15B.4 PRELIMINARY ASSESSMENT OF THE UTILITY OF ASCAT OCEAN SURFACE VECTOR WIND (OSVW) RETRIEVALS AT THE TROPICAL PREDICTION CENTER/NATIONAL HURRICANE CENTER (TPC/NHC)

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1. INTRODUCTION

Europe's first operational polar-orbiting meteorological satellite system, METOP-A, was successfully launched on October 19, 2006. The METOP-A satellite carries as part of its payload the Advanced Scatterometer (ASCAT). ASCAT is the first officially operational active microwave sensor capable of providing near-surface ocean wind field measurements. ASCAT is designed to retrieve surface wind speed and direction over the oceans, and it builds upon the experience gained from the C-band scatterometers onboard the European ERS-1 and ERS-2 research satellites. ASCAT therefore represents a successful transition of a research capability to operations.

Tropical Prediction Center/National Hurricane Center (TPC/NHC) forecasters have had access to OSVW retrievals from the NASA QuikSCAT, a research satellite launched in 1999, for several years. QuikSCAT data with 25 km horizontal resolution have been available since the fall of 1999, with higher-resolution (12.5 km) data available since January 2003. The forecasters have become quite familiar with the strengths and weaknesses of QuikSCAT during the past several years. To determine the particular strengths and weaknesses of ASCAT and to assess its utility at TPC/NHC, an evaluation of the ASCAT data has begun. The evaluation to date has been inherently preliminary.

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2. DATA SOURCES AND STUDY METHODOLOGY

OSVW retrievals from the ASCAT instrument have been available in near real time in operational National Center AWIPS (N-AWIPS) workstations at TPC/NHC since 27 June 2007. The ASCAT retrievals are obtained at TPC/NHC via NOAA/NESDIS, which processes the raw data and runs the retrieval algorithms. The N-AWIPS display of ASCAT data is similar to that of the existing data from QuikSCAT, with the differences arising due to fundamental differences between the two instruments.

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ASCAT capabilities differ from QuikSCAT, due to ASCAT's narrower data swaths, coarser resolution (and therefore lesser sensitivity to high wind speeds), and reduced sensitivity to rain. The ASCAT automated wind vector retrievals are available in N-AWIPS at horizontal spacings of 50 and 25-km, about half the resolution of the QuikSCAT retrievals (provided at 25 and 12.5-km spacing). Since the stated true resolution of the ASCAT retrievals is 50 km, the 25-km version is created essentially via horizontal interpolation and is not, actually equivalent to the 25-km QuikSCAT product**.**

The evaluation of ASCAT data for use in tropical cyclone analysis has been less comprehensive, mainly due to initial limitations in data quality and display capabilities, which have been evolving since the data first, became available at TPC/NHC last summer. Preliminary findings, primarily related to ASCAT coverage issues, are presented next in Section 3.

The Tropical Analysis and Forecast Branch (TAFB) of the TPC/NHC has marine forecast responsibility over the Tropical North Atlantic and eastern North Pacific oceans. An operational comparison between QuikSCAT and ASCAT data was conducted by TAFB forecasters during the period from 25 October 2007 through 8 February 2008. Forecasters were given an evaluation sheet to compare QuikSCAT and ASCAT wind retrievals for significant wind events occurring at several fixed locations in the eastern North Pacific basin (including the Gulf of Tehuantepec and Gulf of Papagayo) and the Atlantic basin (including the Gulf of Mexico and Caribbean Sea). Forecasters filled out the evaluation form during each operational shift, or three times per day. Forecasters noted the pass times for both scatterometer data sets and whether a pass missed the area of concern. In addition, forecasters provided the maximum surface wind vector observed in the 50 and 25-km ASCAT data and the 25 and 12.5 km QuikSCAT data. Results of this comparison are presented in Section 4.

3. RESULTS – TROPICAL CYCLONES

The narrow swaths of ASCAT result in significant coverage limitations that are acute at the tropical and subtropical latitudes that comprise TPC/NHC's area of responsibility, where the gaps between swaths from consecutive orbits are the largest. In order to quantify the lesser coverage of ASCAT as compared to QuikSCAT, Fig. 1 below compares the percentage of tropical cyclone centers in the Atlantic basin during 2007 that were sampled by QuikSCAT versus the percentage sampled by ASCAT (this analysis also includes the period prior to when the data became displayable in N-AWIPS). Overall, QuikSCAT sampled more than twice the number of cyclone centers than did ASCAT.

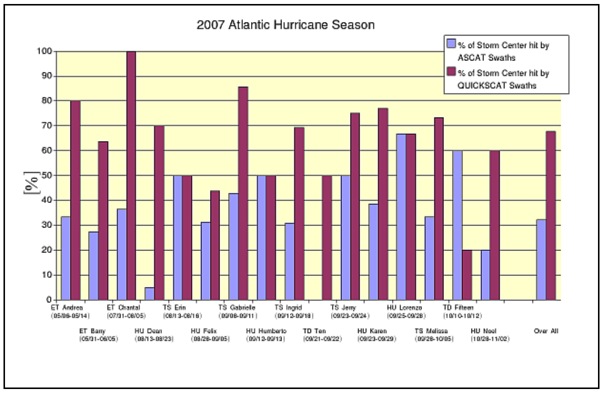

Figure 1. Comparison of the percentage of tropical cyclone circulation centers in the Atlantic basin during 2007 (on a storm-by-storm basis and overall) that were sampled by QuikSCAT (red bars) and ASCAT (blue bars), relative to the maximum possible number of overpasses.

Even when ASCAT did pass over a tropical cyclone during the 2007 hurricane season, it was not possible to assess the ability of ASCAT to provide tropical cyclone center location "fixes" or intensity (maximum sustained surface wind) estimates. This limitation was due to the lack of ability via N-AWIPS (prior to early December 2007) to display ASCAT data in two ways that have proven very important in utilizing QuikSCAT for these purposes. First, N-AWIPS could not display retrieved vectors that failed a quality control check before the data were transmitted to TPC/NHC, which was often triggered near the centers of tropical cyclones. This made obtaining reliable center "fixes" and intensity estimates impossible. Second, not until early December could we view the two ASCAT directional ambiguities at each retrieval location, which must be analyzed in order to maximize the reliability of a position and intensity estimate. Tropical Storm Olga did form after these capabilities became available, but its proximity to the landmasses of the Greater Antilles prohibited the use of ASCAT for center fixing. It is not yet clear if the ASCAT wind speed estimates in a maximum wind band well north of Olga's center were accurate. Evaluation of ASCAT throughout the 2008 hurricane season, with these newer display capabilities in place, should result in a more informative assessment of the utility of ASCAT in tropical cyclone analysis. It is already clear, however, that the lesser coverage provided by ASCAT as compared to QuikSCAT will significantly limit its utility in tropical cyclone analysis.

4. RESULTS – MARINE FORECASTING

The evaluation forms described earlier were filled out by both the Atlantic and eastern Pacific forecasters in TAFB, and the results were computed separately for each basin. For the eastern North Pacific areas of responsibility, there were a total of 95 evaluated passes noted on the evaluation forms (combining all passes from both the QuikSCAT and ASCAT scatterometers. 68 of these passes were near or over the Gulf of Tehuantepec and 27 passes were near or over the Gulf of Papagayo. It is in these regions near the coast of Central America that some of the most hazardous marine weather conditions in the eastern North Pacific area are found during the fall and winter months. A pass was considered a "miss" if it did not capture the geographic area of expected peak winds in either the Gulf of Tehuantepec or the Gulf of Papagayo. The comparison reveals a marked difference in the data coverage provided by the two scatterometers. In the case of QuikSCAT, there were a total of 12 missed QuikSCAT passes out of 68 passes in the vicinity of the Gulf of Tehuantepec, or about 18 percent of the total number of passes evaluated. The number of missing ASCAT passes was much higher in the Gulf of Tehuantepec, with a total of 28 missing passes or about 41 percent of the total number of passes evaluated. The ratio of missed ASCAT passes to QuikSCAT passes over the Gulf of Tehuantepec during the evaluation period was about 2.33:1.

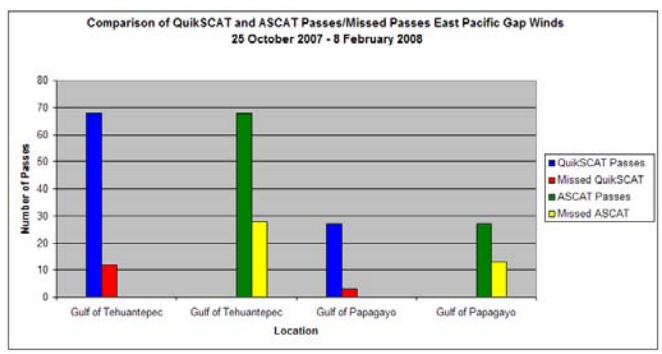

Figure 2. The number of total QuikSCAT and ASCAT passes and missed passes in the Gulf of Tehuantepec and Gulf of Papagayo regions from 25 October 2007 through 8 February 2008.

For the Gulf of Papagayo region, there were a total of 3 missed QuikSCAT passes (about 11 percent) out of 27 passes evaluated. The number of missed ASCAT passes (13) in the Gulf of Papagayo was much higher and represented about 48 percent of the total number of passes evaluated. The ratio of missed ASCAT to QuikSCAT passes in the Gulf of Papagayo was about 4.33:1 (Fig. 2), higher than for the Gulf of Tehuantepec.

In the Atlantic basin, there were a total of 134 evaluated passes combined from the QuikSCAT and ASCAT scatterometers. 66 passes were evaluated in the Gulf of Mexico and 68 passes in the Caribbean Sea. There was an even larger difference in the number of missing passes between the two scatterometers in the Atlantic basin as observed in the eastern Pacific cases. There were only two missed QuikSCAT passes (or about 3 percent) out of 66 over the Gulf of Mexico. The number of missed ASCAT passes was much higher (25, or about 38% of the total number of passes evaluated). The ratio of missed ASCAT passes to QuikSCAT passes over the Gulf of Mexico was about 12.5:1. The values for the number of missed passes in Caribbean Sea were similar. Out of 68 passes evaluated, there were only 3 missed QuikSCAT passes (about 4 per cent of the total) and 19 missed ASCAT passes (about 28 percent of the total). The ratio of missed ASCAT passes to QuikSCAT passes over the Caribbean Sea was 6.33:1 (Fig. 3), or about half the value for the Gulf of Mexico.

As compared to the eastern Pacific cases, the much larger areal extent of a majority of the wind events in the Gulf of Mexico and the Caribbean Sea greatly reduced the chances for a missed pass by the QuikSCAT scatterometer. This was not the case for ASCAT, however, due to the much narrower swath widths, which experienced only slightly lesser miss rates in the Atlantic cases. These results highlight the significant limitations in conducting synoptic-scale surface wind analyses with ASCAT due to its large mid-swath data gap.

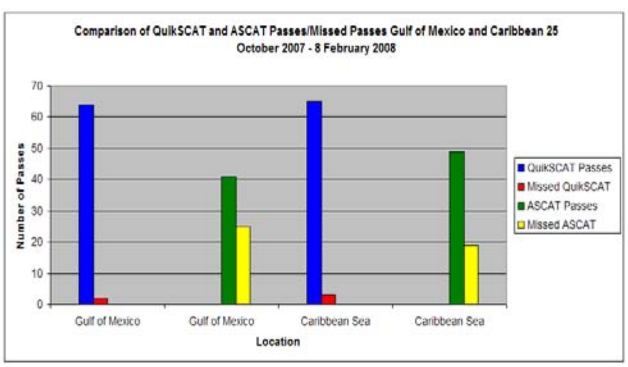

Figure 3. The number of missed QuikSCAT and ASCAT passes relative to the total number evaluated for the Gulf of Mexico and Caribbean Sea from 25 Oct 2007 - 8 Feb 2008.

In addition to coverage comparisons, the magnitudes of the retrieved wind speeds from the two instruments were compared. The peak wind speed retrievals from ASCAT data with 50-km spacing were on average 3.86 kt lower than the 25-km-spacing QuikSCAT winds in the Gulf of Tehuantepec events analyzed. The low bias was similar (4.03 kt) for the 25-km ASCAT winds as compared to the 12.5-km QuikSCAT winds. In the Gulf of Papagayo, where the retrieved wind speeds were generally weaker, the low bias of the 50-km ASCAT winds versus the 25-km QuikSCAT winds was only 1.50 kt. The low bias in ASCAT was similar (1.42 kt) in comparing the higher-resolution data from each instrument (25 km ASCAT and 12.5 km QuikSCAT).

A comparison was also done between the two 25-km-resolution data sets from QuikSCAT and ASCAT. The results reveal negligible overall differences between the ASCAT and QuikSCAT wind speeds, for both the Gulf of Tehuantepec and the Gulf of Papagayo, where the ASCAT winds averaged only .07 kt and 0.92 kt weaker, respectively. Differences become more apparent, however, when restricting the comparison to stronger wind speeds. Fig. 4 is an X-Y scatter plot of the comparison of the 25-km wind retrievals from both scatterometers in the eastern Pacific gap wind areas. This result suggests that ASCAT and QuikSCAT data at the same horizontal spacing are quite comparable in Tehuantepec events for wind speeds of about 20 kt or less, but that QuikSCAT is more sensitive to higher wind speeds as indicated by the low bias exhibited by the 25 km ASCAT data for winds above about 20 kt. This bias is even larger when comparing the higher-resolution 12.5 km QuikSCAT data to the 25 km ASCAT data.

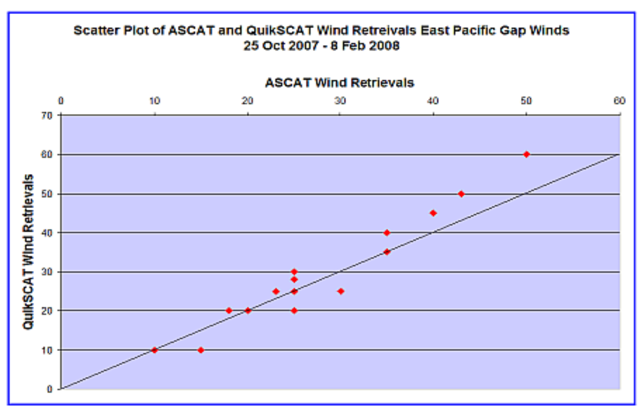

Figure 4. Scatter plot of ASCAT and QuikSCAT 25 km resolution wind retrievals for the East Pacific gap wind areas from 25 Oct 2007 - 8 Feb 2008. Note: Some points represent more than one set of data.

Gulf of Tehuantepec gap wind events are among the most significant wind events in TAFB's eastern Pacific marine forecast areas of responsibility. Climatological studies (Cobb et al. 2003) indicate that an average of 16 gap wind events each year reach at least gale force (34 kt or greater). An average of six events per year reach storm force or greater (48 kt or greater). The low bias exhibited by the ASCAT scatterometer increases in magnitude for winds stronger than about 20-25 kt and is much more apparent for winds of gale and storm force.

Additional evidence of a low bias of ASCAT in comparison to QuikSCAT for strong wind events was found in an evaluation of high-resolution data over the Gulf of Tehuantepec during the 2007-2008 cool season. Seven storm-force wind events were detected by higher-resolution (12.5 km) QuikSCAT data. The higher-resolution (25 km) ASCAT data were only able to capture one storm event with 50-kt retrieved winds. The corresponding higher-resolution QuikSCAT data indicated much stronger, hurricane-force winds of 70 kt, a 20 kt difference that changes the category of warning issued by TAFB. Overall, the results presented in this section indicate that QuikSCAT clearly provides an advantage over ASCAT in detecting the peak winds in these gap wind events due to the higher resolution of the data, larger areal coverage and the overall low bias exhibited by ASCAT in areas of higher winds.

4. SUMMARY AND CONCLUSIONS

TPC/NHC's evaluation to date of the utility of ASCAT in its operations yields the following key preliminary findings:

1. ASCAT provides a new, additional source of OSVW data in the large and mostly data void ocean regions within TPC's areas of responsibility (AOR), and the data will be utilized operationally to the fullest extent possible. TPC's tropical cyclone and marine forecasters are now routinely viewing the data on a daily basis in the course of their operational shifts.

2. The impacts of ASCAT on TPC/NHC operations are not, and are not expected to ever be, as significant as QuikSCAT because of the substantially lesser data coverage arising from the narrower ASCAT swaths. The frequency at which ASCAT data do not sample weather systems of interest in the TPC AOR is the most significant limitation in using the data for operational analysis and forecasting at TPC.

3. A preliminary evaluation indicates that ASCAT appears to reliably retrieve surface wind speeds of about 25-30 kt or less (below tropical storm or gale force) in all weather conditions in the TPC AOR (although we cannot yet confirm this for tropical cyclones due to a data gap near cyclone centers prior to early December 2007). This performance represents an improvement over QuikSCAT which suffers from artificially rain-inflated retrievals at lower wind speeds in areas of rain.

4. ASCAT has a low wind speed bias, which increases with increasing wind speed, for wind speeds exceeding about 25-30 kt in the TPC AOR. This performance generally represents a degradation in capability compared to QuikSCAT.

5. A thorough and meaningful evaluation of ASCAT's retrieval performance in tropical cyclones was not possible during the 2007 hurricane season, due to the lack of displayable ASCAT wind vectors and directional ambiguities in N-AWIPS near the centers of tropical cyclones, an additional limitation of ASCAT compared to QuikSCAT.

6. REFERENCES

Cobb, H. D. III, Daniel P. Brown and Robert Molleda, 2003: Use of QuikSCAT Imagery in the Diagnosis and Detection of Gulf of Tehuantepec Wind Events 1999-2002. Preprints 83rd AMS Annual Meeting, p. 410.