EXAMINATION GEO3-4304 QUATERNARY CLIMATE AND GLOBAL CHANGE

THURSDAY 31 January 2013 10.00 – 13.00 Dr. K.M. Cohen, Prof. H. Middelkoop

Carefully read the questions. Provide complete but not overly lengthy answers.
You may answer in English or in Dutch with mixed-in English terminology. Drawing figures is allowed.
Use the separate answer sheet(s). Fill in your name and student number in upper left corner.

Q1 DEFINITIONS (20 pts = max score this question; total points whole exam is 100 pts)

Briefly explain the meaning of the underlined words in *5 out of the following 6* items:

a) ^{14}C-age calibration
b) 'Supported' and 'Unsupported' in the context of Uranium series dating techniques
c) Eustatic sea level change and Steric sea level change
d) Hydro-isostasy
e) Ensemble climate modeling experiments
f) ENSO

Q2 MILANKOVITCH CLIMATE VARIATION AND PLEISTOCENE SUBDIVISIONS (18 pts)

See Figure Q2 on the separate sheet. Answer on the answer sheet, not on the figure sheet.

a) Provide a correct column header for RECORD A in Figure Q2. Where was it obtained?
b) Provide a correct column header for RECORD B in Figure Q2. Where was it obtained?
c) Provide a correct column group header for GROUP OF DIVISIONS C in Figure Q2.
d) Provide the names of STAGE X (ca. 125 ka) and STAGE Y (ca. 400 ka) in Figure Q2.
e) Provide the name of the transition from MIS 12 to MIS 11.
f) Draw a cartoon map of North America. Indicate the size of its covering ice sheet:
   (i) With a THICK line: during maximum glaciation in a glacial in the Middle Pleistocene,
   (ii) with a THINNER line: during maximum glaciation a glacial in the Early Pleistocene.
   (iii) Briefly explain WHY you draw the line of (ii) where you did.

Q3 EARTHLY CLIMATE FEEDBACK AND SENSITIVITY (8 pt)

See Figure Q3 on the separate sheet. Answer on the answer sheet, not on the figure sheet.

a) Describe the seasonal albedo effect for the Northern Hemisphere winter of 2012-2013
b) Describe the relations between oceans and the observed continental snow cover patterns
c) What latitudes on earth are most sensitive to precession forcing?

Q4 SUB-MILANKOVITCH CLIMATE VARIATION (19 pt)

a) Make a sketch of the Greenland (GRIP/GISP/N-GRIP) ice-core oxygen-isotope record, between 120,000 and 7,000 years ago (never-mind the last few thousand years)
   - In the sketch, indicate the position of MIS 1, MIS 2, MIS 3, MIS 4.
   - In the sketch, indicate the position of the Younger Dryas
b) Isotope fractionation results in more negative δ-values if the lighter isotope is relative enriched. Explain why Greenland ice $\delta^{18}O$ goes from -44 to -35 ‰ from MIS2 to MIS1, whereas MIS $\delta^{18}O$ values decrease from +5 to +3 ‰ over that period.
c) Describe what are 'Bond cycles', with a quoted recurrence of 1,470 +/- 500 yrs. Also answer: Ice-cores are very accurately dated, why is the error on recurrence so large?

Q5 ISOTOPE STRATIGRAPHY, DATING AND CLIMATE VARIATION (14 pt)

You have collected a core of calcareous precipitated mud from a Lateglacial lake in Ireland. On the relevant section of core, you have collected a high resolution $\delta^{18}O$ record from this material. You also have collected independent dates from below and above the calcareous interval (a tephra layer and a radiocarbon date) securing that the muds are from the Lateglacial.

a) Describe how you would use this record for dating control on your record.
What is the dating resolution that would be resolved using your approach?
Are there any pitfalls to be aware of? what are possible disturbances to deal with?
How would you propose to make the dating multi-proxy?

b) Describe how you would use this record as a climate proxy in your record.
For what climatic property (or properties) would you use the precipitated calcareous mud?
Are there any pitfalls to be aware of? What are possible disturbances to deal with?
How would you propose to make the climate reconstruction multi-proxy?

Q6 SEA LEVEL CHANGE AT GLACIAL-INTERGLACIAL TIME SCALES (8 pt)

a) Going from a glacial to an interglacial, sea level change varies regionally due to several factors. List at least four such factors, relevant at this timescale.

Along most coasts around the world (excluding deglaciated areas and areas of very rapid tectonic uplift), the coast line of the Last Interglacial (MIS 5e) is the first paleo-coastline encountered inland from Holocene ones.

b) Only one region is an exception and a MIS 5a coastline is encountered instead.
Please describe: (i) What region is that? (ii) What is (are) the responsible process(es) ?
(iii) What made that only that region is exceptional in MIS 5 high stand recording?

Q7 LAST CENTURY AND NEXT CENTURY CLIMATE CHANGE AND SEA LEVEL RISE (13 pt)

See Figure Q6 on the separate sheet. Answer on the answer sheet, not on the figure sheet.

a) Describe *and* explain the seasonal climatic cycles experienced in the area featured in Fig. Q6 (left column 4 maps), using correct terminology.

b) Explain *the magnitudes* of predicted *deviations* and spatial patterns therein
(= the maps in the right column of Figure Q6)
(i) for season JJAS (*strong* negative in west, *modest* positive in east)
(ii) for season DJF (*near zero* in west, *modest positive* in the south and east)

Copy the graph at the bottom of Figure Q6, including the line showing temperature rise, to your answer sheet.

c) Assuming no further CO2 increase after 2100 (concentration stabilizing at 700 ppm),
(i) complete the graph with sketch of the temperature curve from 2100 to 2500 AD,
(ii) of course, also explain why it projects this way.

d) Assuming no further CO2 increase after 2100 (concentration stabilizing at 700 ppm),
(i) complete the graph - using right axis units – with a sketch projected sea-level rise from 2000 to 2100, and then to 2500 AD.
(ii) Again: explain why it projects this way.

FIGURE Q2

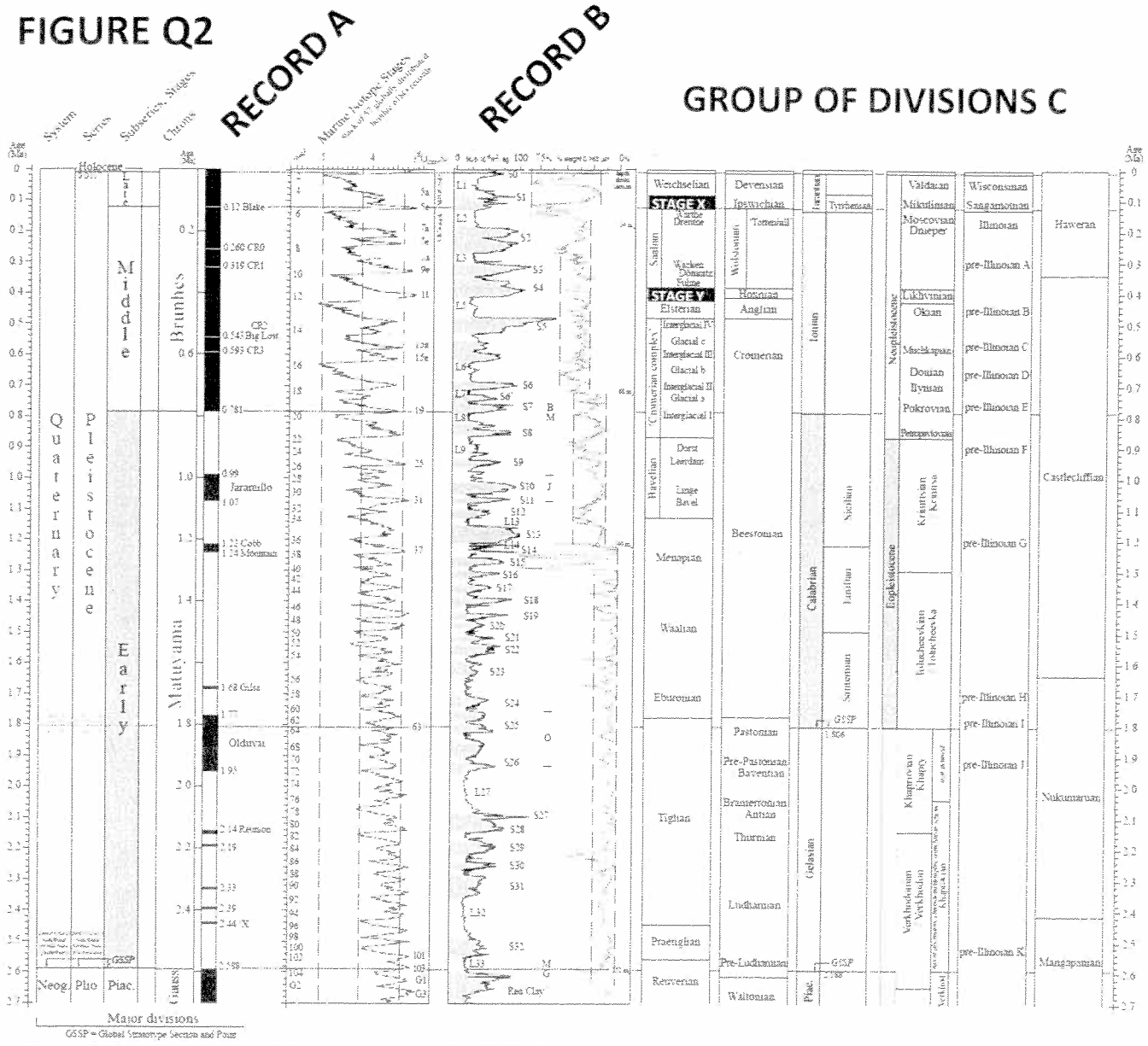
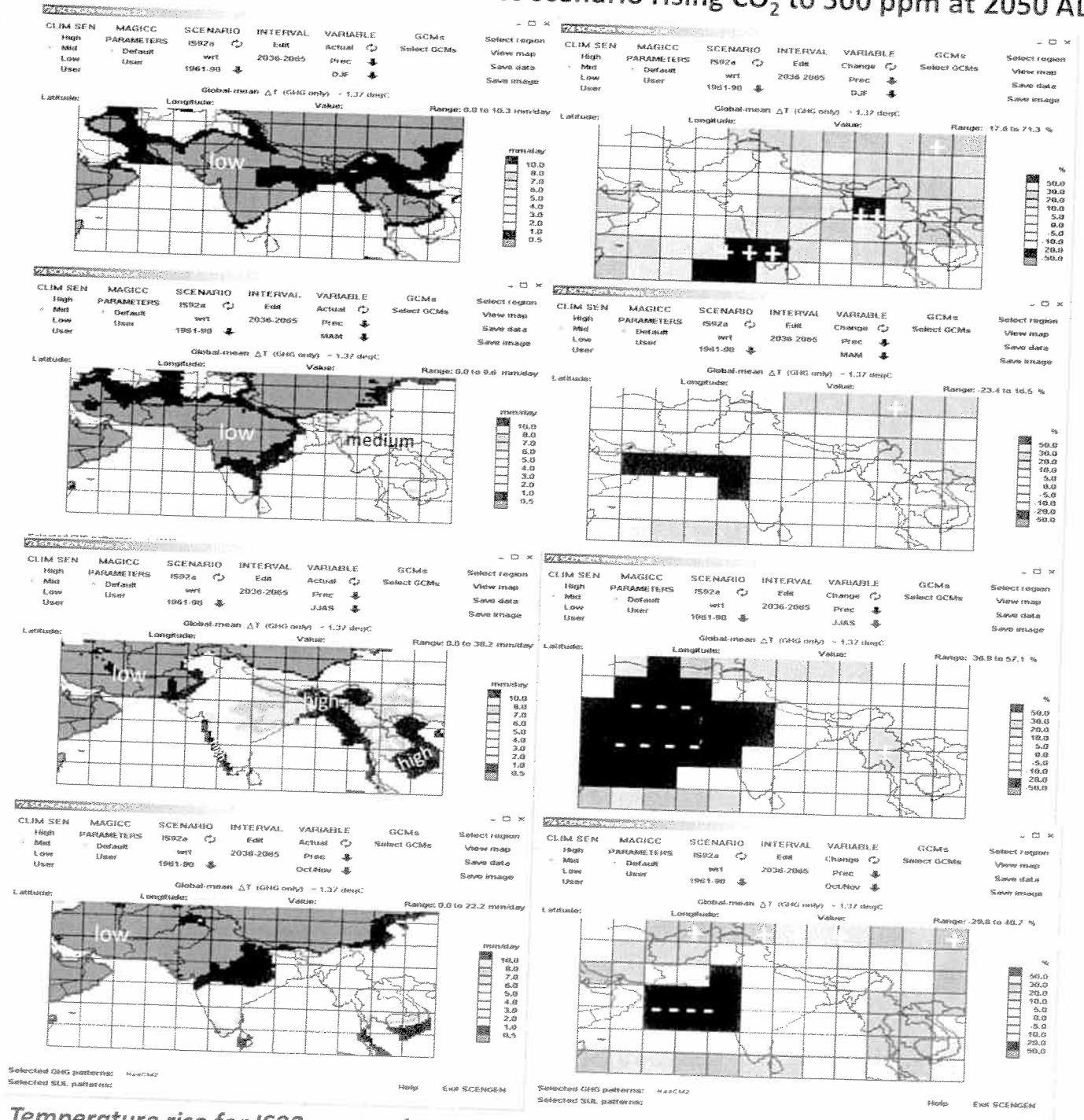


FIGURE Q3 NASA visualisation of actual snow cover dd. 15-Jan-2013

FIGURE Q6 SCENGEN CGM precipitation Output for four seasons, for a future climate scenario rising CO_2 to 500 ppm at 2050 AD



Temperature rise for IS92a scenario