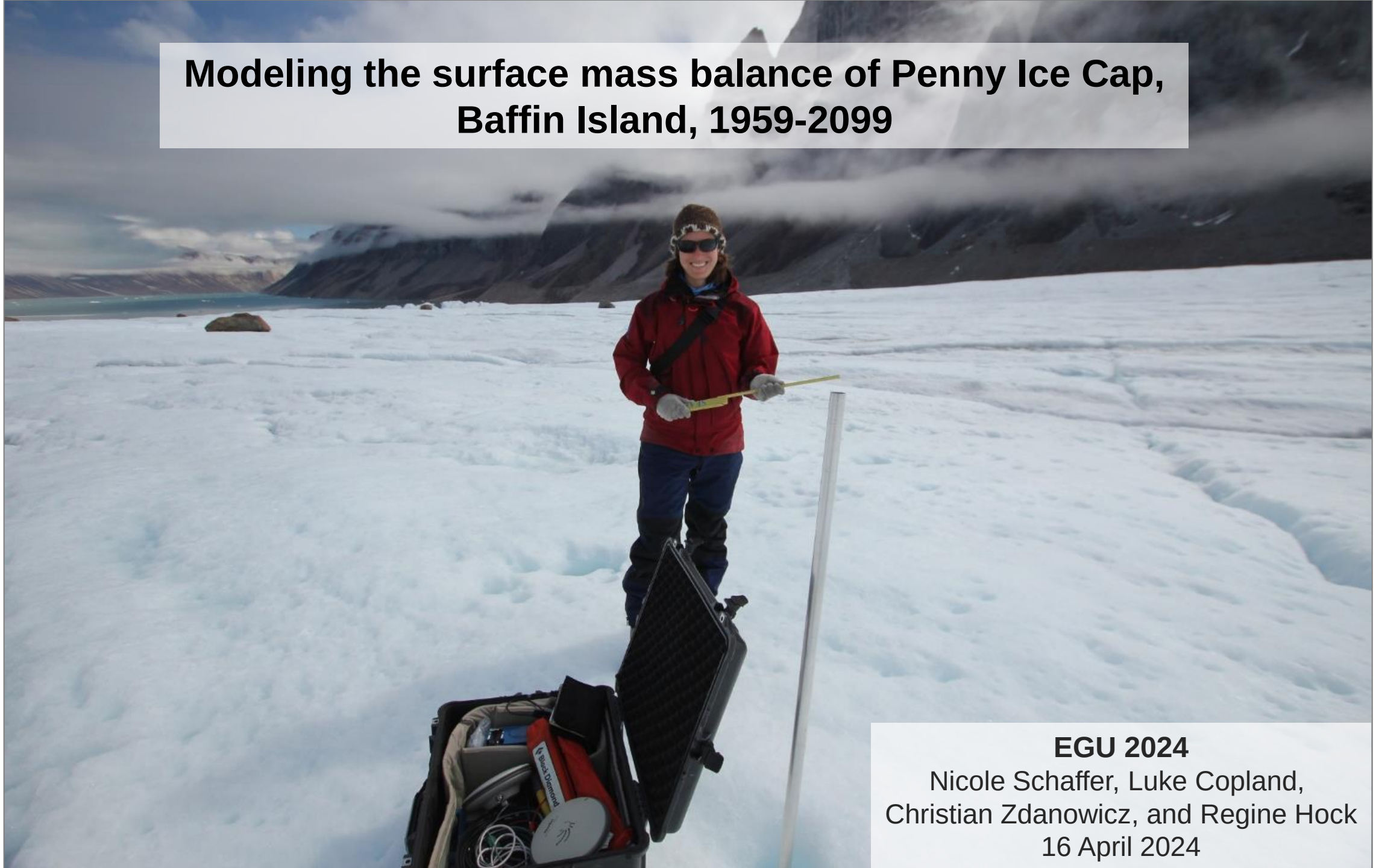
Modeling the surface mass balance of Penny Ice Cap, Baffin Island, 1959-2099



EGU 2024
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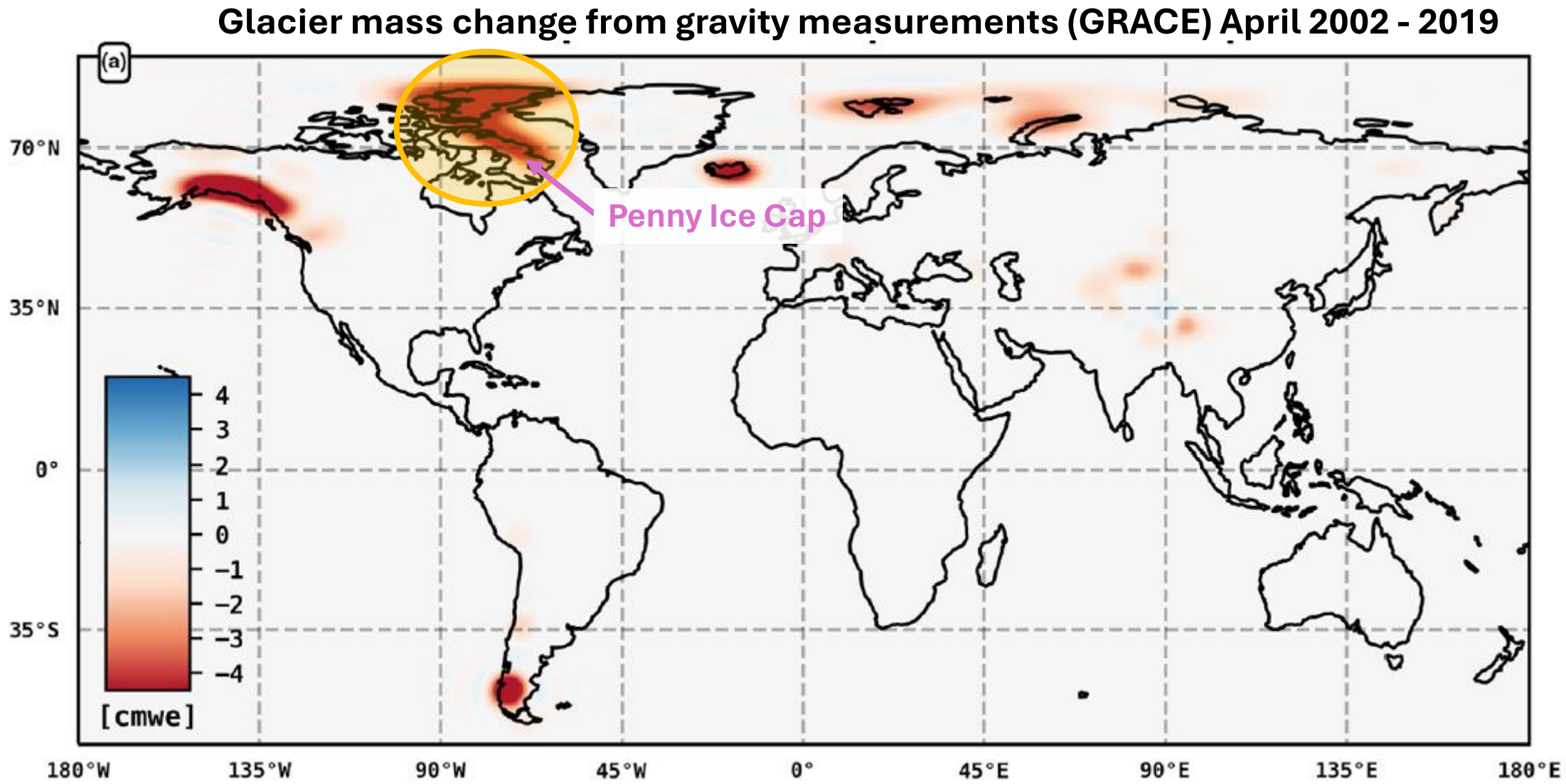
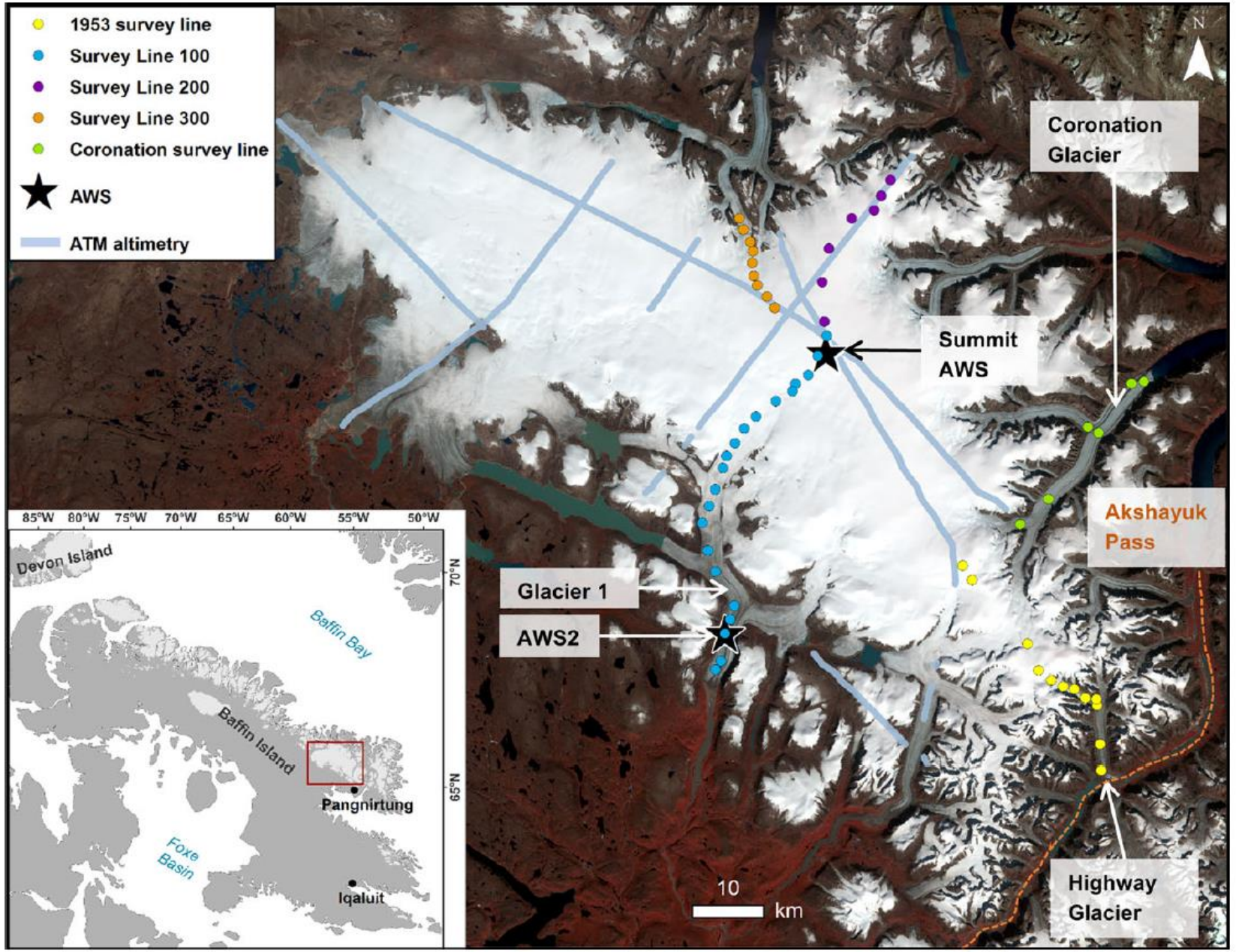
Christian Zdanowicz, and Regine Hock
16 April 2024

Context



(Ciraci et al., 2020)

Penny Ice Cap (PIC), Southern Canadian Arctic (67°N, 66°W)



Study site

- ~6300 km^2 in area
- Summit ~1930 m a.s.l.
- ELA ~1646 m a.s.l.
- Mean SMB -1.2 m w.e.a., 3-4 m^{-1} at low elevations

In situ measurements

- AWS
- SMB data along four survey lines
- ATM altimetry data

Objectives and methodology

How has the mass balance of PIC changed since 1959, and how will it evolve over the remainder of this century?

- Used an enhanced temperature-index model calibrated with in situ data from 2006-2014
- Modeled the SMB of PIC from 1959 to present day
- Projected changes to 2099 based on the RCP4.5 climate scenario

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$$B = C - A - Af$$

glacier-wide Surface mass balance

accumulation

ablation

Frontal ablation (calving)

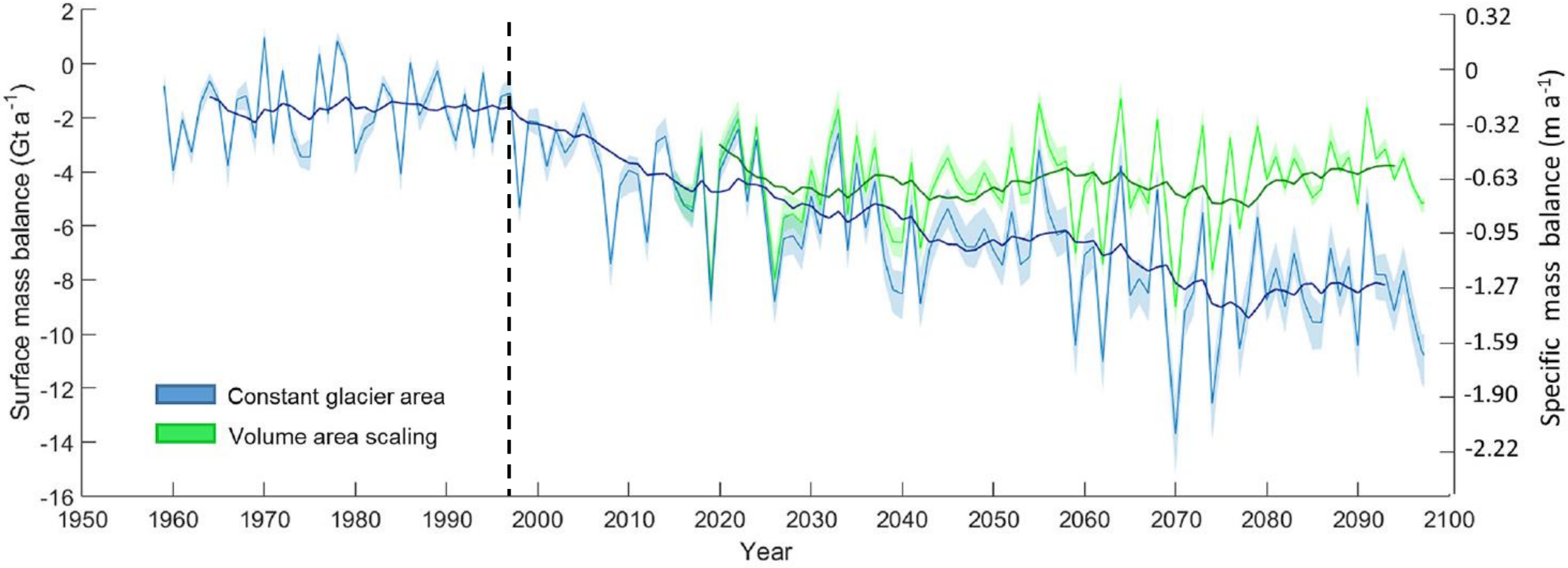
$$c = \delta\, p \begin{cases} \delta = 1, & T \le T_{snow} - 1 \\ \delta = \dfrac{T_{snow}}{2}, & T_{snow} - 1 < T < T_{snow} + 1 \\ \delta = 0, & T \ge T_{snow} + 1 \end{cases}$$

$$a = \begin{cases} (F_m + F_{r\,snow/ice} I)T, & T > 0 \\ 0, & T \le 0 \end{cases}$$

Calibrated with in situ data

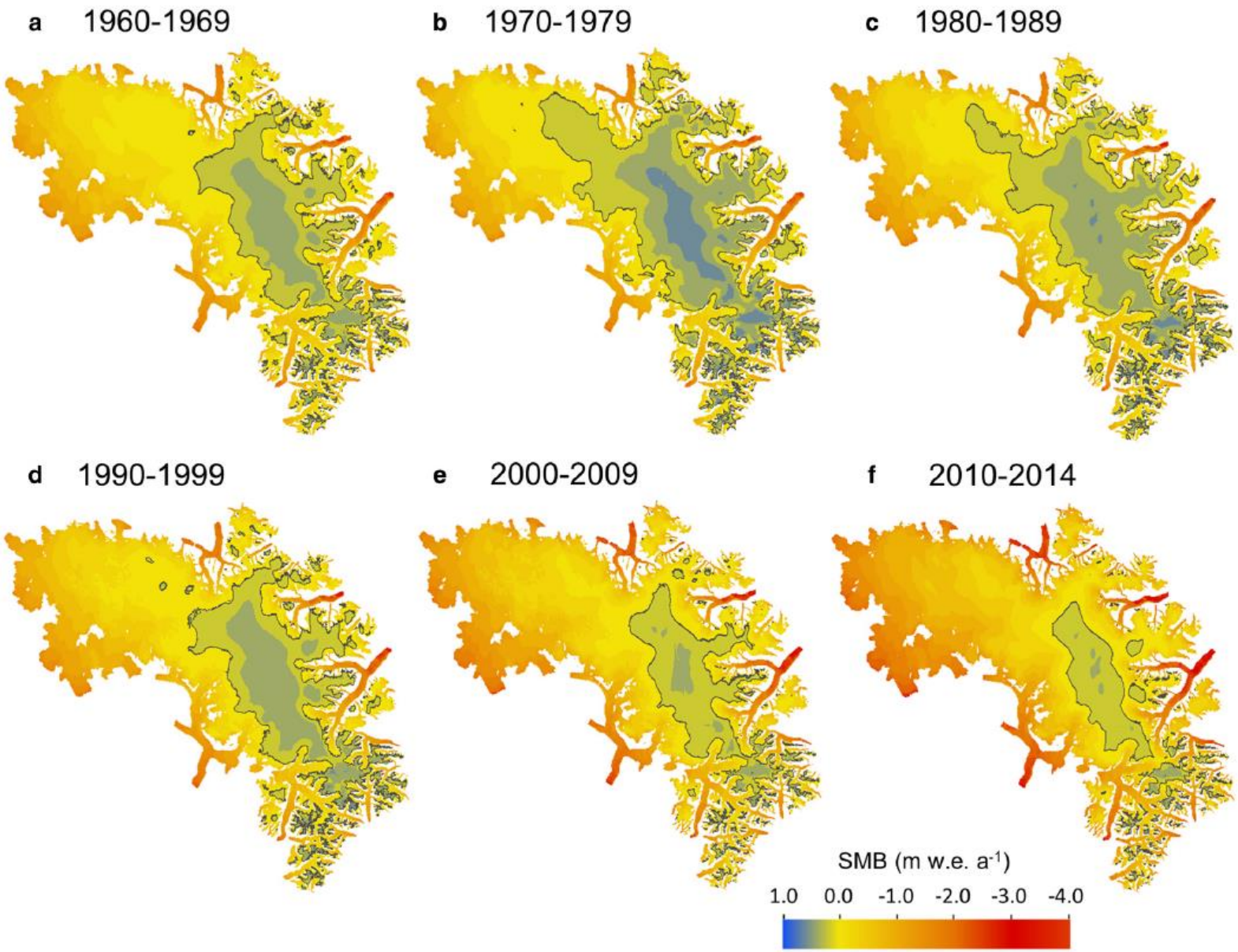
(DETIM; Hock, 1999; https://regine.github.io/meltmodel/)

Results – SMB modeling

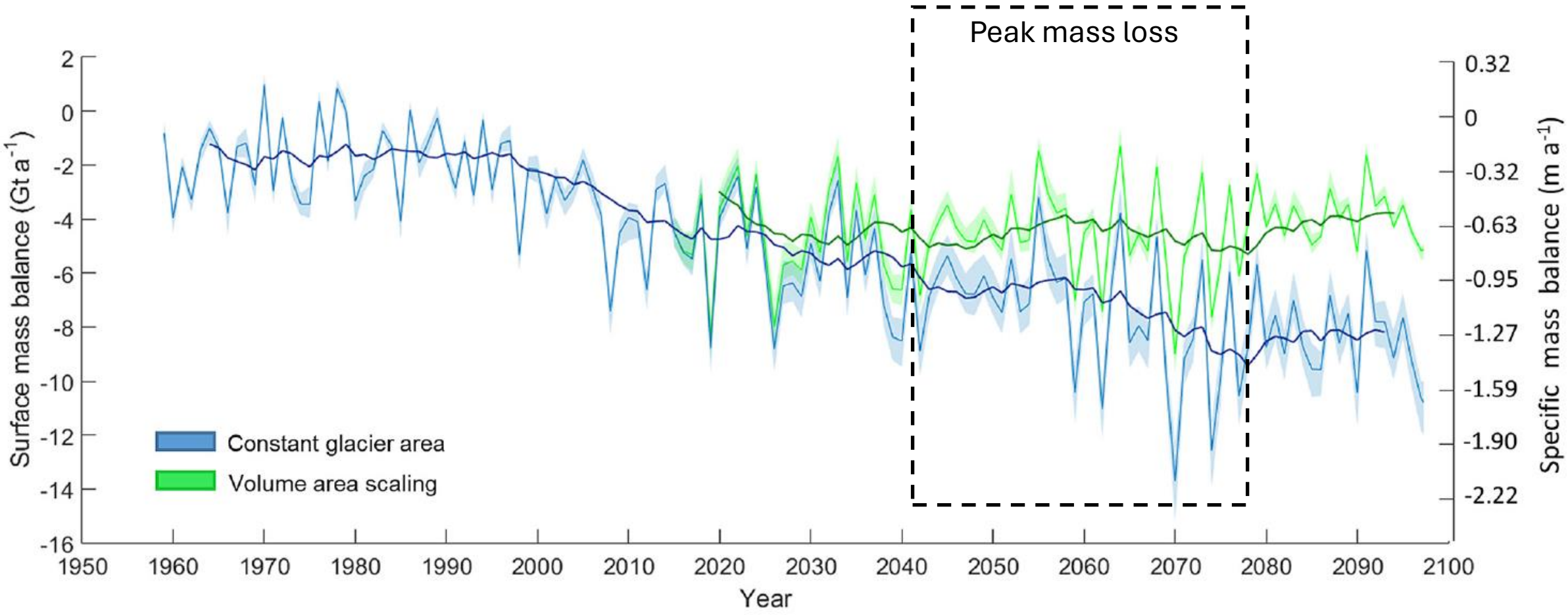


- Increasingly negative mass balance rates since the mid-1990s

Results – SMB modeling

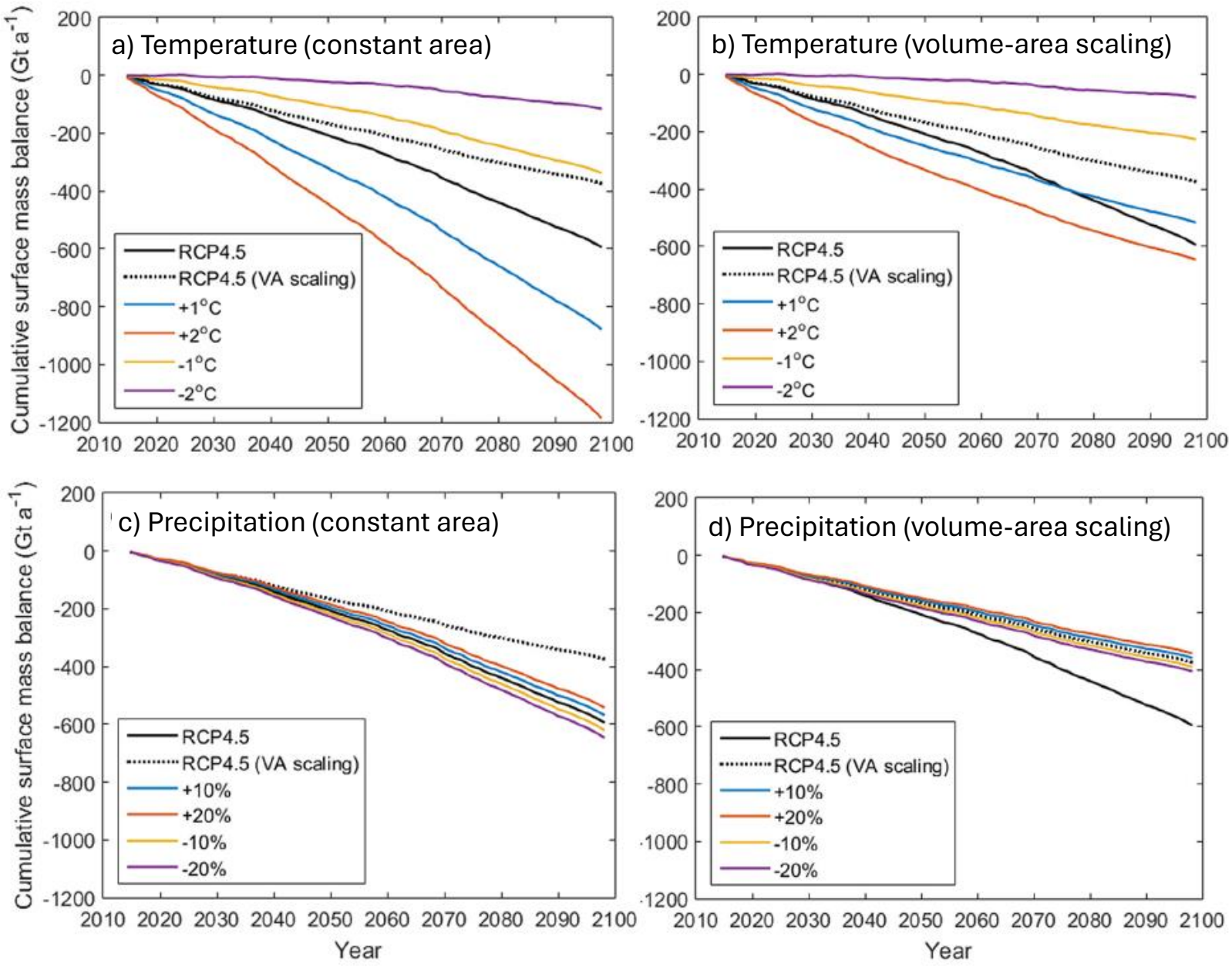


Results – SMB modeling



- Increasingly negative mass balance rates since the mid-1990s
- Peak mass loss projected to occur between ~2040 and 2080
- PIC expected to lose 22-35% of its initial 2014 ice volume by 2099 and disappear entirely between the early 2200s and mid-2400s (RCP 4.5 scenario)

Results – sensitivity analysis



Sensitivity analysis

- projections are ~ 9 times more sensitive to changes in temperature than precipitation
- With an additional 2°C warming, PIC is expected to lose ~37-68% of its initial 2014 ice volume by 2099.

Summary and Conclusions

- The mass loss on PIC has been increasingly negative since the mid-1990s
- Peak mass loss projected to occur between ~2040 and 2080
- PIC expected to lose ~22-35% of its initial 2014 ice volume by 2099 and disappear entirely between the early 2200s and mid-2400s (RCP 4.5 scenario)
- Projections are far more sensitive to changes in temperature than precipitation
- With an additional 2°C warming, PIC is expected to lose ~37-68% of its initial 2014 ice volume by 2099.

THANK YOU!
Qujannamiik!

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References

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