Patryk Sapiega[1], Tamara Zalewska[2]

[1]Institute of Meteorology and Water Management- National Research Institute, Waszyngtona 42, 81-342 Gdynia, ✉ patryk.sapiega@imgw.pl
[2]Institute of Meteorology and Water Management- National Research Institute, Waszyngtona 42, 81-342 Gdynia, ✉ tamara.zalewska@imgw.pl

An integrated system of wind and wave forecasts verified with data from the marine observation system in the southern Baltic region

Introduction. Building and developing marine measurement networks plays an important role in providing information on the state of the sea to validate and calibrate models that warn against dangerous hurricanes and storms. The integrated system wind and wave forecast is an effective tool for detecting and forecasting extreme phenomena that pose a threat to ships, the population of coastal towns and investments at sea and in the coastal zone. Thanks to the verification of models with measuring devices, information with a high degree of verifiability is provided and the data fed of the wave model with a high-resolution model with wind data enables the simulation to be performed without spatial overinterpolation of the forecast results. At the pre-processing stage, bathymetric spatial data with the same resolution and structure as the wind field data from the COSMO model are implemented into the wave model. The COSMO *(Consortium for Small-Scale Modeling)* model provides information on, among other things, wind speed and direction at a resolution of 7 km with a time interval of 3 hours. This model covers almost the entire Baltic Sea and the information assimilated to it comes from the global ICON model. In addition to the wind and bathymetric grids, sea levels, sea currents and calculated initial conditions are implemented into the model. The output data from the SWAN (*Simulating Waves Nearshore)* model are processed and visualized at the post-processing stage, and the obtained results are verified in the open sea zone, in the coastal zone and with the use of additional tools (e.g. satellite data). Based on the pre-processing operations, a waving forecast for 72 hours is calculated with a time step of 3 hours in four domains: the proper Baltic Sea, the South Baltic Sea, Gulf of Gdańsk and Bay of Puck. The output products include significant wave height forecast and assigned sea states according to the Douglas scale, distance period, wave crest length, dead wave height, dissipation energy and wave propagation and scattering direction

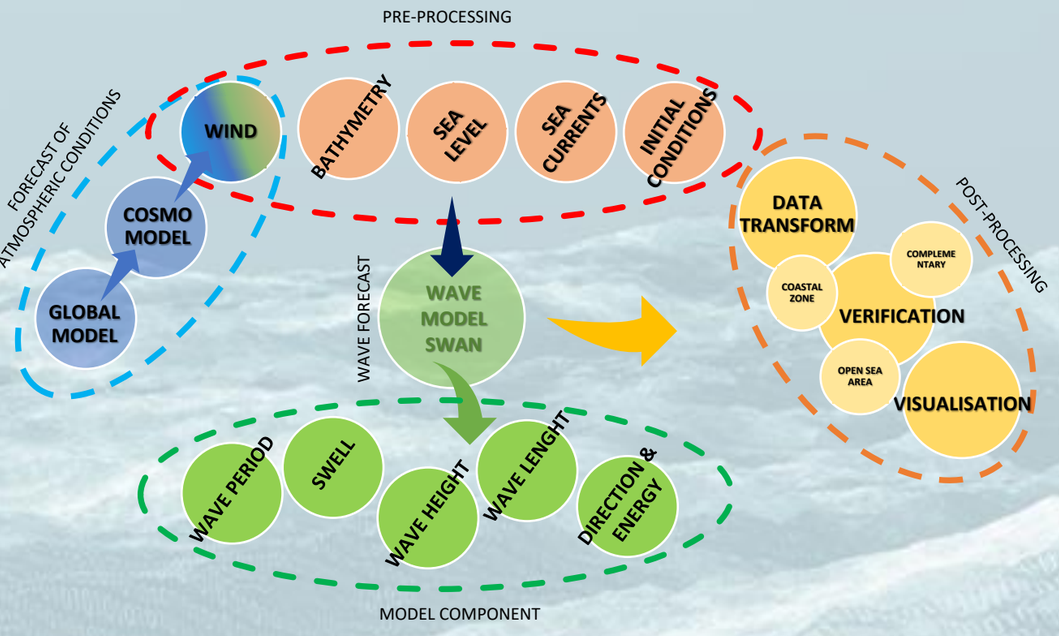

Fig. 1. The course of action and the relationship between the components of models and measurement network

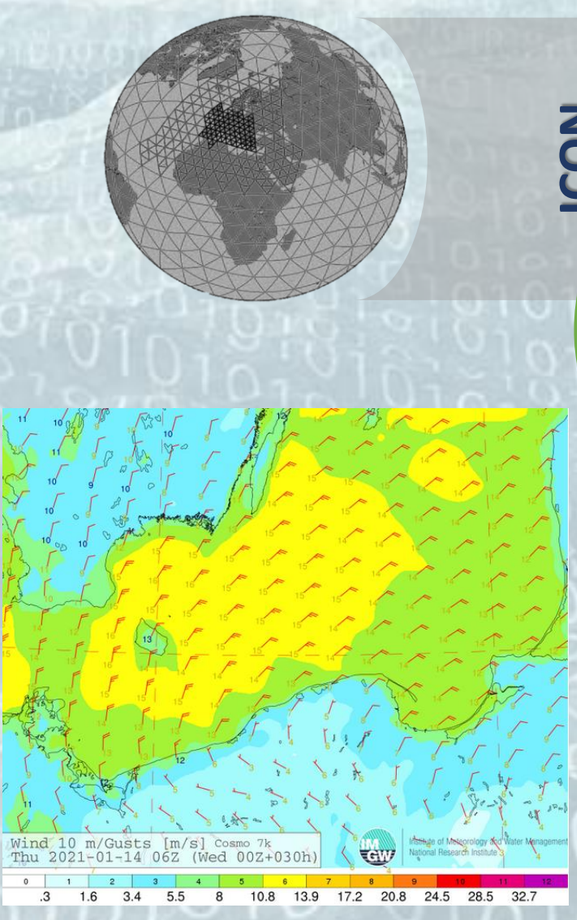

Fig.2. Wind forecast in the southern Baltic in the COSMO model (14.01.2021, 6:00)

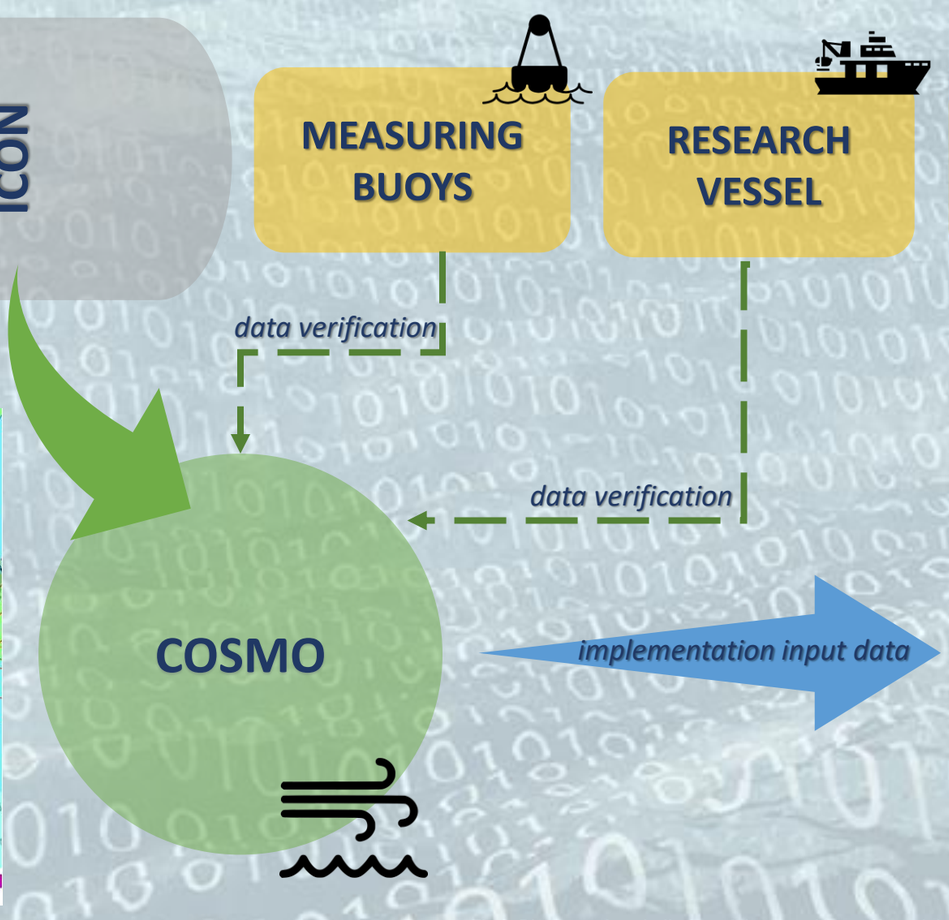

Fig.3. Diagram of assimilation of data used to verify and data-fed models

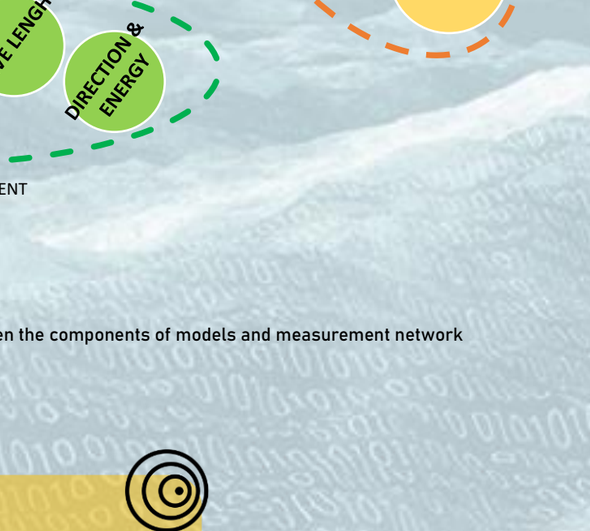

Fig.4. Wave forecast in the southern Baltic in the SWAN model (14.01.2021, 6:00)

SWAN is a third-generation wave model developed at the Delft University of Technology that computes random, short-crested wind-generated waves in coastal regions and inland waters. The forecast of wave parameters calculated in the SWAN model achieves high compliance with the actual measurement values thanks to the verified input data and the applied wave dynamics formulas, the use of which was calibrated based on various types of sources and devices measuring wave height and period. Both the COSMO (Fig. 2) and SWAN (Fig. 4) models forecast results are validated and verified on the basis of measurement data obtained from measurement equipment: meteorological station (LIDAR), Acoustic Wave and Current Profiler (AWAC; NEMO WPA – shared via Maritime Office in Szczecin) and radar (WaveGuide) installed on the oil rig - Petrobaltic (southern Baltic) and three meteorological buoys located in the southern Baltic region (Fig. 6 and 7).

Fig.5. Measurement and model results record (significant wave height) in 2020 at the measurement point - Petrobaltic)

A statistically significant correlation between SWAN model data AWAC data was found ($r = 0.84$, $p = 0.005$). Slightly higher predicted values of the significant wave in relation to the measured values are observed in storm conditions (Fig. 5). The obtained results clearly confirm the credibility of forecasting with the use of the COSMO-SWAN models system

Fig. 6. Measurement network of meteorological and hydrodynamic parameters

Fig. 7. Type of devices included in the measurement network