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Sources and the structure of the weather data used for the optimization of the ship's route

Źródła i struktura danych pogodowych stosowanych przy programowaniu trasy statku

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Abstract

This paper presents sources of weather information necessary and useful when programming the ship route. Particular attention was given for publicly accessible information. Available data was categorized by groups of validity. The localization and the structure of weather data such as resolution, coverage, limitations, forecast time, etc. were described. The principles of naming the files containing the selected weather data in GRIB (gridded binary) format were presented.

Słowa kluczowe: źródła informacji pogodowej, struktura danych, GRIB

Abstrakt

W artykule przedstawiono źródła informacji pogodowej koniecznej i przydatnej podczas programowania trasy statku. Szczególną uwagę poświęcono informacjom ogólnodostępnym. Dostępne dane uszeregowano według grup ważności. Opisano lokalizację i strukturę danych pogodowych, takich jak rozdzielczość, pokrycie, ograniczenia, czas prognozy, itp. Przedstawiono zasady nazewnictwa plików zawierających wybrane dane pogodowe w formacie GRIB.

The sources, structure and availability of a weather data

The basic information required when considering the weather conditions during vessel voyage is information related to the parameters of waves and wind. These elements in biggest degree, but especially waves, effect on behavior of ship, the performance achieved by the movement, safety.

Another group of information is data indicating the limited areas or areas inaccessible for navigation: areas of occurrence of tropical cyclones, ice limits, the range of floating ice, areas of potential ship icing.

The information needed to calculate the exact position of a moving ship, but not always updated in real time, is data on ocean currents.

The last group is the information about the elements of weather conditions affecting the safety and comfort of transport, but not being crucial to the accuracy of the calculations. Here we can include data on the distribution of pressure field, sea surface temperature, air temperature, relative humidity, gusts of wind, fog and visibility, and geopotential height (Fig. 1).

The source of the first group of information is data from NOAA model WAVEWATCH III available in a GRIB format (gridded binary) [1].

The NOAA WAVEWATCH III operational wave model suite consists of a set of five wave models, based on version 2.22 of WAVEWATCH III (Tab. 1):

– the global NWW3 model;
– the regional Alaskan Waters (AKW) model;

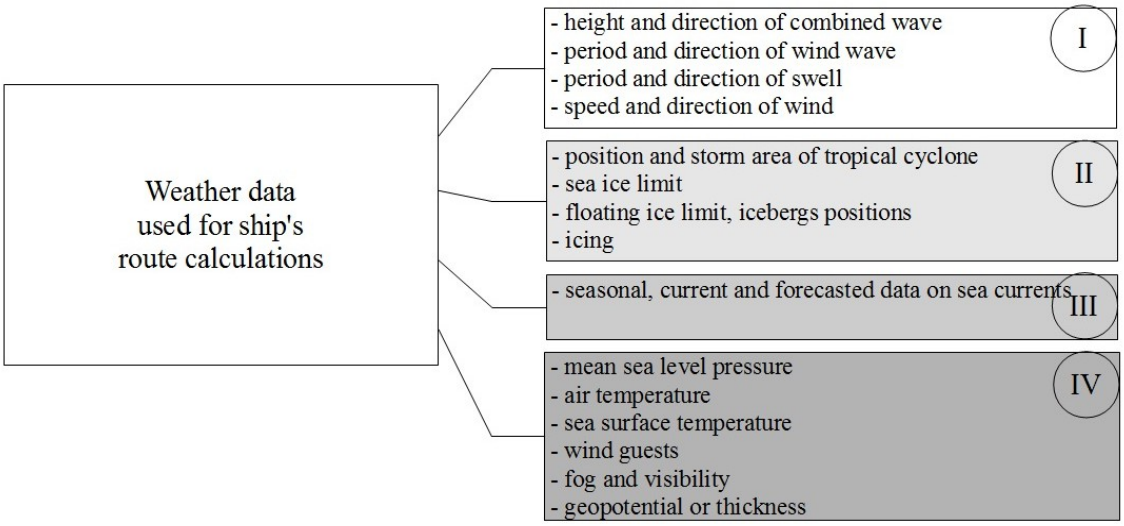

Fig. 1. Weather data for navigation
Rys. 1. Informacje pogodowe dla celów żeglugi

Table 1. Global and regional WAVEWATCH III models
Tabela 1. Globalny i regionalne modele NWW III

Model	Type	Coverage and resolution	Minimal depth [m]
NWW3	global	78°S – 78°N 1.25°× 1.0°	25
AKW	regional	45°N – 75°N; 60°E – 123°W 0.5°× 0.25°	7.5
WNA	regional	0° – 50°N; 98° – 30°W 0.25°	7.5
NAH	regional	0° – 50°N; 98° – 30°W 0.25°	7.5
ENP	regional	5° – 60.25°N; 170° – 77.5°W 0.25°	7.5
NPH	regional	5° – 60.25°N; 170° – 77.5°W 0.25°	7.5

– the regional Western North Atlantic (WNA) model;
– the regional North Atlantic Hurricane (NAH) model;
– the regional Eastern North Pacific (ENP) model,
– the regional North Pacific Hurricane (NPH) model,

All regional models obtain hourly boundary data from the global model. All models are run on the 00z, 06z, 12z and 18z model cycles, and start with a 6 h hindcast to assure continuity of swell. All models provide 126 hour forecasts, with the exception of the NAH model (72 hour forecast). All models are based on shallow water physics without mean currents [2, 3, 4, 5, 6].

Current data from the last main synoptic term and the last data published four times a day during the last week can be found at:

http://nomads.ncep.noaa.gov/pub/data/nccf/com/wave/prod/

Files containing data for the entire area of the ocean are called nww3.t00z.grib.grib2, where the nww3 is WAVEWATCH III model, t00z (or properly t06z, t12z, t18z) validity hour in UTC, and grib.grib2 points to a file recorded in binary grid format, the second version.

Data from the last six observation times are also available on the NCEP ftp server (National Center for Environmental Predictions):

ftp://polar.ncep.noaa.gov/pub/waves/

and then, respectively, file for the whole ocean area containing data of ocean waves and winds is called nww3.all.grb.

Fields of mean wave parameters are available in the WMO GRIB format. The table 2 gives the so-called kpds number, a GRIB identifier and a description of all fields packed in GRIB. The GRIB files contain data at 3 hour intervals, starting at the 0 hour forecast (with no hindcast data).

At a resolution of 1° to 1.25° and covering the area between 78N and 78S it is 288 points on the parallel and 157 on the meridian and thus a total of 45 216 grid points.

Publicly available archival data are located on the NOMADS servers (NOAA Operational Model Archive Distribution System) at:

ftp://polar.ncep.noaa.gov/pub/history/waves/

Here we can find archival data analysis:

– significant wave height (combined wave);
– period of wind waves (primary wave mean period);
– direction of wind waves (primary wave direction);

Table 2. Data included in grib file of WAVEWATCH III model
Tabela 2. Dane zawarte w pliku GRIB modelu operacyjnego WAVEWATCH III

kpds number	GRIB identifier	Description
31	WDIR	Wind direction [°]
32	WIND	Wind speed [m/s]
33	UGRD	Wind U component [m/s]
34	VGRD	Wind V component [m/s]
100	HTSGW	Significant wave height [m]
101	WVDIR	Mean wave direction [°]
103	WVPER	Mean wave period [s]
107	DIRPW	Peak wave direction [°]
108	PERPW	Peak wave period [s]
109	DIRSW	Wind sea direction [°] Undefined if wind too weak to generate wave in spectral model domain.
110	PERSW	Corresponding wind sea period [s]

– *u* and *v* components of wind vector;

daily for 8 terms (00, 03, 06, 09, 12, 15, 18, 21 UTC) from 01 January 1997 to the end of the last completed year.

Information on a substantial part of the second and fourth group of weather data is provided by the model GFS (Global Forecast System) (Tab. 3). The operational GFS consists of the final Global Data Assimilation System, the GFS forecasts (GFS), and the Ensemble forecasts (ENS). The GFS is a consolidation of the forecasts formerly known as the Aviation (AVN) and the Medium Range Forecast (MRF). Output is posted in a resolution of 1 by 1 degree or 0.5 by 0.5 degree equally spaced longitude/latitude grid with 3 hours forecast interval to 180 h, cycled four times daily. The other version of the output is produced twice daily and 2.5 degree equally spaced in longitude/latitude with 12 h forecast interval to 240 h, cycled four times daily.

Sea ice group is a part of the Marine Modeling and Analysis Branch of the Environmental Modeling Center. Sea ice information, as well as visibility [7] information can be found available daily at:

http://nomads.ncep.noaa.gov/pub/data/nccf/com/omb/prod/

In a directory */fog.“date”* files from main therms of the last day and current calculations are present. File *fog.“time”.fvnhg.grib2* consists information about 10 meters above surface visibility

Table 3. Chosen data included in analysis 2.5 degree grib file of GFS model
Tabela 3. Wybrane dane zawarte w pliku z danymi GRIB modelu GFS w rozdzielczości 2,5 na 2,5 stopni

No.	GRIB Parameter	Description
179	PRES	Pressure (ground or water surface) [Pa]
180	HGT	Geopotential Height (ground or water surface) [gpm]
181	TMP	Surface Temperature (ground or water) [K]
191	TMP	2 m above ground Temperature [K]
194	UGRD	U-Component of 10m above ground Wind [m/s]
194.1	VGRD	V-Component of 10m above ground Wind [m/s]
248	GUST	Wind speed (gust) (ground or water surface) [m/s]
249	LAND	Land Cover (1 = land, 0 = sea)
261	PRMSL	Pressure Reduced to MSL [Pa]
Note: Numbers differ due to file type (analysis / forecast / resolution) and name.		

for current situation and one week forecasts in 6 hours step. Whole globe is covered in resolution 1 × 1 degree.

In a directory */sice.“date”* file *seaice.“time”.grb.grib2* can be found. It consists analysis of ice coverage for whole world in resolution of 0.5 × 0.5 degree. Last three days outputs in 6 h step are available.

RTOFS (Atlantic) is a basin-scale ocean forecast system based on the HYbrid Coordinate Ocean Model (HYCOM) (Fig. 2).

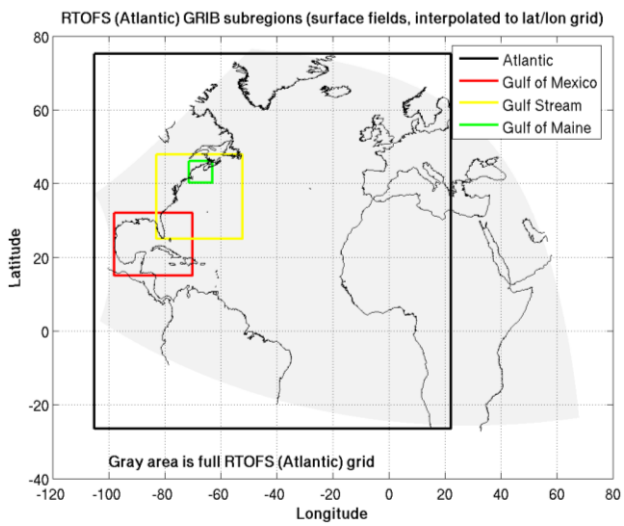

Fig. 2. Area covered by RTOFS (Atlantic) model [8]
Rys. 2. Pokrycie Atlantyku zasięgiem modelu RTOFS [8]

The model contains data on ocean currents, salinity, sea surface temperature, and sea surface level.

The model is run once a day, completing at about 1400Z. Each run starts with a 24 hour assimilation hindcast and produces ocean surface forecasts every hour and full volume forecasts every 24 hours from the 0000Z nowcast out to 120 hours.

RTOFS (Global) is a global ocean forecast system similar to RTOFS (Atlantic). The model is run once a day, completing at about 2230Z. Each run starts with a 2 day hindcast and produces ocean surface forecasts every hour and full volume forecasts every 6 hours from the 0000Z nowcast out to 144 hours.

Current data for Atlantic basin at:

ftp://ftpprd.ncep.noaa.gov/pub/data/nccf/com/ofs/prod/ofs.“date”/

Last month for Atlantic:

http://nomads.ncep.noaa.gov/pub/data/nccf/com/ofs/prod/ofs.“date”/

Resolution of data is 0.255 × 0.255 degree, 500 points on parallel and 400 points on meridian. File ofs_atl.t00z.f“nnn”.atl.grb.std.grib2, where “nnn” is forecast time in hours from starting point, contains information about *U* and *V* component of surface current (UOGRD, VOGRD), water temperature (WTMP), and deviation of sea level from mean (DSLM).

The GRIB file is in format:

ofs_atl_t00z.YYMMDD.ffff.grb

where:

YYYY = year;
MM = month;
DD = day;
ffff = N000 (nowcast), F024 (24-hour forecast), F048 (48-hour forecast), F072 (72-hour forecast), F096 (96-hour forecast), F120 (120-hour forecast).

From global version of the model at:

http://nomads.ncep.noaa.gov/pub/data/nccf/com/rtofs/prod/rtofs.“date”/

Files with whole data (all therms) contain unsupported map projection for some software tools used for grib file decoding.

GRIB files with data on tropical cyclones can be found at:

ftp://ftp.tpc.ncep.noaa.gov/wsp/“year”/“month”/

in compressed form:

tpcprblty.YYYYMMDDHH.grib2.gz

where:

YYYY – year;
MM – month;
DD – day;
HH – hour.

They contain data on the probability of occurrence of winds 34 kt, 50 kt and 64 kt (tropical depression, tropical storm, hurricane), and *U* and *V* components of the vector of associated winds. Covered area is described in table 4.

Table 4. Area covered by tropical cyclon information
Tabela 4. Pokrycie obszaru informacją o cyklonach tropikalnych

Latitude 1	Latitude 2	Longitude 1	Longitude 2	Nx (Number of points on parallel)	Ny (Number of points on meridian)
1	60	100	359	519	119

The 34 knot, 120 hour cumulative wind speed probabilities show probabilities of sustained (1-minute average) surface (10-meter altitude) wind speeds equal to or exceeding 34 kt (tropical storm force) at a regularly spaced (1/2 degree) grid of points. The cumulative periods begin at the start of the forecast period and extend through the entire 5-day forecast period from 0–120 hours.

The 34 knot, 120 hour cumulative surface wind speed probabilities are used to assess the overall risk of experiencing winds of at least 34 knots at a location during the period between hour 0 (the beginning of the forecast) and day 5 (120 hours). This data is based on the official National Hurricane Center (NHC) track, intensity, and wind radii forecast, and on NHC forecast error statistics for those forecasts variables during recent years.

These data are intended for geographic display and analysis at the national level and for large regional areas. The data should be displayed and analyzed at scales appropriate for 1:2,000,000-scale data. No responsibility is assumed by the National Oceanic and Atmospheric Administration in the use of these data.

Possibilities of applying ocean / land data of the GFS model

Grib data of GFS (Global Forecast System) model also include the information of the earth's surface (land / ocean). Land areas correspond to a value of 1, and ocean areas value of 0. Resolution of the information is 0.5 to 0.5 degrees. Information included in “LAND” parameter can be use for

land / water identification in weather route optimization applications. However, it requires some small modifications opening the routes to Mediterranean Sea and Black Sea.

In order to use these data as the description of land area for the purpose of calculation, it should be removed the two points described as the land and replace their value to describe the water area. This is a point lying in the Strait of Gibraltar – the input area of the Mediterranean Sea, and a point in the Dardanelles – the input area on the Black Sea (Figs 3 and 4).

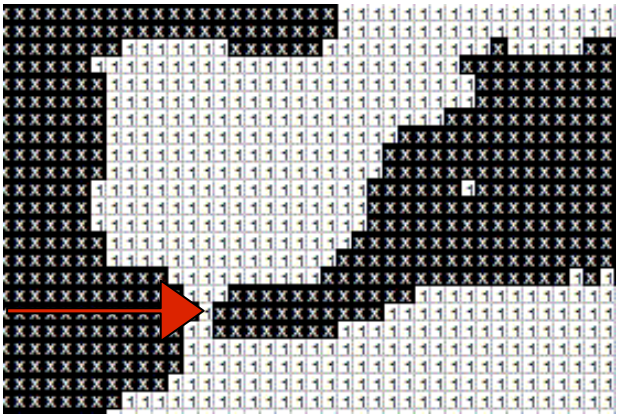

Fig. 3. Strait of Gibraltar area
Rys. 3. Rejon Cieśniny Gibraltarskiej

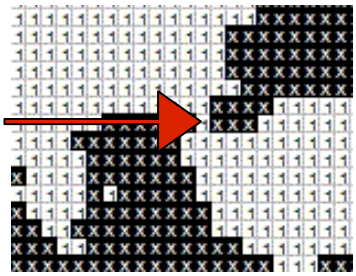

Fig. 4. Dardanelles area
Rys. 4. Rejon Cieśniny Dardanele

Conclusions

The basic data that may be used to calculate the current ship's weather route on the ocean is data from the WAVEWATCH III model in grib2 format. Decoding can be performed using widely available tools tkdegrib:

http://www.nws.noaa.gov/mdl/degrib/

These data can be collected daily at:

http://nomads.ncep.noaa.gov/pub/data/nccf/com/wave/prod/

All other data is an additional information not having fundamental importance for the calculation of the route of the ship, but may be important for its security:

– ice limit and visibility: http://nomads.ncep.noaa.gov/pub/data/nccf/com/omb/prod/;
– tropical cyclone information ftp://ftp.tpc.ncep.noaa.gov/wsp/.

The range of an available data allows for the calculation of routes of ships on the oceans, taking into account both the basic information such as wind and wave parameters, and also to take into account the restrictions from the ice, reduced visibility, or the likelihood of tropical cyclones occurrence.

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