Assignment 1 for GEOL 1820: Geophysical Fluid Dynamics, Waves and Mean Flows Edition Due Sept. 23, 2016

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Contacts

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Getting Help!

I am usually available by email. You can make an appointment other times. Just check my calendar at http://fox-kemper.com/contact and suggest a time that works for you.

1 Problem 1

Revisit the derivations of mass conservation in flux form (Bühler, 2014, Section 1.1.1) and material derivative form (Bühler, 2014, Section 1.1.4 equation (1.15)).

1.1 Flux Form

Derive a flux form differential equation for the conservation of salt, expressed in terms of salinity (a mass fraction of seawater density, e.g., in grams per kilogram), assuming that the only way that salt moves is by fluid advection and that no chemical reactions create or destroy salt. Do not assume that the fluid is incompressible.

1.2 Material Derivative Form

Derive a material derivative form equation for the conservation of salt working from Section 1.1.4 equation (1.15), again expressed in terms of salinity (a mass fraction of seawater density, e.g., in grams per kilogram), assuming that the only way that salt moves is by fluid advection and that no chemical reactions create or destroy salt.

1.3 Diffusion

Salt may also move through water by diffusion (i.e., molecular transport down any large-scale gradients), which does not require advection. Does this affect your salt budget equations? Why do you think diffusion of fluid mass is generally ignored?

2 Problem 2: Shallow water waves with rotation

Problem 1 in section 2.3 of (Bühler, 2014).

3 Problem 3: Adiabatic invariance vs. the pit and the pendulum

Problem 3 in section 2.3 of (Bühler, 2014).

4 Problem 4: Baroclinic Vorticity

Consider (1.45) of section 1.4.2 of (Bühler, 2014). Draw three pictures of isolines of pressure and density each of which has uniform gradient (although possibly in different directions): 1) one that does not produce vorticity, 2) one that produces clockwise vorticity, and 3) one that produces counter-clockwise vorticity. It is easiest to assume that the pressure isolines (isobars) are nearly horizontal.

5 Problem 5: Polar PV

Consider (1.51) of section 1.5 of (Bühler, 2014). Suppose a fluid parcel is rotating together with the earth at the North Pole (f=$2 \cdot 2\pi/24$ hours, $\mathbf{u} = 0$), and that the local entropy, s, increases upward. Relocate this parcel, conserving its entropy, density, and potential vorticity to the South Pole (f=$-2 \cdot 2\pi/24$ hours), where again we assume that entropy increases upward (based on the local vertical), with the same gradient magnitude as at the North Pole. Describe the parcel's rotation relative to the earth.

6 Not required

Problem 2 of section 2.3 is interesting, if you are familiar with the calculus of variations and Hamiltonian methods.

References

Bühler, Oliver 2014 *Waves and mean flows*, 2nd edn. Cambridge, United Kingdom: Cambridge University Press.