

## ***Interactive comment on “N<sub>2</sub>O, NO and CH<sub>4</sub> exchange, and microbial N turnover over a Mediterranean pine forest soil” by P. Rosenkranz et al.***

**P. Rosenkranz et al.**

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Standard deviation for fluxes shown in figure 1 and 2 is given for the 5 measuring chambers. We acknowledge this now in the figure legend.

We do agree with the reviewer that our flux values for N<sub>2</sub>O are very low and close to the detection limit of our system. We now provide some sentences on the detection limit in the Material and Method section: "Due to automated sample air injection we were able to detect even small changes in chamber air N<sub>2</sub>O concentrations with time. Our detection limit for N<sub>2</sub>O concentration changes in sample air at ambient atmospheric N<sub>2</sub>O concentrations was approx. 3 ppbv N<sub>2</sub>O, which is equivalent to a N<sub>2</sub>O flux of 0.6  $\mu\text{g N}_2\text{O-N m}^{-2} \text{ h}^{-1}$ . Fluxes below this detection limit or measurements for which the slope as derived from linear regression was not significantly different from zero were set to zero (approx. 10-15% of all measurements, see also Butterbach-Bahl et al.,

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1998)." Other sources of error may come from e.g. interference of N<sub>2</sub>O measurements with CO<sub>2</sub> and water vapor. But since we always use a pre-column filled with Ascarite (sodiumhydroxide-coated silicate) we can exclude such interferences. This information is now also given in the Material and Methods section. Instead of using the mean of five chambers, we could have also drawn each chamber (error) individually in figures 1 and 2. We tried to do so, but it does not improve the readability of the graph. Therefore, we stayed with the old layout of graphs.

We agree with the referee, that N<sub>2</sub>O and NO emissions are linked to N gross transformation rates. However these N turnover rates are dependent on substrate availability. Under substrate limited conditions N turnover rates will be low even under optimal moisture and temperature conditions. However, denitrifying microbes need a alternative electron acceptor if there is no nitrate available. We extended the discussion on this issue (also addressed by the review of Albrecht Neftel) and do think, that it now gets clear that we always have to deal with simultaneously occurring production and consumption processes of N<sub>2</sub>O in the soil. Flux measurements at the soil surface or concentration measurements of gases in the soil represent the product of both processes and do not allow to conclude on N transformation rates. We do not know anything about nitrate leaching at our site. But due to the low concentrations of nitrate in the soil, we do need to assume that nitrate leaching is of minor importance at our site. This aspect is now also provided in the discussion section: "Thus, both values (ammonium and nitrate concentrations) are significantly lower than those found for many other forest sites across Europe and one can assume that e.g. nitrate leaching is negligible at the San Rossore site."

Concerning the relation between fluxes and soil water content we addressed this issue also within our response to the comments of Albrecht Neftel. What we have not seen is a response of soil moistening on the N<sub>2</sub>O fluxes at the soil surface. This does not mean that production or consumption processes of N<sub>2</sub>O have not changed due to moistening. To see a reaction of moistening one would need to separate between

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both processes, i.e. between uptake and production. This may be done by the use of inhibitors such as low concentrations of  $C_2H_2$ . We added some additional statements in the discussion section to highlight the mentioned points. "However, in our simulated rainfall experiments no positive effect of simulated rainfall on net  $N_2O$  uptake could be demonstrated. This can be interpreted in such a way, that increases in soil moisture stimulated  $N_2O$  production but simultaneously also increased  $N_2O$  consumption, so that the net-effect - as measured at the soil surface as  $N_2O$  flux - was zero. To further study the effect of soil moistening on  $N_2O$  exchange one would need to separate in-situ production and consumption processes. This may be done by the use inhibitors, e.g. low concentrations of  $C_2H_2$  (0.01%), which do mainly effect the nitrification nitrification rather than the denitrification process (Conrad, 2002)."

Yes, the  $CH_4$  uptake work is somewhat decoupled from the N turnover and N flux work. But,  $CH_4$  uptake does depend directly (inhibition of  $CH_4$  uptake) or indirectly (growth of microorganisms performing  $CH_4$  uptake can be limited by limited N supply) on N supply and concentrations. This aspect is provided in the discussion section. We also kept the  $CH_4$  uptake measurements in the results part, since only a few measurements on  $CH_4$  uptake are available for Mediterranean regions.

As suggested by the reviewer we added more details about soil texture (93 % sand, 3 % silt and 4 % clay), organic layer thickness (2.7 cm) and C content (organic layer: 43.8 %; upper 0.01 m mineral soil: 13.9 %; mineral soil in 0.1 m depth: 1.0 %) to the site description.

We now provide details on sampling and on the accuracy of measurements in the Material and Method section: "Soil air samples (5 ml) were drawn with a syringe every three days (eleven sampling days during autumn field campaign in total) and analysed immediately with the gas chromatograph described before using a manual injection port (Breuer et al., 2000). The precision of  $N_2O$  measurements was  $\pm 1.5$  ppbv for  $N_2O$  and  $\pm 5$  ppbv for  $CH_4$ . For further details on the membrane tube technique for measurements of soil gas concentrations see Gut et al. (1998)."

Yes, the reviewer is right that methane oxidation is linked mainly to  $\text{NH}_4^+$ . But there are also studies reporting that high nitrate concentrations will inhibit  $\text{CH}_4$  uptake as well. This is most likely rather an indirect (osmotic effect on the  $\text{CH}_4$  consuming population) than a direct effect. For a good review on this issue see Bodelier and Laanbroek, 2004. We now put ammonium in brackets to highlight that inhibitory effects of inorganic N concentrations on  $\text{CH}_4$  uptake were mainly found for ammonium.

We added some sentences about  $\text{NO}_x$  and  $\text{CH}_4$  to the conclusion section: "Furthermore we showed that the site investigated in this study was a net sink for  $\text{NO}_x$  as well as for  $\text{CH}_4$ . With regard to  $\text{NO}_x$  we demonstrated that  $\text{NO}_2$  deposition dominated over the rather weak  $\text{NO}$  emission."

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