Geophysical Research Abstracts
Vol. 16, EGU2014-1170, 2014
EGU General Assembly 2014

Underground temperatures – evidence of Late Pleistocene-Holocene orbital forcing

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An analysis of temperature-depth profiles measured in deep boreholes (more than 1 km) allows determining ground surface temperature (GST) and surface heat flux (SHF) histories in the period of global climate change at the border of Pleistocene and Holocene. We reconstructed past 40 kyr GST and SHF histories using data obtained from two deep boreholes in Russia (Middle Urals and Karelia). GST histories reveal 12-20 degrees of warming during the Pleistocene-Holocene transition 20-10 kyr BP and much smaller changes during Holocene. SHF changes precede the surface temperature changes by 1-2 kyr. The heat flux started to raise 22 kyr BP, reached its maximum value of 0.09-0.12 watts per square meter 15–10 kyr BP and then began to decrease. A comparison of SHF histories with mean annual variations of insolation at a latitude of 60° N (I), which is determined by changes in the Earth's orbital parameters, shows that all three curves are very similar. The synchronous changes of the heat flux and insolation indicate that ground surface temperature changes were mainly governed by external radiative forcing. While the amplitude ratio SHF/I is approximately 1 per cent. A comparison of the reconstructed GST and SHF with the atmospheric carbon dioxide changes (from the Antarctic ice cores) leads to another important conclusion. Carbon dioxide changes by its shape and chronology are much closer to temperature changes than they are to heat flux changes. The heat flux increase occurred faster, and then 12 kyr ago it began to fall, while the increase in carbon dioxide continues to the present. On the assumption that the reconstructed SHF generally reproduces changes in radiative forcing, one can challenge the hypothesis of the primary role of carbon dioxide and the greenhouse effect in Pleistocene-Holocene transition.