Lab 10: Extratropical cyclones II: Cyclogenesis

Objective: Today you will analyze the synoptic setup for an extratropical cyclone using Python.

Materials: Your laptop, Enthought Python, Internet access.

Procedure:

1) Downloads
   (a) Download `gfs_4_19000101_1200_000.nc` and `files1234.nc` from `http://weather.ou.edu/~metr4424/files/`.
   (b) New and/or updated scripts to download from the class repository (`https://github.com/metr4424/classcode`):

```
plot_qg_diagnostics_forlab10.py (optional)
plot_cross_section_gfs_epv.py
plot_trop_theta_forlab10.py
weather_modules.py
```

   Note you already have your own QG diagnostics and cross section scripts, so you can edit your own versions instead and use mine as examples. You will be using the following new functions in `weather_modules.py`:

```
epv_sphere
thermal_wind_sphere
```

2) QG diagnostics
   (a) Use your QG diagnostics script to obtain a synoptic overview of the situation on this unknown date. Plot whatever you would like to give yourself an idea of the synoptic features that are present at that time to the best of your ability given the limited amount of data. No need to print anything, this is just for yourself so far.
   (b) Use the traditional form of the omega equation to diagnose where you think QG forcings are favorable for the formation of a surface low pressure. Based on the traditional form of the omega equation, where do you expect ascent and from what terms is this forcing from (if any)? Is there cancellation of terms? No need to print and/or hand in any plots at this point.
   (c) Add a section to your script to diagnose vertical motion using the Sutcliffe-Trenberth method discussed in class. See my script `plot_qg_diagnostics_forlab10.py` as an example of how to set this up. In particular make plots of the following:

```
(1) 500 hPa abs. vorticity, 700:300 hPa thicknesses and thermal wind vectors
(2) 500 hPa absolute geostrophic vorticity advection by the thermal wind
(3) GFS omega field
```

   (d) Discuss where you expect QG forcing to lead to ascent at 500 hPa using the Sutcliffe-Trenberth form of the omega equation. Does this change or support your diagnosis from using the traditional form? How does this match with the GFS analyzed vertical motion field?
3) Potential Vorticity
   (a) The script `plot_trop_theta_forlab10.py` plots potential temperature on the 2 PVU

surface (tropopause potential temperature). Use `files1234.nc` to plot the evolution of tropopause potential temperature at the four times available (record numbers 0,1,2,3). Discuss what you observe.

(b) What record number do you think best corresponds to the time you plotted in your QG diagnostics above? Why?

(c) You may have noticed that on the last record (record index 3), an isolated cyclone that was moving along the Gulf coast on the tropopause appears to have spontaneously disappeared. Do you trust this analysis? Why or why not?

(d) Plot east-west cross sections through the core of the isolated cyclone that moves from Texas towards the coast of the Gulf of Mexico. By default, the script plots the Ertel Potential vorticity anomalies (colors), isentropes (solid black contours), 2 PVU surface (single, thick black contour), and ascent (dashed red contours). Do not hand in any plots, but write a discussion that includes the following:

  (i) Variation of the dynamic tropopause. What pressure level does the tropopause extend to in the center of the cyclone? What is the approximate pressure level of the tropopause away from the cyclone?

  (ii) With respect to the tropopause-based cyclone, where is the greatest ascent?

  (iii) Compare the vertical structure of the isentropes both under the cyclone and away from the cyclone. Is there a change in static stability near the tropopause-based cyclone?

  (iv) Is there reason to believe there could be a low pressure center at the surface?

We will continue our analysis of this case next week. Hand in all plots required for printing above in this lab with answers to any questions above by the beginning of class on Wednesday October 24.