Laboration 3B:
Zonal mean flow and β-plane

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Aim

The aim of this assignment is to study and understand waves that are generated when $f(y)$ is sloping planes of the form $f = f_0 + \beta y$. The effect of introducing a zonal mean flow will also be discussed. For this assignment you should use a model with periodic and open (sponge) boundary conditions. The initial disturbance should be in geostrophic balance to avoid gravity waves.

Experiments and model setup

Model setup

- Use an initial disturbance in geostrophic balance. (Tip: when you define h, you also need to program u and v, so that they are in geostrophic balance.)
- Use periodic boundaries in x (East - West).
- Use open boundaries (Sponge) in y (South - North).
- Introduce a zonal mean flow U_0 in the system using LOGICAL (or CASE) so that you can chose to have it on or off in the simulation.
- Program a new Coriolis parameter describing $f = f_0 + \beta y$. In the same sense, use LOGICAL (or CASE) so that you can chose to turn it on or off.

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Experiment 1 - β plane

- Consider a rectangular basin with $L = 7 \cdot 10^6$ m, and $H = 4000$ m in the mid latitudes. Run the model for at least 30 days.
- Start by deriving the phase speed and group velocity for Rossby waves in this linear system. (The derivation should not be included in the report, only the final solution).
- Run the model with a β-plane and without a mean flow ($U_0 = 0$ m/s).
- Describe and explain the evolution of the system.
- Connect the results to theory.
- What kind of waves develop?
- Do they have any distinguishing properties?

Experiment 2 - Phase and group velocities

- Run the model as in Experiment 1, but with different wavenumbers. (Tip: To change wavenumber, change disturbance width).
- Compare the obtained phase speed and group velocity to the theoretical values.

Experiment 3 -The effect of the zonal mean

- Increase the zonal length of the domain to $L_x = 28 \cdot 10^6$ m (Keep the same Δx as in the previous experiments).
- Run the model using a β plane and four different zonal mean flows (choose a zonal flow that lies in the range $0 < U_0 \leq 15$ m/s). Calculate the group velocity for each case.
- Using the results from the previous question, try to find the value at which the Rossby wave becomes stationary. Is the initial condition preserved? If not, explain why.

Good luck!