The Development of a C-Band Advanced Scatterometer (ASCAT) Geophysical Model Function at NOAA/NESDIS

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The Advanced Scatterometer (ASCAT) is a radar instrument, on board the MetOp-A satellite, designed specifically to retrieve ocean surface wind speed and direction. The ASCAT transmits 5.255 GHz (C-band) microwave energy, using vertically polarized fan-beam antennas, to the ocean surface and measures the returned radar backscatter signal from small-scale wind-driven sea surface roughness. ASCAT views the surface from three different azimuth angles across the 550-km measurement swaths on each side of the satellite sub-track. As the satellite travels forward the surface normalized radar cross section (σ^0) are measured from the fore-, mid- and aft-looks, respectively, resulting in a triplet of σ^0 measurements for each wind vector cell. Given knowledge of the ASCAT measurement geometry parameters and the relationship between the σ^0 and wind vector in the current ASCAT Geophysical Model Function (GMF) known as CMOD5, the wind speed and direction can be determined. ASCAT wind retrievals have been validated against NWS Global Data Assimilation System (GDAS) global wind fields, QuikSCAT satellite scatterometer wind retrievals, and oceanic buoy wind measurements. The result shows that ASCAT wind retrieval performance is within 2 m/s RMS error for wind speeds from 3-15 m/s under all weather conditions, and 20° RMS directional error for wind speeds > 5 m/s. However, ASCAT wind speed retrievals are significantly underestimated compared to GDAS and QuikSCAT winds for wind speeds > ~15 m/s.

To further investigate the ASCAT high wind speed retrieval performance, a new GMF is empirically derived for ASCAT using a collocation dataset of ASCAT 50-km σ^0 and near-real-time QuikSCAT 25-km wind field over four months of observations. The GMF is modeled as a harmonic cosine series plus a dc term. The average σ^0 are sorted by combining left- and right-swaths into 21 wind vector cell (WVC) bins, where the mean incidence angles vary from the inner-to-outer swath approximately 27°-63°. For a given WVC, the σ^0 is normalized to the mean value of the incidence angle within the bins. Since the fore- and aft-beam are 90° apart in azimuth, the average of the fore- and aft-beam $\sigma^{0'}$s approximately cancel the harmonic terms resulting only in a dc term. The dc σ^0 is plotted as a function of QuikSCAT wind speed for each incidence angle bin from the fore- and aft- beams, which spans 37°-63°, and from the mid-beam, which spans the lowest end of the incidence angles 27°-36°. A regression analysis is done using a simple equation for wind speed up to 50 m/s. Another regression analysis is done for each of the coefficients found previously as a function of incidence angle to complete a dc term model function. For the higher harmonic terms, the functional forms and coefficients are adopted from CMOD5 to complete our revised GMF.

New ASCAT wind retrievals were generated using above GMF and subsequently validated. The resulting wind speed histogram is shown to be dependent on WVC bins, which means the GMF needs further adjustments. Instead of correcting the sigma-0, we are rather correcting the retrieved wind speeds that align the wind speed histograms at different WVC bins. After applying the wind speed corrections, a validation analysis shows that wind speed retrievals are improved for wind speed > 15 m/s and are better by 5 m/s for the same standard deviation error of 2 m/s than the original wind speed, while wind direction retrievals remain the same for all wind speeds as expected.