Climate Feedbacks in CAM4 & CAM5

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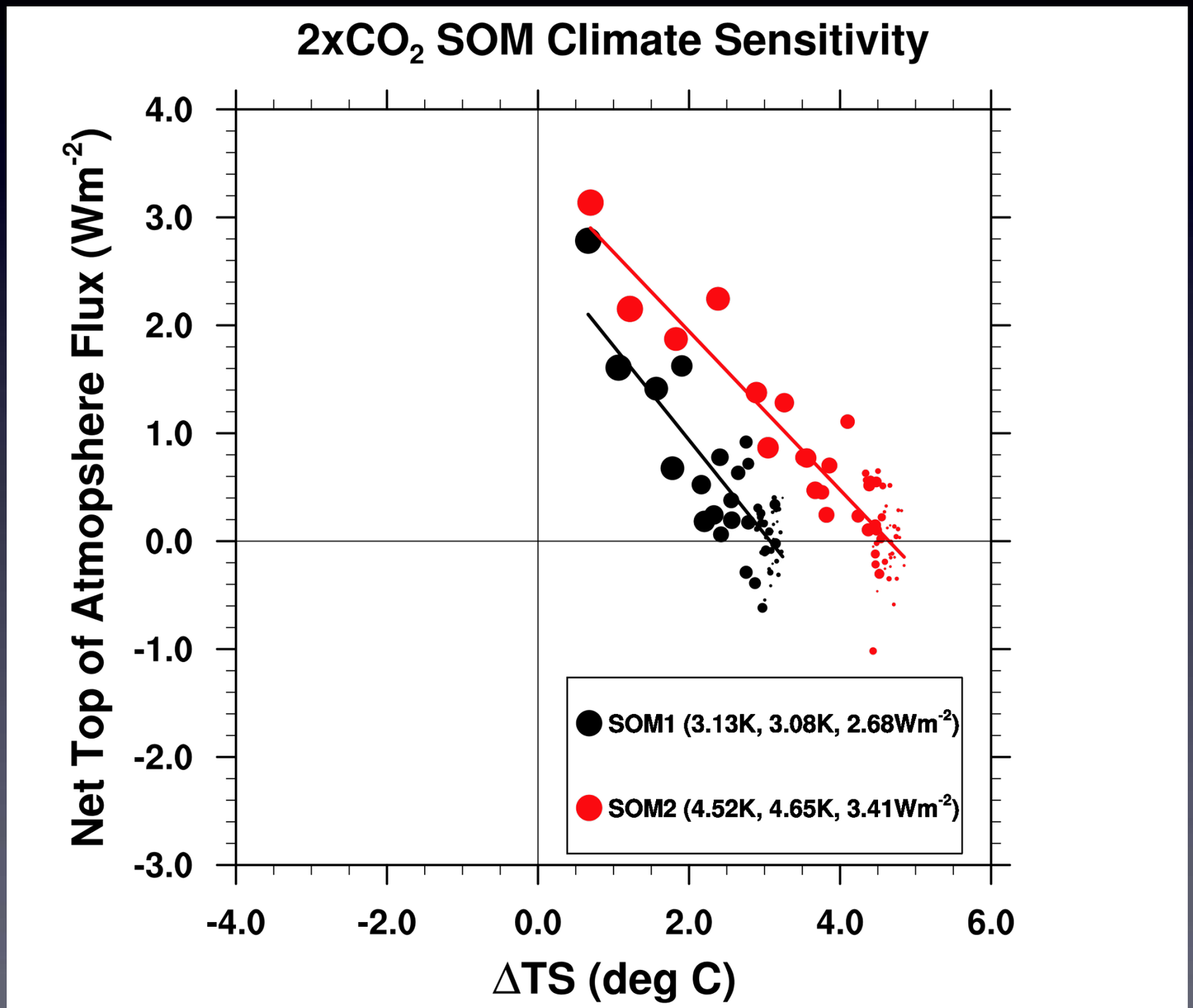
CAM5 v. CAM4

CCSM/CESM Climate Sensitivity:

CAM4= 3.1K CAM5= 4.5K



Outline

- Why is climate sensitivity different?
- What drives it? Feedback processes
- Explore climate feedbacks
- Describe method, runs
- Show preliminary comparisons
- May have an answer… you can guess!

Radiative Kernel Method

Key feedbacks ($\lambda = \Sigma\lambda_x$):

T (& lapse rate Γ), H_2O, Albedo, Clouds

Decompose with a ‘Kernel’

$\Delta F = \lambda\ \Delta Ts$ or $\lambda = \Delta F / \Delta Ts$ (λ=1/γ)

$\lambda_x = \Delta F/\Delta X\ \Delta X/\Delta Ts$

‘kernel’ K = $\Delta F/\Delta X$ (x,y,z,t)

Method works well, except clouds are a residual

Use CAM3 Kernels (Shell et al 2008). Working on CAM5 (RRTMG) Kernels

Model Simulations

- SOM runs, last 20 years of 40 or 60 year runs.
- ‘Modified Cess’ experiments (prescribe dTs)

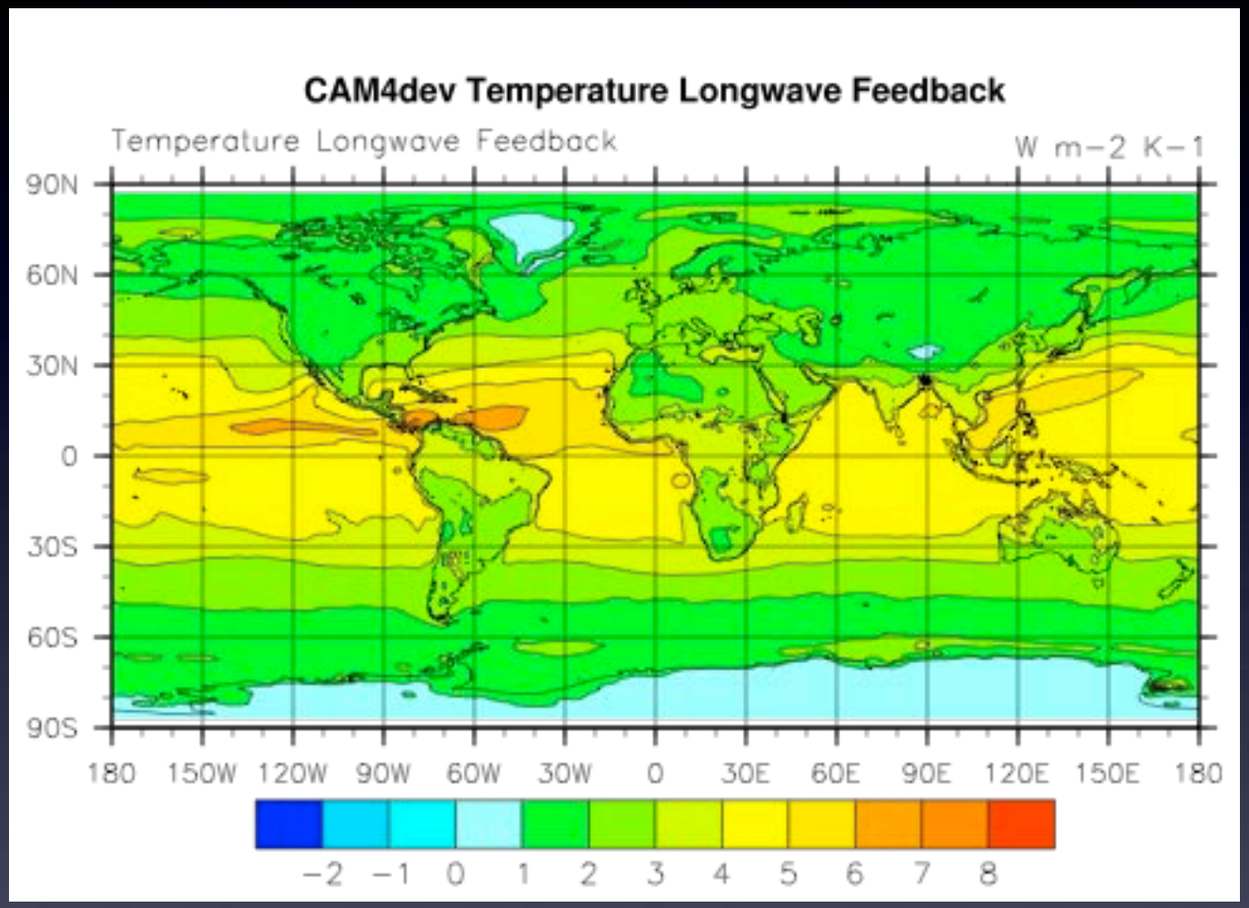
Near Final Development versions of:

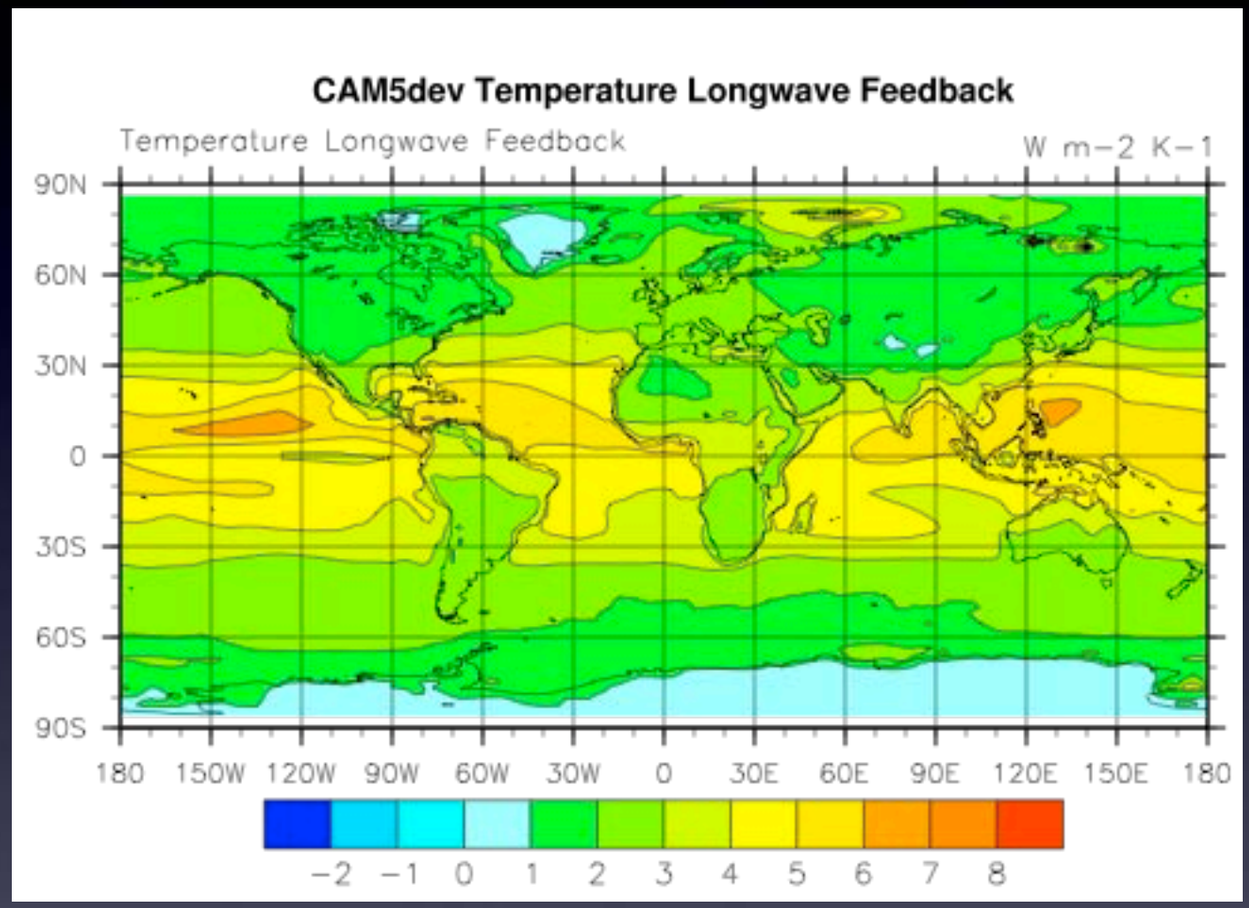
- CAM4 & CAM5 in CCSM4α

WARNING: Draft versions. Analysis is pending Not for citation or attribution!

CAM4

CAM5

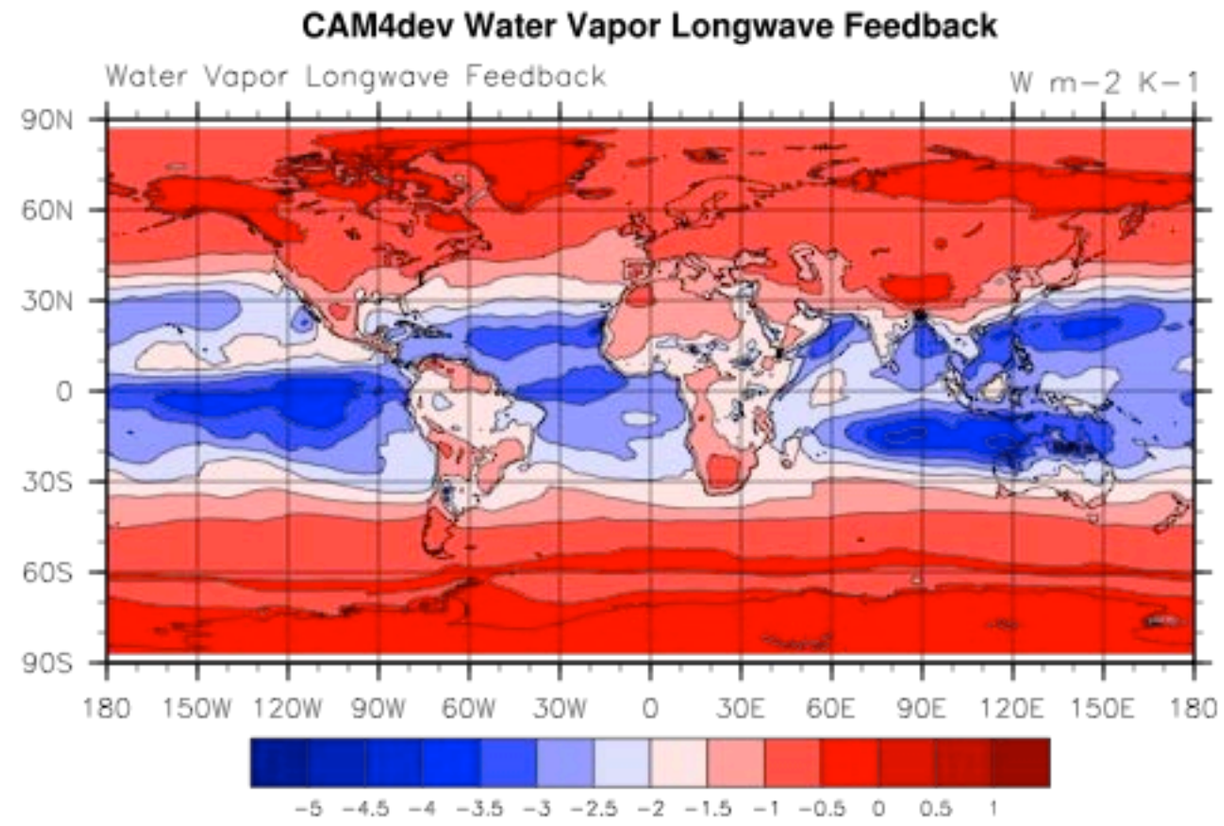


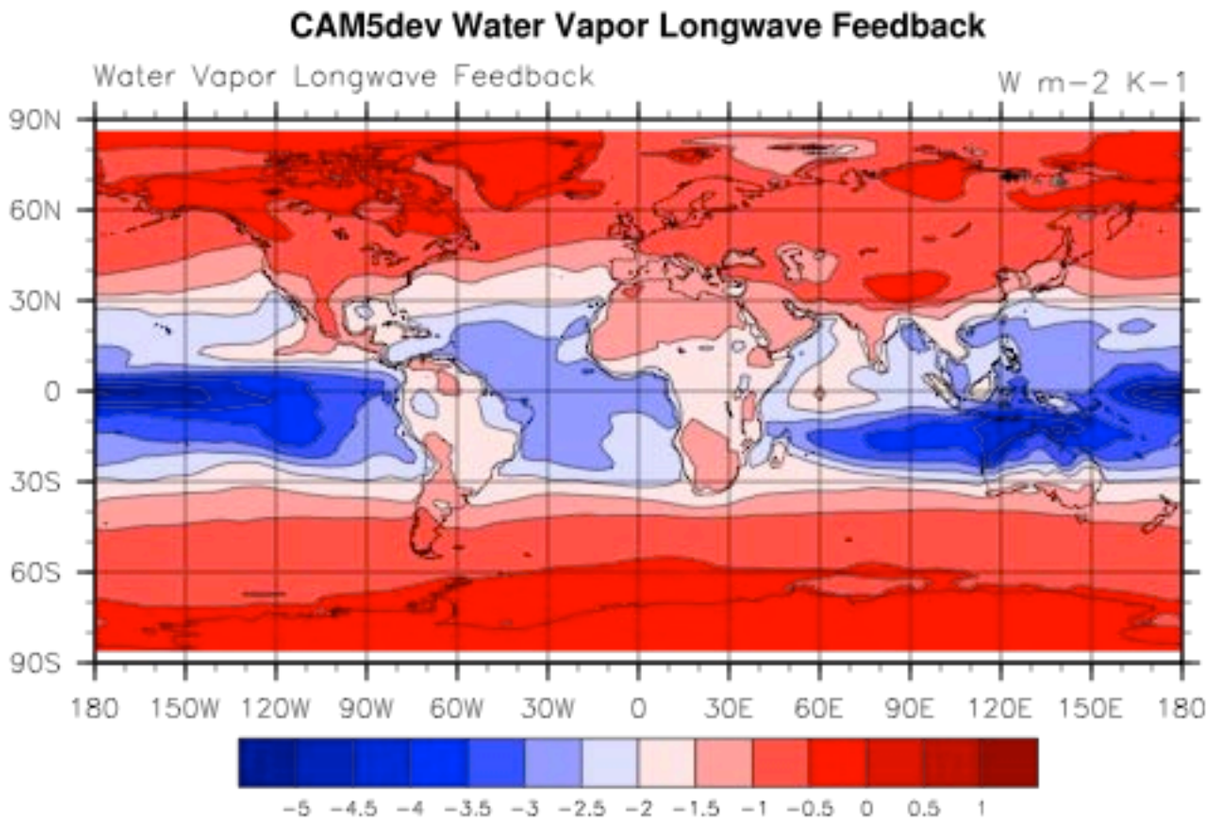


Temp (Planck) Feedback

CAM4

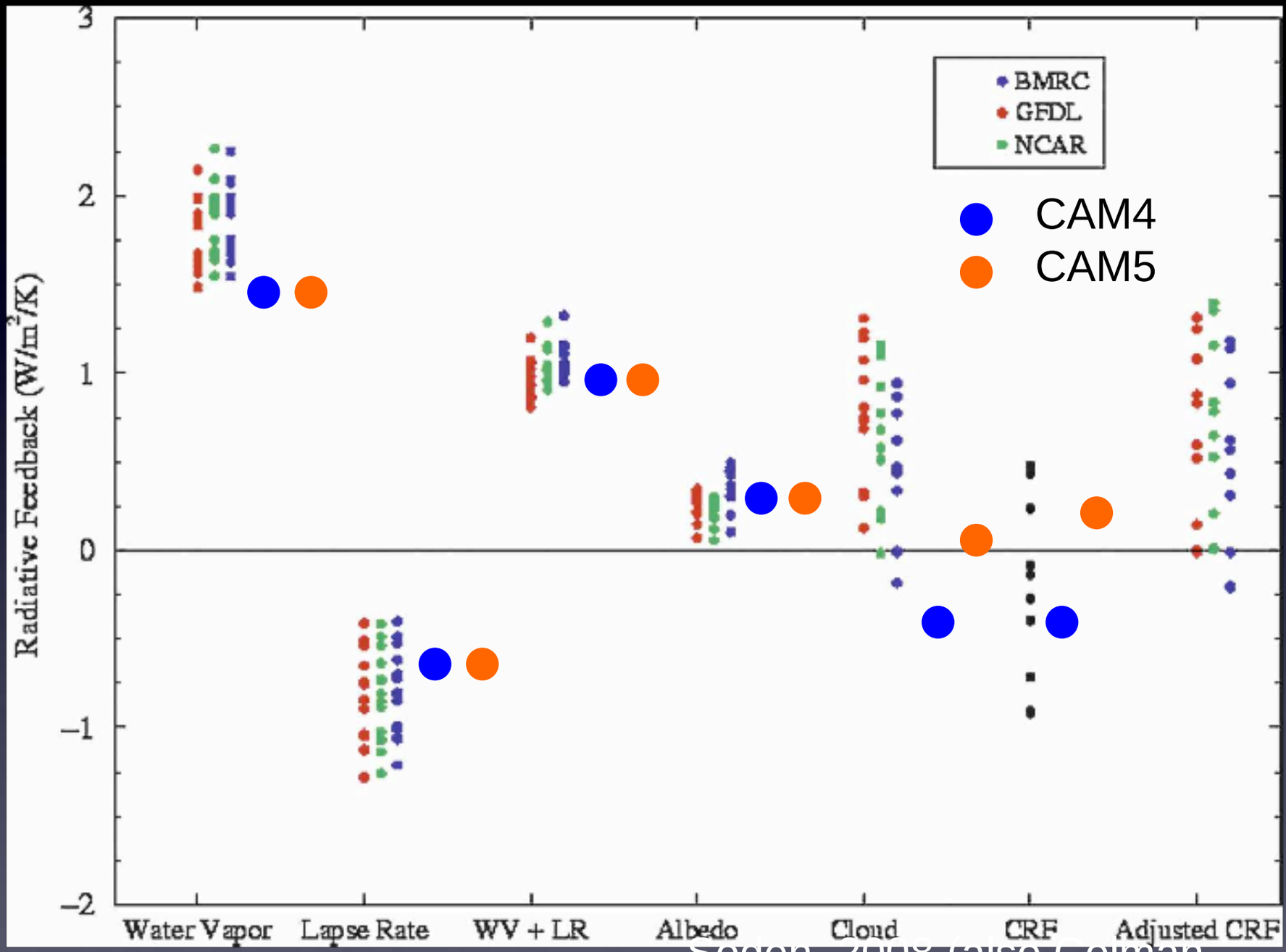
CAM5





LW H_2O Feedbacks

Comparison

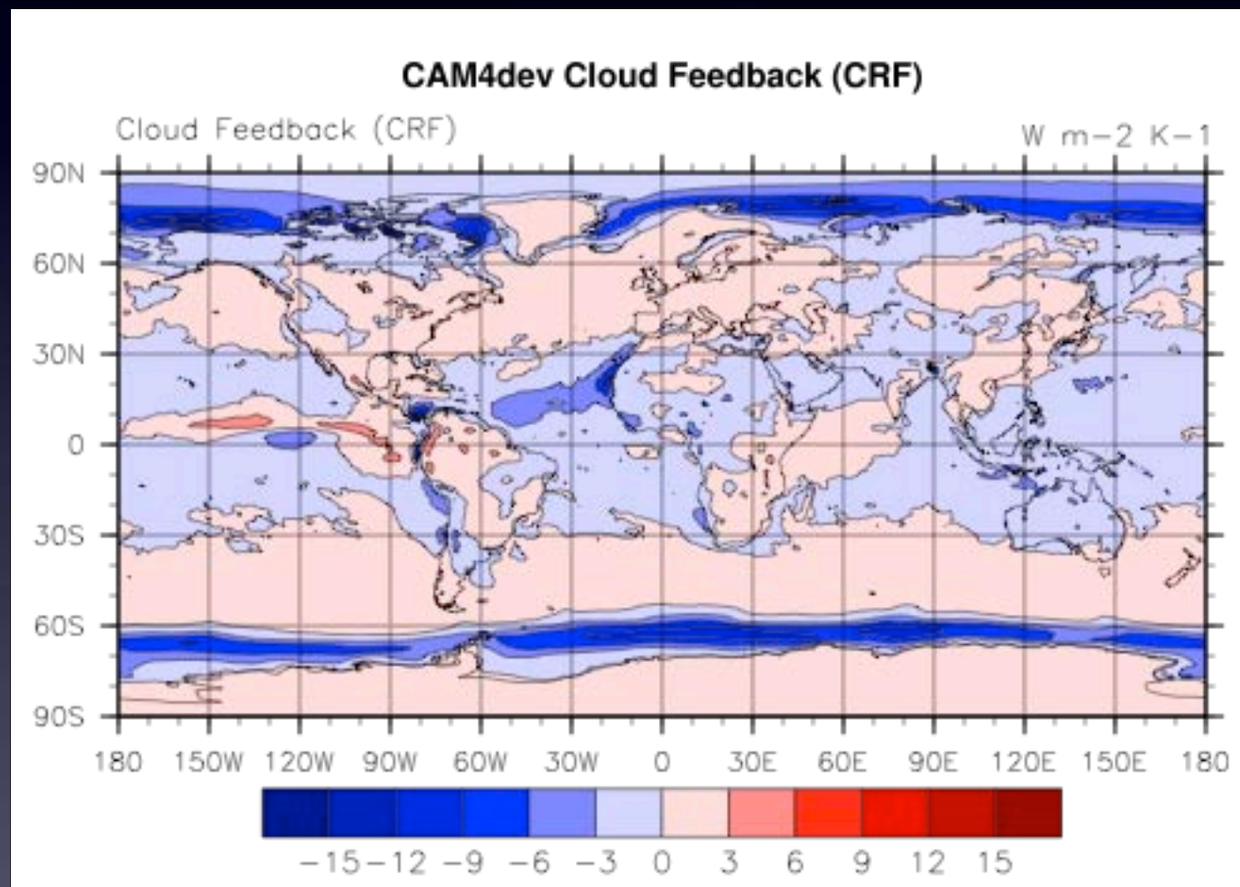


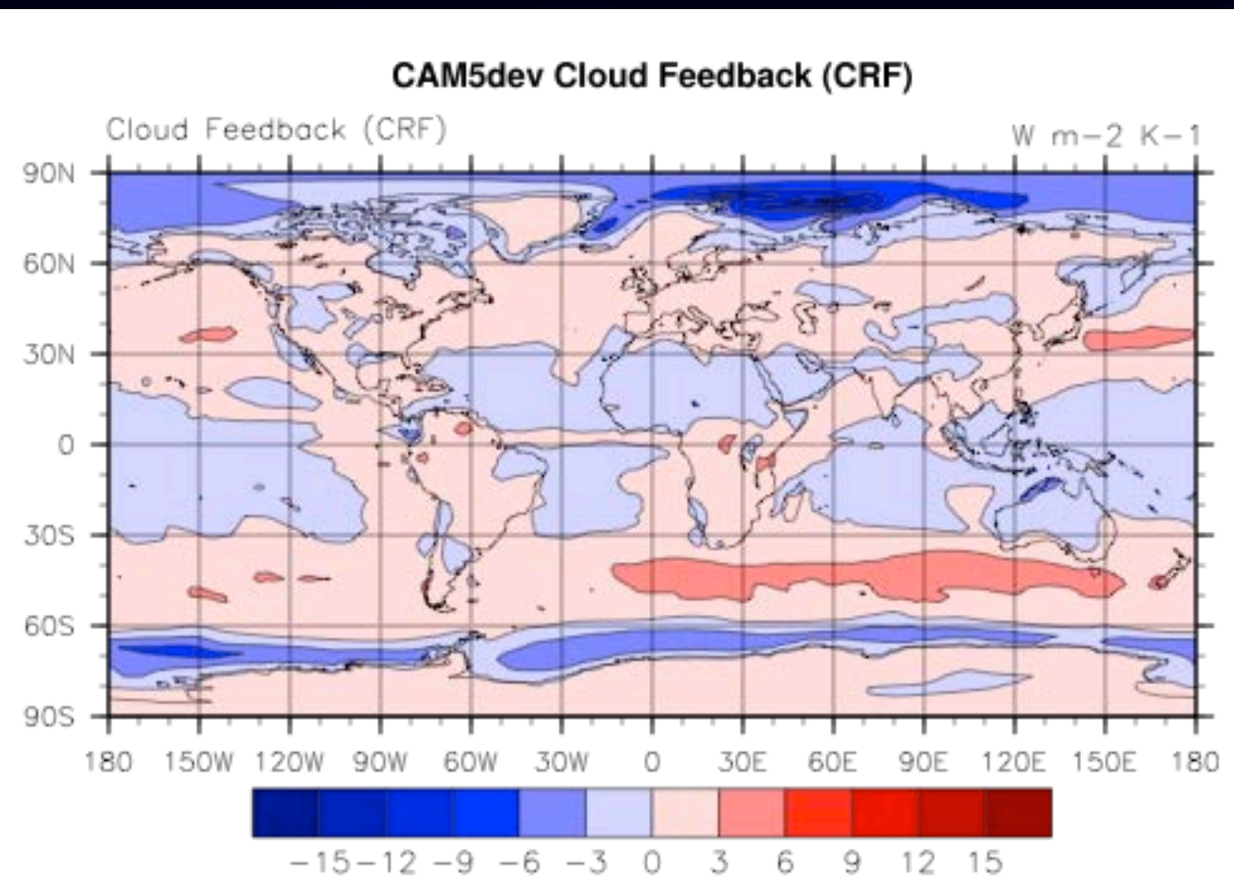
Soden, 2008 (also Colman, Bony)

Cloud Feedbacks

CAM4

CAM5

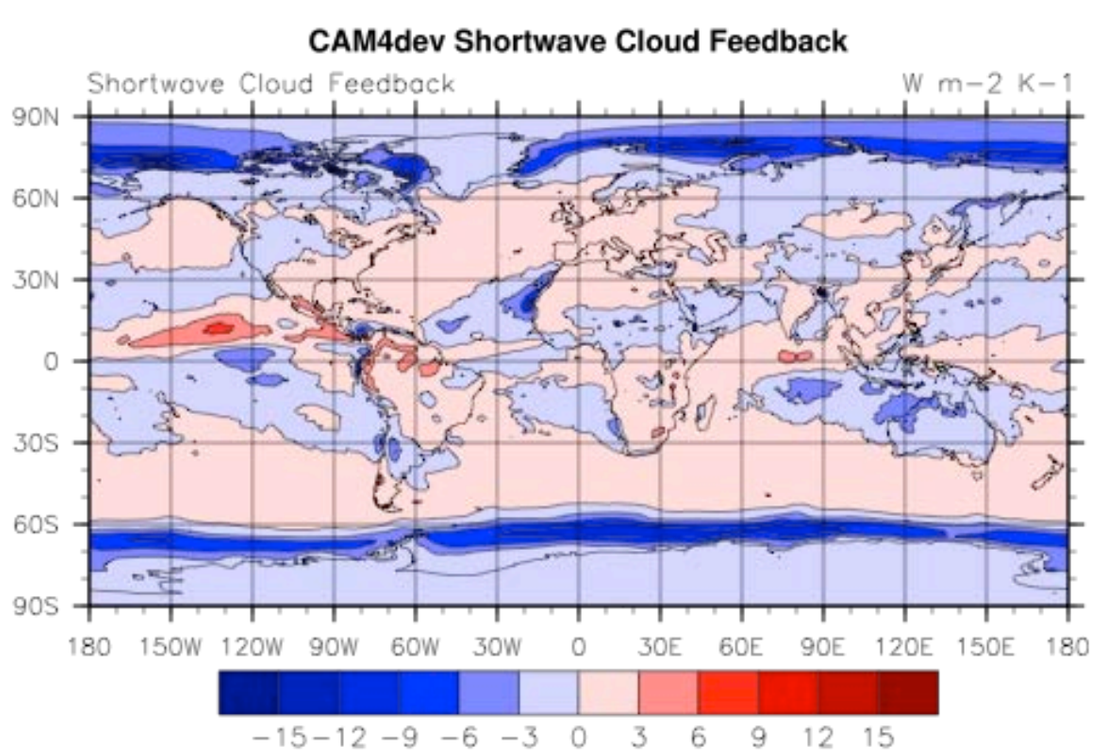




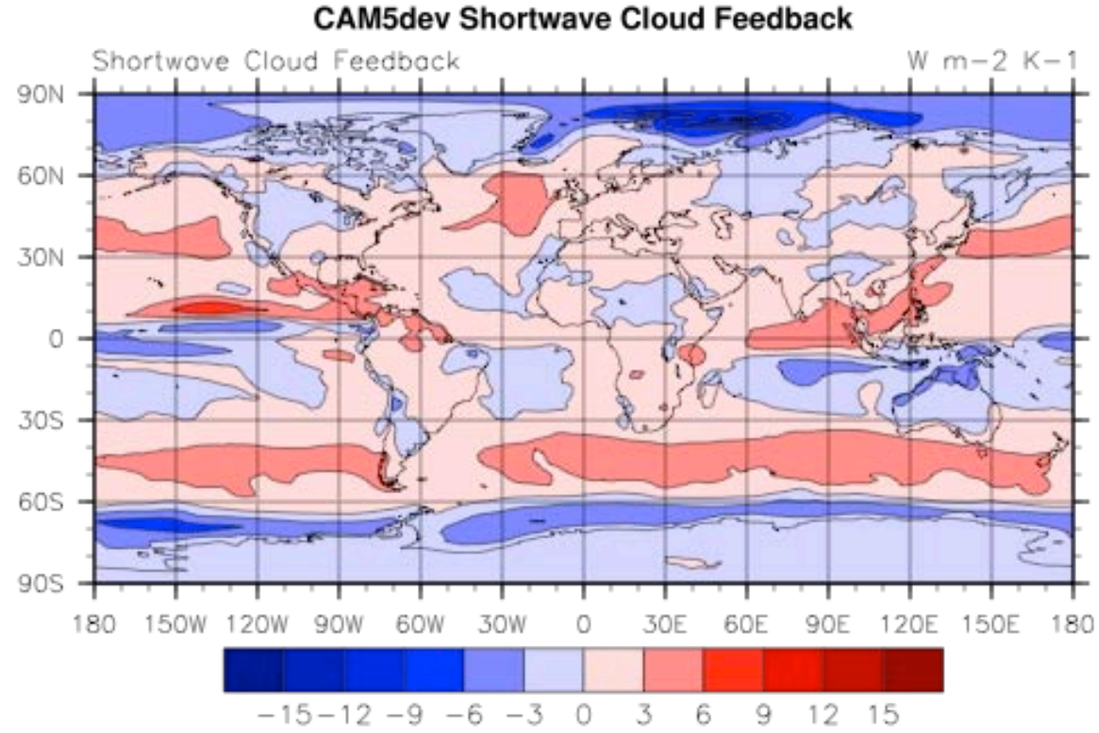
CAM4 has stronger negative CRF

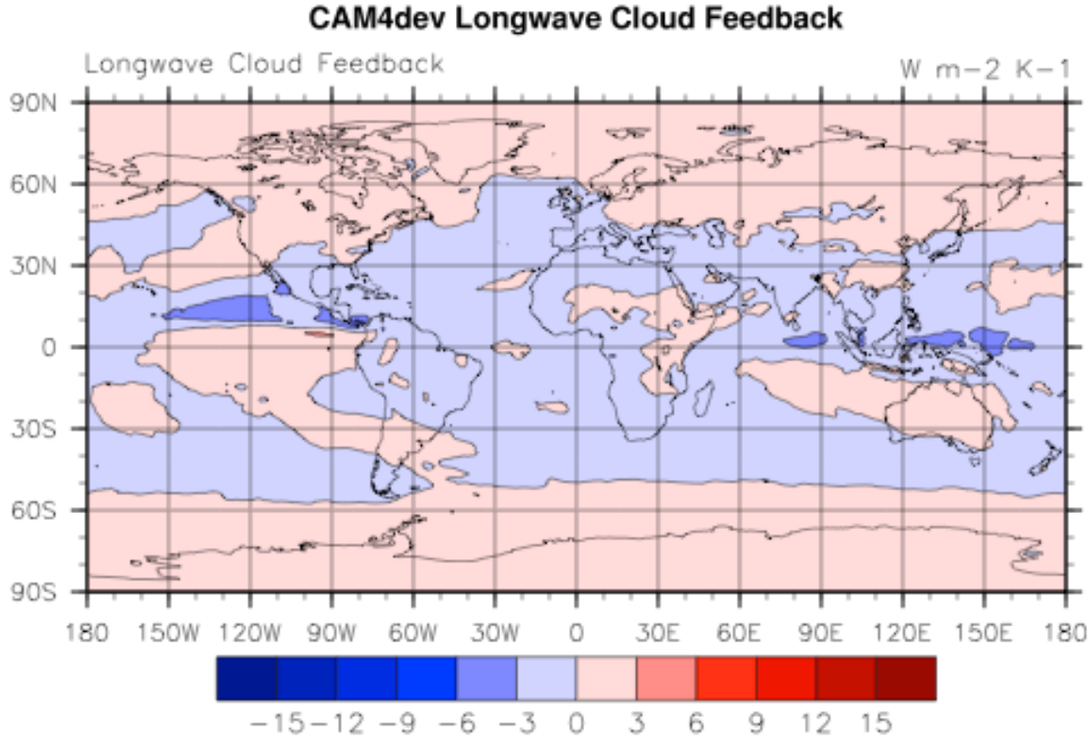
CAM5 has +CRF in mid-latitudes

LW & SW Feedbacks

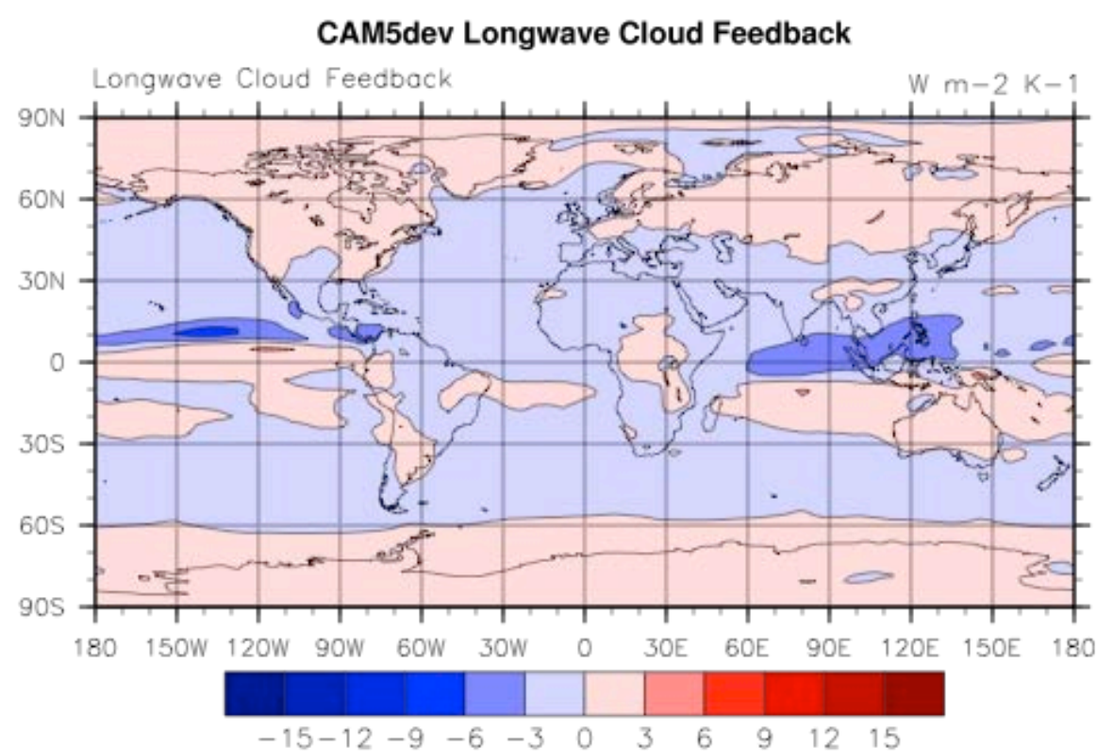


SW





LW



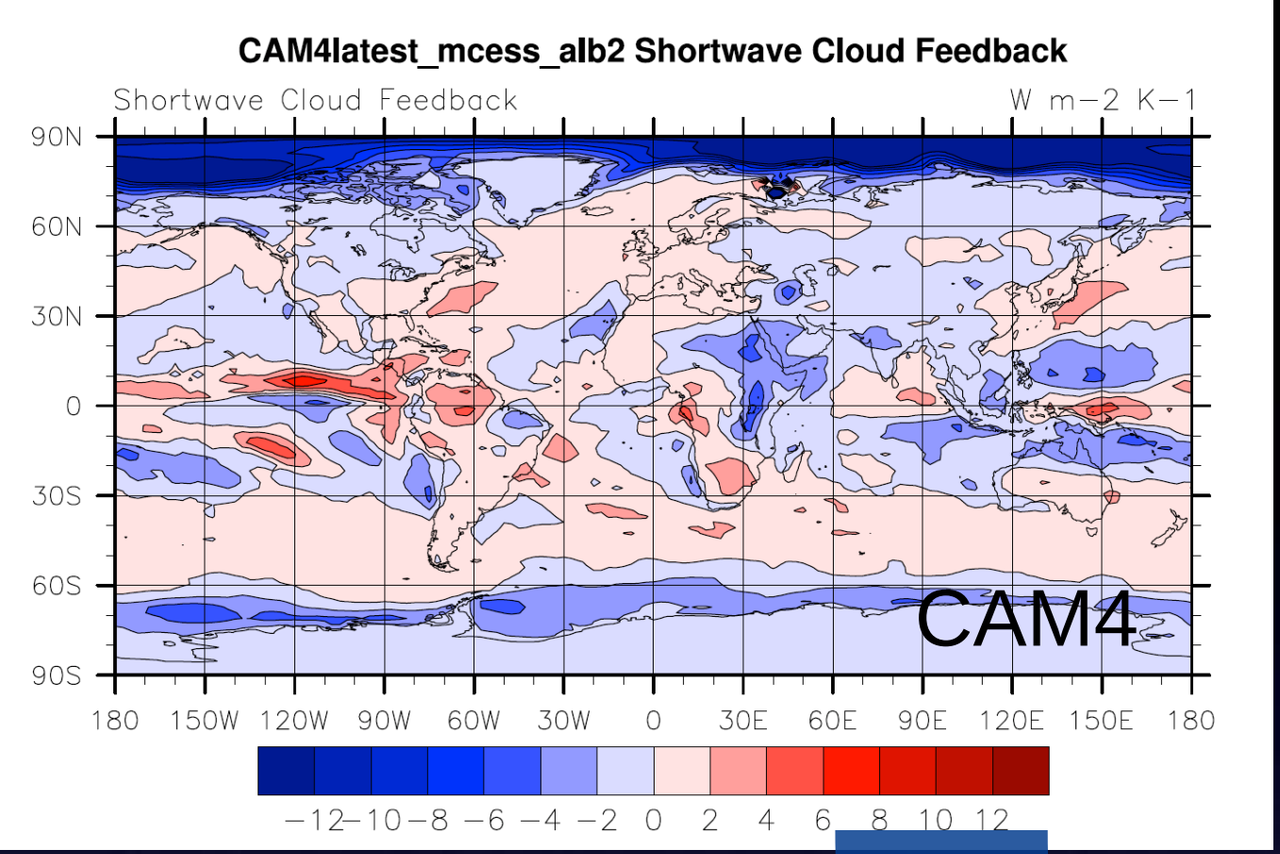
Which processes?

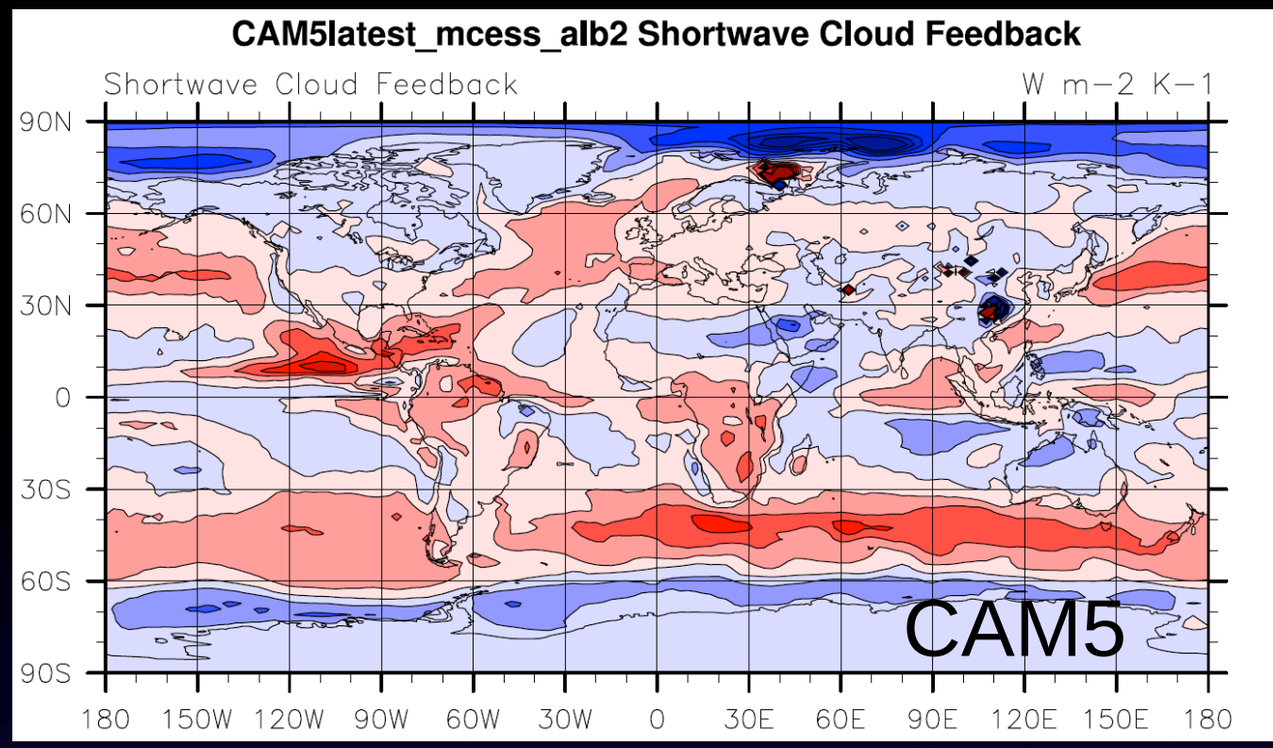
- SW Cloud forcing is biggest change
- What processes change it?
- CAM4-5: Micro, Macro, Radiation, Aerosols, Boundary Layer, Shallow Convection
- Where?
- Explore by analyzing kernels in a series of stand-alone runs

λ_x ‘Evolution’

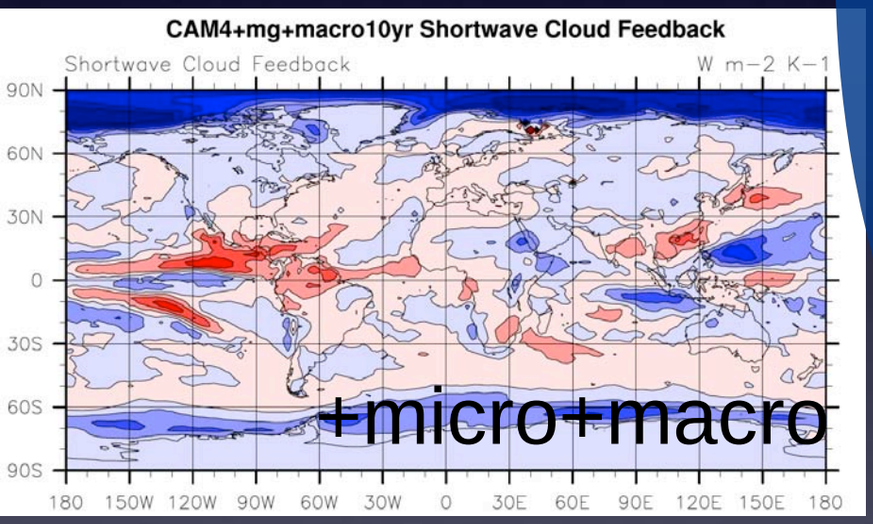
$Wm^{-2}\ K^{-1}$

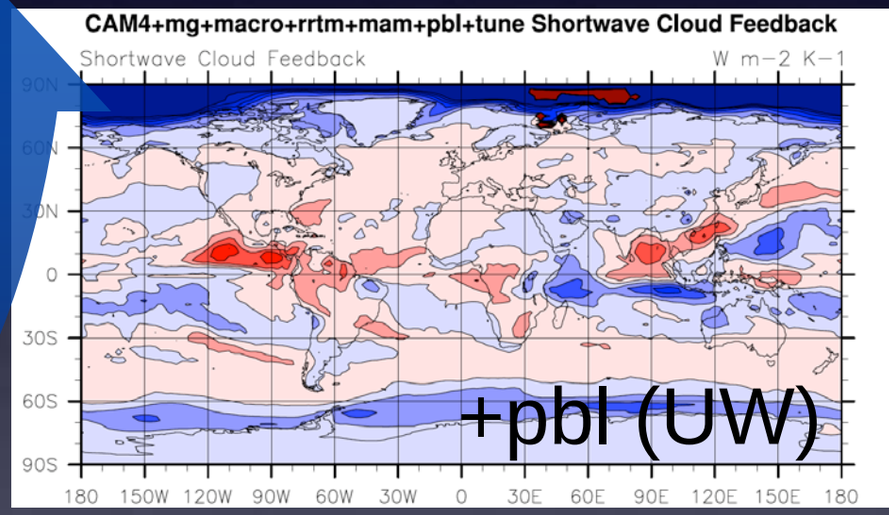
Feedback	CAM4 SOM	CAM4	+micro	+macro	+rad	+aero	+pbl	+shcu= CAM5	CAM5 SOM
Albedo	0.34	0.30	0.24	0.20	0.33	0.34	0.36	0.25	0.28
T	-3.14	-3.14	-3.13	-3.20	-3.22	-3.26	-3.21	-3.15	-3.17
Lapse Rate	-0.68	-0.67	-0.69	-0.74	-0.74	-0.77	-0.76	-0.68	-0.70
Q	1.92	1.88	1.83	1.95	1.94	1.96	1.91	1.90	1.91
Cld LW	-0.28	-0.21	0.28	-0.25	-0.29	-0.29	-0.31	-0.44	-0.47
Cld SW	-0.20	-0.23	-1.00	-0.07	0.13	0.22	-0.19	0.80	0.67
Cld Tot	-0.48	-0.44	-0.72	-0.32	-0.16	-0.07	-0.49	0.36	0.20
Cld Residual	-0.06	0.37	0.37	0.28	0.43	0.47	0.48	0.32	0.44

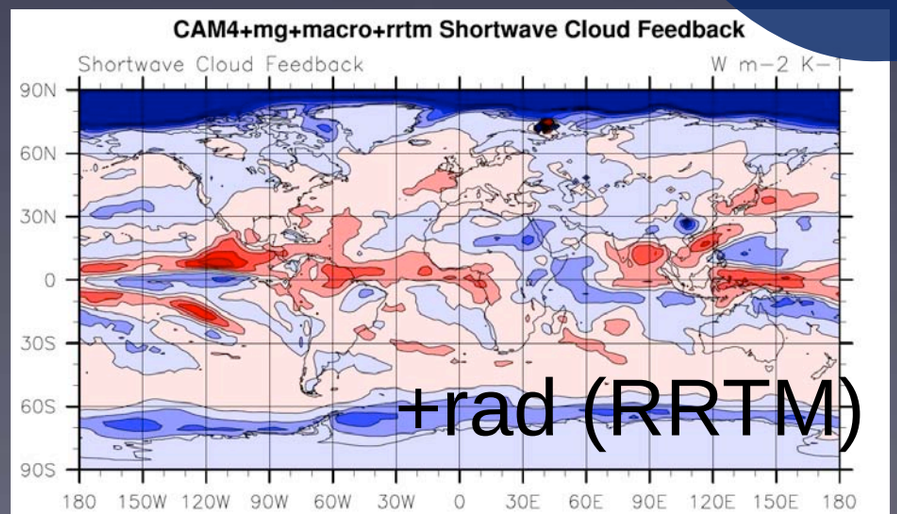


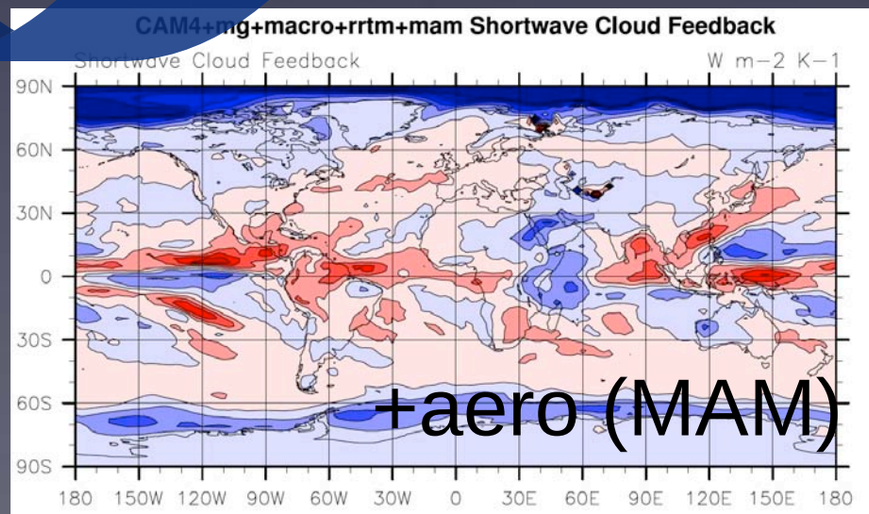


+ UW shallowcu









Initial Results

- CAM5 has higher climate sensitivity than CAM 4
- Difference driven by λ_{cld} (SW)
- Not just stratocumulus: mid-latitude λ_{cld} (SW) especially Southern Ocean
- What drives changes?
  - Tropics: Cloud Optics (radiation)
  - Mid-Lats: PBL and/or Shallow Cu
- Paper for CCSM/CESM Special issue

Plans

- Finalize CAM5 kernels and compare with CAM3 (Conley, Lamarque paper)
- Further analysis of results and Cloud Radiative forcing changes
- Paper for special issue on what drives climate sensitivity