Using Wind Derivative Spectra to Compare Noise Characteristics from Scatterometer Based Wind Records

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INTRODUCTION

Improving the accuracy of winds from space borne scatterometers is an important task, as improvements also lead to better estimation of wind derivatives (divergence and vorticity) important to ocean forcing and weather forecasting. However, there are inconsistencies between the swath characteristics of different wind products used to calculate wind derivatives even with small differences in wind speed magnitude. This study investigates the spatial characteristics of wind derivatives through a spectral analysis of four scatterometer wind products from the NASA MEaSUREs program, whose aim is the creation of a consistent data record of ocean surface winds from different observing platforms. The scatterometer wind records are from the NASA QuikSCAT and KNMI ASCAT missions, with two new products developed at the NASA Jet Propulsion Laboratory based on ASCAT measurements (see talk April 26th, 10:00 ET by Svetla Histrova-Veleva). The four wind products are compared for across-track consistency of vorticity spectra and seasonal comparisons are made.

OBJECTIVE

- Compare the differences between spatial wavenumber spectra for different scatterometer products to identify the noise characteristics and the effects of smoothing and show how these characteristics are represented in the wind derivative power density spectra.

DATA

All data is from 2008

- NASA QuikSCAT L2B 12.5 km v4.1 (GMF: Ku-SST)
- KNMI ASCAT-A L2 12.5 km Coastal (GMF: CMOD7)
- NASA MEaSUREs ASCAT-A L2 12.5 km (GMF: CMOD7)
- NASA MEaSUREs ASCAT-A L2 12.5 km Adjusted (GMF: CMOD7 adj. with Ku-SST)

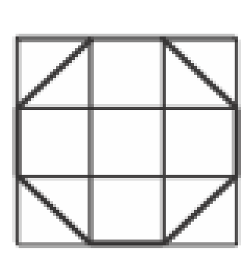
DERIVATIVE CALCULATIONS

The calculation for wind vorticity and divergence used here was originally performed by Ford and Bourassa (2010) and later by Holbach and Bourassa (2017). Vorticity and divergence are calculated for each swath individually using a line integral technique developed for irregularly spaced swathed data on a non-uniform grid. First, a polygon shape of grid points surrounding a wind vector grid cell is used to approximate a circle about which the winds are integrated to calculate the circulation of vorticity and divergence around the grid cell given by the equations below. Because the polygons are composed of a series of straight segments, the circulation of vorticity ($C_{vort} = \oint \boldsymbol{v} \cdot \boldsymbol{dl}$) becomes $\sum_{i=1}^{n} \boldsymbol{v} \cdot \boldsymbol{dl}$ where i represents the line segments from 1 to n. Area averaged relative vorticity ($\boldsymbol{V}$) and divergence ($\boldsymbol{D}$) is calculated for the wind vector cell by dividing the respective circulation by the polygon area ($\boldsymbol{A}$).

$$C_{vort} = \oint \boldsymbol{v} \cdot \boldsymbol{dl} = \sum_{i=1}^{n} \frac{1}{2}(u_{i+1} + u_i, v_{i+1} + v_i) \cdot (x_{i+1} - x_i, y_{i+1} - y_i)$$

$$C_{div} = \oint \boldsymbol{v} \times \boldsymbol{dl} = \sum_{i=1}^{n} \frac{1}{2}(u_{i+1} + u_i, v_{i+1} + v_i) \times (x_{i+1} - x_i, y_{i+1} - y_i)$$

$$\boldsymbol{V} = \frac{\boldsymbol{C_{vort}}}{\boldsymbol{A}}, \quad \boldsymbol{D} = \frac{\boldsymbol{C_{div}}}{\boldsymbol{A}}$$



37.5 km ring size diameter of in-swath points

POWER SPECTRA DENSITY CALCULATION

- Specta were computed within the bounding box in the North Atlantic shown in Fig. 1.

Calculation Steps

1. Within the bounding box, we found the longest "string" of non-missing values for each along-swath column meeting a minimum length of 1875 km.
2. Trim all of the strings to the same length.
3. Remove the linear trend from each string.
4. Use a fast Fourier transform to compute the spectra for each string.
5. Sum all of the spectrum for each string over the period of interest and compute the average spectra.

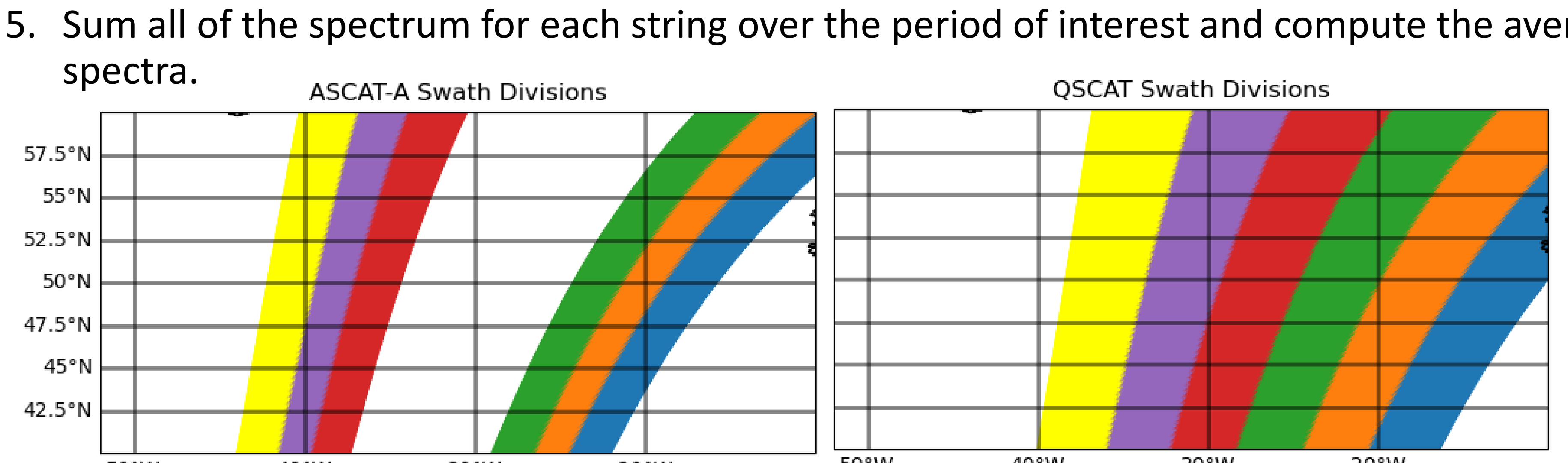


Figure 1. Across-swath divisions used in the calculation of spectra shown in Fig. 4. This is also the Northern Atlantic region used for all spectra calculations.

2008 JFM NATL Spectra

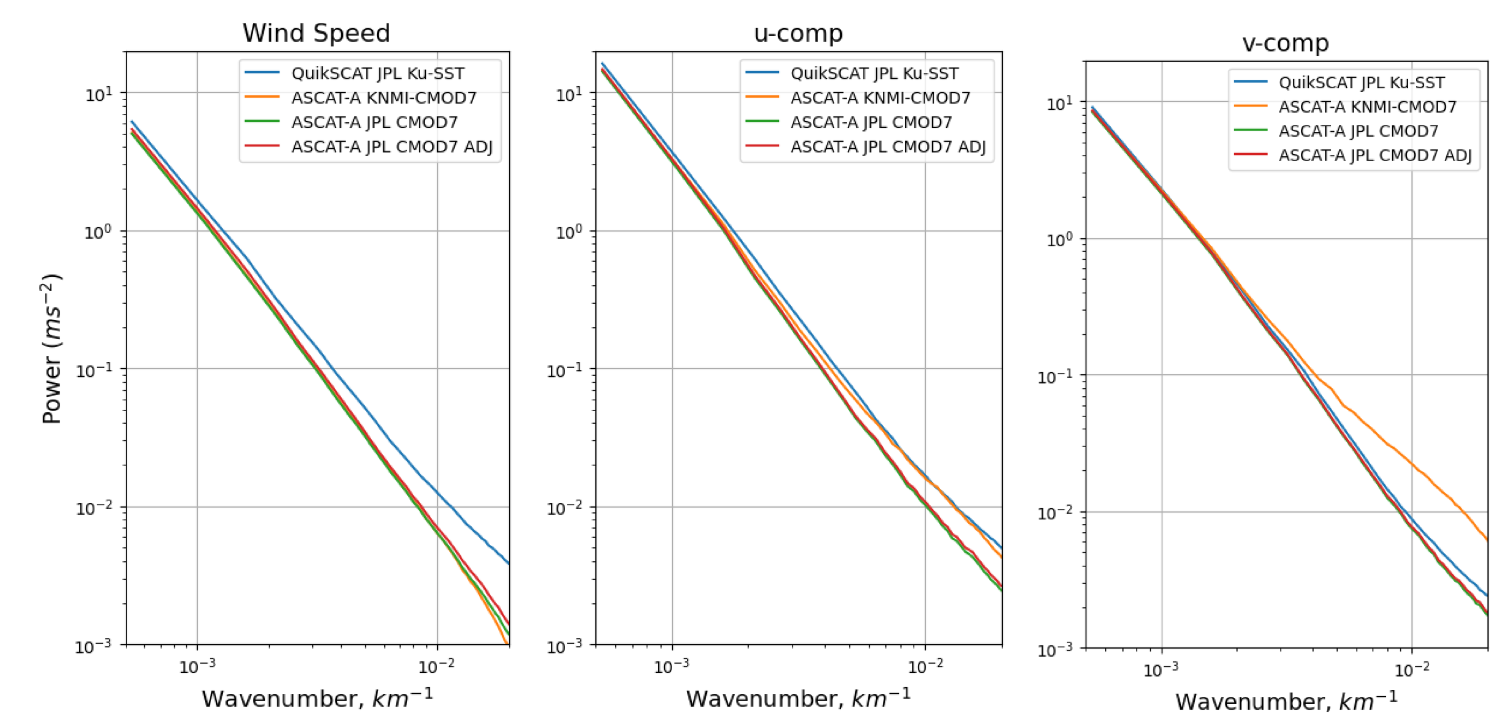


Figure 2. Wavenumber spectra comparisons for wind speed magnitude (left), u-component (center) and v-component (right) for the four different scatterometer products color-coded in the legend. The spectra are computed as a seasonal average from January, February and March (JFM) in 2008.

- Wind speed magnitude spectra from ASCAT-A KNMI and JPL products are consistent, however, there is more noise in the u and v-components of ASCAT-A KNMI.

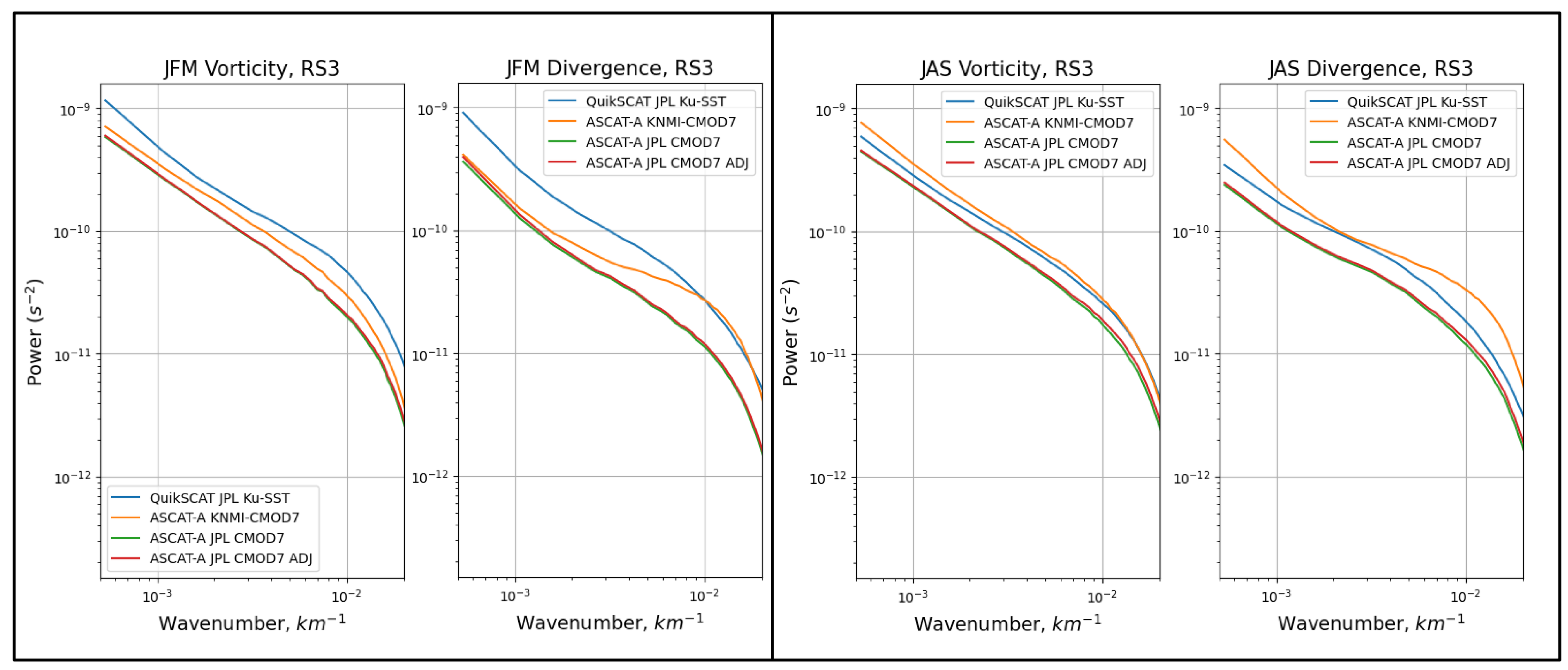


Figure 3. Seasonal average wavenumber spectra comparisons of vorticity and divergence for January-February-March (left) and July-August-September (right). Calculated with 37.5 km averaging diameter (ring size 3).

- Vorticity and divergence spectra from ASCAT-A JPL are seasonally consistent.
- QuikSCAT exhibits higher power (more noise) in the winter across the entire spectrum.
- KNMI ASCAT-A divergence exhibits higher power in the high wavenumber (low wavelength) range than the JPL ASCAT products.

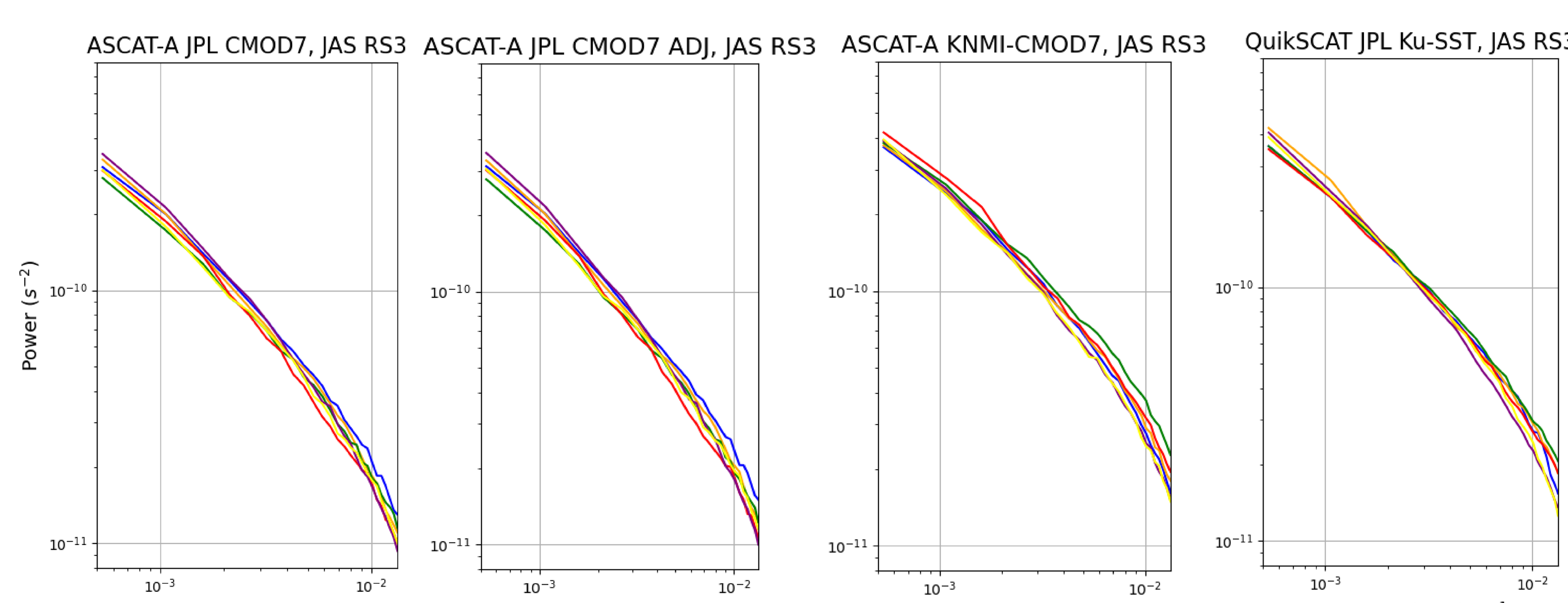


Figure 4. Across-swath consistency of vorticity spectra. The swath divisions are color-coded by the position and colors shown in Fig. 1. Spectra are computed for JAS, 2008.

- There is good consistency in the vorticity spectra across the swath for all four scatterometer products. This is an overall improvement from past product versions (see Holbach and Bourassa (2017).

DISCUSSION

The consistency of vorticity and divergence spectra are compared for four different scatterometer products. There is overall higher power in the high wavenumber range for ASCAT-A KNMI and QuikSCAT JPL compared to the two new ASCAT-A products from JPL. This could be indicative of higher noise in the first two products or more smoothing in the JPL ASCAT products. An inspection of the swath data (not shown) reveals the presence of more small-scale features in the ASCAT-A KNMI derivatives compared to the ASCAT-A JPL derivatives. For future investigation, a detailed analysis of known features contributing to vorticity and divergence may help to illuminate the differences in the noise characteristics shown here.

ACKNOWLEDGEMENTS

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