Examination Quaternary Geology and Climate Change **GEO3-4303**

Wednesday 16 April 2008
Teacher: Dr. H. Middelkoop

Carefully read the questions and provide complete answers (with explanation!) in Dutch or English language

1. Definitions

Briefly indicate the meaning of *5 out of the following* 6 items:

a) Forebulge
b) SRES scenarios
c) OSL dating
d) Compensation depth
e) Heinrich event
f) Global Warming Potential of a greenhouse gas / aerosol

2. Time control

a. The ^{14}C method has been widely applied in dating materials containing carbon. What is the approximate half-life of ^{14}C?
b. Explain why you need less material in AMS ^{14}C dating than in the conventional ^{14}C dating method.
c. Give at least three methods that can be used for chronological correlation between different ice cores.
d. Explain the K-Ar method and indicate how this dating method contributes to the chronological framework of the Quaternary.

3. Climate forcing and responses

a. Orbital variations are a major cause of climate change during the Quaternary. Which are the characteristic periods of the Obliquity, Precession and Eccentricity, and explain for each of these whether or not these orbital variations have the same radiation effect on both hemispheres at the same time.
b. The $\partial^{18}O$ curves of benthic forams in Ocean cores reflect the volume of continental ice sheets. Does the timing of the curves exactly fits the timing of the orbital forcing, or is there a lead or lag in the response? Explain.
c. Which mechanism causes the Deep Water formation in the Northern Atlantic; how has this mechanism been affected during the past 100 ka; and what were the climatologic consequences?
d. Sapropel records in the Mediterranean Sea and freshwater diatom records in ocean cores near Africa reflect variations in monsoon intensity. Which orbital parameter drives this monsoon intensity, and how? Do these records show a lag or lead when compared to the timing of the orbital forcing? Explain why.

4. Ice cores and ocean records

a. Draw the shape of the $\delta^{18}O$ curve for the past 150.000 years in the Summit (GISP2/GRIP) ice record from Greenland; indicate (schematically) glacial and interglacial periods, Younger Dryas, Dansgaard-Oeschger events and Bond cycles.

b. Explain how differences in precipitation rates on the ice sheets can be determined to compare between the Greenland and Antarctic ice cores, and between glacials and interglacials. Give at least two methods.

c. $\delta^{18}O$ curves can be obtained from ice cores, and from planktonic forams and benthic forams in ocean cores. What is the approximate value range of each of these during glacial and interglacial times?

d. The ^{13}C isotope records ($\delta^{13}C$) from forams in Pacific Ocean cores show fluctuations that reflect glacial cycles. Explain which mechanism(s) caused these $\delta^{13}C$ fluctuations and whether there is a difference between $\delta^{13}C$ values in planktonic and benthic forams.

5. Modeling past climates

A research team proposes to use a General Circulation Model (GCM) to simulate the climate that occurred during the Younger Dryas period. For this experiment three groups of data are required: 1) the external climate forcing; 2) geographical boundary conditions for the model, 3) climate proxy data to verify the model results.

a. Which external forcings determined the climate during the Younger Dryas, and how can the magnitude of each of these forcings be reconstructed for this period? Mention at least 3 different forcings.

b. Which geographical data that influence the global climate patterns are required to carry out the simulations, and how are these reconstructed (and dated) for the simulated period?

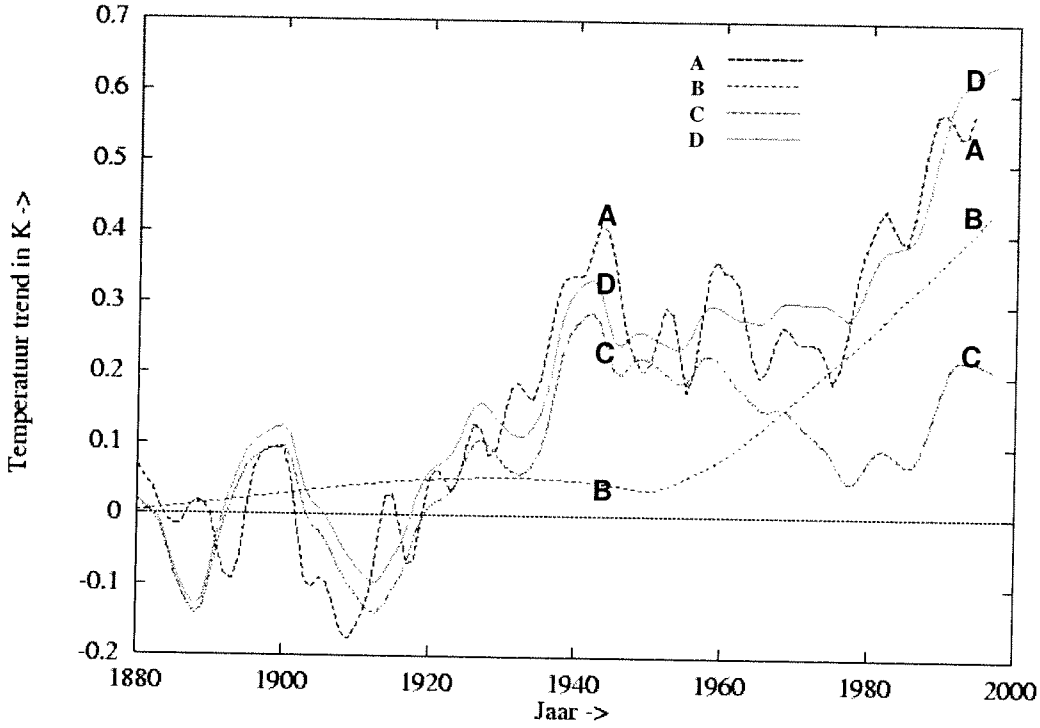
c. Which proxies (and how can these be dated) for the climate during the Younger Dryas might be used to evaluate the climate model results?

6. Climate forcing and global warming

a. The figure below shows 4 graphs, each indicating a different trend in global mean temperature over the period 1880 – 2000. Graph A is the observed temperature. The other graphs were obtained using GCM experiments driven by different (combinations of) climate forcings. Explain which forcing is reflected by the curves B, C and D.

b. Which external climate forcings will determine the global climate in the next century? Indicate over which time scales variations in these forcing apply, and whether their strength can be predicted in advance.

c. The IPCC scenarios result in a wide range of global temperature rise over the forthcoming century. What are the causes of this large uncertainty?


Temperatuur trend in K ->
Jaar ->
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
-0.1
-0.2
1880
1900
1920
1940
1960
1980
2000
A
B
C
D