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Detection and Attribution of the Weakening of Global Angular Momentum

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The slowing down of the circulation in a warming climate due to anthropogenic forcings is still not understood. How internal variability and anthropogenic forced response in climate models influence the weakening of global angular momentum is still unclear. Here in this study, we utilise a 100-member ensemble simulation (CESM2-LENS) to detect and attribute the causes of the slowing down of atmospheric circulation. We observe a progressive decrease in angular momentum, projected to continue until 2100. The rate of weakening is observed to accelerate within the 1980~2020 period closely resembling the Atlantic Multidecadal Oscillation (AMO) and Pacific Decadal Oscillation (PDO) shift, with the entering of the positive phase of AMO and the negative phase of the PDO during the end of the 20th Century. Using, multivariate linear regression analysis, we provide the combined role of AMO, PDO, and GMST (a proxy for climate change signal) in influencing the angular momentum changes during the 20th and 21st centuries. Further, we use a statistical-based approach applied to the ensemble simulations to extract the indirect response (internal variability) and provide the linkage of the AMO and PDO shift in contributing to the weakening rate. We annotate that the shift in the AMO and PDO phases in the mid-1990s weakened the upper-level westerlies over the Northern Atlantic Pacific region and accelerated the weakening of the Hadley Cell circulation. This was due to internal variability contributing to the global angular momentum balance change. Our results elucidate the potential role of the climate system's internal variability and anthropogenic forcings in modulating the distribution of the global angular momentum.

Keywords: Angular momentum; Atmospheric Circulation; Anthropogenic Forced Response; Atlantic Multidecadal Oscillation (AMO); Pacific Decadal Oscillation (PDO); Hadley Cell; Atlantic-Pacific walker cell