Quantifying landscape-level annual nitrous oxide fluxes in the Tibetan Plateau

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Abstract

Quantifying landscape nitrous oxide (N_2O) fluxes and identifying how they are spatio-temporally controlled are critical for predicting N_2O fluxes feedback to climate change and/or human disturbances. Here, we measured two-year N_2O fluxes and environmental variables from a typical landscape in the Tibetan Plateau. Annual N_2O emissions showed large spatial variations (0.05–0.78 kg N ha^{-1} yr^{-1} from meadows to forest) which was significantly ($p <$ 0.01) controlled by soil carbon-to-nitrogen ratios and dissolved organic carbon concentrations. Results also highlighted the importance of the non-growing seasons (particular soil freeze-thaw period) as they contributed 12–57% to annual fluxes.

Keywords: Carbon nitrogen ratio, Landscape, Nitrous oxide, Non-growing season, Tibetan Plateau

1. Introduction

Tibetan Plateau (TP, the ‘third pole’ of the earth), is a key region for studing climate change (Seddon et al., 2016). It has been observed that there existing a high spatial heterogenity in ecosystems types in this plateau (Chen et al., 2013). Therefore, one can postulate that N_2O fluxes vary largely among ecosystems, as the high heterogenity in soil hydro-thermal conditions, soil properties, and microbial processess. However, there is a scaricity for this information in the TP. Accordingly, we initiated this study from a typical alpine landscape in the eastern TP, and we hypothesized that the magnitudes of soil N_2O emissions increased with increasing soil moisture across ecosystems (i.e., from steppes to wetlands), and we also hypothesized that N_2O emission during the non-growing season may contribute substantially to annual fluxes, as the long vegetation dormant period.

2. Materials and method

The study was conducted in grazed meadows and steppes, original forests as well as drained and grazed wetlands in the eastern TP (Fig. 1A). N_2O fluxes were measured by chamber-based gas charomatograph method with high sampling frequencies throughout the year. Soil (0–10 cm) variables were simultaneously measured during gas samplings.

3. Results and discussion

3.1 Spatio-temporal variations in N_2O fluxes

Soils of all ecosystems generally functioned as net sources for atmospheric N_2O, and soil N_2O emissions show distinct seasonal patterns (Fig. 1B). Total annual soil N_2O emissions ranged from 0.05 to 0.78 kg N ha^{-1} yr^{-1} with non-growing season and freeze-thaw period contributed 12–57 (mean ± standard error: 36 ± 4.8%) and 3.3–37% (mean 16 ± 4.0%), respectively.

3.2 Environmental controls on N_2O fluxes

Total annual soil N_2O emissions were exponentially correlated with soil (0–10 cm) C/N ratio ($n = 8$, $r^2 = 0.96$, $p < 0.01$) and annual mean soil dissolved organic carbon concentrations (DOC, mg C kg^{-1} dry soil) ($n = 14$, $r^2 = 0.32$, $p < 0.01$) across ecosytems (Fig. 1C).

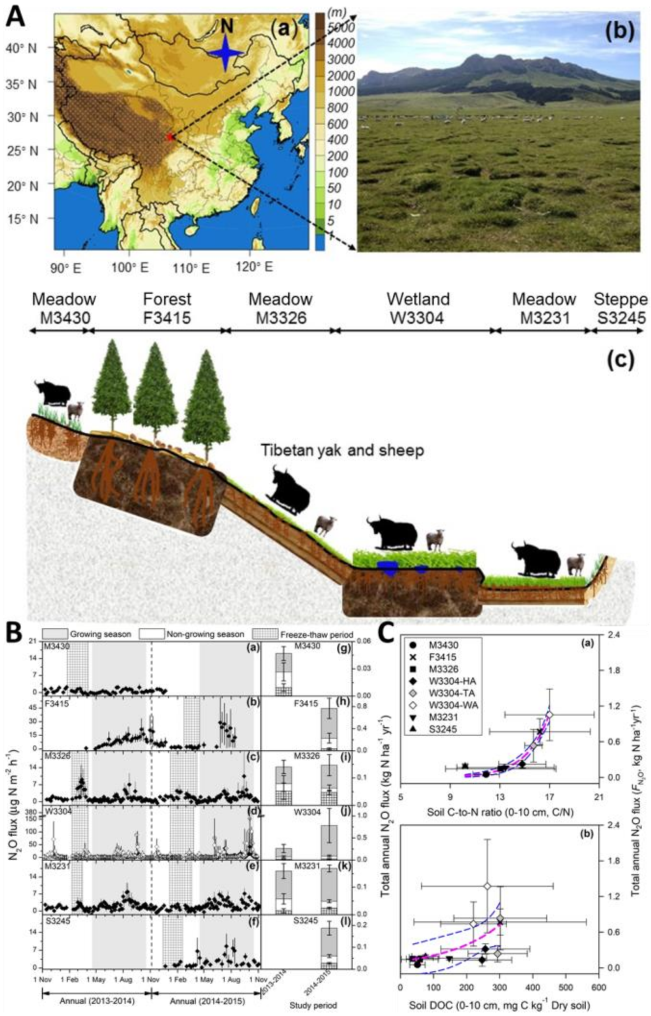

Fig. 1 A typical landscape in the eastern TP (A), seasonal variations and total annual N_2O fluxes for different ecosystems (B), and environmental controls on the spatial variations of N_2O fluxes for ecosystems within the landscape (C). HA (hummock areas), TA (transitional areas), WA (water areas) are the micro-topographies in W3304.

4. Conclusion

The landscape-level annual measurement is important for promoting our understanding of spatio-temporal varibility and controlling factors of N_2O fluxes in the climate change sensitive regions, such as Tibetan Plateau. Long-term measurements are necessary to better understand N_2O fluxes feedbacks to the changing climate.

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