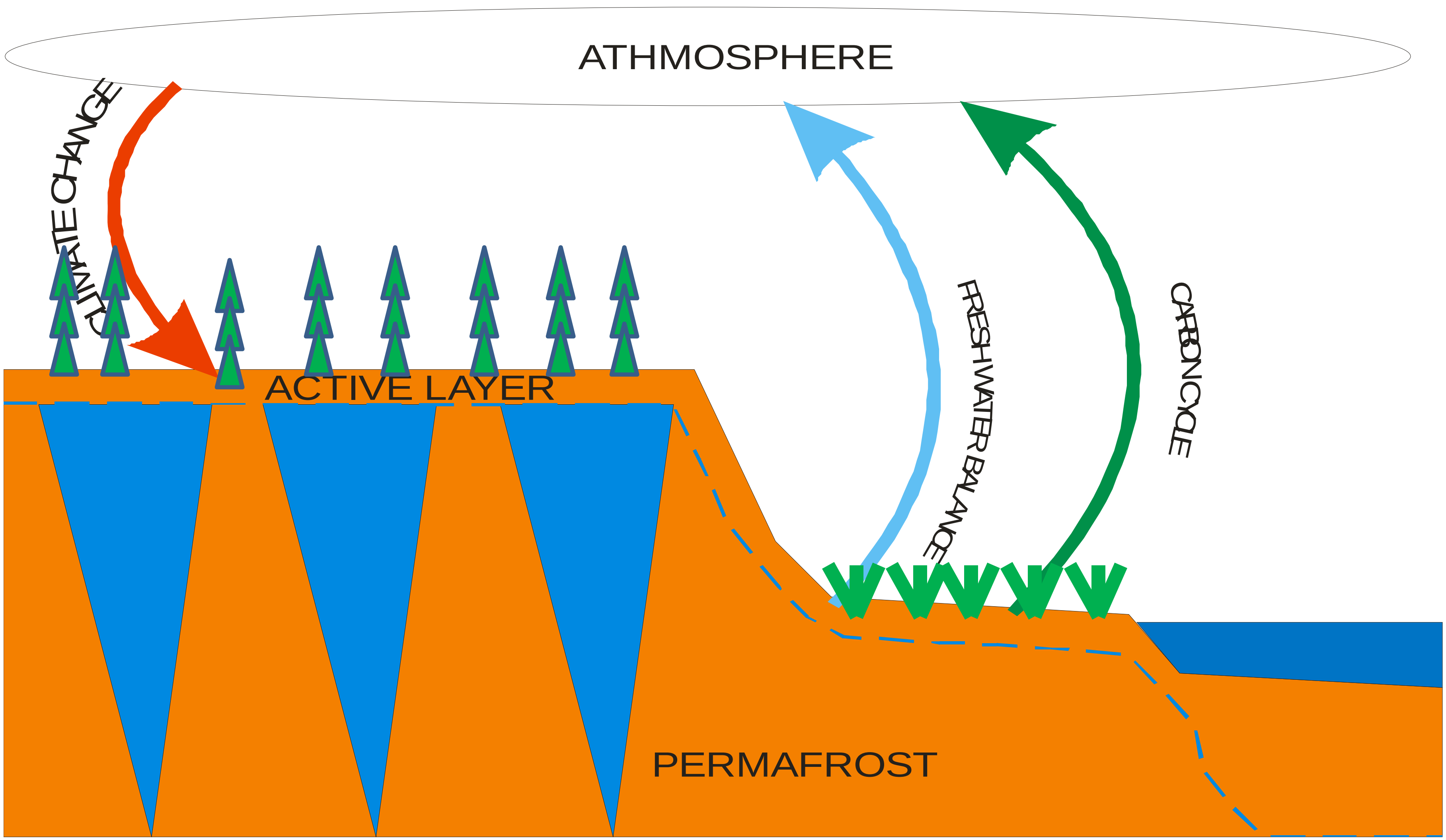
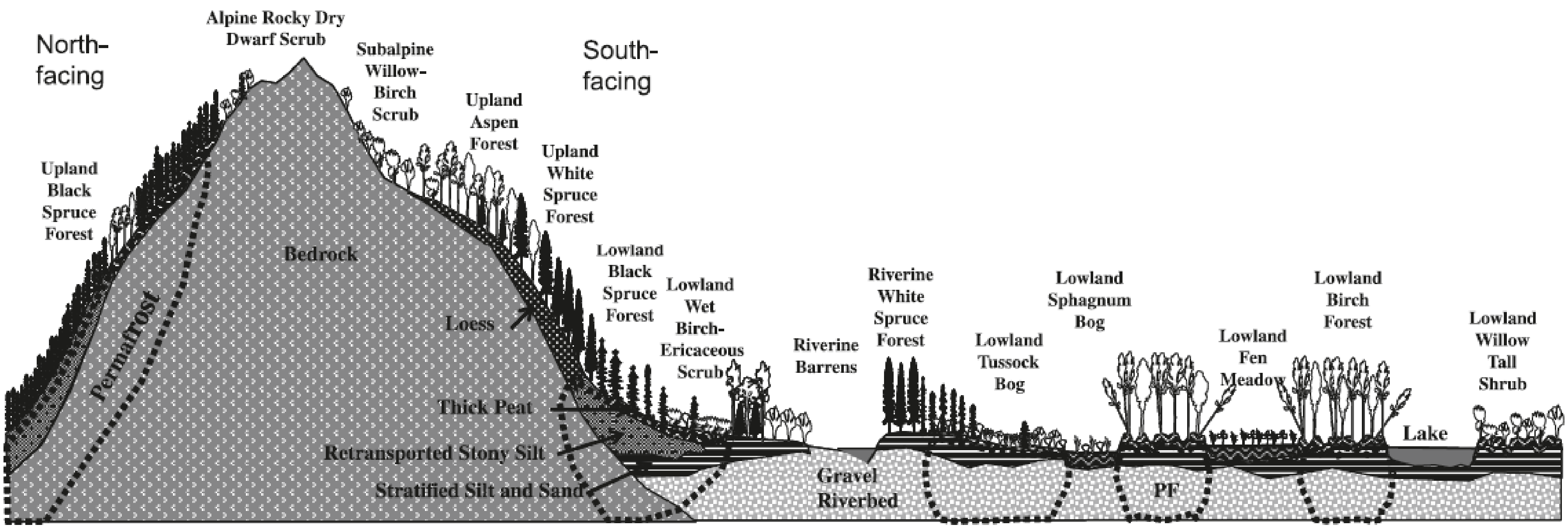
Influence of ecosystem conditions on permafrost temperature dynamics of the lower Kolyma region

Alexander Kholodov[1], Susan Natali[2], Valentin V Spektor[3], Sergey Davydov[4], Sergei A Zimov[4], Varvara Andreeva[3,5]

1. Geophysical Institute UAF
2. Woods Hole Research Center
3. Melnikov Permafrost Institute RAS
4. North-East Science Station Pacific Institute of Geography RAS
5. North-East Federal University

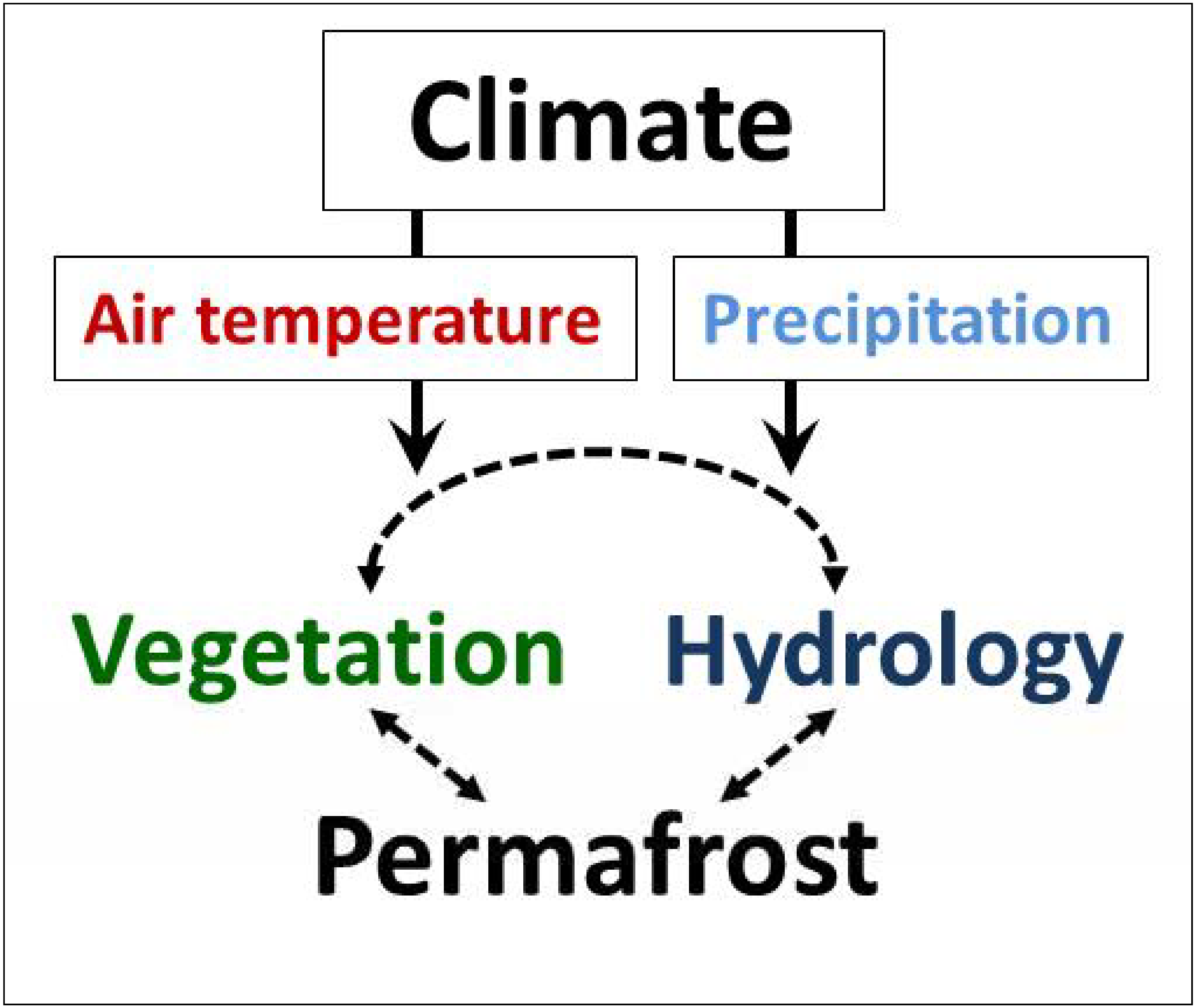

ATHMOSPHERE
CLIMATE CHANGE
FRESHWATER BALANCE
CARBON CYCLE
ACTIVE LAYER
PERMAFROST

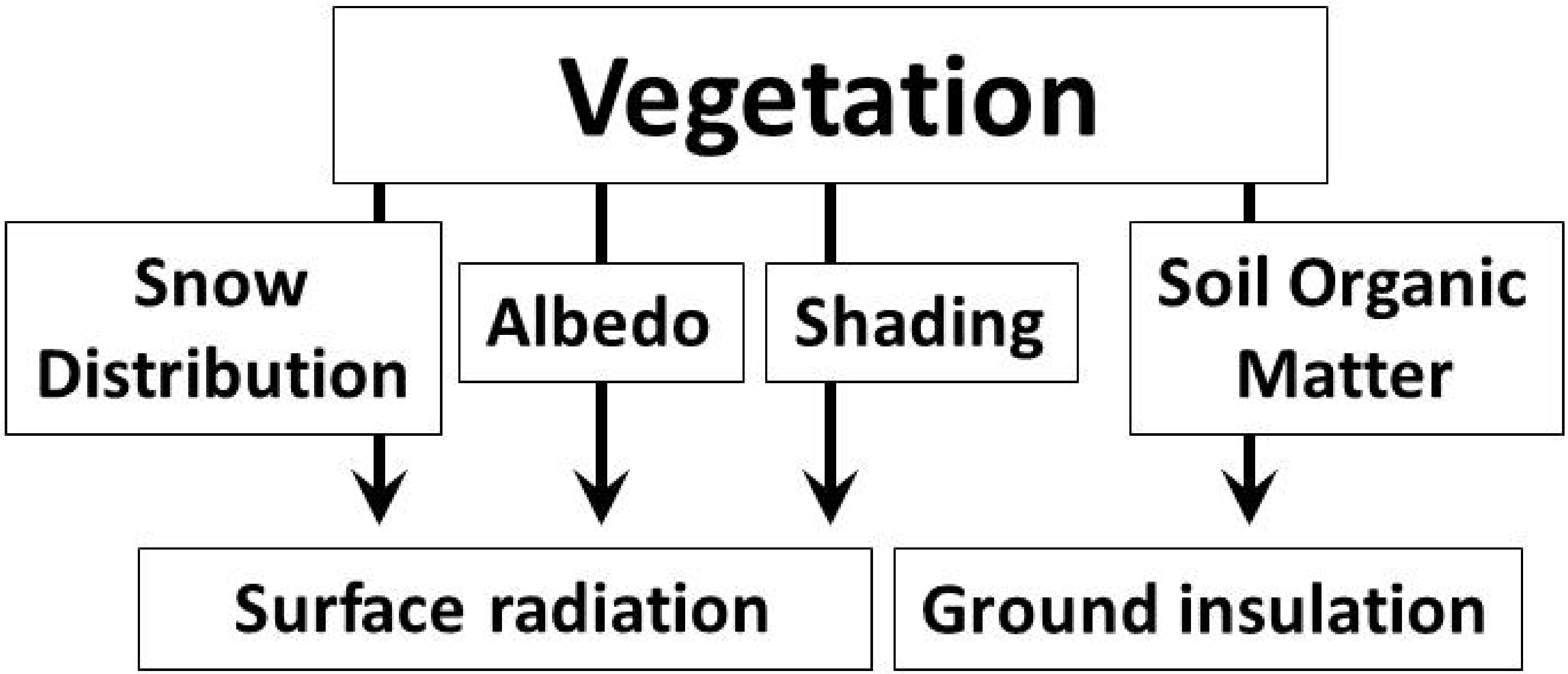
The resilience and vulnerability of permafrost to climate change depends on complex interactions among topography,
water, soil, vegetation, and snow, which allow permafrost to persist at mean annual air temperatures (MAATs) as
high as +2^{o}C and degrade at MAATs as low as –20^{o}C. (Jorgenson et al., 2010)



Schematic of common covarying ecosystem components across boreal ecosystems in central Alaska.

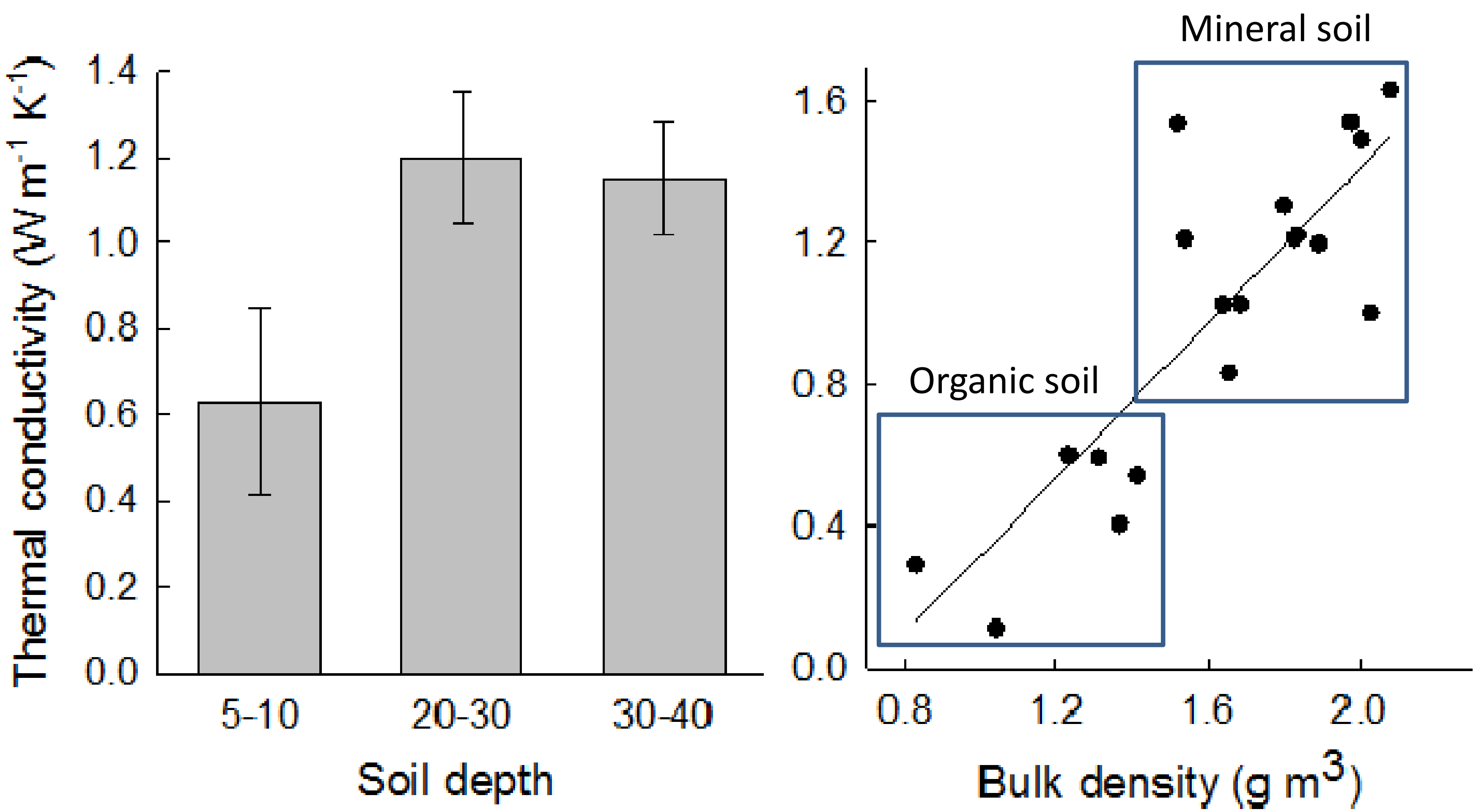
SCHEME OF PERMAFROST–LANDSCAPE INTERACTIONS IN THE CONTEXT OF A CHANGING CLIMATE.




Vegetation
Snow Distribution
Albedo
Shading
Soil Organic Matter
Surface radiation
Ground insulation

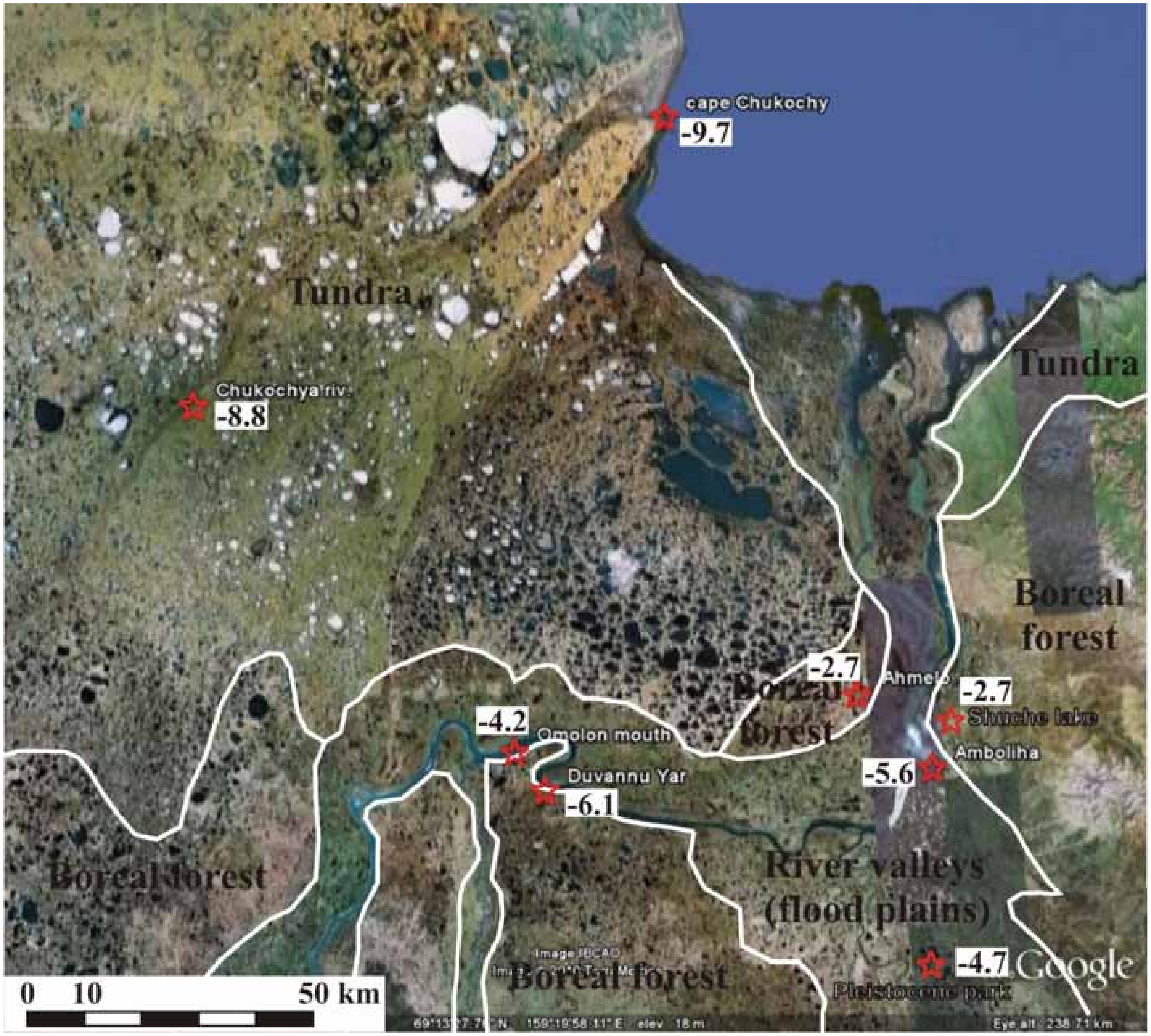
AN EXAMPLE OF SNOW REDISTRIBUTION DUE TO TUSSOCKY MICROTOPOGRAPHY

THERMAL CONDUCTIVITY OF UNFROZEN SOIL FROM IN THE INVESTIGATED AREA



Left panel: Conductivity of organic (5-10 cm) soil was lower than mineral (20-40 cm). Right panel: The positive relationship between bulk density (low in organic soil) and thermal conductivity

MAP OF INVESTIGATED AREA, BOREHOLES LOCATION AND RECENT PERMAFROST TEMPERATURE



GOALS

Develop approach for sampling ecological variables alongside permafrost temperature monitoring

Determine and quantify key parameters of ecosystem most important for thermal state of permafrost

Estimate influence of vegetation and soil parameters on the thermal state of permafrost at the lower Kolyma region

DRILLING

TEMPERATURE MEASUREMENTS

Data logger HOBO U-12 with termistors TMC-HD. The set allow to do measurements with resolution 0.004^{o}C and accuracy 0.02^{o}C

THERMAL CONDUCTIVITY MEASUREMENTS

Thermal conductivity of soil was measured using the single probe needle sensor. A needle probe inserted horizontally into the soil was heated during 2 minutes and rate of temperature changes was measured. Thermal conductivity was calculated based on the temperature increasing rate

TERRESTRIAL SURVEY

TREES

Woody debris;
Canopy cover;
Larch biomass;
Snag biomass and density;
Trees per m^2

UNDERSTORY

Live biomass;
Overstory deciduous cover;
Understory shrub cover;
Moss & lichens cover;
Herb cover

SOIL

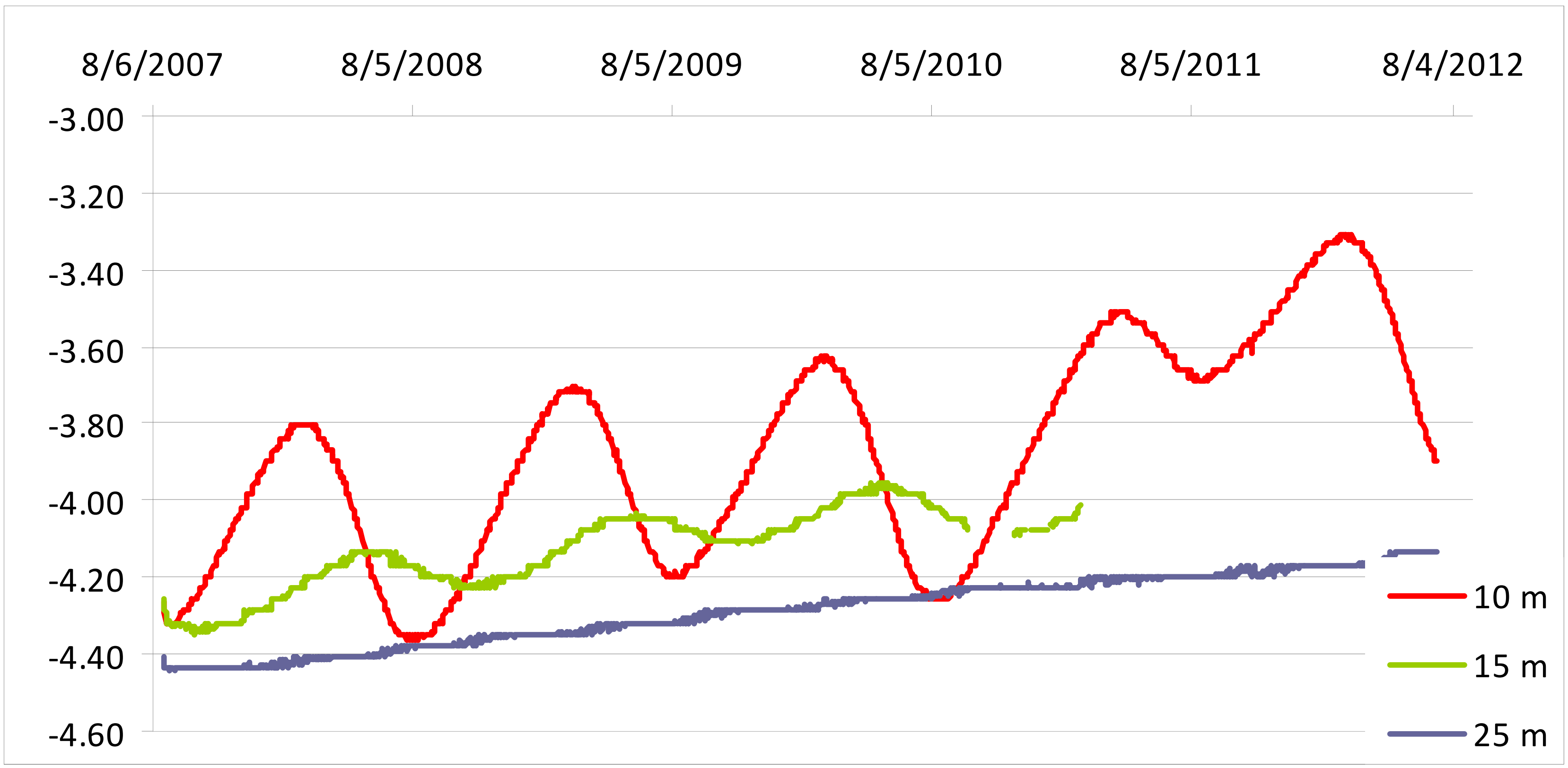
Thaw depth;
Organic layer depth;
C pool in upper 10 and 20 cm
Carbon content;
Soil bulk density and moisture

OMOLON RIVER MOUTH

Terrestrial survey was not conducted yet

OMOLON RIVER MOUTH

MAGT at the 25 m depth (2012) **-4.2°C** Positive trend, °C/year **0.063**



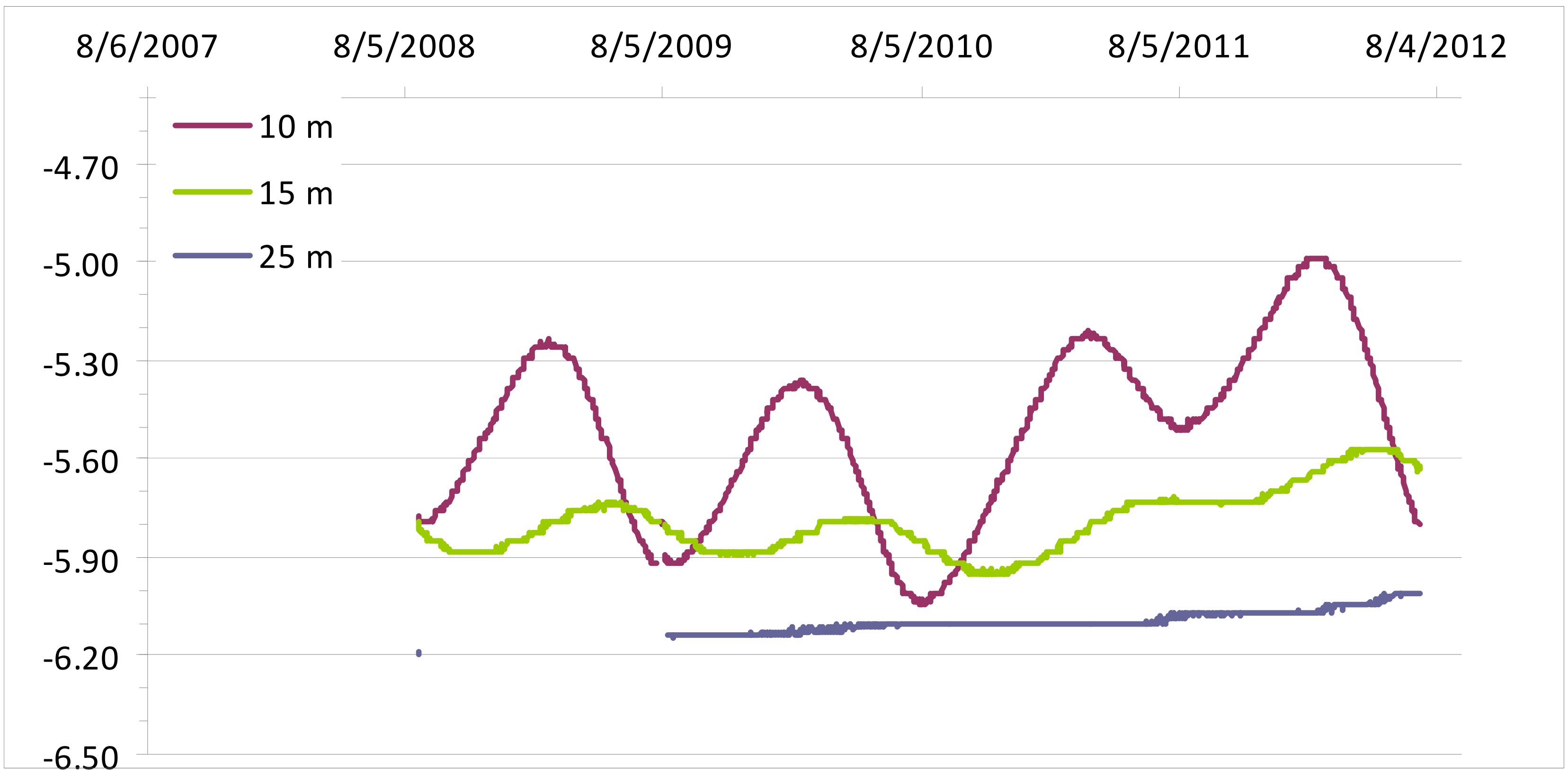
DUVANNY YAR

Terrestrial survey was conducted in 2012

Organic Layer depth (cm)	C pool, 10 cm (g/m^2)	C pool, 20 cm (g/m^2)	Mineral soil (MS) % carbon	OS bulk density (g/cm^3)	MS bulk density (g/cm^3)	MS moisture GWC	Understory live biomass (g/m^2)	Overstory deciduous % Cover	Understory Shrub, % Cover	Moss, % Cover	Lichen, % Cover
13.8	3483	7913	7.11	0.10	0.61	96.2	nd	nd	20.8	37.6	2.3

DUVANNY YAR

MAGT at the 25 m depth (2012) -6.1^{o}C Positive trend, ^{o}C/year **0.035**



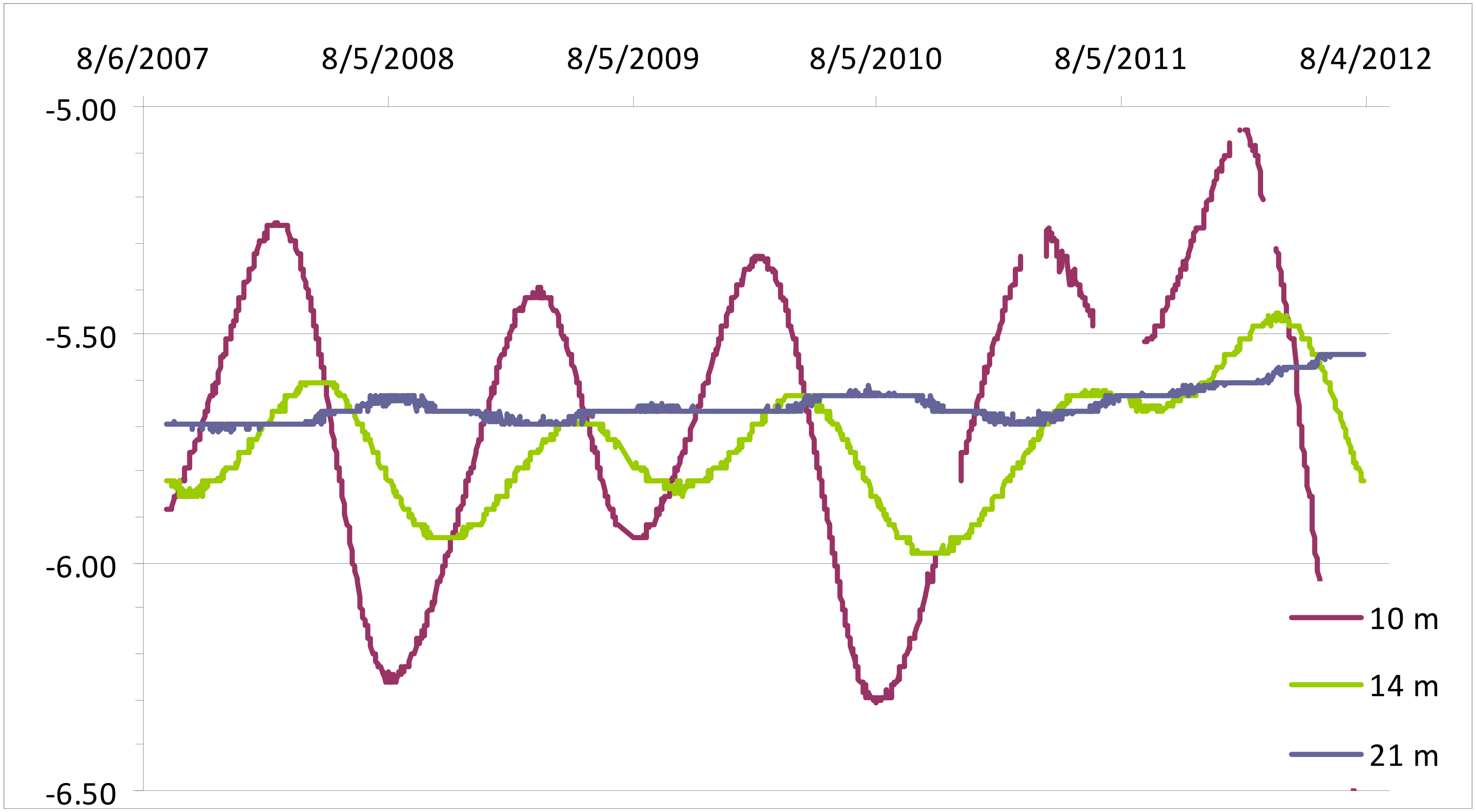
AMBOLIHA

Terrestrial survey was conducted in 2012

Organic Layer depth (cm)	C pool, 10 cm (g/m^2)	C pool, 20 cm (g/m^2)	Mineral soil (MS) % carbon	OS bulk density (g/cm^3)	MS bulk density (g/cm^3)	MS moisture GWC	Understory live biomass (g/m^2)	Overstory deciduous % Cover	Understory Shrub, % Cover	Moss, % Cover	Lichen, % Cover
0.0	3979	7958	17.4	nd	0.23	248.1	581	2.9	14.0	0.2	0.0

AMBOLIHA

MAGT at the 21 m depth (2012) **-5.6^{o}C** Positive trend, ^{o}C/year **0.019**



PLEISTOCENE PARK

Terrestrial survey was conducted in 2012

Organic Layer depth (cm)	C pool, 10 cm (g/m^2)	C pool, 20 cm (g/m^2)	Mineral soil (MS) % carbon	OS bulk density (g/cm^3)	MS bulk density (g/cm^3)	MS moisture GWC	Understory live biomass (g/m^2)	Overstory deciduous % Cover	Understory Shrub, % Cover	Moss, % Cover	Lichen, % Cover
0.0	3958	7915	9.6	nd	0.46	75.8	2345	6.5	0.6	0.0	0.0

Ground temperature at the 13.5 m depth (2012) -4.7°C Borehole was drilled in 2012

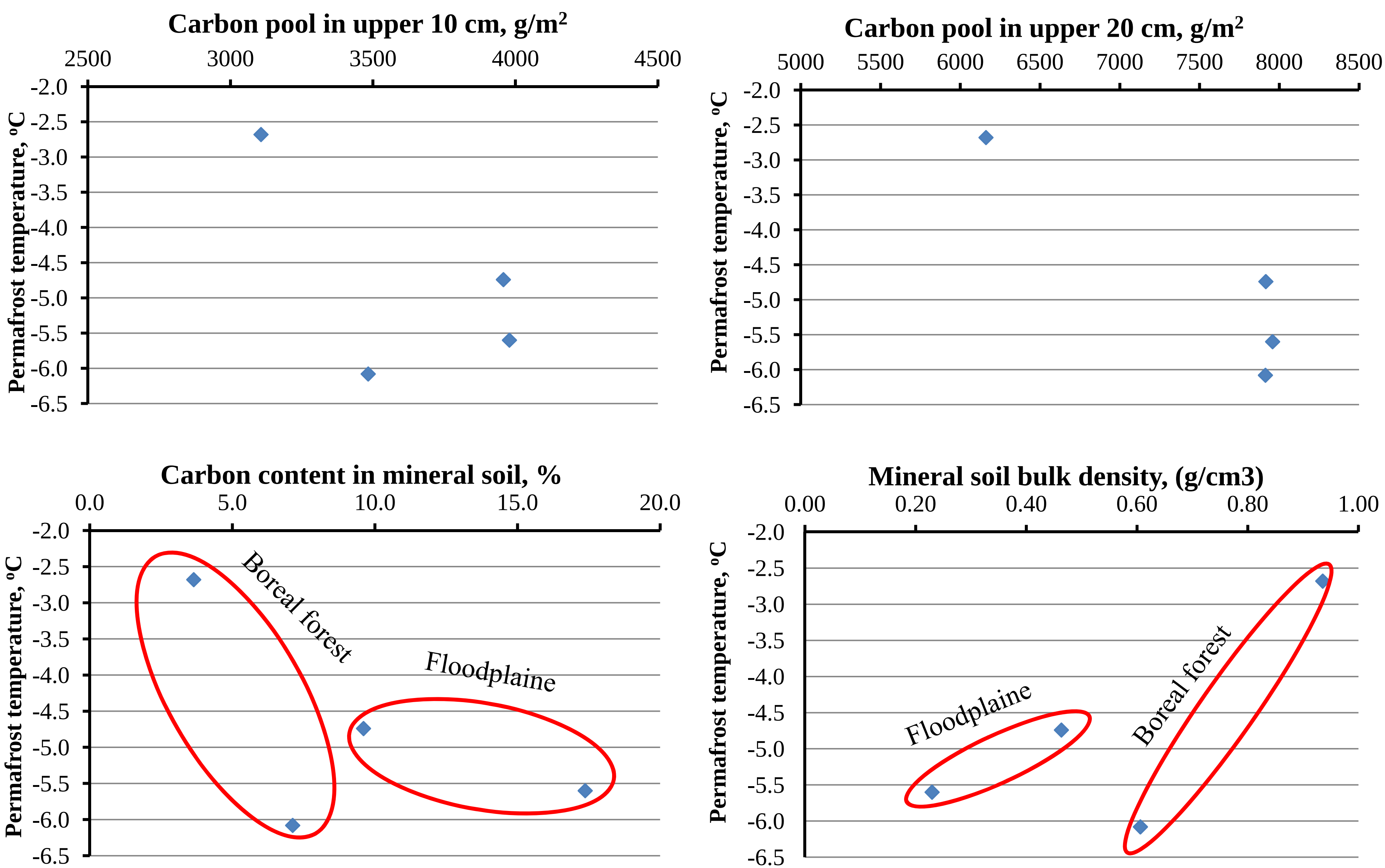
SHUCHE LAKE

Terrestrial survey was conducted in 2012

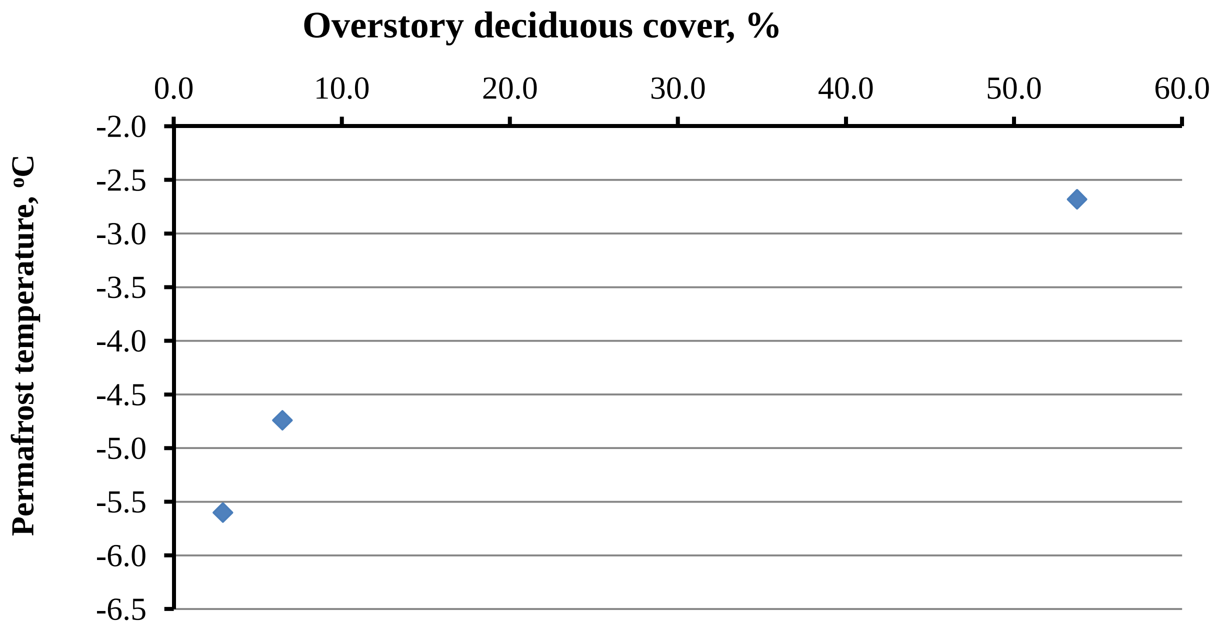
Organic Layer depth (cm)	C pool, 10 cm (g/m^2)	C pool, 20 cm (g/m^2)	Mineral soil (MS) % carbon	OS bulk density (g/cm^3)	MS bulk density (g/cm^3)	MS moisture GWC	Understory live biomass (g/m^2)	Overstory deciduous % Cover	Understory Shrub, % Cover	Moss, % Cover	Lichen, % Cover
13.8	3107	6161	3.64	0.11	0.94	48.7	1171	53.8	51.5	20.2	5.5

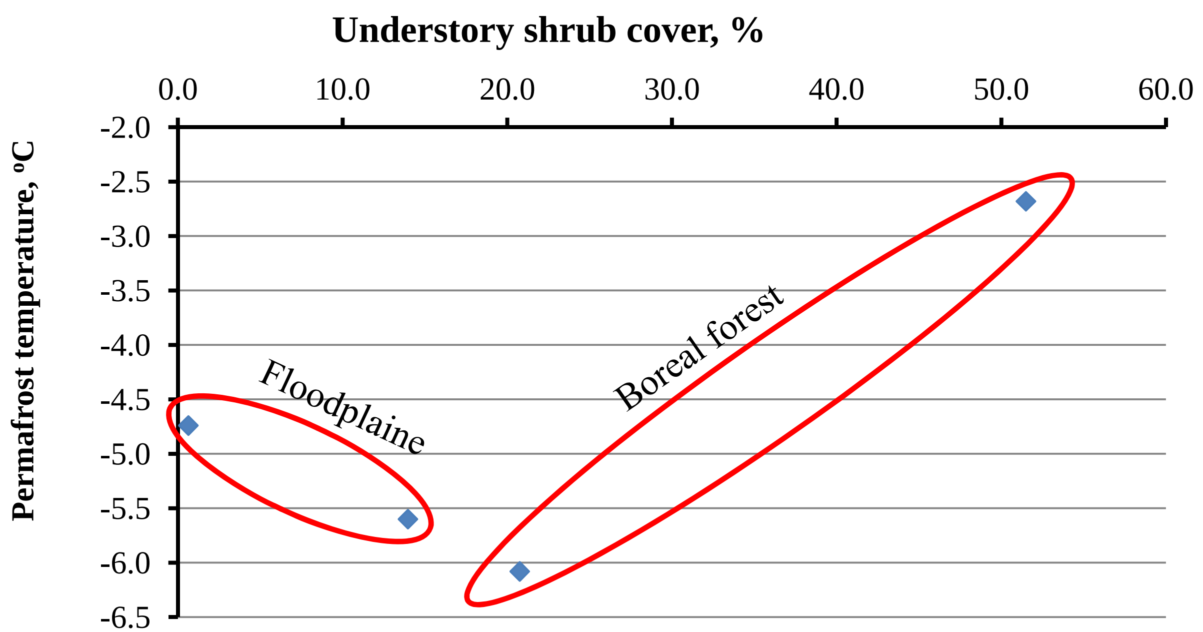
Ground temperature at the 13.5 m depth (2012) -2.7°C!!! Borehole was drilled in 2012

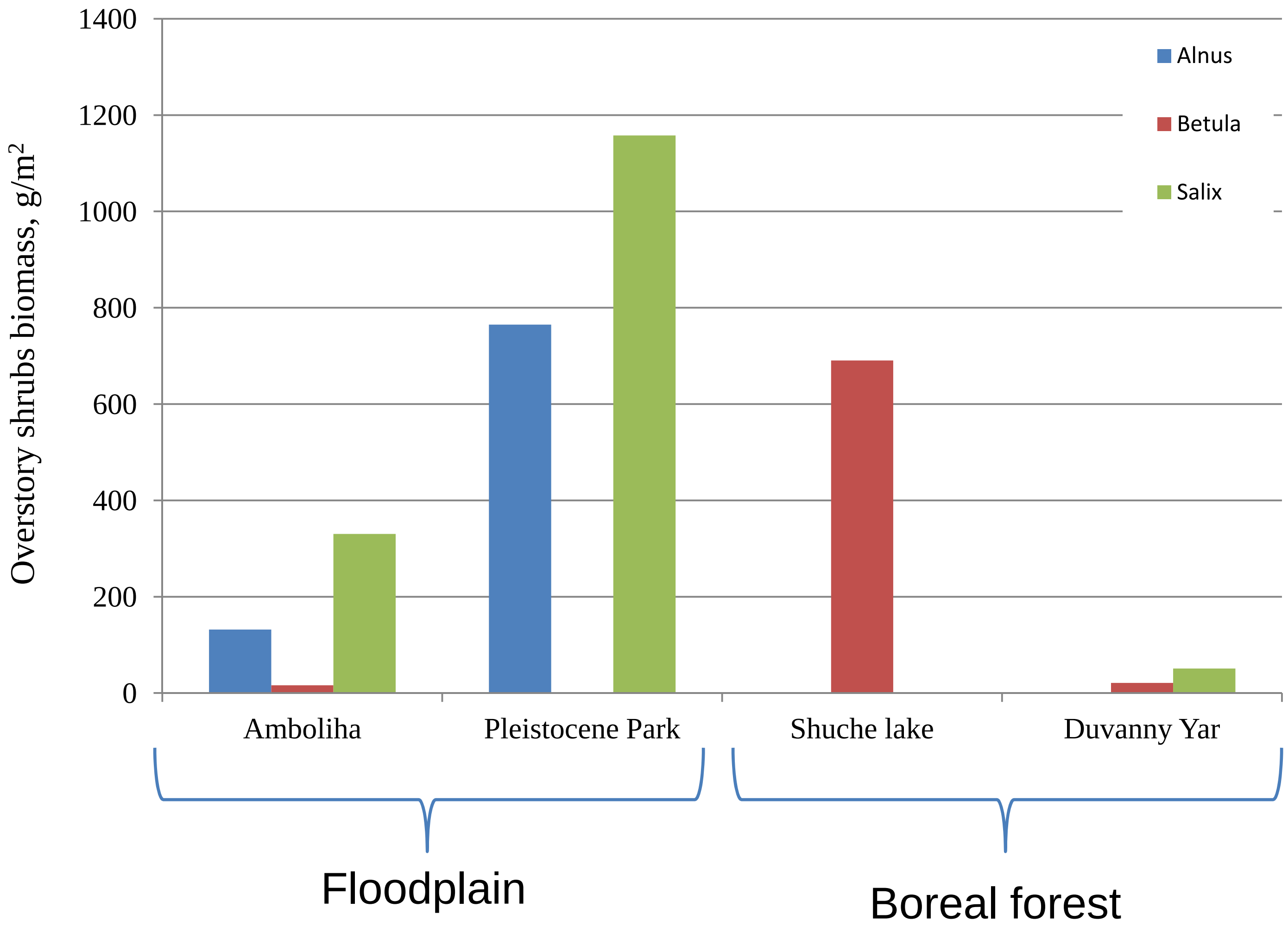
CORRELATION OF PERMAFROST TEMPERATURE AND SOIL PARAMETERS



CORRELATION OF PERMAFROST TEMPERATURE AND UNDERSTORY PARAMETERS







Overstory shrubs biomass, g/m2
1400
1200
1000
800
600
400
200
0
Alnus
Betula
Salix
Amboliha
Pleistocene Park
Shuche lake
Duvanny Yar
Floodplain
Boreal forest

CONCLUSIONS

Temperature of permafrost existing in the same climatic zone can be up to 4°C different in different ecosystems in the investigated area.

Most important factors affecting permafrost temperature are organic layer thickness, TOC in active layer soil, soil bulk density and type and density of understory vegetation.

Increasing of organic content in active layer reduces permafrost temperature and climate impact on its dynamics.

Shrubs influence on permafrost temperature depends on species, so it can work different in different ecosystems

Based on the current research we would **strongly recommend to take in consideration climate induced ecosystem shift** (i.e. changes of vegetation structure, increasing of bioproductivity and soil organic carbon accumulation) when doing long-term permafrost dynamics modeling and forecasts.

AKNOWLEDGEMENTS

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