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Evolution of anomalies of salinity of surface waters of Arctic Ocean and their possible influence on climate changes

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Numerous of model simulations of ice extent in Arctic Ocean predict almost full disappearance of sea ice in Arctic regions by 2050. However, the nature, as against models, does not suffer the unidirectional processes. By means of various feedback responses system aspires to come in an equilibrium condition. In Arctic regions one of the most powerful generators of a negative feedback is the fresh-water stream to Greenland Sea and Northern Atlantic. Increasing or decreasing of a fresh-water volume from the Arctic basin to Greenland Sea and Northern Atlantic results in significant changes in climatic system.

At the Oceanology department of Arctic and Antarctic Research Institute (AARI) (St-Petersburg, Russia) in 2007, on the basis of the incorporated Russian-American database of the oceanographic data, reconstruction of long-term time series of average salinity of ocean surface was executed. The received time series describes the period from 1950 to 1993. For allocation of the processes determining formation of changes of average salinity of surface waters in Arctic basin the correlation analysis of interrelation of the received time series and several physical parameters which could affect formation of changes of salinity was executed. We found counter-intuitive result: formation of long-term changes of average salinity of surface waters of Arctic basin in the winter period does not depend on changes of a Siberian rivers runoff. Factors of correlation do not exceed -0,31. At the same time, clear inverse relationship of salinity of surface waters from volumes of the ice formed in flaw lead polynyas of the Siberian shelf seas is revealed. In this case factors of correlation change from -0,56 to -0,7. The maximum factor of correlation is -0,7. It characterizes interrelation of total volume of the ice formed in flaw lead polynyas of all seas of the Siberian shelf and average salinity of surface waters of Arctic basin.

Thus, at increase of volumes of the ice formed in flaw lead polynyas there is a reduction of average salinity of surface waters of Arctic basin. In the winter period obvious influence of waters of a river runoff on a hydrological situation of this or that sea is limited to a zone of distribution of fast ice and a narrow zone of flaw lead polynyas between fast ice and drift ice. That fresh water from the Arctic seas is transferred in the Arctic basin. There should be a certain effective mechanism to carry it. Presence of clear interrelation of salinity of surface waters and volumes of ice formed in polynyas, allows us to offer the following circuit of formation of average salinity of surface waters in the Arctic basin. The ice formed in polynya, is constantly taken out for limits of an area of flaw lead polynyas. This ice accumulates the fresh water acting with a river runoff. New ice hummocking and accumulate snow – the next source of fresh water. In the summer period ice is melting and forms surface fresh layer. In the cold period of year, presence of thick ice not allows accumulating all fresh water, and the zone of fresh water is forming. These fresh water areas could exist for months.

In the reports [1] was offered a hypothesis describing formation of distant connections in climatic system. In the hypothesis offered by us about a role of polynyas in formation of distant feedback in climatic system the most important and, unfortunately, the least certain parameter is «reaching time» of climatic signal from a place of origin (in flaw lead polynya area) up to the Greenland sea and Northern Atlantic. For an estimation of reaching time» we tried to trace drift of this anomaly from polynyas to Greenland Sea. For the initial moment of anomaly genesis month of the maximal development of polynya (when ice production of it was maximal) was chosen. Core of freshwater anomaly was determined for several polynyas. Using results of our simulations, data from database with areas of polynyas, wind stress data and current speed data from several sources, we got vector diagrams

of drift of anomalies. Within the limits of the seas were taken into account a vector of constant currents. The vector of displacement within the limits of each of the seas represented the sum of constant current and average for one month of a vector of isobaric drift. In the Arctic basin we used only a vector of isobaric drift. Vectors of isobaric drift are constructed by I. Karelin (AARI, St-Petersburg, Russia) on the basis of average for one month of fields of ground pressure. As shown in numerous researches, monthly averaging most adequately allow us to display a field of wind drift of ice. For construction of vector diagrams on sphere we used «MapInfo Professional 7.5».

For conviction of a reality of our hypothetical assumptions of carry of anomalies of salinity we have executed comparison of a spatial-temporal arrangement of areas vector diagrams we got with an arrangement of real anomalies of the salinity revealed as a result of instrumental observations. Such results of comparison have surpassed all expectations. We got confirmation of position of fresh water areas from instrumental observations executed in 2005-2007 by several cruises of AARI institute. Thus good concurrence of time and the location of areas of abnormal fleshing, received by theoretical and instrumentally observed conditions is marked. The map of a field of anomalies of the salinity, constructed for 2007 is most indicative. On this map a number of isolated fresh water areas in surface waters clearly allocated. To each of these areas of observed freshening there corresponds predicted passage of core of predicted anomaly.

We could conclude that there is concurrence of predicted fresh water anomalies and observed fresh water areas. It allows us to say hypothesis is working. Flaw lead polynyas really forming significant anomalies of salinity which being distributed in Arctic basin. These anomalies keep the properties within several years. Hydrodynamic aspects of distribution of anomalies are not clear yet. But the fact of formation and distribution of anomalies of salinity of surface waters in Arctic basin could be taken for granted.

In a case when the climatic signal from the several seas simultaneously reach Greenland Sea climatically significant anomaly of fresh water of ice could appear. It capable to result in sharp change of a climatic situation. Probably, the similar situation was in 1963-1964 years when «Great Salinity Anomaly» was observed in North Atlantic. Changes of atmospheric circulation was so significant, that in Arctic regions has rather sharply increased ice cover areas and the temperature of air has gone down. In our opinion similar conditions could arise in the present period when after several years of extreme development of flaw lead polynyas extreme freshwater anomaly which reaching of Greenland Sea is possible to expect 2008-2009 should be generated. In 2008 several freshwater anomalies generated in various flaw lead polynyas in 2003-2004 years already has left to Greenland sea and in April, July and November has reached Northern Atlantic. Synoptic situations which, in our opinion, can be connected to the given phenomenon, and also reaction of the Arctic seas to the given atmospheric processes are shown.

The analysis of a map of drift of anomalies allows us to conclude, that in 2009 it is necessary to expect an exit of the strong salinity anomaly generated from several large polynyas. To the given event there will correspond reduction of repeatability and reduction of areas of polynyas in the seas of the Siberian shelf, easing of carrying out concerning warm air masses to the Central Arctic regions and increase here ground atmospheric pressure in the cold period of year. In the summer period will take place strengthening of ice cover and, hence - downturn of temperature of air in Arctic regions. We could assume we are at the break point of temperature change and next year there will be cooling in Arctic.

[1] Popov A., Rubchenia A. Flaw polynyas as a source of long-distance connections
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