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Atmospheric Chemistry and Physics Discussions

# *Interactive comment on* "Constraining the relationships between aerosol height, aerosol optical depth and total column trace gas measurements using remote sensing and models" *by* Shuo Wang et al.

**Anonymous Referee #1**

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Summary-

The paper compares a simple plume model and a multiple linear regression (MLR) model approach to observed plume heights from MISR. The plume model and MLR models use overlapping data sets to predict plume height. The authors find that the plume model generally under performs the MLR models.

The use of overlapping data to train the MLR models and to get predictions from the plume model is interesting. However, the use of a single plume model from 1965



is poorly motivated. The authors need to discuss in detail the current state of the field in plume modelling (which I feel must have progressed somewhat in the past 50 years) and compare several plume models to the MLR models. At some level the MLR model will always get a better agreement with data because mathematically it is going to always minimize unexplained variance, in contrast to the plume model, which is based on some physical understanding. This overfitting problem could be solved by training the MLR model in one region and applying it to other regions. The authors also train 7 MLR models based on a combination of different predictors. The way that this feeds into the comparisons between the 'regression model' and plume model is poorly described. The authors need to either use all the predictors, or come up with some objective methodology to throw out some (eg machine learning).

The paper seems rushed and has many grammatical errors. The number of figures must be increased to make it clearer what the analysis shows. The statistical analysis is unclear and in some cases contradictory and arbitrary (the authors describe predictors as orthogonal and then include a predictor that is a ratio of other predictors, data that agrees too poorly is thrown out).

There is no comparison of these results to any sort of reasonable chemical transport model (for instance MERRA2 might even have sufficient data to tell us about plume height and would be a more fair comparison).

Because I feel that the amount of work to add additional plume models, make the regression analysis more objective, and incorporate some chemical transport modelling results requires more work than can be accomplished in a review period I recommend rejection. ———- L18 Just saying the MLR model does a better job is a bit disingenuous. Linear least squares will always maximize variance explained. The authors need to show that they do some sort of out of sample testing.

L32 Use of significant should be reserved for statistical statements. Consider using 'substantial'.

L34 ‘and are known’

L35 I believe biomass burning is also emitted at the surface and you mean it is moved into the upper atmosphere.

L40 The statement that aerosols above the PBL have a bigger influence on the atmosphere may be true in some context, and the authors do provide citations, but they need to be a bit more specific here. I assume they mean in some sort of normalized sense (eg Pinatubo had a big influence on global mean temperature, but in an integrated sense aerosol in the boundary layer probably has a bigger impact). Either way, while a very interesting point to make, the authors might want to expand on this statement a bit for clarity.

L45 Who used? I think the authors have a typo and all the citations have stuck together.

L53 Lidar isn’t capitalized: https://www-calipso.larc.nasa.gov/

L81 Large majority is redundant

L99 typo, remove ‘the’

L144 Specifically

L145 Does this mean that when you have cloud or aerosol you don’t get CO measurements?

L156 NO2 also has substantial industrial sources. The way that this is written implies that NO2 is only from fires.

L187 Note that inputs are not necessarily orthogonal, unless you pretreat inputs somehow. For example, NO2/CO is going to be correlated with NO2 and CO.

L188 Typo in this sentence.

L216 This sentence is very unclear- how are you ‘injecting additional information’? As you say earlier all data sets have to be present. This seems to imply that data



points with missing data will sometimes be considered and additional information will sometimes be ‘injected’.

L218 It is also unclear how you intend to reduce bias. Do you mean that you will try out data sets that measure the same quantity to get an estimate of bias.

L254 It would be good to define FRP somewhere in the intro or methods in terms of its physics (for people outside the biomass burning community).

L270 something that I think needs to be discussed in the use of this plume rise model is that it is based on a model from 1965. In the methods there need to be a few sentences on why this model has not been improved upon since then, or why it is an appropriate comparison to the MLR model. Not discussing this runs the risk of making the plume model seem like a straw man to those outside the plume modelling community. Another aspect of this plume rise model is that earlier the authors state that it begins to fail for small fires. The analysis should really be subset to fires that satisfy the assumptions going into the model, rather than degrading the model with fires that the plume rise model is not designed for.

L329 A citation to a review article here might be helpful.

L332 Different than each other? Do you mean when the plume model and the measurements? If this is the case this also seems fairly arbitrary to be testing the model and throwing out the results when they are poor.

L340 Is this just a function of bias from the plume rise model treating fires that are smaller and thus don’t satisfy assumptions in the model?

L341 how well the data what?

L344 While I understand the attraction of minimizing the number of figures, but this article only has 3 in the main text. I feel that the PDFs of modeled and observed plume heights could be moved to the main text.

L365 How does the analysis account for times when the area is very crowded with burning? How does it tell where plumes actually originate from? Can a plume from another fire be mistagged or affect plumes from a nearby fire?

L375 A clear list of assumptions in the methods would be good. I assume there is more than one plume rise model in the literature (for example https://link.springer.com/article/10.1007/s10661-005-1611-y). The authors must show results from at least two leading plume rise models to show that the poor results of the 1965 model are not just due to poor construction of the model and limitations in what it can do (and applying the model outside of its assumed conditions).

L385 Is this because Argentina is dominated by the Pampas and fires tend to be over large areas and are uniform and the meteorology is relatively less complex?

L397 I think rather than coming up with 7 combinations of predictors a better approach might be to only have one model with all the predictors or use some sort of objective algorithm (eg machine learning) to remove low explained variance predictors. Arbitrarily coming up with 7 models seems like it will almost always guarantee a model works well.

L408 Fragment

L411 Again, I don't understand how this is an evaluation if predictions that agree too poorly are removed.

L430 The three regions shown in Fig 3 are for a few plumes (judging by plotted data points) and for only a subset of the plumes in Fig1.

L478 Which of the regression models is the new method?

L483 What are the 'modelled results' in contrast to the plume and regression models?

L497 Somewhere there needs to a scatter plot of MLR model plume height versus observations. One possibility is that you are just fitting the mean. The MLR model



is guaranteed to do this well (it minimizes unexplained variance). To do this correctly you should train the model on one region and apply it to other regions to get rid of the overfitting problem.

Fig1 I am not sure how useful this plot is because the dots obscure the land surface type.

Fig2 Please use some different line styles and markers. Most of these colors are indistinguishable.

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