Numerical modelling of atmospheres and oceans

MTMW14 Revision Test

4 February 2003 12-13:00 (1 hour)

To obtain the total of 50 marks please answer all 3 questions.

1. General Circulation Models (GCMs) use a variety of different numerical schemes to solve the equations of fluid motion:

   a) why do GCMs solve the primitive equations rather than the more exact Navier-Stokes equations? Which two types of wave are absent in primitive equation solutions? **[5 marks]**

   b) What is meant by a *semi-implicit scheme* and why are they used? **[5 marks]**

   c) briefly describe using a sketch and simple equations the main steps in the semi-Lagrangian method, **[5 marks]**

   d) what are the advantages of using spectral methods for modelling the global atmosphere? **[5 marks]**

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2. The 1-d non-linear Burger's equation is given by

$$\frac{\partial u}{\partial t} + u\frac{\partial u}{\partial x} = 0$$

a) write down a centered finite difference approximation to this equation. **[5 marks]**

b) write down a flux-form centered difference approximation by first expressing the advection term as the divergence of a flux. **[5 marks]**

c) is the centered advection scheme numerically stable? If not, explain what might be done to make it numerically stable?

[5 marks]

d) name two other approximation methods that are frequently used to represent fluid fields and explain briefly their advantages compared to using finite differences.

[5 marks]

3. Physical parameterizations are very important components of numerical models

a) name two processes that need to be parameterized and explain what would happen if they were not included in numerical models. **[5 marks]**

b) describe briefly how sub-grid scale horizontal mixing is parameterised in models. **[5 marks]**

c) why is the parameterization of convection a more important issue for atmosphere models than for ocean models? **[5 marks]**