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Temperature Changes in the Altai Are Driven by Solar and Anthropogenic Forcing

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In order to place recent climate change in a longer term context and to answer the important question whether the magnitude and rate of the 20th century climate change exceed the natural variability, highly resolved, millennial scale temperature reconstructions are required. Whereas there is already a high data coverage for certain areas in the world (as *e.g.* Europe), only very few long-term temperature reconstructions are available for West-Siberia. The Altai region is of particular interest, since it is within a highly continental area, revealing a stronger warming than other regions in the world during the last 50 years.

In 2001, a 139 m long ice core was drilled at the Belukha glacier, near the highest mountain of the Altai. The ice core was cut into 3600 samples at –20 °C in the cold room. The deepest sample was dated to the year 1250. Thus, the ice core contains climate information covering the past 750 years.

Temperatures in the Altai were reconstructed using the ice core oxygen isotope ($\delta^{18}O$) record, measured with an isotope mass spectrometer. It was demonstrated that the $\delta^{18}O$ record followed closely the atmospheric temperatures at a nearby weather station over the past 130 years and can therefore be used as a temperature proxy. The established temperature record was compared with proxy records of solar activity (solar modulation derived from ^{10}Be measurements in polar ice cores and ^{14}C records from tree rings). The Altai temperature record is significantly correlated with the solar activity proxies in the period 1250–1850, suggesting that the sun was one of the main driving forces for the temperature variation during the pre-industrial period. The temperatures followed the solar forcing with a time lag of 20 years, underlining the importance of indirect sun-climate mechanisms involving ocean-induced changes in atmospheric circulation. During the past 150 years, however, the temperatures in the Altai have shown a much higher rate of increase than that of solar activity. The strong increase in the industrial period correlates with the increase in the concentration of the greenhouse gas CO_2 over this time.

Our results clearly demonstrate that at this continental site in the Altai region the 20th century temperatures are beyond the natural range of variability of the preceding 700 years.

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Reference

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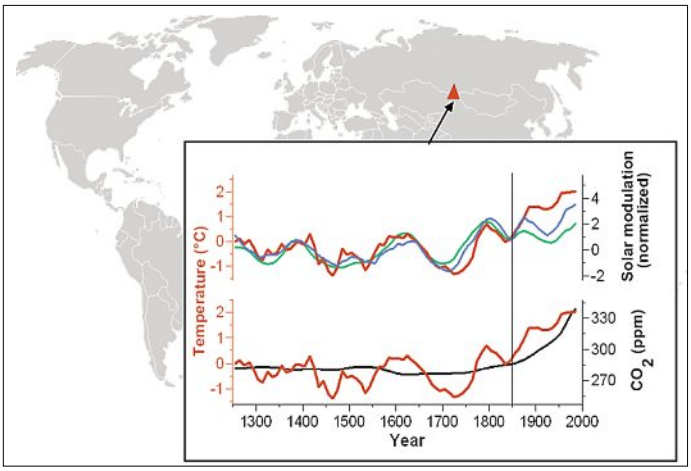
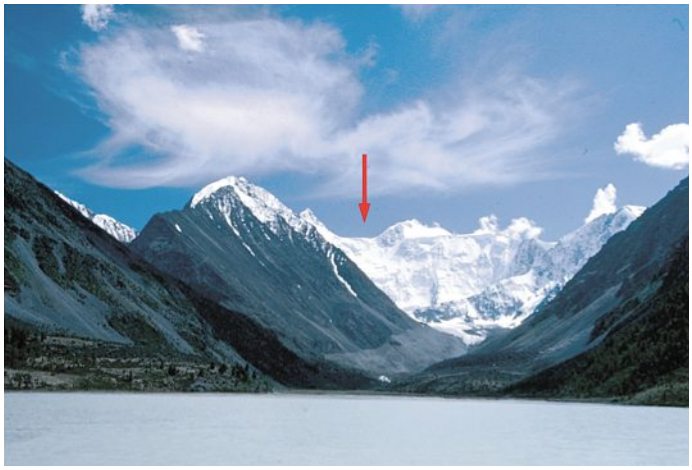


Location of the drilling site (triangle) and the Altai temperature reconstruction (red) compared with solar activity inferred from ^{10}Be (blue) and ^{14}C (green) and CO_2 concentration (black). The solar modulation curves were shifted by 20 years (average value of the lag between solar forcing and temperature response). The vertical line divides the pre-industrial era (1250–1850) from the last 150 years.



Belukha massif in the Siberian Altai and the Ak-kem lake (photo: Patrick Ginot). The 139 m long ice core was drilled in 2001 in the saddle between west and east summit (49°48'N, 86°34'E, 4062 m asl).

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