Agro-Climatic Monitoring and Forecast of Agricultural Productivity Changes in Russia in the XXI century

A. D. Kleshchenko, V. N. Pavlova

Fifth Session of North Eurasian Climate Outlook Forum (NEACOF-5) , Moscow

29.10-01.11.2013

National Research Institute on Agricultural Meteorology (NRIAM) –

is one of the leading Institutes of the Federal Service for Hydrometeorology and Environmental Monitoring of Russia (Roshydromet)

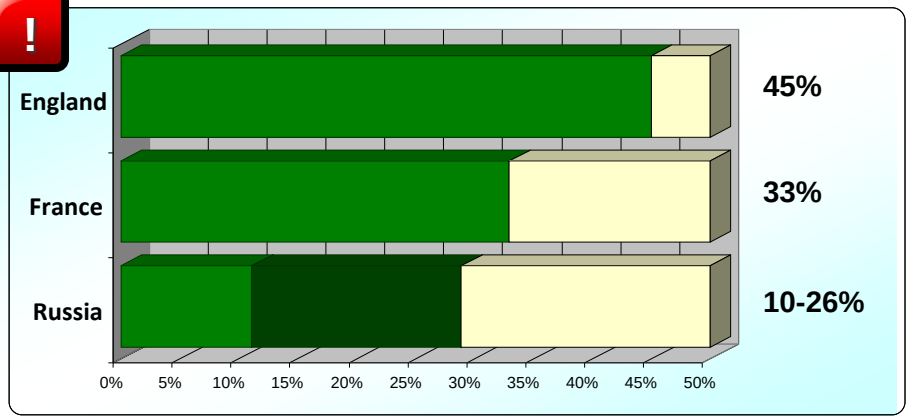
- **The Institute was established in 1977 (as a separate entity)**
- **At the present time there are 70 employees, including 6 professors and 18 candidates of science**
- **The main objective of the Institute is to study weather and climate influence on the growth, development and productivity of crops**

Agricultural Production – Weather-Related Risks and Threats

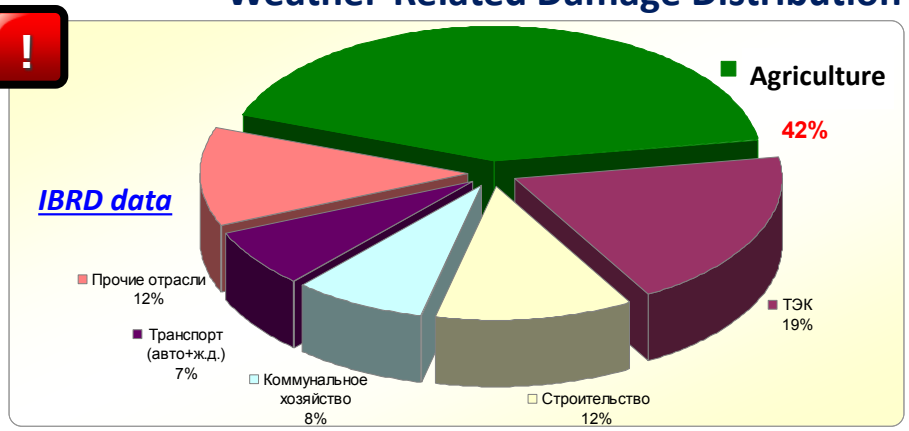
Всероссийский НИИ сельскохозяйственной метеорологии

Russia	2008	2010	Weather-related yield loss
Gross harvest of cereals and grain legumes, millions of tonn	108.2	61.0	47,2 mln.t 43,6%

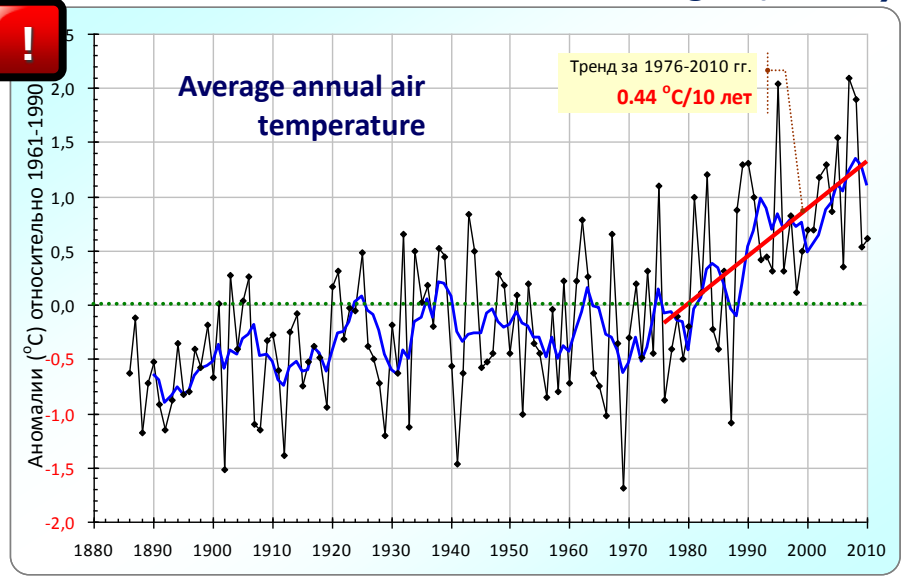
The Use of Climate Resources



Weather-Related Damage Distribution



Climate Changes (Russia)



Examples of Information Products: Agro-Climatic Effects of Climate Change

Всероссийский НИИ сельскохозяйственной метеорологии

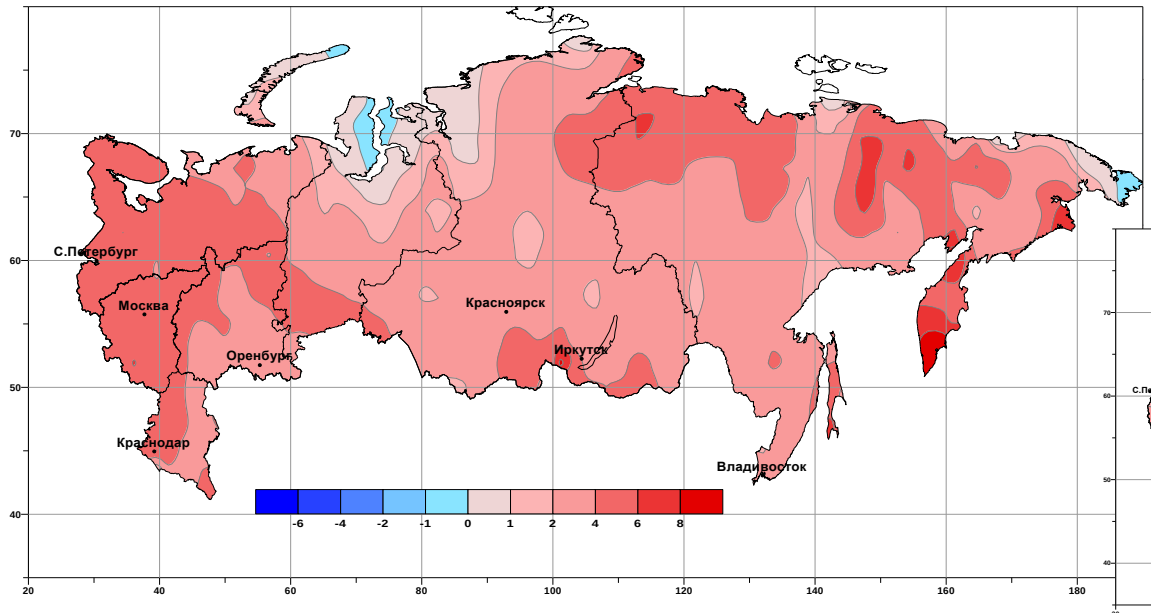
Numerical Simulation System is developed to research climate and agricultural changes.

The System allows:

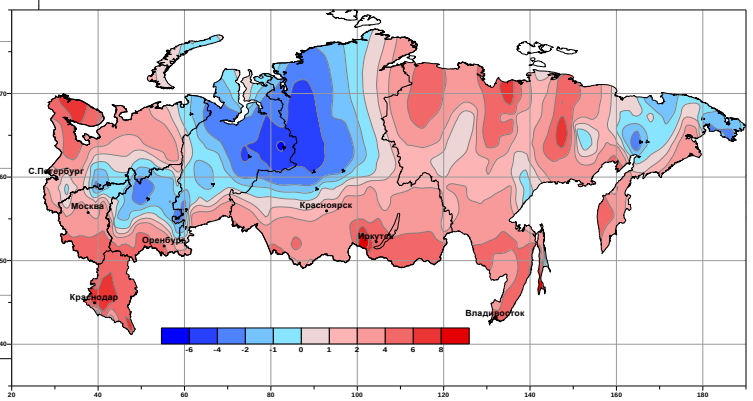
- ***To assess the conditions of major crops yield formation***
- ***To estimate climate risks for agriculture***
- ***To develop dynamic optimization schemes of the use of weather and climate resources of the area***
- ***To estimate the trends of agro-climatic resources***

The trend of the number of days with air temperature above 10°C (days/10 years)

1976-2012

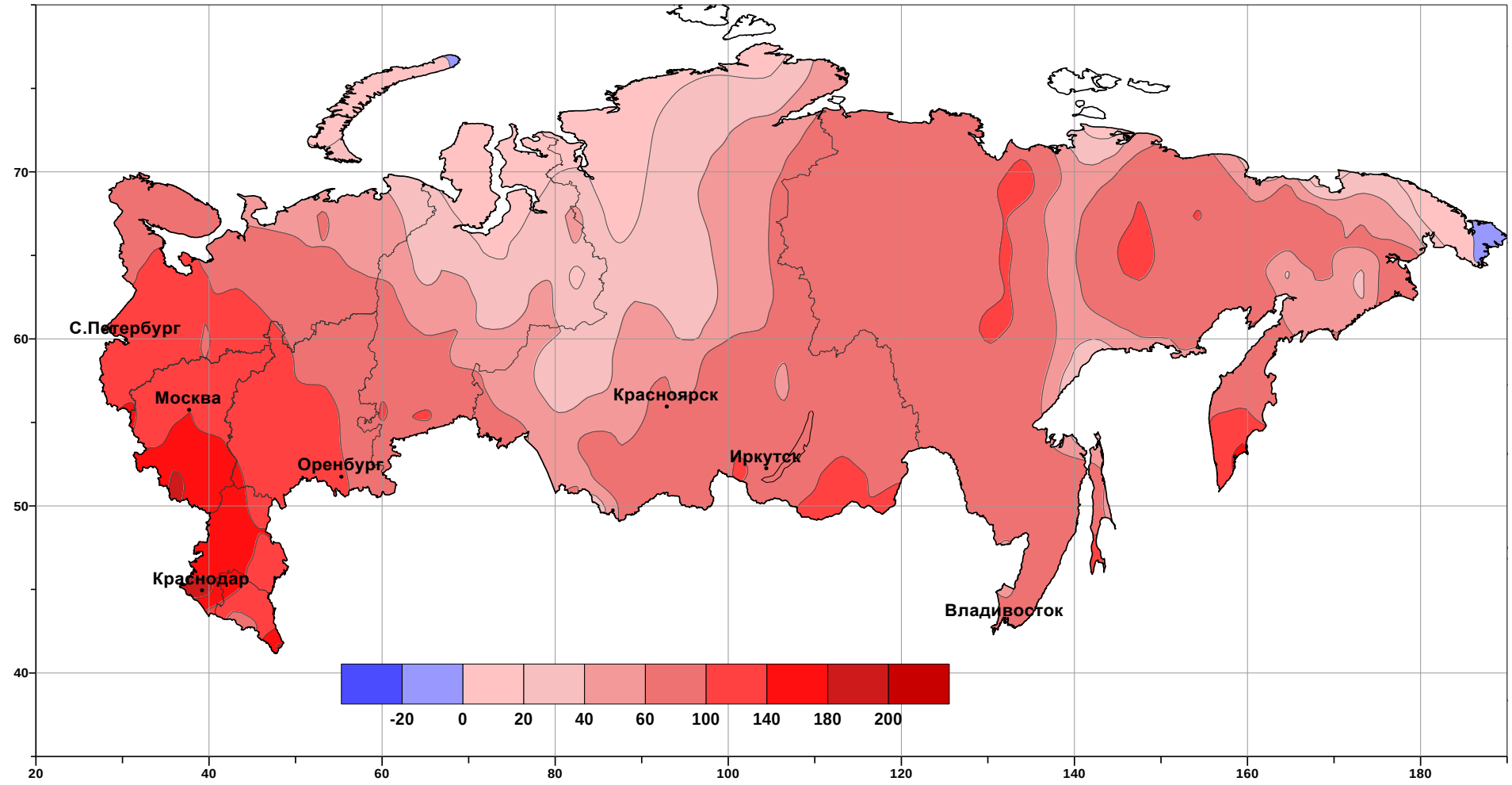


1976-2000



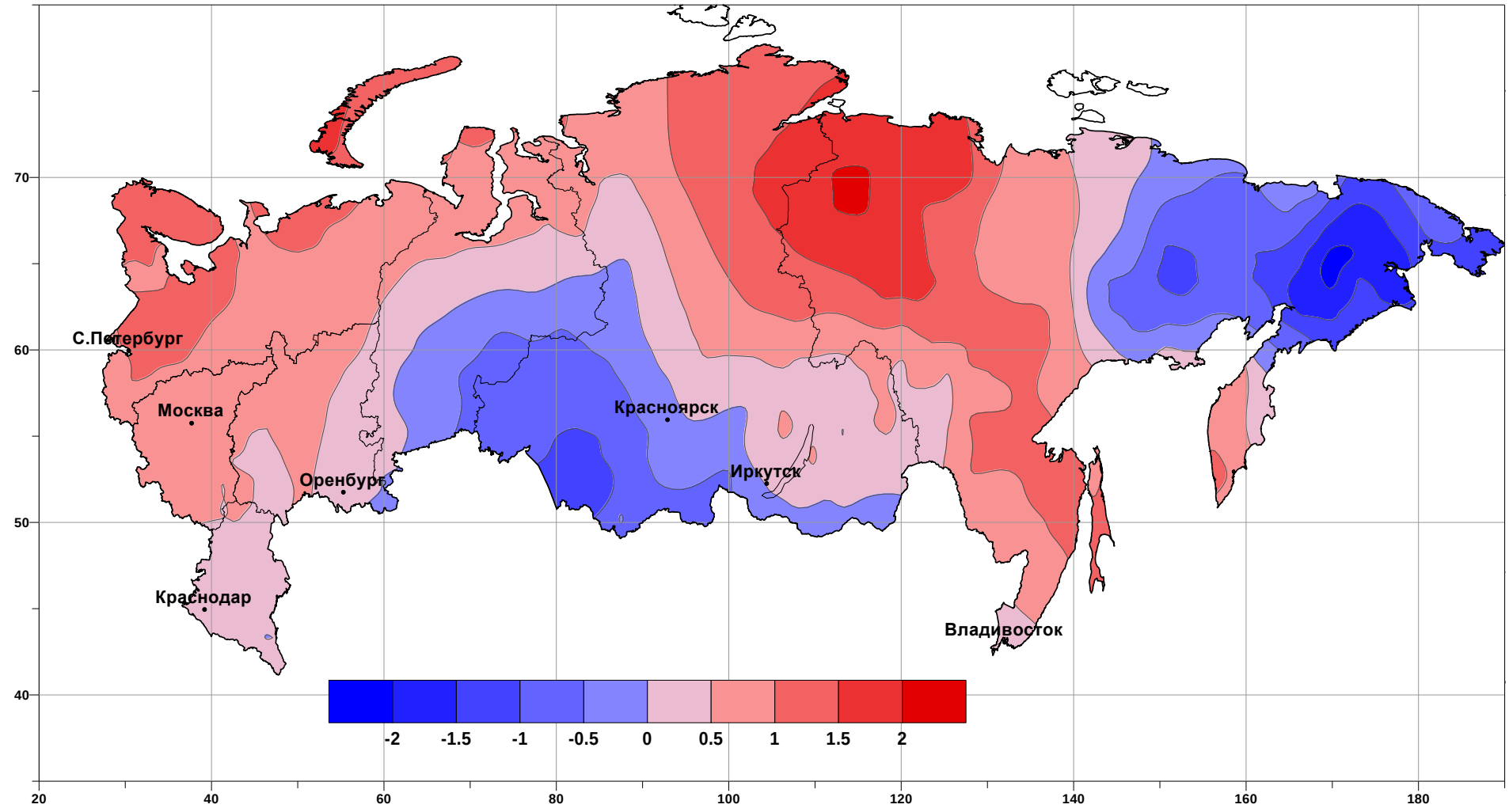
The Average Rate of Change in Active Temperature Sums (˚C/10 years) for the period from 1976 to 2012

Всероссийский НИИ сельскохозяйственной метеорологии



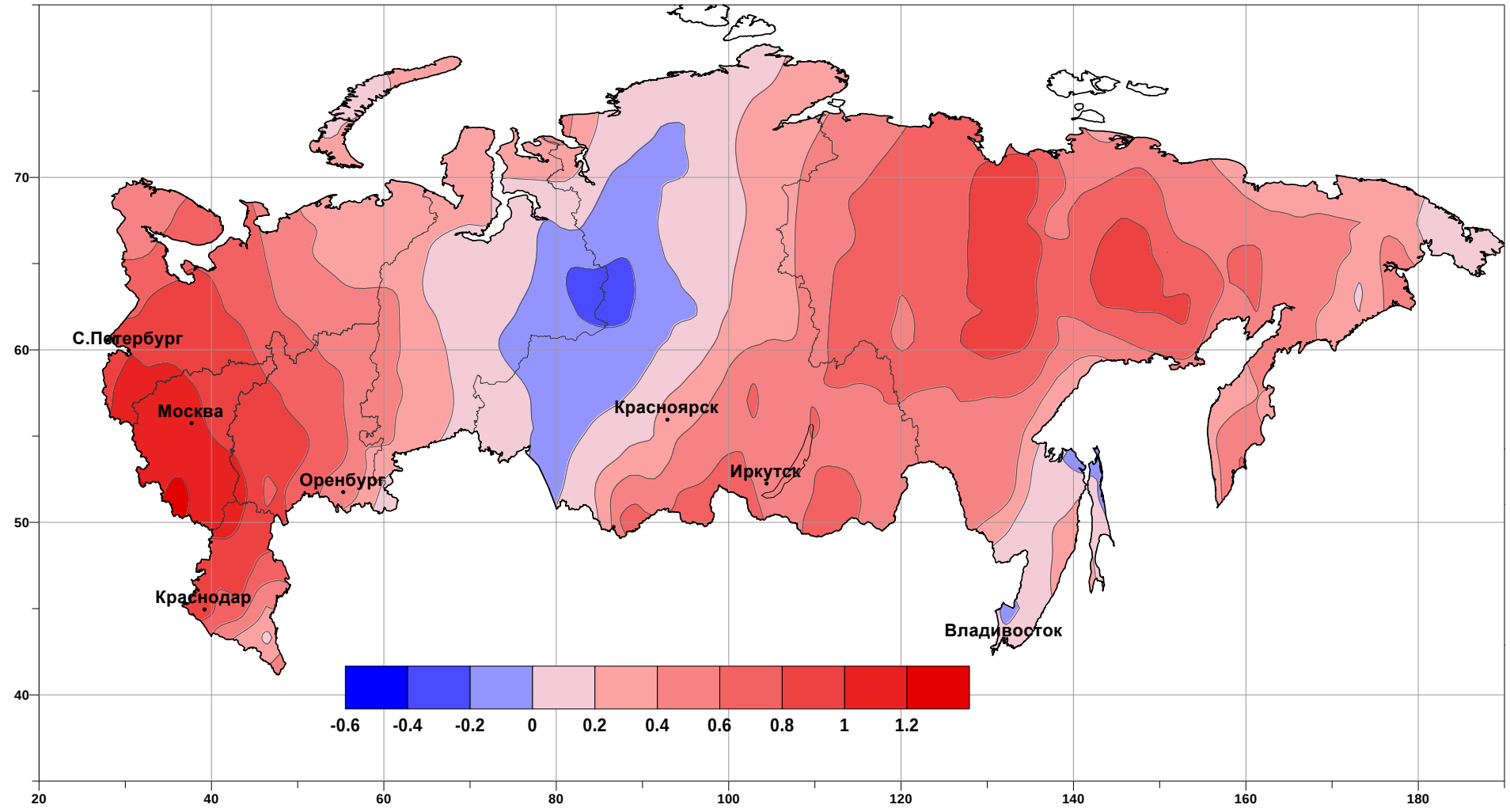
The Average Rate of January Temperature Change (˚C/10 years) for the period from 1976 to 2012

Всероссийский НИИ сельскохозяйственной метеорологии
ВНИИСХМ



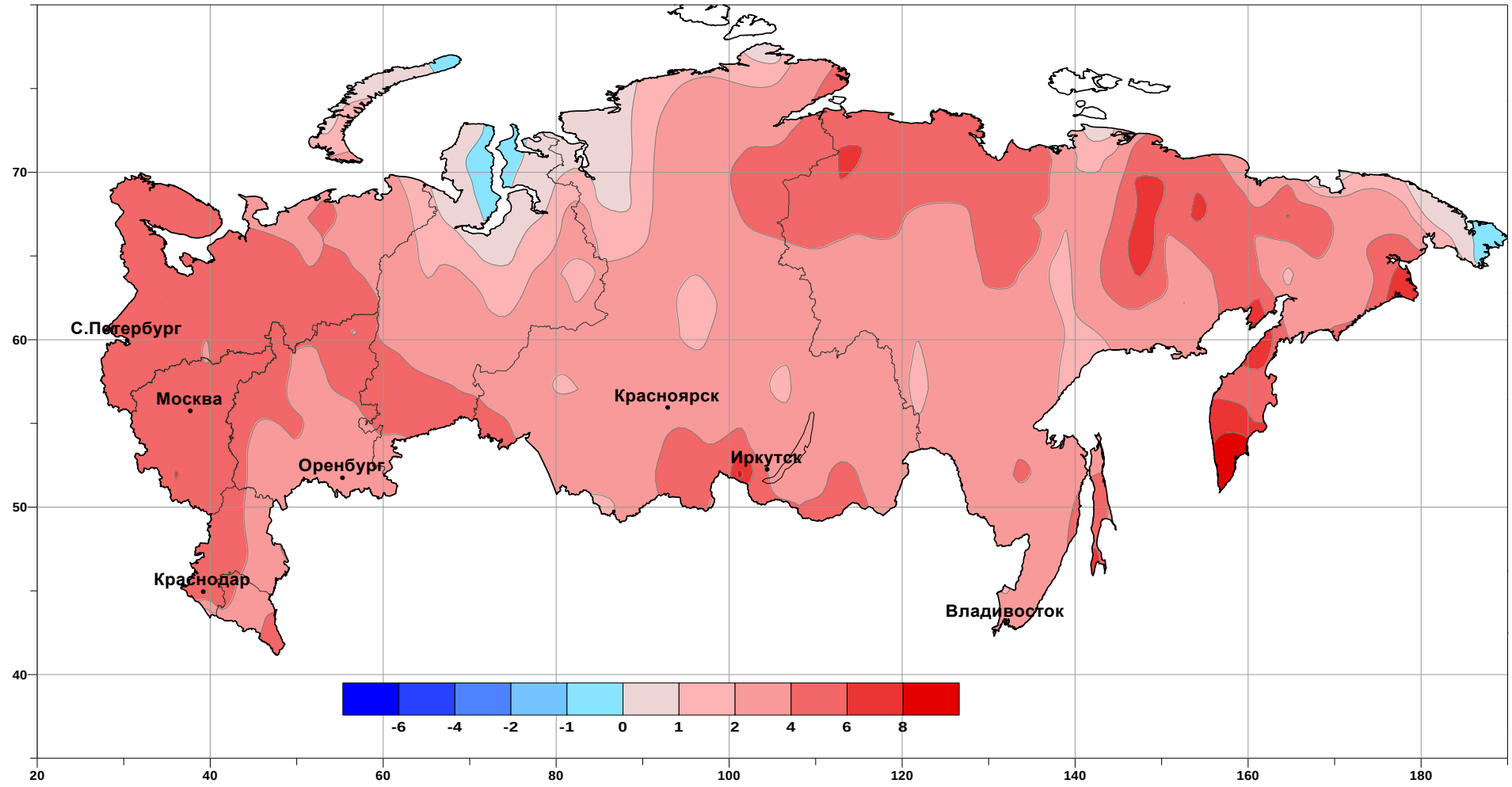
The Average Rate of July Temperature Change (˚C/10 years) for the period from 1976 to 2012

Всероссийский НИИ сельскохозяйственной метеорологии
ВНИИСХМ



The Average Rate of Change in the Number of Days with Air Temperature Above 10˚C for the period from 1976 to 2012

Всероссийский НИИ сельскохозяйственной метеорологии



Indices

Dryness Index

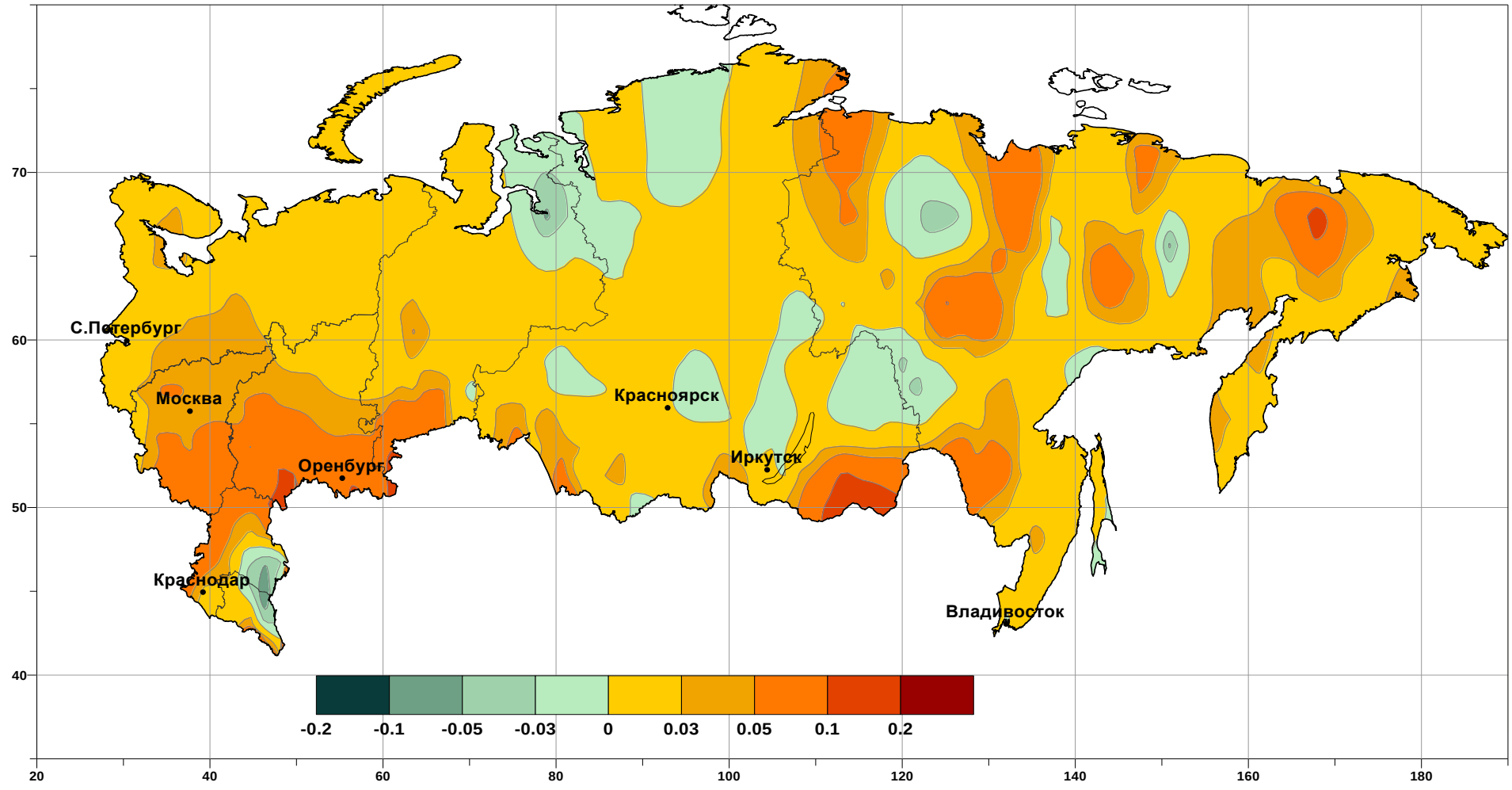
$$ИС = \frac{0{,}18\Sigma t_{>10^0}}{r_{I-XII}}$$

Moisture Index

$$КУ = \frac{0{,}5r_{X-III} + r_{IV-VIII}}{0{,}18\Sigma t_{IV-VIII}}$$

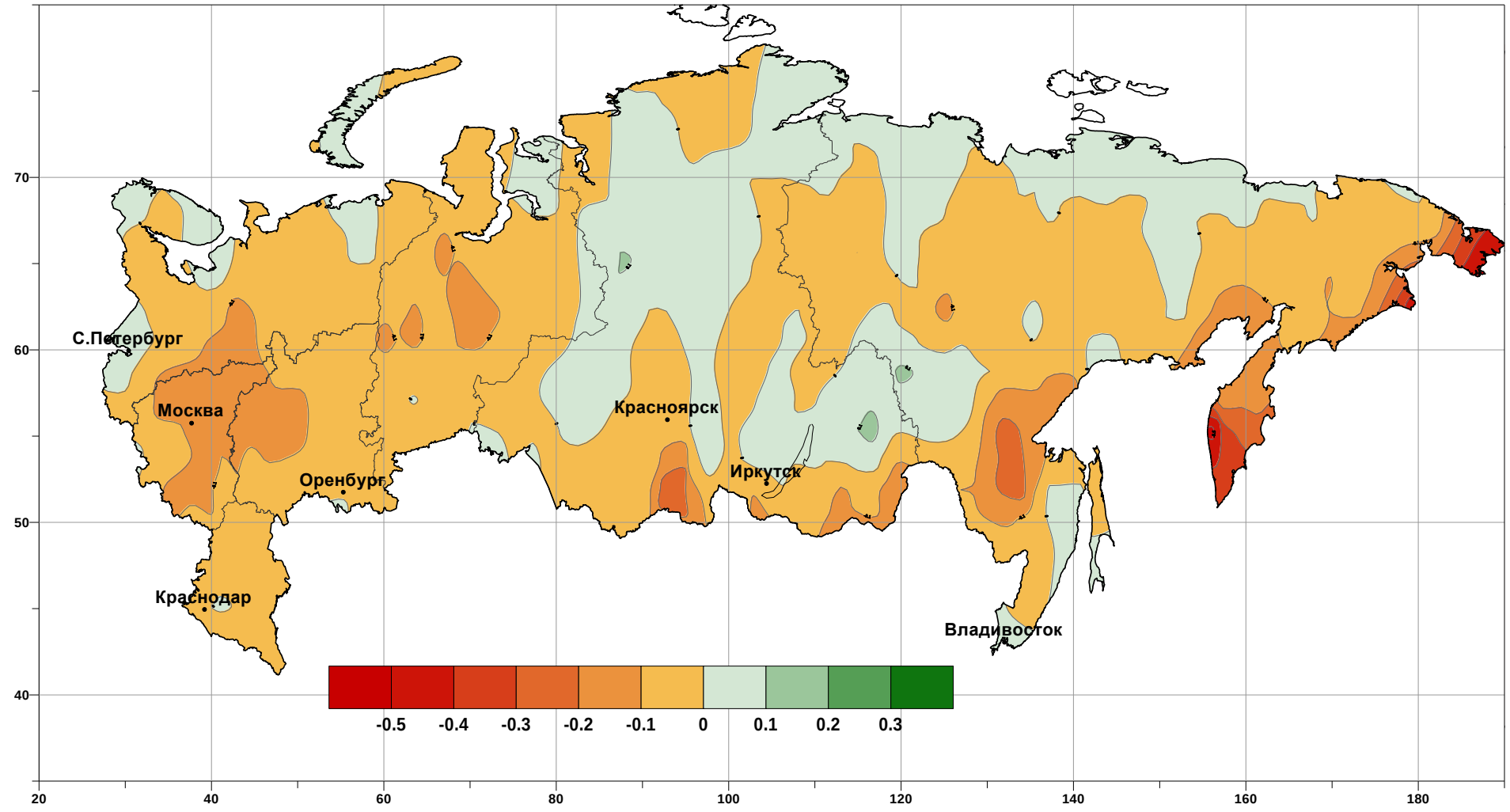
The Average Rate of Budyko Dryness Index Change (1/10 years) for the period from 1976 to 2012

Всероссийский НИИ сельскохозяйственной метеорологии
ВНИИСХМ



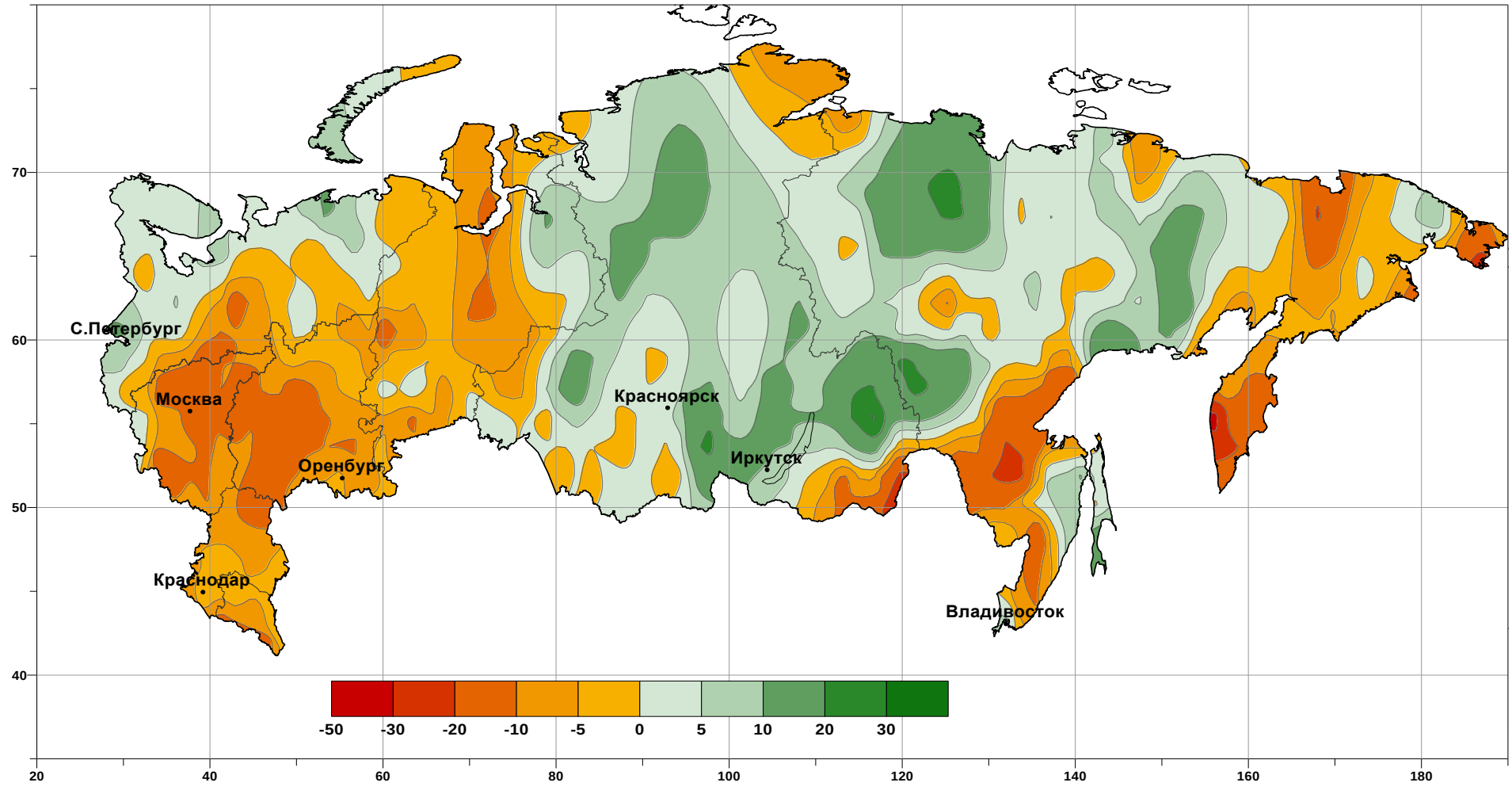
The Average Rate of Moisture Index Change (1/10 years) for the period from 1976 to 2012 (May and Summer)

Всероссийский НИИ сельскохозяйственной метеорологии
ВНИИСХМ



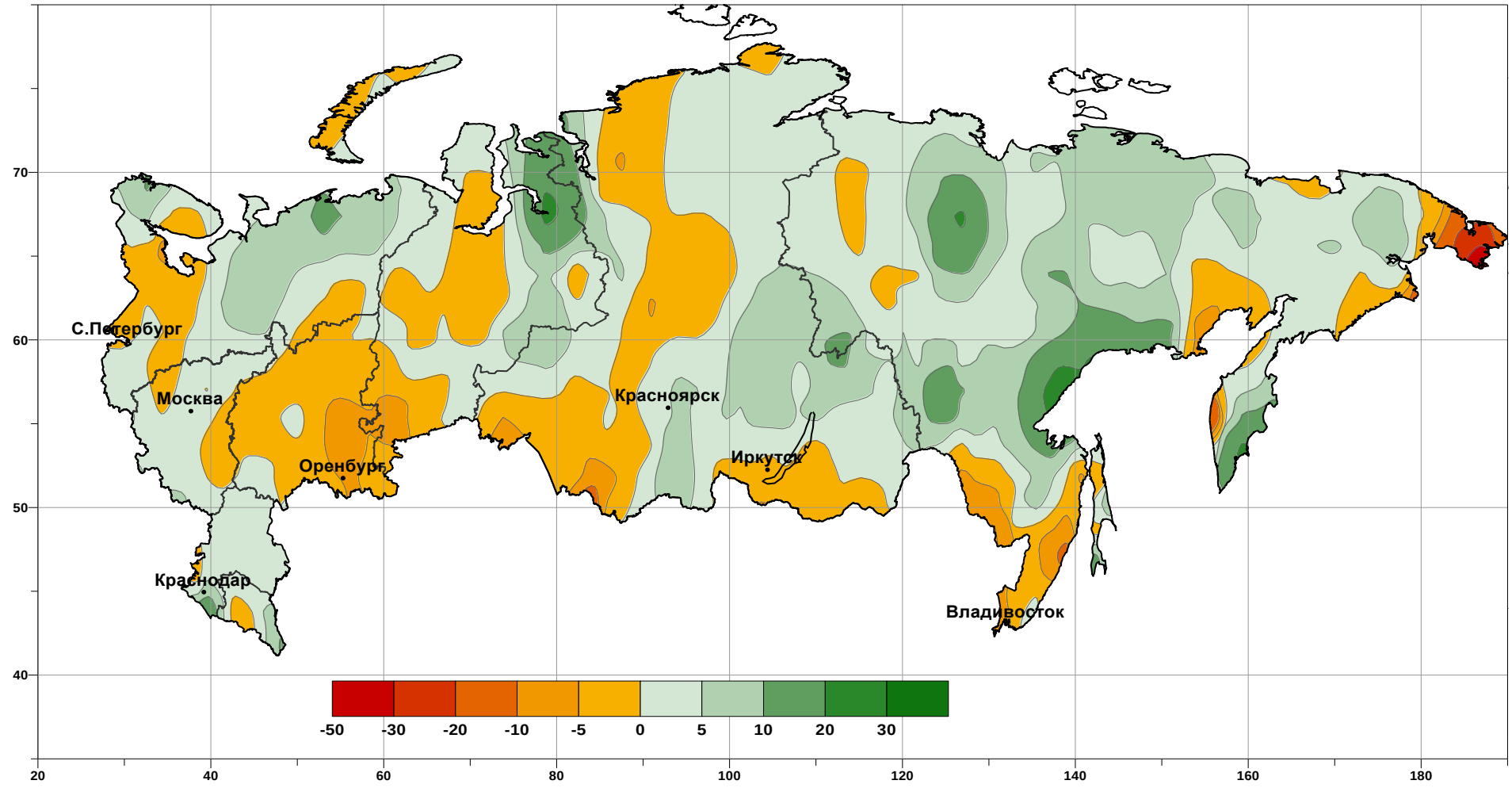
The Average Rate of Change in Summer Precipitation Sum (mm/10 years) for the period from 1976 to 2012

Всероссийский НИИ сельскохозяйственной метеорологии
ВНИИСХМ



The Average Rate of Change in Autumn Precipitation Sum (mm/10 years) for the period from 1976 to 2012

Всероссийский НИИ сельскохозяйственной метеорологии
ВНИИСХМ



The Estimation of Agro-Climatic Indicators Trends for the period from 1976 to 2010

Всероссийский НИИ сельскохозяйственной метеорологии

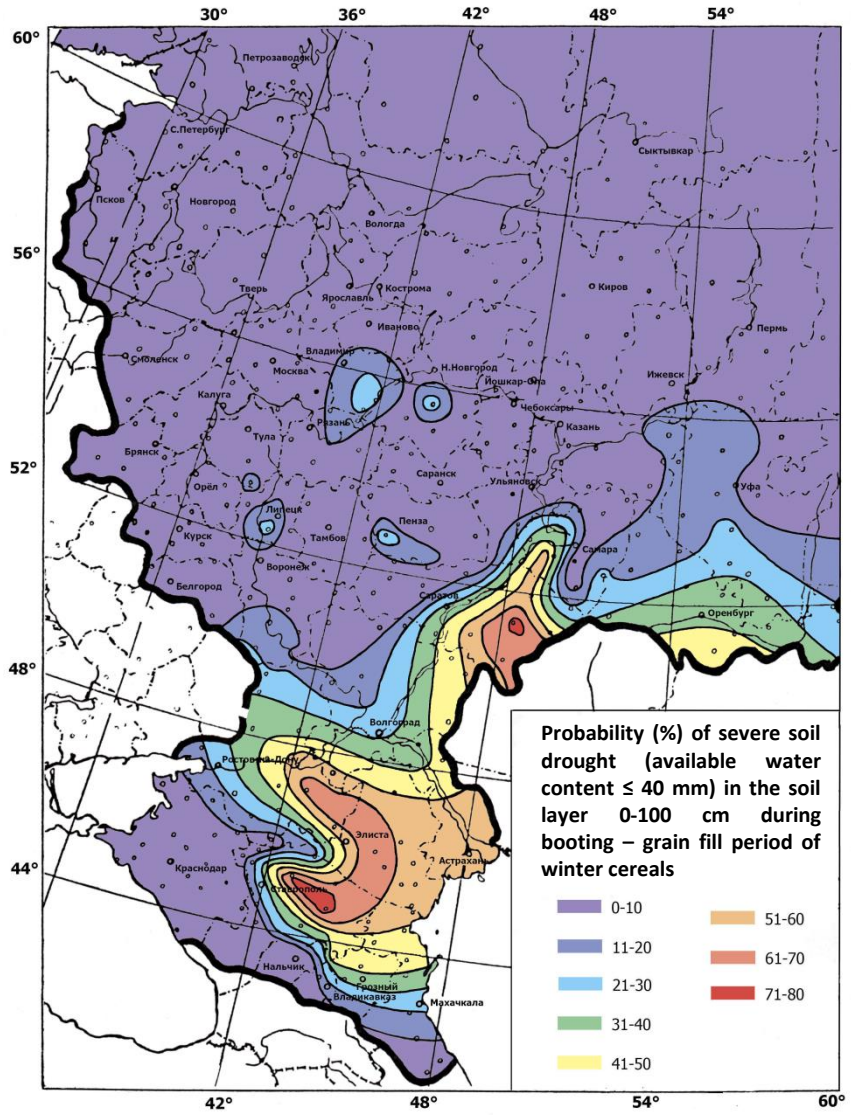
Federal district	Heat and moisture availability changes (for 10 years)							
	winter		spring		summer		autumn	
	T, ˚C	P, mm	T, ˚C	P, mm	T, ˚C	P, mm	T, ˚C	P, mm
Central	0,74	-3	0,47	-1	0,73	-14	0,57	0
Northwestern	0,90	6	0,36	6	0,57	-1	0,47	-3
Volga	0,53	0	0,47	6	0,57	-12	0,65	-5
Southern	0,34	1	0,27	9	0,64	-4	0,53	12
Ural	0,27	1	0,45	8	0,25	-4	0,65	0
Siberian	0,06	2	0,64	3	0,25	7	0,23	2
Far Eastern	0,46	5	0,3	8	0,26	6	0,44	-4
Russia	*0,41*	*2*	*0,45*	*5*	*0,42*	*-2*	*0,46*	*0*

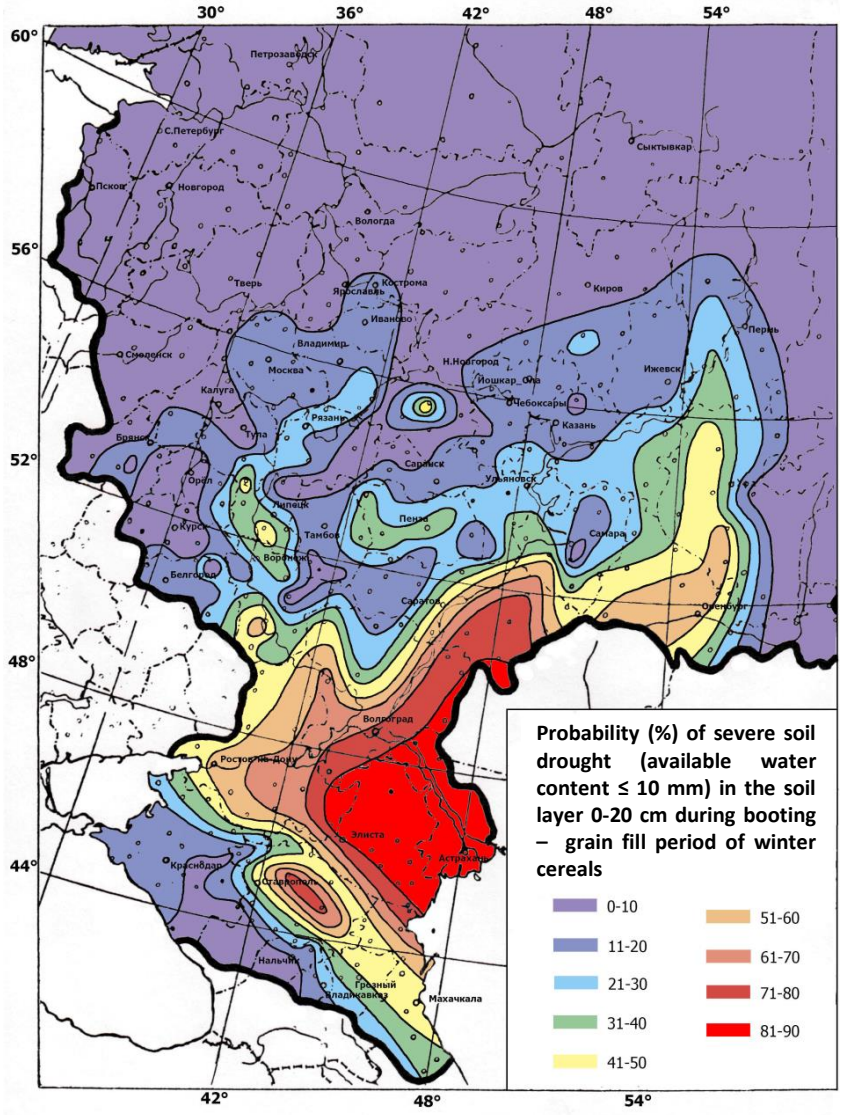
The Estimation of Agro-Climatic Indicators Trends for the period from 1976 to 2010

Всероссийский НИИ сельскохозяйственной метеорологии

Federal district	Heat and moisture availability changes (for 10 years)			
	Hydro-Thermal Coefficient	Budyko Dryness Index	The number of days with T > 10˚C	Sums of T > 10˚C
Central	-0,115	0,064	3	131
Northwestern	-0,032	0,026	3	106
Volga	-0,081	0,056	2	93
Southern	-0,019	-0,015	4	134
Ural	-0,023	0,015	2	62
Siberian	0,011	-0,003	3	55
Far Eastern	0,022	0,011	3	68
Russia	*-0,033*	*0,021*	*3*	*84*

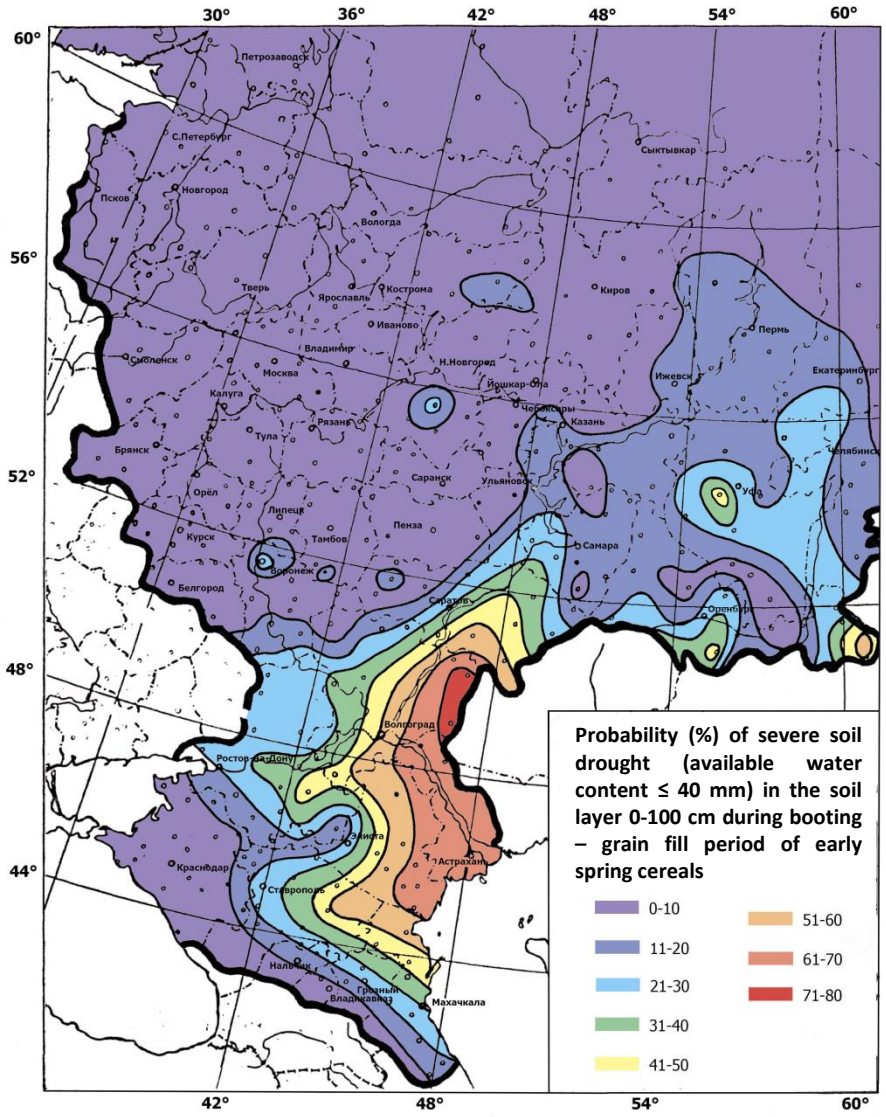
The Risk of Severe Soil Droughts under Winter Cereals (%)

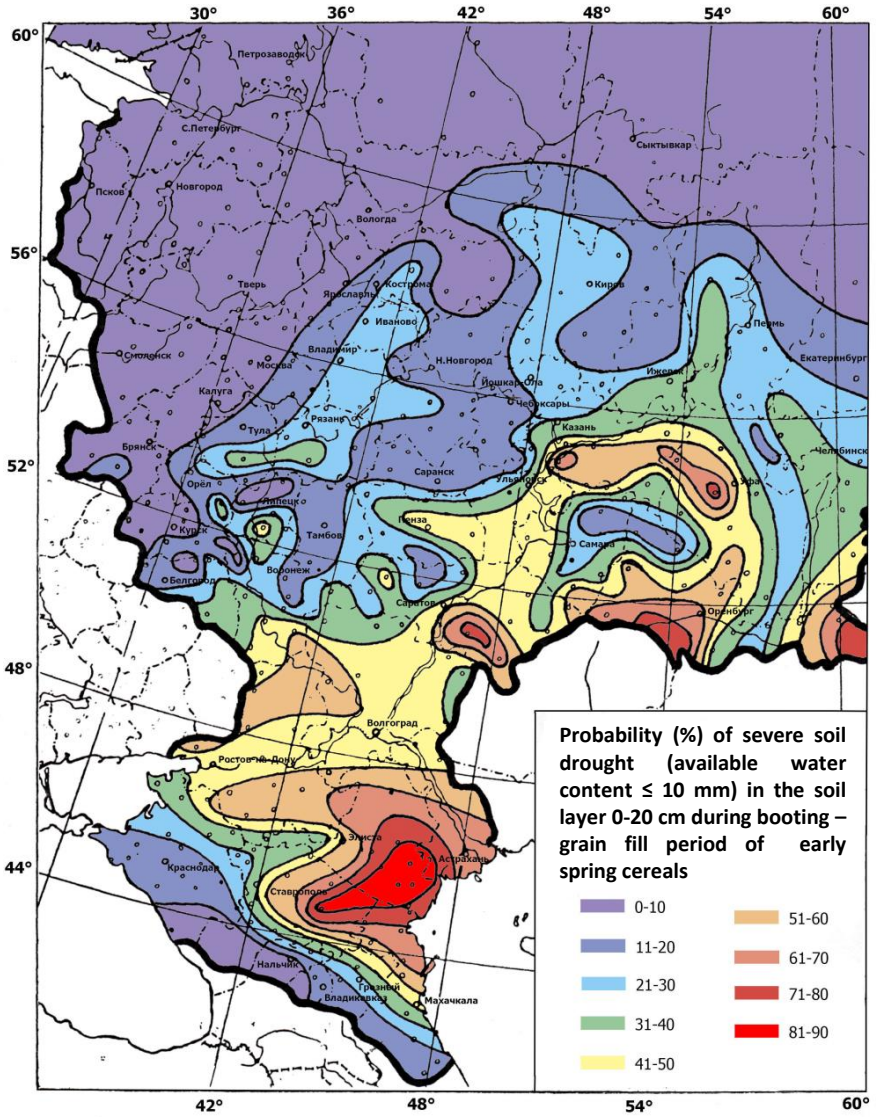




The Risk of Severe Soil Droughts under Early Spring Cereals (%)

Всероссийский НИИ сельскохозяйственной метеорологии
ВНИИСХМ





Bio-Climatic Potential (BCP) Distribution

Всероссийский НИИ сельскохозяйственной метеорологии

Country	N, days	R, mm	Sums of T > 10°	Moisture coefficients		BCP, t/ha	Wheat yield, t/ha
				KW	HTC		
Finland	150	280	1369	1,13	1,57	8,5	
England	288	662	2208	1,22	1,56	13,5	6,10
Germany	239	509	2614	0,90	1,43	14,5	5,52
France	301	600	3237	0,84	1,22	16,5	5,51
Italy	335	781	4761	0,73	1,26	14,6	2,85
Poland	208	432	2377	0,93	1,53	14,4	3,24
Hungrary	245	470	3336	0,61	1,04	14,6	4,19
Russia	176	302	2270	0,66	1,20	10,3	1,53

The Use of Resources (%)

$$R = Y / BCP * 100\%$$

England	45
Germany	38
France	33
Hungary	29
Poland	22
Russia	15

BCP under Current Climate Conditions (t/ha of Dry Biomass)

Всероссийский НИИ сельскохозяйственной метеорологии

Economic region	Current climate, t/ha			
	BCP_0	BCP_N	BCP_W	BCP_{WN}
Northern	4,7	10,6	4,8	10,6
Northwestern	5,5	11,8	5,5	11,8
Kaliningrad	6,0	14,9	6,1	14,9
Central	5,2	12,9	5,7	13,2
Volga-Vyatka	4,6	11,8	5,3	12,4
Central Black Earth	6,2	12,5	9,2	14,9
Volga, north	5,0	11,3	8,0	14,0
Volga, south	3,7	5,8	9,3	15,9
North Caucasus	7,1	10,1	12,2	17,2
Ural	5,3	10,6	7,1	12,2
West Siberian	5,8	10,7	7,3	11,8
East Siberian	5,4	10,4	6,2	10,6
Far Eastern	5,7	12,2	6,0	12,3
Russia	*5,3*	*10,8*	*7,3*	*13,2*

BCP Application for Analog Forecast

$$y_i = \frac{BCP_i}{BCP_a} * y_a$$

Analog Forecast of Cereals Yield when Achieving European Level of the Use of Resources (q/ha)

Всероссийский НИИ сельскохозяйственной метеорологии

Federal Subjects	Actual yield (2005-2008)	Expected yield under sufficient	
		mineral nutrition	mineral nutrition and moisture
Kaliningrad oblast	33,7	74,5	74,6
Leningrad oblast	35,1	55,8	55,9
Pskov oblast	14,3	62,8	63,1
Novgorod oblast	17,7	61,8	62,2
Yaroslavl oblast	16,9	58,1	58,4
Moscow oblast	29,0	63,2	63,0
Voronezh oblast	26,6	58,2	74,7
Samara oblast	15,2	51,0	71,6
Krasnodar krai	56,4	59,4	91,7
Novosibirsk oblast	16,4	55,4	58,6
Altai krai	13,5	53,8	63,5
Primorsky krai	17,0	70,8	71,2

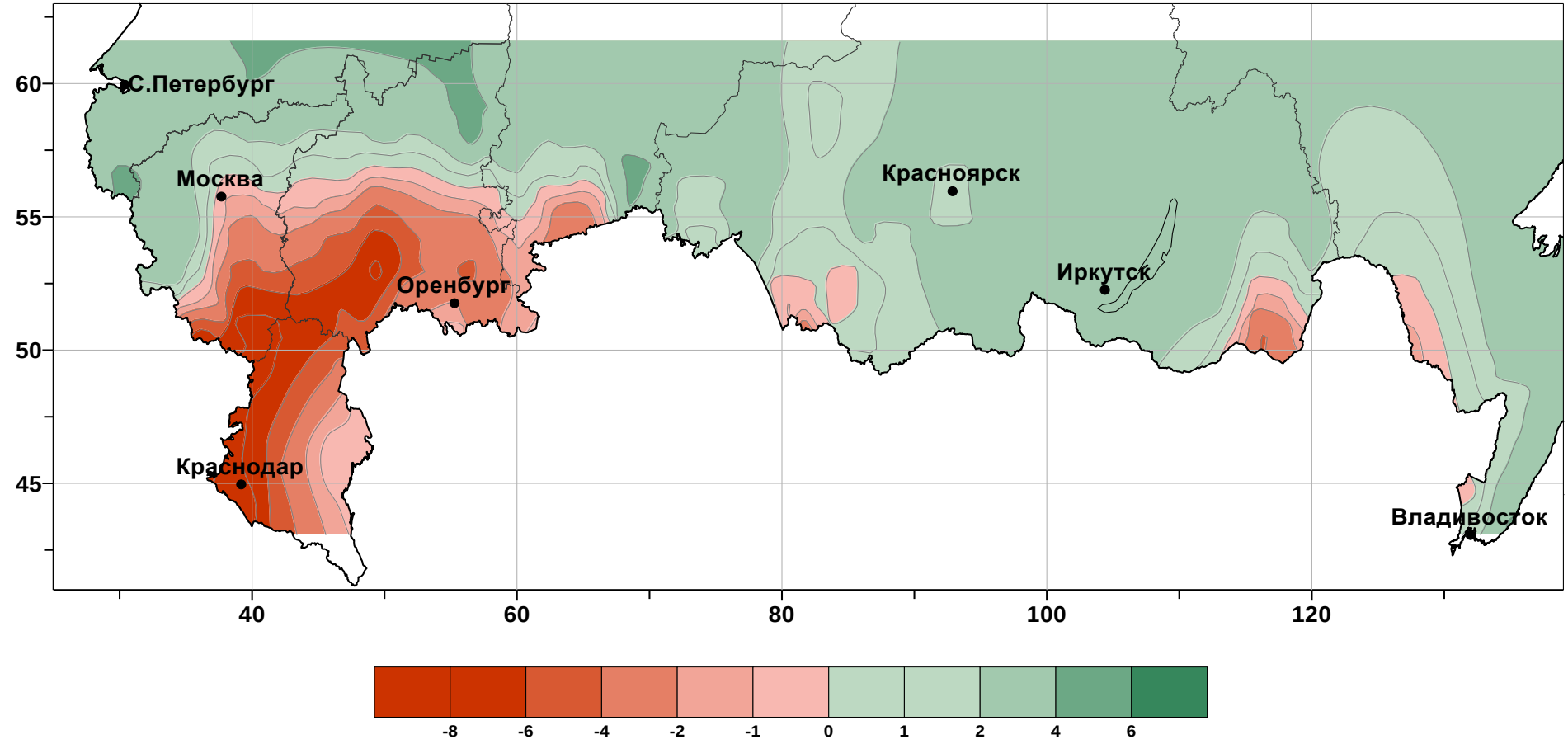
Analog Forecast of Cereals Yield when Achieving European Level of the Use of Resources (q/ha)

Всероссийский НИИ сельскохозяйственной метеорологии ВНИИСХМ

Economic region	Expected yield under sufficient	
	mineral nutrition	mineral nutrition and moisture
Northwestern	61,0	61,2
Central	63,5	65,0
Volga-Vyatka	58,0	61,0
Central Black Earth	62,0	74,0
Volga, north	54,5	67,0
Volga, south	29,5	79,5
North Caucasus	48,5	85,5
Ural	50,0	63,5
West Siberian	53,5	59,0
East Siberian	51,5	53,0
Far Eastern	61,5	62,0
Russia	*54,0*	*66,4*

Climate-Related Trend of BCP under High Level of Fertility for the period from 1976 – 2012 (q/ha for 10 years)

Всероссийский НИИ сельскохозяйственной метеорологии



Yield Reaction on Possible Climate Changes by GFDL Scenario (in % from the current level)

Всероссийский НИИ сельскохозяйственной метеорологии

Economic region	Scenario realisation period, years			
	30-40	60-70	30-40	60-70
	Cereals		Forage crops	
Northern	26	24	22	32
Northwestern	22	12	21	24
Kaliningrad	34	25	22	22
Central	27	25	19	24
Volga-Vyatka	20	26	21	30
Central Black Earth	15	15	20	24
Volga, north	16	19	24	30
Volga, south	7	30	5	14
North Caucasus	-6	-7	2	3
Ural	11	16	14	28
West Siberian	-7	-1	6	19
East Siberian	-12	-18	0	0
Far Eastern	10	12	6	13
Russia	*11*	*14*	*13*	*21*

Climate-Related Trends of Cereals Yield in the Federal Districts for the period from 1975 to 2006 (q/ha for 10 years)

Всероссийский НИИ сельскохозяйственной метеорологии

Federal district	Gross harvest, millions of tonn	Cereals and grain legumes, total	Winter wheat	Spring barley
Volga	21,92	0,32	0,47	0,26
Southern	26,22	0,30	0,36	0,44
Central	15,31	-0,02	0,06	-0,02
Siberian	12,84	0,16	–	0,19
Far Eastern	0,41	0,23	–	0,23
Ural	4,75	0,23	0,10	0,15

Climate-Related Changes in Cereals and Grain Legumes Yield (in whole) in the Major Grain-Producing Subjects (1975-2006)

Всероссийский НИИ сельскохозяйственной метеорологии

Federal subject	Yield changes	
	q/ha for 10 years	% for 10 years
Altai krai	0,23	2,20
Orenburg oblast	0,51	5,24
Rostov oblast	0,17	0,90
Saratov oblast	0,70	6,34
Omsk oblast	0,45	3,68
Volgograd oblast	0,61	4,81
Krasnodar krai	0,23	0,67
Stavropol krai	1,13	4,93
Bashkortostan republic	0,23	2,20
Tatarstan republic	0,51	5,24
Average for the region	*0,48*	*3,62*

Climate-Related Trends of Winter Wheat Yield in the Major Grain-Producing Subjects (1975-2006)

Всероссийский НИИ сельскохозяйственной метеорологии
ВНИИСХМ

Federal subject	Yield changes	
	q/ha for 10 years	% for 10 years
Rostov oblast	0,88	3,64
Krasnodar krai	3,86	10,50
Stavropol krai	2,75	11,28
Volgograd krai	0,65	2,80
Saratov krai	2,50	14,9
Voronezh	0,43	1,84
Penza oblast	1,91	11,58
Tambov oblast	0,41	1,97

The Main Conclusions. Adaptation Measures

Всероссийский НИИ сельскохозяйственной метеорологии

In whole, climate changes are favourable for 85% of Russian territory

Russia has great reserve for agricultural production expansion due to the climate component of BCP

Non-chernozem zone can significantly improve the productivity of agricultural production in Russia

Non-Chernozem Regions of European Russia

- The increase of late-ripening and more fruitful crops cultivation
- The increase of second stubble crops cultivation
- The increase of fertilizers and means and methods for protecting crops from pests

North Caucasus, Lower Volga Region

- The increase of drought-resistant crops cultivation (maize, sunflower, millet)
- The expansion of viticulture, horticulture, tea production, citrus plants growing, cotton-growing perspectives
- Early realisation of significant irrigation works

Sustainable agricultural development in Russia and the required growth of its productivity up to 2015 and for the longer term can be assured only provided that urgent measures on adaptive intensification of agriculture in non-chernozem zone, and above all Central and Northwestern Federal Districts including Kaliningrad region are adopted. Special emphasis should be drawn to increase the level of agricultural insurance in Russia.

Thanks for your attention!