Overview of the CESM1.5 simulation

Cécile Hannay

David Bailey, Pete Bogenschutz, Gokhan Danabasoglu, Jim Edwards, Andrew Gettelman, Marika Holland, Jean-Francois Lamarque, David Lawrence, Keith Lindsay, Rich Neale, Keith Oleson, Bill Sacks, John Truesdale, Mariana Vertenstein and gazillions of others

CESM1.5: Many new babies !

Land
CLM5

Atmosphere
CAM5.5

Sea-ice
CICE5

Land Ice
CISM2

River Model
MOSART

Ocean
POP2
+BGC

CESM1.5: Building individual components

Land
CLM5

Atmosphere
CAM5.5

Sea-ice
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Land Ice
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River Model
MOSART

CESM1.5: Coupling individual components

Land
CLM5

Atmosphere
CAM5.5

Sea-ice
CICE5

Land Ice
CISM2

River Model
MOSART

Ocean
POP2
+BGC

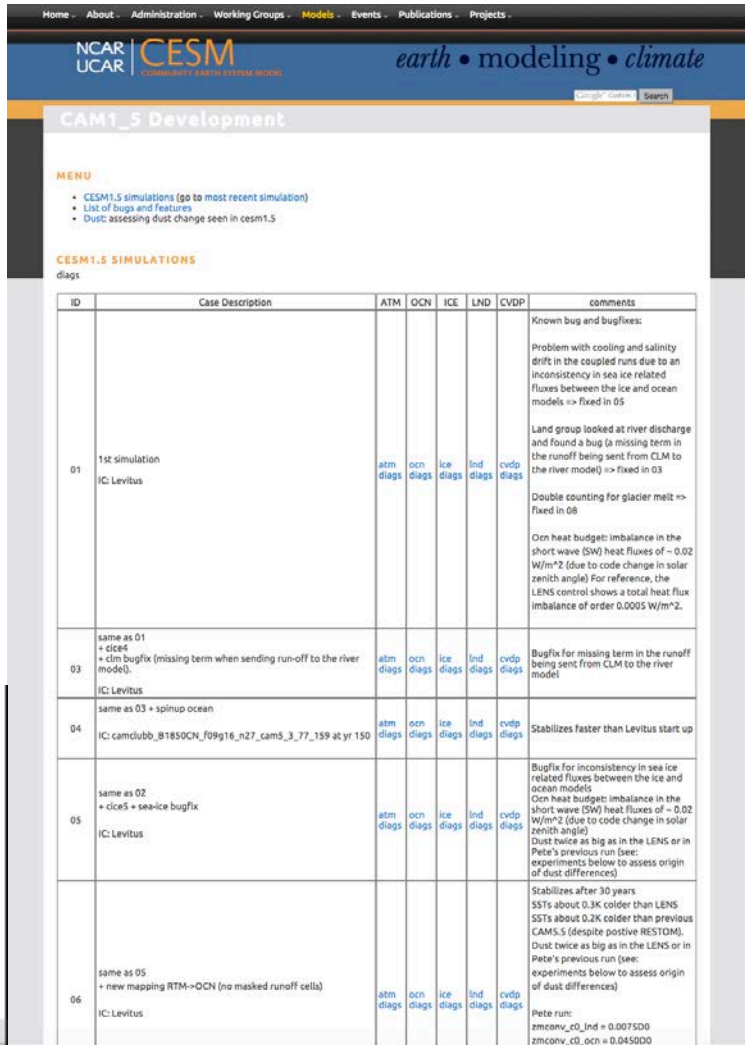
What could happen at coupling ?

CESM1.5: Development simulations

http://www.cesm.ucar.edu/working_groups/Atmosphere/development/cesm1_5/

At a glance

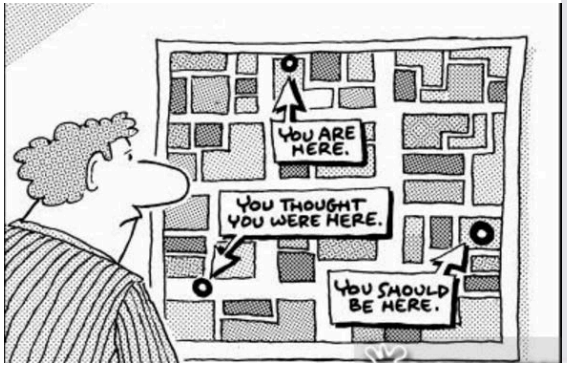
- **Huge team effort started in Mid November 2015**
- **2 co-chair meetings/week**
- **34 experiments ("cases")**
- **1300+ years of simulations + diagnostics**



ID	Case Description	ATM	OCN	ICE	LND	CVDP	comments
01	1st simulation IC: Levitus	atm diags	ocn diags	ice diags	lnd diags	cvdp diags	Known bug and bugfixes: Problem with cooling and salinity drift in the coupled runs due to an inconsistency in sea ice related fluxes between the ice and ocean models => fixed in 05 Land group looked at river discharge and found a bug (a missing term in the runoff being sent from CLM to the river model) => fixed in 03 Double counting for glacier melt => fixed in 08 Ocn heat budget: imbalance in the short wave (SW) heat fluxes of ~ 0.02 W/m^2 (due to code change in solar zenith angle) For reference, the LENS control shows a total heat flux imbalance of order 0.0005 W/m^2.
03	same as 01 + cice4 + clm bugfix (missing term when sending run-off to the river model). IC: Levitus	atm diags	ocn diags	ice diags	lnd diags	cvdp diags	Bugfix for missing term in the runoff being sent from CLM to the river model
04	same as 03 + spinup ocean IC: camclubb_B1850CN_f09g16_n27_cam5_3_77_159 at yr 150	atm diags	ocn diags	ice diags	lnd diags	cvdp diags	Stabilizes faster than Levitus start up
05	same as 02 + cice5 + sea-ice bugfix IC: Levitus	atm diags	ocn diags	ice diags	lnd diags	cvdp diags	Bugfix for inconsistency in sea ice related fluxes between the ice and ocean models Ocn heat budget: imbalance in the short wave (SW) heat fluxes of ~ 0.02 W/m^2 (due to code change in solar zenith angle) Dust twice as big as in the LENS or in Pete's previous run (see: experiments below to assess origin of dust differences)
06	same as 05 + new mapping RTM->OCN (no masked runoff cells) IC: Levitus	atm diags	ocn diags	ice diags	lnd diags	cvdp diags	Stabilizes after 30 years SSTs about 0.3K colder than LENS SSTs about 0.2K colder than previous CAM5.5 (despite postive RESTOM). Dust twice as big as in the LENS or in Pete's previous run (see: experiments below to assess origin of dust differences) Pete run: zmconv_c0_lnd = 0.0075D0 zmconv_c0_ocn = 0.0450D0

Where are we ?

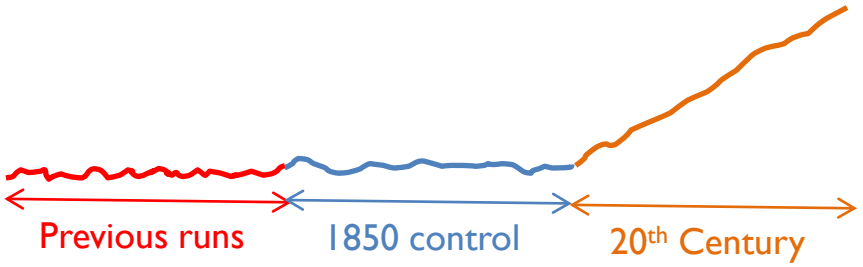
- **a lot of progress made**
- **a lot more needs to be done**



Our best configuration so far: "28"

Coupled simulations

- 1850 Control (100 years)
- 20th century (1850-2005)



Additional simulations

- AMIP simulation (1979-2005)
- High frequency runs
- Indirect effect (pre-industrial versus present aerosol)
- Climate sensitivity (2xCO_2 with Slab Ocean Model) – in progress

How to reproduce "28"

- Experimental tag + namelist modifications
- Details will be available next week at:

http://www.cesm.ucar.edu/working_groups/Atmosphere/development/cesm1_5/

Our best configuration so far: "28"

Coupled simulations

- **1850 Control (100 years)**
- **20th century (1850-2005)**

⟺ **LENS**
Observations

Additional simulations

- **AMIP simulation (1979-2005)**
- **High frequency runs**
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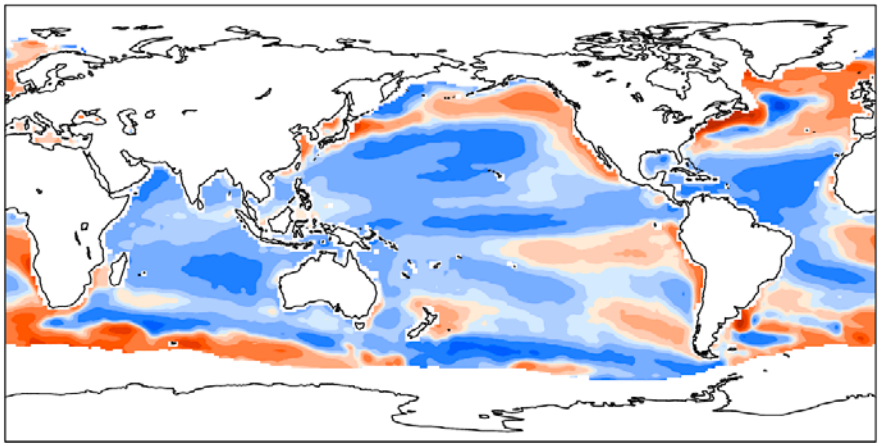
Sea Surface Temperature (SST) bias

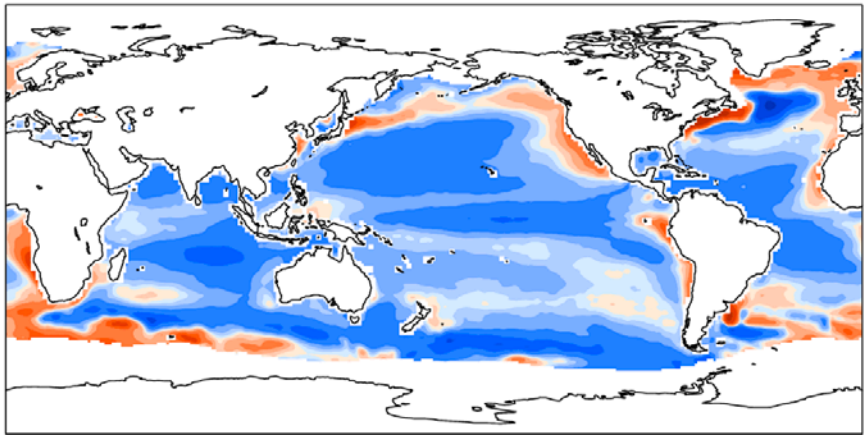
LENS versus obs

Bias = -0.24K
RMSE = 0.91



CESM1.5 versus obs

Bias = -0.62K
RMSE = 1.12



SST climatologies
HadISST/OI.v2 (1870-1900)
LENS (yrs 402-421)
CESM1.5 (yrs 75-99)

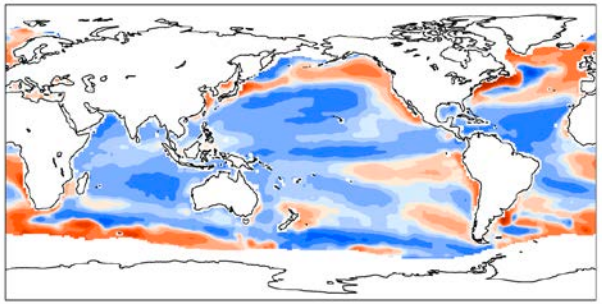
Now who do we blame ?

Add
CAM5.5
CLM5
CICE5
MOSART
CSIM2

→CESM1.5 significantly colder than observations (-0.62K)

Sea Surface Temperature (SST) bias

LENS



Bias = -0.24K
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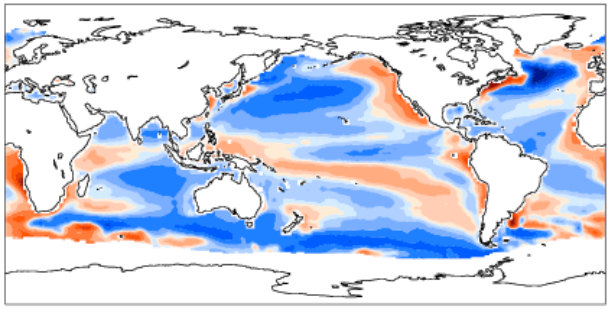
LENS + CAM5.5

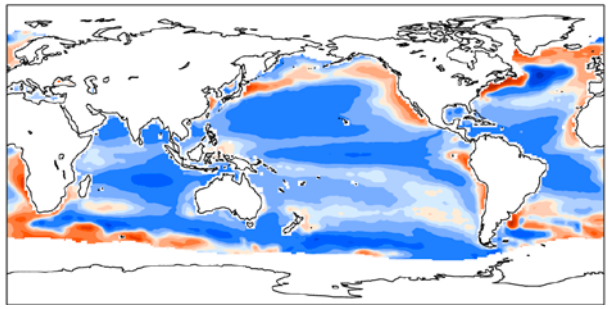


Bias = -0.32K
RMSE = 1.03

Intermediate version

Add CAM5.5

CESM1.5



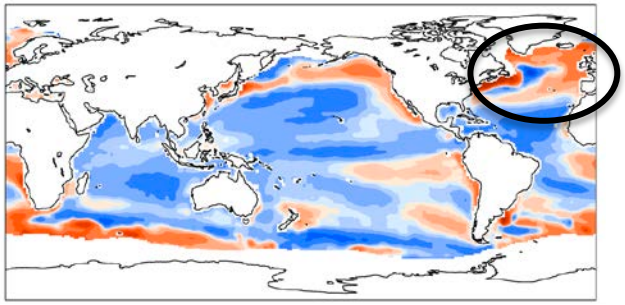
Bias = -0.62K
RMSE = 1.12

Add CLM5, CICE5, MOSART, CSIM2

➔ **Jump in SST bias when adding all new components but CAM**

Sea Surface Temperature (SST) bias

LENS



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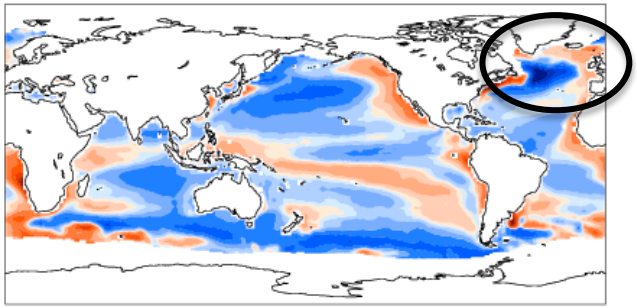

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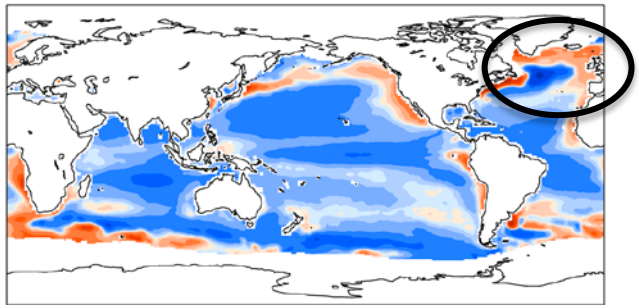


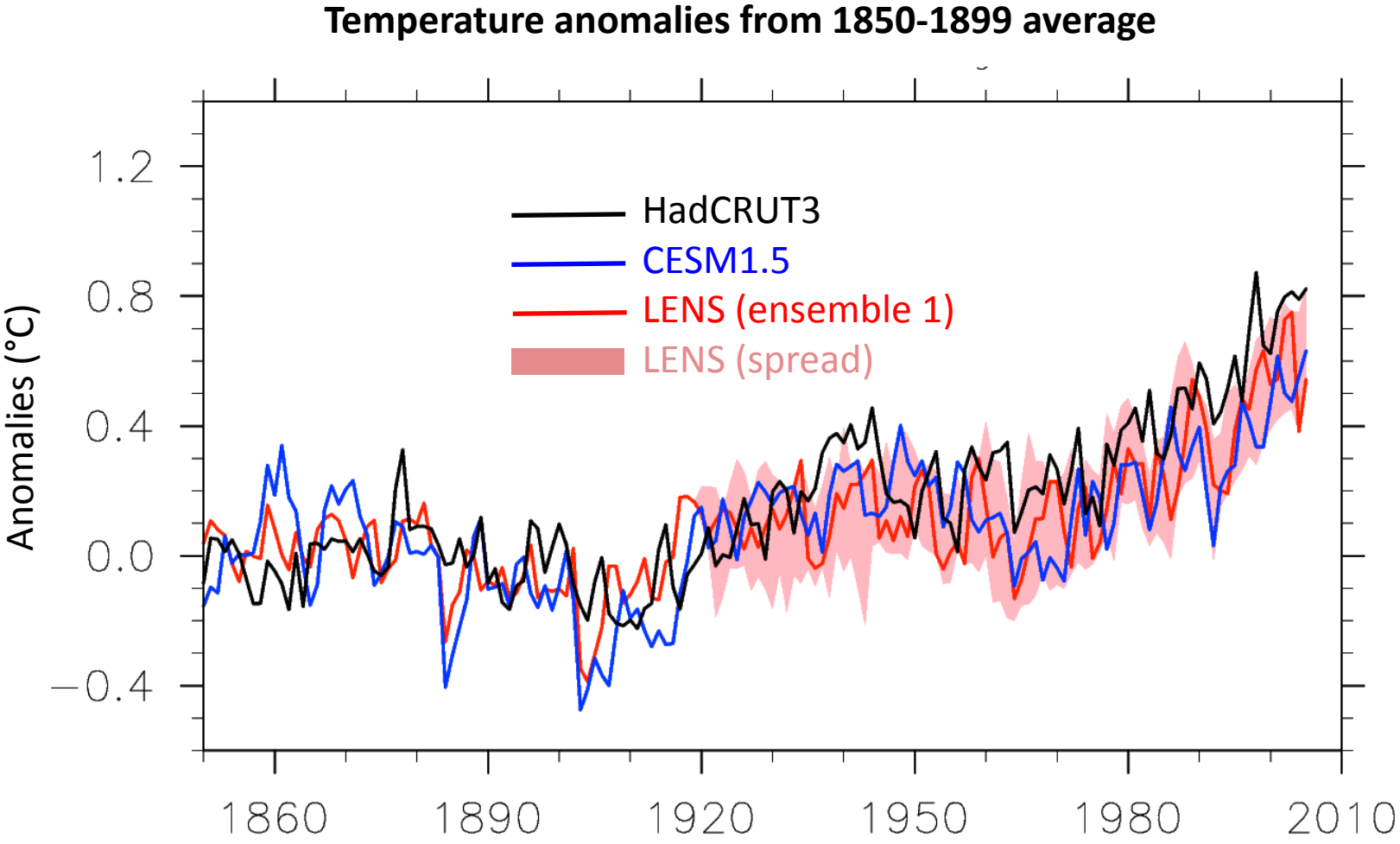
Bias = -0.62K
RMSE = 1.12

Add CLM5, CICE5, MOSART, CSIM2

➔ Jump in SST bias when adding all new components but CAM

➔ Colder North Atlantic was in CAM5.5 (indeed started with CAM5.4)

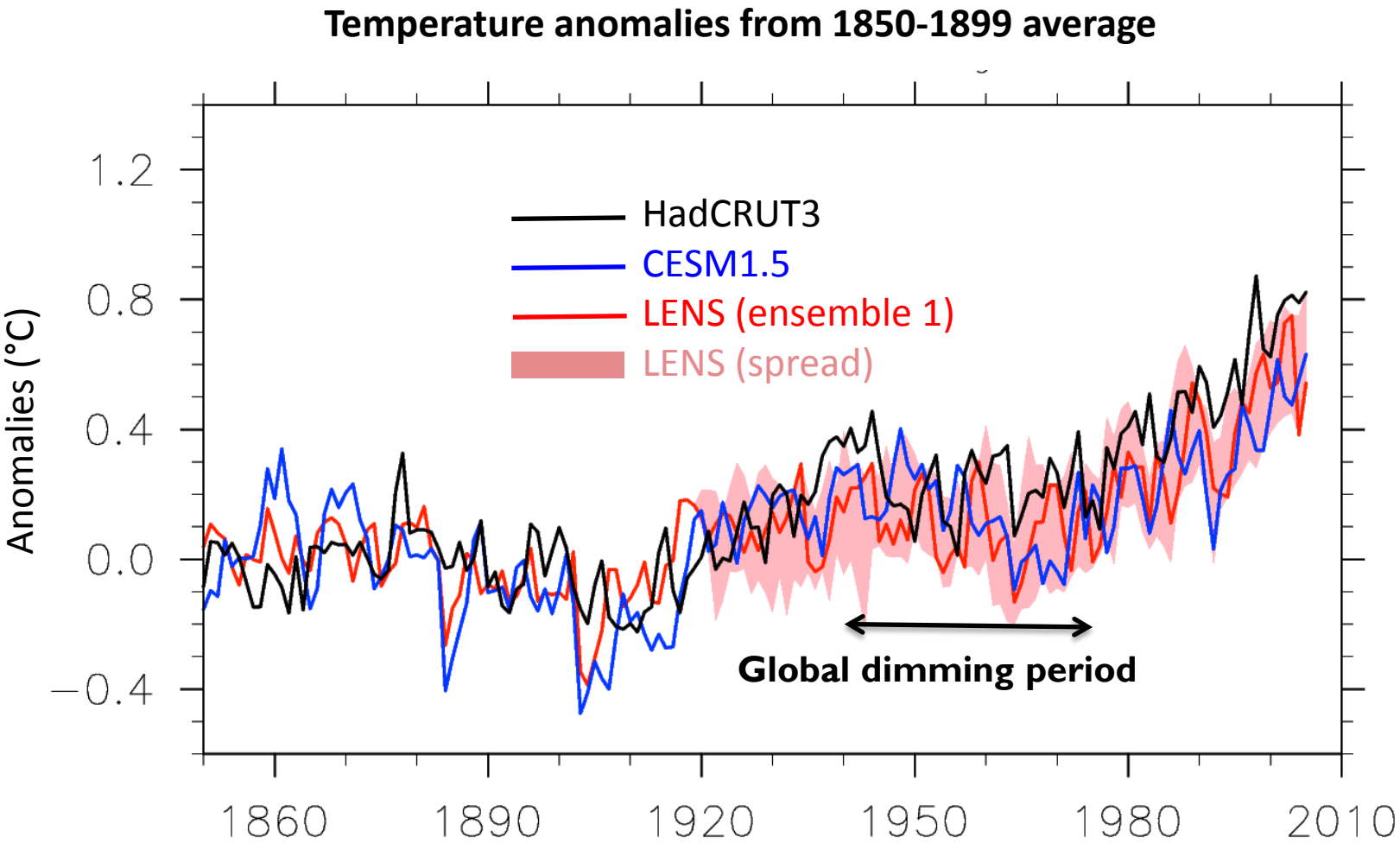
20th Century Global Surface Temperature



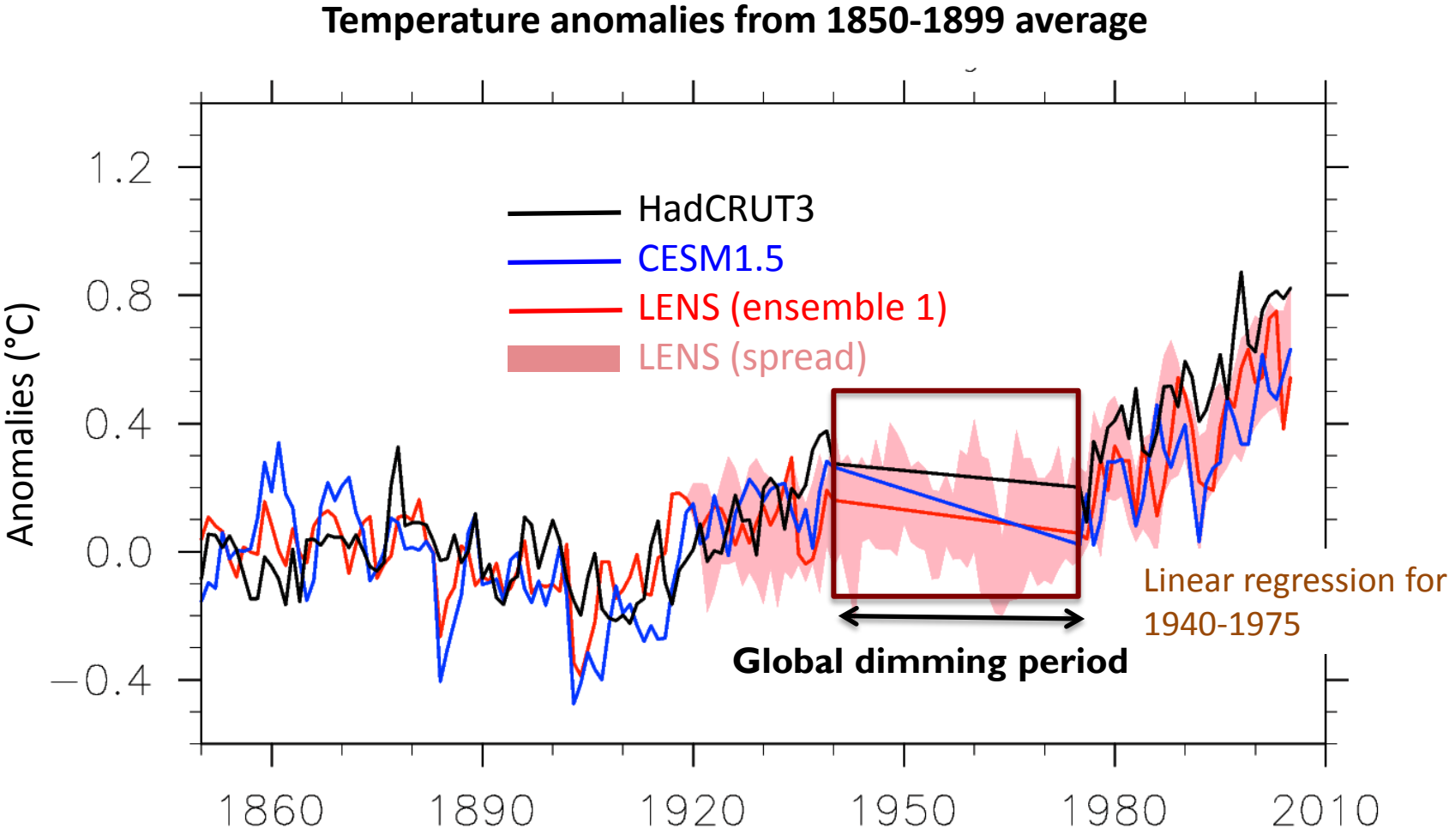
➔ **CESM1.5 is more or less in the spread of LENS**

➔ **LENS is warming a bit less than the HadCRUT3**

20th Century Global Surface Temperature



20th Century Global Surface Temperature

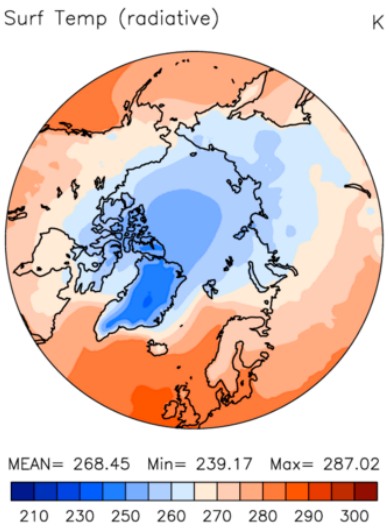


➔ **Aerosol indirect effect is strong in CESM1.5**

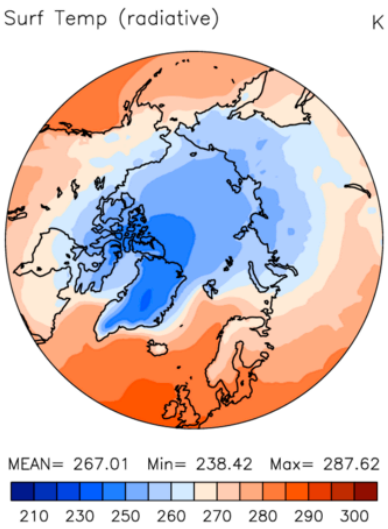
➔ **Currently exploring ways to reduce it (new autoconversion)**

Arctic Surface Temperature (ANN)

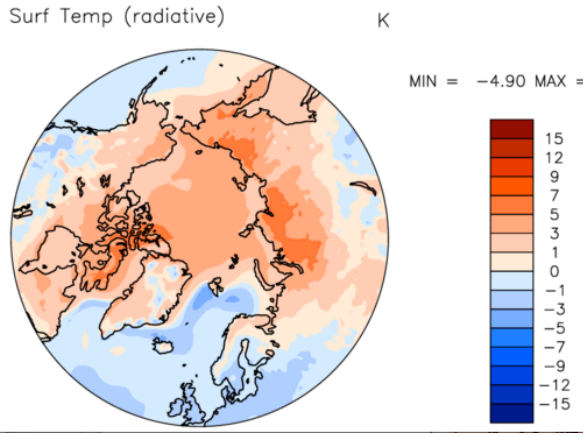
CESM1.5



LENS



CESM1.5 - LENS



➔ **Arctic TS is warmer in CESM1.5 than in LENS**

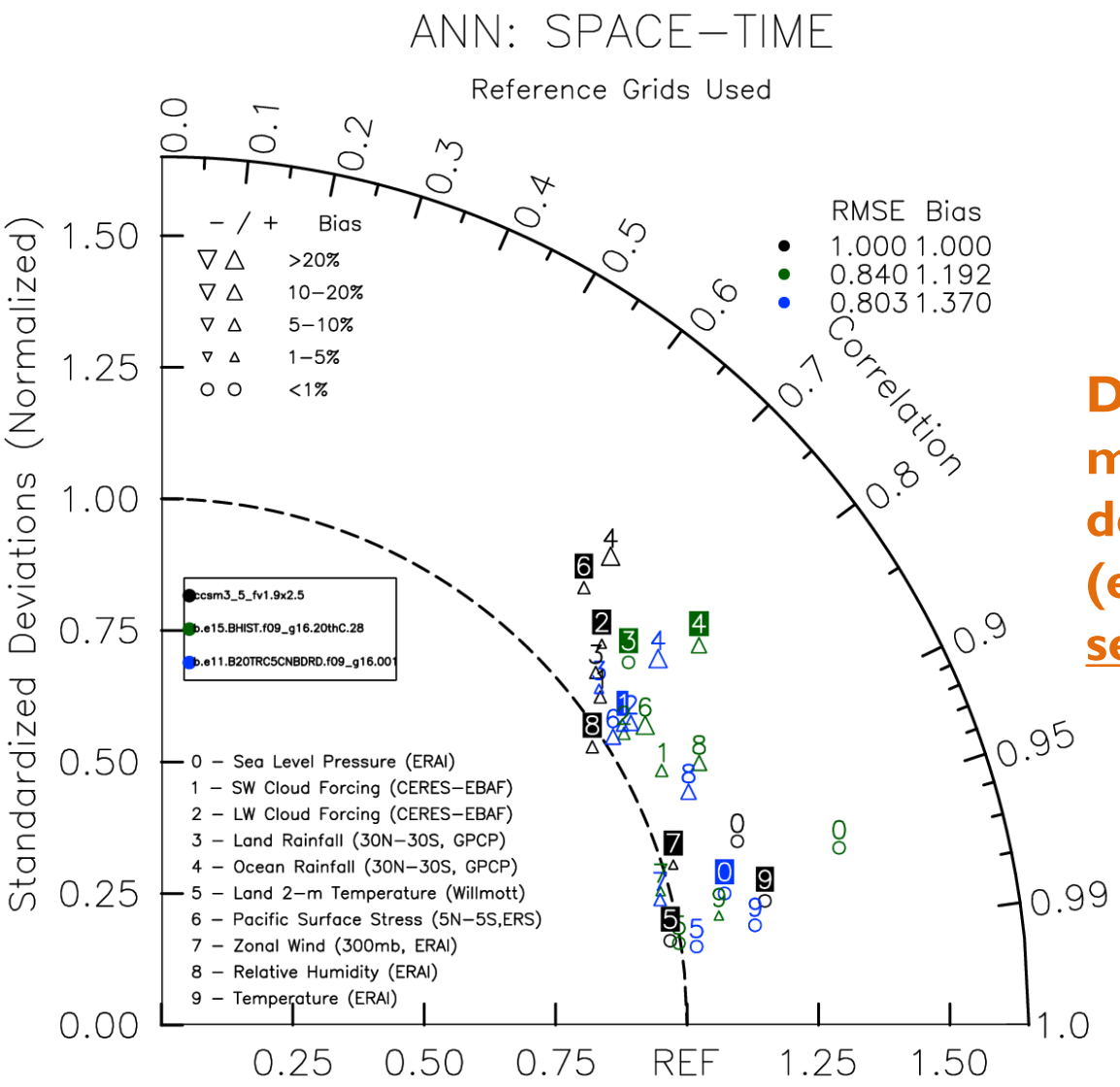
Now who do we blame ?

Intermediate simulations show that

➔ **Arctic TS is very sensitive to CLM albedo and evaporation**

➔ **CAM also contributes to Arctic warming**

Taylor scores in LENS and CESM1.5



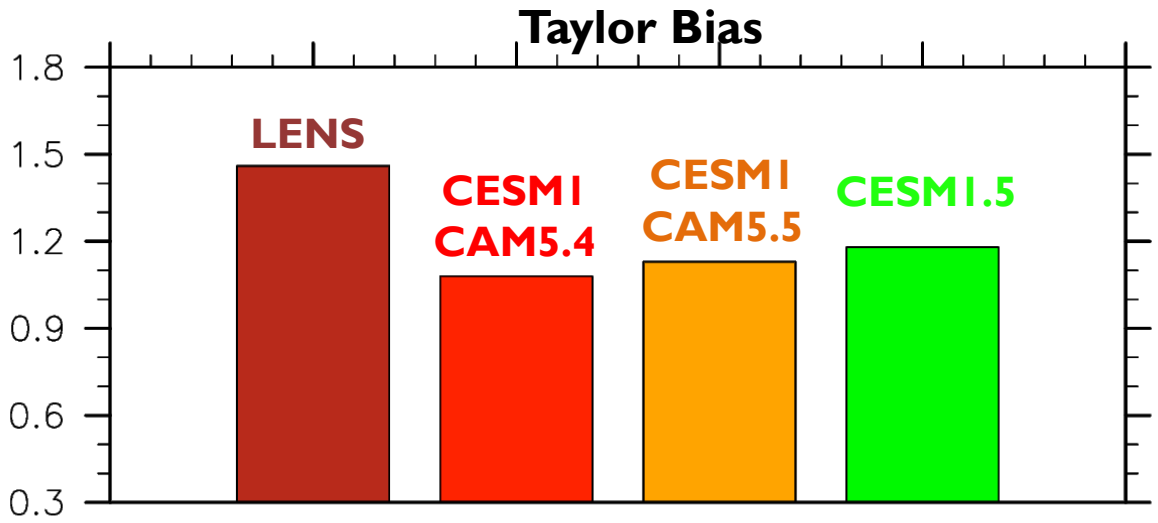
	RMSE	Bias
CESM1.5	0.84	1.19
LENS	0.80	1.37

Degraded RMSE in CESM1.5 mainly comes from degradation in rainfall (especially over land) and sea-level pressure

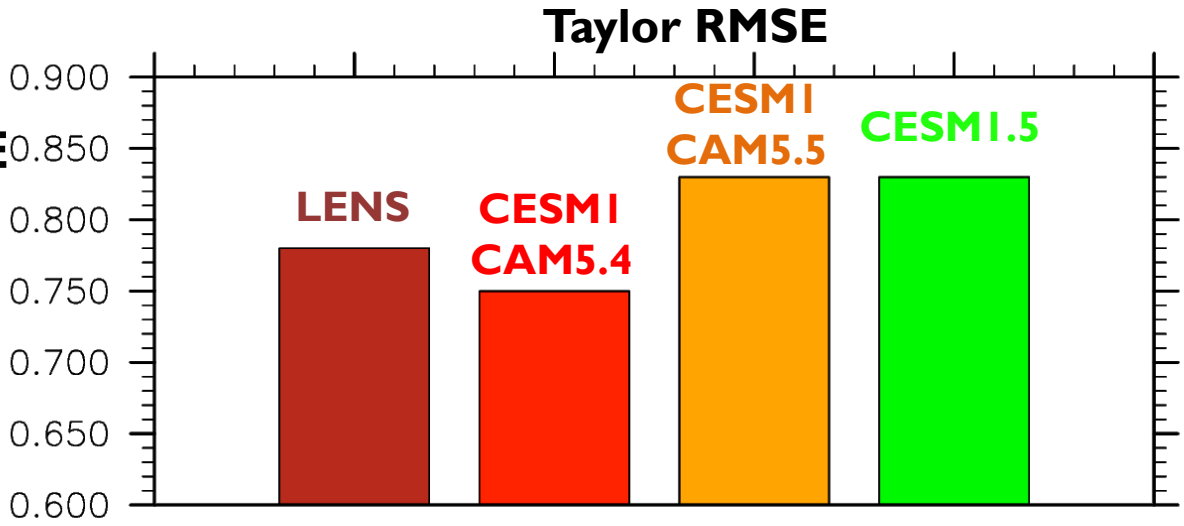
Now who do we blame ?

Evolution of the Taylor scores since LENS

Improvement in Taylor bias starting with CAM5.4

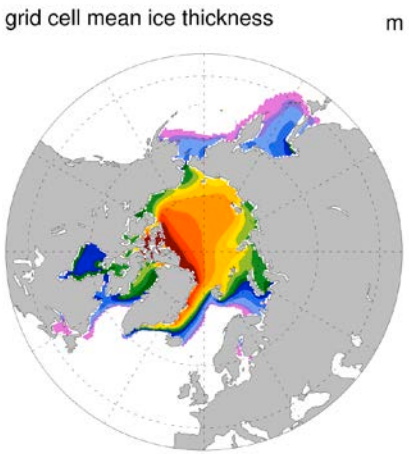


Degradation in Taylor RMSE starting with CAM5.5

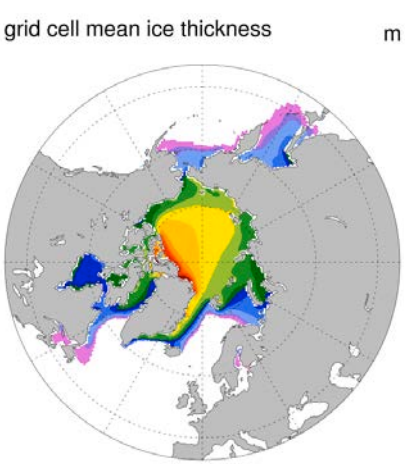


Sea-ice thickness

LENS

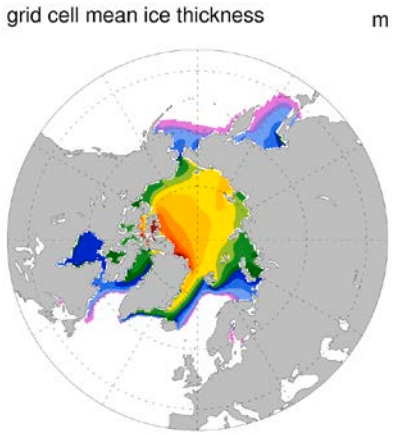


CESM1/CAM5.4

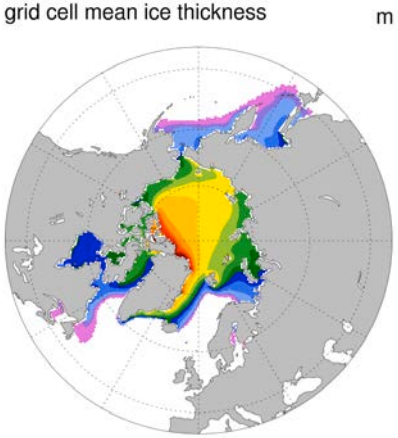


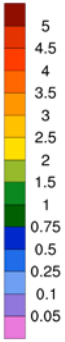
➔ It started with the introduction of CAM5.4

CESM1.5



CESM1/CAM5.5

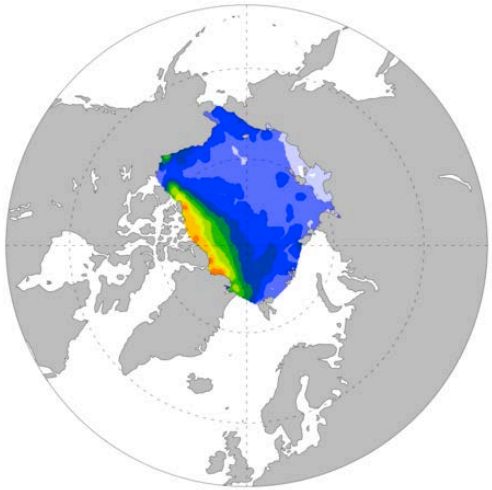




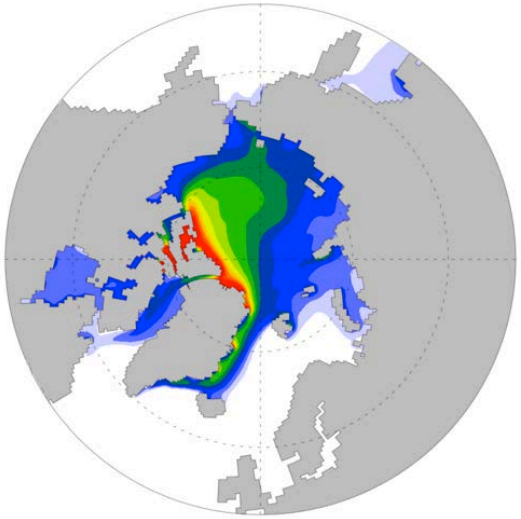
➔ Sea-ice is thinner in CESM1.5 than LENS (despite colder North Atlantic)

Sea-ice thickness at the end of the 20th century

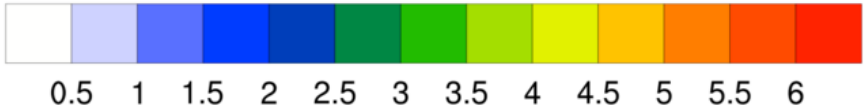
Obs: Ice Sat
2001-2005



LENS
2001-2005



CESM1.5
2001-2005

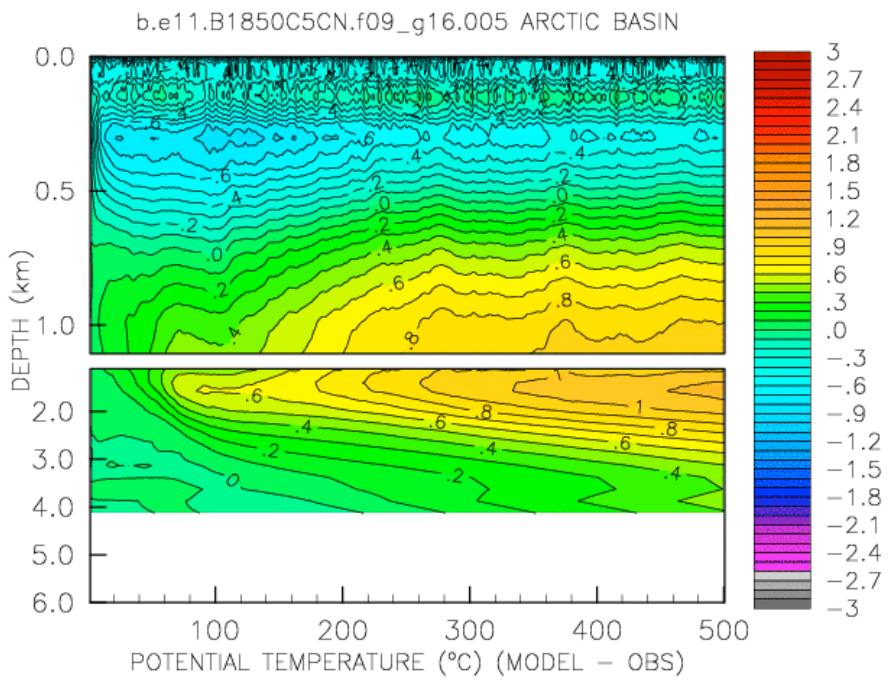


➔ **Sea-ice might be too thin in CESM1.5 (while LENS sea-ice is likely to thick)**

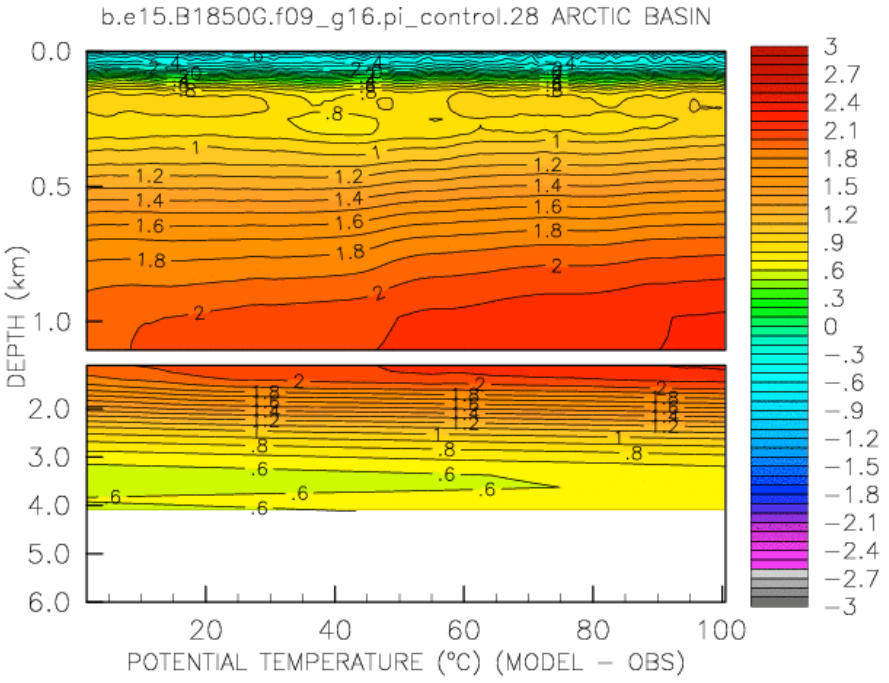
➔ **Tuning of sea-ice albedo can be done if needed**

Ocean Temperature Bias in the Arctic

LENS



CESM1.5



➔ **Sub-surface warming in Arctic ocean**

➔ **This might be a concern (or not)**

Now who do we blame ?

➔ **Already was in CAM5.5 but amplified when adding other components**

Summary and next steps

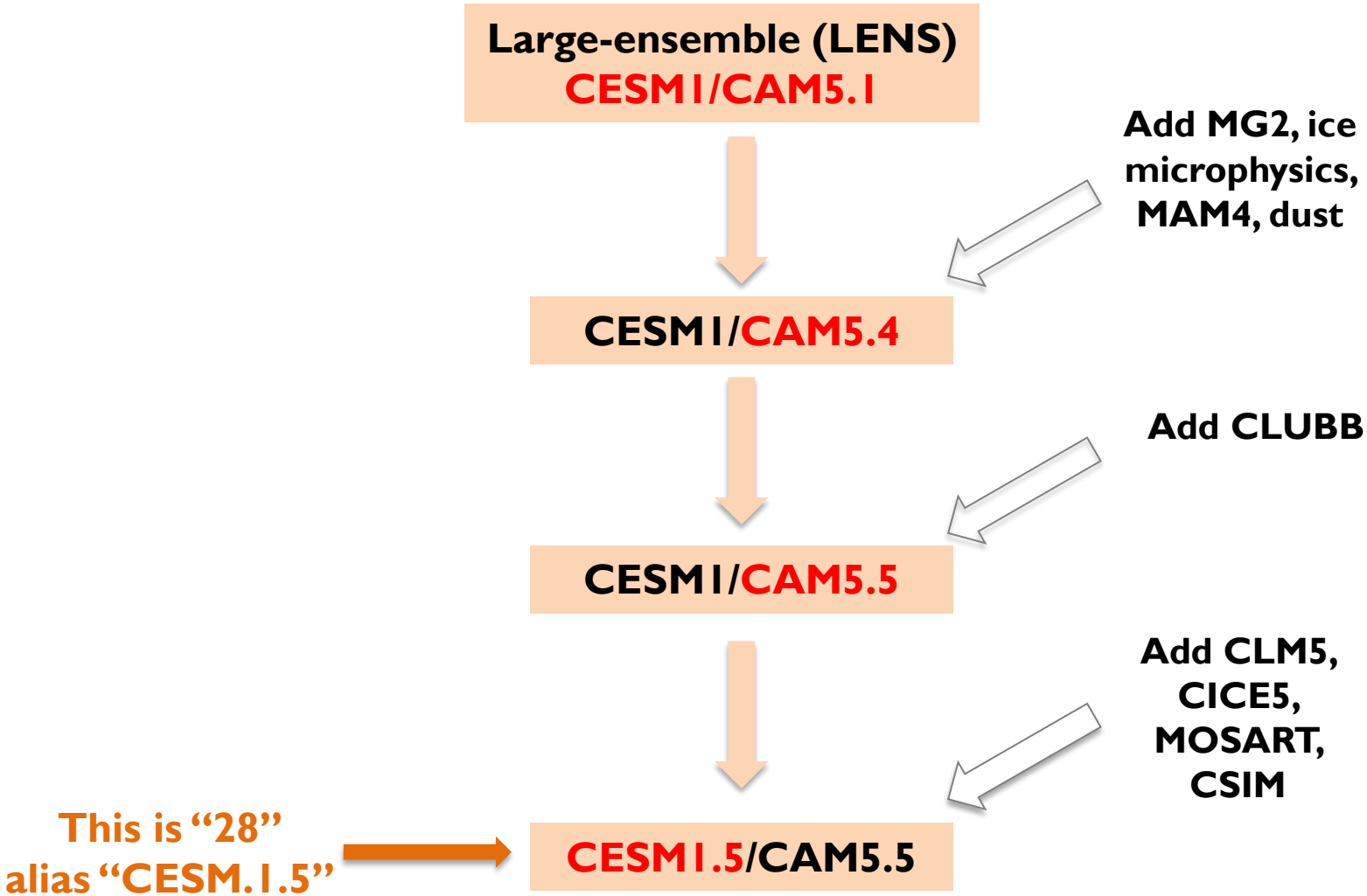
- **We provide a first simulation of CESM1.5**

- **Evolution of biases in CESM1.5 since LENS includes:**
  - **SSTs too cold → everybody but CAM ?**
  - **Precipitation bias over land increases → CAM**
  - **Indirect effect likely too large → CAM**
  - **Sea-ice is thinner in CESM1.5 → CAM ?**
  - **Arctic ocean 1-km warm layer → everybody ?**
  - **Arctic TS is warmer in CESM1.5 than in LENS → CLM and CAM ?**

Now who do we blame ?

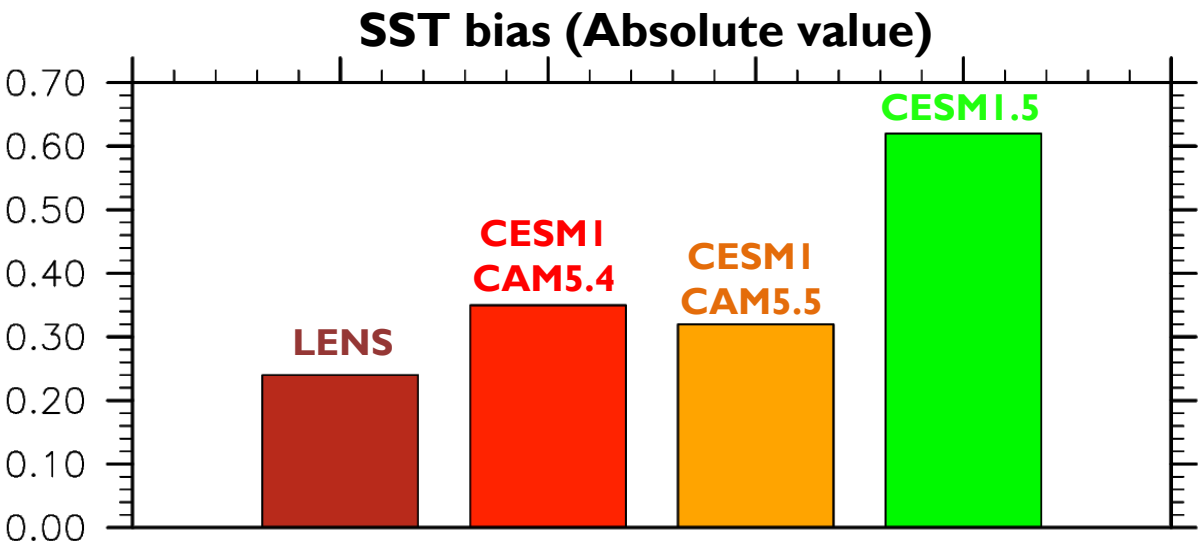
- **Some of the next steps involve:**
  - **New set of tuning parameters to improve SSTs and precipitation biases**
  - **New autoconversion parameterization to reduce aerosol indirect effect**
  - **Tuning sea-ice albedo to increase ice thickness (if needed)**
  - **And many more … (More details in mini-Breck talks)**

Who are the predecessors ?

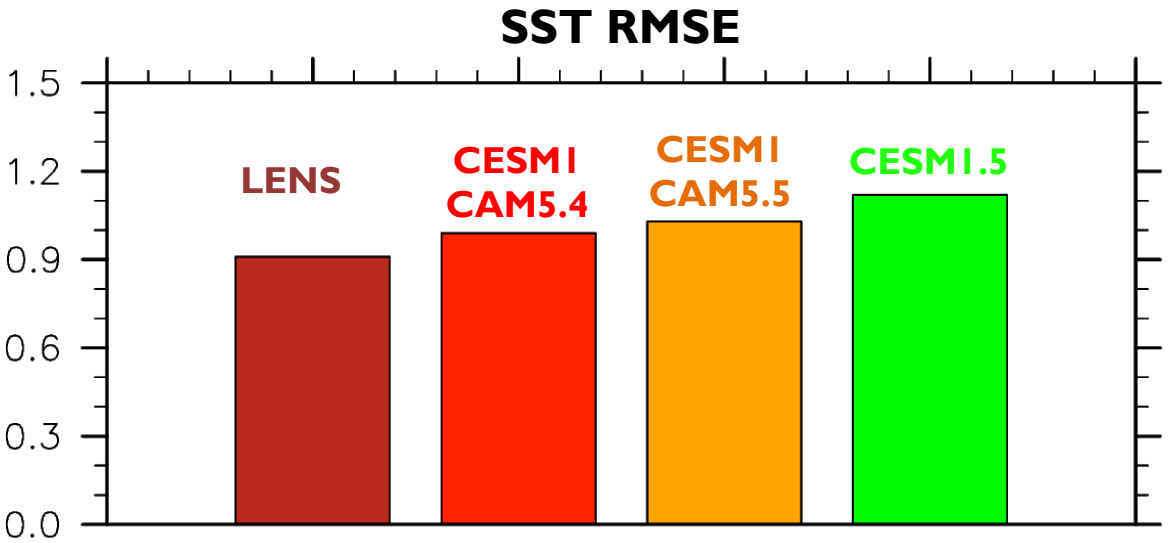


Evolution of the SST bias since LENS

Jump in SST bias when introducing other components



Steady increase in RMSE since LENS



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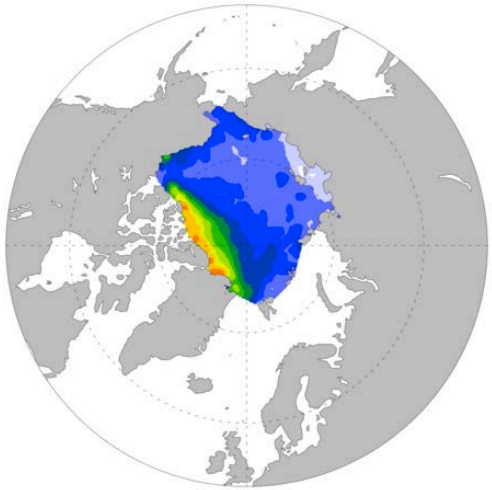
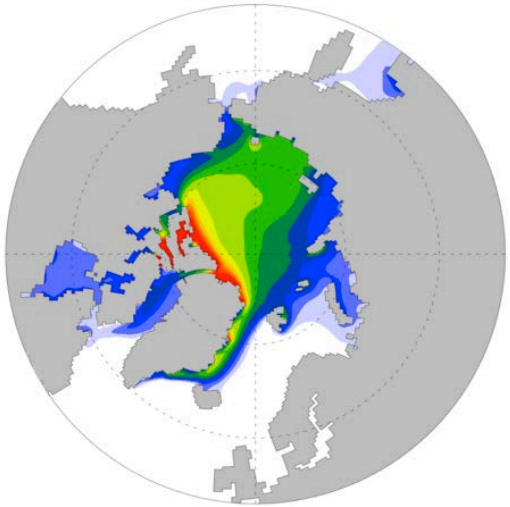
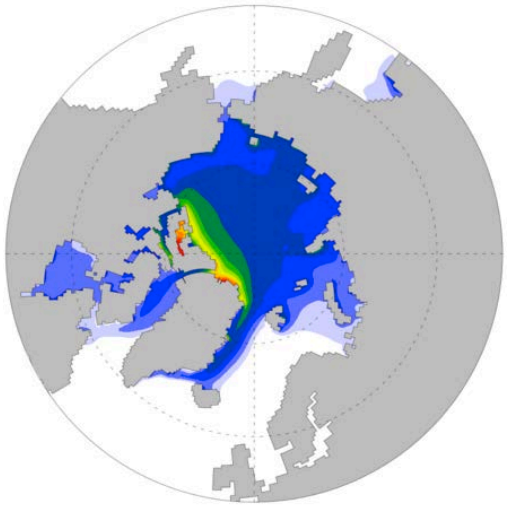
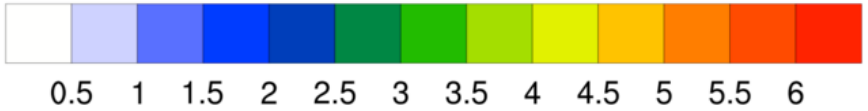


LENS
1981-2005



CESM1.5
1981-2005





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➔ **Tuning of sea-ice albedo can be done if needed**