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A45E-1884 - Earth's Transient Climate Sensitivity Evaluated From AR6 Estimates of Total Forcing and Observed Time Series of Global Temperature Change

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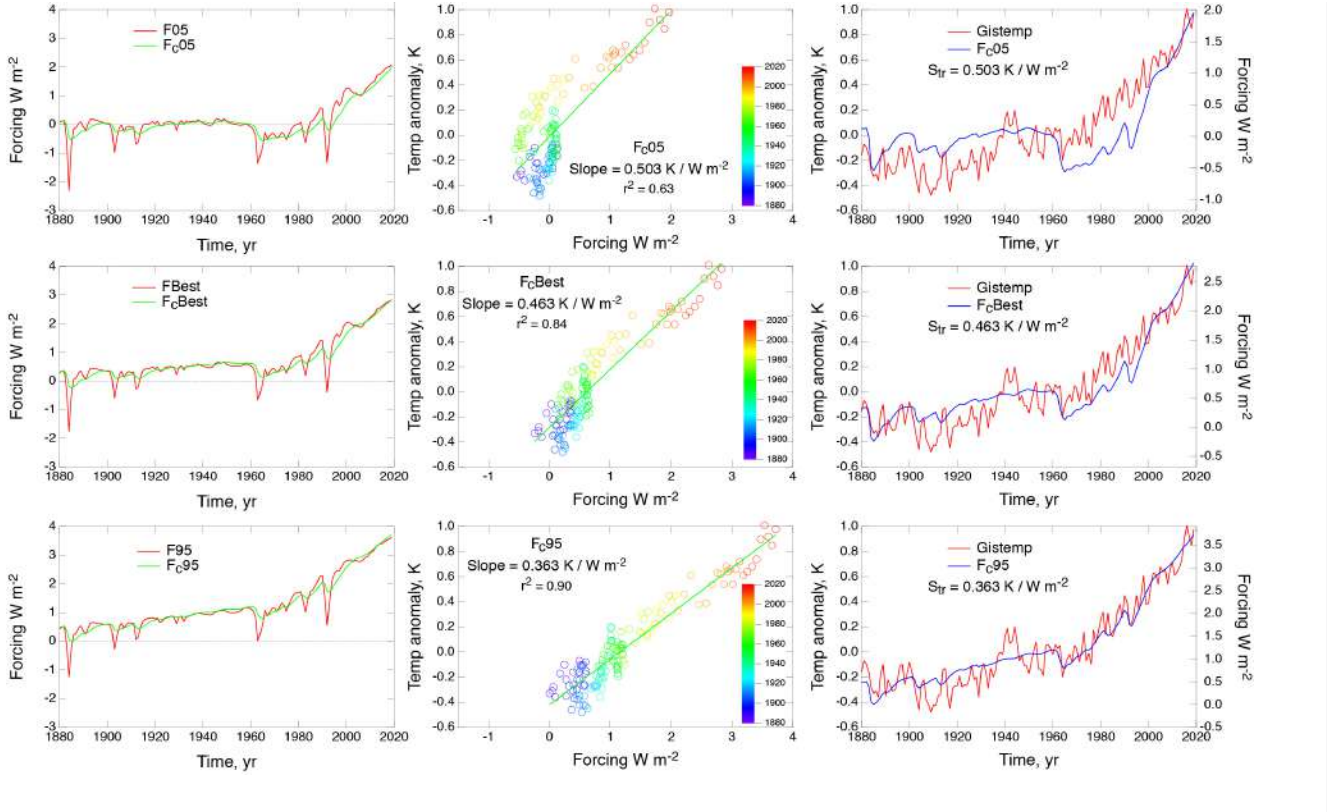
Abstract

Earth's transient climate sensitivity S_{tr} is the rapid change, plateauing at ~5 yr, in global mean surface temperature GMST per change in forcing (*e.g.*, Held *et al.*, *JGR*, 2010). S_{tr} is readily evaluated from time series of total forcing F and temperature anomaly ΔT as the slope of a regression of ΔT *vs* F, with ΔT from model or observations and F generally modeled based on change in atmospheric composition.

Prior estimates of S_{tr} have varied quite widely, mainly because of uncertainty in aerosol forcing. F is evaluated as total non-aerosol forcing, dominated by positive GHG forcing, plus negative aerosol forcing; large magnitude aerosol forcing results in small F and in turn high S_{tr}, and vice versa. Forcing time series derived from the Fifth IPCC Assessment Report (AR5, 2013) resulted in best estimate S_{tr} 0.35 K (W m^{-2})$^{-1}$; 5% to 95% uncertainty range 0. 27 to 0.55 (Schwartz, *JGR*, 2018).

New time series of total forcing from the (2021) Sixth IPCC Assessment report (AR6) permit similar evaluation of S_{tr}, **Figure 1**, as 0.46 (0.36 to 0.50) K (W m^{-2})$^{-1}$. The increase in best-estimate S_{tr} is due to increased magnitude of best-estimate aerosol forcing in AR6 *vs*. AR5. Poor long-term correlation of forcing time series and observed ΔT for the 5% forcing estimate (large negative aerosol forcing added to GHG forcing, yielding low total forcing) suggests that that the corresponding bound on aerosol forcing magnitude may be an over-estimate, with the correlation substantially improved for best estimate and even more so for lowest estimate of aerosol forcing magnitude, thus more consistent with lower values of S_{tr}. A somewhat higher range of S_{tr}, 0.42 to 0.75 K (W m^{-2})$^{-1}$, is obtained using time series of forcings obtained with individual models (Smith *et al.*, ACP, 2020).

Figure 1. Time series of total forcing F and as convolved with 5-year decaying exponential F_c (*left*); correlations of observed temperature anomaly ΔT (GISS) *vs* F_c (*center*); slope denotes transient sensitivity S_{tr}; and time series of ΔT (*right*; left axis) and F_c (right axis, scaled to ΔT by S_{tr}). Top row, lower 5% bound on forcing time series; middle row, best estimate forcing; bottom row, 95% bound. Forcing data from draft AR6 report, expected release August 9, 2021, potentially subject to change.



Plain-language Summary

Earth's transient climate sensitivity S_{tr}, the rapid change in global mean surface temperature GMST per change in forcing, plateauing at about 5 years, characterizes the major fraction of GMST response to forcing. S_{tr} is readily evaluated from time series of temperature anomaly ΔT and total forcing Ftot. Here ΔT observed since 1880 is used together with best-estimate and 5% and 95% confidence-interval forcing time series in the 2021 IPCC AR6 assessment to evaluate S_{tr}, yielding best estimate 0.46 K $(W\ m^{-2})^{-1}$ and associated 5-95% uncertainty range 0.36 to 0.50 K $(W\ m^{-2})^{-1}$, somewhat lower, and with smaller uncertainty, than the values obtained with forcings from the 2013 AR5 report. Poor long-term correlation of forcing time series and observed GMST anomaly for 5% forcing estimate (large negative aerosol forcing yielding low total forcing) suggests that that the corresponding bound on aerosol forcing magnitude may be overestimated; the correlation improves substantially for the best estimate aerosol forcing and even more for the lowest estimate of aerosol forcing magnitude, more consistent with lower values of S_{tr}. This would have important implications for control of future climate change by reduction of CO_2 emissions from fossil fuel combustion with concomitant reduction of combustion derived aerosols.