frontiers | Frontiers in Earth Science

EDITORIAL
published: 30 June 2022
doi: 10.3389/feart.2022.930834

Editorial: Observing, Modeling and Understanding Processes in Natural and Managed Peatlands

Michel Bechtold[1], Björn Klöve[2], Annalea Lohila[3,4], Massimo Lupascu[5], Line Rochefort[6] and Hanna Silvennoinen[7]*

[1]Department of Earth and Environmental Sciences, KU Leuven, Leuven, Belgium, [2]Water Resources Engineering, University of Oulu, Oulu, Finland, [3]Climate System Research, Finnish Meteorological Institute, Helsinki, Finland, [4]Institute for Atmospheric and Earth System Research/Physics, Faculty of Science, University of Helsinki, Helsinki, Finland, [5]Geography Department, National University of Singapore, Singapore, Singapore, [6]Département de phytologie, Laval University, Quebec, QC, Canada, [7]Norwegian Institute for Nature Research (NINA), Trondheim, Norway

Keywords: greenhouse gas emissions, ecohydrology, peatlands, wetlands, carbon cycle, ecology, restoration, rewetting

Editorial on the Research Topic

Observing, Modeling and Understanding Processes in Natural and Managed Peatlands

OPEN ACCESS

Edited and reviewed by:
Wouter Buytaert,
Imperial College London,
United Kingdom

****Correspondence:***
Michel Bechtold
michel.bechtold@kuleuven.be

Specialty section:
This article was submitted to Hydrosphere, a section of the journal Frontiers in Earth Science

Received: *28 April 2022*
Accepted: *23 May 2022*
Published: *30 June 2022*

Citation:
Bechtold M, Klöve B, Lohila A, Lupascu M, Rochefort L and Silvennoinen H (2022) Editorial: Observing, Modeling and Understanding Processes in Natural and Managed Peatlands. Front. Earth Sci. 10:930834. doi: 10.3389/feart.2022.930834

INTRODUCTION

Peatlands play a critical role in our climate system. Although they cover only 3% of the global land surface, they store about one third of the world's soil carbon pool. The carbon-rich peat layers accumulated in locations of almost permanently waterlogged conditions over several thousands of years. However, the transition from the Holocene to the Anthropocene exerts a long-lasting change in peatland climatic and nutrient boundary conditions. The global impact of these changes on the stability of peatland ecosystems and their emissions of the greenhouse gases (GHG) carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) is currently unknown. In contrast, it is well known that the direct anthropogenic disturbance of peatlands by drainage and land use changes for agriculture, forestry and peat extraction severely alters the GHG budget of peatlands turning them into global hotspots of CO_2 emissions. New land use and management options that effectively mitigate peatland loss and maintain their important related ecosystem services are urgently needed. A deep understanding of peatland processes that can be combined with socio-economic and legal aspects is crucial for human society to explore and manage the future of Earth's pristine, disturbed and used peatlands.

This Research Topic assembles 14 original research papers (+ one corrigendum) and one review paper on various aspects of peatland processes. The Research Topic of papers includes research on peatlands at northern and tropical latitudes and provides new insights into the dynamics of their water, energy, carbon and nitrogen cycles of both natural and managed peatlands. Furthermore, innovative techniques are presented that are important for the upscaling of GHG emissions and their driving factors.

Carbon and Nitrogen Cycle of Natural Peatlands

The water cycle exerts a first order control on peatland processes such as the carbon cycle. The mesocosm study by Kim et al. shows that individual components of the water cycle component can interact with other peatland functions in a complex manner. In their experiments, the change of a specific feature of water level dynamics, i.e., the increase of the frequency of fluctuations, inhibited the growth of *Sphagnum* due to fungal infection and at the same time promoted peat decomposition. This, in turn, may severely destabilize peatland carbon storage. The result also has important implications for the paludiculture practice of *Sphagnum* farming for which biomass production might be maximized by establishing more stable water levels. With another mesocosm experiment, the study of Li et al. shows the fast response of vegetation composition to experimental warming which in turn controlled C fluxes together with water level dynamics. Thus, long-term monitoring of hydrology and vegetation change under climate warming is essential to examine their interactions in determining C fluxes in peatlands. In another study on CH_4 concentrations in ponds in Eastern Siberian peatlands by Rehder et al., the water level in ponds influenced water stratification and the fraction of vascular plants, which in turn mainly controlled CH_4 concentrations for similar pond types. The study, however, also shows that more research is needed to understand drivers that explain CH_4 concentration variability across different pond types.

The possible response of the carbon cycle to global warming was analyzed at a larger scale for the whole Hudson Bay Lowlands in Canada by McLaughlin and Packalen using a Bayesian Belief Network. In their approach, they combined a dataset synthesis on carbon fluxes and its drivers with expert knowledge on causal relationships between system variables. Their modeling results indicate an overall drying of peat under severely warmer climate scenarios that eventually reduces peat carbon sink strength due to increased peat combustion by changing fire activity, among other factors. Any upscaling approach requires best available data on the distribution of peatlands including their types and present carbon stocks. In this context, the study of Bourgeau-Chavez et al. demonstrates that the joint use of multi-temporal synthetic aperture radar (SAR) and optical remote sensing over the Amazonian peatlands improves the mapping accuracy compared to previous approaches. They attribute this improvement to the additional information contained in the strong moisture sensitivity of the SAR data. The strong seasonal hydrological dynamics present in the region generated features in the data that differed across ecotypes.

Compared to the carbon cycle, relatively little research has been conducted on the N cycle in peatlands although the critical interaction between both cycles is well known. Yin et al. provide a systematic review of peatland N cycling and quantified that over northern peatlands the N input through biological N fixation is about 3–4 times higher than by N deposition. However, they emphasize that the uncertainties of the current estimates of the biological N fixation are generally large. This counts in particular for the tropical peatlands for which studies on the N cycle are very limited.

Lateral release of carbon and other substances from peatlands can critically affect ecosystems in the surroundings of peatlands. In this context, Don Racasa et al. provide a detailed analysis of submarine groundwater discharge for a non-tidal coastal peatland located at the Baltic Sea. Using a numerical study, they showed that the release of carbon fluxes and other substances from the peatland through submarine groundwater discharge is probably highest for peatlands with high water levels, large saturated hydraulic conductivities and/or a dune dike or belt.

Peatland Management and Restoration

Several papers in this Research Topic deal with managed and restored peatlands. A detailed understanding of the hydrology of managed and restored peatlands is crucial to efficiently improve their GHG balance. In this regard, Ahmad et al. compared water level fluctuations in a drained and rewetted fen in Germany and showed that differences in the response of water level variation to meteorological conditions can be related to differences in the soil water storage capacity of two peatland sites. The study indicates the difficulty of establishing stable water level conditions given the expected increase in evaporative demands under global warming scenarios once peat properties are altered and thus less capable of buffering water level fluctuations.

Setting land aside from agricultural production has been proposed as a strategy to reduce GHG emissions from drained peatlands, restore natural habitats, and increase C sequestration. By comparing GHG measurements from a set-aside site and a cultivated site in Sweden, the study of Berglund et al. however indicates that the impact is likely limited for the reduction of CO_2 emissions unless drainage is also terminated. In a series of mesocosm experiments of Swedish agricultural peat soils, Norberg et al. examined factors controlling the emission of CH_4 and N_2O emissions. While measured CH_4 emissions were generally low, N_2O emissions were high for low pH and near-saturated conditions. Also biotic factors were found to be important as specific assemblages of nitrogen cycling guilds were detected in soils with low N_2O emissions.

The processes controlling the carbon balance of two drained forested peatlands in Finland with contrasting nutrient content was investigated by Kasimir et al. using a process-oriented model that was calibrated on data of the two sites. They found that the higher fraction of moss vegetation in the nutrient poor site was key for higher carbon accumulation despite lower photosynthesis because the moss added larger litter quantities with a resistant quality and also limited water depletion during dry spells. For tropical peatlands in Kalimantan, Swails et al. assessed changes of the GHG budget associated with peat swamp forest disturbance and conversion to oil palm plantation. The conversion to oil palm plantation implied a large net increase in peat GHG emissions, mainly released as CO_2. Also past land-use change strongly impacted peat net GHG emissions in a secondary peat swamp forest, decades following conversion and without active drainage.

While the direct measurement of GHG emissions is time-consuming and unaffordable for monitoring at many locations, Evans et al. propose a low-cost method that builds upon the link between subsidence and CO_2 emissions that typically control the GHG budget of drained peatlands. The method is image-based and measures peat surface motion and water level using commercially available time-lapse cameras and image processing tools. The proposed method offers the potential to be employed at large scale at multiple sites and is thus suitable for identifying areas of active carbon loss, targeting climate change mitigation interventions, and evaluating intervention outcomes.

Given the strong evidence that only high water levels can substantially mitigate GHG emissions from managed peatlands, economically attractive paludiculture practices need to be developed. In this context, Nielsen et al. investigated how harvest and fertilization frequency can be optimized to maximize protein yield and extractability of the flood-tolerant grasses tall fescue and reed canary grass in a fen-type peatland of Denmark. They concluded that these grasses have the potential for an enhanced valorization that goes beyond the common utilization for bioenergy. Economically feasible solutions are also urgently needed for peatland restoration projects. Experience in the restoration of peatlands impacted by mineral linear disturbances such as roads is rather limited which is addressed by Pouliot et al. They evaluated the efficiency of burying the mineral material in place below excavated peat in Quebec that was previously underlying the road. The 3-year post-restoration results suggested that the technique meets ecological restoration goals and is thus a cost-effective method in comparison to others that would include the complete removal of the mineral material.

SYNTHESIS

The papers compiled in this Research Topic make important contributions to our capability of observing, modeling and understanding processes in natural and managed peatlands. Several studies illustrated that the biogeochemical links between soil, water and vegetation as well as microbiology are very close and also complex in peatlands and thus require an integrative analysis of peatland functioning. Further advances in observational techniques and more comprehensive lab and field monitoring programs as well as international peatland databases are needed as a basis for integrative analyses that will eventually enable us to improve our predictions of the response of peatland processes to management decisions or climate change.

AUTHOR CONTRIBUTIONS

All authors listed have made a substantial, direct, and intellectual contribution to the work and approved it for publication.

FUNDING

BM acknowledges the support by the Research Foundation Flanders (FWO, G095720N).

ACKNOWLEDGMENTS

We would like to thank all authors and reviewers who have contributed to this Research Topic of papers and acknowledge the funding agencies involved in this research. We thank Klaus-Holger Knorr, Gilles Colinet, and Samuel Abiven for serving as additional handling editors.

Conflict of Interest: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.