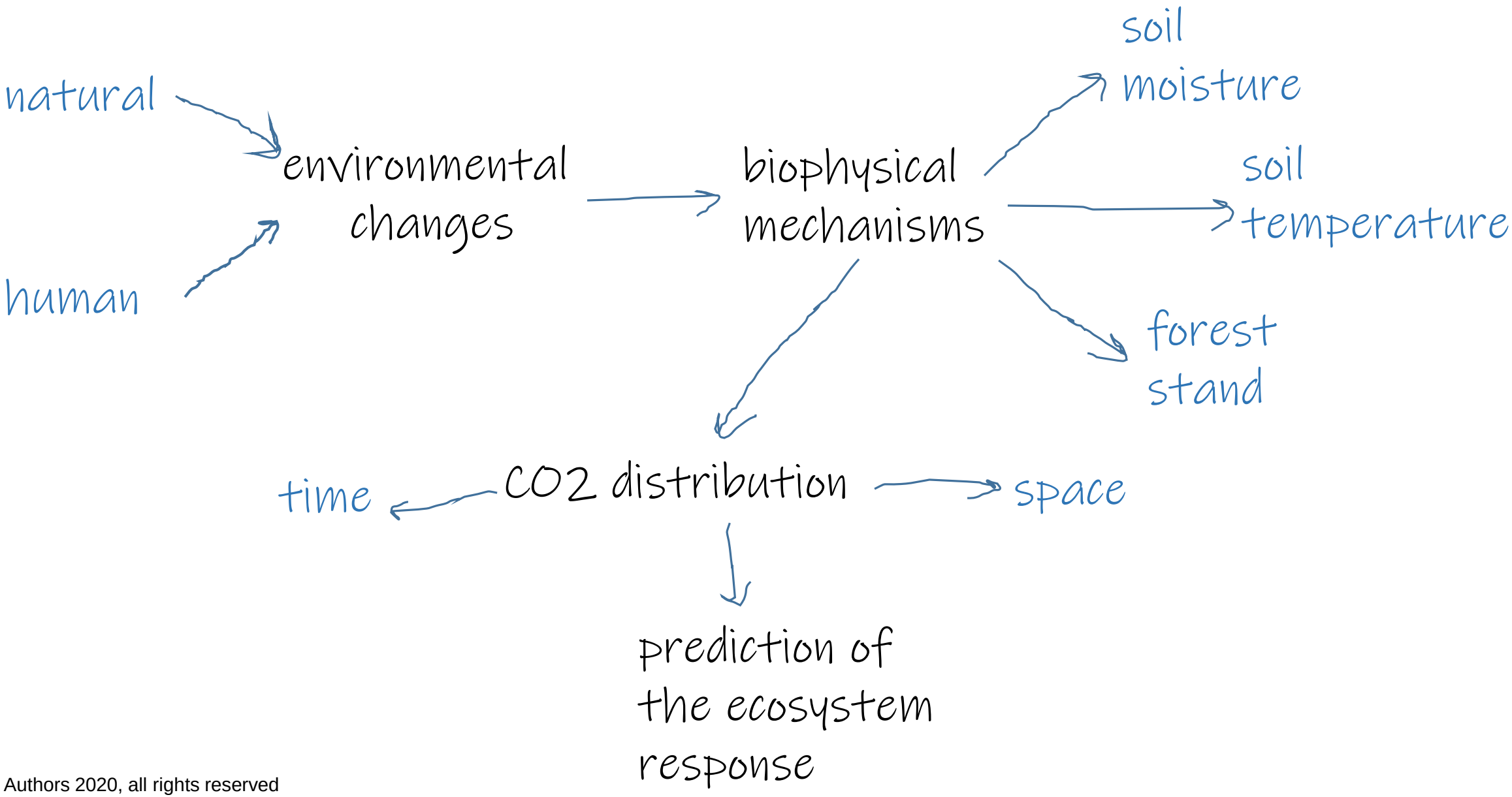
Soil fluxes and surface microtopography in a hemiboreal forest: space, time and models

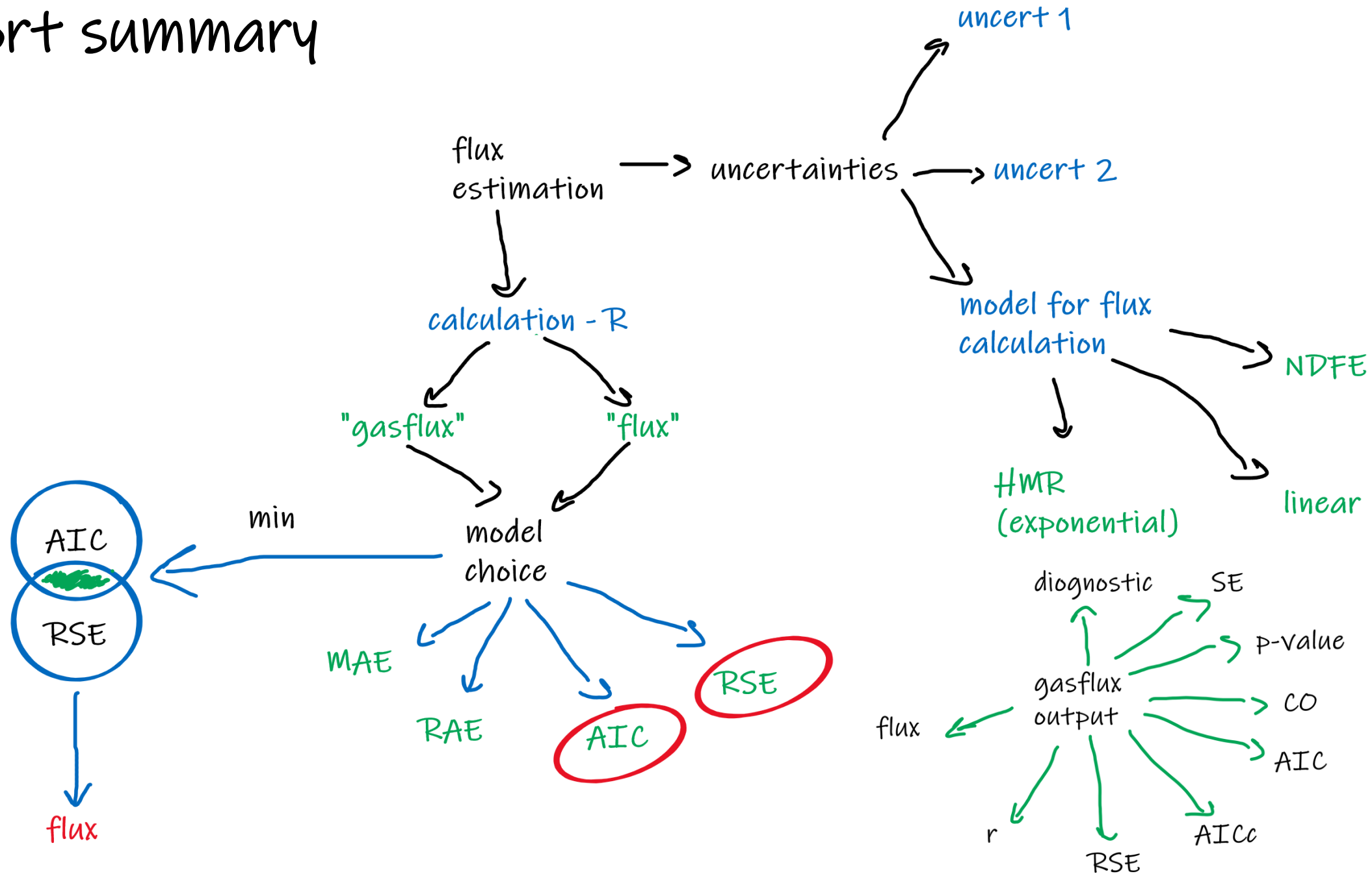
Dmitrii Krasnov, Alisa Krasnova, Steffen M. Noe

Estonian University of Life Sciences, Tartu, Estonia

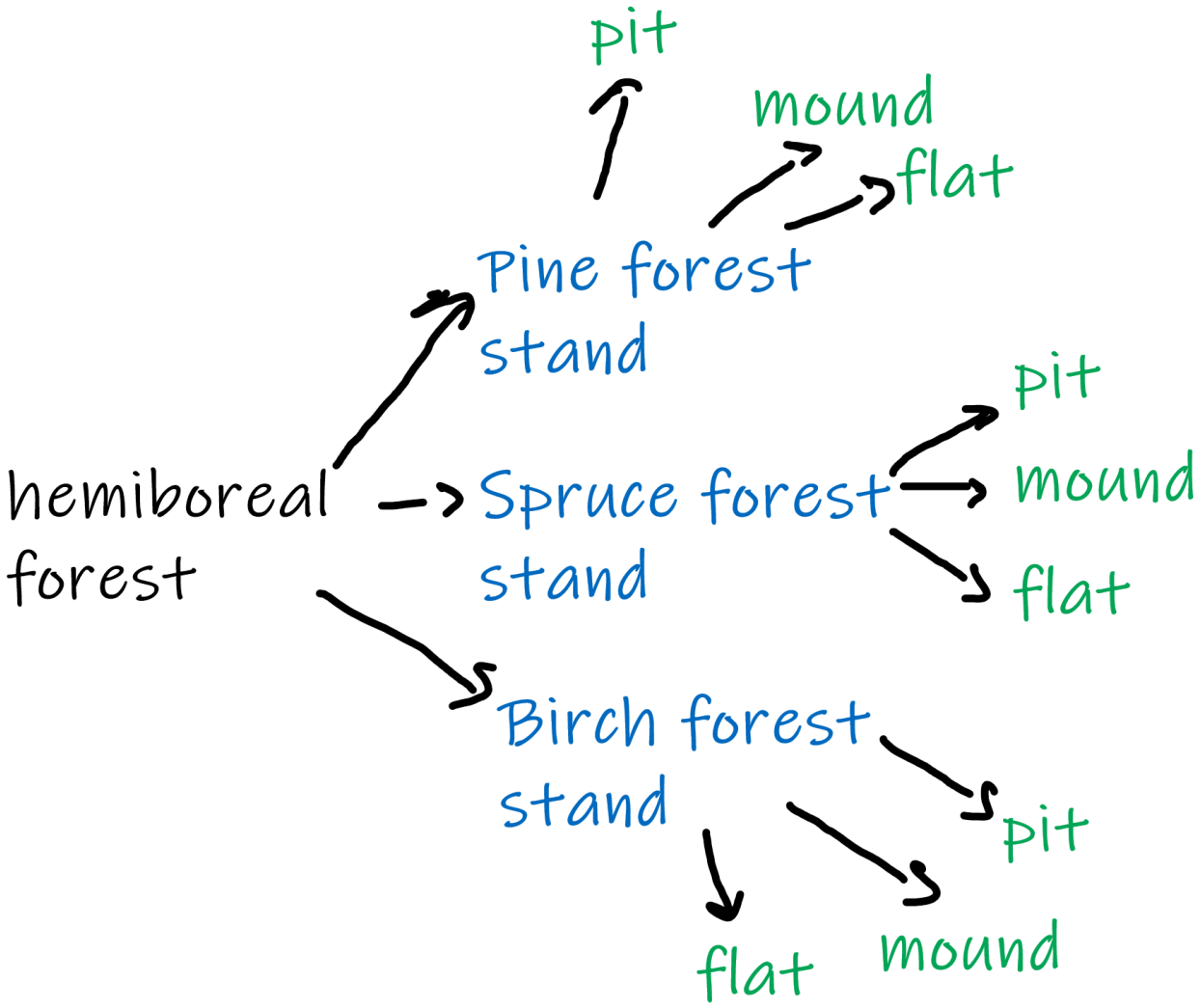
Short summary

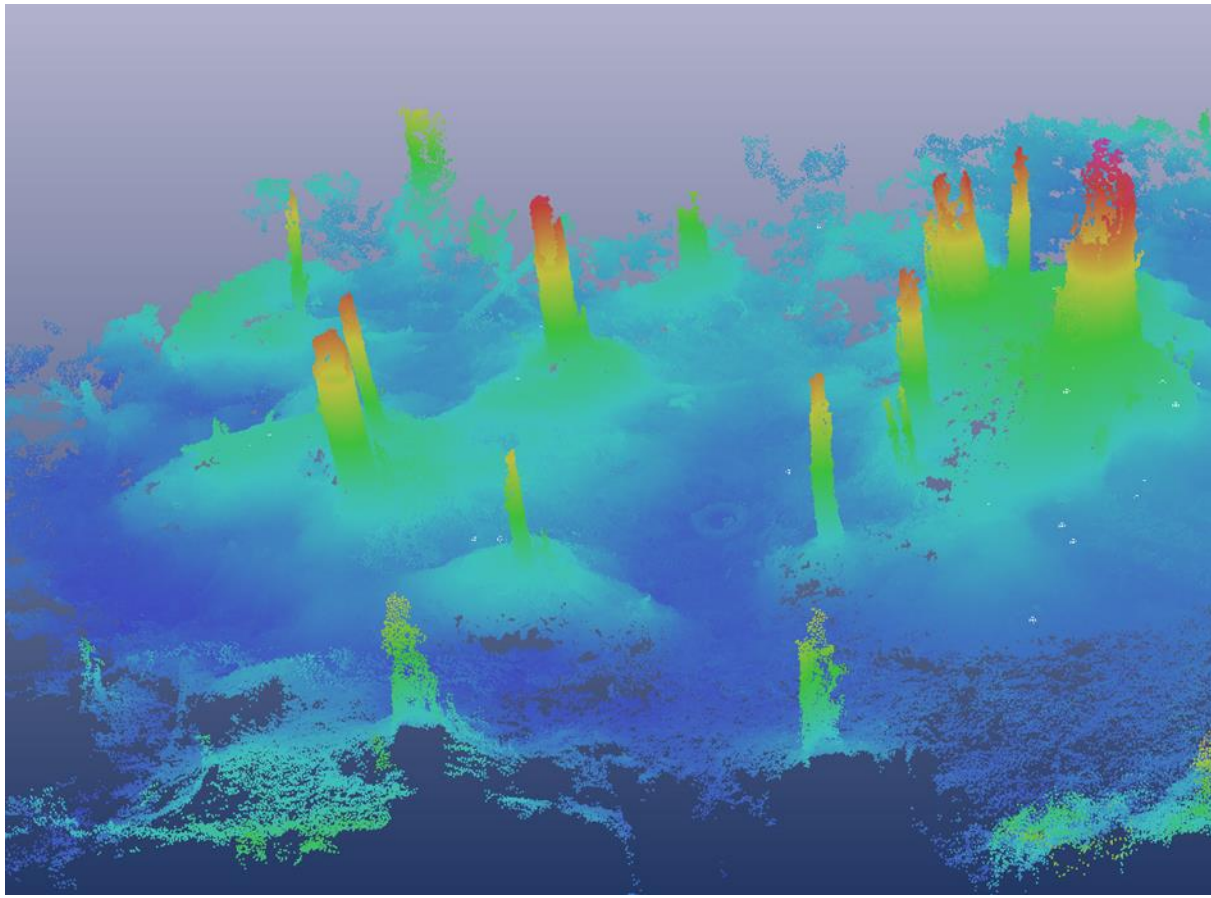


Short summary



Short summary





Consequences of forest floor microtopography

pit

mound

→ pit and mound microtopography

↓

alters a number of ecologically important soil surface and subsurface characteristics (Liechty, H. O., et al. 1997)

soil and forest floor temperatures (Dwyer and Merriam 1981; Beatty 1984; Beatty and Stone 1986; Schaetzl 1990),

accumulation of litter and thickness of O-horizons (Hart et al. 1962; Lyford and MacLean 1966; Dwyer and Merriam 1981; Schaetzl et al. 1990.),

thickness and distribution of soil horizons (Veneman et al. 1984; Beatty and Stone 1986; Schaetzl et al. 1990; Schaetzl 1990),

elemental content, concentration, or availability (Stone 1975; Beatty 1984; Beatty and Stone 1986)

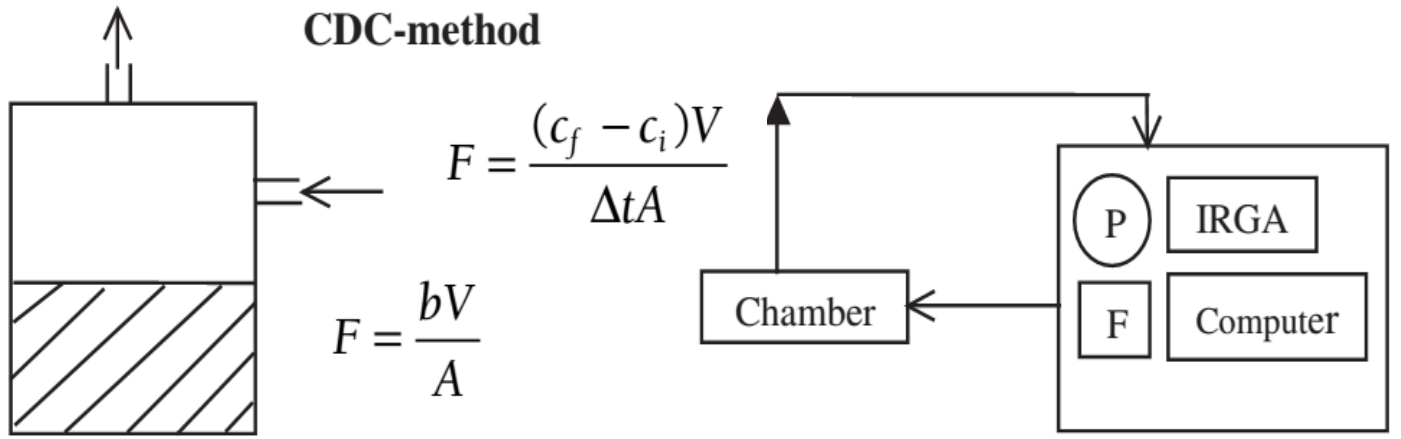
pit – depression cased by any reason

mound – any elevation

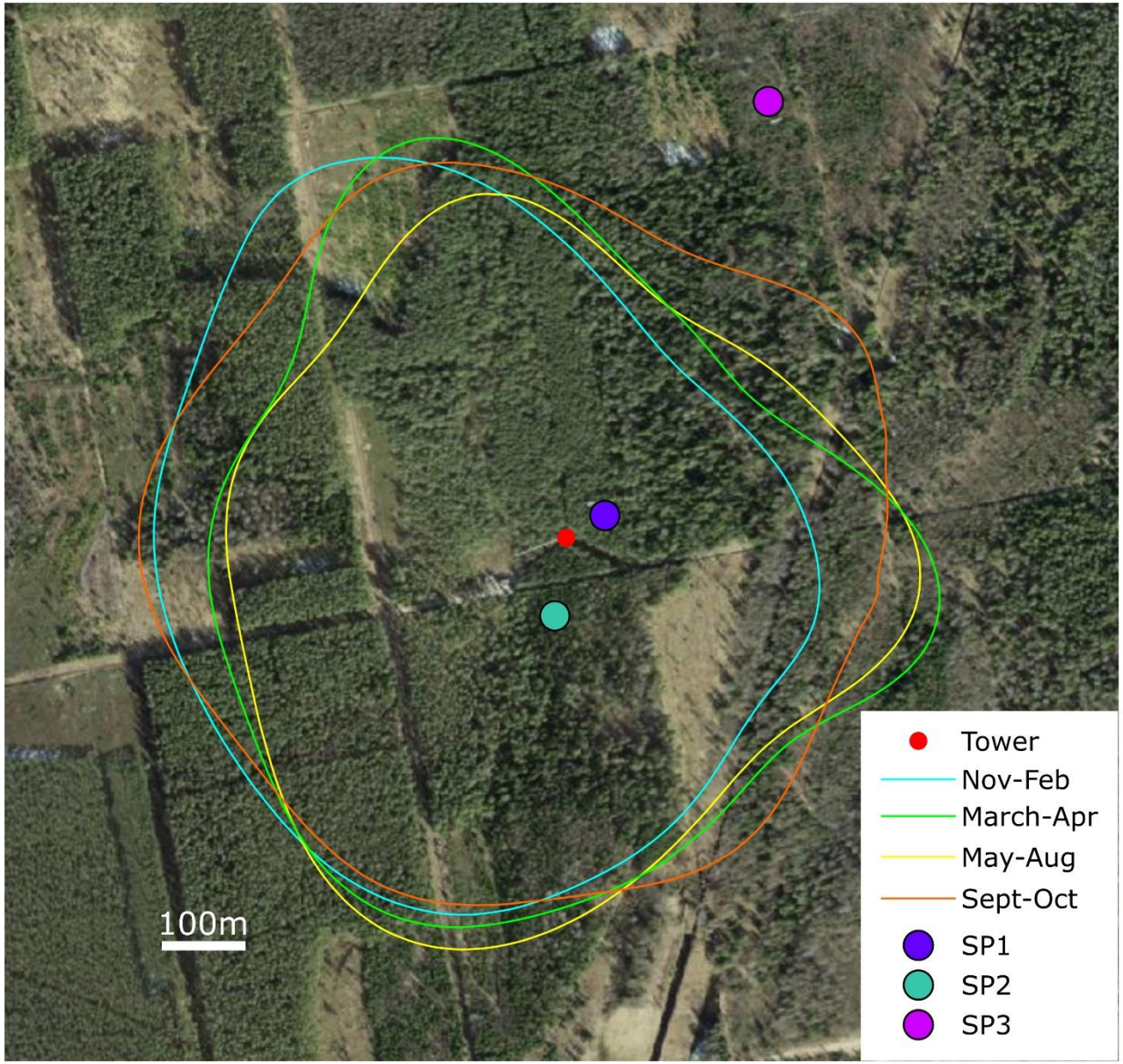
flat – area between pits and mounds

Methods

- Soil respiration was measured weekly with non-steady-state flow manual chambers.
- Each chamber was equipped with Vaisala GMP343 infrared gas analyzer sensor for CO2 measurements, Vaisala HM70 humidity meter to measure the humidity and temperature, and a small fan for mixing of air inside the chamber.
- Chamber volume is 23.8 L (0.0238 m3).
- Nine PVC collars were installed per sample plot according to microtopographical positions.
- Collars basal area was 0.073 m2 (305mm).



Sample plot locations



- Atmospheric tower
- SP1 - Pine forest
- SP2 - Spruce forest
- SP3 – Birch forest

Fig by © Alisa Krasnova (alisa.krasnova@emu.ee)

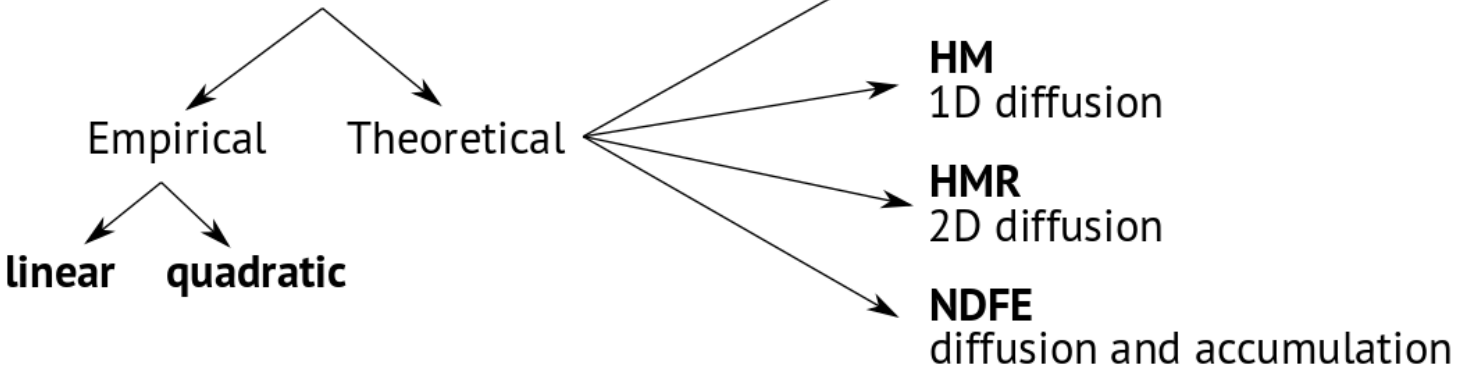
Ax example of video of 3D model:

https://youtu.be/hhbUAC4zmIk

https://youtu.be/hT2sEH8mC7M

Available models for flux calculation

Evaluated models



General assumptions:
During the chamber deployment, soil and headspace air temperature, PAR, air pressure and headspace turbulence are assumed to be constant and approximately equal to ambient conditions.

Quadratic (Wagner et al, 1997)

Exponential (Kutzbach et al, 2007)

HM (Hutchinson & Mosier, 1981)

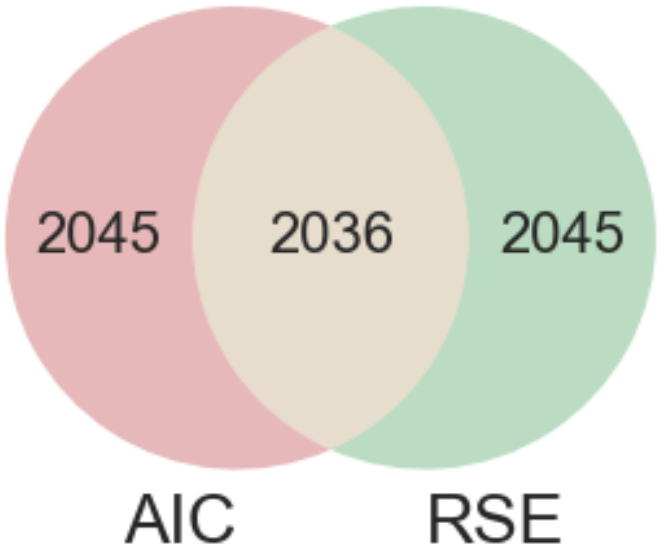
HMR - Extended HM model (Pedersen et al, 2010)
NDFE - Non-steady state Diffusion Flux Estimator (Livingston et al, 2005)

Model specific assumptions:	**Models**					
	lin	quadr	exp	HM	HMR	NDFE
Linear change in gas concentration from soil to the atmosphere	✓	✓				
Gas concentration changes linearly with depth				✓	✓	✓
The presence of the horizontal transport					✓	
The presence of the vertical transport				✓	✓	✓
Constant source of gas concentration				✓	✓	✓
Uniform soil properties beneath chamber				✓	✓	✓
No biological uptake	✓	✓	✓	✓	✓	✓
Constant photosynthesis	✓	✓	✓	✓	✓	✓
Constant respiration of the plants	✓	✓	✓	✓	✓	✓

Model selection

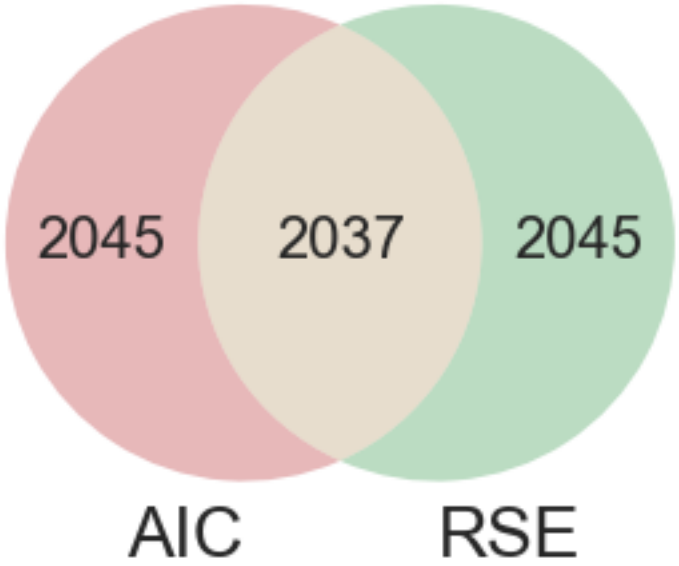
Model for the flux calculation was chosen based on two criteria: AIC and RSE
In total 2045 measurements were done. Each criteria (AIC and RSE) was applied separately and then Vienne diagram was constricted. The intersection area represents the cases when both criteria have similar performance

Linear model



HMR

NDFE



In case of different results of AIC and RSE, a model for flux calculation was chosen based on individual investigation of each case

Soil respiration calculated using linear and combined models (linear, HMR and NDFE) in different microtopographical positions in Pine, Spruce and Birch forest stand. Monthly medians.

linear model

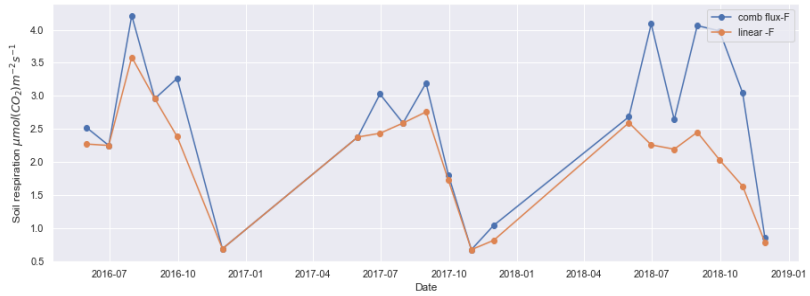
combined model

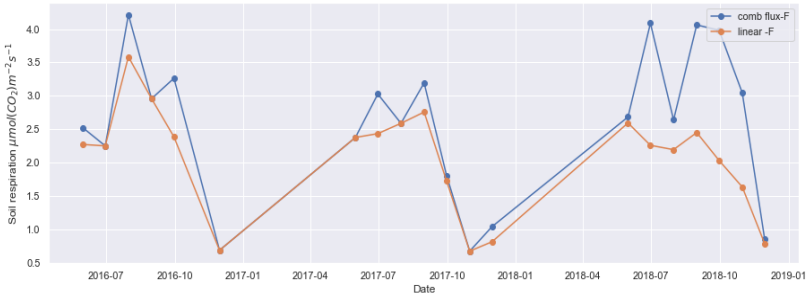
Units: $mmol(CO_2)m^{-2}s^{-1}$)

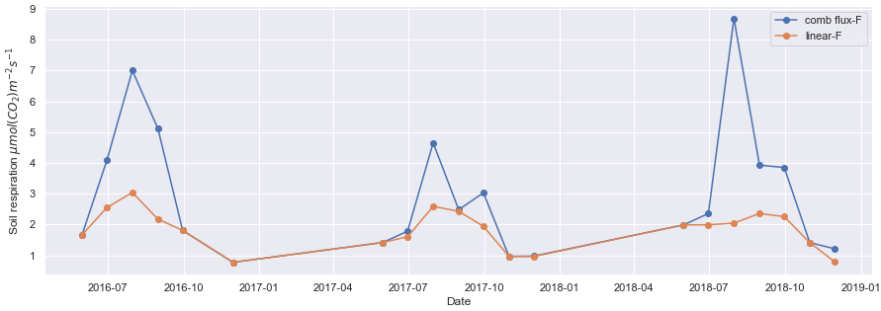
Pine

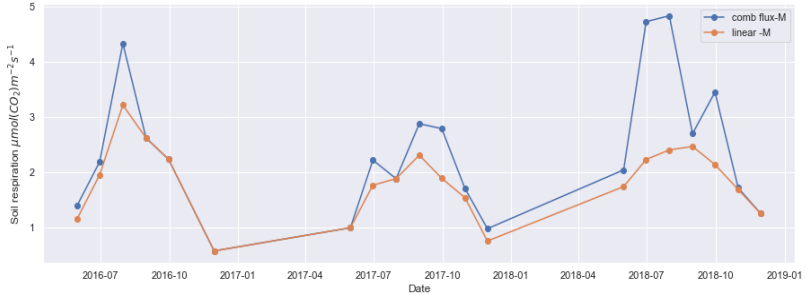
Spruce

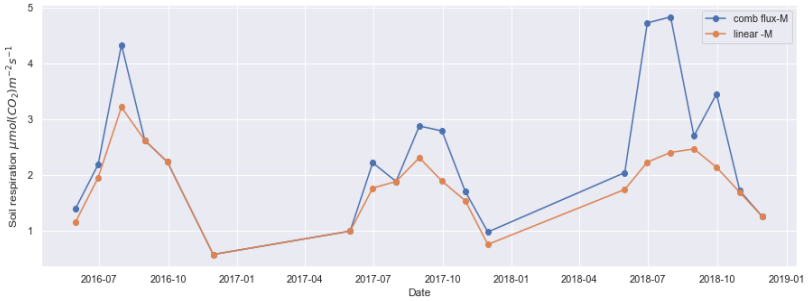
Birch

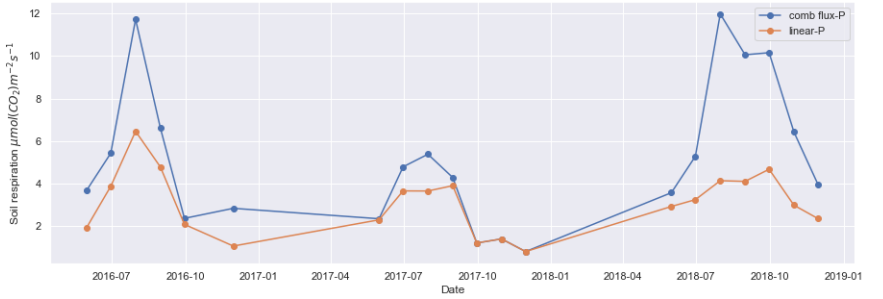


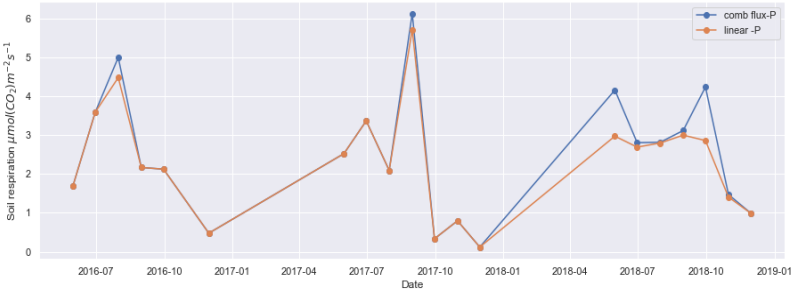


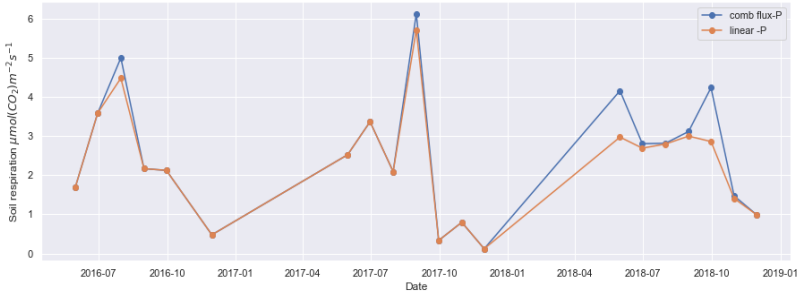


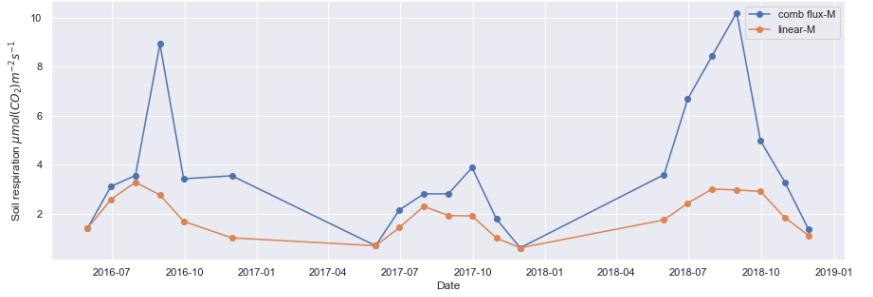












Conclusions

1. Model selection is one of the major sources of uncertainties in the flux estimation

2. Available packages for the flux estimation in both, R and Python software make the choice difficult and create additional source of uncertainties because of the calculation algorithms differences

3. Module approach with software development allows to utilise the strengths of both languages for flux calculations

4. Dynamic model choice for each measurement without human interference gives better results

5. Soil respiration has distinctive spatial pattern which is necessary to take into account for carbon balance estimation

www.emu.ee
Eesti Maaülikool
Estonian University of Life Sciences

SMEAR Estonia

EESTI KESKKONNA-OBSERVATOORIUM

Pan Eurasian Experiment
PEEX

TARTU OBSERVATORY
space research centre

TARTU ÜLIKOOL
1632
UNIVERSITAS TARTUENSIS

SA Järvselja
Õppe- ja Katsemetskond

TERAUSE TIPPKESKUS
ECOLCHANGE
CENTRE OF EXCELLENCE

RINGO | Readiness of ICOS

ERA-PLANET

ACTRiS

Euroopa Liit
Euroopa
Regionaalarengu Fond

Eesti tuleviku heaks