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Space-time features of climate changes in the Altai Mountains and alpine landscapes response

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The mountain ecosystems and such elements as upper treeline, snowline and glaciers are highly sensitive to climate changes. The Altai Mountains are located in the Inner Asia on the border of Russia, Mongolia, China and Kazakhstan. The uniqueness of the Altai landscapes lies in its great variety as these mountains are higher than 4 km and are located on the zonal border between steppes and semi-deserts and on the border between continental and sharply continental climates. The main purpose of the research is to reveal space-time features of regional climate changes and the reaction of different altitudinal zonation elements.
The 1935(1940)-2004 time series of the seasonal air temperature and precipitation from 14 weather stations from 300 to 2600 m a.s.l. were statistically analyzed applying regression, correlation, spectral and cluster analyses. To extend the time series over the past 350-400 years, mean summer temperature and precipitation in the Central and South-Eastern Altai were reconstructed applying dendroclimatological methods and using the WSL Dendro data base.
Comparing to the Northern Hemisphere the tendency of air temperature increase in the second half of the 20th century over the Altai Mountains has been observed generally earlier, since 1950s. Maximum warming rate in the last quarter of the 20th century is typical to winter in the Altai (0,85°C/10 years) as well as in the entire Northern Hemisphere. Minimum warming rate is observed in autumn (0,17°C/10 years). The analysis of climate change spatial patterns showed that the most intense temperature increase during the last 20-30 years is specific to the most arid part of the region - South-Eastern Altai. There are periods of synchronous and asynchronous temperature changes in the Altai region against the background of global climate changes. Synchronous changes in the Altai and entire Northern Hemisphere are observed in all seasons only from 1975 to 2004 years, in the Altai and polar latitudes in spring and summer at the same period. At the turn of the XX-XXI centuries warming rates slow down in the Altai region while the temperature level is still high. These changes are partly associated with the circulation epochs, especially in winter. For example, winter temperature intensive increase stopped in the early 1990s along with the beginning of new circulation epoch. Spectral analysis revealed the important role of natural cyclical recurrence in climate changes in the region, for example quasi-biennial, solar and Brückner (35-40 years) cycles.
The dendrochronological analysis was employed to range the tendency of climate changes over the pre-instrumental period. According to the dendrochronological reconstruction mean summer temperature increased from the end of the Little Ice Age (LIA) to its maximum in the 1990s by approximately 2°C, to the average for the period 1986-2004 years – about 1,3°C. Recent fast warming especially from the mid-1980s in the Altai Mountains is non-exclusive. The similar abrupt increase of mean summer temperature was observed, for example, in the second half of the 19th century.
This research also focuses on the climatic conditionality of the altitudinal belts spatial distribution, upper treeline and glaciers dynamics. Vertical hydrothermal gradients were employed to characterize each altitudinal belt in different geobotanical provinces of the Altai Mountains by the climatic area of distribution. As treeline against the other belt borders strongly limited by summer temperature, its eventual dynamics since the end of the LIA over the Altai Mountains were estimated and treeline position at different stages of modern regional warming was reconstructed. Theoretical evaluation shows that mean summer temperature increase of 1.3°C from the end of the LIA (1860-1880 yrs) to the period of 1986-2004 yrs caused treeline to rise by 180-280 m in different localities of the Altai Mountains.