

**Seasonal and interannual variations in the spread of the Razdolnaya and Tumannaya Rivers runoffs (Peter the Great Bay, Japan/East Sea) according to the satellite data on SST and ocean color**

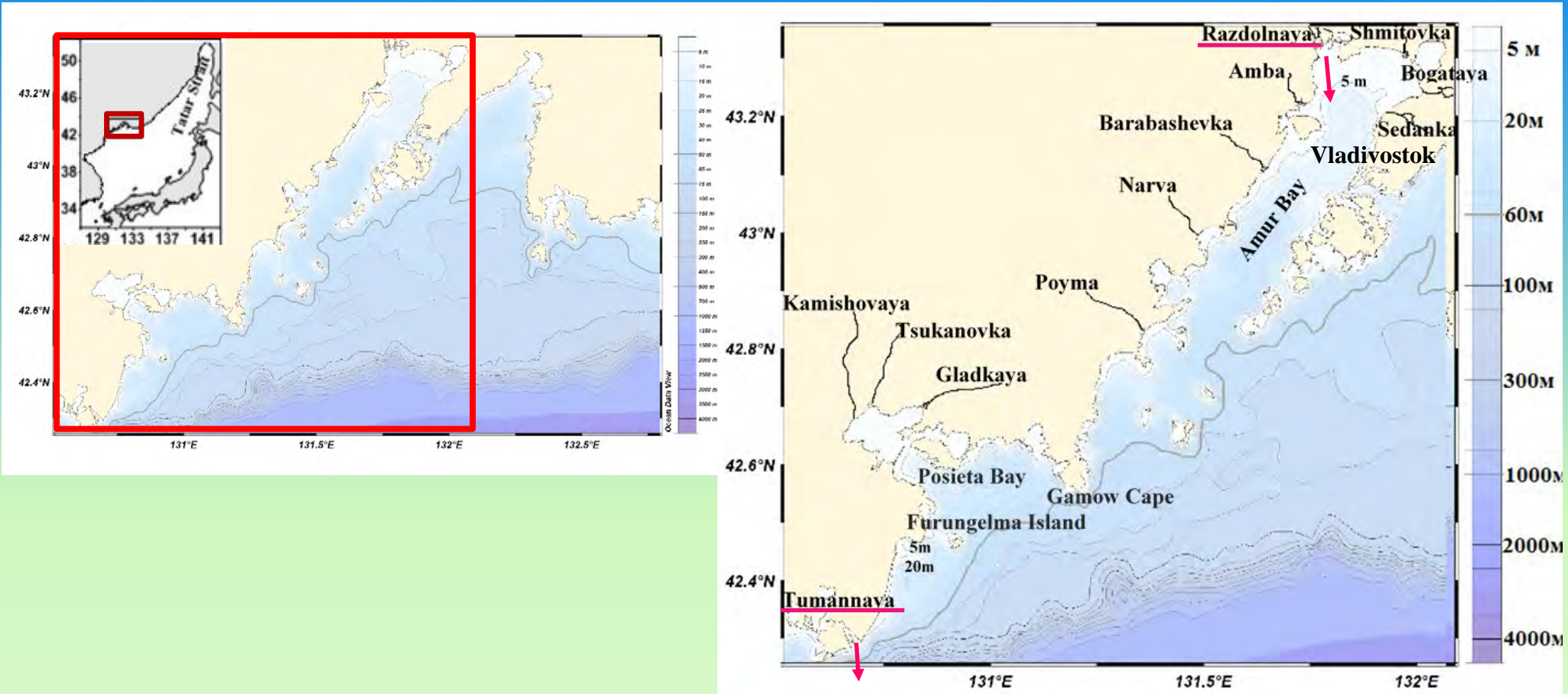
Elena A. Shtraikhert, Sergey P. Zakharkov

Pacific Oceanological Institute, Far Eastern Branch of the Russian Academy of Sciences, [straj@poi.dvo.ru](mailto:straj@poi.dvo.ru)

**Satellite data on the SST (Sea Surface Temperature) and ocean color for cloudless areas allow observe the structures caused by the circulations of the rivers runoffs. These circulations are influenced by variation in the water density. It is due to variations of the wind speed and direction, the continental runoff at the atmospheric precipitation, and in the spring – the ice and snow melting. It influences on the sedimentation and, consequently, the water hypoxia formation. These processes appear in the distribution of phytoplankton cells, organic and suspended matter in the surface layer of water.**

**Purpose** of this work is to characterize the seasonal and interannual variations in structures formed under the Razdolnaya (RR) and Tumannaya (TR) Rivers runoffs influence that appear on satellite distributions of the SST, the chlorophyll-*a*, organic and suspended matter contents indicators, for 2010-2014.

# Region of study

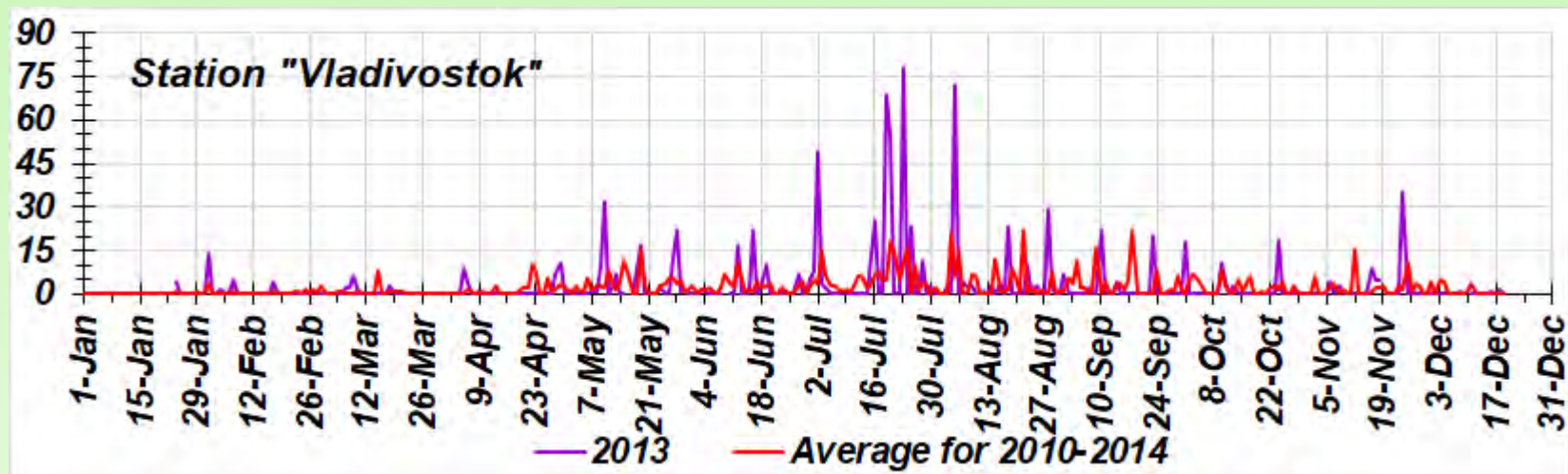


Location of the study region (red rectangle) in Peter the Great Bay and in Japan/East Sea is shown. Locations of the larger rivers confluence in sea are shown on the bathymetric map, which was taken from the site – [pacificinfo.ru/data/cdrom/11/img/3\\_1\\_2/pgb\\_bathy.png](http://pacificinfo.ru/data/cdrom/11/img/3_1_2/pgb_bathy.png). Scale to the right shows the depths. The Razdolnaya and Tumannaya rivers are the largest ones in the Southern Primorye. Locations of their confluence in sea are shown by arrows.

Seasonal variations in the spread of the Razdolnaya and Tumannaya Rivers runoffs are determined by the seasonal variations of the atmospheric precipitation, the wind speed and direction and in the spring – the ice and snow melting.

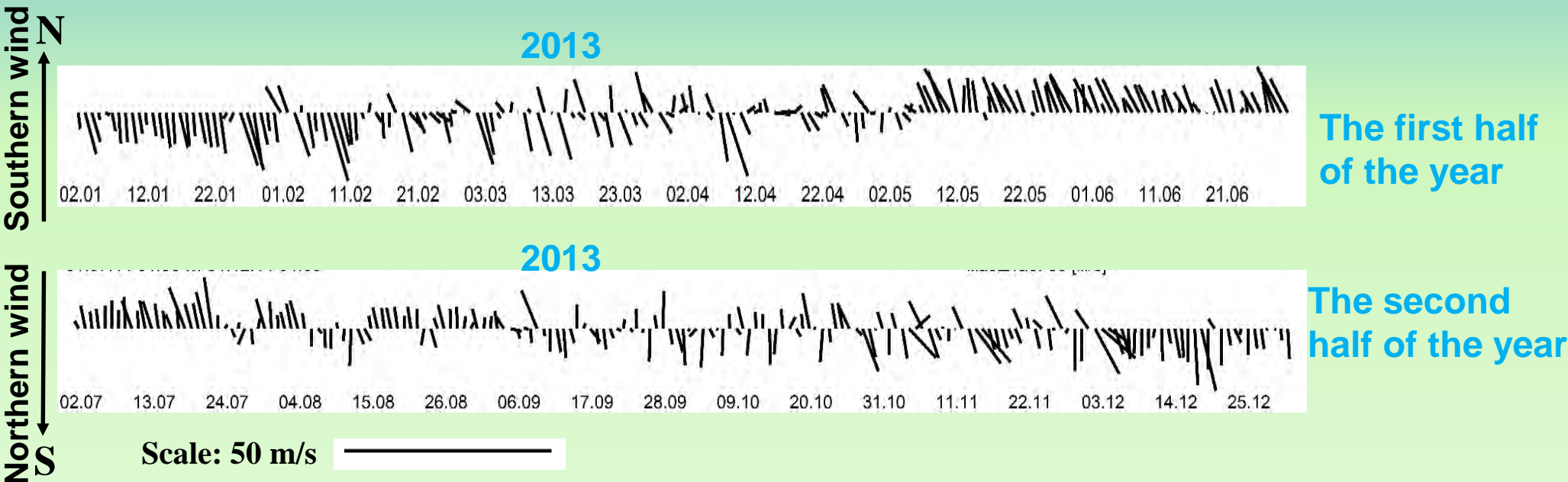
85% of the annual precipitation quantity for the summer period is typical (Oceanographic atlas, 2003).

### Example of distribution of annual precipitation quantity on hydrometeorological station “Vladivostok”



During winter monsoons, from October-November to March, the winds of the northern and north-western direction predominate. In spring, at the shift of the winter monsoon to the summer one, the winds are not stable. In summer, the south-eastern winds predominate in the Peter the Great Bay (Oceanographic atlas, 2003).

### Example of annual distribution of wind speed and direction by days on the hydrometeorological station “Vladivostok”



# Data

## Satellite data

Used in this study the satellite data are from the MODIS-Aqua sensor for 2010-2014. In this study we used the distributions of the characteristics on Ocean Color and SST. Estimate of Ocean Color characteristics are based on the analyze of sea radiance in visible spectral range. Used by us the estimate of SST are based on the analyze of sea radiance in infrared spectral range. Ocean Color characteristics used in our study are the indicators of main optically active components (phytoplankton, organic and suspended matter) contents. Composition and content of optically active components determinate the water color.

## Ocean Color characteristics

**Chlorophyll-a concentration (Chl)**, calculated according to OC3 Algorithm),

**Chlorophyll-a fluorescence (FL)** at a spectral band of 678 nm,

**Coefficient of light absorption by detritus and yellow substance** (characteristic of Colored Dissolved Organic Matter, CDOM), calculated according to QAA (Quasi-Analytical Algorithm) at a spectral band of 443 nm ( $a_{dg}$ ),

**Coefficient of light backscattering by suspended particles**, calculated according to QAA at a spectral band of 443 nm ( $b_{bp}$ ).

## Hydrometeorological characteristics

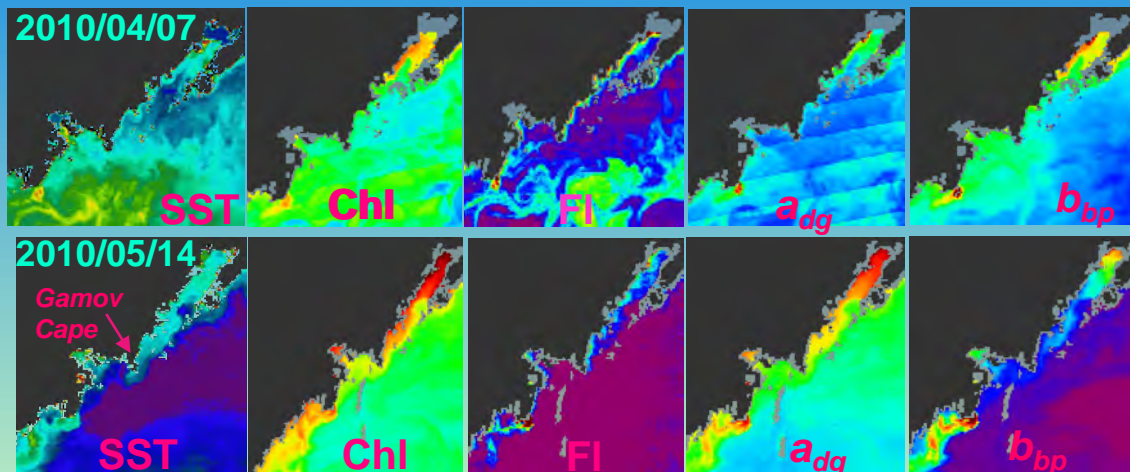
**Sea Surface Temperature (SST)** was obtained using the level 1 data from the MODIS-Aqua **Wind Speed and Direction**,

**Quantity of Atmospheric Precipitation** from the hydrometeorological stations Vladivostok and Posyet (data obtained via the Weather Schedule Web-site).

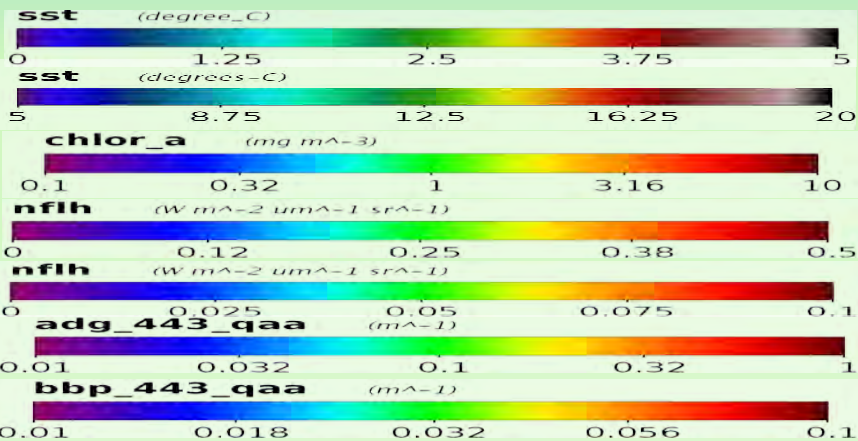
**Distributions of Ocean Color characteristics and SST** were obtained using the data of level 1 from the NASA's Ocean Color Web-site (<http://oceancolor.gsfc.nasa.gov>) and the SeaDAS software of versions 6.4 and 7.3

# Spring (distributions formed mainly under the influence of northern winds)

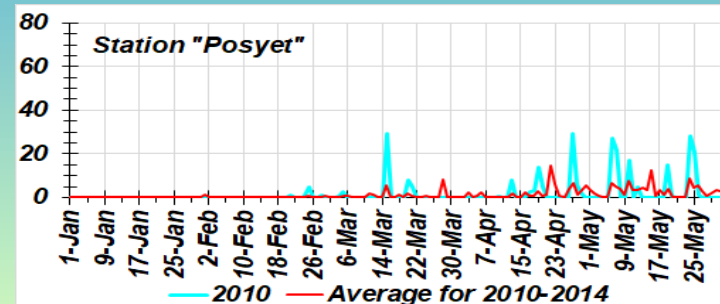
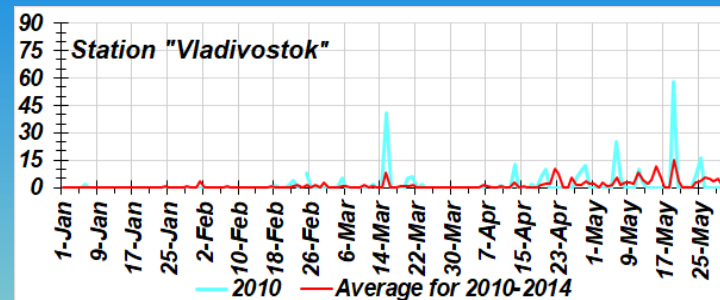
## Distributions of SST and Ocean Color characteristics



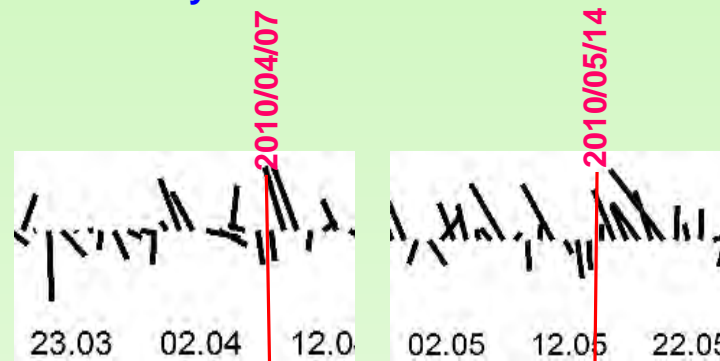
Scale



Gray color on Chl, FI,  $a_{dg}$ ,  $b_{bp}$  distributions means the absence of data. On SST distribution the data in these areas, except the strip near the coast, have errors. Therefore they must be also attributed to absent data.



Average daily distribution of atmospheric precipitation quantity in 2010 and line of red color means the daily averaged value for 5 years from 2010 to 2014

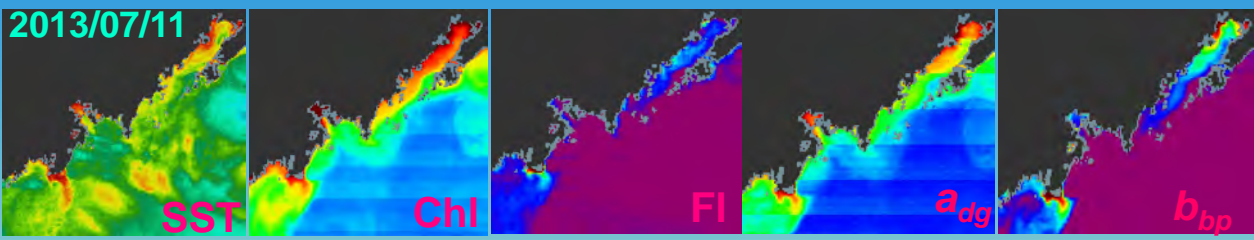


Scale: 50 m/s

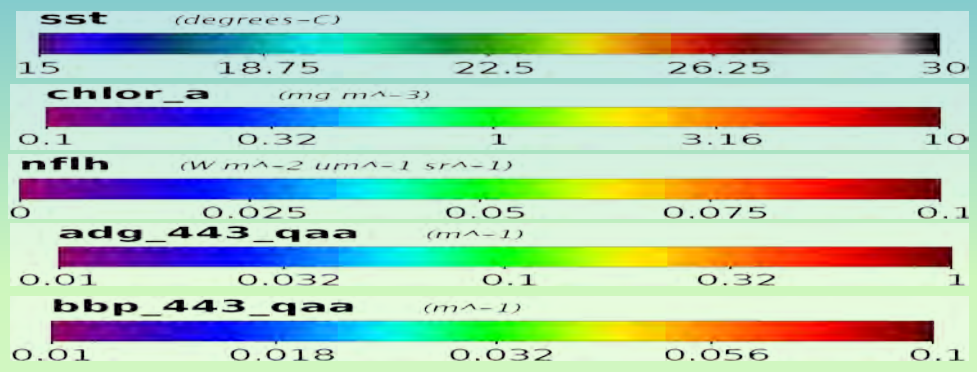
Average daily distribution of wind speed and direction

# Summer (distributions formed mainly under the influence of northern winds)

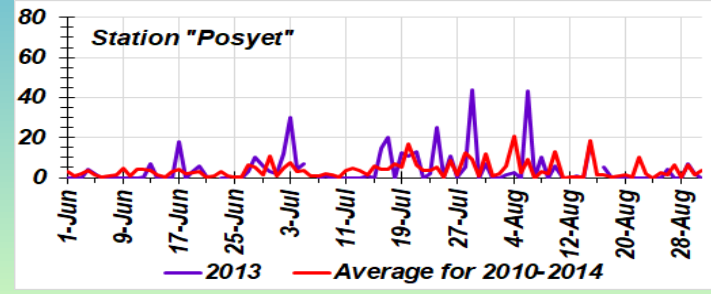
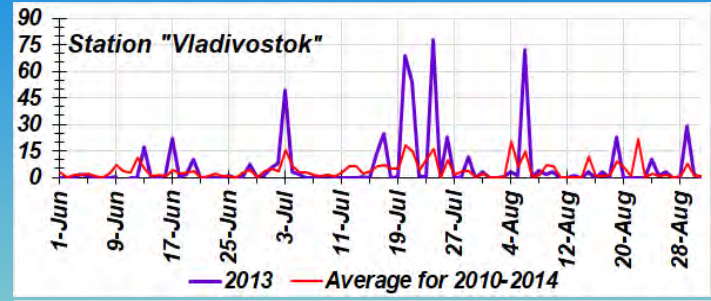
## Distributions of SST and Ocean Color characteristics



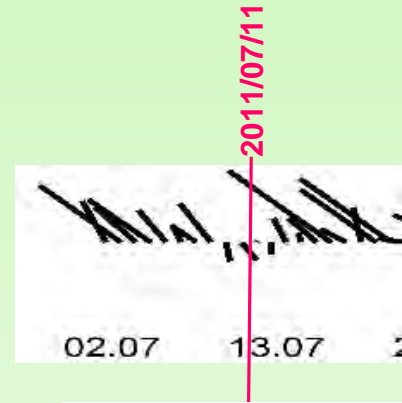
Scale



Gray color on Chl, FI,  $a_{dg}$ ,  $b_{bp}$  distributions means the absence of data. On SST distribution the data in these areas, except the strip near the coast, have errors. Therefore they must be also attributed to absent data.



Average daily distribution of atmospheric precipitation quantity in 2013 and line of red color means the daily averaged value for 5 years from 2010 to 2014



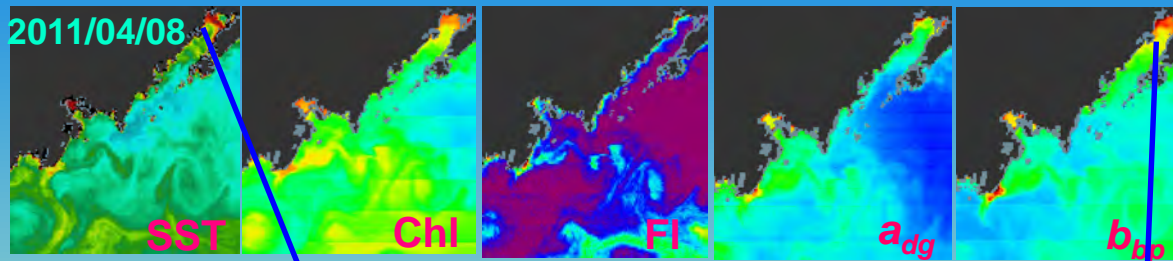
Scale: 50 m/s

Average daily distribution of wind speed and direction

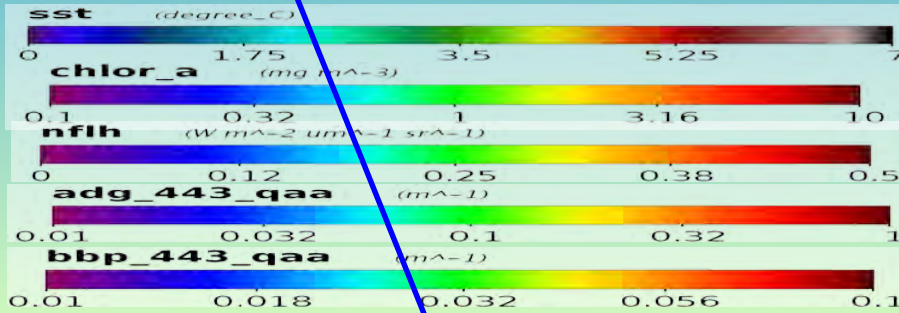


# Spring (distributions formed mainly under the influence of southern winds)

## Distributions of SST and Ocean Color characteristics

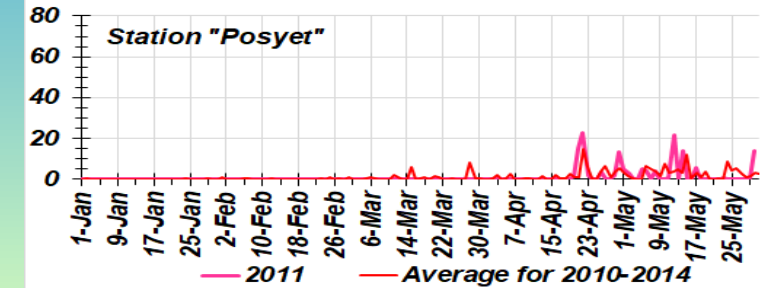
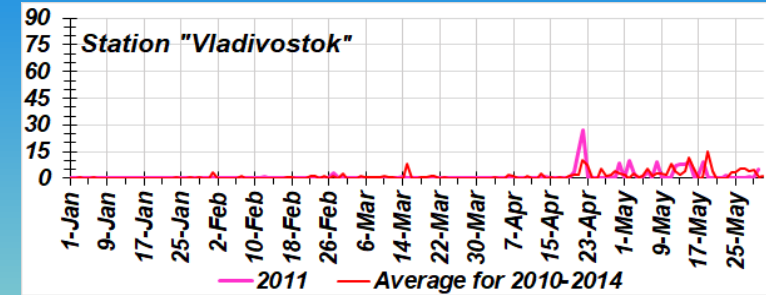
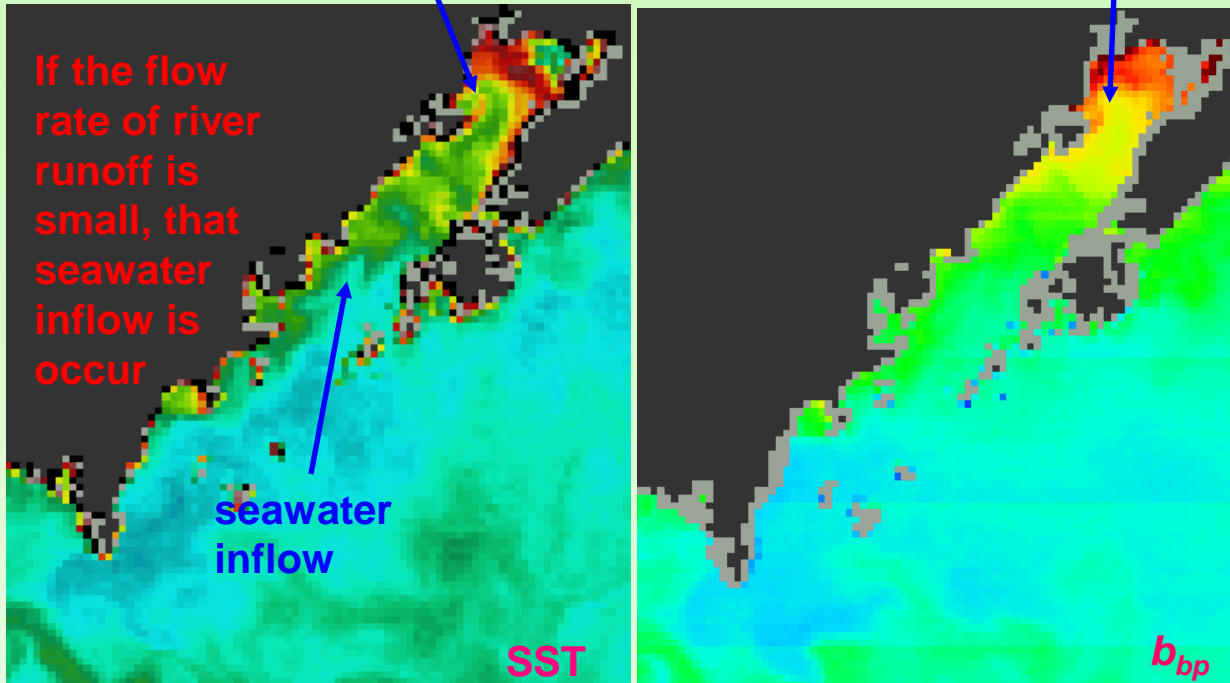


### Scale



If the flow rate of river runoff is small, that seawater inflow is occur

seawater inflow



Average daily distribution of atmospheric precipitation quantity in 2011 and line of red color means the daily averaged value for 5 years from 2010 to 2014

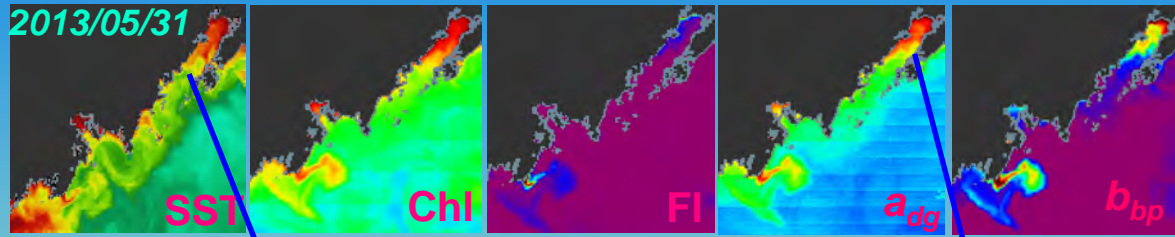


Scale: 50 m/s

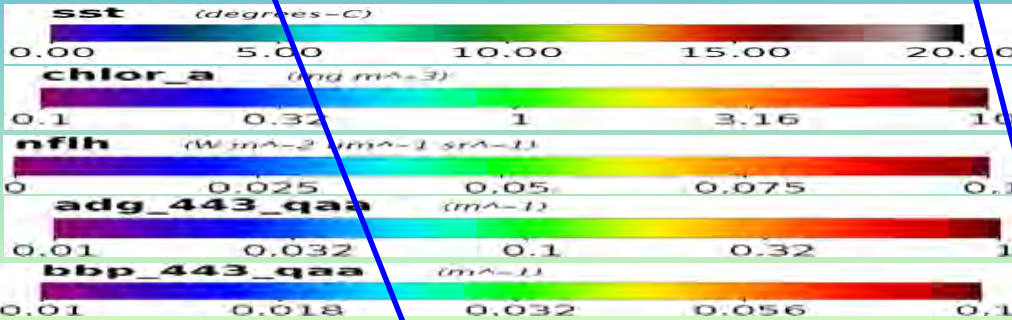
Average daily distribution of wind speed and direction

# Spring (distributions formed mainly under the influence of southern winds)

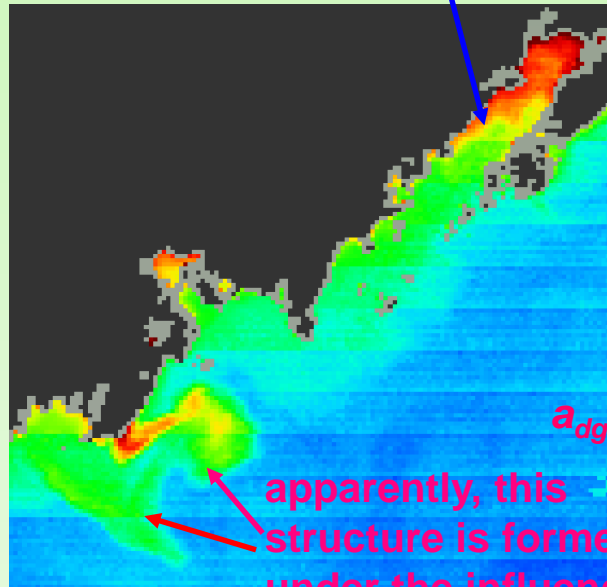
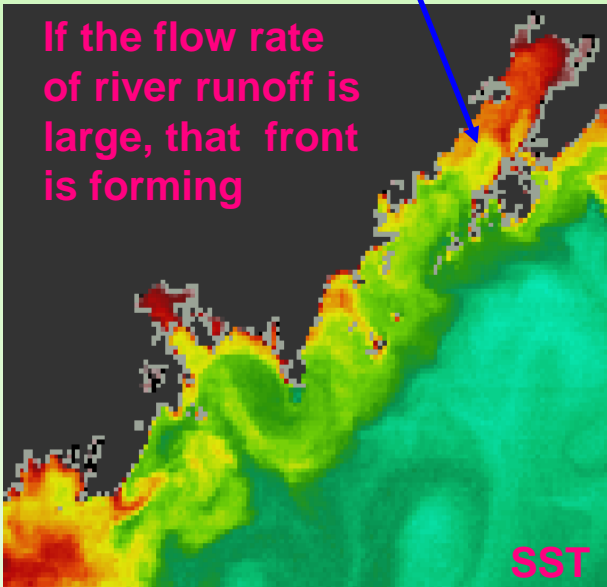
## Distributions of SST and Ocean Color characteristics



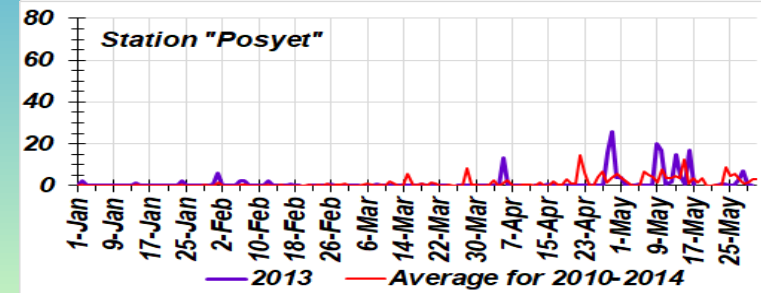
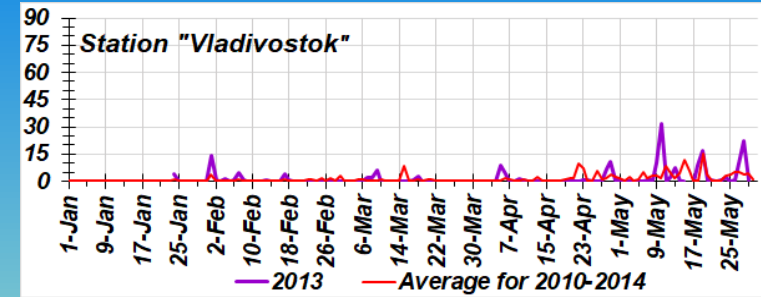
### Scale



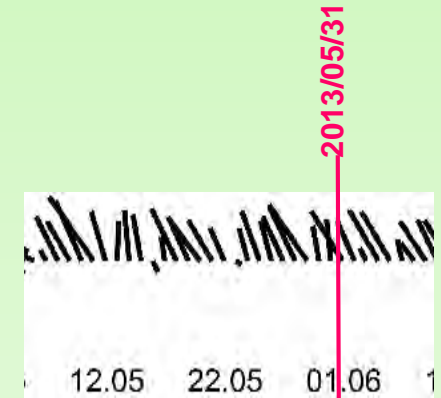
If the flow rate of river runoff is large, that front is forming



apparently, this structure is formed under the influence of the ebb



Average daily distribution of atmospheric precipitation quantity in 2013 and line of red color means the daily averaged value for 5 years from 2010 to 2014

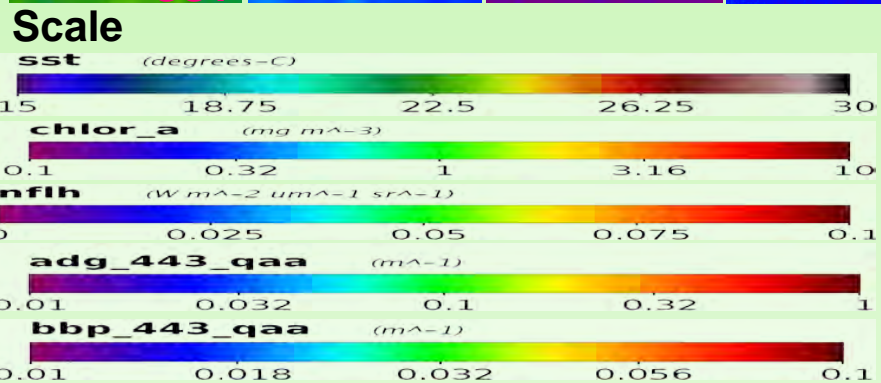
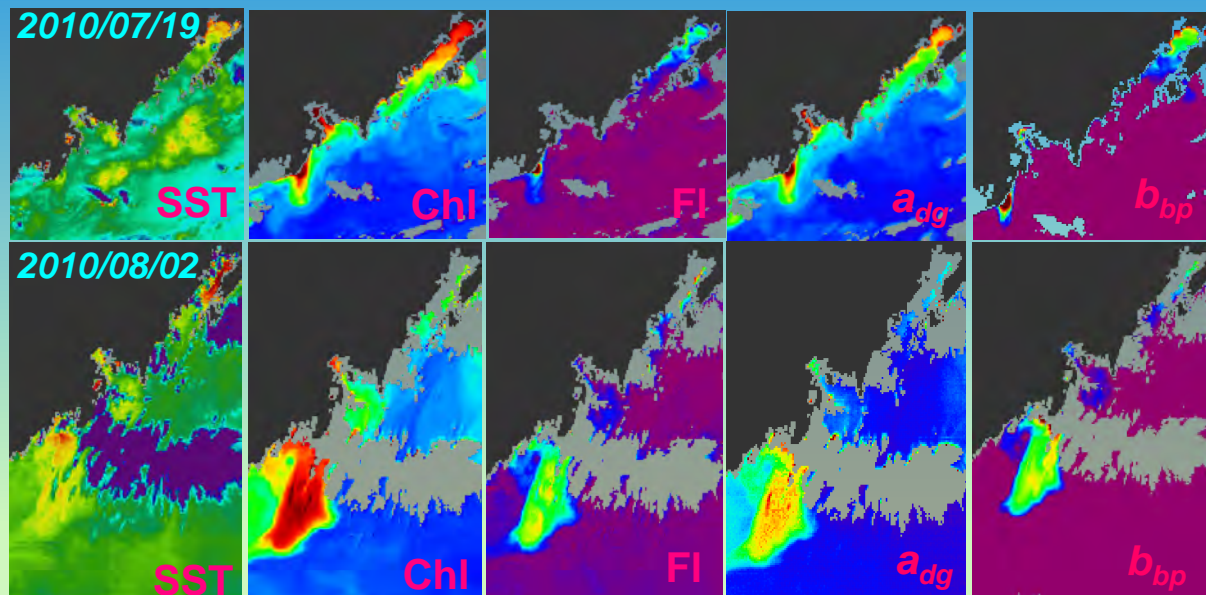


Scale: 50 m/s

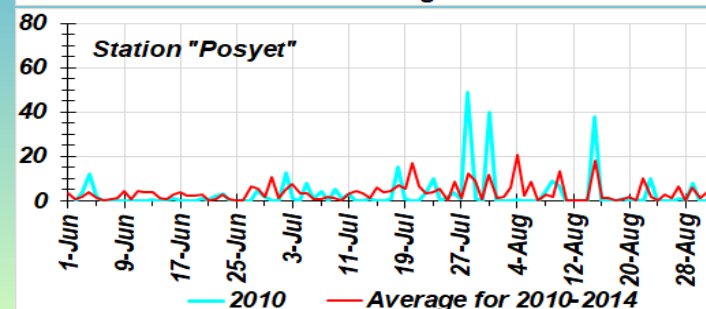
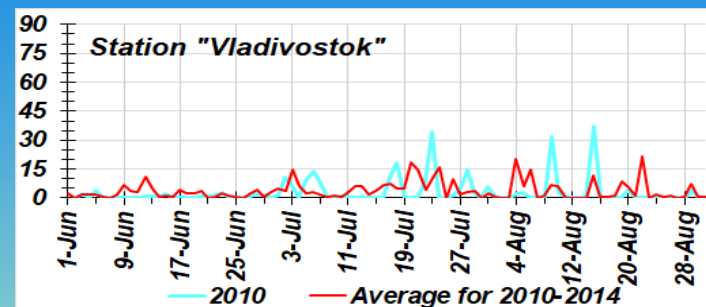
Average daily distribution of wind speed and direction

# Summer (cases, when the runoff of the Tumannaya River is spreading in the opposite direction from the direction of the wind)

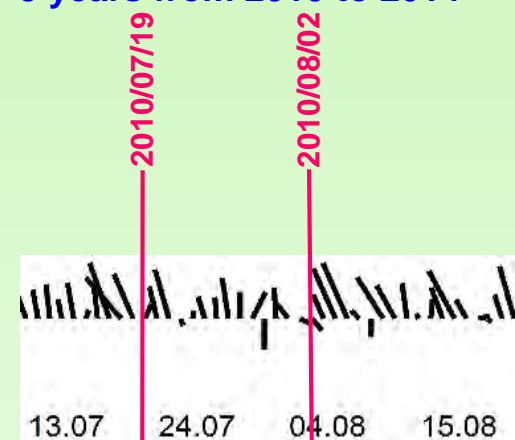
## Distributions of SST and Ocean Color characteristics



Gray color on Chl, FI,  $a_{dg}$ ,  $b_{bp}$  distributions means the absence of data. On SST distribution the data in these areas, except the strip near the coast, have errors. Therefore they must be also attributed to absent data.



Average daily distribution of atmospheric precipitation quantity in 2010 and line of red color means the daily averaged value for 5 years from 2010 to 2014



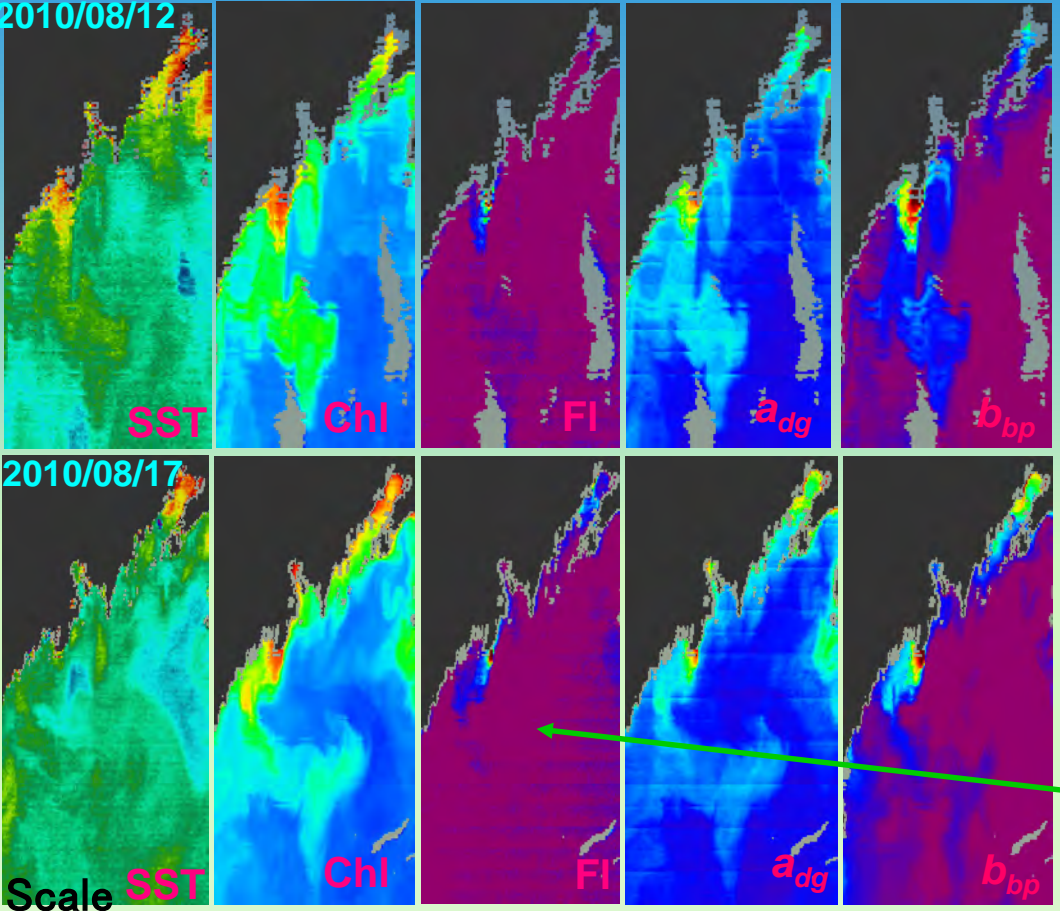
Scale: 50 m/s

Average daily distribution of wind speed and direction

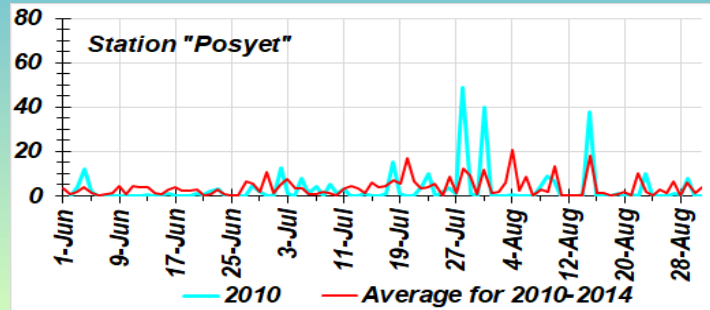
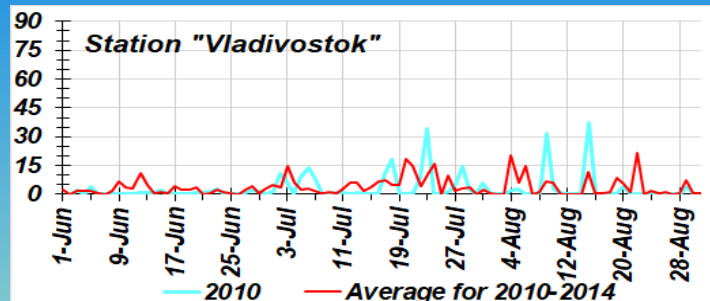
# Summer (cases, when the runoff of the Tumannaya River is spreading in the opposite direction from the direction of the wind)

Continuation of the situation from 2010/08/02

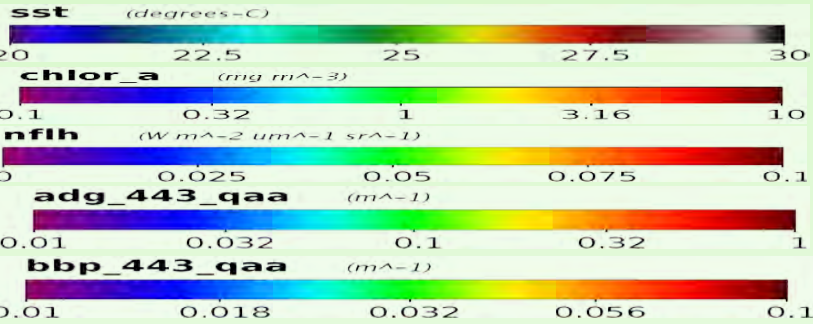
Distributions of SST and Ocean Color characteristics



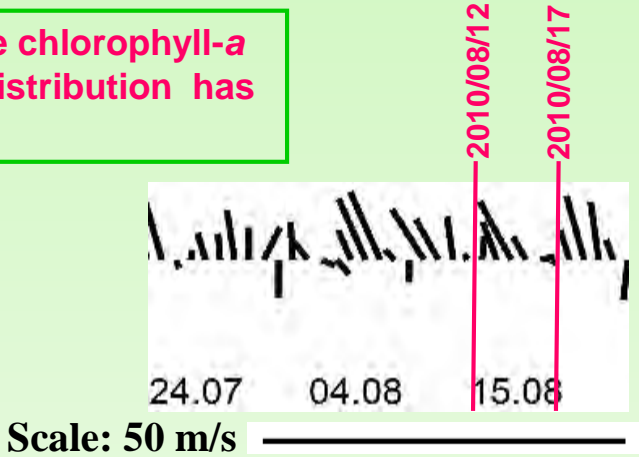
Structure at the chlorophyll-a fluorescence distribution has disappeared



Average daily distribution of atmospheric precipitation quantity in 2010 and line of red color means the daily averaged value for 5 years from 2010 to 2014



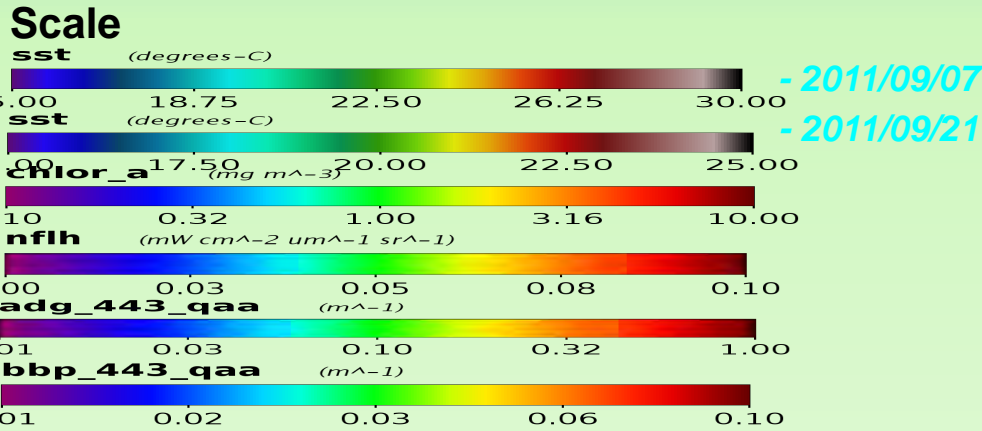
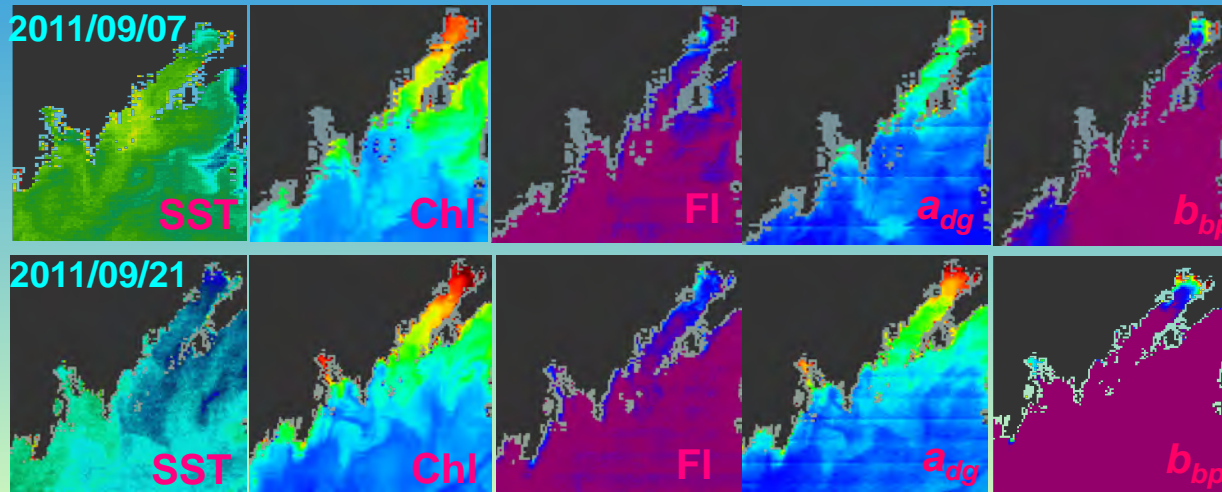
Gray color on Chl, FI,  $a_{dg}$ ,  $b_{bp}$  distributions means the absence of data. On SST distribution the data in these areas, except the strip near the coast, have errors. Therefore they must be also attributed to absent data.



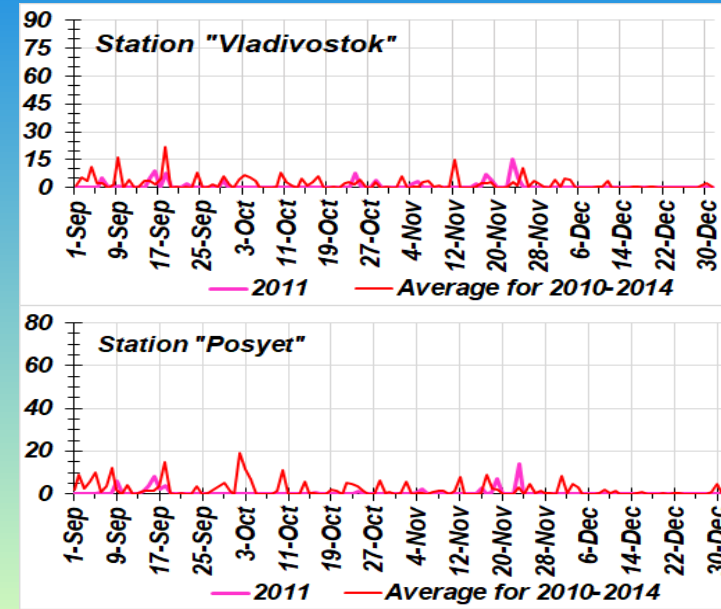
Average daily distribution of wind speed and direction

**Autumn** ( autumn is characterized by a decrease of atmospheric precipitation, and, therefore, the decrease of the continental runoff)

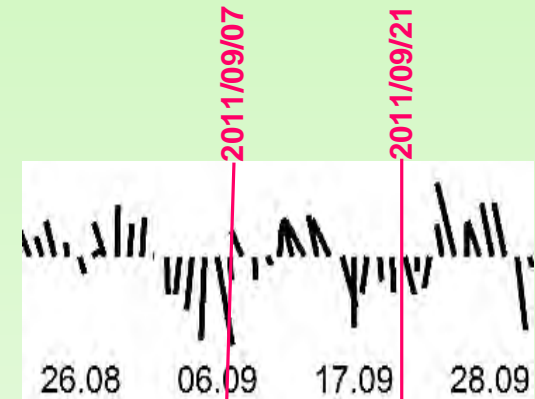
**Distributions of SST and Ocean Color characteristics**



Gray color on Chl, FI,  $a_{dg}$ ,  $b_{bp}$  distributions means the absence of data. On SST distribution the data in these areas, except the strip near the coast, have errors. Therefore they must be also attributed to absent data.



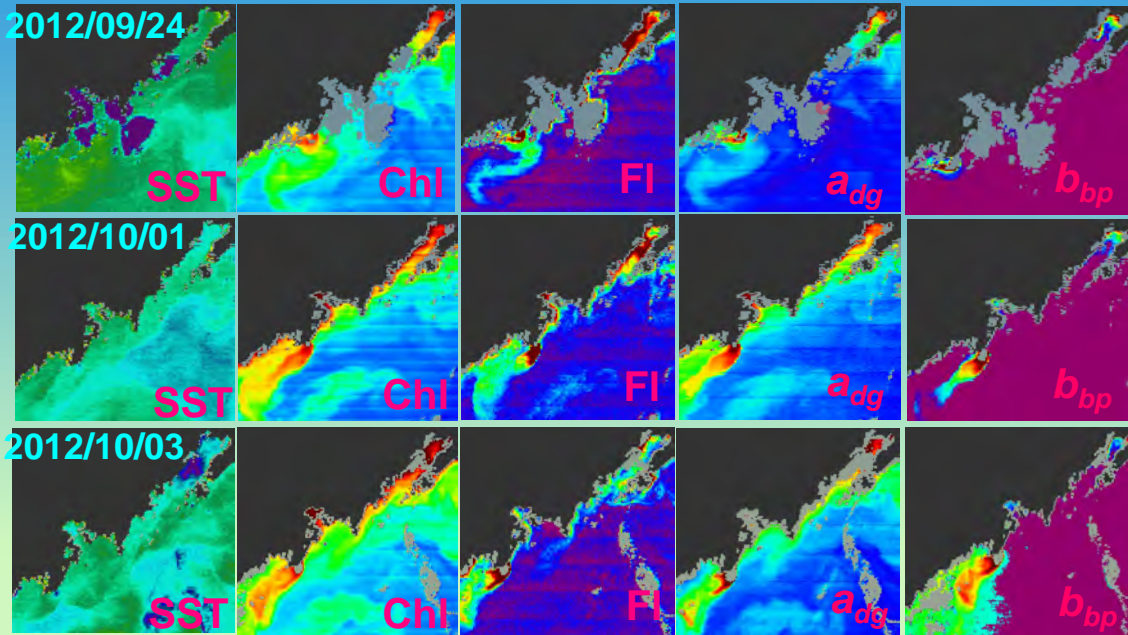
Average daily distribution of atmospheric precipitation quantity in 2011 and line of red color means the daily averaged value for 5 years from 2010 to 2014



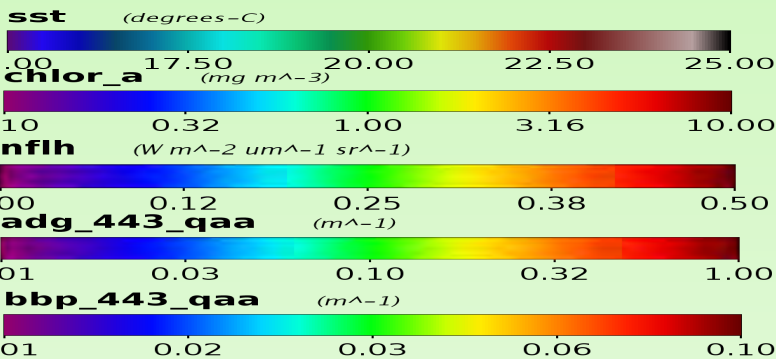
Scale: 50 m/s   
Average daily distribution of wind speed and direction

**Autumn** ( autumn is characterized by a decrease in atmospheric precipitation, and, therefore, the decrease of the continental runoff)

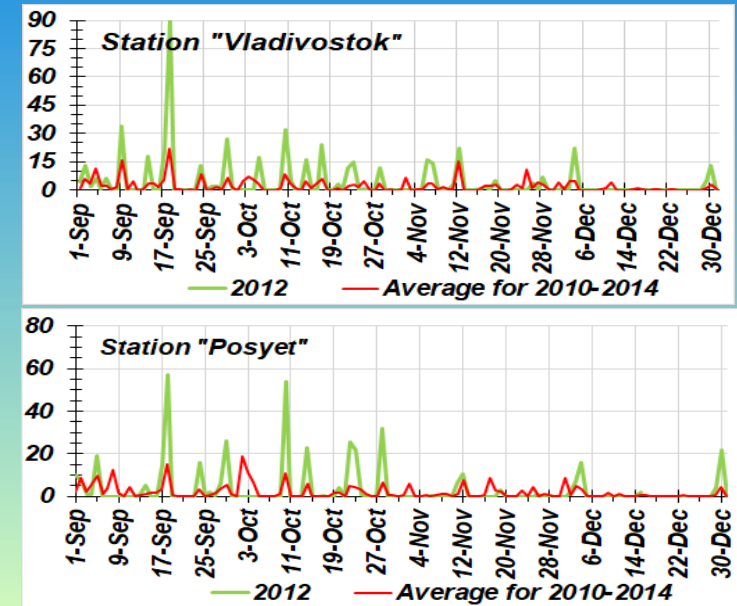
**Distributions of SST and Ocean Color characteristics**



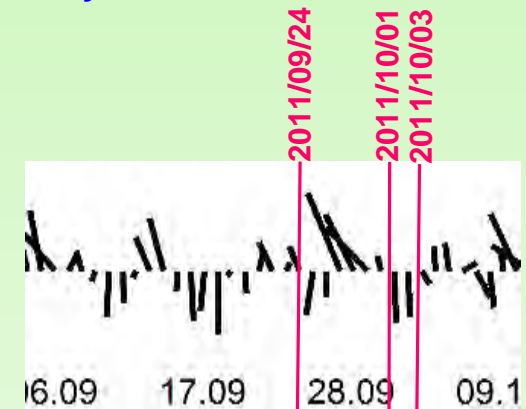
**Scale**



Gray color on Chl, FI,  $a_{dg}$ ,  $b_{bp}$  distributions means the absence of data. On SST distribution the data in these areas, except the strip near the coast, have errors. Therefore they must be also attributed to absent data.



Average daily distribution of atmospheric precipitation quantity in 2012 and line of red color means the daily averaged value for 5 years from 2010 to 2014

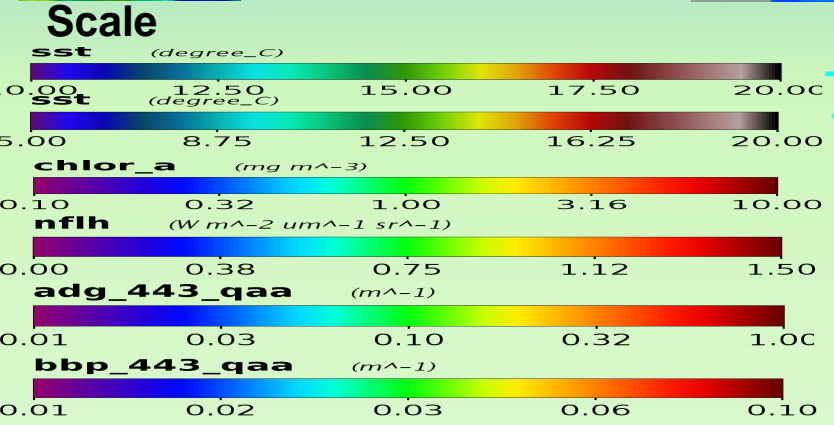
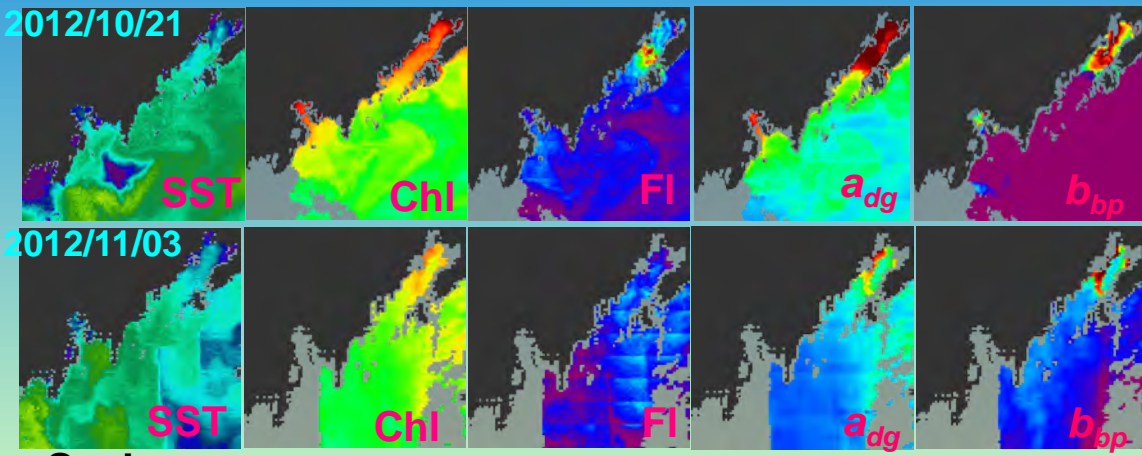


Scale: 50 m/s

Average daily distribution of wind speed and direction

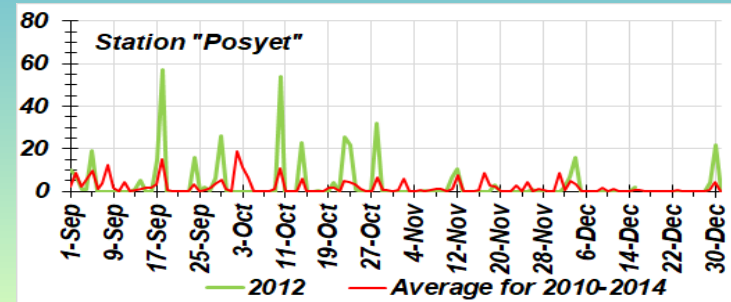
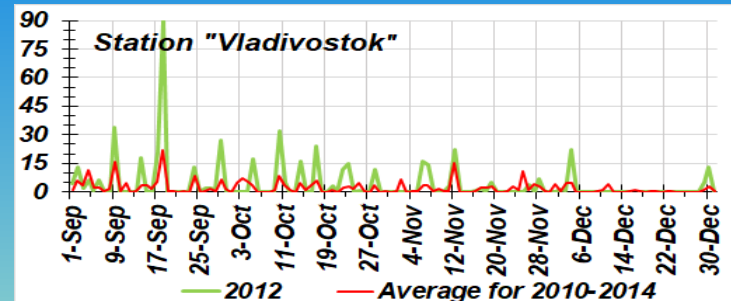
**Autumn** ( autumn is characterized by a decrease in atmospheric precipitation, and, therefore, the decrease of the continental runoff)

**Distributions of SST and Ocean Color characteristics**

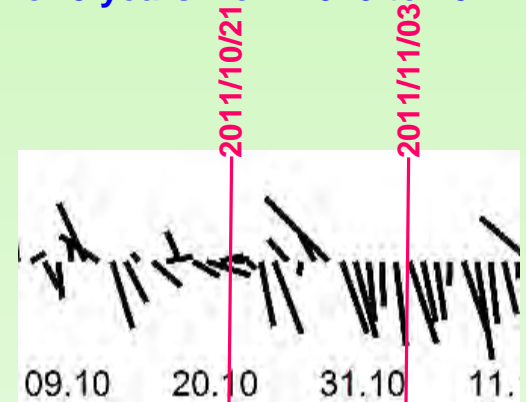


- 2012/10/21;  
- 2012/11/03;

Gray color on Chl, FI,  $a_{dg}$ ,  $b_{bp}$  distributions means the absence of data. On SST distribution the data in these areas, except the strip near the coast, have errors. Therefore they must be also attributed to absent data.



Average daily distribution of atmospheric precipitation quantity in 2012 and line of red color means the daily averaged value for 5 years from 2010 to 2014



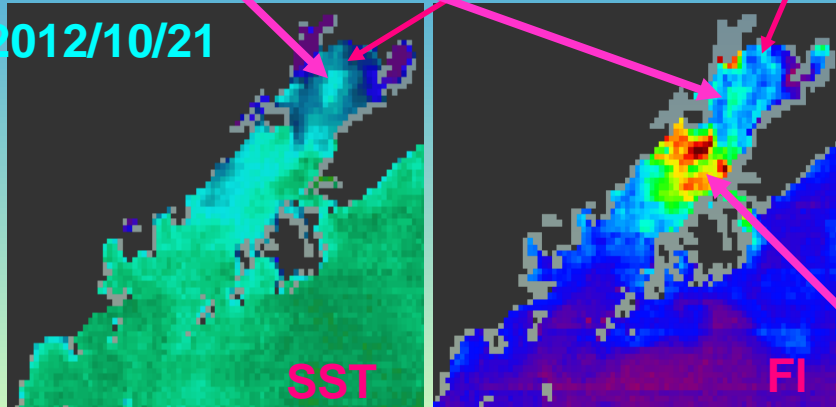
Scale: 50 m/s

Average daily distribution of wind speed and direction

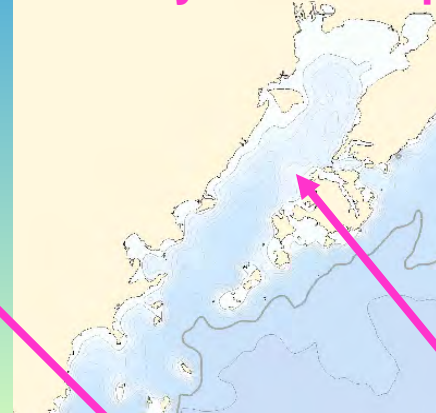
# Appearance of the cyclonic flow in the Amur Bay

Elevated values of characteristics in the center of the gyre

2012/10/21



Bathymetric map



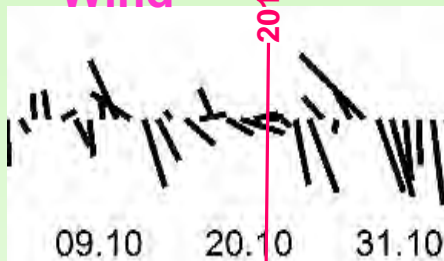
Hill on bottom

Scale

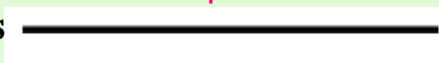


Appearance of the water upwelling and therefore nutrients in surface layer at interaction of cyclonic water movement with the bottom topography. Not optical influence of bottom.

Wind



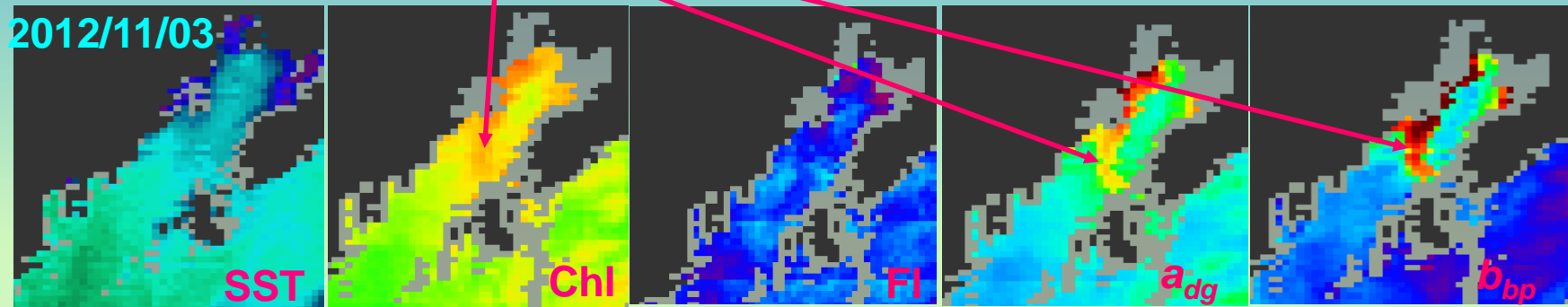
Scale: 50 m/s





# Deviation of the river plume under the influence of north –western wind

Due to the Coriolis force the the Razdolnaya River flows, as a rule, along the western coast the Amur Bay. However, the strongly north-western wind deviates the weak water stream toward other side



Scale

**sst** (degree\_C)



**chlor\_a** ( $mg\ m^{-3}$ )



**nflh** ( $W\ m^{-2}\ \mu m^{-1}\ sr^{-1}$ )



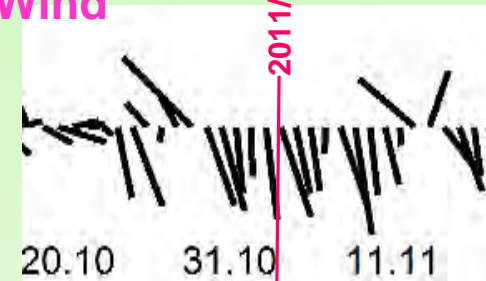
**adg\_443\_qaa** ( $m^{-1}$ )



**bbp\_443\_qaa** ( $m^{-1}$ )



Wind



Scale: 50 m/s



# Conclusions

## Features of seasonal variations in the spread of the Razdolnaya and Tumannaya Rivers runoff

- It is noted that during the floods on the Razdolnaya River :  
at the northern winds, the influence of this river water with smaller rivers located along the western coast of the Amur Bay (AB) can reach the Gamow Cape, at winds of southern directions in the northern AB part the front separating the areas having high and low values of SST and ocean color characteristics is formed.
- Plume of the Tumannaya River spreads, as a rule, on a distance of up to 30 km in the direction determined by the flow rate of the runoff current, wind speed and direction, Coriolis force: at the northern wind the plume is directed on the south-west, at the south-eastern wind the impact, which is comparable with the impact of the river flow, the plume is directed on the north-east, at the high flow rate of the river runoff current the plume is directed on the south.
- With a decrease in the discharge of the Razdolnaya River at the strong northwestern wind from about 5-7 m/s in the northern part of the AB, the river plume are deviating from western AB coast and the cyclonic structures can be formed.

# Conclusions

## Features of interannual variations in the spread of the Razdolnaya and Tumannaya Rivers runoff

- It was noted the greatest extension of the Tumannaya River water toward the open Japan/East Sea part (about 80-100 km) was in 2010.
- In the autumn of 2012 the Razdolnaya and Tumannaya Rivers runoff in the comparison with other considered years is increased. It is accompanied by the increased precipitation quantity almost up to the middle October.

**Thank you  
for attention**