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Influence of Subtropical Jets on the Equatorial Spectrum: implications for future changes in Kelvin waves and MJO variance

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Projected changes of tropical Convectively Coupled Equatorial Waves (CCEWs) due to increased greenhouse gases, and the dynamical mechanism that forces those changes, are investigated in 13 state-of-the-art models from phase 6 of the Coupled Model Intercomparison Project (CMIP6). The equatorial wave spectrum in the historical simulation from most of these models quantitatively (and even quantitatively) resembles that observed, a remarkable improvement from CMIP5. Most models project a future increase in power spectra for the Madden-Julian Oscillation (MJO), while nearly all project a robust increase for Kelvin Waves (KW). In contrast, the power spectrum weakens for most other wavenumber-frequency combinations, including higher wavenumber Equatorial Rossby waves (ER). In addition to strengthening, KW also shift toward higher phase speeds (or equivalent depths). These changes are even more pronounced in models with smaller biases in their historical simulations.

The qualitatively different projected response of the different CCEWs (e.g., KW strengthening vs. ER weakening) suggest that dynamical forcings have an important role in the physical mechanism of the changes. This hypothesis is tested using targeted simulations of the Model of an Idealised Moist Atmosphere (MiMA) in which we impose perturbations in upper-troposphere zonal winds mimicking projected end-of-century changes in wind. These simulations demonstrate that future changes in KW and the MJO strongly depend on changes in the South Pacific subtropical jet. A similar dependence is also evident in the CMIP6 models. However, the winds in the south Pacific subtropical jets in the historical simulation of these CMIP6 models are highly biased, and models with a stronger change in the jet tend to project a stronger intensification of both the MJO and KW. It is therefore necessary to account for this bias in the subtropical winds in order to provide more reliable projections of the KW and the MJO.