The St.-Petersburg Department of P.P.Shirshov Institute of Oceanology

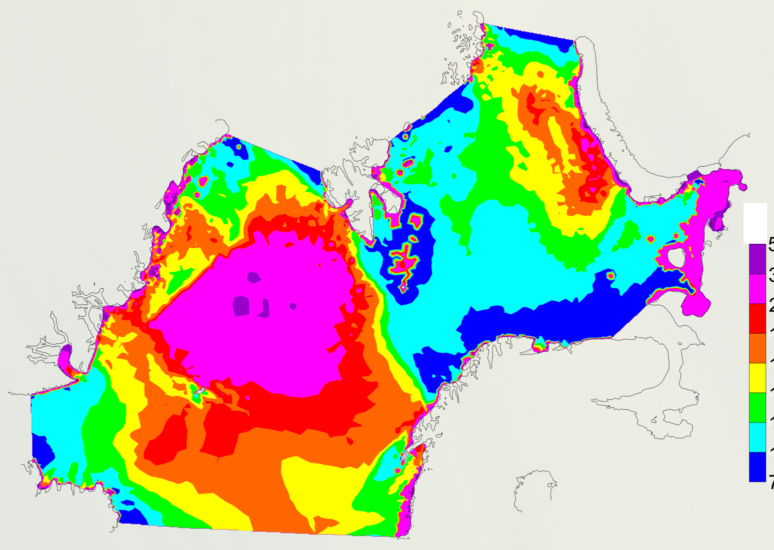
Laboratory of numerical experiments in ocean dynamics

Ocean Modelling of Regional Processes

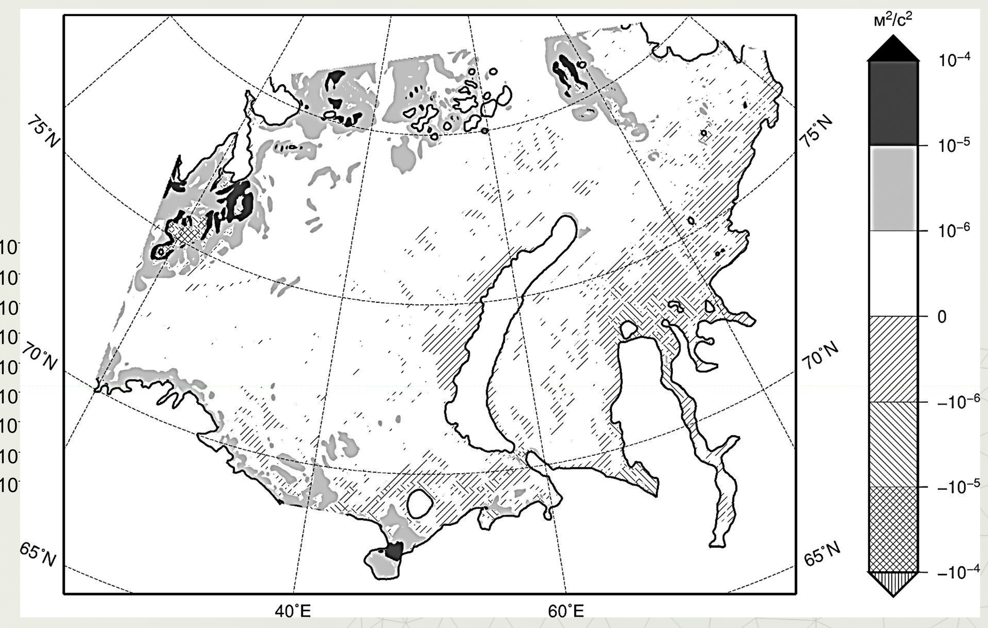
The impact of the spatial variability in bottom roughness on tidal dynamics and energetics

3-D finite-element hydrostatic model QUODDY-4 is modified by including a module for the drag coefficient determined on the basis of new resistance laws for the bottom boundary layer. Changes of tidal characteristics due to the spatial inhomogeneity of the drag coefficient are significant, and moreover for average (over tidal cycle) bed shear stress these changes are the same order or slightly less than the absolute values of the bottom stress. This finding implies that the concept of a "constant drag coefficient" should be revised (*Kagan et al., 2012; Kagan and Timofeev, 2015a*)

Coefficient of bottom friction in the North European Basin

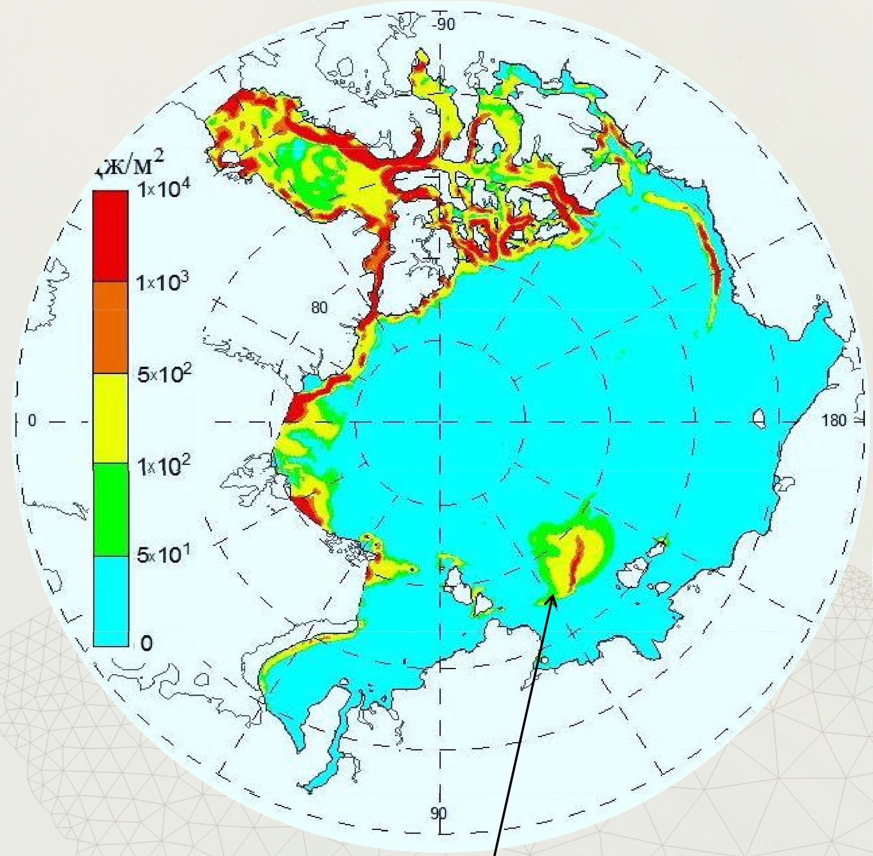


The difference between the absolute values of the average bed shear stress with constant drag coefficient and ones with variable drag coefficient in the Barents and Kara seas

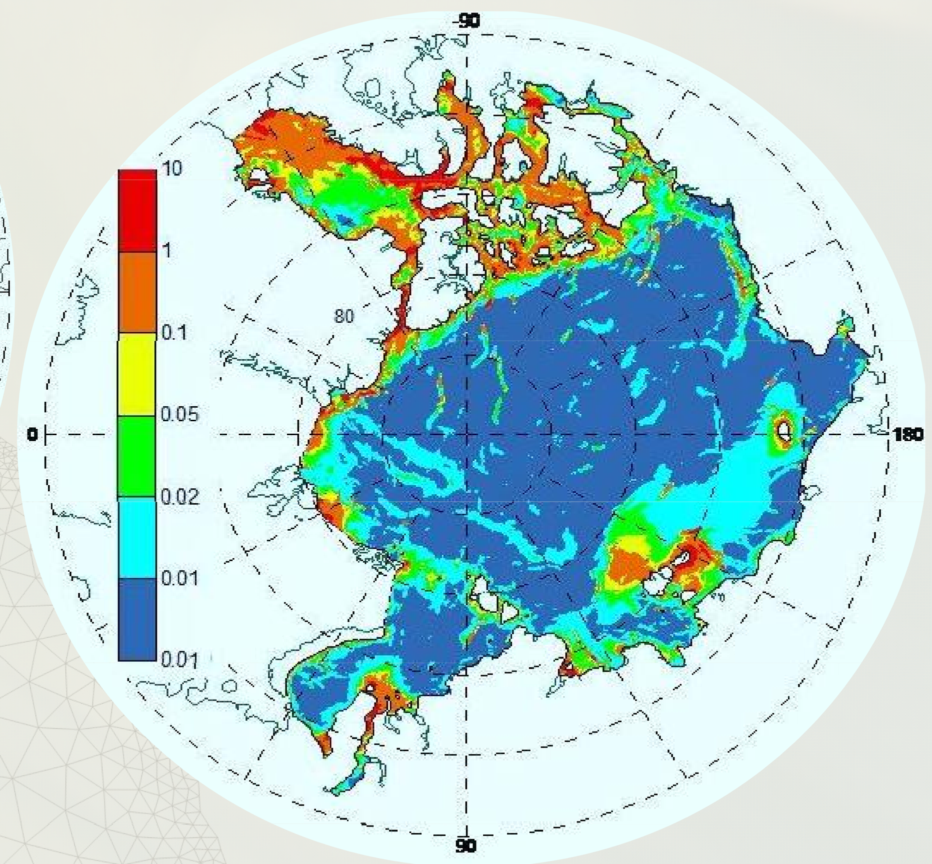


Internal tide and diapycnic mixing induced by internal tidal waves in the Arctic Ocean: Model estimates

Density of baroclinic tidal energy in the Arctic Ocean



Averaged (in vertical) coefficient of diapycnic mixing (cm^2s^{-1}) in the summer



Hotspot of internal tide generation on the continental slope to the northwest of the New Siberian Islands

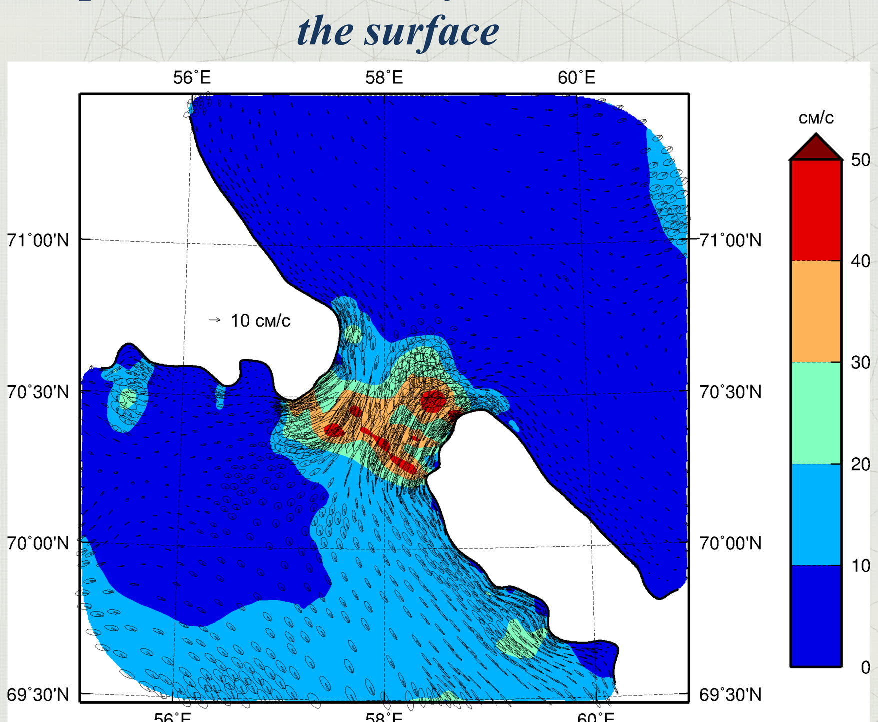
Averaged over the area the coefficient of diapycnic mixing is only several times less than the canonical value of the vertical turbulent viscosity coefficient in the deep layer of the Ocean

(*Kagan et al., 2010; 2011*)

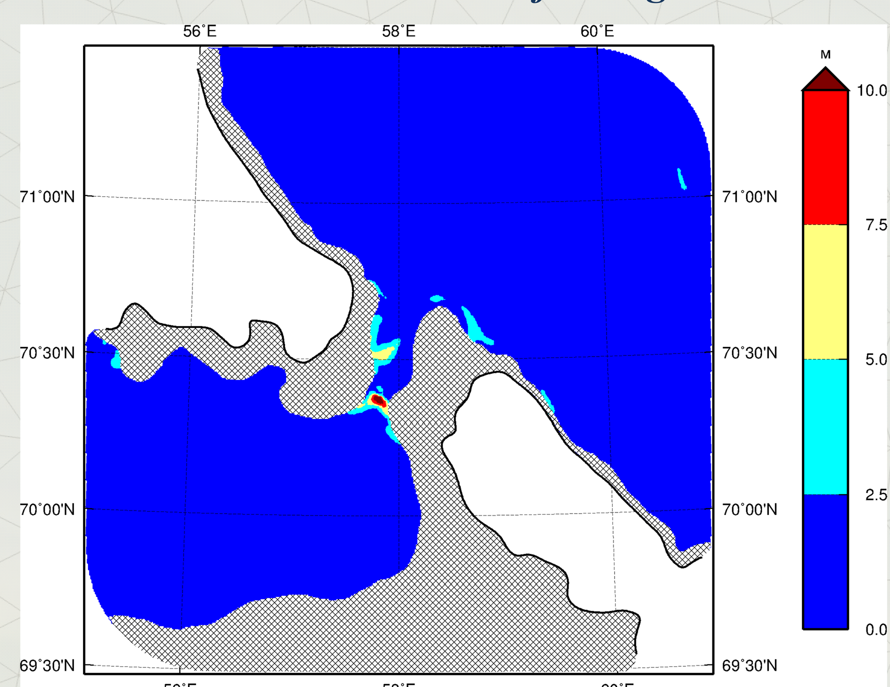
Modeling of the stationary circulation and semidiurnal surface and internal tides in the Strait of Kara Gates

The finite element mesh of the Strait has horizontal resolution from 0.5 to 2 km. The 3-D QUODDY-4 model if forced by either stationary difference of the free surface level at the open boundaries of the study domain, or by tidal elevations at the same boundaries, or by means of both concurrently. It is shown that the maximum internal tidal waves' amplitudes are detected where internal tidal waves propagate against the stationary flow (*Kagan and Timofeev, 2015b*)

Ellipses and velocities of tidal currents on the surface



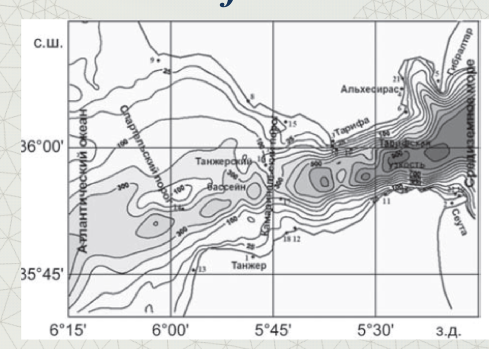
The amplitudes of internal tidal waves on the pycnocline's depth in the Strait of Kara Gate at the combined forcing



Nonhydrostatic dynamics in straits of the World Ocean

A numerical models of strait dynamics are developed to assess the significance of the non-hydrostatic effects and classification of the Straits from the perspective of a rational approach for modeling non-hydrostatic dynamics, facilitating the choice between increasing the accuracy of the model and reducing the computation costs

Bathymetry in Strait of Gibraltar

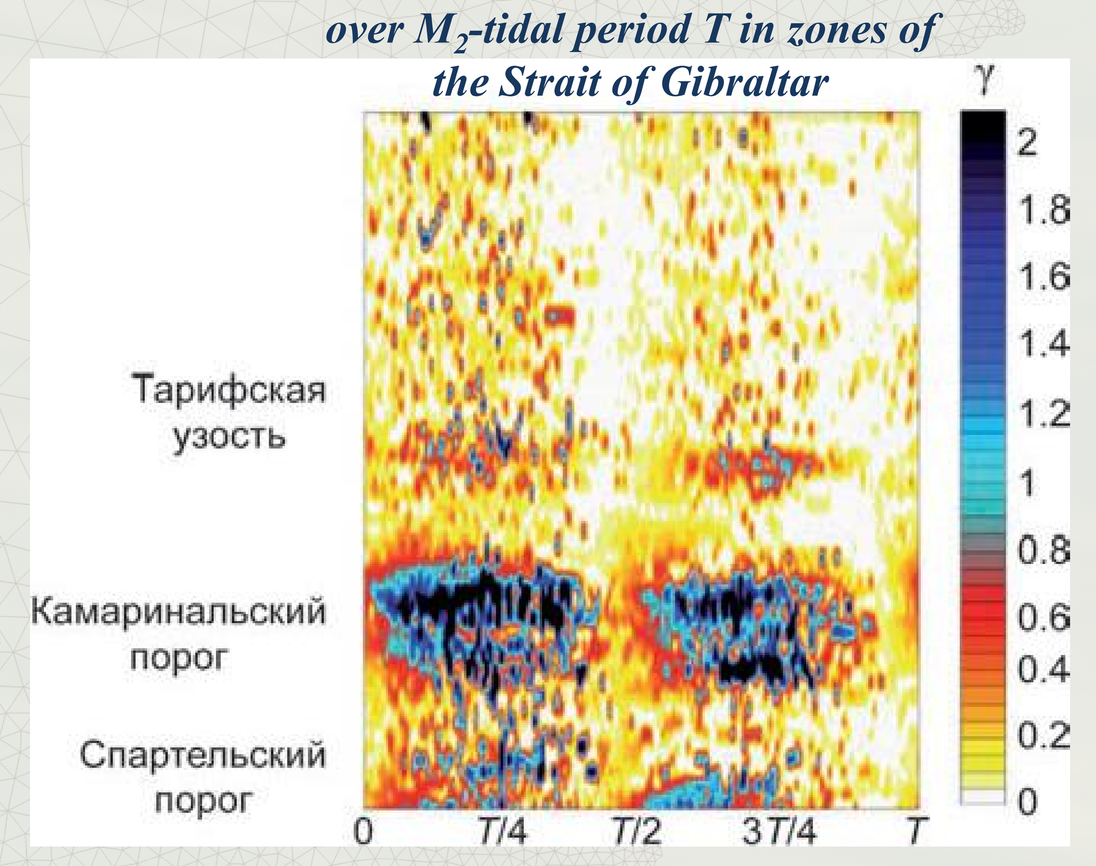


Criteria of significance of non-hydrostatics

$$\gamma = \frac{U^2 tg^2\alpha}{N^2 h_*^2}$$

U	Local velocity
N	Buoyancy frequency
$tg\alpha = H / L$	Bottom slope
h_0, h	Depth above top and sole of a mountain
$h_0 \le h_* \le h$	

Significance of non-hydrostatic effects ($\gamma \sim O(1)$) over M_2-tidal period T in zones of the Strait of Gibraltar



The method was applied to simulate the non-hydrostatic barotropic-baroclinic interaction over seamount in the straits of Messina, Gibraltar and Bab-el-Mandeb (Voltzinger and Androsov, 2013; 2016)

The Laboratory was founded in 1973

Heads of the Laboratory:

- 1973 - 2013 – professor B.A. Kagan
- since 2013 – D.A. Romanenkov

The most important scientific results :

- Developing ocean block of the coupled atmosphere-ocean circulation model (IO RAS model). One of first in the world numerical experiments on seasonal variability of the global circulation in the barotropic and two-layer Ocean.
- Formulation of the resistance law for the oscillatory turbulent bottom boundary layer and its modification based on the concept of the weak interaction between wind waves and low-frequency movements.
- Study of spectral problem for the World Ocean and evolution of the free oscillation spectrum of the Ocean in different periods of the Earth's geological history.
- A stochastic model of the Earth-Moon tidal evolution taking into account fluctuating effects of the continental drift.
- General approach to the modeling of surface and internal tides and assessment of the contribution of tidal dynamics in regional climate of sea basins.
- Technology for prediction of tidal ice drift and tidal compression/rarefaction of ice fields in the Arctic Ocean seas.
- Justification of the method of modelling of catastrophic events in the sea coastal zone with landslide processes