FORCE - FORecasting hydrological response, Carbon balance and emissions from different types of mires in arctic-to-temperate zone transect in abrupt climatic change

Mires (specific wetland ecosystems preserved in a near-natural state and capable to accumulate peat soil under the constant saturation originating either from rainwater or groundwater) remain the most significant terrestrial carbon stock of the world. The most up to date research results have informed that former estimates of the amounts of carbon stored in mires can be underestimated by even as high as 100%. Dominant direct drivers of mire status originate from hydrology, namely the type (i.e., rain- or groundwater feeding) and quantities of water supplied to a mire and removed from this system in result of natural drainage and evapotranspiration. On top of the inappropriate management of these ecosystems persisting under the pressure of agriculture and industry, the abrupt climatic change expressed as quick warming and thawing of permafrost, longer droughts and seasonal shifts in precipitation can also significantly influence water flow processes and accumulation of peat. Impaired peat accumulation processes can result in a positive feedback of the emission of CO_2 as a response to supply of mineral-rich groundwater (resulting from permafrost thaw and increase of the fen catchment area in Arctic palsa mires) and water balance changes (resulting from shortages of water in temperate fens and sloping fens).

FORCE project focuses at the verification of the hypothesis that water balance and carbon balance of mires remains in a positive feedback with the abrupt climatic changes, resulting in expected decrease of carbon accumulation in peatlands and an increased emission of greenhouse gasses. Therefore, within the project, the team of 18 specialists representing 6 research units will solve several research tasks grouped in 6 separate workpackages (WPs). We intend to examine in detail groundwater flow processes, isotope composition of C, H and O in groundwater, surface water, soil and vegetation of 7 mires located in arcitc-to-temperate gradient (5 objects in Norway, 2 objects in Poland), covering a range of latitudes from 53.5^{o}N up to some 70^{o}N. We also plan to reveal the amounts of CO_2 transported by groundwater to the mires analysed and see how does the probable emission of CO_2 from groundwater in mires contribute to total emission of CO_2 from mires. Abrupt climatic changes and their influence on mire ecosystems will be described on the basis of literature review and data analysis in WP1. 10 campaigns of field research on each of the mires (WP2) will be scheduled in order to install necessary measurement devices and to collect data for the modelling (groundwater levels, samples of soil for hydraulic conductivity estimation, water samples). Origin of water in particular zones of the mire will be modelled (WP3) in order to reveal the origin of water supplying particular objects. Isotope composition of water will be revealed in order to confirm the origin of water feeding particular zones of the mire and calibrate groundwater flow models. Statistical analyses of model parameters (WP4) in a Monte Carlo based approach will be used to specify probable range of parameters representing abrupt climatic change (e.g., temperature-driven evapotranspiration changes; changes of porosity and hydraulic conductivity of aquifers modelled in WP3) and to assess the most probable responses of hydrological systems of mires to these expected abrupt climate change. Laboratory estimation of isotope composition of C, O and H in groundwater together with the precise assessment of concentrations and emissions of CO_2 and CH_4 and Net Ecosystem Exchange (WP5) will allow to specify on the role of other-than-'traditional' sources of greenhouse gasses emissions from mire, including the processes of ecosystem respiration, evasions from aquatic ecosystems and groundwater. Integration of results based on the estimates of the probability of occurrence of specific hydrological pressures to mires (output of WP4) together with the information on contemporary emissions from the examined mires (output of WP5) will allow to assess the probability of the occurrence of feedbacks stated in the main hypothesis of the project. Bayesian belief network will be applied as a final tool (WP6) to provide the range of probabilities of occurrence of climate-induced pressures and response of natural fen mires to these pressures, integrating results of the project.

Majority of the processes to be tackled in the FORCE project has not been addressed in the scientific literature so far (e.g., emissions of CO_2 from groundwater depressurized at the mire/groundwater interface; assessment of the share of emissions from aquatic ecosystems and groundwater to the emissions from the peat; assessing the role of the abrupt climatic changes in hydrological processes of mires and their catchments). Novelty of research tasks and expected results and outputs of the project related to the verification of its main hypothesis are likely to influence the global perspective of the need for conservation of natural mires and considering abrupt climatic change as a challenge for mire-related and water-related elements of carbon cycle in the global scale. It is likely that the messages resulting from the FORCE project implementation will influence international NGO strategies oriented at promotion of mire research and conservation, placing new threads of emissions and carbon accumulation in a management context. The FORCE project is intended to promote development of scientific staff of research institutions participating in the application, including providing positions to 2 post doc researchers and 1 Ph.D. student. Interdisciplinarity of the research team and scheduled tasks promotes the integration of physical, technical, biological and Earth sciences.