Evaluation of dynamics of agroclimatic conditions by the methods of trend and factor analysis

Оценка изменений агроклиматических условий методами трендового и факторного анализа

Суховеева О.Э.
Лаборатория антропогенных изменений климатической системы
Институт географии РАН

Topicality

- Climate is the global scale factor that formed ecosystems and laid the foundation of production activities.
- The most noteworthy climate changes in all regions of the zone were registered in the last years that may be proved by comparing figures obtained with climatic norm records.
- One of the results of present climate warming is the change of agroclimatic conditions.
- The accurate calculations of these changes will let to neutralize their negative consequences for agriculture and crop production.
- Different methods of agroclimatic conditions evaluations are used.

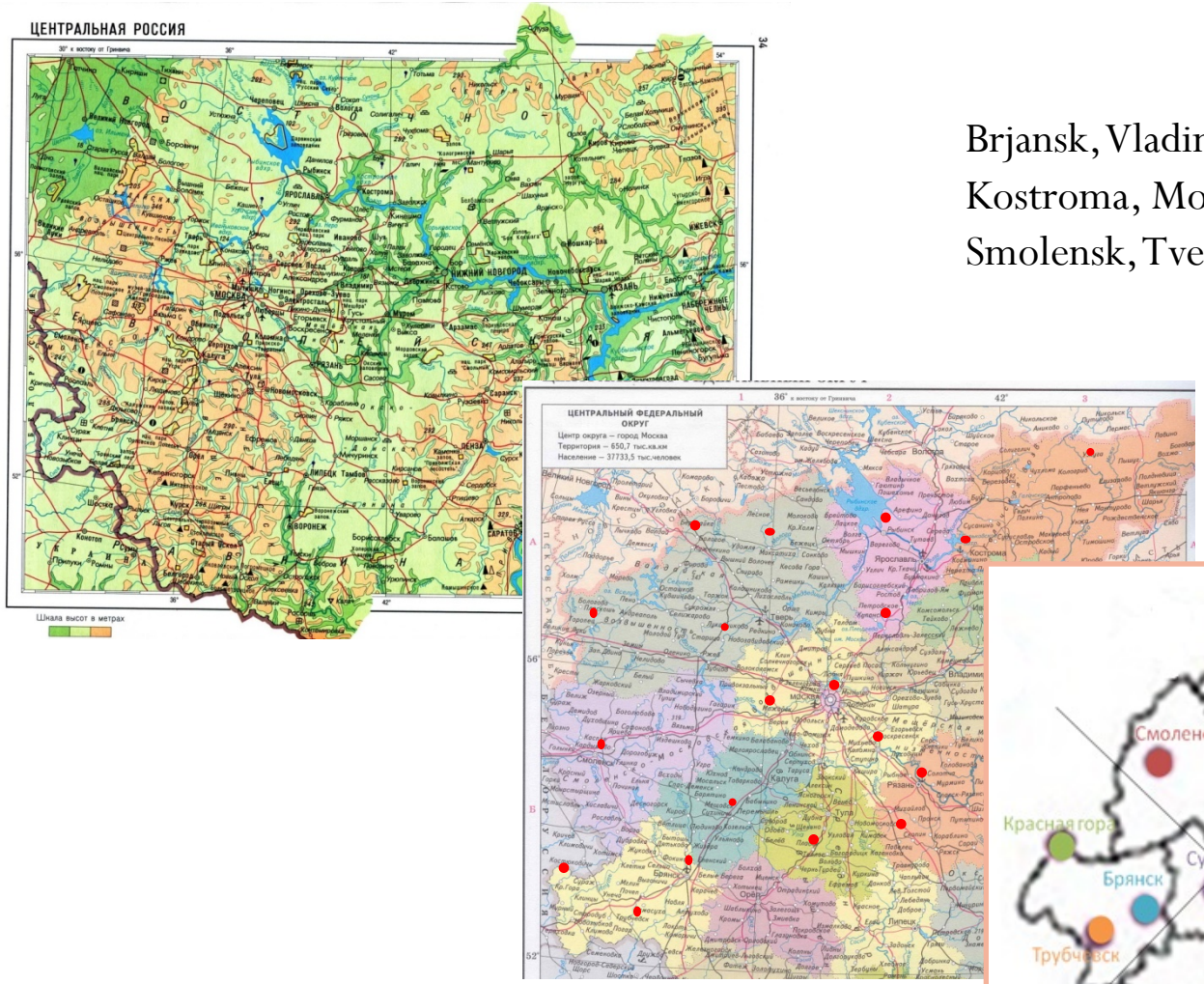
Purpose

- The aim of the present research is to determine regularities of change of agroclimatic conditions during the century period taking into account the last 30 years, and to classify the climatic parameters.

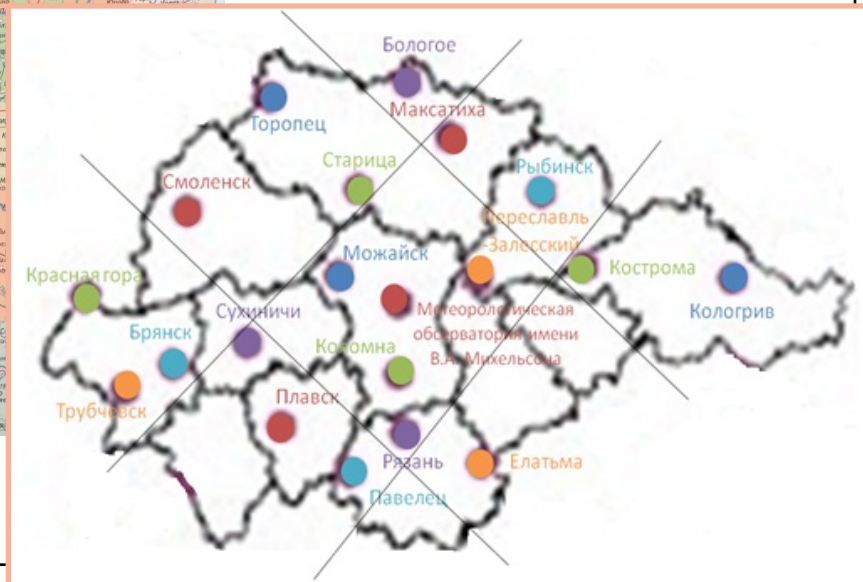
Materials and methods

- Materials of the investigation were longstanding data of 20 meteorological observatories of Central Non-Black Soil Zone over the period from 1881 to 2012.
- All-Russia Research Institute of Hydrometeorological Information – World Data Centre data
- Heat and moisture supply were estimated. Regularities and oscillations of air temperature, amount of precipitations, active temperature sum and hydrothermal coefficients changes were determined.
- Intervals for comparison of climatic parameters:
  - From beginning observation until 1980 (climatic norm, before start of climate warming)
  - The last 30 years (1981-2012), period of current climatic changes
- Factor analysis:
  - Three the longest data rows – Moscow, Ryazan, Kostroma
  - Program Statistica
  - Method "varimax raw"
  - Scree and Kaiser criterions

Central Non-Black soil area



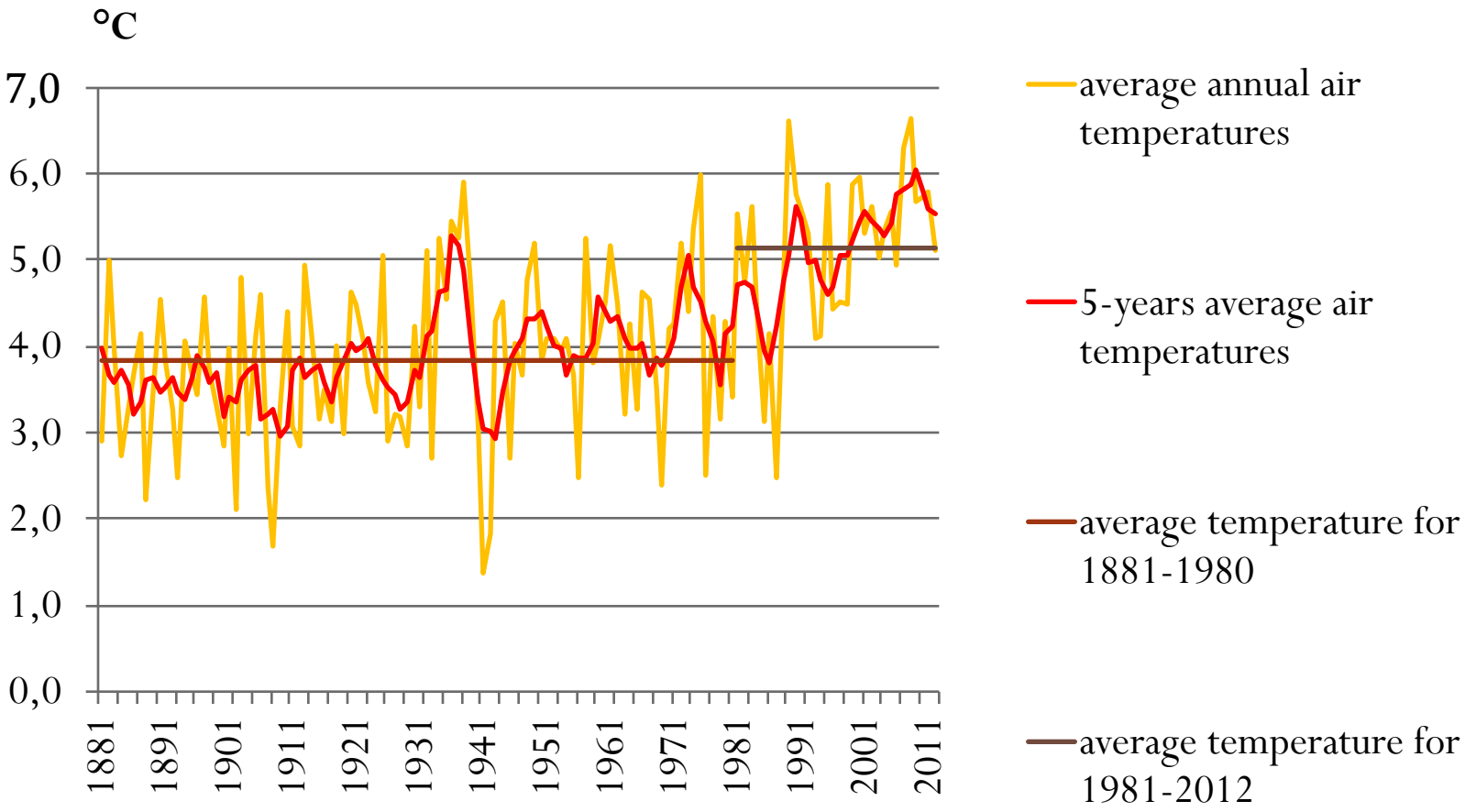
Brjansk, Vladimir, Ivanovo, Kaluga, Kostroma, Moscow, Orel, Rjazan, Smolensk, Tver, Tula, Jaroslavl regions



Trend analysis

- During the last 30 years in the Central Nonblack Soil Zone there happened increase of average annual and average monthly air temperatures, continuation of warm and vegetation period.
- The strong and intensive upward heat supply trend, especially for the last three decades, has been marked.
- Moistening becomes unstable but in vegetation period average moisture content increases.

Air temperature dynamics over the period 1881-2012

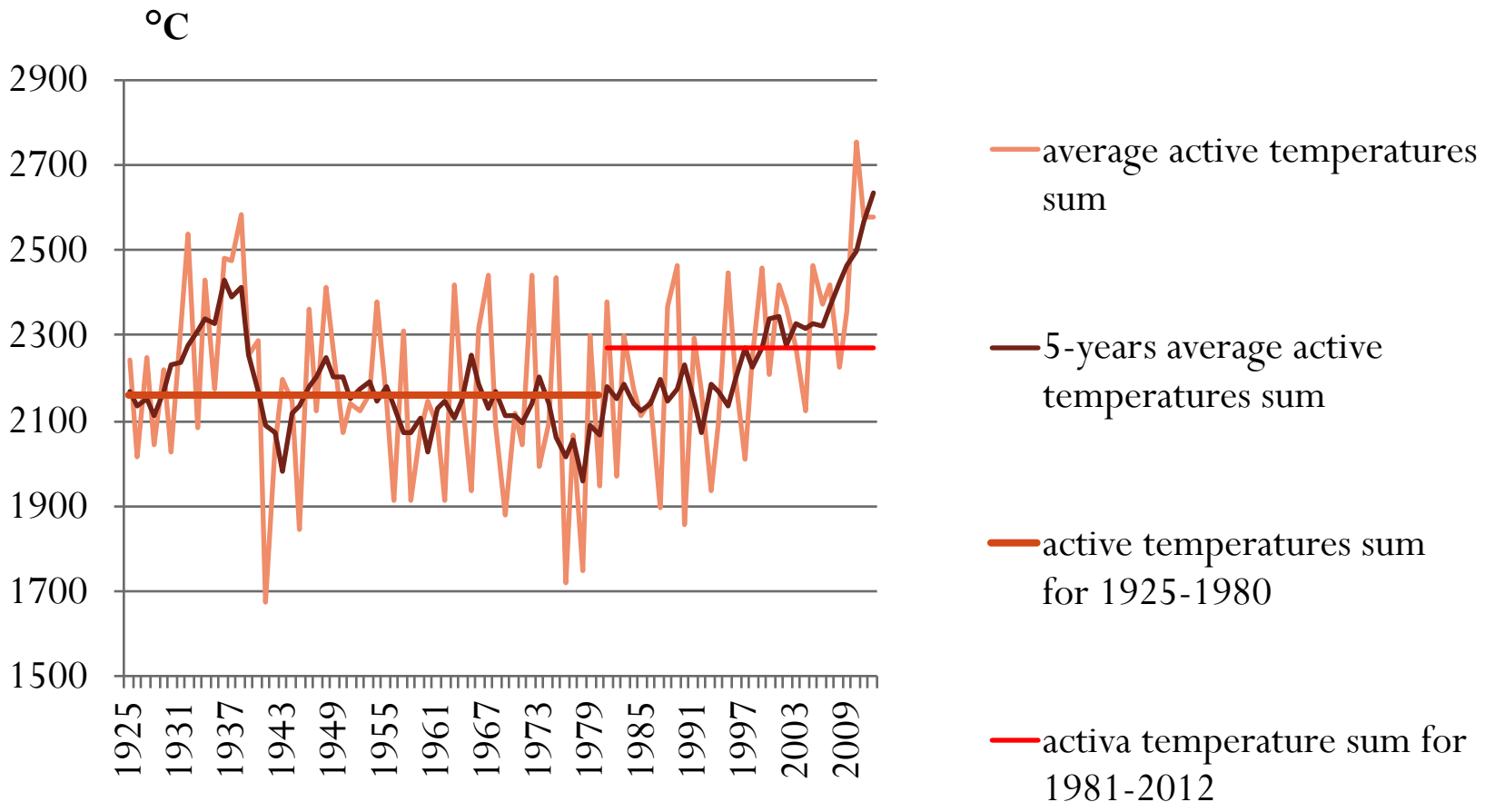


Air temperatures dynamics over the period 1981-2012, °C/10 years

I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Year
0,85	0,48	0,60	0,47	0,27	0,13	0,21	0,06	0,06	0,28	-0,03	0,29	0,30

Parameters	°C / 10 years
Average annual, Russia, official documents	0,43
Average annual	0,30
January, average	0,85
January, maximal (Bryansk, Tver, Yaroslavl, Moscow, Ryazan regions)	> 0,90
February, average	0,48
March, average	0,60
March, maximal (Smolensk, Bryansk, Kostroma, Moscow, Ryazan regions)	> 0,64
April, average	0,47
June, August, September, November	< 0,13

Growing degree days dynamics over the period 1925-2012



Calculation of growing degree days

Stations	All period	Before 1980 г.	1981-2012 гг.	°C/10 years
Бологое	1998,1 ± 221,3	–	2050,3 ± 199,0	
Торопец	2086,8 ± 221,0	–	2139,6 ± 202,7	
Старица	2049,3 ± 209,2	–	2092,4 ± 209,2	
Смоленск	2112,7 ± 223,9	2015,3 ± 204,9	2222,3 ± 193,7	64,7
Брянск	2381,3 ± 251,8	2296,6 ± 232,8	2487,1 ± 237,2	59,5
Красная гора	2453,3 ± 221,9	2374,8 ± 197,7	2557,1 ± 211,9	57,0
Трубчевск	2462,1 ± 238,0	–	2513,1 ± 222,4	
Кологрив	1799,4 ± 192,5	–	1840,0 ± 195,9	
Максатиха	1990,9 ± 221,6	–	2053,9 ± 205,7	
Рыбинск	2065,5 ± 207,4	1978,1 ± 185,4	2150,1 ± 194,3	53,8
Кострома	2046,2 ± 211,3	1987,9 ± 189,7	2148,3 ± 211,0	50,1
Переславль-Залесский	2105,5 ± 226,8	–	2172,3 ± 213,2	
Можайск	2121,6 ± 234,9	2047,6 ± 211,9	2225,5 ± 229,0	55,6
Коломна	2330,3 ± 251,7	–	2432,3 ± 231,9	
Елатьма	2320,6 ± 220,9	2294,9 ± 213,1	2394,5 ± 229,8	31,1
Сухиничи	2257,5 ± 248,5	–	2311,4 ± 220,5	
Рязань	2375,4 ± 236,8	2334,4 ± 226,5	2447,3 ± 240,8	35,3
Плавск	2402,0 ± 271,6	–	2455,8 ± 267,9	
Павелец	2339,4 ± 250,2	2284,4 ± 242,1	2416,9 ± 244,3	41,4
Average	2194,6 ± 229,6	2179,3 ± 211,6	2280,9 ± 219,0	49,8

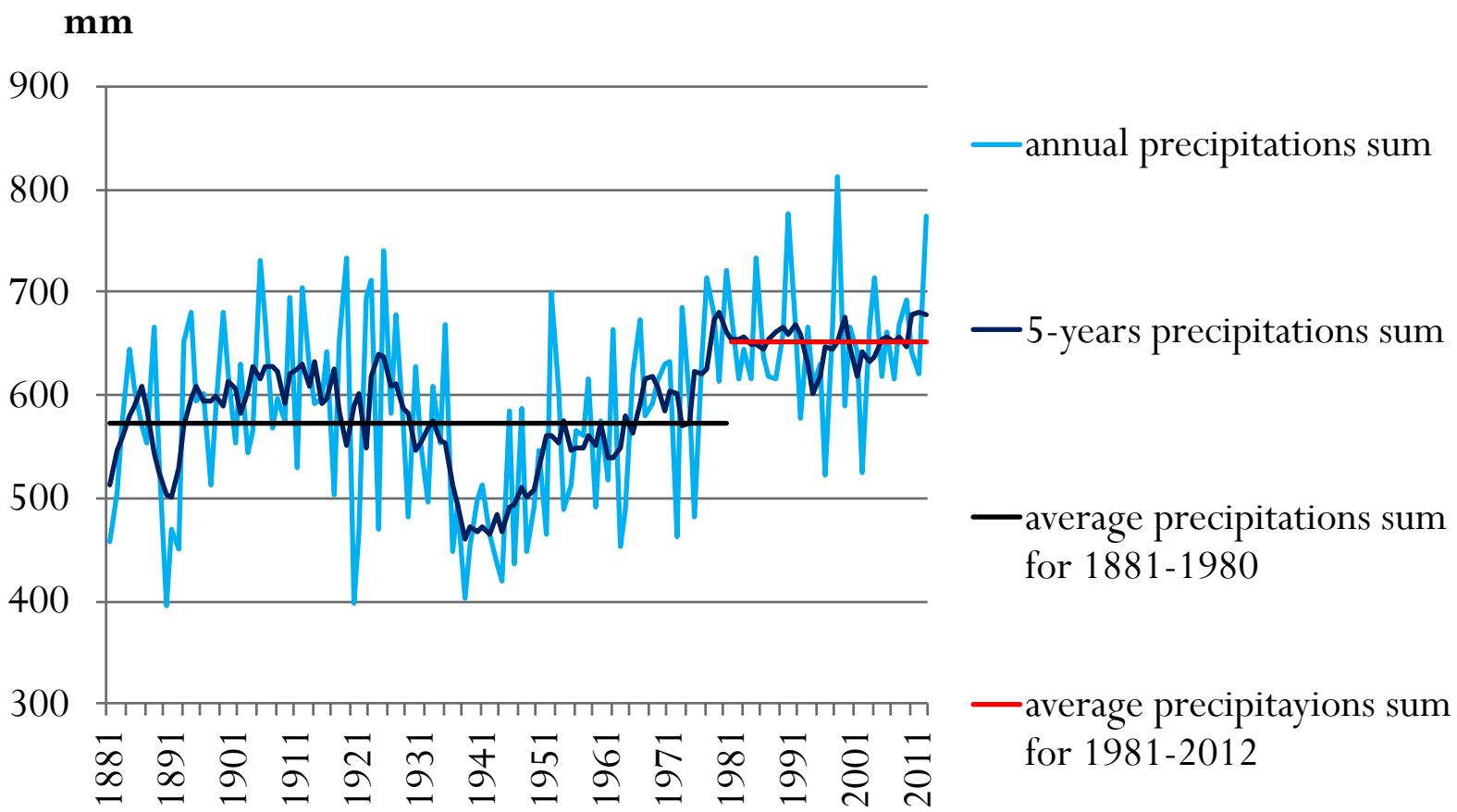
Characteristics of growing degree days over the period 1981-2012

Periods	Active temperature sum, °C
Before 1980	2179 ± 212
1981-2012	2281 ± 219

Sum of active temperatures dynamics	°C/10 years
Средняя	49,8
Смоленск	64,7
Брянск	59,5
Красная гора	57,0
Можайск	55,6
Второй оценочный доклад	96

Maximal heat supply	
Красная гора	2557 °C
Трубчевск	2513 °C
Брянск	2487 °C
Minimal hear supply	
Максатиха	2054 °C
Бологое	2050 °C
Кологрив	1840 °C

Precipitation dynamics over the period 1881-2012

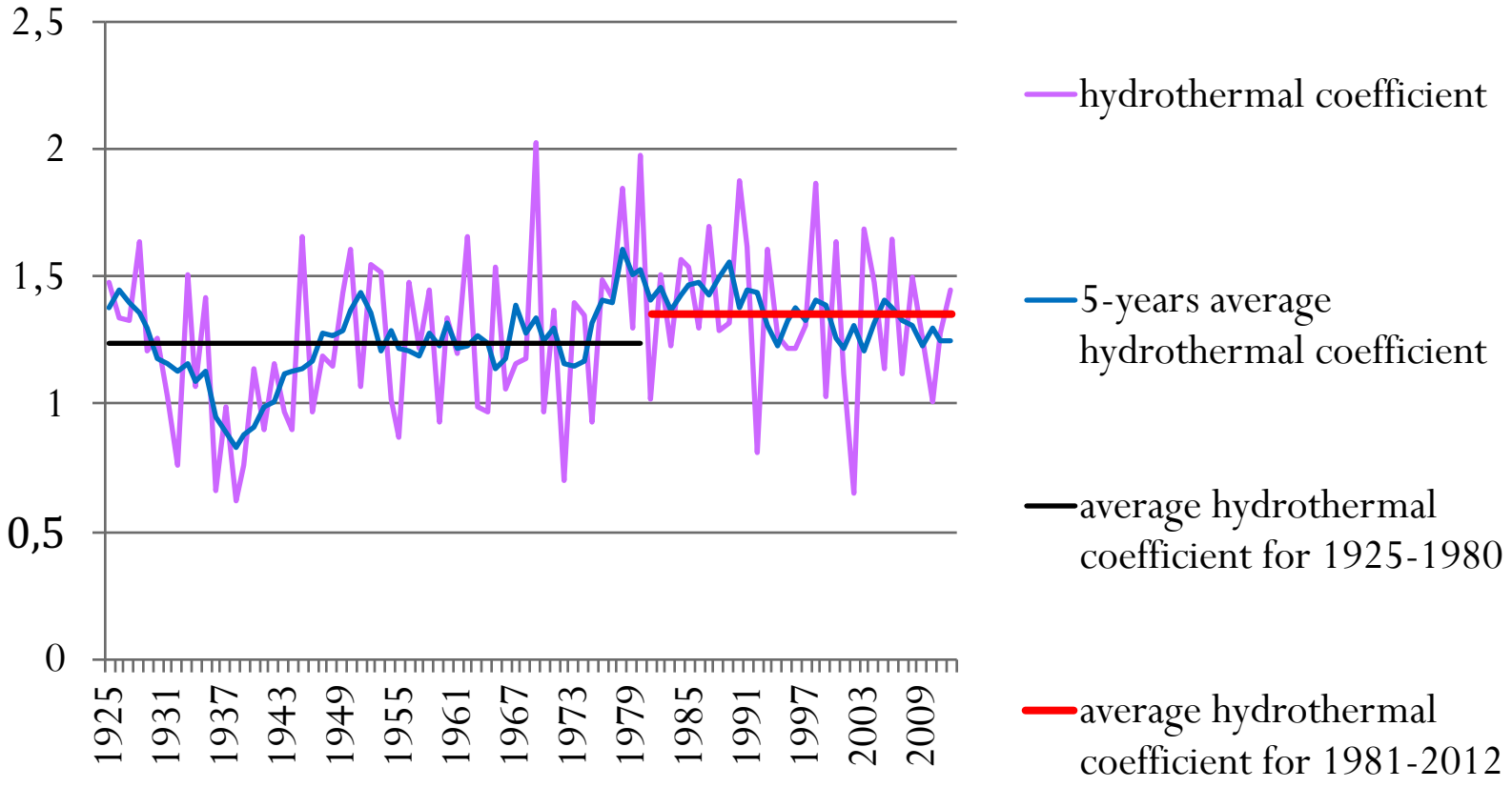


Precipitations dynamics over the period 1981-2012, mm/10 years

I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Year
4,26	3,27	1,77	0,95	-0,48	4,29	0,20	1,26	2,84	3,82	2,53	3,20	26,95

Characteristics	mm/ 10 years
Average annual, Russia, official documents	9,6
Average annual	27,0
Average annual, maximal, Western regions	> 30,0
Average monthly, Russia, official documents	0,8
Winter and summer months in Western regions, autumn months in Southern regions	> 5,0

Hydrothermal coefficient dynamics over the period 1925-2012



Hydrothermal coefficients calculation

Stations	All period	Before 1980 г.	1981-2012	/ 10 years
Бологое	1,45 ± 0,41	–	1,48 ± 0,42	
Торопец	1,57 ± 0,48	–	1,62 ± 0,51	
Старица	1,53 ± 0,50	–	1,58 ± 0,45	
Смоленск	1,51 ± 0,44	1,45 ± 0,41	1,56 ± 0,48	0,03
Брянск	1,32 ± 0,36	1,29 ± 0,40	1,37 ± 0,31	0,03
Красная гора	1,28 ± 0,38	1,19 ± 0,39	1,40 ± 0,34	0,07
Трубчевск	1,26 ± 0,37	–	1,27 ± 0,36	
Кологрив	1,32 ± 0,48	–	1,27 ± 0,38	
Максатиха	1,40 ± 0,42	–	1,41 ± 0,45	
Рыбинск	1,37 ± 0,41	1,37 ± 0,41	1,37 ± 0,42	0,00
Кострома	1,25 ± 0,40	1,22 ± 0,40	1,29 ± 0,41	0,02
Переславль-Залесский	1,29 ± 0,42	–	1,29 ± 0,44	
Можайск	1,39 ± 0,43	1,33 ± 0,42	1,48 ± 0,45	0,05
Коломна	1,17 ± 0,31	–	1,16 ± 0,26	
Елатьма	1,22 ± 1,10	1,23 ± 1,25	1,20 ± 0,45	-0,01
Сухиничи	1,32 ± 0,39	–	1,37 ± 0,33	
Рязань	1,09 ± 0,37	1,09 ± 0,39	1,10 ± 0,34	0,00
Плавск	1,26 ± 0,41	–	1,34 ± 0,39	
Павелец	1,08 ± 0,36	1,08 ± 0,40	1,07 ± 0,32	0,00
Average	1,32 ± 0,44	1,25 ± 0,50	1,34 ± 0,40	

Characteristics of moisture supply over the period 1981-2012

Periods	Hydrothermal coefficient
Before 1980	1,25 ± 0,50
1981-2012	1,34 ± 0,40

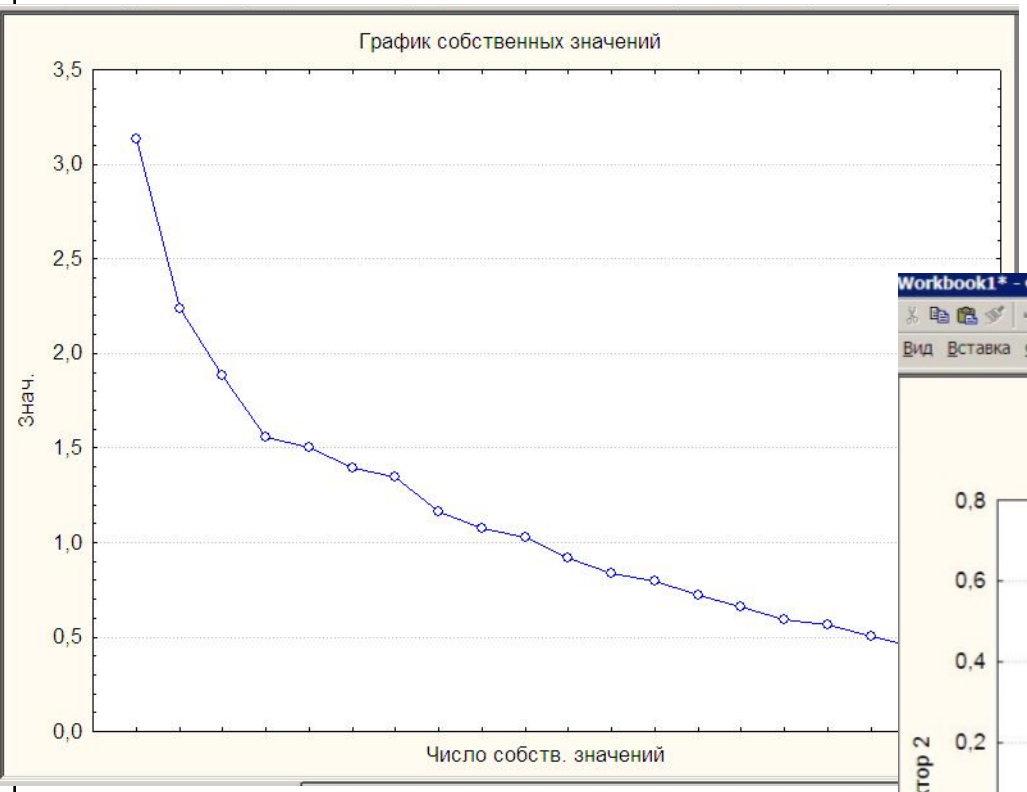
Hydrothermal coefficients dynamics	/10 years
Средняя	0,02
Можайск	0,05
Красная гора	0,07

Maximal moisture supply	
Торопец	1,62
Старица	1,58
Смоленск	1,56
Minimal moisture supply	
Коломна	1,16
Рязань	1,10
Павелец	1,07

Factor analysis

- Climatic conditions were classified into three factors according to the method of factor analysis:
  - the first – winter temperatures till the beginning of active vegetation period,
  - the second – autumn temperatures till the formation of stable snow cower,
  - the third (only in southern territories) – precipitations and temperature of the central summer months.

Factors of climatic conditions (graphical results)



Results of factor analysis (factor loadings)

Regions		Moscow			Ryazan			Kostroma	
Factors		1	2	3	1	2	3	1	2
Air temperature, °C	I	0,599	0,005	-0,138	-0,081	0,630	0,075	0,491	0,048
	II	0,640	-0,048	0,144	-0,095	0,596	-0,050	0,583	0,020
	III	0,667	0,206	0,173	0,134	0,700	-0,067	0,705	-0,026
	IV	0,682	-0,002	0,082	0,086	0,596	0,005	0,561	0,006
	V	0,178	0,320	0,218	0,399	0,167	0,236	0,250	0,273
	VI	0,076	0,036	0,642	0,433	0,099	-0,359	0,370	-0,260
	VII	0,220	0,088	0,635	0,643	0,243	0,009	0,222	0,545
	VIII	0,077	0,539	0,125	0,737	-0,097	0,139	-0,073	0,611
	IX	0,267	0,592	-0,078	0,193	-0,082	0,611	0,002	0,505
	X	0,292	0,383	-0,091	-0,015	0,013	0,476	0,221	0,092
	XI	-0,169	0,580	0,227	0,066	0,025	0,696	-0,046	0,509
	XII	0,551	-0,104	-0,105	0,022	0,067	0,107	0,093	-0,226
Precipitations, mm	I	0,380	0,075	-0,297	0,101	0,479	-0,064	0,549	0,033
	II	0,566	-0,162	0,164	0,099	0,437	-0,022	0,652	0,051
	III	0,135	-0,323	0,283	-0,144	0,459	0,200	0,479	0,160
	IV	-0,089	0,440	-0,107	0,008	-0,075	0,394	0,192	0,353
	V	-0,160	0,039	-0,103	-0,509	-0,073	-0,082	-0,087	-0,158
	VI	0,009	0,096	-0,663	-0,430	0,041	0,343	-0,133	0,167
	VII	0,024	-0,084	-0,406	-0,590	-0,062	0,065	0,098	-0,421
	VIII	0,191	-0,577	0,179	-0,584	0,163	-0,108	0,051	-0,455
	IX	-0,257	-0,011	0,010	-0,045	0,210	-0,205	-0,048	-0,169
	X	-0,065	0,253	0,279	0,104	0,231	0,085	0,238	0,304
	XI	0,071	0,432	0,182	0,017	0,220	0,413	0,178	0,362
	XII	0,367	-0,112	-0,037	-0,117	0,261	0,054	0,477	-0,100
Eigenvalues		3,023	2,236	1,999	2,588	2,561	1,875	3,055	2,243
Share of dispersion		0,126	0,093	0,083	0,108	0,107	0,078	0,127	0,093

Conclusions

- Transformation of vegetation period conditions has made recent climate changes more noticeable,
- The strong and intensive upward average annual temperature and heat supply trend, especially for the last three decades, had been marked,
- The duration of warm and vegetation periods increases. Moistening becomes unstable.
- There are sharp deflections from average indexes in the some years, especially in the last decades,
- Agroclimatic conditions have been classified into three factors according by the method of factor analysis – winter, autumn, and summer.