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Wave Hindcasting Versus Observation for a Heavy Storm on the Israel Mediterranean Coast

Michael Stiassnie*
Technion — Israel Institute of Technology, Haifa, Israel

Abstract

A comparison between the observed and hindcast wave parameters (breaker height and period) for the heavy storm of mid-January 1968 is presented. It is hoped that the satisfactory correlation obtained will increase confidence in the frequently used and almost unique Ashdod wave observation data set, as well as in the applicability of the wave spectra forecasting method for the eastern Mediterranean.

Introduction

Almost all coastal engineering projects and theoretical investigations regarding the Israel Mediterranean coast rely upon a single set of observed wave data. These observations were obtained by the Coast Study Division of the Israel Ports Authority at Ashdod during the period 1958–1971. The purpose of this note is to offer a partial check of this important data set. The check is accomplished by comparing the observed wave heights and wave periods with those obtained by wave hindcasting from meteorological maps for the heaviest storm recorded, which occurred in January 1968. The hindcasting results, which are based on the wave spectra statistics method of Pierson, Neumann and James (1971), may serve to encourage Israel meteorologists who have used this advanced method for several years. The significant wave height in deep water, on the 13th of January 1968, was about 7 m with maximum breaker heights reaching nearly 10 m. According to Rosen (1977), such a heavy storm has a probability of recurring about once every 20 yr.

Meteorological and Oceanographical Data

The data used in the present work consists of the maximum breaker height, maxH_b (the highest of about 20 successive observed breakers), the average wave period T, the wave direction, and the wind direction and speed as measured by the Coast Study Division (1969). These measurements, which were taken three times daily at 0600, 0900, and 1200 GMT

* Research-Fellow.

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TABLE 1. Meteorological and Oceanographical Data at Ashdod, Taken from Coast Study Division (1969)

Date (Jan. 1968)	Hour (G.M.T.)	Max H_b (meters)	T (seconds)	Wave direction	Wind speed (knots)	Wind direction
12	06	1.2	5	W	12	SE
12	09	1.5	7	W	15	S
12	12	1.8	7	W	16	SSW
13	06	5.5	10	W	25	SSW
13	09	7.5	12	W	28	SSW
13	12	8.5	12	W	28	SW
14	06	8	13	W	15	S
14	09	7.8	14	W	27	SW
14	12	7.2	12	W	28	SW
15	06	6	10	WNW	24	W
15	09	6.5	11	WNW	33	SW
15	12	7	12	WNW	37	W
16	06	5.5	10	WNW	15	NW
16	09	4.5	9	NW	19	NW
16	12	3.8	8	WNW	15	WNW
17	06	3.5	8	W	19	WSW
17	09	3.3	8	W	19	WSW
17	12	3	8	W	18	WSW
18	06	1.2	6	WNW	6	E
18	09	1.2	6	WNW	VAR	—
18	12	1.2	6	WNW	7	N

are presented in the Table 1. The wave hindcasting was based on winds taken from a complete sequence of synoptic meteorological surface maps, obtained from the archives of the Israel Meteorological Service. This relatively rare meteorological situation was characterized by long fetches (up to 500 nautical miles) and high wind intensities (up to 40 knots) of considerable duration.

The comparison between measurements and hindcasting was made for 1200 GMT on the 12th through 17th January 1968. The relevant storm conditions, as deduced from the meteorological maps are presented in Table 2. It is important to emphasize that the determination of these storm conditions is, to a certain extent, subjective and relies, at least partially, on the personal experience of the author.

TABLE 2.

Date (January 1968)	12	13	14	15	16	17
Average wind velocity (knots)	24	32	28	28	20	18
Average wind direction	SW	W	WSW	WNW	W	WSW
Fetch length (nautical miles)	50	500	350	200	200	100
Storm duration (h)	8	24	48	72	96	120

Wave Hindcasting

The hindcasting, which was performed in accordance with the wave spectra statistics method of Pierson et al. (1971), yielded the results shown in Table 3.

To clarify the above results we note that (i) in all cases considered the fetch limitations were more severe than the duration limitations. (ii) The effective fetches were calculated according to C.E.R.C. (1973, p. 3–31). The appropriate factor was found to be between 0.6 and 1. (iii) The number E may be defined as twice the variance of a large number of values from points equally spaced in time as chosen from a wave record. This number actually represents the wave energy and can be used to compute various statistical wave heights. (iv) For the storm of the 12th, which had a southwest direction, an angular spreading factor of 50% was taken, while for all other conditions this factor was taken equal to 100%.

Maximum Breaker Height

Since the observed data consists of what the Coast Study Division (1969) report calls "maximum breaker height", some hindcast maximum breaker must be deduced in order to get a reasonable basis for comparison. Starting from E we compute, for the deepwater conditions, the average of the heights of the 1/10 highest waves, $H_{1/10}$ (in meters). According to Pierson et al. (1971, p. 11) it may be computed by the formula:

TABLE 3.

Date (January 1968)	12	13	14	15	16	17
Fetch limited storm	yes	yes	no	yes	no	no
The effective fetch (nautical miles)	50	300	230	200	200	100
Fully developed sea	no	no	yes	no	yes	yes
The number E (ft^2)	2.3	70	42	38	7.7	4.6
The period of maximum spectral energy (s)	–	13	11	11	8	7
The highest existing period (s)	6.5	15	15	14	11	10

$$H_{1/10} = 1.08\, E^{1/2} \qquad (1)$$

Then, the maximum breaker height (in meters) is calculated, according to Komar and Gaughan (1972), by:

$$\max \tilde{H}_b = 0.62\, T^{0.4}\, H_{1/10}^{0.8} \qquad (2)$$

where T is the period of maximum spectral energy.

For the dates 13th to 17th refraction was taken into account. The approximate refraction coefficients K_R were found according to C.E.R.C. (1973, p. 2–70). Finall, the hindcast maximum breaker height is given by:

$$\max H_b = K_R^{0.8} \max \tilde{H}_b \qquad (3)$$

The numerical results are given in Table 4.

TABLE 4.

Date (January 1968)	12	13	14	15	16	17
E (ft^2)	2.3	70	42	38	7.7	4.6
$H_{1/10}$(m)	1.6	9	7	6.7	3.0	2.3
K_R	1	0.97	0.92	0.99	0.96	0.92
maxH_b(m)	1.8	9.7	7.1	7.3	3.3	2.4

Observations Versus Hindcasting

The observed and computed wave parameter values are given in Table 5. The agreement between the observed and hindcast values of the breaker heights, as well as between the wave periods seems quite satisfactory. The differences during the storm, from the beginning through the peak to the storm decay, are at worst, about 20% for the heights and 10% for the periods.

Results and Conclusions

Fair agreement between observed and hindcast wave heights and periods was obtained for the heavy storm of mid-January 1968. Although only this storm was considered, this agreement offers some kind of justification to the engineers and scientists who base their considerations on the Ashdod wave data set, as well as for the meteorologist who uses the wave spectrum model for the eastern Mediterranean.

TABLE 5.

Date (January 1968)	12	13	14	15	16	17
Observed breaker height (m)	1.8	8.5	7.2	7	3.7	3
Computed breaker height (m)	1.8	9.7	7.1	7.3	3.3	2.4
Observed wave period (s)	7	12	12	12	8	8
Computed wave period (s)	6	13	11	11	8	7

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