National Weather Service
Office of Meteorology

Technical Procedures Bulletin

Subject: Ocean Surface Wind Speeds retrieved from DMSP Satellites

Series No. 467

Science Division, **Silver Spring, MD 20910**

THIS IS A NEW BULLETIN ON THIS SUBJECT

This bulletin, prepared by Mr. W. H. Gemmill, Mr. L. D. Burroughs, and Ms. V. M. Gerald of the Ocean Modeling Branch (OMB), Environmental Modeling Center (EMC), National Centers for Environmental Prediction (NCEP), describes "NCEP improved" ocean surface wind speed data at 20 m above the sea surface, columnar liquid water data, and columnar water vapor data retrieved from the SSM/I sensor on the DSMP satellites which is being prepared for distribution through AWIPS, FOS, and GTS in BUFR format.

These data are expected to become operational in late March 2000. They will be issued 4 times a day and contain 6 hours of data centered on the synoptic hours. The issuance times will be approximately 0400, 1000, 1600, and 2200 UTC. Data from all the currently operational DSMP satellites will be included. Currently, there are 3 operational satellites (f11, f13, and f14) in polar orbit. The orbit times are approximately 102 minutes with two orbits per day over any given area (one ascending and one descending) per satellite. A passive microwave sensor (SSM/I) is used with 7 channels of brightness temperature data available. Each satellite covers a swath of 1400 km with a spacing and footprint resolution of 25 km.

LeRoy Spayd
Chief, Training and Professional
Development Core

U.S.DEPARTMENT OF COMMERCE **National Oceanic and Atmospheric Administration**

OCEAN SURFACE WIND SPEEDS RETRIEVED FROM DSMP SATELLITES [1]

W. H. Gemmill, L. D. Burroughs, and V. M. Gerald

1. INTRODUCTION

The Defense Meteorological Satellite Program (DMSP) satellite series are polar orbiters. The series started in 1987,and the Defense Department attempts to have three of the satellites in orbit at any given time. Wind speed data at 20m above the sea surface is derived from a 7 channel passive microwave sensor (SSM/I) and have been available to NCEP since the early 1990s. At present there are three DMSP satellites (f11, f13 & f14) in orbit. The SSM/I measures "brightness temperatures" from the ocean surface and intervening atmosphere from seven channels. From these brightness temperatures ocean surface wind speed, columnar water vapor, columnar liquid water, rain rate, sea surface temperature and sea-ice concentrations can be derived. These channels are 19 Ghz (H, V), 22 GHZ (V), 37 GHZ (H, V) and 85 GHZ (H, V) where H is the horizontal polarization, V is the vertical polarization. Each satellite provides data that cover a wide swath (1400 km) with a spacing and footprint resolution of 25 km. Table 1 presents a summary of the characteristics of the SSM/I specifications. The global distribution of data for a six hour period is shown in Fig. 1.

2. ALGORITHM DEVELOPMENT

A number of algorithms or transfer functions have been developed which convert the various SSM/I channel brightness temperatures into surface wind speed. Goodberlet et al. (1989) developed a single linear algorithm (GSW) for use on a global basis. This algorithm as designed and tested met the specified speed accuracy criteria (2 m/sec over the range of wind speeds between 3 and 20 m/sec), but under rain free and low moisture conditions. The accuracy of wind speeds retrieved using this algorithm deteriorates rapidly in areas where rain and heavy cloud cover occur. Wind speeds are flagged as such which leave large areas of no retrievals in active weather regimes (storms or frontal regions). These areas are very regions where wind information is critical. Further, the algorithm was developed on the basis of match ups with buoys where there were almost no wind speeds above 18 m/s. As a result, there is large uncertainty at high wind speeds above 15 m/s. Petty (1993) added a water vapor correction to the linear algorithm. This data is available in real-time through the Shared Processing Center of the U.S. Navy.

Neural networks (NNs) were selected as an alternative method to estimate surface wind speed from the SSM/I brightness temperatures. The NN approach corresponds to a very general nonlinear model for the transfer function, and does not require any *a priori* knowledge about the

---

[1] OMB Contribution Number -

particular form of the input/output relationship. The current version of the NCEP NN algorithm (OMBNN3) is a multi-variate algorithm (Krasnopolsky *et al.*, 1996, 2000) which retrieves ocean surface winds, columnar water vapor, columnar liquid water and SST based on brightness temperatures from 5 SSM/I channels. Application of NN algorithm has led to an improvement in wind speed retrieval accuracy for clear conditions by approximately 20%; for higher moisture/cloudy conditions, the improvement

Table 1. Satellite ocean surface wind specifications for DSMP Satellites.

Type	Polar Orbiter (~102 min/orbit)
Areal Coverage	Twice Daily (one ascending and one descending orbit)
Sensor	Passive Microwave
Receptors	7 microwave channels
Measurement	Brightness Temperature
Frequency Bands	19(H, V), 22(V), 37(H, V), 85(H, V) gHz, where H is horizontal polarization and V is vertical polariztion
Swath (km)	1392
Number of Data Cells	64
Cell Footprint (km)	40
Wind Height (m)	20
Range of Wind Speeds (m/s)	3 - 25
Speed Accuracy	±2 m/s up to 20 m/s and ±10% above 20 m/s
Direction Accuracy	not applicable
Algorithm used	GWS and OMBNN3

was far greater when compared to the GSW algorithm, and there was an improvement in high wind speed retrievals (> 15 m/s) as well. The increase in areal coverage, due to improvement in accuracy, was about 15% on average and higher in areas with active weather systems (see Fig. 2). Further, the interpretation of the three variables together can provide a rather detailed synoptic description of the weather over the ocean (Gemmill and Krasnopolsky, 1999).

The accuracy of SST was not sufficient to be used as an output variable in itself since the SSM/I channels are not suitable for SST. But, there was enough SST signal in the brightness temperatures to contribute positively to the improvement of the wind speeds.

Statistics presented in Table 2 show RMS errors for different wind speed algorithms. Biases were similar at -0.5 m/s (GSWP) to -0.3 m/s (OMBNN3). NN algorithms obviously outperform all other algorithms in terms of standard deviations. OMBNN3 For the total performance over a wide range of wind speeds and weather situations, the OMBNN3 results appear to be the best in terms of bias, standard deviation, and for high wind speeds.

Table 2. Statistics for the operational wind speed algorithms: GSWP, and OMBNN3 for clear and clear plus cloudy conditions (in parentheses) for SSM/I satellite instruments matched with 15,000 buoy observations.

Algorithm	**Bias (m/s)**	**RMSE (m/s)**	**Wind > 15 m/s RMSE (m/s)**
GSWP[2]	-0.2 (-0.5)	1.8 (2.5)	(2.7)
OMBNN3[3]	-0.2 (-0.3)	1.5 (1.7)	(2.3)

Based on the improved performance of OMBNN3, ocean surface wind retrievals were incorporated into GDAS at NCEP in April 1998 (Yu *et al.*, 1997).

3. PRODUCT DISSEMINATION

These data are presently on the Internet at http://polar.wwb.noaa.gov/winds four times a day for the Northeast Pacific and Northwest Atlantic with panels for SSM/I neural network ocean surface wind speeds (Gemmill *et al.*, 2000), columnar water vapor, and columnar liquid water data along with ERS2 wind vector data, ship and buoy data, and a sea level pressure analysis (see Fig. 3).

These data are expected to become operational in late March 2000. They will be issued 4 times a day and contain 6 hours of data centered on the synoptic hours. They will include the following information:

1) Satellite ID
2) Year
3) Month
4) Day
5) Hour
6) Minute
7) Latitude
8) Longitude
9) Ocean surface (20m) wind speed
10) Columnar water vapor
11) Columnar liquid water

The issuance times will be approximately 0400, 1000, 1600, and 2200 UTC. Global data from all the currently operational DSMP satellites will be included. Currently, there are 3 operational satellites (f11, f13, and f14) in polar orbit. The orbit times are approximately 102 minutes with two orbits per day over any given area (one ascending and one descending) per satellite. Each satellite covers a swath of 1400 km with a spacing and footprint resolution of 25 km.

---

[2] Petty (1993)

[3] Krasnopolsky *et al.* (1996)

4. REFERENCES

Gemmill, W. H. and V. M. Krasnopolsky, 1999: The Use of SSM/I Data in Operational Marine Analysis, *Wea. and Forecasting*, **14**, 789-800.

Goodberlet, M. A., C. T. Swift, and J. C. Wilkerson, 1989: Remote sensing of ocean surface winds
with the Special Sensor Microwave/Imager, *J. Geophys. Res.*, **94**, 14,547- 14,555.

Krasnopolsky, V. M., W. H. Gemmill, and L. C. Breaker 1996: A new transfer function for SSM/I based on an expanded neural network architecture. *Tech Note, OMB Contr. No.* 137, National Centers for Environmental Prediction, Washington, DC 38pp.

Krasnoplosky, V. M., W. H. Gemmill, and L. C. Breaker, 2000: A Multi-Parameter empirical algorithm for SSM/I Retrievals. *Can. J. Remote Sensing*. In press.

Petty, G. W., 1993: A comparison of SSM/I algorithms for the estimation of surface wind, *Proc. Shared Processing Network*, DMSP SSM/I Algorithm Symposium, Monterrey, CA.,8-10 June, 1993.

Yu, T.-W., M. D. Iredell, and D. Keyser 1997: Global data assimilation and forecast experiments using SSM/I wind speed data derived from a neural network algorithm. *Wea. and Forecasting*, **12**, 859-865.

FIGURES

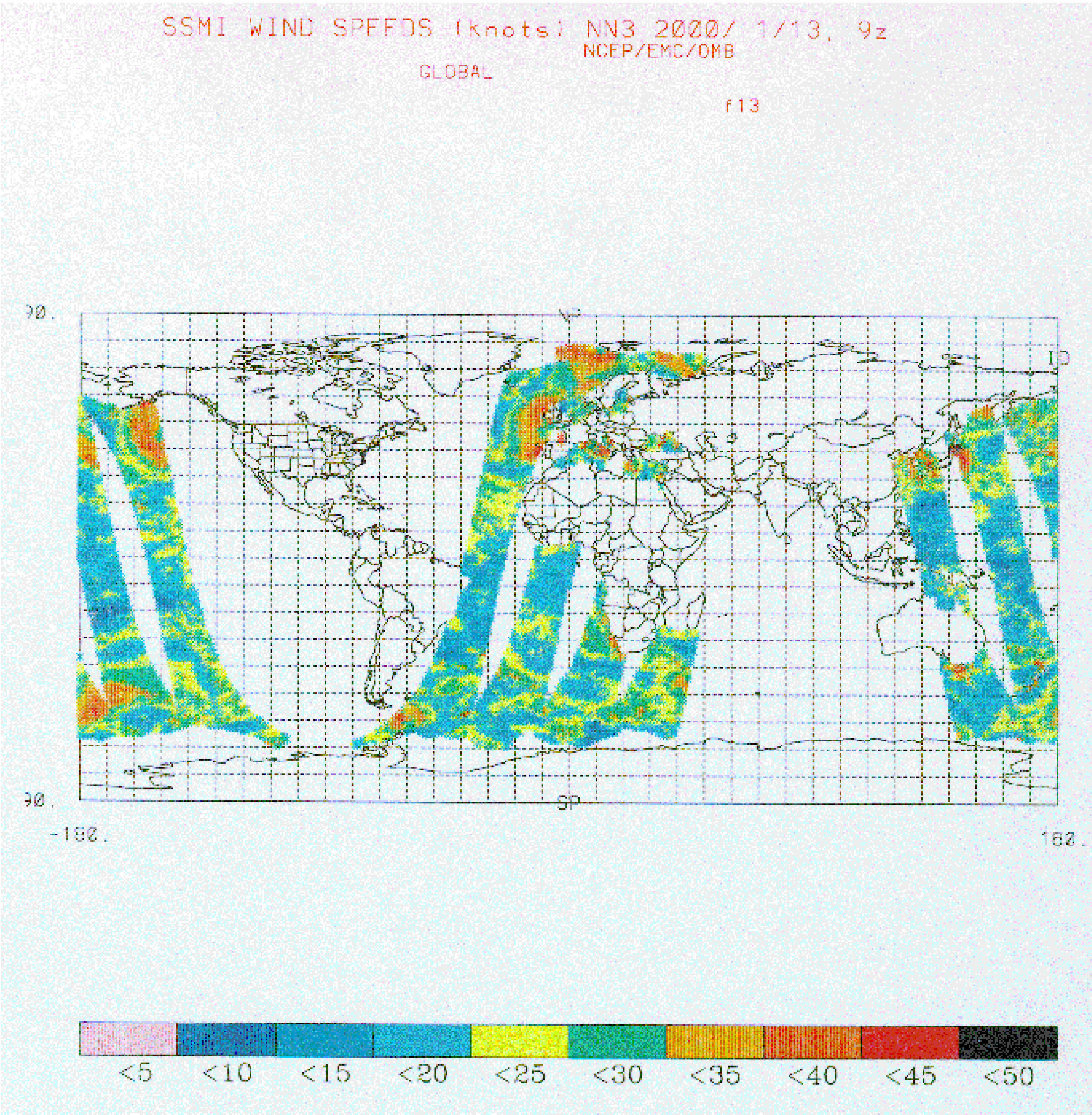

Figure 1. SSM/I wind speed coverage from satellite F13 for January 13, 2000 for the six hour period from 0300 to 0900 UTC.

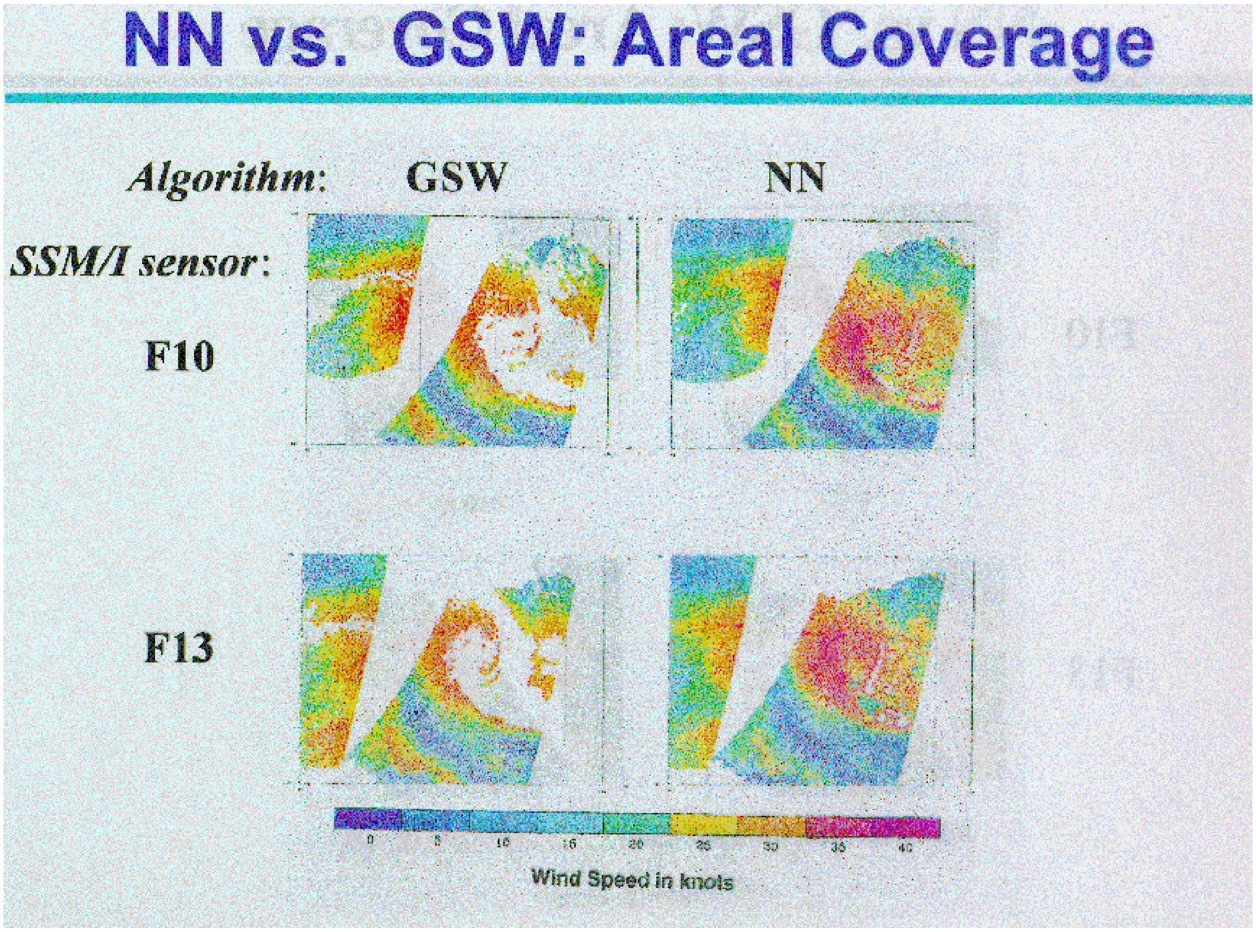

Figure 2. Comparison of coverage between GSW and OMB NN for 2 DSMP satellites. Upper left
GSW for f10; upper right OMB NN for f10; lower left GSW for f13, and lower right OMB NN for f13.

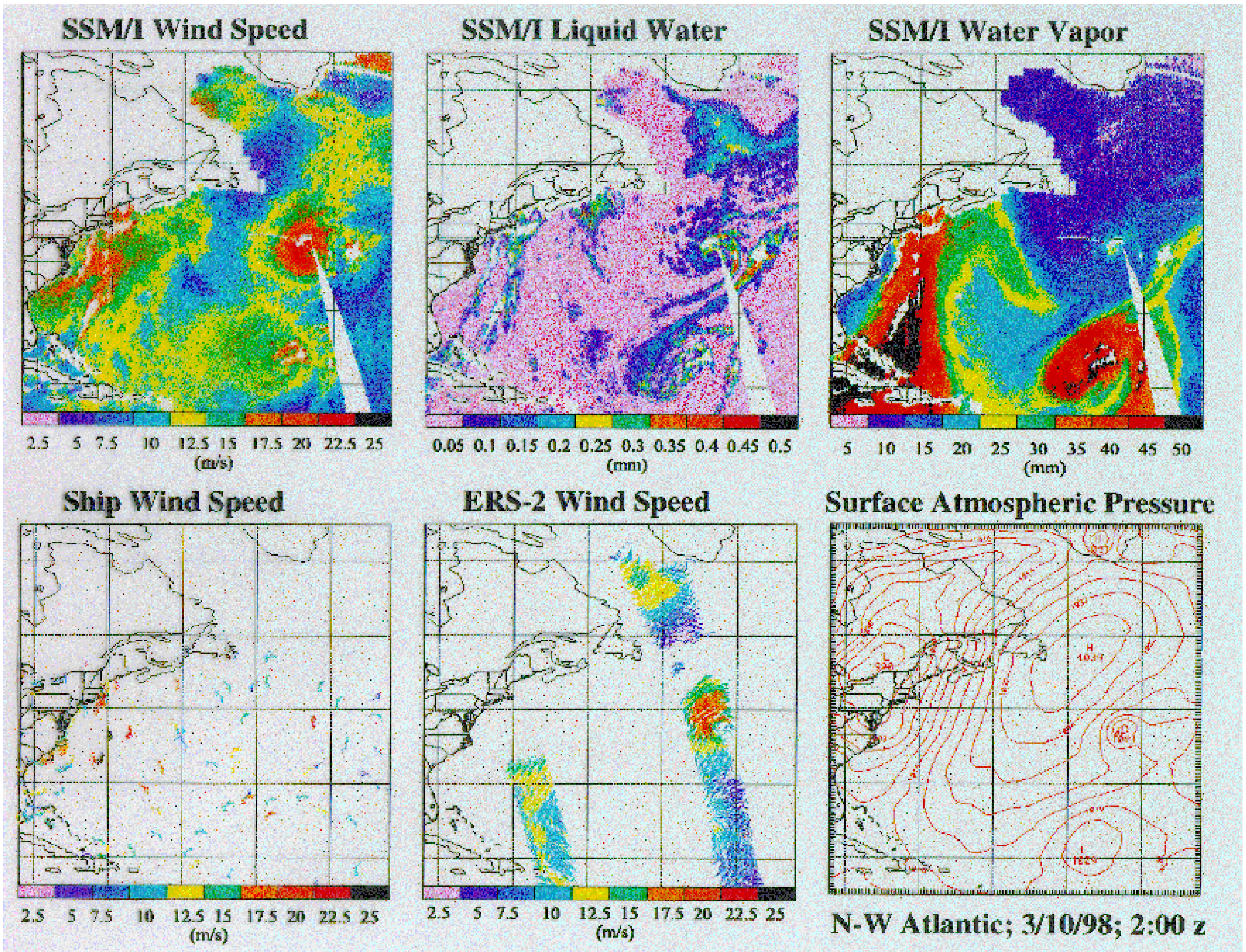

Figure 3. Satellite and other data available on the Internet: upper left - SSMI Wind Speed, upper center - SSMI Liquid Water, upper right - SSMI Water Vapor, lower left - Ship Winds, lower center - ERS2 Winds, and lower right - Surface Pressure Analysis.