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Hydrology and Earth System Sciences Discussions

Interactive comment on "Riverine transport of biogenic elements to the Baltic Sea – past and possible future perspectives" *by* C. Humborg et al.

Anonymous Referee #2

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General Comments

This paper presents a novel, insightful and provocative application of a hydrologically based nutrient-loading model (Mörth et al. 2007) and other considerations in the exploration of the consequences of future economic and climatologic changes. While lacking in the detailed dynamics that many would like to see in hydro-biogeochemical models, this model has the advantage of using consistent inputs, assumptions and processes through out the many watersheds and countries in the Baltic catchment. Details of the model and its calibration are not included, but were recently published by Mörth et al. Of course, all models have their shortcomings and not are entirely accurate, however this modeling approach allows one to address "what if" questions based on differing socioeconomic drivers, policy options and national actions and produce results that are robust in direction and range if not highly accurate.

The questions addressed in the paper are within the scope of the journal and highly relevant to the challenges to society in the 21st century. The presentation is concise, but references are provided to additional details, sources of information, and supporting literature.

Three scenarios of N and P loading are modeled, dealing with advanced waste treatment of point sources, reduction in the use of phosphate-based detergent, and increased animal production in agriculture. The consideration of the effects of climate change on Si and carbon delivery is separate from these analyses and does not seem to be based on the CSIM hydrological model at all. However, there is no expressed consideration of the effects of climate change on N and P delivery and the modeling scenarios assume the continuation of the contemporary hydrological regime into the future. While it is beyond the scope to the paper to run the N and P loads model under these changing hydrological conditions–and in fact the model is not calibrated for these new regimes–it would still tie the two parts of the paper together better if the authors discussed the likely consequences of the warmer and wetter (at least in winter) conditions forecast for the transitional nations by the IPCC and other assessments.

Specific Comments

The authors admit that the assumptions for animal agricultural intensification in scenario iii are rather extreme. Animal protein consumption in the transitional countries would have to increase only by 40% to equal that in Denmark. Furthermore, it is unlikely that such 4 to 30-fold increases in animal densities could be physically achieved and even if they could there would hardly be enough people in Europe to consume this production. However, it is important to keep in mind that the increase in and concentration of animal production in eastern countries (1098:12-16) is being driven not only by increases in economic condition and consequent animal protein consumption within those countries, but also because of a shift in animal production into the region

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from western Europe and, to some extent even North America, which are increasingly "outsourcing" animal production because of economic, environmental and social acceptability factors. Also, the assumptions used do not fully capture the increased cropping and increased application of fertilizers that will be required to support the increases in animal production. These points should be brought into the discussion while qualifying the assumptions and predictions of scenario iii.

While an extensive discussion of the effects of eutrophication in the Baltic Sea is beyond the scope of this paper, in order to place these results in the context of the concerns about nutrient loading in the Baltic brief information and references should be presented related to the following: HELCOM nutrient-load reduction goals; how N, P and Si affect phytoplankton composition (e.g. why reductions in P and increases in N would reduce Cyanobacteria and increase dinoflagellates); and the likely response times to nutrient load reductions. On the last two points, reference to and brief discussion of the important synthesis of Vahtera et al. (Ambio 36:286-294) seems appropriate: response to P load reductions will take a long time, but may also result in significant reductions in N fixation. In that regard also, increased in riverine N loading may have greater consequences for the nearshore waters of the Baltic.

In the same vein, the brief mention of the potential consequences of increased DOC concentrations in the Baltic requires at least a reference, if not a bit more discussion. Also it should be appreciated that the alkalinity of Baltic waters will be affected not only by river runoff, but also by equilibrium with the higher concentrations of CO_2 in the atmosphere, which are also causing ocean acidification, and by potential further reductions in atmospheric deposition of N and S.

Technical Corrections

1096:9. "livestock" in lieu of "live stock"
1096:19. In general, use "because" in lieu of "since" in such usage (also 1097:4, 1099:13, 1099:18)

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1097:4. “changes . . .translate”
1097:22. “southeastern”
1097:24-25. “are generally less densely populated . . . compared with the more populous and cultivated watersheds of the southeast.”
1099:4-8. “with a large N-surplus–i.e, N inputs per hectare as fertilizer, manure, feed and atmospheric deposition minus outputs as agricultural export and human consumption (references)–actually showed decreasing”
1099:14. “. . . Sea contribute only 4% of the TN”
1099:17 Grant et al. (2006, Ambio 35:117-123) also provide more recent information on the nutrient load reductions achieved in Danish agriculture. 1099:21-22. “In Poland, which contributes about 30-40%”
1099:25-26. “(Sapek, 1999). This was about half the application rates used in Denmark”
1099:27. “total amounts of fertilizers (N, P, K) are given" Potash is the form of K used.
1100:15-16. “in the 1990s in Poland and the percentage of the population . . . increased
” 1101:1. “more like Polish agriculture”
1101:29. “The effects of not better cleaning”
1103:9. “fluxes that constitute roughly 60%”
1103:15. “Russia (31%; 36%)” Added for consistency with other countries. Also, it is not clear in how it is presented here or in Table 5 that these percentages are the percent of the reduction attributed to that country, rather than the percent reduction in the load from that country.
1104:16. “for pigs an increase”
1105:9. ”were about twice as high”
1105:15. “weathering rates of silicate materials are related"
1105:20. “Lake Ladoga . . . that probably sequesters efficiently.”
1105:21. “Low yields were”
1105:23. “southeastern”

1106:2-4. “geological subregion of the Baltic catchment: both Sweden . . . for Swedish rivers and”
1106:18. Unclear what these units are.
1107:15. “drive” in lieu of “thrive”
1109:17. “”of the Baltic Sea, along with an increase”
1109:28. “even more topsoil, leading to”
1110:21. “density as high as”
1110:25. “a realistic possibility in the”
1119. Only emissions from milk cows vary among countries, otherwise the same assumptions apply. This table is given in Mörth et al. 2007; does it need to be included here as well?
1020. The association of the columns with the scenarios should be made more clear in this table. The caption would be clearer if it stated “predicted under” rather than “caused by” the various scenarios. Also the caption should make it clear that these percentages are the percent of the reduction attributed to that country, rather than the percent reduction in the load from that country.
1131. Surely Figure 9 and its caption are mislabeled as “longitude” instead of “latitude.”

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 4, 1095, 2007.