Geophysical Research Abstracts
Vol. 20, EGU2018-13486, 2018
EGU General Assembly 2018

Impact of flooding on N2O fluxes from tree stems in a grey alder forest

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Forest soils are considered to be an important natural source of nitrous oxide (N2O). Flooding changes soil redox potential and alters greenhouse gas (GHG) fluxes. Further, plant species react differently under stress conditions, depending on soil characteristics, time, temperature intensity, or characterisation of the stressing event in general. In 2017, we conducted an experiment (FluxGAF) using artificial irrigation to simulate flooding stress in order to investigate GHG fluxes in a hemiboreal deciduous forest stand, focusing on the role of fluxes at tree stems and their contribution to total forest fluxes.

The study site is located at a 40-years old Filipendula-site type grey alder (Alnus incana) stand in Estonia, consisting of two experimental plots: a flooded plot (FP; 40×40 m), where in summer 2017 during two weeks water was pumped (55–70 m3 per day) using an irrigation pipe system, and a control plot (CP; 20×20 m). The study period was divided into three periods: pre-flooding (8 July–7 August), flooding (8–21 August) and post-flooding (22 August–7 November).

Nine trees at the FP were equipped with manual static stem chambers (TSC; 0.1, 0.8 and 1.8 m from ground). In addition, automated ground chambers connected to Picarro 2508 analyser measuring N2O fluxes, piezometers, automatic groundwater level wells, soil temperature and moisture sensors (0-10cm) were installed close to each sampled tree. In 8 campaigns composite topsoil samples were taken for physico-chemical analysis in lab. In CP analogous equipment on and around three selected alder trees was established. During 28 campaigns (three times per week at daytime, once per week at night-time). N2O gas samples taken from stem chambers (0, 60, 120 and 180 min) were analysed in laboratory by Shimadzu GC2400.

At irrigation plot, N2O fluxes from the bottom part of the stems significantly increased during irrigation. Compared to CP, fluxes from tree stems at FP were significantly higher. With increasing stem height the fluxes were decreasing. Higher fluxes in flooding time were coherent with higher groundwater levels and soil moisture. At night time, the flux dynamics shows a similar pattern, however with lower values compared to daytime. Additionally, several site- and tree-specific factors such as soil nitrogen concentration, as well as presence of lichens and mosses (cryptogamic covers) on stem bark influenced the flux values. N2O fluxes from soil significantly increased during the flooding being, however, significantly higher than those from tree stems.

Our results show that stem fluxes of N2O, especially during extreme events such as flooding, are important elements in forest nitrogen cycles and must be included in relevant models.

Key words: Automated ground chambers; Cryptogamic surfaces; Forest nitrogen cycle; Nitrous oxide; Soil nitrogen; Stem chambers; Stress indicators