

This study considers the interactive effects of climate, land use, atmospheric CO₂, nitrogen deposition and fertilizer use, and tropospheric O₃ concentrations on global N₂O and CH₄ emissions from 1981 to 2010 through a series of simulations using the Dynamic Land Ecosystem Model. The primary goals of this paper were to (1) estimate the magnitude of CH₄ and N₂O fluxes and (2) explore spatiotemporal variations in terrestrial CH₄ and N₂O fluxes as influenced by the above-mentioned environmental factors.

The topic of this study is interesting, and I appreciate that the authors attempt to investigate a variety of environmental factors that may directly/indirectly impact global N₂O and CH₄ emissions.

However, a substantial restructuring and polishing of the manuscript is needed prior to publication. The wording is redundant in many places, and certain aspects are not clearly explained.

Primary Comments:

1. The authors mention that large uncertainties may result when scaling up localized measurements to obtain regional and global budgets, as these methods do not represent the biophysical processes regulating N₂O and CH₄ fluxes. However, I find it interesting that the N₂O budget estimates for this study are very similar (12.52 Tg N yr⁻¹ vs. 13.31 Tg N yr⁻¹) to those reported in Xu *et al* (2008), which were developed by empirically extrapolating in-situ fluxes. Although the authors acknowledge this on P19828, there is no explanation as to why the use of a more detailed process based biogeochemical model that accounts for various environmental factors (i.e. climate, land use, atmospheric CO₂, nitrogen deposition and fertilizer use, and tropospheric O₃ concentrations) would not produce vastly different results. This needs to be addressed in the manuscript.

While Table 1 provides a list of the in-situ flux observations used to verify the DLEM CH₄ and N₂O estimates, it would be helpful to also provide figures showing the spatial locations of these sites, and the statistical relationship between the observed and estimated fluxes. It is also not clear, in Table 1, which DLEM fluxes are from previous studies (as mentioned on P19820). It would be better to report only fluxes resulting from the simulations used in this study, unless the other studies mentioned used the same parameterization and input data.

Xu X, Tian H, Hui D 2008 Convergence in the relationship of CO₂ and N₂O exchanges between soil and atmosphere within terrestrial ecosystems. *Global Change Biology* 14: 1651-1660

2. The introduction would benefit from extensive reorganization. If the goal of this study is to examine the impact of climate, land use, atmospheric CO₂, nitrogen deposition and fertilizer use, and tropospheric O₃ concentrations on global N₂O and CH₄ emissions, the authors need to make it clear to the reader how/why these factors are important. As currently presented, the information provided is not easy to follow and often reads as a long list (e.g. L21-29, P19814). For example, please explain the mechanisms by which increases in atmospheric CO₂ and changes in tropospheric O₃ concentrations might impact global N₂O and CH₄ emissions.

In section 2.2 (Model description) a couple of sentences are needed to explain the process by which changes in O₃ and atmospheric CO₂ can impact the simulated N₂O and CH₄ fluxes. This is not apparent, especially since a detailed description of the model is not provided.

The impacts of increasing atmospheric CO₂ and O₃ concentrations on the N₂O and/or CH₄ budgets were not mentioned (or were not apparent) in the discussion. Did these changes significantly influence the resulting emission budgets? If not, why? Please discuss.

3. This study uses an empirical model (Davidson *et al* 2000) to separate N₂O fluxes from NO and N₂ during the denitrification process. This so-called ‘leaky pipe’ approach (Eq. 2) is regulated only by volumetric water content. Is it possible that changes in temperature will affect the ratio of gases converted to N₂O? Do the N_{nit} and N_{denit} rates vary with temperature, or are they treated as static parameters in the model?

4. In the discussion, the relative importance of each environmental factor (temperature, land use, atmospheric CO₂, nitrogen fertilization, tropospheric O₃ concentrations, etc.) in driving regional/global changes in simulated N₂O and CH₄ fluxes is not entirely apparent, nor are the interactions between these addressed. Instead, the focus seems to be more on bivariate trends and correlations. The authors should attempt to discuss the potential effects of climate/environmental interactions on the global N₂O and CH₄ budgets.

For example, although increases in N₂O and CH₄ are attributed to air temperature (in addition to changes in rice production area and heightened fertilizer use), there is no mention of the corresponding effects of increasing precipitation (particularly for the tropics and polar climate zones, Table 3) on the DLEM emission budgets. Did this lead to significant changes in modeled volumetric water content (VWC)? If so, it seems like this would result in higher N₂O and CH₄ fluxes. Similarly, are the observed increases in CH₄ uptake from 2000 to 2010 related only to increases in temperature, or are they also influenced by changes in VWC (e.g. P19825)? Please discuss.

Additional Comments:

P19813. L11. Is the impact of permafrost on N₂O and CH₄ fluxes directly relevant in this paper? If not, is it necessary to mention this here?

L15. Why are literature-based estimates provided for global CH₄ budgets, but not for N₂O?

P19814. L24-29. This sentence is difficult to read, as it essentially is a very long list. Please keep an eye on verb usage (e.g. L25 & L29).

P19815. L4-5. I do not recall mention of elevated CO₂ effects on CH₄ seasonality in the results and discussion. If not, is this information necessary?

L2-9 are a little redundant. You could just mention that few studies have examined the interacting effects of multiple environmental changes on global CH₄ and N₂O emissions.

P19816. L9. A reference should be provided for the CRUNCEP climate data.

P19816. L13. Should this instead be from 1901-2010?

P19816. Please explain how the daily O₃ index was derived from the monthly AOT40 dataset, and how the EDGAR-HYDE 1.3 emissions data were used to interpolate nitrogen deposition data for 1860, 1993, and 2050. This is not apparent.

P19818. L19. Please check to see that a reference is provided for Davidson *et al* (2000).

P19819. L2. I could not find Lin *et al* (2000) in the references. Please check.

P19825. L14. Pay careful attention to the grammar throughout the ms. E.g. 'to increase' instead of 'increased.'

P19826. L17. Why the rapid increase in N₂O emissions in Europe starting in 2000? If I recall correctly, the prescribed fertilizer use rates were held constant after 2005, due to a lack of input data.

P19827. The wetland distributions used for model N₂O and CH₄ simulations in this study are not provided. This needs to be addressed.