Application of Argo drifter data for quality control of SST received from Remote sensing

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Satellite derived sea surface temperature (SST) data are used for sea diagnosis.

The Argo drifter data are applied for validation of Remote sensing SST data

The special numerical experiments are carried based on the Black Sea baroclinic forecasting model.

The outputs of these experiments show that application of satellite derived SST data compared with the e.g. climatological data of temperature fields significantly enhances the forecast of the Black Sea conditions.

Satellite SST determination

AVHRR _ Advanced Very High resolution radiometer

METOP-A,B

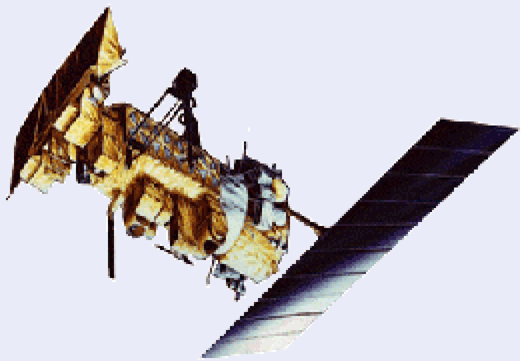
NOAA 15

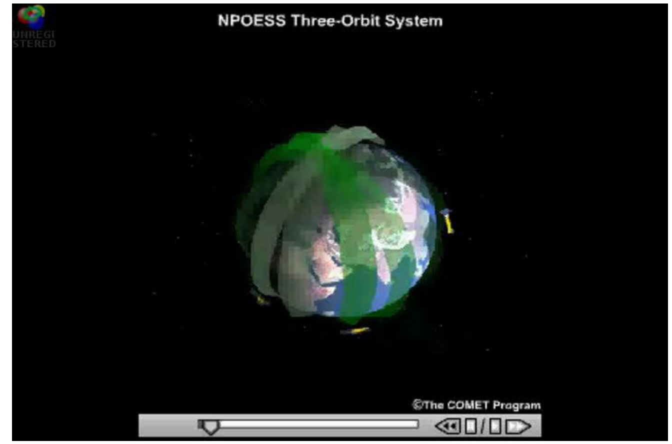
NOAA 16

NOAA 17

NOAA 18

NOAA 19

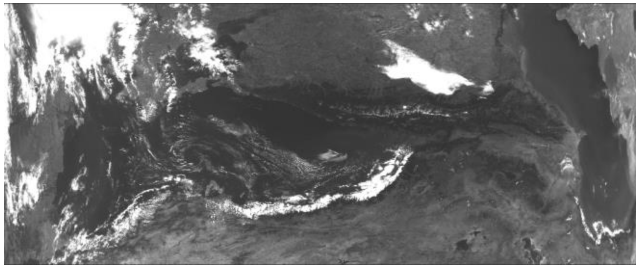




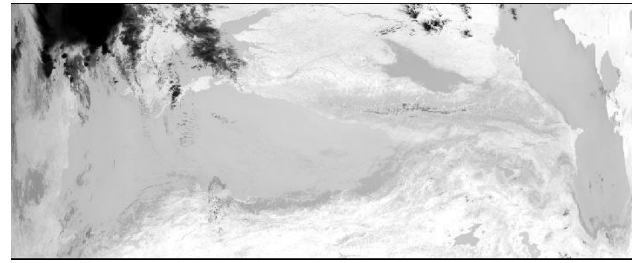
N	Resolution	Wavelength (μm)	Typical Use
1	1.09 km	0.58 - 0.68	Daytime Cloud and Surface mapping
2	1.09 km	0.725 - 1.00	Land water boundaries
3a	1.09 km	1.58 - 1.64	Snow and Ice detection
3b	1.09 km	3.55 - 3.93	Night cloud mapping, SST
4	1.09 km	3.55 - 3.93	Night cloud mapping, SST
5	1.09 km	11.50 - 12.50	SST

Sun Synchronous orbit
800 km above the surface
2 images per day
101 min period
Swath width – 2800 km
The Earth observing cycle – 12 hours.

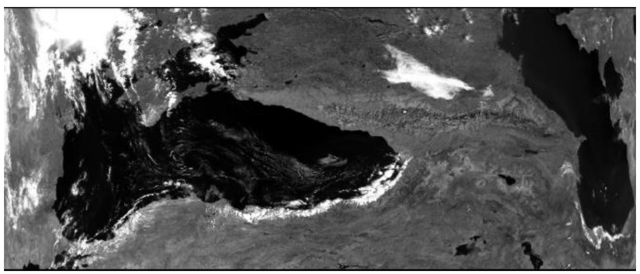
Metop-A, AVHRR, 13 of August, 2007, daytime



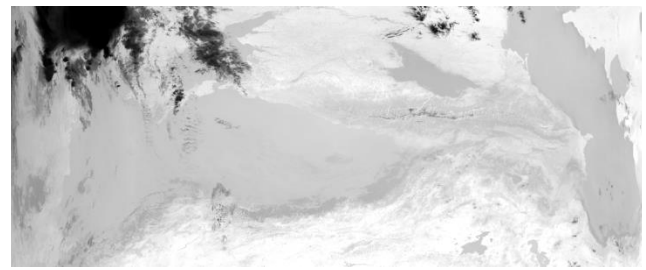
1 Channel, Albedo



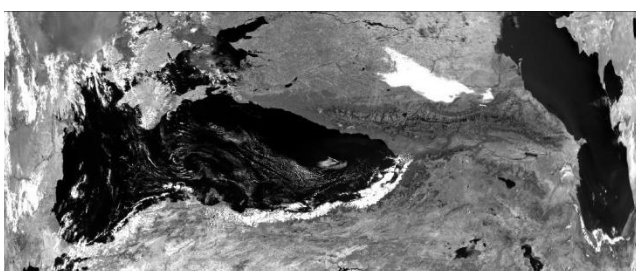
4 Channel, Brightness Temperature



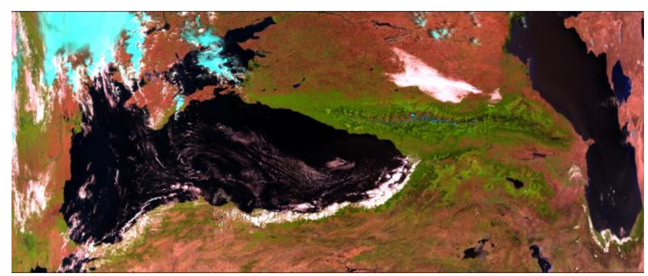
2 Channel Albedo



5 Channel, Brightness Temperature



3a Channel, albedo



3a,2,1 channel RGB composed image

SST calculation - split window algorithm

$$T_{MCSST} = b_0 + b_1 T_4 + b_2 (T_4 - T_5) + b_3 (T_4 - T_5)(\sec\theta - 1) - b_4$$

$$T_{NLSST} = a_0 + a_1 T_4 + a_2 (T_4 - T_5) T_{MCSST} + a_3 (T_4 - T_4)(\sec\theta - 1)$$

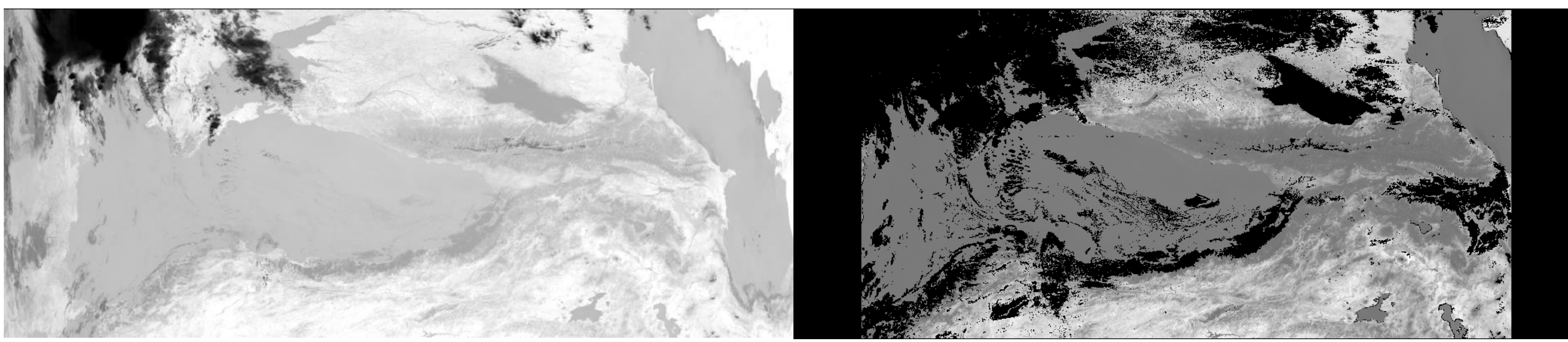
MCSST	b_0	b_1	b_2	b_3
Day	-280.430	1.024530	2.10044	0.784059
Night	-276.075	1.008410	2.23459	0.736946
NLSST	a_0	a_1	a_2	a_3
Day	-253.308	0.934004	0.0724457	0.748044
Night	-255.063	0.939146	0.0750661	0.728430

MCSST – Multi Channel Sea Surface Temperature
NLSST – Non Linear Sea Surface Temperature

Satellite zenit angle < 53^{o}
Cloud mask

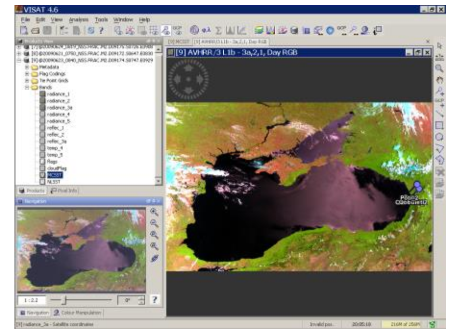
Night mode for Sun Zenith angle more than 75^{o}

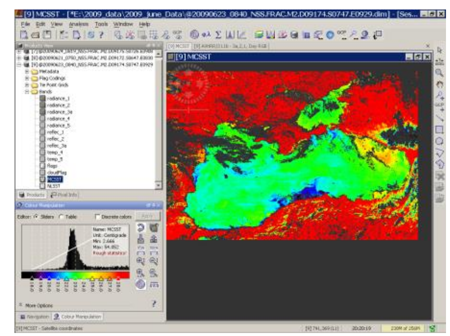
Metop-A, AVHRR, 13 August of 2007



MCSST SST images before and after application of zenit angle and cloud mask restrictions.

Satellite data source and software

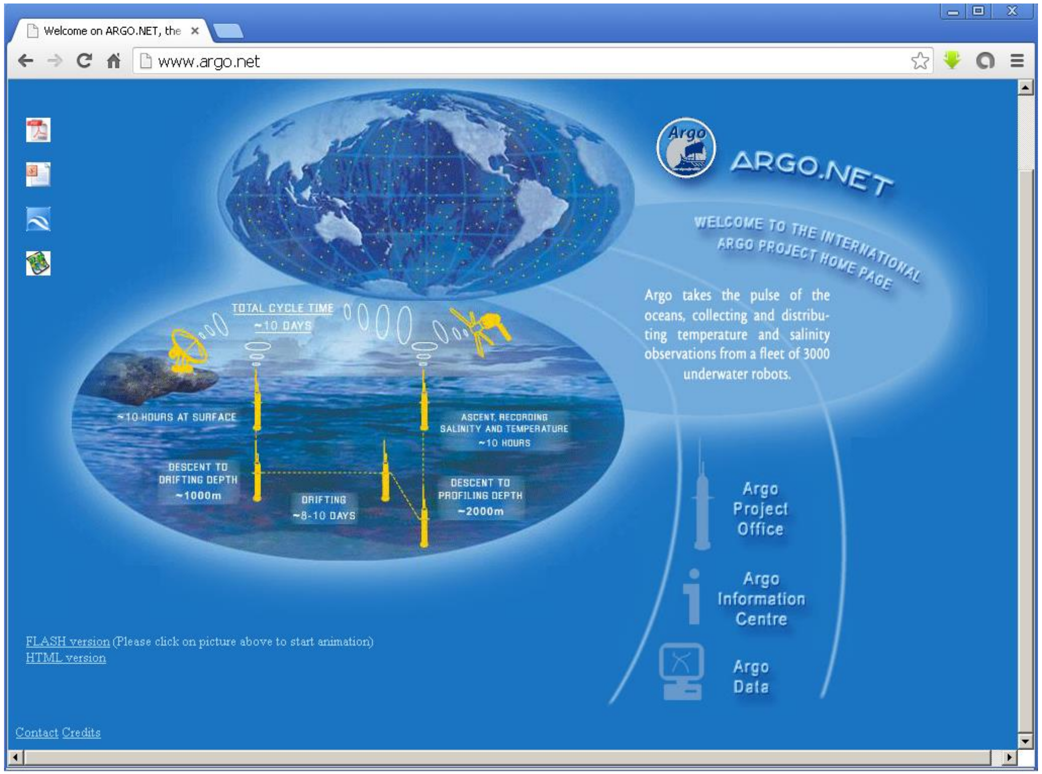


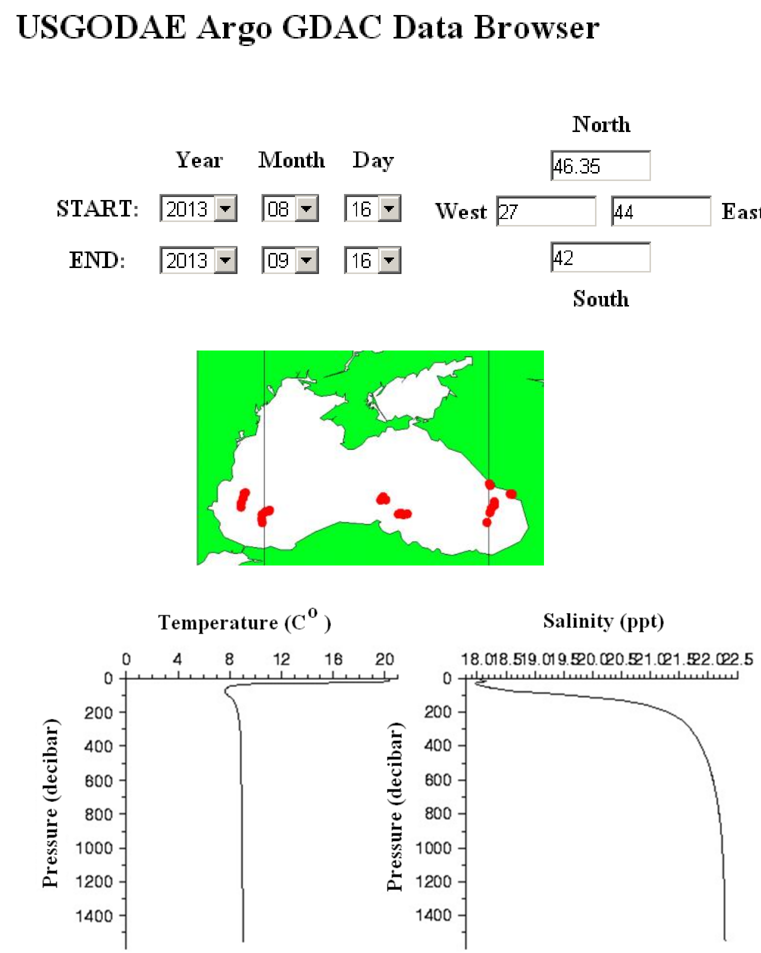


www.**class.noaa**.gov/

www.brockmann-consult.de/cms/web/**beam/**

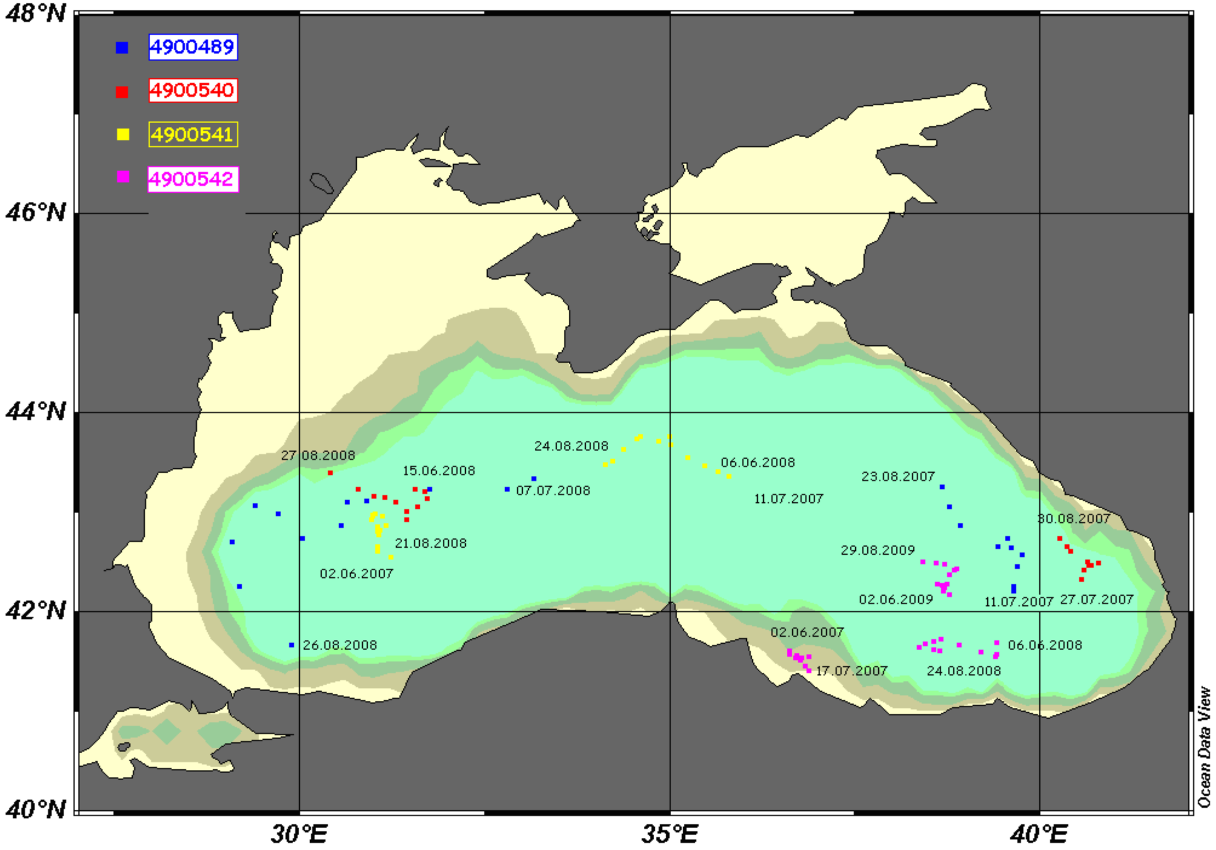
Argo drifter data source





Location plot of Argo drifters

for 2007,2008,2009 summer periods



- Four Argo drifters,
- 31 profiles, = 24 daytime, 7 night.
- Only 17 profile meets demand of max. 1.5 h time interval between drifter and satellite measurement of SST.
- Abs(max(Tdr-Tsat))= 2.05
- Abs(min(Tdr-Tsat) = 0.1
- Mean square deviation = 0.4

SST drifter and satellite data

for 2007-2009 summer seasons

ID	Lat	Long	Press	Temp	MSST	NLSST	Date	Dtime	Stime	dT	dT
4900489	39.633	42.224	4.6	17.695	-	-	6.4.2007	8.36	-		
4900489	39.687	42.454	4.9	16.985	23.282	23.22	6.26.2007	7.54	8.06	-6.297	-6.235
4900489	39.425	42.655	4.9	15.947	26.462	26.47	7.25.2007	8.11	8.04	-10.515	-10.523
4900489	38.676	43.253	4.9	27.003	-	-	8.23.2007	7.14	-		
4900489	31.75	43.228	4.9	20.964	20.663	20.482	6.22.2008	7.25	7.28	0.301	0.482
4900489	30.037	42.737	4.4	24.117	24.437	24.51	7.21.2008	5.49	7.28	-0.32	-0.393
4900489	29.182	42.651	4.8	25.802	-	-	8.19.2008	7.32	-		
4900540	40.36	42.651	4.6	24.358	-	-	8.23.2007	7.15	-		
4900540	31.69	43.211	4.7	18.538	-	-	6.8.2008	8.45			
4900540	31.441	42.929	4.8	24.17	-	-	7.7.2008	8.55	-		
4900541	31.221	42.542	4.8	19.241	18.883	18.929	6.2.2007	8.47	8.15	0.358	0.312
4900541	31.051	42.803	4.4	24.095	-	-	7.1.2007	7.40	-		
4900541	30.985	42.957	4.7	25.83	-	-	7.30.2007	8.06	-		
4900541	31.087	48.818	4.9	25.919	-	-	8.28.2007	8.06	-		
4900541	35.641	43.408	4.7	19.343	19.541	19.516	6.13.2008	8.30	7.14	-0.198	-0.173
4900541	34.988	43.76	4.6	22.887	23.015	22.972	7.12.2008	8.54	7.17	-0.128	-0.085
4900541	34.363	43.633	4.7	24.549	24.45	24.445	8.10.2008	7.46	7.57	0.099	0.104
4900542	36.618	41.61	4.6	20.04	19.592	19.57	6.2.2007	8.48	8.18	0.448	0.47
4900542	39.394	41.575	4.3	18.271	-	-	6.13.2008	7.11	-		
4900542	38.646	41.718	4.6	24.353	23.963	23.638	7.12.2008	7.19	7.14	0.39	0.715
4900542	38.543	41.621	4.5	25.496	-	-	8.10.2008	7.19	-		
4900542	38.65	42.27	4.9	23.853	22.442	22.407	6.25.2009	7.37	7.28	1.411	1.446
4900542	38.748	42.371	4.6	25.761	25.449	25.456	7.24.2009	8.01	8.03	0.312	0.305
4900542	38.571	42.486	4.7	23.185	22.731	22.666	2.22.2009	7.18	8.01	0.454	0.519
4900489	38.921	42.868	4.9	27.005	26.348	26.428	8.8.2007	19.24	18.27	0.657	0.577
4900540	40.687	42.47	4.7	15.841	-	-	6.11.2007	16.43	-		
4900540	40.59	42.415	4.8	19.959	21.78	22.009	7.10.2007	17.13	18.35	-1.821	-2.05
4900540	31.288	43.099	4.8	25.155	-	-	7.21.2008	17.12	-		
4900542	36.711	41.553	4.5	22.215	23.0876	23.074	6.16.2007	18.07	18.34	-0.8726	-0.859
4900542	36.688	41.553	4.3	22.867	-	-	7.15.2007	18.36	-		
4900542	39.183	41.597	4.6	23.347	23.229	23.19	6.27.2008	19.29	18.47	0.118	0.157

Four Argo drifters,

31 profiles, = 24 daytime, 7 night.

Only 17 profile meets demand of max. 1.5 h time interval between drifter and satellite measurement of SST.

Abs(max(Tdr-Tsat))= 2.05

Abs(min(Tdr-Tsat) = 0.1

Standard deviation = 0.5

Numerical Experiments with application of remote sensing SST as initial temperature fields

The *Black Sea baroclinic forecasting model is used.* [Kordzadze A. A., Demetrashvili D. I].

Model is based on the integration of the ocean hydrodynamic equations in hydrostatic approximation.

The Model takes into account the following factors:

- Thermochaline and wind influence of atmosphere;
- Adsorbtion of Sun short wave radiation by upper layers of the sea;
- Bosphorus straight water exchange with Mediterrian Sea;
- Flow of the river Danube;
- Change of coefficients of horizontal and vertical turbulent viscosity and diffusion;
- Sea configuration and relief of Sea bed.

This model experiments have methodological nature and the developed marine conditions predictions are not the real operational forecasts of the Black Sea conditions. Therefore, based on these experiments it can be concluded about perspectives of creation of technological line of the marine conditions operational prediction.

Integration of Equations

can be divided:

- Obtaining of climatic hydrophysical fields; (hydrodynamical flow, Sea temperature, Salinity)
- Adaptation phase; (uses this fields as an initial conditions of integration)
- Forecasting phase.

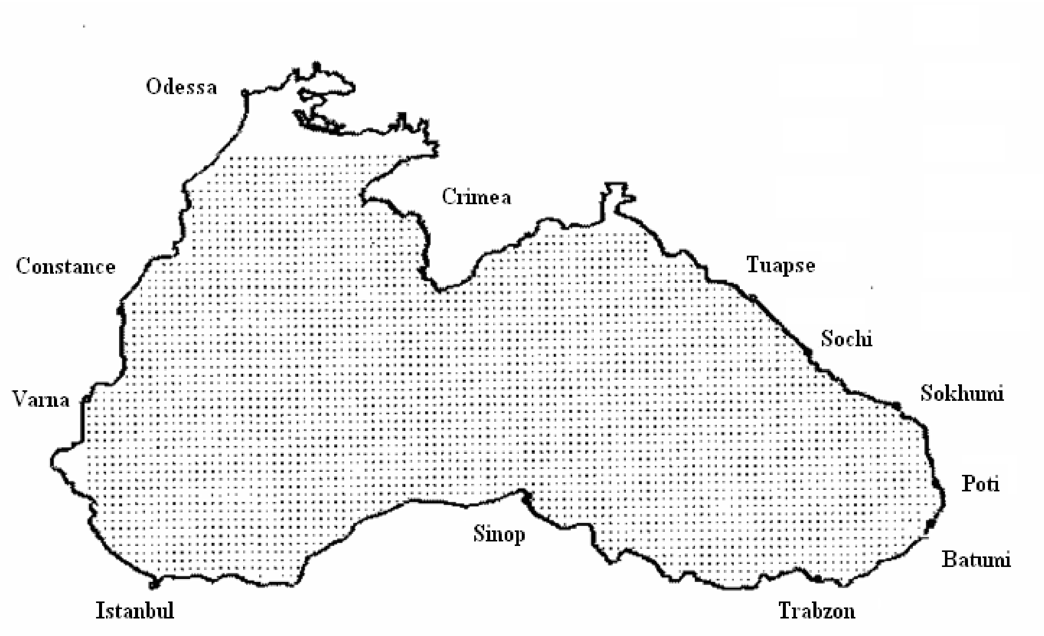
Calculation stages

- At the first stage the integration of the equations is carried out with zero initial conditions and until the attainment of semi stationary regime. The outputs of these calculations (hydrodynamic flow, sea temperature, salinity) are used as the initial conditions for adaptation phase.

- The integration of the equations at adaptation phase is carried out with model climate conditions instead of the zero initial conditions. Also calculation of meteorological fields (precipitation, intensity of evaporation, wind and heat fluxes) is necessary with application of the hydrodinamical model of atmosphere.

- In adaptation phase the impact of initial conditions are weakened and the output is determined by exposure to the atmosphere. Evidently the marine initial conditions are close to real initial hydrological regime and these fields (hydrodynamic flow, sea temperature, salinity) are used as initial for forecasting range.

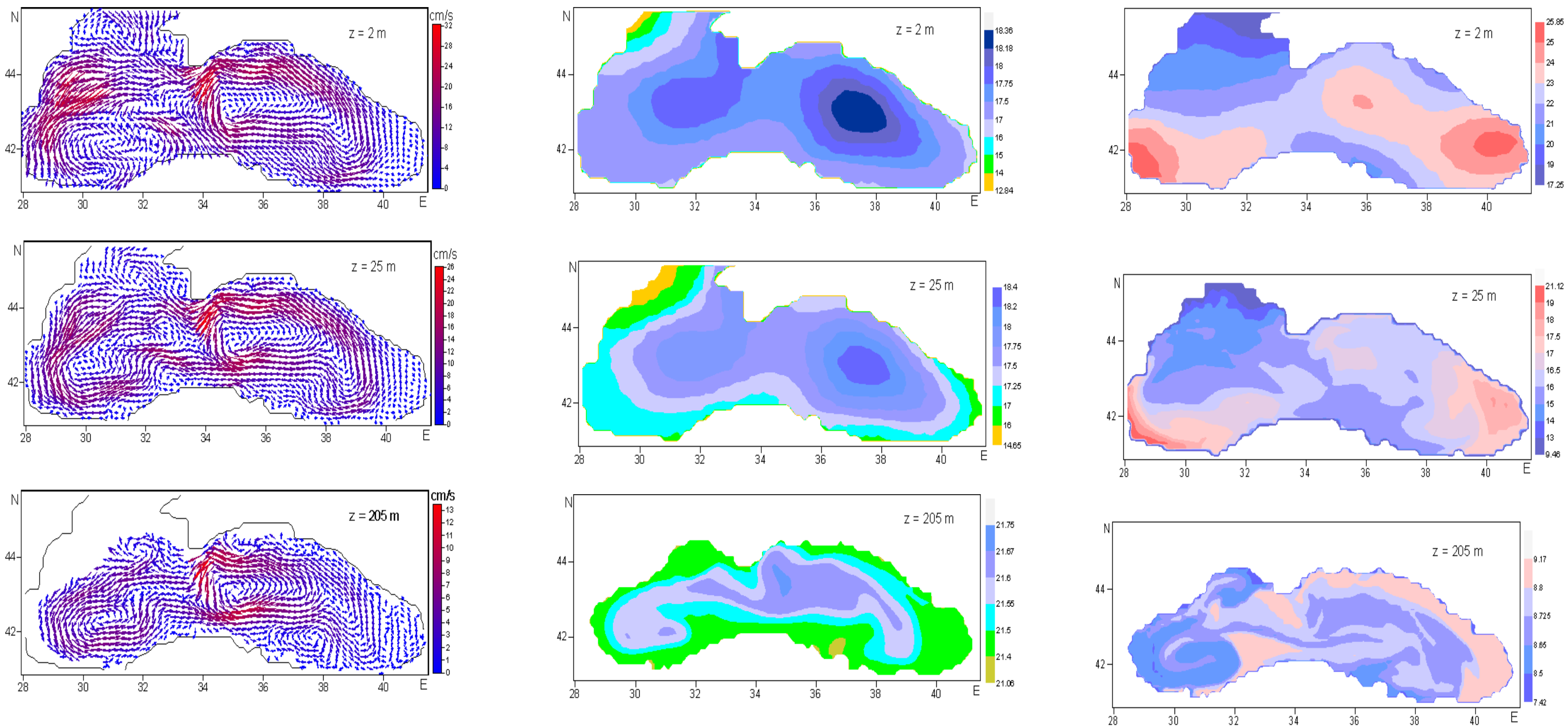
Black Sea surface regular greed



Greed dimentions: 255x111 =
24975 knots

Black Sea Basin takes 15875 knots
Spatial resulotion = 5 km
Temporal step of calculation = 1 hour

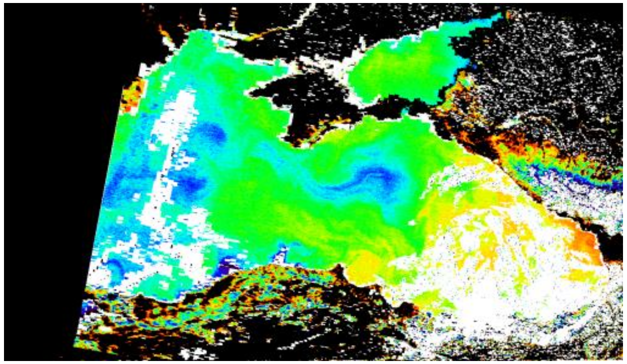
Hydrodynamic flow, salinity, Sea temperature 3D fields



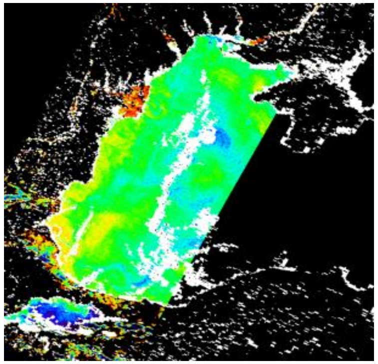
Total number of calculated horizons is 32 with unequal step.

AVHRR sensor coverage of Black sea

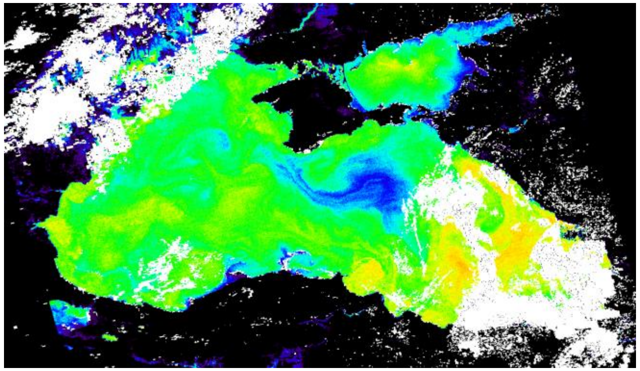
August of 25, 2010, Metop-A, AVHRR, SST images



a. 07:51 h



b. 09:44 h



c. 18:15 h

For cloud covered areas Reynolds monthly SST climatology data was used. These analyses were based on ship and buoy SST data supplemented with satellite SST retrievals.

Integration stages of numeric experiments

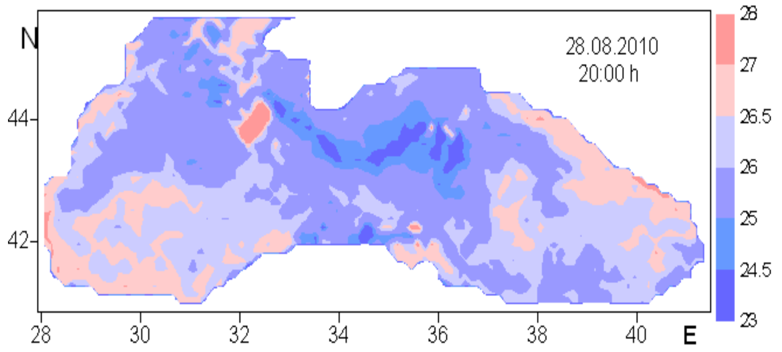
2010, August 23 – September 2
2010, June 29 – July 9
2009, July 22- August 1

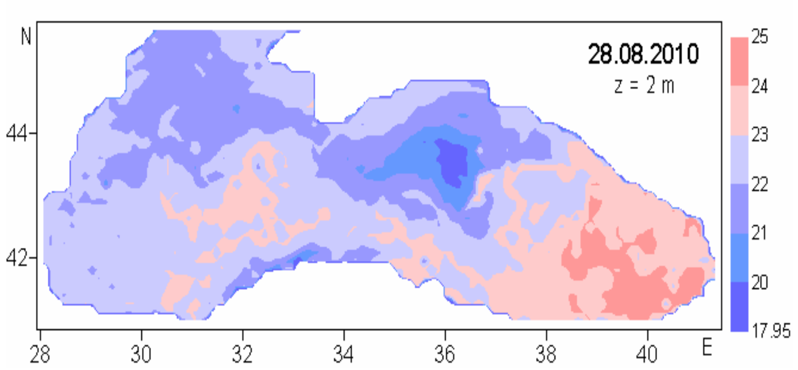
Adaptation stage: Starts August, 23, 12:00, ends 28 August 20:00.
For this period 12 satellite derived SST fields were applied.

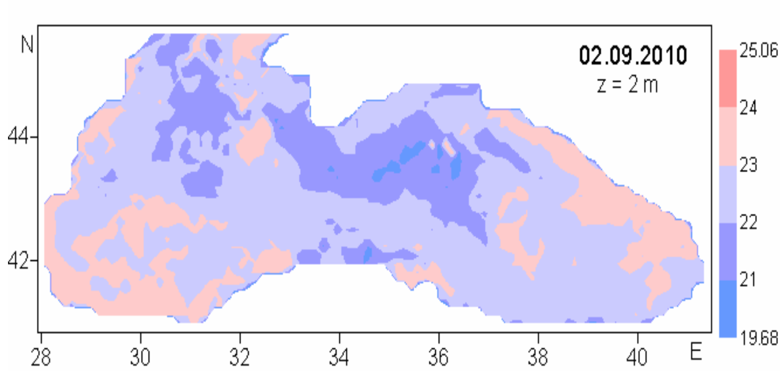
Forecasting stage starts 28 August, at 20:00, ends 2 of September, 12:00,
For this period Satellite derived SST field of 28 August was used.

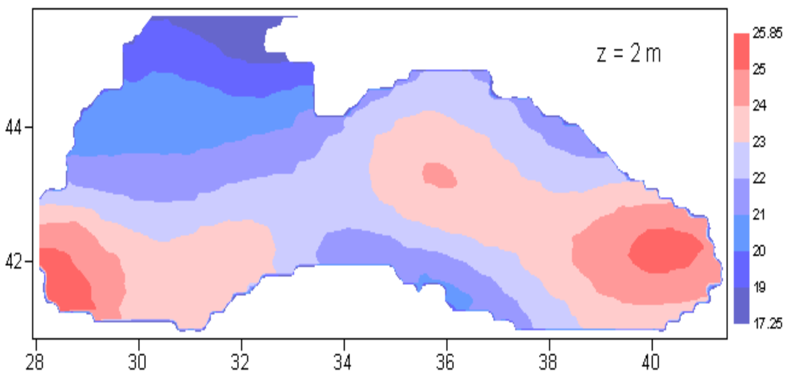
Result was compared with Satellite derived SST field for 2 of September

Calculated Temperature fields









Evaluation of calculation results

$$\sigma_1 = \sqrt{\frac{\Sigma(D_{i,j} - M_{i,j})^2}{N}} \qquad \sigma_2 = \sqrt{\frac{\Sigma(D_{i,j} - K_{i,j})^2}{N}}$$

$D_{i,j}$ - Remote Sensing SST value in (i,j) grid point

$M_{i,j}$ - Forecasted value of the temperature in (i,j) grid point

$K_{i,j}$ - Modelled climatic field temperature in (i,j) grid point

calculation results

2010, August 23 – September 2

$\sigma_1 = 1.4055$ $\sigma_2 = 1.9336$

$\max(\text{abs}(D_{i,j} - M_{i,j})) = 4.11^0C$, $\max(\text{abs}(D_{i,j} - K_{i,j})) = 7.053^0C$

$\min(\text{abs}(D_{i,j} - M_{i,j})) = 0.001^0C$; $\min(\text{abs}(D_{i,j} - K_{i,j})) = 0.021^0C$

2010, June 29 – July 9

$\sigma_1 = 1.653$ $\sigma_2 = 2.182$

$\max(\text{abs}(D_{i,j} - M_{i,j})) = 5.2\ ^0C$, $\max(\text{abs}(D_{i,j} - K_{i,j})) = 6.3\ ^0C$

$\min(\text{abs}(D_{i,j} - M_{i,j})) = 0.021^0C$; $\min(\text{abs}(D_{i,j} - K_{i,j})) = 0.051^0C$

2009, July 22- August 1

$\sigma_1 = 1.586$ $\sigma_2 = 2.117$

$\max(\text{abs}(D_{i,j} - M_{i,j})) = 5.43^0C$, $\max(\text{abs}(D_{i,j} - K_{i,j})) = 6.14\ ^0C$

$\min(\text{abs}(D_{i,j} - M_{i,j})) = 0.016^0C$; $\min(\text{abs}(D_{i,j} - K_{i,j})) = 0.042\ ^0C$

We’d like to exprss appreciation

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- Organizers of Argo workshop, October 2010

Thank you