State of CESM

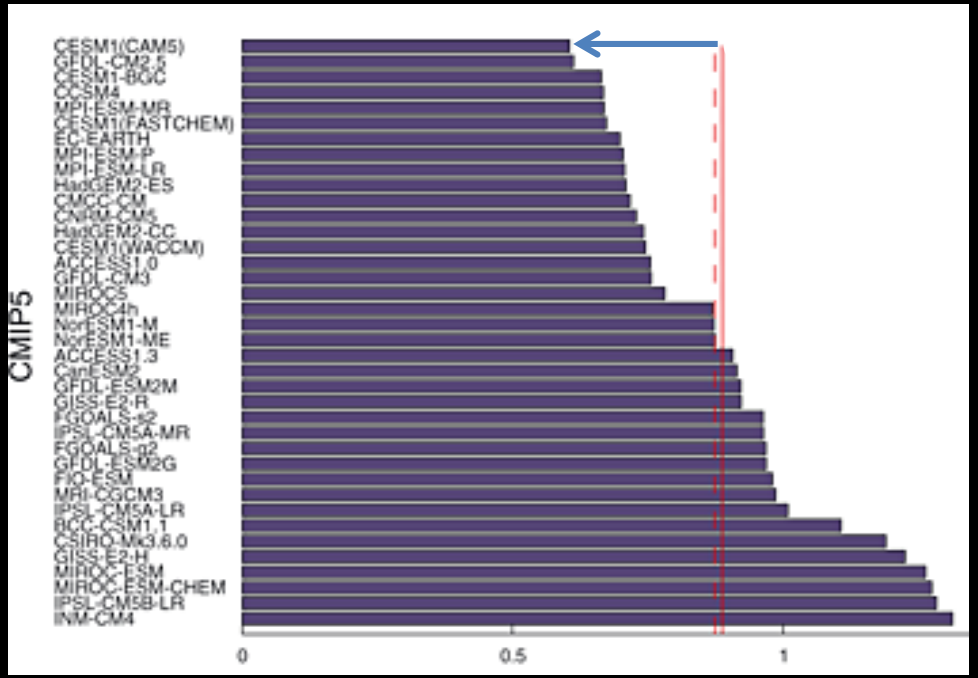
Jean-François Lamarque
CESM Chief Scientist

CESM1 (Released June 2010)

Figure courtesy of Steve Ghan and DOE Graphics team

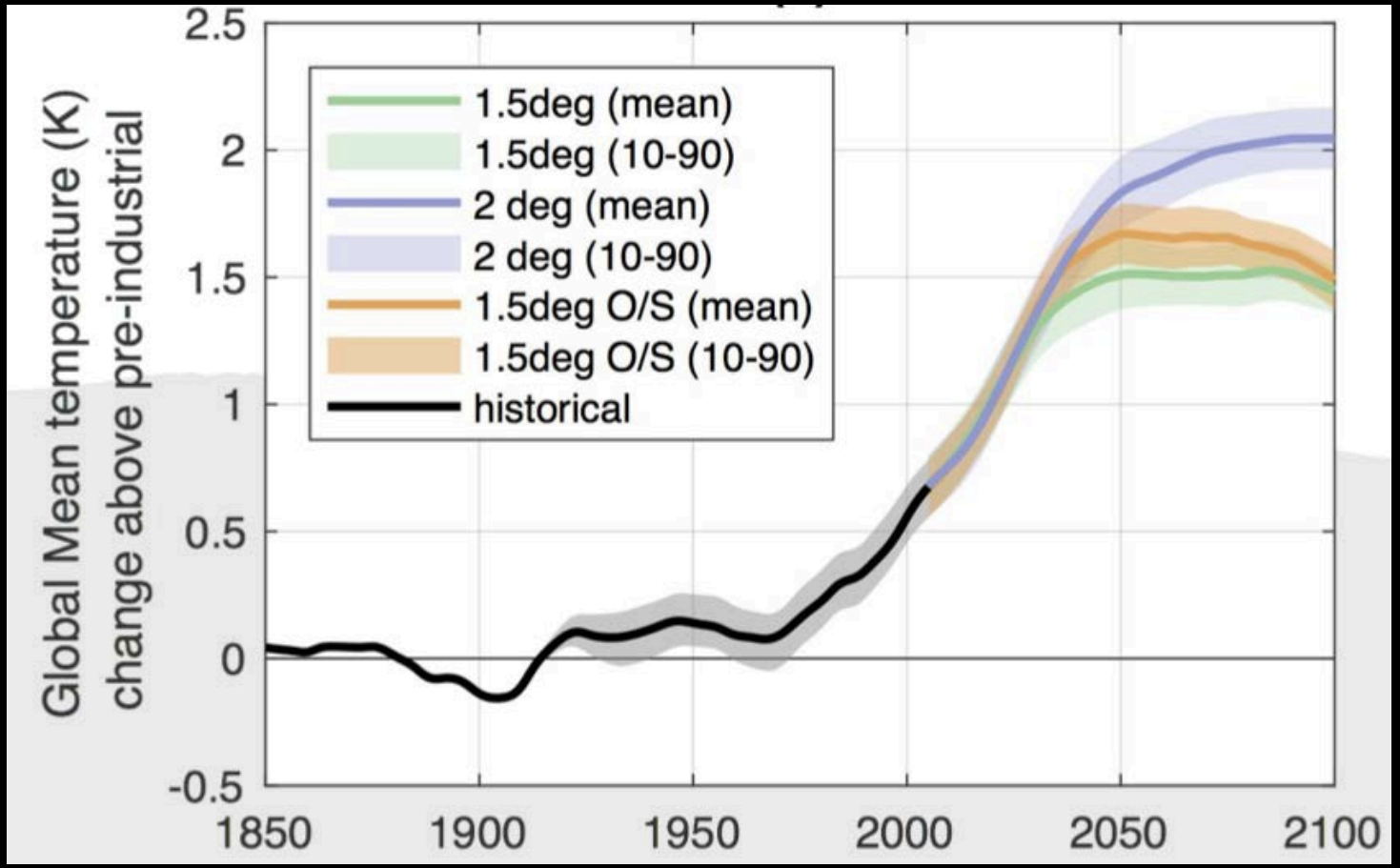
The Community Earth System Model: A Framework for Collaborative Research

J.W. Hurrell, M.M. Holland, P.R. Gent, S. Ghan, J.E. Kay, P.J. Kushner, J.-F. Lamarque, W.G. Large, D. Lawrence, K. Lindsay, W.H. Lipscomb, M.C. Long, N. Mahowald, D.R. Marsh, R.B. Neale, P. Rasch, S. Vavrus, M. Vertenstein, D. Bader, W. D. Collins, J.J. Hack, J. Kiehl, S. Marshall, BAMS, 2013



Normalized distance to obs. of temperature and precip. Knutti et al., GRL, 2013

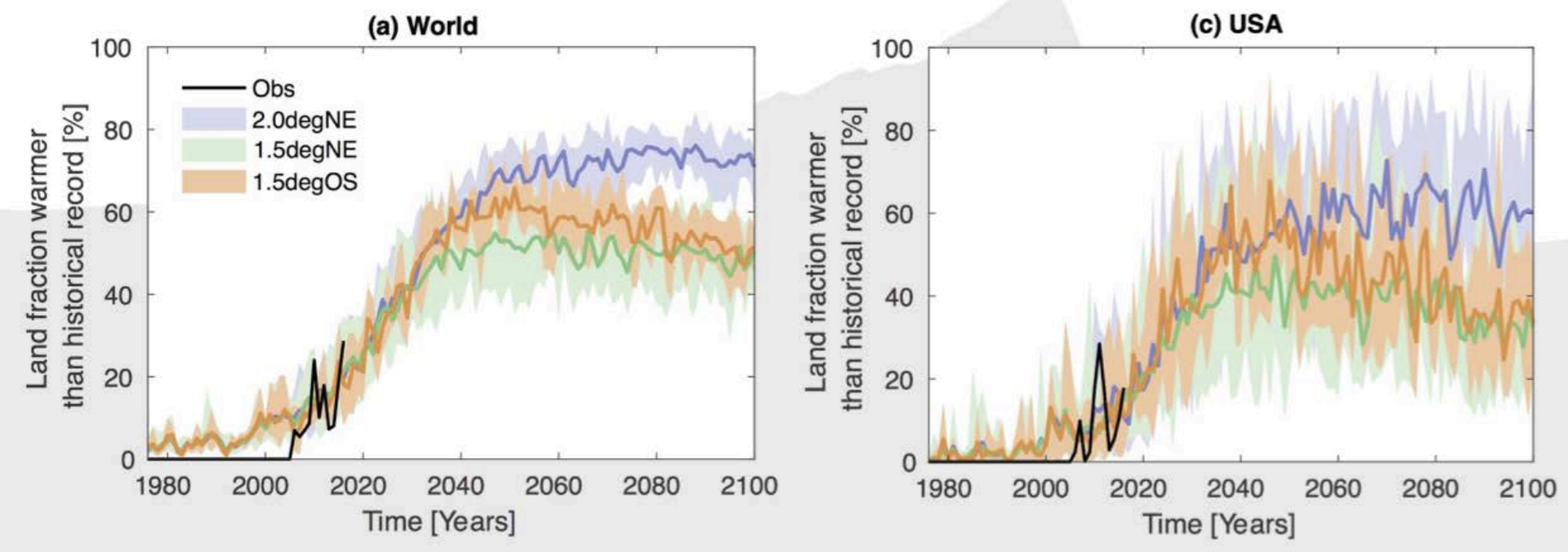
CESM Low Emission Ensemble



Slide from B. Sanderson

CESM Low Emission Ensemble

Temperature record exceedance



Slide from B. Sanderson

CESM2

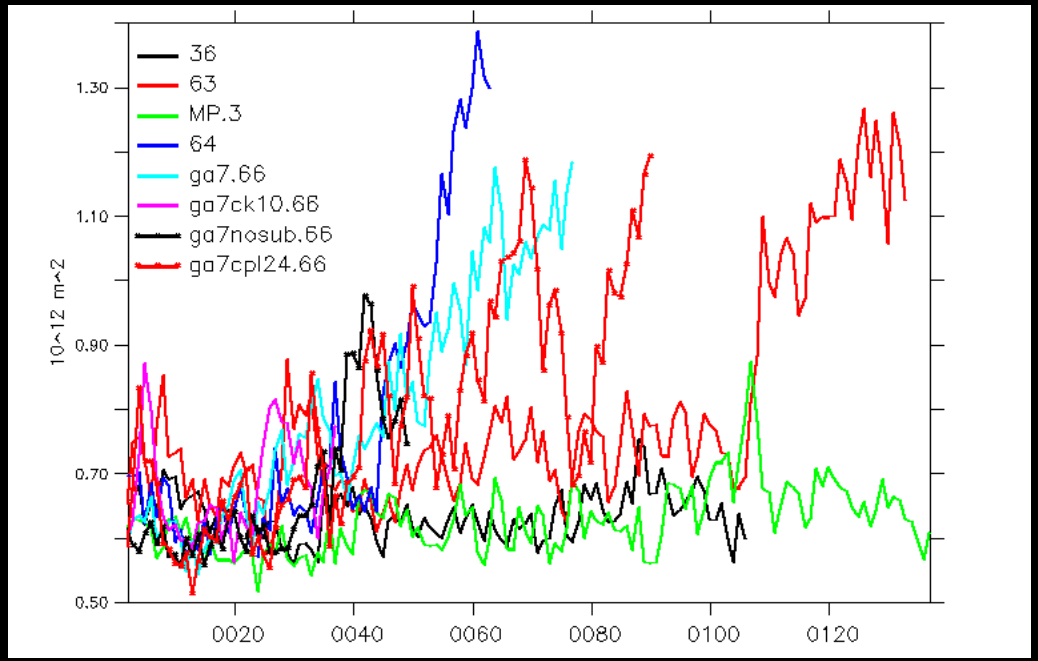
Many many thanks to the whole CESM community for the hard work in building CESM2!!

Changes beyond simulation #125

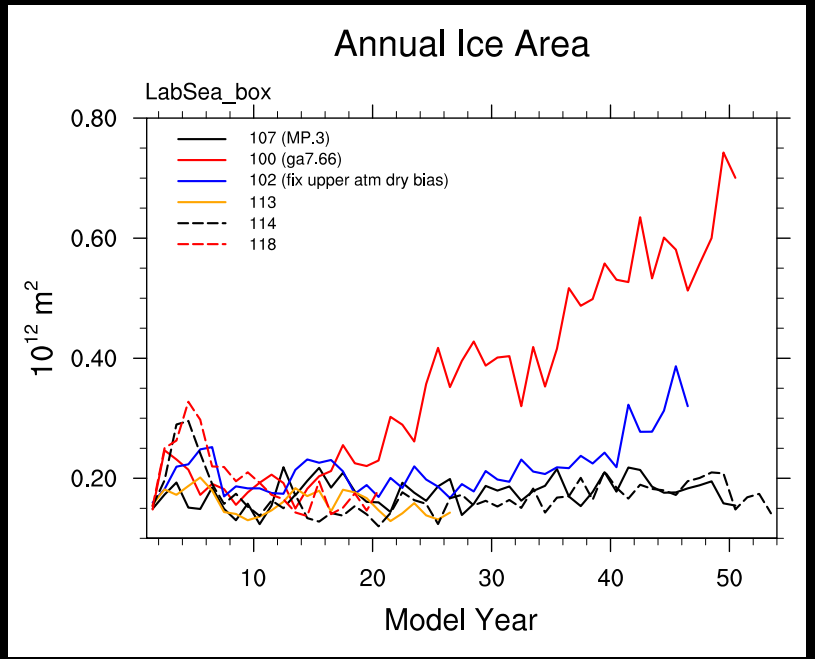
- Results from CESM2 simulation #125 released to community February 9. Results shown here come mostly from that configuration
- Changes for final version:
  - Subgrid topography representation around Greenland (different scale due to very strong winds)
  - Caspian sea: from ocean model to land model (lake)
  - Update to land vegetation parameters (little climate impact, mostly for carbon-cycle improvements)
  - CMIP6 emissions

CESM2: update from June 2016

- Major issue #1: sea-ice over Labrador



Identified June 2016

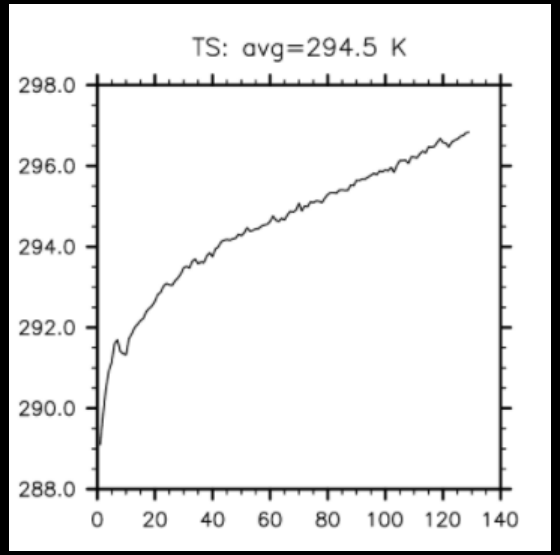


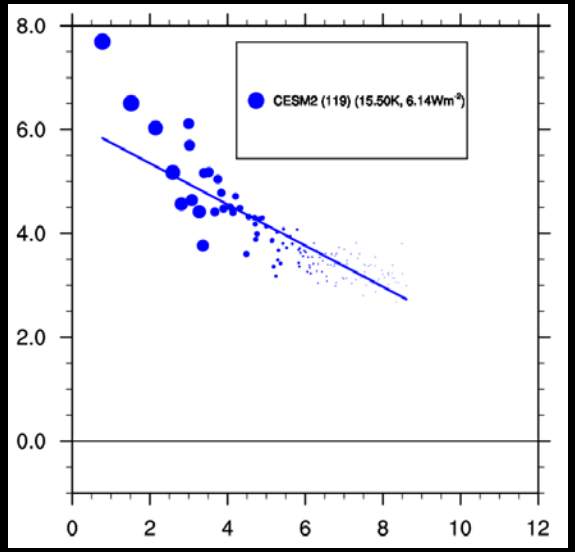
Solved Oct. 2016

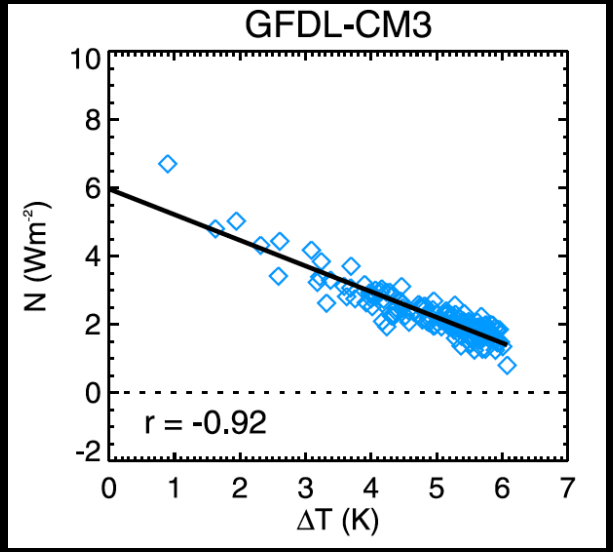
CESM2: update from June 2016

- Major issue #2: un-physical climate sensitivity

4x CO2, coupled





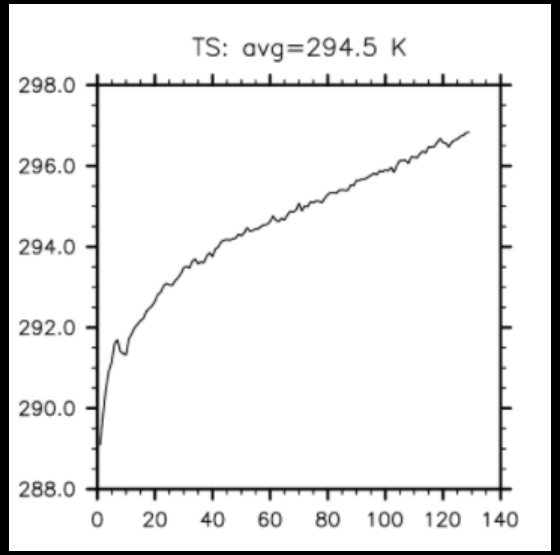


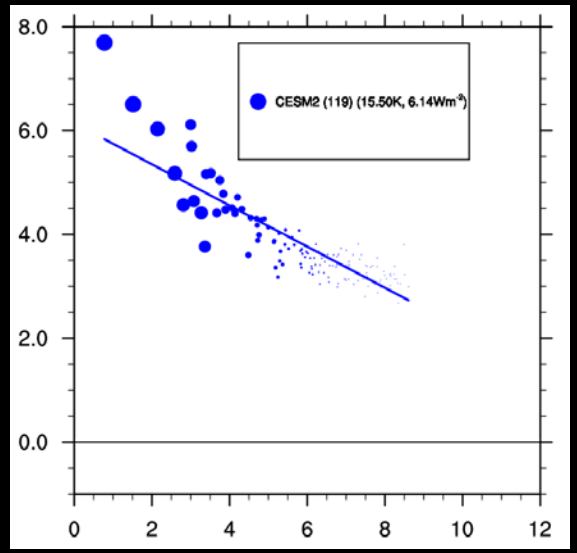
Identified Nov. 2016

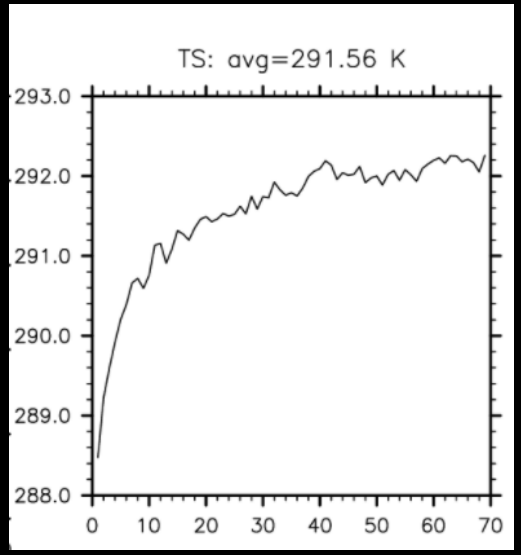
CESM2: update from June 2016

- Major issue #2: un-physical climate sensitivity

4x CO2, coupled







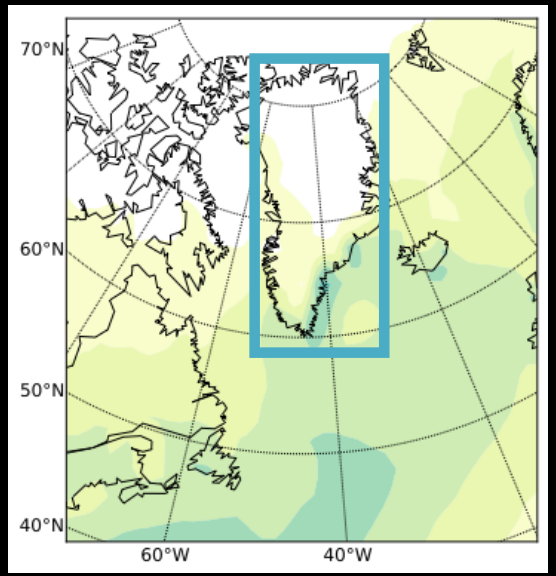
Identified Nov. 2016

Solved Dec. 2016

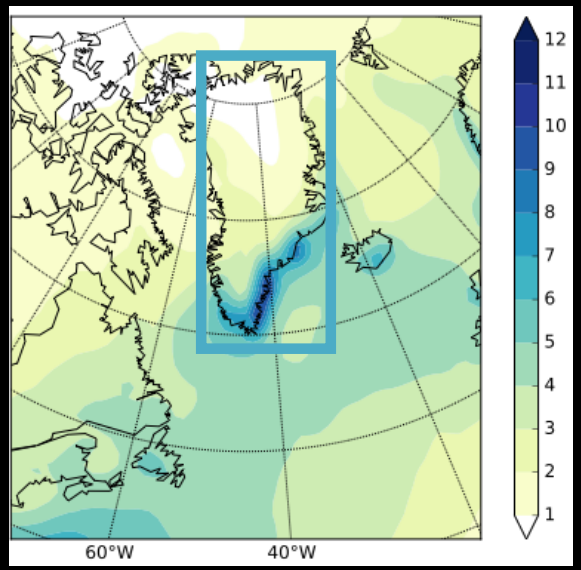
CESM2: update from June 2016

- Minor focus: Greenland surface mass balance

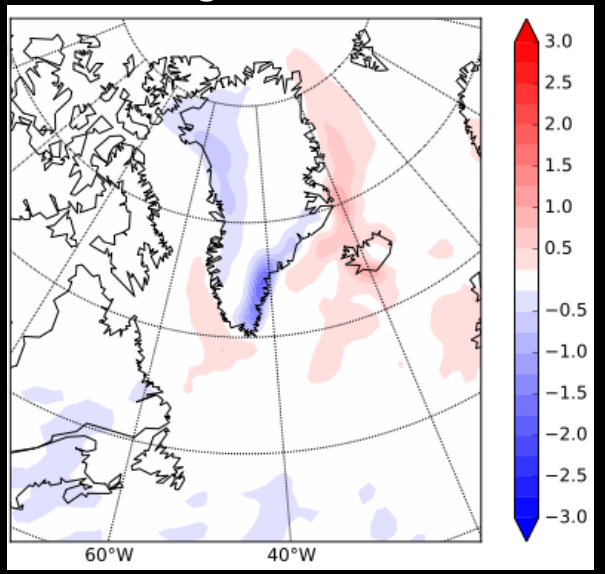
ERA-Interim



CESM 119



GrIS edge fix—control



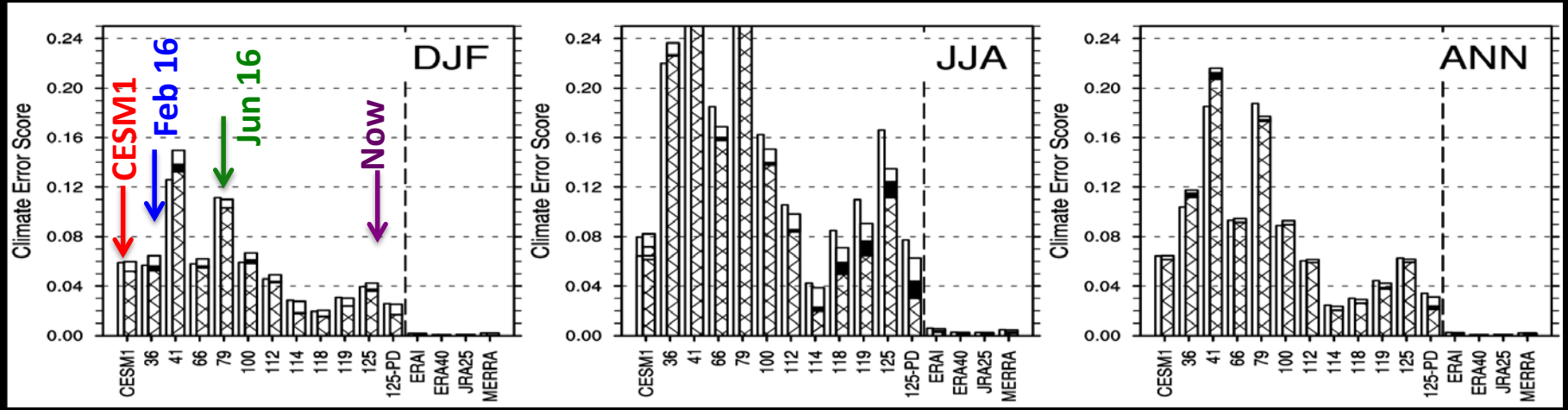
Analysis started in Oct. 2016

Improved Jan. 2017

But impact on SSWs?

Slice from M. Lofverstrom (NCAR)

Skill Score (current simulation:#125)



Phase errors (a)

Conditional bias (b)

Unconditional bias (c)

Scaled variance ratio

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

- General monotonic improvement from CESM1 (DJF/ANN)
- Large initial degradation in JJA mostly recovered
- Removing super-saturation -> improved skill, but slightly higher climate sensitivity
- Land model strongly impacts JJA score (new land at 118).

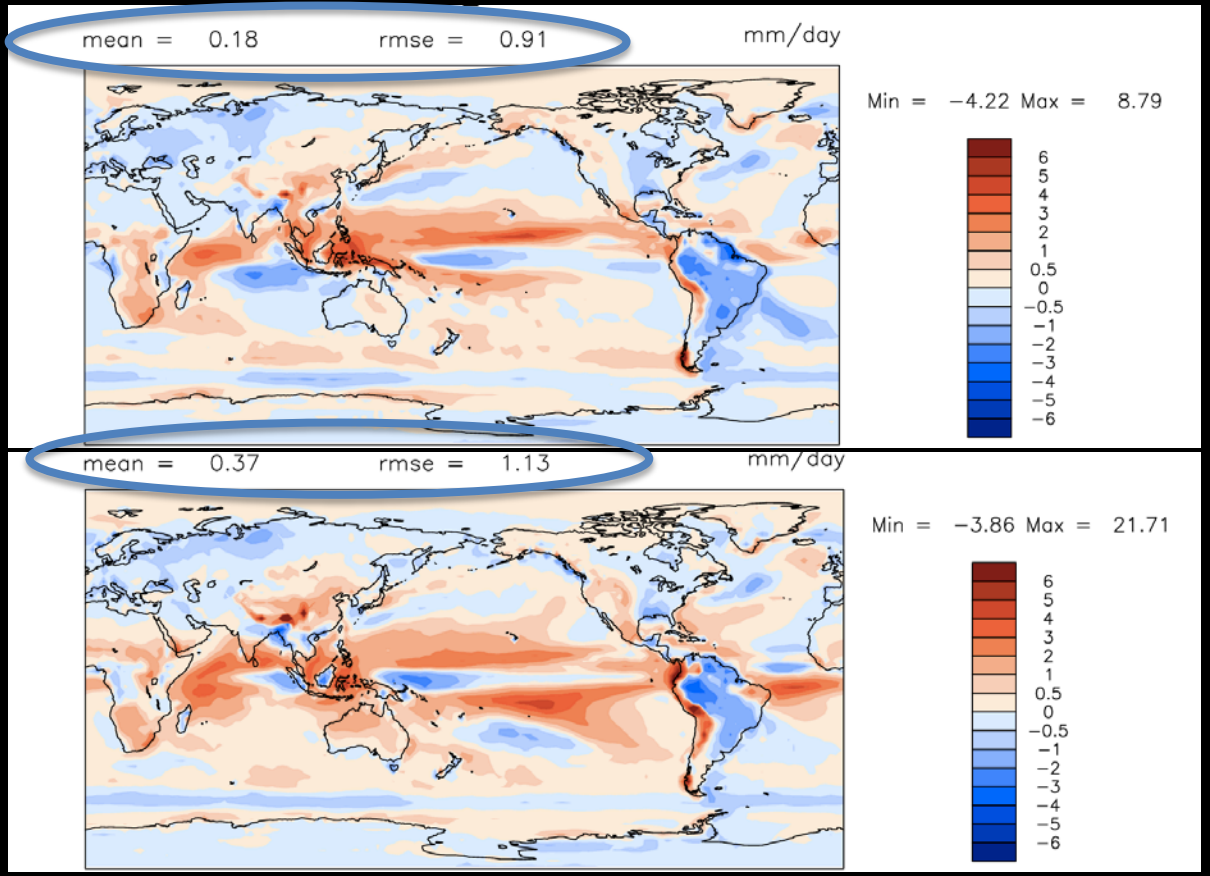
Slide from R. Neale

CESM2: Comparison to CESM1 LENS

CESM2

Bias w.r.t. GPCP
(annual precip.)

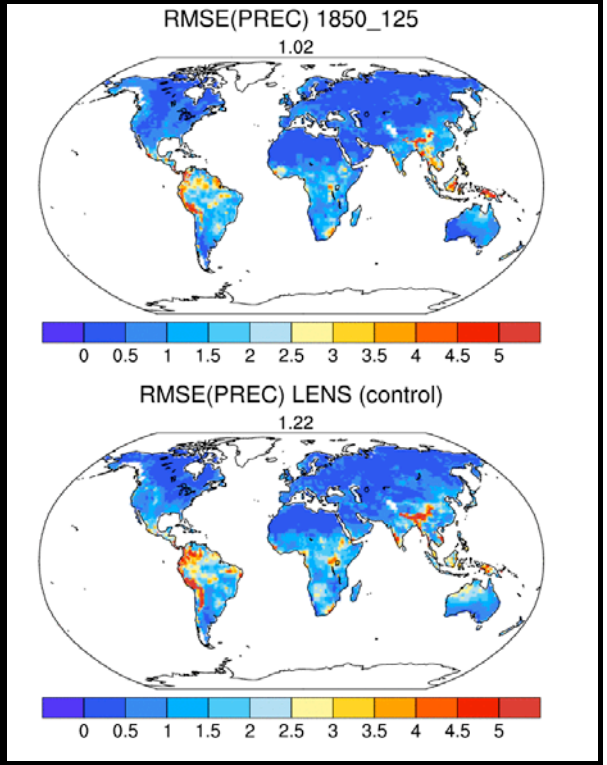
CESM1
(LENS)

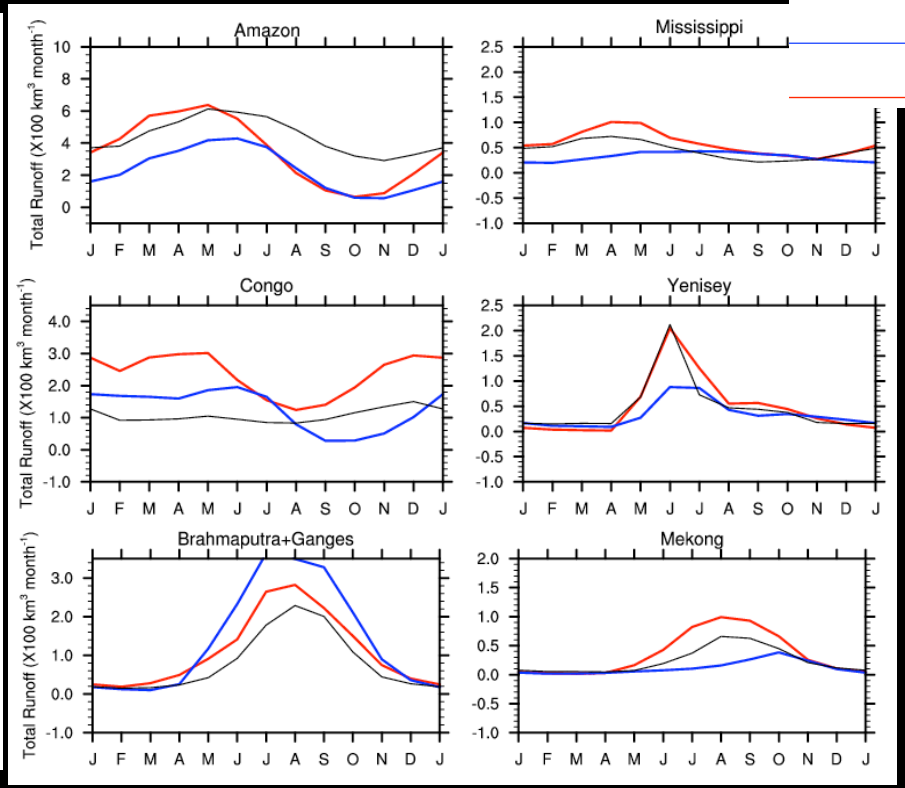


Slice from R. Neale

CESM2: Comparison to CESM1 LENS

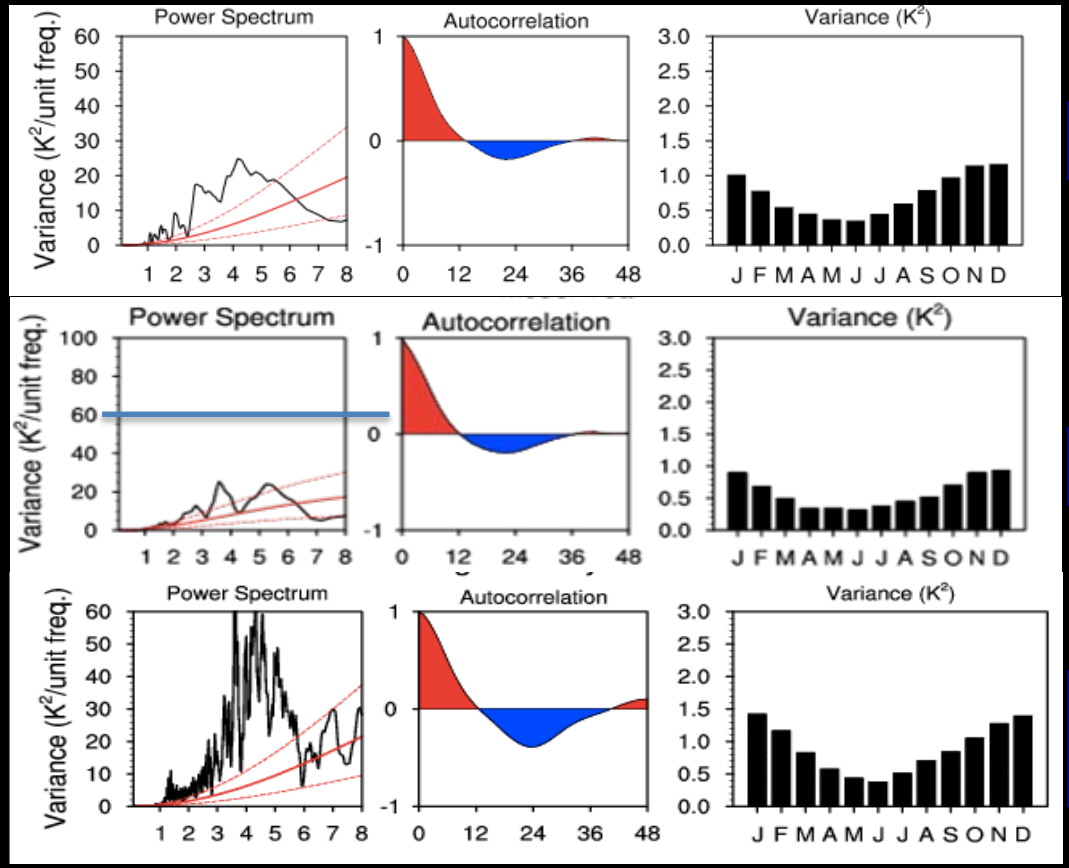
Improved precip over land and river discharge





Slice from D. Lawrence

ENSO in CESM2



CESM2

Obs.

CESM1 (LENS)

Slide from R. Neale

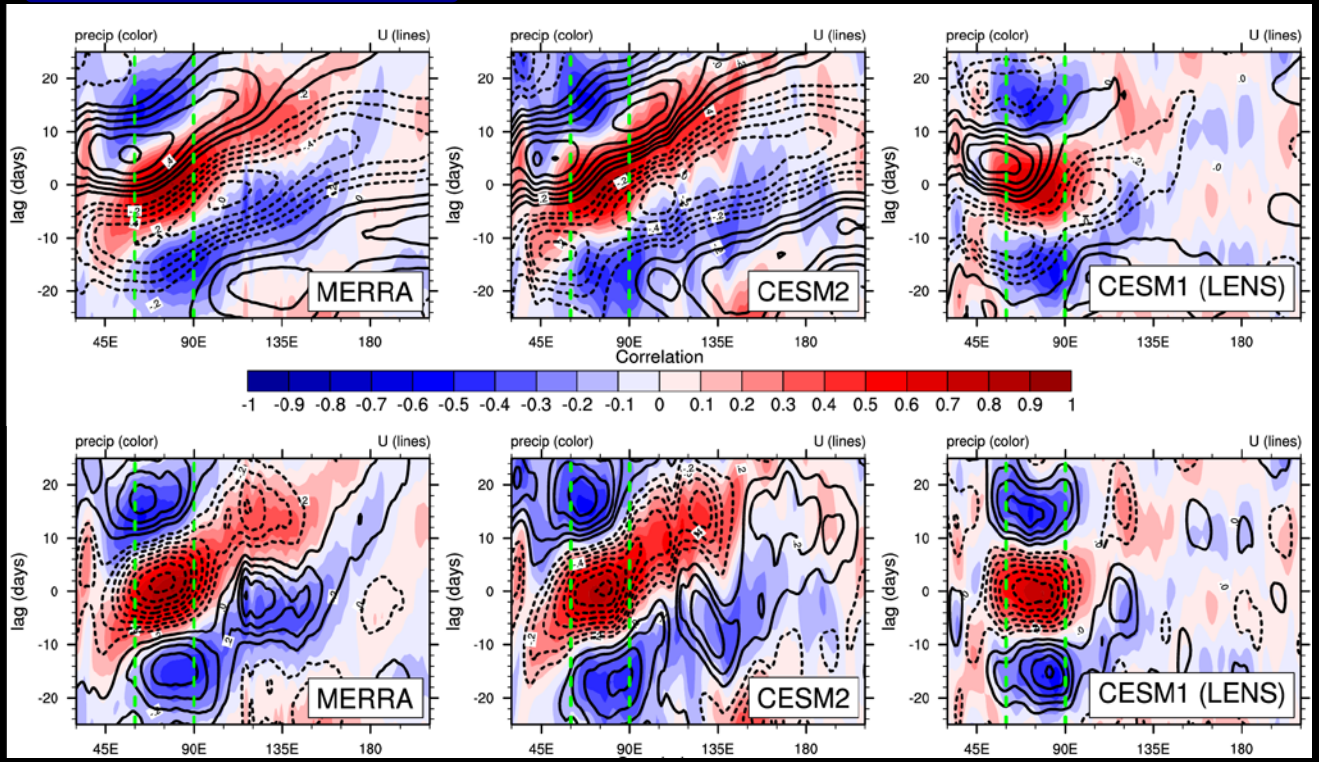
CESM2: Comparison to CESM1 LENS

Precipitation

Lines: 850-mb U

Madden-Julian Oscillation

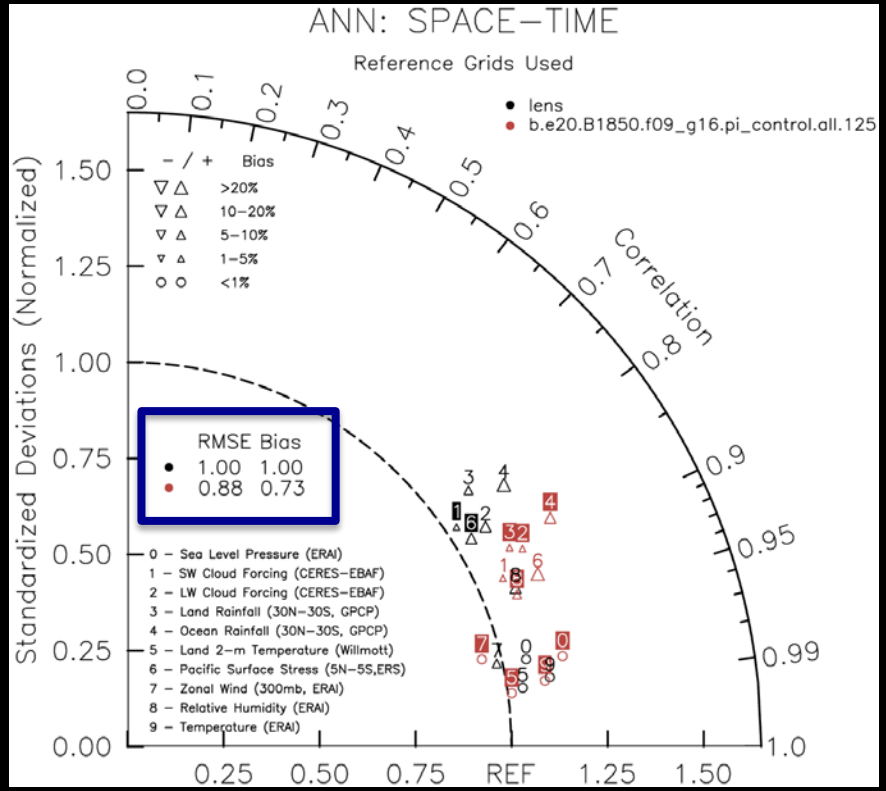
- Lag correlation with Indian-Ocean precip
- 20-100day band pass filter, 10S-10N
- 9 years, DJFMAM



Lines: OLR

Slice from R. Neale

CESM2: Comparison to CESM1 LENS



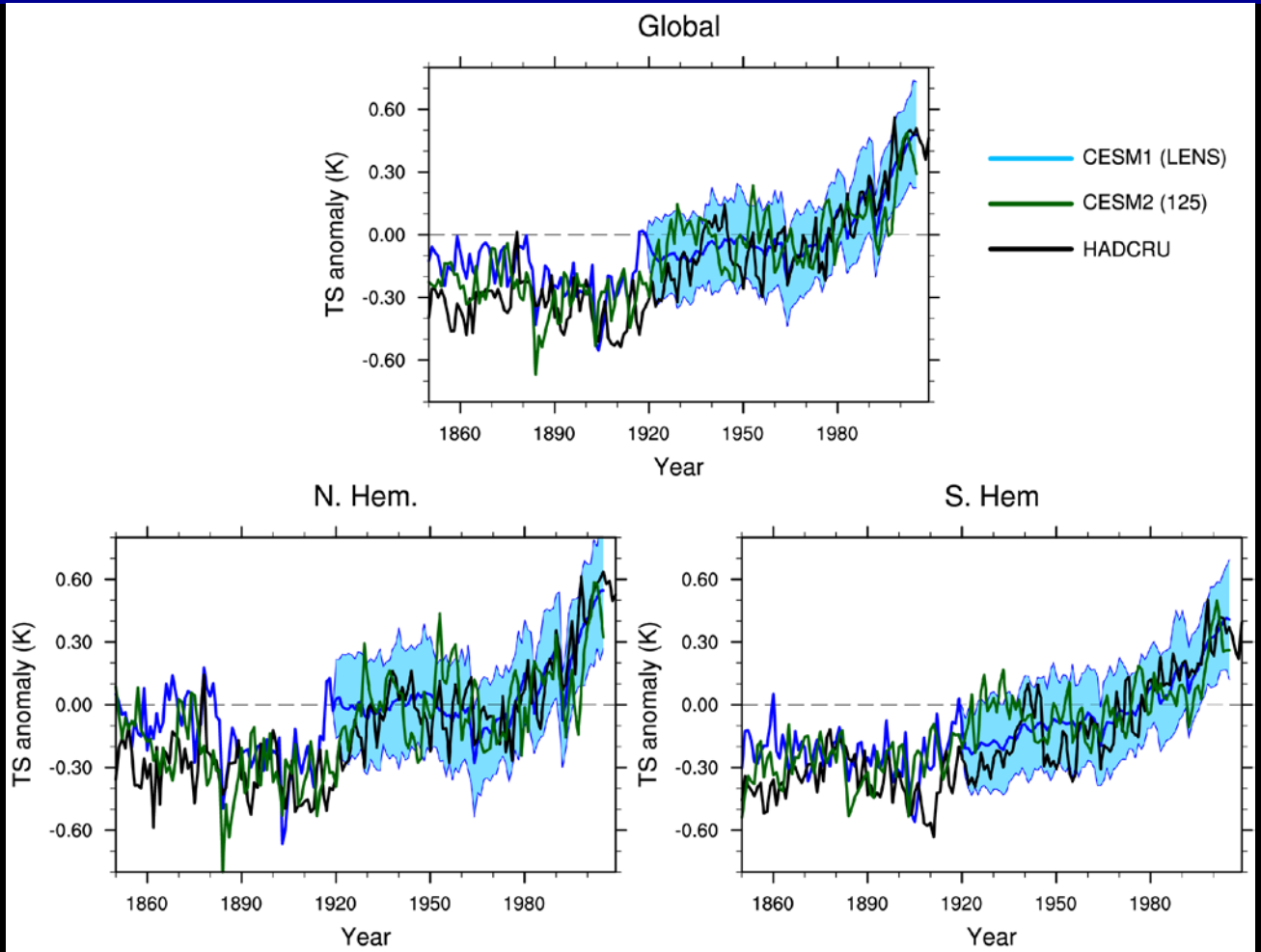
Summary

- Metric mean improved **bias** and **RMSE**
- Largest improvements in tropical precipitation (3,4), SWCF (1) and Pacific surface stress (6)
- Surface pressure field (0) degrading slightly (mostly variance)

Slice from R. Neale

CESM2: 20th century smoke test

TS normalized 1961-1990



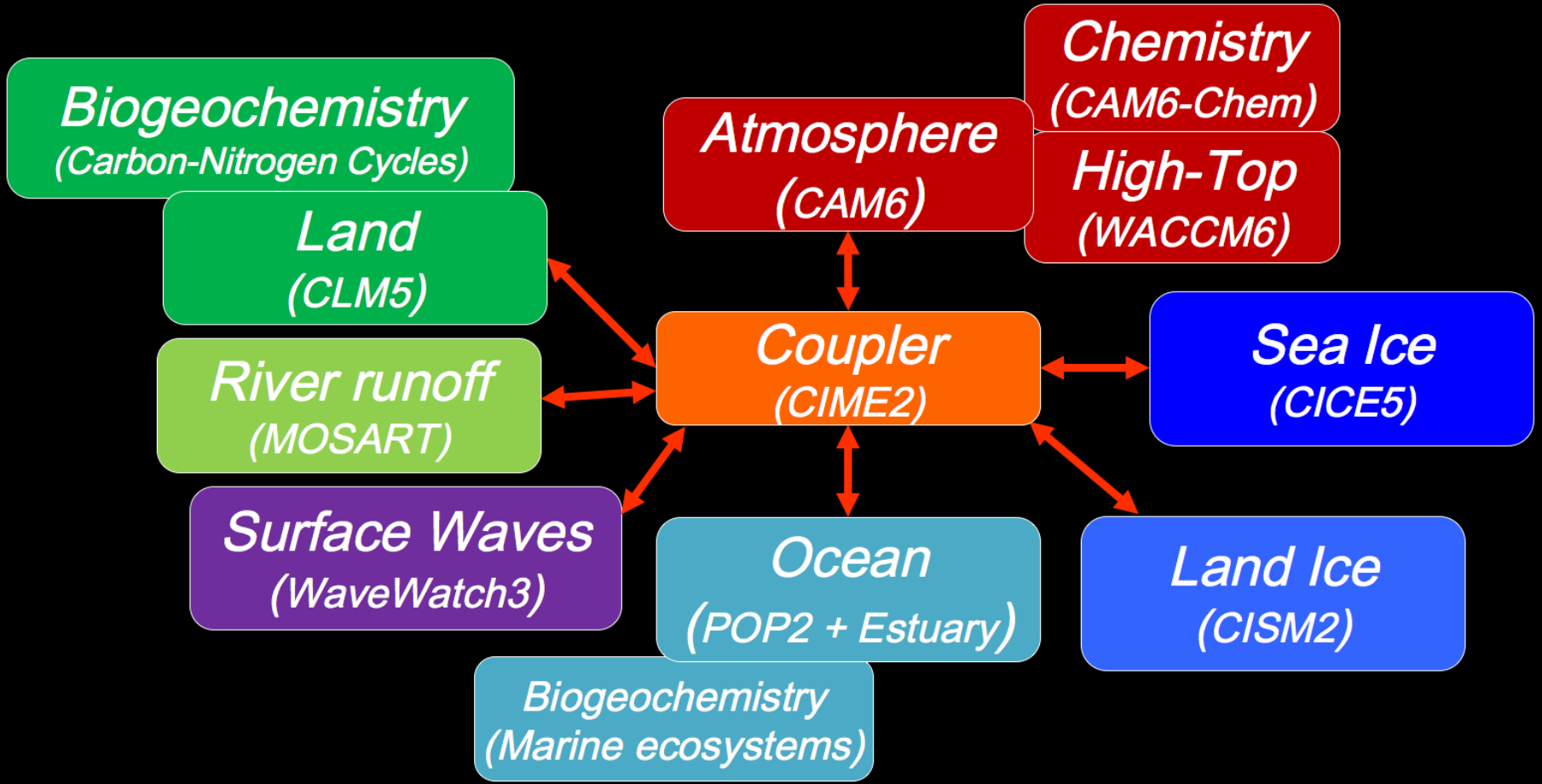
CESM2: Timeline for release

- Final configuration: done Friday Feb 24!
- Start PI run with final configuration this week
- Testing/documentation/clean up
  - > needs approximately 3 months
- Release of 1^{o} version (including portion of CMIP6 PI control) May-June 2017
- Papers will be submitted to JAMES

CESM2: Additional information

- Out-of-the-box CESM configurations for idealized setups (Held-Suarez, moist baroclinic wave with Kessler physics, terminator chemistry, …) for CAM-FV and CAM-SE
- Work underway for high-resolution testing (but will not be scientifically released as part of the CESM2.0)
- Isotope-enabled version of CESM will also be released later (2.1, probably by end of the 2017)

CESM2: Final configuration



CESM2: Remaining areas of weakness

- Precipitation over land areas (esp. Amazon and Central US), incl. Greenland
- Cold climate in 1850

  – > those are the known ones!

CMIP6

CMIP6: computer allocation

- As part of the CSL 2016-2018 proposal, 250M core-hours were requested (and approved) for Yellowstone usage
- Provides sufficient computing time for the DECK and all requested Tier 1 experiments
- Additional simulations (Tier 2) part of the standard (i.e. WG-driven) CSL pool

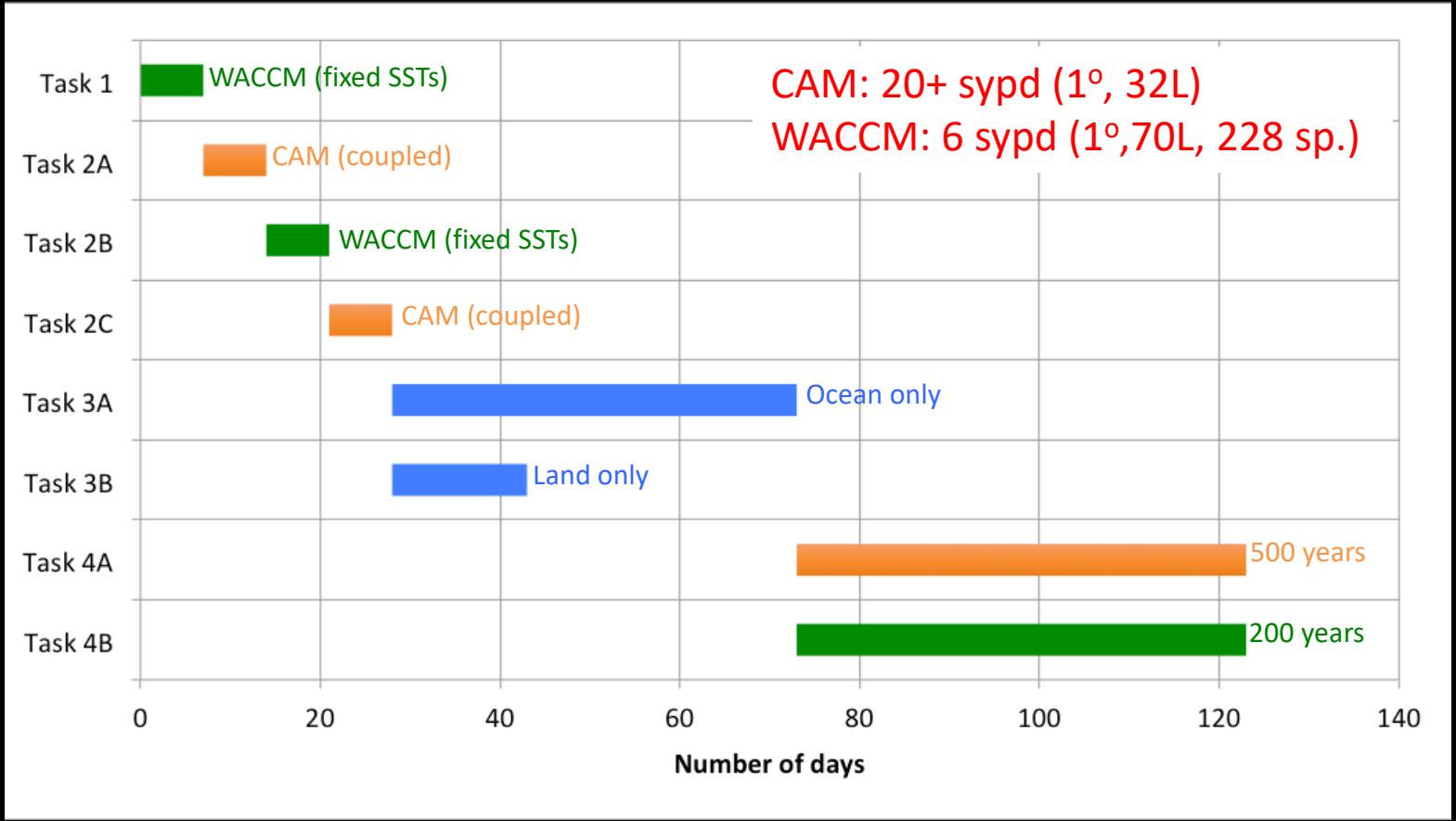
CMIP6: simulation breakdown DECK + Tier 1

- CESM2-CAM6-1°: ≈17,000 years
- CESM2-WACCM6-1°: ≈5,000 years
- CESM-CAM6-1/4°: ≈200 years
- Several PB of generated data
  - > working extensively with CISL on data management and overall throughput

CMIP6: timeline and workflow

- Approx. 10 months to perform all DECK and TIER1 simulations on Yellowstone
- 4 months needed before branching from PI control!

CMIP6: timeline and workflow



CMIP6: core team

- Assembled a team of experienced CESM users
  - Cécile Hannay
  - Bob Tomas
  - 1-2 TBD
  - CISL members (S. Mickelson/D. Hart/E. Nienhouse)

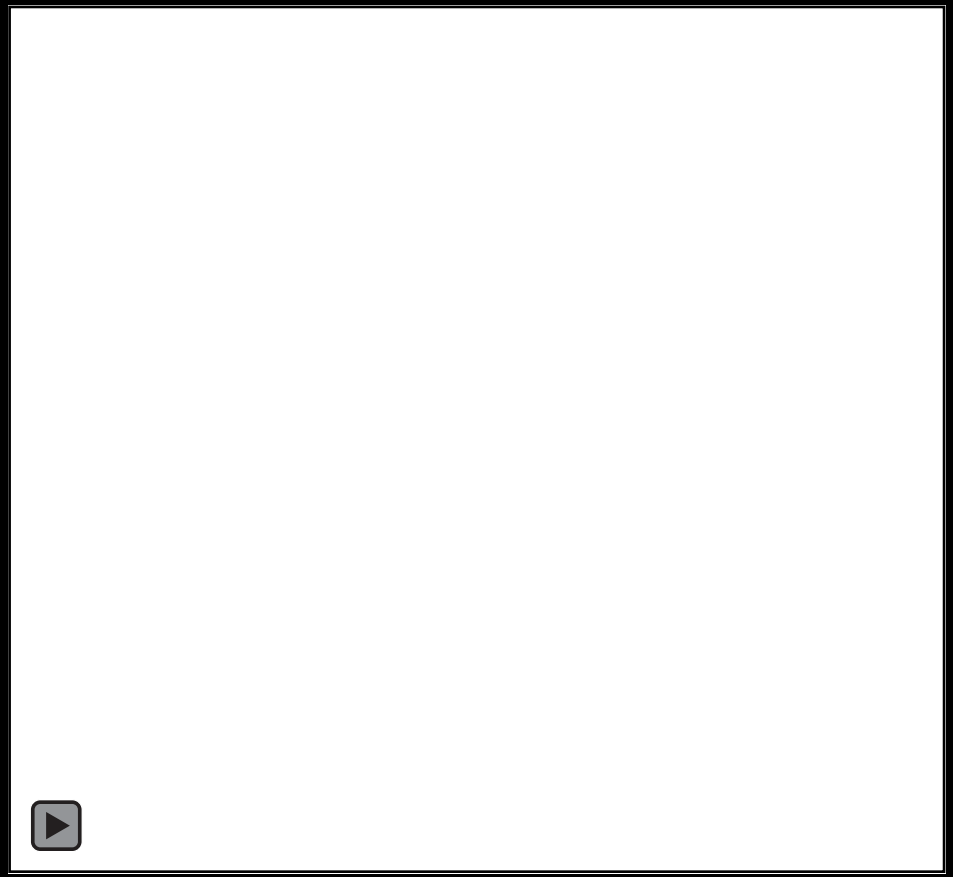
CMIP6: MIPs participation

MIP acronym	MIP name	Name of primary sponsor(s)
AerChemMIP	Aerosols and Chemistry Model Intercomparison Project	Lamarque/Emmons
C4MIP	Coupled Climate Carbon Cycle Model Intercomparison Project	Lindsay
CFMIP	Cloud Feedback Model Intercomparison Project	Medeiros/Kay (CU)/Klein (LLNL)
DAMIP	Detection and Attribution Model Intercomparison Project	Tebaldi/Arblaster
DCPP	Decadal Climate Prediction Project	Danabasoglu/Meehl
GeoMIP	Geoengineering Model Intercomparison Project	Tilmes/Mills
GMMIP	Global Monsoons Model Intercomparison Project	Fasullo/Kinter (COLA)
HighResMIP	High Resolution Model Intercomparison Project	Neale/Bacmeister
ISMIP6	Ice Sheet Model Intercomparison Project for CMIP6	Lipscomb (LANL)/Otto-Bliesner
LS3MIP	Land Surface, Snow and Soil Moisture	D. Lawrence
LUMIP	Land-Use Model Intercomparison Project	D. Lawrence/P. Lawrence
OMIP/OCMIP	Ocean Model Intercomparison Project	Danabasoglu
PMIP	Palaeoclimate Modelling Intercomparison Project	Otto-Bliesner
RFMIP	Radiative Forcing Model Intercomparison Project	Gettelman/Neale
ScenarioMIP	Scenario Model Intercomparison Project	Meehl/O'Neill/P. Lawrence
VolMIP	Volcanic Forcings Model Intercomparison Project	Mills/Otto-Bliesner
Data only		
CORDEX	Coordinated Regional Climate Downscaling Experiment	Mearns/Gutowski
DynVar	Dynamics and Variability of the Stratosphereâ€Troposphere System	Marsh
SIMIP	Sea-Ice Model Intercomparison Project	Bailey/Holland/Jahn (CU)/Hunke (LANL)
VIAAB	VIA Advisory Board for CMIP6	Mearns/O'Neill

CONCLUSIONS

- CESM2 configuration is finalized and final check is on-going
- Strong improvements in many aspects of the model!
- Release will occur in May-June 2017
- Multi-step process to provide a traceable pre-industrial control; will take approx. 3-4 months
- Strong ramp-up in CMIP6 will occur starting in June; expecting to perform all 1-degree simulations DECK/Tier1 by end of 2017

Questions? Comments?



High-resolution (25 km atmosphere, 0.1^{o} ocean) coupled simulation captures short-term variability (hurricanes) and seasonal variations (sea-ice)

Movie from J. Small and T. Scheitlin