Bulletin of the Maritime Institute

Gdańsk, 2001, 28, 2

BEATA KOWALSKA, IDA STANISŁAWCZYK, MONIKA MYKITA
Institute of Meteorology and Water Management,
Maritime Branch in Gdynia, Poland

QUALITY ASSESSMENT OF THE HIROMB WATER LEVEL FORECAST FOR THE POLISH COASTAL ZONE

Abstract

The aim of this paper is to compare the observed water level and the results of HIROMB model for the same period. Real sea level values, collected in the data base of the Institute of Meteorology and Water Management in Gdynia were measured by Polish water gauges situated along the west part of coast and around the Gulf of Gdańsk. The analysed data were from the period 15.08.1998 - 28.05.1999, and the forecast lead time was equal to 24 hours. The assumed reference level, equal to 500 cm, caused too high forecast levels and marked differences between observed and computed sea levels. In order to improve the results of modelling a new reference level has been established. Having introduced the new reference level, a better agreement between the observed and computed values was obtained in most cases. The validation of modelled results was carried out by means of the chosen statistical indicators.

1. Introduction

The main task of the Maritime Hydrological Forecasting Office is hydrological and sea ice protection of the Polish coastal zone. In our routine service several models are applied computing sea level values. Current comparison between results of these models is carried out. In 1999, the HIROMB model was tested [1]. The hydrodynamic-numerical model HIROMB (High Resolution Operational Model for the Baltic) was developed, as a result of co-operation of the Baltic countries, and was installed at the SMHI. It delivers a forecast of water level, sea temperature and salinity, currents and ice conditions. Based on the results from HIROMB, a quality assessment was carried out on the HIROMB water level forecast for the Polish coastal zone. For the purpose of the elaboration the data on sea level from four stations, situated on the west part of Polish coast and around the Gulf of Gdańsk, was used. The data for the period from 15.08.1998 and ending on 28.05.1999, were analysed. The forecast lead time was a span of 24 hours. It should be stressed that this time span comprised autumn and winter months when the frequency of storm surges is very high. The forecast of sea level was based on the simple formula:

$$h=H+\Delta h$$

where:

H (cm) – assumed reference level
h (cm) – forecast sea level
Δh (cm) – forecast computed by HIROMB.

2. Comparison of the observed water level and computed by HIROMB in Świnoujście

Świnoujście is situated at the most western end of the Polish coast line. During the testing season very high sea level values, exceeding the warning levels, were not observed at this gauge station. The water level fell within the range from 458 to 556 cm. The results in Tab. 1 point out that the values were not adequately represented by the model. There were significant differences between the observed sea levels and those computed by the model. The forecasted sea levels were too high, probably due to assuming the reference level H = 500 cm (in accordance with the model base). The sea level = 500 cm is the value averaged for many years.

Table 1. Water levels observed and computed by HIROMB in Świnoujście

Sea level	Observed	Computed with reference level = 500 cm	Computed with new reference level
Maximum	556	583	551
Minimum	458	481	449
Mean value	505	540	508

Because of significant differences between the observed and calculated values, a new reference level was calculated and the results of computations with the new reference level are presented as HIROMB - new reference level (HIROMB - NRL), whereas the results of HIROMB with reference level = 500 are presented as HIROMB - 500RL. After the introduction of the new reference level a better agreement was obtained between the observations and model computations. The difference between the mean levels in both series was 3 cm in the testing series and 2 cm in the verification series.

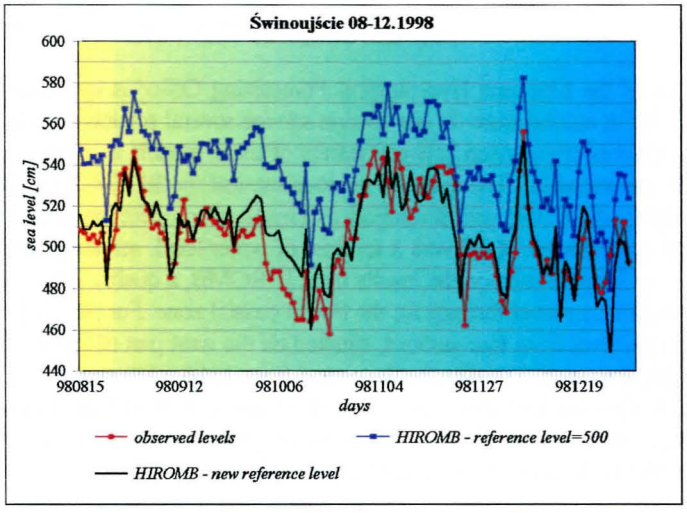

Fig. 1. Sea level changes at Świnoujście observed and computed by HIROMB

The comparison between observed and modelled sea levels in Świnoujście for the period August-December 1998 is shown in Fig. 1. The values, computed by the model at

12.00 UTC every day, are presented here. In the considered period, the real sea levels were not adequately represented by the computed values with reference level 500 cm. 500RL data the forecasted sea levels were too high. However, a good agreement between measured sea levels and results computed with the new reference level - NRL, was obtained.

3. Comparison of water level observed and computed by HIROMB in the Gulf of Gdańsk

The comparison of sea levels measured and obtained from HIROMB, was continued for water gauge stations situated around the Gulf of Gdańsk: Hel, Gdynia, Gdańsk [1]. During the testing season, very high sea level - above the warning levels, was observed at these gauge stations. The water levels ranged from 471 to 568 cm (Tab. 2). Similar to Świnoujście, there were marked differences between the measured sea levels and those computed by the model. The difference between the results of 500RL computations and the observed sea level was 12 cm for the highest sea level, 40 cm for the lowest sea level and 23 cm in the case of the mean sea level.

Table 2. Water levels observed and computed by HIROMB in Hel, 08.1998-05.1999

Sea level	Observed	Computed with reference level = 500 cm	Computed with new reference level
Maximum	568	580	555
Minimum	471	511	486
Mean value	516	539	514

The forecasted sea levels were too high and it was due to the assumed reference level $H = 500$ cm, meaning it was necessary to find a new reference level, considerably lower from the default. After the introduction of the new reference level a better agreement was obtained between the observations and model computations and the difference in the mean levels was 2 cm.

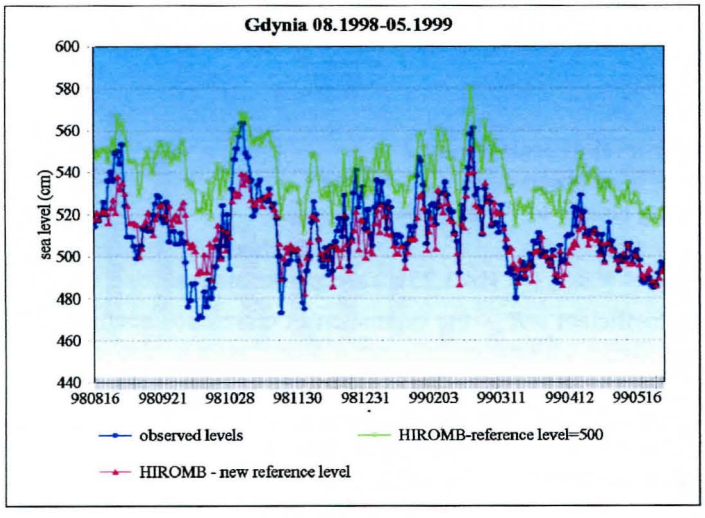

Fig. 2. Results of HIROMB sea level forecast and real sea levels in Gdynia

The comparison of the results of HIROMB forecast with two reference levels, 500RL and NRL, and the real sea levels in Gdynia in the period August 1998 – May 1999, is shown in Fig. 2.

The significant differences between observations and results of computations, are due to unsuitable reference level. However, in the range sea level from 490 to 530 cm, quite a good agreement between the real and even HIROMB 500RL values can be seen, but then in the range above 540 cm and below 490 cm, that is in extreme conditions, large discrepancies are noticeable.

4. Validation of the model

Validation of the model was carried out in accordance with methods of research models, obligatory in the Institute of Meteorology and Water Management. These statistical methods have been worked out by Mayer [2] in accordance with the WMO rules.

The validation of results of the model was carried out for series of 244 forecast data using statistical indicators:

- effectiveness – e – as a function of standard error of the method and standard deviation of the forecast variable;

$$e = \frac{S_{yx}}{S_y}$$

where
S_{yx} – standard error of the method,
S_y – standard deviation of forecast variable.

The following classes of the forecast effectiveness can be distinguished:

$0 \le e \le 0.4$	very good
$0.4 < e \le 0.6$	good
$0.6 < e \le 0.8$	satisfactory
$0.8 < e \le 1$	unsatisfactory

- relation of mean values – V – as a function of water level forecast to time t and water level observed at a given time t;

$$V = \frac{\Sigma H_p}{\Sigma H_o}$$

where
H_p – water level forecast to time t
H_o – water level observed in a given time t.
The following classes of V can be distinguished:

$V = 1$	ideal method
$0.75 < V < 1;\ 1 < V < 1.25$	acceptable method

- correlation coefficient – R — the estimation of correlation coefficient between the observed and forecast sea-level, comprised of four classes of methods:

$R = 1$	ideal method
$0.99 < R < 1$	excellent method
$0.95 < R \le 0.99$	very good method
$0.90 < R \le 0.95$	good method
$0.85 < R \le 0.90$	satisfactory method
$R \le 0.85$	unsatisfactory

The data used for validation were divided into four groups in respect of wind direction generating changes of sea levels, so some information, about model reaction on meteorological data, was obtained. The criteria of wind direction were defined as follows :

wind – N 315° - 44°
wind – E 45° - 134°
wind – S 135° - 224°
wind – W 225° - 314°

Table 3. Validation indicators - Hel

Hel VIII 1998 - VI 1999

	Effectiveness	SWS	Correlation
500RL	unsatisfactory	acceptable	satisfactory
NRL	satisfactory	ideal	satisfactory
NRL, Wind-N	satisfactory.	acceptable	very good
NRL, Wind-E	unsatisfactory	acceptable	unsatisfactory
NRL, Wind-S	satisfactory	ideal	good
NRL, Wind-W	satisfactory	acceptable	satisfactory

Table 4. Validation indicators - Gdynia

Gdynia VIII 1998 - VI 1999

	Effectiveness	SWS	Correlation
500RL	unsatisfactory	acceptable	satisfactory
NRL	satisfactory	ideal	satisfactory
NRL, Wind N	satisfactory	acceptable	very good
NRL, Wind E	unsatisfactory	acceptable	unsatisfactory
NRL, Wind S	satisfactory	ideal	good
NRL, Wind W	satisfactory	acceptable	satisfactory

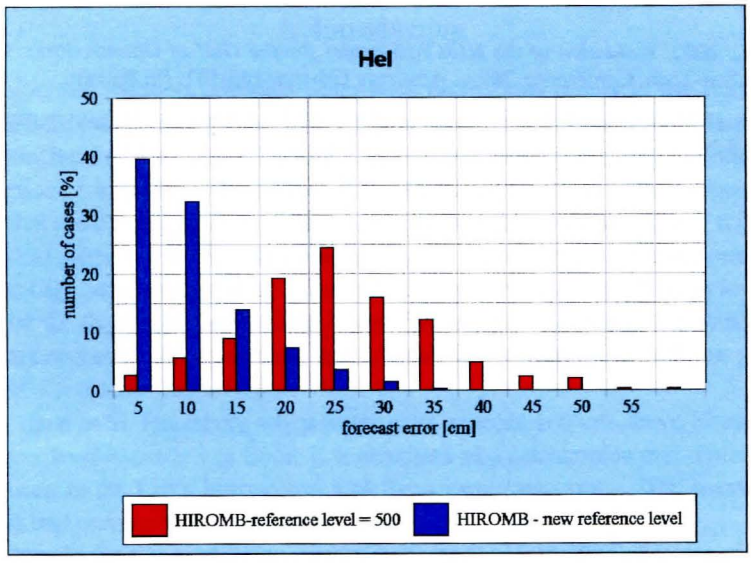

Fig. 3 Analysis of forecast errors for HIROMB in Hel

The analysis of the coefficient of correlation indicated reaction of the model on the changes of sea levels. The results of validation showed better values of indicators for HIROMB with the revised reference level – NRL than for 500RL. Very good correlation was found only for wind from the northern direction. The validation indicators were the same for Gdynia and Hel station (Tab. 3, Tab. 4).

The analysis of forecast errors for 500RL and NRL, for the Hel station, was conducted and the results are presented in Fig. 3.

For the 500RL, the forecast error less than 10 cm was obtained for 9% of cases whilst for the NRL, the forecast error less than 10 cm, was received for 73% of cases. The introduction of a new reference level caused an improvement of sea level forecast.

5. Final remarks

The changes of sea levels were shown by the HIROMB model very well. Predicted values obtained from model were too high due to the not suitable reference level. The period used for the analysis of HIROMB was comparatively short. After the introduction of the new reference level, a better agreement between sea level values measured and computed by model, was obtained. The validation indicators were more satisfactory for the forecast computed with the new reference level.

In order to improve the results of the model, from the operational point of view, two problems should be solved in the future:

- too high reference level
- modelling extreme sea levels.

In the future this model should be tested for long period of time and for other stations of the Polish coast.

References

[1] Mykita M., 2000, *Validation of the HIROMB model for the Gulf of Gdańsk,* Proc. 12th International Sci.-Tech. Conference, Naval Academy Gdynia, 143-151. (In Polish).

[2] Mayer W., 1979, *Instruction for elaboration of hydrological forecast*, IMWM Publ., Warszawa. (In Polish).