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Continuous multi-plot measurements of CO₂, CH₄, N₂O and H₂O in a managed boreal forest – The importance of accounting for all greenhouse gases

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In order to assess the effects of different management practices on the exchange of greenhouse gases (GHG), it is desirable to perform repeated and parallel measurements on both experimental and control plots. Here we demonstrate how a system system combining eddy covariance and gradient techniques can be used to perform this assessment in a managed forest ecosystem.

The net effects of clear-cutting and stump harvesting on GHG fluxes were studied at the ICOS site Norunda, Sweden. Micrometeorological measurements (i.e., fluxgradient measurements in 3 m tall towers) allowed for quantification of CO₂, CH₄ and H₂O fluxes (from May 2010) as well as N₂O and H₂O fluxes (from June 2011) at two stump harvested plots and two control plots. There was one wetter and one drier plot of each treatment. Air was continuously sampled at two heights in the towers and gas concentrations were analyzed for CH₄, CO₂, H₂O (LGR DLT-100, Los Gatos Research) and N₂O, H₂O (QCL Mini Monitor, Aerodyne Research). Friction velocities and sensible heat fluxes were measured by sonic anemometers (Gill Windmaster, Gill Instruments Ltd). Automatic chamber measurements (CO₂, CH₄, H₂O) were carried out in the adjacent forest stand and at the clear-cut during 2010.

Average CO₂ emissions for the first year ranged between 14.4–20.2 ton CO₂ ha⁻¹ yr⁻¹. The clear-cut became waterlogged after harvest and a comparison of fluxgradient data and chamber data (from the adjacent forest stand) indicated a switch from a weak CH₄ sink to a significant source at all plots. The CH₄ emissions ranged between 0.8–4.5 ton CO₂-eq. ha⁻¹ yr⁻¹. N₂O emissions ranged between 0.4– 2.6 ton CO₂-eq. ha⁻¹ yr⁻¹. Enhanced N₂O emission on the drier stump harvested plot was the only clear treatment effect on GHG fluxes that was observed. Mean CH₄ and N₂O emissions for the first year of measurements amounted up to 29% and 20% of the mean annual CO₂ emissions, respectively. This highlights the importance of including all GHG when assessing the climate impacts of different forest management options. Our results show that continuous multi-plot measurements of the main GHGs are possible also at sites where GHG fluxes are low, at a reasonable cost and with reduced plot inter-comparison uncertainties.