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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Operational mapping of atmospheric nitrogen deposition to the Baltic Sea" *by* O. Hertel et al.

O. Hertel et al.

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We are happy that referee #1 agrees to the importance of reaching a high spatial and temporal resolution in order to better investigate the connections between the nitrogen deposition to the sea and algal blooms, since this forms the basic idea of the submitted paper.

We are furthermore grateful for the very useful suggestions for improvements of the paper, and we have of course tried to meet as many of these suggestions as possible in the attached revised manuscript.

The referee #1 asks for a discussion of the advantages and disadvantages of the model system compared with other models. In section Ş3.3 Discussion of model performanceŤ there was a brief outline of advantages and disadvantages of the Lagrangian model and how this compares with Eulerian model systems. This section has been

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somewhat extended in order to meet the wishes of the referee.

Referee #1 furthermore asks for a paragraph where the present deposition estimates are compared with values from EMEP, HELCOM etc. Such a comparison has now been added to the section Ş3.3 Discussion of model performanceŤ including a table where literature values are listed together with the present estimate.

Referee #1 finds a weakness in the comparison with measurements, which is performed for mainly coastal stations where the meteorology e.g. the wind directions may be strongly affected by highly local conditions. The referee suggests that the model may perform differently for coastal and inland stations and that a more attentive investigation would have helped trace back some deficiencies in the model. Only three of the selected stations are inland (although still relatively close to the coast). The selection of stations was made aiming at comparing the model results for marine conditions. A detailed analysis where local meteorological conditions were taken into account would need access to local meteorological observations, which was not available for the present study. However, we have added a discussion concerning the uncertainties inferred by the fact that local meteorological conditions may have strong impact especially when the high temporal resolution (e.g. diurnal mean values) is considered.

Referee #1 requests more details about the basic meteorological input and how input data are treated in the model system. The model description in section Ş2 The prognostic model systemŤ has therefore been extended with more details concerning the used input data and how they are used in the model system.

Referee #1 has a specific comment regarding a mentioned 50% N-load from atmospheric deposition on p. 3495 line 15, where the request is to specify whether this regards coastal waters or the Baltic Sea as such. The results from Rosenberg et al. (1990) concerned the entire Baltic Sea basin, and this is now clearly stated in the text.

Referee #1 requests a diagram showing the input data from the various sources that the ACDEP calculations are based on. Since there are only two different models (DEOM

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and Eta) providing these data and the THOR system is just the overall system which these two models are a part of, we have decided just to clarify this in the text.

Referee #1 was confused by the two different spatial resolutions (16.67km x 16.67km and 30km x 30km) referred to in the paper. These resolutions are for emissions and grid of receptor points, respectively. In fact a third spatial resolution concerns the meteorological input data from the Eta model (approximately 39km x 39km). Since the model is a variable scale Lagrangian model, it is no constrain that input data need necessarily to be on the same resolution. Calculations are performed for a 30km x 30km grid of receptor points. However, this has been clarified in the paper.

Referee #1 asks for more details concerning handling of exchange with a reservoir layer at the top of the model domain and similarly how clouds above the domain are considered. A small section concerning vertical exchange between model layers where K-theory is applied has now extended the description of the model. A the top of the domain an influx of ozone is assumed, whereas for all other species exchange at the top of the model domain has been neglected. Similarly a small section has been added regarding in what way information about cloud cover is treated in the model.

Referee #1 finds that the plume growth of 1/10 should be better substantiated. We have added a reference to Hanna, Briggs and HoskerŠs handbook on atmospheric dispersion and extended the argumentation for the highly simplified parameterisation of horizontal dispersion.

Referee #1 requested a discussion about the representativeness of the monitoring stations. An analysis of each of the stations would be very demanding. In the analysis we trust in EMEPŠs capability in selecting locations for the monitoring sites and have just made a selection of a sub-group of mainly coastal stations distributed over the entire Baltic region. However, a short discussion concerning the difficulties in comparing point measurements at a monitoring station with model calculations that represent an average over a certain area has been added.

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Referee #1 claims that no explanation for over- or underestimation of modelled values vs. observed ones are provided in the text. Specifically the referee asks for addressing the models ability to simulate chemical transformation. However, in section Ş3.3 Discussion of model performanceŤ we have provided a list of main uncertainties in model calculations and pointed at where improvements could be obtained in the future.

Referee #1 finds that we state too high satisfaction with correlations below 0.7. We have moderated our formulations somewhat.

Referee #1 asks for explanation of time period for precipitation data shown in Figure 9. The figure show annual precipitation observed and modelled Ű this has now been added to the figure caption.

Referee #1 question our statement that the surface topographic details are not sufficiently resolved in the relatively coarse resolution in the currently applied version of Eta and whether this may explain the lacking ability to reproduce the observed precipitation fields. The operational Eta model at NERI has a horizontal grid resolution at 0.25 x 0.25 degrees, which corresponds to approximately 39km over Denmark. A combination of this grid resolution and the applied version of the Eta step-mountain coordinate system with 32 layers have the effect that the Danish land-masses have zero height in the Eta model. Even though Denmark is relatively flat compared to other countries, a not yet published investigation has revealed that part of the precipitation that falls over Denmark is due to orographic effects Ű this is widely accepted by Danish meteorologists. We have thus added a short paragraph in the text.

Referee #1 requested figures on the overall nitrogen deposition loads of the Baltic Sea and a comparison of the obtained geographic distribution with values in literature. This was not a straightforward task since it demands knowledge about the part of a grid cell that is covered by water. However, the overall load of the Baltic Sea is now provided in the text and the result compared with values in Literature. The obtained geographic distribution is discussed and compared with the results from the EMEP model.

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Referee #1 furthermore requests a discussion about the climatic features of 1999 compared with other years. We have added a discussion about precipitation amounts that where fairly high that year.

Referee #1 is perfectly right that Abstract line 16 should read 1999 and not 2000, this has been corrected in the text.

Referee #1 requests a number of references p.3501 line 9, this has now been added in the text.

Referee #1 suggest ŞdistributedŤ replaced by ŞstratifiedŤ p.3501 last line. This has been corrected in the text.

Referee #1 suggest ŞdataŤ substituted by ŞstationsŤ in Table 1Šs caption. Also this has been corrected in the text.

On request of refereee #1 we have changed the figure captions for figure 1,2 and 3, so that they now read Şstation codesŤ instead of ŞstationsŤ.

Also on request of referee #1 we have modified the figure captions of figure 1,2 and 3 so that they start by ŞComparison between observed and calculations annual mean..Ť

However, we have found no reason for modifying the scales of Figs 5 and 7 since the reader does not need to compare the absolute values directly Ű the main goal is to compare the distribution.

Referee #1 rightly points at the fact that the axis text in Fig. 7 reads wet deposition, whereas the values refer to concentrations in precipitation. This has now been corrected.

On request from referee #1 we have modified figure 9Šs caption to read ŞGridded precipitation on a 10km x 10 km grid from observed..Ť.

Referee #1 suggests to superimpose isolines of deposition obtained in other publications to make an interesting comparison in Fig. 11. However, we have not obtained

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values from the year 1999 in literature. Furthermore most values in literature are observations from single sites. We have instead discussed the results with respect to geographic distribution and compared this with EMEP values. Furthermore we have provided a table with literature values and discussed how these values compare with the present findings.

Referee #1 suggested a colour scaling of the receptor points aiming a making the interpretation easier. We have followed this very fine suggestion.

Interactive comment on Atmos. Chem. Phys. Discuss., 3, 3493, 2003.