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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Simultaneous assimilation of ozone profiles from multiple UV-VIS satellite instruments" *by* Jacob van Peet et al.

Anonymous Referee #1

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General Comments:

This paper presented the first effort to perform simultaneous assimilation of ozone profile products from two UV-Visible instruments (i.e., GOME-2 and OMI) using an extended Kalman filter in which the TM5 CTM is used for forecast. The assimilation methodology is described in detail: the basic approach and the critical improvements over previous assimilation including observation error characterization using a new method, model error growth and model correlation matrix and bias correction of both GOME-2 and OMI data with ozonesonde data. The temporal variation of OmF and OmA values are discussed in detail for various assimilation runs and the assimilation is validated with ozonesonde data. It was shown that the simultaneous assimilation of both GOME-2 and OMI data improve the assimilation results of a single instrument by

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reducing the mean biases especially between 100-10 hpa. This scope of the paper is very suitable for publication in ACP. It is generally well written and organized. However, this study only shows the improvement in terms of mean biases and does not show the improvement in the reduction of standard deviation of the differences (or 25-75% range), which can be more convincing as both GOME-2 and OMI data are bias corrected before the assimilation. Some of the discussion and figures about the OMI L0 to L1 processor updates and the OmF and OmA statistics requires more clarification and could be improved. Overall, I recommend it to be published after addressing the following comments.

Specific Comments:

1. In abstract, it is good to add the improvement in terms of standard deviation of the differences, which I think it is a more important criterion.

2. P3, L32, Is the retrieval done at 65 km x 48 km? According to the readme document of the OMO3PRO product, it is retrieved at 13 km x 48 km although only 1 out of 5 pixels along the track is retrieved.

3. P5, in section 4, what is the physical meaning of state vector x (i.e., model ozone profiles?) and measurement vector y (i.e., satellite retrievals of ozone profiles)? This is probably not clear to readers who are not familiar with data assimilation. What does the superscript f mean as it is not defined.

4. P5, L23, H is already defined on L13, not need to repeat here.

5. P5, in the last paragraph, is the linear interpolation performed actually using the cumulative profiles of ozone column instead of model profiles of partial ozone column (DU/layer)?

6. P6, L31, instead of using a small fraction of the retrievals, have you tried to average all retrievals to the model grid? In this way, the spatial resolution matches with the model, retrieval noise is reduced, and more retrievals are utilized to maximize the

amount of retrieval information in the assimilation process.

7. P7, L26, the integration time of 1B is always 0.1875s. Do you mean that the integration time of 283-307 nm (previously part of 1A and now part of 1B) changes from 1.5s to 0.1875s? If so, please make it clear.

8. P8, in the paragraph of L10: the update of L0 to L1 processor corrected a bug in the noise calculation of the old L0 to L1 processing, reducing the noise by a factor of approximately SQRT(2) to SQRT(5) depending on the number of integrations per observation. So the noise calculation in the updated L0 to L1 processor should be correct and better. Since your estimate of noise compares quite well with the old one, do you think if the noise calculation in the updated L0 to L1 processor is wrong or is there any limitation in your approach using equation (14)? Also, the noise difference before and after the update of the L0 to L1 processor should be a factor of $\sim$ SQRT(2) to SQRT(5), not a factor of 5. Furthermore, all the OMI level 1b data have been reprocessed with the new processor. So for the OMI ozone profile product before February 1, 2010, has it been reprocessed using the new level 1b data? In Figure 2, left panel is for Feb 25, 2006 and the right panel is for Feb 5, 2010. I think that it is even better to compare the data from the same day, one with older processor and one with the updated processor.

9. P9, L4, what is the meaning of A in the equation?

10. Table 1 caption, it is useful to add the meaning of a (i.e., maximum relative error of the model)

11. P10, L22, why using fitted correlations rather than the calculated correlations?

12. In Section 5.4, what are the coincidence criteria (e.g., time difference and distance) between GOME-2/OMI and ozone sonde observations? What are the ozonesonde stations used in this study? It is good to add a table of ozonesonde locations and the number of profiles used at each location.

13. P11, L15-16, please make it clear what latitude bands this figure is for? Or do you

mean all the data at all latitudes?

14. P14, Why the 1A/1B boundary in GOME-2 change decreases the surface layer OmF and OmA as the wavelengths contributing to the surface layer retrievals are longer wavelengths (e.g., 2B) that do not change.

15. P15, the sudden change at the start of 2009 for GOME-2 above 10 hPa is likely due to the change of 1A/1B boundary in December 2008.

16. In section 6.1, the OmF and OmA for the assimilation of one single instrument is not mentioned and discussed in this section while the conclusion mentions that "The OmF and OmA of the simultaneous assimilation of both is between . . . (P22, L1-2)." I suggest adding OmF and/or OmA for the assimilation of one single instrument on Figures 6 and 7 and add some discussion. Also the sentence in the conclusion is not clear: the OmF and OmA values are calculated for each instrument even for simultaneous assimilation, so it is not clear about what "between" mean. Are OmF and OmA values for GOME-2/OMI of simultaneous assimilation smaller than those of single assimilation? 17. P16, L13, what do you mean "the OmF differences become so large?" Do you mean the difference between OmF for GOME-2 and OmF for OMI? Also it is not clear about "only the OMI data have changed." Please clarify it.

18. P18, L6, in "The expected and observed OmF are somewhat closer to the 1-to-1 line" and in conclusion (P22, L2-3), Figure 11 seems to contradict to this as more data points are clearly far away from 1-to-1 line in the bottom panels. Also please add slope and correlation to show the improvement quantitatively.

19. Section 6.4, because the GOME-2, OMI retrievals are bias-corrected, it is more useful to examine the standard deviations of the differences between model/assimilations and ozone sonde (or 25%/75% percentiles of the differences) than showing the median differences to demonstrate the improvement quantitatively. Please add a figure or add panels to Figure 12 to show the comparisons of these quantities for the four runs.

Technical comments 1. P1, L2, change “satellite” to “satellites”

2. P1, L16, change to “designated as”

3. P2, L8, change “((S)BUV)” to “SBUV”

4. P2, L13, move “observed” before “once or twice a day”

5. P2, L14, change it to “Ultraviolet”

6. P3, L7, change “a tropospheric ozone column” to “the tropospheric ozone column”

7. P3, L16-17, change it to “and in section 3 the chemical transport model that we use for the data assimilation is described” or “and section 3 describes the chemical transport model that we use for the data assimilation”

8. P3, L32, change to “two UV”

9. P4, L30, change to “meteorological”

10. P13, L2, change “An important diagnostic . . .. are the differences” to “An important diagnostic . . . is the difference”

11. P17, L5, change “OMI data is missing” to “OMI data are missing”

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