Combining livestock production information in a process based vegetation model to reconstruct the history of grassland management

Journal: Biogeosciences Discuss.

General comments:

This study attempted to reconstruct the history of grassland management by integrating grazing-ruminant stocking density maps, wild-herbivores population density maps, nitrogen fertilizer application maps as well as nitrogen deposition maps to develop grassland management intensity maps. This land use information is very important to global change studies and very interesting as well. The attempt of integrating those scattered data in various scales is valuable even though the methods might be over-simplified. The manuscript, however, poorly delivered this information. I think the title of this manuscript delivered interesting and clear information about the study, but the main text lost focus that were specified in the title and the abstract. The method sections (in both the main text and the SI) are very confusing and could be more organized. Some descriptions on modeling or calculation were unnecessarily complicated, and some assumptions for extrapolating data need to be checked carefully. Overall, the current version requires major revisions before considered for publication.

Specific comments:

<u>ORCHIDEE-GM model</u>

(1) 'Results' and 'Discussion' of the current version made this manuscript read like evaluating the performance of the updated version of ORCHIDEE-GM model that includes livestock data to estimate global grass biomass. The model is a key piece in this study, which generates the NPP and GPP, but it seems the goal of this study is actually 'combining livestock production' and 'to reconstruct the history of grassland management'. If so, the main text should be reorganized. The evaluation-related sections could be combined.
(2) The model-related descriptions in the 'Material and Methods' section are not clear. At page 4 line 28-32, it is not clear what was updated in the model v3.1. Only bug-corrections? Are there any updates in modeling ecological processes or management activities?
(3) At page 5 line 22-25, the author listed the input data, but the output was never clearly described in the manuscript. This information may be described in previous publications, but it would be good to briefly describe in this manuscript. Line 12-15 at page 7 reads like descriptions of output, but confusing. I think this part is very important as it is related to how the authors defined and quantified 'management intensity', so it needs to be clearly presented.
(4) Does '… not use a land-cover map in the simulations, but rather consider that grasslands are distributed all over the world' mean the areas that are not characterized as grassland in a land-cover map have zero grass productivities in your productivity maps?
(5) Line 14-15 at page 8, how the Y_{grazed} is calculated from $D_{grazing,m,k}$? I think this is a key step of this study and should be described clearly.

<u>Variables, equations and data conversions</u>

There are many equations and data conversions in this manuscript. The authors should define variables clearly and present units for important variables (e.g. D in text S2), so that the readers can easily follow the ideas of producing those data sets. Or, a table listing those variables and associated data sources might be helpful.

(6) I think the assumption at Line 4-5 at page SI_3 might be wrong as the ratio of the total ruminant density between years can be calculated based on the assumptions in text S2. I could be wrong, but I think the authors should carefully check the conversion and should not make too many assumptions arbitrarily as this might affect the results significantly. A brief interpretation of my thoughts:

From Equations S1, S2 and S3:

$$D_{m,k} = \left(\sum_i D_{i,k} \times F_{i,j} \right)_m = \left(\sum_i \frac{N_{i,k}}{A_k} \times \frac{ME_{i,j}}{N_{i,j} \times ME_{LU}} \right)_m$$

$$= \frac{1}{A_k ME_{LU}} \left(\sum_i \frac{N_{i,k}}{N_{i,j}} \times ME_{i,j} \right)_m = \frac{1}{A_k ME_{LU}} \left(\sum_i r_{i,k} \times ME_{i,j} \right)_m$$

$$\frac{D_{m1,k}}{D_{m2,k}} = \frac{\left(\sum_i r_{i,k} \times ME_{i,j} \right)_{m1}}{\left(\sum_i r_{i,k} \times ME_{i,j} \right)_{m2}}$$

in which A_k is the area of grid k and $r_{i,k}$ is the ratio of the number of livestock category *i* in grid *k* to the one in country *j*. This number can be easily calculated based on GLW v 2.0 dataset, and I believe it is not constant for different livestock categories and in all grids. But:

$\frac{ME_{m1,j}}{ME_{m2,j}} = \frac{\left(\sum_i ME_{i,j} \right)_{m1}}{\left(\sum_i ME_{i,j} \right)_{m2}}$. If assuming $\frac{D_{m1,k}}{D_{m2,k}} = \frac{ME_{m1,j}}{ME_{m2,j}}$, that means $r_{i,k}$ is assumed constant for all animals and across all grids in country *j*, which could be wrong if the GLW v 2.0 dataset shows it is not.

(7) This point may be trivial, so it is just a suggestion. I don't think the variable of ME index ($I_{m,j}$, page 8 and page SI_3) is really necessary unless the ME index has some other meanings. The assumptions seemed just to be: $\frac{GBU_{m1,k}}{GBU_{m2,k}} = \frac{ME_{m1,j}}{ME_{m2,j}}$ and $\frac{D_{m1,k}}{D_{m2,k}} = \frac{ME_{m1,j}}{ME_{m2,j}}$. The ME index made the conversions more complicated than it should be.