Resolving Vorticity in New Wind Products: Advantages of Finer Resolution and Improved Retrievals through Rain

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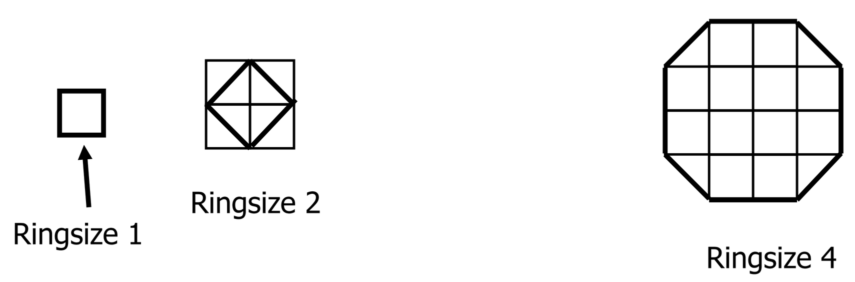
Mapping of finer resolution vorticity from swaths of scatterometer data has been hampered by an inherently noisy calculation and serious rain contamination in areas that are of relatively great interest. Recent advances in finer resolution winds and improved retrievals in rain improve the accuracy of finer scale vorticity calculations. The details of the vorticity calculation are given below.The examples highlight the advantages of new products and the BYU Ultra High Resolution winds.

Vorticity Methodology

Relative vorticity is determined by dividing the circulation by the area.

$$\zeta = C / A$$

- Only data on the perimeter of the shape contribute to the calculation.
- As the shape becomes larger, it becomes more circular.



- Rain flagged data are not used in the calculation
- Random errors are much larger for ringsize 1 and 2 than for averages over more data (ringsize 3 or greater)
  - Random errors for ringsize 1 and 2 are similar is magnitude
- Circulation is calculated as a line integral about a "shape" using the circulation theorem.
  - $C = \oint \mathbf{v} \cdot \mathbf{dl}$
  - "shape" is dependent on available data: polygon (triangle, square …).
  - Linearly interpolate wind vectors between adjacent good observations.
    - Spline fit results in a slight improvement over linear interpolation
  - Too many missing points on the "shape" perimeter (<80%; except 75% for square shapes) and the vorticity isn't calculated.

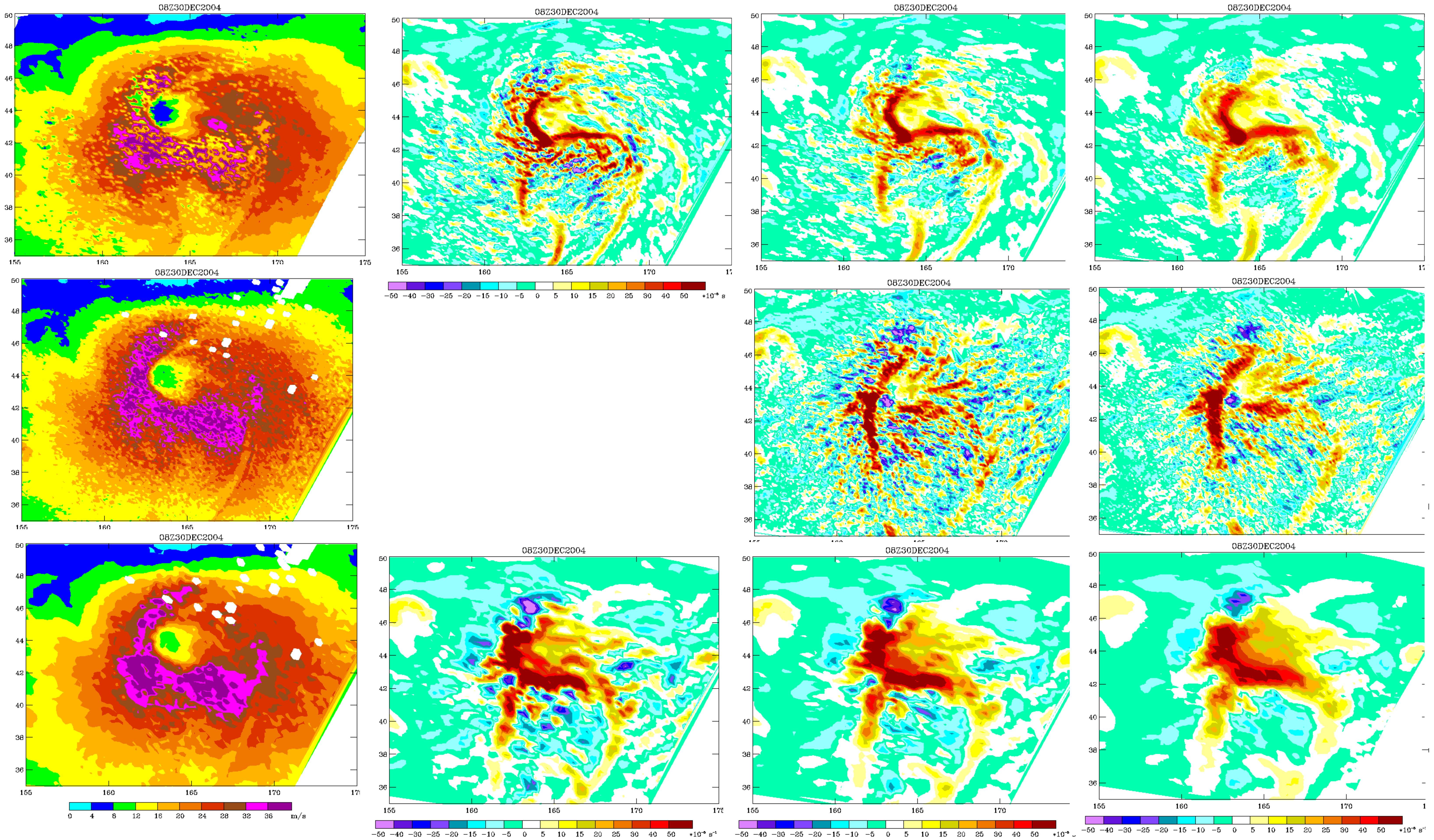


Figure 1. Intense Mid-latitude Warm Core Seclusion analyzed with three difference wind JPL products. Wind speeds are shown in the first column, and area averaged vorticity are in the other columns. The 2nd column shows averaging with a three grid cell diameter; the third column has a four grid cell diameter; and the right column has a six grid cell diameter. The bottom row is the traditional 25km JPL product. The middle row is the JPL 12.5km product, and the top row shows the new JPL neural

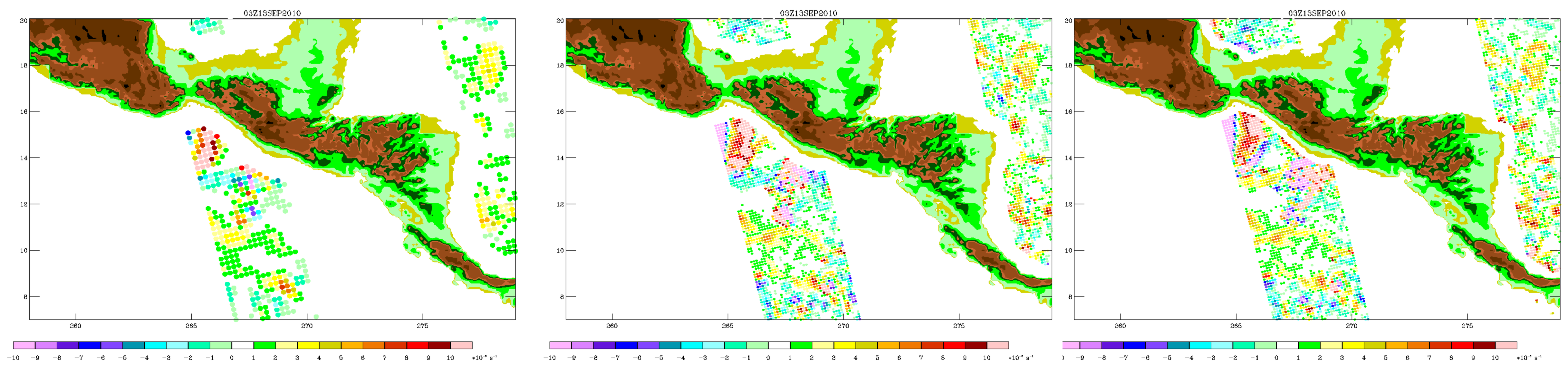


Figure 2. ASCAT-based vorticity around Central America, area averaged with a 5 grid cell diameter. The grid spacing of the wind product has an enormous influence on the ability to identify small scale and near coastal features. The grid spacing is 25km (left), 12.5km (middle) and 6.25km (right).

We also examine the influences of using 12.5km and 6.25km grid spacing on vorticity calculations. The finer resolution can be used to reduce noise for any set spatial averaging scale greater than a circle with a diameter of two grid cells. Alternatively, they can be used to increase resolution with a smaller or no change in noise. A further advantage of smaller spatial scales is smaller biases in voriticy (smaller reduction in extremes) due associated with spatial averaging. This tropical example highlights the advantages of finer resolution. Examples of vorticity associated with gap flow are shown using ASCAT 25km, 12.5km, and 6.25km products.

Mid-latitude (Fig. 1) and tropical cases (Fig. 2) are used to illustrate these advances. The new JPL neural net (NN; Fig. 1 top row) retrievals are an attempt to improve the accuracy of wind vectors in rainy conditions. For a very strong mid-latitude cyclone, the vorticity determined from these NN retrievals are compared to traditional results (Fig. 1; middle and bottom rows. The NN-based vorticities are clearly an improvement over the older products. The finer grid spacing of the NN product makes a substantial reduction in the noise, as is better demonstrated in Fig. 2 with ASCAT products. The JPL 12.5km shows a much better representation of the atmospheric fronts than the older 25km product; however, the increase in noise indicates that the 12.5km product has considerably more noise than the 25km product.

The features are much clearer when determined from the highest resolution product, as seen in Fig. 1 and Fig. 2. The finer resolution also allows for calculations much closer to the coast. The BYU ultra fine resolution (UHR) 2.5km QSCAT product is also used to examine gap flow. The BYU product has excellent resolution of wind speed, but has rather noisy directions: the BYU product is not optimized for calculating vector differences. Consequently, the BYU UHR product must be averaged across a greater number of grid cells than would be expected for the standard products. Nevertheless, we find that vorticity determined with the BYU product better represents smaller scale features.

In summary, both finer resolution and improved accuracy of rain contaminated retrievals result in improved derivative fields. Based on these results, we recommend continued improvements in spatial resolution and correction for rain contamination.

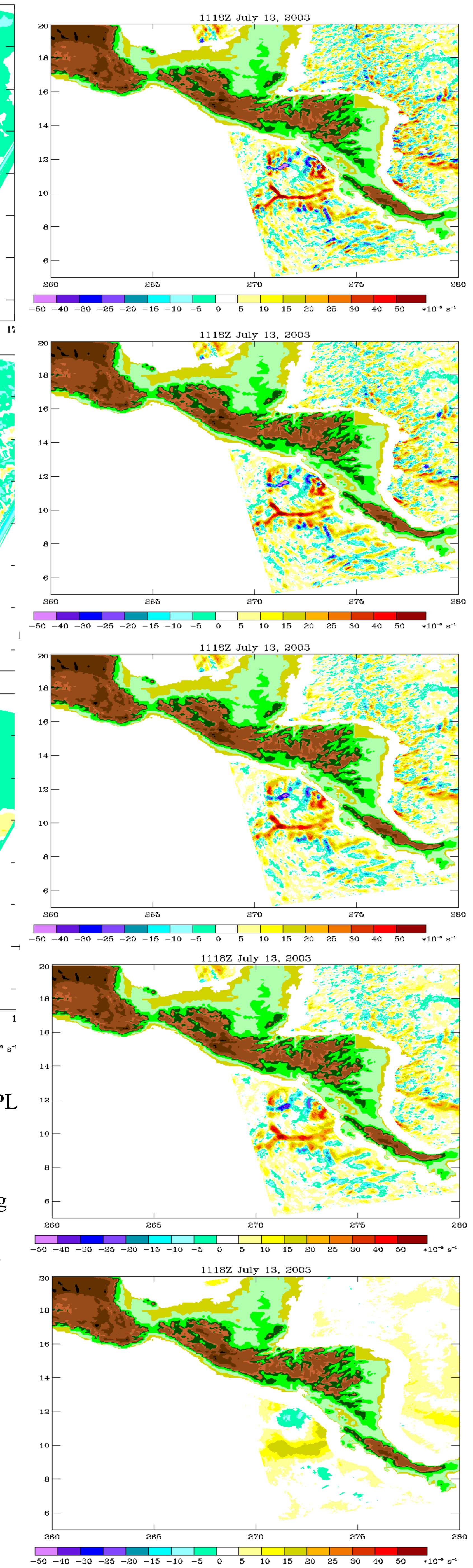


Figure 3. Vorticity determined from BYU UHR winds smoothed at various diameters (top to bottom) of 25, 30, 35, 40, and 125km.

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