

# A (subgrid) song of ice and thaw

Estimating lateral thaw of permafrost peat plateaus

Noah Smith<sup>1</sup>, Sarah Chadburn<sup>1</sup>, Eleanor Burke<sup>2</sup>, Iain Hartley et al.

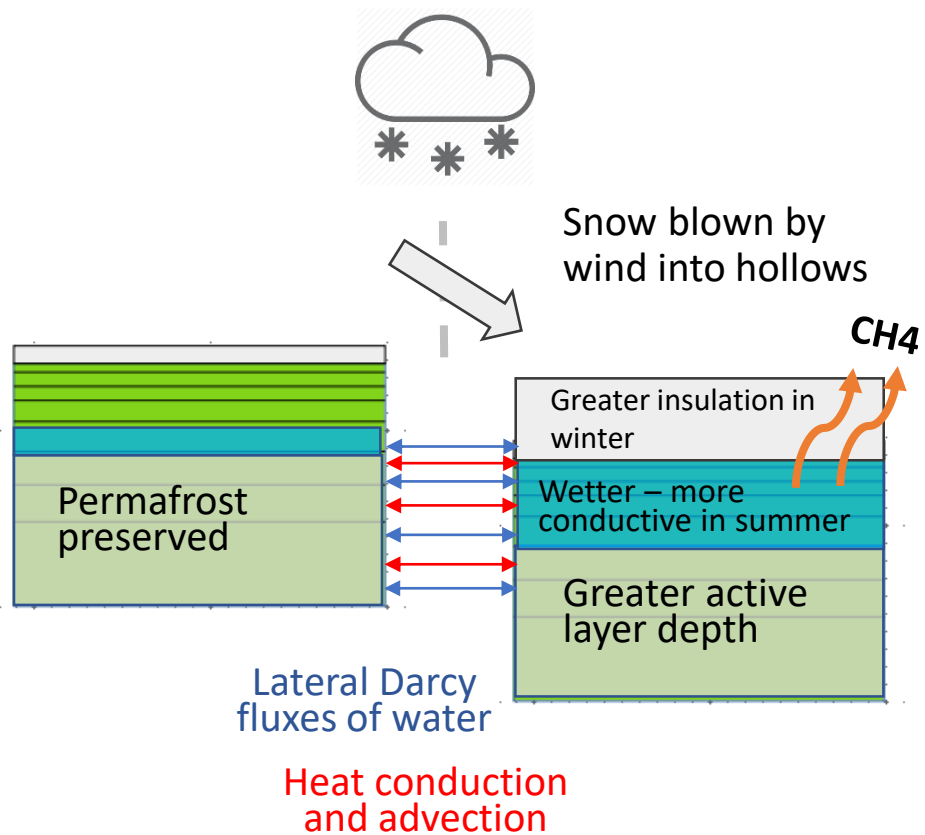
<sup>1</sup>University of Exeter, <sup>2</sup>Met Office



# Previously in JULES...

Explicitly modelling microtopography

Two interacting columns  
with elevation difference



Ice wedge polygons  
@ Samoylov and Kytalyk



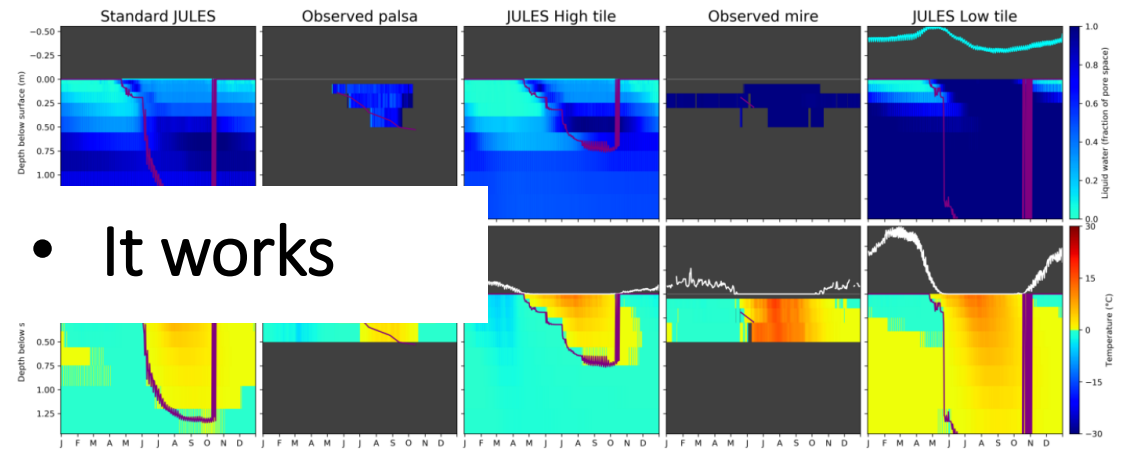
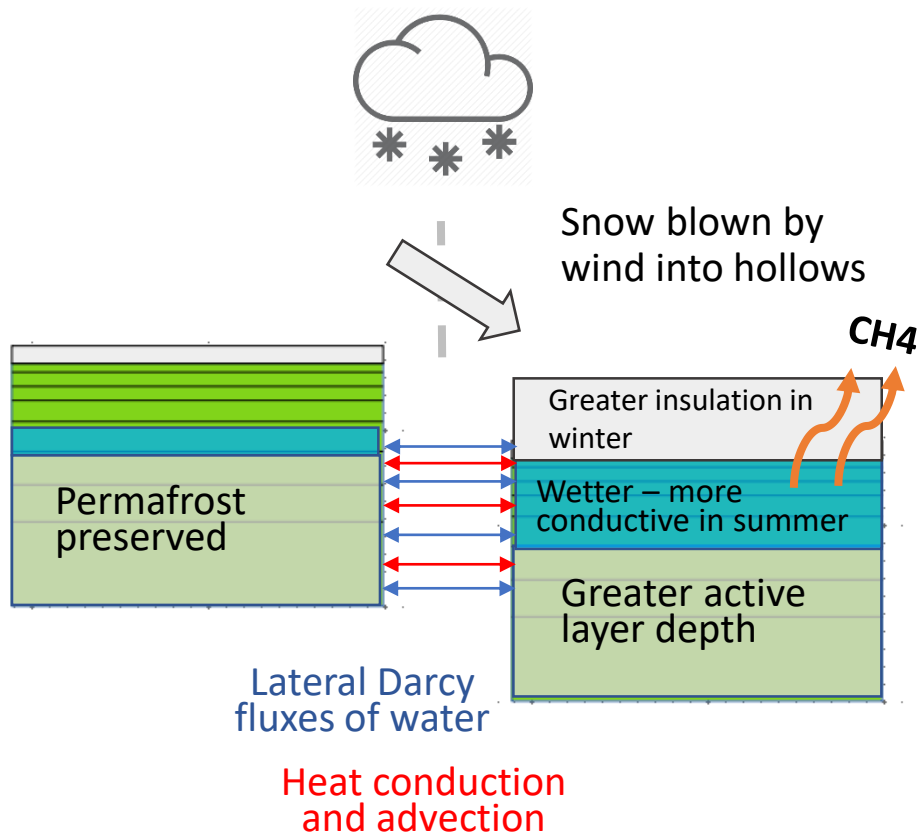
Palsa - mires  
@ Iskoras and Stordalen



# What we found

Explicitly modelling microtopography

Two interacting columns with elevation difference



• It works



<https://doi.org/10.5194/gmd-2021-285>  
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Submitted as: development and technical paper

Abstract Discussion Metrics

26 Oct 2021

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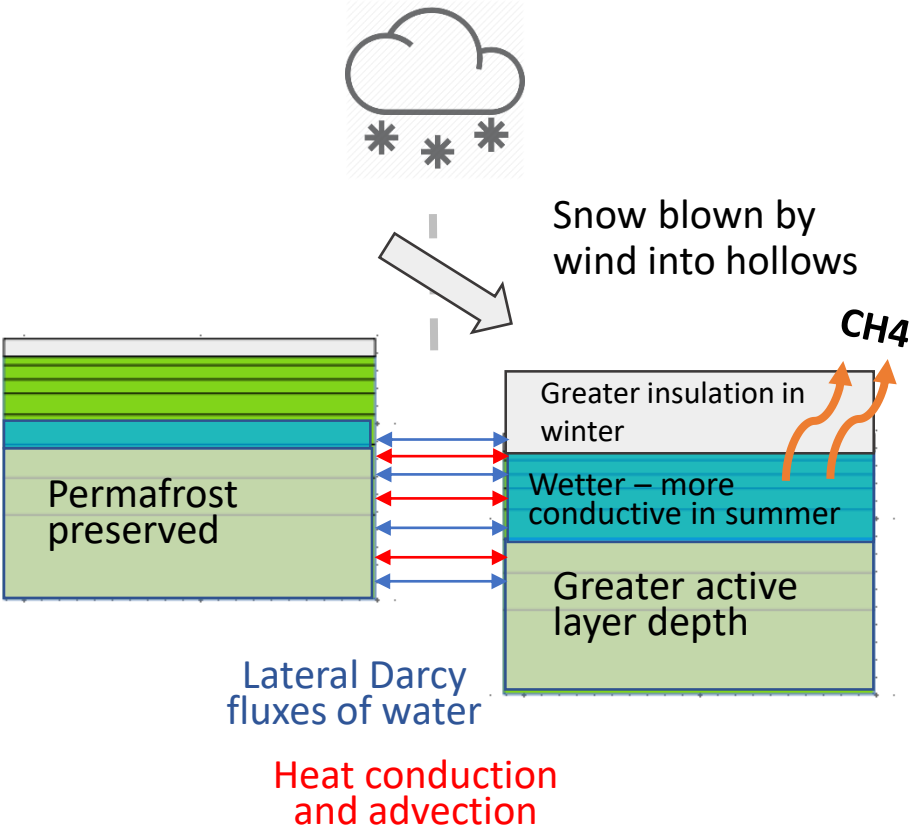
## Explicitly modelling microtopography in permafrost landscapes in a land-surface model (JULES vn5.4\_microtopography)

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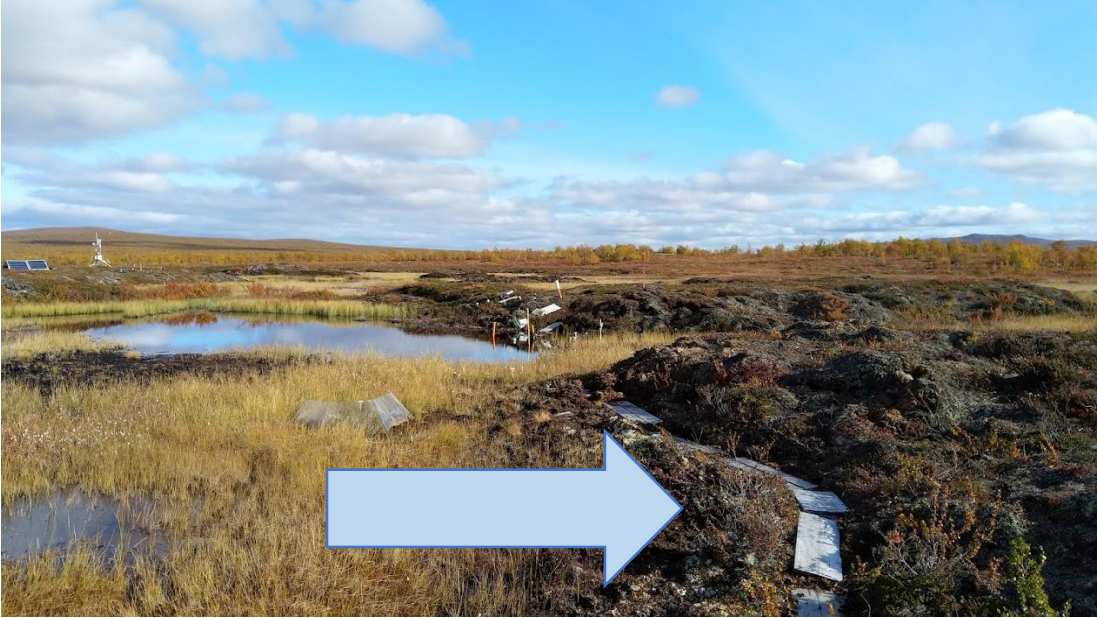
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# Questions...

Two interacting columns with elevation difference



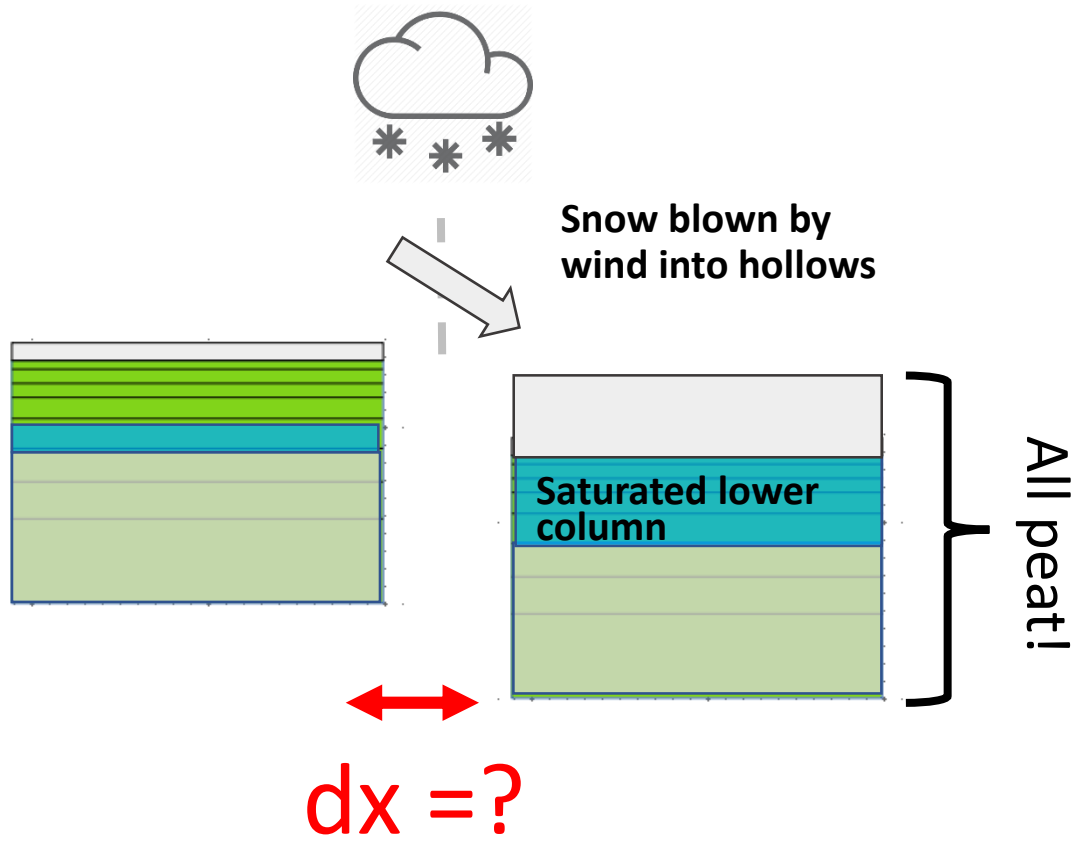
- Will this work on the pan-arctic scale?
- How quickly will thaw happen?



# Pan-arctic palsas

Making simplifications

Two tiles simplified

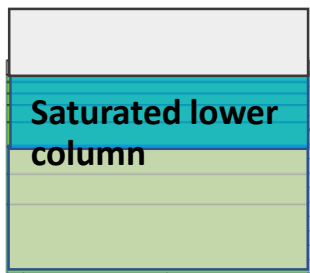
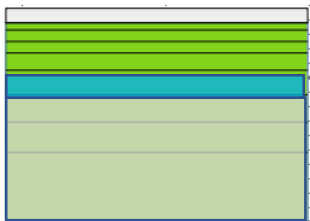


# Pan-arctic palsas

Two tiles simplified



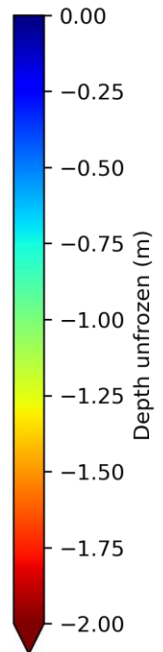
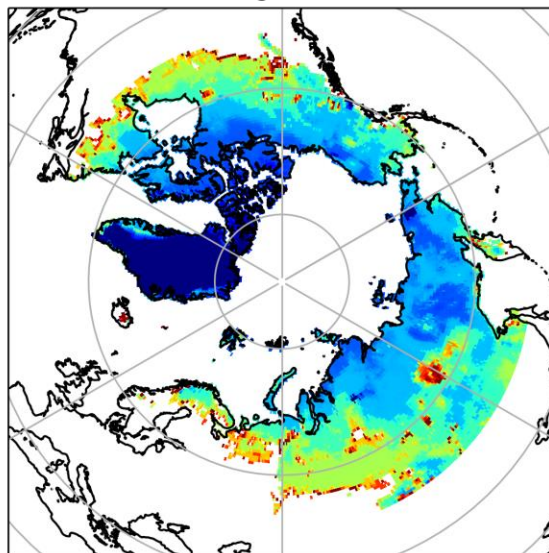
Snow blown by wind into hollows



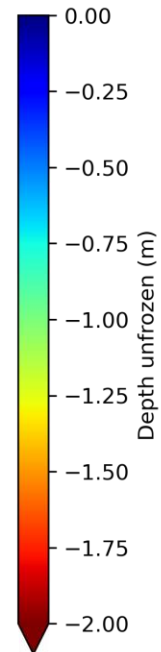
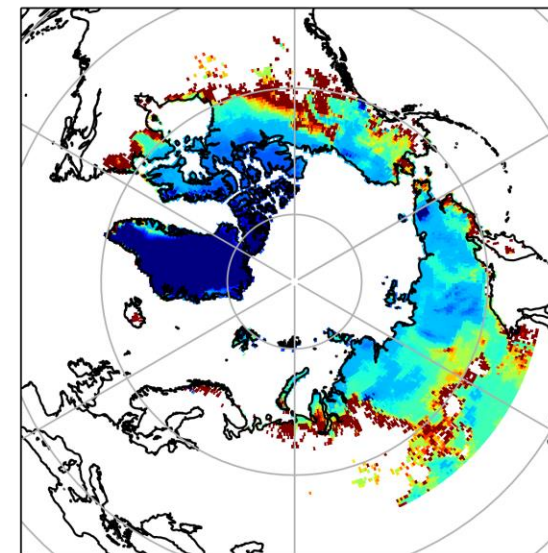
All peati

Maximum depth\_unfrozen between 2005-02-01 and 2015-01-01

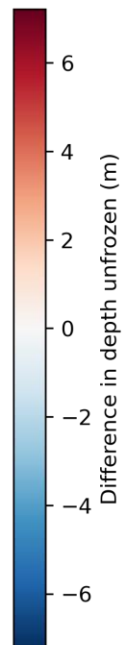
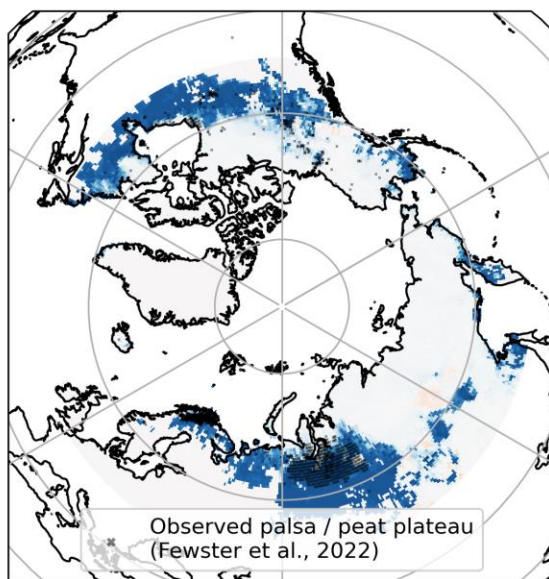
High tile



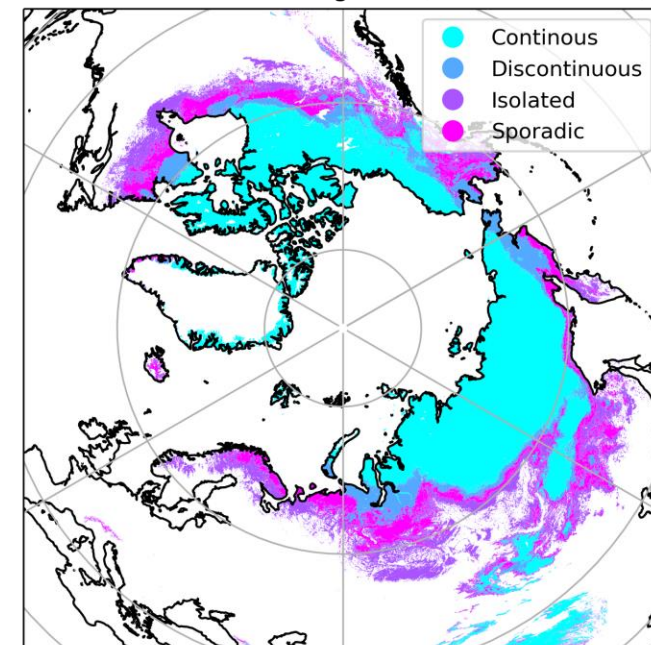
Low tile



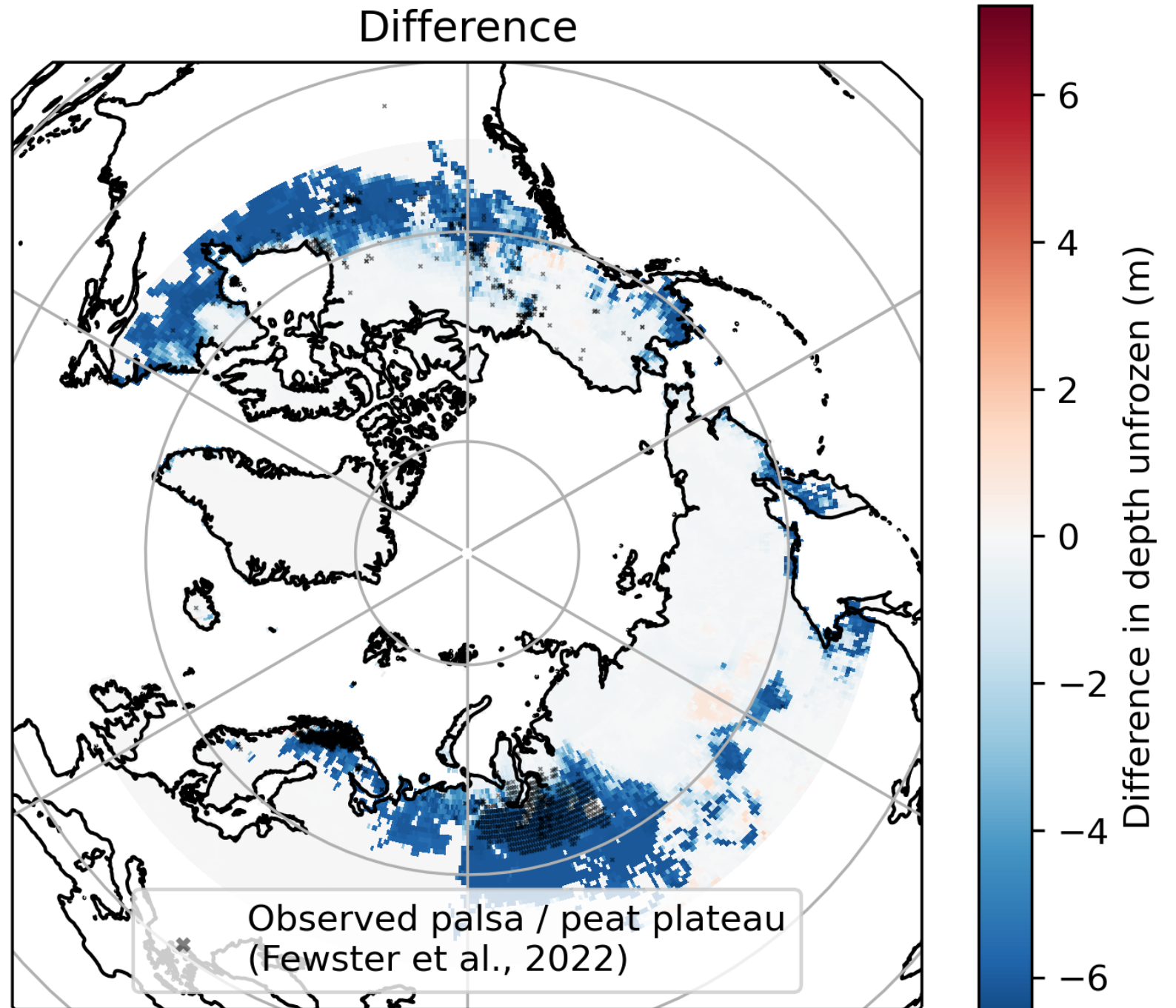
Difference



Permafrost extent categories (Obu et al., 2019)

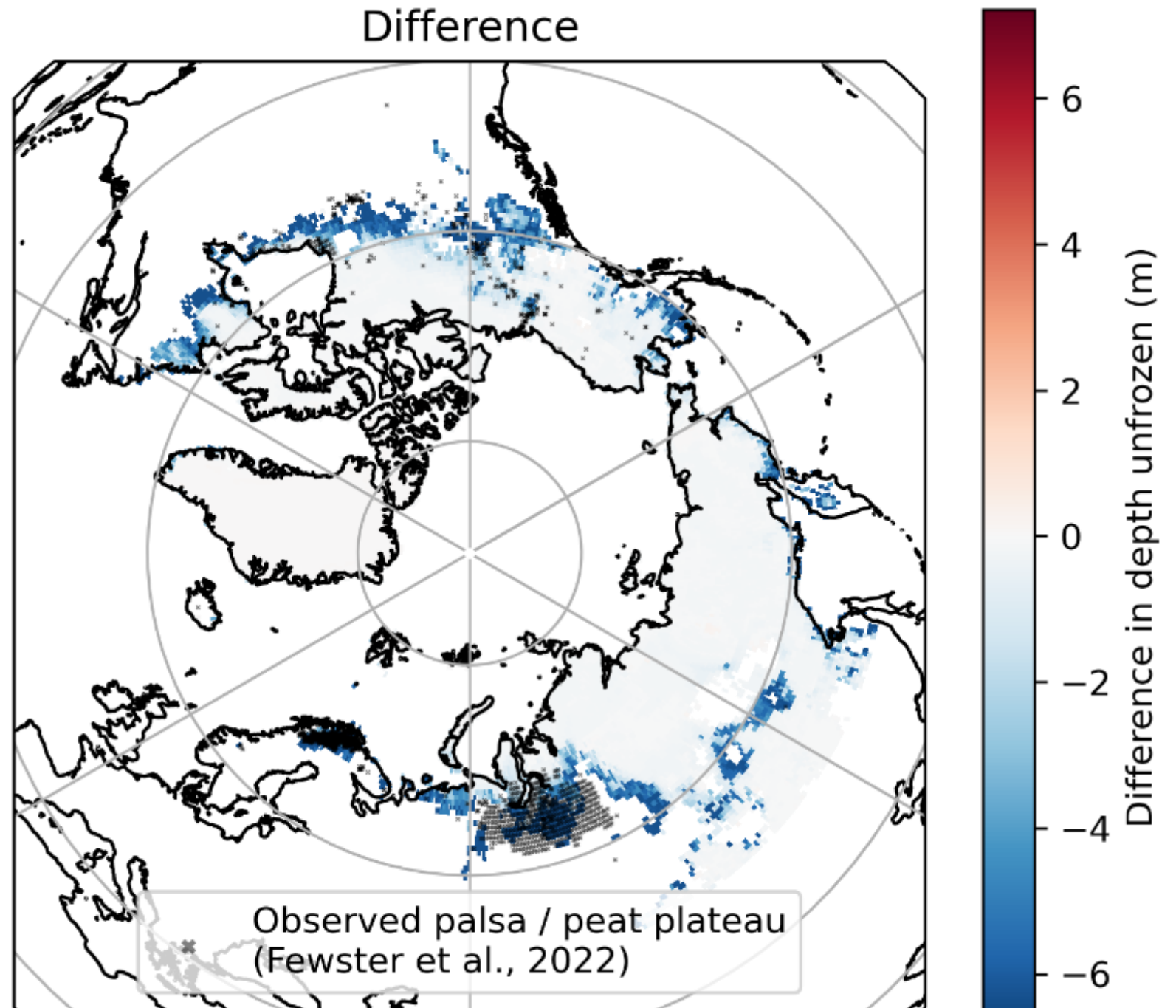


# Pan-arctic palsas



# Pan-arctic palsas

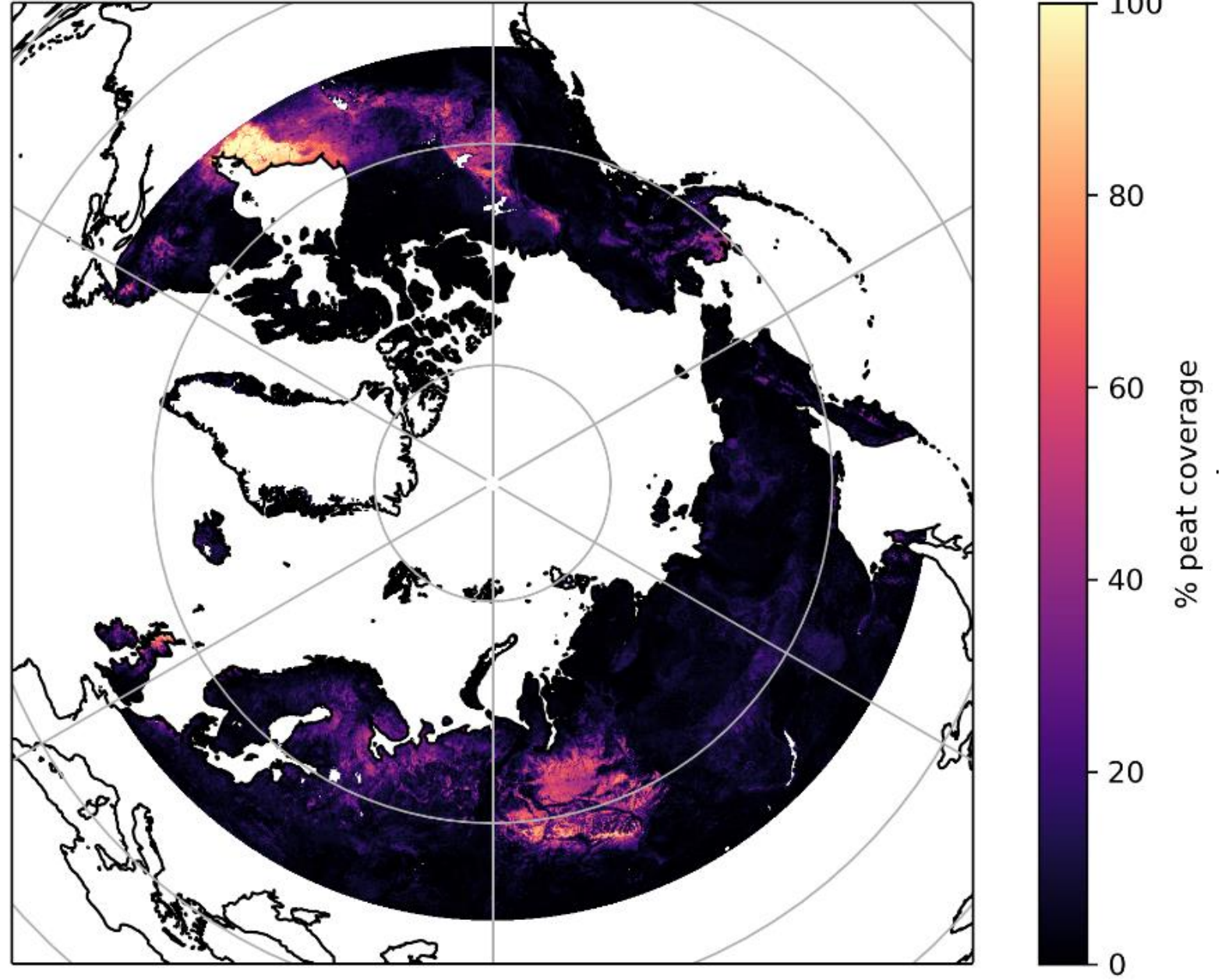
Filtered for regions where  
high tile thaw depth  $\geq 1$  m



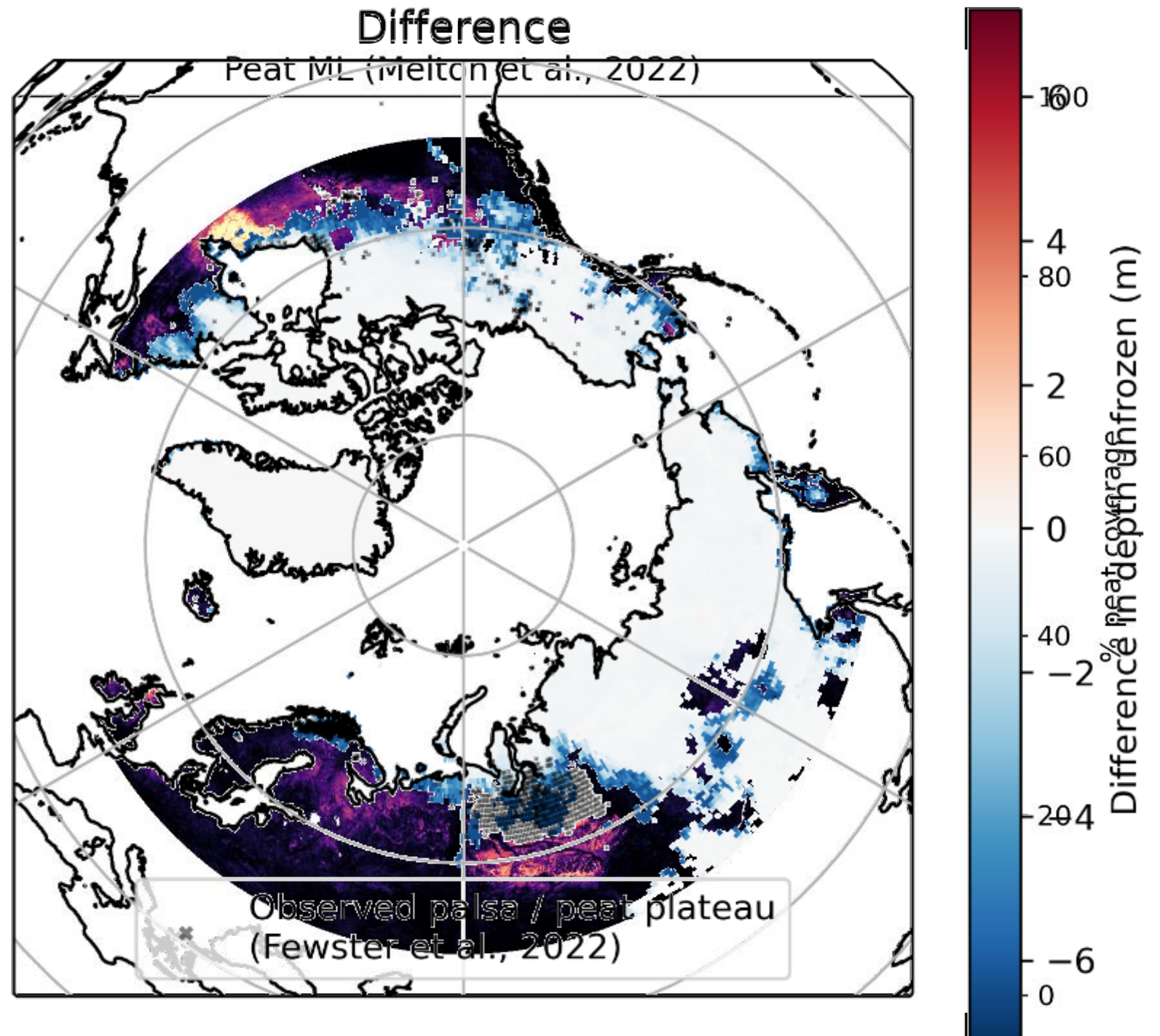


# Pan-arctic palsas

Difference  
Peat ML (Melton et al., 2022)



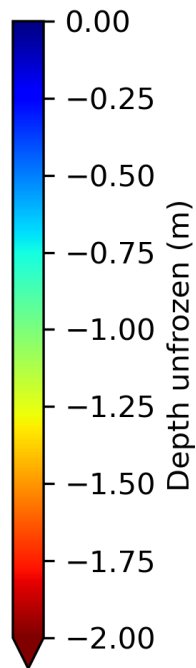
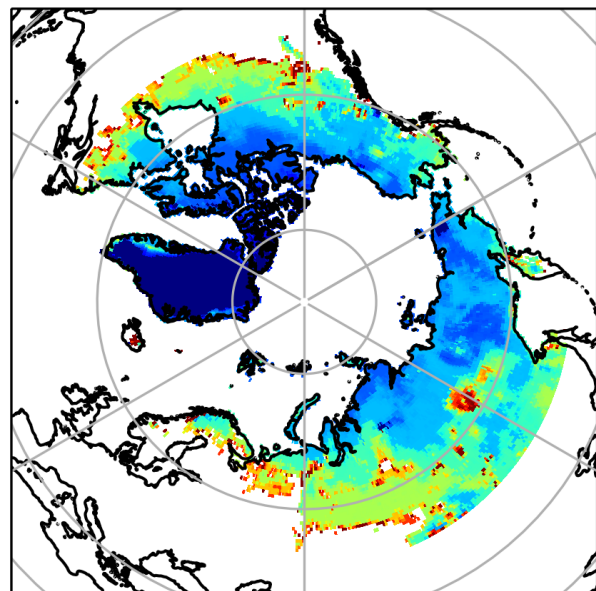
# Pan-arctic palsas



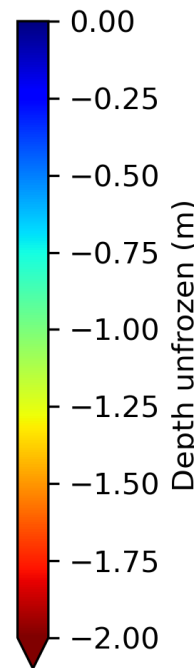
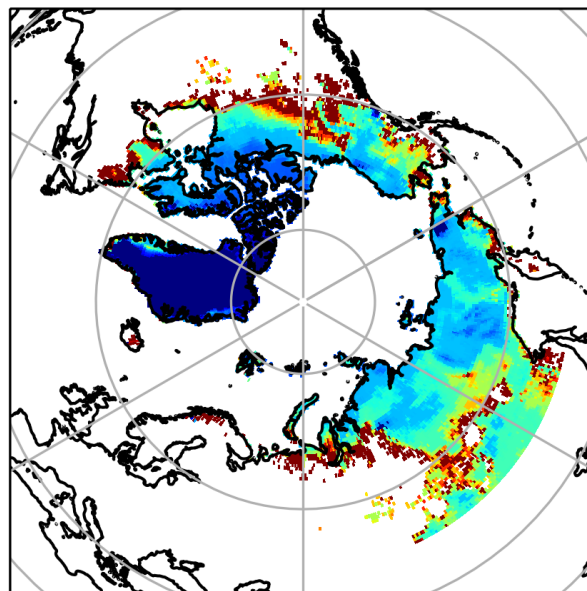
# 'Current' (2005 – 2015)

'current' maximum depth\_unfrozen between 2005-02-01 and 2015-01-01

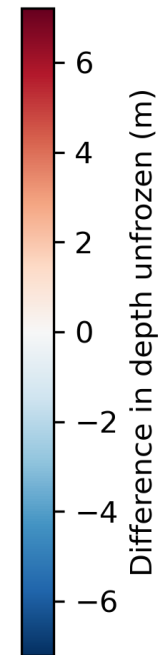
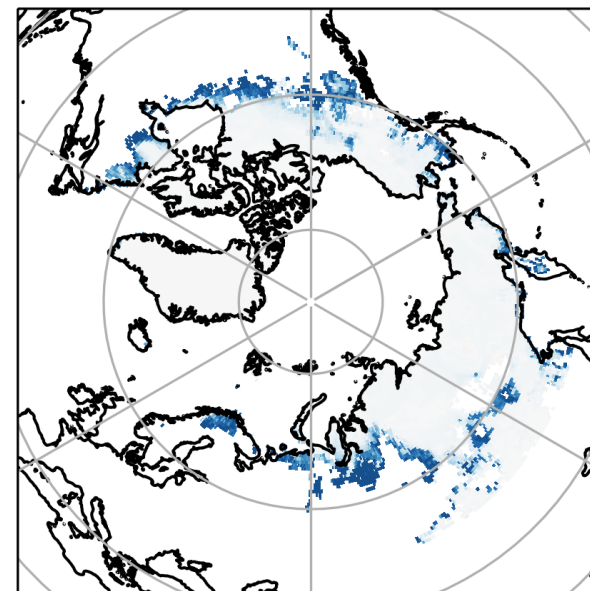
High tile



Low tile



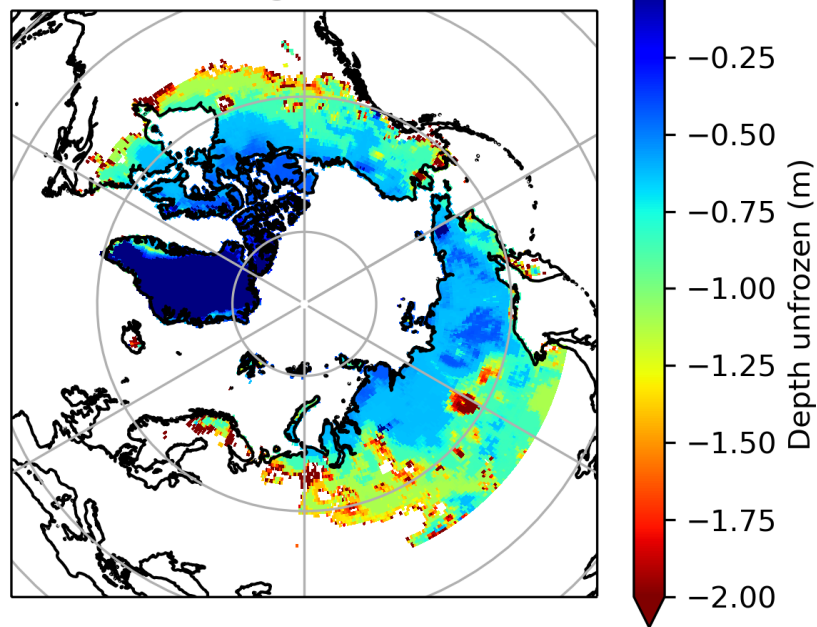
Diff w/ high tile thaw is <1m



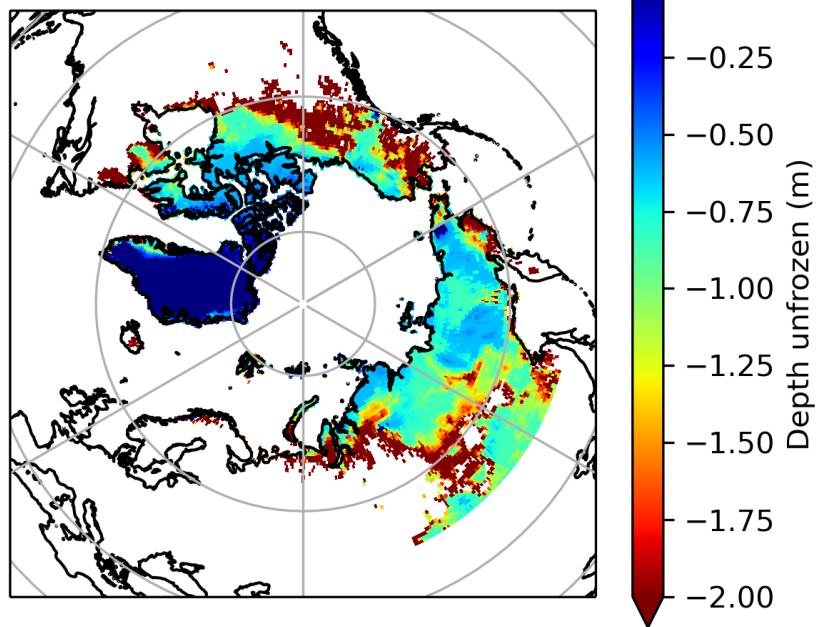
# 'ssp126' (2072 – 2082)

ssp 126 Maximum depth\_unfrozen between 2072-02-01 and 2082-01-01

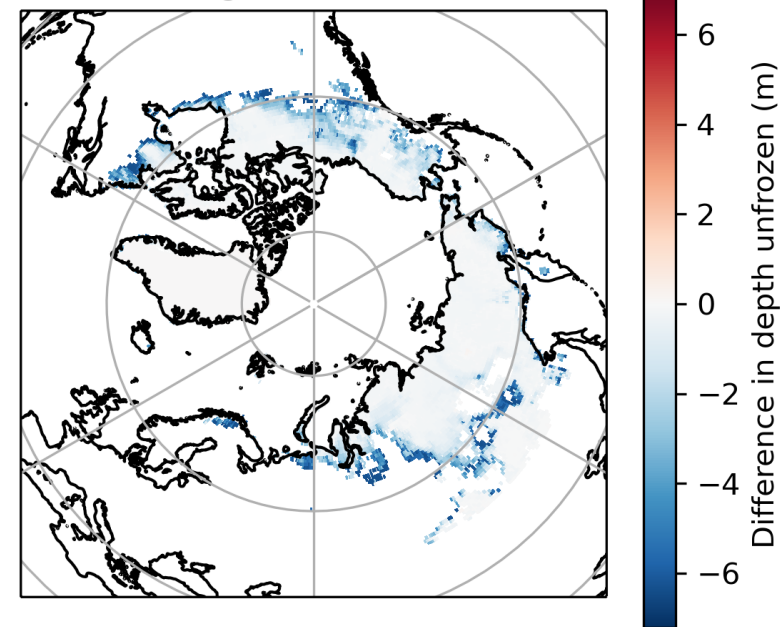
High tile



Low tile



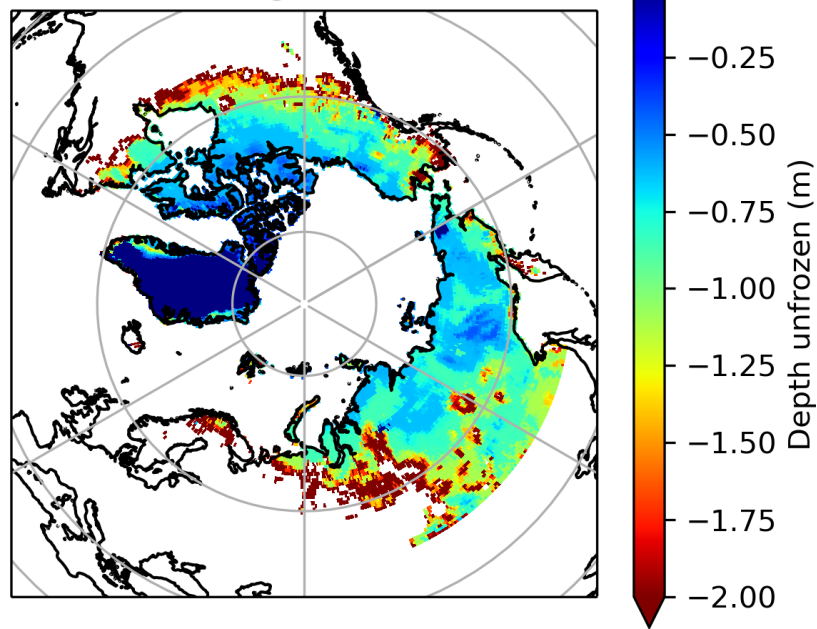
Diff w/ high tile thaw is <1m



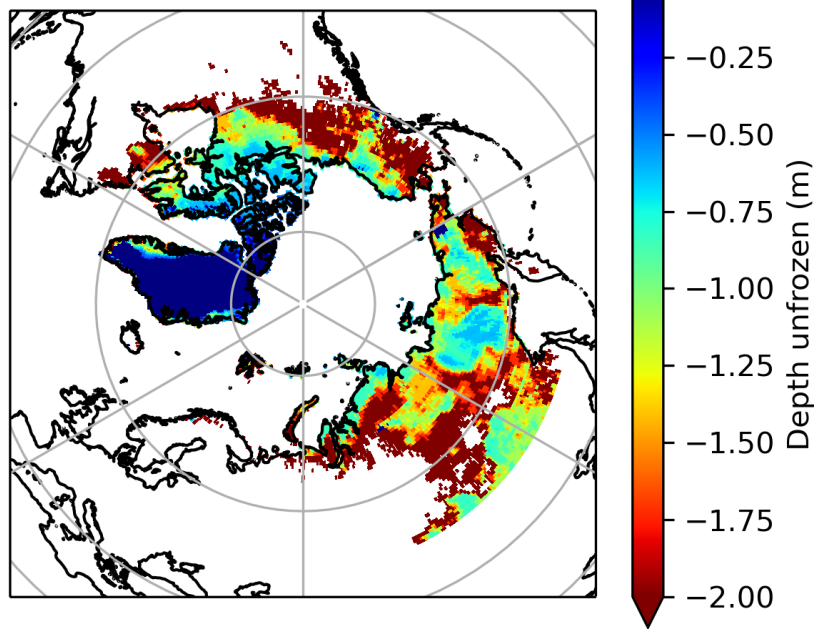
# 'ssp370' (2072 – 2082)

ssp 370 Maximum depth\_unfrozen between 2072-02-01 and 2082-01-01

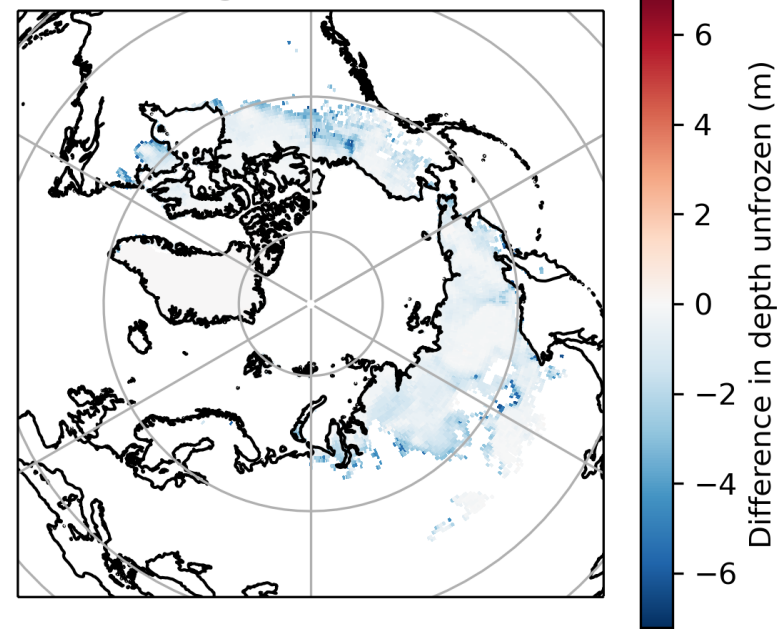
High tile



Low tile



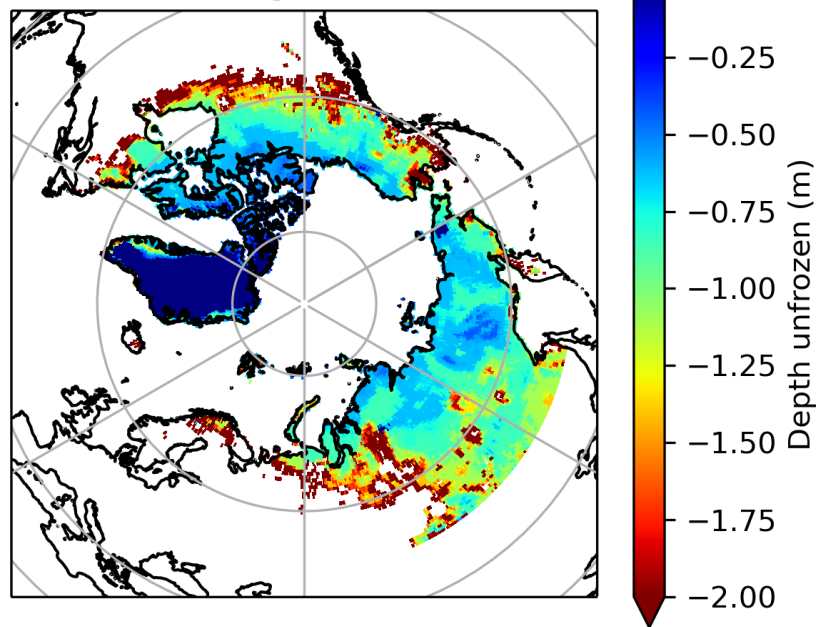
Diff w/ high tile thaw is <1m



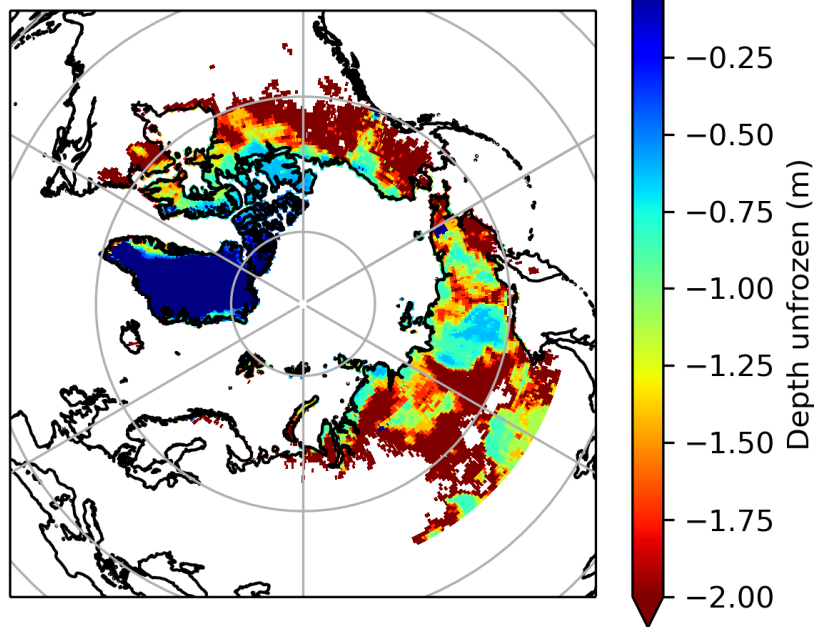
# 'ssp585' (2072 – 2082)

ssp 585 Maximum depth\_unfrozen between 2072-02-01 and 2082-01-01

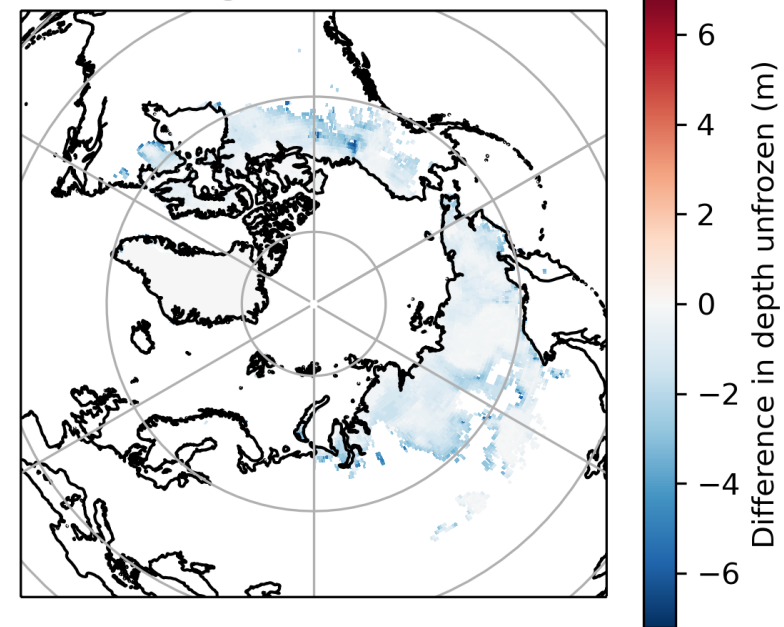
High tile



Low tile

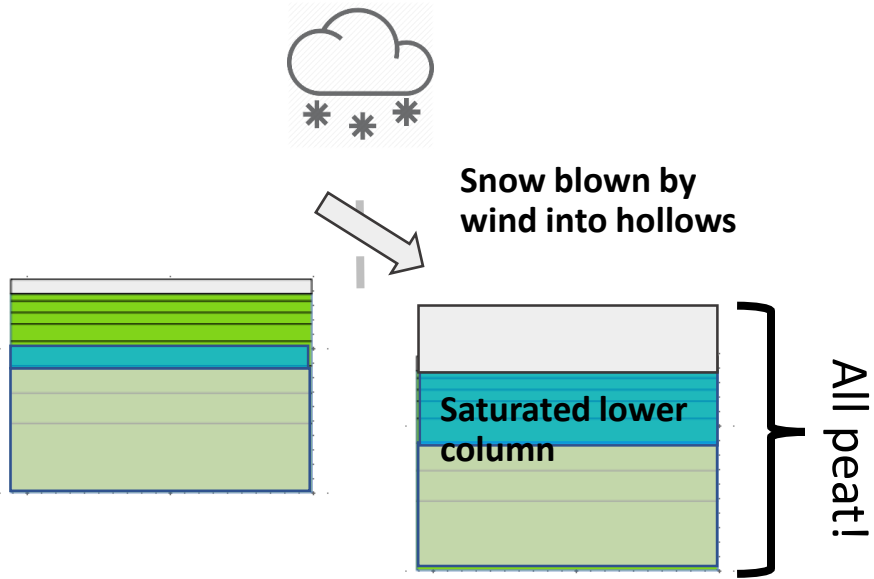


Diff w/ high tile thaw is <1m



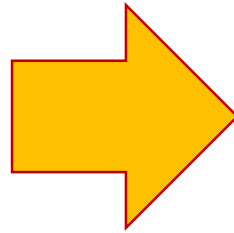
# Lateral thaw

Two tile JULES



$\longleftrightarrow$   
 $dx = ?$

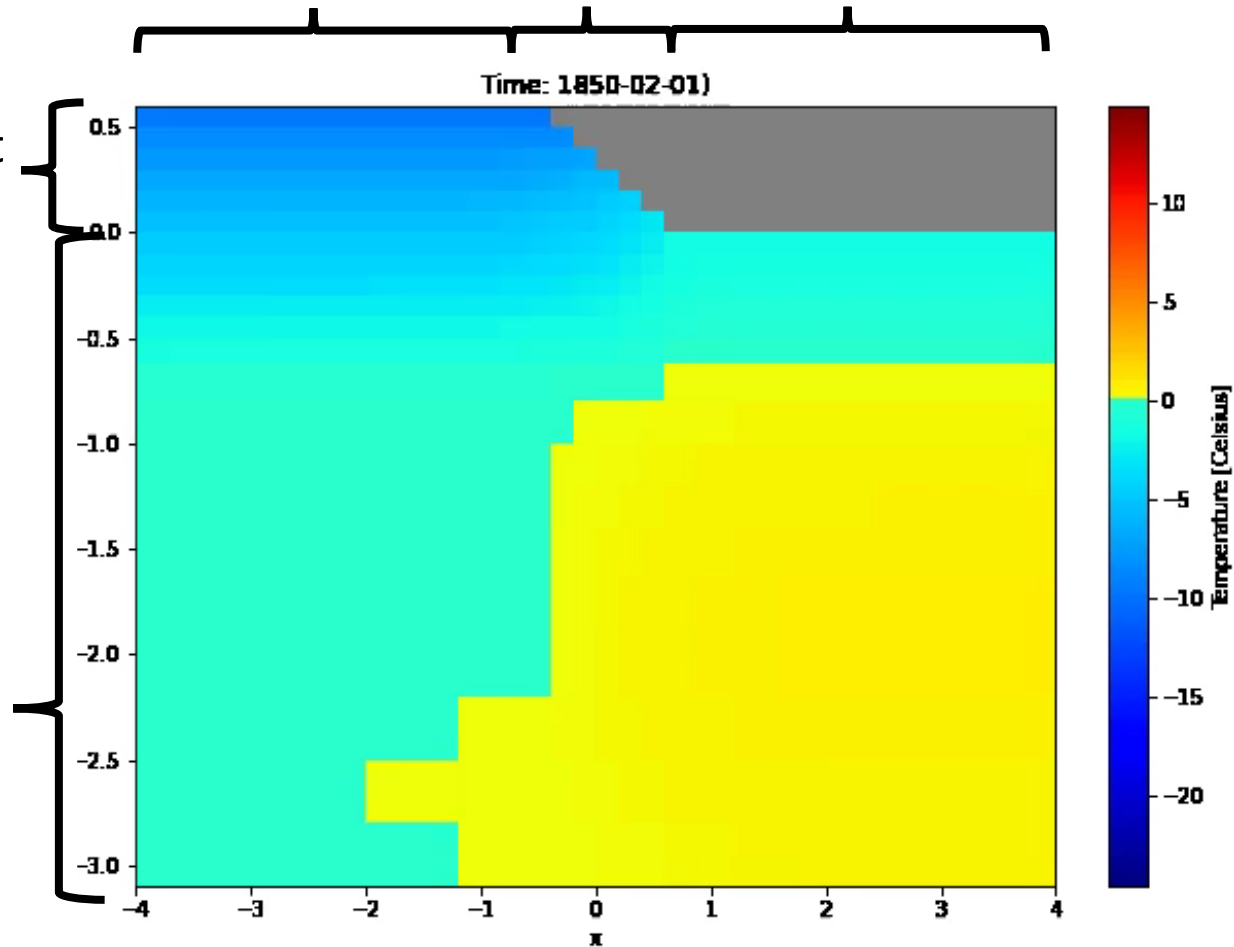
Peat water contents set by high tile



Saturated

## 2D transect (offline)

Surface temperatures set by JULES output

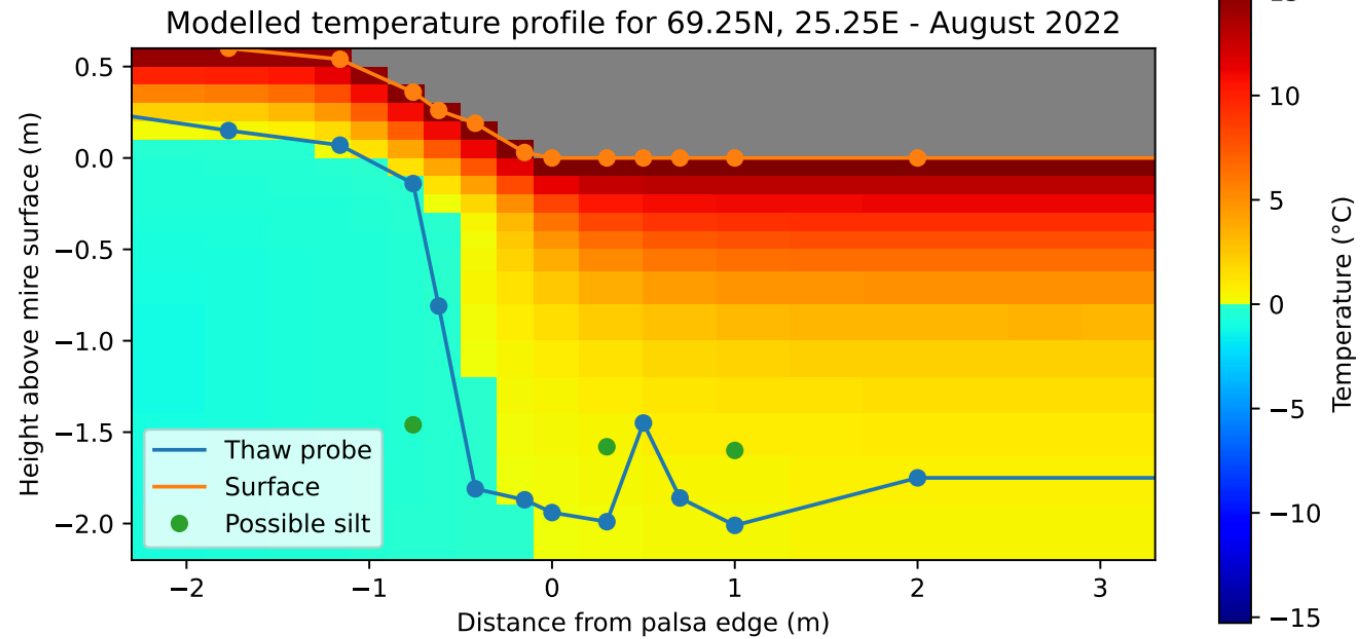
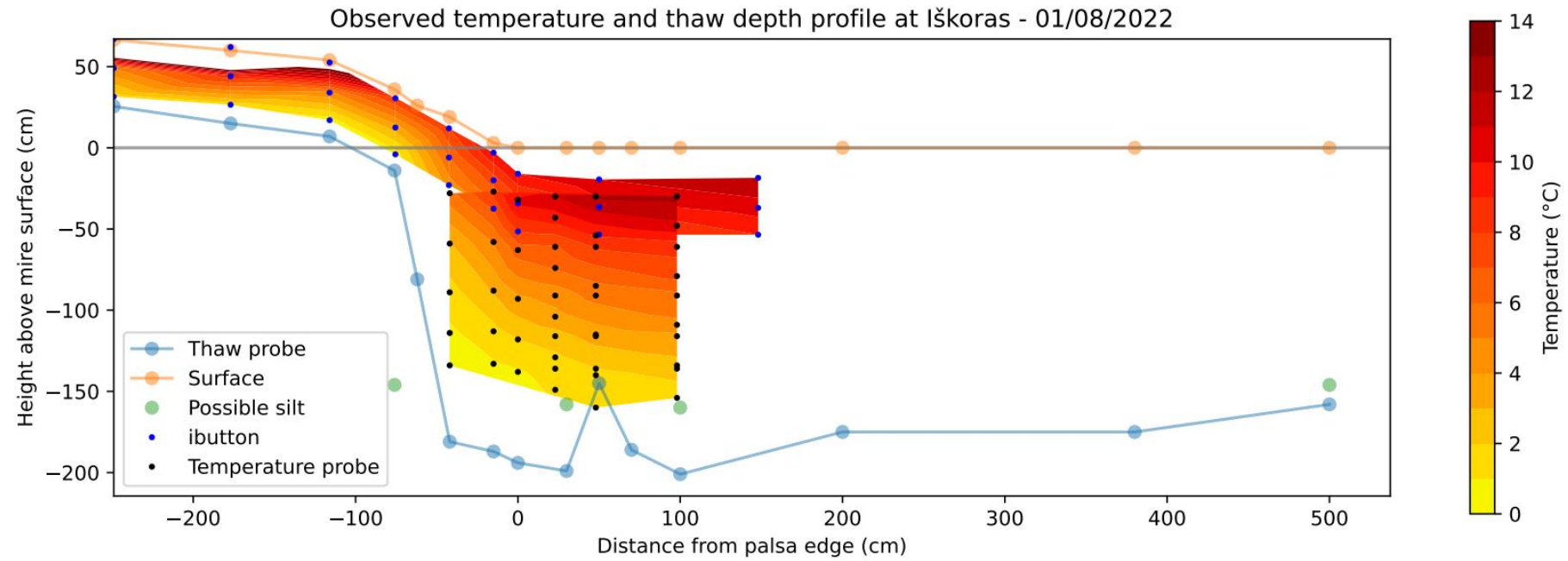


# Validation at Iskoras

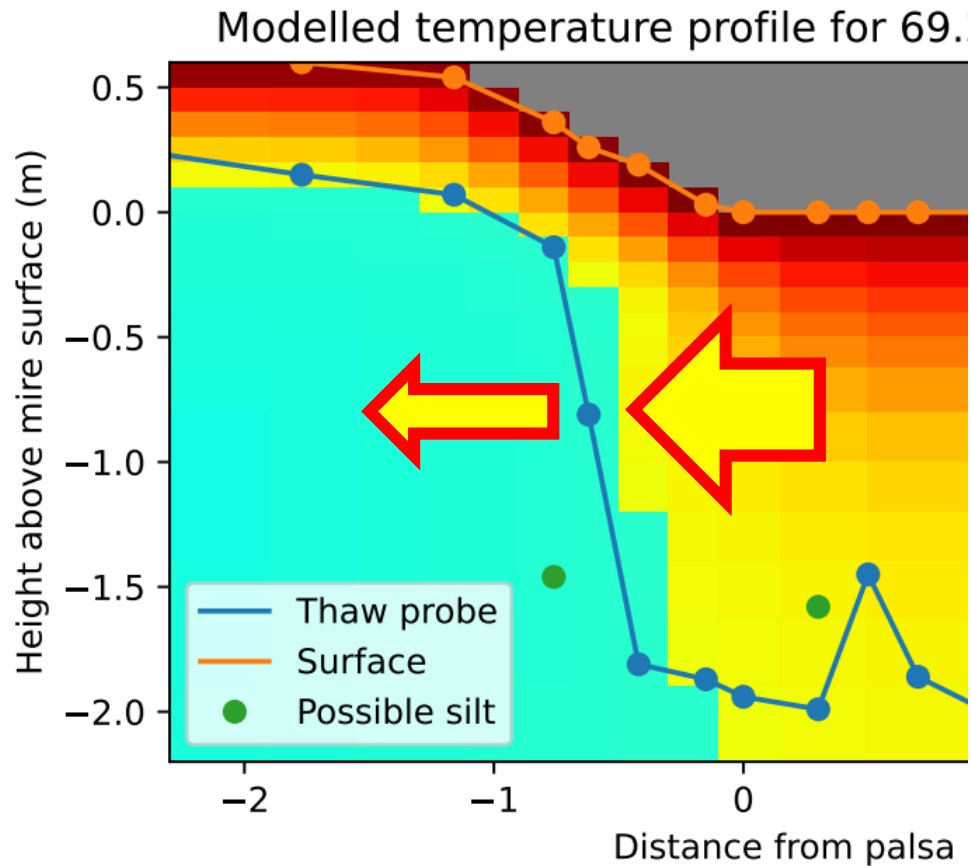




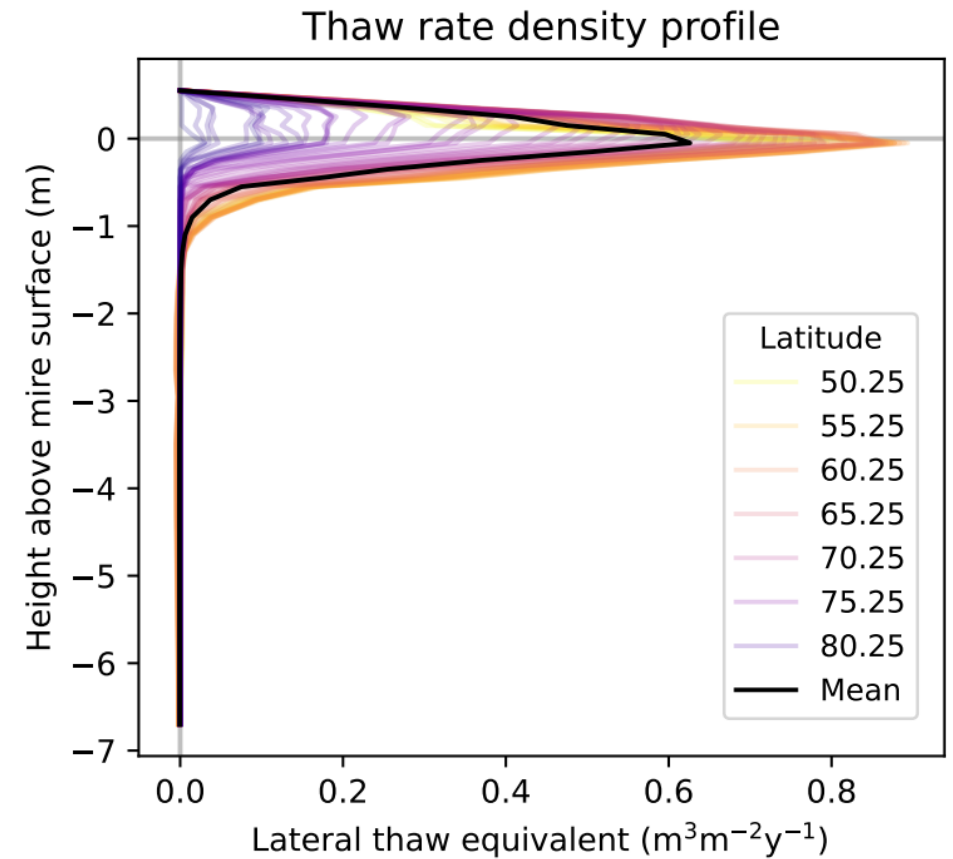
# Validation at Iskoras



# Estimating lateral thaw rate

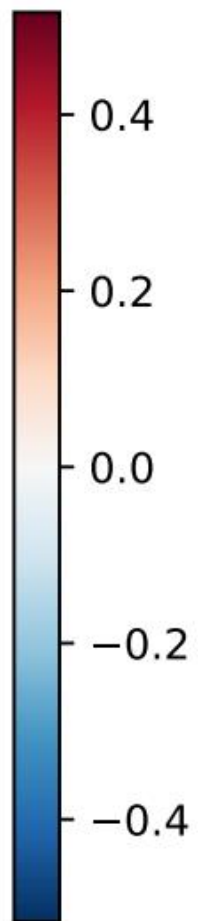
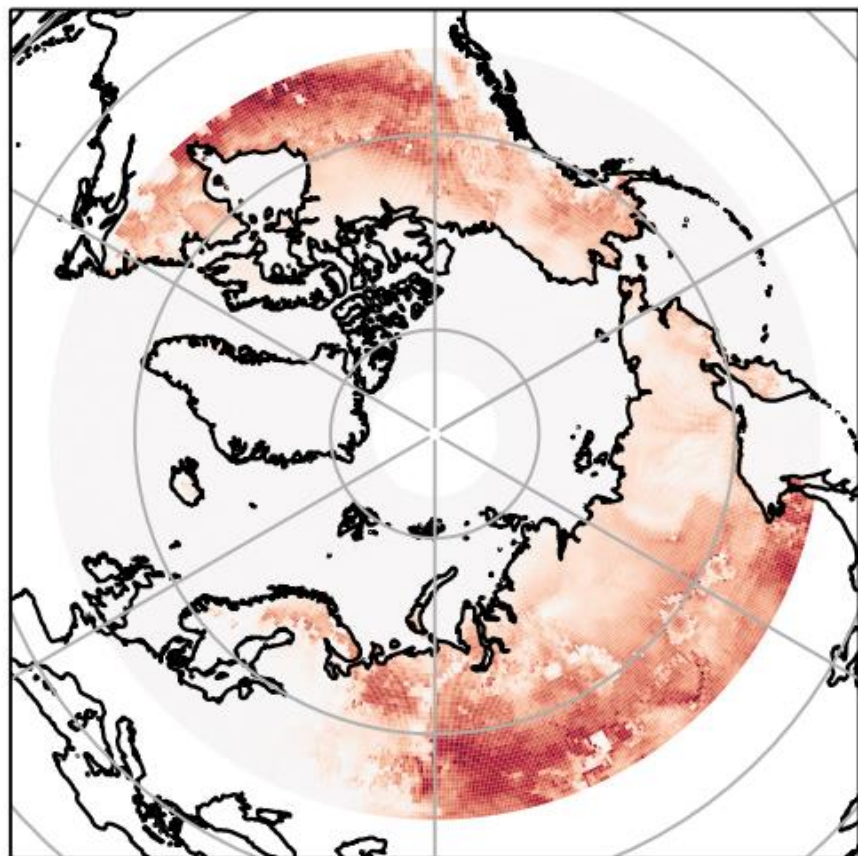


**Plan 1:** lateral thaw equivalent to net energy flowing laterally into the frozen-unfrozen interface.

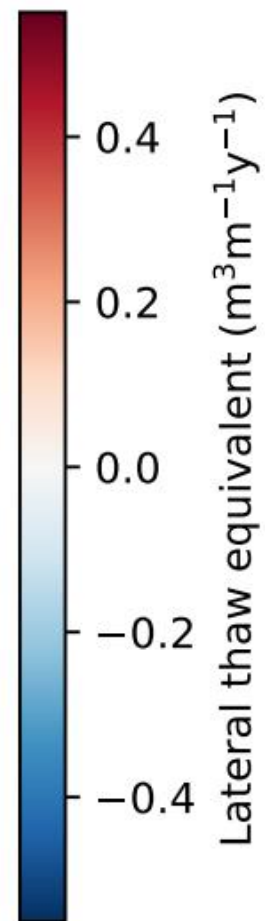
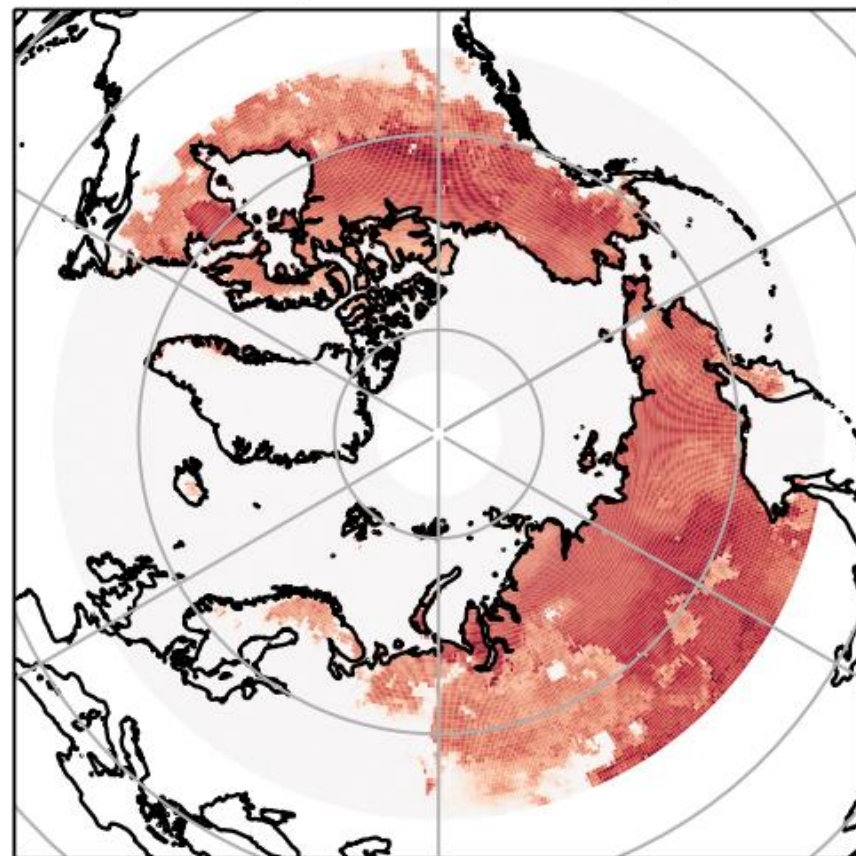


## Lateral thaw distribution above 50N (2015-2025)

### Below surface of mire

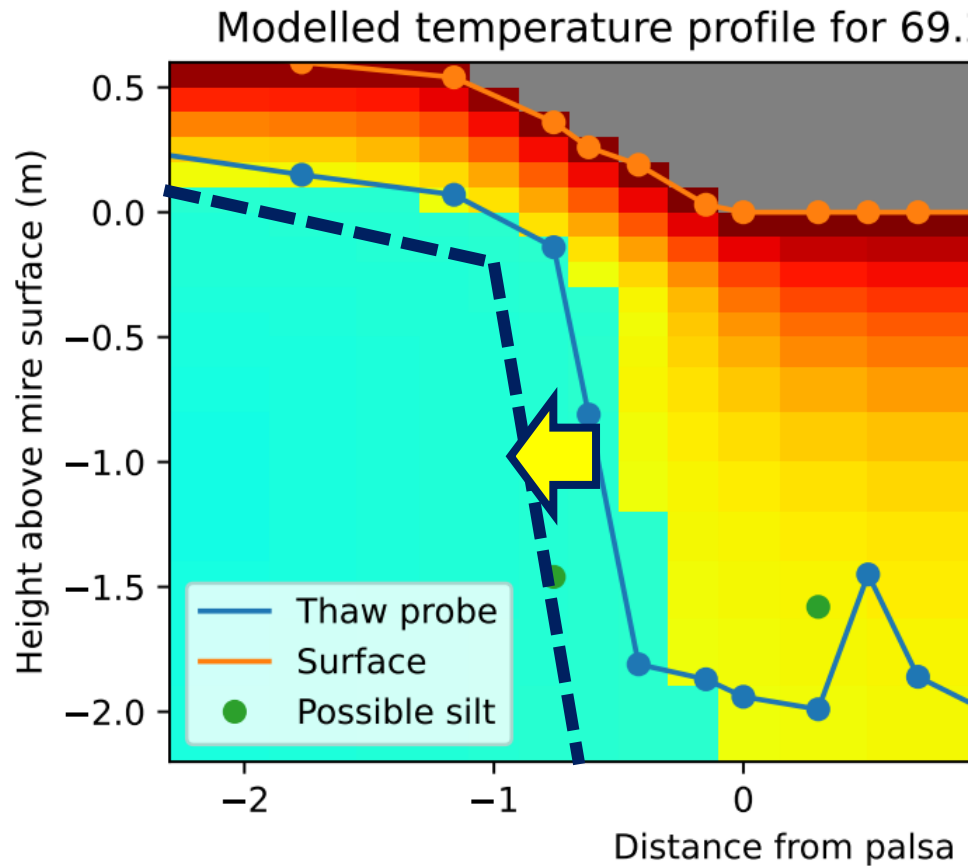


### Below palsa active layer



Lateral thaw equivalent ( $\text{m}^3\text{m}^{-1}\text{y}^{-1}$ )

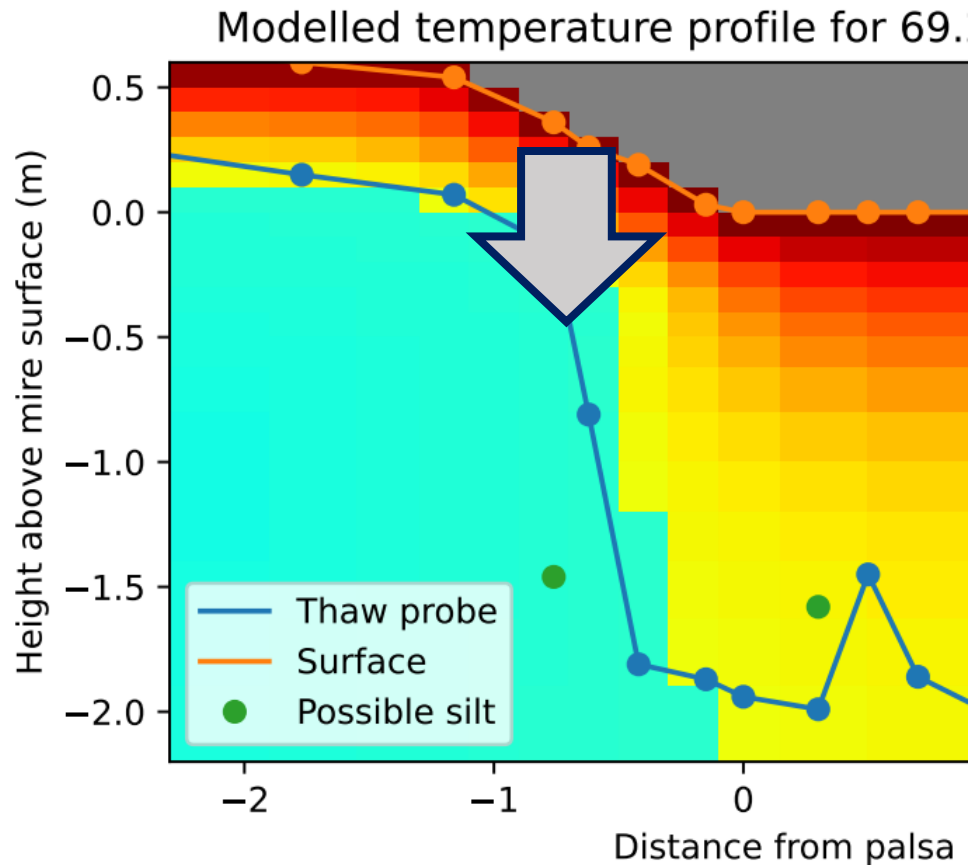
# Estimating lateral thaw rate



**Plan 1:** lateral thaw equivalent to net energy flowing laterally into the frozen-unfrozen interface.

**Plan 2:** thaw rate = amount thawed beyond reference

# Estimating lateral thaw rate



**Plan 1:** lateral thaw equivalent to net energy flowing laterally into the frozen-unfrozen interface.

**Plan 2:** thaw rate = amount thawed beyond reference.

**Plan 3:** go for it and simulate subsidence by ice thawing.

# To do: lateral thaw rate → area thawed?

Forests on thawing permafrost: fragmentation, edge effects, and net forest loss (Baltzer et al. 2013)

Vegetation Canopy and Radiation Controls on Permafrost Plateau Evolution within the Discontinuous Permafrost Zone, Northwest Territories, Canada (Chasmer et al. 2013)

Accelerated thawing of subarctic peatland permafrost over the last 50 years (Payette et al. 2004)

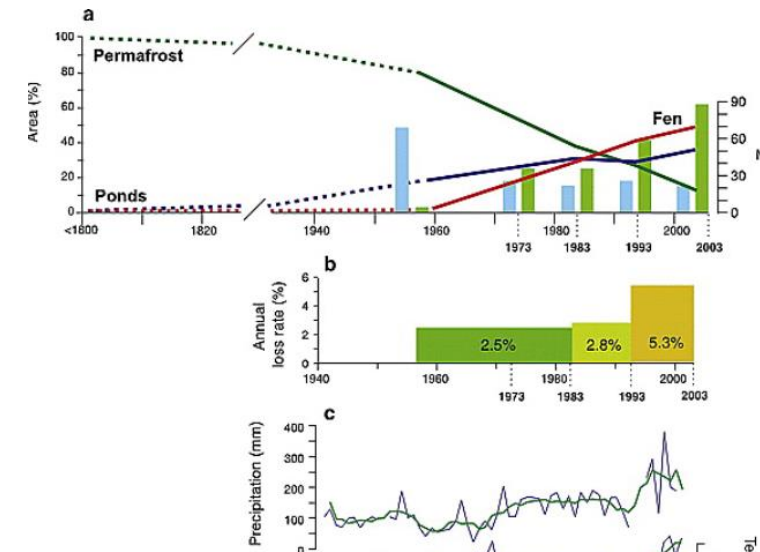
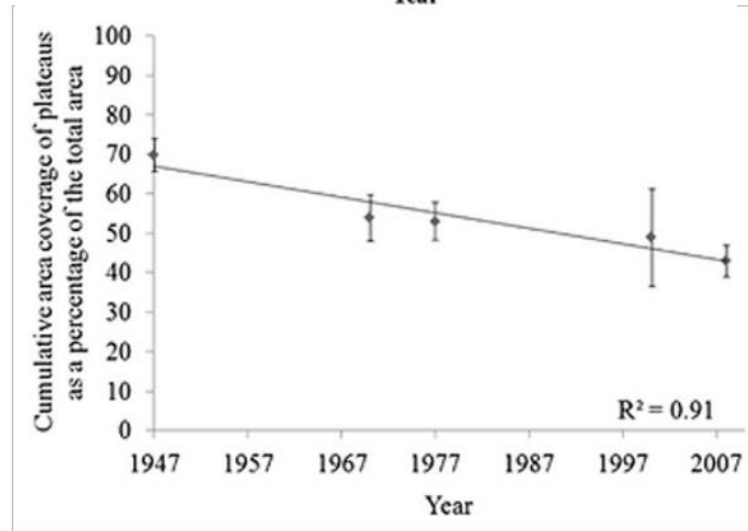
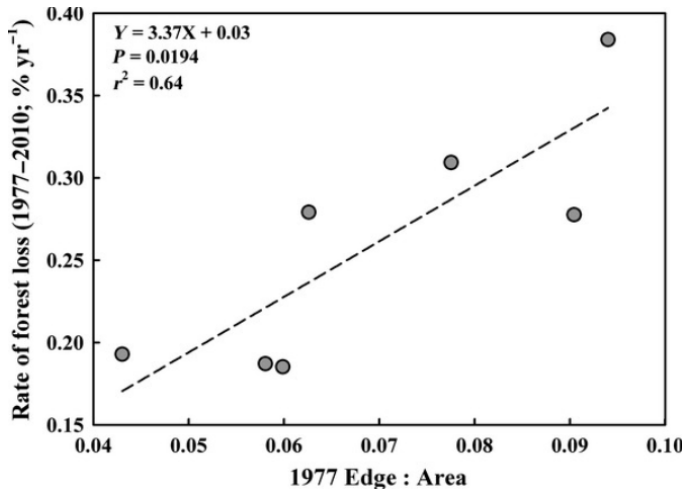
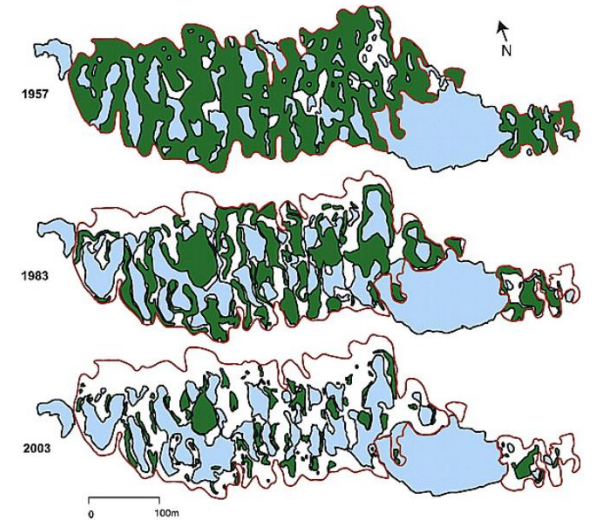
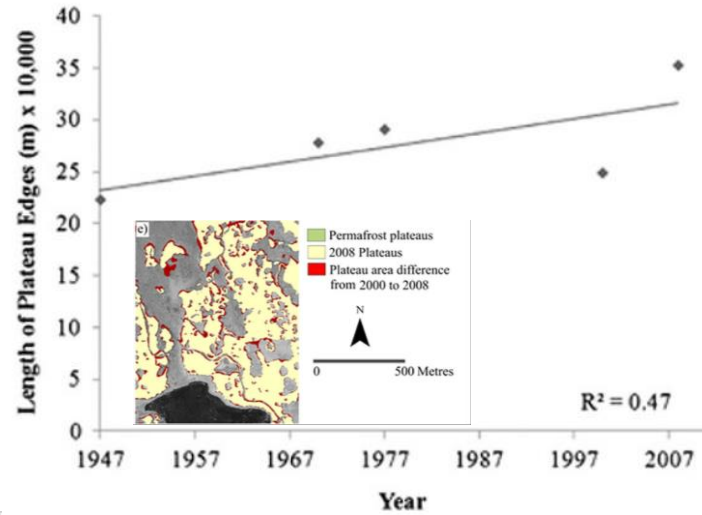
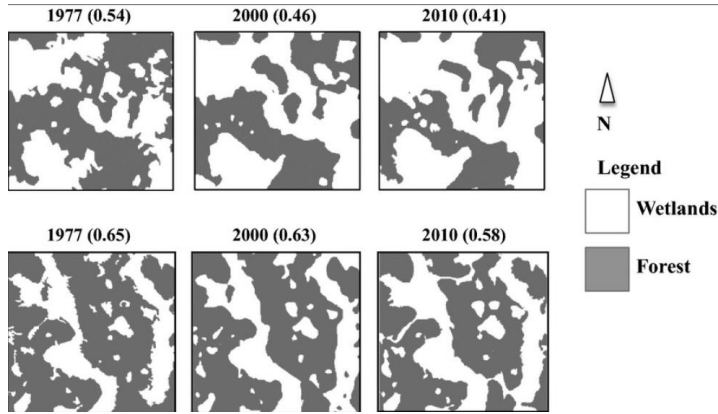


Figure 3

[Open in figure viewer](#)

[PowerPoint](#)

