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MARINE FORECAST SYSTEM IN MARITIME INSTITUTE FOR AIDING SALVAGE ACTIONS AND ECONOMICAL ACTIVITIES IN THE SEA. PRESENT STATE OF DEVELOPMENT

Abstract

In the paper the system of digital marine forecast, covering the Polish area of the Baltic Sea, developed in the Department of Operational Oceanography, Maritime Institute, for the needs of rescue services and marine administration, is described. The present system uses data from different Polish and foreign operational centres, and generates its own forecast, as it is in the case of wind waves or object drift. The combined forecast is processed into the formats demanded by the services and is available also in Internet at Department's web site.

Introduction

There is still increasing request for fast access to actual and reliable marine forecast, covering basic parameters of both the atmosphere and sea state. This information is very important for safety of human activities in the sea, such as navigation, harbour operation, fisheries, combating hazards for marine environment, dredging activities, realization of hydro-technical investments etc. The most important forecast parameters for the sea are wind, waves, surface currents and ice phenomena. For effectiveness of activities in some special cases such as rescue or combating oil spills, it may be also necessary to know sea surface temperature, air temperature and water salinity. Lack of such forecast when immediate decision concerning navigation is needed, during extreme and highly variable hydro-meteorological situations may cause large threat to life of people in the sea and floating equipment losses.

Preparing of forecast for oil spill propagation, drift of floating objects or castaways in the open sea also needs fast and direct access to reliable and actual marine forecast of important hydrodynamic fields. High reliability of wind field forecast is here extremely important, as wind action is a main force generating dynamic phenomena in the sea. Last four years (1996-99) it was proved by calibration measurements during POLRODEX experiments, that wind recordings at land stations are not describing real wind conditions in the open sea, sometimes lowering its velocity more than twice. Anchored in May 2000 north east from Władysławowo harbour by the Maritime Institute, the autonomic buoy with different devices, continuously recording the measurement meteorological and hydrological data and radio transmission of the measured data improves the situation (Fig. 1). The buoy is a component of the large integrated computer aided rescue and oil combating system in Poland. However, to base oil spill forecast, drift of a castaway or a life-raft forecast on the point measurements of wind or current at one single level is improper, as temporal and spatial variability of wind and current field over all sea area is too high.

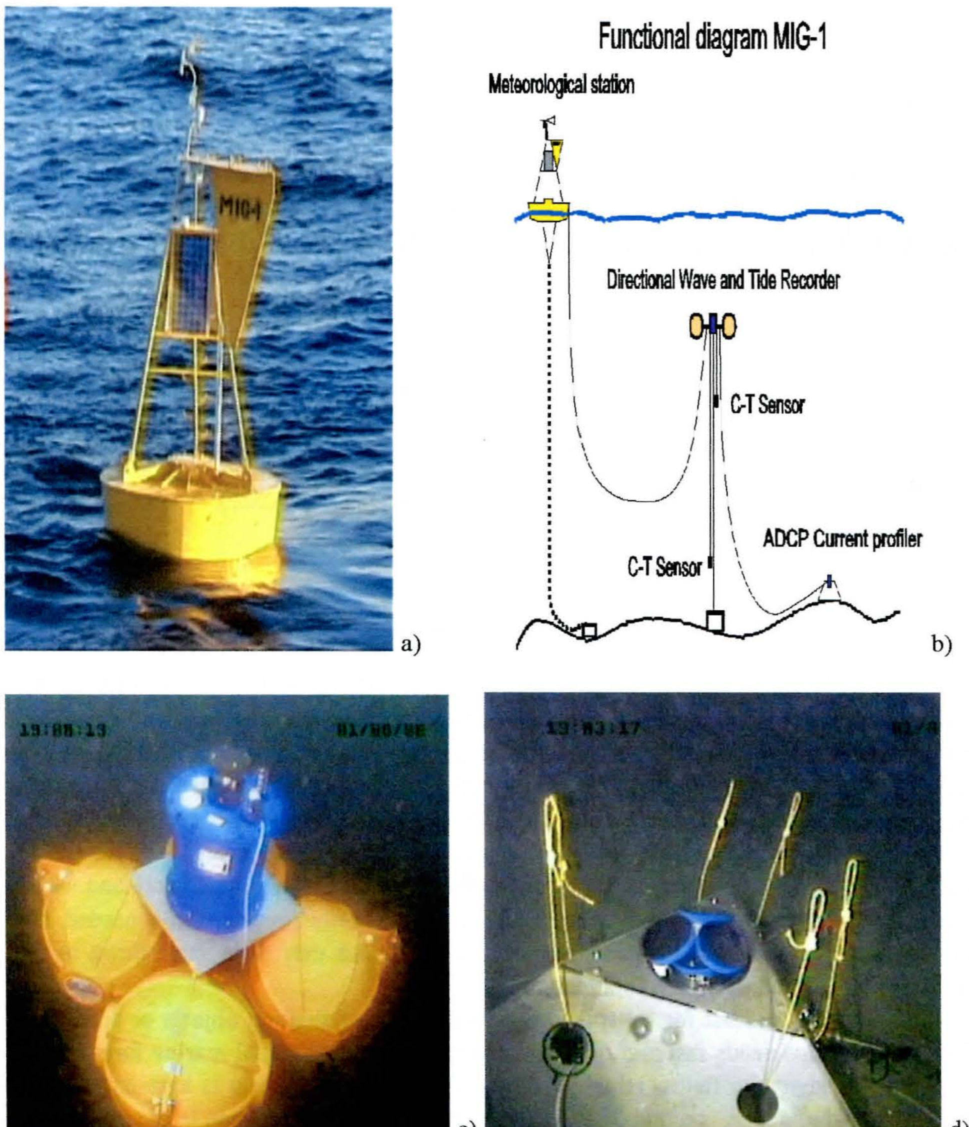

Fig 1. Autonomous buoy MIG-1 anchored north-east from Władysławowo harbour a) general view on the sea, b) functional diagram, c) Valeport for tide and wave recording, d) ADCP current profiler

Systems predicting drift of objects at the sea surface shall take into account different scales of the modelled phenomena, and parameters describing driving forces shall be averaged in adequate spatial and temporal intervals. *In situ* measurements are very important, because they open the possibility to check forecast reliability, under the condition that both, measured and calculated, time series are long enough to enable standard statistical analysis. It is worth to stress that the basic condition for reliable forecast of a castaway or an oil spill drift is fast access to data of operational models for wind, currents and waves, run with adequate spatial and temporal resolution, giving reliable results [1,7].

At present, Internet is a common form of marine forecast dissemination. Different kinds of marine forecast around the Baltic Sea are now transmitted mainly via Internet. It concerns meteorological forecast calculated in Interdisciplinary Centre for Mathematical and Computational Modelling, Warsaw University (ICM UW) [8] (Fig. 2), hydrodynamic forecast calculated by Institute of Oceanography, Gdańsk University (IO UG), Swedish Meteorological and Hydrological Institute (SMHI, Norrköping) (Figs. 3 and 4), Federal Maritime and Hydrographic Agency (BSH, Hamburg) and some other service and scientific institutions. For a large number of customers the forecast is accessible only in the graphical form. It is mostly satisfactory for public recipients, but for marine services (rescue services, maritime administration) this form is not sufficient. That is why Maritime Institute has undertaken the task to arrange marine forecast parameters in the format required by these services. In the operational mode, following work shall be done everyday:

- reception of meteorological forecast from ICM,
- reception of hydrodynamic forecast from SMHI,
- calculation of wave forecast in the Baltic Sea,
- near real-time transmission of measured data from the Maritime Institute's autonomous buoy in the open sea (meteorological parameters, wave parameters, sea currents, water temperature and salinity from different sea layers),
- predicted and measured data recording in the data base of CAROCS system,
- data completeness and correctness checking, and data storage.

Collected measured and calculated data will be transmitted to the institutions doing marine forecast around the Baltic Sea. This is also a contribution of Poland to HIROMB Partnership, which has been established to implement operational hydrodynamic forecast, necessary in computer aided rescue and oil combating in the Baltic Sea.

Exploitation and development in Maritime Institute data base with sea forecast in CAROCS system

Digital, predicted data for the Baltic Sea area are received automatically every morning and stored on servers in the Department of Operational Oceanography. The data include meteorological conditions over the Baltic Sea and surrounding land areas, calculated in ICM UW and hydrodynamic conditions transmitted from SMHI. Automatic data transmission is enabled by special software called HIRNET, worked out in the Department of Operational Oceanography. HIRNET software is made especially for the purposes of data exchange among the members of HIROMB Partnership, but now it is still developed and updated and it contains some functions for decoding and processing data. HIRNET is also recognised as a Polish contribution to HIROMB. It can perform following functions:

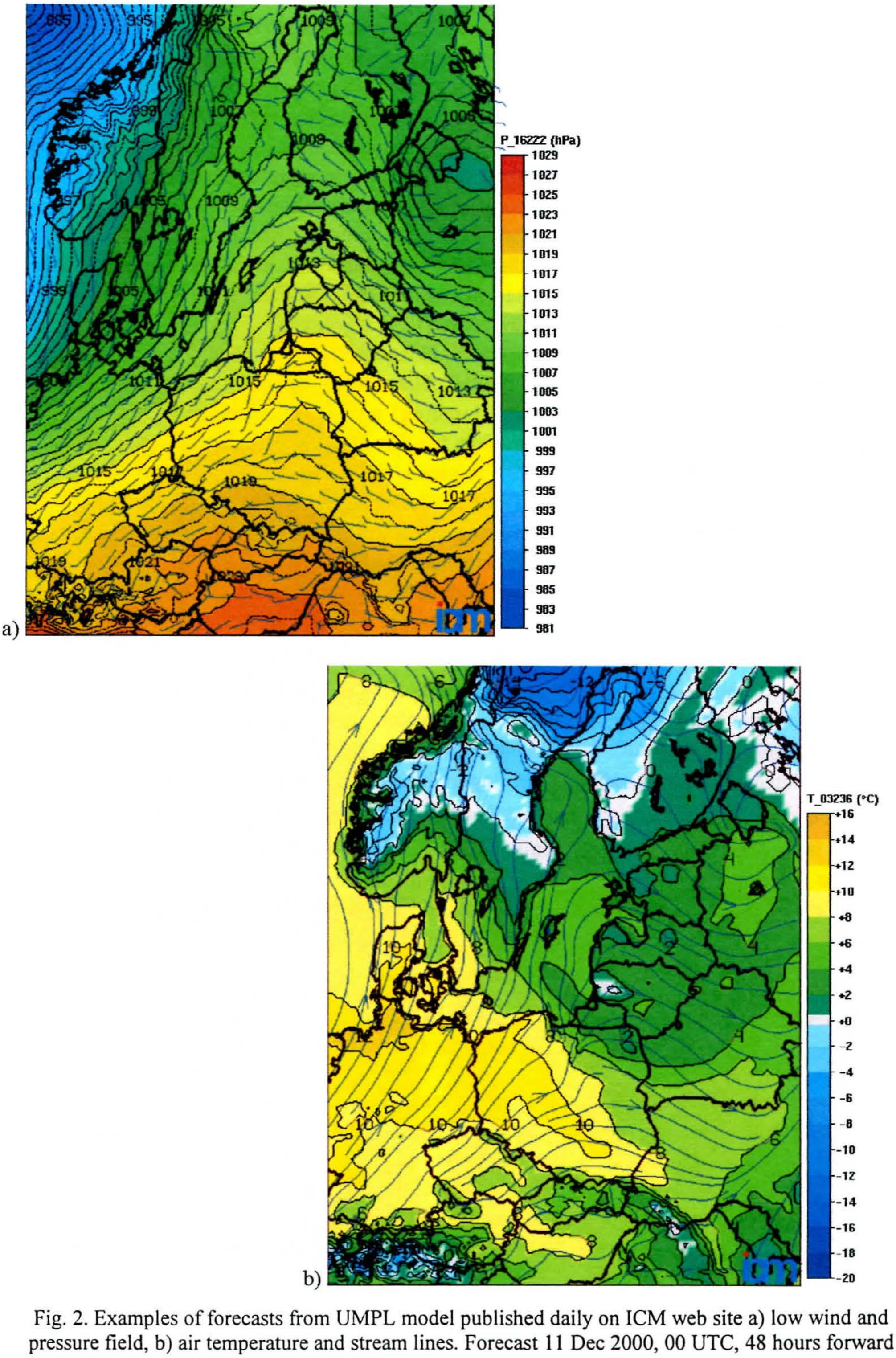

Fig. 2. Examples of forecasts from UMPL model published daily on ICM web site a) low wind and pressure field, b) air temperature and stream lines. Forecast 11 Dec 2000, 00 UTC, 48 hours forward

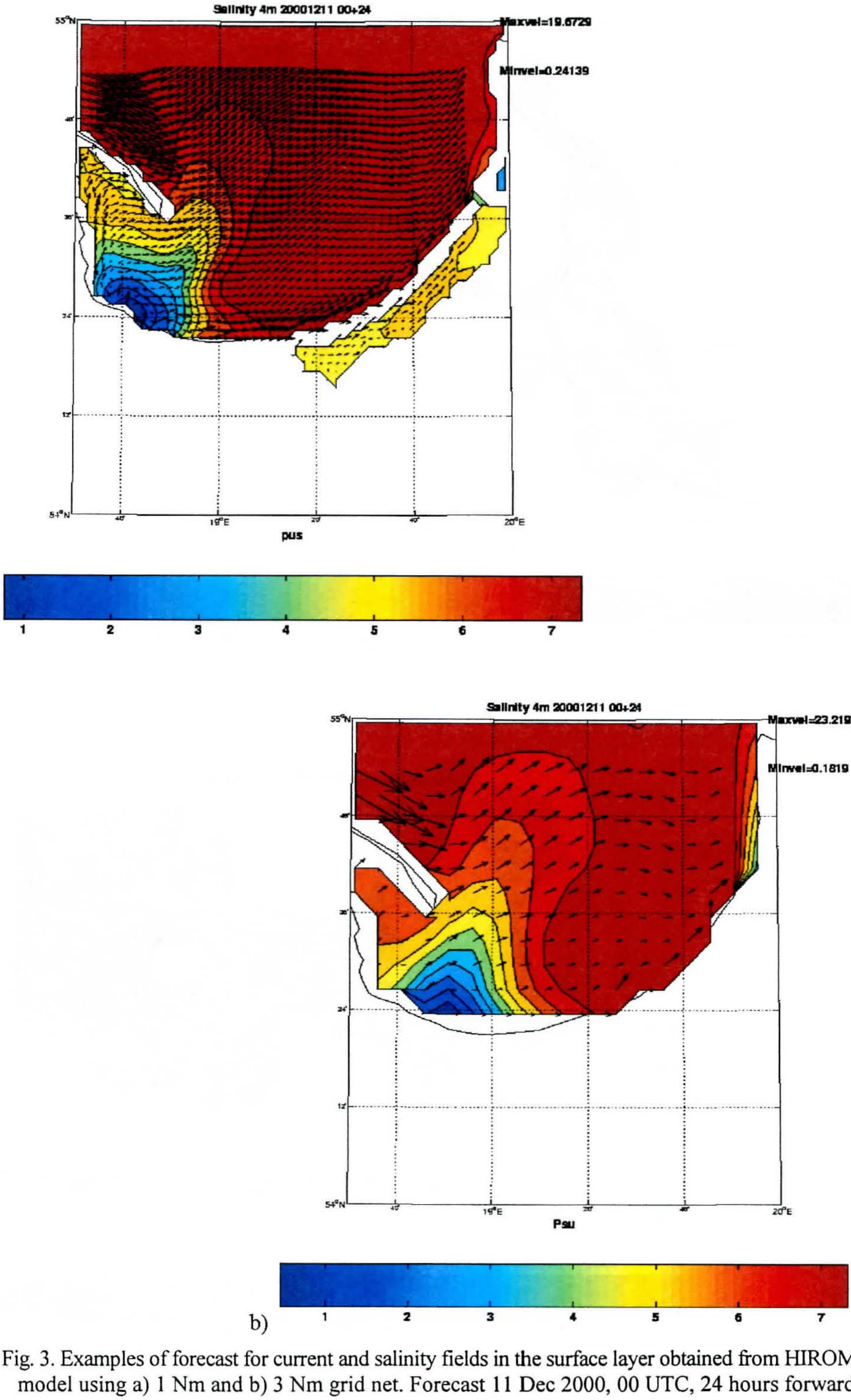

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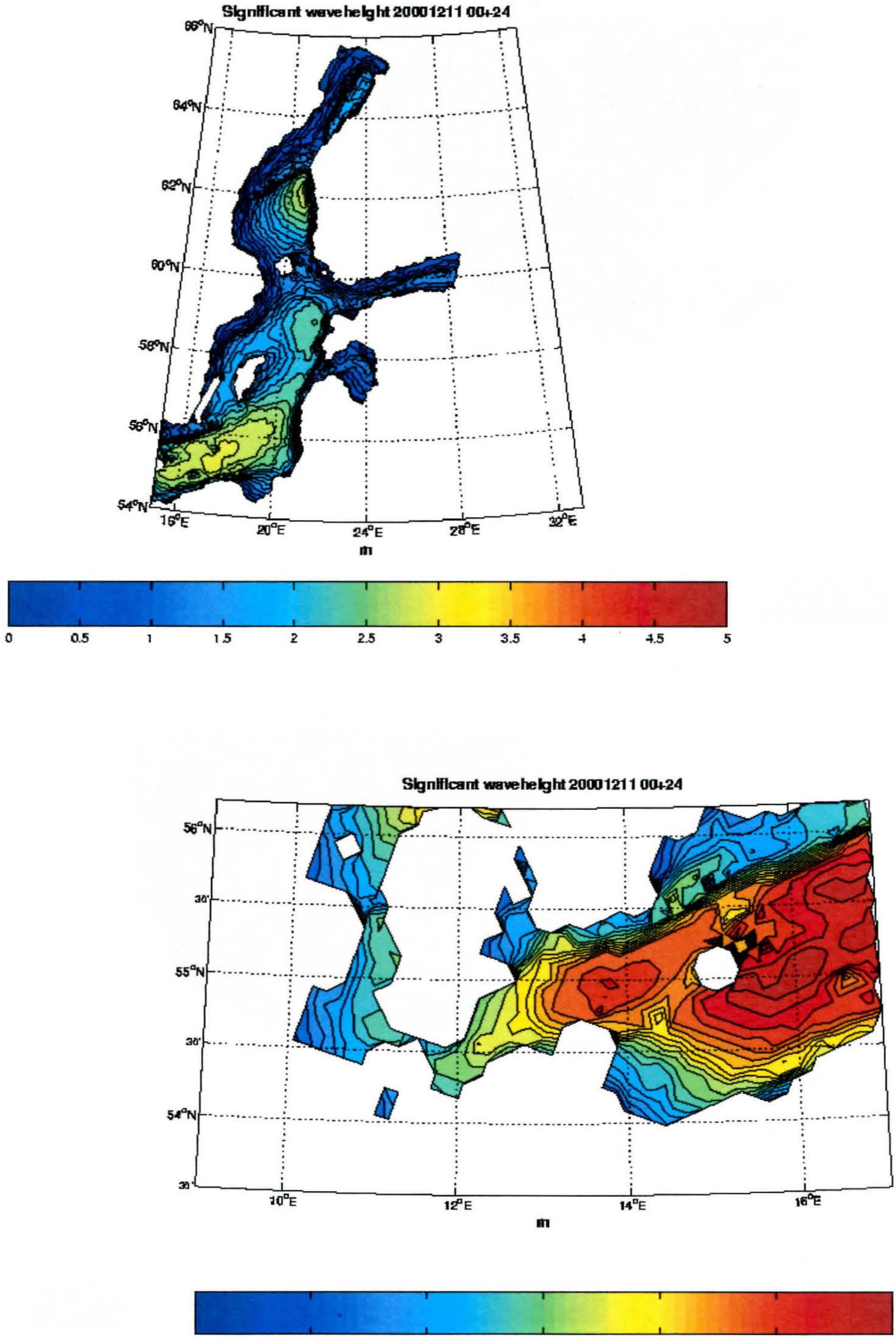
Fig. 3. Examples of forecast for current and salinity fields in the surface layer obtained from HIROMB model using a) 1 Nm and b) 3 Nm grid net. Forecast 11 Dec 2000, 00 UTC, 24 hours forward



a) b)

Fig. 4. Examples of significant wave height forecast obtained from HYPAS model a) all the Baltic Sea area, b) south-western part of the sea. Forecast 11 Dec 2000, 00 UTC, 24 hours forward

- it checks if customer is authorized to receive the data,
- at certain moment it checks if there are new files with the forecast in the forecast centre; if not, it repeats its check with a given time interval until the new files are cached on the server's storage,
- it downloads binary forecast files,
- it decodes binary files into ASCII files.

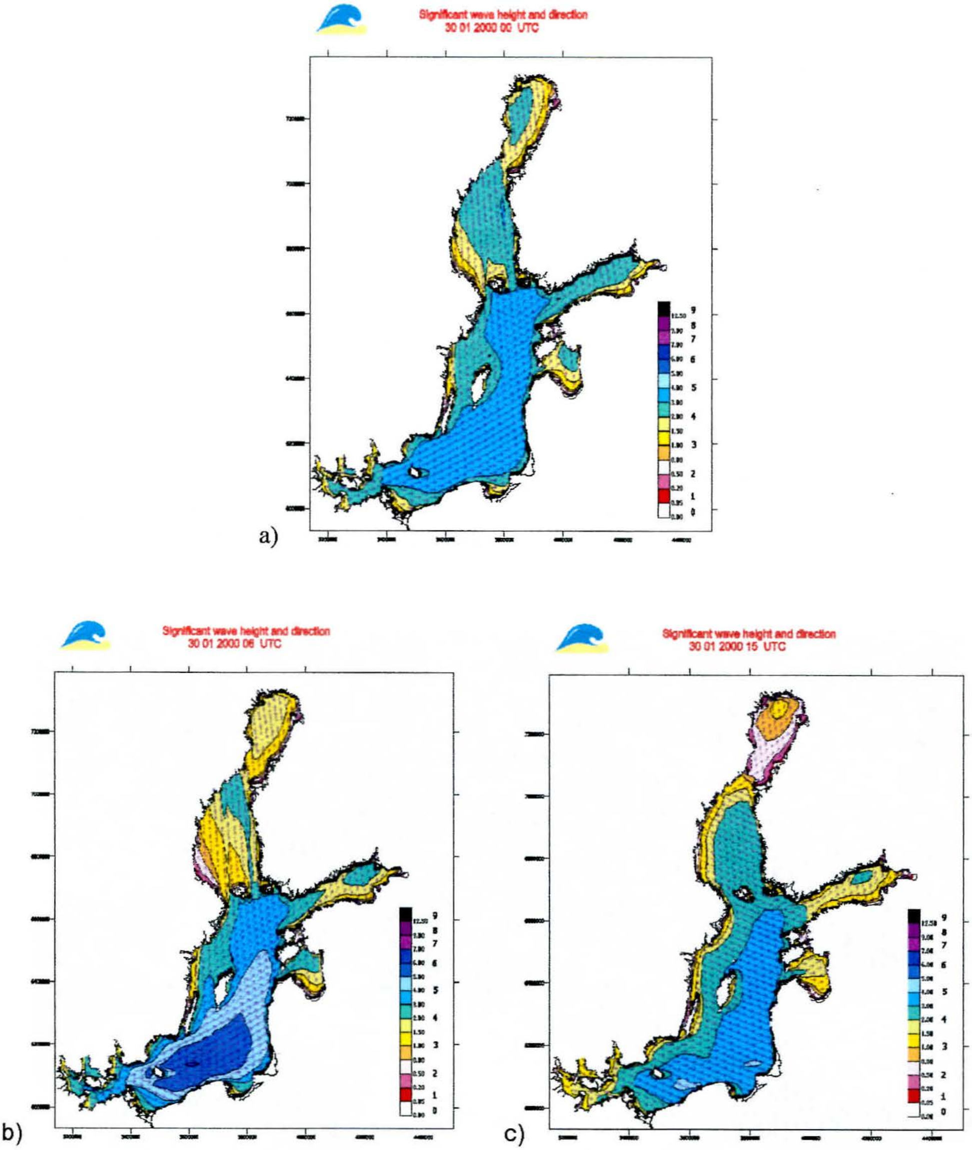


Fig. 5. Forecast of typical gale evolution over southern part of the Baltic Sea during winter season by WAM model. Significant wave height field and direction of wave propagation a) at the gale beginning (30.01.2000 00 UTC), b) time of its maximum extension (30.01.2000 06 UTC), c) during of the last phase of gale (30.01.2000 15 UTC)

Files received twice a day from ICM contain forecast of following fields: wind velocity and direction, atmospheric pressure, air temperature and humidity, cloudiness every hour beginning from the 0:00 hour of the day of the forecast generation up to 48 hours later (Fig. 2). SMHI data are transmitted once a day in the morning, and the forecast package contains water level, ice parameters, three-dimensional distributions of current velocity and direction, water temperature and salinity (Fig. 3). The important parameter for the drift forecast and for the optimisation of rescue decisions, is wave field. This forecast was previously available in the Maritime Institute only partly (wave height) and only in the graphical form (Fig. 4). It was the reason for the implementation of the prognostic wave model for the Baltic Sea The WAM (Wave Model) was chosen as a modern, third generation model. The model is run using the wind forecast data obtained from ICM UW (Fig. 5).

The ArcView enhancement - Internet Map Server, preparing information in graphical form, is used for making the sea forecast maps accessible via Internet by the http (www) protocol (Fig. 6). From the user's point of view, the most important element is the net application, written in Java language, which enables data transmission. This application enables the following activities with the sea forecast maps:

- panning of the map centre at the monitor screen,
- enlargement (reduction) of the scale of the map at the screen,
- call of the maps for the chosen time (both hindcast and forecast)
- preparation of the map printout on a printer.

Presently software to extract data measured at buoy MIG-1 are ready (Fig. 7). Communication between Maritime Institute and Coordinating Centre of Polish Ship Salvage Company in Gdynia was established this year using digital link ISDN. It allows for direct connection and using CAROCS system information by salvage inspectors [2].

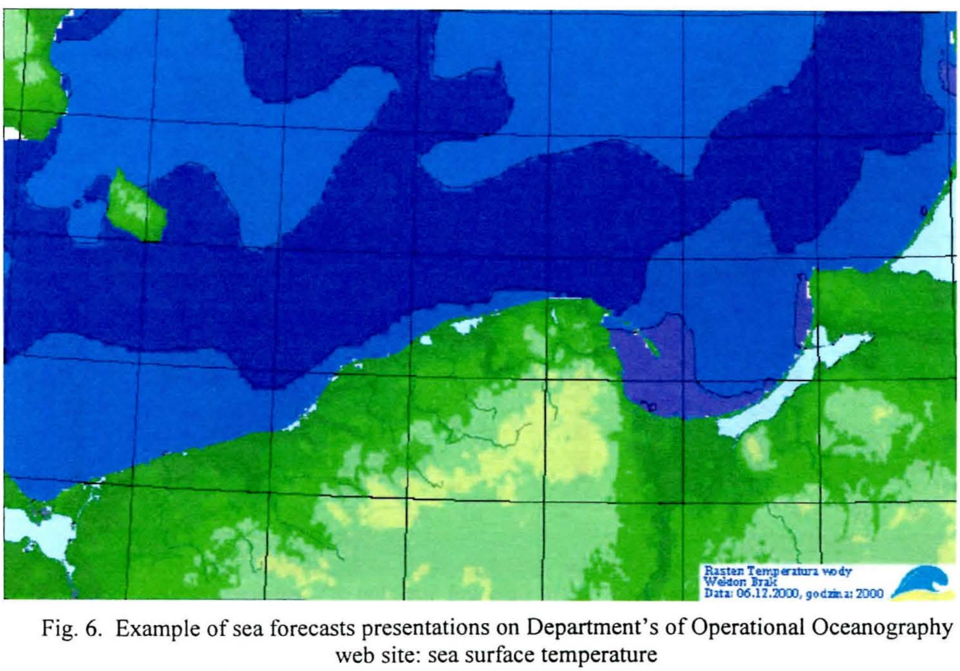


Fig. 6. Example of sea forecasts presentations on Department's of Operational Oceanography web site: sea surface temperature

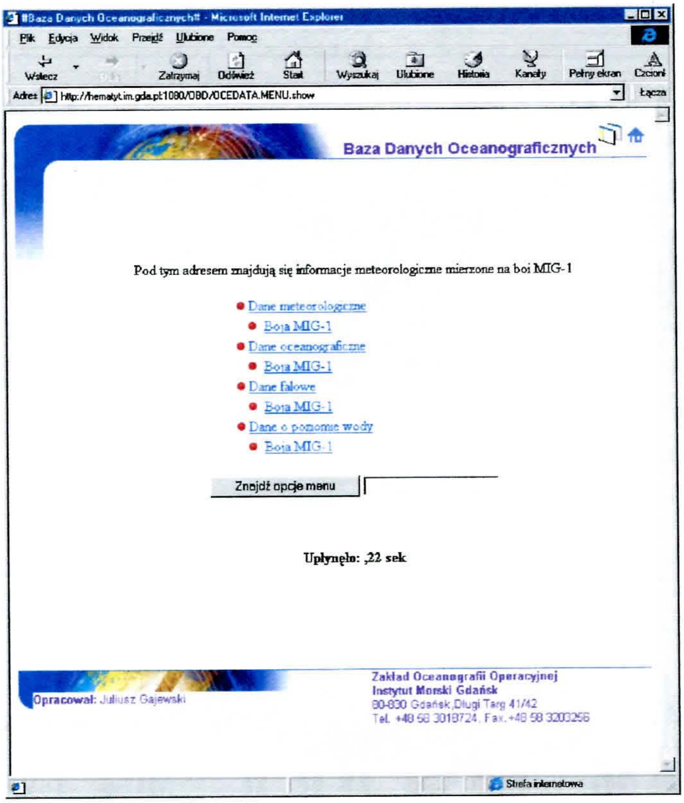


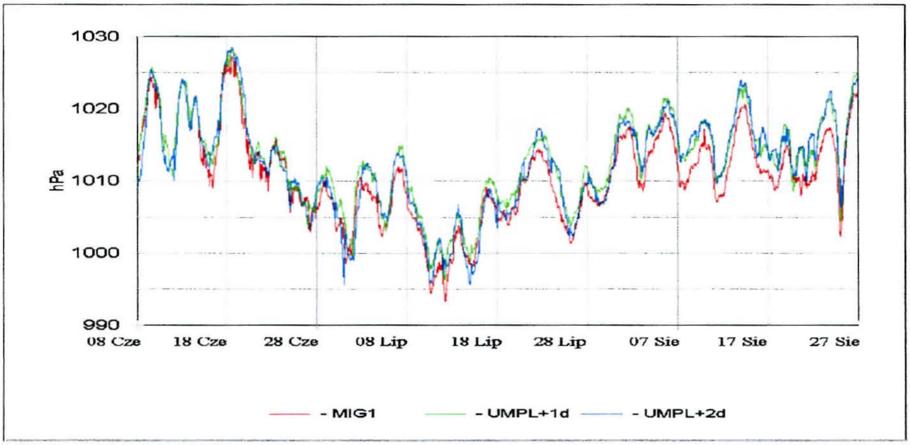
Fig. 7. Oceanographic Data Base web site

Verification of numerical forecast by the data registered in the open sea by MIG-1 buoy

In Operational Oceanography Department marine forecast system is still extended [7]. It is carried out both in collaboration with Polish scientists (POLRODEX experiments [3,5], other common investigations financed by State Committee for Scientific Research) and with maritime services of Baltic Sea states (in frame of HIROMB Partnership). Field measurements, like those done by buoy MIG-1 at sea, play very important role.

Up to present time of MIG-1 buoy exploitation (started 19th May 2000) all meteorological data, registered over the sea surface by automatic meteo station were received, collected and examined. This information comprising barometric pressure, air temperature, relative humidity, solar radiation, wind speed and direction is prepared twice each hour and sent by cellular telephone net to the Institutes server. It can be transmitted immediately each hour, or if any troubles with connection occur they can be stored in the system memory (up to half year) and transmitted when possibility arise.

Up till now (December 2000), we have obtained practically continuous (with only some breaks of several hours) set comprising meteorological data from place at the open sea, about 8 Nm from the coast. Such long series of observations from one point at the sea near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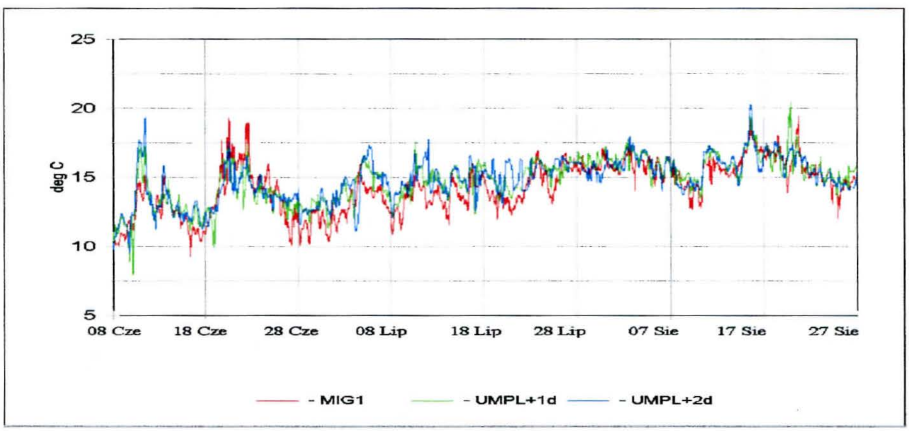
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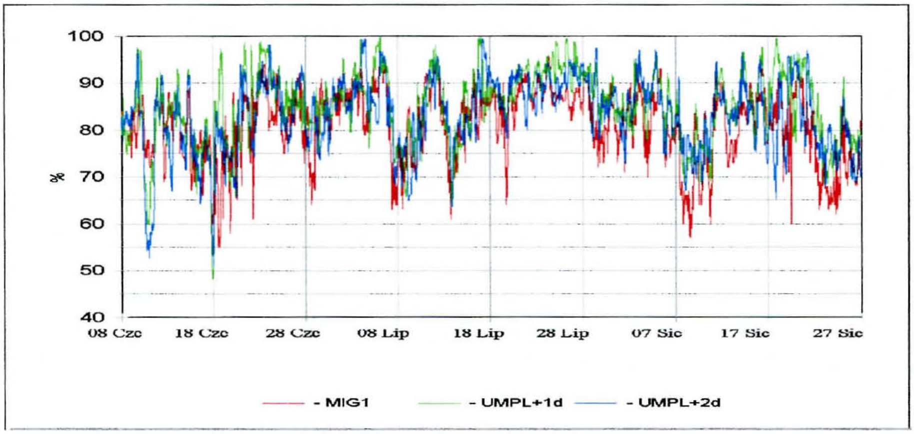
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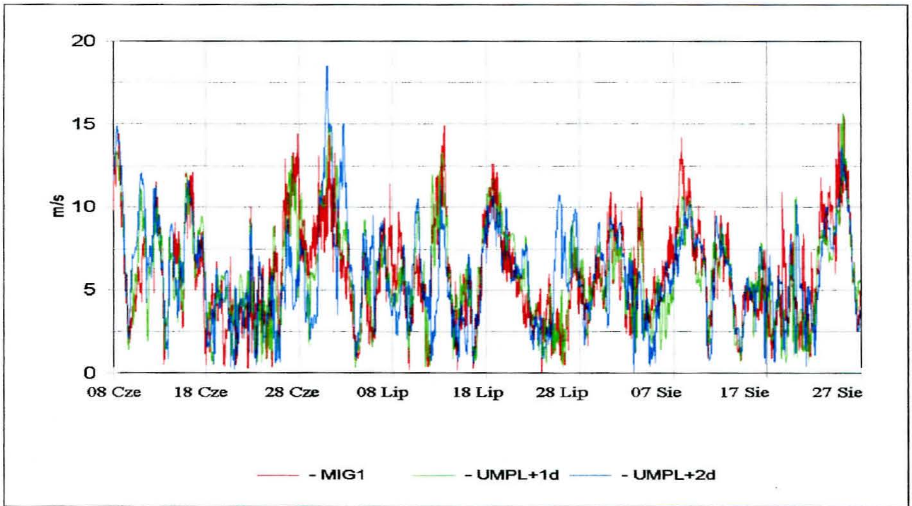

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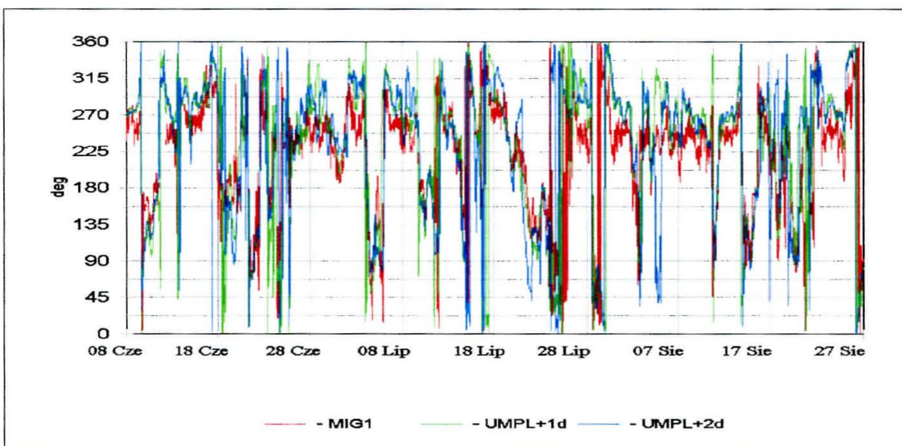


e)

Fig. 8. Meteorological parameters at the open sea recorded on MIG buoy during the summer months 2000 and predicted by UMPL mesoscale atmospheric model: a) atmosphere pressure, b) air temperature, c) relative humidity, d) wind speed, e) wind direction

the Polish coast were not recorded yet. These data were checked and compared with the results of numerical mesoscale atmosphere model – UMPL. The comparison was done for the first and the second day of 48-hours forecast. Fig. 8 a-e presents recorded meteorological parameters together with the curves of the first (UMPL+1d) and the second (UMPL+2d) day of prediction for three summer months of the year 2000.

From this set of pictures we can see quite good consistency between observations done at sea and simulated by UMPL model. As expected, the results of prediction for the first day are better than for the second one. It has to be stressed that there are no possibilities to check this data set with other independent observation series. Meteorological data originated from coastal stations show a strong influence of sea-coast interactions and strongly depend on local orography of the coastal area.

In Tab. 1 statistical data for comparison of registered and simulated meteorological parameters were compiled, taking in to account scalar values for all time of registrations at the sea. The statistical parameters include: total number of observations (N), maximum (MAX), minimum (MIN) and average (AVG) differences between observations and simulations, as well standard deviation (STD) and correlation coefficient (R).

Tab.1. Statistical data for comparison of observed and simulated meteorological parameters over the sea during 19 May – 01. Dec 2000 – for the first (0 - 24h) and second (24 - 48h) day of forecast

	Barometric pressure		Air temperature		Relative humidity		Wind speed		Parallel wind component		Meridian wind component	
	+24h	+48 h	+24h	+48 h	+24h	+48 h	+24h	+48 h	+24h	+48 h	+24h	+48 h
N	4531	4531	4595	4595	4595	4595	4595	4595	4595	4595	4595	4595
MAX.	5.2	5.5	7.3	5.6	78.0	27.3	8.7	9.3	17.0	16.4	15.2	13.2
MIN.	-9.3	-12.0	-6.7	-7.0	-37.1	-30.7	-7.5	-12.0	-18.9	-20.1	-14.5	-13.9
AVG.	-2.60	-2.68	-0.67	-0.68	-3.18	-2.24	-0.25	-0.25	-0.78	-0.61	0.43	0.56
STD	1.34	2.13	1.42	1.52	7.00	7.36	1.97	2.57	3.54	3.96	3.40	3.69
R	0.983	0.961	0.907	0.891	0.700	0.668	0.770	0.627	0.765	0.711	0.617	0.560

As we can see there is a quite good consistence for simulation of the pressure and temperature data, slightly worse is for humidity and wind parameters. In case of relative humidity, simulations give higher values than observed on buoy. But in the case of wind it seems that hydrostatic mesoscale model UMPL has no possibilities to describe interaction sea – land phenomena like breeze. It can be seen for the course of wind speed, that simulated curve is considerably smoother than that obtained from registrations at the sea.

Wave modelling basing on numerical wind fields

There is a strong need for the reliable wave forecast in the Polish EEZ of the Baltic Sea. Wave forecast is especially important in harbour areas, along the frequent ship routes, in roadsteds and anchorage areas, along the coasts, exposed for erosion caused by waves and wave-induced currents. Access to reliable wave forecast is essential also during rescue operations in the sea and combating oil spills. Analysis of wave parameters for a long time of observations (simulations) may be very useful for planning coastal protection [4,6].

It is obvious that wind is the most important driving force in the dynamics of the Baltic Sea. Digital wind data for the entire area over the basin in concern make it possible to run models of different hydrophysical fields. Daily transmission of wind forecast from ICM enabled us to implement WAM model (cycle 4) for the wave forecast in the Baltic Sea. WAM is a wide used spectral numerical model for wave analysis and forecast in the oceans and seas [9]. The model gives complete two - dimensional wind wave spectra in any node of the numerical grid.

Unfortunately, there are still no satisfactory data from the underwater part of measuring devices; it concerns also the wave rider from MIG-1 buoy (Fig. 1c). By courtesy of Dr. Paplińska from the Polish Academy of Sciences' Institute of Hydroengineering, Gdańsk, we obtained wave data series recorded by directional wave rider, anchored near Lubiatowo at the depth of 20 m. These data have been used for comparison with the WAM model results, calculated in Maritime Institute, for different forecast time (0, 1-24, 25-48 hours). Table 2 shows results of statistical analysis for the differences between measured and computed values of the significant wave height and propagation direction in February 1999 in the point at sea near Lubiatowo.

Tab. 2 Statistical analysis for the wave observations (near Lubiatowo) and numerical WAM model computations.

	Significant wave height (m)			Mean wave direction (deg)		
	+0 day	+1day	+2days	+0 day	+1day	+2days
Mean differences	0.28	0.32	0.32	21	24	27
Max. differences	1.68	1.84	1.12	165	176	179
STD	0.25	0.29	0.23	24	29	34
R	0.92	0.89	0.89	0.82	0.74	0.58

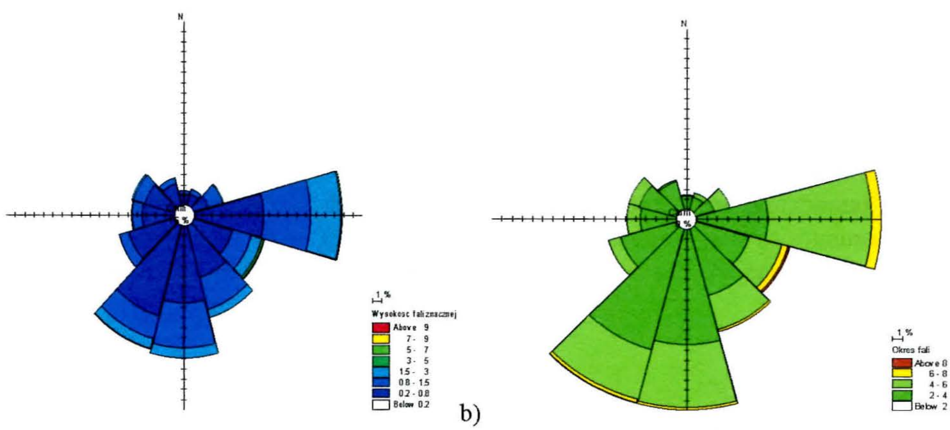
a) 

Fig. 9. Directional distribution of significant wave parameters in the point of 54°57'N, 18°42'E; a) wave height, b) wave period

In case of the lack of empirical material, long series of wave calculations based on real wind fields can characterize wave parameters. Yet the series of calculations are not covering long periods, however, it is interesting to analyse existing data. For example, in the open sea area of Władysławowo, in the point of co-ordinates 54°57'N and 18°42'E, wave parameters have been estimated on the basis of the WAM model, used in the Maritime Institute for the wave forecast in the Polish zone of the Baltic Sea, for the period of 01.09.1998 - 01.09.2000.

The results of the analysis are shown in two figures (in both figures directions of wave propagation are shown). Fig. 9a shows directional distribution of significant wave height (wave height rose). It is clearly seen that in the open sea area two dominating wave directions can be differentiated – first northern, for the waves coming from the north (and northeast), the second for the waves coming from the western Baltic. The wave fetch for waves coming from the western Baltic is not so large as in case of waving coming from north, but the first waves are larger because of stronger winds blowing from west. It is also worth to stress that the rate of larger wave heights is larger for waves coming from west, The analysis of the Fig. 9b leads practically to the same conclusions, the rate of largest periods is larger for waves propagating eastwards.

Conclusions

The system of digital marine forecast, covering the Polish area of the Baltic Sea is permanently conducted and developed in the Department of Operational Oceanography, Maritime Institute, for the needs of rescue services and marine administration. The present system uses data from different Polish and foreign operational centres, as well generates its own forecast, as it is in the case of wind waves and drift of objects. The combined forecast is processed into the formats demanded by the services and is available also in Internet at our web site.

Among the all forecasts, the wind forecast is one of the main input (driving force) for calculations of hydrodynamic parameters (waves, currents etc.) forecast. The key to reliable marine forecast system is the reliability of wind forecast, so it is hard to overestimate wind forecast importance in the system. In the Maritime Institute, numerical wind fields computed by the mesoscale atmosphere model UMPL in the University of Warsaw are used. These fields can serve directly for assessment of expected wind conditions over the sea, they are also the necessary input information for initialisation of different marine hydrodynamic models.

The autonomous buoy, anchored recently in the Polish area of the Baltic Sea, gives us the opportunity to compare results of measurements not only with UMPL atmosphere model data, but also with the hydrodynamic models like HIROMB, POM and WAM.

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