Dynamics 2 | Exercise 7, Summer semester 2014
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Exercise 7

June 30, 2014

The aim of this exercise is to understand the propegation of shallow water waves and examine deep ocean circulation.

There is a R program to calculate both 1D and 2D waves.

1. For both 1D and 2D waves:
   - Run the program: Which type of waves do you see?
   - Change the constants of water depth H, gravity g, describe your observations!
   - Can you roughly estimate the phase speed of the waves?
2. Consider a geostrophic flow (u, v)
$$-fv = -\frac{1}{\rho_0}\frac{\partial p}{\partial x} fu = -\frac{1}{\rho_0}\frac{\partial p}{\partial y} \tag{1}$$
with pressure $p(x, y, z, t)$.
Use the hydrostatic approximation
$$\frac{\partial p}{\partial z} = -g\rho \tag{2}$$
and equation (1) in order to derive the meridional overturning stream function $\Phi(y, z)$ as a fuction of density ρ at the basin boundaries! Φ is defined via
$$\Phi(y, z) = \int_0^z \frac{\partial \Phi}{\partial \tilde{z}}\, d\tilde{z} \tag{3}$$
$$\frac{\partial \Phi}{\partial \tilde{z}} = \int_{x_e}^{x_w} v(x, y, \tilde{z})\, dx \quad \text{(zonally integrated transport)}, \tag{4}$$
where x_e and x_w are the eastward and westward boundaries in the ocean basin (think e.g. of the Atlantic Ocean). Units of Φ are $m^3 s^{-1}$. At the surface $\Phi(y, 0) = 0$.
3. It is observed that water sinks in to the deep ocean in polar regions of the atlantic basin at a rate of 15 Sv.
   - How long would it take to 'fill up' the Atlantic basin? (Assume $10^{14} m^2$ and $5km$ depth)
   - Supposing that the local sinking is balanced by large-scale upwelling, estimate the strength of this upwelling. Express your answer in $m\ y^{-1}$.

Notes on submission form of the exercises: *Two students work together in one group. Each group has to submit only one solution. The answers to the questions shall be send to paul.gierz@awi.de.*