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Natural Hazards and Risks in a Changing World

Geo X

ALFRED-WEGENER-INSTITUT
HELMHOLTZ-ZENTRUM FÜR POLAR- UND MEERESFORSCHUNG

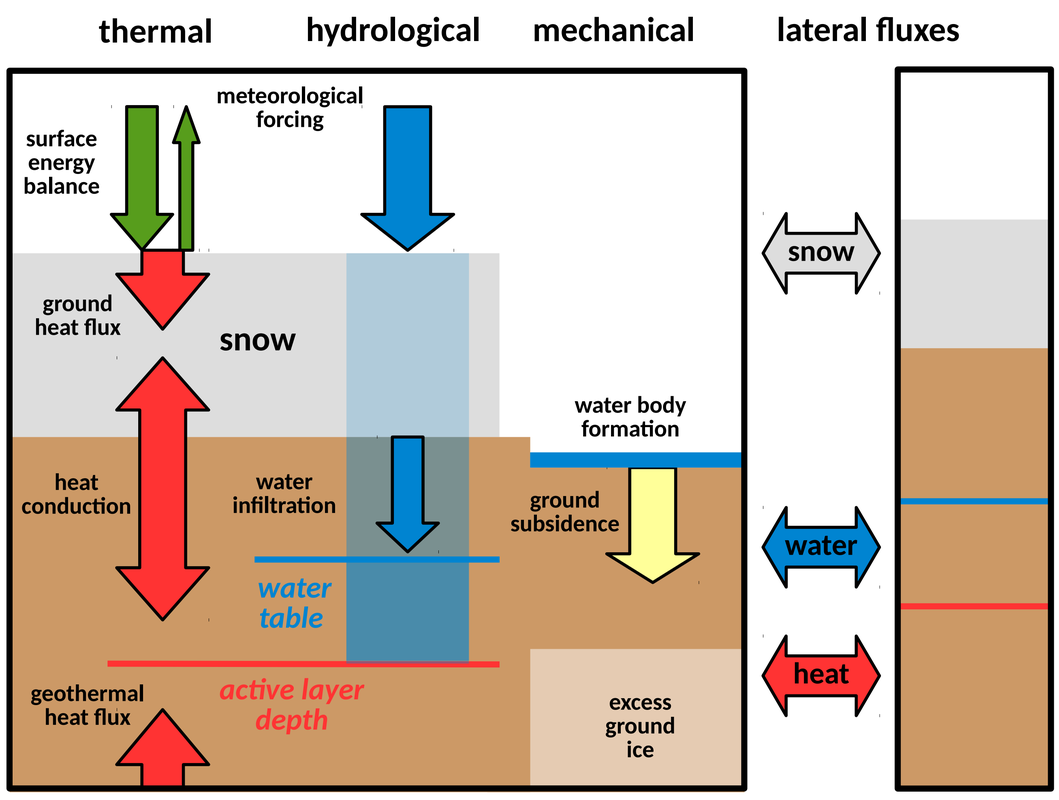
Modelling Rapid Changes in Ice-Rich Permafrost Landscapes

Motivation

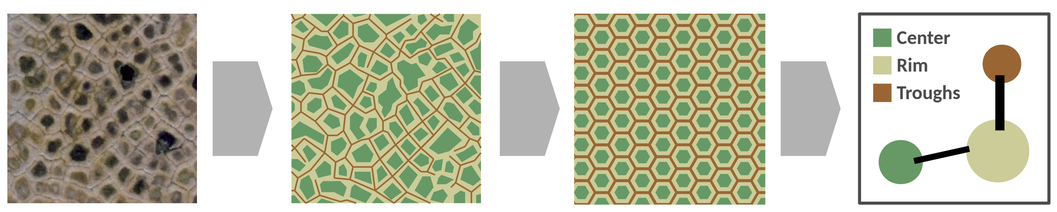
- **Ice-rich ground** is present in large parts of the permafrost region and is **susceptible to rapid thawing** and associated **ground subsidence**.
- This process is called **thermokarst** and poses **risks to ecosystems and infrastructure**, but it can also be **initiated by infrastructural changes**.
- **Small-scale permafrost degradation** is not represented in large-scale models, but considerably **impacts energy, water and carbon budgets**.

Modelling framework

CryoGrid3 Land Surface Model

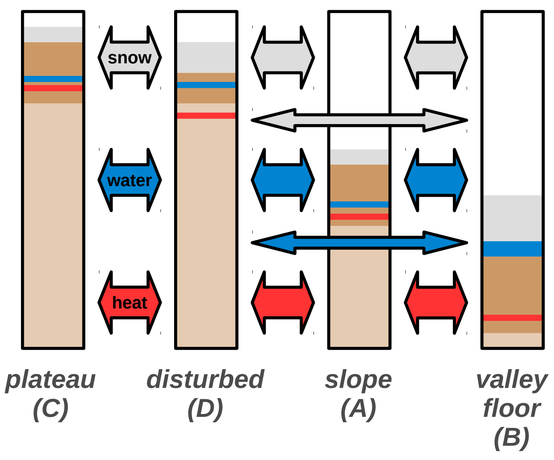


Tiling approach (semi-distributed)



Thermo-erosion

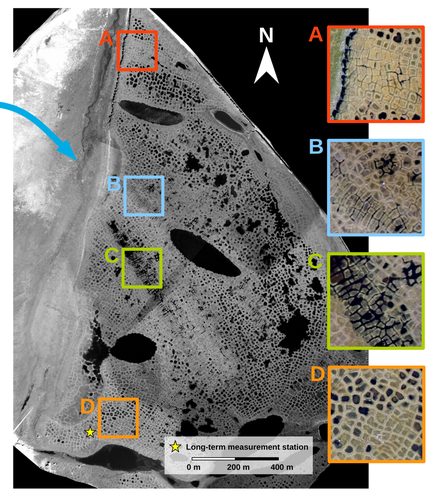
How can **thermo-erosional valleys** and **retrogressive thaw slumps** be represented in a tile-based modelling framework?



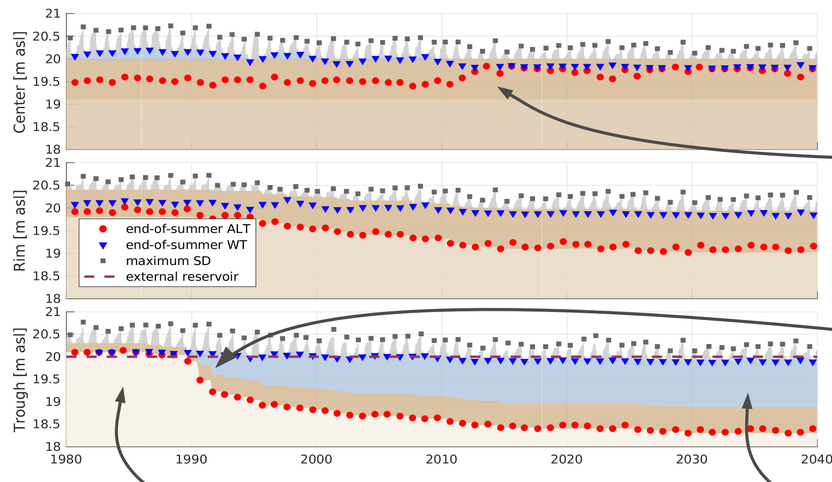
lateral** and **vertical thawing — *dynamically **changing areas***

Ice-wedge thermokarst

- Simulation of ice-wedge degradation possible with **tile-based approach**
- **Hydrological conditions** can explain spatial variability under identical climate
- Ice-wedge degradation leads to substantially changed water fluxes



Simulation results



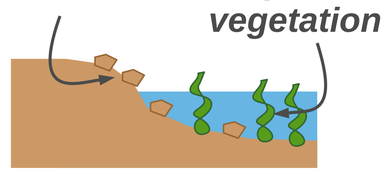
*subsurface **regime shift***

***positive feedback** accelerates thawing*

*(meta-)stable, **low-centred polygons***

*stabilized, **high-centred polygons***

lateral erosion *aquatic vegetation*



How can **stabilizing feedbacks** be incorporated into CryoGrid3?

How does a **changing climate** affect ice-wedge degradation?

Infrastructure thermokarst

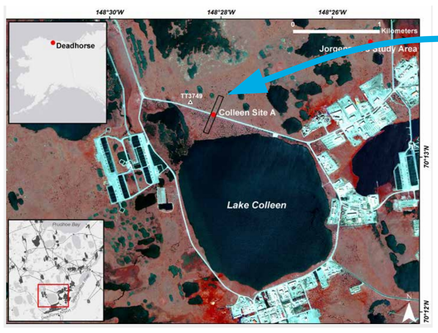
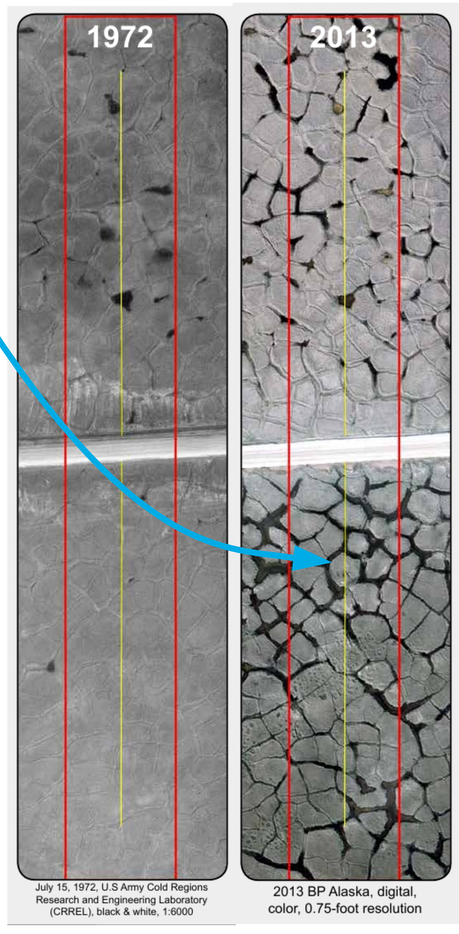


Image: (Buchhorn et al., 2015)

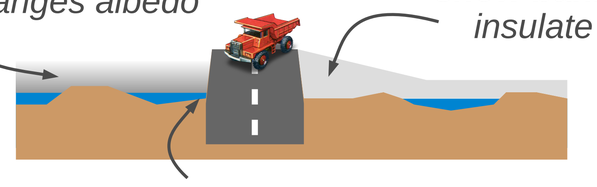
Images: (Buchhorn et al., 2015)



***roadside thermokarst** formation*

***road dust** changes albedo*

***snow banks** insulate*



*road is **hydrological barrier***

What are the **driving processes?**

Which processes drive the **asymmetric degradation** at the two roadsides?

References

Westermann, S., Langer, M., Boike, J., Heikenfeld, M., Peter, M., Etzelmüller, B., & Krinner, G. (2016). Simulating the thermal regime and thaw processes of ice-rich permafrost ground with the land-surface model CryoGrid 3. *Geoscientific Model Development*, 9(2), 523–546.

Buchhorn, M., Raynolds, M. K., Walker, D. A., Kanevskiy, M., Matyshak, G., Shur, Y., Peirce, J. (2015). Effects of 45 years of heavy road traffic and infrastructure on permafrost and tundra at Prudhoe Bay, Alaska *AGU General Assembly,* Abstract GC23J-1215

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