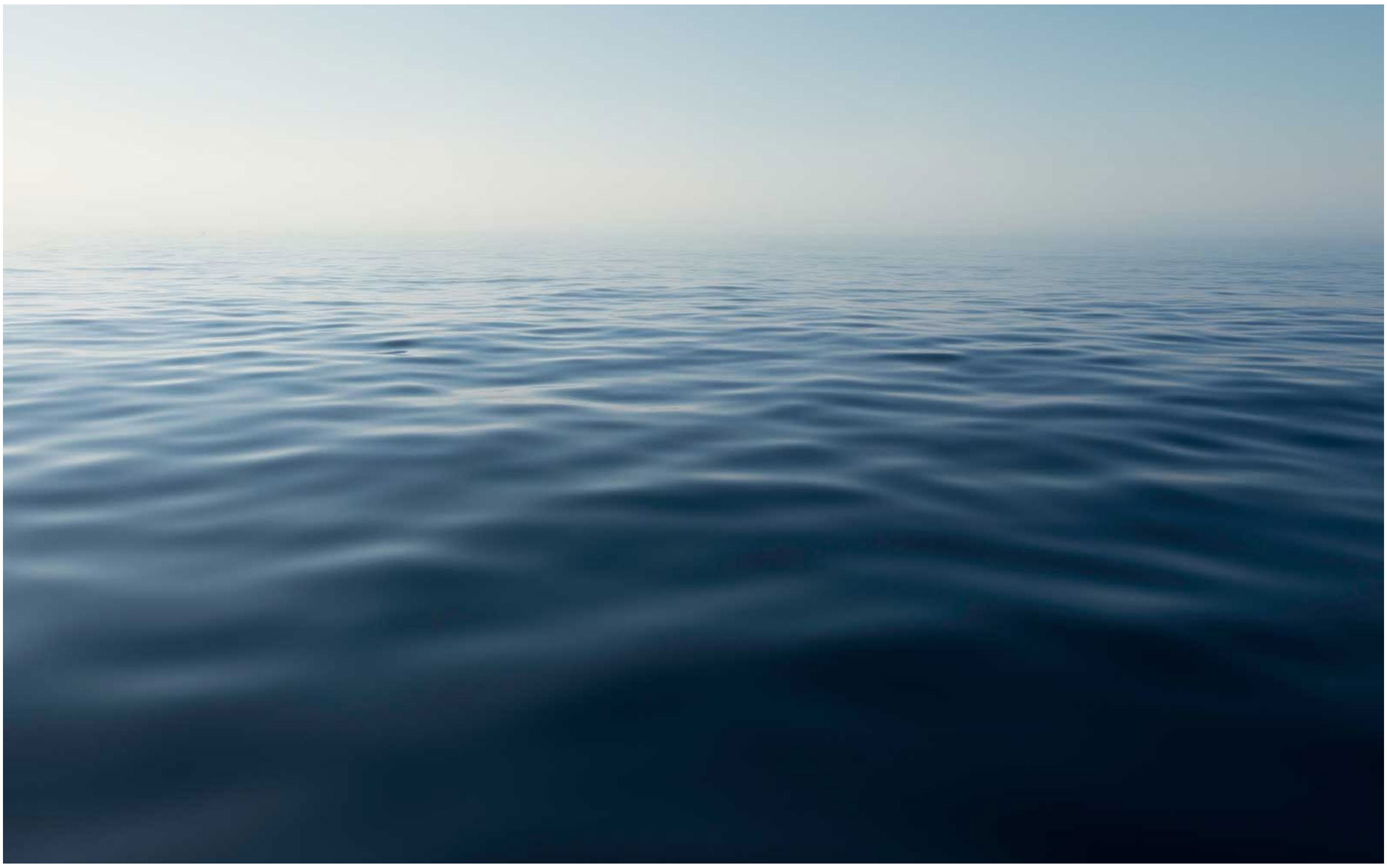
Hydrodynamic and Tidal Modeling

Our life activity is closely connected with the oceans, about 80 % of the world's population lives at a distance of no more than 1.5 kilometers from the ocean coast. The processes taking place in the oceans are undeniably important and have a significant impact on the states and on the individual sectors of the economy related to maritime activities such as navigation, fishing, marine farming, construction and operation of offshore structures, extraction, and transportation of mineral resources.



Under the influence of natural and anthropogenic factors, changes occur in the structure of oceanic processes, which have a significant impact on the various areas of activity. According to the World Bank and the World Economic Forum, weather-related risks have been at the top of the global risk rankings for several years. Oceanic processes can cause flooding, destruction and erosion of the coastline, sediments that interfere with navigation due to changes in the bottom topography, etc.

Forecasts and continuous monitoring of maritime weather make it possible to minimize the damage from extreme situations due to the early warnings about the adverse conditions.

Monitoring of marine processes is carried out thanks to the timely receipt of measurements from the modern observation systems (moored and drifting meteorological and oceanographic buoys, tools for the obtaining satellite data of water surface temperature, wind speed and currents, wind waves, sea surface level variations) and automated devices for collecting hydrometeorological information.

The IMS4 CLDB module allows storing of collected real-time data in a single unified structure. The data are verified by post-processing methods to improve the quality of observational information entering a single database. It provides the user with quick access to the processed data, which can later be used in other modules of the IMS4 system, for example visualized using IMS4 MAPS.

Hydrodynamic modeling is used to predict and evaluate changes in the variables of the aquatic environment at the various scales - from global (seas, oceans) to local (lagoons, lakes, shallow waters). Numerical models are able to predict such characteristics as profiles of the currents, temperature, water salinity, ocean surface level, tidal effects, and many others. The MicroStep-MIS operational forecasting system for marine hydrometeorological services is based on a complex of full-fledged modern ocean models.

The numerical model NEMO ("Nucleus for European Modeling of the Ocean"), developed by a European consortium for solving prognostic problems on a regional and global scale, is used for forecasting over large water areas. To adapt the model to the forecast region, MicroStep-MIS uses the flexible model tuning functionality. Thanks to the mechanism of nested grids (including those with multiple nesting one into another), the most detailed representation of the forecast on a regular grid (resolution up to 1 km) is achieved. The vertical structure can be described in various coordinate systems, which makes it possible to achieve the optimal location and number of vertical levels and obtain the most detailed prognostic picture in the water layer of interest at a certain depth. In addition to predicting the main characteristics of the seas and oceans, such as temperature, salinity, surface level, and many others, the NEMO model includes several associated modules for solving problems in biogeochemistry, biooptics, sediment modeling and sea ice dynamics.

For modeling on the smaller scales, the use of a local, small-scale SHYFEM model is provided. The SHYFEM (Fine Element Model for Coastal Seas) model is used for a wide range of problems in modeling the hydrodynamics of the aquatic environment in lagoons, open seas, coastal seas, estuaries and lakes. It is also adapted to work in very small and shallow pools, in shallow water (surf zone) and tidal swamps. Due to the use of the Finite Element Method for solving hydrodynamic equations in conjunction with the use of efficient algorithms, it is excellent for describing the processes occurring in basin regions with complex bathymetry and coastline geometry. The interface makes it possible to predict processes with high resolution only in necessary areas of the studied water reservoir, while in other rest areas the resolution can be much coarser (optional).

The main feature of the SHYFEM model is the calculation on a single unstructured grid of variable resolution without the use of additional nested grids. Thanks to this, the model setup looks more concise, and the necessary computing resources are distributed more rationally. This feature is a big advantage of the model, since its implementation is impossible using the much more common finite difference method.

The large volumes of prognostic information, especially in the form of three-dimensional fields, require a convenient interface for their displaying and qualitative analysis. MicroStep-MIS implements the IMS4 Maps visualization module for these purposes. Multiple layers of 2D data can be displayed in a modern web interface as colored fields, contours, and observation data points.