



Inter-hemispheric differences in the energy budgets and its components, and its evolution during the 20th Century

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The evolution of the climate system during the 20th Century, from an energy budget point of view, has significantly differed from what would have been if only the increasing greenhouse gas (GHG) forcing would have been present. We address this here, by taking into account the inter-hemispheric asymmetries in the energy budget and its components at the Top-of-Atmosphere (TOA), at the surface and in the atmosphere, as a residual. Asymmetries are related to the evolution in cross-equatorial transport (CET) anomalies throughout the century. Two multi-model ensemble from the CMIP5 project are considered: one (ALL), accounting for the realistic superposition of all known evolving forcings, the other (GHG) only for the spatially homogeneous GHG forcing. In other words, the comparison allows for distinguishing the asymmetry in the response of the system from an asymmetry in the forcing. We find that in the GHG ensemble the Northern Hemisphere (NH) warms more than the Southern Hemisphere (SH), while in both hemispheres similar EB anomalies occur at the TOA, mainly due to increasing shortwave absorption. CETs are to a large extent stationary. On the contrary, in the ALL ensemble the two hemispheres warm similarly, while the SH exhibits a positive EB anomaly twice as large as in the NH, mainly because of a reduced LW emission in the SH, with oceanic CET anomalies directed towards the NH. The LW emission changes are ascribed to the different role of clouds in the two hemispheres. The ocean heat content (OHC) tendency per unit surface area is similar in the two hemispheres, so that in ALL the energy budget asymmetries determine the CET changes. These are related to the inter-hemispheric asymmetry in the aerosol forcing, which is stronger in the NH than in the SH. Generally, models exhibit biases in the reproduction of CET in present-day conditions. These biases are not ascribed to forcings and feedbacks, rather they are intrinsic to the models.

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