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Do smooth non-viscous atmospheric normal modes exist?

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Smooth normal modes are considered as the building blocks of linear atmospheric and oceanic dynamics. Nevertheless, eigenvalue problems of non-viscous atmospheric and oceanic flows are frequently of mixed type, hyperbolic for lower latitudes and elliptic for higher latitudes. Such eigenvalue problems are mathematically ill-posed and the existence of smooth solutions is questionable.

We will solve simplified and general mixed type boundary value problems of geophysical flows by standard finite difference methods to discuss typical features and shortcomings of such numerical solutions. It appears that the numerical solutions always possess discrete eigenvalue spectra even though discrete spectra do not exist for all hyperbolic or mixed type boundary value problems. Moreover, due to low resolution, the existence of singularities like internal boundary layers can easily be overlooked when numerical solutions are studied.