Influence of environment factors on phytoplankton blooms in Peter the Great Bay (Sea of Japan) in winter-spring

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Processes such as seasonal warming, wind mixing, desalination of the superficial layer, and variability of photosynthetically available radiation can influence phytoplankton growth. In coastal areas the increased water runoff from coast at atmospheric precipitation can also influence on phytoplankton.

The goal of this work is to analyze the chlorophyll-a concentration variability in three zones of Peter the Great Bay in winter-spring taken into account the influence the increased coastal runoff at atmospheric precipitation.

Data

Satellite data

A series of 8-day ("week") composite estimates on
Chlorophyll-a concentration (Chl-a),
Photosynthetically Available Radiation (FAR) from SeaWiFS (OrbView-2) color scanner,
Near-Surface Wind Speed (obtained as 1-day data and composed to 8-day estimates) from QuikSCAT satellite,
Quantity of Atmospheric Precipitation (obtained as 1-day data and composed to 8-day estimates) from the TRMM satellite for January - May, 2000-2007,
Sea Surface Temperature (SST) from MODIS (Aqua) for January - May, 2003-2007 and MODIS (Terra) for January - May, 2000-2002,
Fluorescence Line Height (normalized) (FLH)from MODIS (Aqua) for January - May, 2003-2007,
Chromophoric Dissolved Organic Matter index (DOMI) from SeaWiFS (OrbView-2) for January - May, 2000-2007.

Acknowledgements

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

This study was implemented using additionally to a series of satellite 8-day composite estimates on chlorophyll-a concentration (Chl-*a*), FAR, the sea-surface wind speed and the quantity of atmospheric precipitation, the 8-day composite Ocean Color products giving the complementary information about satellite Chl-a estimate and environment. These products are Fluorescence Line Height (normalized), Chromophoric Dissolved Organic Matter index.

Chlorophyll fluorescence is the light energy not used at photosynthesis.

Chlorophyll fluorescence is determined as $Fl = Chl \times \langle a^*_{ph} \rangle \times iPAR \times \varphi$

$(Chl$ *is the chlorophyll concentration,* $\langle a^*_{ph} \rangle$ *is the spectrally − averaged, chlorophyll − −specific phytoplankton absorption coefficient,* $iPAR$ *is the flux of phytosynthetically active radiation,* φ *is the quantum yield of fluorescence (Kiefer et al., 1989)).*

Ratio of Fl/Chl shows the physiological state of the phytoplankton .

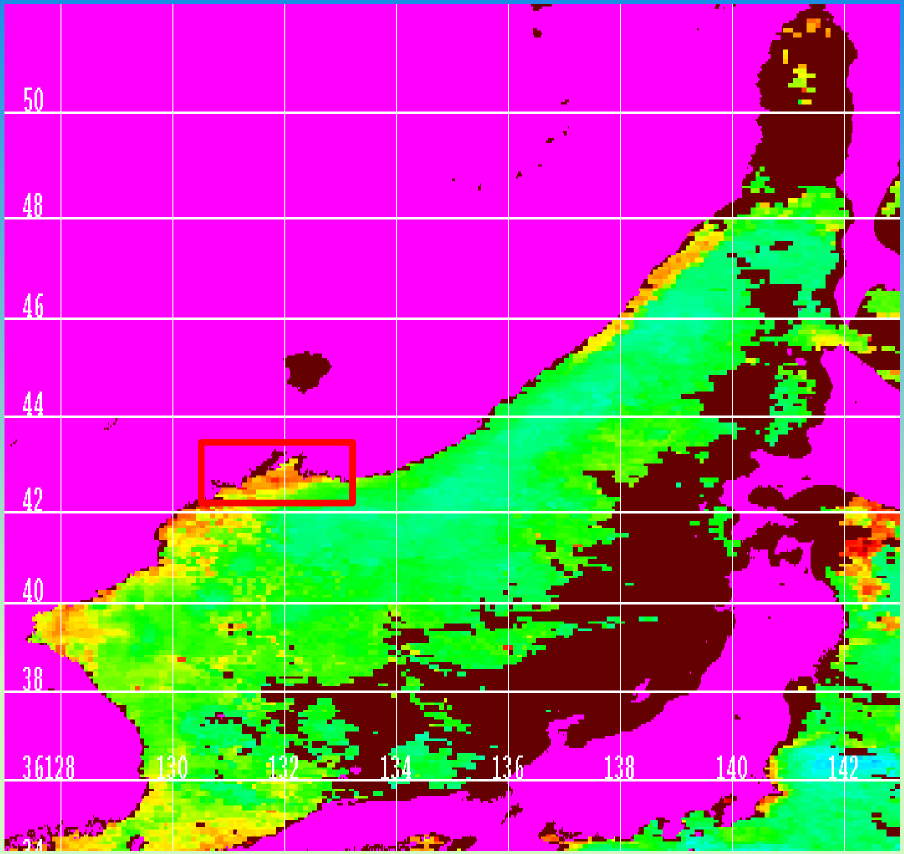
Fluorescence Line Height (normalized) (FLH) is normalized by downwelling irradiance:

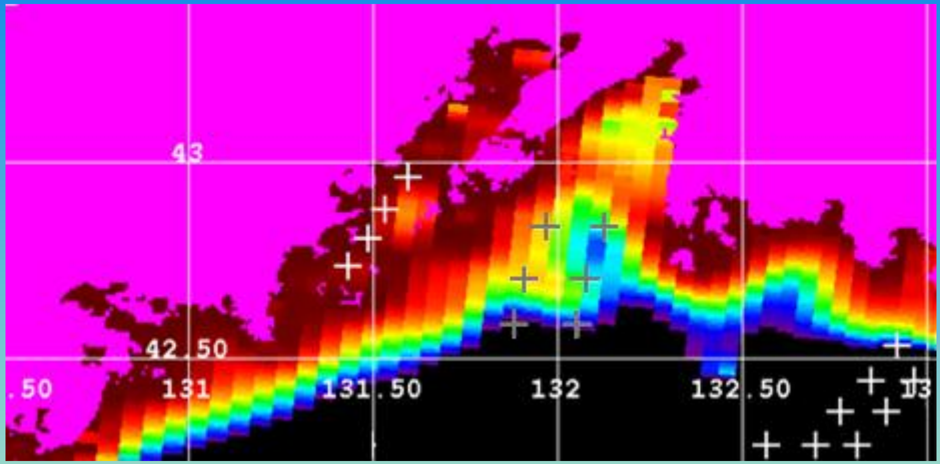
$$FLH = F_0(678)\frac{Lw,f(0^+,678)}{E_d(0^+,678)}$$

$(L_{w,f}(0^+,678)$ *is fluoresced radiance, also called fluorescence line height,* $F_0(\lambda)$ *is the solar irradiance spectrum at the top of the atmosphere,* $F_0(678) = const,$ $E_d(0^+,\lambda)$ *is downwelling irradiance just above the sea surface (Behrenfeld et al., 2009)).*

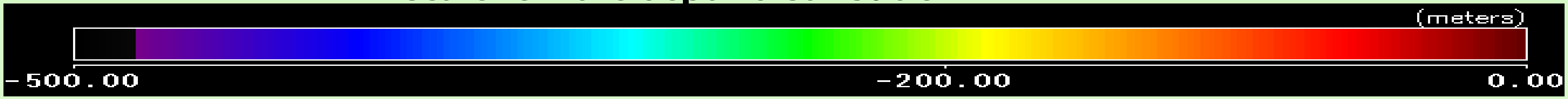
Fluorescence is an indicator both the amount of chlorophyll and the photosynthesis rate .

Chromophoric Dissolved Organic Matter index (I_{CDOM}) quantifies a relative departure (either an excess or a deficit) with respect to the standard Chl-a-dependent CDOM content. This index can serve as the indicator of satellite Chl-a estimates errors which are caused the dissolved organic matter not correlated with Chl-a (Morel, Gentili, 2009).

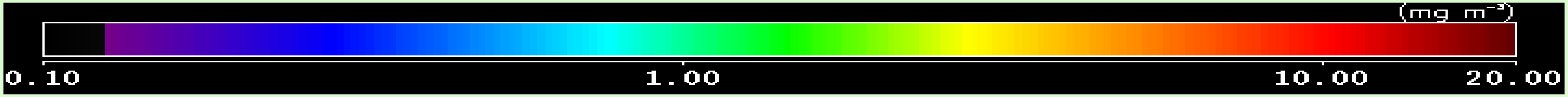




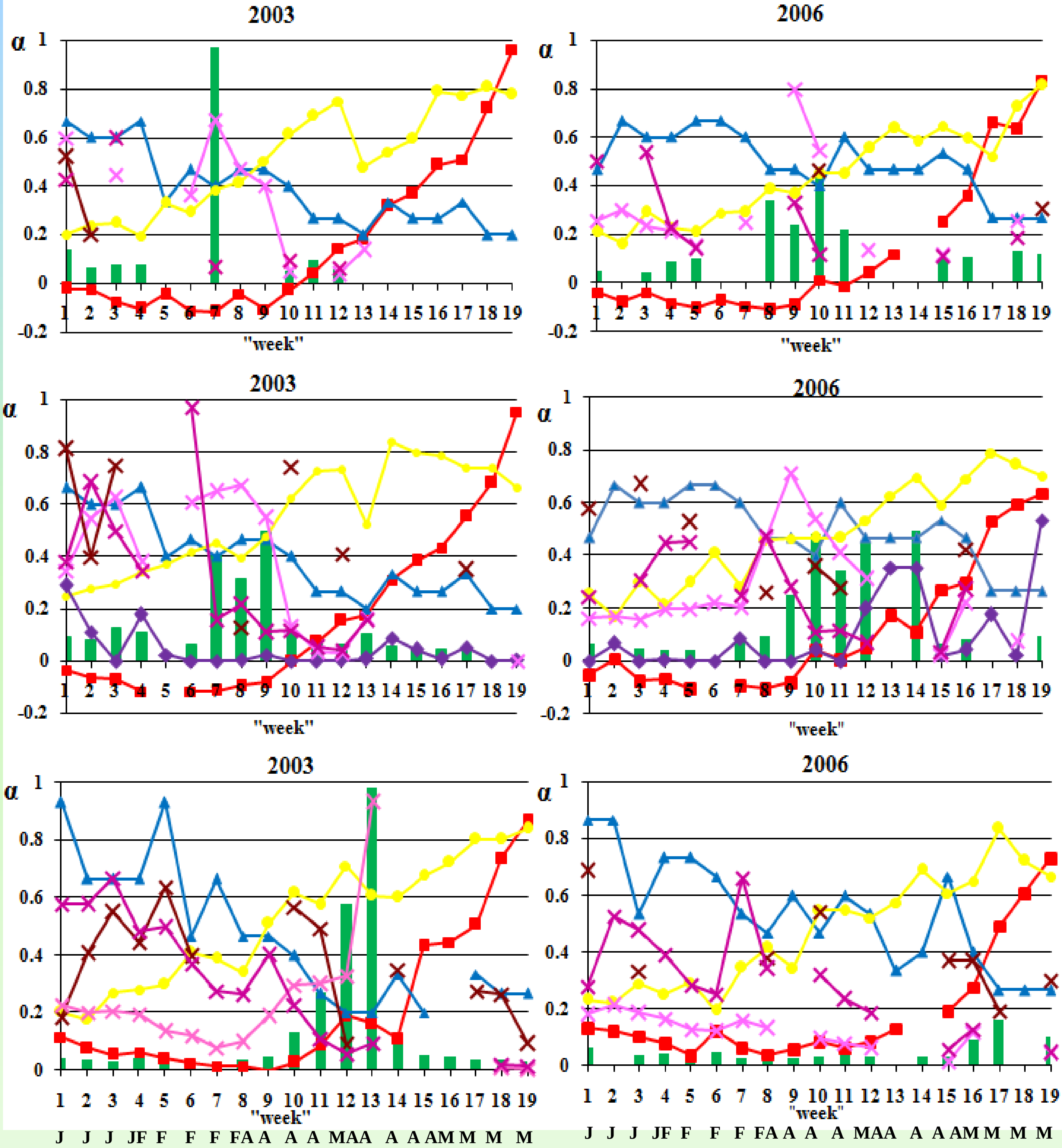
scale for the depth distribution



scale for the Cchl-a distribution



Composite distribution of chlorophyll-a concentration in Sea of Japan (the left) for the period of March 5-12, 2000 and bathymetric map of Peter the Great Bay (the right). The location of Peter the Great Bay is shown and locations for analysis of chlorophyll-a concentration.



Variation of 8-days ("week") satellite chlorophyll-a concentration (Cchl-a, mg/m^3) in Peter the Great Bay (top panel – for Amur Bay, medium panel - for Ussuri Bay, bottom panel – for the zone of the Primorye Current) from 1st to 19th "week" for 2003 and 2006 and corresponding values of SST (red line), wind speed (blue line), FAR (yellow line), FLH (pink line), FLH/Cchl (crimson line), DOMI (brown line). Violet line on the diagram for zone 1 shows the quantity of atmospheric precipitation, averaged for Peter the Great Bay. Values were normalized by maximum value.

Maxima: Cchl-a - 10 mg/m^3

SST - 13°C, wind speed - 15 m/sec,

FAR - 60Einsteins/m^2×day,

quantity of atmospheric precipitation - 45 mm,

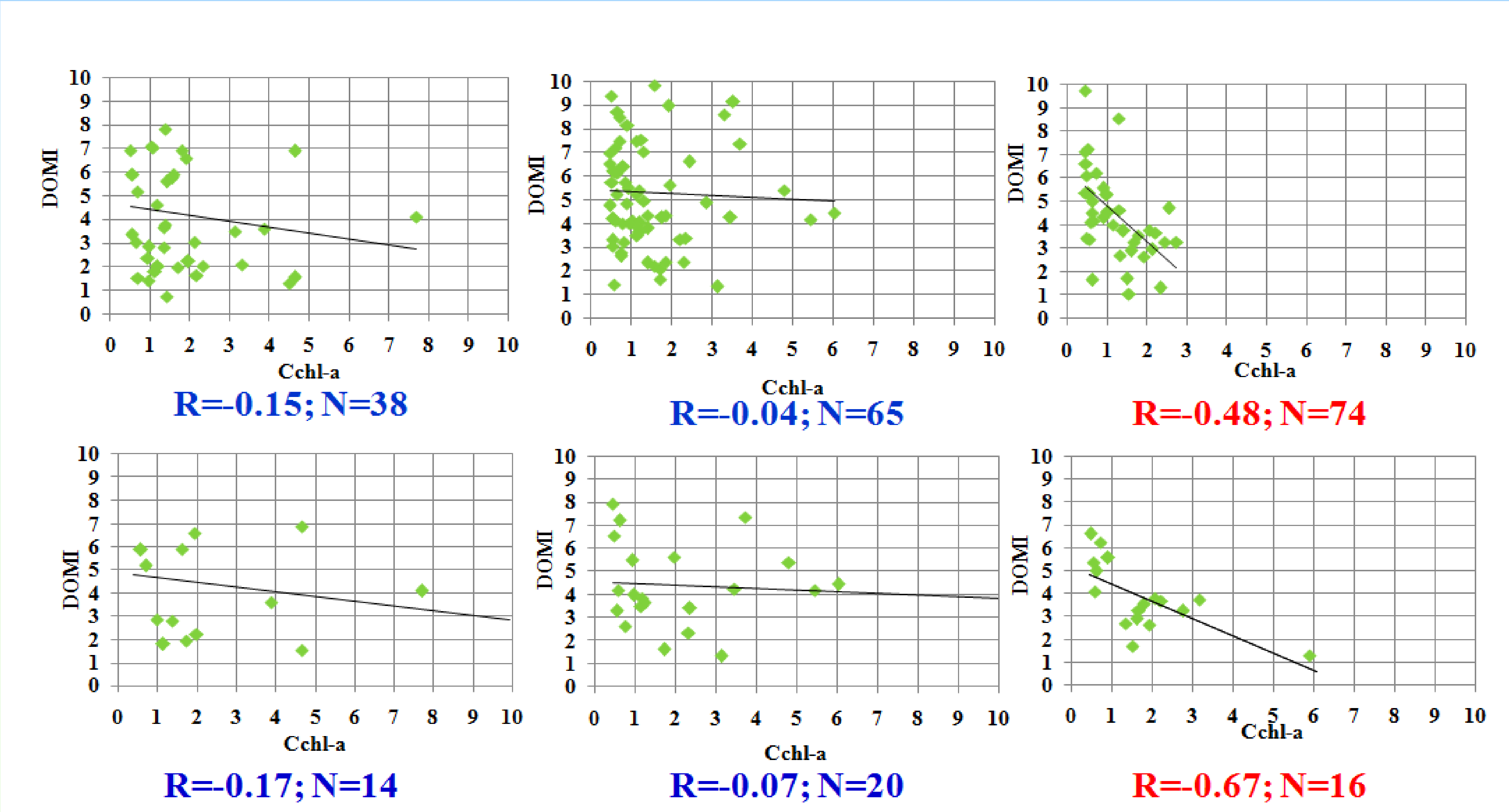
FLH – 0.03 mWcm^-2 μm^-1 sr^-1,

FLH/Cchl – 0.03 mWcm^-2 μm^-1 sr^-1 per mg m^-3

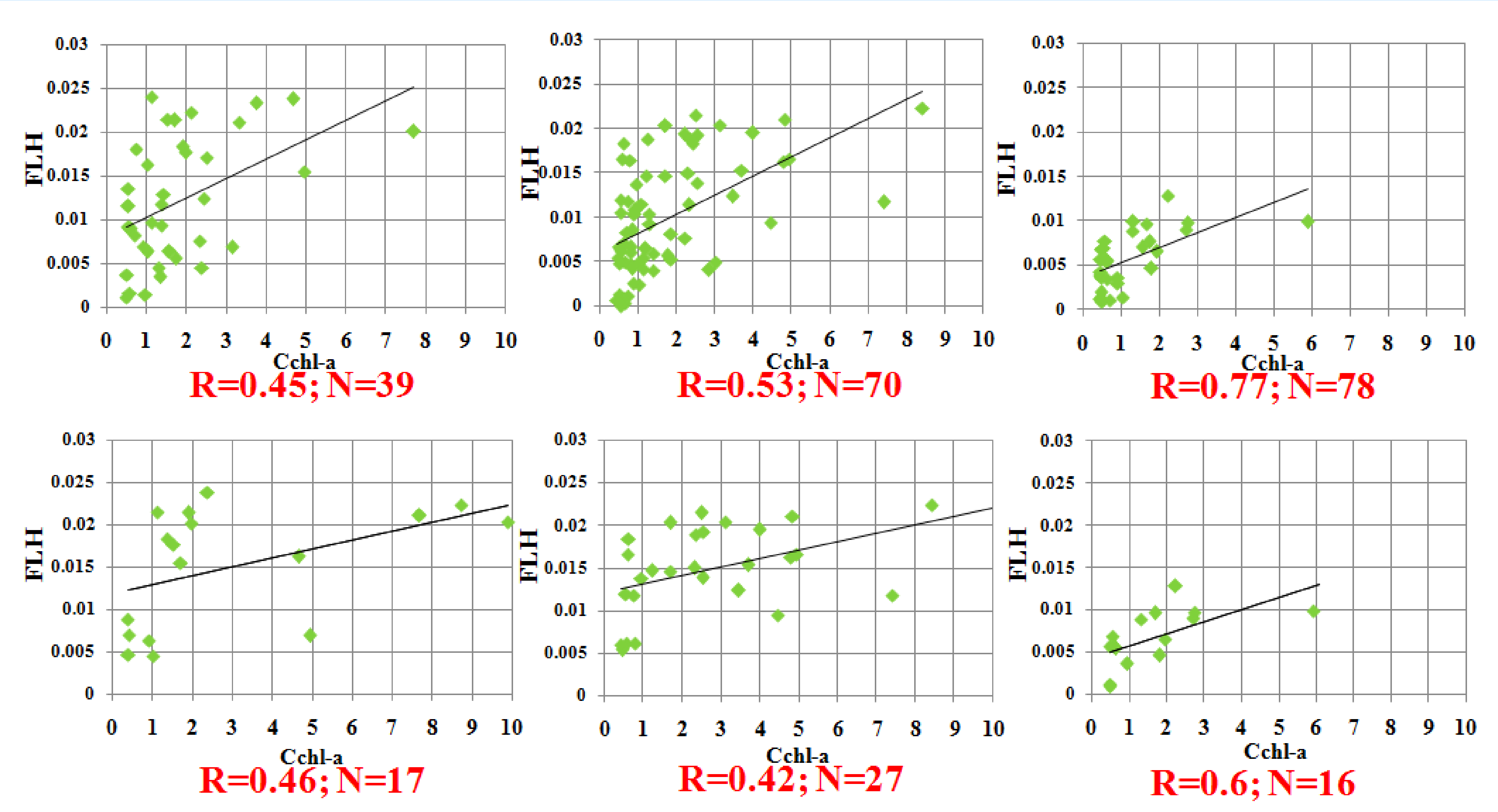
Correlation between Cchl-a and SST, wind speed (V), FAR, DOMI, FLH

(a number of points is shown in brackets, the statistical significant of correlation coefficients are shown by red color, while the insignificant correlation- by blue color)

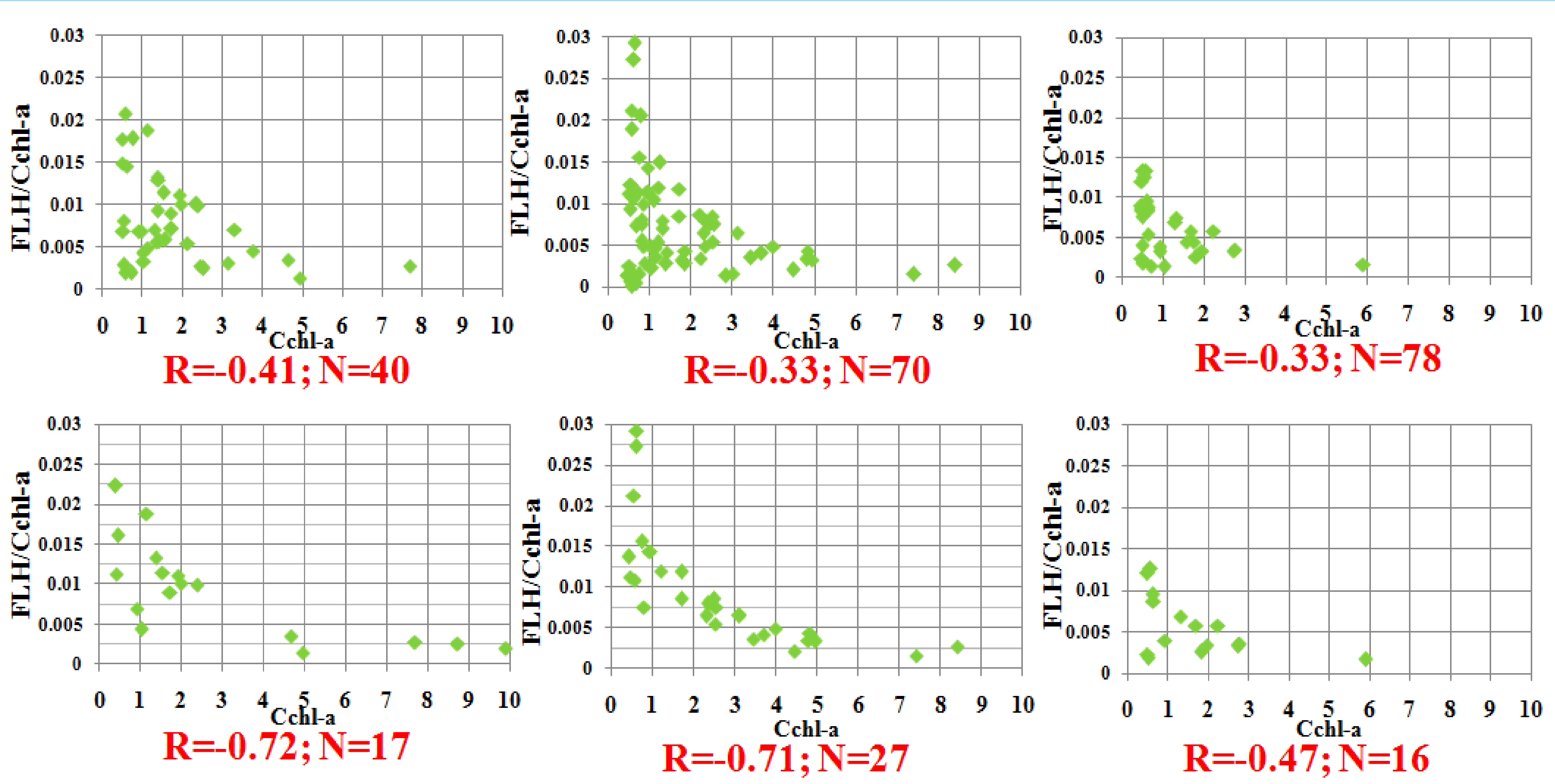
	Cchl-SST	Cchl-V	Cchl-FAR	Cchl-DOMI	Cchl-FLH
Amur Bay					
from 1st “week” to the Cchl-a maximum	-0.22 (37)	-0.54 (38)	0.62 (31)	-0.12 (21)	0.49 (20)
from the beginning of Cchl-a increase to its maximum	-0.01 (25)	-0.58 (27)	0.55 (20)	-0.17 (14)	0.46 (17)
Ussuri Bay					
from 1st “week” to the Cchl-a maximum	0.02 (47)	-0.55 (48)	0.61 (49)	-0.21 (33)	0.52 (41)
from the beginning of Cchl-a increase to its maximum	0.28 (30)	-0.43 (32)	0.51(30)	-0.07 (20)	0.42 (27)
zone of the Primorye Current					
from 1st “week” to the Cchl-a maximum	0.5 (105)	-0.54 (117)	0.52 (116)	-0.51(49)	0.8 (67)
from the beginning of Cchl-a increase to its maximum	0.36 (34)	-0.52 (34)	0.11 (34)	-0.67 (16)	0.6 (16)



Scattering diagrams: Cchl-a vs. DOMI in Amur Bay (first column), Ussuri Bay (second column), and the zone of the Primorye Current (third column) from 1st to 19st "week" (top panel) and from the beginning of Chl-a increase to its maximum (bottom panel). Below diagrams the correlation coefficients (R) and a number of diagram points are presented. The statistical significant of correlation coefficients are shown by red color, while the insignificant correlation- by blue color.

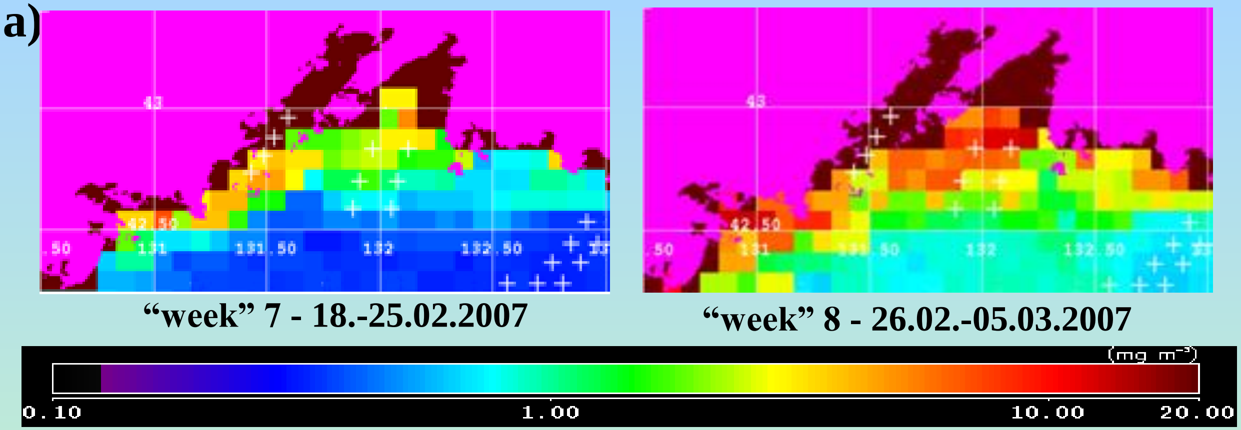


Scattering diagrams: Cchl-a (mg/m^3) vs. FLH (mW/ cm^2 μm sr) in Amur Bay (first column), Ussuri Bay (second column), and the zone of the Primorye Current (third column) from 1st to 19st "week" (top panel) and from the beginning of Cchl-a increase to its maximum (bottom panel). Below diagrams the correlation coefficients (R) and a number of diagram points are presented. The statistical significant of correlation coefficients are shown by red color, while the insignificant correlation- by blue color.



Scattering diagrams: Cchl-a (mg/m^3) vs. FLH/Cchl-a (mW/ cm^2 µm sr per mg/m^3) in Amur Bay (first column), Ussuri Bay (second column), and the zone of the Primorye Current (third column) from 1st to 19st "week" (top panel) and from the beginning of Cchl-a increase to its maximum (bottom panel). **Below diagrams the correlation coefficients (R) and a number of diagram points are presented. The statistical significant of correlation coefficients are shown by red color, while the insignificant correlation- by blue color**

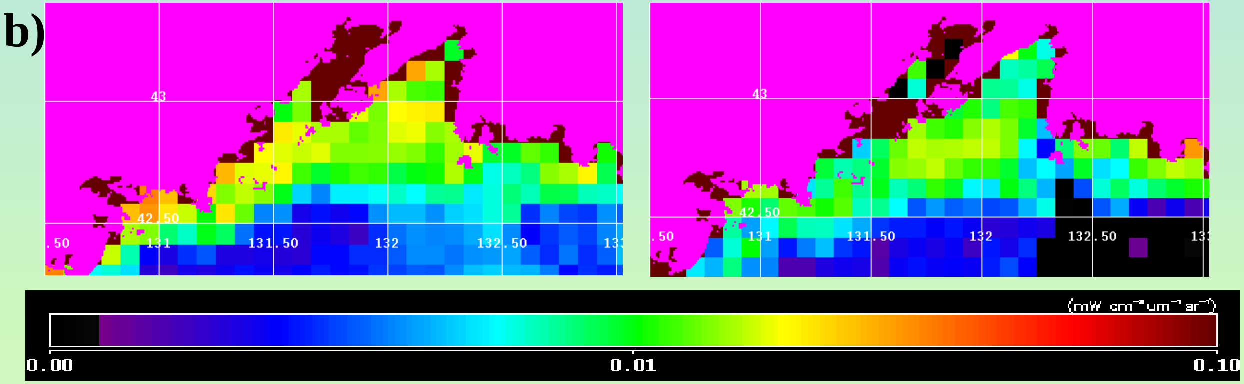
a)



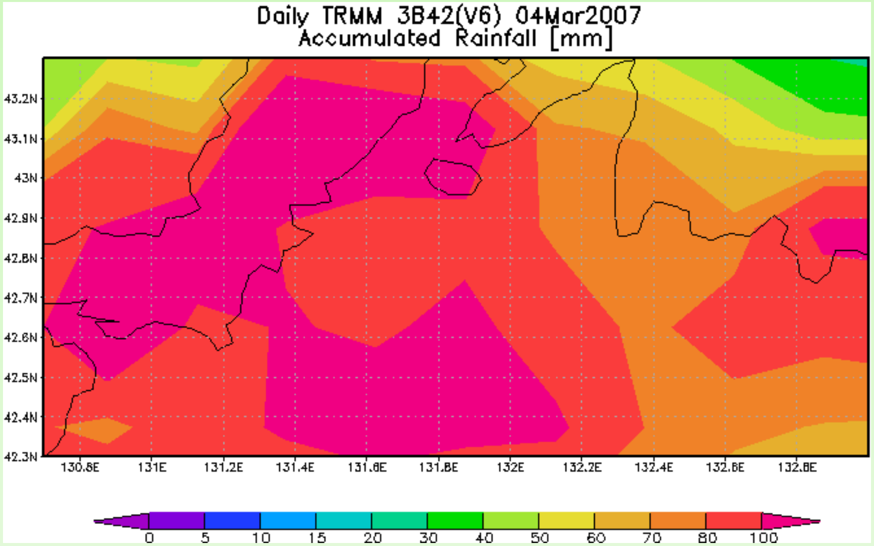
"week" 7 - 18.-25.02.2007

"week" 8 - 26.02.-05.03.2007

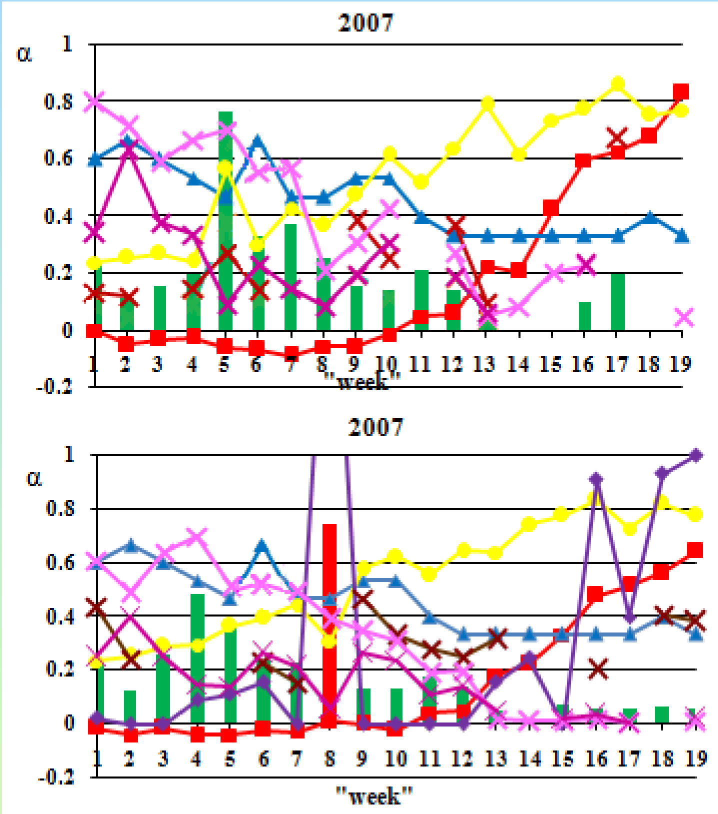
b)



c)

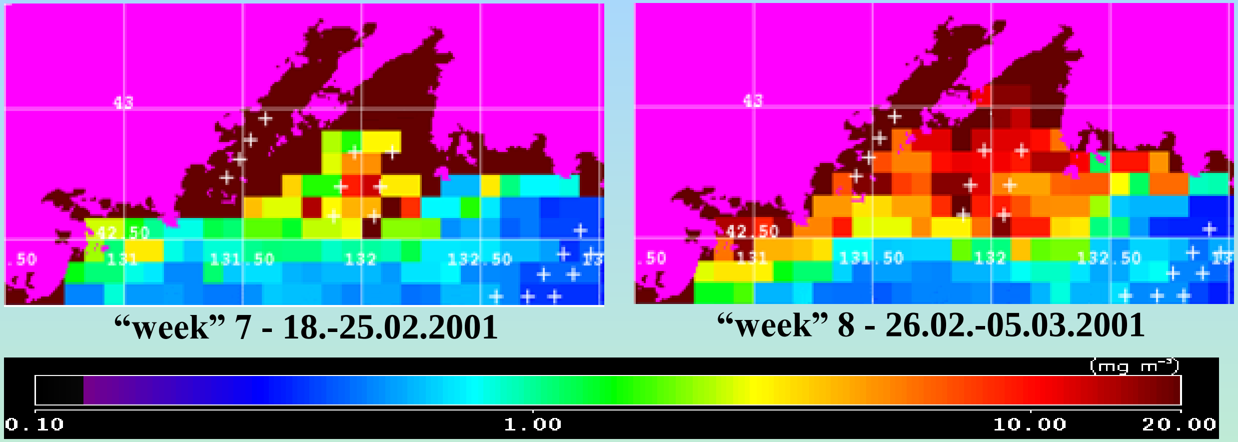


d)



Study of the Cchl-a increase on "week" 8, 2007: a) Cchl-a distributions on "week" 7, 8 and corresponding distributions of b) Fluorescence Line Height; c) atmospheric precipitation d) temporal course of Cchl-a, averaged by points in Amur Bay (top panel) and Ussuri Bay (bottom panel)

a)



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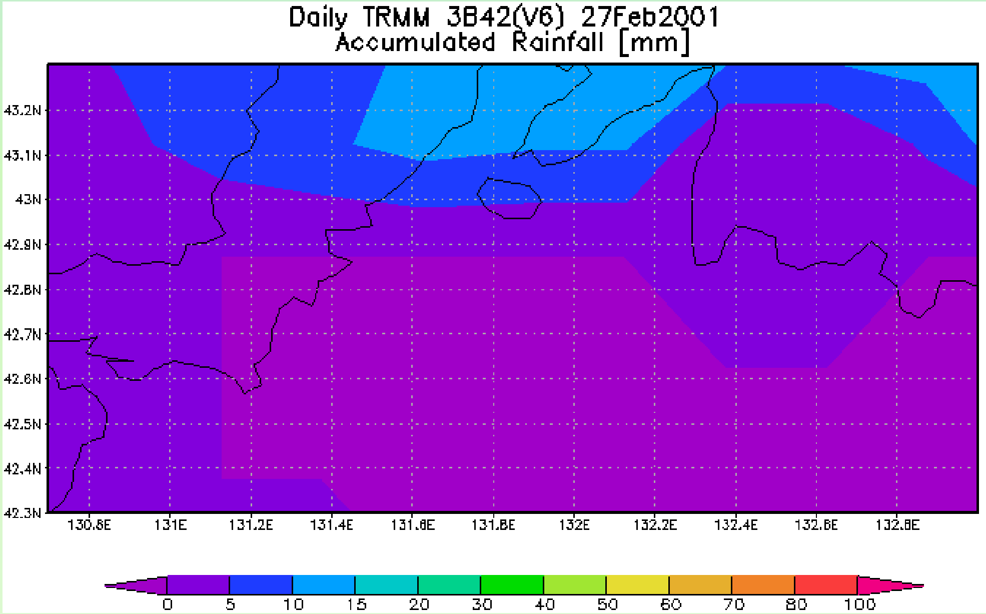

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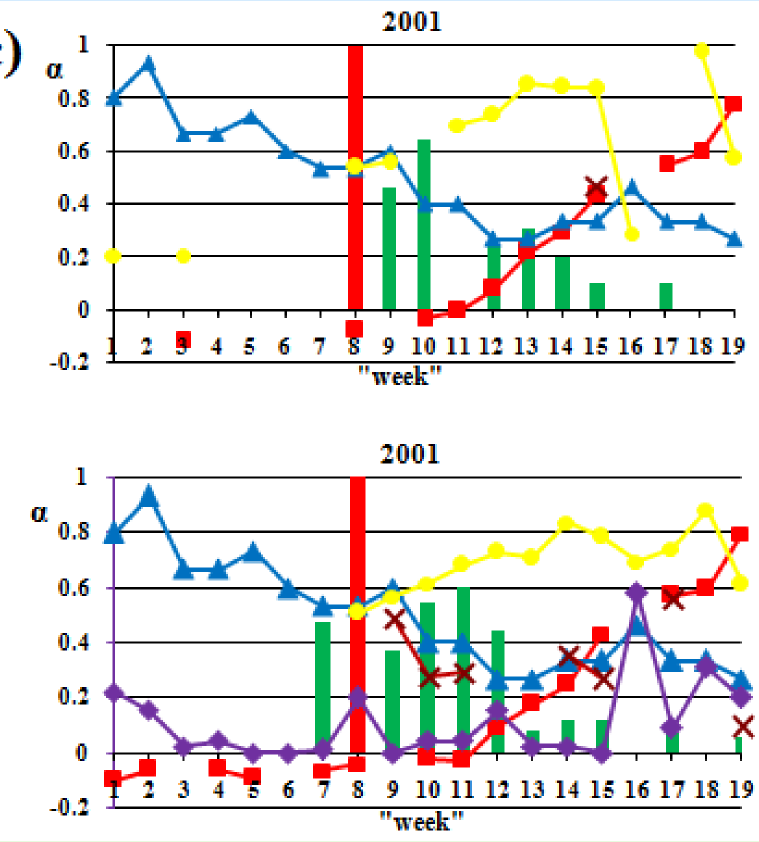

Study of the Cchl-a increase on “week” 8, 2001: a) Cchl-a distributions on “week” 7, 8 and corresponding distribution of b) atmospheric precipitation, c) temporal course of Cchl-a, averaged by points in Amur Bay (top panel) and Ussuri Bay (bottom panel)

CONCLUSIONS

-In coastal zone (Amur Bay, Ussuri Bay) Chl-a does not correlate with Dissolved Organic Matter index, while in the zone of the Primorye Current – correlate. It is possibly caused by the coastal runoff in coastal zone. (Coastal runoff is the additional source of dissolved organic matter independently from Chl-a, dissolved organic matter influences on the error of satellite Chl-a estimate).

-Fluorescence per Chl-a at the zone of the Primorye Current from January to May is lower than in the coastal zone. It can be related to the difference of physiological phytoplankton state, determined e. g. the phytoplankton species, environment state.

-Sharp strong satellite Chl-a increase is caused by the increasing coastal runoff arising due to the atmospheric precipitation.

Thank you
for attention