Diagnosing jet waveguidability in the presence of large-amplitude eddies

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The waveguidability of an upper tropospheric zonal jet quantifies its propensity to duct Rossby waves in the zonal direction. This property has played a central role in previous attempts to explain large wave amplitudes and the subsequent occurrence of extreme weather. In these studies, waveguidability was diagnosed with the help of the refractive index using the zonal average of the observed flow as the relevant background state. Here, it is argued that this method is problematic both conceptually and mathematically.

The issue is investigated in the framework of the non-divergent barotropic model. This model allows the straightforward computation of an alternative "zonalized" background state, which is obtained through conservative symmetrisation of potential vorticity contours and which is argued to be superior to the zonal average. Using an idealized prototypical flow configuration with large-amplitude eddies, it is shown that the two different choices for the background state yield very different results; in particular, the zonal-mean background state diagnoses a zonal waveguide, while the zonalized background state does not. This result suggests that the existence of a waveguide in the zonal mean background state is a consequence of, rather than a precondition for large wave amplitudes, and it would mean that the direction of causality is opposite to the usual argument.

The analysis is applied to two heatwave episodes from summer 2003 and 2010, yielding essentially the same result. It is concluded that previous arguments about the role of waveguidability for extreme weather need to be carefully re-evaluated to prevent misinterpretation in the future.