SEASONAL FLUCTUATION OF SURGE HEIGHTS AT ALEXANDRIA (EGYPT)

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ABSTRACT

Surge heights of Alexandria coastal water were calculated by removing the predicted tide level from the observed sea level for four years period (1977 -1980), and denoted as the residuals, or surges .

Four types of residuals were identified according to the four seasons of the year (Spring , Summer , Autumn and Winter). The general characteristics of these residuals were investigated as well as the meteorological conditions affecting them.

INTRODUCTION

At Alexandria , the most apparent feature of the weather is the evidence of four seasons. By analysing the residuals phenomena with the meteorological conditions associated them, it can be clearly seen that there are four types of residuals accordingto the four seasons of the year.

The present discussion is concerned with the properties and the description of the seasonal residuals phenomena at Alexandria coastal water to identify the general pattern of these residuals for each season which are important for navigation and for the design of harbours and other coastal installations.

Data and method of analysis

The data used are the hourly sea level values in the Western Harbour of Alexandria for the four years (1977 - 1980). The residuals were calculated by subtracting the predicted tidal heights from the recorded sea level.

The daily residuals were determined for the four seasons , where , Spring (March, April , May), Summer (June , July , August) , Autumn (September , October , November) and Winter (December , January , February).

RESULTS

The general agreement between the variations in the residuals with the variations of meteorological conditions during the four seasons of the year has led to classify the Alexandria residuals to four types as follows.

Spring residuals

From the study on surge heights by Moursy , 1976 , Hamed , 1983 , and Moursy, 1989, it can be concluded that , winds acting from South West and South East directions induce an uprise of sea level . On the other hand , low water are caused by winds blowing from North East, North and North West sector.

The prevailing winds during spring season are usually between North West and North East, and consequently very low negative residuals occur . The gradual daily rise and fall in these spring residuals for the four years (1977 - 1980) are shown in fig. 1, which shows that the lowest values are often found in March where the minimum daily residuals reached -20.2 cm in 1977 ,-23.4 cm in 1978, -25.9 cm in 1979 and -24.6 cm in 1980. In general, the marked feature of these residuals is its lowering under the zero level. The prediction of these low water levels may be required for warning purposes specially for very large vessels which may be navigating with small under -keel clearances.

Summer residuals

The summer residuals are characterized by its high positive values during the whole season except few days at the beginning of June, while July and August show the highest residuals.

Fig.2 illustrates the behavior of the daily summer residuals for the investigated period, where the changes in the heights differ from year to another, but still have high level values .

The maximum height of the daily summer residuals ranges from 14.8 cm in 1979 to 20.7 cm in 1978. These high level values of the residuals may be attributed to the West - East large scale pressure gradient over the Central and Eastern Mediterranean,

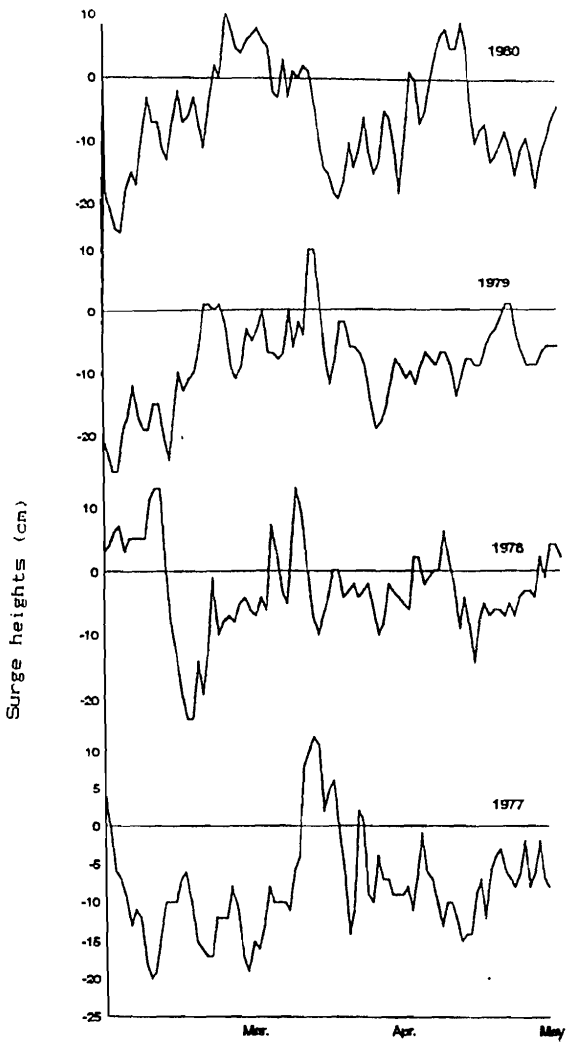

Figure 1: Daily variation of surge heights during Spring season (1977-1980).

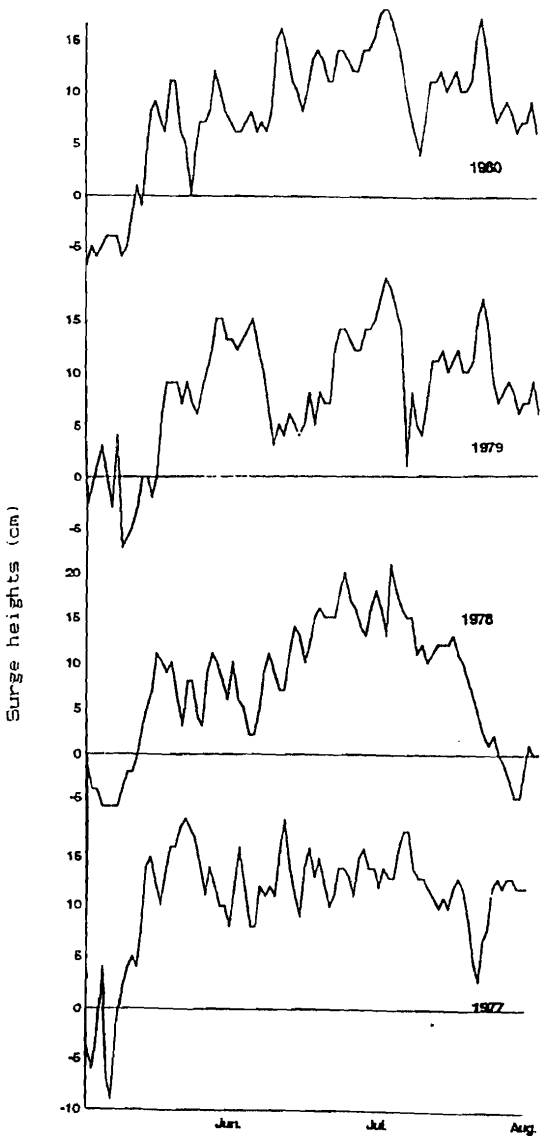

Figure 2: Daily variation of surge heights during Summer season (1977-1980).

as well as the local effect of atmospheric pressure. In addition, the changes in the water volume due to temperature in summer season would be compatible with a higher sea level during this season.

Autumn residuals

The general pattern of the Autumn residuals shows small positive values at the first half of the season (End of summer), then starts increasing or decreasing according to the local weather conditions.

The variations of Autumn residuals are compound and sometimes difficult to define. The highest positive value during the investigated period occurred in November, 1980 (23.8 cm) while the lowest one was in November , 1978 (-18.8 cm). These changes in the daily residuals may be the result of the wind pattern during this season which passes by a transitional period with relatively scattered wind directions and leads to the variability in the residuals which can be seen in fig. 3.

Winter residuals

The most characteristic features of winter residuals are the existence of high positive storm surges, it extends over periods of several days. The storm condition during winter occur when the center of the Cyclone over the Eastern Mediterranean passes near the Egyptian coast with wind speed up to 22 knots and sometimes gusts of 60 knots, accompanied by low pressure.

The variations in daily surge heights at Alexandria during winter season can be seen in fig. 4. where January and December are the months of highest peak surges, it reached 40 cm. So, it must be taken into consideration for navigational purposes especially during the period of severe storms.

The disturbances in the residual heights (Changing from high positive surges to low negative surges at short time) in fig 4 are produced by the scattered wind during this season. The generation of the high positive surges are strongly affected by the intensive South Westerly wind.

Meteorological conditions affecting the surge heights

Heaps, 1967 pointed out that the surge at any location derived from observation of sea level may be regarded as consisting of a part generated by wind stress acting generally over the sea surface, and a part generated by barometric pressure. When adepression moves into a sea area the atmospheric pressure acting normal to the sea

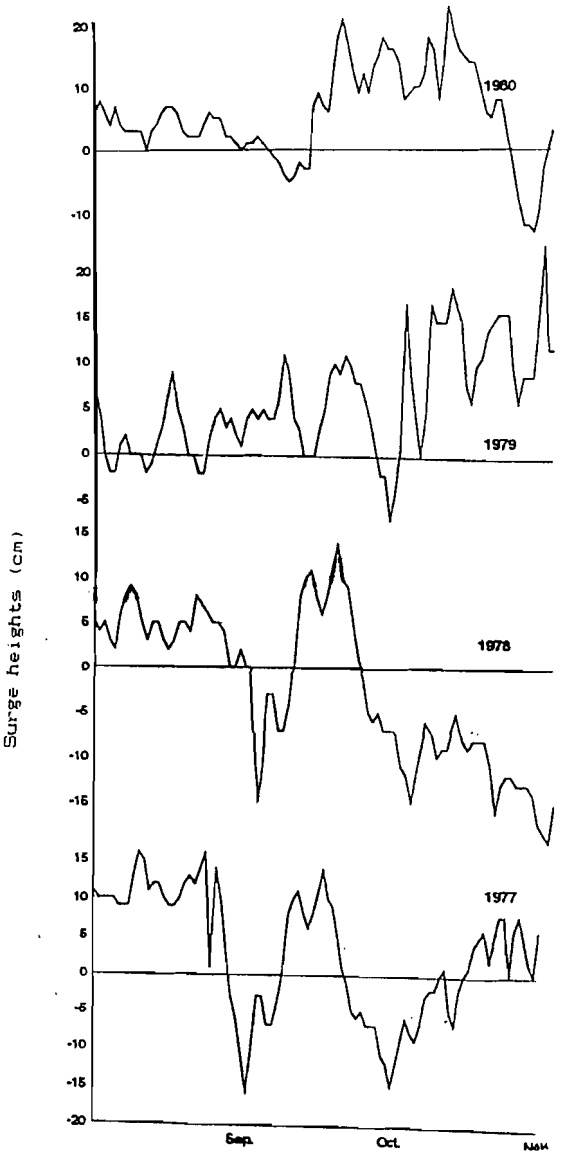

Figure 3: Daily variation of surge heights during Autumn season (1977-1980).

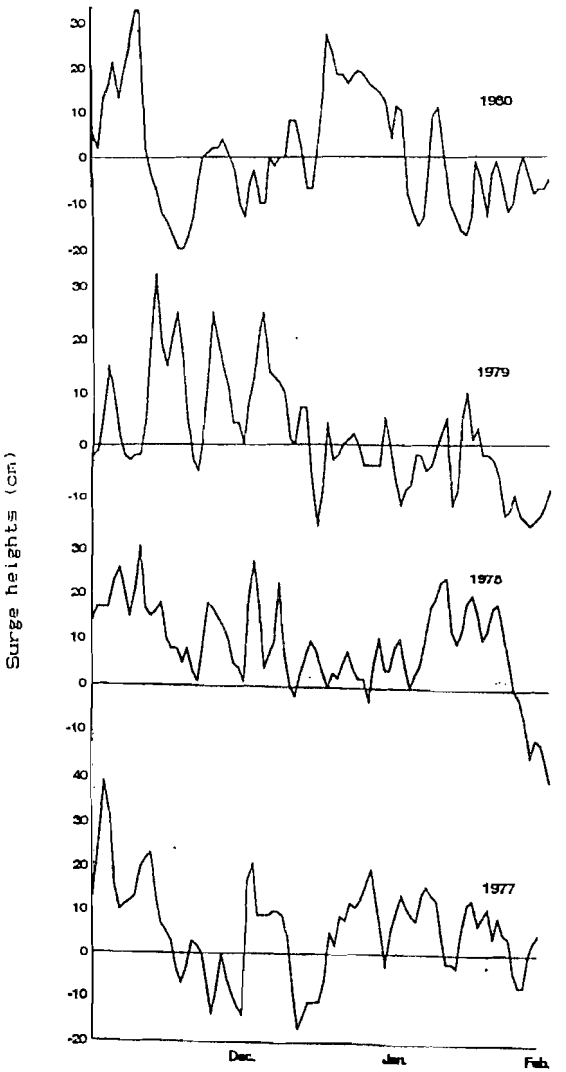

Figure 4: Daily variation of surge heights during Winter season (1977-1980).

surface falls and, as a consequence, the sea level rises. As the depression leaves the area, the pressure rises and the sea level falls.

The most important factor affecting weather in the Eastern Mediterranean is the pressure pattern over the Balkan and the Central Mediterranean. Anonymous, 1960 illustrated that, in summer, there is an anticyclonic system with a large pressure persisting over the Eastern Mediterranean. This pressure distribution generates low wind speeds from North West at Alexandria, with large scale pressure gradient from west to east. On the other hand, during winter season, the Eastern and Central Mediterranean part are areas of cyclonic formations associated with depressions moving from west to east, and strongly generated winds and frequently occurring storms at Alexandria.

Detailed knowledge of the pressure differences between the Eastern and Central Mediterranean was given by Striem, 1972, where monthly barometric pressure have been calculated for Haifa and Port Said representing condition on the Eastern Mediterranean coast and for the Central Mediterranean by averaging barometric pressure at Rome, Taranto, Cagliari and Malta. The results indicate that during winter the barometric pressure in the Central Mediterranean is lower than it is in the Eastern basin, and this would be compatible with a lower sea level in the Eastern Mediterranean. During summer the barometric pressure in the Central Mediterranean is higher than that of the Eastern basin, and this would be in line with a higher sea level in the Eastern Mediterranean.

For South Eastern Mediterranean, the monthly barometric pressure have been calculated for Haifa, Port Said and Alexandria. The greatest observed differences between the Central and South Eastern Mediterranean pressure are found in July and August. Fig 5 illustrates these differences during the year, and shows the agreement between these pressure differences and the seasonal fluctuation of surge heights at Alexandria. It also shows the coincidence between the inverted barometric pressure at Alexandria with the surge heights , which indicate that the pressure has an important influence on sea level. However, there are notable differences between the two curve specially during winter months, which may be attributed to the effect of wind forces and directions during storms.

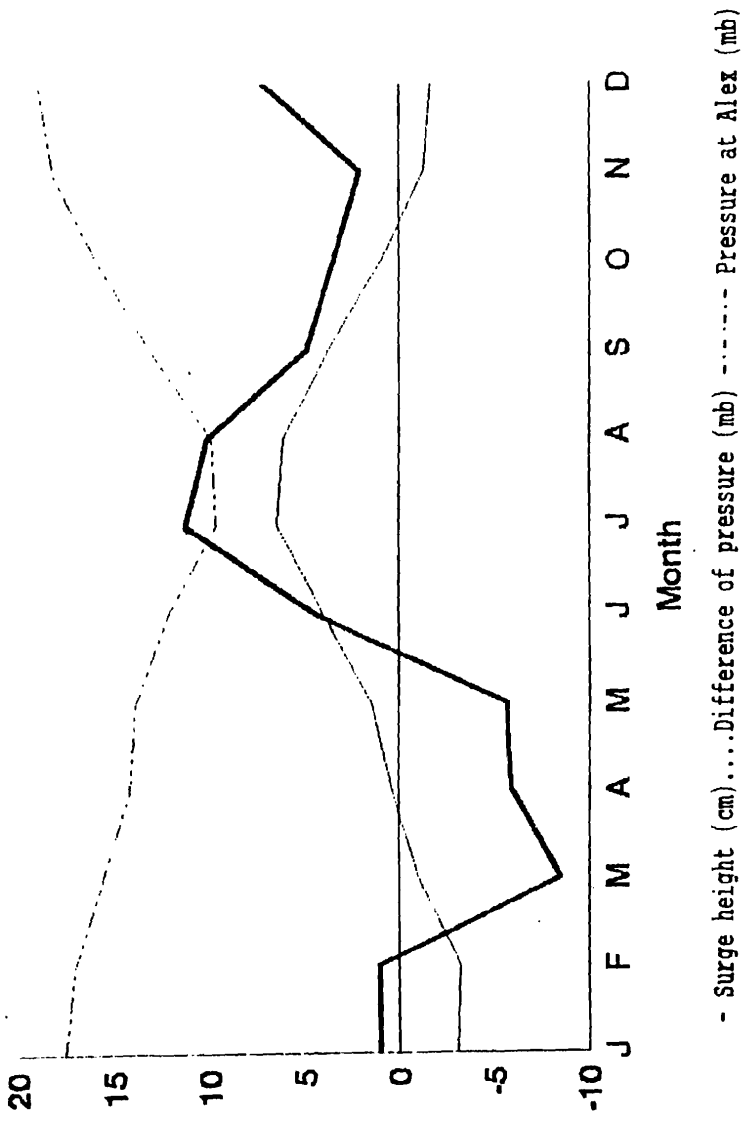

Figure 5: Relation between monthly surge height, pressure at Alex. and the pressure difference between Central and South Eastern Medi.

SUMMARY AND CONCLUSIONS

Surge heights (Residuals) were obtained by removing the predicted tidal height from the observed height of sea level . The seasonal variations of the daily residuals show four types, one for each season of the year (Spring , Summer, Autumn, and Winter).

The lowest residual observed was in spring season, it is known by negative surge. The minimum daily value during the investigated period was between -20 cm to -26 cm. These phenomena are attributed to the North -Westerly wind at the end of winter.

The most marked feature for summer season residuals is its high level values, specially in July and August. The highest daily residual reached 20.7 cm. These phenomena are due to the lowering of pressure system in the South Eastern than in the Central Mediterranean and consequently high sea level during summer at Alexandria.

Autumn residuals show large irregular changes in both positive and negative residuals. It may be the result of scattered wind direction during this season which passes by a transitional period.

The highest positive storm surges are often found in winter season, where storm conditions extend over periods of several days. The maximum daily surge during the investigated period reached 40 cm. It must be taken into consideration for navigational purposes.

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