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The fast response of the tropical circulation to CO_2 forcing

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We analyze CMIP5 idealized climate experiments with abrupt quadrupling of atmospheric CO_2 to understand the fast response of the tropical overturning circulation to this forcing and the main contributors to this response. We define a measure for the circulation intensity based on pressure velocity in the tropical subsidence regions. In doing so, we play on the advantage of the subsidence regions in being dynamically stable and on the fact that, from a measurement point of view, the observation of these regions is prone to less uncertainty than the convective regions. Also, the subsidence regions are less sensitive to the Global Circulation Model's cloud and precipitation parametrization schemes. Our method allows to decompose the circulation intensity relative change (with respect to a control state) into a sum of the relative changes in subsidence area, static stability and atmospheric cooling rate. Also, we use aqua planet and realistic planet experiments to look into the effect of the land-sea differentiated heating on the total change in circulation strength. We find that on the mean the tropical circulation slows down and this change is dominated by the cooling rate reduction, as the other factors show a positive change. The cooling rate reduction results from the direct radiative effect of increased CO_2 concentration in the atmosphere. We find that even in a realistic planet setup the circulation change is dominated by the changes in the subsidence regions over the oceans, but the land-sea differentiated heating also contributes to the slow-down of the circulation by driving the vertical expansion of the tropics.