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Global Warming – Does it Always Mean Regional Warming?

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ABSTRACT. Proxy data obtained for warm epochs of the last 125 ka permitted to estimate global paleotemperatures at the last interglacial optimum (5e oxygen isotope stage) at 1.8–2 °C above the present one, and at the Holocene optimum (stage 1) at 0.7 to 1 °C higher than at present. Those values are of particular interest as they are approximately equal to temperature growth to be expected in the 21st century due to the greenhouse effect. As follows from spatial paleoclimatic reconstructions for the mentioned epochs, the warming would be most pronounced in high latitudes (compared with today, at the interglacial optimum Eurasian Arctic regions were 8–12 °C warmer in winter and 6–8 °C in summer; at the Holocene optimum the warming amounted to 4 and 3 °C, respectively). The positive deviations, however, gradually decreased towards mid-latitudes, and many regions south of 30–40°N show either negligible or even slightly negative deviations. According to preliminary data, proportion of such regions in the last interglacial could be about 25% of the whole Northern Hemisphere area. As for annual precipitation, reconstructions showed general increase in rainfall amount at the last interglacial optimum, with potential evaporation in high and middle latitudes increasing accordingly. At the Holocene optimum rainfall amount was locally lower than now, though subtropical and tropical regions show a considerable increase in moisture supply.

KEY WORDS: paleoclimatic reconstructions, spatial differentiation, climatic optima.

Introduction

According to generally accepted estimates of the global temperature changes due to human impact, the temperature is expected to rise by 1 °C in the first half of the 21st century and by ~2 °C in the 2nd half (Hougton et al., 1996). Paleogeographic reconstructions based on data obtained in the course of multidisciplinary research, show with fair degree of certainty, that during the last natural macro-cycle there were warm epochs when mean values of the global annual temperature were close to those expected in the near future. Among them, of particular interest are the Holocene optimum (~6–5 ka BP) and the last interglacial (Eemian, Sangamon, Mikulino) optimum marked by global temperature rise by 0.8–1 °C and 1.8–2 °C, respectively. Both epochs have been thoroughly studied using an integrated approach; the results obtained permit to visualize spatial differentiation of paleoclimatic parameters which, in its turn, opens the way to forecast regional environmental responses to the predicted climatic changes (Frenzel et al., 1992).

Paleoclimatic reconstructions of the Holocene Optimum

Spatial paleoclimatic reconstructions for the Holocene optimum were based on pollen data processed using information-statistic method (Klimanov, 1985). It appears that a rise in the near-surface air temperature by 1 °C leads to essential redistribution in heat and moisture supply. General increase in thermal level can be assigned to considerable warming of high latitudes. Maps of both summer and winter isotherms show temperatures in the arctic coastal regions to exceed those of today by at least 3 °C; warming in subpolar regions in North America and Eurasia amounted to 2 °C (Velichko et al., 1997), but did not exceed 1 °C over major part of mid-latitudes. Positive deviations continue to decrease southward and become negligible between 40 and 35°N. Still further south, to the equator, deviation values do not exceed 1 °C and are negative locally (in North America and Africa). Positive deviations up to 2 °C are reconstructed for coastal regions of China and Japan (presumably as a result of warmer air brought by monsoon from the ocean). Maps of January isotherms show slightly higher temperatures over Central Asia.

Map of annual precipitation reveals a much more complicated picture. The most significant increase in rainfall (by 200–300 mm) occurred in tropical regions. The positive deviations continue northward, towards mid-latitudes, gradually decreasing in range. Within mid-latitudes, deviations were most diversified. In the north of Western Europe, the rainfall amount was close to the present one; southern Europe shows somewhat higher rainfall, much like eastern Eurasia (by ~ 50 mm per year and more). It should be noted, however, that there existed regions of reduced precipitation (as compared with the present). Thus, central East European Plain and southern West Siberia received about 25–50 mm less precipitations than at present; rainfall in central and eastern USA appeared to be much less than today - by 100 mm per year and more (Webb III, 1985).

Therefore, at this level of global warming, a circumpolar belt seems to exist in middle latitudes which included a few regions of definitely reduced rainfall. Further north, a stable tendency for precipitation growth is seen both in North America and Eurasia, though the range of increase did not exceed 100 mm per year.

Paleoclimatic reconstructions of the Last Interglacial Optimum (~ 125 ka BP)

More pronounced and somewhat different (which is particularly true for rainfall) were changes in hydrothermal regime during the last interglacial, when average global temperature was about 1.8–2 °C above the present-day values. On the land, paleotemperatures and paleo-precipitation were reconstructed using fossil plant data. The methods applied (areagrams and climagrams) were developed by Grichuk (1985) and based on concepts by W. Szafer and J. Iversen. Temperatures and rainfall over the ocean were taken from literature (Barash, 1988; Ruddiman, 1985; Blyum et al., 1999).

On the whole, two special features of the last interglacial climate are evident: first, both heat and moisture supply were much higher than at present; and second, the climatic characteristics were much more equally distributed along latitudes (Velichko et. al., 1991; Velichko et. al., in press). At the same time, there is quite distinct zonal pattern in the distribution of temperatures and rainfall.

As for temperatures, a well pronounced circumpolar area of positive deviations from the present-day values, covering high and partly middle latitudes is registered both in summer and in winter. For summer temperatures, the range of deviation increased from the Atlantic (1–1.5 °C in northern British Isles) eastwards (to 4–6 °C in Asian Arctic).

Even greater warming marked winter period, with the same tendency in deviations' distribution along latitude. The warming did not exceed 2 °C on the British Isles, but it was up to 12 °C in Eastern Siberia. It should be noted, however, that even in Siberia the positive deviations decrease from north to south and become negligible at about 50°N.

Regions located south of these latitudes, that is southern East Europe and northern Central Asia, featured summer temperatures slightly below the present-day values. This belt is traced westwards, along the northern Mediterranean. The phenomenon seems to be of global occurrence, as the same results were obtained from some deep-sea cores in the Atlantic. Data on intertropical zone suggest that similar areas of insignificant deviations (both positive and negative) in temperatures could exist in low latitudes as well.

Latitudinal differentiation is clearly seen in precipitation distribution; in this case, however, we may speak with confidence only about the Old World. Thus, in maritime regions of Europe annual rainfall exceeded that of today by 200–250 mm, that is by 25–50%; an increase by 50–70% (by 200 mm) occurred in Asian Arctic. Even greater increases in precipitation took place over practically the whole territory of western Europe and major portion of central Europe. Here, the amount of precipitation increased by 300 mm and more. In Eastern Europe the growth was not so conspicuous (not more than by 50 mm). It should be noted, that in the Holocene these regions belonged to a circumpolar (though discontinuous) belt of reduced precipitation. Farther south, practically all of the arid and semi-arid regions both in Eurasia and northern Africa received considerably more rainfall that now (by 200–300 mm in steppes of Eurasia, by 100 mm in the Aral region and Kazakhstan, by 100 to 200 mm in the northwest of Africa).

It can be easily seen that the belt of maximum relative increase in precipitation roughly coincides with the belt marked by occasional areas of slightly negative deviation of temperatures, that is, some cooling.

Conclusions

Comparison between reconstructions of paleoclimatic characteristics obtained for two warm epoch of the past may be summarized as follows.

A rise in global temperature (either by 1 or 2 °C) results in noticeable warming of high latitudes. The range of warming decreases southwards, and lower latitudes feature either slightly negative of negligible positive deviations from the present-day values. It is worth noting that the same regularity was characteristic for older warm epochs marked by more considerable global warming (the Pliocene and Eocene optima). The greater global warming, the higher temperatures are in high latitudes, though in every case positive deviations are damped out at ~ 45–35°N.

There are also conspicuous changes in rainfall distribution, though spatial distribution of deviations in rainfall amount depends on the range of global warming. At global warming by 1°C, large areas of reduced rainfall form a discontinuous belt within modern arid and semiarid regions. At warming by 2 °C, on the contrary, these regions show distinct increase in rainfall. High latitudes were marked by a steady increase in precipitation and most pronounced rise in temperatures both at the Holocene and Late Pleistocene optima.

Maps of potential evaporation compiled for those warm epochs suggest that in spite of the increase in precipitation, humidity in high (and partly in middle) latitudes could be somewhat reduced because of increased evaporation due to higher temperature. That would inevitably have affected ecosystems.

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Last Interglacial End

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ABSTRACT. Last interglacial ended approximately 115 thousand years ago, when the Norwegian warm current was substantially reduced and the dominant near-meridional circulation in Europe turned into near-zonal. Sites in southwestern Europe continued to experience temperate climate. Build-up of the Early Glacial ice was accompanied by the warming of equatorial ocean. Some features of the seasonal and geographic distribution of recent temperature and precipitation anomalies indicate that the cause of the ongoing global warming has a significant natural component.

KEY WORDS: Last Interglacial, Eemian, global warming, El Niño.

There were four interglacials in the last half million years and ours is the fifth one. Past interglacials invariably ended with the increase of solar energy income to low latitudes in boreal spring, compensated by decrease to high latitudes in autumn. The change was caused by orbital shift. A qualitatively similar shift is taking place now (Kukla et al., 1992).

The question is whether the current interglacial will :

1) -last into foreseeable future, maintained by increasing levels of greenhouse gases,
2) -end suddenly with a catastrophic breakdown of thermohaline circulation, or
3) -gradually turn into a colder world following the orbitally driven blueprint of past interglacials, only in part modified by the artificial increase of greenhouse effect.

Seasonal and geographic patterns of the temperature and precipitation departures during the last fifty years point to the third variant as the most likely. Recently observed global warming is marked by a seasonally uniform air surface temperature increase and precipitation decrease in the tropics, opposed by a relatively minor changes of latitudinally averaged temperature in the high latitudes of both hemispheres (Kukla et al., 1998). Two features show that there must be a substantial natural component in the current climate change. It is the lack of preferential Arctic warming expected from the general circulation models of the CO_2 impact, and the cooling experienced between the1940s and the late1970s, when carbon dioxide concentrations were rapidly increasing.

The Eemfest workshop held in October 1999 at Lamont Observatory of Columbia University reviewed currently available information on the ending of the last interglacial. It was concluded that the interglacial climate was very similar to current times, and partly even more temperate and less volatile. The span of relative climatic calm was equally long, if not longer, as the current warm period. During that time, represented by the marine isotope oxygen stage (MIS) 5e, lasting from approximately 130 to 116 ka ago (Martinson et al., 1987), the natural environment over much of the globe resembled the conditions of the last 10 ka. A tall mixed hardwood forest with close canopy covered much of Europe and the warm currents reached far north. Only toward the very end of MIS 5e and only in the northernmost North Atlantic were the pulses of increased ice rafting and cold water detected (Seidenkrantz and Knudsen, 1994). Reports of high climate variability in the last interglacial, based on misinterpretations of Greenland ice cores and on incorrectly dated pollen sites in Europe, are misleading. The glacier in the southern part of Greenland was substantially reduced, reached a lower elevation and was affected by summer melt. The upper parts of the pollen bearing sediments of Eemian biozone in Vosges and in Massif Central in France, considered earlier to be of interglacial age, were deposited in Early Glacial. (Kukla et al., 1997)

At the time of the MIS 5e/5d boundary, some 115 to 116 ka ago, the orbital configuration was closely similar to the current one (Kukla and Gavin, 1992). Since about that time, the cli-