The catalytic effect of near-inertial waves on β-plane zonal jets

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Zonal jets and inertia-gravity waves are ubiquitous on planets such as Earth, Jupiter and Saturn. Motivated by the modification of energy flux of balanced flow by inertia-gravity waves, this paper studies the impact of near-inertial waves (NIWs) on zonal jets on a β-plane. Using a two-dimensional quasi-geostrophic and NIW coupled system on a β-plane[1], we find NIWs catalytically impact several features of zonal jets. NIWs inhibit jet formation due to the wave's catalytic induction of downscale mean energy flux, which is shown in Figure 1. As the strength of NIW increases, a critical point exists beyond which zonal jets are annihilated. The jet spacing is captured by the Rhines scale $L \sim \sqrt{U/\beta}$ with U estimated from the upscale energy flux induced by the mean flow alone, which again shows that the NIWs' impact is catalytic. Also, the temporal asymmetry of NIWs leads to the spatial asymmetry of jet dynamics. The jet profiles are asymmetric with a stronger shear on the left flank. And similar to the left turning of vortex dipole under the impact of NIWs, the NIW-modified jets migrate poleward. NIW also shows a catalytic role in jet migration: the net momentum flux directly induced by NIW is of secondary importance in the zonal mean momentum dynamics and impedes jet migration, while the advective effect of NIW-modified mean flow dominates the jet migration velocity.

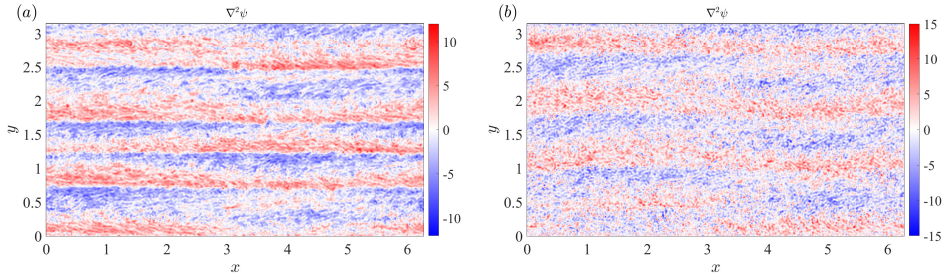

Figure 1: Snapshots of mean vorticity fields, $\nabla^2\psi$, at statistically steady states with fixed mean energy injection rate but different NIW energy injection rates. In the panel (b) there is a stranger NIW energy injection than that in the panel (a).

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[1]Xie and Vanneste, *J. Fluid Mech.* **774**, 143–169 (2015).