UNIVERSITÄT BERN

OESCHGER CENTRE
CLIMATE CHANGE RESEARCH

When snow and ice are gone

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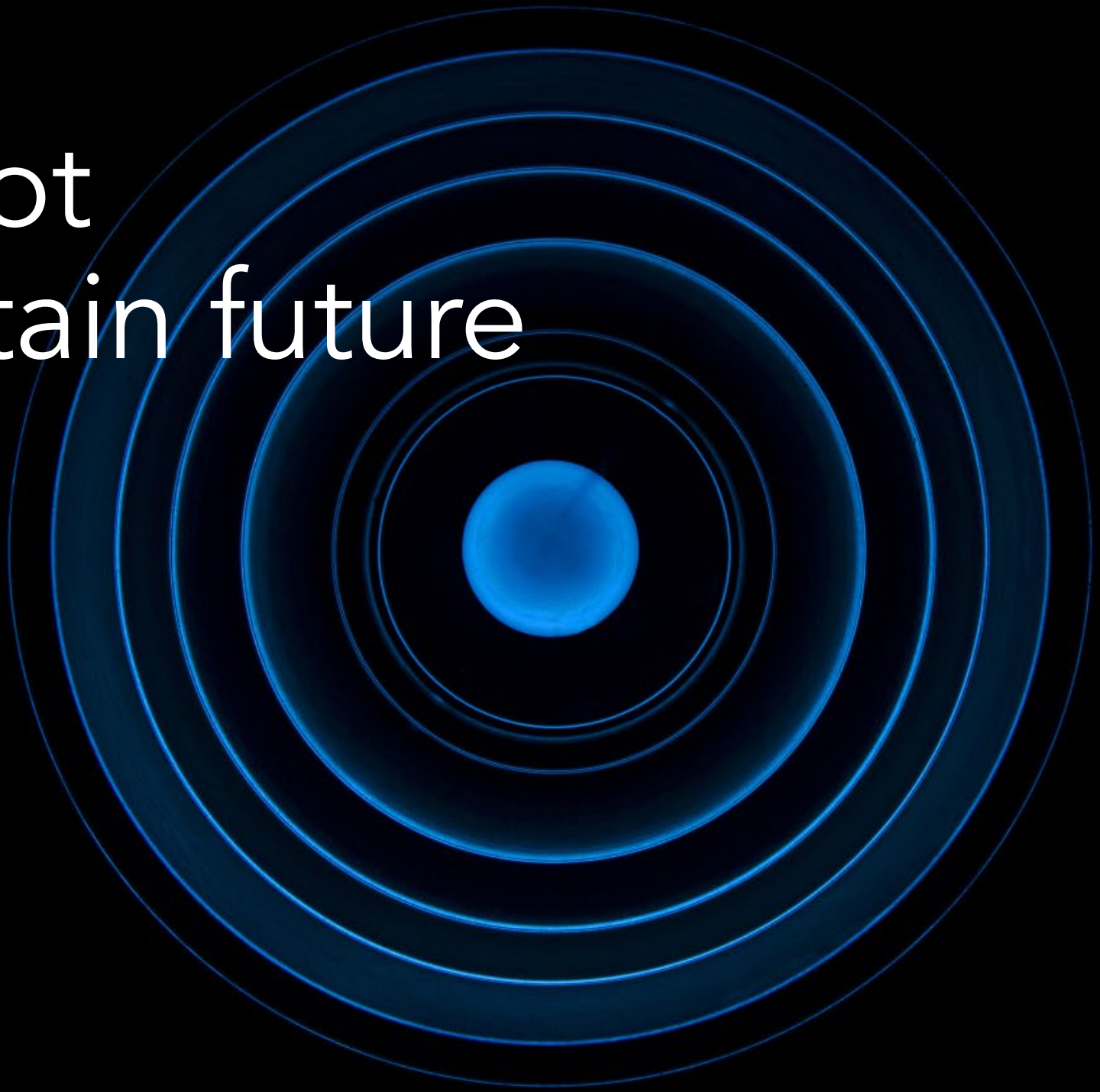
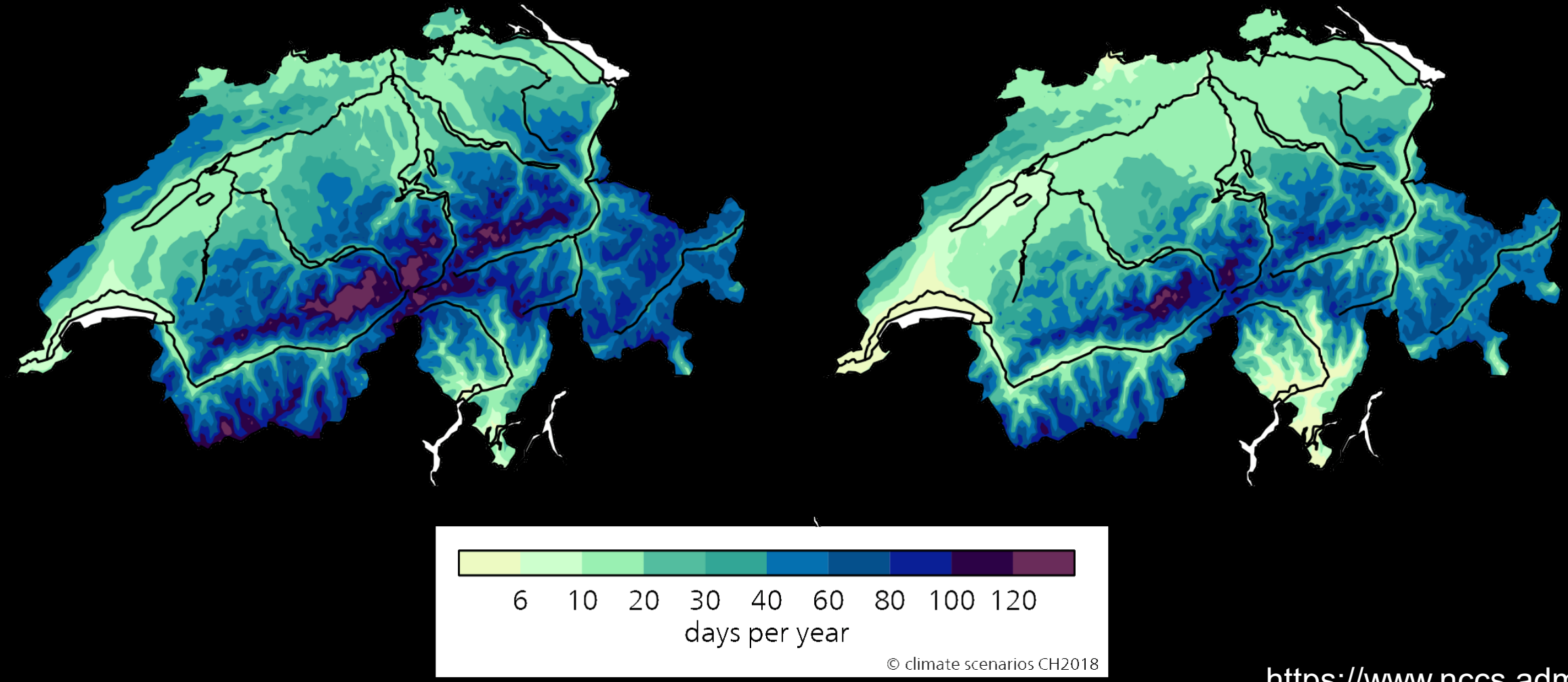
The not uncertain future



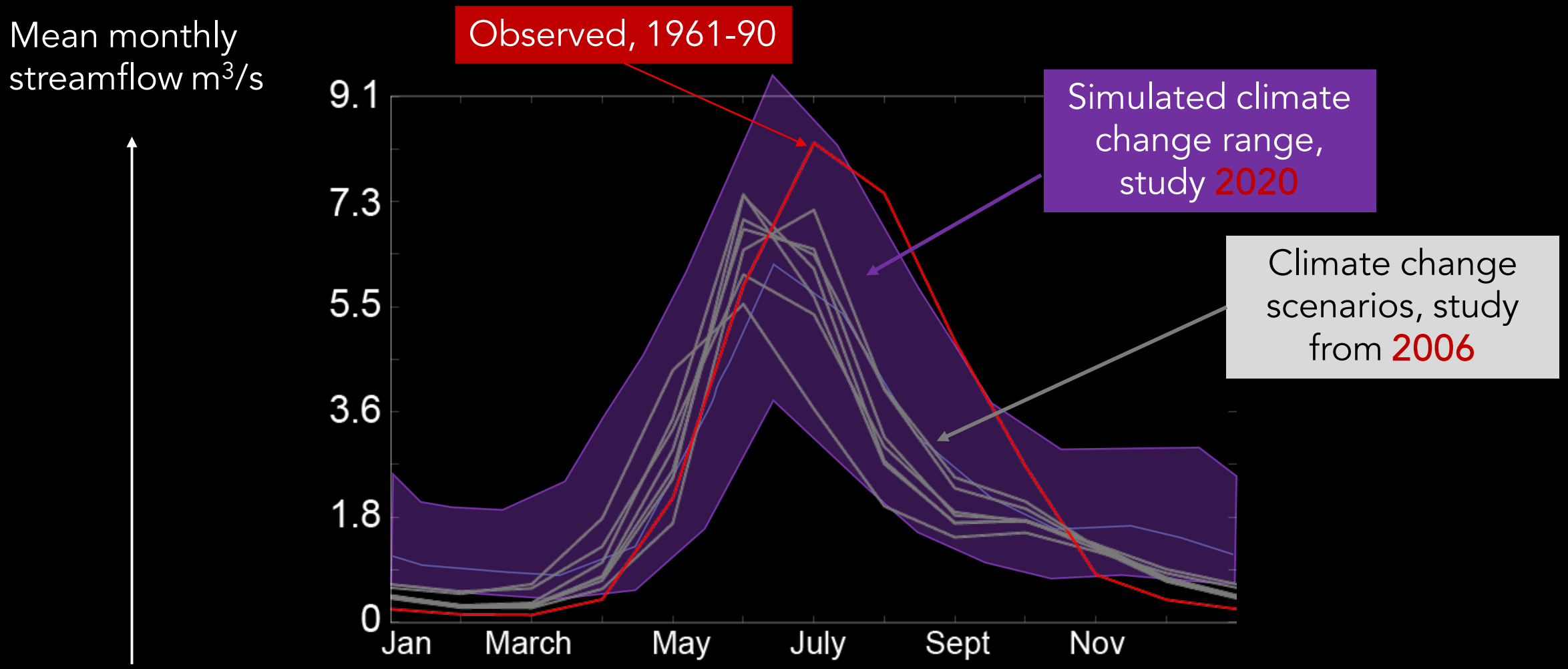
Days with fresh snow, 1981-2010
Observations, yearly mean

Days with fresh snow, **2085**, RCP 4.5
median, estimate, yearly mean



https://www.nccs.admin.ch

Monthly streamflow Rhone at Gletsch, 2070-2099



Hydromapscc.ch, Data and analysis:
Freudiger et al., UniZH, 2020

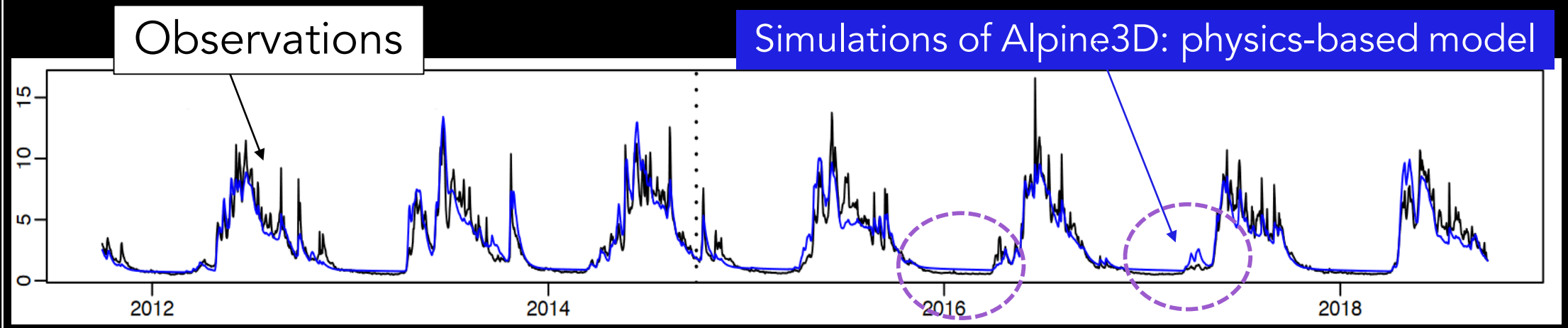

What we do not see
© Merlin Lightpainting

Quality of model simulations

Confidence in such simulations?

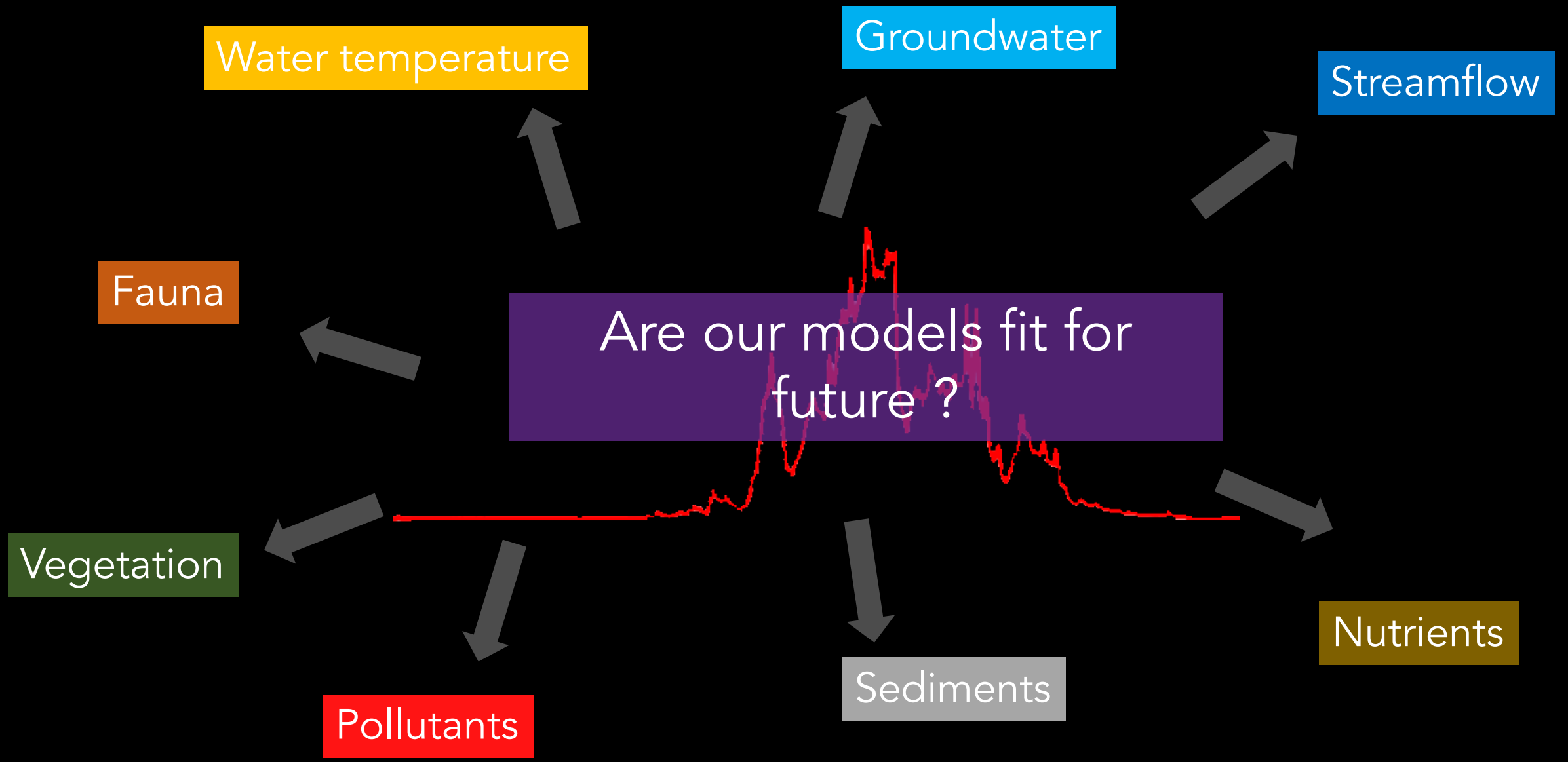
Daily streamflow mm/d

Models have systematic difficulties



Inn river, Michel et al., 2022, HESS

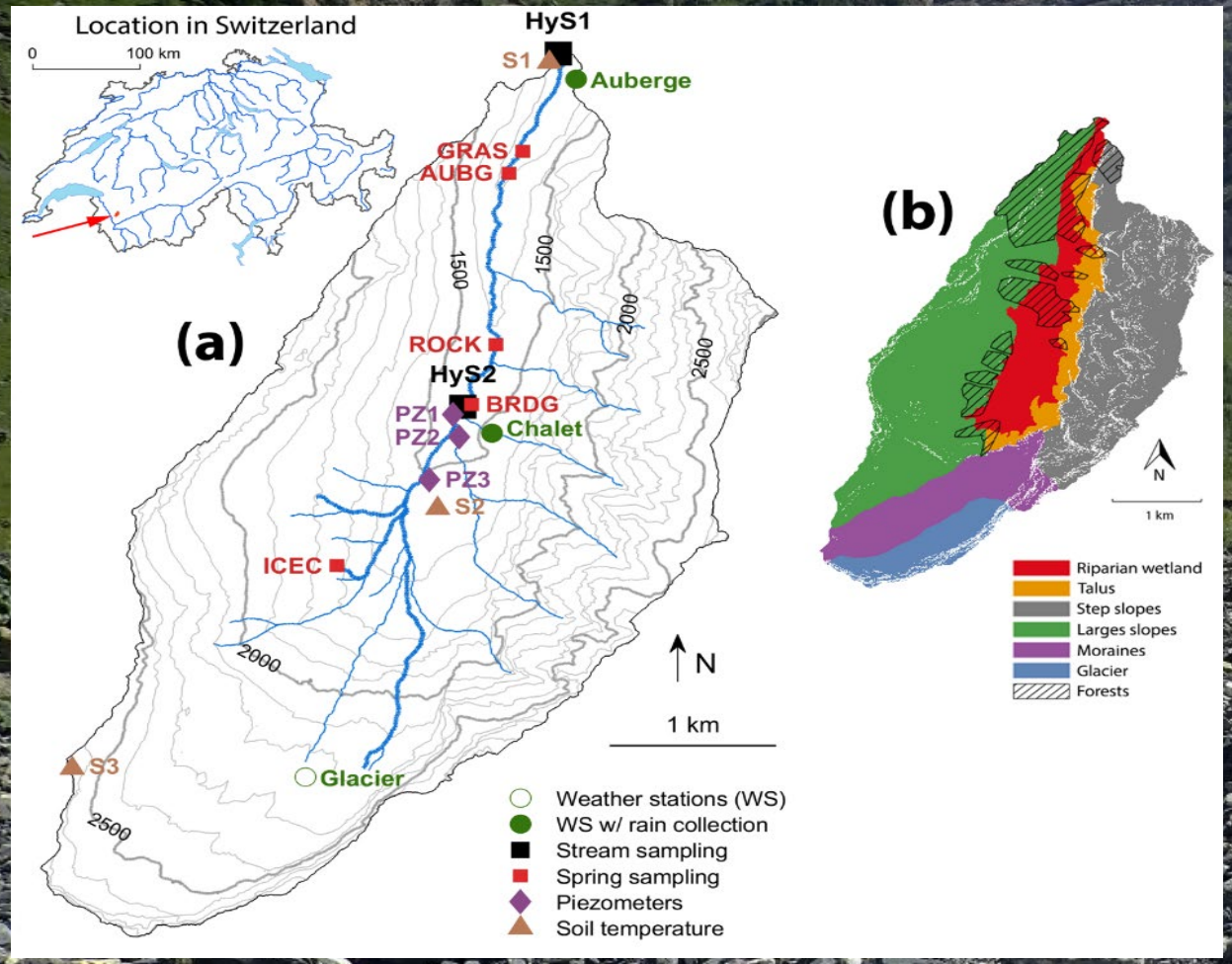
Is this a problem?


Water temperature
Groundwater
Streamflow
Fauna
Are our models fit for future ?
Vegetation
Nutrients
Pollutants
Sediments

What is wrong ?

- Snow accumulation and melt patterns ?
    - Winter melt ?
    - Melt on frozen ground ?
- Representation of melt water release from snowpack?
- Subsurface flow paths?
- Hillslope – stream network connectivity ?
- Surface-groundwater interactions ?

Example: Flowpaths dynamics in in the Vallon de Nant



Role of subsurface flow paths through the seasons?

14 $km^{2,}$ 1200 - 3051 m asl., small glacier

Michelon et al., 2023

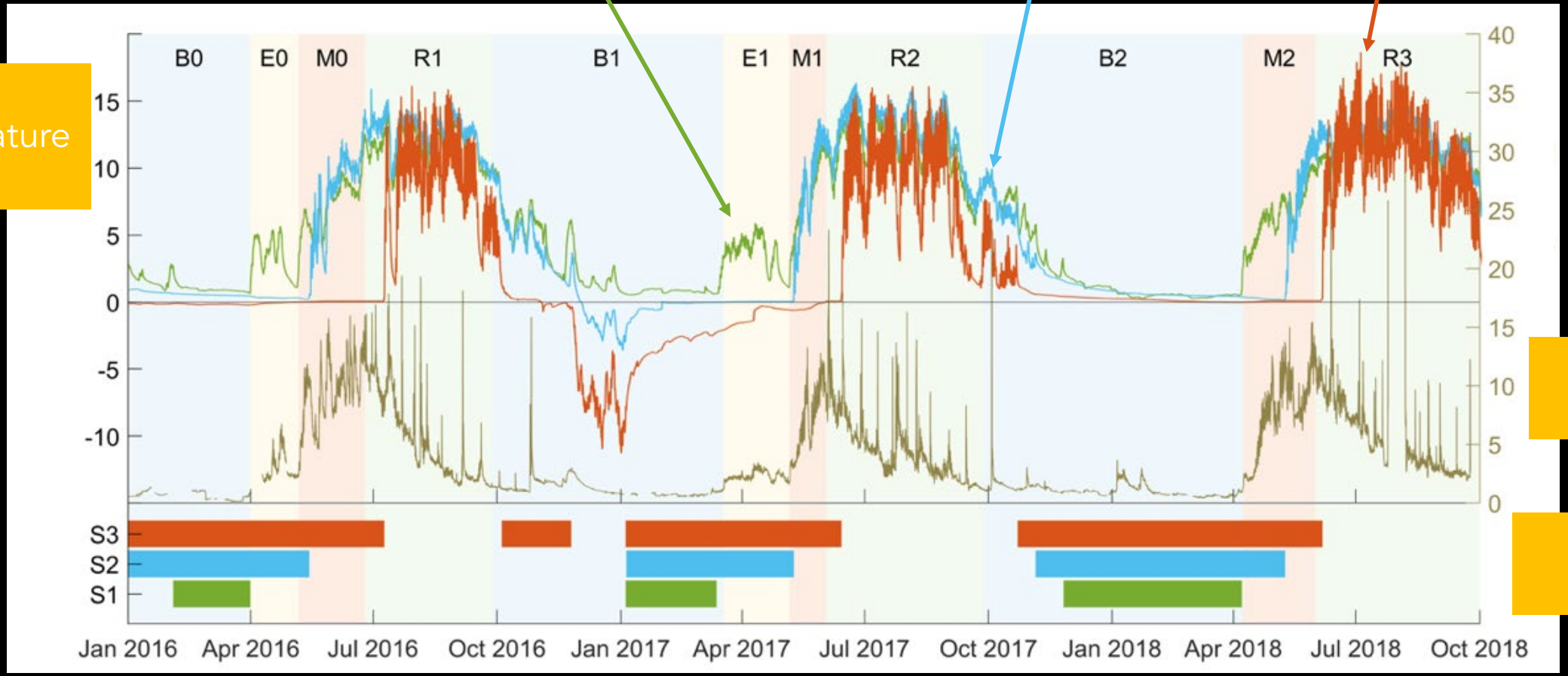
Value of soil temperature observations

Elevation 2640 m a.s.l.

Elevation 1530 m a.s.l.

Elevation 1240 m a.s.l.

Soil temperature °C



Streamflow mm/d

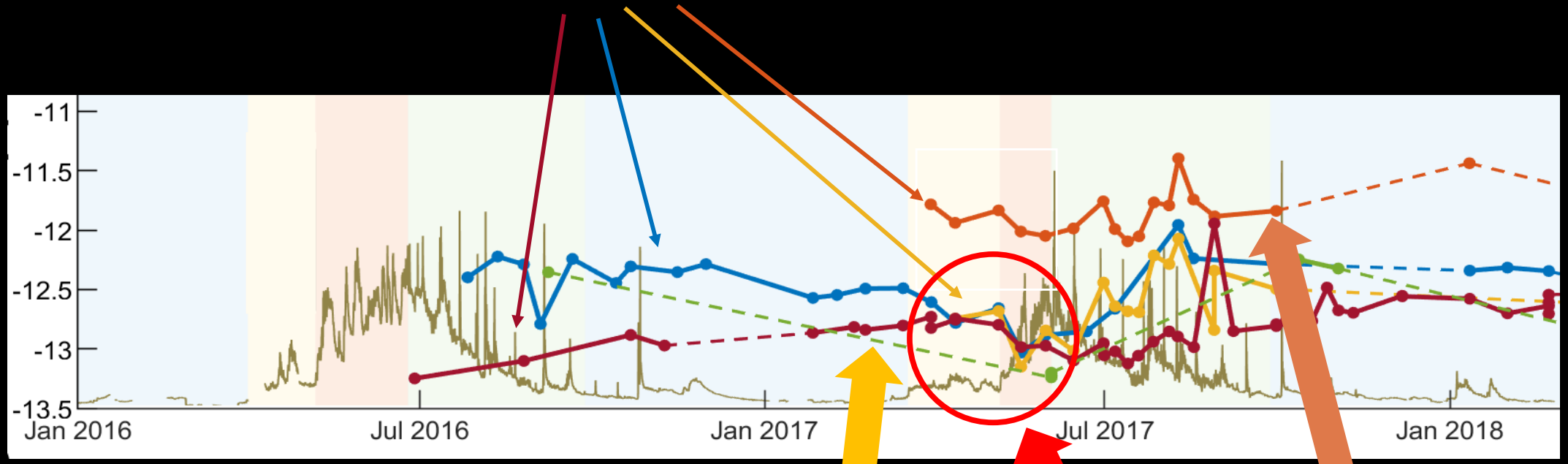
Snow cover presence

Michelon et al., 2023

Stable isotopes of water

$\delta^{18}O$ (‰)

Samples from different springs and shallow groundwater



Gradual change over winter: water input

… except for one

Reset of the subsurface during melt onset

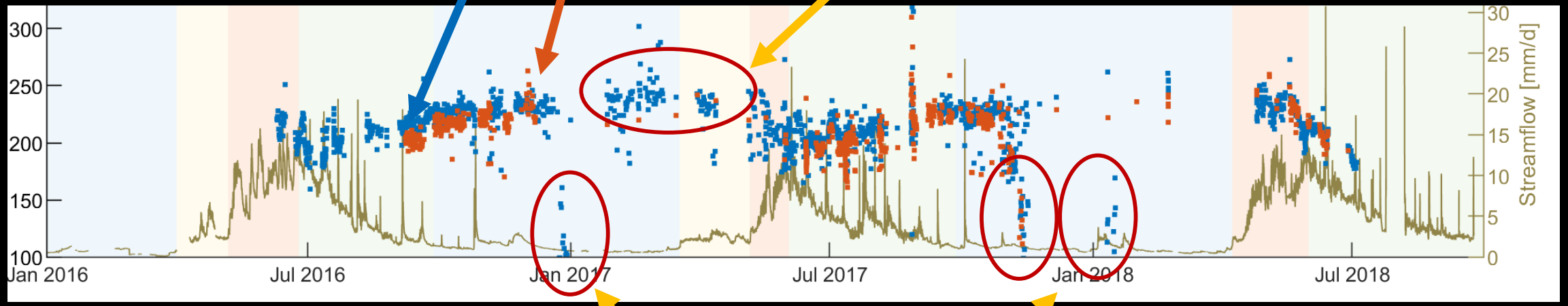
Michelon et al., 2023

Electrical conductivity (EC) in streamflow

Electrical conductivity µS/cm

Streamflow samples from two locations

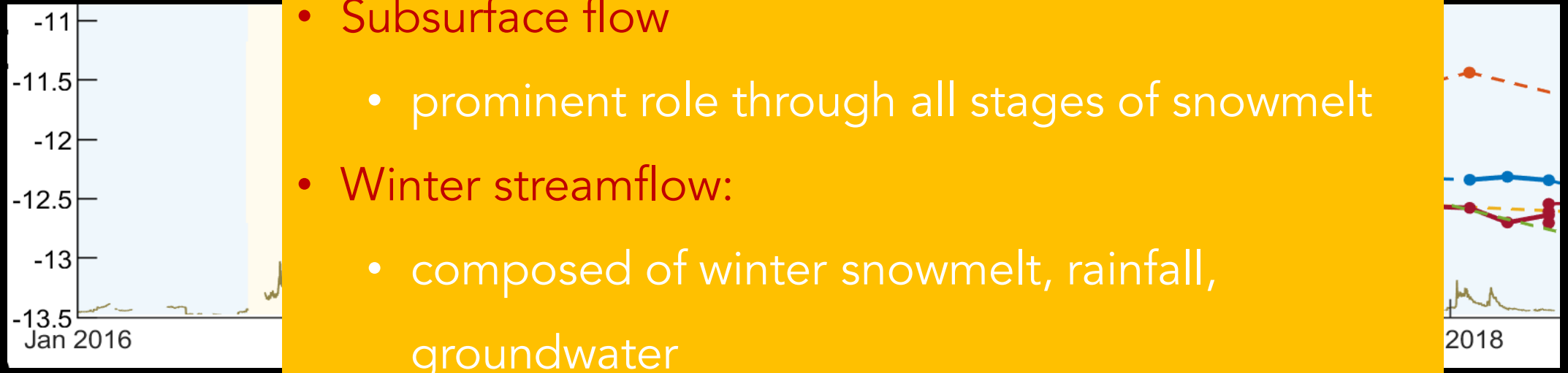
High values throughout the melt season: subsurface flow



Drop in EC during mid-winter rainfall events: rainfall on highly connected areas

Michelon et al., 2023

Stable isotopes of water



- Subsurface flow
  - prominent role through all stages of snowmelt
- Winter streamflow:
  - composed of winter snowmelt, rainfall, groundwater

Michelon et al., 2023

Take home Vallon de Nant

- Understanding water flow paths with tracers at high-elevation:
  - Sampling before melt onset : baseline
  - Water temperature
    - subsurface connectivity: disentangle EC values from shallow vs deeper flow paths

- Winter melt & winter subsurface runoff: more present than what we think?
  - Conditions hydrologic response during melt period
  - … and groundwater recharge at the annual scale.

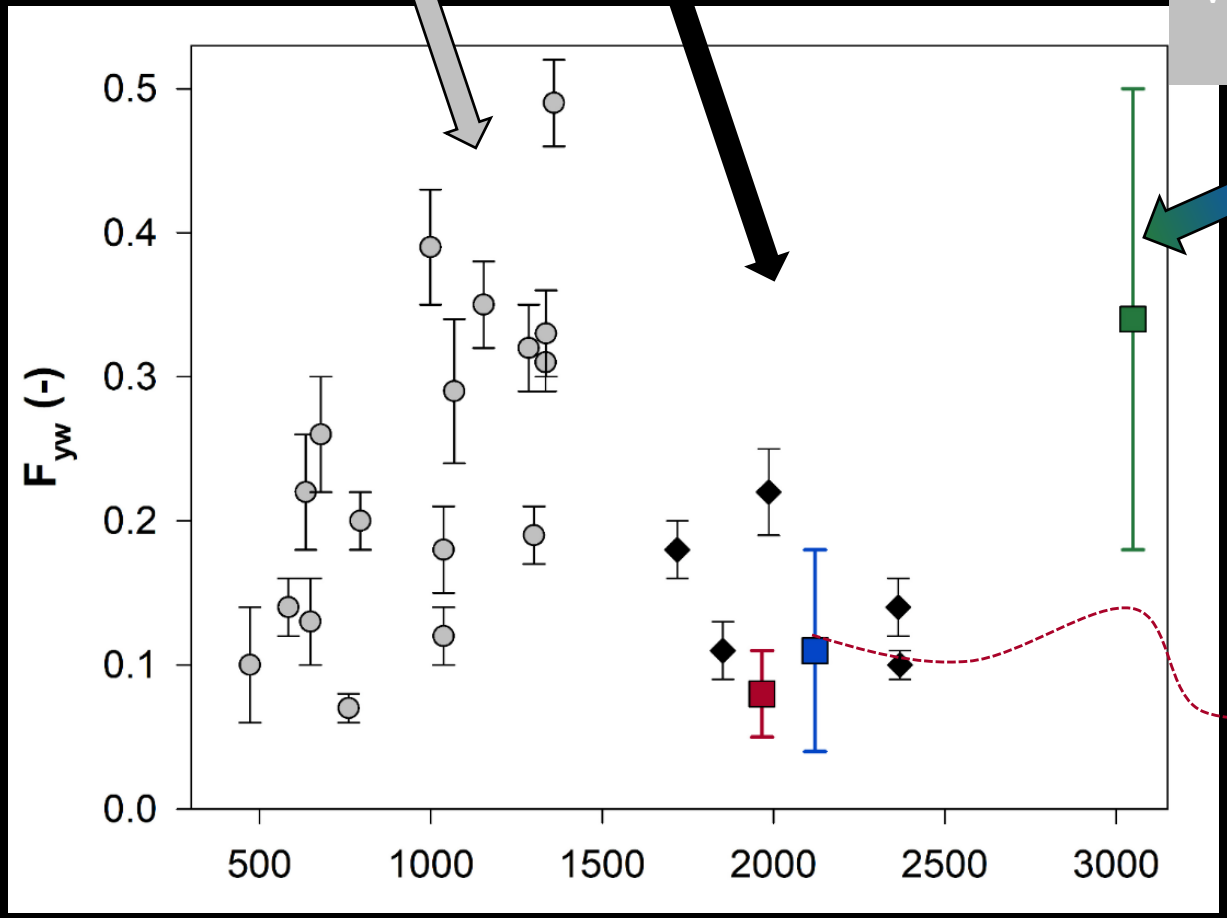
Prominent role of subsurface flow confirmed by water age

Values from von Freyberg et al., 2018

Values from Ceperley et al., 2020

Young water fractions (Kirchner, 2016)

Water younger than 2-3 months



Vallon de Nant

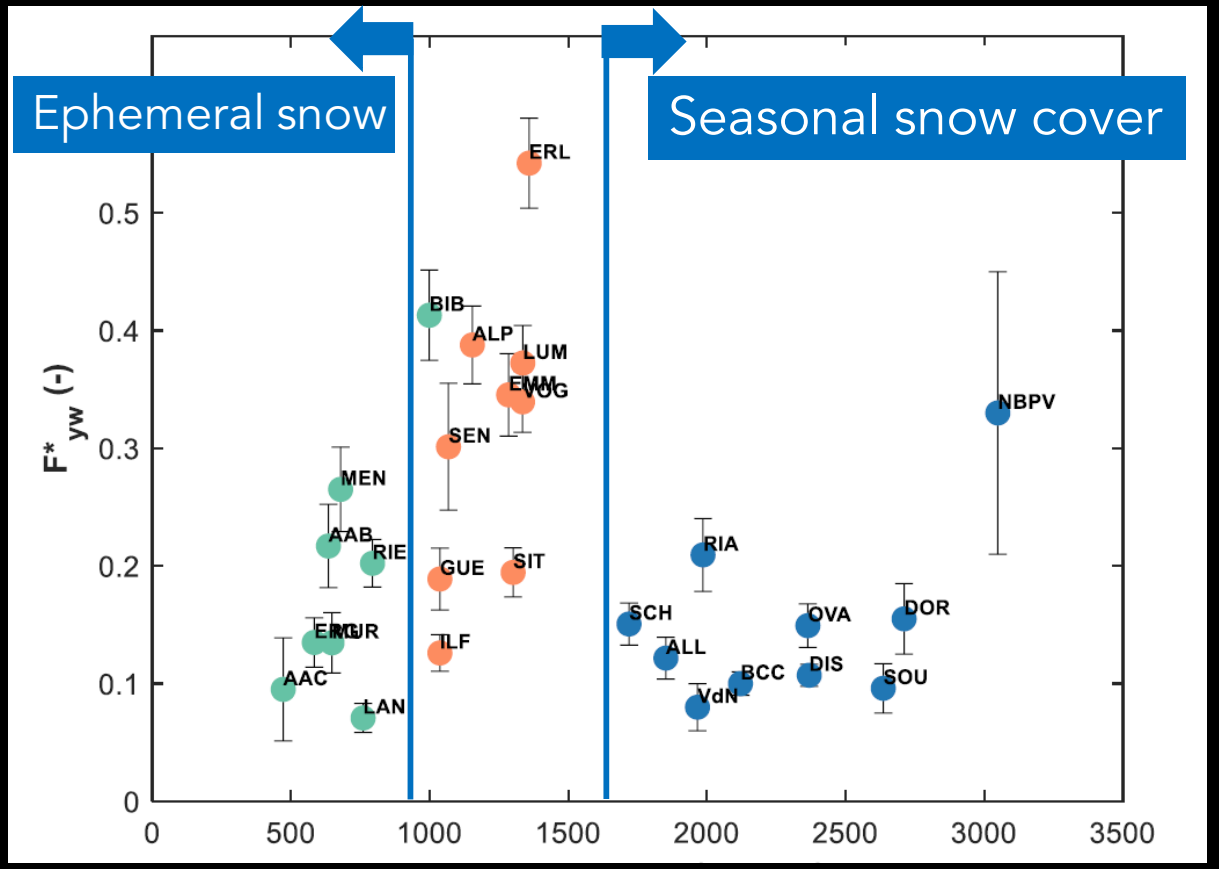
Ceperley et al., 2020, Hydrol. Proc.

Prominent role of subsurface flow confirmed by water age

Young water fractions (Kirchner, 2016)

Water younger than 2-3 months

Gentile et al., 2022, in revision



Mean catchment elevation

Little young water at high elevations: subsurface storage !

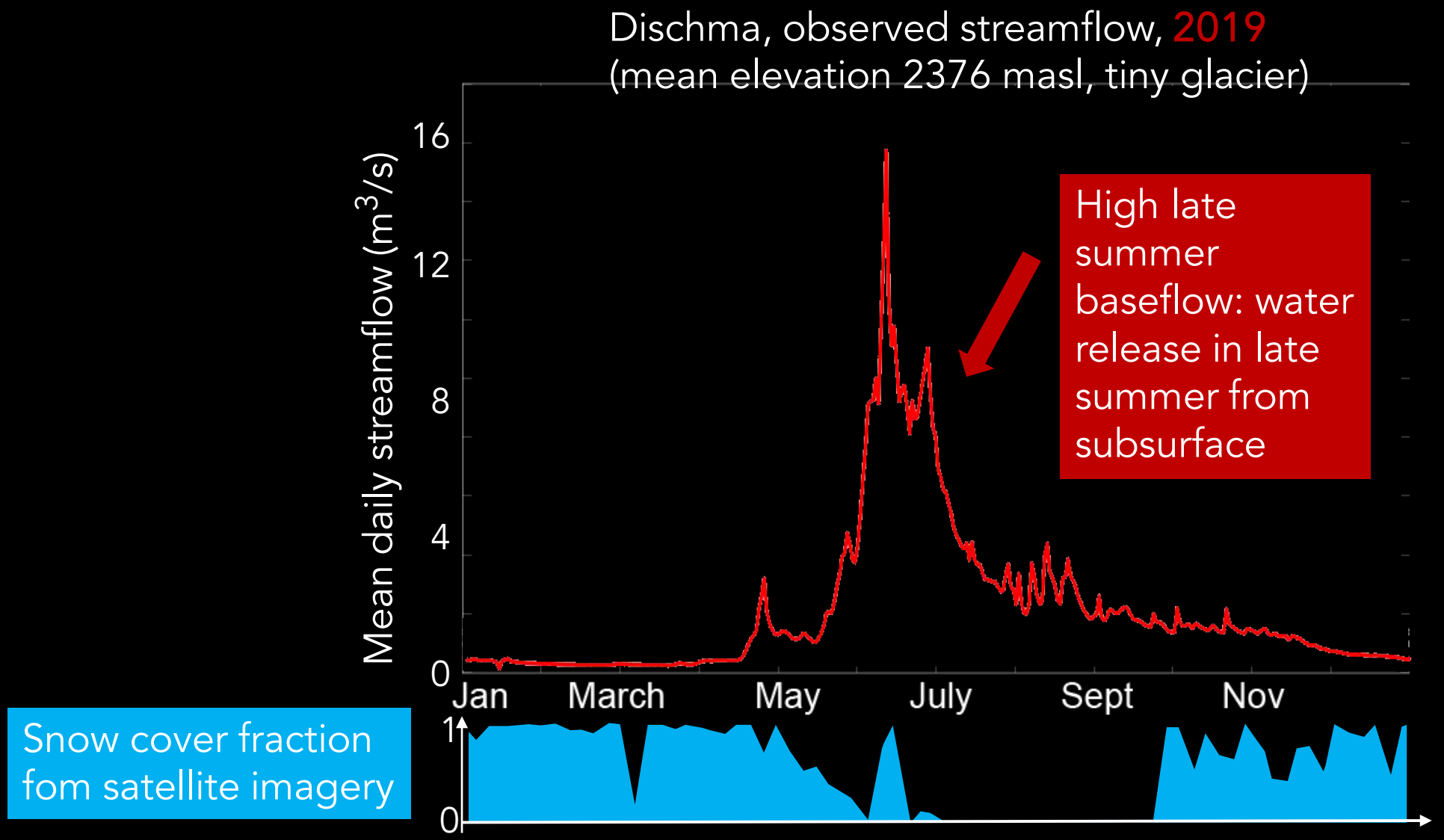
EGU23-1230 | Orals | HS2.2.7

What explains low young water fractions at high elevations?

Alessio Gentile, Davide Canone, Natalie Ceperley, Davide Gisolo, Maurizio Previati, Giulia Zuecco, Bettina Schaefli, and Stefano Ferraris

Thu, 27 Apr, 09:40–09:50 Room C

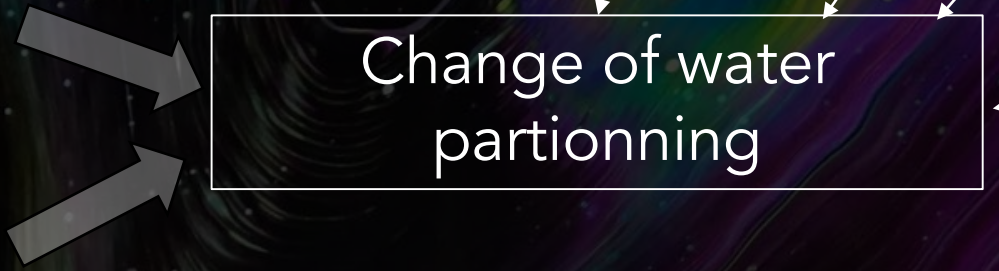
What do young water fractions tell us ?



Conclusion

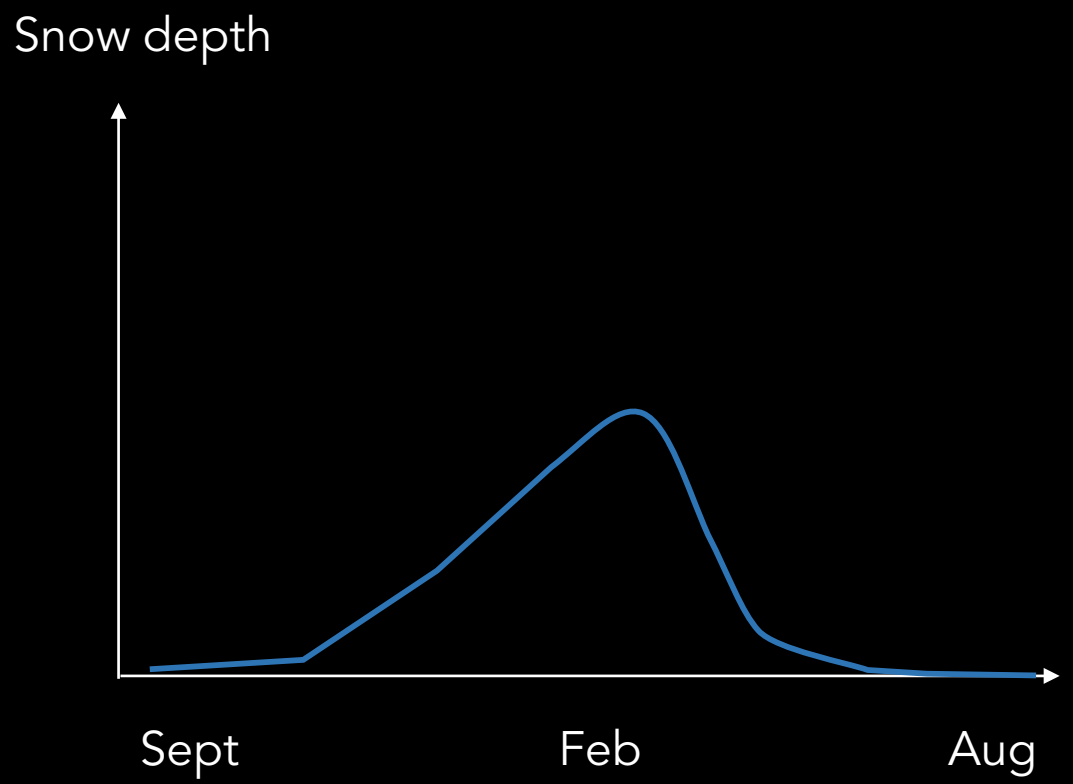
Transition from seasonal to ephemeral snow

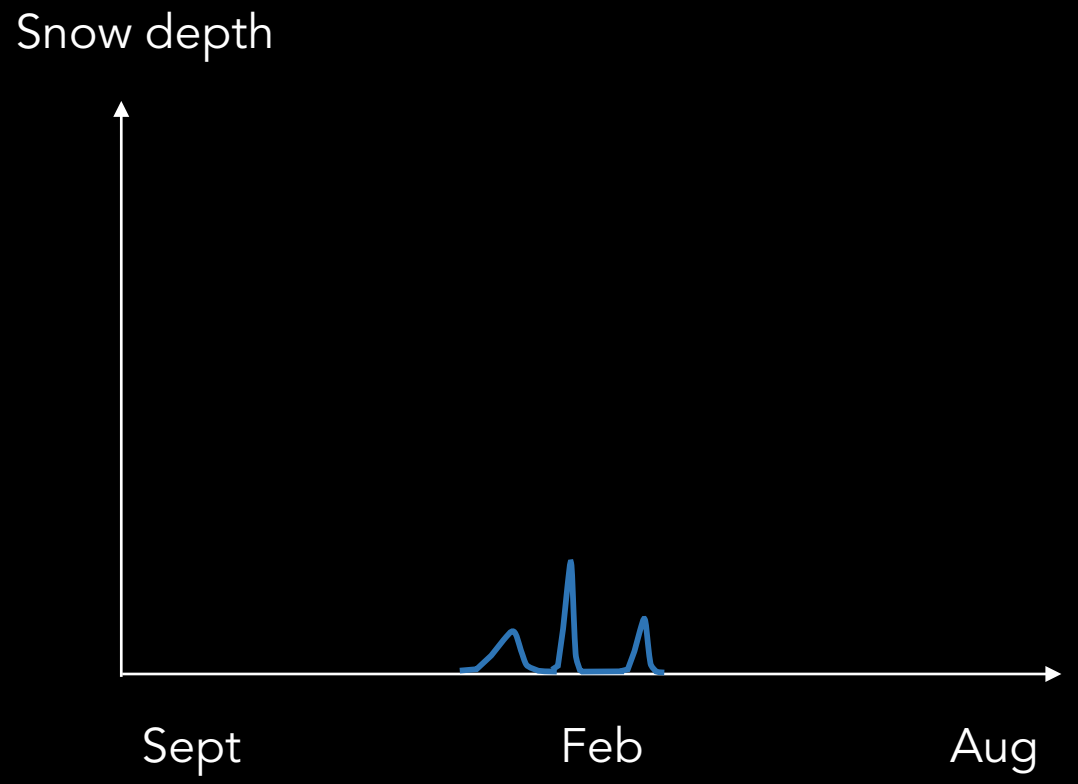
Transition from glacier-covered to no glacier

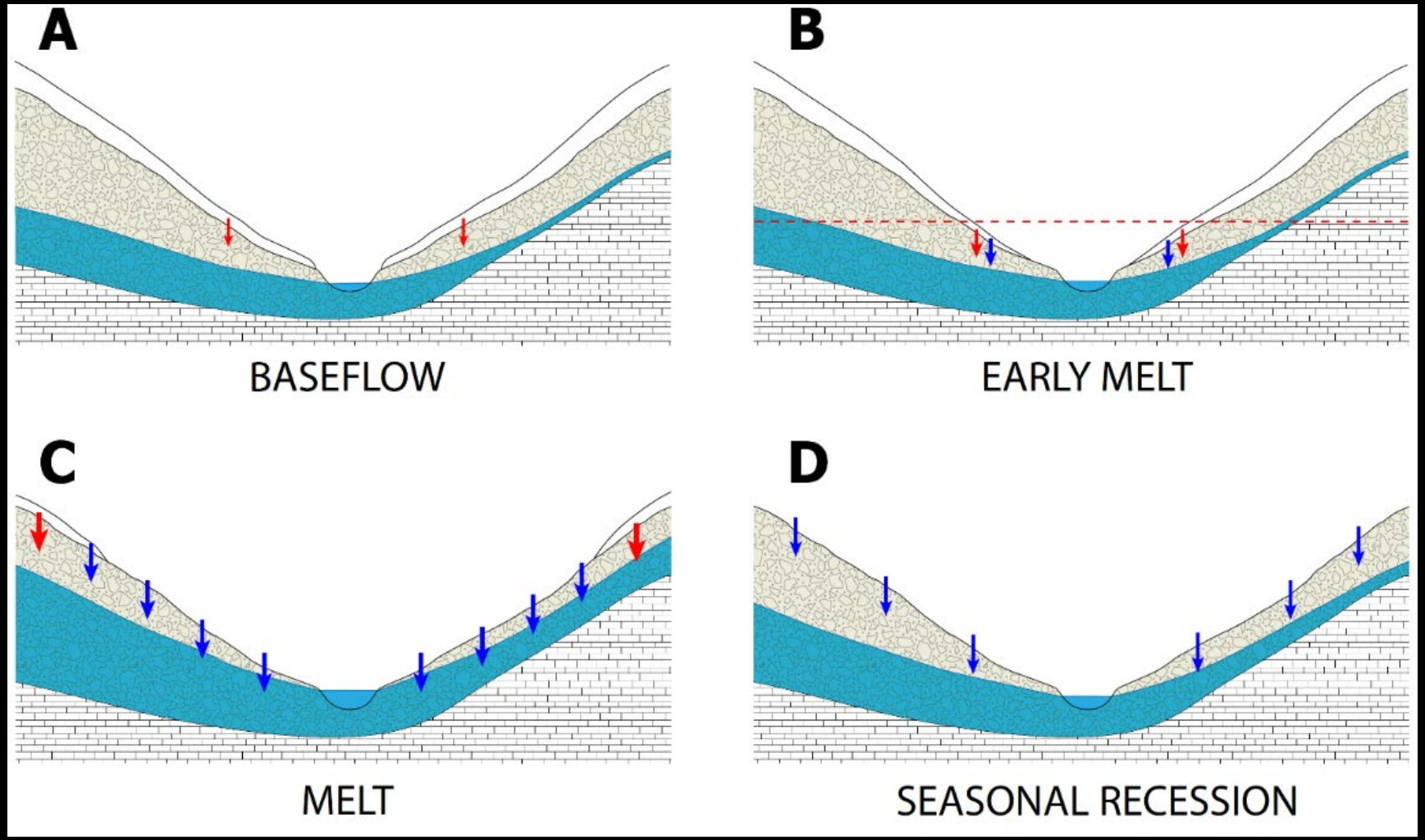


No simple “warming-induced” upshift of models developed for lower elevations

Transition from **seasonal** ⇨ to **ephemeral** snow cover







Michelon et al., 2023