Review: "Effects of fire and grazing on biogeochemical cycles in Brazilian pastures using LPJmL5-Pasture-Burning" (egusphere-2025-922)

Overview

In this manuscript, the authors describe how they implemented an algorithm for pasture burning date into the LPJmL dynamic global vegetation model (DGVM). This sort of development is really important—ranchers in many parts of the world exert a strong influence on the frequency and timing of fire in grasslands, which can make a big difference on ecosystem dynamics. Most DGVMs have no such representation of fire management practices, especially an endogenous one (as opposed to one prescribed from input files). While it seems that other data limitations prevent this feature from being commonly used in general LPJmL runs, this capability is an important first step.

The authors do not just describe the technical capability, however. They also use the updated model to assess the separate and joint impacts of management fire and grazing on ecosystem carbon and nitrogen. The results show that both processes are important to represent in DGVMs.

I'm very happy to see a manuscript like this. The paper is mostly written well, and the figures are mostly good, with interpretations mostly well-supported. However, I have a major methodological concern along with a number of smaller questions and suggestions.

Major comments

The main thing I'm concerned about here is how grazed nitrogen is handled in the model. There's no citation in the Methods, as far as I noticed, pointing to information about how LPJmL grazing works at all, actually. N isn't mentioned alongside C at L131-133 as being partially returned to the soil via animal waste after grazing. That initially led me to think it wasn't. Then at L267, "manure (in grazing systems)" is mentioned as one input to the soil. But what fraction of the consumed N? And is it only feces or is it also urine? Then again, in Fig. 10, neither manure nor urine are explicitly mentioned. They might be included in "harvest N" with that color showing *net* harvest N loss, but that's not explained. And finally, Fig. 11 does have manure again.

If a realistic fraction of the grazed N isn't returned to the soil, I have serious doubts about the LPJmL model's fitness for the purpose of analyzing impacts of grazing on soil N and thus leaf C:N ratio too. See Selbie et al. (2015, DOI 10.1016/bs.agron.2014.09.004): "Ruminants excrete as much as 70–95% of the nitrogen (N) they consume."

If the N analyses are kept, some text needs to be added to the Methods describing biological nitrogen fixation (BNF) in LPJmL. Are both symbiotic and asymbiotic BNF represented? How do they work?

Other comments

1) I would like to see some text added to the Discussion or Conclusion about what work would be needed in order for this feature to become commonly enabled in LPJmL runs. Is it just livestock density maps (both historical and for future scenarios) that are holding it back?
2) The Appendices are strange. Appendix A has only one figure—why not combine the two Appendices? That figure, Fig. A1, is also the very last to be mentioned in the main text (and only as "Sec. A", not "Fig. A1"); it should thus be last in the Appendix as well. Finally, there are four Appendix figures not mentioned in the main text: Figs. B2–3 and B5–6.
3) All figures except Fig. 1, or at least certain labels in those figures, seem have JPEG artifacts. In most cases these should be replaced with entirely vector-based figures (.eps or .pdf). Failing that, PNG should be used. JPEG should only be used for photos (and don't just convert JPEGs to PNG!). See https://www.biogeosciences.net/submission.html#figurestables for more information.
4) The "matrix"-type figures (Figs. 4–9) need a fair amount of work:
    a. All of these figures should have color bars. It should also be made obvious when subplots share a color bar.
    b. There are many cells in these figures with black text on a dark background. This should be avoided, for instance by adding a white outline or "glow" around all text that overlays a non-white background.
    c. Some of these seem to be true values, while others are changes relative to a baseline. This is hard to keep track of and introduces an extra mental load in interpreting them. Please consider standardizing on one or the other.
    d. In some of these, white represents "excluded because of insufficient biomass for grazing," whereas in others it's burgundy. This should be standardized to burgundy (or even better for colorblind readers, black). I say this because white is confusing: In Figs. 4-5, the lightest color (yellow) is low-impact, the darkest color (dark red) is high-impact, and pure white is the highest impact of all. The color scale goes light-dark-light.
    e. Most of the cells in these matrices represent a "bad" impact, so it makes sense they are represented by a yellow-red color scale. However, some represent a "good" impact—e.g., some treatments in Fig. 8 showing soil N

enrichment. In such cases, they should *not* be on the same color scale, because they are qualitatively different. Something other than yellow-red should thus be used—e.g., blues.

f. An extra column should be added to the right side of every matrix giving the results with no fire.

Other comments:

5) L152: Cite Rothermel.
6) L157-166 (Sect. 2.2.1): Since the Brunel et al. (2021) and Waha et al. (2012) papers are not open-access, more detail should be given here (or in an Appendix/Supplement) on the Chalumeau algorithm and its implementation. For instance, how often is the burning date updated? Does it use a rolling window to calculate seasonality variables? What's the difference between the "burning date" vs. the strategies (e.g. "early spring")? Etc.
7) L190: Would it be accurate to replace "utilised" with "combusted"? If so, please do. If not, please explain what "utilised" means here.
8) L224-233: Is other fire allowed to happen during these experiments? I.e., are the only ignitions allowed due to intentional pasture management burning, or is the rest of SPITFIRE operating at the same time?
9) L227-229: It's not until this sentence until I understood what this paragraph was supposed to be describing; until then I was pretty confused. Please move it to the top of the paragraph and edit as needed for flow.
10) L230-231: I'm not sure I understand this correctly. How many replicates does this result in? 2 + 5 + 10 = 17?
11) L233: Are the four strategies something that the Chalumeau algorithm produces for each gridcell? Or are they things you switch between for different experiments?
12) L241-243: "may" is confusing. Is this something you're doing or not?
13) L250-253: "Since burning practices are closely linked to livestock activity, it would be unreasonable to retain scenarios where burning renders the pasture insufficiently productive to sustain animal feeding. Therefore, during the analysis, scenarios where the averaged dry matter intake over 70 years of core simulation phase falls below this threshold are excluded."
14) L262-268 (Sect. 2.4.3): Why is this in the "Post-processing" section? It would be more appropriate near Sect. 2.1.3 ("Soil nitrogen pools").
15) L277: "pre-establish" should be "pre-established".
16) L276-284: This text needs to mention that it's discussing the Cerrado site specifically.

17) L288: What nitrogen deficit? It hasn't been previously established that NPP is N-limited under any conditions or treatment.
18) L295: "the dry matter intake decreases down to 25% falling below the viability threshold" is hard to understand. Please revise.
19) L297–299: How is this result possible?
20) (L298) Fig. 4d: Why were no scenarios excluded (colored white) due to biomass being too low for grazing?
21) L304:
    a. Why does recently-established grazing have such a higher average dry matter intake?
    b. Are these numbers for the "no burning" treatment specifically?
22) (L311) Fig. 6:
    a. It'd be nice to have the site names in the figure title, as is done for similar figures.
    b. C:N normalized to a percentage feels wrong, I think because it's a result of both the numerator and the denominator. Consider changing to actual values instead of percentage.
23) L316-317: What is this "optimum" value? Optimum for what?
24) L317: Move "only" to after "practices".
25) L321: What "initial nitrogen deficit"? Deficit relative to what?
26) (L329) Fig. 8:
    a. Title and first sentence of caption should say that these numbers represent the *change in* C:N ratio. That's different from all the other such figures.
    b. Cells with negative values (indicating enrichment) should not also be yellow. Maybe a light blue instead.
    c. C:N change as a percentage feels wrong, I think because it can result from either a change in the numerator or the denominator. Consider changing to actual values instead of percentage.
    d. Subplot (d): Why were no scenarios excluded (colored white) due to biomass being too low for grazing?
27) L330: "significantly" implies a statistical test that I don't think was performed.
28) L336: Replace "primarily" with "entirely".
29) (L338) Fig. 9b, d: Why were no scenarios excluded (colored white) due to biomass being too low for grazing?
30) L343-344: This statement doesn't seem to be true for grazing alone, except maybe for the Caatinga site.
31) (L346) Fig. 10:

a. This figure was very confusing at first. I was eventually able to understand it: The colors only represent N *loss* mechanisms, so the top of the bar is N *inputs* (as the authors mention), and then the colors go down from there, with the bottom of the bar representing the N *balance*. I think that last point should be explained in the caption. It is much more typical for these kinds of plots to have inputs stacking on top of the zero line and losses below, with a star or something to note the net flux.
b. And indeed, that's what you do in Fig. 11! I strongly suggest switching Fig. 10 to this format, using the same colors for deposition and BNF as in Fig. 11
c. Dark blue color label should be "Nitrification + denitrification".

32) L351-352: Are you saying that both BNF and litterfall are directly attributable to the plant C and N pools? Is that because LPJmL doesn't represent asymbiotic BNF?
33) L354: "which in turn are affected by the same fate." What is the antecedent of "which" here? "nitrogen uptake"? In that case, "are" should be "is".
34) L355-356: My interpretation is that this is because low-biomass plants can't "pay" for much symbiotic BNF—is that right? This should be explained.
35) L356:
    a. This statement doesn't make sense in the context of Fig. 11, which deals with soil N only, not ecosystem N.
    b. The "primarily due to minimal grazing" part of this statement is not supported by Figs. 10 or 11. Fig. 10c suggests that most N losses from the Caatinga system are due to leaching, not grazing (harvest N loss). While the harvest N bars are needed in most cases to drop the net flux below the zero line in Fig. 10c, that figure *only* shows the result for the Caatinga with grazing on. It can't be safely assumed that ecosystem or soil N flux would be positive without grazing, because without grazing many parts of the system are changed. The authors performed more experiments than are shown here, but if those experiments support this assertion, they should be presented somewhere and cited here.
36) (L358) Fig. 11:
    a. Please add a star or something to each bar representing the net N flux.
    b. Dark blue color label should be "Nitrification + denitrification".
37) L369-371: What drives the ratio of allocated C:N and how it changes after disturbance?
38) L371: Again, what "deficit"? Are plants N-limited?
39) L378-382:
    a. Note that it's still not a beneficial effect even in the Pampas. I think "in wetter regions like the Pampas, fire and grazing can coexist with higher vegetation

productivity" should thus be struck, or at least strongly modified. Even the highest-biomass cell in Figs. 5c-d (i.e., grazing + fire in the Pampas) represents a 17% reduction of leaf biomass relative to the control treatment.

   b. "favourably" should be "favourable".

40) L393: "Sec. A" should be "Appendix A". Also, why is Fig. A1 in an Appendix Section all by itself? Wouldn't it be simpler to just have one Appendix with all additional results? In addition, am I right that this is the first time Fig. A1 is mentioned anywhere? In that case it should come later in the Appendix, because other Appendix figures have already been mentioned.
41) L409: "an initial reduction in intake" when? With the introduction of fire?
42) L413: "this example"—which?
43) L430: "relevant" is probably not the right word, since in the next sentence you say that's not how it works in the real world.
44) L435:
   a. Surely not "all plant biomass is treated as fuel"—maybe just aboveground?
   b. "moribund" is probably not the right word. At least, it's not very clear how "nearly dead" plant parts are most affected.
45) L438: "functionality specially" should be "functionality, especially".
46) L448: "parsimonious" is probably not the right word.
47) Throughout:
   a. Use of "significant" implies a statistical test when none was performed. This mostly happens in figure captions but is also present in the main text.