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Interactive comment on "ASAM v2.7: a compressible atmospheric model with a Cartesian cut cell approach" *by* M. Jähn et al.

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Subject: Response to RC C1326: 'Review of the manuscript', L. Bonaventura, 05 Aug 2014

Thank you for your response and critical remarks.

reg. 1) Paper design Parts of the used methods are already described in other papers like Hinneburg, D., Knoth, O. (2005): Non-dissipative cloud transport in Eulerian grid models by the volume-of-fluid (VOF) method. Atmos. Environ., 39, 4321-4330.

Doyle, J. D., Gaberšek, S., Jiang, Q., Bernardet, L., Brown, J. M., Dörnbrack, A., Filaus, E., Grubišić, V., Kirshbaum, D. J., Knoth, O., Koch, S., Schmidli, J., Stiperski, I., Vosper, S., Zhong, S. (2011): An intercomparison of T-REX mountain wave simulations

and implications for mesoscale predictability. Mon. Wea. Rev., 139, 2811-2831.

Jebens, S., Knoth, O., Weiner, R. (2011): Partially implicit peer methods for the compressible Euler equations. J. Comput. Phys., 230, 4955-4974.

In our paper, we would like to give a short overview about the actual numerical implementation without going too much into detail, e.g. how it has been done for the DALES model: T. Heus, C. C. van Heerwaarden, H. J. J. Jonker, A. Pier Siebesma, S. Axelsen, K. van den Dries, O. Geoffroy, A. F. Moene, D. Pino, S. R. de Roode, and J. Vilà-Guerau de Arellano (2010): Formulation of the Dutch Atmospheric Large-Eddy Simulation (DALES) and overview of its applications. Geosci. Model Dev., 3, 415-444.

However, we would like to present the main flavor of the algorithms, where not all of them are mathematically profounded.

reg. 2) Shaved cell method For the spatial discretization only the six partial face areas and the partial cell volume and the grid sizes of the underlying Cartesian mesh are used. For a proper visualization we smooth the orography in such a way that the intersection of a grid cell and the orography can be described by a single possible nonplanar polygon. Or in other words, a cartesian cell is divided in at most two parts, a free part and a solid part.

reg. 3) Details on numerics a) To approximate the pressure gradient at the interface of two grid cells with only the pressure values of the two grid cells there is some freedom in choosing the grid size. Whereas in Adcroft et al. the grid size is chosen to preserve energy in their model. We follow Ng et al. (2009): Y.-T. Ng, H. Chen, C. Min and F. Gibou (2009): Guidelines for Poisson Solvers on Irregular Domains with Dirichlet Boundary Conditions Using the Ghost Fluid Method. Journal of Scientific Computing, 41, 300-320.

We have implemented both versions in our code and found that the second one is more suitable to simulate flows in hydrostatic balance.

b) A reference profile was used in earlier versions and is now discarded. See the discussion above.

c) Yes, for advection the amount of computation is doubled for the three velocity components but this is negligible compared to the number of transported scalars in sophisticated microphysical schemes. This approach avoids separate advection routines for the momentum components. We have also implemented a version with only on cell centered velocity components for advection and back interpolation, which seems to be more diffusive.

reg. 4) Reference paper to finite volume concepts We are aware of this paper and will cite it.

reg. 5) Idealized benchmarks In the papers by Giraldo et al. and Norman et al. the initial bubble is different from the one described by Straka et al. Compare with the test suite of Skamarock: http://www2.mmm.ucar.edu/projects/srnwp_tests/density/density.html. We have also tried this initial perturbation and get similar results and get a front that is on the left side of the 15 km mark (see attached figure). The actual contour spacing in Fig. 5 is 1 K. The 2 K in the caption is a typo and will be corrected. It might also be a bit of misleading to show the 300 K contour line. In most figures in the literature they start 299.5 K and 1 K steps.

a) + b) We will add a moist test case with steeper orography and compare our results with the ones from the following work: Kunz, M., Wassermann, S. (2011): Sensitivity of flow dynamics and orographic precipitation to changing ambient conditions in idealized model simulations. Meteorologische Zeitschrift, 20(2), 199–215.

reg. 6) Semi-implicit solvers Rosenbrock-W-methods are a special class of linearly implicit solvers. In these methods the compressible system is handled as a whole. Their application in numerical weather prediction is already described in an Oberwolfach Report in Knoth (2006). Since the approximated Jacobian can be "arbitrarily" chosen,

different types of explicitnesses can be reached. Especially two types of "pressure" solvers result from this approach where for most applications the simpler approach is sufficient. Both iterative linear solvers, BiCGStab and GMRES, are standard iterative methods and work well with suitable preconditioners. The number of iterations for the two iterative methods are problem dependent. They increase with increasing time step and are usually in the range of 2 to 5 iterations. Unfortunately the iterative solver for the sound part (pressure solver) do not scale well in case of a parallel use of the model. The parallelization is not described in this paper and will postponed to further special topics of the model. There is no connection to the work by Klein et al.

Interactive comment on Geosci. Model Dev. Discuss., 7, 4463, 2014.

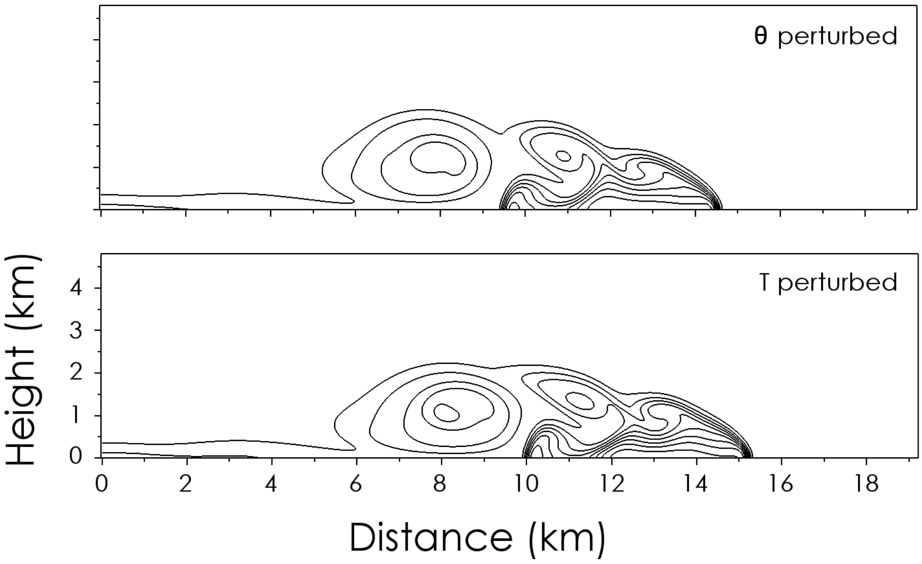

Fig. 1. Cold bubble test case: potential temperature isolines (contour interval 1 K, starting at 299.5 K) at t=900 s. Since the result is symmetric, only the right part of the model domain is shown.