Wind-Driven Upwelling/Downwelling over a Periodic Channel Test Case

1 Physical & Computational domains

- The physical domain size is $L_x = 20$ km in the east-west direction and $L_y = 80$ km in the north-south direction.
- The number of grid points for the computational domain is $(n_x, n_y, n_z) = (16, 64, 16)$; the grid resolution in the horizontal is

$$(\Delta x, \Delta y) = (L_x/n_x, L_y/n_y) = (1.25, 1.25)\ \mathrm{km}$$

- In the vertical the grid is stretched with a resolution of 1.6 m for the top-most grid box and 46 m for the bottom-most grid box. The vertical grid for at rest (i.e. for a zero free-surface) and for a total depth of $D_{\max} = 150$ m is

level	z	Δz
16	0.000	
15	-1.621	1.621
14	-3.263	1.642
13	-4.948	1.685
12	-6.711	1.763
11	-8.598	1.887
10	-10.681	2.083
9	-13.070	2.389
8	-15.935	2.865
7	-19.537	3.602
6	-24.283	4.746
5	-30.799	6.516
4	-40.059	9.26
3	-53.566	13.507
2	-73.655	20.055
1	-103.935	30.28
0	-150.000	46.065

- Bathymetry definition for $x \in [0, L_x]$ and $y \in [0, L_y]$:

$$h(x, y) = \min\{D_{\max}, 84.5 + 66.526\tanh(0.00015(f(y) - 0.125L_y))\}$$

with $D_{\max} = 150$ m and $f(y) = y$ for $y \le L_y/2$ and $f(y) = L_y - y + \Delta y$ otherwise.

2 Boundary conditions

- East-west periodic

- North-South closed (no-slip or free-slip conditions)
- Linear bottom drag
$$K_m \partial_z \mathbf{u}_h|_{z=-h} = r_D \mathbf{u}_h(z = z_{\text{bot}})$$
with $r_D = 3 \times 10^{-4}$ m s^{-1} and $\mathbf{u}_h(z = z_{\text{bot}})$ the velocity in the bottom-most grid box.
- Surface wind-stress
$$K_m \partial_z \mathbf{u}_h|_{z=\eta} = \frac{\boldsymbol{\tau}}{\rho_0}$$
with $\boldsymbol{\tau} = (\tau_x, 0)$ and
$$\tau_x = \begin{cases} -0.1 \sin\left(\frac{\pi}{4} t_{\text{days}}\right), & \text{for } t_{\text{days}} \leq 2 \text{ days} \\ -0.1, & \text{for } t_{\text{days}} > 2 \text{ days} \end{cases}$$
with t_{days} the time in days since the beginning of the simulation.
- No surface heat flux

3 Physical & computational parameters

- f-plane approximation: $f(x, y) = -8.26 \times 10^{-5}$ s^{-1}
- Linear equation of state
$$\rho(x, y, z) = \rho_0 \left(1 - \beta(T(x, y, z) - T_0)\right)$$
with $\rho_0 = 1027$ kg m^3, $\beta = 0.28\ ^0C^{-1}$, and $T_0 = 14\ ^0C$.
- Vertical eddy-viscosity (K_m) and eddy-diffusivity (K_s):
$$K_m = 0.002 + 0.008 \exp\left(\frac{(z - \eta)}{D_{\text{max}}}\right), \qquad K_t = 10^{-6} \text{m}^2 \text{ s}^{-1}$$
- Total integration time: 5 days.
- FYI: for Croco we have a baroclinic time-step of $\Delta t_{3d} = 960$ sec and a barotropic time-step of $\Delta t_{2d} = 20$ sec

4 Initialization

- Initial conditions:
$$u(x, y, z) = v(x, y, z) = 0 \text{ m s}^{-1}, \qquad \eta(x, y) = 0 \text{ m}$$
and for temperature ($z \in [-h, 0]$):
$$T(x, y, z) = T_0 + 4 \tanh\left(\frac{(z - z_0)}{\text{hz}}\right) + \frac{(z - z_1)}{\text{strat}}$$
with $z_0 = -35$ m, hz $= 6.5$m, $z_1 = -75$ m, and strat $= 150$ m C^{-1}.