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Interactive comment on "Nitrogen leaching from natural ecosystems under global change: a modelling study" *by* Maarten C. Braakhekke et al.

Anonymous Referee #2

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Braakhekke et al. present a model study quantifying the respective contributions of changes in nitrogen (N) deposition, climate and atmospheric CO2 concentration on changes in N leaching from natural ecosystems. They find that increasing N deposition is the major driver behind simulated changes in N leaching, with smaller contribution from climate change and increasing CO2. They further highlight the role of fire in shaping N losses. The conclusions drawn have a sound basis on the the results discussed here. Overall, the manuscript is well written and clearly structured.

However, I find that the discussion of gaseous losses in the manuscript is lacking. Leaching losses are often the major loss, but gaseous losses are not negligible and can regionally dominated total N losses (Houlton et al. 2015). Accordingly, the role of gaseous losses needs to be considered when the ratio of leaching:inputs is discussed.

The author state in the introduction that "N leaching, while sometimes reported in global modelling studies, does generally not receive specific attention [...]". Therefore, due to the lack of evaluation of simulated loss terms, the reliability of global models in respect to the loss terms has to be considered low. This is true for LPJ as previous studies did not evaluate the loss fluxes sufficiently (Smith et al 2014 Warling et al., 2014). Unfortunately, the study by Braakhekke et al. does not improve this situation although data sets exist to evaluate. For example, the simulated gaseous loss fraction can be compared to reconstructions from delta 15 N measurements and models by Houlton et al. (2015) and, more recently Goll et al. (2017). There are regional differences in the dominant loss pathway between this study (Figure 3) and the mentioned studies which should be discussed.

The role of fire in shaping N loss pathways on global is a novel aspect of this study. The analysis would benefit from information on how simulated fire emissions and the contribution of wildfires to N deposition (forcing) compare to each other. Such information is completely lacking in the manuscript.

In the abstract is stated "Predicted global N leaching from natural lands rose from 13.6 Tg N yr-1 in 1901–1911 to 18.5 Tg N yr-1 in 1997–2006, accounting for land-use changes." (P1L25/26). Did the authors account for land-use change? The information in the manuscript is insufficient to tell to what extent land use (change) and for example associated nitrogen fertilization was accounted for.

Minor P2L14: reference missing P4L27: what is the criteria applied to define when the equilibrium state is reached? P5L12: how are the grass PFTs being more competitive than trees in the model? P11:13: BNF estimates were revised down since Cleveland et al. 1999. Please account for newer estimates here; for example see Vitousek et al. 2013 , Sullivan et al. 2014. P14L23: The authors state that N deposition is the dominant factor driving spatial differences in the leaching rate. This needs to shown, as this is not apparent. I rather would suspect differences in the hydrological cycle to dominate spatial leaching patterns. P14L26: how is the correction done. This should be stated

in the method sections. Figure 4: the ratios, denitrification:inputs and fire:inputs, would be interesting to see and to better understand the lack of non-linearity in the simulated leaching:input ratio (Figure 6) P14L30: the substantial underestimation of BNF in LPJ should lead to lower leaching rates. This should be discussed.

Reference: Houlton, Benjamin Z., Alison R. Marklein, and Edith Bai. "Representation of nitrogen in climate change forecasts." Nature Climate Change 5.5 (2015): 398-401. Goll, D. S., Winkler, A. J., Raddatz, T., Dong, N., Prentice, I. C., Ciais, P., and Brovkin, V.: Carbon-nitrogen interactions in idealized simulations with JSBACH (version 3.10), Geosci. Model Dev. Discuss., doi:10.5194/gmd-2016-304, in review, 2017.

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