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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.

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Response to Referee #2

- I feel the paper could indicate some other reasons for which models may estimate exceedance erroneously. For example the paper indicates the 5 land classes and vegetation specific canopy resistance: this is important because deposition averaged over different ecosystems in a square can not be used to estimate exceedance (witness problems with earlier versions of the EMEP model in the EC's CAFE program). Similarly the paper mentions local scale orographic enhancement, where models that exclude this will systematically underestimate deposition. This would help to empha-

size that the analysis undertaken focuses on using a single set of model results for the finest grid, and averaging them over coarser grids; so that no differences between models or model runs is involved.

A discussion on the difference between various model parameterisations has been included in the introduction: “Significant differences in estimation of the exceedance of critical loads may be obtained with different modelling techniques. Choice of chemical parameterisation, calculation of deposition velocities and estimation of precipitation are all factors which can lead to a divergence amongst models in their estimation of nitrogen deposition. The seeder-feeder effect is explicitly represented in FRAME (Fournier et al., 2005) with an enhanced washout coefficient applied to orographic remain. This simulates the efficient removal of particulate nitrogen incorporated in cloud droplets and washed out from precipitation from above. Eulerian models, i.e. EMEP (Fagerli et al., 2011; Vieno et al., 2010a) and CMAQ: Chemel et al., 2010) have more complex microphysical schemes for formation of rain and cloud but do not explicitly include a parameterisation of the seeder-feeder effect. The representation of land cover and deposition to different vegetation types may vary between models and their applications. Whilst some applications use a dominant land category to derive deposition in each model grid square, others calculate deposition explicitly to different land categories. For ammonia gas in particular, the dry deposition velocity may be approximately an order of magnitude higher for forest and acid grassland than for improved grassland. Five different land classes are represented in FRAME (forest, semi-natural grassland, improved grassland, arable and urban). In the EMEP model 16 land classes are used, including sub-divisions of the arable and forest classes for detailed ecosystem effects studies.”

- I am a little concerned how the results might be extrapolated to other situations. A finer grid resolution can either lead to a higher or a lower exceedance, as is evident from table 3 for different ecosystems. This can be explained very simply mathematically by a figure comparing the frequency distributions of deposition for different grid sizes for

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a specific class of ecosystem, where the curves will cross over; and whether the area exceeded increases or decreases depends on the critical load relative to the cross-over level. Such a figure could be useful, and used to contrast the situation for montane for example, with other eocystem classes. It also makes it clear why exceedance for the highest 5%ile increases so sharply with grid resolution, and how this might differ for other percentiles.

This is an interesting suggestion. However, given the length of the revised paper following response to the four reviews, we prefer not to extend the article any further by inclusion of an additional set of analyses.

- The section on model validation gives references with respect to deposition, but focuses mainly on validation of NO2 concentrations. This seems a bit odd as there is no attempt to compare with critical levels for NO2 concentrations. - References have been given for previous model validation exercises with wet deposition. Gas concentrations are considered to be particularly sensitive to model grid resolution, so we refer to Hallsworth et al (2010) regarding model validation for variable grid resolution ammonia concentrations and give details on NO2 validation in this work. The main focus of the paper is on exceedance of critical loads. However we agree with the reviewer that exceedance of the critical level is of interest and have included an additional plot of UK NOx concentrations illustrating exceedance of the critical level as well as the following text:

"High nitrogen deposition can be seen close to major cities (i.e. London, Birmingham, Manchester) and along major highways, due to high NOx concentrations from road transport. The critical level for NOx concentrations as applied to natural ecosystems has been set as 30 μg m-3 (UBA, 2004). As illustrated in figure 2(b) this concentration is exceeded in areas of high road transport intensity, calculated with the model to be 5.2 % of the total area of the UK. However, it is important to note that these emission source areas have a high density of urban land area and a relatively low coincidence with natural ecosystems. Comparison with the 1 km resolution land cover map used in

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FRAME showed that exceedance of the critical load for NOx concentrations occurred over 33.4% of urban land area. 4.2% of forested land and 2.1 % of land with semi-natural grass land was calculated to have annual NOx concentrations in exceedance of the critical level."

- In fact there is an error in the title which should really be critical "loads" rather than "levels", as the paper is concerned with deposition and not concentrations. The title of the paper was changed to "The Influence of Model Grid Resolution on Estimation of National Scale Nitrogen Deposition and Exceedance of Critical Loads"

- The text is well written and clear but there are a few minor points: page 1, last line I suggest "emissions from farm animal wastes" page 2, line 5. Delete "Subsequent" and then "Atmospheric oxidation of NOx and chemical reaction can lead to...." - The recommended changes to the text have been made.

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