Norway grants

Activity 3.3. GHG emission factors for fen peat soils and recommendations for improvements of the national GHG inventory

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Overall goal:

- To improve national GHG inventory (LULUCF sector, grassland category)

Specific objective:

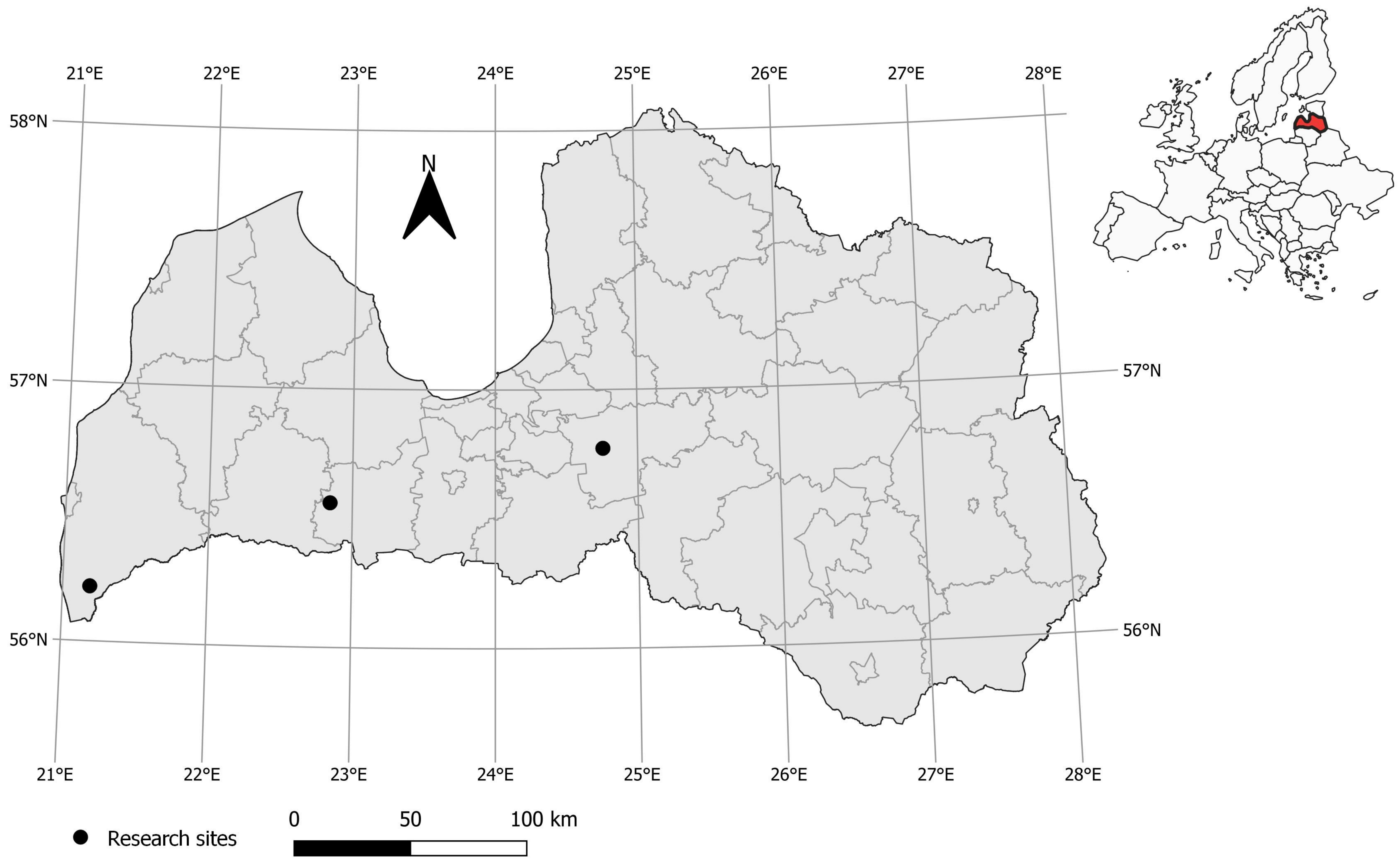
- To estimate soil-to-atmosphere CO_2, CH_4 and N_2O fluxes from drained shallow organic soils in grassland in Latvia.
    - Impact of thickness of organic soil layer on magnitude of GHG fluxes;
    - Impact of organic carbon (C) content and stock in soil on magnitude of GHG fluxes.

Material and methods

Research sites

- The study was conducted:
  - in <u>three research sites </u>in grassland with drained organic soil (fen organic soil)
  - in central and western part of Latvia (belonging to the hemiboreal zone of Europe)
  - in period from July 2021 to June 2023 (24 consecutive months).

Research site	Subplot	Thickness of organic soil layer, cm	Mean groundwater level ± S.E. (range), cm
Research site 1	A	15	87.6 ± 2.4 (47-118)
	B	20	96.1 ± 2.5 (60-126)
	C	30	98.8 ± 2.6 (58-127)
Research site 2	A	20	55.4 ± 3.1 (0-121)
	B	40	54.8 ± 3.3 (8-125)
	C	70	27.2 ± 3.8 (0-123)
Research site 3	A	10	89.2 ± 4.0 (0-146)
	B	15	84.2 ± 4.0 (0-144)
	C	25	75.6 ± 8.8 (16-124)



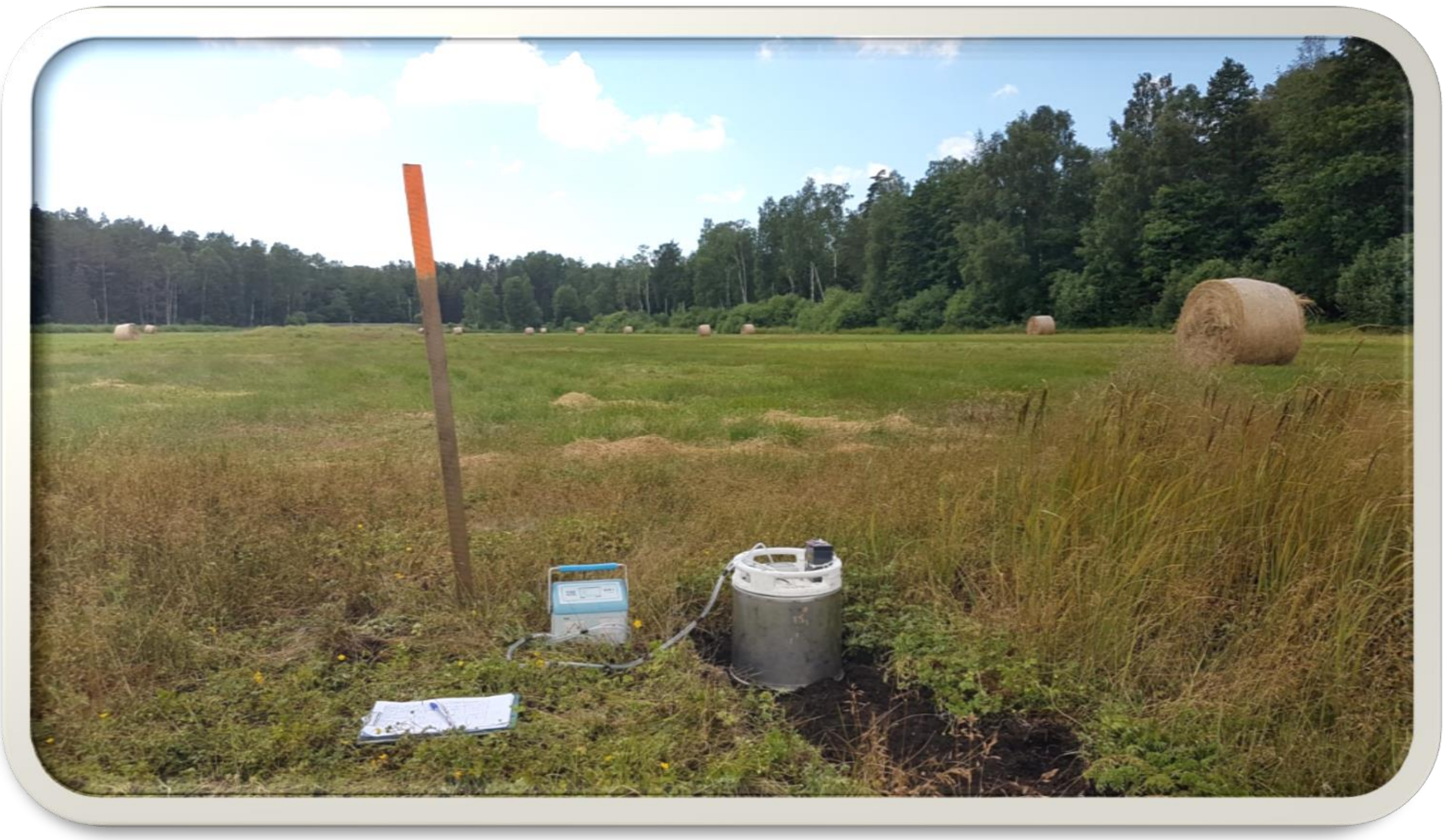
Material and methods

GHG sampling design and measurements

- Soil total respiration (R_{tot} – CO_2 fluxes which include both soil autotrophic and heterotrophic respiration), CH_4 and N_2O flux sampling were conducted with manual non-transparent chambers at the nine replicate per research site.
  - Chambers with a volume of 0.065 m^3 were used.
  - After chamber position on permanently installed collar, gas samples (100 cm^3 each) were taken every 10 min during 30 min period (four samples per sampling set).
  - In laboratory, CO_2, CH_4 and N_2O concentrations in gas samples were determined using a gas chromatograph Shimadzu Nexis GC-230 equipped with FID and ECD detectors (software LabSolutions).
- Soil heterotrophic respiration (R_{het}) was measured during the vegetation periods with an EGM5 spectrometer using a manual non-transparent chamber (volume of 0.023 m^3).
  - In the R_{het} measurement spots, vegetation was removed and ingrowth of roots was avoided by trenching using geotextile.
  - Each measurement of R_{het} continued for 180 seconds at three replicates in each subplot.

Main additional measurements

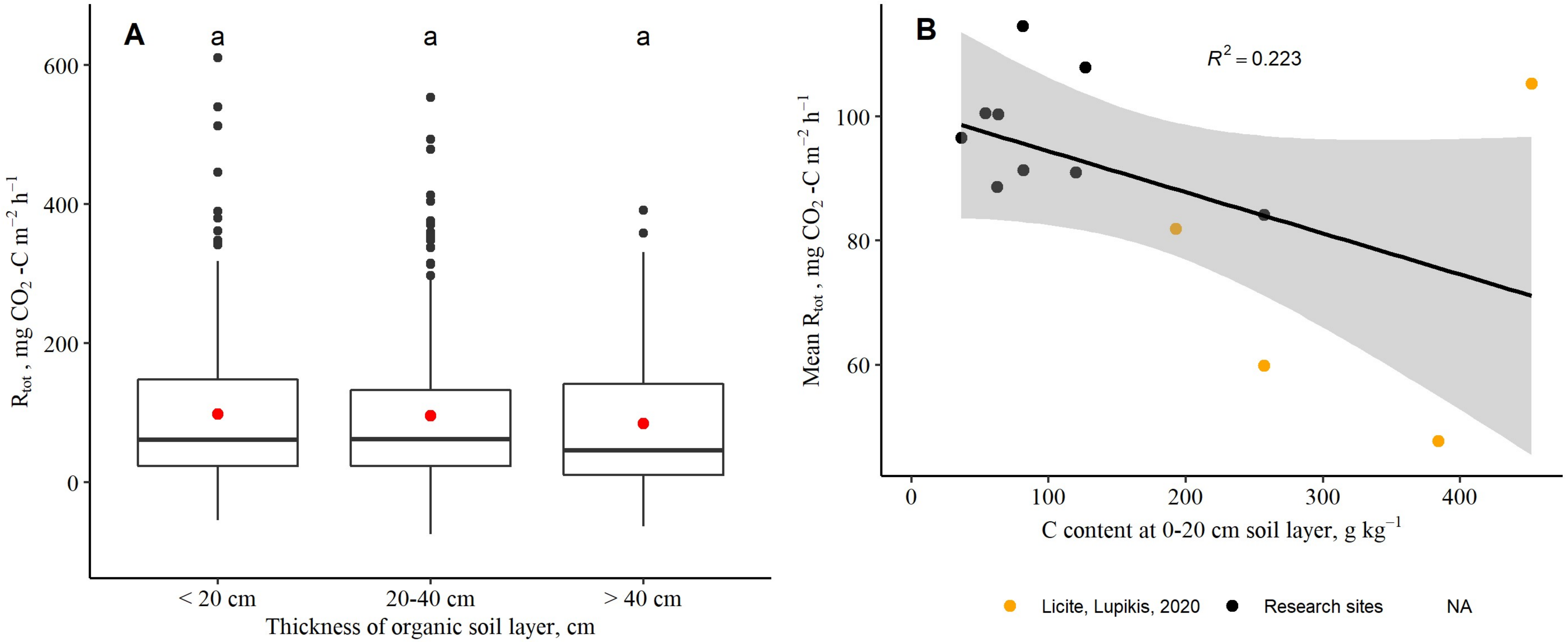
- Soil sampling and analyses
  - 0–10 cm, 10–20 cm, 20–30 cm, 30–40 cm, 40–50 cm, 50–75 cm and 75–100 cm
  - Soil general chemistry
- Measurements of environmental variables
  - Air temperature
  - Soil temperature and moisture
  - Groundwater level
  - Groundwater general chemistry
- Estimation of carbon input with above- and below-ground parts of vegetation
  - Above- and belowground parts of vegetation were sampled in 625 cm^2 square sample plots at four repetitions in each subplot.



Results and discussion

Soil total respiration – sum of an autotrophic and heterotrophic component

Mean R_{tot} among different subplots ranged from 84.2 ± 28.8 to 114.6 ± 33.7 mg C m^{-2} h^{-1}.



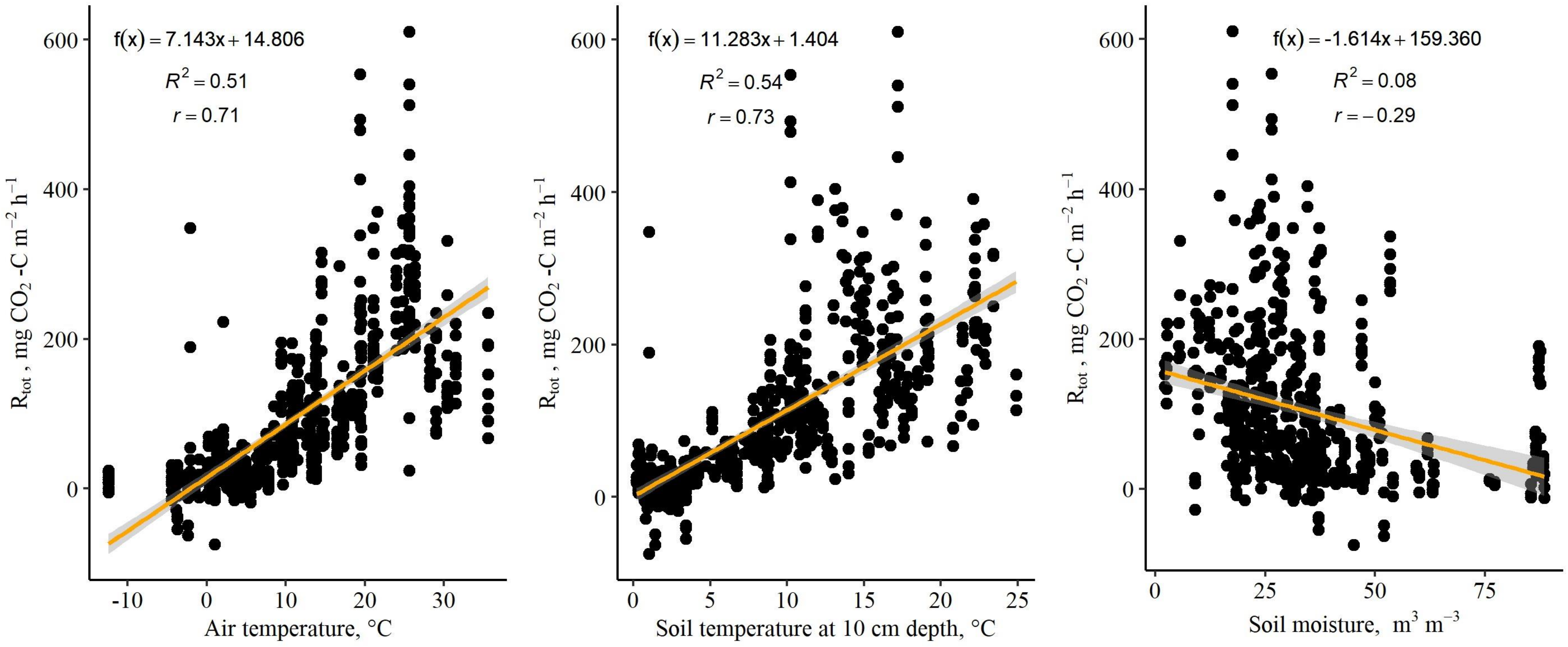
A: Variation of instantaneous soil total respiration (R_{tot}) depending on thickness of organic soil layer

B: Relationship between mean R_{tot} and carbon (C) content at 0-20 cm soil layer

- Mean R_{tot} reflects values calculated as average from monthly means covering all calendar months and, thus, seasons;
- Black dots represent results obtained within this study, yellow points represent results obtained in grassland with deep peat soil in Latvia by Licite and Lupiķis (2020).

Results and discussion

Soil total respiration

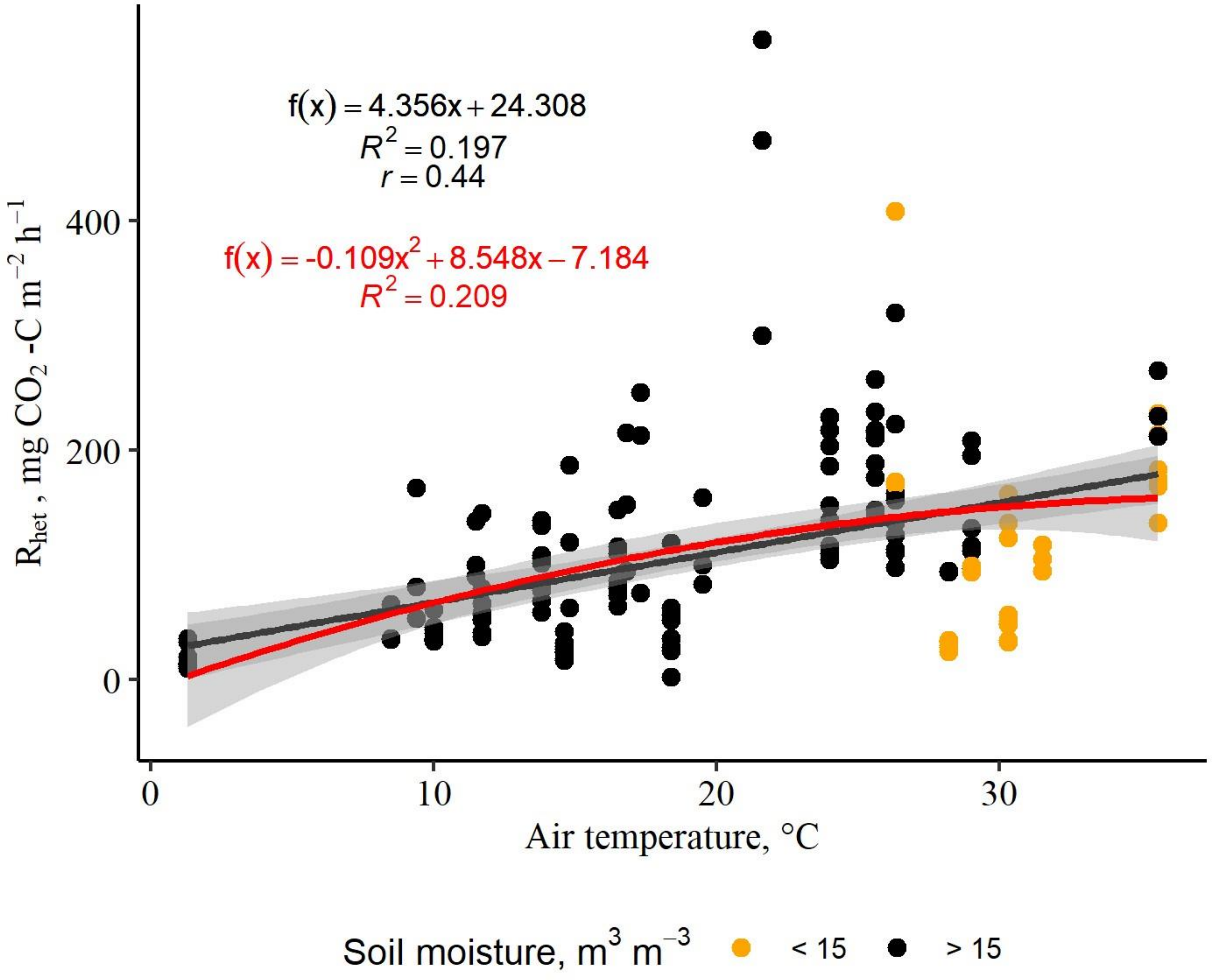


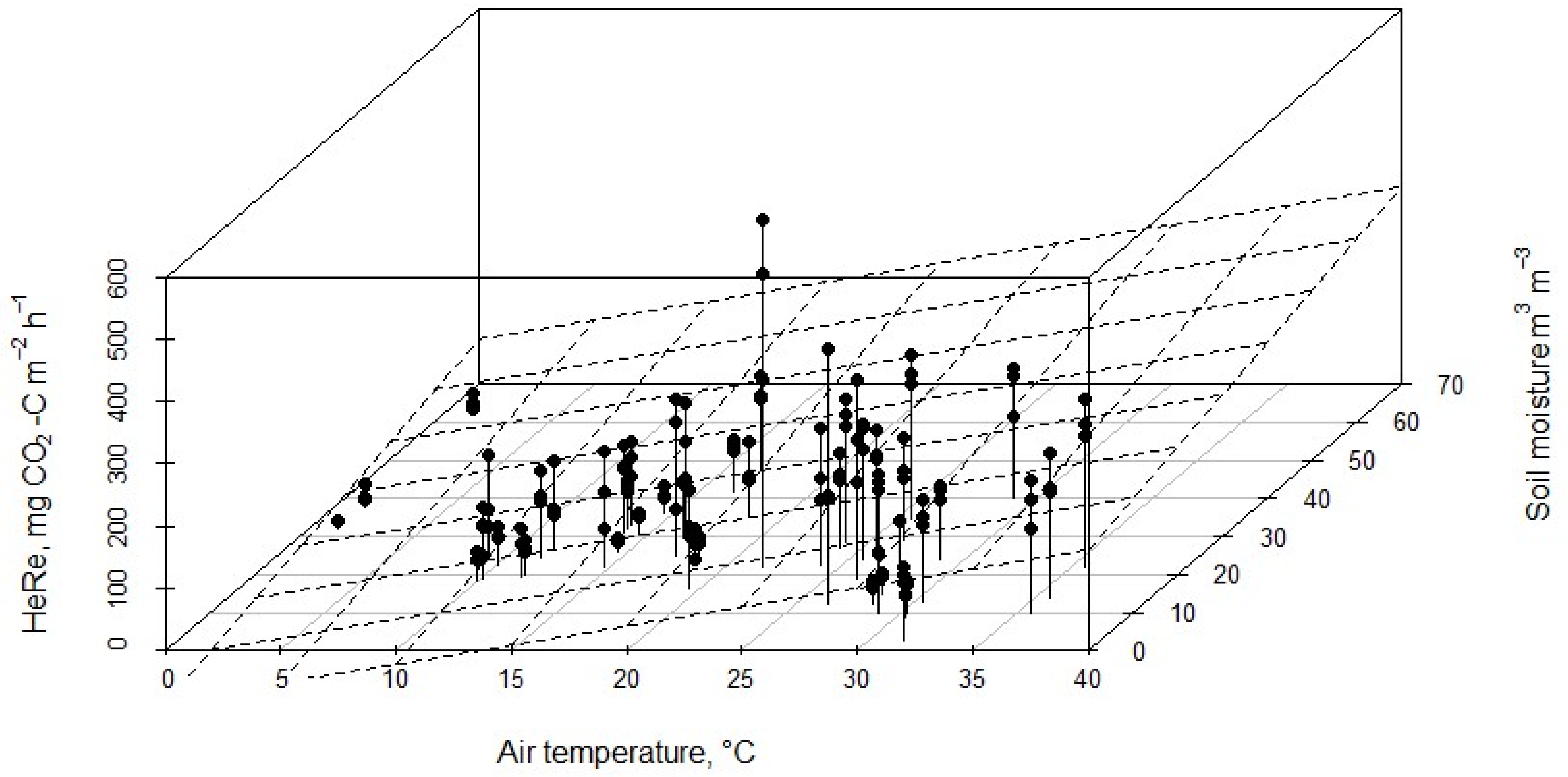
Relationship between instantaneous soil total respiration (R_{tot}) and air temperature, soil temperature at 10 cm depth and soil moisture.

Results and discussion

Soil heterotrophic respiration (soil CO_2 fluxes from the microbial decomposition of soil organic matter)

In period from April to November, mean R_{het} among different subplots ranged from 74.2 ± 17.8 to 150.1 ± 29.9 mg C m^{-2} h^{-1}.



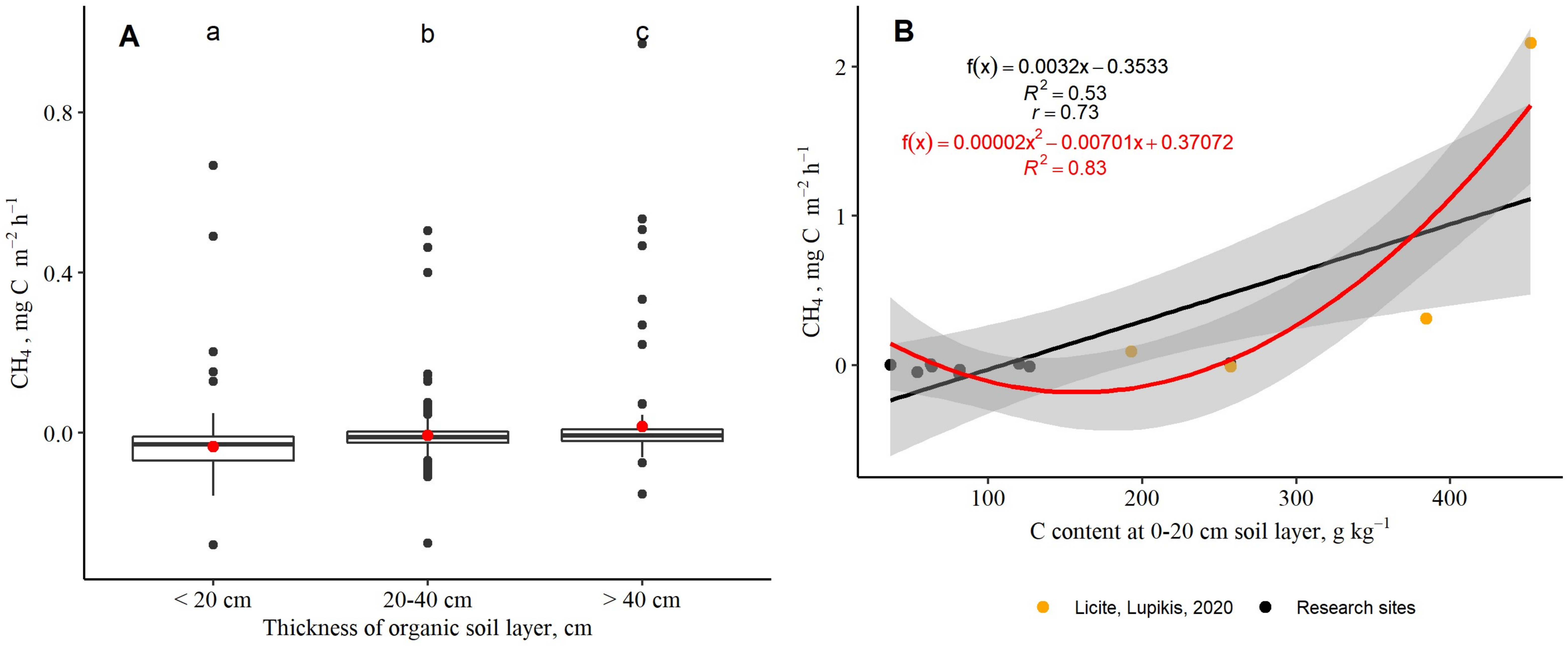


Relationship between instantaneous soil heterotrophic respiration (R_{het}) and air temperature and soil moisture.

Results and discussion

Instantaneous soil-to-atmosphere CH_4 fluxes

Most of the study period, weak removals or zero CH_4 fluxes were observed; CH_4 fluxes rarely exceeded 0.50 mg CH_4-C m^{-2} h^{-1}.



A: Variation of instantaneous soil-to-atmosphere CH_4 fluxes depending on thickness of organic soil layer.

- Different lowercase letters show statistically significant differences ($p < 0.05$).

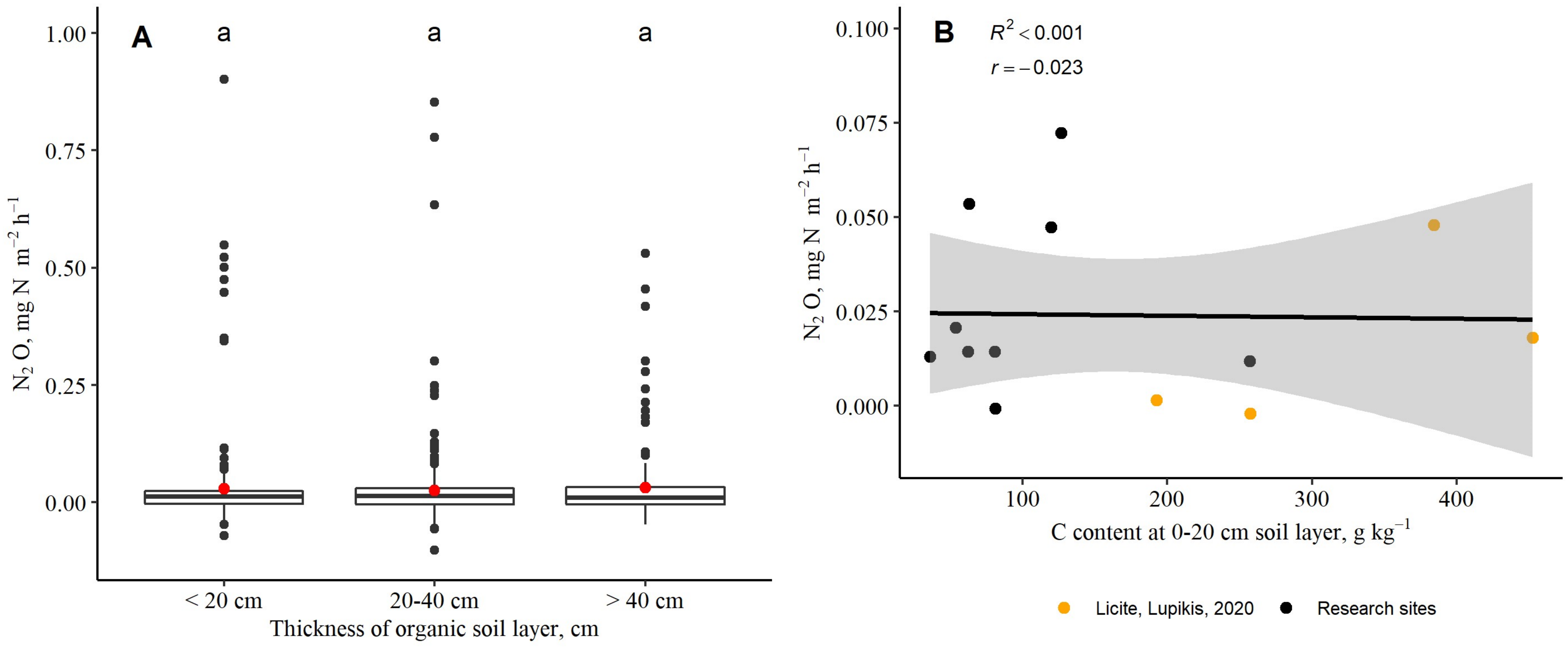
B: Relationship between mean CH_4 fluxes and carbon (C) content at 0-20 cm soil layer.

- Mean CH_4 flux reflects values calculated as average from monthly means covering all calendar months and, thus, seasons.
- Black dots represent results obtained within this study, yellow points represent results obtained in grassland with deep peat soil in Latvia by Licite, Lupiķis, 2020.

Results and discussion

Instantaneous soil-to-atmosphere N_2O fluxes

Low N_2O fluxes in all research sites with some peaks not exceeding 1.0 mg N_2O-N m^{-2} h^{-1}.



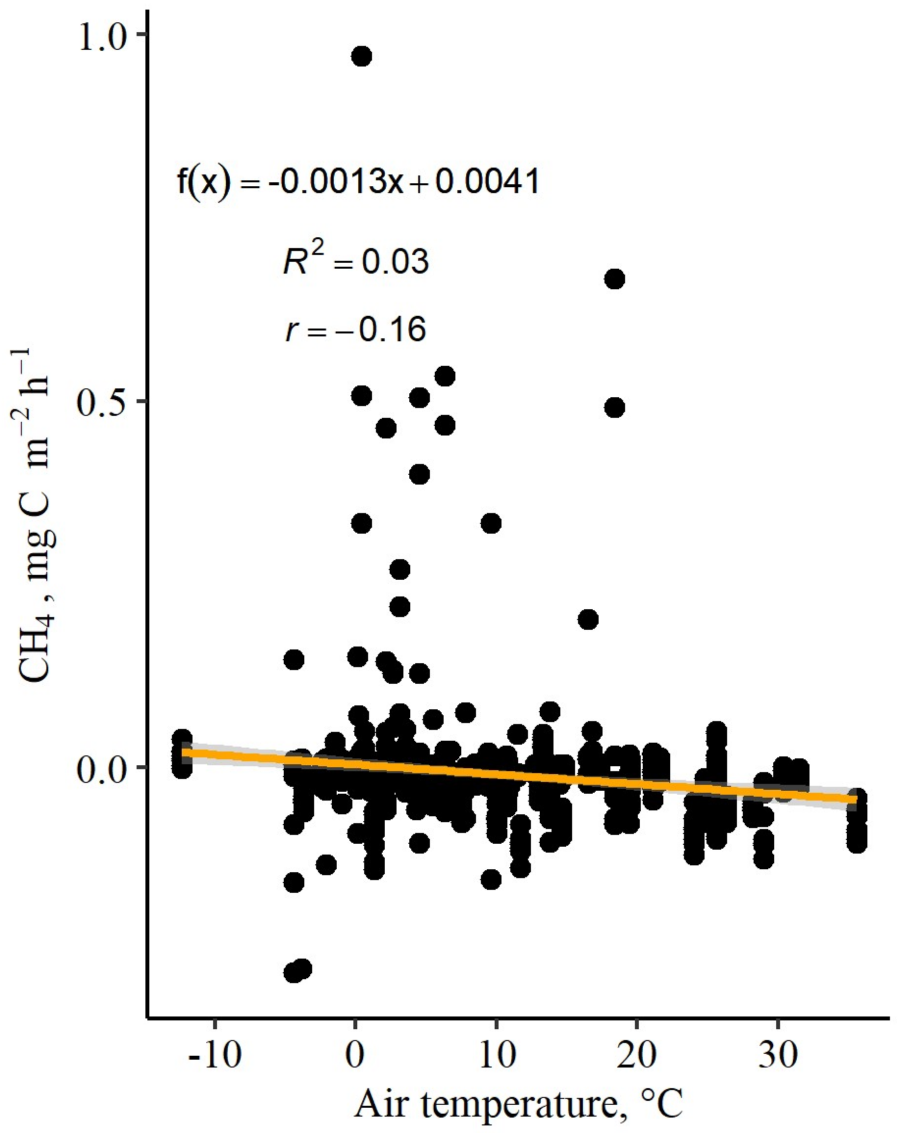
A: Variation of instantaneous soil-to-atmosphere N_2O fluxes depending on thickness of organic soil layer.
B: Relationship between mean N_2O fluxes and carbon (C) content at 0-20 cm soil layer.

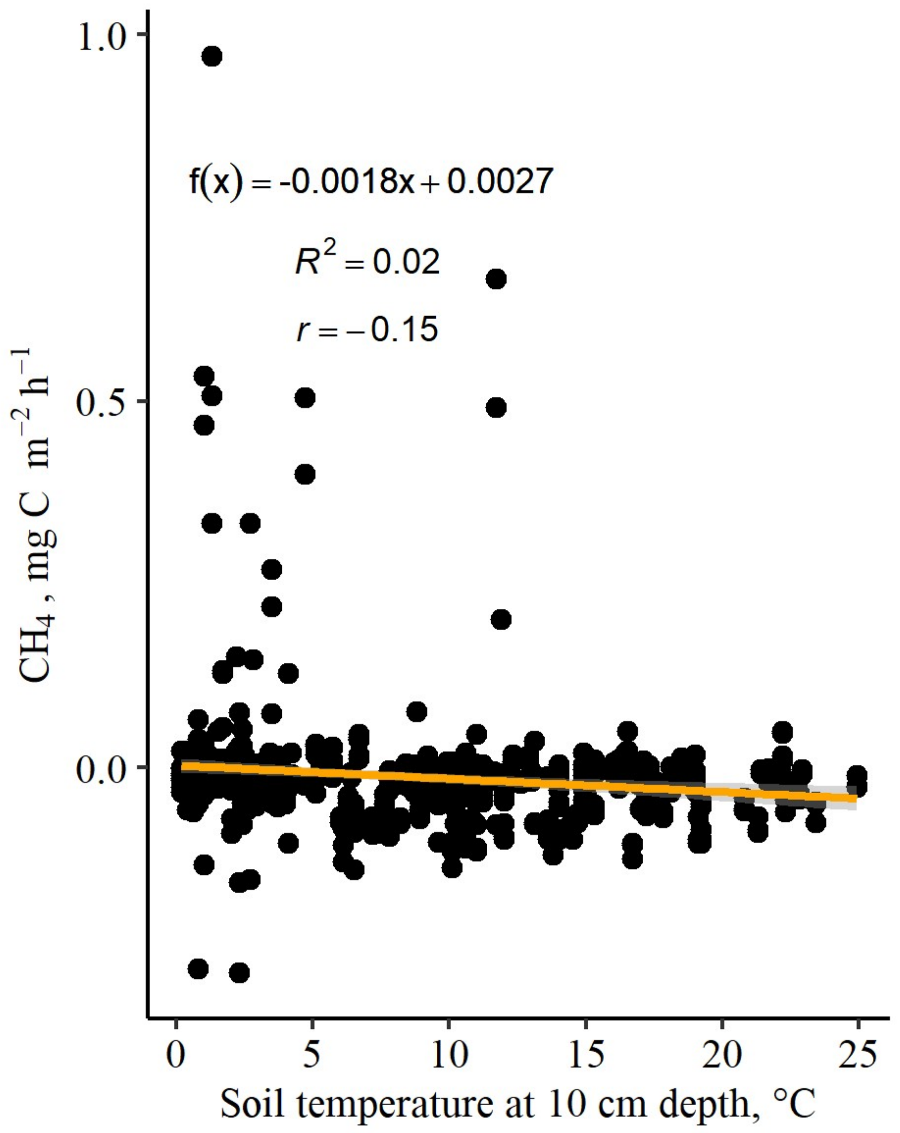
- Mean N_2O flux reflects values calculated as average from monthly means covering all calendar months and, thus, seasons.
- Black dots represent results obtained within this study, yellow points represent results obtained in grassland with deep peat soil in Latvia by Licite, Lupiķis, 2020.

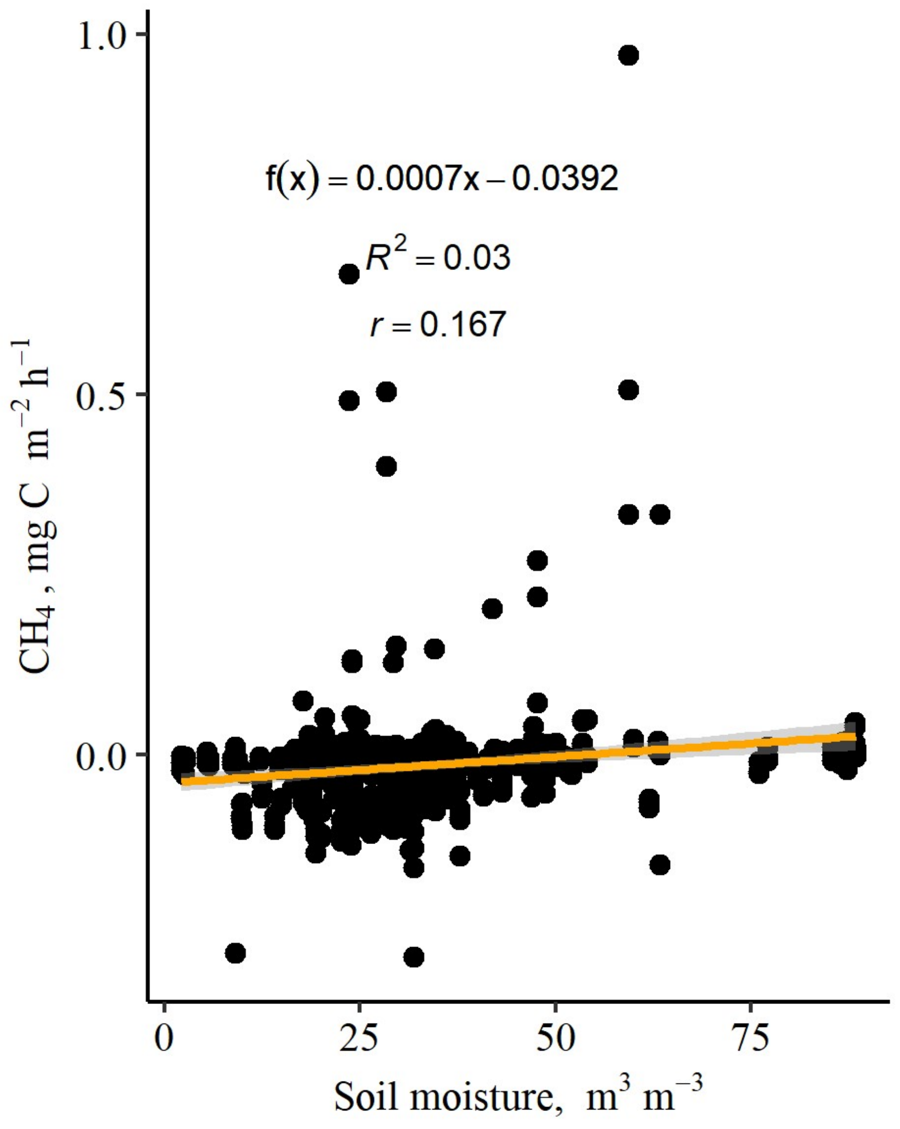
Results and discussion

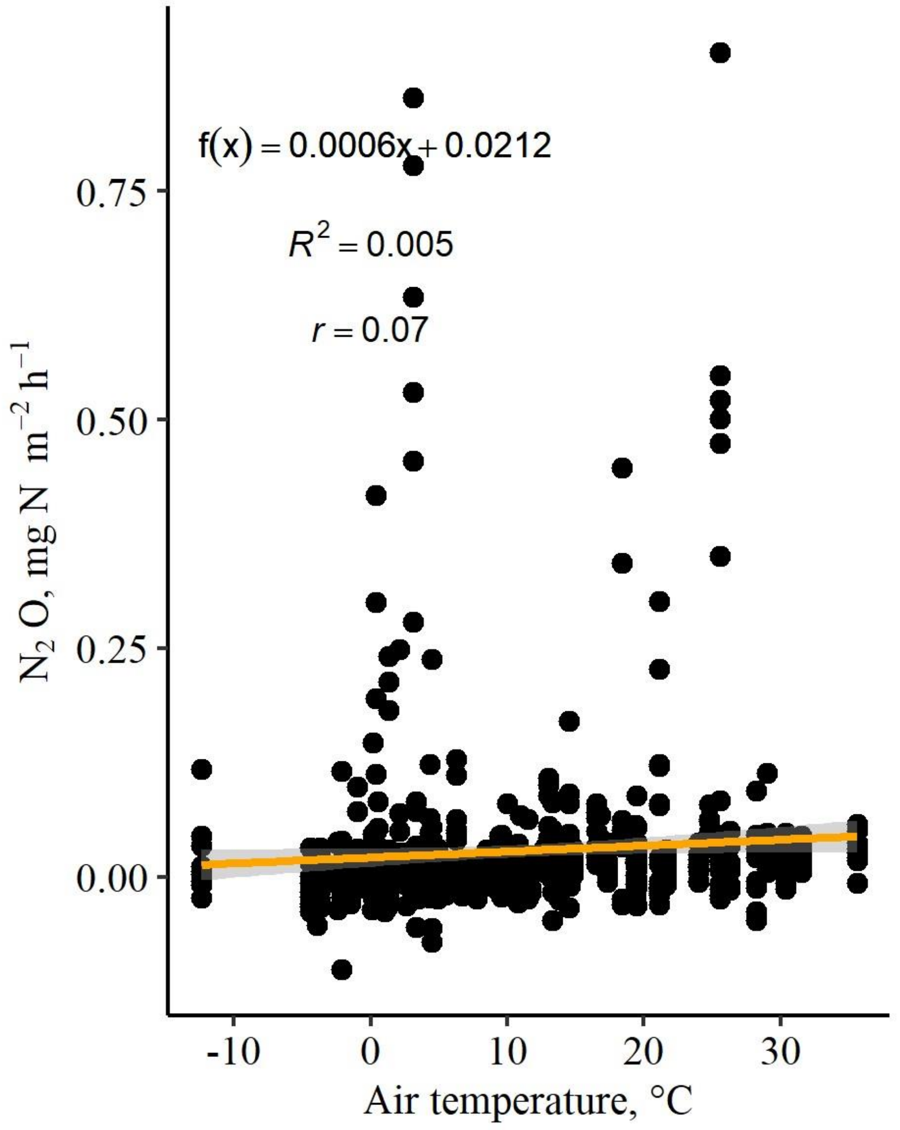
Instantaneous soil-to-atmosphere CH_4 and N_2O fluxes

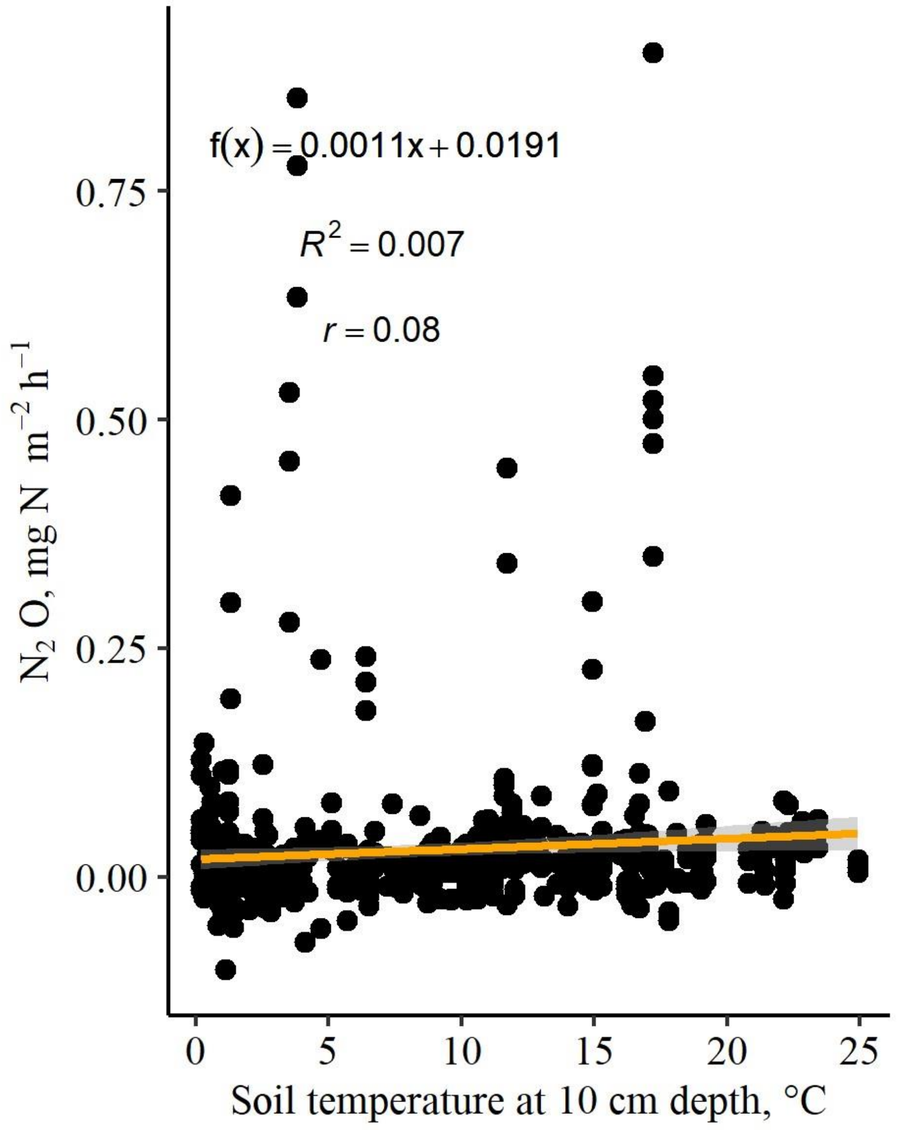
Relationship between instantaneous soil-to-atmosphere CH_4 and N_2O fluxes and air temperature, soil temperature at 10 cm depth and soil moisture.

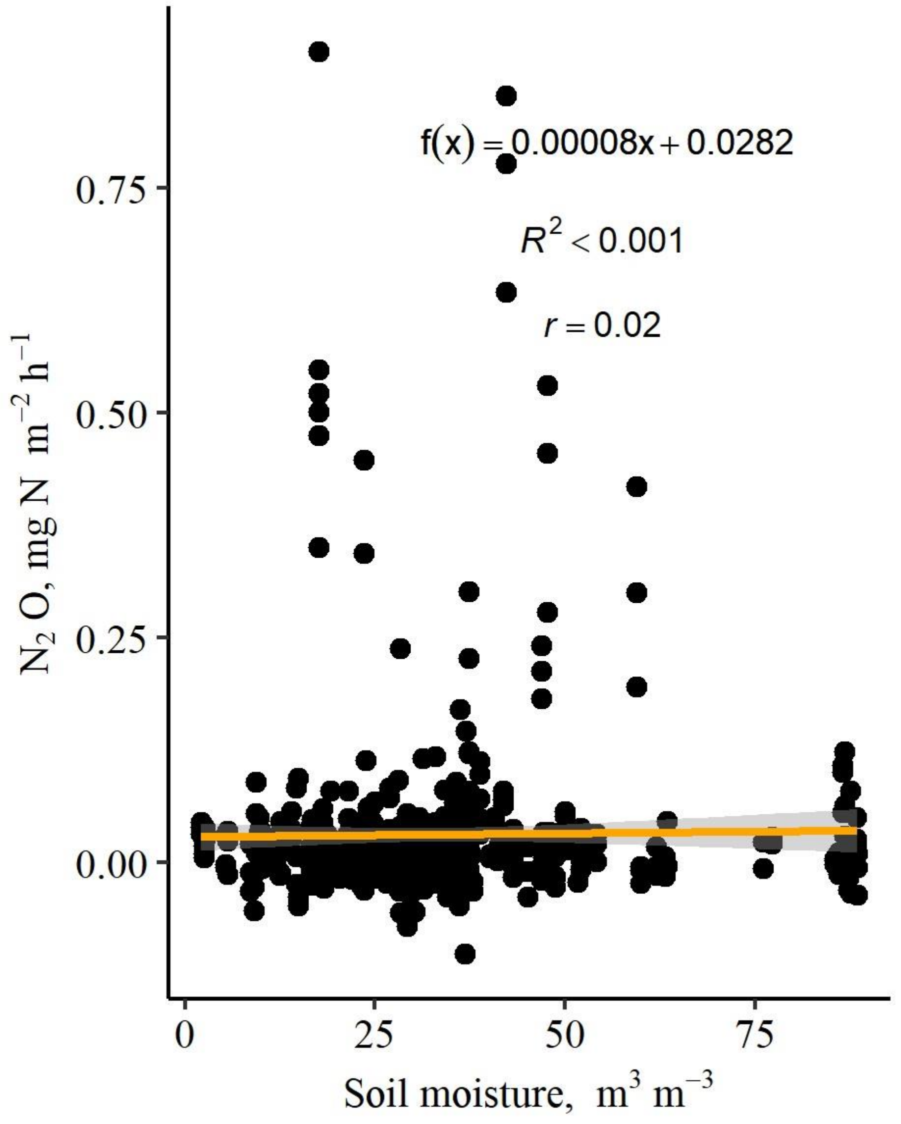












Results and discussion

Annual GHG fluxes

Thickness of organic soil layer, cm	Research site (RS), subplot	CH_4, kg C ha^{-1} yr^{-1}	N_2O, kg N ha^{-1} yr^{-1}	R_{tot}, t C ha^{-1} yr^{-1}	R_{het}, t C ha^{-1} yr^{-1}	C_{input}, t C ha^{-1} yr^{-1}	R_{het} - C_{input}, t C ha^{-1} yr^{-1}
< 20 cm	RS1, A	-0.66	4.63	8.78	6.17	1.28	4.90
	RS3, A	-5.03	1.27	10.09	7.09	2.01	5.08
	RS3, B	-4.09	1.81	8.85	6.22	2.62	3.60
20-40 cm	RS1, B	0.59	1.23	7.76	5.46	1.67	3.78
	RS1, C	0.26	1.15	8.47	5.95	2.72	3.23
	RS2, A	-0.82	6.29	9.52	6.69	4.01	2.69
	RS3, C	-2.73	-0.06	8.04	5.65	2.87	2.78
> 40 cm	RS2, B	0.86	4.12	8.03	5.64	3.58	2.06
	RS2, C	1.07	1.03	7.42	5.21	2.01	3.21
< 20 cm	**Average**	**-3.26 ± 1.33**	**2.39 ± 0.70**	**8.55 ± 0.29**	**6.01 ± 0.20**	**2.53 ± 0.30**	**3.48 ± 0.33**
20-40 cm	**Average**	**-0.68 ± 0.75**					
> 40 cm	**Average**	**0.96 ± 0.10**					
Deep peat soil with thickness of organic soil layer > 40 cm and C content in soil at 0-20 cm > 190 g kg^{-1} (Licite, Lupikis, 2020)		57.8 ± 44.3	0.26 ± 0.25	-	-	-	4.39 ± 0.87
IPCC provided emission factors for drained grassland (deep-drained, nutrient-rich, temperate) (IPCC, 2014)		16 (95% confidence interval 2.4-29)	8.2 (95% confidence interval 4.9-11)	-	-	-	6.1 (95% confidence interval 5.0-7.3)

Conclusions

- Shallow organic soils in grassland in Latvia were sources of net CO_2 emissions (mean 3.48 ± 0.33 t CO_2-C ha^{-1} yr^{-1}) which also were the main component of total soil GHG emission budget, mostly sources of N_2O emissions (mean 2.39 ± 0.70 kg N_2O-N ha^{-1} yr^{-1}), while they can both emit and consume atmospheric CH_4 depending on thickness of organic soil layer (mean -1.17 ± 0.75 kg CH_4-C ha^{-1} yr^{-1}).

- In general, soil-to-atmosphere GHG fluxes from shallow organic soils in grassland in Latvia were lower than those provided by the IPCC for deep-drained, nutrient-rich areas in temperate zone, as well as net CO_2 and CH_4 emissions from shallow organic soils were lower than those estimated previously in grassland with deep peat soils in Latvia.

- The directions for future research include further work to increase accuracy of GHG fluxes from drained organic soils in agricultural land as well as to evaluate additional affecting factors, e.g., soil compaction and nutritional regime.

- Potential title of the research article:
    - Soil-to-atmosphere GHG fluxes from shallow organic soils in grassland in Latvia