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.

January 2012 **MTMA39**

Answer Book
Data Sheet
Figure for Question 2(c)
Any bilingual English language dictionary permitted
Only Casio-fx83 calculators are permitted

UNIVERSITY OF READING

FORECASTING SYSTEMS AND APPLICATIONS (MTMA39)

Two hours

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) All NWP models include 3 equations of motion that predict the evolution of the 3 components of the wind vector. The equation below shows the equation for the zonal (i.e. west-east) wind component *u*.

(1) (2) (3) (4) (5) (6) (7)

Describe in words the physical meaning of each term in this equation.

(10 marks)

(b) By considering typical near-surface wind speeds of $10ms^{-1}$ in the horizontal and $1cms^{-1}$ in the vertical and a typical horizontal pressure gradient of 1hPa per 100km, suggest which of the terms (2) to (6) could be neglected in this equation in the vicinity of 55°N without significant loss of accuracy.

(15 marks)

(c) Describe briefly how term (7) in this equation is dealt with within NWP models.

(5 marks)

List 4 other physical processes which must be represented in an NWP model and which are dealt with in a similar way to term (7).

(8 marks)

(d) List and briefly discuss 4 potential sources of predictability for NWP forecasts at *monthly to seasonal* timescales.

(12 marks)

2. (a) The atmosphere is a non-linear chaotic system which means that there is an upper limit on how far in advance deterministic weather predictions can be made. This upper limit is itself unpredictable. Discuss how *ensemble forecasting techniques* can be used to address this issue. Your answer should include a brief explanation of what is meant by ensemble techniques.

(19 marks)

(b) Describe the ECMWF ensemble prediction system. You should state how many ensemble members are used, how the perturbations to the initial conditions are calculated and what resolution the ensemble members are run at relative to the high resolution deterministic forecast that ECMWF also performs.

(18 marks)

(c) The figure provided with this question shows an EPSgram from the ECMWF ensemble forecasting system for a location in Senegal, West Africa.

Explain the meaning of the "box and whisker" symbols used in this forecast.

(6 marks)

Of the 4 variables shown in this figure, which do you think is the most reliably predictable through the period of this forecast?

(2 marks)

Towards the end of the forecast it appears that night-time minimum temperature becomes less predictable than daytime maximum temperature. Suggest a reason why this might be.

(5 marks)

3. (a) Many weather forecasts are of a type where they can be verified as either right or wrong – e.g. whether it will snow tomorrow in Reading. By drawing up a 2 x 2 contingency table for a forecast of this type, explain both in words and as equations the following verification measures:

(i) Hit Rate
(ii) False Alarm Rate
(iii) Critical Success Index

For what category of event would the Critical Success Index be the most appropriate measure of forecast skill?

(20 marks)

You are a forecast customer for whom the financial cost of taking action based on a weather forecast is very high, but the losses incurred by not taking action when the forecast turns out to be wrong are rather small. Which of the above 3 measures would you be most interested in when deciding who to buy your forecasts from? State briefly why this is.

(6 marks)

(b) Describe a *graphical* way of measuring the skill of probability forecasts, using a diagram to illustrate the method. Use this figure to define both the *reliability* and the *resolution* of probability forecasts.

(15 marks)

Define the *uncertainty* of the forecast and show how it is combined with reliability and resolution to calculate the Brier Score.

State how the Brier Score can be presented as a *skill score*, and describe two possible "zero skill" forecast methods that could be used in calculating such a skill score.

(9 marks)

[End of Question paper]