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Interactive comment on "A Modular Arbitrary-Order Ocean-Atmosphere Model: MAOOAM v1.0" *by* Lesley De Cruz et al.

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We would like to thank Anonymous Referee #1 for their encouraging and constructive comments, which have improved the manuscript. Below is a list of modifications that we have implemented based on your specific comments.

The section Introduction is clear as well as the presentation of the numerical treatments that is accompanied by a necessary Appendix that I think is never cited in the text; this could help the reader.

Thank you for pointing this out. We have adapted the following paragraphs, so as to refer to the relevant sections in the Appendix.

The original paragraph (P5-L14-15) read:

"We reiterate these in Appendix A, and extend them with the formulae for both the ocean and the ocean-atmosphere coupling terms."

The new version (P5-L14-15) reads:

"We reiterate these algebraic formulae in Sect. A1 of Appendix A, and extend them with the formulae for both the ocean-atmosphere coupling terms, and the ocean inner products in Sect. A2. "

We have added the following sentence to the paragraph at (P6-L1):

"The elements of the tensor $\mathcal{T}_{i,j,k}$ are specified in Appendix B."

At P1-L24: an acronym has not been declared (please check author guide if reference you provided is enough).

Indeed. The sentence:

"The first of these, OA-QG-WS v1 (Vannitsem, 2014), features only mechanical coupling between the ocean and the atmosphere, and uses 12 atmospheric variables following Charney and Straus (1980) and four oceanic modes following Pierini (2011)."

has been changed to (P1-L23-24):

"The first of these, OA-QG-WS v1 (Vannitsem, 2014), for Ocean-Atmosphere - Quasi-Geostrophic - Wind Stress, features only mechanical coupling between the ocean and the atmosphere, and uses 12 atmospheric variables following Charney and Straus (1980) and four oceanic modes following Pierini (2011)."

At P2-L30: could you explain the origin of the values (found in table 1) you have used for interfacial friction and why they have the same value? Thank you.

The estimation of the parameters k_d and k'_d as well as other parameters is detailed in Vannitsem (2015). In Nese and Dutton (1993) the (non-dimensionalized) parameter k is estimated to lie within [0.1,0.01]. Our choice of $k_d = k'_d = 3 \times 10^{-6}$ corresponds to a value of $k = 0.0145$ and $k' = 2k = 0.0290$, with $k_d = 2k\ f_0$ and $k'_d = k\ f_0$. The parameters k_d and k'_d are chosen to have the same value, as was done in Charney and Straus (1980).

The sentence on P7-L3 originally read:

"These were selected so as to lie within the realistic bounds derived in Vannitsem (2015)."

This has been corrected as follows (P7-L3-5 in the new version):

"The parameter values for L, L_R, λ, r, d, C_o, C_a, k_d and k'_d were selected as detailed in Vannitsem et al. (2015). The same value was chosen for k_d and k'_d, as was done in Charney and Strauss (1980), see also Vannitsem and De Cruz (2014)."

At P6-L6-10: You could reformulate the paragraph, which gives fragmented information. I would not use the word "similar"; you could briefly explain why you use Heun method. You could inform the reader about any available parallelized version somewhere else (e.g. conclusions).

Thank you for your suggestion. We have reformulated the original paragraph:

"Two implementations of MAOOAM are provided as supplementary material: one in Lua and one in Fortran. The Lua code is optimized for LuaJIT, a just-in-time compiler for Lua (Pall, 2015). The performance of both implementations is similar. The model equations are numerically integrated using the Heun method, but one can choose a different integration method; as an example, a fourth-order Runge-Kutta integrator is also included in the Lua implementation. This implementation is also available in a parallelized version, which uses MPI."

We have quantified the "similar" performance, and clarified the use of the Heun method. The paragraph now reads (P6-L6-10 in the new version):

"Two implementations of MAOOAM are provided as supplementary material: one in Lua

and one in Fortran. The Lua code is optimized for LuaJIT, a just-in-time compiler for Lua (Pall, 2015), and runs about 20% slower than the Fortran version. By default, the model equations are numerically integrated using the Heun method. We have tested higher-accuracy methods, but these did not significantly change the results. The integration method can easily be changed; as an example, a fourth-order Runge-Kutta integrator is also included in the Lua implementation."

Furthermore, we have moved the information on the parallelized version to Sect. 5: Code availability. The paragraph read:

"MAOOAM v1.0 is freely available for research purposes in the supplementary material and is also available at http://github.com/Climdyn/MAOOAM. In addition, the code is archived at http://dx.doi.org/10.5281/zenodo.47507 and http://dx.doi.org/10.5281/zenodo.47510 (parallel version)."

This has been extended to (P10-L32 to P11-L2 in the new version):

"MAOOAM v1.0 is freely available for research purposes in the supplementary material and is also available at http://github.com/Climdyn/MAOOAM. In addition, the code is archived at http://dx.doi.org/10.5281/zenodo.47507. A version of the Lua implementation which is parallelized using MPI is also available at http://github.com/Climdyn/MAOOAM/tree/mpi. The parallelized version is archived at http://dx.doi.org/10.5281/zenodo.47510."

P6-L24-25: I feel it is not necessary to state this point here.

We have removed the sentence: "The ease with which these quantities can be computed makes MAOOAM useful for applications in data assimilation, sensitivity analyses and predictability studies."

P8-L7: beta in equation 22 was not defined, please verify if it would be necessary in this context.

It is the same beta as in Eqs. (1)-(3), but given the different context, we have repeated the definition for the sake of clarity (P8-L10 of the new version): " and $\beta = df/dy$ is the meridional derivative of the Coriolis parameter f."

P8-L19-21: what you state in this sentence could be better-understood weather you assign the same range to y-axis for all figures (at least for those that are more comparable).

We have adapted the y-axis for all plots in Figs. 7 and 8, except for the lowest model resolution, which has a significantly wider range.

P8-L22: could you add reference or be more specific on such feature of the LFV of the NAO?

We have rephrased this more clearly, and added the relevant references. The original sentence read:

"Moreover, at high resolution this LFV is weaker, which seems closer to reality as revealed, for instance, by the weak LFV of the NAO index."

The new sentence reads (P8-L23-25):

"Moreover, at high resolution this LFV is weaker than for the VDDG model version, but it seems closer to the actual dynamics found for the North-Atlantic Oscillation (NAO) as discussed in Li and Wang (2003) and Stephenson et al. (2000)."

P8-L29-30: this aspect is very interesting and it is a pity to find it sparse along the text. Why not to write a more comprehensive brief paragraph in Conclusions, stating potential further experiments that might unveil the reason of such feature?

Following your suggestion, we have removed the following sentence from Sect. 3:

"Note also that, at higher resolution, the structure of the LFV seems to depend on whether $H^{\max}$, $M^{\max}$, $H_o^{\max}$ and $P_o^{\max}$, $P^{\max}$ are even or odd numbers."

Instead, we have added this paragraph to the conclusion (P10-L22-26 of the new ver-

sion):

"Another interesting finding is the change of structure of the climatologies of the ocean gyres when choosing even or odd wave numbers ($H^{\max}$, $M^{\max}$, $H_o^{\max}$ and $P_o^{\max}$, $P^{\max}$). Is this feature purely associated with the convergence toward a spatially continuous field, or does it reflect specific properties of the dynamical equations, such as symmetries or invariance? These questions are still open and will be the subject of a future investigation that should allow to clarify what is the best set of modes needed for the ocean description."

P9-L28: You use the word "version" to indicate both, this new MAOOAM v1.0 versus the previous VDDG and each configuration of the model that is defined in Table 2. Am I right? I will use version in the first case and configuration in the second one.

Thank you for pointing this out. We have replaced the ambiguous word "version" by "configuration" throughout the manuscript, where needed.

P9-L15-17: I think you could avoid this sentence here in two ways: by introducing MAOOAM as part of an existing model hierarchy in Introduction or by saying this in Conclusion.

We have removed the following sentence from Sect. 3 (P9-L15-17 in the old version):

"It must however be stressed that the VDDG model is still an important tool in this hierarchy of models since it already contains the basic mechanisms leading to low-frequency variability."

The following sentence has been added to the Conclusion (P10,L20-21 in the new version):

"Note that the VDDG model is still an important tool in this hierarchy of models, since it already contains the basic mechanisms leading to the LFV."

P10-L1-23: I think you could improve this part of Conclusion in order to make it clearer.

We have restructured and added content in the Conclusion, following your suggestions above. Thank you for these valuable comments. In addition, we have clarified the sentence (P10-L5-6):

“Consequently, none of the solutions presented so far have satisfactorily converged toward a dynamics that correctly reflects the wave-dominated behaviour of the coupled ocean-atmosphere system. ”

The new version now reads (P10-L7-10):

“Consequently, none of the solutions presented so far have satisfactorily converged toward a dynamics that correctly reflects the wave-dominated regime of the coupled ocean-atmosphere system. This regime corresponds to a resolution associated with the Rhines scale (which for the ocean is equal to 100 km, or equivalently, to wavenumbers of the order of $H_o^{\max}/2 \approx P_o^{\max} \approx 50$).”

A version of the manuscript will be provided, in which all changes are highlighted.

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