

**Divergent growth trends and climatic response of  
*Picea obovata* along elevational gradient in  
Western Sayan mountains, Siberia**

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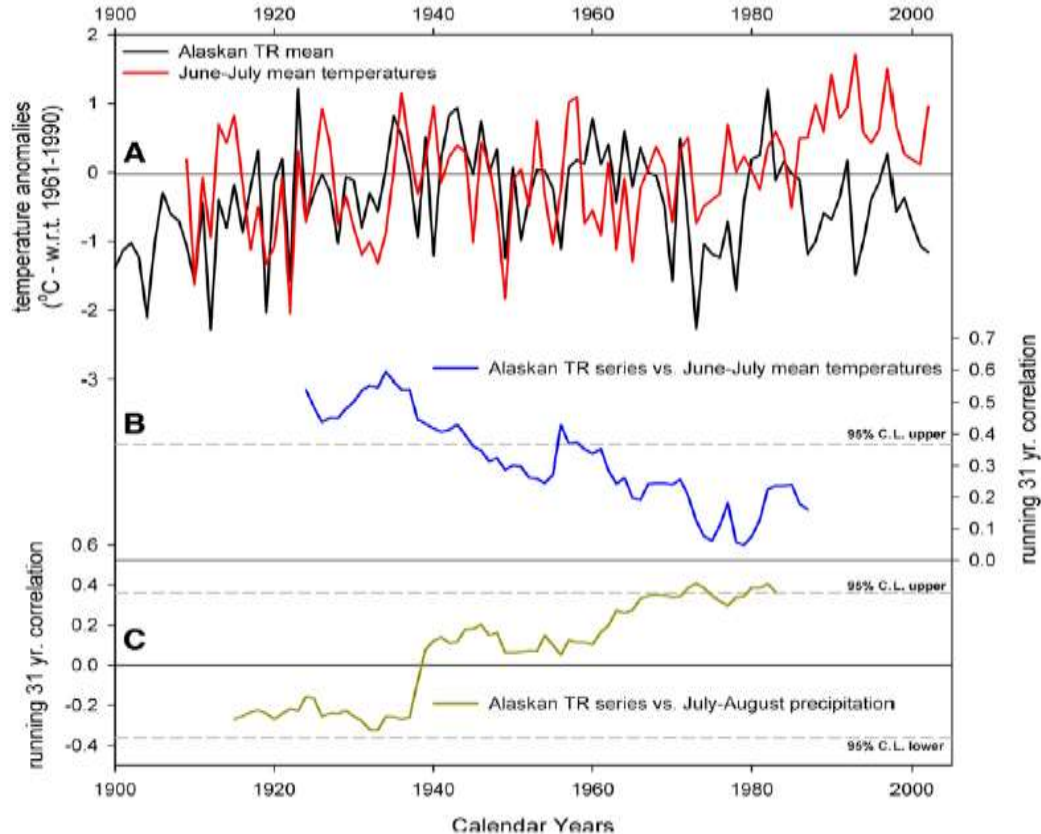
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# Discussed reasons of divergence in tree growth under elevated temperature (current climate changes)

- Increased drought stress
  - Decreased sensitivity to temperature
  - “Dimming effect”
  - Non-linear response to temperature and precipitation
  - Changes in seasonality
- Scales:
- Hemispheric
  - Regional
  - Local

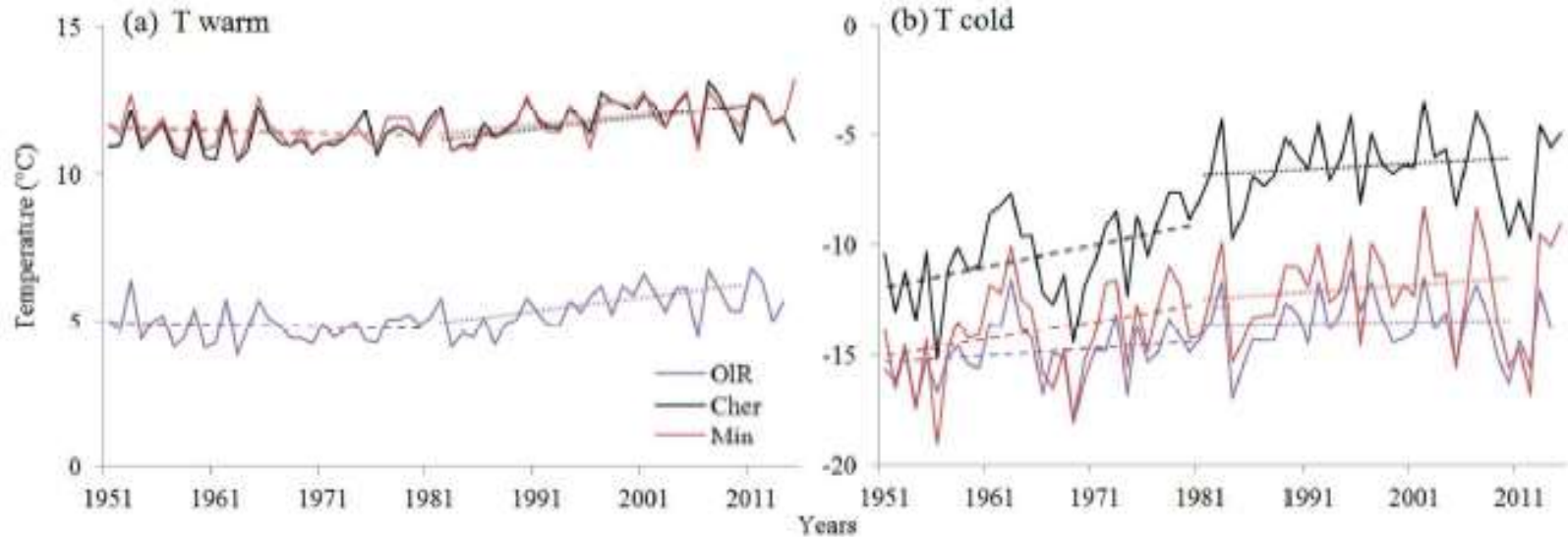
# Classic example of divergence problem in tree-ring – climate relations (D'Arrigo et al., 2008)



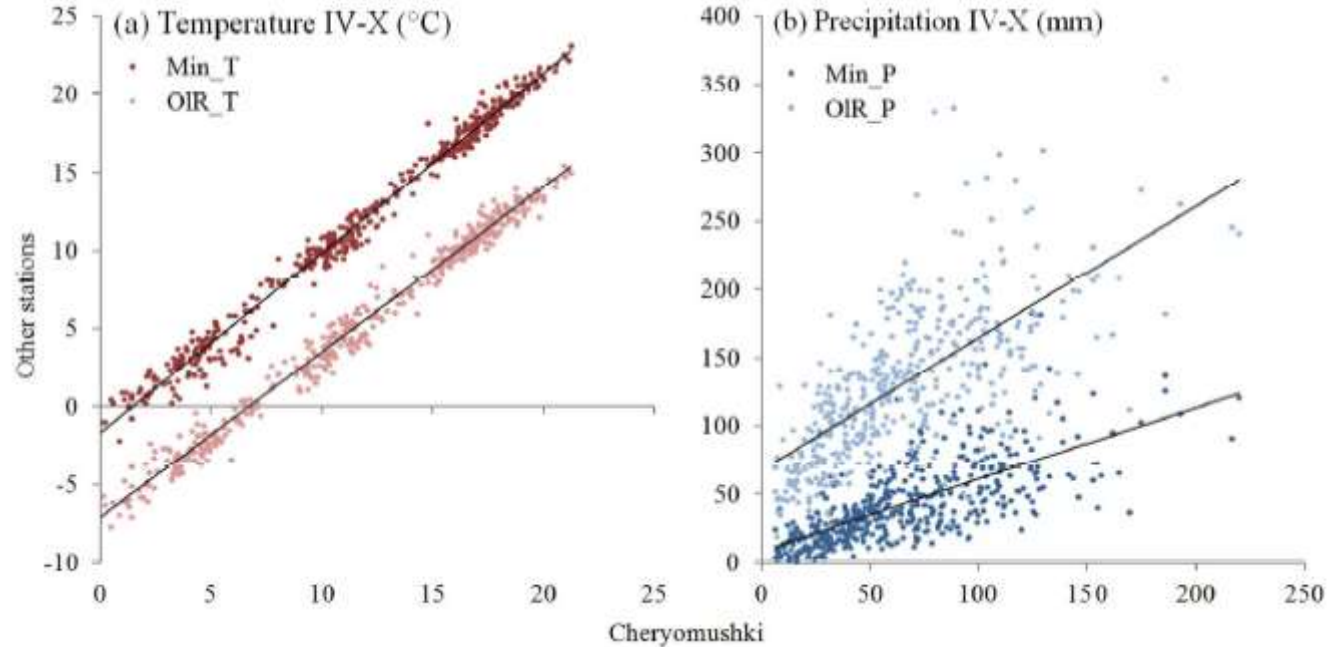
# Site location



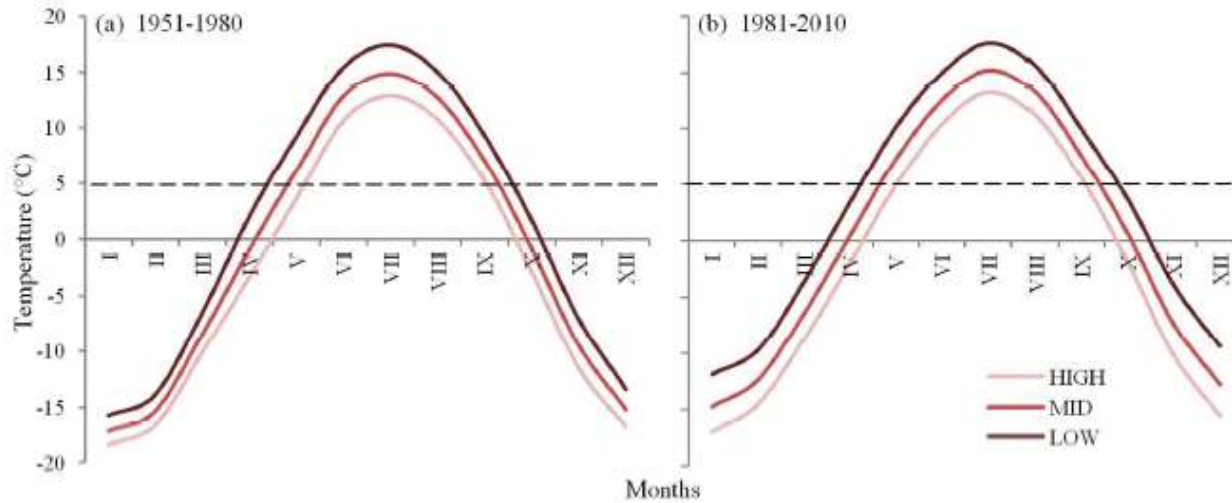
# Climatic trends in study area



# Relationship between basic climatic variables for available meteostations



# Seasonal temperature changes in different elevations



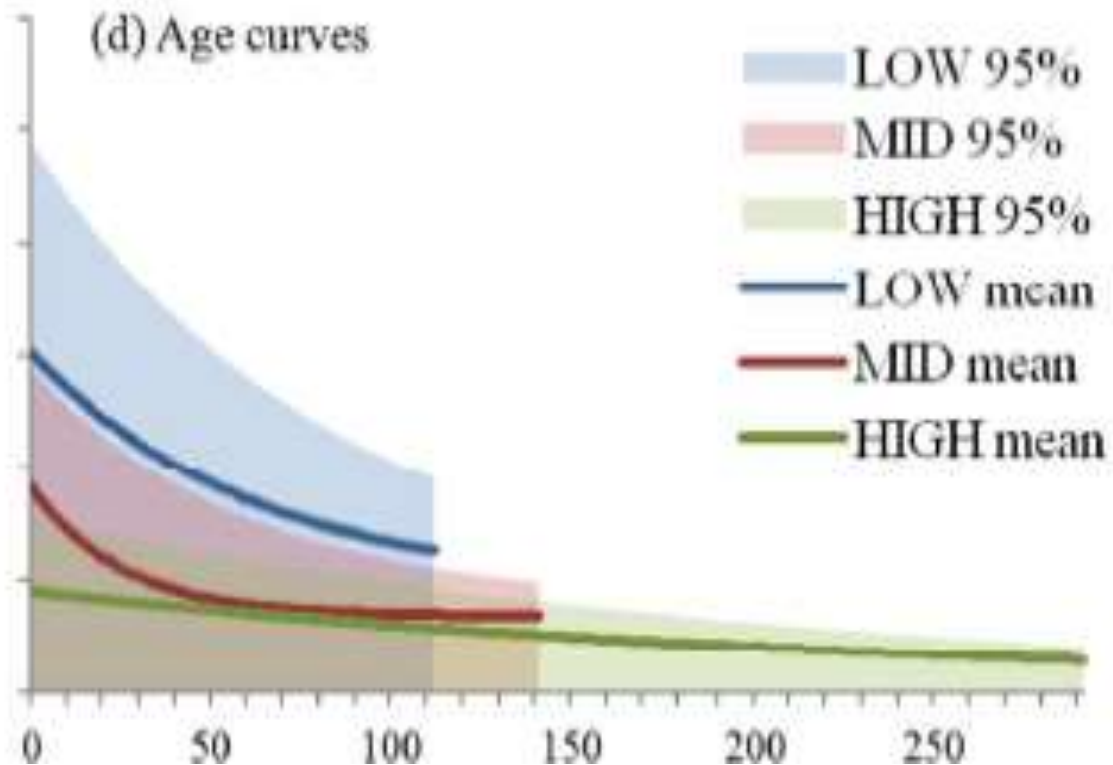
## Climatic data averaged for two periods

Station	Coordinates			Average climatic variables for 1951-1980 / 1981-2010 periods					
				Mean temperature, T (°C)			Precipitation, P (mm)		
	N	E	h (m asl)	XI-III	IV-X	year	XI-III	IV-X	year
Cheryomushki (Cher)	52.87°	91.42°	330	<u>-10.5±2.0</u>	<u>11.2±0.53</u>	<u>2.1±0.9</u>	<u>73±21</u>	<u>447±86</u>	<u>519±92</u>
				-6.4±1.6	11.9±0.6	4.3±0.9	75±27	464±74	539±78
Minusinsk (Min)	53.70°	91.70°	250	<u>-14.1±2.1</u>	<u>11.4±0.6</u>	<u>0.8±0.9</u>	<u>49±19</u>	<u>290±59</u>	339±63
				-12.1±2.0	11.8±0.7	1.9±1.0	48±14	314±56	362±60
Olenya Rechka (OLR)	52.80°	93.23°	1400	<u>-15.0±1.4</u>	<u>4.8±0.6</u>	<u>-3.5±0.7</u>	<u>322±71</u>	<u>930±142</u>	<u>1252±156</u>
				-13.9±1.3	5.4±0.7	-2.6±0.8	325±98	911±148	1236±181

Mean ± standard deviation are calculated for months with negative (XI-III) and positive (IV-X) temperatures, which were estimated from Cheryomushki station data. Significant at  $p < 0.05$  differences between mean values for 1951-1980 and 1981-2010 periods are hold.



## Age curves (mean and individual range)

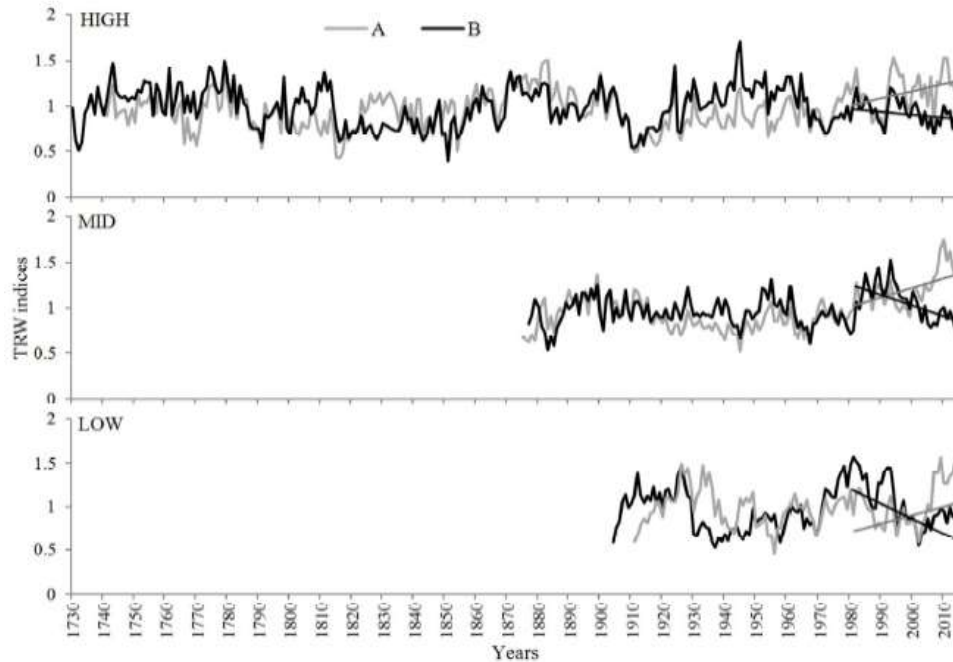


## Basic statistics of sub-groups of tree-ring chronologies

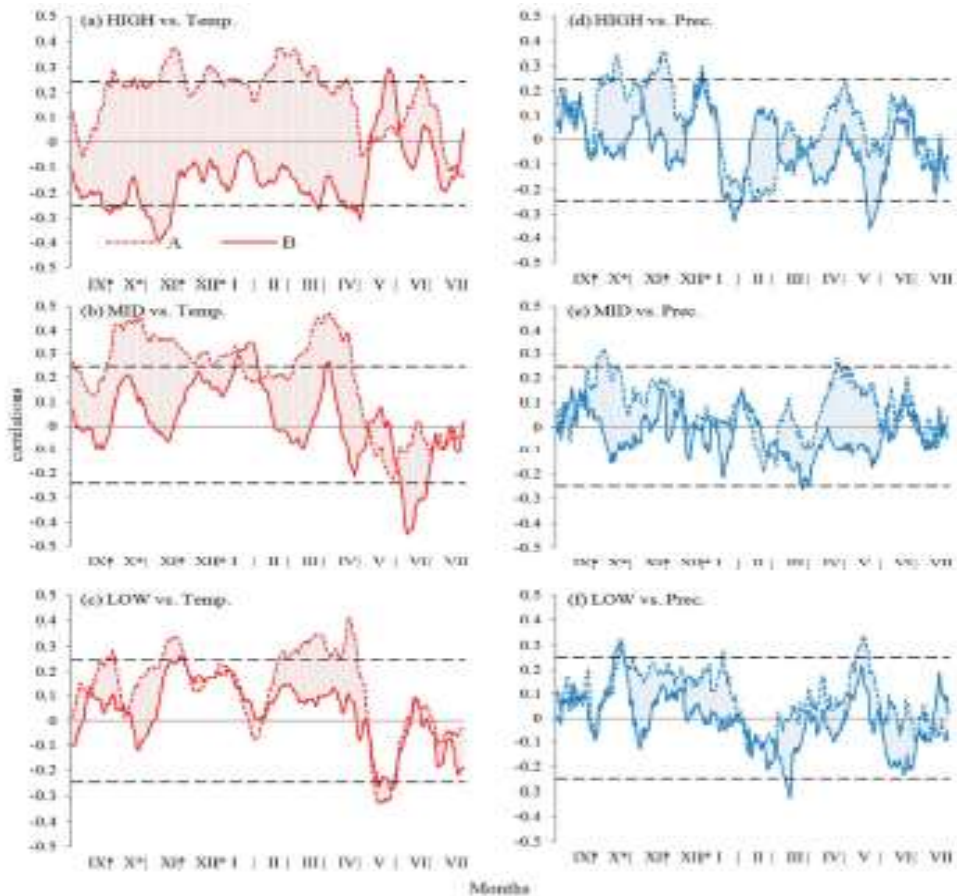
Statistic characteristics	Chronology								
	LOW	LOW A	LOW B	MID	MID A	MID B	HIGH	HIGH A	HIGH B
	General								
Time span, years (calendar / length)	<u>1904-2015</u> 112	<u>1911-2015</u> 105	<u>1904-2015</u> 112	<u>1875-2015</u> 141	<u>1875-2015</u> 141	<u>1877-2015</u> 139	<u>1724-2015</u> 292	<u>1740-2015</u> 276	<u>1724-2015</u> 292
Number of trees	28	11	16	41	24	16	38	15	23
Age, years (min-max / average)	<u>39-112</u> 72	<u>39-103</u> 60	<u>47-112</u> 83	<u>36-141</u> 111	<u>36-141</u> 95	<u>36-139</u> 100	<u>73-292</u> 170	<u>73-276</u> 157	<u>73-292</u> 140
Mean TRW, mm (min-max / average)	<u>1.12-3.98</u> 2.25	<u>1.12-3.01</u> 2.36	<u>1.37-3.98</u> 2.09	<u>0.23-1.77</u> 0.99	<u>0.41-1.66</u> 0.95	<u>0.23-1.77</u> 1.02	<u>0.38-1.13</u> 0.72	<u>0.38-1.11</u> 0.67	<u>0.42-1.11</u> 0.76
	Standard indexed chronologies								
Standard deviation	0.202	0.226	0.254	0.170	0.224	0.168	0.187	0.221	0.211
Mean inter-series correlation*	0.265	0.405	0.430	0.240	0.351	0.329	0.272	0.291	0.396
Signal-to-noise ratio	10.1	7.5	12.1	12.9	13.0	7.8	14.2	6.2	15.1
Mean sensitivity	0.139	0.140	0.125	0.119	0.126	0.124	0.140	0.160	0.142
First-order autocorrelation	0.752	0.688	0.830	0.656	0.770	0.640	0.564	0.621	0.648

\* Mean inter-series correlation calculated with 50-year window and 1-year step.

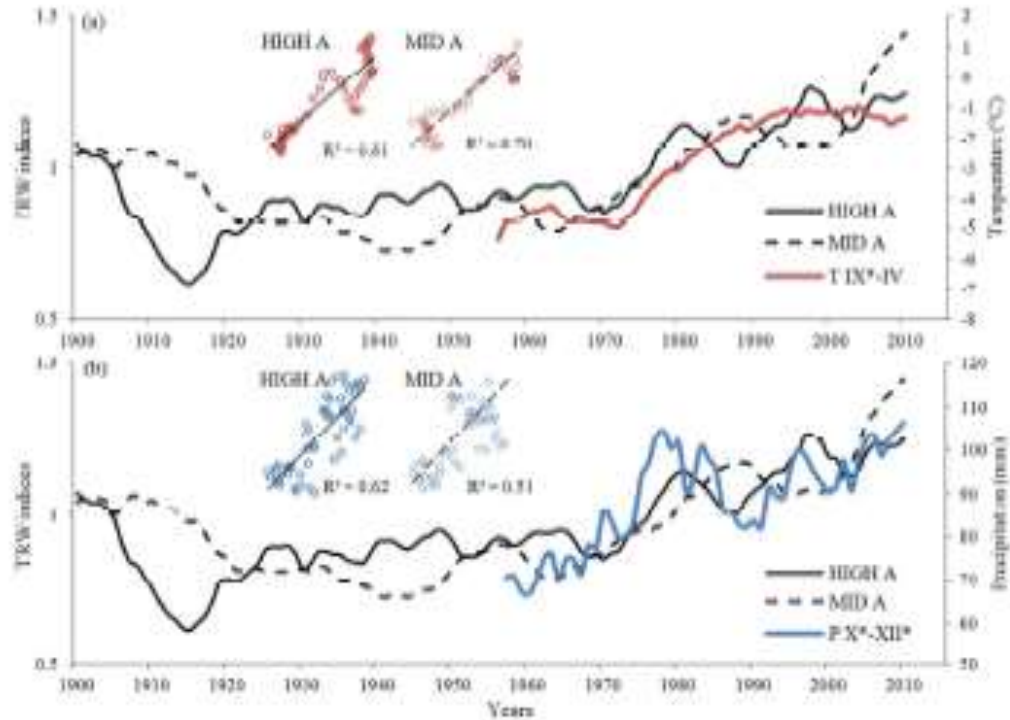
# Sub-group tree ring width chronologies



# Sub-group tree-ring chronology — climate correlation with moving window



# Long-term trends in climate and chronologies



# Conclusion

1. In mountain forest ecosystems the micro-conditions significantly modify the climatic effect on the tree growth.
2. Divergence in growth trends is related to combination of soil properties and climate.
3. Significant winter temperature effect on tree growth is fixed and this result has important consequences for large mountain area in South Siberia covered by spruce forests.
4. Tree growth response to winter temperature is not unique which means that continued warming in Siberia open new questions for ecosystems stability and development.

## Local (topological) features – high elevation (1320 m asl)





**Thank you for attention**

