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Large scale atmospheric circulation patterns in DeepMIP simulations

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Paleoclimate models help us understand the complex influence of high CO_2 concentration and other boundary conditions on large scale atmospheric circulation patterns. Based on meridional heat transport analysis we investigate different phenomena, such as the Hadley cell, the monsoon and extratropical cyclones, in simulations from the Deep-Time Model Intercomparison Project (DeepMIP). For the analysis we compare preindustrial and early Eocene simulations at a range of CO_2 levels (1x, 3x and 6x preindustrial values), which are targeting the climate of the Early Eocene Climatic Optimum (EECO; 53-49 Ma).

Meridional heat transfer analysis shows asymmetric changes due to rising CO_2 concentrations in the northern and southern Hadley cells', which we investigate further. In the DeepMIP simulations, the global monsoon systems transport more latent heat from the subtropics to the higher latitudes, which shows a more intensive hydrological cycle than in present day climate. Though, the global area influenced by monsoons is smaller in the early Eocene than today due to the differences in paleogeography. Fossil pollen and isotopic records from the Paleocene-Eocene Thermal Maximum (PETM) from arid Central Asia show that rainfall temporarily doubled and that monsoon expanded into the continental interior during these extreme hyperthermal conditions. This is not well captured in the DeepMIP simulations and suggests that even more mechanisms strengthened the development of East Asian monsoon, such as orbital forcing and vegetation feedbacks, that should be considered in future simulations. At the midlatitudes, cyclones' climatology was also likely different in the Eocene, especially over Eurasia, which was more fragmented, and marginal seas influenced the cyclogenesis through land-sea thermal contrast. The analysis identifies the processes that are affected by the Eocene boundary conditions and that are sensitive to the CO_2 increase, which has high relevance to our future climate projections.