

Interactive comment on “A Holocene record of mercury accumulation in a pristine lake in Southernmost South America (53 S) – climatic and environmental drivers” by Y.-M. Hermanns and H. Biester

Y.-M. Hermanns and H. Biester

y-m.hermanns@tu-bs.de

Received and published: 3 October 2011

We thank Rereferee 1 for his helpful comments and answer as follows: RC: referee comment, AR: author response

RC 1: My only semi-major comment relates to the last sentence in the paper: “we conclude that Hg accumulation in the catchment soils due to atmospheric deposition and bedrock weathering is in balance with the export of organically bound Hg from the catchment soils.” This sounds at first read that authors are suggesting that

C3406

Hg(in)=Hg(out) of the catchment: :but surely this is not the case and that the soils are a net sink of Hg. A refinement of what they mean by this would also help in establishing a context from these results that could be used to help understand the more dramatic non-steady state situation that catchments are currently experiencing around the world.

AR 1: We agree with the referee that this statement is probably misleading and we will delete it. We just wanted to depict, that fluxes of Hg from the catchment into the lake remained comparatively constant in a long term throughout the Holocene. In a short term, however, our results show that, under natural conditions, terrestrial Hg fluxes can be highly variable. This is especially important concerning the enhanced Hg loadings of soils due to the increased Hg emissions since the Industrial Revolution. This “additional Hg” is now potentially prone to remobilization, transportation into aquatic systems and further bioaccumulation.

RC 2: In general, I think it is not appropriate to start sentences with chemical symbols: :spell out element name instead.

AR 2: We agree with the referee and will change that in the manuscript.

RC 3: Page 6556, line 5: :change “years” to “year”: :also, add the lake name to the abstract.

AR 3: We agree and will change that.

RC 4: Page 6556, line 18 (and elsewhere):“as carbon storage in the soils and transport into the lake have increased: :” How does the biogeochemical trajectory of this lake compare to that of the work of Engstrom and colleagues (Engstrom, D.R., S.C. Fritz, J.E. Almendinger and S. Juggins (2000) Chemical and biological trends during lake evolution in recently deglaciated terrain, Nature, 408, 161-166.): :similar, different?

AR 4: The study of Engstrom et al. (2000) shows a strong coupling between the primary terrestrial succession in newly deglaciated catchments and the development of

C3407

lakes in boreal regions, getting more dilute and acidic with time and receiving rising fluxes of DOC, which, in consequence, alters the lakes biology. We propose that the development of Lake Hambre and its catchment fits quite well with this concept of lake development for boreal lakes as it was established by Engstrom et al (2000) and will add an accordant reference. After the retreat of the glacier the terrestrial vegetation established and the amounts of terrestrial C accumulated in the sediments increased succesively. This implies that terrestrial DOC fluxes increased as well, suggesting a comparable development to what Engstrom et al. have described, including a drop in lake water pH and probably decreasing fluxes of dissolved solids and nutrients due to soil weathering. However, we do not have any information on how important ground water fluxes are for the hydrology and chemistry in Lake Hambre and, based on our data set, we can hardly evaluate the influence of terrestrial primary succesion on the aquatic bioproductivty in Lake Hambre. The rise in C/N ratios and C concentrations over time indicates a rise in terrestrial C fluxes as the major trend, but does not allow any conclusion about changes in aquatic productivity in a long term (although it's obvious that increasing DOM fluxes combined with changing nutrient fluxes as well as pH changes within the lake have an effect on aquatic productivity). However, we did not study a proxy solely representing changes in aquatic productivity. Today, the lake is rather productive during summer month, as indicated by lots of diatoms in the water column as well as in surfical sediments.

RC 5: Page 6558, line 20: :change "lake Hambre" to "Lake Hambre".

AR 5: We will change that.

RC 6: Page 6559, line 12: : "there were no other disturbances due to anthropogenic activities" That you know of? Or is there a very good history of the area?

AR 6: We will restrict our statements adding " at least to our knowledge" in line 12 on page 6559. However, the area has been always very sparsely populated by wandering tribes of Patagonian Indians, who were hunter-gatherer and did not clear the forests.

C3408

RC 7: Page 6559, line 17: :change "After opening the core: : ." to "After opening, the core: : ." add the comma. By the way, how was the core opened?

AR 7: We will insert the comma. The core was cut in two halves lengthside using a stainless steel saw.

RC 8: In the results and discussion section, the ratios of Hg to Cu and Y and a comparison to their average crustal ratios could be made. This is done in essence during the PCA and other discussions, but a simple x-y plot might to the trick.

AR 8: Ratios of Hg/Cu or Y/Cu might be helpful in two different aspects. First, a comparison between the ratios in the sediments with crustal ratios might show, if one element is enriched compared to another during its transport into the lake. We did this in essence by comparing concentrations of Hg, Cu and Y in the sediments with concentrations of the local rocks and soils, which is as we think a better reference than mean crustal abundances. Second: Elemental ratios in sediment cores could help to examine differences of given elements in their reaction towards changing transport processes or sedimentary conditions through time. This was, as the referee stated, already done during the PCA and, to account for long term changes, via the calculation of enrichment/depletion factors between the different sections (see p 6572, line 15 – p 6573, line 27). Y and Cu decrease to a similar magnitude (factor of about 3 from sec I to sec III), while Hg remains constant, which will consequently lead to a comparable decrease the Hg/Cu or Hg/Y ratios through time. As the second reviewer stated that the manuscript is a bit long we decided to omit further statistical data, which does not go beyond of what is already covered by the PCA.

RC 9: There is no indication of up-core increases in Hg associated with industrial Activity though the sampling resolution (1 cm) and nominal sediment accumulation rate (1.3 cm/y) should have made this possible. Any explanation?

AR 9: The coring technique using a piston corer often does not allow an undisturbed recovering of the uppermost very soft sediment layer (sapropel here). We therefore did

C3409

not recover the uppermost few cm with the piston core, but used a gravity corer for that section instead, which is usually correlated with the piston core afterwards. In this particular case there are three arguments leading us to decide against showing the gravity core as well. First, the discussion of the anthropogenic influence on atmospheric Hg fluxes and Hg accumulation in Lake Hambre is beyond the scope of our manuscript. Secondly, which is even more important, the catchment forests were clear-cut about 100 years ago, which drastically influenced erosion and therefore fluxes of OM, and major and trace elements into the lake, which we assume overwrites anthropogenic signals from long range transport (emissions in the Northern Hemisphere). Third, the evaluation of this section demands ^{210}Pb dating, which is difficult to obtain due to the low atmospheric ^{210}Pb fluxes in this part of the world.

Interactive comment on Biogeosciences Discuss., 8, 6555, 2011.

C3410