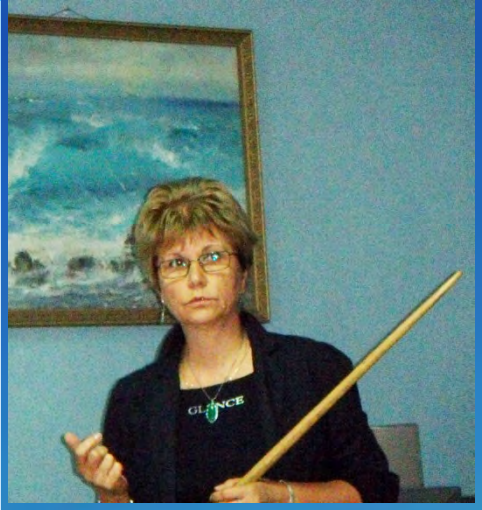

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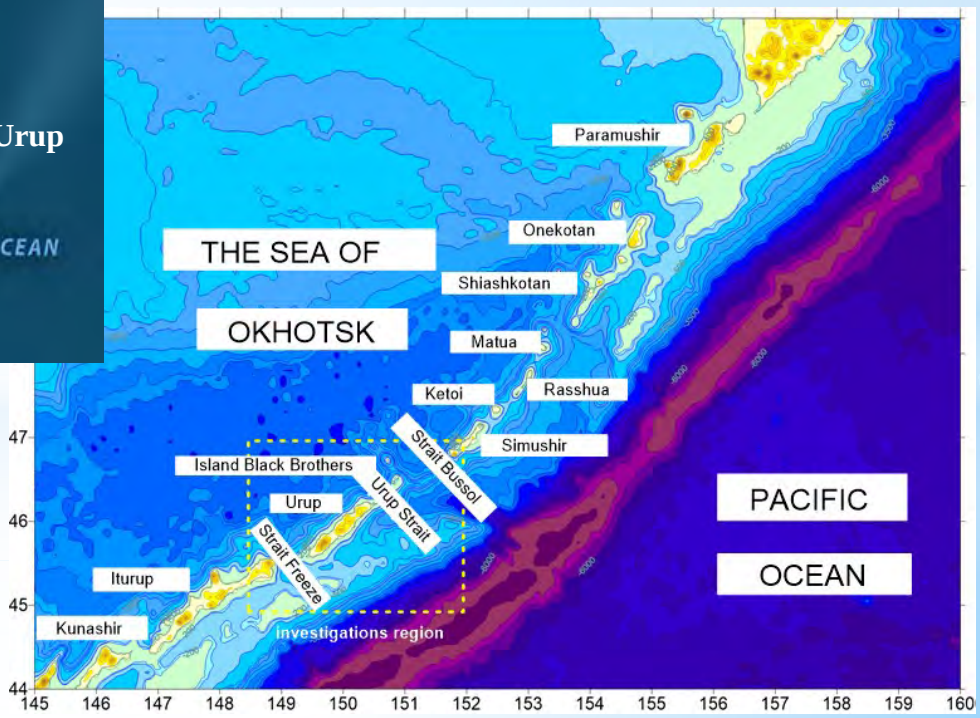
The role of regional atmospheric processes in the formation of the structure of currents in region of the straits surrounding Urup Island (Kuril island system)

Kuril archipelago

Kuril Island Arc, which includes more than 30 major islands and many smaller islands stretching for 1,200 km from the island of Hokkaido to the Kamchatka Peninsula, separating the Sea of Okhotsk from the Pacific Ocean.

Thus, the Kuril Island Arc is a zone of transition from the harsh arctic conditions of the Sea of Okhotsk (Northern Kuril) to a mild climate subarctic Pacific (Southern Kuril).

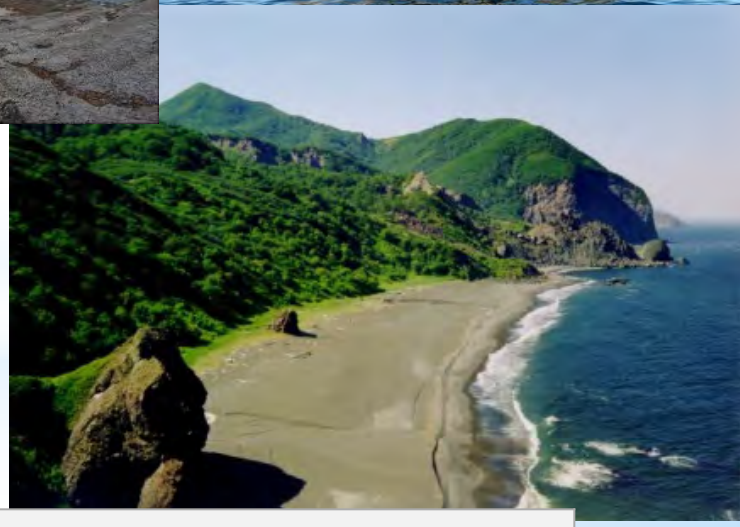


Deep straits Bussol and Kruzenshtern are separated the Kuril Islands into three groups: the northern, central and southern.

Urup Island

"Urup" translated from the Ainu language means "sweetfish"

Water temperature in summer in straits Bussol and Freeze: 1.5-2.0°C.

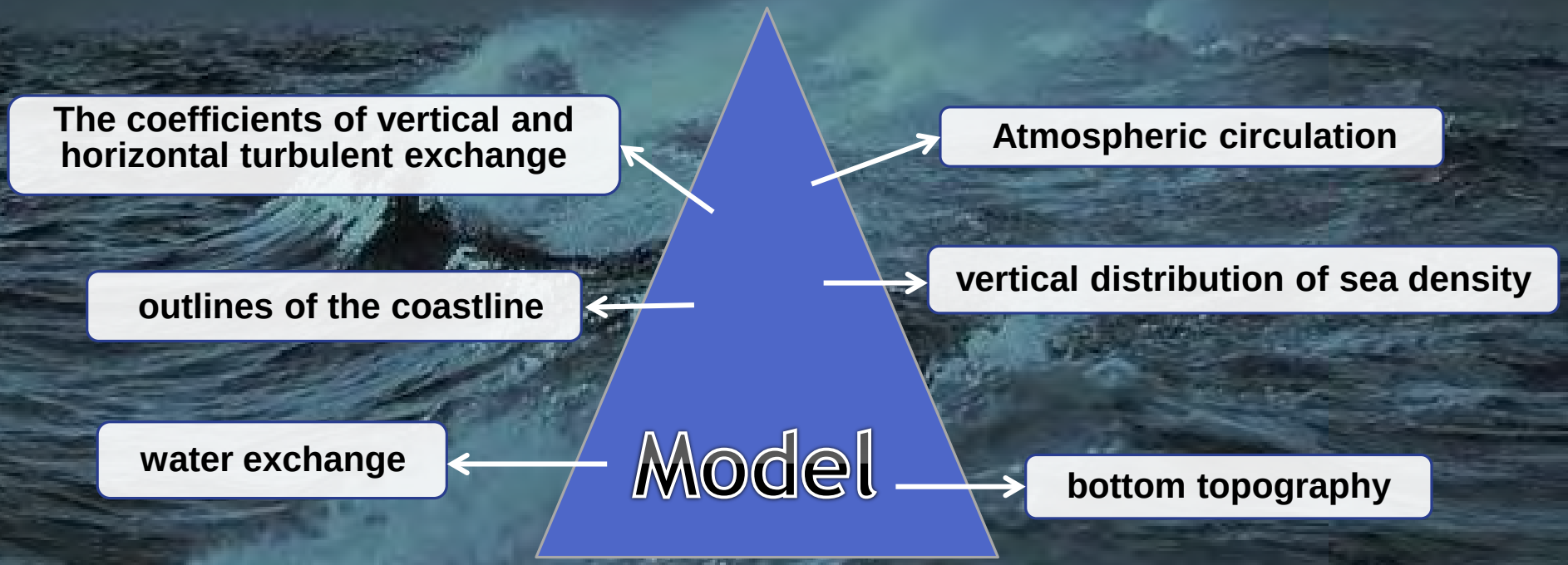


The average daily air temperature (°C)												
I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	year
−4,8	−5,9	−3,7	0,3	3,4	5,9	8,9	**10,9**	10,3	6,9	2,0	−2,0	2,7

The purpose of this investigation:

is to study the spatial and temporal variability of water anticyclonic structures in the zone of Urup under the influence of "the north-western" type of atmospheric processes based on numerical modeling. Quasi-stationary baroclinic model was used for the realization of this goal.

The model takes into account the following parameters:



For the decision of the given task the hydrodynamic model within the framework of which integral functions of the stream from a surface to the bottom (full streams) have been designed. The model takes into account different information: atmosphere-hydrosphere-litosphere.

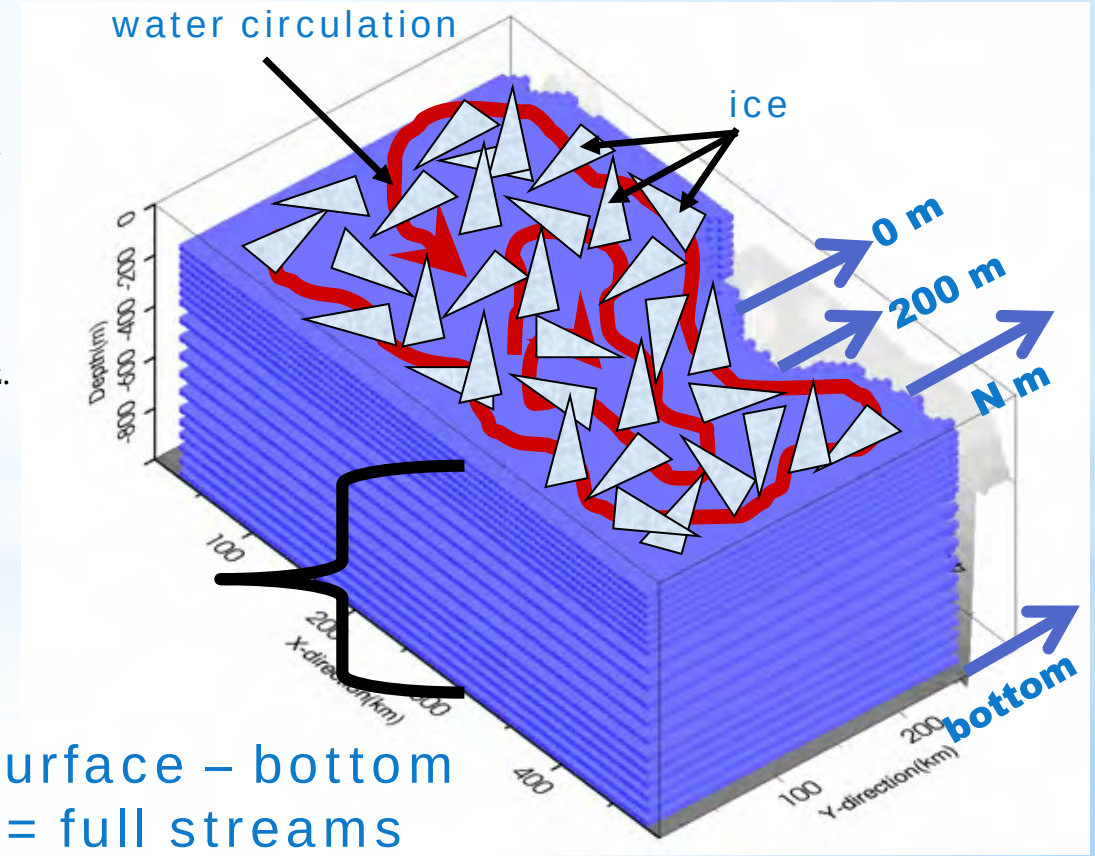
Calculation of the water circulation not only on a surface, but also from the surface to any chosen horizon, down to a bottom and not only for one-coherent (sea or ocean), but also multicoherent (sea-strait-ocean) of areas.

During the winter period the model automatically takes into account the formation of ice on the sea surface expecting integral water circulation under ice.

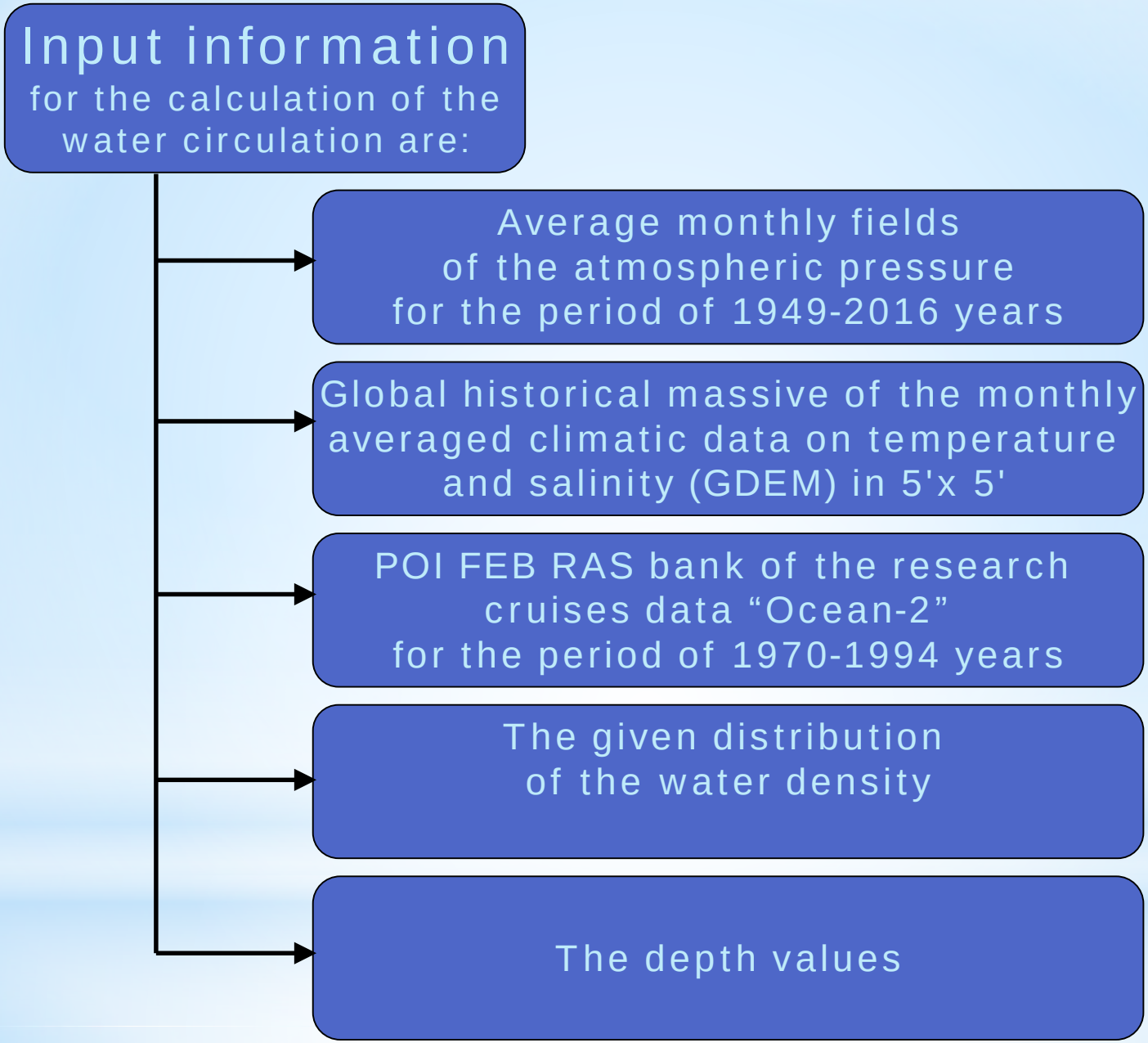
The temperature (T_0), salinity(S_0), atmospheric pressure (P) are known on liquid boundaries at z = 0, where z - vertical component (coordinate pointing vertically downwards), T_0 - water temperature on the surface, S_0 - salinity at the surface, P- the atmospheric pressure in the nodes of the computational grid, corresponding for the "north-western" type of synoptic situations.

Wind stress was calculated from field of the atmospheric pressure. Conditions of sticking on the bottom are taken at z=H, so the speed of currents at the bottom is U = V = W = 0, where U, V, W - components of currents along the axes x, y, z.

The circulation of water in the upper quasi-homogeneous layer has been designed within the framework of the selected model using the initial data in the region of Urup Island on a uniform grid 5x 5‘ (9 km). This grid was chosen because the study region includes not only the submarine shelf, where the Rossby baroclinic radius is 2 km, but the deep-water Kuril-Kamchatka hollow and the deep-water Kuril basin, where the Rossby radius is 18-20 km.



surface – bottom
= full streams



The following meteorological seasons were selected to identify the behavior of the anticyclonic structures and atmospheric processes: winter - January, spring - March, summer - July, autumn – October.

TYPING OF THE ATMOSPHERIC PROCESSES

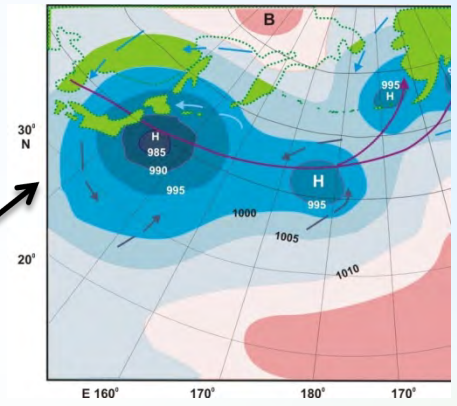
The main materials for the typing of atmospheric processes over the North Pacific Ocean served daily surface synoptic maps of the North Pacific for 4 main synoptic period: 00, 06, 12, 18 hours Greenwich, which are compiled in the Primorsky hydrometeorological weather centre from 1949 to the present.

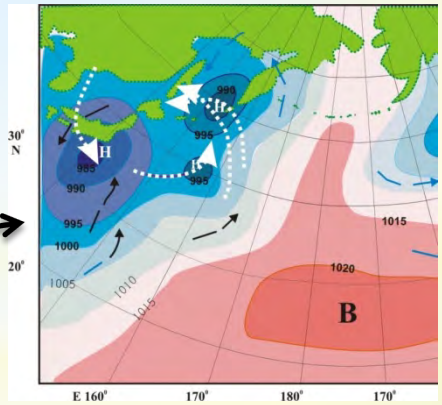
Three main signs were the basis of typing:

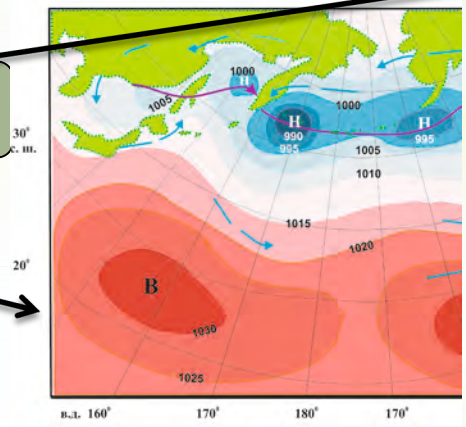
1. The geographical position of the main trajectories of cyclones;
2. The geographical position of areas high pressure;
3. The direction of movement of air masses and their common characteristics: wet or dry, warm or cold, continental or marine.

Types of the atmospheric circulation (Antonina Polyakova, 1999):

- **‘north-western’**
- **‘okhotsk-aleutian’**
- **‘latitudinal-aleutian ’**







Long-term (1949 – 2016) average monthly recurrence of the atmospheric types (%)

Months:											
I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
"North-western" ***Recurrence is high and is observed during all seasons of year***											
30.4	42.6	42.6	42.3	34.5	46.0	48.7	45.0	32.2	26.4	31.0	27.0
"Okhotsk-aleutian" ***Recurrence is almost high and is observed during 10 months***											
13.0	11.3	21.3	29.7	35.0	27.3	26.5	23.5	32.6	28.7	19.7	17.7
"Latitudinal-aleutian" ***Recurrence is less active and is observed during 8 months***											
6.9	6.0	8.7	14.0	13.5	7.6	17.4	24.5	21.0	21.0	20.0	13.2

Long-term (1949 – 2016) average monthly continuous duration of action of the atmospheric types (days)

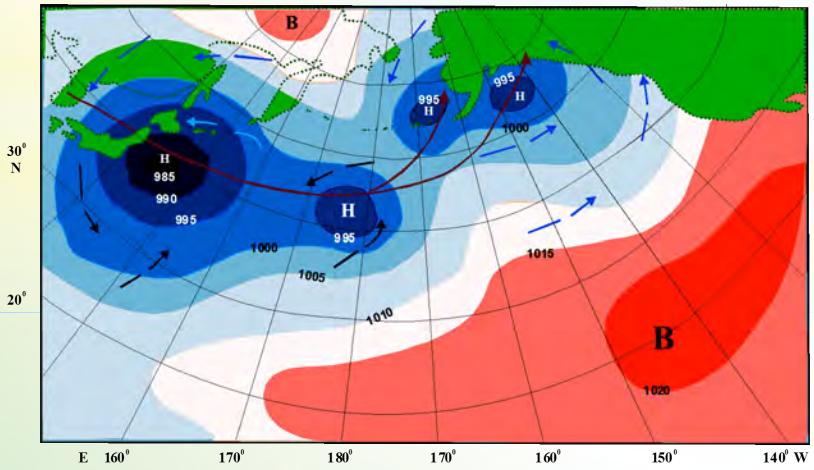
Months:											
I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
“North-western”											
12.5	13.5	16.0	14.0	13.5	14.5	15.5	14.0	11.0	9.0	11.5	12.0
“Okhotsk-aleutian”											
9.0	7.0	12.0	13.0	13.0	11.5	10.0	9.5	11.5	11.0	8.5	7.0
“Latitudinal-aleutian”											
7.5	5.0	7.0	9.0	6.5	7.0	8.5	10.5	8.5	10.0	9.0	7.0

“North-western” type of the atmospheric circulation

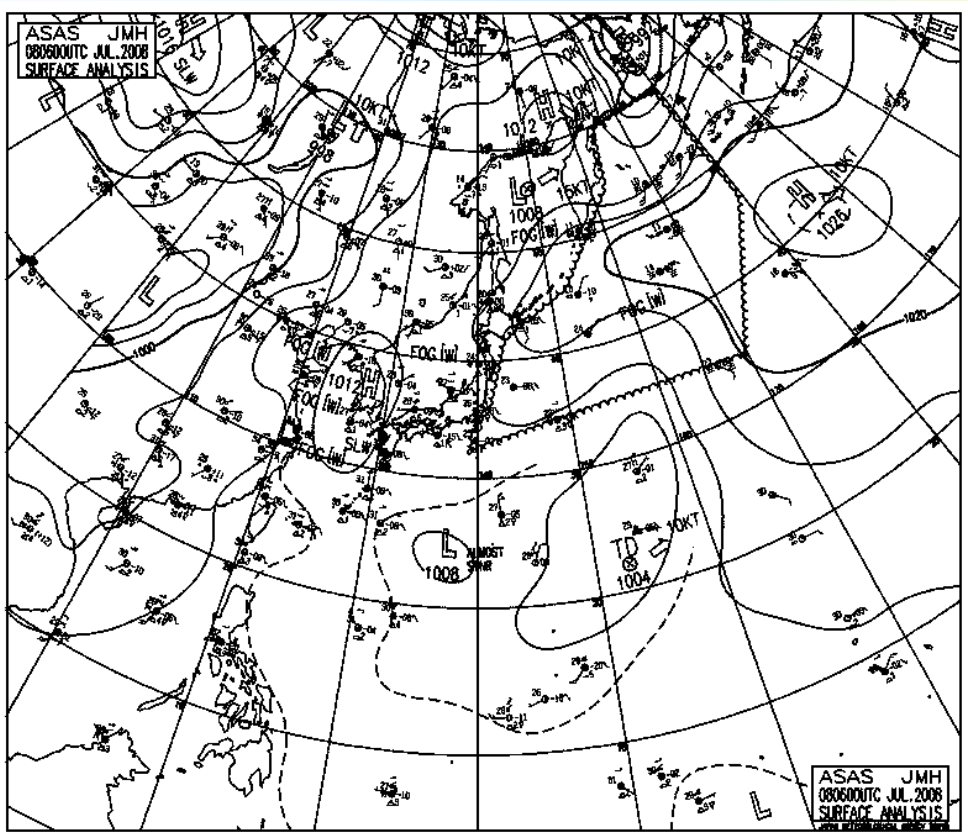
is characterized by the following features:

- **The main trajectories of cyclones are located in NW Pacific**
- **Cyclones move to NE from Japan towards Aleutian Islands**

- **cyclones have the different depth and intensity;**
- **cyclones are occurred during all seasons of year;**
- **the existence of single cyclone is 1-3 days;**
- **maximal intensity of cyclones is observed during winter and autumn, minimal one - spring and summer;**



- **two constant anticyclones are observed: the first - above the Far East, the second - above south-eastern part of Pacific.**

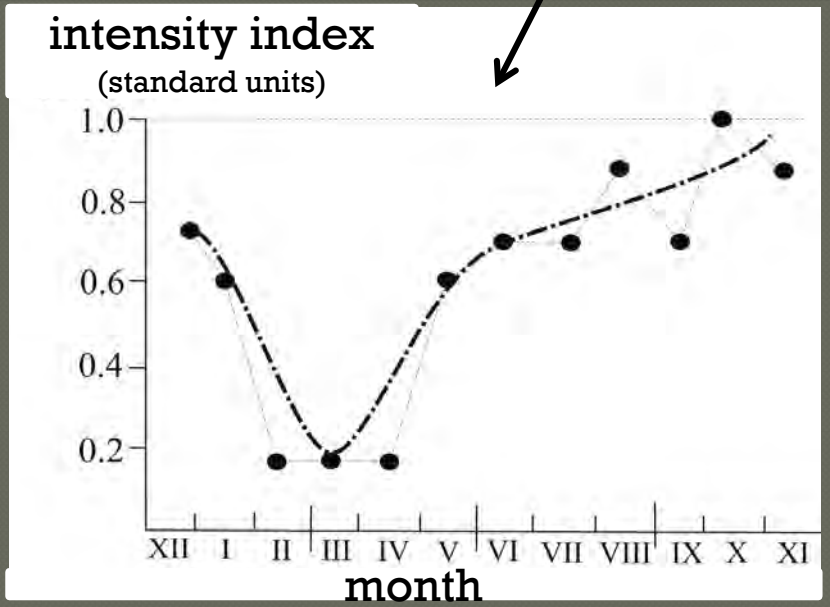


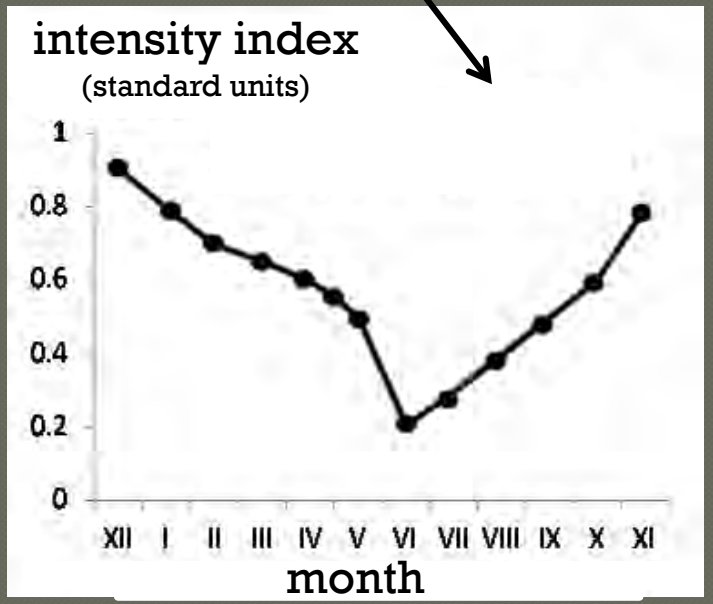
Analysis of the maps shows that this region is characterized by complex general picture of currents with different meandering and vortex formation. However, against this background, it is possible to identify the main features of the seasonal variability of water circulation. We consider the variability of wind intensity and water circulation as its main parameters.

The wind intensity is taken as the maximum wind speed and its duration, which are collectively expressed in nominal units. As a result, the so-called normalized variability index of atmospheric processes was calculated. For the unit of this index, the maximum repeatability of the synoptic situation for this region is taken.

For the **intensity of water circulation**, we take the maximum value of the difference between the current functions of the water masses between the two current surfaces of the stream per unit of time.

Graph of temporal variability of anticyclonic structures and "NW" atmosheric type





Analysis of maps of monthly average water circulation indicates that the maximum intensity of anticyclonic water structures is observed in autumn and winter, and its minimum is observed at the end of winter (February) and spring (March, April).

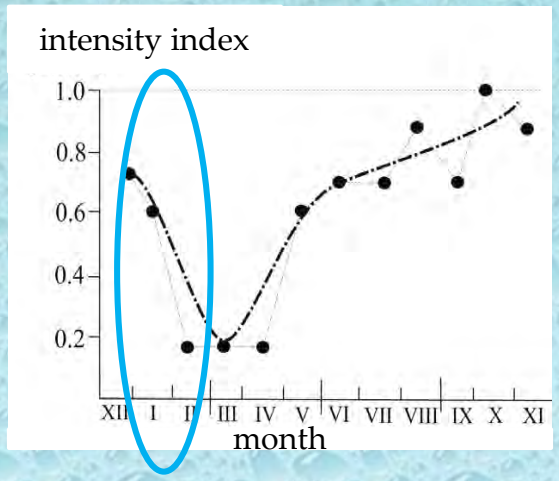
Maximum intensity of "NW" type of atmospheric processes is observed in winter and autumn, min – spring.

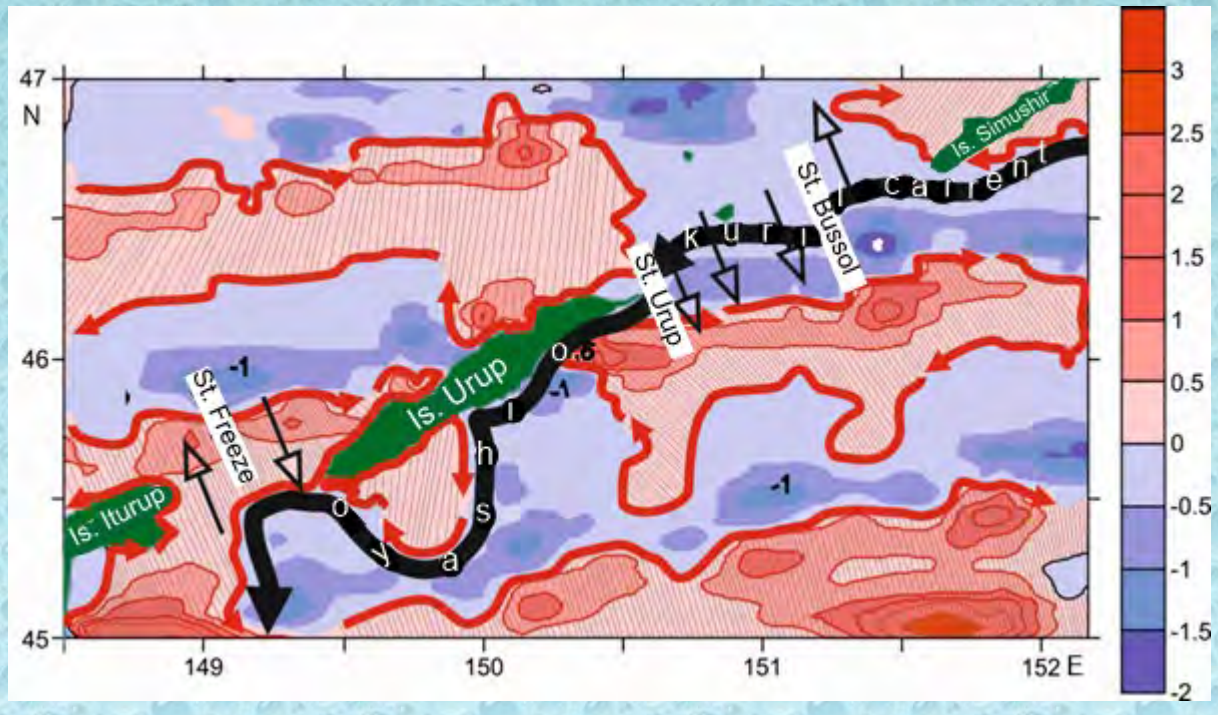
The hydrodynamic structures are reformed after the action of the wind with delay.

In winter, the intensity of water anticyclonic activity is relatively high in the initial period, as a continuation of the autumn and decreasing towards the end of the season. This is probably due to the fact that ice cover is destroyed at the end of winter (February) until the spring (March-April).

In January, there is a powerful anticyclone stretched along latitude 46˚30' in the Sea of Okhotsk. In the Pacific are formed two anticyclonic gyres - one along the 46°N and the other - the southern sublatitudinal anticyclone with several sub-mesoscale eddies along the 45°N.

The Kuril current does not change its direction, and ***Oyashio*** is deflected to the south of the central part of Urup. On the basis of Japanese investigations deviation of the Oyashio current in the region of Urup takes place up to 42˚N.

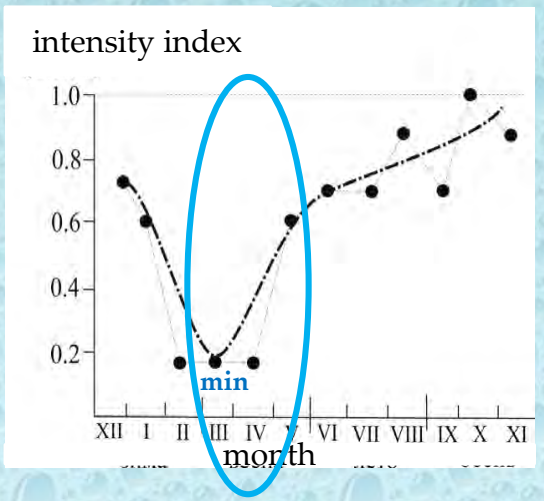


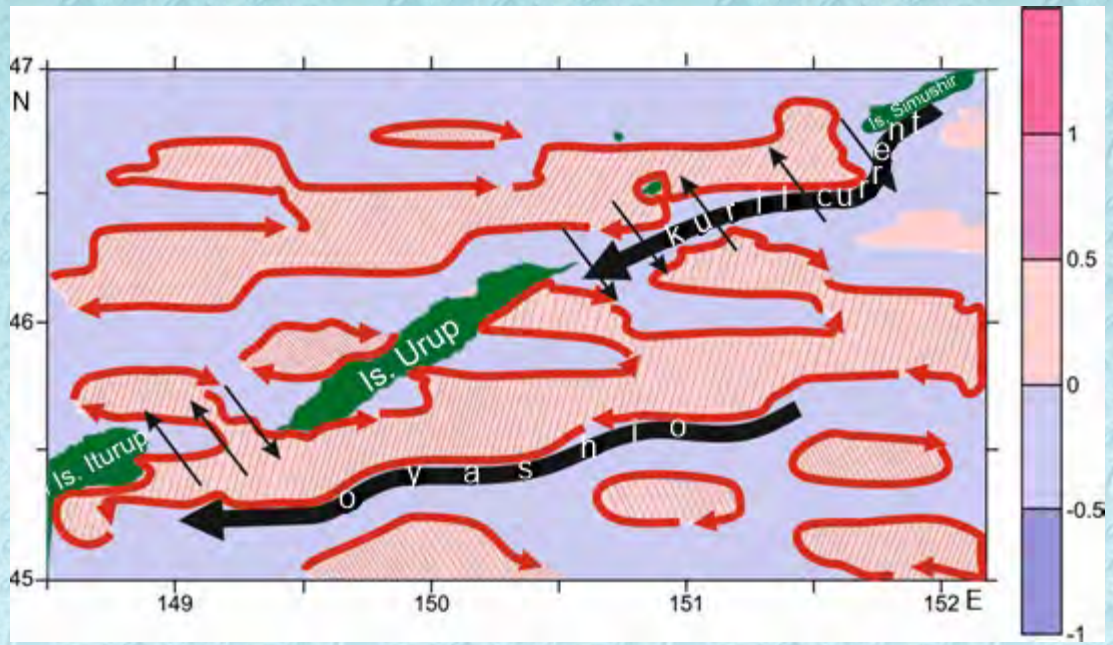


Functions of the stream on the surface (1x10⁷sm³/sec) for "north-western" type of atmospheric processes In **January** at the period 1949-2016

In spring intensity of anticyclonic activity is low in March and April, but increases in May. Intensive ice melting in the Sea of Okhotsk in the spring, and an active outflow of cold water into the Pacific Ocean play a significant role in the formation of the spring picture of current.
Anticyclonic structure stretched in latitudinal direction.

The Kuril current is unchanged, but ***Oyashio*** is traced to the south of Urup approximately 15-30 miles along the 45˚15'- 45˚30‘ N. It is known that the width of current Oyashio along the Kuril Islands ranges from 100 to 300 miles, therefore deviation of the Oyashio in principle is normal.



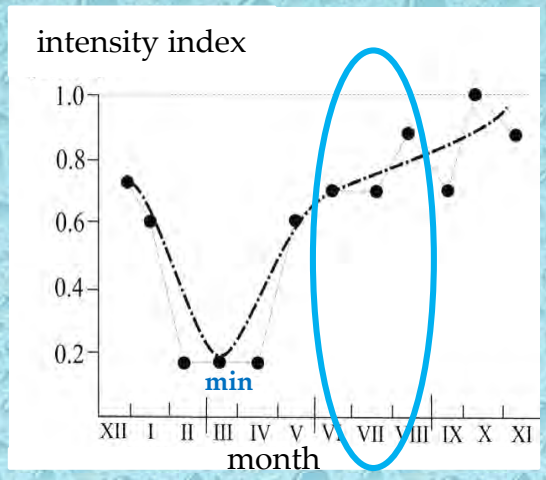


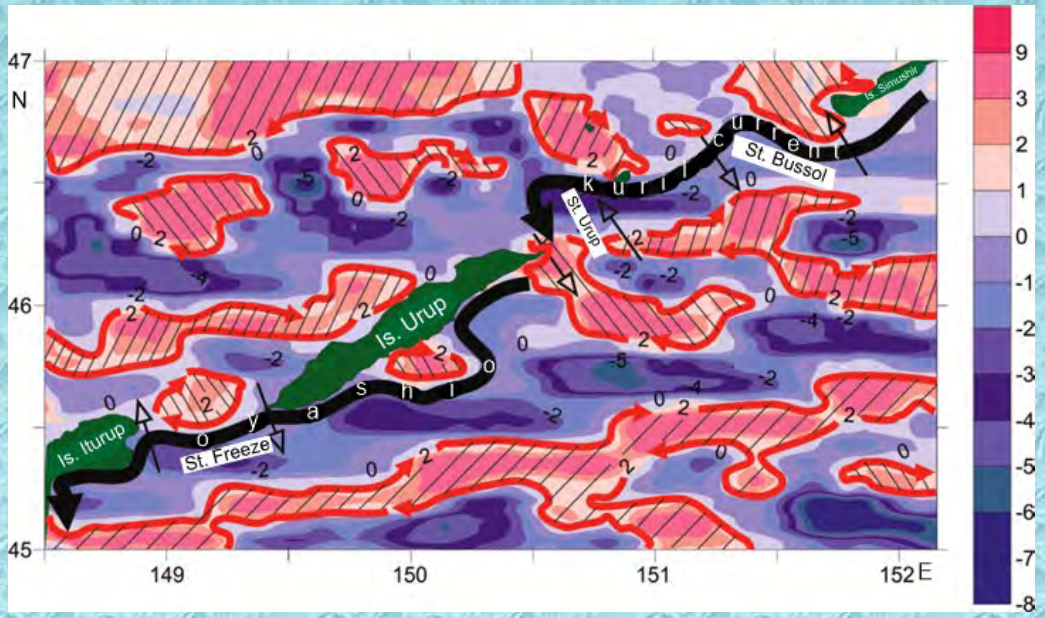
Functions of the stream on the surface (1x10⁷sm³/sec) for "north-western“ type of atmospheric processes in **Mart** at the period 1949-2016

In the **summer** the intensity of anticyclonic structures significantly are increased. Anticyclonic fields increases territorially, but medium structures. And the stream function values increase.

In July, small and medium anticyclonic structures are scattered in the Sea of Okhotsk and the Pacific Ocean.

During the summer months the ***Kuril current*** does not change its position, but ***Oyashio*** current deviates slightly in the center of Urup.



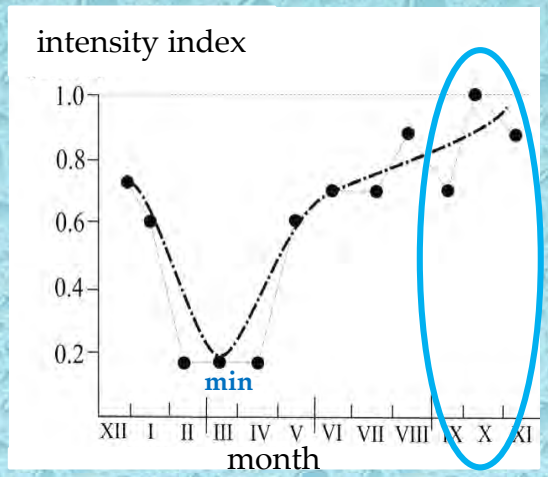


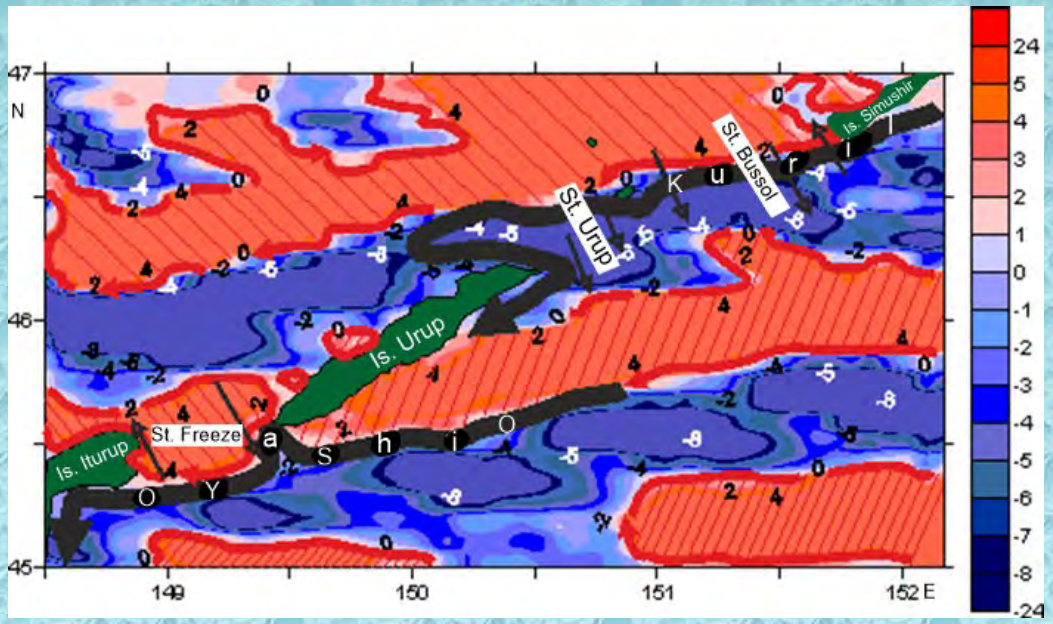
Functions of the stream on the surface (1x10^{7}sm^3/sec) for "north-western" type of atmospheric processes in **July** at the period 1949-2016

Autumn is the apogee of activity hydrodynamic structures as anticyclonic and cyclonic. The stream function values are the maximum (2.2x10^{7}sm^3/ sec).

October is the most expressive month of the year. Three anticyclonic gyres have reached its maximum development in the north (46˚15 '- 47° N), the center (45˚20' - 46° N) and southern waters (45˚ - 45˚30 'N).

The ***Kuril current*** is curved in the direction of the Sea of Okhotsk, and ***Oyashio*** current makes a bend to the south of Urup.





Functions of the stream on the surface (1x10^{7}sm^3/sec) for "north-western" type of atmospheric processes in **October** at the period 1949-2016

CONCLUSIONS

- **Seasonal spatial and temporal anticyclonic circulation of surface waters has been calculated for the first time in zone of Urup Island under the influence of "the north-western" type of atmospheric processes in the period 1949-2016;**
- **All possible causes of anticyclonic activity were formulated: constant presence of flows in the sea and the ocean, propagating in opposite directions (Oyashio Current and water of the Sea of Okhotsk) near the Kuril chain, and its convergence; wind transverse vorticity; tides; lithosphere thermal flow, volcanic activity Kuril arc;**
- **The correlation between the "north-western" type of atmospheric circulation and anticyclonic water circulation was established: full compliance with the seasonal variability and match the orientation from the south-west to north-east;**
- **Single powerful anticyclonic structures were detected at the beginning of winter, that spring it is divided into two separate of quite powerful cycles and summer its are breaks down into a number of smaller eddies and vortices with their further merger fall. This relationship probably due to the fact that the complex hydrological and geological processes focused on the studied area, taking into account the impact of this type of atmospheric processes;**
- **Significant changes in the waters Oyashio occur in the range of synoptic scale of variability of within-month oceanographic processes. Kuril current is unchanged practically to all seasons of the year, as the most stable.**


Thank you for attention