Mesoscale Meteorological Modeling: Spring 2008
Homework #5

1. Consider the tank model discussed in class, which can be used to represent the pressure gradient force:

$$\frac{\partial u'}{\partial t} = -g\frac{\partial h}{\partial x}$$

$$\frac{\partial h}{\partial t} = -h_o\frac{\partial u'}{\partial x}$$

Program this model using a centered-in-space, implicit, forward-in-time scheme. Recall that this is necessary to maintain numerical stability. For simplicity, you may assume that the ratio g/h_o is equal to one (see p. 312 of Pielke text). Integrate the model forward in time and calculate the amplitude decay and ratio of computational to analytic phase speeds as in Table 10-5 in the Pielke text. Use the same algorithms you developed in Homework #4. Discuss your results.

2. For the forward upstream differencing scheme (equation 10-13 in the Pielke text) you programmed in Homework #4, replace the cyclic boundary conditions with an oscillatory cosine function at an inflow boundary and an Orlanski radiative boundary condition at the outflow boundary. For the oscillatory cosine function, I suggest:

$$\varphi^t_{i=LB} = \varphi_{max}\, cos(k(x - ct))$$

Where "c" is the Courant number and φ_{max} is the average maximum amplitude in the domain.

How does this change the errors for amplitude and phase? Use the same algorithms you developed in Homework #4.

3. Repeat Task #2, this time using the tank model you programmed for Task #1. If there inflow at the lateral boundary conditions, I suggest an oscillatory cosine function of the form:

$$h^t_{i=LB} = h_{max}\, cos(k(x \pm \sqrt{gh_o}\,t))$$

Where a similar procedure as in Task #2 is used to compute h_{max}. A plus sign is used in the above equation for the right lateral boundary, a minus sign for the left lateral boundary. If there is outflow, use an Orlanski radiative boundary condition. Discuss how your results differ from Task #1. Feel free to display your results in graphical format as part of your discussion.