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**Geoscientific
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Discussions**

Interactive comment on "Linkage between an advanced air quality model and a mechanistic watershed model" *by* K. Vijayaraghavan et al.

Anonymous Referee #2

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General Comments

The paper describes the steps and species mappings necessary to take output from an air quality modeling system and produce input for a watershed model. The results of using inputs from an air quality modeling system for the watershed model are then compared to results obtained using watershed model standard inputs.

The paper makes a central point of the putting together linkage processing of outputs from CMAQ-MADRID-APT to produce inputs to WARMF, a GIS-based watershed model. CMAQ-MADRID-APT is also called AMSTERDAM. The two major features are (1) the ability to read the AMSTERDAM and MCIP IO/API netCDF files and then create ASCII files for WARMF input and (2) the ability to provide consistency between the meteorology used to drive the air quality and watershed models. The other three features

listed seem much less worthy of mentioning. The first feature doesn't seem so unique because the FORTRAN model outputs are converted to ASCII anyway. Whether the post-processing is done before or after converting to ASCII is not a strong selling point. However, an issue that is not dealt with is going between the FORTRAN world and the GIS world. Since the linkage software consists of FORTRAN code and UNIX shell scripts, that would suggest they are not going to be run by the typical GIS watershed modeler, who will be working in a Windows environment. This would seem to be a weakness of the approach to linkage presented here. What was the rationale for that approach? Then in the summary section several benefits of using outputs of AMSTERDAM and MCIP as input to WARMF are given (which could have been achieved without this software), but there is no statement as to how the linkage software has helped the process. This is a lack. It does not appear that an actual stand-alone software package with documentation has been produced. If it has, then it needs to be noted. The need for some type of linkage could be better motivated by bringing out the notion of cross-media pollutant trading (from page 1522) in the introduction.

The second feature drives the content of the paper. The paper is poorly organized to present the information to create this capability, however. Figure 1 presents a reasonable structure that is not used effectively. Descriptions of steps in the creation of files are scattered among different sections that are also describing features of the models and non-linkage information. It would be easier to follow if the description of the linkage development followed Figure 1 and was consolidated to one place, or at most two places, in the paper: temporal aspects and spatial aspects. Right now the reader has to go back and forth between different sections and tables and dig out the information. The description should follow the 4 groups of input files shown in Figure 1.

Some simple statement needs to introduce a temporal section and a spatial section. For the temporal aspects, it would appear that except for dry deposition velocity and precipitation concentration the linkage software is taking hourly AMSTERDAM and MCIP output, collecting appropriate species together and assigning them to WARMF

species names and providing hourly input files for WARMF. This is pretty straightforward, but the way it is presented makes it seem overly complicated. The same succinct summary, except for dry deposition, can be made regarding the spatial use of pseudo stations. WARMF appears to be doing most of the work internally. In addition, there are a couple of adjustments WARMF makes internally to the meteorological data that are not represented by the flows in Figure 1. These internal adjustments need to continue to be described as well in the revised structure. Interestingly, the linkage was "held hostage" to the general input data requirements of WARMF.

It is the demonstration of the second feature in Section 3 Testing of the linkage that makes the paper interesting and potentially instructive. This seems to be the stronger component of the paper, even though it is not the reason given for the paper. It is a useful addition that could take center stage. Unfortunately, differences are simply presented and there is little explanation of them provided. For some instances a quick sensitivity with WARMF would provide an answer or interpretation that would strengthen the presentation.

A more generally useful linkage development would seem to be to set up the linkage software for both CMAQ (modal information) and CMAQ-MADRID (sectional information) so the user could choose. The same basic information is in the two models, starting with CMAQ version 4.7. This could then be produced as a stand-alone software package. Also, the paper does not discuss how the AMSTERDAM data are stored and accessed. Are the model hourly data stored as daily files, concatenated monthly files, concatenated annual files? Was the file access automatic, under the control of a single script or was human intervention required?

Specific Comments

Page 1507, lines 3-5: This sentence seems irrelevant to the paper.

Page 1507, line 6: It seems there ought to be a transition paragraph here that characterizes what was done before and what is different about this linkage approach.

Page 1507, lines 26-29; 1508, lines1-2: (AMSTERDAM evaluation). Can the authors summarize the basic results for the reader? Also, which references relate to atmospheric deposition of S and N? Only Hg appears to be evaluated.

Page 1508, line 4: What does "capabilities of GIS" mean?

Page 1508, line 7: "... move with water in time and space over the interconnected terrestrial and aquatic ecosystems." How are the ecosystems interconnected? What is the spatial resolution? Later we find that it is 1 km2 for this work. Is this the typical WARMF resolution?

Page 1509, line 15: The post-processing software presented here converts the model output to ASCII anyway (page 1510), as any post-processing reader could do. So why is this capability an important distinction? The authors need to better explain the advantages they see.

Page 1509, lines 16-17: Point (3) seems overstated and doesn't add much and point (4) is unclear and could be omitted.

Page 1510, lines 25-27: Is the delineation of the subdomain of AMSTERDAM cells to be used preformed separately or as part of the linkage software? It appears this is an external step.

Page 1511, line 7: The description is missing how the multiplier is calculated.

Page 1511, lines 8-10: Is the temperature value as a function of elevation also applied to the MCIP pseudo-station data with its higher spatial resolution? Is this lapse rate some universal function or is it derived empirically from some data set? Probably not derived from local data.

Page 1511, line 28 to Pg 1512, line 2: "The linkage software provides hourly outputs from AMSTERDAM and MCIP to WARMF which then performs necessary temporal aggregation." This is an important sentence. Then on line 7 it is noted that WARMF accepts daily or hourly meteorological data as input (presumable also air concentra-

tion data). It should be explained that it is simpler to set the linkage up for hourly input data. This was a choice. It should be noted and explained. Presumably the daily data required are not exactly the same as the hourly data and more extensive external processing of MCIP output would be required. This approach takes advantage of WARMF capabilities. Then on line 14, the phrase "hourly meteorological fields required by WARMF" should be changed. Hourly fields are not required, but they are desired.

Page 1512, lines 14-16: This phrase belongs in some overview section of the linkage after the choice of inputting hourly data has been explained, but not here.

Page 1513, lines 11-24: It seems this section should come later, maybe as part of the discussion section. It is out of place here.

Page 1514, lines 15-16: How are the concentrations in precipitation calculated? Are they based on daily or monthly accumulations? Or are they computed hourly? Please clarify and also give the rationale for creating concentrations in precipitation rather than using the deposition flux directly from AMSTERDAM

Page 1514, lines 23-25: The comment about data fusion seems out of place here. One would not want to perform such a procedure in WARMF. Suggest omitting.

Page 1515, Section 2.5 on Dry deposition velocities: What is the rationale for this approach, since much more detail is available from AMSTERDAM? It is unclear how WARMF is apportioning the monthly averaged dry deposition velocity to hours within the month. Is there any interpolation between months or is the same value used for every day/hour within the month? Presumably the hourly concentrations are multiplied by the average deposition velocity. Why set fine and coarse PM deposition velocities to those for elemental carbon when they are available for all of the species from MCIP?

Page 1518, lines 16-17: It would help to provide a very brief summary of the main results on the impact on flow rates.

Page 1518, line 15: How large would the difference be if only the CASTNET-available

species were used from AMSTERDAM? Would the difference increase greatly? Seems like this would be easy to find out.

Page 1518, line 16: How much of this difference is due to precipitation difference?

Page 1519, line 1: The interpretation that atmospheric deposition is not an important contributor to the subwatershed should be figured out in a sensitivity study and presented in the paper, not just mentioned as a speculation.

Page 1519, lines 8-14: The importance of the differences in treating dry deposition should be investigated and potentially the approach used by WARMF should be revised if the differences are important. Why not use the flux from AMSTERDAM. The authors have a chance to inform us about this and suggest whether or not WARMF warrants revision.

Page 1519, Section 3.3 Nitrate: WARMF should be run with only the CASTNET-available species from AMSTERDAM as an interpretive sensitivity. Same for ammonia.

Page 1520, line 8: Accounting for coarse PM nitrate has to be a minor contributor to the results. This explanation could be removed.

Page 1520, lines 10-14: This point should also be in the summary. What does this tell us? Relative to the point on page 1522 about trading, this result possibly tells us that as long as air is a small contributor to nitrogen loading the linkage doesn't make an interpretable difference on the performance of the watershed model. But then the point about the linkage of the two models being useful for trading analyses is meaningless. The authors need to reconcile this information with their claims about the value of linkage for trading analyses. And it should be put in the summary section.

Page 1521, line 15: Such a low deposition velocity does not make sense. Why was it not changed for the WARMF baseline?

Page 1521, lines 22-24: The linkage does not allow one to perform source apportionment. The model has to be constructed to allow such calculations or it is done through

sensitivity analyses. One can make source apportionment calculations using data, e.g., the SPARROW model; the linkage of the two models is not required.

Page 1522, lines 3-5: The last sentence in this paragraph does not belong in a summary section. It should be omitted.

Page 1522, lines 6-7: How does the linkage connect individual atmospheric point source to water quality consequences? It seems the point is being put forth relative to all atmospheric sources treated as nonpoint sources in the water quality model.

Page 1522, lines 15-17: The thoughts in this paragraph culminate here with the statement about providing a "rigorous scientific framework". These thoughts belong in the introduction to the paper, and then revisited in the summary, as to why we would care about linkage in the first place and make an effort to develop it. This would help motivate the paper.

Tables 2 & 4: Why not combine these two tables? Consolidate.

Table 5: How do the WARMF modelers define all of these dry deposition velocities from the available observations? Are some left blank?

Figure 2: It would be helpful to provide the dimensions of the box in the Catawba River Watershed insert in km

Figures 4, 5 & 6: The two cases cannot be distinguished. Were they supposed to be in color?

Technical Corrections

Page 1505, Line 11: The phrase "not discharging directly to the watershed" does not make sense when discussing nonpoint sources of loading. Suggest "not discharging directly to the water bodies in a watershed."

Page 1505, line12: Suggest "are typically driven" instead of "are often driven"

Page 1505, lines 15-16: Suggest adding "if there are gradients that are not captured" after ". . . and pollutant concentrations."

Page 1509, line 15: Suggest inserting "ability to provide" after (2).

Page 1511, line 17: Suggest using "time steps" instead of "timescales".

Page 1512, line 20: Delete "are converted".

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