Ishizaki, H., K. Okazaki, T. Sakazaki, and K. Ishioka, 2025: Eigenvalue analysis of atmospheric free oscillations under the influence of a zonal mean field. *J. Meteor. Soc. Japan*, **103**, http://doi.org/10.2151/jmsj.2025-021.

Plain Language Summary: Theoretical Solutions for atmospheric free oscillations are given in the classical tidal theory, where a stationary atmosphere is assumed. In this study, a linear eigenvalue analysis of zonal mean fields of zonal wind and temperature using the primitive equations is performed and the effects of the background fields on the free oscillations are investigated. The eigenfrequencies and vertical structures of eigenmodes obtained by the eigenvalue analysis are qualitatively consistent with those of corresponding eigenmodes detected from reanalysis data by a recent study.

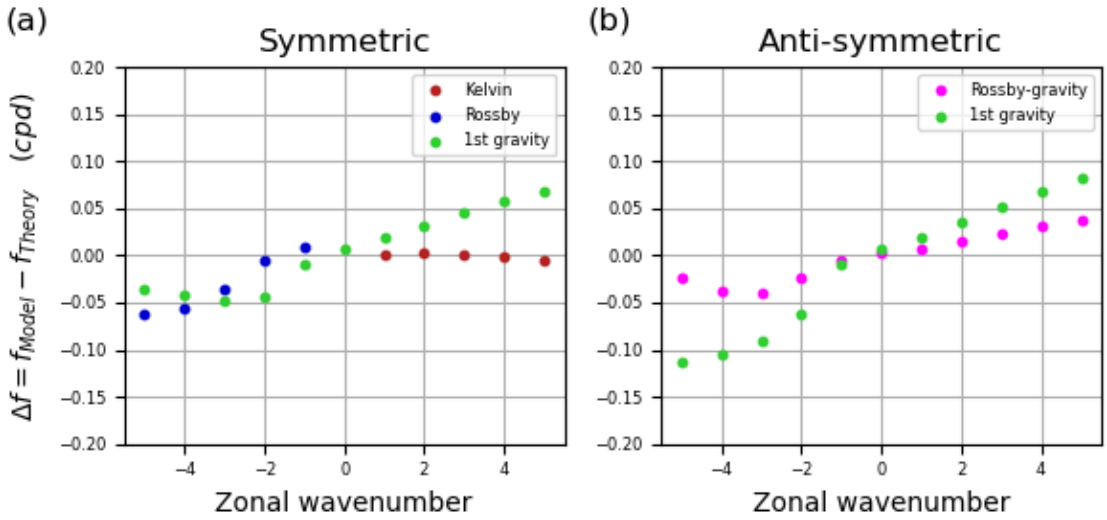

Figure 1. Deviations (Δf: vertical axis) between the eigenfrequencies obtained from the eigenvalue analysis for the zonal mean zonal wind and the zonal mean temperature field (f_{Model}) and those obtained from the Laplace tidal equation at the equivalent depth of 10 km (f_{Theory}). The horizontal axis is the zonal wavenumber, with positive values indicating eastward modes and negative values westward modes. (a): for equatorially symmetric modes (Kelvin mode, 1st gravity mode, and the gravest Rossby mode). (b): for equatorially antisymmetric modes (Rossby-gravity mode and 1st gravity mode). The color legend is shown in the figure.

- The Doppler shift by the zonal wind is the dominant effect of the background field on the eigenfrequencies of free oscillation modes, but for the gravest Rossby mode of zonal wavenumber 1, the phase speed is faster than the theoretical solution because the effect of latitudinal gradient of temperature field exceeds that of zonal wind.
- For the Rossby and westward Rossby-gravity modes with large zonal wavenumbers, the vertical phases are tilted to the west with decreasing pressure, which is demonstrated due to the effect of climatological easterly wind in the equatorial stratosphere using the corresponding dispersion relations on the equatorial β-plane.