Geophysical Research Abstracts
Vol. 21, EGU2019-8875, 2019
EGU General Assembly 2019

Response of planetary albedo to insolation perturbations

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In the observations, there is almost a hemispheric symmetry of top-of-atmosphere reflected shortwave radiation (RSUT). This is in contrast to the surface reflected shortwave radiation (RSUS) revealing a clear hemispheric asymmetry. In their article, Voigt et al. (2013) could not rule out that the symmetry of RSUT is accidental, and found that the location of the ITCZ and clouds compensate for the asymmetry of RSUS.

Here, we question, to what extent the compensation of the asymmetry is accidental. We analyze Max Planck Institute Earth System Model 1 (MPI-ESM1) experiments performed for the ETIN-MIP project. These experiments are characterized by reduced insolation in different latitude bands: in the northern and southern extra tropics (NE and SE), and in the southern tropics (ST). We are mainly interested in the role of clouds, especially, whether there are compensating effects.

In the control experiment, the hemispheric difference of RSUT is about 1 W/m2, which is only slightly larger than the observed value of 0.1 W/m2. In SE and ST, the hemispheric difference of RSUT increases to about 4 W/m2, while in NE, the difference is almost zero. Under consideration of RSUT control, these differences fit the signs of the prescribed hemispheric differences of insolation of about -6.3 (6.3) W/m2 in NE (SE) and 4.5 W/m2 in ST, which means that the hemispheric asymmetry of insolation is at least partly compensated by the asymmetry of RSUT. However, the numbers e.g. for NE and SE clearly differ.

The largest atmospheric state changes are obtained in ST with an anomalous low-level cross-equatorial northward flow accompanied by increased cloud cover north and decreased cloud cover south of the equator. This eventually leads to a single ITCZ structure, which fits to observations. In NE and SE, there is a clear double ITCZ similar as in the control experiment. However, both experiments strongly differ in other atmospheric responses. In NE, increased cloud cover in the latitude band with reduced insolation leads to an RSUT increase, representing a positive feedback mechanism. In contrast, only small cloud changes are found in the southern extra tropics in SE. Because of this marginal cloud effect, the reduction of RSUT in response to the reduced insolation is larger in SE than in NE in the corresponding latitude band.

From these preliminary results we conclude that in MPI-ESM1, RSUT seems to be forced to a small hemispheric asymmetry depending on the latitudinal distribution of incoming radiation. Cloud and circulation processes represent both, positive and negative feedback mechanisms.

Reference:
Voigt, A., B. Stevens, J. Bader, T. Mauritsen (2013). The Observed Hemispheric Symmetry in Reflected Shortwave Irradiance. J. Climate, 26, DOI: 10.1175/JCLI-D-12-00132.1.