ASSIMILATION EXPERIMENTS AT NCEP DESIGNED TO TEST QUALITY CONTROL PROCEDURES AND EFFECTIVE SCALE RESOLUTIONS FOR QUIKSCAT / SEAWINDS DATA

Yu, T.-W.,* and W. H. Gemmill

Environmental Modeling Center, National Centers for Environmental Prediction
NWS, NOAA, Washington, D. C. 20233

1. INTRODUCTION

Since January 15, 2002, QuikSCAT wind data have been operationally used in the global data assimilation system (GDAS) at the National Centers for Environmental Prediction (NCEP). However, there remain at least two outstanding issues on the use of QuikSCAT wind data in operational numerical weather prediction. The first issue is related to the rain contamination problem in QuikSCAT wind data, and therefore design of a good quality control procedure for the data becomes critically important. This paper investigates two quality control procedures especially designed for QuikSCAT winds. The second issue concerns with what scale resolutions of QuikSCAT wind data are the most effective and compatible to the NCEP atmospheric analysis and data assimilation system. This is an important issue because NCEP global forecast model and data assimilation systems are undergoing numerous improvements since early 2002. Mesoscale features inherent in the QuikSCAT wind data, which cannot be resolved in the NCEP global data assimilation system in 2002 may be resolvable in the current operational system. This paper presents some results of several global data assimilation and forecast experiments designed to investigate these two outstanding issues on the operational use of QuikSCAT wind data at NCEP.

2. QUALITY CONTROL OF QUIKSCAT WINDS

The NCEP operational GDAS employs a global forecast system (GFS) as the forecast model, and uses a spectral statistical analysis scheme (SSI) for atmospheric analyses (Parrish and Derber, 1992). Use of QuikSCAT winds in the SSI analyses scheme is subject to two steps of quality control procedures. The first step quality control procedure, which pertains only to the QuikSCAT wind data, and is applied before the wind data are used in the SSI analysis scheme, is one of the main focuses of this study.

* Corresponding author address: T.-W. Yu, Environmental Modeling Center, NCEP, NWS, NOAA, Washington D.C., 20233, Email: Tsann.Yu@noaa.gov, phone:301-763-8000 x 7217
NCEP/MMAB Contribution No. 232

The second step is the OIQC quality control procedure, which essentially performs a gross error check and a buddy check among like kinds of data, and is applied to all of global observations within the SSI analysis scheme (Wollen,1991). Detailed investigation of the OIQC quality control procedure is the subject of forthcoming articles, but suffices it to point out that the OIQC procedure eliminates only about 0.1% of the QuikSCAT wind data in a GDAS cycle. Table 1 shows a distribution of TOSSLIST of QuikSCAT wind data rejected by the OIQC quality control procedure for 0000 UTC January 19, 2001 of the NCEP global data assimilation cycle. These numbers are quite typical, and they show that the total number of QuikSCAT wind data in the analysis cycle is 193,142, of which only 266 observations are rejected by the OIQC quality control procedure. Further, of the 266 rejected observations (TOSSLIST), about 30 % of them have a rain probability of greater than 50 %. On the other hand, as is to be discussed later in this section, applying the first step quality control procedure eliminates about 2% to 5% of the total QuikSCAT data, and therefore, is more pertinent and important for the use of QuikSCAT wind data in the NCEP analysis and data assimilation experiments.

For the first step quality control of QuikSCAT wind data, a simple procedure based on JPL rain flag detectors (Huddleson and Stiles, 2000) is currently being used in NCEP's operational GDAS. With this quality control procedure, any QuikSCAT winds with a JPL rain flag probability of greater than 10% are not used in the assimilation system. The rational for selecting the 10% probability as a threshold value is based on an investigation reported in Gemmill (2003), which shows that any data with a rain probability of greater than 10% are of very poor quality. One problem of this approach, however, is that some of the good quality QuikSCAT wind data over weather producing storm areas may be discarded. However, over the weather active areas where rain occurs, ocean surface winds would be important. To address this deficiency, Portebella and Stoffelen (2001, 2002) have developed a quality control procedure based on analyses of maximum likelihood estimates, hereafter refereed to as the

KNMI_QC procedure, which is capable of differentiating good from bad quality data, especially over the rainy storm areas of the oceans.

For this study, a new quality control procedure designed for QuikSCAT winds is investigated, following the recommendations reported in Portabella and Stoffelen (2002). This procedure uses the KNMI_QC procedure over the sweet spot region, and a combined JPL_QC and KNMI_QC procedures over the nadir region of the satellite swath. Table 2 shows typical rejection statistics from the two quality control procedures for two days of NCEP GDAS runs during January 28 and 29, 2003. From Table 2, one can see that applying the JPL_QC procedure rejects about 5% of the total data points, while applying the new quality control procedure rejects about 2% of the total data points. Thus, many more good QuikSCAT wind data were presumably kept by the new quality control procedure over the storm areas, thereby useful for improving the atmospheric analyses. These good quality QuikSCAT winds over the storm areas of the oceans would presumably be eliminated by the JPL_QC procedure otherwise.

To investigate this new quality control procedure for assimilating the QuikSCAT wind data, a global data assimilation experiment was recently conducted using the NCEP operational GDAS (T254,L64). The experiment started on April 8, 2003, and ending on May 31, 2003 for a period of 53 days. Preliminary results, based on the anomaly correlations and RMS errors of heights and winds at 1000 mb, 850 mb, 500 mb, and 200 mb, show that one the average, applying this new quality control procedure to the QuikSCAT data in the assimilation leads to a small improvement in the short range height and wind fields forecasts as compared to those from the control experiment which uses JPL_ QC procedure for QuikSCAT wind data. Though the overall statistics do not show a large improvement using this new quality control procedure in the assimilation experiment, one would expect that for some special synoptic cases where QuikSCAT wind data kept by the new quality control procedure over storm and rainy areas will contribute to a large significant improvement in the analyses as well as forecasts. Details of case studies are under investigation, and the results together with those of anomaly and RMS statistics from the assimilation and forecast experiments will be presented at the conference.

3. EFFECTIVE SCALES OF QUIKSCAT WIND DATA RESOLUTION

The full horizontal spatial resolution of the QuikSCAT wind data is 25 km, and within a +/- 3 hours window of a synoptic analysis cycle, there can be as many as 140,000 to 200,000 observations (see Table 2). Earlier assimilation and forecast experiments conducted at NCEP and other operational centers such as NASA and ECMWF, showed that use of the full resolution data did not lead to any significant impact. However, further assimilation results at NCEP show that use of the coarser resolution QuikSCAT wind data did indeed lead to a positive impact on heights and winds forecasts over the Northern and Southern Hemispheres, as well as over the tropics (see Yu, 2003). Thus, NCEP implemented QuikSCAT winds of one degree by one degree longitude-latitude grid superobed resolution in its operational GDAS in January 15, 2002. The number of QuikSCAT winds after the one degree superobing process is less than 10,000, and amounts to about 6.25% of total numbers from the full resolution (25 km) data shown in Table 2. Using the one degree longitude-latitude grid box superobed data results in a coarser horizontal resolution of equivalent to about 100 km, and that is compatible to that of the analysis and GFS model resolution, which had a lower resolution (T172, L42) at that time. The disadvantage of using the coarser resolution data is that mesoscale features associated with the QuikSCAT wind data are filtered out in the superobing process, and therefore they are not contribute to improve the initial atmospheric analyses for numerical weather prediction.

In October, 2002, a higher resolution global forecast model (T254, L64) with improved model physics in convection was implemented at NCEP. This corresponds to a horizontal resolution of the analysis and forecast model of about 70 km. In view of this improvement in the horizontal resolution, a parallel assimilation experiment was conducted in January 2003 to test higher resolution (in half degree longitude-latitude superobed grid box) QuikSCAT winds .in NCEP GDAS. The number of QuikSCAT wind data in half degree superobed resolution amounts to about 40,000, and is about 25% of the total numbers shown in Table 2. The assimilation results showed a further improvement in the forecasts of wind and mass fields in the tropics. Hence, the half degree longitude-latitude superobed QuikSCAT wind data were implemented at NCEP GDAS on March 11, 2003.

Most recently, in anticipation to the arrival of ADEO-II SeaWinds data (12 km spatial resolution), another data assimilation experiment was conducted using the full resolution (25 km) QuikSCAT wind data at NCEP. Preliminary results show that use of the full resolution QuikSCAT wind data in NCEP GDAS does not lead a significant improvement in the forecasts. This suggests that scales of resolution associated with the data may not be compatible with the current operational SSI analysis resolution, and as such any finer scales features contained in the full resolution QuikSCAT winds are not useful to the initial analyses. Details of the results of these assimilation and forecast experiments are under investigation, and will be discussed in the conference.

4. SUMMARY

QuikSCAT wind data have been used operationally in the NCEP global data assimilation system since January 2002. However, there remain a number of problems on the use of the remotely sensed satellite ocean surface wind data in numerical weather prediction. These problems include the directional ambiguity associated with scatterometer winds in general, and the rain contamination problem, together with effective scales of resolution for the QuikSCAT winds in particular. In view of the fact that over the global oceans there are relatively very few ship and buoy observations, these QuikSCAT surface wind data are very most important for numerical weather prediction.

This paper discusses preliminary results of several data assimilation and forecast experiments at NCEP designed to resolve the two outstanding issues on the use of QuikSCAT wind data for numerical weather prediction. On the issue of quality control for handling rain contaminated QuikSCAT wind data, assimilation and forecast results show that the new QC procedure based on a combined JPL_QC and KNMI_QC method is promising. This new quality control procedure allows more useful data over the storm areas to improve the initial analyses, thereby improving short range numerical weather forecasts. On the issue of effective scales of QuikSCAT wind data resolution, assimilation and forecast results show that with the current SSI analysis scheme being limited to about 60 km horizontal resolution, use of QuikSCAT winds with a half degree superobed resolution (about 50 km resolution) can be very effective. However, use of the full resolution QuikSCAT wind data (of about 25 km horizontal spatial resolution) in GDAS does not lead to a significant improvement in the forecasts. This scale resolution issue associated with QuikSCAT and AEDO-II SeaWinds data should be further investigated when the NCEP analysis and GFS model resolution is further reduced in the future.

REFERENCES

Gemmill, W. H., 2003: Comparison of rain quality control procedures for “real-time” QuikSCAT wind retrievals, NCEP / MMAB Technical Note, No. 231

Huddleston, J.H., and B. W. Stiles, 2000: A multidimensional histogram rain flagging techniques for SeaWinds on QuikSCAT, IEEE 2000, International Geophysics and Remote Sensing Symposium IGARRS 2000, Honolulu, Hawaii, 3 pp.

Parrish, D., and J.C. Derber, 1992: The National Meteorological Center’s spectral statistical interpolation analysis system, *Mon. Wea. Rev.*, 120, 1747-1763.

Portabella, M., and A. Stoffelen, 2001: Rain detection and quality control of SeaWinds, J. Atmos. & Oceanic Tech.., 15, 304-313

Portabella, M., and A. Stoffelen, 2002: Quality control and wind retrieval for SeaWinds, Scientific Report WR-2002-01, KNMI, De Bilt, 2002, 125 pp.
.

Woolen, J.-W., 1991: New NMC operational OI quality control, preprint paper presented at the 9th Conference on Numerical Weather Prediction of the American Meteorological Society, Denver, Colorado, pp. 24-27

Yu, T. -W., 2003: Operational use of QuikSCAT winds in NCEP GDAS, preprint papser presented at the 12th Conference on Satellite Meteorology and Oceanography, Long Beach, CA, Feb. 9-13, 2003.

Table 1. Distribution of TOSSLIST QuikSCAT wind data rejected by the OIQC quality control procedure for 0000 UTC January 19, 2001 of the NCEP global data assimilation cycle.

JPL_QC Rain Flag Probability (%)	No. of QuikSCAT Wind Data	Mean Wind Speed (m/sec)	No. of Rejected QuikSCAT data	Percentage (%) of TOSSLIST Distrubution
> 50 %	1833	16.14	78	29.3
50 % - 25 %	1502	13.11	18	6.8
25 % - 10 %	3283	12.96	27	10.2
10 % - 5 %	6083	13.25	26	10.2
5 % - 1 %	38,760	11.59	70	26.3
1 % - 0 %	102,146	7.83	29	10.9
= 0 %	39,534	5.17	18	6.8

Table 2. Percentage (%) of QuikSCAT winds rejected by the two quality control procedures during January 28, and January 29, 2003 NCEP global data assimilation cycles

GDAS Cycles	No. of QuikSCAT winds (25km, full resolution)	JPL_QC (NCEP OPNL)	JPL_QC + KNMI_QC (New Method)
1/28/00z	141,887	4.9	2.6
1/28/06z	188,025	4.1	1.2
1/28/12z	140,246	5.1	1.9
1/28/18z	178,974	4.4	1.6
1/29/00z	146,548	5.2	2.3
1/29/06z	187,349	4.8	2.0
1/29/12z	134,949	3.2	1.1
1/29/18z	174,510	5.1	1.7