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Tropical Cyclone Environmental Vertical Wind Shear Analysis Using a Microwave Sounder

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1. INTRODUCTION

The area averaged vertical wind shear (VWS) imposed on a tropical cyclone circulation has an important influence on its intensity. Numerical model analyses and model fields that optimize satellite motion wind vector data have been used to quantify and measure the VWS forcing. An alternate method of tropical cyclone VWS analysis uses the Advanced Microwave Sounder Unit (AMSU) on the NOAA polar orbiting satellites. The AMSU antenna temperatures are used to retrieve temperature soundings from which the mass field is inferred. The three-dimensional wind field can then be estimated by solving the nonlinear balance equation from the retrieved height fields. A tropical cyclone centered circle is then used to area average the winds for environmental VWS computations.

2. AMSU MEASUREMENTS

The AMSU data swath width (~2300 km) will often provide enough coverage to observe a tropical cyclone (TC) and its immediate environment with a single orbital pass. AMSU-based TC products and data were collected in real-time by an operational TC intensity and structure algorithm (Demuth et al. 2006) run at the National Centers for Environmental Prediction (NCEP). Vertical profiles of temperature and columnar Total Precipitable Water (TPW) and Cloud Liquid Water (CLW) are retrieved from the AMSU antenna temperatures for each field of view following a standard procedure described in Demuth et al. (2004). A routine is then applied to define the TC-centered mass field. From this analysis under assumption of balanced flow, the three-dimensional wind field is computed following Bessho et al. (2006). The VWS is computed for each case by using the average wind within a TC-centered 600 km radius circle, and taking the vector difference of the 200 and 850-hPa levels. For this study Atlantic tropical cyclones during the period 2004-2007 were analyzed and provided a total of 67 hurricane and tropical storm cases.

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3. NCEP GFS MODEL COMPUTATIONS

NCEP Global Forecast System (GFS) Model analyses at 6-h intervals were used to evaluate the independent AMSU measurements of VWS. For each AMSU computation, the following data were compiled: storm number, date/time, Best Track TC center latitude/longitude, center's distance to land, and Best Track maximum wind speed. To complete the data set, the NCEP GFS winds along with the 6-h Best Track center locations, gave computations of 200-850-hPa VWS within a R=600 km circle. The 6-h NCEP GFS-based VWS quantities were interpolated to the time of the AMSU passes to give 1453 paired observations of VWS. Figure 1 is a scatter plot of AMSU-based versus NCEP GFS-based VWS calculations along with the best fit and correlation statistics. There is reasonably good agreement between the two independent computations over a large range of VWS values.

4. COMPARISONS

Figure 2 shows an example of the VWS associated with Hurricane Philippe (2005). The VWS increases rapidly from very low values late on September 17 to quite high vertical shear by late on September 19. This shear ultimately limited Philippe in its development to a minimal Category 1 hurricane.

Another example, Hurricane Wilma in Figure 3, was associated with low VWS during its entire lifetime except during later periods when it was accelerating to the northeast. There is good agreement between the AMSU and GFS in the observed vertical shear changes, even though the values are quite small.

Hurricane Helene (2006) (Fig. 4) was well observed by AMSU and also showed excellent agreement with the GFS vertical shear. Note that Figure 4 includes more data points than in Figs. 2-3, including some cases with two AMSU values at the same time. An additional AMSU VWS computation was included with some cases when an updated center location was also used. Also, for the 2006 cases, an additional satellite (NOAA-18) with AMSU became available.

5. DISCUSSION

There was a problem encountered with the AMSU measurements, in some situations when the tropical cyclone is located close to a land mass. This is because the AMSU retrieval method cannot retrieve CLW and TPW over land. Because CLW is used to improve temperature retrievals that are adversely affected by attenuation (i.e. rain) and ice scattering associated with deep convective clouds, the final temperature field can contain errors large enough to significantly impact the wind field estimates. Those situations with which a large proportion of the R=600 km computation circle is over land, will likely not give reliable AMSU-based VWS measurements.

Despite this drawback, our comparison of the AMSU and GFS observations suggest that the AMSU may indeed be useful in providing independent operational vertical wind shear observations. Even if there is no improvement over the numerical model analyses in capturing the important changes, the frequency and timeliness of the observations may be improved.

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REFERENCES:

Bessho, K., M. DeMaria, J.A. Knaff, 2006: Tropical Cyclone Wind Retrievals from the Advanced Microwave Sounder Unit (AMSU): Application to Surface Wind Analysis. *J. of Applied Meteorology.* **45**, 399 - 415**.**

Demuth, J., M. DeMaria, and J.A. Knaff, 2006: Improvement of Advanced Microwave Sounding Unit Tropical Cyclone Intensity and Size Estimation Algorithms, *Journal of Applied Meteorology and Climatology*, **45**, 1573–1581.

____, ____, ____, and T. H. Vonder Haar, 2004: Validation of an advanced microwave sounder unit (AMSU) tropical cyclone intensity and size estimation algorithm, *J. App. Met.*, **43**, 282-296.

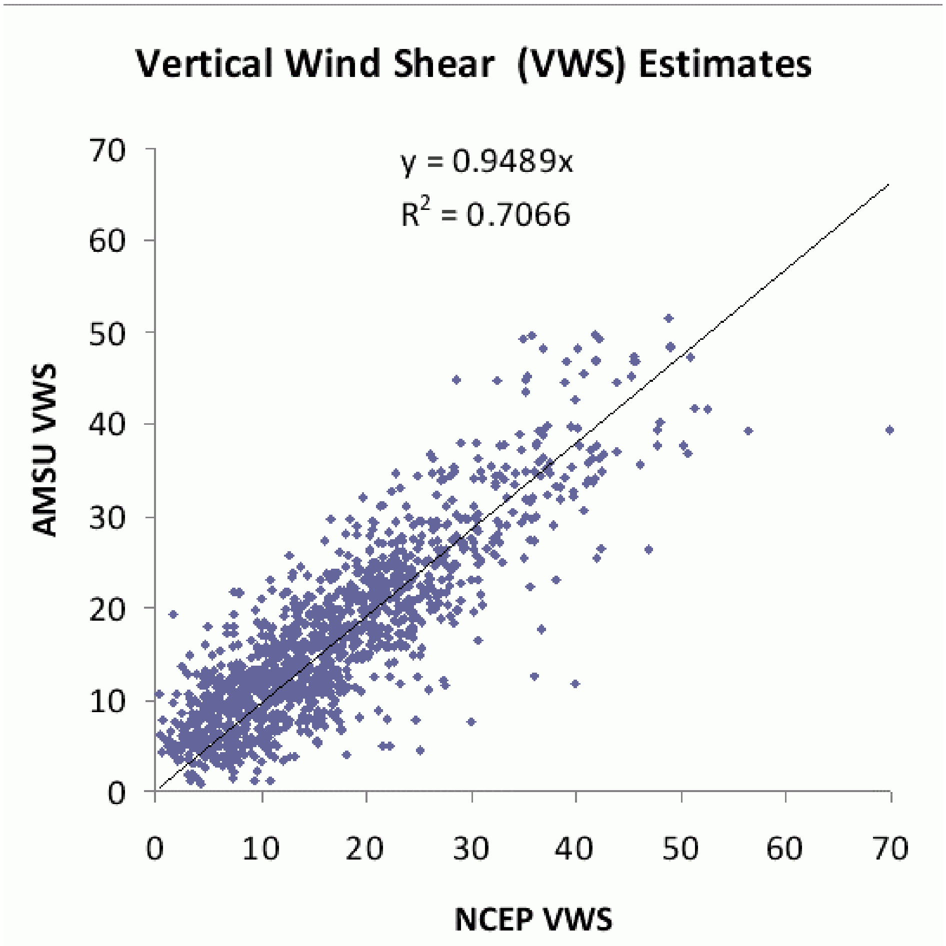

Figure 1: Scatter plot of AMSU versus NCEP GFS VWS speed (kt).

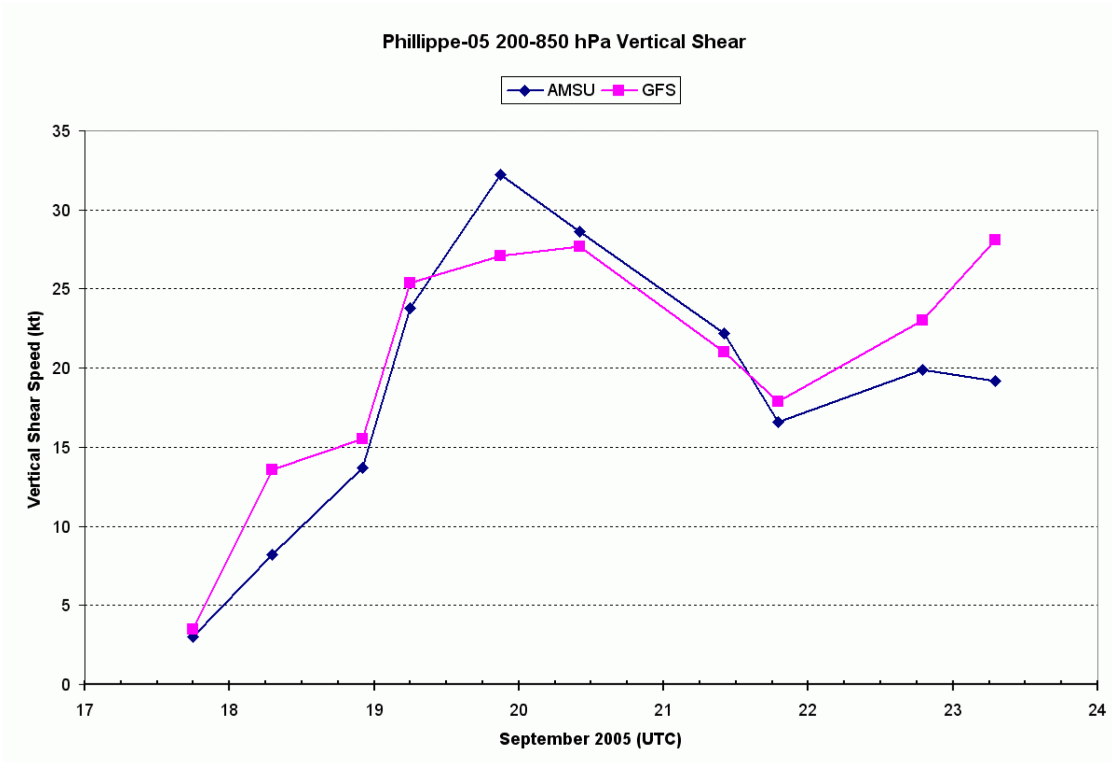

Figure 2. AMSU and NCEP GFS vertical wind shear speed (kt) with Hurricane Phillippe (2005).

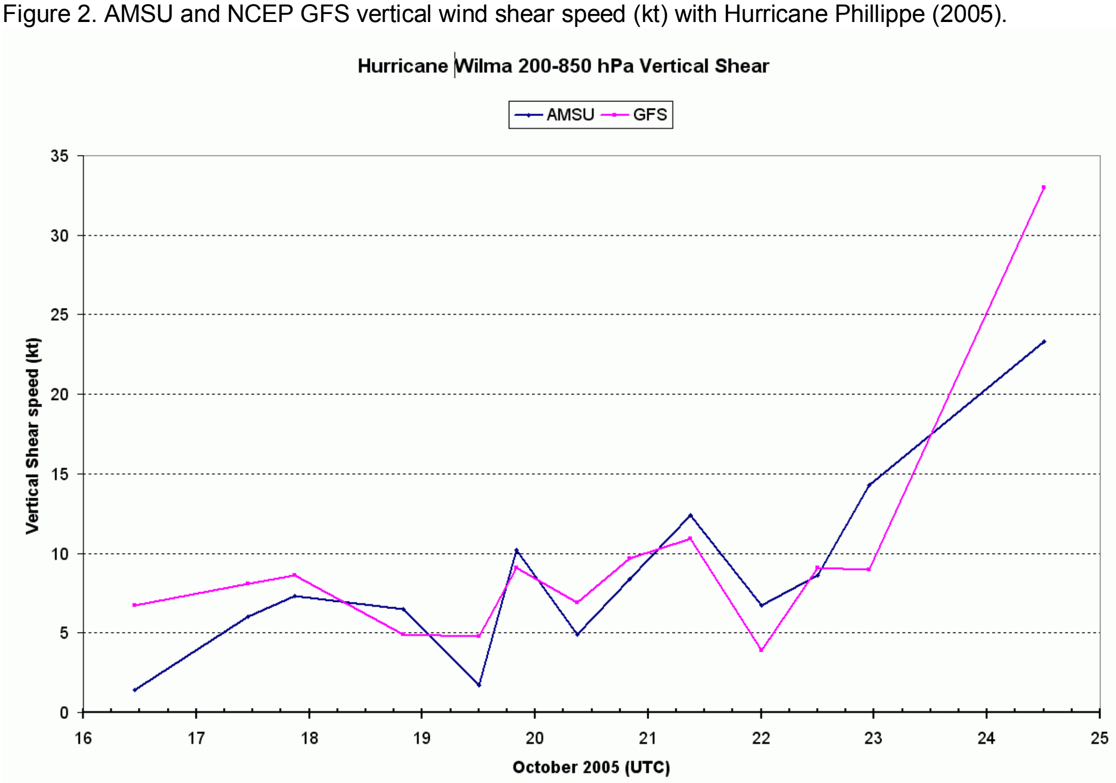

Figure 3. AMSU and NCEP GFS vertical wind shear speed (kt) with Hurricane Wilma (2005).

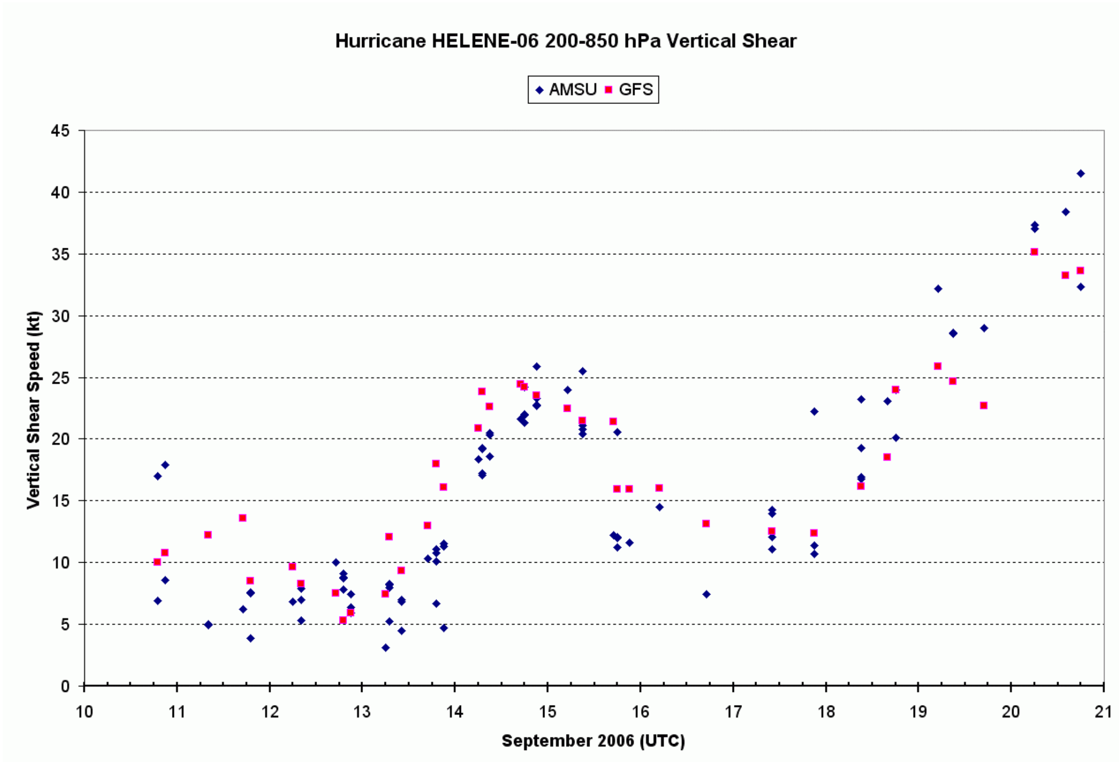

Figure 4. AMSU and NCEP GFS vertical wind shear speed (kt) with Hurricane Helene (2006)