

**Candidates are admitted to the examination room ten minutes before the start of the examination. On admission to the examination room, you are permitted to acquaint yourself with the instructions below and to read the question paper.**

**Do not write anything until the invigilator informs you that you may start the examination. You will be given five minutes at the end of the examination to complete the front of any answer books used.**

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**April 2012**

**Answer Book  
Data Sheet**

**Any bilingual English language dictionary permitted  
Only Casio-fx83 calculators are permitted**

Final Examination for MSc

Course in Applied Meteorology  
Course in Atmosphere, Oceans and Climate  
Course in Data Assimilation and Inverse Modelling in Geosciences  
Course in Applied Meteorology and Climate with Management

**MTMG16**

**Climate Change**

Two hours

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Answer **ANY TWO** questions

The marks for the individual components of each question are given in [ ] brackets. The total mark for the paper is 100

1.

(a) In a simple energy balance model, the outgoing longwave radiation (OLR) is approximated by  $OLR = \epsilon' \sigma T_s^4$ . Calculate the black body feedback parameter ( $Y_{BB}$ ,  $Wm^{-2}K^{-1}$ ) assuming  $\epsilon' = 0.6$ ,  $\sigma = 5.67 \times 10^{-8} Wm^{-2}K^{-4}$  and  $T_s = 289 K$ . [3 marks]

(b) If  $\epsilon'$  falls with temperature at the rate  $d\epsilon'/dT_s = -0.002 K^{-1}$  what is the overall response,  $dOLR/dT_s$  for the initial values of  $\epsilon'$ ,  $\sigma$  and  $T_s$  given above? [3 marks]

(c) What climate process does the response of  $\epsilon'$  to  $T_s$  constitute in this simple case and what is its magnitude? [4 marks]

(d) A climate model has an overall climate feedback parameter  $Y = 2 Wm^{-2}K^{-1}$ . Satellite observations suggest that the model underestimates the increase in cloud albedo with cloud liquid water content. Briefly discuss how improving this process in the model could *potentially* affect its simulated cloud feedback? [6 marks]

(e) On updating the model parametrizations, the overall feedback parameter  $Y$  increases from 2 to  $3 Wm^{-2}K^{-1}$ . What effect would this have on the model equilibrium temperature ( $\Delta T_{eq}$ ) response to a radiative forcing,  $\Delta F$ ? [4 marks]

(f) Radiative forcing from a change in carbon dioxide ( $CO_2$ ) concentration (in ppmv) from a base level,  $C_0$ , to a new concentration,  $C$ , can be estimated by:  
 $\Delta F = 5.35 \ln(C/C_0)$ .  
Since 1900,  $CO_2$  concentrations have risen from around 290 to 390 ppmv and global temperature change ( $\Delta T$ ) has been about +0.7 K. Assuming  $\Delta F = Y \Delta T$ , what is the estimated feedback parameter,  $Y$ . Detail why this method is incorrect. [10 marks]

(g) What radiative forcings are thought to determine the timing of glacial cycles? [10 marks]

(h) With respect to (g) what latitudes and seasons are thought to be crucial and why? [10 marks]

2) (a) A climate model is used to make future projections of global temperature. Briefly explain how uncertainty in socio-economic responses may be accounted for. [6 marks]

(b) In climate model simulations, how is uncertainty relating to natural unforced variability accounted for? Explain the difference between unforced variability and natural variability. [6 marks]

(c) Briefly explain how unforced variability within the climate system arises with reference to El Niño. [6 marks]

(d) Briefly describe how uncertainty in climate feedback processes may be quantified or estimated from climate model simulations? [6 marks]

(e) What is meant by vulnerability to climate change? How is this linked to damage? [6 marks]

(f) Briefly describe how adaptation and mitigation can influence this potential damage? [8 marks]

(g) Why are current populations committed to rises in temperature and sea level if atmospheric composition was held fixed from today? [6 marks]

(h) Considering the simple equation for transient climate change:

$$\Delta T(t) = \Delta T_{eq} (1 - e^{-tY/C_s})$$

briefly explain which variables determine the time-scale of temperature change. [6 marks]

3. An analysis of global temperatures over the recent decade has shown little discernible global warming. Articles published in the press are reporting these results as evidence against human-caused warming of climate. Write a brief for ministers on the evidence for human-caused climate change and the relevance of recent temperature trends in the last decade to policy on avoiding dangerous climate change. Your brief should cover the following points:

- a. The evidence for human-induced warming of climate [10 marks]
- b. Understanding and attributing past climate change and relevance to future projections [10 marks]
- c. Natural unforced variability of climate [10 marks]
- d. Plausible causes of the recent lack of warming and relevance for projections of future climate change [10 marks]

The ministers require a clear, logical structure without jargon. It is also useful to include supporting published papers of relevance. [10 marks]

[End of Question paper]