Geophysical Research Abstracts
Vol. 20, EGU2018-6324-3, 2018
EGU General Assembly 2018

A temperature forcing concept for analysis of Earth's surface temperature response to small disturbances

Ulrich Schumann (1) and Bernhard Mayer (2)

(1) Deutsches Zentrum für Luft- und Raumfahrt, Institut für Physik der Atmosphäre, Oberpfaffenhofen, Germany (ulrich.schumann@dlr.de), (2) Ludwig-Maximilians-Universität München, Lehrstuhl für Experimentelle Meteorologie, Munich (Germany)

This paper discusses the sensitivity of the Earth's surface temperature to regional disturbances such as contrails, and presents a new concept for quantifying the temperature response. In the first part, this paper summarizes the results of a recent conceptual study of surface temperature sensitivity to radiative forcing (RF) by contrail cirrus showing that the sensitivity varies depending on the ratio of time scales of energy transport by mixing and radiation (Schumann and Mayer, ACP, 2017, doi: 10.5194/acp-17-13833-2017). In a second part, the paper presents a new "Temperature Forcing" (TF) concept which may help to overcome such limitations of the RF concept.

In the conceptual study, surface temperature sensitivity to RF by contrail cirrus and the related RF efficacy relative to a CO_2 forcing has been investigated in a one-dimensional idealized model of the atmosphere. The model includes energy transport by shortwave (SW) and longwave (LW) radiation and by mixing in an otherwise fixed reference atmosphere (no other feedbacks). Radiation transfer is calculated using libRadtran. Mixing includes convective adjustment and turbulent diffusion. The surface temperature sensitivity to given contrail RF depends strongly on the time scales of energy transport by mixing and radiation. Without mixing, a large fraction of the energy induced into the upper troposphere by radiation due to contrails or similar disturbances gets lost to space before it can contribute to surface warming. Because of different radiative heating rate profiles in the troposphere, the local surface-temperature sensitivity to stratosphere-adjusted RF is larger for SW than for LW contrail forcing. Hence, surface warming by contrails may be smaller than suggested by the net RF at TOA.

The TF concept is a method designed to efficiently estimate the equilibrium temperature change in a climate system for a given disturbance as a function of precomputed results for a set of reference disturbances. For this purpose we apply a fast simplified and a computationally more expensive comprehensive climate model to set up the relationships between disturbance and climate response for a set of reference disturbances. The equilibrium temperature change for a given disturbance is then derived from the result of the fast model and an additive correction derived from a linear combination of the reference solutions. The method is tested with the same one-dimensional radiative-mixing model as described before for small cirrus and CO_2 disturbances, including water vapor feedback. A demonstration with a full comprehensive climate model has still to be done.