

Институт географии РАН
Лаборатория эволюционной географии

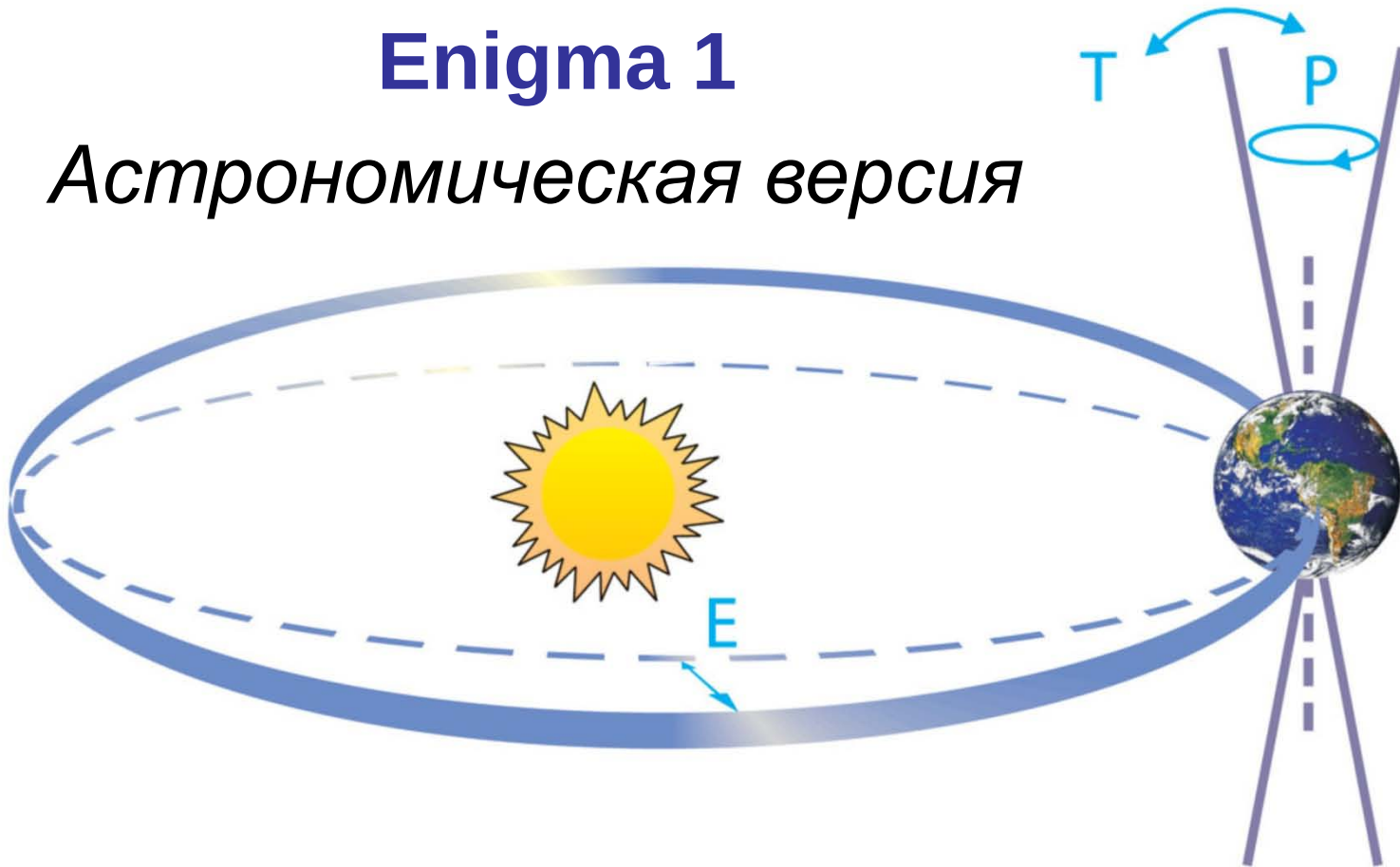
А.А. Величко

*Поиски причин разномасштабных
ландшафтно-климатических
изменений*

paleo_igras@mail.ru

Enigma 1

Астрономическая версия



Schematic of the Earth's orbital changes (Milankovitch cycles) that drive the ice age cycles. 'T' denotes changes in the tilt (or obliquity) of the Earth's axis, 'E' denotes changes in the eccentricity of the orbit (due to variations in the minor axis of the ellipse), and 'P' denotes precession, that is, changes in the direction of the axis tilt at a given point of the orbit. Source: Rahmstorf and Schellnhuber (2006).

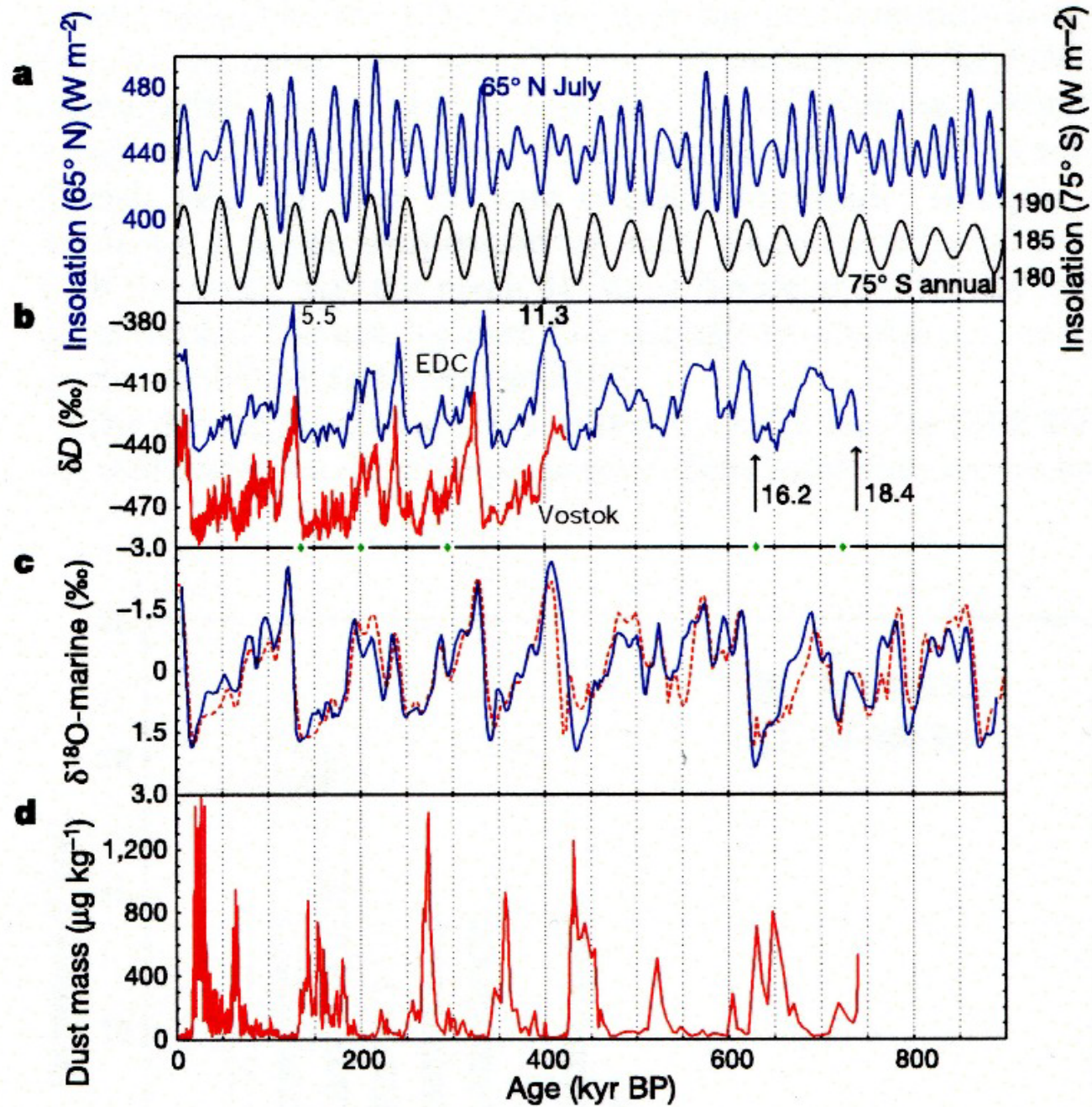
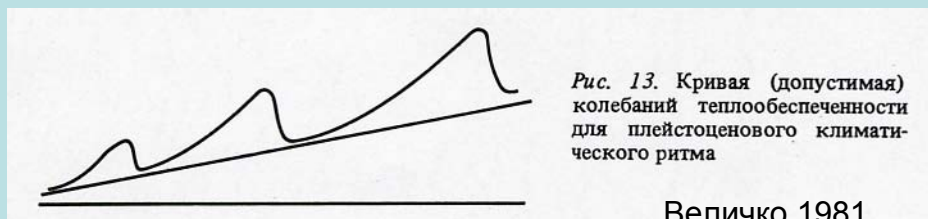
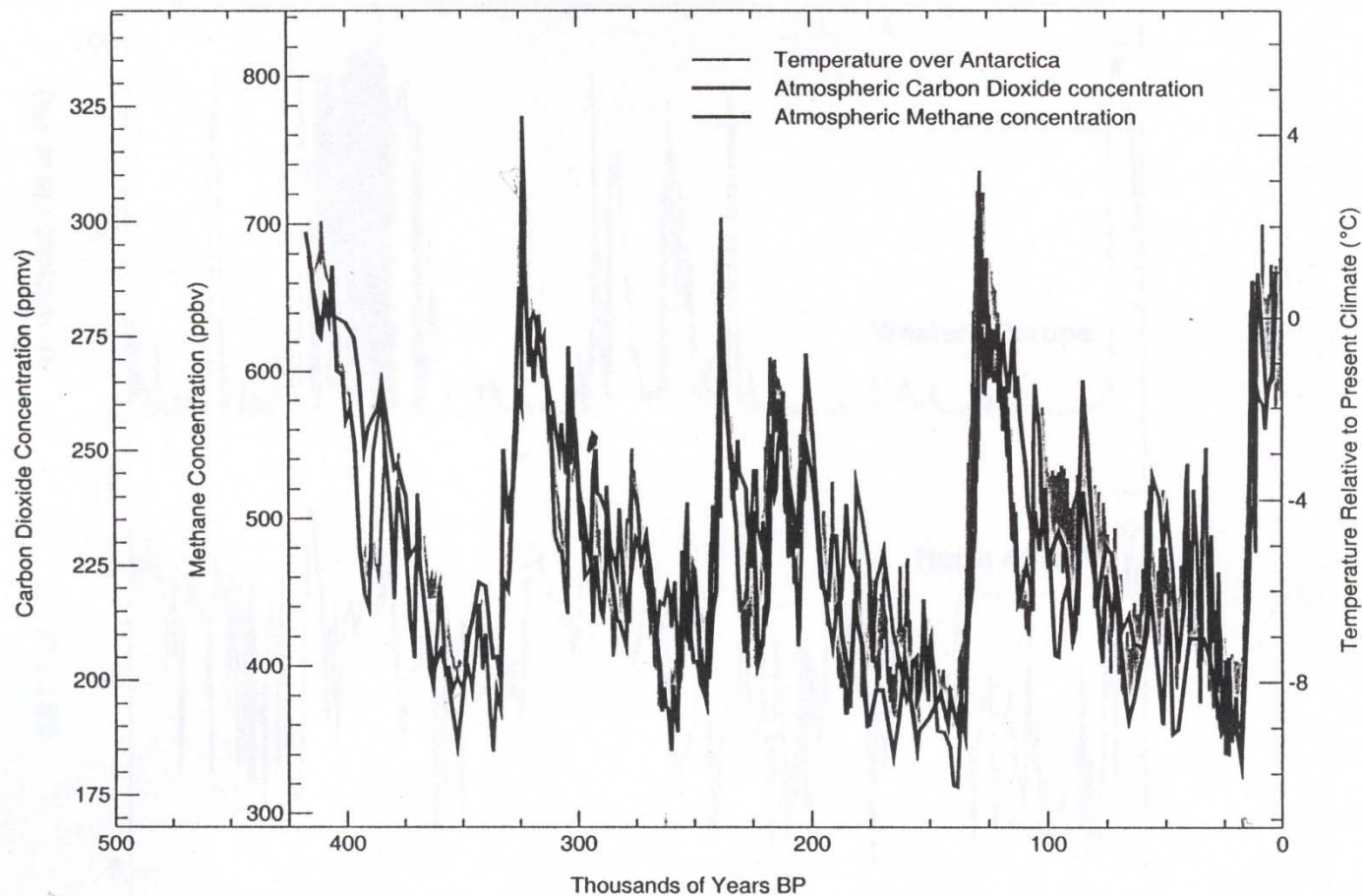


Figure 2 Comparison of EPICA Dome C data with other palaeoclimatic records.

Асимметрия термического сигнала Станция «Восток». (Petit et al., 1999)



Величко, 1981

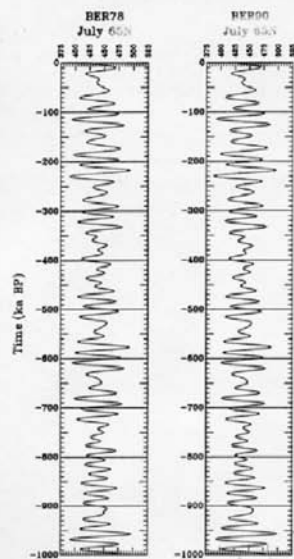


FIG. 10. Comparison between BER78 and BER90 of the long-term variations of the 65N mid-month July insolation from 1 Ma BP to the present.

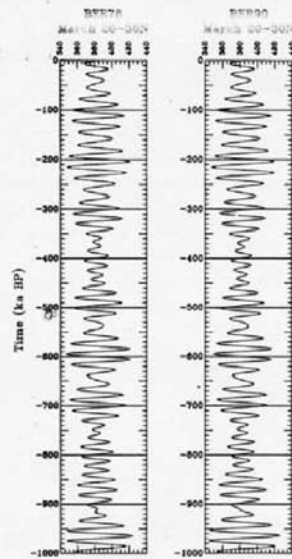


FIG. 12. Comparison between BER78 and BER90 of the long-term variations of the monthly mean insolation for March 20N-30N from 1 Ma BP to the present.



FIG. 11. Comparison between BER78 and BER90 of the long-term variations of the 65N mid-month July insolation from 2 Ma BP to 1 Ma BP.

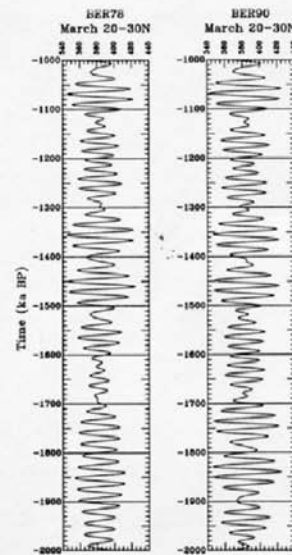
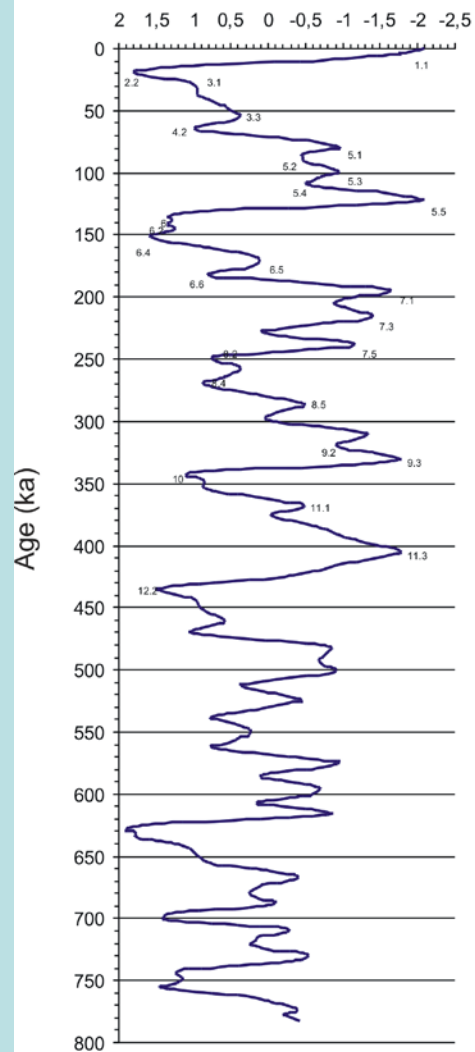


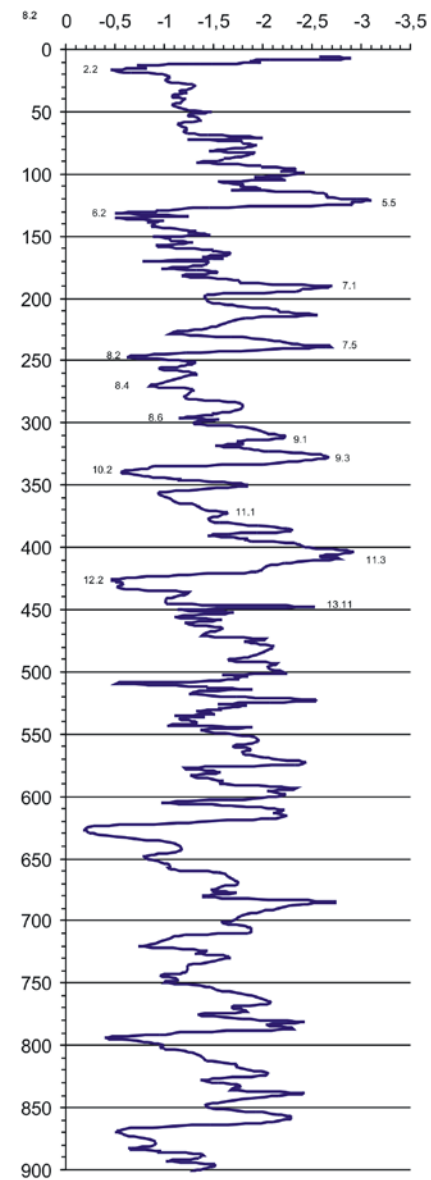
FIG. 13. Comparison between BER78 and BER90 of the long-term variations of the monthly mean insolation for March 20N-30N from 2 Ma BP to 1 Ma BP.

Изотопно-кислородные кривые (δO^{18}) для последнего миллиона лет

SRECMAP



Low Latitude
(Md900963 + site 677)

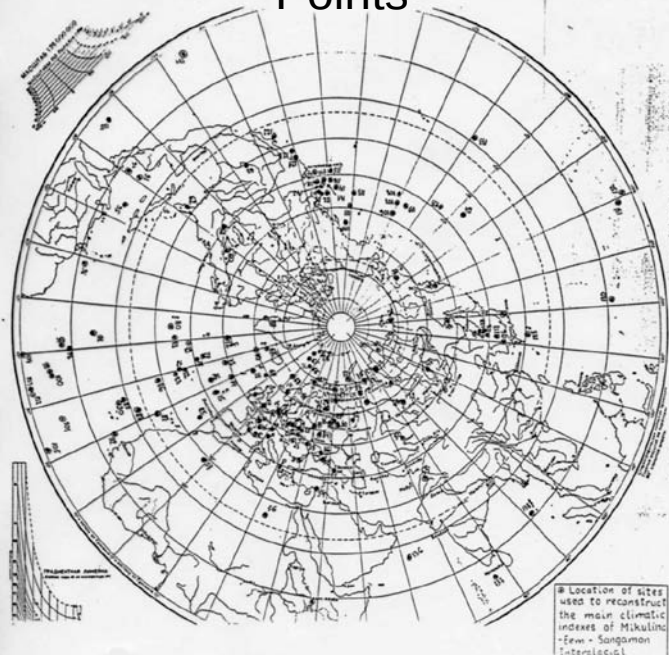


Противоречия в структуре колебаний

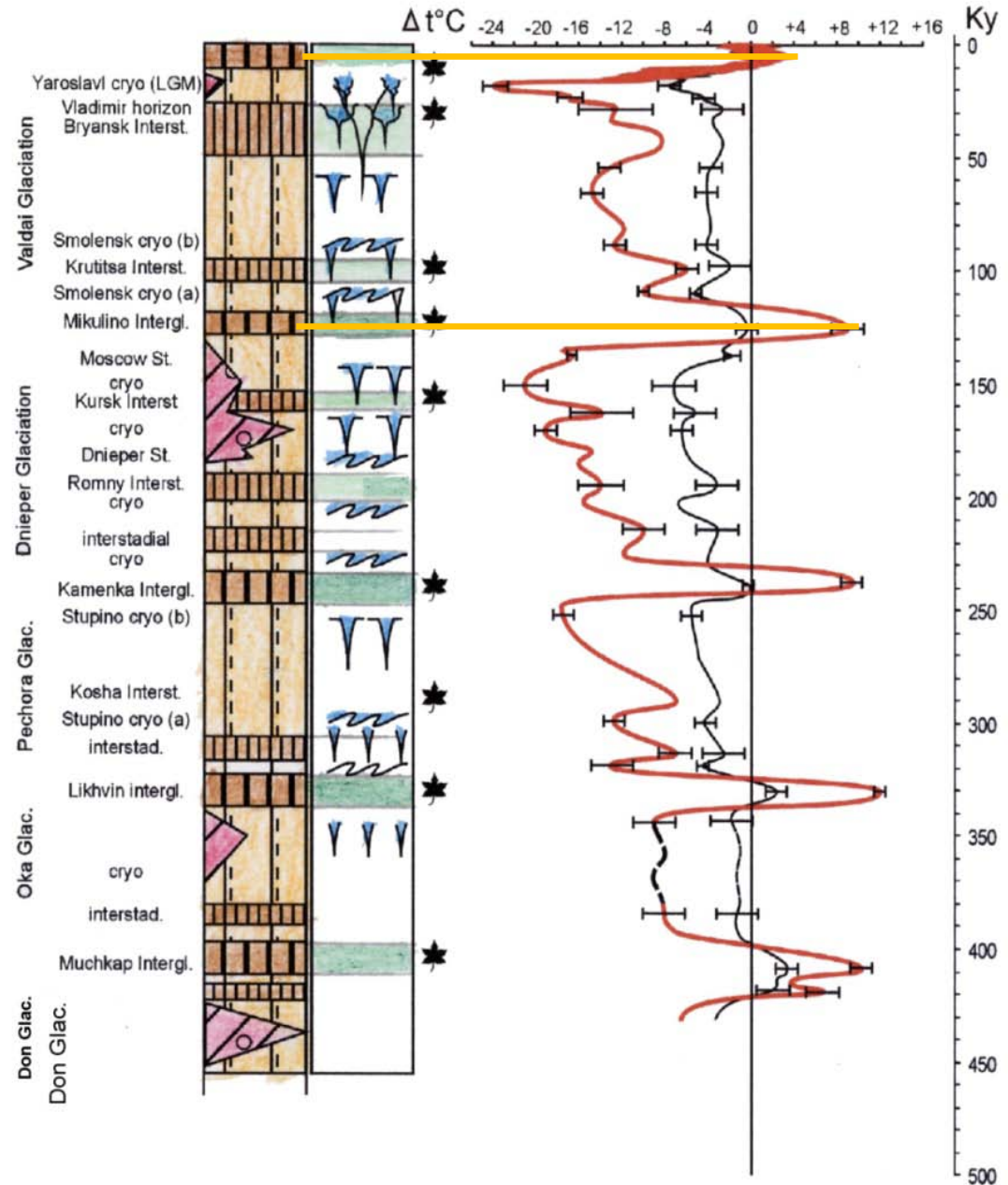
Enigma 2

*Сопоставление астрономической гипотезы
Миланковича и палеоданных*

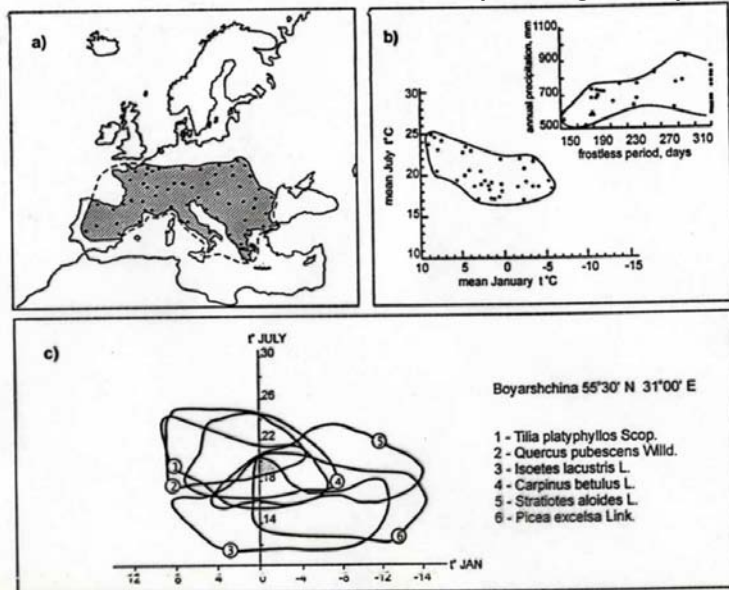
Points



Temperature curve for the last 450 KY



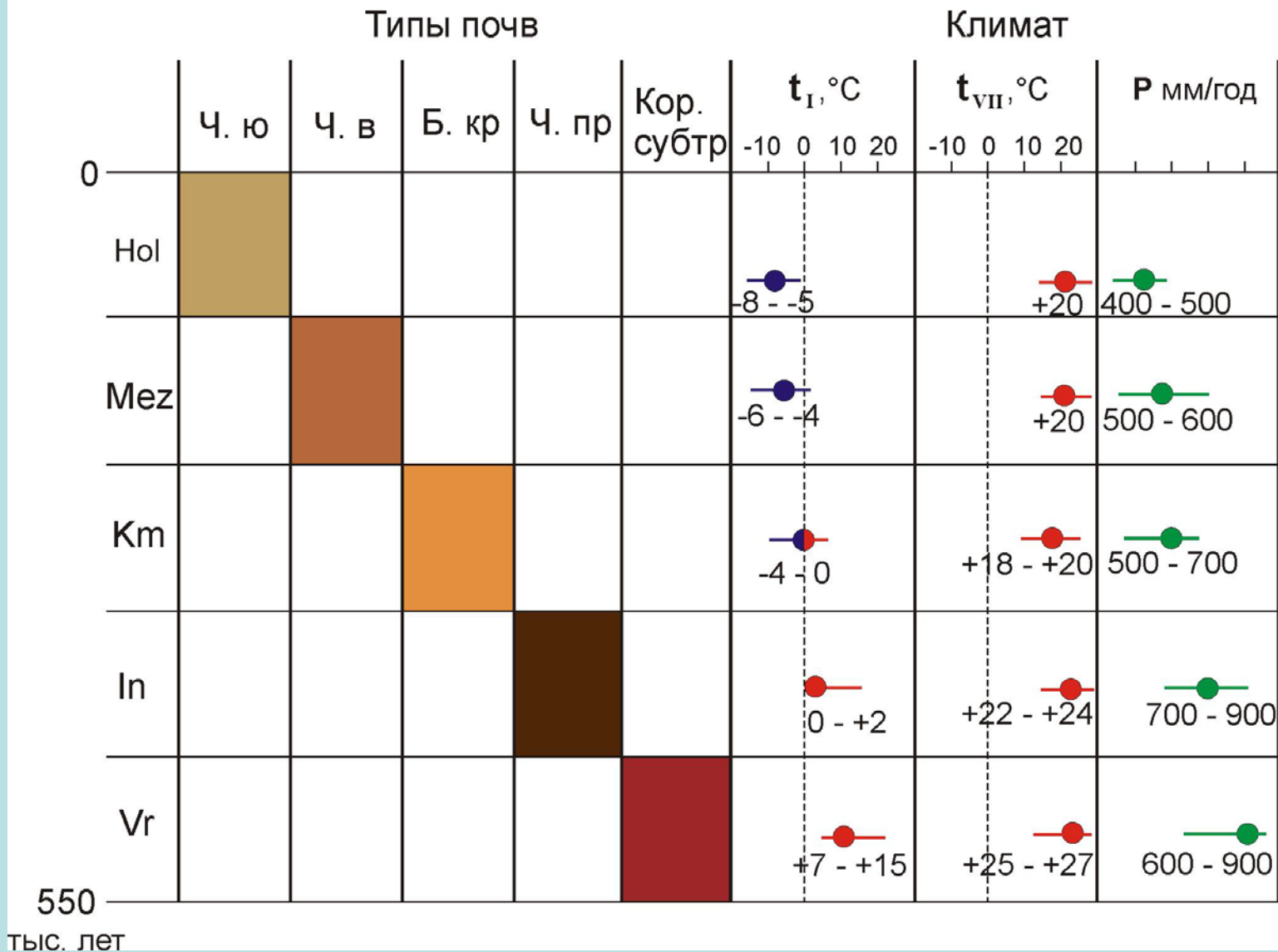
Reconstructions method (climagrams)



(a) present-day range of *Tilia platyphyllos* Scop. (black dots correspond to the meteorological stations); (b) climagrams compiled for the species; (c) a climagram based on the fossil flora of the climatic optimum of the Mikulino Interglacial from the Boyarshchina site.

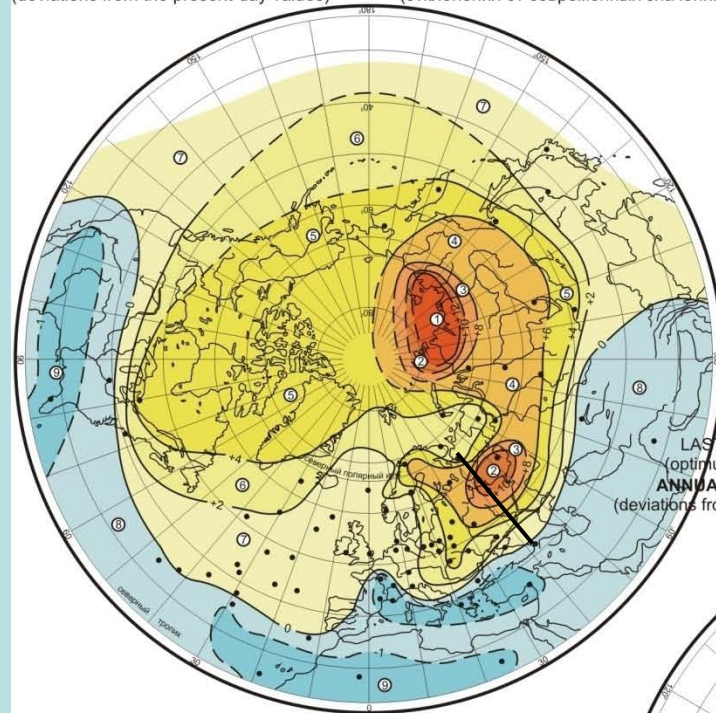
Приазовье

Смена типов почвообразования межледниковий плейстоцена и их климатические характеристики



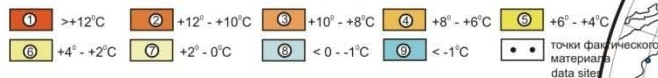
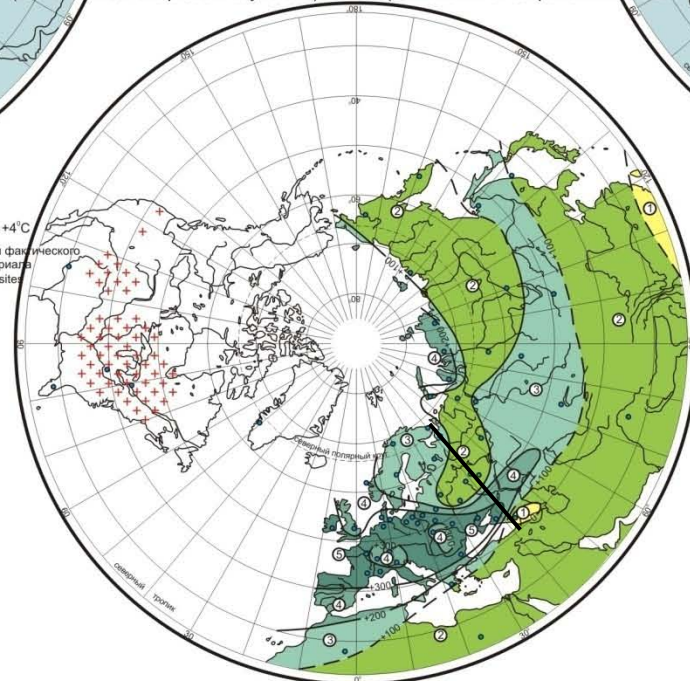
LAST INTERGLACIAL
(optimum ~125 000 yr BP)
JANUARY MEAN TEMPERATURE
(deviations from the present-day values)

ПОСЛЕДНЕЕ МЕЖЛЕДНИКОВЬЕ
(климатический оптимум ~125 000 л.н.)
СРЕДНЯЯ ТЕМПЕРАТУРА ЯНВАРЯ
(отклонения от современных значений)



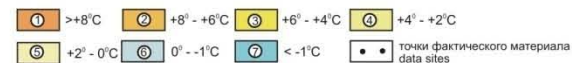
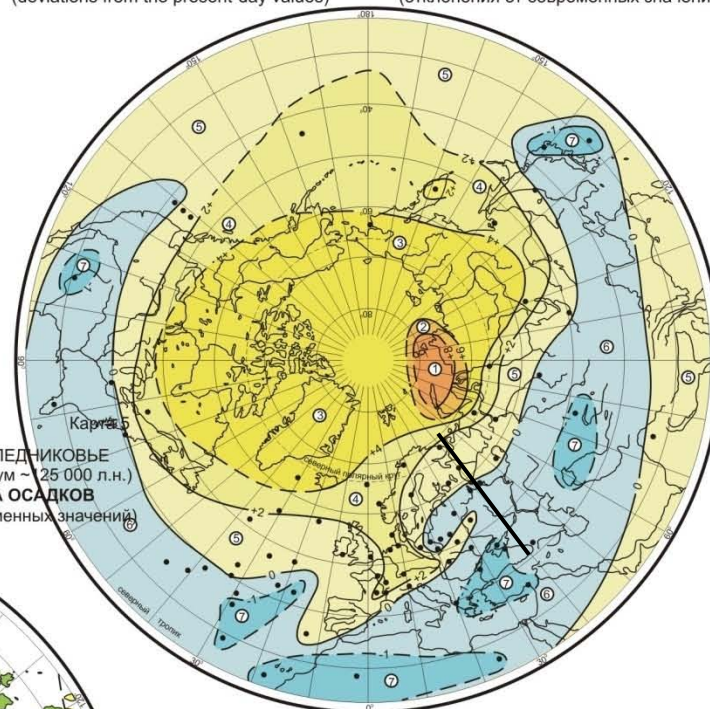
LAST INTERGLACIAL
(optimum ~125 000 yr BP)
ANNUAL PRECIPITATION
(deviations from the present-day values)

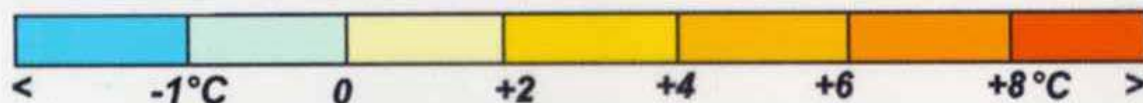
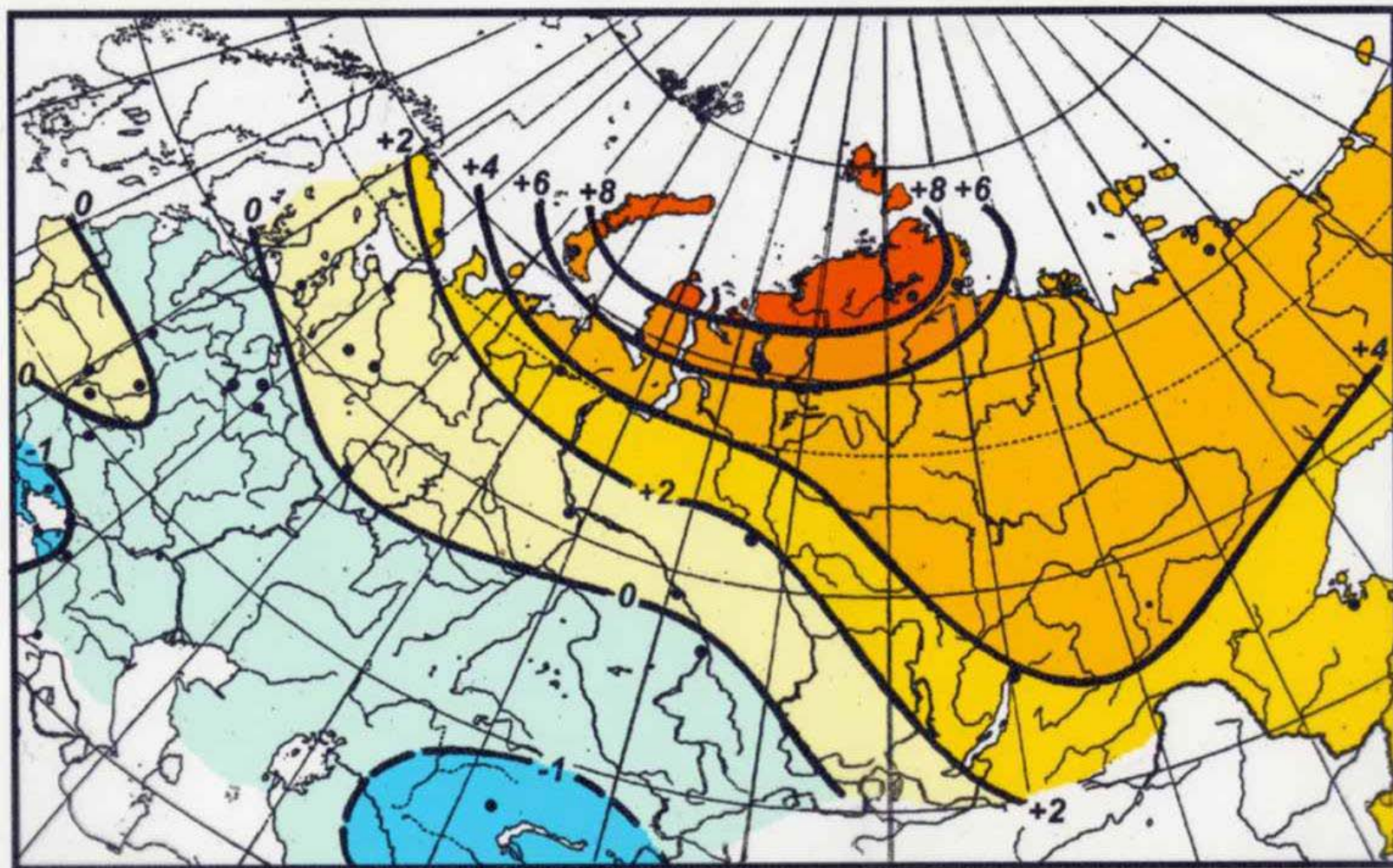
ПОСЛЕДНЕЕ МЕЖЛЕДНИКОВЬЕ
(климатический оптимум ~125 000 л.н.)
ГОДОВАЯ СУММА ОСАДКОВ
(отклонения от современных значений)



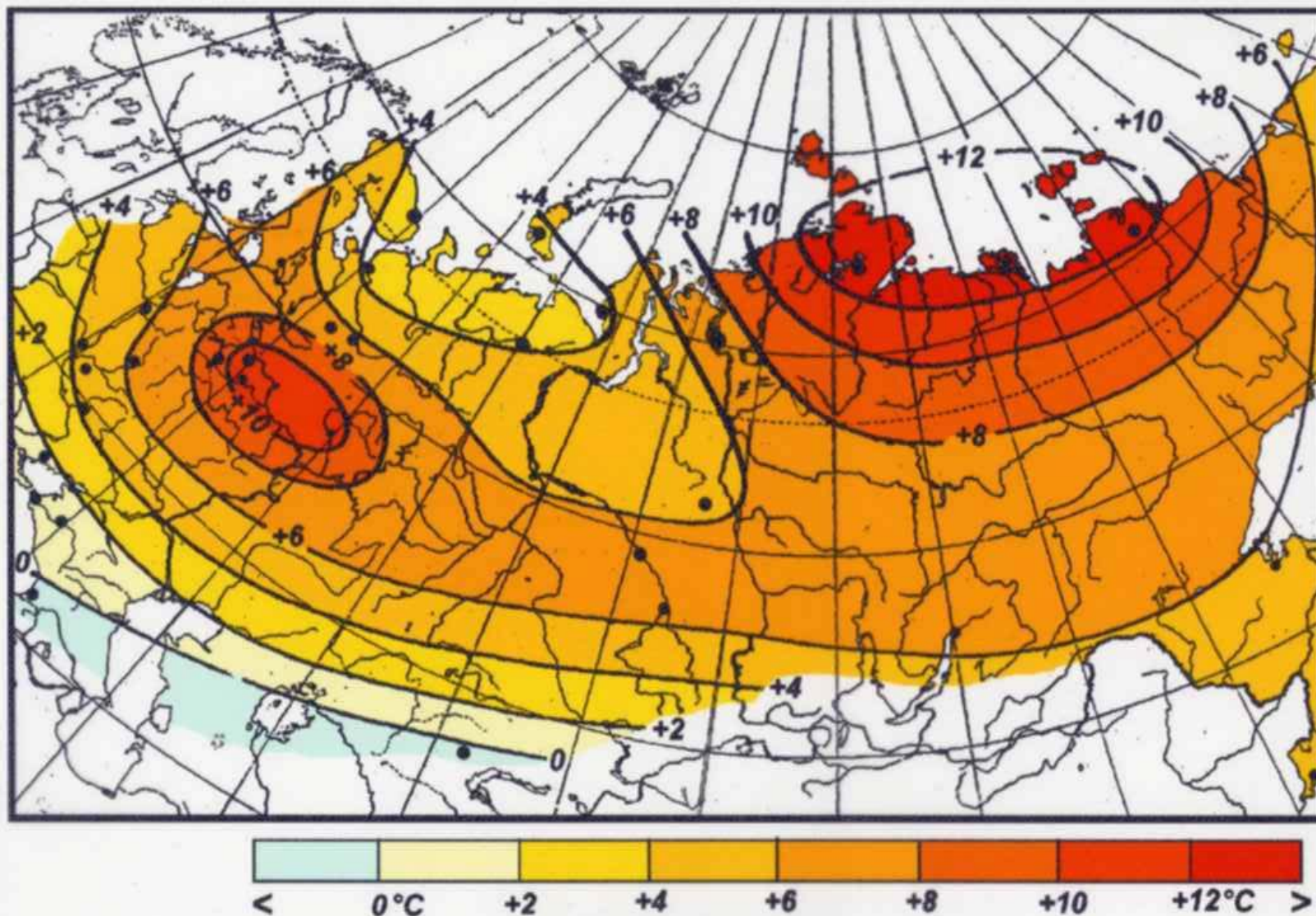
LAST INTERGLACIAL
(optimum ~125 000 yr BP)
JULY MEAN TEMPERATURE
(deviations from the present-day values)

ПОСЛЕДНЕЕ МЕЖЛЕДНИКОВЬЕ
(климатический оптимум ~125 000 л.н.)
СРЕДНЯЯ ТЕМПЕРАТУРА ИЮЛЯ
(отклонения от современных значений)

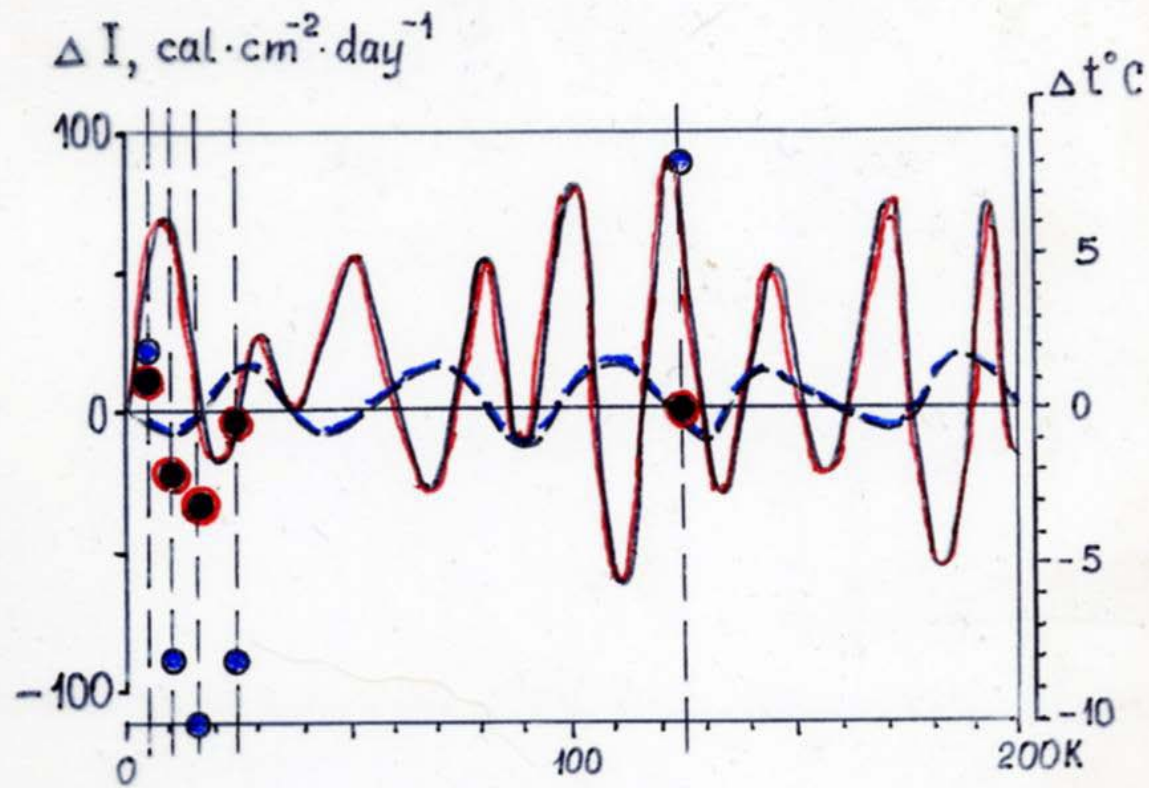




Climatic optimum of the Mikulino (Eemian) Interglacial (about 125,000 years BP)
Mean July temperature, deviations from modern values



Climatic optimum of the Mikulino (Eemian) Interglacial (about 125,000 years BP)
Mean January temperature, deviation from modern values

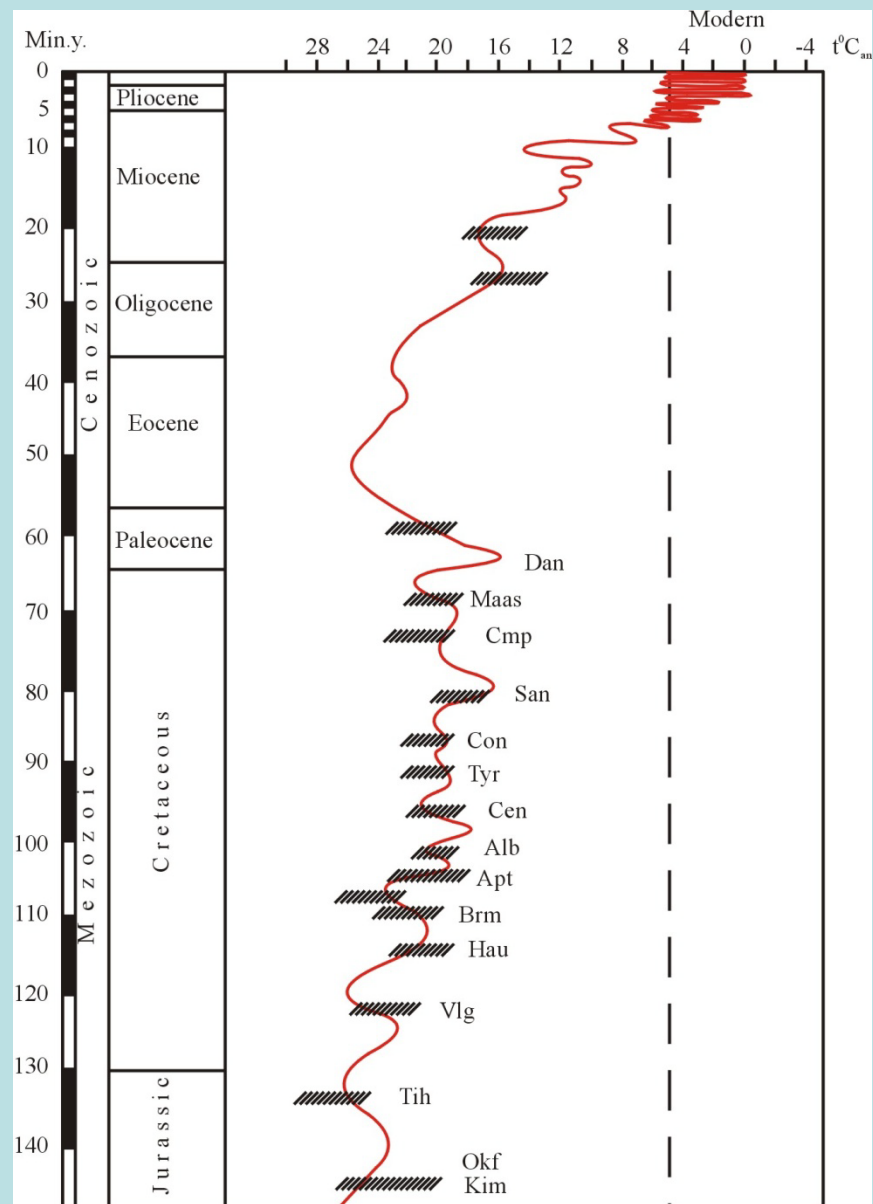


Long term variations of January ($\sim$) and July ($\sim$) monthly mean insolation (adapted from Berger, Pestiaux, 1982) for zonal 10° belt centered at 55°N , and mean January ($\odot$) and July ($\bullet$) temperature deviations from present-day values (paleoreconstructions).

Несоответствие в знаке отклонения зимних и летних температур

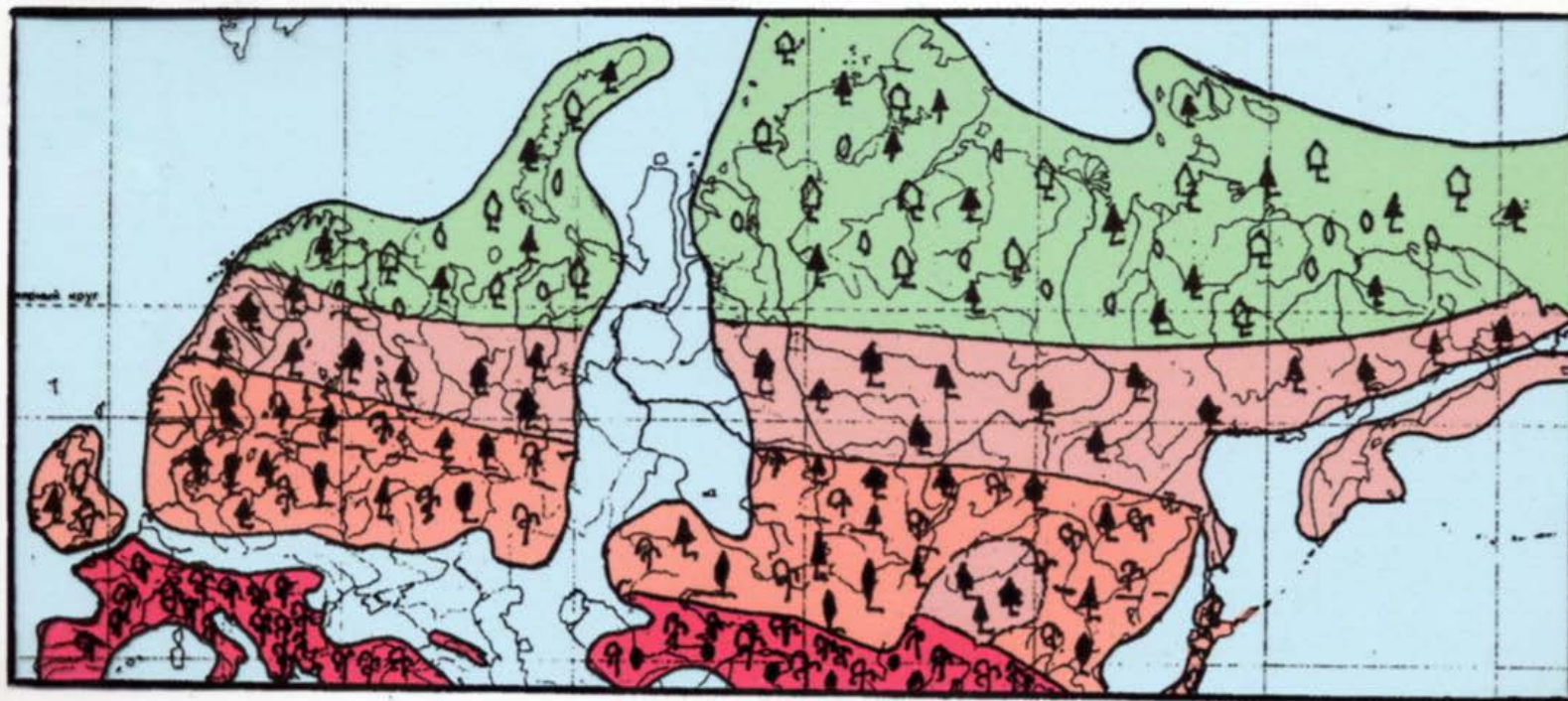
Enigma 3

Позиция квартера в системе мегациклов



Southern part of East-European plain. Change of mean annual temperature during last 150 mln.y.
(By A.Velichko, N.Yasamanov)

Climatic Optimum for Northern Eurasia During the Eocene



Tropics



Sub-tropics with many tropical elements



Sub-tropics

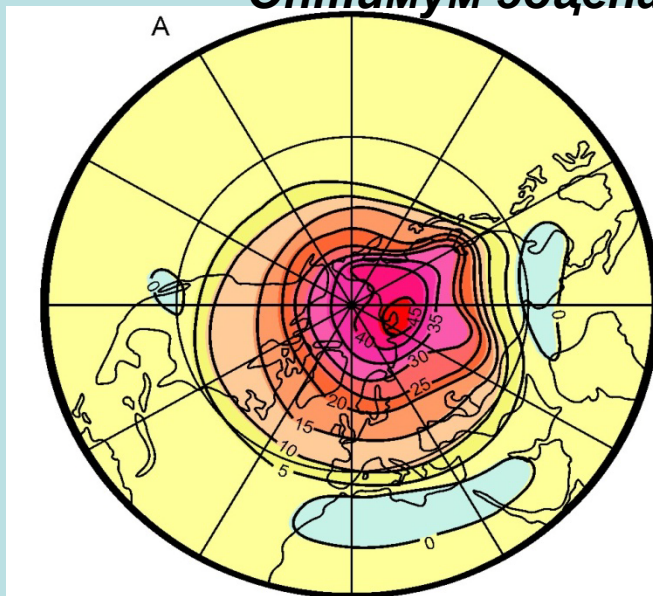


Warm temperate

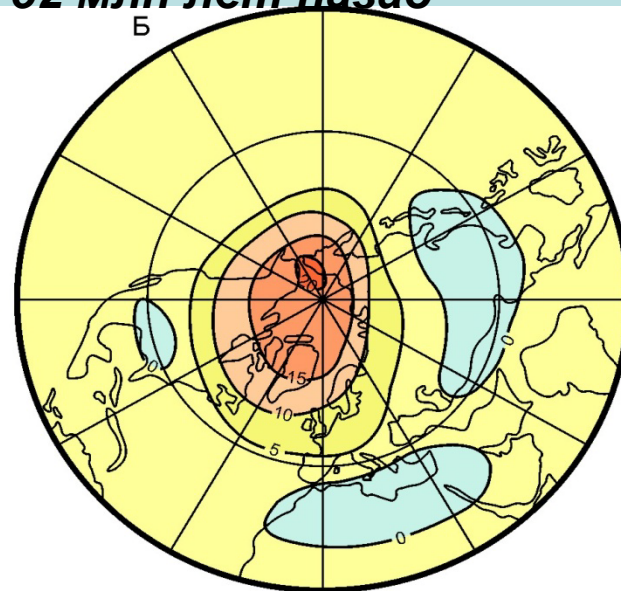
Реконструкция палеотемператур Северного полушария в отклонениях от современных значений

Оптимум эоцена – 52 млн лет назад

январь

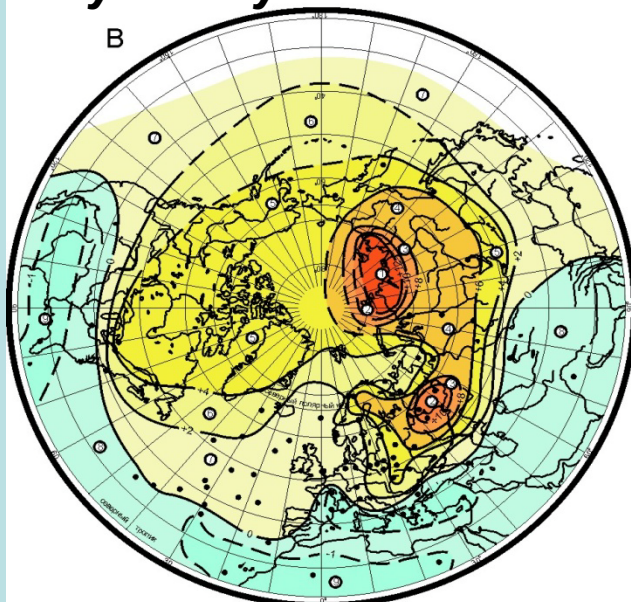


июль

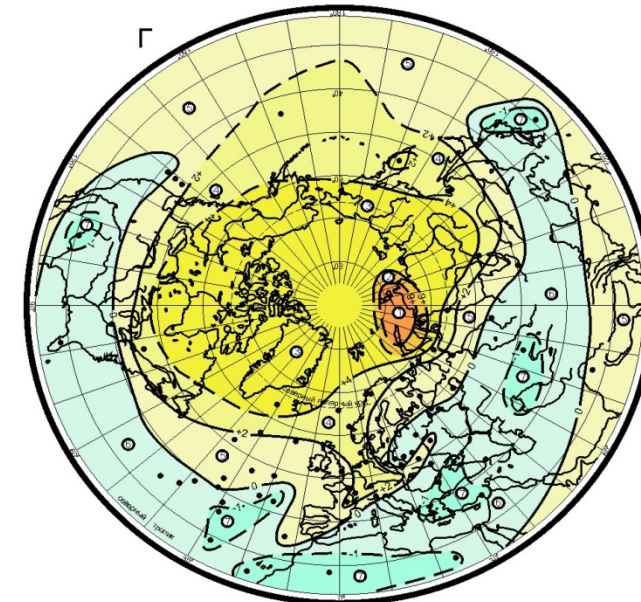


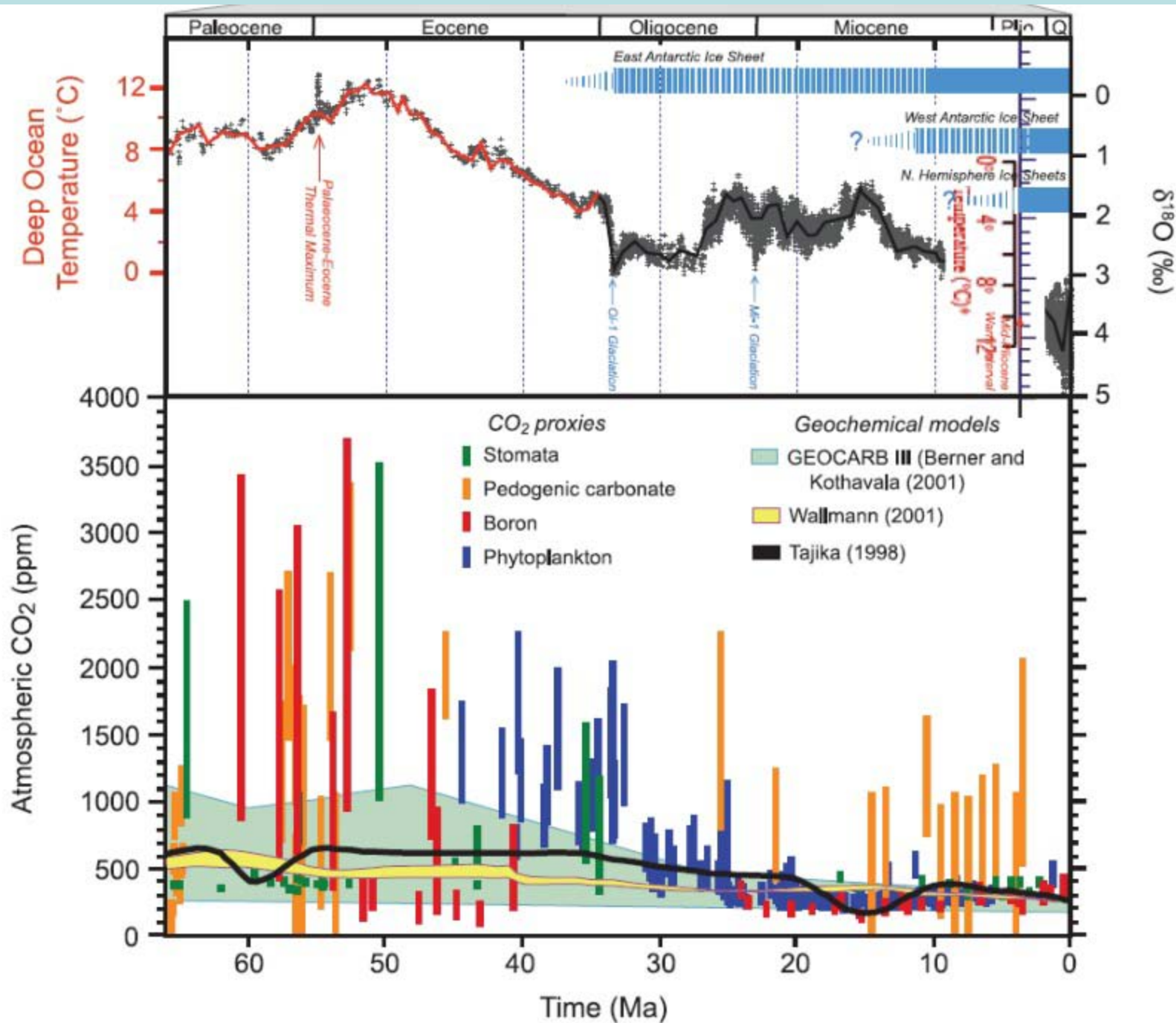
Оптимум микулинского межледникового – 125 тыс. лет назад

январь



июль





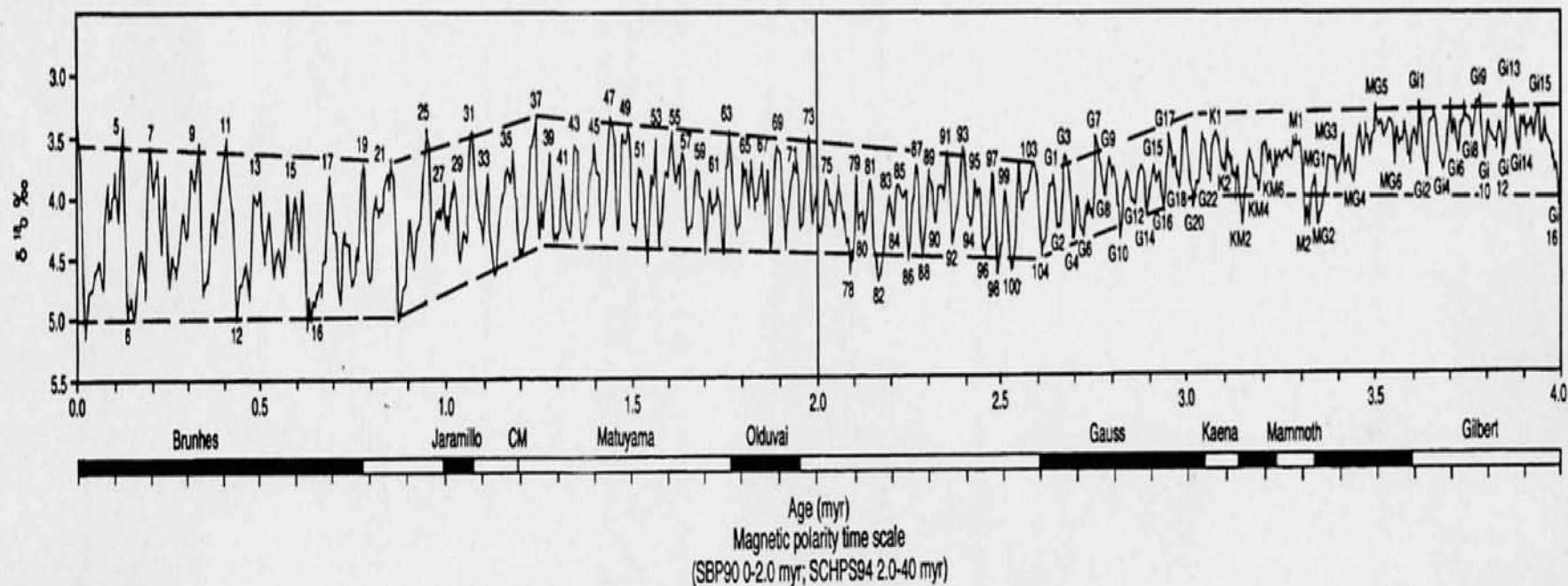


FIG. 1. Oxygen isotope record for the period 4.0 Ma to present (after Shackleton, 1995). Data have been derived from the SPECMAP stack for the interval 0–0.62 Ma, ODP Site 677 for the interval 0.62–2.0 Ma and ODP Site 846 for the interval 2.0–4.0 Ma.

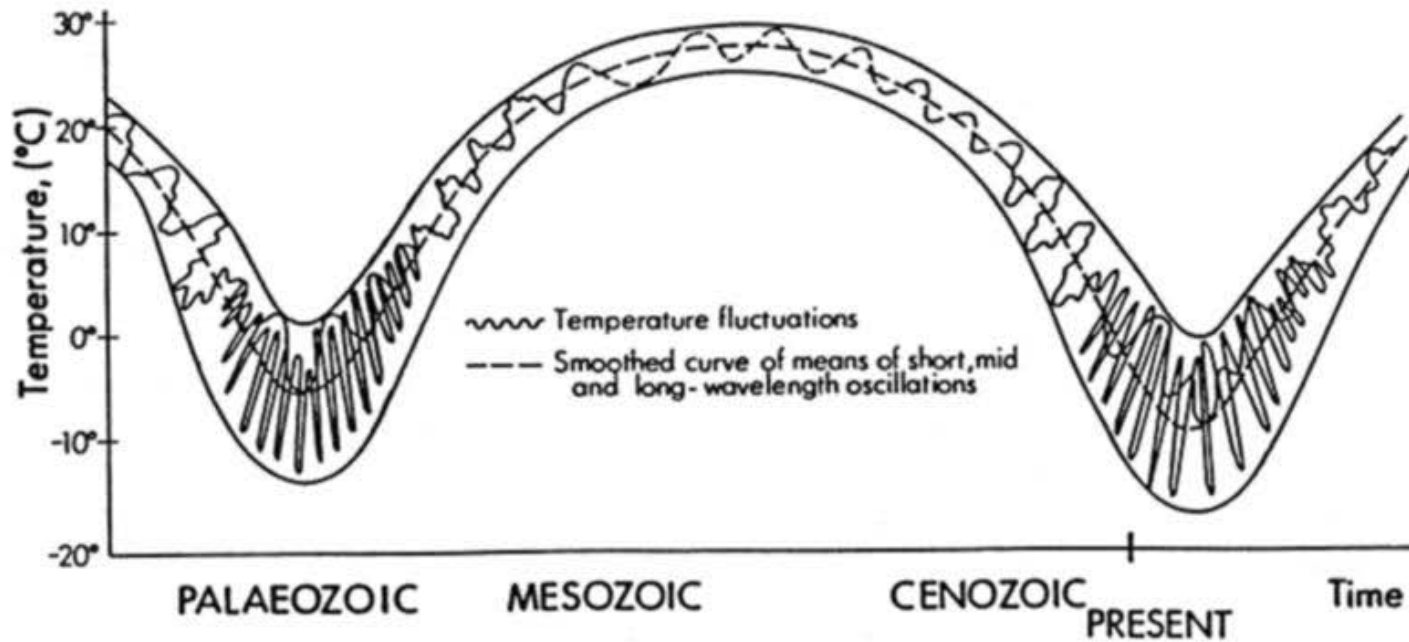


FIG. 2. Scheme of the Phanerozoic megacycle of temperature fluctuations. The Mesozoic was marked by longwave oscillations, with periods of 15–20 Ma. These were replaced during the Early and Mid-Cenozoic by midwave oscillations with periods of 2–5 Ma, and during the Quaternary by shortwave oscillations with periods of 100–150 ka.

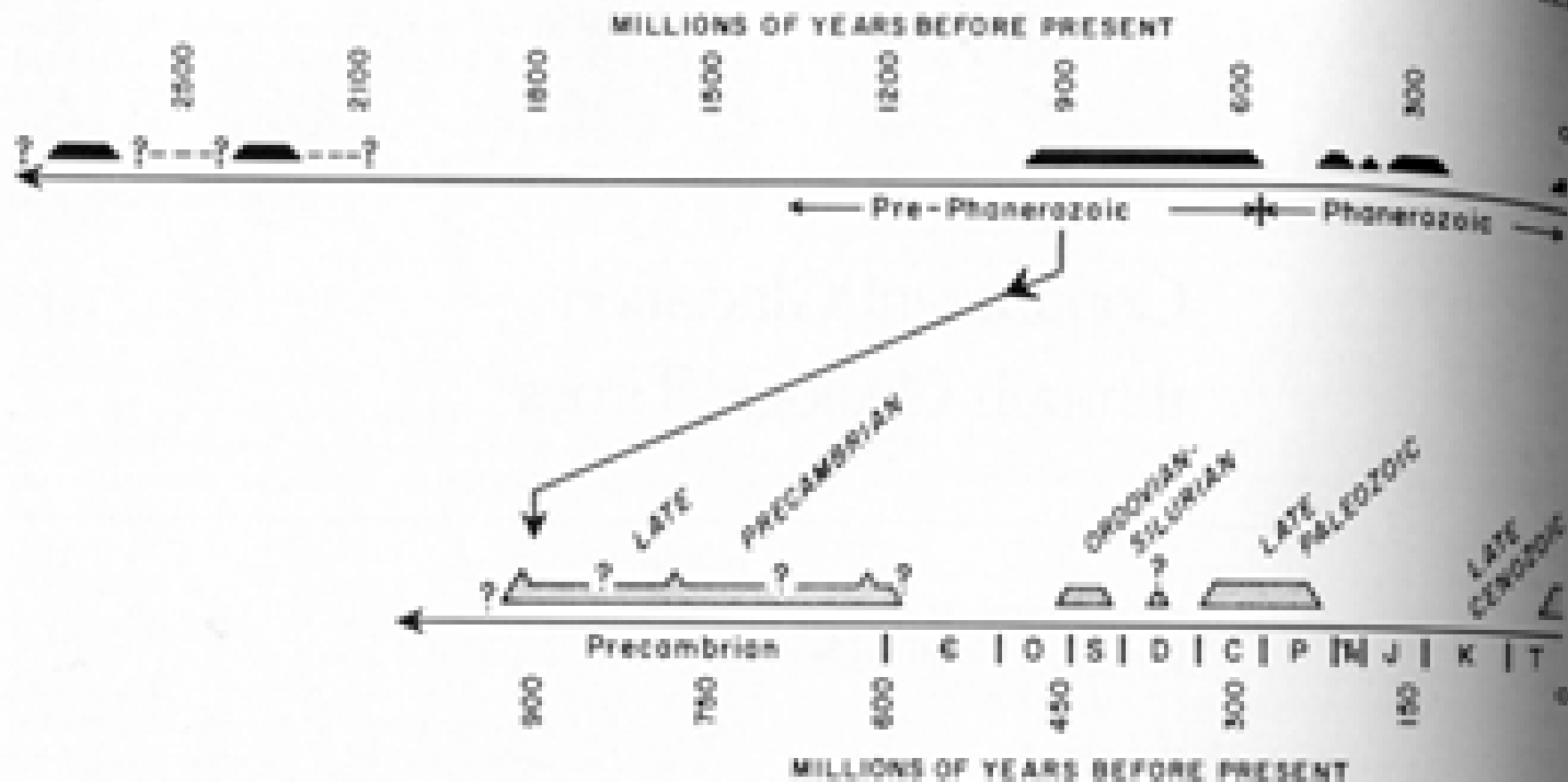
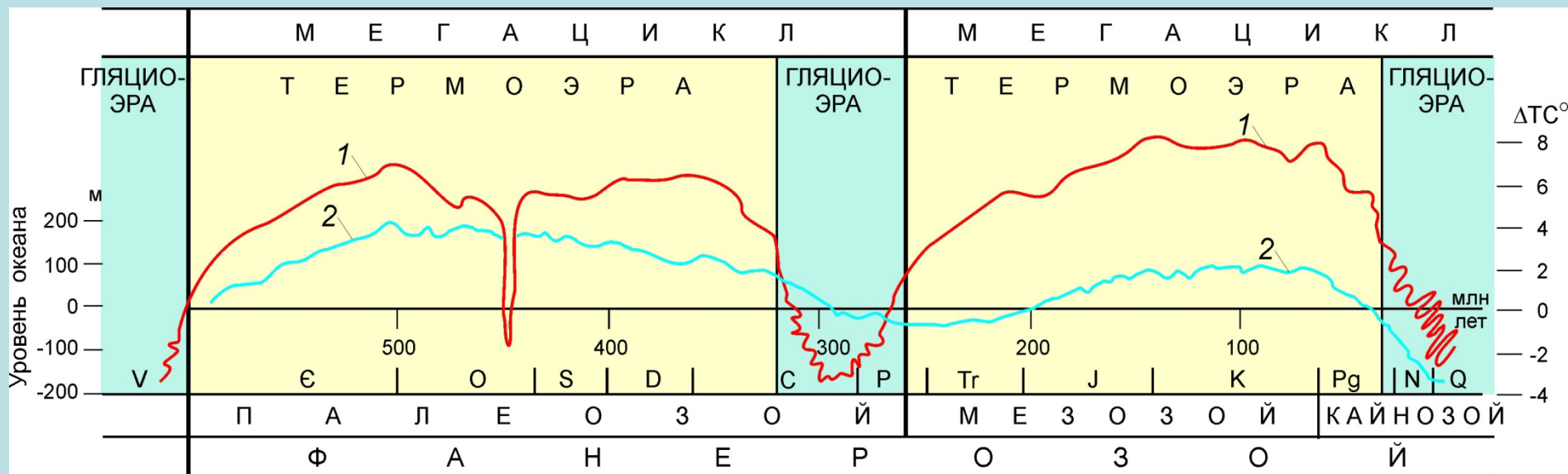


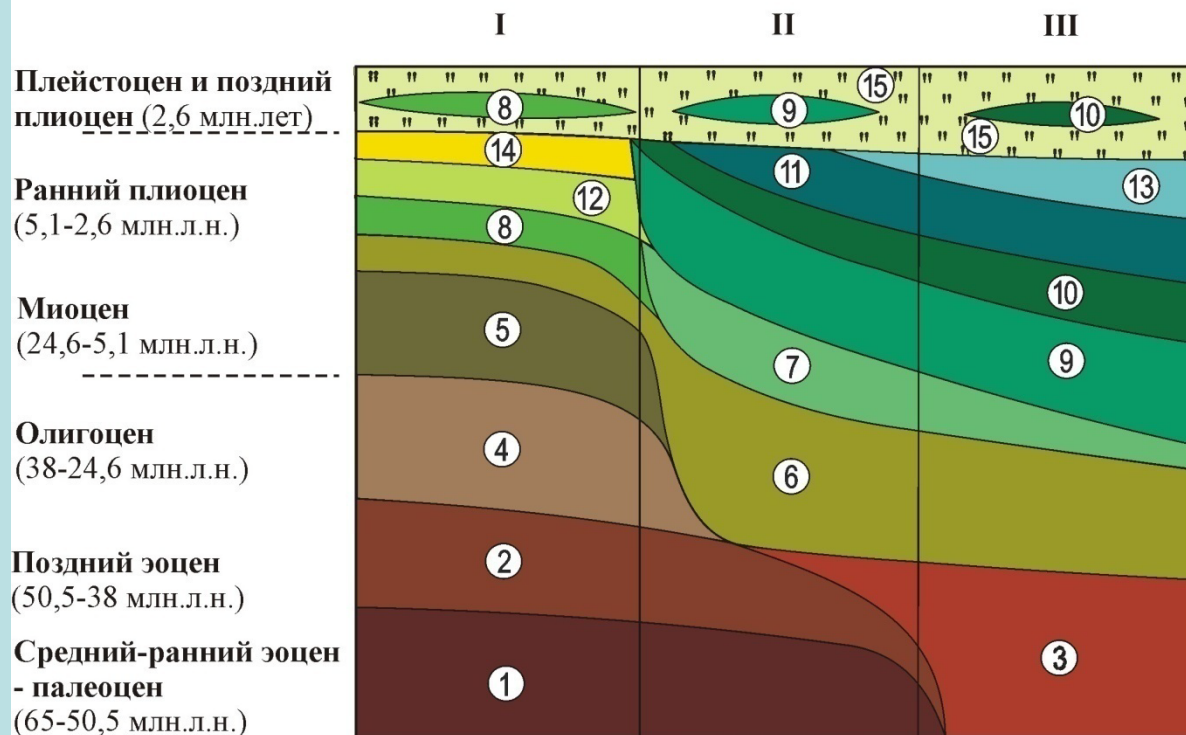
FIGURE 4.1 Occurrence in time of ancient ice ages plotted linearly, to two scales. O, Ordovician; S, Silurian; D, Devonian; C, Carboniferous; P, Permian; Tr, Triassic; J, Jurassic; K, Cretaceous; T, Tertiary.

Структура мегациклов в фанерозое



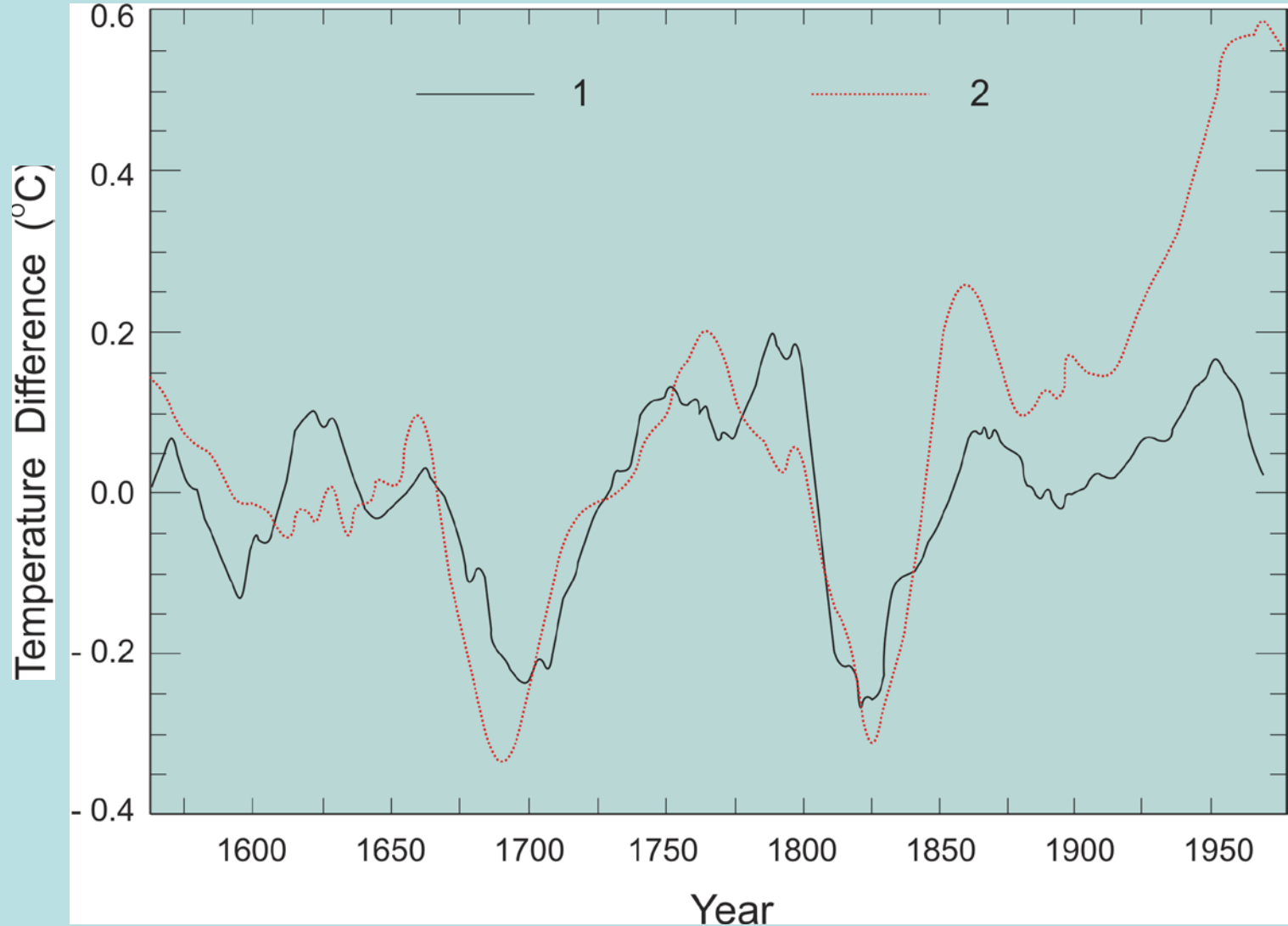
1. Температурная кривая
2. Изменения уровня океана

ФОРМИРОВАНИЕ ТИПОВ ЗОНАЛЬНОСТИ, ОБУСЛОВЛЕННЫХ ИЗМЕНЕНИЯМИ ГИДРОТЕРМИЧЕСКОГО РЕЖИМА, В КАЙНОЗОЕ



Изменения климата за последние 500 лет по моделям:

- 1 – HadCM3 с учетом естественных действующих факторов (циклы солнечной активности);
- 2 - ECHO-G с учетом естественных (циклы солнечной активности) и антропогенных действующих факторов

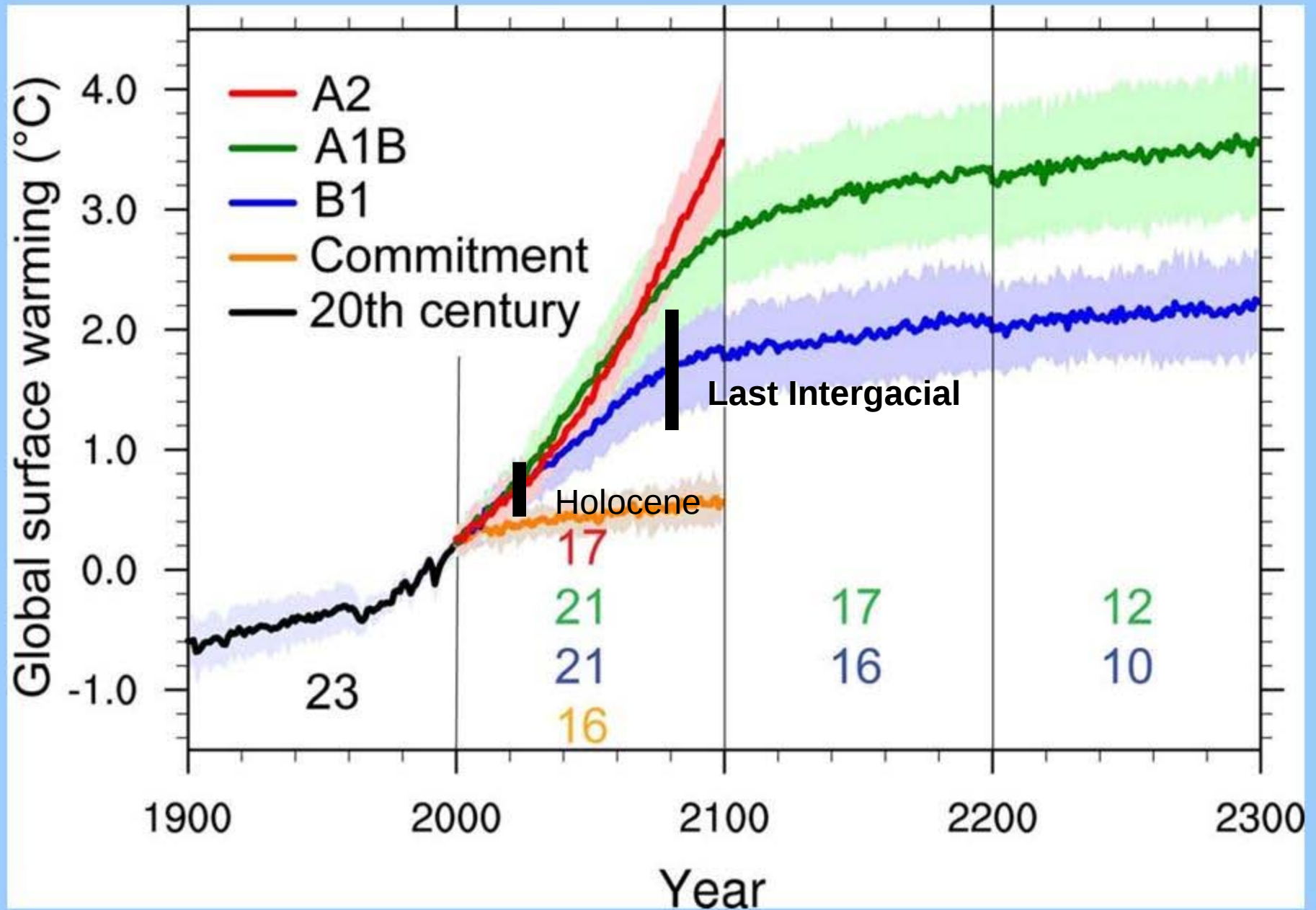


Проблема генезиса мегациклов

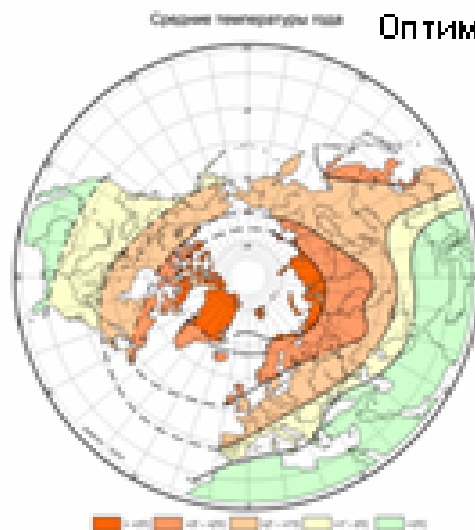
Enigma 4

*Сопоставление данных численного
моделирования
и реконструкций палеоклимата*

IPCC 2007



Holocene and Last interglacial optimum mean annual temperatures

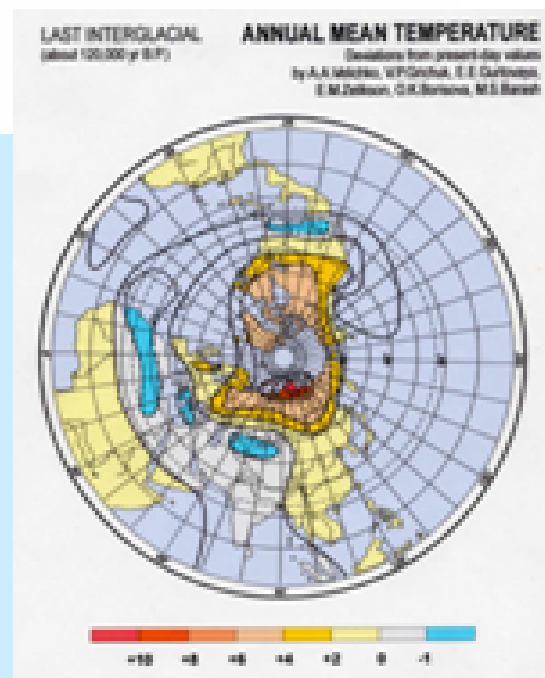


φ	$\Delta t_{\text{с}}$	$\Delta S_{\text{с}}$	$\Delta t_{\text{с}} \cdot \Delta S_{\text{с}}$
90°	1,0°	1	1,0
80°	1,9°	1	1,9
70°	2,3°	3	10,3
60°	1,3°	7	10,3
50°	0,9°	9	8,1
40°	0,3°	11	3,3
30°	0,1°	13	1,3
20°	0,1°	13	1,3
10°	0,0°	13	0,0
0°	0,0°	17	0,0

$\Sigma = 47,1$

Holocene optimum
Mean annual temperature

$$\Delta T^{\circ}\text{C} = \frac{47,6}{81} = 0,65^{\circ}\text{--}0,7^{\circ}$$



Оптимум микулинского межледникового ~ 125 т.л.н.

Среднегодовая температура

mean annual temperature during the minimum interglacial optimum (average for the Northern hemisphere) – deviations from the present values

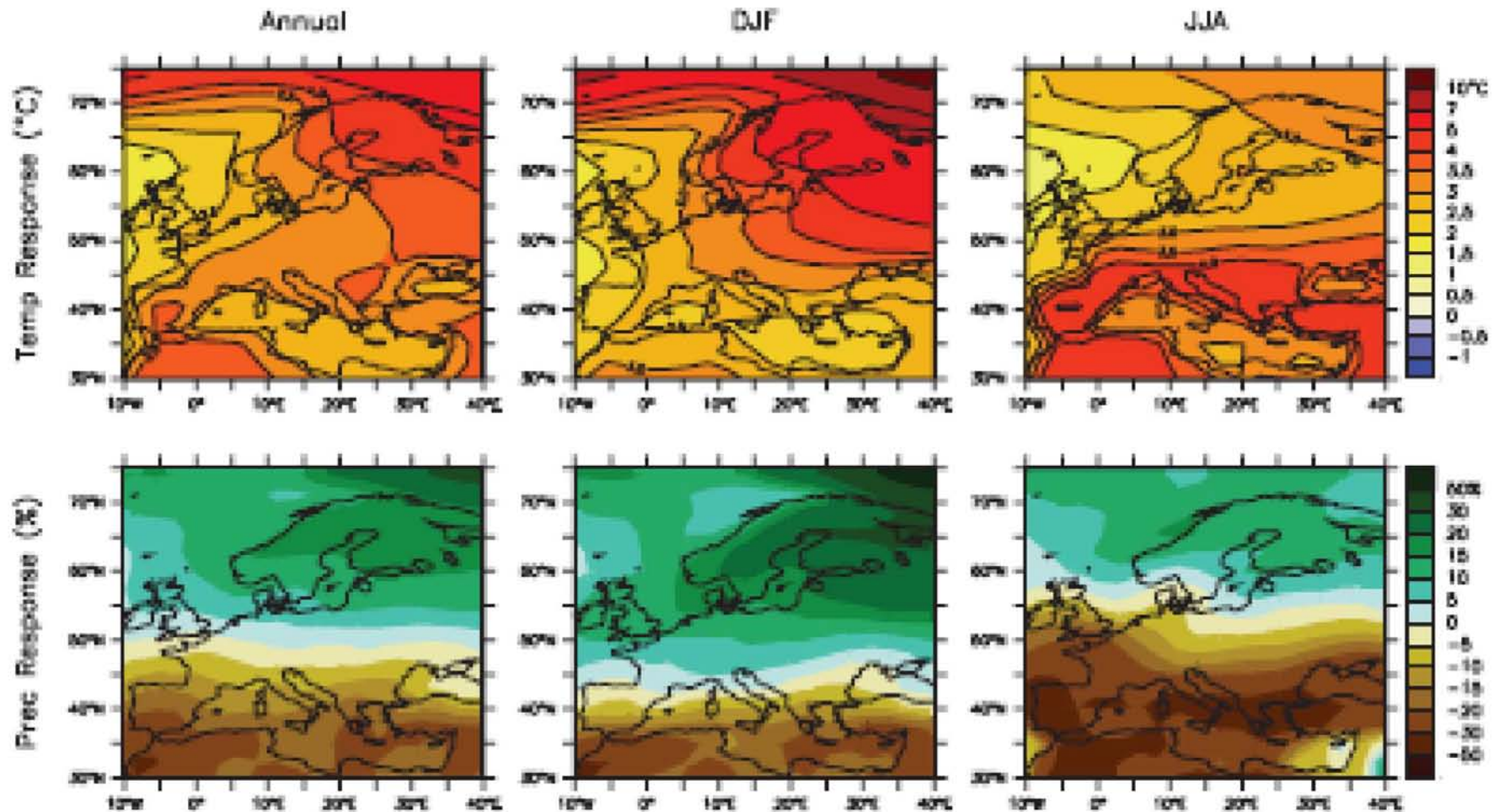
φ	$\Delta t_{\text{с}}$	$\Delta S_{\text{с}}$	$\Delta t_{\text{с}} \cdot \Delta S_{\text{с}}$
90°	+5°	2,0	9,0
80°	6,1°	+0	24,4
70°	+3°	6,1	26,2
60°	2,5°	9,1	22,8
50°	1,2°	10,6	12,7
40°	1,1°	12,0	13,2
30°	0,2°	13,5	10,8
20°	1,0°	13,9	13,9
10°	1,0°	14,5	14,5
0°			

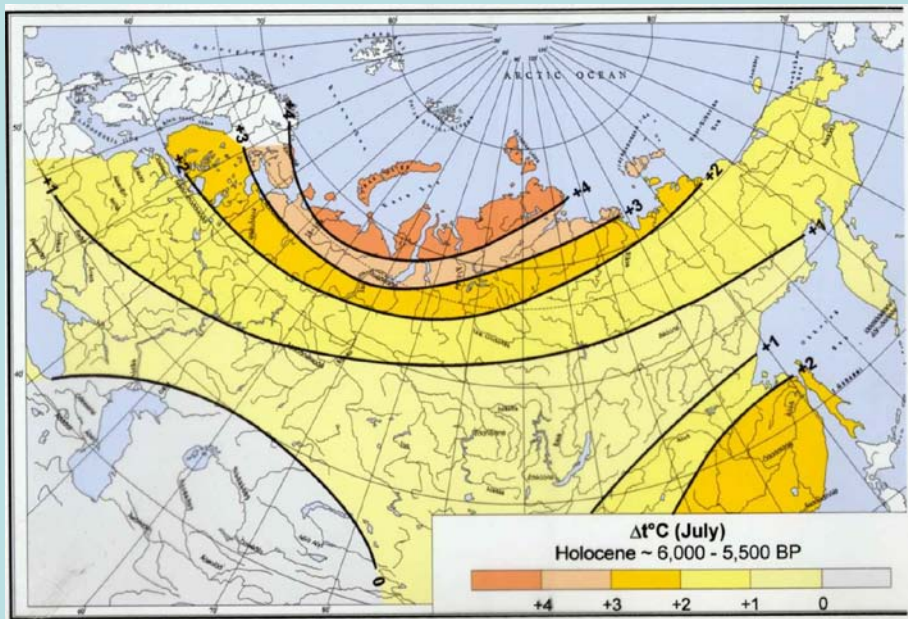
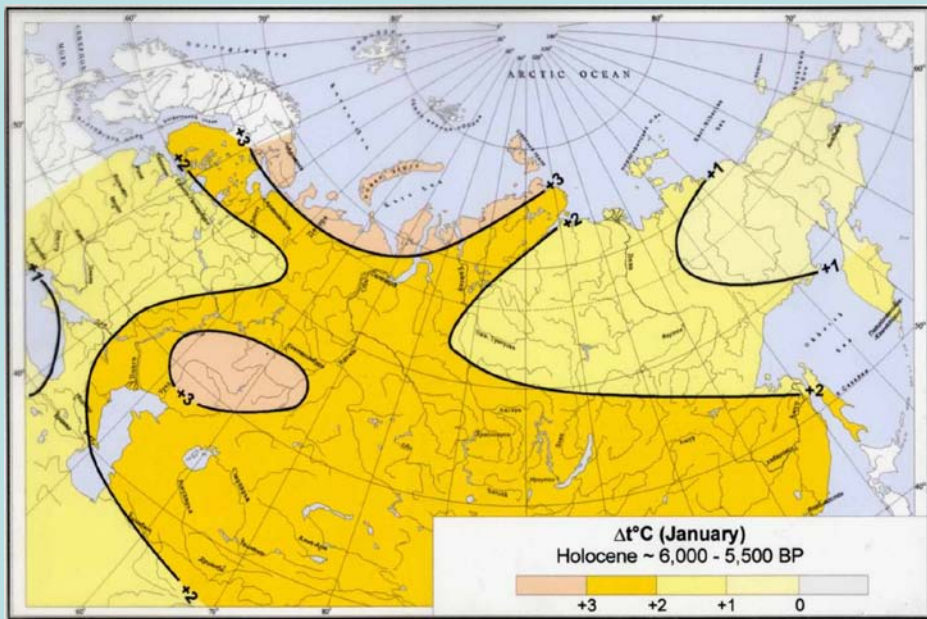
$\Sigma = 147,5$

$S = 2297h$

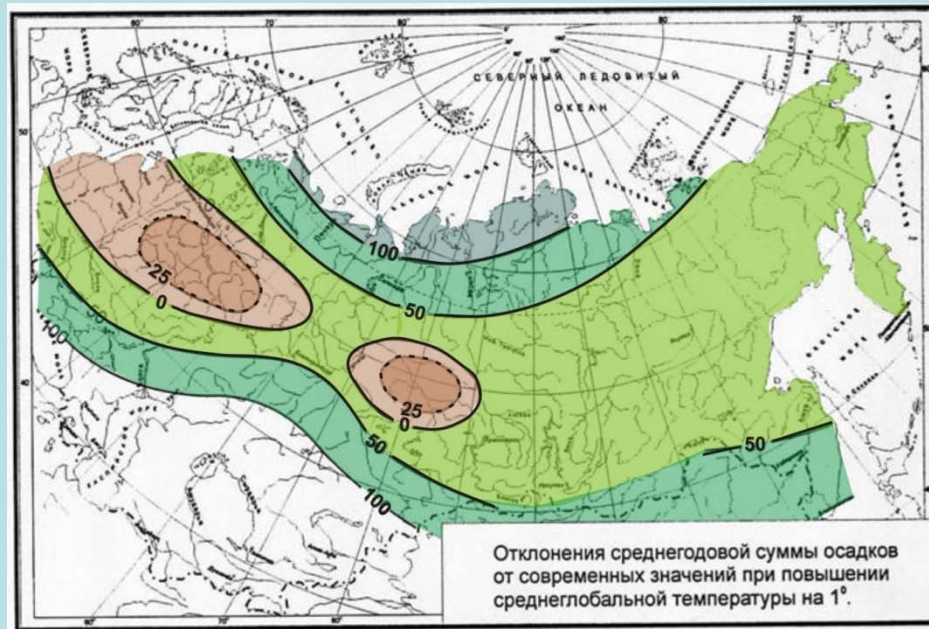
$$\Delta T^{\circ}\text{C} = \frac{147,5}{80} = 1,7^{\circ}$$

Temperature and precipitation changes over Europe from the MMD-A1B simulations.
 Top row: Annual mean, DJF and JJA temperature change between 1980 to 1999
 and 2080 to 2099, averaged over 21 models.
 IPCC - 2007

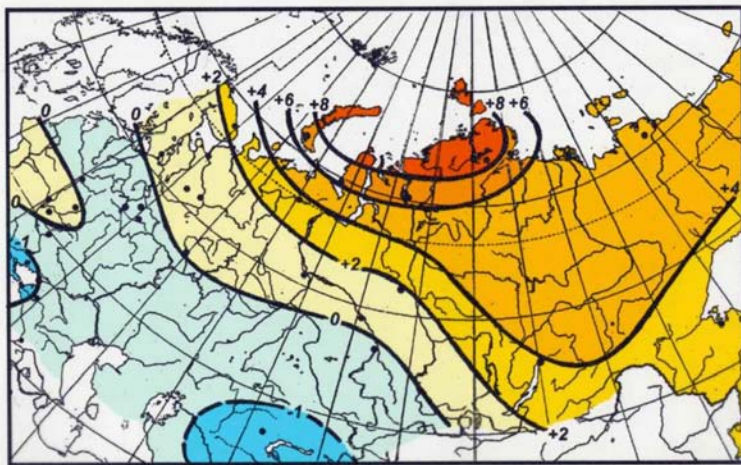




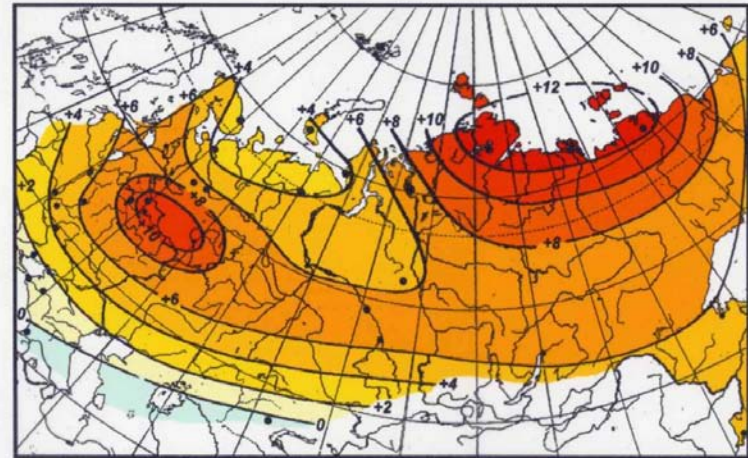
Оптимум голоцена ($\Delta T_{\text{glob}} +0,6-0,7^{\circ}\text{C}$)
Holocene optimum (mean global temperature by $+0,6-0,7^{\circ}\text{C}$)



ΔP_{annual}

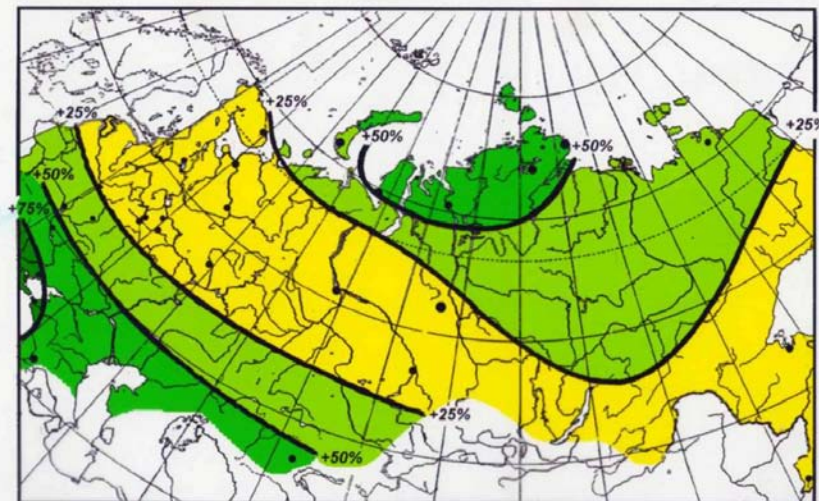


Climatic optimum of the Mikulino (Eemian) Interglacial (about 125,000 years BP)
Mean July temperature, deviations from modern values



Climatic optimum of the Mikulino (Eemian) Interglacial (about 125,000 years BP)
Mean January temperature, deviation from modern values

Оптимум микулинского межледниковья ($\Delta T_{\text{glob}} \sim +1,7^{\circ}\text{C}$)
Last interglacial optimum



Climatic optimum of the Mikulino (Eemian) Interglacial (about 125,000 years BP)
Annual precipitation, deviation from modern values

Moisture estimation

Coefficient of moisture by C.W.Thornthwaite

$$\text{CMT} = P_{\text{I-XII}} / E_o$$

$$E_o = 1,6 (10T/J)^a$$

E_o – evaporation cm/month⁻¹

T – average month t° (got into account only the months with the positive temperature during the year)

$A = f(I)$, I – index of the latitude correction

Changes in moisture supply in the second half of the XX
century and projected for XXI century
(based on paleoanalogues – the Holocene
and the Last Interglacial optimums on East European plain)
by C.W.Thornthwaite coefficient

	* Modern by A.N.Zolotokrylin and E.A.Cherenkova			Projection by Paleodata, A.A. Velichko et al.	
Zone	1936–1960 *	1961–1990 *	1991–2000 *	XXI century (1 st half) $\Delta T +0,7^{\circ}\text{C}$ Holocene opt.	XXI century (2nd half) $\Delta T +1,7^{\circ}\text{C}$ Last Intgl. opt
Broadleaved forests	0,89	1,01	0,99 (-)	1,15	1,15
Forest-steppe	0,76	0,92	0,86 (-)	0,53 (-)	1,09
Steppe	0,67	0,76	0,77	0,87	0,85

Расхождение в степени увлажнения,
прогнозируемого по данным
численного моделирования
и данным палеоаналогов



РЕСПУБЛИКАНСКИЙ НАУЧНО-ИССЛЕДОВАТЕЛЬСКИЙ ЦЕНТР
ГЕОГРАФИИ
ЛАБОРАТОРИЯ
ЭКОЛОГИИ
ГЕОГРАФИИ

Спасибо за внимание!

