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RESPONSE OF CIRCULATION INDEXES IN THE LOWER ATMOSPHERE OF NORTHERN HEMISPHERE TO SOLAR CYCLE

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ABSTRACT

- The results of the statistical analysis of the relationship of circulation characteristics in the lower atmosphere of the Northern hemisphere with the cycle of Solar activity are presented.
- **Data (1899-2016):** 1) the duration of different types of elementary circulation mechanism, ECM – **Dzerdzeevskii** classification;
2) time series of **Wolf numbers**.
- Applied statistical analysis the method of "**superimposed epochs**", the elements of correlation and spectral analysis.
- **Results:**
 - the increase of solar activity leads to the increase in the duration of meridional circulation forms;
 - Seasonal differences in the effect of the Sun on the lower atmosphere were also found.

Boris Dzerdzeevsky

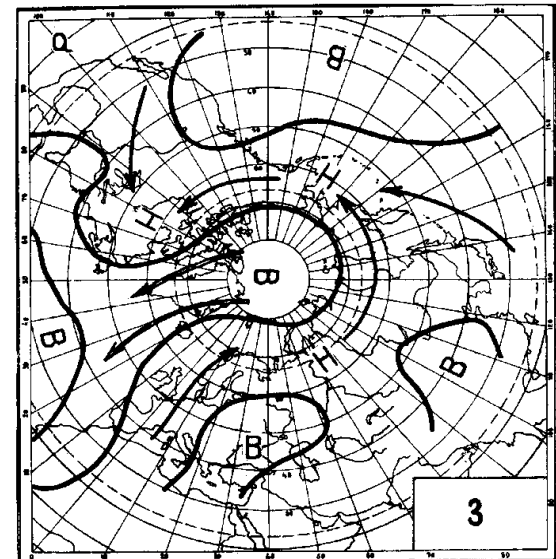
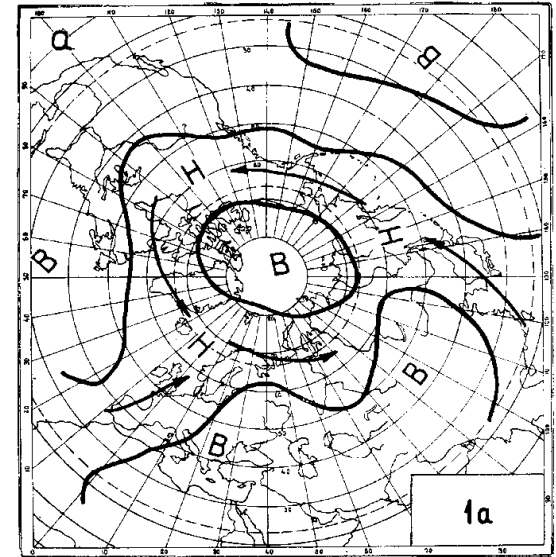


1898 - 1971

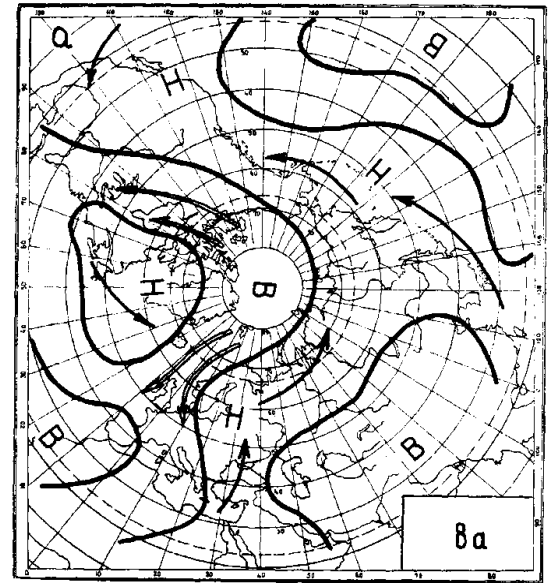
Classification of circulation mechanisms of the Northern hemisphere by B. L. Dzerdzeevsky*)

- **1 group** – zonal type (Z anticyclone at the North pole blocking processes are absent), near-polar ring of cyclones (ECM 1 и 2);
- **2 group** – Disturbance of Zonal flow (DZ), anticyclone at the pole and one blocking process in any sector (ECM 3-7 types);

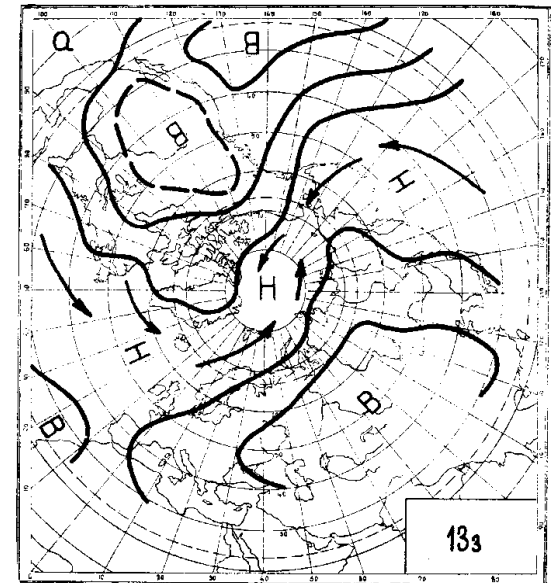
**)classification is developed on the basis of maps of sea level pressure and temperature, maps of baric topography AT-500*



3 group – Meridional Northern type (MN): anticyclone in the polar region and 2-4 blocking processes and outputs of southern cyclones. Inter-latitudinal exchange of air masses (ECM of 8-12 types prevails);



4 group – Meridional Southern type (MS): above the pole – cyclone, the output of southern cyclones in 3-4 sectors of the hemisphere (ECM 13 type).

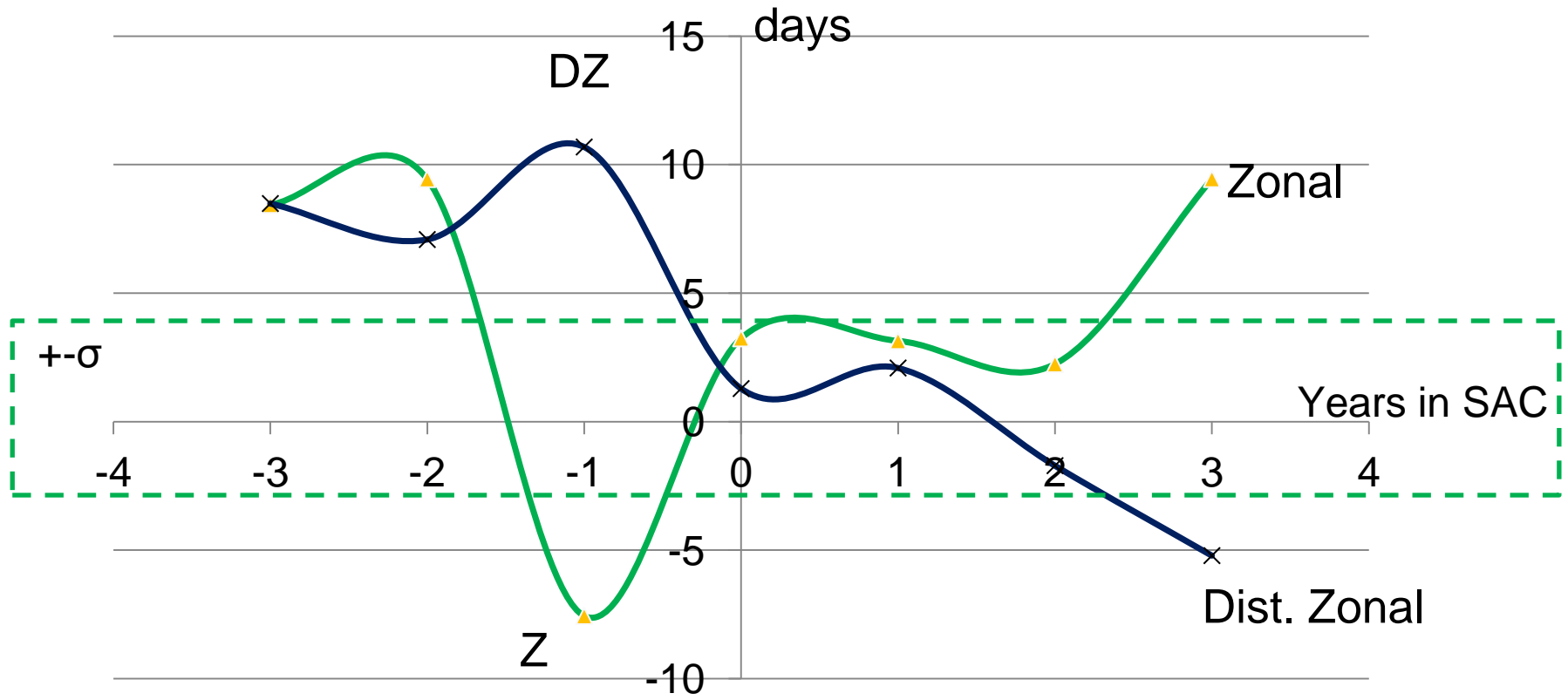


I. The effect of Solar Activity Cycle (W) on the duration of ECM obtained by the Method of Superimposed Epochs (MSE)

	Zonal	DZ	MN	MS
The average duration of ECM, days in year	25,4	88,2	197,4	48,6
Standard deviation of the mean(σ), days	1,5	3,4	3,2	4,6
The correlation coefficient obtained by MSE with key-days near Solar max	-0,53	-0,62	0,15	-0,3
Direct correlation between W and ECM, 1899-2016	0,13	-0,06	-0,13	0,1

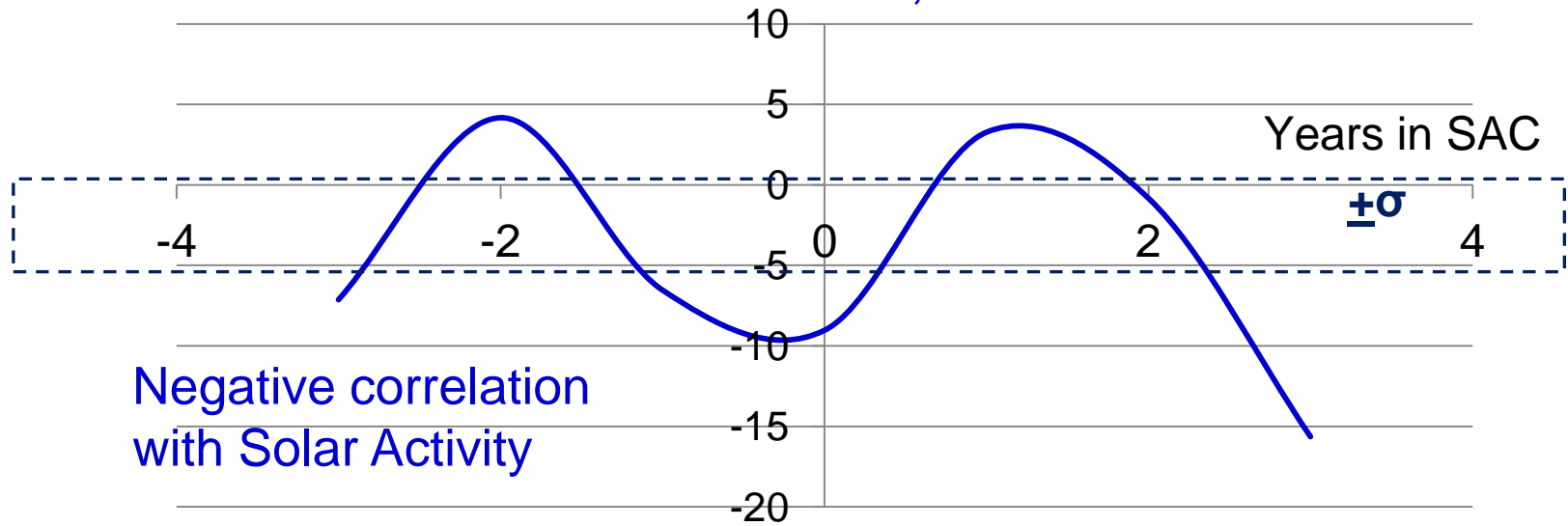
1.1. Deviation from the average long-term value of the duration at the year ECM groups in Solar Activity Cycle, Method of Superimposed Epochs

MSE: Z and DZ groups (total by types within the group)

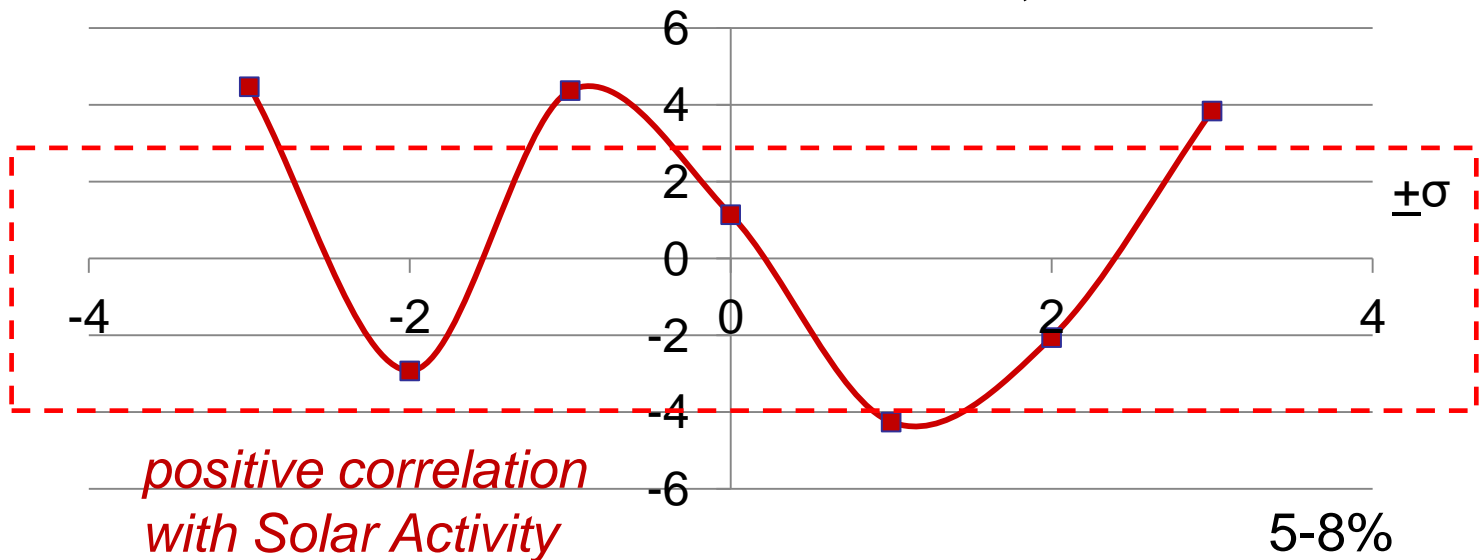


"0" - max of Solar Activity Cycle

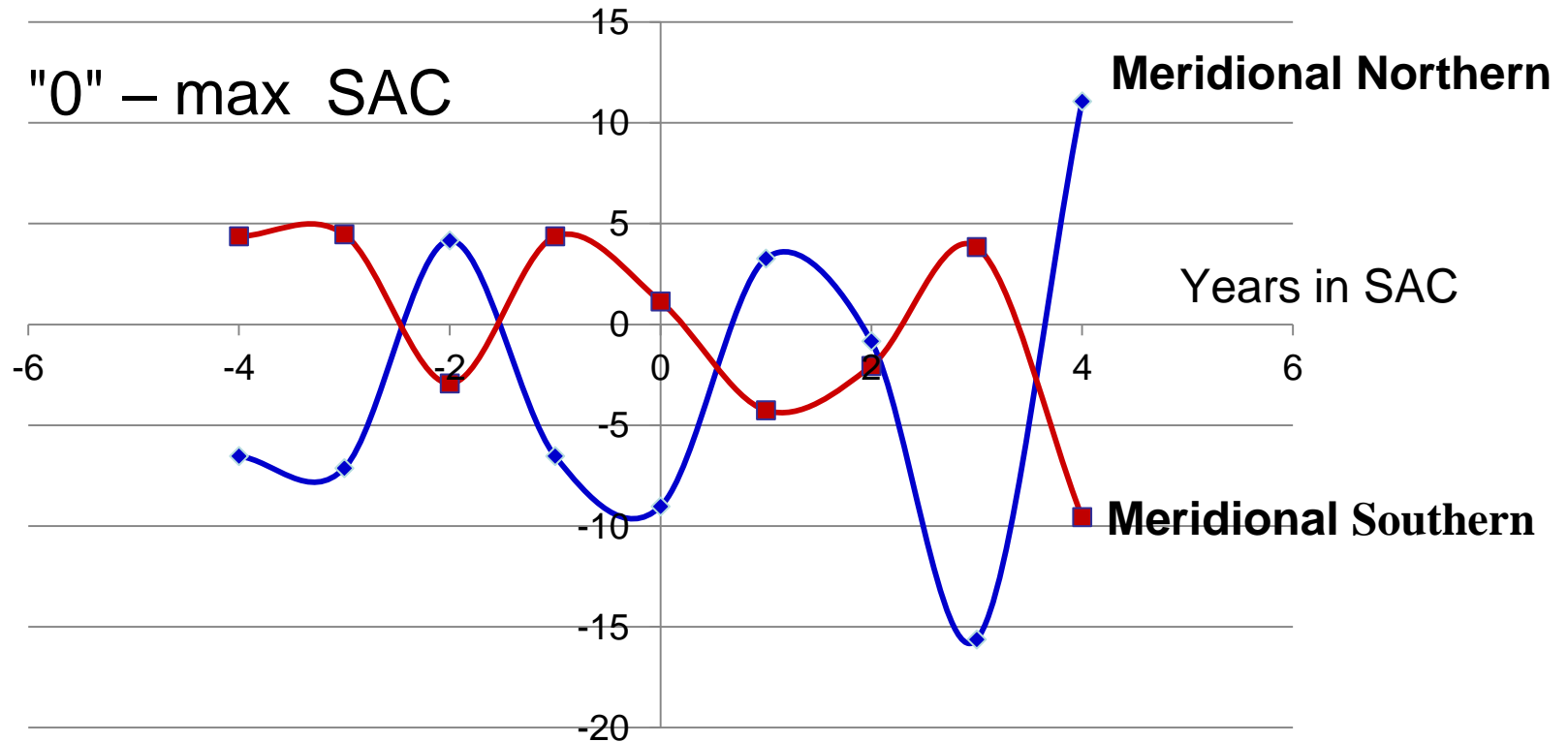
Meridional Northern, "0"- max



Meridional Southern, "0" - max



Deviation from the average long-term value of the duration of ECM groups in SAC, Method of Superimposed Epochs for MN and MS groups



Correlation by MSE: $R = -0,90$ (MN and MS);

direct correlation
(1800-2008 years): $R^* = -0,35$.

1.2. Seasonal effects

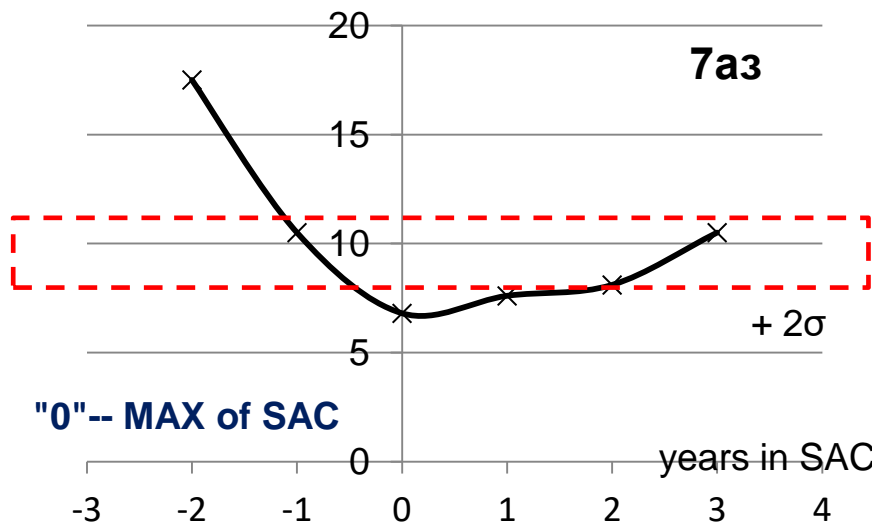
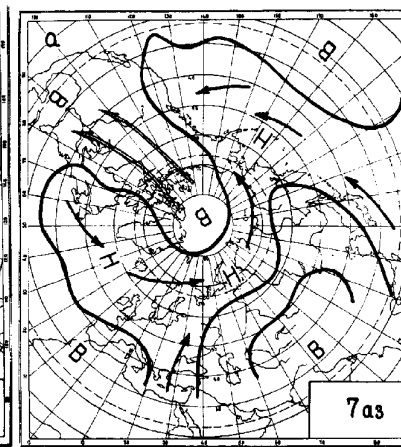
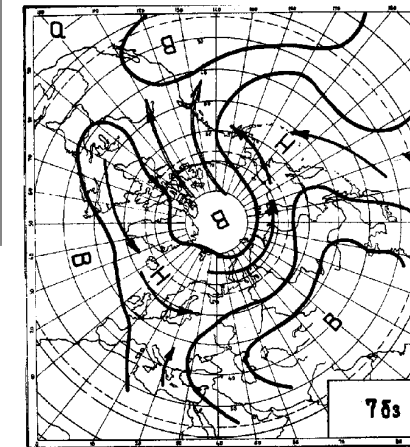
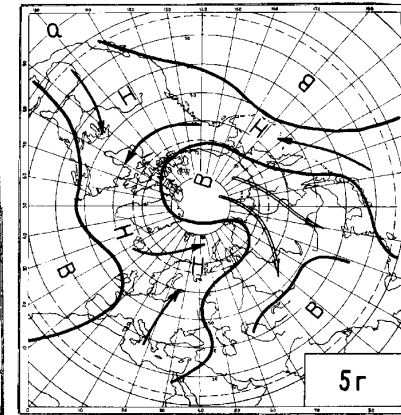
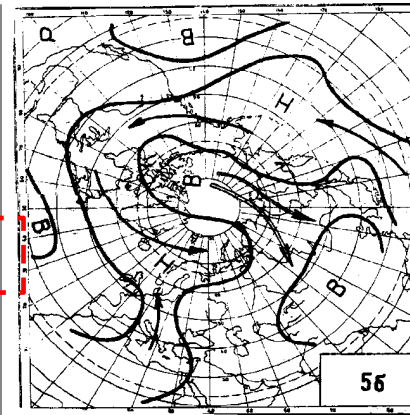
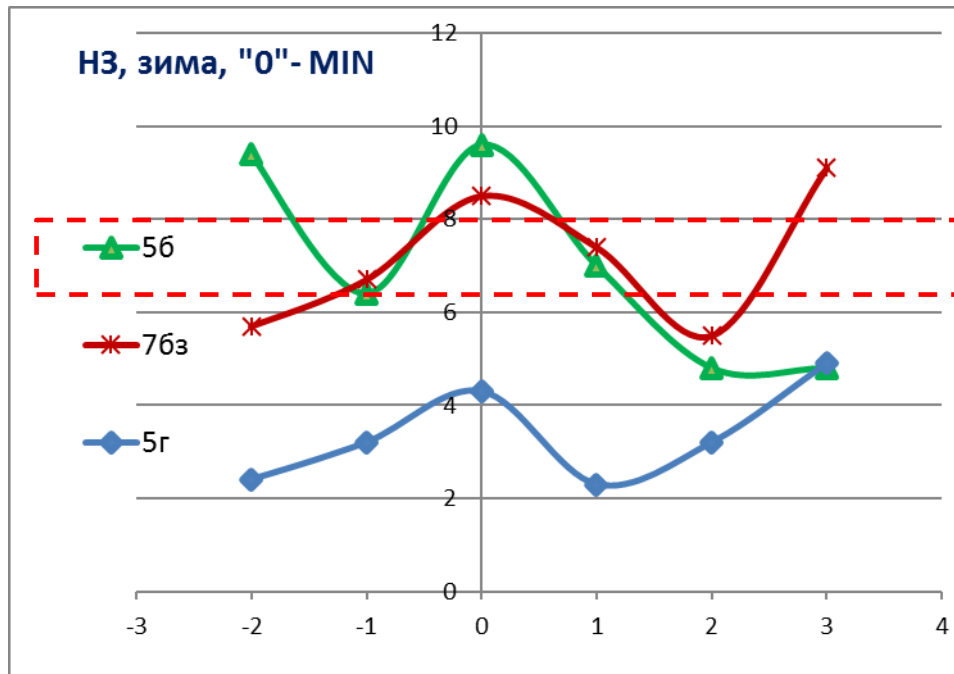
According to [1] certain types of circulation occur only in certain seasons.

Seasonal circulation groups:

Winter	5а, 5б, 5г, 7аз, 7 бз, 11а, 11б, 11в, 12 бз, 13з
Summer	2а, 2б, 2в, 4б, 4в, 6, 7 ал,7 бл, 8 бл, 8 гл, 9а, 10б, 13л
spring-autumn	10а, 12а, 12 бл, 12вл
early spring -early winter	1а,1б, 4а, 5в, 8а, 8 бз, 8 вз, 9б,11г,12г.

Winter Circulation types (duration in year, days)

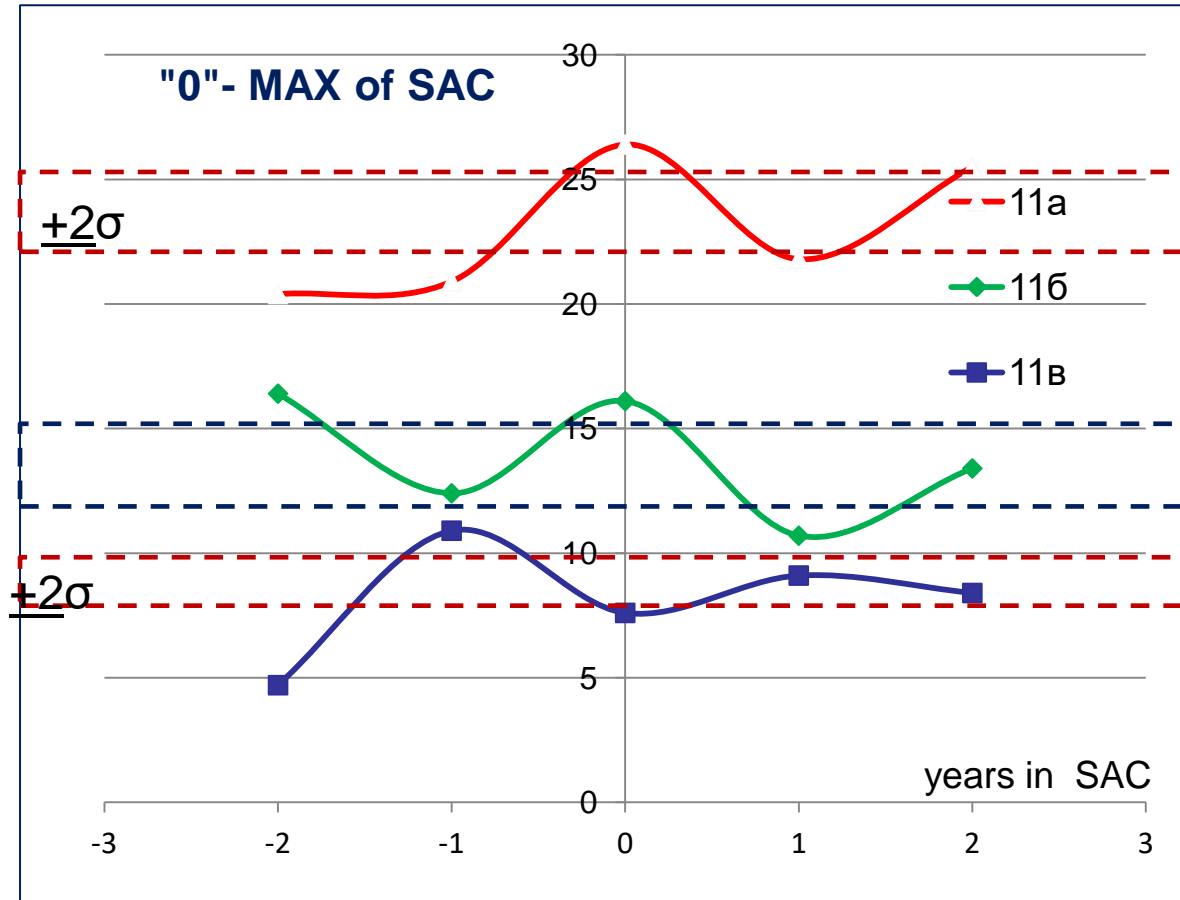
Disturbance Zonal flow group - **Negative relation with solar activity.**



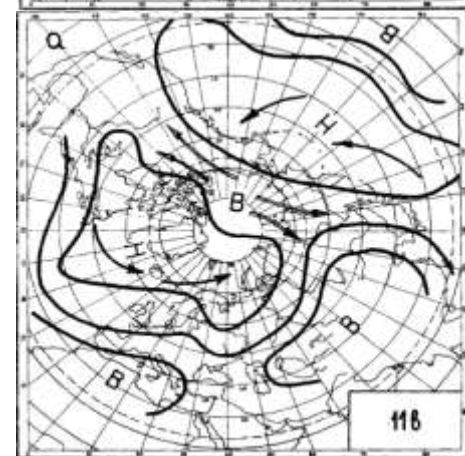
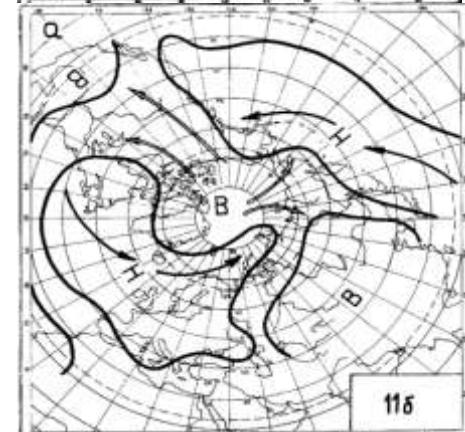
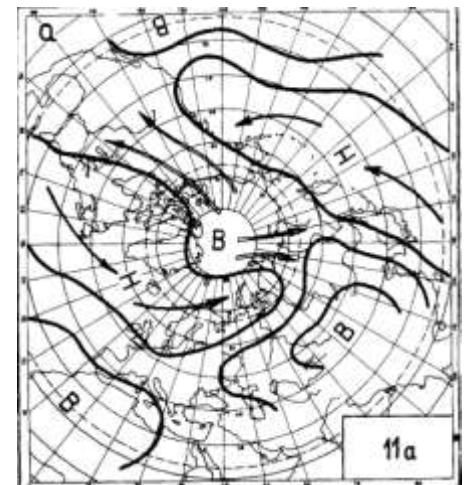
56 – 23%
 5г – 15%
 76з – 39%
 7аз – 28%

WINTER, Meridional Northern groupe -

positive correlation for 11a and 116 with SAC

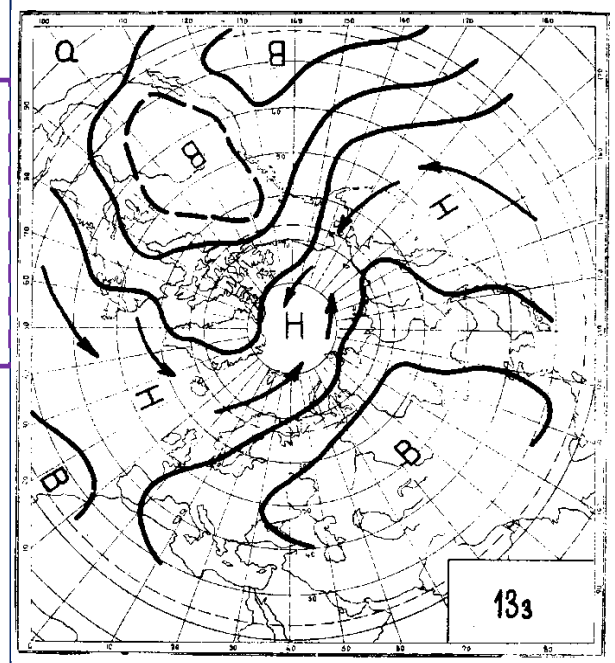
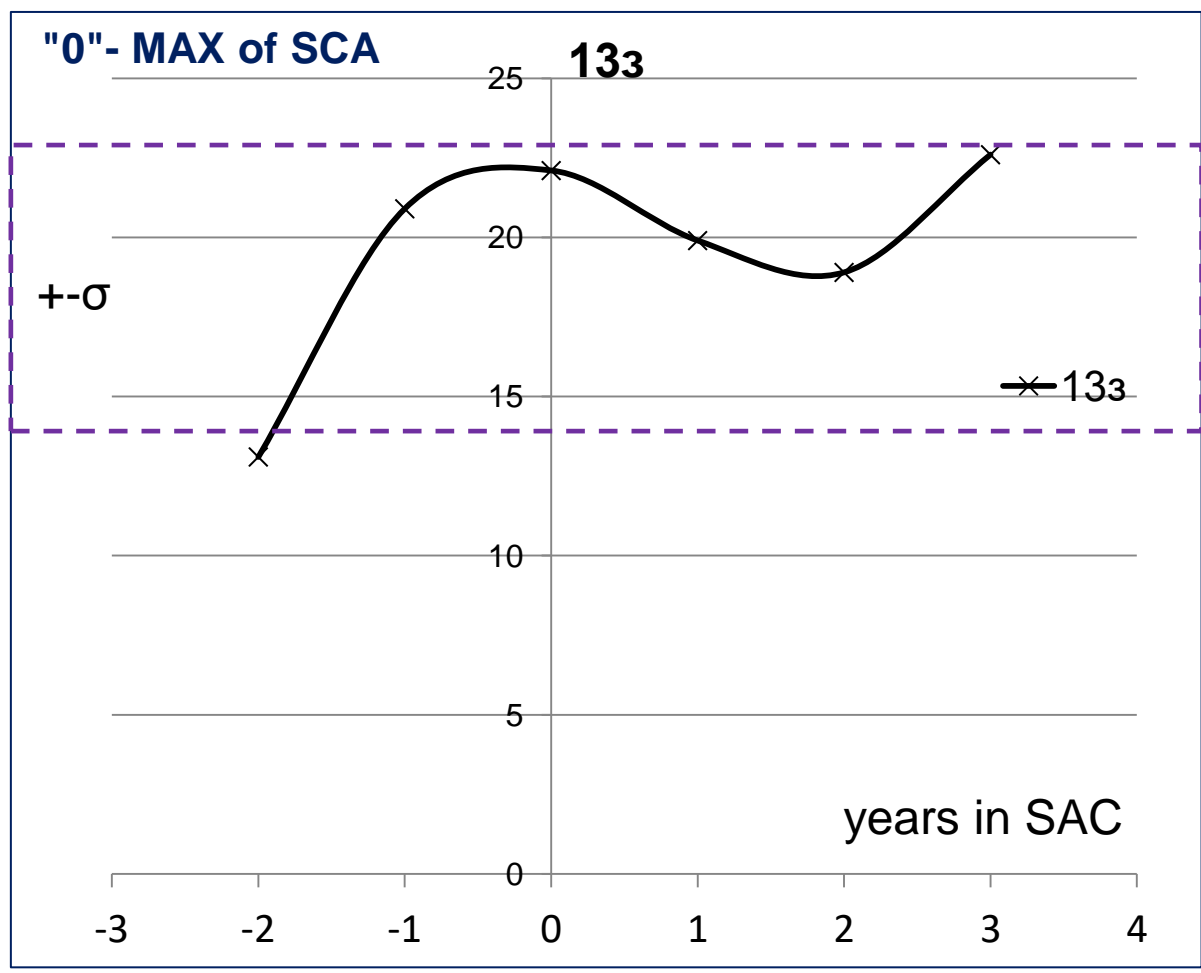


11a - 12%, 116 - 47%, 11B - 6%



WINTER, Meridional Southern type

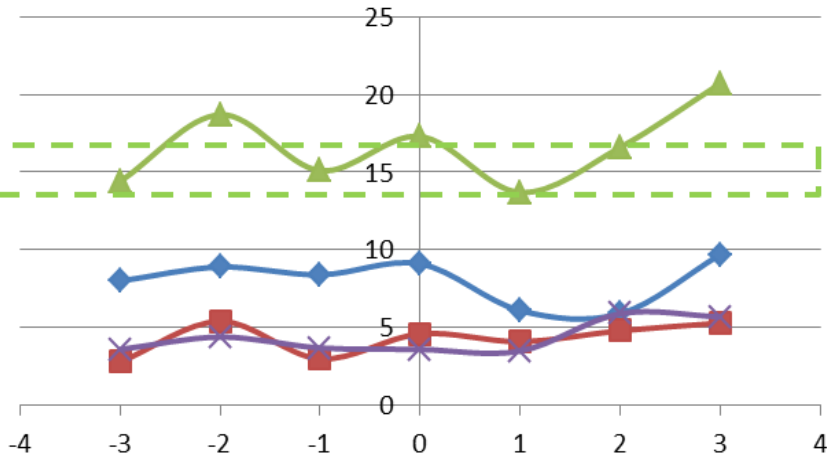
The result is insignificant



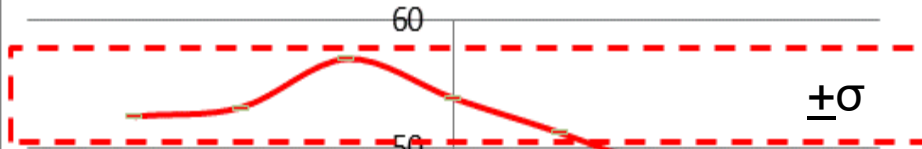
SUMMER

The result is insignificant

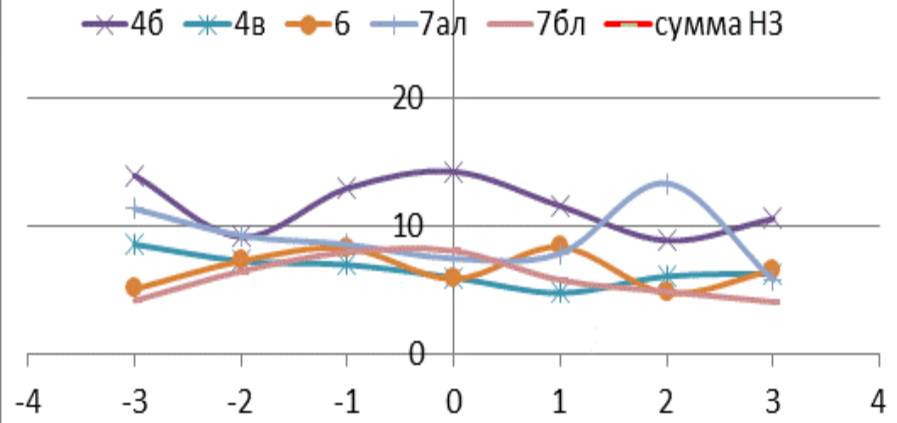
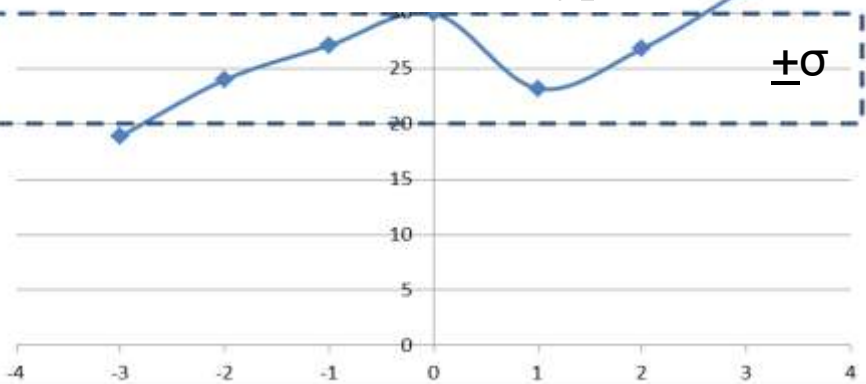
Zonal type,
"0"- MAX



Disturbance of zonal flow type, 0"- MAX



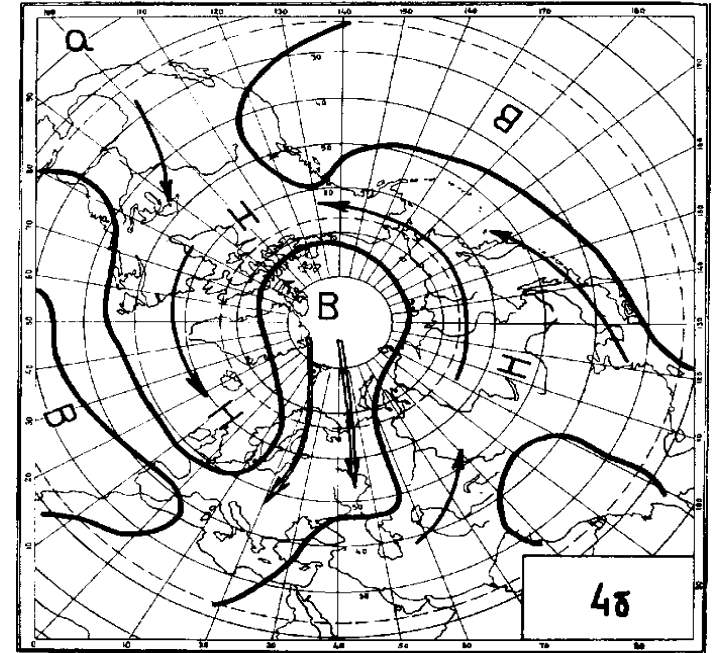
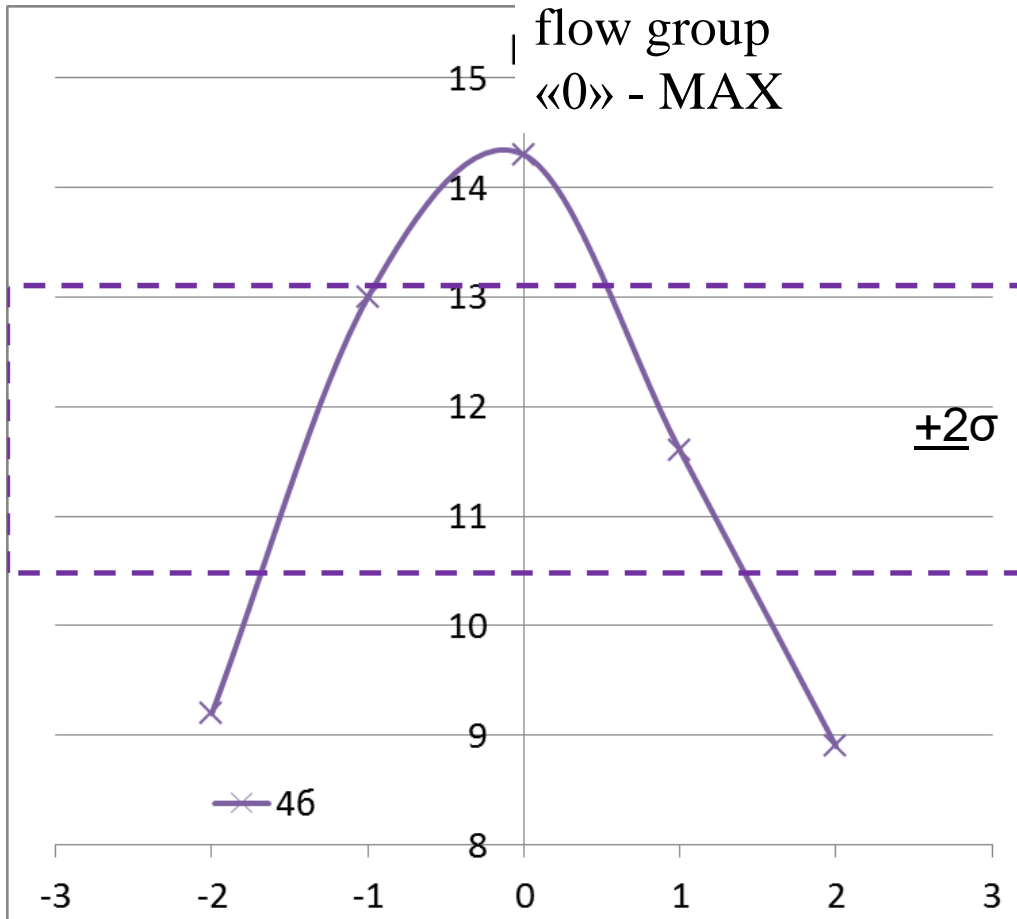
Meridional Southern type,



SUMMER

46 - positive relationship with SAC

Disturbance of Zonal
flow group
«0» - MAX

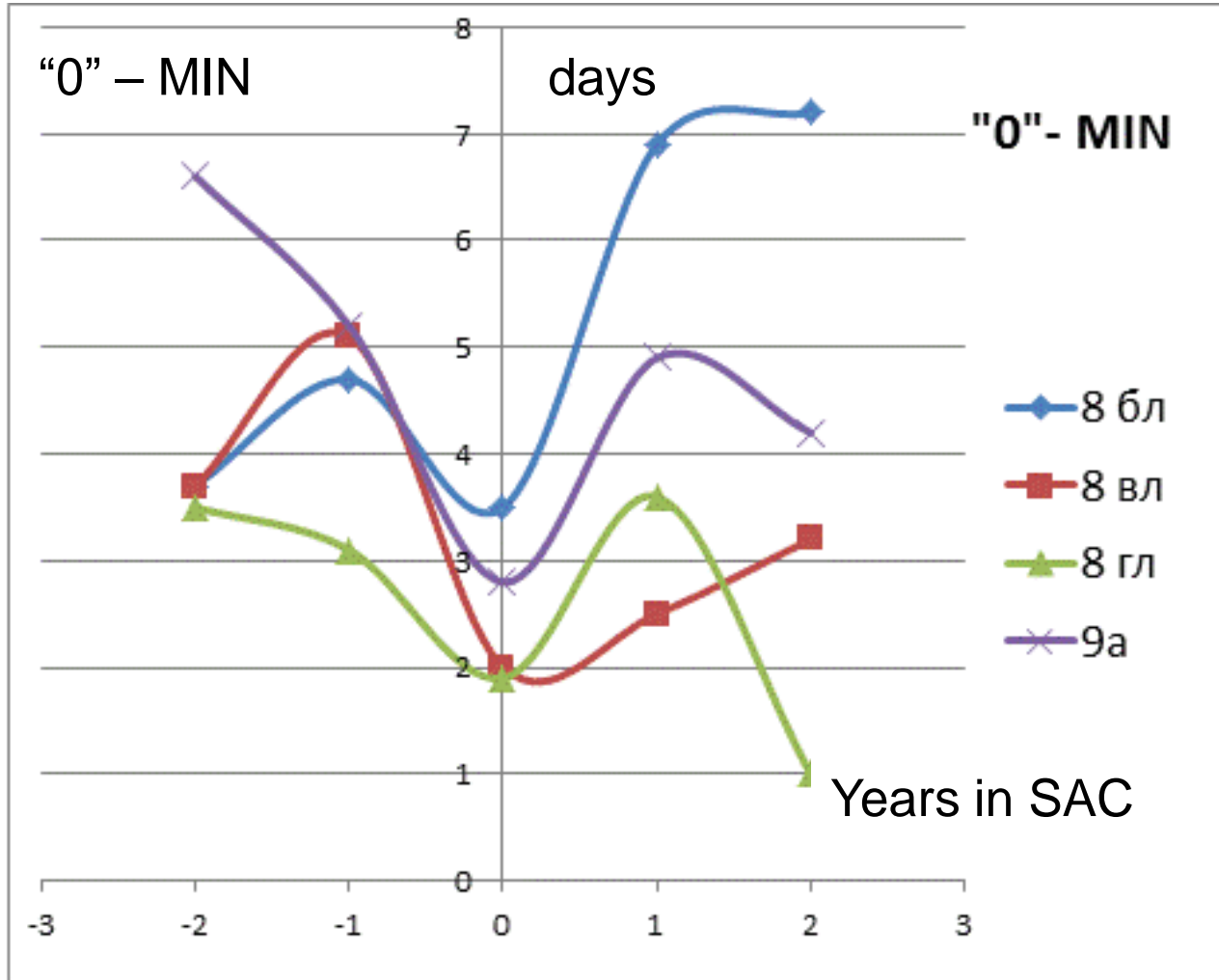


23% from average value

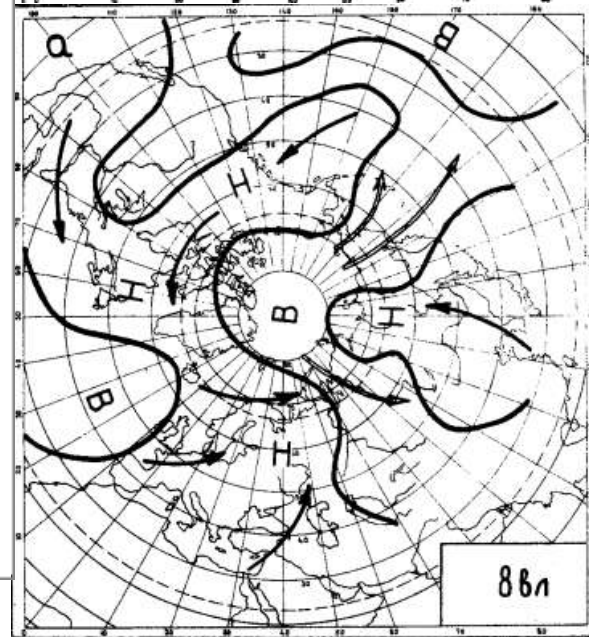
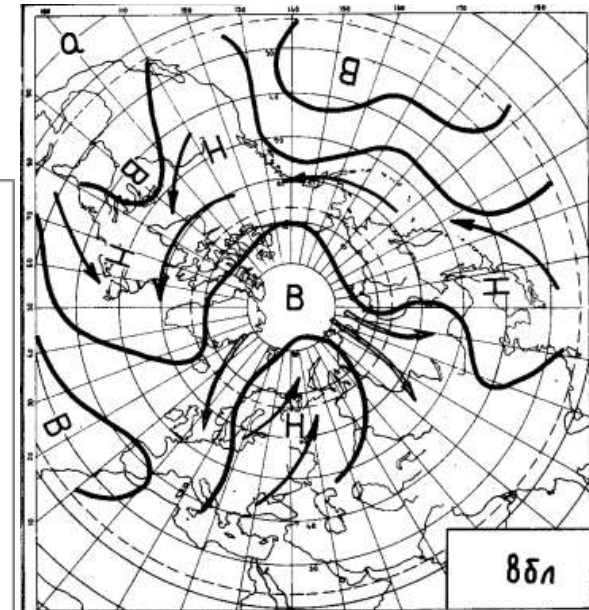
SUMMER

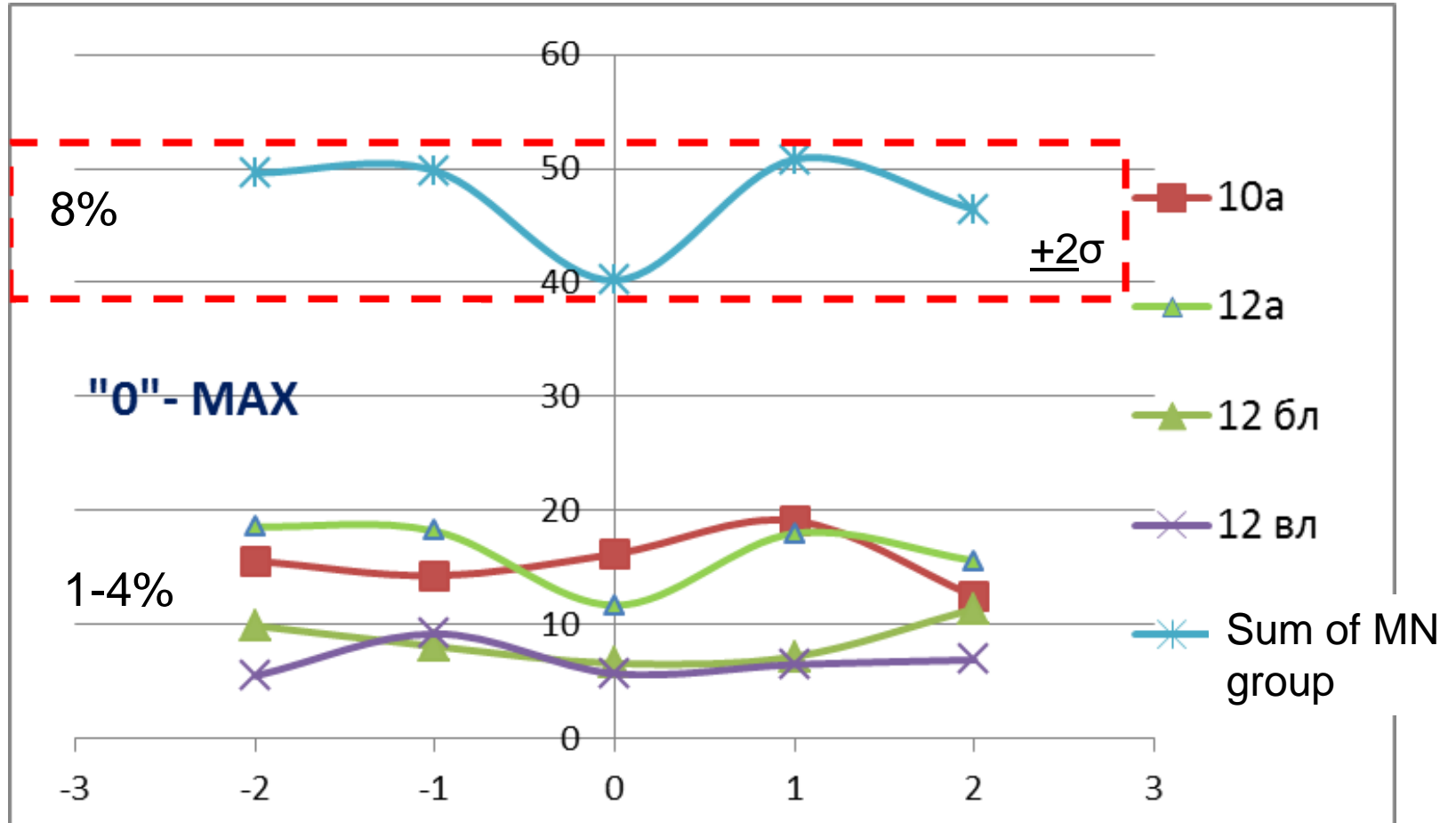
Meridional Northern group

46 - positive relationship with SAC



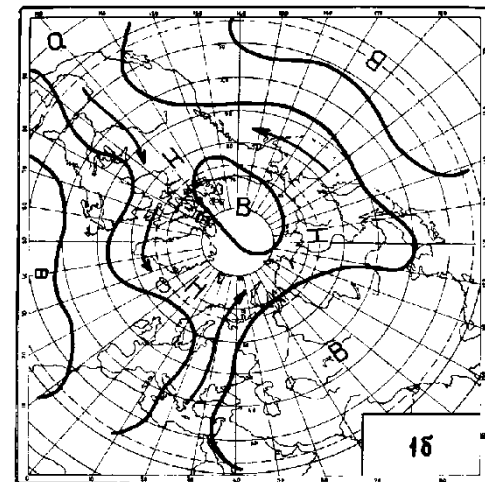
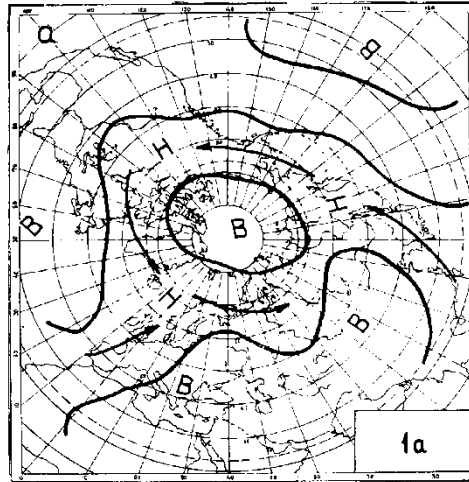
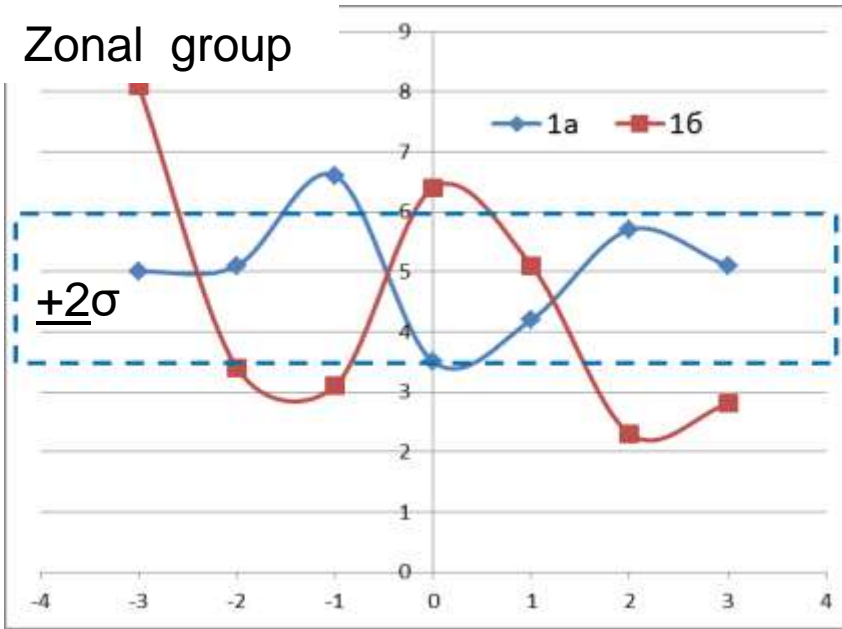
9-10% from average value





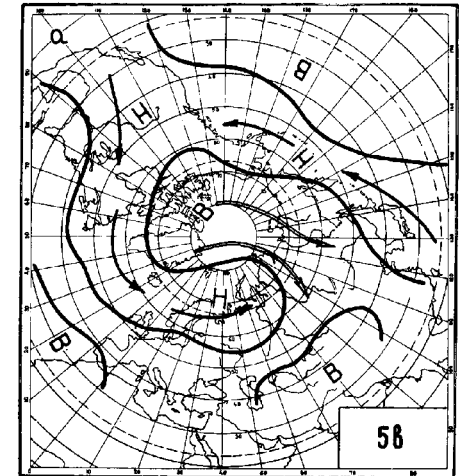
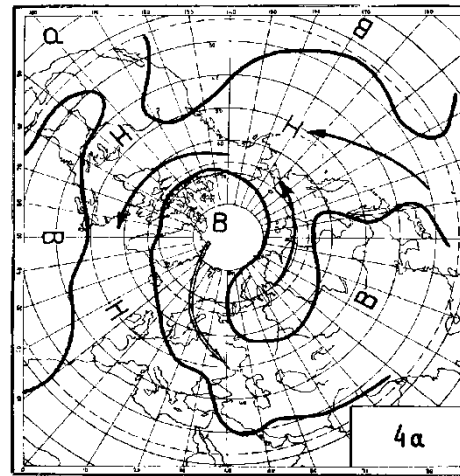
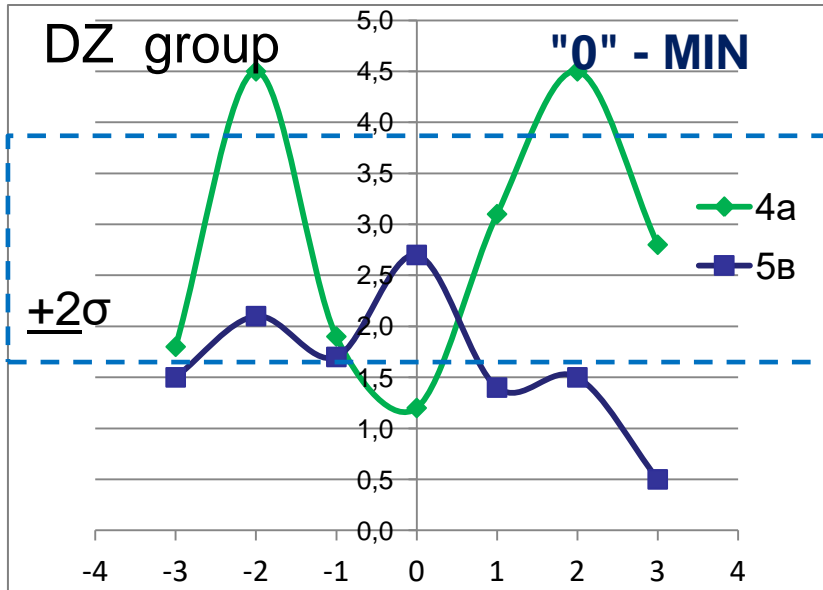
EARLY SPRING - EARLY WINTER

Zonal group



Zonal group
1a, 16 - $\pm 32\%$

DZ group



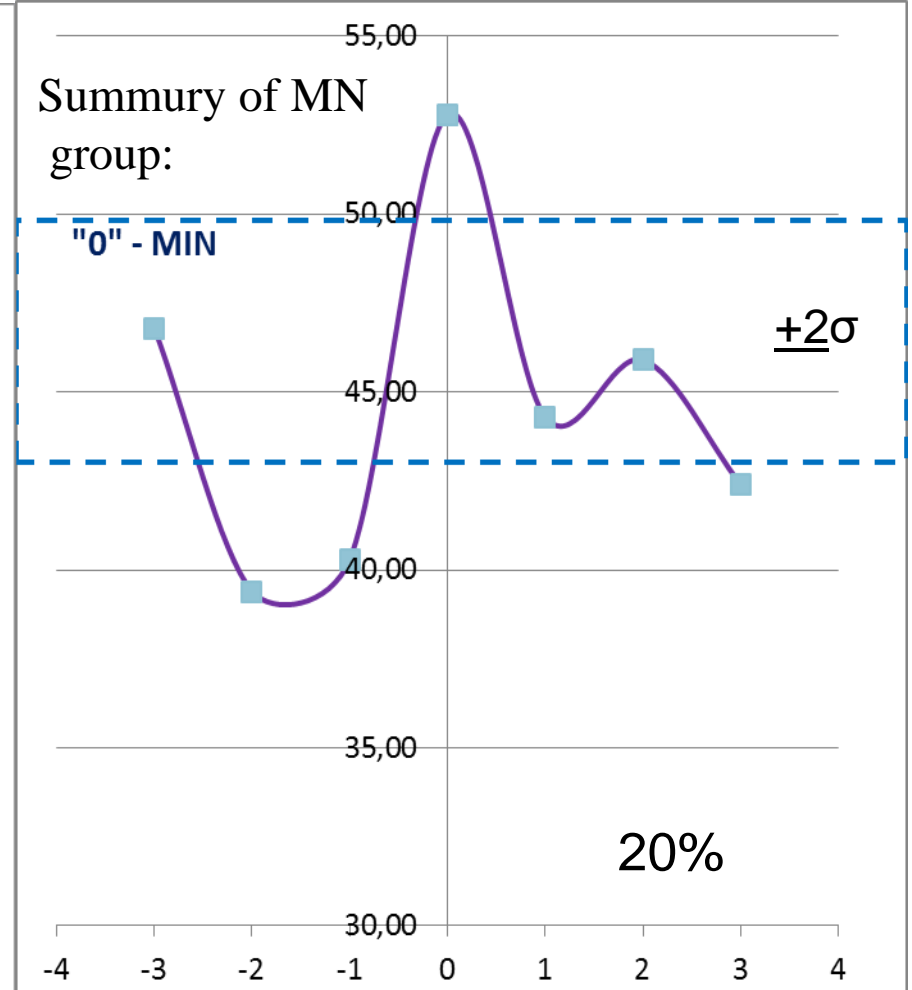
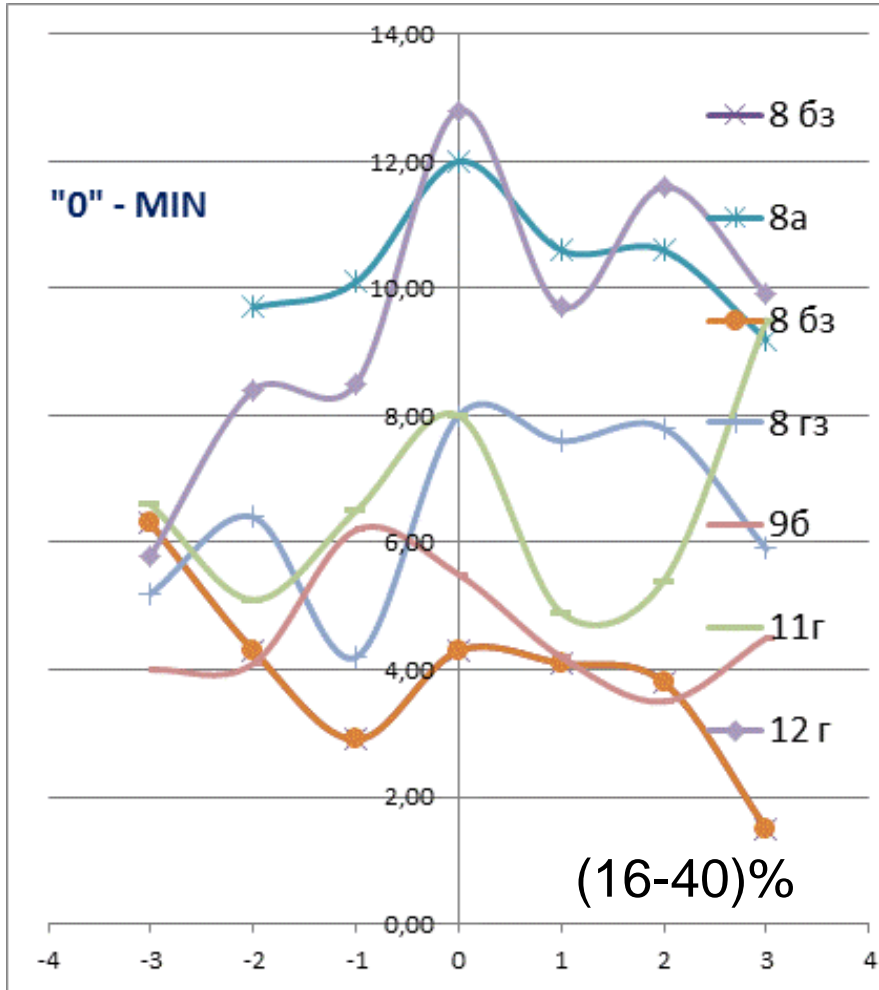
Disturbance of zonal flow (DZ) group

4a - (-58)%
5B - (+38)%

EARLY SPRING - EARLY WINTER

Meridional Northern group:

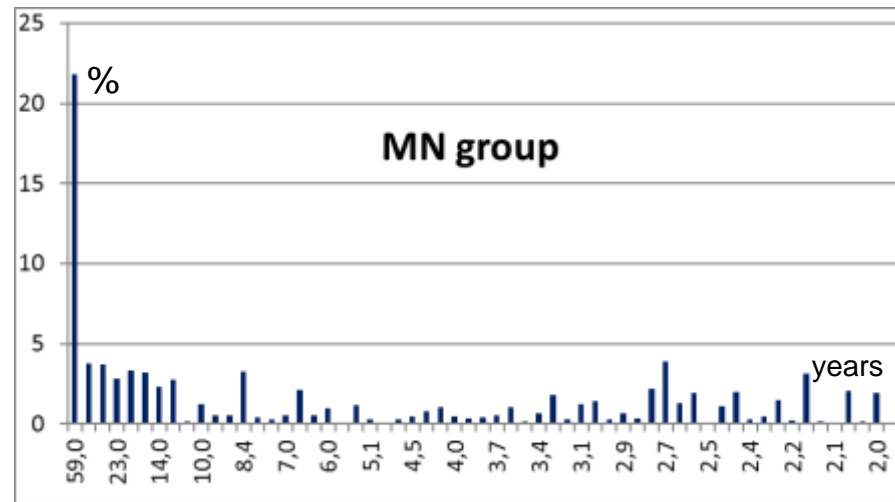
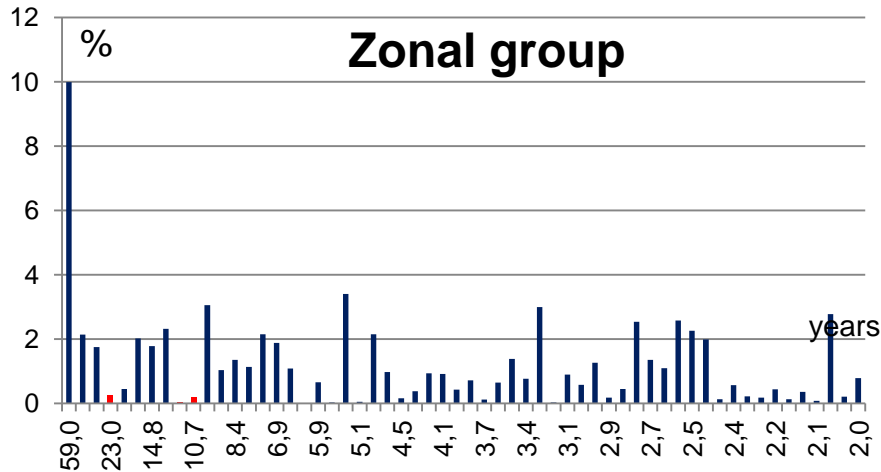
Significant negative relationship with Solar Activity



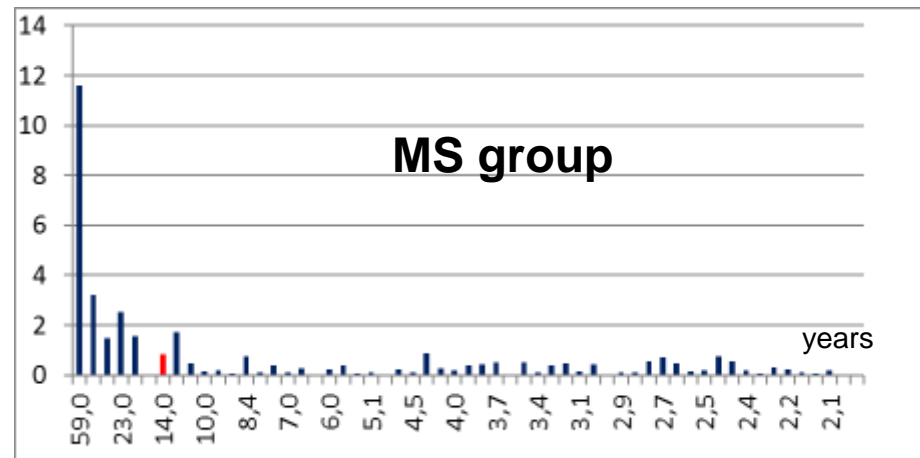
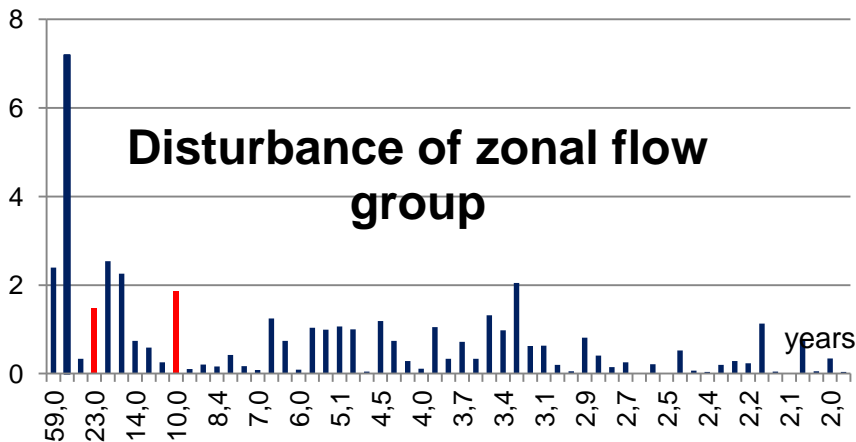
II. Circulation group duration Fourier analysis (1899-2016)

- Time series of deviations from the average long-term value of the duration of the total circulation groups (Z, DZ, MN and MS) and also some separate types of circulation were assumed.
- The ratio (%) of the intensity of individual harmonics of decomposition to the dispersion value in was calculated. Thus, these values indicate the contribution of individual harmonics to the overall variability of the series.

(Time series 1899-2016)

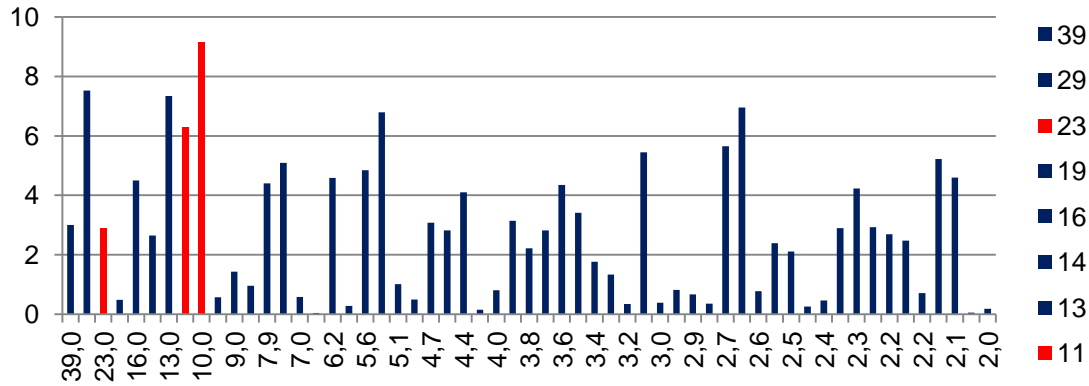


The maximum intensity of a harmonic with a period of about 60 years (7-22%)

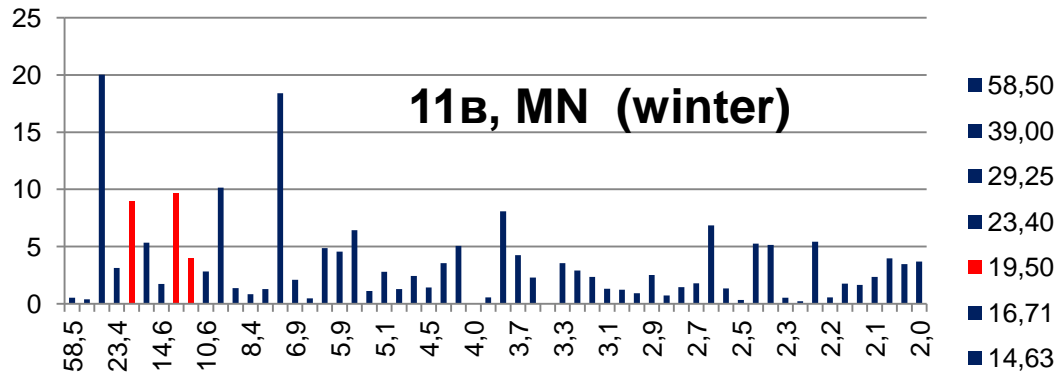


Contribution of harmonics with a period of 10-11 years does not exceed 3%

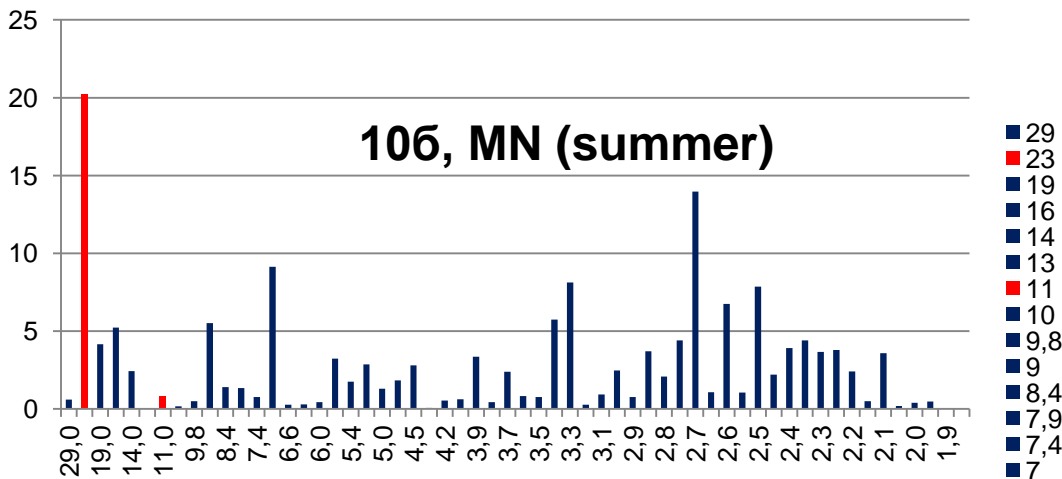
116 , MN (winter)



11B, MN (winter)



106, MN (summer)



For some types of MN group in winter, the intensity of harmonics with $T=11$ and $T=22$ years increases to 10-20%

CONCLUSIONS

1. Seasonal differences in the relationship between Solar Activity and circulation types were found:

solar activity increases the duration of meridional forms of circulation (MN) at winter and summer, and reduce one at the early-winter.

2. A negative relationship for Disturbance of zonal flow (DZ) group in winter was found also.

During the transitional synoptic seasons (spring-autumn, early-winter) the dependence becomes more complicated.

3. The correlation coefficient between the superimposed MS and MN series is $R = -0.90$ in Solar Cycle .

4. 60-year cycle of the duration of the elementary circulation period was found.

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- Kononova N.K. CLASSIFICATION OF CIRCULATION MECHANISMS OF NORTHERN HEMISPHERE BY B.L. DZERDZEEVSKII. The Russian academy of sciences. Institute of geography., 2009. 372 P. <http://www.wdcb.ru/stp/data/SPE/>
- IZMIRAN, <http://www.izmiran.ru/services/saf/archive/>
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- Kukoleva A.A., N.K. Kononova, A.A. Krivolutskii, Manifestation of the Solar Cycle in the Circulation Characteristics of the Lower Atmosphere in the Northern Hemisphere / Geomagnetism and Aeronomy, 2018, Vol. 58, No. 6, pp. 775–783. 2018.

THANK YOU FOR YOUR ATTENTION!