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Biogeosciences Discussions

Interactive comment on "The influence of model grid resolution on estimation of national scale nitrogen deposition and exceedance of critical levels" *by* A. J. Dore et al.

Anonymous Referee #1

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Review of the article: The influence of model grid resolution on estimation of national scale nitrogen deposition and exceedance of critical levels

by A. J. Dore, M. Kryza, J. R. Hall, S. Hallsworth, V. J. D. Keller, M. Vieno, and M. A. Sutton

General comments:

In general, the manuscript is well written and the manuscript addresses an important scientific question that is relevant for Biogeosciences: Nitrogen deposition to sensitive ecosystems! The case is the United Kingdom (England, Scotland, Wales and Northern Ireland). The authors use a well established scientific model FRAME (Fournier

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Discussion Paper

et al., 2004; Fournier et al., 2005; Singles et al., 1998) that is well suited for the particular scientific question. The authors argue that high resolution modelling in certain areas, especially those with important strong sources that contributes to dry deposition nitrogen as well sensitive ecosystems requires high resolution modelling. Practically, the authors show that 50km nitrogen deposition maps that are based on results from state-of-the-art chemistry transport models with continental scale coverage (e.g. Europe) are far from sufficient. The authors also argue that 5km is not sufficient, which is near the practical limit of state-of-the-art national scale chemistry transport models as the EMEP4UK model (Vieno et al., 2010) and that 1km or higher resolution is most likely needed in many regions. As such the results are both relevant to policy as well as they suggest a direction for further research for the modelling community and users of model products from the model community. Personally, I hope that this study will inspire to related studies over the United Kingdom or similar studies in different parts of the world, as the nitrogen issue in general is very relevant to nature, human health and climate and as atmospheric nitrogen depositions and how it is distributed in nature is far from understood.

With respect to methodology, then the authors have used the FRAME model at 1km with 1km input in for meteorology and emission. Results from these model results are then aggregated to two coarser grid resolutions, 5km and 50km that are compared with the 1km model results. These two coarser grid resolutions are identical to grid resolutions used by common CTM model that have been used for either European scale calculations such as the EMEP model (Simpson et al., 2003) or specific UK calculations such as the EMEP4UK model (Vieno et al., 2010) and are as such very relevant. However, the results would have been stronger, if the authors also had chosen to aggregate input data to 5km (neglecting the 50 km resolution) and then also made calculations on a 5km grid in a similar way as in Hallworth et al (2010) as a comparison to the presented calculations. An alternative is however, if sufficient model results from the FRAME model from previous publications (e.g. Hallsworth et al., 2010; Kryza et al., 2011; Zhang et al., 2011) provides sufficient material to provide an in depth

BGD

8, C5023–C5031, 2011

discussion in relation to the three scenarios. This issue is directly related to the aim of the paper. The authors write on page 12084-85: "The aim of this work is to investigate the influence of spatial averaging of modelled air concentrations and deposition (effect 1 above) on the exceedance of critical loads for nitrogen deposition.". From an end-users point of view, this result is very interesting as there is a recommendation to use a 1km reference data set compared to a 5km data set. But from an atmospheric modelling point of view, which is the topic in this manuscript, then in many cases it will make less sense to aggregate this type of model data (based on 1km input data) to a coarser resolution (e.g. reducing the data set which limit the amount of meaningful analysis).

The authors use relatively few citations from peer reviewed journals (15-16) and in comparison to that, a relatively high number of citations from different types of sources such as reports (13-14). Additionally, the manuscript contains a number of unsupported statements, especially in the introduction. I will therefore recommend a thorough investigation of the manuscript with respect to extended use of citations from peer reviewed scientific journals. I have a listed a number of possible locations in a list below this review.

There are a few unclear sections in the manuscript and the paper could benefit from a more in depth discussion concerning uncertainty of the applied methodology and a comparison with similar results, most likely from the UK, Netherlands and Denmark.

Minor comments to the text in the manuscript:

Page 12081 line 8-10: This sentence only concerns in-cloud scavenging. The authors must also consider below cloud scavenging.

Page 12083, line 2.4: The sentence "Models have the added advantage that calculations are made at a large number of model grid cells, invariably with much higher spatial density than that which can be achieved by measurement alone." This statement is likely to general. A good example of high resolution observations with large

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8, C5023–C5031, 2011

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geographical coverage is satellite based observations (e.g. Clarisse et al., 2009).

Page 12083, line 23. Please change “The model operates” to “the long range transport model” and add also the scales for Gaussian local scale model

Page 12083, line 26-29. Please extend the sentence” Vogt (2011) calculated ammonia concentrations and deposition at a 25m resolution in an agricultural landscape. Fine resolution model simulation was demonstrated to be necessary to reproduce measured ammonia concentrations.” The extensions could include a very short description on the tools and methods in a similar manner as the authors describe the OPS and DAMOS systems.

Page 12084, line 24. Please add (FRAME) and the reference as this is the first place in the text the model name is given.

Page 12084. The last section. Here the authors state that they want to use the FRAME model results at 1km, 5km and 50km. A few more lines why exactly it is interesting to study model results at these resolutions and not use the results from previous studies.

Page 12085. The use of an annual precipitation map and its actual resolution is likely to affect the calculated wet deposition. What is the underlying quality of that map, especially with respect to spatial resolution? Additionally, then it is likely an advantage with respect to wet depositions, that the authors use a high quality estimate of the annual precipitation to calculate the wet deposition. Precipitation from numerical models are one of the most uncertain factors. This could go into a specific sub-section or a general topic that discuss uncertainties.

Page 12085, line 18. please correct to the year 2011 in the reference to “after Poland (Kryza et al., 2011)”. I will also suggest tha the authors use recent studies that have been published in Biogeosciences (Zhang et al., 2011)

Page 12085, line 26. The authors name the model FRAME-Europe. This version of the FRAME model is new in the manuscript. Please provide a reference to that model

BGD

8, C5023–C5031, 2011

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or describe what it is.

Page 12088: About emissions in general. It is unclear what type of emissions the authors use for ammonia, except that they originate from the agricultural sector. Do the authors use one uniform emission factor for cattle for the entire model domain? Or do the emission factors depend on both production methods and geographical area (e.g. variations in annual emission due to overall variations in climate)? Do the authors have a hourly, daily or season emission profile (e.g. Hellsten et al., 2008; Skjøth et al., 2011).

12090, line 9. The geographical areas “The Pennines” and “The Lake District” are probably well known by readers with good knowledge of English geography, but less known by others readers. Please be a bit more general (e.g. adding North West England) to The Lake District and similar for The Pennines.

Page 12091, line 13-16. The authors argue that there is a clear improvement in model calculations with increasing resolution. It is partly unclear what the statistics actually cover. The particular section would also improve if the authors discuss the rural and the AURN network model results separately in relation to the purpose of the monitoring sites. The AURN network shows as expected improvements of all parameters down to 1km but the rural stations simulations does not. The authors could highlight that and discuss on more depth the cause to these differences.

Page 12092, line 2-12: The depositions estimates are a bit unclear how the have been made and what the main uncertainties are. Is it right, that the authors calculate depositions to each of the land cover types in the FRAME model (6 land cover types)? And is true that the authors afterwards associate the all the sensitive ecosystems to one of these 6 land cover types, thereby assuming that the deposition to these ecosystem is what have been calculated in the FRAME model (to one of the 6 land cover types)? If so, then there will be a potential systematic error for some ecosystems. If heath and bog use the mechanistic structure of woodlands (e.g. higher roughness) then dry

BGD

8, C5023–C5031, 2011

depositions might be overestimated to heath and bog compared to reality as these ecosystems in reality are less rough than woodlands. Please comment on that, and if it is relevant, then please discuss this in a final version of the manuscript.

Page 12093, line 16-23: This paragraph seems unsupported by scientific arguments. Please explain why, as there are no model simulations that shows both scenarios. Only the scenario in Fig 3 is presented. I need a scenario that presents model results that represents: “In regions where emissions are densely concentrated in areas of intense agriculture and urban agglomerations which are distinctly separated from natural ecosystems, high grid resolution is of lower importance.”

Page 12093, line 29: What is the unit keq Ha-1? This is also seen on Fig 4a,b.

Page 12095, line 1-2: “Less high resolution data (i.e. 5 km) was found to be adequate for calculating national scale summary statistics on the exceedance of critical loads.” I am very uncertain if this conclusion holds. They have aggregated 1 km resolution data that are based on 1km 1 emission input and 1km precipitation estimates to 5km. This is not the same as using 5km input in emission and precipitation and 5km receptor points. This topic is directly related to the second paragraph in this review.

Page 12095, line 3-6: Input data seems to be among the most sensitive things. The authors conclude that improvement on livestock number and agricultural practice is the key. How about dependence on climatic variables (e.g. temperature, precipitation)? This is directly related to the specific question concerning ammonia emissions on page 12088.

Minor comments related to figures and fables in the manuscript:

The number of decimals and accuracy in all figure legends could be re-assessed. As an example: Fig 1a: 100-200 etc would here be more appropriate. Additionally, is part of the green areas (0-100m) actually sea water or just low elevation terrain? Water areas must be without any color. Fig 1b: <1000, 1000-1400 etc would here be more

BGD

8, C5023–C5031, 2011

appropriate. Note that the figure has three cells without colour in the upper left part of the figure. Is this because the legend does not cover the lowest precipitation values? Fig 2: 0, 12, 24, 36,48,60 would here be more appropriate Fig 3a: 0.55-3.68. 0.5-3.7 would here be more appropriate Etc

About Fig 1a. Where do the data about the topography come from and what is the resolution? Please provide a reference.

Table 2. This table is unclear with respect to what it shows. Maximum value and minimum values. Are these model estimates and of what? The table needs units and a description of what the quantities are a summary of.

About Fig 5. The are no units on the axis in the scatter plots.

About Fig 5 (left). It looks as there are fewer red circles in Fig 5 (about 12) compared to blue triangles and green crosses (about 20). Please explain why.

About the Standford Park Site. There is no description of where this site is. Please add coordinates

Figure 3a, 3b. Needs coordinates/distances along the figure sides as on Fig 4a and 4B Figure 4a, 4b. The legend to the right needs a title as in figure 3a,b (NOx air concentrations).

List with possible locations that could benefit from a citation in this manuscript:

Page 12081, line 2: reference to emission inventories on sector based after " ..and road transport" Page 12081, line 5: reference after "vegetation types" Page 12081, line 6: reference after "..nitrate aerosols" Page 12081, line 8: reference after "..kilometres" Page 12081, line 14: reference after "..nitrogen.loving plants" Page 12081, line 18: reference after "..freshwater ecosystems" Page 12082, line 12: reference after "..by 2020" Page 12082, line 23: at least two references of networks that measure reactive N and Nin precipitation as examples after .."of precipitation" Page 12083, line 2: reference after "..natural ecosystems" Page 12083, line 11, at least one reference after "..emis-

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8, C5023–C5031, 2011

sions" as example Page 12083, line 14, please provide reference on at least two nested transport models after "..grid spacing" Page 12083, line 14, please provide reference after ".. multiple stages" Page 12083, line 16: please provide reference after "..grid spacing" Page 12083, line 18: Please provide reference after "..a trajectory model" Page 12083, line 22: please provide reference after "..transport model" Page 12083, line 22, please provide reference after "..transport-deposition model" Page 12084, line 10: please provide reference after ".to 50 km" Page 12084, line 12: please provide reference after "..load and levels" Page 12084, line 25: please provide references after .."Transport Model"

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Interactive comment on Biogeosciences Discuss., 8, 12079, 2011.