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Decomposition of the general atmospheric circulation on a thermodynamic space

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The energetic imbalance due to the differential solar radiation and the oceanic heat transport drives the general atmospheric circulation that redistributes energy from warm regions to cold regions. This redistribution of energy is mainly through exchanges of latent heat (LH) and dry static energy (DSE). The hydrothermal stream function captures the air mass transport on the LH-DSE thermodynamic space to describe the atmospheric circulation in one single representation. For short time scales the hydrothermal stream function is characterised by a single cell describing the moist ascent of air in the tropics, the radiative cooling at midlatitudes and the surface warming and moistening processes following Clausis-Clapeyron relation. For longer time scales (yearly) the stream function splits into three different cells that describe the atmospheric circulation in the tropics, mid- and high-latitudes. These cells are closely linked to the Walker and Hadley cell in tropics, the Ferrell cell in the midlatitudes and the Polar cell at high latitudes. These results are also supported by a Lagrangian decomposition of the atmospheric circulation in the LH-DSE space. We have also analysed the effects of the anthropogenic climate change on these cells. The global atmospheric circulation becomes weaker and wider in the selected thermodynamic coordinates. The larger expansion and weakening is observed in the cell linked to the tropical regions where the mass transport is reduced by 5% per degree of warming. Both the midlatitude and high latitude cells have a weaker response in this scenario, both are shifted to higher DSE values but the mass transport varies very little. These streamfunctions have been computed from data from the Earth System Model EC-Earth. For the future climate change scenario the Representative Concentration Pathway (RCP) 8.5 was selected.