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A daily estimate of phase speed to explore the link between Arctic Amplification and Rossby waves

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Rossby wave activity is intimately related to the day-to-day weather evolution over midlatitudes and to the occurrence of extreme events. Global warming trends may also affect their characteristics: for example, it has been hypothesized that Arctic warming with respect to midlatitudes, known as Arctic Amplification, may lead to a reduction in the speed of Rossby waves, to more frequent atmospheric blocking and to extreme temperature events over midlatitudes. Testing this hypothesis requires an estimate of the evolution and of the variability of phase speed in recent decades and in climate model simulations. However, measuring the phase speed of the global Rossby wave pattern is a complex task, as the midlatitude flow consists of a superposition of waves of different nature (e.g., planetary vs synoptic) across a broad range of wavenumbers and frequencies.

We propose here a framework, based on spectral analysis, to understand the variability of Rossby wave characteristics in reanalysis and their possible future changes. A novel, daily climatology of wave spectra based on gridded upper-level wind data is employed to study the evolution of Rossby wave phase speed over the Northern Hemisphere between March 1979 and November 2018. A global estimate of phase speed is obtained by doing a weighted average of the phase speed of each wave, with the associated spectral coefficients as weights.

Several insights about the drivers of phase speed variability at different time scales and their link with extreme temperature events can be gained from this diagnostic. 1) The occurrence of low phase speeds over Northern Hemisphere midlatitudes is related to a poleward displacement of blocking frequency maxima; conversely, the occurrence of high phase speed is related to blocking occurring at lower latitudes than usual. 2) Periods of low phase speed are associated with the occurrence of anomalous temperatures over Northern Hemisphere midlatitudes in winter, while this linkage is weaker during boreal summer. 3) No significant trend in phase speed has been observed during recent decades, despite the presence of Arctic Amplification. The absence of trend in phase speed is consistent with the evolution of the meridional geopotential gradient during recent decades. On the other hand, the high temporal resolution of the phase speed metric highlights the intraseasonal and interannual variability of Rossby wave propagation and points to 2009/10 as an extreme winter characterized by particularly low phase speed.