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Waveguidability of idealized midlatitude jets and the limitations of ray tracing theory

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Ray paths of stationary Rossby waves emanating from a local mid-latitude source are usually refracted equatorward. However, this general tendency for equatorward propagation is mitigated by the presence of a midlatitude jet which acts as a zonal waveguide. This opens the possibility for circum-global teleconnections and quasi-resonance, which suggests that the ability of a jet to guide a wave in the zonal direction is an important property.

This paper investigates waveguidability of idealized midlatitude jets in a barotropic model on the sphere. A forced-dissipative model configuration with a local source for Rossby waves is used in order to quantify waveguidability by diagnosing the latitudinal distribution of waviness in a longitudinal sector far downstream of the forcing. Systematic sensitivity experiments show that waveguidability increases smoothly with increasing jet amplitude and with decreasing jet width. This result is contrasted with the predictions from two idealized theoretical concepts based (1) on ray tracing as derived from WKB theory and (2) on a sharp jet with a zonally oriented front of potential vorticity. The existence of two so-called turning latitudes, which is the key diagnostic for a zonal waveguide according to ray tracing theory, turns out to be a poor predictor for the dependence of waveguidability on jet amplitude and jet width obtained in the numerical simulations. By contrast, the meridional gradient of potential vorticity correlates fairly well with the diagnosed waveguidability. The poor prediction from ray tracing is not surprising, because the underlying WKB assumptions are not satisfied in the current context.