MASHUP: Snow Redistribution on Arctic Sea Ice and Icepack Model Case Study

David Clemens-Sewall

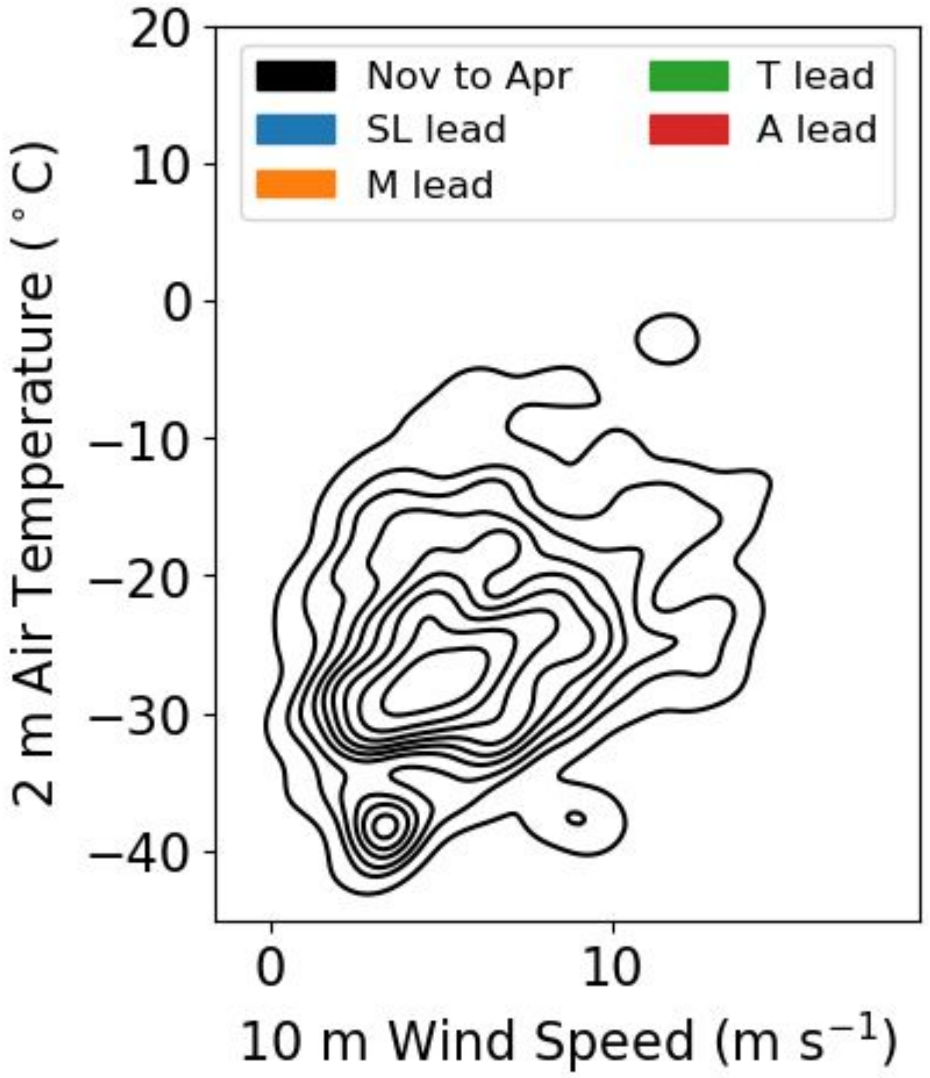
Agenda

- Summary of recent observational work:
  - Snow loss into leads
  - Snow redistribution from level ice to ridges
- Plans for Icepack model case study of the MOSAiC Expedition

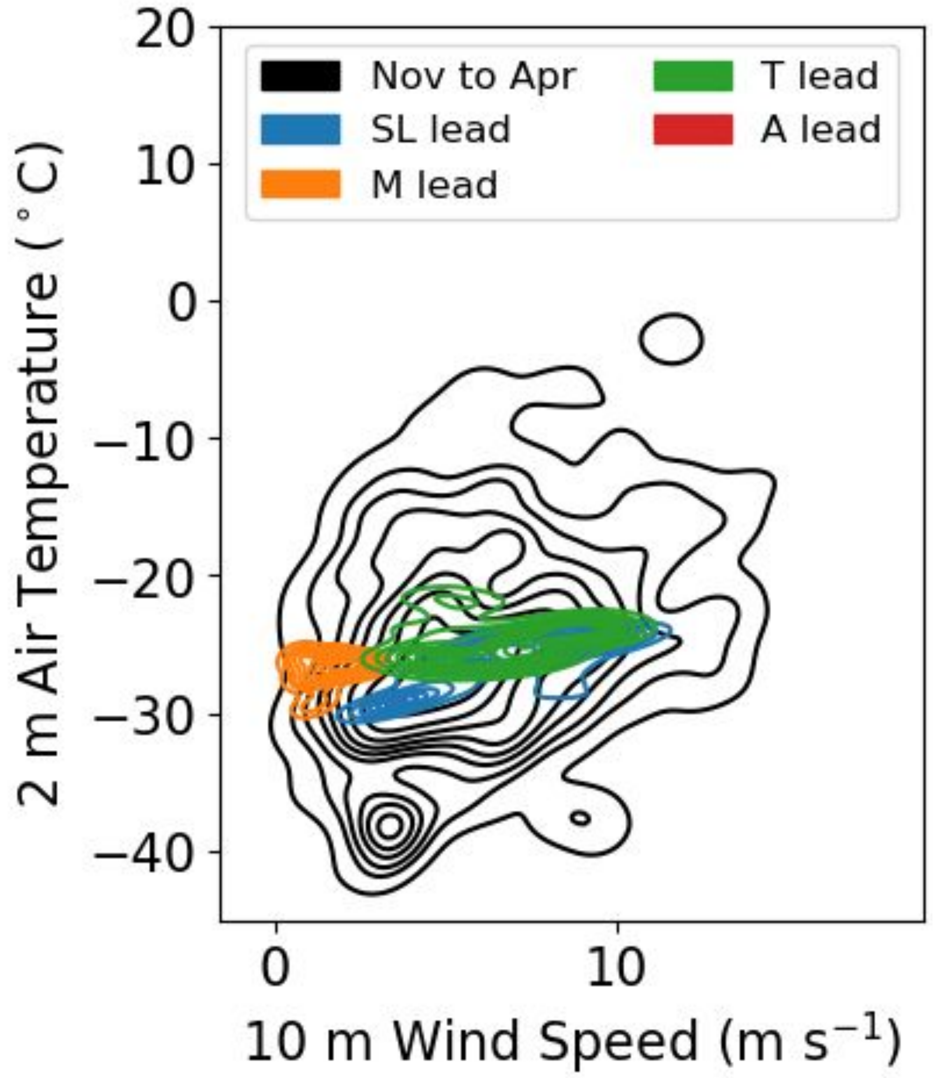
Leads

- When ice dynamics causes divergence, cracks in the ice open, exposing open seawater.
- Any snow that enters the water before the ice freezes is “lost”.
- Based on work in the Antarctic, snow loss into leads is thought to consume a substantial amount (e.g., 25%) of the snow in the Arctic.
- We hypothesized that very little snow is lost into leads, contrary to the general consensus, because the rapidity of the ice freezing would prevent much snow from entering the water.

Leads


Nov to Apr
SL lead
M lead
T lead
A lead
20
10
0
−10
−20
−30
−40
2 m Air Temperature (°C)
0
10
10 m Wind Speed (m s^{-1})

Leads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20
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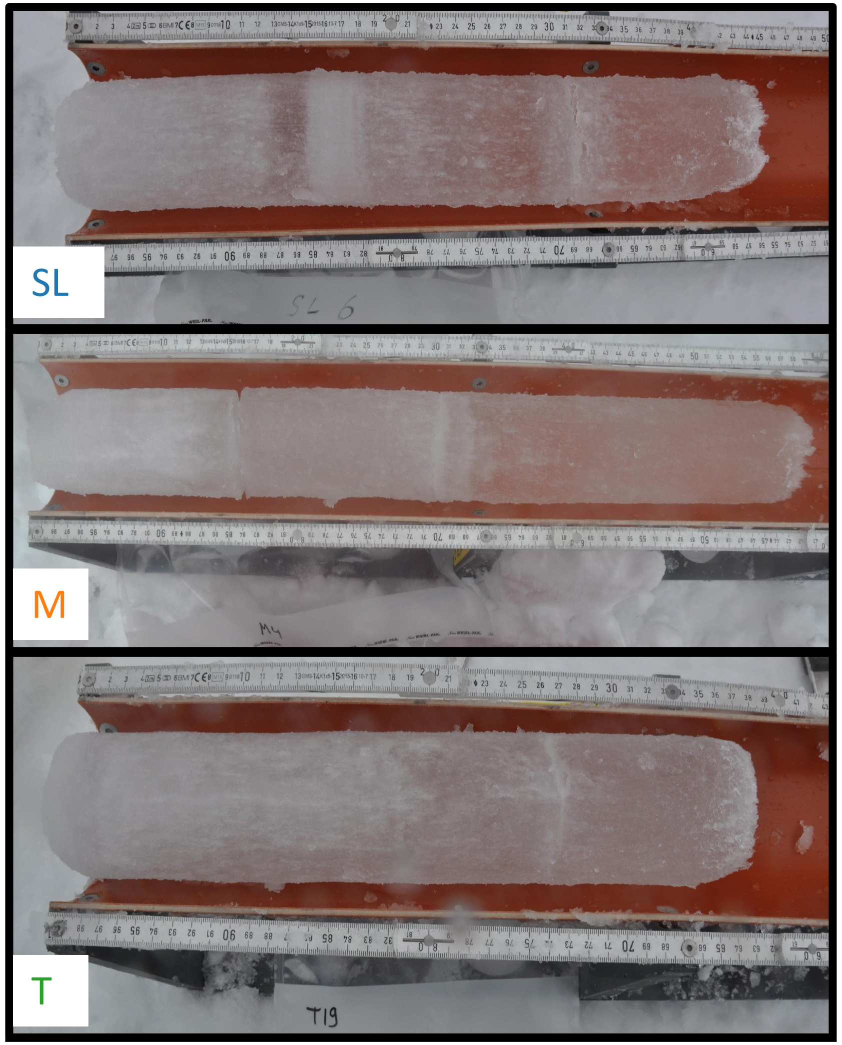
0
10


SL
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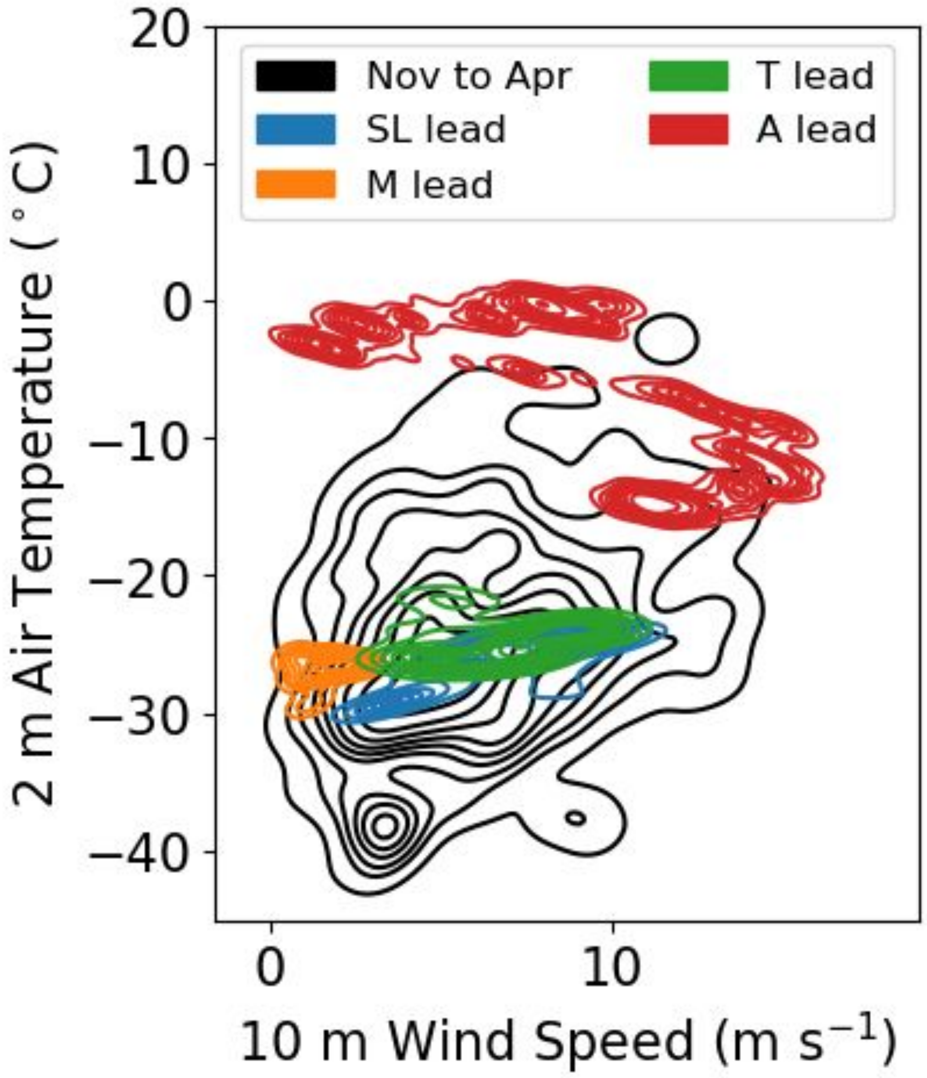
T

Leads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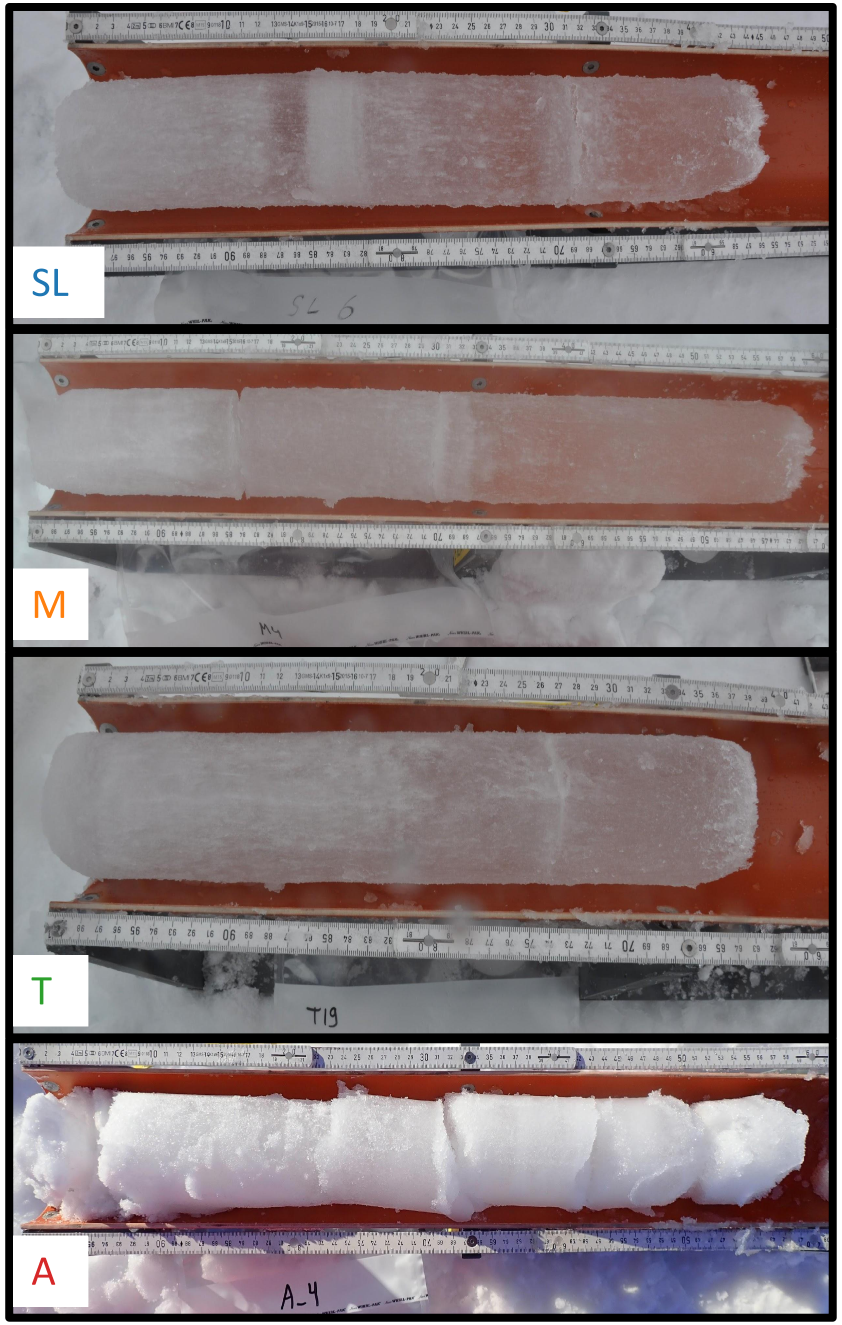
SL
M
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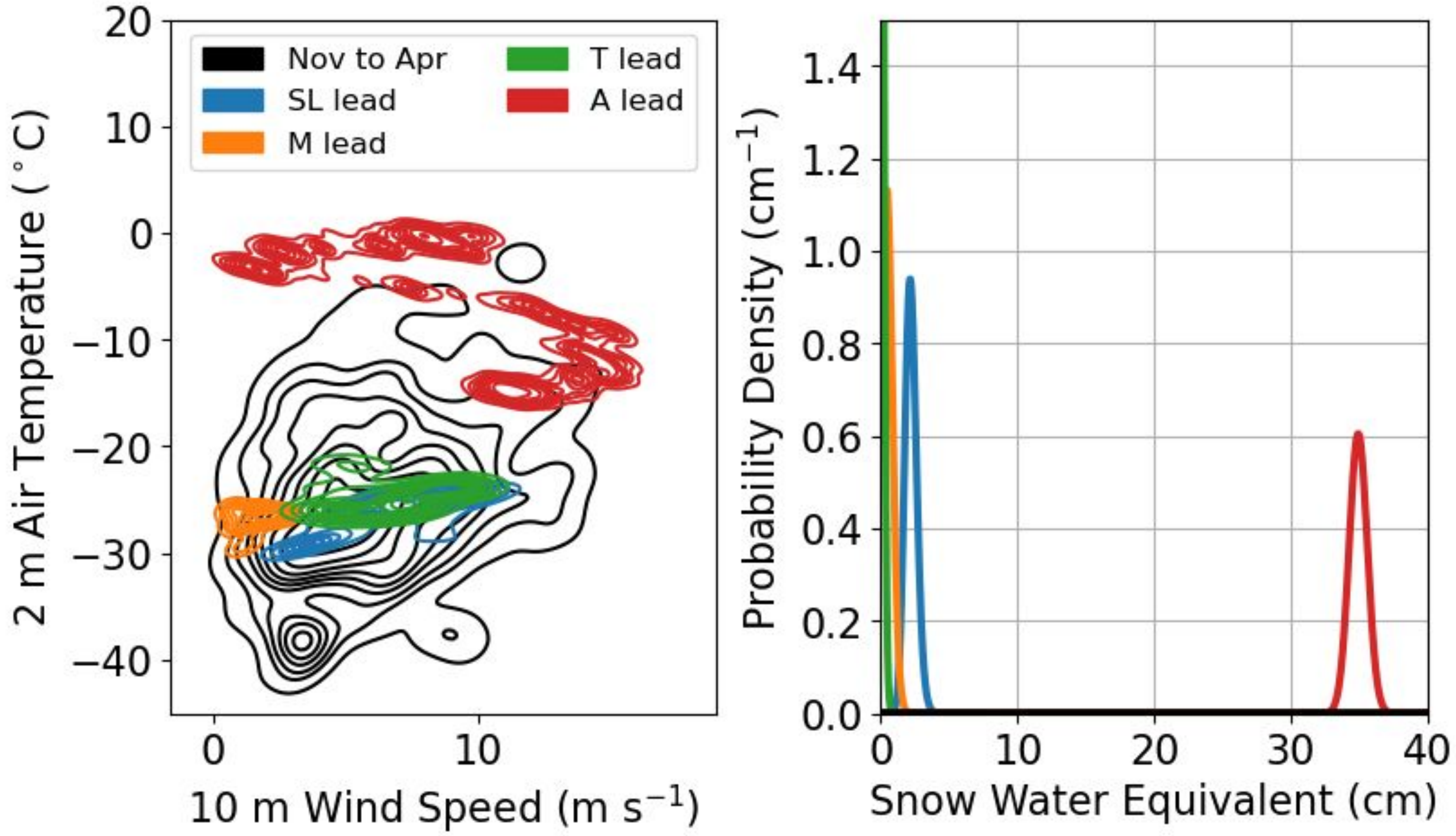
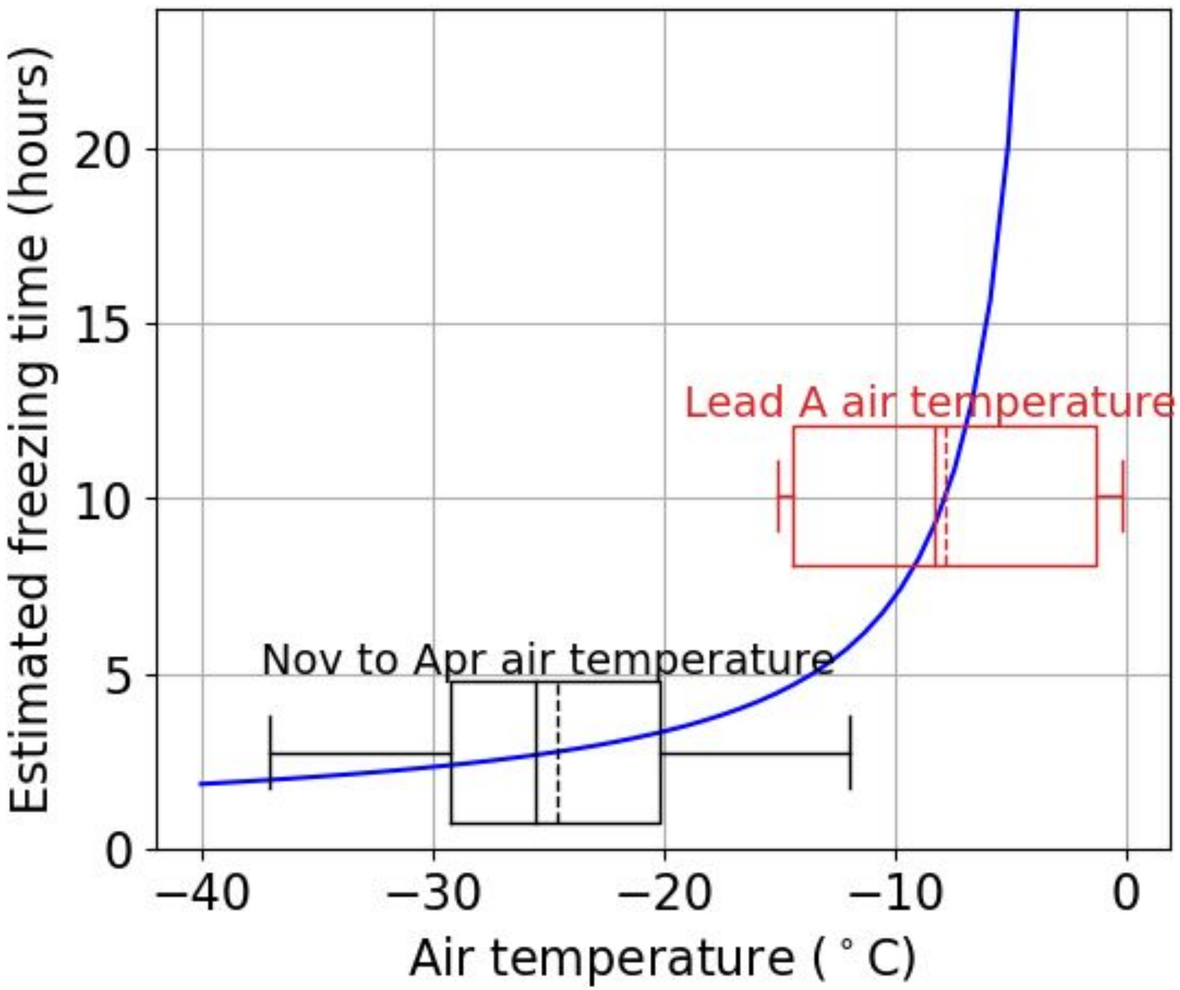
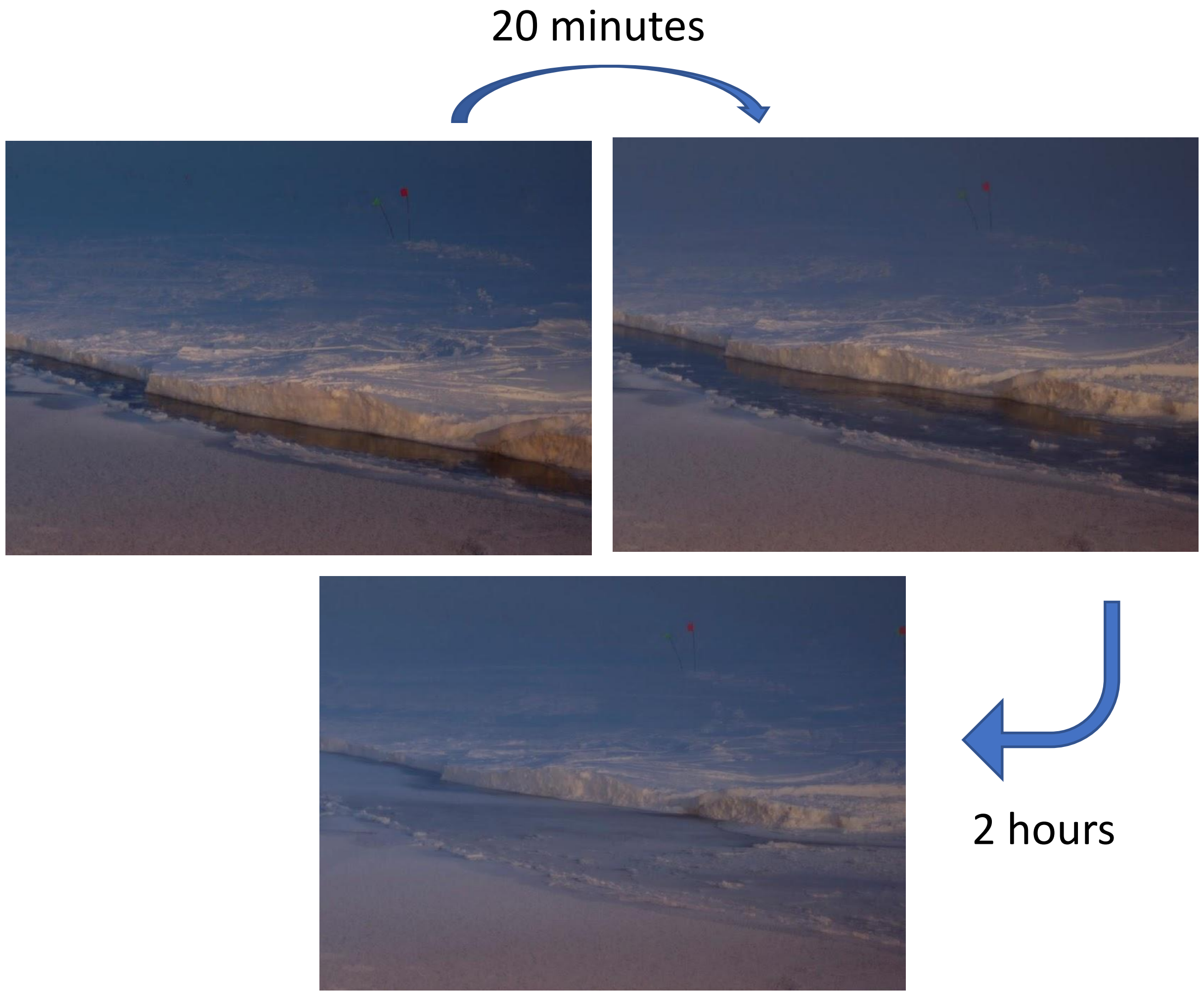
Leads



Nov to Apr
SL lead
M lead
T lead
A lead
2 m Air Temperature (°C)
10 m Wind Speed (m s^{-1})
20
10
0
−10
−20
−30
−40
0
10
Probability Density (cm^{-1})
Snow Water Equivalent (cm)
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0
10
20
30
40

Leads

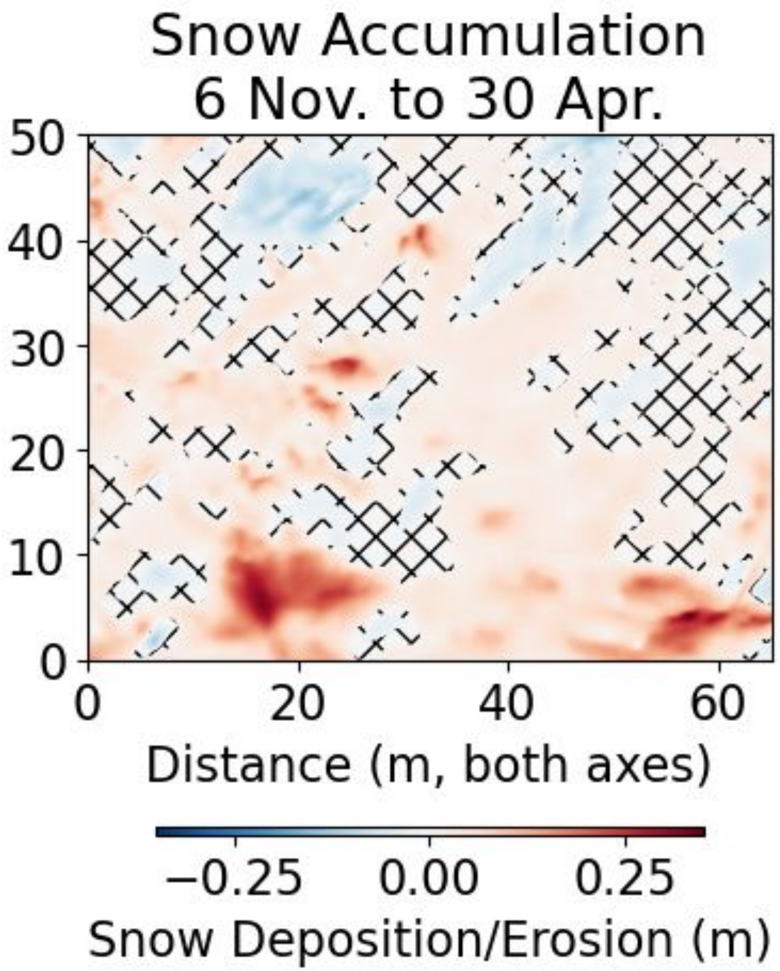




Photos: Manuel Ernst

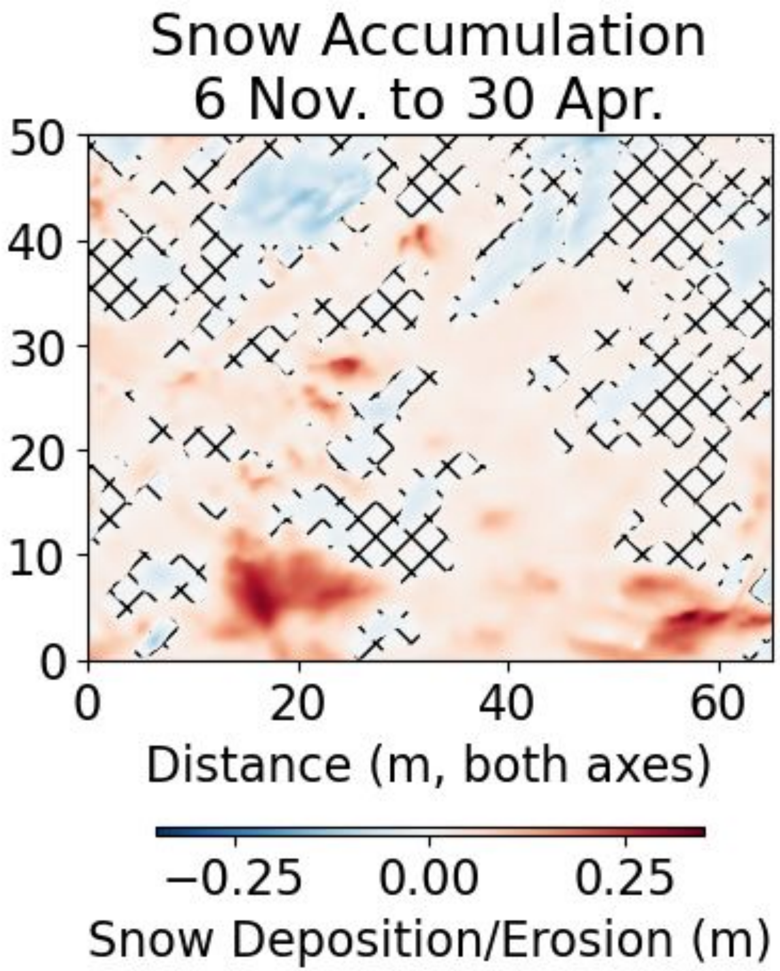
Level Ice and Ridges

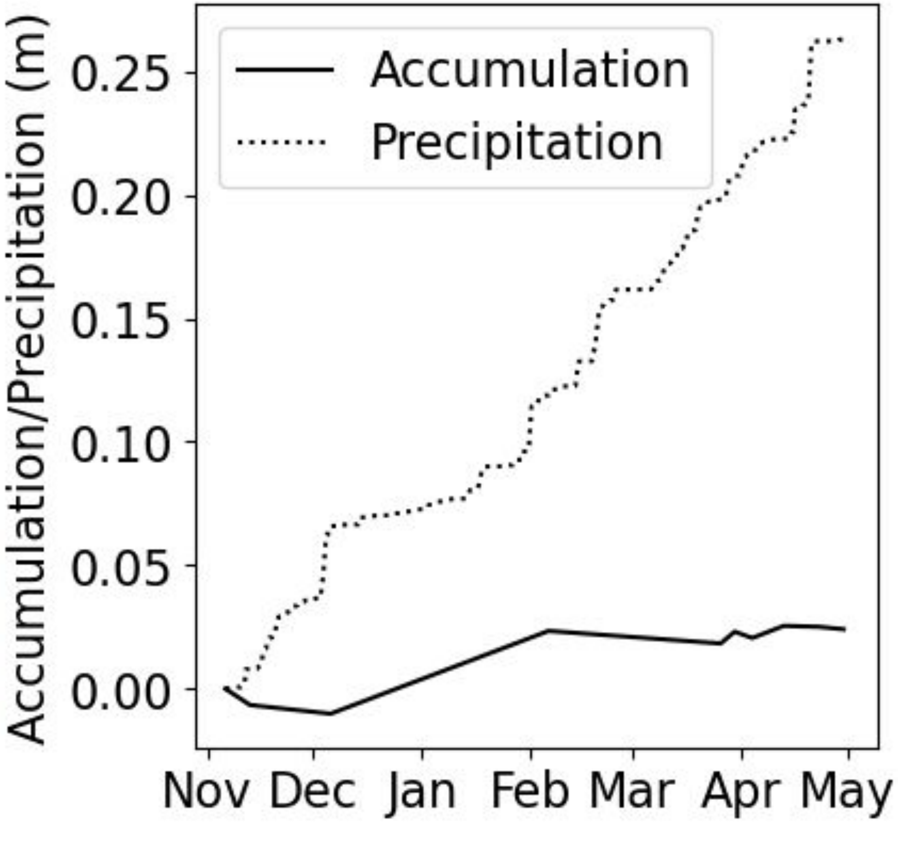
- Level ice accumulated just 2—3 cm of snow from Nov. to Apr.



Level Ice and Ridges

- Level ice accumulated just 2—3 cm of snow from Nov. to Apr.
- Precipitation was ~10x higher.
- Where did the snow go?





Level Ice and Ridges

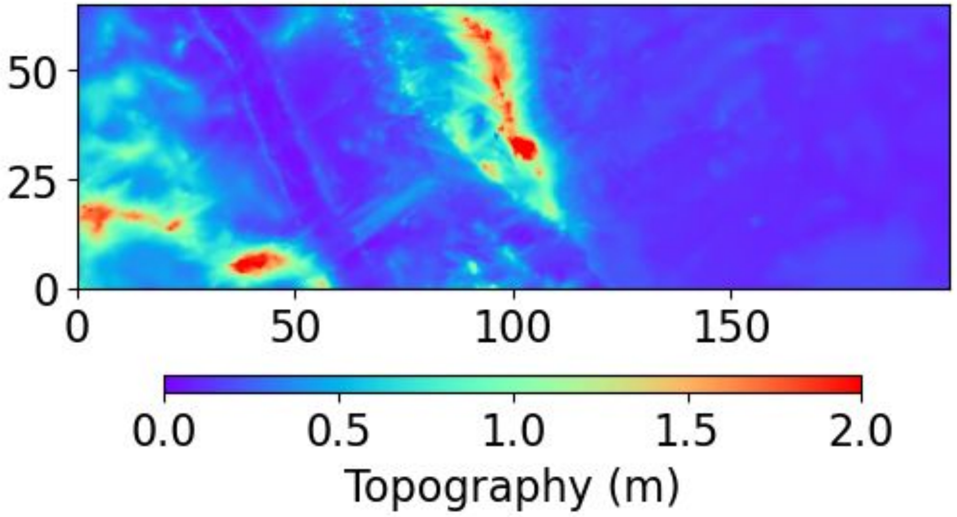
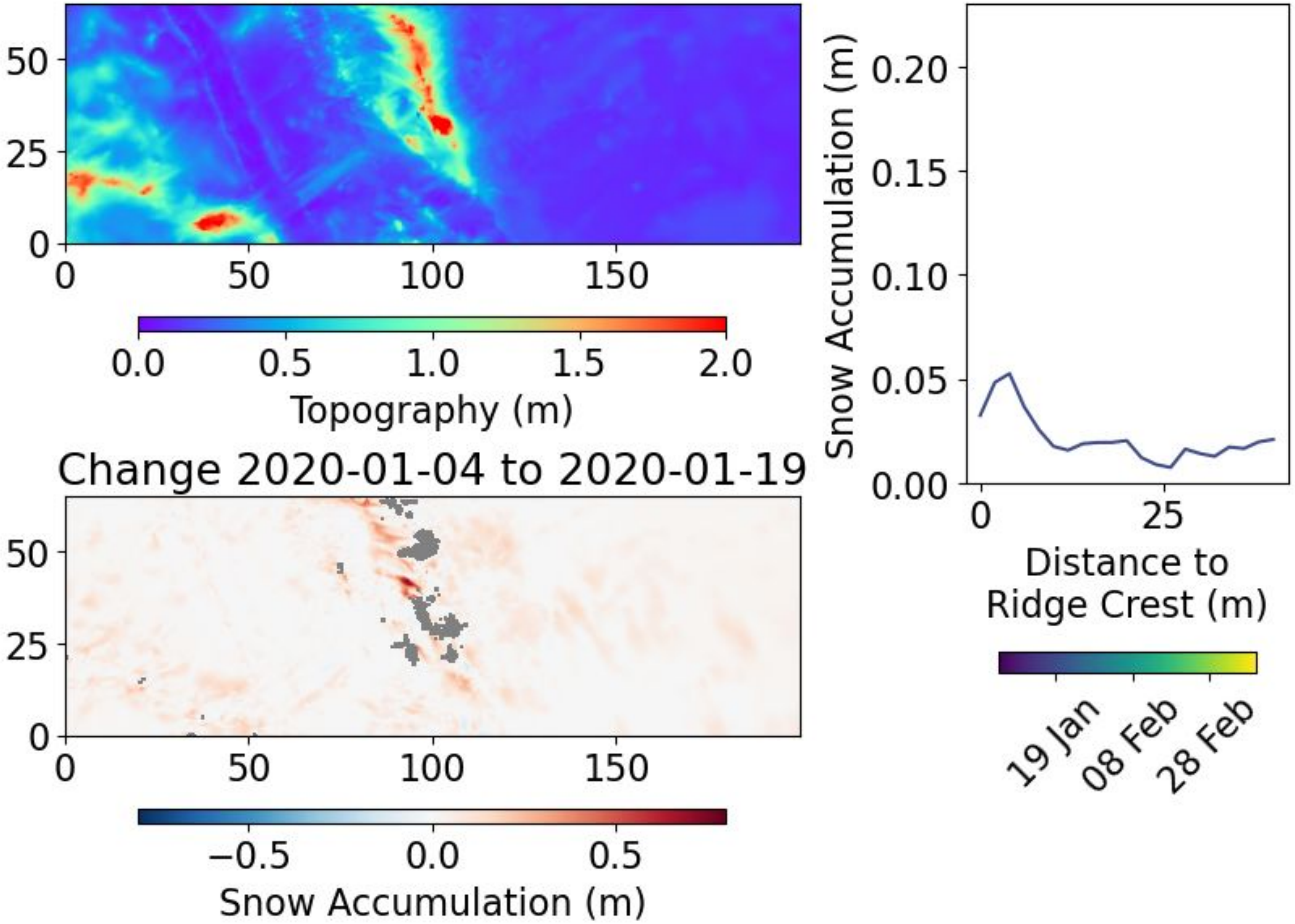


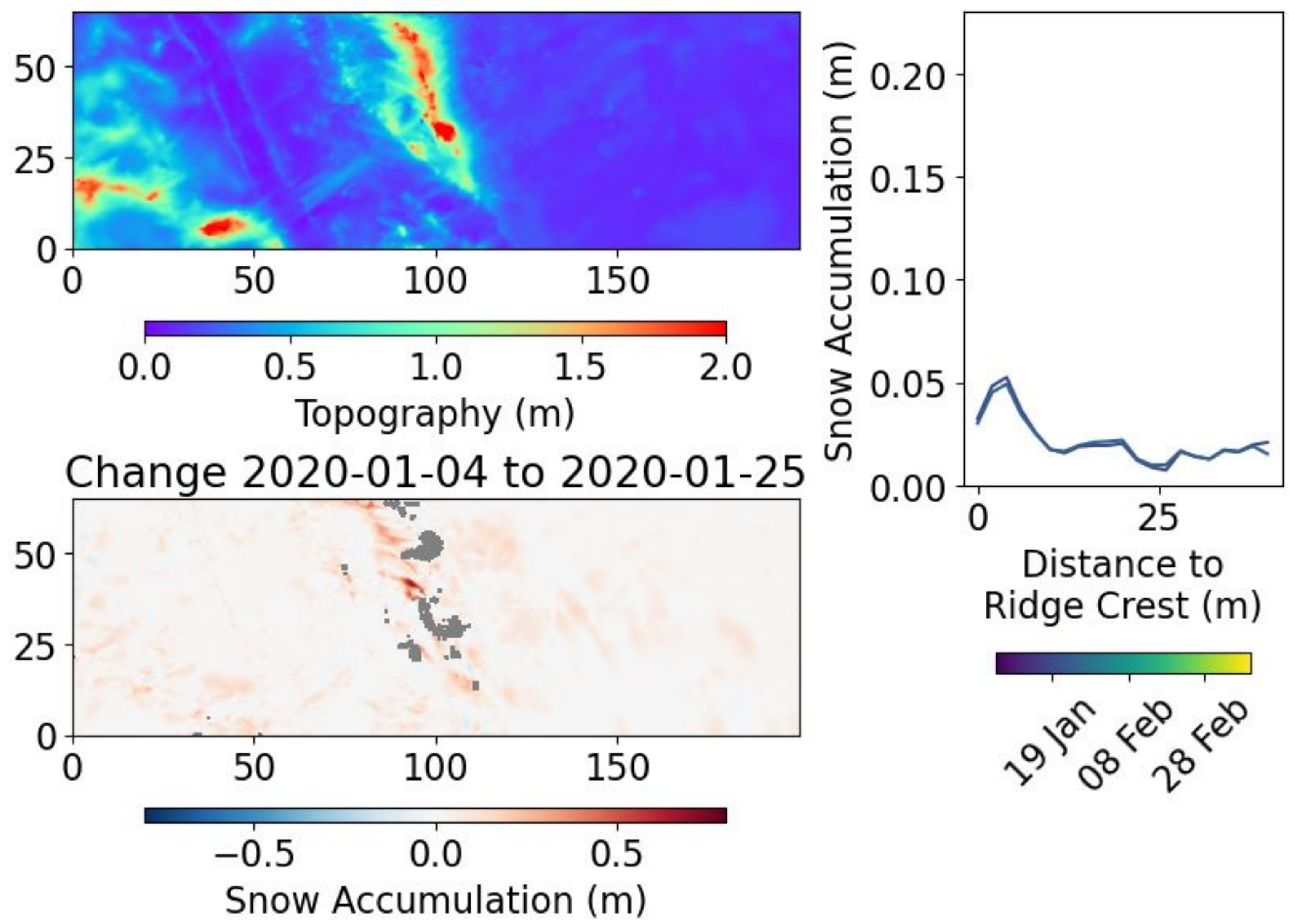
Photo: Michael Gutsche

Level Ice and Ridges



- More snow accumulation near ridges than on level ice.
- Patchy snow accumulation throughout.

Level Ice and Ridges



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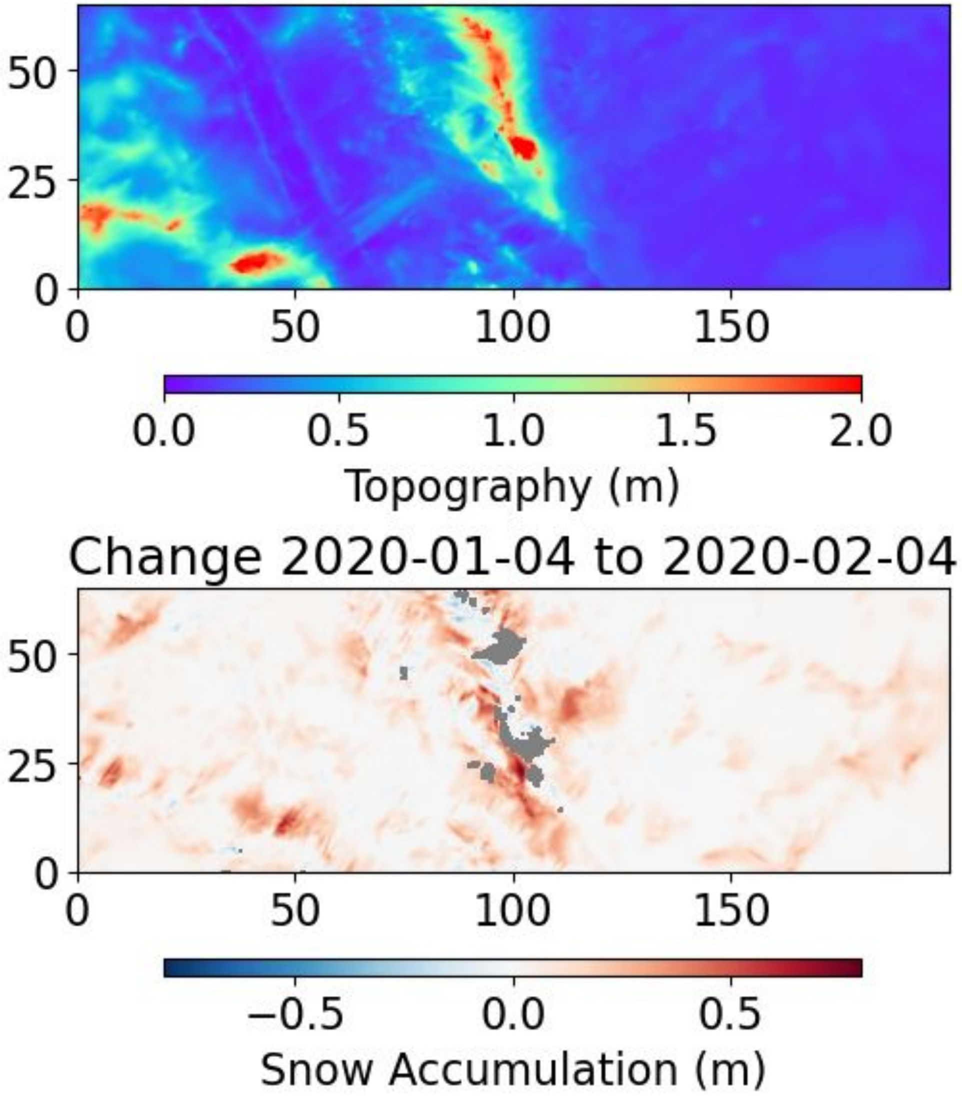
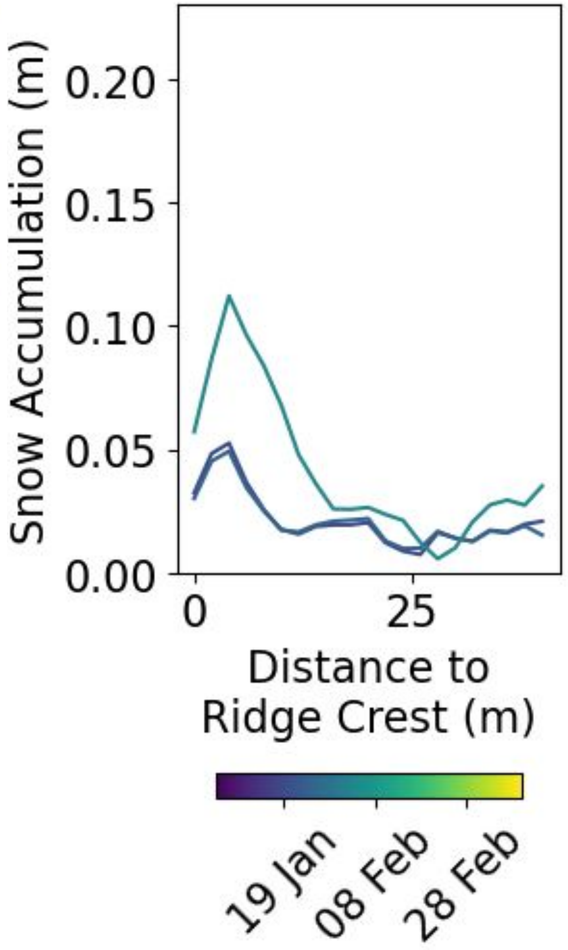
Level Ice and Ridges





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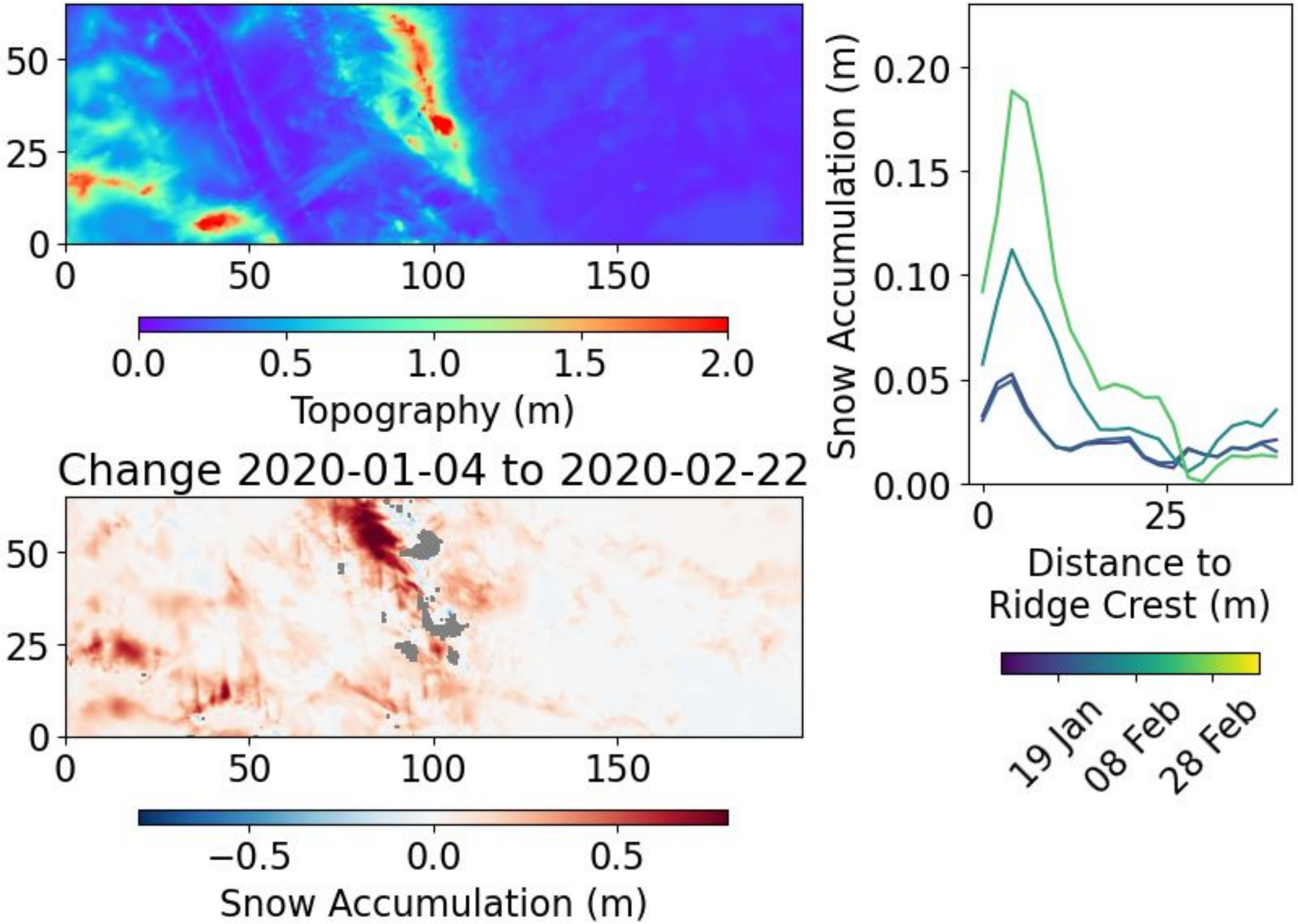
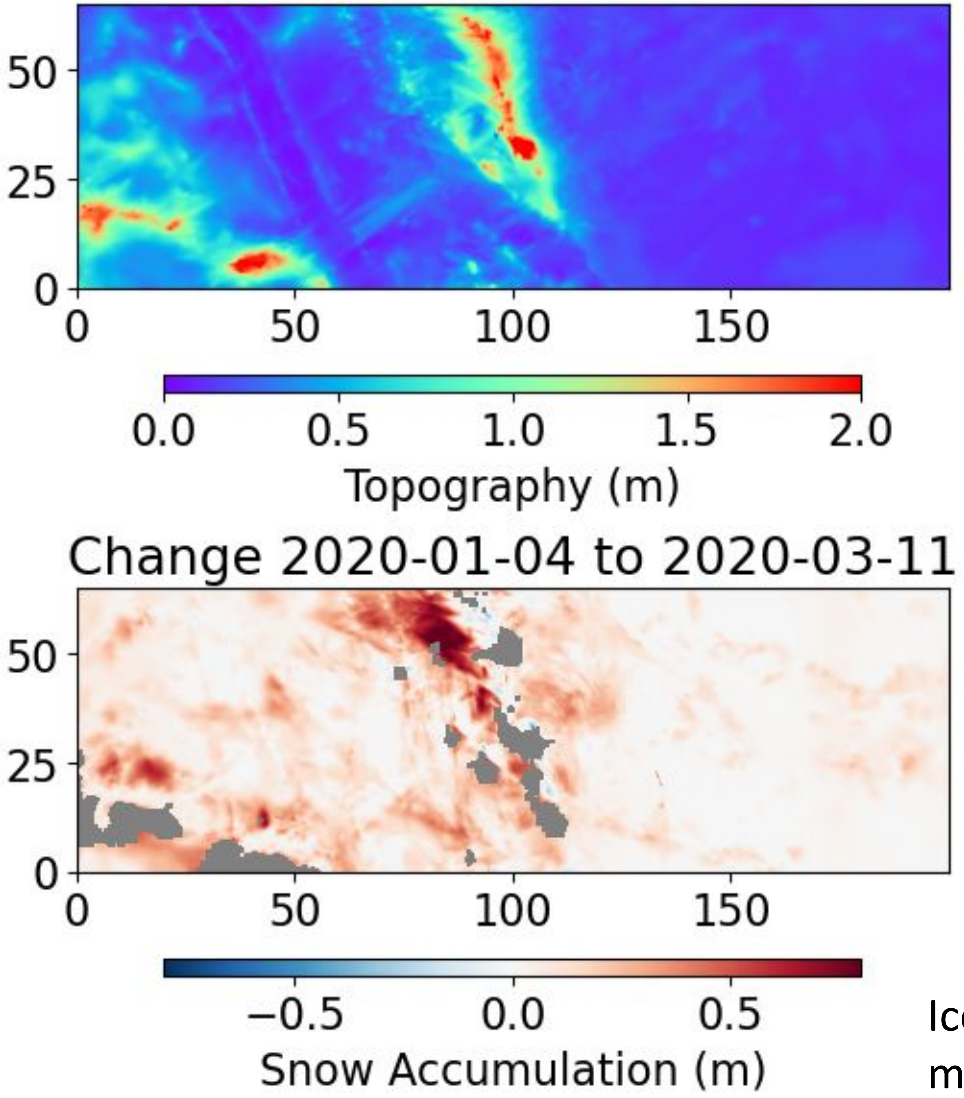
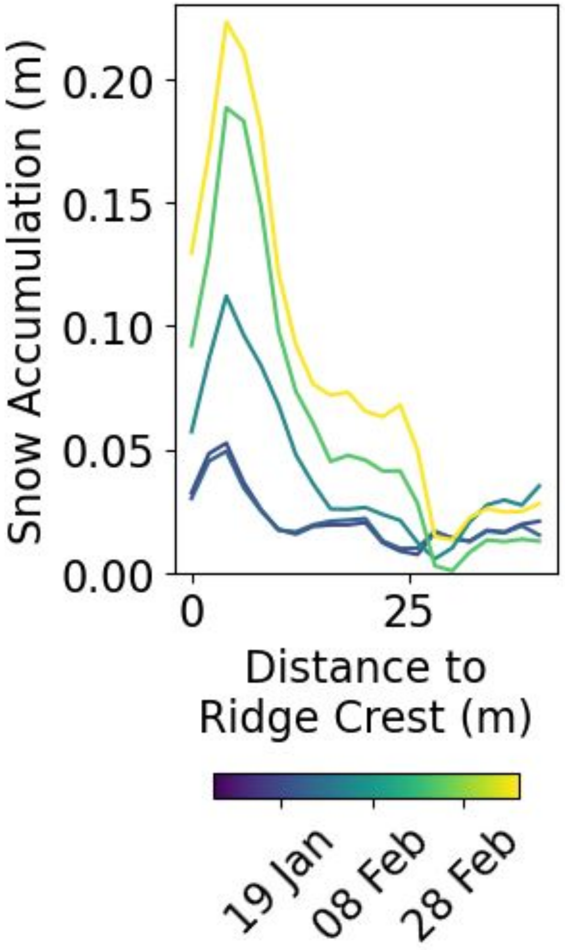
Level Ice and Ridges



- More snow accumulation near ridges than on level ice.
- Patchy snow accumulation throughout.
- Erosion is concentrated in areas of recent deposition.

Level Ice and Ridges



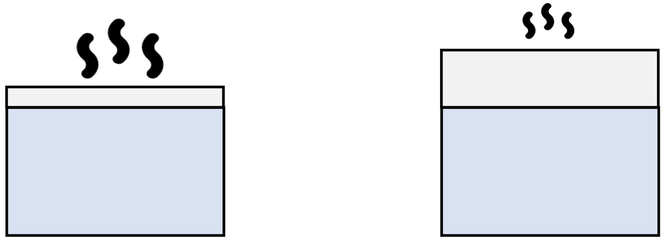


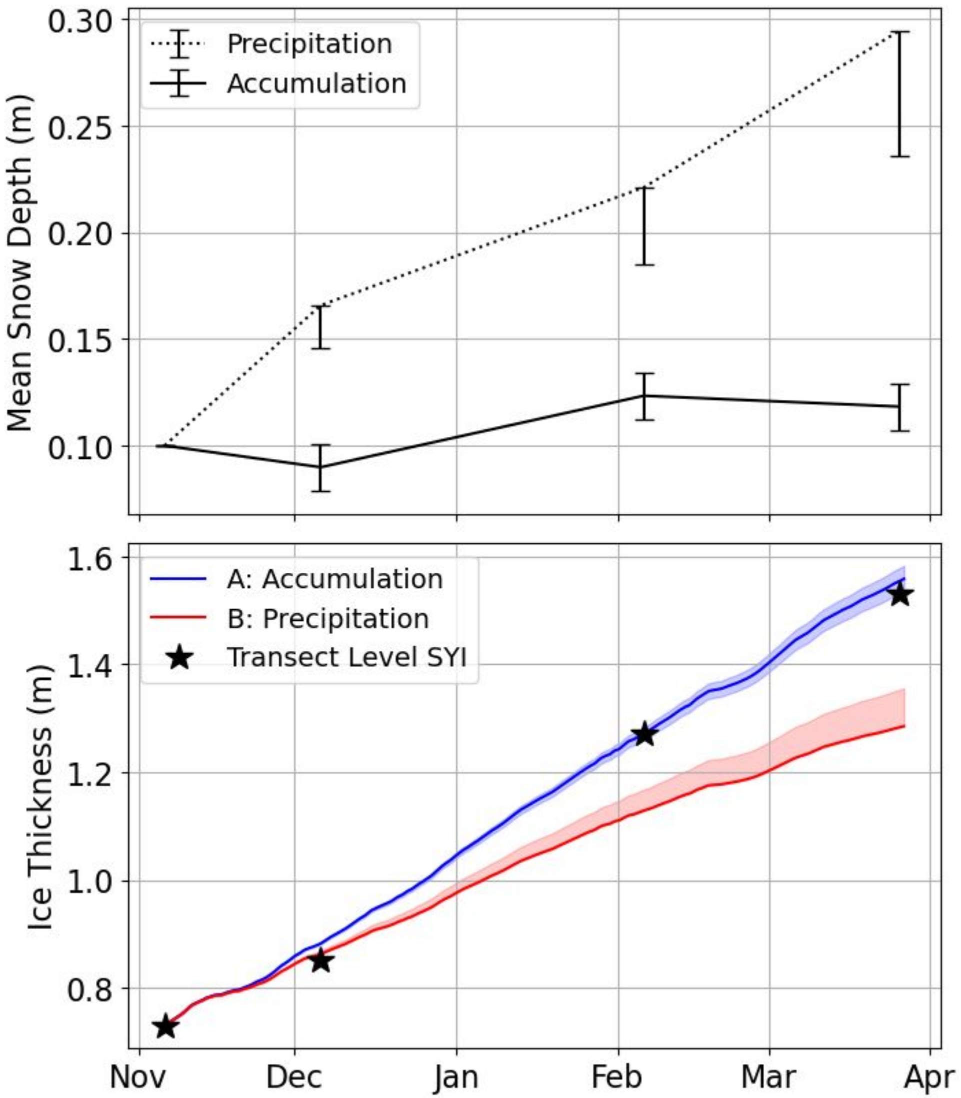
- More snow accumulation near ridges than on level ice.
- Patchy snow accumulation throughout.
- Erosion is concentrated in areas of recent deposition.

Ice deformation interrupted these measurements. Hence more shadowing.

Level Ice and Ridges

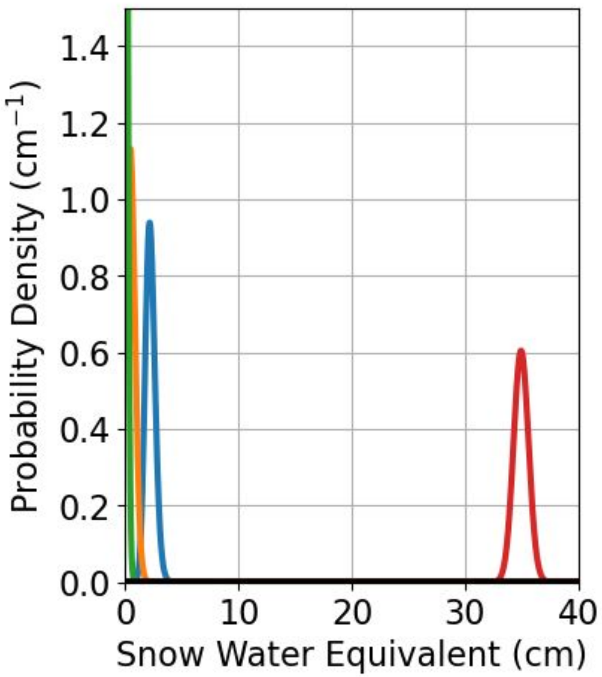
- Snow redistribution to ridges substantially reduced snow accumulation on level ice. Increasing the heat flux from level ice.
- 1-D ice growth simulations suggest that snow redistribution led to a 28—45% increase in ice growth for level, second year ice at MOSAiC from Nov. 6 to Mar. 26.
- Snow redistribution from level ice to near ridges is not currently represented in climate models.

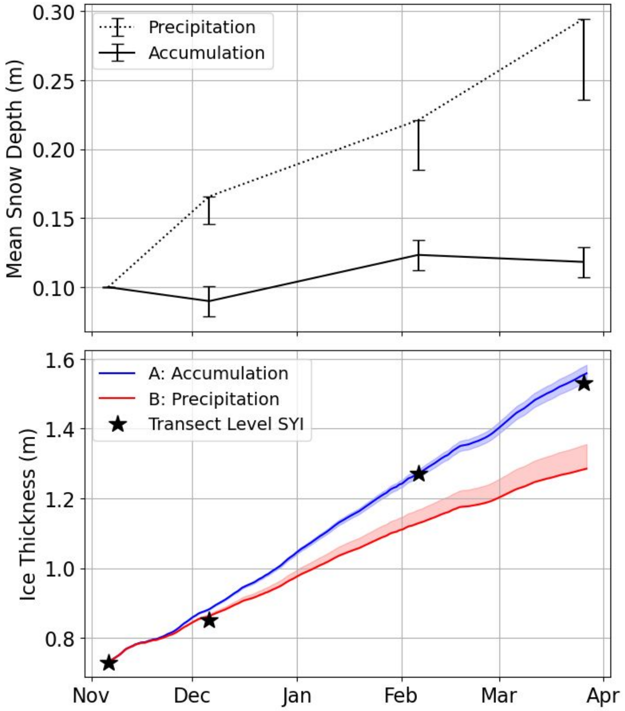




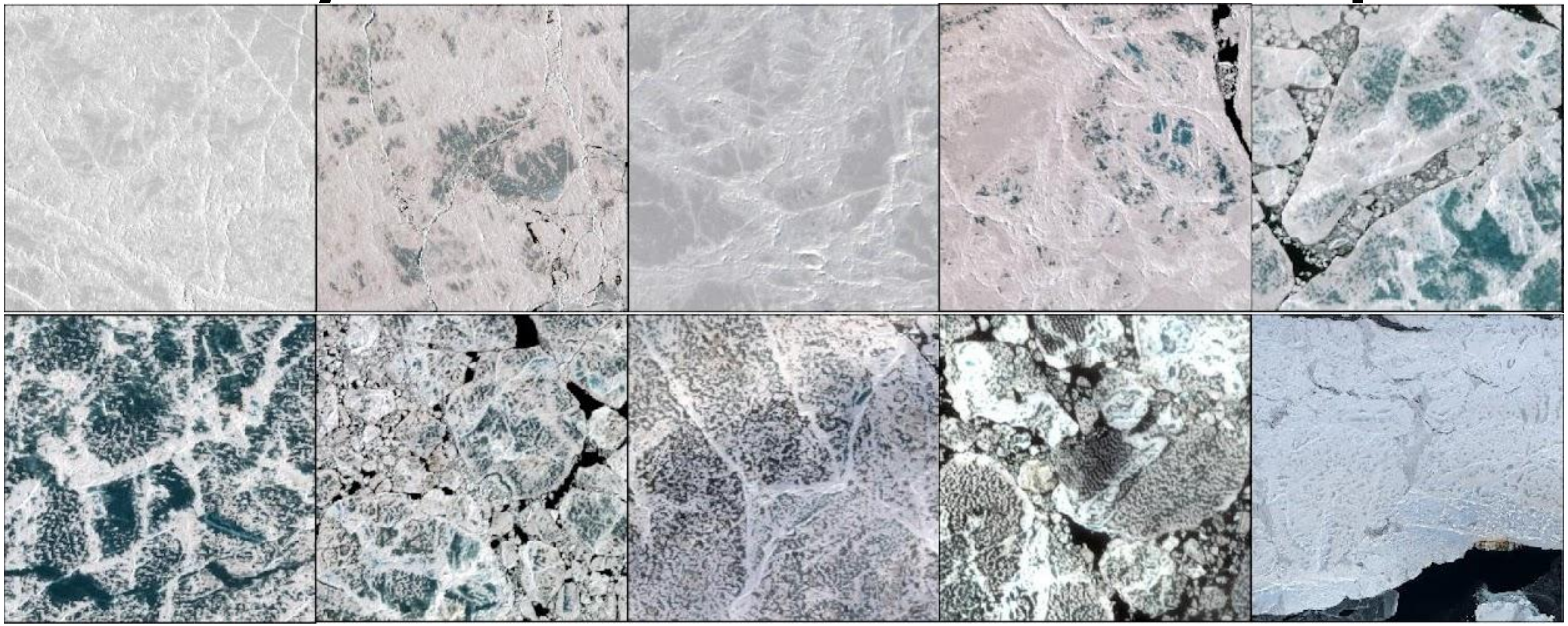
Summary of Observational Work

- Very little snow is lost into leads in typical, wintertime conditions. Exceptional, near-freezing conditions may be required to lose a significant amount of snow.
- Snow redistribution to drifts around ridges substantially limits snow accumulation on level ice. For level second-year ice at MOSAiC this snow redistribution likely increased ice growth by 28 – 45%.





Progress Towards an Icepack Model Case Study for the MOSAiC Expedition

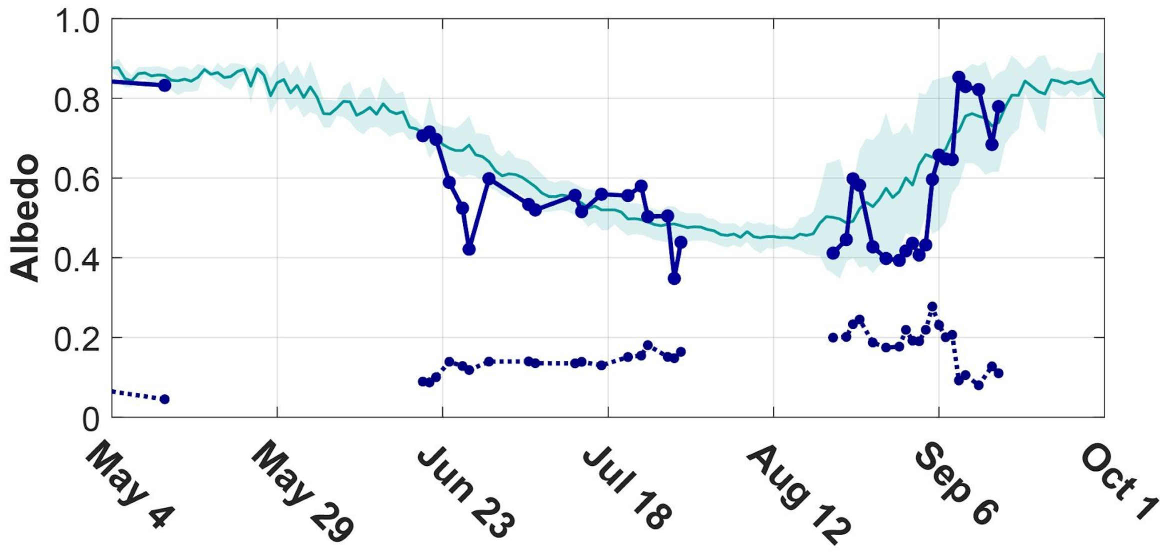


David Clemens-Sewall[1], Marika Holland[1], Angela Bliss[2], Chris Cox[3], Michael Gallagher[3], Jennifer Hutchings[4], Bonnie Light[5], Don Perovich[6], Chris Polashenski[6,7], Kirstin Schulz[8], Maddie Smith[9], Melinda Webster[5]

[1]NCAR, [2]NASA, [3]NOAA, [4]OSU, [5]UW, [6]Dartmouth, [7]CRREL, [8]UT, [9]WHOI

Motivation

Direct comparison between coupled-climate model output and observations is challenging because of internal variability and the potential for offsetting errors.



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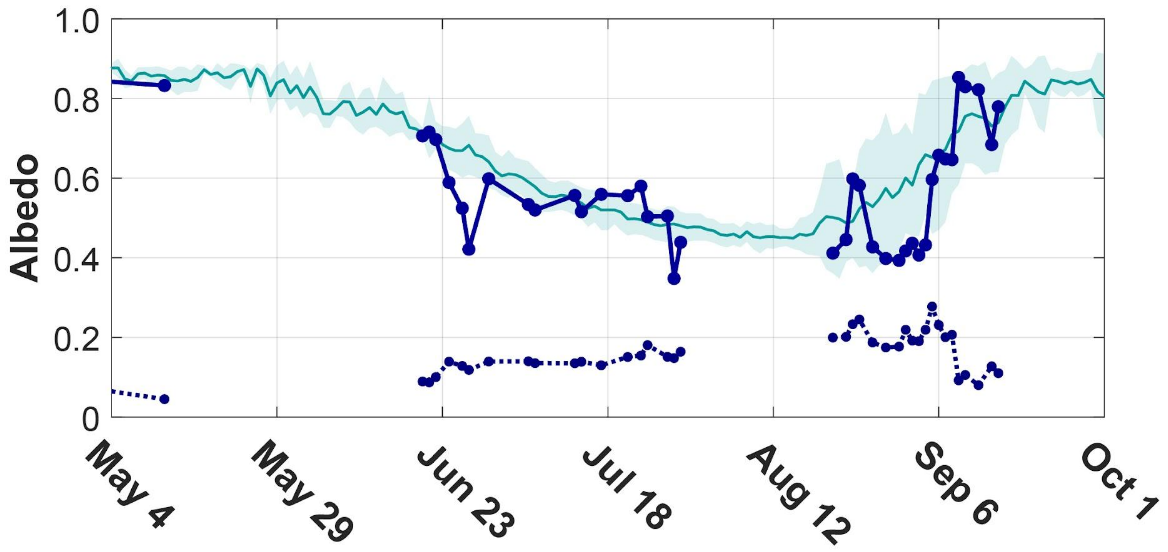
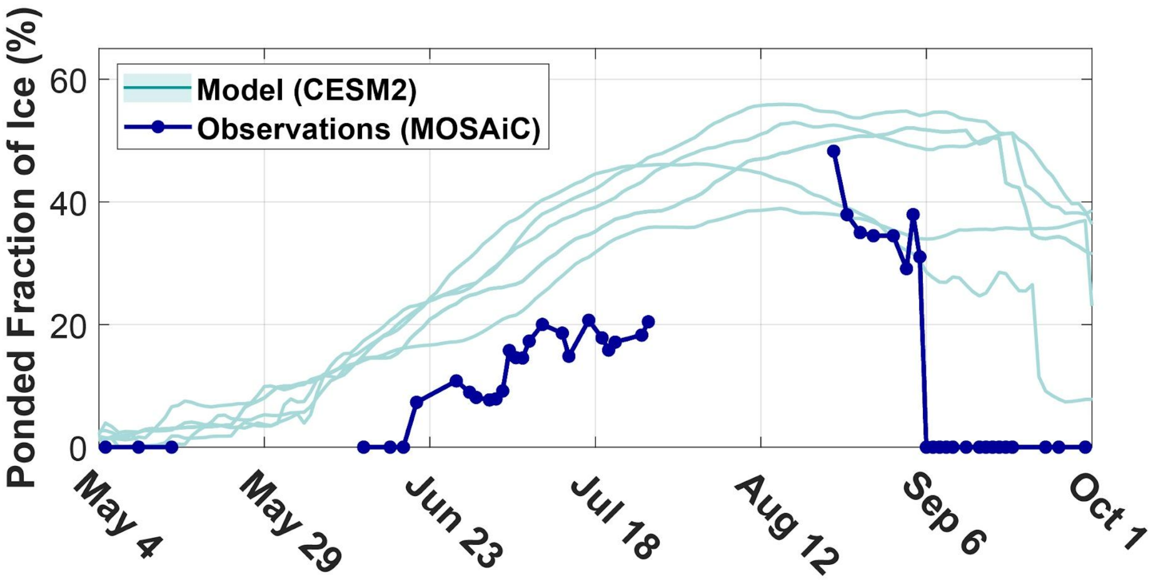
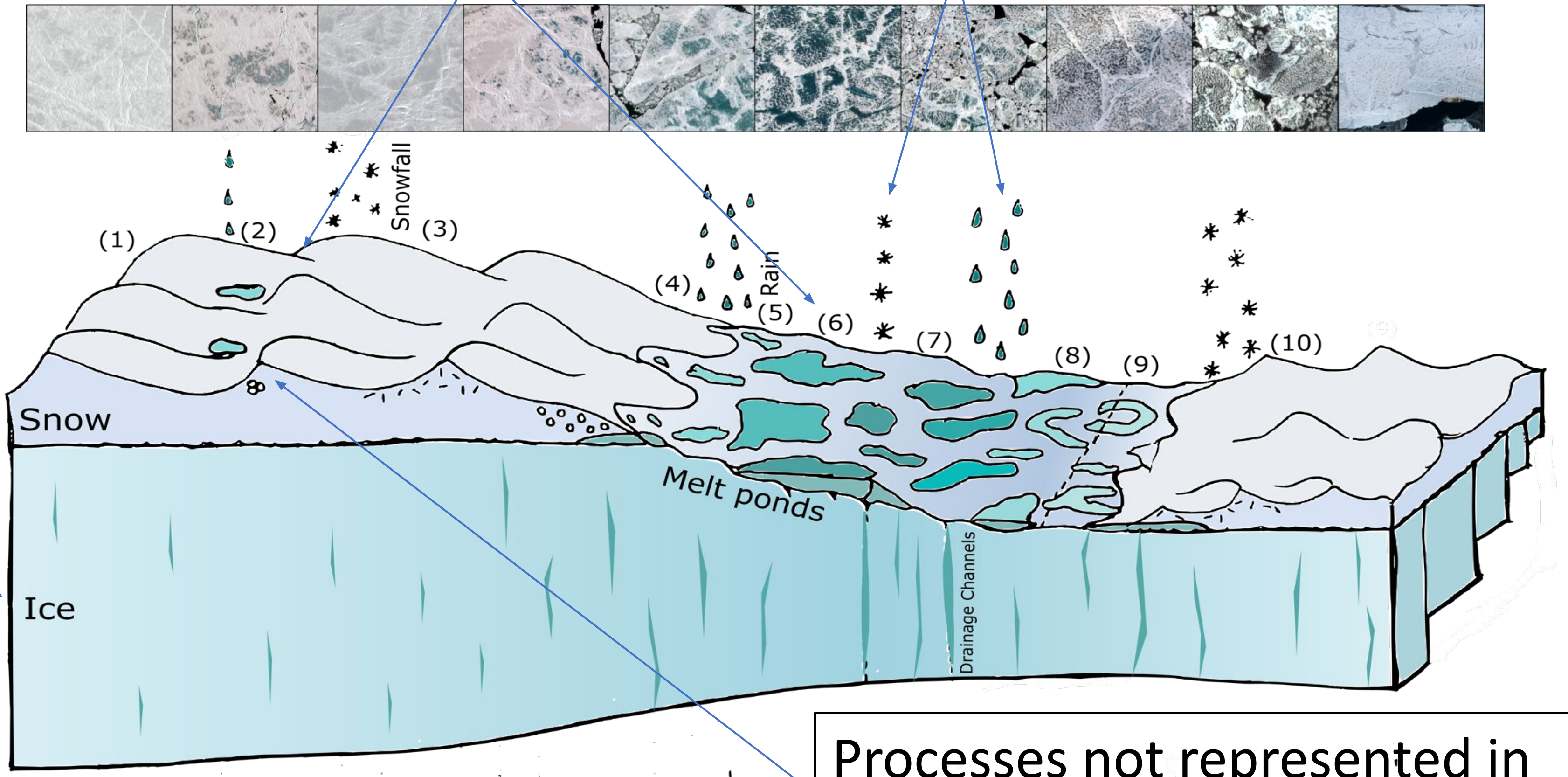




Objectives

Subgridscale spatial variability

Episodic events

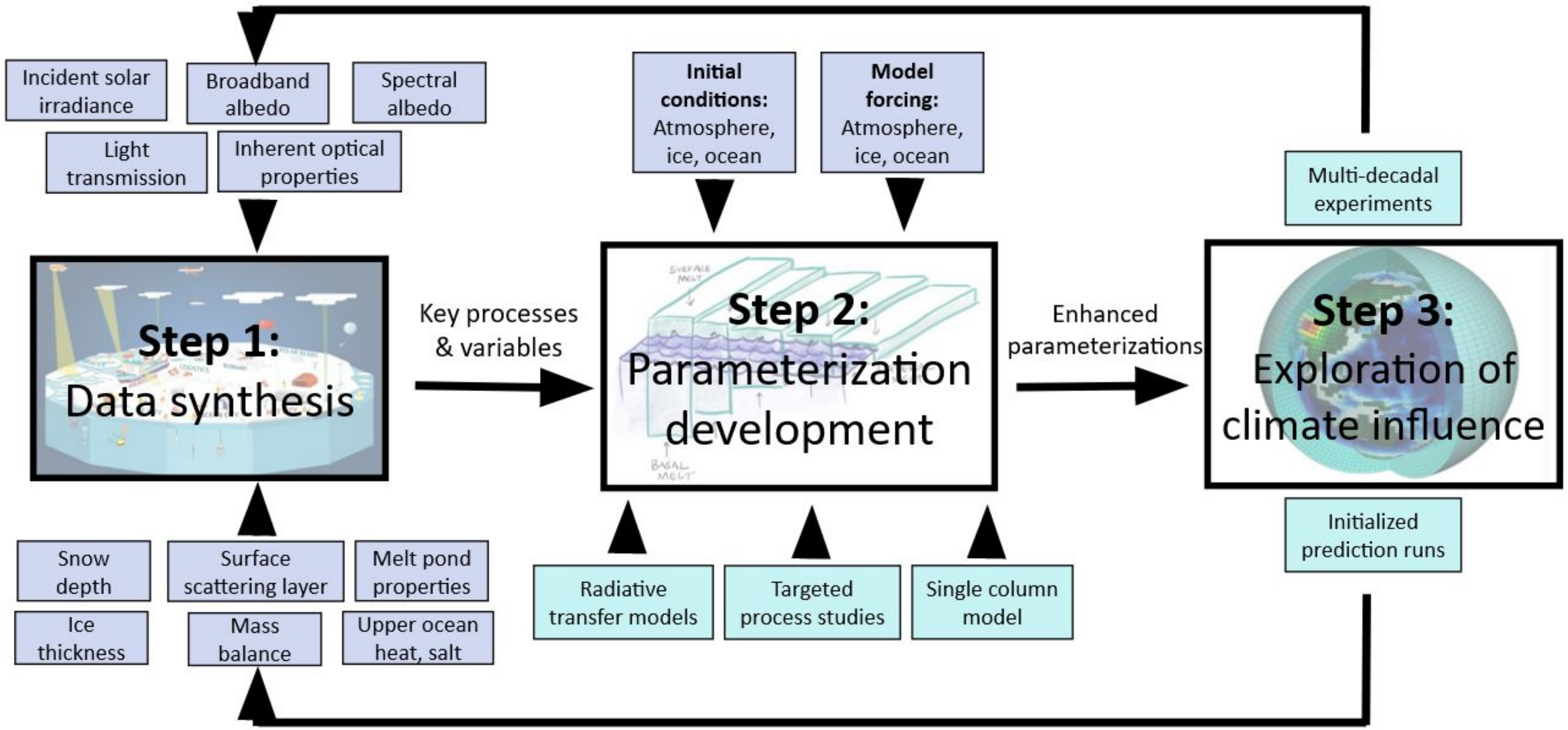


Impacts of initial conditions

Processes not represented in Icepack (e.g., snow redistribution)

Approach

Icepack will be configured as a drifting Lagrangian parcel that is subject to the same forcing as observed during the MOSAiC field experiment.



Approach – Spatial Scales

Scale	Initial Condition	Forcings	Validation
Floe (~1 km) No Deformation	IMBs (hi, hs, internal T), Stakes (hi, hs), Transects -conserved segments (hi, hs), Cores (salinity, isotopes)	Met City (air T, humidity, wind velocity, LWD, SWD), KAZR (precip), PWD22 (precip). Ocean City (oceanic heat flux, sea surface T and S)	Met City (turbulent heat fluxes, LWU), IMBs (hi, hs, internal T), Transects -conserved segments (hi, hs, ponds), Cores (salinity, isotopes), TLS - conserved regions (topography), Albedo + Transmittance, Aerial + Satellite Photography (ponds)
Floe (~1 km) With Deformation	Same as above plus deforming segments of Transects	Same as above plus Ice Radar (div, shear), GPS buoys (div, shear)	Same as above plus deforming regions of Transects + TLS
Local (~10 km) With Deformation	EM-Bird (hi, hs), IMBs (hi, hs, internal T), Cores (salinity	Same as above	Same as above plus EM-Bird (hi, hs), ALS (topography)

Anticipated Challenges

- Accounting for sampling and instrument biases.
- Ice deformation.
- Start of melt season measurement gap.
- Comparing results between different groups using different initial conditions, forcings, and validation.

Potential for Collaborations

- We are assembling merged initial condition, forcing, and validation datasets for the MOSAiC drift.

- Process studies and additional measurements (e.g., BGC, ice deformation, ocean and atmospheric processes, RS, …)

- Infrastructure improvements to CICE Consortium code.

- Contact: dcsewall@ucar.edu