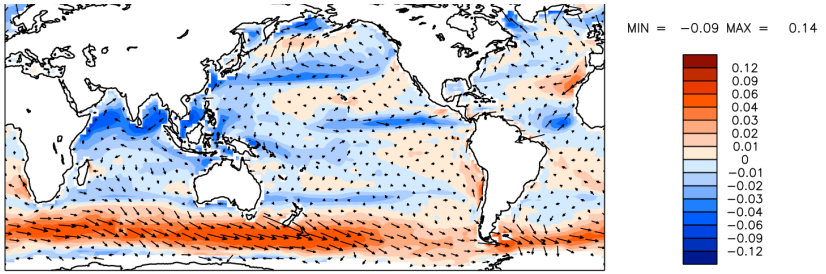


Surface stress errors

CAM-FV - Obs



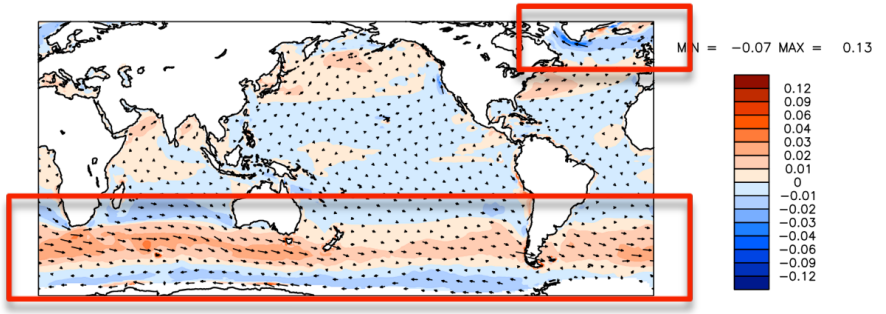
CAM-SE - Obs



Significant differences in surface stress
- Southern oceans
- Close to Greenland

Surface stress differences

CAM-SE – CAM-FV



Outline

- What's new in the CAM5 family ?

- AMIP simulations

- **Coupled simulations** **1850 control runs**

  CESM1.2.0 (CAM-SE) ⇔ CESM1.1.1 (CAM-FV)

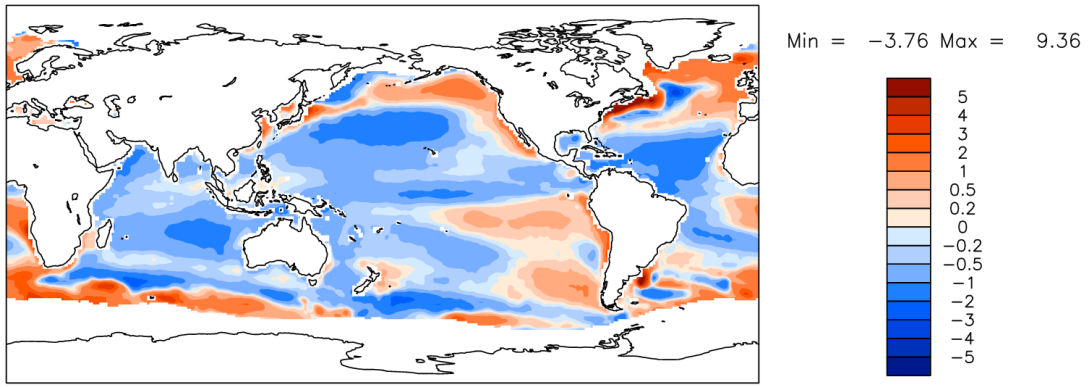
  (90 years) (400+ years)
  "Large-ensemble"

- A few words about timing

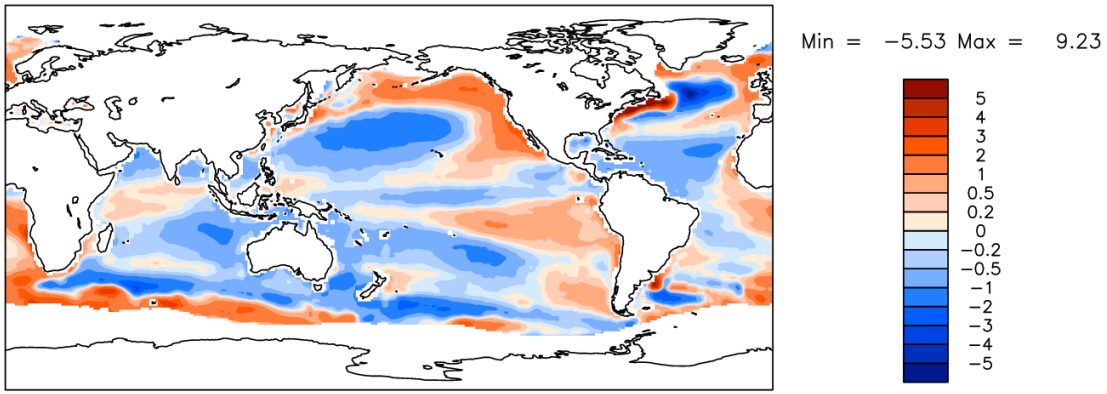
Temperature biases

Model – HadISST (Hurrell, 2008)

CESM1.1.1 (CAM-FV)
mean = -0.18 K
RMSE = 0.90 K



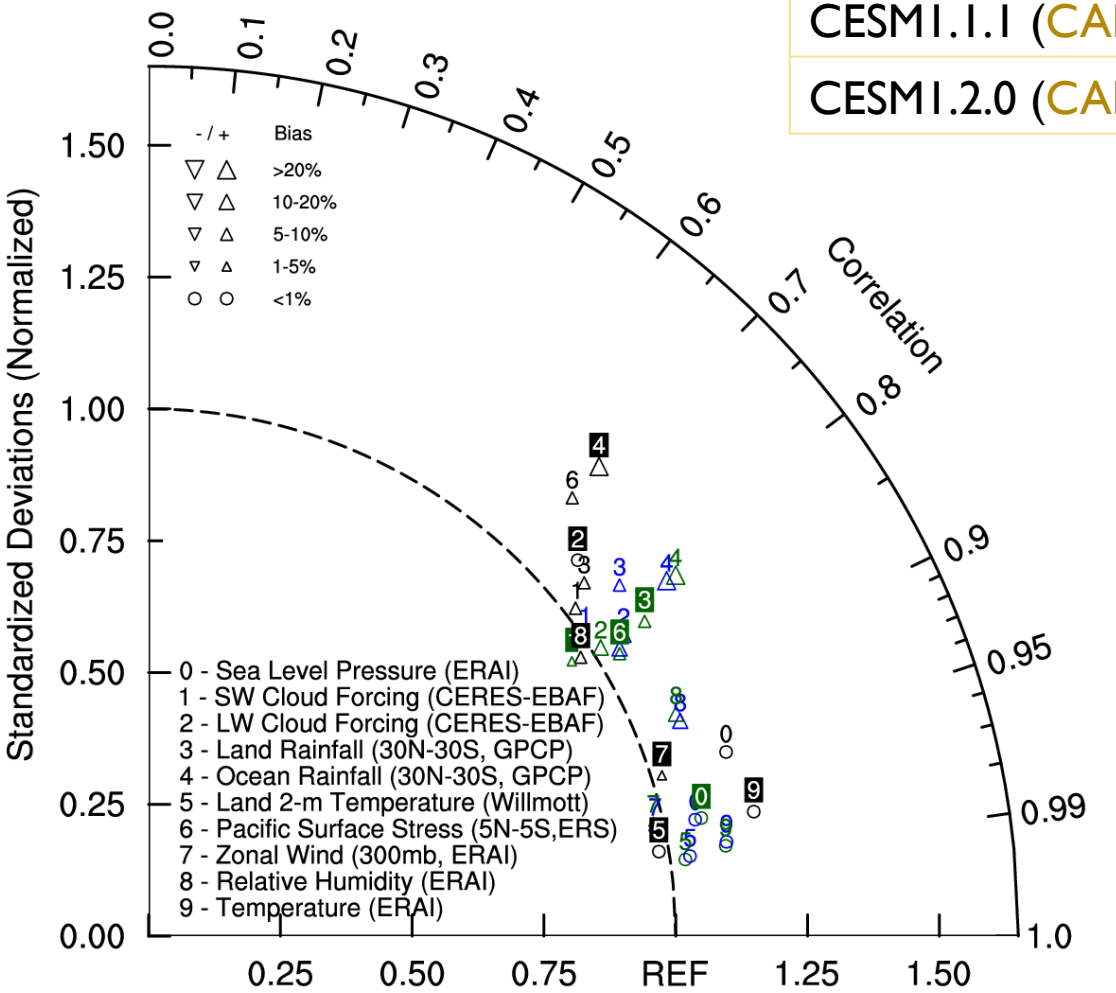
CESM1.2.1 (CAM-SE)
mean = -0.07K
RMSE = 0.88 K



Overall: similar bias pattern

Coupled run: Taylor diagram

	RMSE	Bias
CCSM4 (CAM4-FV)	0.88	0.78
CESM1.1.1 (CAM5-FV)	0.79	1.51
CESM1.2.0 (CAM5-SE)	0.76	1.37



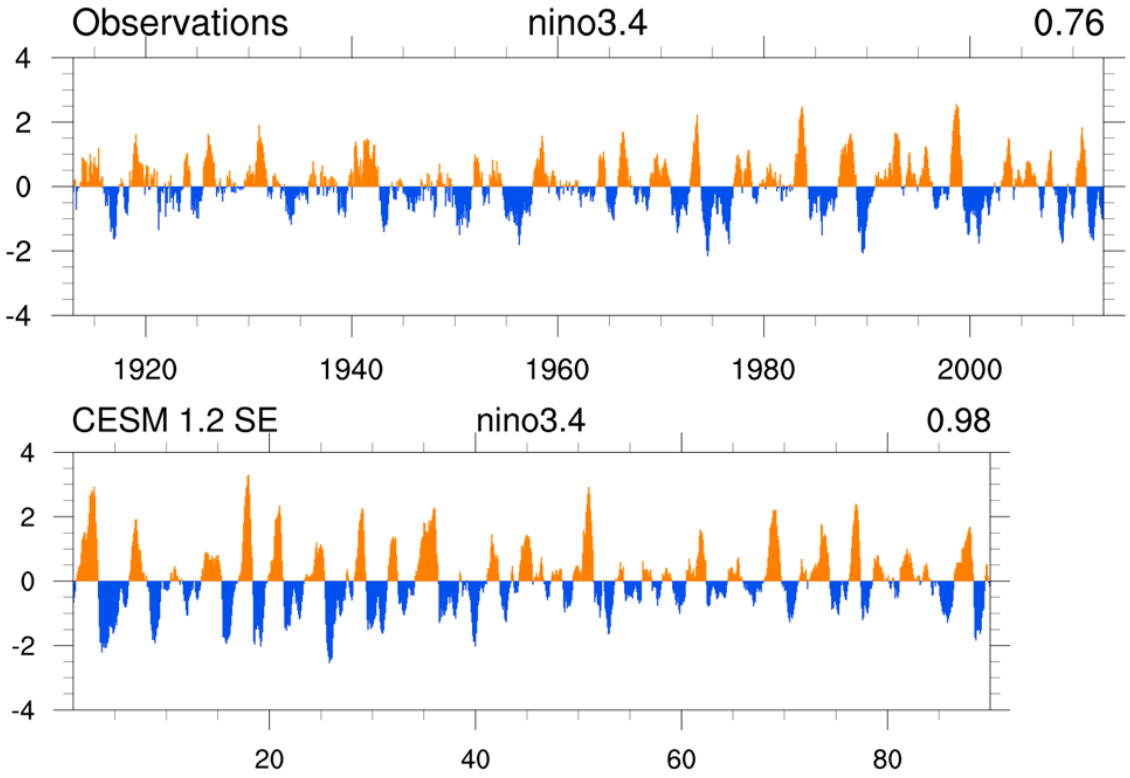
CAM-SE is competitive with CAM-FV

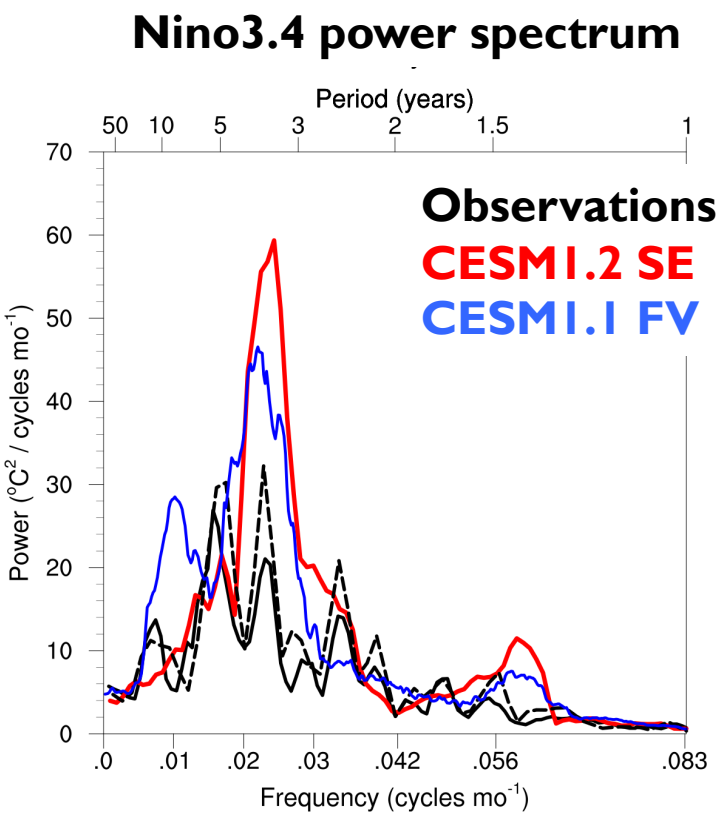
- Reference = CCSM3.5
- CESM1.1.1 (CAM-FV)
- CESM1.2.1 (CAM-SE)

Nino3.4 SST variability

CESM1.2.0 (CAM-SE)
- Realistic 3-6 yr ENSO period
- overestimates ENSO amplitude

Caveat: only 90-year simulation





Courtesy: Adam Phillips

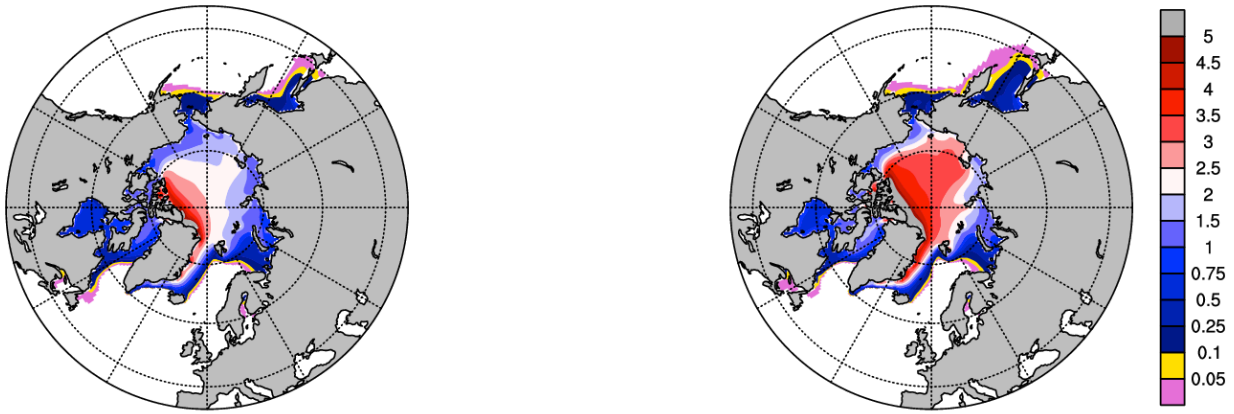
Arctic Sea-Ice

Ice thickness and extent are reduced in CAM-SE
Consistent with warmer sea-ice in CAM-SE.
This might be an issue in 20th century run.

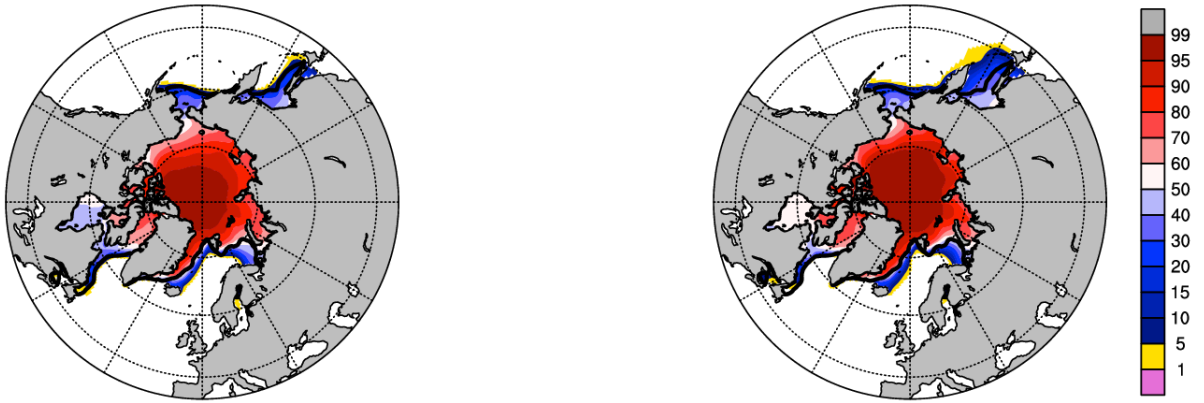
CAM-SE

CAM-FV

Sea-ice thickness



Sea-ice concentration

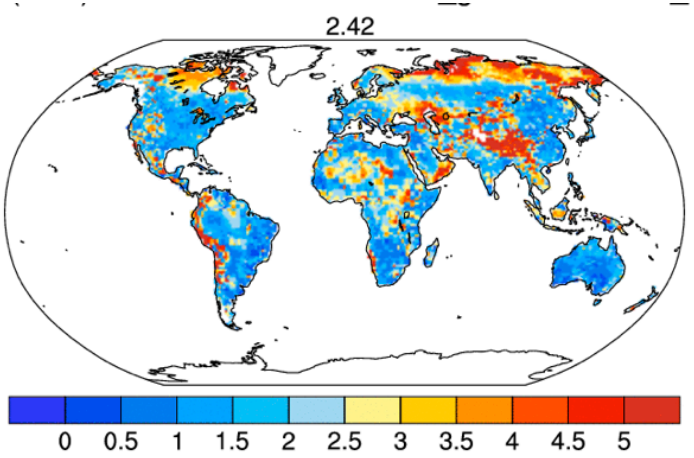


Land mean climate

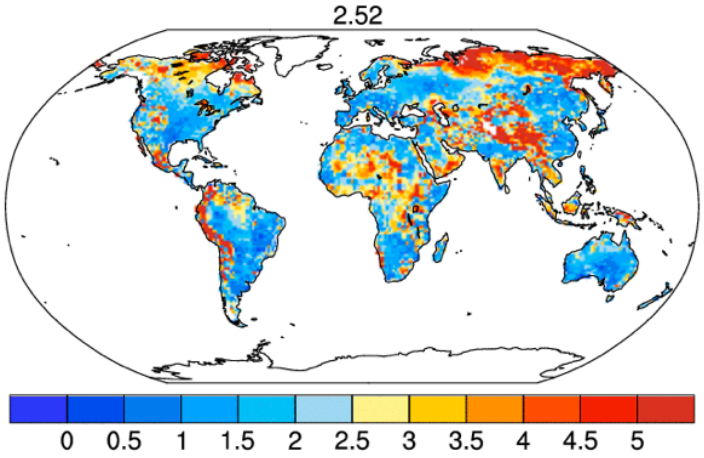
Land diagnostics: overall, CAM-SE is competitive with CAM-FV

RMSE of 2-meter air temperature (TSA)

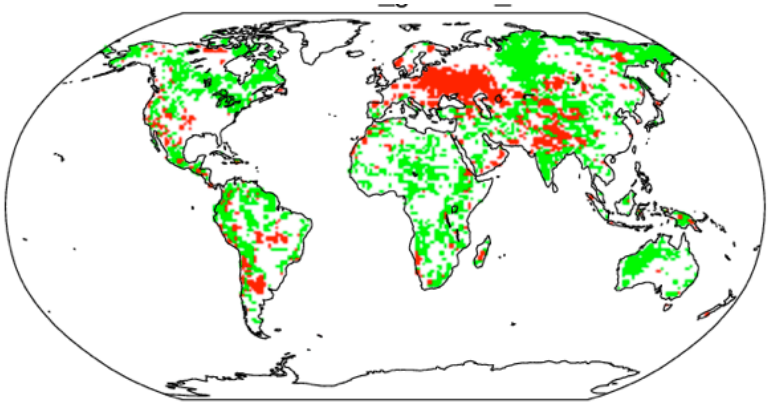
CAM-SE



CAM-FV



Model relative to obs



green means CAM-SE is better

red means CAM-FV is better

Ocean Meridional Overtuning Circulation (MOC)

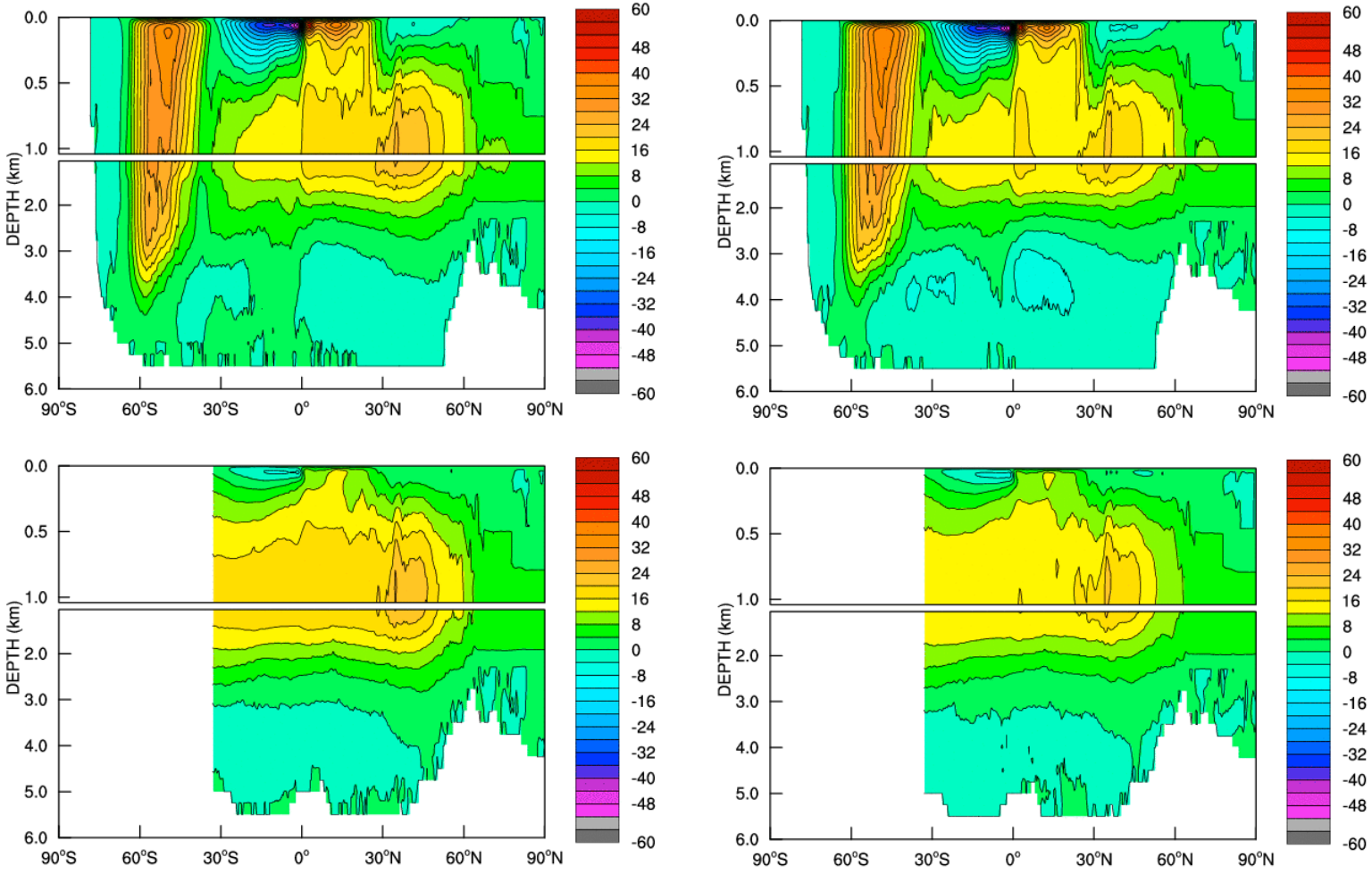
MOC is weaker in CAM-SE (caveat: short run)

CAM-FV

CAM-SE

Global MOC

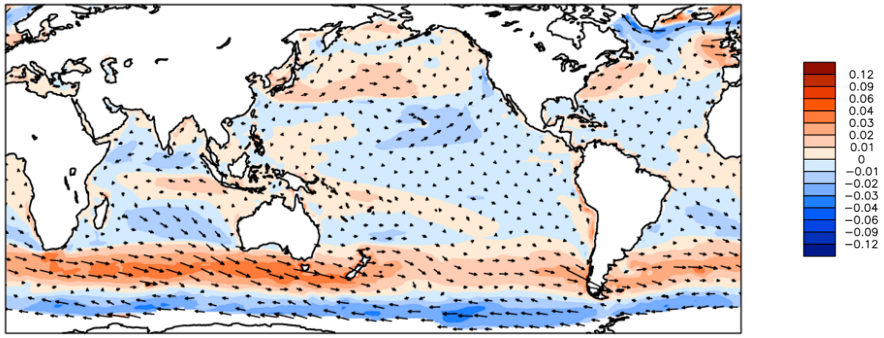
Atlantic MOC



Outstanding questions in the coupled simulation

- Coupled simulation is not scientifically validated yet
  We need longer integrations to validate CAM-SE in coupled mode

Surface wind stress: CAM-SE - CAM-FV

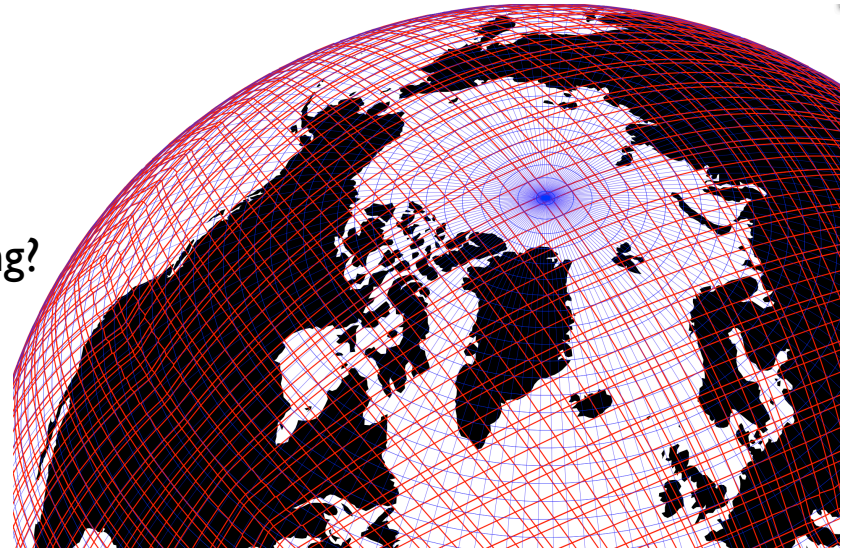


- Surface stress is significantly different
  in CAM-FV and CAM-SE
  What is the impact on the coupled run ?

- Sensitivity to initial condition (ocean) with CAM-SE ?
  Start from: spunup ocean ⇔ Levitus

- Grid differences at high latitudes
  What's the impact on physics and remapping?

Red: CAM-SE grid
Blue: CAM-FV grid
(at about 2 degree)



Plot: courtesy of Peter Lauritzen

Outline

- What's new in the CAM5 family ?
- AMIP simulations
- Coupled simulations
- **A few words about timing**

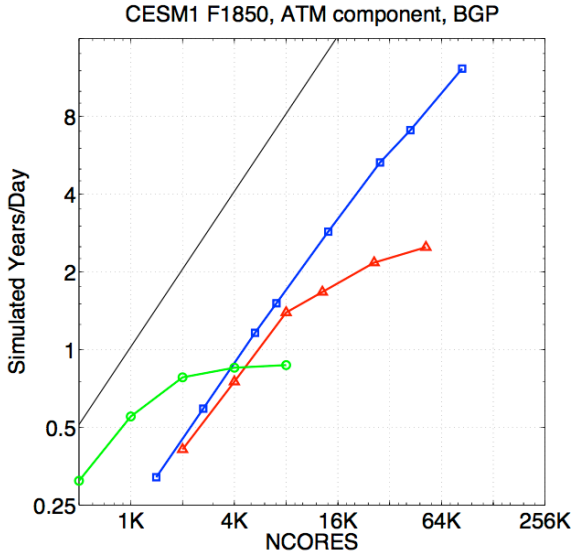
Model cost

- On Yellowstone with ~1K processors
  => cost increase by 50%

Model dycore	Model cost
CESM (CAM-FV 1 deg)	1350 pe-hrs/simulated years
CESM (CAM-SE ne30)	2000 pe-hrs/simulated years

- ne30 is developed as a testbed for CAM-SE
  Target resolution ¼ degree and higher

- Dennis et al. (2012)
¼ degree simulations on intrepid
CAM-SE is a highly scalable dynamical core



¼ degree
CAM-SE
CAM-FV
CAM-EUL

In summary

CAM5.3 was released on June 12, 2013 (as atmosphere component of **CESM1.2.0**)

- Include both FV and SE dycore
- Fix stratocumulus problem present in CAM5.2 with SE dycore

In standalone mode: CAM-SE is definitely ready

AMIP run: CAM-SE is competitive with CAM-FV (better Taylor score)

CAM-SE is not scientifically validated yet in coupled mode.

Initial results of coupled run (CAM-SE compared to CAM-FV):

- Equivalent or better simulation for atmosphere and land component
- Indications that sea-ice maybe be thinner and MOC weaker (caveat: short run)

Outstanding issues

- Impact of surface stress differences
- Grid differences at high latitudes (impact on physics and remapping)
- Sensitivity to the initial condition (ocean) in CAM-SE ?

Thanks