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Walker circulation in a transient climate

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The tropical overturning circulations modulate the heat exchange across the tropics and between the tropics and the poles. The anthropogenic influence on the climate system will affect these circulations, impacting the dynamics of the Earth system. In this work we focus on the Walker circulation. We investigate its temporal and spatial dynamical changes and their link to other climate features, such as surface and sea-surface temperature patterns, El-Niño Southern Oscillation (ENSO), and ocean heat-uptake, both at global and regional scale. In order to determine the impact of anthropogenic climate change on the tropical circulation, we analyze the outputs of 28 general circulation models (GCMs) from the CMIP5 project. We use the experiment with 1% year-1 increase in CO_2 concentration from pre-industrial levels to quadrupling of the concentration. Consistent with previous studies (ex. Ma and Xie 2013), we find that for this experiment most GCMs associate a weakening Walker circulation to a warming transient climate. Due to the role of the Walker Pacific cell in the meridional heat and moisture transport across the tropical Pacific and also the connection to ENSO, we find that a weakened Walker circulation correlates with more extreme El-Niño events, although without a change in their frequency. The spatial analysis of the Pacific Walker cell suggests an eastward displacement of the ascending branch, which is consistent with positive SST anomalies over the tropical Pacific and the link of the Pacific Walker cell to ENSO. Recent studies (ex. England et al. 2014) have linked a strengthened Walker circulation to stronger ocean heat uptake, especially in the western Pacific. The inter-model comparison of the correlation between Walker circulation intensity and ocean heat uptake does not convey a robust response for the investigated experiment. However, there is some evidence that a stronger weakening of the Walker circulation is linked to a higher transient climate response (temperature change by the time of CO_2 doubling), which in turn might be related to a decreased ocean heat uptake. This uncertainty across the models we attribute to the multitude of factors controlling ocean and atmosphere heat exchange, both at global and regional scales, as well as to the present capabilities of GCMs in simulating this exchange.

References:
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