Mid-term Exam

Geophysical Fluid Dynamics I, Spring 2022

Problem 1 (40 pts)
As shown in Figure 1, a vertically uniform but laterally sheared coastal current must climb a bottom escarpment. Assuming that the jet velocity still vanishes offshore, determine the velocity profile and the width of the jet downstream of the escarpment using h_1 =200m, h_2 =160m, U_1 =0.5m/s (maximum velocity in the area with depth h_1), L_1 =10km and f =10^{-4} s^{-1}. (that is, you should obtain U_2 and L_2, and plot the velocity profile). What would happen if the downstream depth were only 100m?

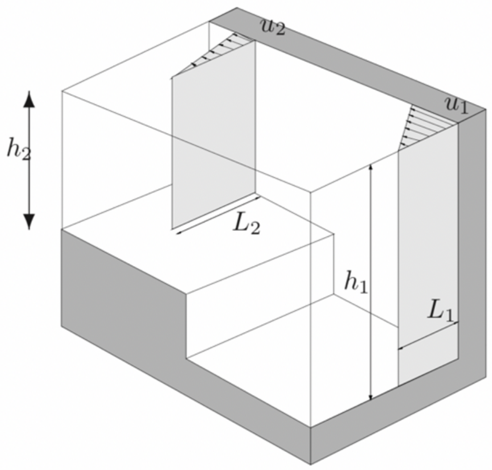

Figure 1: A sheared coastal jet negotiating a bottom escarpment.

Problem 2 (30 pts)
The atmospheric jet stream is a wandering zonal flow of the upper troposphere, which plays a central role in mid-latitude weather. If we ignore the variations in air density, we can model the average jet stream as a purely zonal flow, independent of height and varying meridionally according to

$$\bar{u}(y) = Ue^{\frac{-y^2}{2L^2}}$$

in which the constants U and L, characteristics of the speed and width, are taken as 40 m/s and 570 km, respectively. The jet center (y = 0) is at 45°N where $\beta_0 = 1.61 \times 10^{-11}$ $m^{-1}s^{-1}$. Is the jet stream unstable to zonally propagating waves?

Problem 3 (30 pts)
Read the following literature for barotropic Rossby waves, 1) summarize the wave properties obtained in this study, 2) explain why these waves can be considered as Rossby waves, and 3) discuss the similarities and differences between these waves and the Rossby waves mentioned in our class.

J. Thomas Farrar, 2020. Barotropic Rossby Waves Radiating from Tropical Instability Waves in the Pacific Ocean. Journal of Physical Oceanography, 41(6), 1160–1181.