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Comment on "Climate sensitivity in the Anthropocene" by Previdi et al. (2011)

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Abstract

Attention is called to several inconsistencies and errors in the definition and interpretation of quantities relating to climate sensitivity and feedbacks in the discussions paper "Climate sensitivity in the Anthropocene" by Previdi et al. (2011).

1 Definition of reference temperature

There is inconsistency in the definition of temperature, denoted "surface temperature", by which it is surely meant, as is conventional, global-mean near-surface air temperature, GMST, that affects the value given for the quantity λ_0, the climate response coefficient for the Planck (no-feedback) response to a radiative forcing. Equation (1) of Previdi et al. (2011) relates the change in surface temperature ΔT to the forcing ΔF and the planetary energy imbalance ΔQ following imposition of the forcing as

$$\Delta F = \lambda \, \Delta T + \Delta Q. \tag{1}$$

For the Planck response to a radiative forcing, the investigators give $\lambda_0 \approx 3.8\,\mathrm{W\,m^{-2}\,K^{-1}}$, obtained (in the Supplement) as

$$\lambda_0 = \frac{d\,\sigma\,T_e^4}{d\,T_e} = 4\,\sigma\,T_e^3 \tag{2}$$

where σ is the Stefan-Boltzmann radiation constant ($5.67 \times 10^{-8}\,\mathrm{W\,m^{-2}\,K^{-4}}$) and T_e is taken as the effective emission temperature of Earth such that the outgoing longwave radiation at the top of the atmosphere, $S \approx 239\,\mathrm{W\,m^{-2}} = \sigma\,T_e^4$; whence $T_e \approx 255\,\mathrm{K}$. As the temperature for which the climate response coefficient λ is being defined (Eq. 1) is the *surface* temperature, not the effective radiative temperature of the planet, it is the surface temperature that is pertinent to the evaluation of λ_0 (e.g. Schlesinger, 1986; Roe and Baker, 2007; Schwartz, 2011); for GMST taken as 288 K, $\lambda_0 \approx 3.3\,\mathrm{W\,m^{-2}\,K^{-1}}$.

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2 Climate system response

Previdi et al. (2011) refer to the climate response term $\lambda\ \Delta T$ in Eq. (1) as an "increased LW (longwave) emission" to space that would result from and be proportional to a (positive) "surface temperature change ΔT". This is incorrect. The climate response term denotes the change in the *net* irradiance at the top of the atmosphere, which encompasses changes in both the emitted longwave irradiance *and* the absorbed shortwave irradiance that result from the change in surface temperature. Changes in absorbed shortwave irradiance are expected to result, importantly, from changes in the amount and nature of clouds (cloud feedbacks) and from any changes in surface albedo (snow and ice feedbacks).

3 Unrealized warming

Previdi et al. (2011) state that a climate sensitivity of 6 K for doubled CO_2 ($\Delta F_{2\times} = 3.7\,\mathrm{W\,m^{-2}}$) would indicate that an additional 1.4 K of global warming is still "in the pipeline" as a result of past forcing not yet responded to, on account of the present-day planetary imbalance, which those investigators take as about $0.85\,\mathrm{W\,m^{-2}}$, on top of the ~0.8 K warming that has already occurred, bringing the total increase in global temperature to about 2.2 K above preindustrial levels. Any reckoning of unrealized warming must be based on an assumed present and future radiative forcing. For present (2011) forcing by long-lived greenhouse gases (CO_2, CH_4, N_2O, and chlorofluorocarbons) only, taken as $2.8\,\mathrm{W\,m^{-2}}$ (Hansen et al., 2005, extended at http://data.giss.nasa.gov/modelforce/RadF.txt; Forster et al., 2007, extended) maintained indefinitely, the committed warming, that is, the expected steady-state (commonly denoted "equilibrium") increase in GMST above preindustrial GMST, evaluated as

$$\Delta T_{\mathrm{eq}} = \lambda^{-1}\,\Delta F, \tag{3}$$

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would be equal to the value given by Previdi et al. (2011), 2.2 K, for $\lambda^{-1} = 0.79$ K/(W m^{-2}). This value of the sensitivity coefficient corresponds, for the forcing of doubled CO_2, $\Delta F_{2\times}$, taken as 3.7 W m^{-2}, to an equilibrium climate sensitivity $\Delta T_{2\times} = 2.9$ K, virtually the same as the widely accepted value for "fast" climate system response, 3 K, and is well less than the slow-feedback climate sensitivity 6 K invoked by Previdi et al. (2011) The fact that an increase in GMST of this magnitude has not been realized at present is due mainly to offsetting forcing by anthropogenic aerosols and/or lower equilibrium climate sensitivity, and only to much lesser extent to planetary energy imbalance (Schwartz et al., 2010).

4 Non-radiative forcing

Previdi et al. (2011) (Supplement) introduce a quantity that they denote as a "non-radiative forcing" that accounts for energy exchange between the surface and the atmosphere. As the atmosphere is coupled to the surface on a time scale that is much more rapid than the fast response of GMST to imposed radiative forcings, the disposition between the atmosphere and the surface of the energy imbalance imposed by the forcing is irrelevant for defining or evaluating climate sensitivity as the change in GMST normalized to the radiative forcing that is imposed on the net global-mean top-of-atmosphere irradiance.

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References

Forster, P., Ramaswamy, V., Artaxo, P., Berntsen, T., Betts, R., Fahey, D. W., Haywood, J., Lean, J., Lowe, D. C., Myhre, G., Nganga, J., Prinn, R., Raga, G., Schulz, M., and Van Dorland, R.: Changes in Atmospheric Constituents and in Radiative Forcing, in: Climate Change 2007: The Physical Science Basis, Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, edited by: Solomon, S., Qin, D., Manning, M., Chen, Z., Marquis, M., Averyt, K. B., Tignor, M., and Miller, H. L., Cambridge University Press, Cambridge, UK and New York, NY, USA, 2007.

Hansen, J., Nazarenko, L., Ruedy, R., Sato, M., Willis, J., DelGenio, A., Koch, D., Lacis, A., Lo, K., Menon, S., Tovakov, T., Perlwitz, J., Russell, G., Schmidt, G. A., and Tausnev, N.: Earth's energy imbalance: Confirmation and implications, Science, 308, 1431–1435, doi:1410.1126/science.1110252, 2005.

Previdi, M., Liepert, B. G., Peteet, D. T., Hansen, J., Beerling, D. J., Broccoli, A. J., Frolking, S., Galloway, J. N., Heimann, M., Le Quéré, C., Levitus, S., and Ramaswamy, V.: Climate sensitivity in the Anthropocene, Earth Syst. Dynam. Discuss., 2, 531–550, doi:10.5194/esdd-2-531-2011, 2011.

Roe, G. H. and Baker, M. B.: Why is climate sensitivity so unpredictable?, Science, 318, 629–632, 2007.

Schlesinger, M. E.: Equilibrium and transient climatic warming induced by increased atmospheric CO_2, Clim. Dynam., 1, 35–51, 1986.

Schwartz, S. E.: Feedback and sensitivity in an electrical circuit: An analog for climate models, Climatic Change, 106, 315–326, doi:10.1007/s10584-010-9903-9, 2011.

Schwartz, S. E., Charlson, R. J., Kahn, R. A., Ogren, J. A., and Rodhe, H.: Why Hasn't Earth Warmed as Much as Expected?, J. Climate, 23, 2453–2464, doi:10.1175/2009JCLI3461.1, 2010.

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