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Interactive comment on "Impacts of fertilization on grassland productivity and water quality across the European Alps: insights from a mechanistic model" *by* Martina Botter et al.

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The manuscript by Botter et al. presents results from a model of grassland dynamics, focusing on productivity and nutrient losses along gradients of elevation and fertilization intensity. The topic is interesting and suitable for the audience of Biogeosciences. The process-based model adopted for this study (T&C-BG) is also suitable to answer the main research questions - how does grassland productivity changes across sites in the Alps, and how are productivity and nitrate leaching affected by fertilization regimes? The chosen sites span a wide range of climatic, edaphic, and management conditions, and the model setup and fertilization scenarios in combination with the site-to-site vari-

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Discussion paper

ability allow tackling this question. I have a couple of comments aiming at expanding the scope and impact of the work, and several minor suggestions, listed below.

General comments

- The presented analysis is interesting and complete, but I wonder if it would be possible to run a 'climate change' simulation scenario. Higher temperature is expected to increase the ET/precipitation ratio and decrease soil moisture, which might shift nitrogen losses from leaching to denitrification, or might shift the partitioning of mineral nitrogen in favor of plant biomass unless water stress ensues. These interactions (also in relation to fertilization regimes) would nicely complement the current analyses, and they would increase the potential impact of the work. One option could be to simply use climatic conditions from a lower-elevation site to run simulation at a higher-elevation site, or increase temperature (at constant or variable relative humidity) at a given site. These would of course be rather 'theoretical' explorations, but not dissimilar to those set up to test the effects of altered fertilization.

- The metric used to characterize the efficiency of N conversion to biomass is the ratio of harvested N to N concentration in leachate. Typically, agronomic studies define N-use efficiency as a ratio of N in harvested products over N inputs (fertilization, deposition, fixation if N fixers are present). I wonder if such a metric would be more informative. It would allow comparing sites on a N input basis, and values are easily interpreted as 'partitioning coefficients' telling where the N inputs end up in the system.

Specific and technical comments

General: the chemical formula for nitrate is NO3-, not NO3, so it might be worth adding the superscript minus throughout the manuscript

L15: "unprecedented" sounds a bit an overstatement

L38: how about gaseous losses? Are they important in the nitrogen budgets of these grasslands?

Question 3: this question is rather generic - we know that mechanistic models can provide guidelines, but are these guidelines relevant/applicable? I would actually skip this question altogether, as testing model-based guidelines in the field is outside the scope of the manuscript

L125: check terminology - water leakage or percolation; nutrient leaching (check throughout the manuscript)

L136: it seems that standard meteorological data are enough to drive the modelâĂŤare eddy flux data necessary?

L146: nutrient leaching

L168: water leakage

L181-182: this sentence is not very clear - what should be accounted for?

L186: is this really unrealistic? Later it is stated that N applications follow grass cutting, so the modelled timing of N addition is right - is it the amount of added N that is "unrealistic"?

Section 2.4: I see the point of running the model at steady state for each fertilization scenario, but I wonder if equilibrium is reached over time scales relevant for management. If the system reaches equilibrium after 500 years (just as an example), then we should perhaps focus on the transient dynamics after fertilization regime is changed - that is, a timescale relevant for management decisions rather than a timescale for ecosystem equilibration

L265-266: are the actual cutting times at the field sites available?

L270-275: I would refer to Figure 5 in this paragraph

L332: check singular/plural "feedbacks. . . are realistic"

L399 and 446: verb "to take up", not "to uptake"

L432: how is “optimal fertilization level” defined? As shown in Figure 6, there are diminishing returns on N input, but how can an optimum be defined in these monotonically increasing harvested N vs. input N curves?

Figure 1: is the site Torgnon located in Valtournenche (Valle d’Aosta)? If so, please check the position of the site in this map, as it is outside of Valle d’Aosta, further to the south

Figure 3: would it be possible to highlight the growing season periods? What are the soil moisture sensors measuring during the winter, when the soil is frozen? Is it meaningful to compare modelled soil moisture (I assume liquid phase only) with measured values (affected by both liquid and solid phase) when the soil is frozen? I would focus these comparisons on the growing season only

Figures 4-5: I am not sure I understand why biomass data in Figure 4 do not cover the same year(s) as data shown in Figure 5

Figure 6: “kg” not “Kg” in the axis labels; are the markers and lines indicating the median modelled values (shaded areas are explained in the caption, but I missed the explanation of the lines)?

Table 1: would it be possible to add information on site slope/aspect (if not on flat terrain), and soil type?

Table 3: is net radiation modelled (as affected by modelled energy partitioning at the surface?) or used as an input variable?

Table 4: are the mean values based on the periods with available flux data? Would it be worth including plus/minus standard deviation or some measure of the variability?

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