# Stratified wakes past an isolated topography

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Physical understanding and numerical modelling of turbulent wakes in the natural environment are crucial to ocean and atmospheric sciences. Stratified, rotating wakes past topography have distinct characteristics that are not presented in their unstratified, non-rotating counterparts.

In this study, large-eddy simulations (LES) are conducted for flow past an idealized conical object with base diameter $D$ and height $h$, sitting on a flat bottom. The non-dimensional parameters controlling the dynamics are as follows: the Froude number ($Fr = U_\infty/Nh$), the Rossby number ($Ro = U_\infty/f_c D$), and the Reynolds number ($Re = U_\infty D/\nu$). Here $U_\infty$ is the freestream velocity, $N$ is the buoyancy frequency, $f_c$ is the Coriolis frequency, and $\nu$ is the kinematic viscosity. The Reynolds number is fixed at $Re = 10\,000$ such that the wakes are turbulent, and a wide range of parameters in the $(Fr, Ro)$ space is explored.

With moderately strong stratification ($Fr = O(0.1)$), the imposed potential barrier forces the flow to past the obstacle at both sides, and a Kármán wake vortex pattern is formed in all cases in the examined range of $0.05 < Fr < 0.3$. However, as stratification strengthens ($Fr$ decreases), turbulence with vertical overturning motions is inhibited at the fixed $Re = 10\,000$. Stronger stratification also reduces the vertical length scale $U_\infty/N$. The vortex shedding structures that are found to be vertically coherent as a global mode at $Fr = 0.15$ can no longer maintain their interconnection over the entire height of the obstacle at $Fr = 0.05$.

When $Ro = O(1)$, system rotation introduces an asymmetry between wake vortices that spin in the same direction as rotation (cyclones) and spin in the opposite direction (anticyclones). For example, at the same magnitude of rotation rate, anticyclones could lose stability in the near wake and enhance turbulence production and dissipation. Anticyclonic instabilities are diagnosed in various ways. For the $Fr = 0.15$ cases in particular, a novel approach to extract vortex centers in horizontal planes based on the mean shift algorithm is applied. The ensuing large ensemble of vortices are tracked and characterized in terms of their stability characteristics. The evolution of turbulent stresses as well as dissipation rate is also characterized.

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