Institute of Automation and Control Processes of FEB RAS

THE RESEARCH OF PHYTOPLANKTON ABUNDANCE IN THE SEA OF JAPAN (THE EAST SEA) BY A MATHEMATICAL MODELING WITH USE OF THE SATELLITE DATA

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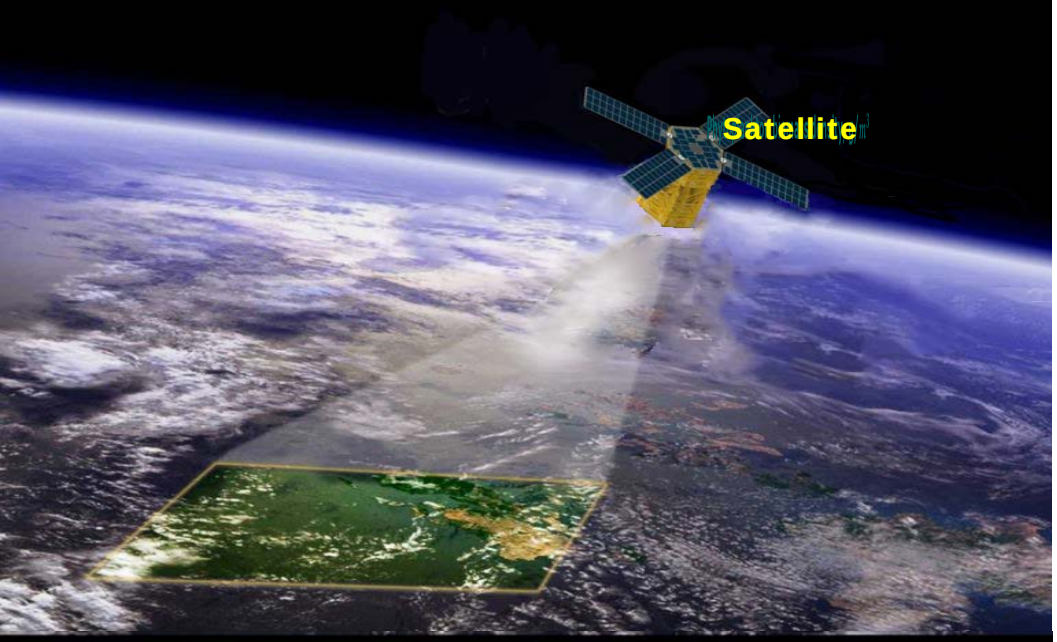
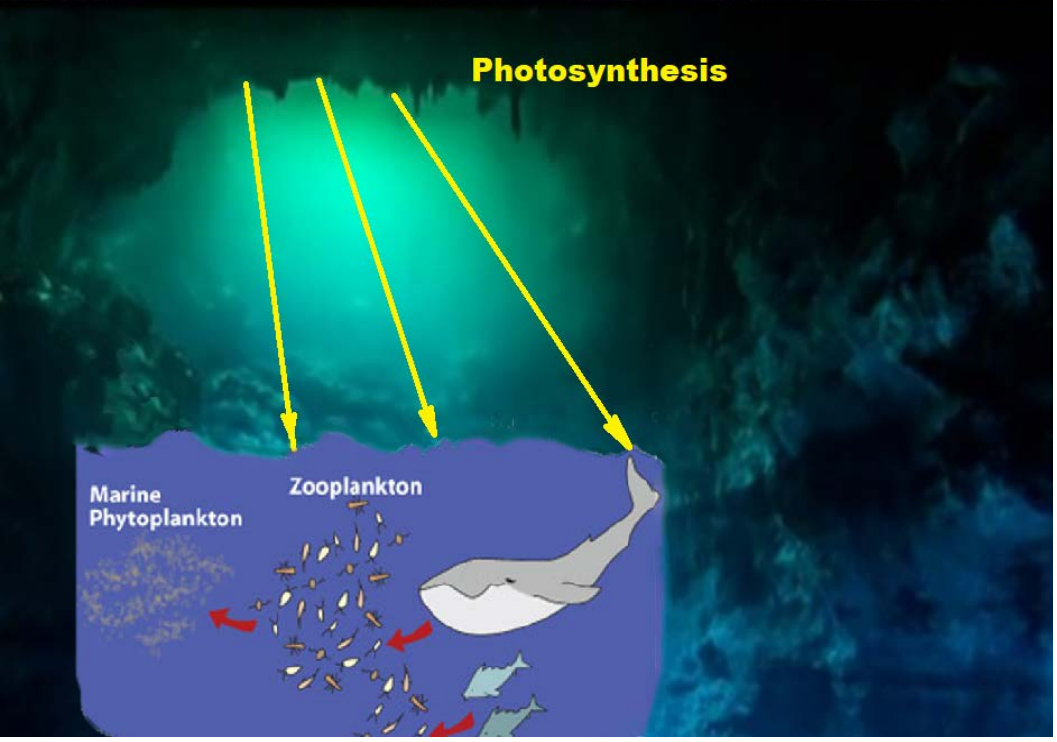


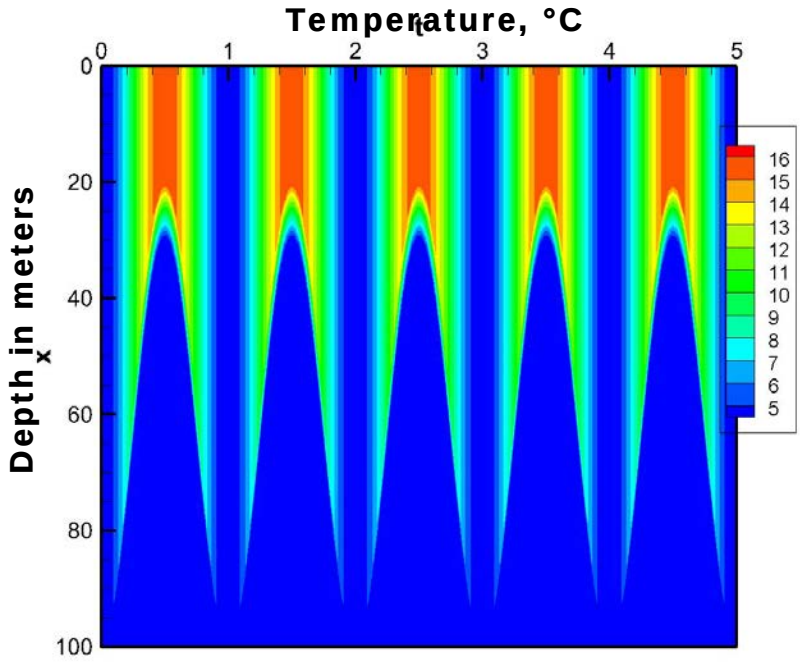


The vertical distribution of phytoplankton biomass and the yearly primary production for the Sea of Japan are gotten. The numerical solutions use the satellite sea-surface sounding data.

There are several models of phytoplankton functioning in a column of water in this presentation. Our scheme of researches consists in next steps:

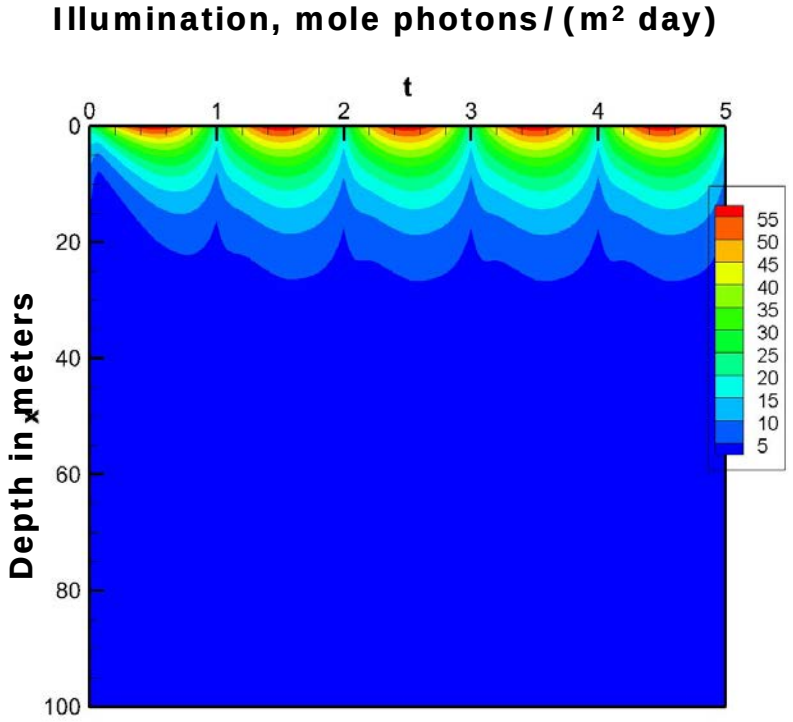
- getting of a satellite data on a sea surface;
- the model restoration of the phytoplankton abundance in the thickness of water;
- the assessment of primary productions for marine ecosystem.

This research may have the effective results for problem of eutrophication assessment in seas.



Time in years

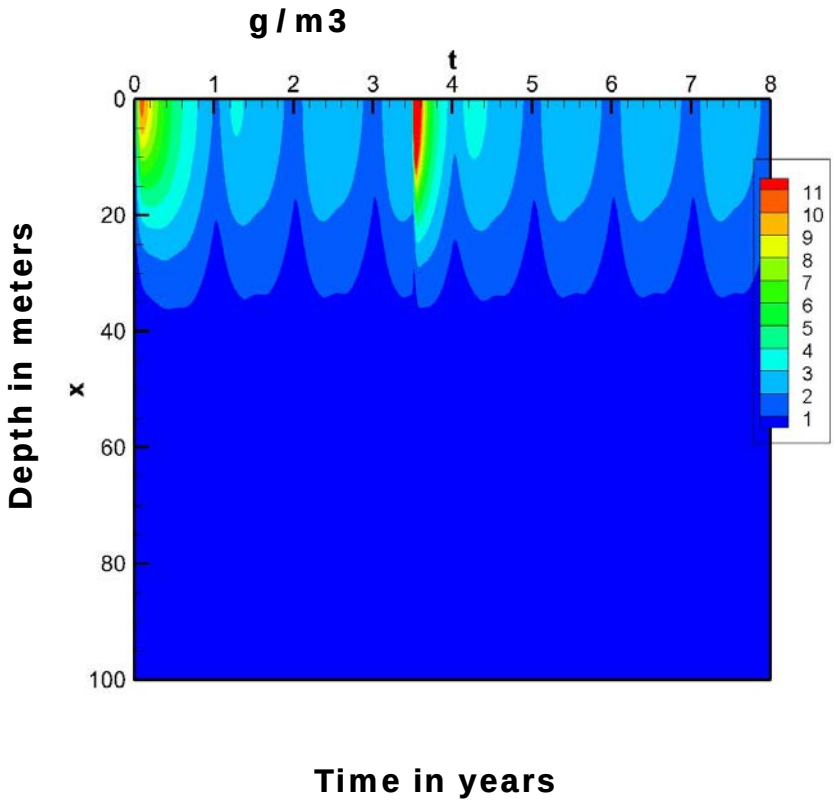
We have a model describing phytoplankton distribution in vertical column of water. The phytoplankton content in the ocean is reconstructed by means of mathematical model of “reaction-diffusion” type.

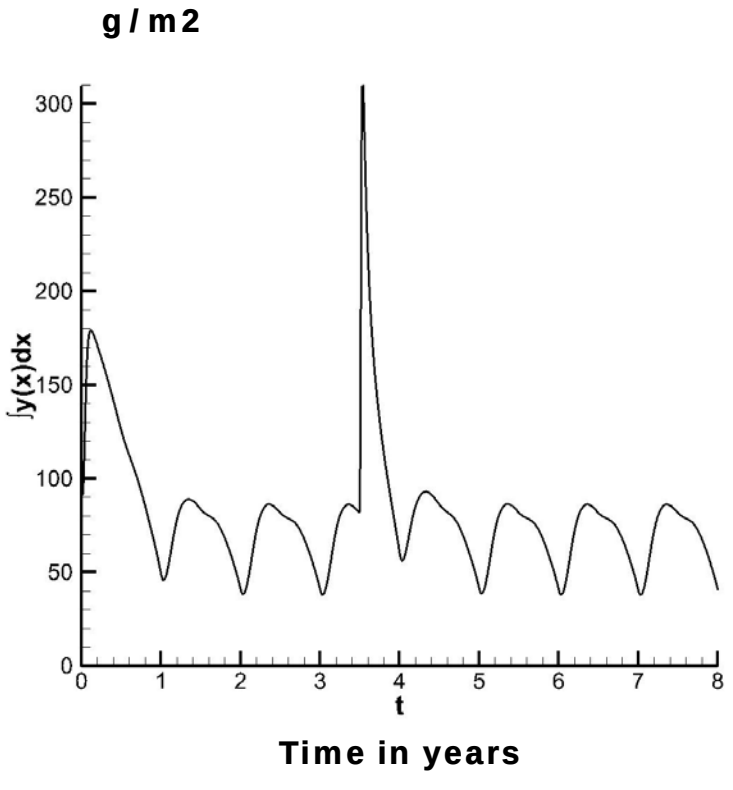


Time in years

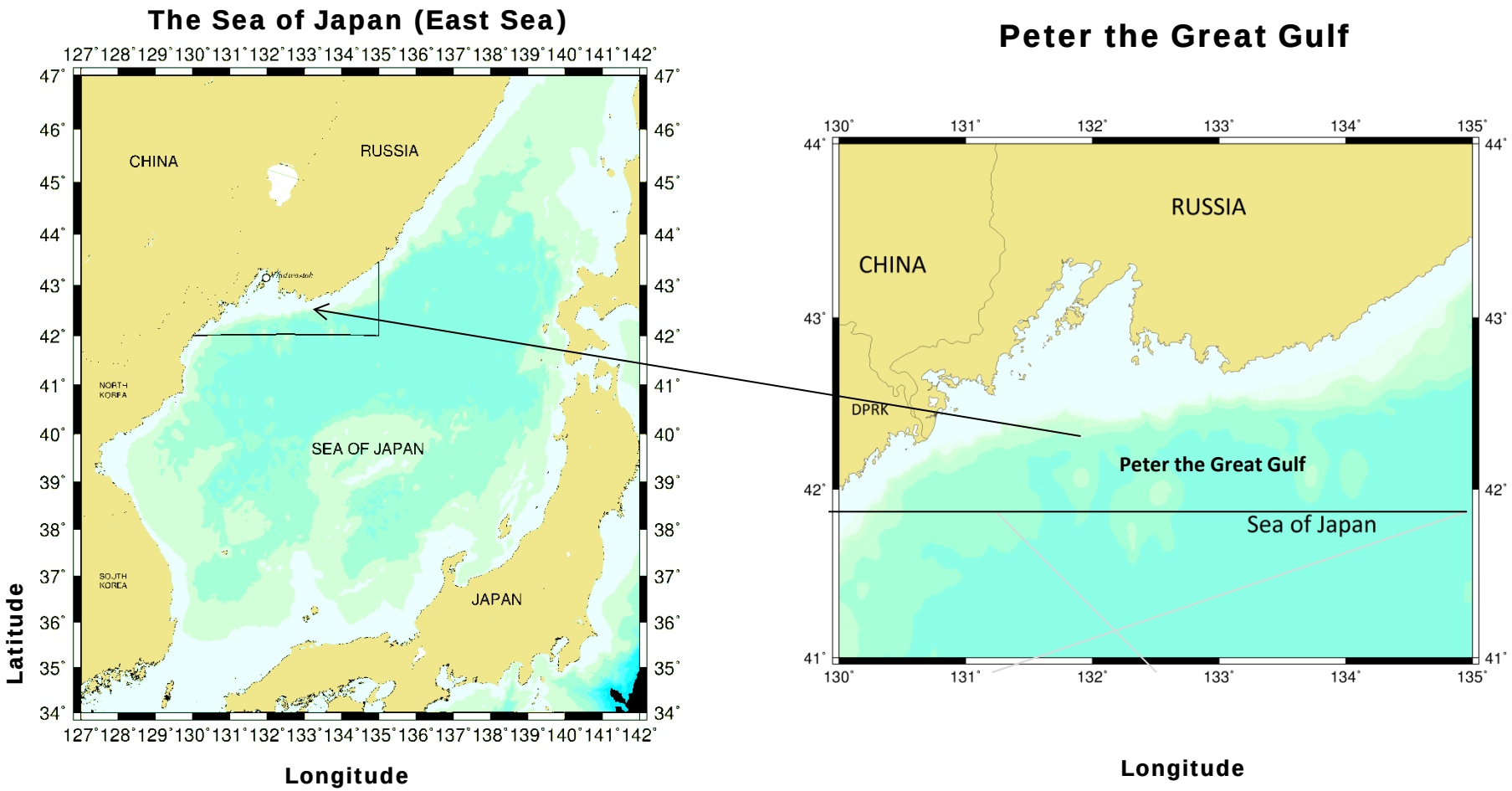
The phytoplankton distribution in a vertical column of water under the influence of illumination, of temperature and of mineral content is simulated. Concentrations of mineral substances and of the phytoplankton are changing under influence of a diffusion. The photosynthetically active radiation and temperature are modelled according to the climatic seasons of the annual cycle.

Phytoplankton abundance





For example we show experiment of introducing mineral nutrient to water surface and its influence on phytoplankton biomass. Volume of added nutrient is quarter part of its content in water. As a result phytoplankton biomass density peaks for one half of year. This influence is absent later.

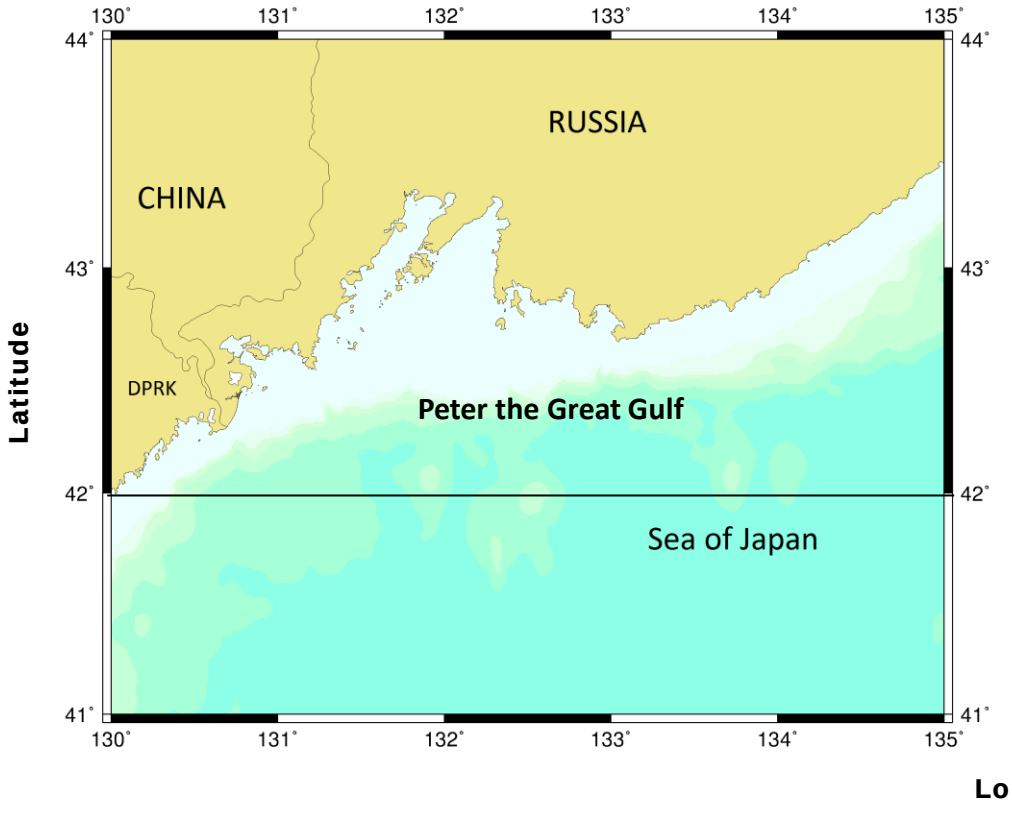


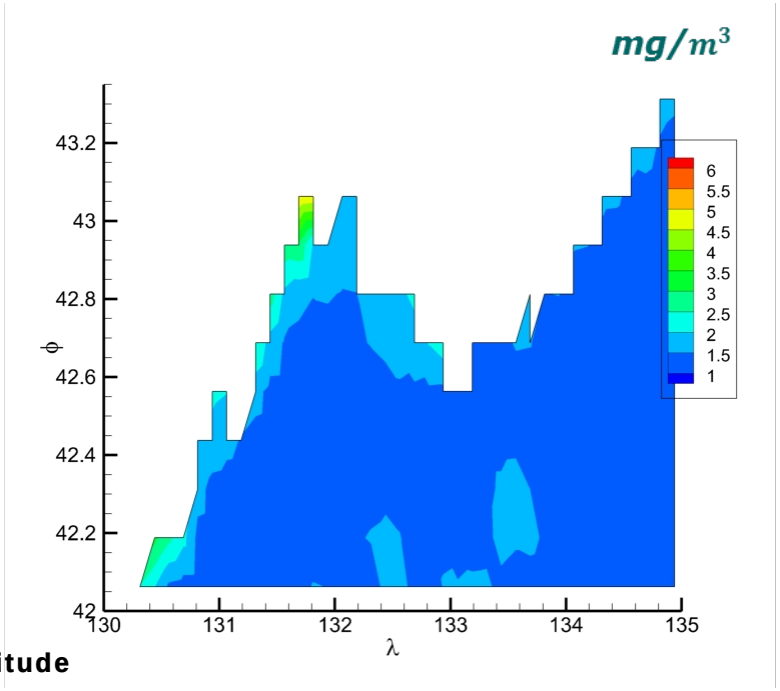
The Sea of Japan and Peter the Great Gulf are objects of modeling. Peter the Great Gulf is situated in North-Western part of Sea of Japan.

The satellite measurements are presented as numerical arrays containing chlorophyll "a" concentration, illumination and temperature for near-surface layer of water. The data are provided by the Center for Regional Satellite Monitoring of Environment, FEB RAS (Vladivostok, Russia). These data are gotten from radiometers MODIS of the satellites AQUA and TERRA. These data are processed by computer program SeaDAS of NASA (see site http://seadas.gsfc.nasa.gov/).

Peter the Great Gulf

Chlorophyll “a” distribution in Peter the Great Gulf for April. Satellite data

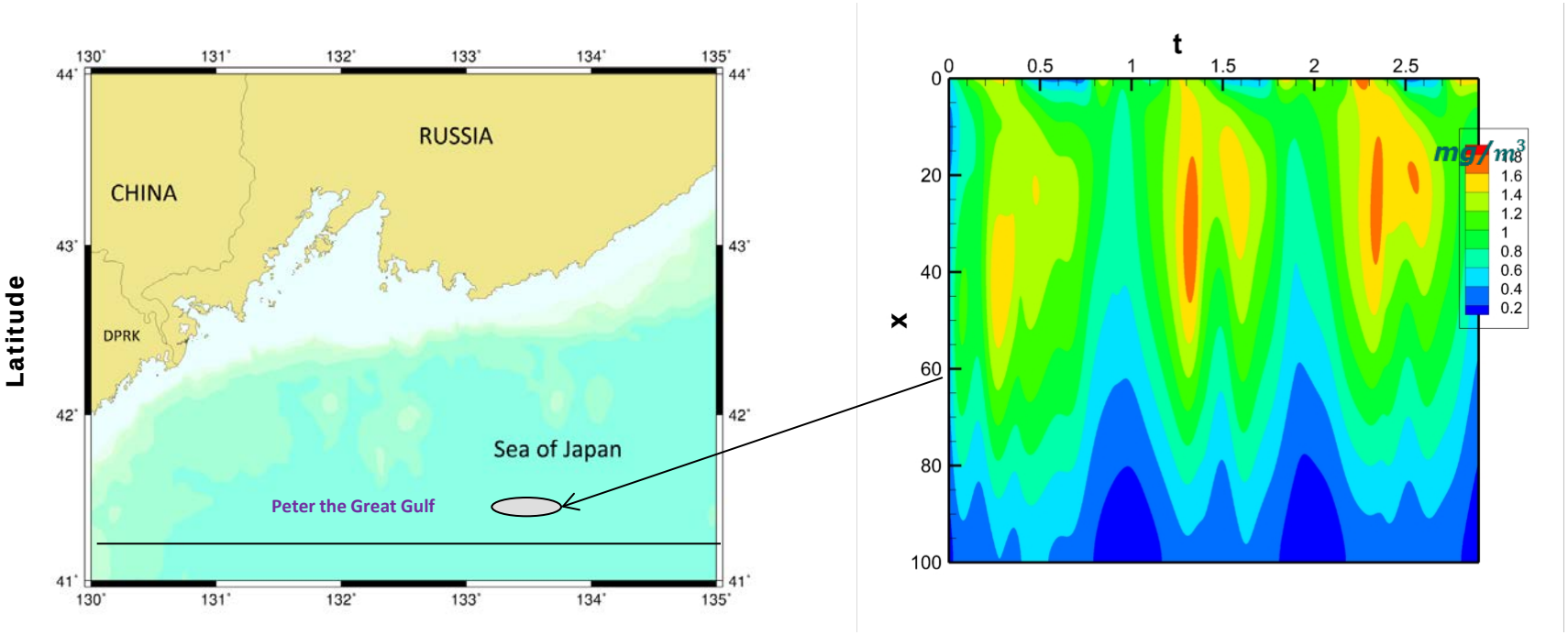




We calculate chlorophyll concentration in marine region. The chlorophyll is located in cells of phytoplankton. We assume that the chlorophyll concentration is proportional to phytoplankton density.

The chlorophyll concentration in surface layer has this form for April 2010. The high concentration is seen near the coast.

Chlorophyll distribution dynamics in vertical column of water in south part of the Gulf

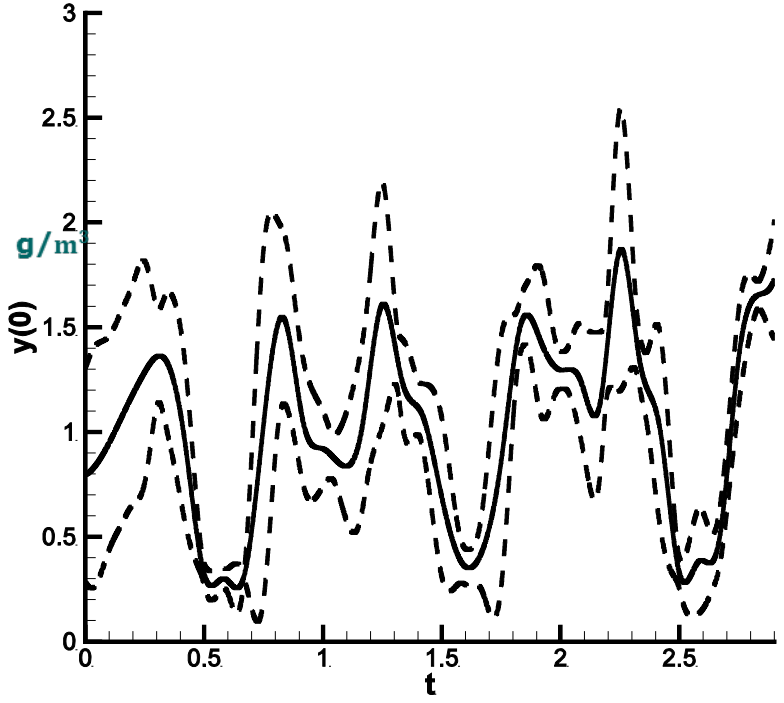


For example chlorophyll distribution dynamics in vertical column of water in south part of Gulf is shown. The concentration has high value at depths about 20 – 30 meters. The satellite can not see the chlorophyll at this depth. The local minimum for the phytoplankton concentration in summer is result of this defect of satellite data. The model can numerically estimate chlorophyll concentration in vertical column of water.

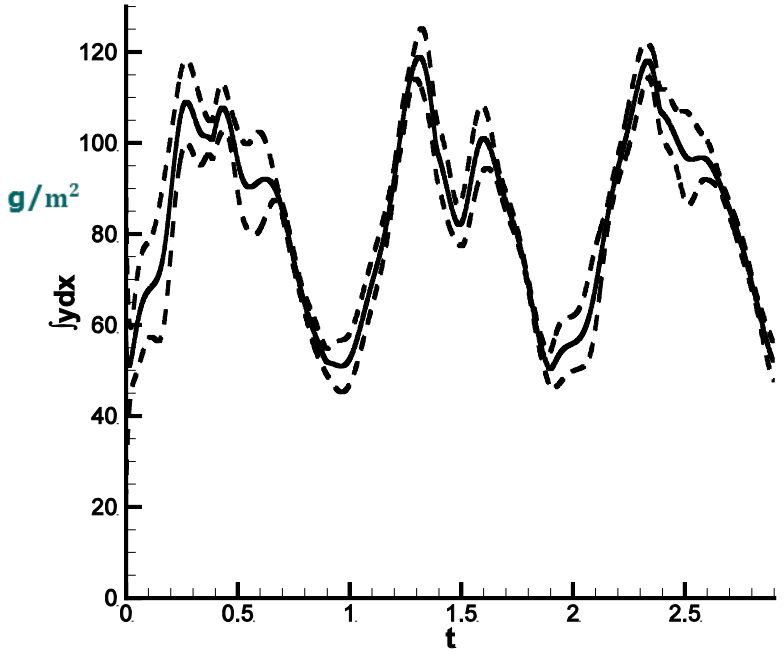
Peter the Great Gulf

Chlorophyll “a” content dynamics

Satellite data.
Concentration on surface



Modeling results.
Content under unit of area in water vertical column



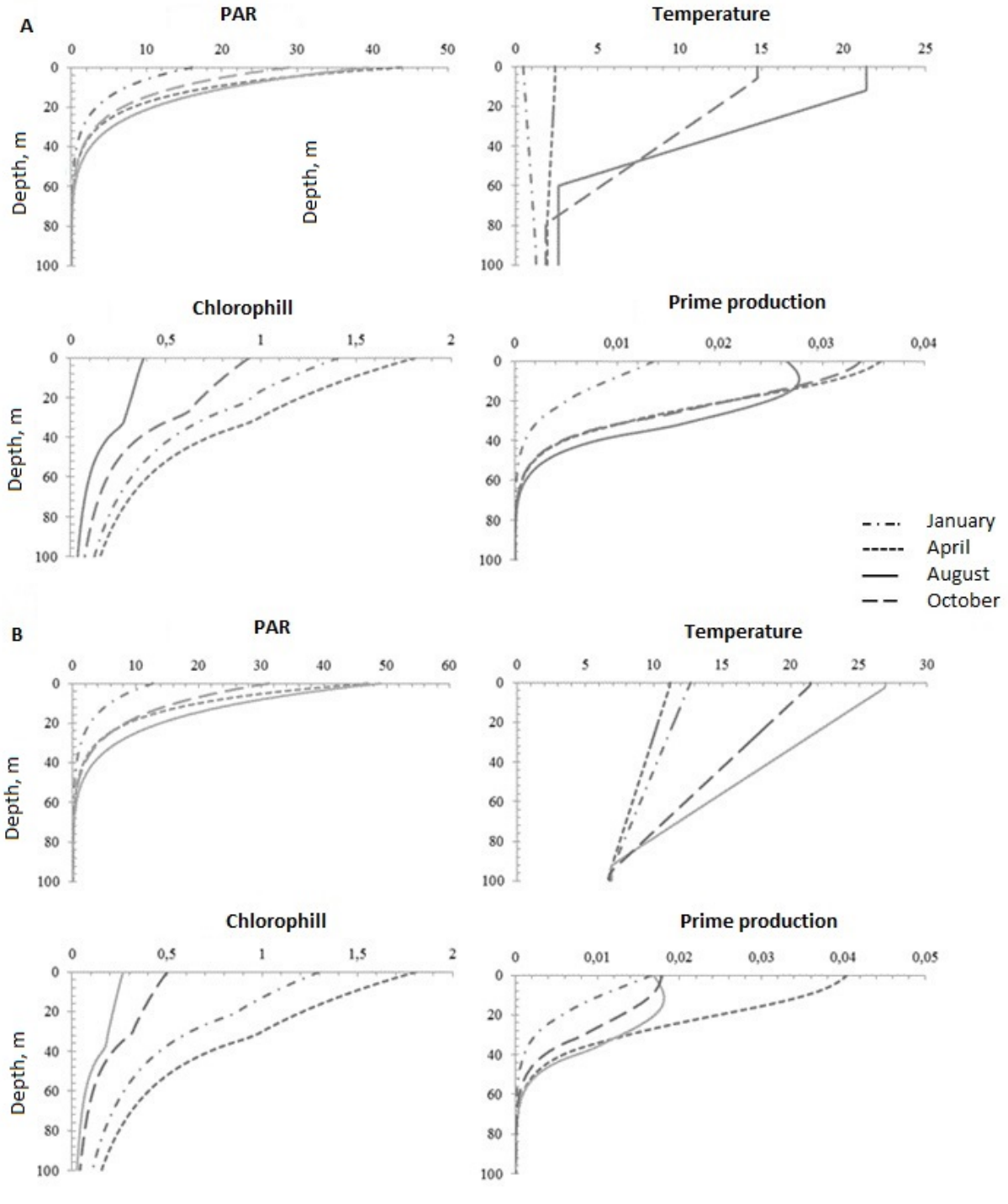
We use model for estimation of the chlorophyll concentration on a basis of surface layer satellite data for Peter the Great Gulf. The model experiments use the satellite data for years 2008 – 2012. We have the seasonal effects of phytoplankton vital activity. The blooms of phytoplankton (chlorophyll) density in spring and autumn are shown. The chlorophyll concentration on the surface layer has strong local minimum in summer for satellite data. But this local minimum is absent or very small for model data. The cause of this contradiction is the chlorophyll distribution in vertical column of water in summer.

The model is applied to interpret remote sounding data for the Sea of Japan. The vertical distribution of phytoplankton and chlorophyll is reconstructed and the dynamics of daily and annual primary production is calculated. The approximate dynamics of integral primary production for each geographic zone of the Sea of Japan from 2008 to 2012 years is calculated. The estimates of the yearly primary production for the whole Sea of Japan are also presented.

The quality of predictions may be enhanced by collecting extended data about mineral nutrients content in a region under consideration and by improving the algorithms of satellite data processing.

General direction for modeling

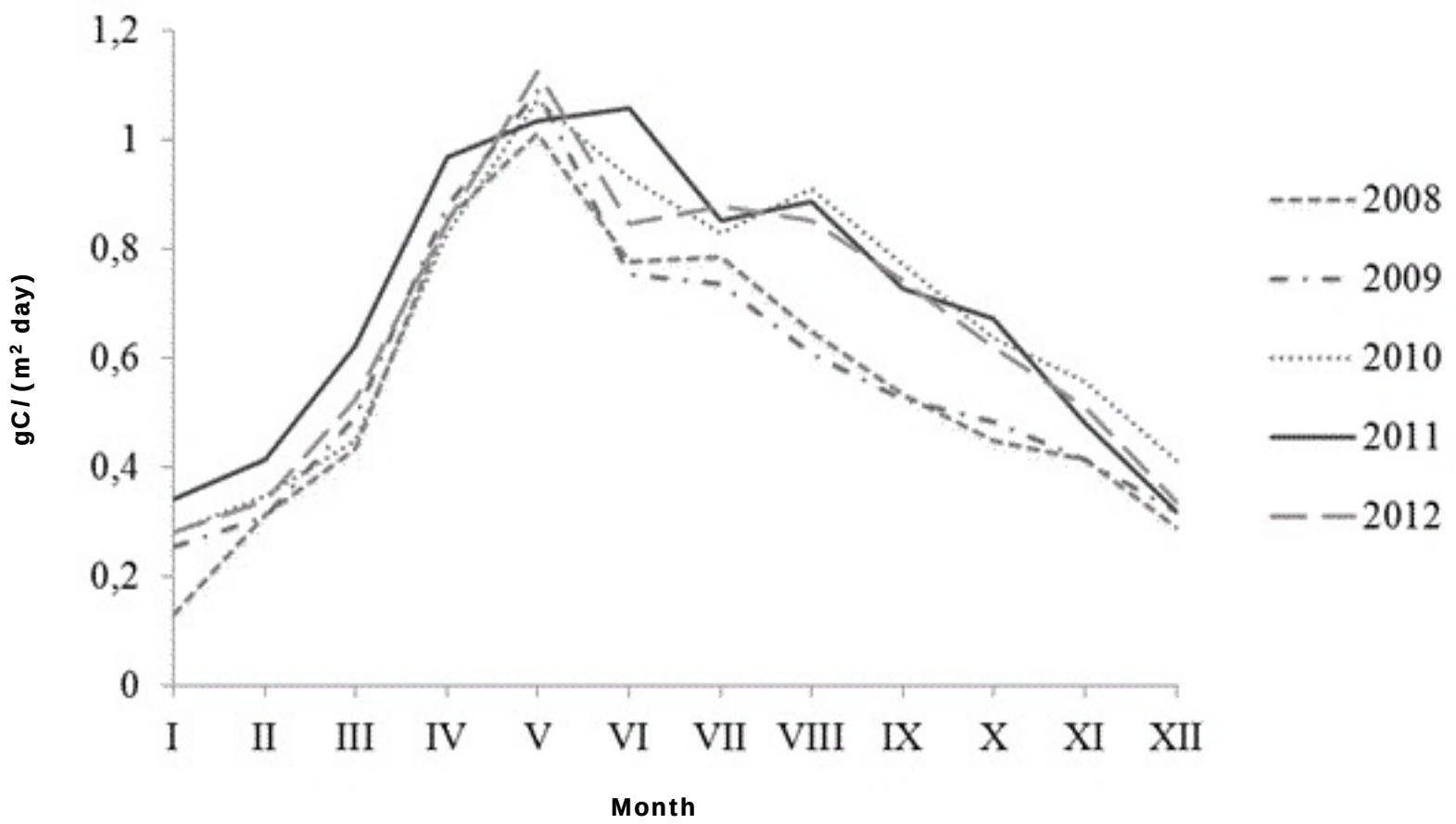
The direction: from north-east to south-west



The distributions of basic characteristics along depth (modeling)

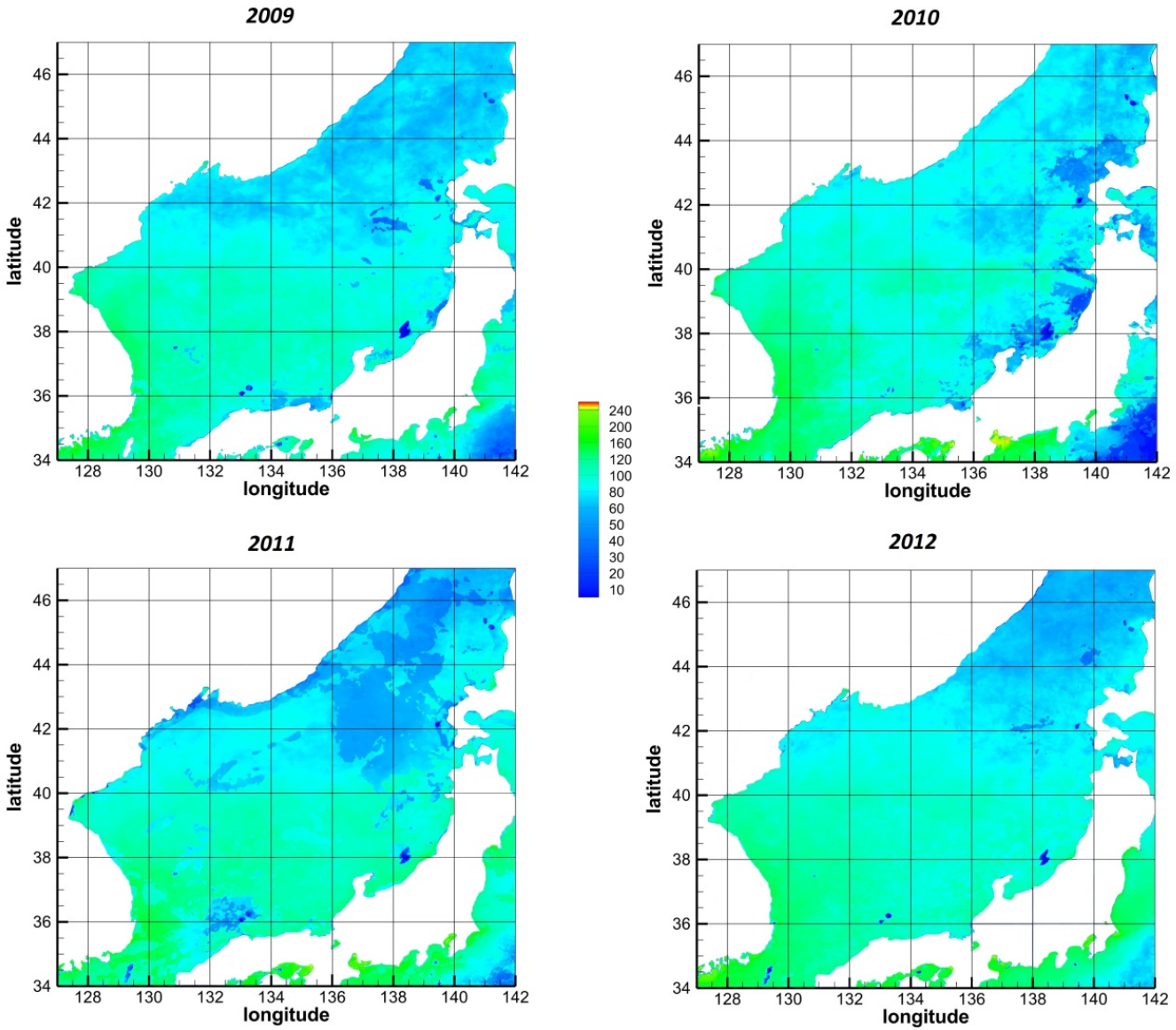
The chlorophyll concentration on the surface layer has strong local minimum in summer for satellite data. But this local minimum is absent or very small for model results. The cause of this contradiction is the chlorophyll distribution in vertical column of water in summer.

Daily production of Sea of Japan



We have the seasonal effects of phytoplankton vital activity. The blooms of phytoplankton density in spring and autumn are shown. Model calculations demonstrate that the growth of primary production is mainly determined by a spring maximum. Autumn maximum is substantially lower.

Biological productivity (gC/(m² year))



Acknowledgement

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Authors express their gratitude to the Multiple Access Center for Satellite Monitoring of the Environment of the Far Eastern Branch of the Russian Academy of Sciences (Vladivostok, Russia).

We made this research and had an end. We can will go farther if this work will have interest from other organizations. This method in part will have effective results in problem of eutrophication for seas.


Thank you for your attention!