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SYNOPTIC CIRCULATION TYPES OF ANTARCTIC PENINSULA AND ADJACENT SOUTH OCEAN REGIONS AND CONNECTED PHENOMENA

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Introduction

In February, 2001 the Ukrainian Antarctic base Academician Vernadsky celebrated the 5th anniversary of its operation. Over that period Ukrainians have mastered all necessary techniques and added some new equipment. The main fields of research are geophysics and meteorology and ozone measurements. Recently all sciences started to be considered in their complexity that reflects natural state of things. Meteorology defines all circulation patterns in troposphere as well as in lower stratosphere and so it is responsible for surface weather and for the background of ozone hole phenomenon. On the other hand geophysics concentrates mainly on the investigation of higher spheres as ionosphere and magnetosphere but it is contiguous to meteorology while considering ozone variability in stratosphere. After the 1st Ukrainian Expedition some descriptions of climate of the base were given in our lecture at XXV Polish Polar Symposium (Govorukha, Timofeyev 1998).

The state of research

The lack of knowledge of the Southern Hemisphere circulation makes it necessary to research synoptic processes and weather conditions. On the contrary to the Northern Hemisphere where there is a number of permanent centers of action (PCA) of lower pressure, in the Southern Hemisphere one can distinguish the whole belt of cyclones. There are some regions with increased frequency of cyclones and therefore with lower averaged pressure. Besides PCA are almost not localized seasonally in the Southern Hemisphere, and anticyclonic processes defined by interaction of PCA of higher pressure – both Pacific and Atlantic subtropical and antarctic continental. Average fields of principal meteorological parameters are characterized by high smoothness and in order to get some typical circulation processes it is necessary to take into account an each synoptic process that brings significant weather to have types of various synoptic processes with their own characteristics that differs from one another.

Looking through the maps of annual average fields of surface pressure (*Atlas Antarctiki* 1967, *Meteorology* 1954) one can recognize some climatological regions of low pressure around the Antarctic and two of them are near Antarctic Peninsula – in the Bellinsghausen Sea and close to eastern side of the Weddell Sea. Weakly-shaped wedge over the northern extremity of the Peninsula is seen only in April and for the rest time of the year the average pressure field shape is close to zonal flow. The analysis of aggregate charts of cyclones and anticyclones and their displacement shows that areas of high pressure dominate near Antarctic Peninsula in July and October but in January and April their frequency is less. But, as a result of our observations, the pressure distribution can vary from year to year.

The weather in the region of the Antarctic Peninsula depends greatly on the development of subtropical anticyclones. Sometimes synoptic changes between cyclones and wedge of subtropical maxima take place with clearly outlined frequency and those processes have seasonal variability and intensification. The Pacific subtropic maximum is known to moves relatively slowly but Atlantic one can move more between seasons (POLEKS 1986). Meridional trajectories of cyclones caused by certain stable systems of tropospheric circulation that are mainly represented by subtropical maxima and anticyclones of middle latitudes.

The purpose of research and the data used

The main purpose of research was to study main low tropospheric processes that form the weather conditions at the Vernadsky base and at the northern part of the Antarctic Peninsula. We used a set of synoptic charts of Chilean military service from March, 1997 to April, 2000 (with insignificant breaks), which cover the area between 40° W to 120W° and from 80°S to 30°S. It made it possible to investigate the main synoptic processes and weather patterns at both the Bellingsghausen and the Weddel Seas and adjacent water area of the South Pacific and the Atlantic. As usual, charts were received twice a day, 06 and 18 GMT. A restricted set of ECMWF surface and 700 hPa GRIB data as well as standard meteorological data of Vernadsky base were used. We used satellite images to describe the evolution of cyclones and main air flows. And we used daily averages of total ozone amount values that were measured by means of Dobson spectrophotometer at the Vernadsky base. This instrument was remained by the British Antarctic Survey (BAS) in the process of Faraday base handover in 1996. Some data of Ukrainian ships' observations made during the seasons of 1998 and in 2000 were used. So we tried to show almost all aspects of research being made at our base. Vladislav Timofeyev participated twice in winterovers at the Vernadsky base and had a good opportunity to investigate real synoptic processes and weather caused by them.

Results of research

General description of climate. 1999 was colder than 1998 but the interannual change of the average air surface temperatures remained in line with the positive trend during last years (fig. 1).

The cold winter spell within late August and mid-September with average air temperature of about –17°C is responsible for minimum temperatures of both months (table 1). But monthly averaged air temperatures were about –9°C and only September 1999 was colder than 1960–1991 mean; in summer the same was in December; the rest months were warmer in 1999.

This cold spell defined future spring and summer weather conditions. Formation of fast ice unusual for recent years resulted in complex sea-ice conditions. The nipping in ice RRS James Clark Ross (BAS) on approaches to Adelaide Island became an outstanding event. Sea temperatures showed lower values in 1999 in comparison with 1998 and snow melting had been delayed until recent months of 1999 (fig. 2). Subsequently it most probably resulted in mean temperatures of the first 3 months of 2000 no higher than 0.0°C.

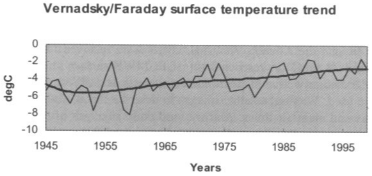


Fig. 1. Annual mean surface air temperature trend at Vernadsky/Faraday base, 1945–1999

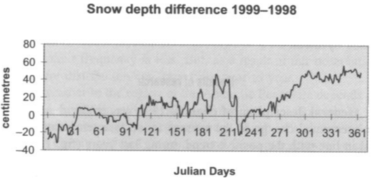


Fig. 2. Snow depth difference between 1999 and 1998 at Vernadsky

Pressure distribution throughout the year showed its usual variability, with some extremes. Usual autumn maximum being observed in April was shifted and observed earlier – in March; in winter there were two peaks: in June and August. In general, the months within March-September had average pressure somewhat higher than average annual one. December's monthly average value of pressure were lower than annual one.

Table 1. Climatological returns for Vernadsky (Argentine Islands) 1999, 1998 and averages within 1961–1990

Month	Mean sea level pressure, mb			Air temperature, °C				
	daily mean	extremes		daily mean			extremes	
		highest	lowest	1999	1998	mean 1961–1990	max. 1999	min. 1999
January	987.3	1001.0	970.7	0.8	1.5	0.7	8.3	–2.2
February	981.7	1001.7	956.8	1.1	1.4	0.7	7.1	–2.0
March	992.0	1009.4	958.0	0.5	0.3	–0.5	5.9	–3.6
April	984.5	1007.0	962.1	–0.6	0.1	–2.4	4.6	–4.9
May	989.7	1020.8	949.2	–1.3	–3.1	–4.3	4.2	–6.2
June	995.4	1014.8	968.8	–4.3	–1.1	–6.3	1.6	–11.6
July	986.8	1018.5	954.9	–3.9	–2.7	–9.0	3.8	–14.0
August	988.5	1016.0	943.7	–9.3	–2.9	–9.8	–0.5	–23.3
September	990.4	1011.0	964.8	–9.0	–6.1	–7.5	2.6	–28.2
October	984.0	1018.2	936.5	–3.5	–3.3	–5.0	2.7	–12.3
November	984.2	1013.6	962.2	–1.5	–1.4	–2.3	4.6	–7.4
December	980.8	1000.2	980.8	–0.9	–0.1	–0.2	4.0	–7.2
Year (Averages)	987.1	1011.0	959.0	–2.7	–1.5	–4.4	4.1	–10.2

Addition: Mean temperatures in 2000: January -0.4; February 0.0; March 0.0°C. Extreme and discussed values are underlined.

Unusual events of deep cyclones with very low pressure were observed in August and in October, 1999. On the 14th, October its value was as low as 936.5 mb that became the second lowest record for the period observed. At the Polish antarctic base Arctowski, some 300 km north, the lowest observed pressure was also connected with this deep depression and amounted to 940.0 mb (Zblewski 2000). Vernadsky had lower value being closer to the center of slow-moved deep depression.

Types of synoptic processes. They have been chosen in dependence on the general weather conditions at Vernadsky base and the northern part of the Peninsula. So, equally with peculiar surface circulation for each typical process we juxtaposed typical surface weather conditions. Formation of local topography circulations at Vernadsky was one of the main factors in the distinguishing of types. Wind direction was as an auxiliary thing. At the basis of about 1200 synoptic charts analysis we have chosen the following types of synoptic processes.

Low pressure systems:

1. Eastward (zonal) moving low pressure systems, representing cyclonic belt of Southern Hemisphere (fig. 3a). Cyclones of this type can move faster close to end of autumn and in winter and can be slower in summer. Trajectories are almost entirely within 55–70°S, and sometimes central parts of these cyclones can pass over the Vernadsky. Sometimes cyclonic centers pass over Drake Passage and it lead to local topography phenomena formations at Vernadsky being at the southern periphery of the cyclone.
2. North-west cyclones, coming from middle latitudes (fig. 3b), bring down warm air and significant warming at Graham Land and sometimes form zone with high pressure gradients above Drake Passage, with south-eastward wind direction at Vernadsky. Foehn phenomenon is formed in strong north-western winds blowing across the Peninsula. Dynamic temperature growth can be added to foehn rise and in total air temperature can reach significant peak values, about 8–10°C. Precipitation very often started to fall at final stage of cyclones' passage of this type (after foehn is ended). At figure 3b the middle-latitude cyclones (between 35 and 50°S) as well as cyclones in Antarctic low pressure belt (southward from 60°S), with their usual positions for winter, are shown.
3. Multi-centers' depressions – usually represents filling-in cyclones, with fronts at their periphery, consist of some centers of low pressure and cover the huge area of the Bellinsghausen Sea (fig. 3c) and sometimes touch the Weddel Sea, slowly crossing the Peninsula if they hadn't been filled in before.
4. Weakly-expressed surface pressure fields. They often can be seen when cyclonic activity is not shaped or at the stage of breakdown of any cyclone over the Bellinsghausen Sea. Development of mesoscale vortexes is possible. This type observed more frequently in spring or beginning of summer and often is connected with both convective clouds and shower precipitation.
5. Frontal activity (out of the central part of cyclone) – may be more pronounced in some years and result in significant temperature

contrast at Vernadsky, up to 15–20°C per 12 hours, as we observed it on cold fronts in 1996. Indirect indicator of cold front power can be nacreous clouds that are formed at significant heights in strong winds when the direction of air flow nearly perpendicular to mountain ridge and the clouds were seen three times in July and August 1996 very expressively. In 1999 no nacreous clouds were seen. On the other hand, almost all cyclones coming up to the Antarctic Peninsula are being occluded and the occlusion front is frequently observed parallel to mountain range of the Antarctic Peninsula.

High pressure systems:

1. The wedge of Pacific subtropic maximum over the Bellinsghausen Sea is shown at the fig. 4a and it is often followed by separate anticyclone formation in mid-latitudes. The wedge is shown in its initial stage with its axis nearly parallel to 105–110° W. In couple days later it as a rule reaches the Antarctic Peninsula and brings down the cold air that can take air temperatures below freezing in summer and can cause cold clear weather in winter. When axis of this wedge moves east off the western coast of the Antarctic Peninsula, advection of warm Pacific air starts and precipitation from Stratus clouds are possible.
2. The wedge of the Atlantic subtropic maximum (fig. 4b). Its axis usually situates some eastward than of the Pacific one and can quickly move to Weddel Sea. The weather at Vernadsky is usually cool in its western position, over the Bellinsghausen Sea. The weather is often connected with relatively warm air inflow, low thin clouds, sometimes drizzle or fog but without strong winds, if the wedge dominates over the Weddel Sea.
3. Blocking wedge is the most favorable situation for settled cool weather throughout the Antarctic Peninsula. The Pacific and the Atlantic subtropical maxima usually unite over South America and one sharp ridge is spreaded far south, often to the base of the Antarctic Peninsula, creating system blocking eastward movement of cyclones. We have settled cold weather at Vernadsky if the wedge locates over the Antarctic Peninsula by its eastern flank, how it was observed by September, 1999 (fig. 4c).

4. The Antarctic wedge – from the continental interior. It is usually weakly expressed and outlined no more than 2 isobars over the Graham Land. It is developed when cyclonic activity is depressed and it is usually attracted to one of the wedges of the subtropic maximum creating united system of high pressure. Obviously, the continental ridge plays a great role in formation of the blocking system.

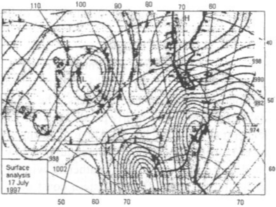


Fig. 3a. Synoptic chart 17 July 1997, 06 GMT. Isobars through 4 mb

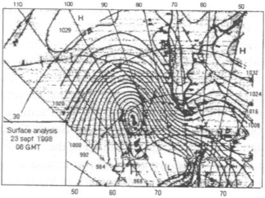


Fig. 3b. Synoptic chart 23 September 1998, 06 GMT

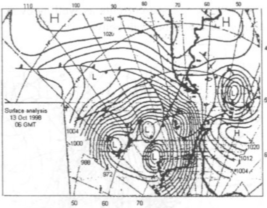


Fig. 3c. Synoptic chart 13 October 1998, 06 GMT

And, finally, we distinguished transitive *zone of interaction* between areas of both low and high pressure systems. It is often observed when the blocking system passes forward or retreats and is usually characterized by strong winds and sometimes by the local wind circulation effects formation (foehn, gusty winds) at Vernadsky when wind direction is eastern. Situation like this may be seen from fig. 4a, where high pressure gradient zone situates over the Tierra del Fuego and turning eastward over Bellinsghauşen Sea get closer to the Antarctic Peninsula.

As usual, cyclones dominate during all seasons but in separate winters or springs the synoptic systems of high pressure can dominate, blocking cyclones passage. Making the comparison of synoptic variability between different seasons of 3 years, we found out that cyclonic activity dominated in 1997 and 1998 but anticyclonic (57% days) was dominant within June-September in 1999, at the Vernadsky.

Types of synoptic processes are described above may not completely describe the synoptic variability in this region of Antarctica because of not so long time series were took into account. For example, only 5 periods with "genuine" blocking were found out but its significance for weather is well-known. However one can think that we considered the most distinctive processes that define in general weather regime, sea-ice and sea-currents as well as even total ozone amount variability, as it will be seen below.

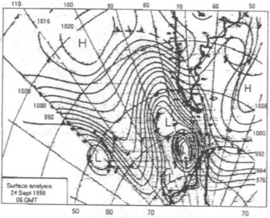


Fig. 4a. Synoptic chart on the 24 September 1998

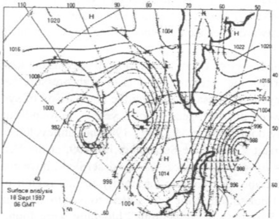


Fig. 4b. Synoptic chart on the 18 September 1997

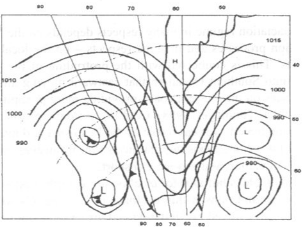


Fig. 4c. Synoptic chart on the 9 September 1999. Isobars through 5 mb

All these processes needed to be considered in their dynamics. For example, both the Pacific and the Atlantic anticyclones may develop in different ways creating or huge high pressure area when both anticyclones are developed well or give the way for cyclones when one of maxima is developed weaker. Situation of interest is shown at fig. 4a, when both Pacific and Atlantic wedges are advanced far south and they block the development of cyclone over eastern Bellinsghausen Sea.

When the Pacific wedge is not developed the Atlantic one's expansion often lead to formation of cyclones of moderate latitudes west off South America as well as strong north-west flow over Drake Passage, how it was mentioned for cyclones of type 2. Both middle latitudes and polar cyclones may merge and create one depression. Sometimes influence of the Peninsula is felt, when two centers of low pressure appear on synoptic chart – east and west off the Peninsula (segmentation of the cyclone). Cold front passage is often followed by the expansion of relatively high pressure. At the fig. 3b the cool air ridge is clearly seen over the Bellinsghausen Sea, just between two southernmost cyclones.

Glaciation and sea-ice

The glaciation regime in many respects depends on the large-scale circulation processes and in some respects – on the local topography effects. This is connected with the protruding of the Antarctic Peninsula into Southern Ocean so that eastward moving air flow firstly influences on the western coast, providing more precipitation there (Govorukha, Timofeyev 1998). Cold flows from the Antarctic continent are dominated over east coast of the Peninsula and make up the conditions for ice-shelf existing that in its turn influences on low tropospheric circulation and sea-ice transport.

The favorable conditions for ablation bring north-west winds with extra-warm air and rains within cyclones of 2nd type. Cyclones of 1st and 3rd type carry mixed precipitation and air temperature nearly zero or just above freezing point. The high rates of ablation were observed within series of cyclones that dominated through 1998. In winter the main conditions for accumulation are connected with snowfalls in eastward moving cyclones and partially – with warm flanks of anticyclones. The best conditions for preservation of snow and ice in winter are existed in long-lived anticyclones or in blocking wedges. Decent melting is observed in summers' days with clear skies at the Vernadsky base being under influence the high-pressure system.

Our research on surface snow and ice were mainly restricted by local island group and added by field research. Galindez Island where Vernadsky stands is covered with the ice cap that has like-cupola shape with relatively smooth central part. 6–7 islands within Argentine Islands contain ice caps with maximum height as 60 m at Galindez. Low levels of caps do not let to determine some glaciological parameters as equilibrium line etc. but observations showed significant regress of ice caps in last years. Accordingly to data of English researchers before 1996 as well as to our further works, the destruction of local ice caps accelerated in last two decades. Events of frequent calving were registered and new crevasses were formed and the negative values of glacier balance were received at the basis of the data of stakes polygon at Galindez Isl., in last four Ukrainian seasons. Only observations at Hovgaard Isl., north 14 km of the Vernadsky base, at elevation as 400 m as high showed that equilibrium line is located no lower this level. It is important to note about some difference between climate both at islands advanced to the sea and on the Antarctic Peninsula outlet and valley glaciers. Marine influence makes weather conditions on islands warmer and the climate at the Peninsula is colder so all balance characteristics may vary. A great quantity of precipitation in 1998 led to significant ablation on local islands glaciers and the possible aftereffect became the outflow of small lake of fresh water just before Vernadsky base and melting out some old things and instruments nearly the old station (Wordie House), closed in 1954. (Now it is a historic site). Formation of big grotto and cave at the Galindez's glacier cliff was also caused by numerous rains through 1998 and in March 1999. Probably, 1998 became the year with maximum annually accumulated precipitation. Six records of maximum monthly sum of precipitation were registered in 1998 (fig. 5).

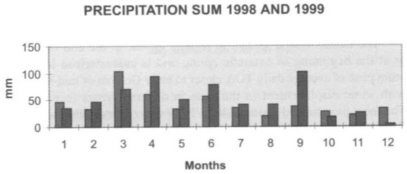


Fig. 5. Precipitation sum for 1999 (left) and 1998 (right), Vernadsky base

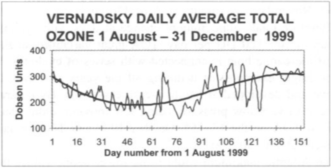
Sea-ice conditions in the closest surroundings of Argentine Islands where Vernadsky stands as well as within the adjacent water area of the Antarctic Peninsula depends greatly on general weather. Firm fast ice was formed here to the mid-September and later there were much of brash ice and floes and bergybits as before the base as in open sea, from October to the end of 1999 and in January 2000. Even in March 2000 we observed remnants of one-year ice carried with southern winds. All of those events was the aftereffect of the cold spell in September, 1999. The main differences of sea-ice situation at present with that one was observed 50 years ago (*Meteorology* 1954) are the following: later time of fast ice formation and duration of its preservation, complete disappearance of ice in internal creeks in summer, absence of multi-years ice and tabular bergs in recent winters. These facts are in correspondence with general positive trend of surface air temperature and warmer winters through the last decade. However, actual sea-ice conditions may be various and depend on circulation type, frosts period duration, both wind velocity and direction and initial state of water areas before freezing.

Ozone measurements are the important component of science program at the Vernadsky base. The base being the former name Faraday before 1996 has one of the longest records of total ozone amount (TOA) in the Antarctic, since 1957, the time of International Geophysical Year. The initial decrease of TOA that thereafter led to ozone hole phenomenon was registered here, by English researches. The continuation of this program is exceptionally important as for general trend analysis as for consideration of the ozone hole development year by year.

The ozone hole is known to usually appear at the end of winter or at the beginning of antarctic spring and is characterized by minimum peak of average daily TOA closer to early October or mid-October, with some displacement in the time in different years (see fig. 6). The most pronounced ozone hole in 1999 was observed by the end of September, and in 1997 – some later. When analyzing the same figure 6, some difference to the left part of both trends can be seen – some local growth of TOA in August 1997 and general drop TOA at the same period in 1999. Both trends became similar after early-November (from nearly 90th day after 1st, August).

There is a well-known circulation background of the ozone hole. It is connected with circumpolar vortex (CPV) development. The timing of negative trend in TOA (till 45–50th day after 1st August) is connected with maximum development of CPV, when TOA became lower over the entire Antarctic. Further on, the process of breakdown of CPV starts and the last drops of TOA in 1999 (between 121st and 136th day) reflects the last appearance of cold stratospheric air containing poor ozone. Some authors say about the dependence of stratospheric circulation on that which is observed in troposphere (Dmitrijev et al. 1989). In our research we found the general dependence of lower tropospheric situation on the ozone variability and showed some aspects of it during the First Ukrainian Antarctic Expedition 1996–97 (Timofeyev 1997). Well-developed cyclones usually carry air containing rich ozone and blocking wedges covering all tropospheric levels contain air with poor ozone (Aleksandrov et al. 1992). Thus time of stable winter anticyclone can be connected with maximum development of CPV and ozone hole phenomenon formation.

a



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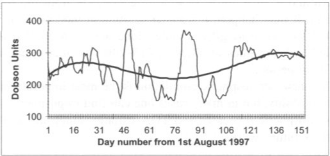

Fig. 6. Daily averaged total ozone amount for the second half of 1999 (a) and 1997 (b), Vernadsky base

Almost all main peaks and minima of TOA during the ozone hole period have its synoptic circulation background. September's 1999 blocking process supported negative trend of daily ozone, and TOA values were lower than 200 Dobson Units (DU) on the 2–5 and 8–11th, September. When the Pacific anticyclone retreats, giving a way for a separate cyclone, TOA increased to 240 DU on the 7th, September. Later TOA dropped to very low values – 138 DU on the 30th, September, when anticyclone dominated again over South Argentina, Drake Passage and Graham Land. General change in daily mean TOA trend into the positive at the very beginning of October was caused by retreating of this anticyclone somewhat northward. TOA increased to 300 DU on the 8th, October, when cyclones finally broke the anticyclone. There is another example for high rates of ozone content dated the 15th, November (maximum TOA of 330 DU).

Therefore total ozone amount change at days with cyclones can reach up to 100–120 DU per day. TOA great variability at the final stage of the ozone hole is connected with series of cyclones. We found the bright examples of it during all the years analyzed, but for intensive and developed at height pressure systems. By contrast, the cyclone with very low pressure, being low moving, didn't cause the growth of TOA on the 13–15th, October 1999 and TOA remained at low levels, about 150–180 DU.

The Atlantic maximum could bring lower ozone values than the Pacific one because the type of tropospheric circulation is set with southern and even south-west wind direction, i.e. from the Antarctic continent. It may happen in summer or autumn months, as it was in March, 2000, when long-lived anticyclone with good settled weather provided as low values of TOA as 215–240 DU, that is unusual for out-of-hole period.

Of course, stratospheric circulation is the most important thing in ozone variability, but in many cases one can find tropospheric response to stratospheric processes and TOA variations and this will be the subject of future works.

Discussion

We found some comparable results with the types of surface synoptic circulation shown by Kejna (1999), namely for both Pacific and Atlantic wedges expansions. Dominant anticyclonic and cyclonic types may be nearly the same for Vernadsky and Arctowski, but it is necessary to expect more differences in weather regime in cyclones because the mountain ridge of Antarctic Peninsula is farther from King George Island.

One can say that synoptic situation at Vernadsky is varied between two essentially different types – clearly shaped zonal flow with some low pressure centers, up to 45°S, and well-outlined blocking wedge. Almost all wedges of subtropical maxima reach the Antarctic Peninsula and this region can be considered not only as one of one well-expressed cyclonic activity but of anticyclogenesis and tropospheric blocking as well, although the latter is rarer. When zonal flow is weakened and series of cyclones crossing the Antarctic Peninsula is interrupted, cold air inflow creates the opportunity for formation of the wedge over the Bellinsghausen Sea. In most cases this wedge is connected with wedge of the Pacific subtropic maximum, and then latter begin to expand to the Antarctic Peninsula. The wedges have a seasonal variability and dominate in August, November and in March, so it is possible to mark out seasonal patterns of stable weather.

Period of good weather in March 2000 was caused by Atlantic wedge, having been stable within 15–31th. Expansion of Atlantic wedge in March is typical for all the years and settled weather conditions provide a good opportunity for safe ship operations at the beginning of antarctic autumn. September's period of blocking in 1999 is usual but it can be shifted in time and in September of 1996 we had very warm weather at the first half of the month with intensification of anticyclone to the second half of the month. Similarly, in 1998 this period was observed some time later, close to the end of the month and to the beginning of October.

It is naturally to expect that colder winters like 1987 (mean temperature of July –20.1, August –12.2, and September –14.1°C) are caused by blocking processes more prolonged in time such as we observed in September 1999. This situation is similar to that we have in the Northern Hemisphere when wedge of the Azor anticyclone stretches northward to Greenland and sometimes to the North Pole region and Iceland minimum of surface pressure disappears in some seasons.

Evolution of subtropical high pressure belt seems to be in connection with Southern Oscillation that is directly depends on El-Niño, famous phenomenon of sea surface temperature anomalies (SSTa) in the equatorial Pacific. Last research showed that ENSO could cause the weather almost on the whole Earth, mainly in both Americas. Meridional effects of ENSO are not still studied well. It is well known now that intensity of both Pacific and Atlantic subtropic maxima is controlled by SSTa. ENSO itself is characterized by two extreme phases: warm and cold ones that have its own response up to high-tropospheric levels (*Proceedings* 1997). The warm event intensifies the Hadley cell in the Southern Hemisphere and is likely to intensify subtropical anticyclones. The opposite situation is in case of cold event. Intensification of subtropic anticyclones can have two further effects: intensification of low pressure belt in the sector of Western Antarctica and (or) anticyclogenesis over the Bellinsghausen Sea and in the region of Antarctic Peninsula. In 1997 ENSO warm episode was shifted later and observed in July. Large sums of precipitation in 1998 could be connected with a greater number of cyclones that in its turn could be caused by ENSO 1997/1998 warm event. A number of cyclones in 1999 were less and at some months anticyclones dominated that could be connected with retreat of ENSO warm event. We possess a restricted set of synoptic charts for 3 years and the conclusions given just above should be added and checked up.

General dependence that was found out in the total ozone amount variability and synoptic tropospheric processes, including the period of the ozone hole, may be used with the purposes of weather predictions as well as for ozone hole behaviour. The study of blocking processes is the matter of special importance.

Our oceanographers revealed one branch of sea currents that flow northward at the western Weddel Sea and turn westward to Bransfield Strait. We found out that that type of circulation can be caused by an eastward series of cyclones (as 1st as 2nd type) moving through Drake Passage with eastern winds at the south part of the Drake. This also could explain the westward migration of ice fields from the Weddel Sea. Sometimes anticyclones can cause the same wind direction but winds within high-pressure systems are usually light.

Conclusions

Synoptic typification carried out on real processes showed that cyclonic activity is on average dominant at the Northern Antarctic

Peninsula but higher pressure systems can dominate in separate seasons. Anticyclones cause relatively cold winter or separate cold spells, with less amount of precipitation and conditions for preservation of snow and ice. Blocking wedge of high pressure causes cold spell at the first half of September 1999 and some aftereffects at the following weather and sea-ice conditions. Nevertheless, on the average all Ukrainian 5 years of observations were comparatively warm and remained in line with positive surface temperature trend. Variability of daily mean total ozone amount at the time of the ozone hole in many respects may correspond to certain change in patterns of tropospheric circulation. Long-lived anticyclones can provide significant drops in total ozone amount in winter or early spring as well as in non-winter months. One can think that for Vernadsky being at the edge of CPV and the ozone hole, the tropospheric synoptic processes are of great importance in ozone variability in Antarctic spring. Some dependence of weather at Vernadsky on Southern Oscillation may be concluded but it is necessary to make more complete research.

Supplement

In connection with centennial anniversary of **Belgica Expedition** (1898–1899) during the time of our winterover we made some trips to places where, according to historical notes, Belgica had passed. In February and March, 2000 we visited *Deliverance Point* – the cape on the Antarctic Peninsula coast and *Cruls Islands*, putted 10–12 kms west off the Vernadsky base. Field observations were made; visits to Cruls Islands were of special interest, with big colonies of furseals and with enigmatic shape of the shoreline, powerful surf and unexpectedly narrow and quiet bays.

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