

## ***Interactive comment on “Influence of short-term transfers on nitrogen fluxes, budgets and indirect N<sub>2</sub>O emissions in rural landscapes” by S. Duret et al.***

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Response to Anonymous Referee #1

Dear Referee#1, We acknowledge you for your valuable comments which have helped us to improve the quality of the manuscript. We answer in details to all your comments in the following. We have taken into account almost all comments.

Major comments

Referee's comment: 1. The title promised the role of short-term effect, but what this exactly is, is not made clear. Furthermore, this paper is more focussing on N fluxes

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in a landscape rather than the indirect N<sub>2</sub>O emissions as promised in the introduction. This type of landscape analyses is not new, but the effect of short-term interaction is. However, the authors does not make clear what they meant by this and what the short-term effect really is.

Authors' response: We agree with the referee. “Short-term” was not clear and has been replaced by “short-range”. The title has been reformulated to be clearer. Furthermore, the paper now focuses on N fluxes, including indirect N emissions, rather than indirect N<sub>2</sub>O emissions specifically.

Referee's comment: 2. In general the description on material and method is not very concise. The model description is rather generic and copy/paste from a previous article (Duret et al., 2011). Furthermore, crucial information on relevant process such as how N<sub>2</sub>O production/ emission is calculated are not given. From a footnote of Table 1 (in the Results section) the reader is informed that the IPCC method was used for N<sub>2</sub>O farm emissions. This aspect should be clearly addressed in the Materials and Methods section. I suggest to briefly summarize the part of the model description taken from Duret et al., (2011) and to extend the Materials and Methods section with the relevant N<sub>2</sub>O emission processes included in the used models and approaches.

Authors' response: The “Materials and methods” section is not a copy/paste, but a summary, from the previous article Duret et al. (2011). Moreover, Referee #2 states that the Methods section is clearly set out. Thus, we have not changed the beginning of this section. However, as suggested by the Referee, we have added information related to N<sub>2</sub>O processes in the description of the agro-ecosystem model. As suggested by the Referee, we have also added a sentence on N<sub>2</sub>O farm emissions in the description of the farm model.

Referee's comment: 3. The methodology to estimate indirect emissions is now fully focussing on N<sub>2</sub>O, whereas the results including also indirect NH<sub>3</sub> emissions. How the indirect NH<sub>3</sub> emissions were calculated and the meaning/relevance of these type

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of emissions is not included in this section. Furthermore, the used procedure to identify the indirect N<sub>2</sub>O emission by " $N_2O_{tot,all} - N_2O_{tot, not}$ ", implies that the authors assume that there is no interaction between the N<sub>r</sub>-input and the other N processes within the model. I am not fully sure, but I presume that a model run without (dry) NH<sub>3</sub> deposition input yields different results for e.g. N plant uptake, N (im)mobilisation, (de)nitrification and by that changes in N<sub>2</sub>O emission that are not solely caused by the cut off of (dry) NH<sub>3</sub> deposition input. I believe that it is relevant that authors address the 'problem' of interaction both in case they are occurring or not.

Authors' response: The methodology presented to calculate indirect emissions of N<sub>2</sub>O is the same for NH<sub>3</sub> and NO<sub>3</sub>. We have corrected the "materials and methods" section by replacing N<sub>2</sub>O by N<sub>r</sub> (NH<sub>3</sub>, NO<sub>3</sub>, N<sub>2</sub>O) which is more generic and makes it possible to present the methodology for the three N<sub>r</sub> species. The 'problem' of interaction is now addressed in the 'result-discussion' section.

4. It is a pity that this research is based on a hypothetical landscape, which limits the relevance of this study. This e.g. limits the validation possibilities. The geographical layer seems more or less realistic and is explained, but the used management information e.g. on the amount of manure and fertilizer etc. is not addressed. I believe that this is relevant information to understand the results. From Table 1 it appears that the average N<sub>r</sub> losses are larger than 100 kg N ha<sup>-1</sup> yr<sup>-1</sup>, this makes the reader very curious about the amount N input (animal manure and fertilizer) that is used or calculated by the model. I strongly advocate to make this more transparent and spend some discussion on the consequences of the use of hypothetical landscape rather than an existing one.

Authors' response: We agree with the Referee. Working on a hypothetical landscape limits the validation possibilities. We asked ourselves the relevancy of presenting the validation methodology, results from measurements and comparison between simulations and measurements. We finally concluded that presenting such a complex methodology accounting for the various compartments of NitroScape would be too

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long for a single paper. Moreover, we would produce a paper with several objectives. Therefore, we chose to focus the paper on the ability of NitroScape to simulate N<sub>r</sub> lateral transfers at the landscape scale and give ranges for the contribution of atmospheric and hydrological pathways to indirect N<sub>r</sub> emissions. Comparisons between N<sub>r</sub> measurements and simulation results are in progress for a next paper. However, we have added a short discussion on using a hypothetical landscape, instead of a real one. Regarding the comment on Table 1 and comparison between N losses and N inputs, N inputs were given in the "Materials and methods. 2.3 The test landscape" section. We have added in Table 1 the average N inputs in the landscape to ease comparisons with simulated values presented in Table 1.

5. In the Discussion a real discussion is missing. It comprises too much repetition of that was presented in the Results section, whereas relevant aspects such as (i) what are the consequence of using a test landscape rather than a 'real' and (ii) a more thorough discussion on the derive indirect N<sub>2</sub>O EF and a comparison to the most recent IPCC guidelines (ie. 2006), which is even lower than previous value (0.75% compared to 2.5%).

Authors' response: We agree with the Referee. The Discussion contained repetitions from the Results section. We have merged both sections in one "Results-Discussion" section to avoid repetitions. A short discussion has been added on using a hypothetical landscape, instead of a real one (see response above). We have also extended the discussion on emission factors.

Specific comments

Referee's comment: P7594 I5: clarify "additional" in this context or skip it.

Authors' response: The word "additional" has been removed and the sentence has been reformulated.

Referee's comment: P7594 I3: "recapture", be consistent in spelling us either "re-

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capture” or “recapture” throughout the paper.

Authors’ response: “Recapture” is now used throughout the paper.

Referee’s comment: P7595 I8-9: Why “re-deposition”? I should say “deposition”

Authors’ response: “Deposition” was used throughout the paper, excepted P7595 I8-9. “Re-deposited” has been replaced by “deposited” at this line.

Referee’s comment: P7595 I11: “...up the slope in the groundwater.” → “..up the slope.”?

Authors’ response: This part of the sentence has been replaced by “upstream”.

Referee’s comment: P7596 I20: Why is grassland not included?

Authors’ response: We do not understand this comment since we indicated 3 lines above that we included “several compartments of the terrestrial ecosystems (livestock buildings, croplands and grasslands)”.

Referee’s comment: P7597 I12: “deposition of Nr pollutants”. Within NitroScape this is limited to NH<sub>3</sub>?

Authors’ response: The referee is right. We used OPS which describes NH<sub>3</sub> processes only. That has been added in section 2.

Referee’s comment: P7599 I13 and I19: not clear what “short-term transfers” means in this context. I presume that long-term transfers are also included.

Authors’ response: The two sentences have been modified to make them clearer. “short-term transfers” has been replaced by “lateral transfers by (both) the (atmospheric and) hydrological pathway(s)”.

Referee’s comment: P7599 I20: Explain why wet deposition is blocked for the atm? Does this include both NH<sub>3</sub> and NO<sub>x</sub>? To me it seems not logical that deposition is partly include the effect of hydro, whereas the total emissions of NH<sub>3</sub> and NO<sub>x</sub> are

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blocked.

Authors’ response: Wet deposition is not blocked in the atm configuration, but no wet deposition (and no NO<sub>3</sub>-) are sent to the hydrological module to prevent leaching and lateral transfer by the hydrological pathway.

Referee’s comment: P7601 I3: Explicitly mention which atmospheric deposition is included in “captNH<sub>3</sub>”, i.e. NH<sub>3</sub> and NO<sub>x</sub> due to emission from the landscape.

Authors’ response: NH<sub>3</sub> has been explicitly mentioned and this sentence has been reformulated to make it clearer.

Referee’s comment: P7601 I17: What about the assumed drainage condition and organic matter content of the uniform distributed silty loamy soil? Please provide some details on this, since these factors are very relevant for the (de)nitrification process and by that for the N<sub>2</sub>O and NO<sub>x</sub> emissions. Furthermore, the assumption of one uniform soil type is also an important aspect to address in the Discussion.

Authors’ response: The soil properties (above 180 cm) are used by the CERES-EGC model in NitroScape. Currently, processes of nitrification and denitrification depend of potential nitrification and denitrification rates which are constants in CERES-EGC and do not depend on organic matter content and drainage conditions. A sentence has been added in the results-discussion section.

Referee’s comment: P7602 I9: “bottom” → “edge”

Authors’ response: This sentence has been reformulated, including replacement of “bottom” by “lowest part”.

Referee’s comment: P7602 I11: “on” → “to”

Authors’ response: The sentence has been reformulated.

Referee’s comment: P7602 I15: I presume that this is not the total deposition but the average. I suggest: “The average NH<sub>3</sub> dry deposition within the landscape was around

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9 kg NH<sub>3</sub>-N ha<sup>-1</sup> yr<sup>-1</sup> for the all land atm configurations (Table 1).”

Authors' response: We agree. This section has been reformulated as suggested.

Referee's comment: P7602 I16-I19: This sentences belongs to Ch. 2. Clarify “ground-water uprising when the water table rose in soil and brought water and NO<sub>3</sub> to the soil surface”, e.g. “water table rise bringing groundwater and dissolved NO<sub>3</sub> into the unsaturated zone”

Authors' response: This sentence has been reformulated and moved to Ch. 2 as suggested by the Referee.

Referee's comment: P7602 I19-I21: This needs an explanation. To my imagination input of NO<sub>3</sub> by groundwater always implies an input of NO<sub>3</sub> which is  $\geq 0$ , i.e. the NO<sub>3</sub> concentration x waterflux.

Authors' response: Since results and discussion have been merged in one single section, this part of the paper has been reformulated.

Referee's comment: P7602 I25: I do not understand this (see also above). Do you mean that the soil profile is flushed laterally? If yes, I suggest to talk about leaching for vertical losses/transport and runoff for lateral losses/transport.

Authors' response: We agree with the referee, this sentence was not clear. We now talk about leaching and lateral transfer only.

Referee's comment: P7603 I2-I3: Support the reader to reader to trace the mentioned figures in the text. This means “16” → “17” and “20” → “21”. Check this also for other figures in the paper.

Authors' response: This sentence has been modified as suggested.

Referee's comment: P7603 I5-I8: This clearly illustrates interaction, see major comments: 0.7 (from atm) + 0 (from hyd) < 0.5 (from all). Elaborate on this in the discussion.

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Authors' response: Interactions between atmospheric and hydrological transfers have been more thoroughly discussed as suggested by the referee.

Referee's comment: P7603 I9:I11: Explain how it is possible there are no NO<sub>x</sub> emissions due to atm and hyd? I should say that these emissions are related to more or less the same processes as N<sub>2</sub>O emission.

Authors' response: We agree with the Referee. NO<sub>x</sub> emissions are simulated by the ecosystem model by taking into account processes of N transformation in soil. NO<sub>x</sub> is not transferred laterally by the atmospheric and hydrological models (see above). Such a structure of the models explain why no NO<sub>x</sub> emissions are due to the atmospheric and hydrological models.

Referee's comment: P7605 I18-I22: Extend this seriously, since this comprises one of the major results of this research. Provide, e.g. all emissions factors you are using in the discussion.

Authors' response: This section has been reformulated and extended as suggested by the Referee since it has been merged with the discussion. Generally speaking, emission factors used in the discussion have been provided.

Referee's comment: P7606 I2-I3: ECETOC (1994) is a rather outdated reference to compare the calculated NH<sub>3</sub> emissions. A quick analyses of the results in ENA Chapter 16 (Leip et al., 2011) yields a soil emission factor for NH<sub>3</sub> for the EU27 of about 9% (when taking Min. fert. and Manure into account). Please, use a more recent reference and be explicit what is compared.

Authors' response: We have used the reference suggested by the Referee and also the EEA/EMEP Guidebook reference (2009), which updates the ECETOC reference (1994).

Referee's comment: P7606 I16: The derived average direct N<sub>2</sub>O emission factors are not mentioned. Please provide these, preferably in the Results section.

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Authors' response: The derived average N<sub>2</sub>O emission factors have been mentioned in section 3.2 as suggested by the Referee.

Referee's comment: P7607 I15-I19: Why are you focusing on the absolute maximum losses. It is better to focus first on the average fluxes and secondly on the large range with (extremely!) high maximums.

Authors' response: The Results section and the Discussion section have been reorganised in one single section. This section now focuses first on the average fluxes and then on the large range of values.

Referee's comment: P7608 I19-I24: Explain why EF<sub>4</sub> for unmanaged soils is much lower than EF<sub>5g</sub> for unmanaged soils.

Authors' response: Hypotheses are given in section 3.3, especially NH<sub>3</sub> needs to be nitrified then denitrified before producing N<sub>2</sub>O, while NO<sub>3</sub> only needs to be denitrified.

Referee's comment: P7609 I2-I3: I do not understand that NH<sub>3</sub> needs to be nitrified before it can be taken up. Most plants have a preference for ammonium uptake compared to nitrate. Furthermore, ammonia can also be taken up by the canopy. Please elaborate on this.

Authors' response: We have discussed this point only regarding denitrification and not regarding N uptake by plant. We agree with the Referee that N can be uptaken by plant either as NO<sub>3</sub><sup>-</sup> or as NH<sub>4</sub><sup>+</sup>, while NH<sub>3</sub> needs to be nitrified prior to denitrification in soil.

Referee's comment: P7609 I15: Not clear what is meant by short-term and long-term processes (see also Major comments). Please, clarify this in the paper.

Authors' response: "Short-term" and "Long-term" have been replaced by "short-range" and "long-range" throughout the paper (see also Response to Referee's comment 1).

Referee's comment: P7614 Table 1: (i) Indicate that these are average fluxes. (ii)

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Explain the meaning of the footnote in Ch. 2. (iii) Explain how it is possible that average N losses are extremely high (NH<sub>3</sub> + NO<sub>3</sub> leaching > 100 kg N ha<sup>-1</sup> yr<sup>-1</sup>, see major comments). In addition, it would be beneficial to include the inputs by chemical fertilizer and animal manure in the table. This is also relevant for the derivation of the emission fractions.

Authors' response: (i) Average fluxes have been added in the table caption. (ii) The footnote has been detailed in Ch. 2. (iii) N inputs by chemical fertilizer and animal manure have been added in the table caption.

Referee's comment: P7615 Fig 1: NO<sub>x</sub> deposition is missing.

Authors' response: NO<sub>x</sub> deposition is not missing since it is not simulated into NitroScape. NO<sub>x</sub> emissions are only simulated by the ecosystem model by taking into account processes of N transformation in soil. NO<sub>x</sub> is not transferred laterally by the atmospheric and hydrological models (see above).

Referee's comment: P7619 Fig 5: "uptake" → "input"?

Authors' response: "uptake" has been replaced by "input".

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