PROJECT INFORMATION

Project title: **The impact of dissolved organic carbon (DOC) and dissolved organic nitrogen (DON) deposition on soil solution DOC and DON**

Project ID: 123

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PROJECT DESCRIPTION

1. Introduction

Dissolved organic carbon plays an important role in the C cycle in natural ecosystems and contributes to the sequestration of C in mineral soils. It is one of the most actively cycling fractions of soil organic C pools and facilitates the transport and/or bioavailability of nutrients and pollutants, such as N, phosphorus (P), sulphur (S) and trace metals. It also forms a major pathway for C transfer from terrestrial to aquatic ecosystems, and provides a significant indirect source of CO_2 emission to the atmosphere. During the past decennia soil solution concentrations and fluxes of DOC increased in many forests, peatlands, streams and lakes of northern and central Europe and eastern North America. This increase has been linked to changes in soil solution chemistry induced by the overall decline of S deposition, suggesting that ecosystems are recovering towards their high-DOC, preindustrial state. The main source of DOC in the soil solution of forests is a number of temperature mediated processes, including plant and root litter decomposition, soil humus mineralization, root exudation, mucilage and microbial activity. Also, a certain amount of DOC reaches the forest floor by throughfall, but little information is available about its impact on soil solution DOC. Although the concentrations of DON in throughfall water and soil solution are correlated with the concentrations of DOC, since N-containing organic building blocks (proteinaceous or heterocyclic-N) are also comprised in the DOC, it is not clear to what extent DON concentrations follow trends in DOC.

Throughfall DOC concentrations and fluxes show a distinct seasonal pattern, with the highest concentrations and fluxes occurring in the autumn. In certain forests (particularly deciduous forests) the seasonal pattern is more complex, with a second peak in spring (mainly May). Several factors are believed to cause this spring peak, including leaching from opening buds and unfolding leaves, pollen distribution and the activity of phytophagous insects. However, more knowledge is needed to separate these effects, which occur simultaneously.

The ICP Forests data provides a unique opportunity to assess, on a large scale and based on a large number of sites, how and to what extent the deposition of DOC and DON influences soil solution DOC and DON concentrations, fluxes and their seasonal patterns. Hypotheses we will test are: 1) The concentrations of DOC and DON in throughfall are related to the concentrations in open field precipitation, 2) The concentrations of DOC and DON in soil solution are influenced by the concentrations of DOC and DON in throughfall, 3) The inter-annual patterns of DOC and DON concentrations in throughfall and soil solution can be explained by specific events in the annual forest life cycle (bud break, unfolding of leaves, pollen distribution, shedding of leaves), 4) Throughfall DOC deposition in May is related to pollen distribution and indicative for seed production, particularly for tree species with masting behaviour.

2. Methods

Available monthly aggregated data for a number of common tree species will be used. Soil water fluxes will be estimated from water balance models for about 40 plots and from throughfall volume using Na^+ as a tracer ion for the other plots. Soil solution DOC and DON fluxes will then be calculated from soil water fluxes and soil solution DOC and DON concentrations. Soil solution DOC and DON fluxes through the deeper mineral soil will be used as an estimate for C and organic N losses below the rooting zone. The volume of bulk precipitation and throughfall will be used to calculate the input of DOC and DON by deposition. Fluxes will be compared to obtain an estimate of the amount (%) of soil solution DOC and DON fluxes that could be explained by atmospheric deposition and canopy-derived DOC and DON. Seasonal patterns of water fluxes, DOC and DON concentrations, DOC/DON ratio and DOC and DON fluxes will be modelled using generalized additive models (GAMs). Also the link between throughfall DOC and DON fluxes, pollen distribution and seed production will be modelled using generalized additive models (GAMs).

2.1 Data

The data that will be used are the concentrations of DOC and DON in precipitation, throughfall and soil solution (organic layer and mineral soil layers) for a selected number of common tree species (*Fagus sylvatica* L., *Quercus robur* L., *Quercus petraea* L., *Pinus sylvestris* L., *Abies alba* Mill. and *Picea abies* L.). Also, the volume of bulk precipitation and throughfall will be used. Litterfall data (annual biomass of fruits and seeds) will be evaluated. Further needed data include soil data (e.g. total C stock) and general plot information (including e.g. altitude, longitude, latitude, tree species, age of the forest stand). Also, additional data on pollen distribution from individual countries will be evaluated. For five Level II plots in Flanders, the amount of pollen in subsamples of throughfall water (April-June) will be determined, if possible.

Data requirements:

- Available monthly aggregated data for deposition (volume, DON, Na^+) per plot (Waldner et al. 2016). DOC depositions still need to be calculated and the deposition dataset needs to be extended with data from 2012 and 2013, using the R-scripts written by Peter Waldner.
- Available monthly aggregated data for soil solution (DOC, DON, Na^+) per plot, measured depth and sampling period (data aggregated by Elisabeth Graf Pannatier and updated by Jim Johnson).
- Water balance data for about 40 plots (mainly in Germany and Switzerland)
- Litterfall data (annual biomass of fruits and seeds)
- Aggregated soil data on the ICP Forest Level II plots (FSCC, INBO)
- General plot information (including e.g. altitude, longitude, latitude, tree species, age of the forest stand) from vTI, Hamburg (Forms GENER, CTO or INV)

2.2 Outline of the data analyses approach

This outline may need to be revised after first exploration of the data. The main idea is that the study will be based on data of three subsets of the ICP Forests level II plots:

Subset I (deposition):

Plots:	ICP Forests Level II plots with >3 years of deposition measurements within the last 10 years
Driver variables	bulk precipitation volume, throughfall volume, concentration of DOC and/or DON in bulk precipitation and throughfall, altitude, longitude, latitude
Water flux calculation	throughfall volume, concentration of Na^+ in throughfall, concentration of Na^+ in soil solution (organic layer and mineral soil)

Subset II (soil solution):

Plots:	ICP Forests Level II plots with > 3 years of deposition measurements > 1 year of soil solution sampling (within the same period as for deposition)
Response variables	concentration and flux of DOC and/or DON in soil solution per depth (organic layer and mineral soil)

Subset III (litterfall):

Plots:	ICP Forests Level II plots with > 5 years of litterfall measurements > 5 years of deposition measurements (within the same period as for litterfall)

3. Expected results

- Calculated inputs of DOC and DON by atmospheric deposition
- Calculated exports of DOC and DON below the rooting zone (C losses)
- Information about the seasonal patterns of DOC and DON in atmospheric deposition and soil solution, and the link between both
- Information about the link between throughfall DOC in spring, pollen distribution and seed production

4. Expected products

- Publication of the results in a scientific journal with co-authorship of participating experts.

Time schedule (beginning and end of the project): 2017–2019

April 2013 Discussion of original project proposal in Expert Panels Deposition, Soil/Soil Solution
April 2017: Presentation of new ideas at the joint session of the Expert Panels Deposition and Soil/Soil Solution
June 2017 Updated Data request filed
June 2017 – March 2018: Update of aggregated deposition data (DOC, recent years)
March-September 2018: Analyses of data
May 2018 Presentation of state of the art at 7th ICP Forests Scientific Conference or 34th Task Force meeting (May 2018)
October 2018 – March 2019: Writing draft paper
March 2019: Discussion of results and paper at a joint session of the Combined Expert Panel Meeting
May 2019 Presentation of final results at 8th ICP Forests Scientific Conference (May 2018)
April-June 2019: Finalize Joint scientific publication and submission
June 2019: End of the project unless there would be an opportunity to write a second paper