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Atmospheric Chemistry and Physics Discussions

Interactive comment on "The influence of internal variability on Earth's energy balance framework and implications for estimating climate sensitivity" *by* Andrew E. Dessler et al.

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Like this reviewer, I enjoyed reading the authors' paper on interesting fundamental issues concerning the traditional energy balance framework. The reviewer suggests some further justification of why the tropical 500 hPa temperature should work better than the global mean. I have some thoughts on this as an extension to my previous short comment SC3.

In the discussion paper the climate feedback parameter $\Theta = \Delta(R - F)/\Delta T_A$ with reference to the mean 500 hPa tropical temperature anomaly T_A, where the tropics are defined as 30°N to 30°S, is discussed. There are also three regional feedback

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parameters considered $\Theta_r = \Delta(R-F)_r/\Delta T_{A,r}, r = 1,2,3$, where index r denotes the three regions 90°N to 19.4°N, 19.4°N to 19.4°S and 19.4°S to 90°S (see Fig. 5 in the discussion paper). However, by definition $T_{A,r}$ denotes the corresponding temperature anomalies averaged over each of the three tropical regions 30°N to 19.4°N, 19.4°N to 19.4°S and 19.4°S to 30°S.

As discussed in my previous comment SC3, if the regional parameters would be constant the global parameter will in general not be a constant but instead satisfying the following equation

$$\begin{aligned} R &= F + \Theta T_A + a_2 a_1(\Theta_2 - \Theta_1)(T_{A,2} - T_{A,1}) + \\ &\quad + a_3 a_1(\Theta_3 - \Theta_1)(T_{A,3} - T_{A,1}) + a_3 a_2(\Theta_3 - \Theta_2)(T_{A,3} - T_{A,2}) \end{aligned} \quad (1)$$

where R is the global TOA flux imbalance and F is the global radiative forcing.

The tropics have less seasonal and regional temperature variations than other regions on the planet, for example, the subarctic one. Thus, the differences in temperatures $T_{A,r}$ between the three tropical regions can be expected to be less than between the three whole regions, covering the whole planet. Consequently, it may be expected that the three last terms in Eq. (1) are adding less flux variation than the three last terms in Eq. (8) in SC3. This may also be valid in case of a corresponding equation using the 500 hPa temperatures, averaged not only over the tropical parts but over the whole regions. This is one reason why a better correlation between $\Delta(R-F)$ and ΔT_A than between $\Delta(R-F)$ and some form of global mean temperature may be expected.

Furthermore, the differences between the feedback parameters Θ_r were less than between the parameters λ_r based on the global mean surface temperature (see Fig. 5 in the discussion paper). This gives also a contribution to the better correlation as discussed in SC3. Perhaps this less difference between the Θ_r parameters may be explained by the changes in the TOA flux being dominated by the changes of the LW radiation and the tropics having a dominating role for the changes of the LW radiation?

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