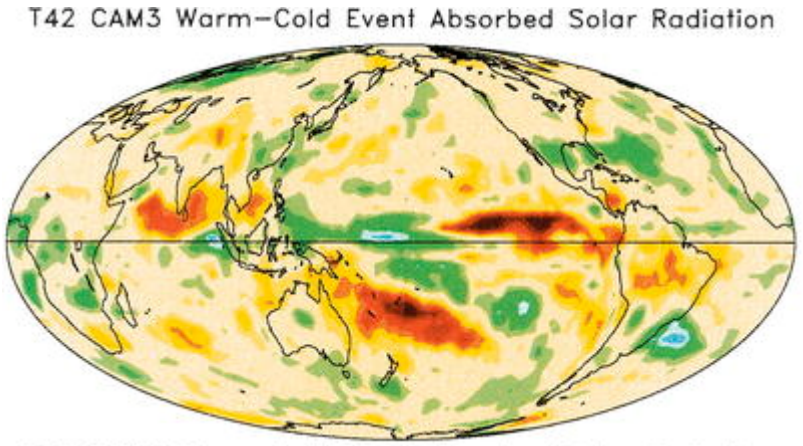
Dissecting Tropical Biases in the NCAR CAM3 and CCSM3

Guang Jun Zhang
Scripps Institution of Oceanography
La Jolla, CA 92093

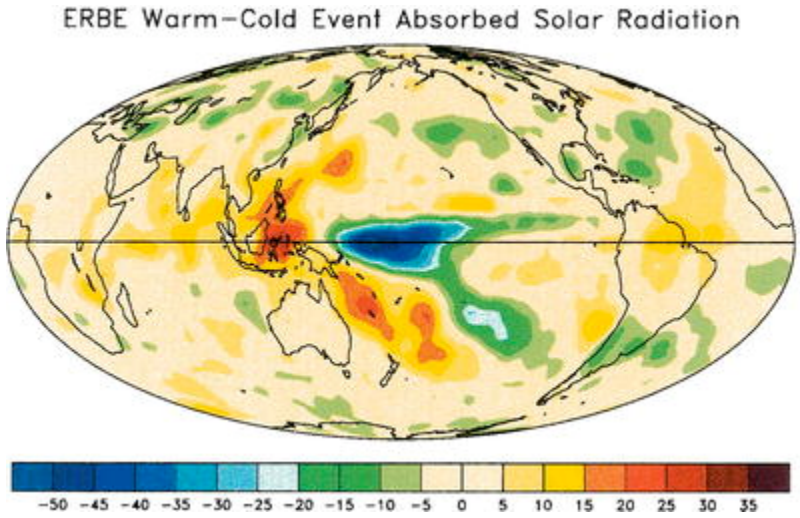
Known Tropical Biases in NCAR CAM3 and CCSM3

- Weak intraseasonal variability
- Lack of SW cloud forcing response to ENSO
- Double ITCZ (particularly in coupled model)
- …….

CAM3



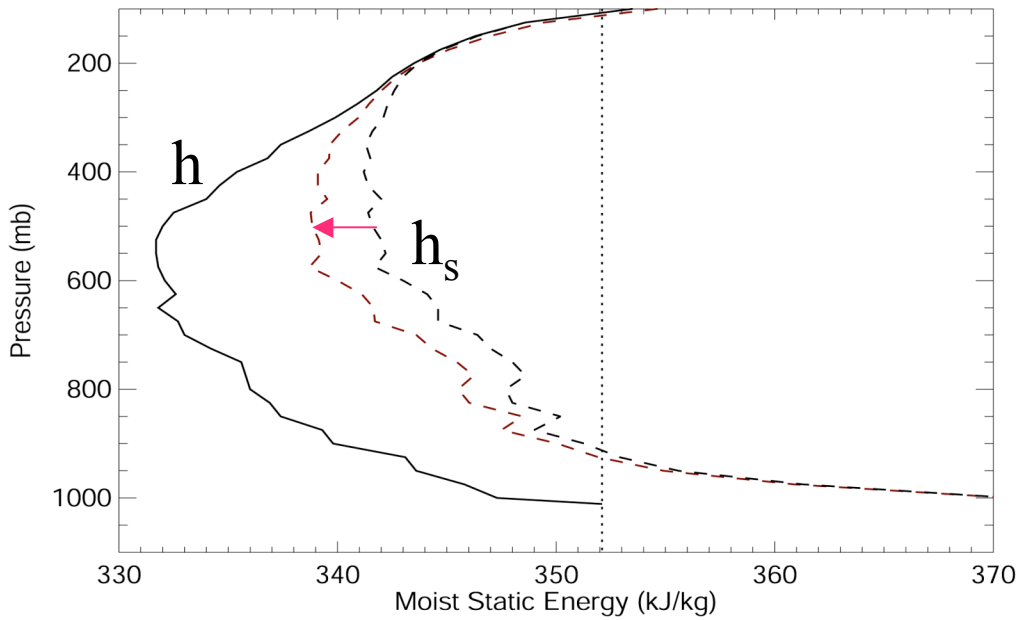
ERBE



Hack et al. 2006

Two CAM3 Simulations

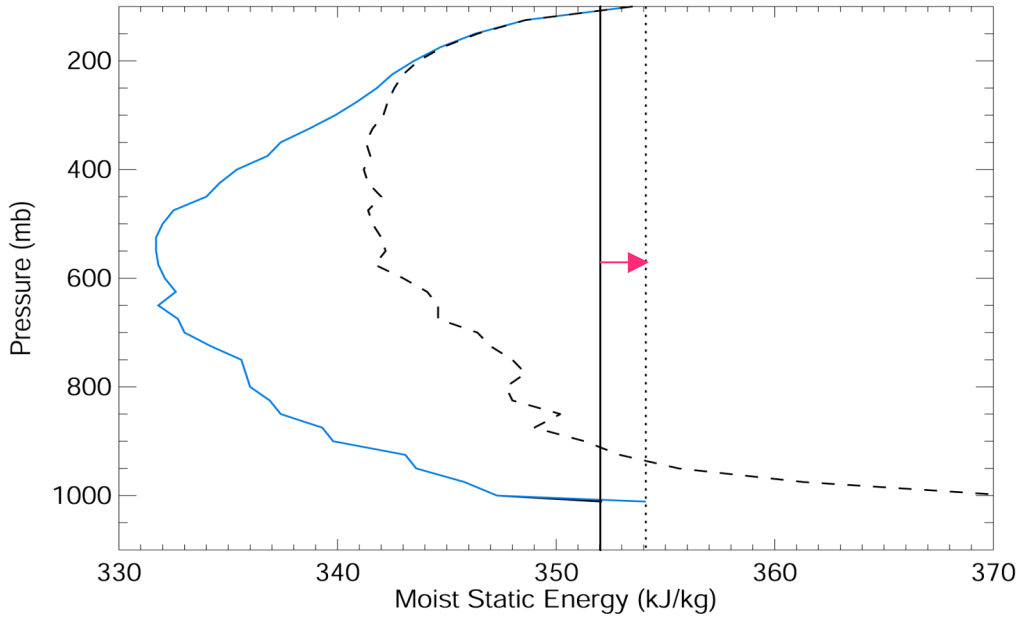
- Standard CAM3 simulation (CAM3 Ctrl) from 1979 to 1995 at T42 using observed SST
- CAM3 simulation using revised Zhang-McFarlane scheme (CAM3 Exp) from 1979 to 1995 at T42 using observed SST



Revised Z-M scheme

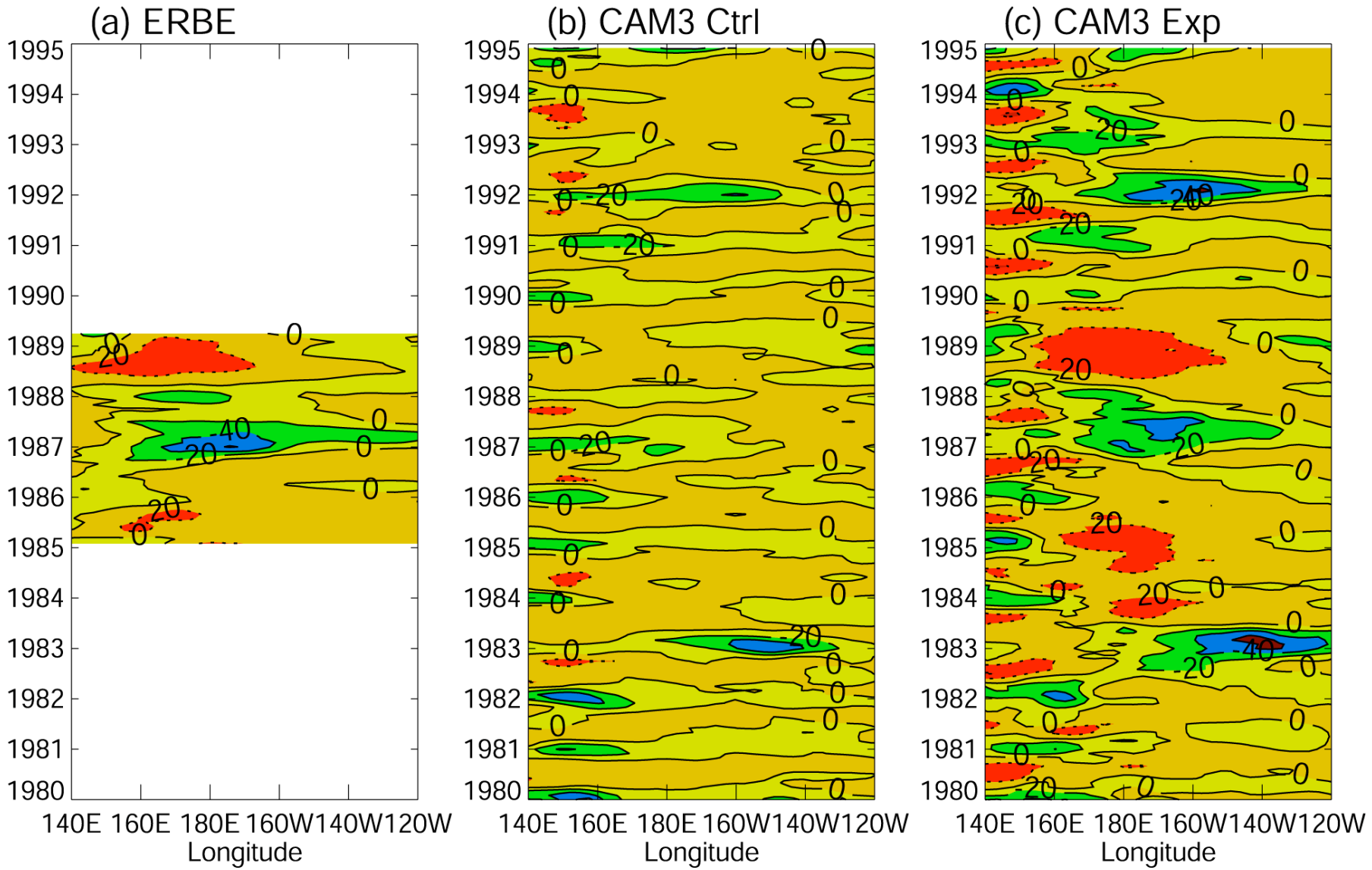
Cooling destabilizes the atmosphere

deep convection



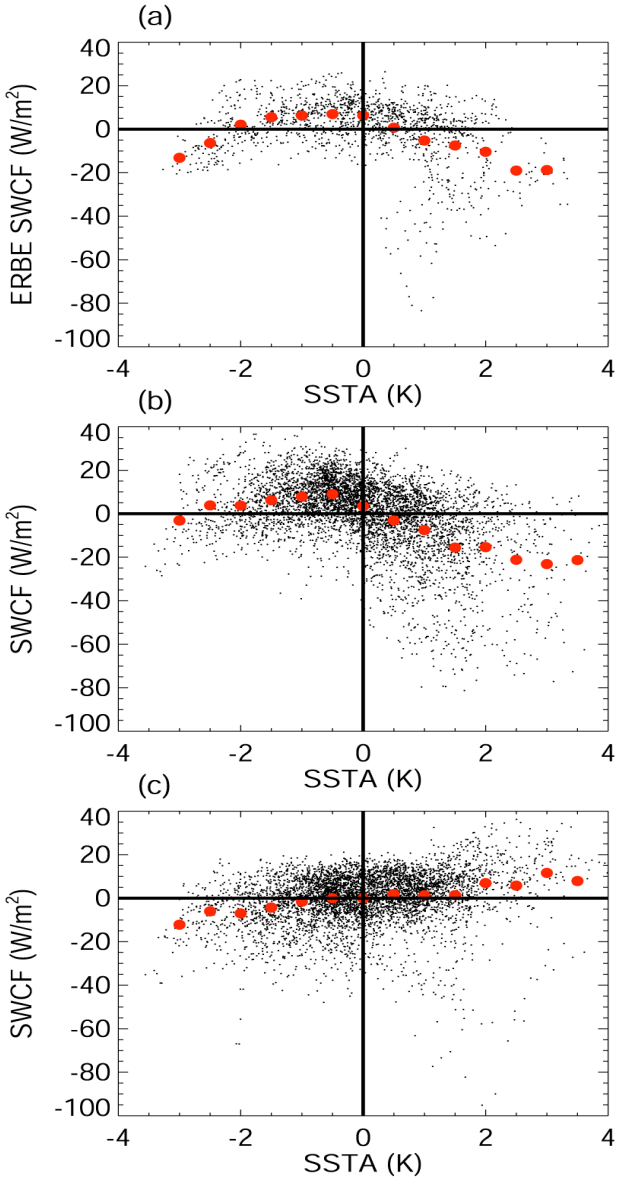
Despite h increase in PBL

no deep convection


(a) ERBE
(b) CAM3 Ctrl
(c) CAM3 Exp
1995
1994
1993
1992
1991
1990
1989
1988
1987
1986
1985
1984
1983
1982
1981
1980
140E 160E 180E 160W 140W 120W
Longitude

(180E,100W)

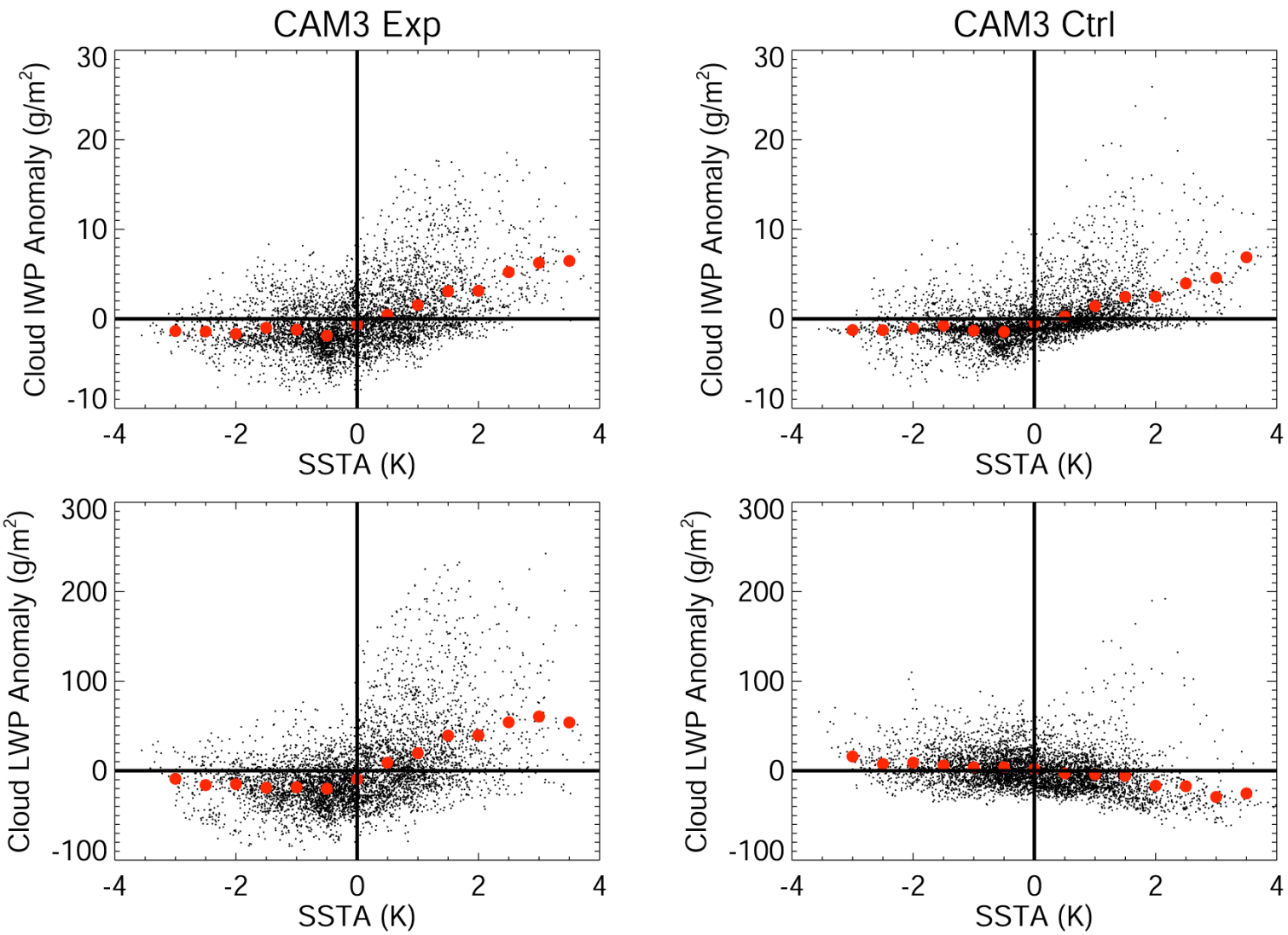
(5S, 5N)

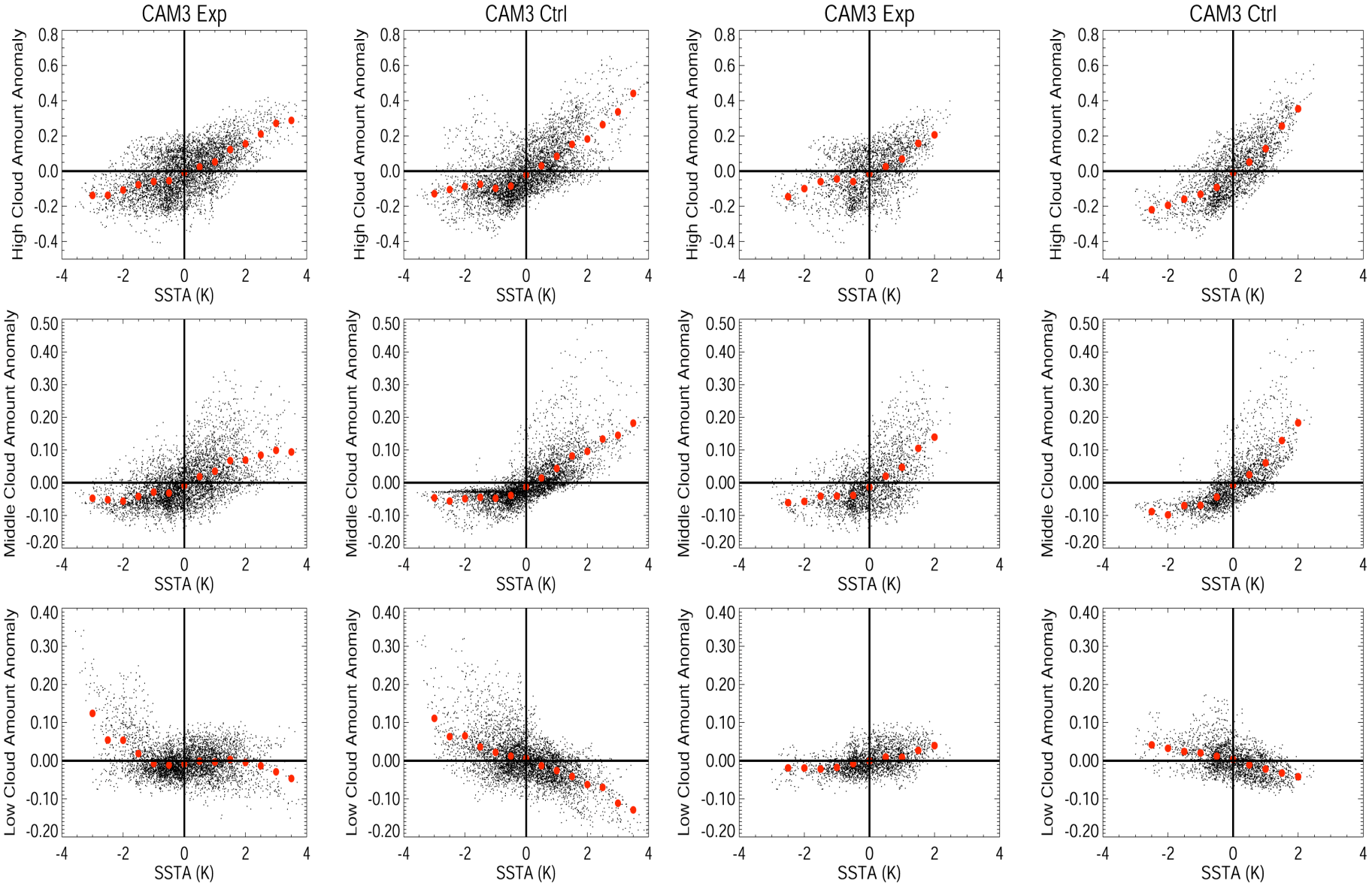


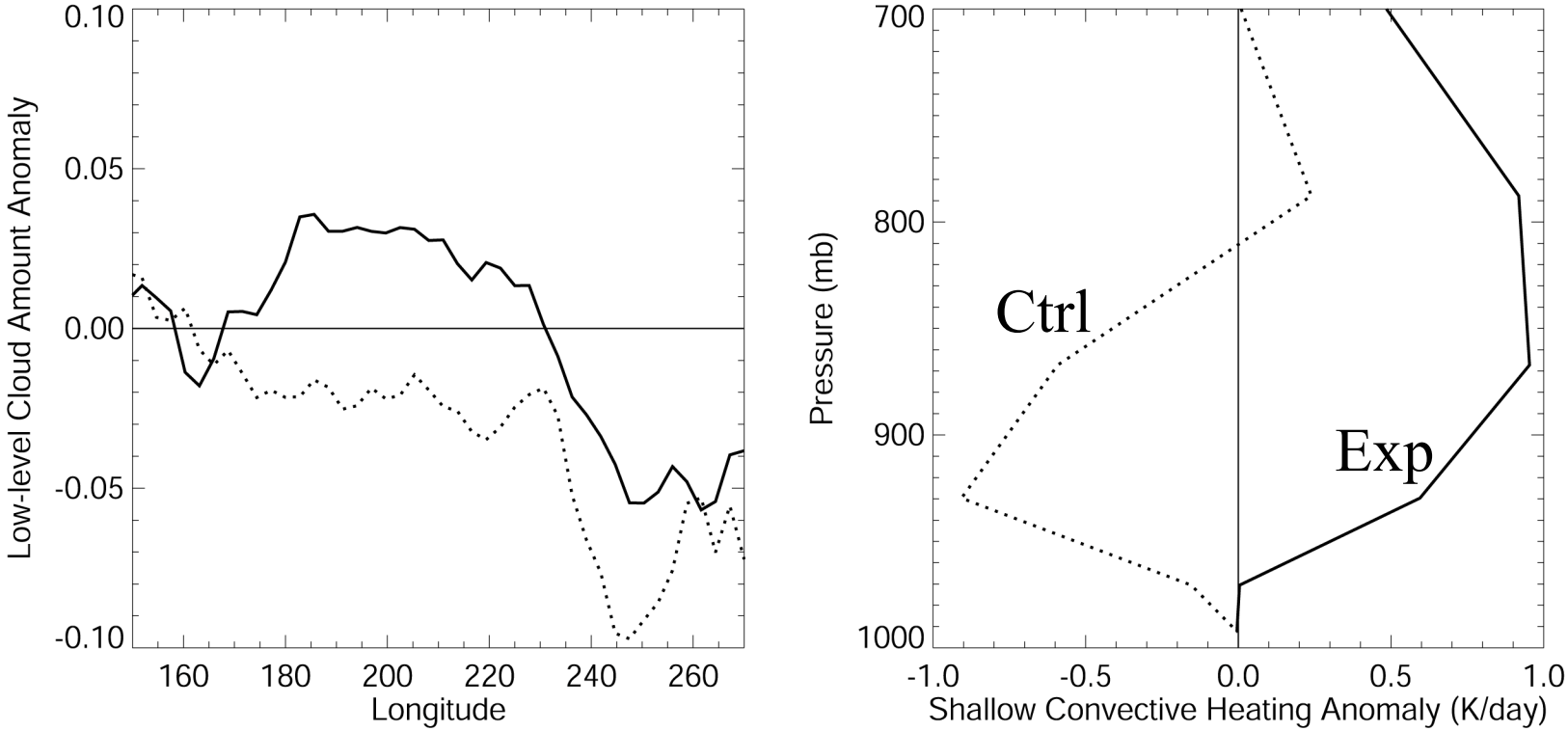
ERBE

CAM3
Exp

CAM3
Ctrl


CAM3 Exp
CAM3 Ctrl
Cloud IWP Anomaly (g/m^2)
Cloud LWP Anomaly (g/m^2)
SSTA (K)
30
20
10
0
-10
300
200
100
-100
-4
-2
0
2
4


180E-100W
180E-140W
CAM3 Exp
CAM3 Ctrl
CAM3 Exp
CAM3 Ctrl
High Cloud Amount Anomaly
Middle Cloud Amount Anomaly
Low Cloud Amount Anomaly
SSTA (K)


0.10
0.05
0.00
-0.05
-0.10
Low-level Cloud Amount Anomaly
160
180
200
220
240
260
Longitude
700
800
900
1000
Pressure (mb)
Ctrl
Exp
-1.0
-0.5
0.0
0.5
1.0
Shallow Convective Heating Anomaly (K/day)

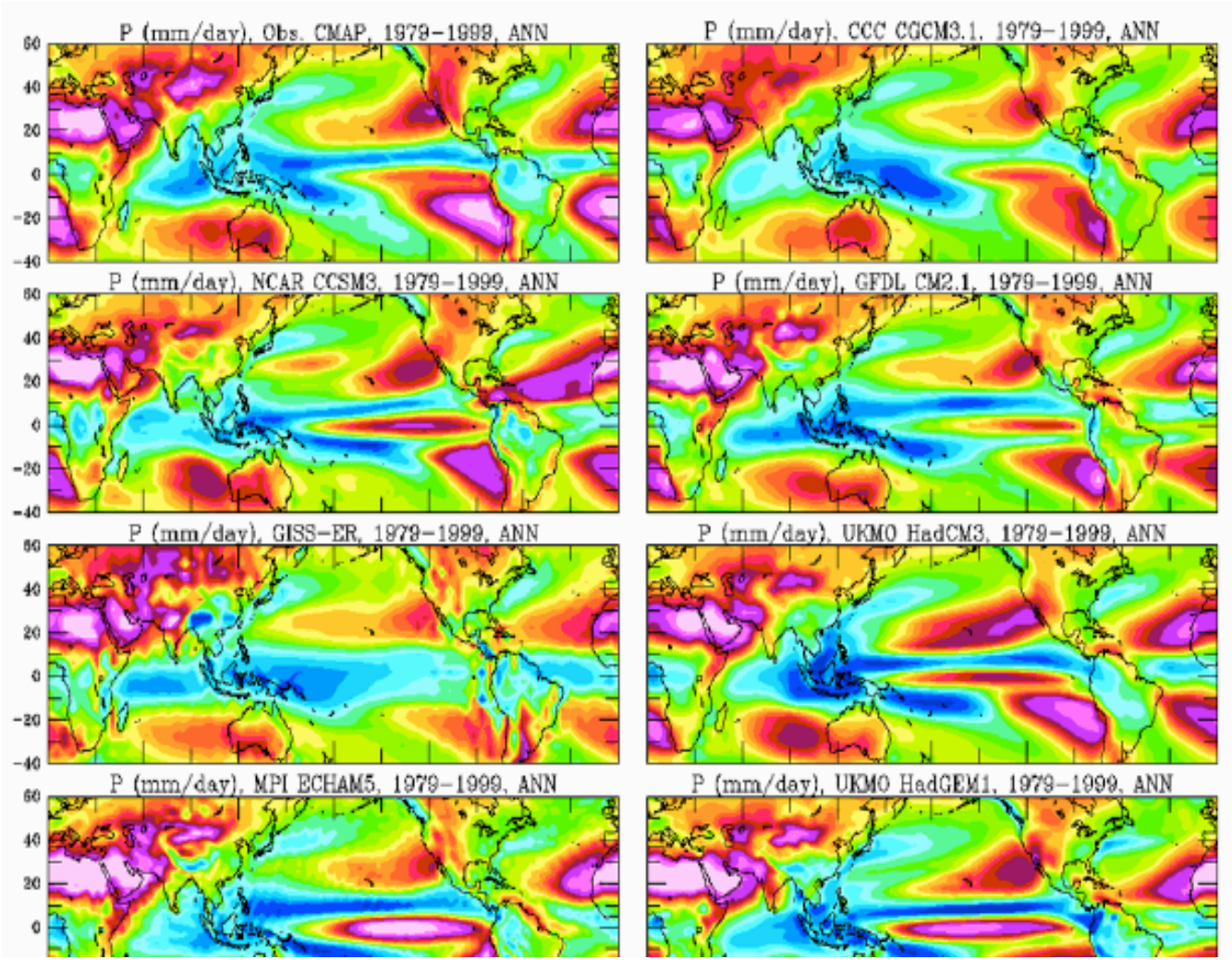
From Dai 2006

Obs

NCAR

GFDL

UKMO



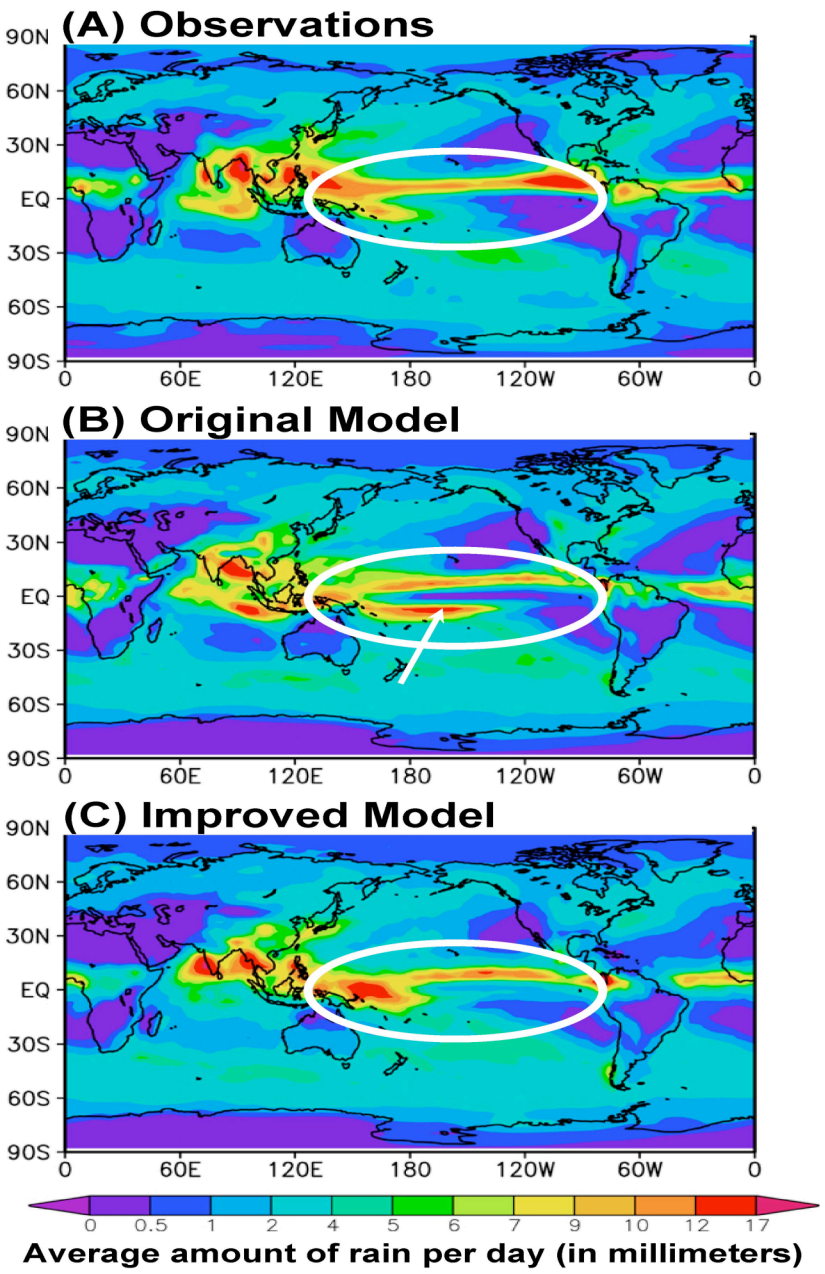
CCSM3 Simulations

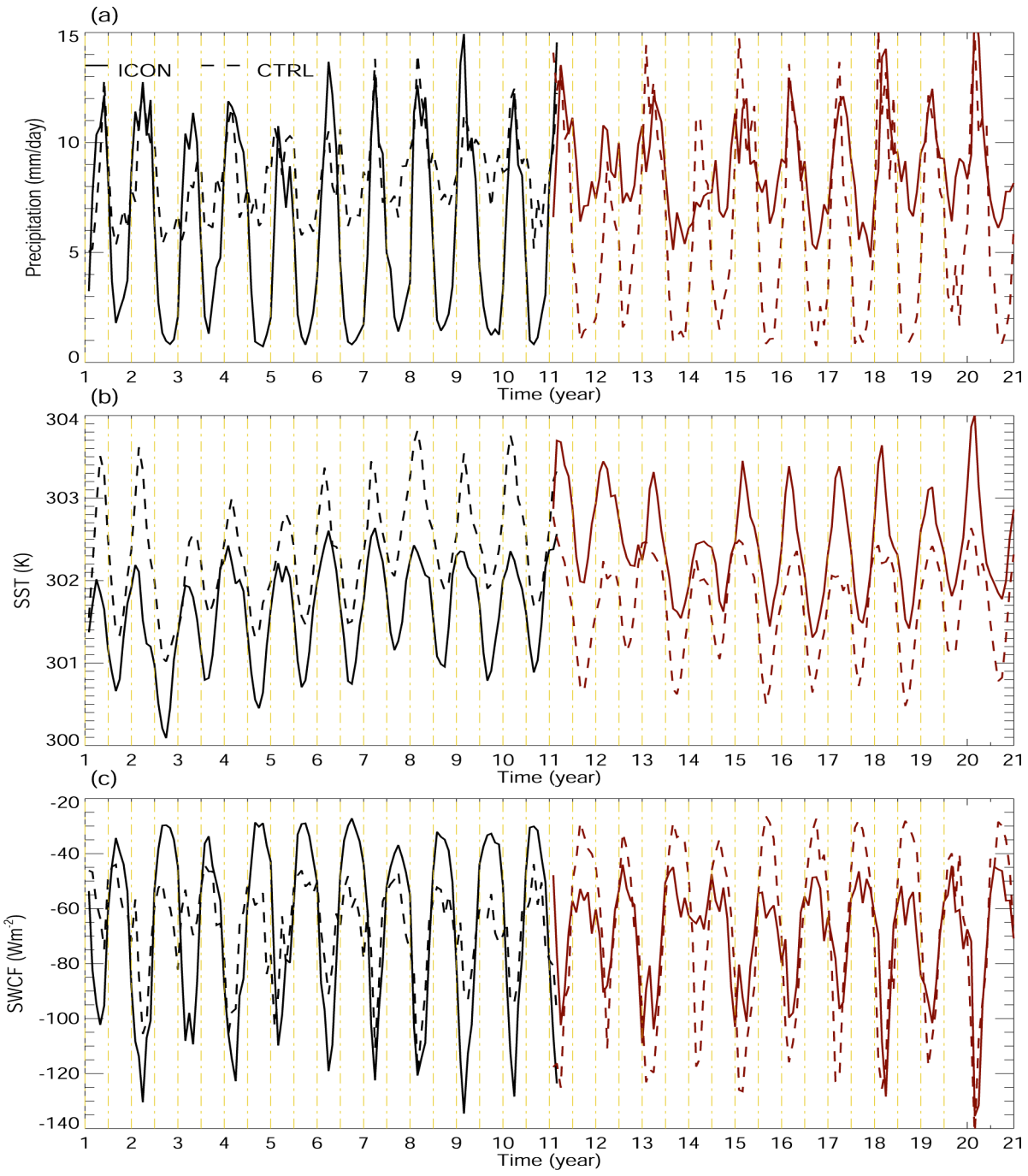
- One 10-yr control run with the standard CCSM3 configuration
- One experiment run identical to the control except with the revised Zhang-McFarlane scheme
- Two more 10-yr runs, starting at the end of the above two runs but with the convection schemes switched

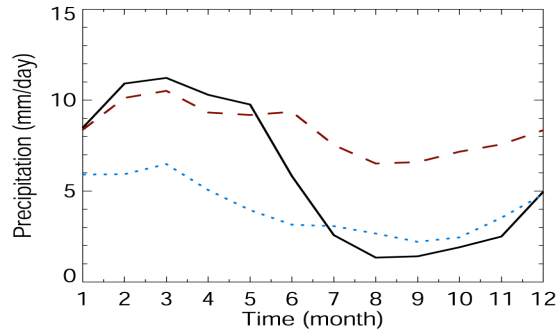
Obs

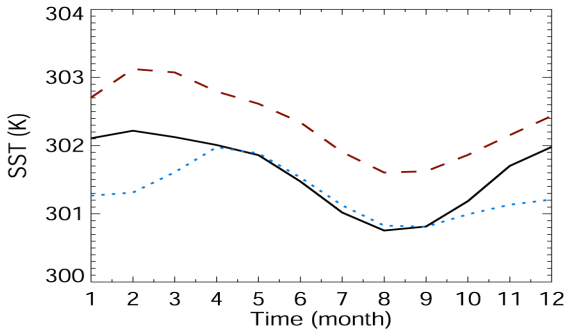
CCSM3 Ctrl

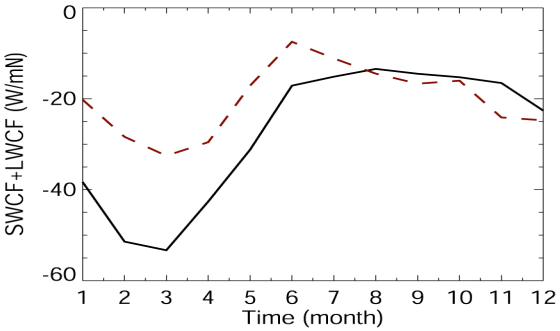
CCSM3 Exp

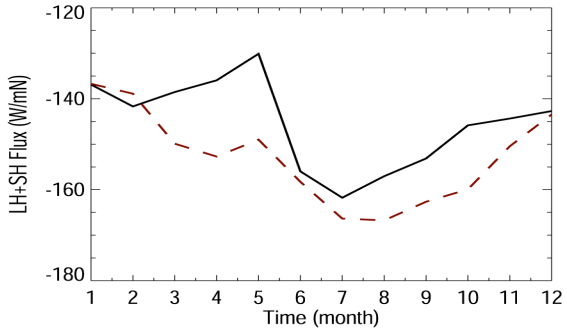


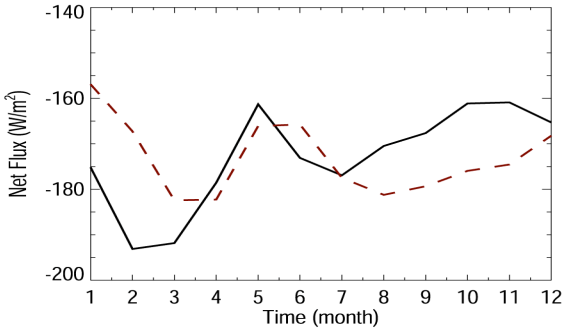

(a)
ICON
CTRL
Precipitation (mm/day)
0
5
10
15
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21
Time (year)
(b)
SST (K)
300
301
302
303
304
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21
Time (year)
(c)
SWCF (Wm-2)
-20
-40
-60
-80
-100
-120
-140
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21
Time (year)

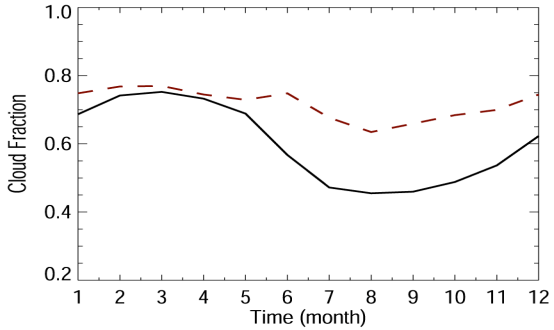


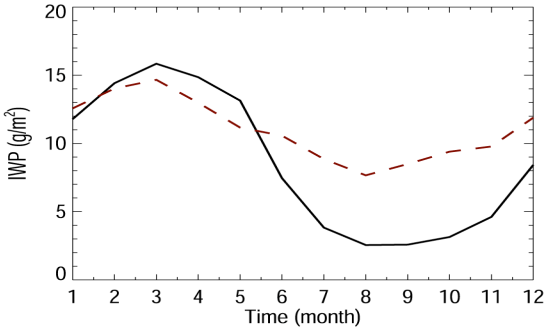


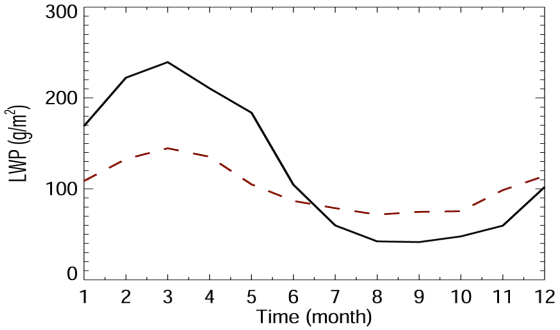












Red: Ctrl

Black: Exp

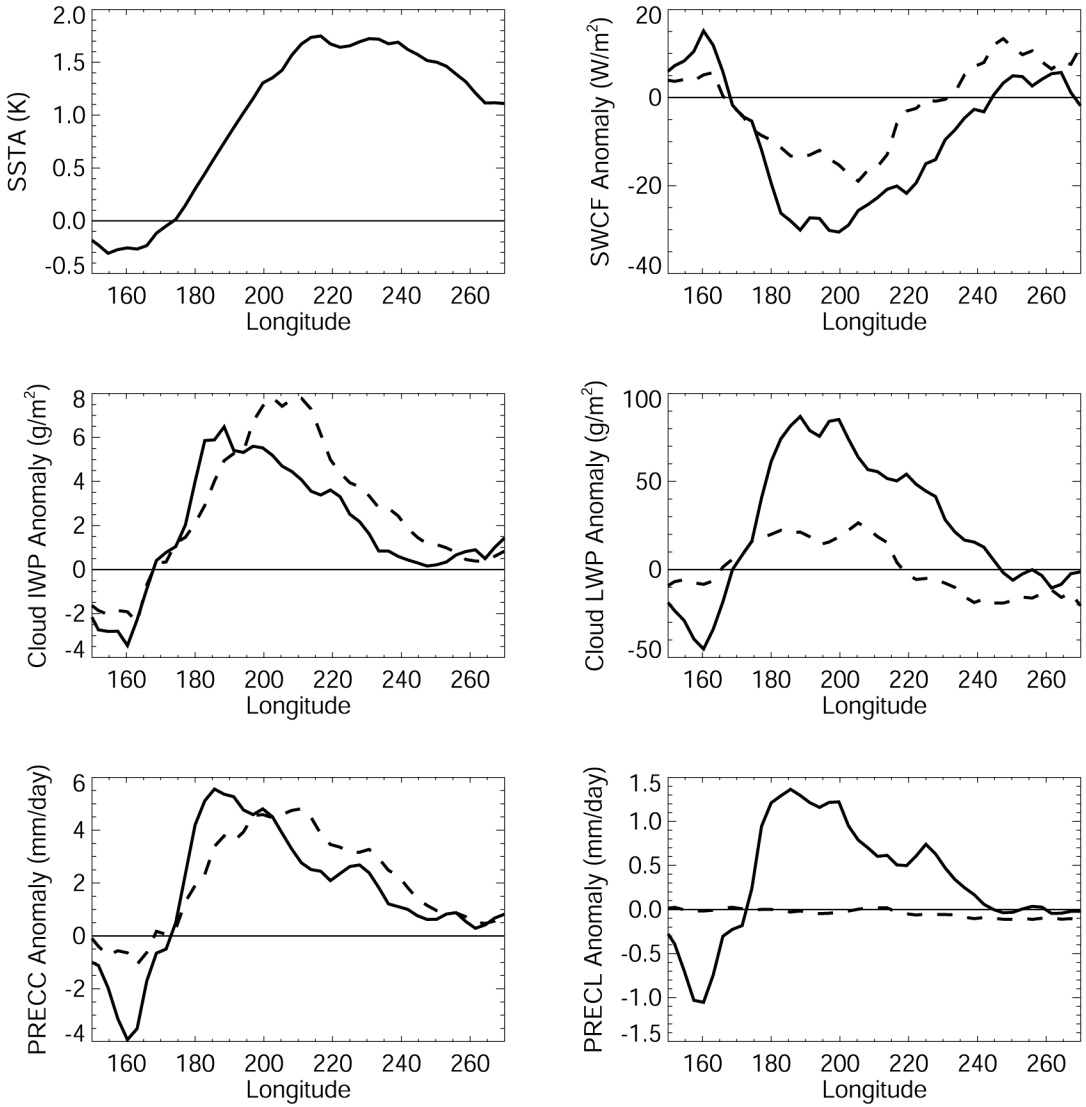
Conclusions

- Lack of SWCF response to ENSO in CAM3 is due to insufficient LWP, shallow convection and low clouds in the central/eastern equatorial Pacific
- Simulation with the revised convection scheme shows none of these deficiencies, and gives a realistic simulation of SWCF during El Nino
- Although only deep convection scheme is modified, the interaction among deep, shallow convection and clouds is clearly a key element in getting the SWCF right

Conclusions (Continued)

- The weak cloud radiative forcing due to low values of LWP in boreal winter and spring leads to high SST and double ITCZ in summer in CCSM3
- This double ITCZ bias can also be alleviated by modifying convection scheme

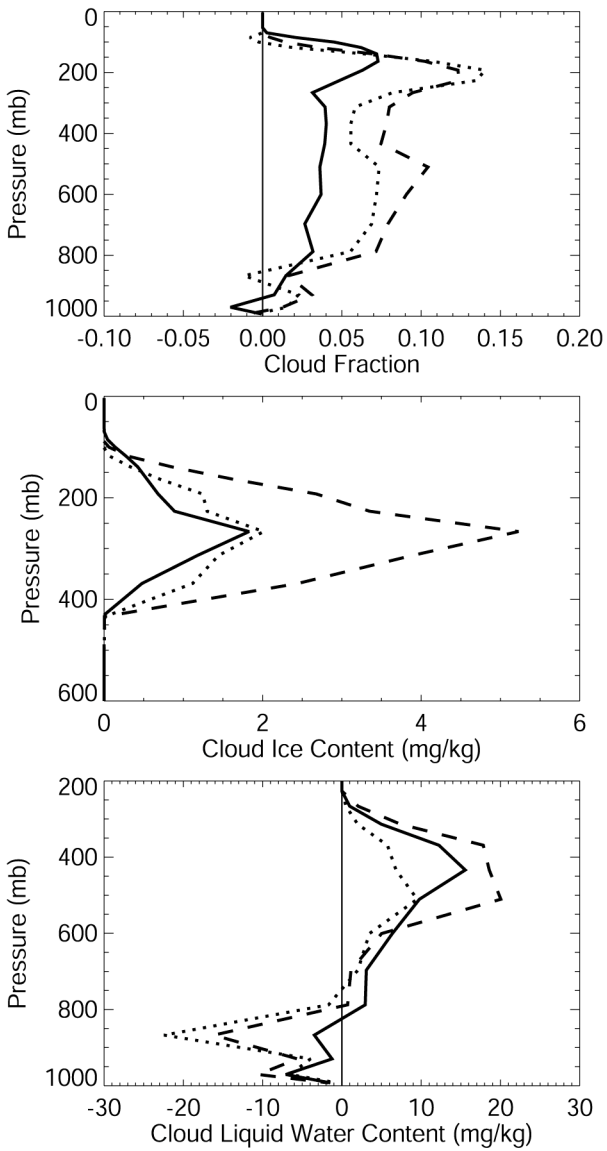
Extra slides



——

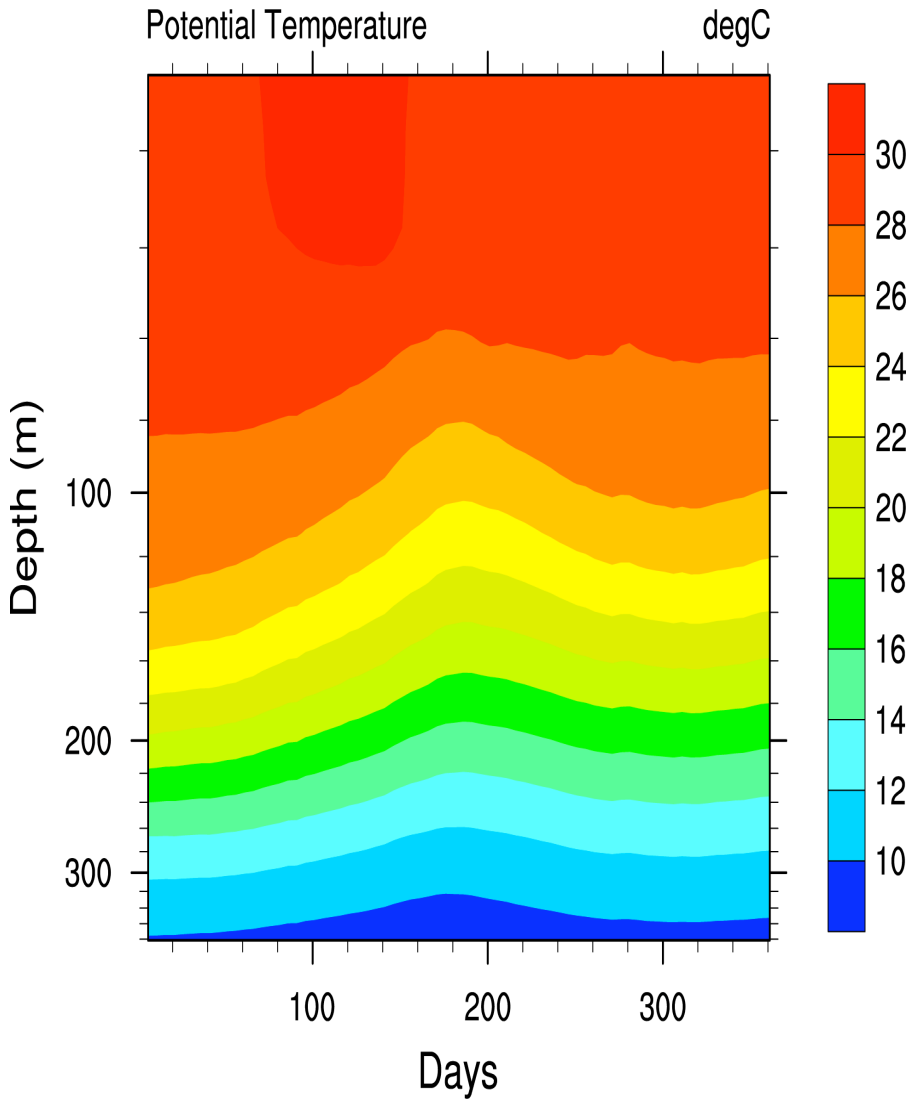
CAM3 Exp

CAM3 Ctrl

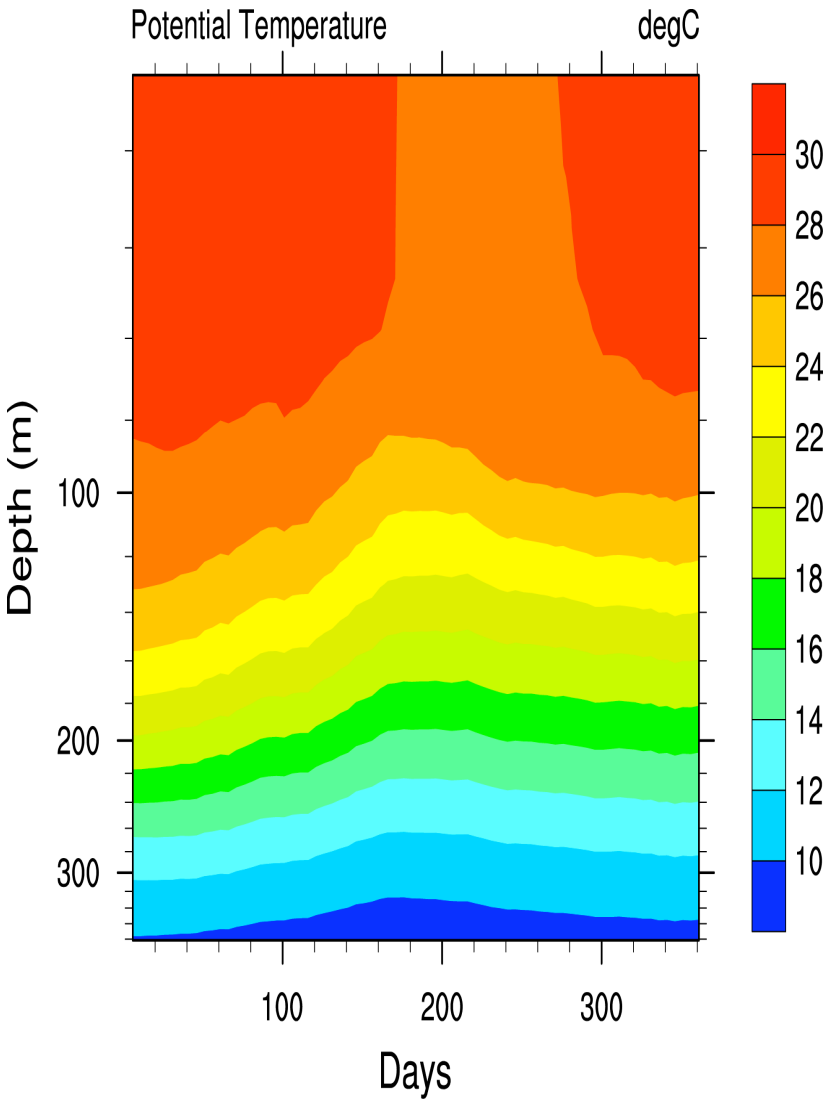


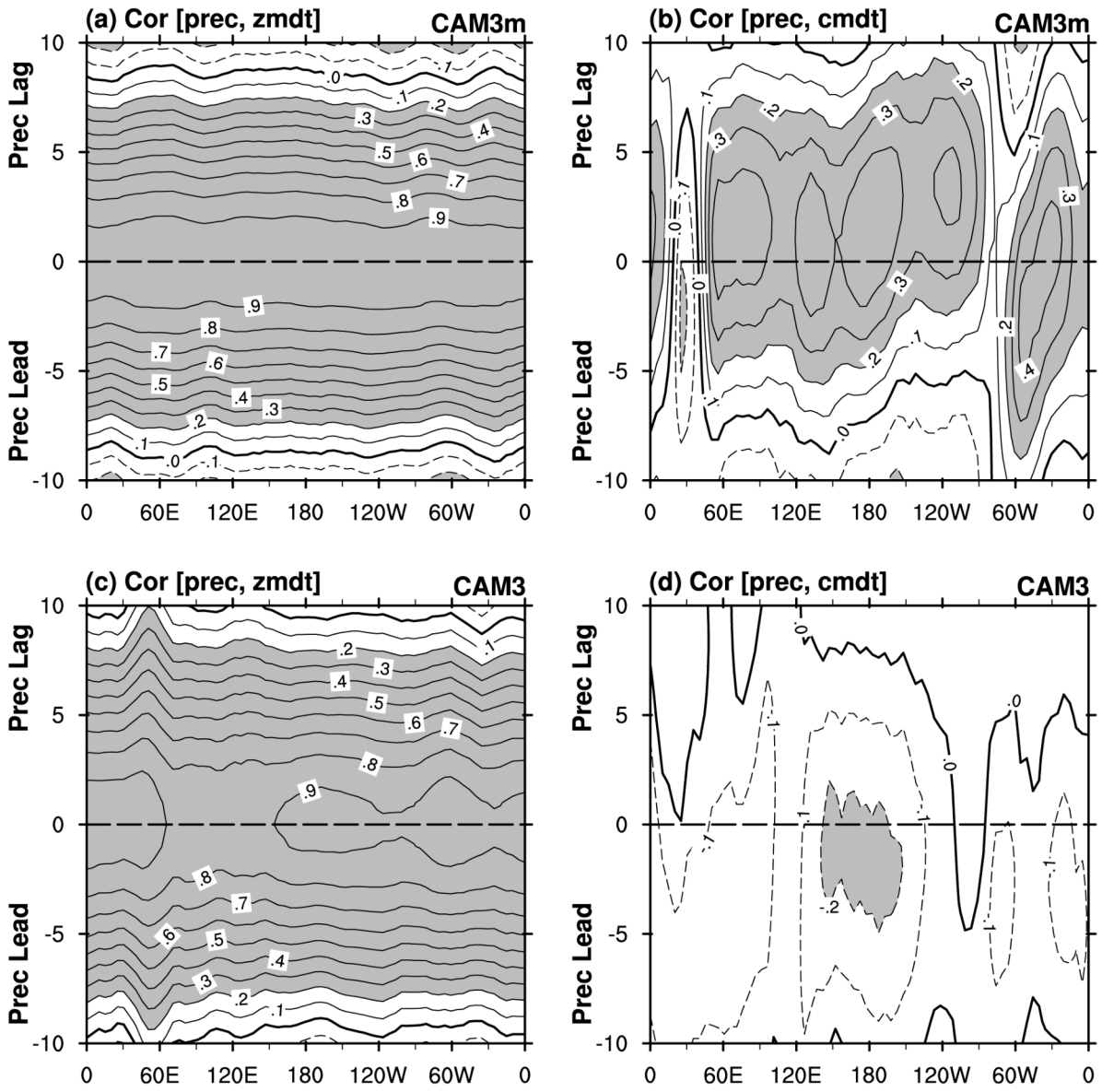
"Generally speaking, CRF and the associated condensed water loading appear to be biased high when compared to available observational estimates." (Hack et al. 2006)

CCSM3 Ctrl



CCSM3 Exp




(a) Cor [prec, zmdt]
CAM3m
(b) Cor [prec, cmdt]
CAM3m
(c) Cor [prec, zmdt]
CAM3
(d) Cor [prec, cmdt]
CAM3
Prec Lag
Prec Lead
10
5
0
-5
-10
0
60E
120E
180
120W
60W
0