Interannual changeability of the ocean-atmosphere state in Argentine Islands region

Yu.I.Popov[1], V.V.Ukrainsky[1], G.P.Milinevsky[2], V.N.Sytov[3]

[1]Ukrainian Science Center of Sea Ecology, Odessa, Ukraine, ypopov@te.net.ua
[2]Ukrainian Antarctic Center, Kyiv, Ukraine, science@uac.gov.ua
[1]Odessa State Ecology University, Odessa, Ukraine

Abstract

The observations of the seawater temperature and salinity in Argentine Island Archipelago region show the strong within-year and interannual variability of the seawater thermal regime for the region last years. During winter the seawater temperature changed from -1.9°C to -1.0°C without considerable interannual variations. The summer period is characterized by year-to-year variations corresponded to atmosphere state. The seawater temperature anomaly to +4.2°C (and to +5.0°C in open water area) was observed during the 2000-2001 summer season. Presumably the conditions of high atmosphere temperature, high insolation level and calm weather were the cause of the seawater temperature increasing. The seawater temperature trend includes the three maximums: +3.5°C for the last decade of December; +5.0°C during January/February; +2.5°C for the first part of March. At the 20 m depth the positive seawater temperature was registered 10-15 days later then at the surface, and at 30 m - 35 days later. The seawaterheating covered all seawater thickness to 35 m depth. At the beginning of March the highest seawater temperature +2.3°C was registered at the depth of 30 m.

The seawater temperature stable conditions were recorder for the 2001-2002-summer period. The water temperature was below zero all summer and very seldom-raised more then -1.0°C. During summer season of 2002-2003 the thermal seawater regime was similar to 2000-2001 season and highest temperature (+3.7°C) close to seawater surface was observed at the end of January - the beginning of February. The 2003-2004 summer seawater temperature dynamics shows the anomalous conditions again. The thermal atmosphere states analyze of the averaged Faraday/Vernadsky data for four warmest and coldest months within 1945-2001 have shown the positive trends. In coldest period the average temperature has increased from -11.0°C to -6.1°C (0.089°C/year), in warmest period - from -0.6°C to + 0.65°C, (0.023°C/year). The thermal seawater regime in the region shows considerable interannual temperature variability with tendency to warming in summer seasons, which probably caused by positive air temperature trend. The problem either warming in the Antarctic Peninsula region caused the seawater anomaly or seawater temperature trend and circulation changes produce the regional climate warming should be discussed further.

Introduction

The ocean-atmosphere thermal state change is the main problem of the modern climate trend [1, 2]. The oceanographic seawater temperature and salinity observations in the different sea layers have been provided at the Ukrainian Antarctic Station Vernadsky (before 1996 the UK Faraday base) since 2000 in the Argentine Islands region (Fig. 1). The four-year 2001-2004 observation results allowed to examine the strong within-year and inter-annual changeability of the seawater thermal regime for the region.

Fig. 1. Seawater temperature and salinity profiling in Argentine Island archipelago region.

Observations

The **winter** thermal seawater state has the mainly homogeneous structure (Fig. 2). During winter the seawater temperature changed from -1.9°C to -1.0°C without considerable inter-annual variations. However the inter-annual changes of the within-year oscillation amplitude have been registered. For example, 2001 and 2003 winters were characterized by the smallest changeability: the surface seawater temperature was approximately near the freezing point (from -1.9 to -1.5°C).

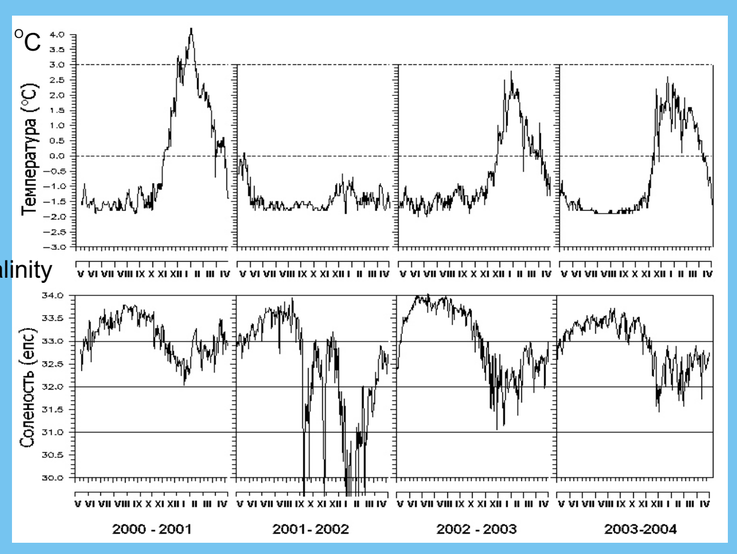

Fig. 2. The variability of the surface temperature and the seawater salinity in the tide gauge region (Meek channel) at the Ukrainian Antarctic station Vernadsky within the period from May 2000 to April 2004.

The **summer** periods were characterized by the strong inter-annual changeability, which connected to atmosphere state (Fig. 1). The very warm conditions, high insolation level and less windy weather in summer 2000-2001 produced increasing of the surface seawater temperature in the coastal zone to +4,0 - +4,2°C, and in the ocean to 4,9°C [3]. The advective factor plays considerable role for the anomalous thermal state formation. The warming up started at the last decade of November 2000. During warm period the surface seawater temperature trend includes the three maximums: +3.5°C for the last decade of December; +5.0°C during January/February; +2.5°C for the first part of March. At the 20 m depth the positive seawater temperature was registered 10-15 days later then at the surface, and at 30 m - 35 days later (Fig. 2). The heating of seawater was registered in 0-35 m layer depth. At the beginning of March the highest seawater temperature +2.3°C was registered at the depth of 30 m. The seawater cooling process was less intensive than the heating at the end of April.

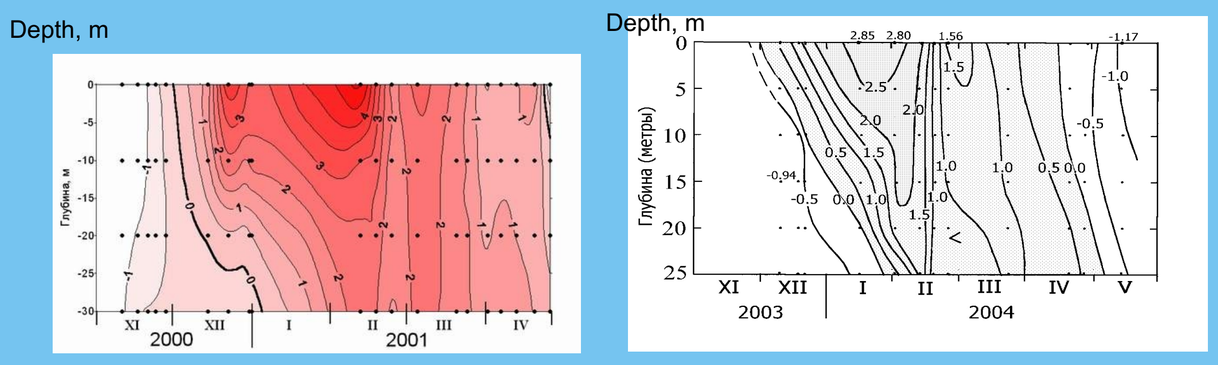

Fig. 3. The annual temperature variability of the 0-30 and 0-25 metres seawater surface layer in the Vernadsky region within the period from November 2000 to April 2001 and from December 2003 to May 2004.

The different from other previous years thermal seawater regime conditions were observed during the summer period 2001-2002. This period the seawater temperature hasn't got the positive values and was lower then 1.0°C. The anomalies were recorded in the seawater salinity regime. The several periods of the surface seawater intensive desalination were observed. The reason of these anomalies is the large-scale processes of the atmosphere circulation, and the seawater surface albedo.

During the summer period 2000-2001 the phase declining the ground atmosphere pressure, has been created by large-scale two-year wave and summer period 2001-2002 was corresponded to the pressure increase phase. The August 2001 - February 2002 period has been characterized by the strong and stable north and northeast winds with the average monthly wind speed value 5-8 m/s, and average modules vector transfer value 5 m/s. Probably, the ocean circulation processes were determined by these atmosphere regime.

During 2001-2002 the great number of icebergs and drifting ice have been observed in the Argentine Islands Archipelago, which could be carried out by wind and current from the western regions of the Bransfield strait and Palmer Archipelago. The large quantities of icebergs and sea ice have screened the heat streaming to the water surface and albedo increasing.

Thermal regime during the summer period 2002-2003 and 2003-2004 was similar as the summer season 2000-2001 (Fig. 2). However, the both periods the seawater temperature was 1.0-1.5°C lower. The surface seawater temperature maximum (2.4-2.7°C) within 2002-2003 was observed on the end January beginning February, and within 2003-2004 season on the mid January. At the summer period 2003-2004 the warm seawater period was more prolonged than similar period in 2002-2003 (approximately on 1 month).

In contrast to the season 2000-2001, at summer 2003-2004 the seawater warming-up on 20 metres depth and the seawater warming-up to 0°C was happen 40-45 days later than for similar surface seawater conditions (Fig. 3). Then, the seawater warming-up speed at summer 2003-2004 was in three times less, than at summer 2000-2001. However, during 2000-2001 the all seawater column was warmed-up, and the near-bottom seawater temperature on the 25 metres depth rose to +1.5°C at the mid February.

The spectral and dispersion analysis of the changeability of the surface seawater thermohaline condition during the warm season has shown, that the long period oscillations developed simultaneously with the synoptic fluctuations with the 9 - 17 days period.

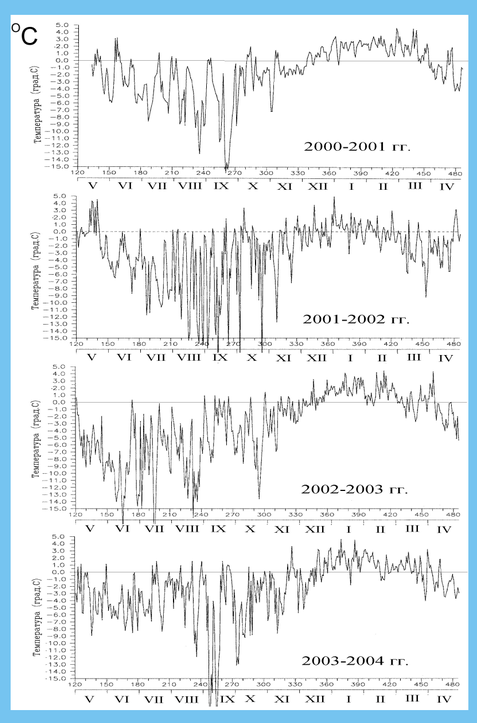

Fig. 4. The average daily air temperature annual variations at the Vernadsky station during the May 2000 - April 2004.

The 3-5 days variations of the temperature and salinity seawater oscillation spectrum maximums were observed. The atmospheric synoptic processes changeability caused these variations. Similar maximums were observed in the atmosphere pressure, air temperature and wind speed spectrums.
The part of the synoptic changeability in different years of the summer period was 3 - 28 % for the temperature fluctuation dispersion and 14-32 % for the seawater salinity fluctuation dispersion. The synoptic variability contribution to the common fluctuation air temperature dispersion for the summer period was 31 - 62 %.
The surface air temperature analysis during the period 1945-2001 for the averaged data of the fourth the coldest and fourth warmest months shows the stable trend. The average temperature for the coldest period has being increased from 11.0°C to 6,1°C, with trend 0,089°C per year, and for warm period: from -0,6°C to + 0,65°C, with trend 0,023°C per year.

°C

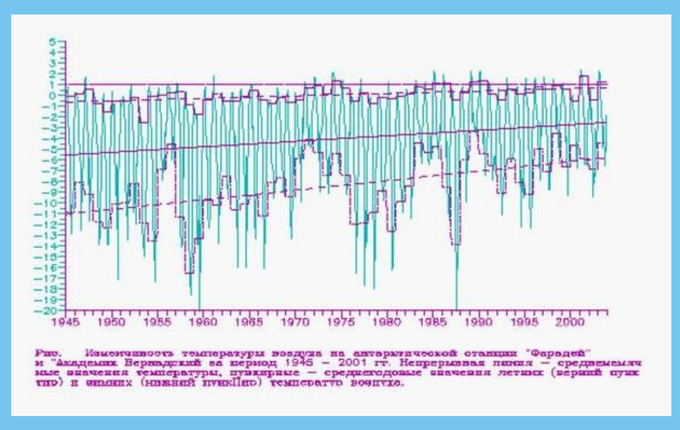

Рис. Изменчивость температуры воздуха на антарктической станции "Фарадей" и "Академик Вернадский за период 1945 – 2001 гг. Непрерывная линия – среднемесячные значения температуры, пунктирные – среднегодовые значения летних (верний пунктир) и зимних (нижний пунктир) температур воздуха.

Fig.5. The surface air temperature variability in the Faraday/Vernadsky station region 1946-2001. Solid line monthly mean values, dash lines annual mean values for summer (top) and winter (bottom).

Conclusion

The seawater thermal state for the summer period in Argentine Islands region shows the significant inter-annual oscillations and the enthalpy increase tendency last years. The seawater temperature maximum + 4,9°C was recorded at summer 2000-2001. This conditions strongly influenced to the surface seawater salinity regime. Big amount of icebergs and drifting ice during summer period produces the intensive water desalination.

The temperature and salinity seawater variability closely connected to the thermal and circulation regimes of the atmosphere and ocean, and to sea ice conditions. The thermal seawater regime in the region shows considerable interannual temperature variability with tendency to warming in summer seasons, which probably caused by positive air temperature trend. The problem either warming in the Antarctic Peninsula region caused the seawater anomaly or seawater temperature trend and circulation changes produce the regional climate warming should be discussed further. The surface air temperature positive trend is caused by the increasing of the average winter temperatures mainly.

This work was partly supported by grants FFD F7/362-2001, and MON A/2-2004.

Reference

1. King J. C. Recent climate variability in the vicinity of the Antarctic Peninsula // International Journal of Climatology, 14, - No 4, - 1994. - P. 357-369.
2. Vaughan D.G., Marshal G.J., Connolley W.M., Parkinson C., Mulvaney R., Hodgson D.A., King J.C., Pudsey C.J., Turner J. Recent rapid regional climate warming on the Antarctic Peninsula // J. Climatic Change. - V. 12 (2).- 2002. - P.1-44.
3. Popov Yu.I., Skrypnik V.V., Timofeev V.E., Ukrainskiy V.V. // Hydrophysical anomalies and their connection with the meteorological regime in the Antarctic station Vernadsky during the summer seasons 2000-2001. // Ukrainian Antarctic Journal. - N 1. - 2003. - P. 79-84.