Synoptic Meteorology I

**Lab 5: Applying the Hypsometric Equation**

Wednesday October 5th, 2022

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Due: October 19th, 2022, at 2:30pm

**Objectives**:

* Explain the vertical structure of warm- and cold-core cyclones and anticyclones using the hypsometric equation and thickness.
* Identify the structure of real-world features (hurricanes, extratropical cyclones) using the hypsometric equation .

**Things to know:**

Feel free to use the Internet and collaborate with your colleagues when answering these questions. For Part II, the requested plots must be obtained using the Jupyter Notebook on our JupyterHub before you can complete the questions. Be sure to review the concepts covered in this tutorial rather than just complete the tasks it requires as you may be asked to use these concepts in a future lab.

**Part I: Using the Hypsometric Equation to Analyze Cyclones and Anticyclones (50 pts)**

1. “Pressure changes more rapidly with height in cold air than in warm air.” Explain why this should be true. (12.5 pts)
2. “Low pressure centers aloft tilt in the direction of the warmer air as you move downward toward the surface.” Explain why this should be true. (12.5 pts)
3. “High pressure centers tilt with increasing height above the surface toward warmer air.” Explain why this should be true. (12.5 pts)
4. “High pressure centers aloft tilt in the direction of the colder air as you move downward toward the surface.” Explain why this should be true. (12.5 pts)

**Part II: Using the Hypsometric Equation to Analyze Real-World Features (50 pts)**

1. Staring with your plots for August 30th, 2021, consider two cyclones on your surface charts, one over the state of Washington (Cyclone A) and one over Louisiana and Mississippi (Cyclone B). Cyclone B is significantly stronger than A at the surface given its lower minimum sea-level pressure, larger horizontal pressure gradient magnitudes, and stronger horizontal wind speeds. At 500 hPa, however, Cyclone A is stronger than Cyclone B, given its lower geopotential height. Using the temperature observations on your maps, specifically how the temperatures near the two cyclones compare to their surroundings, explain why this is to be expected. (20 pts)
2. Focusing now on your plots for July 28th, 2022, consider two anticyclones on your surface charts, one in Florida (Anticyclone A) and the other in Saskatchewan (Anticyclone B). Anticyclone A strengthens with height whereas Anticyclone B dissipates entirely. Using the temperature observations on your maps, specifically how the temperatures near the two anticyclones compare to their surroundings, explain why this is to be expected. (20 pts)

**Part III: Using the Hypsometric Equation to find Geopotential Height (Graduate Students Only; 10 pts)**

Hypsometric Equation:

where Virtual Temperature:

1. Solve the hypsometric equation for and substitute the virtual temperature equation into the hypsometric equation so there is temperature rather than virtual temperature. Show your work. (3 pts)
2. Given the observations for 850 hPa and 1000 hPa below, calculate the height of the 850 hPa isobaric surface using the hypsometric equation. Show all of your work. (3 pts)

LEVEL (hPa) HGHT (m) TEMP (°C) Mixing Ratio

1000.00, 139.00, 28.80, 0.01495

850.00, 17.20, 0.01220

1. Given that the observed 850 hPa height was 1559 meters, hypothesize why your calculated value is different from the observation. (4 pts)