12.843: Large-scale atmosphere and ocean dynamics

(15 units, 3,6,6)

This will be a project-based course with 4 projects during the semester. Each project will comprise a numerical part to illuminate and illustrate the theory, and a data part (drawn from laboratory tank experiments, atmospheric, or ocean observations) to illustrate the phenomena. The major topics are: barotropic vorticity dynamics including inversion and evolution, geostrophic and higher order balance, baroclinic dynamics and the evolution of balanced flows, and stability emphasizing mutual interaction of disturbances. We will expect a writeup on each of the projects covering both the numerical and geophysical parts plus additional derivations as needed.

We have four project topics; each will involve a numerical lab and a physical lab drawn from atmospheric data, ocean data, or a tank experiment. If we have ≤ 3 students, we will pick one of the physical labs; with more students, we will run several topics simultaneously. We will expect a writeup on each of the projects covering both parts plus some additional derivations to help ensure the students know the theory involved in the labs. Derivations will be fairly guided. Students will also give short presentations of the lab work.

http://eddies.mit.edu/∼glenn/12.843

Topics

1. Barotropic vorticity equation: PV waves

- Atmospheric stationary waves
- Rossby waves in altimetry
- Rossby waves in the tank
- Numerics: RW propagation, nonlinear interaction, stability? Or perhaps waves on PV gradients of different sharpness?
- Lectures: vorticity eqn., btve on sphere, rossby waves on sphere and β-plane, RW on front, BT instability

2. Geostrophic and gradient wind balance

- Numerics: balance in 2 layer SW equation
- Hurricane, jet entrance (geostrophic and ageosthrophic flow)
- Gulf Stream geostrophy
- Cylinder collapse (thermal wind in tank)
- Lectures: stratification, Ertel, geostrophy, hydrostatic, adjustment, QG, vortices in QG and SW

3. Baroclinic dynamics: evolution of balanced flow

- Numerics: frontal evolution, BT, BC
- Tropopause wave evolution compared to frontal & RW
- Gulf Stream waves compared
- Tank experiment on shear instability
- Lectures: waves on BC front, β-plane, and sphere, Eady edge waves, vortices, β-drift, frontogenesis

4. Stability: mutual interaction of baroclinic disturbances

- Analysis of 3D inverted flow
- Upper and deep PV contours in Brazil current
- Phase shifts in tank baroclinic inst.
- Numerics: BCI in the channel
- Lectures: stability theorems, counter-propagating waves, baroclinic and mixed inst., equilibration, secondary inst., turbulence

Staff

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