Marchuk Institute of Numerical Mathematics of the Russian Academy of Sciences



INFORMATIONAL COMPUTATIONAL SYSTEM "INM RAS – BALTIC SEA" FOR THE MARINE ENVIRONMENT STATE MONITORING

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NASCA18, Greece, 2018

CONTENTS

- 1. Introduction
- 2. ICS structure
- 3. Data
- 4. Operational forecasting
- 5. ICS interface
- 6. Summary and future plans

INTRODUCTION

- The main objective of the Informational Computational System (ICS) is reliable monitoring and forecasting of hydrophysical fields of the Baltic Sea and risk management
- The ICS includes numerical model of the Baltic Sea hydrothermodynamics, the oil spill model (Agoshkov, Aseev et al., 2014) describing the propagation of a slick at the sea surface and the optimal ship route calculating block (Agoshkov, Zayachkovskiy et al., 2014).



INTRODUCTION



- It is possible to calculate main hydrodynamic parameters:
 - temperature,
 - salinity,
 - velocities,
 - sea level.

using user-friendly interface.

Main possibilities of the ICS are presented in the work.

• ICS is based on the INMOM numerical model of the Baltic Sea hydrothermodynamics developed in the INM RAS. (Zalesny et al., 2013)

The ICS includes:

- the block of variational data assimilation (Agoshkov et al., 2015)
- The tidal forces block (Agoshkov, Assovskii, 2015)
- The data processing module (Zakharova, 2016)
- The interface (Sheloput et al., 2017)

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Spatial distribution of the model is 1/16°×1/32° in the longitude, latitude, respectively, and 25 vertical levels

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The desktop version and web-interface

DATA

The ICS includes a block of SST variational data assimilation.

It is possible to use various observational data in numerical calculations:

2007-2017 years

operational data (2018)

The data source used in the work is a Marine environment monitoring service (http://marine.copernicus.eu) by the European project Copernicus.



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For the assimilation procedures of the operational data we use European ocean-sea surface temperature multi-sensor L3 observations in ICS. It is a daily-mean SST satellite observations.

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For calculations at older times, the observed data corresponded to mean daily Baltic SST according to the data of the Danish Meteorological Institute (Karagali et.al., 2012) are used, recalculated to the grids of the numerical model.

OPERATIONAL FORECASTING



ICS INTERFACE

Desktop version (completed)

Web interface (in progress)

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About us

The Adjoint Equations Group presents resear at the Institute of Numerical Mathematics of F which unites scientists from all research area: Steklov Institute of Mathematics and Institute I. Marchuk, who was a President of Russian Ac is not very large — there are about 70 researc

Our Adjoint Equations Group is headed by Pro of partial differential equations including opti enable to reveal effectively new properties of some interesting contributions in their develo

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Data input Visualization	
Realtime simulation	
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- thermohaline structure and the density of water,
- distribution of basic hydrological and special settings.

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- thermohaline structure and the density of water,
- distribution of basic hydrological and special settings.

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ICS allows one to carry out calculations of the following hydrodynamic parameters:

•temperature,

salinity,

•sea level,

·circulation.

The Baltic Sea dynamics	
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The Baltic Sea dynamics	_ — X
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The Baltic Sea dynamics	
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•temperature,

salinity,

·sea level,

-circulation.

The Baltic Sea dynamics	
File Help	
Data input Visualization	
Type of data	Preview
temperature	Circulation
Circulation Salinity	65N-
🔲 cross-section широте 🔻 in 0,00 ≑	64N- 63N-
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Start	i Exit

ICS allows one to carry out calculations of the following hydrodynamic parameters:

•temperature,

salinity,

•sea level,

•circulation.

THE RISK CONTROL BLOCK

. Kisk control
File Help
Simulation Visualization
Latitute 55,27690000 🔄 Longitude 20,66580000 🌩
Oil mass 180,00
Environment parameters
Path C:/ASEEV/ICS-Baltic_Sea-v1.0-rot-beta/release/RUNS
Period of record 3 🐑 (min)
Simulation parameters
Duration 168 🚖 (h) Beginning of averaging 0 🌲 (h) Ending of averaging 168 🖨 (h)
Max spot apearance time 3 💭 (h) Discritization risk step 60 💭 (min)
Specific damage 100 A (they rule) Begularization param 0.100000 A Iteration param 10.00000
Specific damage 100 v (triods, rub) Regularization param. 0,100000 v Iteration param. 10,00000 v
Results record
Directory 2017.03.16_18.28
Start Evit
EAIL

ICS allows to carry out calculations to solve a class of problems on risk management of oil pollution in the Baltic Sea:

•

to simulate the evolution of the various spot parameters (mass, volume, area, oil, density, viscosity, water content of the emulsion type "waterin-oil") under the influence of different types of methods for removing oil;

THE RISK CONTROL BLOCK

Kisk control	
File Help	
Simulation Visualization	
Simulation	
Туре	Preview
🔘 Oil mass 🛛 🔘 Area 🔘 Volume	
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Dencity Viscosity Water saturation	
	55.5%
Occalization Control Damage	•
Output parameters	55.25 °N
Spot appears time 0 Output time 494	
	55 W
INFO	
	20.25°E 20.5°E 20.75°E 21°E
Coordinate 55.2769, 20.6658	
Mass 180 (tn) Dencity 853.6 (kg/M^3)	
	View
Viscosity 0.0236 (Pa*s) Duration 168 (h)	Dreview In new tab
averaging: from 0 (h) to 168 (h)	
	working directory 2016.09.29_14.16
Discr. risk 60 (min) Spec. damage 0.1 (million rub)	
Reg. param. 0.1 Iter. param. 10	Total damage 1.20706274673 million rub
Start	Exit

- to calculate the dependence of loss on the time of appearance of spots;
- to calculate the final risk value;
- to save and view the results in a graphic form, to download the earlier calculations for the visualization of the results.

THE OPTIMAL SHIP ROUTE BLOCK

Optimal ship route	
File Help	
Simulation Visualization	
Path Parameters	
Start point: latitude 56,99000000 < longitude 19,63000000	
End point: latitude 58,22000000 🚖 longitude 20,99000000 🜩	
Dangerous situation parameters	
Expected value: latitude 57,60000000 🖨 longitude 20,40000000	
Dispersion 1,000000000000	
Damage (conv. units): 0,1400000000000	
Model parameter	
Number of parametrization points 15	
Results record	
Working directory 2017.03.16_17.57	
Start Exit	

ICS allows to carry out calculations of the optimal ship route in stationary threats. In the system one can control the following parameters:

 the starting and ending points of the initial trajectory;

THE OPTIMAL SHIP ROUTE BLOCK

Optimal ship route	<u> </u>
File Help	
Start Exit	

- mathematical expectation and variance of the probability distribution of a stationary threat;
- the damage that can be caused by the threat;
- the number of nodes to discretize the initial trajectory.

ICS WEB-INTERFACE

The multi-user version of the ICS (MU ICS) is designed to perform calculations on remote server without installing special software on the local computer. The goal of developing a MU ICS is to allow one to make calculations remotely, using a convenient web interface for specifying calculation parameters.

This approach has several advantages:

- 1. Possibility of free access to ICS from any PC that has access to the Internet.
- 2. Support for the joint work of a group of users.
- 3. Perspectives for the development of MU ICS are determined by the variety of technical solutions, the possibility of increasing computing power (i.e. the use of clusters, etc.)



SUMMARY

- Variational data assimilation system "INM RAS Baltic Sea" is designed for monitoring and forecasting the state of the Baltic Sea, modeling the processes of transporting pollutants in the sea area, solving a class of problems of minimizing risks and analyzing marine accidents.
- Using the ICS will make it possible to avoid or substantially mitigate the effects of natural and man-made disasters, to provide information support in decision-making on the protection of the environment, exploitation of marine resources and providing the optimal courses of ships.
- One of the features of this system is that it is designed for high-performance computing systems, provides users with the ability to access a web-version of the ICS, assimilates the input data of observations and transmits the output in a graphical and text form.

FUTURE PLANS

• To complete web-version of ICS.

The study was supported by the Russian Science Foundation (project №14-11-00609)

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