Geophysical Research Abstracts
Vol. 16, EGU2014-16109, 2014
EGU General Assembly 2014

A field robot for autonomous laser-based N_2O flux measurements

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N_2O measurements in multi-plot field trials are usually carried out by chamber-based manual gas sampling and subsequent laboratory-based gas chromatographic N_2O determination. Spatial and temporal resolution of these measurements are commonly limited by available manpower. However, high spatial and temporal variability of N_2O fluxes within individual field plots can add large uncertainties to time- and area-integrated flux estimates. Detailed mapping of this variability would improve these estimates, as well as help our understanding of the factors causing N_2O emissions.

An autonomous field robot was developed to increase the sampling frequency and to operate outside normal working hours. The base of this system was designed as an open platform able to carry versatile instrumentation. It consists of an electrically motorized platform powered by a lithium-ion battery pack, which is capable of autonomous navigation by means of a combined high precision real-time kinematic (RTK) GPS and an inertial measurement unit (IMU) system.

On this platform an elevator is mounted, carrying a lateral boom with a static chamber on each side of the robot. Each chamber is equipped with a frame of plastic foam to seal the chamber when lowered onto the ground by the elevator. N_2O flux from the soil covered by the two chambers is sequentially determined by circulating air between each chamber and a laser spectrometer (DLT-100, Los Gatos Research, Mountain View, CA, USA), which monitors the increase in N_2O concentration. The target enclosure time is 1 – 2 minutes, but may be longer when emissions are low. CO_2 concentrations are determined by a CO_2/H_2O gas analyzer (LI-840A, LI-COR Inc., Lincoln, NE, USA). Air temperature and air pressure inside both chambers are continuously monitored and logged. Wind speed and direction are monitored by a 3D sonic anemometer on top of the elevator boom.

This autonomous field robot can operate during day and night time, and its working hours are only limited by the recharge time of the battery pack. It is therefore suited for field studies requiring high temporal and/or spatial resolution.