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Altering climate variability patterns via modified wave-mean flow interactions

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Two important dynamical processes influence the extratropical zonal wind field: angular momentum transport by the thermally direct Hadley circulation (thermal driving T), and momentum flux convergence by atmospheric waves (eddies) that develop in regions of enhanced baroclinicity (eddy driving E). The relationship between extratropical zonal wind variability and these driving processes is investigated using ERA-40 reanalysis data. Indices representing the processes (iT, iE) are defined based on upward vertical velocities in the tropical midtroposphere and meridional convergence of the meridional flux of zonal momentum by eddies, respectively. Zonal wind signatures associated with these indices are identified via composite analysis. In the Atlantic sector, zonal wind variability is mainly associated with momentum flux convergence by baroclinic eddies, supporting the established view that the Atlantic jet is primarily eddy-driven. In the Pacific sector, zonal wind variability is associated with both driving processes, evidence that the Pacific jet is both thermally-driven and eddy-driven. The thermally-driven Pacific jet signature reflects changes in its strength (intensity and longitudinal extent) that resemble the zonal wind anomalies of the Pacific-North America (PNA) pattern. The eddy-driven signature reflects a latitudinal shift of the jet exit region in both sectors that resembles the zonal wind anomalies of the North Atlantic Oscillation (NAO) or West Pacific (WP) patterns. The leading patterns of climate variability in the North Atlantic and Pacific are consistently associated with particular wave-mean flow interactions and also with preferred distributions of variability in the full three-dimensional zonal wind field. The atmospheric circulation in the Southern Hemisphere is likewise affected by the seasonality of the same processes. The above associations are consistently altered in simulations of past and future climates, implying that human-induced climate change may modify the leading patterns of extratropical atmospheric variability in predictable ways.