

**The end of alpine ice cores?
Insights on high altitude climate change
from a state-of-the-art model of
Colle Gnifetti, 4400 m a.s.l.**

Enrico Mattea
University of Fribourg

Introduction







Colle Gnifetti (Stefano Caldera)

Cold glaciers



Colle Gnifetti (Stefano Caldera)

Cold glaciers

- Temperature $< 0\text{ }^{\circ}\text{C}$ year-round



Colle Gnifetti (Stefano Caldera)

Cold glaciers

- Temperature $< 0\text{ }^{\circ}\text{C}$ year-round
- More resilient to climate warming



Colle Gnifetti (Stefano Caldera)

Cold glaciers

- Temperature $< 0\text{ }^{\circ}\text{C}$ year-round
- More resilient to climate warming
- Stable on steep terrain



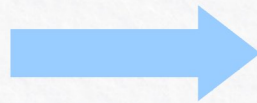
Colle Gnifetti (Stefano Caldera)

Cold glaciers

- Temperature $< 0\text{ }^{\circ}\text{C}$ year-round
- More resilient to climate warming
- Stable on steep terrain
- Preserved layers



Colle Gnifetti (Stefano Caldera)



Ice cores

Colle Gnifetti, 4450 m a.s.l.

Colle Gnifetti, 4450 m a.s.l.

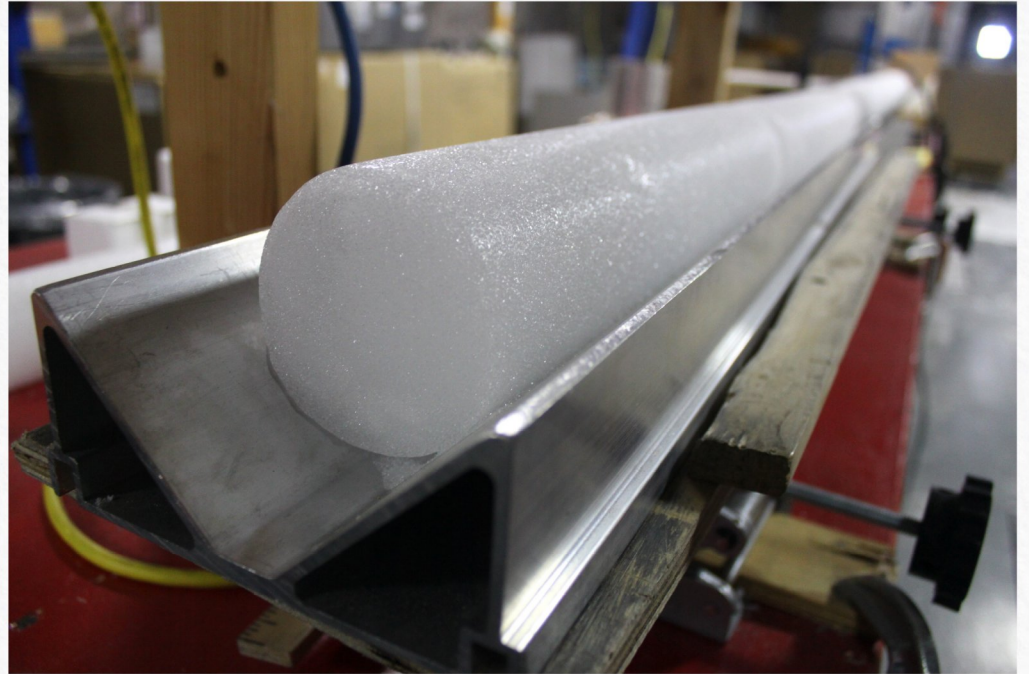
- The most studied cold glacier in the Alps: 40+ years of data!



Martin Hoelzle / Horst Machguth

Colle Gnifetti, 4450 m a.s.l.

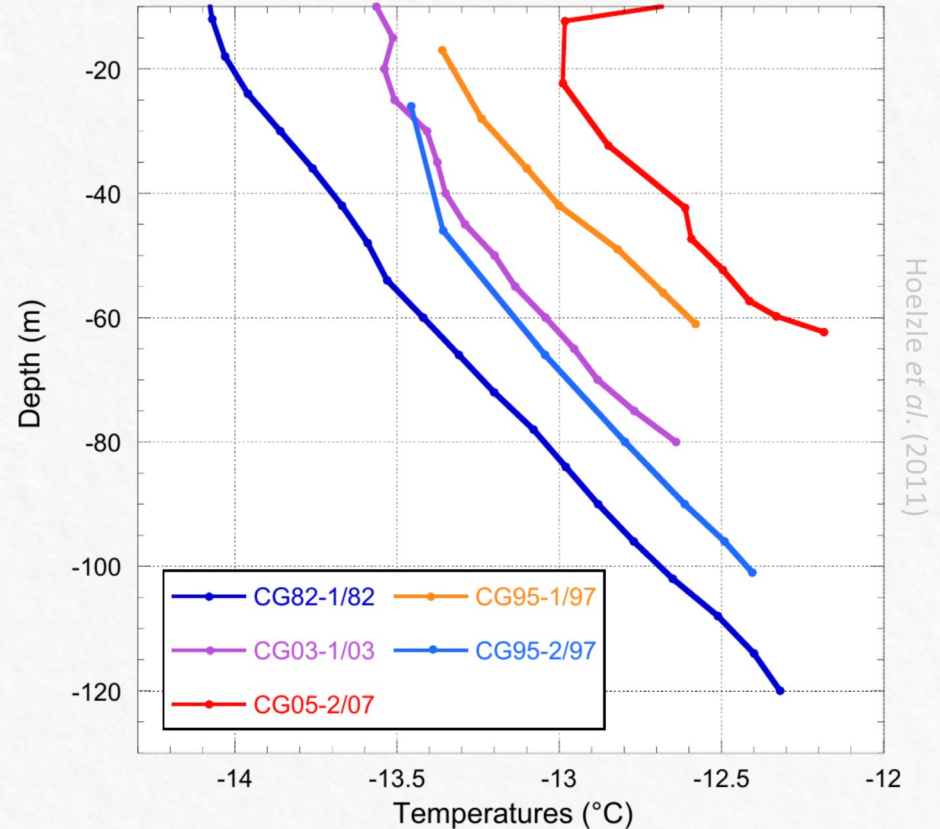
- The most studied cold glacier in the Alps: 40+ years of data!
- Oldest glacier ice in the Alps (19 kyr BP)



Eli Duke

Colle Gnifetti, 4450 m a.s.l.

- The most studied cold glacier in the Alps: 40+ years of data!
- Oldest glacier ice in the Alps (19 kyr BP)
- Recent observations suggest possible warming



Materials and methods

Materials and methods

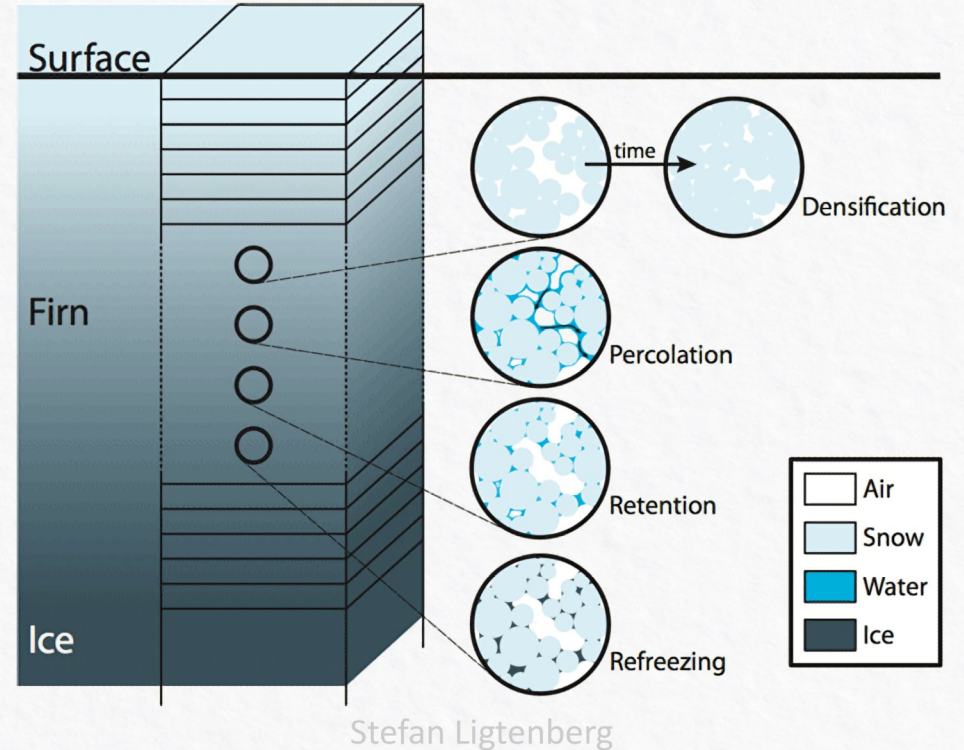
- Little visible change

Materials and methods

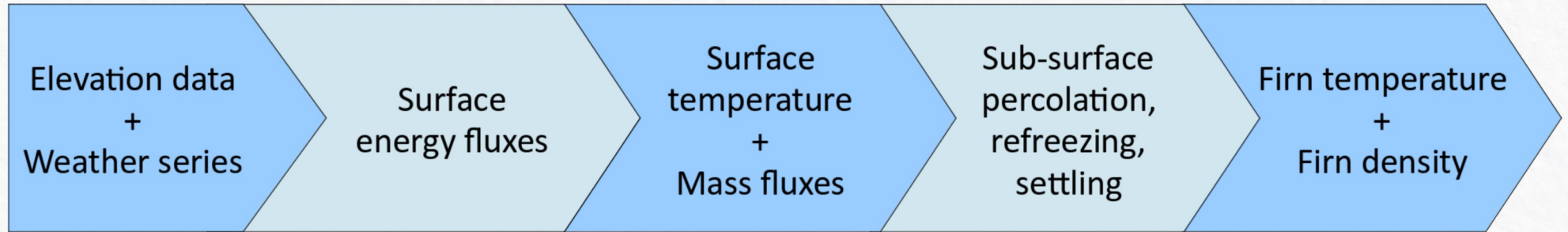
- Little visible change



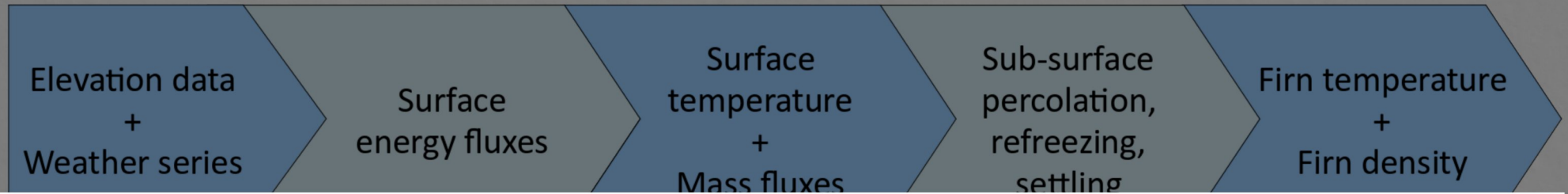
- Numerical model of the glacier



The glacier model

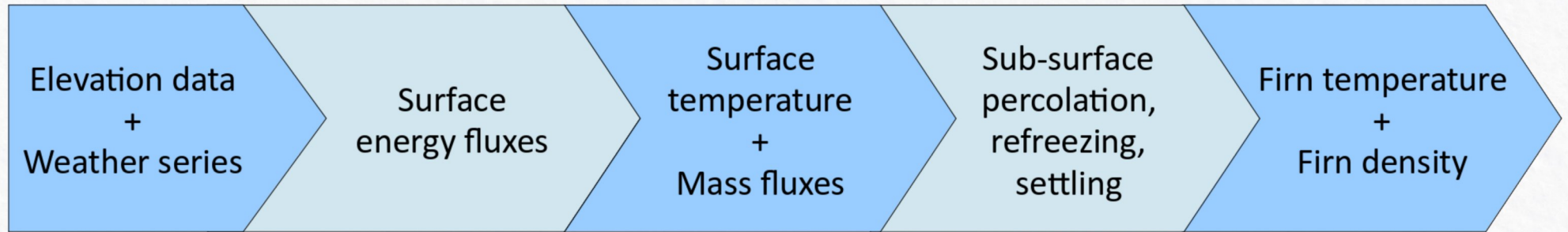


The glacier model

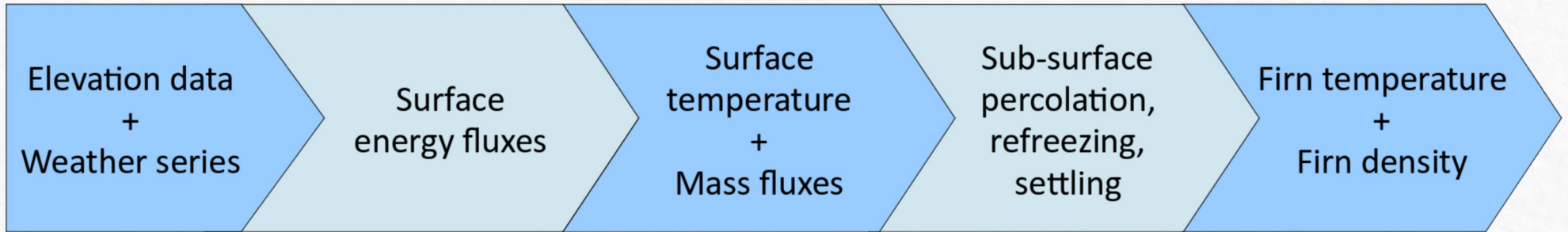


$$Q_{melt} = SW_{net} + LW_{net} + SHF + LHF + GHF$$

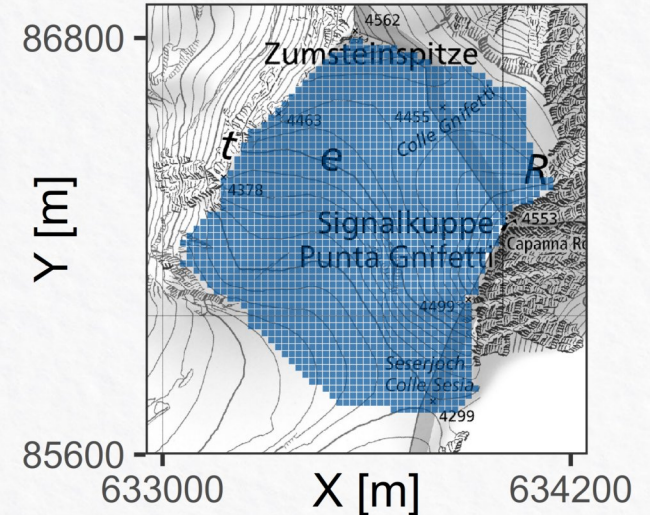
The glacier model



The glacier model



- Simulation with hourly time-step
- On a gridded domain (2000x250)



The Capanna Margherita weather station

The Capanna Margherita weather station

- Located next to Colle Gnifetti



alpina-tour.com

The Capanna Margherita weather station

- Located next to Colle Gnifetti
- Almost 20 years of hourly archives



alpina-tour.com

The Capanna Margherita weather station

- Located next to Colle Gnifetti
- Almost 20 years of hourly archives
- Very harsh operating conditions



alpina-tour.com

The Capanna Margherita weather station

- Located next to Colle Gnifetti
- Almost 20 years of hourly archives
- Very harsh operating conditions

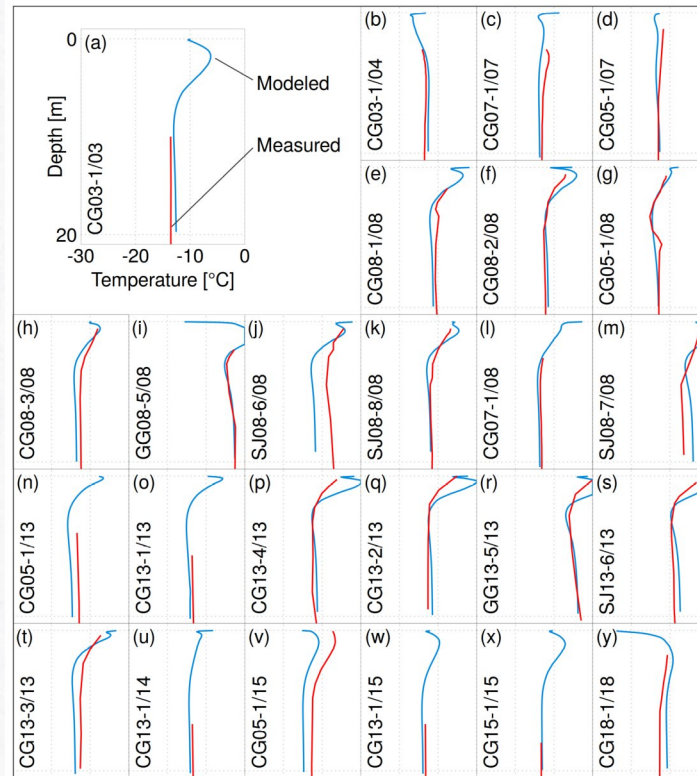


Michele Enzo

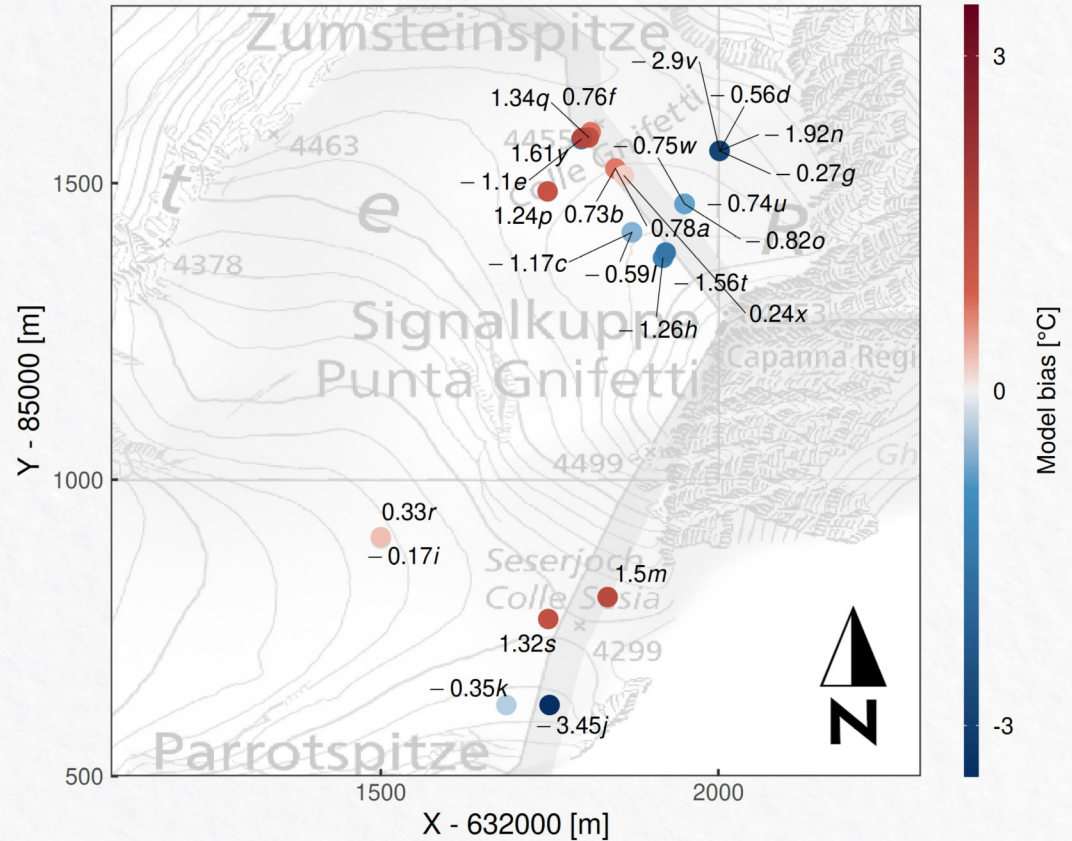
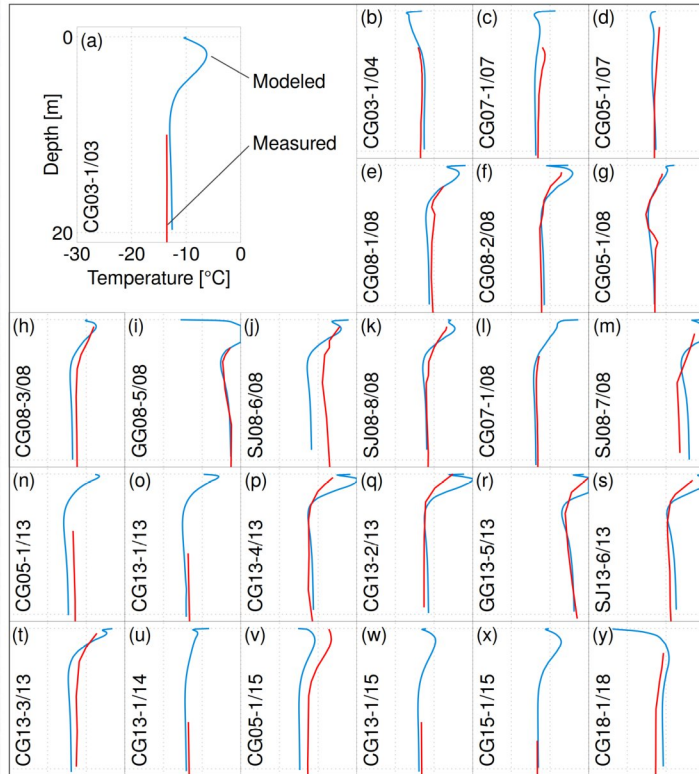
Results and discussion

Model validation

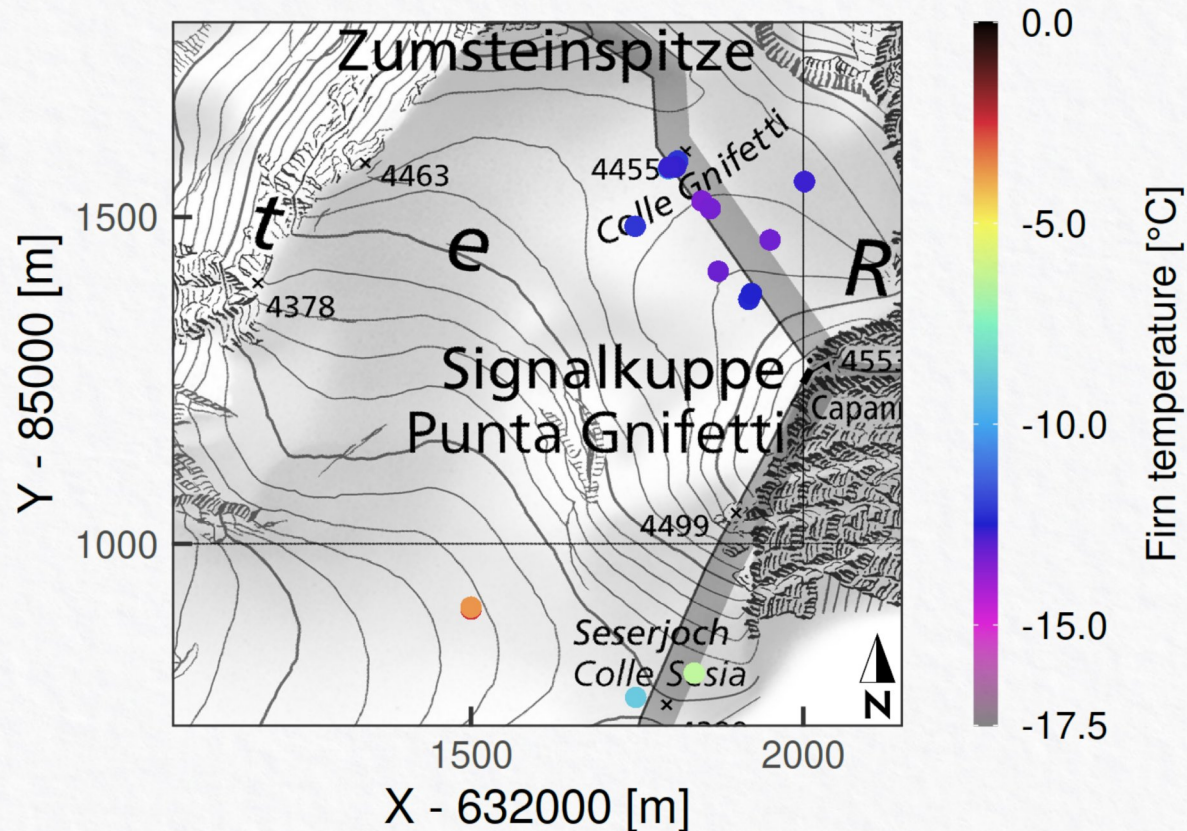
Model validation



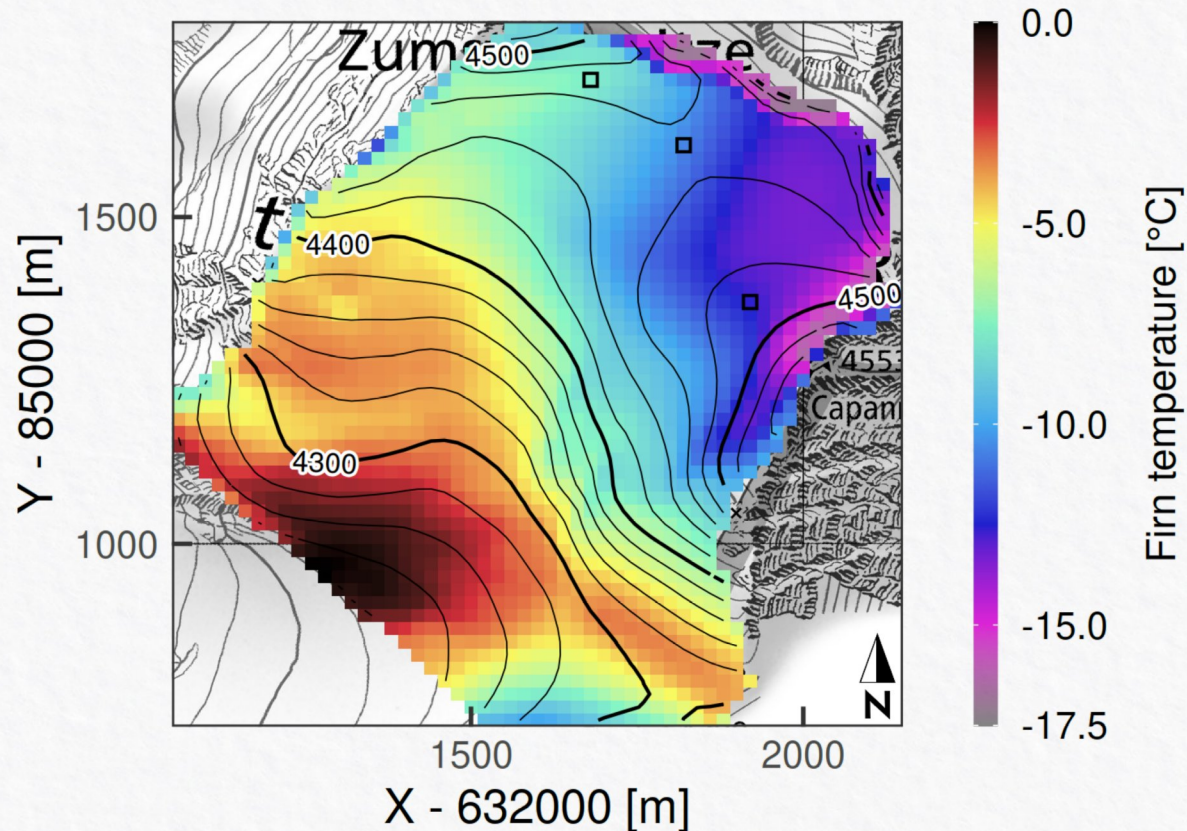
Model validation



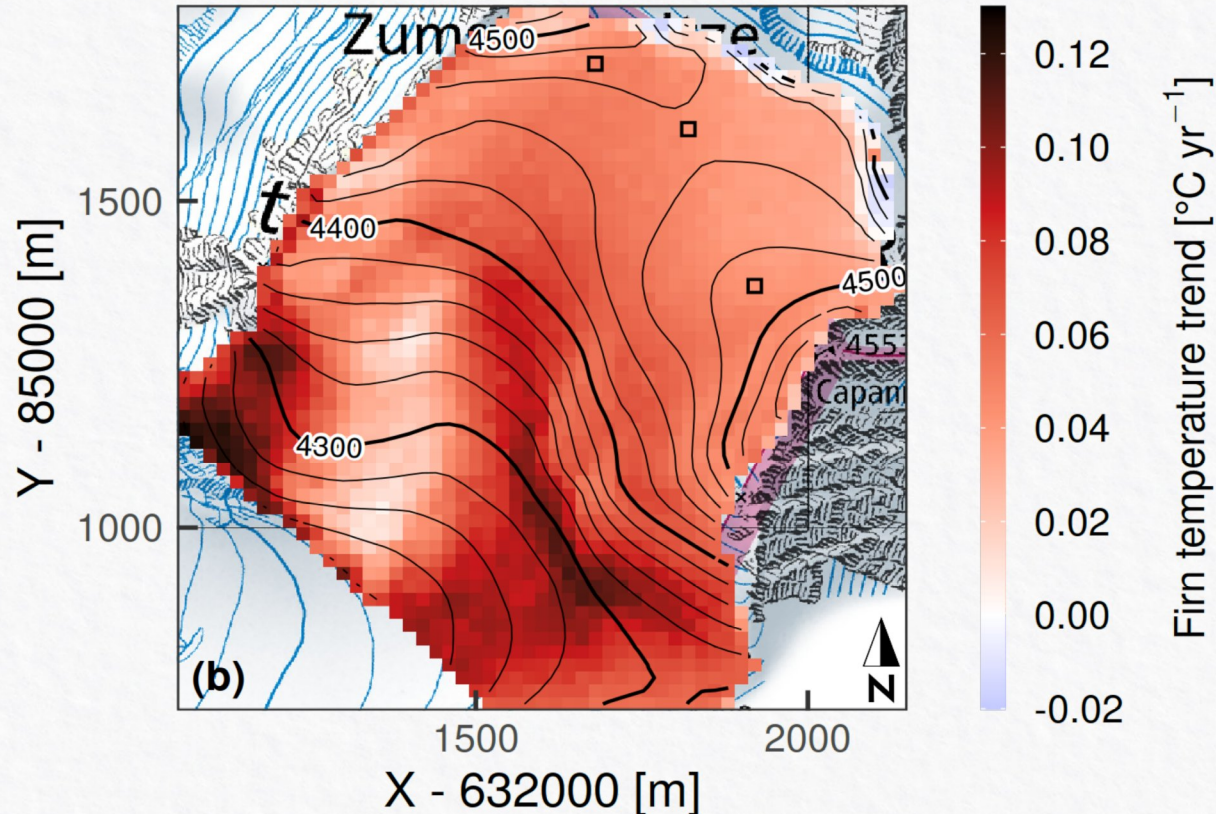
Modeled glacier temperatures



Modeled glacier temperatures

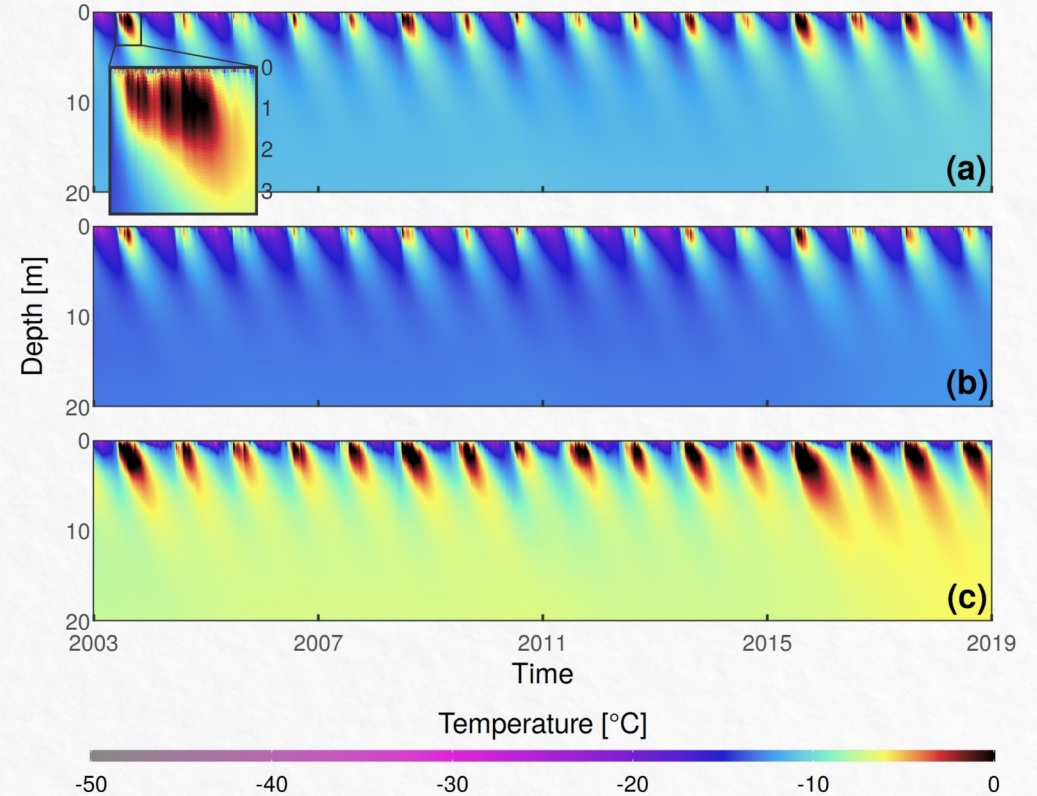


Modeled glacier temperatures



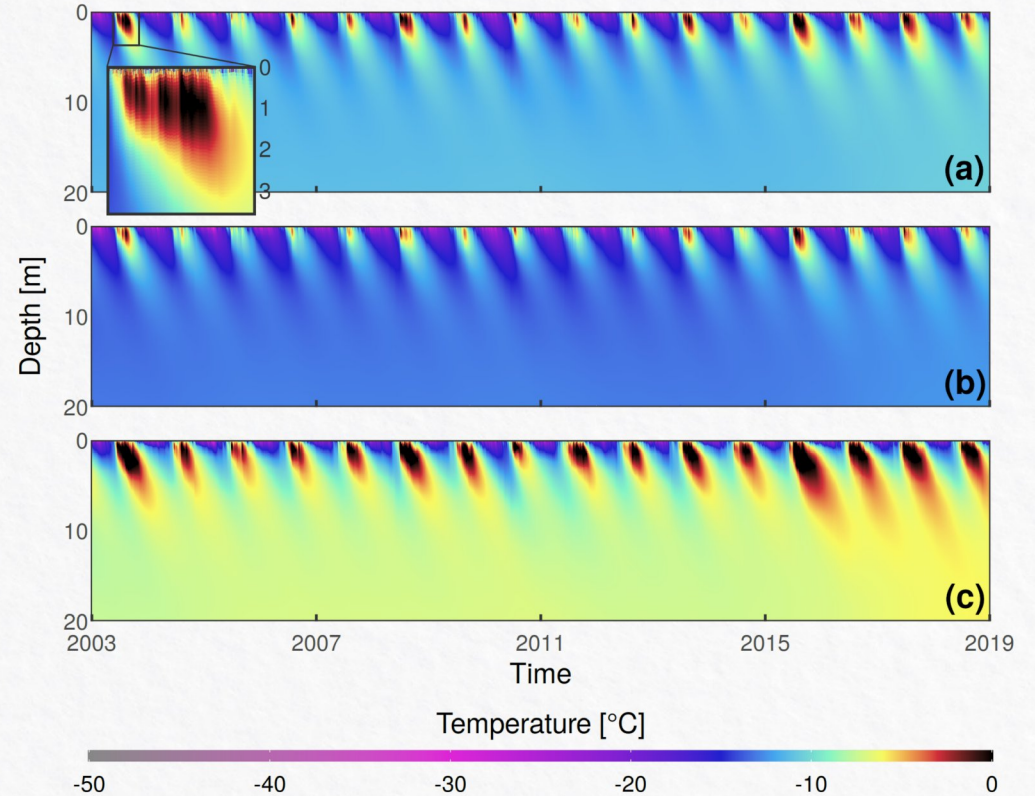
Modeled glacier temperatures

- Heat plumes from summer water infiltration



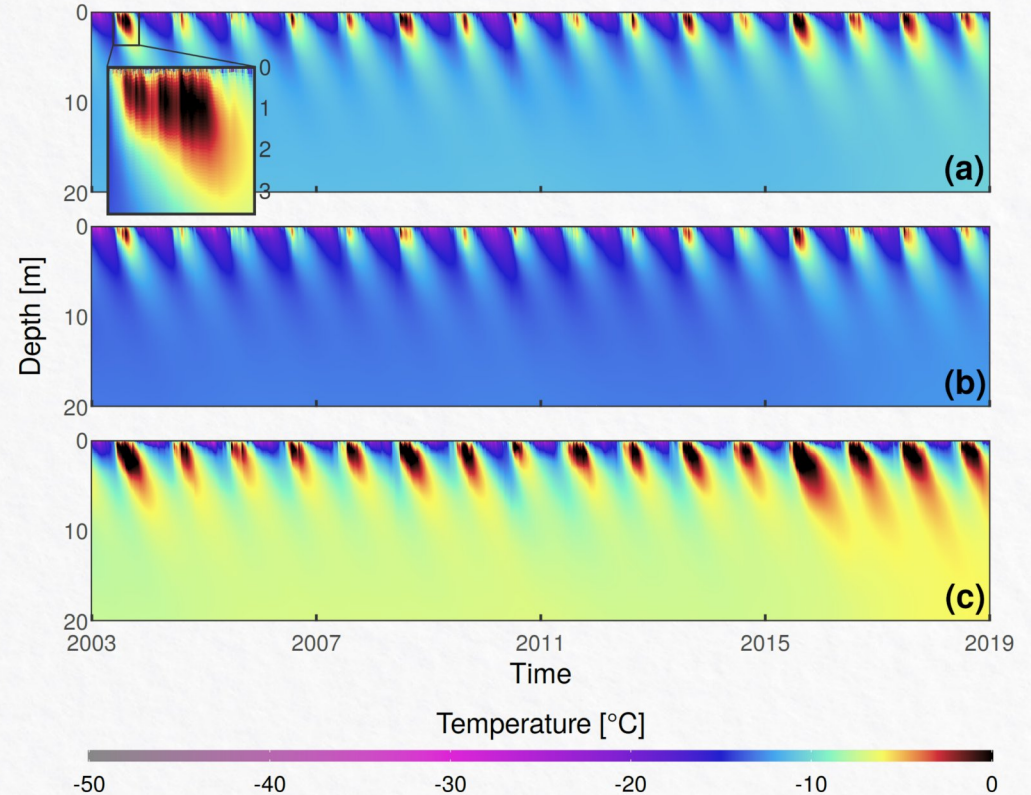
Modeled glacier temperatures

- Heat plumes from summer water infiltration
- Annual temperature cycle down to 20 m depth

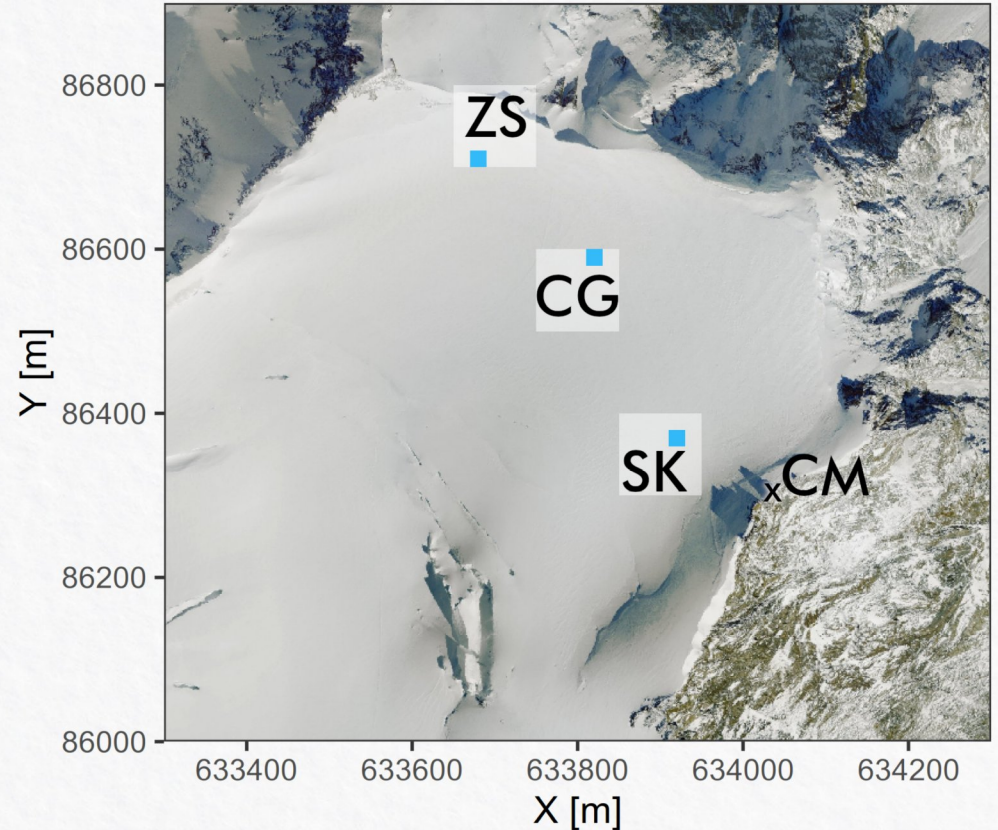
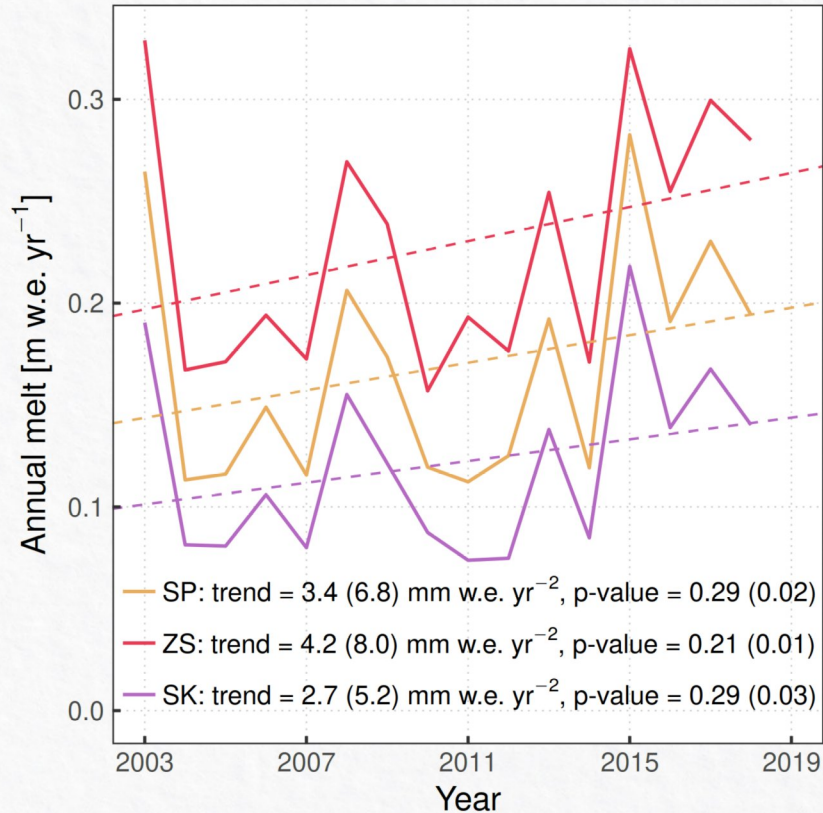


Modeled glacier temperatures

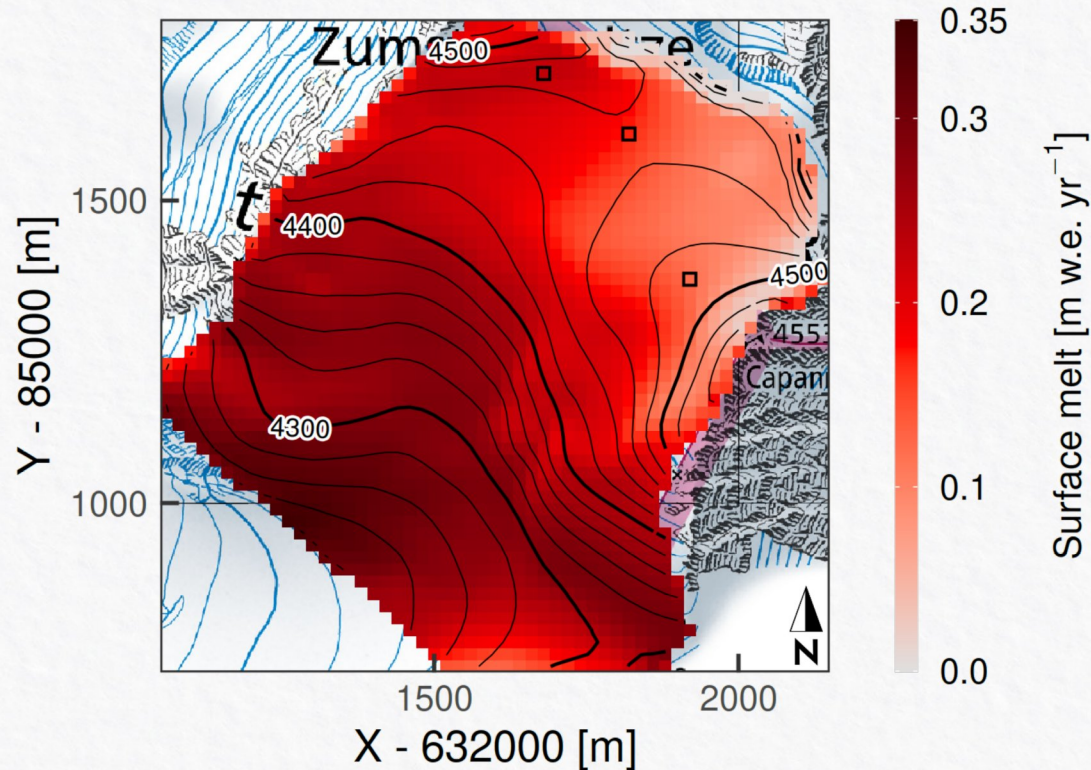
- Heat plumes from summer water infiltration
- Annual temperature cycle down to 20 m depth
- Last 4 years warmer at all depths after extreme 2015 summer



Modeled glacier melt amounts



Modeled glacier melt amounts



Take-home message

Take home message

- Simulation of an alpine cold glacier with a distributed and fully coupled model, using high-quality input data

Take home message

- Simulation of an alpine cold glacier with a distributed and fully coupled model, using high-quality input data
- Temperatures and melt amounts are highly variable and significantly increasing

Take home message

- Simulation of an alpine cold glacier with a distributed and fully coupled model, using high-quality input data
- Temperatures and melt amounts are highly variable and significantly increasing
- Outlook: use the model to **(1)** predict glacier evolution into the future
(2) help to decide drilling locations

A high-altitude mountain peak covered in snow, with a vast sea of clouds below and a clear blue sky above. The mountain's ridges are sharp and rocky, partially covered in white snow. The clouds are thick and white, filling the valley and extending to the horizon. The sky is a deep, clear blue.

Thank you for your attention!