Turbulence generated by an isolated topography in stratified rotating flows

Jinyuan Liu[a,*], Pranav Puthan[a], Sutanu Sarkar[a,b,†]
[a] *University of California San Diego, La Jolla, CA*
[b] *Scripps Institution of Oceanography, La Jolla, CA*

Kármán wakes are frequently observed behind islands in satellite images. This phenomenon akin to two-dimensional bluff-body wakes is a result of strong stratification. With the presence of rotation, the vortex dynamics are further enriched and various types of instabilities are possible.

In order to quantify turbulence, identify the mechanisms responsible for its generation as well as its dependence on stratification and rotation, a series of large-eddy simulations are conducted. The vertical Froude number, $Fr = U/Nh$, varies from 0.075 to 0.40, where U is the freestream velocity, N is the buoyancy frequency, and h is the height of the submerged conical obstacle. For each Fr, three different Rossby numbers ($Ro = U/f_c D$, where f_c is the Coriolis frequency and D is the base diameter) are used, representative of mesoscale and submesoscale dynamics. For all simulations, the buoyancy-scale based Reynolds number, $Re_N = U^2/\nu N = Re_D Fr(h/D)$, is kept constant at 900, resulting in a range of $Re_D = UD/\nu$ from 7500 to 40000. It is found that, in the near wake where turbulence and its dissipation are strong, both vertical shear instability and centrifugal instability are active, indicated by unstable gradient Richardson number and unstable horizontal component of potential vorticity, respectively. Implications for the variability of turbulent dissipation rate will be discussed.

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*jinyuanliu@ucsd.edu, presenter
†ssarkar@ucsd.edu