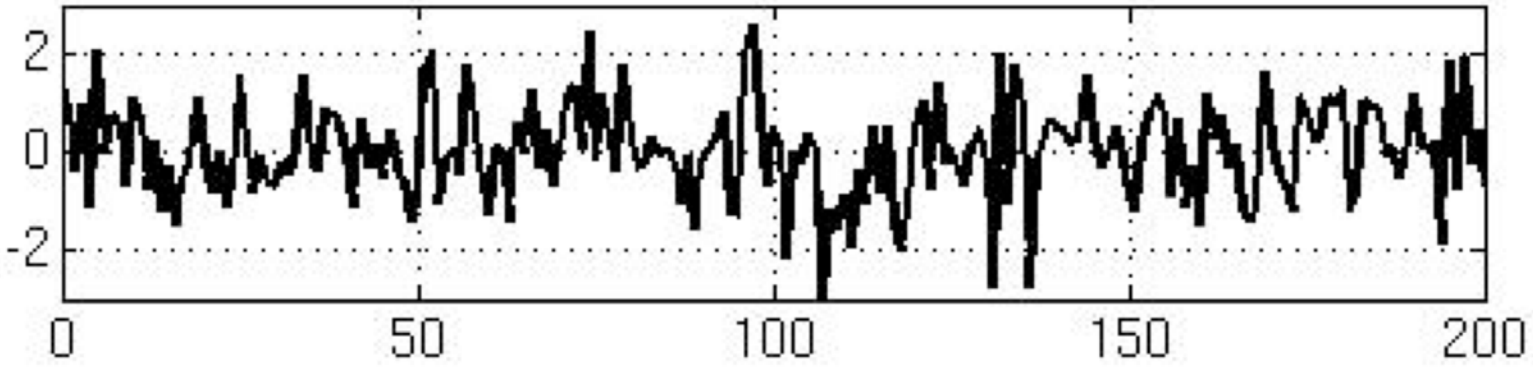
Climate at a point: the effect of random noise

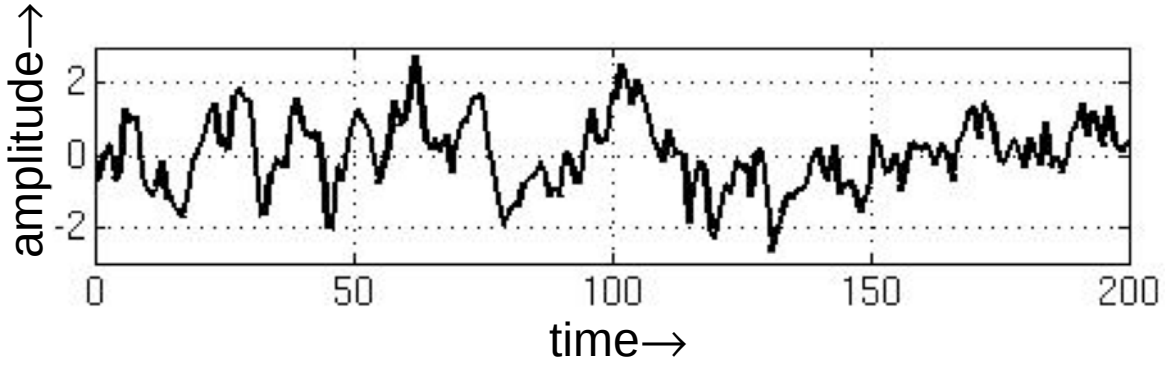
Can always expect random noise
in the climate system:



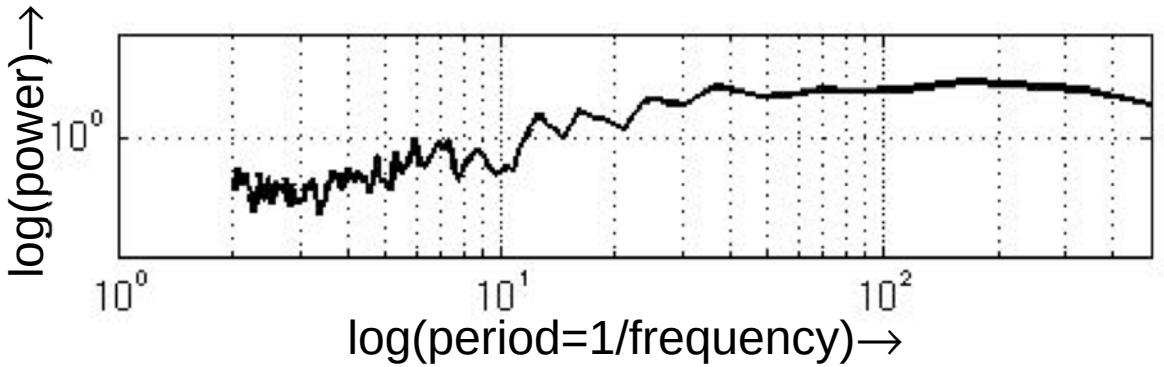
Climate at a point: power spectrum of response to noise

Quick intro to power spectra:
they are an alternative way of describing a time series

Time series



Power spectrum



Gives power (energy) at each sine wave frequency that makes up the time series (analogous to spectrum of light)

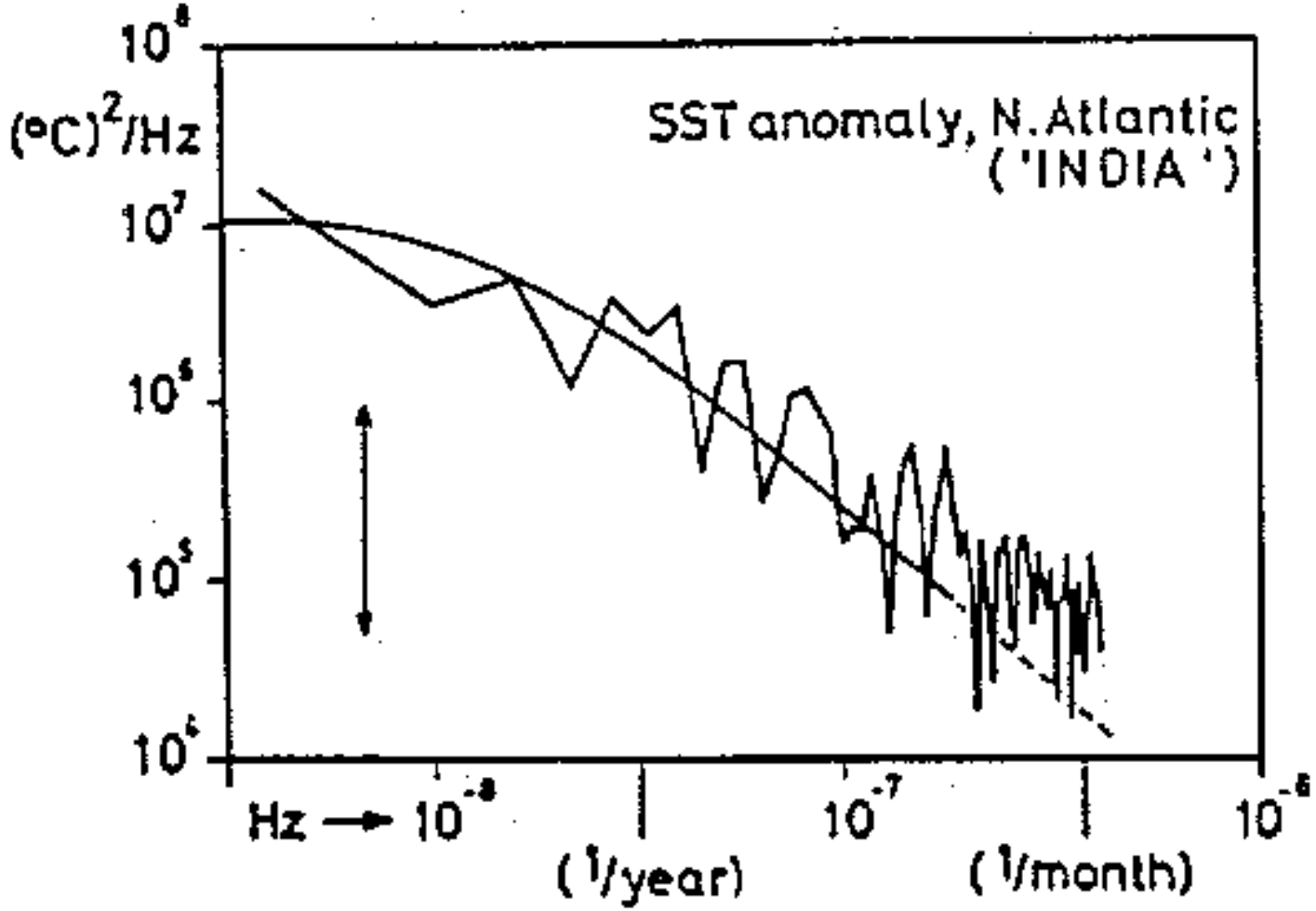


Fig. 5. Spectrum of SST anomaly at Ocean Weather Ship India for the period 1949–1964 (after Frost, 1975). The arrows indicate the 95% confidence interval. The smooth curve was calculated from relation (4.1) with $h = 100$ m, $\lambda = (4.5 \text{ month})^{-1}$.

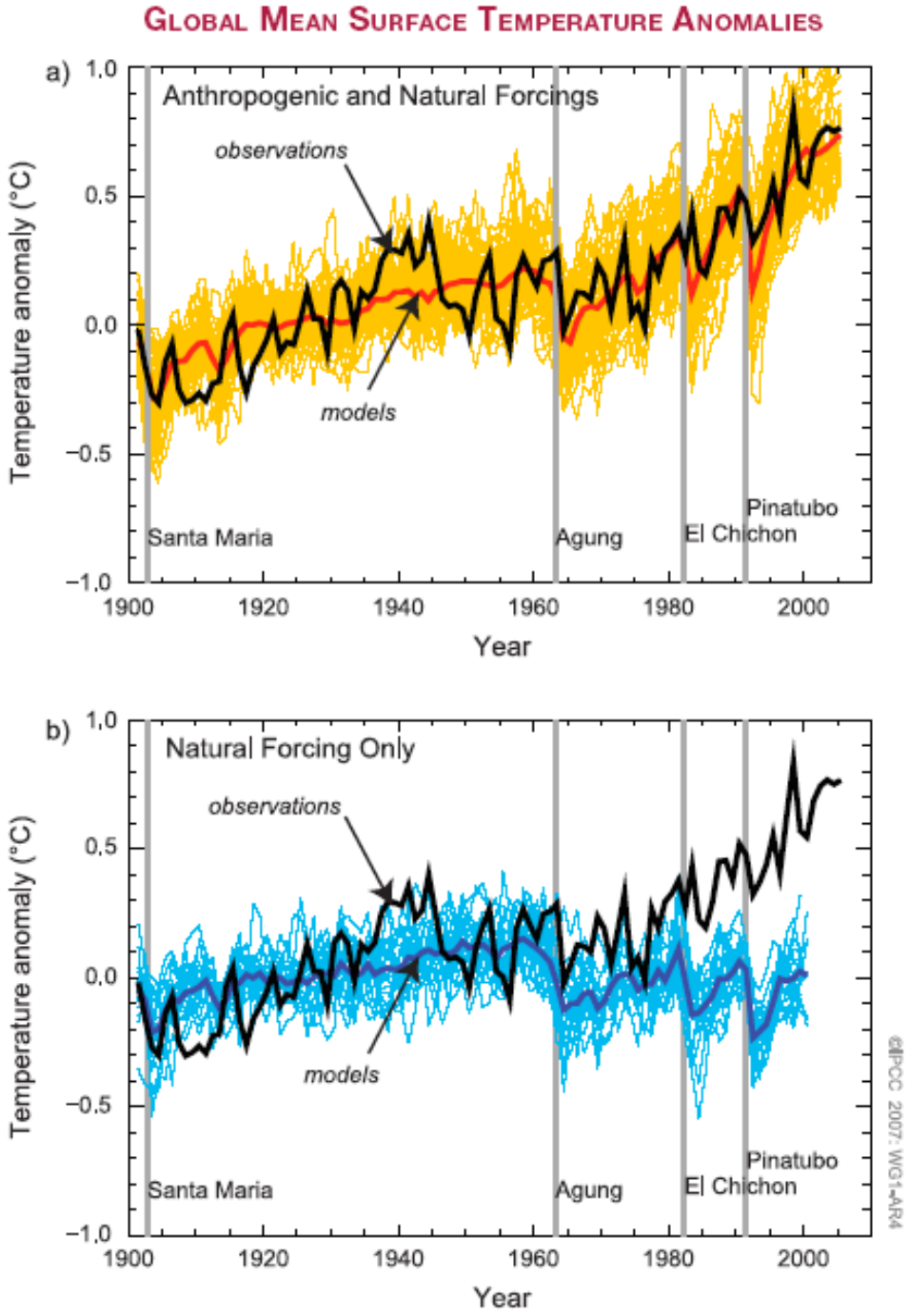


Figure TS.23. *(a) Global mean surface temperature anomalies relative to the period 1901 to 1950, as observed (black line) and as obtained from simulations with both anthropogenic and natural forcings. The thick red curve shows the multi-model ensemble mean and the thin yellow curves show the individual simulations. Vertical grey lines indicate the timing of major volcanic events. (b) As in (a), except that the simulated global mean temperature anomalies are for natural forcings only. The thick blue curve shows the multi-model ensemble mean and the thin lighter blue curves show individual simulations. Each simulation was sampled so that coverage corresponds to that of the observations. {Figure 9.5}*

Projections of Surface Temperatures

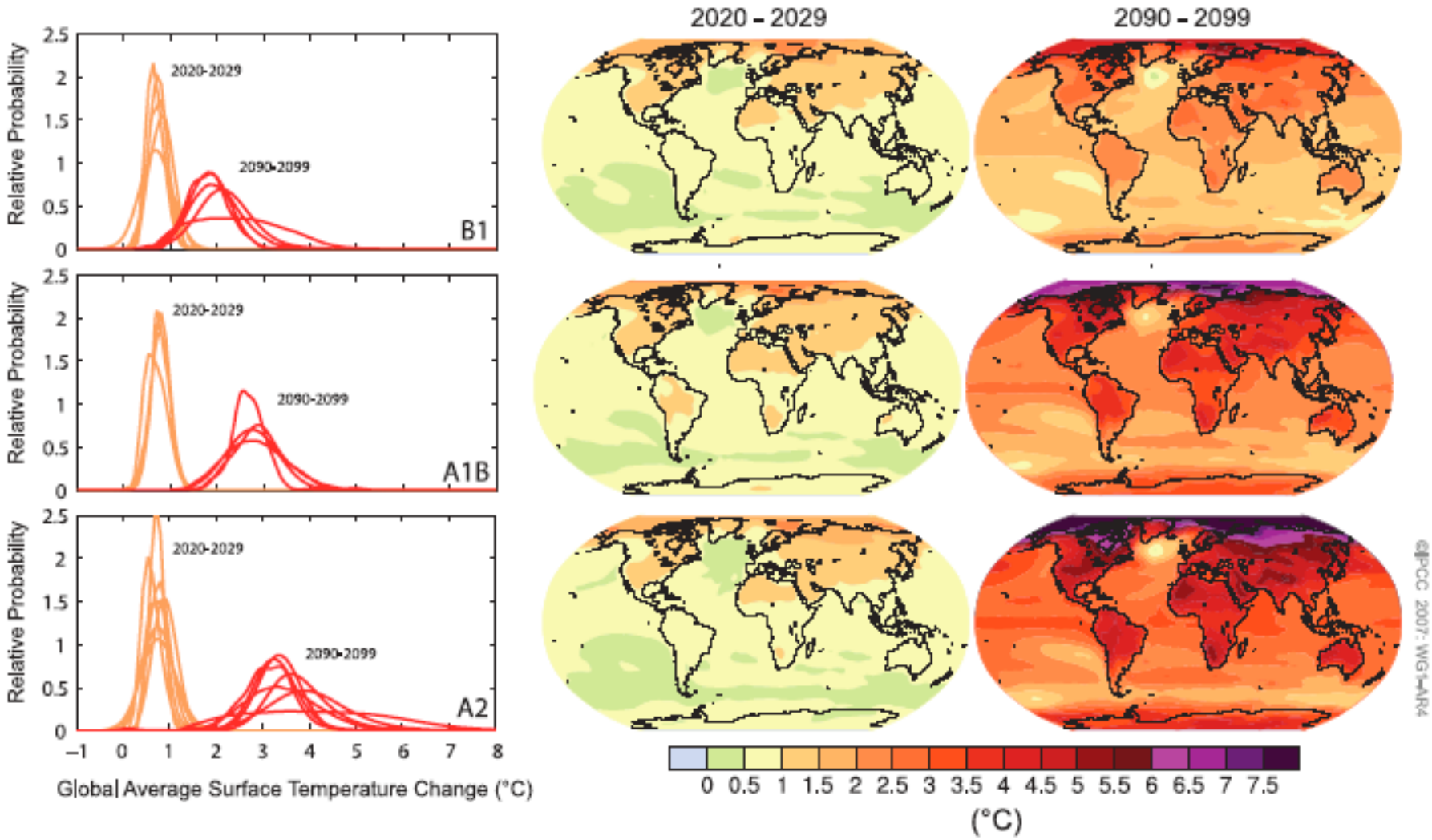


Figure TS.28. *Projected surface temperature changes for the early and late 21st century relative to the period 1980 to 1999. The central and right panels show the AOGCM multi-model average projections (°C) for the B1 (top), A1B (middle) and A2 (bottom) SRES scenarios averaged over the decades 2020 to 2029 (centre) and 2090 to 2099 (right). The left panel shows corresponding uncertainties as the relative probabilities of estimated global average warming from several different AOGCM and EMIC studies for the same periods. Some studies present results only for a subset of the SRES scenarios, or for various model versions. Therefore the difference in the number of curves, shown in the left-hand panels, is due only to differences in the availability of results. {Adapted from Figures 10.8 and 10.28}*

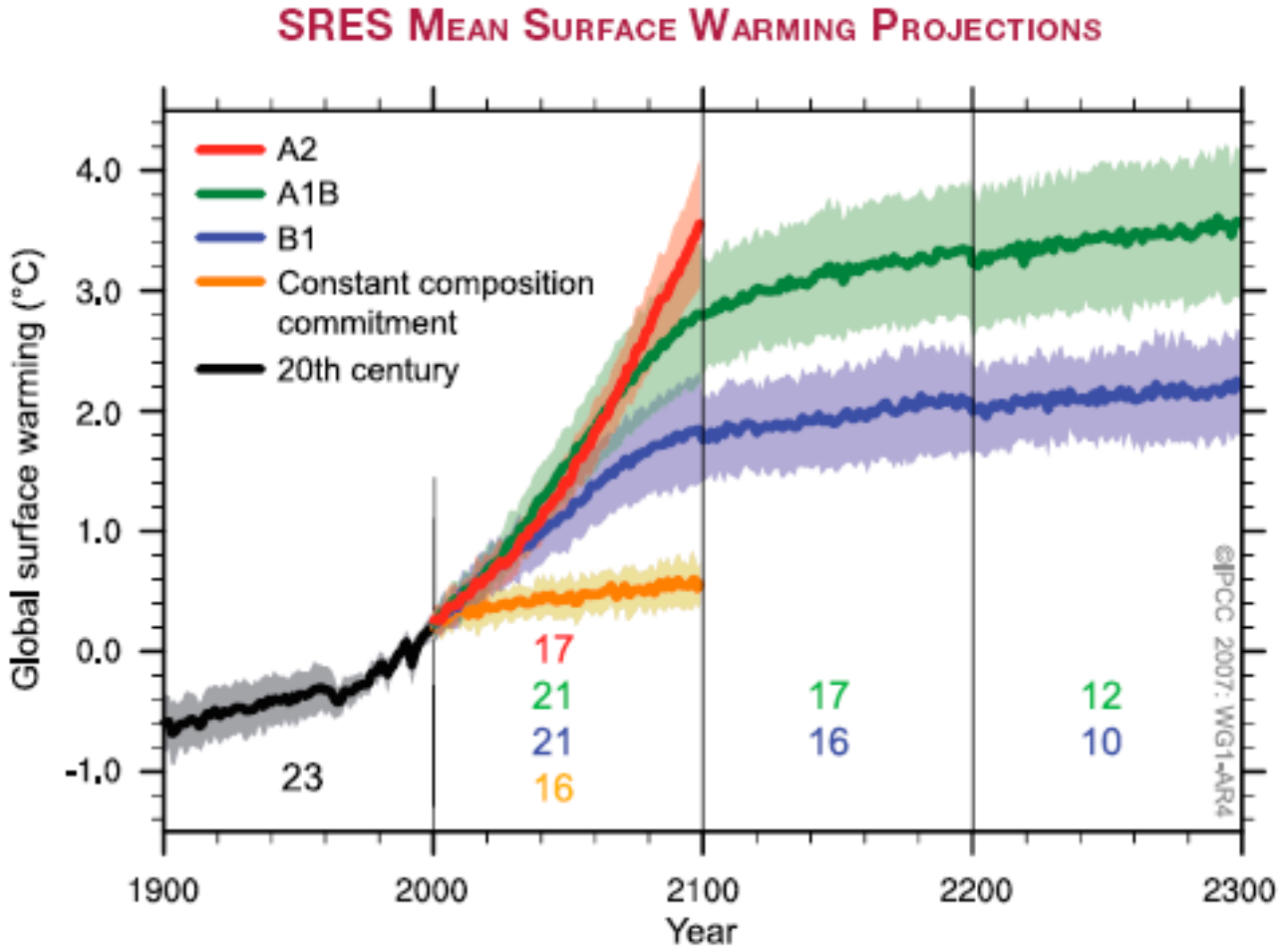
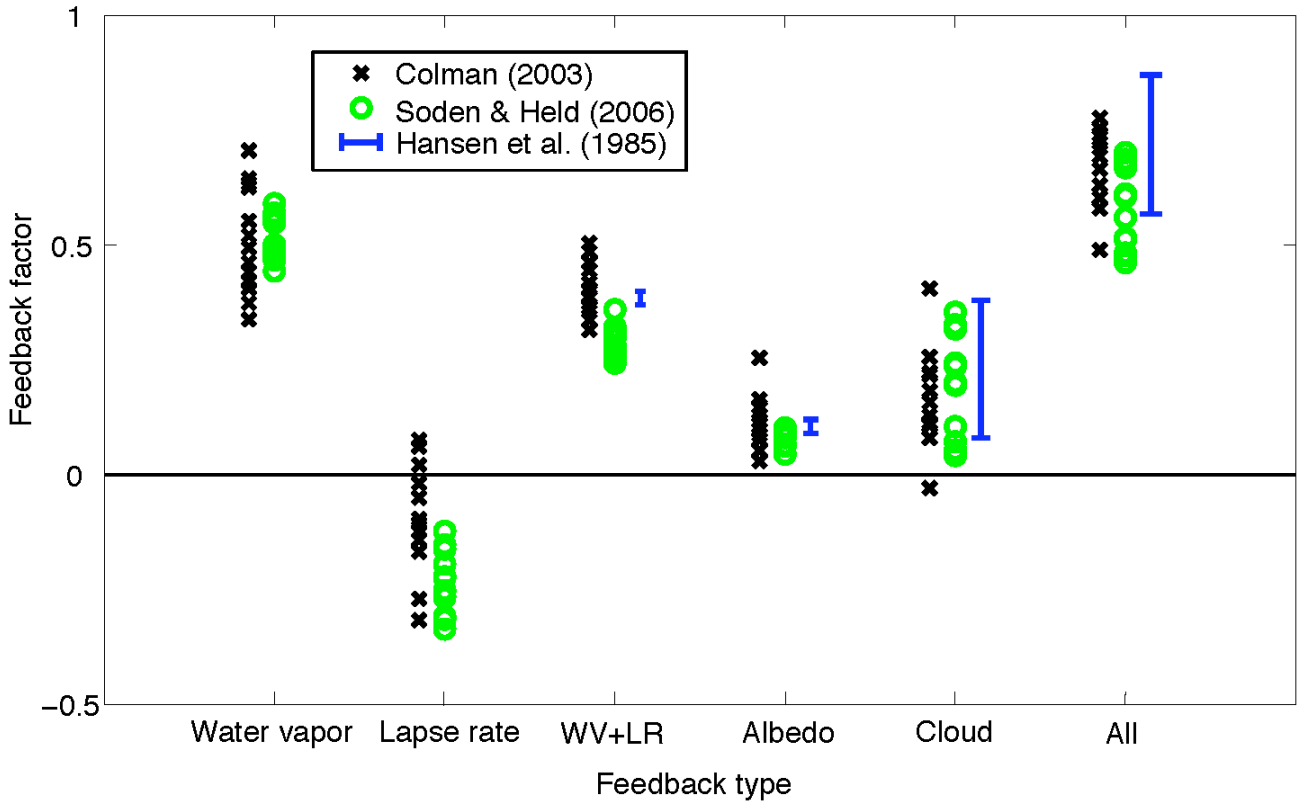


Figure TS.32. *Multi-model means of surface warming (compared to the 1980–1999 base period) for the SRES scenarios A2 (red), A1B (green) and B1 (blue), shown as continuations of the 20th-century simulation. The latter two scenarios are continued beyond the year 2100 with forcing kept constant (committed climate change as it is defined in Box TS.9). An additional experiment, in which the forcing is kept at the year 2000 level is also shown (orange). Linear trends from the corresponding control runs have been removed from these time series. Lines show the multi-model means, shading denotes the ±1 standard deviation range. Discontinuities between different periods have no physical meaning and are caused by the fact that the number of models that have run a given scenario is different for each period and scenario (numbers indicated in figure). For the same reason, uncertainty across scenarios should not be interpreted from this figure (see Section 10.5 for uncertainty estimates). {Figure 10.4}*

Climate feedbacks: estimating from models

From suites of GCMS:



Individual feedbacks uncorrelated among models, so can be simply combined:

Soden & Held (2006):

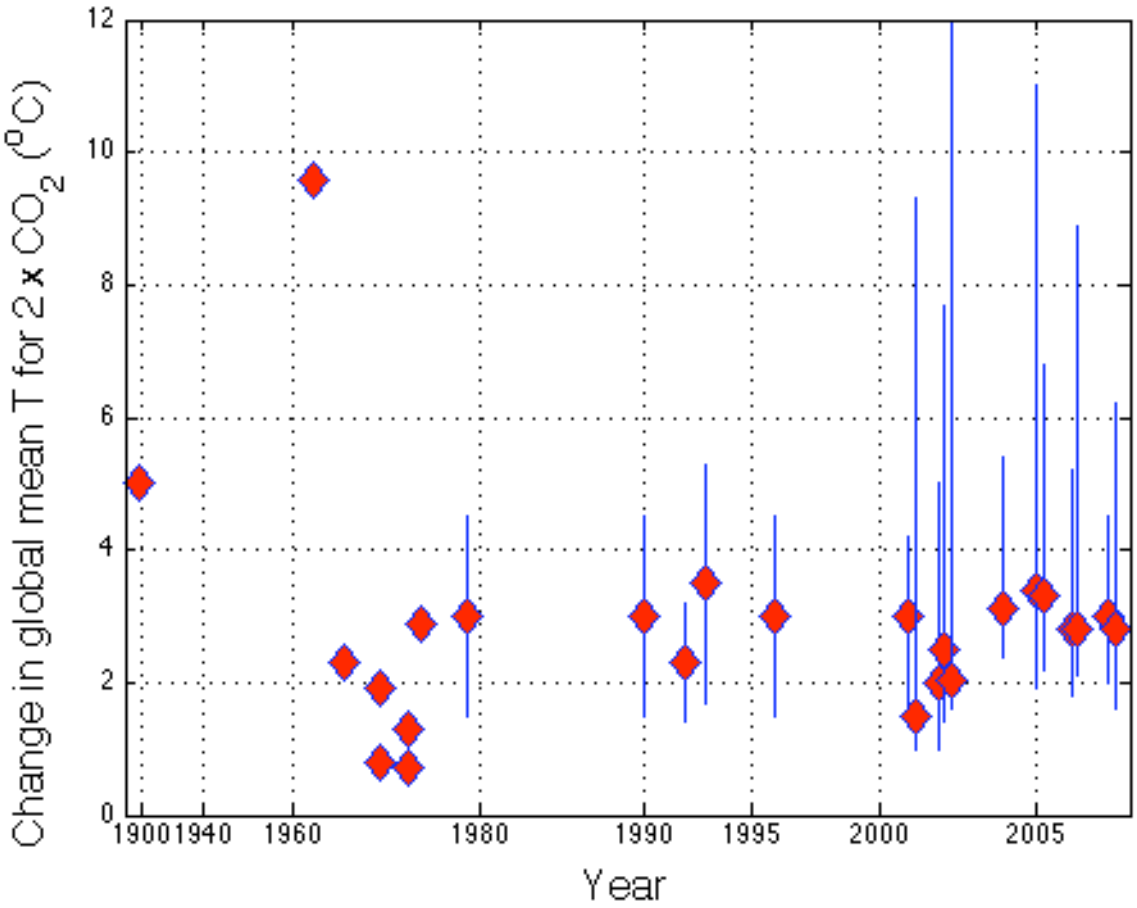
$\bar{f} = 0.62; \sigma_f = 0.13$

Colman (2003):

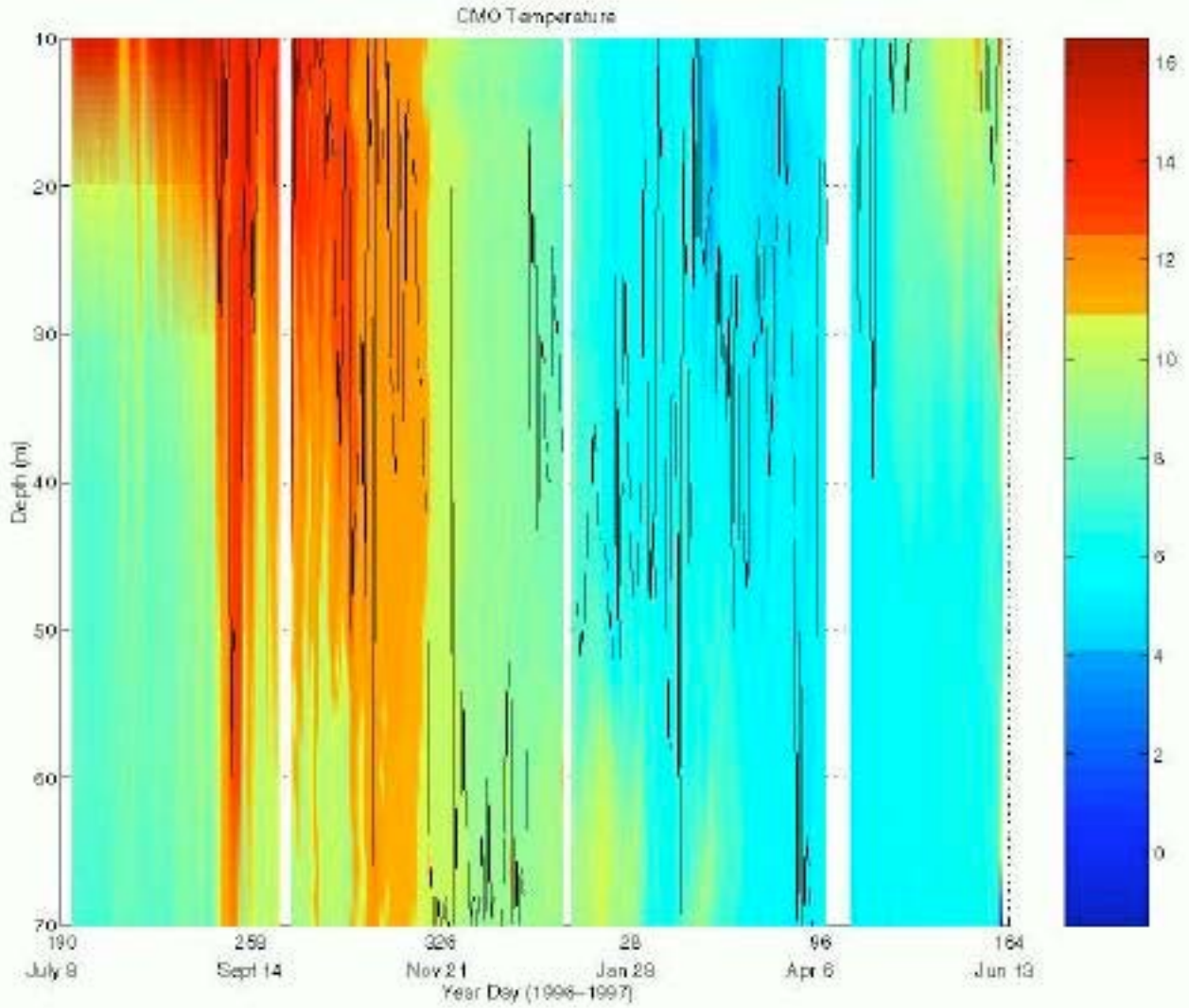
$\bar{f} = 0.70; \sigma_f = 0.14$

Climate Sensitivity: estimates over time

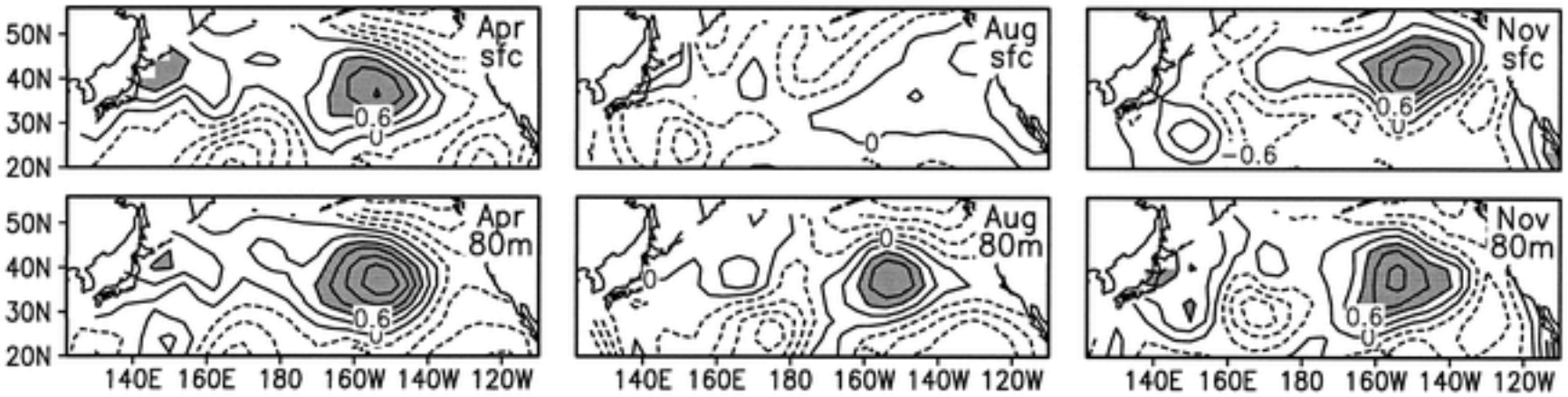
Climate sensitivity ≡ Equilibrium change in global mean, annual mean temperature given CO_2 $\rightarrow$2 x CO_2



1. Arrhenius, 1896
2. Moller, 1963
3. Weatherald and Manabe, 1967
4. Manabe, 1971
5. Rasool and Schneider, 1971
6. Manabe and Weatherald, 1971
7. Sellers, 1974
8. Weare and Snell, 1974
9. NRC Charney report, 1979
10. IPCC1, 1990
11. Hoffert and Covey, 1992
12. IPCC2, 1996
13. Andronova & Schlesinger, 2001
14. IPCC3, 2001
15. Forest et al., 2002
16. Harvey & Kaufmann, 2002
17. Gregory et al., 2002
18. Murphy et al., 2004
19. Piani et al., 2005
20. Stainforth et al., 2005
21. Forest et al., 2006
22. Hegerl et al. 2006
23. IPCC4, 2007
24. Royer et al., 2007


CMO Temperature
Depth (m)
10
20
30
40
50
60
70
190
July 9
259
Sept 14
328
Nov 21
28
Jan 28
96
Apr 6
164
Jun 13
Year Day (1996–1997)
16
14
12
10
8
6
4
2
0

SST re-emergence



Alexander and Deser, 1995