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HIGH-RESOLUTION REGIONAL OCEAN SURFACE WIND FIELDS

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1) INTRODUCTION

In order to accomodate the increasing demand for high resolution analyses (and forecasts) of meteorological fields to support various research programs and operational requirements, efforts have been initiated to develop methods for analyzing high-resolution ocean surface wind fields. Recently, Bumke and Hasse (1989) were able to improve upon the original resolution of a global data assimilation system for ocean wind analyses with a scheme which combines both wind and pressure data over the North Atlantic. Sanders (1990) has compared operational coarse scale objective analyses with manual post analyses to show that the objective analyses have a loss of information over the Northwest Atlantic, especially during the development and passage of a storm.

Thus, a technique was tested to provide objective analysis of high-resolution ocean surface wind fields over the Northwest Atlantic Ocean (U. S. East Coast to 60W, and from 25N to 48N) for coastal applications. These analyses are based on the reanalysis of ocean surface wind data only (ships and fixed buoys) on a fine mesh grid, using the analysed global surface winds on a 2.5 degree latitude / longitude grid as the first guess. The technique used to reanalyse the winds is based on a conditional relaxation method. This method assumes that the ocean surface wind data, which have been quality controlled to reject erroneous reports, contains more information than the coarse first guess alone.

2) METHOD

The analysis procedure treats the u and v components of the wind field independently. The first guess of the u-component is generated by interpolating from the analysis field obtained from the NMC Global Data Assimilation System on a 2.5 X 2.5 degree latitude / longitude grid. These winds are obtained from the mid-point of the lowest sigma layer (LSL) of the model (about 45 m above the ocean surface), and are reduced to 10m using the simple neutral log-profile. Monthly OPC verification statistics of the operational 10 m wind speeds derived from the LSL of the global model generally show a low bias when compared with the wind speed observed at high seas buoys over the NorthWest Atlantic. For October 1990, the 10m wind field was less than the buoys by 0.6 m/s with an RMS of 2.1 m/s. The fine mesh grid was chosen to be 1/2 degrees in longitude and 1/3 degrees in latitude. The u-component of the wind observation is used to correct the u-component at the nearest grid point, and that grid point is tagged as a fixed internal grid point. If more than one observation is used to correct a grid point, the corrections are averaged. The uncorrected ocean grid points are then determined by relaxation, holding boundary, land, and tagged grid points constant. The same procedure is then applied to determine the v-component. The reanalyzed wind field is now the "new" u and v components.

The conditional relaxation method is applied as follows. The Laplacian of the first guess field is formed as the forcing function. The corrected grid points are set as fixed internal grid points, and the non-corrected grid points are determined by numerical relaxation against the forcing function.

It is well documented that the quality of fixed buoy wind data is quite good, where as the quality of ship wind data is poor (Wilkerson and Earl (1990), and Pierson (1990)). Thus, full weight is given to the buoy data, but only 0.7 is given to the ship data when applying the correction to a grid point. For this analysis, only a gross error check is used to reject data that differs from the first guess speed by more than 15 m/s and direction by more than 120 degrees. Further development of quality control procedures is required to better handle the diverse marine data base.

3) RESULTS

Evaluation of the analysis procedure is difficult because of scarce data. There is no independent set of data for evaluation. In this paper, the validation was carried out by withholding one ship observation, re-doing the analysis and then evaluating the withheld observation against its own independent analysis. This is repeated for 10 different ship observations. Because of the expense of such an evaluation method, only two analyses were so evaluated.

The case of October 26, 1990, 12 UTC was selected because an intense storm had formed off Cape Hateras and was moving to the Northeast at the time. The Table (October 26, 12 UTC) compares; A) all the data against the NMC large scale initial first guess analysis, and B) all the data against the reanalysis, and then C) the withheld ship data against its independent reanalysis. The data are summarized by platform type; fixed buoy, ship, and Coastal-Marine Automated Network (C-MAN). The table shows that the initial NMC 10m wind speed analysis is too low by 2.4 m/s (RMS of 4.6 m/s) when compared against the observations. The directional differences are suprisingly small. There is virtually no directional bias and the RMS and the mean absolute difference (ABSD) are both nearly 20 degrees. The statistics with the reanalyzed winds show, as one would expect, a definite improvement. But this is not a fair evaluation; the analysis is expected to closely fit the data to the degree of its allowable influence. What is not known is how well the analysis represents an independent set of winds. This is attempted by evaluating the statistics from the sample of withheld ship data. There was an improvement in the speed bias (-1.9 to -1.2 m/s), and RMS difference (4.5 to 2.5 m/s), slight improvement for the ABSD for direction (18 to 10 degrees) and RMS difference (26 to 19 degrees) for the withheld ship data.

The results were somewhat encouraging for the analysis of 90/10/26 12UTC. Unfortunately, the same can not be said for another special evaluation made on 90/10/06 12 UTC which is probably a more typical October weather pattern. There are several reasons that the reanalyzed winds showed only small improvement. The NOAA fixed buoy network provides good quality wind reports but they are too few and are limited to placement close to the coast (400 km). Ship wind reports are more numerous and cover a wider area, but their quality is much poorer. In most cases, the large scale grid is adequate to depict the ocean wind field. But, in the cases where the scale of the weather systems is too small for the large scale grid, the reanalysis will have its greatest impact. It is evident that the inclusion of full resolution satellite wind data is required to improve the scale and quality of high-resolution wind analyses.

Table

Date 90/10/26/12

A) Observations against First Guess

		Speed				Direction		
	No.	FG	Ob	Diff	RMS	Diff	ABSD	RMS
BUOYS	16	10.8	14.4	-3.6	4.6	0	12	15
C-MAN	13	10.3	13.0	-2.7	5.3	-1	9	11
SHIPS	49	9.5	11.5	-1.9	4.5	0	18	26
TOTAL	78	9.9	12.4	-2.4	4.6	0	18	22

B) Observations against ReAnalysis

		Speed				Direction		
	No.	RA	Ob	Diff	RMS	Diff	ABSD	RMS
BUOYS	14	14.4	14.4	0.0	0.2	-1	2	4
C-MAN	13	13.1	13.0	0.1	1.4	-6	9	19
SHIPS	47	10.5	11.1	-0.6	1.6	0	10	19
TOTAL	74	12.0	12.4	-0.4	1.4	-1	9	17

C) Withheld Data against ReAnalysis

		Speed				Direction		
	No.	WRA	Ob	Diff	RMS	Diff	ABSD	RMS
SHIPS	10	10.3	11.4	-1.1	2.5	1	13	19

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