Scenario:
Winter/Spring day

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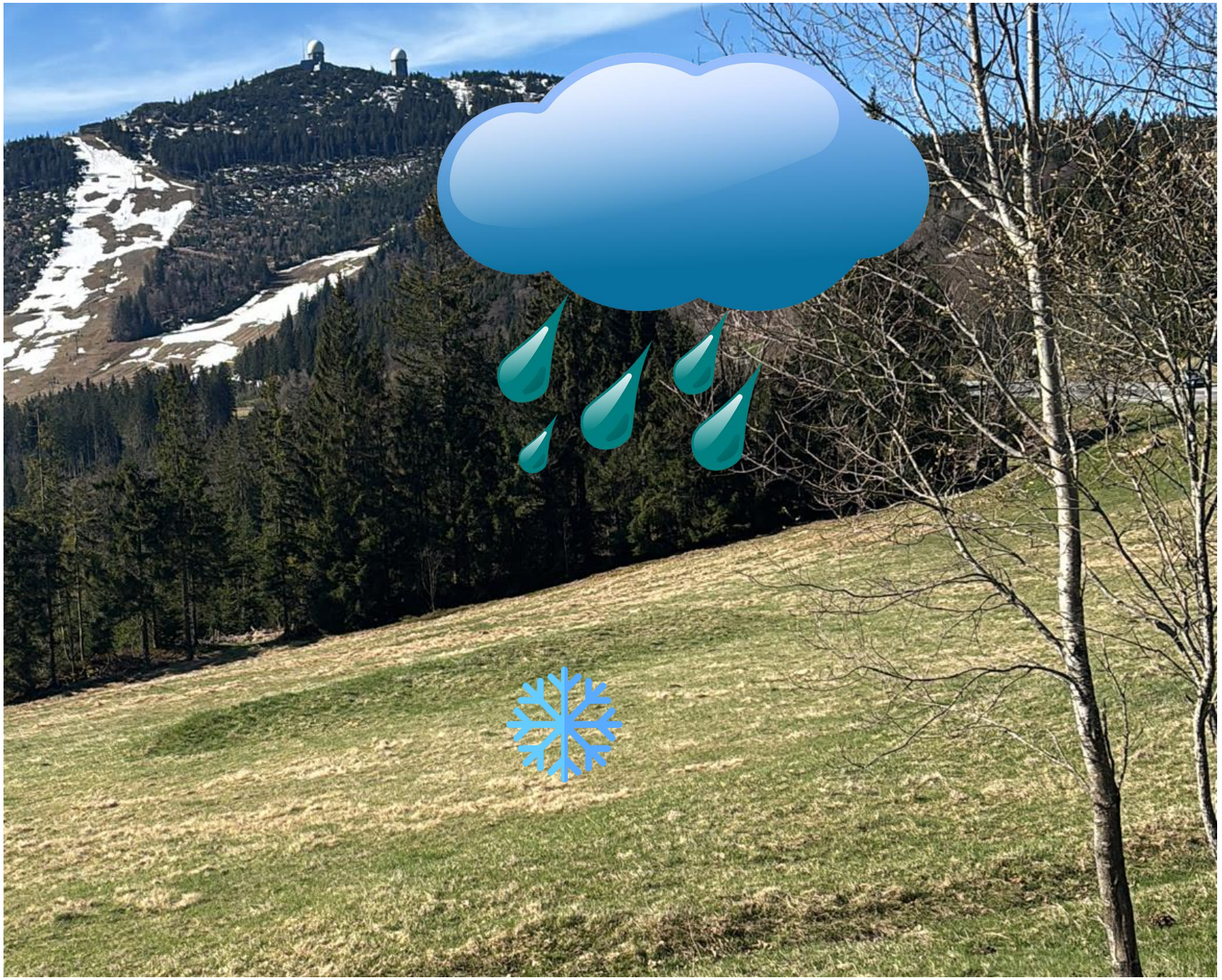
Nighttime – Frost conditions occur



Scenario:
Winter/Spring day

Nighttime – Frost conditions occur

Rain meets frozen soil – What happens?

Sharing is encouraged

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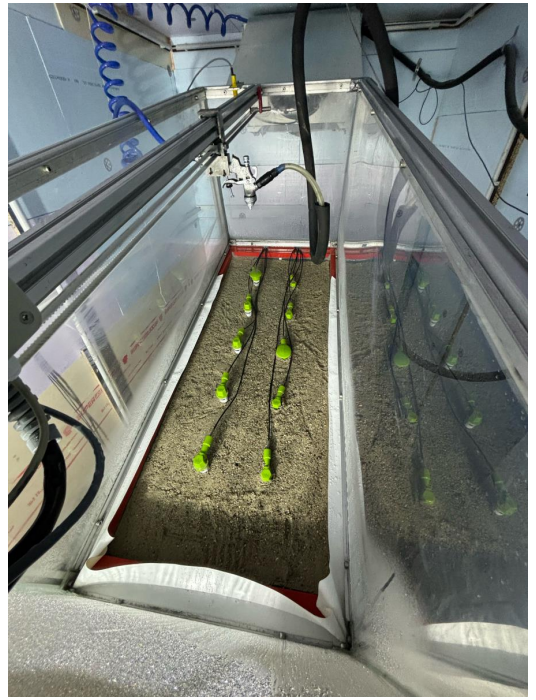
Funded by DFG Deutsche Forschungsgemeinschaft German Research Foundation



Macropore-Driven Infiltration in Frozen Slopes

Large-Scale Experimental Insights with Hydrological and Geotechnical Implications

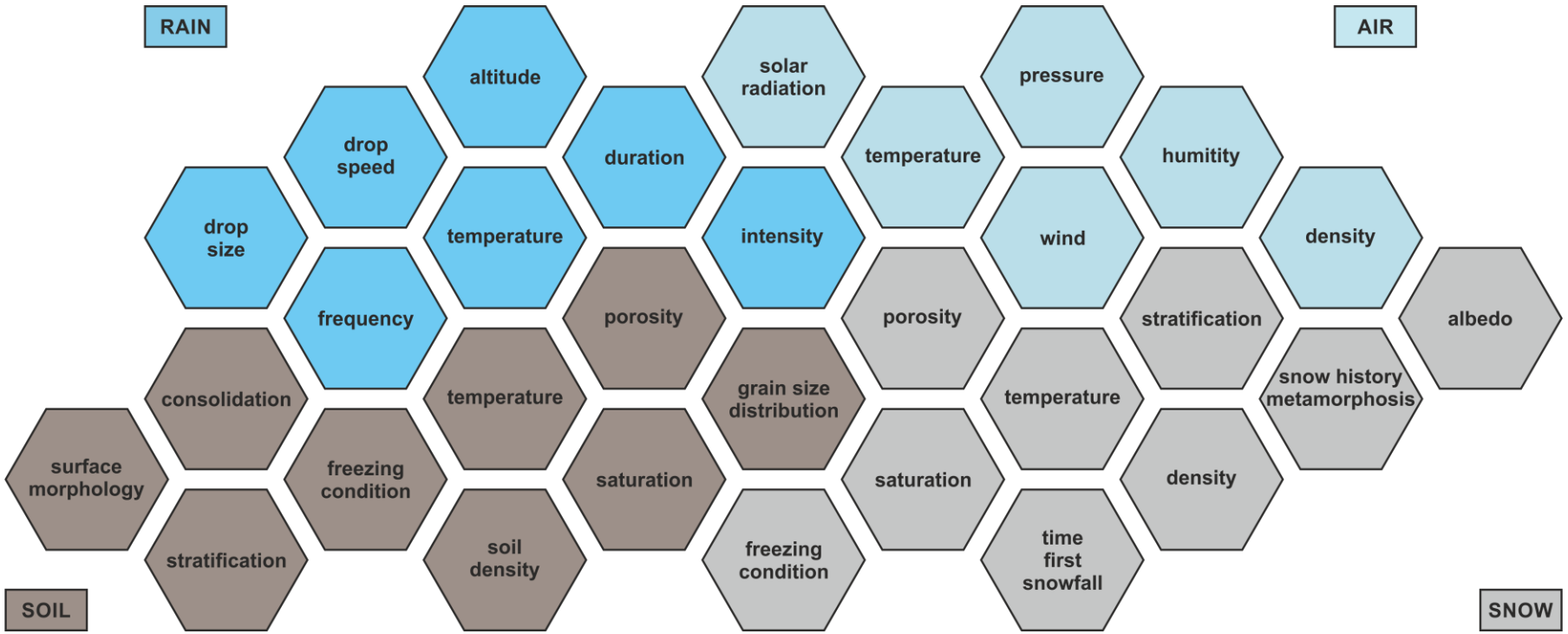
Julian Bauer[1], Sebastian Müller[1] and Ivo Baselt[1]

Presented by Julian Bauer

Vienna, 01. May 2025

[1] Chair of Hydromechanics and Hydraulic Engineering, University of Bundeswehr Munich, Neubiberg, Germany

Relevant parameters for infiltration in frozen soils



Baselt and Heinze 2021, Rain, Snow and Frozen Soil: Open Questions from a Porescale Perspective with Implications for Geohazards

Focus on:

- Soil temperature and freezing condition
- Soil initial water content
- Soil structure (porosity, microstructure and macropores)
- Rain intensity and temperature

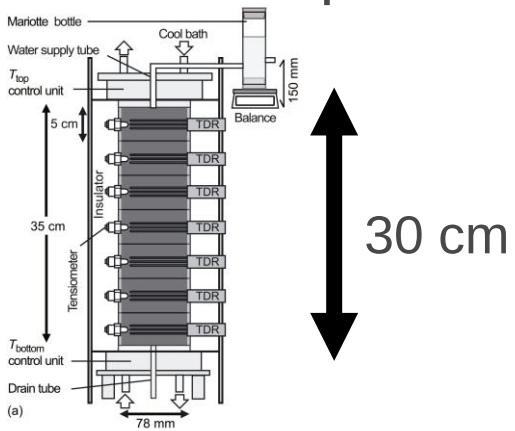
Macropores and why they matter

- Macropores form due to roots, cracks, wormholes
- Every pore larger than 0.08 mm
- Small volume fraction, large impact on infiltration.
- Critical for infiltration into frozen soils (*Watanabe and Kugisaki 2017, Mohammed et al. 2018, Pittman et al. 2020*).

Where do we stand?

Small scale:

1d column experiments



Watanabe and Kugisaki 2017

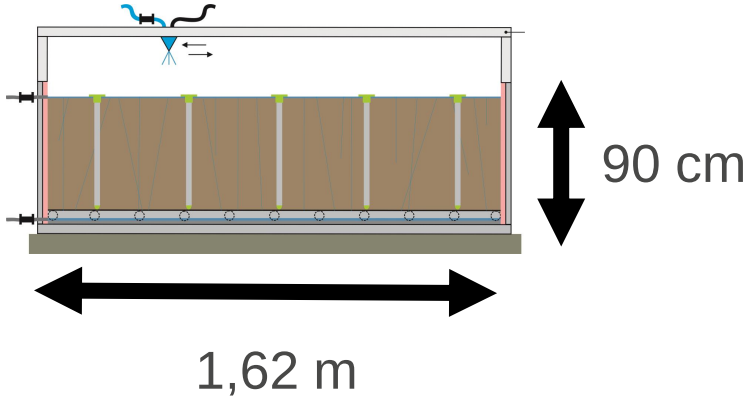
- Highly controlled

  but

- Limited scalability

Intermediate scale:

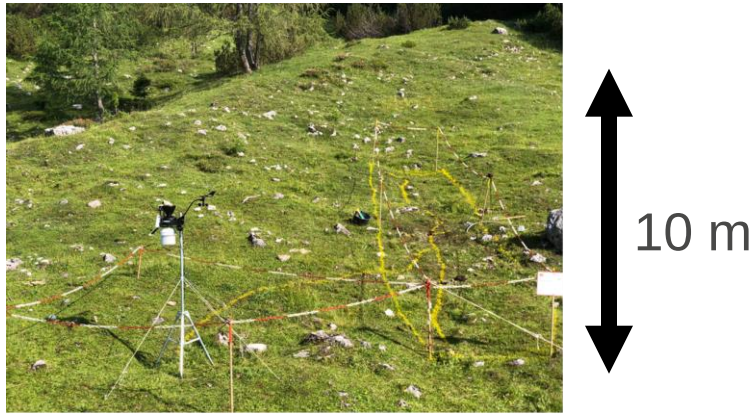
2d soil box experiments



- Controlled conditions
- Captures natural features
- Improved scalability

Large Scale:

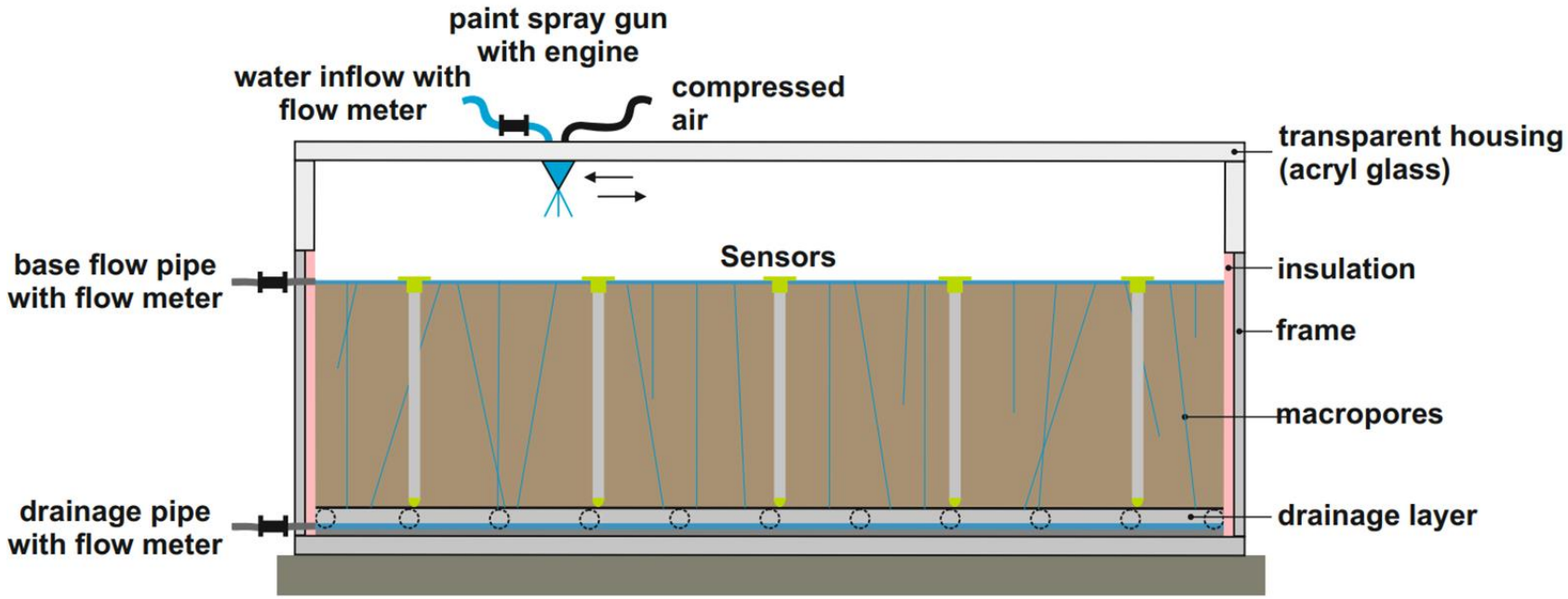
Field observations



- Realisitc data

  but

- Limited process isolation



- Length: 161,5 cm
- Depth: 90 cm
- Width: 60 cm

- Surface Area: 0.97 m^2
- Volume: 0.87 m^3

- Slope adjustable (up to 20°)
- Controlled rain temperature (3-10°C)
- Adjustable rainfall intensity (2-20 l/h)
- Homogeneous irrigation distribution
- Defined sensor positions (soil moisture, temperature)

1. Soil mixing with predefined water content

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2. Filling soil box, defined compaction every 10 cm

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3. **(Optional):** Adding macropore network

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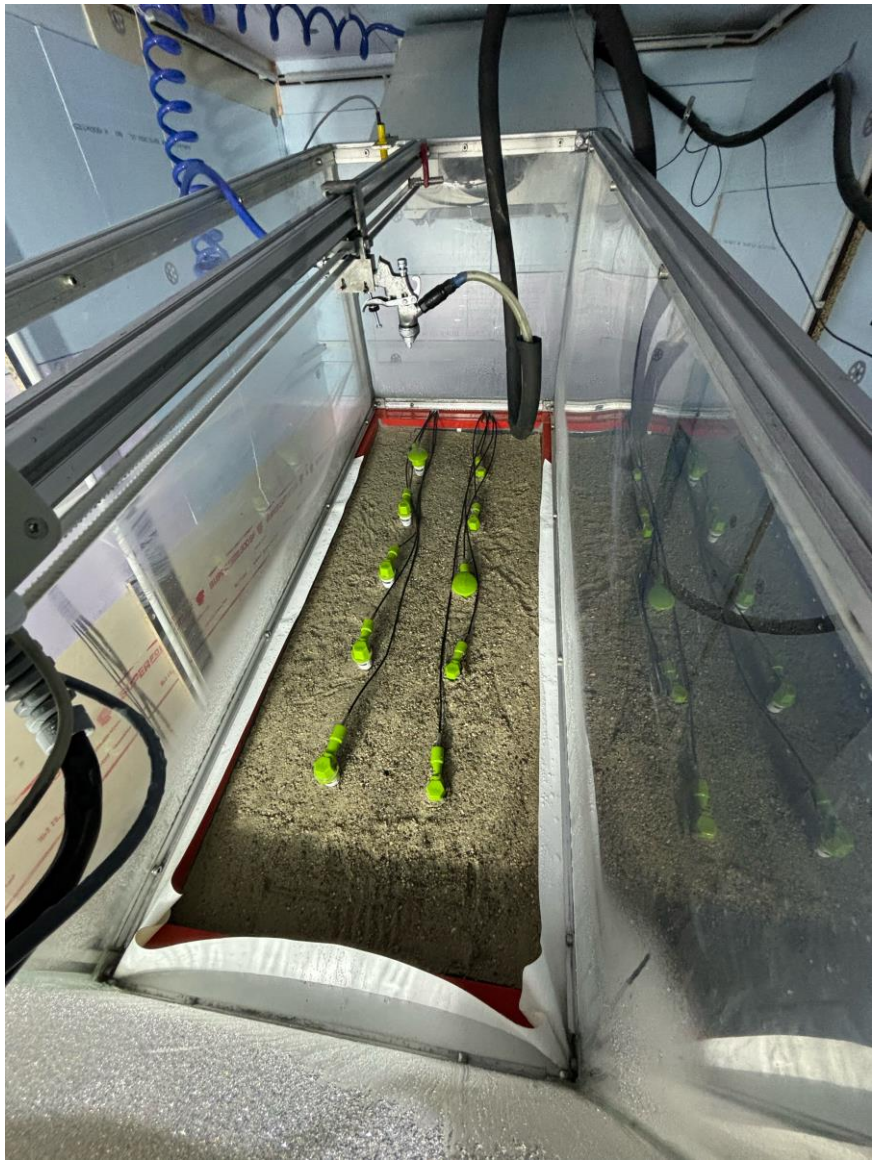
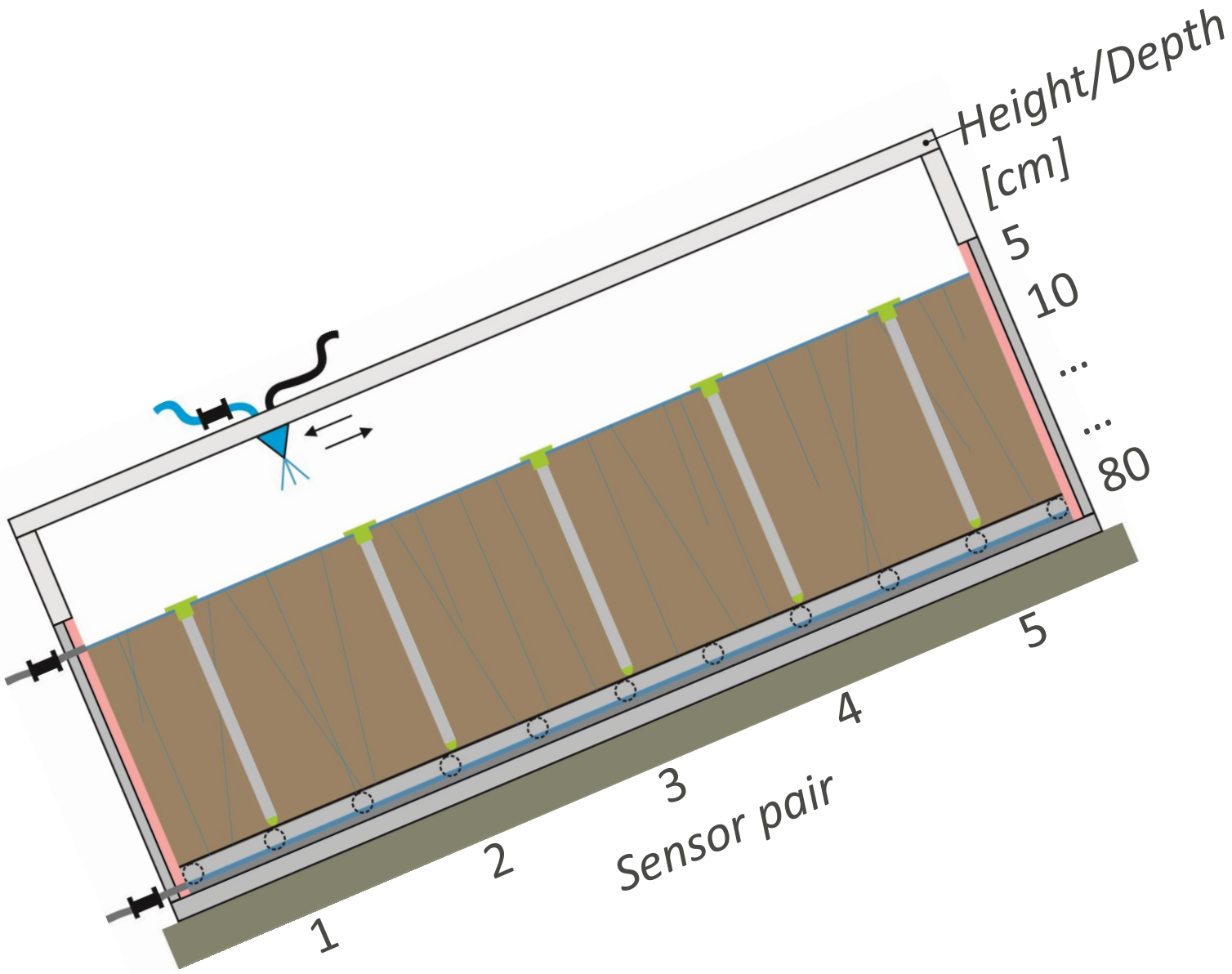
4. Freezing phase (up to 72h)

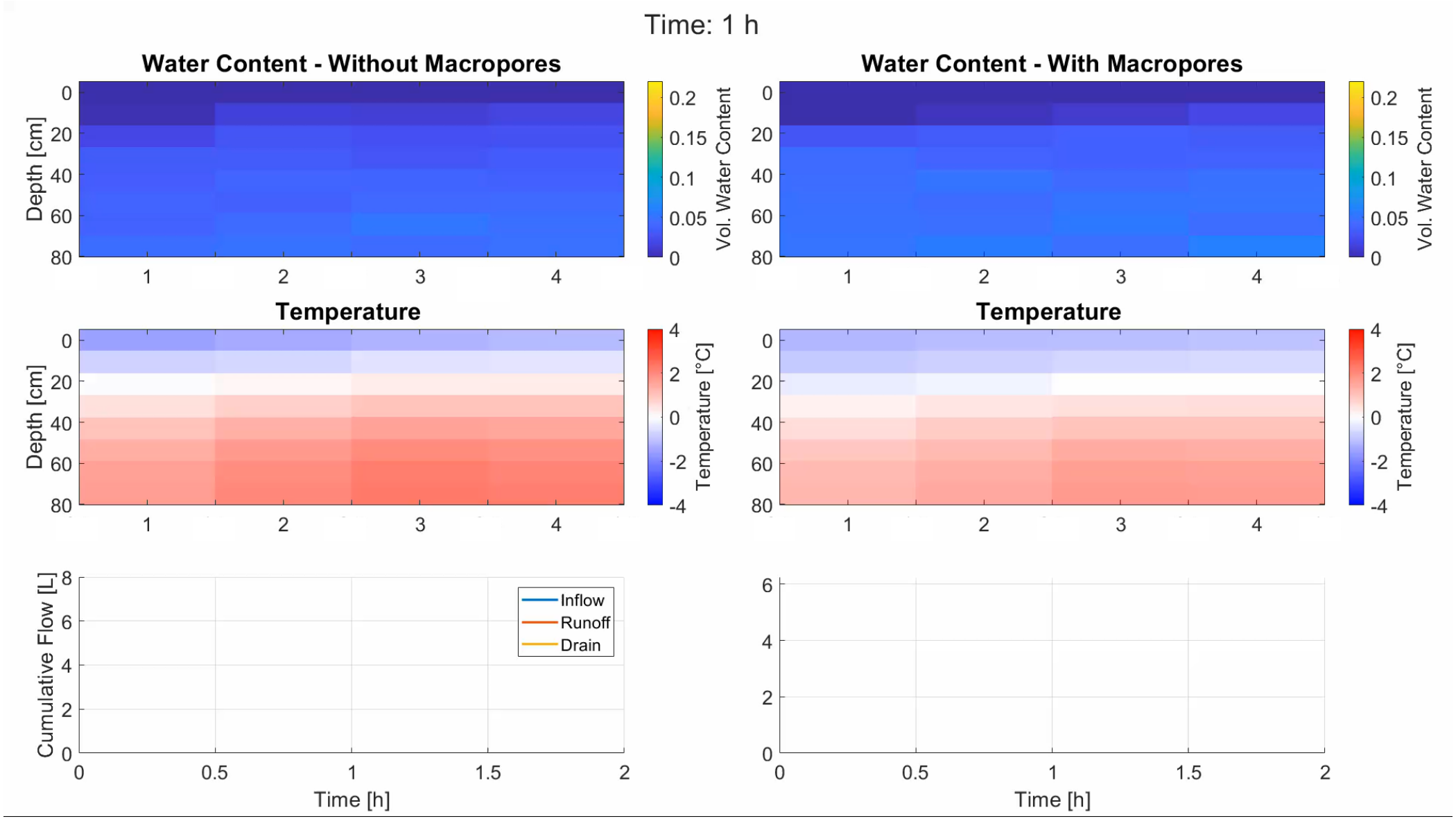
1. Soil mixing with predefined water content
2. Filling soil box, defined compaction every 10 cm
3. **(Optional):** Adding macropore network
4. Freezing phase (up to 72h)
5. Irrigation experiment (up to 50h)





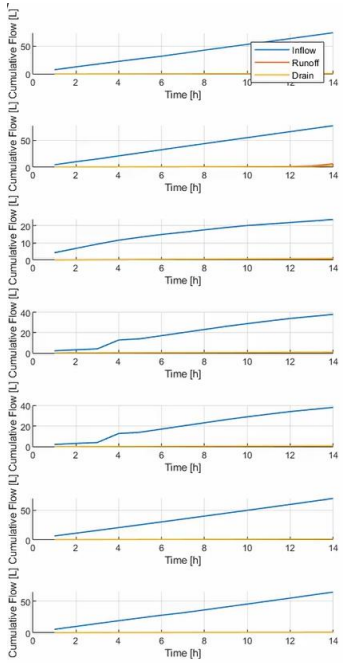
Experiment comparison: with vs. without macropores:

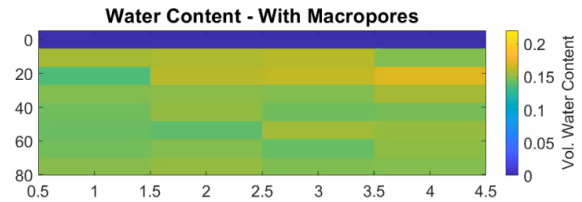
- 10° inclination
- 5 l/h irrigation
- 4 °C rain temperature
- 5 % volumetric water content (before freezing and irrigation)

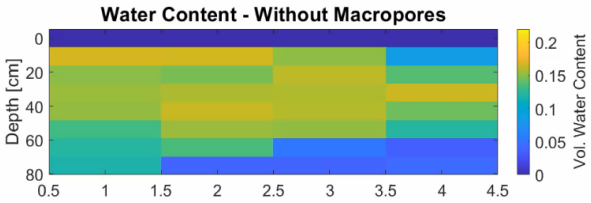

Time: 1 h
Water Content - Without Macropores
Water Content - With Macropores
Depth [cm]
Vol. Water Content
Temperature
Temperature [°C]
Cumulative Flow [L]
Time [h]
Inflow
Runoff
Drain

Key findings from 14 (first) experiments:

- Results are highly sensitive to small parameter changes (particularly rainfall intensity and amount)
- **Macropores** significantly enhance infiltration rates and the thawing process





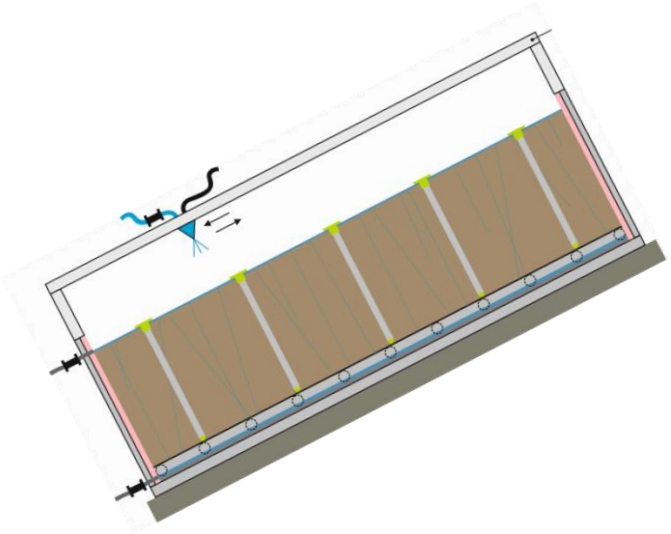


Limitations and uncertainties:

- The experimental setup is still undergoing optimization
  → Remaining uncertainties due to parameter variations

Next:

- Finish the optimization process and conduct **additional experiments** to further clarify the role of macropores



Future steps:

- Geotechnical analysis: assess **slope stability** risks based on measured soil parameters
- Investigate infiltration driven by **snowmelt** and associated consequences

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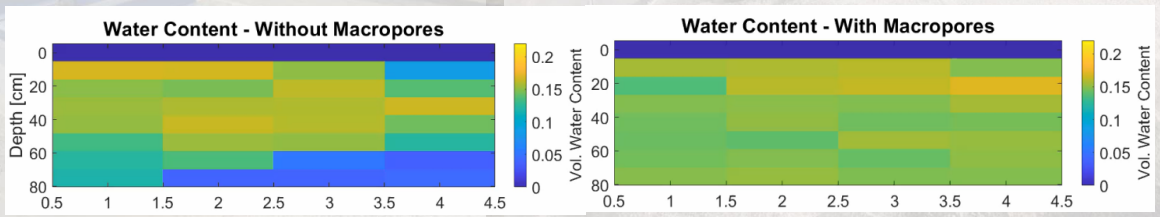
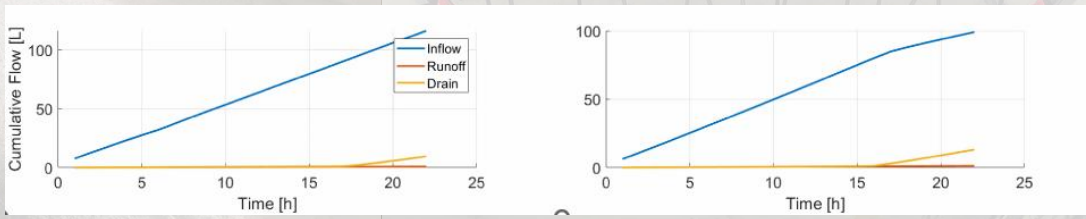
SCAN ME





GEPRIS
Geförderte Projekte der DFG

Thermohydraulische Prozesse während der Wasserinfiltration in gefrorenen Boden mit Auswirkungen auf Geogefahren unter dem Einfluss des Klimawandels

Antragsteller	Dr.-Ing. Ivo Baselt; Dr. Thomas Heinze
Fachliche Zuordnung	Hydrogeologie, Hydrologie, Limnologie, Siedlungswasserwirtschaft, Wasserchemie, Integrierte Wasserressourcen-Bewirtschaftung
Förderung	Förderung seit 2023
Projektkennung	*Deutsche Forschungsgemeinschaft (DFG) - Projektnummer 518478532*

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