SOS: a re-analysis of ERS wind stress observations

G. J. van Oldenborgh, A. Stoffelen, M. Portabella, J. de Kloe, A. Verhoef

A re-analysis of the 1992-2001 ERS scatterometer wind stress measurements has been performed using the latest retrieval algorithms. Two different surface layer schemes yield very similar results. Using triple collocations with TAO/PIRATA buoys and ERA-40 analyses, the error was found to be less than 1m/s per direction at TAO/PIRATA buoy sites. The low coverage means that data gaps are larger than decorrelation lengths and cannot filled in. The data are freely available at the KNMI Climate Explorer web site.

1. Description

Wind stress forces most of the ocean circulation, and plays a crucial role in coupled atmosphere ocean phenomena such as ENSO. Only recently have wind stress measurements achieved the high accuracy needed to study these. We have re-analysed the ERS scatterometer observations over 1992-2001 using the best algorithms available to provide uniformly high-quality wind stress measurements over the entire period. This re-analysis uses the fact that the scatterometer measures the wind relative to the ocean surface, which moves with the ocean currents, leading naturally to wind stress.

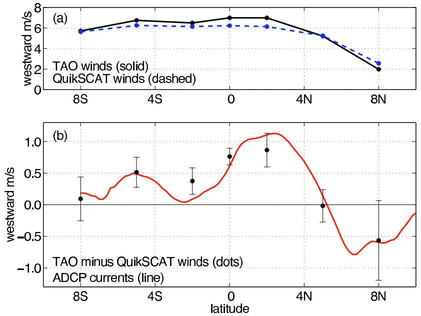

Figure A. The difference between Quickscat and observed surface winds compared with observed ocean currents (Kelly et al, 2001)

2. Surface layer models

Triple collocation of scatterometer wind stress, TAO/PIRATA buoy 4m wind measurements and ERA-40 10m wind estimates were used to calibrate the SOS wind stress and to estimate the errors in each of these datasets. The collocations were mostly within 12.5km and 10 minutes of each other. Only the year 2000 was used. Wind was converted to wind stress using the LKB and ECMWF surface layer models and is shown as $u_*^2 = \tau/\rho$.

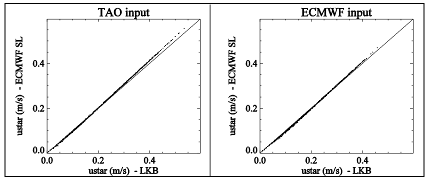

Figure B. Two-dimensional histogram of LKB estimated u_* versus ECMWF SL estimated u for two different input datasets: TAO/PIRATA buoys and ERA-40 re-analysis*

A 5% bias at high u_* values is visible in Fig. B. The main difference between the two models is in the roughness length (z_0) and the stability (L) parameterizations. LKB uses a constant Charnock value, ECMWF uses a substantially larger and sea-state dependent Charnock value; LKB has larger instability than ECMWF. These differences compensate up to medium wind speed. At high winds though, the stability term is much smaller than the roughness term resulting in some small stress bias between the two surface layer models.

3. Wind stress calibration

The error on the scatterometer dataset can be estimated in the tropical points where buoy (TAO/PIRATA) and re-analysis (ERA-40) data are available. This has been performed at all points within 25km and 30minutes in 2000. The scatterometer wind stress is seen to be the most accurate measurement.

[m/s]	σ	δ(ERS)	δ(TAO)	δ(ECMWF)
	Scale 50km			
u_*	3.16	0.90	1.08	1.59
v_*	4.91	0.68	1.07	1.32
	Scale 200km			
u_*	3.12	1.03	1.19	1.51
v_*	4.89	0.85	1.18	1.22

Figure C. Full standard deviation and estimated error of the scatterometer (ERS), buoy (TAO/PIRATA) and re-analysis (ERA-40) wind stress

4. Coverage

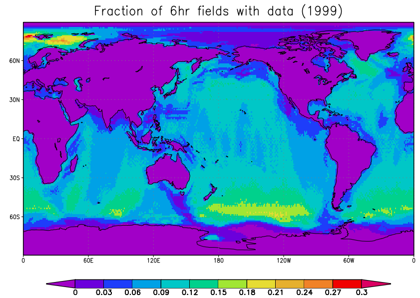

Figure D. Fraction of 6-hourly grids in 1999 with data

As can be seen from Fig. D, coverage of the ERS scattermometers is not complete: on the synoptic time scale only about 10% of the oceans have valid measurements, 20% in the Southern Ocean and less near coasts.

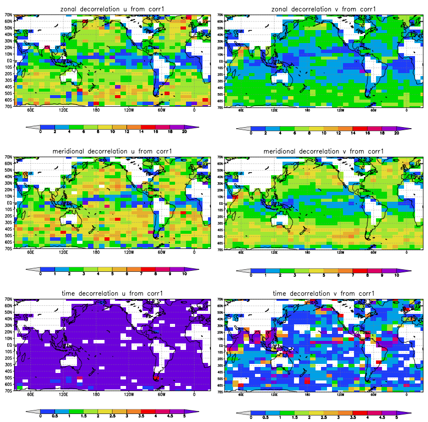

Figure E. Decorrelation scales (in degrees and days) from a fit to a 3D gaussian distribution to the cross-correlations of high-pass filtered data. The off-diagonal elements are not shown.

The decorrelation scales shown in Fig. E are smaller in space and time than the gaps between the data, so interpolation without extra information is impossible. We are considering merging other scatterometer and re-analysis data.

As a self-contained first step the data have been averaged to longer time scales without interpolation or the usage of other data sources.

5. Comparisons

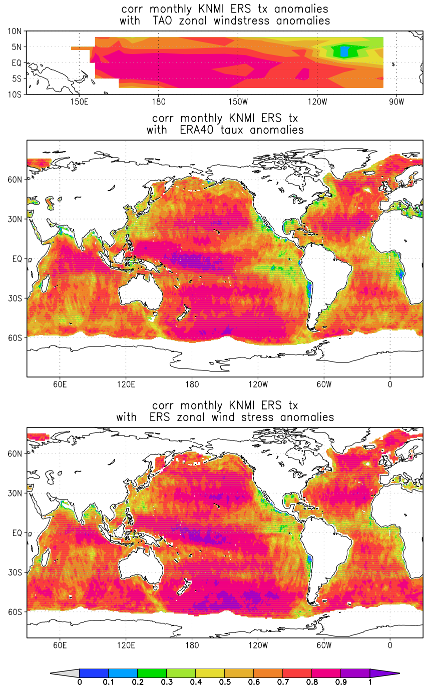

Figure F. Correlation of SOS wind stress with the TAO observations, ERA-40 reanalysis and Ifremer/CERSAT ERS analysis

6. Conclusion

We present a re-analysis of ERS scatterometer wind stress observations. These have been validated against the ERA-40 re-analysis and TAO/PIRATA buoy observations. Coverage is on average 10% per 6 hours. The global 6-hourly wind stress and wind fields are available on a 0.5° grid at the KNMI Climate Explorer in a variety of formats. Daily, pentad and monthly averages of these and higher moments are also available. The fields can be compared with other wind (stress) estimates inside the Climate Explorer web site.

References

Kelly, K. A., S. Dickinson, M.J. McPhaden, and G. C. Johnson, Ocean currents evident in satellite wind data, 2001: Geophys. Res. Lett., 28, 2469-2472

KNMI Climate Explorer, climexp.knmi.nl

KNMI, oldenborgh@knmi.nl

Koninklijk Nederlands Meteorologisch Instituut