You are allowed ten minutes before the start of the examination 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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January 2011

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Answer Book
General Data Sheet
Figures 1 and 2 (for use with Q2)
Any bilingual English language dictionary permitted
Only Casio-fx83 calculators are permitted

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UNIVERSITY OF READING

Final Examination for MSc

Course in Applied Meteorology

MTMA39

Operational Forecasting Systems and Applications

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)   Most major operational weather forecasting centres run more than one operational NWP model. Discuss the various considerations that would lead a forecasting centre to run a "suite" of NWP models.
Describe briefly the models which make up the operational suite run by the U.K. Met Office in terms of domain, grid-spacing, forecast length and the number times per day that each model is run. **You do not need** to describe the ensembles that the Met Office run.

[24 marks]

Limited Area NWP models cover a domain that is smaller than the entire planet. Describe how the boundaries of a Limited Area Model are dealt with in order to allow information to propagate into the domain from outside, and to prevent reflection of information back into the domain at the boundary walls.

[6 marks]

(b)   Physical parametrization is the method by which the impact on the model variables of processes which occur on scales smaller than the model grid-spacing can be represented.

List 5 physical processes which are usually represented by parametrization within NWP models.

[10 marks]

A fundamental assumption in numerical modelling is that there is a scale separation between the parameterized and resolved process. Discuss, with reference to specific physical processes, how this assumption may break down when the grid-spacing of an NWP model gets down to the order of 1km.

[10 marks]

2.

(a)   Explain why weather forecasting is considered to be an "initial value problem".

[5 marks]

4D-VAR data assimilation is a method used by several operational forecasting centres to set the initial conditions for NWP forecasts. Describe briefly how the process of 4D-VAR works, both in terms of the impact of single observations on the model state, and in terms of the impact of many observations on the model trajectory through the "assimilation window". State explicitly the factors that make up the cost function which 4D-VAR attempts to minimize.

[25 marks]

(b)   Figure 1(a), supplied with this exam paper, shows a Met Office surface pressure and frontal analysis chart - i.e. the T+0 situation from an NWP forecast. The pressure field is taken directly from the NWP model and the fronts have been added by a senior forecaster. The time of this chart is 1200 UTC. Figure 1(b) shows an infra-red satellite image for the same time as this analysis chart (note that the map projections are slightly different for these 2 figures).

Using the satellite image, describe the evidence for the positioning of the frontal wave on the cold front to the west of Ireland on the analysis chart. Figure 2(a) shows the infra-red satellite image 2 hours later (i.e. at 1400 UTC). Using the evidence on the image, state how you think the wave on the cold front is developing.
Figure 2(b) shows the T+12 forecast from the NWP model (i.e. the forecast for 0000 UTC the following day). Using the evidence shown in the satellite images, discuss how confident you would be in the forecast development predicted by the model.

[20 marks]

3.

(a) Some major forecasting centres use NWP methods to produce forecasts on seasonal timescales. Describe the modifications that would need to be made to a global domain NWP model in order to make it suitable for seasonal prediction.

[10 marks]

Given the "predictability limit" of approximately 14 days for the atmosphere, list 4 factors that may lead to skilful NWP forecasts for periods of several months?

[8 marks]

(b) Some forecasting centres, particularly in the Tropics, use *empirical* methods for seasonal prediction. Describe how empirical prediction methods work in practice.

[16 marks]

What are the major advantages and disadvantages of using empirical methods to produce seasonal predictions?

[7 marks]

(c) The tropical research group at Colorado State University issues statistical forecasts in November each year for the Atlantic Hurricane season in the following year. For the most recent forecast methodology described in Klotzbach 2008 (*Journal of Geophysical Research*) list the predictors used in their regression model.

Each of the predictors used in this methodology was found to have significant correlations with physical factors known to affect hurricane development during the following August-October period. For each predictor, list *one* physical factor with which there is a significant correlation and which would be expected to affect the activity in the Atlantic Hurricane season.

[9 marks]

(End of Question Paper)