Biases in means, variability, and trends of air-sea fluxes and SST in the CCSM4

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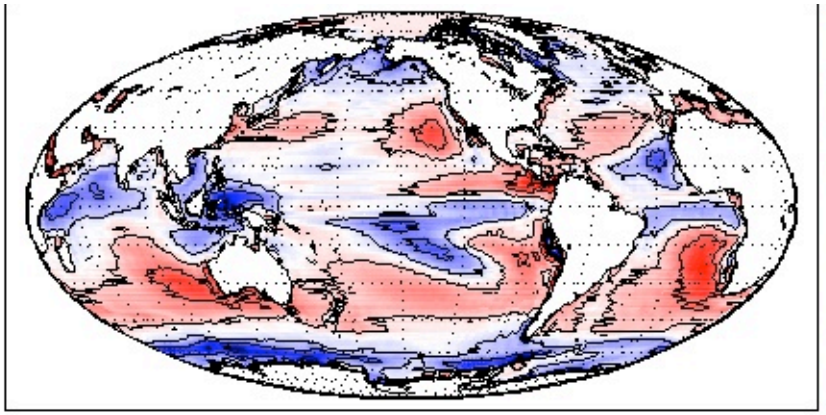
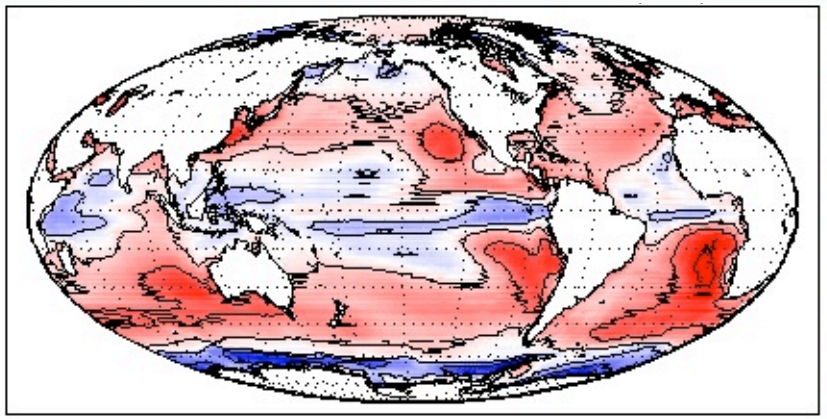
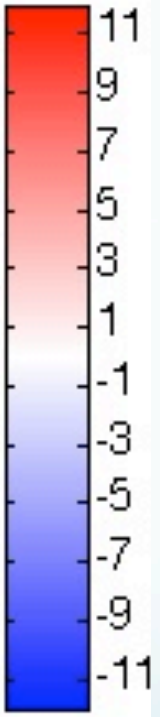
Shortwave radiation bias relative to CORE (W/m^2)

CCSM3-CORE (1980-1999)



CCSM4-CORE (1986-2005)





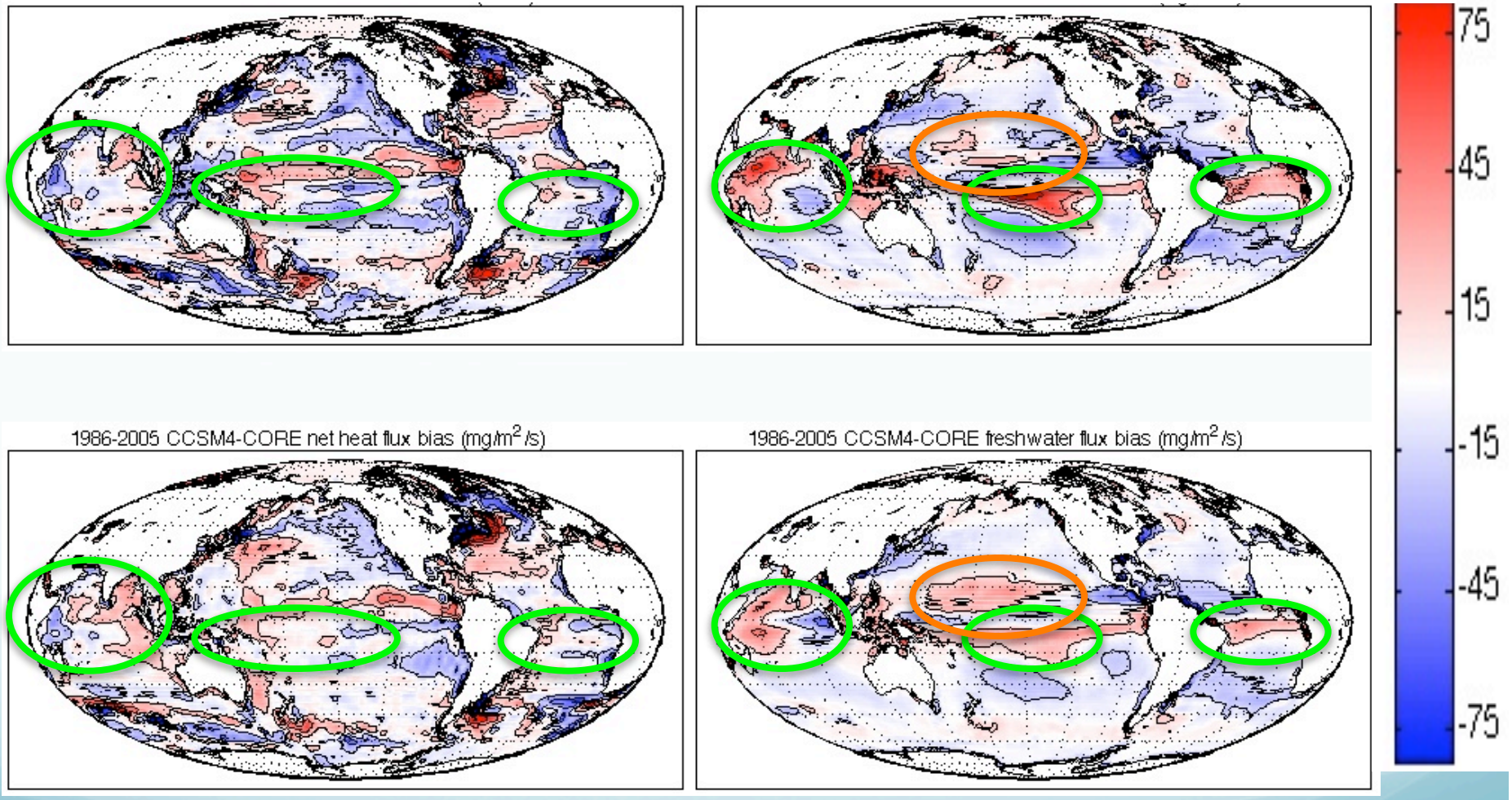
Net flux biases relative to CORE

Net heat flux bias (W/m^2)

Net freshwater flux bias ($mg/m^2/s$)

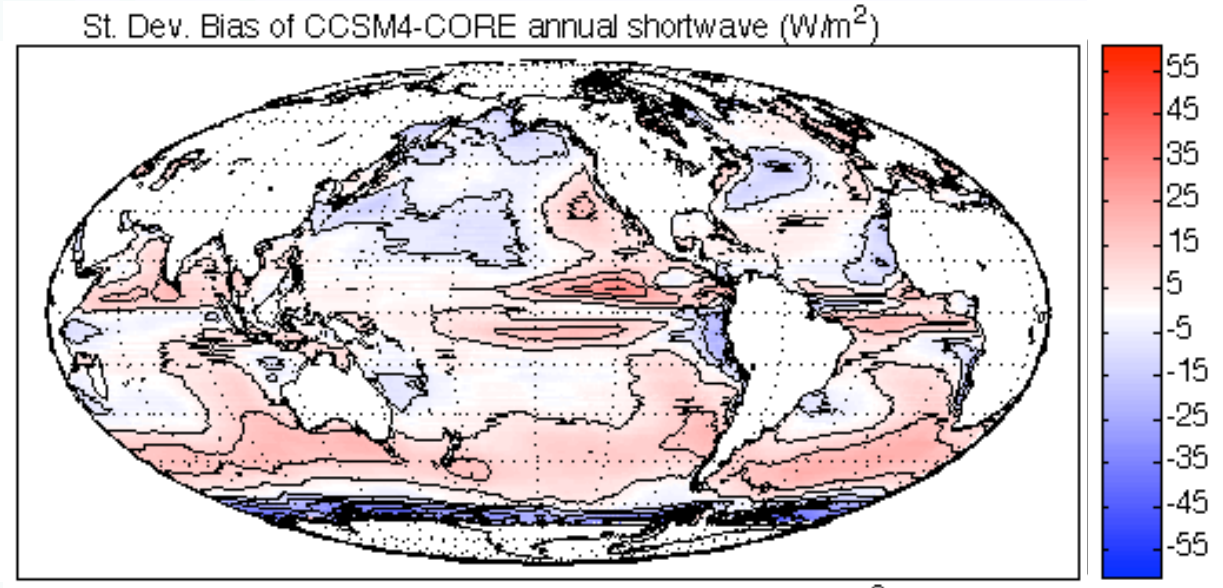
CCSM3-CORE

CCSM4-CORE

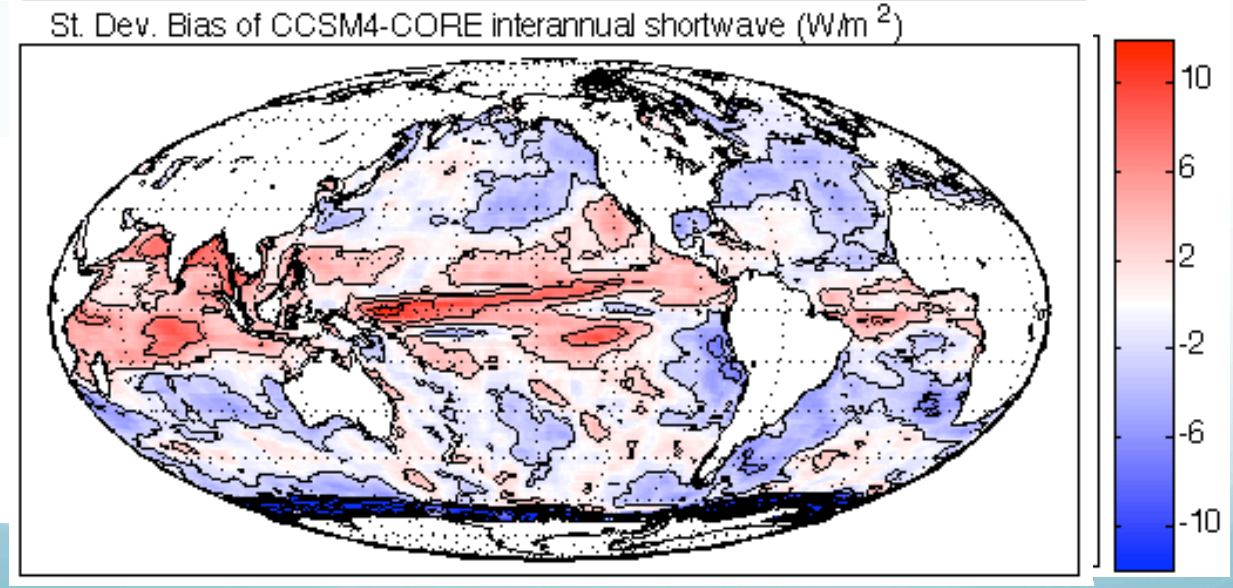


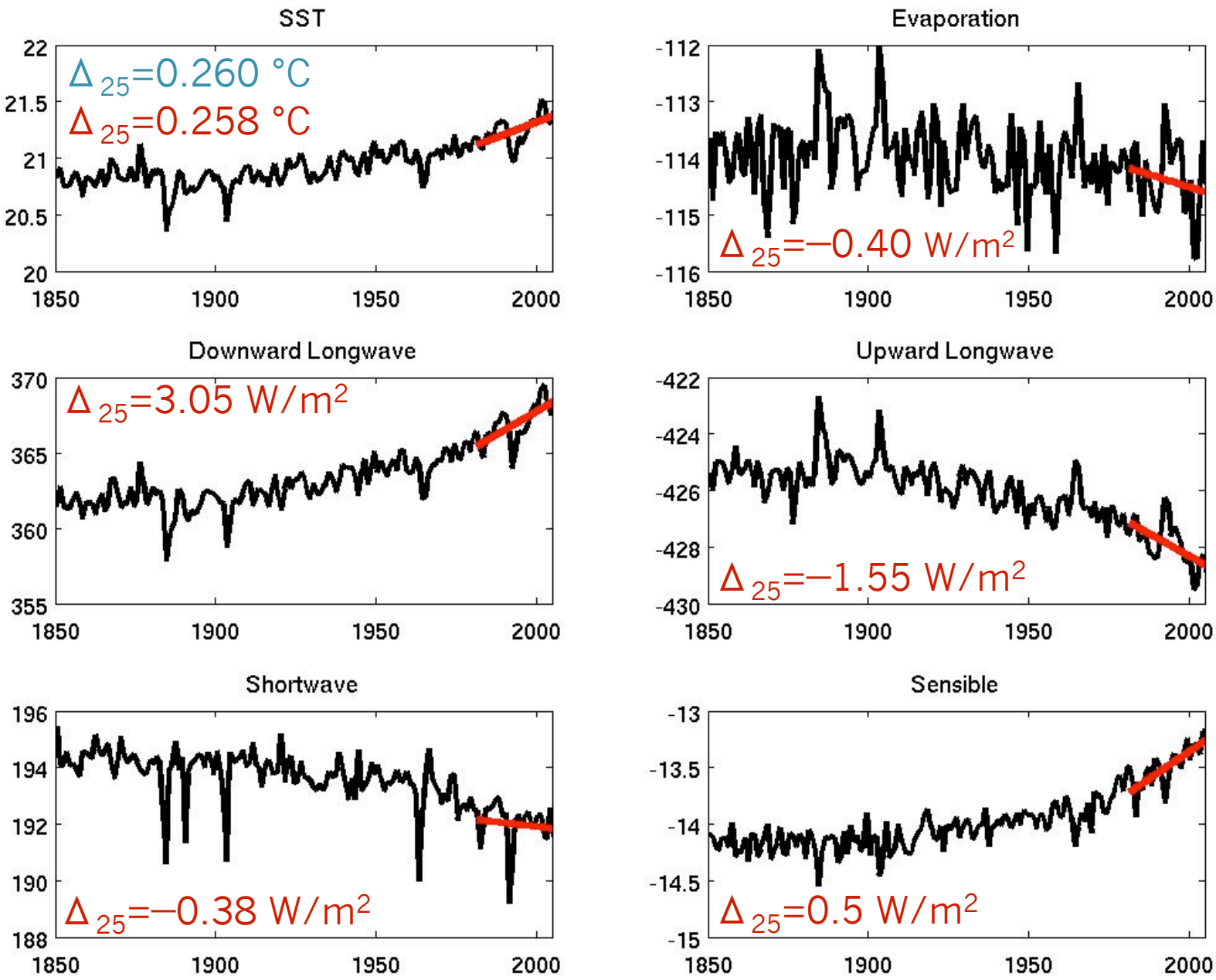
CCSM4 Shortwave Variability Bias
Standard Deviation Bias (W/m^2)

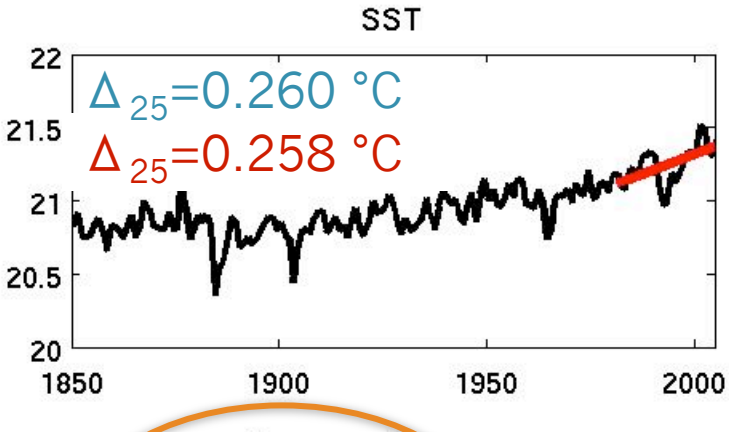
Annual

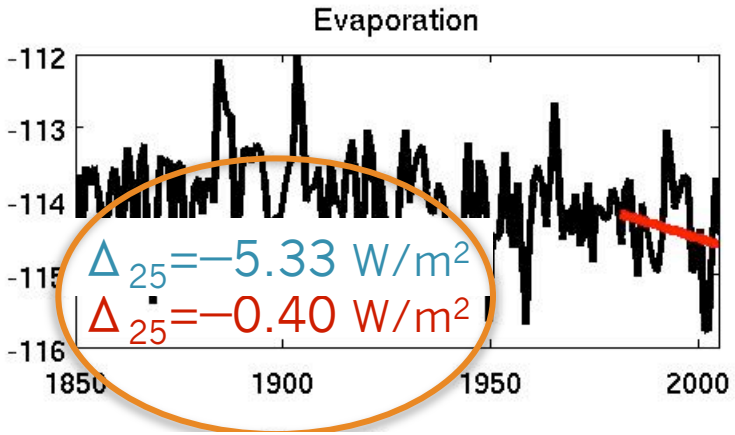


Interannual



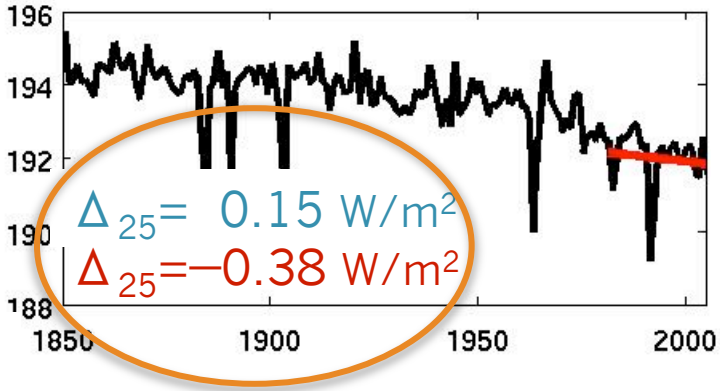

SST
Δ 25=0.260 °C
Δ 25=0.258 °C
22
21.5
21
20.5
20
1850
1900
1950
2000
Evaporation
-112
-113
-114
-115
-116
Δ 25=−0.40 W/m2
Downward Longwave
Δ 25=3.05 W/m2
370
365
360
355
Upward Longwave
-422
-424
-426
-428
-430
Δ 25=−1.55 W/m2
Shortwave
196
194
192
190
188
Δ 25=−0.38 W/m2
Sensible
-13
-13.5
-14
-14.5
-15
Δ 25=0.5 W/m2

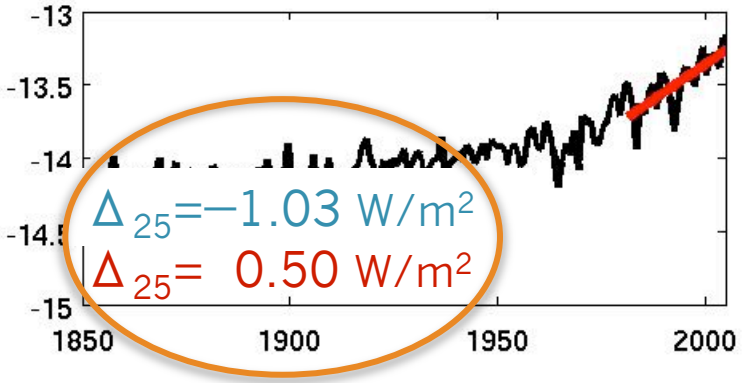




CORE
CORE
$\Delta_{25} Q_{pbl} = -\ 7.88\ W/m^2$

CCSM4
CCSM4
$\Delta_{25} Q_{pbl} = -1.48\ W/m^2$





CORE
CCSM4

Boundary Layer Processes

$$Q_E + Q_H = \rho\, C10\, U10\, (C_p\, \Delta_T + \Lambda\, \Delta_q)$$

Q_E = latent heat flux

Q_H = sensible heat flux

C10 = transfer coefficient

U10 = 10m wind speed

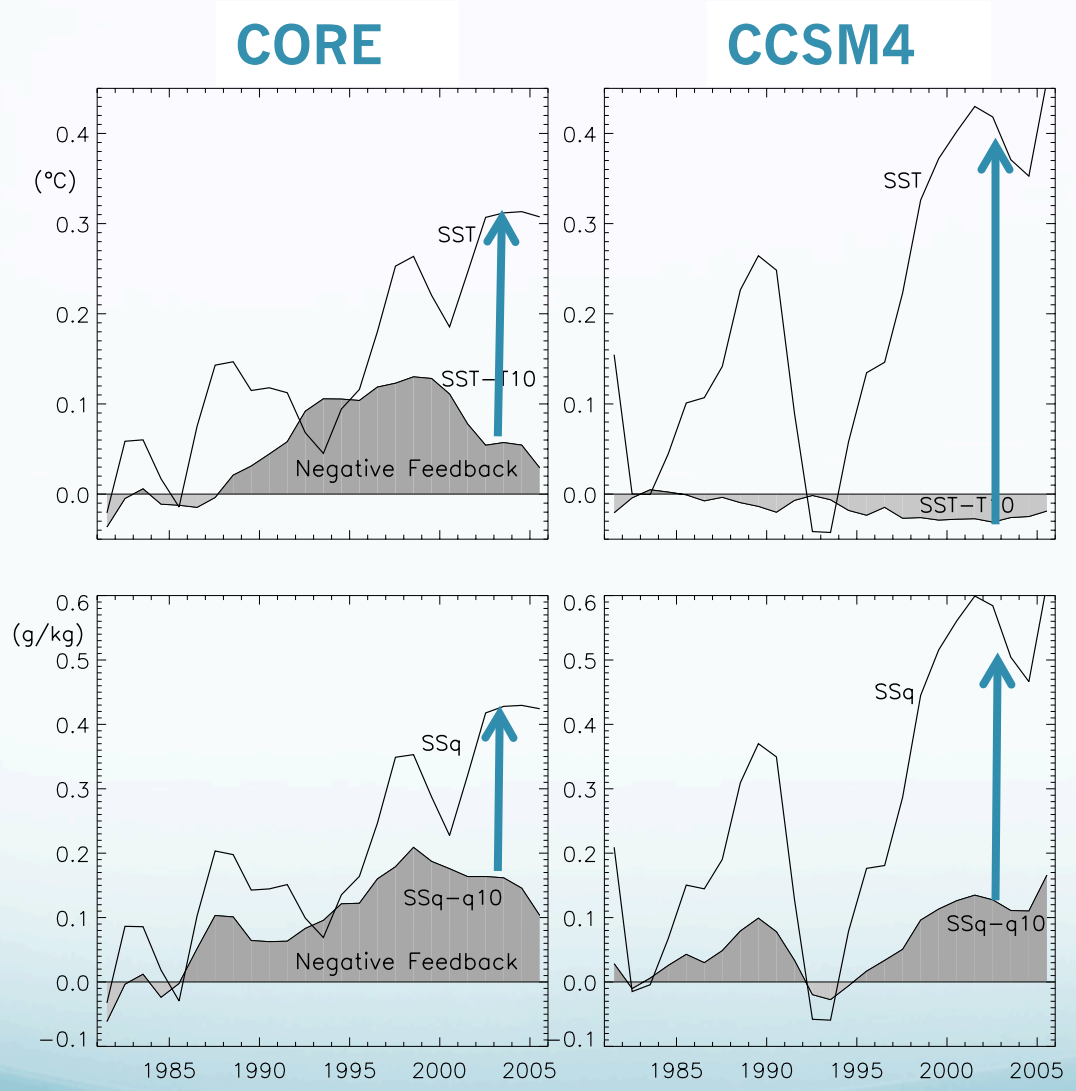
$$\Delta_T = T_{air} - SST$$

$$\Delta_q = q_{air} - SSq$$

Considering wind speed, there is still have a 3.3 W/m^2 discrepancy

SST and Sea-Air Temperature Difference Between 40°N and 40°S

Why is CCSM4 behavior so different from "Observations" ?



Summary

- Mean biases
  - Solar radiation bias is larger in higher latitudes
  - Net bias is smaller: improvements due to improved precipitation and evaporation biases
- Variability
  - Patterns of bias in mean, annual, and interannual are different
  - Annual bias leaves room for improvement
- Trends
  - The late 20th Century trends are not analogous to CORE.
  - The forcing of SST and the flux response during this time period behave differently from CORE.
  - C_{pbl} as a metric for assessing a model's boundary layer

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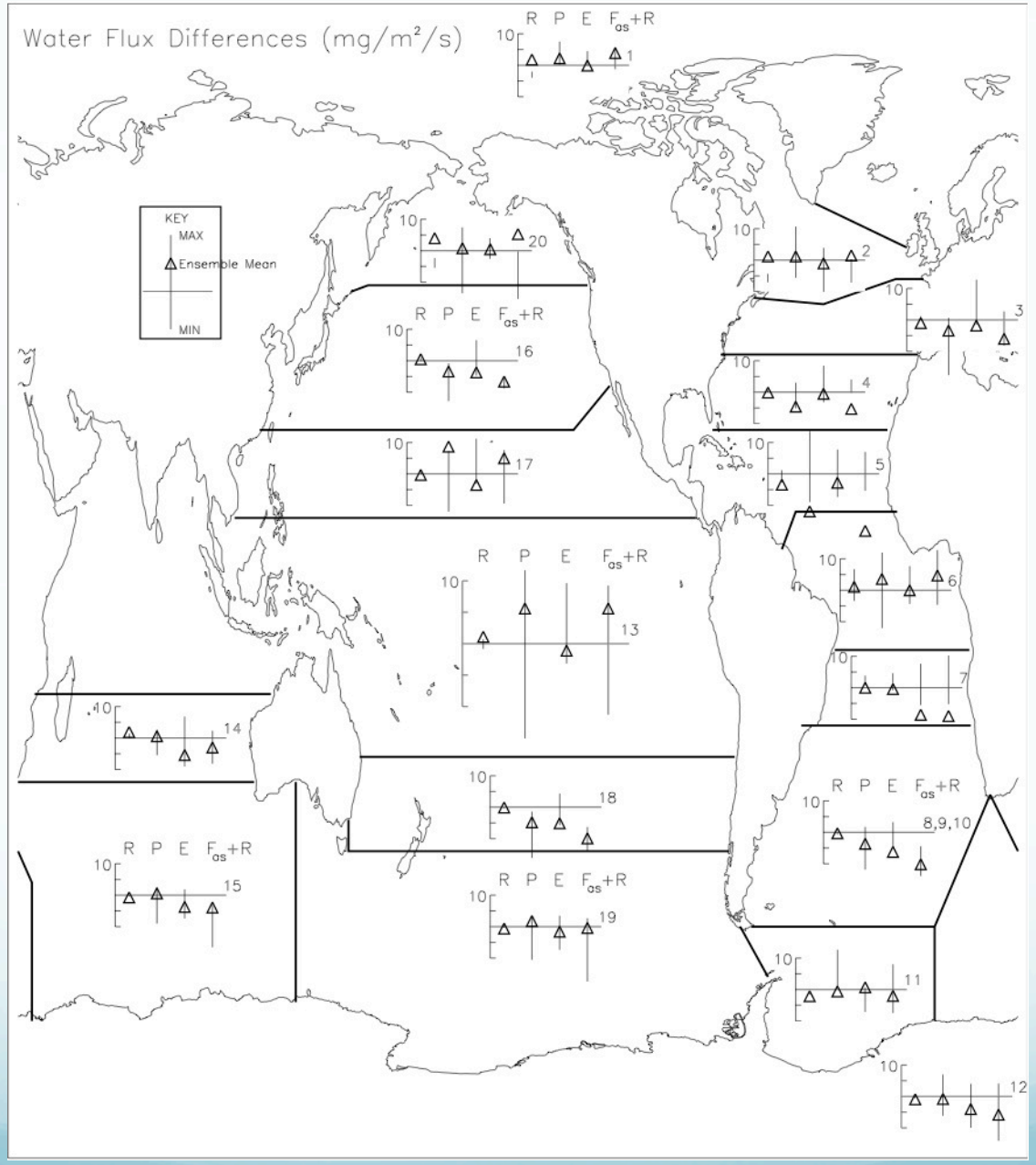
	CCSM4	CORE
$\Delta_{25}\, Q_{pbl}$	-1.48 W/m^2	-7.88 W/m^2
Δ_{25} U10	O(10^{-4})	0.13 m/s
Q_{pbl} change		-3.1 W/m^2
Q_{pbl} remaining	-1.48 W/m^2	-4.78 W/m^2

Boundary Layer Processes

$$Q_{pbl} = LW_{up} + Q_E + Q_H$$

$$C_{pbl} = \frac{\Delta Q_{pbl}}{\Delta SST}$$

Geographical Region	CORE C_{pbl}	CCSM4 C_{pbl}	Ratio
Global	-28	-14	2
North Atlantic	-18	-7	2.6
Equatorial Atlantic	-29	-14	2.1
Indian	-46	-9	5.1
North Pacific	-18	-6	3
Equatorial Pacific	-35	-8	4.4
South Pacific	-33	-9	3.7


Water Flux Differences (mg/m²/s)
R P E Fos+R
10
1
KEY
MAX
Ensemble Mean
MIN
20
2
3
16
4
17
5
13
6
14
7
18
8,9,10
15
19
11
12