Some features of the chlorophyll-a distribution in the north-western part of the Sea of Japan based on near real-time data

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Scientific background. Chlorophyll-a concentration is one of the basic parameters of water bioproductivity. It can serve as an indicator of hydrological, hydrobiological, climatic, and ecological processes. Spatial and temporal coverage of operative observations in near real-time based on satellite data allows to reveal the detailed information about oceanological processes in vast areas.

Objective of our presentation is to show the results of monitoring based on near real-time data on the chlorophyll-a concentration in the north-western part of the Sea of Japan.

Monitoring of chlorophyll-a concentration in near real-time based on satellite data has allowed us to reveal the temporal course, including interannual anomalies, and its distribution at upwelling sites in Peter the Great Bay and in the anticyclonic eddy in the north-western part of the Sea of Japan.

Data

Satellite data

1.Chlorophyll-a concentration from SeaWiFS (OrbView-2) color scanner for 1998-2007 and MODIS(Aqua) spectroradiometer for 2003-2007.

2. Sea Surface Temperature (SST) from NOAA and Aqua satellites.

3. Quantity of atmospheric precipitation from the TRMM satellite.

4.Near-surface wind from QuikScat satellite.

Acknowledgements

We thank NASA/DAAC, CEARAC, Remote Sensing Systems Group for satellite data and distributions.

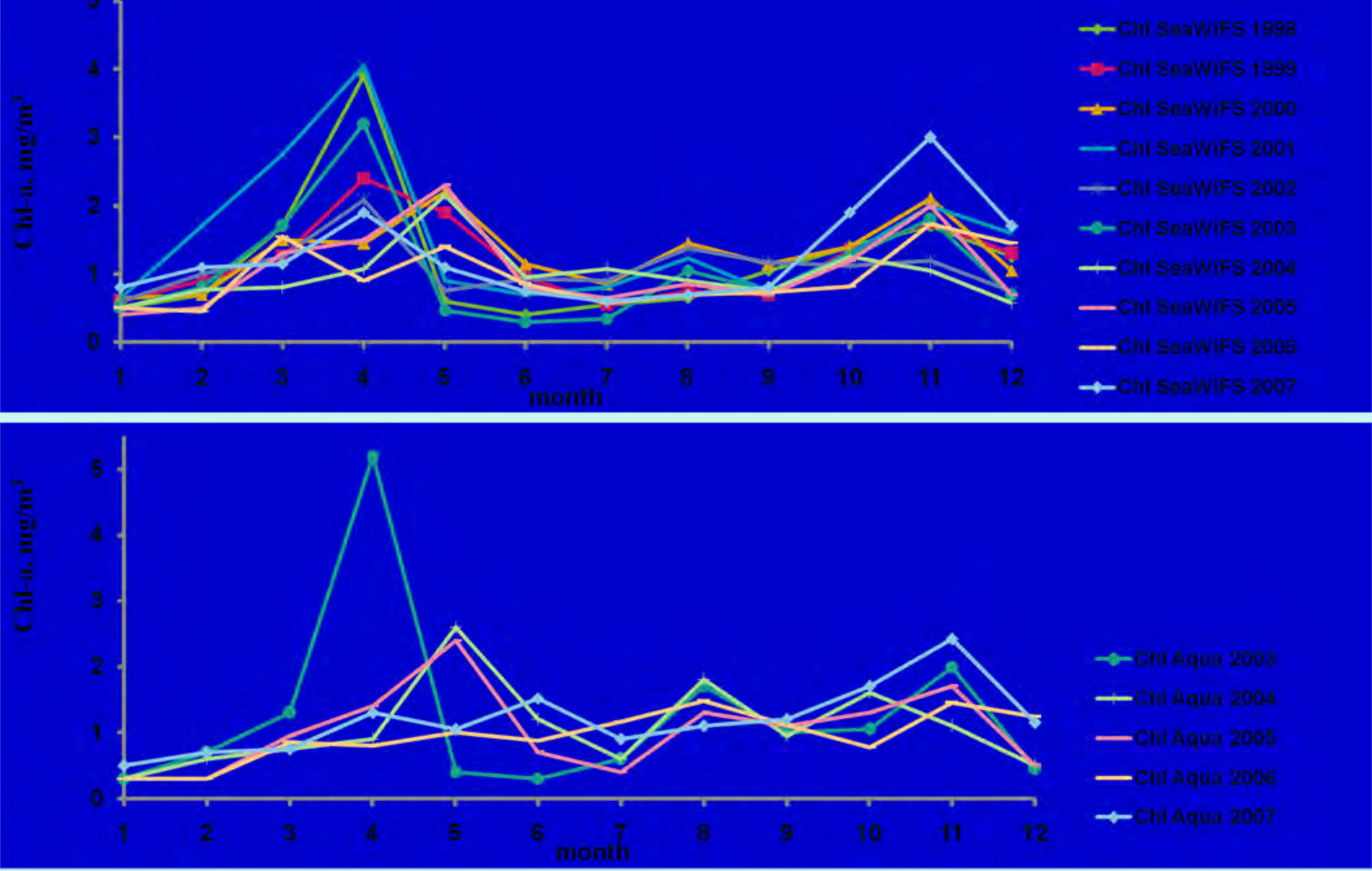


Figure 1. Temporal course of the average monthly chlorophyll-a concentration estimation averaged for Peter the Great Bay according to measurements of the satellite SeaWiFS color scanner for 1998-2007 and MODIS-Aqua spectroradiometer for 2003-2007.

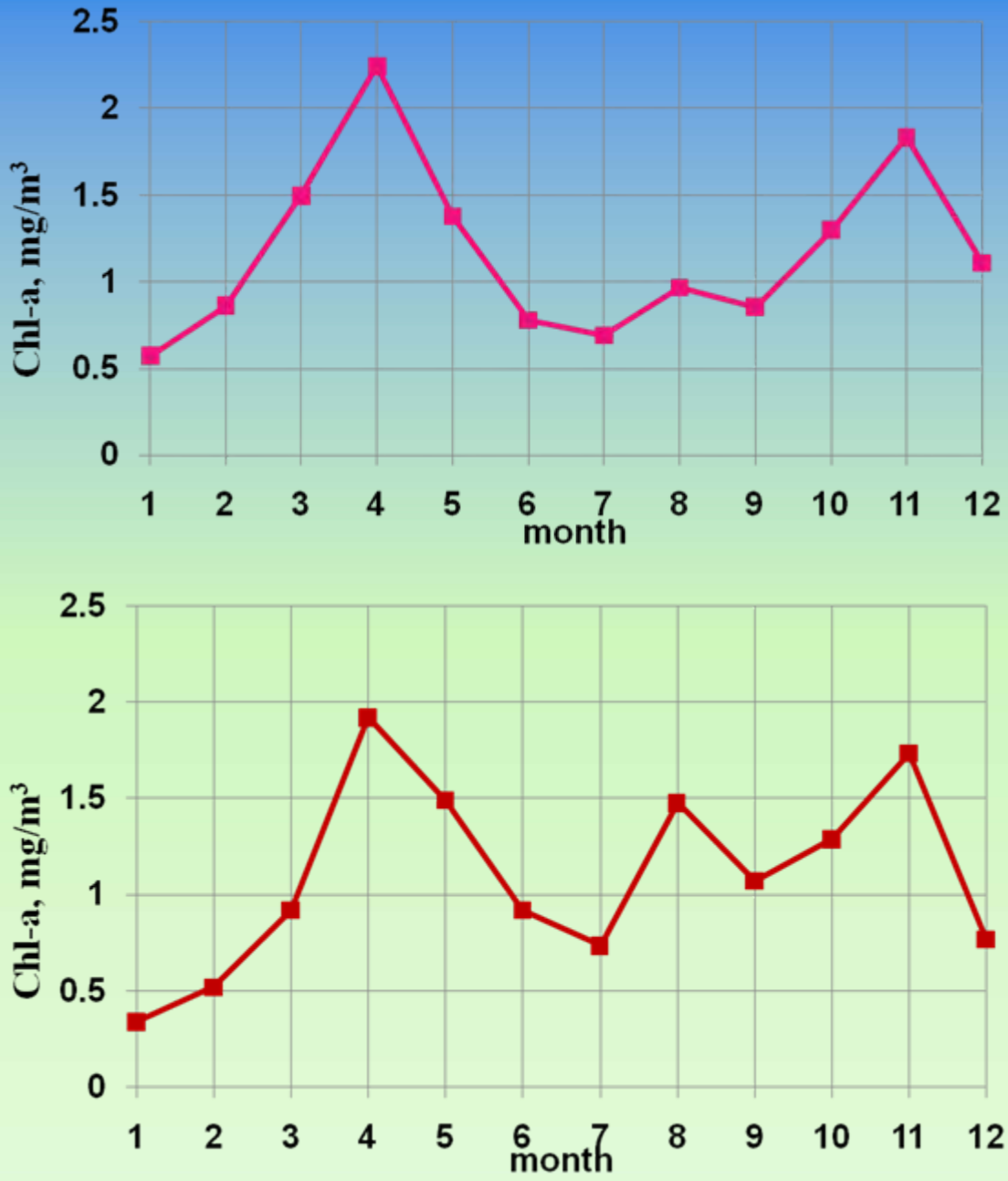


Figure 2. Temporal course of the average monthly chlorophyll-a concentration averaged for 1998-2007 (data from the SeaWiFS color scanner, top diagram) and for 2003-2007 (data from MODIS-Aqua spectroradiometer, bottom diagram) in Peter the Great Bay.

Anomaly indices for the chlorophyll-a concentration were calculated according to formula $A = \frac{C_{chl}(i) - \overline{C_{chl}}}{\sigma_{chl}}$ **,**

where $C_{chl}(i)$ **is the average monthly chlorophyll-a concentration in the specific year,**

$\overline{C}$ **is the average monthly chlorophyll-a concentration averaged for all years,** $\sigma_{chl} = \sqrt{\frac{1}{n}(\sum_{i=1}^{n}(C_{chl}(i) - \overline{C}_{chl})^2}$ **is standard deviation.**

These indices were compared to the anomaly indices which were similarly calculated by us for SST and for the atmospheric precipitation quantity.

Table 1. Anomaly indices for the average monthly chlorophyll-a concentration averaged on Peter the Great Bay in 2003-2007.

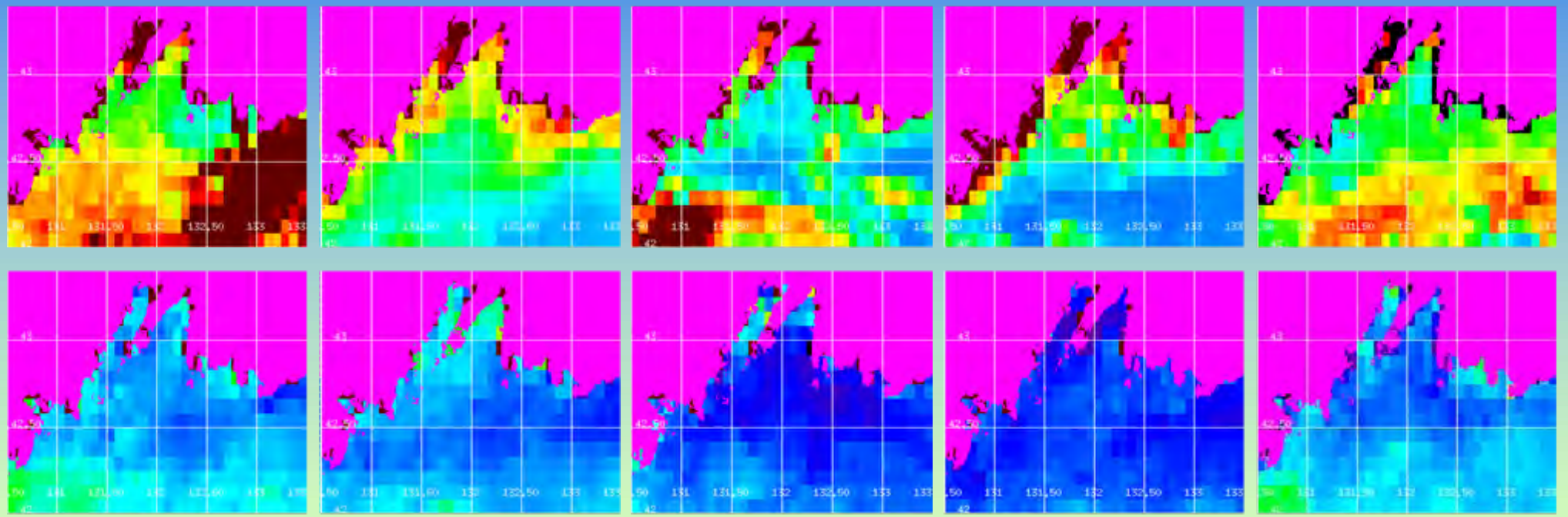
month	***year***				
	2003	***2004***	***2005***	***2006***	***2007***
1	-0.5	-0.5	-0.5	-0.5	**2**
2	0.98	0.47	***-1.2***	***-1.2***	0.98
3	**1.86**	-0.83	0.15	-0.34	-0.83
4	**1.98**	-0.62	-0.31	-0.68	-0.37
5	***-1.27***	**1.29**	1.06	-0.57	-0.51
6	***-1.48***	0.67	-0.57	-0.1	**1.44**
7	-0.5	-0.5	***-1.24***	**1.61**	0.61
8	0.88	**1.27**	-0.69	0.02	***-1.47***
9	-0.82	***-1.39***	0.32	0.43	**1.46**
10	-0.69	0.92	0.04	***-1.48***	**1.21**
11	0.59	***-1.4***	-0.08	-0.63	**1.52**
12	-0.91	-0.77	-0.77	**1.35**	1.09

Table 2. Anomaly indices for the average monthly SST averaged on Peter the Great Bay in 2003-2007.

month	Year				
	2003	2004	2005	2006	2007
1	-1.58	0.74	0.28	-0.65	1.21
2	-1.01	0.73	-0.66	-0.66	1.6
3	-0.15	0.77	-1.69	-0.15	1.23
4	1.44	0.41	-1.03	-1.24	0.41
5	1.48	0.08	-1.52	-0.52	0.48
6	0.36	-0.09	0.81	-1.89	0.81
7	-0.84	1.9	-0.81	-0.27	0.1
8	-0.83	-0.83	0.07	1.88	-0.29
9	0.27	0.1	0.53	-2.14	0.27
10	0.04	-1.21	1.82	-0.32	-0.32
11	-1.77	0.44	-0.29	1.18	0.44
12	-0.4	1.13	-1.46	-0.4	1.13

Table 3. Anomaly indices for the average monthly atmospheric precipitation quantity averaged on Peter the Great Bay in 2003-2007.

month	year				
	2003	2004	2005	2006	2007
1	1.64	-0.87	-0.87	-0.58	0.68
2	-1.64	1.26	-0.55	0.43	0.49
3	-0.92	0.1	-0.71	-0.35	1.88
4	-0.58	-1.09	0.34	1.62	-0.29
5	-1.69	0.99	0.48	-0.57	0.79
6	-0.27	-0.42	-0.53	1.97	-0.76
7	0.58	0.44	1.31	-1.15	-1.19
8	-1.61	-0.23	1.49	0.39	-0.04
9	-0.36	-0.05	-1.12	-0.34	1.87
10	0.51	-1.81	0.79	-0.34	0.86
11	0.31	1.71	-0.44	-0.27	-1.31
12	-1.21	0.97	0.29	-1.15	1.1



-scale for chlorophyll-a concentration

-scale for temperature

Figure 3. Average monthly distributions of chlorophyll-a and temperature for Peter the Great Bay in April of 2003-2007.

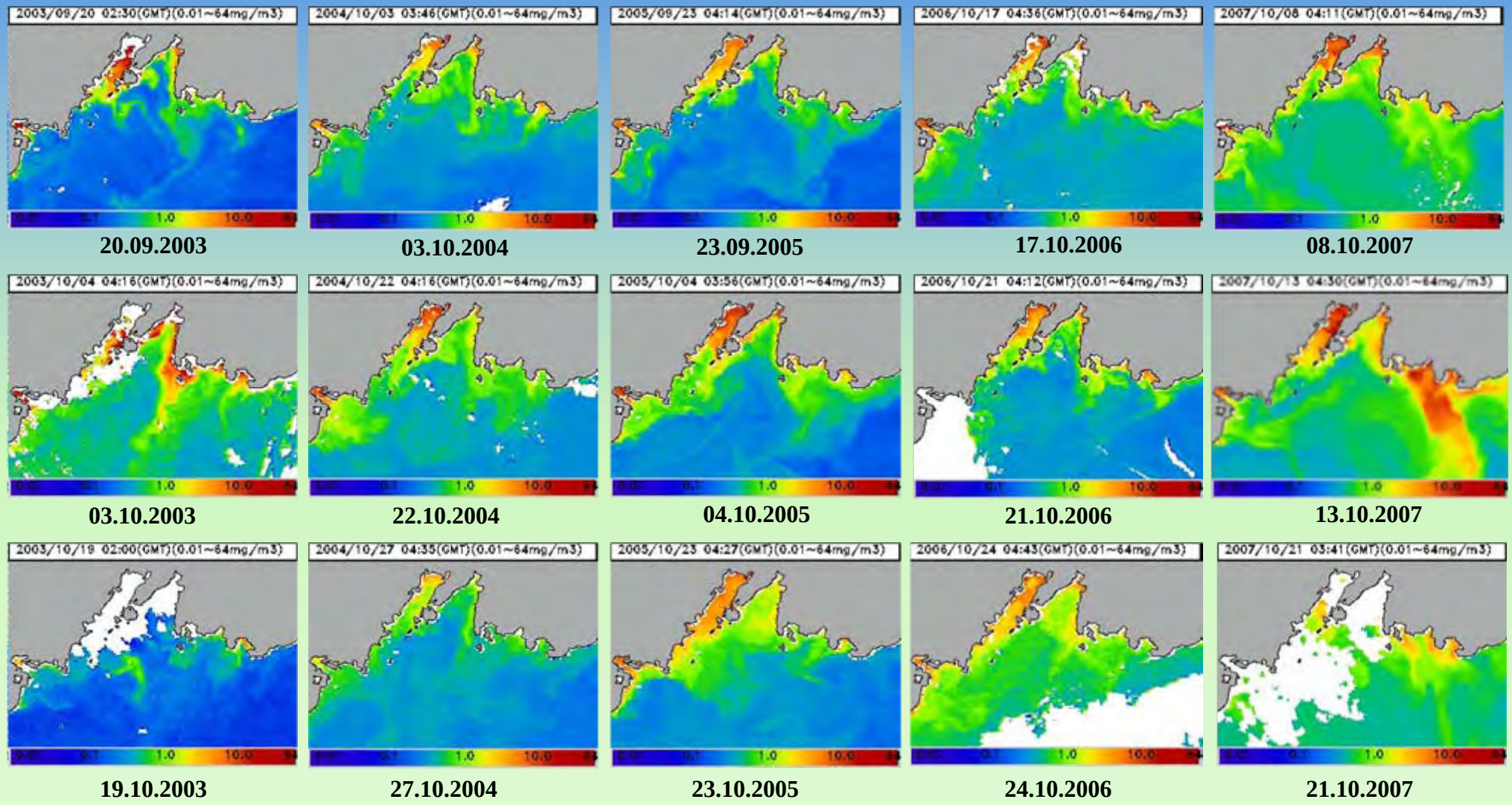


Figure 4. Chlorophyll-a distribution in Peter the Great Bay at the beginning of upwelling (top panel), the maximal appearance of upwelling (middle panel) and the disappearances of upwelling (bottom panel) in 2003-2007.

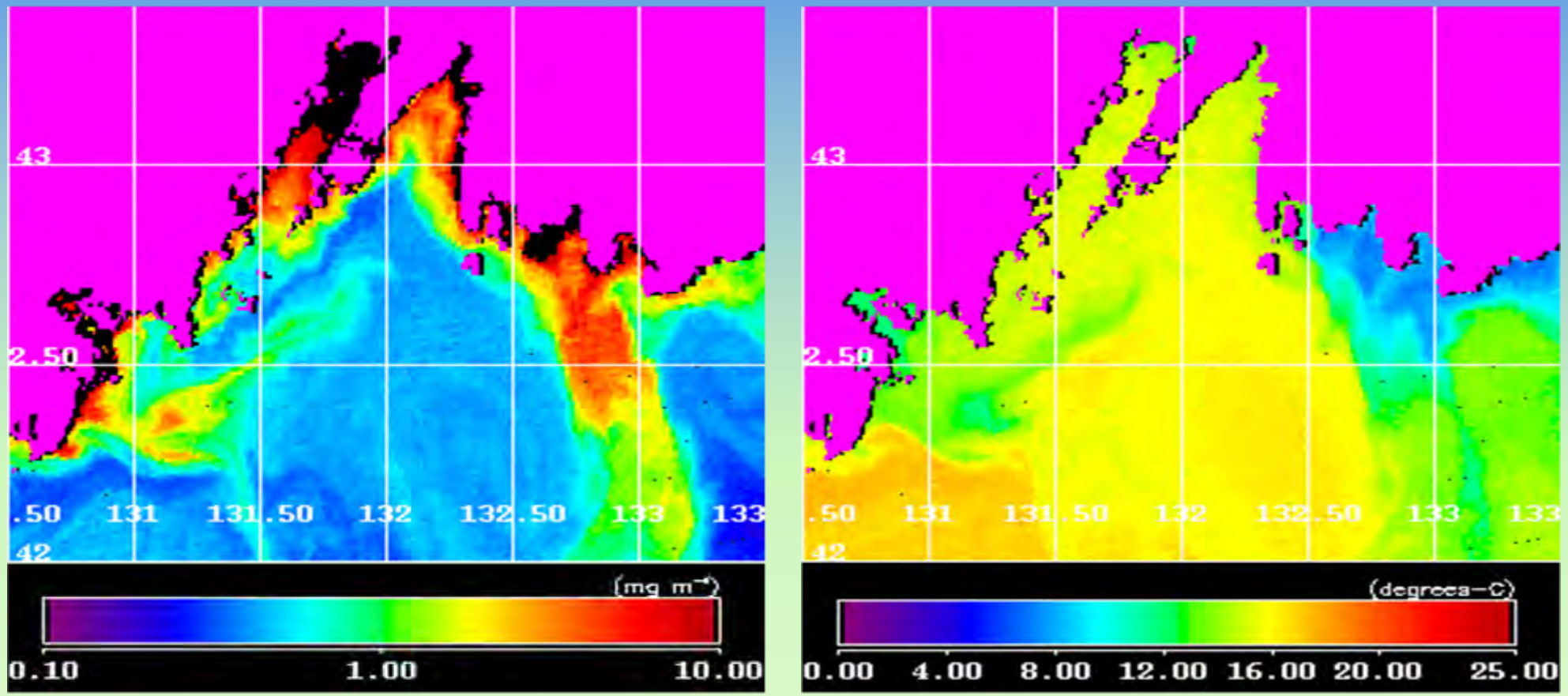
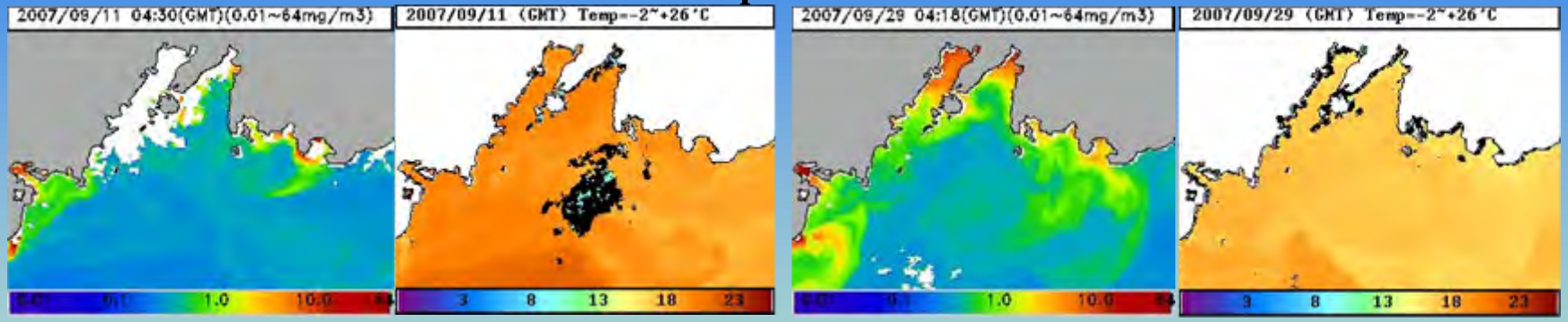


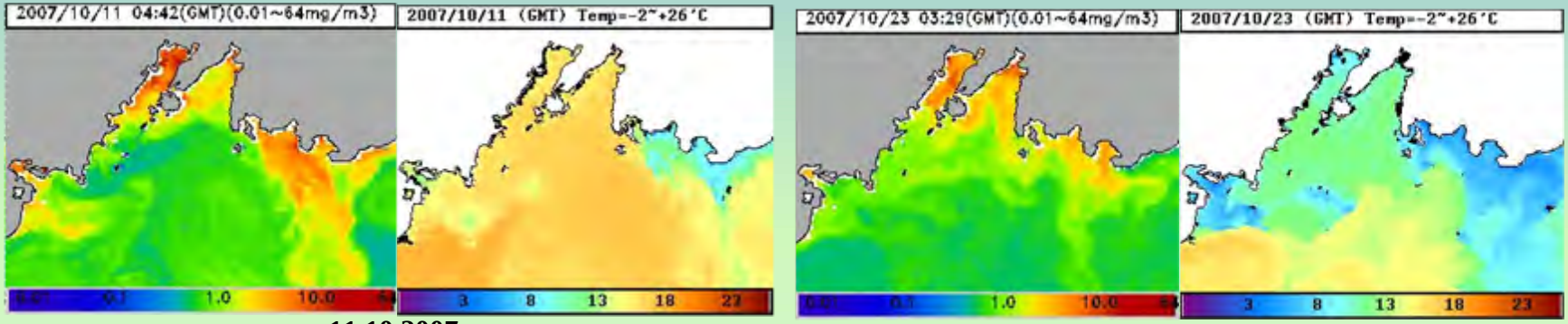
Figure 5. Chlorophyll-a and SST distribution in Peter the Great Bay at the wind upwelling on November 13, 2007.

September



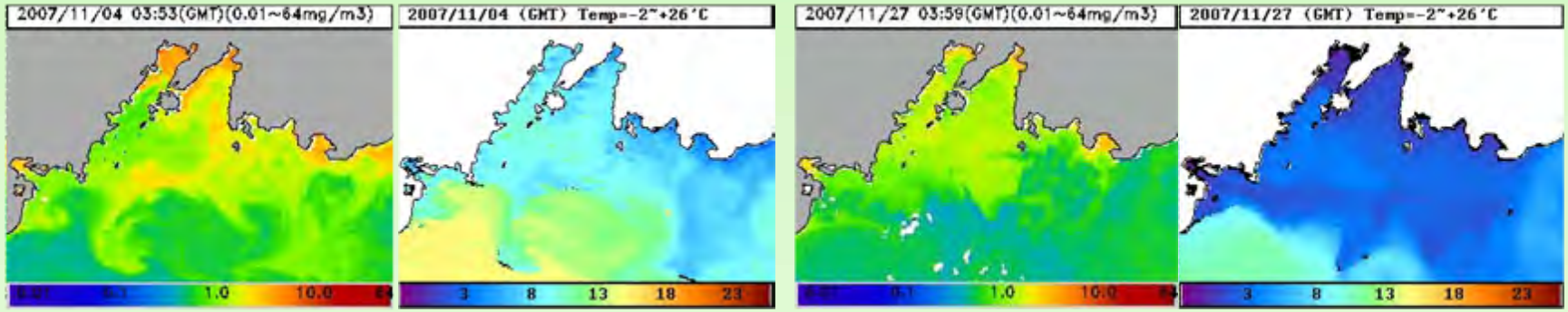
11.09.2007 **29.09.2007**

October



11.10.2007 **23.10.2007**

November



04.11.2007 **27.11.2007**

Figure 6 . Variability of chlorophyll-a and SST distributions in Peter the Great Bay in autumn 2007.

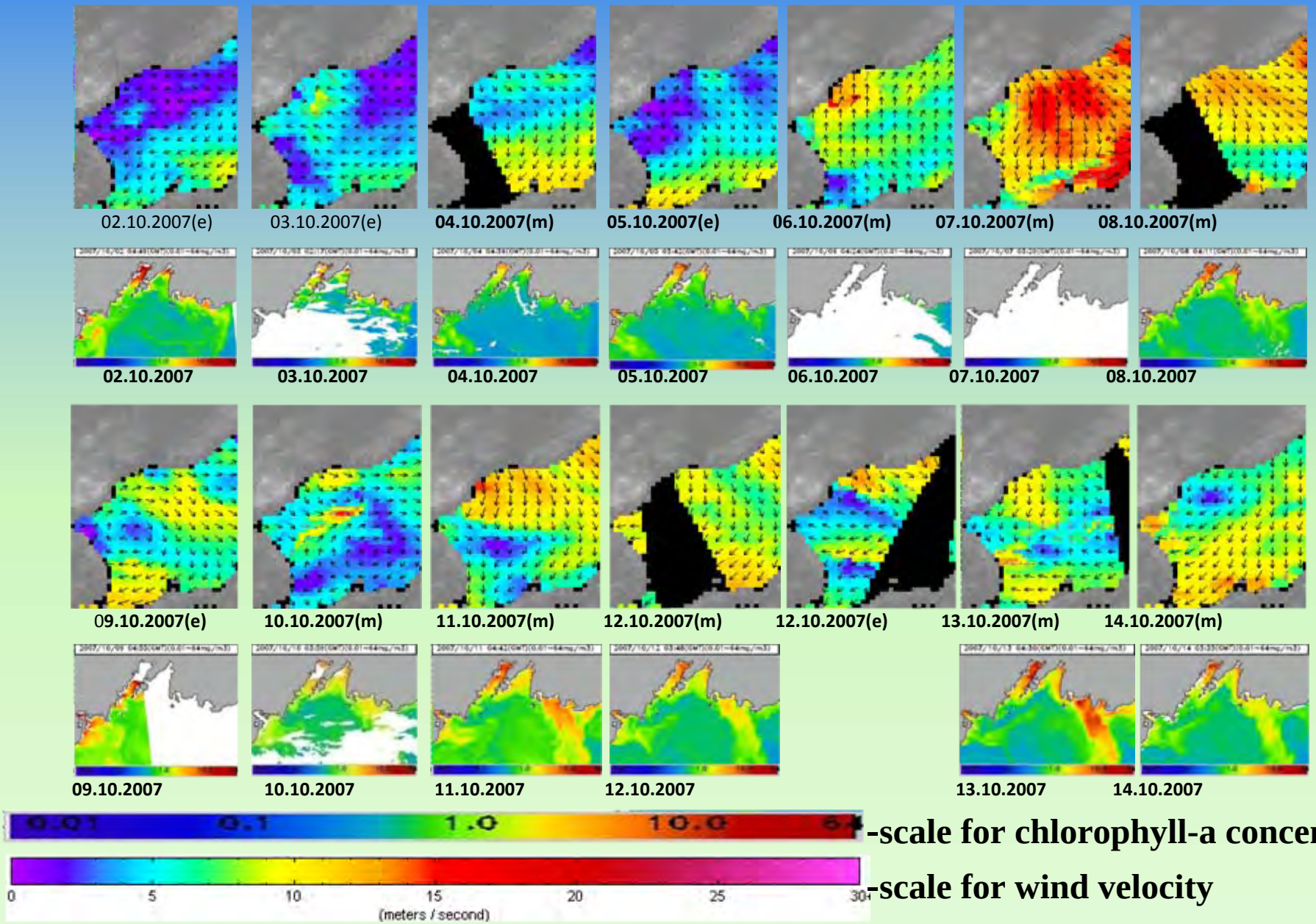
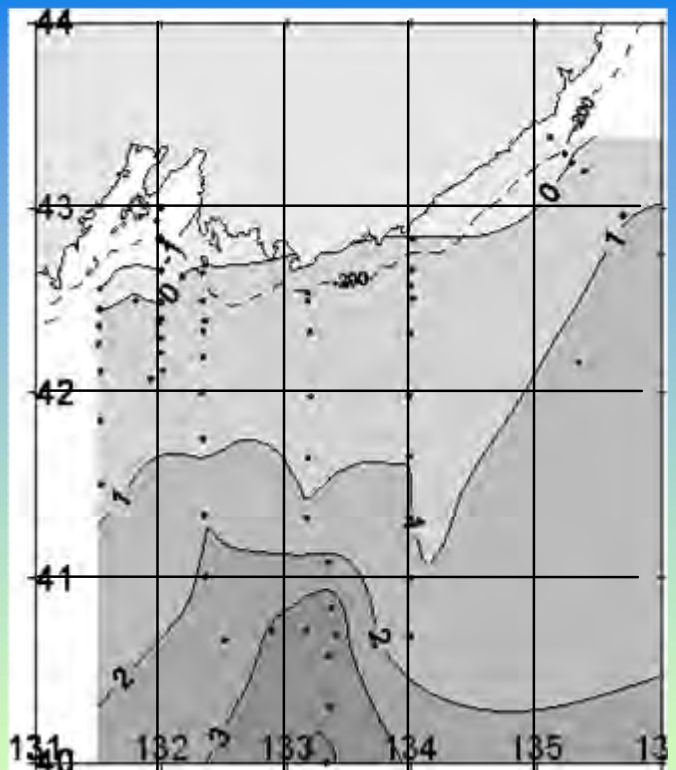
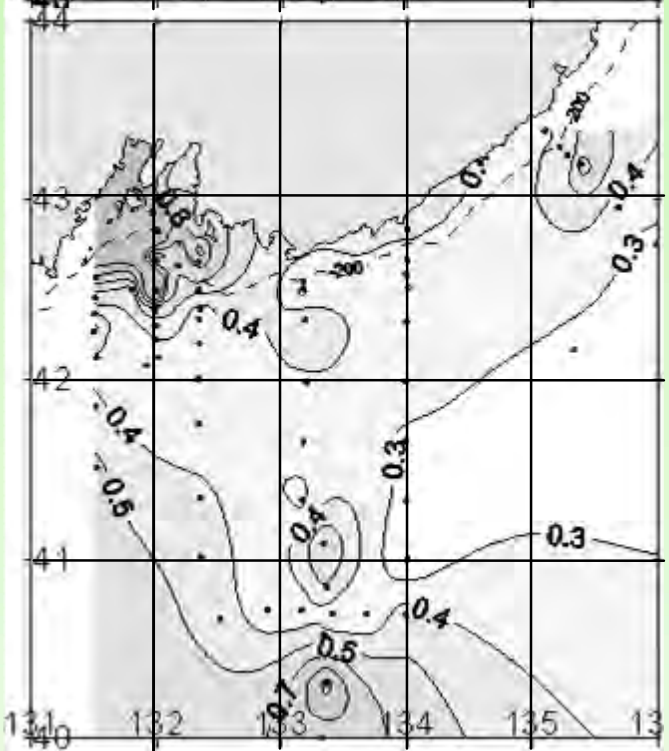
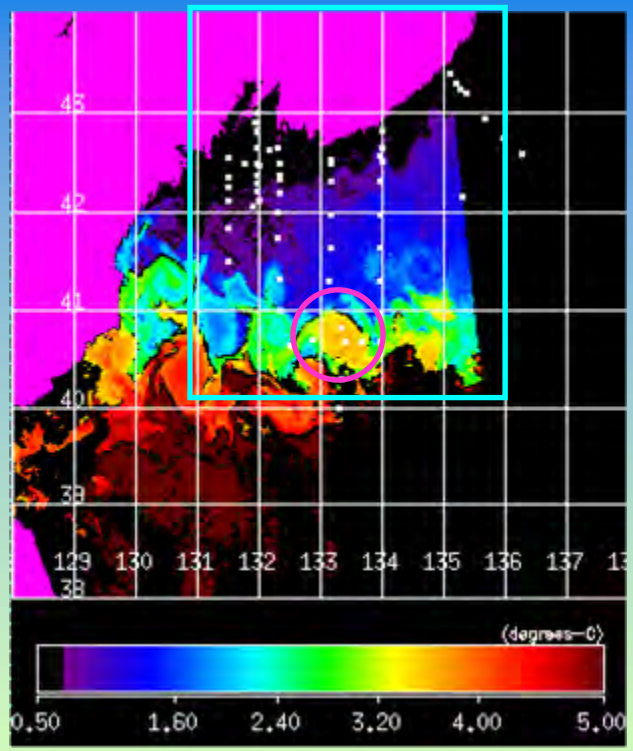


Figure.7. Influence of a wind on chlorophyll-a distribution in 2007. Distributions of a wind from October 2 to 14, 2007 and below their the corresponding chlorophyll-a distributions. Symbols of m or e in brackets mean the satellite observation of a wind in the morning or in the evening.







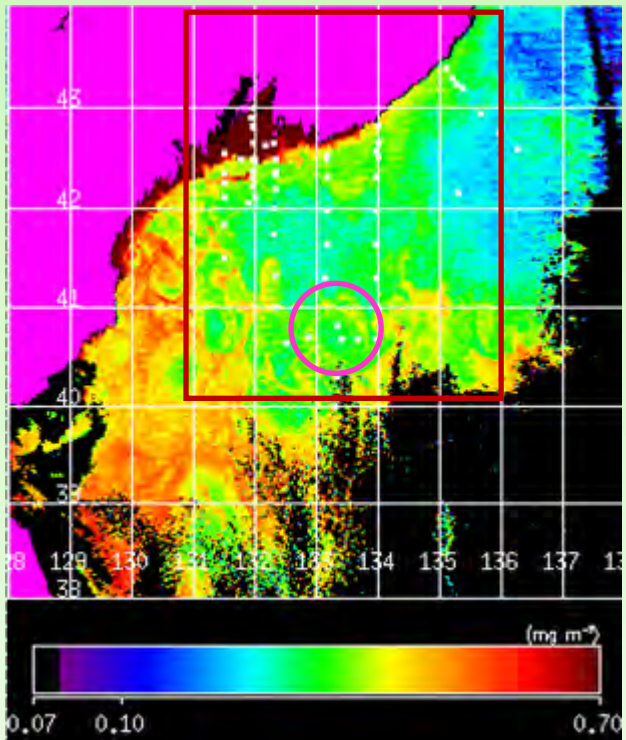


Figure 8. Ship and satellite distributions of the chlorophyll-a concentration and surface temperature. Points show the location of stations implemented in cruise of R/V "Akademik Lavrentiev" (from February 26 to March 9, 2003). Region of this cruise on satellite distributions is shown by rectangle. Location of the eddy is shown by the circle.

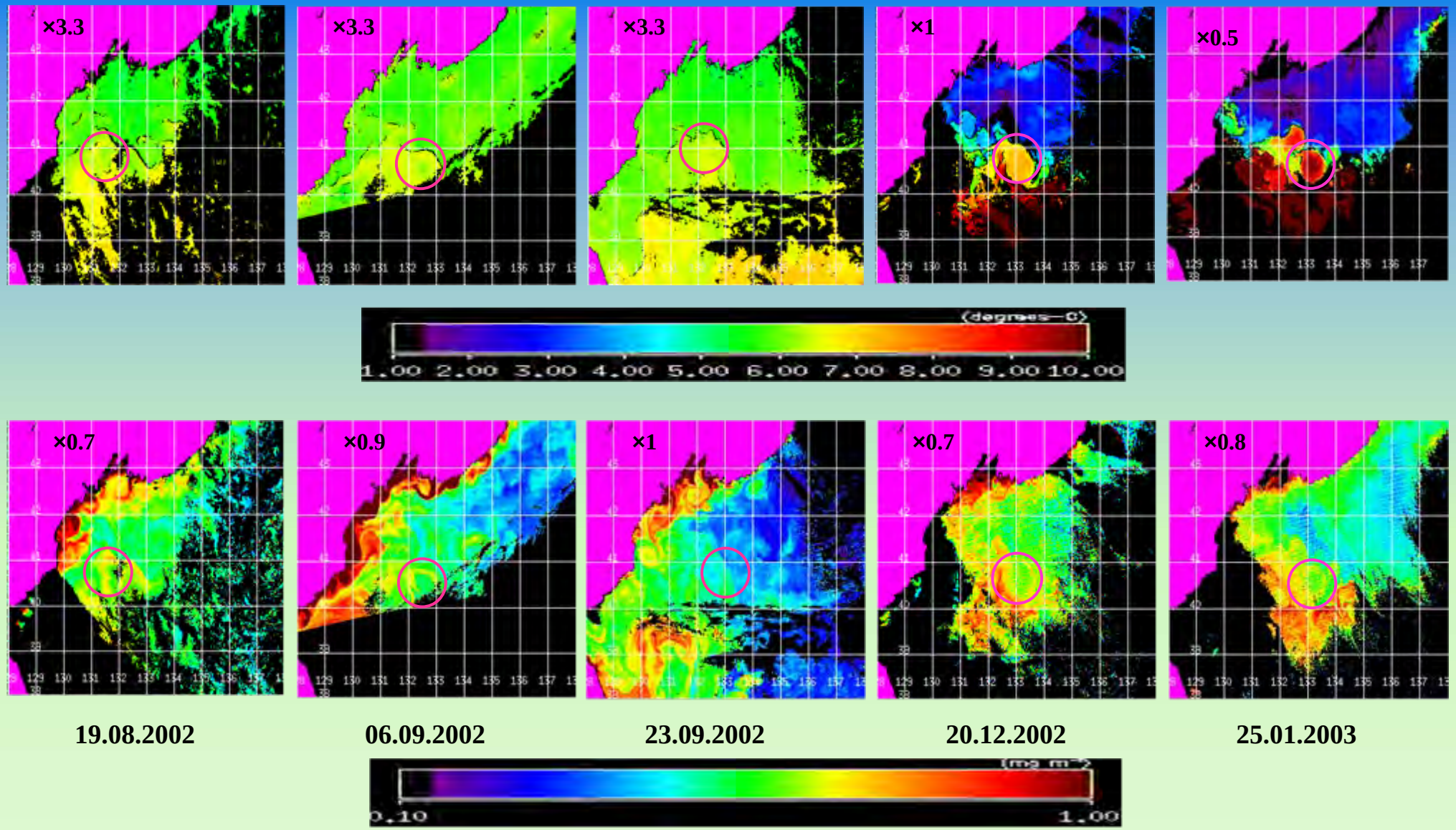


Figure 9. Distributions of chlorophyll-a concentration (bottom panel) and corresponding SST (top panel) in the eddy and outside its. Location of the eddy is shown by circle. Below distributions the scales are given. Coefficients in the upper left corners indicate the variability of these scales.

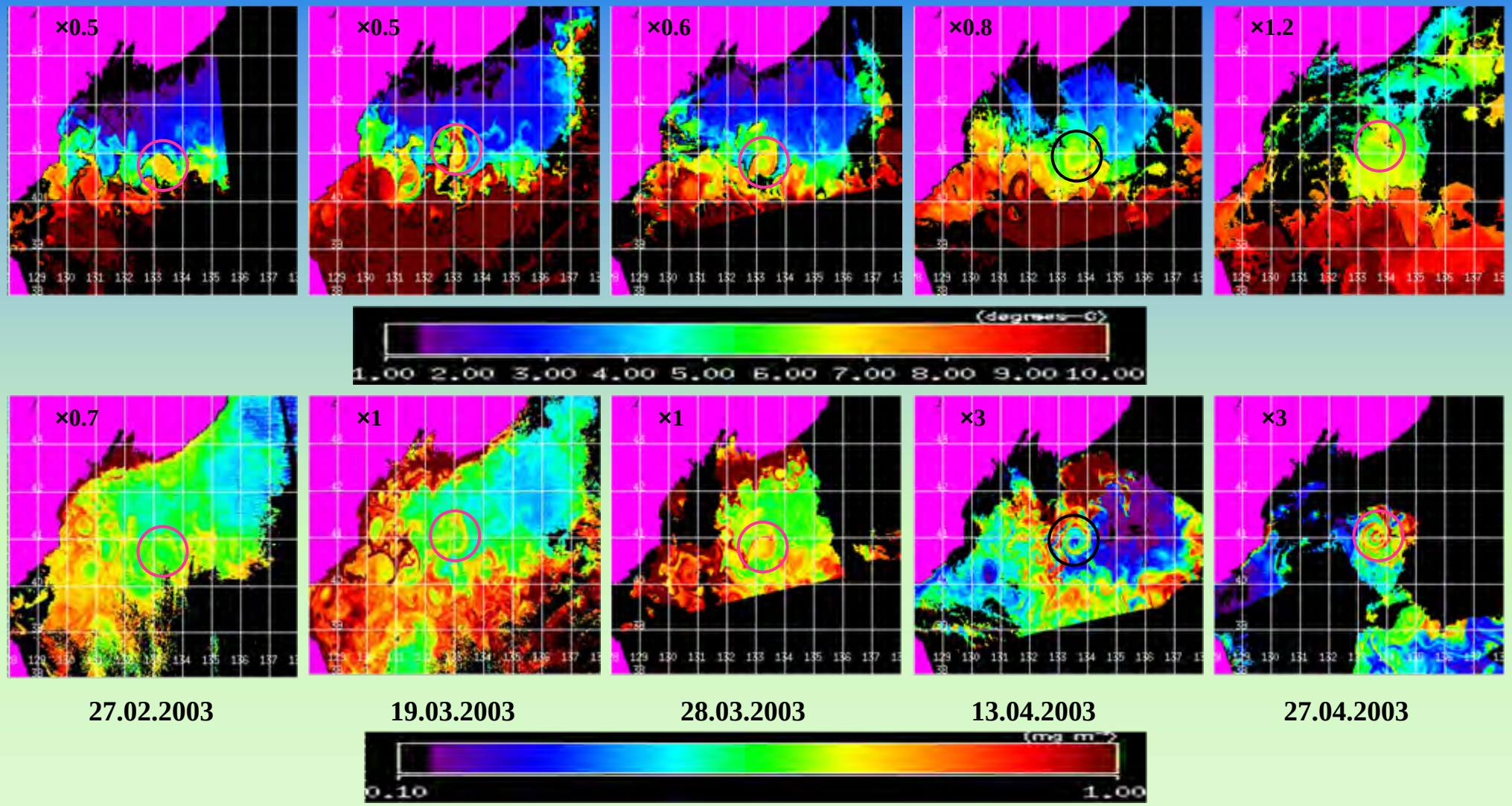


Figure 9 (continuation). Distributions of chlorophyll-a concentration (bottom panel) and corresponding SST (top panel) in the eddy and outside its. Location of the eddy is shown by circle. Below distributions the scales are given. Coefficients in the upper left corners indicate the variability of these scales.

CONCLUSIONS

-According to data of the temporal course in Peter the Great Bay the spring chlorophyll-a concentration maximum is in April-May and the autumn maximum is in November. There is also a summer maximum, which is lesser in comparison with the first two and occurs in August.

-The greatest anomalies of chlorophyll-a concentration for 5 years (from the MODIS-Aqua data) were observed for January, 2007, and April, 2003. It is noted that they are caused mostly by SST anomalies.

-The zone of increased chlorophyll-a concentration caused by wind upwelling was the most appreciable at the north-eastern bay coast. In separate years, it stretched from the coast in the open bay part more than 50 km offshore. October was most favorable for its development.

-The increased chlorophyll-a concentration on the periphery of the anticyclonic eddy located by a ship survey on February 27, 2003, in a region with coordinates of 40.5-41°N, 132.7-134°E were noted in August, 2002 – April, 2003.

Thank you for attention