General comments

This is a very comprehensive study presenting the development and evaluation of a model for ammonia emissions from urine patches in grazed grasslands. This work is an extension to the field scale of a model of urine patches emissions at the patch scale from Moring et al. (2016).

The model description is extensive and mainly focuses on the method used to represent and parameterise the time and space distribution of urine patches depending on the animal presence.

The model makes a reasonable job at simulating the NH_3 emissions measured during two cattle grazing periods of a few days in 2002 and 2003. The sensitivity analysis shows a great sensitivity to soil water field capacity and permanent wilting point which determines the maximum quantity of urine that can be hold.

The paper is well structured, well written and the figures and tables are clear and understandable. The conclusions are well drawn. The manuscript is sometimes hard to read and may be shortened; especially the description and results on the sensitivity analysis may be more synthetic.

My main concern regarding this manuscript is that I failed to understand how the GAG model was integrated in GAG field. From what I understand, the main idea which is clear from Figure 4 and eq. (5) is that in GAG field, fluxes from the field are the sum of the emissions from the urine patches and the exchange between the other surfaces and the atmosphere. However, ammonia fluxes from these two surfaces are both dependent on the ammonia concentration in the atmosphere, as it is well described in the GAG patch model described by Moring et al. (2016). More precisely, in the GAG patch model the concentration at the reference height is necessary, while in the present manuscript the concentration at z_0 also called here "canopy compensation point" is used to drive the exchange between the area without urine patch and the atmosphere. What is unclear is how this canopy compensation point is calculated in the field situation. If calculated from the GAG patch model the assumption is that the distance from one patch to another is small enough so that the concentration at z_0 can be assumed to remain constant. However, one could argue that this concentration at z_0 is an equilibrium point resulting from a given flux and set of resistances above and below that level, in which case it would be fair to consider the total flux Fpatch +Fnon_patch as the flux which drives the canopy compensation point. In reality, though the process is much more complex and involves horizontal advection.

I would therefore suggest the authors to better explain the underlying assumptions made on the driving concentration in the GAG_field and to discuss the potential drawbacks. I would also suggest evaluating the difference when considering Fpatch and Ftotal for driving the z0 concentration in the model.

I also suggest to show the diagram of the resistance model which is assumed in the manuscript. From my understanding, the resistance model would be as shown in Figure 1: an additional "leg" with a resistance R_{ac} + R_{bg} and a potential χ_g. It would also be good to explain the underlying hypotheses.

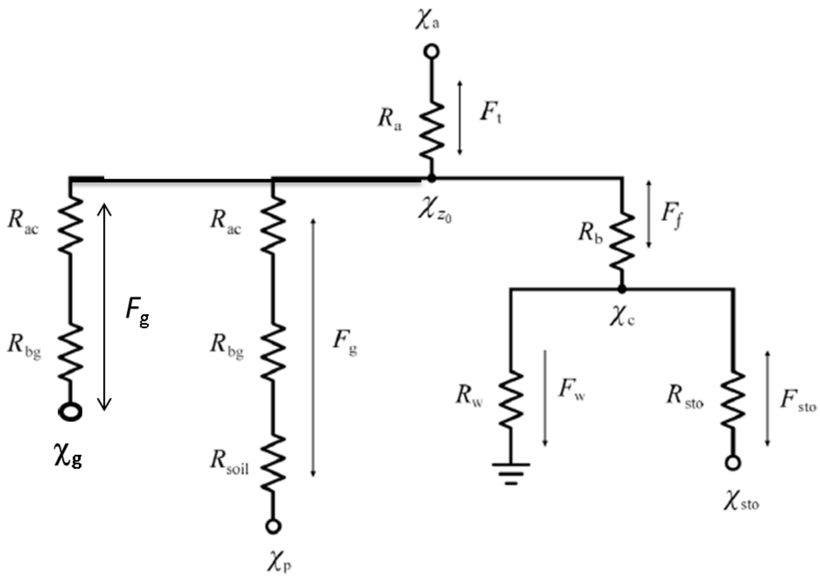

Figure 1. Resistance scheme of the Gag-field model as I understood c_{z0} was used.

Detailed comments

- P5L9: I would suggest telling in a few words what limitations may imply the fact that no water infiltration is taken into account.
- P6L5-L6. I suggest writing which parameter is modelled with a negative binomial (area covered by patch?)
- P8 EQ5: From the equation I understand that n (over the sum symbol) and n(tj) are not the same. Please clarify.
- P9 EQ6 and L6-8: Since χ_{z0} is an equilibrium point between the ground and the atmosphere, I do not understand how it could be parameterised. To me it should depend on the flux and the concentration above. Please clarify and explain clearly the assumptions behind the calculation of the fluxes from non-urine patches area and how these are linked to the urine patches area. May be a resistance scheme in a supplementary material would help the understanding: from what I can understand from the current manuscript, the resistance scheme would be as in the GAG patch model of Moring et al. (2016) with an additional "leg" with a resistance Rac + Rbg and a potential χ_g, starting from χ_{z0}. Is that correct? This would imply in particular that the horizontal distance between urine patches and non-urine patches is supposed null. Once the hypotheses clearly explicated I would also suggest discussing in the discussion section what implication this would have.
- P10L1-20: The second point "ii)" is unclear. Does that mean that the total amount of liquid will be larger than the soil capacity and since no runaway and infiltration is considered this water will "disappear". Could you rephrase in a clearer way?
- P10L18-20. This sentence is unclear. Please rephrase. In particular I do not understand what "the minimum amount of urine that is always allowed to penetrate" is, and how it is linked

with the water budget. I would also suggest justifying why the minimum amount is chosen as 5% and what implication this has.

- P12L29-30: I would have thought that the "unfertilised grassland class" of Massad et al. (2010) would not be adapted here as this grassland does receive nitrogen. Please justify and also discuss the possible implications of choosing a "managed grassland class" in the discussion section.
- P16L2: "of the modelled and measured" : I suggest adding 'NH3 exchange' here.
- P18L10: I suggest changing lower and higher to low and high.
- P18L16-20 and L21-25: I found these two paragraphs unclear. Could you clarify?

Tables and Figures

- Table 5: Explain what is β in the table legend.
- Figure 4: I would suggest adding a resistance scheme to better explain the model.
- Figure 8:I suggest adding the input variables of the model here or in a supplementary material (u_*, Ta, RH, rain, …) as well as the potentials $\chi(z)$, χ_{z0}, χ_g, χ_p. This will ease the understanding of the flux dynamics.

References

- Móring, A. *et al.* A process-based model for ammonia emission from urine patches, GAG (Generation of Ammonia from Grazing): description and sensitivity analysis. *Biogeosciences* **13**, 1837-1861, doi:10.5194/bg-13-1837-2016 (2016).
- Massad, R. S., Nemitz, E. & Sutton, M. A. Review and parameterisation of bi-directional ammonia exchange between vegetation and the atmosphere. *Atmospheric Chemistry and Physics* **10**, 10359-10386, doi:10.5194/acp-10-10359-2010 (2010).