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Review – 10 July 2014

Title: Verification of a non-hydrostatic dynamical core using horizontally spectral element vertically finite difference method: 2-D aspects

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General comments:

This is a well-written manuscript describing a new model that implements a spectral element method (SEM) for the horizontal discretization and a finite difference method (FDM) in the vertical. Clearly the advantage of such a split method is to allow high scalability in the horizontal domain and compatibility in the vertical with established physics parameterizations. The reviewer's main concern with the manuscript was that the model was not tested with flow over steep terrain, however, the authors appear to have already addressed the issue, which was brought up by another reviewer. A few minor issues are addressed below.

Specific comments:

1) With regard to the general comment above, on line 11 of page 3727, the statement about verifying the model's ability to "treat surface elevations associated with the vertical terrain-following coordinate" should probably be reserved for the new section describing the "Schar mountain" experiment.
2) In line 27 of page 3729, what is meant by "degrees of freedom (DOF)"? A short explanation would be good here. DOF is also mentioned in Fig. 6. If DOF means number of GLL grid points, it doesn't make sense that the DOF is the same in both 5th and 8th order experiments, as mentioned in the Fig. 6 caption. For a given resolution (i.e., delta-x), it seems the 8th order experiments have more DOF. Please explain.
3) In lines 15-17 of page 3730, the authors state that the 8th order polynomials at the coarsest resolution are "relieved from the deviation from the converged solution" in Fig. 6c. However, when I compare Figs. 6b and 6c, I don't see much difference between the amount of deviation between the 5th and 8th order solutions at 400m or 200m. Your statement could use some clarification.
4) In line 26 page 3732 to line 4 of page 3733, there is mention of numerical diffusion applied to the momentum and potential temperature, however, there is no mention of

how it is implemented. It seems that a diffusion term applied with the mixed SEM/FDM methods would not be very trivial. It would be good if the authors described their method and/or reference an already published technique if it was used. Also, it would be good to describe what order of diffusion is used, i.e., del-squared or del^4 (hyperdiffusion?).

Technical corrections:

1) On line 12 of page 3721, the definition of eta-dot is written as a partial derivative w.r.t. time. Instead it should be written as the material (substantial) derivative w.r.t. time (i.e., D-eta/DT).
2) In line 8 of page 3727, should the reference to Eq. (24) instead be to Eq. (21)?
3) On line 11 of page 3729, what are x_r and x_c set to?
4) In Equation (25) on page 3731, should a_c be x_c?
5) In Equation (26) on page 3732, what is r_c set to?