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The link between climate sensitivity, cloud radiative effect, and the climatological Hadley cell extent

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This study analyzes CMIP5 model output to examine the covariability of interannual Southern Hemisphere Hadley Cell (HC) edge latitude shifts and shortwave cloud radiative effect (SWCRE). With poleward HC expansion, many models substantially reduce the shortwave radiation reflected by clouds over the lower midlatitude (LML) region, although no such reduction is seen in observations. These biases in HC-SWCRE covariability are linked to biases in the climatological HC edge latitude. Notably, models with excessively equatorward climatological HC edge latitude have weaker climatological LML subsidence and exhibit larger increases in LML subsidence with poleward HC expansion. Because in models increases in subsidence are correlated with increases in SWCRE, models with a more equatorward climatological HC edge latitude also exhibit larger increases in LML SW warming with poleward HC expansion. This behavior, based on interannual variability, has important implications for the CO_2-forced model response and equilibrium climate sensitivity. In $4xCO_2$-forced runs, models with excessively equatorward climatological HC edge latitudes produce stronger LML SW warming and exhibit higher ECS than models with more realistic climatological HC extents. Experiments with an aqua-planet model are used to understand the relative contributions of atmospheric dynamics and cloud microphysics in the interactions between Hadley cell properties and the cloud and radiation fields.