Biogeosciences Discuss., 5, S2147–S2149, 2008
www.biogeosciences-discuss.net/5/S2147/2008/

Biogeosciences Discussions

Interactive comment on "Modeling the dynamic chemical interactions of atmospheric ammonia and other trace gases with measured leaf surface wetness in a managed grassland canopy" *by* J. Burkhardt et al.

J. Burkhardt et al.

Received and published: 3 November 2008

We thank reviewer # 1 for the valuable comments. We reviewed the paper thoroughly with a special focus on clarity.

In the following we address the different general and specific points .

General comments: We are more specific in the introduction now about what was already known. We identify more clearly the gap between the physically explained adsorption of water molecules and the much larger effect of relative humidity frequently observed in field and laboratory experiments. Although we cannot explain it, we dis-

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cuss some possibilities, especially the influence of particulate matter on the leaves. The overall picture as well as the state of the art and the open questions are extensively covered in the meanwhile published overview paper (Sutton et al., BGD, 5, 3347-3407, 2008).

Specific comments: a) This study addressed an intensively managed grassland at a specific site in Germany. However, it addressed all relevant points of ammonia biosphere/atmosphere exchange and probably is the most detailed study on this issue. In this paper, the processes related to the influence especially of leaf wetness on the exchange of ammonia with the atmosphere is investigated and the conclusions should be valid for a wide range of grasslands.

We have clarified these points in the paper by the following statements at the end of the discussion: The shown strong influence of leaf surfaces on ammonia exchange, driven by air humidity but more specifically by persisting leaf wetness should be representative for all kinds off grasslands. The reported importance of litter emissions especially after the cut should especially be valid for intensively managed grasslands.

b) Where possible, leaf wetness measurements should be included into measurement networks. Where this is not possible, relative humidity can be used as a highly correlated factor to ammonia exchange with leaf surfaces. Litter after grassland cuts as an additional ammonia source should also be included.

We added a new paragraph in the discussion of the revised paoper on the need to include leaf wetness measurements into parameterisation schemes: Therefore, leaf wetness measurements should ideally be included into measurement networks. Where this is not possible, relative humidity can be used as a highly correlated factor to ammonia exchange with leaf surfaces. One might also think about a factor to include wetness after rain (causing a deviation from the pure RH-vH2O scheme). And we further added: The Braunschweig experiment has demonstrated that the existence and stratification of different NH3 sources need to be considered in order to improve modeling results.

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Breakage of cells and decomposing organic material on the ground lead to ammonia emissions often exceeding the stomatal contributions of the plants.

c) Addressing the magnitude of current errors in models due incomplete description of NH3 exchange, we added the following statement to the discussion: The present model analysis highlights the complex nature of ammonia biosphere atmosphere exchange, which is dependent on chemical interactions on leaf surfaces, on exchange with biologically regulated foliar compensation points and exchange with ground surface sources such as leaf litter. The focus of the current model is on the chemical interactions occurring on leaf surfaces. These emphasize the way in which leaf surfaces can be both a source and sink of ammonia rather than only a sink as has been considered in simpler models applying a cuticular resistance (Rw). Although modelled desorption events were rather limited in the present assessment, these may be more significant at regional scales, for example in particularly dry conditions, favouring desorption from high ionic strength solutions. The consequence of this effect will be to maintain atmospheric ammonia concentrations, increasing the effective atmospheric residence time of ammonia compared with models that only allow for ammonia deposition. For example, replacing a current simple deposition scheme in a regional atmospheric model with a full bi-directional scheme could easily halve rates of dry deposition. It is clear that further work is required to develop the present model approach to deal with desorption from concentrated solutions and dry surfaces, analogous to gaseous loss from aerosol surfaces (ref), but with the added complexity of additional ions (e.g. base cations) on the leaf surface both from dry deposition and from foliar leaching.

Interactive comment on Biogeosciences Discuss., 5, 2505, 2008.