4D.2 TROPICAL CYCLONE WIND RETRIEVALS FROM THE ADVANCED MICROWAVE SOUNDING UNIT (AMSU): APPLICATION TO SURFACE WIND ANALYSIS

Kotaro Bessho*
Meteorological Research Institute, Tsukuba, Japan
Mark DeMaria
NOAA/NESDIS, Fort Collins, Colorado
John A. Knaff
CIRA/Colorado State University, Fort Collins, Colorado
Julie L. Demuth
National Academy of Sciences, Washington, DC

1. INTRODUCTION

The utility of satellite-based microwave sounders for estimating tropical cyclone (TC) intensity and outer wind field was first discussed in Kidder et al. (1978). They showed a statistical method for estimating outer surface wind speed and Minimum Sea Level Pressure (MSLP) from 55.45 GHz channel. Their basic methodology for estimating MSLP has been utilized and improved by several researchers and by using Microwave Sounding Unit (MSU) and the Advanced MSU (AMSU) (see Demuth et al. (2004) for discussion of these).

Instead of using various statistical relationships between AMSU brightness temperatures and TC MSLP as others have, Demuth et al. (2004) chose another approach. They utilized a statistical temperature retrieval to provide input to a physical model (2-d gradient balance) that estimates winds and pressures associated with the TC as based upon AMSU brightness temperatures. A regression model is then utilized to predict TC intensity (MSLP and maximum winds) and radii of significant winds based upon these physically retrieved quantities.

Building on the work of Demuth et al. (2004), this paper discusses a new technique for estimating the surface winds in a TC. Section 2 discusses how three dimensional wind structures are calculated from AMSU data. The next section discusses the comparison of the AMSU-based wind field at 850 hPa with the surface wind fields derived from QuikSCAT. Based on these comparisons, an algorithm for estimating the surface wind field retrieval from the AMSU data is presented. Finally, the retrieval algorithm is validated versus QuikSCAT in two observational cases in Section 5.

2. DDK ALGORITHM AND DATA

In this paper, the algorithm discribed in Demuth et al. (2004), or the DDK algorithm, is used to the estimate the atmospheric environment around TC from AMSU brightness temperatures. The DDK algorithm retrieves atmospheric temperature and geopotential height from AMSU brightness temperature in and around TC with hydrometeor corrections. From these atmospheric temperature and geopotential height fields, three dimensional wind fields (850 hPa to 100 hPa) are estimated by solving the non-linear balance equation using a variational method.

AMSU brightness temperature data from NOAA 15 and 16 during 1999-2002 were used for this study. QuikSCAT sea surface wind data from Remote Sensing Systems were also used for a comparison with AMSU-derived wind field. Fifty-seven cases associated with North Atlantic Ocean and east Pacific Ocean TCs were chosen for this comparison. AMSU and QuikSCAT data were interpolated to a 12^{O} X 12^{O} grid with a 0.2^{O} resolution centered on the TC. These interpolated data were only compared within a radius of 500 km from TC center and when the time differences between two kinds of observations were less than one and a half hours.

3. COMPARISON OF AMSU WIND WITH QUIKSCAT

Figure 1 shows a scatter plots of the wind speeds derived from AMSU at 850 hPa versus those derived from QuikSCAT at the surface. Most of the points in Fig 1 are concentrated along the dotted line showing the nearly linear relationship between AMSU-derived wind speeds at 850 hPa and the surface wind speeds derived from QuikSCAT. Many of the points off a regression are influenced/contaminated by large amounts of cloud liquid water (also retrieved from AMSU) present in the retrieval.

Figure 2 shows dependencies of wind direction difference between the AMSU-derived wind at 850 hPa and the QuikSCAT surface wind as a function of AMSU wind speed. In this figure, the mean and standard deviation of these wind direction differences are binned by AMSU-derived wind speeds every 5 m/s. It is clear from this figure that the biases in the wind direction differences between AMSU and QuikSCAT are a function of AMSU-derived wind speed (e.g., more directional turning occurs at higher wind speeds, etc.).

Using these relationships related wind speed and direction; the surface wind distribution can be retrieved from the 850-hPa AMSU-based wind fields. This new algorithm, referred to as QCOM, adjusts the AMSU wind speed at 850 hPa to surface wind speed using the regression and corrects the AMSU 850-hPa wind directions by subtracting the biases that are a function of wind speed.

4. VALIDATION OF THE QCOM ALGORITHM

QCOM was evaluated in two cases for Hurricanes Floyd (1999) and Michelle (2001). The AMSU wind field at 850 hPa, the corresponding QuikSCAT surface wind and the resulting surface wind field adjusted by QCOM for Hurricane Floyd (1999) are shown in Figures 3,4, and 5, respectively.

**Corresponding auther address:* Kotaro Bessho, Meteorological Research Institute, Tsukuba, Japan, 305-0052; e-mail: kbessho@mri-jma.go.jp

It appears that the QCOM routine produces a wind speed distribution that resembles that of QuikSCAT. Wind directions in QCOM analysis near TC center are also comparable to those from QuikSCAT. However, at greater radii, the QCOM wind directions do not show any improvements. This is because of small vortices that surround the TC in AMSU wind field at 850 hPa – a shortcoming of the AMSU wind retrieval methodology. Similar results were obtained in the Michelle case (not shown here).

5. CONCLUSION

The evaluation of QCOM showed that the algorithm did a good job at adjusting the AMSU wind speeds to surface wind speeds. On other hand, the resulting wind direction estimates were not quite as good suggesting that the bias correction method may have some room for improvement. However, much of the error in direction was the result of the AMSU wind derivation, which may be improved by further refinement of the method used to solve the non-linear balance equation.

Using the results in this paper, horizontal distribution of surface wind in and around TC can be estimated from AMSU brightness temperature data alone. These estimates of surface wind are useful for improving many applications including but not limited to TC warning preparation and initial conditions for numerical prediction of TC.

REFERENCES:

Demuth, J. L., M. DeMaria, J. A. Knaff, and T. H. Vonder Haar, 2004: Validation of an Advanced Microwave Sounding Unit tropical cyclone intensity and size estimation algorithm. *J. App. Meteor.*, **43**,282-296

Kidder, S. Q., W. M. Gray, and T. H. Vonder Haar, 1978: Estimating tropical cyclone central pressure and outer winds from satellite microwave data. *Mon. Wea. Rev.*, **106**, 1458-1464

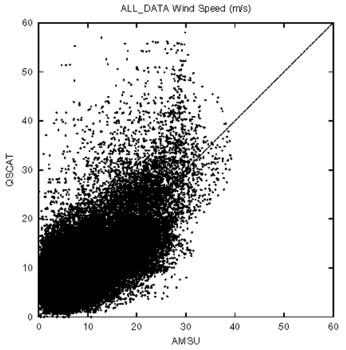

Figure 1. Scatter diagrams of AMSU wind versus QuikSCAT.

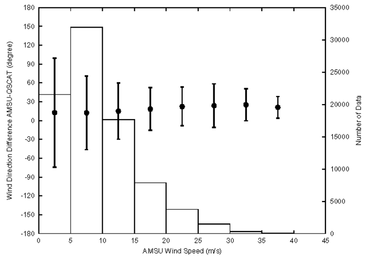

Figure 2. Histogram of total grid numbers, dots of mean, and bars of standard deviation for differences of wind directions.

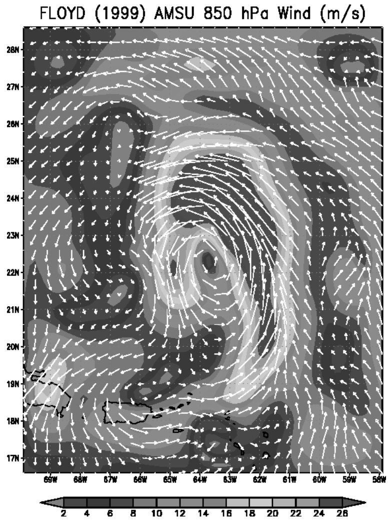

Figure 3. Wind field of AMSU at 850 hPa for Floyd.

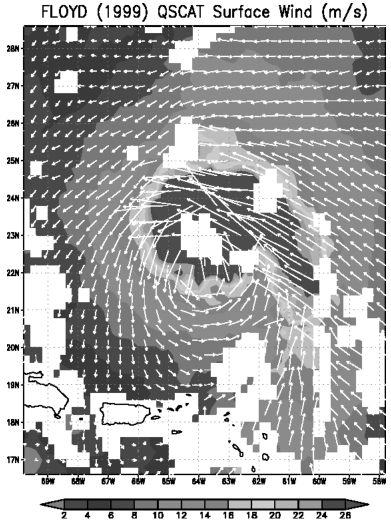

Figure 4. Same as Figure 3, except for QuikSCAT at surface.

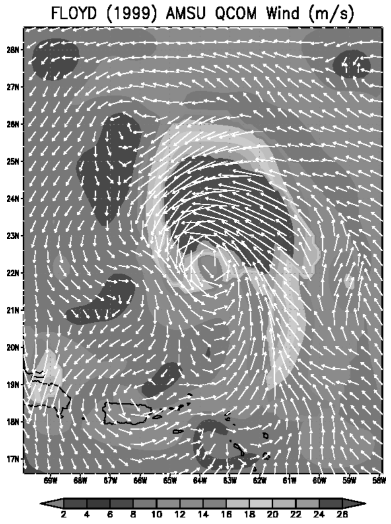

Figure 5. Same as Figure 3, except for QCOM at surface.