The Sensitivity of the Tropical-mean Radiation Budget

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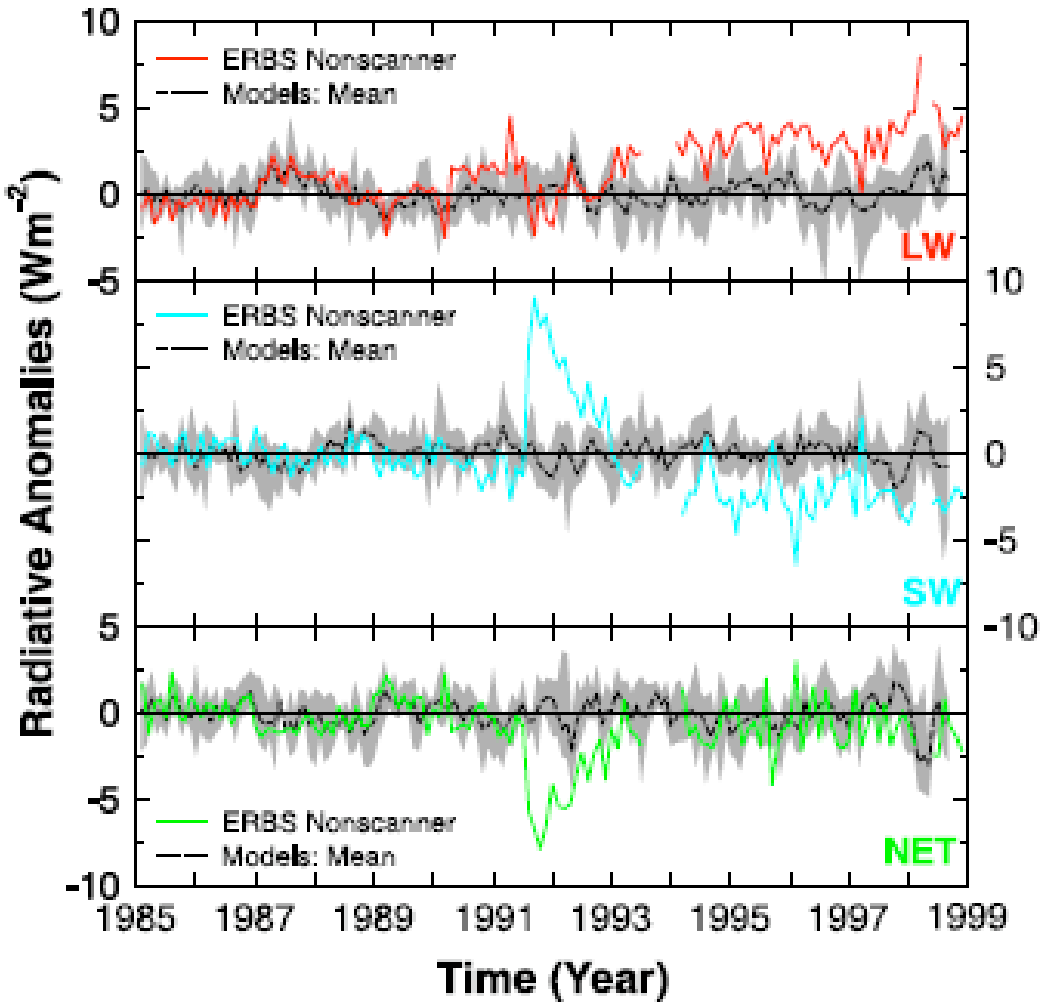
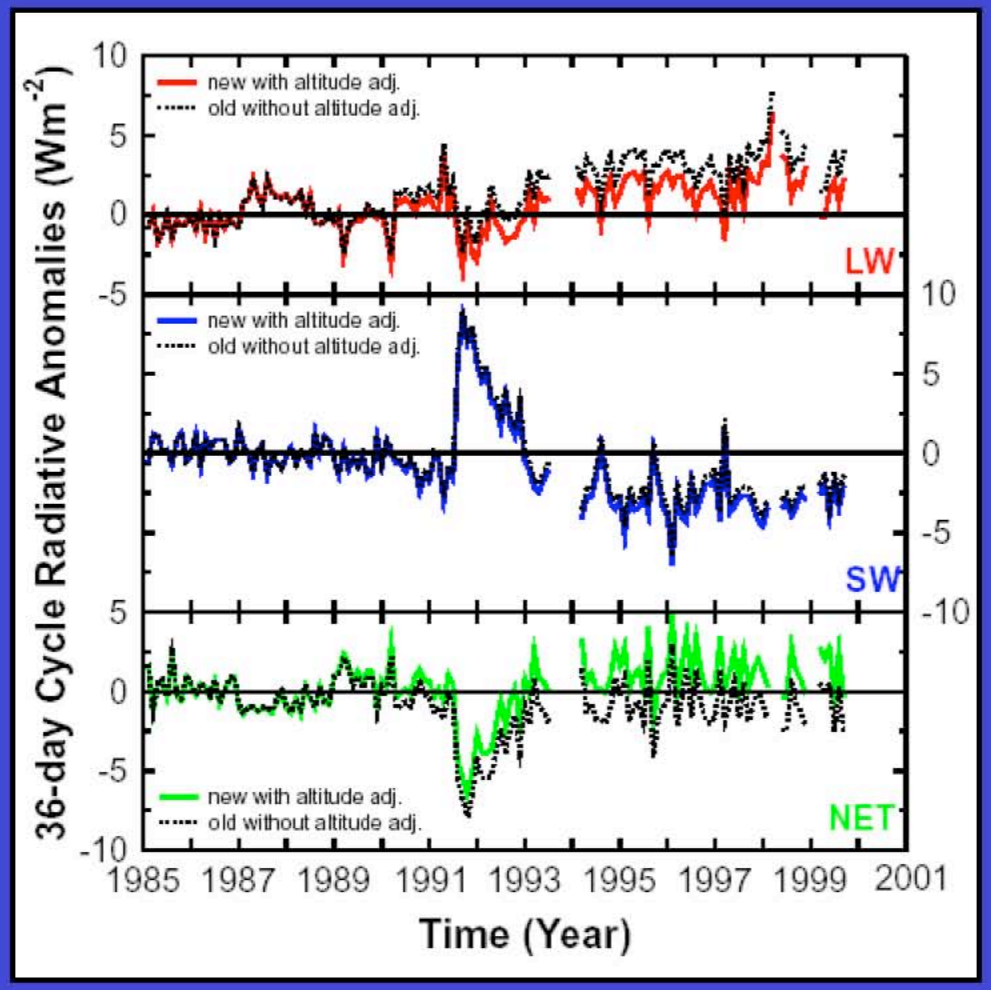


From Wielicki et al. (2002)

Effects on Tropical Mean Decadal Changes



- The Inclusion of ERBS Altitude Changes will Lower the Reported Tropical Mean Decadal Changes in the 2002 Science Paper by About 1.5 Wm^{-2} in the Outgoing Longwave and 0.8 Wm^{-2} in the Reflected Shortwave Fluxes

OLR: 3.5 → 2.0 Wm^{-2}

RSW: -2.5 → -3.3 Wm^{-2}

Courtesy of T. Wong

Hypothesis #1: Tropical Circulation changes (Chen et al. 2002)

Hypothesis #2: Cloud microphysical changes (Wielicki et al. 2002, Wang et al. 2002, Cess and Udelhofen 2003)

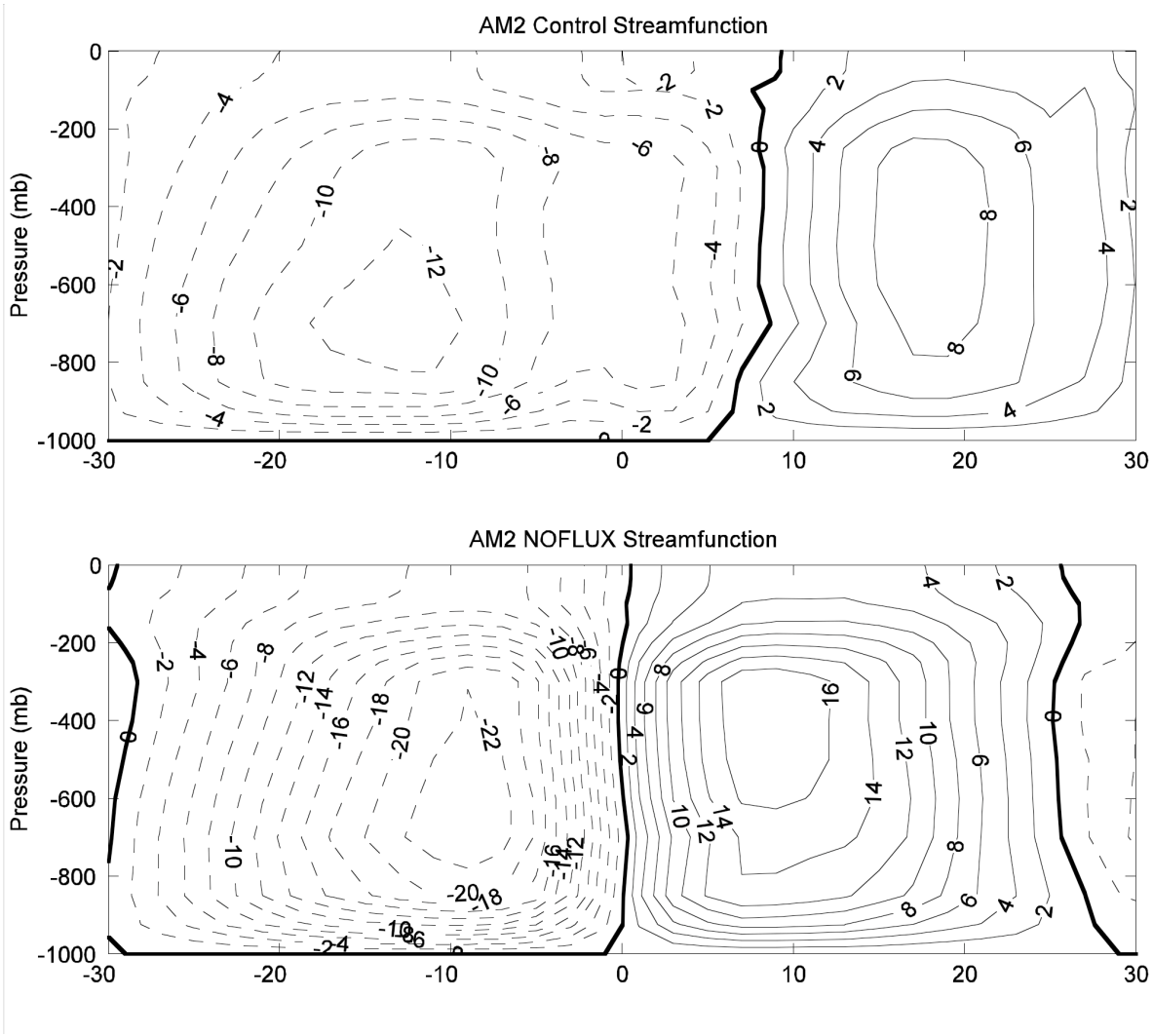
Methodology

If such changes were to occur in a model, could the observed changes in tropical mean TOA fluxes be reproduced?

Hypothesis #1: The effect of changes in the strength of the Hadley cell on tropical mean radiative fluxes

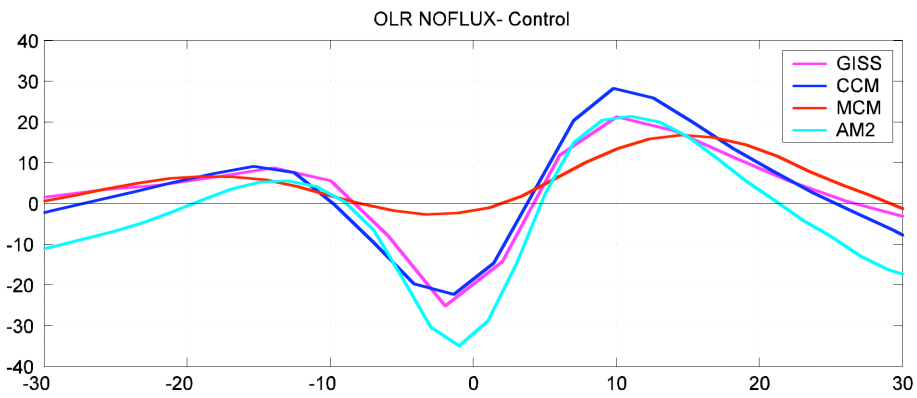
GFDL AM2 **Control** streamfunction

No ocean heat transport streamfunction

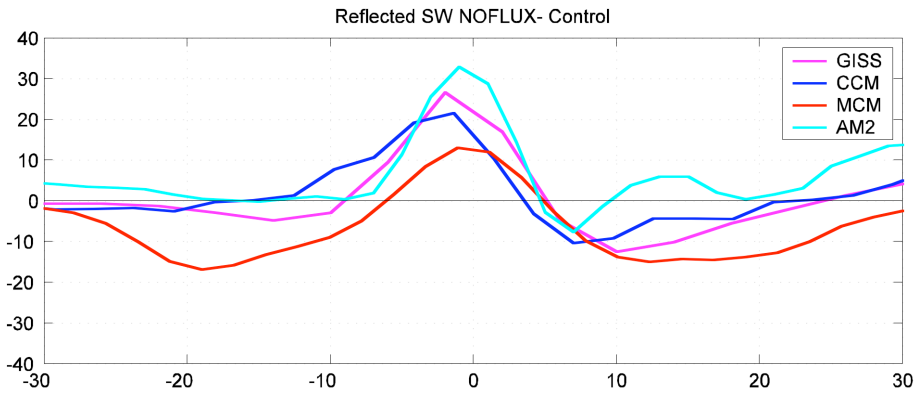


Strong – weak Hadley cell

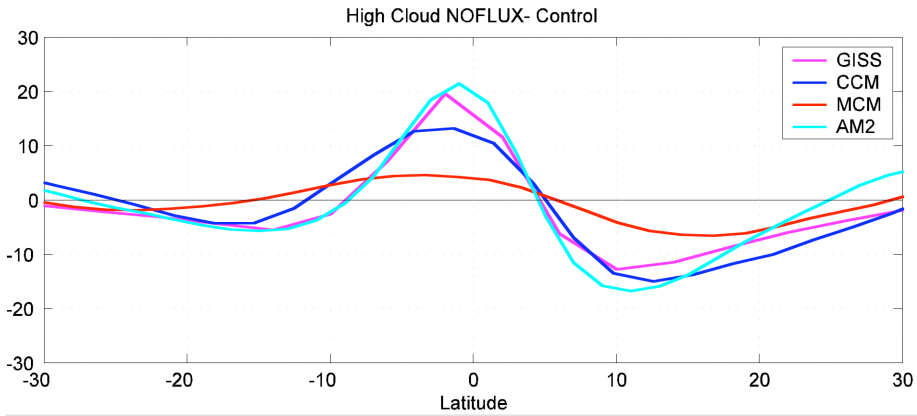
ΔOLR (W/m2)



ΔReflected SW (W/m2)



Δ High cloud (%)

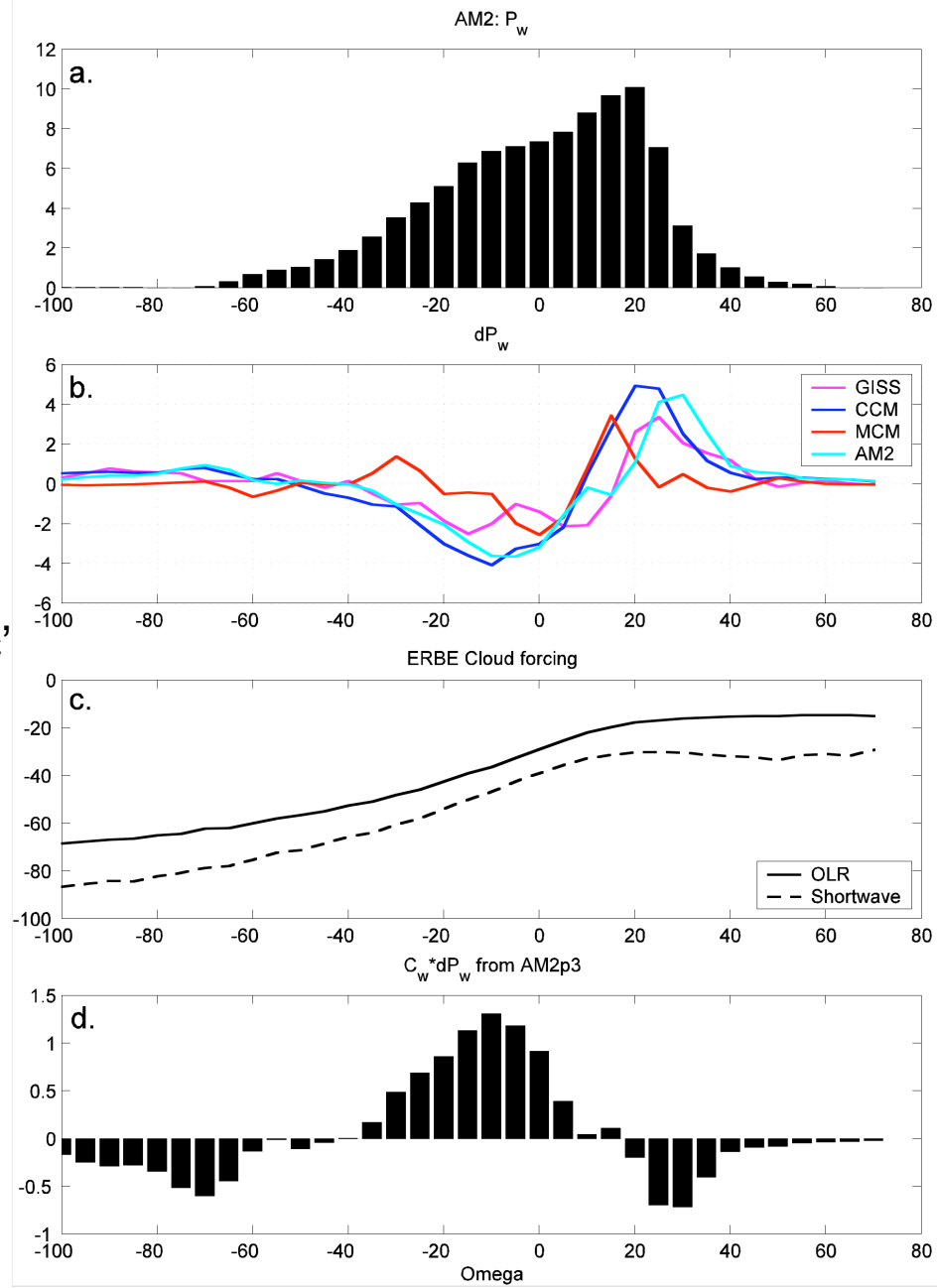


	GISS	CCM	MCM	AM2
ΔHadley max (NH) (percent)	**+93%**	**+105%**	**+98%**	**+91%**
ΔHadley min (SH) (percent)	**+35%**	**+46%**	**+58%**	**+79%**
ΔOLR	**+3.3**	**+3.8**	**+5.8**	**-2.5**
ΔOLR cloudy sky	N/A	+4.0	+1.7	+0.5
ΔOLR clear sky	N/A	-0.2	+4.1	-3.0
ΔSW (reflected)	**0.7**	**1.6**	**-6.9**	**+6.2**
ΔSW cloudy sky	N/A	1.4	-8.3	+4.9
ΔSW clear sky	N/A	0.2	+1.4	+1.3
ΔTotal cloud	-1.4	-1.5	-4.5	+2.7
ΔLow cloud	-0.9	+1.1	-5.5	+7.4
ΔHigh cloud	-1.5	-2.0	-0.6	-1.5

Bony et al. (2004) framework for understanding cloud feedbacks

‘dynamic’ component

‘thermodynamic’ component



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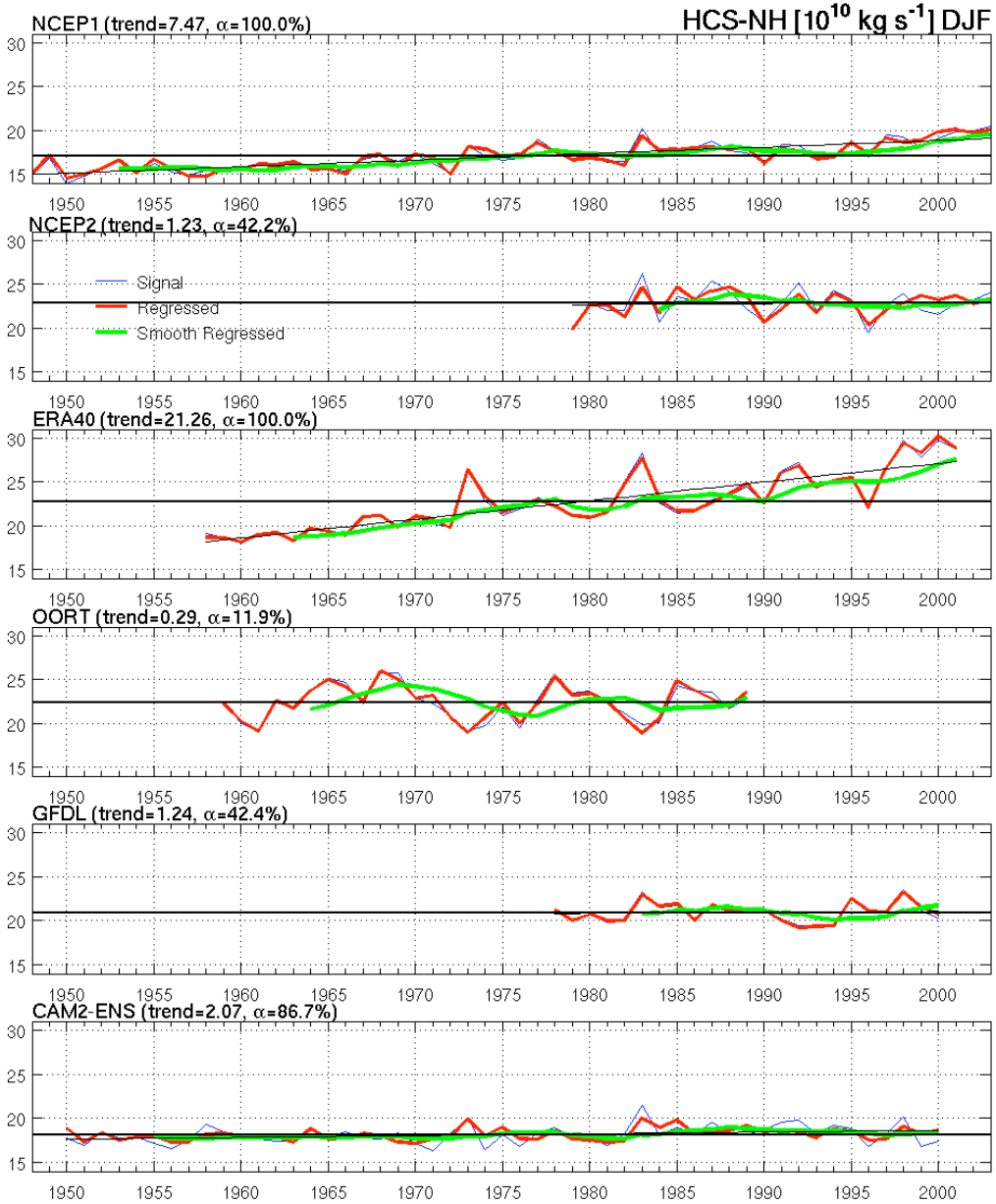
ΔHigh cloud	-1.5	-2.0	-0.6	-1.5

Dynamic cloud radiative forcing: ΔOLR	**+0.6**	**+2.4**	**+0.5**	**+1.6**
Dynamic cloud radiative forcing: Reflected ΔSW	**0.0**	**-1.6**	**-0.4**	**-0.7**

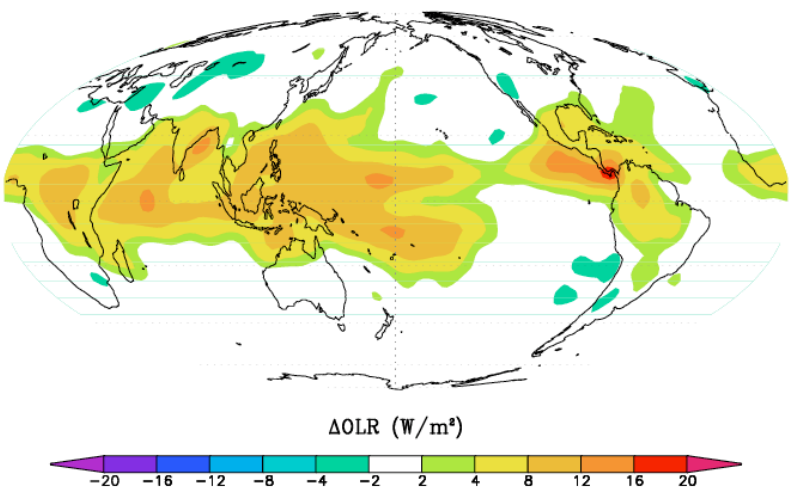
Hadley cell index 1950-2003

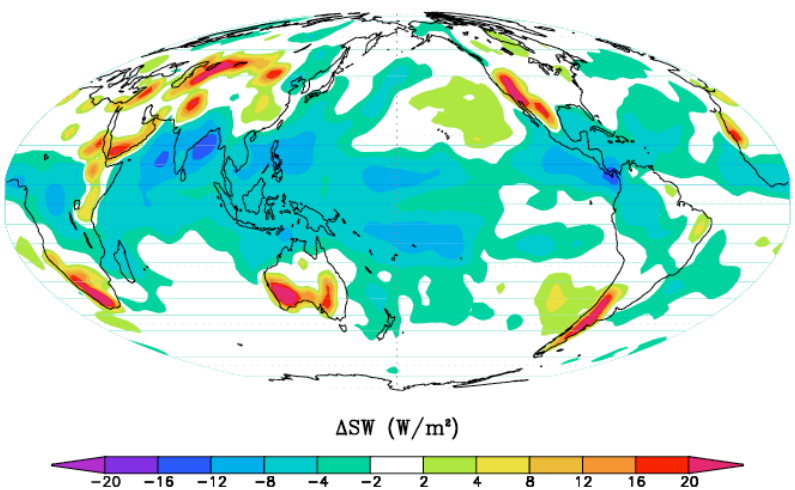
(Mitas and Clement 2004)



Hypothesis #2: The effect of changes in microphysics on tropical mean radiative fluxes

High – low precipitation efficiency (change by 0.5%) in the GFDL model

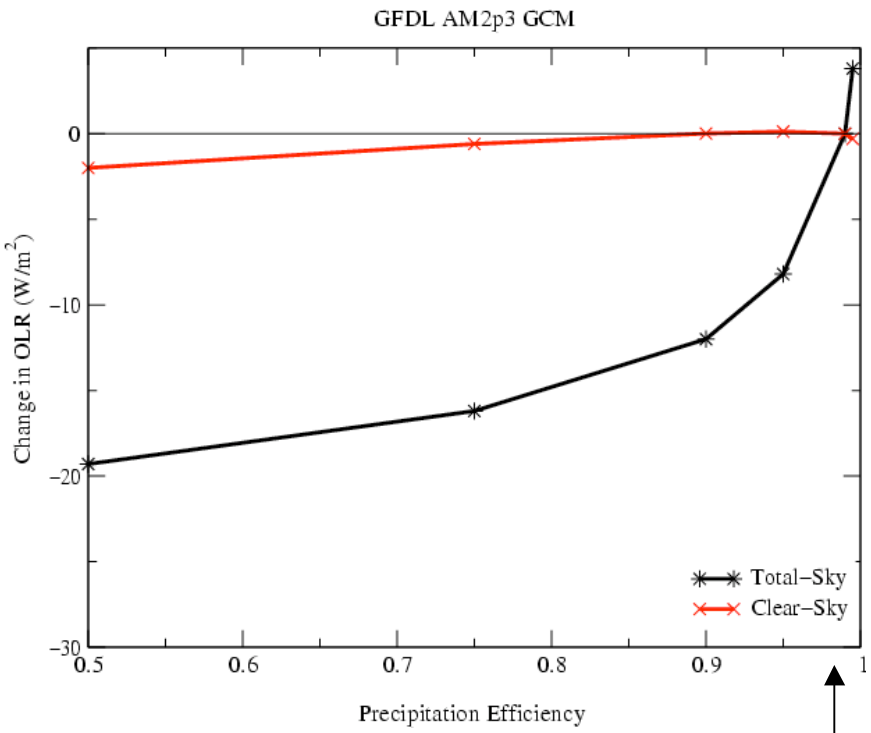


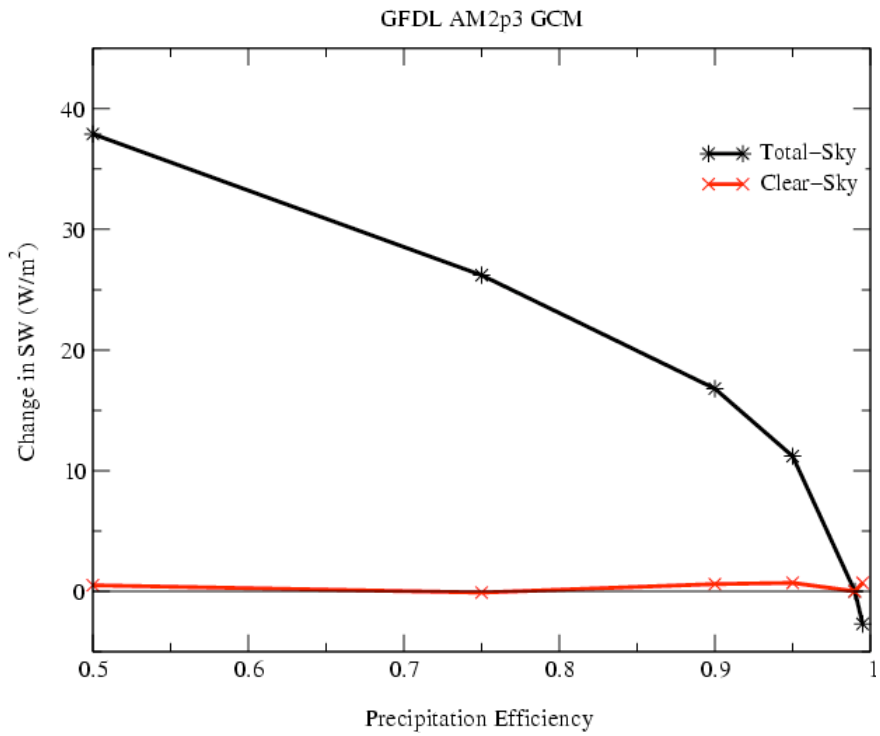


Tropical mean ΔOLR= 3.7

Tropical mean Δ reflected SW= -2.7

Large tropics-wide decrease in high cloud cover





Current model value

Conclusions

- Hypothesis #1: Even in the most sensitive models it would require almost a doubling in strength of the Hadley circulation in order for the model to reproduce the observations

- Hypothesis #2: ERBE-size changes in tropical mean radiative fluxes can be reproduced in a model with minor changes to the precipitation efficiency. *BUT* GFDL model is in the high sensitivity region of parameter range. Further observations are necessary to constrain microphysical parameters

- Some combination of these processes may be necessary to explain all the features of the observations

Strong – weak Hadley cell change in low cloud