FLUCTUATIONS OF THE GLOBAL ATMOSPHERIC CIRCULATION IN THE XX-XXI CENTURIES

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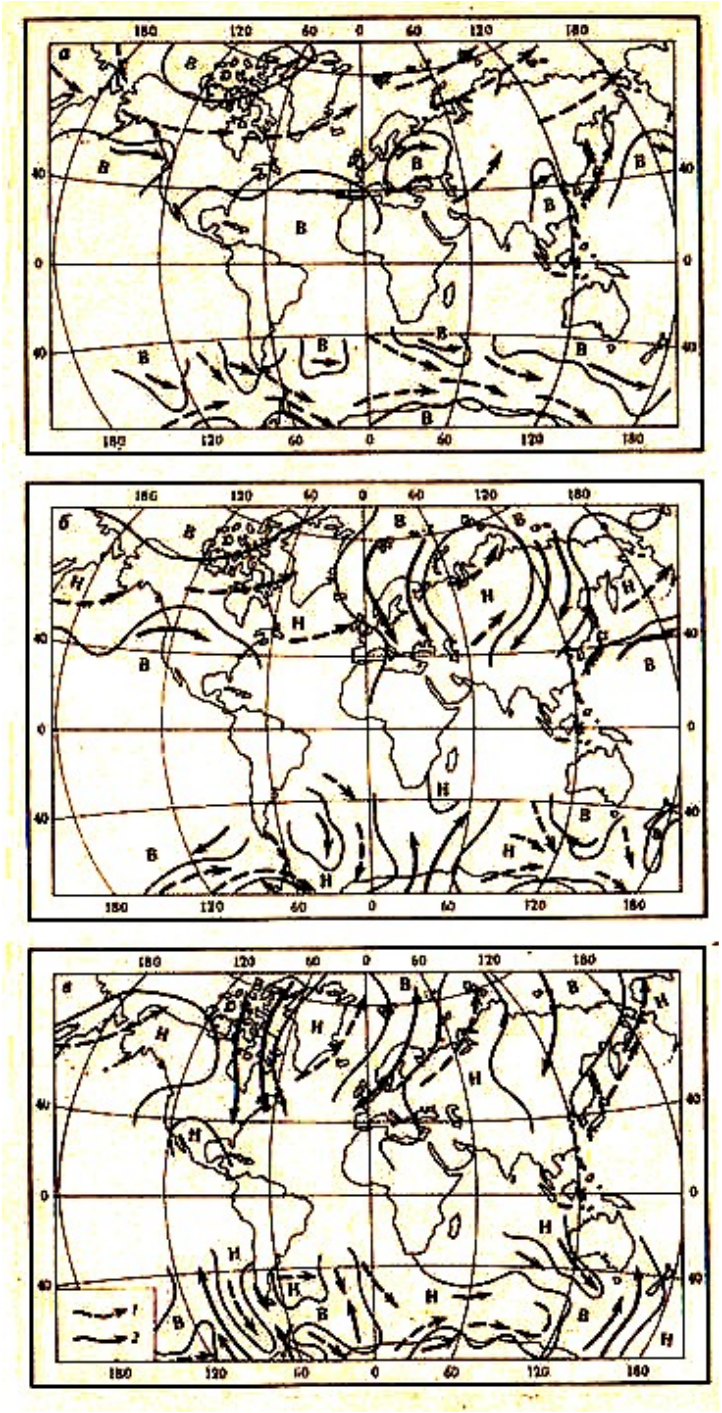
In 1967 BL Dzerdzeevskii [2] revealed the conjugation of atmospheric circulation extratropical latitudes of the Northern and Southern hemispheres. At the zonal circulation, without blocking processes in the Northern Hemisphere, the circulation of a similar nature is marked in the Southern Hemisphere. With the development of the meridional circulation with the blocking processes the same number of them in the Northern and Southern Hemispheres are marked, and the axis of Arctic/antarctic intrusions are on the same longitude (Fig. 1).



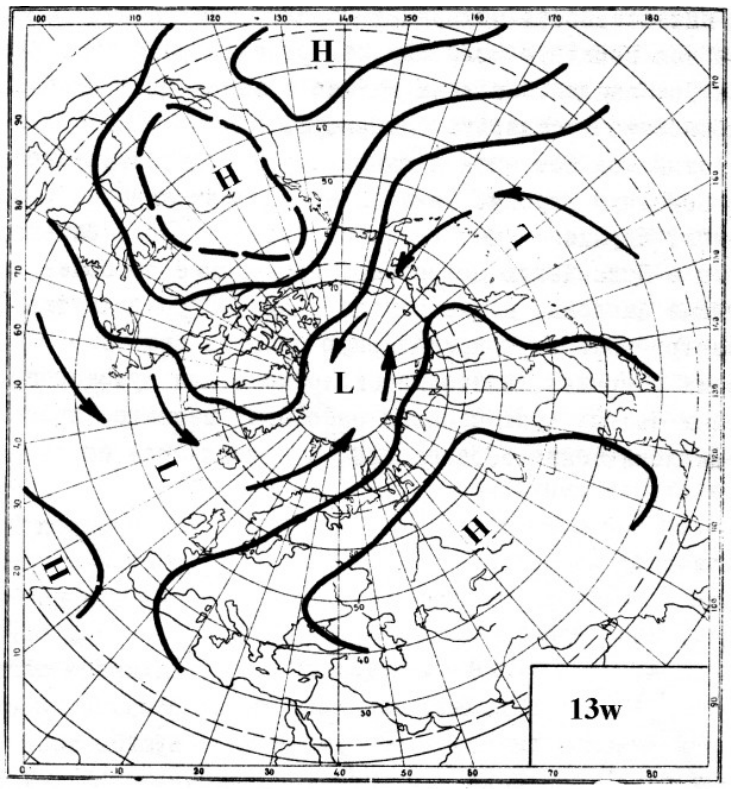
a)

b)

c)

Figure. 1. Comparison of standard schemes of atmospheric circulation over the Northern and Southern hemispheres (Northern - by BL Dzerdzeevskii [1], Southern – by PD Astapenko):
a - zonal circulation, b - two meridional blocking processes in each hemisphere, c - three meridional blocking processes in each hemisphere. Dotted arrows - generalized path of cyclones, solid - anticyclones.

Later on ready-kinematic maps constructed for the 1898-2005 biennium. [4, 5] identified differences in the manifestation of elementary circulation mechanisms (ECM) of the circulation of the poles with cyclones and cyclone exit from low to high latitudes in different hemispheres, and also presented their dynamic schemes (Fig. 2, 3).



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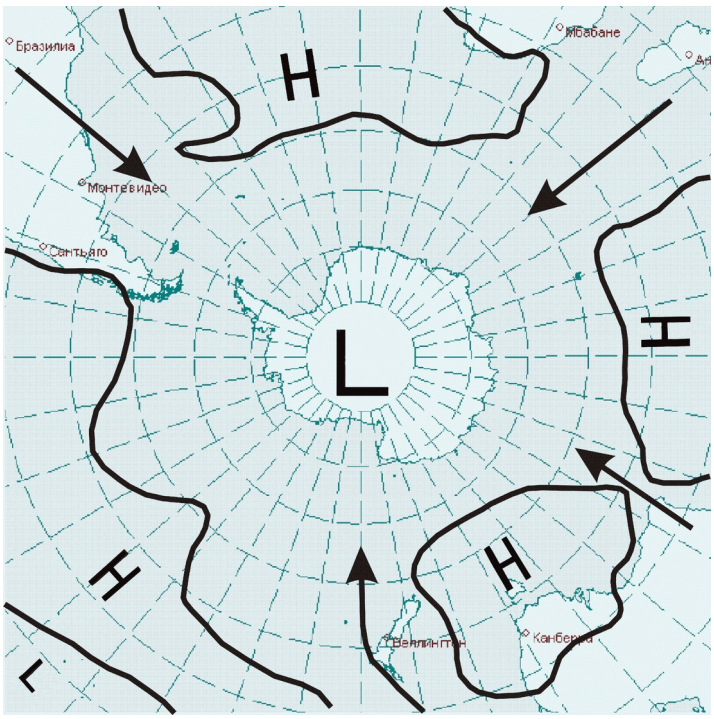

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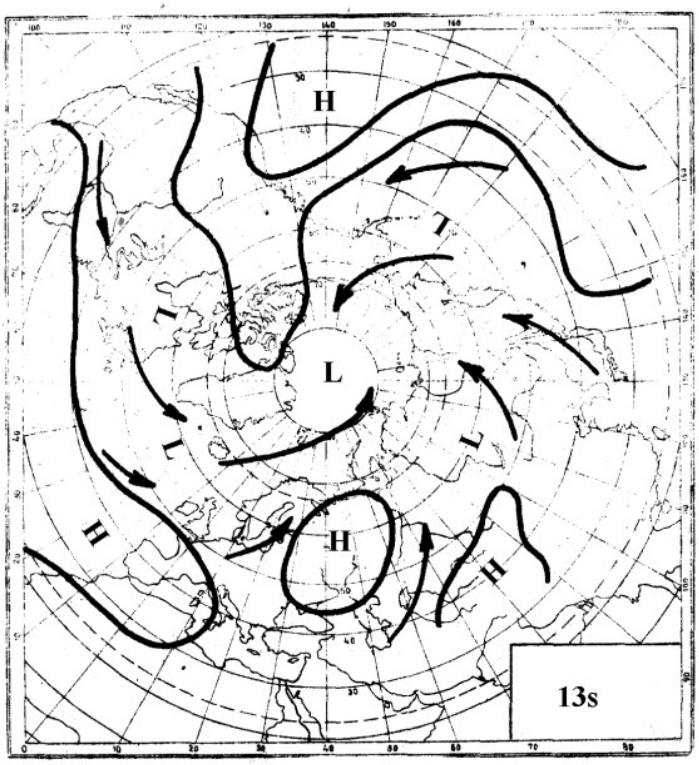
Fig. 2. Dynamic schemes of ECM 13w (for the Northern Hemisphere winter):
a - Northern Hemisphere (by BL Dzerdzeevskii [1]), b - the Southern Hemisphere.



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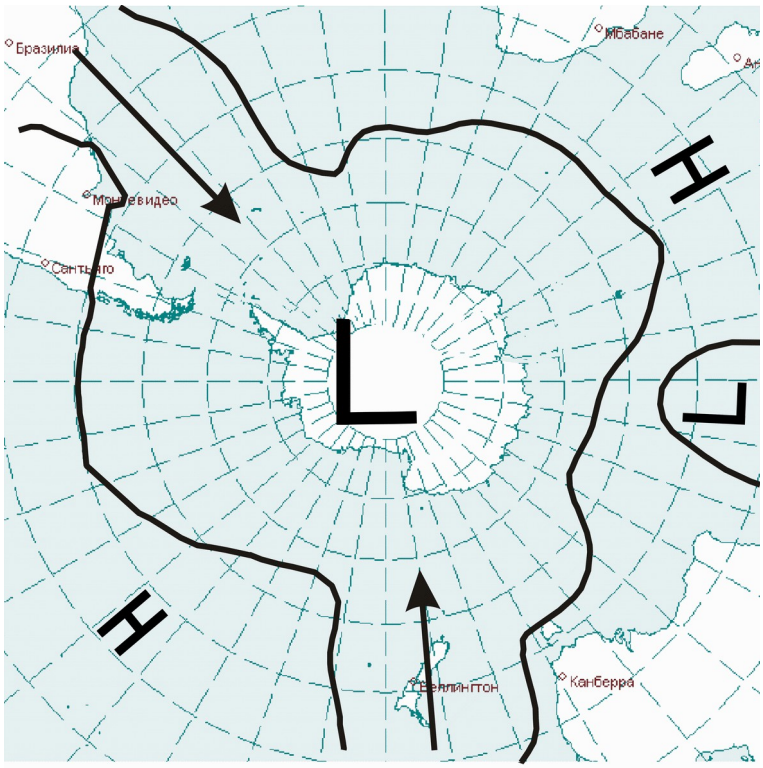

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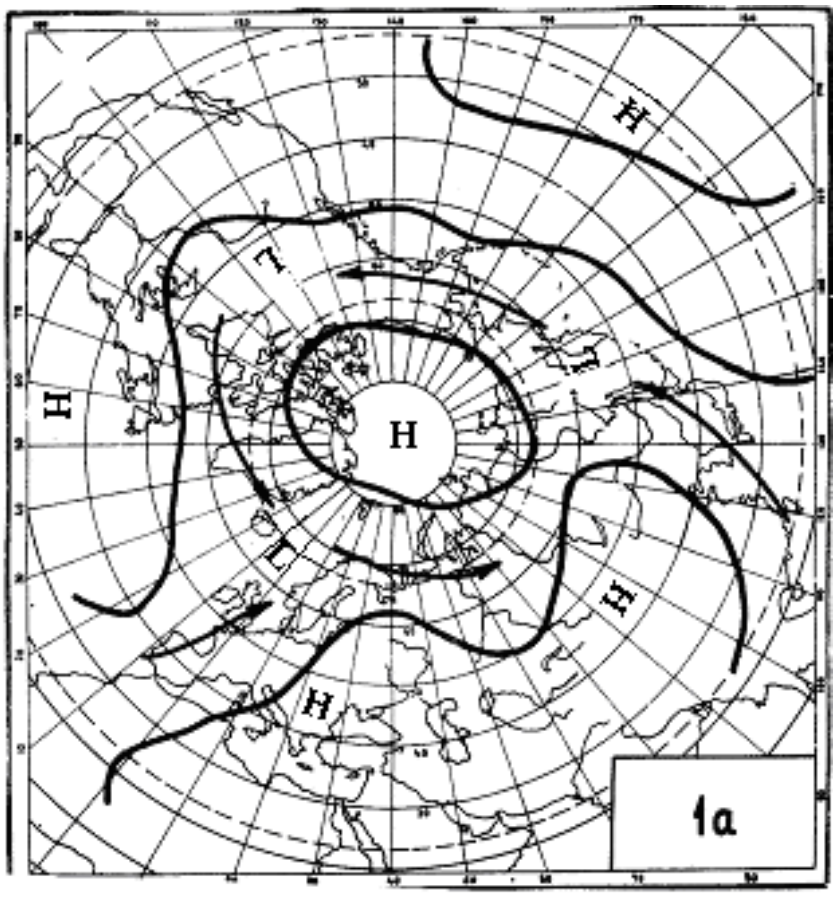
Fig. 3. Dynamic schemes of ECM 13s (summer in the Northern Hemisphere): a - Northern Hemisphere (by BL Dzerdzeevskii) b - the Southern Hemisphere.

It was also revealed that for all macroprocesses in the summer hemisphere more outlets of cyclones from low to high latitudes than in winter (Fig. 4, 5). When ECM transitional season, the situation is the same in different hemispheres (Fig. 6).



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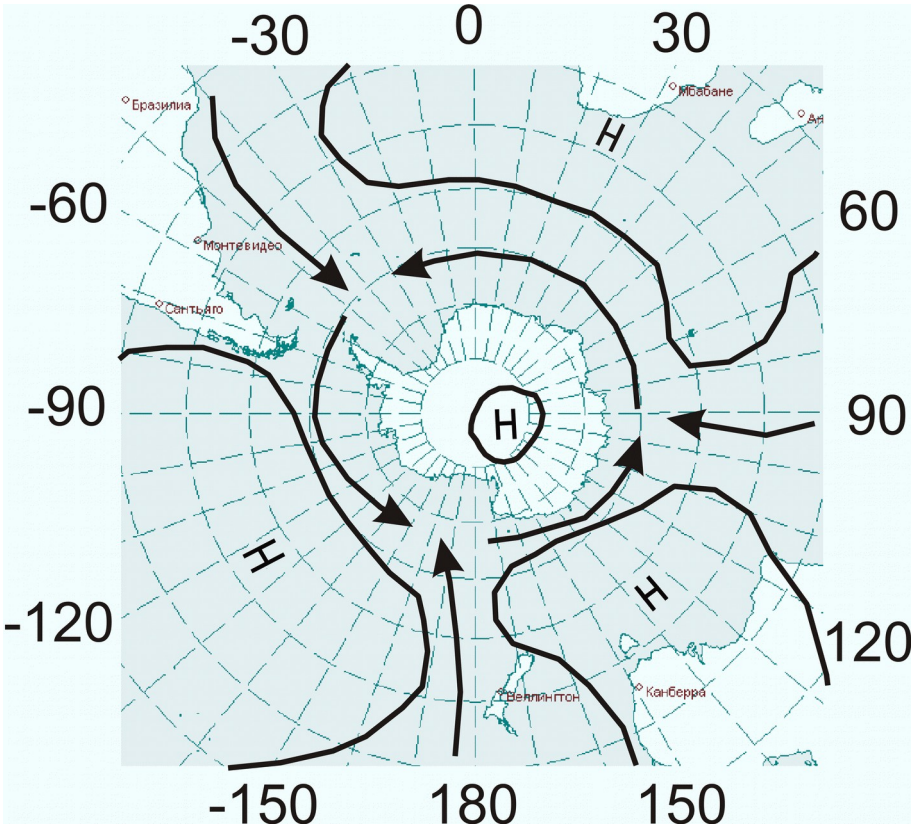

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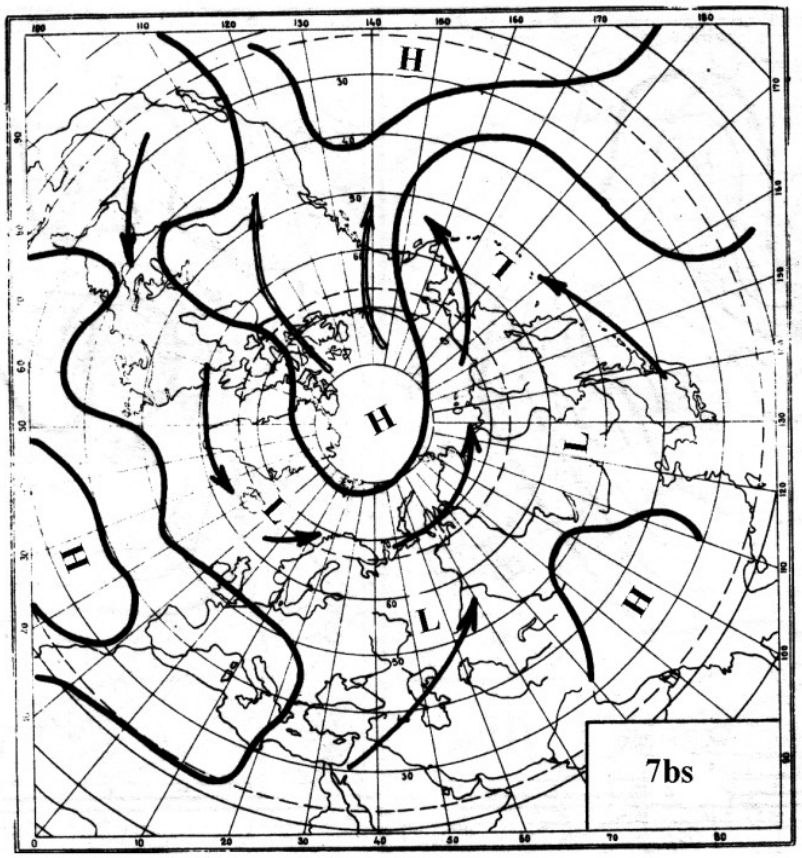
Fig. 4. Dynamic schemes of ECM 1a (zonal circulation, for the Northern Hemisphere winter): a - Northern Hemisphere (by BL Dzerdzeevskii [1]), b - the Southern Hemisphere.



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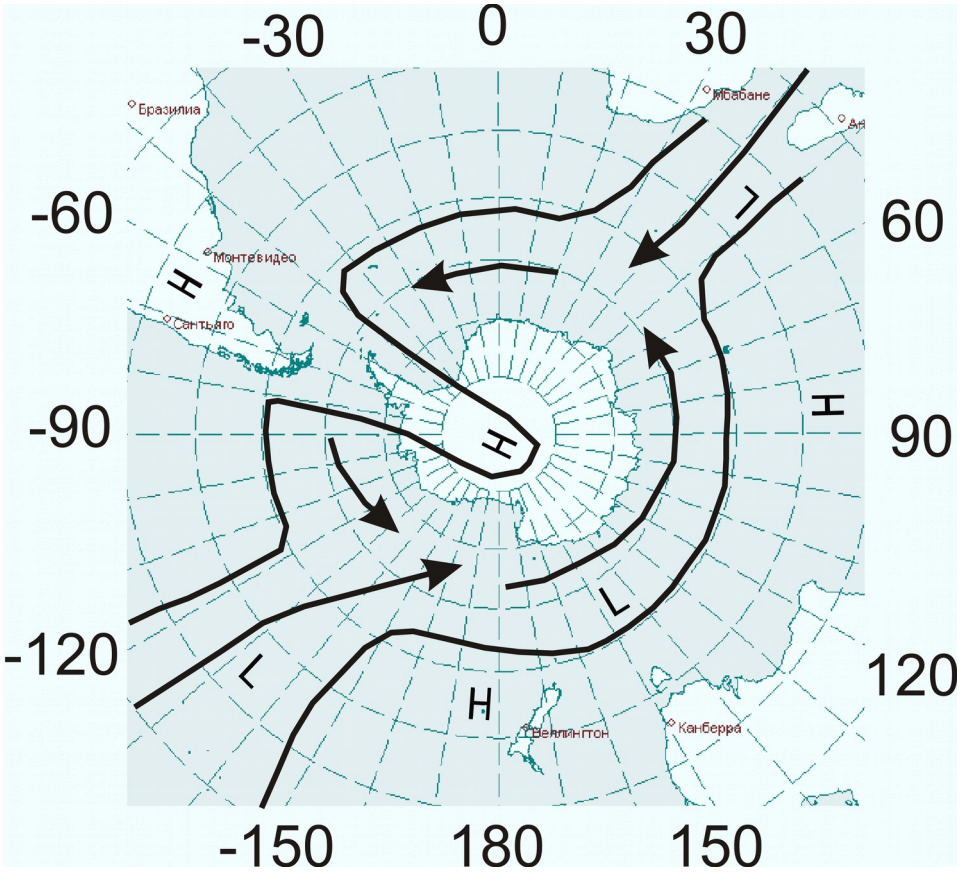
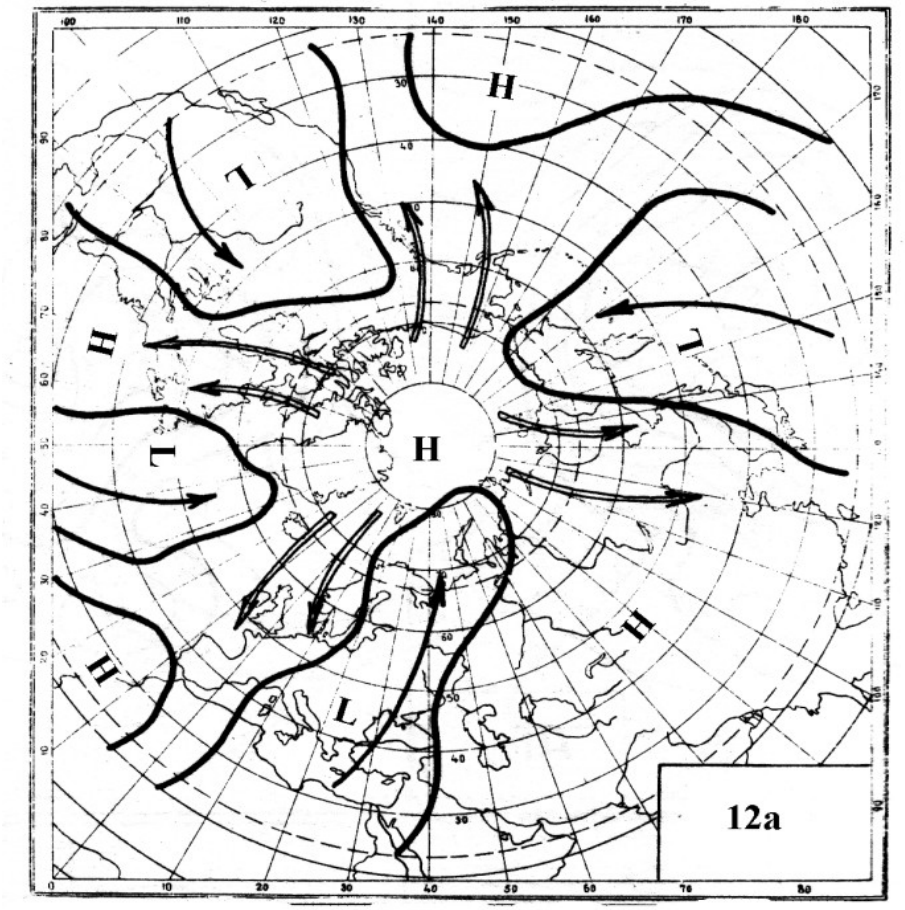


b)

Fig. 5. Dynamic schemes of ECM 7bs (disturbance of zonal circulation, summer in the Northern Hemisphere):

a - Northern Hemisphere (by BL Dzerdzeevskii) b - the Southern Hemisphere.



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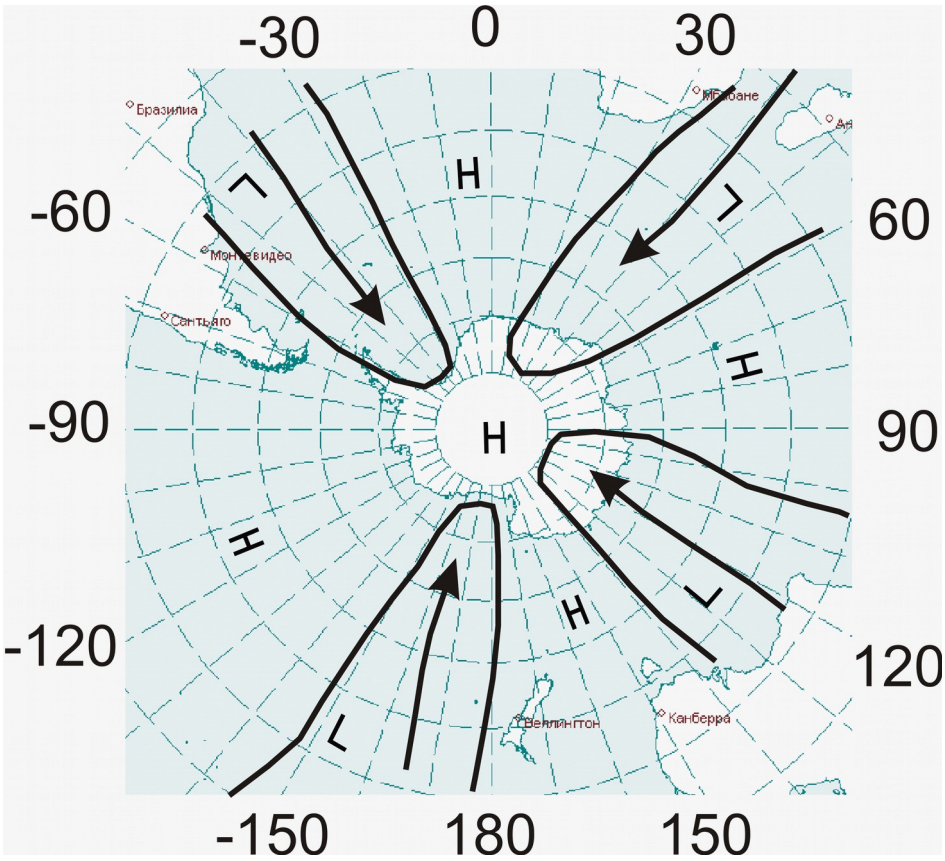

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Fig. 6. Dynamic schemes of ECM 12a (group blocking processes, transitional seasons): a - Northern Hemisphere (by BL Dzerdzeevskii [1]), b - the Southern Hemisphere.

Changing the ECM takes place simultaneously in the two hemispheres, so the total annual duration of each ECM is also the same in the two hemispheres. Consequently, fluctuations in the atmospheric circulation in the extratropical latitudes of the whole Earth were identical.

We consider the fluctuations of the global atmospheric circulation in 1899-2014, in the classification by BL Dzerdzeevskii. Variance analysis of the total annual duration zonal (zonal + disturbance of zonal) and meridional (Arctic / Antarctic invasion + output cyclones from low to high latitudes) macroprocesses from their average values (Fig. 7) showed an increase from the 30-ies of XX century duration interlatitudinal exchange air masses, and for the XXI century, it is maximum for the entire observation period.

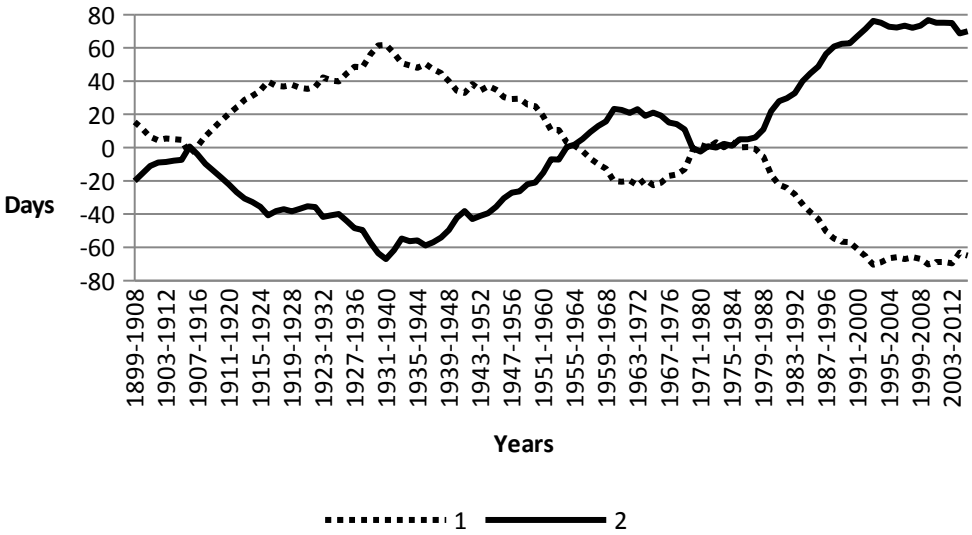


Fig. 7. Ten-year moving average of deviations of the total annual duration of the circulation groups for the 1899-2014 from the average for the same years:
1-zonal circulation, 2 - meridional circulation

Separate analysis of deviations from the average total annual duration of the formation of blocking processes, connecting the Arctic / Antarctic High with the subtropical and output cyclones from low to high latitudes revealed three circulation period (Fig. 8), which differ in the prevalence of positive deviations of the total annual duration of any single group of the average circulation for the entire observation period.

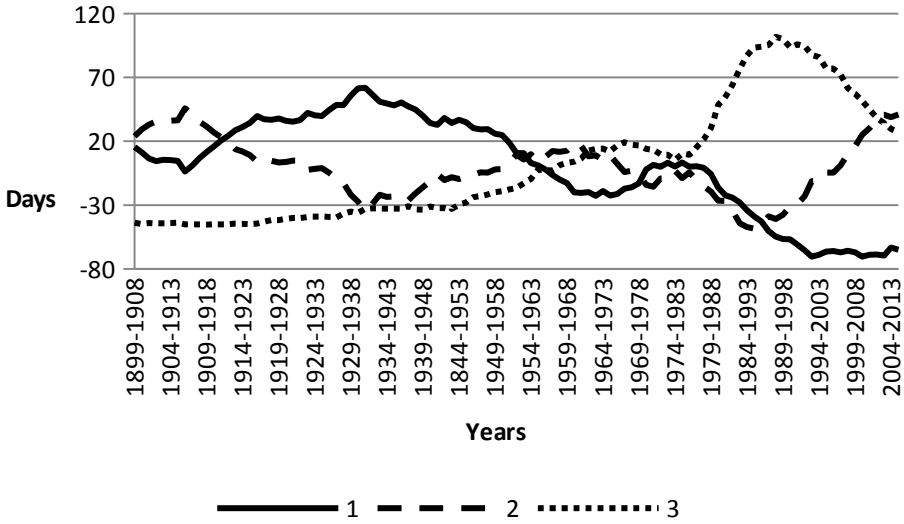
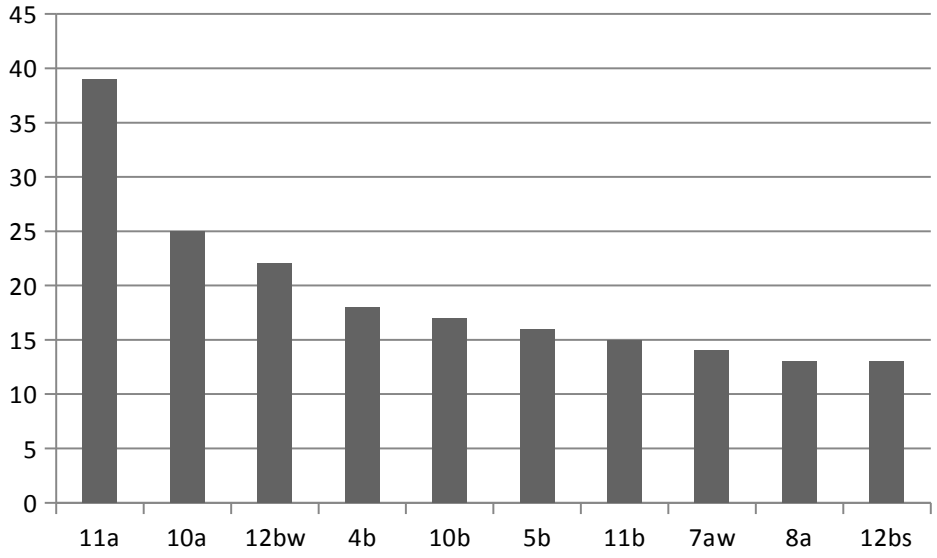


Fig. 8. Ten-year moving average of deviations of the total annual duration of the circulation groups for the 1899-2014 from the average for the same years: 1-zonal circulation, 2-blocking processes, 3-way cyclones from low to high latitudes

In the first epoch (1899-1915) duration of blocking processes was higher than the average; in the second epoch (1916-1956) zonal circulation was higher; in the third epoch (1957 - present) - outputs of cyclones from low to high latitudes. The third epoch is divided into periods. With the overall predominance of positive deviations of duration of the cyclones output from low to high latitudes in 1957-1969 the duration of the blocking process is increased (Fig. 8). In 1970-1980 the duration of the zonal circulation rises to the level of average. In 1981-1997 there is a rapid increase in the total annual duration of the cyclones output from low to high latitudes. From 1998 to the present time there is a new duration surge of blocking processes. It is significant that at this period there are the most significant meteorologically due natural hazards for the entire period of meteorological observation (floods, ice disasters and so on [3, 6-8]).

Total annual duration of the ECM in each epoch was analyzed. Allocated ECM which total duration in average for the epoch exceeds 183 days (Fig. 9).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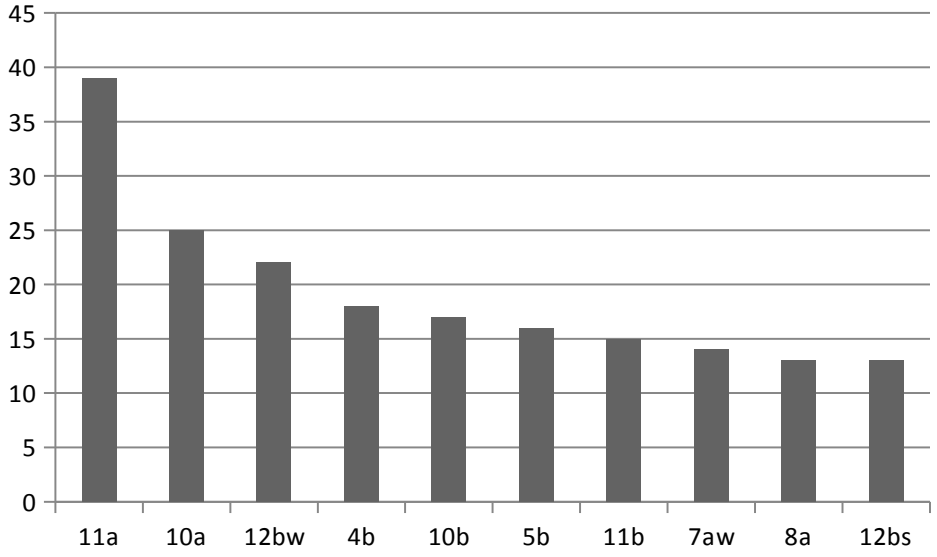
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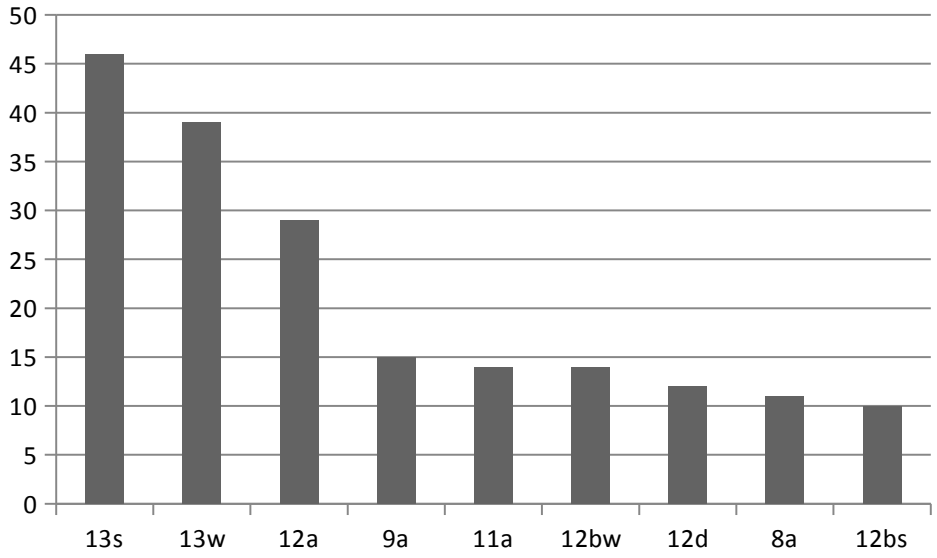
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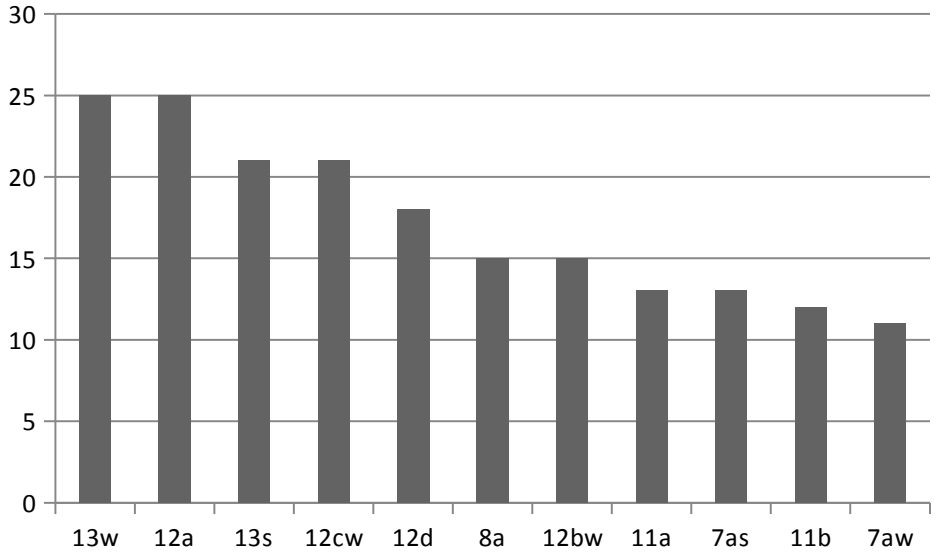
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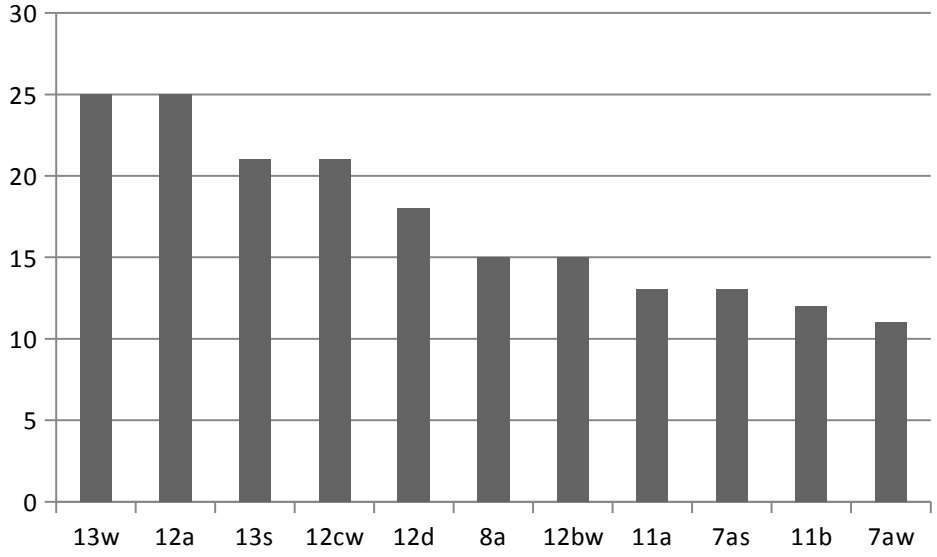
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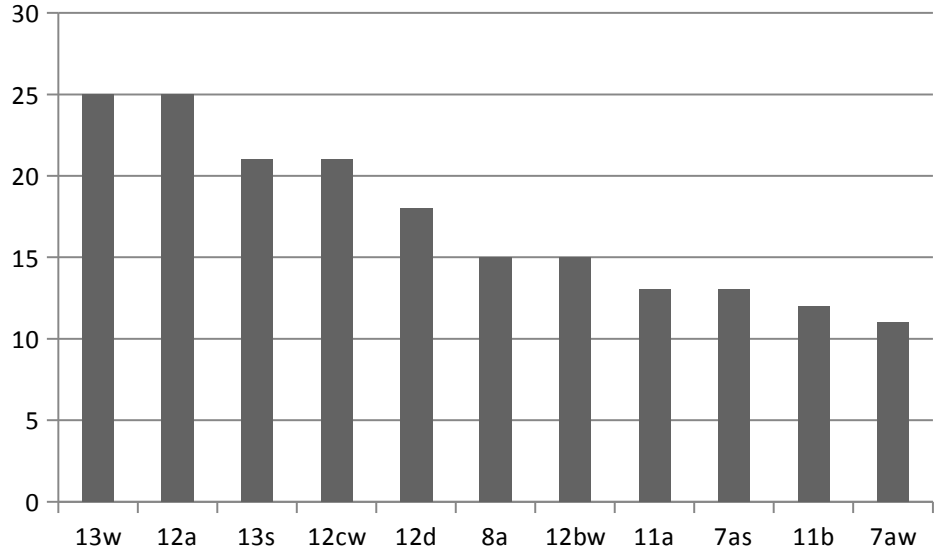
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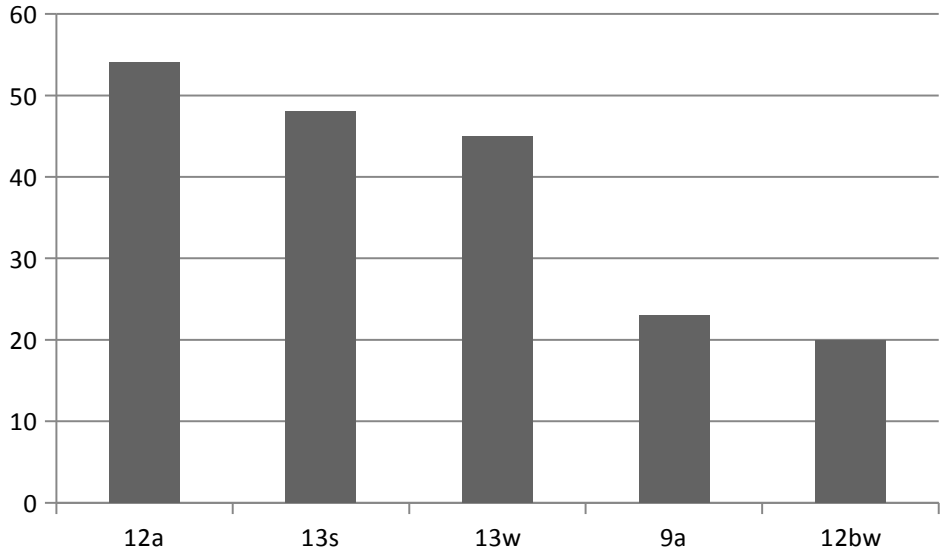

g)

Fig. 9. The longest ECM which average sum results for the specified time period is more than six months: a - first circulation epoch, b - second epoch, c - the third epoch, d - 1957-1969, e - 1970-1980, f - 1981-1997, g - 1998-2014.

Changing of the circulation processes duration affected the global annual mean air temperature (Fig. 10). It decreases with increasing duration of the blocking process (at the end of XIX - early XX centuries, and in the 1960th) and increased during the periods of duration growth of zonal circulation (1920th-1930th) and cyclones output from low to high latitudes (last quarter of the XXth century).

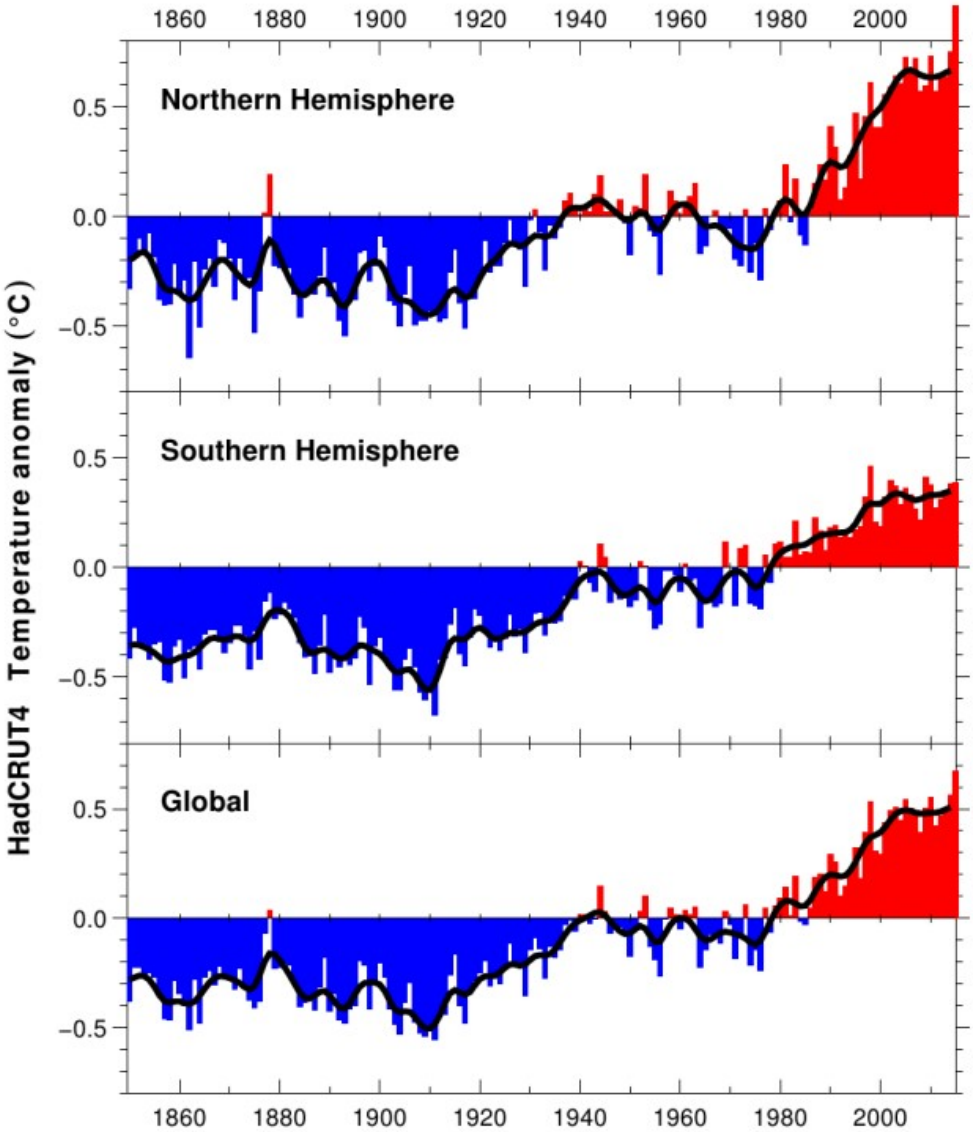

Fig. 10. Deviations mean annual air temperature for the 1850-2014 from. the average for the 1961-1990 period. by http://www.cru.uea.ac.uk/cru/data/temperature/ (HadCRUT4) [9]: a - the Northern Hemisphere, b - the Southern Hemisphere, c - the Global.

Last period (1998-2014) deserves special attention. During this period in the lower troposphere meridional transport of air masses reached its maximum level (on average 335 days per year). Macroprocess with four outputs of cyclones from low to high latitudes in each hemisphere and four Arctic / Antarctic invasions into their rear, which form blocking processes (ECM 12a, Fig. 6) lasts on average 54 days per year (Fig.9g). Macroprocesses with cyclones at the poles without blocking processes, with three cyclones outputs from low to high latitudes in the winter hemisphere and four outputs in the summer hemisphere (ECM 13w and 13s, Fig. 2, 3) lasts on average 93 days per year. A distinctive feature of the last period is the formation of stable anticyclones over the continents in winter and in summer. This in turn leads to a positive temperature extrema in summer time and negative temperature extrema in winter time. The rapid growth of the average annual air temperature is terminated (Fig. 10), although 2014 proved to be the warmest for the entire observation period (global temperature anomaly is 0,564 ° C).

Fluctuations in atmospheric circulation affected the annual amplitude of air temperature, which is calculated as the difference between the daily maximum and minimum in a given year. In the absence of daily data, I calculated the annual amplitude of the difference between the average monthly temperature anomalies of the warmest and the coldest month of the year (Fig. 11).

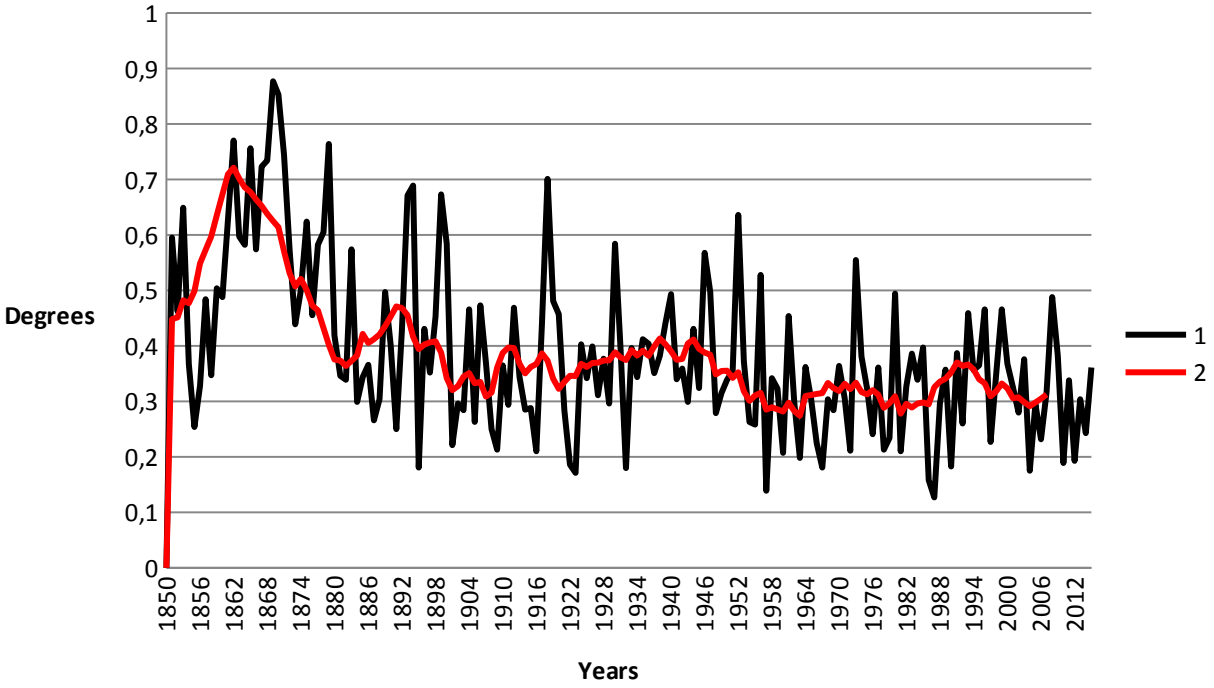

Fig. 11. The annual amplitude of the global surface air temperature for the 1850-2014, count according to http://www.cru.uea.ac.uk/cru/data/temperature/ (HadCRUT4): 1 - the annual amplitude, 2 - 10-year moving average.

The highest annual temperature amplitude observed in the second half of the XIX century, the maximum (0.877 °) - in 1868. Since then, there has been a downward trend amplitude. For the 1899-2014 the maximum amplitude (0,701 °) was observed in 1917 on the border ages blocking and zonal processes. In the first epoch amplitude ranged from 0,21 ° to 0.584 ° at average 0,34 ° C, in the second epoch - from 0,139 ° to 0,701 ° with an average 0,377 °, In the third epoch - from 0,127 ° to 0,555 ° with an average 0,312 °. In the period of 1957-1969 Global annual amplitude of air temperature ranged from 0,181 ° to 0,454 ° with an average 0,277 ° C; during the 1970-1980 - from 0,21 ° to 0,555 ° with an average 0,321 °; during the 1981-1997 - from 0,127 ° to 0,466 ° at an average 0,32 °; during the 1998-2014 - from 0,175 ° to 0,488 ° with an average 0,311 °.

Thus, during the years 1899-2014. annual amplitude of global air temperature was highest in the zonal epoch when interlatitudinal exchange of air masses was the smallest, and anticyclones stand for long periods over the continents, providing excessive heating of the air in the summer and cooling of the winter. The least it was at the beginning of the Third epoch (1957-1969) when grown duration and output cyclones from low to high latitudes and the Arctic/ Antarctic invasions. In the last period after the minimum in 1986, when there was a maximum output cyclones from low to

high latitudes, the annual air temperature amplitude increases again. This is unfavorable for all sectors of the economy.

Conclusions

Create dynamic diagrams ECM Southern Hemisphere allows us to analyze the global circulation of the atmosphere.

In the development of the global atmospheric circulation in the 1899-2014 marked three circulation epoch: blocking processes, zonal and outputs cyclones from low to high latitudes differing prevalence of certain macro-processes.

Fluctuations in global average surface air temperature correspond to fluctuations of the global atmospheric circulation.

Annual amplitude of the global surface air temperature was the highest in the zonal epoch between the smallest interlatitudinal exchange of air masses and the greatest duration of the development anticyclones over the continents. The last decades have seen its growth.

The modern character of the atmospheric circulation caused the increases frequency meteorologically due by natural hazards in different regions of the Earth, including the occurrence of simultaneous disasters ice in the Arctic and Antarctic.

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