Synoptic Meteorology II

**Lab 6: QG Cyclone Development**

Wednesday, April 5th, 2023

(100 pts)

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Due: April 12th, 2023, at 2:30 pm

**Learning Objective**:

* Explain cyclone formation and decay using QG theory.

**Things to know:**

For this lab, you will describe various stages of a midlatitude cyclone’s life cycle. Explain your answers **thoroughly** and **clearly** using QG theory concepts. *Note: For identifying temperature advection and differential temperature advection, use the analyzed isotherms and wind barbs, not the thermal wind.*

Feel free to use the Internet and collaborate with your colleagues when answering these questions. For the entire lab, the requested plots must be obtained using the Jupyter Notebook on our JupyterHub before you can complete the questions.

**Part I: QG Cyclone Development**

1. Create the following plots for March 16th, 2023 at 1200 UTC, March 17th, 2023 at 1200 UTC, and March 19th, 2023 at 0000 UTC: (20 pts)
   1. Surface Observations with isobars (hPa; refer to last semester’s Lab 5 Part 1)
   2. 500 hPa Absolute Vorticity (10-5 s-1), Temperature (°C), Geopotential Heights ( m), and Wind Barbs (kt)
   3. 300 hPa Temperature (°C), Geopotential Heights (m), and Wind Barbs (kt)
2. Using the maps for March 16th, 2023 at 1200 UTC:
   1. Using the QG Height Tendency equation, will the 500 hPa trough over Idaho, Montana, Utah, and Colorado amplify or decay? Will this change in the trough’s intensity increase or decrease the cyclonic absolute vorticity in the trough’s base (Hint: *for this, think of the relationship between the geopotential height and geostrophic relative vorticity*)? Explain. (10 pts)
   2. From the context of the Pettersen-Sutcliffe Development equation, will the surface low over Kansas and Oklahoma continue to deepen or start weakening over the next several hours? To where will the surface low move? How might your interpretation change if precipitation were occurring near the cyclone center? Explain. (10 pts)
3. Using the maps for March 17th, 2023 at 1200 UTC:
   1. How do the midlatitude cyclone’s trough axis and warm and cold fronts align between the surface, 500 hPa, and 300 hPa? What does their orientation say about the midlatitude cyclone’s development stage? Explain your answer. (10 pts)
   2. Using the QG Height Tendency equation, will the 500 hPa trough (now over Minnesota) continue to amplify? Will the trough axis’ orientation change? Explain. (10 pts)
   3. From the context of the Pettersen-Sutcliffe Development equation, will the surface low continue to deepen, and to where will it move? How might your interpretation change if precipitation were occurring near the cyclone center? Explain. (10 pts)
4. Using the maps for March 19th, 2023 at 0000 UTC:
   1. How has the midlatitude cyclone’s vertical alignment changed? How does this differ from earlier? What would this say about the development stage of this low-pressure system? Explain. (10 pts)
   2. From the context of the Pettersen-Sutcliffe Development equation, will the surface low continue to deepen or weaken? Why? (10 pts)
   3. Are there any clues that would say that the surface low is near occlusion? What would occlusion ultimately mean for the strengthening or weakening of the upper-level trough and surface cyclone? Explain. (10 pts)

**Part II: QG Cyclone Development Cont. (Graduate Students Only; 10 pts)**

1. Create the following maps for April 5th, 2023 at 1200 UTC: (2 pts)
   1. Surface Observations with isobars (hPa; refer to last semester’s Lab 5 Part 1)
   2. 500 hPa Absolute Vorticity (10-5 s-1), Temperature (°C), Geopotential Heights ( m), and Wind Barbs (kt)
   3. 300 hPa Temperature (°C), Geopotential Heights (m), and Wind Barbs (kt)
2. Using the maps you just created:
   1. Find a trough on the 500 hPa chart. What does the vertical alignment of features between the surface, 500 hPa, and 300 hPa indicate about the midlatitude cyclone’s development stage? Explain. (4 pts)
   2. For the same midlatitude cyclone as you found in part (a), using the Pettersen-Sutcliffe Development equation, will the surface low continue to deepen and to where will it move? Explain. (4 pts)