Temperature regime of drained and natural peatlands in arid and water-logged years

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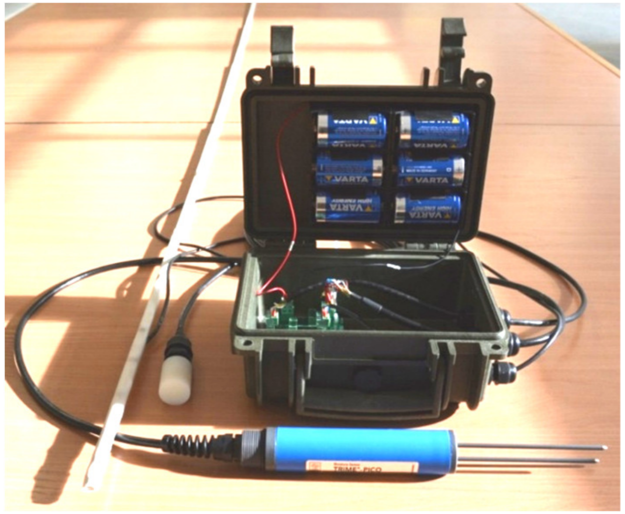
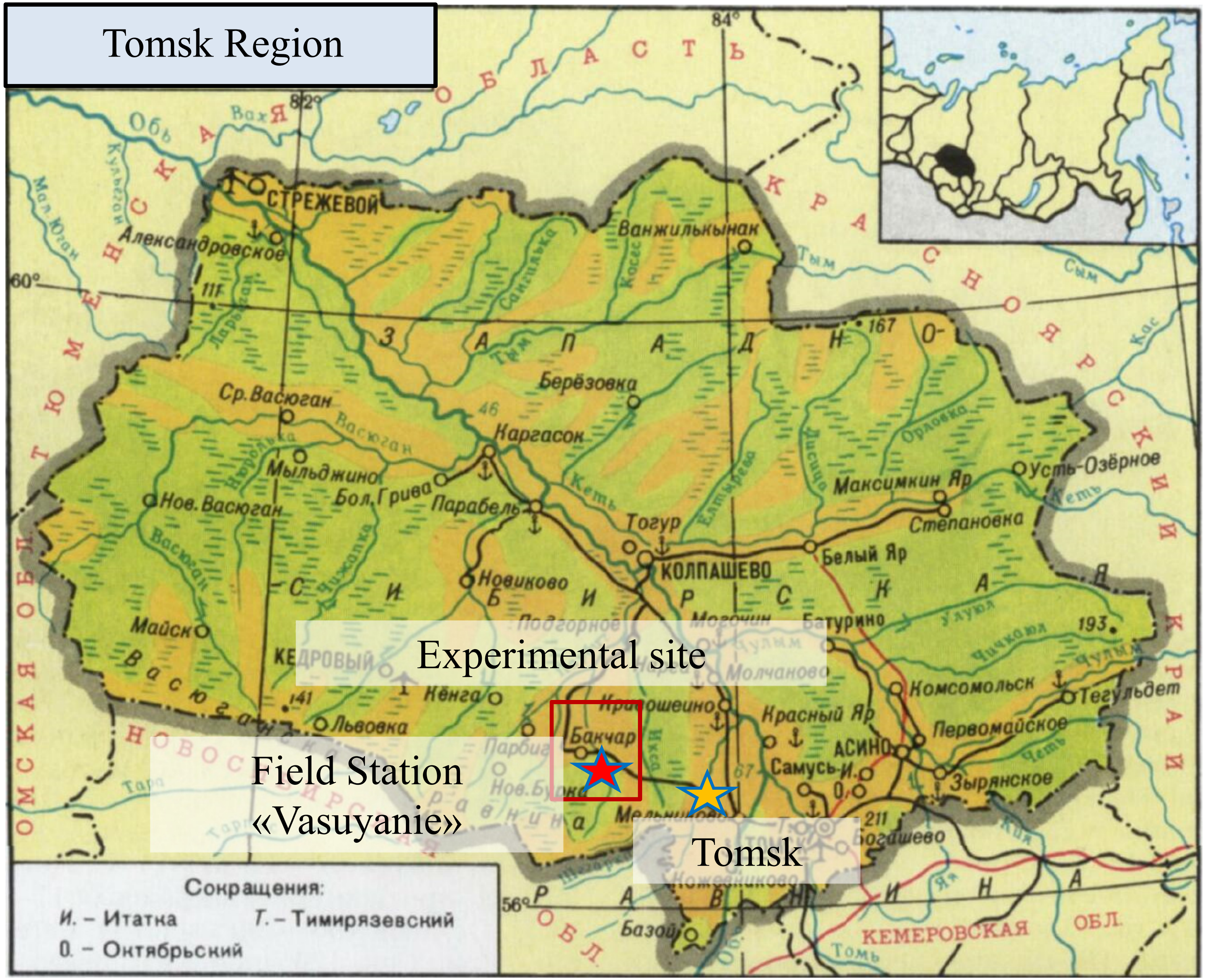
Monavale Vlei
Healthy Wetland Nature
Birds play a key role in dispersing grass seeds.
Insects are critical pollinators of flowers.
Amphibians are very sensitive to environmental change. Their health and numbers are a good indicator of a wetland's health.
There are many species, such as the Giant Bullfrog, that only live in wetlands. Damage to the wetlands is a serious threat to their survival.
Not all parts of a wetland's biodiversity are visible. The soil is a critical part of the ecosystem, and it contains millions of microbes, bacteria, fungi, mould, earthworms, millipedes, and other organisms that actively clean and filter the water, break down organic matter into essential nutrients, and support other life forms.



Atmospheric-soil measuring system (ASMS)

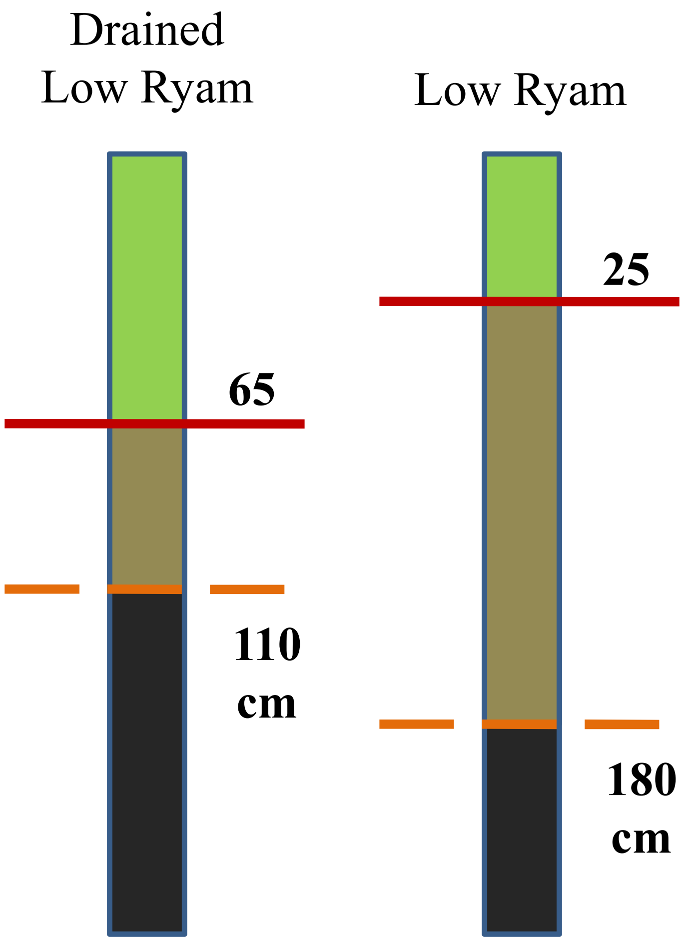
IMCES SB RAS

№	Component part	Measuring range	Accuracy
1	Temperature sensor DS18B20	from -55 to +55°C	±0,1°C
2	Air humidity sensor HIH-5031	from 0 to 100%	±3,5%
3	Soil moisture sensor TRIME-PICO32	from 0 to 100%	±2%
4	Atmospheric pressure sensor MPL3115A2	from 500 to 1100 hPa	±4 hPa
5	Wind speed and direction sensor Davis Anemometer 6410	from 0,9 to 78 m/s from 0 to 360°	±5% ±7%
6	Liquid precipitation sensor Davis 7852M	from 0 to 1000 mm/h	±5%
7	Pyranometer 2 channel (albedometer) Range from 0,35 to 9 μm	from 0 to 2000 W/m^2	±10%
8	The level of groundwater sensor	from 0 to 10,5 m	±1%
9	Snow cover depth sensor	from 0 to 2 m	±0,05 m
10	Ultrasonic sensor of snow cover depth MB7384	from 0 to 4 m	±0,015 m

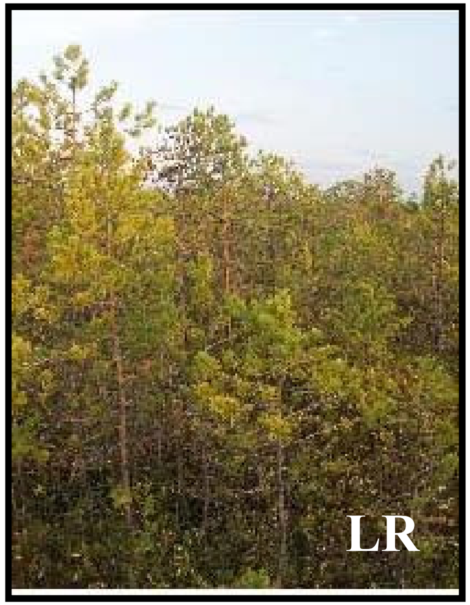


Tomsk Region
Experimental site
Field Station
«Vasuyanie»
Tomsk
СТРЕЖЕВОЙ
Александровское
Ванжилькынак
Берёзовка
Ср.Васюган
Мыльджино
Каргасок
Бол.Грива
Парабель
Нов.Васюган
Тогур
КОЛПАШЕВО
Новиково
Белый Яр
Максимкин Яр
Степановка
Усть-Озёрное
Майск
Кёнга
Львовка
Бакчар
Молчаново
Комсомольск
Тегульдет
Красный Яр
Первомайское
АСИНО
Самусь
Зырянское
Богашево
Базой
Батурино
КЕМЕРОВСКАЯ ОБЛ.
Сокращения:
И. – Итатка
Т. – Тимирязевский
О. – Октябрьский

Experimental sites



Pine-shrub sphagnum ecosystem



– – the peat depth, cm

— the average bog water table level, cm

Measurement period: 11.09.2011 – 13.10.2018
Time step: 15 min
Temperatuer accuracy: 0,1°C
Depth: 0 – 240 cm

– Anaerobic peat – Aerobic peat – Mineral soil

The Ped drought index

$$S_i = \frac{\Delta t_i}{\sigma_t} - \frac{\Delta r_i}{\sigma_r},$$

$\Delta t_i = t_i - t_{norm}$	Anomaly of air temperature for *i*-th time step
σ_t	Standard deviation for air temperature
$\Delta r_i = r_i - r_{norm}$	Anomaly of precipitations for *i*-th time step
σ_r	Standard deviation for atmospheric precipitation

The greatest drought in 2012

The greatest moistening in 2018

Year	Months						
	April	May	June	July	August	September	October
2011	2,60	0,64	1,75	-3,20	-3,49	1,83	1,34
2012	1,80	0,44	4,07	3,42	-1,10	1,56	0,85
2013	0,39	-4,31	-1,30	1,33	0,23	-0,89	0,77
2014	0,57	-1,26	0,54	1,30	1,71	-2,25	-2,53
2015	-1,66	0,16	1,11	0,86	0,16	-2,06	-2,04
2016	0,38	0,55	1,54	-1,54	1,85	3,58	-1,64
2017	0,32	-0,33	-2,14	-0,29	1,33	-0,41	0,54
2018	-2,51	-4,05	-1,74	-1,63	0,56	1,64	1,01

Moistening period

Drought period

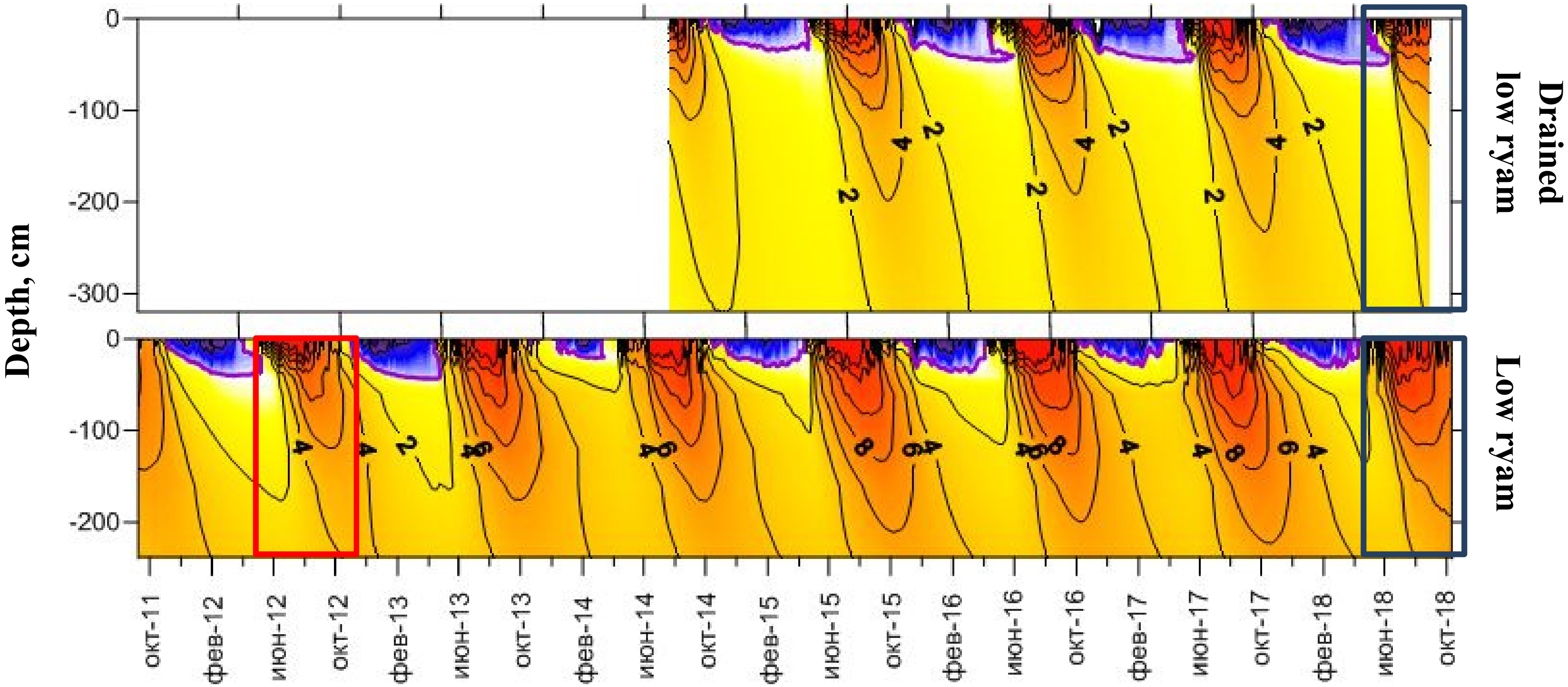
weak ($1 \le |S| < 2$)

moderate ($2 \le |S| < 3$)

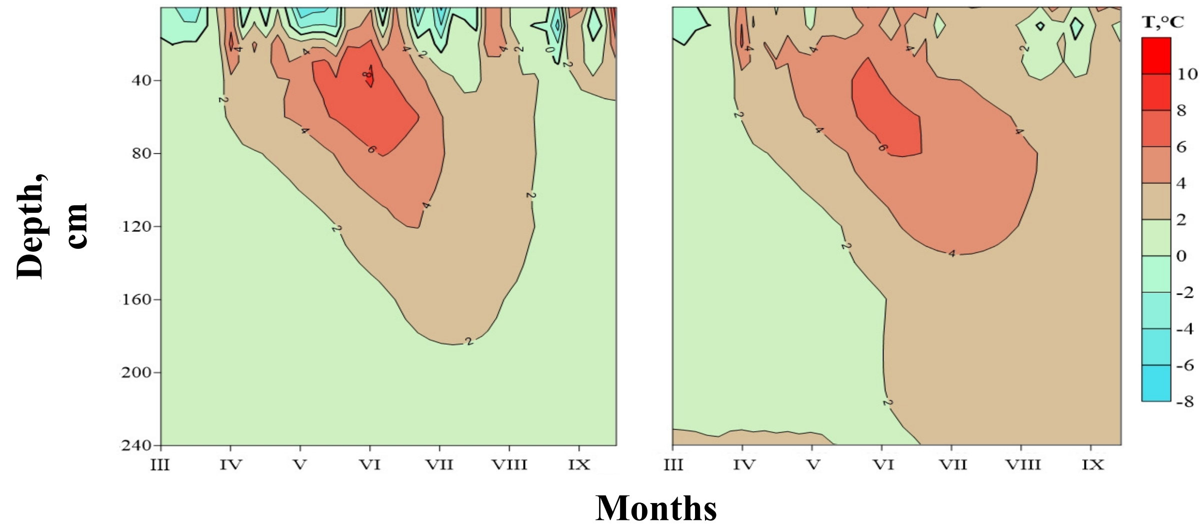
strong ($3 \le |S| < 4$)

Extreme events ($|S| \ge 4$)

Peat soil temperature profile 2011-2018



$\Delta T = T_{\text{low ryam 2018}} - T_{\textit{low ryam 2012}}$ $\Delta T = T_{\text{low ryam 2018}} - T_{\textit{drained low ryam 2018}}$



Soil heat flux estimation from observations

Heat-mass transfer equation $$C\frac{\partial T}{\partial t} = S = -\frac{\partial G}{\partial z} + \Delta F$$

Net change in heat storages $$\Delta S = \int_{z0}^{z1} C\frac{\Delta T}{\Delta t}dz$$

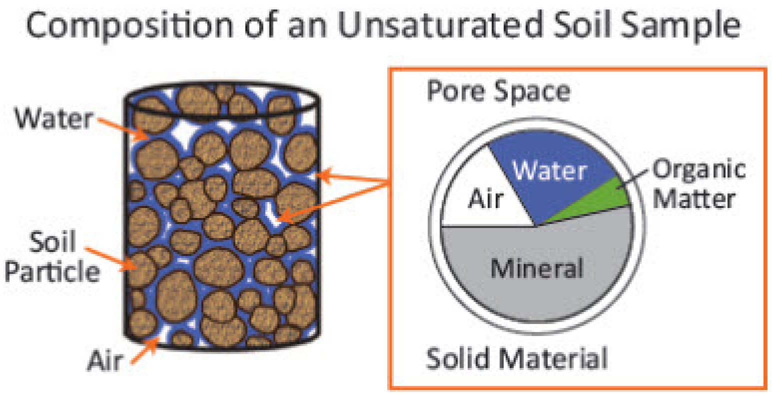
Diffusion heat flux $$G = -k\frac{dT}{dz}$$

Latent (and other) heat flux $$F = S - G$$

$$\frac{\partial T}{\partial z} = \frac{{T_i}^k - {T_{i-1}}^k}{z_i - z_{i-1}}, \qquad \frac{\partial T}{\partial t} = \frac{{T_i}^k - {T_i}^{k-1}}{\Delta t},$$

Soil properties (A + W + I + S)

$$k = k_a A + k_W W + k_i I + k_s(1 - A - W - I)$$
$$C = c_A \rho_A A + c_w \rho_w W + c_I \rho_I I + c_{s1} \rho_{s1}(1 - \Pi) S1 + c_{s2} \rho_{s2}(1 - \Pi)(1 - S1)$$



$\rho_A = 1{,}247\ kg/m^3$ $\quad c_A = 1005\ J/kg/K$

$\rho_w = 1000\ kg/m^3$ $\quad c_w = 4182\ J/kg/K$

$\rho_I = 918\ kg/m^3$ $\quad c_I = 2150\ J/kg/K$

$\rho_{s1} = 1510\ kg/m^3$ $\quad c_{s1} = 1880\ J/kg/K$

$\rho_{s2} = 2700\ kg/m^3$ $\quad c_{s2} = 750\ J/kg/K$

$k_s = 0.05\ W\ m^{-1}\ K^{-1}$ $\quad k_w = 0.59\ W\ m^{-1}\ K^{-1}$

$k_A = 0.025\ W\ m^{-1}\ K^{-1}$ $\quad k_I = 2.25\ W\ m^{-1}\ K^{-1}$

at $z <= WTL$ $\quad W = \Pi,\ A = 0$

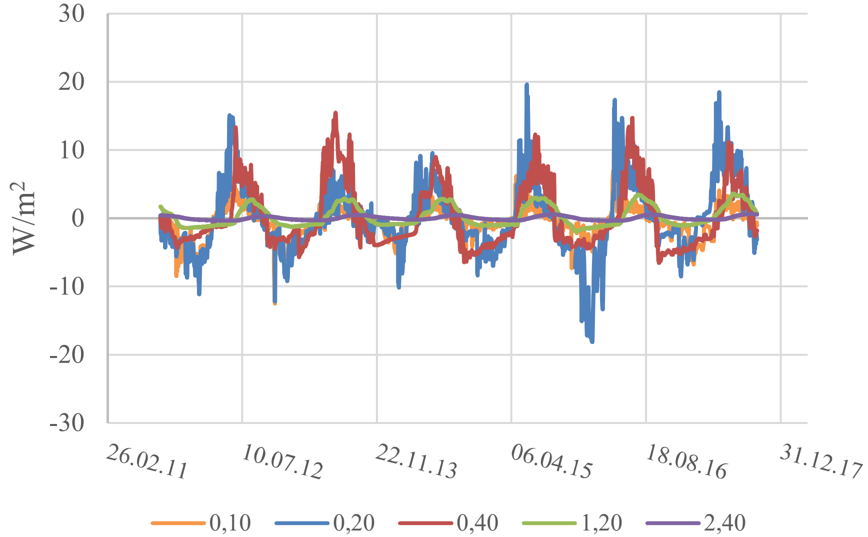
at $z > WTL$ $\quad W = W_0 + (\Pi - W_0)(z/WTL)^2 \quad A = \Pi - W,$

If $T <= 0$, *than* $I = W,\ W = 0,\ A = \Pi - W.$

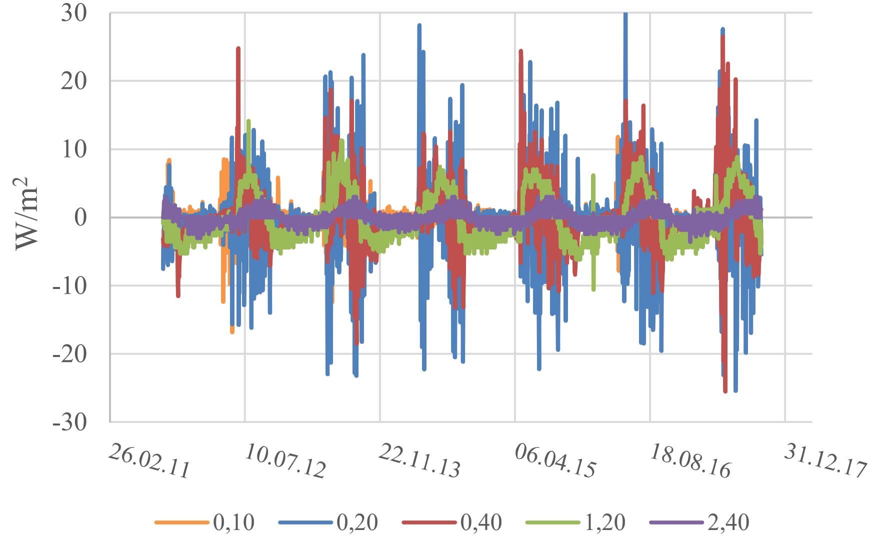
WTL – water table level, cm
W – water content
I – ice content
A – air content
S1 – peat content
S2 – clay content
Π – porosity
C – heat capacity
ρ – density
k – thermal conductivity

Estimation results

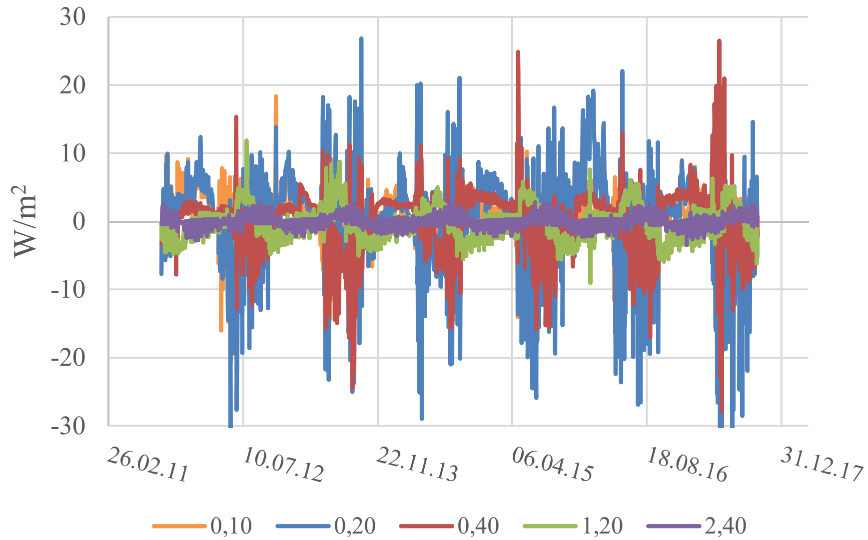
G (Conduction)

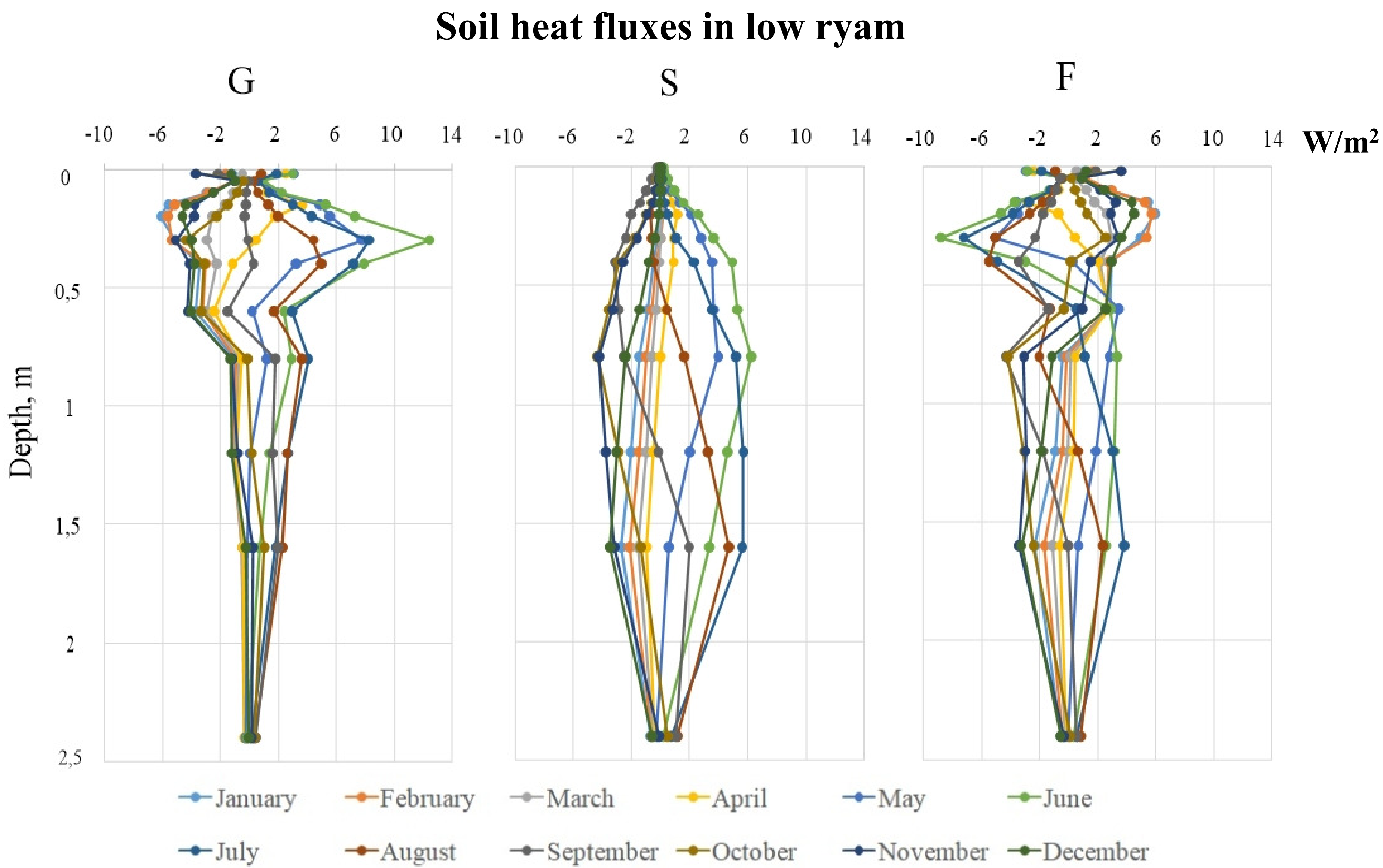


S (Heat storages change)

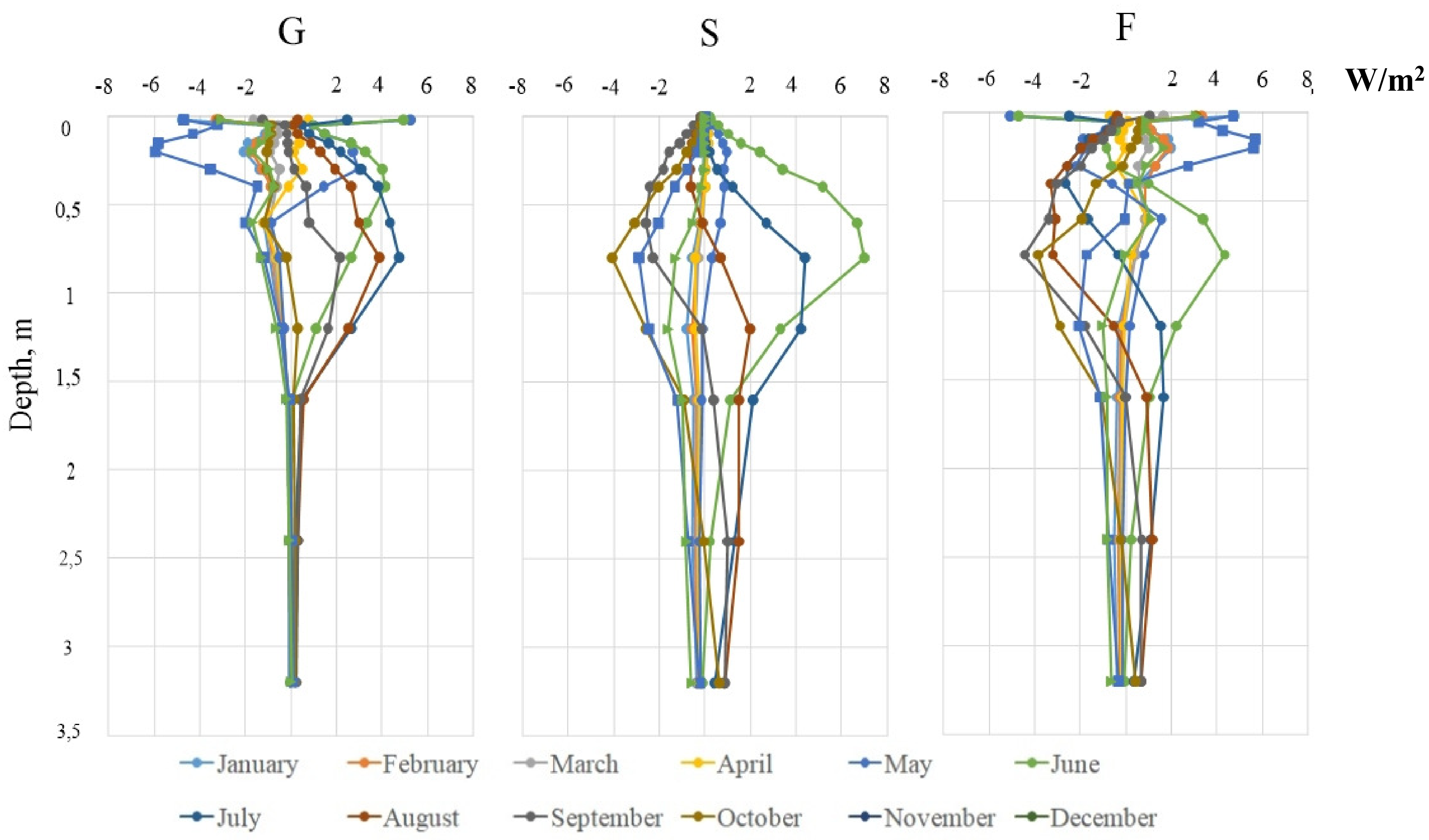


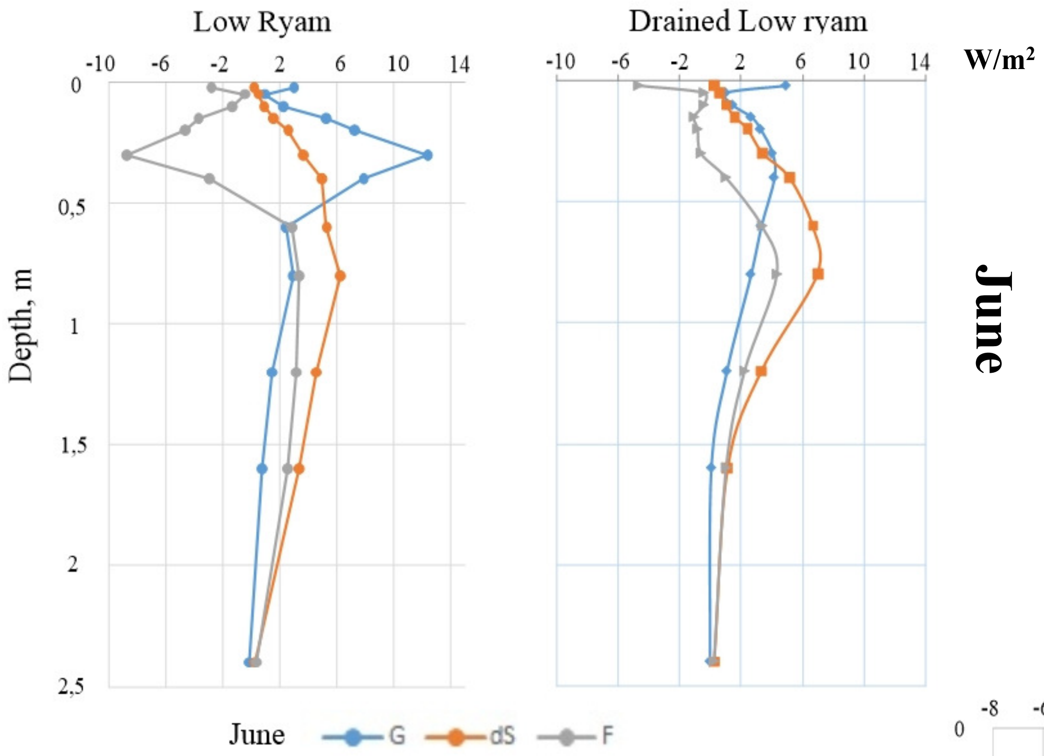
F = S – G (Latent and nonconductive)



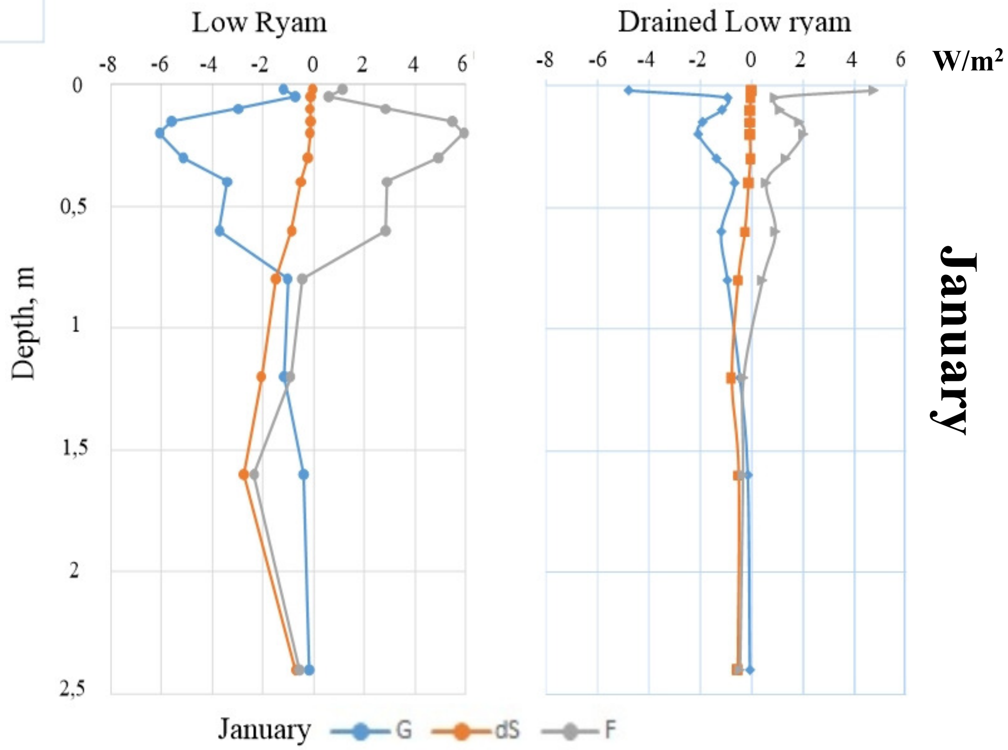

Soil heat fluxes in low ryam
G
S
F
-10 -6 -2 2 6 10 14
W/m2
Depth, m
0
0,5
1
1,5
2
2,5
January
February
March
April
May
June
July
August
September
October
November
December

Soil heat fluxes in drained low ryam





Monthly averaged heat fluxes for low ryam and drained low ryam (June and January)



Conclusions

The analysis of the temperature regime of natural and drained oligotrophic bogs in years with significantly different hydrothermal conditions showed that:

- The main factor controlling the temperature regime of peat deposits is the level of bog waters and, as a result, the peat moisture.

- In an extremely dry and hot year, the temperature of the peat soil is on average lower than in a wet year by 6-10 ° C. In the abnormally hot summer (2012), only the upper 20 cm of soil was warmer than in the over moistened year (2018). The rest of the peat deposit was colder in 2012.

- Drainage of a bog leads to a decrease in the levels of bog waters, and as a result, a decrease in soil temperature in both summer and winter.

THX FOR ATTENTION