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Implementation of Landscape-DNDC model at a nutrient-rich peatland site in southern Finland

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Site

- Lettosuo, southern Finland (60 degrees 38’ N, 23 degrees 57’)
- Drained 1969 using ditches 45 m apart, total area of 65 ha.
- Nutrient rich Vaccinium myrtillus type II (MtkgII).
- A mixed forest site, pine, some birch trees occupying the upper story vegetation (figure 3)
- Spruce making up the secondary canopy, which makes up the main stand after partial cut and some ground vegetation (figure 3).
- Soil carbon ~180kgm^{-2}

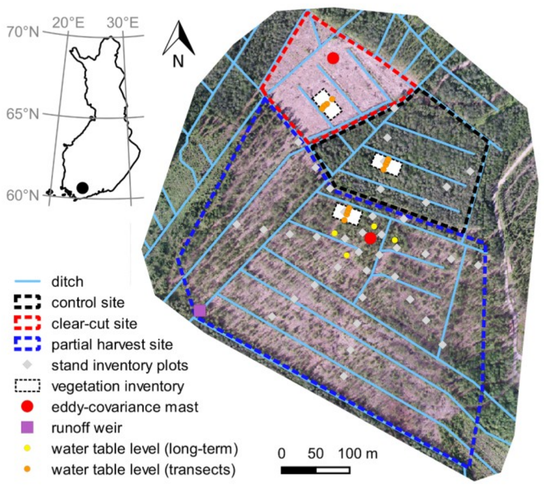

Figure 1: Lettosuo site (Leppä et al. 2020)

Forestry management:

- Before applied management methods whole site was forested.
- Control : Section where no management action took place
- Partial cut: All pine trees were removed during March 2016
- Clear cut: All trees were removed during March 2016. This plot was further modified by restoring the ditches, and the peat soil dug from the ditches were used to make mounds, where new spruce seedling were planted in 2017.

Data

- Used in this study: Control 2010-2018, Partial cut and clear cut 2016-2018
- EC measurement preharvest 2010-2015, post harvest 2016-2018
- Automatic chamber measurement (CH_4) control 05/2015 – 05/2018, partial cut 06/2015 – 12/2018.
- Manual chamber measurement (CH4) clearcut 2016 - 2017
- Watertable 2010 -2018
- LAI estimated from satellite measurement.

Landscape-DNDC model and setup

- Simulates hydrology, physiology, soil-chemistry and micrometeorology in daily or sub-daily scale
- This study: hourly scale
- Simulation 1969-2018
- Pine and birch seedlings, and alpine meadows (Mead) from 1969, and spruce seedlings from 1998.

References

Korkiakoski et al. 2023, Partial cutting of a boreal nutrient-rich peatland forest causes radically less on-site CO2 emissions than clear-cutting.

Leppä et al. 2020, Vegetation controls of water and energy balance of a drained peatland forest: Responses to alternative harvesting practices.

Results:

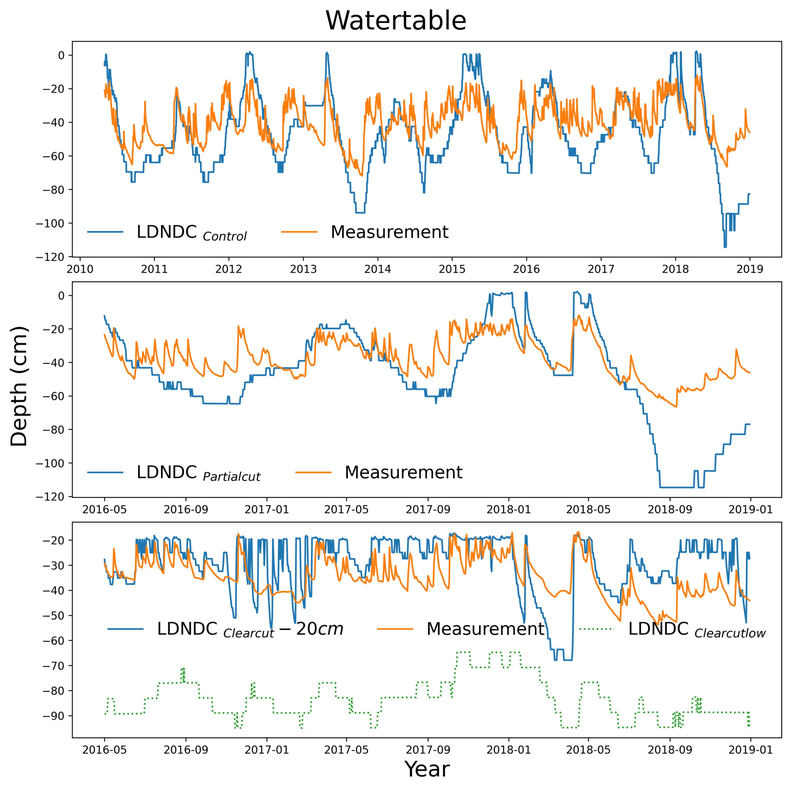

Figure 2 : Measured watertable in orange and modeled watertable in blue color for the control, partial cut and clear cut site. Watertable for the control and partial cut is captured by the model nicely but modeled clearcut water has a offset of -20cm. Dotted green very low watertable is the test to see if the NEEt could be a source of carbon in clearcut case and match with the observations.

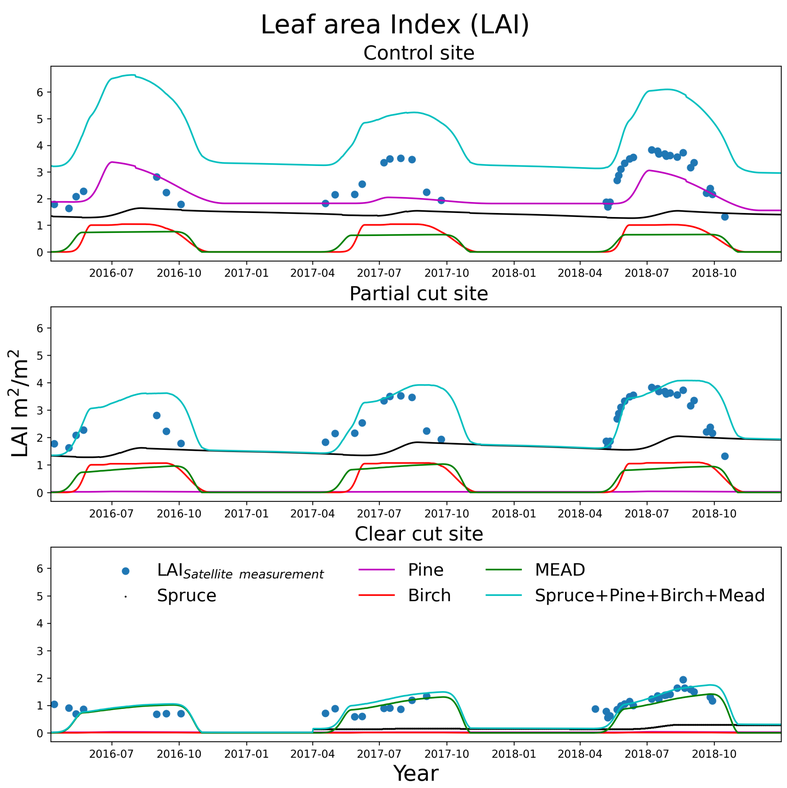

Figure 3: LAI estimated from the satellite measurement (blue dots) and different modeled species LAI shown in different color. In control site for a full grown forest the LAI for the ground vegetation and secondary canopy may not be visible to the satellite. This reason could explain the difference in modeled LAI (spruce+pine+birch+Mead) and the satellite measurement. After thinning in the partial cut site tree density is low so satellite captured the stand LAI properly and the model also simulated LAI nicely. Same is true for the clearcut site.

Conclusions

This study is still work in progress. Model setup for respiration needs to be looked at for all cases. It is possible that the night time respiration is not captured properly by the model at this moment. Watertable is captured well by the simulation for control and partial cut site, while for clear cut site it captures the fluctuations but produces too high watertable and results in high methane emissions. As there are evidence that the greenhouse gas budgets change over time after management, the long time measurement would have the advantage of capturing the recovery of disturbed site. The watertable for clearcut could be simulated correctly but that same setup would not produce the watertable for control site.

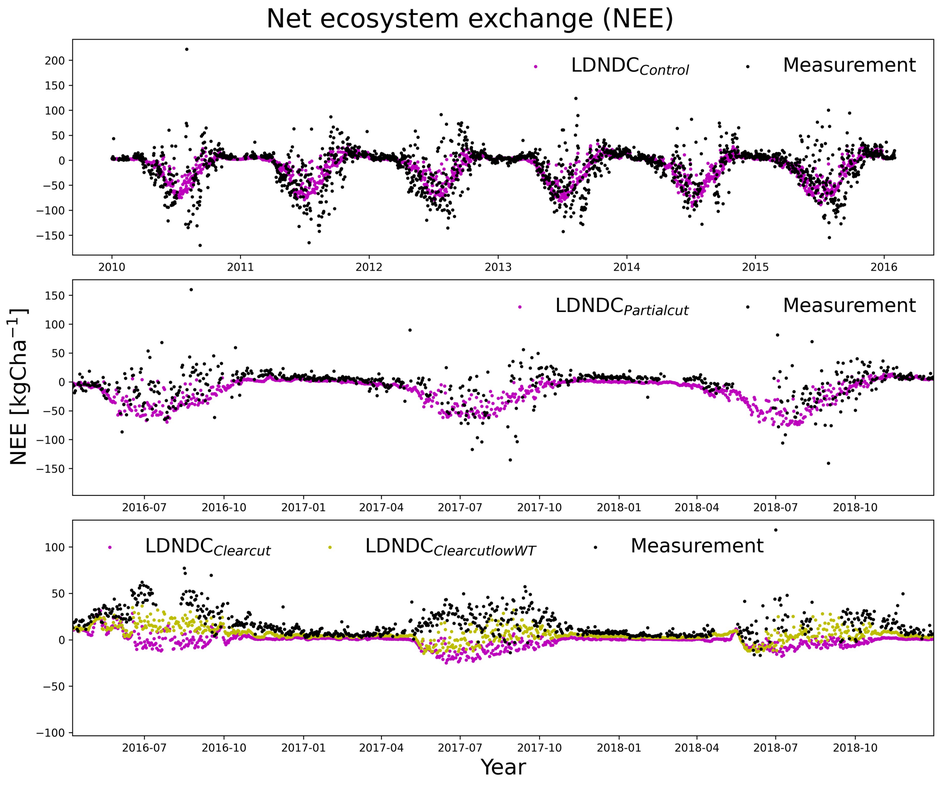

Figure 4: Daily Net ecosystem exchange for the control, partial cut and clear cut. While control and partial cut shows good agreement. Negative values represent sink of carbon in the ecosystem night time respiration may need to be investigated to find the missing respiration also given in the table below. Yellow NEE dots for the clearcut site are from the clearcut test simulation, where watertable was very low shown with dashed line in the clearcut watertable figure.

Table 1: Annual CO2 balance (NEE), gross primary production (GPP), and total ecosystem respiration (TER) before and after management action from model and observations reported by Korkiakoski et al. 2023 (Values given in bold). Negative values represents sink. Model is simulating GPP to a good agreement but there are differences in the modeled NEE and TER, and observations. This discrepancy may have risen from how night respiration is derived in gap-filling the observations. So, further work is needed to optimize the night respiration from the model setup.

	Control **(Observations in bold)**		
Year	NEE	GPP	TER
2010	- 4691 **-572±272**	14698 **14563**	10006 **13909**
2011	- 4274 **-1118±327**	14848 **13309**	10574 **12081**
2012	- 4824 **-927±163**	14519 **13309**	9695 **12218**
2013	- 4627 **-763±218**	15492 **13500**	10864 **12545**
2014	-5230 **-354±218**	16588 **10963**	11358 **10500**
2015	-6180 **-1227±245**	16488 **12736**	10307 **11400**

	Partial cut **(Observations in bold)**			Clearcut **(Observations in bold)**		
Year	NEE	GPP	TER	NEE	GPP	TER
4/2016-3/2017	-4642 **2181±327**	13544 **9490**	8901 **11590**	3792 **8454±381**	2810 **2754**	6602 **11127**
2017	-5607 **900±218**	13005 **9245**	7398 **10090**	1595 **6054±300**	3617 **3518**	5212 **9518**
2018	-5628 **2072±736**	15545 **8890**	9916 **10936**	1582 **6190±300**	4711 **5045**	6293 **11181**

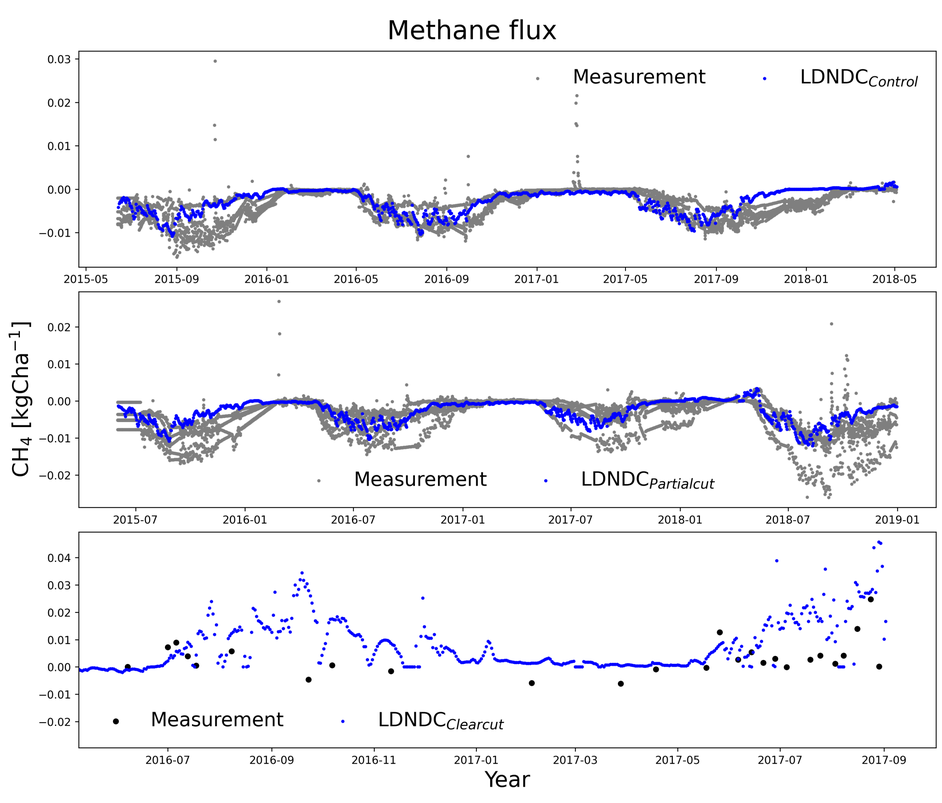

Figure 5: Negative methane flux represent sink of methane**.** Comparison of methane flux between chambers measurements and modeled shows good agreement. Fluctuations are captured well by the model against some of the chamber measurement. Autumn and early winter methane sink is sometimes underestimated by the model.