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How robust is the weakening of the Pacific Walker circulation in CMIP5 idealized transient climate simulations?

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The tropical overturning circulations are likely weakening under increased CO_2 forcing (IPCC 2013). However, insufficient understanding of the circulations' dynamics diminishes the confidence in such a response. Here we investigate the changes in the Pacific Walker circulation under anthropogenic forcing and the sensitivity of its weakening response to internal variability, General Circulation Model (GCM) configuration, and indexing method (Plesca et al. 2017). The internal variability role is analyzed by using a 68-member ensemble of the MPI-ESM-LR model; the influence of model physics is analyzed by using the 28-member CMIP5 ensemble. Three simple, quasi-surface circulation indices, based on mean sea-level pressure, 500 hPa vertical velocity and 200 hPa velocity potential, are computed for each member of the two ensembles. We use the monthly outputs of the CMIP5 idealized transient climate simulations with 1% per year CO_2 increase from pre-industrial level, and investigate the detected circulation response until the moment of CO_2 doubling (70 years). Depending on the indexing method, we find that 50-93% of the MPI-ESM-LR and 54-75% of the CMIP5 ensemble members project significant negative trends in the circulation's intensity. This large spread in the ensembles reduces the confidence that a weakening circulation is a robust feature of climate change. Furthermore, the similar magnitude of the spread in both ensembles shows that the Walker circulation response is strongly influenced by natural variability, even on a 70-year period.

In ongoing work we look into the subsidence regions related to the general tropical circulation. This allows us to remove from the analysis of circulation change the uncertainty related to the cloud and precipitation parametrizations of the GCM. Further, we will investigate aqua planets and realistic planets to quantify the fast response of the circulation to CO_2 increase, as well as the relative roles of the land-sea contrast and the CO_2-related change in radiative cooling, subsidence area and lapse rate.

References:

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