Examination Quaternary Climate and Global Change - GEO3-4303

Tuesday 26 January 2010; 13:00 – 16:00 h; AW Building room C108-110
Teacher: Prof. dr. H. Middelkoop

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

1. Definitions

Give the meaning of *5 out of the following 6* items:

a) IPCC
b) Last termination
c) NADW
d) Global Warming Potential of a greenhouse gas
e) Tephrochronology
f) 'Hockey Stick' (as used in climate research)

2. Ice cores

a. Describe at least 3 methods that can be used to determine age-depth relationships of the Greenland ice cores, and indicate the main limitations of each method.
b. How can we reconstruct variations in precipitation rate on the Antarctic Ice sheet during the past glacial-interglacial cycles? – indicate more than one method.
c. How can we chronologically correlate the oxygen isotope records of the Greenland and Antarctic ice sheets?
d. Although the main climate trends shown in the isotope records of both Greenland and Antarctic ice sheets are similar, there are some differences in the details of the fluctuations in the records. Which are these differences, and what are the causes?

3. Ice and marine records

a. Draw the shape of the $\delta^{18}O$ curve for the past 150.000 year in the Summit (GISP2/GRIP) ice record from Greenland; indicate (schematically) glacial and interglacial periods, Dansgaard-Oeschger events, the Younger Dryas, and Bond cycles. Also give the range of $\delta^{18}O$ values.
b. To what extent are the $\delta^{18}O$ curves of the Summit ice cores similar to the marine $\delta^{18}O$ curves established from benthic forams from the equatorial Pacific, and which are the main differences? Explain in your answer what exactly each of the two $\delta^{18}O$ curves reflects.
c. Indicate how the chronology of $\delta^{18}O$ curves in oceanic cores can be determined for the past 2 million years.
d. ^{13}C isotope records from benthic forams from the Atlantic Ocean might be used as an indicator of variations in the strength of the THC in the Northern Atlantic. Explain why this is so.

4. Climate modeling of the past

A research team proposes to use a General Circulation Model (GCM) to reconstruct the climate 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. Discuss why you would use an atmospheric climate model only or a fully coupled ocean-atmosphere model.
b. Which external forcings determined the global 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.

- orbital
- Solar activity
- ageological

c. Which other process influenced the climate during the Younger Dryas? – explain how.
d. Which geographical data that influenced the global climate pattern are required to carry out the simulation, and how are these reconstructed (and dated) for the simulated period?
e. Which proxies (and how can these be dated) for the climate during the Younger Dryas might be used to evaluate the climate model results?

5. Climate forcing in historic time and future

Van Ulden and Van Dorland of KNMI investigated the contribution of different components to the global temperature rise since 1880 AD. Three of these components are shown in figure 2 as curves A, B and C (the total temperature curve is NOT indicated in this figure).

a. Which signals are indicated by the curves A, B, C? Choose from the following: CO_2 emission, methane emission, aerosols, glacier melting, volcanic eruptions, varying orbital precession, el-Niño, ozon hole, deforestation of the Amazon area, sea level rise, changes in oceanic circulation, variations in solar activity, reforestation of northern hemisphere. Explain your answer.
b. Indicate whether the three you selected under a) are of natural origin and whether they are external forcings or internal mechanisms.

The global temperature over the next century will show considerable year-to-year variation in addition to a more gradual trend, both reflecting internal variations in the climate system and responses to external forcings.

c. If we want to determine the global T in the course of the coming century using a climate model, which external climate forcings can we use as input for the model, and how do we determine their magnitude?

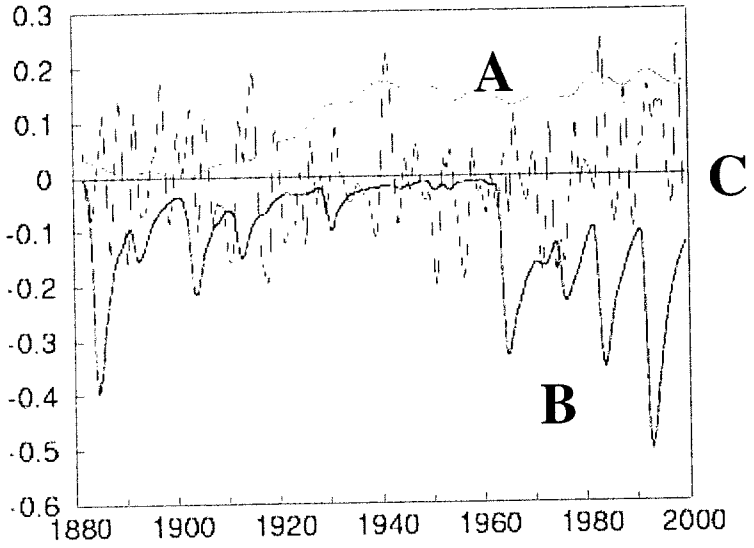

Figure 2 Contribution (in degrees C) of different components to the total global Temperature rise 1880-2000