Remote Sensing of the Arctic Ocean using National Technical Means
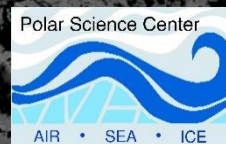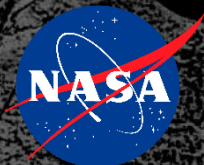
Melinda A. Webster[1], Ignatius G. Rigor[1], Donald K. Perovich[2,3], Jacqueline A. Richter-Menge[2], Christopher M. Polashenski[2], & Bonnie Light[1]

6th Symposium on the Impacts of an Ice-Diminishing
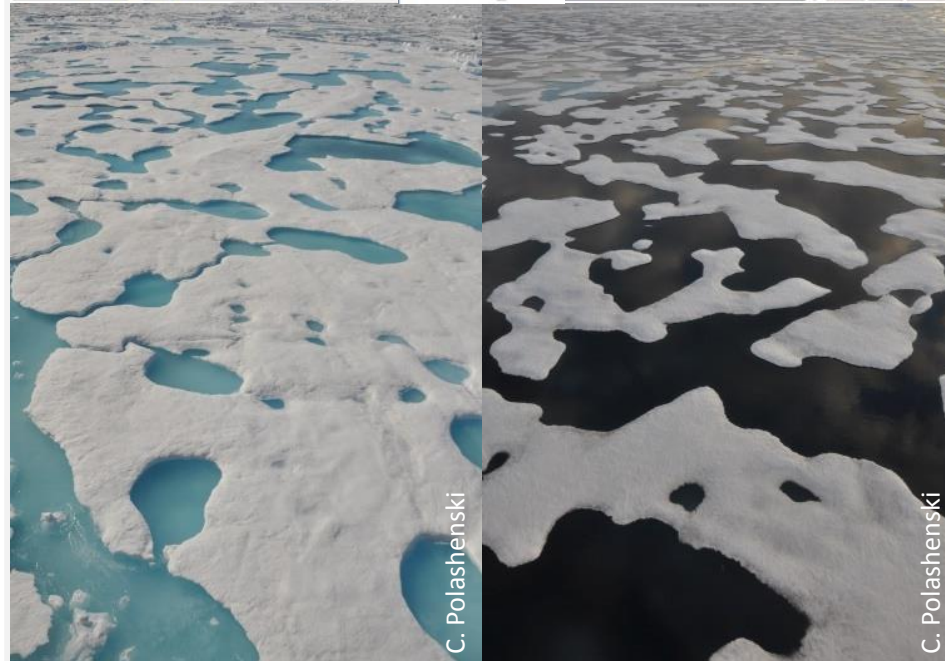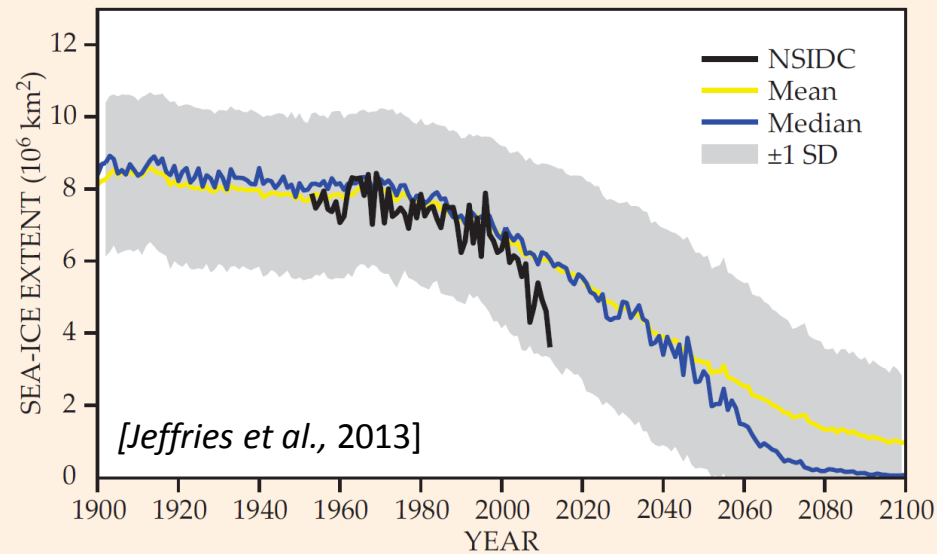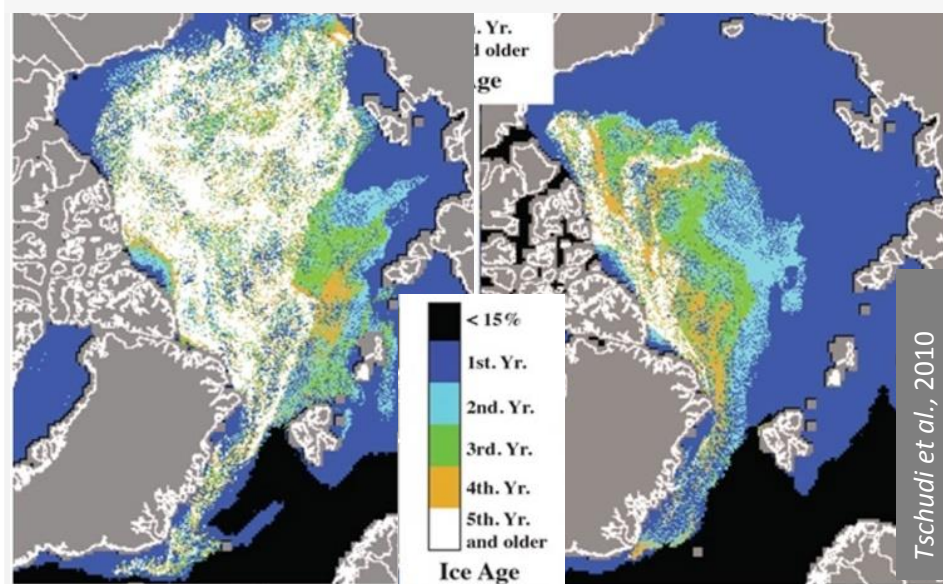Arctic on Naval and Maritime Operations

[1]Polar Science Center, Applied Physics Laboratory, U. of Washington, Seattle, WA.
[2]US Army Corps of Engineers, Engineer Research and Development Center, Cold Regions Research and Engineering Laboratory, Hanover, NH.
[3]Thayer School of Engineering, Dartmouth College, Hanover, NH.

Arctic sea ice: then & now.

Tschudi et al., 2010

< 15%
1st. Yr.
2nd. Yr.
3rd. Yr.
4th. Yr.
5th. Yr. and older
Ice Age

[Jeffries et al., 2013]

NSIDC
Mean
Median
±1 SD

SEA-ICE EXTENT (10^6 km^2)

YEAR

C. Polashenski

C. Polashenski

- Shift to younger ice cover.
  → Changes in processes of the Arctic sea ice system.

- One of the largest areas of uncertainty in modeling sea ice and its changes is melt pond evolution.

2

Melt ponds:

Melt ponds:

- Puddles on the ice surface.

- Low reflectivity (α = 0.3-0.6).

- Increase solar absorption → increased melt.
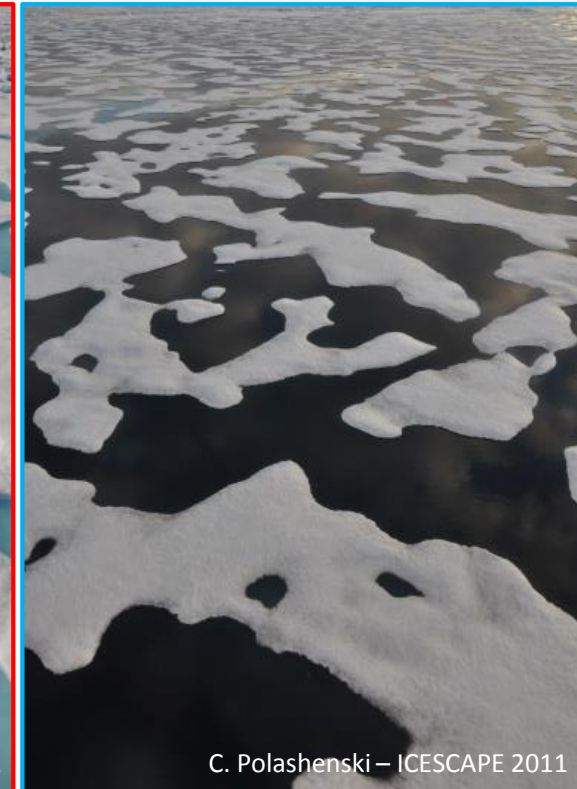
- 2-3x solar transmittance[1,2].
  - More PAR.

Shift to younger ice cover:

- ~30% multiyear[6].

- ~45-75% first-year[3,4,5,lots].

Multiyear

C. Polashenski – ICESCAPE 2011

First-year

C. Polashenski – ICESCAPE 2011

[1]Light et al., (2008); [2]Nicolaus et al., (2012); [3]Scharien and Yackel (2005;
[4]Petrich et al., (2012); [5]Polashenski et al., (2012); [6]Perovich et al., (2002).

~45-75% on landfast first-year ice:

<u>Landfast ice</u>:

- **Is influenced by warm air and dust from nearby land[1].**

- Has a different snow distribution, because landfast ice:

  (1) freezes up earlier, (2) has a fixed orientation to winds, and (3) has extreme surface topography due to near-shore compression.

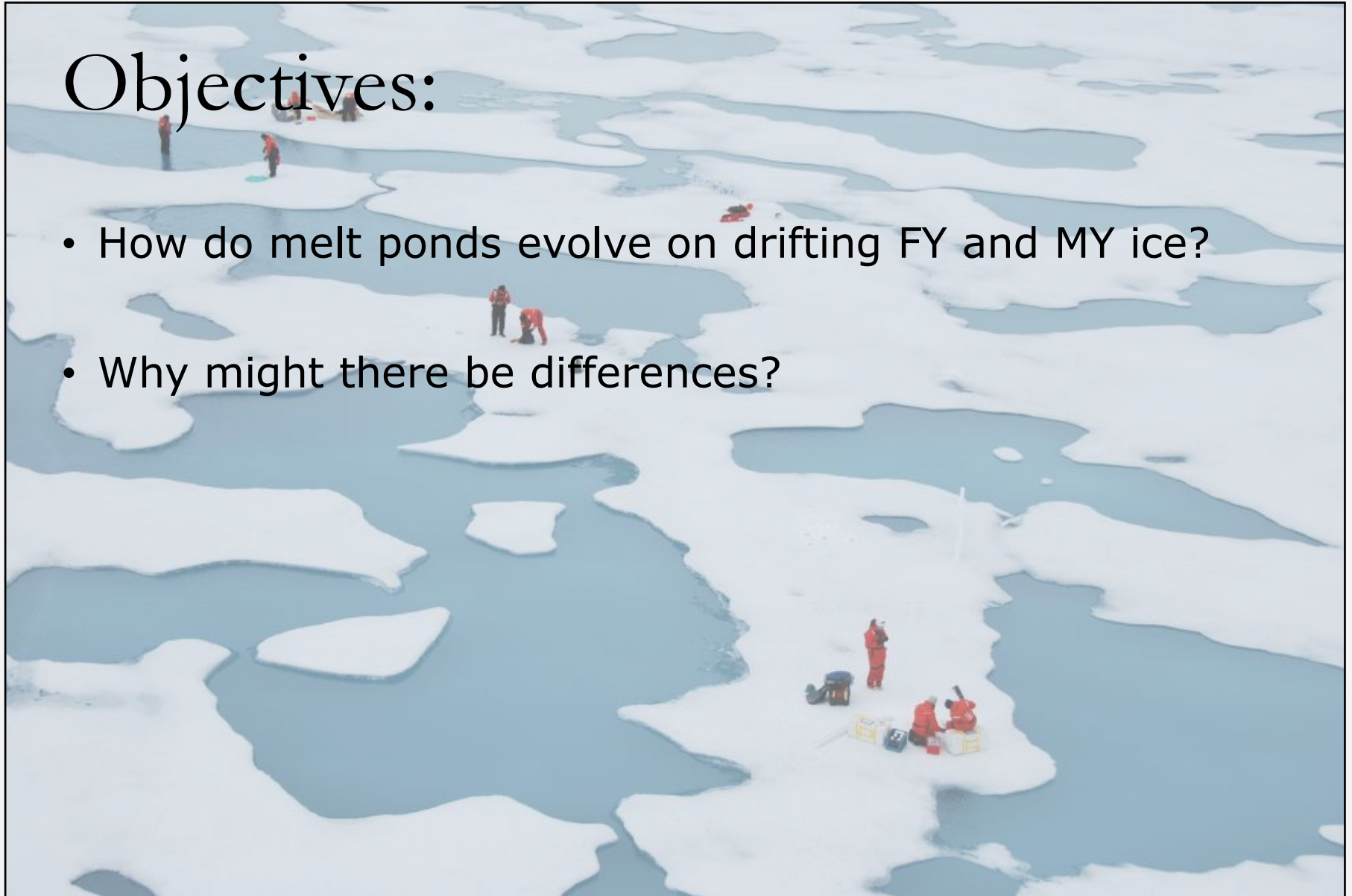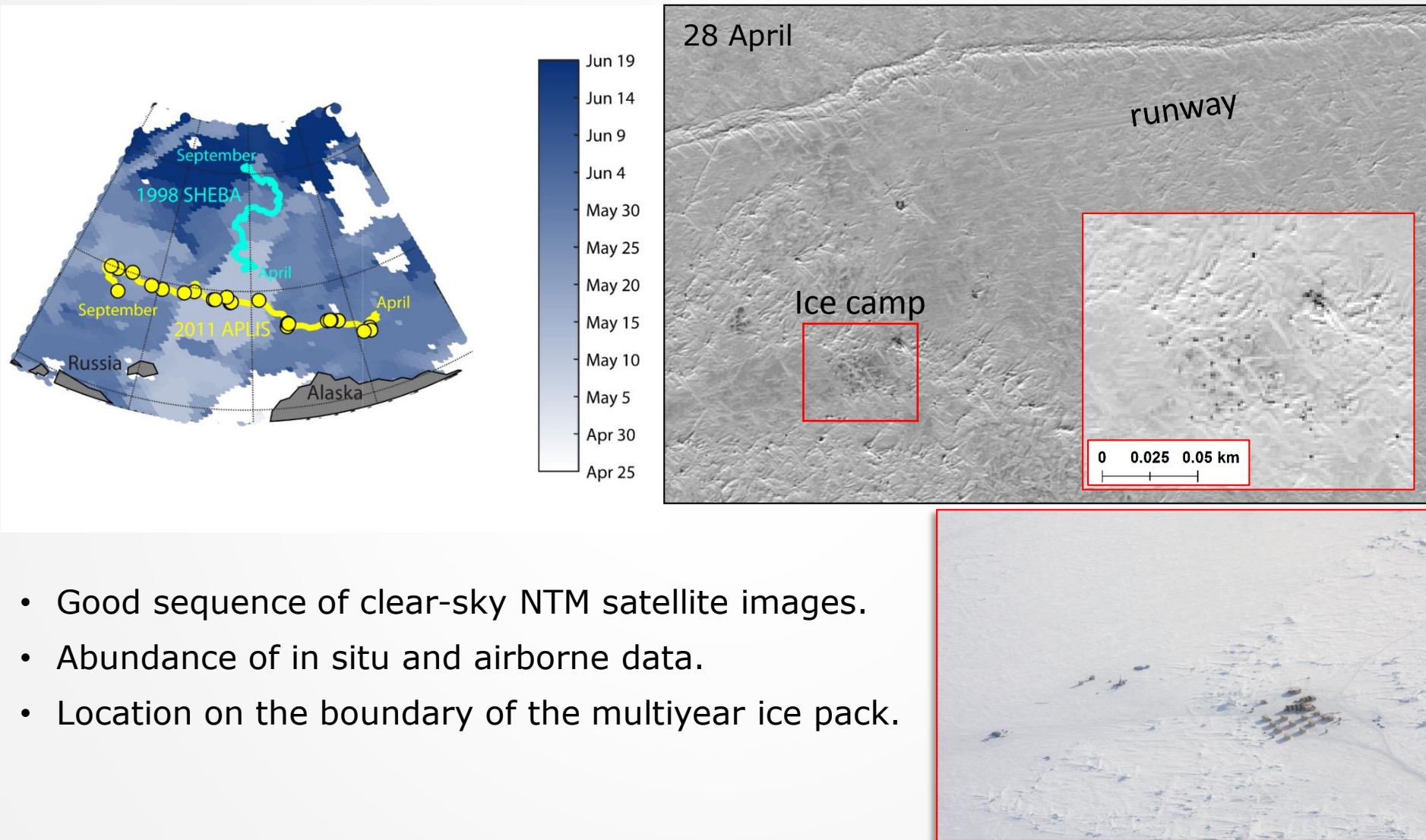Where are the studies from <u>drifting</u>, first-year ice?

[1]*Grenfell and Perovich,* (2004)
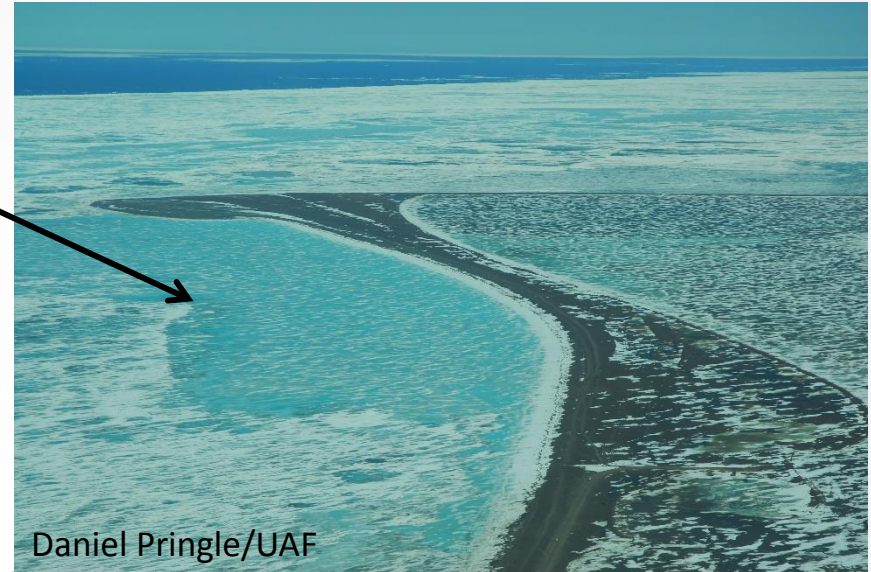
Daniel Pringle/UAF

Objectives:

- How do melt ponds evolve on drifting FY and MY ice?
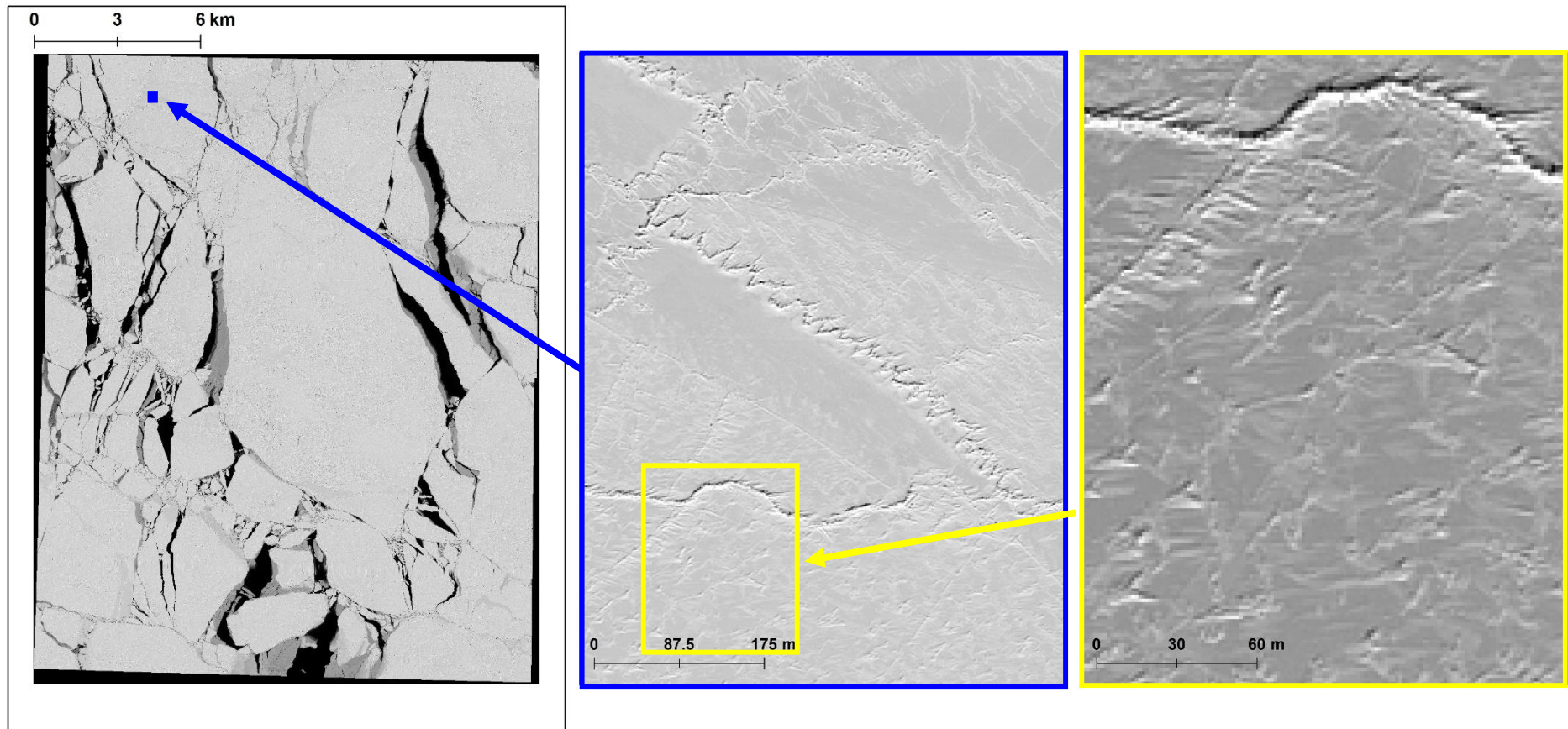
- Why might there be differences?

2011 [NASA OIB-NRL DISTANCE/APLIS/ICEX] site:
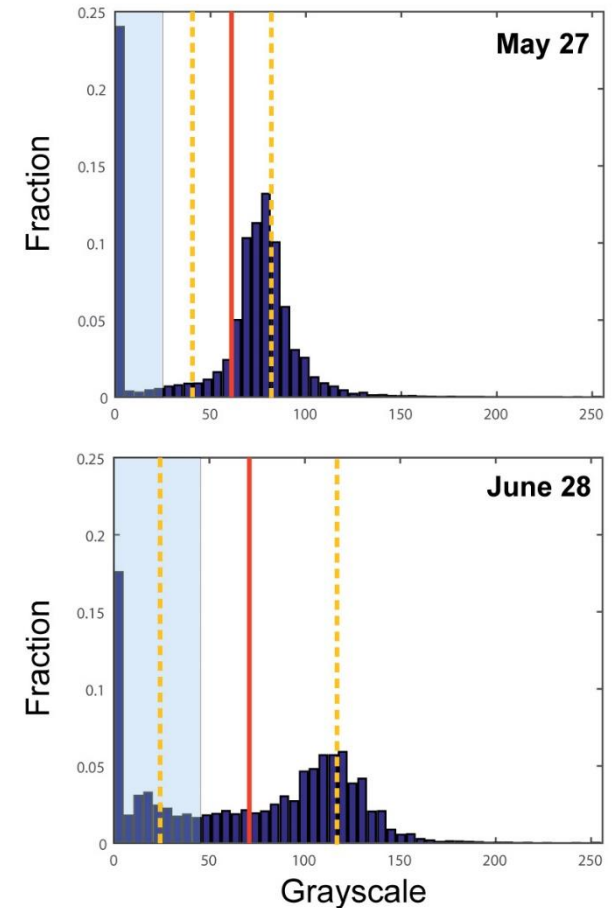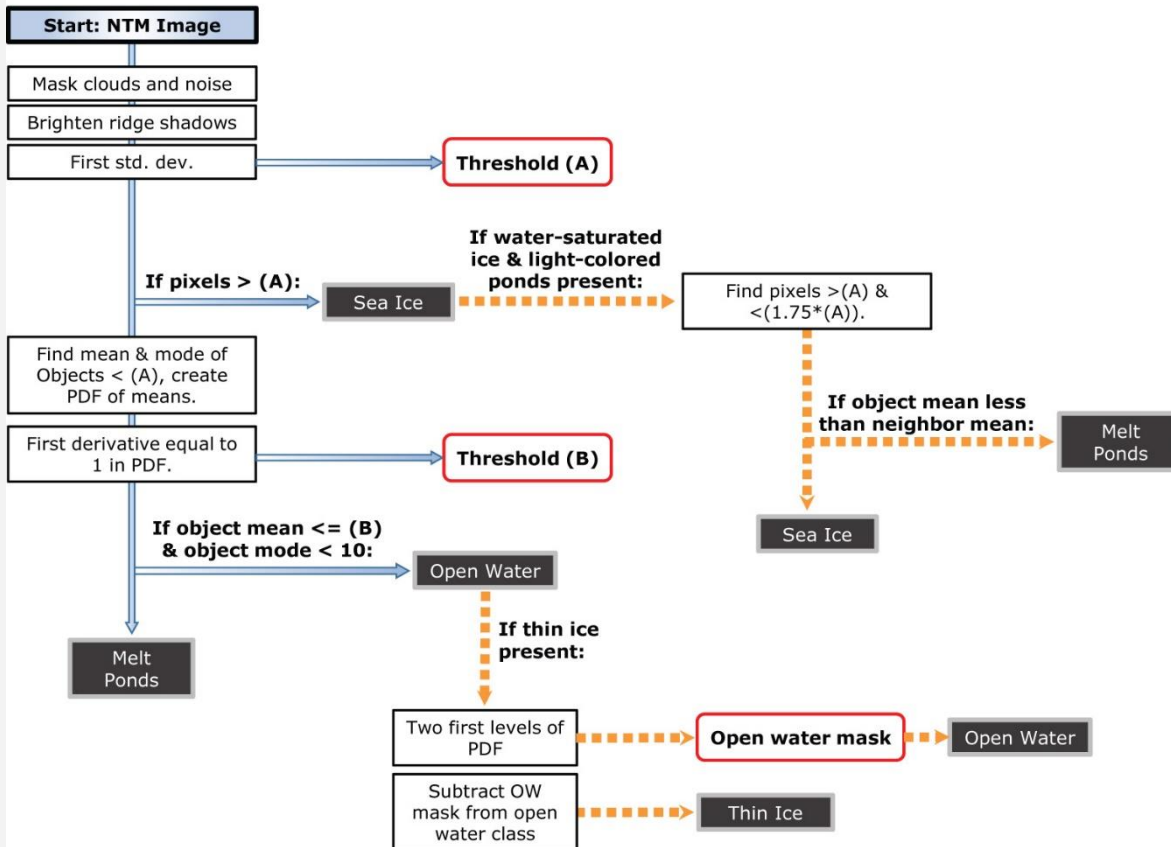

- Good sequence of clear-sky NTM satellite images.
- Abundance of in situ and airborne data.
- Location on the boundary of the multiyear ice pack.

Data: satellite imagery

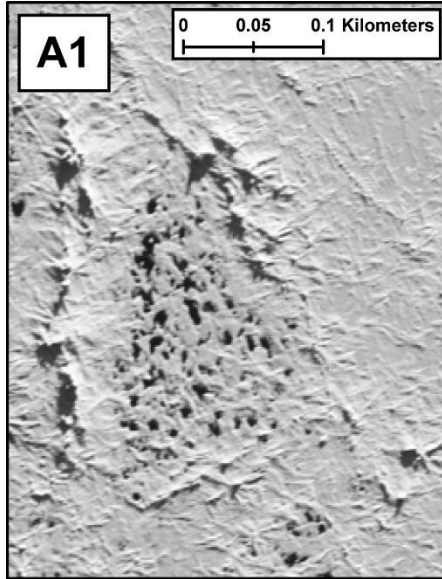NTM panchromatic images, 1-meter resolution, ~15 km x ~15 km
[global fiducials library: http://gfl.usgs.gov/].
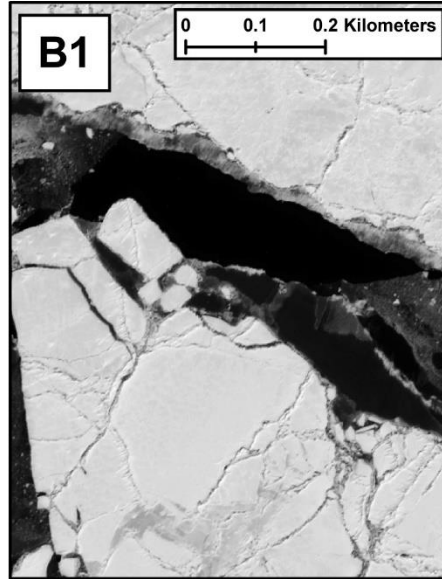
Algorithm Overview:

Output: sea ice, thin ice, melt ponds, and open water
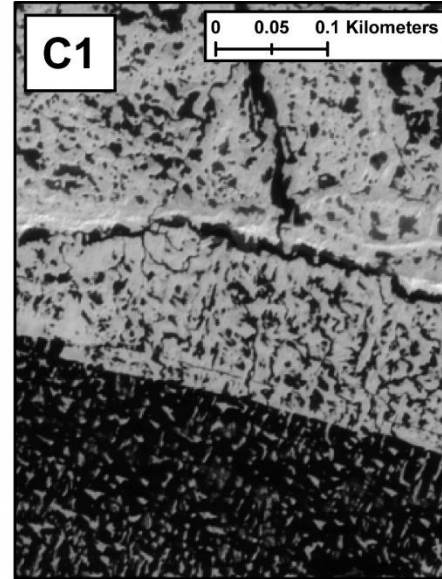
Image classification: ice, ponds, & open water

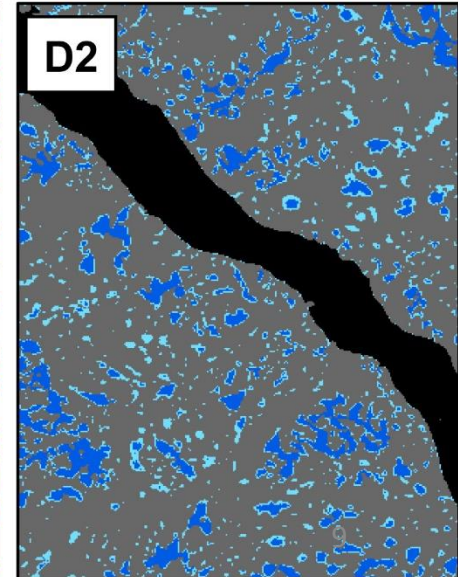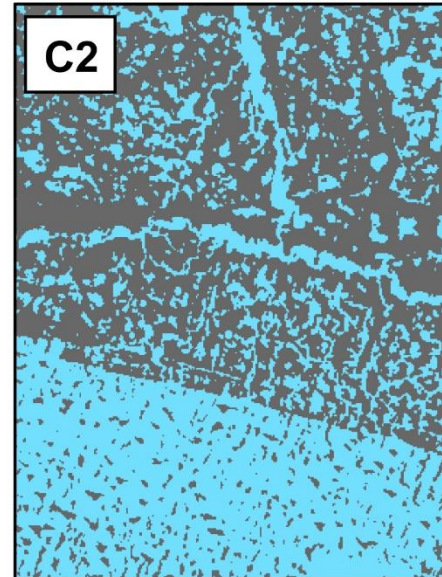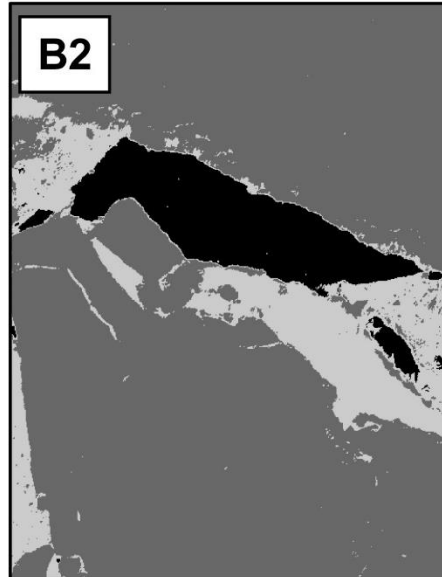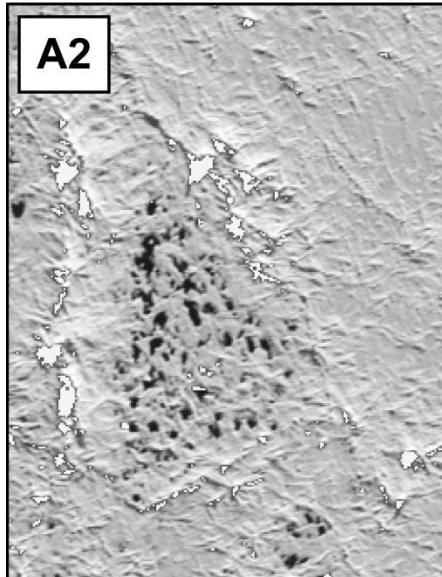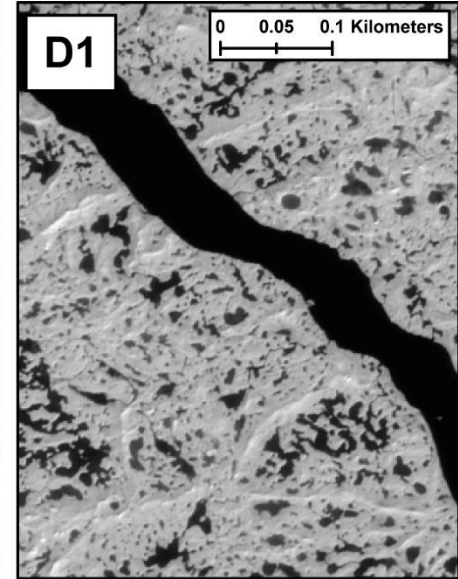**Ridge Shadows**   **Thin ice**   **Complex surfaces**   **Light-colored ponds**
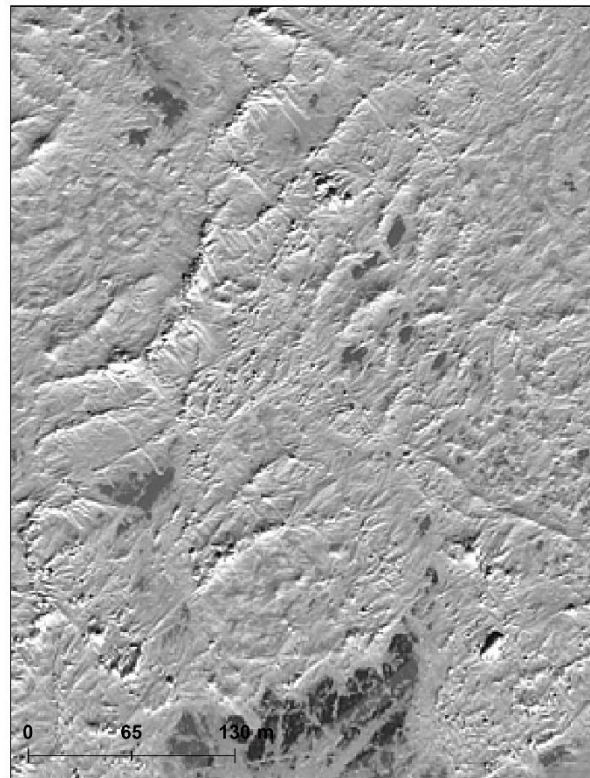
Data: airborne

NASA's Operation IceBridge

- DMS (RGB) imagery to geolocate in situ data, buoys in NTM images, & identify surface features for tracking.

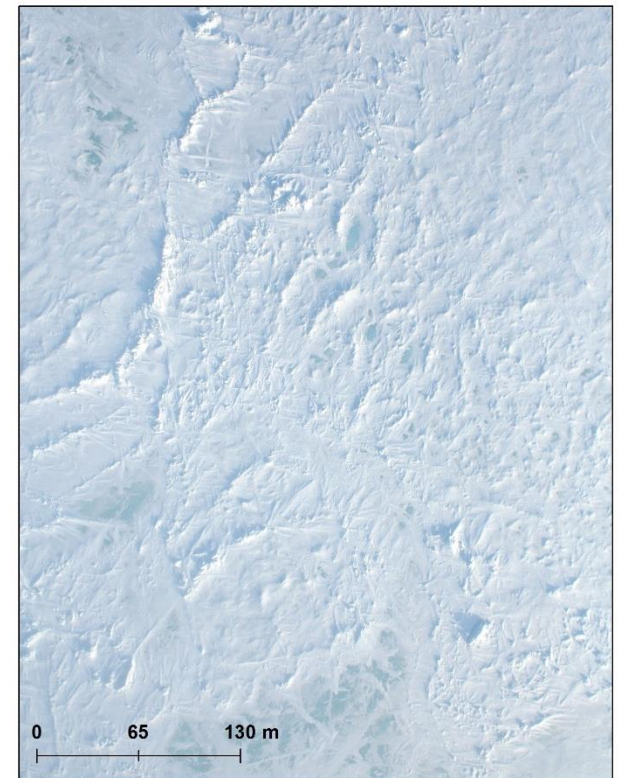- ATM surface elevations for estimating surface roughness and surface elevation gradients.

DMS Image

NTM Image

DMS Image

Buoy

Data: in situ

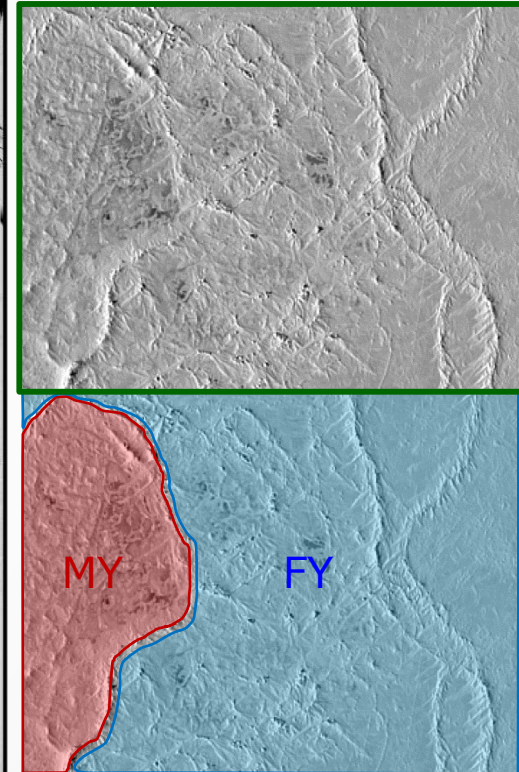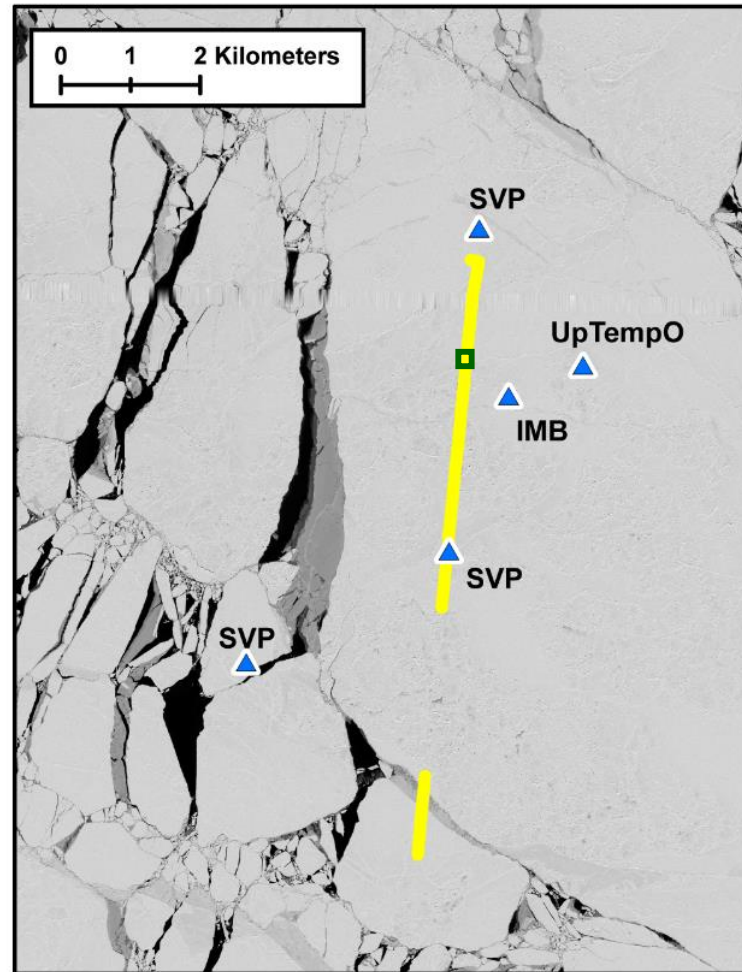**International Arctic Buoy Programme (5 buoys):**
- Data alignment (drifting ice… drifts).
- Information on changing surface conditions.

Snow & ice thickness measurements:
- Pre-melt conditions.
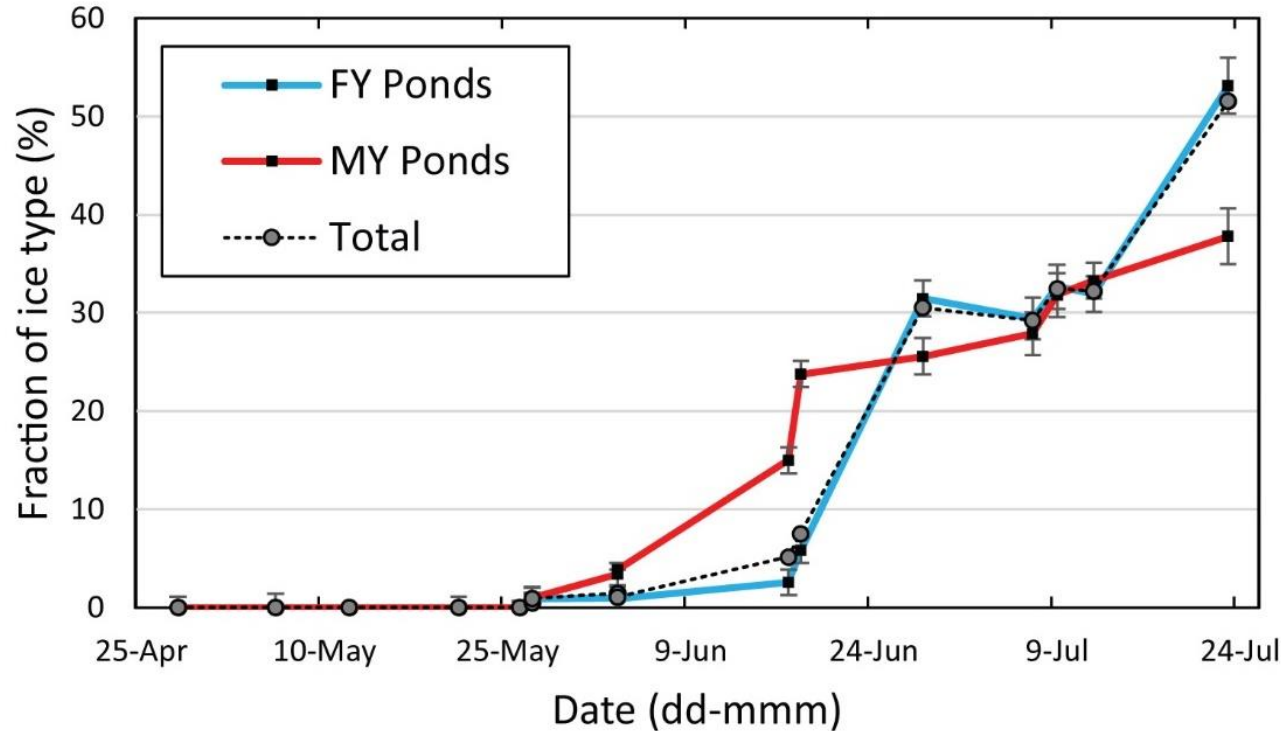
Ice type identifications:
- Validate ice type identification in NTM imagery.

Objectives (again):

- Seasonal melt pond evolution on drifting first-year vs. multiyear ice?

- Why are there differences?
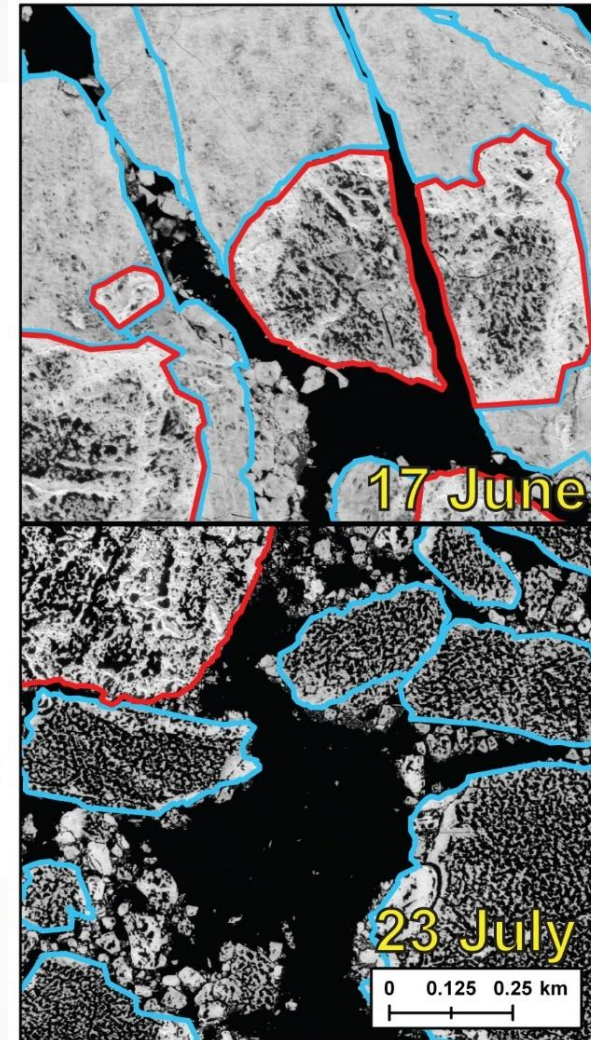
Results: FY vs. MY

- Ponds form on MY earlier by ~3 weeks.
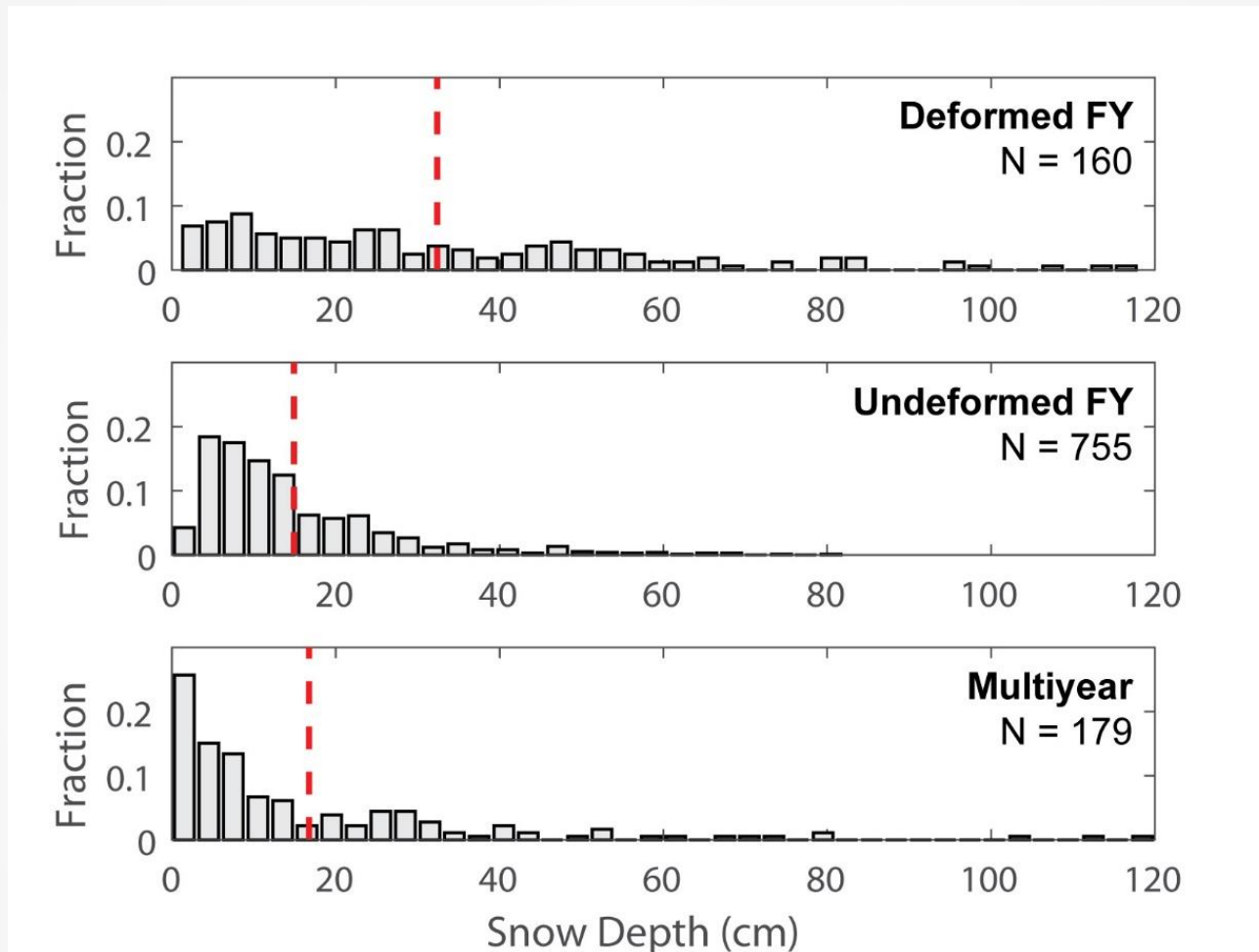- Maximum ponds fractions: 53% (FY) vs. 38% (MY).

Q #1: Why did ponds form earlier on MY ice?
Q #2: Why did the pace of melt change between ice types?
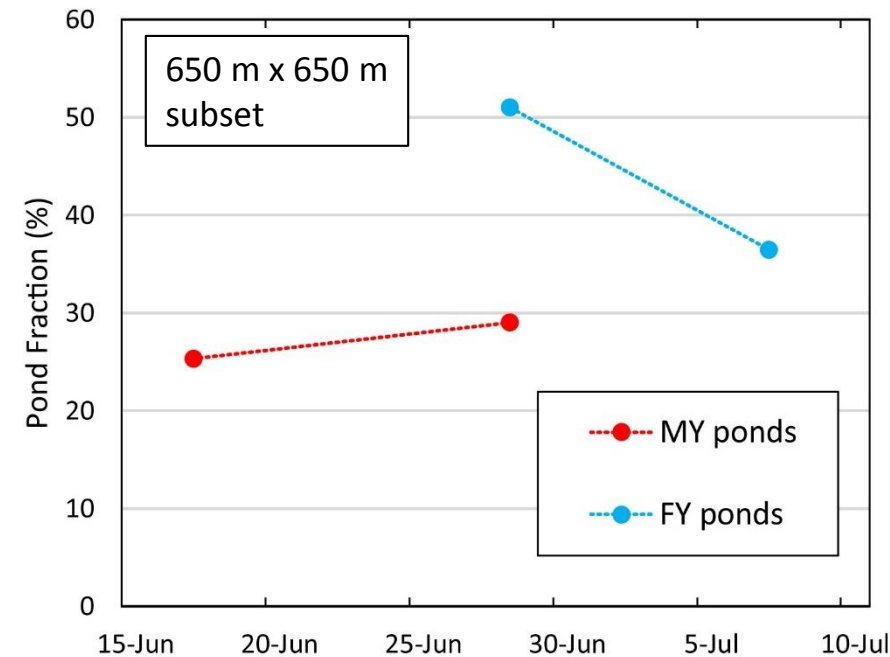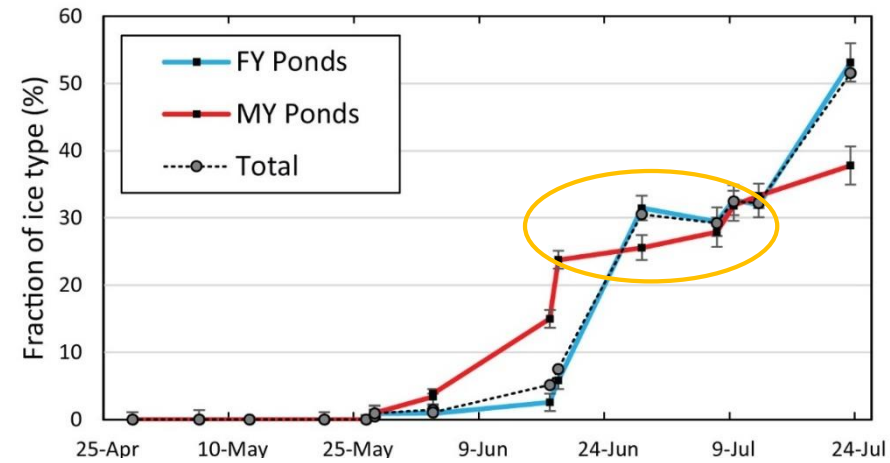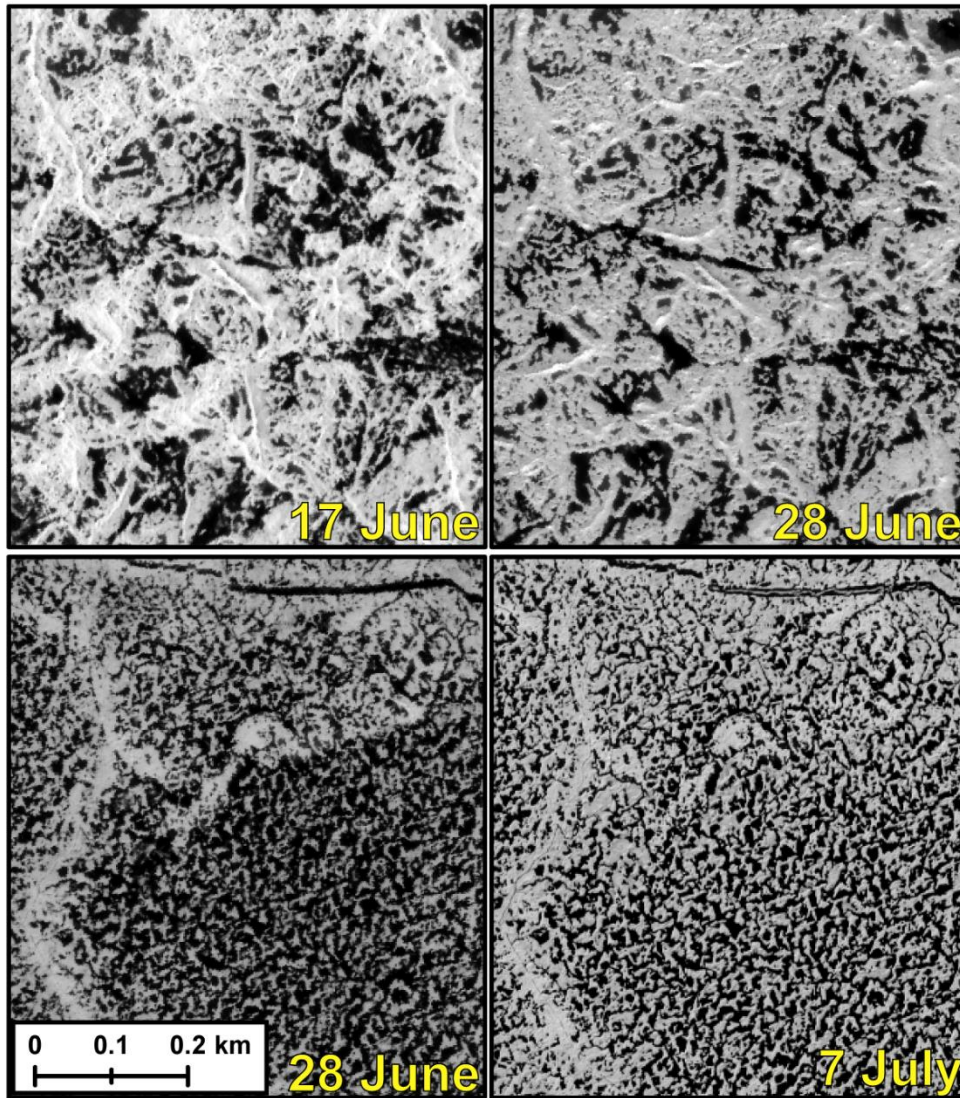Q #3: Where did FY ponds form first?

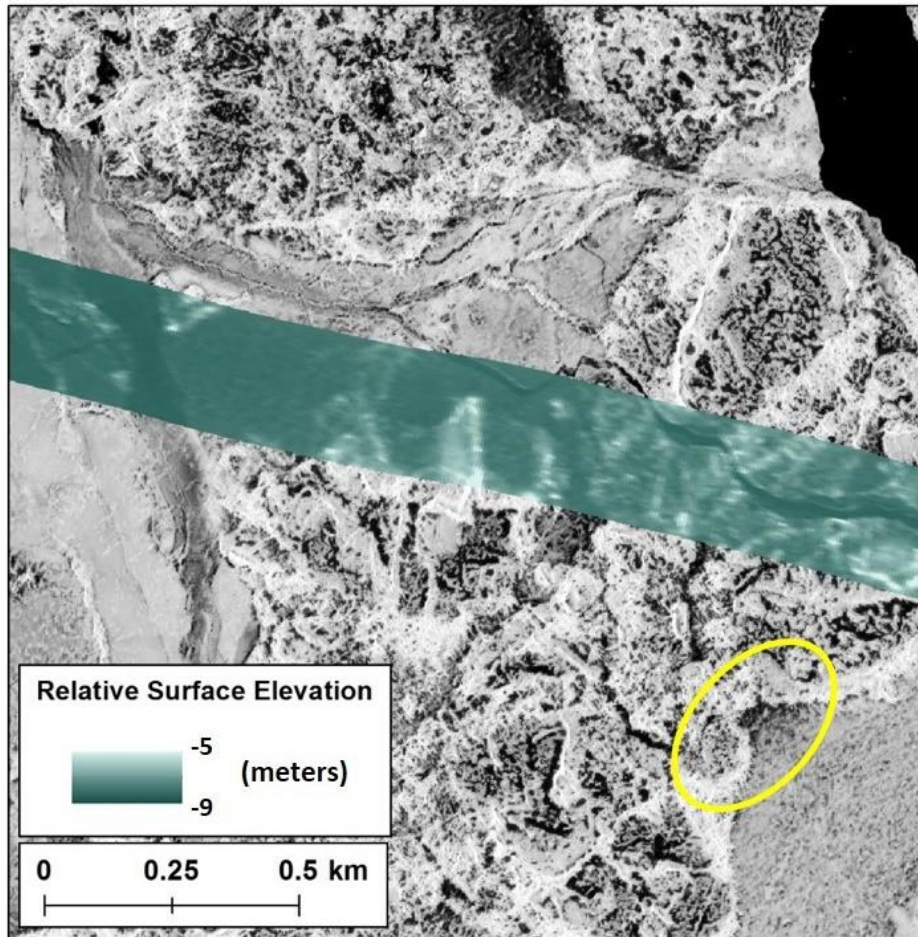# #1 Timing offset: it's all about the snow.

0 – 10 cm deep snow made up **54%** of surveyed MY ice area,
0 – 5 cm deep snow made up **~37%**.

#2 Pace of melt: effects of surface topography

Drainage is spatially and temporally non-uniform on MY ice.

#3: Where did first-year ponds form first?

- FY-MY floe boundaries.
- Boundaries have largest surface elevation gradients.
- Pond onset likely a result of one or a combination of the following:
  - lateral meltwater transport,
  - seawater percolation.

- Importance?
  - These melt pond "hot spots" thermodynamically weaken these boundaries.

Conclusions:

- NTM imagery [from LaGrangian sites] is a valuable tool for studying sea ice processes.
- Developed an algorithm that can accurately identify melt ponds, sea ice, thin ice, and open water.
- Snow depth distribution and surface topography have important roles in melt pond evolution.
  - Ponds formed ~3 weeks earlier on MY ice due to thin snow.
  - MY drainage was spatially and temporally non-uniform due to surface topography.
  - Surface topography affects the timing and location of the earliest FY ponds.
  - Max. pond fractions were 53% (FY) and 38% (MY).

…Why was the snow so thin on the multiyear ice?

Thank you…

Webster, M. A., I. G. Rigor, D. K. Perovich, J. A. Richter-Menge, C. M. Polashenski, and B. Light (in review), Seasonal evolution of melt ponds on drifting Arctic sea ice, *J. Geophys. Res. Oceans.*, doi:10.1029/2015JC011030.