Seasonal progression of melt and snowlines in Alaska from SAR reveals impacts of warming

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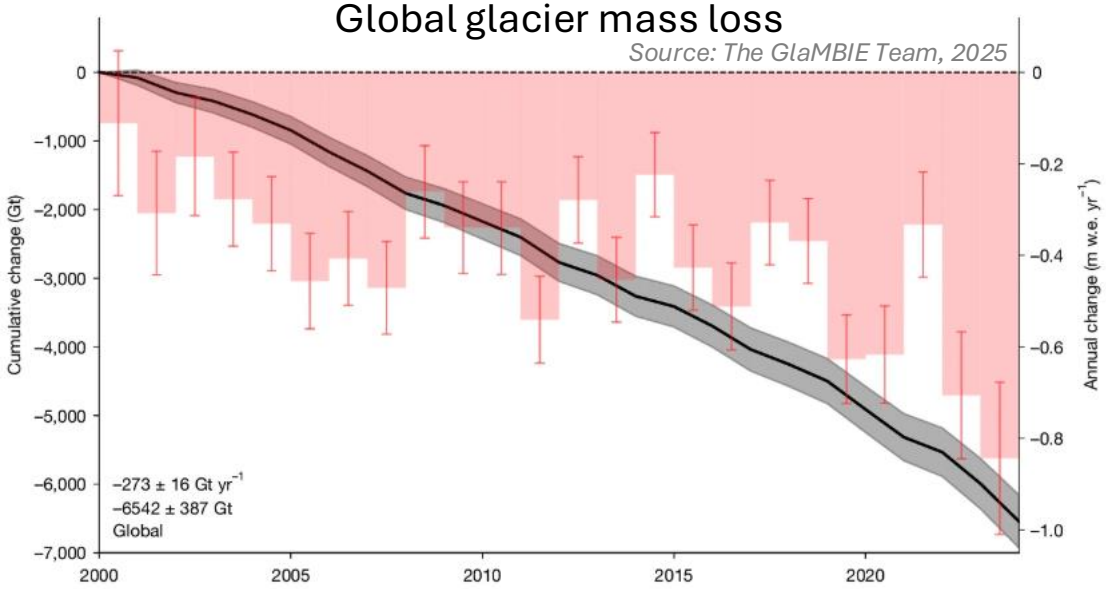
Nizina Glacier, Alaska, 2022

Future advances in glaciology benefit from scalable (sub)seasonal observations

Global glacier mass loss

Source: The GlaMBIE Team, 2025



Synthetic aperture radar (SAR) has potential to reliably observe glaciers at weekly resolution, which is key towards understanding sub-seasonal glacier processes and as calibration for large-scale models

- Sentinel-1 SAR has a 12-day repeat (and two satellites)
- SAR penetrates clouds and doesn't require daylight
- SAR "backscatter" depends solely on physical properties of the surface

DEM differencing

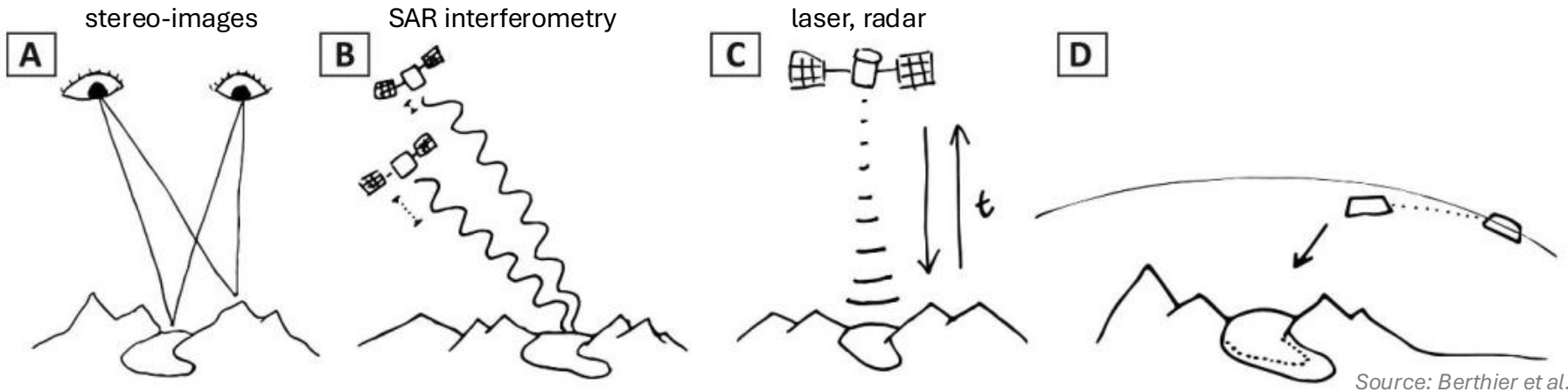
stereo-images

SAR interferometry

Altimetry

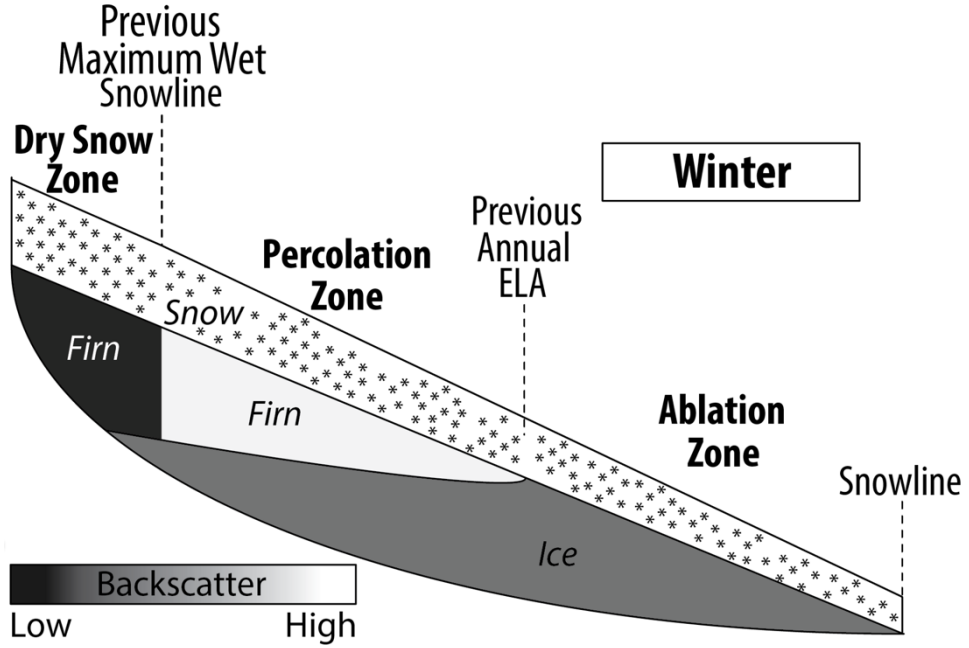
laser, radar

Gravimetry



Source: Berthier et al., 2023

Backscatter indicates glacier surface properties

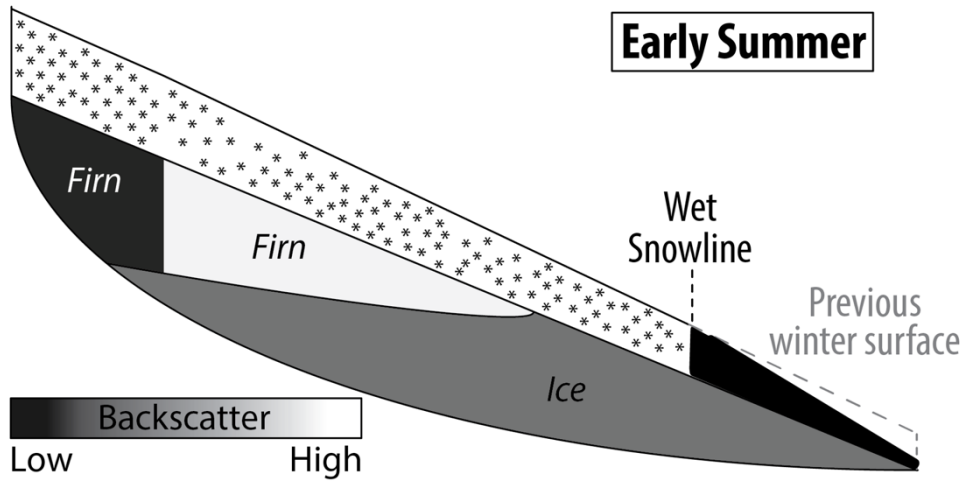


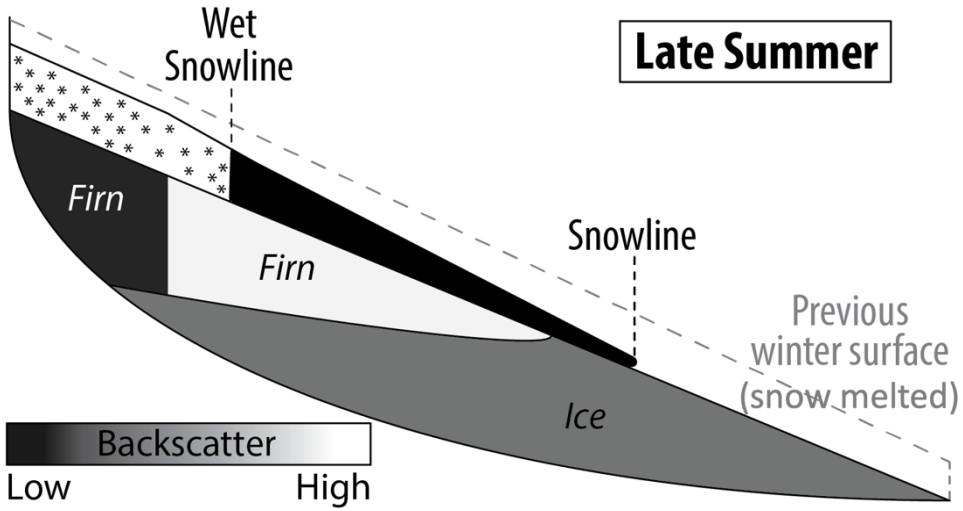
Dry snow allows microwave signal to penetrate surface several meters

Liquid water on surface absorbs signal causing low backscatter

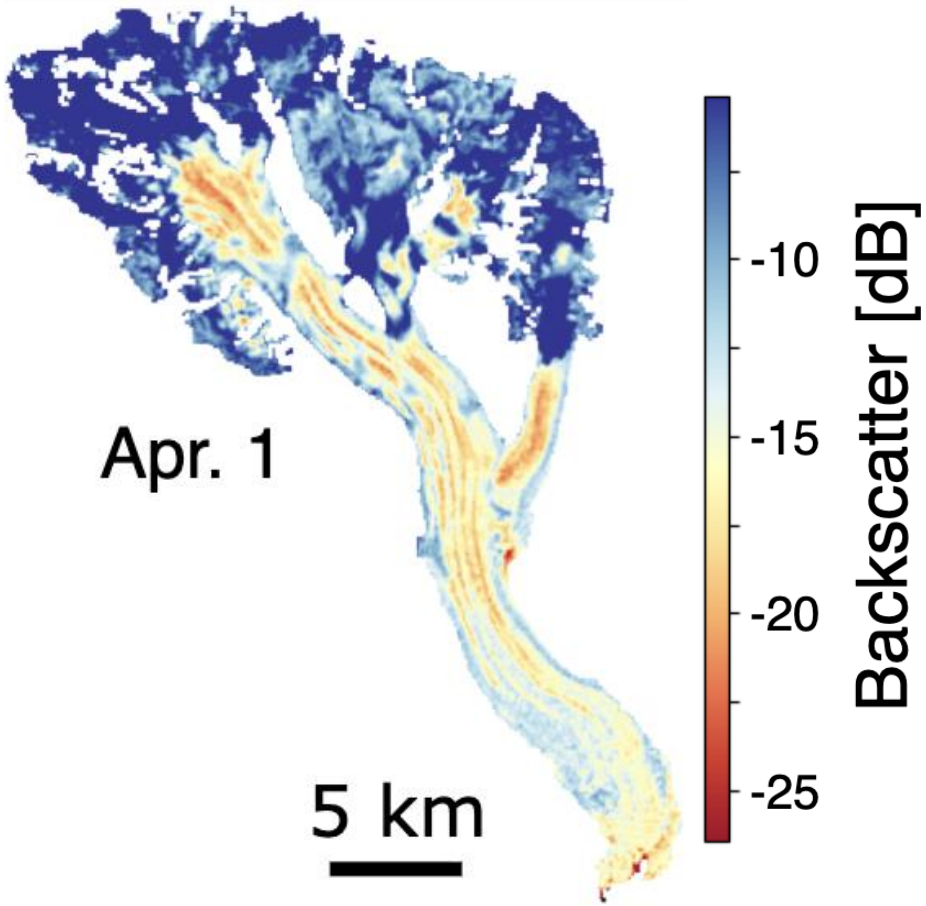
Winter backscatter reveal glacier zones due to characteristic differences

Melt extents apparent from drop in backscatter as liquid is on surface





Spatially-distributed backscatter varies seasonally



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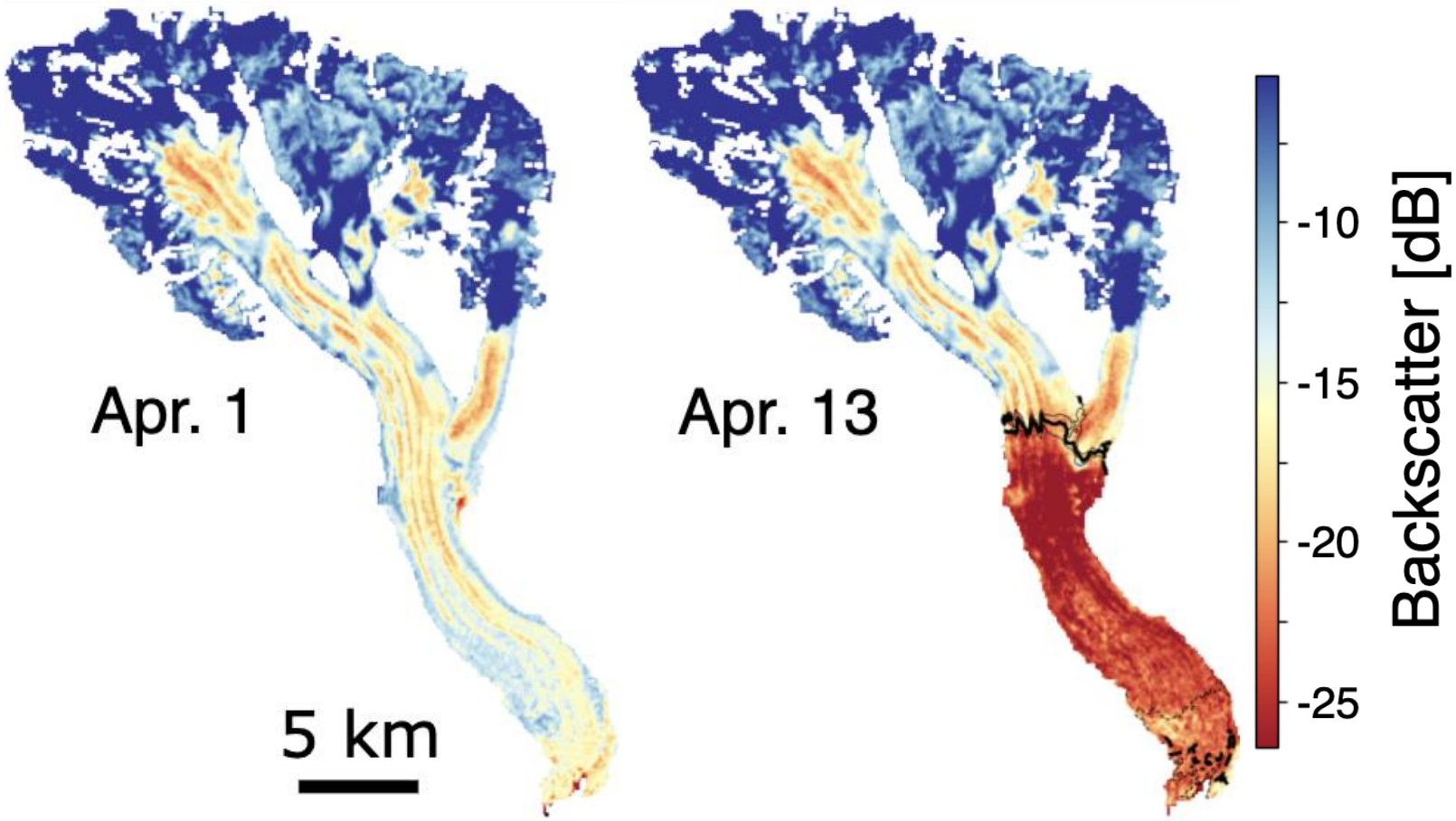

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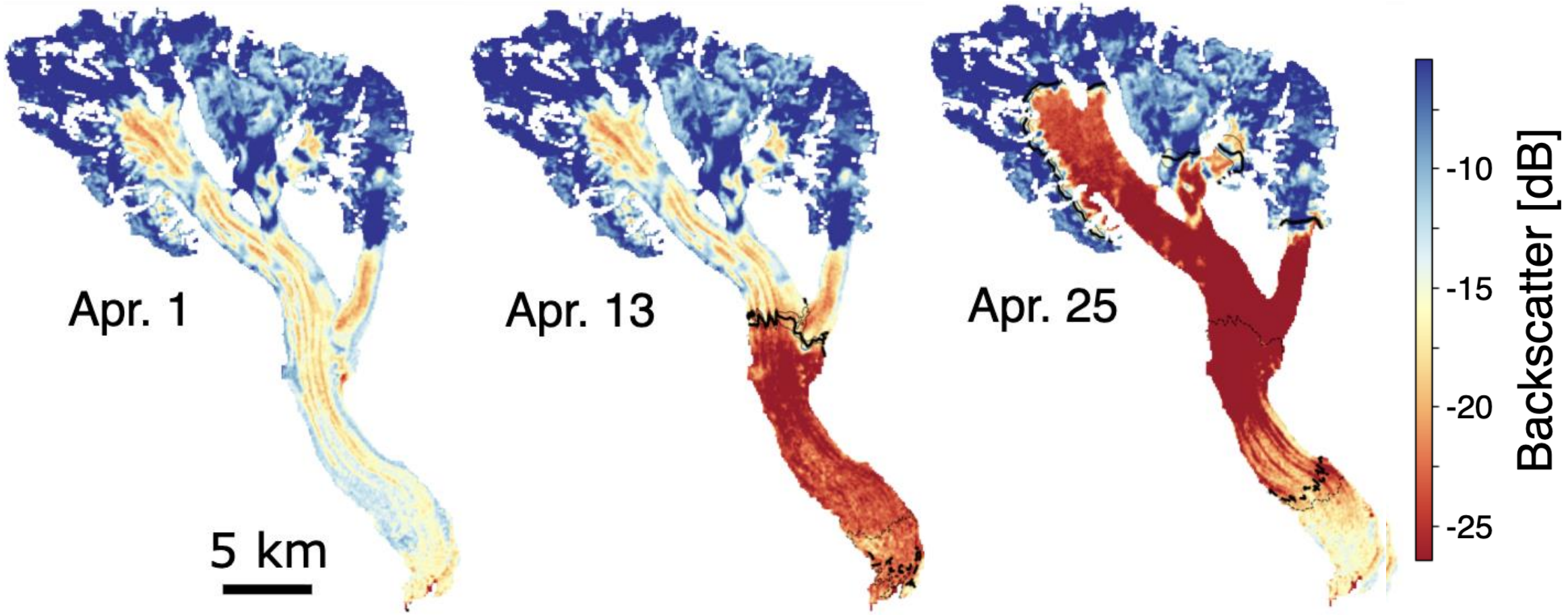

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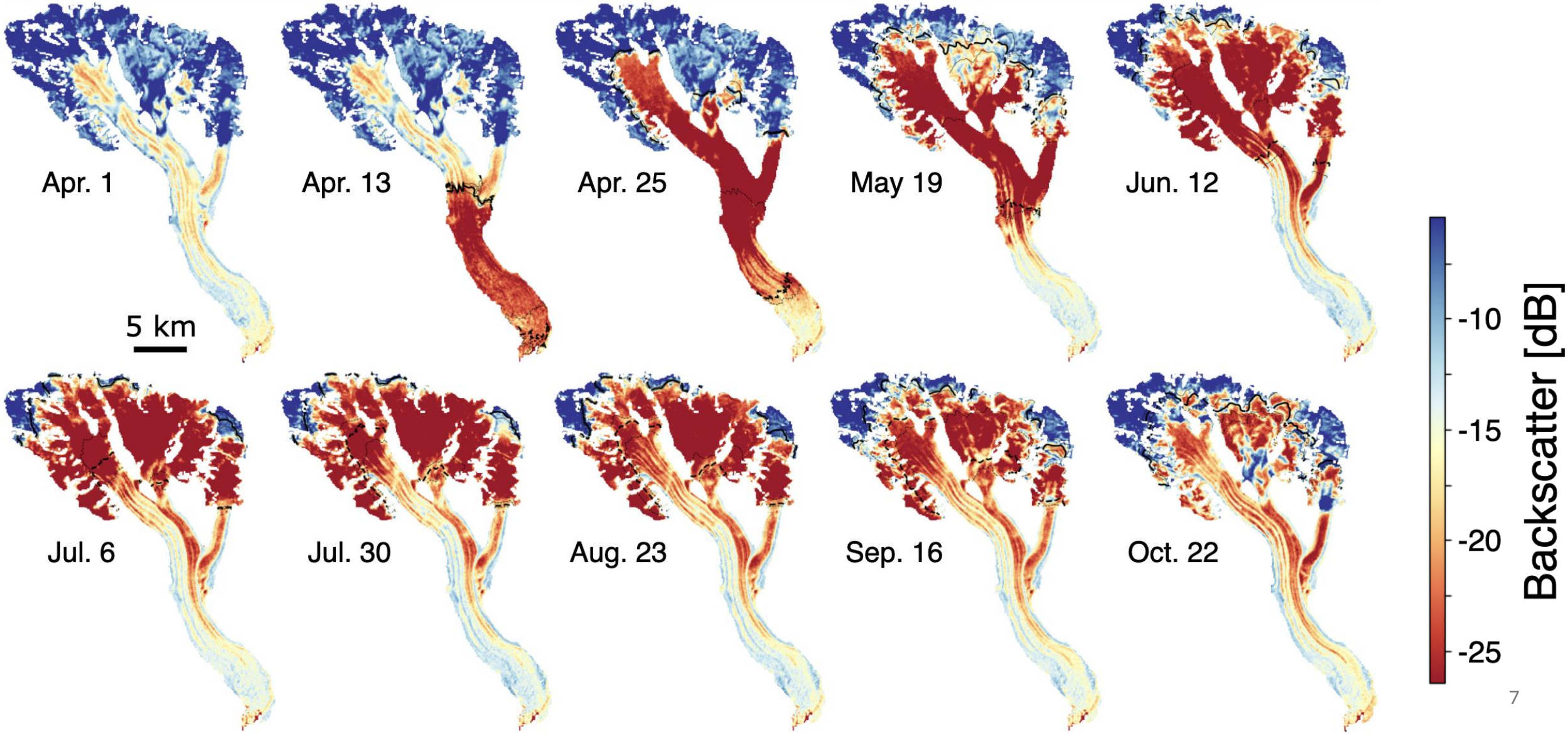
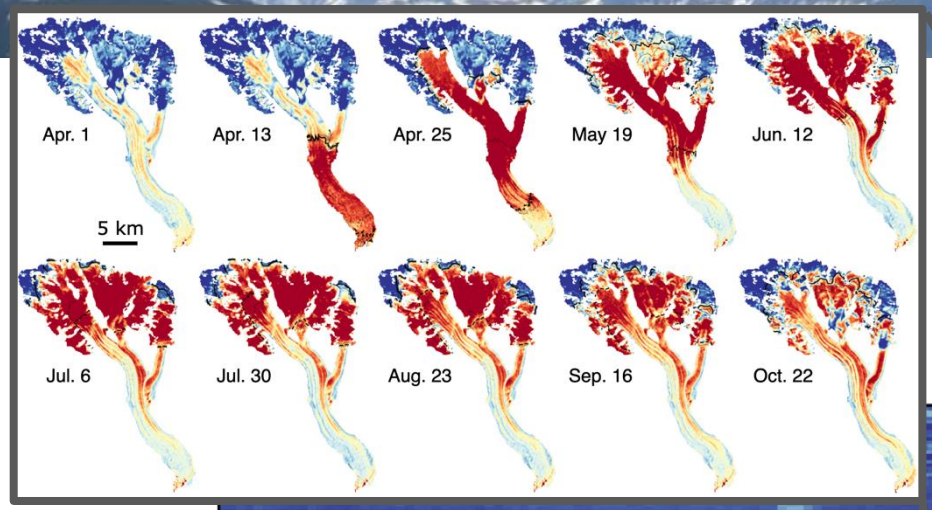
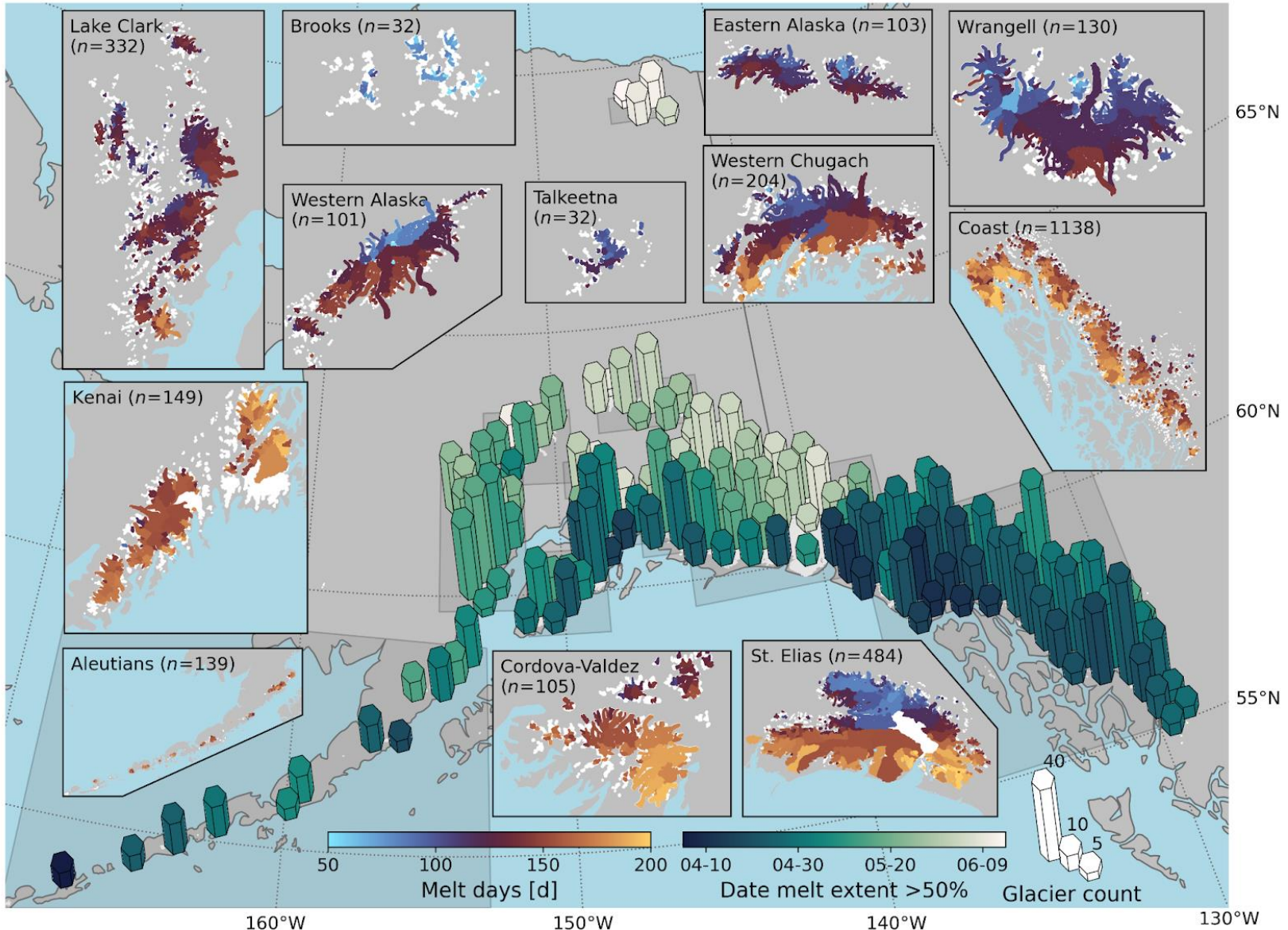


SAR automatically delineated melt and snowlines

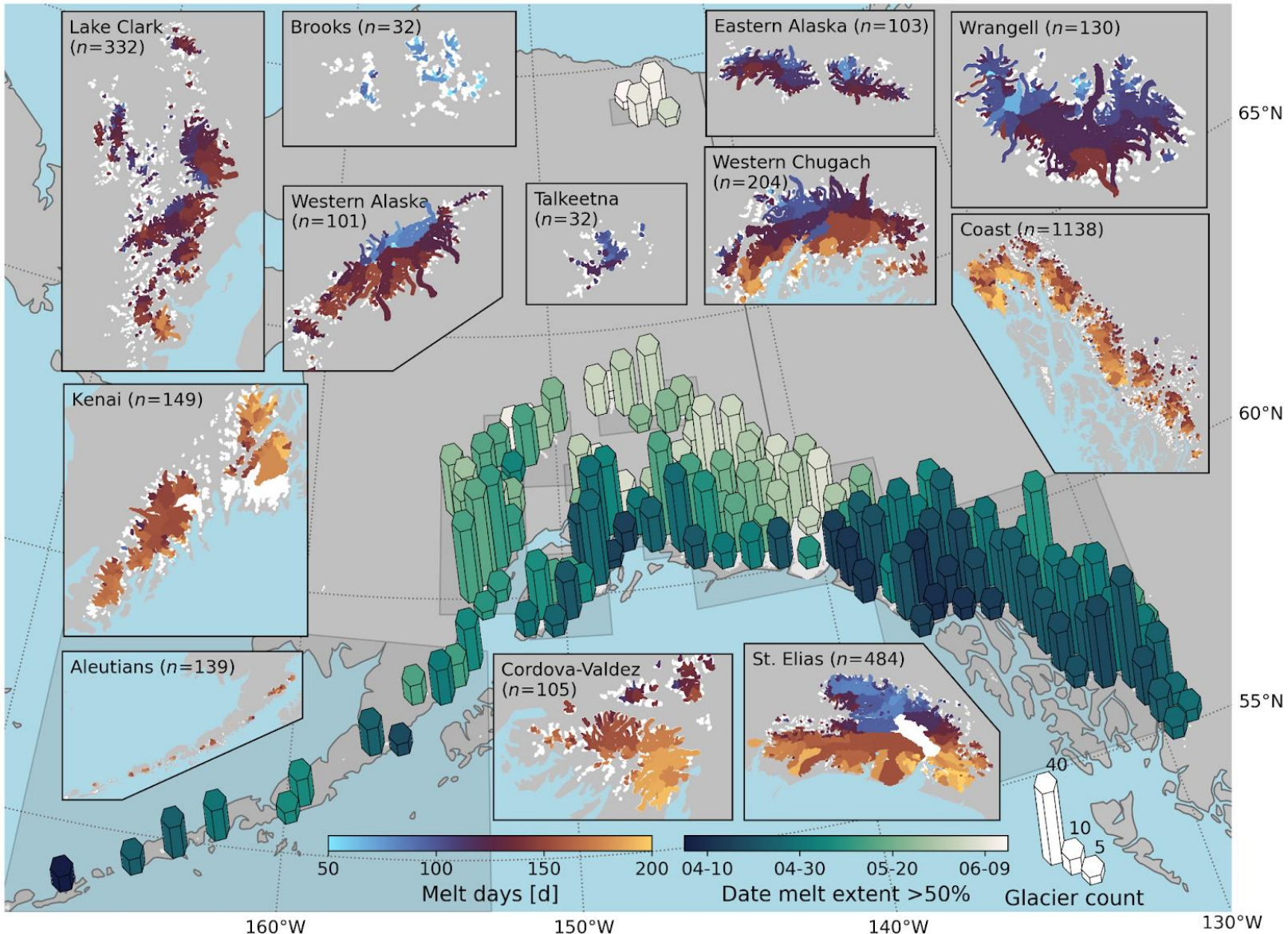


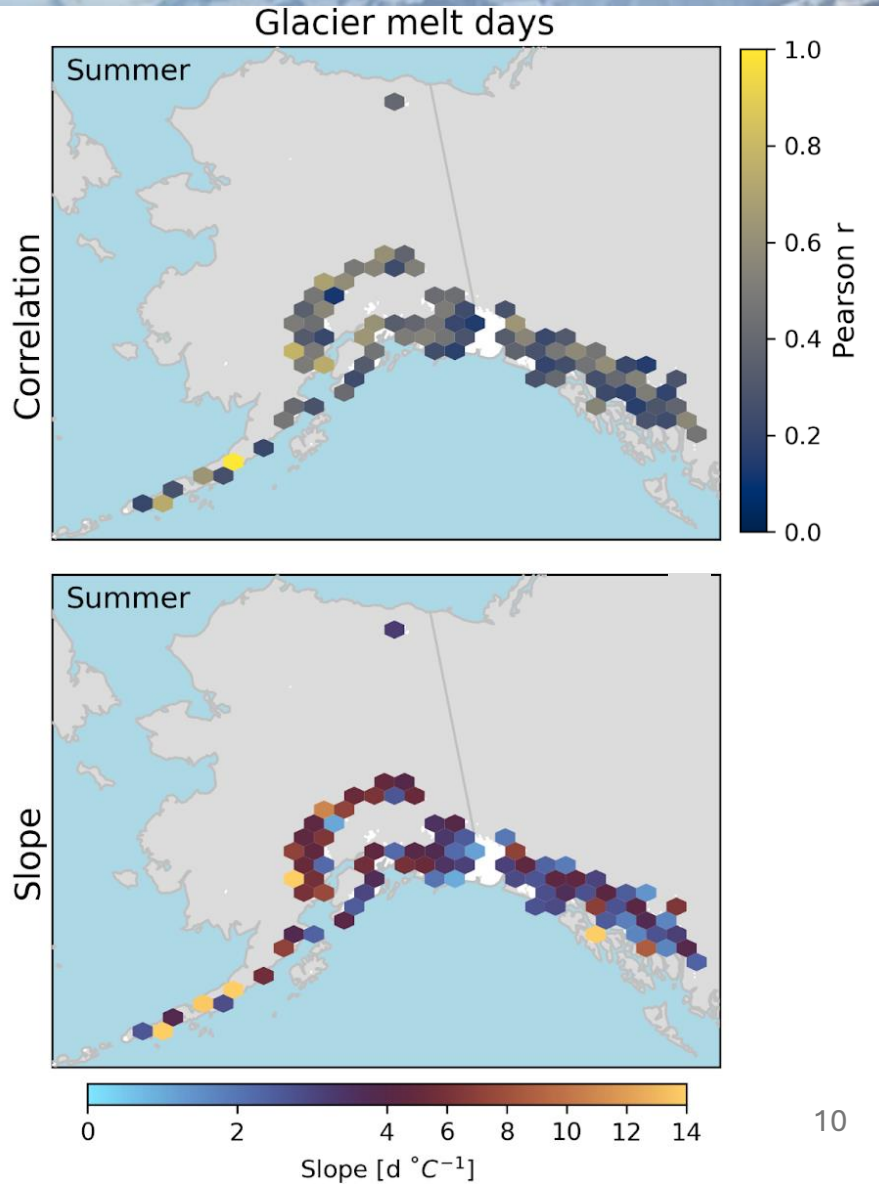
We have these for 99% of RGI region 1 glaciers >2 km²

Melt varies greatly across mountain ranges



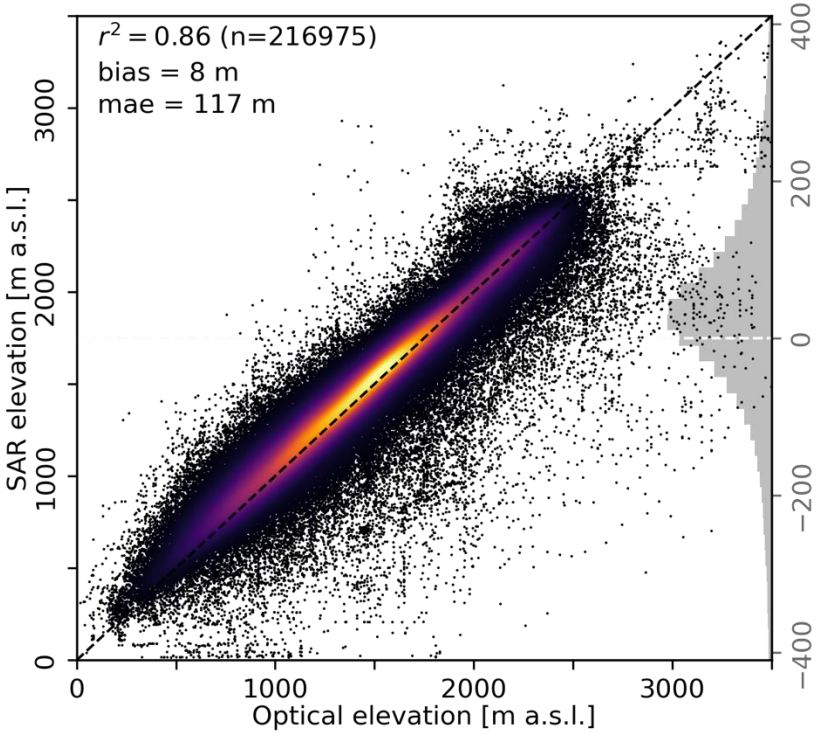
Melt correlates with summer temperature



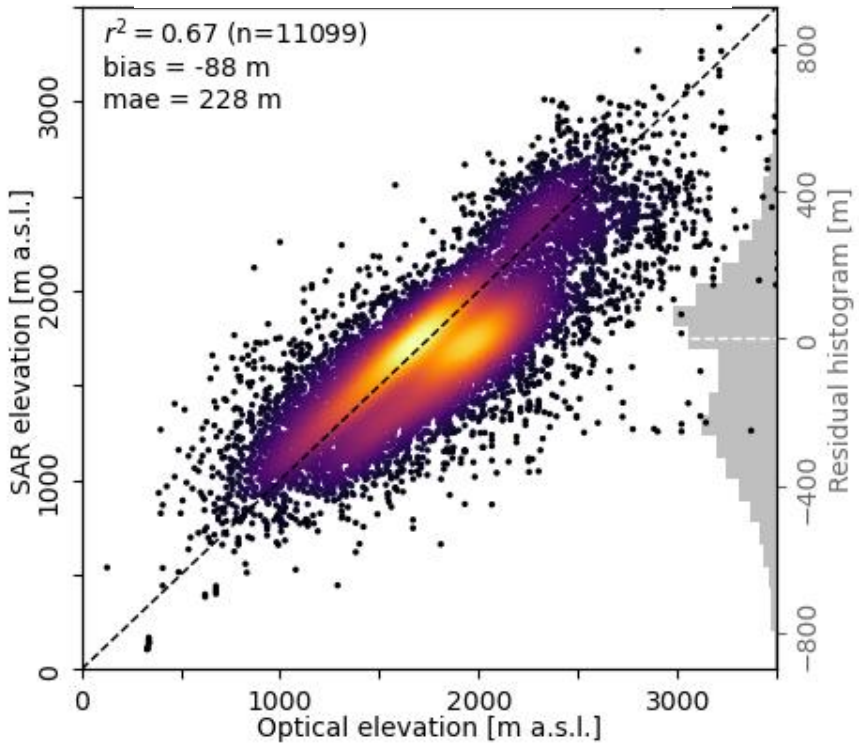


SAR snowlines are as accurate as optical

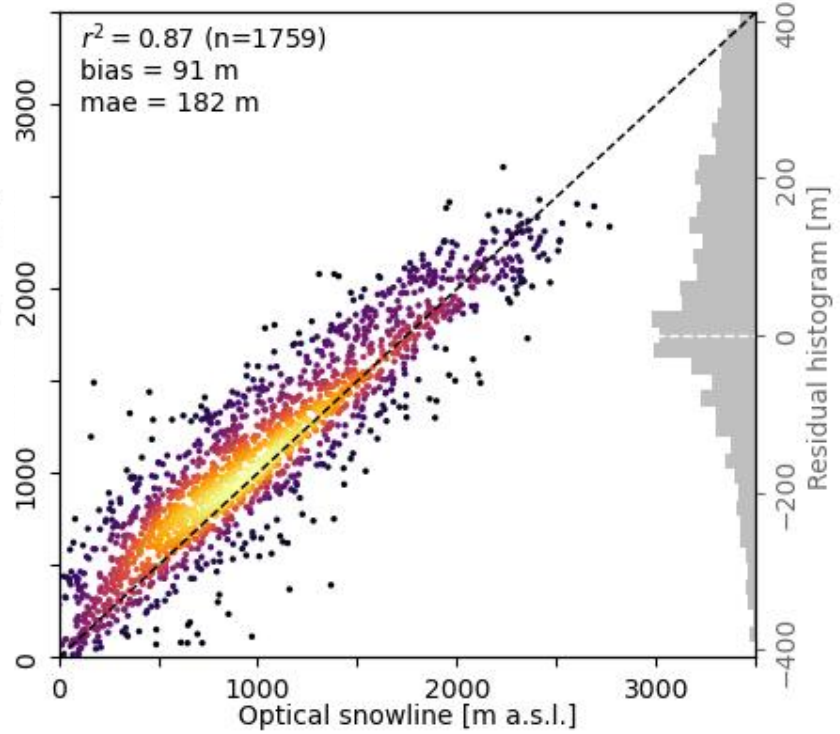
Bevington & Menounos, 2025
2017-2024



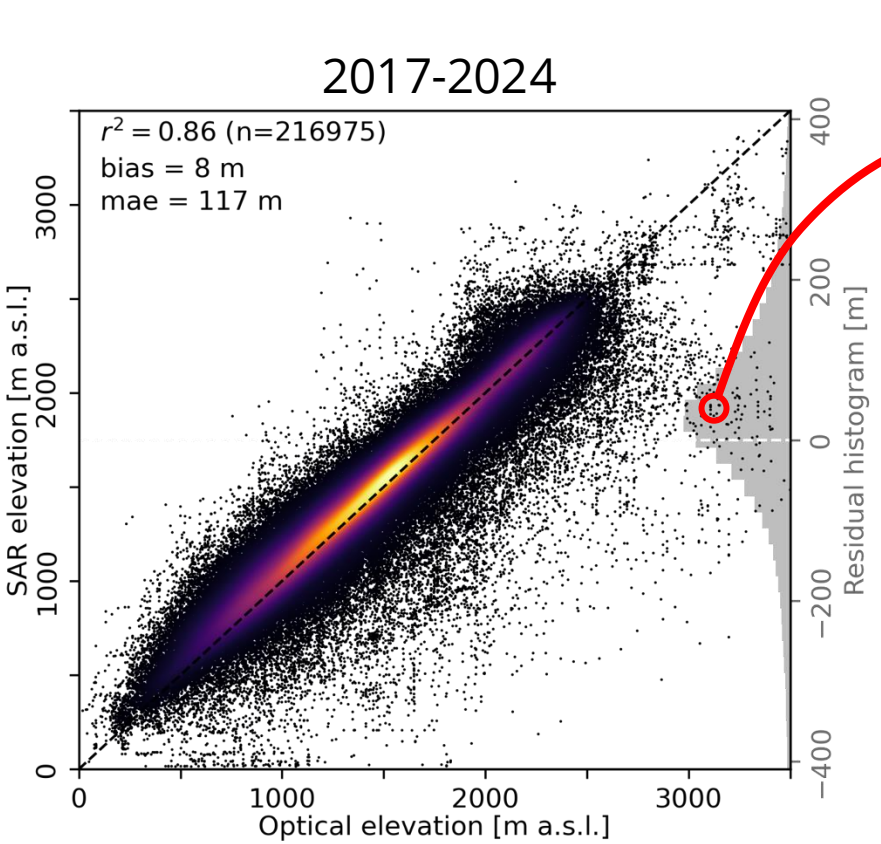
Zeller et al., 2025
2018-2022

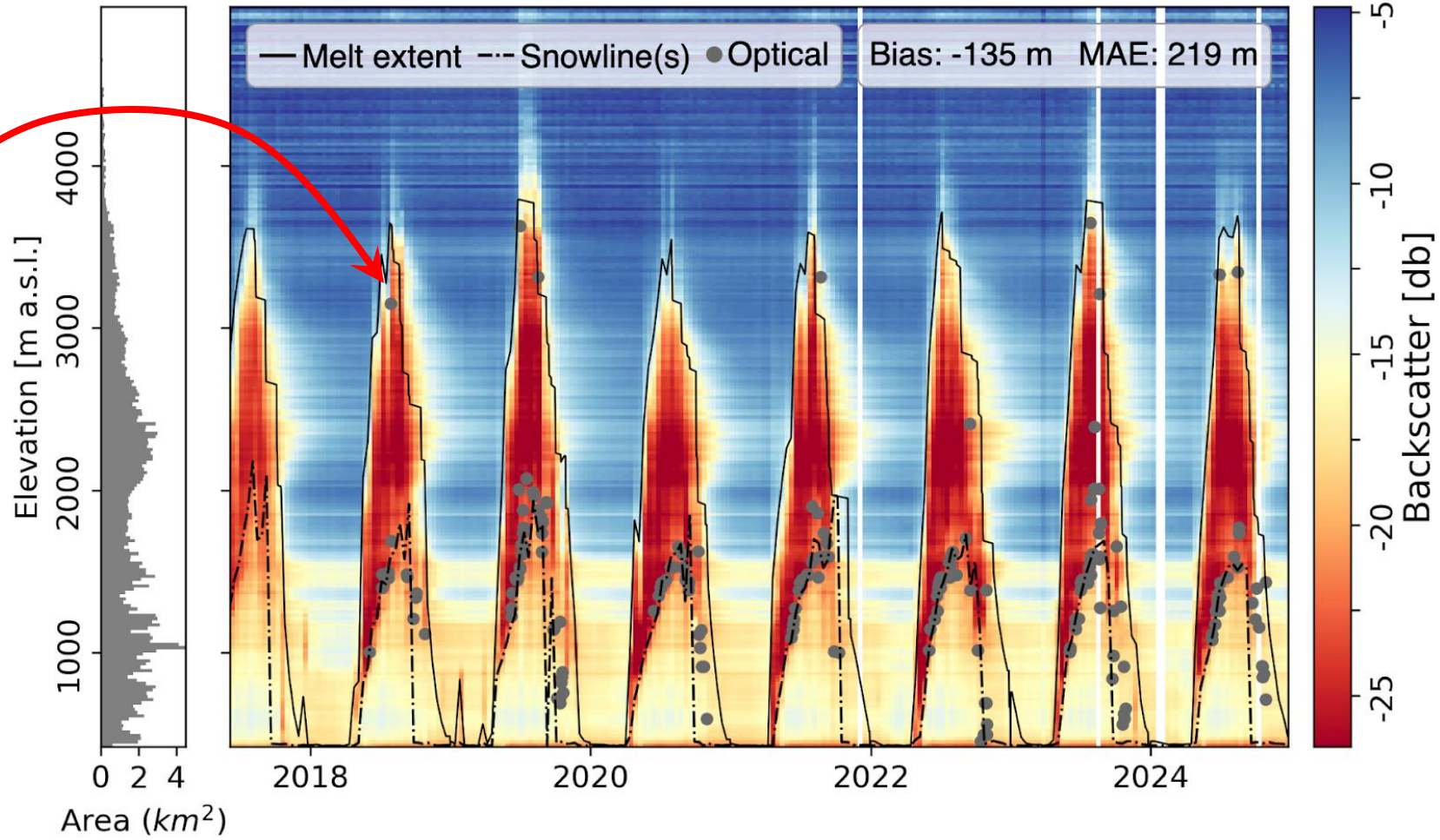


Aberle et al., 2025
2017-2023



SAR snowlines are as accurate as optical datasets





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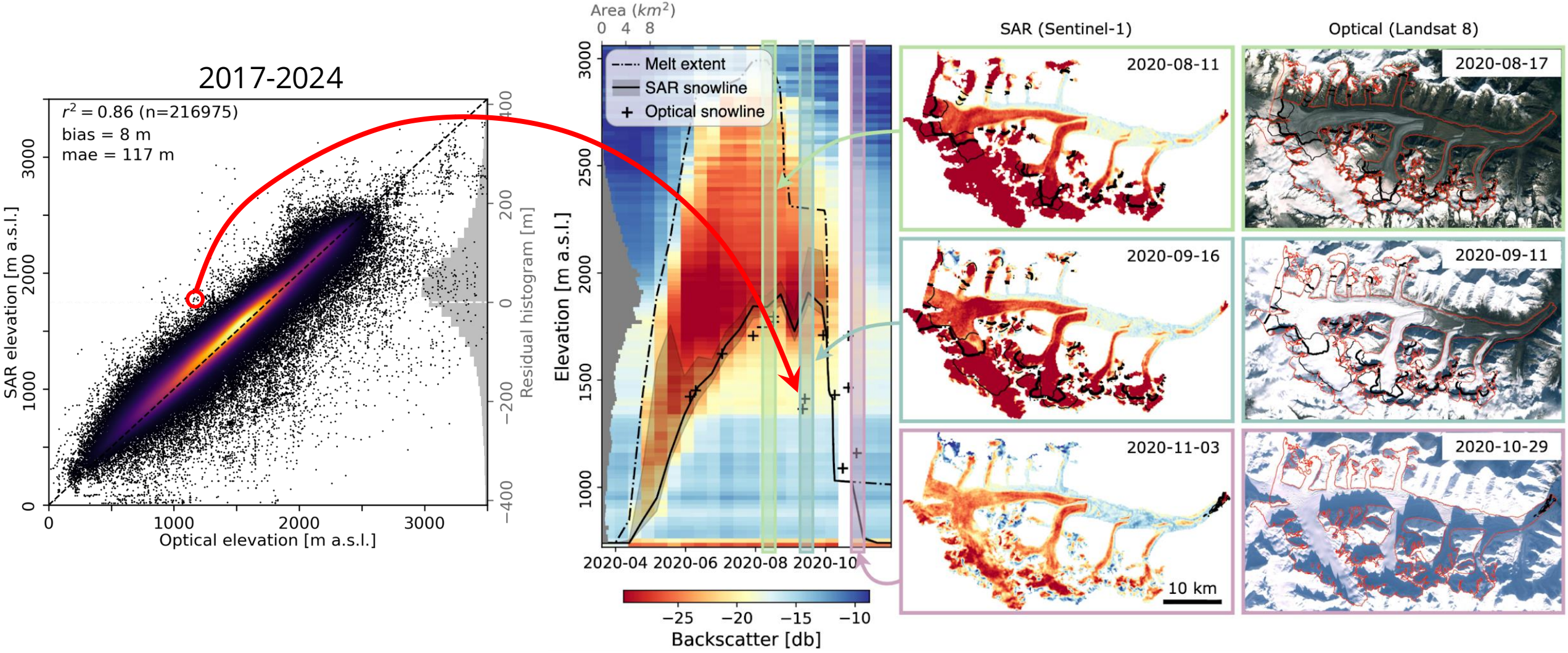
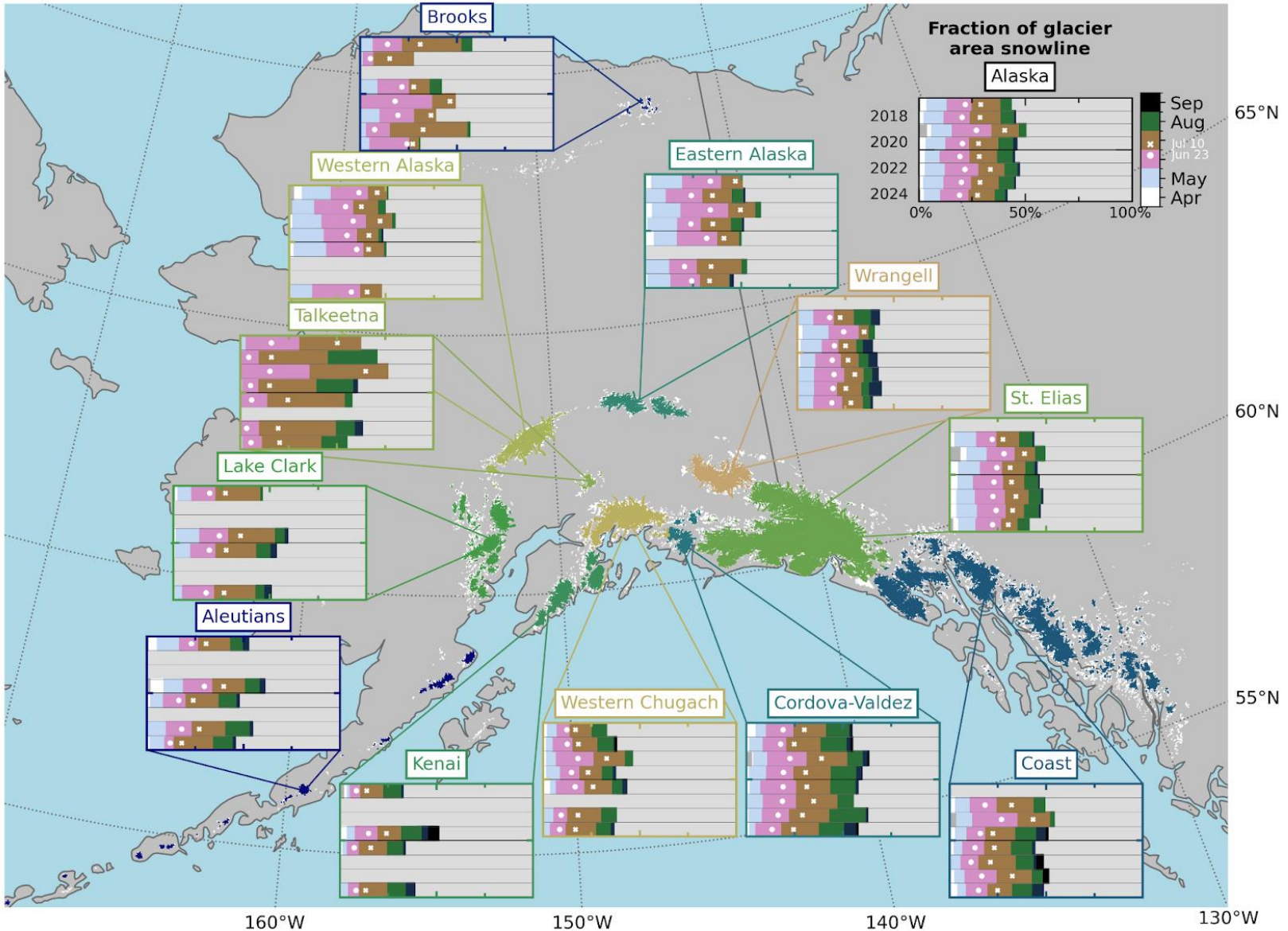


Regional snowlines impacted by heat waves



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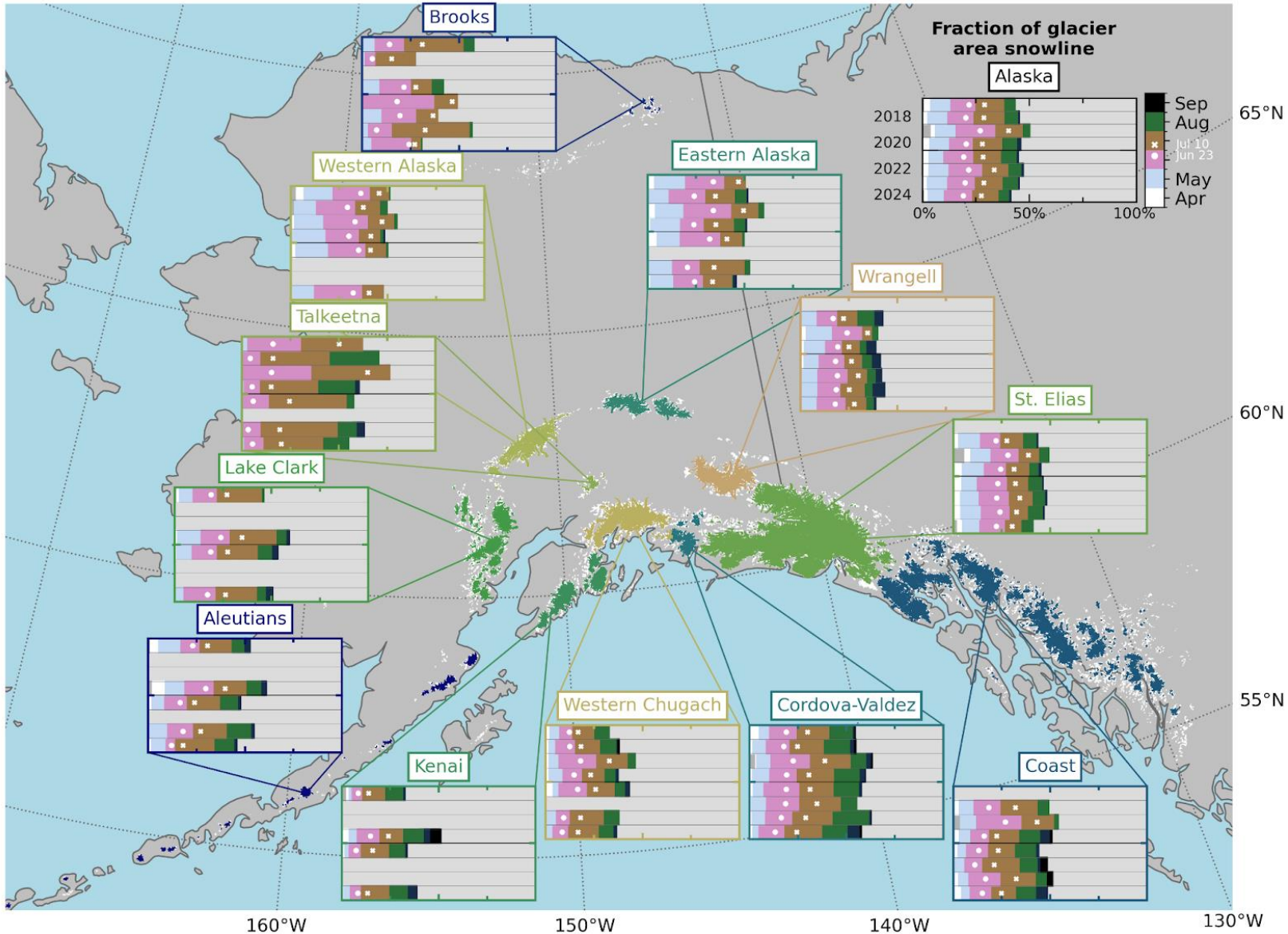
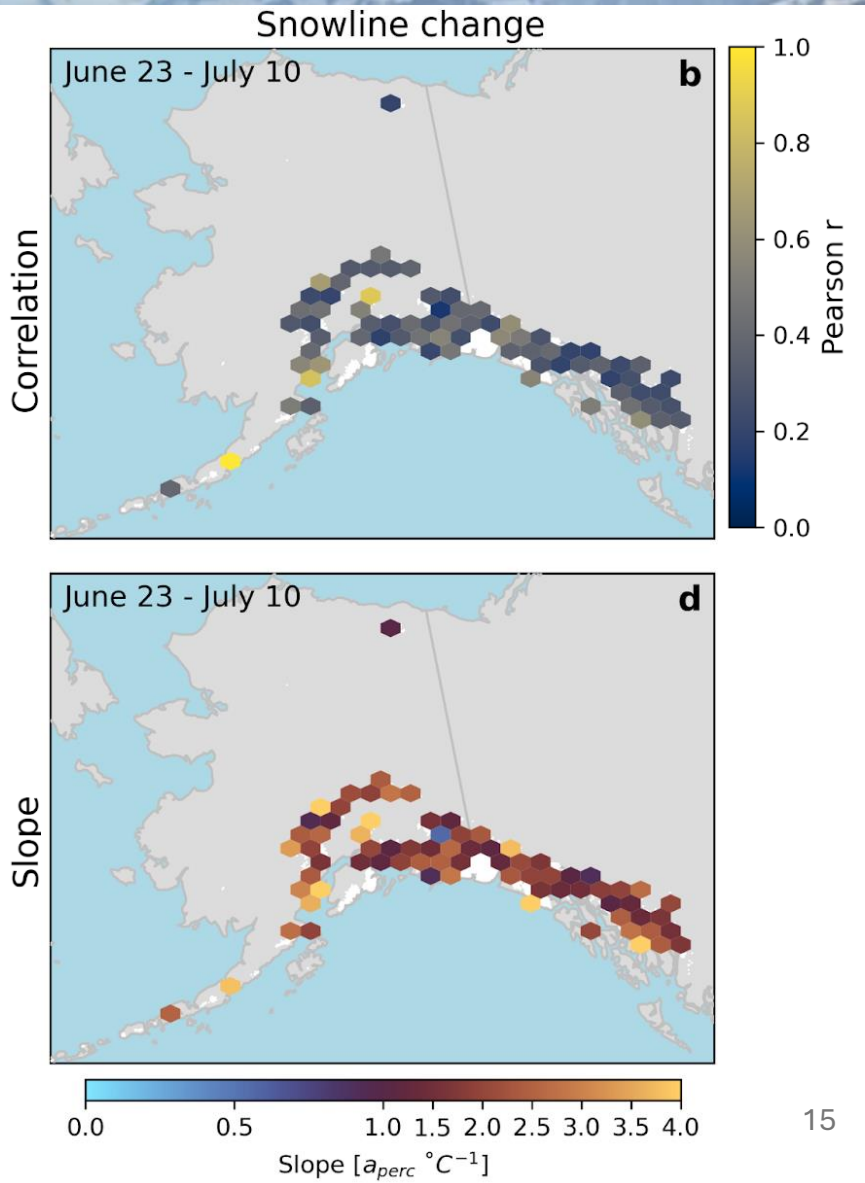
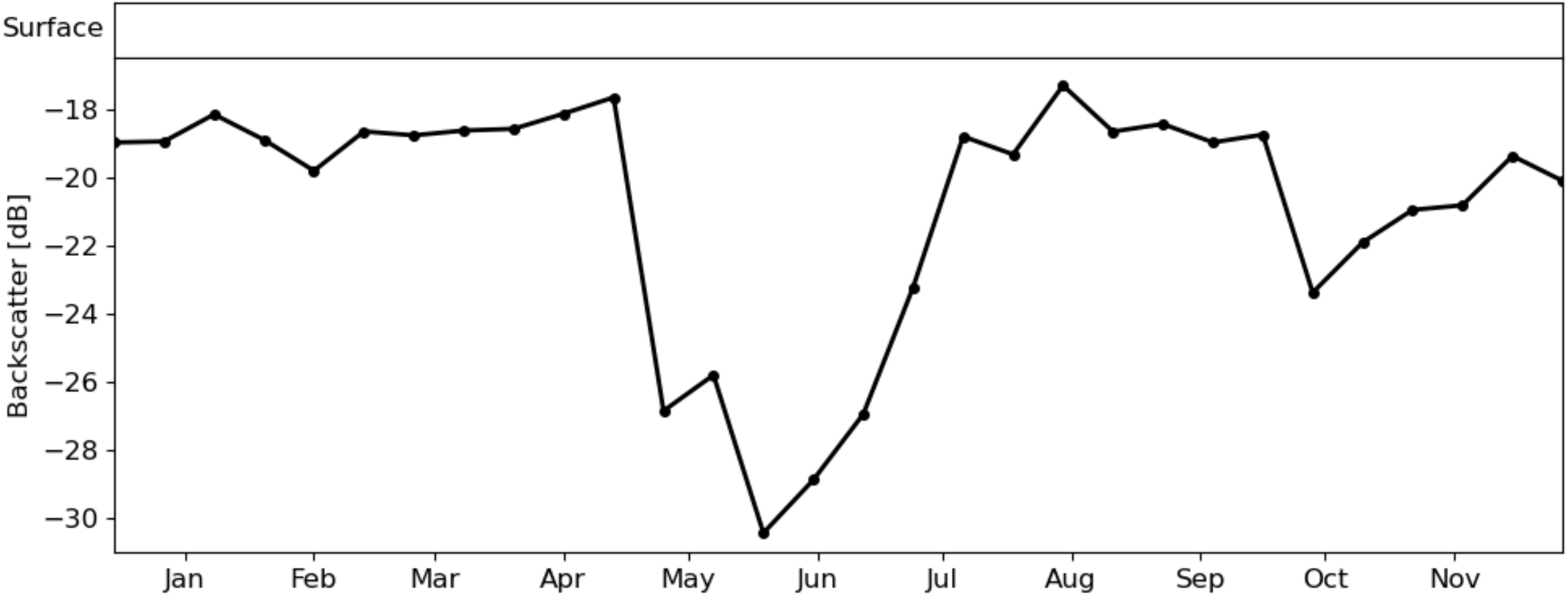




Nizina Glacier, Alaska, 2022

Automated surface delineation per pixel



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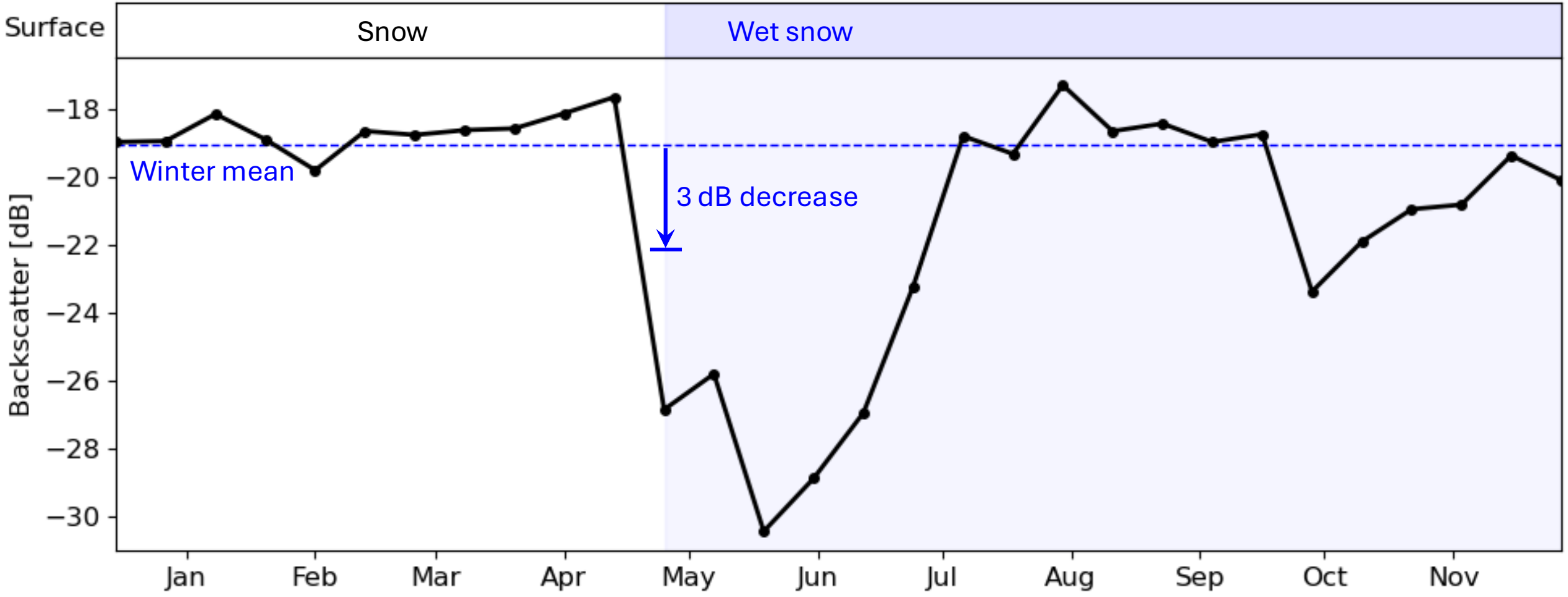

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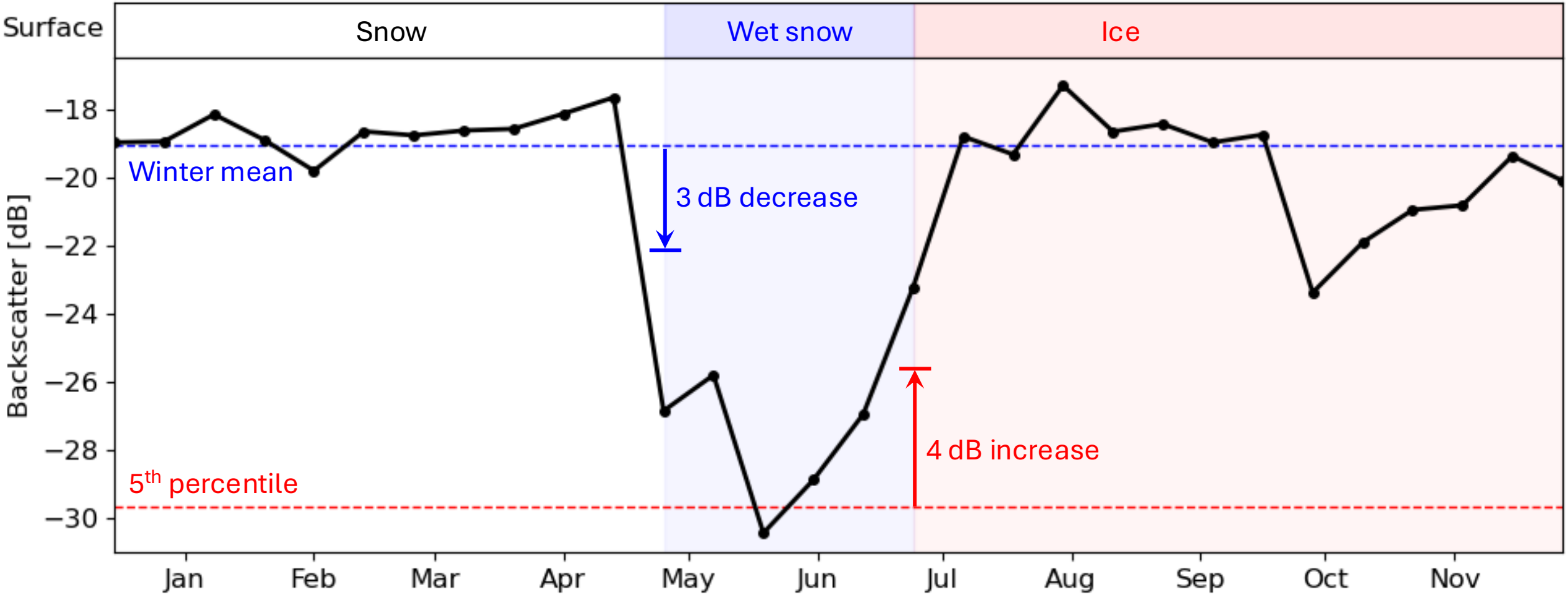

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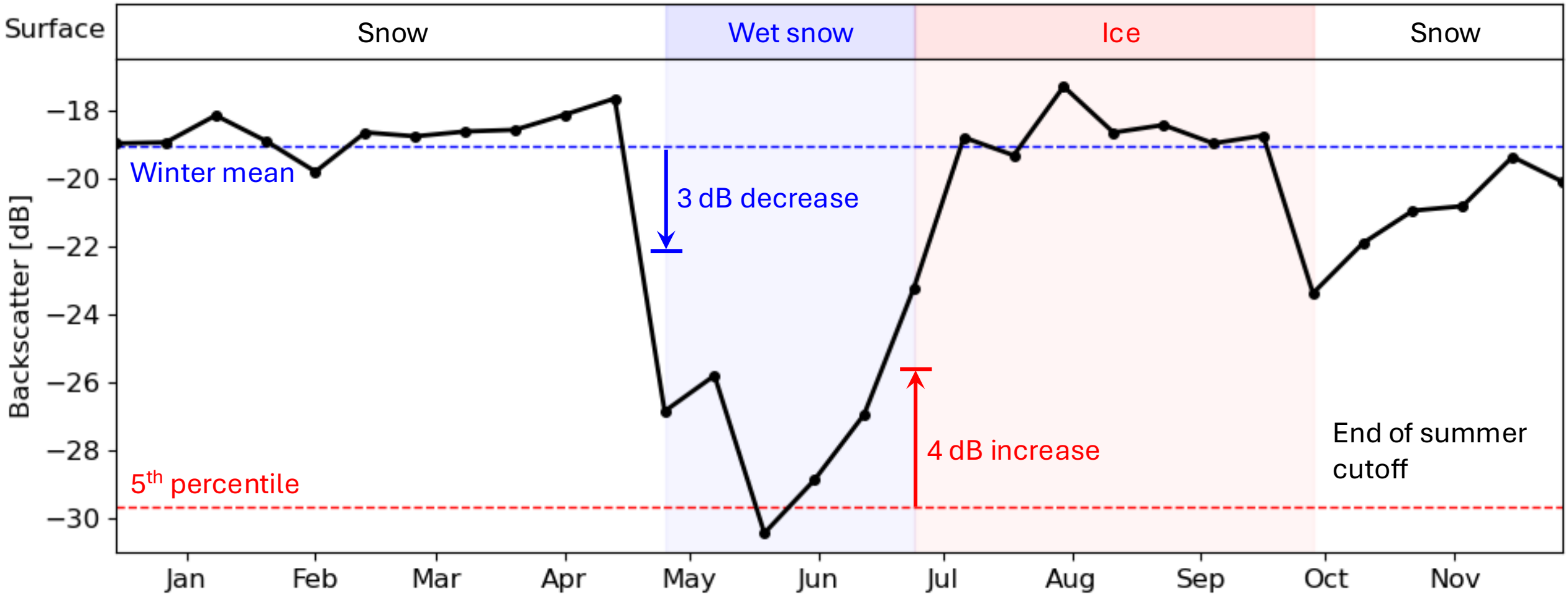

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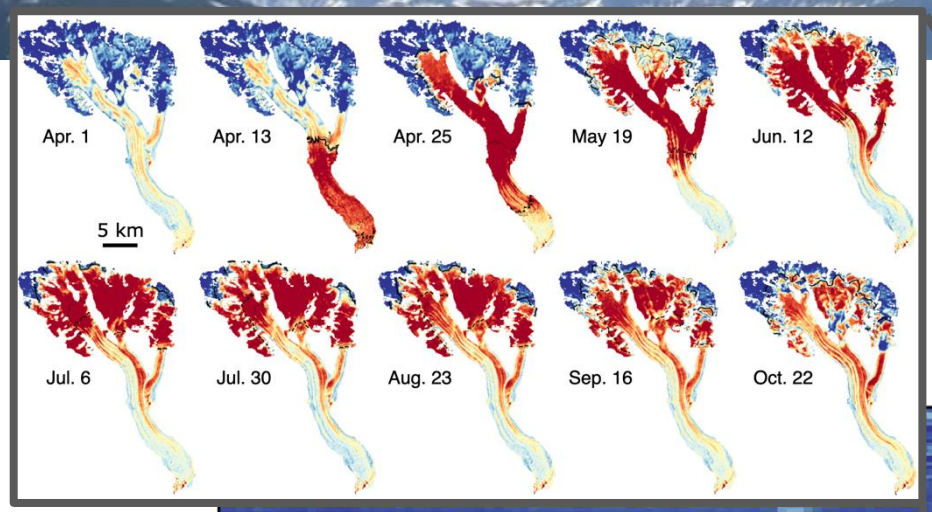

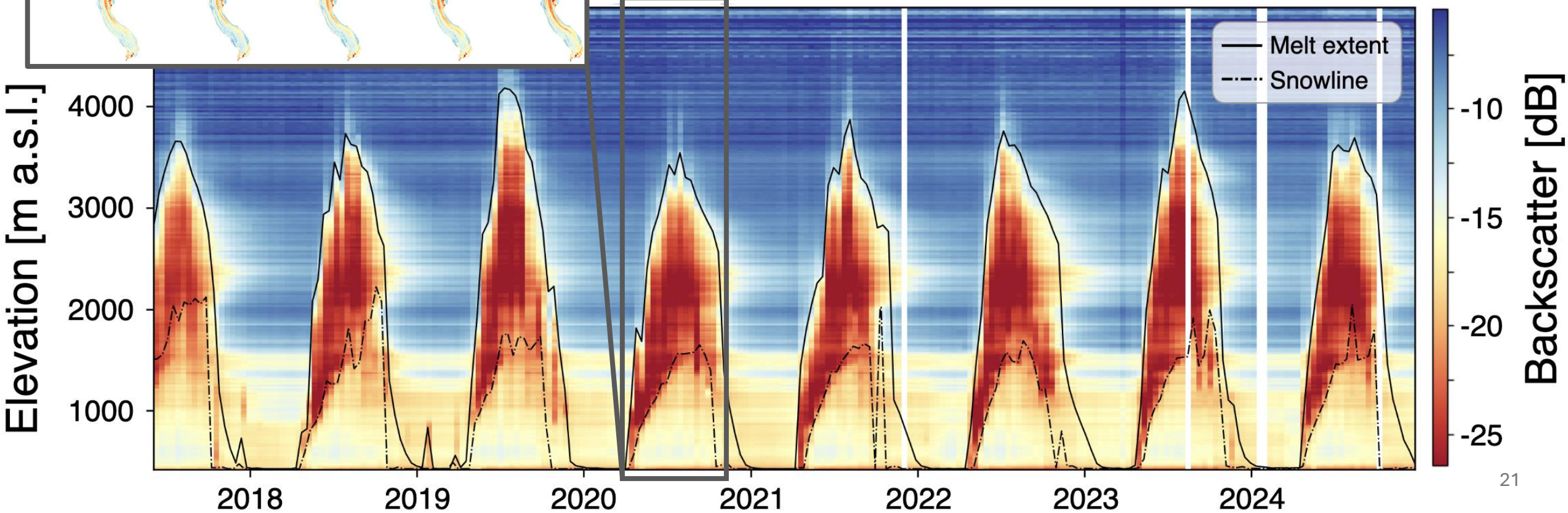

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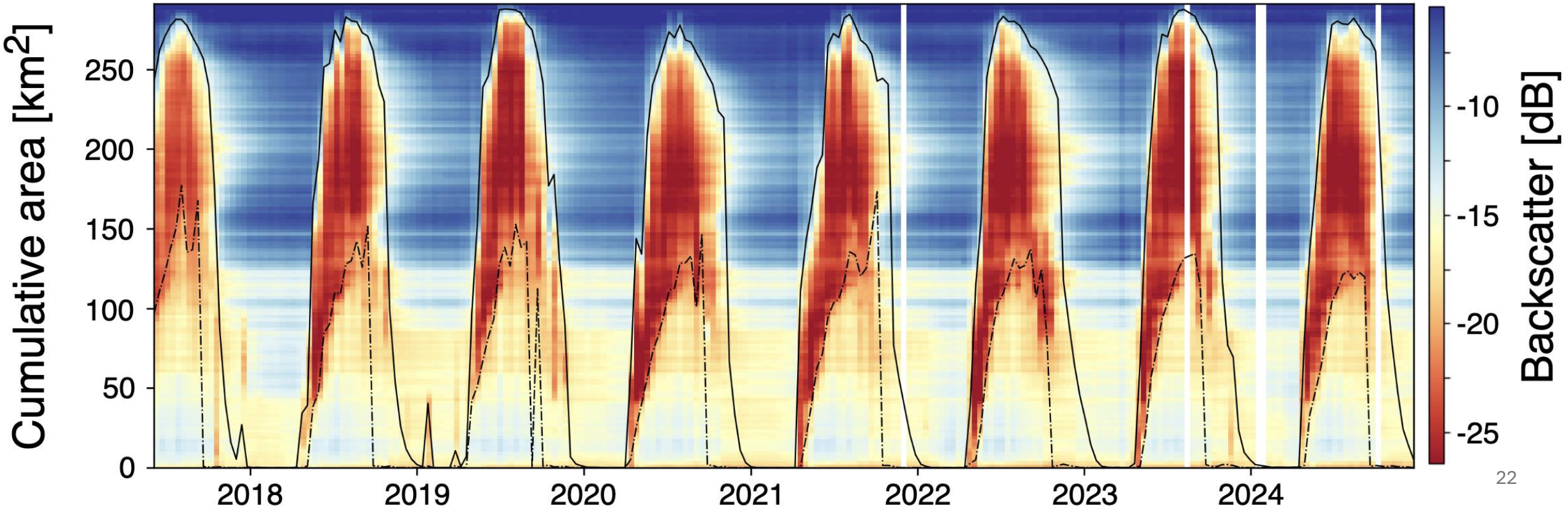
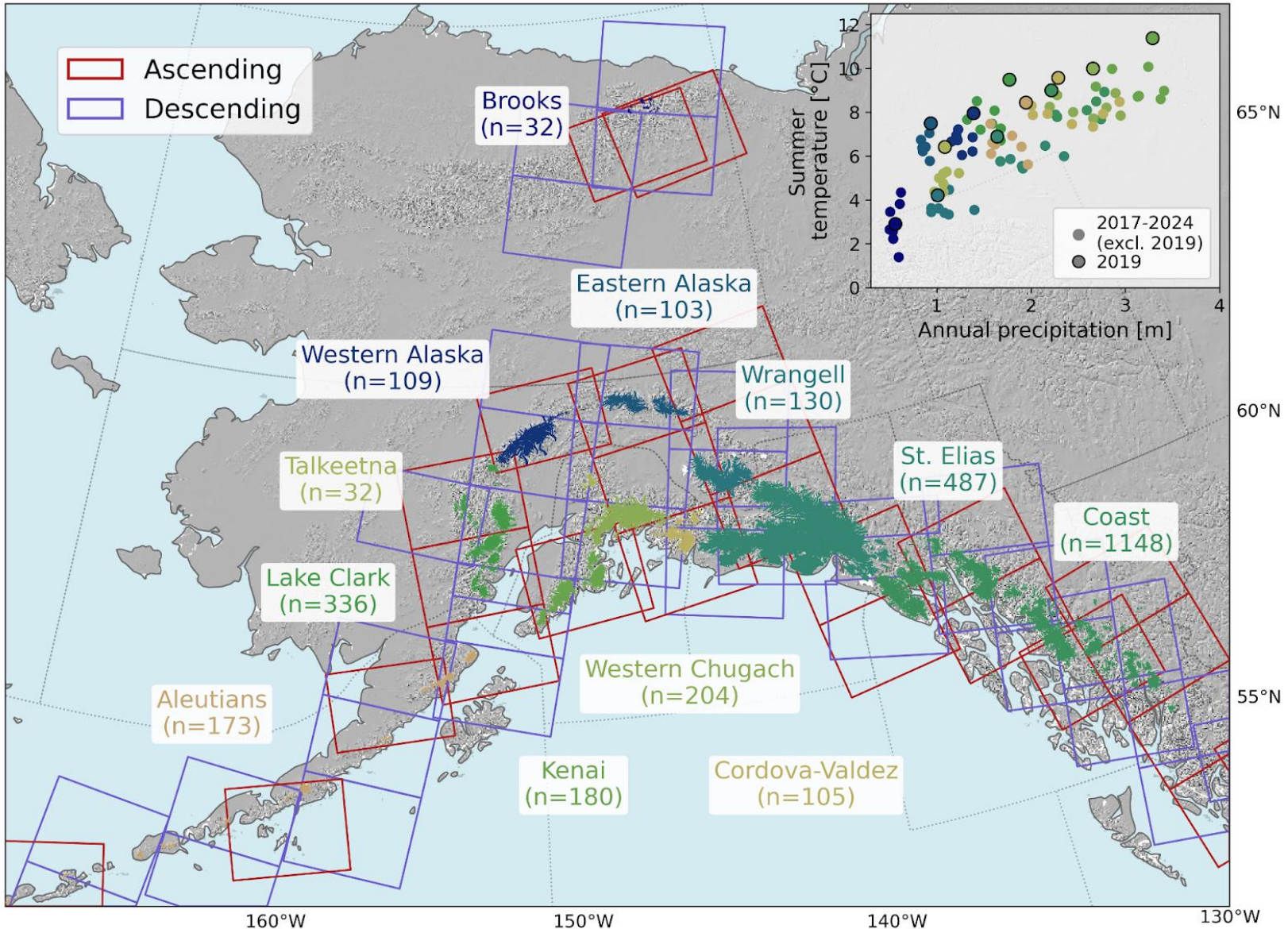
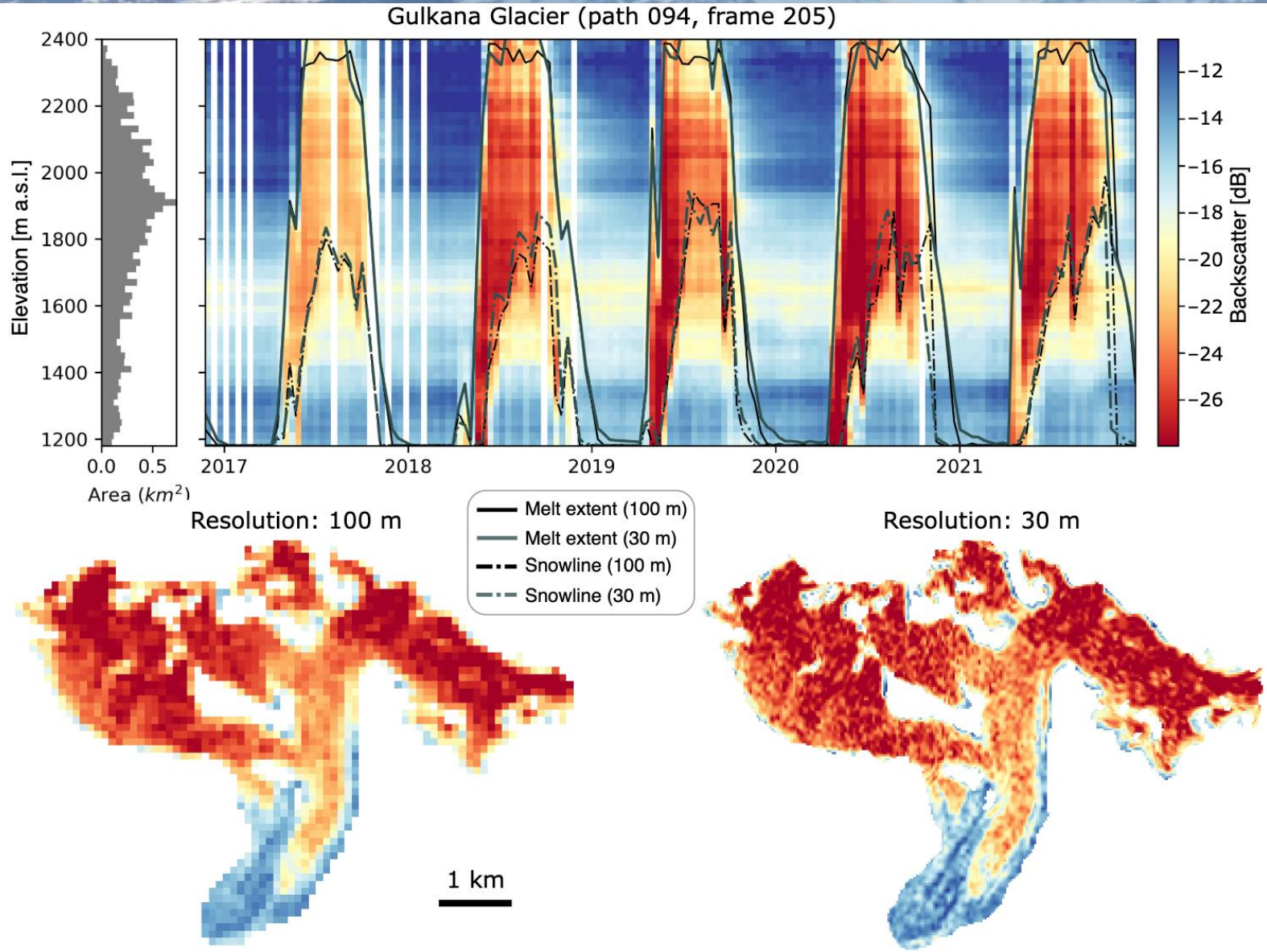


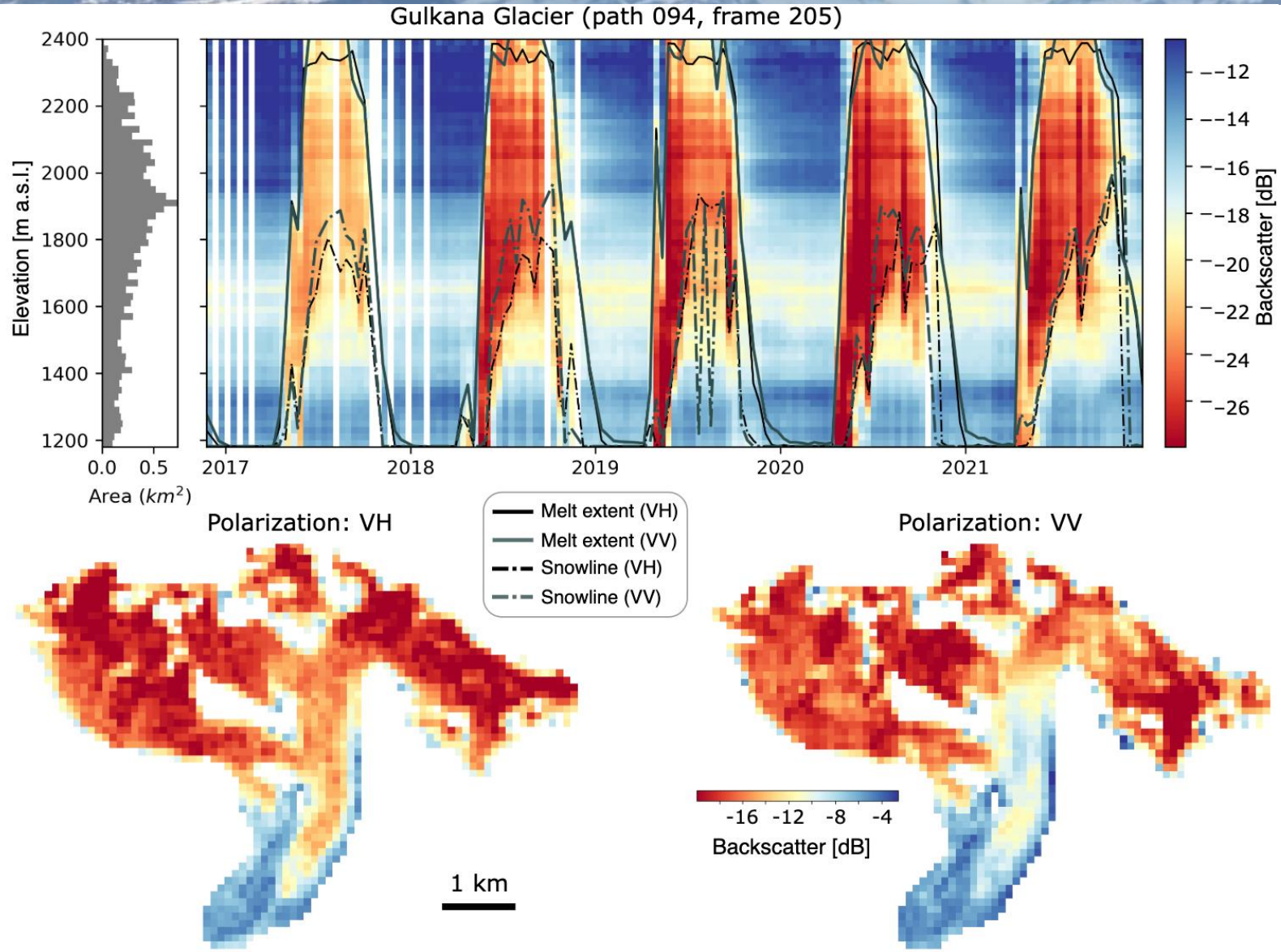
Sentinel-1 SAR coverage spans Alaska subregions



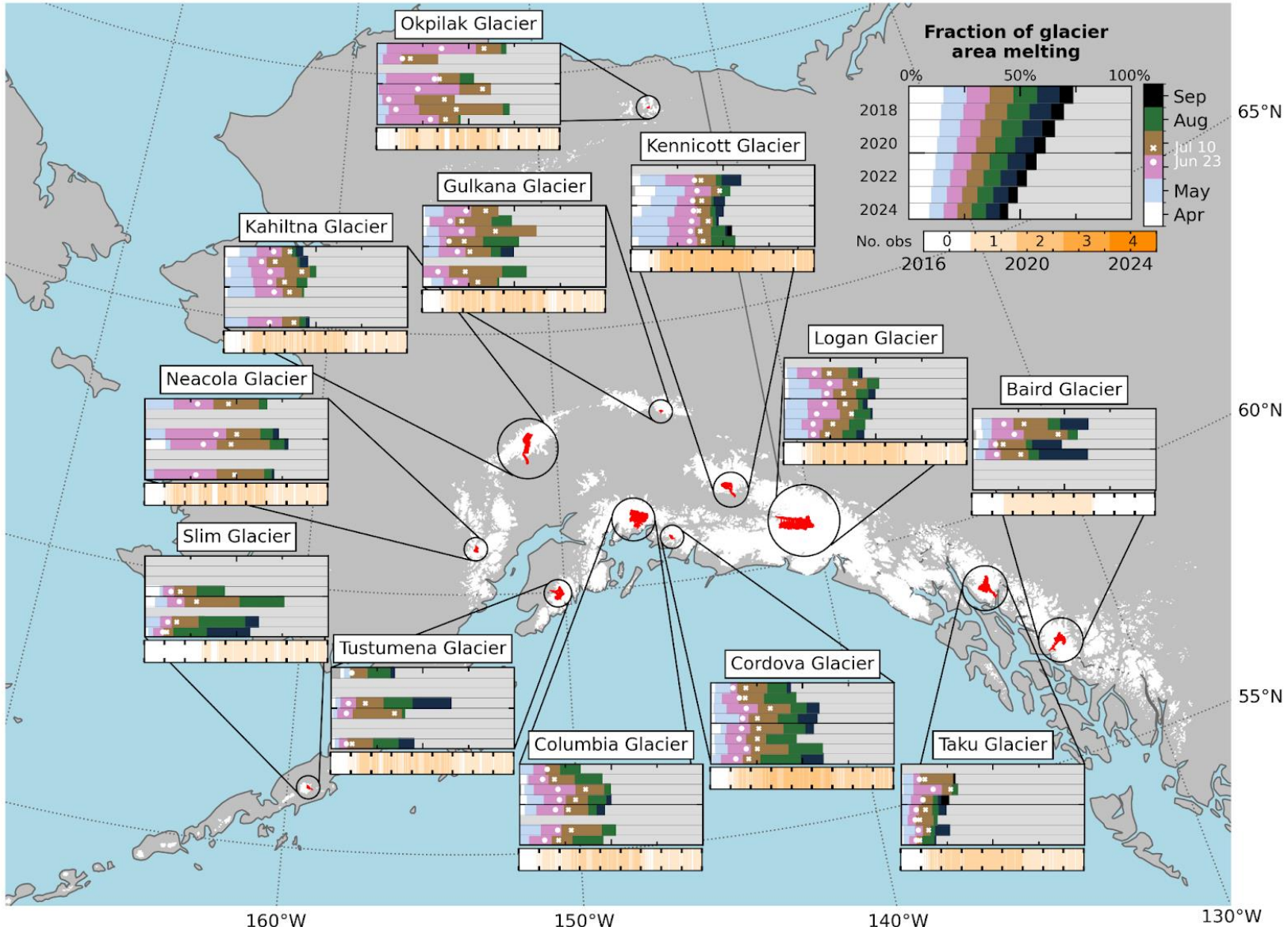
Impact of SAR spatial resolution



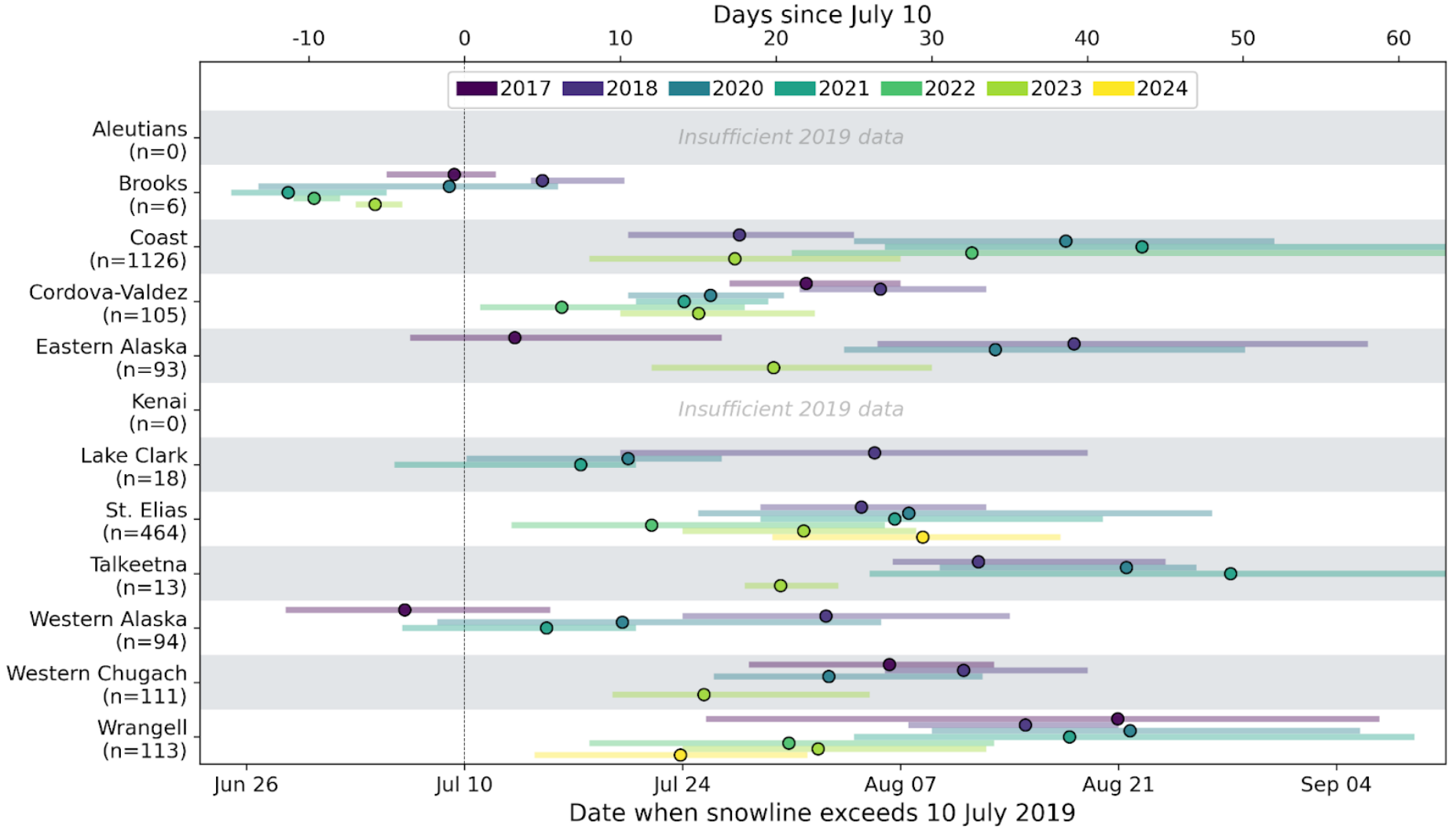
Impact of SAR polarization



Transient snowlines for select Alaska glaciers



Impact of 2019 heat wave on snowline retreat



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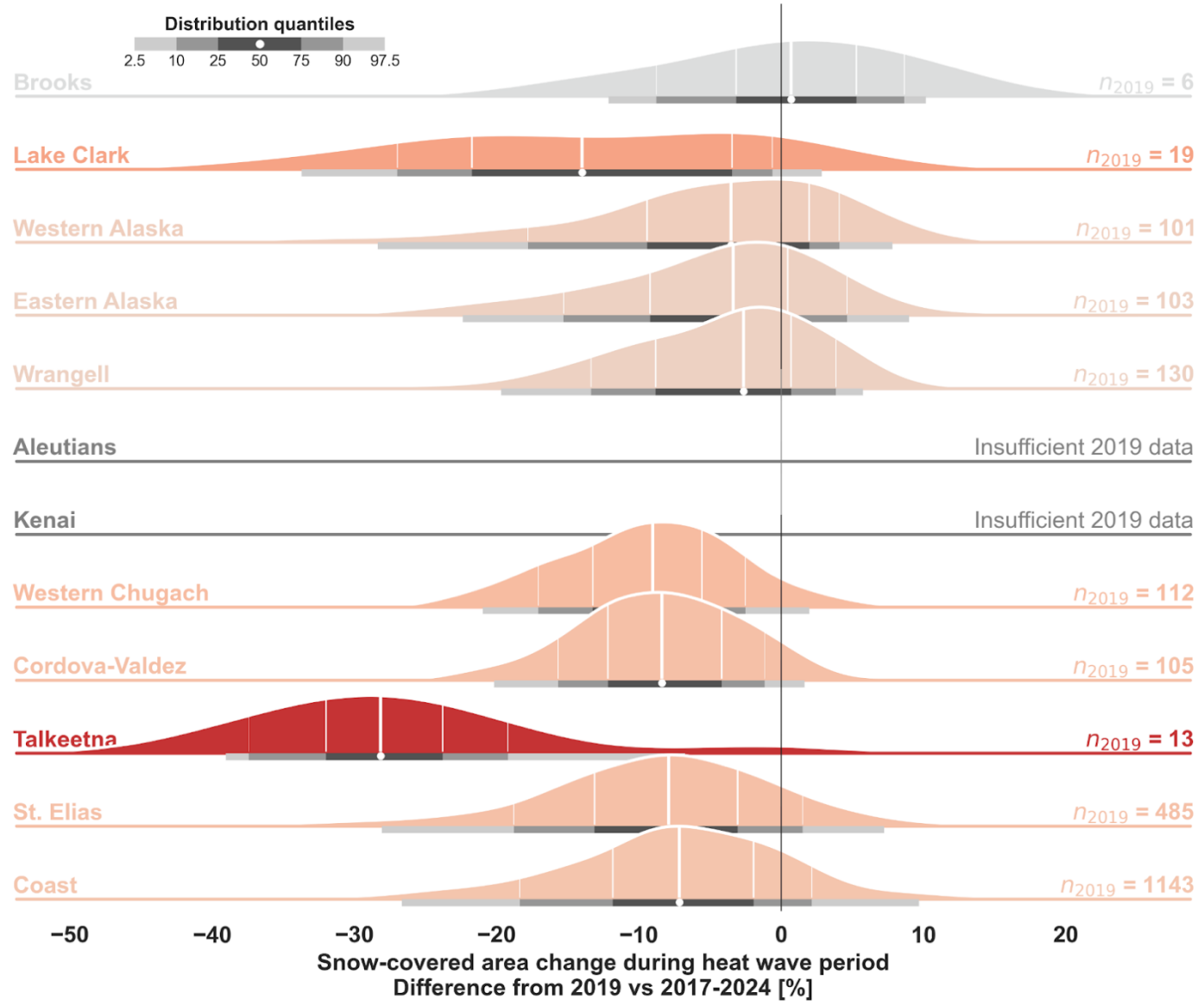
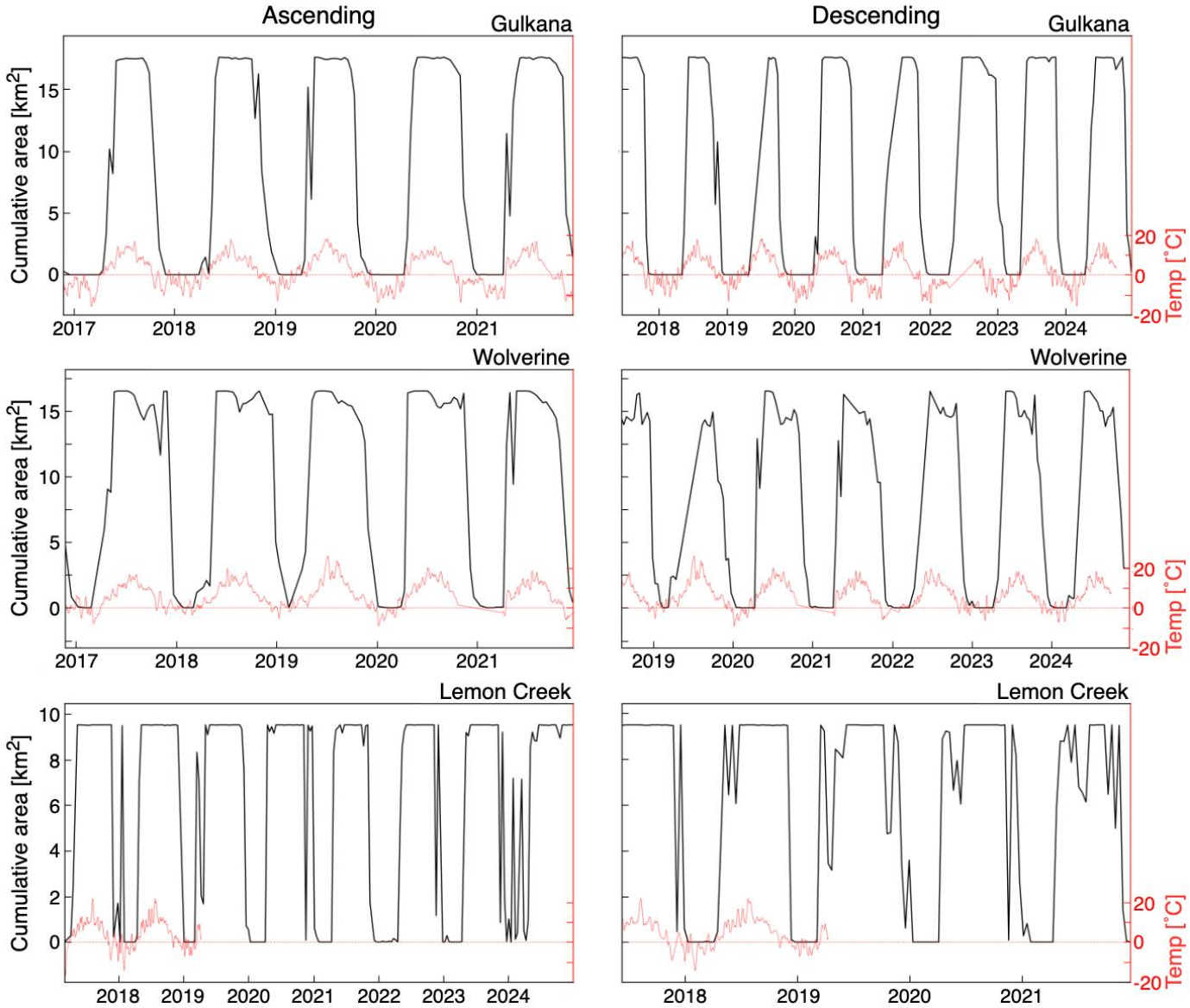
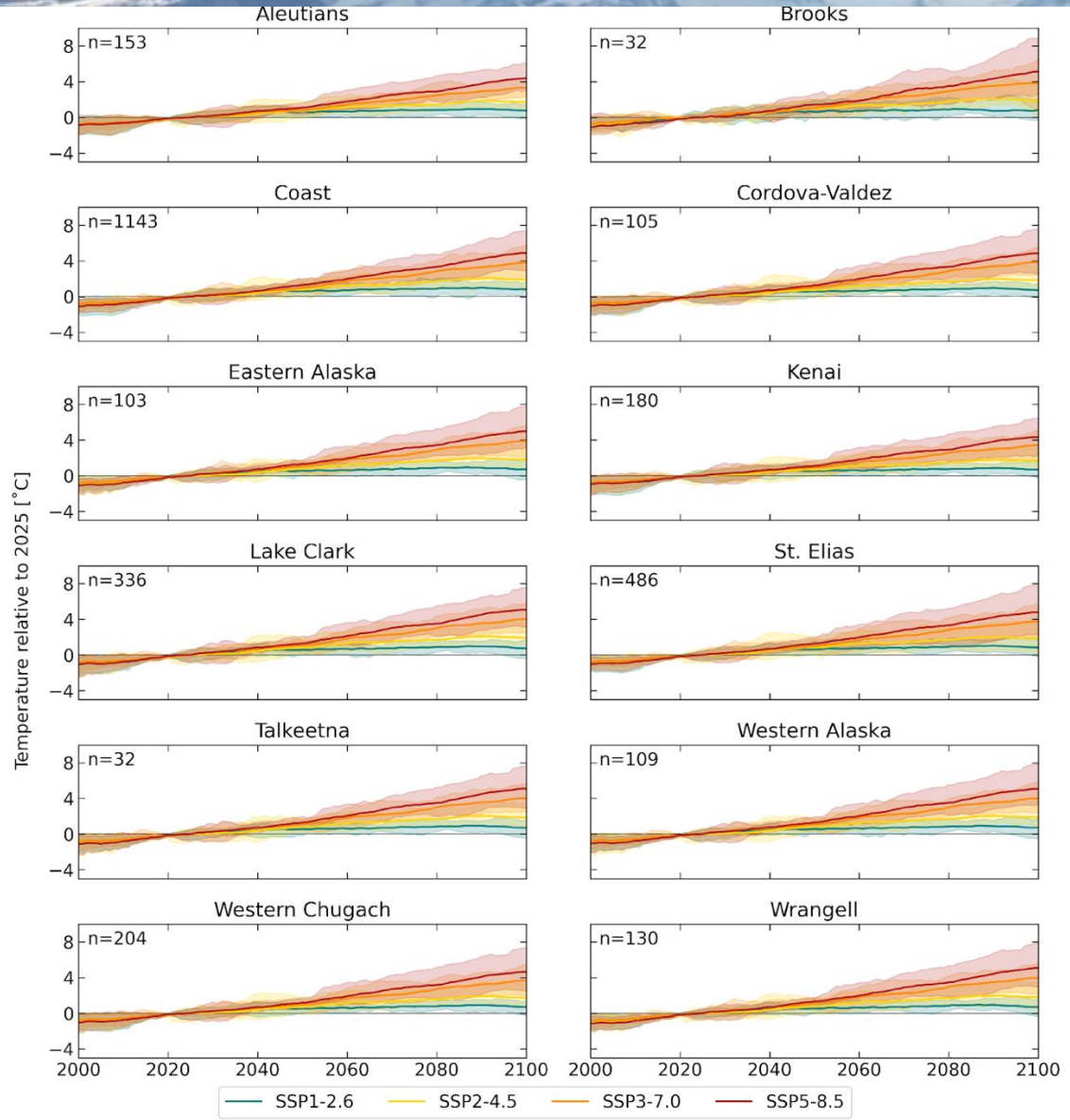


Melt onset coincides with temperature



Projected temperature across Alaska subregions