

Geosci. Model Dev. Discuss., referee comment RC2  
<https://doi.org/10.5194/gmd-2022-176-RC2>, 2022  
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## **Comment on gmd-2022-176**

Anonymous Referee #2

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Referee comment on "Modelling the role of livestock grazing in C and N cycling in grasslands with LPJmL5.0-grazing" by Jens Heinke et al., Geosci. Model Dev. Discuss., <https://doi.org/10.5194/gmd-2022-176-RC2>, 2022

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This paper presents a module for the LPJmL5.0 model to represent the role of grazing lactating dairy cows in N and C cycling in grassland. The new module accounts for feed quality on animal intake and partitioning of C and N between milk, feces, urine, respiration, etc.

The main contribution of this paper is clearly the description of feed quality parameters and its relation to animal intake and metabolism. The section "Model description" is very well written and carefully goes through the main considerations behind the model. This part of the paper has a considerable reuse value for the agro-food system modeling community above and beyond the specifics of the LPJmL model.

Apart from a well-written method section in the paper, the authors have documented their methods in the form of full source code, which in principle ensures full reproducibility of all the calculations. Having no previous experience with the inner workings of LPJmL, I have (within the scope of this review assignment) not been able to assess the quality or completeness of the source code, and so I cannot comment on the code except that it is published and appears at a quick glance to be complete. I applaud the effort to publish the source code and I encourage the authors and colleagues to continue on this path with future work.

A few critical remarks follow, none of which challenge the basic contribution of the paper, but several of which I would strongly suggest to address to ensure that the paper and the applicability of the model is not misunderstood.

First and foremost, I am a little confused about whether the authors see their module as specifically representing lactating dairy cows or as a generic description of grazing livestock using the lactating dairy cow as a representative animal. The formulation of the title and introduction (e.g., line 29), as well as most of the abstract, led me to believe the latter proposition; but the discussion/conclusion section (lines 412-417) rather led me to think that the authors see the model as limited to lactating dairy cows. I would strongly suggest that the model description section (Section 2) be amended (preferably at the start of the section) with a clarifying paragraph on this, and in addition that the discussion and

conclusions be elaborated on the limitations of the model. Indeed, as the authors note (lines 412-413) "grazing dairy systems are not the most important systems globally", and it is therefore crucial to clarify the applicability and limitations of the model to represent grazing livestock.

Second, I find that the framing of the paper is a bit overreaching considering that the new module is concerned only with feed intake and digestibility for lactating dairy cows. The paper at a first glance (title and partly the abstract) appears to cover "livestock grazing" in general. Moreover, the mention in the abstract (lines 9-12) of "effects of management and climate change" and "Optimal stocking densities" and "best NUE, or highest C sequestration" led me to expect a paper dealing also with the effects of livestock grazing management on crop growth. As I understand the model, however, the effect of grazing livestock is only accounted for in terms of animals' grazing intake and partitioning of C and N. Other effects of grazing livestock, such as the effects of defoliation and trampling on botanical composition, crop growth, soil compaction, etc., are not accounted for. The results section (Section 4) shows some results of gross primary productivity (Figure 4) but I cannot easily see how these were derived and so I guess that is from other parts LPJmL model fed with the N and C inputs of the grazing dairy cows, without accounting for other (non-nutrient) effects of grazing livestock on grassland productivity. This is an understandable and completely acceptable limitation of the present study, so the point of my remark is not to complain about the limitation but rather about the mismatch between my expectations of the paper based on the title and abstract and the wide net cast by the introduction.

On the same note, I find that the evaluation section (Section 3) makes a good and convincing validation of the lactating dairy cows' partitioning of N; but it says nothing about grassland productivity.

My suggestion therefore also on this point is to amend the abstract, introduction and discussion/conclusion sections with a clarification of the scope and limitations of the present study. Also the paper's title could perhaps be somehow adjusted to more precisely reflect the scope of the study.

Third, from a practical usage perspective I wonder how the model is prepared to handle grazing only during part of the day and/or the year and supplemental feeding in houses and/or on the pasture. These are common practices in many regions that strongly affect the partitioning of N and C, and therefore I would see little practical use of the model unless it can flexibly handle such variants. I would suggest that the authors at least elaborate on this in the paper; and perhaps they might also be interested in explicitly representing the possibility in the model.

Minor line-specific comments:

L55: The overview of the section skips subsections 2.1 to 2.4.

L79: Perhaps say "20 commonly occurring proteinogenic amino acids" or "The 20 most common amino acids have molar weights between ..." or similar, to avoid any confusion about the total number of naturally occurring amino acids.

L249: "urine of methane" --- probably a typo; should it say "urine or methane"?

L260: "10% activity allowance" --- is this a reasonable estimate for grazing lactating dairy cows? I imagine that the NRC 2001 data are based on lactating dairy cows mostly staying inside eating high-quality feed and not walking around very much on a pasture.

L299: 18.4 MJ/kg gross energy content of "feed" --- strikes me as unspecific and also poorly motivated compared to the high level of detail in most of the model. Should not the gross energy content of the feed (i.e., whatever grows on the grassland, I suppose) be an endogenous variable of the model?

L337 (and elsewhere): The acronym LSU probably means livestock unit? Please spell out the meaning.

L342-343: Atmospheric deposition of N, I suppose, is included as an N input into the grassland with an effect on primary production. What about biological fixation, which is likely in most grasslands at least as big or bigger, and can also vary strongly with pedoclimatic conditions, grazing management, seeding, nutrient inputs, etc.