Atmos. Chem. Phys. Discuss., 10, C3967–C3970, 2010
www.atmos-chem-phys-discuss.net/10/C3967/2010/

Atmospheric Chemistry and Physics Discussions

Interactive comment on "Review and parameterisation of bi-directional ammonia exchange between vegetation and the atmosphere" *by* R.-S. Massad et al.

L. Zhang (Referee)

leiming.zhang@ec.gc.ca

Received and published: 14 June 2010

General comments:

The main purpose of the present study is to propose a generalized two-layer ammonia bi-directional exchange model for applications in chemical transport models. To meet this goal, a detailed review of compensation points and parameterisations for the cuticle resistance (and other resistance components) were first conducted. Formulas and input parameters for the various components of the two-layer model were then proposed. The paper is generally well written and easy to follow. The materials presented here are useful towards improving the representation of bi-directional exchange of atmospheric ammonia in chemical transport models, but the authors do not address the practical problems concerning the incorporation in such models as the availability of data. I also have a few scientific concerns that worth to be considered.

Major concerns:

1. Currently only dry deposition of atmospheric ammonia is considered in the majority of chemical transport models. In order to change the deposition process into a bi-directional process, a two-layer model is proposed in this study. The key addition of the two-layer model compared to traditional dry deposition models is to allow bi-directional exchange through leaf stomata and soil. In many cases, the emission from the soil could be higher than the emission from the stomata. The present study downplays the role of soil emission (and uptake) since nothing on Xg is mentioned in the abstract. The authors have chosen to ignore Xg, in some cases, based on the assumption that the emission from the soil can be either fully or partially captured by the above canopies. Note that the recapturing process is actually built into the equations for Xc, X(z0), and Ft. Thus, theoretically, Xg needs to be included in the model (if soil emission is not negligible) even if soil emissions are recaptured at the above layers.

2. In-canopy resistance to the ground (Rg): In a few places, it is stated that Rg can be set to infinity in order to limit soil emission (if soil emission is not important). However, if soil emission is not important, then deposition to the soil can become important. Setting Rg to infinity will not only be assuming that there is no emission but it will also be assuming that there is no deposition to the soil surface. This assumption is certainly not acceptable considering that ammonia can deposit to any surface quite rapidly.

3. The purpose of an emission/deposition model that is to be implemented in chemical transport models is to produce reasonable flux exchanges above the canopies. Existing dry deposition models have tried to quantify deposition through different paths. The parameterisations for the different resistance components developed in these models have been evaluated with measured total fluxes (e.g., daytime fluxes to stomata, cu-

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ticle, and soil surfaces, and nighttime fluxes to cuticle and soil surfaces). It is quite possible that these parameterisations might underestimate fluxes along one path but these estimated fluxes can then be compensated for by another path. The proposed model picks up parameterisations from different sources for different resistance components. How can we know that the combined resistance parameterisations (the whole model) will perform reasonably, especially over so many different vegetation types? The model as a whole is not evaluated using plant-scale data (despite the fact that the authors have a large data set), nor is it compared with the general overview of the data from the literature.

4. The main goal of the present study is to propose a bi-directional flux model for applications in chemical transport models. A large amount of information that is needed as input for the proposed two-layer model will not be available in chemical transport models at the model grid scale (although it might be available at the plant scale). For example, few chemical transport models have information on fertilization periods, which is key for the Xs and Xg formulations in the proposed model here (Section 4.5). Note that it is more important for chemical transport models to produce long-term average fluxes (e.g., N budget on seasonal and annual scales) and over large areas (e.g., regional scales) than on daily bases. Should the model use more common input information so that the modelling community can benefit from this work?

5. Section 2 reviews the modelling approaches (and parameterisations for the different resistance components) and then Section 3 reviews the resistance components again. I feel that these two sections could be better organized.

6. A large portion of this paper focuses on cuticle resistance parameterization (Rw). The factors included in the proposed parameterization are certainly very important. One important factor that is not mentioned here is friction velocity (or turbulence intensity) which can sometimes play a dominate role on Rw (as can be see from a multi-layer model of Baldocchi, 1988 and a big-leaf model of Zhang et al., 2003).

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7. What are the advantages and disadvantages of this model compared to a few other similar practices that have been done recently, e.g., Cooter et al. (2010); Zhang et al. (2010)? Or at the very least, what are some discussions on the differences among these studies?

8. Conclusion: How big of an impact will be expected from the new proposed model on the air quality model output?

Minor concerns:

1. Is it necessary to discuss Ra and Rb in detail in both Sections 2 and 4? These formulas are not new and the differences between the different formulas are not large.

2. In a previous paper of Nemitz et al.(2000b), different modelling approaches (single and two-layer models) have been discussed in detail. Is Figure 1a still needed here since the paper deals with the two-layer model?

3. From the definition of Rb (also mentioned in this paper), it should be a resistance at the thin layer above the canopy. Would it make more sense if Rb is in the path above Fs, Fw, and Fg? This way, the formula for Xc can be substantially simplified (see Zhang et al., 2010).

4. Tables 5 and 7 provide input parameters for different ecosystems. Do you really think that the information required (e.g., the first column in Table 7) is available at grid scale in common air-quality models?

5. The paper cited Zhang, Wright, Asman (2010) as ‘in preparation’. This manuscript was first submitted to JGR in November 2009 and, as requested, a copy of the submitted version was then sent to the authors of the present paper. I do not think it is appropriate to cite it as ‘in preparation’.

Interactive comment on Atmos. Chem. Phys. Discuss., 10, 10335, 2010.

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