ASL410: Numerical Simulation of Atmosphere and Ocean

Major Examination

Time: 2 Hours

Aids Permitted: Calculator

The set of governing equations of the atmosphere is given in the Appendix

[Square brackets denote alternate phrasing or additional things that are not essential to the answer (but might partly compensate for points on other aspects of that question)]

Please put your Serial Number on **the front page** page of the answer sheet

Q.1: Between the forward difference and central difference which one is more accurate, and how ? In the 1st model time step (marching from Initial condition to the next step), which method (forward or central difference) is used and why ?

[2x2.5 Marks]

Q.3: How weather prediction is different from climate projection (explain from the view points of resolution, initial condition, boundary condition, hydrostatic approximation, and physical forcing ?

convection, waves

(5x1 Marks)

Q.4: Which all terms of the primitive equations are not resolved by the atmospheric models ? How do atmospheric models take those into account ?

(2x2.5 Marks)

Q.6: If a model needs to be developed for the short term weather prediction over India, how are you going to tackle the following issues ?

{5x1 Marks}

i. Which framework *[cubed sphere/lat-lon grid]* is preferable, and why ?
ii. Should the hydrostatic assumption be taken (give the reasoning) ?
iii. Is it necessary to have a scalable model (give the justification on both counts) ?
iv. For what O(resolutions), the model should be developed and tuned ?
v. Will you use (non)uniform vertical resolution ? (give the reasoning)

Q.7: Refer the appendix and answer the following questions

{1x10=10 Marks}

i. Is it possible to **analytically** solve the set of equations ? Give the reasoning of your answer.

ii. What are the sources of **non-linearities** in the governing set of equations ? *[Look at the terms which are non linear and name them on physical context]*

iii. Are the temperature and moisture equations **coupled** ? If yes, explain how ?

iv. At global and annual scales *[if you integrate a equation over the entire globe for at least a year]*, what will be the approximate magnitude (value) of **dq/dt,** If the incoming solar radiation remains same ?

v. At global and annual scales, how do you compare **E with P** *[are they equal, or E >P, or P >E, explain with reasoning in one or two lines]* ?

vi. Name the variables which are used as **initial conditions** ?

vii. Specify the parameters those are used as **lower boundary conditions** ?

viii. Specify the parameters which are used as **boundary conditions at the top of the model ?**

ix. What is the CFL criterion ?

x. In which direction Rossby waves propagate ?

Appendix

$\omega, x, y, z, H, C_p, R$

Wind Forecast Equations

1a. $$\frac{\partial u}{\partial t} = -u\frac{\partial u}{\partial x} - v\frac{\partial u}{\partial y} - \omega\frac{\partial u}{\partial p} + fv - g\frac{\partial z}{\partial x} + F_x$$

1b. $$\frac{\partial v}{\partial t} = -u\frac{\partial v}{\partial x} - v\frac{\partial v}{\partial y} - \omega\frac{\partial v}{\partial p} - fu - g\frac{\partial z}{\partial y} + F_y$$

Continuity Equation

2. $$\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} + \frac{\partial \omega}{\partial p} = 0$$

Temperature Forecast Equation

3. $$\frac{\partial T}{\partial t} = -u\frac{\partial T}{\partial x} - v\frac{\partial T}{\partial y} - \omega\left(\frac{\partial T}{\partial p} - \frac{RT}{c_p p}\right) + \frac{H}{c_p}$$

Moisture Forecast Equation

4. $$\frac{\partial q}{\partial t} = -u\frac{\partial q}{\partial x} - v\frac{\partial q}{\partial y} - \omega\frac{\partial q}{\partial p} + E - P$$

Hydrostatic Equation

5. $$\frac{\partial z}{\partial p} = \frac{RT}{pg}$$