Determination of wind distribution over the Eastern Mediterranean Sea using ERS-1 data

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Abstract – The Mediterranean can be regarded as a transitional zone between the continental influences of Europe and Asia, the desert climate of North Africa and the oceanic effects from the Atlantic. The objective of this work is to determine the wind distribution over the Eastern Mediterranean Sea using data from European Remote sensing Satellite-ERS-1. Wind speed measured by ESR-1 during the period March 1992 to May 1996. The results indicate that the highest values of relative error of wind speed are found in the extreme part of the Eastern Mediterranean, while the lowest values of error of wind speed are found in open sea and off the Egyptian coast.

Keywords: Eastern Mediterranean Sea; ESR-1; wind speed; zonal wind; meridional wind.

1. INTRODUCTION

One factor affecting the temporal and spatial variability of the Mediterranean is the atmosphere, whose strong interaction with the sea has many important consequences, among which dense intermediate and deep water formation, strong seasonal as well as strong inter-annual changes in water properties and dynamical structures (Manzella et al, 2002). In the eastern Mediterranean the Adriatic has been assumed as a site of dense water formation (Pollak, 1951; Gacic *et al.,* 1996), while the Aegean Sea was believed to be a possible source of deep water by Nielsen (1912), Pollak (1951), Wust (1961), Lacombe and Tchemia (I960).

It has been evidenced both by the observation data and numerical modeling that the wind stress curl plays a very important role in the circulation of the southern Ionian (Korres *et al.,* 2000) which periodically shifts from cyclonic to anticyclonic patterens. Such changes are also evident in the nutrient supply to the euphotic zone and in the deep ecosystem, affecting the organic matter produced and exported (Astraldi et al, 2002).

Many empirical studies have been directed at developing an improved satellite altimeter ocean wind speed algorithm using different numerical approaches and data sets (e.g. Brown et al., 1981; Dobson et al., 1987; Chelton and McCabe, 1985; Witter and Chelton, 1991; Glazman and Greysukh,1993; Young, 1993; Lefevre et al., 1994; Freilich and Challenor, 1994).

ERS-1 since 17th July, 1991 continuously observes the continents, world's oceans and the Polar Caps and provides new data in support of a number of conventional quantitative studies to understand the complex processes, which govern our planet. The ERS active microwave sensor operates at 5.4GHz (C band) and provides data on wind speed and direction at a 50 km resolution with a separation of 25 km across a 500 km swath (Glazman and Greysukh,1993).

The aim of the present study is to calculate the wind and its error and therefore determine the wind distribution over the Eastern Mediterranean Sea.

The area of study, which is the Eastern Mediterranean Sea, lies between longitudes 10°E and 36°E and latitudes 30°N and 40°N, as shown in Fig. 1.

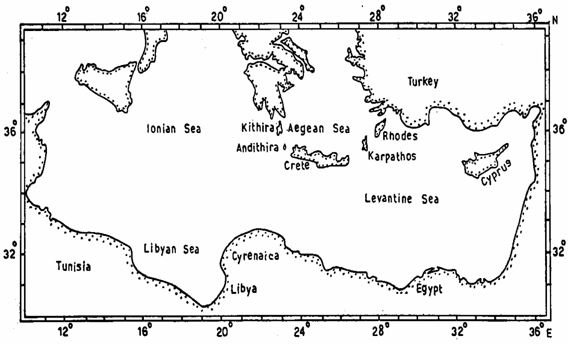

Figure 1. Eastern Mediterranean Sea basin.

2. MATERIALS AND METHODS

Wind data were collected from ERS-1 satellite during the period March 1992 to May 1996.

We used the EetrMWF program, which can select and extract gridded points from the Mean Wind Field Atlas on a CD ROM. The EetrMWF package enables to specify the time period, the geographic area as well as the parameters needed. The wind data were obtained from the aforementioned CD ROM and used to compute the zonal and meridional wind components as well as the wind stress over the area of investigation. Errors in wind speeds were also obtained by means of comparison with the in situ data available at the Internet website http://ingrid.ldeo.Columbia.edu/NOAA/NCEP-NCAR . All the obtained data were saved in ASCII format. The wind speed and its error were tabulated. The MS Excel software has been used to replace rows by columns and vice versa to prepare the data for calculation using the UNESCO WIN-IDAMS software; the data were saved in MS-DOS format.

Utilization of the WIN-IDAMS software in each pixel created a new file, accommodating time series for wind speed and its error for the study period as well as the results of analysis established. The standard deviation was also calculated for wind speed and its error. Correlation coefficients and regression relationships between wind speed and its error were equally obtained. The above-mentioned calculated values were placed into a new file in the Excel environment. A relative error of wind speed was calculated by the following expression:

$$R\% = (\text{error of wind speed}/ \text{wind speed})* 100 \qquad (1)$$

The obtained results were converted into a graphical form using the Golden Surfer 7.1 software.

3. RESULTS AND DISCUSSION

Winds in the Mediterranean basin are mainly westerlies, and there are two important wind regimes: the Mistral and the Etesian winds. The Mistral, a northwesterly wind, is a strong jet that dominates in winter, giving an important meridional component to the wind pattern. It increases the variability of the basin average wind speed amplitudes and directions.

In early summer the Mistral is strongly reduced and its location is shifted to the north (Pierini and Simioli, 1998). The Etesian winds dominate in summer, giving a strong northerly component to the winds pattern, mainly in the Eastern Mediterranean (Castellari et al, 1998).

The magnitude of the wind stress is characterized by a continuous increase during the 50 years period in the Levantine basin. A similar but weaker trend is also evident in the Ionian. The examination of the zonal and meridional wind stress components indicates that the increase in the wind stress magnitude in the former two sub-basins is mainly due to an increase of its meridional component. This results in a shift of almost 20 of the wind stress direction for the Levantine from approximately 27°N to 31°N and for the Ionian from 31°N to 33°N (Lascaratos et al, 2002).

The retrieved results were obtained from 164 pixels. As we see in Fig. 2, the highest values of relative error of wind speed were found in the extreme part of the Eastern Mediterranean.

In the Southern part of the Aegean Sea and the northern part of the Ionian Sea, the range was between (0.86 - 0.98 m/s). While the lowest values of error of wind speed (0.73 - 0.83 m/s) were found in open sea and off the Egyptian coast. The error of wind speed assessed for the west of Cyprus lies in the range 0.73 - 0.89 m/s. The maximum range was found next to Syria (1.01 m/s).

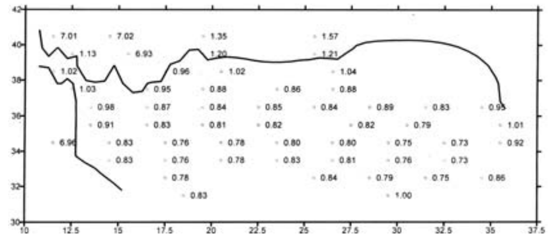

Figure 2. Relative error of wind speed.

As seen in Fig. 3, most of the retrieval results were in the acceptable range of error (13%-19%), the data with the error in excess of 20% have been discarded. In the open sea the relative errors in the range were between (13% - 16%). while off the Egyptian coast the error proved to be in the range (16%-19%).

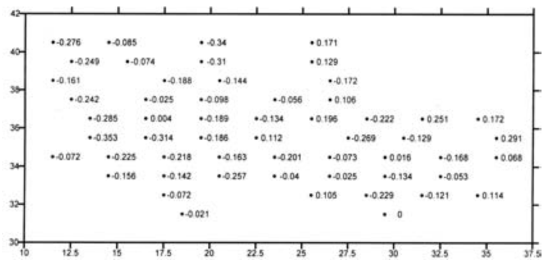

Figure 3. Correlation coefficient of wind speed.

4. CONCLUSION

Wind speed and its error were assessed from ESR-1 data during the period March 1992 to May 1996. The results indicate that the highest values of relative error of wind speed are found in the extreme part of the Eastern Mediterranean.

In the Southern part of the Aegean Sea and the northern part of the Ionian Sea, the error was in the range (0.86 - 0.98 m/s), while the lowest values of error of wind speed (0.73 - 0.83 m/s) were found in open sea and off the Egyptian coast.

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