

**INDIA METEOROLOGICAL DEPARTMENT**

**QUESTION BANK**

**OF**

**ADVANCED METEOROLOGICAL TRAINING**

**COURSE (AMTC)**

**SEMESTER-II EXAMINATION**

**BASED ON 176-181 BATCHES**

**(2015-2021)**

**PAPER-V: CLIMATE SCIENCE**

**India Meteorological Department  
Meteorological Training Institute  
Advanced Meteorological Training Course,  
SEMESTER- II Final Examination**

**PAPER V: Climate Science**

**Q.1 Fill in the blanks**

1. ----- is a major mode of climate variability. (Heat low, ENSO, tropical cyclone)
2. (eastern / western) parts of equatorial Pacific Ocean.
3. \_\_\_\_\_ contributes maximum to greenhouse effect.
4. \_\_\_\_\_ number of parameters are used for current operational LRF model of IMD for issue April forecast.
5. \_\_\_\_\_ are common features of Antarctica Atmosphere.
6. \_\_\_\_\_ is the best tool to simulate climate.
7. \_\_\_\_\_ mountain cast a great \_\_\_\_\_ over southern Argentina.
8. \_\_\_\_\_ a circulation phenomena affects the Gulf states area in the winter over North American Continent.
9. \_\_\_\_\_ are common features of Antarctica atmosphere.
10. \_\_\_\_\_ is a major mode of Climate Variability. (Heat Low/ENSO/Tropical Cyclone)
11. \_\_\_\_\_ coupled model IMD used for Operational long range forecast for Indian summer monsoon rainfall.
12. ....is a major driver of the monsoon interannual variability.
13. .... is a moving oscillation from west to east in equatorial region.
14. .... tier approach is used in climate modelling fully coupled system.
15. 1250 years BP means .....CE (AD)

16. A climate driver with a positive RF value indicates that it has a \_\_\_\_\_ effect on the planet a negative value represents \_\_\_\_\_ effect.
17. A perturbation to the energy balance of  $1 \text{ W m}^{-2}$  (at the top of the atmosphere) results in a response of earth's equivalent black body temperature of -----.
18. A positive NAO index indicates \_\_\_\_\_ than usual sub tropical high pressure centre and a \_\_\_\_\_ than normal Icelandic low.
19. A positive North Atlantic Oscillation index indicates a stronger than usual \_\_\_\_\_ pressure center and a deeper than normal \_\_\_\_\_.
20. Annual precipitation is over \_\_\_\_\_ inches in a narrow strip west of crests of the mountains from Aleutian Peninsula to northern California.
21. Arctic boundary is defined by the position of \_\_\_\_\_ °C isotherm of the warmest month July.
22. As per the new LRF strategy the first stage forecast for the all India summer monsoon rainfall is issued in -----and second stage forecast is issued in ----- .
23. Australia will get \_\_\_\_\_ (less / more) rain in an El Nino year.
24. Average temperature of the global ocean is .....
25. Based on the homogeneity in the summer monsoon rainfall, the four broad geographical regions of India are -----, -----, -----, and -----.
26. Because of location of Australia, on both sides of the Tropic of Capricorn, temperatures far below freezing are to be found only in \_\_\_\_\_ at high elevations.
27. Bermuda ..... is a semipermanent pressure system over Northern Hemisphere.
28. Climate change is \_\_\_\_\_.
29. Climates in entire African Continent over North-South of Equator is similar. Give reason.
30. CMIP3 models are \_\_\_\_\_ models while CMIP5 are \_\_\_\_\_ models.
31. CMIP5 models are run for different \_\_\_\_\_.
32. Cold winter temperature in the Arctic results from surface covered with snow and ice. (state T/F with reason)
33. Conversion of kinetic energy to internal energy or vice versa takes place through the \_\_\_\_\_ term
34. Describe salient features of Climate of Antarctica
35. Direct evaporation of snow is called.....

36. During monsoon, westerly winds prevail along the west coast of India and their interaction with the \_\_\_\_\_ breeze during the \_\_\_\_\_ leads to maximum precipitation at late night/early morning hours.
37. Full form of UNFCCC \_\_\_\_\_
38. Half-life of Radiocarbon (C-14).....years
39. Heavy summer rains of north \_\_\_\_\_ are of \_\_\_\_\_ origin.
40. Humans are creating climate change by burning large amounts of \_\_\_\_\_.
41. In an El-Nino event anomalous warming in SSTs are first observed over ----(eastern / western) parts of equatorial Pacific Ocean.
42. In an El-Nino event anomalous warming in SSTs is first observed over ----
43. In Mexico and Central America, climatic zones depend on \_\_\_\_\_, ranging from subtropical to temperate in higher levels.
44. In normal conditions, the Western Pacific Ocean is ----- than the eastern Pacific Ocean (warmer / cooler) .
45. In Northwest and North Europe and also in most of Central Europe the prevailing winds direction is controlled by \_\_\_\_\_ and \_\_\_\_\_.
46. In the atmosphere of our planet, the most abundant greenhouse gas is ----
47. In the earth's atmosphere, tiny solid or liquid suspended particles of various compositions are called -----
48. In the negative phase of IOD, monsoon will be active over----- parts of India (Most/less).
49. In the positive phase of IOD, monsoon will be active over----- parts of India (Most/less).
50. In the positive phase of IOD, over the western Indian Ocean \_\_\_\_\_ (negative/positive) anomaly in OLR values is noticed.
51. In the Venus planet, the gas responsible for the greenhouse effect is -----
52. In winter, over Asia, precipitation is \_\_\_\_\_ over entire continent.
53. Indian summer monsoon rainfall is deficient when, All India Rainfall is less than \_\_\_% of Long Period of Average
54. Indonesia will get ----- (less / more) rain in an El Nino year.
55. Investigation of diurnal variability of rainfall over land and ocean in the tropics showed that over the continents most precipitation falls as convective showers during the \_\_\_\_\_, while over oceans maximum rainfall occurs at \_\_\_\_\_.

56. IPCC Fifth Assessment Report was a critical scientific input into the UNFCCC Paris Agreement in \_\_\_\_\_.
57. Is issued in -----and second stage forecast is issued in ----- .
58. Kuroshio current is found near..... .
59. Long Range Predictability is better in tropics compared to extra-tropic. \_\_\_\_\_(True/False)
60. Mean annual temperature over India has risen by--- (0.6/1.4).<sup>0</sup>C during 1901-2010 period.
61. MJO has a periodicity of \_\_\_\_\_ days.
62. More than 60% of India's agriculture is \_\_\_\_\_, making the country highly dependent on groundwater.
63. NAO modulates climate of northern extra tropics maximum during -----(Winter, Summer, whole year).
64. Northern Region of African continent is very cool at night due to lack of \_\_\_\_\_, hence strong \_\_\_\_\_.
65. Northwest pacific coast area in the United States has less precipitation. Give reason.
66. Objects near the poles have .....angular momentum than those near the equator.
67. Obliquity (tilt) cycle impact Earth's.....
68. One of the major greenhouse gases present in the atmosphere is .....
69. Operational long range forecast for Indian summer monsoon rainfall of IMD is based on \_\_\_\_\_ model.
70. Over Antarctica, \_\_\_\_\_ reach gale force, kicking up snow and bringing visibility to zero and is termed as \_\_\_\_\_.
71. Over Australia, heavy summer rains of the north are of \_\_\_\_\_ origin and winter precipitation over southern coast is of \_\_\_\_\_ type.
72. Over much of the Europe \_\_\_\_\_ is both abundant and evenly distributed throughout the year.
73. Pacific Oceans are characterized by \_\_\_\_\_(high / low) parts sea surface temperature gradient.
74. Peak intensity of the NAO is noticed during \_\_\_\_\_ the season (Winter/ Summer).

75. Polar continental air mass is \_\_\_\_\_ (cooler / warmer) than the polar maritime air mass.
76. Present day volume mixing ratio of carbon dioxide is approximately.....ppm.
77. Short range forecasting is ..... value problem.
78. South America has a characteristically \_\_\_\_\_ climate.
79. The \_\_\_\_\_ area of Europe receives rainfall in winter; while \_\_\_\_\_ Europe receives that during summer months.
80. The \_\_\_\_\_ air mass dominates weather over Australia during winter.
81. The all-India summer monsoon rainfall is \_\_\_\_\_ (variable/stable) in the long-term sense i.e. over a period of 100 years or more.
82. The atmospheric predictability is driven by ----- & -----.
83. The basic balance equation of water vapor is given by  $\frac{dq}{dt} = \text{_____} + \text{_____}$
84. The decadal patterns of rainfall anomaly indicate the prominent increases in variability during the decades of high \_\_\_\_\_ rainfall.
85. The entire African continent is within the \_\_\_\_\_ zone.
86. The forecast period of the Long range forecast is ----- .
87. The gas responsible for the greenhouse effect on Venus is -----
88. The intra-seasonal 30-60 days oscillation, also known as Madden and Julian Oscillation is linked to the globally \_\_\_\_\_ moving wave number 1 and 2 in the equatorial regions and also characterized by a \_\_\_\_\_ propagation of weather anomalies along the Indian region during southwest monsoon season.
89. The IPCC is currently preparing the Sixth Assessment Report (AR 6), which will be completed in \_\_\_\_\_.
90. The IPCC published its First Assessment Report \_\_\_\_\_.
91. The local rate of change of absolute angular momentum per unit volume is found to be equal to the meridional transport of angular momentum and the \_\_\_\_\_ and \_\_\_\_\_ torques.
92. The mean transport of angular momentum as estimated by Reihl and Yeh (1954) have showed that in the lower layer there occur a net \_\_\_\_\_ transport of angular momentum where as in the upper layer there is a net \_\_\_\_\_ transport.

93. The monsoon season rainfall averaged over the country as whole shows \_\_\_\_\_ (increasing / decreasing / no significant) trend.
94. The most abundant greenhouse gas in the earth's atmosphere is -----
95. The pressure gradient torque per unit mass is \_\_\_\_\_  $a \cos \phi$  and the frictional torque per unit mass is \_\_\_\_\_  $a \cos \phi$ .
96. The primary source of energy for the earth's atmosphere is -----
97. The rate at which solar energy reaches unit area at the earth is called .....
98. The seasonal predictability of the Indian summer monsoon rainfall is limited by the influence of ----- on the mean monsoon circulation.
99. The three large scale see saw oscillations in the global pressure patterns identified by Walker are -----, -----, and -----.
100. The time period between the issue time of the forecast and the beginning of the forecast validity period is called -----.
101. The variability of monsoon resulting on account of the spells of active and break monsoon activity within the season is known as \_\_\_\_\_ (intra-seasonal / intra-annual) variability .
102. The variability of summer monsoon rainfall on a smaller spatial scale is much \_\_\_\_\_ (higher / lower) than that on a regional scale .
103. The variation of all-India rainfall arises primarily from that of rainfall over \_\_\_\_\_ (western / eastern) parts of the country where the coefficient of variation is the \_\_\_\_\_ (highest / lowest).
104. Tiny suspended particles (solid or liquid particles of various compositions) in the Earth's atmosphere are called -----
105. Tropical Cyclones are called as \_\_\_\_\_ in the northwest coast of Australia.
106. Two examples for the natural, internal climate variations causing climate change are ----- & -----.
107. Validity of Long Range Forecast is Greater than \_\_\_\_ days
108. West Asia and coastal regions of Black and Caspian seas receive most of the precipitation in \_\_\_\_\_ (summer / winter).
109. Westerly systems induced by NAO phenomenon, affects the monsoon rainfall over India through modifying ---- (temperature/ humidity gradient).

110. While the major meridional components of the atmospheric circulation is known as the \_\_\_\_\_ circulation, the large scale zonal components of tropical airflow is known as the \_\_\_\_\_ circulation.

## **Q.2 State whether True or False with reasons**

1. A 2 °C rise in the world's average temperatures will make India's summer monsoon highly predictable.
2. A minimum in rainfall in the late night/early morning hours and maximum in the afternoon have been experienced by stations along the foothills of the eastern Himalayas.
3. A perturbation to the energy balance of  $1 \text{ W m}^{-2}$  (at the top of the atmosphere) results in a response of earth's equivalent black body temperature of  $0.266^{\circ}\text{K}$ .
4. A positive IOD SST pattern has been shown to be associated with decreased rainfall over India and Indonesia and parts of central and southern Australia
5. A strong cooling influence is observed over the coastal regions of all the western countries of South America except Colombia.
6. Arctic surface temperatures are higher than Antarctic surface temperature.
7. Big volcanic eruptions impact the Earth's climate.
8. Carbon-14 dating can be used samples older than 50000 years
9. Cold winter temperatures are observed over Arctic.
10. Continental Polar (Cp) air does not exist over South America.
11. During northeast monsoon season the oceanic areas adjoining south peninsular India (south Bay of Bengal, south Arabian sea and the Indian ocean regions) receive more rain 4 to 6 mm of rain in 3 hrs during late night/early morning (03.30 to 06.30 IST), compared to the adjoining coastal areas which may receive 1 to 2 mm of rainfall.
12. During the positive phase of Arctic Oscillation the jet stream is farther south of its average position and storms can be shifted southward of their usual paths.
13. El-Nino-Southern Oscillation events are associated with abundant precipitation in the tropics over a wide area over the western tropical Pacific Ocean, Indonesia, Australia, and India.



14. Extreme southern tip of South America is characterized by year-round cold and damp climate.
15. If the atmospheric torque acts in the opposite direction of rotation of the earth, it would tend to increase the rate of rotation of the earth and decrease the angular momentum of the atmosphere.
16. In Europe, mean annual rainfall decreases from west to east.
17. IPCC Membership is open to all members of the WMO and UN
18. Isotopes of an element have equal number of neutrons
19. Long-range predictability is better in tropics compared to extra-tropics.
20. Maritime climate along the Atlantic Ocean is very narrow.
21. MJO has a tendency to move northward over the Indian region during winter season.
22. Motions of the atmosphere or oceans with or against the gravity force, convert kinetic energy into potential energy.
23. Northern Australia experiences NW monsoon during its summer season.
24. One of the main characteristics that distinguish PDO from ENSO are that the PDO events persisted for 1-to-2 years, while typical ENSO events persisted for 1-to-2 months.
25. Rossby waves are faster than Kelvin waves.
26. Sea Surface Temperature (SST) has more relevance in the extended and seasonal forecast.
27. Stations along the foothills of the eastern Himalayas experience a maximum in rainfall in the late night/early morning hours and minimum in the afternoon.
28. Strong radiational cooling is observed over the Great Sahara desert.
29. The all-India monsoon seasonal rainfall cannot be considered to be a reasonable indicator of the conditions within the country.
30. The atmospheric circulation over a region can be influenced by changes in the sea surface temperature over oceans far away from the region.
31. The country's averaged annual mean temperature during 1901-2020 showed a decreasing trend of  $0.62\text{ }^{\circ}\text{C}/100\text{ years}$
32. The dry epoch in low-frequency variation of monsoon rainfall is characterized by delayed onsets, more break monsoon days and fewer storms and depressions.

33. The earth's atmosphere (with the assumption of black body emission from the atmosphere) would cool at a rate of 1K during the night time, if it were completely insulated from the underlying surface.
34. The ensemble prediction helps in representing uncertainties in the initial conditions.
35. The epochal behaviour of all-India summer monsoon rainfall is same as that of east equatorial Pacific sea surface temperature tendency from winter to spring.
36. The IPCC conduct and publish its own original research.
37. The land areas of Tamil Nadu, Kerala and coastal Andhra Pradesh receive rainfall peaks during the late evening/early night (between 1830 and 2130 IST) the reason for which is due to the convecting heating of the Ocean during late evening/early night and also due to sea breeze and synoptic northeasterly winds bringing rains over the coastal regions.
38. The mass surplus near the equator then begins to disperse eastward as a so-called (down welling) Rossby wave.
39. The North Pacific Decadal Oscillation is a large-scale fluctuation of atmospheric pressure and sea surface temperatures (SST) in the North Pacific Ocean. In terms of atmospheric pressure it is the fluctuation of surface pressure between the North Pacific sub-tropical high and the Aleutian low in the polar region and in terms of SST it is defined as, when the negative SST anomalies in the northwest Pacific ocean and positive SST anomalies in the eastern tropical Pacific Ocean.
40. The regions receiving higher rainfall exhibit lesser variability and vice versa.
41. The SW Monsoon over India develops during the Northern Hemisphere Summer Period.
42. The winter and spring snow cover over Eurasia is inversely correlated with the Indian summer monsoon rainfall.
43. There exist no association between the strength of monsoon and SOI.
44. Tornado Activity is observed over central plain areas of North America.
45. When a North Atlantic oscillation index is positive strong winter storms frequently passes across North Atlantic Ocean in a more northerly track.
46. When forests are cut down or burned, they can no longer store carbon, and the carbon is released to the atmosphere.
47. Winter season in Western Europe is more pleasant than in Eastern Europe.

**Q.3. Answer the following :**

1. (i) Derive Palmen's equation for the meridional flux of angular momentum and explain the various terms. (ii) Explain with the help of diagram that the meridional flux of angular momentum in the lower layer is equatorwards in the subtropics while in the upper layers it is polewards and there is convergence and balance is restored by the downward and upward fluxes into the lower layer.
2. (i) Show that the potential energy and internal energy in the atmosphere are not independent forms of energy, in fact, in hydrostatic equilibrium they are proportional to each other (ii) Also show that the total potential energy is directly proportional to the square of the speed of sound.
3. Briefly describe a positive feedback mechanism that can amplify global warming.
4. Briefly describe the phenomenon of El Nino / Southern Oscillation (ENSO)
5. Briefly describe the phenomenon of the South Asian monsoon
6. Briefly explain different monthly and seasonal forecasts for southwest monsoon rainfall presently issued by IMD.
7. Consider a completely dry atmosphere (no water vapor). If the atmospheric CO<sub>2</sub> concentration is doubled, by how much would the global mean temperature of the Earth increase?
8. Define Climate change. Enlist the factors which causing climate change and what are the indicators of climate change?
9. Define climate sensitivity and feedbacks? Estimate the sensitivity of earth's black body temperature to a change of solar radiation incident at the top of the atmosphere?
10. Define Global warming. Enlist causes of global warming and what are the possible impact of global warming over India (according to IPCC)?
11. Describe NAO phenomenon and its impact on position of the westerly jet stream. How does this phenomenon affect the Indian monsoon?
12. Describe the observed characteristics of climatological-mean surface temperature and atmospheric circulation during January and July.
13. Describe the Wind and Pressure Systems over the Northern Hemisphere Continents during winter and summer seasons in brief.
14. Describe water cycle in atmosphere in simple terms.

15. Differentiate between natural climate variability and global warming. Articulate with examples.
16. Discuss the diurnal variability of Indian southwest monsoon rainfall and state the reasons with help of diagrams for the pattern of diurnal variability of monsoon rainfall witnessed in (i) Cherrapunji, a hill station, (ii) Dibrugarh near the foothills of eastern Himalaya and (iii) Mumbai a coastal station.
17. Enlist theories to study climatic fluctuations.
18. Estimate the equivalent blackbody temperature of the Earth, assuming a planetary albedo of 0.30. Assume that the Earth is in radiative equilibrium. (Hint: Solar constant =  $1368 \text{ W m}^{-2}$ , Stefan-Boltzman constant =  $5.67 \times 10^{-8} \text{ W m}^{-2} \text{ K}^{-4}$ )
19. Explain solar cycle and Sun spots?
20. Explain the ENSO-Monsoon relationship (neutral, El Niño, La Niña) using schematic diagrams of the Walker circulation.
21. Explain the lifecycle of ENSO, and the role of equatorial Kelvin waves in it, with schematic diagrams.
22. Hence or otherwise briefly describe the delayed Oscillator theory of El Nino events.
23. How many parameters are using for current operational LRF model of IMD for issue April (1st Stage) forecast?
24. If the earth's atmosphere emitted radiation to space as a black body (i.e. with the assumption of black body emission from the atmosphere) and if it were completely insulated from the underlying surface, at what rate would it cool during the night? (Hint: Solar constant =  $1368 \text{ W m}^{-2}$ , specific heat of dry air =  $1004 \text{ J kg}^{-1} \text{ K}^{-1}$ , Stefan-Boltzman constant =  $5.67 \times 10^{-8} \text{ W m}^{-2} \text{ K}^{-4}$ )
25. If there is increased sea-ice melting in the Arctic due to a warming environment, how can it affect the thermohaline circulation and the global climate?
26. Impact of climate change on Agriculture.
27. In what way the heating of oceans is different from that of the heating of land?
28. Long Range Predictability is better in tropics compared to extra-tropics. (True/False)
29. Name the various Milankovitch Cycles and explain their impacts on Earth's climate.
30. Seasonal average of weather parameter over the tropics are depend on Slowly varying boundary conditions. (True/False).

31. Sectors and Possible Application Areas of LRF.
32. State any two causes of changes in Earth's energy balance.
33. State one of the proxy used for paleo climate studies.
34. State the difference between weather and climate.
35. What are advantage and limitations of probabilistic and deterministic approach for presentation of seasonal forecast?
36. What are El-Nino and La Nina events? How is an El Nino event defined?
37. What are the adaptation measures to rising sea level?
38. What are the Advantages and Limitations of Statistical and Dynamical Model used for seasonal Prediction?
39. What are the methods used for Seasonal (Long Rang) forecast? What are the Advantages and Limitations of Model used for seasonal Prediction?
40. What are the observed changes in the mean summer monsoon rainfall? Are the CMIP5 historical simulations comparable to these observed changes? What are the CMIP5 future projections for the summer monsoon?
41. What are the observed evidences of changing climate?
42. What is 'Walker Circulation'? Describe its relation with Equatorial Pacific Ocean SSTs.
43. What is an "Earth System Model"?
44. What is Green house effect?
45. What is Greenhouse effect? Enlist greenhouse gases and their sources in Agriculture.
46. What is Indian Ocean Di pole? Mention its role and SHET's role in affecting the monsoon.
47. What is objective of the UNFCCC?
48. What is the average rainfall in South America?
49. What is the Clausius-Clapeyron relation, and how is it connected to increased amount of rainfall in the tropics?
50. What is the range of seasonal variation of average temperature over northern Asia?
51. What is the reverse 'Walker circulation'? Describe its role in the formation of systems over the Bay of Bengal. Hence or otherwise briefly describe its impact on AISMR.
52. What is westerly burst? Describe its role in the formation of an El-Nino event. Hence or otherwise briefly describe the delayed Oscillator theory of El Nino events.

53. Whether the Frontal systems influence the weather over Europe? Why ?
54. Write all the energy equations including total energy equation. Illustrate the various source, conversion and sink terms of the energy cycle through a schematic diagram.
55. Write down the names of the 8 parameters used in the new statistical ensemble forecasting system for season rainfall over the country as a whole introduced by IMD in 2007.
56. Write the energy equations for the rate of change of total potential energy, kinetic energy, latent energy and the total energy, Explaining all the terms of the total energy equations. Illustrate with the help of a diagram the terms which connect the various forms of energy in the atmosphere.

**Q.4. Write short notes on the following:**

1. Africa climate
2. Briefly explain different LRF forecasts presently issued by IMD.
3. Climate feedbacks
4. Climate of Antarctica
5. Climate of Asia
6. Climatological features of Antarctica
7. Climatological features of Asia
8. Climatological features of Australia
9. Climatological features of Europe
10. Climatological features of South America
11. Describe the climatic features of any one of the following continents: a) Australia, b) Africa, c) North America
12. Describe the observed evidences in climate change over the India and Globe.
13. Deterministic and Probabilistic Long Range Forecasts

14. Discuss in Brief PDO and its impact on North Pacific Ocean.
15. Downscaling
16. Explain the surface climatology during winter and summer seasons over any two of the following Region: (a) Africa, (b) Arctic and Antarctic Regions, (c) South America.
17. Explain the Wind and Pressure Systems during winter and summer seasons over any one of the following Continent: (a) Australia, (b) Europe, (c) South America
18. Explain Water Cycle
19. Give salient features of Angular Momentum Cycle.
20. MJO and extended Range Forecast
21. North America Climate
22. North Pacific Circulation
23. Role of ENSO in monsoon variability.
24. State with an example the positive and negative climate feedbacks.
25. Variations in 31 year moving averages of all-India summer monsoon rainfall anomalies and its standard deviation.
26. Walker Circulation
27. Weather modelling and climate modelling
28. What is greenhouse effect? How earth's average surface temperature is maintained around 287K?
29. What is Walker Circulation? Describe its relation with Equatorial Pacific SST's.
30. Write a short notes on 'Walker Circulation' .
31. Define the climate sensitivity? Estimate the apparent climate sensitivity based on estimates of the differences in surface temperature ( $T_S$ ) and forcing (F) between the current climate (denoted as NOW) and the climate around 20,000 years ago (i.e. last glacial maximum, denoted by LGM), with the following data.

$$T_S (\text{NOW}) \text{ minus } T_S (\text{LGM}) \quad \rightarrow 5^{\circ}\text{C}$$

CO<sub>2</sub> (LGM) → 180 ppm

CO<sub>2</sub> (NOW) → 360 ppm

Changes in albedo between the two periods → 0.01