VN Sukachev Institute of forest SB RAS, Krasnoyarsk

Fluxes of chemical elements from Central Siberian Plateau watersheds, underlain by permafrost

R A Kolosov, A S Prokushkin, O S Pokrovsky

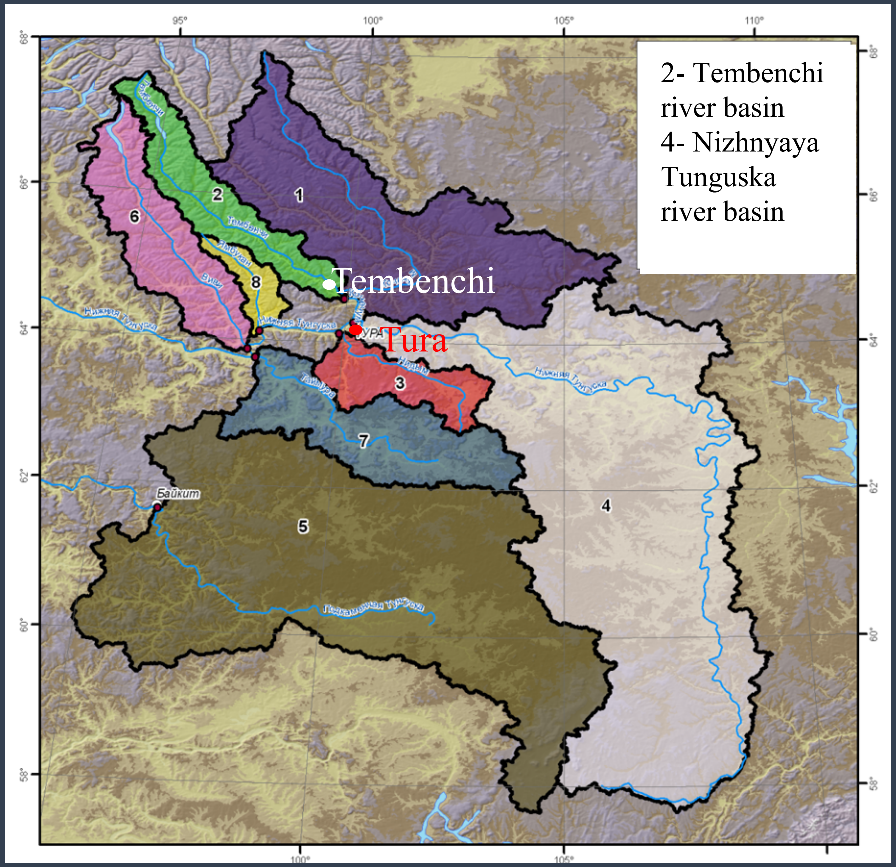
Tomsk, 2016

Purpose

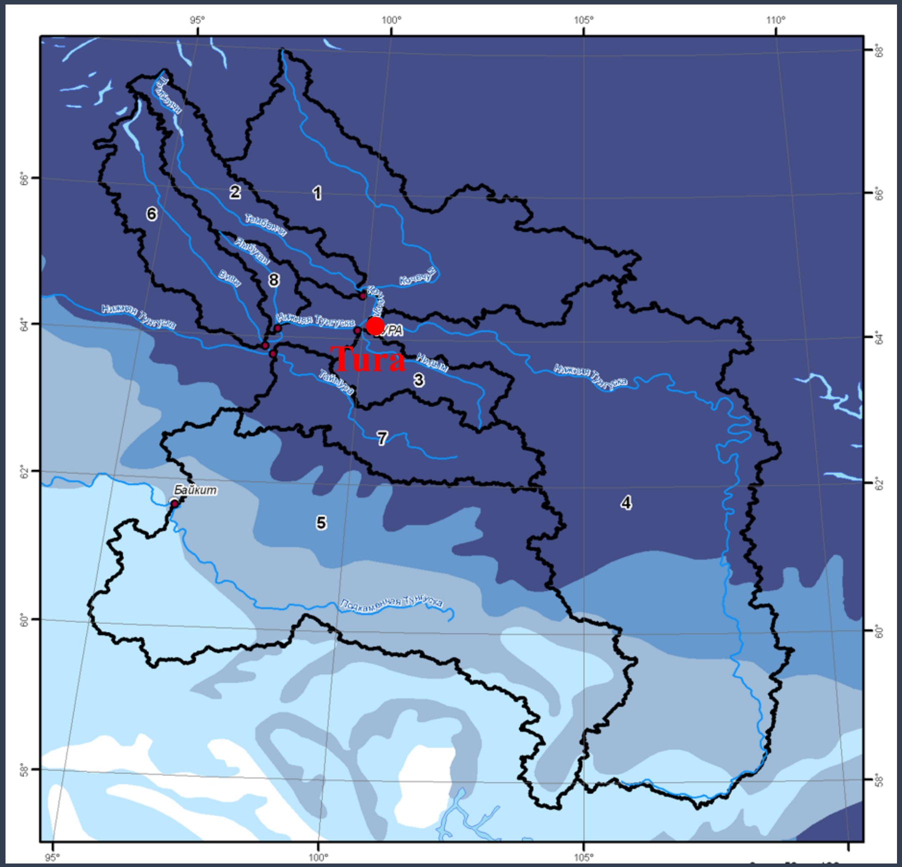
- Our objective was to estimate elements' fluxes (HCO_3^-, SO_4^{2-}, Cl^-, Ca^{2+}, Mg^{2+}) from the Nizhnyaya Tunguska river basin (for the period 1970-2011) and from the Tembenchi river basin (for the period 1960-2011).

Studied area

Picture 1 – Nizhnyaya Tunguska river and Tura location

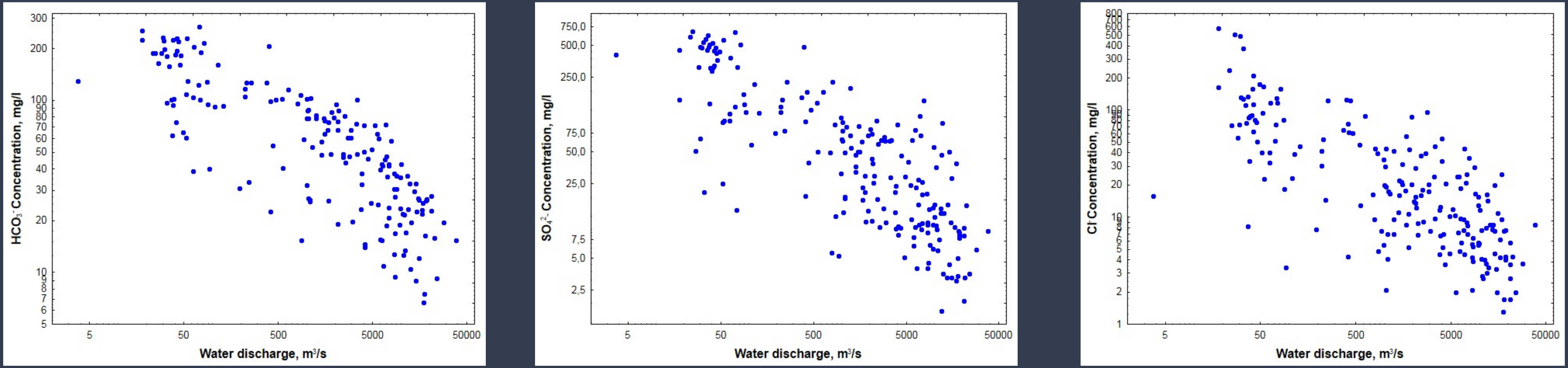


Picture 2 – Studied watersheds



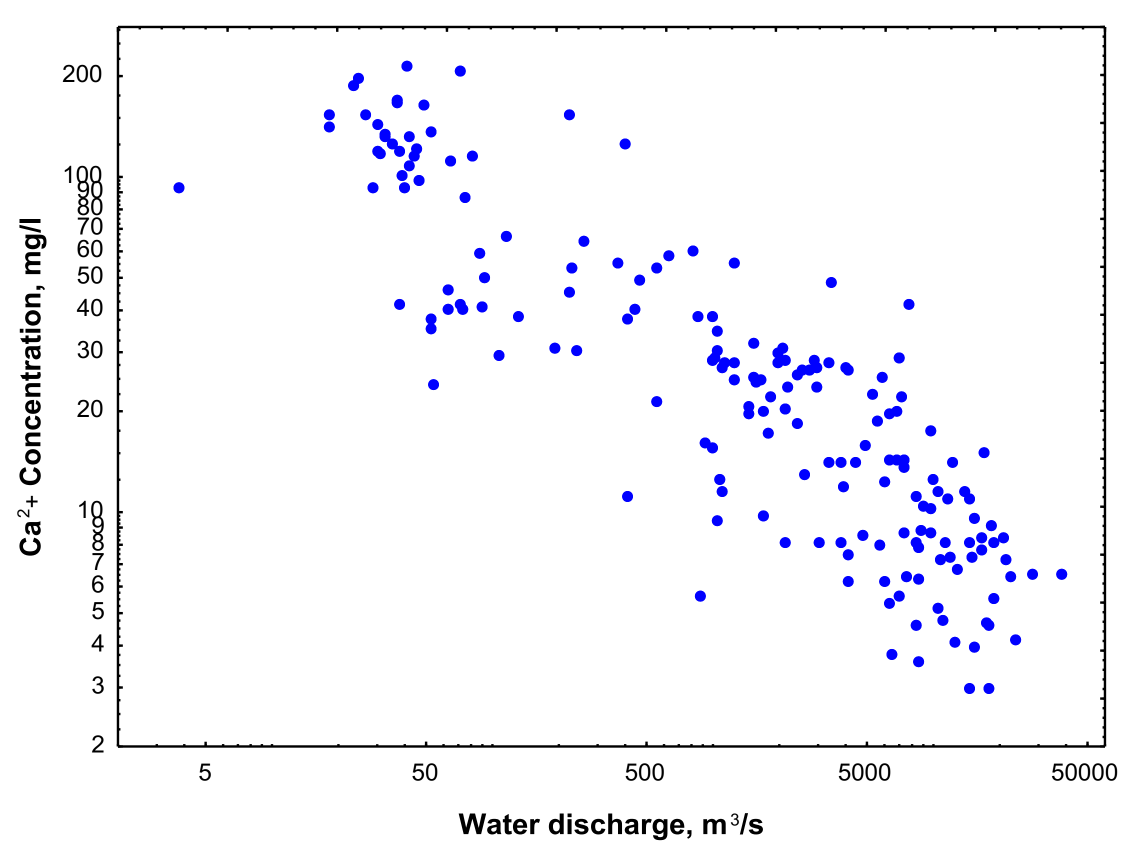
Picture 3 – Permafrost distribution on studied watersheds

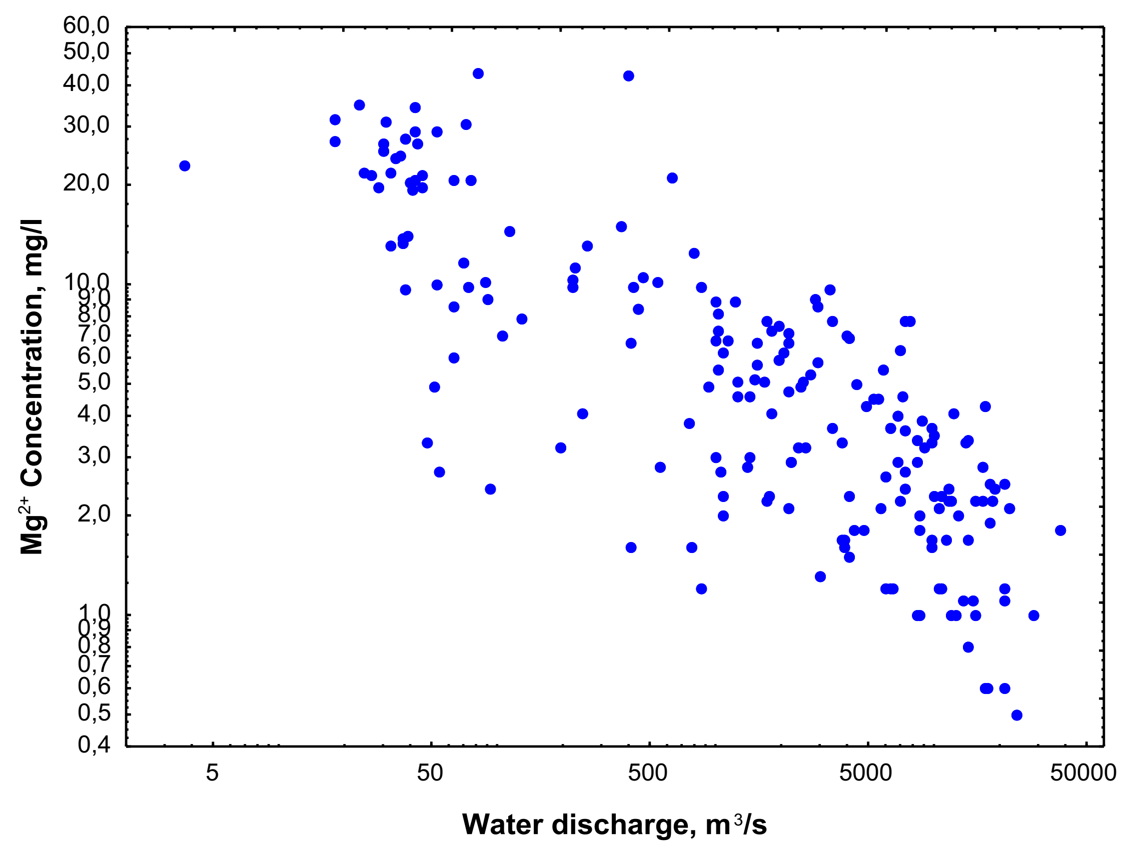
Anions’ concentration



Picture 4 – Anions’ concentration depending on water discharge for Nizhnyaya Tunguska river

Cations' concentration





Picture 5 – Anions' concentration depending on water discharge for Nizhnyaya Tunguska river

Calculating daily fluxes

- 1) elements' concentrations were multiplied by water discharges for all available dates;
- 2) then, we analyzed fluxes (F) dependence on water discharges (Q) for each anion and cation and we found that this dependence could be described by the function $F = a \times Q^{b}$ most significantly (*a* and *b* – coefficients).

Confidence levels (p) for *a* and *b* were obtained with using STATISTICA 10 and all coefficients for entire period and all anions had necessary reliability ($p \leq 0.05$, or $p \geq 95\%$).

Calculating daily fluxes

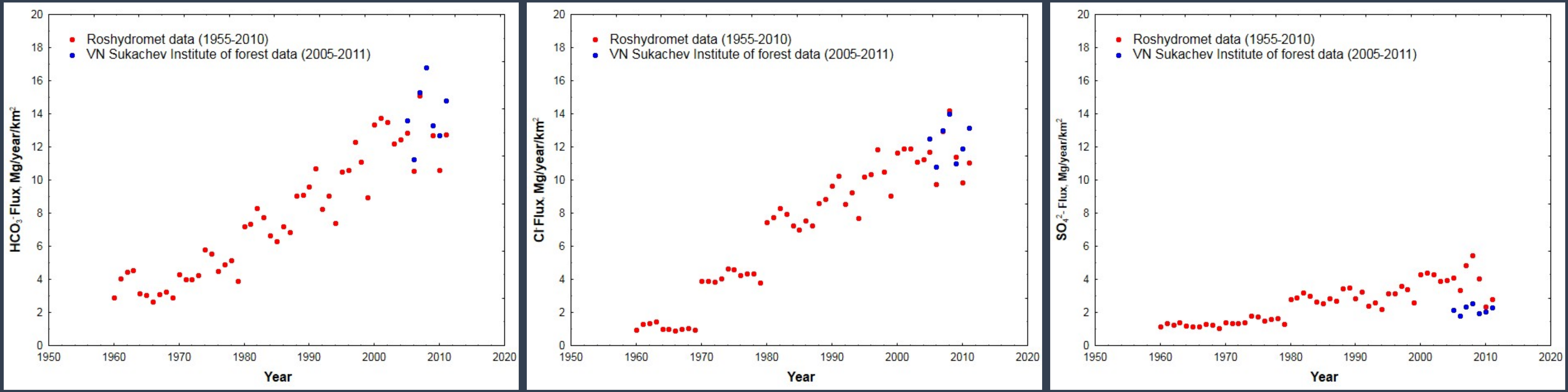
Period	Ion	Coef. a	p-level (a)	Coef. b	p-level (b)
1960-1969	HCO_3^-	20038,23	0,000003	1,171	0,001476
	Cl^-	5976,057	0,000055	1,063	0,017121
	SO_4^{2-}	2976,988	0,000000	0,428	0,013514
	Ca^{2+}	7197,703	0,000005	0,806	0,016817
	Mg^{2+}	1714,972	0,000018	0,713	0,043399
1970-1979	HCO_3^-	14068,43	0,000000	0,539	0,000028
	Cl^-	6310,600	0,000000	0,218	0,000794
	SO_4^{2-}	3683,467	0,000000	0,414	0,000366
	Ca^{2+}	5302,807	0,000000	0,580	0,000005
	Mg^{2+}	1210,830	0,000000	0,438	0,000095
1980-1989	HCO_3^-	24360,5	0,000000	0,568	0,000000
	Cl^-	15447,6	0,000000	0,323	0,029846
	SO_4^{2-}	8052,0	0,000000	0,472	0,000164
	Ca^{2+}	9645,6	0,000000	0,508	0,000001
	Mg^{2+}	2204,6	0,000000	0,648	0,000000
1990-1999	HCO_3^-	26185,72	0,000000	0,561	0,000000
	Cl^-	17955,52	0,000000	0,378	0,000152
	SO_4^{2-}	9237,222	0,000000	0,644	0,000182
	Ca^{2+}	10318,62	0,000000	0,544	0,000000
	Mg^{2+}	2582,497	0,000000	0,572	0,000000
2000-2009	HCO_3^-	35356,4	0,000000	0,558	0,000000
	Cl^-	25688,5	0,000001	0,431	0,010474
	SO_4^{2-}	11703,7	0,000000	0,582	0,000129
	Ca^{2+}	11325,5	0,000000	0,446	0,000009
	Mg^{2+}	3171,8	0,000000	0,530	0,000000
2010-2011	HCO_3^-	31632,7	0,000000	0,556	0,000035
	Cl^-	19263,5	0,000112	0,347	0,016350
	SO_4^{2-}	6435,0	0,000000	0,509	0,000005
	Ca^{2+}	10669,7	0,000001	0,508	0,000178
	Mg^{2+}	4014,2	0,000264	0,642	0,007329

Table 1 – Coefficients *a* and *b* and their p-levels for Nizhnyaya Tunguska river

Period	Ion	Coef. a	p-level (a)	Coef. b	p-level (b)
1970-1979	HCO_3^-	3217,723	0,001020	0,423	0,001740
	Cl^-	1802,189	0,000082	0,501	0,000011
	SO_4^{2-}	4941,416	0,038101	1,172	0,000249
	Ca^{2+}	1353,593	0,001805	0,473	0,001880
	Mg^{2+}	577,1896	0,000034	0,6731	0,000000
1980-1989	HCO_3^-	4947,875	0,000000	0,554	0,000000
	Cl^-	2466,435	0,019524	0,642	0,003189
	SO_4^{2-}	2907,815	0,000003	0,751	0,000000
	Ca^{2+}	1884,785	0,000000	0,561	0,000000
	Mg^{2+}	499,7260	0,000000	0,6654	0,000000
1990-1993	HCO_3^-	4542,223	0,000275	0,595	0,000215
	Cl^-	1899,489	0,002498	0,667	0,001403
	SO_4^{2-}	11229,86	0,001192	1,50	0,000004
	Ca^{2+}	1600,872	0,001867	0,478	0,003851
	Mg^{2+}	1067,322	0,001557	1,114	0,000037
2005-2011	HCO_3^-	8878,808	0,000000	0,660	0,000000
	Cl^-	292,8361	0,000000	0,1464	0,006145
	SO_4^{2-}	273,3801	0,000000	0,6267	0,000000
	Ca^{2+}	1497,382	0,000036	0,396	0,000025
	Mg^{2+}	552,4593	0,000000	0,5802	0,000000

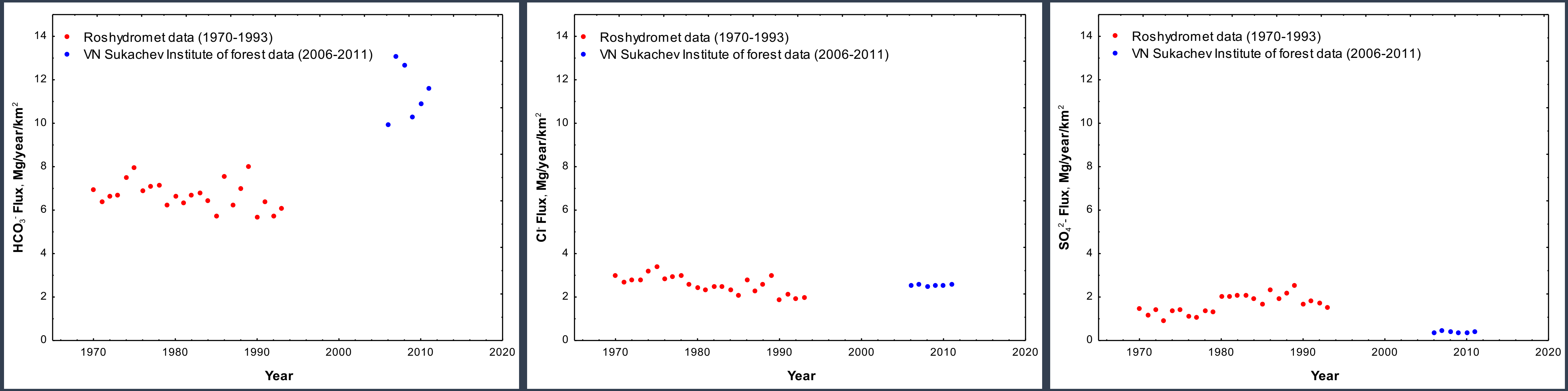
Table 2 – Coefficients *a* and *b* and their p-levels for Tembenchi river

Anions’ fluxes



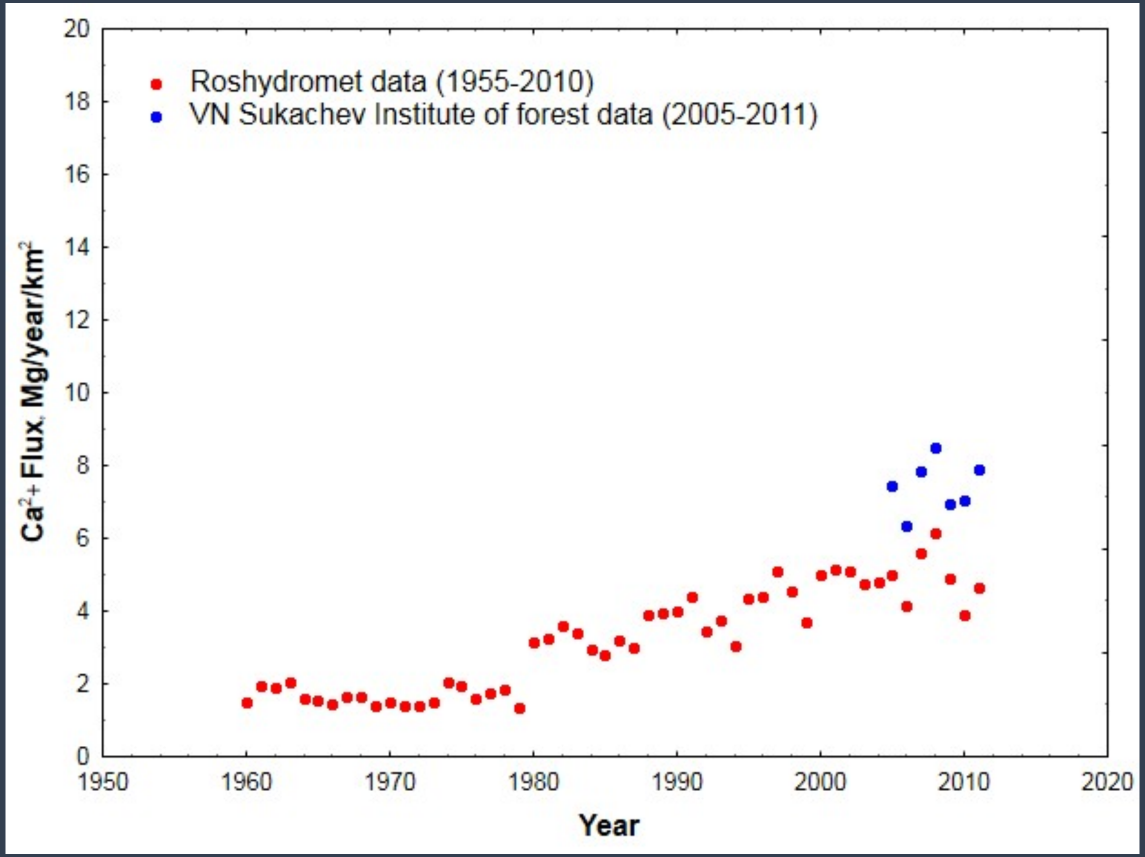
Picture 6 – Annual anions’ fluxes from Nizhnyaya Tunguska watershed (1955-2011)

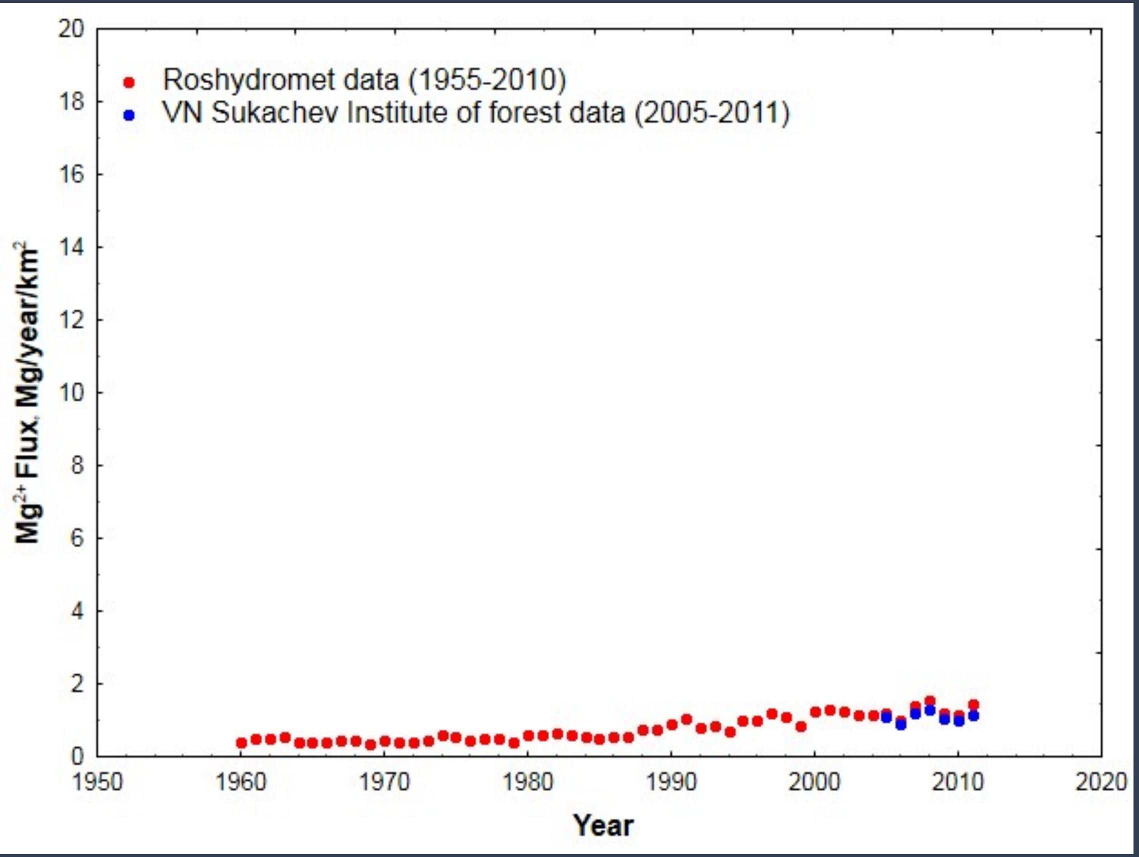
Anions’ fluxes



Picture 7 – Annual anions’ fluxes from Tembenchi watershed (1970-1993, 2006-2011)

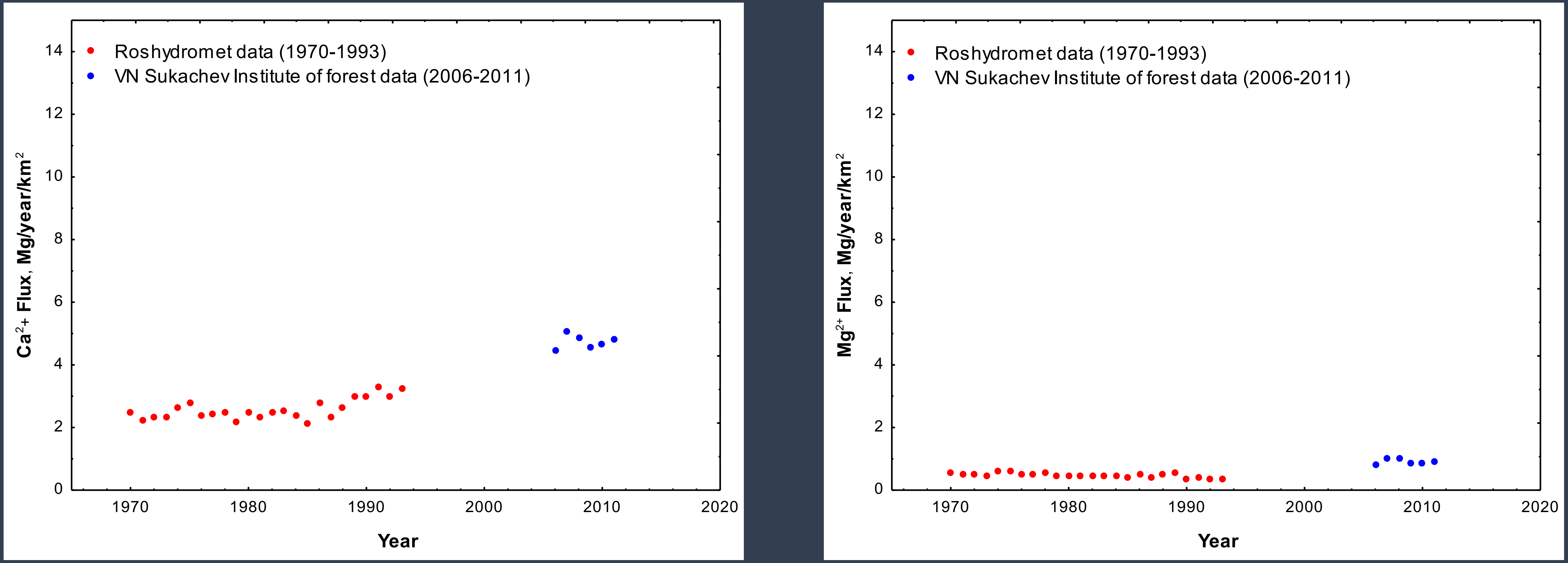
Cations' fluxes





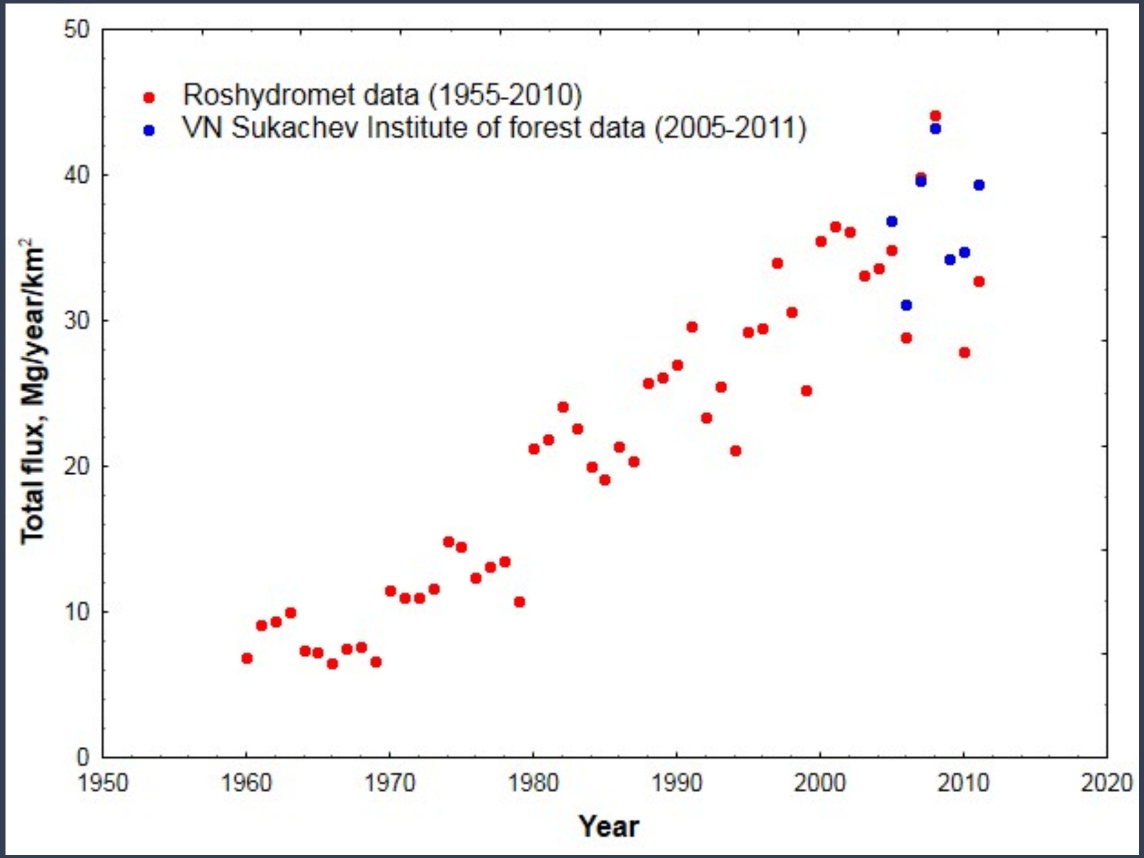
Picture 8 – Annual cations' fluxes from Nizhnyaya Tunguska watershed (1955-2011)

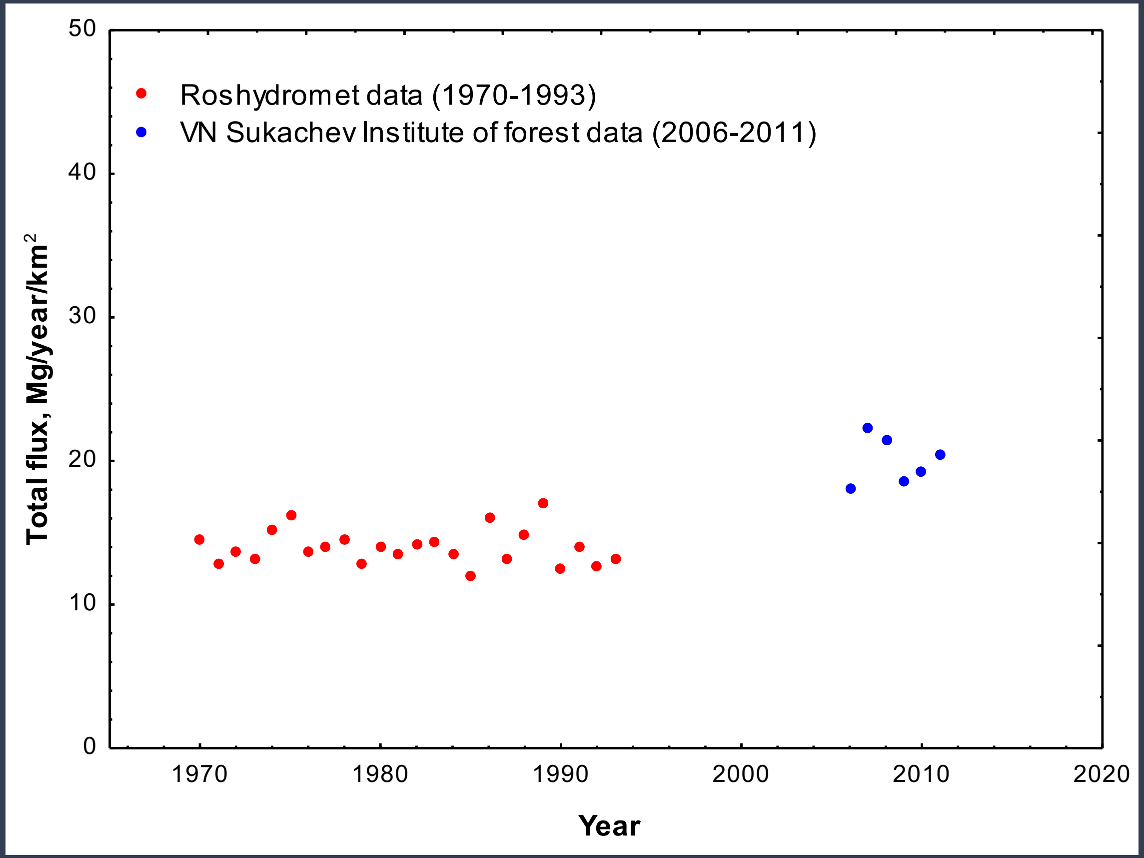
Cations' fluxes



Picture 9 – Annual cations' fluxes from Tembenchi watershed
(1970-1993, 2006-2011)

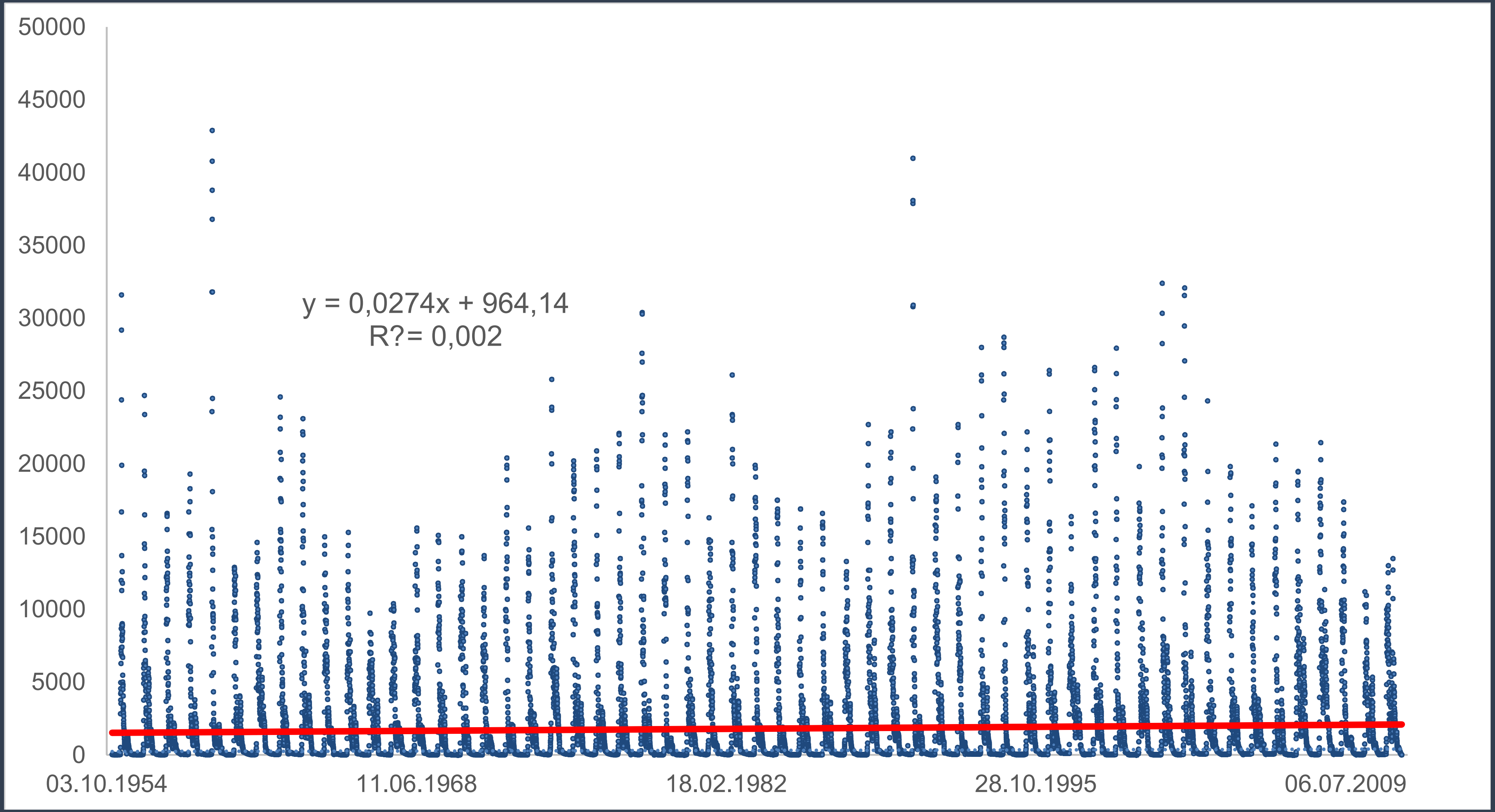
Total flux





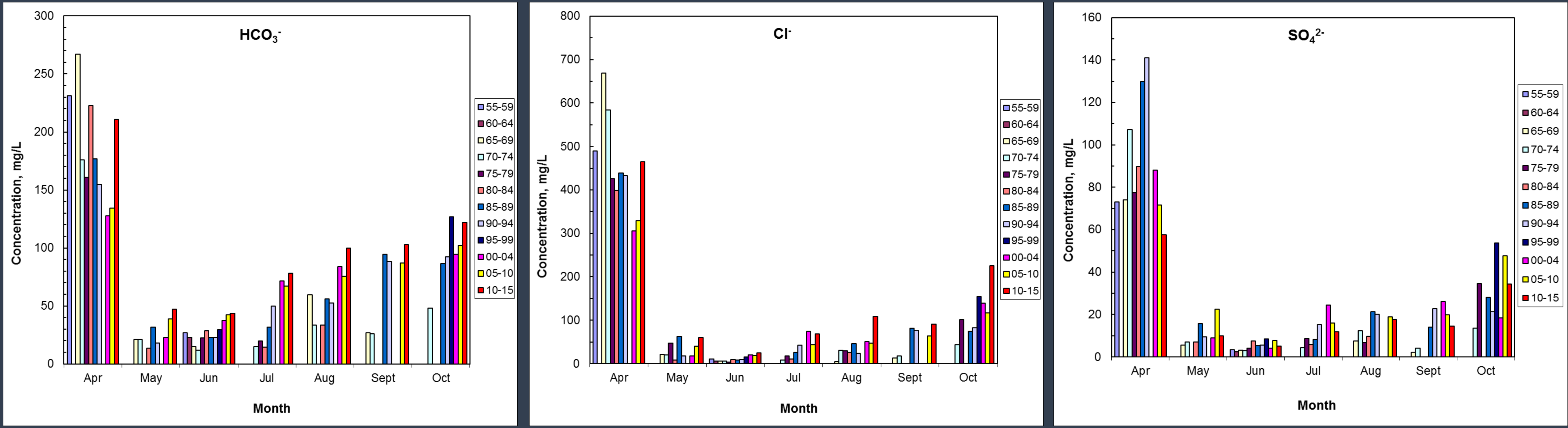
Picture 10 – Total fluxes from Nizhnyaya Tunguska and Tembenchi watersheds for entire periods

Water discharge for entire period



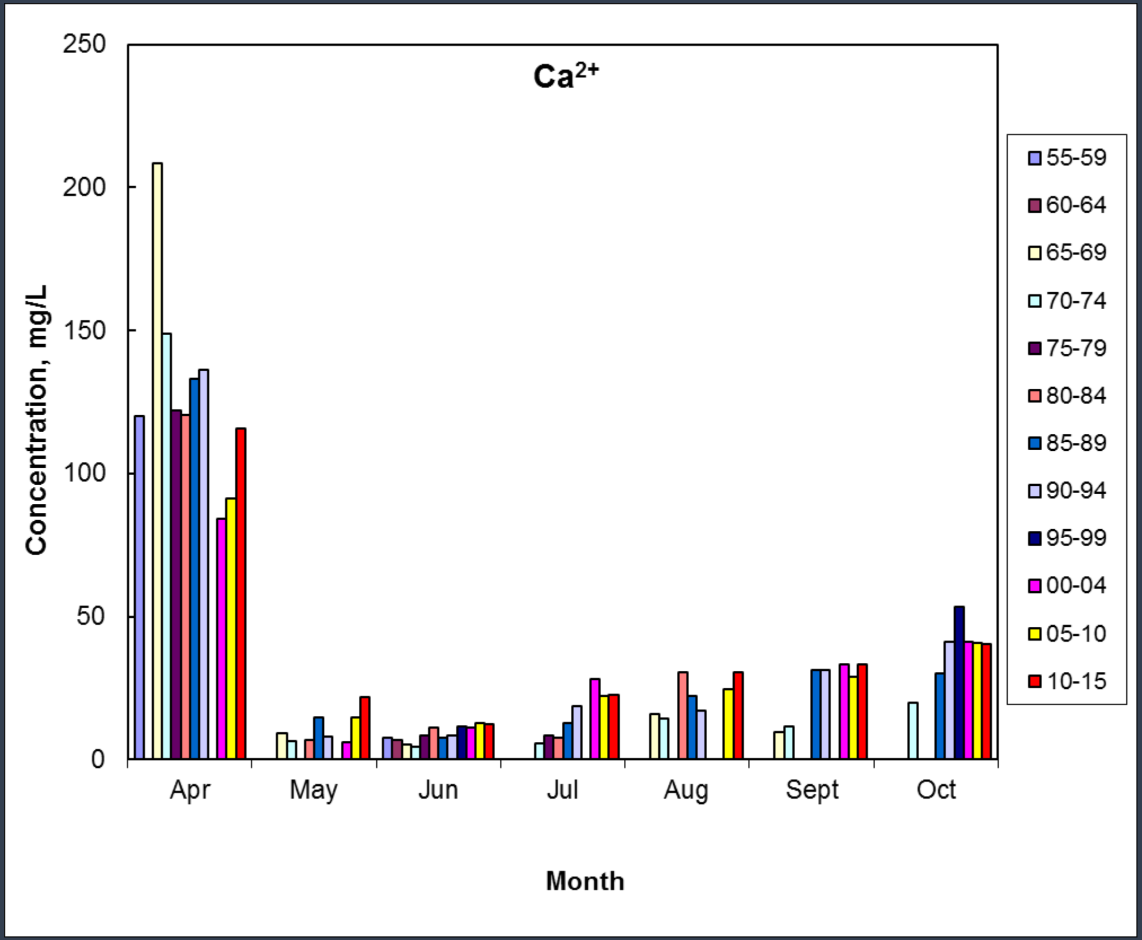
Picture 11 – Water discharge for Nizhnyaya Tunguska from 1955 to 2011

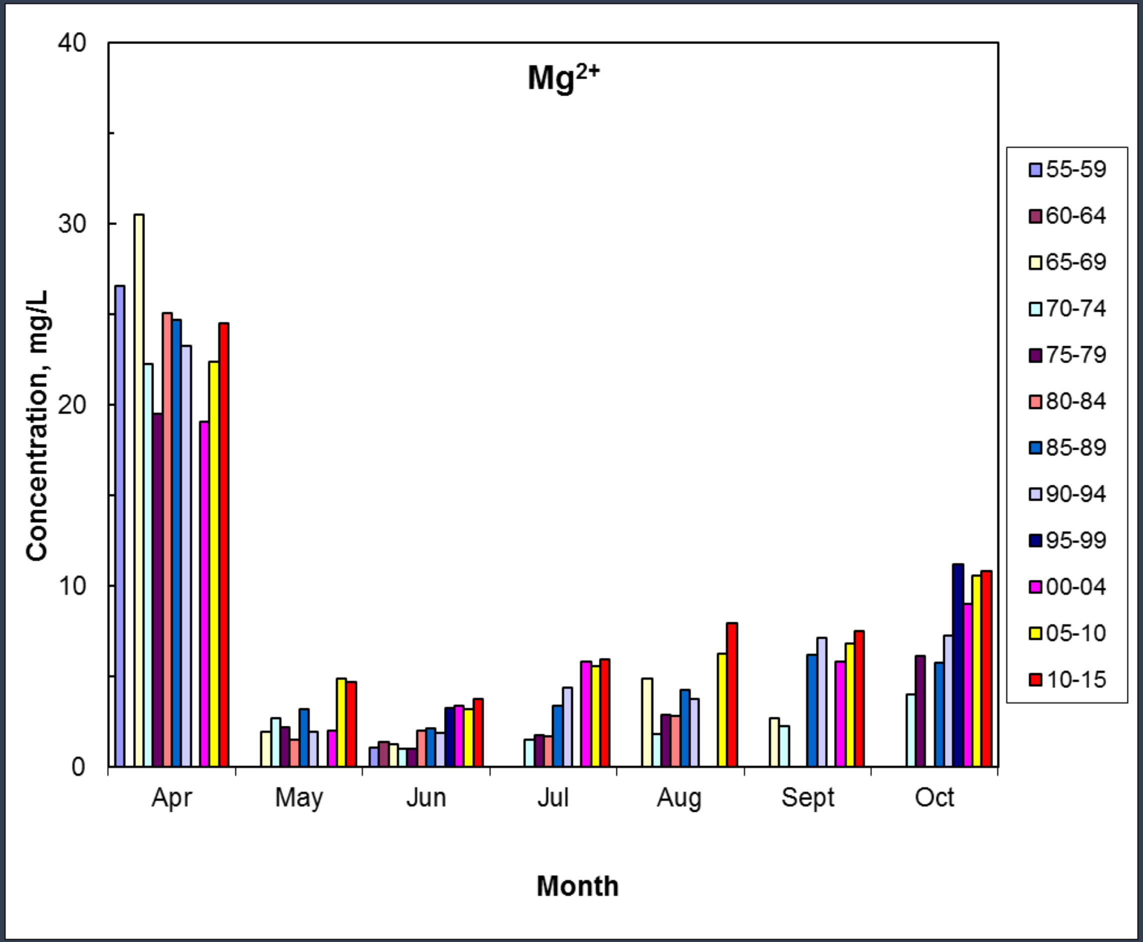
Volume-weighted mean



Picture 12 – Volume-weighted concentration of anions for Nizhnyaya Tunguska river

Volume-weighted mean





Picture 13 – Volume-weighted concentration of cations for Nizhnyaya Tunguska river

Conclusion

- **Total fluxes of studied anions and cations from Nizhnyaya Tunguska and Tembenchi watersheds have been increased for entire period. Possibly, it has been caused by permafrost degradation.**

- This study was financially supported by RSF Grant # 14-24-00113.

- I would like to thank Anatoly Prokushkin and Oleg Pokrovsky for their help in this study.

Thank you for your attention!