

Geosci. Model Dev. Discuss., referee comment RC2
<https://doi.org/10.5194/gmd-2021-74-RC2>, 2021
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Comment on gmd-2021-74

Anonymous Referee #2

Referee comment on "Implementation of aerosol data assimilation in WRFDA (v4.0.3) for WRF-Chem (v3.9.1) using the RACM/MADE-VBS scheme" by Soyoung Ha, Geosci. Model Dev. Discuss., <https://doi.org/10.5194/gmd-2021-74-RC2>, 2021

General comment

This paper presents the implementation of a new interface for assimilating ground-based aerosol and gas species observations in the WRFDA/ WRF-CHEM system. The impacts of assimilating aerosol and 4 gas species observation on forecast performances is evaluated exploiting the Korea- United States Air Quality campaign.

While this paper is relevant for the atmospheric composition data assimilation community, it is difficult to read it and to identify the novelties. The paper has sufficient scientific content for publication, but its structure needs to be improved and the result analysis needs further developments.

Main concerns

- The objective of the paper is not clear. The title mentions aerosol data assimilation while in the abstract the objective of the paper seems to include both aerosol and gas species.

- The text is frequently overwhelmed by technical details and it is difficult to understand the underlying scientific message. For example, in Introduction (line 26-34) and Section2 too many configuration details are given without providing the main characteristics of the models.

- The structure of the text needs substantial improvement to facilitate the reading (and the review) of the text. A dedicated result section is missing. Some general statements on

data assimilation are given in Section 2 while they should be moved to Introduction or removed. Section 3 is mixing methodology details, results and discussions. The results should distinguish i) those related to the "technical evaluation" of the assimilation (e.g. first guess departure) and ii) those related to the interpretation of the analysis and forecast fields in relation with transport, emissions, process representations ...

- the analysis of the results is sometimes too vague and limited to very well-known facts. This work potentially conveys very interesting scientific results which are not reflected in the paper. The description of the results given by each Figure needs further development. I strongly recommend improving the quality of the result description using concise sentences and by removing unnecessary statements (e.g. line 315-316)

- the discussion needs further developments with reference to past studies

- Too little background is given in Introduction to understand the novelty of this work. What is the actual contribution of this work relative to previous aerosol data assimilation studies using WRF-CHEM ?

- authorship: I am surprised to see a single author. Can you justify it ?

- The number of Figures is too large with respect to the scientific content of the paper. I suggest selecting the most essential/informative figures

Specific comments

- Introduction, first paragraph: while meteorology and transport models are important sources of uncertainties, emissions, and process representation/parametrization (e.g. interactions between chemistry and aerosols, aerosol aging ...) can substantially contribute to the forecast errors.

- Introduction, third paragraph (line 26-34): This paragraph is unclear. What is the message ?

- It is difficult to understand the links between the distinct components (WRFDA, WRF-

CHEM, RACM and MADE). My understanding is that MADE and RACM are 2 components of WRF-CHEM ?

- Data and field campaign: A brief description of the field campaign and the associated data is missing. Giving the references is not sufficient, a brief summary should be included in this paper.

- Section 2: This section contains too general sentences (e.g. line 73-77 on the goal of data assimilation) that should be moved to Introduction or removed. This section should focus on the presentation of the WRF-CHEM modelling system.

- Section2: The main model characteristics (atmospheric transport, aerosol scheme, chemistry scheme) are missing.

- Section 2.1: This section is mixing model configuration and model description. General statements on model processes, variables, forcing data sets (emission) should be included in a separate subsection.

- Section 2.2: the general methodological statements on data assimilation (e.g role of variational assimilation lines 138-144, state vector line 153-156, Equation 1, line 195...) are sufficiently known background and it is not necessary to include them in this paper. I suggest to re-write this section by removing all general statements and replace them by appropriate references, and focus on the specific aspects of the data assimilation in WRFDA/WRF-CHEM.

- Section 2.2 line 139: This is linked to one of the general comment about the objective of the paper: is it assimilation of aerosol only or both aerosol and gas species ?

- Section 2: It is not clear how the speciation of aerosol is performed while assimilating PM observations ?

- Section 3, line 299-309 and lines 315-320: These paragraphs belong to the result interpretation or discussion. This confirms the need for a better structure of the paper to facilitate the reading.

- Section 3 : Figure9/line 310-320: the analysis of the correction carried out by the assimilation needs further developments. Regarding gas species, is there any relationship between the increments for ozone and NO₂ ? Regarding the uncertainties in PM

background: emission can be a source of uncertainties as discussed in the text, but this can also be due to model errors. Can you comment on this.

- Section 3 lines 341-353: Can you discuss the differences in forecast errors as a function of forecast time between chemical species ? How does this relate to the lifetime of the chemical species and uncertainties in emission data set.

- Equations 5,6,7 should be moved to method section

- Section 4: the discussion could be more developed, maybe by moving some parts of section 3 to section 4. Particularly, the uncertainties in emission data set and the impact of assimilation depending on the lifetime of the chemical species are poorly discussed. A possible improvement for atmospheric composition data assimilation is the optimization of emission by introducing emission variables in the control vector.

- When referring to model level in the text or Figure caption it would be helpful to indicate the corresponding elevation (e.g this is missing in line 310 and in the caption of Fig 9)

Figure and Table specific comments

- More details and references could be added in Table1

- Table 2 provides very technical information, I wonder if it is relevant for the paper.

- Figure 3: the colour legend is missing

- Figure 4: y axis label, do you mean vertical level ?

- Figure 5: Does the shaded area in light blue indicate one or two standard deviation ?

- Figure 6 and 7: in the legend caption I suggest to replace omb, oma by o-b, o-a. The representation of the total number of stations is not very informative, I suggest to remove it for clarity. I would suggest keeping only Figure 6.

- Figure 12: Can you comment on the peaks of the bias shown by both DA and noDA experiments at 12 and 36h forecast time for domain 1 ?