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Differences in the formation of blocking processes between the Northern and Southern Hemispheres

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Abstract. Mechanisms of formation of blocking processes in the Southern Hemisphere are considered. They are compared with analogous mechanisms in the Northern Hemisphere by using daily synoptic maps of the Northern and Southern Hemispheres. It is found that in the circulation mechanisms of the Southern Hemisphere the process of merging of Antarctic and subtropical anticyclones takes place in a completely different way than in the Northern Hemisphere. The main difference is that in the Northern Hemisphere, as a rule, the ridge of an Arctic anticyclone extends to the low latitudes, but in the Southern Hemisphere the ridge of a subtropical anticyclone extends to the high latitudes, towards Antarctica. An assumption is made that such a peculiarity of circulation leads to the fact that the rear of coastal Antarctic cyclones does not receive cold air masses, as in the cyclones of the Northern Hemisphere, but gets warm in comparison with their frontal part.

1. Introduction

The study of blocking is of great scientific and practical interest. These are large-scale stable processes in the atmosphere. They cause weather and climate abnormalities. The study of these phenomena is important for monitoring the current climate, modeling atmospheric processes, medium-term and long-term weather forecasts.

The study of blocking is carried out by climatic methods, synoptic methods, and hydrodynamic methods. A climatic study of blockings has established areas of their increased and decreased frequency of occurrence. The seasonal distribution of blockings is described. The maximum frequency of blocking in the northern hemisphere is observed in the eastern Atlantic, Europe, and the eastern Pacific [1]. The maximum frequency of blocking in the East Atlantic and Europe is observed in winter. The maximum frequency of blocking over the east of the Pacific Ocean is observed in summer [2]. The main reason for the formation of blocking anticyclones is considered to be nonlinear instability of Rossby waves with intensive energy exchange both with planetary waves and with synoptic vortices (breaking) [3].

It is well-known that the nonlinear phase of instability development is characterized by an intense interaction of a growing wave with movements of other scales. Depending on the energy reserves that can be transmitted to the growing wave, its nonlinear development can lead to the establishment of one of the following nonlinear modes [4]:

1. Stationary mode. Ridges and hollows are formed in the stream, whose axes are oriented meridionally or at an angle to the meridian; they persist for a long time without changing the

amplitude, shape, and wavelength.

2. "Flicker" or pulsation mode: it is also a regular mode, but the ridges and hollows experience slow periodic changes: these are either changes in the amplitude of the waves, or changes in their orientation or, finally, a change in the wave number.

3. Irregular mode type of turbulence.

Blocking is a first or second mode for an unstable Rossby type wave.

The synoptic approach to the study of blocking anticyclones showed that for the anticyclone (blocking) to stay, it is necessary to combine the increase in the amplitude of the planetary tall frontal zone (PTFZ) with the anticyclone of arctic origin entering the region of maximum. The formation of a blocking anticyclone over Eastern Europe is classified as a form of E - circulation to Wangenheim – Girs. It is in this form of circulation that most abnormal weather conditions are most often established [5].

Blocking is formed when anticyclones from the Arctic move to the continent. The displacement to the east (on the continent) of anticyclones from tropical regions does not lead to blocking. This conclusion is confirmed by studies of synoptic processes in the Middle and Lower Volga regions. [6]. Subtropical anticyclones form blocks over the ocean. An example of this is the movement of the Azores anticyclone to the north over the Atlantic Ocean from the subtropics in January 2012 [7].

On the eastern and northeastern periphery of this high-altitude anticyclone, very cold air entered the European part of Russia. At the same time, the average daily temperatures decreased by 10 - 15 ° C compared to the perennial average.

In this work, using the synoptic approach, the task is to consider the mechanisms of blocking formation in the southern hemisphere and to identify the features of establishment of blocking regimes in the northern and southern hemispheres.

2. Materials and methods

To study blocking regimes in the Southern Hemisphere, synoptic conditions leading to the establishment of blockings were analyzed. The studies were performed using daily weather maps and altitude maps of standard isobaric surfaces. The temporary material for the research was 2000-2005. The blocking situation was determined in accordance with the approach described in [8],

$$G(50) = \frac{Z(\varphi_0)-Z(\varphi_s)}{\varphi_s - \varphi_s},$$

$$G(70) = \frac{Z(\varphi_n)-Z(\varphi_0)}{\varphi_n - \varphi_0},$$

where φ_0 = 60° + Δ;
φ_n = 80° + Δ;
φ_s = 40° + Δ;
Δ = -4°; 0°; 4° of latitude.

On a specific longitude of 00 GMT, an implicit blocking was determined. There is blocking if, at least with one knowledge, the following conditions are met:

G(50) > 0,
G970) < - 10 m/1 degree of latitude.

The source material for studying the conjugation of processes in the Northern and Southern Hemispheres was the Calendar of Successive Changes in Elementary Circulation Mechanisms (ECMs) compiled by N. Kononova and posted on the site [9]. ECMs with one, two, three, and four blocking processes in the hemispheres were selected from the “Calendar ...”, and their development during the ECMs action was considered.

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3. Results and discussion

In the Southern Hemisphere, 75 cases of blocking regimes were analyzed. The average duration of the blocking process in summer is five to six days, and in winter it is three to four days. The vast majority of blocking cases (82%) are characterized by the following: the blocking process begins by pulling the ridge of the subtropical anticyclone to the rear of the cyclone located off the coast of Antarctica. In this case the air flows are directed from north to south, that is, from the subtropics to the high latitudes. Moreover, sometimes there is no independent anticyclonic center over Antarctica.

As an example, we cite the process that took place from July 28 to August 1, 2005. On July 28, active cyclonic activity was around the coast of Antarctica. The cyclones were located directly off the coast, except for the Pacific one. There was an extensive anticyclone along the Pacific coast, elongated in the latitudinal direction. On July 29, only four of all cyclones remained, which became central and stationed over each of the three oceans and in the Antarctic Peninsula. In the next two days spurs from subtropical anticyclones began to spread to the rear of these stationary cyclones. This process culminated in the establishment of blocking regimes in four regions of the Southern Hemisphere near the coast of Antarctica. Three baric ridges are located above the Atlantic, Pacific, and Indian Oceans. The fourth ridge extended from South America through the Antarctic Peninsula all the way to the central part of the mainland (Figure 1). The extension of the baric ridge to the rear of the coastal Antarctic cyclones suggests that a warm air mass enters the rear of such cyclones but not the front.

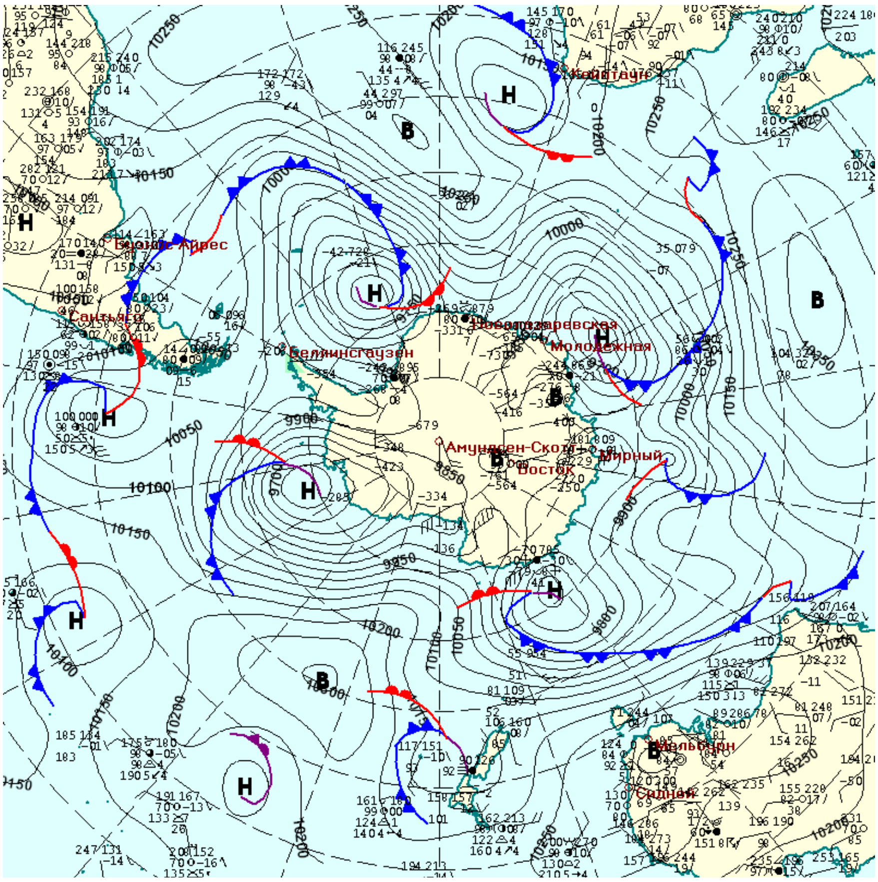

Figure 1. Weather map for August 1, 2005, ECM 12a, Southern Hemisphere.

It is interesting to compare the process of establishing blockages in the Northern and Southern Hemispheres.

For the Northern Hemisphere, the mechanism of occurrence, development, and establishment of blocking regimes is as follows.

In most cases, a combination of arctic and subtropical anticyclones occurs. In this case, the Arctic anticyclone moves with the southern (more often - southeastern) component and, as a result, the subtropical high-pressure band is replenished with fresh Arctic nuclei. This, in turn, maintains high pressure in the tropics [10].

In the 70s of the 20th century, when studying the blocking processes B. L. Dzerdzeevsky [11, 12] found that they develop simultaneously in the Northern and Southern Hemispheres at approximately the same longitudes. The authors of this study verified this statement on the material of 2000-2005. As a result of the analysis, it was found that in 69% of cases the processes in the Northern and Southern Hemispheres are coupled. That is, similar processes (blocking) develop simultaneously at the same longitudes.

In Figure 2 we give an example of a related process in the Northern Hemisphere considered earlier in the Southern Hemisphere. Figure 2 shows the ECM 12a weather map with four blocking processes: over the Atlantic, the Pacific Ocean, Eastern Siberia, and America. According to Figure 2, over the Atlantic an Arctic invasion occurs in the rear of a series of southern cyclones, over the Pacific Ocean it occurs in the rear of the Aleutian cyclone, in Alaska in the rear of the cyclone over America, and in Eastern Siberia in the rear of the Far Eastern cyclonic system. In all cases, in the rear of cyclones the air flows from north to south, that is, cold air masses spread to the rear of the cyclones.

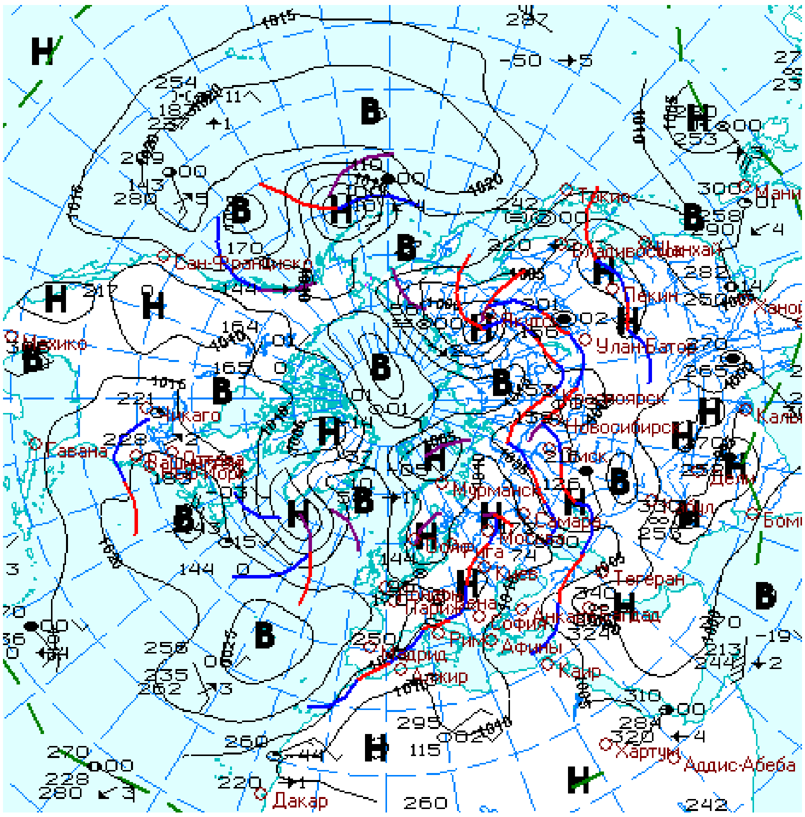

Figure 2. Weather map for August 1, 2005, ECM 12a, Northern Hemisphere.

Thus, the development of blocking processes in the Northern and Southern Hemispheres has its own characteristics. If in the Northern Hemisphere during an Arctic invasion cooling extends from north to south, in the Southern Hemisphere, with the extension of the ridge of the subtropical anticyclone, warm air also spreads from north to south with the anticyclone, but from the low latitudes to high ones.

It is possible that such a difference is due to the fact that the Antarctic anticyclone is much more intensive and larger in area than the Arctic one. It forces subtropical anticyclones to creep in the direction of the area occupied by it. The nature of changes in the air temperature in the Northern and Southern Hemispheres during the formation of blocking processes in the rear of the cyclone is also different. These features should be taken into account when analyzing and modeling the atmospheric circulation of the planet Earth system.

Conclusions

1. In the Northern Hemisphere, the formation of blocking processes usually begins with an arctic invasion which goes southward, combining with a subtropical anticyclone. In this case, a cold air mass flows into the rear of the cyclone.
2. In the Southern Hemisphere, as a rule, the development of a blocking process is carried out by pulling the ridge of a subtropical anticyclone to the pole and then connecting it with an Antarctic anticyclone. In this case, a warm air mass spreads to the rear of the cyclone but not to its front.
3. The correlation between the development of processes in the Northern and Southern Hemispheres has been confirmed with a more recent material (2000-2005).

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