

Geosci. Model Dev. Discuss., referee comment RC1
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Comment on gmd-2020-381

Anonymous Referee #1

Referee comment on "An update on the 4D-LETKF data assimilation system for the whole neutral atmosphere" by Dai Koshin et al., Geosci. Model Dev. Discuss.,
<https://doi.org/10.5194/gmd-2020-381-RC1>, 2021

This paper proposes adaptations to the 4D-LETKF algorithm to better model processes in the whole neutral atmosphere, with a focus on the mesosphere and lower thermosphere (MLT) region. The authors introduce two model adaptations, and assimilate two additional satellite data sources. Changes are benchmarked against the existing model, and compared against in situ independent data sources. The best performance occurs when including both model changes and both new data sources. The authors discuss this improvement in performance in the context of the underlying physics of both the model and the atmosphere. The manuscript is overall clearly presented and argued, but could benefit with increased emphasis on the contribution of the authors, as well as moving some of the content between sections for further clarity. However, I have serious concerns about the provision of scripts to generate the results and figures in the paper and cannot recommend this paper for publication until complete code is provided.

Lack of code provision

Only the source code to run the LETKF is included and there are no configuration files, readme information or scripts for post-processing or producing the figures in the manuscript. There are also no indications of where changes have been made compared to the existing KSMW20. This makes it impossible to review the code correctly, and it is also currently impossible to recreate the scientific content of the paper from the code that is provided. This is in contradiction with the journal policy, and particularly disappointing as it was raised by the editor at an earlier stage in the submission process. On these grounds I must therefore recommend that the paper is rejected, as it does not satisfy the data requirements for GMD.

I include further comments on the paper itself for any future resubmission with the appropriate data and code availability.

Major comments:

- My main comment concerns the discussion of the second model change with the introduction of the new diffusion model. In the numerical results this change leads to improvements compared to just using the IAU filter alone. However, I do not feel this algorithmic change is motivated or explained adequately in the present manuscript. This can easily be changed some of the existing content, and including some additional discussion in the introduction. More specifically:
 - a) The use of the IAU is discussed in detail and at length in the introduction. However the use of the new hyperdiffusion parameter is only introduced in Section 3.2. It is not clear whether this is a standard tuning approach in the KSMW system, or whether this is a new approach from the authors. A couple of additional sentences in the introduction discussing this aspect of the specific model, and what prior work has been done to select this diffusion parameter would clarify whether this is straightforward tuning, or a more conceptual change.
 - b) A new subsection should be introduced in Section 2 which discusses the proposed changes to the hyperdiffusion (between Sections 2.2 and 2.3 in the current manuscript). This can be done by moving existing lines 245 - 256 to the new subsection. As this paragraph concerns the free running model and motivates the new choice of diffusion, it would fit better in the methodology section than in the experimental results. This would also improve the flow of section 3.2. I also suggest an additional sentence which justifies explicitly why an eighth order approach is more appropriate here than the existing fourth order approach.
- I also felt that the authors could emphasise the new contribution of this paper more. This will be helped by the suggestions above, but being more explicit in the conclusion (and possibly the introduction) about the significance of each of the changes would highlight the novelty of the overall paper.
- There were some inconsistencies in notation. The author introduces Ctrl, Exp I, Exp II, Exp III and Exp IV/New in Table 2, but these are not consistently used throughout the manuscript and figures. I suggest replacing Exp IV with New, and including this notation in Figure captions (in addition to the more descriptive current captions). E.g. in Figure 1 replace with "(a) the KSMW analysis (Ctrl), (b) the analysis with the IAU (Exp I)". Similarly in the caption of Figure 4 plus the subplot titles ("Previous" should be "Ctrl")

Minor comments and typographical errors:

- L12 replace "used for the middle atmospheric" with "used for middle atmospheric"
- L26 replace "There also make the dynamics" with "These also make the dynamics"
- L29 replace "predominant" with important or dominant
- L41 replace "cause by the primary" with "caused by the primary"
- The introduction is quite long and there is some repetition e.g. L47 about GCMs not including MLT.
- L62 "meteor radar observations for several years": does this mean "over several real-time years" or "for several model years".
- L69 replace "using the JAGUAR" with "using JAGUAR" or "using the JAGUAR system"

- L82: include a comma after "are assimilated,"
- L8: replace "A forecast initialised by analysis" with "A forecast initialised with an analysis"
- L100: these is an unnecessary linebreak
- L122: This sentence is confusing - maybe split into two sentences or reorder.
- L137; replace "parameters by KSMW20" with "parameters from KSMW20"
- L150: replace "consumes the calculation time about 10 times as much" with "requires 10 times the amount of computation time"
- L153: replace "so as to express" with "in order to express"
- L164: replace "Similar" with "Similarly"
- L192: I believe this line refers to a missing table which describes the independent observation data. Table 2 in the manuscript describes the different assimilation experiments, and I don't see why that is relevant in this sentence.
- L200: "are called the" instead of "are called as the"
- L204: "reproduction" instead of "reproductivity"
- L216: replace "inherently" with "by definition"
- L222: Could the vertical changes throughout the atmosphere be illustrated in a meaningful way?
- L261: Include an extra sentence to make it clear that 1 is good.
- L267: "Finally" instead of "Lastly"
- L270-271: The changes to L and K are small here, and the description makes them sound more significant. Also this sentence could be re-ordered to reduce the number of parentheses.
- 277: "there are no SABER" instead of "there is no SABER"
- L276 - 280: I found the ordering here confusing. I suggest rearranging to 1) inclusion of new observations is important (currently the final sentence). 2) Improvements for SABER correlation vs variances 3) At Davis SSMIS has more impact due to Southern Hemisphere differences.
- L296: It would be less confusing if the ordering were consistent between the figure and the discussion (e.g. from the bottom of the atmosphere to the top).
- L364: replace "allows us to" with "will allow us to" - I don't think this work has been done in the current manuscript
- L451: There should be a linebreak after 2020 for the new citation
- Table 2: The caption could be more informative: e.g. notation for the different experiments considered in this study
- Figure 4: L561 observation should be observations (two occurrences)
- Figure 4: L565: "time period from" not "time period of"