ASSESSMENT OF CLIMATE CHANGES IN NORTHERN REGIONS OF EURASIA

V.I. Shishlov

IMCES SB RAS. 634021, Tomsk, 10/3 Academichesky Ave., shishlov@imces.ru

MATRIX DESCRIPTION of OBSERVATION SERIES

Matrices of monthly characteristics of climate condition for Kolpashevo

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1969	-31	-30.1	-12.5	-3	4.4	15.3	22.2	12.6	7.2	-1.6	-5.9	-19.3
2002	-11.1	-8.1	-4.5	-3.1	11	16.6	17.3	13.8	8.9	-0.4	-9.9	-23
2006	-33.8	-18.8	-6.7	-5.2	7.2	19.8	19.1	12.4	10.1	-0.8	-9.9	-8.5

Matrices of seasonal characteristics of climate condition for Omsk

YEAR	D-J-F	M-A-M	J-J-A	S-O-N	ANN
1977	-20.23	4.77	18.47	2.73	1.43
1990	-13.23	5.2	19.07	1.97	3.25
2006	-18.73	3.3	18.27	2.47	1.33

Matrix describing sequence of climatic system states

YEAR	D-J-F	M-A-M	J-J-A	S-O-N	ANN
1925	-13.53	-0.67	17.1	3.6	1.62
1926	-16.3	-1.63	16.13	2.47	0.17
1927	-18.4	-0.27	17.87	1.8	0.25
1928	-18.7	-2	17.23	1.9	-0.39
1929	-20.77	0.73	18.93	3.13	0.51
1930	-21.67	0.5	17.53	2.33	-0.33
1931	-21.1	0.4	20.03	2.53	0.47
1932	-14.6	2.1	17.43	3.33	2.07
1933	-20.7	0.6	17.77	1	-0.33
1934	-16.1	-2.13	16.1	1.83	-0.08

This matrix is an empirical model of evolution of climatic system states

Aggregation description of regional climate

Performance characteristics of long-term changes :	**Characteristics of annual state:**	**Estimates of seasonal cold and warm periods:**	**Estimates of monthly meteorological variables:**	**Characteristics of**	
				Agroclimate:	**Biocimate:**
• The limits of variability of states • The mean annual • Rhythm perennial changes	• Mean annual meteorological values • Norms matrices • The amplitudes of the annual cycle • Extremes	• The duration • Integral characteristics (temperature sum, precipitation)	•Monthly averages •Extremes • Range	• moisture reserves in soil • temperature regime • FAR • characteristics of the growing season • rhythm hydrothermal conditions	• classes weather • Index volatility • Lack of heat • Period of UFD

Typification of the annual state of the climate on the temperature regime

- type A – duration of the warm period Тгп =9 months,
- type B – duration of Тгп = 8 months,
- type C – duration of Тгп = 7 months,
- type D – duration of Тгп = 6 months,
- type E – duration of Тгп = 5 months,
- type F – duration of Тгп = 4 months,
- type G – duration of Тгп = 3 months.

Description of the multi-year rate changes in temperature – sequence of operators **C, C, C, E, D, C …**

Matrix element of the annual state of the climate **Mij** is given

Год	Тг	Р	Zтп	Zвп	T_{VII}	Dт	$\tau_{хп}$	Тз	T_I	К

where rhythm P ={ C at Тгп=7; D at Т = 6; E at Тгп = 5};

Zтп – sum of the temperatures of the warm period Z;

Dт – deficit temperatures ;

Zвп - sum of the temperatures of the growing season

Aggregation description of climate Omsk

1890	-0,7	C	76	**60**	19	-130	7	-20	-23	К
1892	-0,2	D	83	81	20	-155	7	-18	-20	К
1893	0,8	C	84	74	20	-138	6	-23	**-31**	РК
1898	-1,3	E	71	70	20	-154	7	-19	-22	К
1908	-1,2	E	71	71	17	-153	7	-19	-21	К
1921	1,0	C	86	80	**22**	-144	6	-19	-19	РК
1960	-1,0	D	71	67	17	-142	5	-17	-20	К
1969	**-2,0**	D	72	70	**22**	**-169**	5	**-26**	**-30**	РК
1972	-0,4	C	**70**	**63**	**16**	-129	5	-19	-26	РК
1987	0,7	D	82	81	21	-127	5	-16	-17	К
1991	3,0	C	**97**	**84**	**22**	-118	5	-14	-15	К
2006	1,3	C	83	77	21	-121	6	-19	**-27**	РК
2007	**3,8**	C	90	78	20	**-101**	6	**-10**	**-15**	УК
2008	3,4	C	88	78	**22**	-109	5	-15	-20	К
2009	2,0	C	88	75	18	-108	5	-16	-20	УК

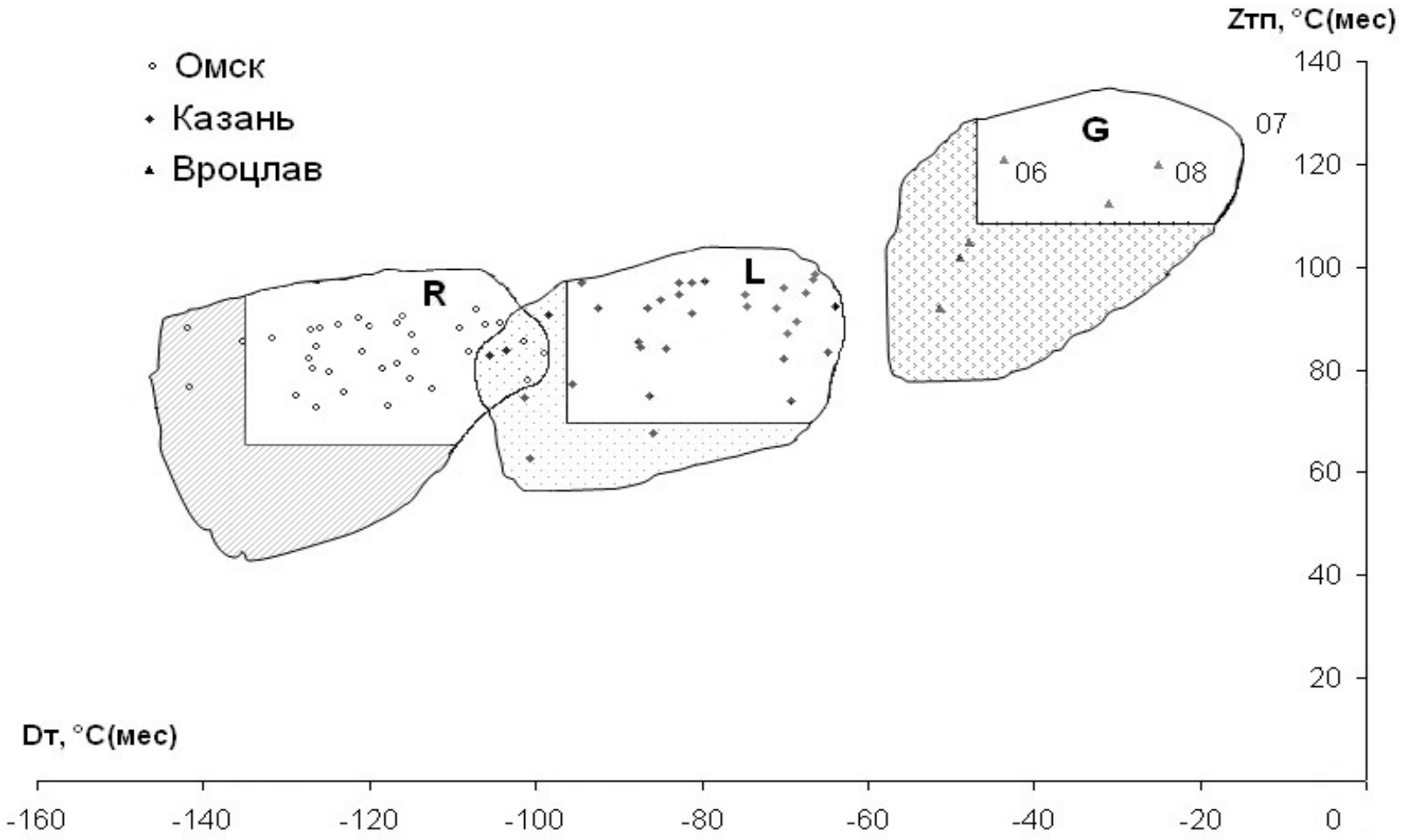
Assessment of multi-stage changes of the regional climates of Eurasia

Year	Wroclaw	Arkhangelsk	Kazan
1838	**6,3** A 94 (91) **-54** (6) **-6,0 (-11)**	**-1,1 D 54 (52) -121 (9) -18 (-21)**	**1,8** C 85 **(77) -112** (7) **-17 (-19)**
1839	8,3 B 103 (93) -47 (7) -1,0 (-2)	1,2 D 66 (62) -105 (7) -10 (-13)	4,0 C 92 (86) -96 (7) -10 (-12)
1843	8,5 A" 95 (84) -35 (6) 1,7 (-1)	0,7 D 53 (49) **-110** (9) -7,0 (-10)	4,3 C 86 (77) -84 (7) -8,0 (-11)
1850	**7,5** A 105 (97) **-48** (6) -4,0 (-9)	0,0 C 61 (54) **-113** (8) -14 (-19)	**1,8 D** 79 (78) **-109** (7) **-16 (-22)**
1851	8,4 A 101 (96) -33 (6) -0,1 (-1)	2,0 C 69 (66) -91 (8) -11 (-15)	4,0 B 96 (88) -103 (7) -12 (-15)
1855	7,4 A 100 (91) **-52** (6) -4,0 (-9)	0,4 C 58 (55) -97 (8) -12 (-17)	4,7 C 92 (80) -64 (7) -9,0 (-12)
1859	9,3 A" 112 (99) -28 (6) 0,7 (-1)	2,3 D 60 (59) -92 (8) -8,0 (-9)	4,2 C 88 (77) -104 (7) -10 (-12)
1863	9,5 A* 118 (94) -31 (6) 1,0 (-2)	2,3 C 65 (59) -91 (9) -9,0 (-9)	4,0 C 83 (79) -92 (7) -10 (-15)
1869	9,0 A" 108 (92) -31 (5) 2,0 (-3)	2,5 C 69 (66) -99 (8) -12 (-13)	4,8 B 101 (92) -85 (7) -12 (-18)
1871	**6,2 A 92 (80) -51 (7) -6,0 (-7)**	**-1,6 D 51 (49) - 139 (9) -20 (-25)**	**1,3 C 80 (73) -103 (7) -19 (-21)**
1872	9,2 A' 118 (93) -42 (6) -2,0 (-5)	0,0 D 55 (52) **-112** (9) -12 (-12)	4,0 C 90 (78) -89 (7) -12 (-16)
1882	9,1 A" 100 (87) -28 (6) 1,0 (1)	0,9 D 57 (56) -99 (9) -8,8 (10)	3,8 D 84 (84) -92 (7) -11 (-13)
1887	79 A 99 (93) -38 (5) -1,5 (-3)	**-1,7 E** 51 (51) **-110** (8) -17 (-19)	4,4 C 92 (85) -90 (7) -9 (-14)
1890	87 A 108 (99) -34 (5) -1,0 (-3)	0,9 D 56 (53) -98 (8) -97 (-15)	4,2 C 95 (86) -84 (7) -11 (-12)
1893	**8,1 A'** 109 (101) **-44** (5) -3,3 **(-9)**	**-2,2 D** 51 (45) **-138 (9) –18** (-12)	**2,6 C** 86 (78) **-109** (7) **-17 (-20)**
1899	95 A 110 (96) -23 (5) 2,5 (2)	**-1,3 D** 46 (43) **-125** (8) -14 (-16)	4,4 C 88 (77) -90 (7) -9 (-13)

1911	9,8 A' 117 (105) -30 (5) 0,9 (6)	0,4 D 52 (47) **-109** (8) -12 (-17)	3,3 B 86 (79) -101 (7) -13 (-16)
1921	9,3 B 111 (100) -30 (6) 1,4 (6)	2,5 D 68 (62) -94 (7) –8,9 (-11)	4,8 C 99 (96) -91 (6) –11 (-12)
1922	**7,2 A** 97 (84) -41 (7) **-3,0 (-5)**	1,9 C (67) **-107** (8) -12 (-14)	4,1 C 91 (83) -95 (7) -13 (-14)
1925	8,8 A" 96 (86) -28 (5) 2,1(0)	**1,7 C** 59 (58) -87 (8) **-7,1** (-10)	5,5 B 94 (86) -72 (7) -7,6 (-9)
1929	**6,7 A" 101** (92) **-57 (6) -7,1 (-13)**	**0,2 D** 60 (56) (7) **-13 (-18)**	**2,5 D** 84 (79) **-109 (7) -15 (-20)**
1930	9,4 A 109 (99) -29 (5) 1,0 (0)	1,9 D 58 (53) -7,5 (-12)	3,4 C 86 (80) -88 (7) -13 (-15)
1940	**6,7 A 88 (81) -56 (7) -7,1 (-11)**	**0,0 D 64 (63) 0 (-22)**	3,0 C 89 (84) **-103 (8) -15 (-21)**
1941	**6,7 A** 92 (80) -43 (7) **-3,8 (-7)**	**-1,2 D 49 (47) -105 (8)** 13 (-18)	**1,2 D 72 (70) -105 (8)** -14 (-16)
1942	7,6 A 104 (101) **-56** (6) **–4,6 (-9)**	**-0,9 D** 57 (56) **-106 (7) -16 (-19)**	**1,2 C** 81 (75) **-124 (7) -17 (-21)**
1956	**6,6 A'** 96 (94) **-52** (6) **–5,2 (-13)**	**-1,2 D** 55 (55) **-120 (8) -17 (-21)**	**1,0 C** 82 (74) **-110** (7) **-18 (-20)**
1963	**6,9 B** 109 (102) –46 (6) **-8,4 (-11)**	0,3 C 56 (49) -14 (-17)	3,1 C 91 (82) -102 (7) -13 (-18)
1970	**6,8 A 99 (93) -53 (6) -5,6 (-8)**	**-1,6 D 47** (43) **-105 -16 (-20)**	**1,0 C 77 (70) -115 (7) -18 (-22)**
1972	7,8 A' 101 (90) -42 (7) -2 (-6)	**1,1 D** 54 (46) -13 (-16)	3,3 C 96 (85) -94 (7) **-13 (-21)**
1976	8,1 A 99 (93) -40 (6) -0,5 (-1)	**0,1 D** 51 (50) -12 (-18)	**1,8 D** 77 (72) –101 (7) **-13 (-17)**
1978	8,2 A 100 (89) -38 (6) -0,1 (-1)	**-0,3 D** 49 (47) -101 (7) **-13 (-18)**	3,3 C 75 (69) 86 (7) -10 (-12)
1979	7,6 A' 89 (81) **-45** (6) **-4 (-7)**	**1,5 D** -10,7 (-13)	2,6 D 83 (81) **-106** (7) **-15 (-18)**
1985	**7,1 A'** 104 (97) **-49 (5) -5 (-9)**	**-1,0 D 59 (52) -133 (9) -19,5 (-25)**	2,7 C 84 (77) **-107** (7) -13 (-15)
1987	**7,2 A** 101 (95) **-48 (5) -4 (-10)**	**-1,0 D** 62 **-16,4 (-21)**	2,3 C 84 (80) 21 -104 (7) **-13 (-20)**
1988	9,0 A' 107 (100) -32 (5) 2,1 (1)	3,2 C 72 (68) -88 (7) -9,3 (-12)	4,4 C 97 (88) -95 -11 (-13)

1991	8,9 A'' 106 (93) -25 (5) 1,6 (0)	1,8 C 63 (57) -97 (9) -11 (-15)	5,3 C 97 (82) -80 (7) -9 (-11)
1994	9,8 A' 112 (92) -30 (5) 1,7 (-1)	0,7 C -12 (-15)	3,5 C 84 (75) **-100** (8) -11 (-17)
1996	**7,2 B** 99 (93) -51 (5) **-4,1 (-5)**	**1,2 C** 56 (51) **-12 (-13)**	4,1 B -93 (7) -11 (-14)
1997	8,2 A 108 (96) **- 45** (5) –1,8 (4)	0,5 E 56 (56) -98 (9) -12 (-15)	
1998	9,5 A" 112 (101) -26 (6) 2,8 (2)	**-0,3 D** 61 (58) **-121** (8) –15 (-22)	3,8 C 87 (82)
1999	9,6 A' 115 (105) –33 (5) 0,4 (0)	0,3 C 62 (54) **-116** (9) -15 (-18)	4,6 C 92 (85) -80 (7) -8,0 (-9)
2001	9,5 A" 113 (102) -28 (5) 1,3 (0)	1,2 D 65 (61) -97 (8) -11 (-16)	6,0 C 95 (91) -68 (6) –6,4 (-9)
2002	10,1 A' 119 (110) -25(5) 1,4 (-2)	0,5 D 55 (53) -103 (8) -11 (-13)	5,3 C 87 (81) -70 (7) -7,0 (-12)
2003	8,7 A' 113 (103) -40 (5) **–2,7 (-3)**	2,1 D 66 (62) **-113** (8) **-14 (-18)**	3,9 C 92 (80) -93 (7) **-13 (-18)**
2005	9,1 A' 108 (103) -32 (5) 0,5 (-2)	2,9 C 72 (65) -88 (7) -8,7 (-11)	5,2 B 97 (85) -81 (7) -8,9 (-12)
2006	9,1 A' 117 (110) **-44** (5) **–2,4 (-6)**	0,8 C 64 (61) -96 (7) -13 (-16)	4,4 C 95 (84) -83 (7) -12 (-16)
2007	10,5 A* 125 (118) -16 (5) 3,8 (2,7)	2,9 C 67 (61) -82 (8) -9 (-18)	6,0 C 99 (86) -66 (7) -6,6 (-14)
2008	10,2 A 121 (104) -25 (5) 2,6(1)	2,7 C 66 (61) -79 (8) -6 (-7)	5,6 C 95 (77) -75 (6) -9,8(-12)
2009	9,4 A' 116 (104) -31 (5) -1 (-3)	2,3 D 61 (60) -75 (9) -8 (-12)	5,7 C 96 75 -70 (7) -8,4 (-11)

Assessment of changes of states of the regional climates of Eurasia



MATRIX DESCRIPTION OF GEOGRAPHIC OBJECTS AND PARAMETRIC FIELDS

When using matrix description of geographical objects and distribution of parametric fields, we use geographic reference for information on spatially distributed objects. In this position of each element of the matrix is uniquely associated with geographic coordinates (rows correspond to the latitudinal bands, and the columns-meridians).

The distribution of annual (seasonal) weather variables on the territory of Siberia in the designated area with E60°-110° and N52°-67° described by the following matrix.

60°		80°	100°	ВД		
M_{11}	M_{12}		M_{14}		67°C Ш	M_{11}-Salekhard; M_{12}-Tarko-Sale; M_{14}-Туруханск; M_{21}-Khanty-Mansijsk; M_{22}-Surgut; M_{24}-Bor ; M_{31}-Tobolsk; M_{32}-Tara; M_{33}-Kolpashevo; M_{34}-Enisejsk; M_{42}-Omsk; M_{43}-Tomsk; M_{44}-Krasnoyarsk; M_{45}-Bratsk; M_{53}-Barnaul; M_{54}-Minusinsk; M_{55}-Irkutsk
M_{21}	M_{22}		M_{24}		63 °	
M_{31}	M_{32}	M_{33}	M_{34}		60 °	
	M_{42}	M_{43}	M_{44}	M_{45}	57 °	
		M_{53}	M_{54}	M_{55}	52 °	

Assessment of spatial-temporal changes of Siberia climate

-7.7F 37-29			-9.9F 36-32	1890
-2.5E 66-23	-5.5E 51-24			
-1.2D* 63-18	-1.5D* 63-19		-3.7D* 57-24	
	-0.7C 76-20	-2.9D* 59-21	-0.4D* 72-21	
		-0.5D* 71-15	-0.1D* 73-19	-1.8D* 59-21

-7.0F 35-26			-7.0F 44-27	1899
0.D* 65-18	-1.4D* 55-19			
2.4C 80-15	-0.1D 72-19		0.5C 66-19	
3,1C 81-16	2.4C 83-17	1.7C 72-16	2.9C 77-17	
		2.9C 83-16	1.4C 76-19	0.3D 67-19

-9.0F 33-30	-9.6F 40-36	M	-9.7F 42-38	1969
-4.9E 52-30	-5.8E 51-32	M	-7.1E 54-36	
-3.5E 59-30	-3.4E 64-31	-4.2E 62-31	-4.4E 65-33	
	-2.0D 72-30	-2.7E 68-30	-1.5E 69-26	-3.8E 60-29
		-1.0C 80-29	-0.7C 82-29	-1.6D 69-28

-2.9D 46-13	-2.7E 49-16		-3.4E 44-20	1995
1.5D 73-13			-2,2D 55-18	
2.6C 82-15		1.1C 74-16	0.5D 66-16	
	3.1C 89-17	4.8C 90-15		0.8C 66-15
		3D* 81-15	2.5C 83-17	1.9C 74-14

-7.6F 42-30	-6.8F 40-37		-7.5E 51-38	2006
-1.9E 64-30	-3.1E 64-35		-4.9E 64-38	
-0.1D* 71-28	-0.3D* 73-30	-2.2E 69-34	-2.8E 67-31	
	1.3C 83-27	0.8D E75-29	-0.3D* 71-25	-2E 66-22
		2.0C 84-24	0.2D* 76-21	0.3C 72-19

-4.1E 47-29	-3.2E 51-31	M_{13}	-4.1F 48-33	2007
0.8C 71-24	0.7C 62-24	M_{23}	-1.1D 62-26	
2.6C 80-19	2.8C 81-18	1.6C 73-20	1.4D 72-18	
	3.8C 90-15	3.1C 84-14	3.7C 82-11	1.4C 74-14.2
		3.6C 93-10	4.1C 90-12	2.9C 82-13

-4.4E 41-29	-3.7E 49-20	M_{13}	-4.7E 51-27	2008
0.4C 63-16		M_{32}	-2.5E 59-29	
1.9C 71-18		1.0D* 69-22	0.4D 69-27	
	3.4C 88-20	2.7C 80-20	2.6C 76-21	1.1D* 65-14
			3.3C 87-21	2.1C 76-14

Assessment of climate changes in regions of Siberia

Matrix element of the annual state of the climate **Mij** is given [Тг P Zтп (Zвп) T_I],

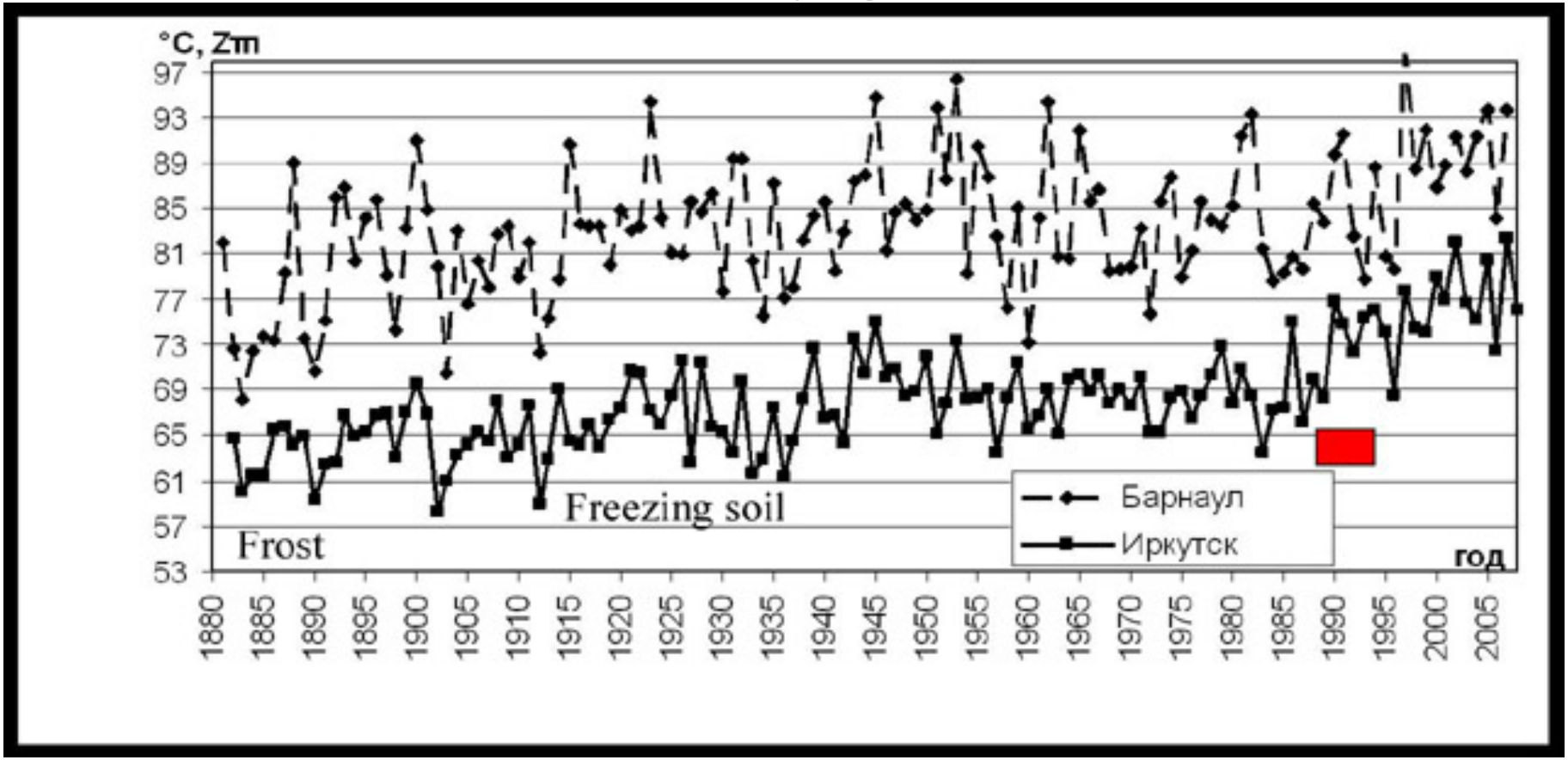
where rhythm P ={ C at Ттп=7; D at T = 6; E at Ттп = 5; Zтп – sum of the temperatures of the warm period

Zвп – sum of the temperatures of the growing season ; T_I – January temperature

Годы	Барнаул	Курган	Омск	Минусинск
1890	-0,5D 71(58) -15		-0,7C76(60)-20	
1893	1,4C 87(64) -28		0,8C84(62) -31	
1894	1,8D80(65)-21	0,8D77(65)-19	0,4D76(63)-19	
1899	2,9C83(65)-16	3,1C81(68)-16	2,4C81(64)-17	
1908	1,3C83(70)-18	-0,4D73(62)-20	-1,2E71(61)-21	
1920	2,1C85(70)-17	1,3D88(72)-20	1.2D82(69)-20	1,2C86(69)-25
1921	1,4C83(68)-15	1,2C90(75)-20	1,0C86(70)-22	1,1C83(66)-20
1933	0,8C80(66)-25	0,4C82(64)-23	0,3C78(63)-23	1,3D76(64)-28
1934	0,9D76(68)-15	1,8D76(64)-15	-0,1D70(60)-17	1,1E67(60)-20
1936	0,7D77(60)-17	2,5C86(67)-14	0,7D76(60)-20	1,6D72(58)-26
1941	1,4C79(65)-20	-0,3D73(60)-20	-0,9D71(59)-21	0C76(63)-23
1950	0,1D85(70)-18	0,1C81(60)-24	-0.3C80(63)-23	-1,1D80(68)-23
1958	2,1C76(63)-17	2,6C82(69)-16	1,1D74(64)-19	0,6C85(62)-21
1960	-0,1C73(60)-17	0,2C75(57)-18	-1D71(57)-20	0,2D76(61)-20

1967	**1,1C87(66)-18**	**1,8C90(67)-25**	**1C87(66)-25**	**-0,9C73(62)-29**
1969	**1,0C80(65)-29**	**1,3D72(58)-29**	**-2D72(60)-30**	**0,7C82 (66)-29**
1972	**1,1C76(60)-22**	**0,8C78(61)-28**	**-0,4C70(56)-26**	**0,6C78(60)-28**
1975	**1,8C79(63)-21**	**2,9C90(68)-18**	**2,0C81(64)-17**	**0,2D77(64)-27**
1983	**3,9C81(65)-10**	**4,0C82(68)-10**	**3,6C83(66)-11**	**0,4D76(63)-21**
1987	**1,4C80(67)-14**	**1,0C85(73)-18**	**0,7D82(71)-17**	**0,7C79(64)-16**
1988	**2,5C85(64)-19**	**2,8C92(70)-17**	**2,4C82(67)-20**	**1,7C81(61)-20**
1989	**3,2C84(67)-13**	**3,1C89(73)-17**	**2,4C83(69)-16**	**2,3C82(65)-15**
1996	**1,1C80(67)-22**		**0,3D74(65)-21**	**0,3C76(65)-22**
2006	**2,0C84(67)-24**		**1,3C83(67) -27**	**0,2D76(63) -21**
2007	**3,6C93(68)-10**		**3,8C90(65) -15**	**4,1C90(68)-12**

The influence of cryogenic conditions



The variation of the estimated characteristics of the temperature of the warm period in Barnaul and Irkutsk.

The rhythm of change in temperature C D D C D E D D C up to 1988

The rhythm C C C D C C C D C since 1988 г.

Reduce heat: soil warming, meltin of frozen soil, warming meltin layer.

Increase the heat balance of underlying surface and the growth of climatic resources .

Summary

- Warming in the winter seasons are linked with an increase in the intensity of zonal circulation in the northern latitudes, the growth of high cyclonic activity, and with a shift to the north of the motion trajectories of cyclones
- Revealed the special status of the regional climate of Eastern Europe with a few extremes of valuation characteristics.
- In the regions of Western Europe, new centennial maxima assessment characteristics after 1988 Тг, Zтп, Zвп и Тз appeared after 1988.
- Established the following trends of regional climate change in Western Siberia:
  - Variability of conditions has increased;
  - Continentality (К) has decreased at preservation of sharply continental conditions (РК) with frosty winter and drough (З) in summer;
  - The tendency of growth of number of warm conditions of the cold period of year with plentiful deposits (cyclogenesis, advection of heat);
  - The number of damp (Г) annual conditions with intense water cycle has increased.

The warming of cold regions in Siberia hamper factors is: Sea ice cover of the Siberian Arctic, permafrost, topographic relief (plateau, Altai, Sayan), peculiarities of atmospheric circulation: Siberian anticyclone, baric ridges of high pressure (Arctic - Eastern Siberia), Depression in the warm season (Western Siberia), advection of cold air masses from the Arctic, Polar Urals, north-eastern region of Siberia.