Redevelopment of a Scatterometer Model Function Using Nine Years of QuikScat Data

Lucrezia Ricciardulli, Deborah K. Smith, Chelle Gentemann, Frank J. Wentz

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Why ReDevelop the GMF?

QSCAT-1 and KU2001 winds in the range of 3-20m/s agree well with each other and also agree with buoy, ship observations and radiometer winds. Standard deviations are in the range of 1 m/s or less (based on findings by Bourassa, Ebuchi, Freilich, Wentz, and others). So why re-evaluate the current geophysical model function (GMF) in use?

The original development of both the QSCAT-1 and KU2001 GMFs were based on a limited amount of data, particularly for winds above 15 m/s. Not only do we now have many more buoy data and in new locations, we also have 9 years of QuikScat data to work with instead of 1 year. Figure 1 below shows the increase in buoys between 1999 and 2007. Note the new RAMA buoys available in the Indian Ocean, the extended coverage of the PIRATA array, and the increase in NDBC buoys in the coastal US regions. The number of buoy wind vectors greater than 25 m/s increased from 364 in 2002 to 638 in 2008. There are now 2000 more winds above 20 m/s in the buoy data than in 2001 when the model function was last refined.

We also better understand where high winds occur and how different types of high wind events are observed by scatterometers. A map of high wind occurence (Figure 2 below) shows that most of the high wind regions exist where there are no buoy observations. For developing the model function above 15 m/s, we must, therefore, useother data sources.

Using this greater quantity of data, we plan to revise and update the GMF, better understand the dependence of wind direction harmonics on winds at speeds greater than 15 m/s, and determine the effect of currents on buoy to QuikScat intercomparisons.

The new GMF we are working on uses

Buoy data for wind speeds up to 15 m/s
NCEP GDAS winds for wind speeds and directions up to 25 m/s
Tropical cyclone case studies and H*wind comparisons for high wind speeds

Rather than develop a separate GMF for high winds, we are developing a single GMF to cover all winds. The new GMF is still under development, but we show some preliminary results here.

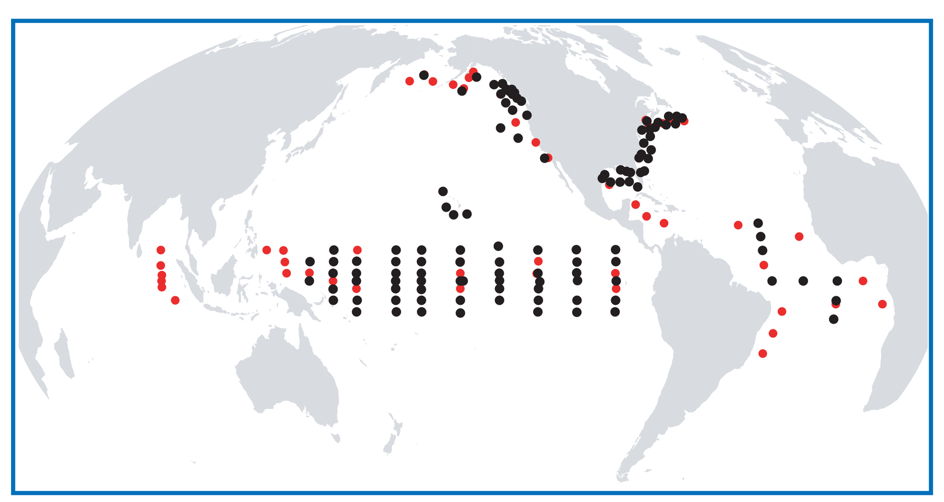

Fig. 1. Moored buoys in 1999 (black) and those added by 2007 (red)

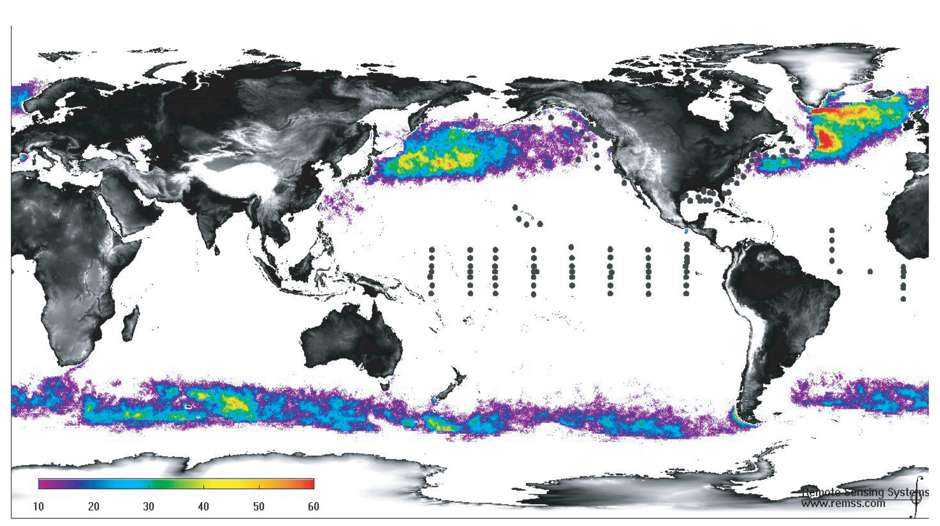

Fig. 2. Number of winds > 30 m/s per 0.25 deg cell in 9 years of QuikScat data

Using 9-years of QuikScat Data:

We have begun by analyzing 9-years of QuikScat sigma-0 measurements (July 1999 to July 2008) that are binned by polarity (incidence angle), wind direction, and wind speed using NCEP GDAS wind speeds and wind directions. Care was taken to remove rain affected data using tightly collocated radiometer rain rates. From this data set, we developed an analytical GMF as a harmonic function of relative direction with wind-dependent coefficients. Figure 3 shows the model function obtained from the NCEP data. An analytical fit to the data is shown with smooth lines. Due to fewer data at wind speeds greater than 20 m/s, the curves show greater variability. The highest wind speeds were for 30 m/s, but there are clearly too few data to use at this range (red Xs). We refer to this model function as KuNCEP.

A similar approach was taken using moored buoy winds for the binning of QuikScat sigma-0 data. Figure 4 shows an example of the data for one of the PIRATA buoys. Other buoys look similar. Some buoys were omitted from the analysis due to too little variation in wind direction or too few observations. The data for the good buoys were then fit to a polynomial equation. We refer to this model function as KuBUOY.

We find that both KuNCEP and KuBUOY confirm the quality of the Ku-2001 GMF at winds between 3 and 15 m/s (see section below). For developing a model function at higher winds, another approach would be needed. Case studies were used to adjust the Ku-2001 GMF. In 9 years our collection of case studies have increased and we use these and radiometer winds from WindSat (see Thomas Meissner's talk) to develop the GMF above 25 m/s.

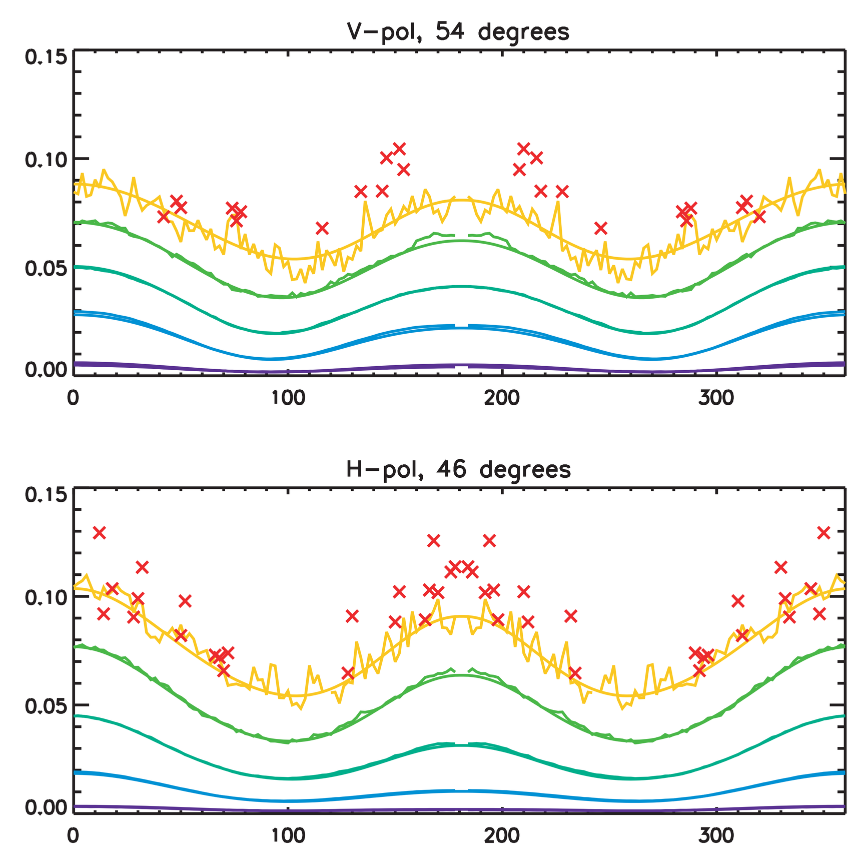

Fig. 3. Model function derived from 9-years of QuikScat data and NCEP GDAS winds. Colored lines are for wind speeds (5 - 25 m/s). X is used when few data were available (30 m/s). Irregular lines are from data, smooth lines are an 6th-order polynomial fit to the data.

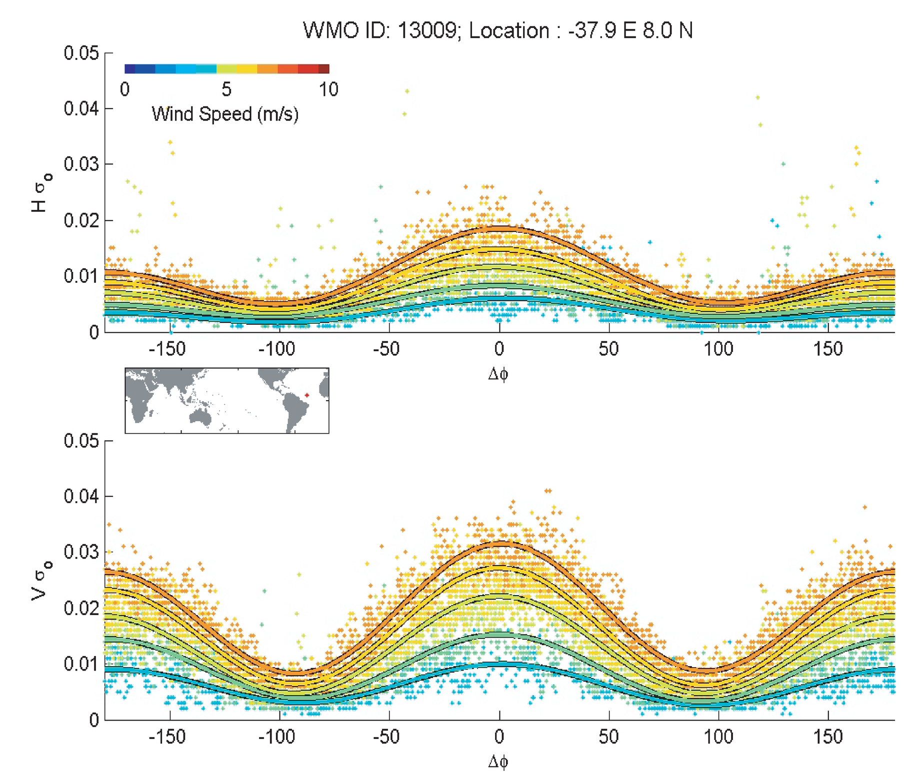

Figure 4.QuikScat Sigma-0 data binned by directional difference and wind speed for one PIRATA buoy (see inset map for location). Data from over 100 buoys were used to derive a model function. Buoys with poor wind variability or limited amount of data were omitted from the analysis.

Comparison with QSCAT-1 and Ku-2001:

Both the buoy and NCEP derived model functions (KuBUOY and KuNCEP) are compared with QSCAT-1 and Ku-2001 in Figure 5 shown at right. The plot confirms that both QSCAT-1 and Ku-2001 model functions agree with KuNCEP and KuBUOY findings in the 3 to 15 m/s range. Beyond 20 m/s, however, differences are present that we expect.

Both KuNCEP and KuBUOY model functions are derived using winds that are known to be low at high winds speeds. Buoys do not measure high winds with great accuracy due to ocean conditions (tipping of buoy in high waves, sheltering in wave troughs), and NCEP GDAS 1-deg resolution winds underestimate 0.25 deg winds (no adjustment was applied to account for this in the model function creation).

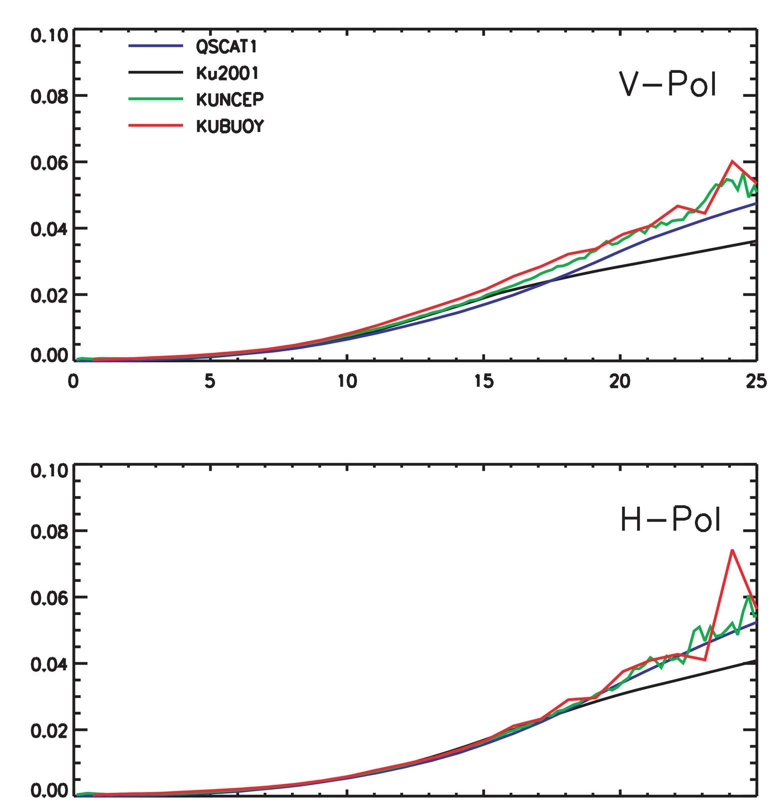

Figure 5. Crosswind plot of 4 model functions

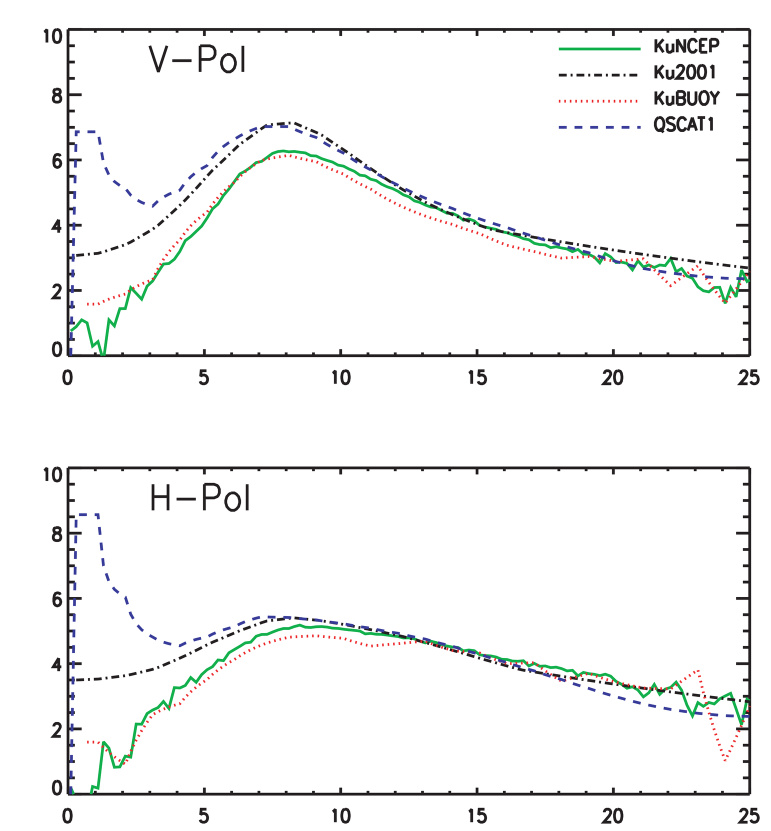

Figure 6. A2 coefficient for 4 model functions

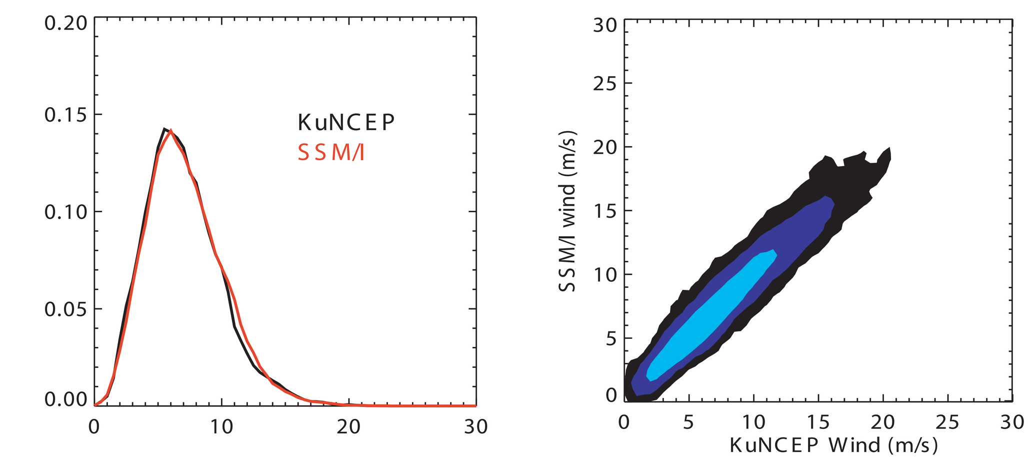

Figure 7. Comparison of KuNCEP model winds to SSM/I for a small subset of orbits.

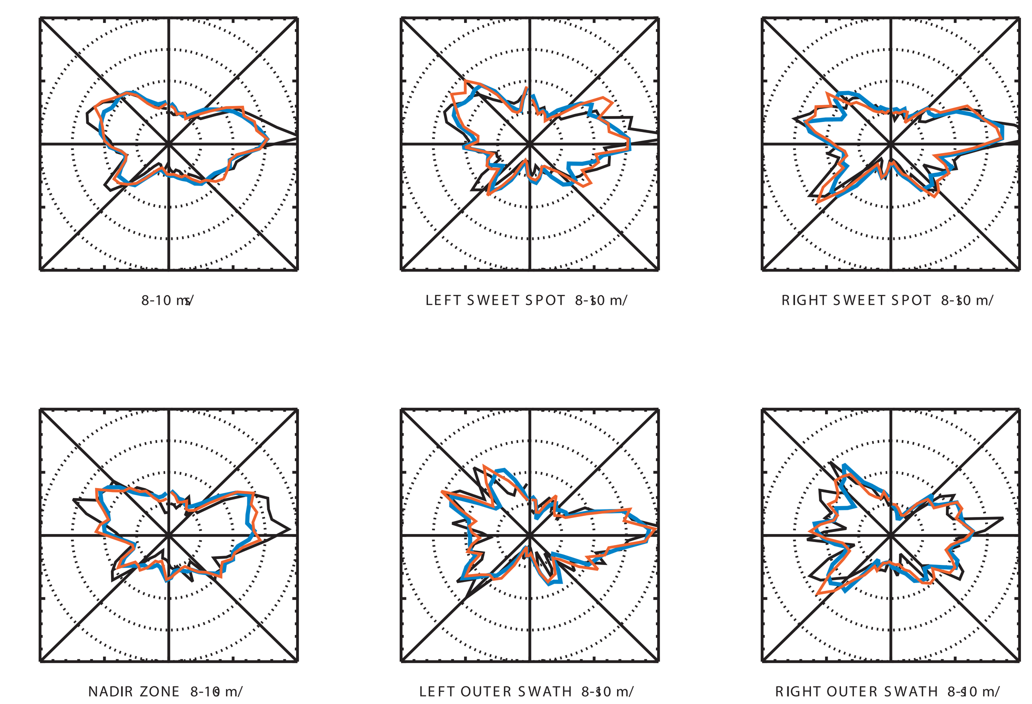

Figure 8. KuNCEP(red) and QSCAT-1(blue) vs NCEP(black) Direction Histograms for 8-10 m/s wind speed bin

Performance:

We used our testbed environment to process 30 orbits of data with the KuNCEP model function. Comparisons were then made radiometer and weather model winds. All comparisons are performed for rain-free conditions using SSM/I, TMI, and AMSR-E rain rates and the QuikScat rain flag to disqualify data from the comparisons. Results show that standard deviations for wind speed remain the same for SSM/I, TMI and AMSR-E (0.8 ,0.5, and 0.7 m/s respectively) as for Ku-2001. Wind speed biases increase slightly (by 0.2 m.s). Figure 7 above, shows the good agreement with SSM/I winds Plots for TMI look similar.

As expected, wind speed standard deviation when compared with NCEP winds decreases (1.3 m/s for KuNCEP vs. 1.5 m/s for Ku-2001). The wind diredtion standard deviation increases by 1 degree (from 16 to 17 deg). Figure 8 shows the directional histograms with NCEP GDAS and QSCAT-1 winds for the 8-10 m/s bin. Plots at other wind speed bins show similar agreement. In 30 orbits, too few data exist above 14 m/s to determine any problems with the GMF. We expect to process a larger data set in the next few months.

One case study is plotted below for both Ku-2001 winds and KuNCEP. This high wind example of rain-free winds behind a strong Pacific front demonstrates the lower winds obtained with KuNCEP. U.Wash pressure model shows maximum winds of 45 m/s in this storm.