Master OFFWIND

Coastal Dynamics

Problem: Ekman Layer and Upwelling

Consider a homogeneous, incompressible ocean with density $\rho = 1025\,\mathrm{kg/m^3}$. A steady wind blows over the surface in the x-direction, producing a surface stress of $\tau_0 = 0.1$ Pa. The water depth is large enough to assume a semi-infinite ocean. The Coriolis parameter at the location is $f = 10^{-4}\ \mathrm{s^{-1}}$, and the eddy viscosity in the ocean is $\nu = 10^{-2}\ \mathrm{m^2/s}$.

1. Assuming steady, linear flow, write the equations governing the horizontal velocities $u(z)$ and $v(z)$ in the Ekman layer.
2. Compute the Ekman layer depth δ_E.
3. Find the direction of the net transport in the Ekman layer relative to the wind direction.
4. Estimate the vertical velocity (Ekman pumping) at the base of the Ekman layer if the wind stress varies spatially as $\tau_x(y) = \tau_0 \cos\left(\frac{\pi y}{L}\right), \quad \tau_y = 0$ with $L = 100$ km.

Problem : Tea Leaves

It is observed that fragments of tea leaves at the bottom of a stirred tea cup conglomerate toward the center. Explain this phenomenon with Ekman-layer dynamics. Also explain why the tea leaves go to the center irrespectively of the direction of stirring (clockwise or counterclockwise).