PLANT-SOIL RESPONSES TO EXPERIMENTAL PERMAFROST THAW

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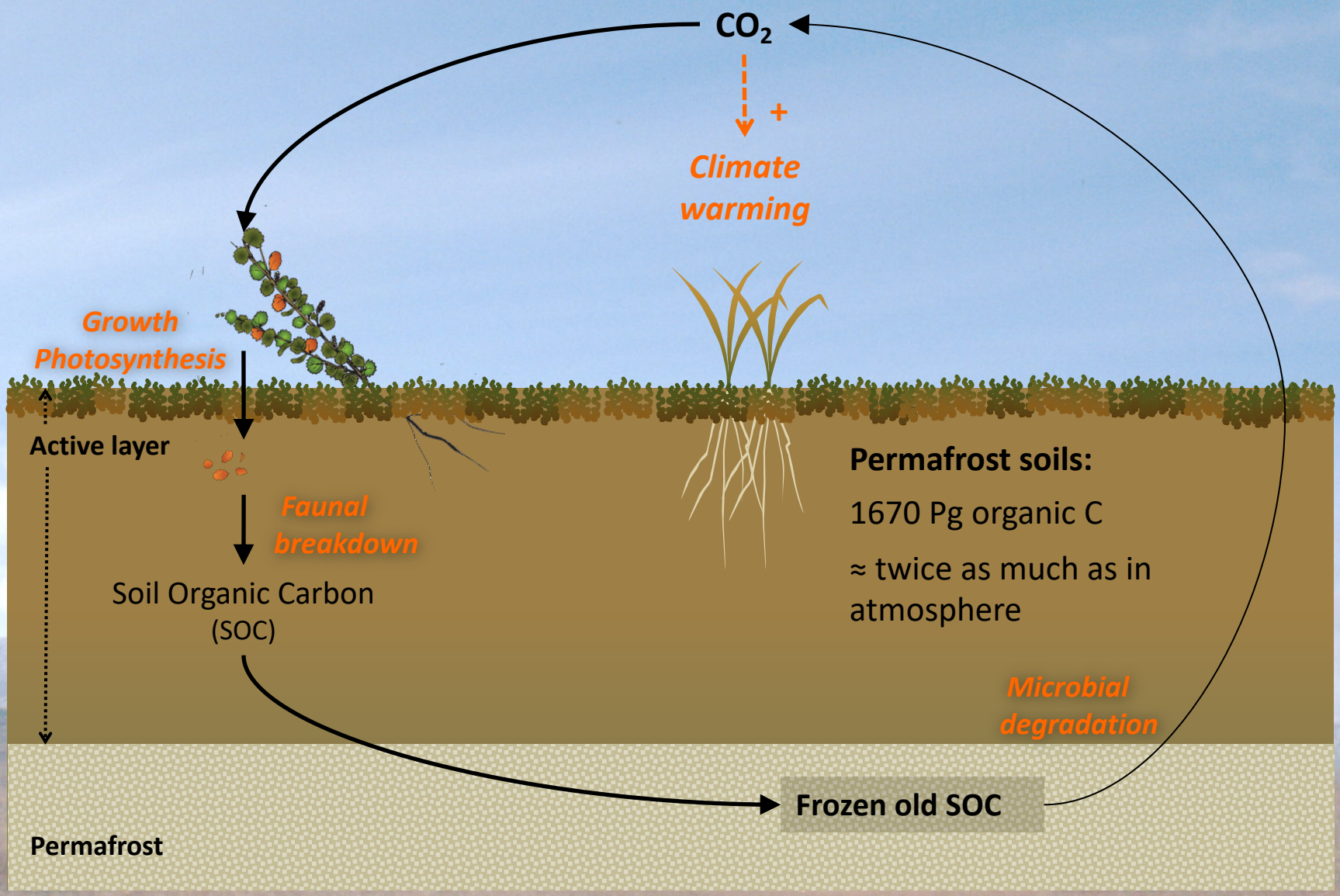
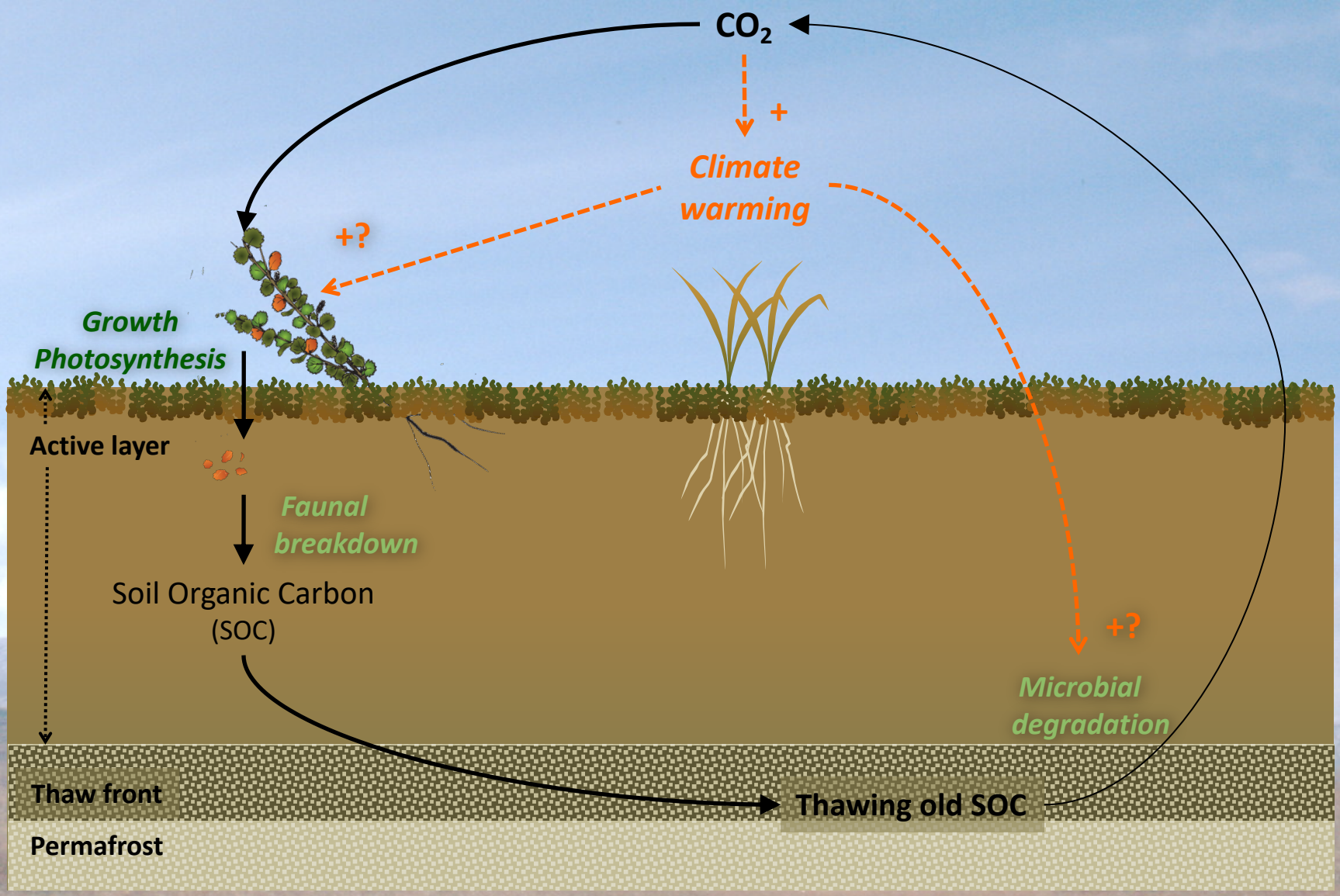
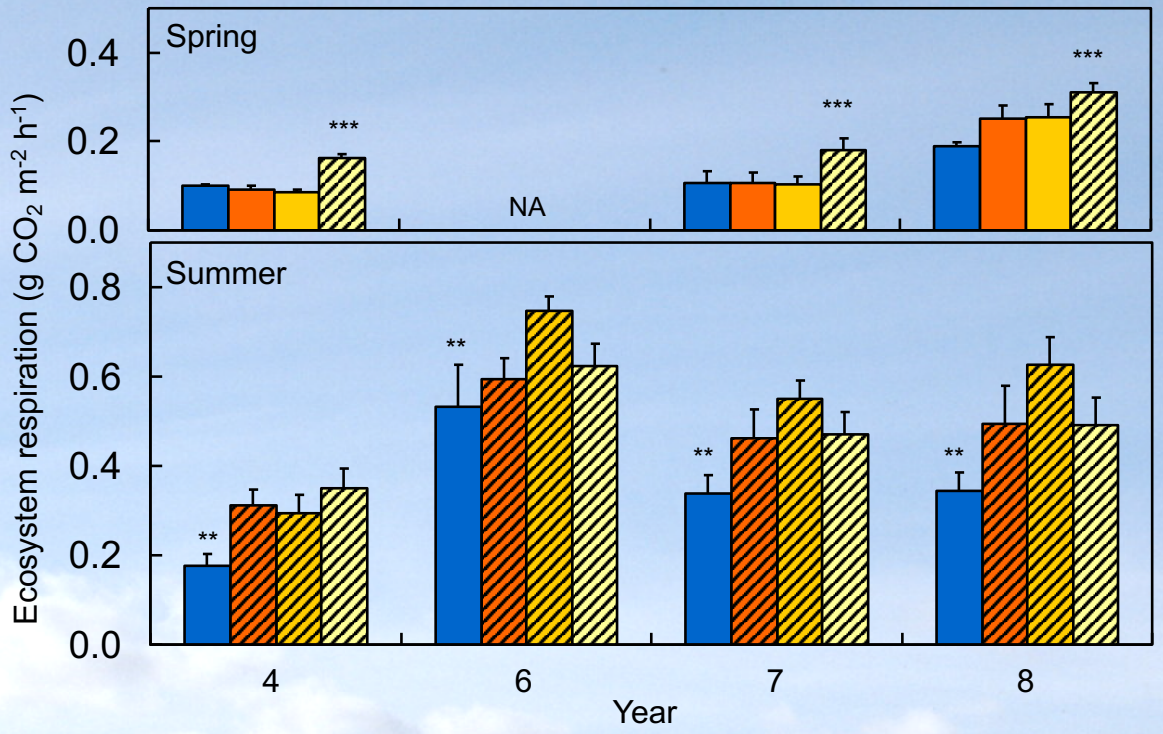
Carbon cycle in the Arctic



Arctic ecosystem carbon feedbacks to our climate



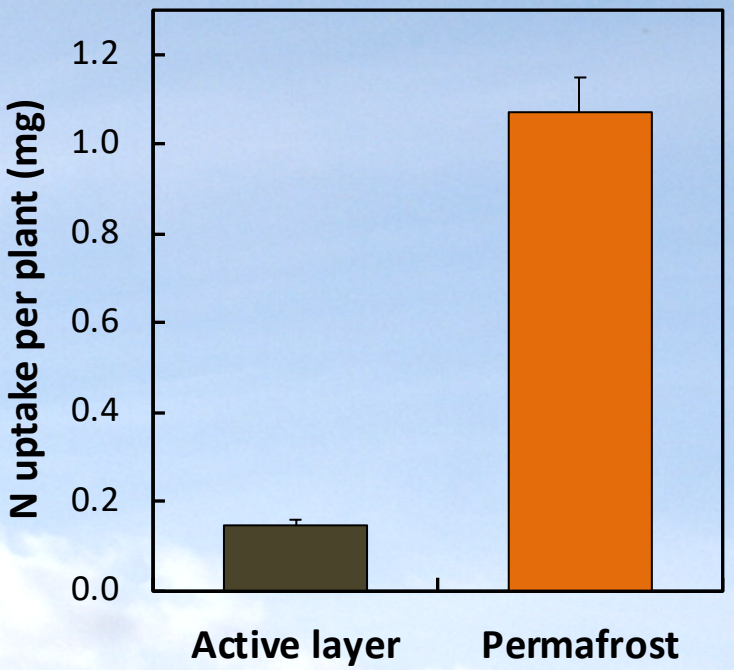
Climate warming effects on ecosystem respiration



Dorrepaal et al. (2009)
Nature 460: 616-619

Long-term warming response, especially in deep soil layers

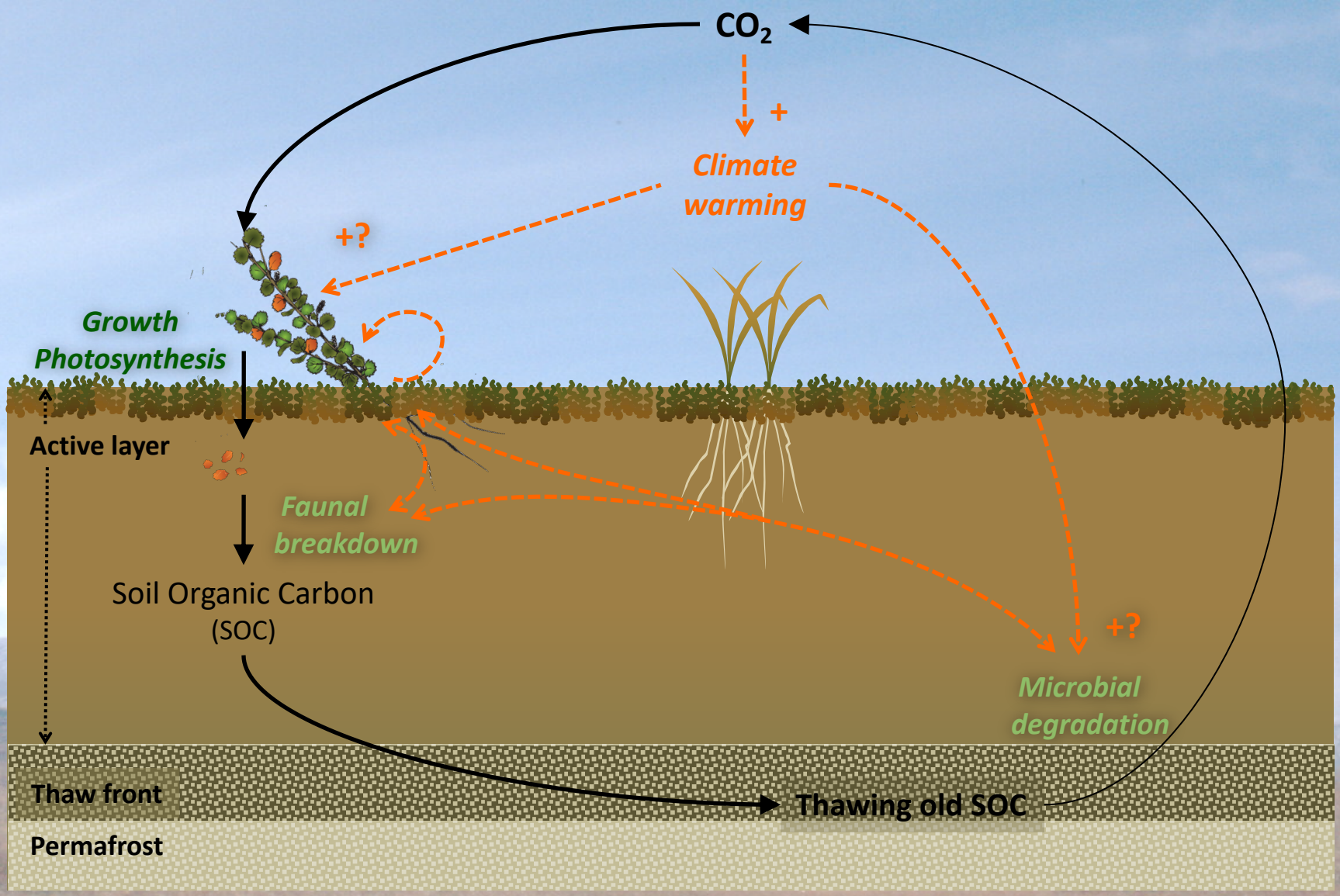
Permafrost thaw effects on nutrient availability



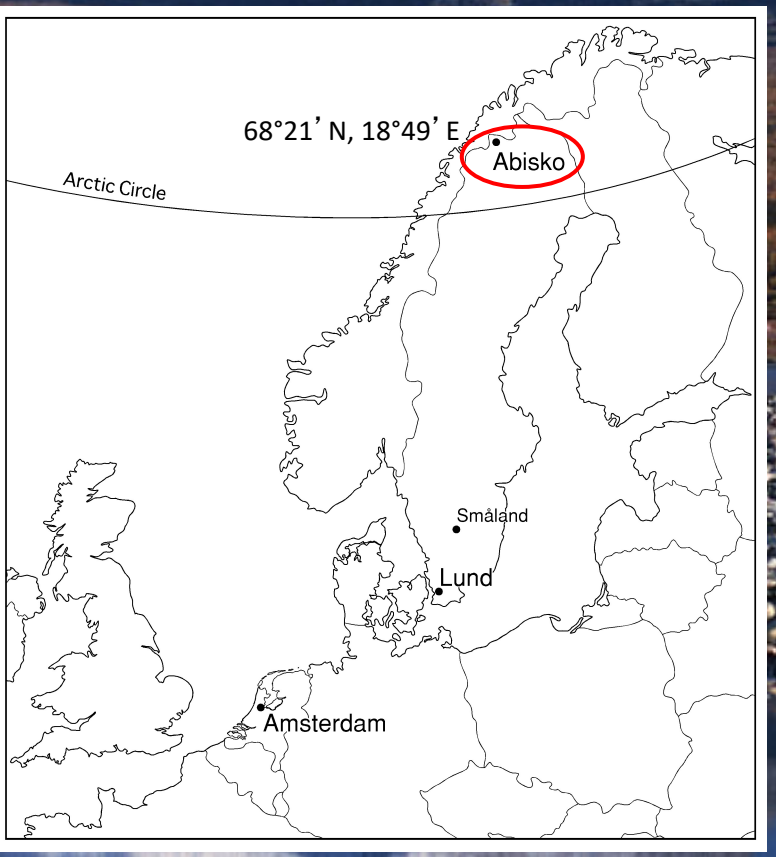
Keuper et al. (2012)
Global Change Biology 18: 1998-2007

High availability of plant-available N in deep soil layers

Arctic ecosystem interactions feedback to our climate



Abisko Scientific Research Station (Sweden)

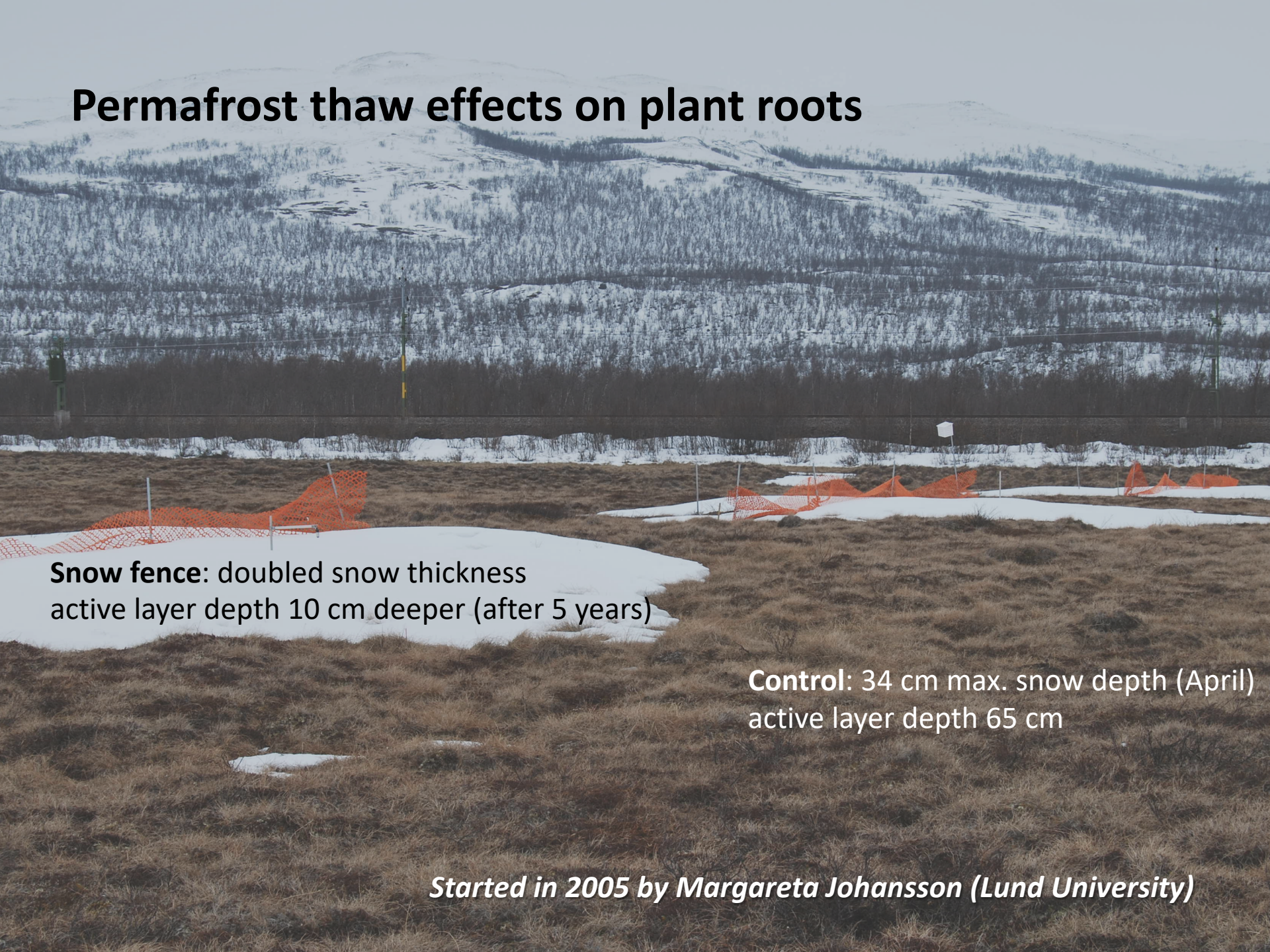


1500 m.a.s.l.

350 m.a.s.l.

Photo: Frank Trosien

Permafrost thaw effects on plant roots



Snow fence: doubled snow thickness
active layer depth 10 cm deeper (after 5 years)

Control: 34 cm max. snow depth (April)
active layer depth 65 cm

Started in 2005 by Margareta Johansson (Lund University)

Permafrost thaw effects on plant roots

Snow fence: Surface subsidence
-> wet depressions (strongest in spring)

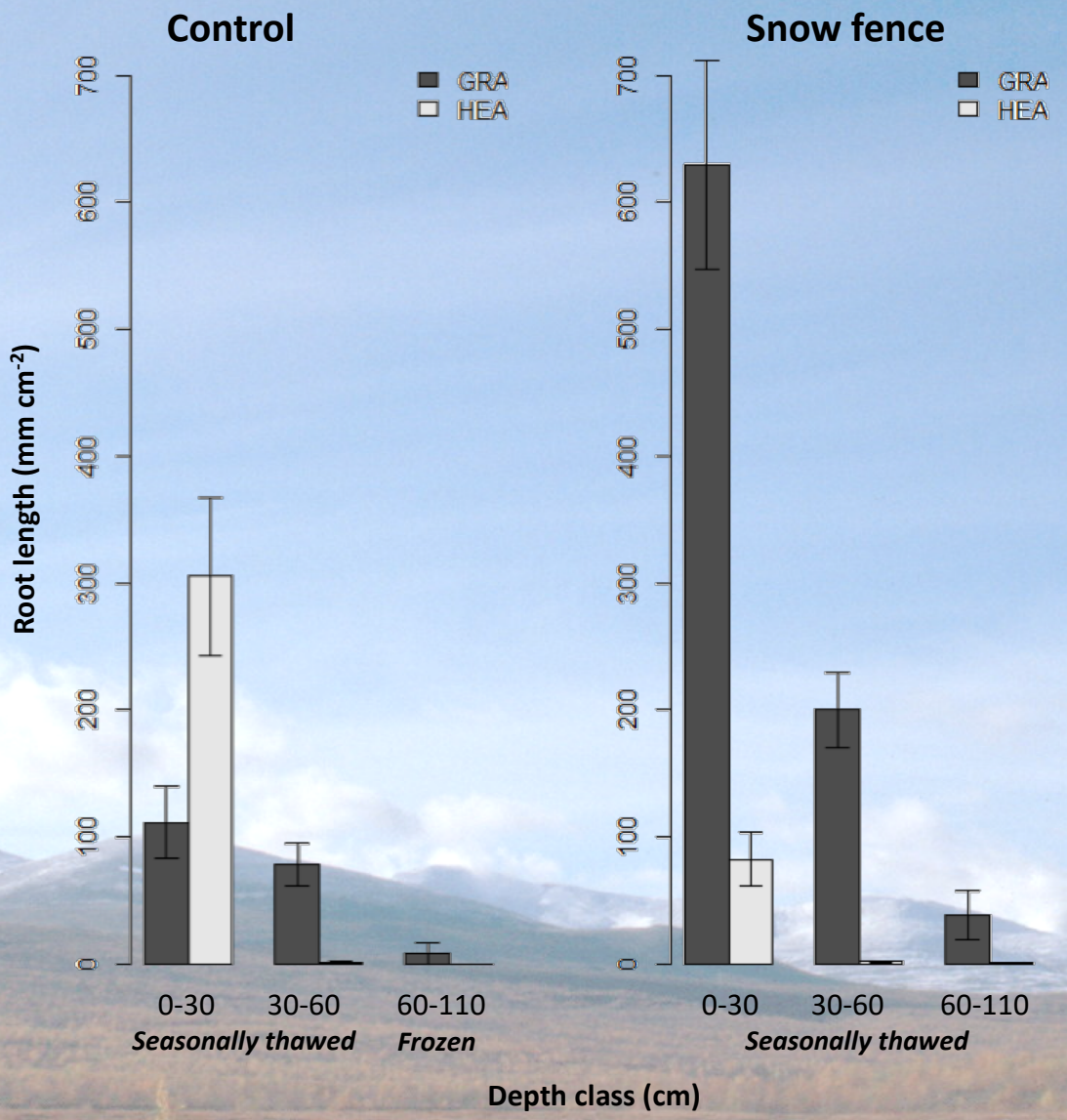
Photo: Maja Wressel

Permafrost thaw effects on plant roots

Root growth measured in
2014-2015 (after 9-10 winters)

Snow fence: Surface subsidence + wet depressions
-> *Eriophorum vaginatum*

Permafrost thaw effects on plant roots



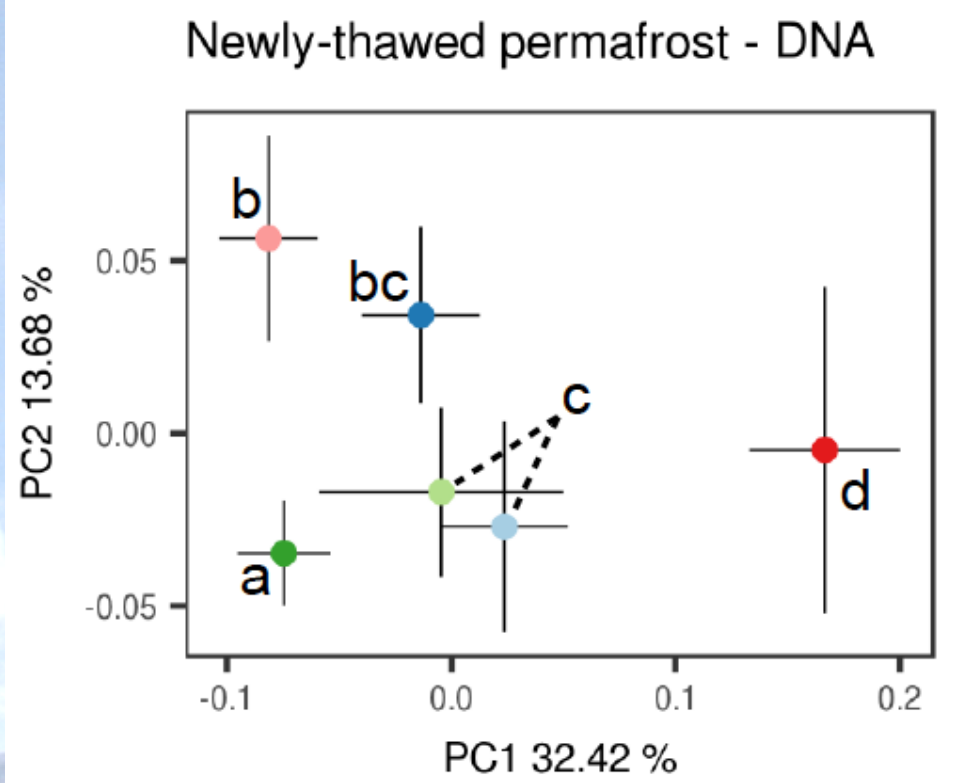
Grasses/sedges (*Eriophorum*)

Heather/shrubs (e.g. *Rubus*, *Andromeda*, *Empetrum*)

Measured in 2014-2015 (after 9-10 winters)

Blume-Werry et al. submitted.

Plant effects on soil microbes

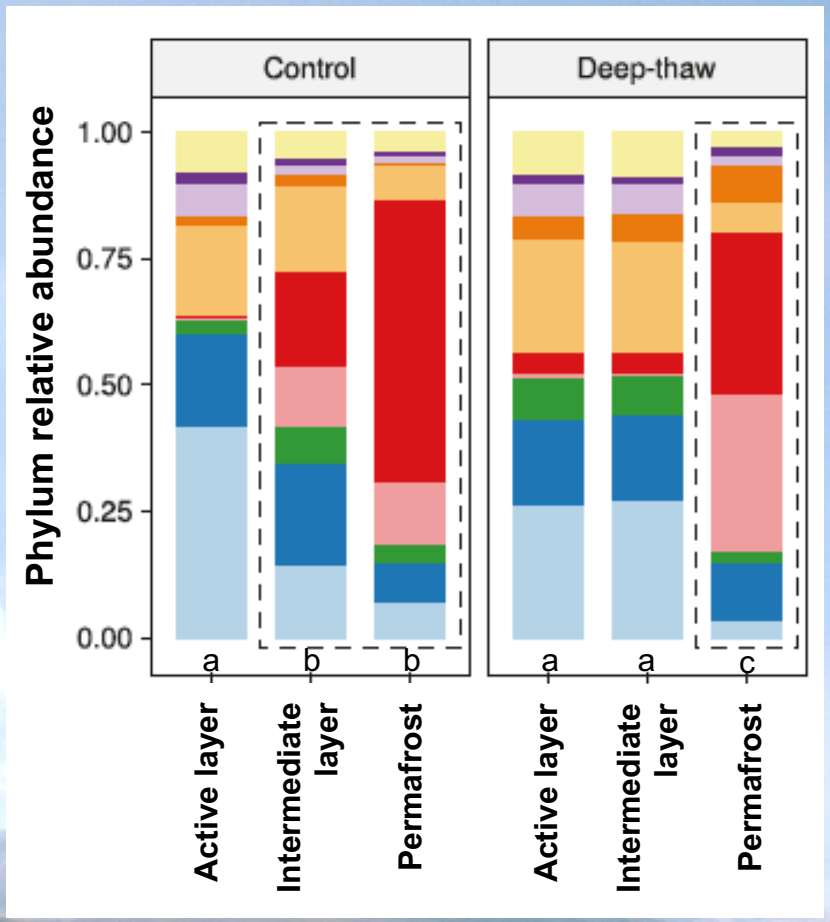


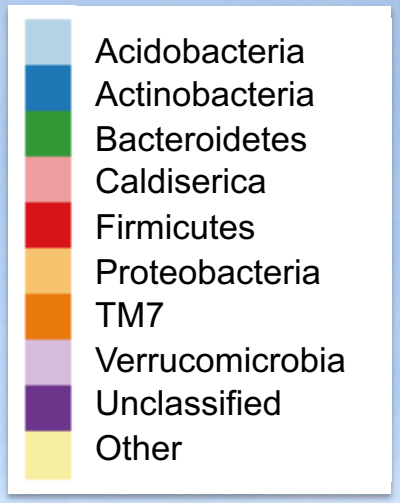
Monteux et al. (2018)
in prep.

- *Empetrum nigrum*
- *Andromeda polifolia*
- *Betula nana*
- *Eriophorum vaginatum*
- *Rubus chamaemorus*
- *Bulk soil*

Rhizosphere bacterial community structure in permafrost soil varies between plant species

Permafrost thaw effects on soil microbes





Monteux et al. (2018)
ISME Journal 12: 2129-2141

Bacterial community structure:

- converges in intermediate layer to AL
- shows increased aerobic abundance
- explains variation in soil respiration

Permafrost thaw on a slope: initiating thermokarst?

Downslope

Snow fence (6; 1m high; 10 x 10m):
doubled snow thickness
3 °C higher winter soil temperature

Control (6; 10 x 10m):
57 cm max. snow depth (March)

Ice Cut site (started 2014):

- *Tussock tundra*
- *Gentle slope*
- *'Yedoma'-like permafrost (>49 ka BP at 5-m; Brown and Kreig 1983)*
- *1 open-top chamber + 1 summer control in every plot (started 2016)*

Photo: Maja Wressel

Active layer depth

Dorrepaal et al. unpubl. data

Approx. 3.5 cm extra thaw

Surface elevation change

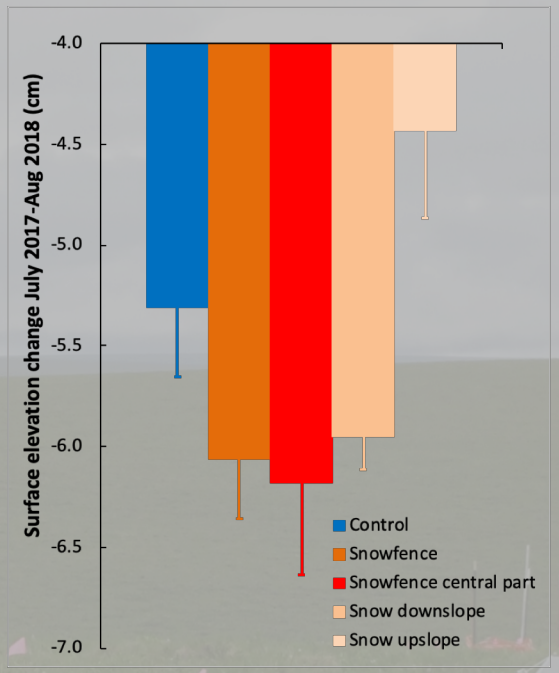
Surface elevation change

July 2017-Aug 2018

Control

-0.06	-0.06	-0.06	-0.05	-0.05
-0.05	-0.05	-0.05	-0.06	-0.06
-0.05	-0.05	-0.04	-0.06	-0.05
-0.07	-0.06	-0.05	-0.06	-0.05
-0.07	-0.06	-0.05	-0.05	-0.04
-0.07	-0.05	-0.04	-0.05	-0.05
-0.06	-0.05	-0.05	-0.06	-0.05
-0.06	-0.05	-0.06	-0.05	-0.05
-0.06	-0.05	-0.06	-0.04	-0.04
-0.05	-0.05	-0.05	-0.05	-0.06
-0.05	-0.05	-0.05	-0.06	-0.03

2.5m between transects;
1m between points



Downslope

		-0.07	-0.07	-0.06	-0.05	-0.05		
-0.06	-0.06	-0.05	-0.06	-0.06	-0.07	-0.06	-0.06	-0.05
-0.05	-0.07	-0.06	-0.07	-0.08	-0.07	-0.06	-0.06	-0.04
-0.05	-0.06	-0.07	-0.07	-0.07	-0.05	-0.05	-0.05	-0.04
-0.06	-0.06	-0.06	-0.07	-0.08	-0.05	-0.04	-0.05	-0.04
-0.06	-0.07	-0.06	-0.11	-0.09	-0.05	-0.04	-0.06	-0.04
-0.06	-0.07	-0.07	-0.05	-0.06	-0.06	-0.05	-0.05	-0.05
-0.07	-0.06	-0.07	-0.06	-0.05	-0.05	-0.05	-0.04	-0.03
-0.05	-0.06	-0.07	-0.06	-0.05	-0.06	-0.04	-0.04	-0.05
-0.07	-0.05	-0.06	-0.07	-0.07	-0.04	-0.05	-0.03	-0.03
-0.05	-0.05	-0.05	-0.07	-0.05	-0.06	-0.05	-0.03	-0.05

Upslope

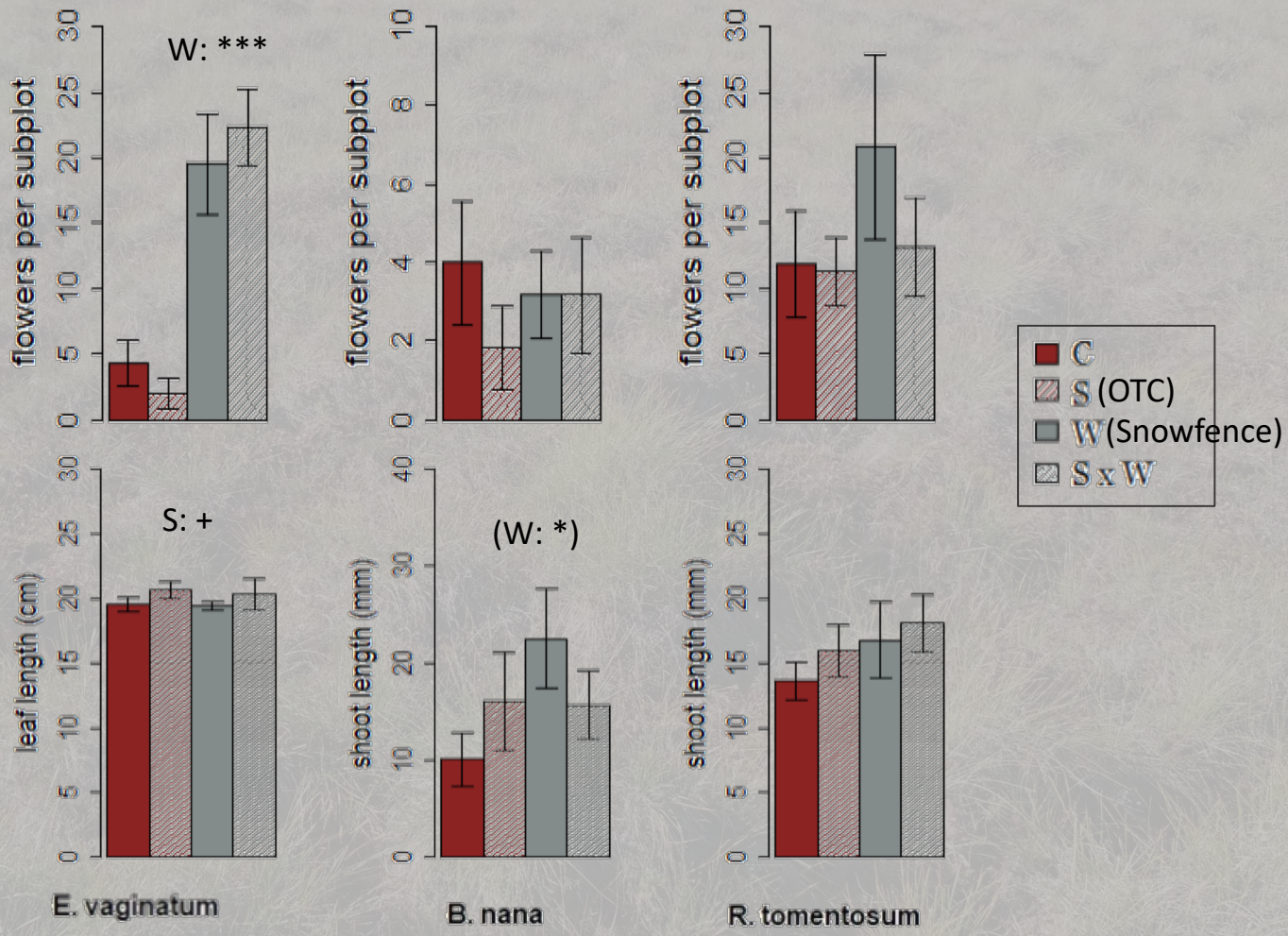
Snowfence

(Height in m)

Dorrepaal et al.
unpubl. data

Some plant responses

2017:



Wressel et al. unpubl. data

Things we measured so far

With help from TFS (GIS and EDC !!!)

Abiotic:

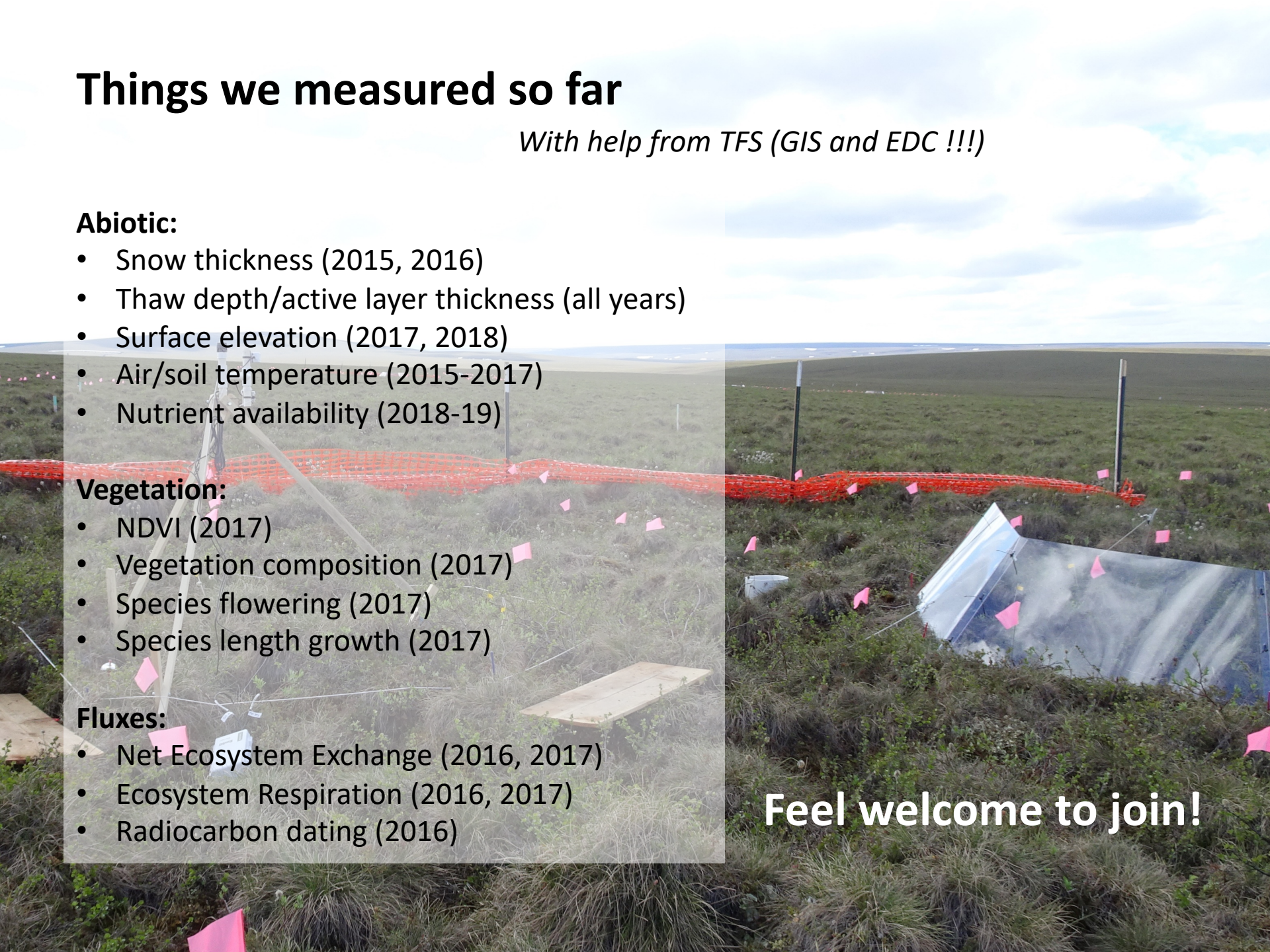
- Snow thickness (2015, 2016)
- Thaw depth/active layer thickness (all years)
- Surface elevation (2017, 2018)
- Air/soil temperature (2015-2017)
- Nutrient availability (2018-19)

Vegetation:

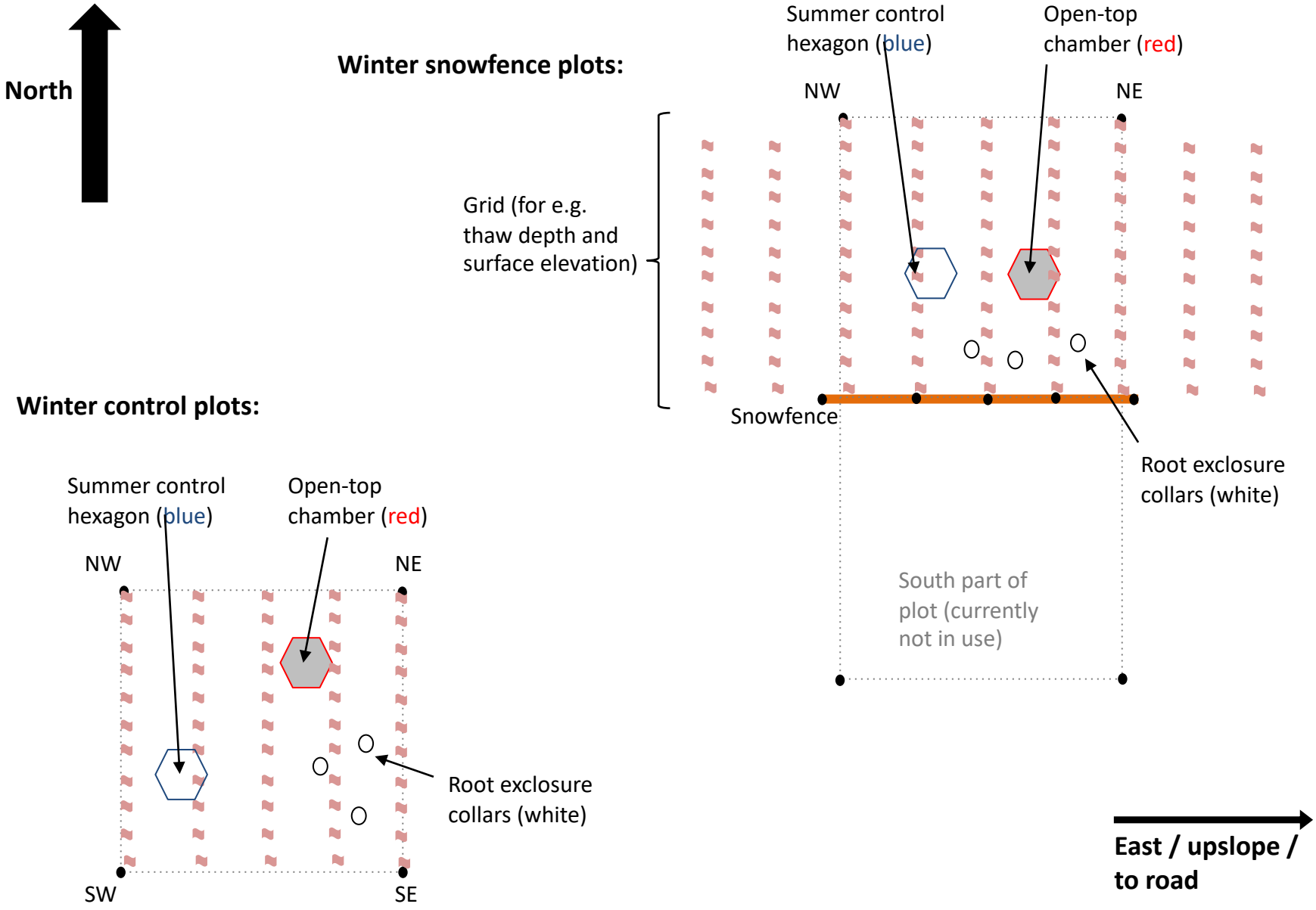
- NDVI (2017)
- Vegetation composition (2017)
- Species flowering (2017)
- Species length growth (2017)

Fluxes:

- Net Ecosystem Exchange (2016, 2017)
- Ecosystem Respiration (2016, 2017)
- Radiocarbon dating (2016)



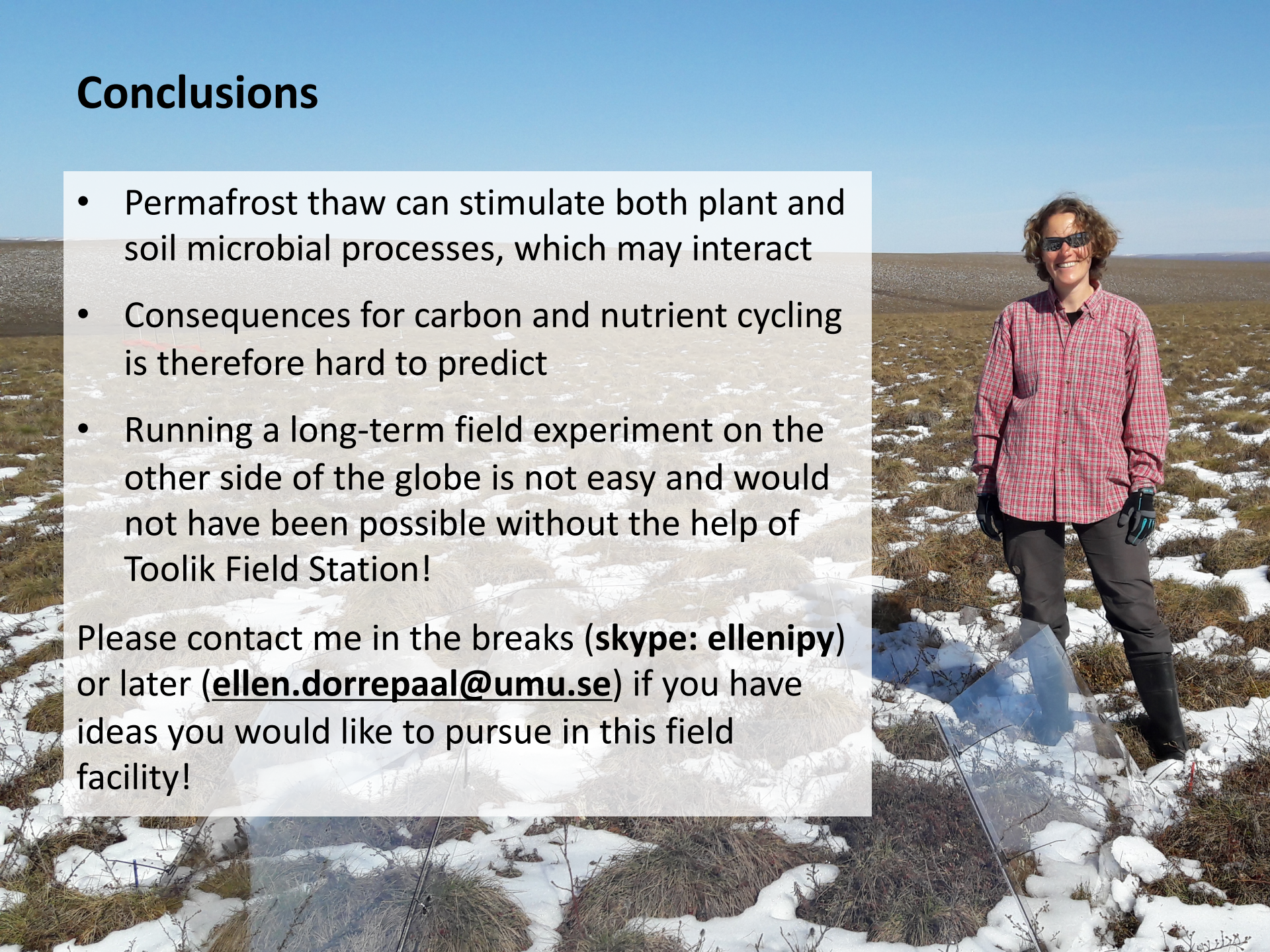
Feel welcome to join!


North
Winter snowfence plots:
Summer control hexagon (blue)
Open-top chamber (red)
NW
NE
Grid (for e.g. thaw depth and surface elevation)
Snowfence
Root exclosure collars (white)
South part of plot (currently not in use)
Winter control plots:
Summer control hexagon (blue)
Open-top chamber (red)
NW
NE
Root exclosure collars (white)
SW
SE
East / upslope / to road

Conclusions

- Permafrost thaw can stimulate both plant and soil microbial processes, which may interact
- Consequences for carbon and nutrient cycling is therefore hard to predict
- Running a long-term field experiment on the other side of the globe is not easy and would not have been possible without the help of Toolik Field Station!

Please contact me in the breaks (**skype: ellenipy**) or later (**ellen.dorrepaal@umu.se**) if you have ideas you would like to pursue in this field facility!



Plant-soil responses to experimental permafrost thaw

Many thanks to:

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FIELD-ASSISTANTS / STUDENTS

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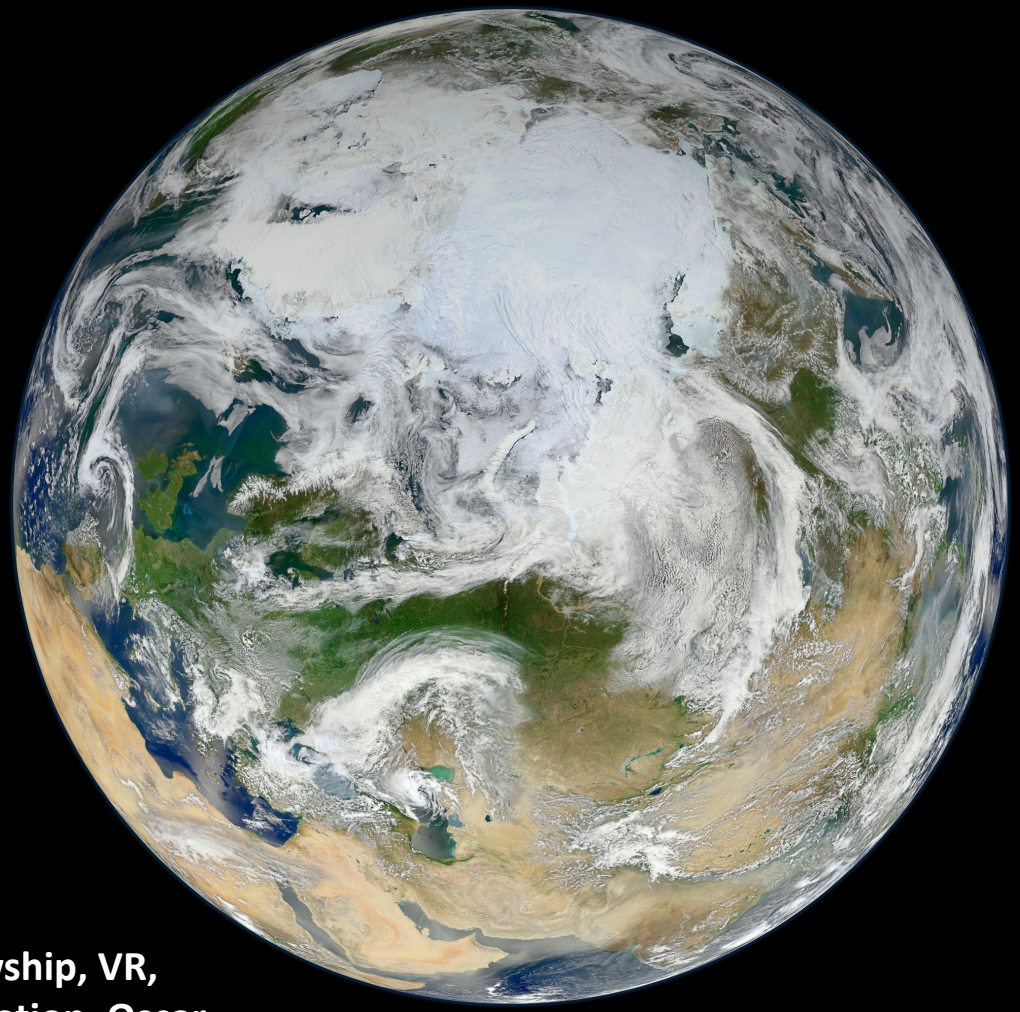
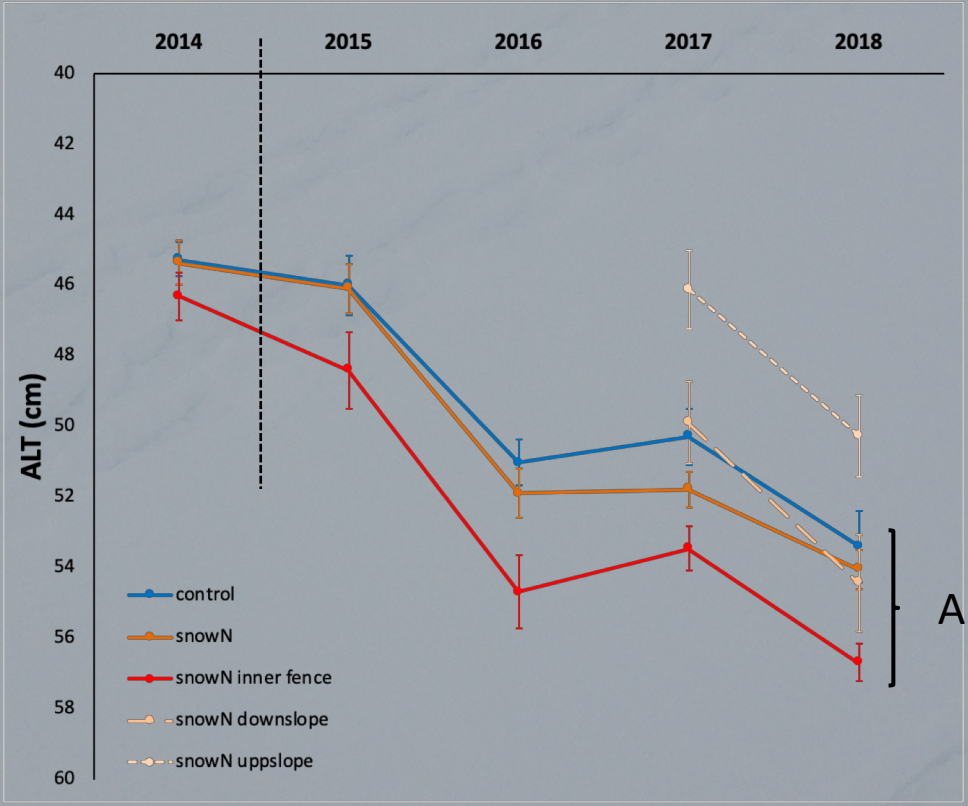


Active layer depth



Dorrepaal et al. unpubl. data

Approx. 3.5 cm extra thaw