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Published in:
Geophysical Research Abstracts

2012

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Geophysical Research Abstracts
Vol. 14, EGU2012-5391-1, 2012
EGU General Assembly 2012

Towards a Full Greenhouse Gas Budget at a Clear-Cut and Stump Harvested Boreal Forest Site in Sweden

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Clear-cutting and subsequent site preparation is common forest management practice in Sweden. In addition, stump harvesting (for bioenergy production) following clear-cutting has become more common in recent years. The net effects of clear-cutting/stump harvesting on greenhouse gas (GHG) fluxes are however not well-known. A full assessment of the benefits of any management practice has to include all greenhouse gases. Recent development of fast-response gas analyzers has made eddy covariance (EC) measurements of water vapor (H_2O), carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) possible. The applicability of these analyzers is however limited by high cost and in some cases by high power demand. By using the so-called flux-gradient method, it is possible to use one set of gas analyzers for a multi-tower setup to reduce both cost and total power consumption. In addition, using the same analyzers for measurements at several plots reduces systematic errors and minimizes the need for calibration.

The effects of clear-cutting and stump harvesting on GHG fluxes were studied at Norunda forest in central Sweden. Four different plots were established on a new clear-cut. All plots were clear-cut (early 2009) and site prepared (May 2010). Two of the plots were then stump harvested. On each of the plots, a 3 m high tower was erected and equipped for flux-gradient measurements of CO_2, H_2O, CH_4(May 2010 – October 2011), and N_2O (June 2011 - October 2011) exchanges. Friction velocities and sensible heat fluxes were measured by sonic anemometers (Gill Windmaster, Gill Instruments Ltd). Air was continuously sampled at two heights in the towers and gas concentrations were analyzed for CH_4, CO_2, H_2O (LGR DLT-100, Los Gatos Research) and N_2O (QCL Mini Monitor, Aerodyne Research). In addition, EC flux measurements of CO_2 and H_2O (Li-7500, LI-COR) were carried out on two of the plots (one of each treatment). The EC measurements allows for verification of CO_2 and H_2O fluxes from the flux-gradient measurements.

The clear-cut became waterlogged after harvest in 2009. Two of the plots (one of each treatment) were significantly wetter than the other two. All plots were on average sources of CO_2, with daily average fluxes ranging between -2.5 and +5.8 μmol $m^{-2}s^{-1}$. The ingrowth of new vegetation was faster on the wetter plots, resulting in lower average CO_2 emissions. Preliminary results indicate a switch from a weak CH_4 sink to a significant CH_4 source at all plots (higher emissions from the two wetter plots). Daily average CH_4 fluxes ranged between -7.9 and +218.4 μmol $m^{-2}h^{-1}$. There were significant N_2O emissions on all plots during the main growing season of 2011, with large emissions following heavy rain events. N_2O fluxes ranged between -63.7 and +403.7 μg $m^{-2}h^{-1}$ but without clear differences between wetter and drier plots as in the case with CO_2 and CH_4. Available data (including EC flux data for verification of the flux-gradient measurements) will be added to the time series and presented (in terms of CO_2 equivalents) at the conference.