

# Modelling the thermal regime of perched talus slopes

*The Gislá landslide (06/10/2020, Iceland)*

Contributors:

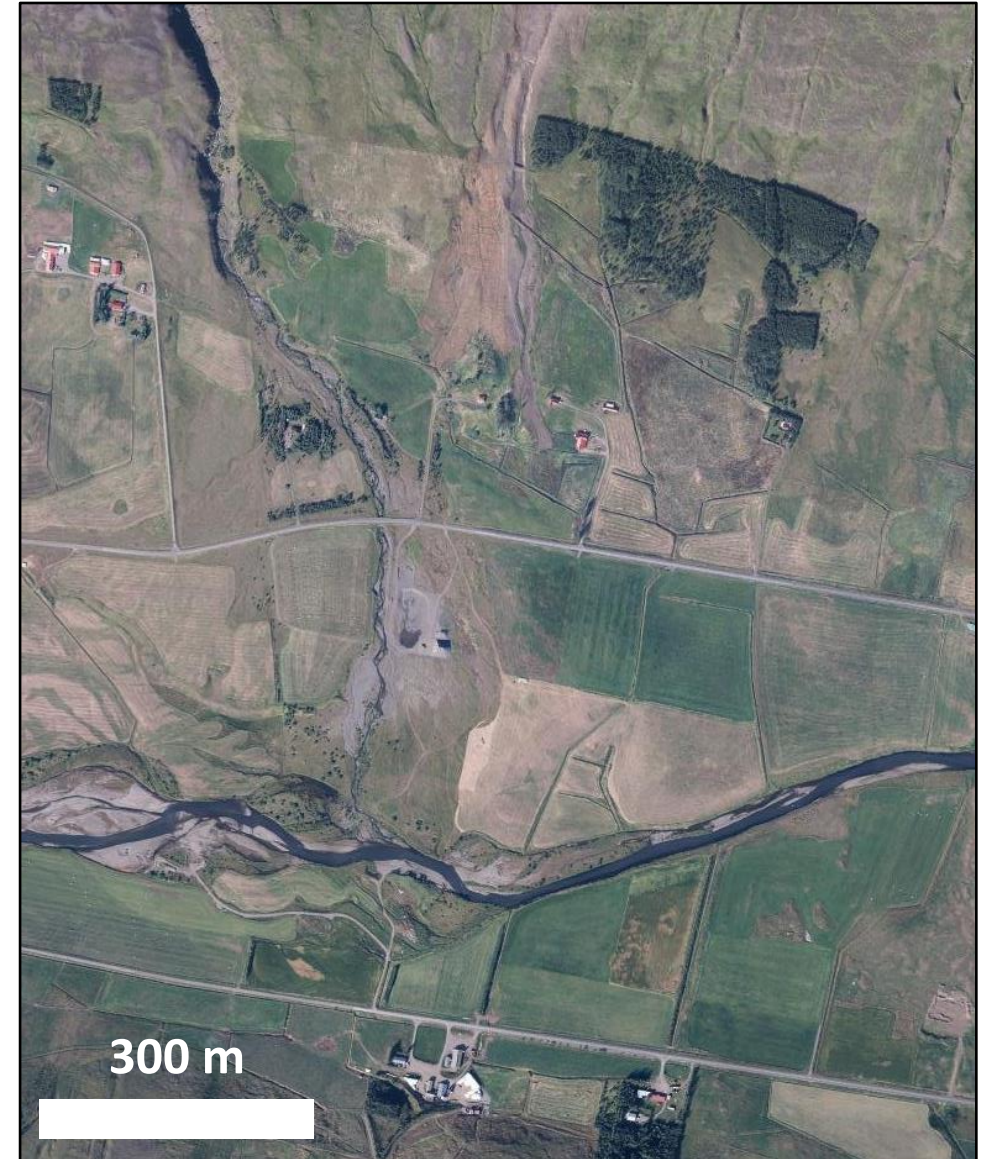
**Meven Philippe**, Florence Magnin, Jean-Yves Josnin,  
Costanza Morino, Nicolas Monzie, Skafti Brynjólfsson



# Permafrost landslide hazard

Permafrost degradation can generate **landslides...**

...which represent an **increasing hazard in mountain environments**



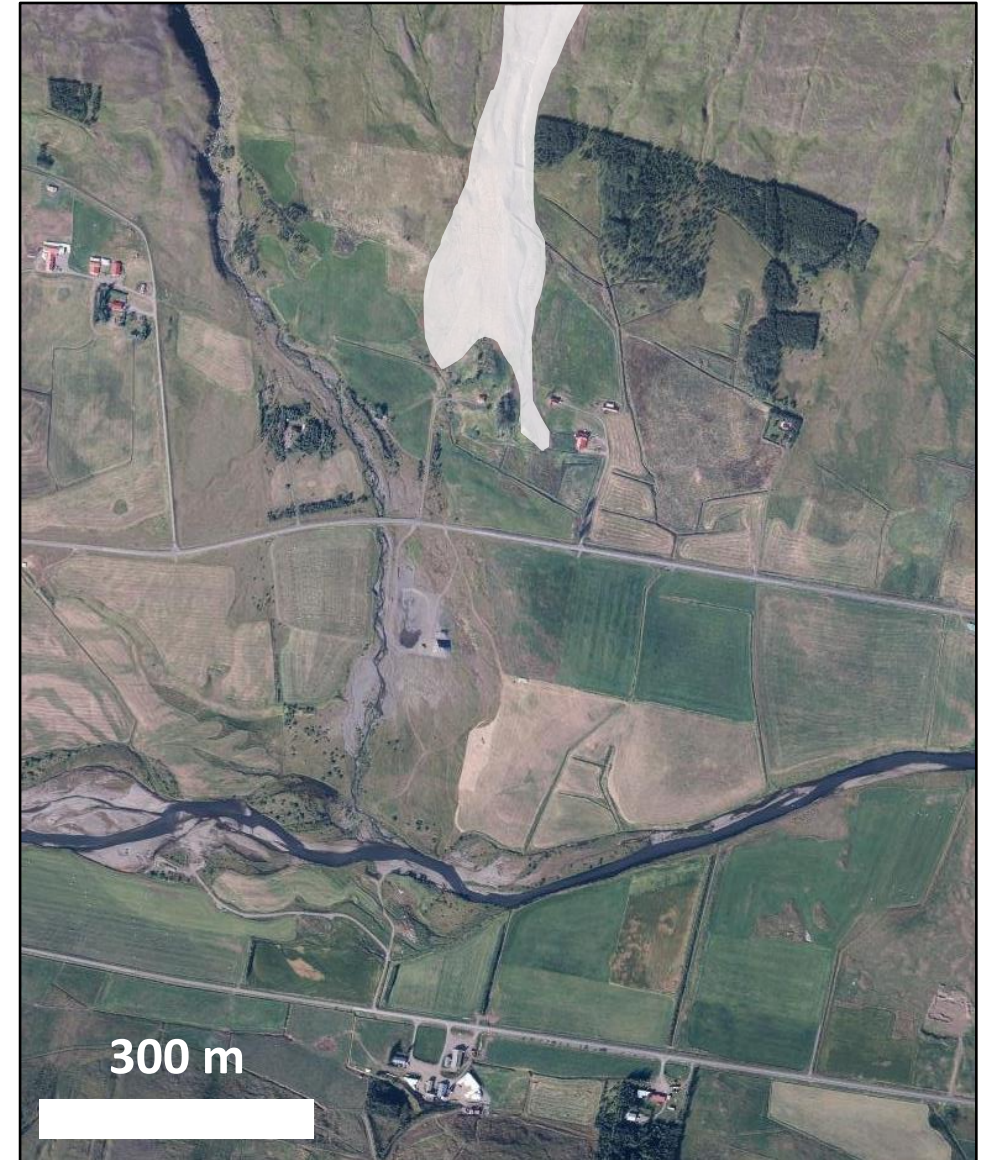
*the Gislá landslide (map.is)*



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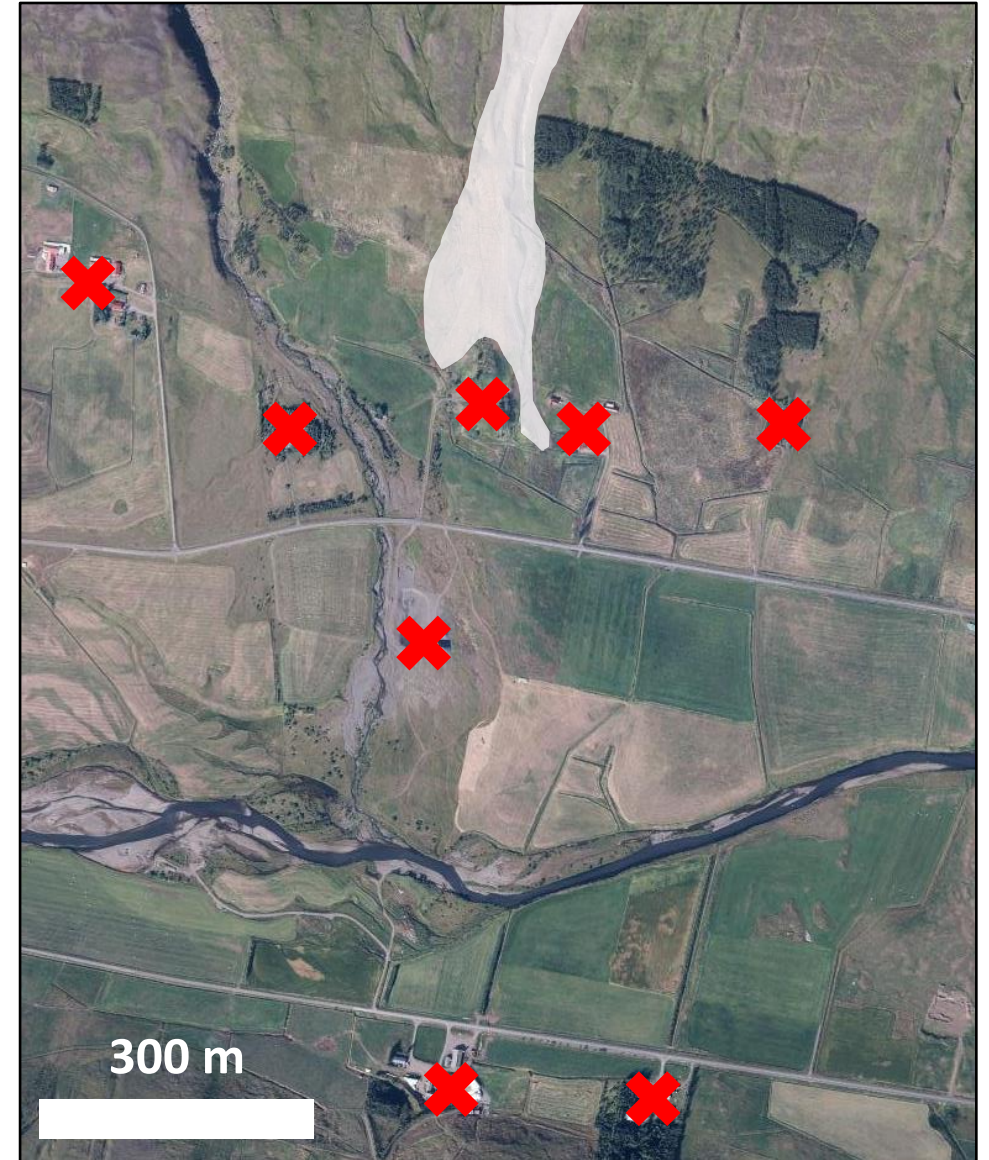


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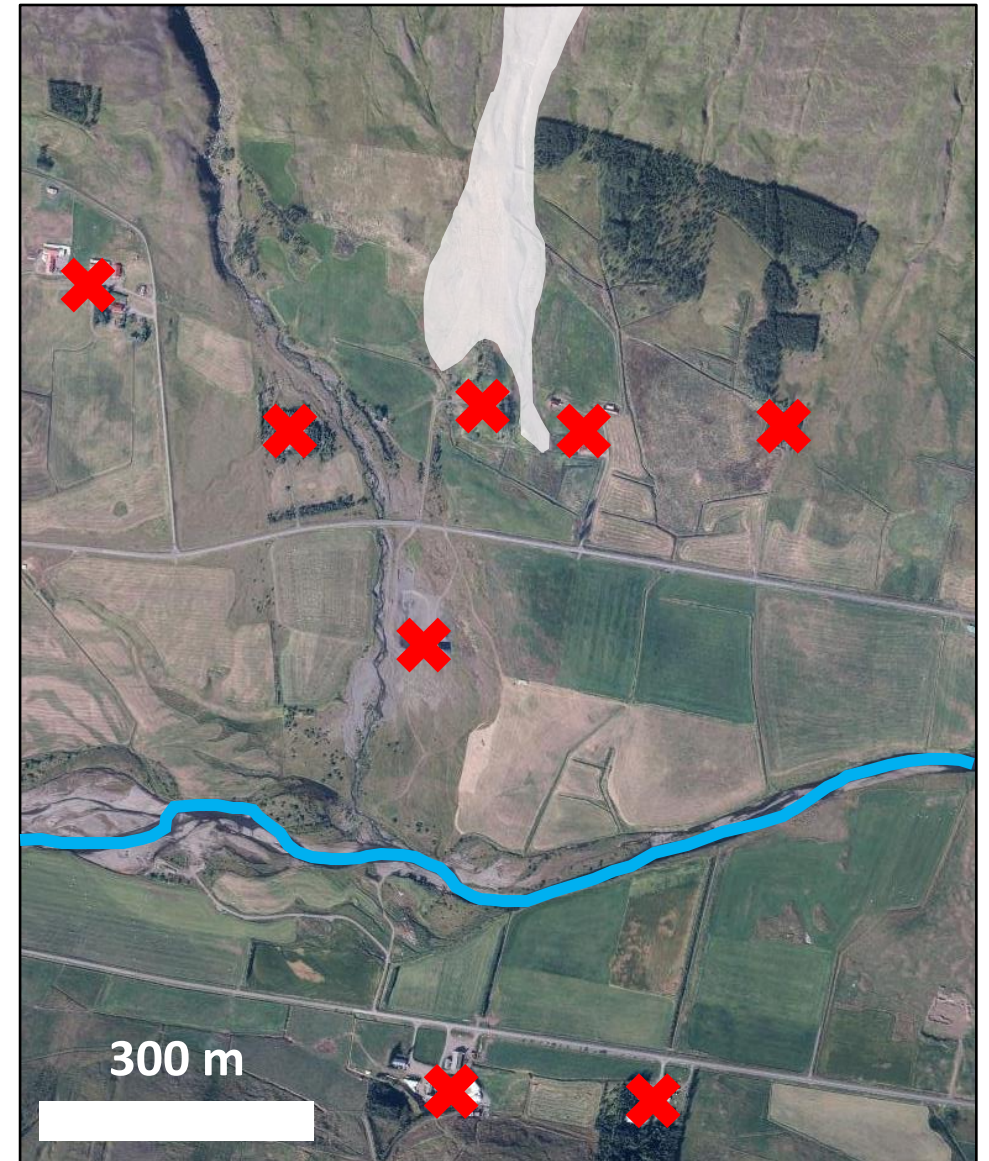
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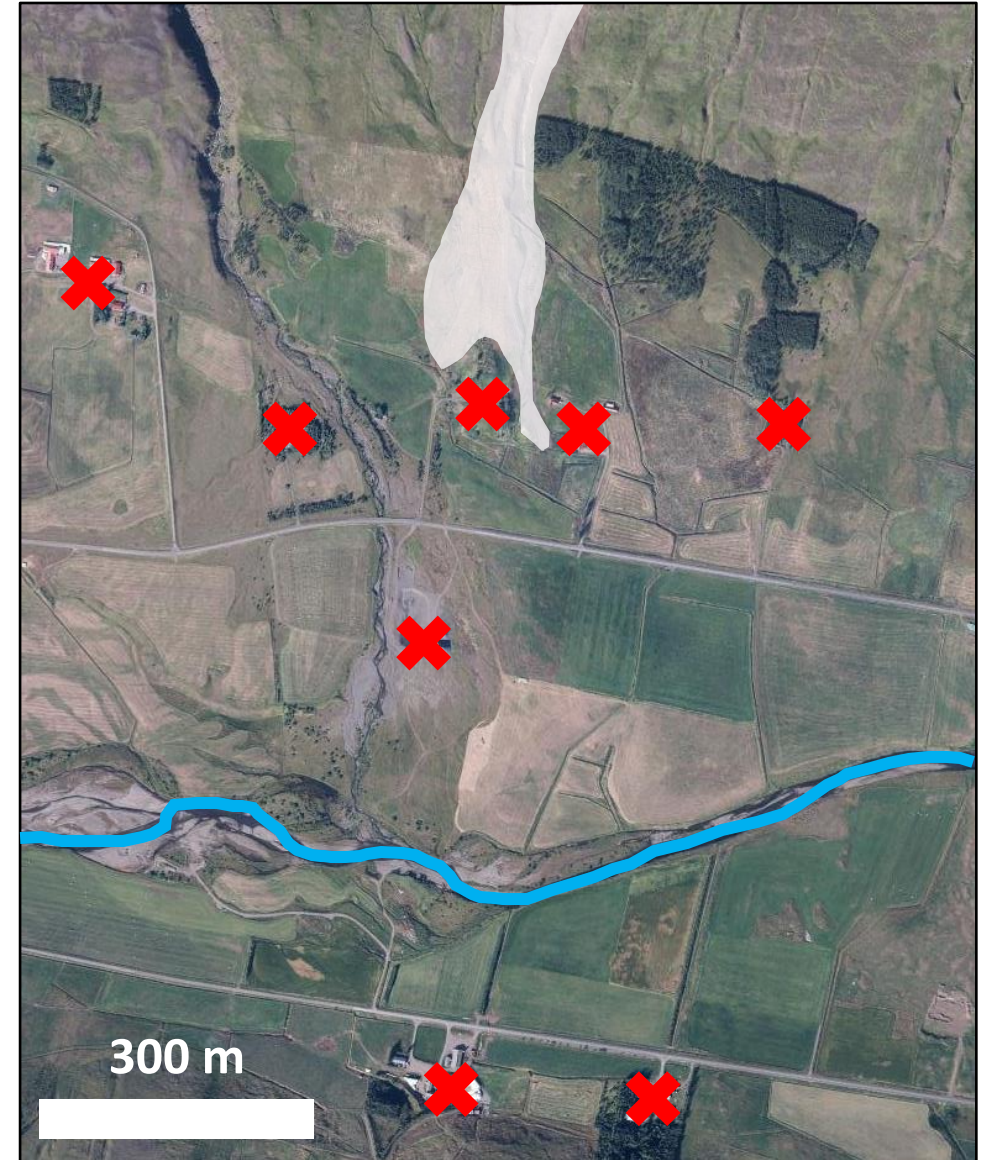
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# Permafrost landslide hazard

Permafrost degradation can generate **landslides...**

...which represent an **increasing hazard in mountain environments**

→ **predicting permafrost boundaries is crucial for prevention/protection purposes**



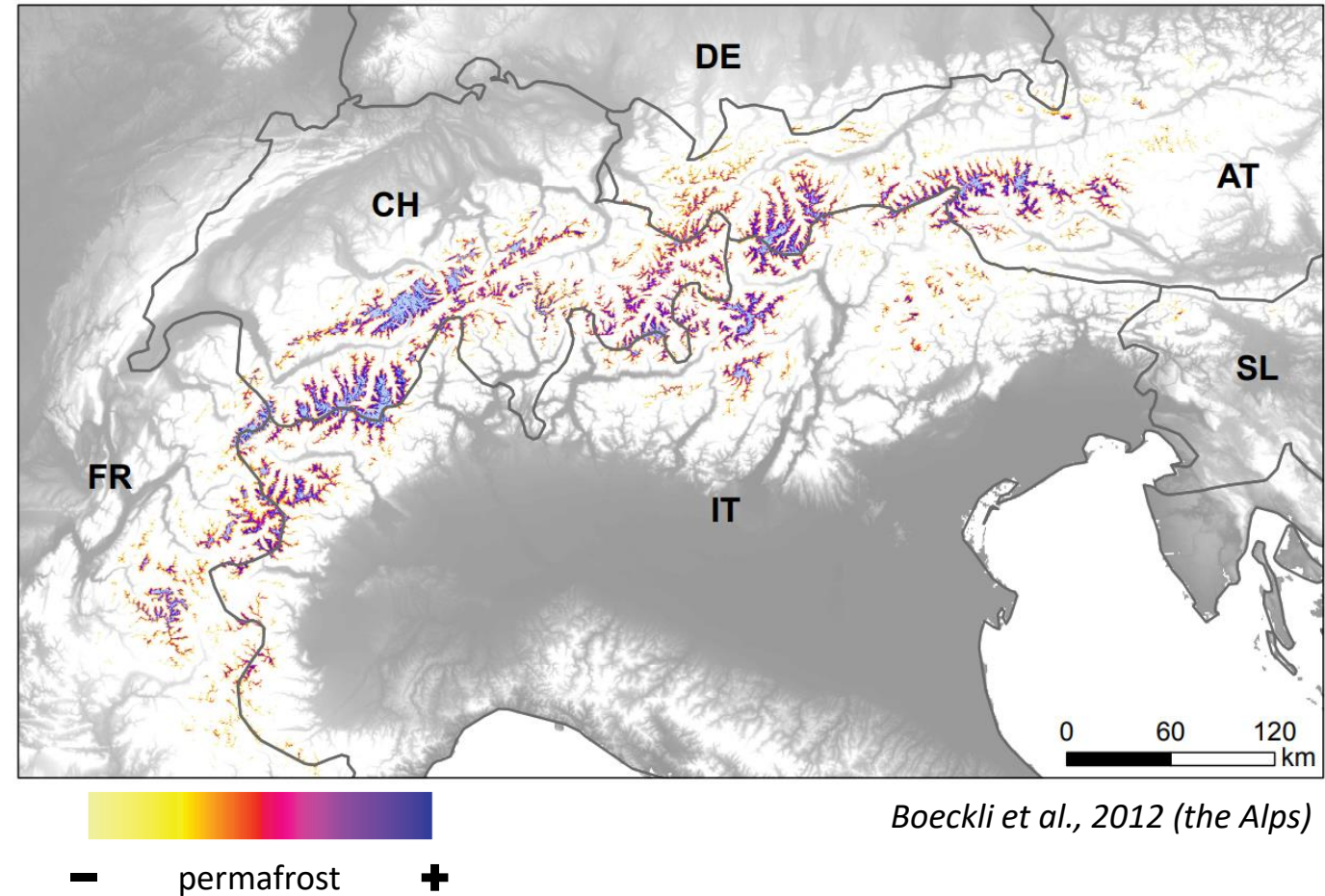
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# Permafrost models

To predict permafrost occurrence:

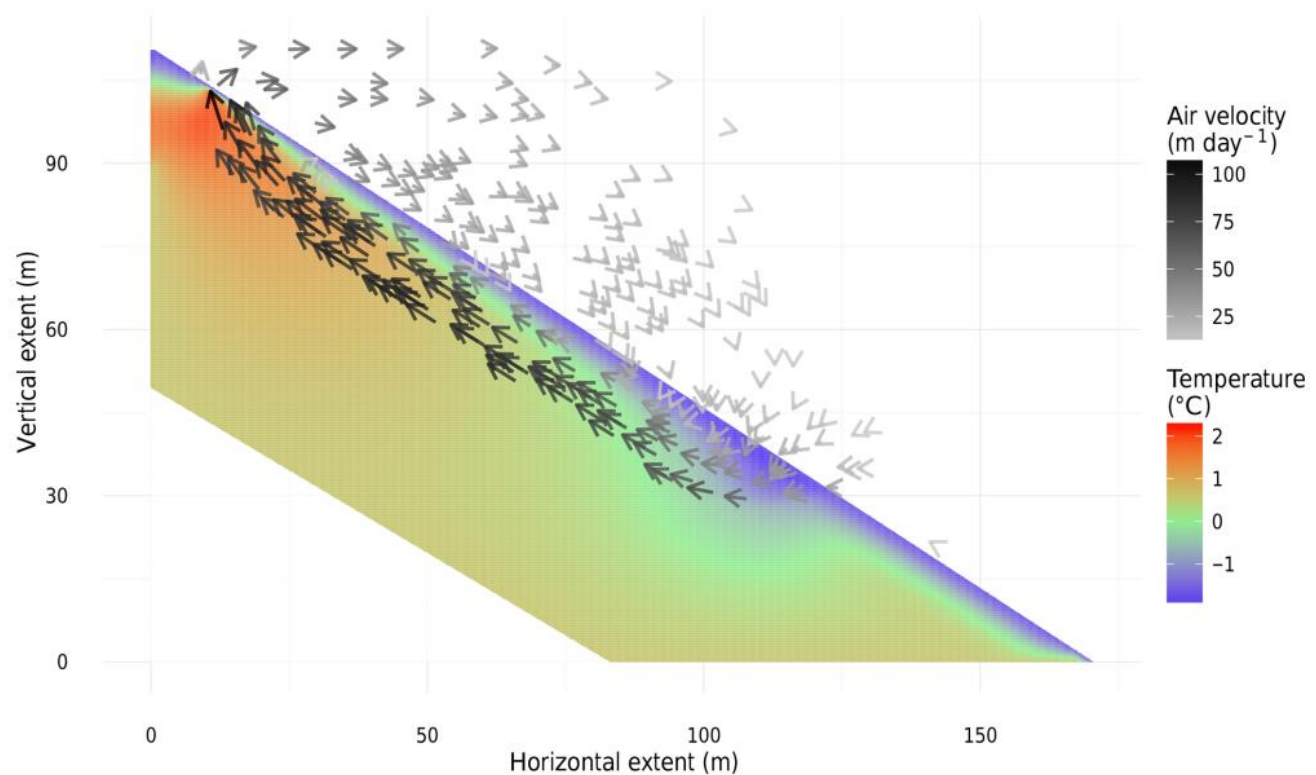
- **statistical models**
  - from **topoclimatic data**
  - **large scale modelling**



# Permafrost models

To predict permafrost occurrence:

- **statistical models**
  - from **topoclimatic data**
  - **large scale modelling**
- **physic-based models**
  - compute **physical processes**
  - at **site scale**
  - can predict **azonal permafrost**

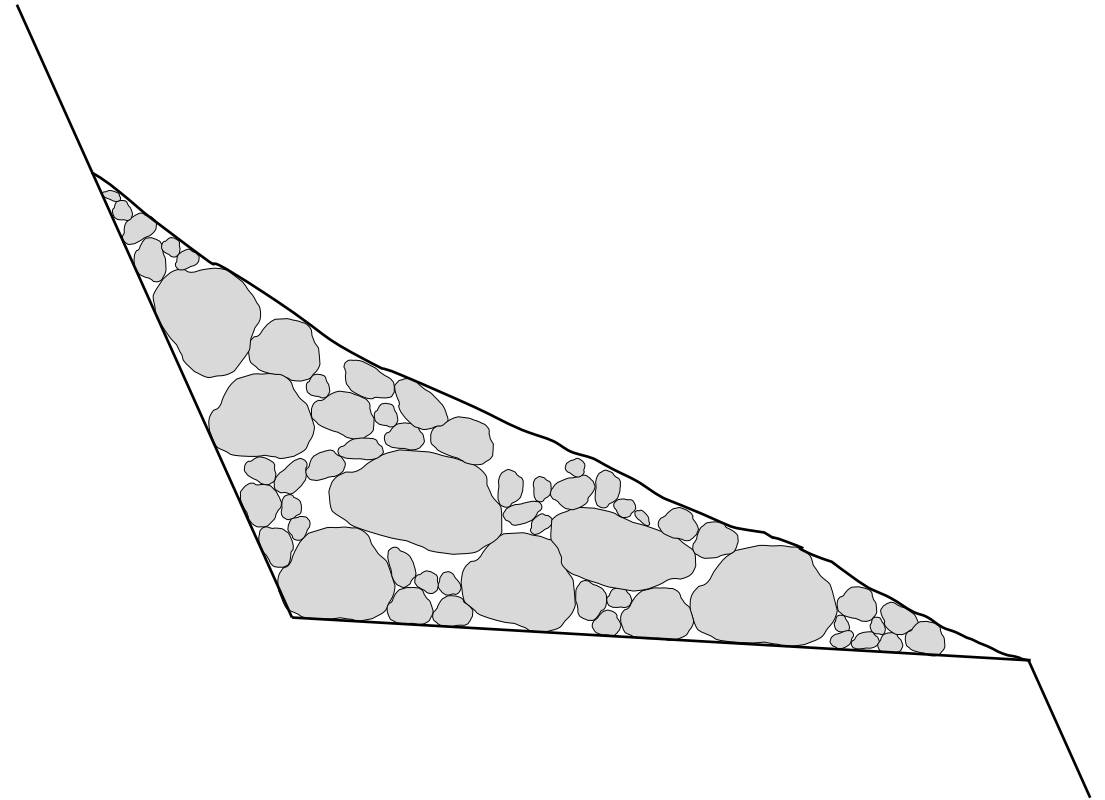


*Wicky et al., 2024 (in a talus slope)*



# The 'chimney effect'

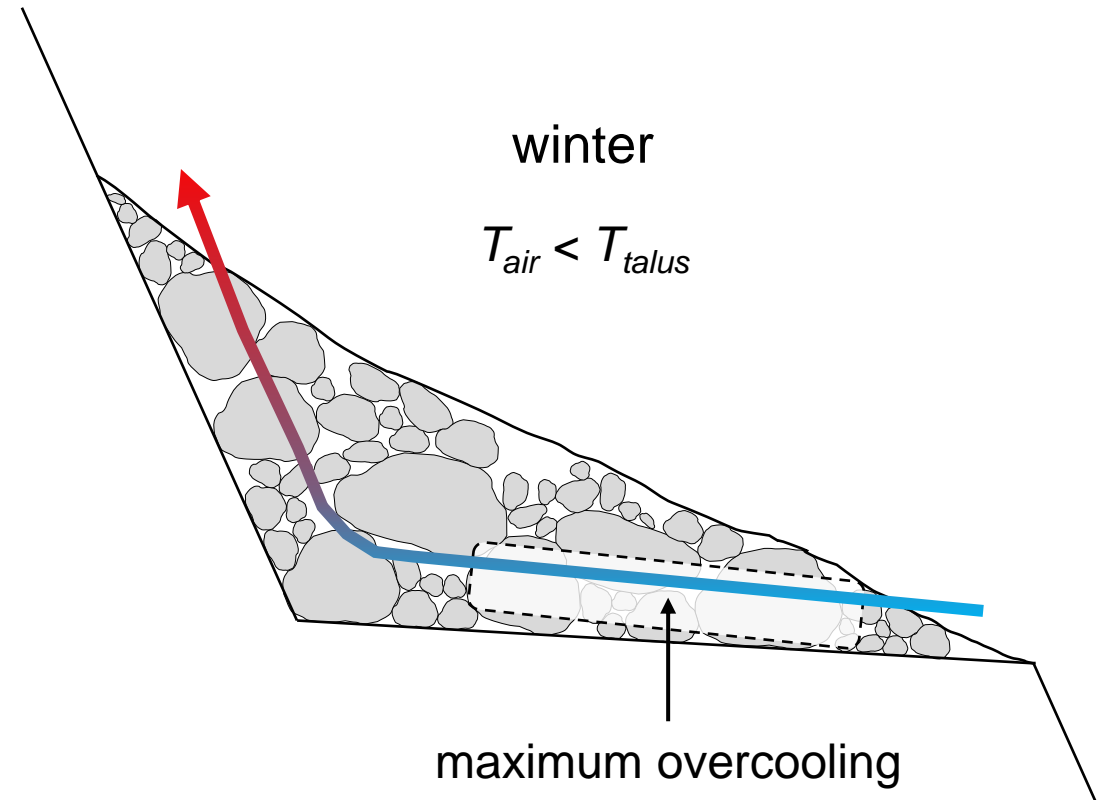
In talus slope, particular air convection can take place - the '**chimney effect**'



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In talus slope, particular air convection can take place - the '**chimney effect**'

→ **winter:** suction of cold air at the base of the talus

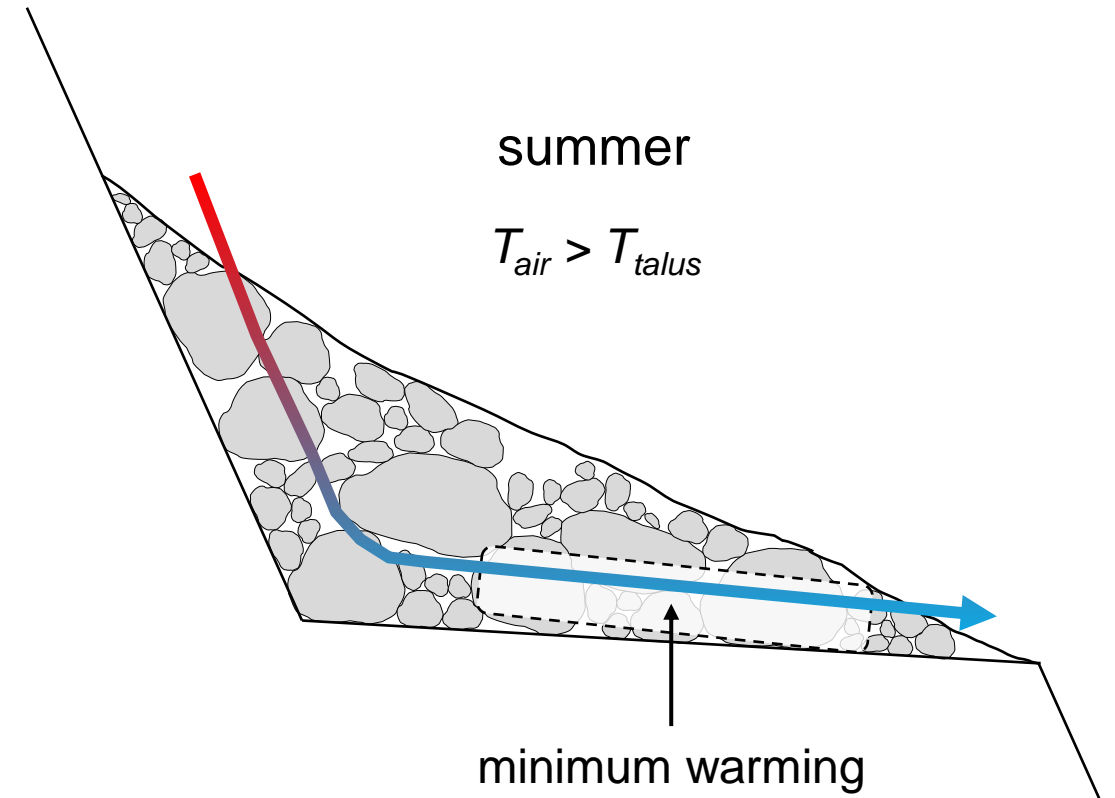




# The 'chimney effect'

In talus slope, particular air convection can take place - the '**chimney effect**'

- **winter:** suction of cold air at the base of the talus
- **summer:** gravitational flow of cold air to the base of the talus

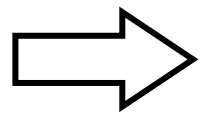


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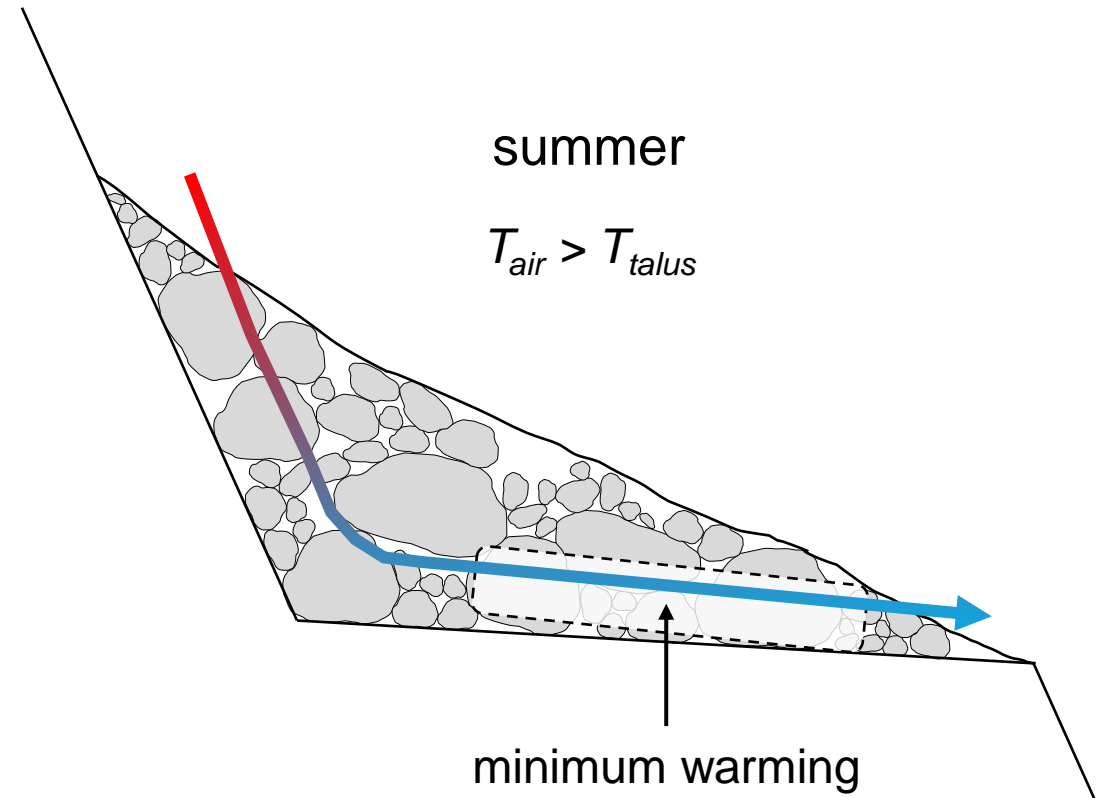
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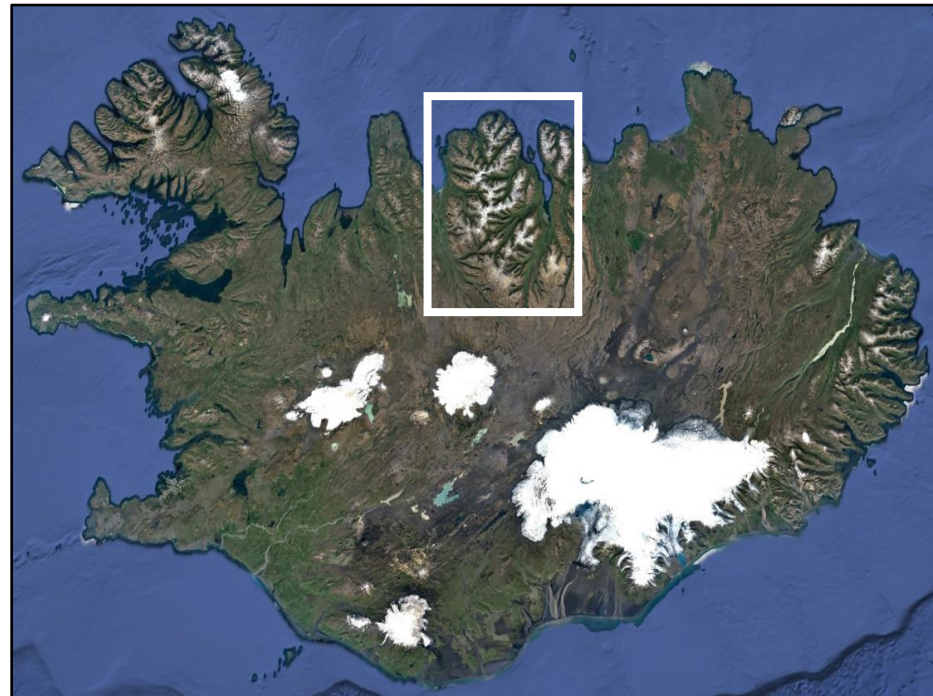


**Thermal dynamics of talus slopes are poorly understood**



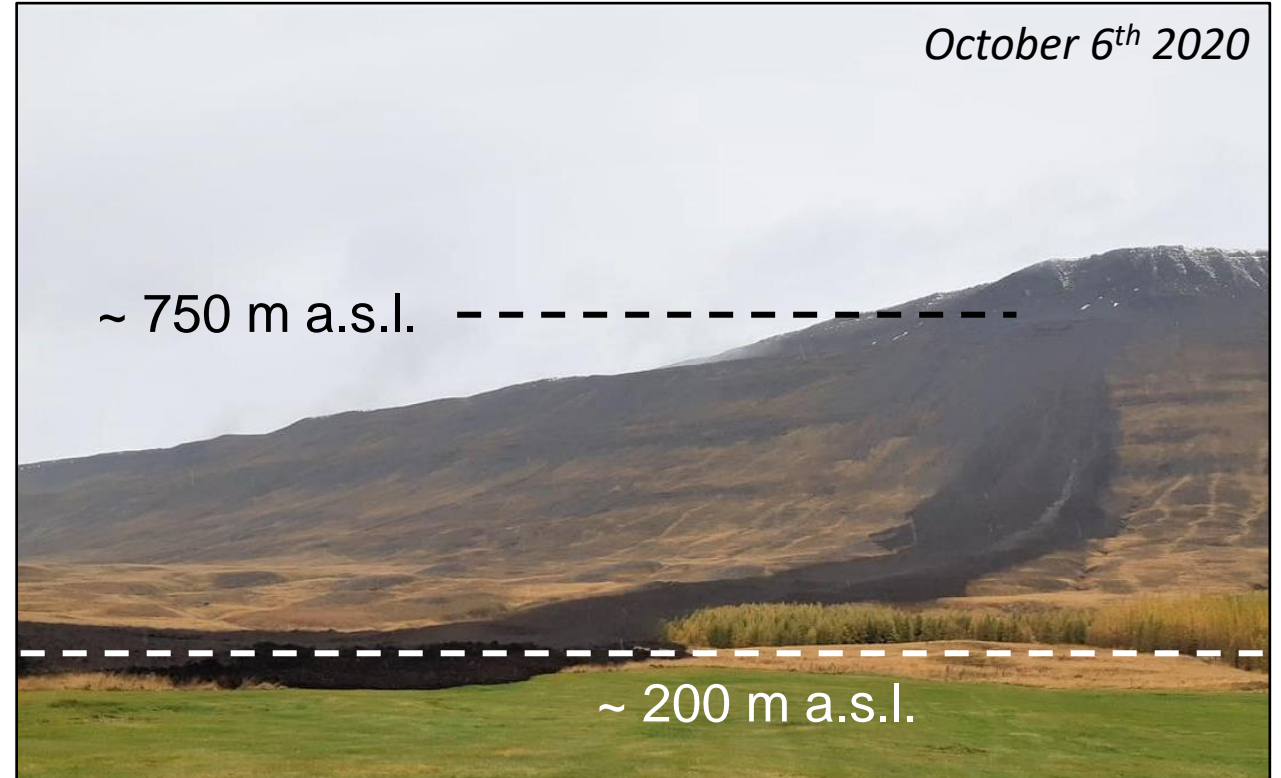


## The Gislá landslide (October 6<sup>th</sup> 2020):



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- source: **perched talus slope**







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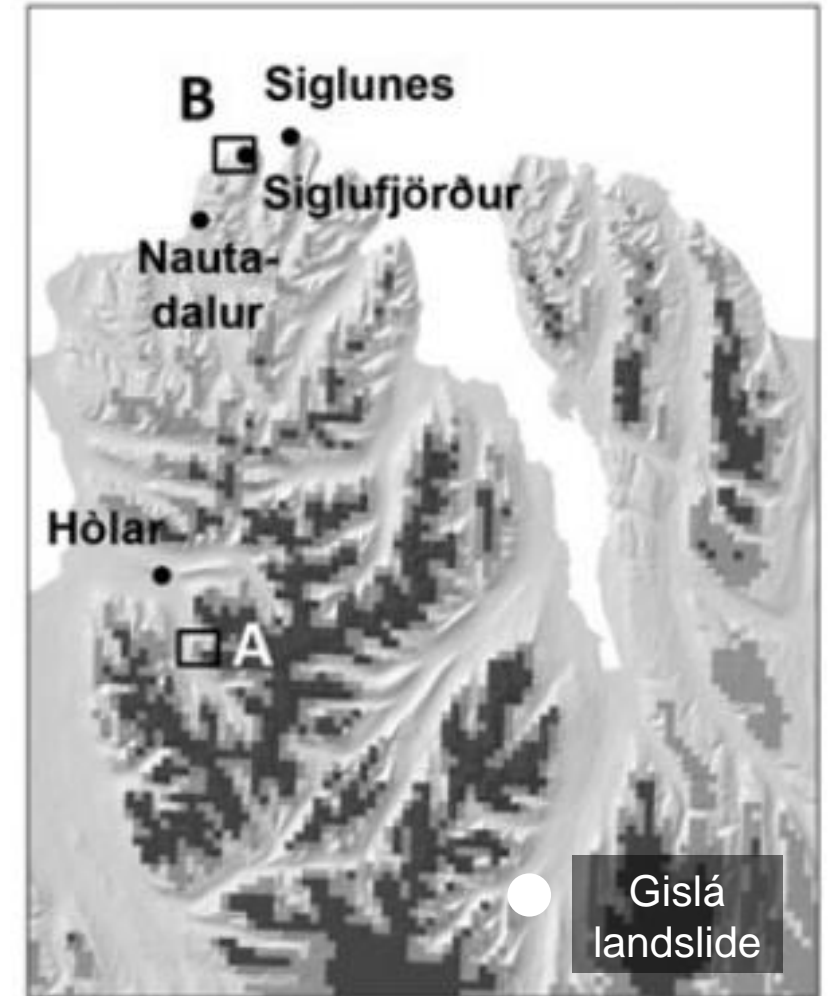
- source: **perched talus slope**
- **ice-cemented material** in the deposits (molards)...



## The Gislá landslide (October 6<sup>th</sup> 2020):

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- **ice-cemented material** in the deposits (molards)...
- ... but located **outside of permafrost climatic boundaries**

continuous permafrost   
discontinuous permafrost 

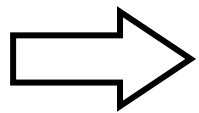


*Lilleøren et al. (2013)*

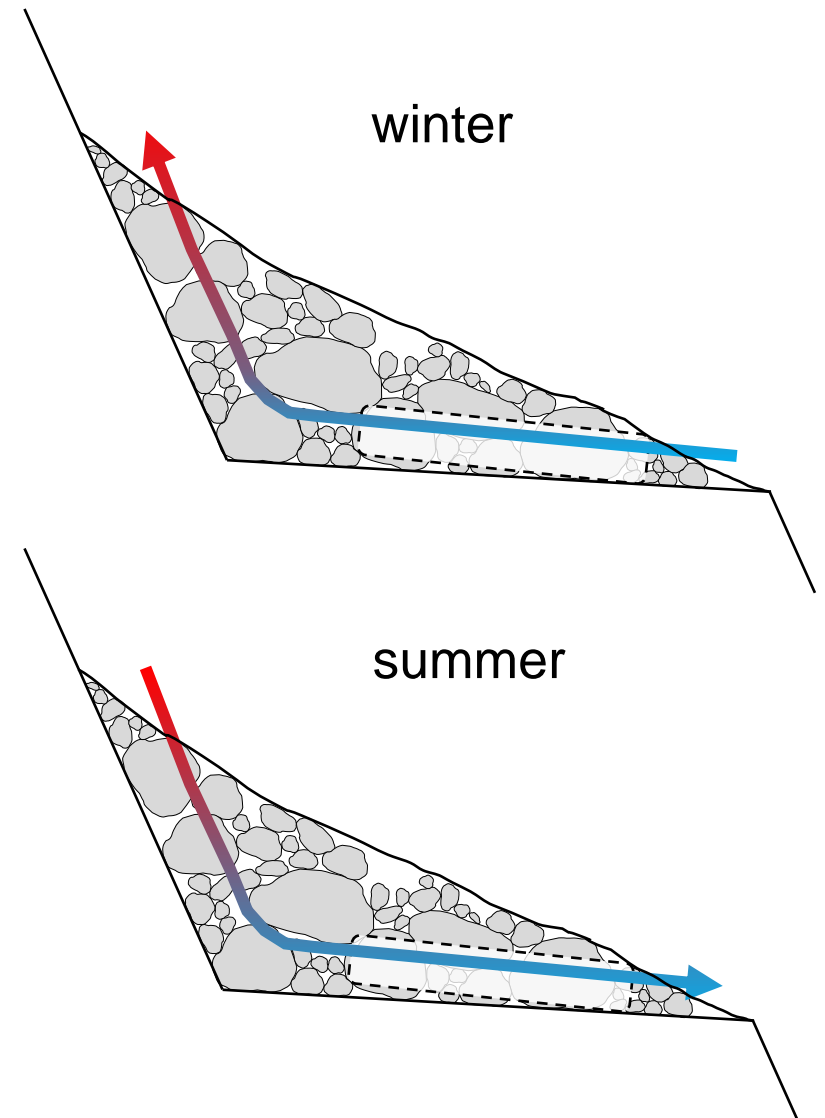


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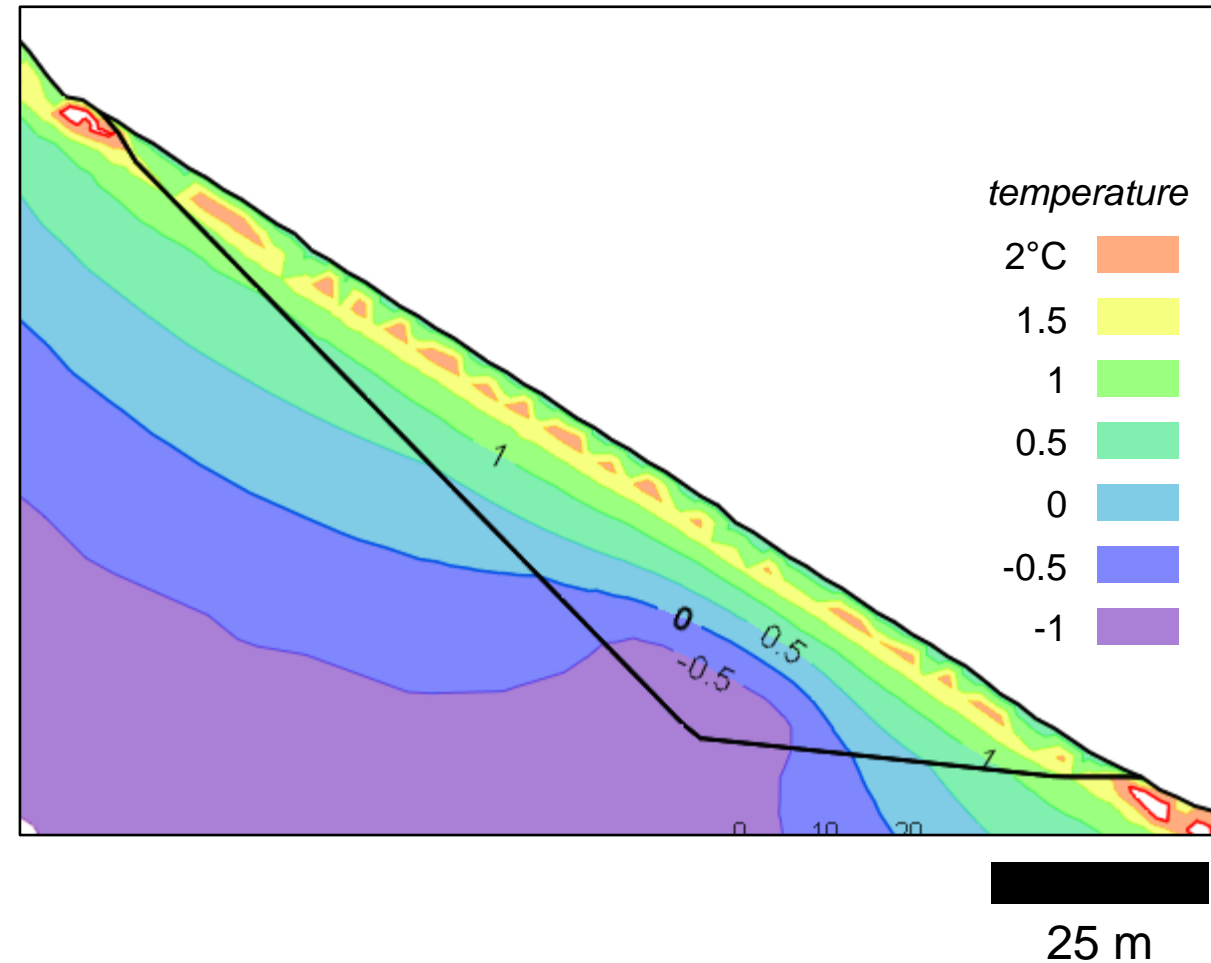


**persistence of permafrost due to the chimney effect ?**



- 1. Can permafrost persist in the Gislá talus slope until the date of the landslide?**
- 2. What was its thermal state at the date of the landslide?**
- 3. What thermal properties of the Gislá talus slope are required to maintain permafrost?**

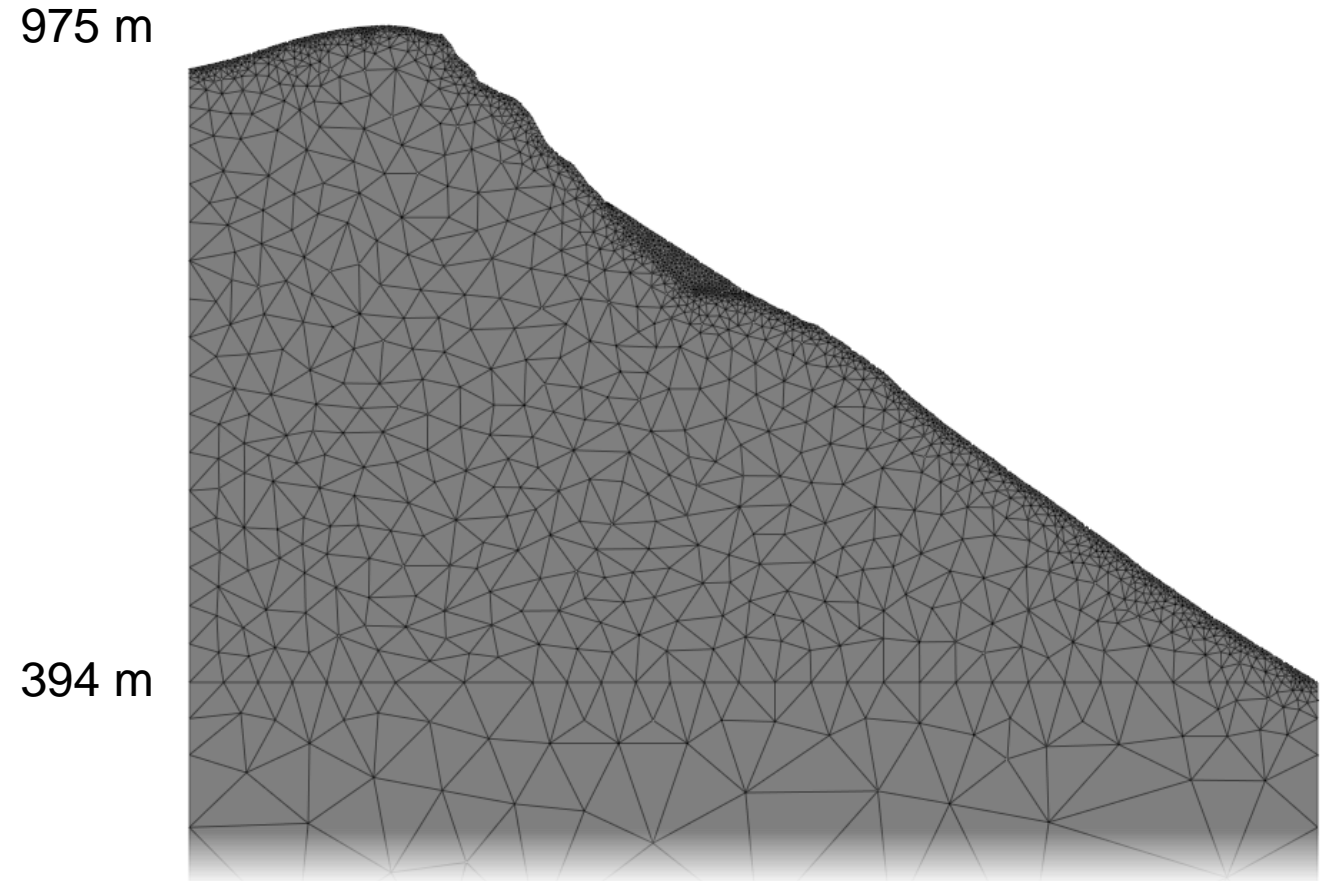
- computation of **heat transfer equations**
- **Finite-Element Method** (FEFLOW commercial software)
- modelling of the **thermal dynamics from -20,000 to present**
- evaluation of **permafrost conditions at the date of the Gislá landslide**





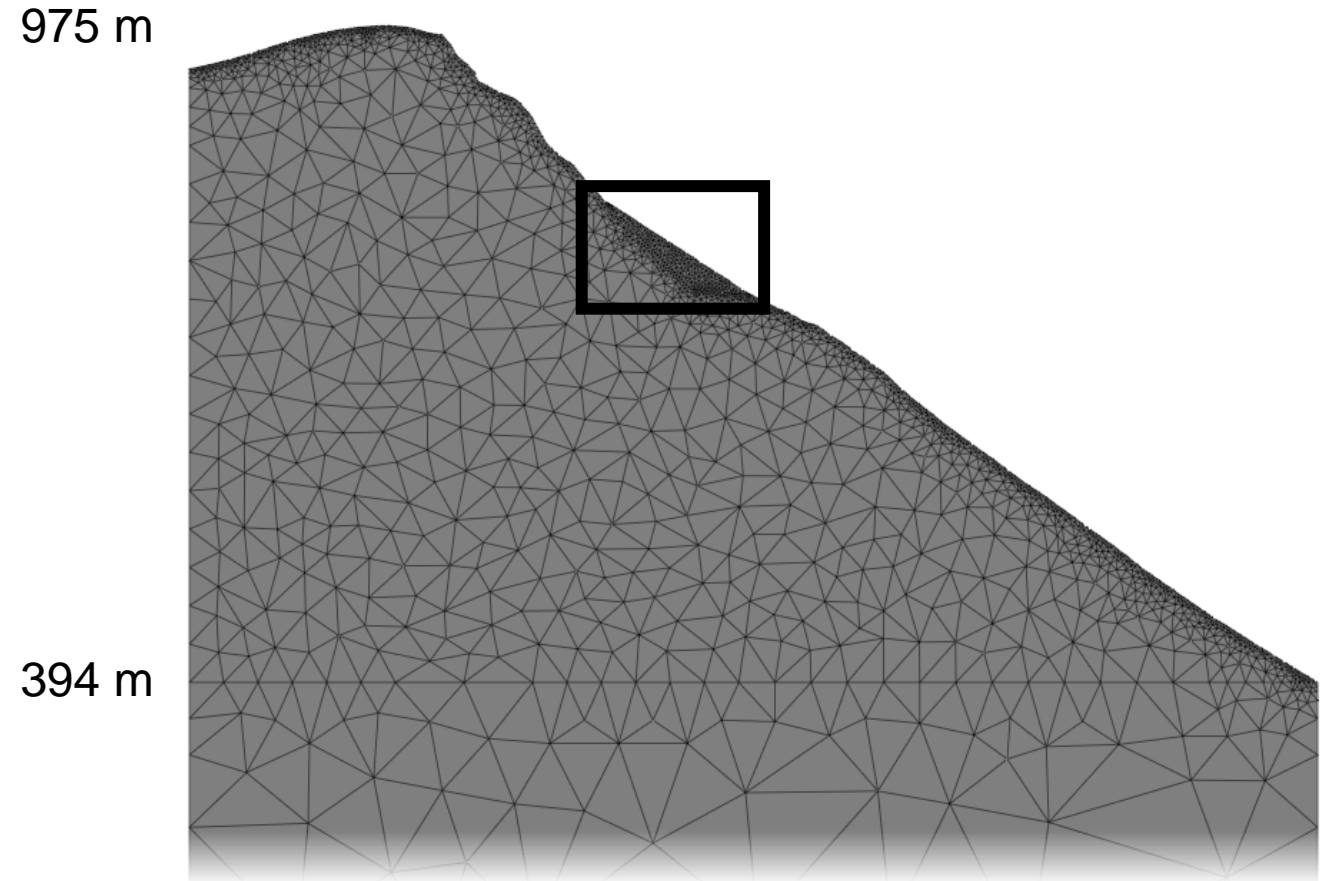
## Heat transfer modelling within the Gislá perched talus slope:

1. definition of 2D site geometry



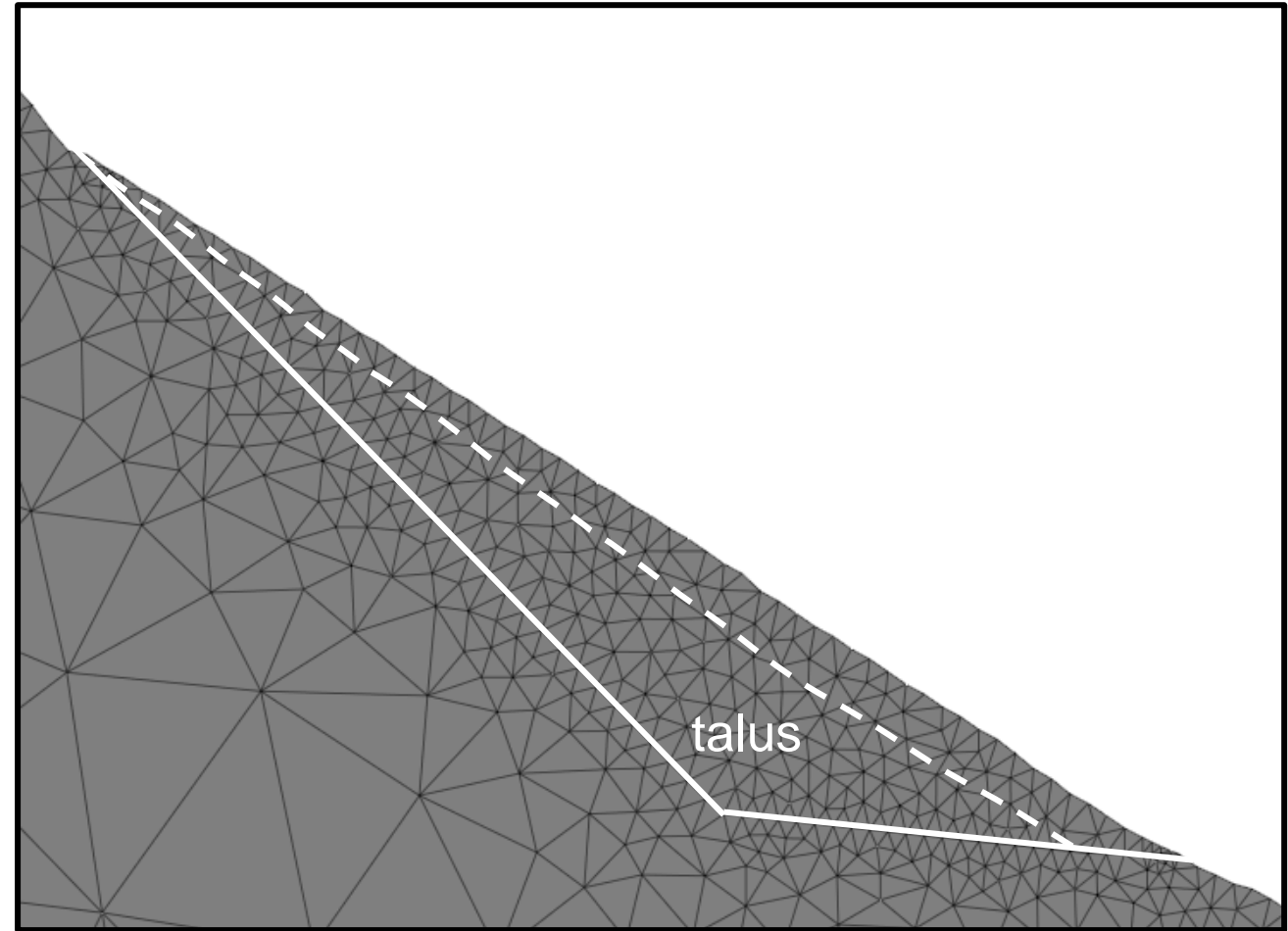
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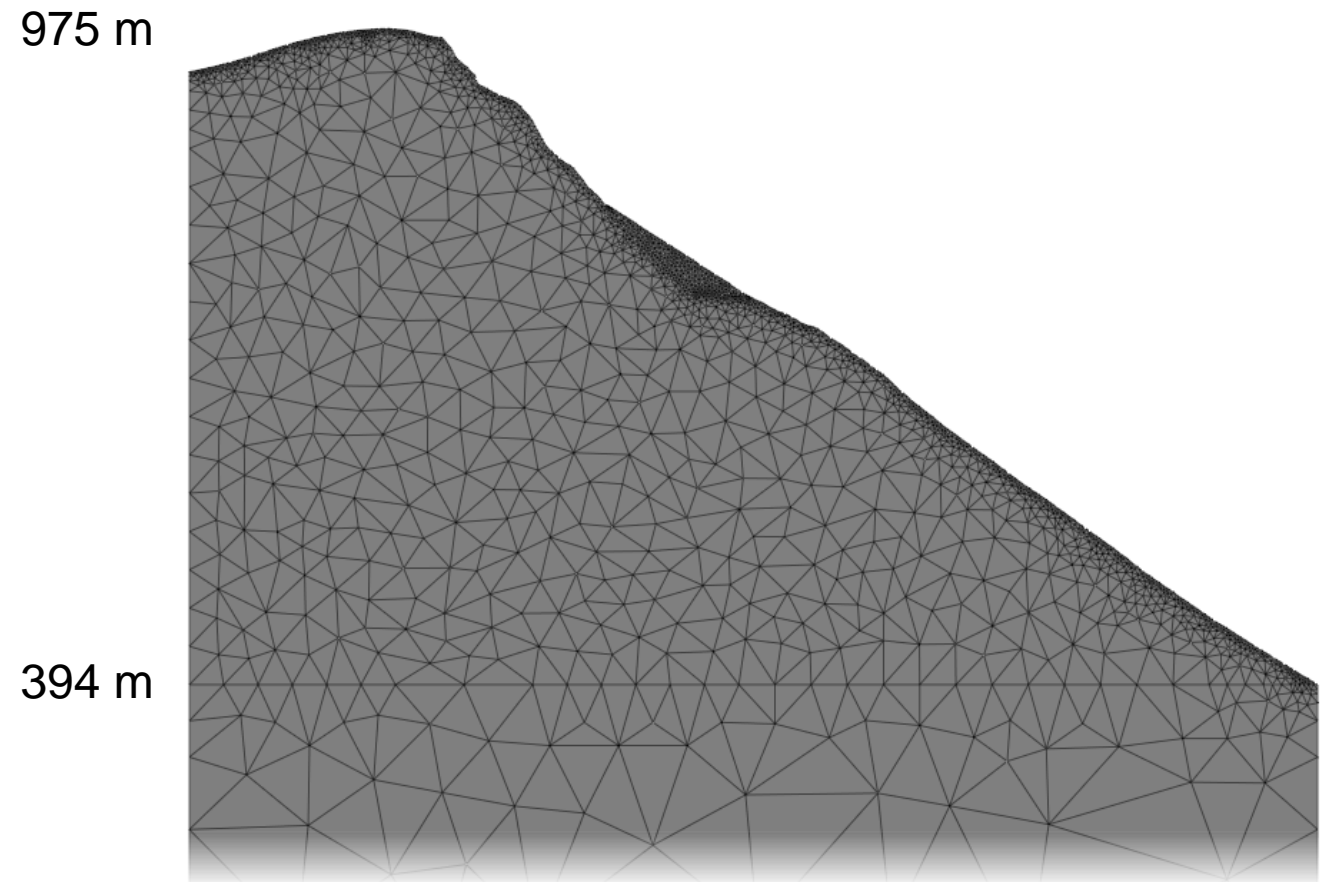
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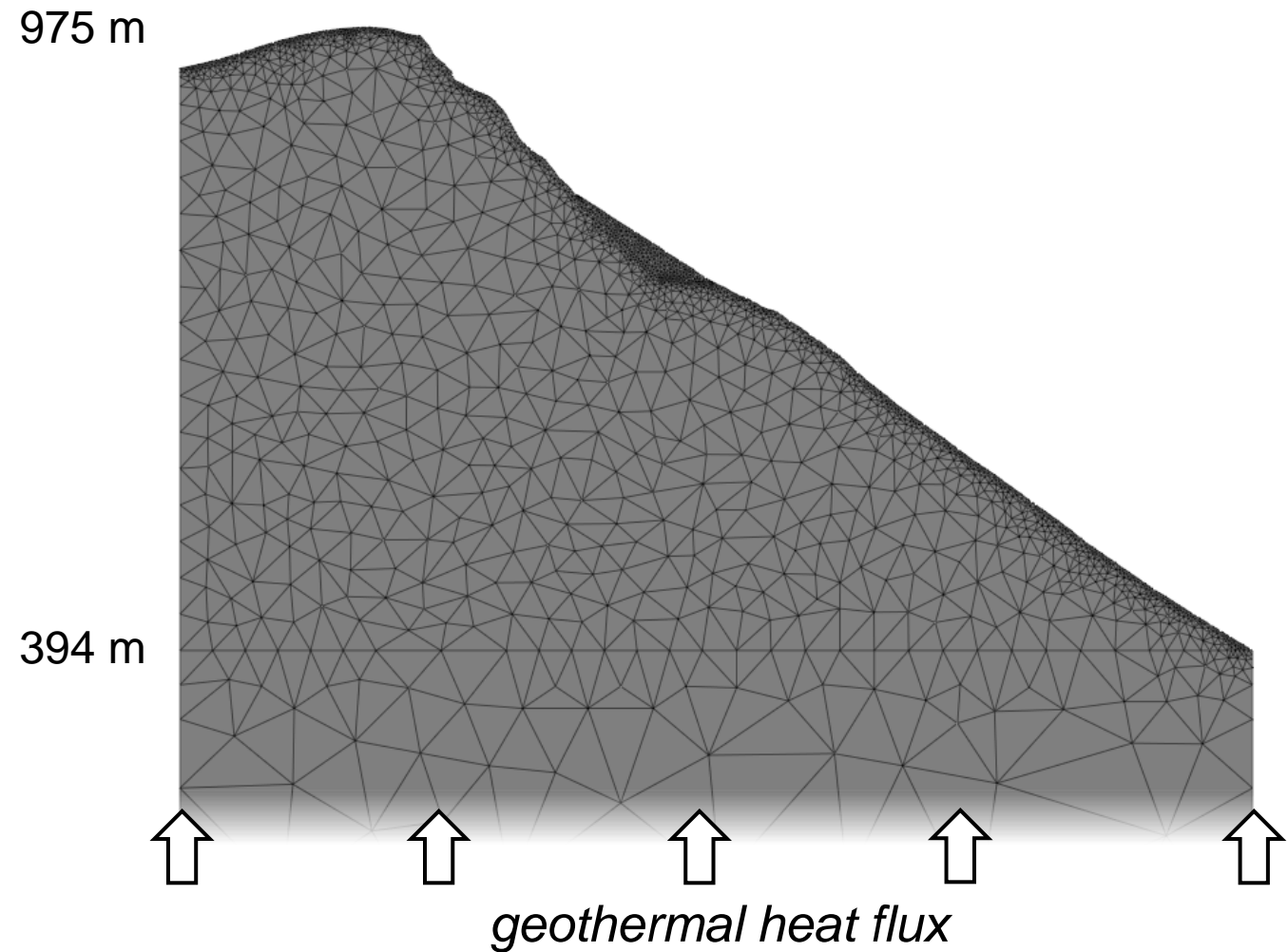
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2. construction of temperature time series (boundary conditions)



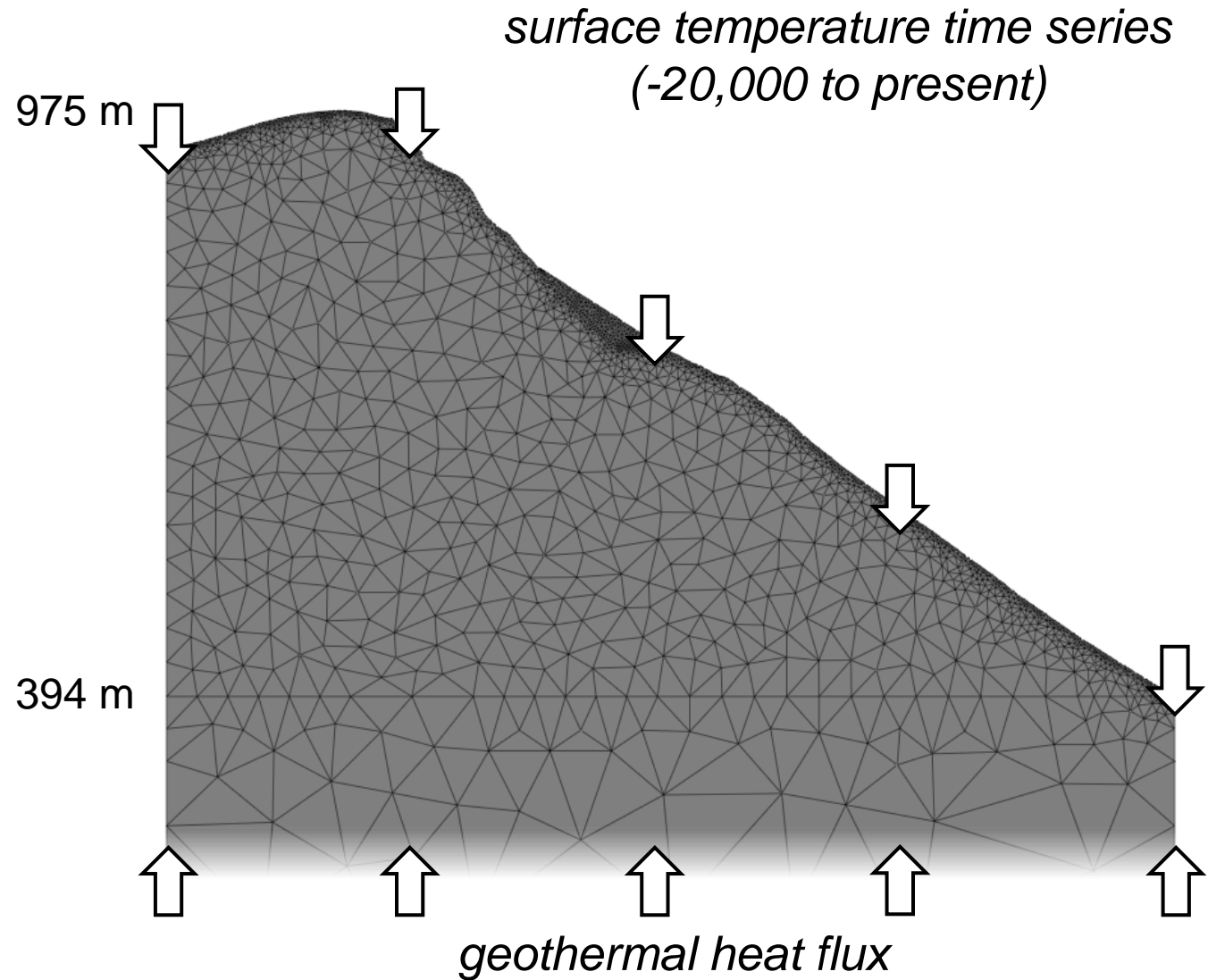
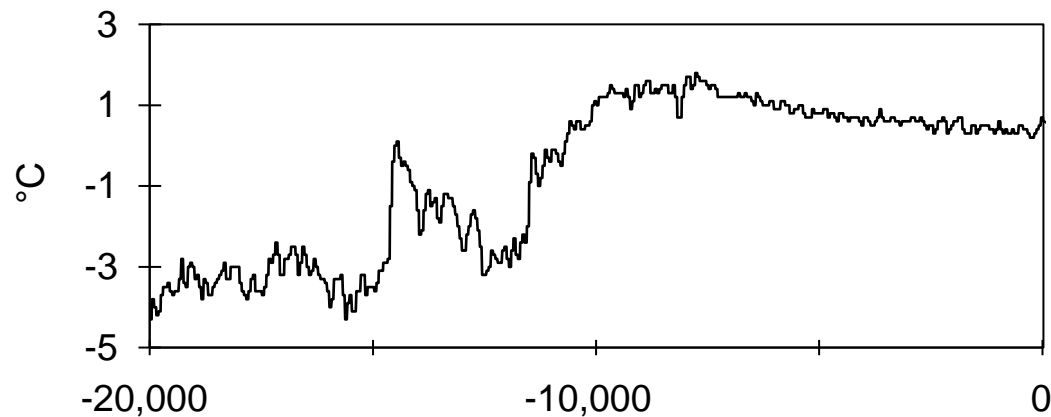
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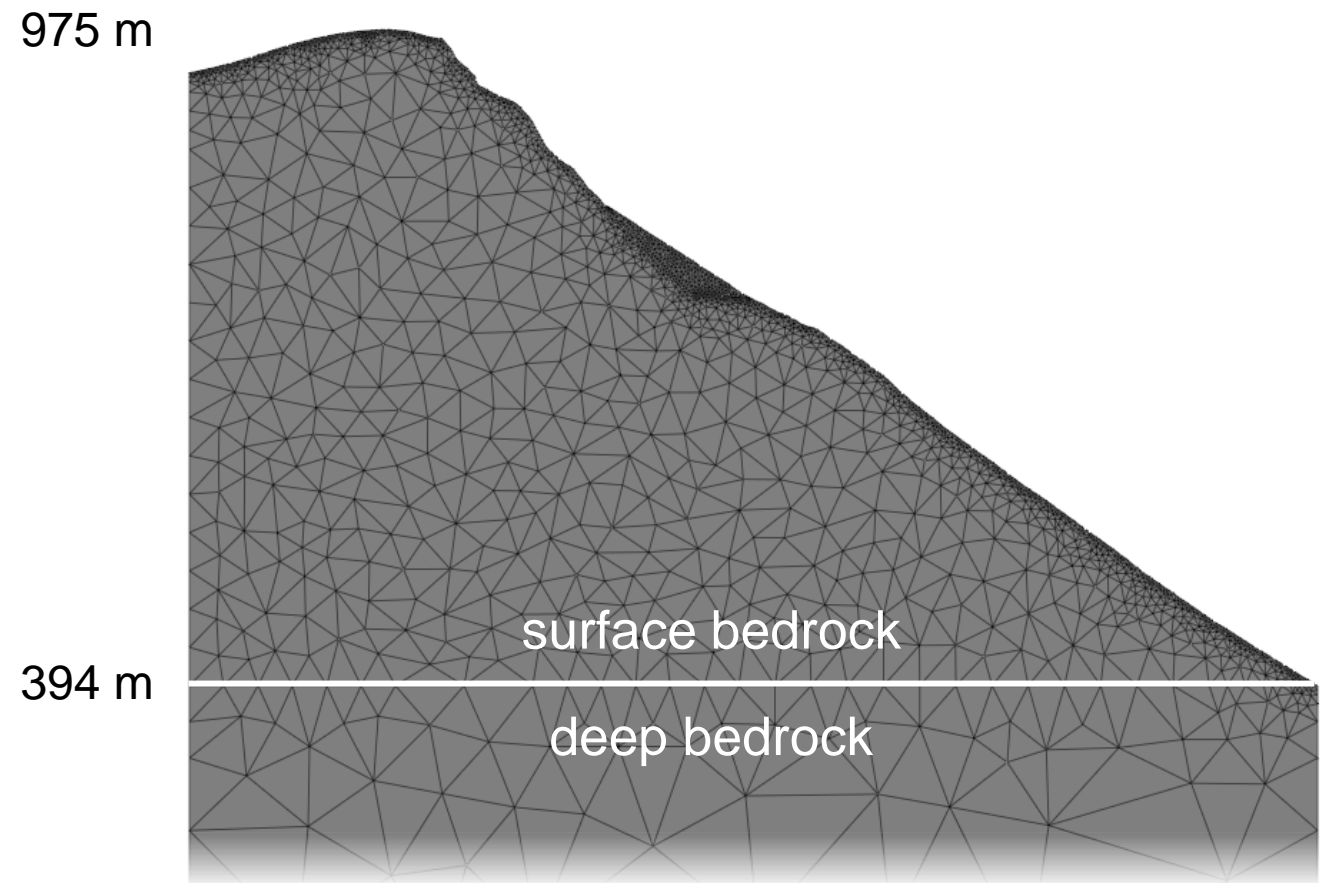
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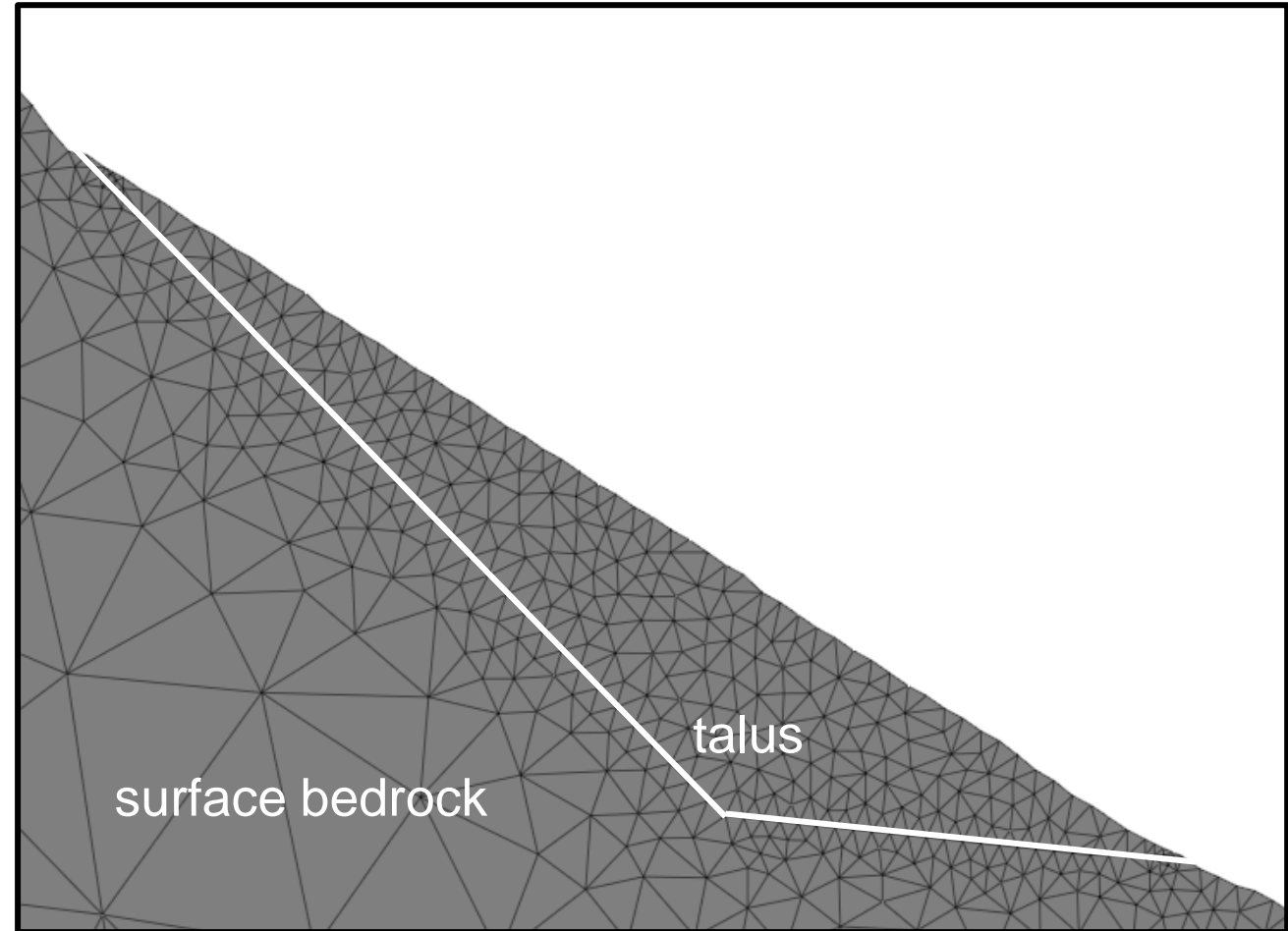
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1. definition of 2D site geometry
2. construction of temperature time series (boundary conditions)
3. modelling approach:
  - *division in sections*
  - *meshing*



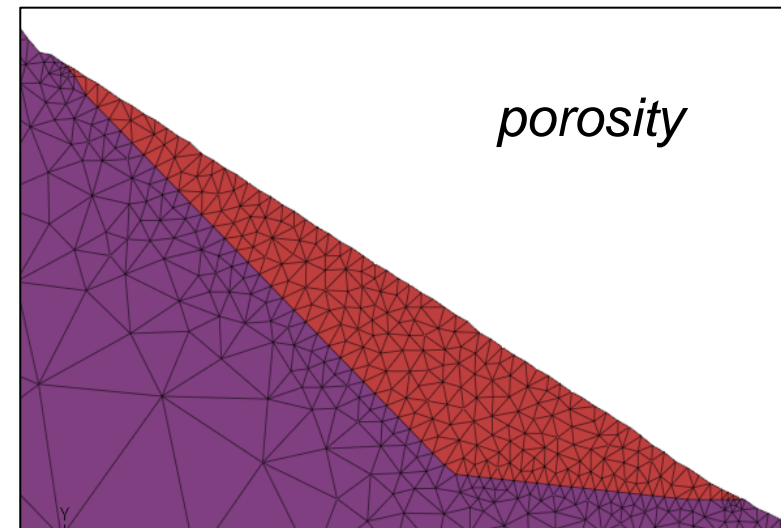
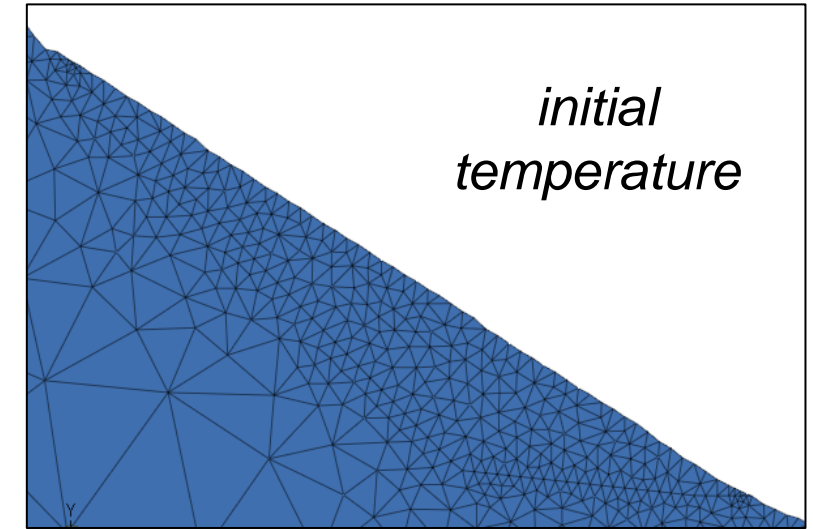
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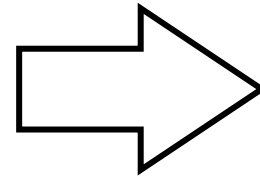
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**models are good to go!**

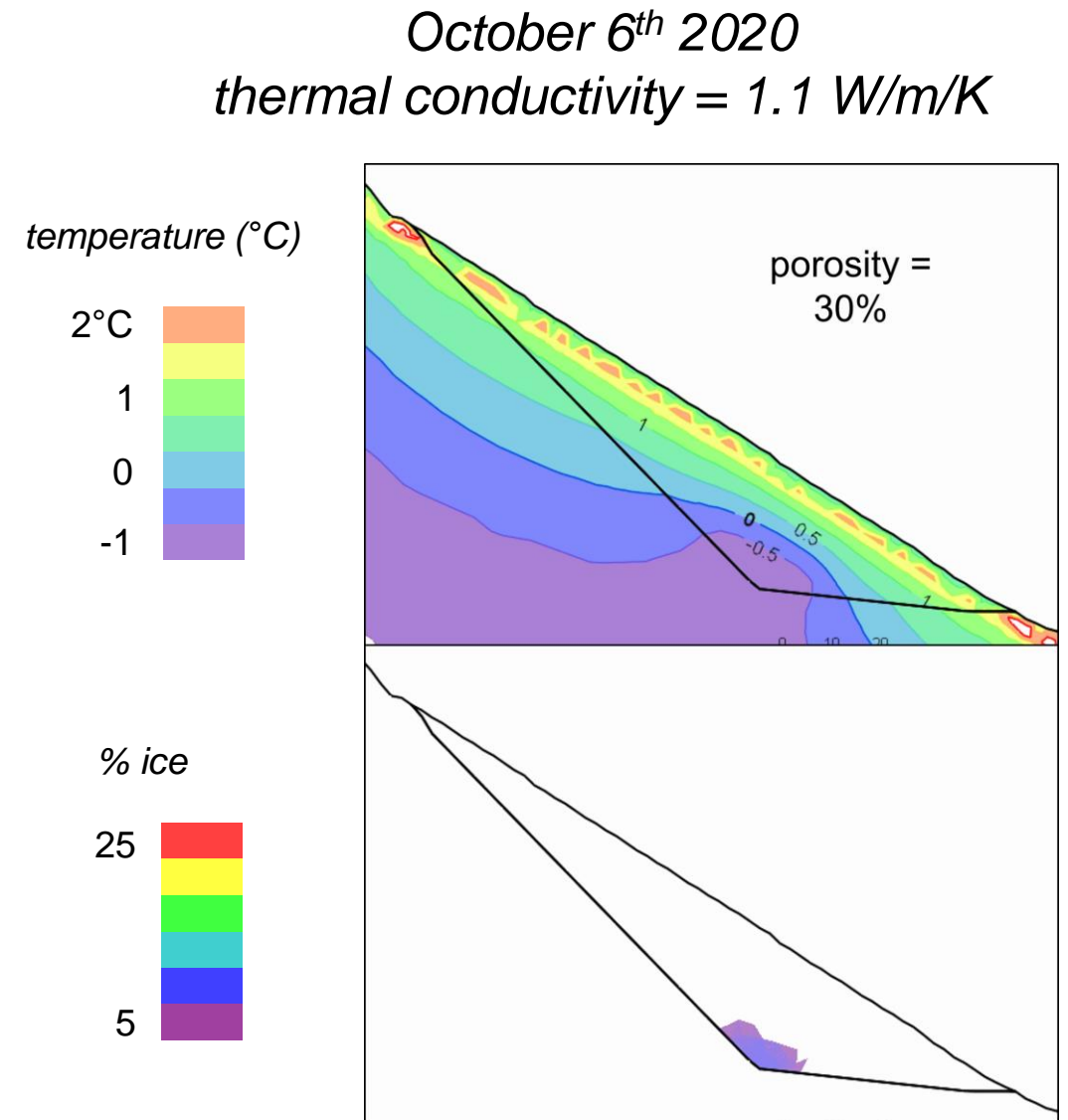


# Model sensitivity to porosity/ice content

Final temperature/permafrost conditions mainly depend on:

1. the **porosity** and **initial ice content** of the talus slope

→ **higher porosity/ice content**  
= **greater permafrost persistence**

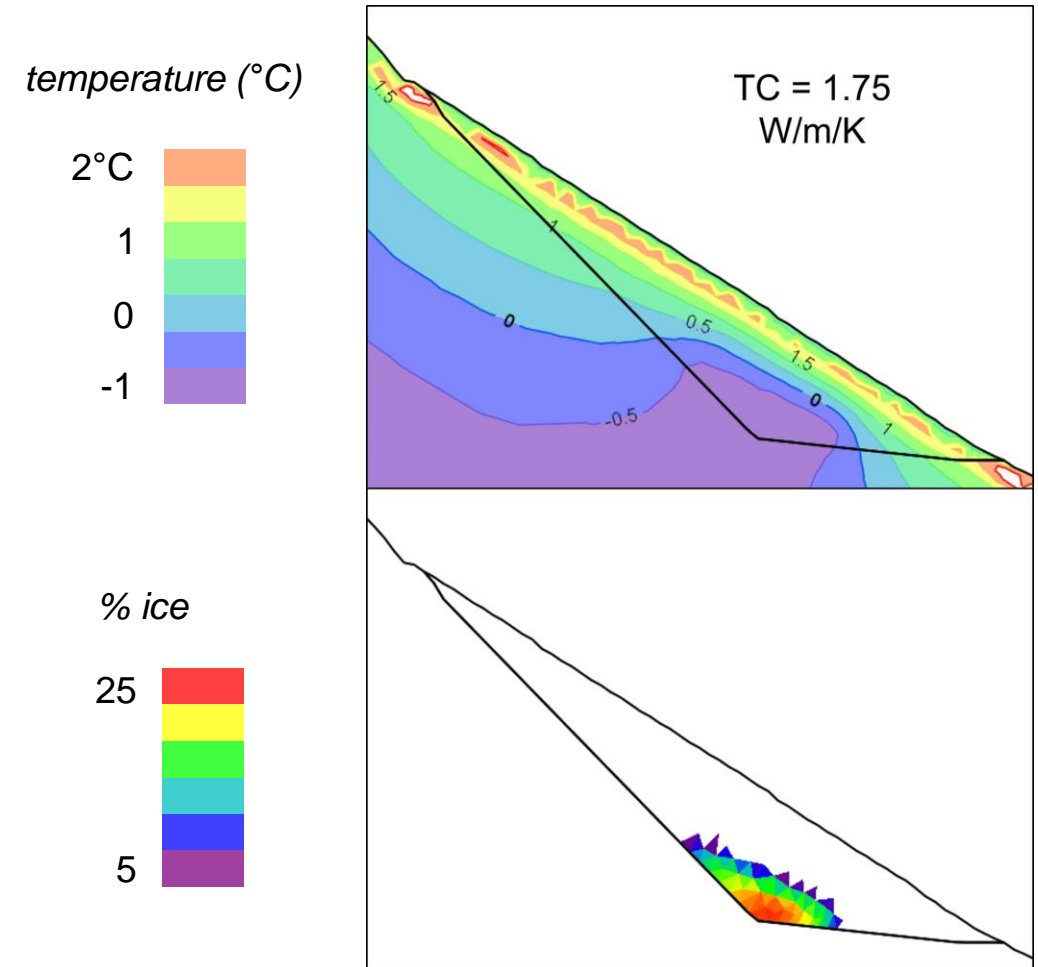


# Model sensitivity to the thermal conductivity

Final temperature/permafrost conditions mainly depend on:

1. the **porosity** and **initial ice content** of the talus slope  
→ higher porosity/ice content = greater permafrost persistence
2. the **thermal conductivity** of the rock  
→ lower thermal conductivity = greater permafrost persistence

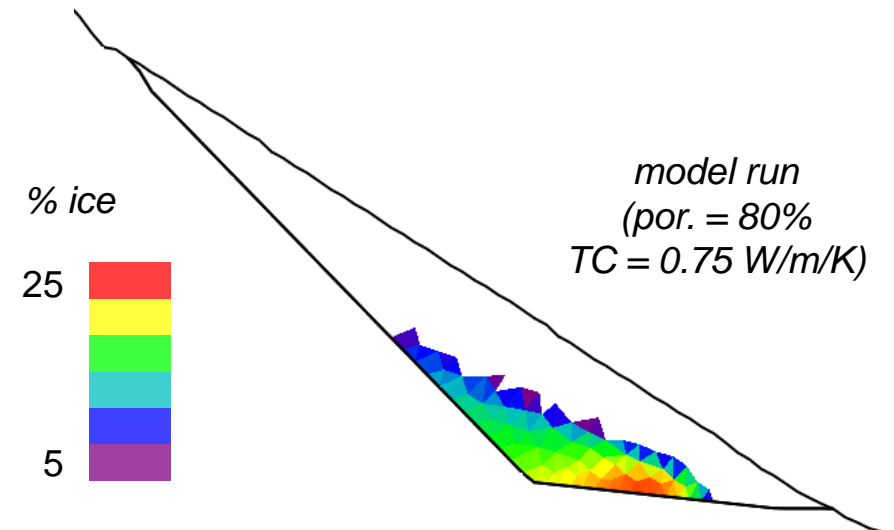
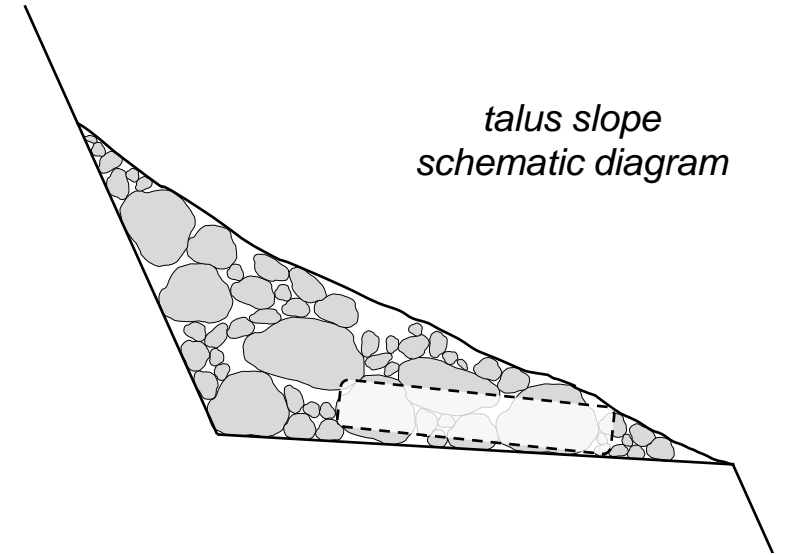
October 6<sup>th</sup> 2020  
*porosity/initial ice content = 80%*





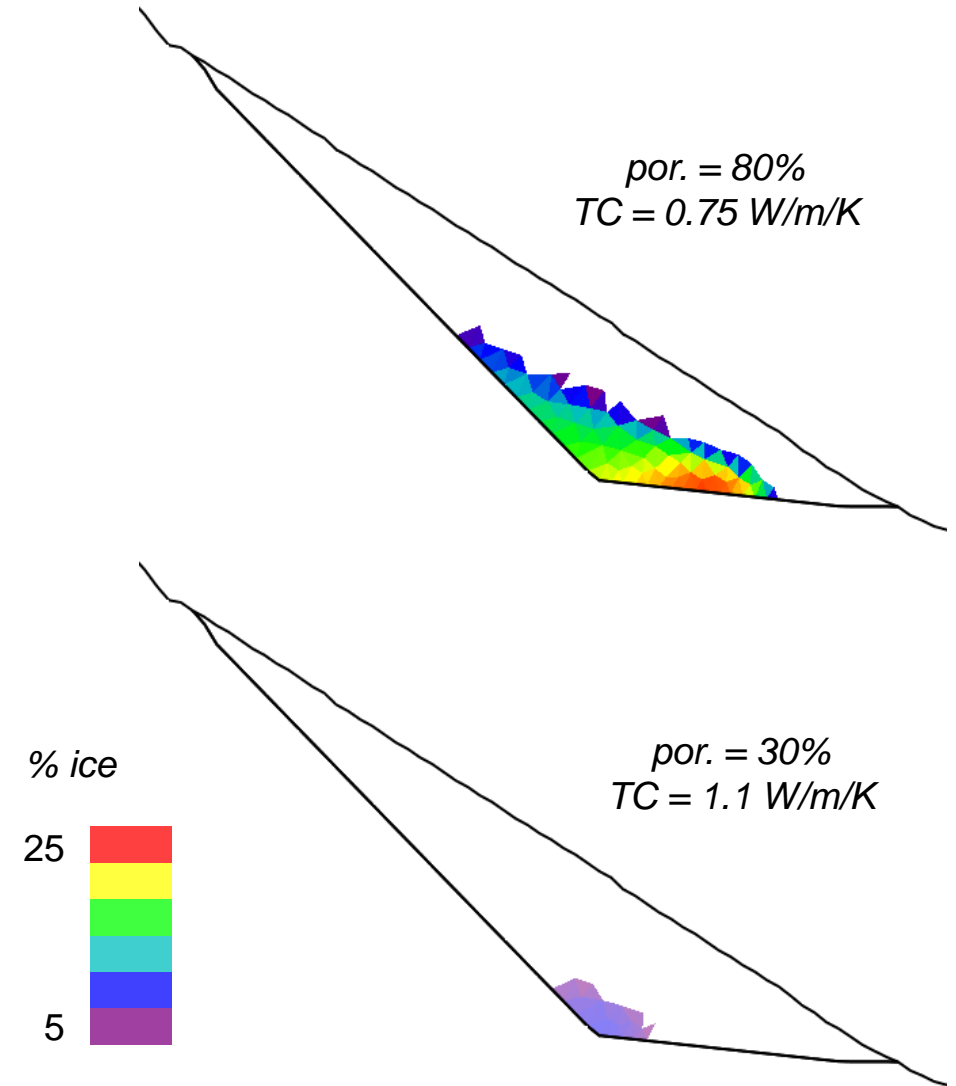
## 1. Can permafrost persist in the Gislá talus slope until the date of the landslide?

→ Yes - permafrost persists **at the base of the talus**, as expected with a **chimney effect**



## 2. What was the thermal state of permafrost at the date of the landslide?

- **25% of ice persists** at the base, with the most ice-conservative scenario
- **nearly no ice persists** with the least ice-conservative ones



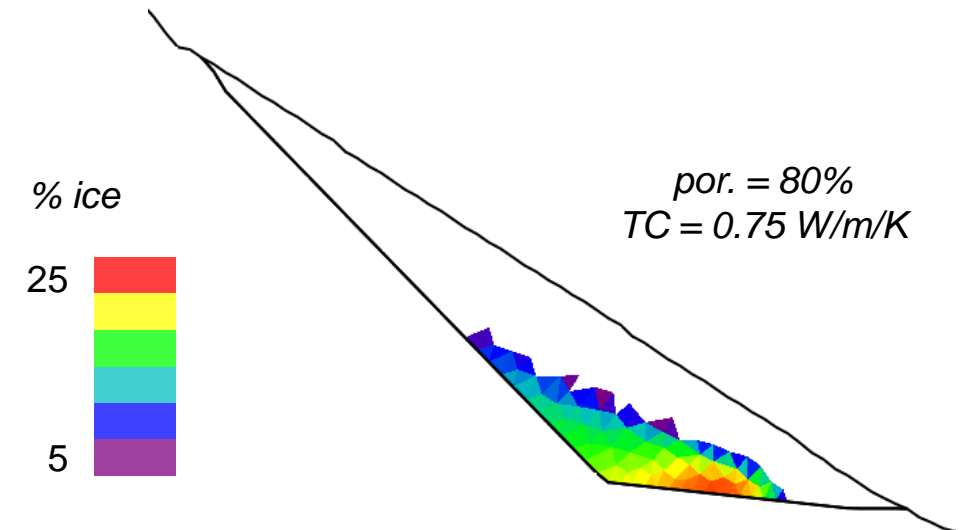
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→ **ice-cemented material** in the landslide deposits indicate a **relatively high ice content** (~ 50%)



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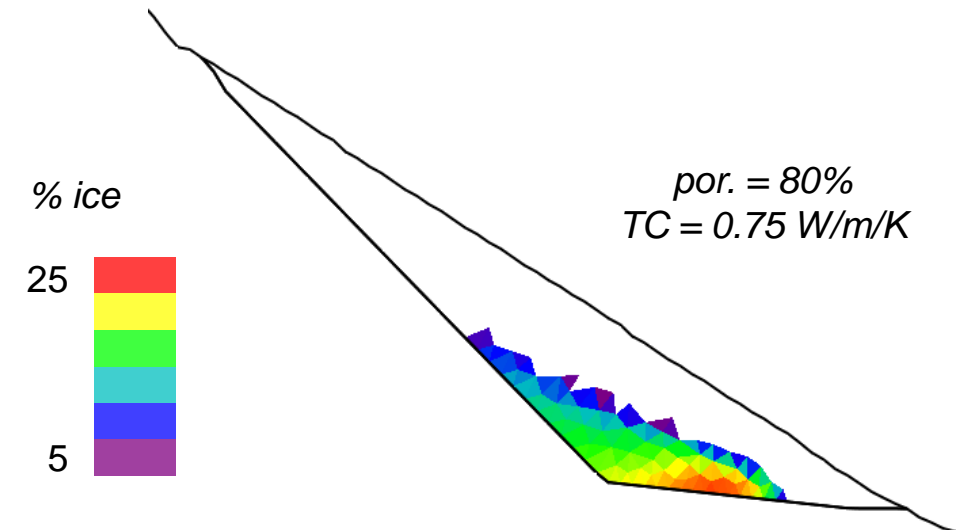
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- **ice-cemented material** in the landslide deposits indicate a **relatively high ice content** (~ 50%)
- the most ice-conservative scenario shows **lower ice content** (25%)
- modelling air convection would **increase the final ice content**



# Thank you for your attention!

