Homework 7

due Oct. 28, 2015

[50 pts.]

Name: ______________________________

Estimate of Time Spent: ____________________ Actual Time Spent: ____________________

Overview

For this assignment and the following assignment, you will each design and run model simulations with the *non-divergent barotropic vorticity equation on the sphere*. Specifically, you will be looking at the propagation of Rossby waves.

The full project will be split across two one-week assignments.

- The first assignment (this one, HW 7) will require that you read the necessary documentation, get the model setup, and demonstrate that you can access the data.
- The second assignment (next one, HW 8) will have you design a model experiment, run the necessary simulations, and then write-up a thorough, professional report on your findings. You will be allowed to change *whatever you want* within the model to test how it modifies the propagation of Rossby waves. You will then present your results to the class in a short (~ 5 minute) presentation.

The Model

The model you will run is a component of the FMS[1] Atmospheric Dynamical Cores of NOAA's Geophysical Fluid Dynamics Laboratory (GFDL). Specifically, you will be running the barotropic model using spectral coordinates. Using ω to denote the total radial component of the vorticity ($\omega = f + \zeta$), the barotropic vorticity equation can be written as:

$$\frac{D\omega}{Dt} = 0 \quad \text{or} \quad \frac{\partial \zeta}{\partial t} + \mathbf{v} \cdot \nabla \omega = 0 \tag{0.1}$$

If the flow is non-divergent, then we can also write this as

$$\frac{\partial \omega}{\partial t} + \nabla(\mathbf{v}\omega) = 0 \tag{0.2}$$

[1] Flexible Modeling System

The barotropic model that you will be running is solving the above equation but in spherical coordinates. That is it...well, except one additional term is needed in the numerical (modeling) world - that is, a dissipation term that accounts for the finite resolution of the model. If the model had infinite resolution, no dissipation term would be necessary. However, due to the finite resolution, a diffusion-type term is added to account for all of the vorticity variance that *should* be dissipated at smaller scales, but isn't because the model doesn't resolve those scales. This dissipation term takes the following form:

$$-\nu(-1)^n\nabla^{2n}\zeta = -\nu(-1)^4\nabla^8\zeta \tag{0.3}$$

since $n = 4$ for the initial setup you will use. Thus, the model actually integrates the following equation:

$$\boxed{\frac{\partial(f+\zeta)}{\partial t} = -\mathbf{v}\cdot\nabla(f+\zeta) - \nu(-1)^n\nabla^{2n}\zeta} \tag{0.4}$$

This Assignment

1. Read the Barotropic Model pdf (on the webpage) cover to cover. This document accompanies the FMS code and provides a thorough overview of the barotropic model you will be using, and includes a discussion of the basic theory and the numerical schemes implemented. *I do not expect you to understand everything in this document*, but I want you to read it and do your best. Furthermore, Section 5 (page 10) describes the Rossby-wave simulation you will be running and experimenting with - so read this carefully and keep it handy!

2. Get your version of the model setup on ozone (the cluster) and compile the default code (easier written than done!). There is an accompanying pdf that describes how to get the model up and running with specific step-by-step instructions.

3. Run the model in its default configuration for 25 days (the default length of time) and plot the vorticity field (latitude vs longitude) on days 1, 5, 10, and 25. Briefly discuss what you see.