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Geoscientific Model Development Discussions

Interactive comment on "Evaluation of oceanic and atmospheric trajectory schemes in the TRACMASS trajectory model v6.0" *by* Kristofer Döös et al.

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This is a useful manuscript that documents some important numerical details related to Lagrangian trajectory analysis. The authors are leads for the TRACMASS code, and they bring decades of experience and leadership to the problem. I recommend publication. However, I ask that many details missing from the manuscript be exposed and discussed. Here are my specific requests along with minor edit points.

Note that I will focus my comments on those that complement those from the other reviewer. In particular, this reviewer raises an important point about distinction between "accurate" and mass conserving. It would be useful for the authors to discuss this point.

GENERAL COMMENTS

–As detailed here, and in the earlier literature, the TRACMASS approach performs an analytic integration of the trajectory within a grid cell. This point is emphasized in the present manuscript. Importantly, this integration is enabled by an **assumption** that the subgrid scale velocity components are linear functions of their corresponding directions: [u(x), v(y), w(z)]. Surprisingly, this critical assumption is not explicity noted in the present manuscript. It should in fact be emphasized and defended.

How/where will it break down? As written, words such as "the trajectory solutions are exact" (pg 5, line 10) make it look like TRACMASS is performing magic. Instead, it is following an exact treatment based on the assumption of subgrid [u(x), v(y), w(z)].

–The differential equations for the position within a grid cell are given by equation (17) for the stationary case, and equation (26) for the time-dependent case. Both equations are offered to the reader as if they should be an obvious consequence of something a priori. However, both equations need more build up to motivate and rationalize.

The only statement to suggest where equation (17) comes from is line 19 on pg 5:

"The transport and position within the grid box are now related by U = dr/dx...".

However, this is a statement that offers no motivation nor a derivation. What is the basis for this relation?

So as written, equations (17) and (26) seemingly appear from no where, and the reader is left scratching his/her head. Sans shared intuition, these equations remain mere black boxes to the reader, which is of no use to the reader.

–At the end of Section 2, I found myself wanting to see a clear schematic to summarize the stationary method and the time-dependent method. Likely these schematics appear in the basic literature. But given that you are rederiving the methods here, it would serve the reader well to have such schematics presented again, perhaps in an updated manner. These schematics could offer far more conceptual understanding

than the maths presented in Section 2.

–The word "this" is used many placed without qualifying. The reader is often left wondering what "this" referes to. Please be more careful with letting the reader know what "this" refers to. It is important to do so in order not to lose the reader, especially the novice.

SPECIFIC COMMENTS

pg 2, line 25: "This in contrast..." suggest changing to "This method contrasts to the..."

pg 3, line 11: change "an GCM" to "a GCM"

pg 4, equation (4): The grid cell thickness is a function of (i,j,k,n). However, this space-time dependence is not consistently displayed in the manuscript, such as in equation (8) where we only see dependence on (k,n). Where it is relevant, and where (i,j) are exhibited for Delta x and Delta y, please also display such dependence for Delta z.

pg 4, line 17: not all ocean GCMs are incompressible (e.g., MOM and MITgcm have non-Boussinesq compressible options). So please qualify this statement; e.g., "many ocean models are incompressible".

pg 4, equations (9), (10), (12): As written, these equations are not usable when integrating within the model code online, unless we have the n+1 value of the thickness, density, and/or pressure. So please comment on what operationally you mean by these equations.

pg 5, line 16: It is useful to here state that r = x/Delta x is defined separately for each direction and for each grid cell. Namely, there is no assumption that Delta x is uniform across the model.

pg 5, line 16: change "velocity" to "transport"

pg 6, lines 9-10: this sentence appears to be an orphan from another paragraph. Perhaps it should go into the previous paragraph, though with some editing to reduce

redundancy.

pg 6, line 30: remove "with" at start of line.

pg 6, line 30: Global GCMs are often run with time steps of **hours** to minutes. For example, the GFDL-CM2.1 ocean component, which is one degree, uses a 2hours time step. GFDL-CM2.5, which is 1/4 degree, uses 30minutes.

pg 7, line 11: I believe that "spatial resolution" should be changed to "spatial grid spacing". Namely, resolution is a pure number whereas grid spacing has units of length. You are stating (Delta x,Delta y,Delta z), which is grid spacing, not resolution.

pg 7, equation (25): which time level do you use for Delta z in the case where the grid cell thickness is a function of time? n? n-1? average?

pg 9, line 15: suggest "...is that in the time-dependent scheme, the transit times..."

pg 11, line 8 and title to Section 3.1: No one has proven that 1/12th degree **resolves** mesoscale eddies globally. Instead, such models **admit** mesoscale eddies, but they are surely not fully resolved globally. So to state the ORCA12 is "eddy resolving" is an overstatement that is not justified.

pg 12, line 32: what is "this" referring to in the middle of the line?

pg 13, line 17: "the the"

pg 13, line 32: "...quantify this **difference** we compared..."

pg 14, line 26: It is stated here that the time-dependent scheme is more accurate than the alternatives. I suspect that it is indeed more accurate. But I see no where in the paper where a "truth" is used to base this conclusion. Or did I miss something??

pg 15, lines 14, 16, 25: please specify what "this" refers to on each of these lines. The reader should not be asked to assume he/she knows what you are referring to.

Figure 1 caption. Remove first "blue" in the second sentence.

Figure 2 caption "the the"

END OF REVIEW

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