# Screening of severe storms for possible rogue waves

M. Glozman, M. Sladkevich†

Coastal and Marine Engineering Research Institute Ltd (CAMERI), Haifa, 3200004, Israel

†Corresponding author: Michael Sladkevich, e-mail: michslad@technion.ac.il

Coastal and Marine Engineering Research Institute Ltd (CAMERI) conducts wave measurements for Israel Ports Development & Assets Company Ltd (IPC) using IPC-owned Datawell directional waverider buoys at two locations near Israeli coast: Ashdod since April 1992 and Haifa since November 1993. Data from those measurements is used for different types of studies, including statistical and extreme value analysis. All major storms (peak of significant wave height $H_s$ over 6 m) starting from December 2010 were searched for outstanding events, using time series of buoy displacements as extracted from buoys dataloggers. This method eliminates any possibility of interference-induced errors. Two such events were encountered: one of January 7, 2015 at Haifa, and the other of January 19, 2018 at Ashdod. For each such event the buoy manufacturer was contacted for their opinion and possible explanation. While the first event should most probably be considered as artifact, the second one (January 19, 2018) was most probably a real event which quantitative parameters were distorted by the buoy data processing procedure. This paper reports details about the event of January 19, 2018, including close correlation between wave and wind records.

*Keywords*: wind waves, wave measurement, freak waves.

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## Introduction

Systematic wave measurements in Israel started in mid-1950s at Ashdod port. Initially those were based on visual observations, followed by non-directional waverider buoys since 1980s.

Coastal and Marine Engineering Research Institute Ltd (CAMERI) conducts wave measurements for Israel Ports Development & Assets Company Ltd. (IPC) http://www.israports.org.il/en/Pages/default.aspx using IPC-owned Datawell directional waverider buoys (Datawell BV of the Netherlands http://www.datawell.nl) at two locations near Israeli coast: Ashdod since April 1992 and Haifa since November 1993. Data from those measurements is used for different types of studies, including statistical and extreme value analysis. Recently there is also requirement from some clients for information indicative of freak waves. There are numerous papers dedicated to observations and analysis of rogue waves, including catalogs of events [1–4]. For this reason all major storms (peak of significant wave height $H_s$ over 6 m) starting from December 2010 were searched for outstanding events, using time series of buoy displacements as extracted from buoys dataloggers. This paper reports details about the event of January 19, 2018 at Ashdod, including close correlation between wave and wind records.

## 1. Short description of the wave measuring system

The wave measuring system of Datawell directional waverider buoy consists of three accelerometers, a compass and a pitch and roll sensors, that are sampled at 3.84 Hz. However, those raw data are neither stored on-board nor transmitted. The only available data regarding buoy motion are computed buoy displacements, stored at 1.28 Hz, which are calculated on-board via integration-filtering procedure developed by Datawell under assumption of a particular dynamics of buoy motion corresponding to the wind waves (wave period = 1–30 s, or 0.03–1 Hz). Water surface motion corresponding to singular freak wave will be inevitably distorted by such procedure. Buoy data is transmitted in real time to a shore receiver. Starting with Mk III model the Datawell directional waverider buoys are equipped with dataloggers. This buoy model is used by CAMERI since 2010. We consider the data from the buoy datalogger the most reliable, as it was not subjected to any interference, and the displacements in datalogger files are presented by 16 bit signed integers, instead of just 12 bit signed integers in buoy radio-frequency (RF) transmissions. So for buoy RF transmissions displacements for rogue waves will be almost inevitably clipped.

## 2. Wave climate along Israeli Mediterranean coast

Wave measuring buoys are deployed at Haifa and Ashdod locations at 24 m depth, some 2 km from the shore. The distance between the buoys is about 110 km (see Fig. 1). Wave heights measured at the two locations are similar, while the wave direction usually differ by some 10–15°. The observed wave data and analysis of it appear in CAMERI reports submitted to IPC.

Fig. 2 represents wave heights measured at Haifa from November 1993 till March 2018. The winter season for this part of Mediterranean region includes five months from November till March. The rest of the year is considered summer season. Strong storms with wave height $H_s$ over 4 m are usually observed only during winter seasons. For all measuring period starting from 1992, the highest observed $H_s$ was 7.3 m (Haifa 20.02.2001, 17:56 GMT), storms with peaks over 7 m $H_s$ were observed four times, and storms with peaks over 6 m $H_s$ were observed ten times.

The statistical analysis of extreme events using the Peaks Over Threshold (POT) method indicates 7 m $H_s$ as wave with return period of 10 years, 8 m $H_s$ as wave with return period of 50 years and 8.5 m $H_s$ as wave with return period of 100 years.

## 3. Possible rogue wave events

During screening of severe storms (peak of significant wave height $H_s$ over 6 m) from all available datalogger records two outstanding events were encountered: January 7, 2015 at Haifa and January 19, 2018 at Ashdod. The time series of $H_s$ for both those storms are given


Fig. 1. Study site (Google Earth Image) and Datawell directional waverider buoys

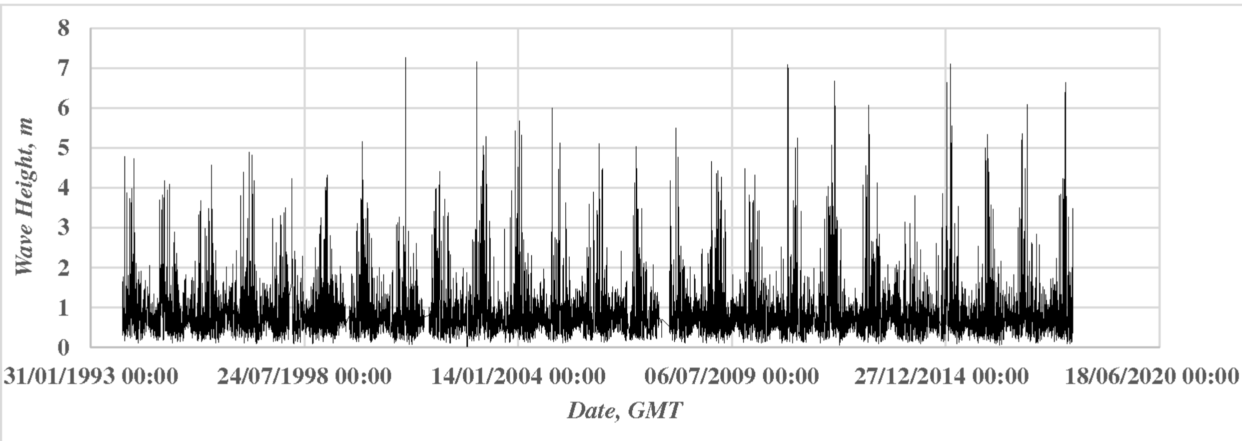


Fig. 2. Wave heights measured at Haifa from November 1993 till March 2018

in Fig. 3. Note that in both cases $H_s$ corresponding to the events themselves are excluded as unreliable according to buoy manufacturer recommendation.

Buoy displacements for those two outstanding events are shown in Fig. 4 and Fig. 5 correspondingly. Horizontal buoy movements recorded at Haifa on January 7, 2015 exceed significantly its vertical movement and reach around 100 m, which seems unrealistic. In the Ashdod record from January 19, 2018 buoy displacements in all three directions are of comparable magnitude around $\sim$ 20 m.

For each such event the buoy manufacturer was contacted for their opinion and possible explanation. While the first event should most probably be considered as artifact, caused by plunging breaker covering the buoy, the second one (January 19, 2018) was most probably a real rogue wave event which quantitative parameters were distorted by the buoy data processing procedure, which was specifically designed under assumption of wind wave dynamics.

In the buoy deployment areas wind parameters are measured as well, using shore stations equipped with professional grade wind sets (Vaisala WA15). The distance between those shore station and respective buoys is about 2 km. Full raw data (wind speed and direction as 5-seconds averages) is available. Wind and wave measuring system are completely separated.

Weather map (analysis) for Eastern Mediterranean for January 19, 2018 00:00 GMT is shown in Fig. 6. A strong cyclone centered near Cyprus can be observed.

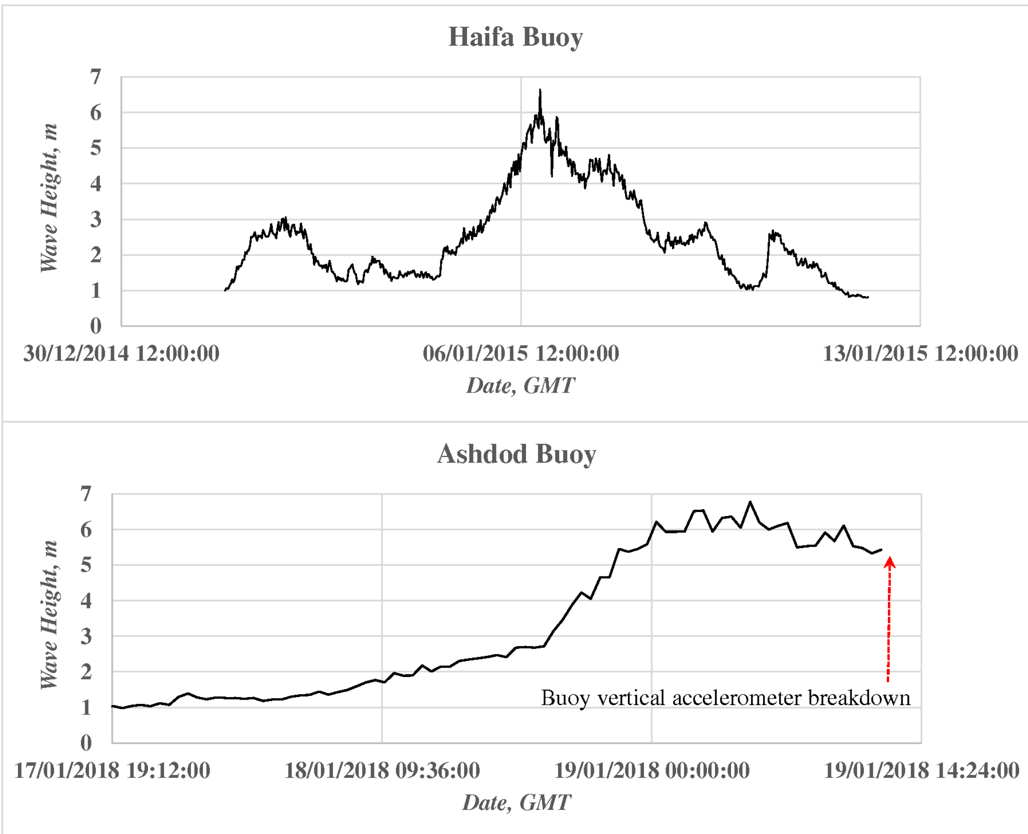


Fig. 3. Time series of $H_s$ for storms with outstanding events: upper part Haifa, January 7, 2015, lower part Ashdod, January 19, 2018. Note that in both cases $H_s$ corresponding to the events themselves are excluded as unreliable according to buoy manufacturer recommendation

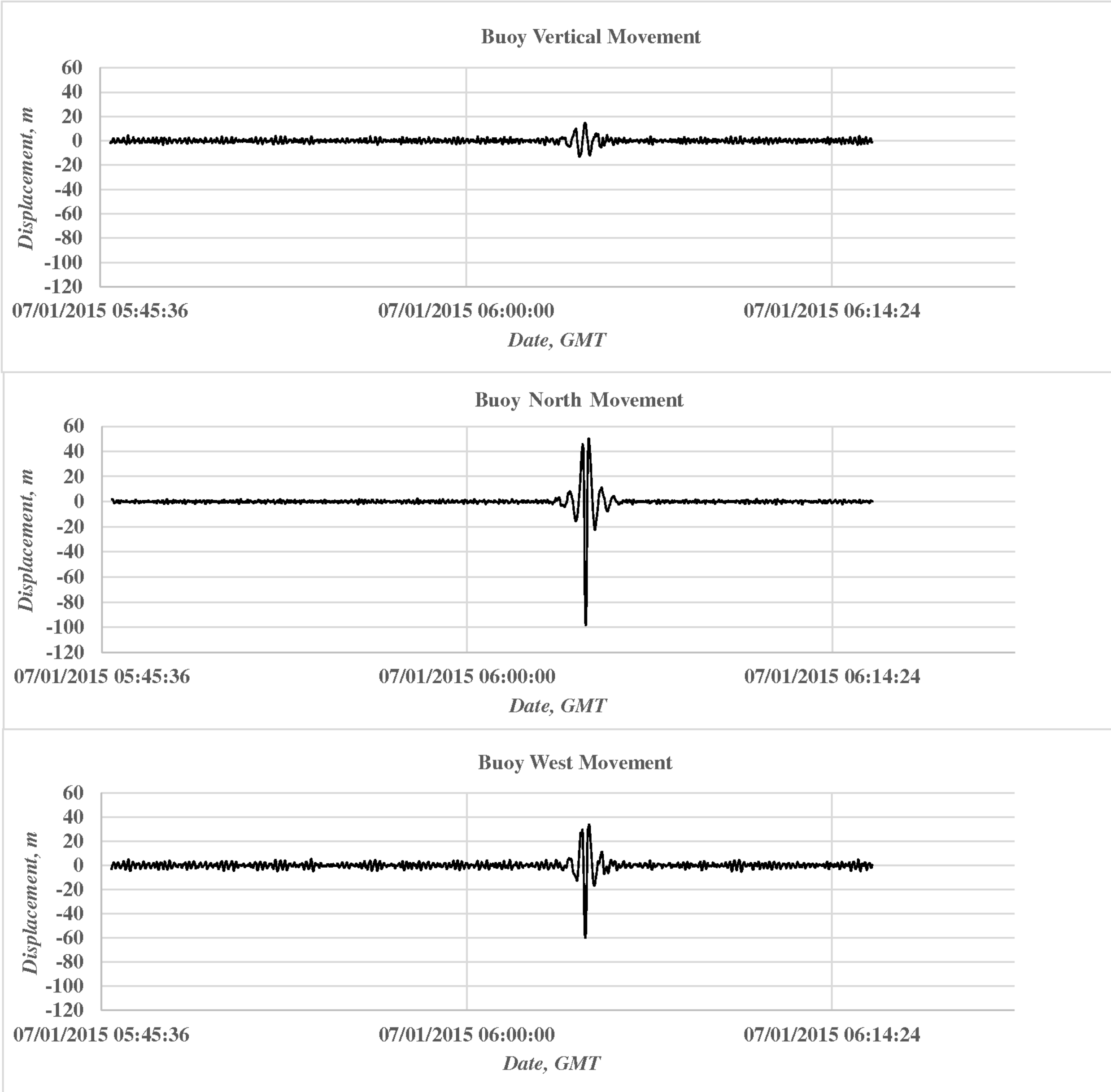


Fig. 4. Buoy displacements observed at Haifa on January 7, 2015

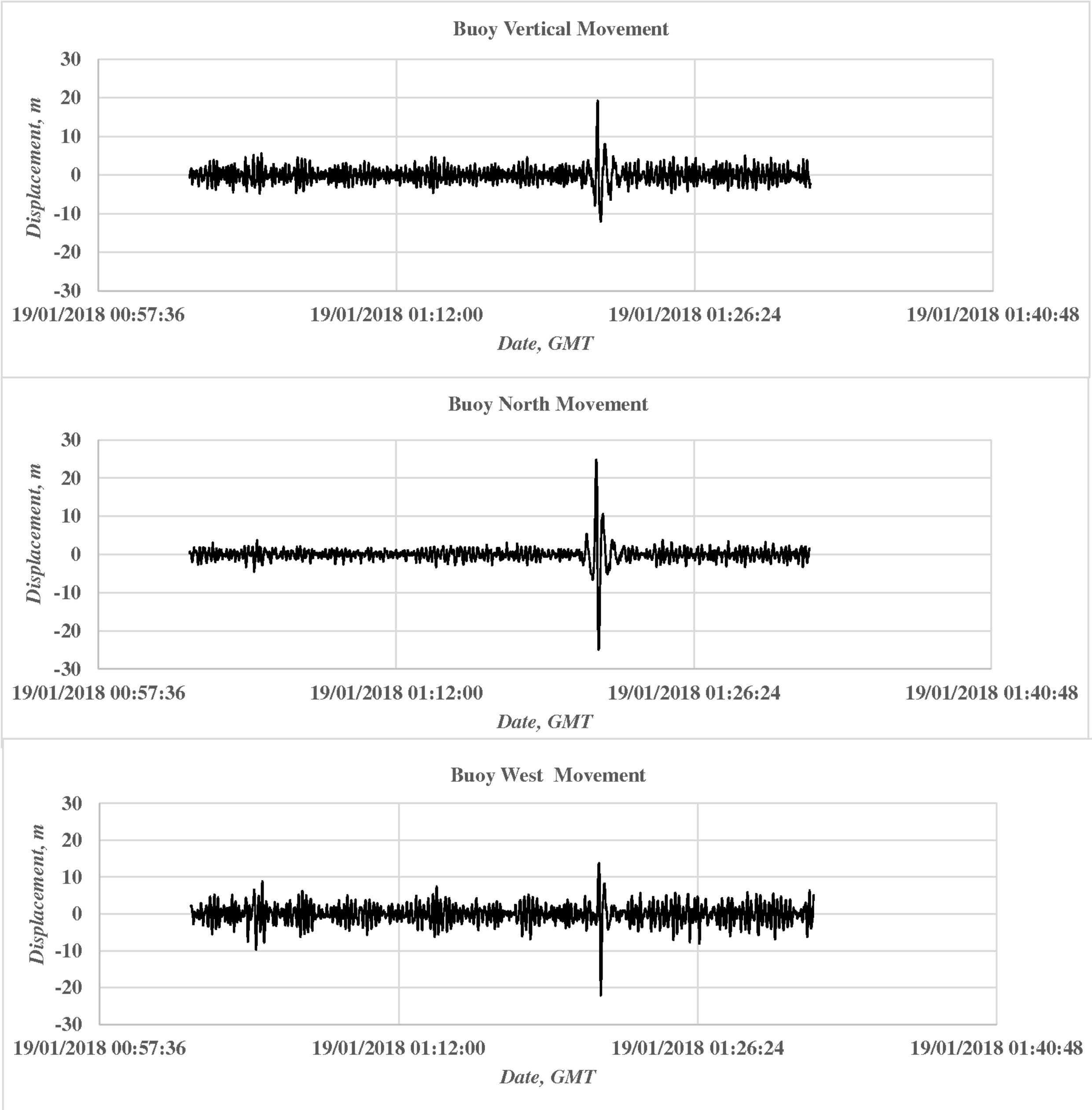


Fig. 5. Buoy displacements observed at Ashdod on January 19, 2018

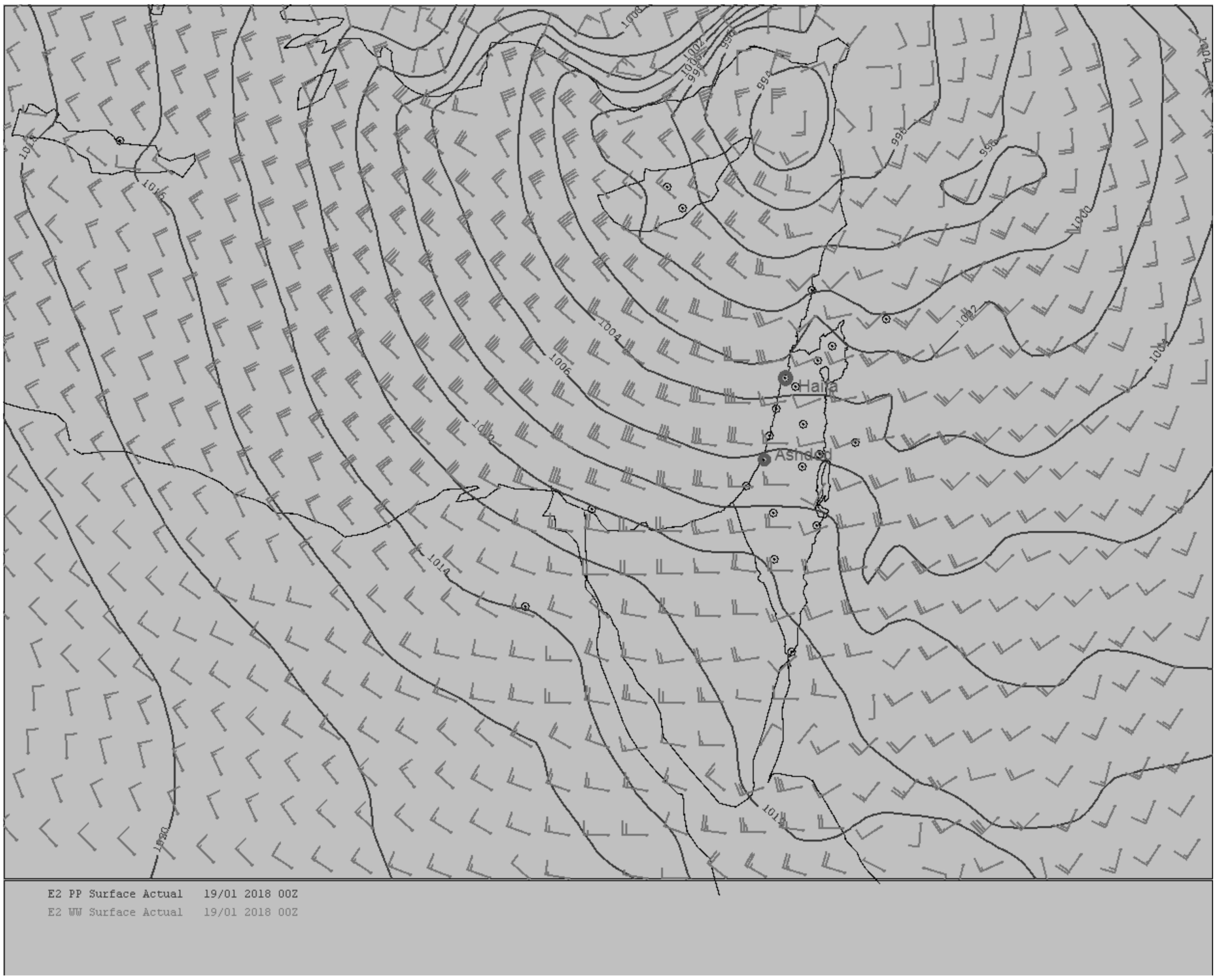


Fig. 6. Wind speed (arrows) and surface pressure (isobars) analysis map for Eastern Mediterranean for January 19, 2018 00:00 GMT. Courtesy of Israeli Meteorological Service

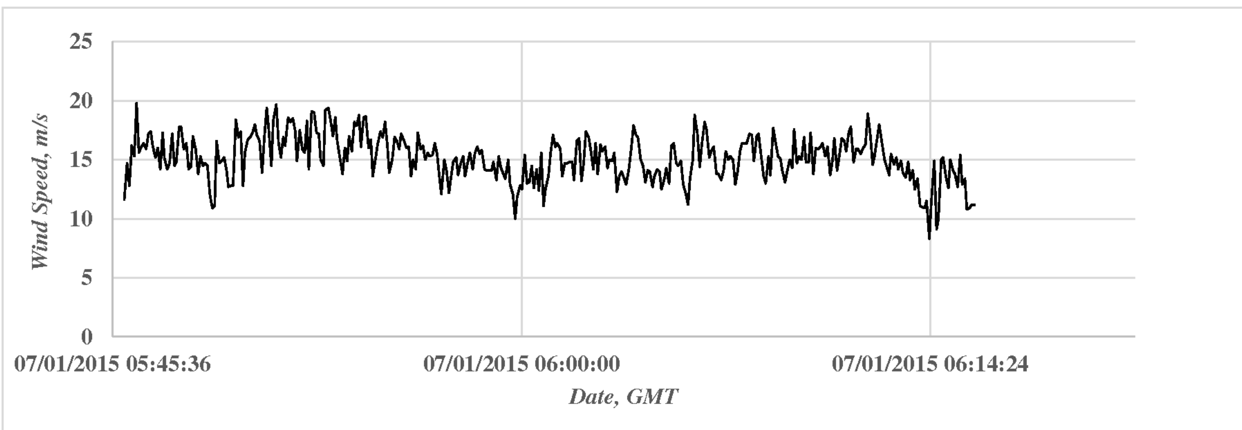


Fig. 7. Wind speed in Haifa area during storm of January 7, 2015

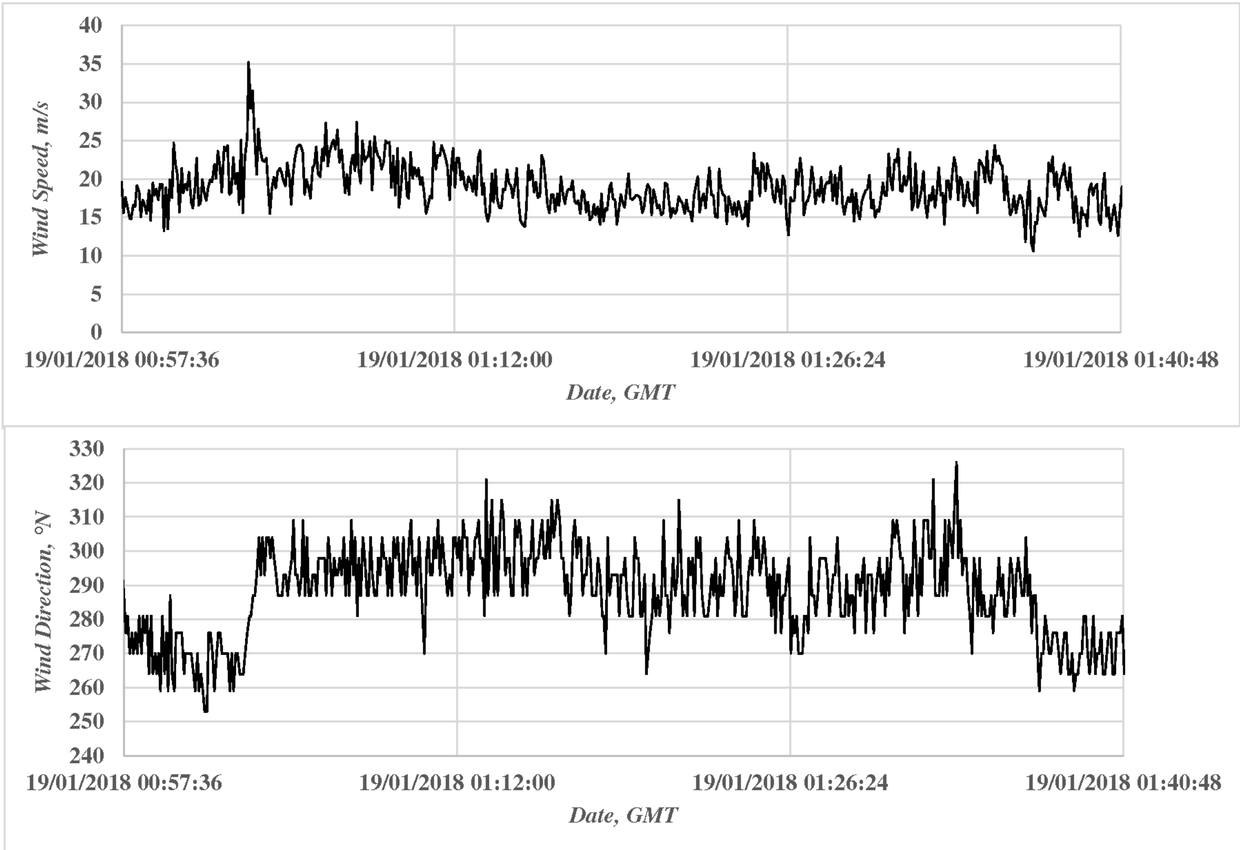


Fig. 8. Wind speed and direction in Ashdod area during storm of January 19, 2018

During storm in Haifa at January 7, 2015 wind speed was about 15–20 m/s (see Fig. 7), which is typical for severe storms in this region. In Ashdod area during storm of January 19, 2018 some 18 minutes prior to possible rogue wave event an extreme wind gust of 35 m/s was recorded, accompanied by sudden change of wind direction by 30–35° toward North (see Fig. 8). The hull and the mooring system of the affected buoy have no signs of mechanical blow by some external object, so the buoy motion should faithfully represent the motion of the surrounding water. Unfortunately, as stated above, the raw sensor data is not available, and the integrated-filtered displacements were processed under very specific assumptions and as such are inevitably distorted quantitatively. Another fact worth mentioning is that 11 hours after the possible rogue wave event buoy ceased normal operation. During repair at the manufacturer facility it turned out that the vertical accelerometer was mechanically broken. So all signs indicate that that buoy experienced some very extreme action of hydrodynamic origin.

## Conclusions

At the 19th of January, 2018 in the Ashdod area (Israel) Datawell directional waverider buoy registered an outstanding wave event. Analysis of external conditions of this buoy and its mooring system, of the recorded displacement data, and consultation with the buoy manufacturer clearly indicate that that anomalous record was caused by real natural event.

This indication is reinforced by the presence of anomalous wind gust of 35 m/s in the wind record, accompanied by sudden change in wind direction by some 30–35° just 18 minutes prior to the outstanding wave event.

Due to the fact that the raw data from the buoy sensors is unavailable, and the on-board processing (integration-filtering to get displacements) is based on assumptions of dynamics of buoy motion corresponding to the wind waves with periods of 1. . . 30 s, it is not possible to estimate quantitatively the parameters of the observed outstanding wave. Nevertheless, data presented in this study point in direction of freak wave as possible cause of that peculiar observation.

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## References

[1] **Cavaleri, L., Barbariol, F., Benetazzo, A., Bertotti, L., Bidlot, J.-R., Janssen, P., Wedi, N.** The Draupner wave: A fresh look and the emerging view // Bull. of the Amer. Meteorological Soc. 2016. Vol. 121, No. 8. P. 6061–6075.

[2] **Cavaleri, L., Benetazzo, A., Barbariol, F., Bidlot, J.-R., Janssen, P.** The Draupner event: the large wave and the emerging view // Bull. of the Amer. Meteorological Soc. 2017. P. 729–735.

[3] **Van Groesen, E., Wijaya, A.P.** High waves in Draupner seas. Pt 2: Observation and prediction from synthetic radar images // J. Ocean Eng. and Marine Energy. 2017. No. 3. P. 325–332.

[4] **Nikolkina, I., Didenkulova, I.** Catalogue of rogue waves reported in media in 2006–2010 // Nat. Hazards. 2012. No. 61. P. 989–1006.

[5] **Levin, A., Glozman, M., Sladkevich, M., Kroszynski, U., Kit, E.** Processing of hydrographic data for the Ashdod Region: Technical Report No. 736, Israel. Coastal and Marine Engineering Research Institute, 2011. 270 p.

[6] **Levin, A., Glozman, M., Sladkevich, M., Kroszynski, U., Kit, E., Drimer, N.** Processing of hydrographic data for the Haifa Region: Technical Report No. 737, Israel. Coastal and Marine Engineering Research Institute, 2011. 328 p.

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