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Climatic responses of the carbon cycle in Finland assessed by regional modelling

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The carbon cycle of the northern ecosystems is strongly influenced by the climatic variables. The changing climate may thus have noticeably impact on the carbon balances in the high-latitude regions. In this work we assessed the carbon balance of the Finnish ecosystems with a process-based biosphere model JSBACH that is a global model but can also be run at regional and site scales. We prepared the meteorological forcing for the model run by using a regional climate model REMO with new land cover data set based on European Corine Database. Our spatial resolution was 0.167 degrees and the time step for the simulation was one hour.

We also made site level simulations at four eddy covariance measurement sites to evaluate the model performance. The sites included three forests and one agricultural site, all located in Finland and the forests were covering a wide north-south latitudinal gradient. Model performance was satisfactory, but the drought-induced drawdowns in the carbon fluxes were not replicated by the model. Surprisingly, the simulation results matched better the observations with the meteorological forcing taken from the REMO run than the simulation results run with the locally observed meteorology. The reason for this was the too early emergence of carbon fluxes when run with the site data, which was compensated by slightly colder spring temperatures of the regional run forcing. The two different forcings led to different directions on the annual carbon fluxes, i.e. sink or source, on some years. Additionally, we performed some tests to initialize the model with observed biomass and soil carbon pools to assess how the model that is usually run with steady state assumption performs.

The modelled carbon balance for Finland was comparable to other estimations that were based, e.g., on forest inventory or inverse modeling. When subdividing Finland along the north-south direction, carbon fluxes in northern part of Finland had different characteristics in their behavior compared to other regions. This is partly related to different land cover types and partly to the environmental conditions: northern Finland had smallest fraction of forests and a higher percentage of deciduous forests than other regions.

We studied the impact of climatic variables on the carbon fluxes during different seasons in the whole Finland and three sub-regions during years 2001-2010. We found that temperature was the most important controlling factor of the carbon fluxes, whereas the precipitation did not have a large role according to the modeling results. The warmer autumns led to increase in the respiration flux that influenced the whole annual carbon balance. Some grid points showed increasing trend in respiration, otherwise no trends in carbon fluxes were present during our study period.