ASR Atmospheric System Research

U.S. DEPARTMENT OF ENERGY

1

2

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# The Ground Effect: Snow, Ice, and Tundra Albedo in the Arctic


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Snow cover on Arctic tundra and sea ice is thin and wind-blown. The snow is deposited on substrates with micro-relief nearly equal in height the mean snow depth, and meso-relief that can either pond or drain melt water.

During the spring melt, the water in the snow can coarsen snow grains, reducing albedo, or refreeze in pore spaces as superimposed ice, retarding melt. Under the snow, the water can pond or run-off. Albedo trajectories are controlled by these complex melt processes.

**Research Question**:

*How does snowmelt drive the seasonal evolution of land and sea surface albedos in the Alaskan high Arctic, and particularly, what are the relevant melt processes and their driving factors?*

1
2
3
4
5
6

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# 3 Field Sites


Core daily measurements (depth, spectral albedo, density, layering, liquid water distribution, grain size, contaminants, orthomosaic airphotos etc.) were focused on a 200-m line at each site, as shown to the left, and by colored circles to the right.

## ARM

- @ NSA (North Slope Alaska)
- 2.7 km from Chukchi Sea
- 11° slope
- low tundra vegetation
- water-drainage ditch at ~50m

## BEO

- 6 km inland
- low polygon tundra
- little hydraulic gradient
- low-center polygon & ice wedge ponding


## ICE

- on Elson Lagoon
- 1 km from Chukchi Sea
- smooth ice
- dune snow
- melt ponds

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2

3

4

5

6

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# Daily Measurements

[Watch the video of our field work here]

A

A: Spectral albedo (ASD)

B

B: Superimposed ice/basal water

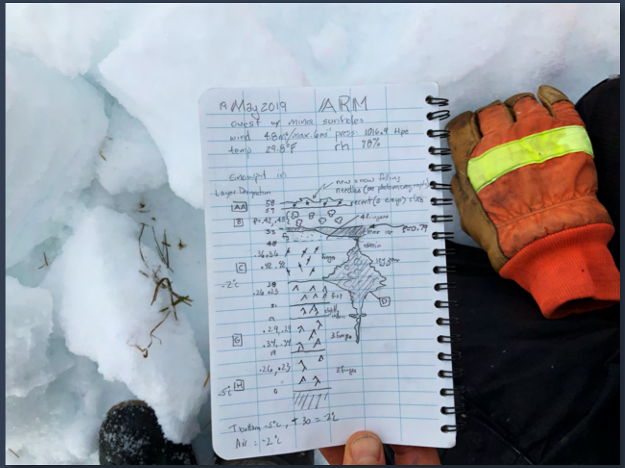
C

C: Pole photos for orthomosaics & DEM

D

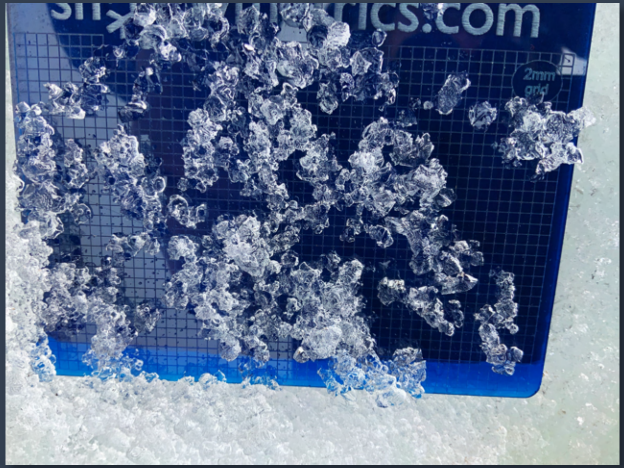
D: Snow pits

E



E: Detail notes: surface & substrate conditions

F



F: Grain size

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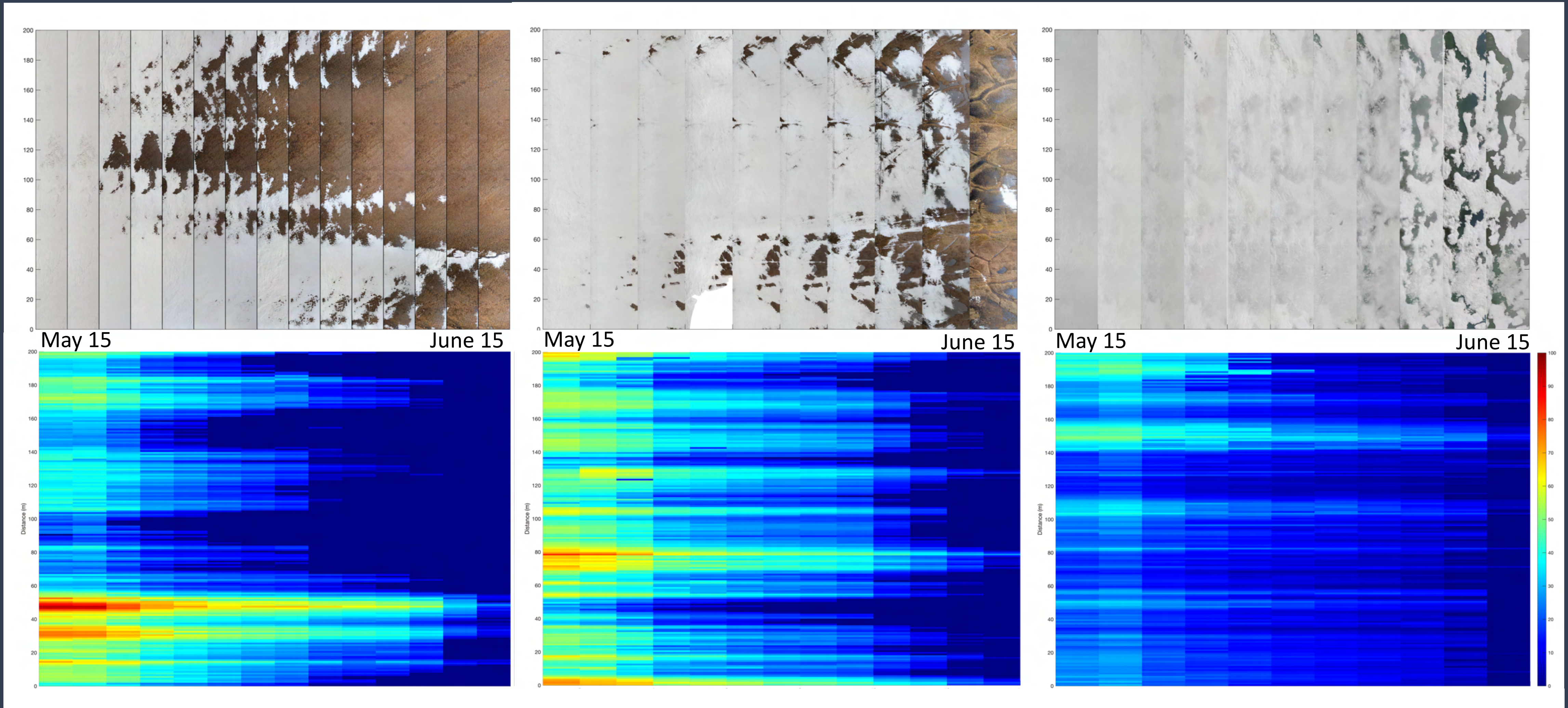
# Observation: Different melt patterns at 3 field sites

→ with most rapid snow clearance at best-drained site, longest lasting snow where snow was deep and retained melt water in and under the snow



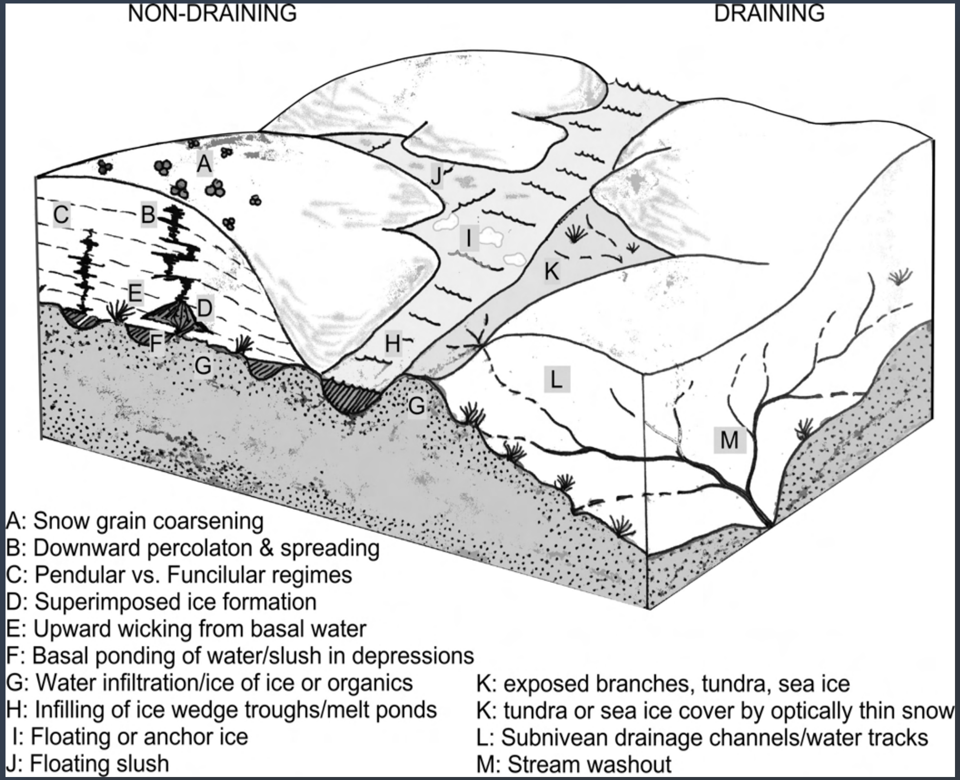
**ARM** **BEO** **ICE**

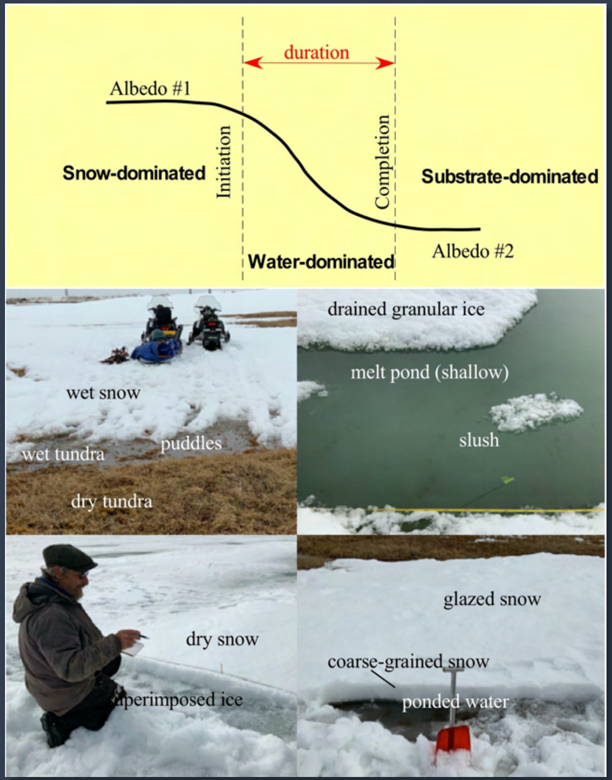


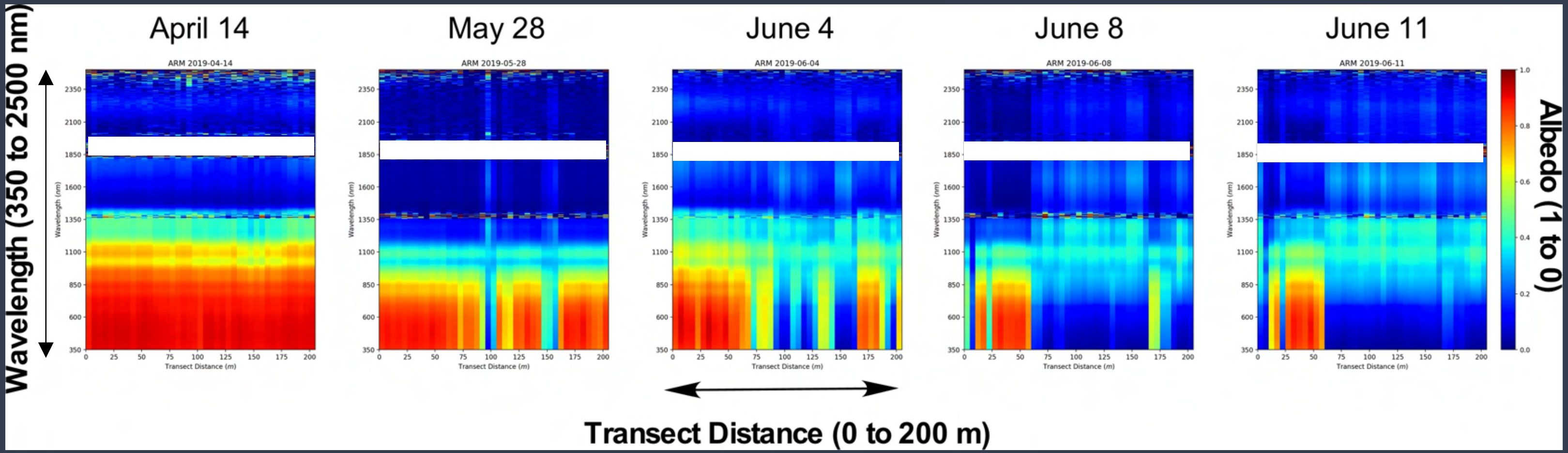

Above: Orthomosaic images taken from our three field sites over the course of the melt period.
Below: Corresponding snow depth measurements (cm) along the 200 meter transects at the three sites over the course of the melt.

# *14* Critical melt processes at work—What matters most for albedo?

1
2
3
4
5
6




The transition from snow-covered (~0.8) to snow-free (~0.1) albedos (bottom sequence), an 8x reduction in reflectivity, is a function of **melt stage**, and the nature (slope and micro-relief) of the **substrate**, moderated by the **weather sequence** during the melt.

**Preliminary results** suggest longwave losses during the short Arctic night may be important in that they can create basal and interstitial water freezing, prolonging the melt, while water drainage may hasten it.

# What comes next?

1
2
3
4
5
6

- Repeat 2019 measurements in 2022 and 2023
- Obtain permission for **drone** flights for better DEM modeling & snow volume calculations
- Add moveable Kipp & Zonen radiometers to obtain irradiances
- Add Chukchi site with ridged/rafted ice
- Create albedo catalog with surface descriptions & photos
- Quantify water fate using various tracing methods & give greater attention to water distribution
- Implement SnowModel (computer modeling code) for refined snow patch melt scenarios

➔ This sequence will help us *reduce 14 down to fewer critical processes* to consider, and allow us to eventually extrapolate our results over watersheds and larger Arctic regions.

*We acknowledge that our field sites are located on the traditional and present lands of the Iñupiat and that the University of Alaska Fairbanks' Troth Yeddha' campus is in the traditional homelands of the Lower Tanana Dene.*

Thanks to ARM and UIC Science for logistical support

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