Lab 8: Quasigeostrophic Theory II: QG height tendency equation

Objective: To examine the nature of the forcing terms in the QG height tendency equation while continuing to learning Python.

Materials: Your laptop, Enthought Python, Internet access, pencil, eraser, and colored pencils.

Procedure:

1) Downloads
   (a) We will be using last week's netcdf file (named `gfs_4_20120918_1200_000.nc`), and a new one named `gfs_4_20120918_1200_ghgtonly.nc`. The file `gfs_4_20120918_1200_ghgtonly.nc` contains geopotential heights only. The first record is valid at the analysis time of 12 UTC, while the second record is a 3 hour forecast valid the same day at 15 UTC. Both netcdf files are available from `http://weather.ou.edu/~metr4424/files/`.
   (b) There are no new scripts required for you to download from the class repository, however, you may download my QG diagnostic script at (`https://github.com/metr4424/classcode`):

       plot_qg_diagnostics_forlab8.py

   Feel free to build from my script instead, or just keep using yours. Now that you have experience with Python, it may be easier to build from mine, which is already set up to add in the the calculations for this lab.
2) Plots

   (a) You can continue developing your Python diagnostics script that you created in the previous lab, or use mine instead (see downloads above if you want to see/get mine).
   (b) Produce a set of analyses with the following 3 figures for determining χ:

       700hPa temperatures and geostrophic wind
       300hPa temperatures and geostrophic wind
       500 hPa absolute geostrophic vorticity

   If you are following my script, search for 'putstuffhere' or 'diagnostic==1' for places to perform your calculations. My script is set for the following plots:

       Temperatures and wind on the upper level
       Absolute geostrophic vorticity and wind on the middle level
       Differential temperature advection
       Absolute geostrophic vorticity advection on the middle level
       3 hour change in geopotential heights on the middle level

   Note that the script is set up to plot **either** the upper level or lower level field and contours, not both. So you will need to change your contours and winds accordingly when making a 700 hPa and 300 hPa plot.
   (c) On each of the 3 plots printed out from above, determine the locations of temperature advection and vorticity advection by hand. Label areas of warm temperature advection with a '+' and cold temperature advection with a '-'. Label areas of cyclonic and anticyclonic absolute vorticity advection with 'CVA' and 'AVA', respectively. Feel free

to use any colored pencil you prefer, just as long as everything is clearly labeled in the end.

(d) Using Python, print a plot of differential temperature advection using temperature at 700 hPa and temperature at 300 hPa. Label where you expect to see geopotential heights increasing and decreasing over the next few hours from the differential temperature advection term using a '+' symbol for height increases and '-' symbol for height decreases.

(e) Using Python, print a plot of absolute vorticity advection at 500 hPa. Label where you expect to see geopotential heights increasing and decreasing over the next few hours from the vorticity advection term using a '+' symbol for height increases and '-' symbol for height decreases.

(f) Based on QG theory and the QG height tendency equation, discuss where you would expect significant increases and/or decreases in geopotential height over the next several hours. Keep in mind the two terms can either combine or cancel.

(g) Plot the geopotential height tendency. This can be done by taking record index 1 (the 3 hour forecast from the GFS forecast run initialized at 12 UTC) in the geopotential height array in `gfs_4_20120918_1200_ghgtonly.nc` and subtracting the heights at record index 0 (the GFS height analysis at 12 UTC).

(h) Compare and discuss similarities and differences between your analysis using QG theory and the actual changes in geopotential height. Be specific on locations where results are similar and different. If there are differences, speculate on what you think could be causing those differences (remember the assumptions in QG theory). Note also that there was an extensive area of clouds and precipitation in the northeastern United States and Appalachians, which extended above the 500 hPa level. What role would diabatic processes play in this situation?

Hand in all plots required for printing above in this lab with answers to any questions above. This lab is due at the beginning of class on Wednesday October 10.

Calculation	Suggested contour interval value (`cint`)	Colormap suggestion
Temperature	2°C	No colormap
Absolute geostrophic vorticity	8×10^{-6} s^{-1}	hot_r
Differential temperature advection	4×10^{-6} K m^{-2}	bwr
Absolute geostrophic vorticity advection	5×10^{-11} s^{-2}	bwr
χ	2 meters	bwr

Table 1: Suggested contour intervals and colormap names for plots.