Assignment 1
CM615 Climate change impacts and adaptation
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Q.1. Briefly answer the following:
A. Define climate change and provide two observational evidences that support its occurrence. *(3 marks)*
B. What is global warming? Explain how it relates to climate change. *(2 marks)*
C. Describe how greenhouse gases influence Earth's energy balance. *(2 marks)*
D. Explain how aerosols impact Earth's energy balance. *(2 marks)*
E. Write the mathematical expression representing radiative equilibrium in Earth's energy budget. *(2 marks)*
F. Define climate forcing (or radiative forcing) and climate response. Give one example each of positive and negative feedback mechanisms. *(3 marks)*

Q.2. Determine how much carbon (in gigatonnes, GtC) corresponds to an increase of 1 ppm in atmospheric CO_2. Then, convert the current atmospheric CO_2 concentration into its equivalent carbon stock. *(4+2 marks)*

Q.3. Given Earth's emission temperature as 255K and planetary albedo as 30%, analyze two hypothetical scenarios:
i. If Earth's albedo decreases by 10%
ii. If albedo remains the same, but the infrared absorptivity of the atmosphere doubles

Compute the emission temperature and surface temperature for both cases, assuming a leaky atmosphere model or partially absorbing atmosphere. *(3+3 marks)*

Discuss the real-world conditions under which these scenarios could occur and their implications for Earth's climate and energy budget. *(2+2 marks)*

Q.4. Calculate the emission temperatures of Venus and Mars, given:

- Their mean orbital distances: **0.72 AU (Venus), 1.52 AU (Mars)**
- Solar flux at Earth's orbit: **1367 W/m²**, which decreases with the square of distance
- Planetary albedo: **0.77 (Venus), 0.24 (Mars)**

(6 marks)

Q.5. Use **Modtran** (tropospheric atmosphere, looking down mode) to analyze the impact of greenhouse gases on Earth's outgoing infrared flux. Comment on the Upward IR Heat Flux and emission spectra for the following cases:
i. Set all atmospheric gases to zero.
ii. Use default settings for all gases except CO_2, which is set to 4 ppm and 440 ppm.
iii. Keep all gases at default except water vapor, which is set to 1x and 4x water vapour scale.
(3×3 = 9 marks)

Q.6. Plot the trends of annually averaged Tmin and Tmax over India for two periods: 1950-1975 and 2000-2023. Perform this analysis for the entire country and four specific regions:

- **North**: (74–80°E, 28–36°N)
- **South**: (74–80°E, 14–22°N)
- **East**: (80–94°E, 22–28°N)
- **West**: (70–80°E, 21–28°N)

Compare the results and provide insights based on the plots. *((2.5+2.5)×4 = 20 marks)*