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Standing wave contributions to the linear interference effect in stratosphere-troposphere coupling

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A body of literature by Hayashi and others [Hayashi 1973, 1977, 1979; Pratt, 1976] developed a decomposition of the wavenumber-frequency spectrum into standing and travelling waves. These techniques directly decompose the power spectrum—that is, the amplitudes squared—into standing and travelling parts. This, incorrectly, does not allow for a term representing the covariance between these waves. We propose a simple decomposition based on the 2D Fourier transform which allows one to directly compute the variance of the standing and travelling waves, as well as the covariance between them. Applying this decomposition to geopotential height anomalies in the Northern Hemisphere winter, we show the dominance of standing waves for planetary wavenumbers 1 through 3, especially in the stratosphere, and that wave-1 anomalies have a significant westward travelling component in the high-latitude (60N to 80N) troposphere.

Variations in the relative zonal phasing between a wave anomaly and the background climatological wave pattern—the "linear interference" effect—are known to explain a large part of the planetary wave driving of the polar stratosphere in both hemispheres. While the linear interference effect is robust across observations, models of varying degrees of complexity, and in response to various types of perturbations, it is not well understood dynamically. We use the above-described decomposition into standing and travelling waves to investigate the drivers of linear interference. We find that the linear part of the wave activity flux is primarily driven by the standing waves, at all vertical levels. This can be understood by noting that the longitudinal positions of the antinodes of the standing waves are typically close to being aligned with the maximum and minimum of the background climatology. We discuss implications for predictability of wave activity flux, and hence polar vortex strength variability.