Reviewer #2

As a scientific paper instead of data report, however, I have some concerns that need to be further stressed or clarified. Those mainly include the motivation, scientific findings and result evaluation. Details follow.

First of all, I feel the scientific motivation should be better stressed in the Introduction. What is the main purpose of the study? It should be clearly stated. Developing a new method for data fusion, or improving the estimation of global deposition (how to prove it then), or something else?

Response: We thank the reviewer for the comments. We have changed the phrasing at the end of the introduction to explicitly state the goal of the study.

Lines 82-85: "The main purpose of our study is to demonstrate the viability of a straightforward but globally applicable MMF approach while remaining consistent with previous work that provides impact assessments for various communities."

Similarly, could the authors justify their main findings (e.g., the changed estimation of total deposition?) How to demonstrate the numbers were more reasonable compared to existing ones?

Response: We thank the reviewer for the comment. The whole point of MMF is that the numbers will be more reasonable by definition because we are fusing the model estimates toward measured deposition. Tan et al. 2018 describes the lack of agreement between model estimates and measurements in places where there are measurements and we help to fix that by explicitly incorporating measurements to change the model values to more closely match the measured values in places where there are measurements.

Lines 97-100. I can understand that most of dry deposition were obtained based on this method. I am wondering, however, is it possible to collect some dry deposition data from direct observation instead of the inferential method. The latter actually bears some uncertainty from modeled dry deposition velocity.

Response: We thank the reviewer for the comment. Unfortunately, there are only very few direct dry deposition data available worldwide, and the use in a global modelling exercise is very limited. In addition, since our study uses the year 2010 based on the HTAP-II modeling year; we are limited only to data that were collected in 2010 and are publicly available. Of course, in the future, it would be wonderful to have more dry deposition observations.

The procedure part. It is unclear to me whether the authors applied the same IDW method as before, or they made some improvement on the methodology? More importantly, I feel an evaluation on the datasets should be made before conducting the data fusion. For example, how were the observation data compared with simulation applied in this study? Moreover, if

there was big difference between observation and simulation, is it still reasonable to apply the current data fusion method?

Response: We thank the reviewer for the comment. We have not made any improvements to the IDW methodology; but we have changed some aspects of the procedure (we use monthly data rather than weekly). The point of this paper is to demonstrate that existing methods can be applied with existing data on a global scale. There are well-documented downsides to IDW, but we wanted to demonstrate measurement-model fusion with a method that is already routinely in use in the National Atmospheric Deposition Program (NADP) of the US. The observation data were compared with the simulation data and evaluated in previous work (Tan et al., 2018, Li et al., 2019). There is a big difference between observations and the simulated data in some areas; our work seeks to adjust the simulated data to more closely match the observations, and to demonstrate how this influences calculated deposition.

Lines 202-203 (Figure 4). It is quite hard to read "higher observation in Asia are also better reproduced with MMF". Could some quantitative numbers be given?

Response: We have redone our analysis wit three different maximum distances of interpolation and rephrased the sentence to reflect the results.

"Figures 4, S4 and S5 show the difference between HTAP-II MMM and MMF nitrogen and sulfur deposition in North America, Europe, and Asia in mg/m^2 with different interpolation distances. As the interpolation distance increases, locations with a single measurement that is very different from the model will influence the surrounding grid cells to be higher than the model. This effect is in particular pronounced for sulfur deposition in Southeast Asia (Figure 4 B3) where the MMF procedure increases deposition by up to 250 mg/m2 relative to the MMM values."

Similarly, lines 226-229. The analysis for the figures are quite descriptive and simple. Can you make more careful comparison and suggest the performance of the three modeling work compared to available measurements?

Response: More details were added to the paragraph describing the figure: "While the TDep maps have been aggregated to the 1x1 degree resolution of the HTAP fields, there is still different regional variation in the deposition patterns in the TDep maps than the HTAP II maps. In particular, TDep is capturing higher west coast values that HTAP II does not while showing lower values in the Midwest/New York/Pennsylvania region."

Figure 6. Why compare wet NH4+ only? It is necessary to provide the comparison for all the species and to make a judgment on data fusion quality.

Response: We thank the reviewer for the comment. The comparison for the other species were added as supplementary Figures 2 and 3.
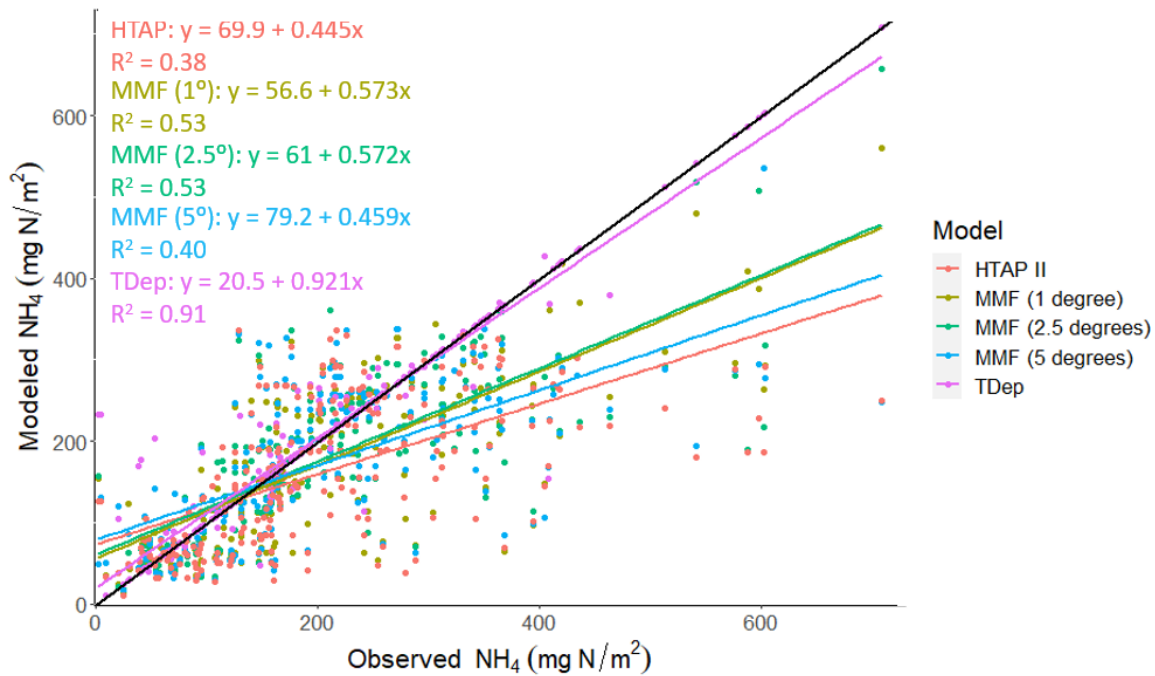
Figure S2. Observed and modeled wet NH₄ deposition in the US in 2010. Each NADP/NTN wet deposition measurement and the associated HTAP II, TDep, or MMF NH_4 wet deposition value. The black line is the 1:1 line.
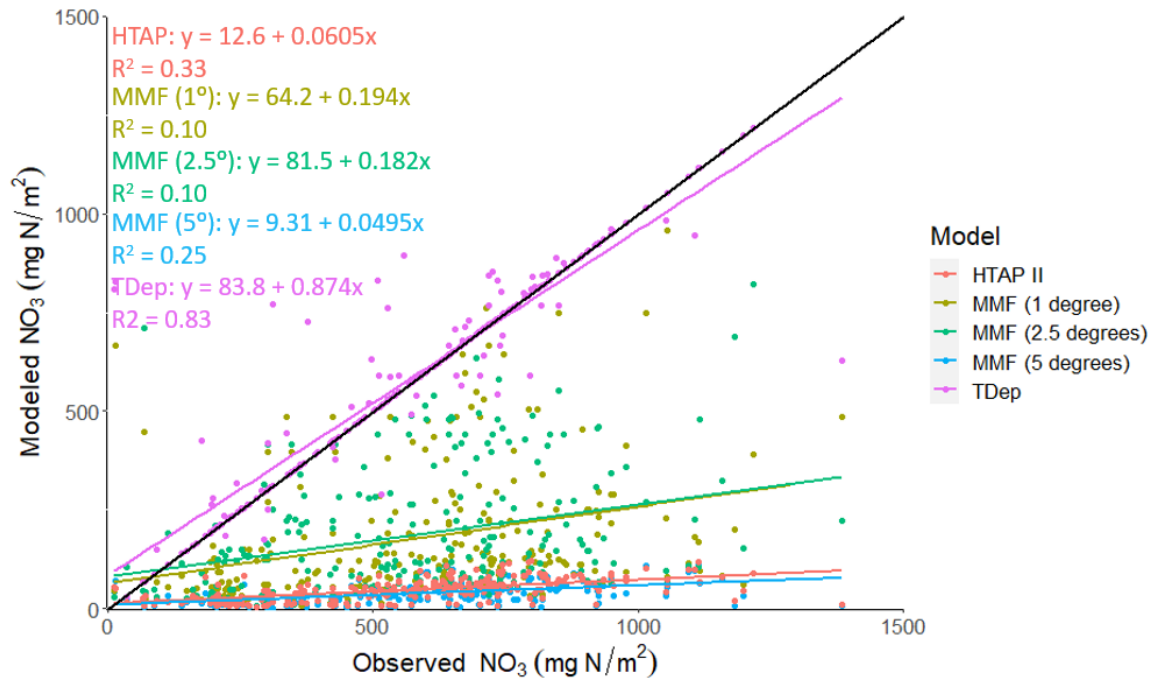

Figure S3. Observed and modeled wet NO₃ deposition in the US in 2010. Each NADP/NTN wet deposition measurement and the associated HTAP II, TDep, or MMF NO_3 wet deposition value. The black line is the 1:1 line.

Line 233-234. Does that mean TDep performed better than this work or the database was more reliable? Then what is the necessity of current work? Should think it over.

Response: Yes, TDep performs better but it is only available for the US. We are trying to broaden their approach to the rest of the world.

Minor issues:

The title could be quite confusing. "Budget " might not be a proper word as current paper just focused on the deposition.

Response: We thank the reviewer for the comment. We have changed the title to "Global Nitrogen and Sulfur Deposition Mapping Using a Measurement-Model Fusion Approach" and removed the word "budget."

There is no need to repeat the reference when it is included in a sentence.

Response: We have removed instances where the reference is repeated after being stated in the sentence.

Figure 3: The x-axis and y-axis should be clearly labeled.

Response: We have added letter labels to all graphs.

The language should be improved. Some clauses were not well organized.

Response: We have tried to improve the language where possible.