PHY2006 Partial Differential Equations Group Project – individual effort

Project

As it is not possible for your to do an in-person project, the project has been modified to make it possible to be completed on an individual basis. A written report on the project should be submitted (as a pdf) to Canvas with the same deadline (Wed 3 Nov). The report is worth 10% of the module mark.

Objectives

In this project you will solve a climate change model governed by a 1-dimensional (latitude), time dependent differential equation. For your project you should complete the following tasks

- Do some background reading using the notes provided and other sources on the physical problem of modelling climate change
- From the 1D PDE model formulated in the notes, write down a finite difference equation of the PDE and show how this can solved numerically
- Use the Matlab code provided to solve the PDE numerically. Some basic parameters should be changed (e.g. CO_2 concentration) to evaluate the effect on the temperature distribution on Earth.

Specific Instructions

1. Numerical Finite Difference Equation
    a. From the PDE write down a forward-in-time finite difference equation from which a numerical solution is obtained (check this agrees with what is implemented in the Matlab programme)
    b. Explain how the Neuman boundary condition dT/dx=0 is applied at the poles in the numerical solution (again check that this matches what is in the Matlab code)
2. Test the finite difference code - *ClimateModelFDM_Explicit_basic.m*
    a. Read through the code and make sure you understand what it is doing. There are comments throughout explaining each part of the programme.
    b. Run the code with default parameters τ =0.6, K = 0.5, N = 5000, M=50. Three figures are plotted. Read the comments in the code to find out what each represents.
    c. Change τ (IR_trans) and K to see how this affects the Temperature distribution. What physical changes does this represent? Where is there disagreement with the experimental data and why? Are the temperatures of the south and north pole the same? Can you explain your findings?
    d. Note how the temperature distribution evolves in time. How long does it take to reach an equilibrium temperature distribution?

Written Report

Your report should include the following:

- An appropriate title
- A short introduction to the background and Physics of Climate Change
- Present the 1D PDE equation to be solved. It is not necessary to show how this is derived, but it is important to explain what the terms and parameters represent physically
- A step-by-step derivation of a finite difference equation of the PDE used for the Matlab code
- Present the results of the numerical solutions from the Matlab code and your investigation of the relevant parameters
- A short Discussion/Conclusion
- References