Kohlenstoff im Permafrost: Bildung, Umwandlung und Freisetzung – CarboPerm

CarboPerm is a joint BMBF project. The aim is to investigate the formation, transformation and release of organic carbon in permafrost using a multidisciplinary research approach (geographical, microbiological, isotope geochemical observations, analyses and models) in order to close current knowledge gaps in permafrost research. This will aid our understanding of the development of permafrost landscapes in the wake of global warming and its impact on the global carbon balance. The relevant modern and fossil processes of the C cycle in permafrost will be extensively analysed at key Siberian locations (Dmitri Laptev Strait, Lena Delta and Kolyma Lowlands) and on samples collected by drilling, from exposures, and excavations using field, laboratory and model experiments.

CarboPerm brings together German and Russian permafrost experts in several sub-projects (SPs): "Fossil carbon: Structure, properties and dynamics", "Age and quality of the organic material", "Modern carbon dynamics of permafrost landscapes", "Microbial carbon transformation", and "Process-oriented modelling of carbon dynamics".

The sub-project **Process-oriented modelling of soil carbon dynamics in permafrost regions**, involving MPI-BGC in Jena and MPI-M in Hamburg, will bring together the results of the other sub-projects to create a theory of carbon dynamics under permafrost conditions. A model environment featuring mathematical descriptions of relevant processes will be generated which explains CO_2 and CH_4 flows on a short time scale and spatial patterns of soil carbon profiles on a long time scale, linked to environmental conditions. The underlying biological processes are strongly influenced by the thermal and hydrological conditions within the seasonal thaw zone and in the permafrost. In reaching this objective, we will take the high degree of vertical and horizontal heterogeneity in the ecosystem quantities in the tundra into consideration.

Detailed models will be developed on local to regional scales which formalise the process knowledge of the other sub-projects and explain observations on the different spatial scales from pedon through to ecosystem. The following processes will have to be described by a number of differential equations:

- Vertical transport of energy, water and carbon
- Stabilisation and destabilisation of organic material in the soil matrix
- Dynamics of microbial biomass and population in relation to environmental conditions
- Microbial breakdown and conversion of organic material, CO_2 and CH_4 emissions, methanotropy
- Transport of SOM and POM into and out of the system

We will also focus on the horizontal heterogeneity within a grid cell and the dynamics of the water level (aerobic/anaerobic) in relation to soil property, terrain gradient and heat dynamics. Feeding such a process model with climate data and [CO_2] scenarios will permit an initial assessment of the vulnerability of the soil carbon in the permafrost and the future CO_2 balance and methane emissions of different tundra regions.

A generalisation of the key processes on the landscape scale has been planned for implementation in the JSBACH global ecosystem model. This involves consistent coupling of physical and biogeochemical elements of the land surface schema and will be carried out in close collaboration with the MPI-BGC and MPI-M groups. The model will be evaluated using global data records and compared with other global models. Also, a peat dynamics model for boreal and polar wetland areas will be used to quantify the accumulation of organic material during the interglacial and interstadial periods. For the first time organic C quantities will be estimated in regions for which no information on peat density is available. The feedback mechanisms between the Arctic land surface and atmosphere and resulting consequences for the future climate and future carbon flows will be studied in interactive simulations of the MPI-ESM forced only by scenarios of fossil fuel emissions.