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EVALUATION OF EMPIRICAL TRANSFER FUNCTIONS FOR ERS-1 SCATTEROMETER DATA AT NMC

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1. INTRODUCTION

The ERS-1 scatterometer measures the roughness of the sea surface generated by ocean winds, and has the advantage of being able to produce both a wind speed and direction for a given radar backscatter measurement. In order to obtain a speed and direction from the measurement, a backscatter-to-wind empirical transfer function is necessary. NMC has recently begun a study of five of the different transfer functions delivered to the European Space Agency (ESA). The study compares derived scatterometer wind vector solutions from each empirical transfer function with collocated wind data from oceanic buoys.

Currently, data from the scatterometer are being received at NMC, in real time, in the form of a "Fast Delivery" product from ESA. The "Fast Delivery" product contains both wind vectors, derived from ESA's own operational transfer function, as well as direct radar backscatter measurements (σ_0 values) obtained from the three antennas on board the spacecraft. The the "Fast Delivery" wind vectors have been found to be inadequate for operational use. These winds often produce non-meteorological flow fields, when compared with a background pressure field from the NMC global model. Worse, such problems as adjacent cells giving directions 180 degrees opposite of each other, as well as false zones of convergence and divergence, have been observed in the data. Thus, NMC has decided to develop its own processing of the σ_0 data in order to make the scatterometer vectors more useful.

After the data have been received and unpacked, several quality checks are performed, including a check for sea ice (SST <= 0 C) using the NMC global analysis (GDAS) sea surface temperature. The next step in the processing requires the use of an empirical transfer function to obtain up to six, but usually four, wind direction solutions for a given radar backscatter. A statistical minimization method is employed during the inversion procedure, and the final selection of the most probable direction is guided by the NMC global surface wind analysis. The total processing package developed at NMC combines NOAA software design and quality control with inversion and ambiguity removal techniques developed at the UK Met Office, along with the use of the NMC global model fields.

For each of five selected transfer functions, wind vectors obtained by the NMC processing have been compared with observations from coastal and open ocean buoys. The "Fast Delivery" vectors have also been compared with the buoys. The five selected transfer algorithms include those developed by: ECMWF (CMOD 4), IFREMER (CMOD5I), ESA (CMOD5L), the University of Hamburg, (CMOD6), and NASA-JPL/Oregon State University (CMOD7). The buoy network, shown in Figure 1, includes both the NOAA fixed buoys and TOGA buoys, covering both the mid-latitudes and the tropics. The time window for matching scatterometer to buoy observation was set to plus or minus three hours (see Figure 2), and the space window was set to accept scatterometer data within a one degree box centered at the buoy location. Since the ERS-1 satellite produces about fourteen 500 km wide swaths of data per day, with further gaps in the data likely after quality checking and processing, the number of ERS-1 scatterometer matchups with buoy observations per day may be relatively small. Hence, the period of the evaluation covers six months, from September 1993 to March 1994, in order to obtain a large statistical sample.

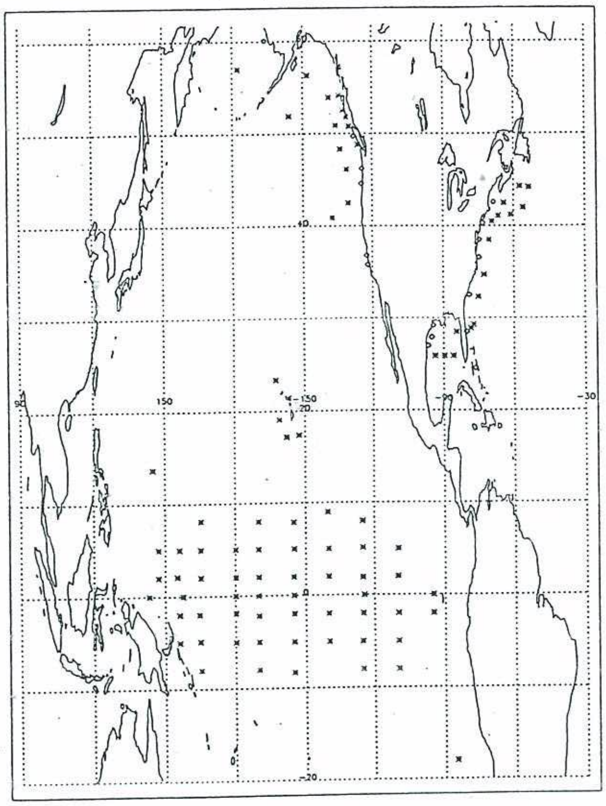

Figure 1: Open Ocean (*) and Coastal (♦) Buoys from NOAA and TOGA networks.

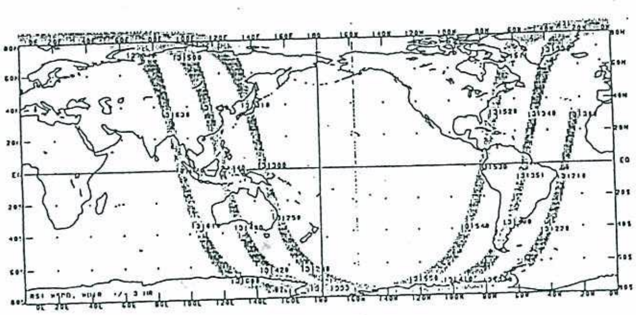

Figure 2: Typical ERS-1 Scatterometer orbits. Time window is approximately six hours (+/- 3 hrs).

2. RESULTS

Gross statistics have been computed using the buoy network as ground truth. The results are summarized in Table 1. The first five models listed in Table 1 represent the result of NMC's processing of the σ_0 data to winds, for each given transfer function.

Model	SPD BIAS	RMS	DIR BIAS	RMS
CMOD4	-0.4	1.9	5.7	34.9
CMOD5I	0.4	1.9	5.2	34.9
CMOD5L	-1.2	2.4	5.7	35.1
CMOD6	-1.2	2.3	4.7	38.2
CMOD7	-0.8	2.3	5.3	38.6
ESA FD	-0.4	1.8	0.4	58.0

Table 1: Comparison of RMS error and Bias for various transfer functions used in processing ERS-1 wind data.

The last model shown is the "Fast Delivery" product, also using CMOD4, but processed by ESA with a different ambiguity removal and minimization scheme than NMC. Note that while each of the five transfer functions result in comparable statistics for directional bias and RMS, the "Fast Delivery" winds are clearly shown to have the largest directional RMS error. This confirms quantitatively what was earlier noted concerning problems with the fast delivery vectors. The processing of the σ_0 data with any of the five transfer functions signifigantly improves the directional RMS error. By comparison, collocating the ten meter winds from the NMC global model with the buoys, using the same procedure as the scatterometer data, resulted in a RMS error of 1.9 m/s for speed and 31.7 degrees for direction. With regard to speed, the various models appear very similar when looking at gross statistics. These can be somewhat misleading, however; for example, transfer function CMOD4 produces magnitudes higher than the buoy observations at low wind speeds (less than 5 m/s), and lower magnitudes than the buoys at high wind speeds (greater than 12.5 m/s). The best "fit" to the buoy data was found to be at moderate wind speeds (between 5 m/s and 12.5m/s). Other transfer functions exhibit different biases relative to the buoys when categorized by wind speed. Overall, CMOD4 and CMOD5I appear to be the leading