CESM1-CAM5
1 degree coupled simulation

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What's new since Breckenridge ?

CESM1-CAM5 simulations include:

- **CAM5.1: includes some bugfixes + retunings**
- **1-degree resolution**
- **Use CLM4CN (prognostic carbon and nitrogen cycle in the land model)**

What's in CAM5.1

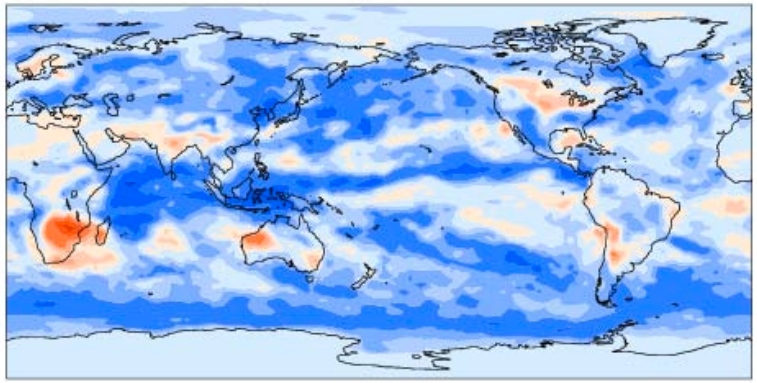
- **CAM5.1 = CAM5 + several bug fixes**

- **Changes: small effect except …**

  bug fix for size of snow particles used in radiation

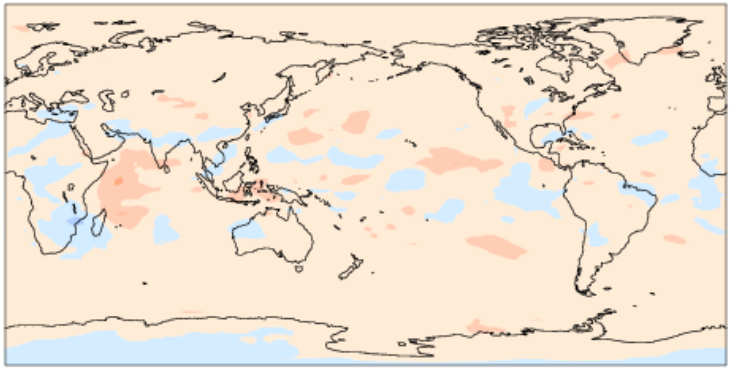
  snow particles smaller -> more reflective -> large impact

SWCF, ANN

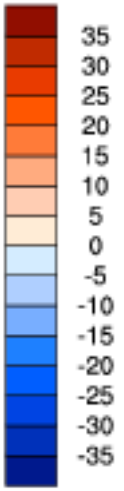


Mean = -3.52 W/m2

LWCF, ANN



Mean = 2.30 W/m2



- **Change required retuning**

Model versions and simulations

Models versions

- **CCSM4: CAM4 – 1deg (released in April 2010)**
- **CESM1: CAM5 – 2deg (released in June 2010)**
- **CESM1: CAM5.1 – 1deg (will be released soon)**

Simulations

- **1850 control**
- **20th century**
- **Climate sensitivity simulation (SOM)**
- **Aerosol indirect effect**

Model versions and simulations

Models versions

- **CCSM4: CAM4 – 1deg => CAM4 (1deg)**
- **CESM1: CAM5 – 2deg => CAM5 (2deg)**
- **CESM1: CAM5.1 – 1deg => CAM5.1 (1deg)**

Simulations

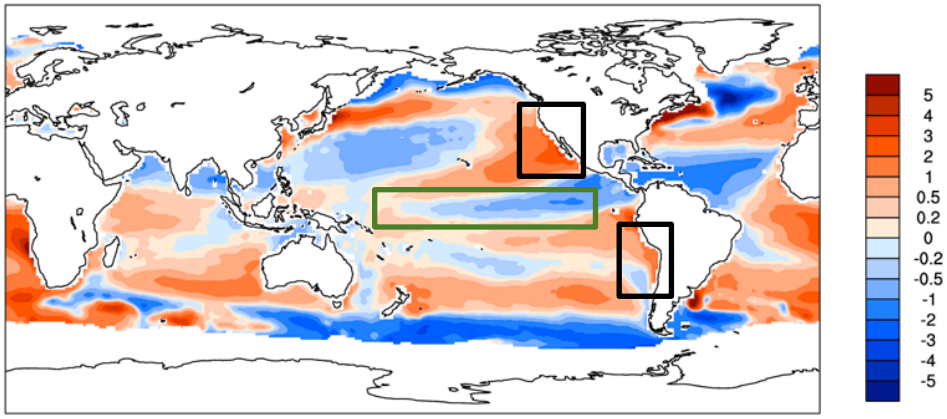
- **1850 control**
- **20th century**
- **Climate sensitivity simulation (SOM)**
- **Aerosol indirect effect**

1850 controls: SSTs versus Hurrell 2008

- **Temperature errors:**
  Model versus Hurrell 2008
- **RMSE reduced in CAM5.1, 1 deg**
- **Error in key regions (Eastern ocean, Pacific cold tongue)**

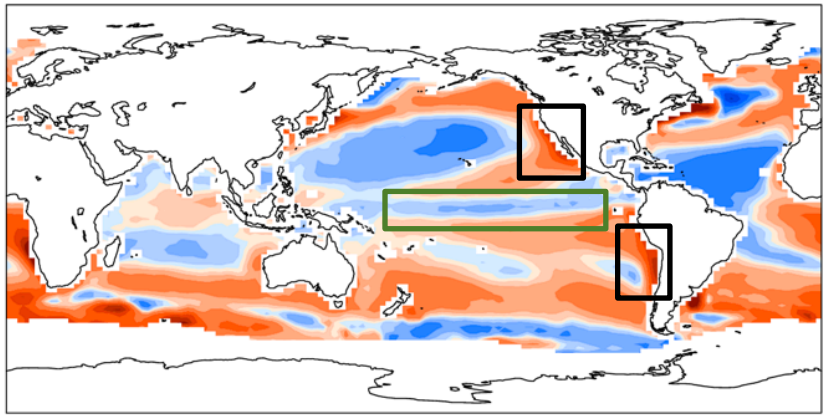
CAM4 – 1deg

Mean = 0.18
RMSE = 1.07



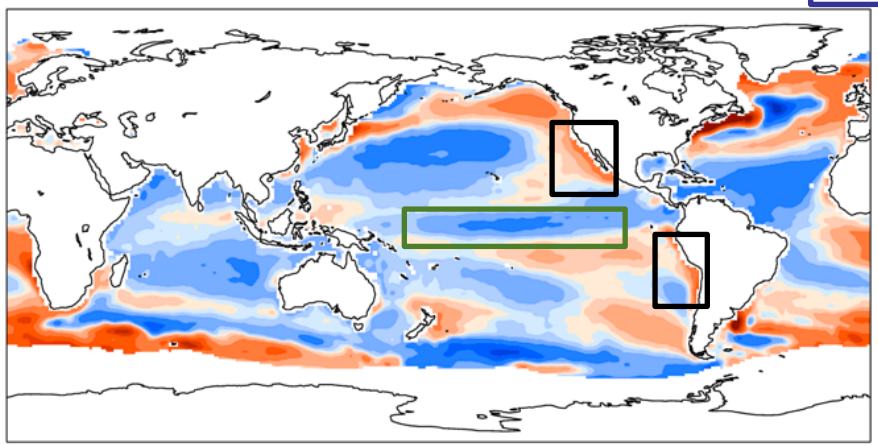
CAM5 – 2deg

Mean = 0.42
RMSE = 1.17

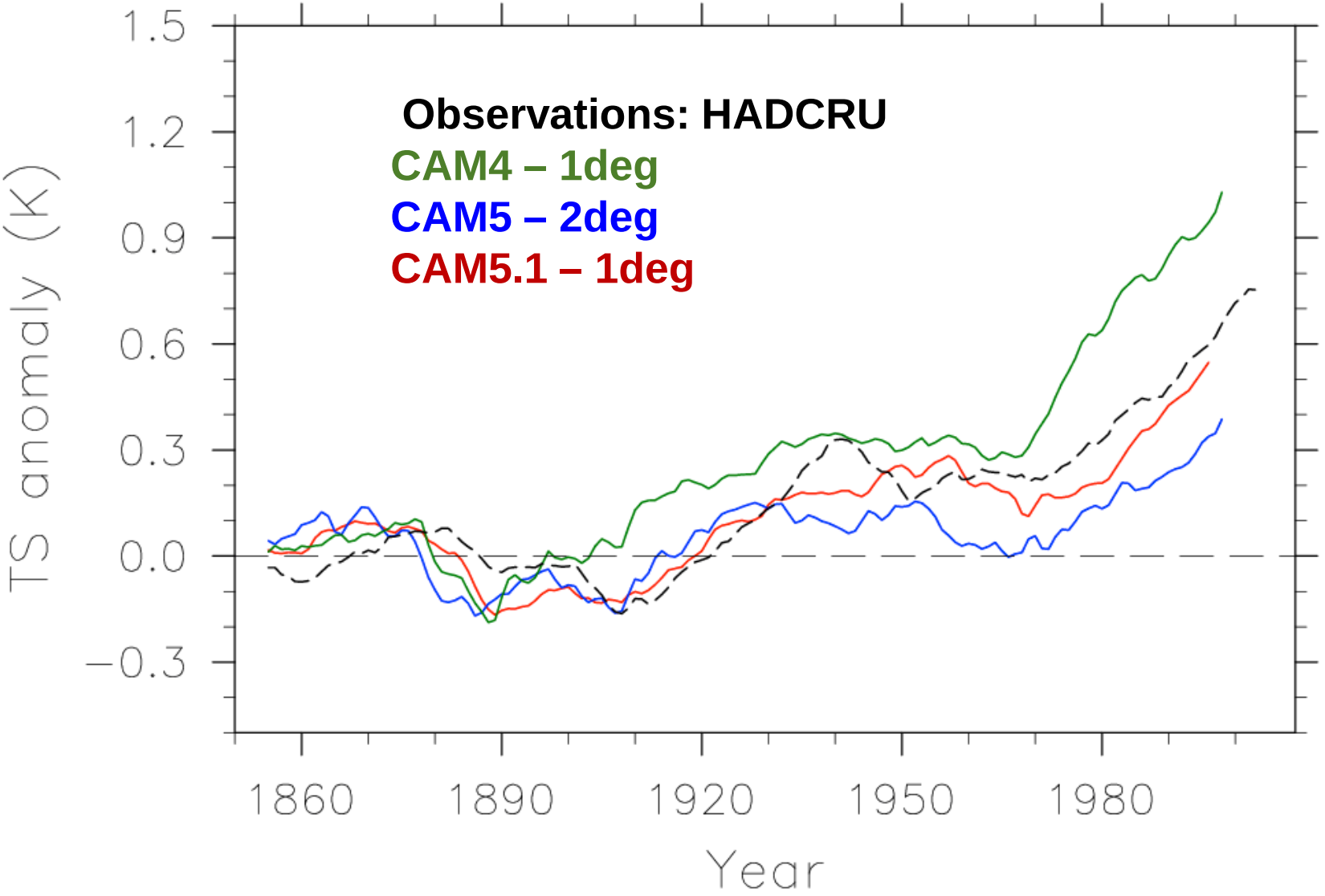


CAM5.1 – 1deg

Mean = -0.10
RMSE = 0.94



20th century: Surface temperature



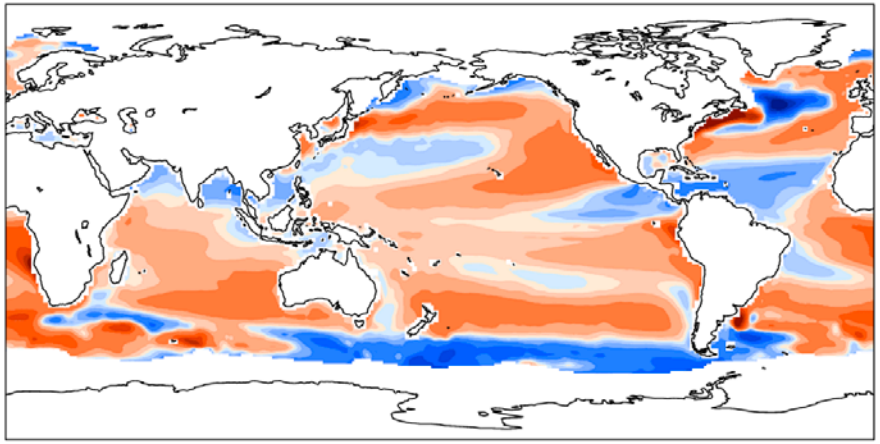
Late 20th century: SSTs versus Hurrell 2008

- **Temperature errors:**
  Model versus Hurrell 2008

CAM4: too much warming
CAM5.1: 20th century ends up a bit too cold

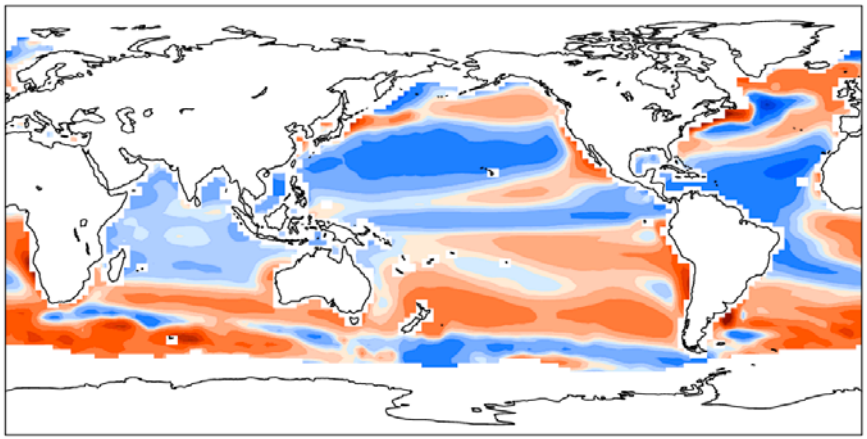
CAM4 – 1deg

Mean = 0.40
RMSE = 1.09



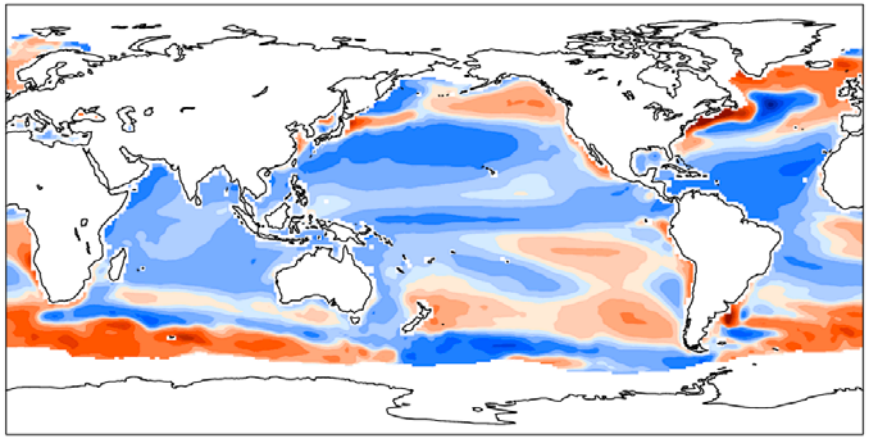
CAM5 – 2deg

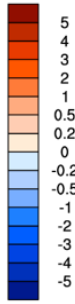
Mean = 0.12
RMSE = 1.07



CAM5.1 – 1deg

Mean = -0.21
RMSE = 0.97





Late 20th century: 2-meter Temperature

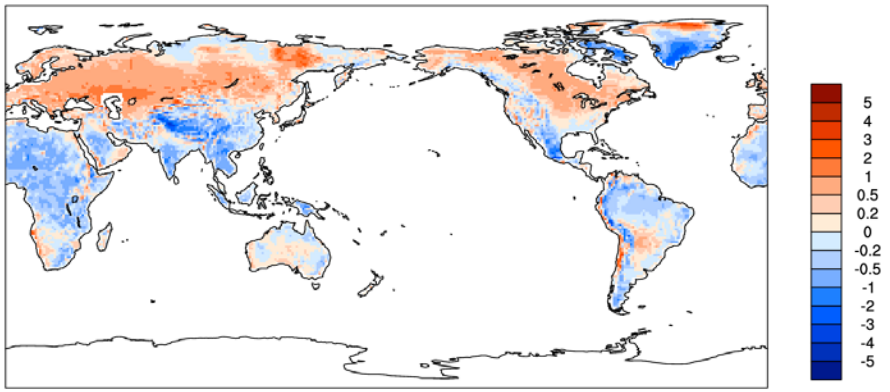
- **Temperature errors:**
  Model versus CRU

- **CAM4: warming too much at mid-latitudes (no indirect effect)**

- **CAM5.1: not enough polar amplification**

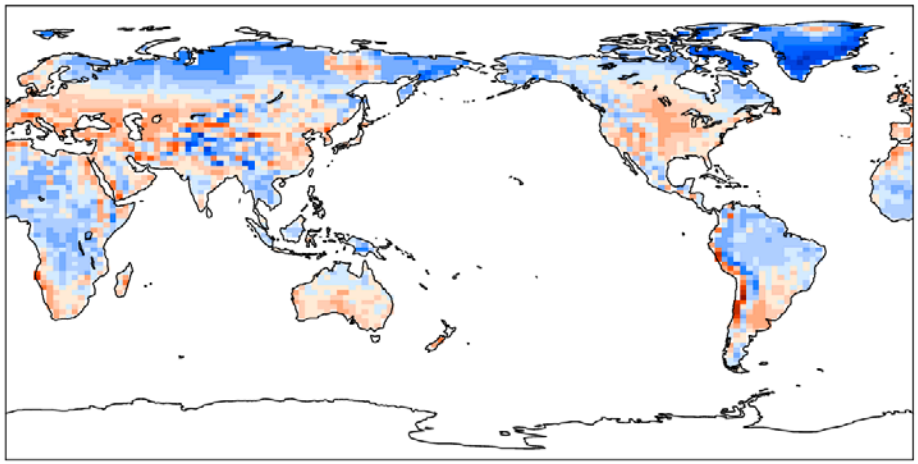
CAM4 – 1deg

Mean = 0.02
RMSE = 2.13



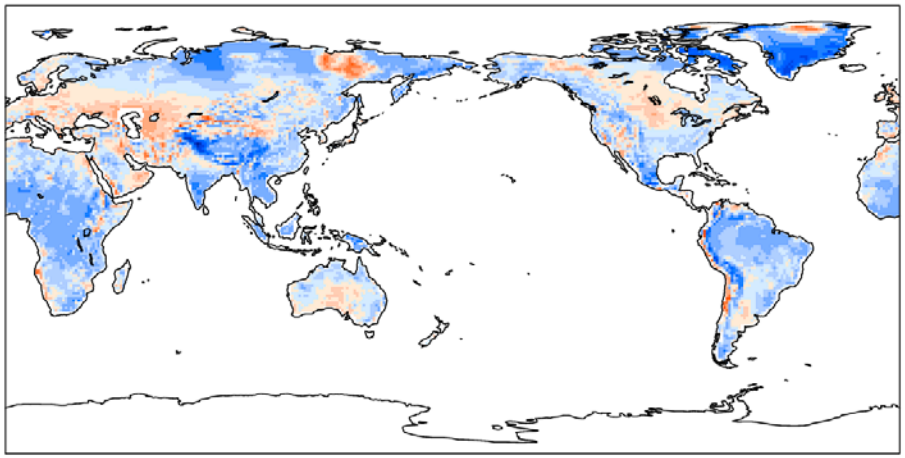
CAM5 – 2deg

Mean = -0.29
RMSE = 2.36



CAM5.1 – 1deg

Mean = -0.81
RMSE = 2.05



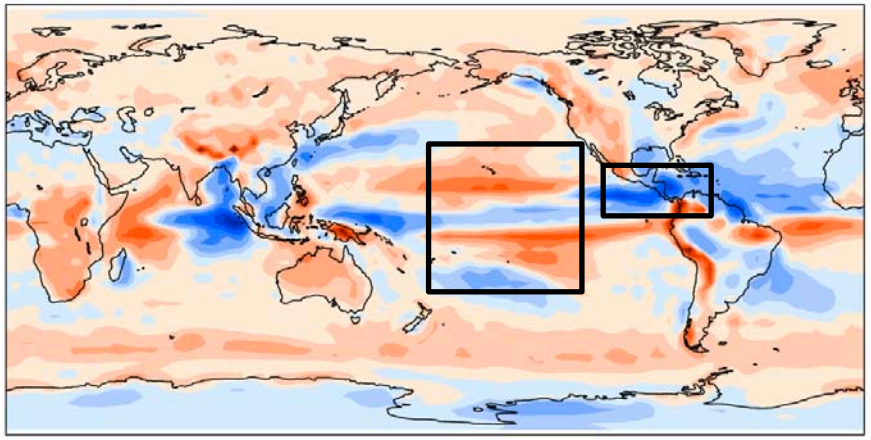
Late 20th century: precipitation versus CMAP

- **Temperature errors:**
  Model versus CMAP (Xie-Arkin)

- **Local improvements but globally, no significant improvement with CAM5 (twin ITCZ still present)**

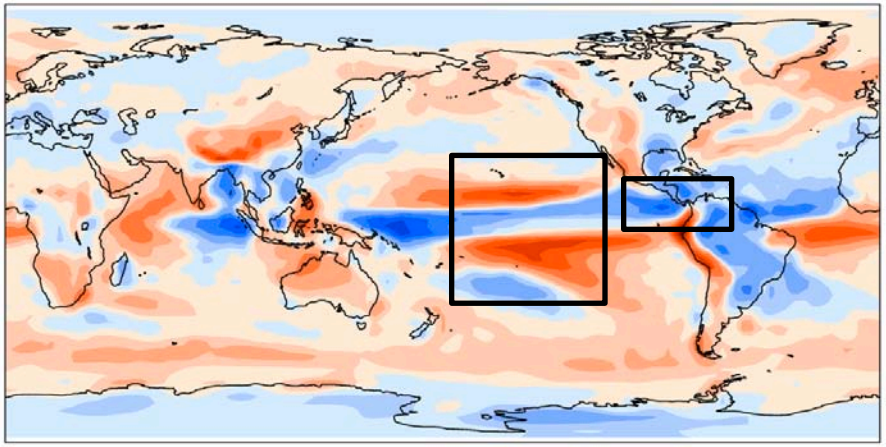
CAM4 – 1deg

Mean = 0.27
RMSE = 1.09



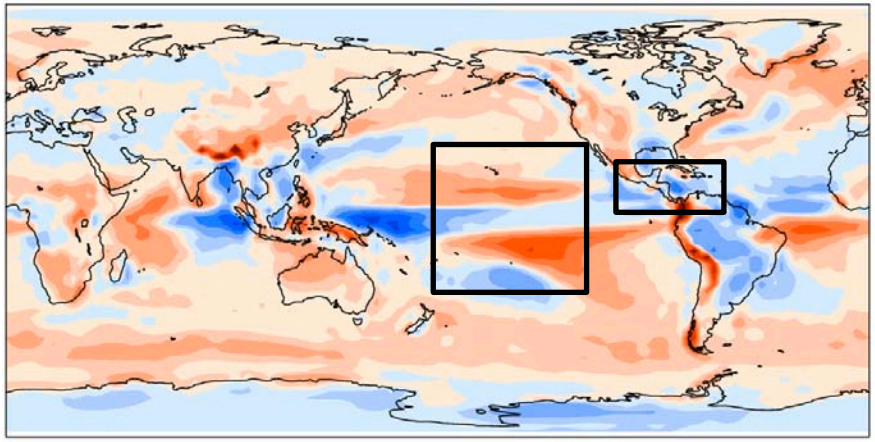
CAM5 – 2deg

Mean = 0.27
RMSE = 1.14



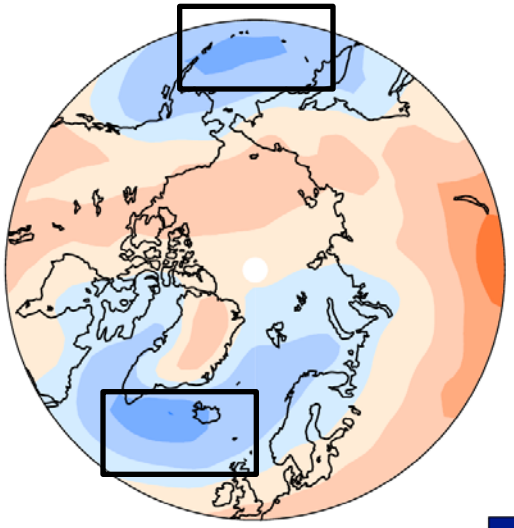
CAM5.1 – 1deg

Mean = 0.34
RMSE = 1.06

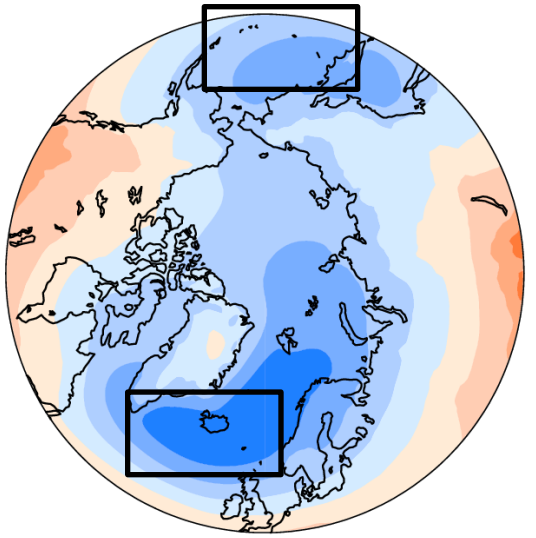


Late 20th century: SLP versus NCEP

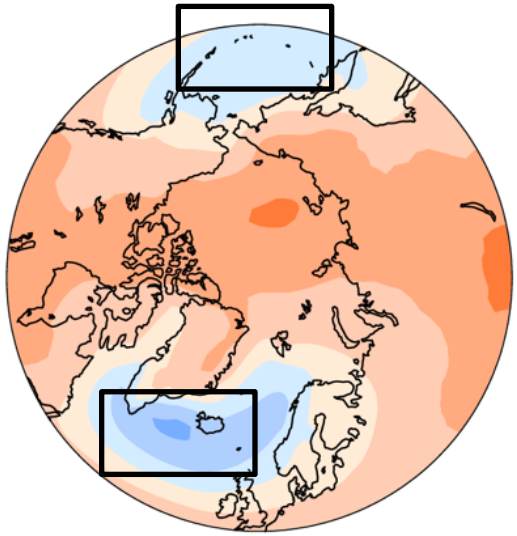
NCEP



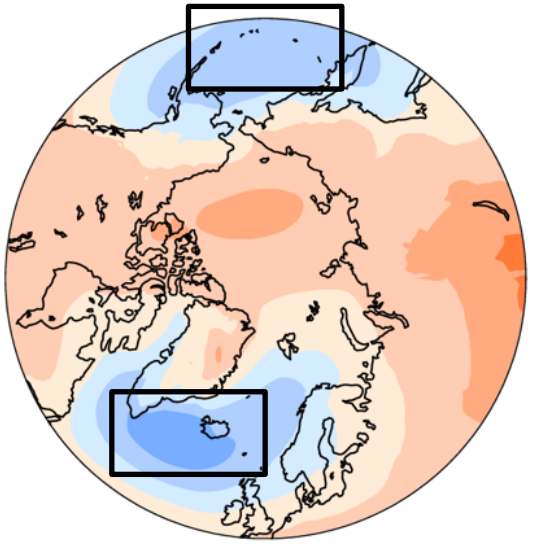
CAM4
1deg



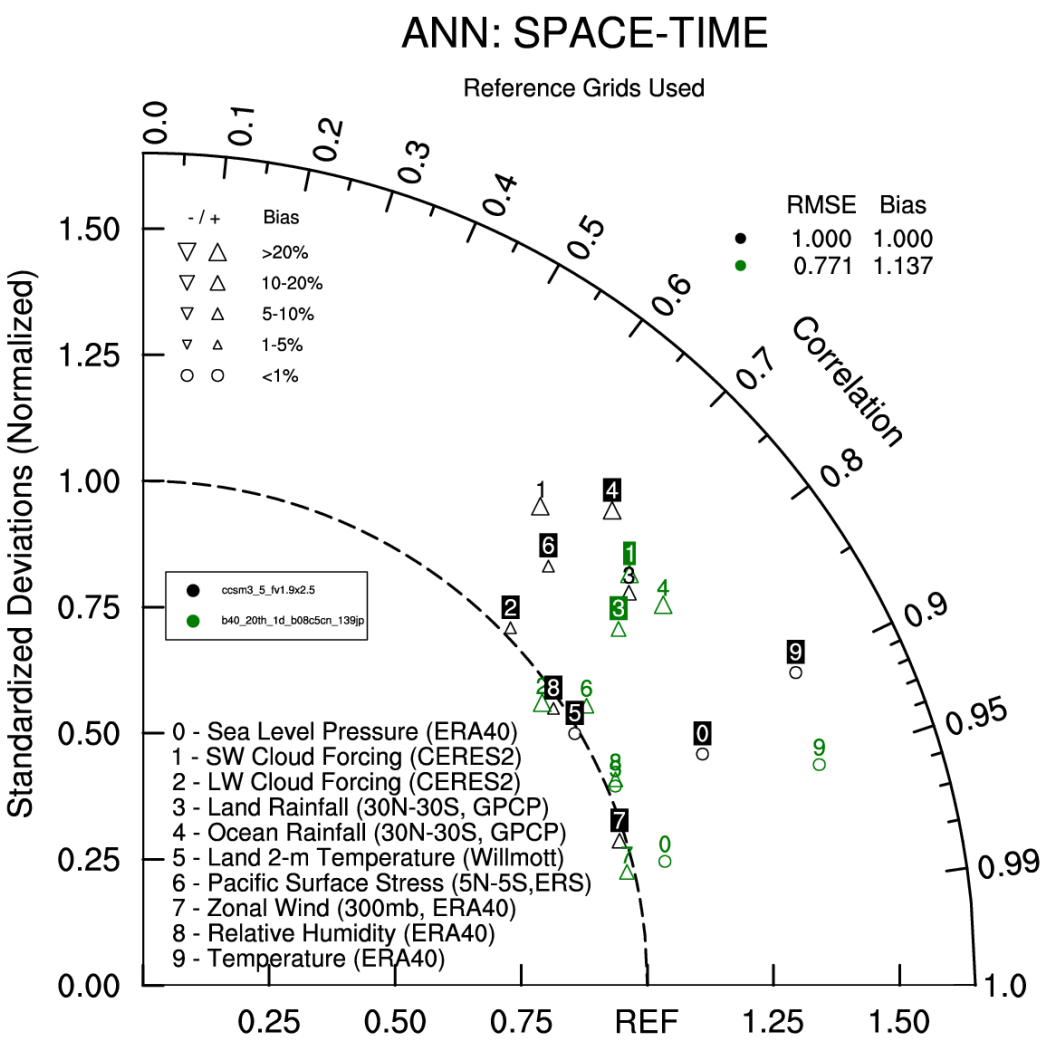
CAM5
2deg



CAM5.1
1deg



Late 20th century: Taylor diagrams



CAM3.5 – 2deg

Bias = 1.0
RMSE = 1.0

CAM4 – 1deg

Bias = 0.88
RMSE = 0.88

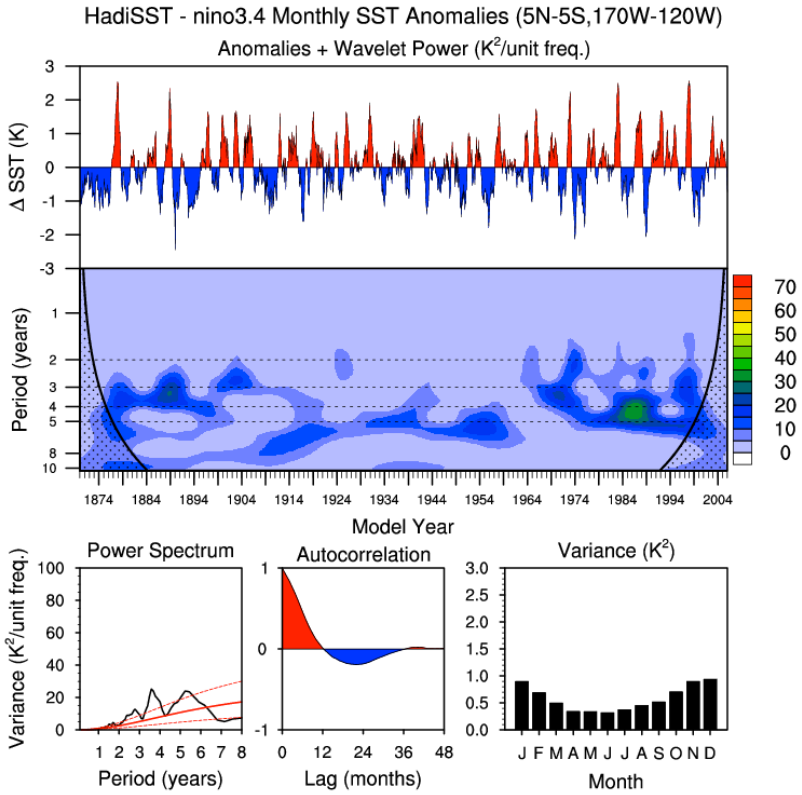
CAM5 – 2deg

Bias = 1.09
RMSE = 0.86

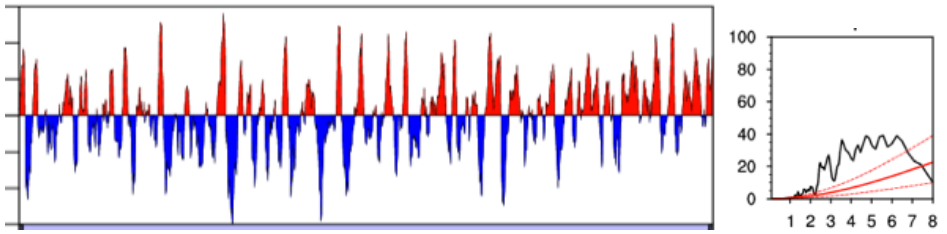
CAM5.1 – 1deg

Bias = 1.14
RMSE = 0.77

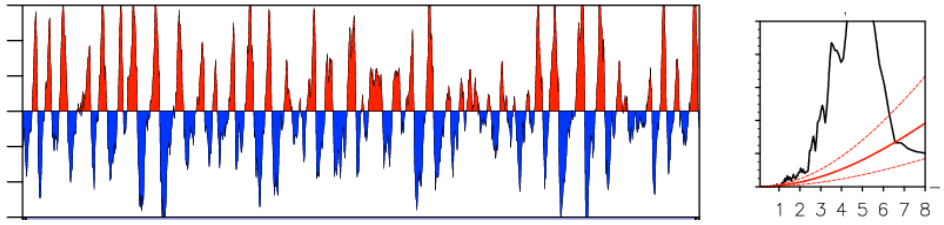
ENSO: nino3.4 over 20th century



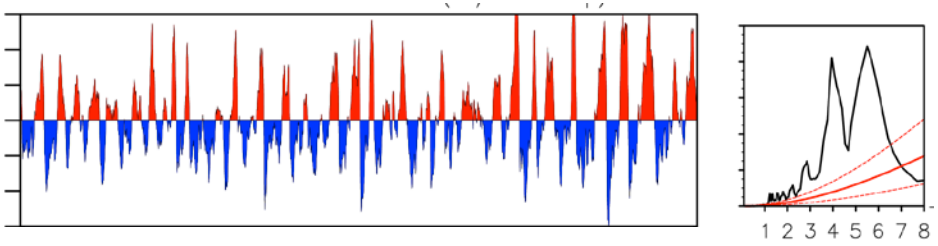
CAM4-1deg



CAM5-2deg



CAM5.1-1deg



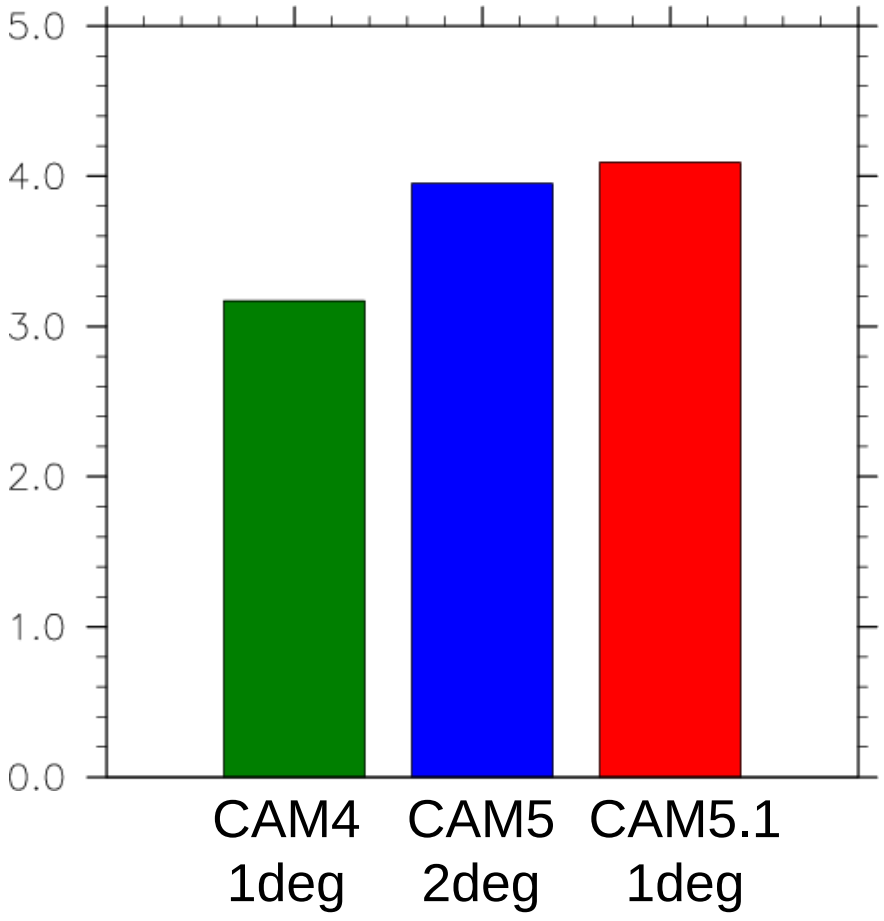
- **CAM4: good simulation of nino3.4**
- **CAM5: amplitude too large**
- **CAM5.1: amplitude somewhat reduced**

Climate sensitivity

- **Change in SST at equilibrium due to a doubling of CO2**

- **Sensitivity is obtained from SOM simulations**

- **Qflux is obtained from a 50-year period of a well-balanced 1850 fully coupled simulation**



CAM4 (1deg) = 3.17 K
CAM5 (2deg) = 3.95 K
CAM5.1 (1deg) = 4.08 K

Aerosol: direct and indirect effect

Direct effect

- aerosols scatter and absorb solar and infrared radiation

Indirect effect

- If aerosols increase => number of cloud droplets increase
  => droplet size decrease
  => for same LWP, clouds are brighter

	Direct effect W/m2 (SW only)	Indirect effect W/m2 (SW+LW)
CAM5 – 2 degree	-0.59	-1.22
CAM5.1 – 1 degree	-0.21	-1.01
IPCC values	-0.5 [-0.9 to -0.1]	-0.7 [-1.8 to -0.3]

Sea-ice thickness: Loss over 20th century

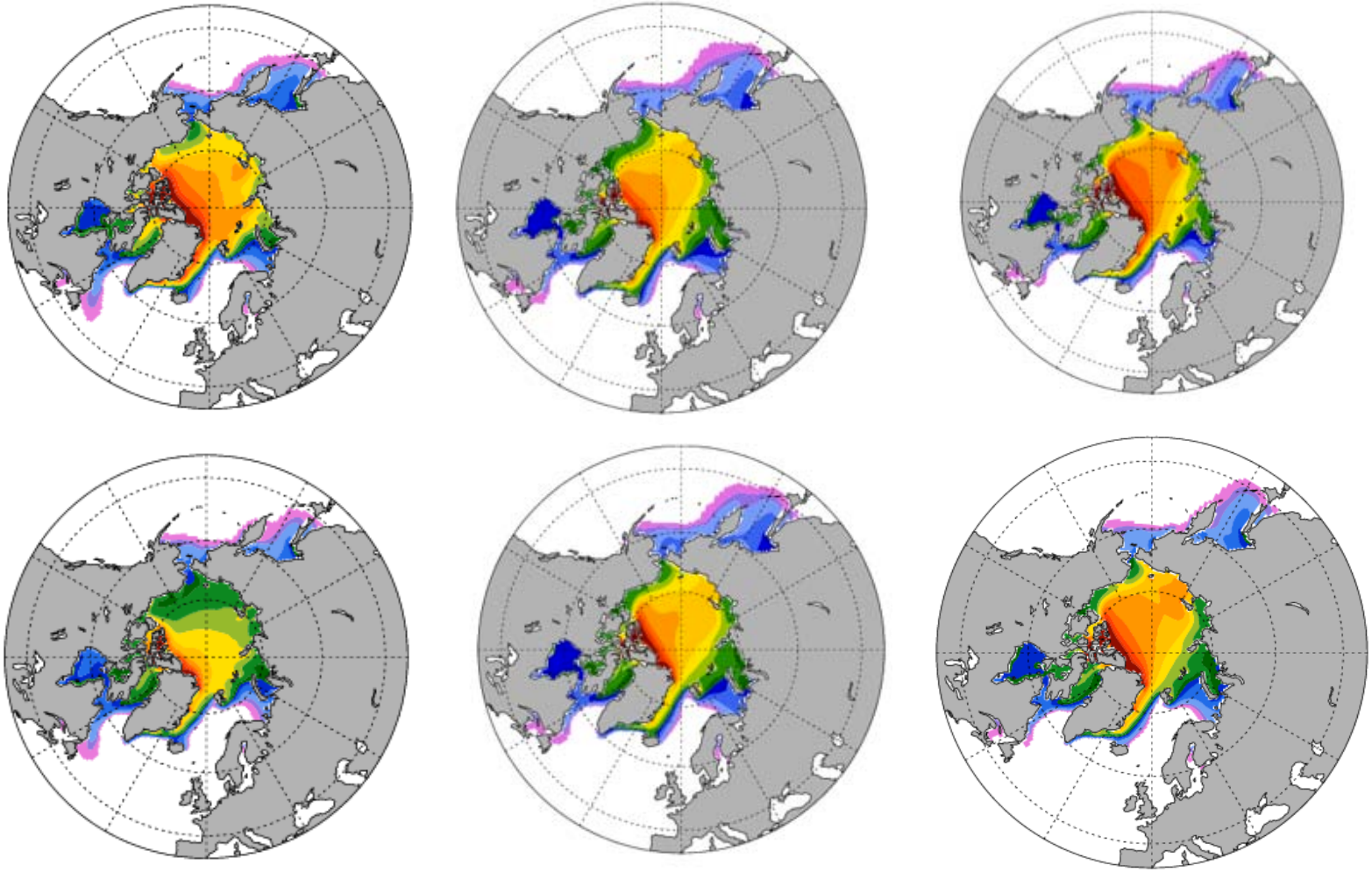
CAM4-1deg

CAM5-2deg

CAM5.1-1deg

1850

Late 20th century



Summary

• **Latest CESM simulations include: CAM5.1 at 1-degree resolution using CLM4CN (prognostic carbon and nitrogen cycle in the land)**

• **Overall, CAM5 produces better simulation than CAM4:**

CAM5-2deg ⇔ CAM4-1deg; CAM5-1deg ⇔ CAM4-0.5deg

More realistic surface temperatures, better scores (Taylor diagrams)
But some biases remain (precipitation, double ITCZ)

• **Climate variability: CAM4 reproduced nino3.4 fairly well, CAM5-2deg: amplitude too large**
CAM5.1-1deg: amplitude reduced.

• **Aerosol direct and indirect effect are reduced in CAM5.1**
AIE: -1.01 W/m2 and ADE: 0.21 W/m2

• **Climate sensitivity is larger in CAM5 (~4K) than in CAM4 (~3.2K). CAM5 and CAM5.1 have similar climate sensitivity**