1a) The table below gives the Model Output Statistics (MOS) from the NAM model initialized 0000 UTC 28 Aug. 2018 for Omaha, NE. The WDR row gives the wind direction, and the WSP row gives the wind speed in knots.

Convert the WDR and WSP at 1800 UTC 28 Aug. 2018 to a wind vector. (Hint: Keep in mind that the meteorological convention is to measure the wind from the direction it is coming from, e.g., 0° is northerly, 90° is easterly, 180° is southerly, 270° is westerly. However, in math, angles are measured relative to the positive x-axis, with angles increasing counterclockwise. Be sure to convert from meteorological angles to mathematical angles before computing vector components!)

b) The verifying KOMA METAR at 1800 UTC 28 Aug. 2018 is

KOMA 281752Z 34018KT 2 1/2SM VCTS -RA BR BKN009 BKN015CB OVC030 22/19 A2984

What is the NAM’s vector wind error at 1800 UTC 28 Aug. 2018? What is the magnitude of the error?

2a) The following table gives wind measurements at various pressure levels taken by a radiosonde at 1800 UTC 15 May 2018 at Albany, NY. There were severe thunderstorms observed south of Albany that same afternoon.

<table>
<thead>
<tr>
<th>pressure (mb)</th>
<th>u (m/s)</th>
<th>v (m/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1000</td>
<td>0.5</td>
<td>0.9</td>
</tr>
<tr>
<td>850</td>
<td>17.9</td>
<td>6.5</td>
</tr>
<tr>
<td>700</td>
<td>25.1</td>
<td>2.2</td>
</tr>
<tr>
<td>500</td>
<td>40.5</td>
<td>7.1</td>
</tr>
</tbody>
</table>
Forecasters are interested in the mean wind of the sounding because it affects how fast storms move. Calculate the mean wind vector and mean wind speed from the sounding data.

b) A hodograph is a useful way of displaying wind information from a sounding. To construct one, plot the wind vectors in order of increasing altitude (decreasing pressure), all emanating from the origin. Next, in the same order, connect the heads (arrows) of the vectors. Construct a hodograph using the wind information from the table above.

c) On your hodograph, mark the vector difference between the wind at 500 mb minus the wind at 1000 mb. What is the magnitude of this vector, i.e., the vertical wind shear magnitude? Forecasters typically look for vertical wind shear magnitudes between the lower and middle troposphere in excess of 20 m/s for severe weather along with large amounts of instability. Knowing there is ample instability on this day, was the data alerting forecasters to the imminent possibility of severe weather?

3a) The figure below shows temperatures observed at New York State Mesonet stations at 2000 UTC 21 Feb. 2018, as a strong cold front was moving through the area. Calculate the horizontal temperature gradient at Glenville, NY (given by the star).

b) The temperature advection is defined as the negative of the dot product of the horizontal wind velocity and the horizontal temperature gradient. Let the horizontal wind velocity (m/s) be

$$\vec{v} = 8\hat{i} - 2\hat{j}$$

Calculate the temperature advection at Glenville, NY.

4) Given the following wind velocity,

$$\vec{u} = \frac{1}{x + y} \left( -y\hat{i} + x\hat{j} + 0\hat{k} \right)$$, where $x > 0$ and $y > 0$

a) Where is the wind nondivergent ($\nabla \cdot \vec{u} = 0$)?

b) Where is the wind irrotational ($\hat{k} \cdot (\nabla \times \vec{u}) = 0$)?