

## ***Interactive comment on “Linking agricultural crop management and air quality models for regional to national-scale nitrogen assessments” by E. J. Cooter et al.***

**Anonymous Referee #2**

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### **GENERAL COMMENTS**

This manuscript presents a new atmospheric application of EPIC, a semi-empirical process-based model of commercial fertilizer application for the United States that is capable of high spatial and temporal resolution. When coupled to a process-based regional air quality model with a bidirectional treatment of ammonia emissions (CMAQ v5.0), this modeling system can produce high-resolution estimates of NH<sub>3</sub> emissions across the continental U.S. Evaluation of an example simulation for 2002 yielded improved statistical scores for simulated atmospheric particle nitrate compared to a base simulation that used NH<sub>3</sub> emissions allocated using a factor-based emissions process-

C2819

ing approach. The process-based nature of the EPIC model will also allow evaluation of alternative fertilizer management practices associated with potential air-quality management policies or climate-change adaptation strategies.

The model and application methodology appear to be state of the science, and the authors have provided a good description of the model, its inputs, and results from comparisons with other fertilizer application models and with air quality measurements for its coupled application with a regional air quality model. The manuscript itself is in general well structured and well written. I have attached some comments and questions for the authors to consider, but I would recommend that this manuscript be accepted after minor revision.

### **SPECIFIC COMMENTS**

1. Given the title of this manuscript, would it be appropriate to include a reference in the Background and Introduction section to the 2011 EPA Scientific Advisory Board report on reactive nitrogen in the United States (see <http://yosemite.epa.gov/sab/sabproduct.nsf/0/67057225CC780623852578F10059533D/File/SAB-11-013-unsigned.pdf>)?

2. As may be the case for many potential readers of this paper I do not have a lot of familiarity with the EPIC model. Section 2 of the manuscript gives a very good overview of this model and how it was set up and used in this study, but there are still some additional details that I would like to know:

\* If EPIC is a field-scale model (p. 6099, l. 17), how does it handle multiple fields and grids, i.e., arrays of fields?

\* Section 2.1 mentions a target grid (p. 6100, l. 22), but to me this term merely suggests a design goal. The rest of Section 2 then mentions grid cells a few times and Figure 3 is discussed, but it is not until the unexplained 14,400 factor appears in Eq. 1

C2820

that there is strong evidence that EPIC was in fact run for a continental-scale 12 km by 12 km grid on some unmentioned map projection. The paper would be strengthened if a sentence could be added here to say that in fact EPIC was run for a continental 12 km by 12 km rectangular grid on such-and-such a map projection. Then some text should be added to Sections 2.1 to 2.3 to explain how the various agriculture-related input data sets were allocated to this 12 km by 12 km grid and, conversely, how the county-level inorganic N use values presented in Fig. 5a were obtained from this grid.

\* Section 2.1.2 mentions that the USGS NLCD, which contains 29 aggregate land use categories, was used but it does not mention exactly which of those 29 categories were used in this study. This information seems to be provided later on in Section 3.2, but it might be more appropriate to mention it earlier in the manuscript.

\* Section 2.1.3 mentions that there are 150,000 8-digit HUCs in the continental U.S. with an average areal extent of  $\sim 2,000 \text{ km}^2$ , which implies a total area of  $\sim 300$  million  $\text{km}^2$ , but my understanding is that the area of the continental U.S. is a bit over 9 million  $\text{km}^2$ . Please check and correct as necessary.

\* Section 2.1.3 mentions that EPIC was run for a 25-year spin-up period, Section 2.1.4 describes the weather data needed as input by EPIC, and Section 4 talks about coupling EPIC output to CMAQ, but I was not able to find any discussion of the time step used by EPIC or the time resolution of EPIC inputs or outputs. Please add this information to the manuscript.

\* Section 4 lists the EPIC outputs supplied to CMAQ as "fertilization rates, timing, method, and managed soil pH values". Up to this point in the manuscript, however, the only previous mention of soil pH was that it is one of the soil characteristics that must

C2821

be *input* to EPIC (Sec. 2.1.3). Is soil pH also a time-dependent prognostic field that is predicted by EPIC and that was referred to by the general term "soil characteristics" on p. 6103, l. 5?

3. I am not entirely clear on the way the contribution of manure to  $\text{NH}_3$  emissions was handled. In Eq. 1 it is subtracted from crop N demand, although the text does not explain why this was done. Presumably this was to allow an apples-to-apple comparison with the other estimates of commercial fertilizer application shown in Fig. 5. But in Section 4 it is not indicated whether or not the EPIC fertilization rate estimates that are supplied to CMAQ do include manure application.

4. The discussion of Eq. 1 in Section 3.2 does not explain the purpose or give the units of the 14,400 factor.

5. For the 5-year average annual inorganic N use values calculated by EPIC and plotted in Fig. 5a, how much interannual variability is there in this field given that the weather simulator described in Sec. 2.1.4 apparently generates (hourly? daily?) statistical fluctuations?

6. In Section 4, with respect to the synchronization between EPIC outputs and CMAQ time steps, what is the frequency of EPIC outputs and what is the CMAQ time step that was used for the 2002 simulation?

7. In Section 4, concerning the statement on p. 6108, l. 22 that "Ammonia evasion and  $\text{NH}_4^+$  nitrification losses were modeled for each CMAQ soil layer", how many CMAQ soil layers were there?

8. In Section 4 the comparison of CMAQ  $\text{PM}_{2.5}\text{-NO}_3$  predictions with CSN and IMPROVE  $\text{PM}_{2.5}\text{-NO}_3$  measurements shown in Figure 7 might be bewildering to some readers. No explanation is given in the text as to why a  $\text{PM}_{2.5}\text{-NO}_3$  comparison was performed as opposed to a  $\text{PM}_{2.5}\text{-NH}_4$  comparison or why particle nitrate is a good proxy for particle ammonium. And can the authors comment on how similar the results

C2822

were for the comparison of CMAQ predictions with CSN  $PM_{2.5}$ - $NO_3$  vs.  $PM_{2.5}$ - $NH_4$ ? Note that the similarity in evaluation results between the CSN urban measurements (Fig. 7b) and IMPROVE rural measurements (Fig. 7c) supports the statement that particle ammonium is a regional pollutant.

9. One conclusion listed in Section 5 is that the EPIC predicted planting date “should fall within 10 days of observed dates” (p. 6110, l. 7). I am not sure that conclusion was discussed or supported in Sec. 3.1 or elsewhere in the manuscript.

#### TECHNICAL AND TYPOGRAPHICAL CORRECTIONS

p. 6096, l. 12: Should soil processes also be mentioned?

p. 6096, l. 20: Would “atmospheric *particle* nitrate concentrations” be more accurate?

p. 6099, l. 2: “effect” rather than “affect”.

p. 6099, l. 22: Perhaps “... the construction of terraces and the installation of tile ...”.

p. 6101, l. 24: “US Corn Belt”?

p. 6106, l. 16-17: Which of the USEPA and USGS estimates is the larger one?

p. 6107, l. 25: If CMAQ is a “modeling system” (l. 19), then do you really want to say that the CMAQ CTM is also a “modeling system”?

p. 6107, l. 26-27: Concerning emissions being parameterized as emission factors, would it be more accurate to say “the product of emission factors and activity rates”?

p. 6108, l. 6: “coarse aerosols”

p. 6110, l. 23: “generation of *I/O API* formatted”?

p. 6112, l. 4: “allocate”?

p. 6117: I noticed two missing references:

C2823

\* Sutton et al. (1998); see p. 6098

\* Sutton et al. (2011); see p. 6097

p. 6118, l. 4: Reference in Table 1 caption to Fig. 1 should be to Fig. 2. And what is the “organizing principle” for the order of the production regions as given?

p. 6118, Table 1: The “PA” column does not sum to 100. Is the value for manure missing?

p. 6121: Would “USDA Farm Production Regions” be a better caption (cf. Sec. 2.1.1).

p. 6123, Fig. 4: Better x-axis caption might be “Week Ending Julian Day”.

p. 6124, Fig. 5: Perhaps “(A) 5-yr average *annual* plant ... of inorganic N use (*kg/county*)”?

p. 6126, Fig. 7: The acronyms “CONUS” and “CAFO” are not defined in the manuscript; are  $NH_3$  emissions from on-road mobile sources as reported in the 2005 NEI also considered? Also, “CSN”, not “STN”? And perhaps “Monthly model ambient  $NO_3$  biases for 2002 at urban ...”

p. 6126, Fig. 7: Doesn’t the black line in the box-and-whiskers plots represent the *mean* bias?

p. 6126, Fig. 7: Can the y-axis labels and the embedded keys in the three panels be made any larger?

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C2824