

On admission to the examination room, you should acquaint yourself with the instructions below. You must listen carefully to all instructions given by the invigilators. You may read the question paper, but must 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.

**DO NOT REMOVE THIS QUESTION PAPER FROM THE EXAM ROOM.**

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MTMG19/MT4YD 2014/15 A001

Answer Book  
Data Sheet

Blank tephigram for question 3

Any bilingual English language dictionary permitted

Any non-programmable calculators are permitted

**UNIVERSITY OF READING**

**Tropical Weather Systems (MTMG19)**

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) Describe the main processes involved in the formation of the Asian summer monsoon making reference to the various gradients involved. Describe the characteristics and seasonality of the associated winds and precipitation for India, including a sketch of the circulation if desired. [13 marks]
- (b) The monsoon circulation developing over the Arabian Sea results in an important ocean feedback. Briefly describe the origin and location of this feedback including its sign. Describe the seasonal cycle of sea-surface temperature (SST) in the Arabian Sea as a result. What is the subsequent impact on the atmosphere of this feedback? [7 marks]
- (c) Describe the two main features acting to organise monsoon variability on synoptic and subseasonal/intraseasonal time scales. For monsoon depressions, include reference to their typical track and direction of travel, and explain your reasoning with reasoning, and likely location of landfall over India. For intraseasonal variability, describe the direction of propagation, typical period and possible impacts on both the daily rainfall pattern and total seasonal monsoon rainfall. [15 marks]
- (d) India receives around 850mm rainfall on average during its summer monsoon. Calculate the latent heating generated in the atmospheric column by the implied condensation associated with this precipitation. [5 marks]

- (e) As is typical, rainfall during the monsoon is generated by convective clouds extending through the depth of the troposphere. By using your answer to part (d), calculate a tropospheric heating rate in K/day assuming it is spread evenly though the season. Assuming equilibrium conditions and no large-scale circulation, what is the process balancing this condensational heating?  
[10 marks]
- 2 (a) Describe the main characteristics (spatial scale, periodicity, seasonality, direction of propagation, winds, convection) of the Madden-Julian Oscillation and draw one or more sketches of its structure. Where is the MJO usually found?  
[15 marks]
- (b) Ahead of the MJO convection, light winds lead to reduced surface evaporation causing a reduction in latent heat flux by about  $15 \text{ W/m}^2$ , while enhanced solar radiation under reduced cloudiness increases the solar radiation reaching the surface by around  $20 \text{ W/m}^2$ . These anomalies are applied to the ocean mixed layer, of climatological depth approximately 40m in the eastern Indian Ocean for around 10 days as the event passes. Calculate the resulting change in the sea surface temperature and comment on whether the value given is realistic.  
[13 marks]
- (c) Describe how the passage of the MJO alters the diurnal cycle of SST.  
[7 marks]

- (d) Describe mechanisms by which the MJO may:
- (i) alter the weather in the extratropics; and [5 marks]
  - (ii) help initiate El Nino. [10 marks]

- 3 (a) Data from a tropical radiosonde ascent over land are given in the table below; plot these data on the tephigram chart provided and label the two curves for Drybulb and Dewpoint temperature. Mark on the chart the lifting condensation level, level of free convection and level of neutral buoyancy and also record these values on your answer sheet, together with a definition for these terms. [12 marks]

Pressure (hPa)	Dry bulb temperature (°C)	Dewpoint temperature (°C)
1000	34	21
900	30	18
800	23	8
700	12	3
600	0	-5
500	-9	-30
400	-18	-45
300	-32	-60
200	-40	-60

- (b) Estimate the CAPE for an ascent of an air parcel starting at 1000hPa, given that CAPE is defined as:

$$CAPE = \int_{LNB}^{LFC} R_d (T_p - T_a) d \ln p,$$

where  $T_p$  is the temperature of the lifted air parcel and  $T_a$  is the ambient temperature of the environment.

Both your markings on the chart and calculation methodology must be clear.

[11 marks]

- (c) What must be overcome before a parcel at the surface can ascend to the level of free convection? Give an equation for this in the same form as indicated in part (b) above and calculate this value from the radiosonde ascent.

[8 marks]

- (d) Briefly describe the positive feedback process that increases CAPE during development of a tropical depression or cyclone.

[4 marks]

- (e) Entrainment is a process by which developing clouds may not reach their full height. Briefly describe entrainment and discuss the difficulties in modelling tropical convection, making reference to the relevant horizontal scales in observations of convective clouds and in typical climate models.

[15 marks]

(End of Question Paper)