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Estimations of climate sensitivity based on top-of-atmosphere radiation imbalance

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Abstract. Large climate feedback uncertainties limit the accuracy in predicting the response of the Earth's climate to the increase of CO_2 concentration within the atmosphere. This study explores a potential to reduce uncertainties in climate sensitivity estimations using energy balance analysis, especially top-of-atmosphere (TOA) radiation imbalance. The time-scales studied generally cover from decade to century, that is, middle-range climate sensitivity is considered, which is directly related to the climate issue caused by atmospheric CO_2 change. The significant difference between current analysis and previous energy balance models is that the current study targets at the boundary condition problem instead of solving the initial condition problem. Additionally, climate system memory and deep ocean heat transport are considered. The climate feedbacks are obtained based on the constraints of the TOA radiation imbalance and surface temperature measurements of the present climate. In this study, the TOA imbalance value of 0.85 W/m^2 is used. Note that this imbalance value has large uncertainties. Based on this value, a positive climate feedback with a feedback coefficient ranging from −1.3 to −1.0 W/m^2/K is found. The range of feedback coefficient is determined by climate system memory. The longer the memory, the stronger the positive feedback. The estimated time constant of the climate is large (70~120 years) mainly owing to the deep ocean heat transport, implying that the system may be not in an equilibrium state under the external forcing during the industrial era. For the doubled-CO_2 climate (or 3.7 W/m^2 forcing), the estimated global warming would be 3.1 K if the current estimate of 0.85 W/m^2 TOA net radiative heating could be confirmed. With accurate long-term measurements of TOA radiation, the analysis method suggested by this study provides a great potential in the estimations of middle-range climate sensitivity.

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