Surface temperature reconstruction from borehole data and oak's ring width chronology in Kunashir Island, Russia

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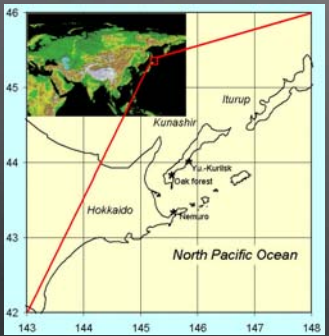
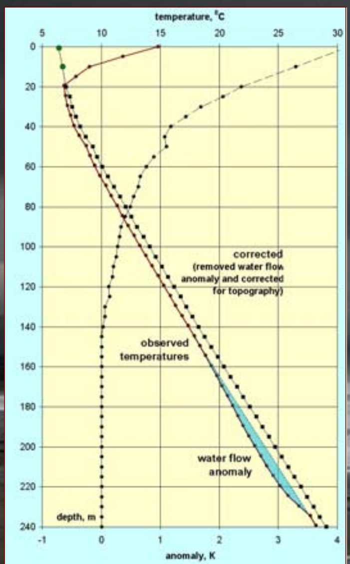
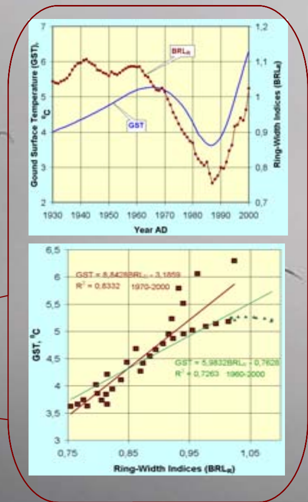
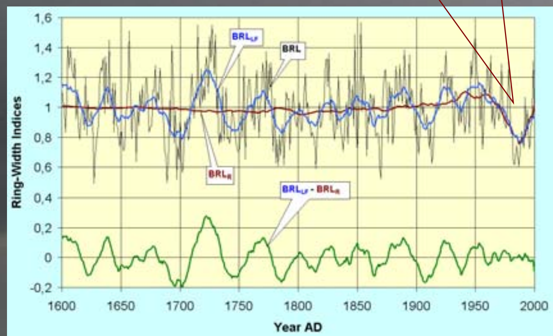
INTRODUCTION Borehole temperature reconstruction and oak's ring width index series in Kunashir (the southernmost island in the Kuril chain) were integrated in order to reconstruct surface temperature variations in the last four centuries. Temperature measurements in the Kun-1 borehole, located near Yuzhno-Kurilsk about 200 m from the Pacific coast, was performed in 2007 to the depth of 240 m. Tree-ring samples were collected from 20 oak trees (*Quercus crispula*) in the forest located 37 km south of Yuzhno-Kurilsk and within 1 km of the Pacific Ocean.



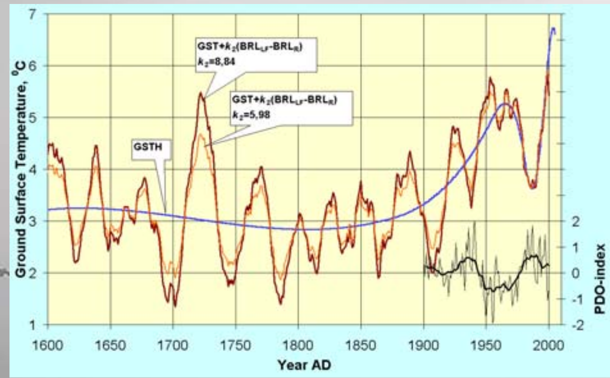


Thermal diffusivity of rocks (tuffs) was determined by analysis of diurnal temperature wave attenuation and phase shift with depth (0.6 10^{-6} m^2/s). Prior to paleoclimatic interpretation the temperature-depth profile was topographically corrected and the local anomaly, induced by water flow, was eliminated. The ground surface temperature (GST) reconstruction reveals a cold period with mean annual temperature equal to 3˚C from AD1600 to the second half of 19th century, which coincides with the Little Ice Age. The subsequent warming resulted in the increase of mean annual temperature up to more than 6˚C by the end of 20th century.





The BRL chronology was developed from the raw ring width series using ARSTAN detrending procedure (Jackoby et al., 2004). The reconstruction shows a strong annual and multidecadal variability with the predominance of periods 30-50 years long, having spectral properties similar to the Pacific Decadal Oscillation (PDO), which largely controls temperature and precipitation in the region. Unlike the geothermal reconstruction BRL chronology does not demonstrate any century-long trends. However both reconstructions reproduce the cooling in 1970s-early 1990s.



Integration of the two paleoclimatic proxies is based on the assumption that the soil temperature strongly influences both borehole temperature and ring width variability but in a different frequency domain. The procedure of integration of the two proxies included: i) smoothing of the BRL chronology by a running windows of unequal length progressively increasing while moving toward the past in order to construct the curve BRL_R, operating in the same frequency domain that does the GST-reconstruction; ii) calibration of BRL chronology in terms of surface temperature using GST reconstruction in the interval of their maximum coherence with a simultaneous correction of the efficient thermal diffusivity, which determines the time scale of GST curve (as result of this procedure the value of thermal diffusivity had increased up to 0.7 10^{-6} m^2/s); iii) smoothing of the BRL chronology by a running windows of a constant length in order to eliminate the high frequency variability and preserve the multidecadal variations (BRL_{LF}); iv) construction of integrated surface temperature curve ($GST_{INT}=GST+k(BRL_{LF} - BRL_R)$, where k is a sensitivity coefficient.

The integrated curve of surface temperature retains both centennial and multidecadal temperature variations, and the amplitudes of these variations are commensurable (Standard Deviations are 0.68˚C and 0.53˚C correspondingly. According to our reconstruction the peaks of surface temperature in Kunashir were centered near 1600, 1638, 1677, 1722, 1770, 1801, 1827, 1850, 1884, 1925, during 1954-1973 and since the year 2001, and they broadly correspond to the "cool" PDO phases.

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