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Land use GHG emissions and mitigation options, simulated by CoupModel

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Abstract

Climate change and greenhouse gas (GHG) emissions are one of the major challenges to the humankind of 21st Century. This thesis focuses on understanding, estimating and suggesting mitigation of the GHG emissions (mainly N_2O and CO_2) from the land use sector, specifically from forest ecosystems on drained peatlands but also from willow production on agricultural clay soil. This is achieved by merging a detailed process-oriented model, CoupModel with available data collected with state of art measurement techniques.

The results show the CoupModel is able to simulate soil N_2O and CO_2 emissions for both land use types, despite not precisely capturing each measured N_2O peak, which still remains a challenge. Model analysis reveals the major N_2O emission controlling factors for afforested drained peatlands are vegetation and groundwater level, while fertilization and soil water status are the controlling factors for willow production on clay soil. Over a full forest rotation the forest trees act as a C sink and the drained peat soil as a source, of fairly similar size and the forest ecosystem is an overall GHG sink. However, also including the fate of the harvested forest, indirect GHG emissions, would switch this extended system (from the production site to the fate of the products) into an overall large GHG source. The modelling also predicts rewetting spruce forest on drained peatlands into willow, reed canary grass or wetland could possibly avoid GHG emissions by 33%, 72% and 89% respectively. In a cost-benefit analysis, the two wettest scenarios, wetland and reed canary grass, the monetized social benefits exceed the costs, when using social costs of carbon as a proxy for the value of GHG emissions, beside profits made from sold products and also value of biodiversity, avoided CO_2 due to both replacement of cement and steel in buildings as well as fossil fuels for heating and electricity production.

These findings provided in this thesis fill some knowledge gaps of modeling N_2O emission and GHG balance over full forest rotation on drained peatlands, provide perspectives for mitigation GHG emissions from drained peatlands and bioenergy production on clay soil. In addition, the calibrated parameters and correlations between the parameter and variables in this thesis provide guidelines for future modeling of GHG for similar types of systems.

Keywords: GHG; CO_2; N_2O; forest; drained peatland; clay soil; willow; soil nitrate leaching; modeling; CoupModel; Generalized likelihood uncertainty estimation (GLUE); Land use; mitigation option; Cost benefit analysis