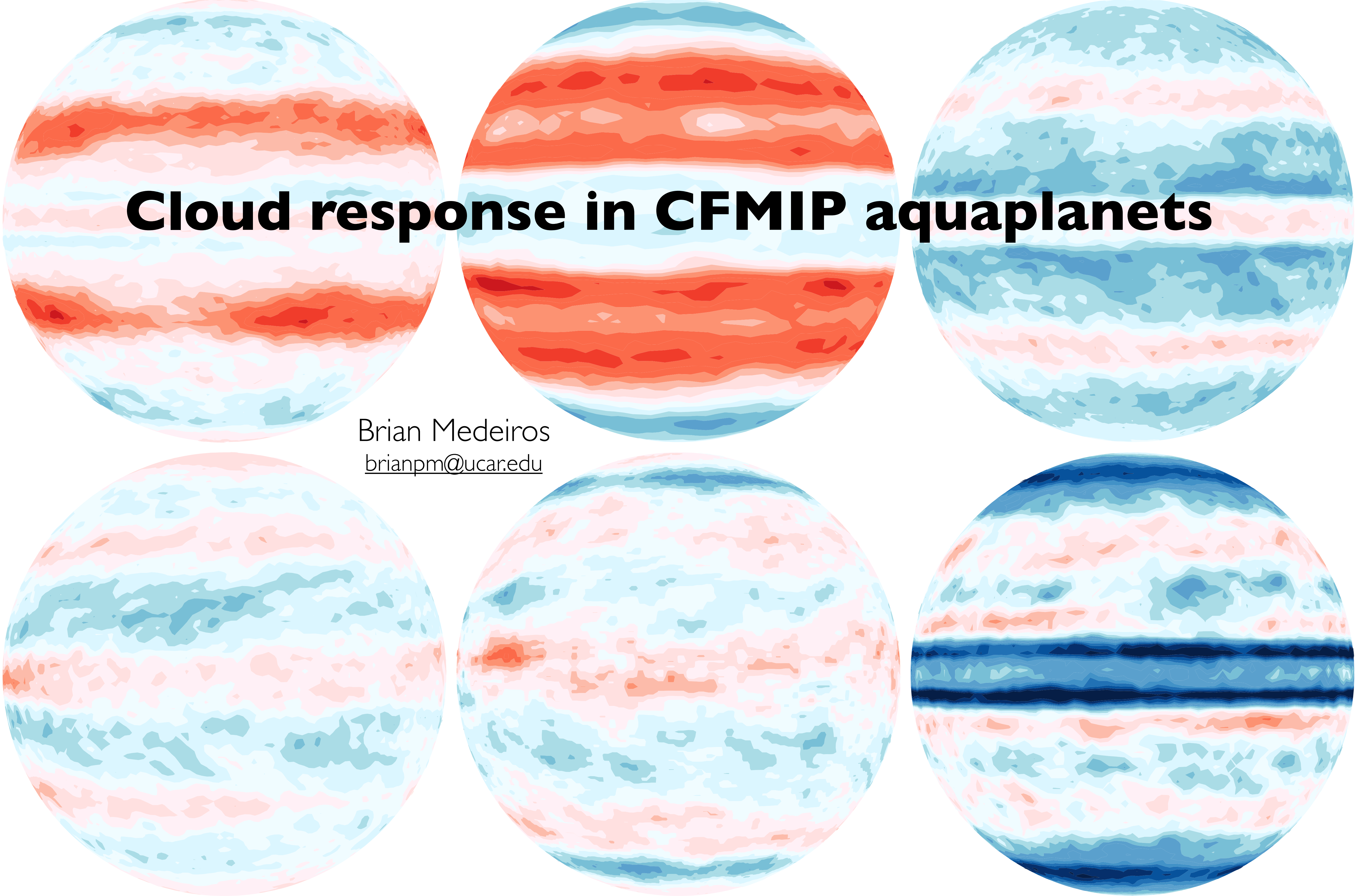
Cloud response in CFMIP aquaplanets



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Atmospheric Modeling & Predictability

Office of Science
U.S. DEPARTMENT OF ENERGY

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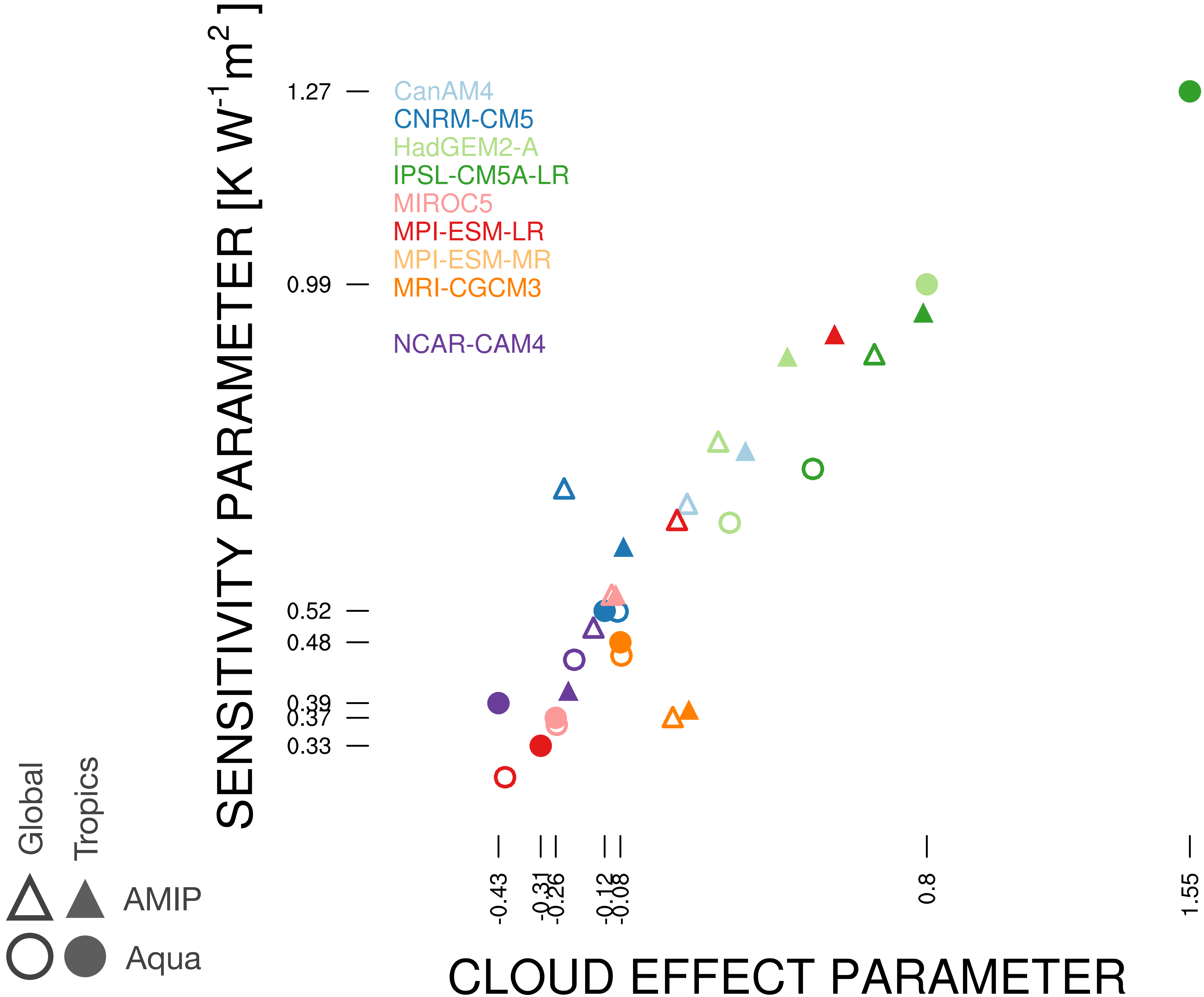
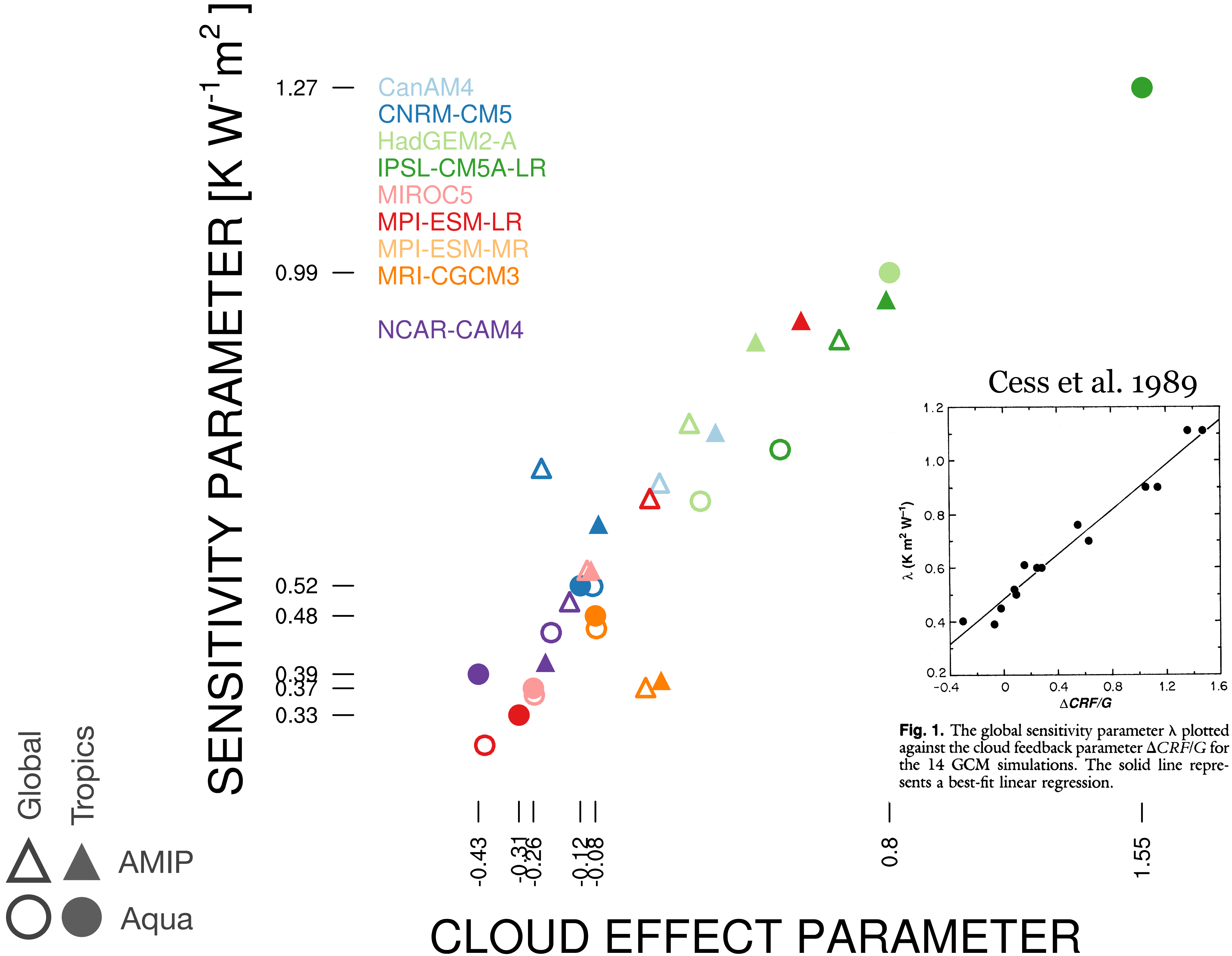
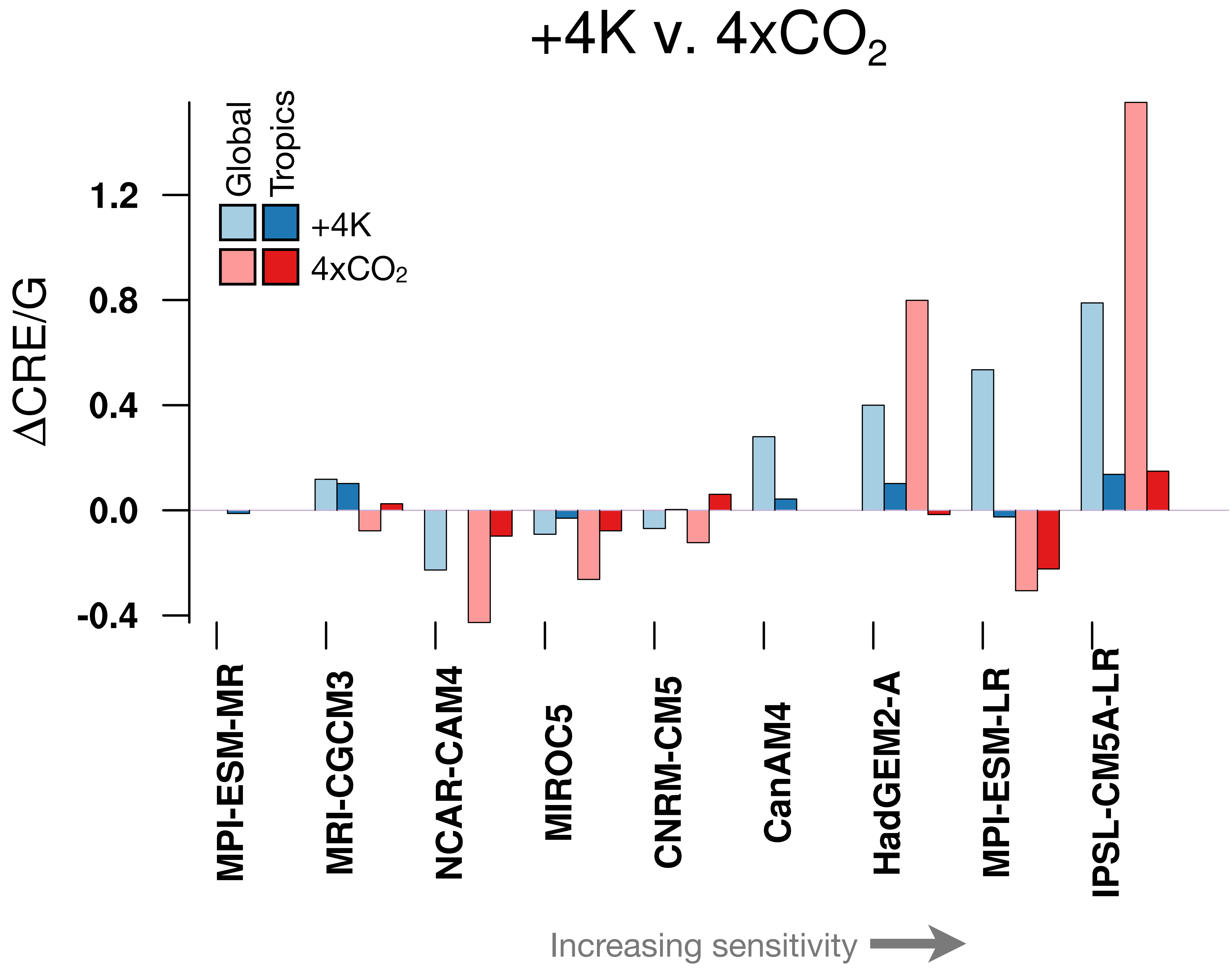
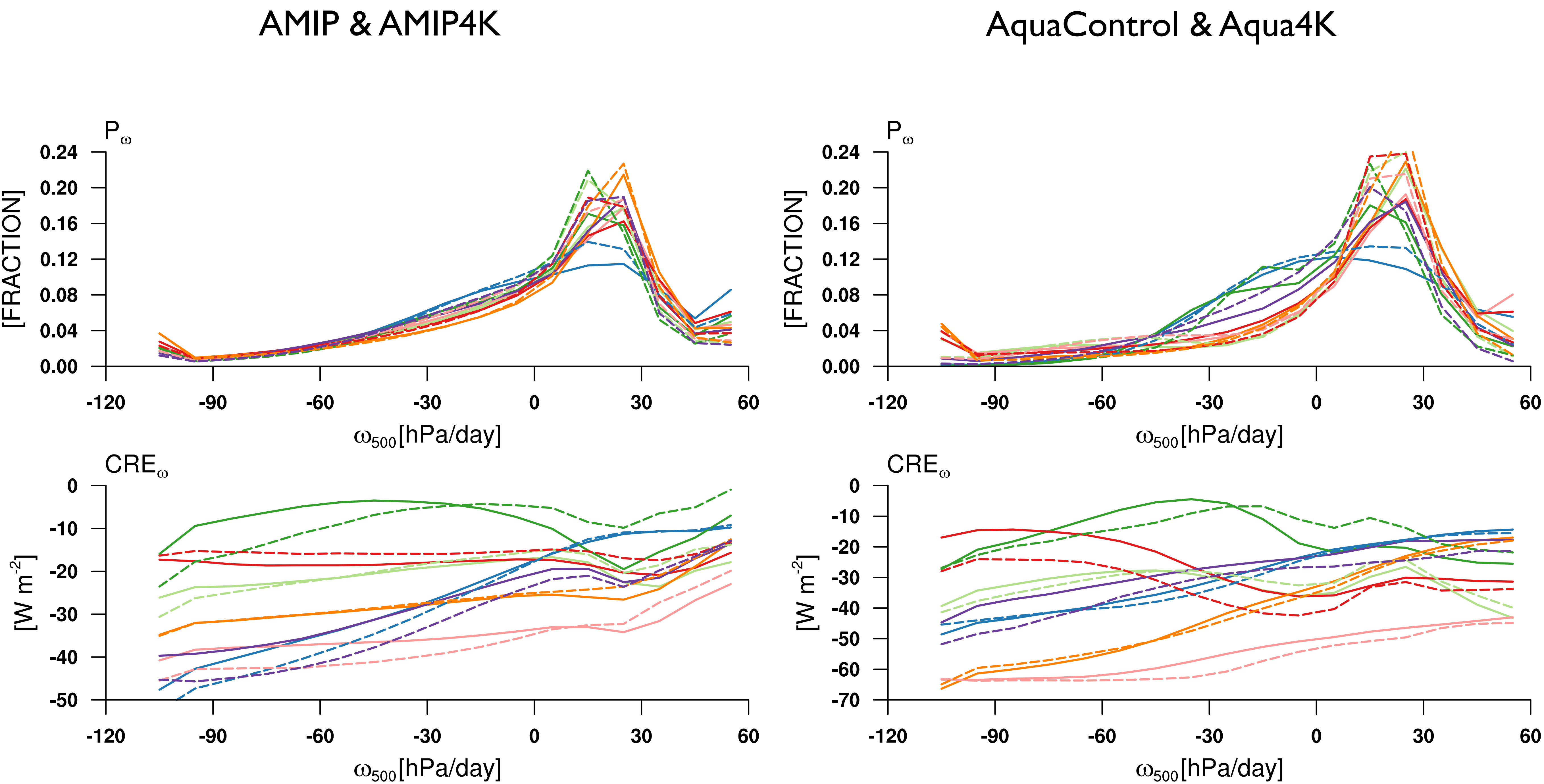
	AMIP			AquaPlanet		
	Control (23)	SST+4K (8)	CO2x4 (10)	Control (7)	SST+4K (7)	CO2x4 (7)
CanAM4 (64x128xL35)	X	X	X	O	O	O
CNRM-CM5 (128x256xL31)	X	X	X	X	X	X
HadGEM2-A (145x192xL38)	X	X	X	X	X	X
IPSL-CM5A-LR (96x96xL39)	X	X	X	X	X	X
MIROC5 (128x256xL40)	X	X	X	X	X	X
MPI-ESM-LR (96x192xL47)	X	X	X	+	+	+
MPI-ESM-MR (96x192xL95)	X	O	X	O	O	O
MRI-CGCM3 (160x320xL35)	X	X	X	X	X	X
FGOALS-s2/g2	?	?	?	?	?	?
NCAR-CAM4 (192x288xL26)	X	+	O	+	+	+


SENSITIVITY PARAMETER [K W^{-1} m^2]
CLOUD EFFECT PARAMETER
1.27
0.99
0.52
0.48
0.39
0.37
0.33
-0.43
-0.31
-0.26
-0.12
-0.08
0.8
1.55
CanAM4
CNRM-CM5
HadGEM2-A
IPSL-CM5A-LR
MIROC5
MPI-ESM-LR
MPI-ESM-MR
MRI-CGCM3
NCAR-CAM4
Global
Tropics
AMIP
Aqua


SENSITIVITY PARAMETER [K W-1 m2]
1.27
0.99
0.52
0.48
0.39
0.37
0.33
CanAM4
CNRM-CM5
HadGEM2-A
IPSL-CM5A-LR
MIROC5
MPI-ESM-LR
MPI-ESM-MR
MRI-CGCM3
NCAR-CAM4
-0.43
-0.31
-0.26
-0.12
-0.08
0.8
1.55
CLOUD EFFECT PARAMETER
Global
Tropics
AMIP
Aqua
Cess et al. 1989
λ (K m2 W-1)
ΔCRF/G
Fig. 1. The global sensitivity parameter λ plotted against the cloud feedback parameter ΔCRF/G for the 14 GCM simulations. The solid line represents a best-fit linear regression.

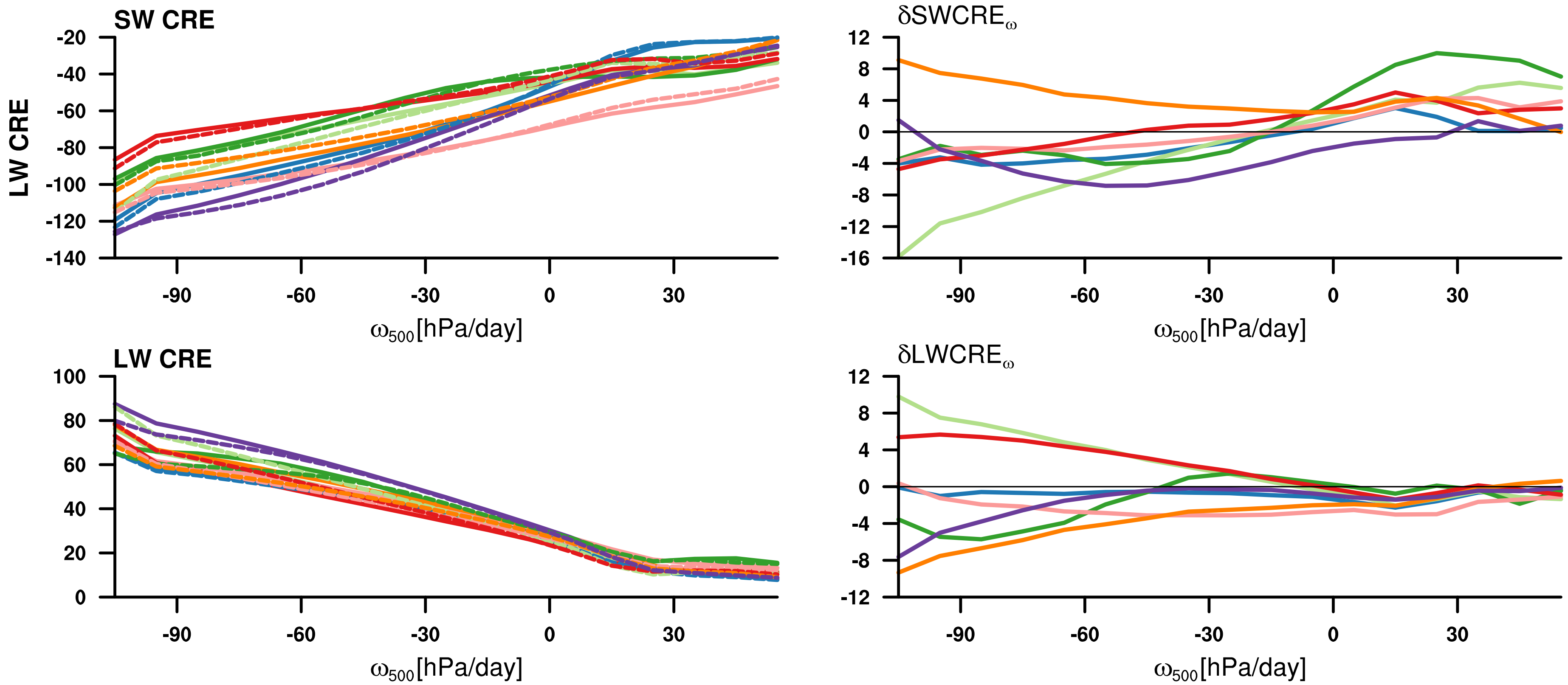


+4K v. 4xCO_2
ΔCRE/G
1.2
0.8
0.4
0.0
-0.4
Global
Tropics
+4K
4xCO_2
MPI-ESM-MR
MRI-CGCM3
NCAR-CAM4
MIROC5
CNRM-CM5
CanAM4
HadGEM2-A
MPI-ESM-LR
IPSL-CM5A-LR
Increasing sensitivity

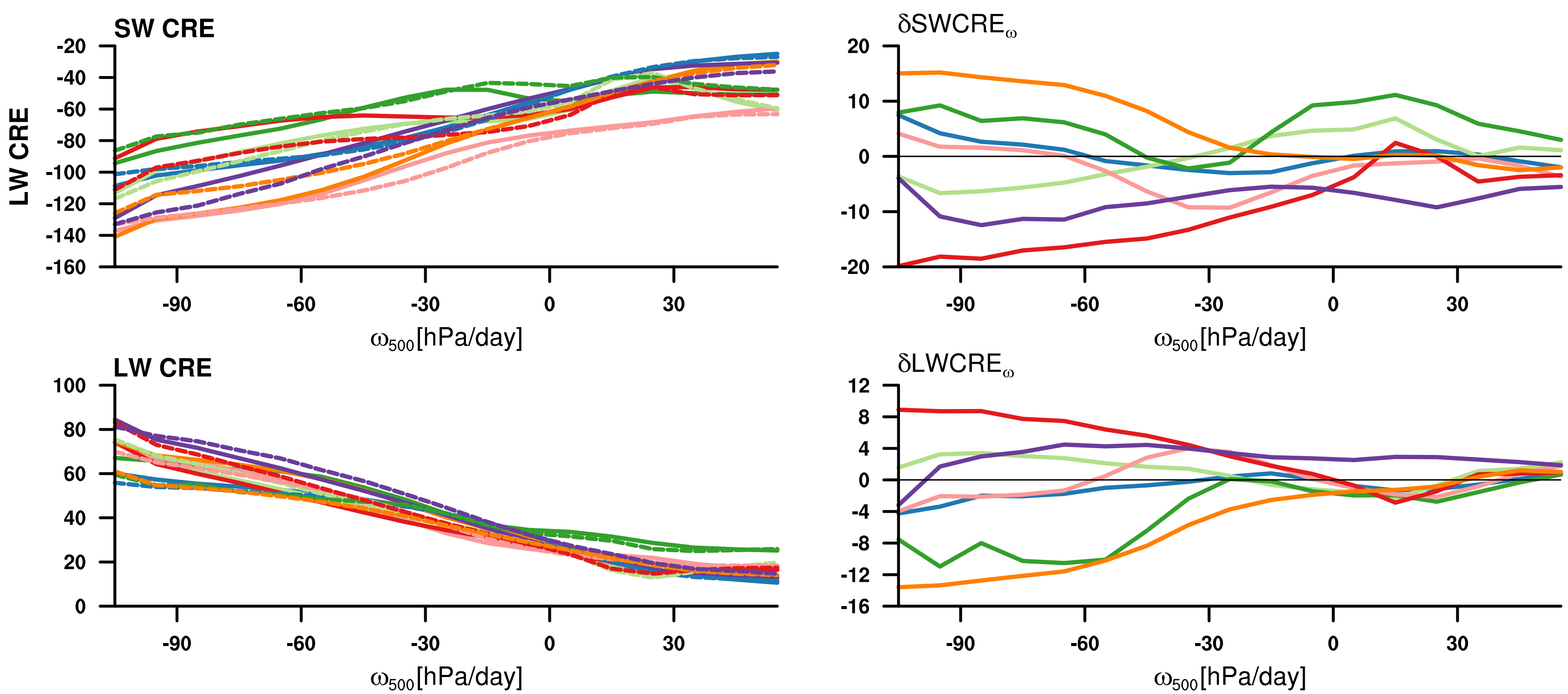


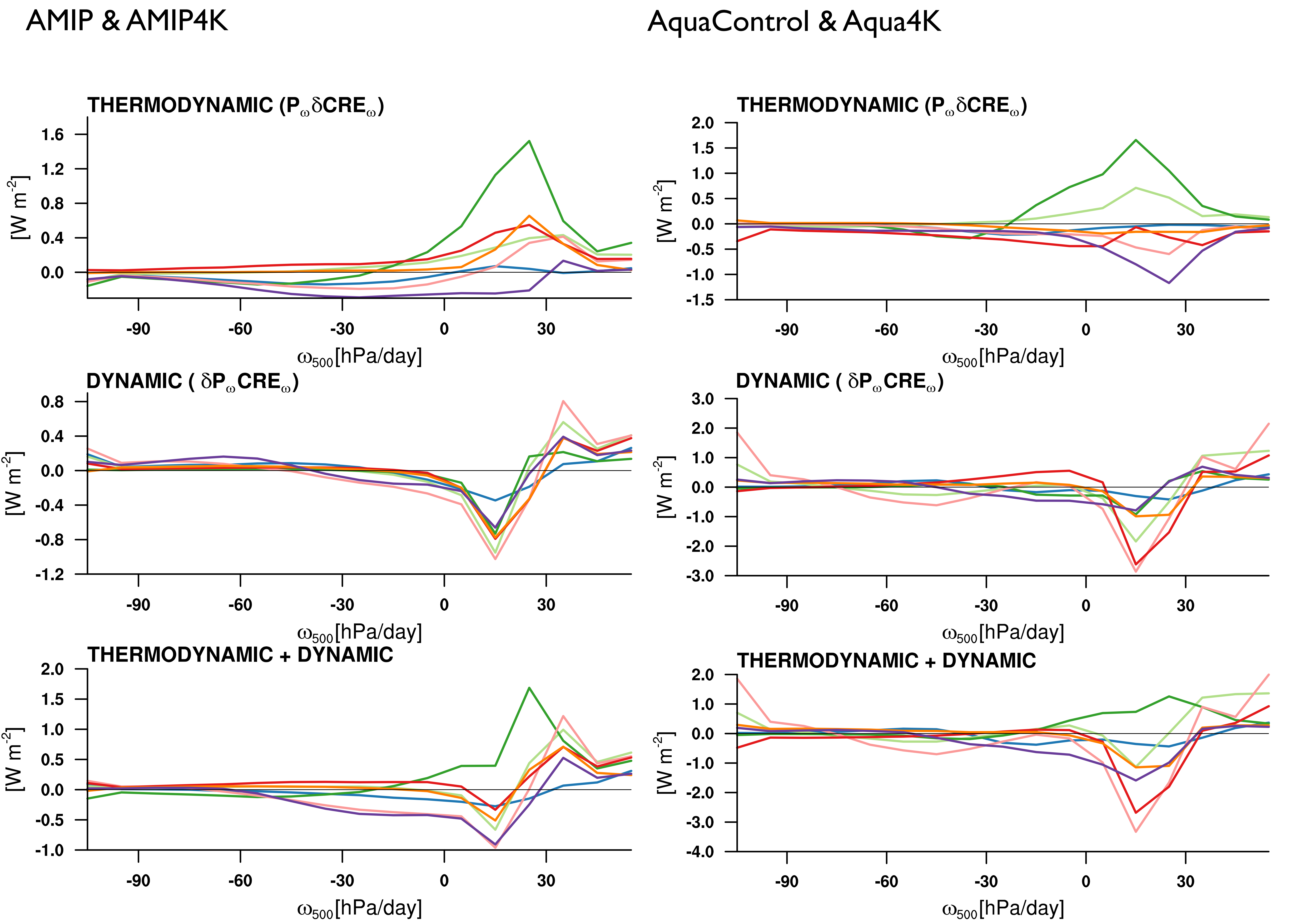
AMIP & AMIP4K
AquaControl & Aqua4K
P_ω
[FRACTION]
0.24
0.20
0.16
0.12
0.08
0.04
0.00
-120
-90
-60
-30
0
30
60
ω_{500}[hPa/day]
CRE_ω
[W m^{-2}]
0
-10
-20
-30
-40
-50
-60
-70

AMIP & AMIP4K



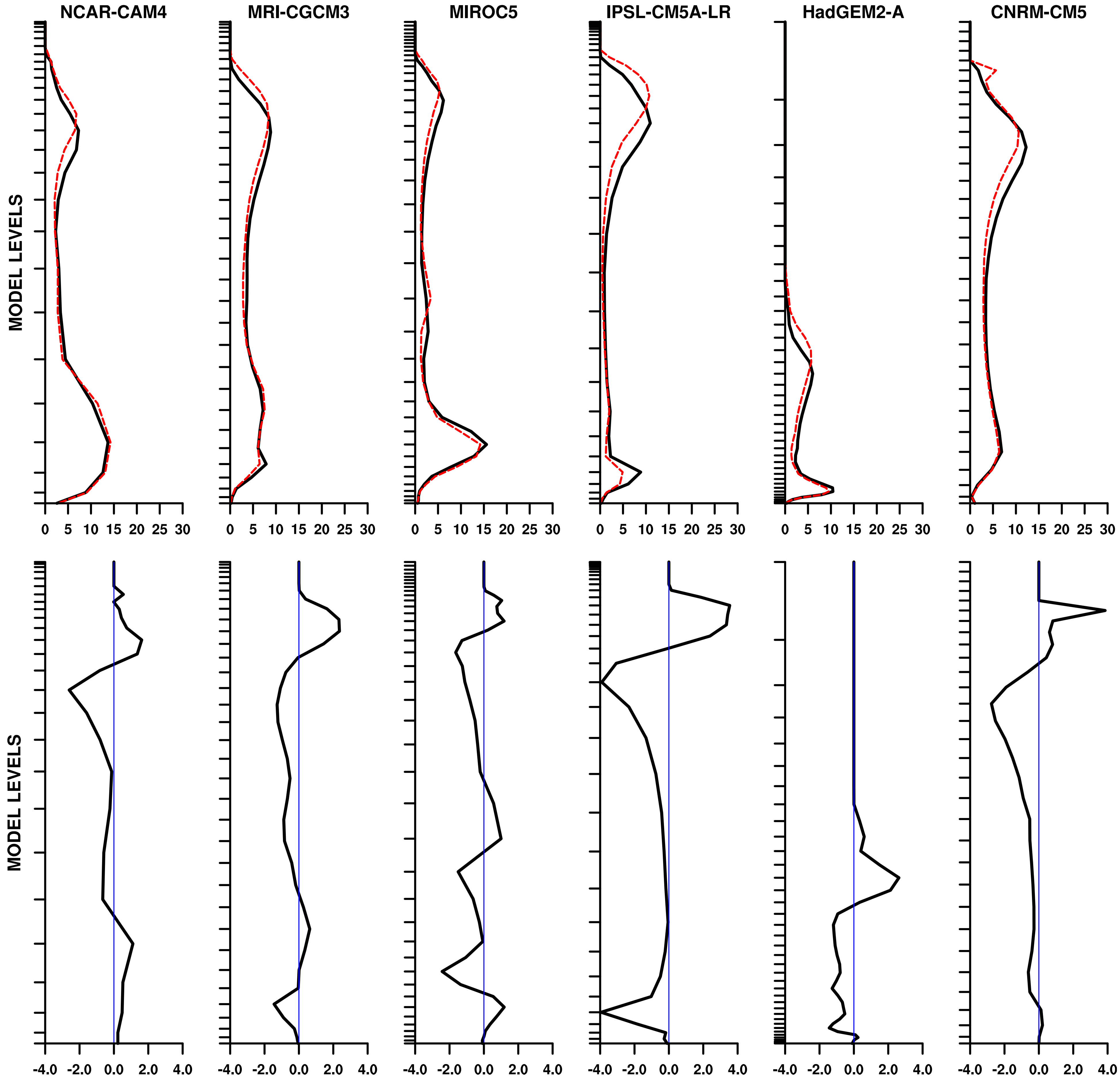
AquaControl & Aqua4K



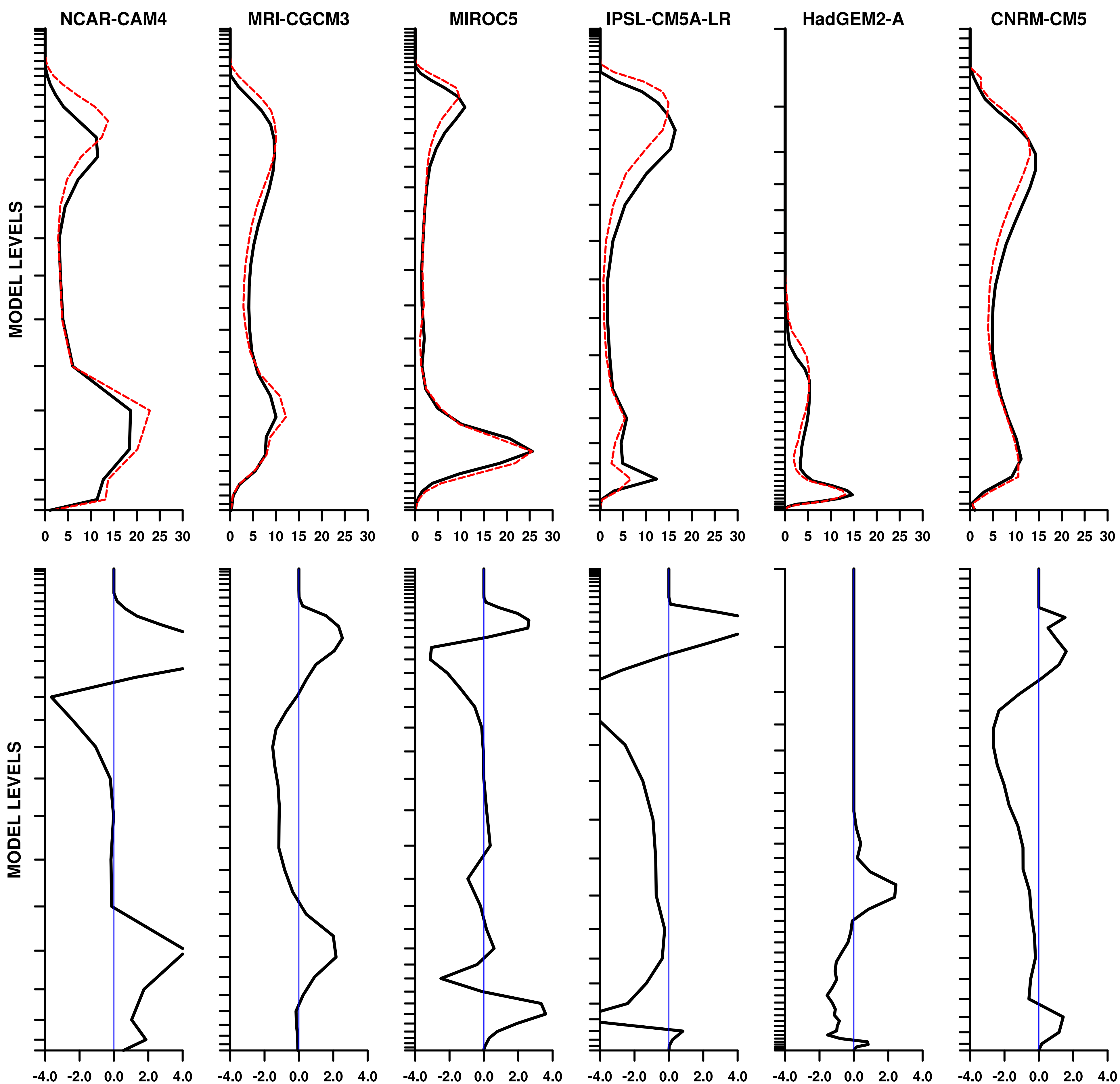


AMIP & AMIP4K
AquaControl & Aqua4K
THERMODYNAMIC (PωδCREω)
DYNAMIC (δPωCREω)
THERMODYNAMIC + DYNAMIC
[W m-2]
ω500[hPa/day]
-90
-60
-30
0
30

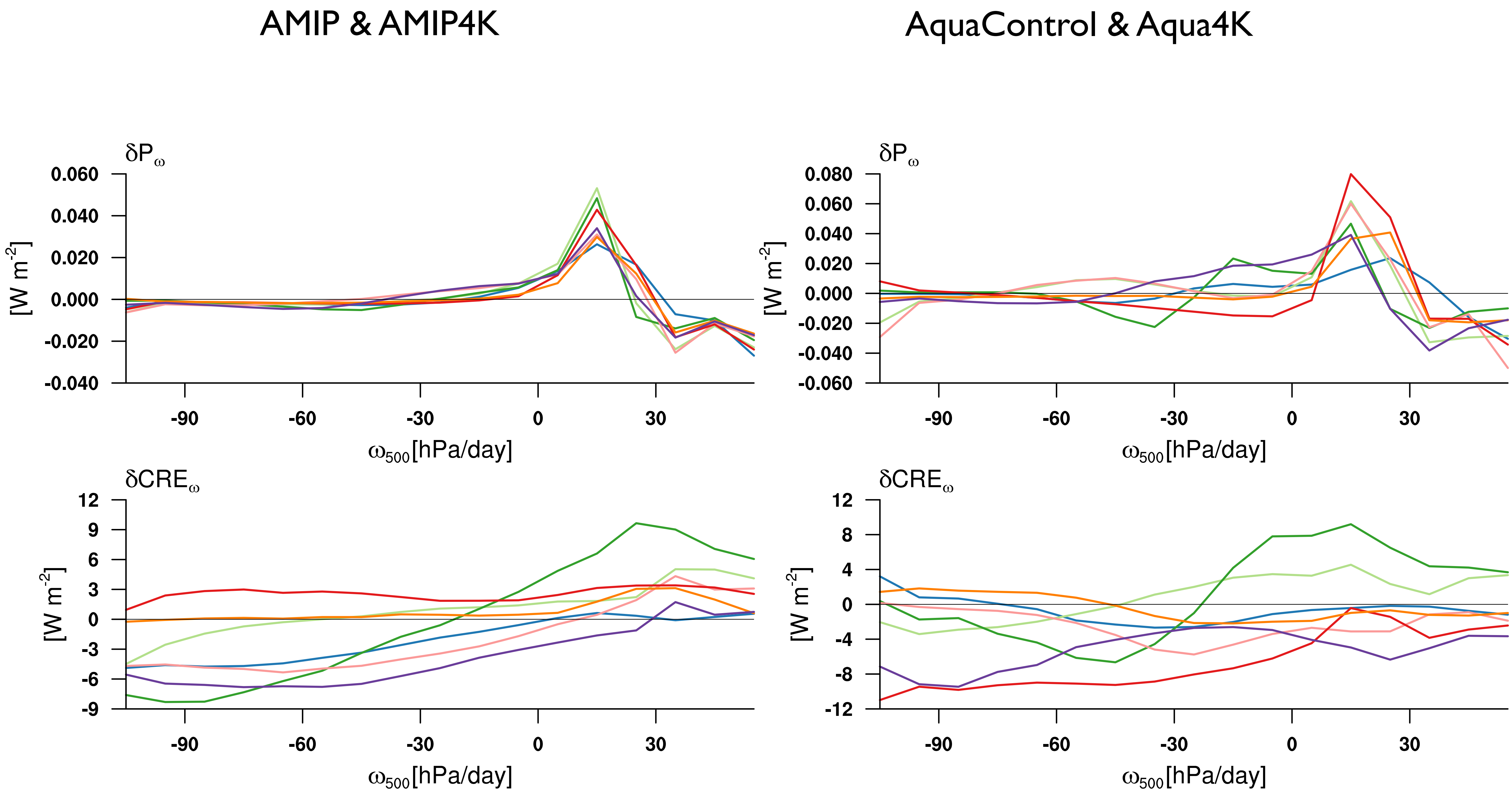
AMIP & AMIP4K
Cloud Fraction profiles
in subsidence regimes



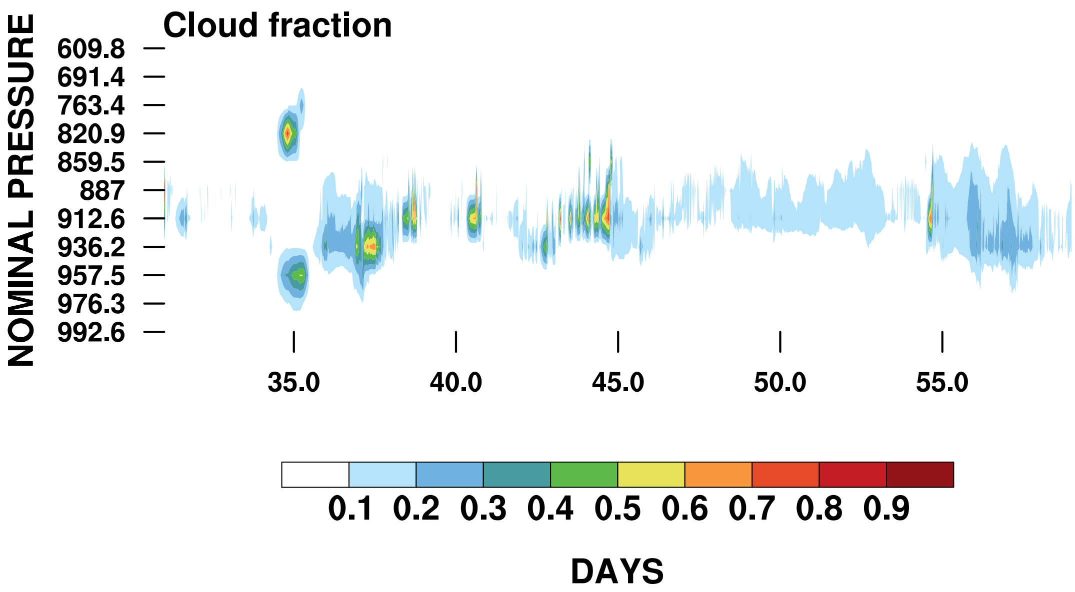
AquaControl & Aqua4K
Cloud Fraction profiles
in subsidence regimes



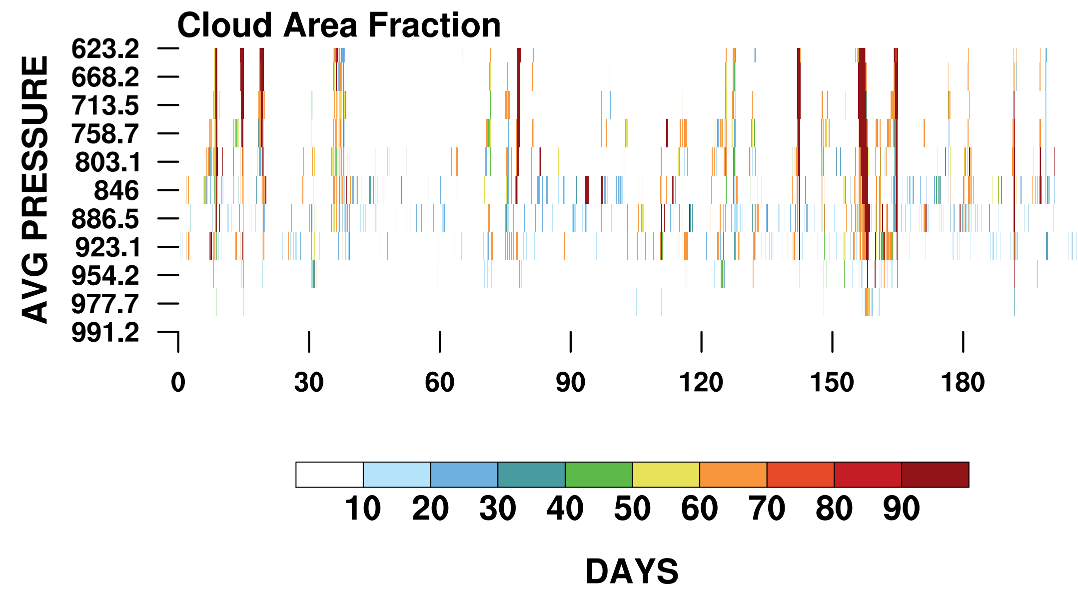
- Aquaplanets capture climate response of Earth-like configurations for most models.
- Cloud adjustment is generally smaller than the cloud response to SST+4.
- SST+4 response narrows PDF of ω_{500} enhancing importance of weak subsidence cloud response.
- Thermodynamic term in $0 > \omega_{500}$ is most important for most (not all) models/configurations. (SW effects)
- Shallow cumulus remain the most likely source of model disagreement in cloud response.
- NEXT:
  - simulator output to compare fraction/optical depth changes
  - organize subsidence by LTS


AMIP & AMIP4K
AquaControl & Aqua4K
δP_ω
[W m^-2]
0.060
0.040
0.020
0.000
-0.020
-0.040
-90
-60
-30
0
30
ω_500 [hPa/day]
δP_ω
0.080
0.060
0.040
0.020
0.000
-0.020
-0.040
-0.060
δCRE_ω
12
9
6
3
0
-3
-6
-9
δCRE_ω
12
8
4
0
-4
-8
-12

NCAR-CAM5 AquaControl @18S



CNRM-CM5 AquaControl @site46



NCAR-CAM5 AquaControl @12S