Making the case for explicitly modelling microtopography in permafrost landscapes

Noah Smith (University of Exeter) + Sarah Chadburn, Eleanor Burke & more!

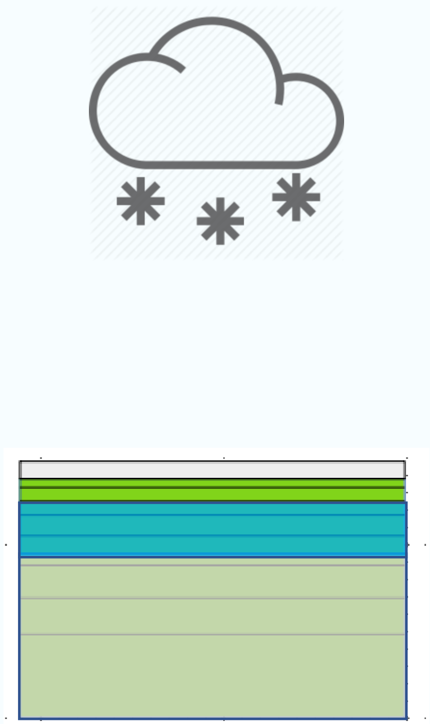


Why model microtopography?

Methane & carbon fluxes!

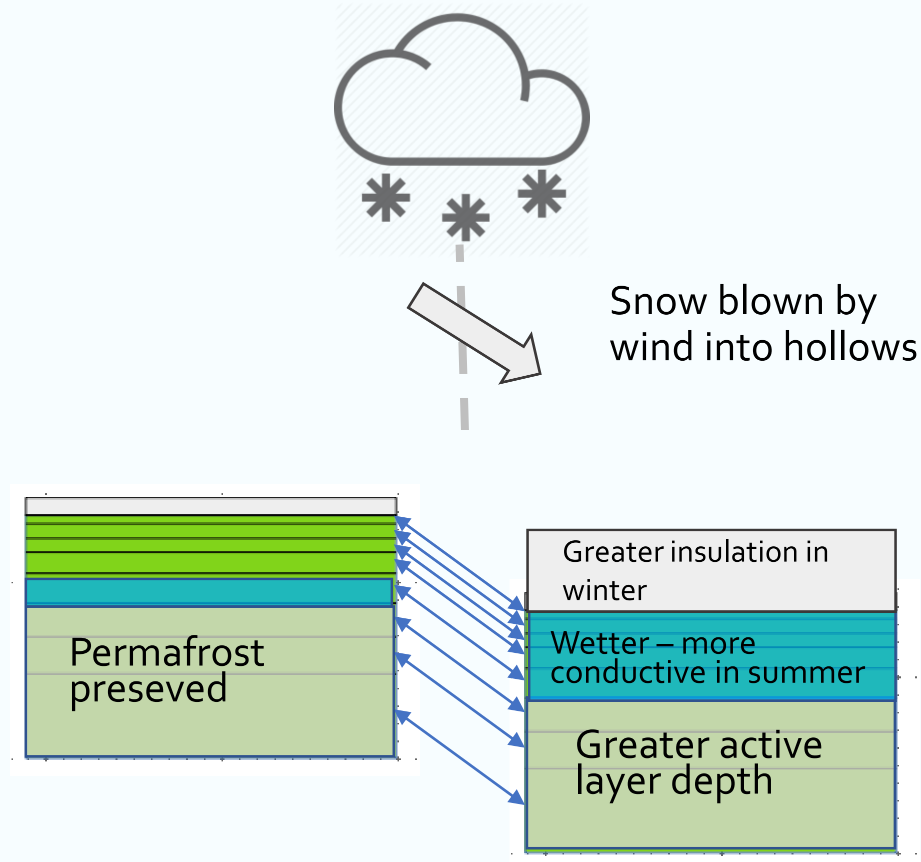
The permafrost landscape is highly heterogeneous
→ Leading to feedbacks exacerbating permafrost thaw
→ And also changing carbon fluxes

Single soil column



(multiply methane production by wetland fraction)

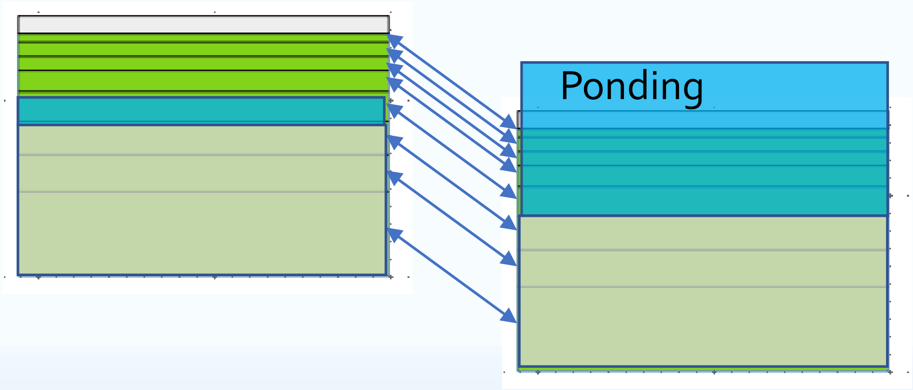
Two interacting columns with an elevation difference



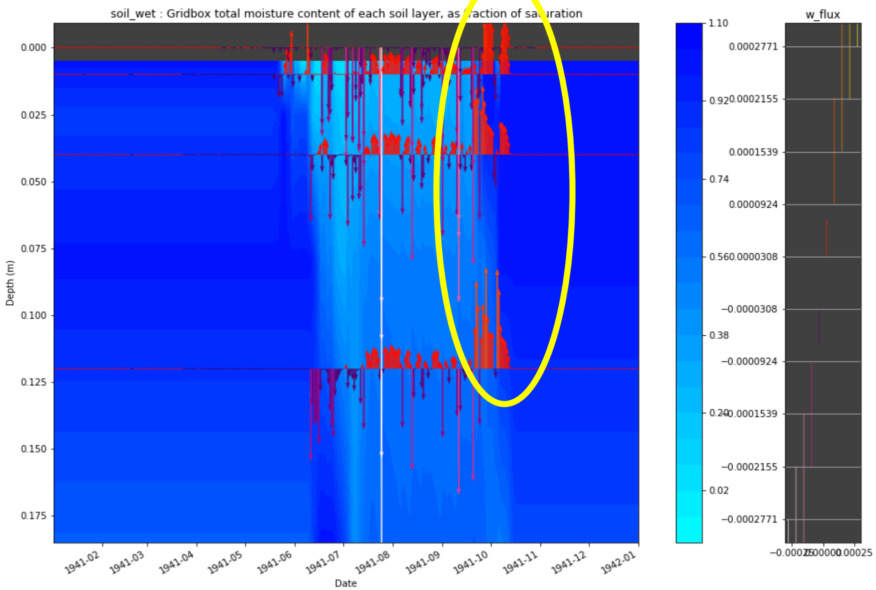
Lateral Darcy fluxes of water

Making wetlands wet

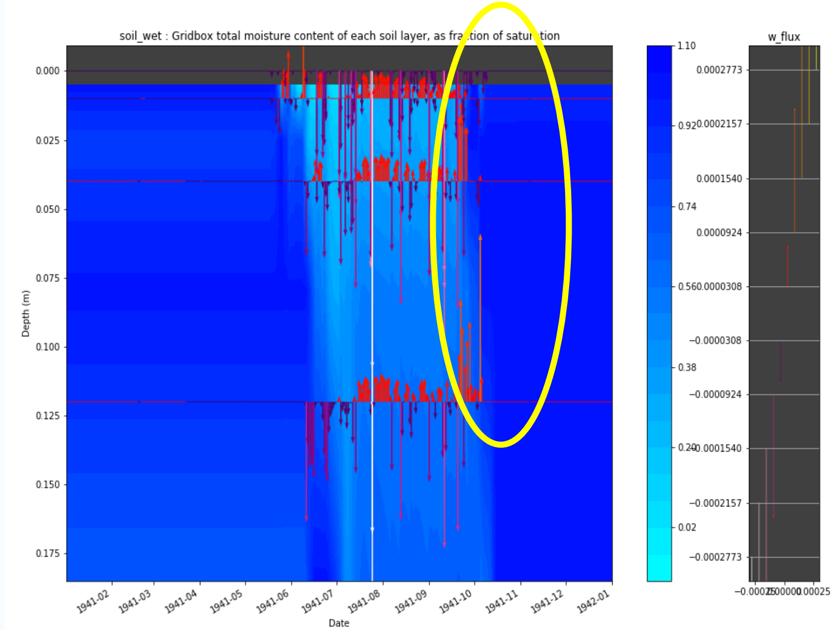
- Surface ponding
- Correction for saturation numerics (l_soilsatupdown)
- Evaporation correction for very wet soil – Sarah Chadburn
- qbase is off (for the moment)



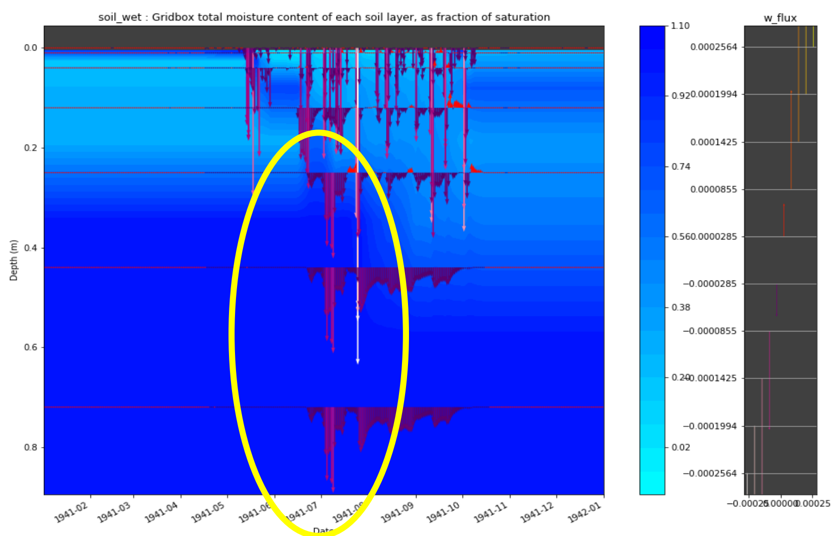
l_soilsatup = .true.



'soilsat updown'



soilsat down



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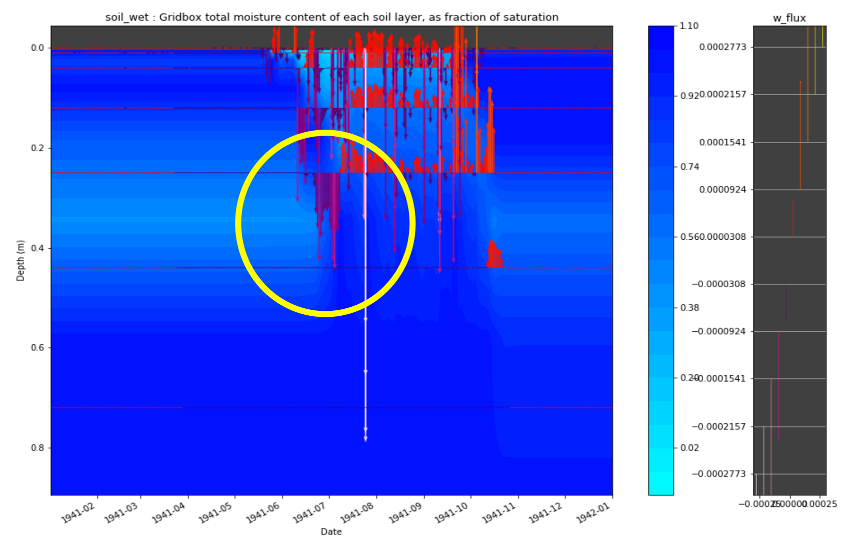
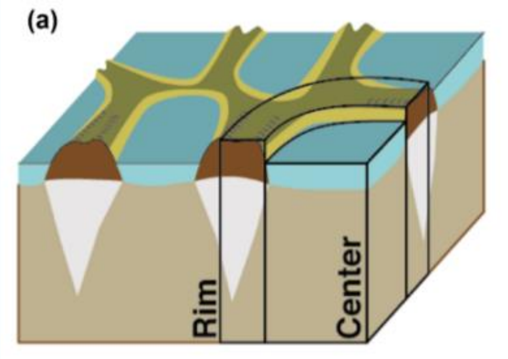
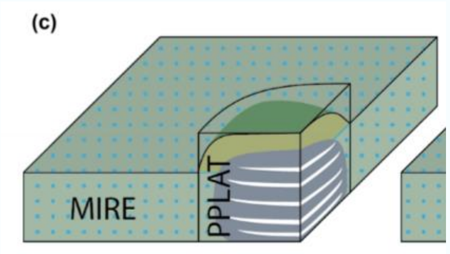


Site simulations

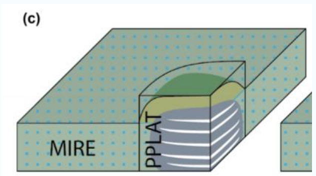
Continuous permafrost:
Ice wedge polygons



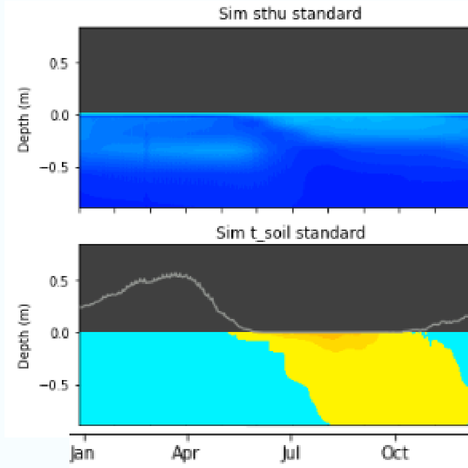
Discontinuous permafrost:
Palsa mire



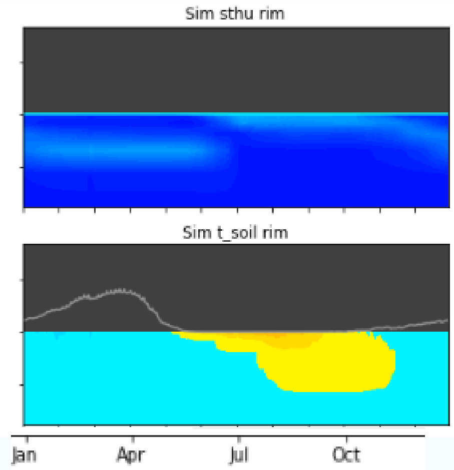
Discontinuous permafrost: Palsa mire



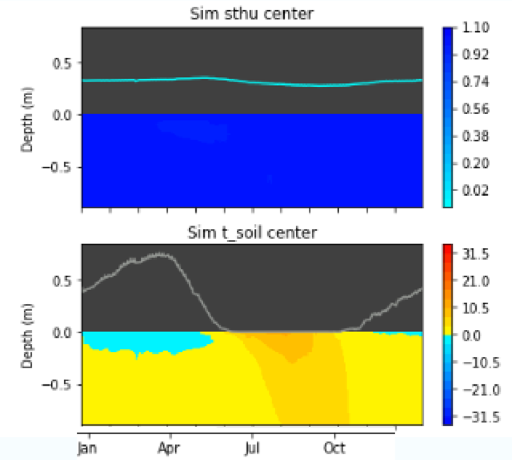
Standard (wetter) JULES



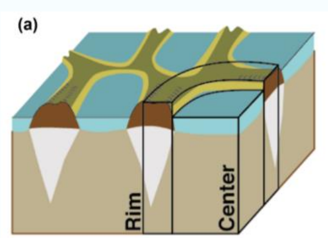
Raised Palsa



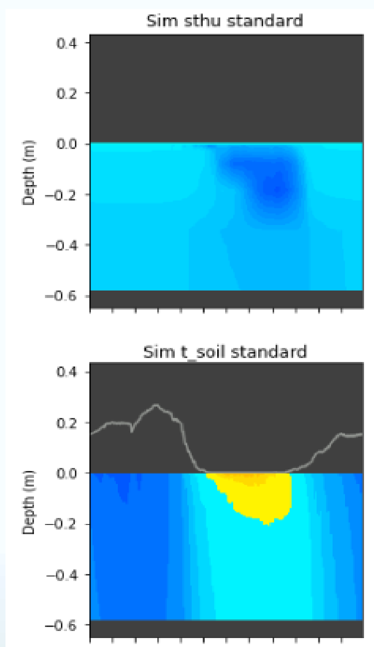
Lower Mire



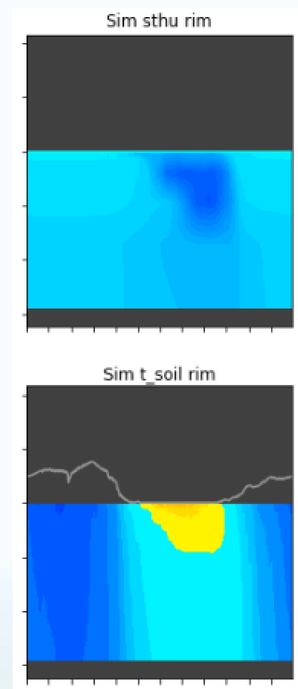
Continuous permafrost: Ice wedge polygons



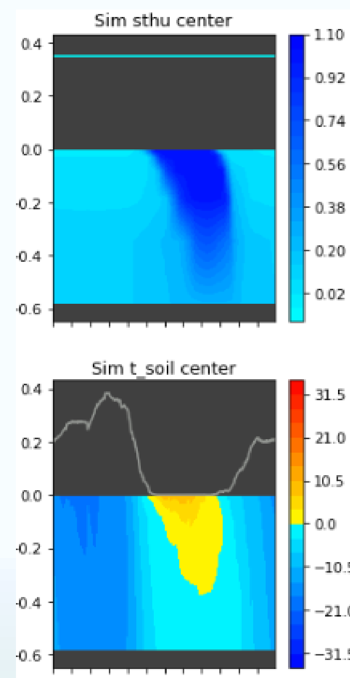
Standard (wetter) JULES



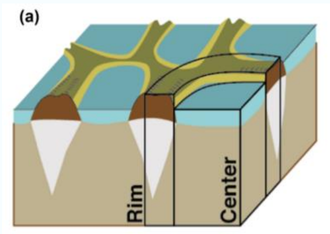
Polygon rim

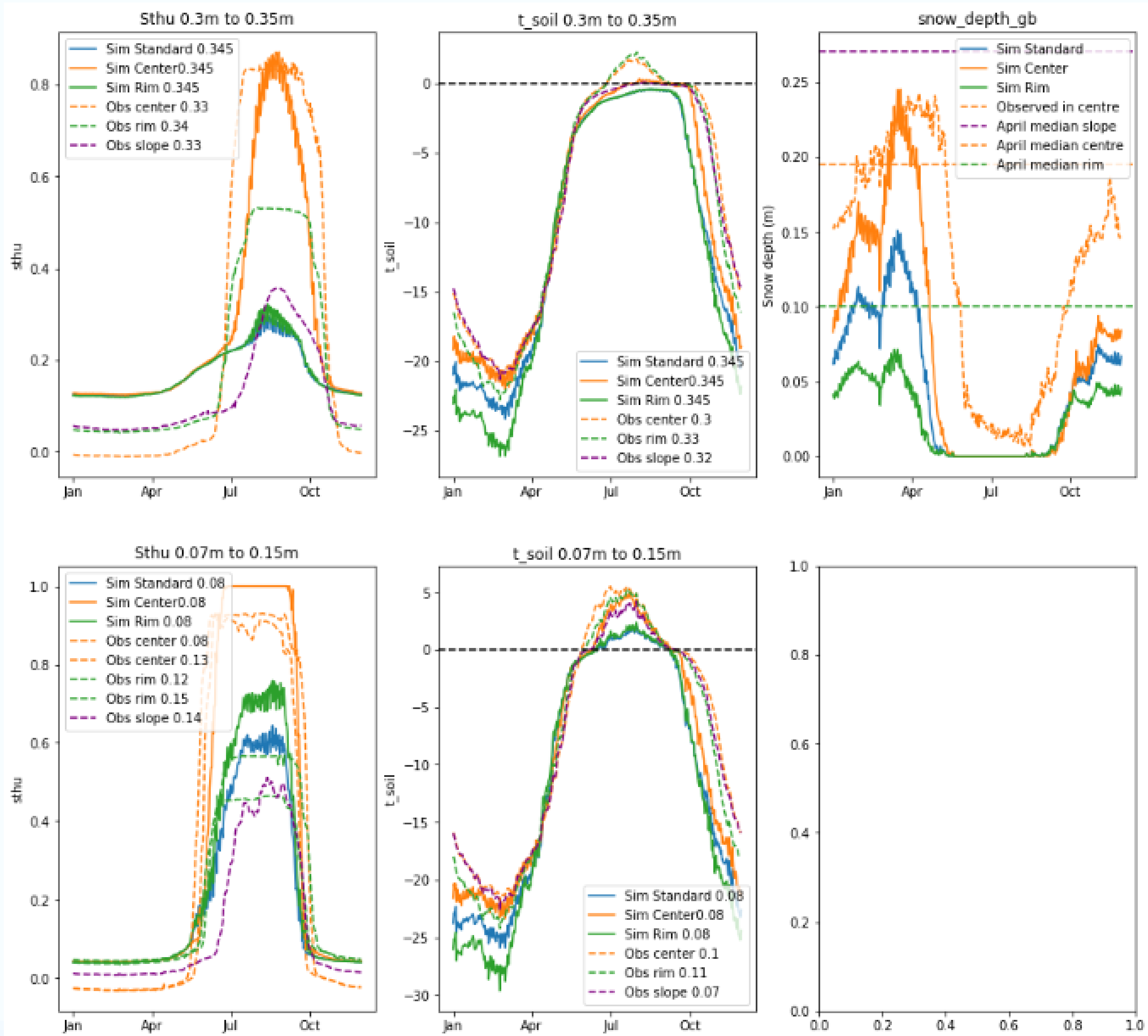


Polygon centre



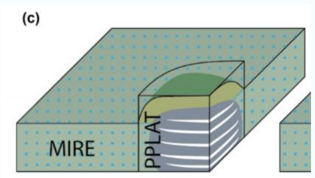
Continuous permafrost: Ice wedge polygons

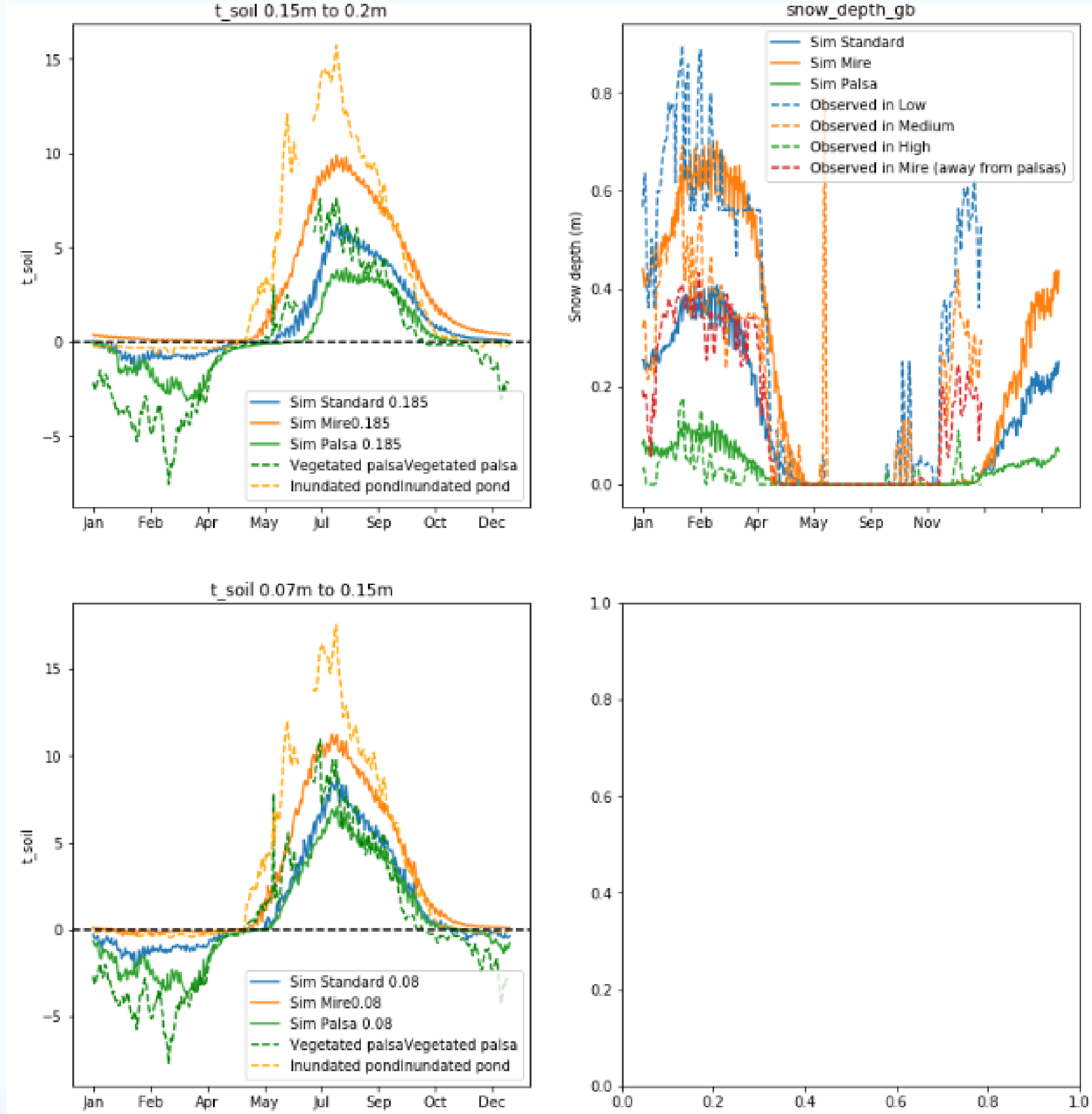




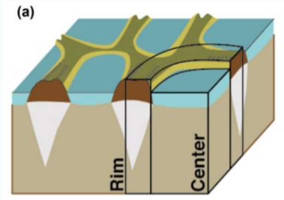
(Samoylov)

Discontinuous permafrost: Palsa mire



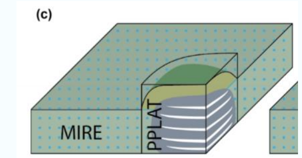


(Iskoras)

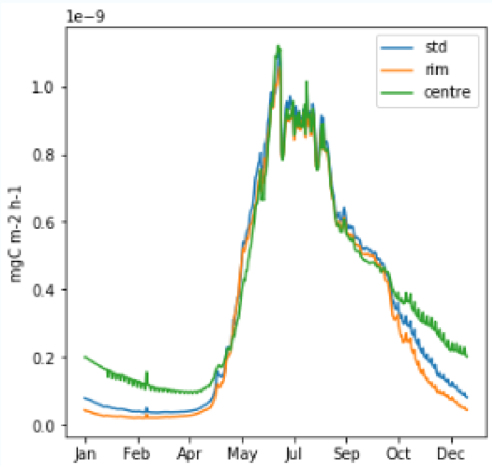


Effect on Methane

(early results)

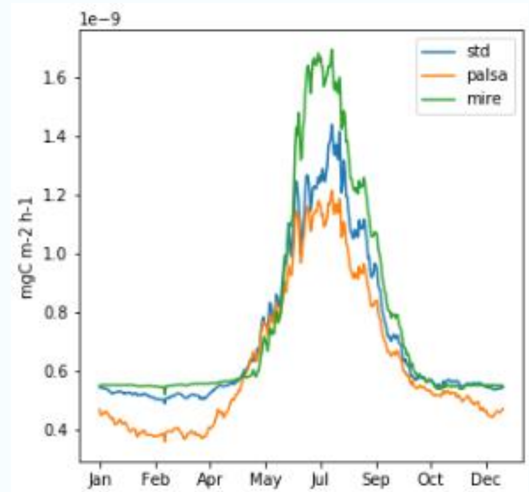


Kytalyk



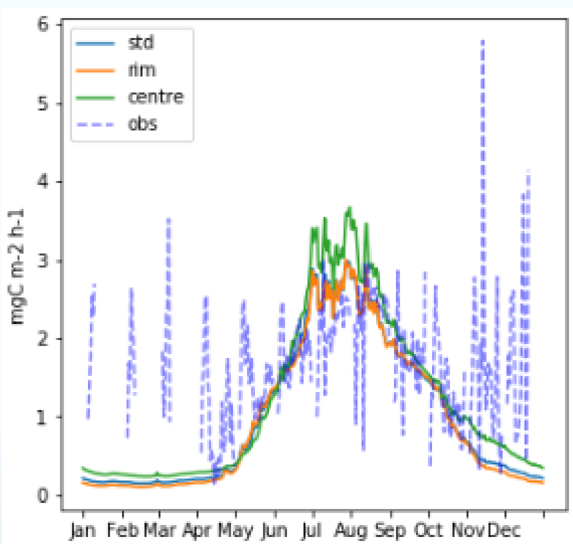
Centre is
10% > wet Jules
19% > Rim

Iskoras



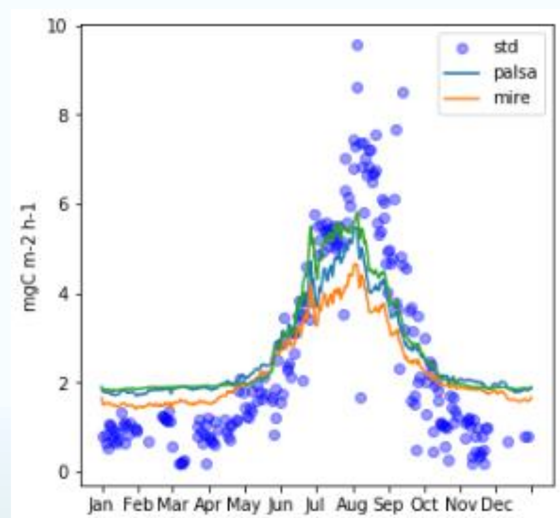
Mire is
9% > wet Jules
23% > Rim

Samoylov, Siberia



Centre is
12% > wet Jules
21% > Rim

Stordalen mire, Abisko



Mire is
4% > wet Jules
19% > Rim

Final slide

- Microtopography has ~ 10% difference to methane fluxes vs std JULES
- However change in methane emissions is driven by the change in wetland area and permafrost extent
- …which is driven in part by microtopographic effects (e.g. thermokarst).
- This approach may also better enable modelling soil carbon history and labile carbon