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Challenges of deriving a complete biosphere greenhouse gas balance through integration of terrestrial and aquatic ecosystems

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Past research efforts have mostly focused on separately investigating the exchange of greenhouse gases (GHGs) within the limits of different terrestrial and aquatic ecosystem types. More recently however, it has been recognized that GHG exchanges and budgets are not limited to boundaries of the terrestrial or aquatic biosphere components and instead are often tightly linked amongst the different ecosystem types. Primarily the aquatic production and export of GHGs due to substrate supply or discharge from surrounding terrestrial ecosystems play a major role in regional GHG budgets. Understanding the mechanisms and drivers of this connectivity between different terrestrial and aquatic ecosystem GHG exchanges is therefore necessary to develop landscape-level GHG budgets and to understand their sensitivity to disturbances of the biosphere. Moreover, the exchange of carbon dioxide (CO_2) as the most important GHG species has been the primary research objective with regards to obtaining better estimates of the carbon sequestration potential of the biosphere. However, methane (CH4) and nitrous oxide (N2O) emissions may offset CO_2 sinks and considerably affect the complete GHG balance in both terrestrial and aquatic systems. Including their contribution and improved knowledge on the dynamics of these two gas species is therefore essential for complete GHG budget estimates. At present, the integration of terrestrial and aquatic GHG exchanges toward landscape GHG budgets poses numerous challenges. These include the need for a better knowledge of i) the contribution of CH4 and N2O to the GHG budgets within contrasting terrestrial (forests, peatlands, grasslands, croplands) and aquatic (lake, streams) ecosystems when integrated over a full year, ii) the effect of ecosystem properties (e.g. age and/or development stage, size of water body) on the GHG balance, iii) the impact of management effects (e.g. nitrogen fertilizer application), iv) differences among climate regions and v) the role of the spatial composition of landscape elements in modifying the aquatic GHG transport. In addition, present methodological limitations exist which currently create considerable uncertainties for estimates of complete biosphere GHG budgets. Recent data from various case studies in Canada, Ireland and Sweden will be used here to highlight the importance of these considerations.