WATER RESOURCES OF THE RUSSIAN ARCTIC RIVERS UNDER THE INFLUENCE OF CLIMATE CHANGES AND LARGE-SCALE WATER MANAGEMENT

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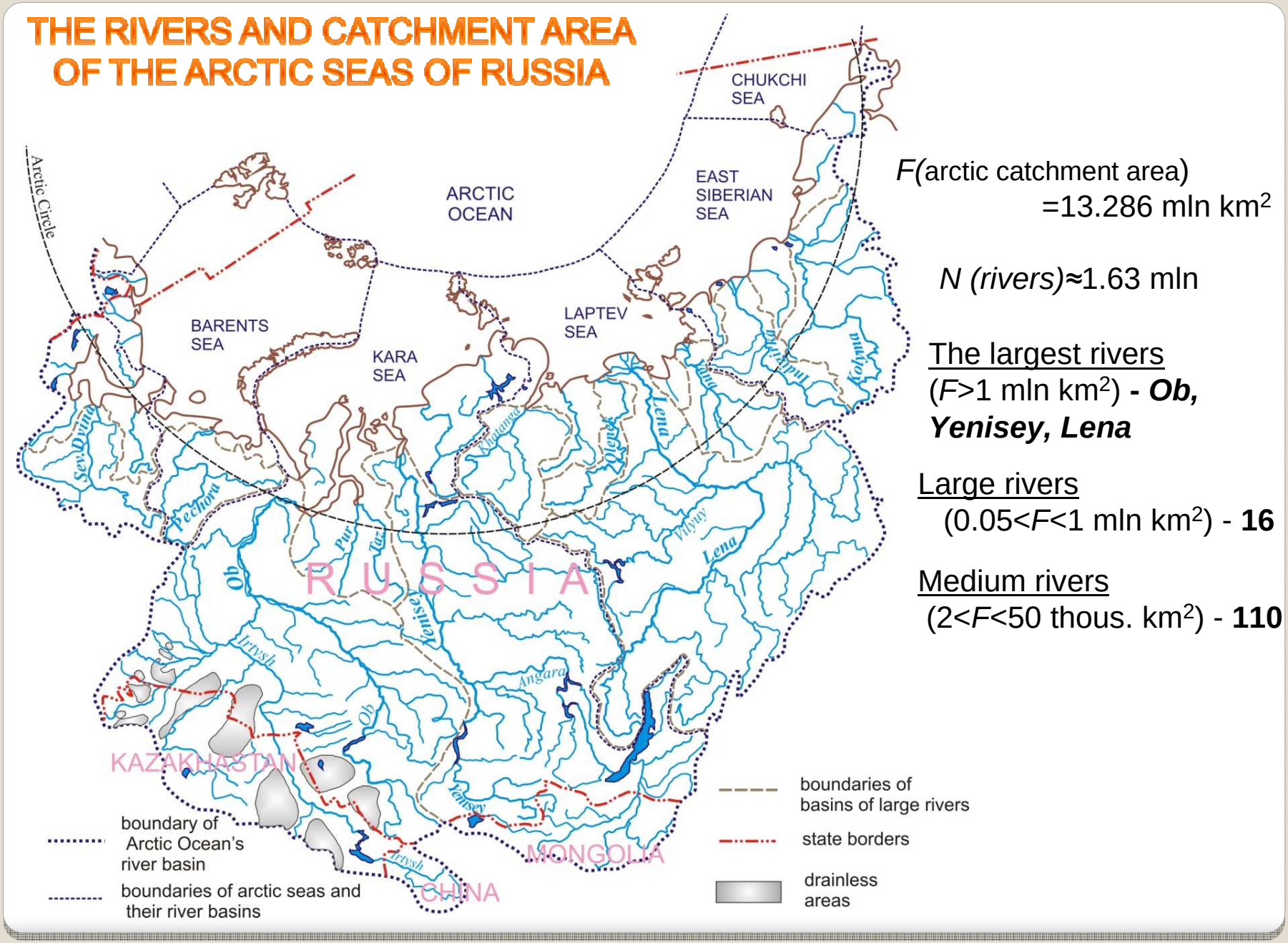
International research-to-practice conference «WATER SUSTAINABILITY IN THE XXI CENTURY: CHALLENGES AND SOLUTIONS»

THE RIVERS AND CATCHMENT AREA OF THE ARCTIC SEAS OF RUSSIA



*F(*arctic catchment area) =13.286 mln km^2

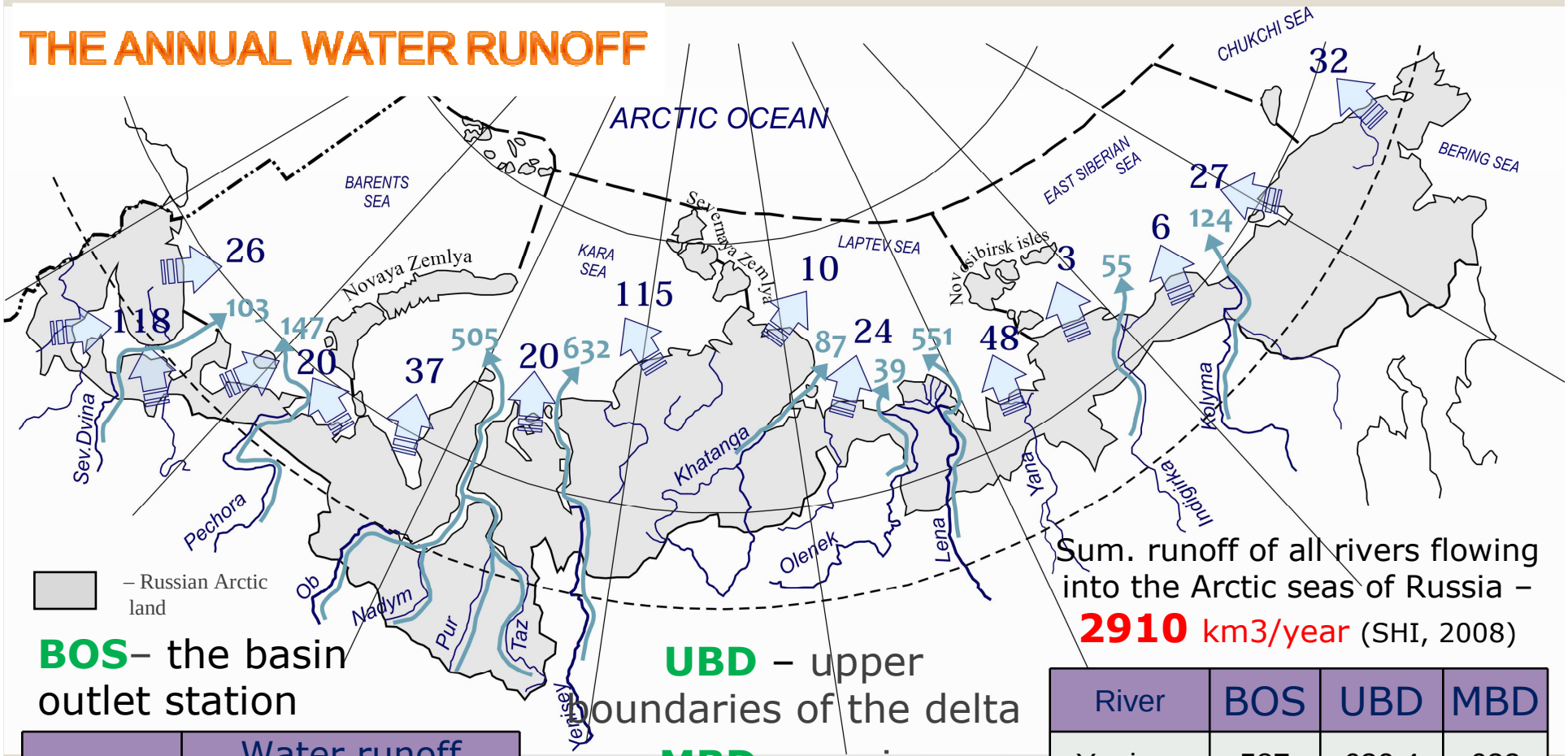
N (rivers)≈1.63 mln

The largest rivers (*F*>1 mln km^2) - ***Ob, Yenisey, Lena***

Large rivers (0.05<*F*<1 mln km^2) - **16**

Medium rivers (2<*F*<50 thous. km^2) - **110**

THE ANNUAL WATER RUNOFF



Sum. runoff of all rivers flowing into the Arctic seas of Russia – **2910** km3/year (SHI, 2008)

BOS– the basin outlet station

UBD – upper boundaries of the delta

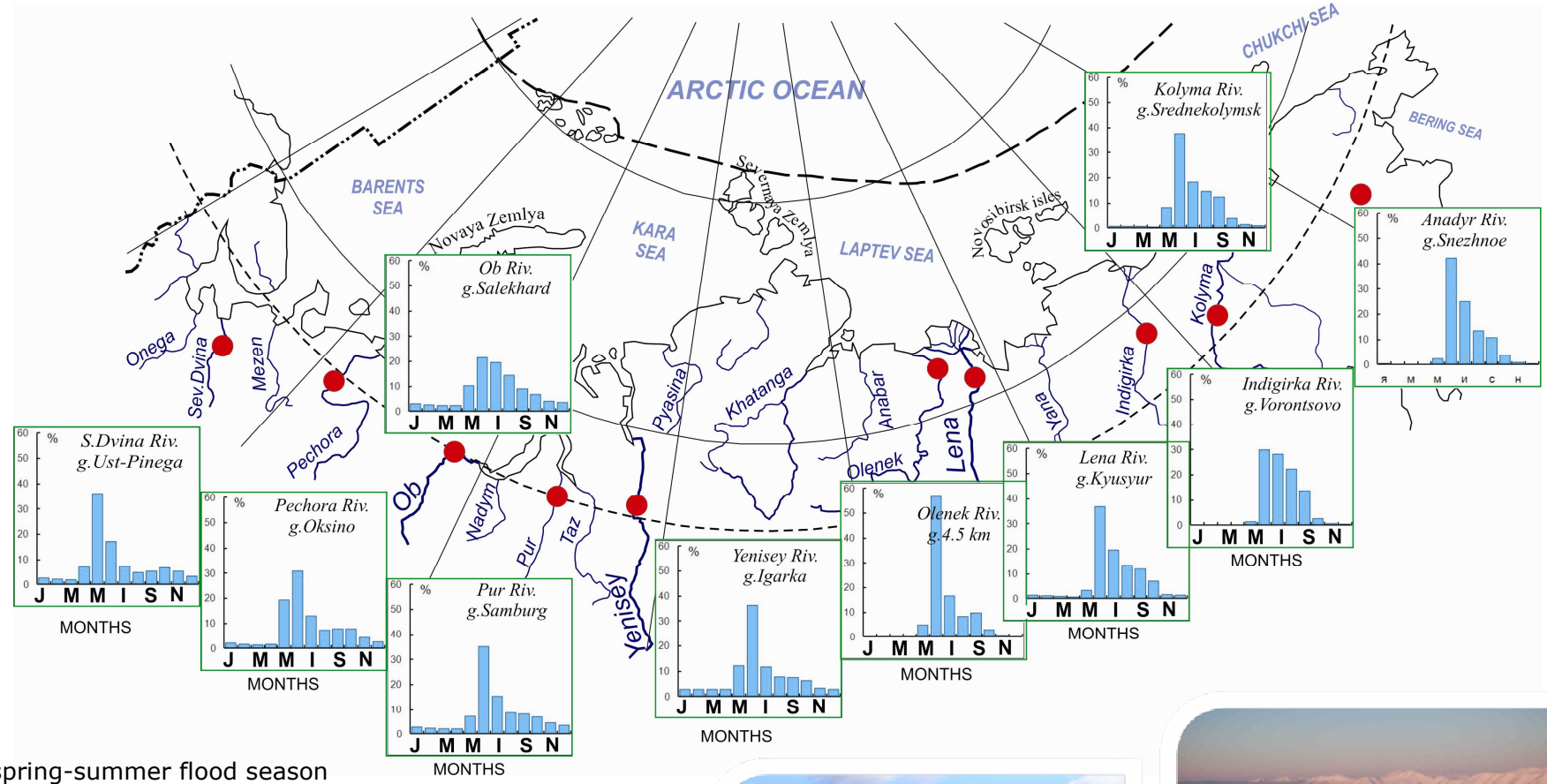
MBD - marine boundary of the delta

River	Water runoff (1935-2013), km³/year		
	BOS	UBD	MBD
Sev. Dvina	100	102.6	103
Mezen	20.1	-	27.3
Pechora	110	-	147

River	BOS	UBD	MBD
Ob	398	407	408
Pur	28.4	32.7	32.9
Taz	33.5	45.6	45.8

River	BOS	UBD	MBD
Yenisey	587	630.4	632
Olenek	35.3	38.7	38.8
Lena	540	546	550
Yana	33.6	34.2	35.1
Indigirka	51.8	54.8	55.4
Kolyma	104	123.6	124

INTRA-ANNUAL RELATIVE DISTRIBUTION OF WATER RUNOFF



spring-summer flood season

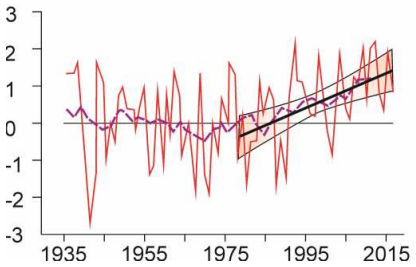
summer-autumn low-water season

winter low-water season

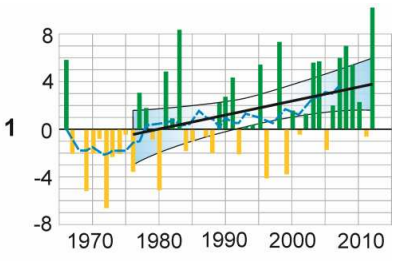
CLIMATE CHANGES

Roshydromet, 2014

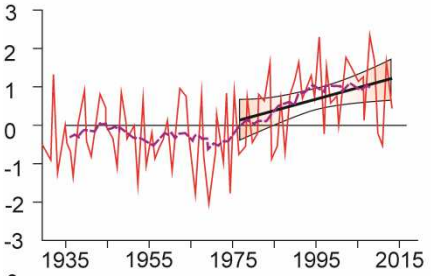
anomalies of the air temperature



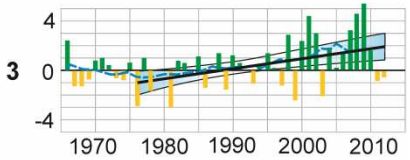
anomalies of precipitation amounts

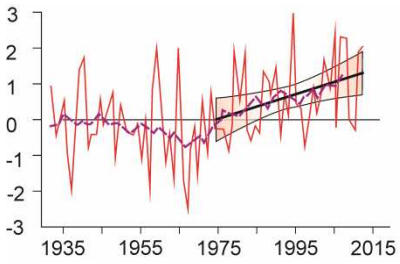


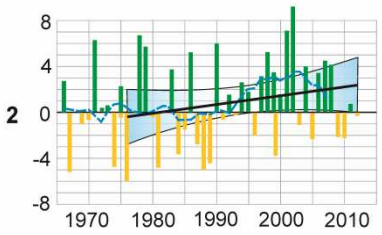
anomalies of the air temperature

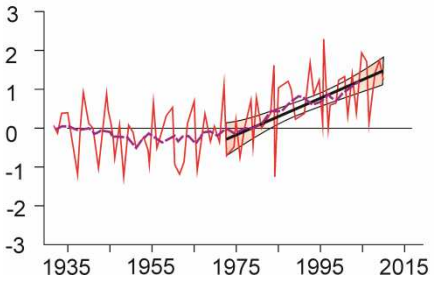


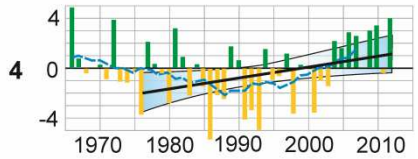
anomalies of precipitation amounts





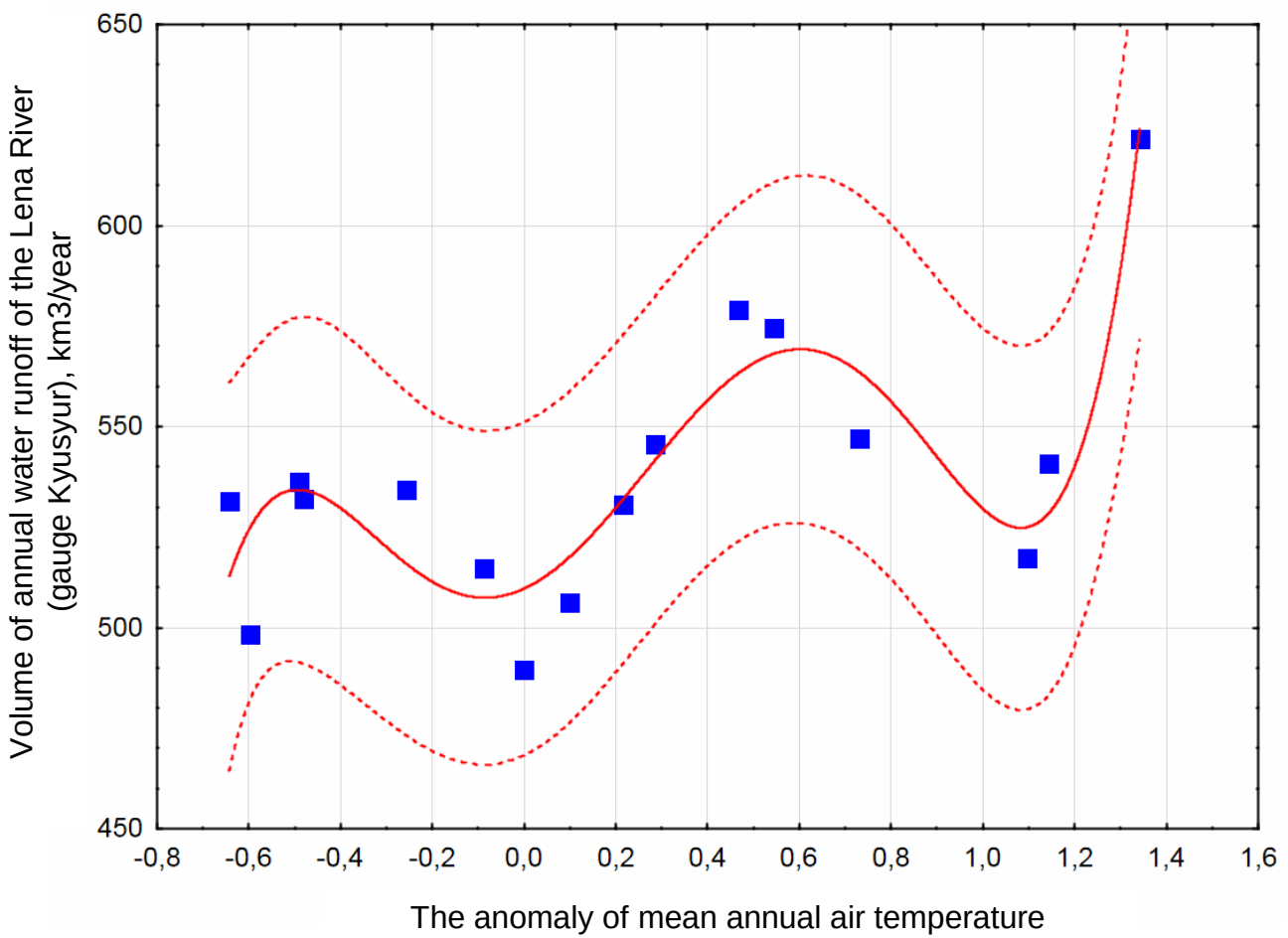






CHANGES IN ANNUAL WATER RUNOFF OF THE LENA RIVER DEPENDING ON THE AIR TEMPERATURE IN THE RIVER BASIN

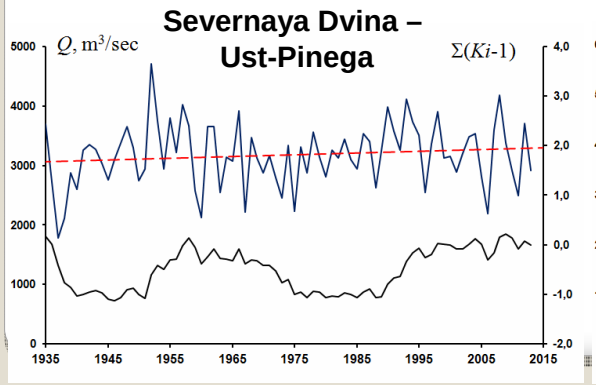
water flow and air temperature were averaged for 5-years

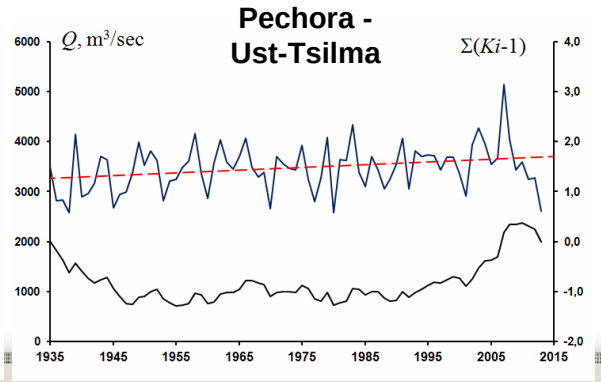


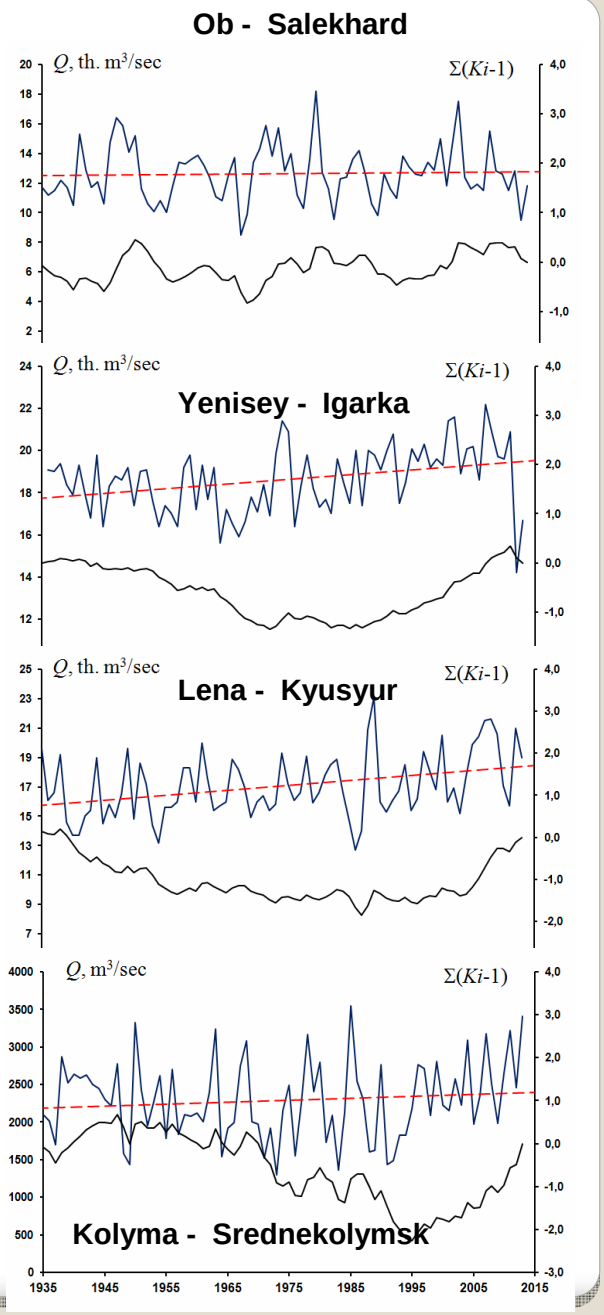
LONG-TERM CHANGES OF THE ANNUAL WATER RUNOFF

River – hydrometric station	$\Delta W_Q/\Delta y$*	The linear trend coefficient, km³/1year	
		1935-2013	1975-2013
Sev.Dvina - Ust-Pinega	+5.3%/+15mm	+0.098	+0.091
Mezen - Malonisogorskaya	-1.7%/-6mm	+0.005	+0.029
Pechora - Ust-Tsilma	+4.6%/+20mm	+0.173	+0.184
Ob - Salekhard	-0.4%/-0.7mm	+0.089	-0.089
Yenisey - Igarka	+5.4%/+13mm	+0.696	+0.922
Olenek - Sukhana	+12.2%/+21mm	+0.066	+0.113
Lena - Kyusyur	+7.4%/+16mm	+1.080	+2.214
Yana – Jiangky/Yubileynaya	*+12.8%/+18mm*	-	-
Kolyma - Srednekolymsk	+4.6%/+9mm	+0.081	+0.451

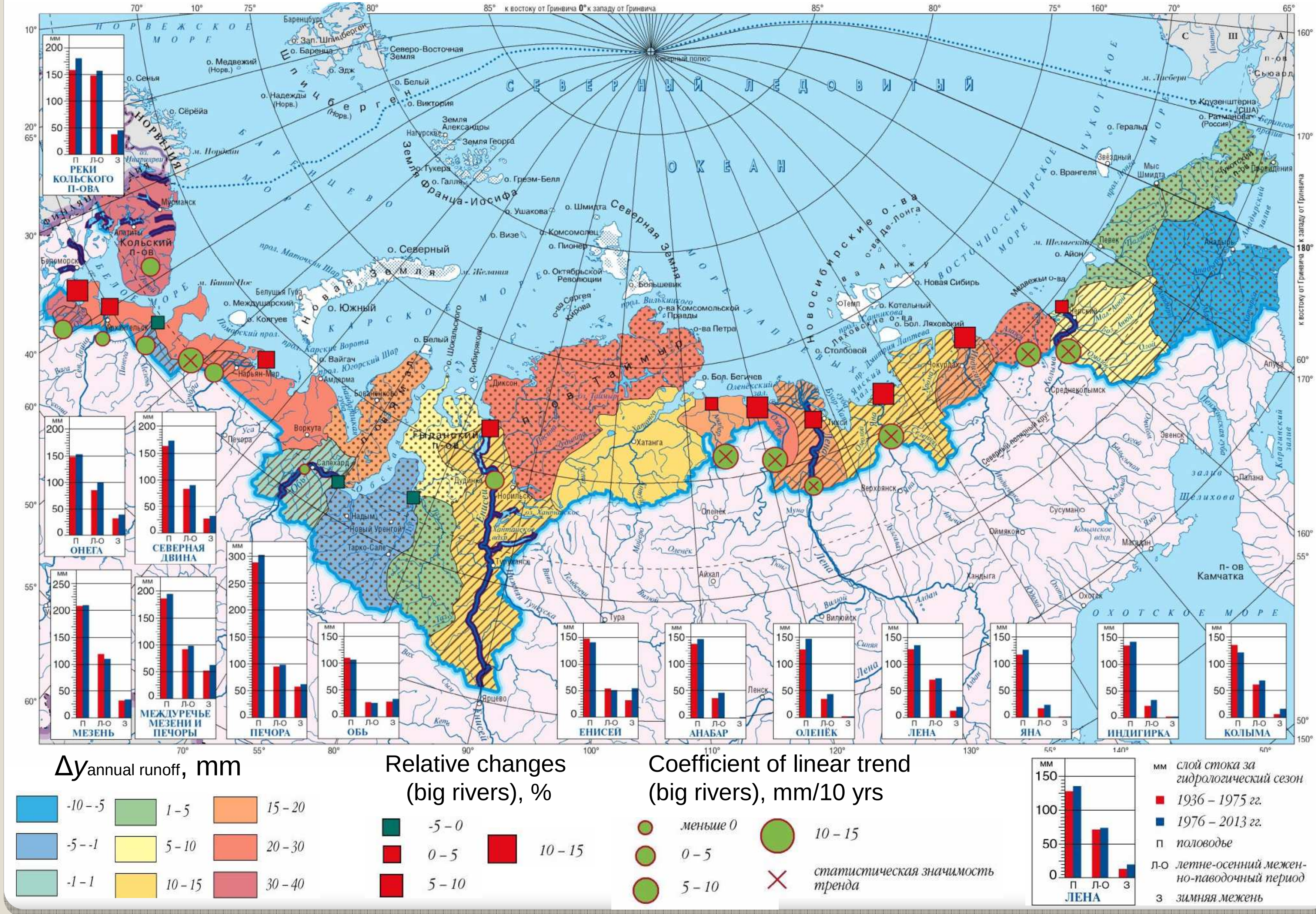
*change of annual water runoff in 1976-2013 in comparison with the value of annual water runoff in 1935-1975





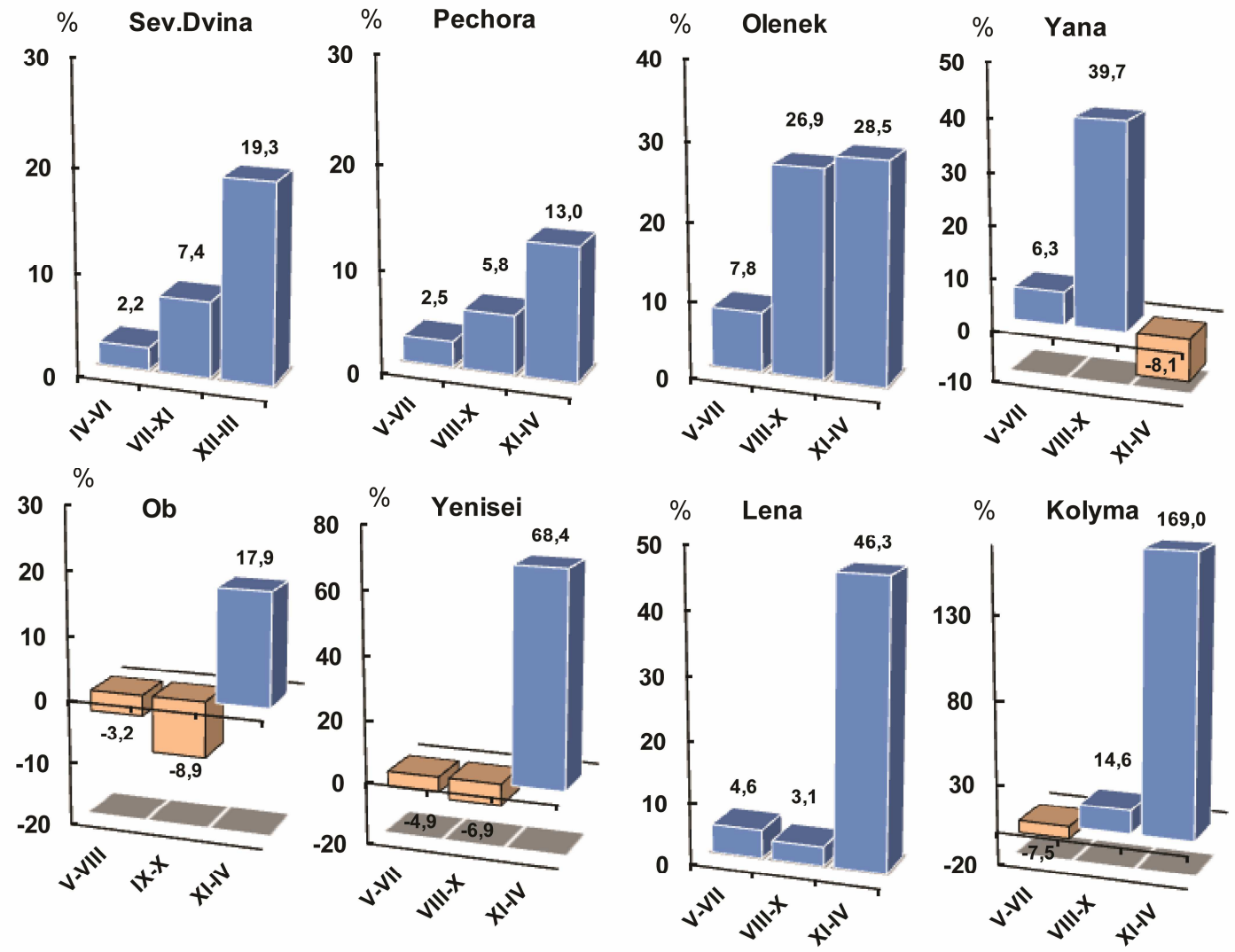


LONG-TERM CHANGES OF THE ANNUAL AND SEASONAL WATER RUNOFF

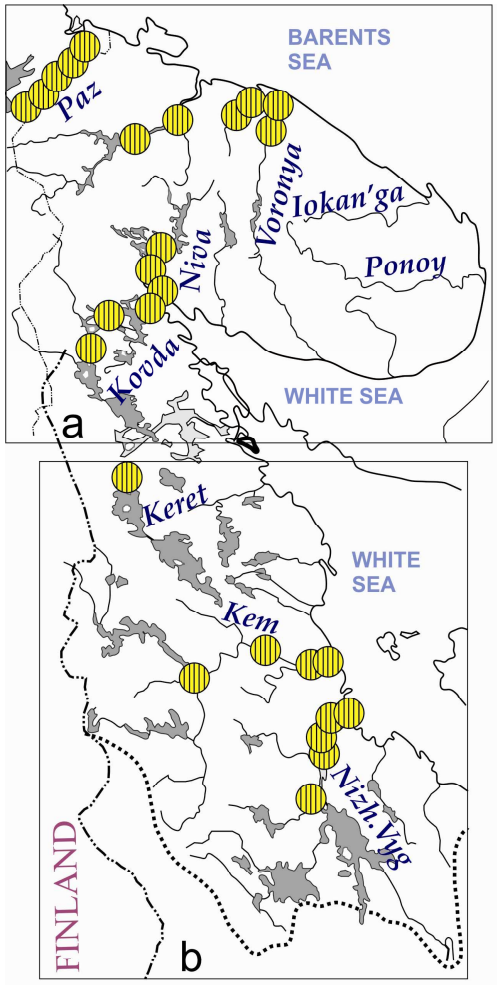


CHANGES OF THE SEASON WATER RUNOFF

in 1976-2013 in comparison with 1935-1975



THE MAIN RESERVOIRS IN THE ARCTIC RIVER BASINS



The one-time effects:

1. Withdrawal of water runoff of rivers during the initial filling of the reservoir and water saturation of ground of its bottom and banks.
2. Changing the hydrographic characteristics of rivers

The annual impact:

1. Daily, weekly, seasonal and inter-annual regulation of water discharges and levels.
2. The annual loss of water flow through evaporation from the surface of reservoirs and water logging areas.
3. Reducing the losses of water runoff in the downstream (due to decrease in the frequency and duration of flooding of floodplain)

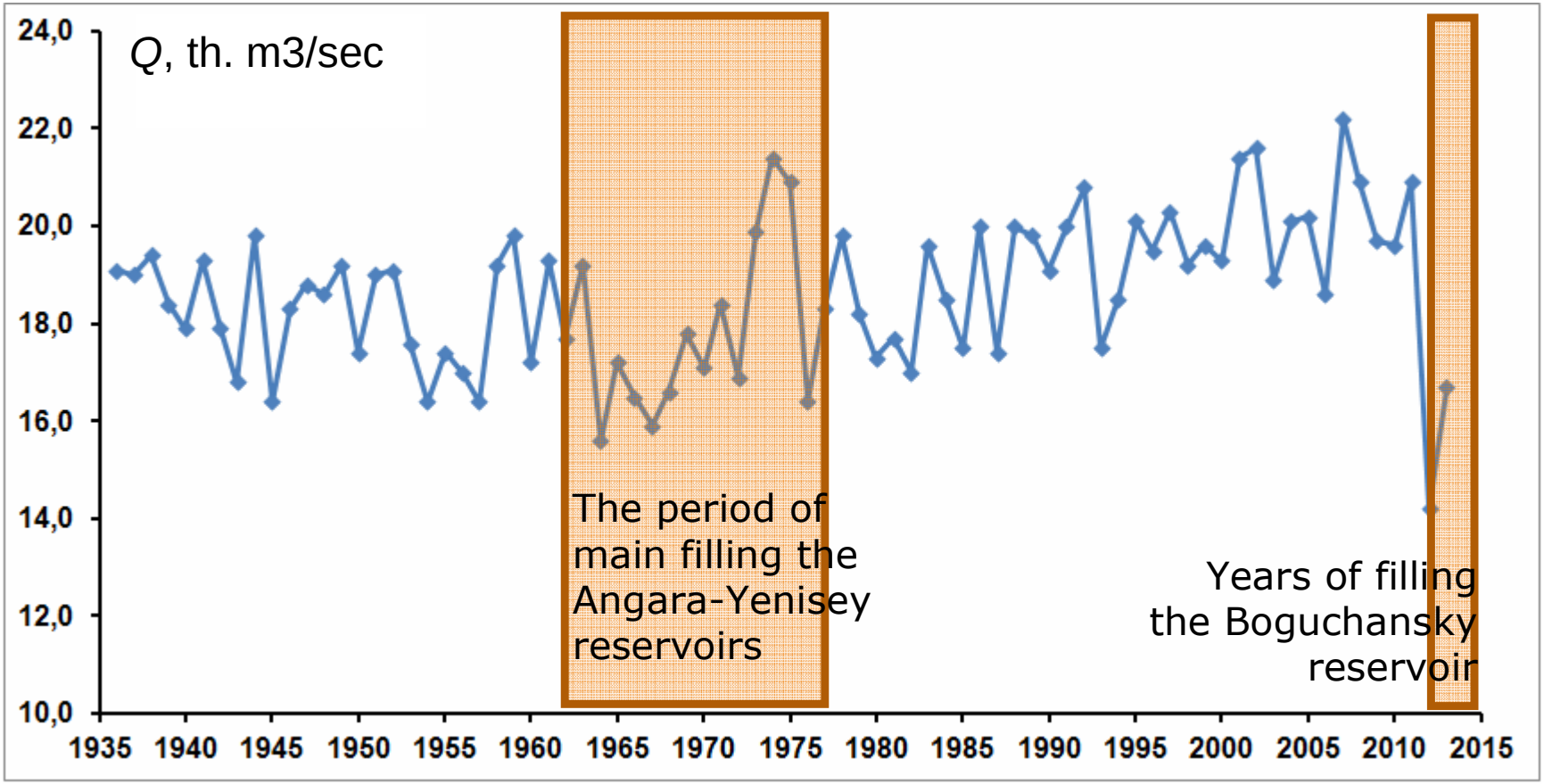
ASPECTS OF THE INFLUENCE OF RESERVOIRS ON RIVERS AND THEIR RUNOFF

LOSSES OF ANNUAL WATER FLOW DUE TO THE RESERVOIRS

River basin *water reservoirs*	Withdrawal of water runoff, km³		Losses of water runoff through evaporation, km³/yr		
	Filling of the dead storage	The water saturation of the bottom and banks	Total	Additional	
				From the water surface	From the water logging areas
Kola peninsula and Karelia	38.75	–	–/2.50*	–	–
Ob river basin:	24.8	–	*5.25*	–	–
Novosibirskoe	4.40	0.13	0.59	0.16	0.02
Bukhtarminskoe	18.81	–	3.65	–	–
Yenisey river basin:	*308*	–	*5.5*	–	–
Sayano-Shushenskoe	16.04	–	0.31	0.19	0.02
Krasnoyarskoe	42.87	–	1.24	0.61	0.32
Irkutskoe	1.65	0.15	0.02/13.2*	–	–
Bratskoe	121.1	7.35	1.94	0.29	0.03
Ust-Ilimskoe	56.19	–	0.60	0.18	0.01
Boguchanskoe	55.9	–	*0.72*	–	–
Kureiskoe	2.66	–	0.17	0.04	0.03
Khantaiskoe	10.71	–	–/0.53*	0.14	0.07
Lena river basin:	19.0	–	*0.90*	*0.20*	–
Vilyuiskoe 1,2	18.05	–	0.85	0.17	0.10
Vilyuiskoe 3	0.90	–	0.04	–	–
Kolyma river basin:	10.64		*0.21*		
Kolymskoe	7.84	–	0.13	0.03	0.02
Ust-Srednekanskoe	2.80	–	0.08	–	–

according to V.S.Vuglinskii (1991) and the authors of the report

THE IMPACT OF THE INITIAL FILLING THE ANGARA-YENISEY RESERVOIRS ON ANNUAL WATER FLOW AT THE YENISEY RIVER MOUTH



LOSSES OF ANNUAL WATER FLOW DUE TO THE RESERVOIRS

River basin *water reservoirs*	Withdrawal of water runoff, km^3		Losses of water runoff through evaporation, km^3/yr		
	Filling of the dead storage	The water saturation of the bottom and banks	Total	Additional	
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Kola peninsula and Karelia	38.75	–	–/2.50*	–	–
Ob river basin:	24.8	–	*5.25*	–	–
Novosibirskoe	4.40	0.13	0.59	0.16	0.02
Bukhtarminskoe	18.81	–	3.65	–	–
Yenisey river basin:	*308*	–	*5.5*	–	–
Sayano-Shushenskoe	16.04	–	0.31	0.19	0.02
Krasnoyarskoe	42.87	–	1.24	0.61	0.32
Irkutskoe	1.65	0.15	0.02/13.2**	–	–
Bratskoe	121.1	7.35	1.94	0.29	0.03
Ust-Ilimskoe	56.19	–	0.60	0.18	0.01
Boguchanskoe	55.9	–	*0.72*	–	–
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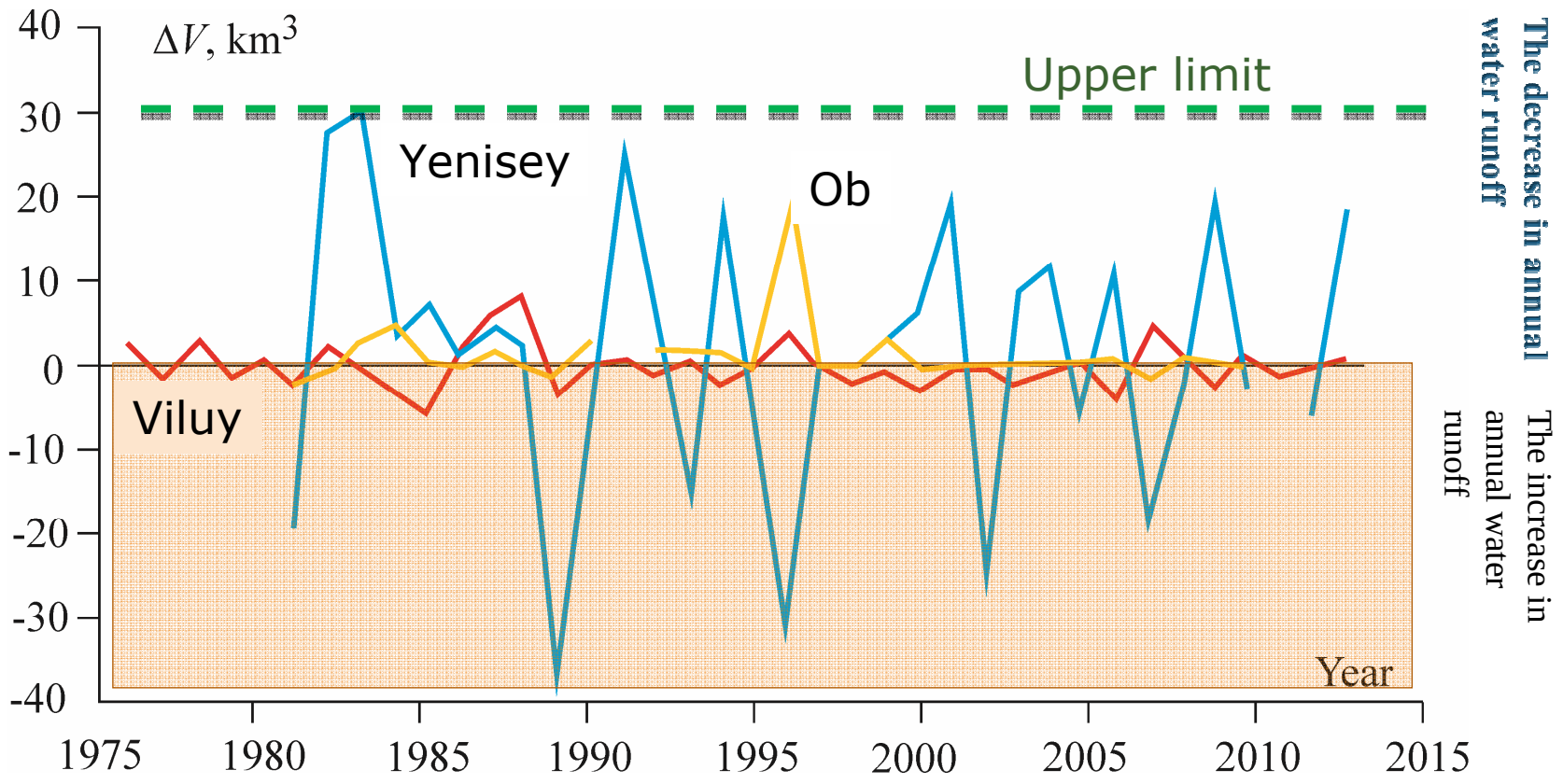
Vilyuiskoe 3	0.90	–	0.04	–	–
Kolyma river basin:	10.64		*0.21*		
Kolymskoe	7.84	–	0.13	0.03	0.02
Ust-Srednekanskoe	2.80	–	0.08	–	–

*according to V.S.Vuglinskii (1991) and the authors of the report

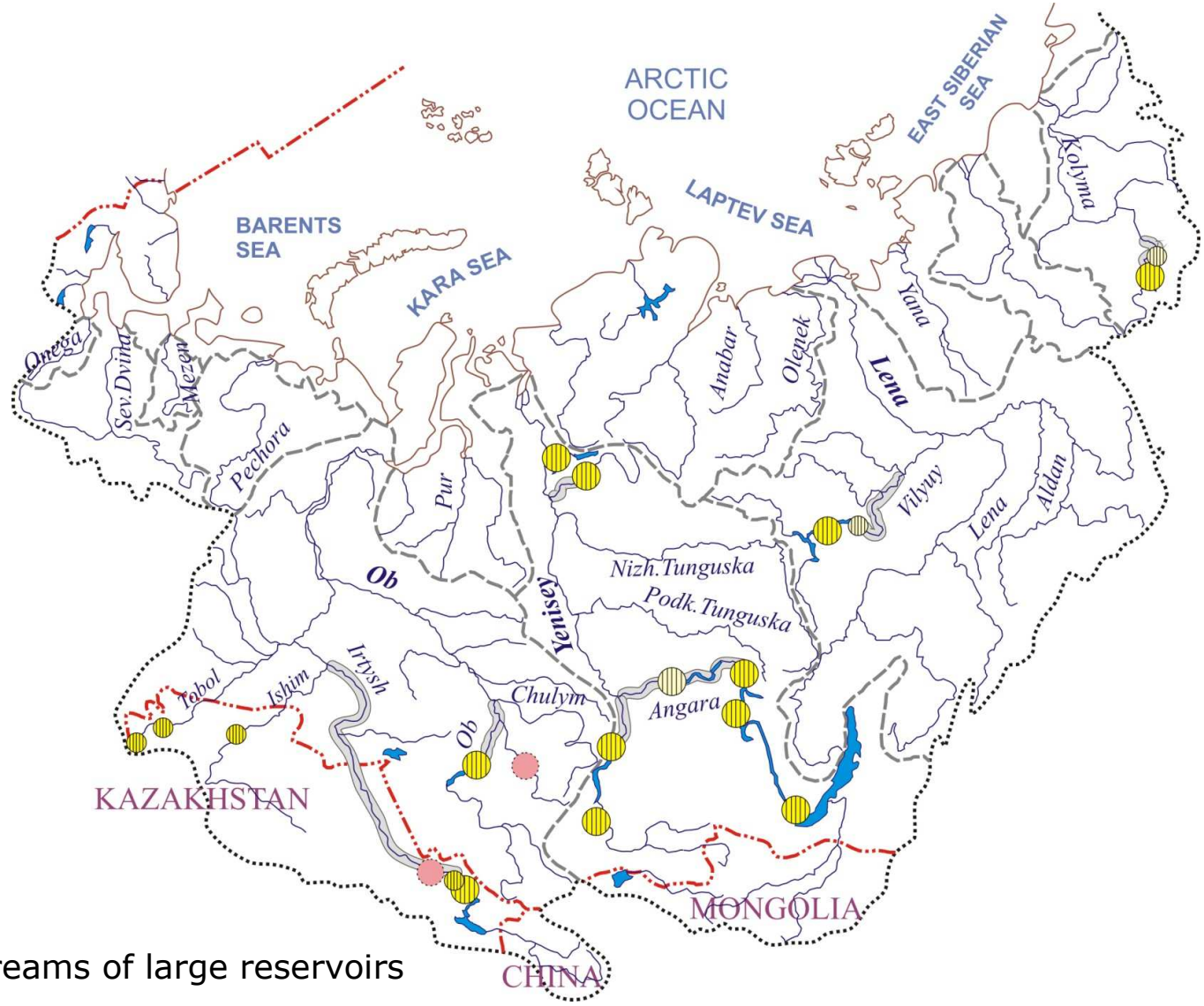
** in the denominator taking into account evaporation from lakes

LONG-TERM REGULATION OF WATER RUNOFF

accumulation of river waters in the reservoirs

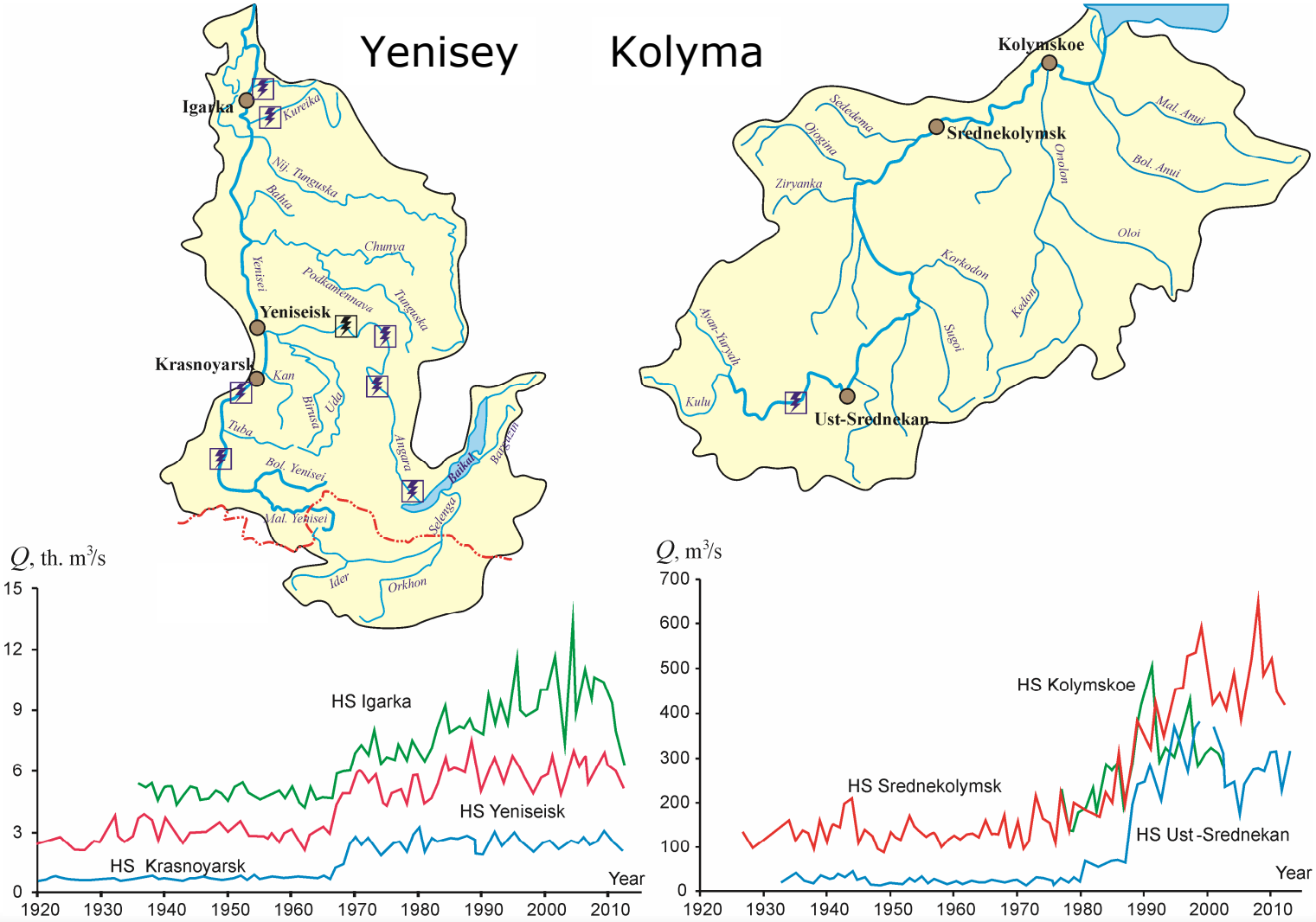


CHANGES OF HYDROGRAPHIC CHARACTERISTICS IN THE ASIAN PART OF THE ARCTIC WATERSHED

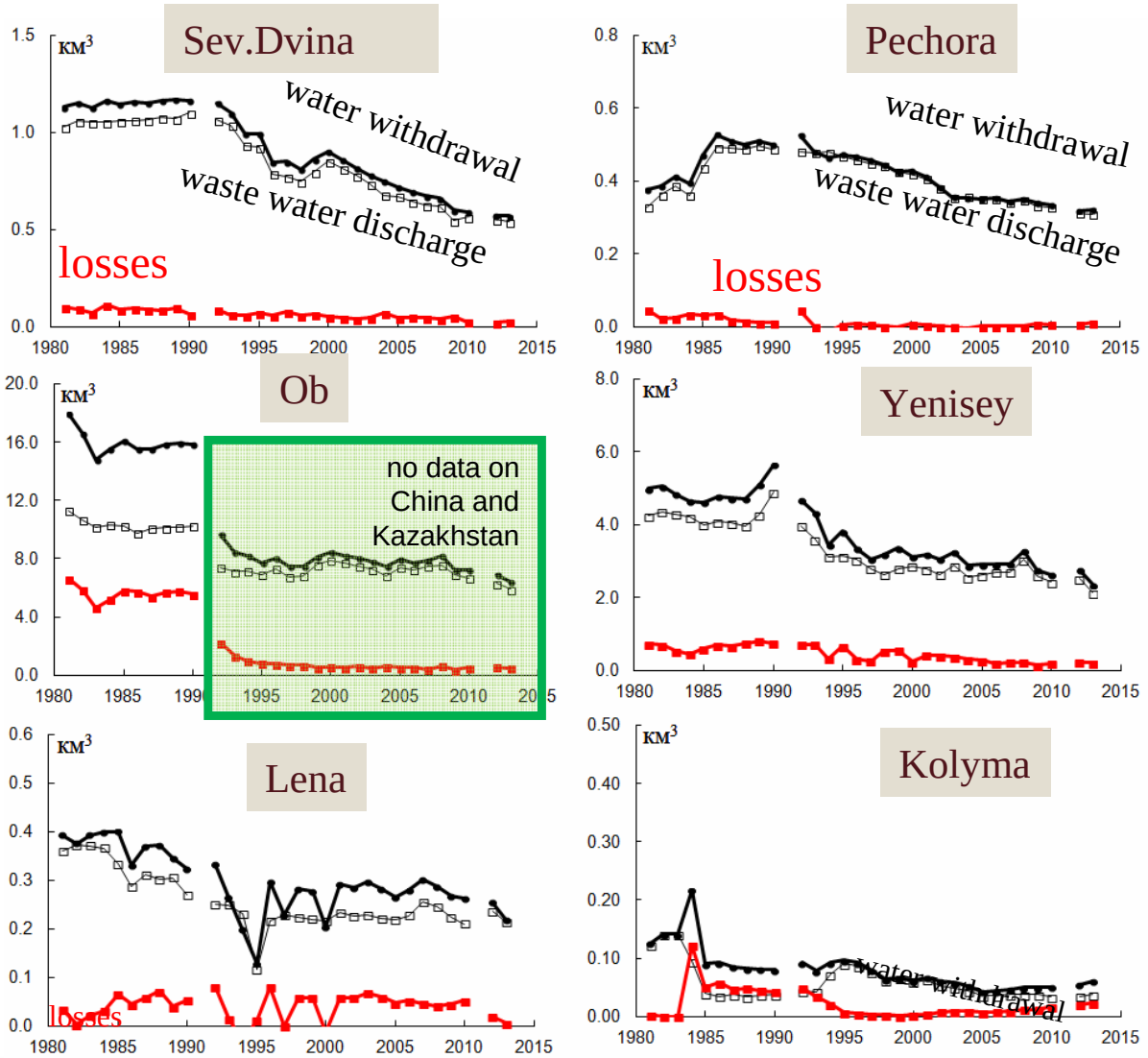


downstreams of large reservoirs

LONG-TERM CHANGES OF WINTER RUNOFF OF THE REGULATED RIVERS



LONG-TERM DYNAMICS OF WATER USE IN THE RIVER BASINS OF THE RUSSIAN ARCTIC

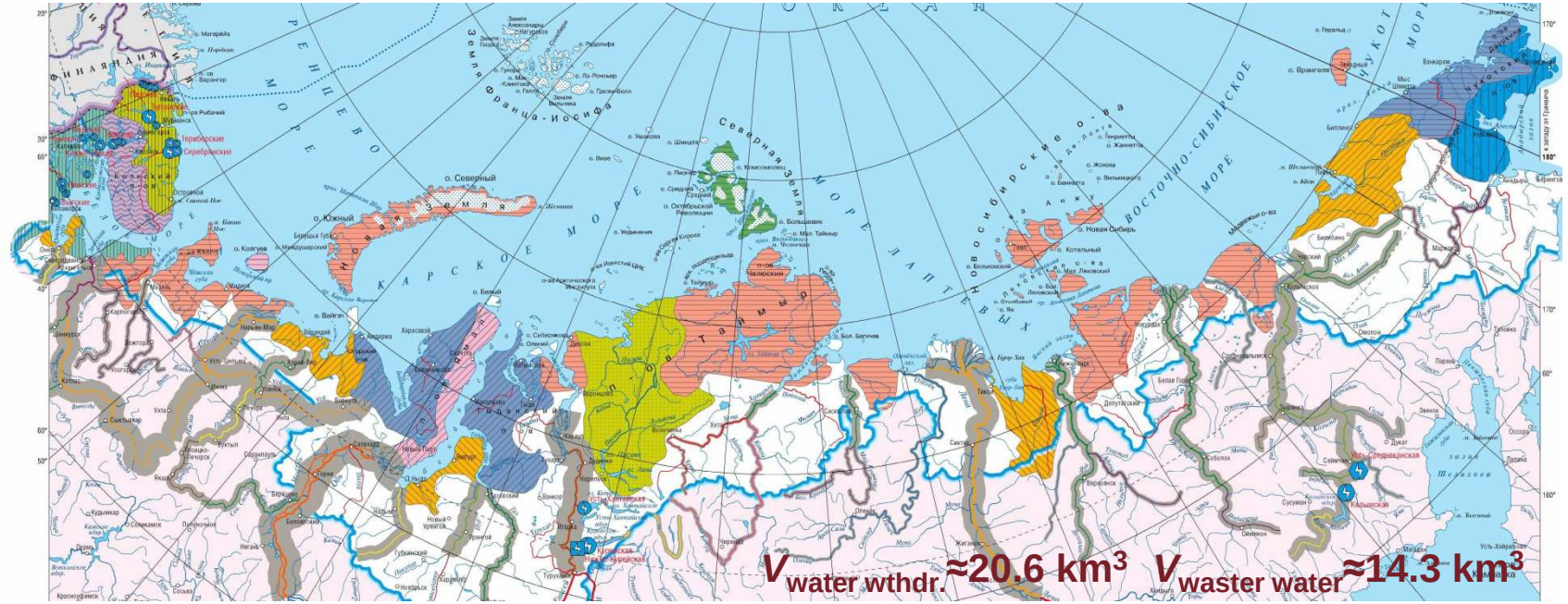


Total water consumptive in the basins of the rivers of the Russian Arctic (in the 1980s.):

$V_{\text{water wthdr.}} \approx 25.5\ \text{km}^3$

$V_{\text{waster water}} \approx 18.5\ \text{km}^3$

PRESENT-DAY (2004-2013 yrs) SUMMARY WATER CONSUMPTIVE IN THE BASINS OF THE RIVERS OF THE RUSSIAN ARCTIC



Water intake and wastewater discharges in large river basins (for river reaches, cumulative), million m3/year

Water withdrawal

менее 0,1
0,1 - 0,5
0,5 - 1
1 - 5
5 - 10
10 - 50
50 - 100
100 - 1 000
2 500 - 5 000
10 000 - 15 000

Waste water discharges

0,001 и меньше
0,001 - 0,1
0,1 - 0,5
0,5 - 1,0
1,0 - 5,0
5,0 - 10
10 - 50
50 -100
100 - 500
500 - 1 000
2 500 - 5 000
5 000 - 10 000

Water intake and wastewater discharges on the local catchments of the Arctic seas, million m3/year

Water withdrawal

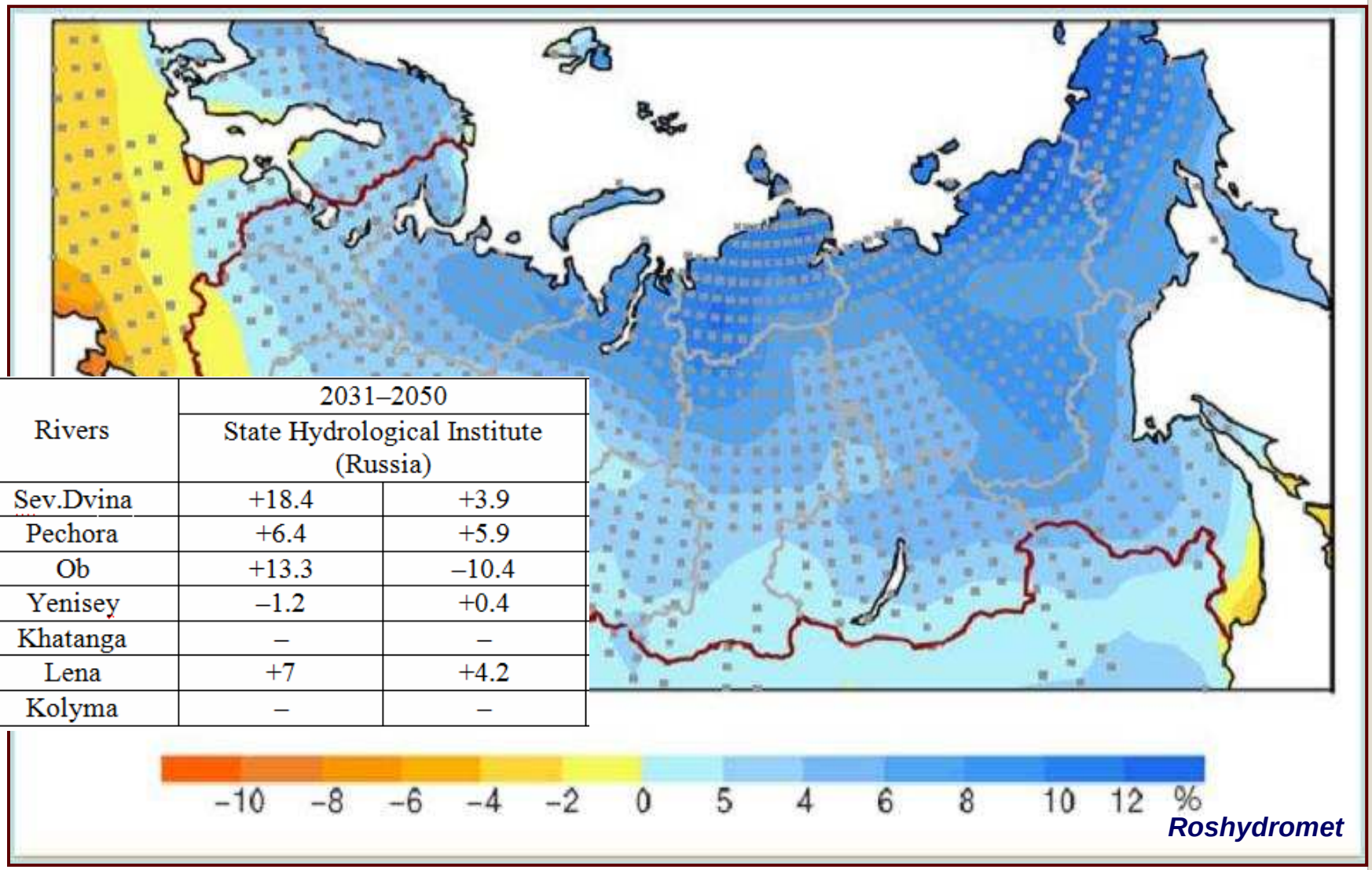
0,01 и меньше
0,01 - 0,1
0,1 - 0,5
0,5 - 1,0
1,0 - 5,0
10 - 50
50 - 100
100 - 500
1 000 - 2 000

Waste water discharges

0,01 - 0,1
0,1 - 1,0
1,0 - 5,0
10 - 50
50 -100
100 - 500
1 000 - 2 000

Expected changes in annual runoff of Russian Arctic rivers

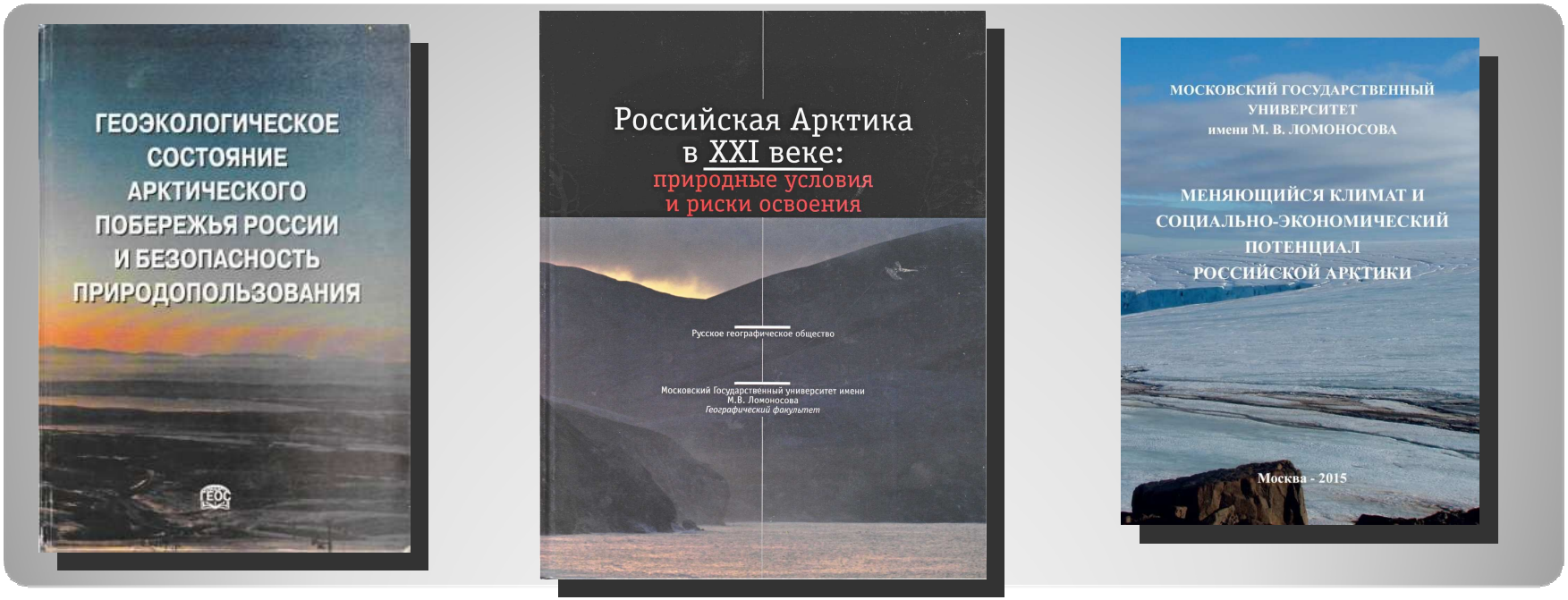
(% relative to the runoff value in1961-1990 (map) and in1980-1999 (table))



Rivers	2031–2050	
	State Hydrological Institute (Russia)	
Sev.Dvina	+18.4	+3.9
Pechora	+6.4	+5.9
Ob	+13.3	–10.4
Yenisey	–1.2	+0.4
Khatanga	–	–
Lena	+7	+4.2
Kolyma	–	–

River basin	2004–2013		2025–2030	
	water withdrawal	Water waste	water withdrawal*	Water waste
Rivers of the Murmansk region	1794	1739	No data	No data
Onega	10,4	8,8	17,3	15,1
Sev.Dvina	697	610	2121	1997
Mezen	1,0	0,7	2,8	1,7
Pechora	420	352	745	618
Ob	13762**	8748**	16300**	No data
Pur	97,2	35,9	129	40,4
Taz	1,9	1,2	2,7	0,6
Yenisei	3009	2633	10060	8818
Lena	298	295	408	320
Yana	6,6	4,3	9,9	6,6
Indigirka	7,5	4,0	12,5	9,8
Alazeya	0,11	No data	0,11	No data

* from surface and underground sources (damage to runoff – irreversible water losses); ** data on water consumption in the territory of Kazakhstan and PRC are unavailable; in parentheses – rough data



THANK YOU FOR ATTENTION!

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