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Experiments Using NSCAT Data in the NCEP Global Data Assimilation and Forecast System[1]

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1. Introduction/motivation

The NASA scatterometer (NSCAT) aboard the Japanese satellite ADEOS provided unprecedented coverage of marine surface winds during it's short-lived mission. Unfortunately, the satellite mission failed (June 1997) before the data were ever used in any of NCEP's operational numerical weather prediction model. One of the goals[1] of the NSCAT mission was to "develop improved methods of assimilating wind data into numerical weather and wave prediction models." Despite the fact that the NSCAT data never made it into an operational model, the question of what kind of impact it would have had on today's numerical weather prediction models remains valid. Several future scatterometer missions are planned, including the QSCAT launch in the spring of 1999. Thus a retrospective test of NSCAT data in the NCEP global data assimilation and forecast model system may help to answer questions about data assimilation and assist in planning and developing improved methods of data assimilation of satellite surface winds. This paper describes the assimilation and forecast experiments used to test the NSCAT data in the NCEP global model system and the results obtained from the experiments.

2. The NSCAT sensor

The NSCAT was a microwave radar scatterometer which measured the roughness of the ocean surface, which was then converted into wind vectors over the world's oceans. The NSCAT was a double-sided radar, with three fixed antenna beams on each side of the satellite orbit, scanning two 600 km wide bands of ocean. The coverage was such that every two days, at least 90% of the Earth's ice-free oceans were sampled. NSCAT transmitted quick pulses of microwave energy which were then reflected or backscattered and measured at a receiving antenna. The basic design of a three-stick scatterometer was similar to that of ERS-1 and ERS-2.

The data were processed by NASA-JPL and provided to NCEP by NESDIS. Typical six-hour coverage of NSCAT data is shown in figure 1. The data were ingested on a workstation and some preliminary validation against buoys was done (Gemmill and Chang, 1997). Statistics showed that the NSCAT speeds were comparable to ERS-1 and ERS-2 in terms of RMS error, and directions were also generally good. Some quality control problems were noted with the NESDIS "fast-delivery" winds, such as unusually high wind speeds along the inside edge of the satellite track, and areas of poor ambiguity removal (figure 2). In general, NSCAT wind speeds were observed to be greater in areas of high winds than ERS-1, ERS-2 or SSM/I.

3. Experimental Design

To test the impact of NSCAT data on the current NCEP global model system, a 16 day period during May and June of 1997 was chosen. At this time, ERS-2 data were not yet being

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1 NASA-JPL NSCAT home page:
http://winds.jpl.nasa.gov/missions/nscat/nscatindex.html

assimilated into the NCEP global data assimilation system (GDAS). This was due to the fact that during a conversion between two computer systems, the ERS-1 satellite was replaced by the ERS-2 satellite and validation of the wind data was not yet completed . SSM/I wind speed data were included in the NCEP GDAS at this time. The experiments documented here used a T62 version of the NCEP global model, roughly equivalent to 100 km resolution at the equator. The data assimilation system and model codes used were those that ran operationally at NCEP in June of 1997, including the direct assimilation of satellite radiances.

During the period May 31 - June 15, NSCAT wind vectors were packed into BUFR and then merged into the prepdata file, which is then read by the analysis code. This approach was similar to what was initially done with ERS-1 data in order to assimilate the winds into the GDAS (Yu, 1995). A control run was initiated starting May 31, 0000 GMT. The control run included all conventional data sources, such as rawinsondes, ships, SSM/I and satellite radiances, except no scatterometer data. Every six hours, a new analysis was produced. A 120 hour (five day) MRF forecast was generated once daily, at 0000 GMT, from the analysis. The parallel run was identical to the control, with the important exception that NSCAT wind vectors were now included along with the other conventional data types.

A series of one control and three parallel experiments were performed. The control experiment used all available conventional data, including satellite radiances and SSM/I wind speeds. The first parallel experiment used the NSCAT "fast-delivery" vectors, which NCEP was receiving operationally in 1997. A second parallel used the NSCAT "science" data, obtained from NASA-JPL, which were not available in near real-time but were of a higher quality generally. A third parallel experiment involved using the same science dataset, but reduced the observational error assigned to the data, in order to increase the weight of the data. This will be described in more detail in the following section.

Table 1

Model Experiments

1. CONTROL	Conventional Data, SSM/I wind speeds, satellite radiances
2. NSCAT-FD	CONTROL + NSCAT "fast-delivery" data
3. NSCAT-SC	CONTROL + NSCAT "science" data
4. NSCAT-SE	CONTROL + NSCAT "science" data, reduced observation error

4. Results: Anomaly Correlation Scores

The results of the experiments 1-3 are presented in figure 3a-d, in terms of anomaly correlation scores for day 1 - 5 forecasts. The anomaly correlation is a measure of the forecast skill that correlates the forecast anomaly, defined as the difference between the forecast and climatology, and the verifying analysis anomaly. The verifying analysis is provided by the model, in this case the GDAS analysis. The sample size for these results is 11 cases, from the period May 31 - June 10. The 1000 hPa (near-surface) anomaly correlation scores for the Northern and Southern Hemisphere are shown in figure 3a and 3b, respectively.

In the Northern Hemisphere, the impact of the NSCAT-FD and NSCAT-SC data appears to be very small, as the scores for day 1 - day 5 are nearly identical to that of the CONTROL run. There appears, however, to be a very small but noticeable improvement in the anomaly correlation score of the NSCAT-SC data compared with the control and the NSCAT-FD at day 5. In the Southern Hemisphere, both the NSCAT-FD and the NSCAT-SC show a clear positive improvement in anomaly correlation scores over the CONTROL. The "fast-delivery" data (NSCAT-FD) actually shows the highest score at day 5. The improvement in forecast accuracy