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Regional GHG emission transfer functions of peatlands: An analysis based on water levels from process-based hydrological modeling

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At the point scale, many studies on greenhouse gas (GHG) emissions from peatlands are focused on developing accurate transfer functions that relate the amount of GHG emissions to site characteristics, like water table depth, vegetation and physical and chemical soil properties. Given that for a specific peatland environment such a 'point-scale' transfer function is uniquely defined, it can be spatially applied when the necessary spatial information about the function parameters is available. Assuming the point-scale transfer function was developed on an annual time scale, the spatially-variable average site conditions of one year (e.g. annual mean water table depth) can be translated into a regional estimate of the total GHG budget. When the conditions of the system change, e.g. due to rewetting measures or different climatic conditions, changes of the regional GHG budget can be estimated by applying the point-scale transfer function to the new site conditions.

Here, we discuss the behavior of the GHG budget variability against changes of the spatial water table depth distribution. The latter is obtained from spatially-distributed process-based hydrological modeling using the hydrological modeling framework SIMGRO (Alterra Wageningen). The interaction of groundwater, unsaturated zone and surface water fluxes was modeled for a peatland area of 200 ha (Großes Moor, Gifhorn, Germany) using spatial information on vegetation, peat layer thickness, hydraulic properties, surface water system, system boundary conditions and a laser-scan digital elevation model (DEM) as well as measured water level time series as calibration input. Based on the water level data from various hydrological scenarios, GHG budgets were estimated. Results demonstrate that the analysis of the GHG budgets as a function of different mean regional water table depths provides insights into the behavior of the regional GHG budget for the study area. The resulting curves can be called 'regional transfer functions'. In contrast to the point-scale transfer function, the regional transfer function is not unique and depends on the specific change of the hydrological status. For the study area discussed here, the regional transfer functions show that, at the regional scale, climate neutral conditions are difficult to achieve by rewetting measures. The regional transfer functions also indicate the hydrological condition that leads to the lowest total sum of GHG emissions, for which trade-off between methane and CO_2 emissions is optimal at the regional scale.