SOMPA

WP 3
Modelling peatland GHG emissions

HELSINGIN YLIOPISTO

ILMATIETEEN LAITOS

Aims:

● A modelling tool to simulate effects of different management options on the CO_2 and CH_4 exchange of peatland forest soils.
● Predictions of CO_2 and CH_4 emissions of peatland forests of Finland under different management practices. Modelling enables considering a wide regional scope and scenarios.

Models:

● JSBACH is the biosphere component of MPI-Earth System Model. It accounts for soil and vegetation energy and carbon balances.
● HIMMELI (HelsinkI Model of MEthane buiLd-up and emIssion) is a separate peatland CH_4 module, designed originally for pristine peatlands.

Model development / modification

- Implementing a new vegetation type, forested peatland, in JSBACH, with connection between cutting intensity and peatland water level.
- Combining HIMMELI with JSBACH.
- Modifying HIMMELI to improve simulation of CH_4 fluxes of drained peatlands.

Manuscript underway

Modelling the harvesting effects on CO_2 and CH_4 fluxes from peatland forest floor by the JSBACH-HIMMELI model

X. Li, T. Markkanen, M. Korkiakoski, A. Lohila, A. Leppänen, T. Aalto, T. Kleinen, M. Peltoniemi, R. Mäkipää, M Raivonen

We aim to model the management effects on water table depth, CH_4 and CO_2 fluxes from the soil of peatland forest site Lettosuo

Model structure

Meteorological forcings

T_{Air}
Air pressure
Precipitation
RH

Wind speed
SW radiation
LW radiation

JSBACH
(land surface component of MPI-ESM)

T_{soil}
Water table depth

Anaerobic decomposition rate

HIMMELI

CH_4 and CO_2 fluxes from forest soil

Model development

JSBACH

- peatland YASSO
- Water table adjustment coefficient linked with leaf area index (LAI)
- LAI varies with management practices

Modified HIMMELI

- testing different treatment of moving water table level

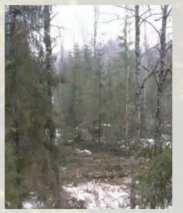
Model evaluation

Model results evaluated with 2-3 years post-management field data from Lettosuo, Finland

Nutrient-rich peatland forest, drained in 1969, forest management conducted in 2016

Clear Cut

Control



Partial harvest

Preliminary results

Our model:

- simulates reasonably the seasonal variation of and the effects of alternative forest harvestings on water table level

- is able to simulate uptake of CH_4 at the non-harvested and partially harvested site, and CH_4 emission at the clearcutting site, as was observed in measurements

- simulates a dynamic trade-off between soil CH_4 and CO_2 flux, depending on changes in ground water level

Manuscript underway:

ILMATIETEEN LAITOS
METEOROLOGISKA INSTITUTET
FINNISH METEOROLOGICAL INSTITUTE

Climate scenario simulations of peatland forest site carbon balances under continuous cover and rotation forestry

Tiina Markkanen, FMI
Leif Backman, Xuefei Li, Maarit Raivonen, Antti Leppänen, Tuula Aalto et. al.

JSBACH-FOM-HIMMELI

- HIMMELI is a methane production and transport model.
- JSBACH is a land surface model accounting for soil and vegetation energy and carbon balances (no nutrients explicitly in our version).
- FOM module for even aged forestry with carbon allocation in growth and clear cut -cycles.
- YASSO soil carbon model for mineral soils.
- Water table level regulated by transpiration.
- Peatlands with slowed decay rates within the water-logged (thus anoxic) fraction of soil carbon (T. Kleinen).
  - Slow decaying deeper pools (i.e. YASSO humus), usually water-logged
  - Fast decaying upper pools (i.e. YASSO AWEN), often anoxic

Lettosuo case as baseline

(Korkiakoski et al 2016, 2019, Leppä et al 2020)

- Draining in 1969 resulted in pine forest growth.
- Stem wood 248m³/ha~=15kg/m²
- Soil carbon 156+-72kg(C)/m² currently
- Clear cut took place in 2016.
- WTD rose of 23 cm.
- Net CO_2 source increased during the first years.
- From CH_4 sink to small source.
- Also a thinning plot with a reduction of 70% DBH.

Regional model set-up

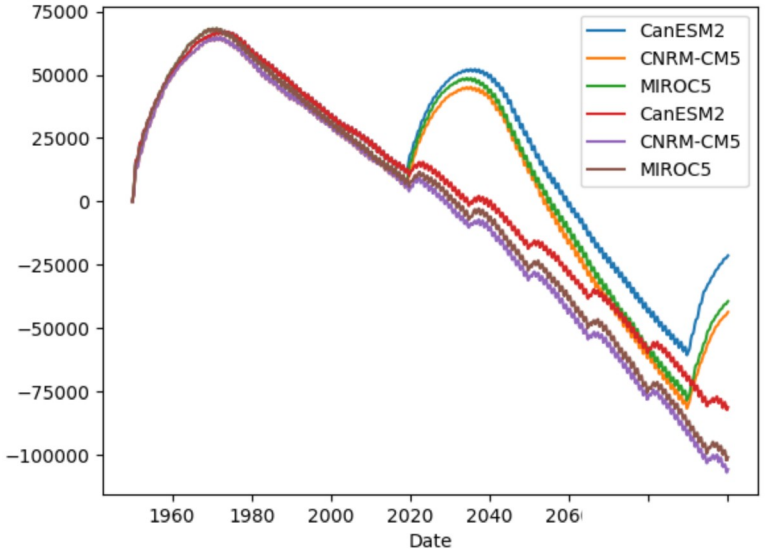
- Forest growth initialisation in 1950
- Initial soil carbon of 155kg(C)/m^2
- Clear cut in 2019 and consequent growth of 70 years or a
- Thinning with reduction of 50% of woody biomass, first in 2020 and then in every 15th year.
- In thinning 23% of above ground wood is relocated to soil pools

  50% of underground litter and cutting slash goes to slow pools and 50% to fast pools.
- Climatic forcing with three Euro-CORDEX climate scenarios up to the end of the century for three Finnish regions: Uusimaa, Pohjois-Karjala, Lappi.
  - CanESM2, CNRM-CM5, MIROC5 ESMs downscaled with a regional climate model and bias adjusted towards historical climate.
  - Lettosuo is located in Uusimaa.

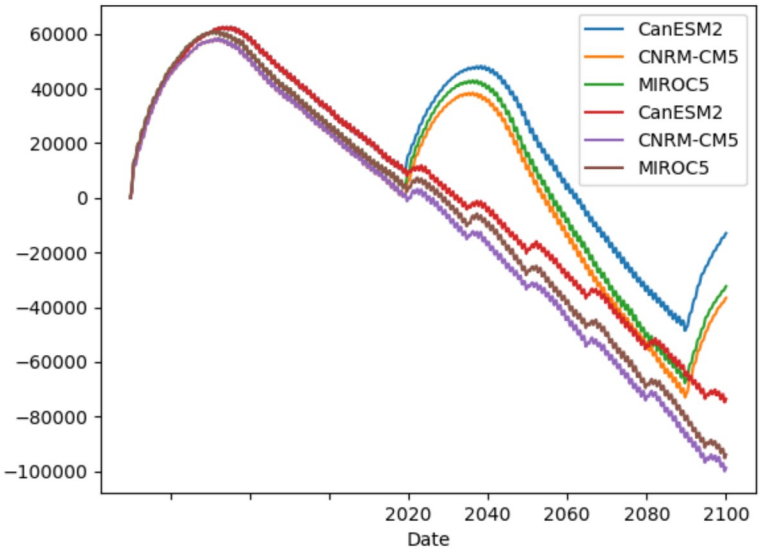
Preliminary results, an example:

CO_2 balance, cumulative (kg(C)/ha)

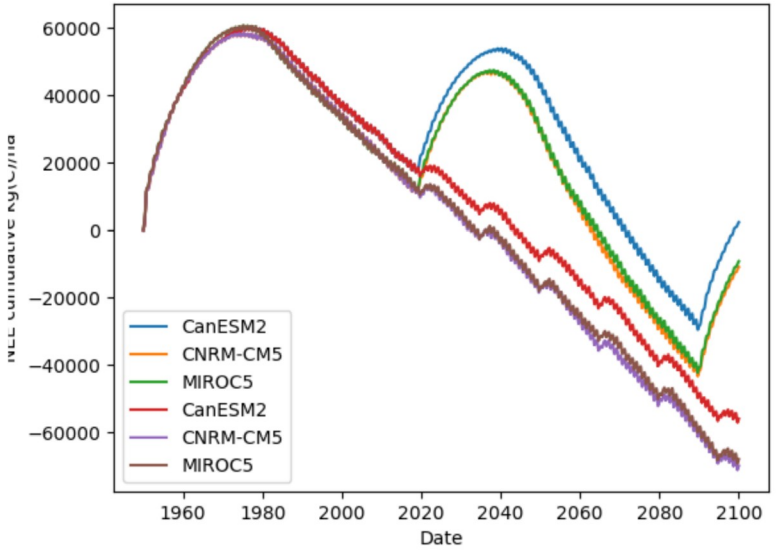
Net Ecosystem Exchange (NEE), Uusimaa



Pohjois-Karjala



Lappi



Preliminary results

- Carbon balance terms are sensitive to climate drivers.
- Net Primary Productivity (NPP) increases because of rising temperatures and CO_2 fertilisation.
- Current day soil carbon loss is followed by accumulation of soil carbon of different degree depending on the management.
- The accumulation is linked to cutting slash fraction and its allocation to soil carbon pool fractions.
- NEE is close to balance or small cumulative sink. Net Biome Production (NBP) is a different story still.
- Methane emissions increase towards the end of the century.
- Water table rises because increasing precipitation and decreasing conductance.
- Water table might limit growth.
- CO_2 fertilisation effect may be too strong.