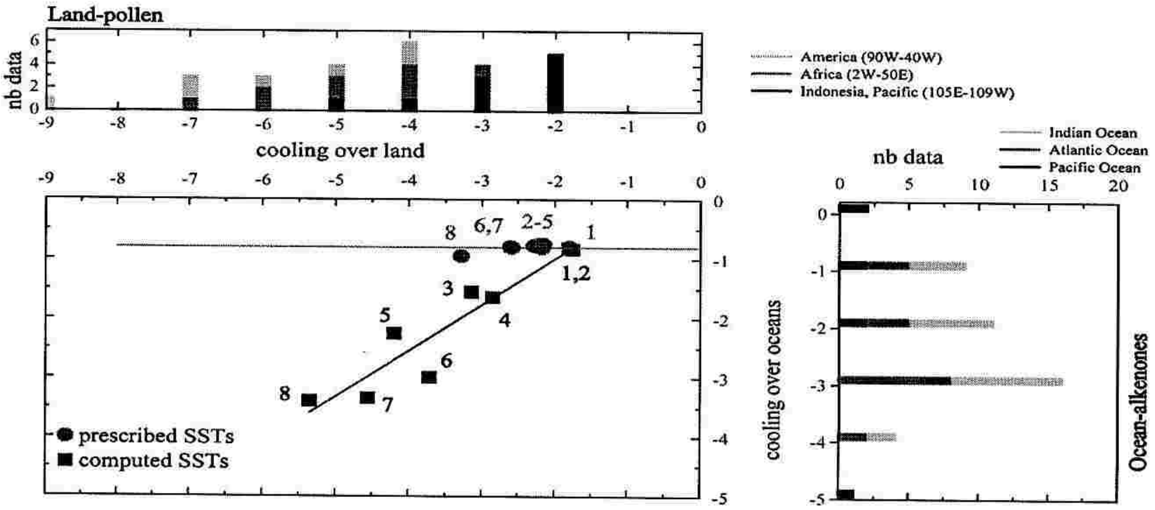

Fig. 1. State of the art in model/data compared with new coupled simulations using AOGCMs.

picture of terrestrial and marine data (Pierrehumbert, 1999) and some comments will be made on results obtained by models involved in PMIP but using computed SSTs derived from coupling the AGCMs with a slab ocean (9 different models (Pinot et al., 1999)).

KEY WORDS: tropical cooling, Last Glacial Maximum, model/data comparison.

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The Last Glacial - Interglacial Temperature Contrast Directly From the Present Subsurface Temperatures

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ABSTRACT. Ground surface temperature (GST) history can be evaluated by analysing the present-day temperature-depth profiles measured in boreholes. Due to the diffusive character of the process, however, the resolution of the method decreases quickly for the more remote events. The reconstructed GST at a given moment in the past is a weighted average of temperature over a certain period of time. The present study shows that because the cold climate of the last (Weichselian) glacial prevailed in the period of 75–10 ka, there is a chance to obtain its mean GST, despite the large averaging intervals, from temperature profiles measured in deep boreholes. Thise fact is on the GST inversions of carefully selected profiles, 3 from the Czech Republic and 2 from Slovenia, the depth of which ranges between 1.5 and 2.4 km. In order to suppress the non-climatic noise and to extract the common signal, were carried out for the Czech and the Slovenian boreholes, respectively. The Czech data show the minimum at 17 ka and the warming of 58 K. The Slovenian data have the minimum at 16 ka and the warming amounts to 7 K. These results agree well *with information extracted earlier from the German KTB superdeep borehole, where the inversion of the temperature log indicated 10 K warming since the glacial minimum, and represent a direct and independent estimate of the difference between glacial and interglacial conditions typical for the region of Central Europe.*

KEY WORDS: glacial/interglacial temperature contrast, borehole temperatures, central Europe.

Introduction

Climate changes are accompanied by temperature changes on the Earth's surface. It follows from the heat conduction theory that changes in surface temperature penetrate into the subsurface with amplitude diminishing and the phase lagging with depth. By applying this theory on the present temperature profiles measured in boreholes, some information can be obtained about the past surface conditions. Due to the low thermal diffusivity of rocks, GST changes propagate downward slowly and are recorded as transient perturbations to the steady state temperature field. The temperature profile measured in a borehole a few hundred metres deep may contain information about the GST changes in the last millennium and boreholes 1500–2000 m deep may yield the GST history of the end of the last (Weichselian) ice age and succesive Holocene variations. However, GST histories can be degraded by random or systematic noise in the subsurface temperature data and in the measured thermophysical values of the rocks (Clow,1992; Shen et al., 1995). This contribution focuses on the GST inversions of carefully selected profiles, 3 from the Czech Republic and 2 from Slovenia, the depth of which ranges between 1.5 and 2.4 km.

Data

We used boreholes deeper than 1500 with sufficient knowledge of thermal conductivity of the encountered rocks and reliable temperature logging. As a result of the selection process, three boreholes from the Czech Republic (NP-522, SV-6 and De-1) and two boreholes from Slovenia (Lj-1, Se-1) were retained from the set of temperature logs available from these two countries. The borehole coordinates and the profile depth ranges are given in Table 1 and the measured temperature profiles are shown in Fig. 1.

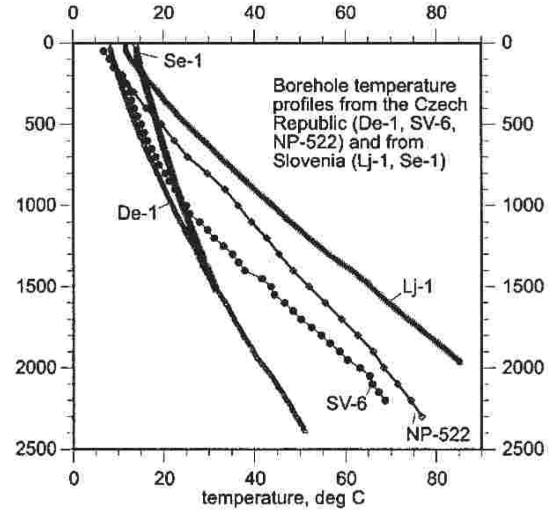

Fig.1. The temperature-depth profiles investigated in the study.

Name	Latitude	Longitude	Altitude, m a.s.l.	Depth range,m
NP-522, Tichá	49°33'00"N	18°14'24"E	443	100–2400
Sv-6, Čeladná	49°30'30"N	18°20'24"E	526	50–2200
De-1, Dětřichov	49°49'06"N	17°23'00"E	613	100–2400
Se-1, Šempeter	45°55'19"N	13°38'14"E	68	30–1518
Lj-1, Ljutomer	46°30'52"N	16°11'41"E	250	20–1965

Tab. 1. Location, altitude and the depth range of the logs investigated in the study.

Method and results of the ground surface temperature reconstructions

The reconstruction of the GST history from a subsurface temperature profile represents an inverse problem. Due to its complexity, all inversion techniques developed up to now assume conductive heat transfer through one-dimensional heterogeneous media as a link between past temperature changes at the surface and the present-day subsurface temperature variations with depth. In processing the data, the widely used inverse method called functional space inversion (FSI) of Shen and Beck (1992) was employed. To enhance the signal-to-noise ratio, we carried out the joint inversions (Beltrami and Mareschal, 1992; Pollack et al., 1996) of the Czech and Slovenian temperature profiles. The inferred history of the GST variations is very similar for the both groups (Fig. 2). The glacial/interglacial contrast amounts to 7–8 K and the GST minimum is located at about 16–17 ka.

Discussion of the results and conclusions

The results of the study can be compared with GST history extracted from the German superdeep hole KTB (Fig. 2). The 4000m deep log from the KTB pilot hole, which is very

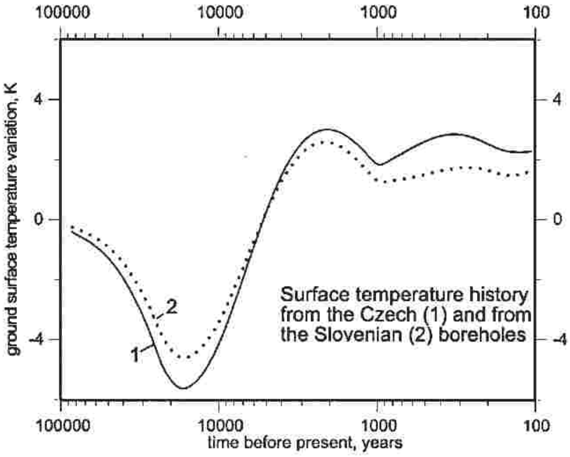

Fig. 2. History of the ground surface temperature variations obtained by joint inversion of the Czech (1) and the Slovenian (2) temperature profiles.

probably close to the virgin pre-drilling rock temperature was inverted by Clauser et al. (1997). The reconstructed amplitude of the glacial/interglacial warming is nearly 10 K. Another high value, although for much higher latitude of 72.6 °N, was obtained by a Monte Carlo inversion of the 3000m deep temperature profile measured through the Greenland Ice Core Project borehole (Dahl-Jensen et al., 1998). It suggested amplitude of the postglacial warming 23 K.

Although the study showed that the resolving power of the inversion procedure on the time scale of the last glacial/interglacial transition is limited and very likely in the individual cases biased due to the various factors, it seems to be evident that there is the climatic signal of this event in the present subsurface temperature field of central Europe and that the ground surface temperature contrast between the glacial minimum and postglacial optimum was of the order of 10 K.

Acknowledgements

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Climate Impact on River Processes, Landforms and Deposits in the Last Glacial

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ABSTRACT. Soil cohesion and peak discharges are the main climate-derived factors that determine river processes. They are related to vegetation cover and permafrost conditions. Climatic effects on Quaternary river systems are time-scale dependent. The response time of river processes to climatic changes may restrict their sensitivity to adapt to short climatic oscillations.

KEY WORDS: Quaternary rivers, fluvial geomorphology, climate impact, periglacial rivers.

The effect of time scale

Fluvial morphological and sedimentological development works simultaneously at the different scales, superposing the smaller scaled effects on the larger ones (Schumm, 1975). This development results from various intrinsic dynamics and extrinsic forces. It has been shown that the response of the fluvial system to changing climatic conditions is dependent on the considered time scale (Vandenberghe, 1995).

- *glacial/interglacial level (10^5–10^6 years)*

The traditional concepts of climatically determined morphologic and sedimentological phenomena are born from that climatic cyclicity: terrace staircases, plan form changes and grain-size alternations of the fluvial deposits. Indications for glacial climatic conditions were indeed found at many occasions in the coarse terrace deposits. The erosional gaps are not so easy to characterize, but apparently there is no other place for them than in the interglacials.

- *intra-glacial cycles (10^3–10^5 years)*

The coarse terrace deposits, attributed to glacial stages (with a duration of ten thousands years), are often only a few meters thick (or less) and could be deposited in very short times. Also the grain size of cold deposits may be very different due to considerable climatic variation within a glacial period (van Huissteden, 1990; van Huissteden and Vandenberghe, 1988) and also to intrinsic evolution (e.g. Kasse et al., 1995). In addition interglacials should not explicitly be identified as erosional periods: many Holocene rivers are very calm and there even seems to be some aggradation in the valley floors instead of erosion.

All these facts led to the development of a more detailed conceptual model of fluvial development (Vandenberghe, 1993, 1995). It identifies especially the climatic transitions as phases of morphological instability and thus erosion. In the glacial