Stochastic sampling of CAM4 parametric uncertainties

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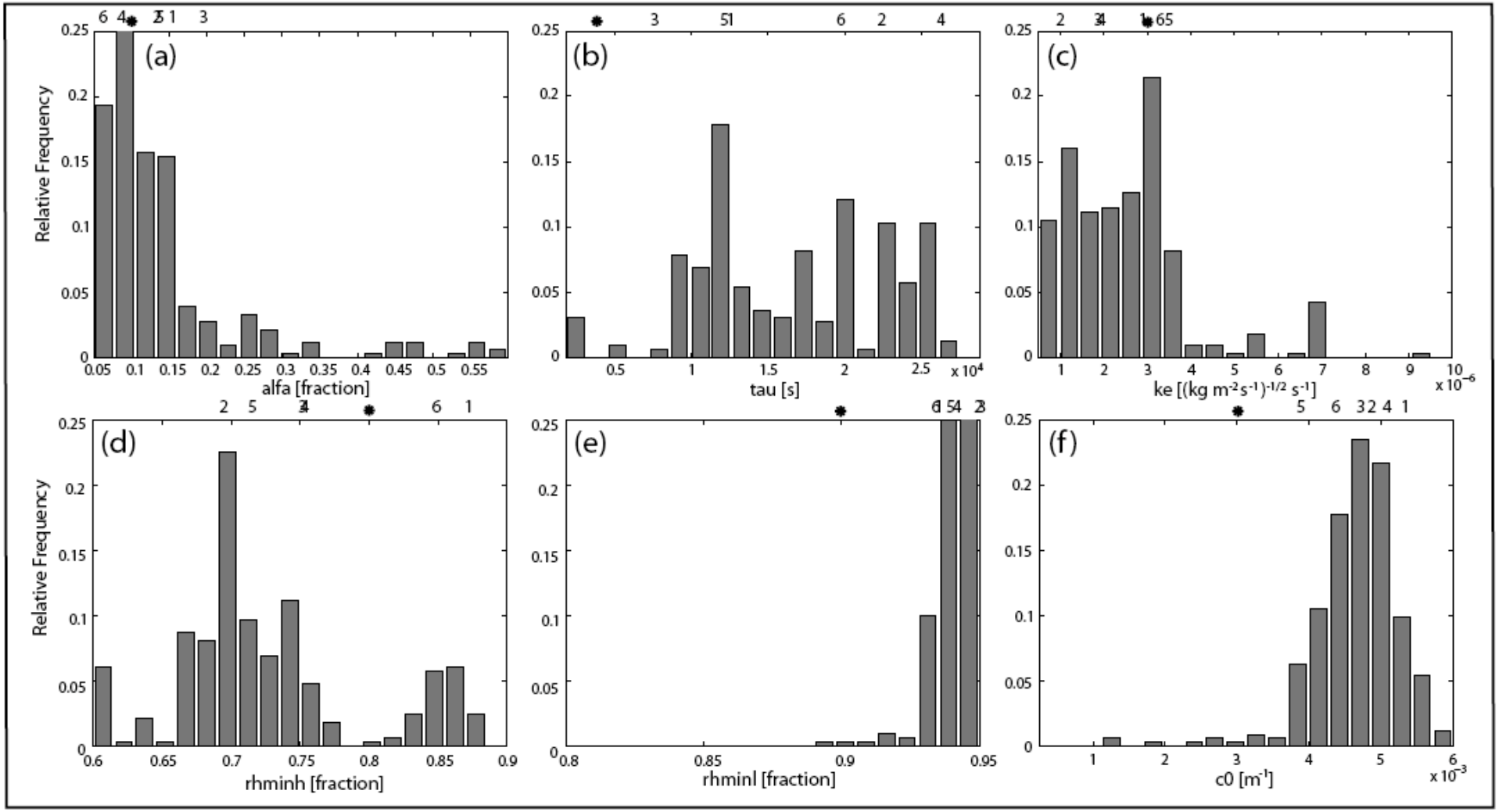
1. Sampling will start this spring. Seeking input on model metrics and parameters.

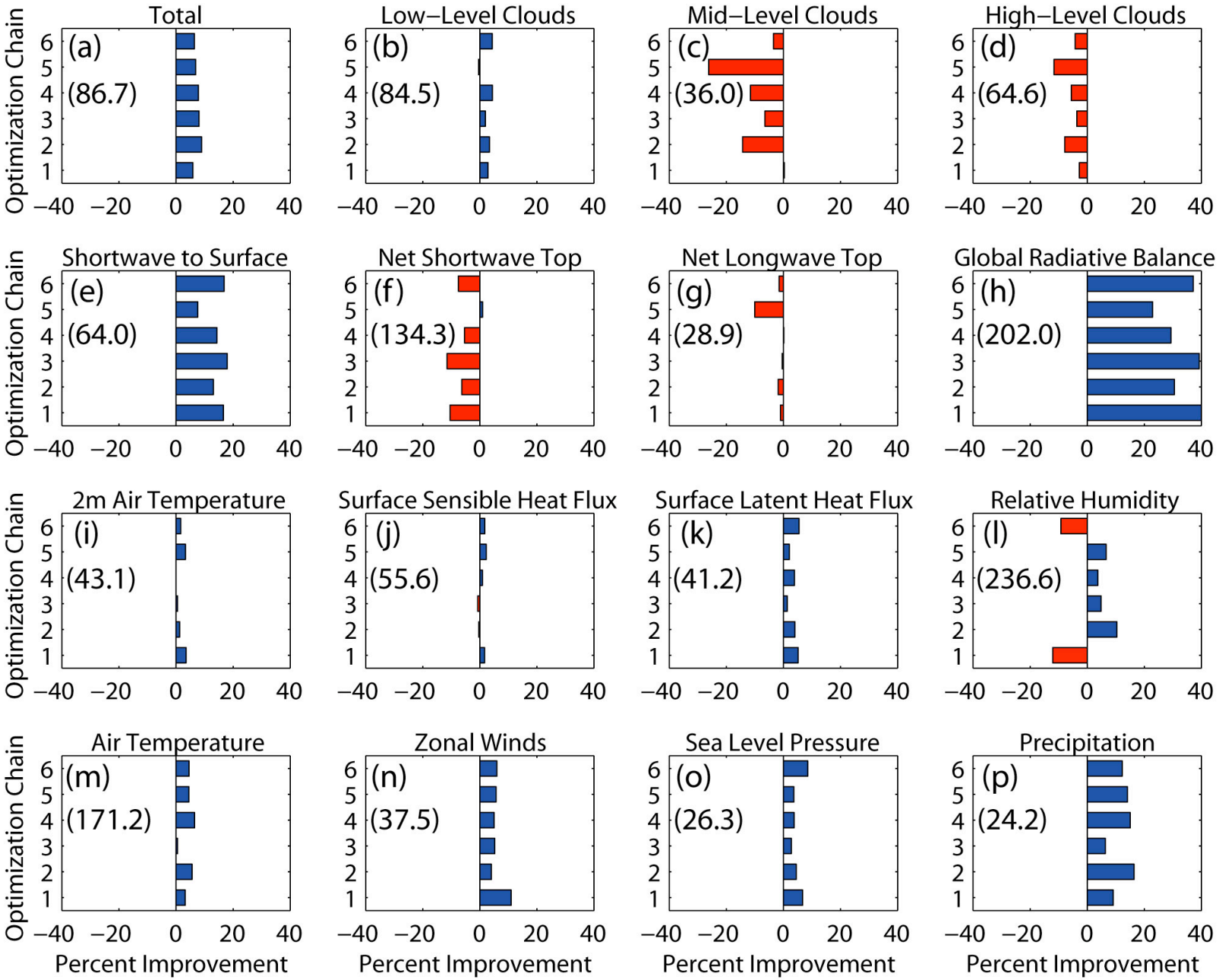
2. Interested in both model development and uncertainty estimation.

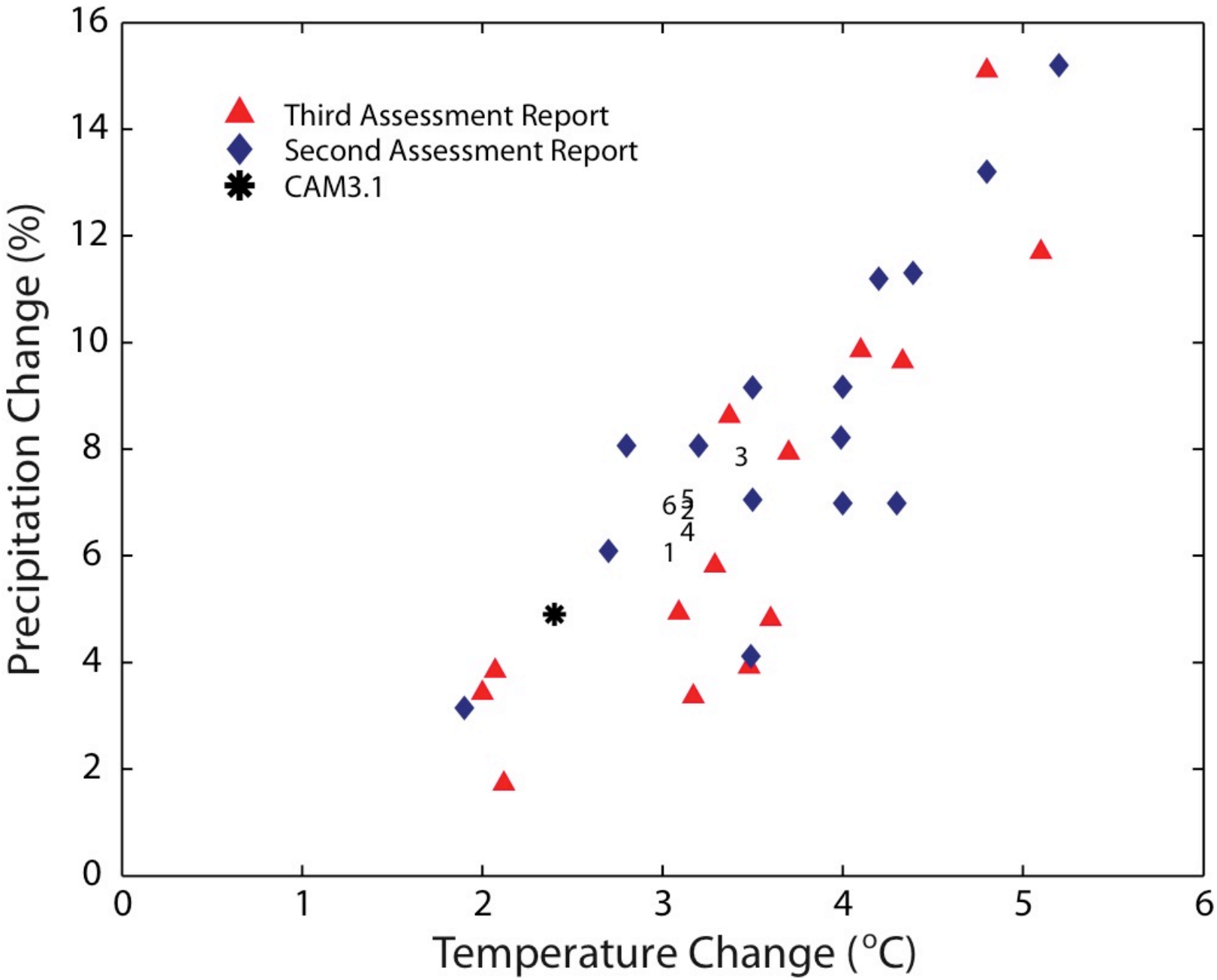
3. Focusing now on processes important to regional and global sensitivity to CO2 forcing (clouds, convection, radiation).

Parameter	Definition	Value Ranges
RHMINL [%/100]	Low cloud critical relative humidity	
RHMINH [%/100]	High cloud critical relative humidity	
ALFA [fraction]	Initial cloud downdraft mass flux	
TAU [hours]	Consumption rate of CAPE	
ke [$(kg\ m^{-2}\ s^{-1})^{-1/2} s^{-1}$]	Environmental air entrainment rate	
c0 [m^{-1}]	Precipitation efficiency	

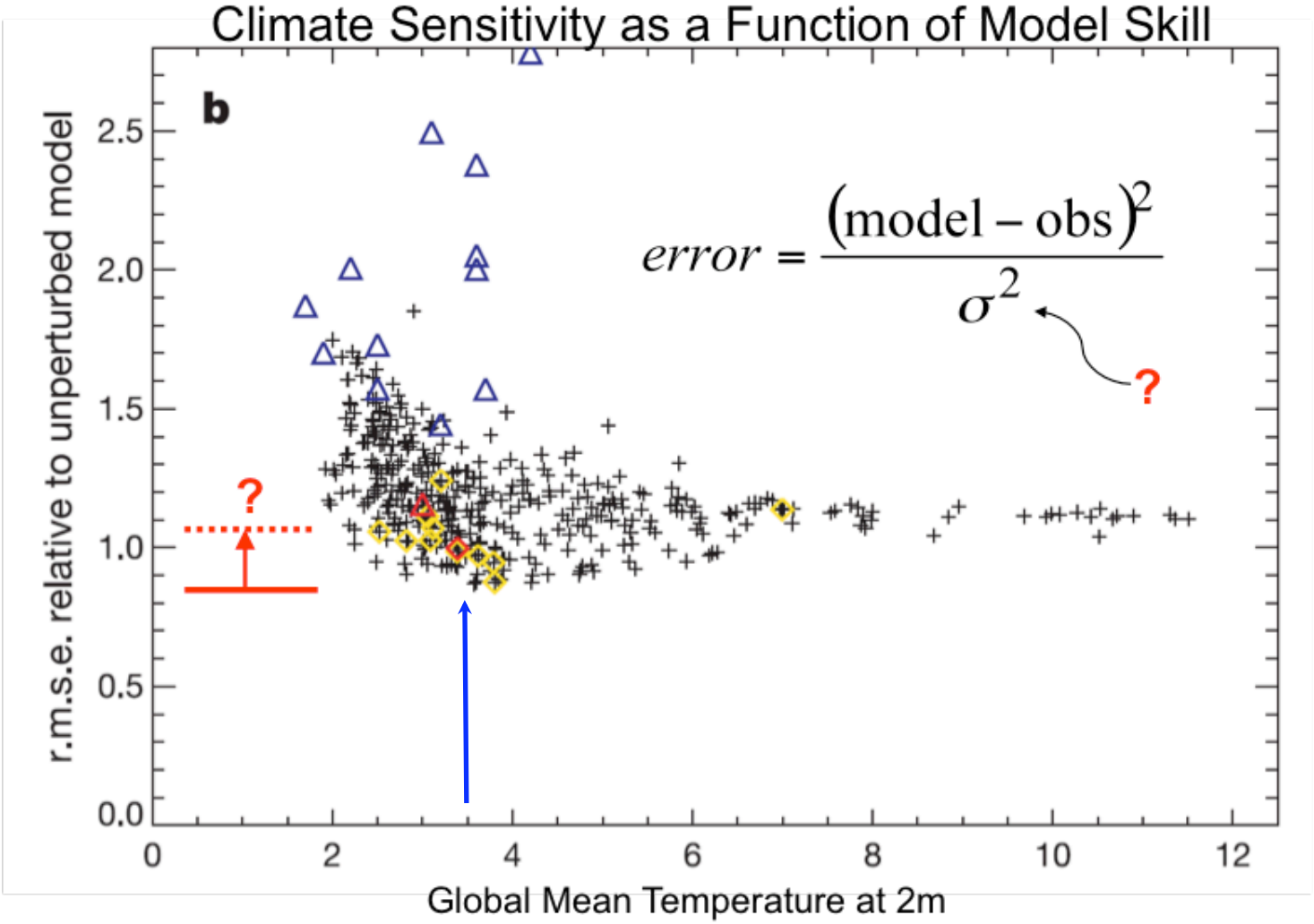
For more information about experiment see Jackson et al., 2008, J. Climate.


(a)
(b)
(c)
(d)
(e)
(f)
Relative Frequency
alfa [fraction]
tau [s]
x 10^4
ke [(kg m^-2 s^-1)^-1/2 s^-1]
x 10^-6
rhminh [fraction]
rhminl [fraction]
c0 [m^-1]
x 10^-3


Total
(a)
(86.7)
Low–Level Clouds
(b)
(84.5)
Mid–Level Clouds
(c)
(36.0)
High–Level Clouds
(d)
(64.6)
Shortwave to Surface
(e)
(64.0)
Net Shortwave Top
(f)
(134.3)
Net Longwave Top
(g)
(28.9)
Global Radiative Balance
(h)
(202.0)
2m Air Temperature
(i)
(43.1)
Surface Sensible Heat Flux
(j)
(55.6)
Surface Latent Heat Flux
(k)
(41.2)
Relative Humidity
(l)
(236.6)
Air Temperature
(m)
(171.2)
Zonal Winds
(n)
(37.5)
Sea Level Pressure
(o)
(26.3)
Precipitation
(p)
(24.2)
Optimization Chain
Percent Improvement
1
2
3
4
5
6
−40
−20
0
20
40


Third Assessment Report
Second Assessment Report
CAM3.1
Precipitation Change (%)
Temperature Change (°C)
0
2
4
6
8
10
12
14
16
0
1
2
3
4
5
6
1
2
3
4
5
6

Uncertainty quantification with the
Hadley Center model (group 2)



Grid-search, no rejections,
no weighting

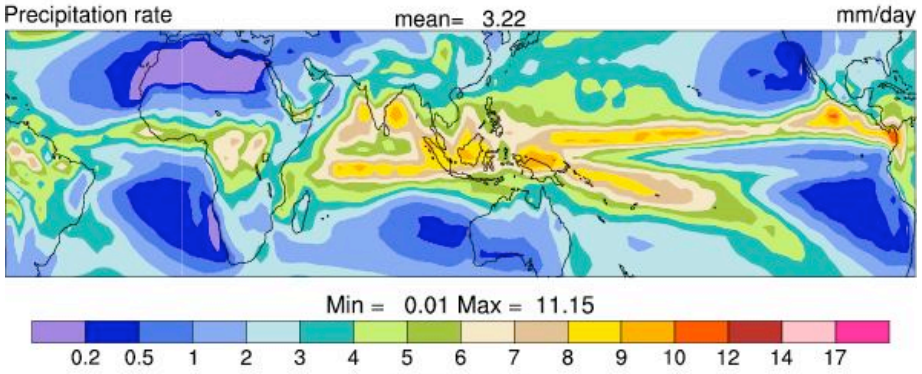
(Stainforth et al., Nature 2005)

Analysis of Changes

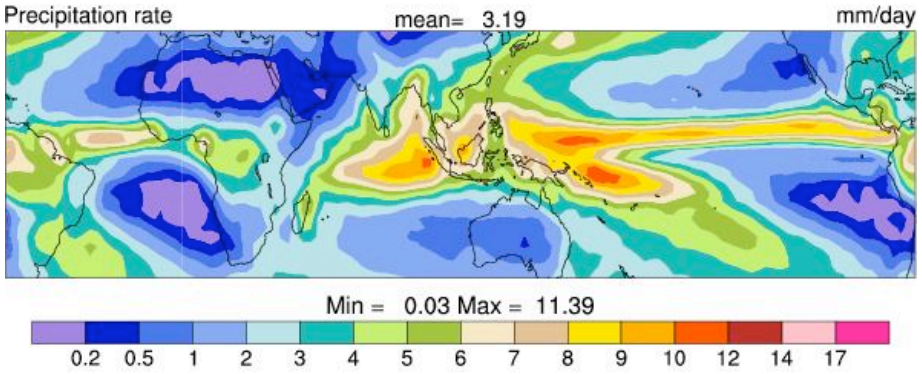
- http://www.ig.utexas.edu/people/staff/charles/uncertainties_in_model_predictio.htm

ANN

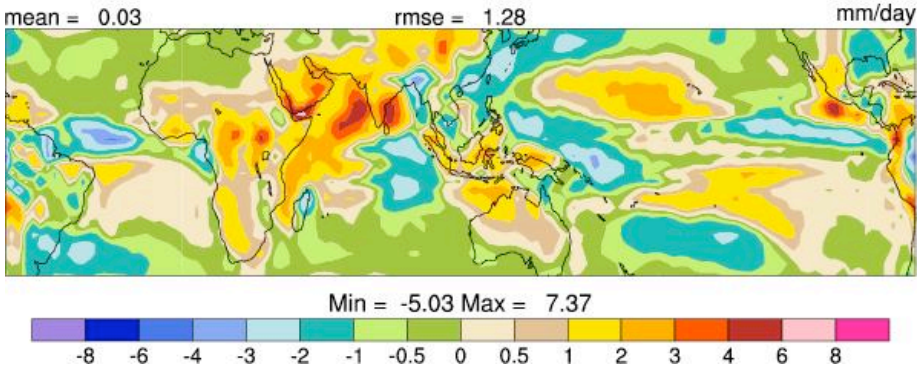
camrun.DEFAULT2 (yrs 1990-1999)



XIE-ARKIN



camrun.DEFAULT2 - XIE-ARKIN



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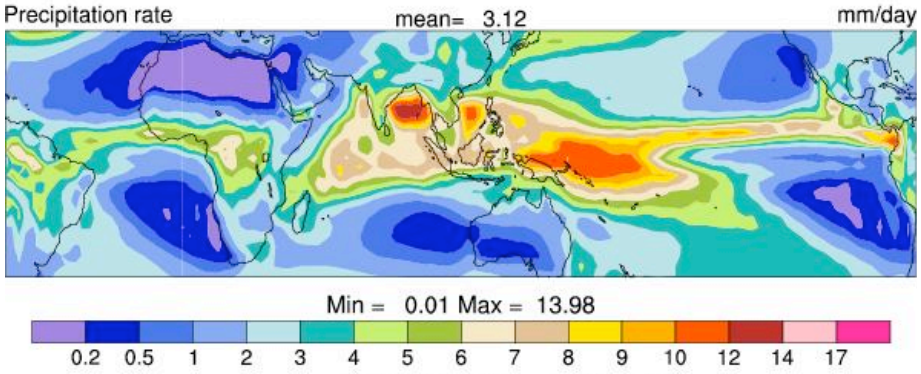
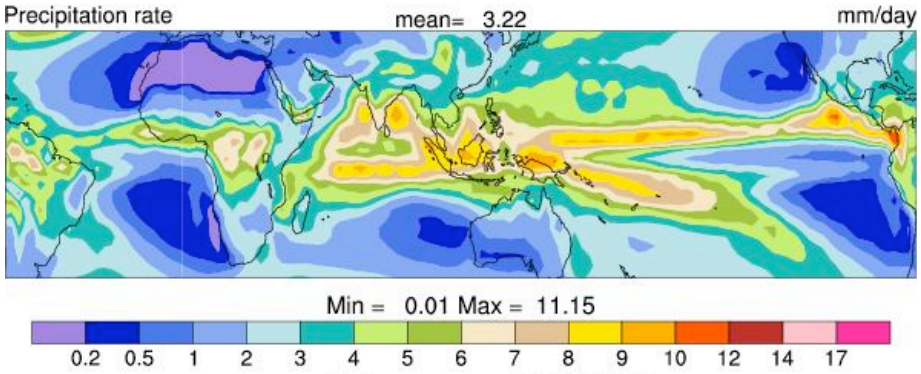
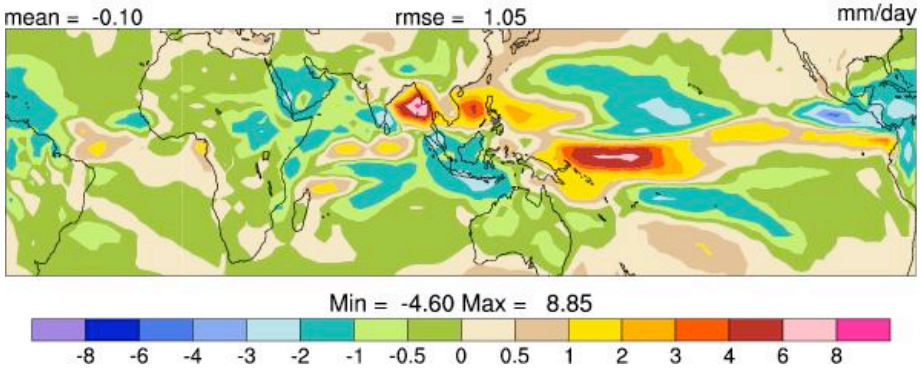
sensitivity (yrs 40-49)



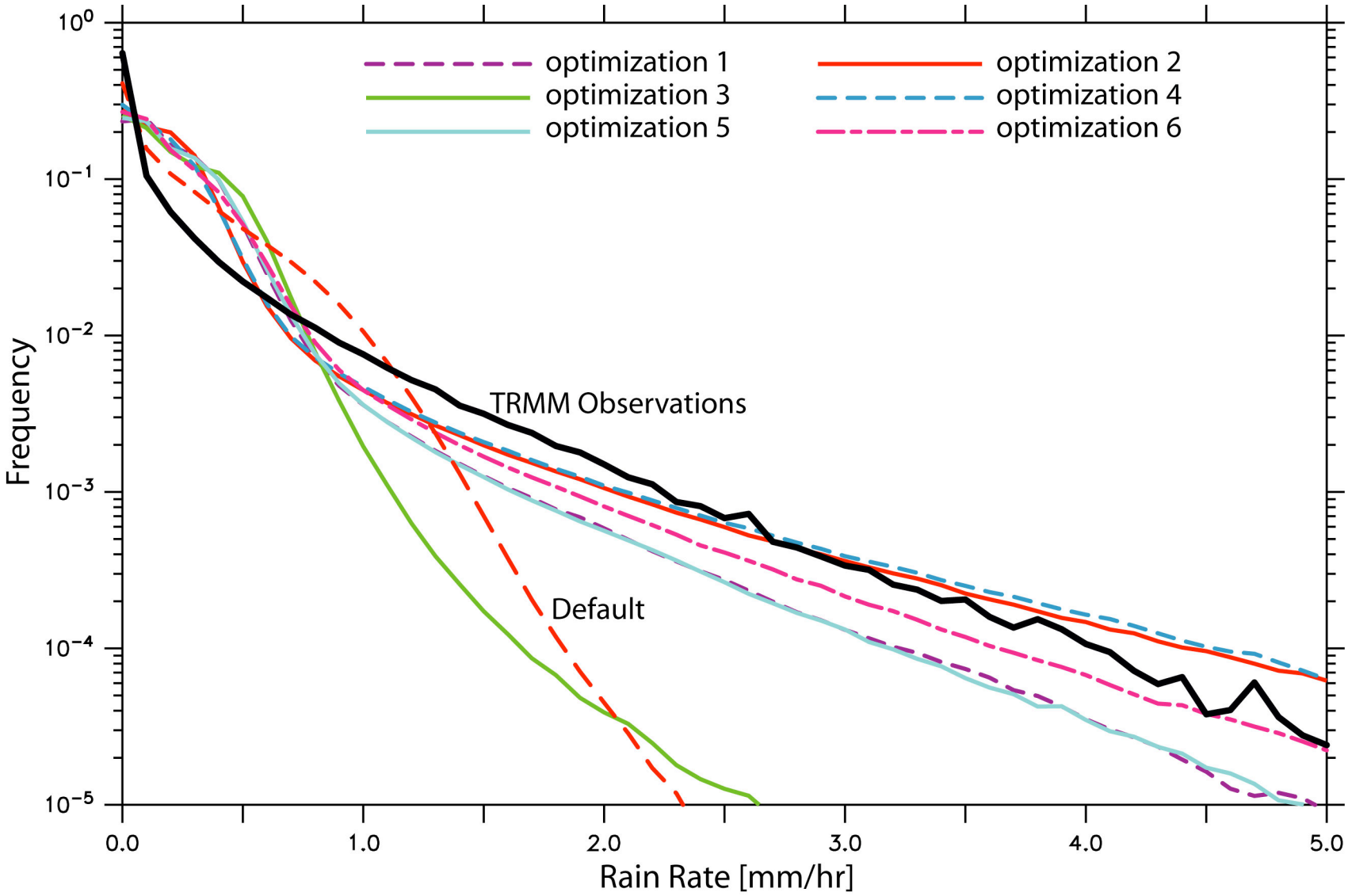
camrun.DEFAULT2 (yrs 1990-1999)



sensitivity - camrun.DEFAULT2

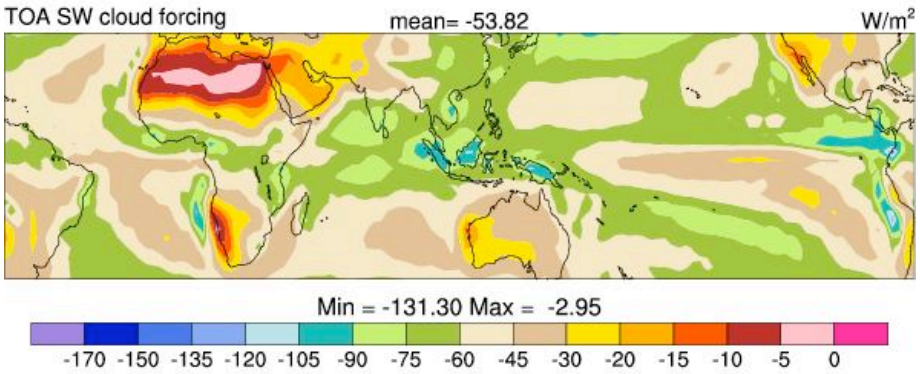


Unanticipated Improvements in tropical rain variability

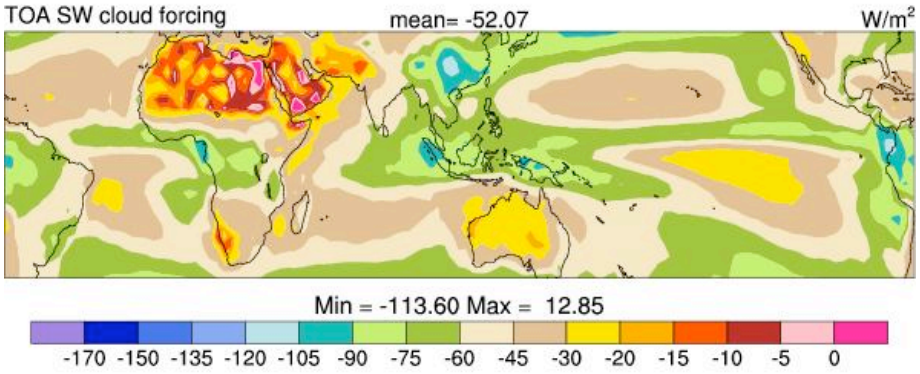


ANN

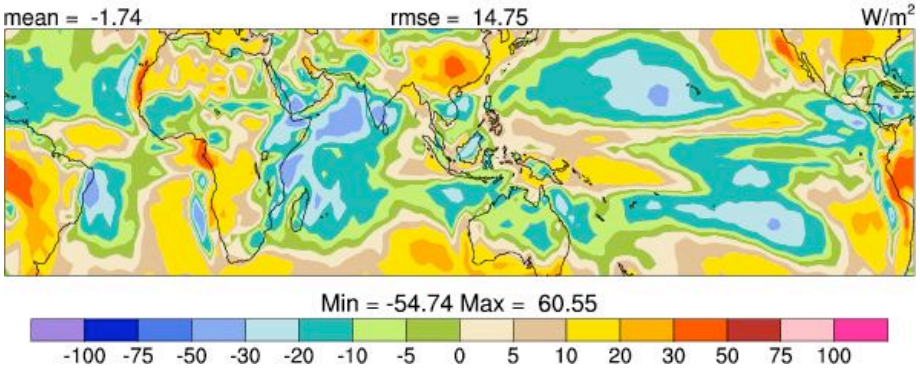
camrun.DEFAULT2 (yrs 1990-1999)



ERBE

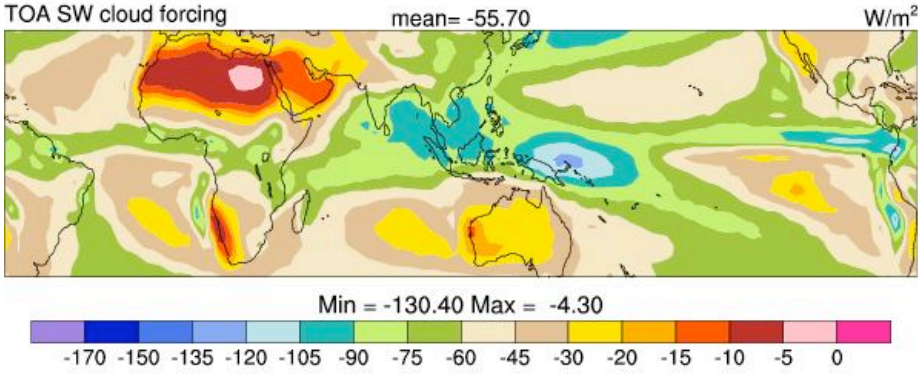


camrun.DEFAULT2 - ERBE

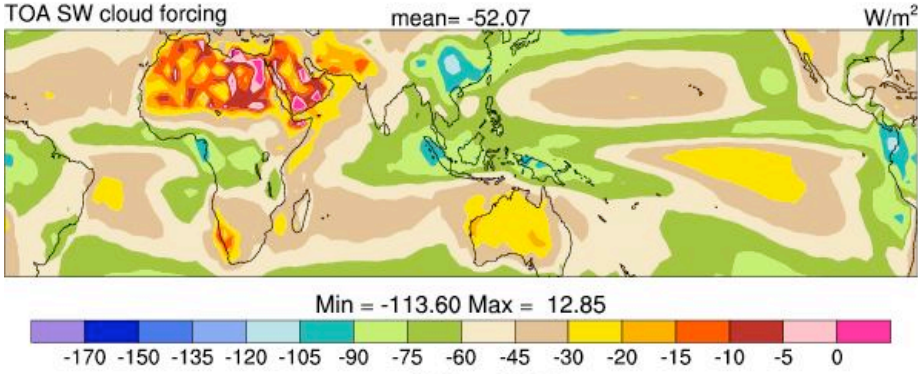


ANN

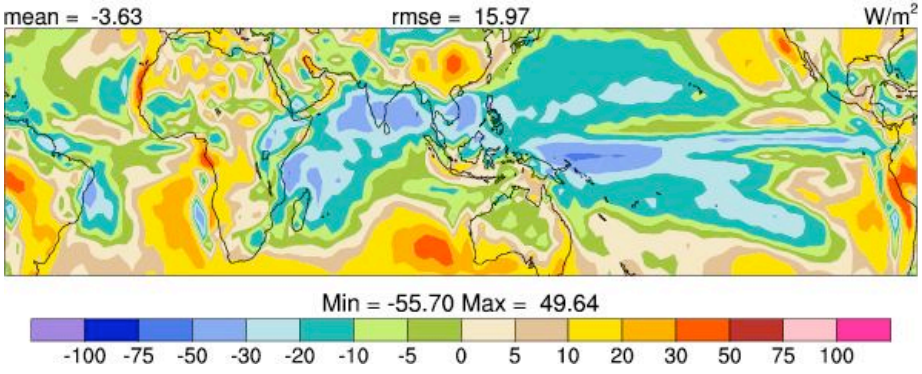
sensitivity (yrs 40-49)



ERBE



sensitivity - ERBE



camrun.DEFAULT2 (yrs 1990-1999)

TOA upward LW flux mean= 234.83 W/m^2

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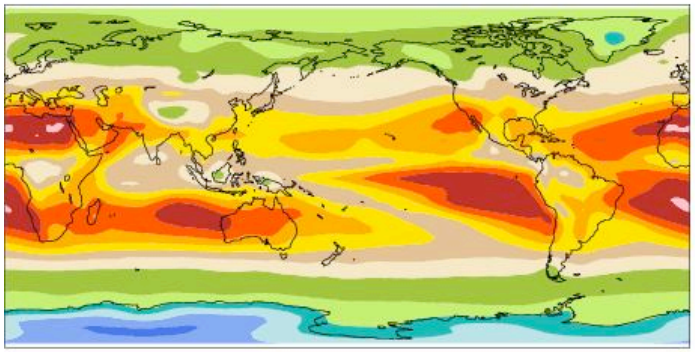
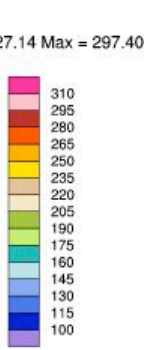
Min = 127.14 Max = 297.40





sensitivity (yrs 40-49)

TOM net LW flux mean= 232.46 W/m^2

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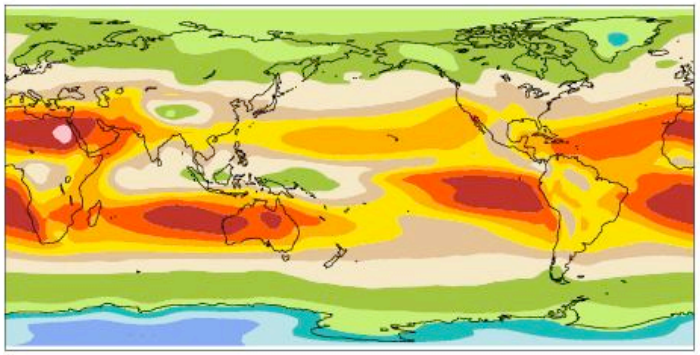
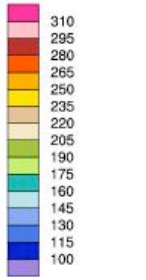
Min = 129.80 Max = 298.34

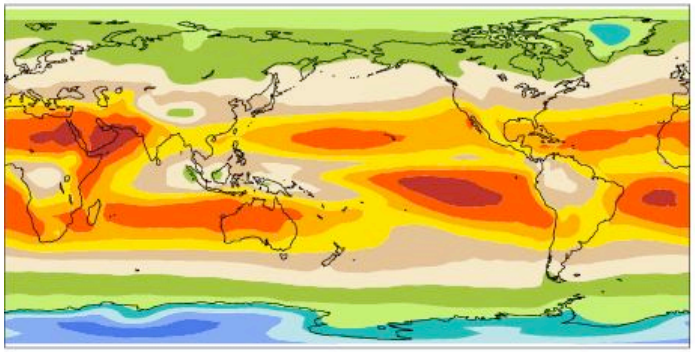


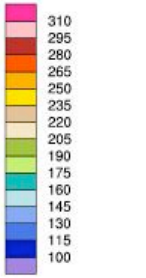


ERBE

TOA upward LW flux mean= 233.95 W/m^2

Min = 124.45 Max = 292.40

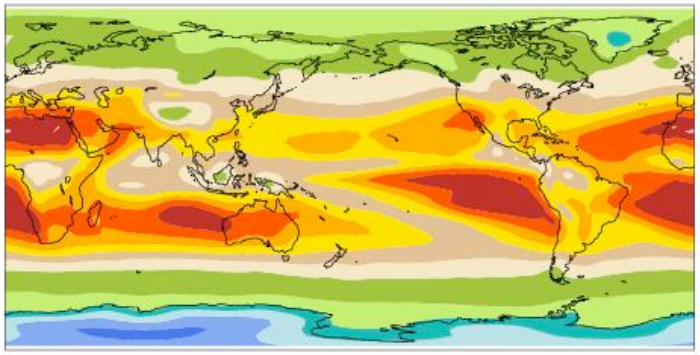


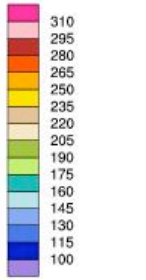


camrun.DEFAULT2 (yrs 1990-1999)

TOM net LW flux mean= 233.70 W/m^2

Min = 126.30 Max = 296.20

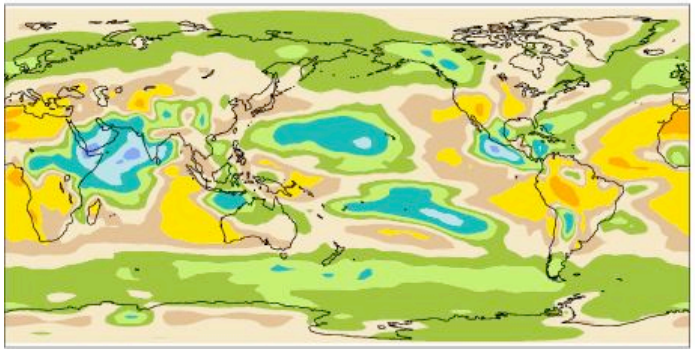


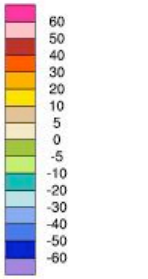


camrun.DEFAULT2 - ERBE

mean = 0.89 rmse = 8.88 W/m^2

Min = -39.62 Max = 29.94

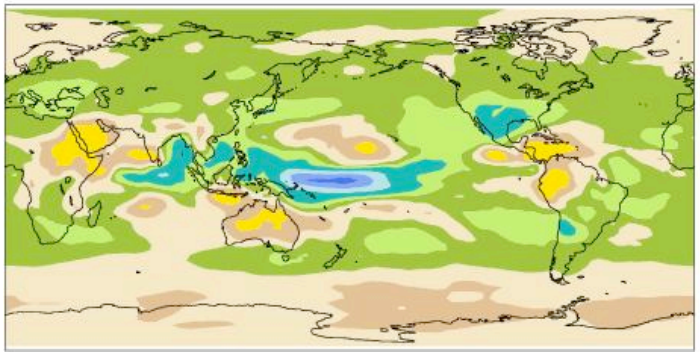


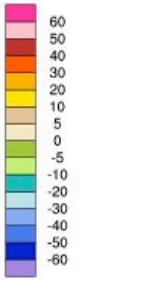


sensitivity - camrun.DEFAULT2

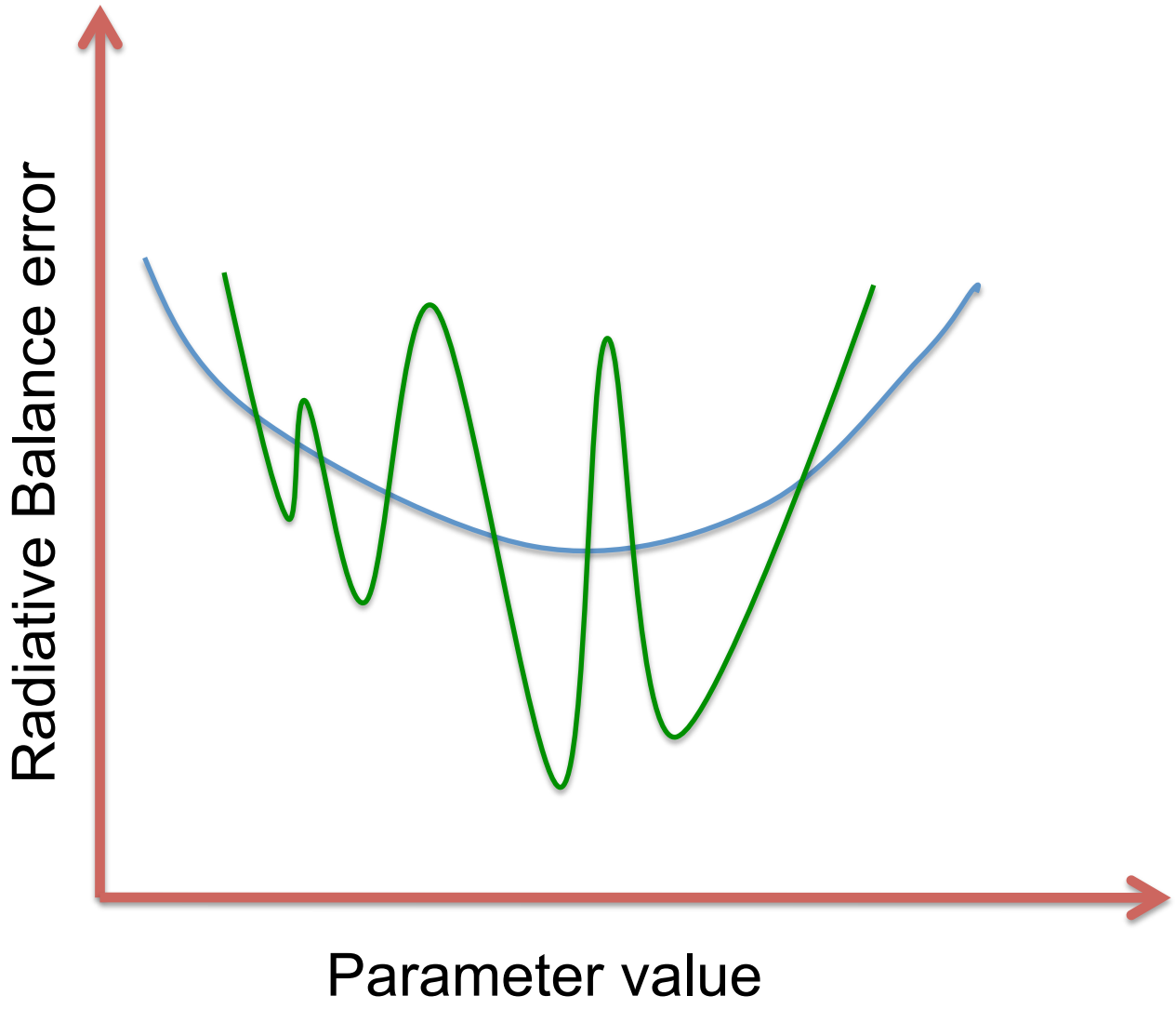
mean = -1.23 rmse = 6.61 W/m^2

Min = -46.06 Max = 19.74





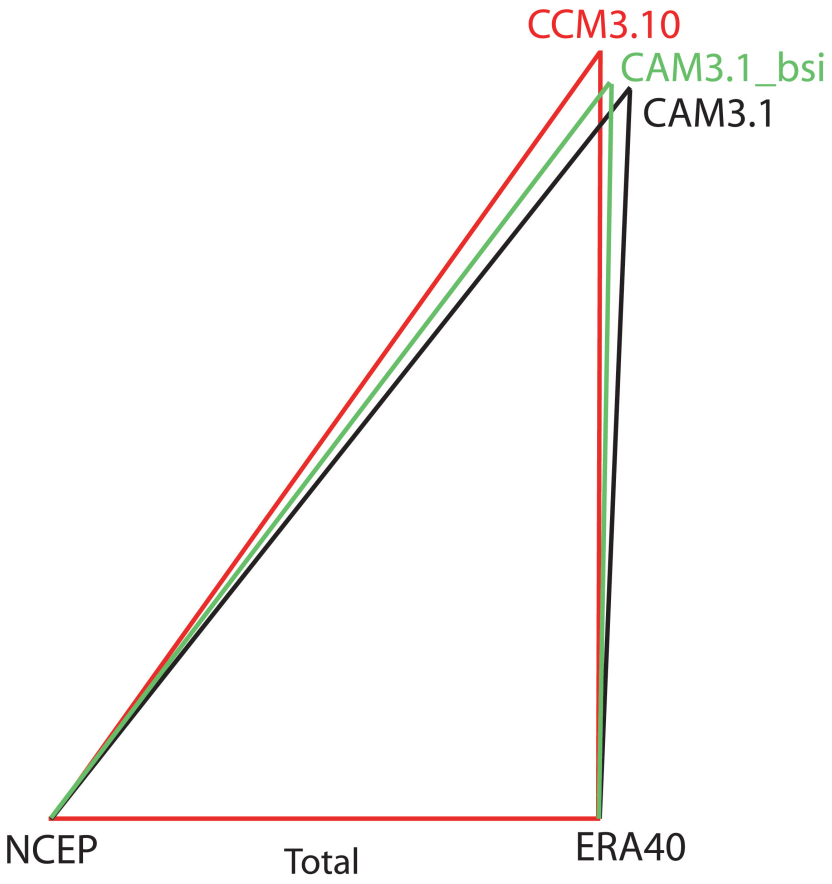
Found that global radiative balance is extremely sensitive to small changes in parameter values.

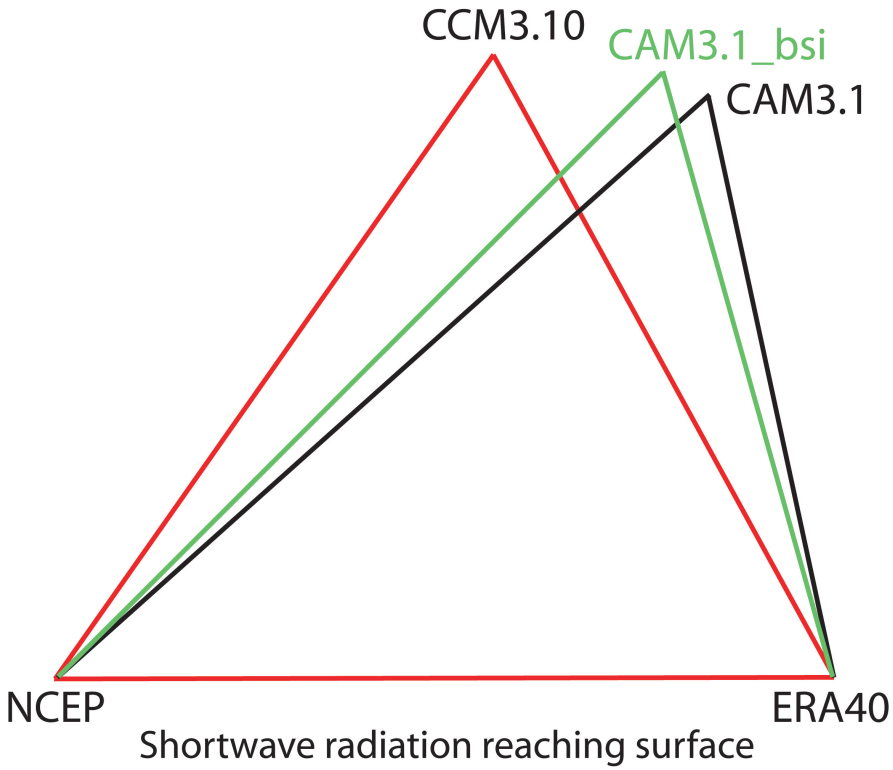


Model-Data Comparison of:

1. **Low-level clouds**, 1990-2001, ISCCP satellite observations (Rossow et al. 1991)
2. **Mid-level clouds**, 1990-2001, ISCCP satellite observations (Rossow et al. 1991)
3. **High-level clouds**, 1990-2001, ISCCP satellite observations (Rossow et al. 1991)
4. **Net shortwave top**, 1985-1989, ERBE satellite observations (Barkstrom et al. 1989)
5. **Net longwave top**, 1985-1989, ERBE satellite observations (Barkstrom et al. 1989)
6. **Global radiative balance top**, 0.3 Watts/m2, imposed.
7. **Shortwave radiation to surface**, 1990-2001, NCEP reanalysis data (Kalnay et al. 1991, Kistler et al.2001)
8. **2m air temperature**, 1990-2001, NCEP reanalysis data (Kalnay et al. 1991, Kistler et al. 2001)
9. **Surface sensible heat flux**, 1990-2001, NCEP reanalysis data (Kalnay et al. 1991, Kistler et al. 2001)
10. **Surface latent heat flux**, 1990-2001, NCEP reanalysis data (Kalnay et al. 1991, Kistler et al. 2001)
11. **Relative humidity (zonal mean)**, 1990-2001, NCEP reanalysis data (Kalnay et al. 1991, Kistler et al.2001)
12. **Air temperature (zonal mean)**, 1990-2001, NCEP reanalysis data (Kalnay et al. 1991, Kistler et al. 2001)
13. **Zonal winds (zonal mean)**, 1990-2001, NCEP reanalysis data (Kalnay et al. 1991, Kistler et al. 2001)
14. **Sea level pressure**, 1990-2001, NCEP reanalysis data (Kalnay et al. 1991, Kistler et al. 2001)
15. **Precipitation**, 1990-2001, CMAP instrumental record (Xie and Arkin 1996, 1997)

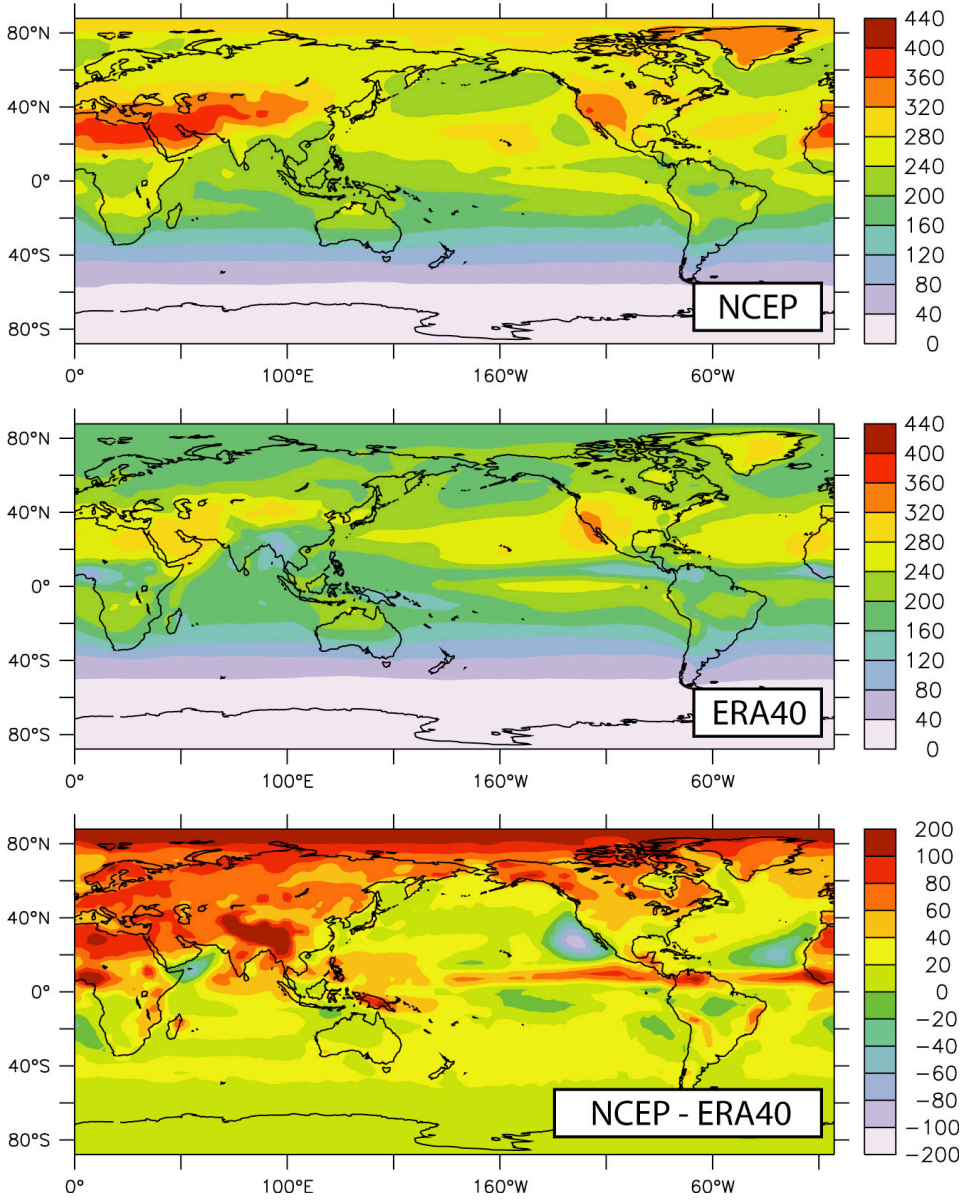
Observational Uncertainty (as estimated from reanalysis) is as large as modeling uncertainty….



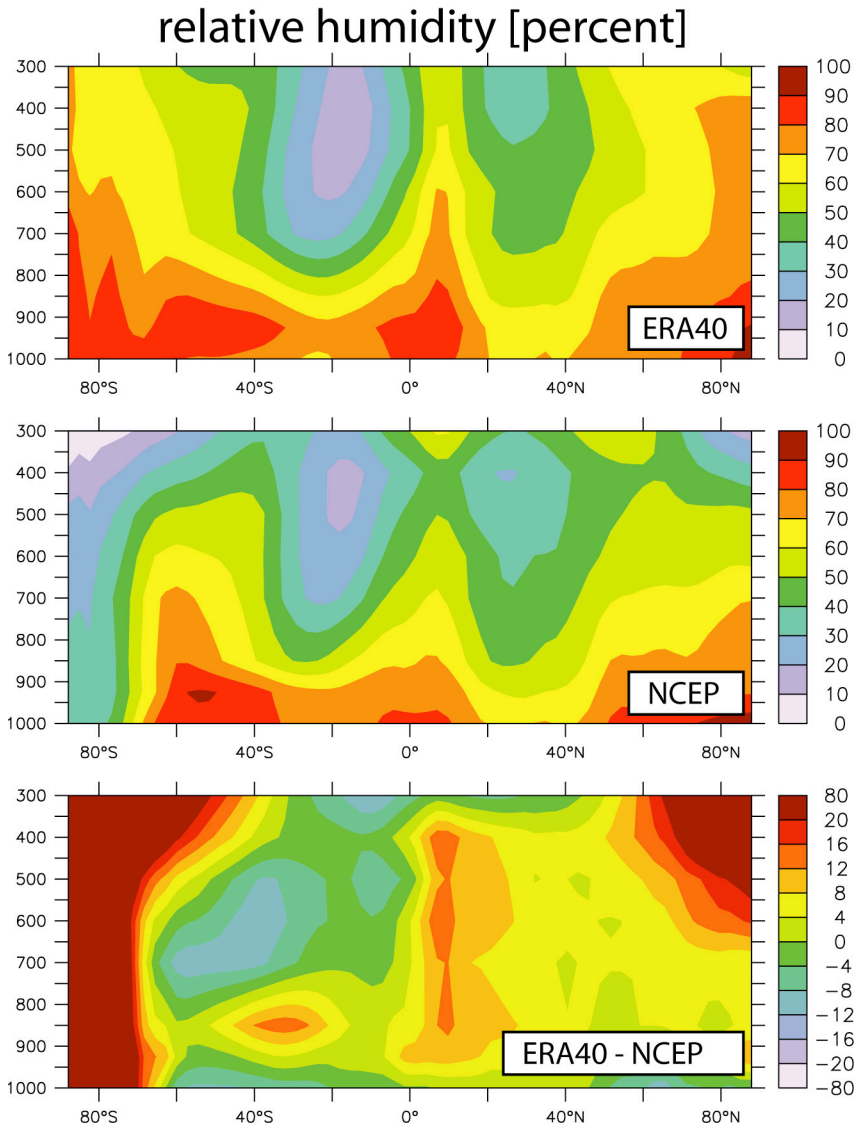


June – July NCEP discrepancies with ERA40

shortwave reaching surface [Watts/m^2]



June – July NCEP discrepancies with ERA40



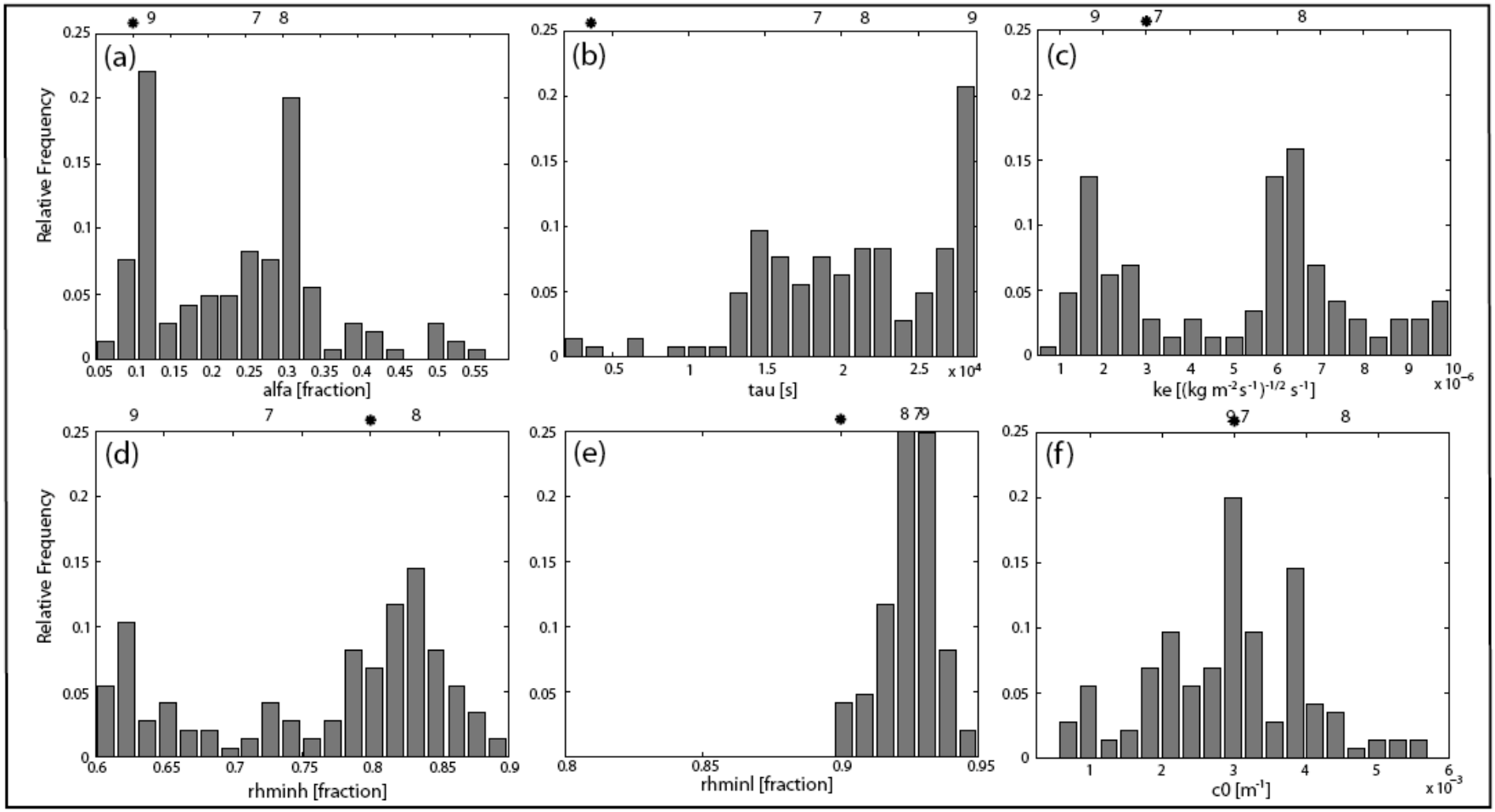
Next Analysis Choices

1. Exclude fields overly sensitive to reanalysis uncertainty
    1. Nix shortwave radiation to surface
    2. Nix zonal mean relative humidity

2. Target ERA40

3. Target parameters important to clouds, convection, radiation (ice particles?).

4. Uncertainties from long integration of CCSM3
    1. Use gap between ERA40 and NCEP?


(a)
(b)
(c)
(d)
(e)
(f)
Relative Frequency
alfa [fraction]
tau [s]
x 10^4
ke [(kg m^-2 s^-1)^-1/2 s^-1]
x 10^-6
rhminh [fraction]
rhminl [fraction]
c0 [m^-1]
x 10^-3