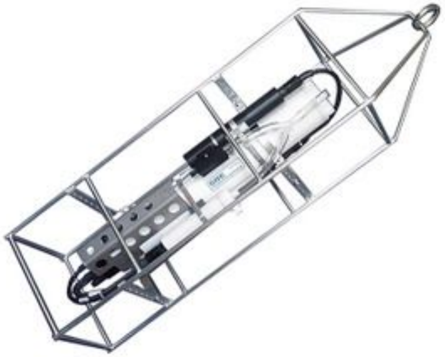
ИНФОРМАЦИОННЫЕ ТЕХНОЛОГИИ В ОКЕАНОЛОГИИ

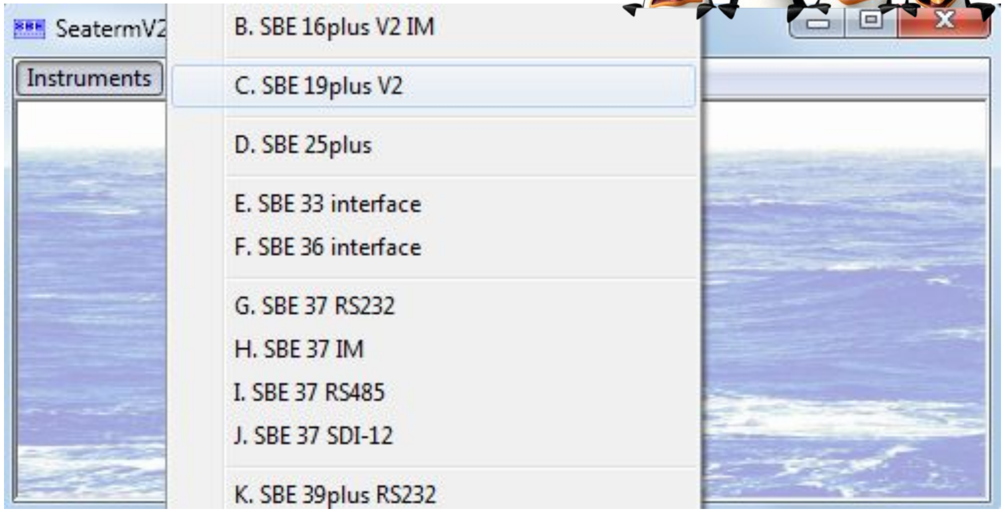
Максимовская Татьяна
ММБИ КНЦ РАН

- Натурные данные
- Дистанционное зондирование
- Модельные данные

Первичная обработка



Seaterm



SeatermV2

Instruments

B. SBE 16plus V2 IM

C. SBE 19plus V2

D. SBE 25plus

E. SBE 33 interface

F. SBE 36 interface

G. SBE 37 RS232

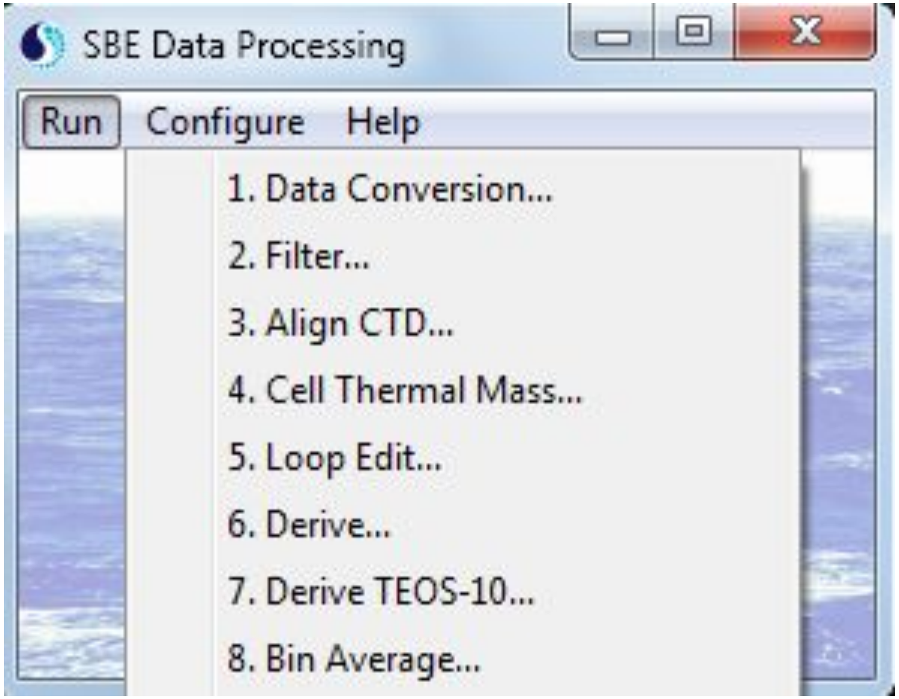
H. SBE 37 IM

I. SBE 37 RS485

J. SBE 37 SDI-12

K. SBE 39plus RS232

SBEDataProcessing



SBE Data Processing

Run Configure Help

1. Data Conversion...
2. Filter...
3. Align CTD...
4. Cell Thermal Mass...
5. Loop Edit...
6. Derive...
7. Derive TEOS-10...
8. Bin Average...

Golden Software

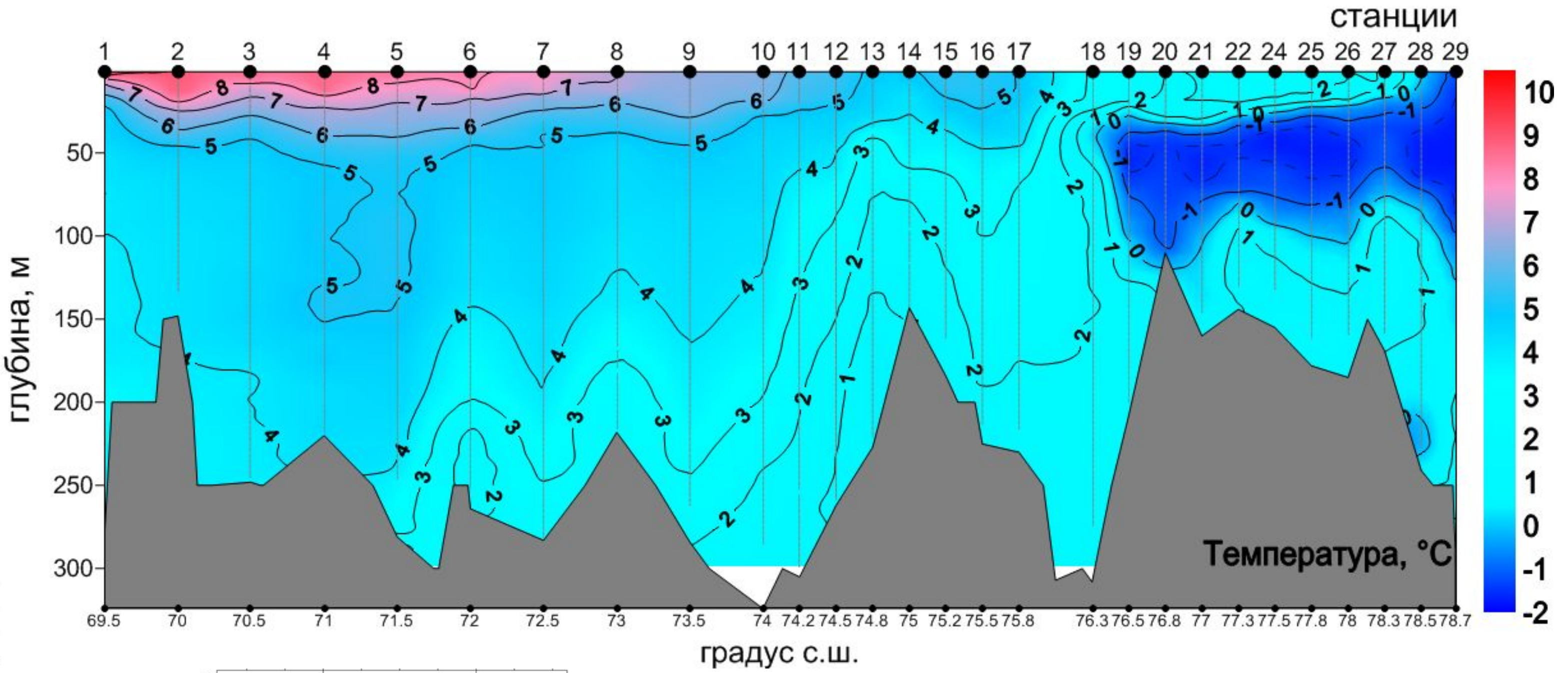
Surfer

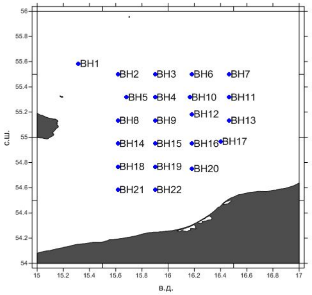
Grapher

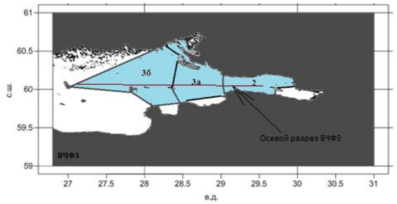
Voxler

MapViewer

Surfer


станции
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 24 25 26 27 28 29
глубина, м
50
100
150
200
250
300
69.5 70 70.5 71 71.5 72 72.5 73 73.5 74 74.2 74.5 74.8 75 75.2 75.5 75.8 76.3 76.5 76.8 77 77.3 77.5 77.8 78 78.3 78.5 78.7
градус с.ш.
Температура, °С
10 9 8 7 6 5 4 3 2 1 0 -1 -2


BH1
BH2 BH3 BH6 BH7
BH5 BH4 BH10 BH11
BH12
BH8 BH9 BH13
BH14 BH15 BH16 BH17
BH18 BH19 BH20
BH21 BH22
с.ш.
56 55.8 55.6 55.4 55.2 55 54.8 54.6 54.4 54.2 54
15 15.2 15.4 15.6 15.8 16 16.2 16.4 16.6 16.8 17
в.д.


3б
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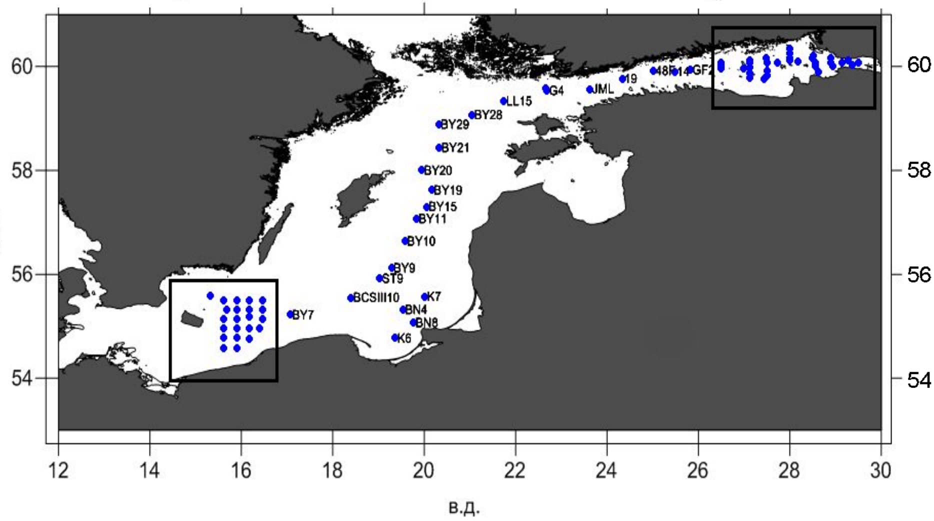
Осевой разрез ВЧФЗ
ВЧФЗ
с.ш.
61 60.5 60 59.5 59
27 27.5 28 28.5 29 29.5 30 30.5 31
в.д.


LL15
G4
JML
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48F
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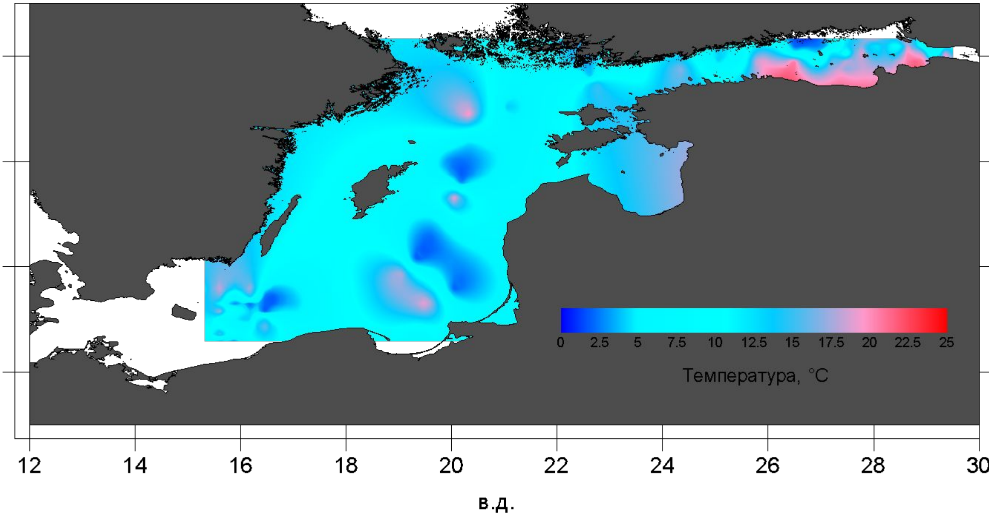
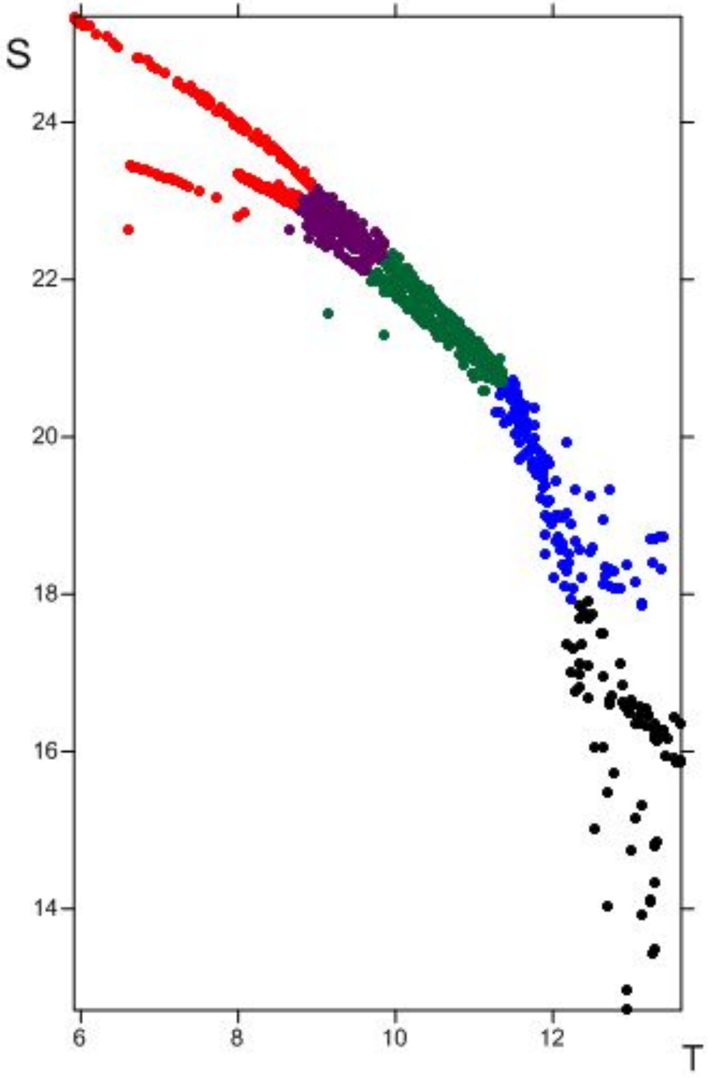
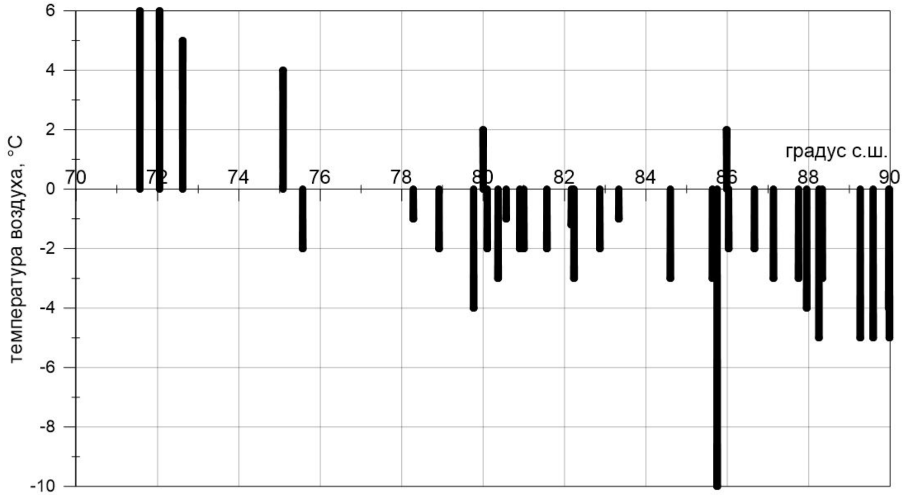
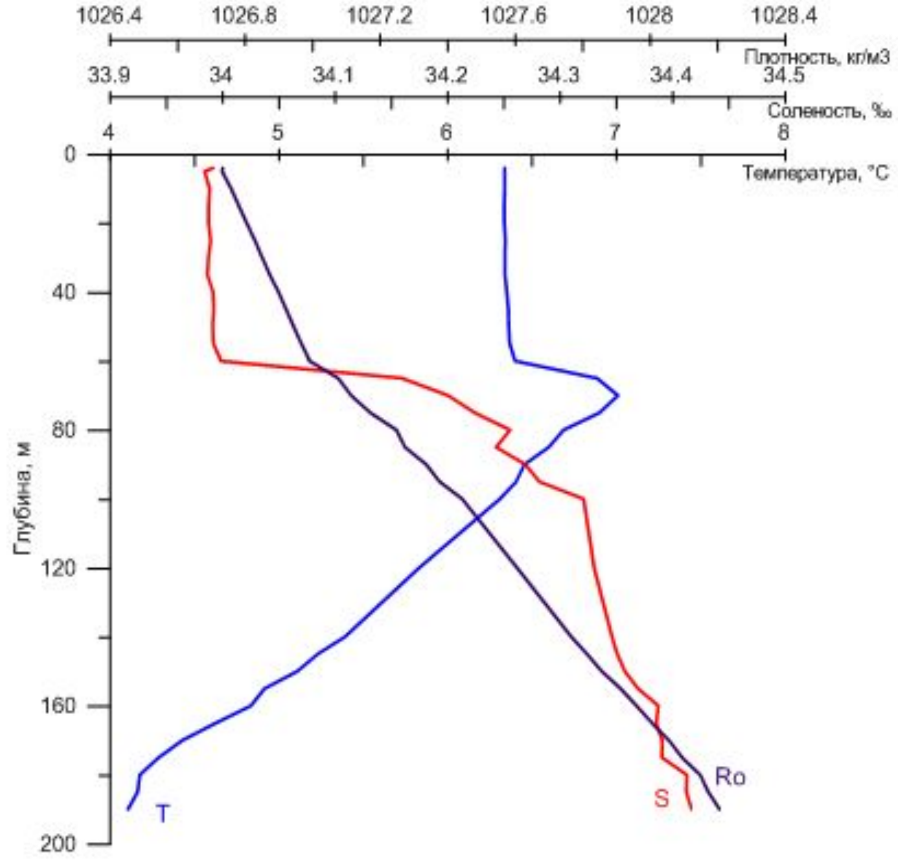
GF2
BY28
BY29
BY21
BY20
BY19
BY15
BY11
BY10
BY9
ST9
BCSIII10
K7
BN4
BN8
K6
BY7
60 58 56 54
12 14 16 18 20 22 24 26 28 30
в.д.


60 58 56 54
0 2.5 5 7.5 10 12.5 15 17.5 20 22.5 25
Температура, °С
12 14 16 18 20 22 24 26 28 30
в.д.

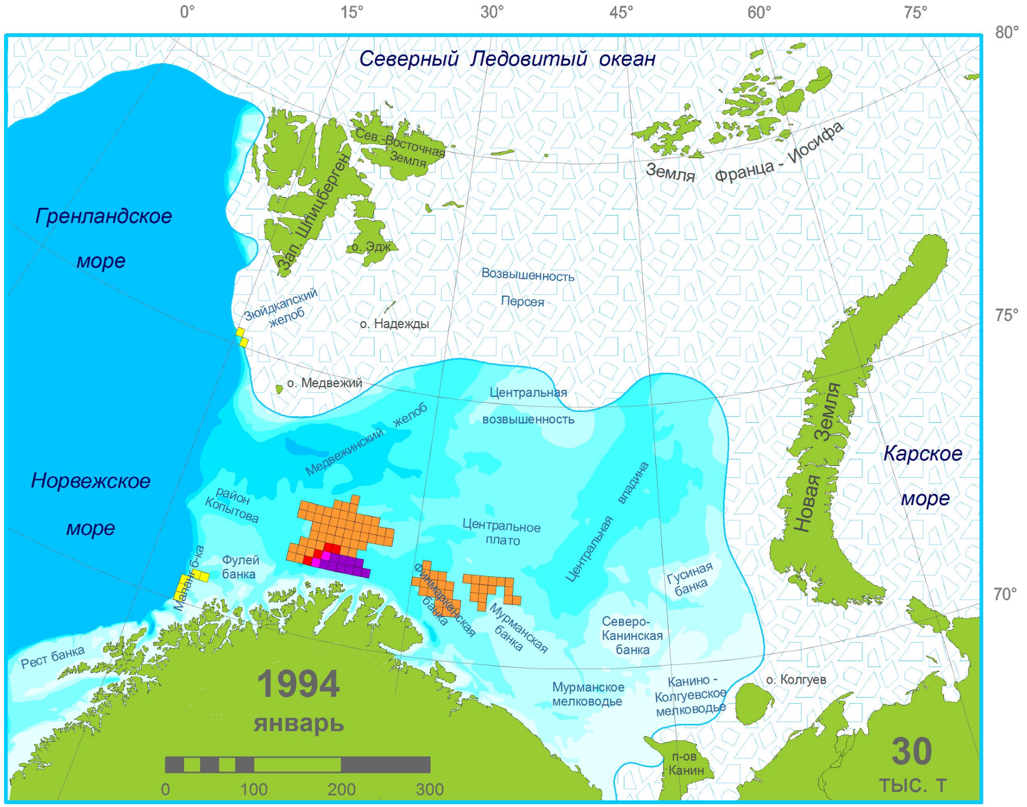
Grapher


S
24
22
20
18
16
14
6
8
10
12
T


температура воздуха, °С
6
4
2
0
-2
-4
-6
-8
-10
градус с.ш.
70
72
74
76
78
80
82
84
86
88
90


1026.4
1026.8
1027.2
1027.6
1028
1028.4
Плотность, кг/м3
33.9
34
34.1
34.2
34.3
34.4
34.5
Соленость, ‰
4
5
6
7
8
Температура, °С
Глубина, м
0
40
80
120
160
200
T
S
Ro

MapViewer


0°
15°
30°
45°
60°
75°
80°
75°
70°
Северный Ледовитый океан
Гренландское море
Норвежское море
Карское море
Сев.-Восточная Земля
Зап. Шпицберген
о. Эдж
Земля Франца - Иосифа
Зюйдкапский желоб
о. Надежды
Возвышенность Персея
о. Медвежий
Центральная возвышенность
Медвежинский желоб
район Копытова
Фулей банка
Малан б-ка
Центральное плато
Центральная впадина
Новая Земля
Гусиная банка
Финмаркенская банка
Мурманская банка
Северо-Канинская банка
Рест банка
Мурманское мелководье
Канино - Колгуевское мелководье
о. Колгуев
п-ов Канин
1994
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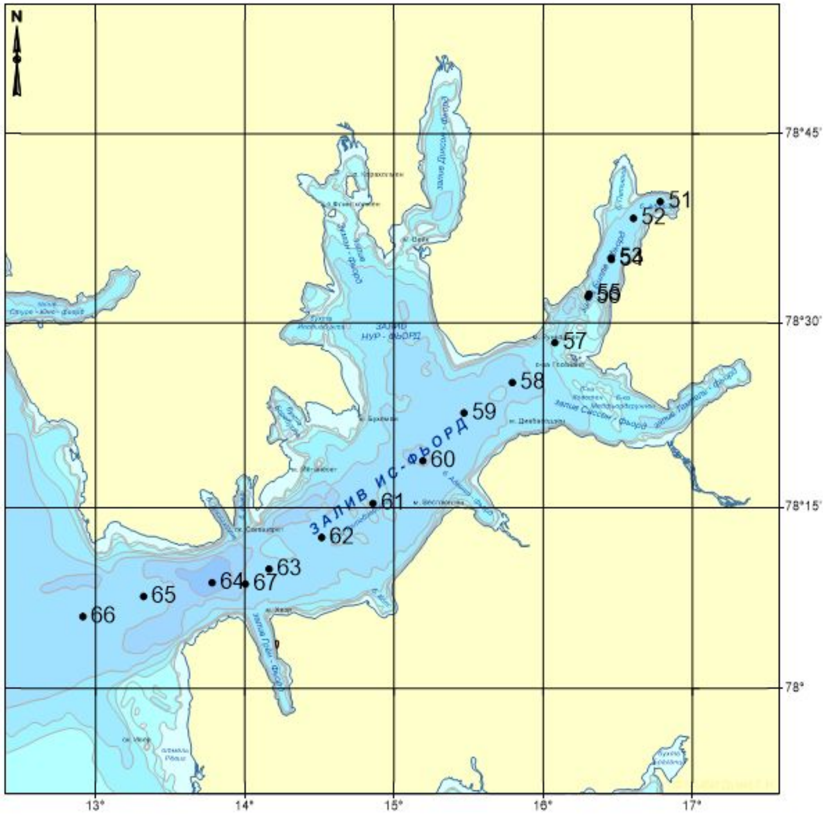
100
200
300
30
тыс. т


N
51
52
53
54
55
56
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58
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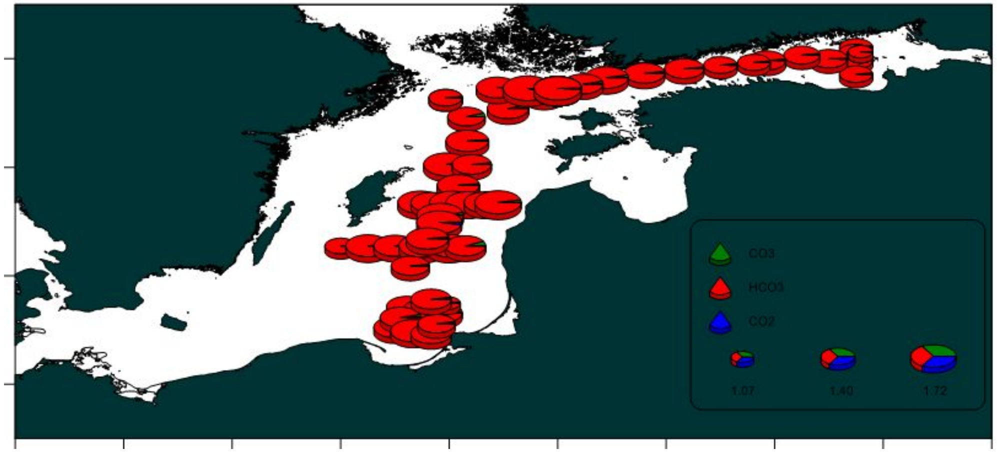
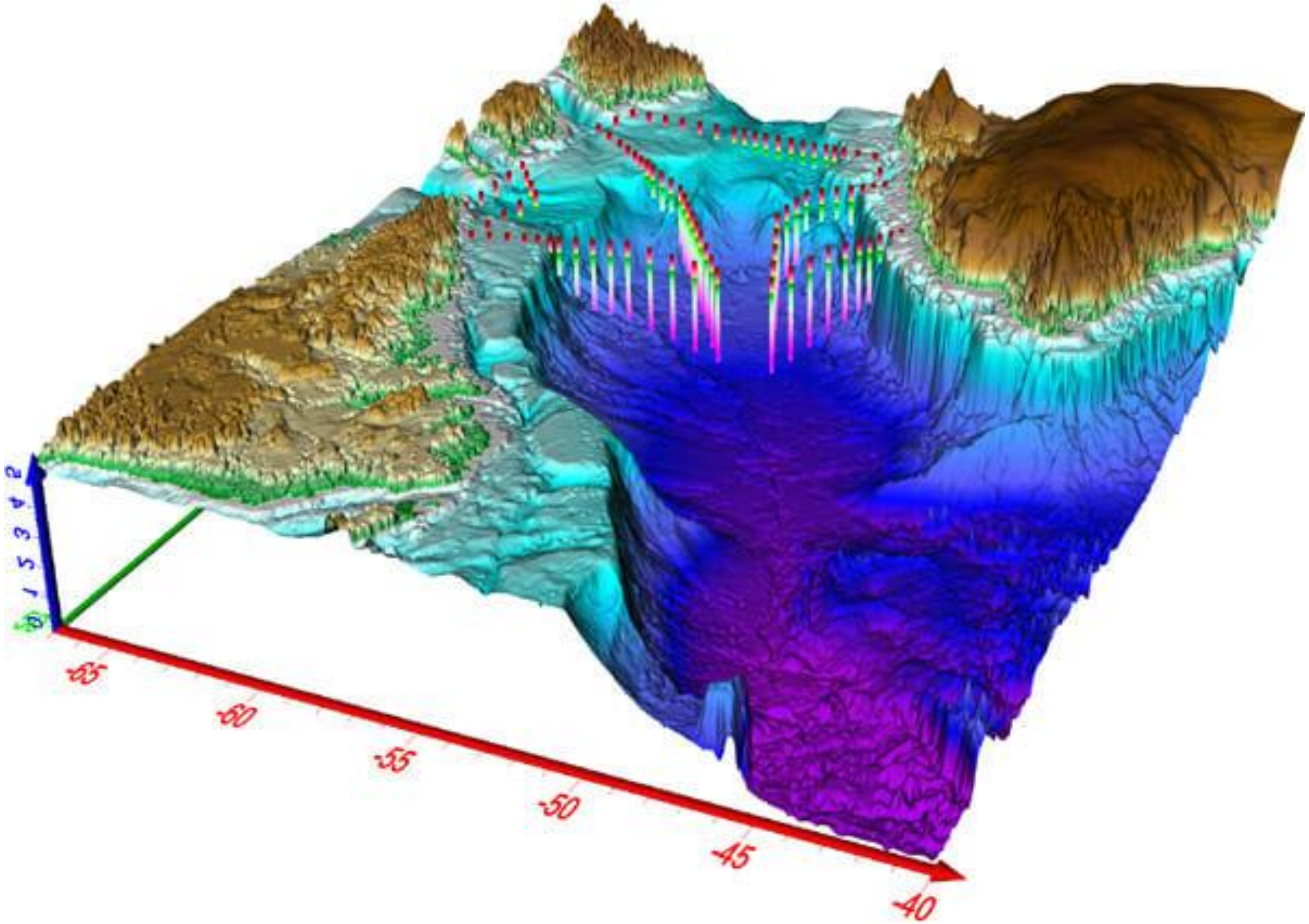
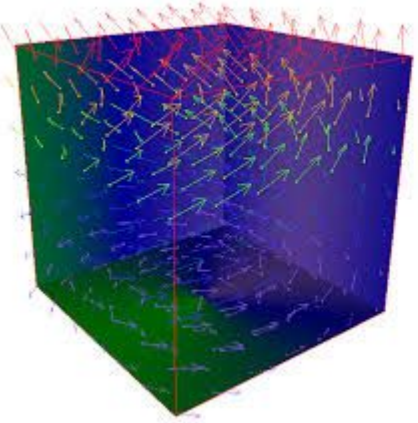
60
61
62
63
64
65
66
67
ЗАЛИВ ИС-ФЬОРД
ЗАЛИВ НУР-ФЬОРД
залив Сассен-фьорд
78°45'
78°30'
78°15'
78°
13°
14°
15°
16°
17°

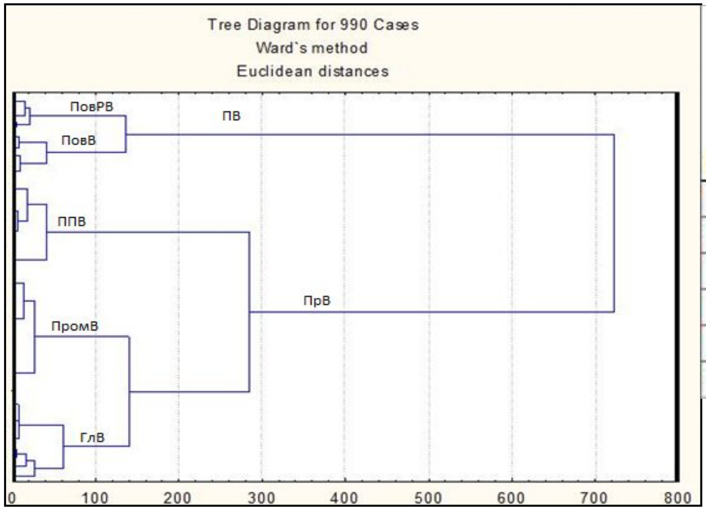

CO3
HCO3
CO2
1.07
1.40
1.72

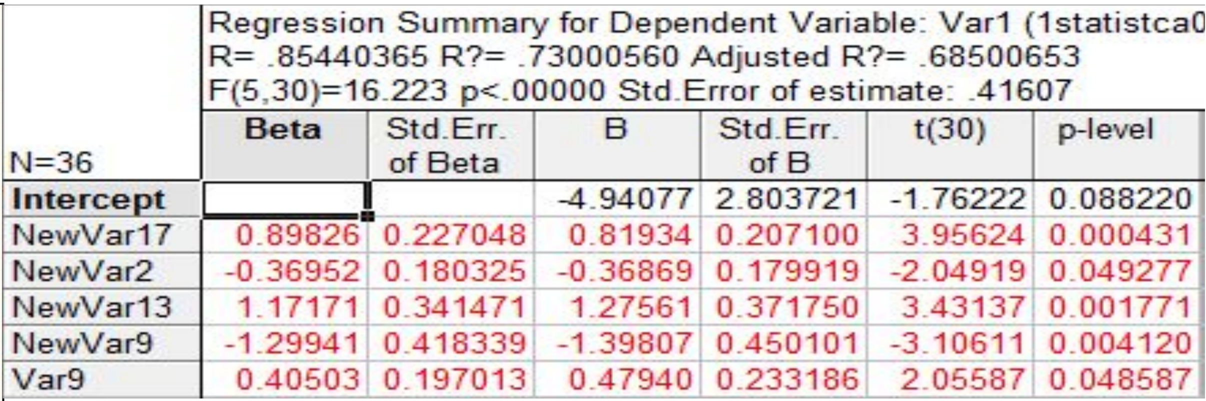
Voxler


-65
-60
-55
-50
-45
-40



Статистическая обработка данных в Statistica и надстройках Excel

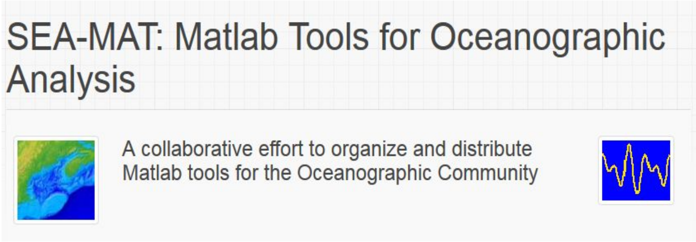




Regression Summary for Dependent Variable: Var1 (1statistca0
R= .85440365 R?= .73000560 Adjusted R?= .68500653
F(5,30)=16.223 p<.00000 Std.Error of estimate: .41607

N=36	Beta	Std.Err. of Beta	B	Std.Err. of B	t(30)	p-level
Intercept			-4.94077	2.803721	-1.76222	0.088220
NewVar17	0.89826	0.227048	0.81934	0.207100	3.95624	0.000431
NewVar2	-0.36952	0.180325	-0.36869	0.179919	-2.04919	0.049277
NewVar13	1.17171	0.341471	1.27561	0.371750	3.43137	0.001771
NewVar9	-1.29941	0.418339	-1.39807	0.450101	-3.10611	0.004120
Var9	0.40503	0.197013	0.47940	0.233186	2.05587	0.048587

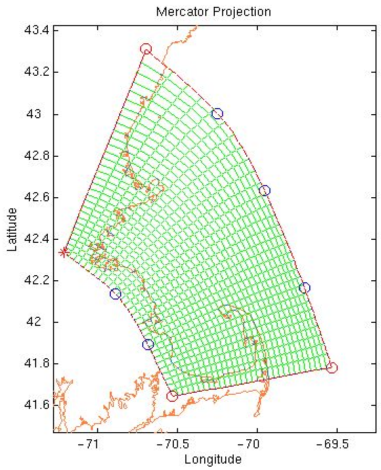
Статистика, расчеты, визуализация с помощью Matlab

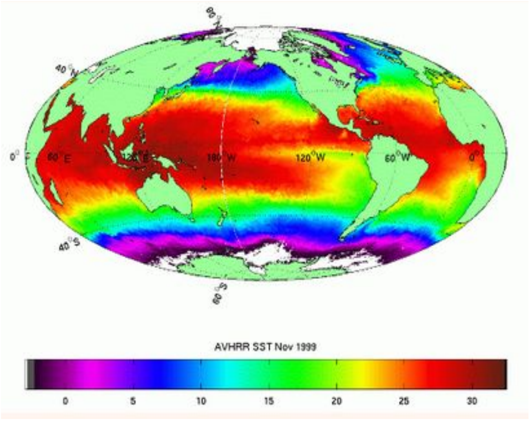


SEA-MAT: Matlab Tools for Oceanographic Analysis

A collaborative effort to organize and distribute Matlab tools for the Oceanographic Community

Orthogonal curvilinear grid creator for Matlab





Дистанционное зондирование

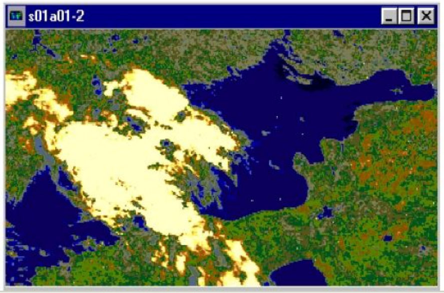


Рис.1.15. Альбедо подстилающей поверхности по данным второго канала AVHRR. Большое облако над Финским заливом

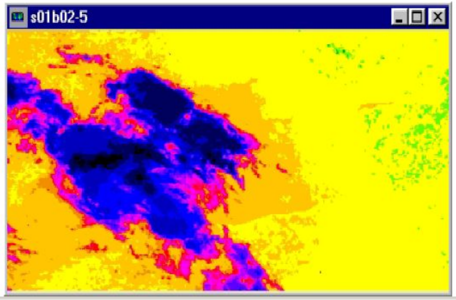


Рис.1.16. Яркостная температура по данным пятого канала AVHRR. Большое облако над Финским заливом

LearnEO!

Bilko image processing software

Спутник	Тип съемки	Разрешение	Типы данных*	Годы архива	Страна
ALOS	Оптическая	2,5	1*	2006-2011	Япония
		10	2*		
	Радиолокационная	7-100	L-диапазон		
Cartosat-1 (IRS-P5)	Оптическая	2,5	1	2007-2009	Индия
IRS-1C/1D	Оптическая	5,8	1*	2002-2009	Индия
		23,5	2*		
		188			
ResourceSat-1 (IRS-P6)	Оптическая	5,8	1*	2006-2009	Индия
		5,8	2*		
		23,5			
		55			
SPOT 2	Оптическая	10	1*	2006-2009	Франция
		20	2*		
SPOT 4	Оптическая	10	1*	2006-2012	Франция
		20	2*		
Landsat 7	Оптическая	15	1*	1999-2003	США
		30	2*		
		60			
Landsat 5	Оптическая	30	2*	2006-2011	США
		120			
Radarsat-1	Радиолокационная	8	С-диапазон	2004-2013	Канада
		25			
		50			
		100			
ENVISAT-1 (ASAR)	Радиолокационная	30	С-диапазон	2007-2012	ESA
		150			
		1000			

1* – Панхроматический режим, 2* – Мультиспектральный режим.

ГИДРОДИНАМИЧЕСКИЕ МОДЕЛИ ЦИРКУЛЯЦИИ ОКЕАНА

ACADIA

ACOM

BatTri

BOM

BRIOS

DROG3D

CLIO

COHERENS

DieCAST

ECBILT

ECOM-si

FLAME

FMS

FRAM

FUNDY

GMODEL

GOTM

HIM

HOPE

HYCOM

LSM

MICOM

MITgcm

MOM

MOMA

NCOM

NEMO

NLOM

NUBBLE

OCCAM

OCCOMM

OPA

OSMOM

PEQMOD

POCM

POLCOMS

POM

POP

Poseidon

POSUM

QTCM

QUODDY

ROMS

SCRUM

SEA

SEOM

SPEM

TOMS

The Princeton Ocean Model (POM)

Уравнения модели:

$$\frac{\partial DU}{\partial x}+\frac{\partial DV}{\partial y}+\frac{\partial \omega}{\partial \sigma}+\frac{\partial \eta}{\partial t}=0$$

$$\frac{\partial UD}{\partial t}+\frac{\partial U^2D}{\partial x}+\frac{\partial UVD}{\partial y}+\frac{\partial U\omega}{\partial \sigma}-fVD+gD\frac{\partial \eta}{\partial x}+\frac{gD^2}{\rho_o}\int_\sigma^o\left[\frac{\partial \rho'}{\partial x}-\frac{\sigma'}{D}\frac{\partial D}{\partial x}\frac{\partial \rho'}{\partial \sigma'}\right]d\sigma'=\frac{\partial}{\partial \sigma}\left[\frac{K_M}{D}\frac{\partial U}{\partial \sigma}\right]+F$$

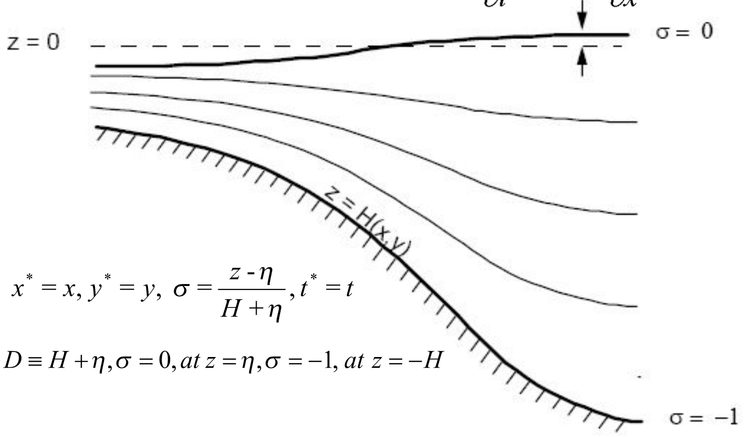
$$\frac{\partial VD}{\partial t}+\frac{\partial UVD}{\partial x}+\frac{\partial V^2D}{\partial y}+\frac{\partial V\omega}{\partial \sigma}+fUD+gD\frac{\partial \eta}{\partial y}+\frac{gD^2}{\rho_o}\int_\sigma^o\left[\frac{\partial \rho'}{\partial y}-\frac{\sigma'}{D}\frac{\partial D}{\partial y}\frac{\partial \rho'}{\partial \sigma'}\right]d\sigma'=\frac{\partial}{\partial \sigma}\left[\frac{K_M}{D}\frac{\partial V}{\partial \sigma}\right]+F$$

$$\frac{\partial TD}{\partial t}+\frac{\partial TUD}{\partial x}+\frac{\partial TVD}{\partial y}+\frac{\partial T\omega}{\partial \sigma}=\frac{\partial}{\partial \sigma}\left[\frac{K_H}{D}\frac{\partial T}{\partial \sigma}\right]+F_T-\frac{\partial R}{\partial z}$$

$$\frac{\partial SD}{\partial t}+\frac{\partial SUD}{\partial x}+\frac{\partial SVD}{\partial y}+\frac{\partial S\omega}{\partial \sigma}=\frac{\partial}{\partial \sigma}\left[\frac{K_H}{D}\frac{\partial S}{\partial \sigma}\right]+F$$

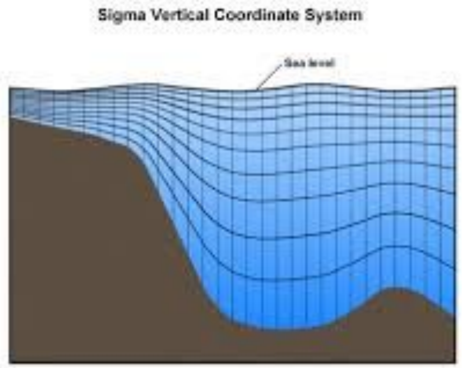
$$\frac{\partial q^2D}{\partial t}+\frac{\partial Uq^2D}{\partial x}+\frac{\partial Vq^2D}{\partial y}+\frac{\partial \omega q^2}{\partial \sigma}=\frac{\partial}{\partial \sigma}\left[\frac{K_q}{D}\frac{\partial q^2}{\partial \sigma}\right]+\frac{2K_M}{D}\left[\left(\frac{\partial U}{\partial \sigma}\right)^2+\left(\frac{\partial V}{\partial \sigma}\right)^2\right]+\frac{2g}{\rho_o}K_H\frac{\partial \tilde{\rho}}{\partial \sigma}-\frac{2Dq^3}{B_1\boxtimes}+F_q$$

$$\frac{\partial q^2\boxtimes D}{\partial t}+\frac{\partial Uq^2\boxtimes D}{\partial x}+\frac{\partial Vq^2\boxtimes D}{\partial y}+\frac{\partial \omega q^2\boxtimes}{\partial \sigma}=\frac{\partial}{\partial s}\left[\frac{K_q}{D}\frac{\partial q^2\boxtimes}{\partial \sigma}\right]+E_1\boxtimes\left(\frac{K_M}{D}\left[\left(\frac{\partial U}{\partial \sigma}\right)^2+\left(\frac{\partial V}{\partial \sigma}\right)^2\right]+E_3\frac{g}{\rho_o}K_H\frac{\partial \tilde{\rho}}{\partial \sigma}\right)\tilde{W}-\frac{Dq^3}{B_1}+F$$



$$x^*=x,\ y^*=y,\ \sigma=\frac{z-\eta}{H+\eta},t^*=t$$

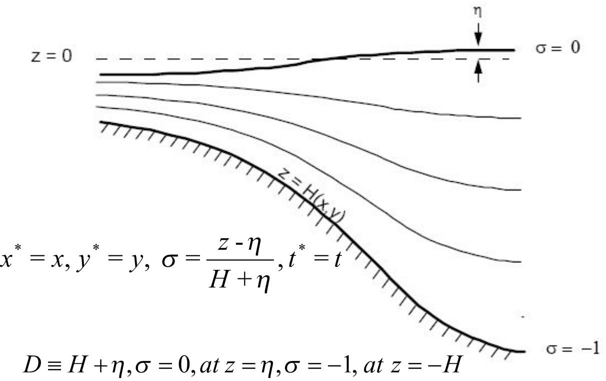
$$D\equiv H+\eta,\sigma=0, at\ z=\eta,\sigma=-1, at\ z=-H$$



Гидродинамическая модель макета системы диагноза-прогноза Черного моря

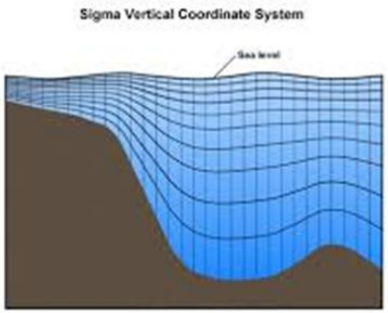
В основе макета системы диагноза и прогноза динамики Черного моря лежит модель циркуляции с фиксированным пространственным разрешением, созданная на базе модели циркуляции Принстонского университета – POM (The Princeton Ocean Model).

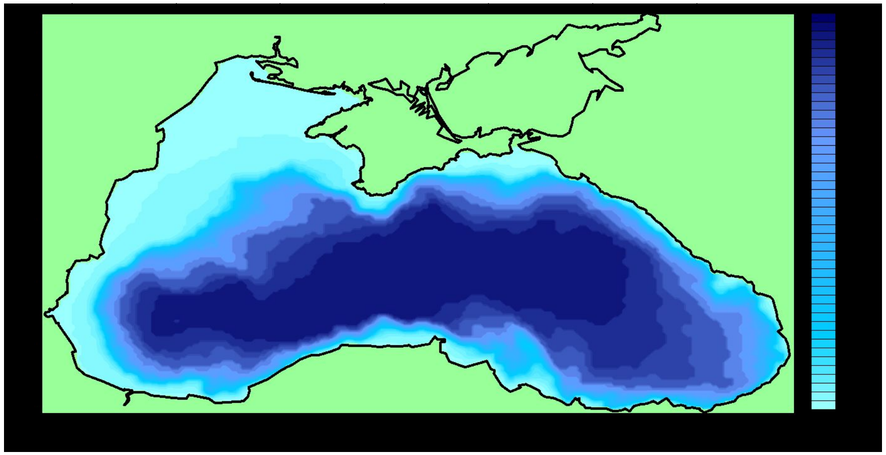
- Аппроксимация традиционной примитивной системы уравнений на сетке C;
- Горизонтальное пространственное разрешение: dx=dy=4.8 км (236x130 узлов сетки);
- 36 σ-уровней по вертикали, сгущающихся к морской поверхности;
- Использование алгоритма разделения по модам (бароклинной и баротропной);
- Параметризация вертикального турбулентного перемешивания с помощью встроенной модели турбулентности Меллора-Ямады;
- Задаются среднемесячные климатические значения расходов в устьях рек и проливов.



$$x^* = x,\ y^* = y,\ \sigma = \frac{z - \eta}{H + \eta},\ t^* = t$$

$$D \equiv H + \eta, \sigma = 0, at\ z = \eta, \sigma = -1, at\ z = -H$$





Область интегрирования модели

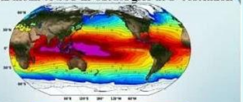
The Nucleus for European Modelling of the Ocean – NEMO

The NEMO System Team*

The Nucleus of European Modelling of the Ocean (NEMO) is a state-of-the-art modelling framework for oceanographic research, operational oceanography, seasonal forecast and climate studies. NEMO includes 5 major components: the blue ocean (ocean dynamics, NEMO-OPA); the white ocean (sea-ice, NEMO-LIM); the green ocean (biogeochemistry, NEMO-TOP); the adaptive mesh refinement software (AGRIF) and the assimilation component (NEMO-TAM). Some reference configurations allowing to set-up and validate the applications and a set of scripts and tools (the "environment") to use the system are also available to the users community. The evolution and reliability of NEMO are organised and controlled by a European Consortium between CNRS (France), Mercator-Ocean (France), NERC (UK), UKMO (UK), CMCC (Italy) and INGV (Italy). NEMO evolves through the improvement of the existing components, the creation of new components, and the improvement and generalization of the "environment". As improvements are validated, they are implemented in the shared references, in order to ensure the reliability of the system, to allow projects to find the appropriate version and to keep track of the evolutions.

ORCA-LIM Reference Configuration

Annual mean of SST in ORCA grid at 1° resolution



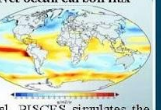
The ORCA family is a series of global ocean configurations that are run together with the LIM sea-ice model, using various resolutions from 2° to 1/12°. Only the ORCA2 is provided with all its input files. This version of ORCA2 has 31 levels in the vertical, with the highest resolution (10m) in the upper 150m.

OPA

is a primitive equation model (Arakawa-C) for regional and global ocean circulation (z-, s-levels or hybrid). It is a flexible tool for studying ocean and its interactions with the others earth system components over a wide range of spatial and temporal scales. Various physical choices are available to describe ocean physics (vertical / horizontal mixing, barotropic EGWs, momentum and tracers advection, momentum equations, BBL schemes, Filtered, Time-splitting, explicit, Solar penetration, Surface Forcing, Tides, Flexible LOBC treatments, Vertical Physics).

ORCA-PISCES Reference Configuration

Net ocean carbon flux



ORCA-PISCES is the ORCA-LIM configuration coupled either online or offline with PISCES biogeochemical model. PISCES simulates the lower marin ecosystem trophic levels (phyto / microzoo / mesozooplankton) and the biogeochemical cycles of carbon and main nutrients (P, N, Fe, and Si). The model is intended to be used for both regional and global configurations at high or low spatial resolutions as well as for short and long-term analyses

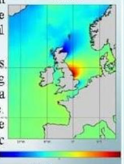
TOP

the passive tracer package includes a transport component and a coupling framework with the distributed PISCES biogeochemical model or external models like the BFM (http://bfm-community.eu), as well as more simple tracer models for CFC and Bomb C14.

AGRIF

The adaptive mesh refinement software
NEMO module to perform two-way nested simulation. It creates the grid coordinates, the surface forcing and the initial conditions required by each child model. It sets-up MPP configuration tool and manages the communications during the run.

AAM Reference Configuration

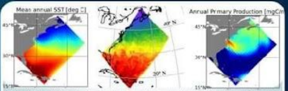


AMM12 configuration gives an example of the use of NEMO for coastal forecasting.

The configuration uses stretched terrain following coordinates along with a non-linear free surface. Open boundaries provide barotropic and baroclinic data and tidal forcing.

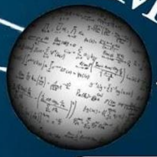
The Configuration uses time-splitting enabling it to efficiently resolve the tides. The instantaneous SSH signal, dominated by the tides, is shown in the plot on the right.

GYRE-TOP Reference Configuration



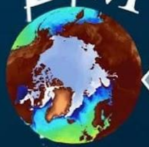
An idealized domain with analytical forcing to simulate the seasonal cycle of a double-gyre dynamic, coupled or not with a biogeochemical model. The standard configuration is a β-plane with regular 1° horizontal resolution. The flexibility of the configuration allows the user to modify it by changing a few parameters. This allows to investigate the generation of a large number of interacting, transient eddies and their contribution to the large scale circulation.

TAM

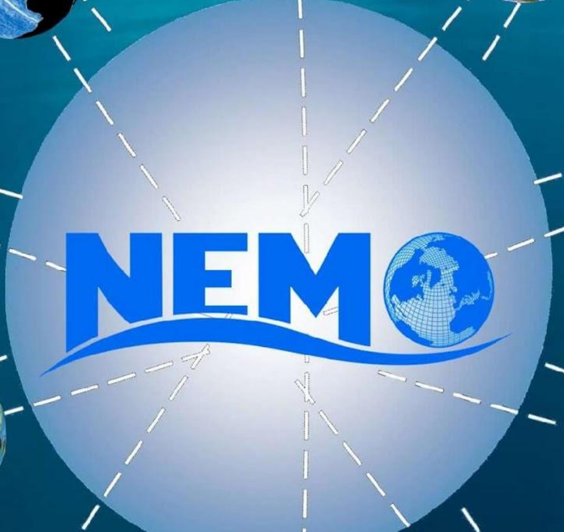


Tangent and Adjoin Model
It is the Tangent and Adjoint Model of the ocean dynamic part (OPA). TAM will not released with every NEMO version.

LIM



LIM3
the latest version of the Louvain-la-Neuve sea-ice model including a new thermodynamics (Vancoppenolle *et al.* Ocean Modelling 2008) and a C-grid Elasto-Visco-Plastic rheology.



The *NEMO System Team* is in charge of the shared NEMO reference and its evolutions. The members of this team are the experts on the NEMO system. The System Team:

-ensures the user support on the NEMO reference and the reference configurations;
-ensures the sustainable development of NEMO;
-carries out the agreed plan and schedule of work approved by the steering committee.

- Incorporation into NEMO of new developments (scientific or technical)
- Re-organization of code to improve its readability, orthogonality or structure
- Optimization of NEMO on the computers available in the consortium
- Maintenance of the paper and on-line documentation
- Configuration control of the available versions of NEMO
- Testing and release of new versions (typically once or twice a year)
- Making NEMO readily available to the scientific community
- Providing assistance to users
- Support for user meetings (held typically once a year)
- Assistance in scientific development in an area of high priority

The NEMO System Team

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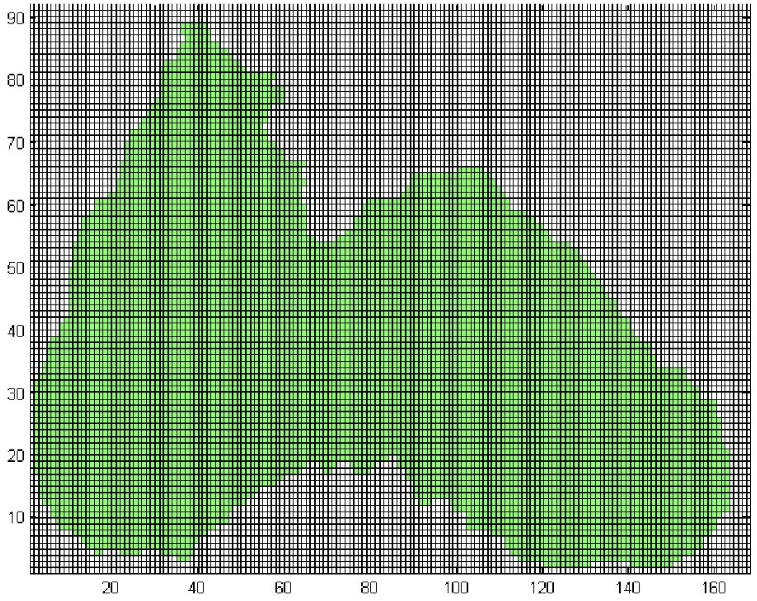
Geoscientific Model Development NEMO Special Issue open indefinitely

MODEL SET-UP

NEMO: 3-D, Baroclinic, hydrostatic, Arakawa C grid.

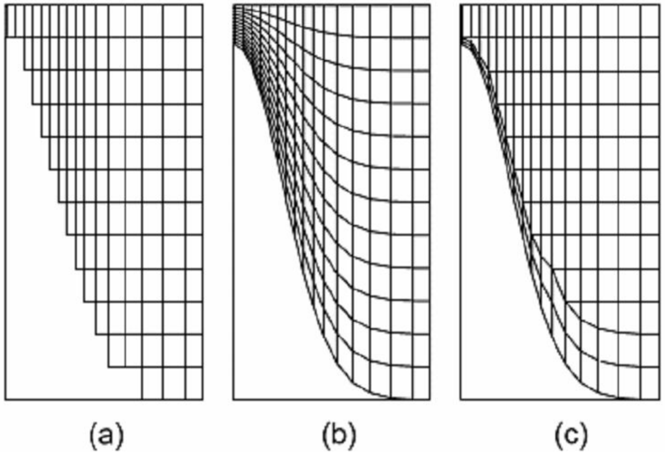
Model domain:
Lat : from 41 to 46.7 °N ; Long: from 28 to 42 °E
Bathymetry: ETOPO 5' slightly smoothed / corrected
Horizontal Resolution:

BLS-24: 1/24° x 1/24° ~ 4.6 x 3.5 km
Vertical resolution: 33 vertical levels (various discretization schemes)
Lateral boundaries: rivers and Bosphorous (in-out), monthly data



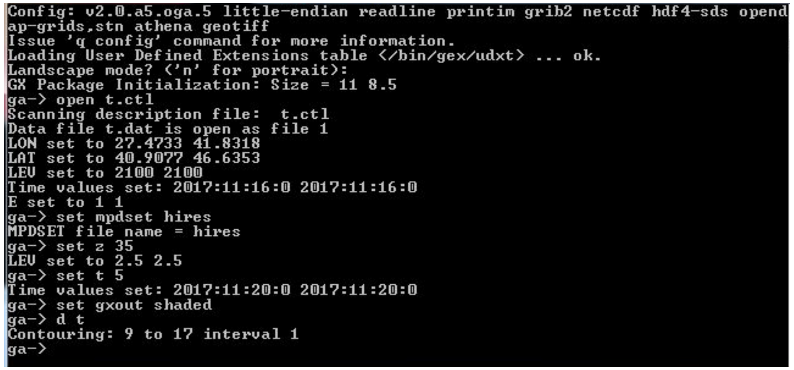
Forcing:
6h re-analysis data (8 parameters): Wind (U,V), SL pressure, SL air temperature, SL specific humidity, precipitation, Long wave radiation, Short wave radiation
[sources: NCEP, (low-res), DFS5.2 (low-res), SKIRION (high res)]

VERTICAL GRIDS

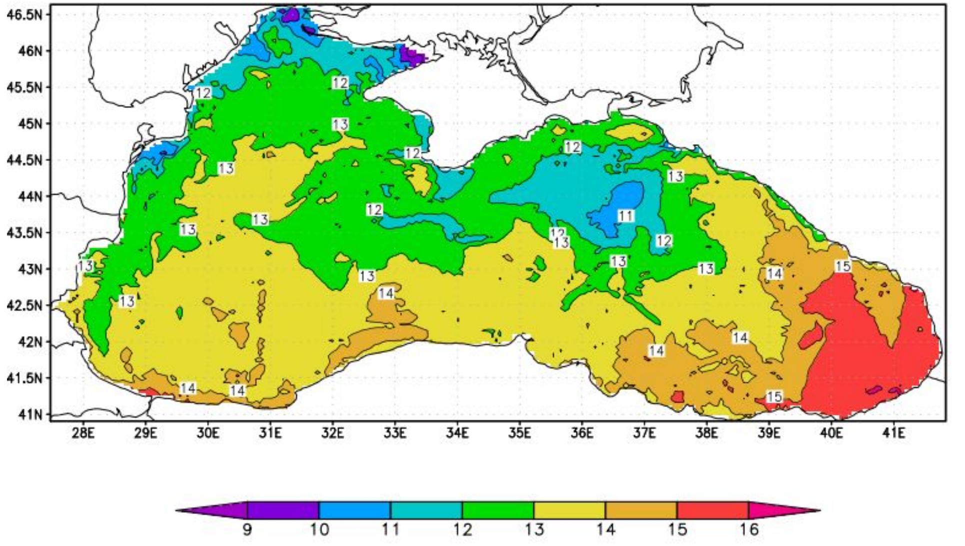


Standard vertical grids in NEMO:
z-level (a) ,
sigma/s-level (b) ,
z-on-top-of-sigma (c)

Grid Analysis and Display System



```
Config: v2.0.a5.oga.5 little-endian readline printim grib2 netcdf hdf4-sds opend
ap-grids,stn athena geotiff
Issue 'q config' command for more information.
Loading User Defined Extensions table </bin/gex/udxt> ... ok.
Landscape mode? ('n' for portrait):
GX Package Initialization: Size = 11 8.5
ga-> open t.ctl
Scanning description file:  t.ctl
Data file t.dat is open as file 1
LON set to 27.4733 41.8318
LAT set to 40.9077 46.6353
LEV set to 2100 2100
Time values set: 2017:11:16:0 2017:11:16:0
E set to 1 1
ga-> set mpdset hires
MPDSET file name = hires
ga-> set z 35
LEV set to 2.5 2.5
ga-> set t 5
Time values set: 2017:11:20:0 2017:11:20:0
ga-> set gxout shaded
ga-> d t
Contouring: 9 to 17 interval 1
ga->
```


46.5N
46N
45.5N
45N
44.5N
44N
43.5N
43N
42.5N
42N
41.5N
41N
28E
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34E
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36E
37E
38E
39E
40E
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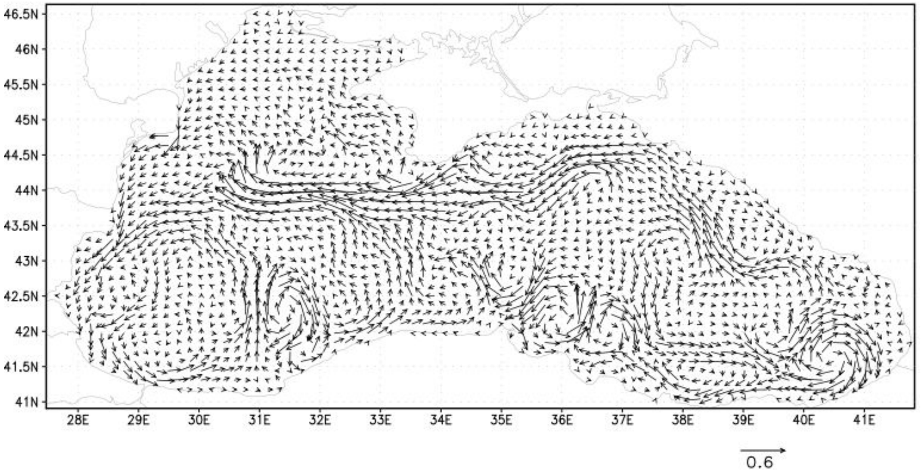
16

GrADS: COLA/IGES 2017-11-23-14:20


46.5N
46N
45.5N
45N
44.5N
44N
43.5N
43N
42.5N
42N
41.5N
41N
28E
29E
30E
31E
32E
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37E
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39E
40E
41E
0.6

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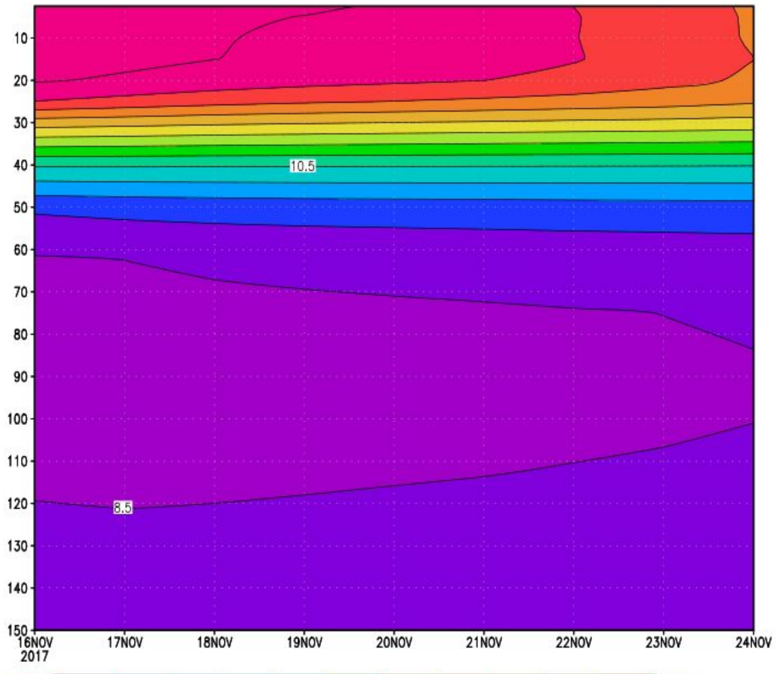

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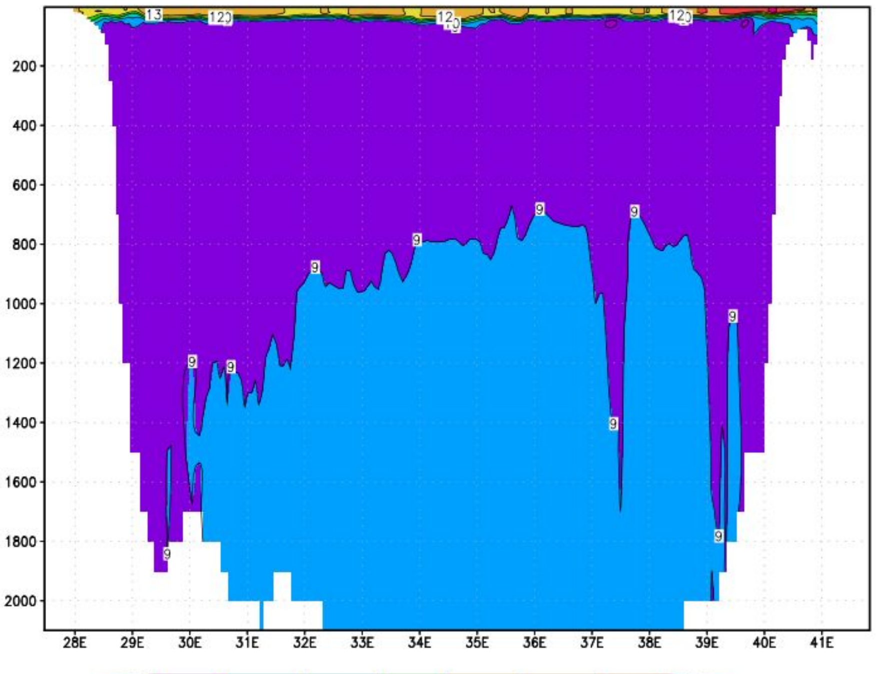

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Благодарю за внимание!