ROYAL CIVIL SERVICE COMMISSION
BHUTAN CIVIL SERVICE EXAMINATION (BCSE) 2022
EXAMINATION CATEGORY: TECHNICAL

PAPER III: SUBJECT SPECIALISATION PAPER FOR METEOROLOGY AND CLIMATE STUDIES

Date : October 9, 2022
Total Marks : 100
Writing Time : 150 minutes (2.5 hours)
Reading Time : 15 minutes (prior to writing time)

GENERAL INSTRUCTIONS:

1. Write your Registration Number clearly and correctly on the Answer Booklet.
2. The first 15 minutes is to check the number of pages of Question Paper, printing errors, clarify doubts and to read the instructions. You are NOT permitted to write during this time.
3. This paper consists of **TWO SECTIONS**, namely SECTION A & SECTION B:
   - **SECTION A** has two parts: Part I - 30 Multiple Choice Questions
     Part II - 4 Short Answer Questions
     All questions under SECTION A are **COMPULSORY**.
   - **SECTION B** consists of two Case Studies. Choose only **ONE** case study and answer the questions of your choice.
4. All answers should be written on the Answer Booklet provided to you. Candidates are not allowed to write anything on the question paper. If required, ask for additional Answer Booklet.
5. All answers should be written with correct numbering of Section, Part and Question Number in the Answer Booklet provided to you. Note that any answer written without indicating the Section, Part and Question Number will NOT be evaluated and no marks will be awarded.
6. Begin each Section and Part on a fresh page of the Answer Booklet.
7. You are not permitted to tear off any sheet(s) of the Answer Booklet as well as the Question Paper.
8. Use of any other paper including paper for rough work is not permitted.
9. **You must hand over the Answer Booklet to the Invigilator before leaving the examination hall.**
10. This paper has **8 printed pages**, including this instruction page.

GOOD LUCK

SECTION A

PART I: Multiple Choice Questions [30 marks]

Choose the correct answer and write down the letter of your chosen answer in the Answer Booklet against the question number e.g. 31 (d). Each question carries ONE mark. Any double writing, smudgy answers or writing more than one choice shall not be evaluated.

1. Air in the _____ is primarily heated by _____, through the process of _____.
   a) stratosphere, the Earth's surface, conduction
   b) troposphere, the Earth's surface, latent heat release and radiation
   c) troposphere, the sun, radiation
   d) troposphere, the sun, latent heat release and radiation

2. Complete the following sentence. Remotely-sensed observations
   a) are based on the interactions of atmospheric constituents with electromagnetic radiation.
   b) are an insignificant fraction of observations over the tropics.
   c) provide exact measurements of atmospheric variables.
   d) facilitate continuous analysis of weather and climate where the surface data network is sparse.

3. The phenomenon of 'trade winds' takes place due to _____.
   a) conduction of heat
   b) convection of heat
   c) radiation
   d) None of the above

4. Freely moving bodies are
   a) deflected to their right in the northern hemisphere.
   b) deflected to their right in the southern hemisphere.
   c) deflected upwards at the equator.
   d) unaffected by the earth's movements.

5. What is a cloudburst?
   a) It refers to 50mm rain over a period of time.
   b) It refers to sudden and copious rainfall over a small area which often lasts for few minutes.
   c) It is caused by rapid condensation of very high clouds.
   d) It refers to a thunderstorm with little rain.

6. Which one among the following forces is the most powerful in determining movement of wind including its velocity?
   a) Gravitational force
   b) Centrifugal force
   c) Frictional force
   d) Pressure gradient force

7. The most important factor in thunder development is _____.
   a) atmospheric stability
   b) atmospheric instability
   c) abundance of moisture
   d) temperature inversion

8. The water content in the atmosphere
   a) is independent of temperature.
   b) increases as temperature increases.
   c) decreases as temperature increases.
   d) either increases or decreases with temperature increase.

9. Which of the statements below about El Niño is wrong?
   a) El Niño is an interaction between the sea-surface and the atmosphere.
   b) El Niño has the opposite effect on sea-surface temperature as La Niña.
   c) The main effect of an El Niño is a warmer Atlantic sea-surface temperature.
   d) The net integrated effect of El Niño is a slightly warmer global temperature.

10. Describe the change of the earth's visible albedo if the polar ice caps melt:
   a) It will go up.
   b) It will first go up, then go down.
   c) It will not change.
   d) It will go down.

11. El Nino and El Nina are changes in the climate induced by humans.
   a) True
   b) False

12. What causes the changes in climate?
   a) Solar variability
   b) Volcanic activity
   c) Carbon cycle
   d) All of the above

13. Which one of the following statements is **INCORRECT**?
   a) Climate models use mathematical simulations to reproduce climate system interactions.
   b) Climate projections are used to predict the weather in different regions.
   c) No-climate-policy baseline refers to the projected baseline emissions based on current policies presently in place around the world.
   d) A forecast is a prediction of what the weather will be like in the short to medium term.

14. Which of the following contributes least to carbon footprint?
   a) Riding a bike to the office.
   b) Driving a car to the shops.
   c) Travelling by aeroplane.
   d) Taking a city bus.

15. Which one of the following is the cloud that is dark-grey or black layer, found at very low height and brings the real rain?
   a) Altocumulus
   b) Cirrostratus
   c) Nimbostratus
   d) Cumulonimbus

16. The continuous circulation of water among the hydrosphere, atmosphere and lithosphere is:
    a) Water circulation
    b) Hydrologic cycle
    c) Hydro-equilibrium
    d) Precipitation

17. From the given climatic conditions which have its worst effects on the building structure in Bhutan?
    a) Humidity
    b) Hot summer days
    c) Cold winter days
    d) Heavy rain

18. What method do NWP models use to account for processes and features that they cannot resolve?
    a) Parameterisation
    b) Post-processing
    c) Eliminate inconsistent observations
    d) Increasing grid box density

19. Which of the following is a **TRUE** statement regarding the effect of increasing model resolution?
    a) Increasing model resolution can increase temperature gradients and thus wind speeds.
    b) Increasing resolution in the atmospheric model will have little effect on the ocean and vice versa.
    c) Increasing model resolution always reduces model bias.
    d) Increasing model resolution is easy and need less computational resources

20. The jet stream, jet streaks, longwave pattern, and amplification pattern of troughs and ridges is analyzed at:
    a) 300 mb
    b) 700 mb
    c) 850 mb
    d) Surface

21. Which of the following is **NOT TRUE** regarding the clouds?
    a) They act like insulation in that they have a moderating influence on temperatures.
    b) It is estimated that at any given time, around 67% of Earth's surface is covered by clouds.
    c) They transport energy from the surface to the atmosphere in the form of latent heat.
    d) They cause the surface temperature to increase during the rainy season in the tropics.

22. What sea temperature is needed for tropical cyclones to form?
    a) 20.5°C
    b) 26.5°C
    c) 23.5°C
    d) 22.5°C

23. What is the name given to tropical storms forming at Bay of Bengal?
    a) Hurricanes
    b) Cyclones
    c) Typhoons
    d) Nor'westers

24. What is the supreme decision-making body of the United Nations Framework Convention on Climate Change (UNFCCC)?
    a) Conference of the Parties (COP)
    b) Intergovernmental Panel on Climate Change (IPCC)
    c) United Nations Environment Programme (UNEP)
    d) United Nations Development Programme (UNDP)

25. The 2015 Paris Agreement, adopted in Paris on 12 December 2015, marks the latest step in the evolution of the UN climate change regime and builds on the work undertaken under the Convention. The Paris Agreement charts a new course in the global effort to combat climate change. What temperature rise does the agreement strive to keep the world from exceeding?
    a) 3 degrees Celsius
    b) 1 degree Celsius
    c) 1.5 degrees Celsius
    d) 2.5 degrees Celsius

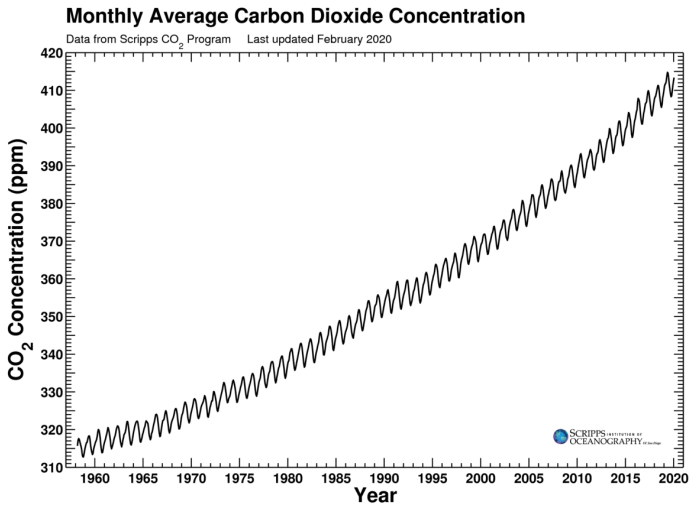
26. How long does CO2 remain in the atmosphere?
    a) CO2 washes out of the atmosphere seasonally.
    b) CO2 remains in the atmosphere for 5-10 years.
    c) CO2 remains in the atmosphere for up to 200 years, or more.
    d) CO2 remains in the atmosphere for 20-50 years.

27. If we stopped burning fossil fuels today, what would happen to the climate?
    a) Earth's average temperature would continue to rise.
    b) Temperatures would continue to warm, then begin to cool down in 100 years or more.
    c) Temperatures would fluctuate, but stay the same on average.
    d) Temperatures would stop increasing once greenhouse gas concentrations stopped increasing.

28. Anticyclones
    a) do not have winds in the upper atmosphere that follow height contours.
    b) are associated with sub geostrophic winds.
    c) have air spiralling into them at lower elevations.
    d) have clockwise winds in the Northern Hemisphere.

29. The effect of friction on air
    a) increases the Coriolis force.
    b) increases with height.
    c) increases wind speed.
    d) is relevant only within the planetary boundary layer.

30. This is a graph of carbon dioxide in Earth's atmosphere, measured since 1958.



Based on the graph above, what causes the annual up-and-down fluctuation in CO2 in the atmosphere?

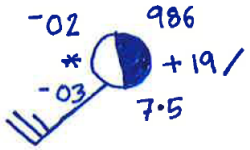
a) People use more energy in the winter.
b) Plants take up more CO2 during the Northern Hemisphere summer.
c) Oil refineries are shut down periodically in the summer.
d) During the Southern hemisphere's winter, strong winds circulate CO2 down into the Southern Hemisphere.

PART II – Short Answer Questions [20 marks]

This part has 4 Short Answer Questions. Answer ALL the questions. Each question carries 5 marks. Mark for each sub-question is indicated in the brackets.

1. What is the Ensemble Prediction System (EPS) and how does this help in prediction? Explain with a schematic diagram. **[5 marks]**

2. Weather chart symbol is plotted from the synoptic weather station located at Thimphu on 20th February 2022 as below:



   a) Rewrite the weather variables reported from the station with units for temperature (°C), pressure (mb), wind speed (knots) and direction? **[2 marks]**

   b) Describe the weather condition reported at Thimphu. What type of weather will most likely be in Thimphu during the next few hours? **[3 marks]**

3. List down the similarities and difference between the Global Climate Model (100km resolution) and Regional Climate Model (25 km resolution)? **[5 marks]**

4. What is global climate change? Explain impacts of climate change in Bhutan that you have experienced? **[5 marks]**

SECTION B: Case Study [50 marks]

Choose either CASE I OR CASE II from this section. Each case study carries 50 marks. Mark for each sub-question is indicated in the brackets.

CASE I - Seasonal and Inter-annual variability

Seasonal prediction aims at providing useful information about the "climate" that can be expected in the coming months. The predictions are generally based on the sea surface temperature anomalies like El Niño–Southern Oscillation (ENSO). Numerical Weather Prediction (NWP) models and dynamical statistical tools are used for prediction of ENSO and accordingly predict the rainfall and temperature of the adjoining area. Based on the historical climate information, teleconnections of the probable effects of the different phases of ENSO across the world are illustrated in the figure below. In the context of seasonal prediction and modelling answer the following questions:

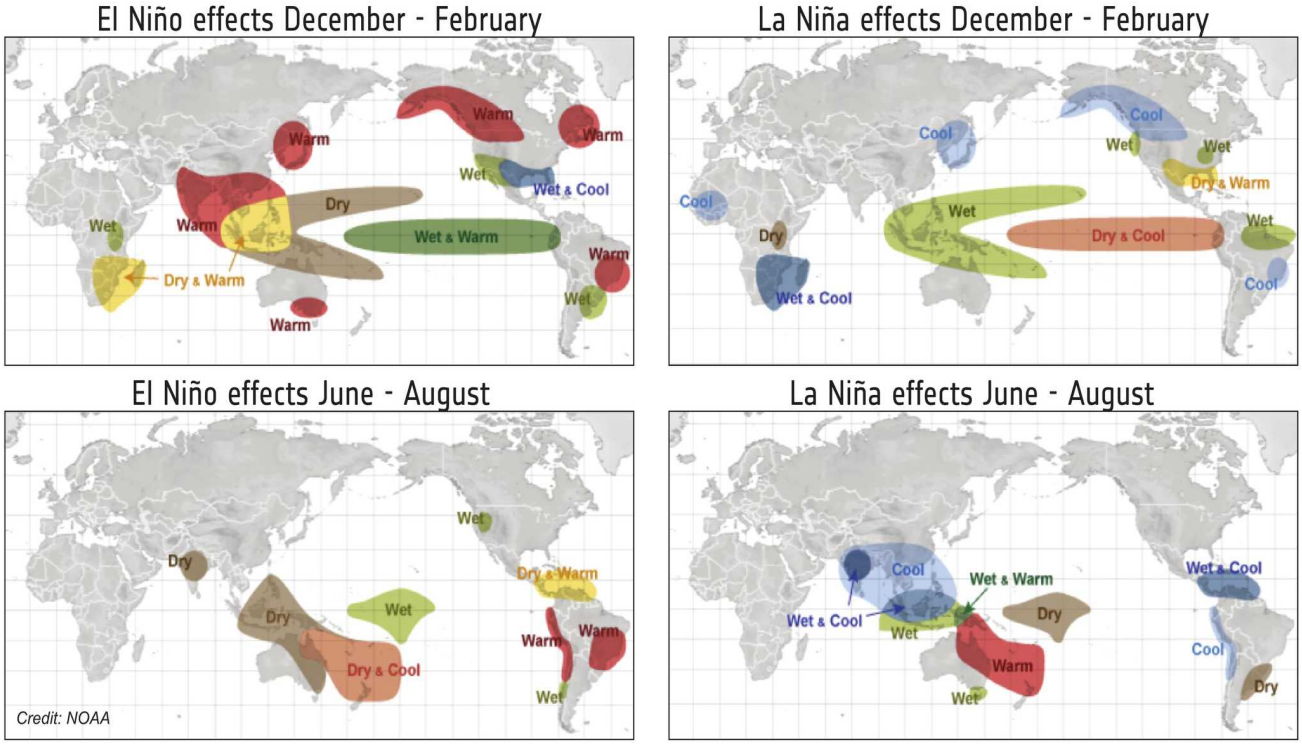


Figure: Effects of ENSO across the world

1. What is an El Niño Southern Oscillation (ENSO)? Where does it occur? How does this event affect the temperature and rainfall of Bhutan during the winter and summer season? **[15 marks]**

2. What is monsoon? How does the Summer and Winter monsoon occurs in South Asia? **[15 marks]**

3. Briefly explain who are the potential users of the seasonal forecast in Bhutan? **[10 marks]**

4. Briefly explain the weather, climate and climate change? **[10 marks]**

CASE II- Extreme weather prediction

National Centre for Hydrology and Meteorology (NCHM) in Bhutan provides public weather services including advisories and warnings on the extreme weather such as heavy snowfall, rainfall, windstorm, thunderstorm and cyclone. It is difficult to predict weather for a mountainous area like Bhutan, however, NHCM is trying its best to provide accurate weather forecasts based on the available resources and experience. Paddy harvesting season in Bhutan starts from October and forecasts of precipitation are useful in planning the harvest. The post monsoon season is also a period of active cyclone events originating from the Bay of Bengal and Arabian Sea.

Weather forecaster issued an advisory and warning on 15 October 2021, on light to moderate rainfall across the country for the next three days via BBS, Kuensel, websites and social media (Wechats and whatsapp). Due to low pressure development over north-east India and adjoining areas, starting from 17 October 2021, Bhutan received continuous rainfall for three days across the country. The farmers in the western parts of the country have already started paddy harvesting and most of the harvest was drenched with rain, thus, destroying the majority of the paddy. There were numerous comments by public sectors and media towards NCHM questioning the reliability of the forecast and dissemination of information to the farmers.

To the above context answer the following questions:

1. Give your opinion, what were the reasons for failure in making decision that could have avoided the loss of paddy harvest. Your answer should include, belief/trust of local people, means of information dissemination platform and decision making. **[15 marks]**

2. Why is weather forecasting challenging for mountainous areas and rugged terrain? Briefly describe how we can improve weather forecasting over these areas. **[15 marks]**

3. Farmers are the end user of the weather forecast. Do you think the short-range weather forecast (1 to 3 days) information is enough for farmers? Suggest different ranges of forecast information farmers can use. **[10 marks]**

4. If you were a weather forecaster in NCHM, how would you respond, when the media asks you about the reliability of the forecast and uncertainties? **[10 marks]**

TASHI DELEK