Committed warming and the pattern effect

Appendix: ECS estimation in abrupt4xCO2 simulations and pitfalls of using annual mean data

Zhou et al. point out that a long term λ value derived from regressing over years 21–150 rather than 1–150, which there is a case for and is sometimes done, would be smaller and hence produce a larger estimate of the (forced element of the) historical pattern effect. However, a model's interannual internal variability (particularly evident in Figure 1after the first 20 years or so) can noticeably bias the slope estimate over years 21–150 of abrupt4xCO2 data if annual means are used, if its climate feedback for interannual variability differs from that to CO_2 forcing over the analysis period. It is therefore better practice to regress pentadal or other multiyear mean data to estimate λ over years 21–150.

Figure 3 repeats Figure 1 but using pentadal rather than annual mean data. It can be seen just how linear the CAM5.3 model behaviour is once the effects of interannual variability are dampened. The years 1–150 and 1–20 regression slopes (and hence λ estimates) are both about 4%–5% smaller than when using annual mean data. However, the ECS and effective climate sensitivity estimates are barely changed; the latter is now only 1% (rather than 2.4%) below the ECS estimate.

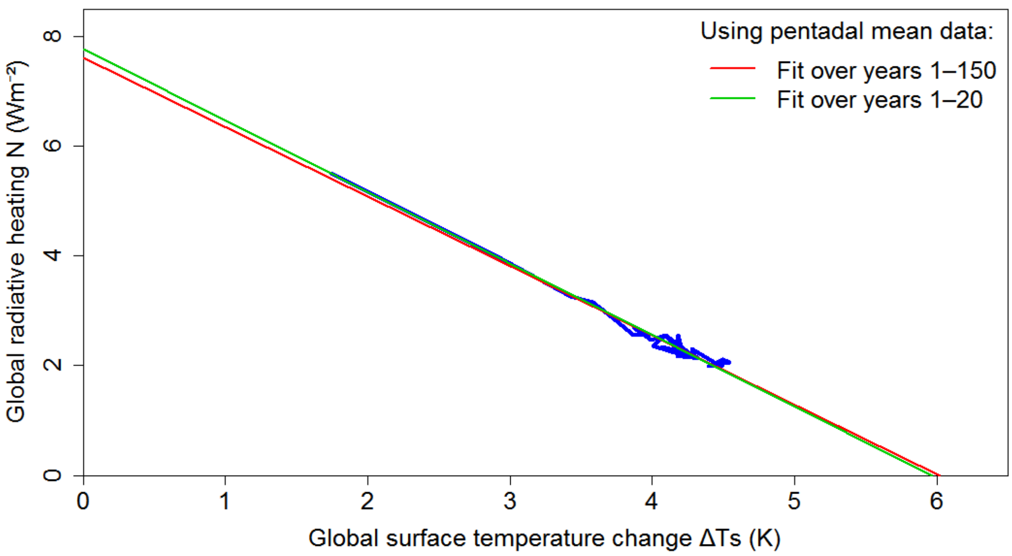

Figure 3. Plot of pentadal mean ΔTs and N values over the 150 year CESM1.2.1-CAM5.3 abrupt4xCO2 simulation, and linear OLS regression fits thereto over years 1–150 and 1–20.

Regressing over pentads formed for years 21–150 data would give an ECS estimate 6.4% higher than that using years 1–150 data (fit line not shown), and a substantially smaller λ estimate. However, if years 21–150 pentadal data were regressed the other way around (ΔTs on N, not N on ΔTs) then the ECS estimate would be less than 1% above that using years 1–150 data, and the λ estimate would be considerably closer to that using years 1–150 data. When annual mean data is regressed, the difference in λ estimates over these two periods depends to a much greater extent on which way round the regression is performed. The substantially larger impact on regression over years 21–150 than over years 1–150 of random variability in Ts (or T) and N, results from the forced change being much lower over that period. That results in lower data correlation. Using pentadal rather than annual means substantially improves the forced-signal-to-noise ratio and hence the data correlation and regression accuracy.

Even when pentadal means are used, there is some uncertainty in the ECS estimate, and large uncertainty in the λ estimate, when using data spanning years 21–150. By contrast, when using years 1–150 data ECS estimation is almost unaffected, and λ estimation is affected by under 3%, by which way round the regression is performed when using pentadal mean data (although the way round regression is performed does noticeably affect both ECS and λ estimates when using annual mean data).

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