Changes of sediment flux of secondary branches at pan-Arctic deltas

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In this report we investigate possible influence of climate warming on the delta morphology of the rivers flowing in permafrost and emptying into the Arctic Ocean. **(1)** All rivers under consideration (Table) show increase trends of annual water discharge <*Q*>. Even at the delta head of Kolyma River <*Q*> increases despite of two dams regulating water flow *W* at the upper stream of the river. Modern data were obtained from [Shiklomanov et al., 2020]. **(2)** Our recent investigations of water flow *W* distribution among delta branches of the rivers Lena and Mackenzie show redistribution of the flow into the secondary channels as water flow at the delta head increases [Dolgopolova, Isupova, 2020]. The behaviour of other deltas displays the same pattern. The estimate of long-term change of flow distribution at the deltas is presented in the Table and in Figures (???). (3) Assuming distribution of sediment flow W_S redistributes accordingly to the *W* we research the effect of W_S increase at the secondary branches on the sediment deposition located at the deltas sea edges by cosmic images.

River deltas at the circum-Arctic map of permafrost and ground ice conditions from National Snow and Ice Data (Last modified May 12, 2011) https://databasin.org/datasets/

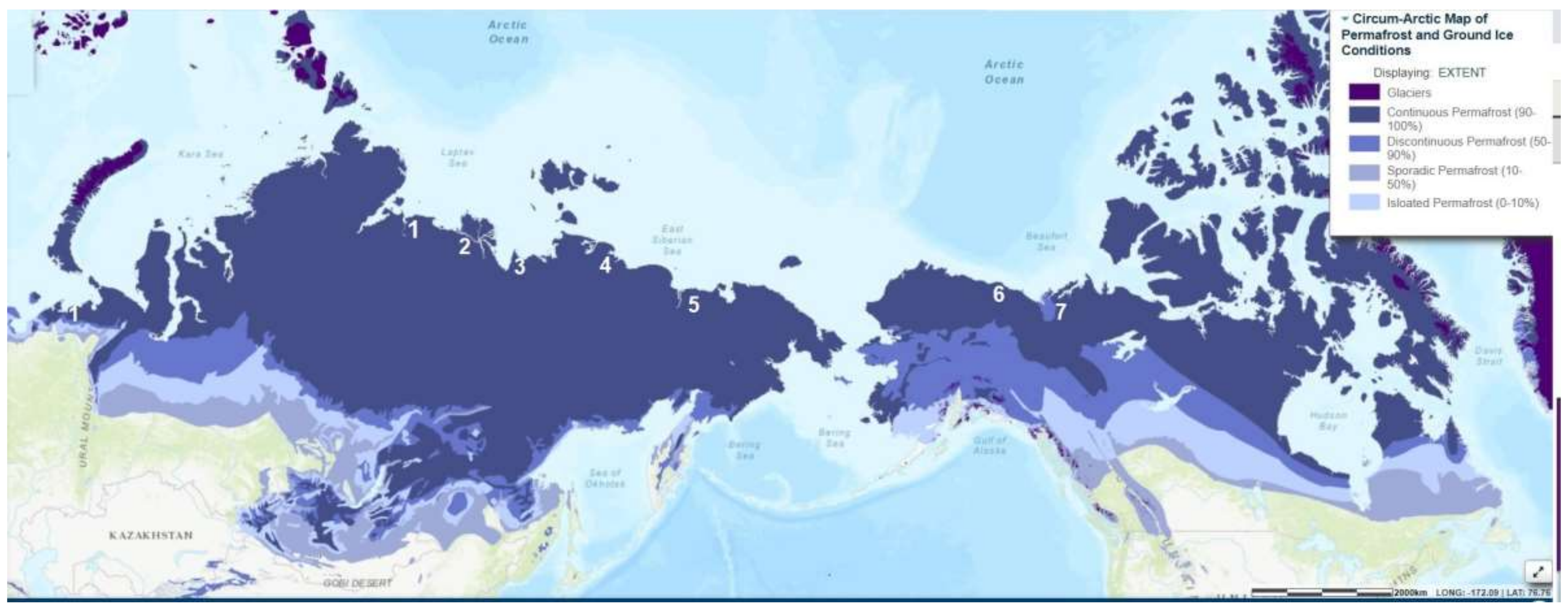
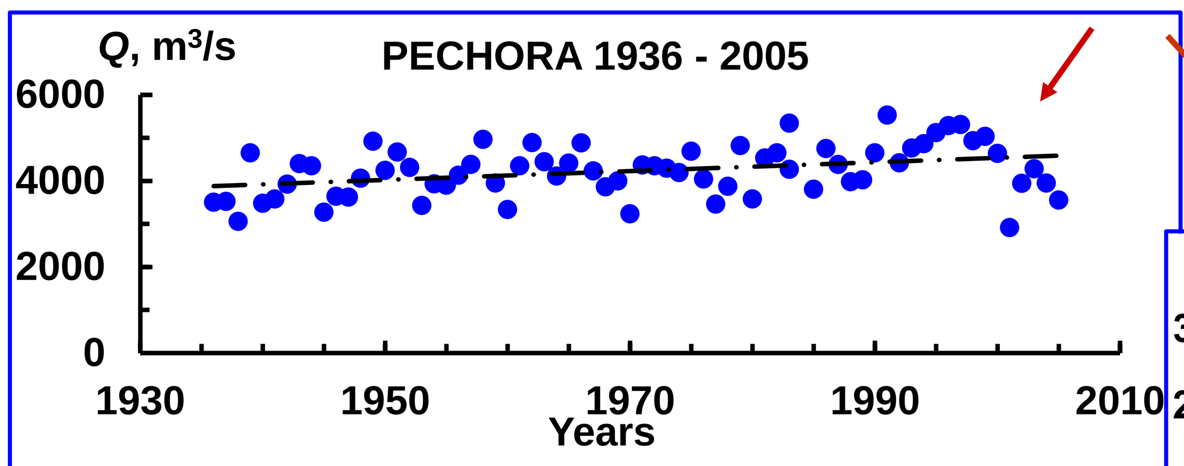


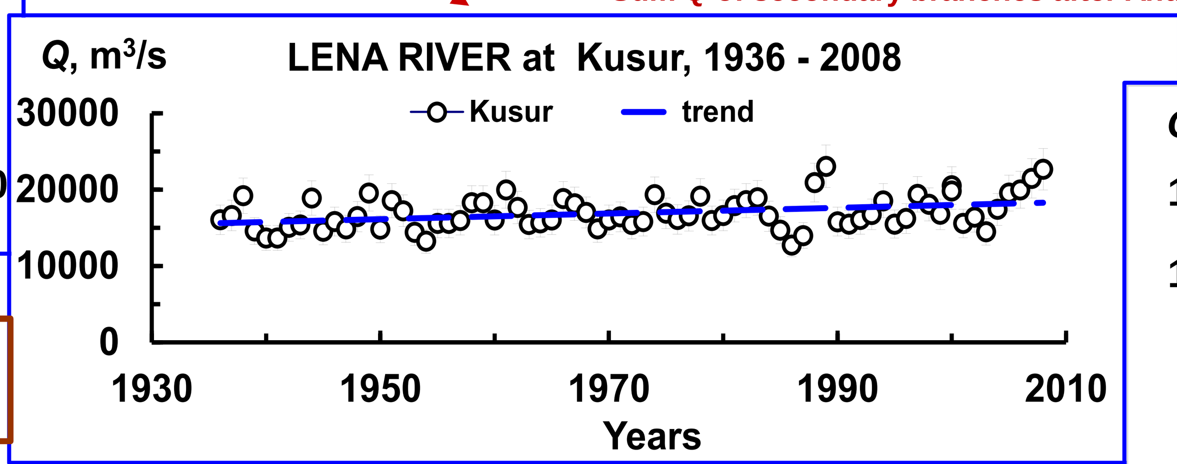
Table notations: <*Q*>, W_s average annual discharge and sediment flow at delta head, $Q'=Q/\langle Q\rangle$, $Q_{br\ modern}$, Q_{brmax} modern flow distribution due to climate warming and to spring maximal *Q* at delta head

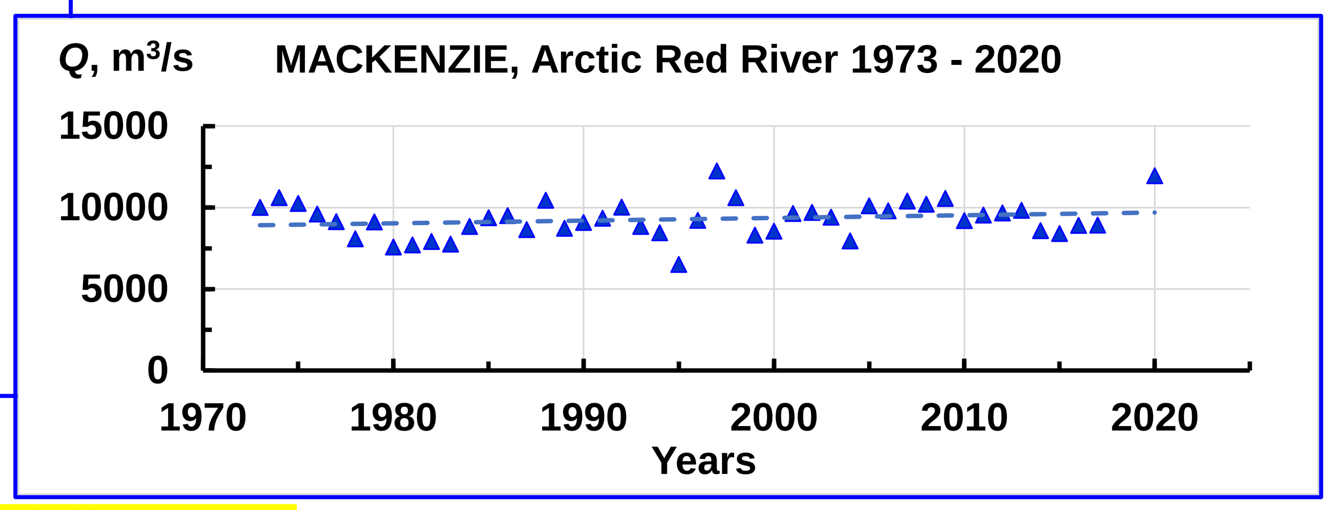
River, branches	<Q>, m³/s	Q', %/yr	$Q_{br\ modern}$, %	$Q_{br\ max}$, %	W_s, $W_{s\ br}\cdot10^6$ t/yr
Lena (2):	17178	0.16			22.7
Olenekskaya			5.49	9.58	1.25
Tumatskaya			4.19	11.90	0.95
Bykovskaya			27.38	28.65	6.22
Mackenzie (6):	9261	0.21			128
West			4.63	7.46	5.93
East			1.24	2.71	1.59
Pechora* (1)	4234	0.15	44	67.15	8.5/1.71
Kolyma (5)	3320	0.11	–	–	12.3/3.16
Indigirka (4)	1603	0.18	7.89	11.10	11.9/0.94
Yana (3)	1063	0.56	27.84	73.22	4.2/1.17
Sagavanirktok (7):	132	1.2			1.0
East 2			9.72	50.58	0.1
East 3			0.18	3.85	0.002

*Sum *Q* of secondary branches after Andeg node at M. Pechora, for which Q modern= 45.78 % Q at the delta head

1. Examples of increasing Q trends at the delta heads



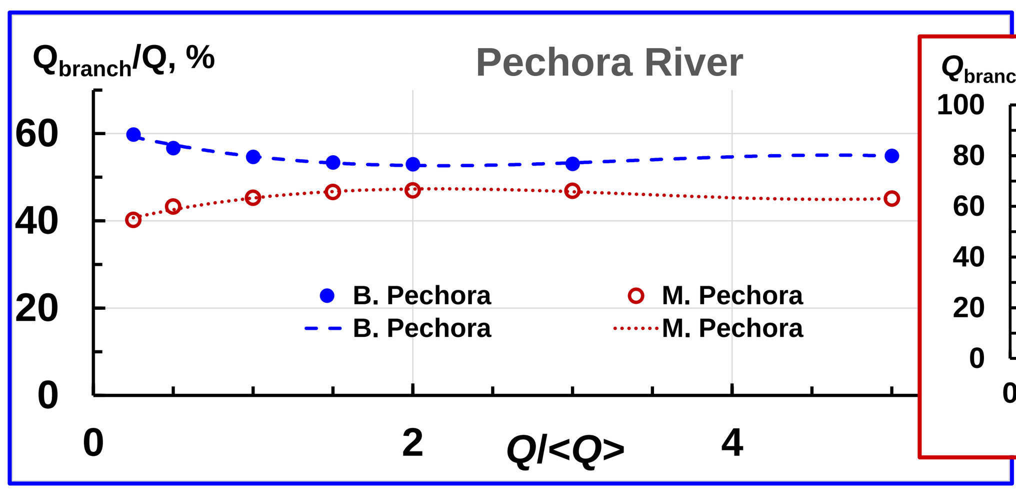


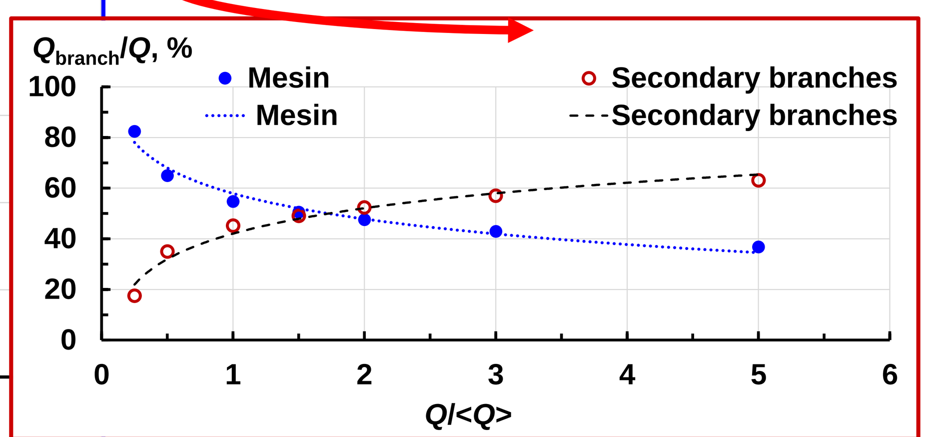


2. Distribution of river flow among delta channels as a function of Q at the delta heads

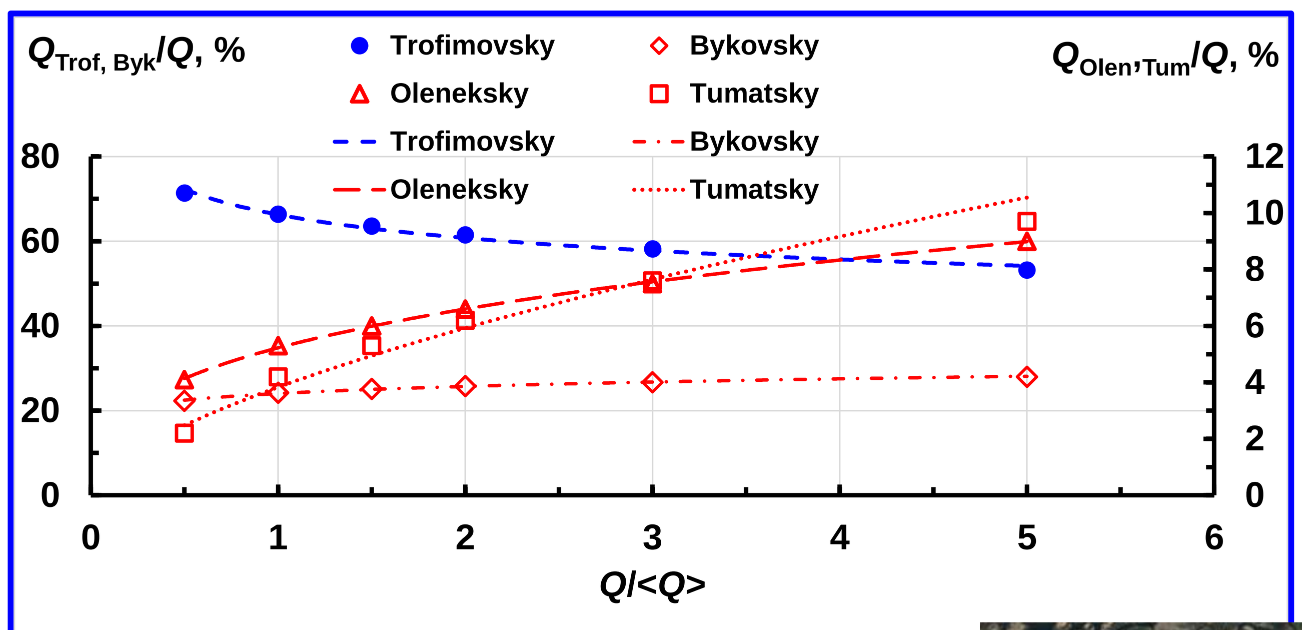
Flow at two main branches Bolshaya and Malaya Pechora, and flow distribution after Andeg mode

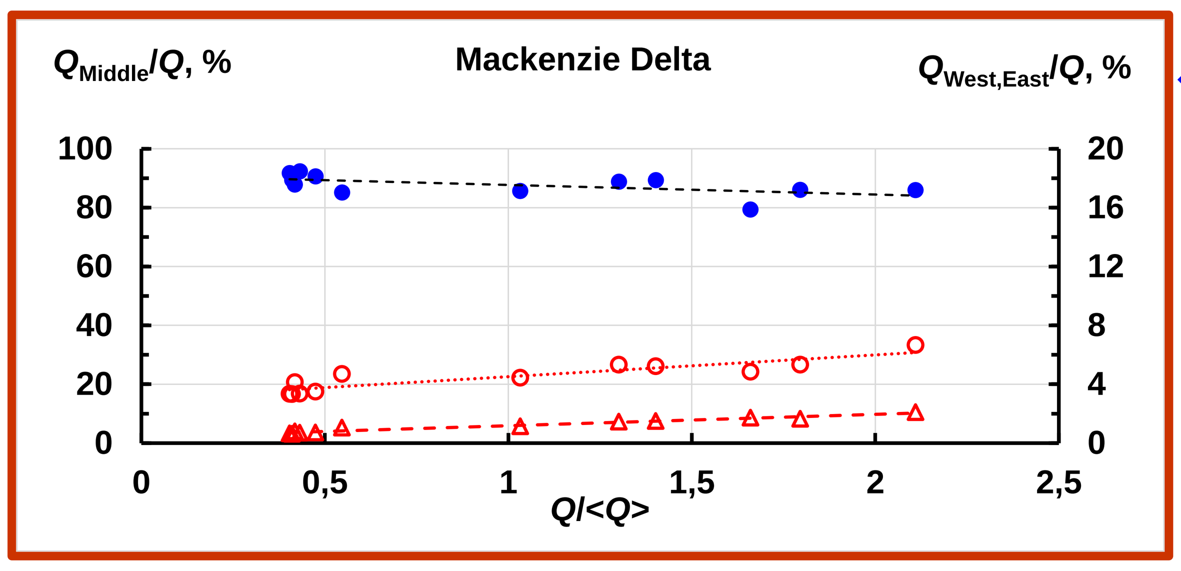
Data *Q* shares of branches of Russian Deltas were borrowed from [Magritskiy et al., 2013]



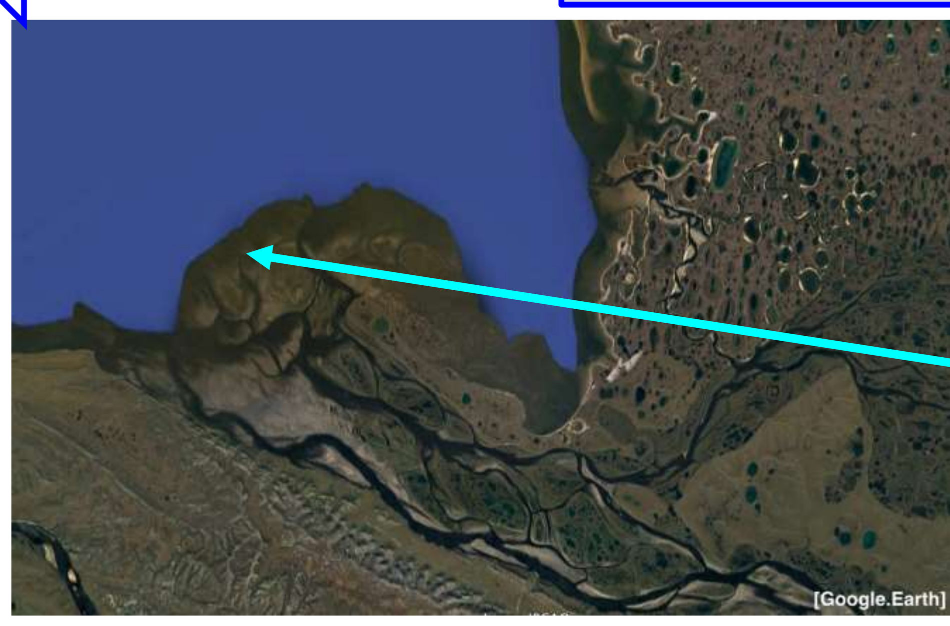


LENA DELTA



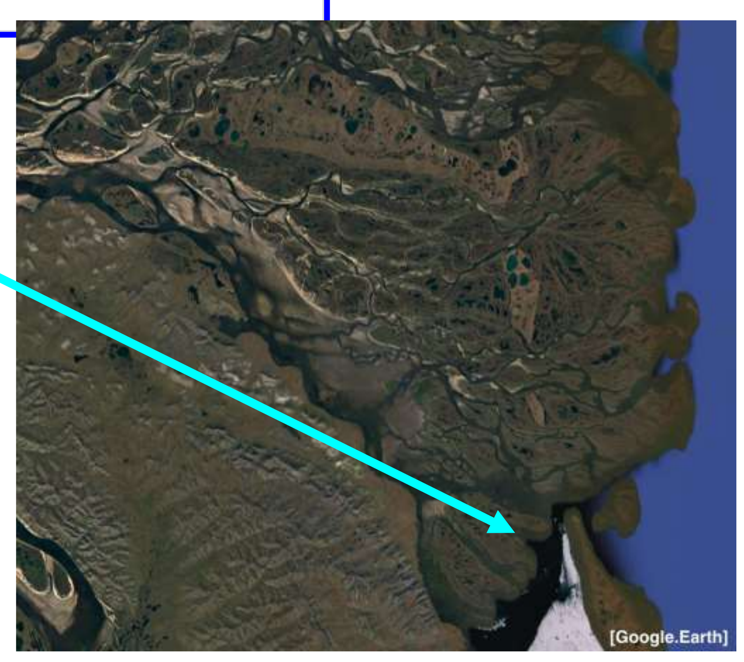


https://wateroffice.ec.gc.ca
[Carson et al., 1998]



[GoogleEarth, 03.06.2021]

Bykovskiy Channel, Length of mouth bar – 20 km
Olenekskiy Channel Length of mouth bar – 28 km
[Mikhailov, 1997]



3. Examples of images of delta sea edges and mouth bars

CONCLUDING REMARKS

- ✓ Increasing long-term *Q* trends were obtained for all pan-Arctic rivers, including strongly regulated Kolyma R.
- ✓ Investigation of river flow distribution between delta branches shows its dependence on the magnitude of *Q* at the delta head: the larger Q, the higher the shear of the secondary branches flow.
- ✓ This pattern enables one to predict the increase of sediment flow at the secondary branches and settling-out at their mouths in case of catastrophic increase of *Q* at the delta head.

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