Atmospheric Science 582—Winter 2014

Homework 1

1. Derive the expression for the phase speed of semi-discrete approximations to Lele's alternative 4th-order compact scheme (3.53).

2. Using the matlab code provided as a starting point, compute solutions to the spike problem and the two-wave problem considered in Fig. 3.11.

(a) For the spike, simulate until the solution translates **10 grid cells** and show solutions using 3rd-order upstream biased and Lele's compact scheme (3.53). Try Lele's scheme with and without a 6th-derivative filter with filter value $\gamma_6 = 0.01$. Submit a pair of plots for the final time, one showing filtered results, the other non-filtered.

(b) For the two-wave problem simulate until the solution translates **30 grid cells** (once around the domain). Compare 2nd-order centered, 4th-order centered and Lele's compact scheme (3.53). Try them all with and without a 6th-derivative filter with filter value $\gamma_6 = 0.01$. Submit a pair of plots for the final time, one showing filtered results, the other non-filtered.

(c) Discuss the results obtained in (a) and (b) and their implications for designing finite-difference schemes.

The matlab files `fig3_7.m`, `first_biased.m` and `second_centered.m` should be place in the same directory and can be used to plot the either panel of Fig. 3.7 (except the centered 4th-order scheme is omitted) by commenting out appropriate parts of the initialization. You can use these files as a starting point and add code to solve this problem. Note that the matlab construct `x=A\b` solves `Ax=b` and uses knowledge of the structure of the matrix A to do this efficiently. This will be handy when computing Lele's scheme.

Due Wednesday, January 23rd