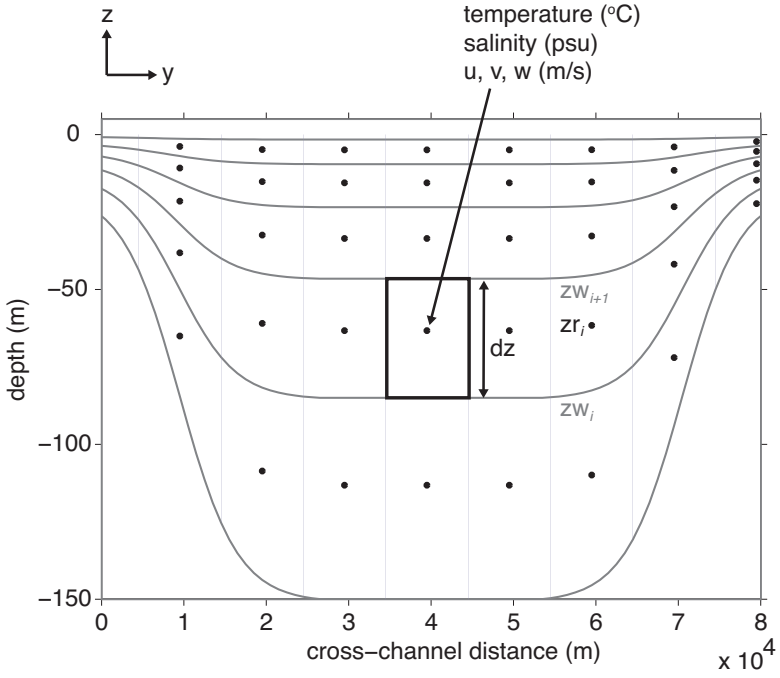
PO Final homework

Consider an infinitely long channel with a stable temperature stratification in the northern hemisphere. The channel geometry is shown as the figure on the right. (x,y,z) denotes (along-channel, cross-channel, vertical) direction. At t = 0, along-channel wind stress of 0.1 Pa (i.e. τx = -0.1 Pa, pointing into the page) is applied to the water surface. The associated Ekman transport then leads to upwelling and downwelling at the sides of the channel.



We have set up such a case and used a 3D numerical model to solve for the velocity and temperature fields (see upwelling.mat). The black dots (just show a few here) are the location where temperature and velocity are recorded (run course_data_mat.m to see how to plot T, u,v distributions). For example, in upwelling.mat, the dimension of the along-channel velocity u = (21, 16, 82). This means, it has 21 time points, 16 vertical levels, and 82 points across the channel. Note that this is sigma coordinate in the vertical.

Questions

(1) Use the linear equation of state (see course_data_mat.m) to compute the density and plot the density distribution. Identify upwelling and downwelling regions.

(2) Use thermal wind relation to infer along-channel geostrophic flow u_g and compare your result with the model output u. Away from the boundary layers, you should find u_g to be consistent with u.

(hint: you need to compute $d\rho/dy$ to get the thermal wind shear. You then have to choose a reference level to do the vertical integration to obtain $u_g(z)$. For example, you can use u(t,1,:) at zr(t,1,:) as the reference level (i.e. the bottom velocity that the model gives you).

(3) Pick a point near the domain center. Plot the vertical structure of ageostrophic velocity (u-ug, v). You should see the Ekman spiral.

You can then compare (u-ug,v) against the analytical solution of Ekman spiral (Homework # 4). Comment on what you find.

data needed for PO HW:

upwelling.mat

course_data_mat.m - descriptions of variable names
- example to plot temp, salt, u, v
- info about linear equation of state