LONG-TERM CALIBRATION OF WIND AND WAVES IN THE MEDITERRANEAN SEA

L.CavalerI, L.Bertotti, and M.Sclavo

ISDGM-CNR, S.Polo 1364, 30125 Venice, Italy

INTRODUCTION

We have faced the task of assembling a very accurate data set of wind and wave data in the Mediterranean Sea. The Mediterranean is a very active basin, whose meteorology is dominated by the contrasting climates at its southern and northern borders, The hot climate of North Africa contrasts markedly with the stormy weather of Central and Southern Europe. Most of the storms come from the North-West sector, while relatively frequent inflows of Siberian air bring cold north-easterly winds on the northern part of the basin. These storms can reach the African coast, but with a reduced strength. The latter part of the basin is interested by southerly winds (sirocco, kamsin) which can bring warm southerly storms up to the northern part of the Mediterranean Sea. The complicate orography all along most of the borders makes the evaluation of the surface winds a difficult challenge, with a strong variability both in space and time. As it will be shown in the section in the results, this has implications on the accuracy of the available model data.

During the last decade satellite data have become more and more common. They provide a wealth of information, with the further advantage of being weather independent. They measure preferably in the open sea, off the coast. From the point of view of an atlas, one limitation is the time interval with which the data are measured, the choice when defining the orbit being between a more dense coverage sparse in time or more frequent passes at larger space interval.

The only source that provides a complete and dense coverage in space and time is numerical modelling. Both meteorological and wave models have reached a high degree of sophistication. Available from the archive of the various meteo-oceanographic centres, they can confidently be used for long term statistics. However, while the quality of the meteorological output is very high, the surface winds, the ones we care about for oceanographic and navigation purposes, tend to be more affected by the proximity of land. In these areas, and particularly in the enclosed basins like the Mediterranean Sea, the standard model data do not stand by themselves for a reliable statistics.

The solution comes in the combined use of both the model and satellite data. The model data provide the coverage, in time and space, while the satellite provide the required accuracy. Therefore the technique consists in using the satellite data to calibrate the model data, which are then used to evaluate the required statistics.

THE DATA SOURCES

We have made used of the model data from the archive of the European Centre for Medium-Range Weather Forecasts (ECMWF, Reading, U.K.). The Centre produce daily meteorological forecasts and analysis data, the latter ones representing the best possible estimate of the situation at a given time. Since July 1992 ECMWF run also a wave model, whose input information are the surface winds provided by the meteorological model. Both these models are run on a global scale (see Simmons, 1991 and Komen et al, 1994 for a full description of the two models and their results). Surface winds and wave information have been extracted at 0.5 degree interval for the whole Mediterranean Sea. They cover a full ten year period, from July 1992 till June 2002. The data are available at 6 hour interval, for the synoptic hours 00, 06, 12, 18 UTC.

During the ten year period we have considered (July 1992 – June 2002), the resolution of the meteorological model was changed twice. In 1998 ECMWF passed from T213 to T319, the number representing the truncation level in the two-dimensional Fourier series expansion used to describe the fields. Then, in November 2000, a major change was introduced with the shift to T511 (~40 km resolution. While the change from T213 to T319 did not cause large variations in the quality of the model results, the shift to T511 was a momentous event, that led to a substantial improvement of the results. Therefore it would not be correct to carry out a single calibration on the ten year data-set we have at disposal. The divide line is at 21 November 2000, when the model was moved to T511. Two separate and distinct calibrations have been carried out, for the period before and after this date.

The satellites considered as a reference for calibration are ERS1-2 and Topex. However, the previous assimilation of part of the satellite data in the meteorological and wave models precludes their use for the calibration of the model data. Therefore for the actual calibration we can make use of the following data:
wind speed, Topex and ERS1-2 altimeter data,
wave height, Topex altimeter data; ERS-1 altimeter data, i.e. till 1995; ERS-2 altimeter data, only for sufficiently large wave heights, and only till 1998.

CALIBRATION PROCEDURE

The model data have been extracted at 0.5 degree intervals, for both wind and waves, for the whole Mediterranean Sea. The data are available at the archiving six hour interval (four times a day). Hence from the ten year period, almost 15,000 data are available for each grid point.

As a rule the satellite data, taken along the ground track of the flight orbit, do not coincide with the positions (the grid points) and times (synoptic times at six hour interval) where the model data are available. Therefore for each satellite measurement, an interpolation in time and space has been done to derive the corresponding model estimate. This has led to a large data-set of corresponding couples of satellite-model data, distributed throughout the basin. Then each couple has been assigned to the closest grid point (with 0.5 degree resolution). For each grid point this has produced a set of couples, that could be used for the statistics, at that grid point, between model and satellite data. In particular we have evaluated for each grid point the best-fit slope between model and measured data, and their scatter around the best-fit. While the slope provides an estimate of the required local correction coefficients, the scatter is an indication of its reliability.

The different amount of data available at the various locations and the local orographic characteristics lead to a reliability of the results rather variable in space. Therefore, rather than considering the single calibration values at all the 0.5 degree grid points (about 950 of them), we have deemed more scientifically sound to consider only a reduced selected number of them (about 240), each summarising the information available in the surrounding area, in so reducing the uncertainty of the final results.

RESULTS AND DISCUSSION

Following the procedure described in the previous section, we have evaluated the correction coefficients for the chosen subset of Mediterranean grid points. The resulting maps, as isolines, for wind speed and wave height, are shown respectively in Figure 1 and Figure 2 for the period from July 1992 till November 2000. Note that the figures show the slope of the best-fit lines, which can be interpreted as the inverse of the correction coefficients required at each location.

Analysing the distribution of the isolines, it is immediately evident that their value grows moving from North to South. In other words the quality of the model results increase moving from the European toward the African coasts. This reflects the fact that most of the storms that affect the basin come from the North to North-West sector and the influence of land in the first few hundreds of kilometres off the coast. Besides the whole northern border of the Mediterranean Sea is characterised by a pronounced orography, that further affects the wind, hence the wave, fields. From the figures this is evident all along the Alboran Sea, the Western Mediterranean Sea, the Ligurian and Adriatic seas, the Aegean Sea and just south of Turkey. On the contrary the African storms, i.e. winds blowing from the Sahara, are relatively rare and in any case they are not affected, in Libya and Egypt, by a marked orography.

The calibration facors so obtained have been used to correct the original model data, providing a high quality time series for wind and waves in the Mediterranean Sea.

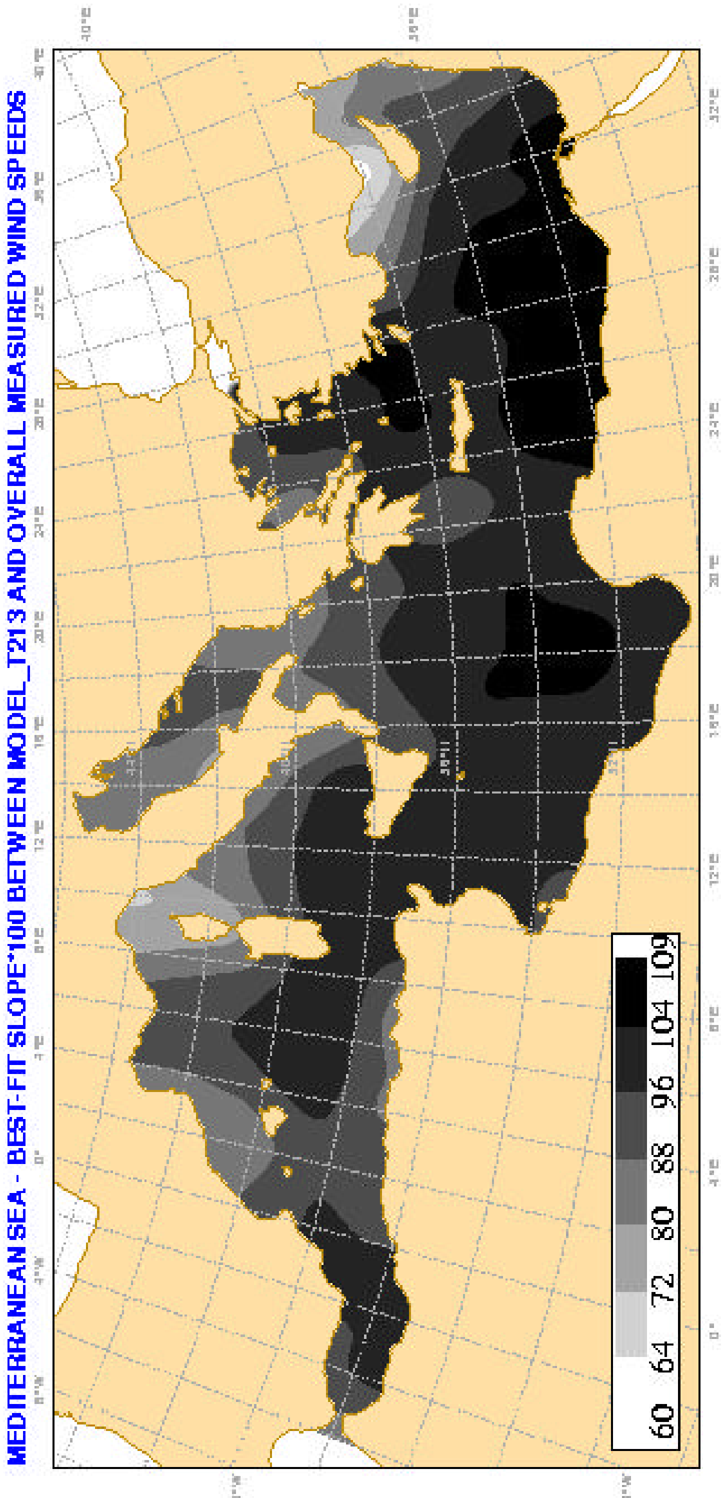

Figure 1 – Distribution of the best-fit slope between modelled and satellite measured wind speeds. Figures are slope*100. The period considered is before 21 November 2000.

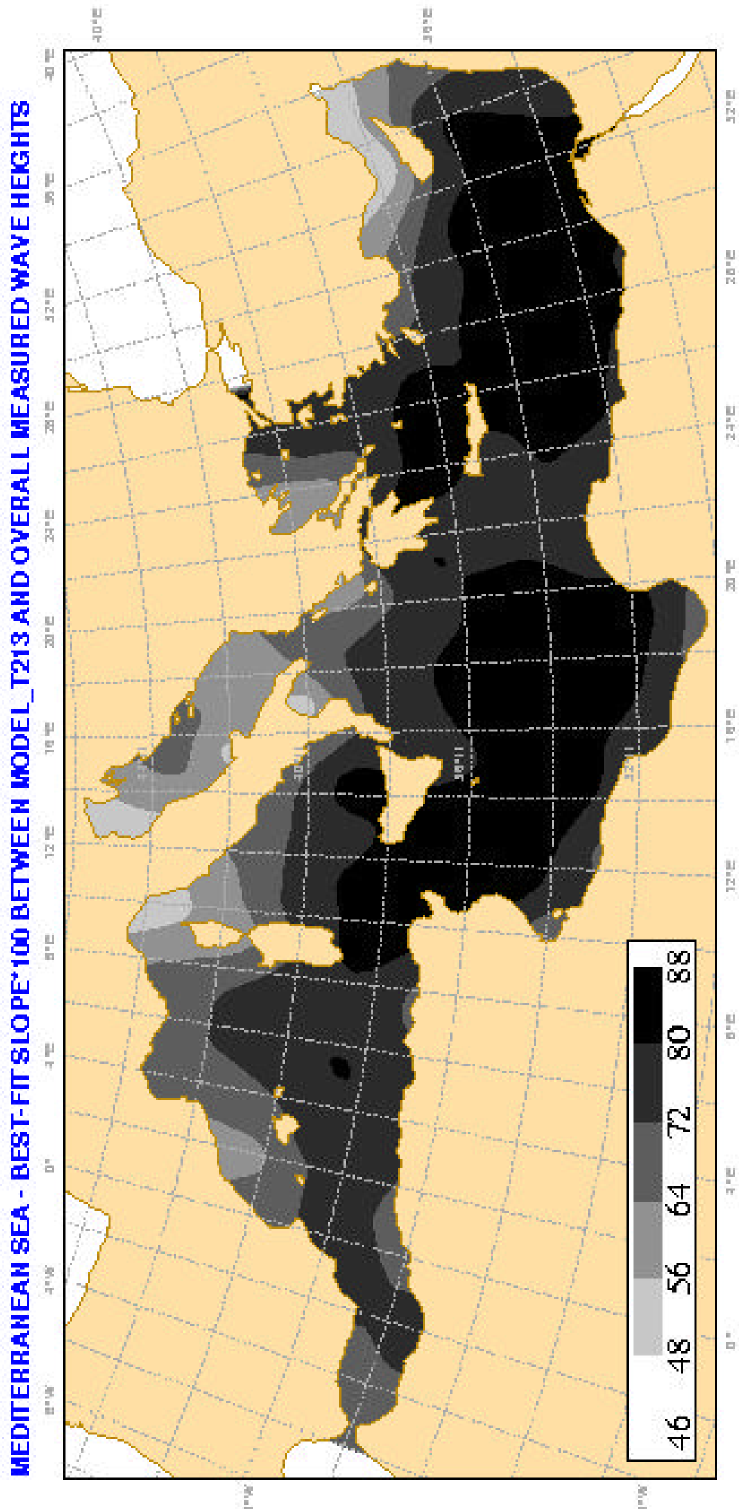

Figure 2 – Distribution of the best-fit slope between modelled and satellite measured wave heights. Figures are slope*100. The period considered is before 21 November 2000.