

Review of

Atmospheric deposition of nitrogen to the Baltic Sea in the period 1995–2006

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General Comments

The environmental impact of nitrogen deposition and eutrophication is currently a major global concern. This paper describes an important application of atmospheric transport models, assessing the influence of emissions reductions on nitrogen deposition as well as inter-annual variability of meteorology. The paper is clearly presented and well referenced with appropriate graphs and tables. The main issue which I think needs attention is some inclusion of validation of the model with measurements or reference to such a study. Subject to a response to this point, I am pleased to recommend the paper for publication in its present form. I have noted a few minor corrections and raised a number of other comments for the authors' consideration.

Specific Comments

Introduction:

“The nitrogen input entering the Baltic Sea is both airborne and waterborne, whereas phosphorus input is mostly waterborne (HELCOM, 2010). Atmospheric deposition of nitrogen accounts for approximately one quarter to one third of the total nitrogen load to the Baltic Sea (HELCOM, 2005a)”

This suggests that two thirds to three quarters of nitrogen entering the Baltic Sea is waterborne. Presumably this contribution will also have decreased as emissions have gone down, though this may depend on the response of soil to nitrogen deposition. Can the authors refer to any studies which estimate how this input may have changed during the period of the atmospheric modelling study?

Introduction and section 2:

“Under normal operation, the EMEP model is frequently improved and changed, almost every year and often different model versions are applied for calculating transport and deposition in different years. The same applies to meteorological data, which can be provided by different Numerical weather Prediction 15 models in different years. By selecting the 1995–2006 period, we managed to avoid this kind of problems in the present study.”

This is an important statement and demonstrates the difficulties associated with applying atmospheric transport models to assessing environmental responses to changes in pollutant emissions. The same could also be said of emissions estimates. Techniques for inventories and spatial mapping of emissions have also changed significantly during the period of a decade and a half. How did the study account for this?

The validity of any atmospheric transport modelling study relies on the model having been compared with measurements. These results are not included here. Certainly the EMEP

unified model has been extensively validated against measurements. I don't think a detailed validation against measurements is required here but some reference to or summary of such a study for nitrogen compounds should be included.

The standard computational domain of the EMEP model is shown in Fig. 1 together with slightly smaller domain which was used for calculations presented here. The Baltic Sea Basin is located in the centre of reduced model domain, which is large enough for the estimation of nitrogen deposition and source receptor allocation for the Baltic Sea basin.

I suggest to state the model grid resolution and number of x and y grid points here.

Fig. 5. *Calculated annual deposition to the Baltic Sea basin of: dry oxidized, wet oxidised, dry reduced and wet reduced nitrogen in the period 1995–2006. Units: Gg N a⁻¹.*

Units: should be: Gg N Ha⁻¹.

Page 1812: *A large inter-annual variability can be seen in oxidised wet and reduced wet deposition, whereas, inter-annual variability in oxidised dry and oxidised wet deposition remains relatively low.*

This should be ... oxidised dry and **reduced dry** deposition ...

Page 1812: *In this case, other than precipitation, meteorological factors like annual patterns of wind direction, mixing height and temperature play an important role in the deposition.*

Can the authors be more explicit here? Perhaps greater large scale advection of air from high emissions areas in the south of the study is responsible?

Conclusion: *The average, over the period 1997–2006 contribution of Germany, United Kingdom and Poland and Denmark to total nitrogen deposition into the Baltic Sea basin is 20%, 12% and 10%, respectively.*

Should this be ... Germany, Poland and Denmark ... ?

Conclusion: *There is also a systematic increase of contribution from the international ship traffic on the Baltic Sea from 4% in 1997 to 5% in 2006.*

Presumably this is due to increasing international shipping traffic (and oxidised nitrogen emissions) whilst emissions from land have fallen. Can some comment be made on changes to shipping emissions? Perhaps these emissions could be included in Table 1?

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