

Geosci. Model Dev. Discuss., referee comment RC2  
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## Comment on gmd-2021-172

Anonymous Referee #2

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Referee comment on "Development of aerosol optical properties for improving the MESSy photolysis module in the GEM-MACH v2.4 air quality model and application for calculating photolysis rates in a biomass burning plume" by Mahtab Majdzadeh et al., Geosci. Model Dev. Discuss., <https://doi.org/10.5194/gmd-2021-172-RC2>, 2021

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### General comments

This paper presents updates made in the aerosol feedbacks and photolysis rates implemented in the GEM-MACH model. The document is well explained, easy to read and the research is in the scope of GMD. These improvements in the code are very clever and represent a state-of-the-art model that is a great contribution to the field. The results are good; however, I would recommend adding more explanations and discussion to the figures and explaining why the model shows some biases in certain cases. Please, read my comments below where I note them.

### Specific comments

Is there any particular reason the simulation periods were chosen to be January and June 2018? I believe a more useful study would have been conducting simulations during July-August 2019, since NASA's FIREX-AQ field campaign compiled data that would have been useful for assessing the model, specially the photolysis developments.

Section 2.1: You say that you created an initial lookup table using the refractive indices of 6 aerosols, however in the introduction, you mention that GEM-MACH considers 8 aerosols. What are these 6 aerosols you considered for creating the lookup table? What happens with the other 2 components that you do not have data for?

Section 2.4: You used CFFEPS biomass burning emissions. Does this inventory include fire emissions outside Canada? If not, did you account for fires in the US?

Section 3.1: Figure 4 shows many AERONET sites that fall within the domain of the simulations. Why do you use just focus in 4 of them? I think an explanation is needed somewhere in this section or the section before. Also, I think more discussion should be added to this figure since it is just mentioned in section 3.2.1.

Figure 6 shows that some high AOD values from AERONET in Toronto are not well represented by the model. Could this be because of long-range transport of smoke plumes that are not well simulated by the model? I think you can add more discussion about these particular days.

Figure 9: I am surprised that GEM-MACH underestimates the AODs in the whole domain for both seasons since the comparison with the AERONET stations is good. What can be happening? Perhaps you could include a (c) panel showing the AOD from MODIS.

Figure 14: MODIS L3 data is too coarse (I think 1 degree resolution). For your case I think using AOD from MODIS MAIAC (3 km) would be more appropriate to compare against your simulations.

### **In line comments**

Line 202: Consider rewording the sentence that begins with "Using the hygroscopic...". It is long and difficult to understand.

Line 203: the parentheses in "(Section 2.2" never closes.

Line 220: it seems there is an extra "(".

Lines 489-499: You can mix this paragraph with the following one since you are describing and discussing Fig. 6. E.g.: "were used to plot these time series. The sample size for Toronto...". Also, I suggest sticking to the nomenclature shown in Table 3 for each simulation instead of saying "GEM-MACH AOD" since this can cause misunderstandings.

Lines 507-508: "There is a higher correlation for Toronto compared to FortMcKay for both seasons." But why?

Lines 602-604: I do not think the resolution of GEM-MACH is the problem here. MERRA-2

and the MODIS data you used are much coarser than 10km. Also, the second maxima shown in MERRA-2 does not appear well in the MODIS data. I see some gray shades in that place that would mean that is a grid point not available from MODIS. I think maybe CFFEPS is underestimating the fire emissions, and that could also explain the discrepancies shown in Fig. 9.