Geophysical Research Abstracts
Vol. 15, EGU2013-11933-2, 2013
EGU General Assembly 2013

Linking terrestrial and aquatic organic carbon in boreal lake sediments

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The coupling of terrestrial and aquatic carbon cycling has been well-recognized, but often difficult to characterize. The quantification of the aquatic versus terrestrial organic carbon (OC) sources plays an essential part in our understanding of the fate of the OC. Lake sediments, and boreal lake sediments in particular are well-recognized sites for the sequestration of OC, comparable to soils and living biomass. However, a clear picture about the extent of the aquatic versus terrestrial OC sources in lake sediments is currently lacking. Measurements of the non-exchangeable $\delta^2\mathrm{H}_n$ of the organic matter have become increasingly used to trace OC sources. Difficulties in measuring $\delta^2\mathrm{H}_n$ in bulk sediments, largely due to mineral matrix interference, are still hampering the implementation of this approach. Moreover, the separation of the terrestrial versus aquatic end members is not well established. We sampled surface sediment layers from 15 lakes, from the alpine subarctic and across the boreal forest zone, spanning a wide range, along the gradient of aquatic - terrestrial OC sources. The organic soil layer, groundwater dissolved organic carbon (DOC_G) as well as algae, were also sampled and analyzed for $\delta^2\mathrm{H}_n$ as a measure of terrestrial and aquatic end members, respectively. Moreover, the $\delta^2\mathrm{H}_n$ of soil water-extract (DOC_S) was also used to assess the contribution to the terrestrial end member. Soil, sediment and DOC_S samples were demineralized based on the implementation of a recently described method using a stepwise hydrofluoric - hydrochloric acid treatment, and in combination with solid-phase extraction of solubilized OC, to achieve high OC recovery. All samples were water-steam equilibrated prior to measurement of $\delta^2\mathrm{H}_n$. We show that the removal of the mineral matrix implemented here opens new insights not possible before. We discuss the use of $\delta^2\mathrm{H}_n$ in tracing the contribution of terrestrial versus aquatic OC sources as a new tool in linking terrestrial and aquatic carbon cycling.