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Radiative impact of clouds and water vapor on shifts of the extratropical jet under global warming

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The extratropical jets guide storms, provide wind stress to the ocean circulation, and control patterns of cloudiness and humidity, because of which they are important characteristics of today's climate as well as the response to global warming. Climate model simulations consistently show that global warming will shift the extratropical jets poleward in the annual- and zonal-mean. Despite this qualitative consensus, however, quantitative projections of future jet shifts differ by several degrees latitude between climate models. Here, it is argued that part of this uncertainty results from uncertainty in the radiative response of clouds and water vapor to global warming. First, aquaplanet simulations of phase 5 of the Coupled Model Intercomparison Project (CMIP5) are analyzed to show that the model differences in the jet shift are correlated with model differences in the response of upper-troposphere lower-stratosphere (UTLS) temperatures, cloud ice, and water vapor. Second, to understand these correlations, simulations are conducted with two CMIP5 aquaplanet models, MPI-ESM and IPSL-CM5A, and with clouds and water vapor prescribed in the radiation scheme. It is found that clouds and water vapor both shift the jet and affect vertical and meridional UTLS temperature gradients. Consistent with previous studies, increased tropical water vapor contracts the jet towards the equator while increased extratropical water vapor shifts the jet towards the pole. Radiative changes of clouds lead to poleward jet shifts, with tropical, subtropical and extratropical clouds all contributing to the poleward jet shift. The jet shift from clouds and water vapor scales with changes in the meridional UTLS temperature gradient and vertical stability. Thus, in a third step a quasi-geostrophic model is used to quantify the relative roles of meridional gradients and vertical stability on the jet shift.