P3.17 ANALYSIS OF SUBTROPICAL CYCLONES USING NASA QUIKSCAT DATA

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1. Introduction

Between 04-07 February 2001, a Kona low (a Hawaiian name for subtropical cyclones) developed approximately 500nm northeast of the Hawaiian Islands. This system was tracked by the Air Force Weather Agency (AFWA) Meteorological Satellite (METSAT) Applications Branch using the Hebert / Poteat (H/P) Analysis Method (Hebert/Poteat 1975). Surface wind data from the NASA QuikSCAT satellite was employed operationally to further fine-tune AFWA's manually produced analyses. This presentation will demonstrate the practical utility of NASA QuikSCAT data fields, including examples of subtropical cyclones for other ocean basins. Cross-comparisons will be made between the NASA QuikSCAT wind field and similar data sets from the Defense Meteorological Satellite Program (DMSP) Special Sensor Microwave Imager.

In figure 1, the Kona low is shown. The image is a 1600 UTC infrared shot from the DMSP F13 Satellite Operational Linescan System (OLS). QuikSCAT observations from the 1400 UTC pass (two hours earlier than the DMSP imagery) clearly show the surface circulation. This image served as the primary motivation behind this study, which intends to describe how well the QuikSCAT winds handle the overall structural features of a subtropical cyclone. Because of the characteristic lack of convection near the surface circulation center of subtropical lows, the NASA QuikSCAT SeaWinds sensor has the ability to measure near surface winds with greater accuracy than over the

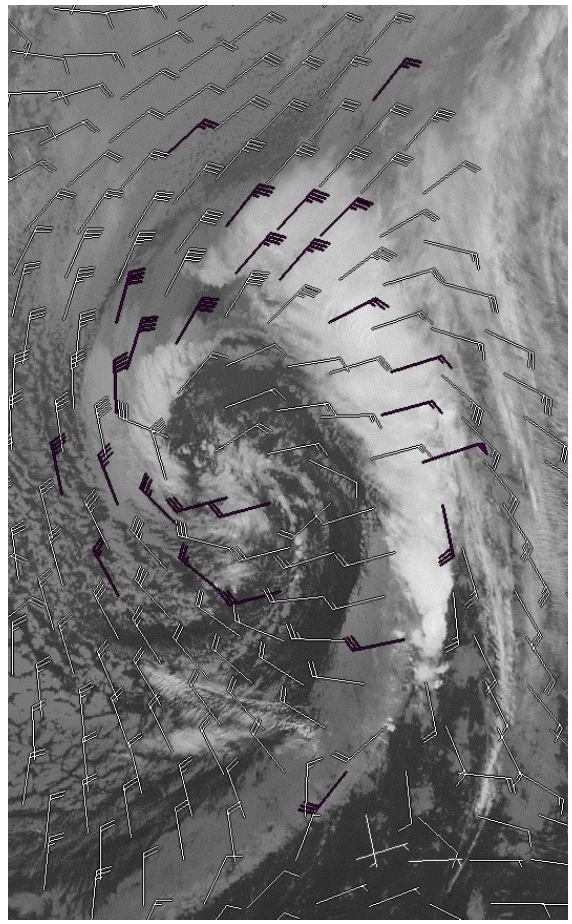

Figure 1. Feb 04, 2001, 16 UTC DMSP IR image with 1400 UTC QuikSCAT winds overlaid.

center of tropical cyclones, where convection can cause a degradation in the accuracy of these winds. This study has several goals: (1) it hopes to provide an assessment of the QuikSCAT winds in a nearly ideal situation for the sensor, (2) it provides an easily displayed comparison of cloud and surface features from multiple satellite sensors, and (3) it provides a starting point in

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further use of QuikSCAT winds in the analysis of both subtropical and tropical cyclones.

2. Data and Methodology

DMSP imagery, including data from the Special Sensor Microwave Imager (SSM/I), was obtained from the Satellite Data Handling System (SDHS) of the Air Force Weather Agency (AFWA). Visible, Infrared, and Microwave imagery (SSM/I) was retrieved and analyzed for examining details of the subtropical vortex because of its ability to determine scalar Ocean Surface Wind (OSW) speeds.

From the SSM/I, the 19, 22 and 37 GHz channels are used for determining surface wind speed. The Goodberlet, Swift and Wilkerson algorithm (1989) was used to calculate the SSM/I OSW product. SSM/I data provides surface wind estimates with 50km (25nm) resolution up to gale force and beyond. Erroneous wind speeds can be produced by convective rainfall that can lead to high wind speeds, similar to the QuikSCAT. Due to the lack of surface observations over open ocean areas, SSM/I provides a useful cross-correlation data source for the QuikSCAT winds. In the case of the OSW product at AFWA, the rain contaminated data is rendered black in color on the display.

The wind barbs from the SeaWinds sensor are actually a visualization of the 'Near-Real-Time' (NRT) data being calculated by Dr. Paul Chang of NOAA NESDIS. NESDIS ships a portion of this data set (called NRT 'lite' files) to AFWA for operational forecast use. The rain flagged winds are depicted in a dark purple color in this display. Note: this preprint depicts the near gale winds in dark grey. Also, all scalar winds/wind barbs in the graphics are depicted in knots.

The QuikSCAT wind barbs were overlaid on top of both types of DMSP data (OLS and SSM/I Ocean Surface Winds). The SSM/I OSW product is color coded to a consistent scale – Dark blue is 0-10 knots, Aqua-Green is 10-20 knots, Yellow is 20-25, Orange ranges from 25-30, and all winds over 30 knots are depicted in shades of red. The QuikSCAT winds follow an approximately similar scale. The analyses were performed using the Satellite Image Display and Analysis System (SIDAS), a satellite image manipulation interface. Numerous examples from 2001 were studied - only a small sample will be discussed. The direct display of QuikSCAT wind barbs on the SSM/I OSW data makes it simple to determine the degree to which the SSM/I and QuikSCAT agree on wind speed measurement.

3. Results and Discussion

The DMSP SSM/I data easily depicts the subtropical vortex wind speed distribution (Fig.2). This image comes from February 05, 2001, at 0300 UTC. The feature is synoptic scale in size, with numerous interesting mesoscale features. Figure 3 shows the QuikSCAT data, from approximately the same time, imaged over the DMSP OLS IR data. An isotach analysis of both figures 2 and 3 reveal a strong similarity between the wind fields of both. The regions of near gale force winds (30 knots and over) are very closely aligned. The winds found outside this area (15-25 knots) seem to show slightly stronger winds on the QuikSCAT (by approximately 5 knots) as opposed to the SSM/I OSW.

This analysis technique can then be augmented by directly overlaying the QuikSCAT winds on the SSM/I OSW product directly. Figure 4 shows an example of this from another subtropical system on 23 March, 2001, at 0700 UTC. Both the QuikSCAT and DMSP were very close to each other in time. Notice that similar conclusions can be drawn more readily in this display: the near gale winds are well correlated, but there is a slightly stronger depiction of surface winds in the QuikSCAT over the SSM/I OSW product in the 15-25 knot wind range – the QuikSCAT tends to be about 5 knots higher than the SSM/I winds. Because there are very few surface reports available for inter-comparison, it is difficult to say which is the "right" wind speed. Hebert / Poteat (1975) tends to show a more broad distribution of wind speeds in the 'typical' subtropical cyclone, which would suggest that the QuikSCAT gives the more realistic solution. This 5 knot 'bias' is minor in comparison to the accuracy of the near gale winds, however, and leads the author to suggest that the QuikSCAT data can provide a good estimate of near gale force wind speed distribution in cyclones that do not exhibit excessive rain contamination.

An additional observation is also in order. In connection with rain bands in tropical cyclones, Anthes (1982) indicates that rain bands are associated with "…a mesoscale trough of low pressure (which) occurs along the leading edge of the band…this pressure trough is in advance of the heaviest rainfall by one quarter wavelength, where the width of the band is taken as one-half the wavelength." Further, Anthes states that "…the mean low level winds in the vicinity of [rain] bands show convergence into the mesoscale pressure trough…". The imagery in figures 1 and

3 strongly suggests that the same is happening in subtropical cyclones. Consider figure 5 (an expansion of figure 1). In the area located southeast of the cyclone center, there is a well-defined convergence line, associated with a convective rainband. This situation is strikingly similar to the description of rainbands in tropical

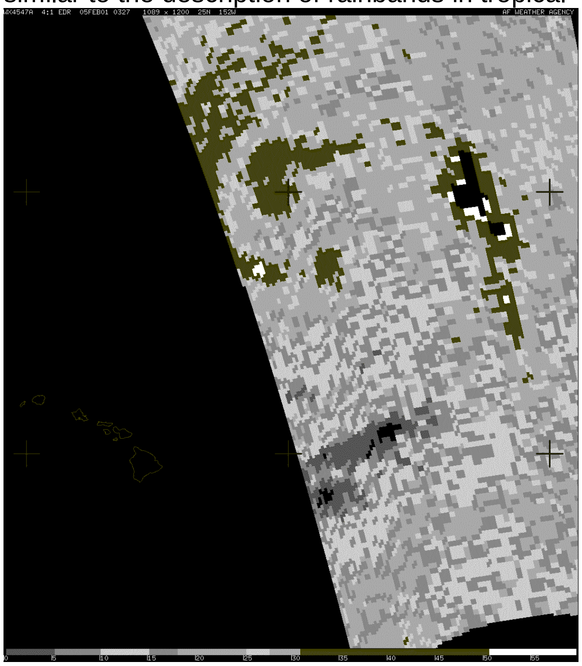

Figure 2. DMSP Ocean Surface Winds

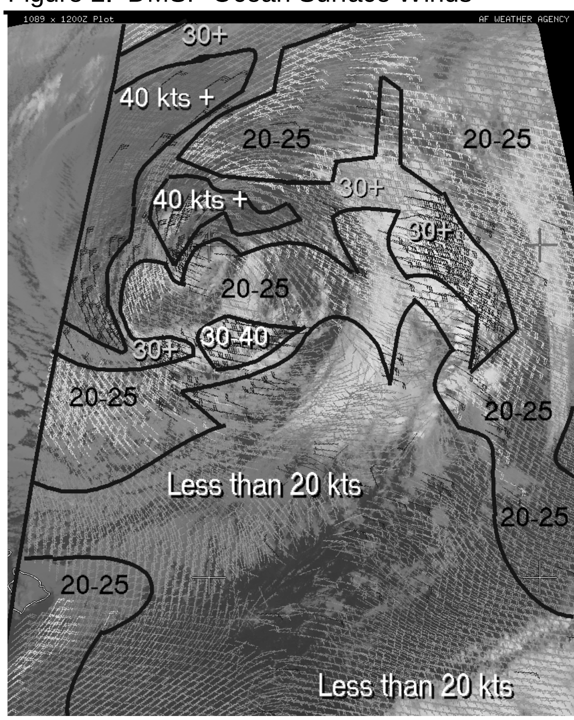

Figure 3. DMSP OLS IR image of the subtropical vortex with QuikSCAT winds overlaid

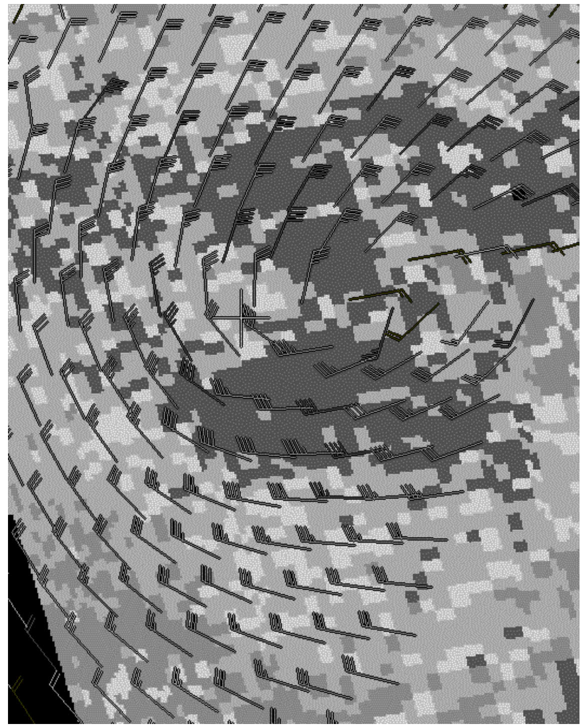

Figure 4. DMSP SSM/I OSW data of a subtropical low with QuikSCAT winds (23 March 2001, 07Z)

cyclones. This similarity gives some hope that this capability can be exploited when QuikSCAT data is used to analyse tropical cyclones. The potential benefit includes the capability to more accurately forecast tropical cyclone motion, in addition to rainfall in the rainband itself (the possibility exists to calculate divergence values and thence more accurately forecast the development of convection).

An additional benefit from this study: the QuikSCAT, with its ability to detect high winds in low cloud cover scenarios, may be used to add more objectivity in the analysis process of estimating subtropical cyclone intensity using the Hebert/Poteat technique. H/P is hampered by a strong reliance on subjective, manual analysis. QuikSCAT could easily handle this situation.

4. Conclusion:

QuikSCAT data was considered over subtropical cyclones and compared to DMSP SSMI data. Overall, the two compared favorably, with the QuikSCAT estimating slightly high wind estimates in the 15-25 knot range, but otherwise performed well in the gale force wind regime. A number of mesoscale features were observed, giving the forecaster a potentially valuable aid when dealing with both subtropical and (potentially) tropical cyclones. There may be some similarity in the nature of the rainbands of subtropical cyclones, as compared to those found in tropical cyclones.

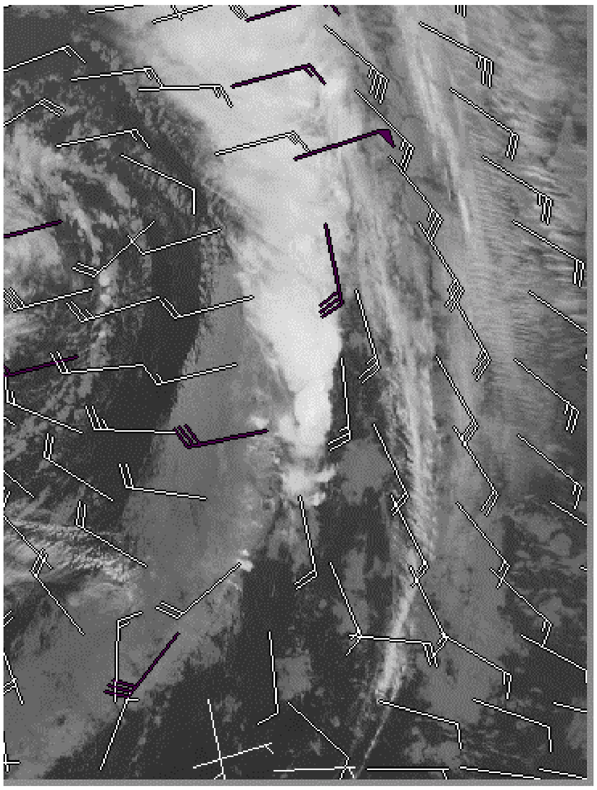

Figure 5. DMSP Feb 04, 2001, 16 UTC IR image with 1400 UTC QuikSCAT winds overlaid. The imagery has been zoomed in to focus on the region of surface convergence to the southeast of the cyclone center

5. Acknowledgements:

The author would like to thank Dr. Paul Chang of NOAA NESDIS for the use of the NASA QuikSCAT lite data and for technical advice.

6. References

Anthes, R.A., 1982: Tropical Cyclones: Their Structure and Evolution, AMS Meteorological Monographs, Volume 19, February 1982, Number 41, American Meteorological Society, 45 Beacon St. Boston MA 02108, pp. 39-41

Goodberlet, M.A., C.T. Swift and J.C. Wilkerson, 1989: Remote sensing of ocean surface winds with the Special Sensor Microwave/Imager. J. of Geophys. Res., 94, 14547-14555

Hebert, P.H., K.O. and Poteat, 1975: A satellite classification technique for subtropical cyclones. NOAA Technical Memorandum NWS SR-83, Scientific Services Division, Southern Region, NOAA/NWS, Fort Worth Texas, July 1975