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The Contribution of Lakes to the European Carbon Budget

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Large amounts of carbon entering lakes via stream inflow, mostly as DOC, are subject of diverse altering processes resulting in carbon sedimentation or degassing as CO_2 or CH_4. Carbon sedimentation in lakes is one of the rare natural processes that withdraw carbon from the atmosphere and store it permanently for geological time scales. On the other hand lakes seem to be generally CO_2 oversaturated and thus function as carbon sources with respect to the atmosphere. Because of their minor spatial coverage lakes are mostly neglected in studies concerning the global carbon cycle. So far estimates of carbon fluxes or even the spatial coverage of lakes are very imprecise.

Based on sedimentation data from 183 lakes and surface water data from 1495 lakes in Europe a detailed GIS analysis was carried out to identify controlling factors of carbon sedimentation and CO_2 gas exchange with the atmosphere. Results were used for a pan-European estimate of resulting carbon fluxes. Additionally, the European lake area was recalculated especially considering the role of small lakes that has been largely underestimated. We calculated a total European lake area of 240 000 km^2 consisting of over 300 000 lakes larger 0.1 km^2. This is ca. 40 % more than found in existing lake databases.

Carbon accumulation in lake sediments is generally low although it can reach considerable rates in individual small lakes. Comparatively high accumulations rates used for previous estimates are not reflected in our data. Mean carbon accumulation in small lakes is exceeding those in large ones. Pre-historic and historic human impact such as soil erosion raised carbon sedimentation in many lakes due to higher input of allochthonous material and thus a better preservation of organic matter. Further, recent eutrophication of lakes can cause increased carbon sediment concentrations. Because the affected layers are still exposed to degradation the long-term effect remain uncertain. The Holocene long-term mean of total European carbon accumulation in lake sediments was estimated at 1.25 Mio t a^{-1}.

CO_2 evasion via the lake surface is exceeding the long-term carbon storage in sediments by more than an order of magnitude. CO_2 concentrations in lake surface water are strongly varying with time. Almost all lakes showed periodical variations due to primary productivity with low CO_2 concentrations during algae bloom. Undersaturation was only occasionally reached in accordant spring or autumn. Erratic events like strong precipitation, ice break up or unusual water mixing may lead to enormous oversaturation resulting in high CO_2 emissions. These events are mainly affecting the total budget and are at the same time a source of major errors in estimates because of insufficient sampling intervals in most lakes. We estimated an emission of 17 Mio t a^{-1} C as CO_2 from European lakes.