Homework #6 – ATOC 5050 (Fall 2018)
Due by the end of class on Thursday 15 November 2018

Instructions: Complete the following problems showing all necessary work. Answers that are not legible or do not show the necessary work will be given a grade of zero.

1a. Rewrite the horizontal momentum equations in the natural coordinate system (equation 3.9 and 3.10 in H&H) using a height vertical coordinate rather than a pressure vertical coordinate.

1b. Rewrite the governing equations for geostrophic flow (3.11), inertial flow (3.12), cyclostrophic flow (3.14), and gradient flow (3.15) using a height vertical coordinate rather than a pressure vertical coordinate.

2a. Calculate the Rossby number for the atmospheric flows listed in the table below. Assume a latitude of 43.3°N for all of the atmospheric flows considered.

<table>
<thead>
<tr>
<th>Atmospheric flow</th>
<th>Wind Speed (m s⁻¹)</th>
<th>Radius (m)</th>
<th>Direction of rotation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dust devil</td>
<td>10</td>
<td>10</td>
<td>CCW</td>
</tr>
<tr>
<td>Tornado</td>
<td>100</td>
<td>500</td>
<td>CCW</td>
</tr>
<tr>
<td>Hurricane</td>
<td>50</td>
<td>10⁴</td>
<td>CCW</td>
</tr>
<tr>
<td>Synoptic cyclone</td>
<td>10</td>
<td>10⁵</td>
<td>CCW</td>
</tr>
</tbody>
</table>

2b. Calculate the magnitude of the change in pressure from the center to the edge of circulation for each flow listed in this table for cyclostrophic, geostrophic, and gradient wind balance.

2c. Which balanced flow approximation(s) give a reasonable estimate of the pressure change and which balanced flow approximation is most accurate for each type of flow? Explain your answer.

2d. Describe physically why the change in pressure calculated in part b differs between the cyclostrophic and geostrophic wind calculations.

3a. Create a table similar to that in the lecture notes for all possible cases of the gradient wind in the Southern Hemisphere.

3b. Draw a figure that illustrates the force balance for each of the possible gradient wind solutions in your table, similar to Figure 3.5 in H&H.

3c. Which gradient wind solutions correspond to baric or antibaric flow?

3d. Which gradient wind solutions correspond to cyclonic or anticyclonic flow?

4. Use the 500 mb map for 12Z 27 Oct 2006, on the class web page, to answer this question.

4a. Calculate the Rossby number for the flow around the low over northeastern Oklahoma, using the observed wind at Shreveport, LA (SHV).

4b. Calculate the geostrophic and gradient wind speed at SHV using this map.

4c. Which value calculated in 4b gives the best estimate of the observed wind at SHV? Is this consistent with the value of the Rossby number you found in 4a? Explain your answer.
5a. H&H 3.10

5b. Is the geostrophic wind veering or backing with height in this layer?

6a. H&H 3.11

6b. Are your answers to 5b and 6a consistent? Explain your answer.