P1.37 Comparisons and Evaluations between the Oceansat-2 (OSCAT) and ASCAT Scatterometers over Tropical Cyclones Analysis

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1. Introduction

This paper summarizes the characteristics of the current suite of satellite-based ocean surface wind vector detectors available for near real-time use in tropical cyclone (TC) analysis. The loss of the QuikSCAT instrument in 2009 and now the recent loss of the Oceansat-2 (OSCAT) sensor (March, 2014) has made it more important than ever to understand the capabilities and characteristics of each of the remaining global ocean surface wind sensors, specifically the two European Advanced Scatterometers A&B (ASCAT) and the US Navy's WindSAT passive sensor. This is vital for future planning of new instruments and the development of robust procedures to take advantage of the unique capabilities of each new wind sensor as it becomes available for near real-time TC analysis.

2. GOALS for Satellite-Based Ocean Surface wind Sensors

The success of the 10-year QuikSCAT program has shown how useful these sensors can be to obtain near real-time surface data over remotely tracking TCs that were near to impossible to obtain in the past over much of the globe's tropical oceans, except in areas of aircraft reconnaissance and Doppler radar coverage. And even in these areas, data were subject to limited tracks and coverage, usually as the TCs approached the coast. The QuikSCAT data provided forecasters with the ability to accurately identify tropical cyclone center positions, determine outer wind structure and provide a minimum (at least) value of maximum intensity. Of course, not everything was straight forward, and some more indirect procedures needed to be developed…and learned. Use of not only the wind vectors, but also the ambiguities, the normalized radar cross-sections (NRCS) and the many possible overlays of both traditional IR/Vis imagery and the various microwave images were often required in order for the analyst to understand the effects of rain contamination, data resolution and the tuning of the retrieval algorithm. A summary for comparison of the most recent ocean surface wind vector sensors is shown in Table 1.

3. Coverage of Satellite-Based Ocean Surface wind Sensors

With the loss of the QuikSCAT sensor, daily coverage was greatly reduced from approximately 90% of the tropical oceans to less than half. The addition of a second ASCAT sensor and the wide field of view of the

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Sensor/Sat	QuikSCAT	ASCAT A/B	WindSAT	OSCAT-2
TYPE	Active	Active	Passive	Active
AGENCY/re-Processed	JPL/NESDIS	ESA/KNMI	US Navy	India/KNMI
LAUNCH/END	1999/Nov09(end)	2006/12	2003	2009/Mar14(end)
SWATH (KM)	1800	2 X 550	~1100	1836
GAP (KM)	0	600	N/A	N/A
RESOLUTION (KM)	25 (12.5)	50 (25)	25	50 (25)
SPEED (KT)	4-80	5-60	10-40	5-60?
FREQ (GHz)	13.4 (Ku-Band)	5.6 (C-Band)	6.8	13.5(Ku-Band)
COVERAGE (90%)	1 Day	~1 Days (w/two)	~2 Days	~1 Days
ASCND NODE (LST)	600	2200	1800	2400

Table1. Ocean surface wind sensors in orbit

OSCAT sensor (Fig 1) temporarily brought back the old coverage. However, as noted in Edson (2010), the Ku-band frequency of the OSCAT, also brought back the concern for rain sensitivity as it was for the QuikSCAT instrument. The addition of the second ASCAT sensor, at least brought another C-Band instrument and its less sensitivity to moderate to heavy rain situations (unlike the existing, but wider WindSAT, a passive microwave sensor, which is extremely vulnerable to signal interference in even light rain situations). One disappointment of the second ASCAT is that it added only an additional 100km coverage to each orbital path. On the other hand, it does provide for better redundancy to check for suspected measurements, especially in rain, and as a backup in case one instrument goes down.

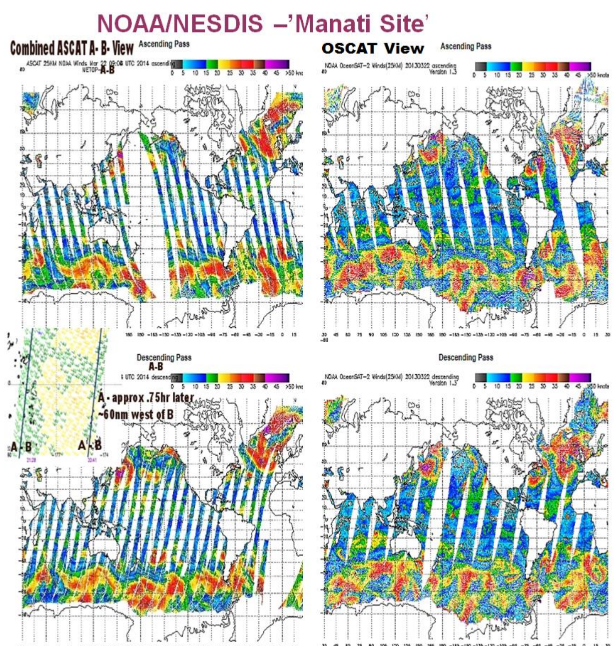

Fig. 1. Coverage of the combined ASCAT A and ASCAT B sensors as compared to the now ex-OSCAT sensor.

4. Types of Data and Data Displays

Ocean surface wind vector measurements are available in a variety of data displays, which includes the wind vectors, the ambiguities for each vector, and a Normalized Radar Cross-section of the data (which basically shows the raw amplitude of the σ_o signal). In addition, organizations such as the BYU Microwave Earth Remote Sensing (MERS) laboratory have developed for both the ASCAT and OSCAT, high resolution depictions which produce noisier data but at resolutions of around 6km. These have proven to be very useful for depicting structure and are less sensitive to center positioning accuracies as in the wind field. Fig 2 shows the various displays along with a comparison 85h TRMM image over Typhoon Fitow near Okinawa.

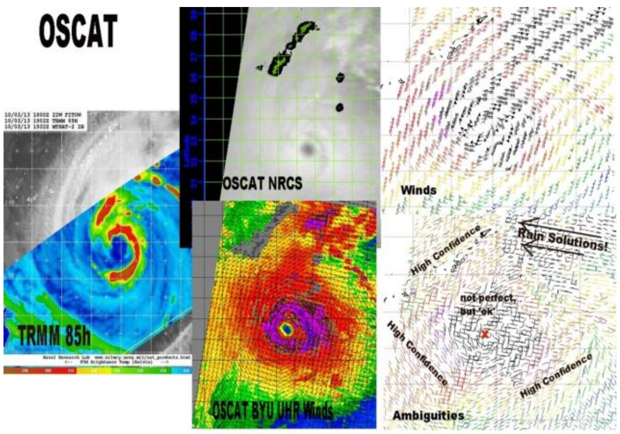

Fig 2. Four types of OSCAT scatterometer data used to evaluate tropical include surface wind data plus an 85h TRMM image for comparison for Typhoon Fitow (22W). Similar views are available with the ASCAT data.

5. Comparisons and Evaluations over Tropical Cyclones

The key to evaluating new sensor measurements in near real-time is by obtaining regular, consistent data to analyze. Getting data that is sometimes good and sometimes bad leads to low confidence and is less likely to be used by the forecaster with time restrictions and standard procedures for what (he) thinks are more reliable and/or consistent. After two years of examining OSCAT data, it appears that the developers were still trying to work out solutions: ambiguities were not always reliable and there seemed to be an overabundance of rain contaminated solutions. The ASCAT data, on the other hand, appears to have improved over this same period of time. Winds have become more reliable at higher winds speeds with new retrieval techniques and the ambiguity displays clearly depict the good data from the 'less reliable data'…something a forecaster wants. Fig 3 shows an example of where OSCAT data clearly needed help with the model NWP to select the proper wind solutions. Figs 4 and 5 show excellent depictions by ASCAT for an intense typhoon and also for one undergoing extratropical transition. In both situations, center positioning and outer wind structure are significant goals (max intensities would be expected to be less

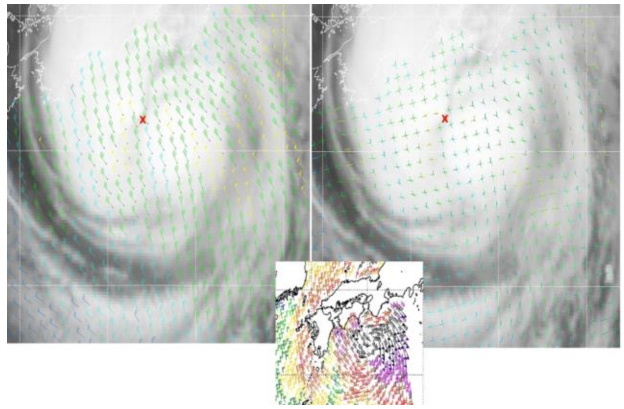

Fig 3. Example of an OSCAT depiction of Typhoon Man-Yi (16W) approaching Japan. In this case, the two larger images show the wind and ambiguity fields without an NWP bogus. The smaller image with a nudge from the GFS depicts the circulation, but gives little confidence to the solution if an accurate NWP presentation had not been available.

reliable due to resolution and strong gradient considerations in these systems…although not too bad in this case).

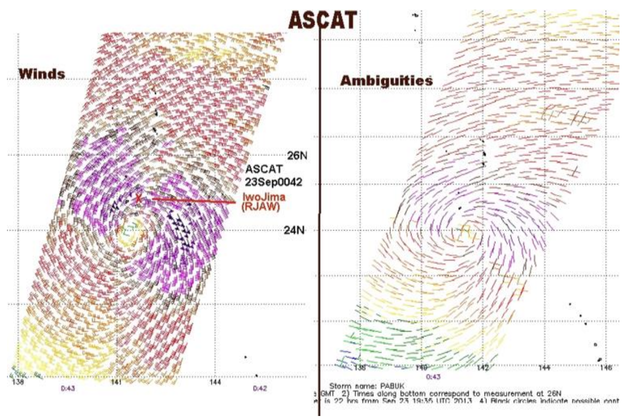

Fig 4. ASCAT depiction of Typhoon Pabuk (19W) approaching Iwo Jima. Note the dominance of two-solution ambiguities (straight line vectors moving out from a center point) depicting reliable wind directions and winds close to that of the island station.

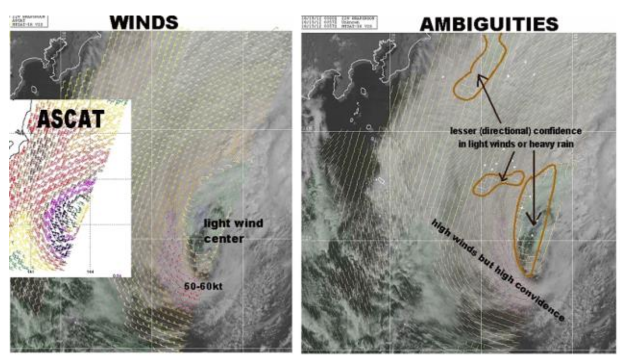

Fig 5. ASCAT solution for Typhoon Prapiroon (22W) in the process of becoming extratropical southeast of Japan. The characteristic elongated light wind center and the horseshoe-like depiction of maximum winds are easily seen.

6. Integrated Approach to Analysis

In Fig 6 and Fig 7 examples are given to show how scatterometer data can aid in the use of the IR Dvorak intensity technique, which can be difficult to perform when the center position (or positions) is uncertain.

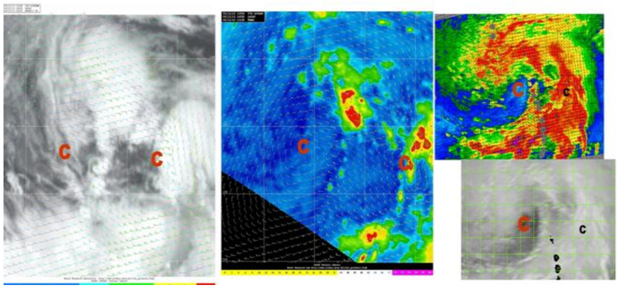

Fig 6. Development of Typhoon ManYi (16W) within a monsoon gyre. This is typically very difficult to evaluate with just the traditional Dvorak Intensity technique as there may be multiple center positions and usually the existing wind field cannot be properly interpreted with IR imagery, alone.

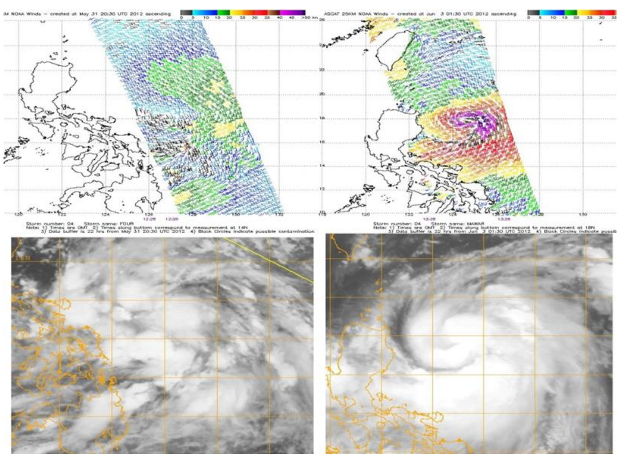

Fig 7. The 48 hour rapid development of Typhoon Mawar (04W) is typically missed and ends up being 'low and slow' in the Dvorak technique if scatterometer data (or other microwave data) are not there for further guidance.

7. Future Scatterometer and Capabilities

In some ways we are back where we stood in 2010. However, we at least have two (2) ESA ASCAT scatterometer instruments. We also have better techniques to use these data than we did four years ago. The OSCAT scatterometer was useful while it lasted, but never fulfilled our need to replace the reliable QuikSCAT sensor. Other possible temporary solutions are scheduled to come along, such as the RapidSCAT set to launch with the International Space Station his summer; plus there is hope for a joint effort with Japan (JAXA) and the US (NASA) to develop a Dual Frequency Scatterometer (DFS) and possibly also a JPL-proposed Extended Ocean Vector Wind Mission (XOVWM) scatterometer in the coming years. As discussed in Edson, 2010, we are still in need of a long range plan such as that proposed in 2008 (Jelenak and Chang, 2008) to include such capabilities as:

- The Ability to detect Higher Wind Speeds
- To have Higher Resolution with less 'gaps'
- To be Less Sensitive to Rain (or be able to detect when rainfall is affecting the measurements)
- To have shorter 'refresh' time (minimum 4X/Day)
- To have an Automated Capability to determine the correct Ambiguity Solutions (especially in regards to developing TC circulation centers in the tropics)

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8. REFERENCES

Edson, R.T., M.A. Lander, C.E. Cantrell, J.L Franklin, P.S. Chang and J.D. Hawkins, 2002: Operational use of QuikSCAT over tropical cyclones. Proceedings of the 25th Conference on Hurricanes and Tropical Meteorology, San Diego, CA.

Edson, Roger T., 2004: Tropical Cyclone Analysis Techniques from QuikSCAT NRCS, Wind and Ambiguity Data and Microwave Imagery. The *26th Conference on Hurricanes and Tropical Meteorology*, Miami Beach, FL, Amer.Meteor.Soc., 278-279.

Edson, Roger T., 2010: Life after QuikSCAT…Tropical Cyclone Analysis using Microwave Imagery and Data. The *29th Conference on Hurricanes and Tropical Meteorology*, Tucson, AZ, Amer.Meteor.Soc., PDF_168761. (email: Roger.Edson@noaa.gov)

Jelenak, Z. and P. Chang (Ed); 2008: NOAA Operational Satellite Ocean Surface Vector Winds QuikSCAT Follow-On Mission: User Impact Study Report. Available at: http://manati.orbit.nesdis.noaa.gov/SVW_nextgen/QFO_user_impact_study_final.pdf

Velden, C.S., and Coauthors, 2006: The Dvorak tropical cyclone intensity estimation technique: A satellite-based method that has endured for over 30 years. Bull. Amer. Meteor. Soc., 87, 1195–1210.