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Dynamics of vegetation cover and quantitative paleoclimate reconstructions in Western Sayan Mountains from Late Glacial to the present time according to palynological study

of Yuzhno-Buybinskoe mire

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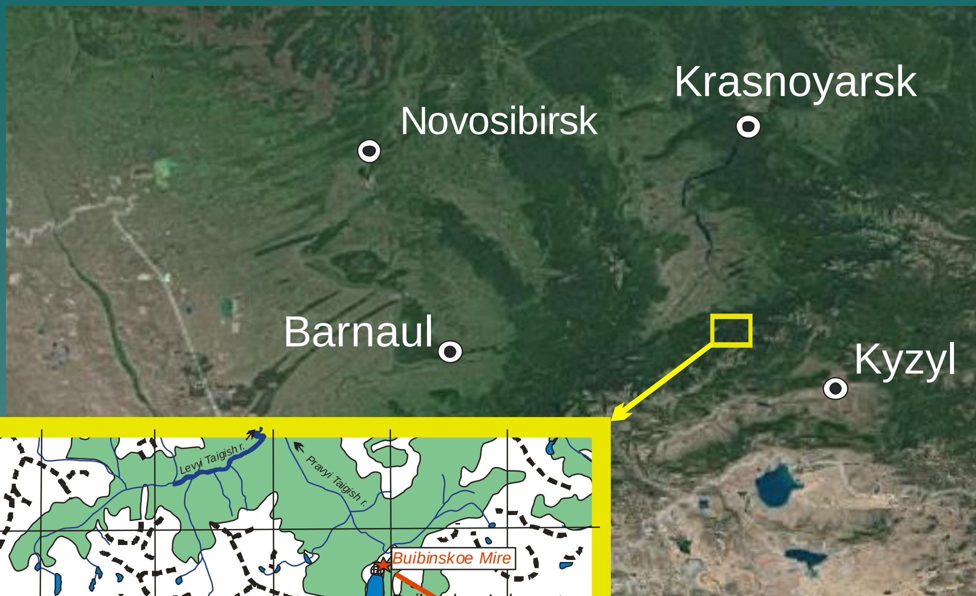
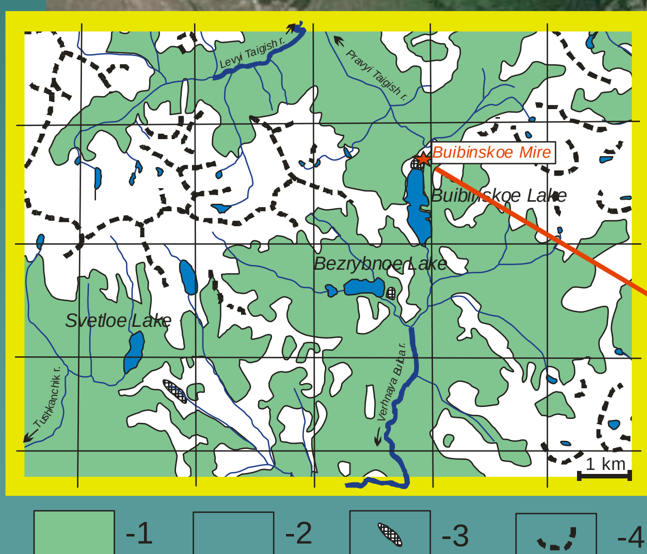
Location of Yuzhno-Buibinskoe mire in Western Sayan Mountains





1 - dark coniferous mountain taiga
2 - alpine vegetation
3 - peat mires
4 - mountain crests

- For palaeogegraphic aim mountain mire Yuzhno-Buibinskoye (52 ° 50'22 "N, 93 ° 31'23''S, 1377 m a.s.l.) located at the northern edge of the high-mountain Buibinskoye Lake in the Ergaki Nature Reserve of Western Sayan Mountains (Fig. 1) in south Siberia (Russia) have been investigated by spore-pollen and radiocarbon methods. Basing on pollen data a quantitative palaeoclimatic reconstructions were performed.

The lake has outlet to south flowing Buiba River. The hollow of lake and mire have glacial origin. In the mire 600 cm sediments are composed mostly by lake sediments – gyttja. Sedge-moss peat forms only upper 130 cm of sediments.

Geographical setting of study area

- Vegetation cover is represented by dark-coniferous mountain taiga with *Abies sibirica* and *Pinus sibirica* on its upper limit contacting with subalpine and alpine vegetation, above which nival altitudinal belt of Western Sayan is located.
- Most of precipitation came with Atlantic cyclones carried by westerlies. The climate is sharply continental with long and cold winters and short cool summers. The average January temperature is -20° - -25ºC, average temperature of July 10-12ºC, average annual temperature is -5,8ºC. Average annual precipitation is 346-1200 mm.

Methods

- Spore pollen analysis of peat-lake sediments was performed by traditional method (Moor et al., 1993).The spore-pollen diagram was constructed using the Tilia program (Grimm. 2004).

- Radiocarbon dating was made by LSC and AMS methods.

- For quantitative palaeoclimatic reconstructions based on palaeopollen data, we used our own transfer functions (table 2), based on transfer function model proposed by Ter Braak and co-authors (Ter Braak, 1989).

- The reconstruction of past climatic parameters (mean July T, mean January T, average annual precipitation) were carried out using the obtained transfer functions. For calculations, the program PAST 1.87b and Statistica 6.0 were used.

- Method “biomisation” have been used for reconstruction of past biomes basing on palaeopollen data (Prentice et al., 1996; Tarasov et al., 1998).

Methods

- Radiocarbon dating was made by LSC and AMS methods in radiocarbon laboratories in Novosibirsk (Russia) and in University of Georgia (USA). Radiocarbon dates were calibrated according to (Stuiver and Reimer, 1993).

Table 1. Radiocarbon dates for Yuzhno-Buibinskoe Mire peat-lake sediment core.

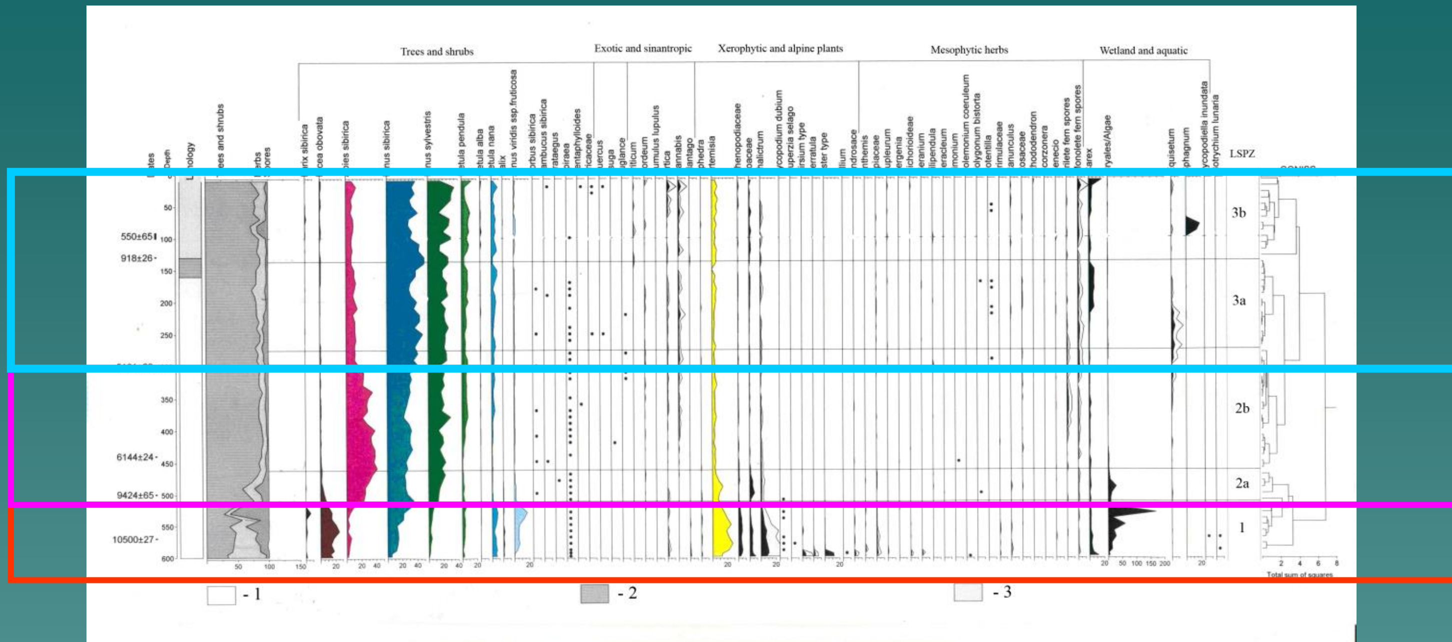
Depth from surface (cm)	Methos of dating	Uncalibrated 14C age (yr BP)	Calibrated 14C age (yr BP)	Laboratory №
90-100	LSC	550±65	577	СОАН-9039
290-300	AMS	5161±23	5920	NSK_UGAMS-21784
430-440	AMS	6144±24	7066	NSK_UGAMS-21805
500-501	AMS	9424±65	10512	UGAMS-4188
560-570	AMS	10500±27	12476	NSK_UGAMS-21785

Table 2. Transfer functions calculated by the weighted average method for 118 modern pollen spectra of the Altai-Sayan region

	Pinus sylvestris	*Pinus sibirica*	*Abies sibirica*	*Picea obovata*	*Larix sibirica*	*Betula pendula*	*Betula alba*	*Betula nana*	*Artemisia*
Mean January temperature transfer function									
Optimum	-22,3696	-23,9217	-19,6304	-23,8789	-24,4796	-20,1474	-21,2609	-22,4826	-27,8822
Tolerence	5,06748	5,44401	2,86387	5,55169	5,77281	3,30622	4,34973	4,85509	6,40755
Maximum	66,4336	66,1538	32,5397	32,6087	11,7647	65,415	17,7725	48,6772	85,6079
Mean July temperature transfer function									
Optimum	16,0256	15,2797	17,0553	15,8173	15,2419	16,6769	16,4126	15,5336	16,622
Tolerence	1,78663	1,68745	1,62067	1,73939	1,52726	1,45922	1,76083	1,67788	1,65888
Maximum	66,4336	66,1538	32,5397	32,6087	11,7647	65,415	17,7725	48,6772	85,6079
Mean annual precipitation transfer function									
Optimum	525,762	472,404	896,016	521,377	345,167	681,102	596,725	335,871	335,871
Tolerence	309,585	329,616	440,358	344,8	226,016	375,436	338,568	257,187	257,187
Maximum	66,4336	66,1538	32,5397	32,6087	11,7647	65,415	17,7725	85,6079	85,6079

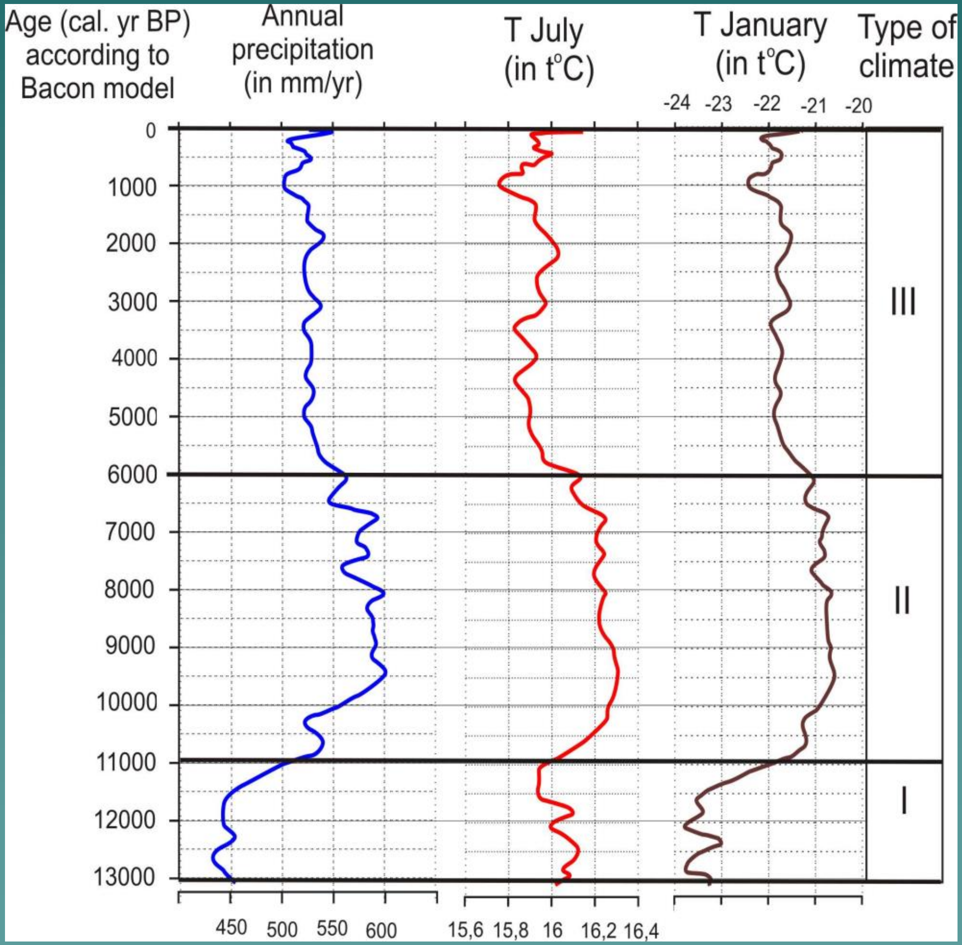
- For quantitative palaeoclimatic reconstructions based on pollen data, we used our own transfer functions (table 2), compiled by the weighted average method for 120 modern spore-pollen spectra (Blyakharchuk, 2017) and the corresponding climatic parameters. The optima of pollen taxa with respect to climatic indicators are defined as the weighted average of this indicator in modern pollen samples, and tolerance - as the error of the weighted average (Lakin, 1990). This is transfer function model proposed by Ter Braak and co-authors (Ter Braak, 1989).

Spores-pollen diagram of Yuzhno-Buibinskoe Mre reflects changes of the three main types of vegetation which dominated the study area from the Late Glacial to modern time and reflected in 3 main Local Spore Pollen Zones (LPZ):



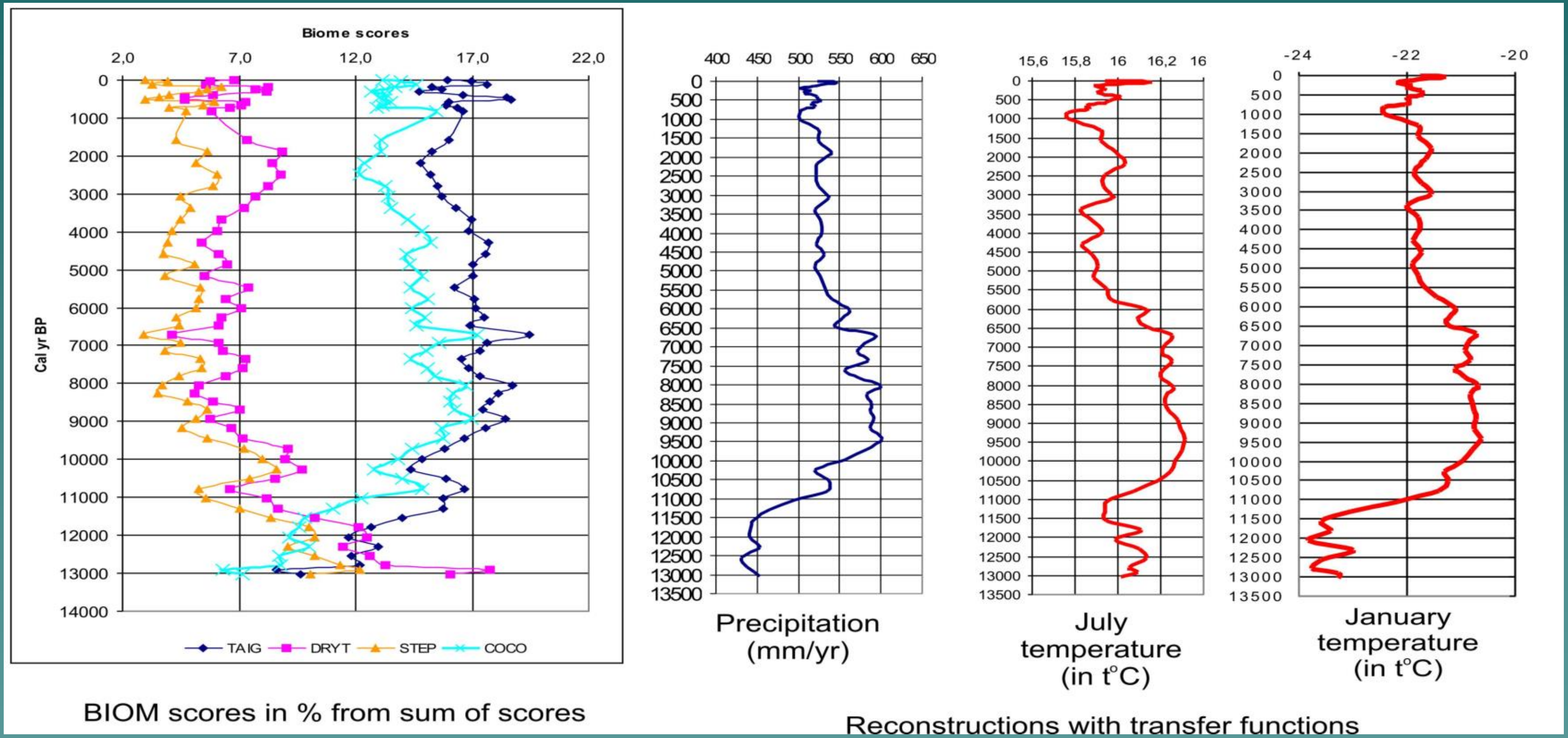
- <u>LSPZ -1.</u> The beginning of the lake sedimentation started in the crio-arid landscapes of the Yanger Dryas covered by unique complex vegetation of forest-tundra-steppe. In the vegetation at those time, open steppe landscapes with groves of spruce-larch forest were common. The climate was sharp continental and dry.
- <u>LSPZ -2 .</u> About 11000 cal. yr BP in early Holocene this type of vegetation was quickly replaced by mountain forests dominated by fir (*Abies sibirica*) and Siberian pine (*Pinus sibirica*). Pine forests with birch spread on foothills of the Western Sauyan Mountains. Probably, considerable humidification and warming of the climate during this period caused the rapid spread of closed forests from Siberian cedar (*Pinus sibirica*) and fir (*Abies sibirica*). In Atlantic period palynological data and quantitative paleoclimatic reconstructions say about a more humid and warm climate compared to the modern one, when fir forest with the participation of Siberian cedar dominated in the mountain forests of Western Sayan, and birch-pine forests spread in the foothills.
- <u>LSPZ -3.</u> During next stage of vegetation, which started about 5000 cal. yr BP and represents late Holocene, domination in mountain forests passed from fir to Siberian pine which indicates a cooling of the climate and a decrease in the amount of precipitation.. This type of vegetation cover is character also for modern mountain forests of the Western Sayan. With the reduction of the role of fir in mountain forests the belt of subalpine shrubs began to expand like during Late Glacial time.

Quantitative palaeoclimatic reconstructions based on palaeopollen data from Buibinskoye mire with use of transfer function for Altai-Sayan mountain region (Table 2) evidence about:



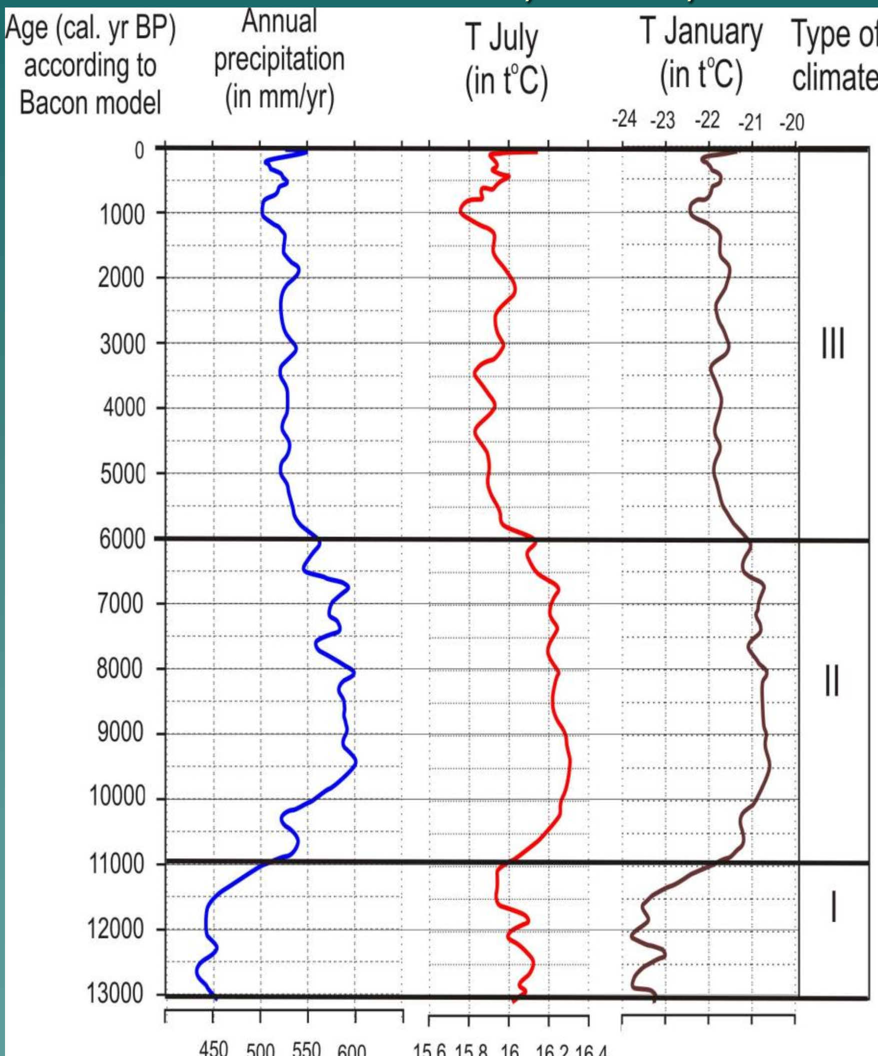
- cryo-arid climate in this region in Late Glacial time till 11000 cal. yr BP;
- humid and warm climate in Middle Holocene;
- and humid and cool climate - in late Holocene after 5000 cal yr BP.

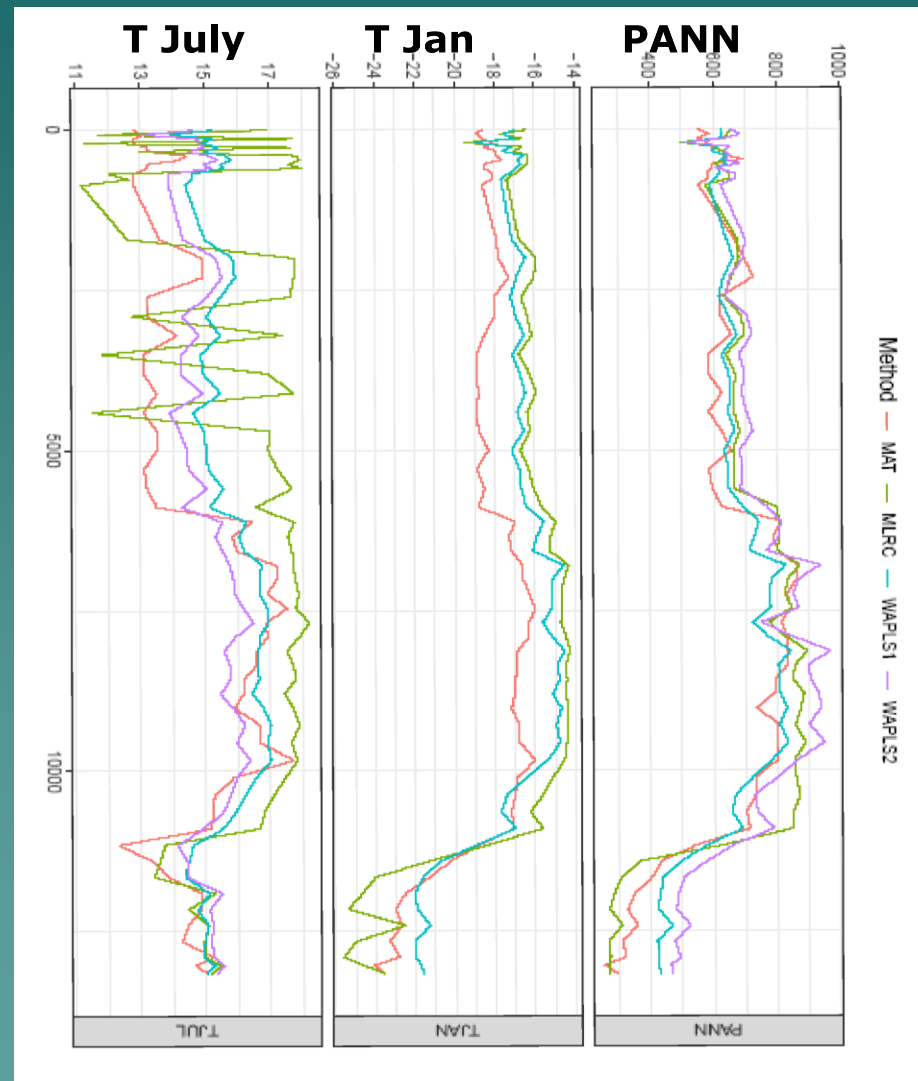
Correlation of biomes reconstruction (method of Prentice et al., 1996) with quantitative palaeoclimatic reconstructions with use of transfer function (method of Ter Braak, 1989) for Altai-Sayan region based on pollen data of Buibinskoye Mire.



This is fully conformed by results of biomization (left graphics), which show dominance of steppe and dry tundra biomes in late Glacial time, and taiga biom – in middle and late Holocene

General trends of quantitatve palaeoclimatic reconstructions performed with use of presented transfer functions are well conformed by other methods, such as: MAT, MLRC, VAPLS1 and VAPLS2 (right graphics)





Conclusion

- 1. Three types of postglacial climate were clearly manifested in the Altai-Sayan region - Late Glacial, Middle Holocene, and Late Holocene. Vegetation cover changes according to these types of climate.
- 2. During Late Glacial time the territory of the Altai-Sayan mountain region was influenced by a sharp continental arid climate with more severe winters and relatively warm summer seasons. This favored for spreading of a special type of vegetation - tundra-forest-steppe.
- 3. Quantitative palaeoclimatic reconstructions show, that cooling of climate in Late Glacial was caused mostly by low winter temperatures combined with low annual precipitation, while summer temperatures were equal or even higher than modern. This is character for areas of unticyclonic influence.
- 4. During early and middle Holocene time winter temperatures and annual amount of precipitation considerably increased, that favored for quick spreading of dark coniferous forests with dominant role of *Abies sibirica*.
- 5. In Late Holocene gradual return to the climatic parameters of the pre-Holocene time can be observed with less humid and more continental climate. This caused decline of *Abies sibirica* in mountain forests and dominance of *Pinus sibirica* in the mountain and *Pnus sylvestris* - on low mountain areas.


hank you for your attention