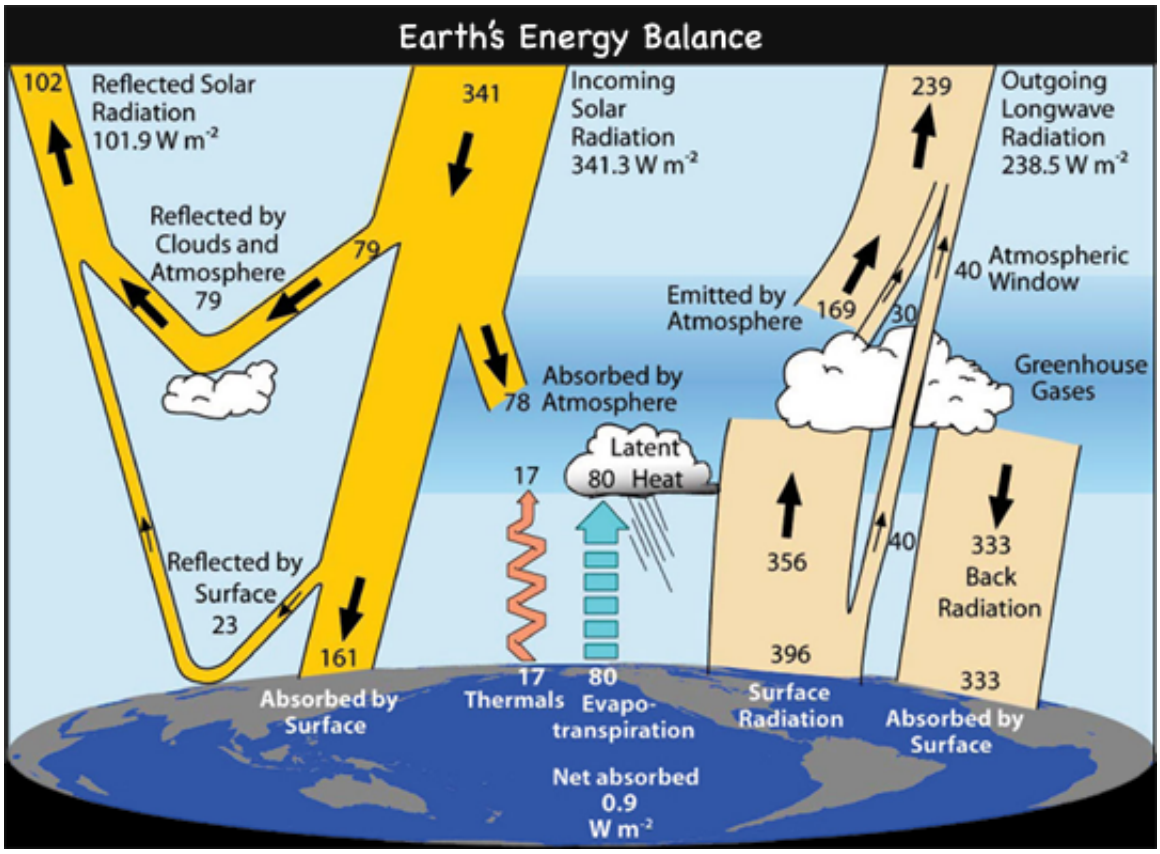
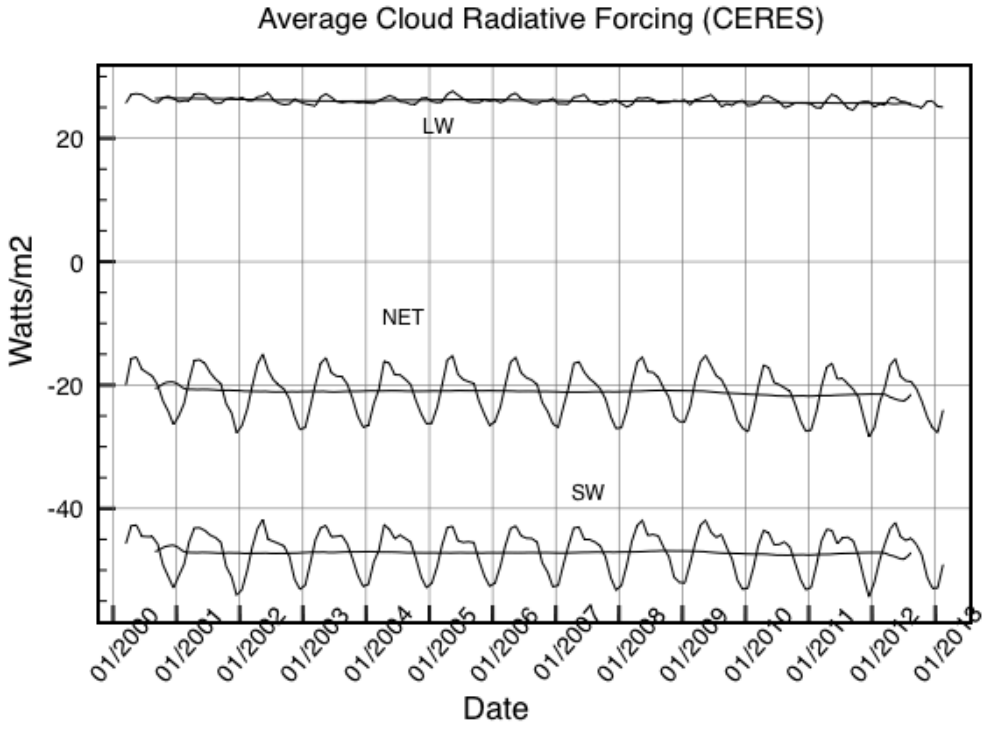
Motivation for the cloud-forcing model

Consider the energy balance diagram (Trenberth et al. 2009).



On average we have 161 W/m2 absorbed by the surface and 79 W/m2 reflected back to space by clouds. If the Earth had no clouds and all else remained the same then a "clear sky" Earth surface would receive 161+79 = 240 W/m2. This is our starting point. Now we cover the Earth with 100% cloud cover. There will be an enhanced greenhouse effect from clouds and an increased albedo. The net effect of clouds we call net cloud forcing in the model and has essentially been measured by CERES. See figure below where SW is the measured global average flux of reflected SW solar radiation, LW is the decrease of outgoing IR (enhanced GHE) and NET is the difference or net radiative cooling effect of clouds .



The net effect of clouds is a cooling of -22W/m2. So for our 100% covered Earth the net effect (albedo-GHE) can be considered to be a reduction of incident solar radiation. Everything else GHE from CO2 water vapor is assumed to remain the same.

Now consider the real case where global cloud cover fraction is CC. We now have

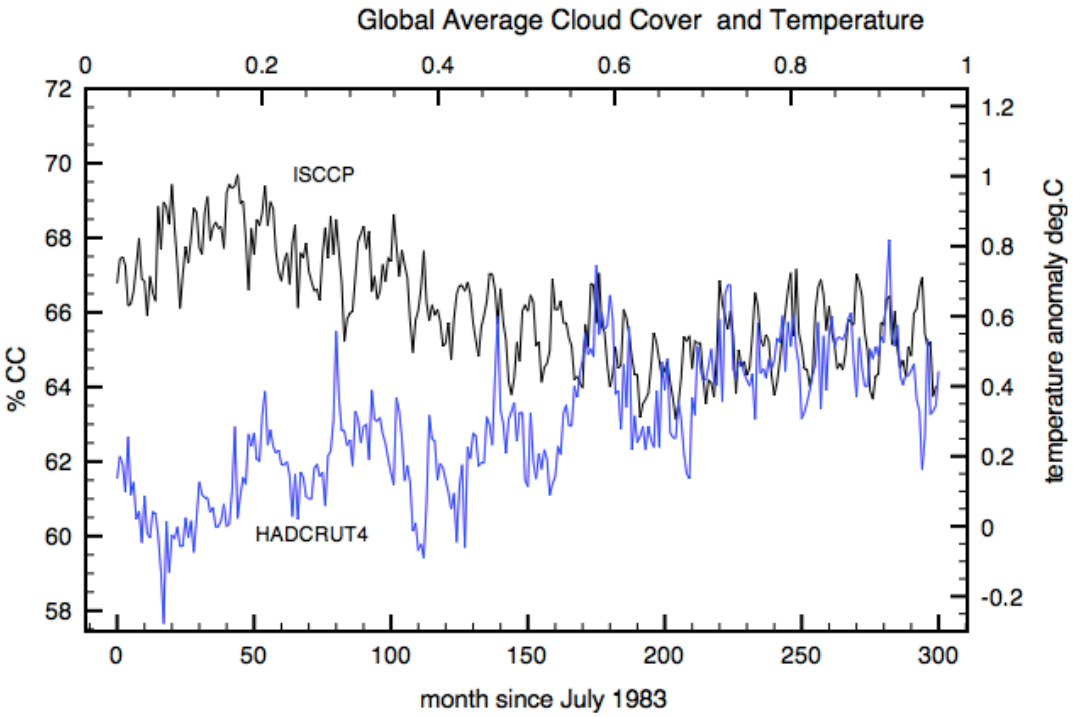
(1-CC)*240 + CC*240*NCF

CERES tells us that 240*NCF = 218 so NCF = 0.91

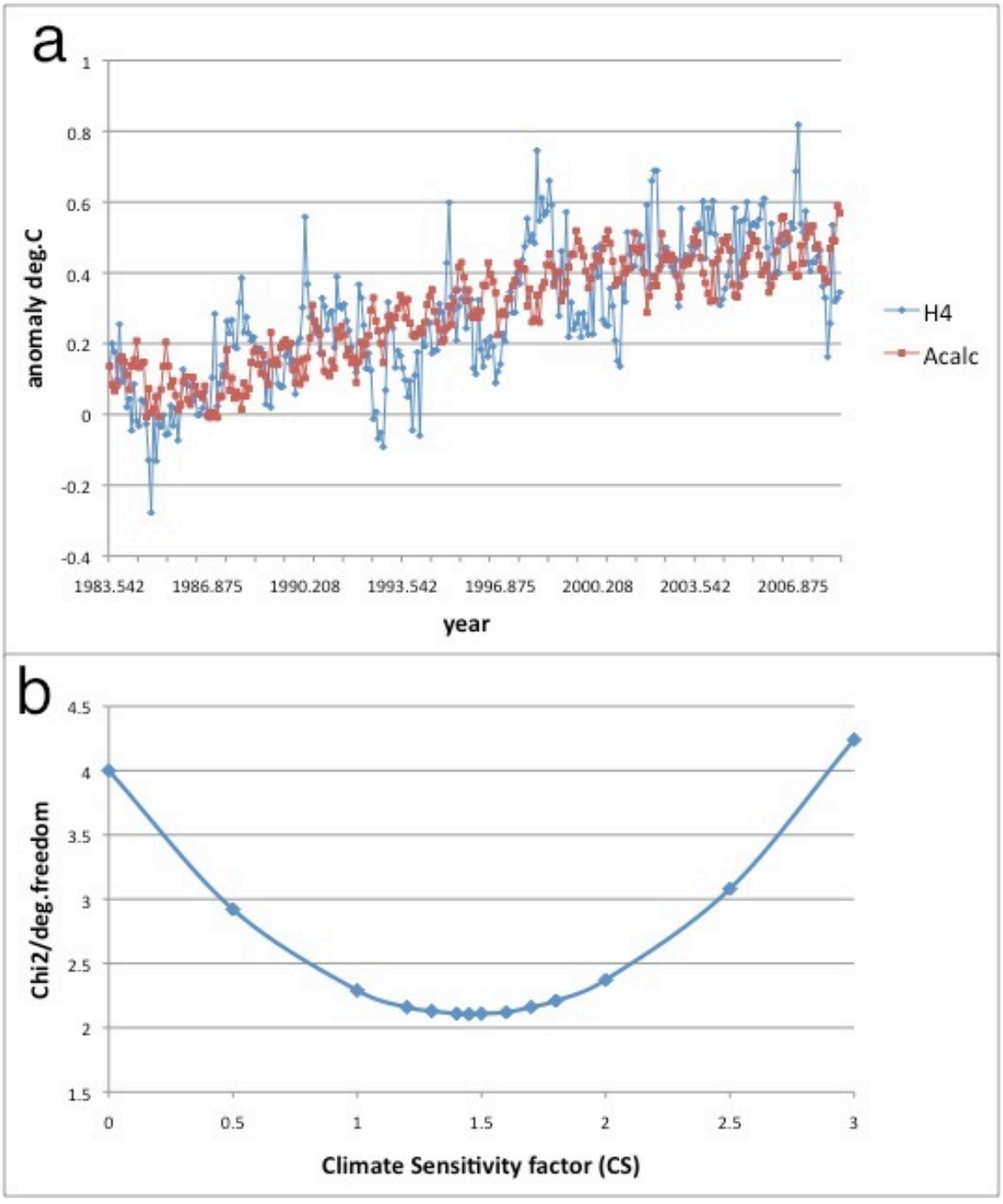
If for example global cloud cover reduces from 70% to 68% the overall effect on the Earth's energy balance is

(0.32*240 + 0.68*218) - (0.3*240 + 0.7*218) = 0.02(240 - 218) = 0.44 W/m2

ISCCP data show that cloud cover reduced from ~68% in 1984 to 65% in 1999. This explains just over half the observed climate change. The rest is due to CO2 emissions. It also explains the pause in global warming after 2000 when cloud cover stabilized and increased slightly.



The model shows that a TCR = 1.6 ± 0.3 C is able to reproduce very well the last nearly 3 decades of global temperatures (HADCRUT4) covering the rapid warming until 1999 and the pause since then. The comparison of model and data are shown below a) together with the variation of χ^2/degree of freedom and TCR b).


a
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
anomaly deg.C
1983.542
1986.875
1990.208
1993.542
1996.875
2000.208
2003.542
2006.875
year
H4
Acalc
b
4.5
4
3.5
3
2.5
2
1.5
Chi2/deg.freedom
0
0.5
1
1.5
2
2.5
3
Climate Sensitivity factor (CS)