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***Interactive comment on* “Uncertainties in model predictions of nitrogen fluxes from agro-ecosystems in Europe” by J. Kros et al.**

J. Kros et al.

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We thank the reviewer for the appraisal and suggestions, which have helped us to improve the manuscript. We have carefully tried to address the issues raised and to revise the paper accordingly. In the revision we have been able to incorporate nearly all the suggestions of the referees as explained in our responses to each reviewer. Below the essence of the questions and suggestions of the reviewer (RE) are given along with our author (AU) replies

RE: - The paper suffers from numerous repetitions, making it often confusing, and many paragraphs are unclear. A first estimate is that the text can be reduced by 30% by removing repetitions and shortening all lengthy sentences. - The paper in many places lacks structure (e.g. discussion in the results section, conclusions in the discussion

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section), and this makes reading and understanding a difficult task. - Many choices made by the authors have not been supported by good arguments. AU: We agree that the manuscript contains some repetitions. This was done to assist the reader, but apparently this does not have the expected effect for this reviewer. We revised our manuscript and tried to reduce the length by removing unnecessary repetitions and shortening lengthy sentences. We also made a clearer distinction between results, discussion and conclusions

RE: -Page 6054: The example of de Vries et al. (2003) is given, stating that this study did not cover the uncertainty due to spatial model inputs. Readers would expect then that in this paper the uncertainty in spatially explicit data is analyzed. If this is so important, why not include this aspect. Why is it beyond the scope of this work (page 6059)? Computing time can not be an argument any longer. AU: Our study does include the uncertainty due to spatial model inputs (as stated in the introduction), which includes e.g. N input data and N crop uptake data, but it does not include the uncertainty in spatially distributed categorical data, referring to the uncertainty in land use maps and soil maps (as mentioned in the preceding sentence). We clarified this better in the text by the following changes. At Page 6054 we changed l 19:20 into: “We present a MC propagation analysis with INTEGRATOR at the European scale, while taken spatial correlation into account.” At Page 6059 we changed l 14:16 into: “Contrary to the uncertainty of spatially distributed continuous data, as included in this study, the modelling of uncertainty in spatially distributed categorical variables is as yet a challenging task (Heuvelink et al., 2007), which was beyond the scope of this work.

RE: -Page 6055, last para, first sentence: completely unclear what the authors intend to say. AU: We changed this sentence into: “INTEGRATOR calculates the total manure production for each FSSNUTS region, i.e. Farm Structure Survey (FSS) regions which are either at NUTS (Nomenclature of Territorial Units for Statistics) 2 or 3 level (Leip et al., 2008). The manure production was calculated from the animal numbers, available at FSSNUTS level, and the N excretion per animal category, available at country level.”

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RE: -Page 6055, last line: it is not clear how animal manure is distributed in the model, and how it differs between countries. AU: All manure produced in housing and manure storage systems within a FSSNUTS region, corrected for nutrient losses (gaseous and leaching) in these storage systems, is distribute over fodder crops grassland, fodder crops and arable land within that region (no manure transport between regions). The distribution of animal manure over grassland, fodder maize and arable land, is country dependent. We clarified this in the manuscript.

RE: -Page 6056, first line: reference is needed here. AU: National fertilizer N application was based on FAO statistics (<http://faostat.fao.org/>). We added this reference.

RE: -Page 6056, 2nd para: a lot of attention is paid to the modeling of leaching from stored manure, but is remains unclear how leaching and surface runoff are computed. AU: We clarified this by stating that this was based on the water fluxes: “The division of total N leaching over downward leaching and subsurface runoff is derived by multiplying the total N leaching by a subsurface runoff fraction for the water flux that depends on soil texture, slope and landuse, based on Keuskamp et al. (2012).”

RE: -Page 6055-6056: it is unclear how N withdrawal by crops is computed. AU: The yields of arable crops for each country were derived from FAOSTAT on a country basis (<http://faostat.fao.org/>). The N contents of harvested crop products and the amount of crop residues and the relation with N inputs were based on literature We clarified this in the text.

RE: -Page 6055-6056: perhaps summarize all the N budget terms in a table with some accompanying text would be easier for readers. Please order the budget terms in a meaningful order to help readers. AU: We included a paragraph to introduce and clarify the N budget terms.

RE: -Page 6057: faostat needs a reference. AU: This was added (<http://faostat.fao.org/>).

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RE: -Page 6057, 2nd paragraph: data on animal populations are from Klaassen et al, but where did they obtain the data? What is the are weighting, both for animals and fertilizer (previous page). AU: The animal numbers from Klaassen were based on national data provided by national experts. We clarified this in the text.

RE: -Page 6058: uncertainties resulting from model structure only make sense when the input data are the same. AU: We do not agree or do not understand what is meant. Same input data makes sense when comparing uncertainties in the structure of different models, but is not relevant when focussing at one model. Investigations on the effects of model structure with different model may be relevant because the model structure is might be dependent of the model input.

RE: -Page 6059, last line: what is a plot? Is it the same as an NCU? AU: A plot is much smaller than an NCU but since we ignore spatial variability within NCU's the size of the plot is immaterial and all inputs are assumed to be constant within an NCU.

RE: Page 6060 line 10-13: Why were lognormal distributions assumed, and why were spatial and cross-correlations log-transformed? The chance to draw the default value is largest. So a uniform distribution is probably a wiser choice. In addition, the arguments are lacking for selecting lognormal distributions and why using logtransformations. AU: We used a lognormal distribution in those cases where the data or experience showed that the variable has a skew distribution. The tails of the distribution can have a marked influence on model outcomes and it is important to take this into account. It would not work with a uniform distribution.

RE: -Page 6060, line 15: it is stated that CV is used rather than SD, but this is not correct. Both are used, and it is not discussed why in some cases CV and in other cases SD. AU: Agreed. We changed the text and discussed the reason for using either CV or SD.

RE: -Page 6060, line 23: crop uptake is not from statistics, but it is in the group of input data taken from statistics with a low CV. In addition, these statistics are on a country

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scale and then downscaled to smaller regions. This procedure may imply considerable uncertainty. A discussion on the grouping of input data in CV classes is missing. AU: This is a relevant point, what was already discussed in more general terms in the discussion section. We now extended this discussion.

RE: -Page 6062-6062: complete abacadabra. AU: Not clear where this refers to. We have reconsidered the text on page 6062 as whole and slightly reformulate it and hope to have made it more clear now.

RE: -Page 6064, 3d paragraph: it is stated that 1000 model runs is adequate, so please provide arguments for this statement. Our experience is that with so many variables this may not be adequate. AU: This assertion is based on the fact that repeating the analysis with the same sample size did not lead to large differences in results. There is also no theoretical reason why the sample size should be larger when there are more uncertain inputs.

RE: -Section 3.3: seven groups? Table 5 and figure 6 show only six! 56 parameters? Page 606 line 12 says 51! AU: We improved the representation of ‘model input’ groups. We now combined table 4 and 5 into one table.

RE: -In section 4.1.2 the authors discuss that the variation in uncertainty in nitrogen leaching and runoff is related to soil properties. Is the variability in uncertainty or uncertainty meant here (spatially explicit variables were not included). This contrasts with section 4.2, where the uncertainty in nitrogen leaching and runoff is mainly caused by nitrogen inputs, leaching parameters and crop uptake??? AU: We improved this discussion and made clear that the leaching parameters are related to soil properties.

RE: -Page 6068, last para: this is complete abacadabra!!!! AU: We improved this paragraph. We changed it into: “The uncertainty in INTEGRATOR outputs decreases when outputs are aggregated to larger areas (i.e. from NCU to NUTS or country). Note that this result is obtained while taken spatial correlations between uncertain inputs into account Presumably most regional uncertainty assessment studies ignore spa-

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tial correlation and assume that inputs are constant over space, which will lead to an overestimation of uncertainty at coarse spatial scales.

RE: -Section 5, first part and section 5.1: several times the authors state that neglecting spatial correlation leads to overestimation of uncertainties. This discussion could be reduced considerably, and, in addition, it is not interesting to know that N₂O emission is some part of the Netherlands is 20.5 kg per hectare per year. AU: We reconsider the this section an tried make it more condensed. We agreed that the N₂O emission in not interesting in this context, but it was included to clarify the origin of the relative uncertainty of 52%.

RE: -section 5: comparison with uncertainty estimates of ammonia emissions by Beusen et al. 2008) Atmospheric Environment is lacking. AU: We included this reference for the comparison of the uncertainty in the NH₃ emission estimates: “From a global scale uncertainty analysis Beusen et al (2008) calculated a range of 27–38 (with a mean of 32) Tg yr⁻¹ for the global NH₃-N emission from agricultural systems, i.e. a relative uncertainty of 11%, which is slightly lower than the 16% from this study.”

RE: -Section 5.1: is relative uncertainty of 7% for USA substantially smaller than 12% for EU27? My guess is that it is very much the same, in view of the difference between US and European agriculture. In fact, are these numbers comparable? AU: We explained how the relative uncertainty of 7% due to input data was derived for the for USA and argue that this is an estimate that could be comparable with our results. We agree, however, that this is not “substantially smaller”. We changed this in “smaller”.

-Page 6071, 2nd para, last sentence: very good remark that validation with measurements is a good approach. I guess that this remark fits better in the introduction. AU: Agree that this can also be a remark in the introduction. However, in this context it was a remark in addition to the model structural uncertainties discussion. Therefore, we left it in the discussion.

RE: -Section 5: is the robustness analysis not discussed? AU: We now added a brief

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discussion on robustness analysis.

RE: -Section 4.3: I suggest to have a true conclusions section, and not hidden in the discussion. In addition, stating that something is rather low needs some comparison: is lower than something else. AU:We introduced a true conclusions section by combining the conclusions from the chapter 5 (the first three paragraphs) and section 5.3 (concluding remarks).

Some detailed comments: - Avoid “used approach”. This is Dutch. AU: We avoid this.

RE: - Avoid “more or less” and other confusing expressions. Something is true or not, but not more or less true. AU: We avoid this.

RE: - Page6068, 1st line: what is the uncertainty due to robustness scenarios? AU: We now explained this in the added discussion on robustness analysis (see remark above).

RE: - Page 6068, line 10: only nitrogen fluxes were analyzed. AU: We removed green-house gas.

RE: - Avoid “As discussed before”. AU: We avoid this

RE: - Variable names may be the same as in the model code, but for readers names like ctNplmx_gi are difficult to understand and remember. AU: We changed the names into more understandable abbreviations

RE: - Figure 6: Nle_sw is correct? AU: No, we changed this into Nro sw.Thanks

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