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Geoscientific Model Development Discussions

Interactive comment on "Inherently mass-conservative version of the semi-Lagrangian Absolute Vorticity (SL-AV) atmospheric model dynamical core" *by* V. V. Shashkin and M. A. Tolstykh

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Dear Prof. Kaas,

Thank you for throughout review of our manuscript. Below are point by point replies to your comments.

Reviewer: Page 4810, line 6. Insert "A" before "Semi-implicit".
Reply: Corrected in the revised version.

Reviewer: Page 4810, line 7. I suggest to change "while" to "but".
Reply: Corrected.

Reviewer: Page 4810, line 11-12. I suggest to modify the sentence "The inherently ... article ensures ..." to "The new inherently mass-conservative version of the SL-AV model dynamical core presented here ensures ...".
Reply: Corrected.

Reviewer: Page 4810, line 25 - page 4811, line 1. I suggest to modify the sentence "The constituents ..." to the following: "In the absence of sources and sinks and chemical transformations the mass field of such constituents is characterized by local and global mass conservation.".
Reply: Corrected.

Reviewer: Page 4811, line 2. Delete "both"
Reply: Corrected.

Reviewer: Page 4812, line 6. You have described some aspects of the SL-AV model in this article, but I think you should provide a reference to a documentation manual if it exists (although it might be in Russian).
Reply: The SL-AV documentation is a book in Russian. We will provide reference to it, along with http link to the English abstract.

Reviewer: Page 4812, line 25. In the list of equations the continuity is missing.
Reply: Here we list the equations which discretizations are the same in standard (non-conservative) and presented mass-conservative version. Actually, the discretization of continuity equation was changed in mass-conservative version, so it is not present in the list.

Reviewer: Page 4813, line 1. Change "Non-conservative" to "The non-conservative".
Reply: Corrected.

Reviewer: Page 4813, line 15. I suggest to change "heat and" to "first equation of thermodynamics and the"
Reply: Corrected.

Reviewer: Page 4814, line 6. I suggest to change "the vector" to "a vector"
Reply: Corrected.

Reviewer: Page 4814, line 18. Change "Sect. 2.2" to "Sect. 3.2"
Reply: Here is the section numbering issue that will be corrected in the revised version of manuscript.

Reviewer: Page 4814, last line. Strictly speaking $\delta V(t)$ is not a volume but of course it represents a volume.
Reply: We will write this more clearly.

Reviewer: Page 4816, line 11. Change "while" to "by"
Reply: Corrected.

Reviewer: Page 4816, Eq. (11). There are Δt's missing in front of the last two $()$'s
Reply: Corrected.

Reviewer: Page 4817, line 1. Replace "The" with "A"
Reply: Corrected.

Reviewer: Page 4817, line 3. It is suggested to change "... model top to σ. Equation (11) is ..." to ".. model top to each σ level and Eq. (11) is then ..."
Reply: Corrected.

Reviewer: Page 4817 - 4818. It would ease readability if you briefly explain how the weakly non-linear term $(fD)^{n+1}$ in Eq (8) is dealt with when the equation system is to

be solved.
Reply: Corrected.

Reviewer: Page 4819, line 10. Although it may sound trivial, you must explain to the reader that one has to divide m or M with gravity g in order to get real mass with the typical unit of kg.
Reply: Corrected.

Reviewer: Page 4819, line 16. Replace "In" with "On"
Reply: Corrected.

Reviewer: Page 4820, line 21. Replace "2012, for the" with "2012, for a"
Reply: Corrected.

Reviewer: Page 4822, Eq. (20). On the left hand side replace $\sigma_{K+1/2}^{n+1}$ with $\dot{\sigma}_{K+1/2}^{n+1}$
Reply: Corrected.

Reviewer: Page 4823, line 10. Would be nice with reference describing how the implicit diffusion equation is solved.
Reply: Corrected.

Reviewer: Page 4824, line 27. Replace "one" with "that"
Reply: Corrected.

Reviewer: Page 4826, line 16. Change "Semi-implicit" to "A semi-implicit"
Reply: Corrected.

Reviewer: Page 4827, line 1. It is proposed to add "have here" before "presented"
Reply: Corrected.

Reviewer: Page 4827, line 28ff. It seems a bit old fashioned to use a σ coordinate

model. I have not thought carefully about it but I think you should include a discussion on the possibilities for applying the techniquie outlined in the present paper in a hybrid σ pressure coordinate model.
Reply: Implementation of the hybrid σ pressure coordinate in the SL-AV model is still a work to be done. This obviously will lead to some changes in SI discretization, but it looks like there is no principal problem in doing this. The implementation of hybrid σ-pressure vertical coordinates in mass-conserving version also looks possible and fully 3D nature of the underlying mass-conservative transport algorithm (no floating Lagrangian levels) enhances this possibility. We believe that the meaningful discussion on the hybrid σ-pressure vertical coordinates implementation in the SL-AV framework is beyond the scope of the article, but this should be stated as one of the directions of the future work.

Reviewer: It would also be nice with some discussion on the stability of the new scheme when long time steps are used (i.e. maximum Courant no's of 2 - 4)
Reply: Please note that the presented relatively small Courant numbers of 0.72 (in the mountain induced Rossby wave test) and 1.3 (in the baroclinic instability test) are the initial Courant numbers. The maximum developed circulation Courant numbers observed with the chosen time steps are $C_\lambda \approx 3.0$, $C_\varphi \approx 1.8$ in the mountain induced Rossby wave test case and $C_\lambda \approx 3.5$, $C_\varphi \approx 1.3$ in the baroclinic instability test case. This will be clearly stated out in the revised version of the manuscript.

Interactive comment on Geosci. Model Dev. Discuss., 6, 4809, 2013.