Spring 2003: ATMS 581/AMATH 586/MATH 586

Numerical Analysis of Time Dependent Problems

MWF 2:30-3:20, Room MEB 246
Final Exam: Tuesday, June 10, 2:30-4:20 PM

Instructor: Professor Dale Durran
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Office hours: TTh 2:00-3:00

Textbook: Durran, D.R., 1999: *Numerical Methods for Wave Equations in Geophysical Fluid Dynamics.* Springer-Verlag.

Supplementary Notes: Le Veque, R.J., 2002: *Finite Difference Methods for Differential Equations.* (download from ftp site)

Overview: The purpose of the course is to obtain a thorough understanding of the basic numerical techniques that form the foundation for the computer models commonly used to simulate time dependent systems. The theoretical properties of each basic numerical technique will be illustrated by constructing simple models using MATLAB. Some modeling results will be presented as demonstrations in class; other modeling exercises will be assigned as homework.

Course Outline

Introduction

- Two prototypical physical problems
    1. Diffusion dominated
    2. Advection dominated
- Overview of numerical solution strategies.
    1. Finite difference, finite volume
    2. Spectral, finite element

Ordinary Differential Equations

- Single-step, single-stage methods for IVP
    1. Accuracy, consistency, local and global errors
    2. Stability, convergence
- In search of better schemes

1. Multi-stage methods
2. Multi-step methods
3. Stiff ODEs

Diffusion Equations

- Diffusion in one spatial dimension
  1. Method of lines
  2. Stiffness of the difussion equation
  3. Stability, convergence
- Multi-dimensional problems
- Series expansion methods
  1. The spectral method
  2. The finite element method

Advection Equations

- Upstream differencing
  1. Stability, convergence
  2. The CFL condition
- Higher-order methods
  1. Truncation error and the modified equation
  2. User-controlled dissipation
- Finite volume methods
  1. Conservation form
  2. Limiters
- Spectral and pseudo-spectral methods
- Multi-dimensional problems

Advection-Diffusion Equations

Grading: 65% of the grade will be based on 5 homework assignments; the remaining 35% on the final.