Permafrost and greenhouse gases efflux of terrestrial ecosystems: relationship, spatial variability, trend of climate change (West Siberia, Russia)

SPSAS Climate Change

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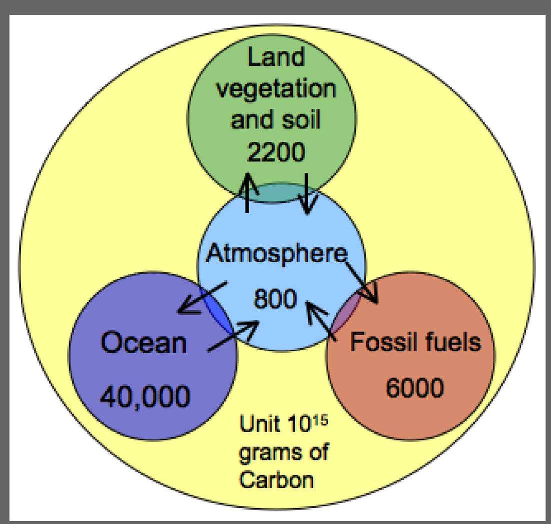
Why this is Important?



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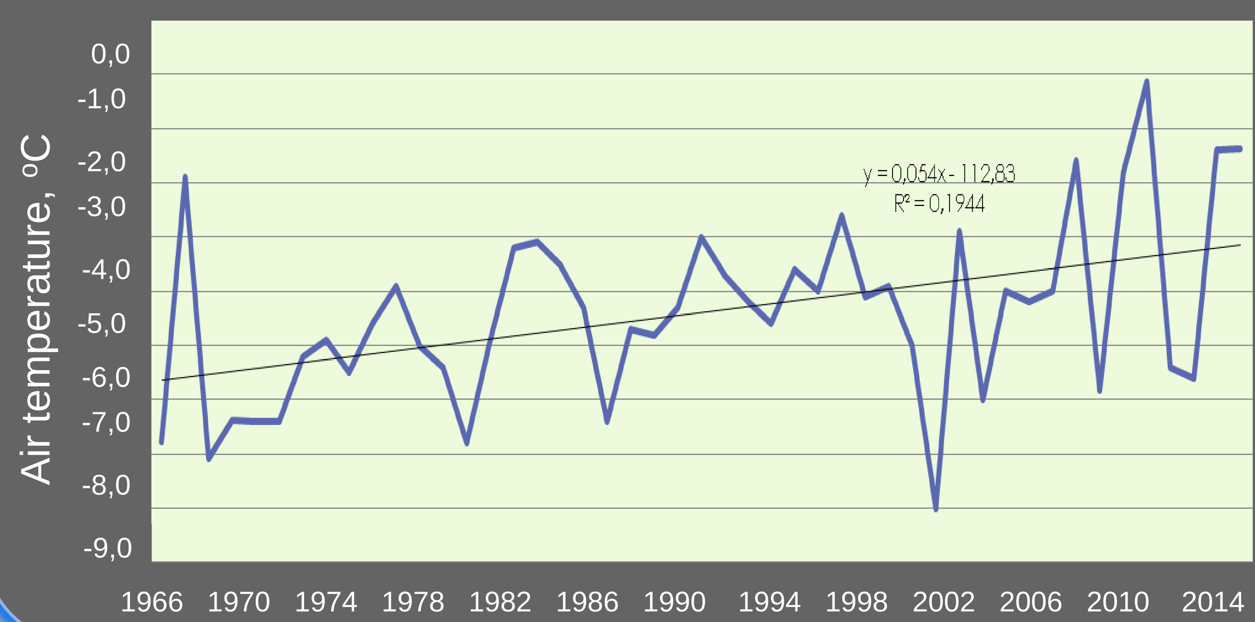
Polar terrestrial ecosystems and permafrost-affected soils are **unique indicators** of climate change in the early stages. **Soil CO_2 efflux** is one of the major pathways by carbon is released back into the atmosphere. Recent studies emphasize the significant contribution of **soil CO_2 efflux** to the **global carbon pool**. Soils of polar terrestrial ecosystems represent a **unique natural object** and provide functional diversity and integrity of northern taiga ecosystems of West Siberia.

The Main Question

What role do play the **polar ecosystems** in global **carbon cycle**? **How** was related variability of **active layer thickness** and **efflux of greenhouse gases** from permafrost-affected soils of terrestrial ecosystems under climate change?

Climate Change in Polar Region

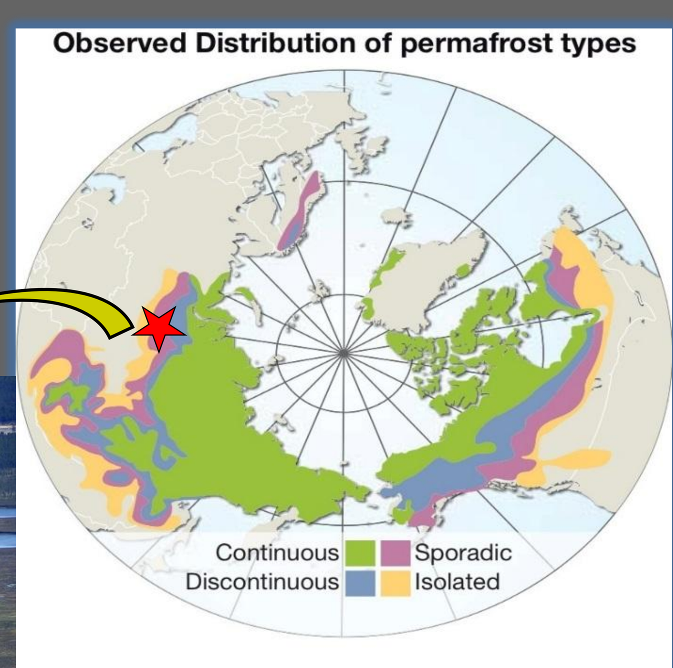
Fluctuation of Annual Mean Air Temperature

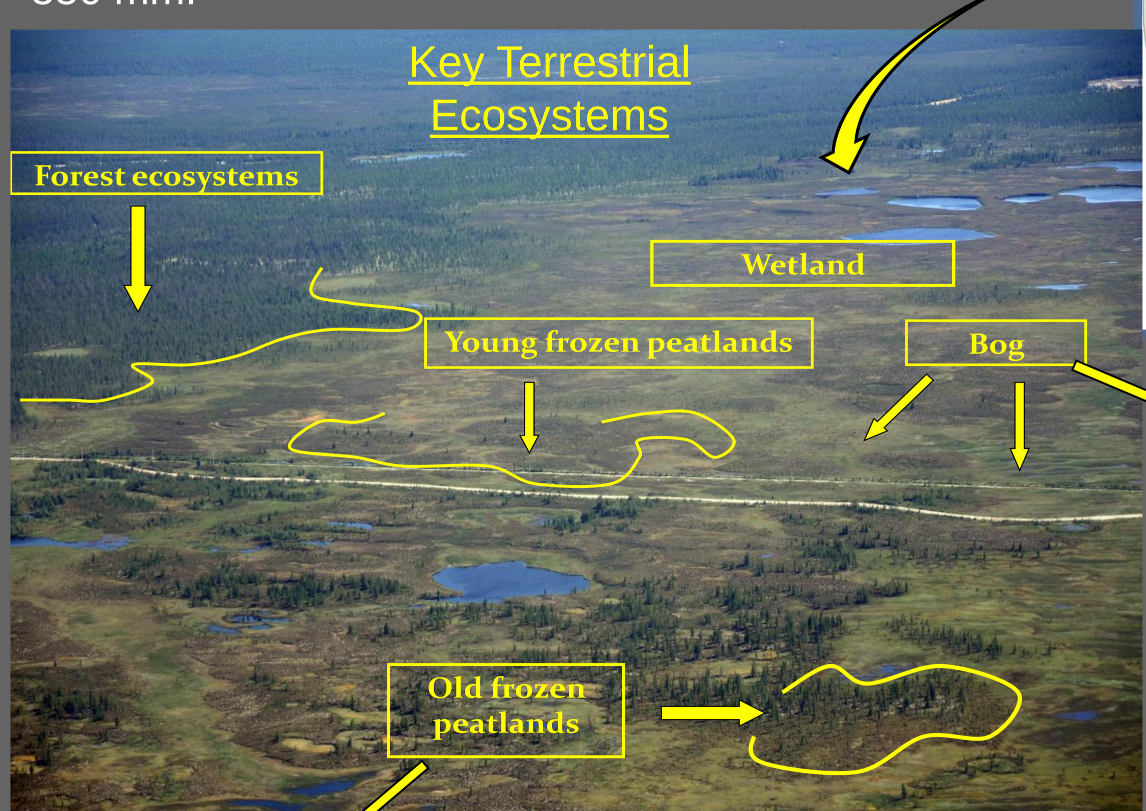


The climatic record (weather stations in North-West Siberia) indicates a progressive **growth** of annual mean air temperatures **of ~2,5°C over the past 48 years**, due to increase in both summer and winter temperatures. The contribution of winter warming is ~2 times greater that of summer warming.

Research Area

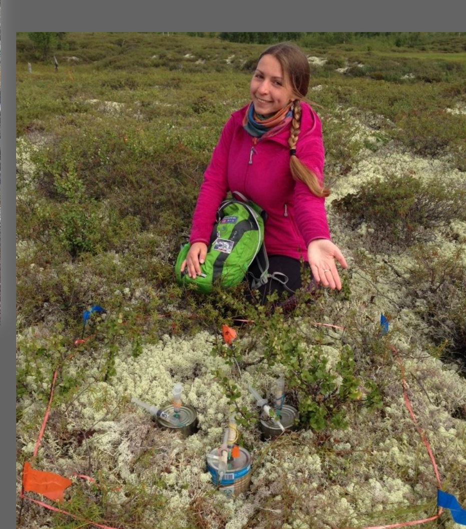
Research area is located on the north of Western Siberia (**Nadym** District, **Russia**; N65º18' E72º52') within the northern boundary of north taiga. It's zone of **sporadic permafrost**. Mean annual air temperature of -4,5°C, annual mean precipitation is 550 mm.





Methods

Regime monitoring of the carbon dioxide efflux from the soil surface *(close non-steady-state non-through-flow chambers method)* (Smagin, 2005; Reth et al., 2005; Bekele et al., 2007)



In the field

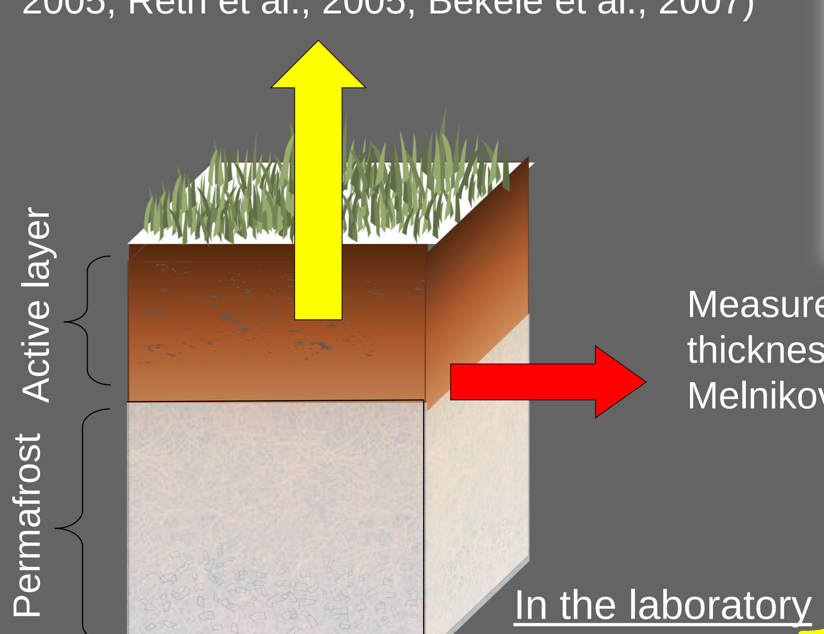


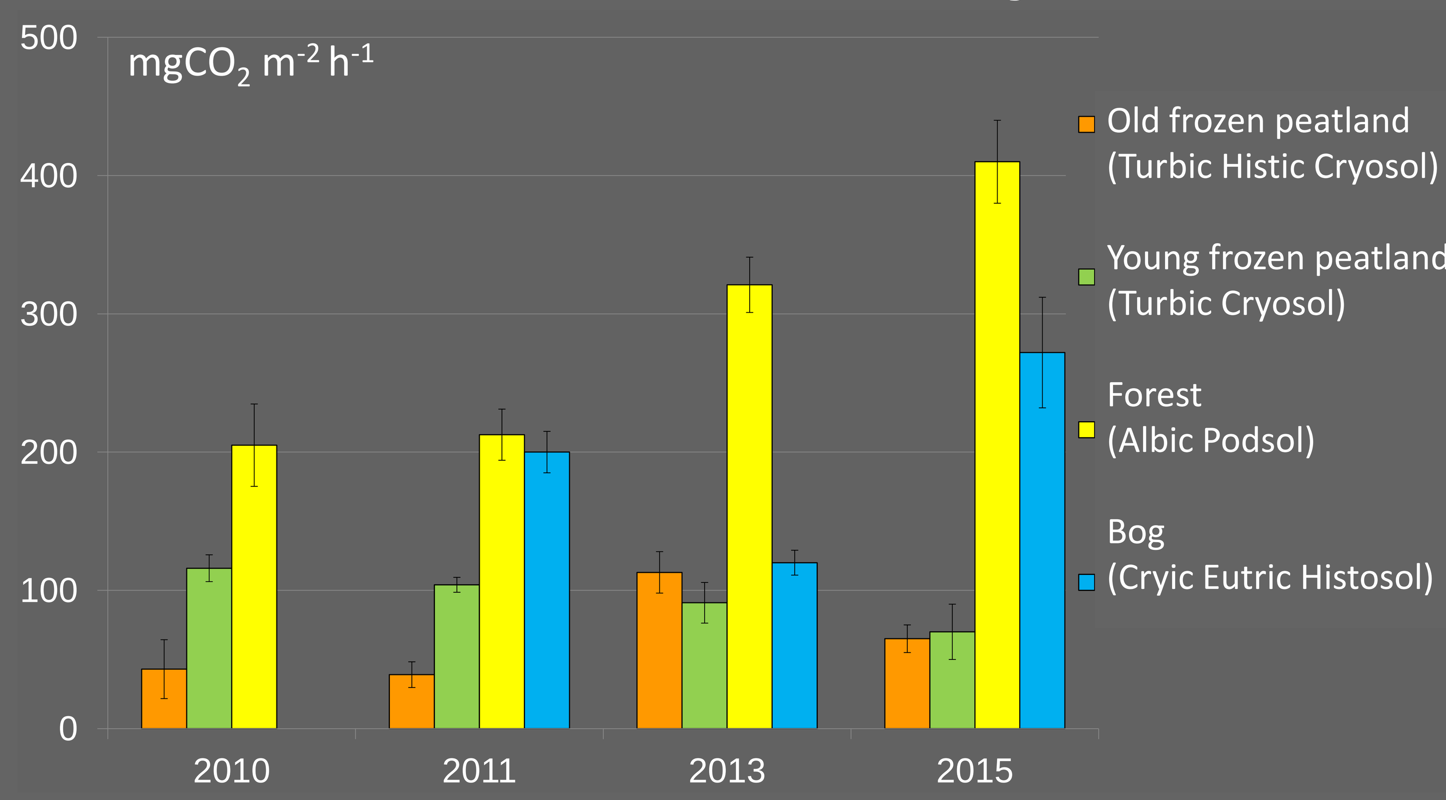
Figure adapted from Striegl et al., 2005

Measurement of active layer thickness (GOST RF 26262-84; Melnikov et al., 2005)

In the laboratory

- Content of the total organic carbon (TOC)
- Carbon of microbial biomass (MC) in the upper 10 cm of soil by chloroform fumigation-extraction (FE) method (Brooks et al., 1985; Makarov et al., 2013)
- Carbon of water-extractable organic matter (WEOC) (extraction of 0.005M K_2SO_4) TOC-V_{CPN} (Chantigny et al., 2003; Embacher et al., 2007)

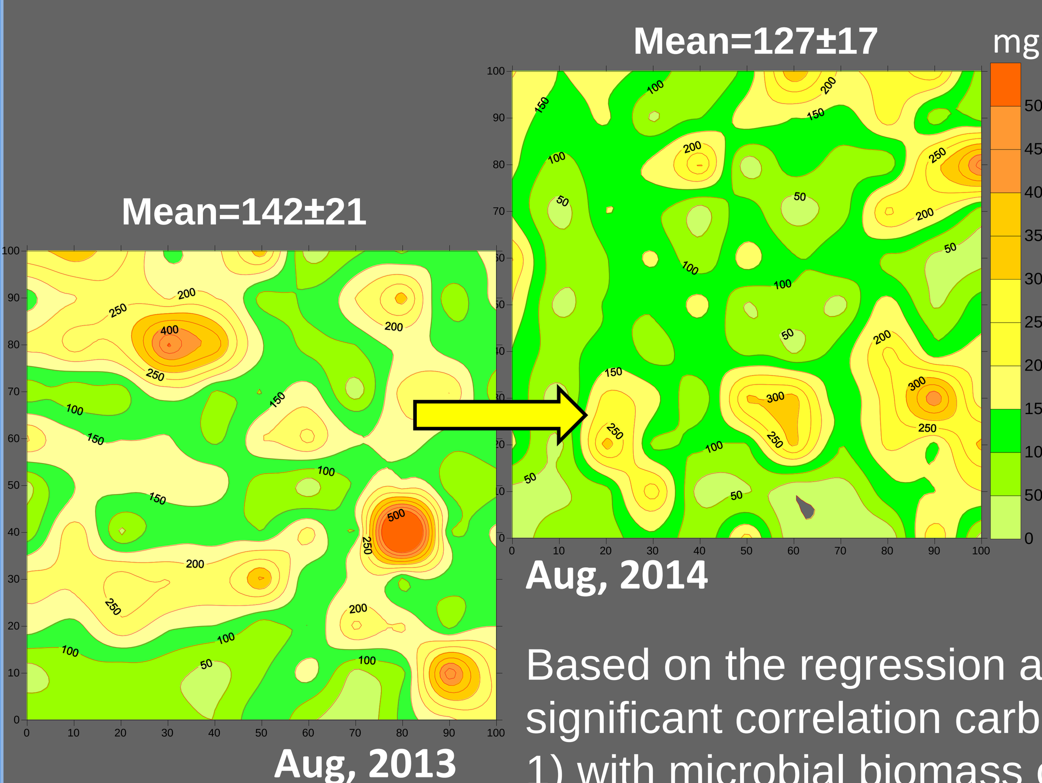
Carbon Efflux From Soils of Key Terrestrial Ecosystems



The value of CO_2 efflux and the MC:TOC ratio were ecosystem-specific and may be used as indicators of environmental changes.

The **main factor** which determine the soil carbon dioxide production and carbon effluxes is the depth of permafrost table (**active layer thickness**), it determine the type of ecosystem in such transitional landscapes and organic matter transformation processes.

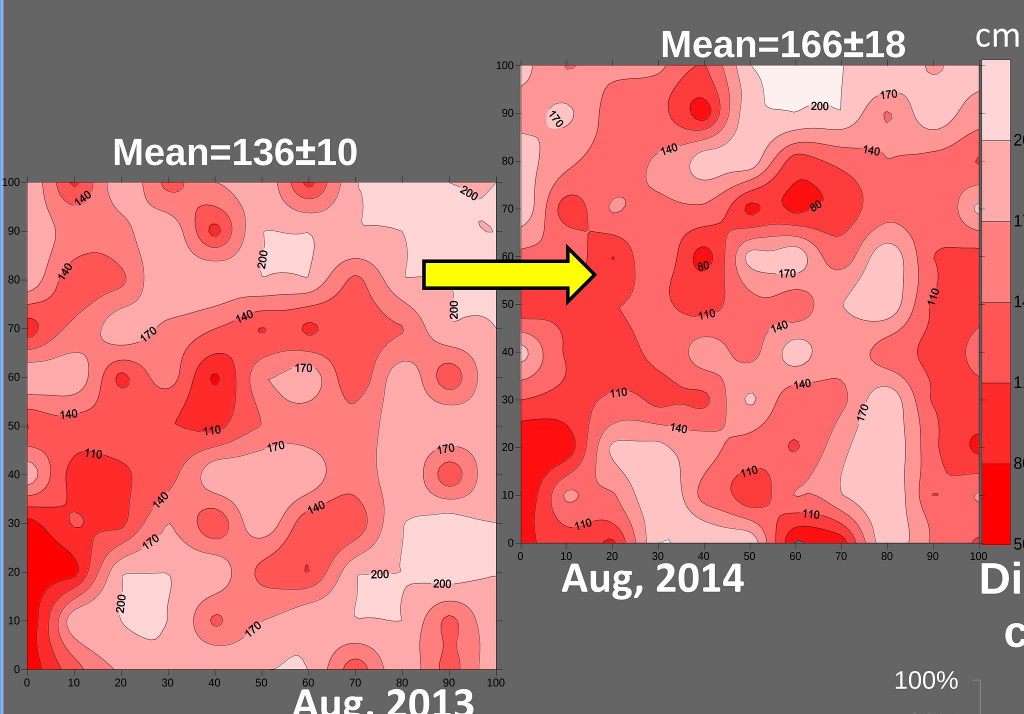
Spatial and Temporal Variability of Carbon Efflux from Peatland and Bog Soils



	Peatland (2013)	Peatland (2014)	Bog (2013)	Bog (2014)
Valid N	74	74	42	42
Mean	158	120	127	133
Std. Dev.	90	80	65	87
Coef. Var., %	62	71	51	65

Based on the regression analysis was revealed high and significant correlation carbon dioxide efflux from peatland soils:
1) with microbial biomass carbon (MC) in the upper 10 cm soil layer ***(r=0,25, p-level<0,05)***,
2) with the active layer thickness ***(r=0,45, p-level<0,05).***

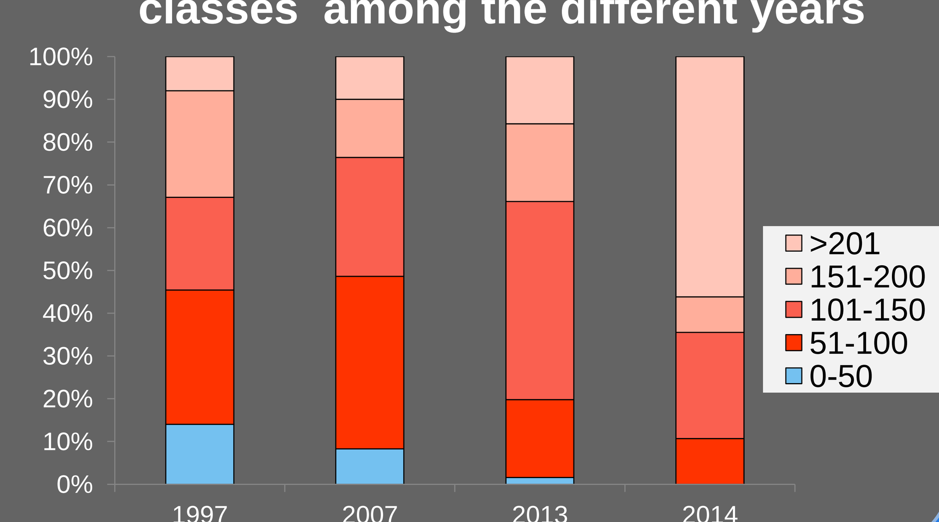
Spatial and Temporal Variability of Active Layer Thickness



	Peatland (2013)	Peatland (2014)	Bog (2013)	Bog (2014)
Valid N	76	76	45	45
Mean	133	156	144	182
Std. Dev.	47	48	40	33
Coef. Var., %	36	31	28	18

Average active layer thickness increased **from 119±6 to 166±8 cm** from **1997 to 2014**. Area with small active layer thickness (<50 cm) decreased from 14% to 0%. Areas with deepest thaw (more than 200 cm) increased from 8 to 56% and are developed in large sedge-moss pools within peatlands and in bog.

Distribution of active-layer thickness classes among the different years



Conclusion

•**Growth** of active layer thickness (from 119±6 to 166±8 cm) **is related with** progressive growth of annual air temperature (climatic data from weather station "Nadym",1997-2014).
•The results show that the **active layer thickness** in our experimental area in the Siberian taiga is an important control of **greenhouse gases efflux**.
•**It is important** to note that over the last ten years, have become more frequent climatic **anomalies** such as very cold or very warm winters, dry summers. Significant **inter-annual fluctuations** may lead to displacement of the existing climate balance.
•**Soil** properties (**CO_2 efflux** and content of total, microbial, water-extractable organic carbon) and **landscape** properties of frozen peatlands (**active layer thickness**) are characterized by high **spatial variability**. **Underestimation** of the spatial variability of soil and vegetation cover in the region of discontinuous permafrost can lead to substantial distortion of estimates of the total greenhouse gases balance.
•Understanding of the **contribution of polar terrestrial ecosystems** in global carbon cycle is very important for the assessment of interaction between ocean, atmosphere and soil.

Key references

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3. Goncharova O.Yu, Bobrik A.A., Matyshak G.V., Makarov M.I. The role of soil cover in maintaining the structural and functional integrity of northern taiga ecosystems in Western Siberia // Contemporary Problems of Ecology. 2016. Vol. 9, no. 1. P. 1–8.

Acknowledgments

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