P1.83 A METHOD OF APPLYING QUIKSCAT DATA FOR TROPICAL CYCLONE INITIALIZATION

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1. INTRODUCTION

One of the difficulties in numerical tropical cyclone (TC) forecast is the lack of enough observations to properly describe initial conditions. Lately, QuikSCAT data become available and have helped forecasters in operational TC forecast (Edson et al. 2002). QuikSCAT data are surface wind velocity observations measured by the backscattering of active satellite-borne radar signals over ocean. The satellite measurement has a relatively wide scanning swath (1800 km), a 25 km resolution and no contamination by clouds. These characters make them very valuable for observing TC circulation. However, there are limitations to the QuikSCAT data as well. For example, the polar orbiting satellite measurement is only available over ocean with irregular observing time, about twice daily. The measurement is quite accurate in wind speed but there are 4 possible solutions for wind direction requiring further retrieval. The measurement may be contaminated by heavy rain that limits its accuracy in measuring surface winds near TC centers. Near-real-time QuikSCAT data operationally received from National Environmental Satellite, Data and Information Service (NESDIS) have been used in the data assimilation of Navy operational models, including Coupled Ocean/Atmosphere Mesoscale Prediction System (COAMPS[TM+]). However, the surface wind data have a relatively small impact on 3-dimensional TC analysis since they are analyzed as single level data by a 3-dimensinal analysis method. To work around with these limitations and increase their influence, we at NRL have developed a method to apply QuikSCAT data to improving COAMPS[TM] TC initialization. The method objectively determines TC 34 kt and 50 kt wind radii from the operationally retrieved QuikSCAT data and then used these objectively extracted TC structure parameters to enhance the COAMPS[TM] TC initialization.

2. DATA SOURCE AND QUALITY CONTROL

The near-real-time QuikSCAT data received from NEDSIS at Fleet Numerical Meteorology and Oceanography Center (FNMOC) contains 4 sets of possible solutions, quality flags, and a set of solution retrieved at NEDSIS. Once FNMOC receives the QuikSCAT data, it does its own retrieval by using Navy's global model forecast. We use both NESDIS and FNMOC retrieved QuikSCAT data after they pass the following quality control and adjustment. The surface wind data set is discarded if the quality flag indicates that (1) not enough good backscatter cross-section (σ_o), (2) poor azimuth diversity among σ_o, (3) no wind retrieval, (4) unusable rain flag, and (5) rain flag on but without good data quality. Hersbach et al. (2003) has shown that too many good quality data around TCs are rain flagged. Following their approach, we accept the rain-flagged data set if all 4 possible solutions are available and the wind direction difference between the first two rank solutions is greater than 135^o. Furthermore, Stiles and Yueh (2001) show that heavy rain may cause backscattering signals to overestimate low winds (<10 m/s) and underestimate high winds (>15 m/s). Therefore, we adjust the wind speed of those accepted rain-flagged data by a factor to decrease the speed of low winds up to 20% and increase the speed of high winds up to 30%.

3. INITIALIZATION METHOD WITH QUIKSCAT DATA

COAMPS[TM] uses a bogus data method to initialize TCs in which 41 bogus data are created within a 6-degree radius of an observed TC center and used as must-accepted soundings in the COAMPS[TM] analysis (Liou 2002). The bogus data are constructed by adding TC circulation modeled by a Rankine vortex model with its parameters computed by fitting maximum wind and 34 kt and 50 kt wind radius observations to the model wind profile, to a environmental flow obtained from spectrally truncated global analysis fields. The initialization method described here is to enhance the accuracy of the observed 34 kt and 50 kt wind radii by objectively extracting them from the operationally available QuikSCAT data. In this way, the accurate part of the QuikSCAT observations, wind speed, will be emphasized and the influence of the data will be expanded to 3 dimensions through the Rankine vortex model structure.

The operational COAMPS[TM] is run with 6h data assimilation cycles. For a given data assimilation time, the QuikSCAT at data within a +3h and –3h time window are searched for those located within a 6-degree radius of all TC centers at that time. If there are enough QuikSCAT data within the 6-degree domain, the following TC structure retrieval process is performed. After the quality control and rain contamination adjustment described above, the environmental flow is subtracted from the surface wind data and the data are interpolated to a polar coordinate centered at each observed TC location. The interpolated wind data are used to compute radially averaged wind speed in every 10 km from the center at each quadrant of the observed TCs. The averaged wind speed at each TC quadrant is least square fitted to a fifth order polynomial using a regression method. The least square fitting is done for a range from the radius of maximum wind to the radius of 30 kt. The wind speed profile represented by this fifth order polynomial is then used to determine 34 kt and 50 kt wind radii by searching for these two wind speeds outward from the maximum wind radius and inward from the 30 kt radius. If the results of the two direction searches are different, the

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averaged value is used. This extraction of 34 kt and 50 kt wind radii is performed for both NEDSIS and FNMOC retrieved QuikSCAT data. If the extractions of 34 kt or 50 kt wind radii are available from both retrievals, the averaged value is used. To be more continuous in time, the objectively determined 34 kt and 50 kt wind radii are used to average with, rather than replace, those TC parameters from the forecast centers. The 34 kt and 50 kt wind radii enhanced by the QuikSCAT data are then used in the COAMPS™ TC initialization procedure.

4. EVALUATION AND IMPACT ON TC FORECAST

For a 3-month period from 8 July to 8 October 2002, we have compared all 34 kt and 50 kt wind radii objectively extracted from the operationally available QuikSCAT date with those available from the forecast centers. We have also compared 48h TC track and structure forecast with and without the QuikSCAT data enhancement for 36 cases selected from 5 TCs. In the 3-month period, there is 28% chance that QuikSCAT data are available near TC centers. The mean difference between the objectively extracted 34 kt wind radii and those from the forecast centers is about -8 nautical miles (NM), and the root-mean-square (RMS) difference between the two is about 45 NM. The mean and RMS difference for the 50 kt wind radii are 16 NM and 42 NM, respectively. Since a typical 34 kt wind radius is greater than 125 NM and a typical 50 kt wind radius is less than 75 NM, the above difference is more significant for the 50 kt wind radius than the 34 kt wind radius. From the evaluation of individual cases, we find that the objectively extracted 34 kt and 50 kt wind radii are more consistent with the available QuikSCAT data (Fig. 1). In the 36 cases of COAMPS™ 48h forecast, the QuikSCAT data enhancement improves both the track and wind structure forecast (Fig. 2).

5. SUMMARY

To expand the QuikSCAT data influence and enhance the accuracy of 34 kt and 50 kt wind radii in the COAMPS™ TC initialization, we have developed an objective method to extract the 34 kt and 50 kt radii from the operationally available QuikSCAT data. During the 3-month test and evaluation, the object method is proven to be reliable and accurate in extracting the 34 kt and 50 kt wind radii. The initialization enhancement improves both TC track and structure forecast. This object method may also be used by the forecast centers to help forecasters in determining the TC wind structure parameters.

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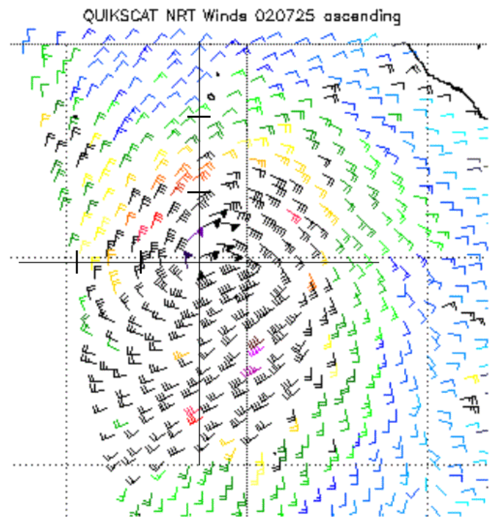

Fig.1. QuikSCAT winds at 1200 UTC 25 July 2002 with tick marks for every100 NM from the TC center. Radii of 34 kt winds at 4 quadrants are 200, 75, 75, and 125 NM from the forecast center and 114, 213, 104, and 104 NM from the objective method. The 50 kt radii are 75, 50, 50, 75 NM; and 82, 137, 70, 61 NM, respectively.

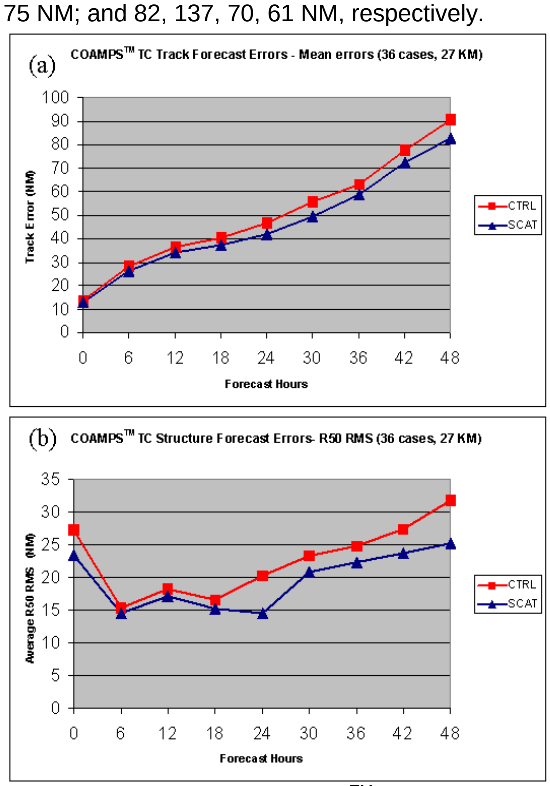

Fig. 2. Comparison of COAMPS™ TC (a) track and (b) 50 kt wind radius forecast errors with (triangles) and without (boxes) QuikSCAT data enhancement.