

## ***Interactive comment on “The significance of nitrous oxide emission from biofuel crops on arable land: a Swedish perspective” by Å. Kasimir Klemedtsson and K. A. Smith***

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The authors' responses to Anonymous referee #1.

Referee #1: Over all this paper points to the importance of improving the ability to predict N<sub>2</sub>O emission, it focuses on grain crop use for bioenergy. It examines limitation of first generation biofuel to offset GHG emission. Comments: The observation that nitrous oxide emission occurs in the winter especially during thawing is consistent with results in the northern USA and other countries.

Authors' response: We appreciate the comment about winter emissions at thawing. This is one of the explanations why we think emissions were found to be less coupled

C3272

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Discussion Paper



to N-addition, and we will mention this in the revised text.

Referee #1: Page 6750 line 15-24: Excellent point, when observed in the short-term, N<sub>2</sub>O flux does seem to increase with N-additions. However, N<sub>2</sub>O emission continues as long as there is labile N, which likely would be true in native systems, with a substantial pool of organic matter. P. 6756 Line 16 – relationship to soil carbon consistent with work published by Liebig et al., 2006 Soil response to long-term grazing in the northern Great Plains of North America. Agric. Ecosys. Environ. 115:270-276. Their work noted the relationship of N<sub>2</sub>O to labile N and C.

Authors' response: We think the first comment relates to page 6748 line 15-24 (not p. 6750) under Method. We agree that N<sub>2</sub>O emission continues as long as there is labile N in the system, as do Liebig et al. 2006, whose paper points to the importance of long term management for emissions. The Logården farm has not been managed for >70 years as in Liebig et al. but for 20 years; long term experiments are very valuable, since land use history has an influence on the emissions experienced today, as we will also discuss in our revised paper. In the paper by Liebig et al. a correlation of N<sub>2</sub>O to carbon content in the soil was found. We mention organic soils containing huge amounts of carbon and nitrogen which are a source for high emissions, of both N<sub>2</sub>O and CO<sub>2</sub>. In our study we are not especially searching for explanatory factors, but aim to give a view on what can be realistic emissions and how these may be estimated based on existing methods; of course, explanatory factors are then used in these calculations. Of the factors included in the estimation functions by Freibauer Kaltschmitt, soil C and N were found to be the most decisive for the emission. We will try to be much clearer on this aspect, in the revised version.

Referee #1: A few items to consider: This discussion is focused exclusively on first-generation fossil fuels. It may be worthwhile to make this obvious even in the title.

Authors' response: Yes this is about first generation biofuel production only. Second generation biofuel production is not considered here. The title will be changed, to clarify

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that this paper is about agricultural grain production intended for biofuels.

Referee #1: Also on p. 6747 line 11 – add ‘grain’ after crop yield.

Authors’ response: We have changed it into “crop grain yield”.

Referee #1: Although, the focus is N<sub>2</sub>O consider a brief discussion that addresses if/how other GHG may be impacted by using grain for ethanol.

Authors’ response: In sections 4.4 and 4.5 we will discuss the LCA which includes other GHG emissions than N<sub>2</sub>O, e.g. CO<sub>2</sub> emissions from energy use in the refinery and fertiliser production. Table 3 will show the size of these emissions. We will also include text on allocation to spent grains. Influences on taking agricultural land for fuel production, moving food production elsewhere, and possible implications will also be discussed.

Referee #1: P. 6750 – line 12; when you state ‘at least one-year’ are you implying that emission were measured all months of the year. It would be helpful if this was clarified. In the supplemental data A, add frequency and interval of sampling, also add if measurement were made during thawing.

Authors’ response: Our aim was to include all months of the year in the measurements. However, there are a few studies having gaps during winter months including our Swedish measurements, due to practical reasons. Nevertheless, the studies covered most of the year and the total period covered more than a year. Supplementary data A has been completed with information on frequency and duration of measurements, and also whether winter/thawing emissions had been spotted. After scrutinizing the papers once again to find winter/thawing emission occasions, we have deleted some data and added some. This will make some small changes to Figure 2.

Referee #1: P. 6754 line 25-26: What are the regression coefficients? Add  $r^2$  and P values for fig. 2. It will make the relationship or lack thereof more apparent.

Authors’ response: Regression coefficients will be added both in the text and in the

C3274

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8, C3272–C3275, 2011

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figure.

Referee #1: Also consider adding a line showing the median.

Authors' response: We have considered adding a line showing the median. But it may be confusing since it may easily be perceived as the average. Also the regression is not far from the constant average or median numbers, so we would prefer not to add a line in the figure,.

Referee #1: p. 6756 line 11 – ethanol refinery? Clarify

Authors' response: We will change this to “ethanol production plant” or similar.

Referee #1: P. figure 3 when was the fertilizer applied?

Authors' response: More explicit description of the experimental farms, management and measurement arrangements will be added to the methods section, including the month of fertiliser addition, amounts and type.

Referee #1: If first-generation biofuel have limited ability to meet the EU standards for GHG mitigation, then what are strategies to enhance GHG mitigation? Perhaps a future project may be to estimate the potential of second-generation biofuels to mitigate GHG emission.

Authors' response: Biofuels have been perceived as a way of mitigating emissions but it is often forgotten that producing the fuels inevitably also requires energy and causes emissions; there are never zero emissions. It is when N<sub>2</sub>O emissions are included that total emissions associated with producing the fuel approach the amounts emitted when fossil fuels are used. We are convinced that second generation biofuels have the potential to mitigate emissions, because of the lower associated N<sub>2</sub>O emissions, and we agree that a future project could usefully estimate the extent of the mitigation. We will add a sentence to this effect.

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C3275

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8, C3272–C3275, 2011

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