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The hemispheric distribution of reflected shortwave radiation in observations and aquaplanet climates

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We present results from an investigation of the hemispheric distribution of reflected shortwave radiation in observations and in climate model simulations of aquaplanets.

For the present-day Earth, the concentration of land masses and aerosols in the Northern hemisphere suggests that the Northern hemisphere should reflect more shortwave radiation than the Southern hemisphere. However, as we show, data from the CERES mission continues to suggest that the clouds compensate for differences in reflected clear-sky radiation, so that the difference in the total reflected shortwave radiation, at $0.1\,\mathrm{Wm}^{-2}$, is indistinguishable from zero. We then devise a variety of methods to estimate the degrees of freedom in the reflected shortwave radiation. Based on this, we demonstrate that the hemispheric symmetry in reflected shortwave radiation is likely the consequence of dynamical processes.

We further perform aquaplanet simulations using ECHAM6 with a perturbed ocean albedo to study how aquaplanet climates respond to surface albedo perturbations. To focus on the role of clouds, sea-ice formation is inhibited and ocean heat transport is fixed in the simulations. The ocean albedo perturbations are asymmetric with respect to the equator such that their global-mean radiative forcing is zero. The hemisphere with decreased ocean albedo warms while the hemisphere with increased ocean albedo cools. This leads to cross-equatorial energy transport from the decreased ocean albedo hemisphere into the increased ocean albedo hemisphere, which is associated with a shift of the intertropical convergence zone and deep convective clouds into the darker hemisphere. These tropical cloud changes work against the imposed ocean albedo perturbation and are an important mechanism that may contribute to the observed symmetry in hemispheric albedo.