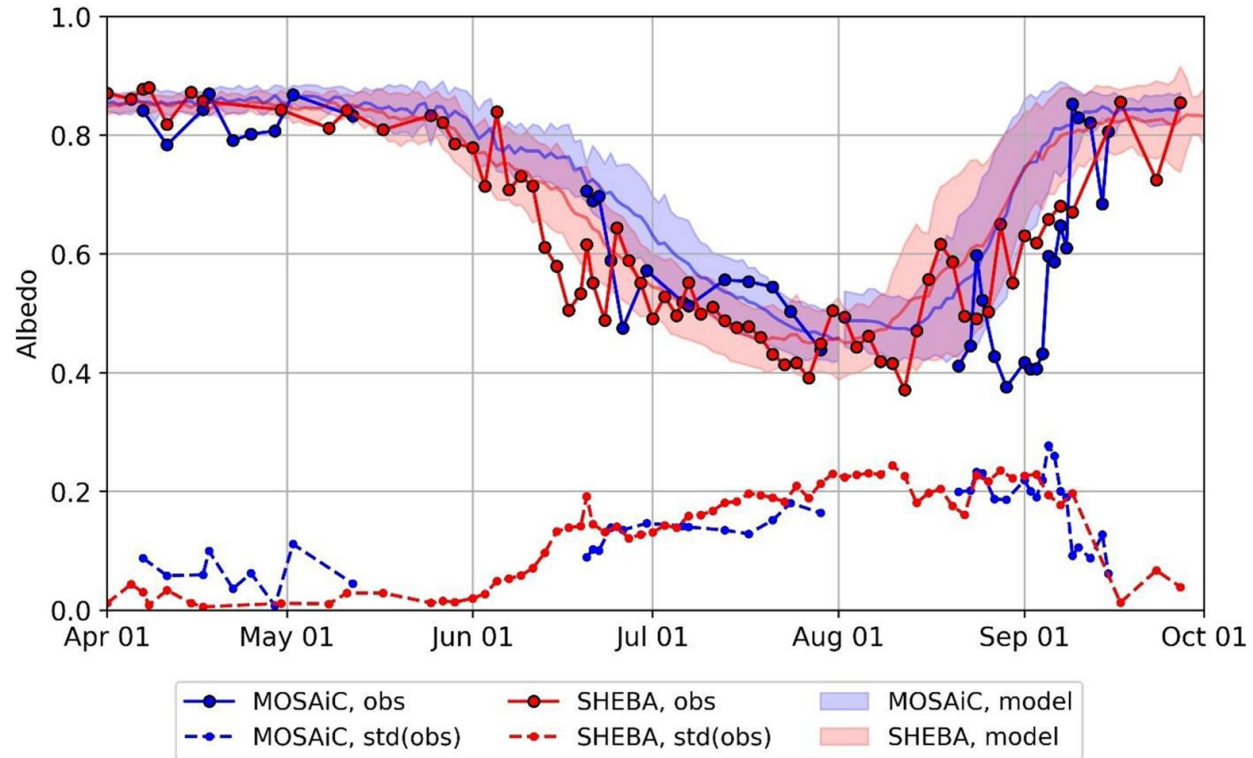# Too shallow: a deep dive into melt ponds in Icepack and observations
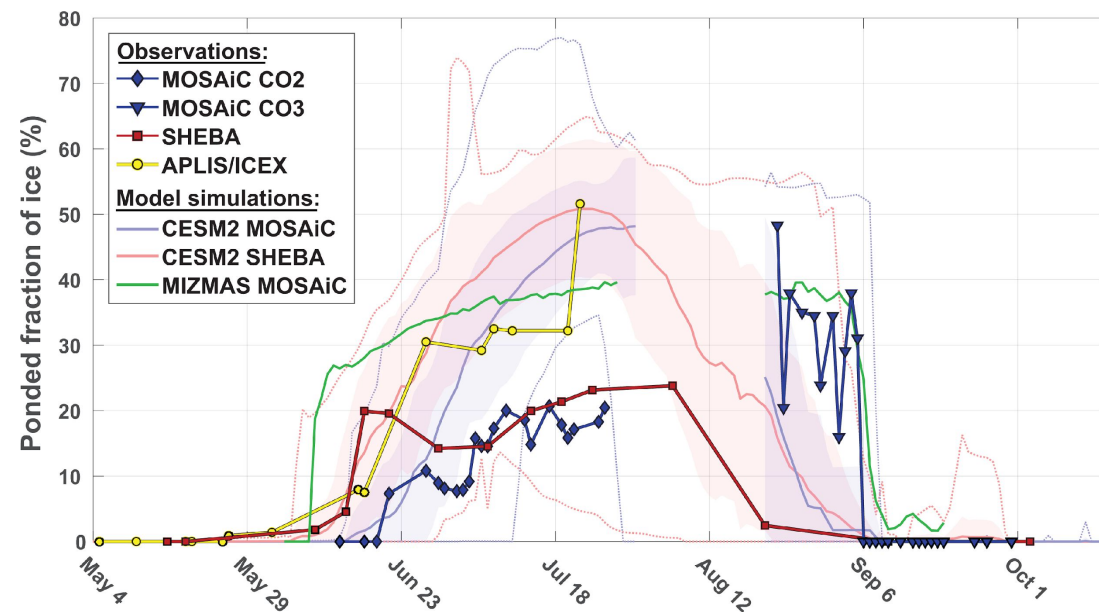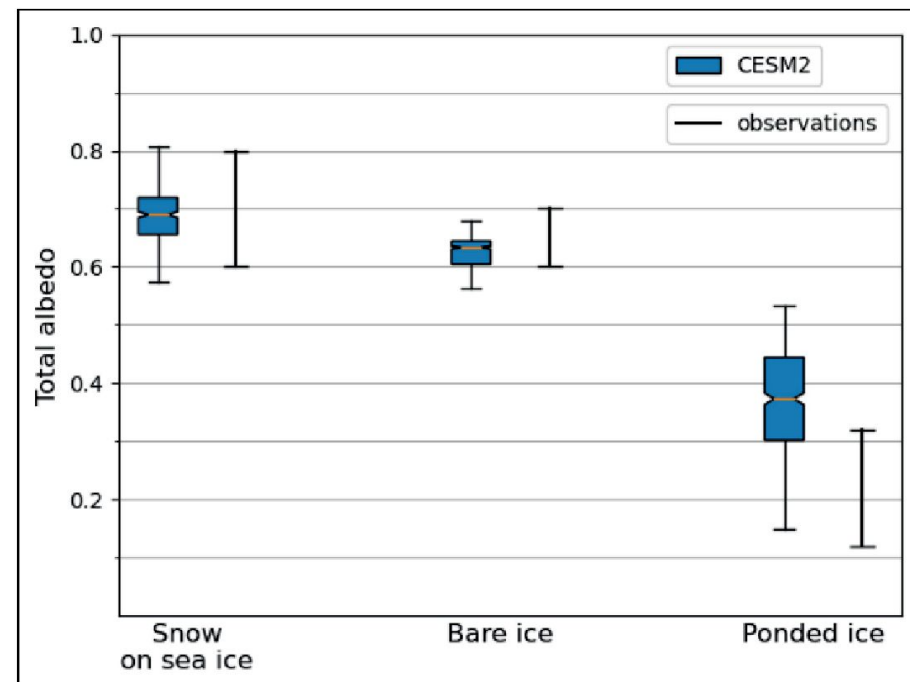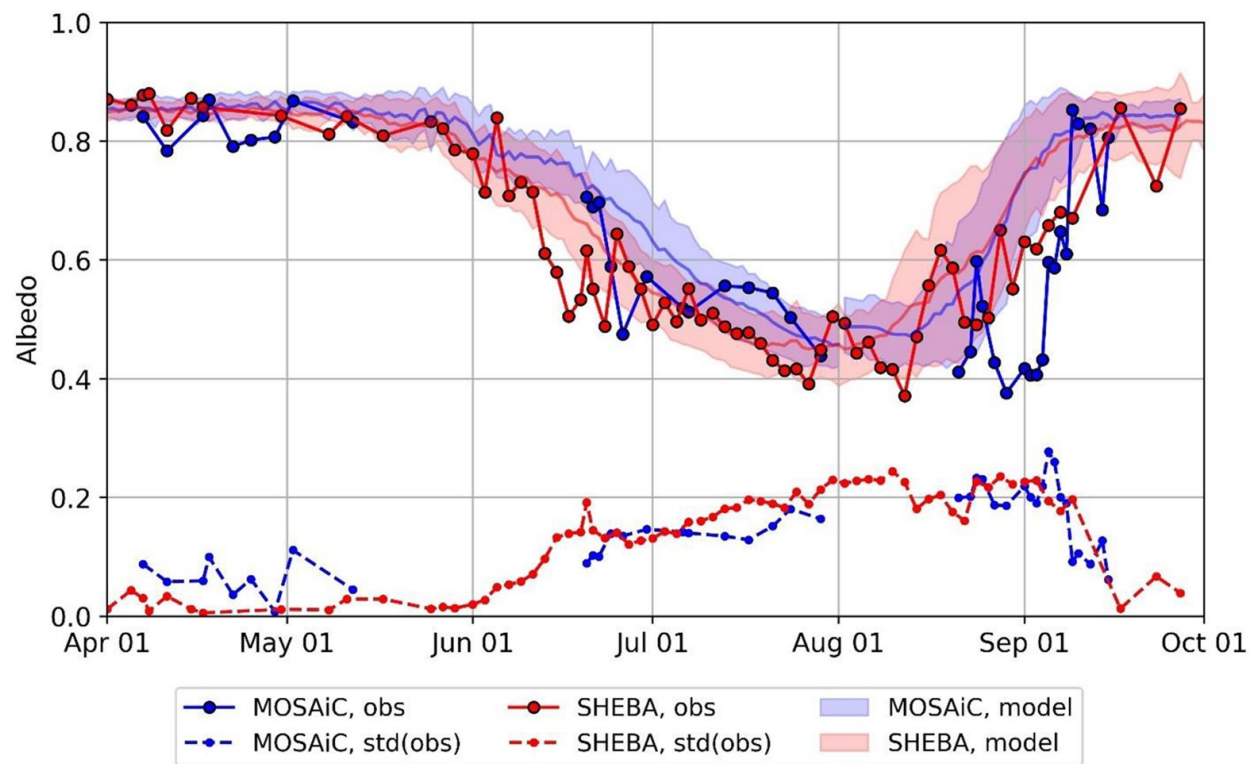
David Clemens-Sewall, Marika Holland, Dave Bailey, Bonnie Light, Don Perovich, Chris Polashenski, Maddie Smith, Melinda Webster

Motivation

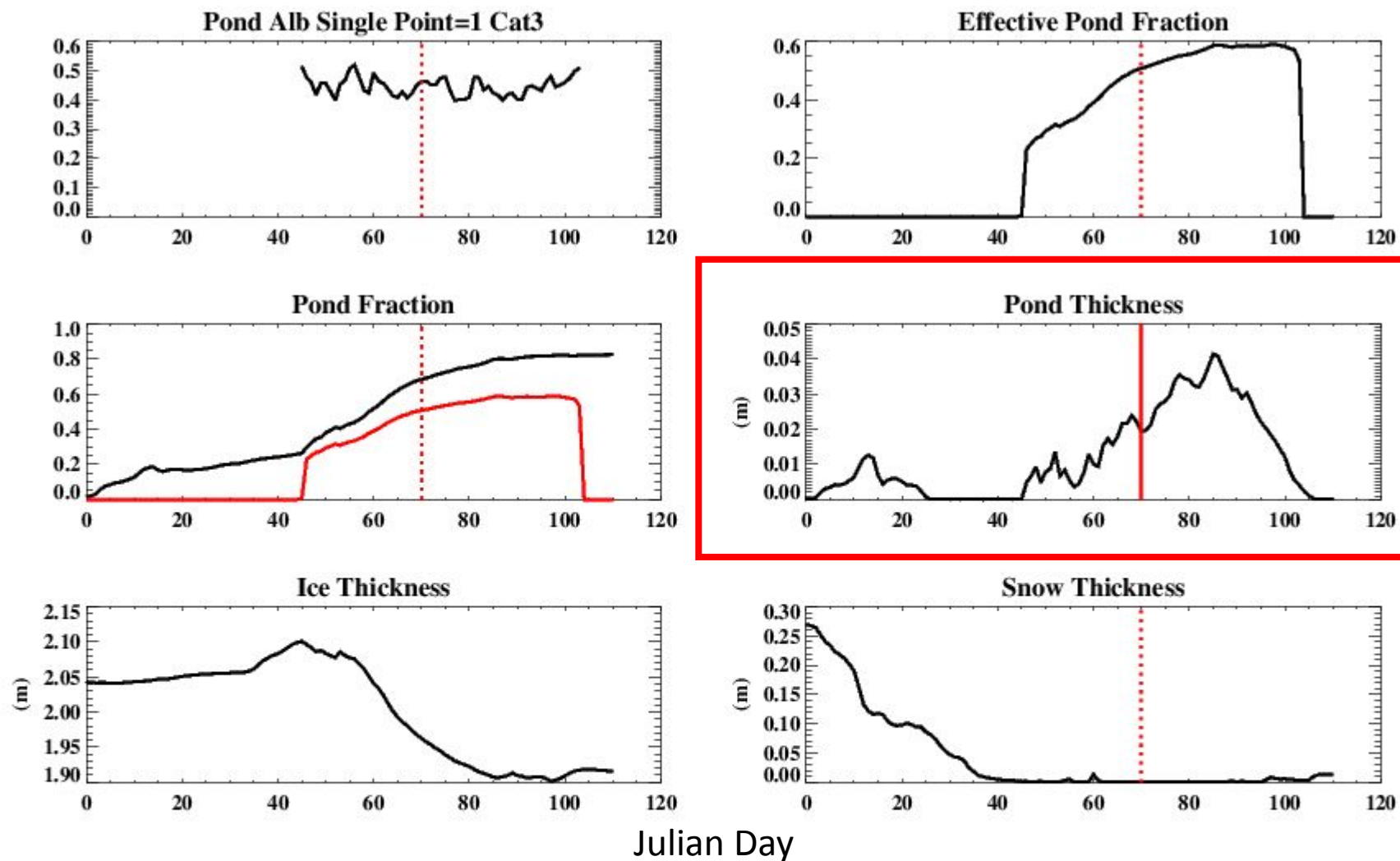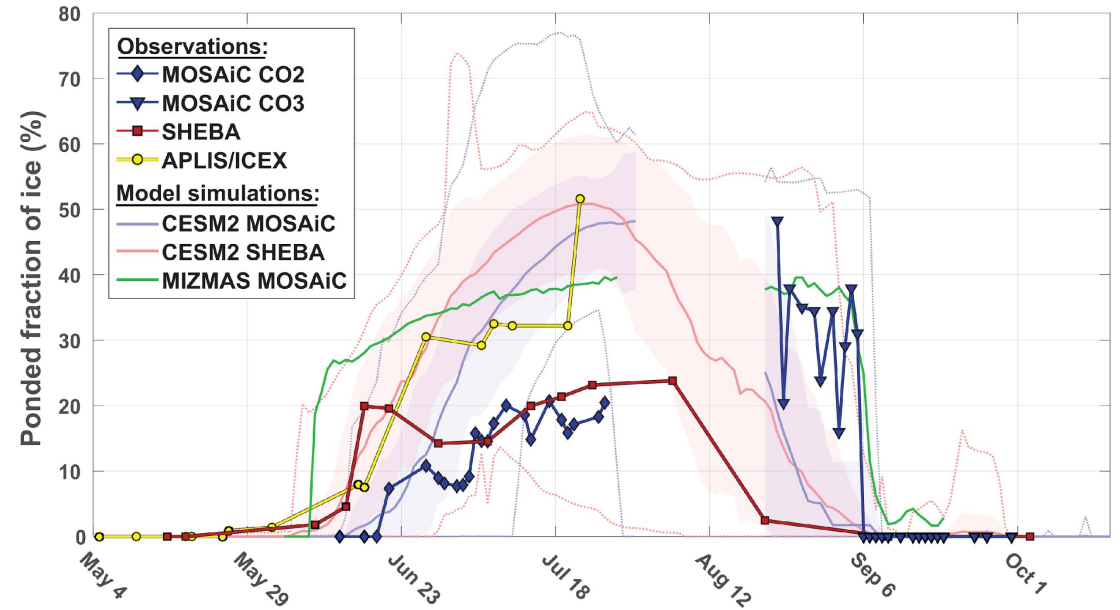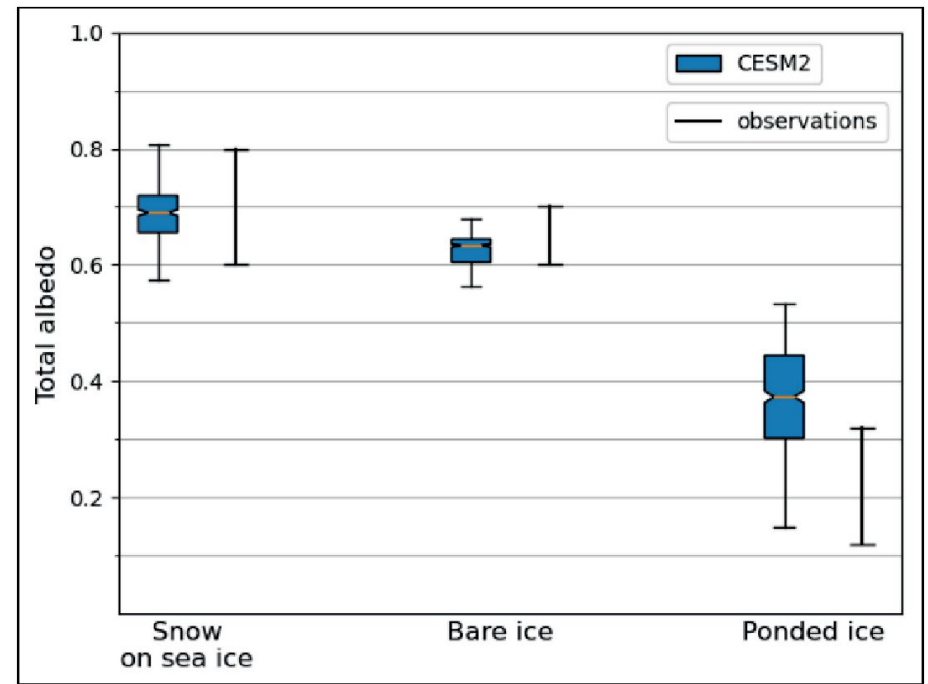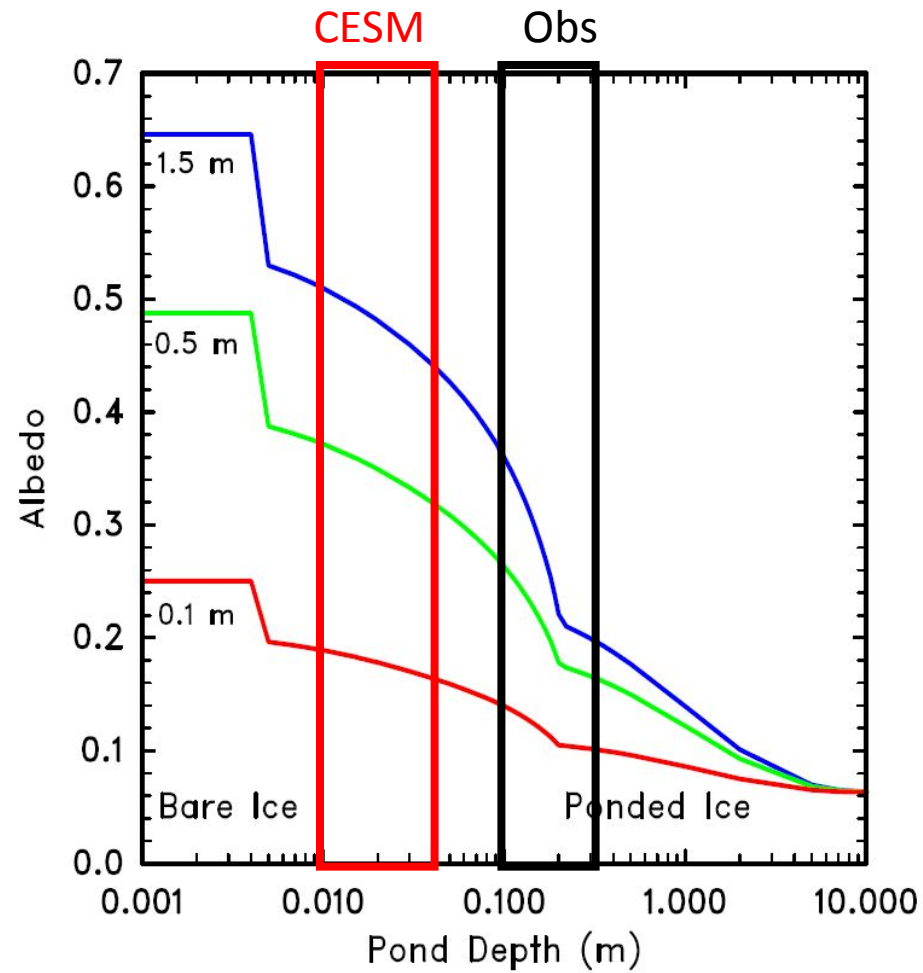Light et al. 2022

Motivation

Light et al. 2022, Webster et al. 2021

Motivation

Motivation

Light et al. 2022, Webster et al. 2021, Briegleb and Light 2007
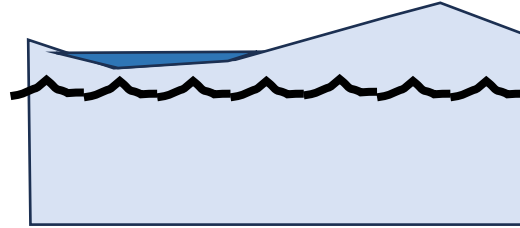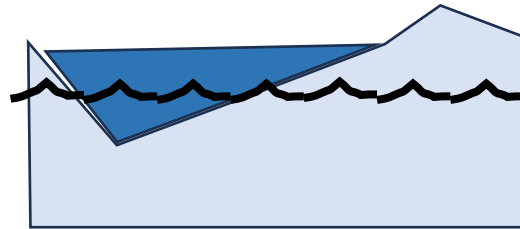
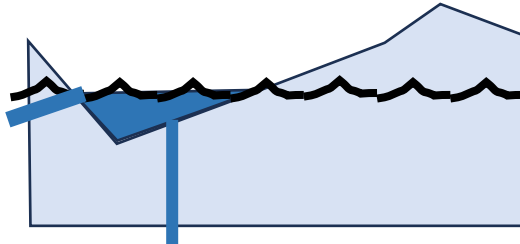# Lifecycle of a melt pond

Observations

Meltwater fills depressions on impermeable ice creating above-freeboard ponds.
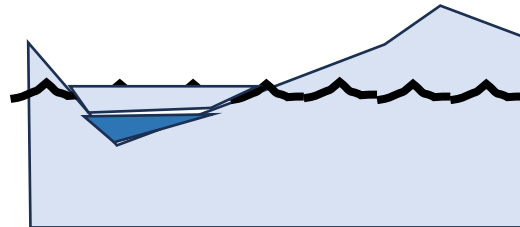
Low-albedo ponds accelerate melt, lowering pond base below freeboard.

Drainage through flaws and percolation lowers pond surfaces to freeboard.
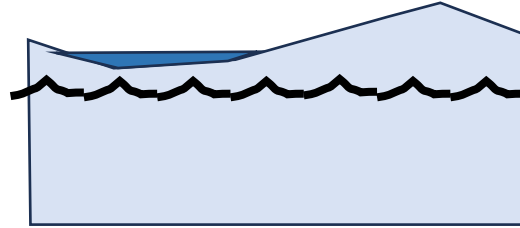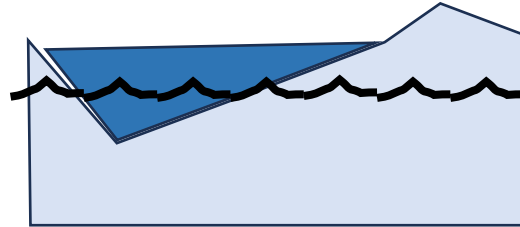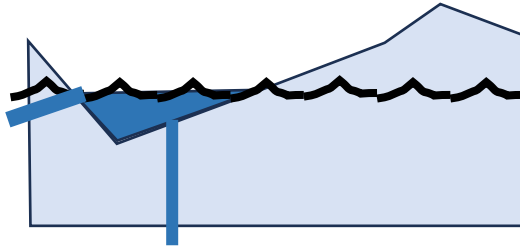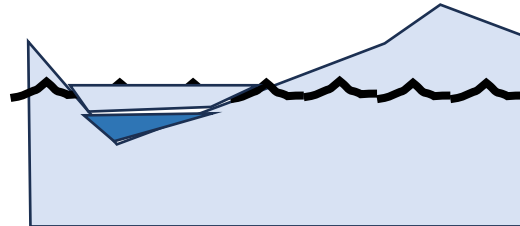**~20-40% pond coverage**

Pond surfaces remain at freeboard until refreezing or ice disintegrates.
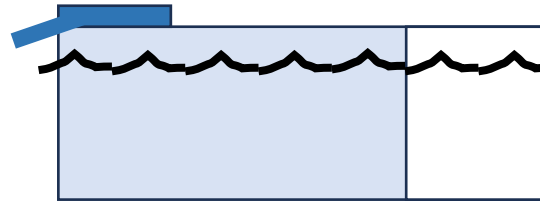
Lifecycle of a melt pond

Observations

Icepack currently

Meltwater fills depressions on impermeable ice creating above-freeboard ponds.		Ponds are perched above the ice surface and exponentially decay.
Low-albedo ponds accelerate melt, lowering pond base below freeboard.		Pond area and depth grow by fixed ratio. Drainage only reduces depth.
Drainage through flaws and percolation lowers pond surfaces to freeboard. **~20-40% pond coverage**		The pressure head for percolation drainage assumes perched ponds.
Pond surfaces remain at freeboard until refreezing or ice disintegrates.		If pond mass would depress ice locally below freeboard, instantaneous drainage.

Lifecycle of a melt pond
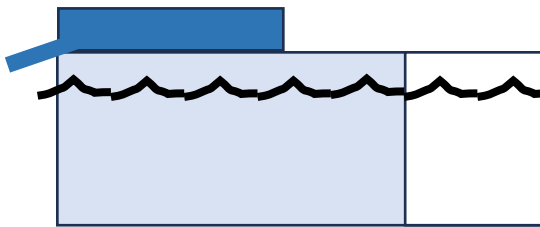
Observations

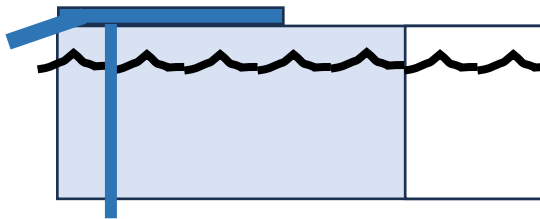Polashenski et al., 2012

Icepack currently

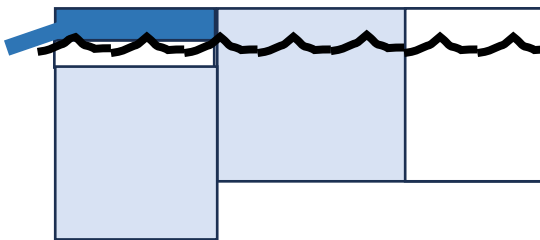Ponds are perched above the ice surface and **exponentially decay.**

Pond area and depth grow by fixed ratio. **Drainage only reduces depth.**

The pressure head for percolation drainage **assumes perched ponds**.

If pond mass would depress ice locally below freeboard, instantaneous drainage.

Lifecycle of a melt pond

Observations

25 July 2020

	Ice	Ponds
Mean	1.624	0.185
Median	1.104	0.151
Stdev	1.204	0.125
Pond fraction	0.183	

43% $h_p/h_i \leq 0.1$

MOSAiC transect obs.

Icepack currently

Ponds are perched above the ice surface and exponentially decay.

Pond area and depth grow by fixed ratio. Drainage only reduces depth.

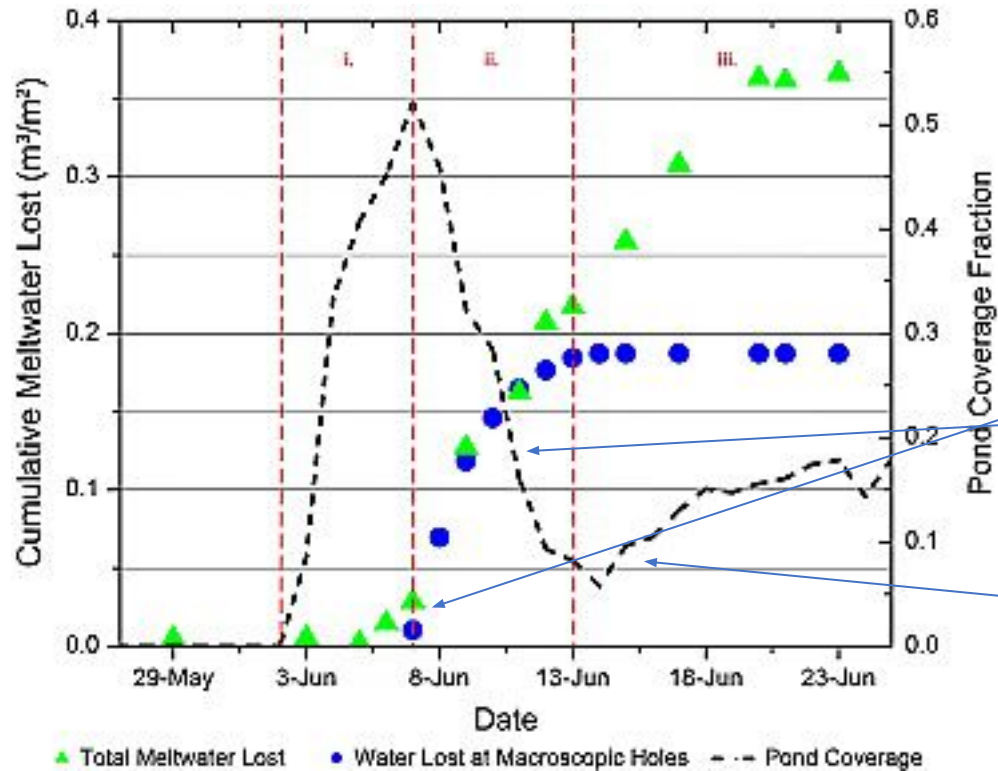The pressure head for percolation drainage assumes perched ponds.

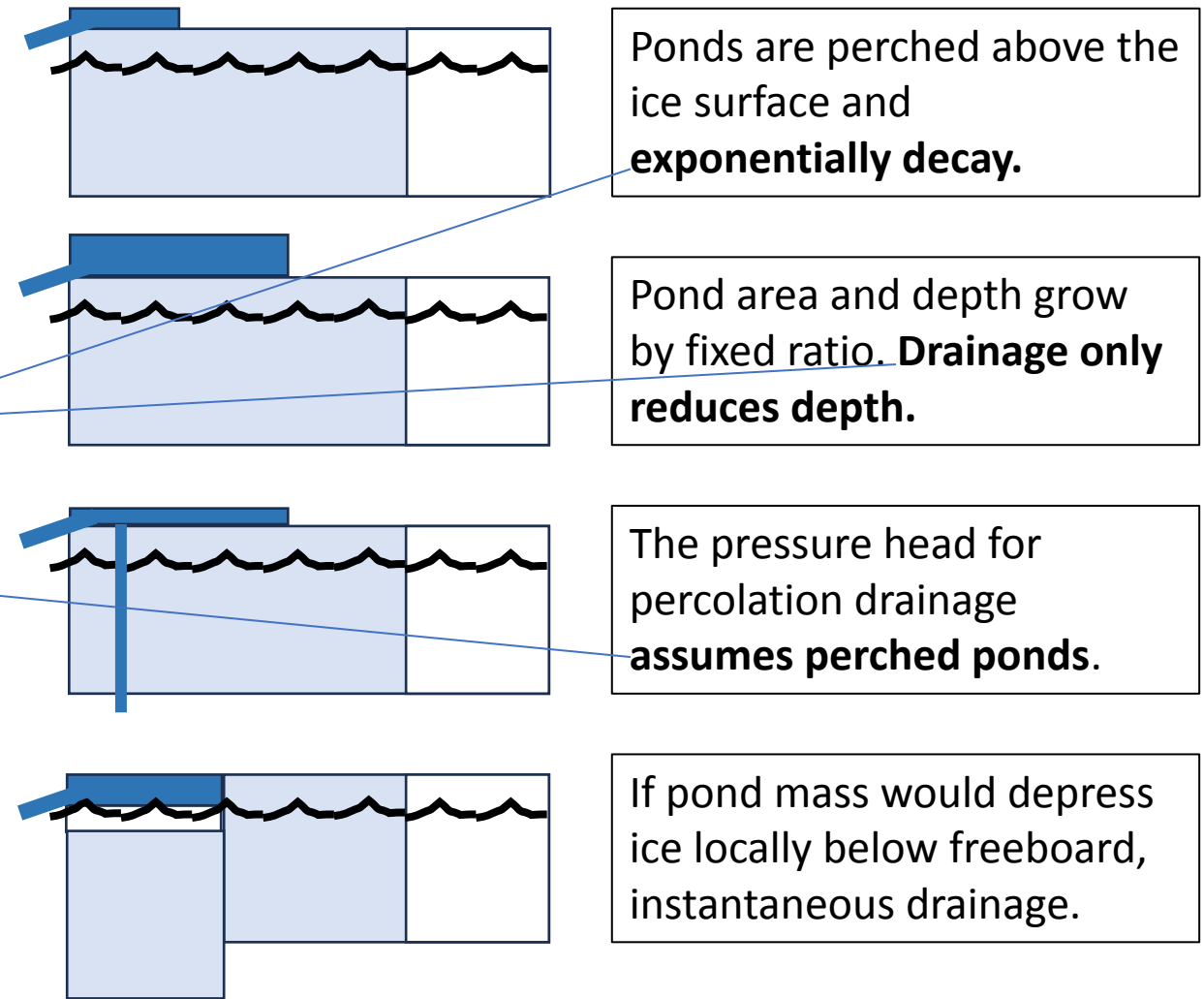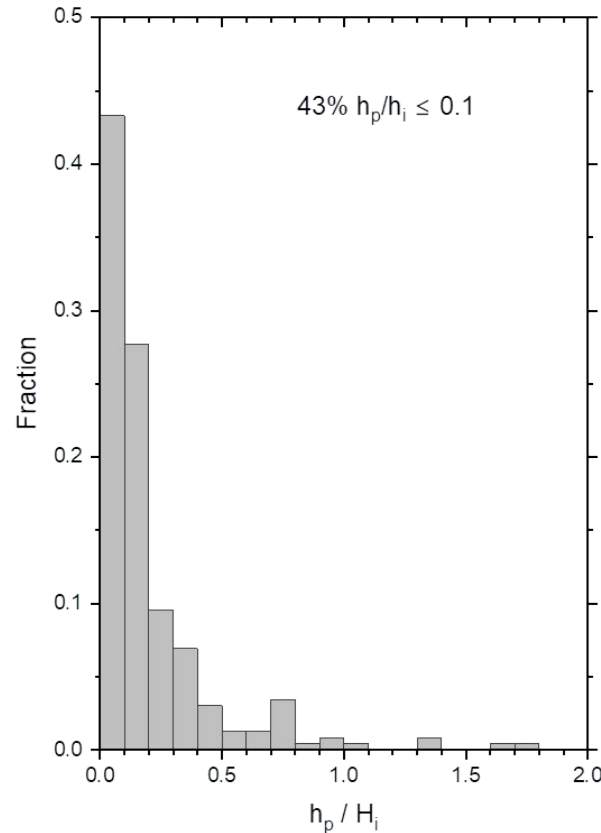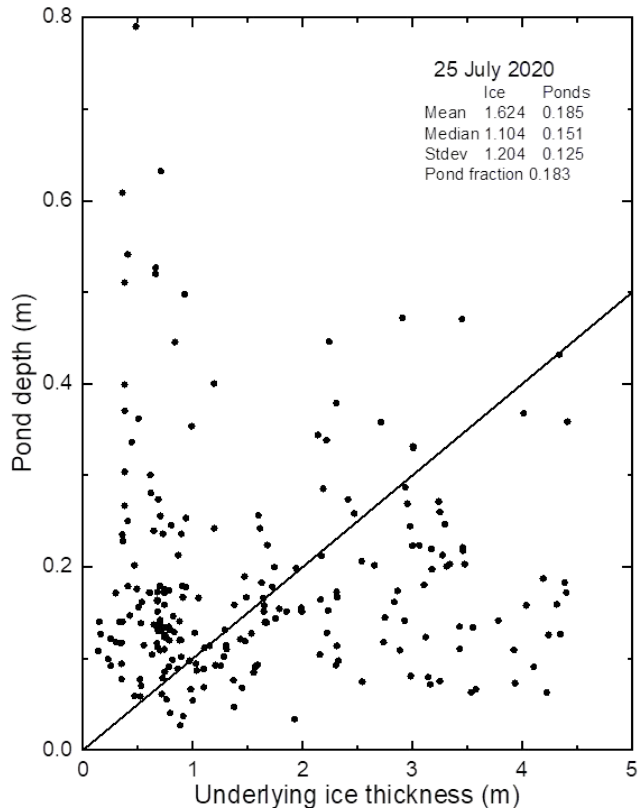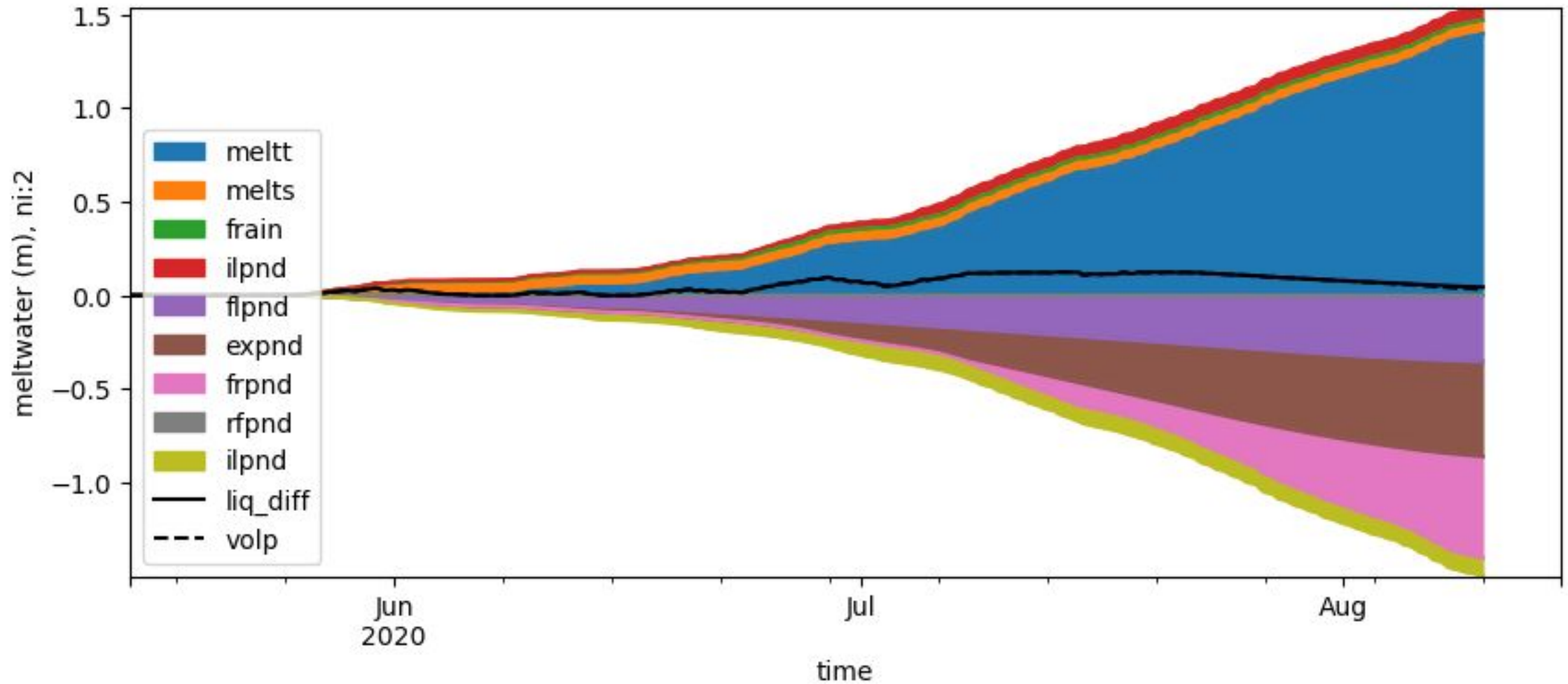**If pond mass would depress ice locally below freeboard, instantaneous drainage.**

Meltwater Budget (default case)

Meltwater Budget (rfracmin=1)

Meltwater Budget (MOSAiC FYI)

MOSAiC level fyi

Icepack vs. MOSAiC Observations

Proposed changes

<u>Icepack proposed</u>

1. Explicitly represent hypsometry -> controls depth-area changes and enables sea level ponds.
   1. based on target sea level area fraction and isostatic balance.
2. Exponential drainage driven by pressure head.
3. Pressure head computed from hypsometry.
4. Freeboard constraint applied to entire category.

<u>Icepack currently</u>

Ponds are perched above the ice surface and exponentially decay.

Pond area and depth grow by fixed ratio. Drainage only reduces depth.

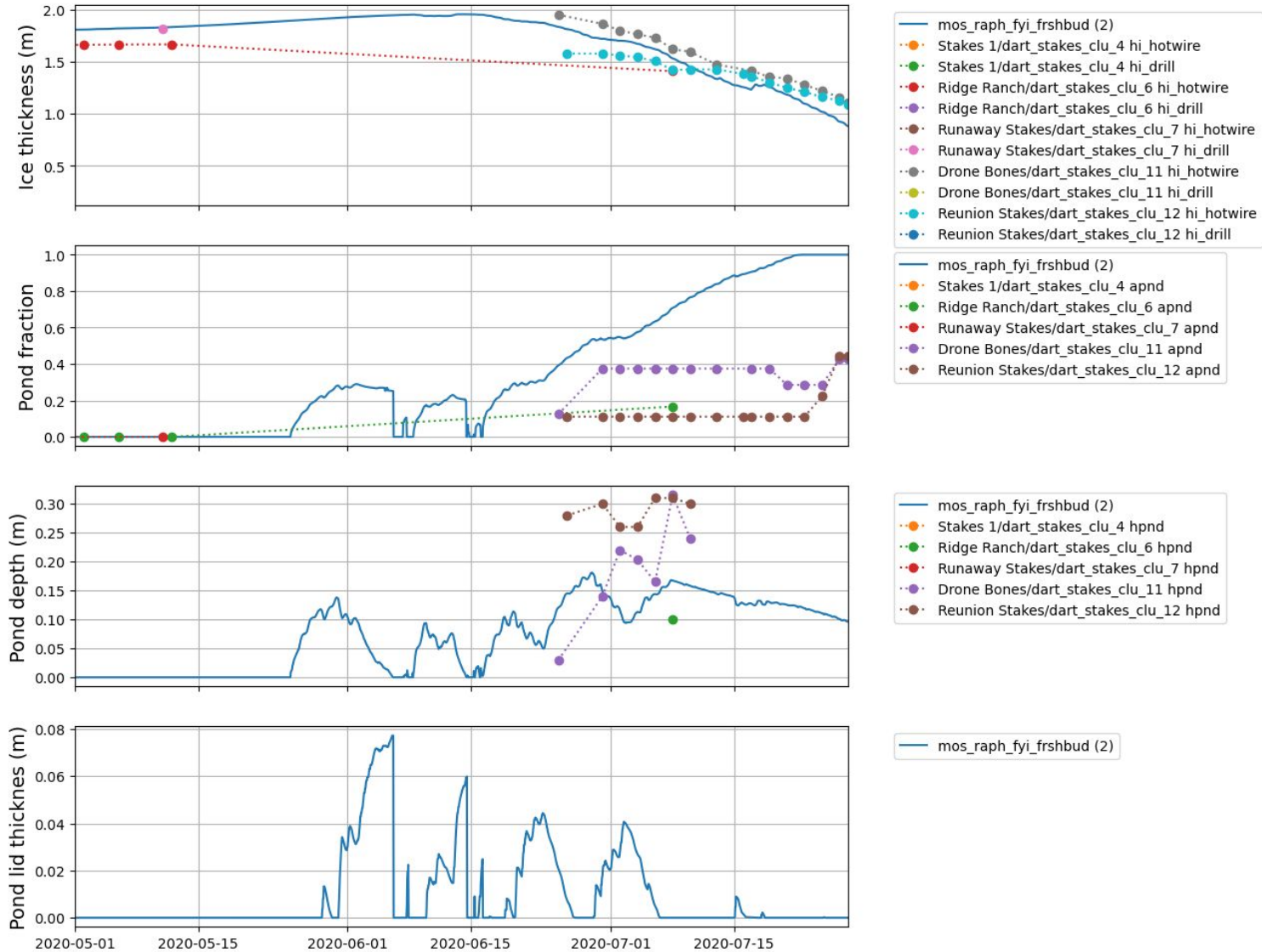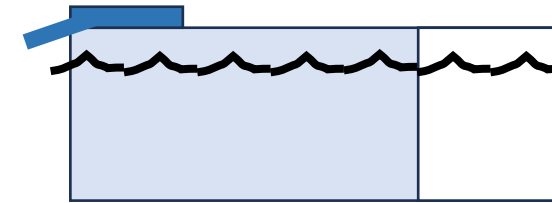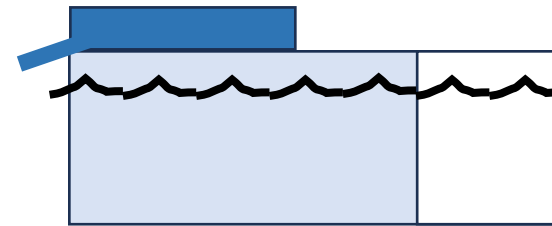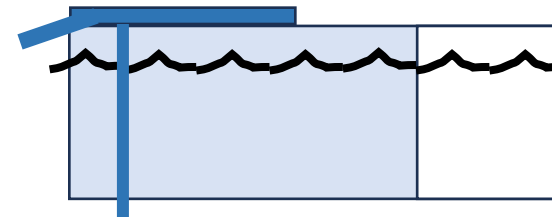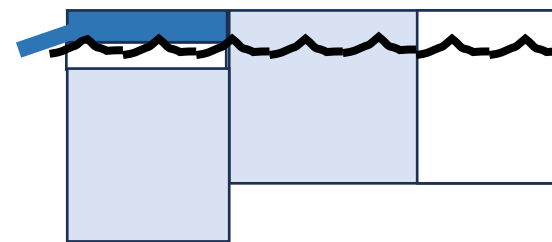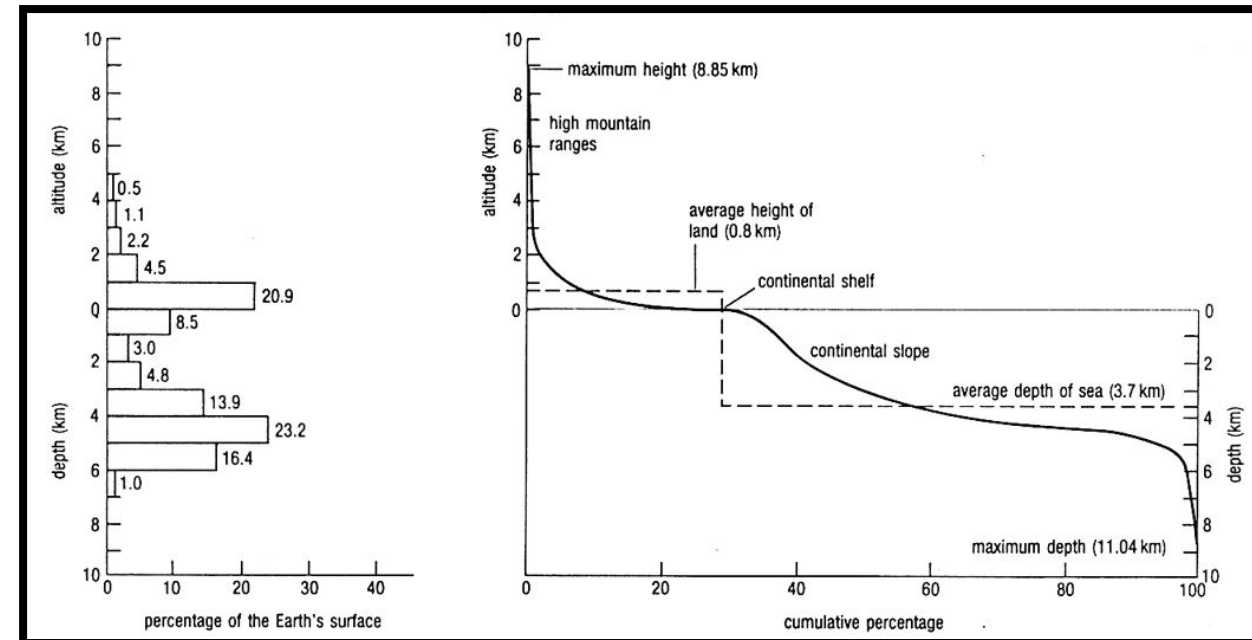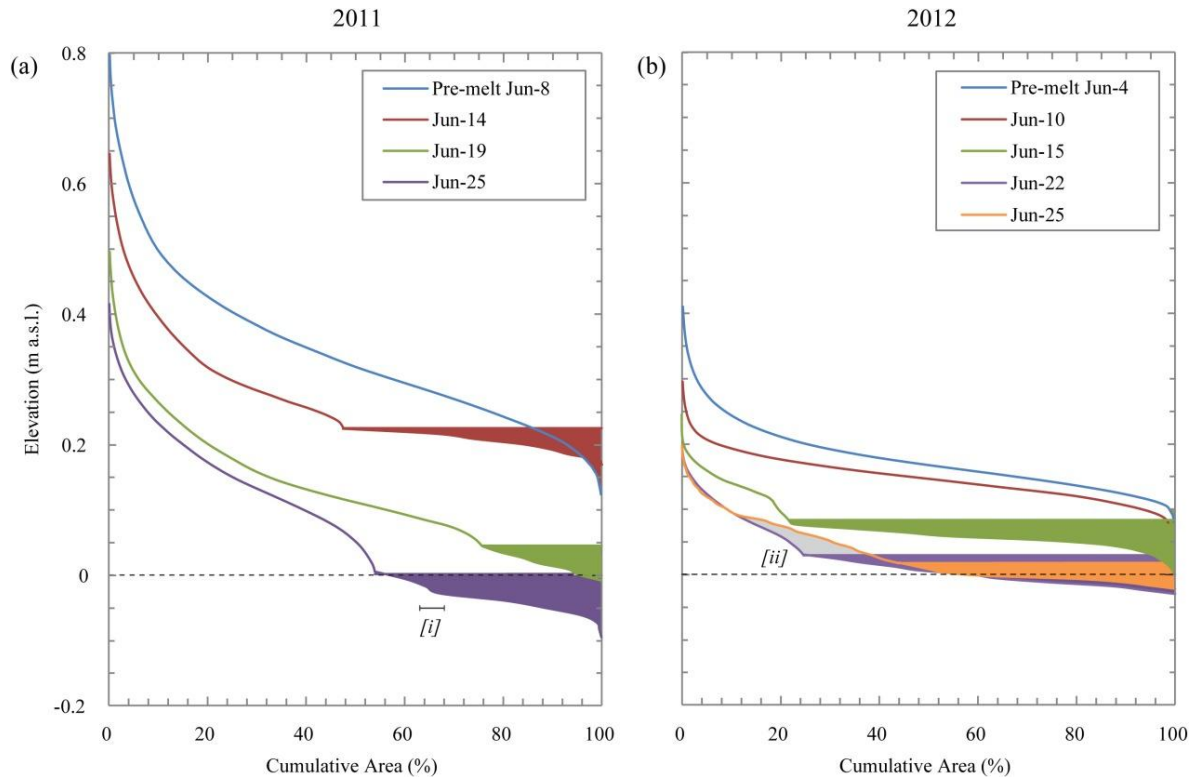The pressure head for percolation drainage assumes perched ponds.

If pond mass would depress ice locally below freeboard, instantaneous drainage.

Hypsometry

"the measurement of the elevation and depth of features of Earth's surface relative to mean sea level"
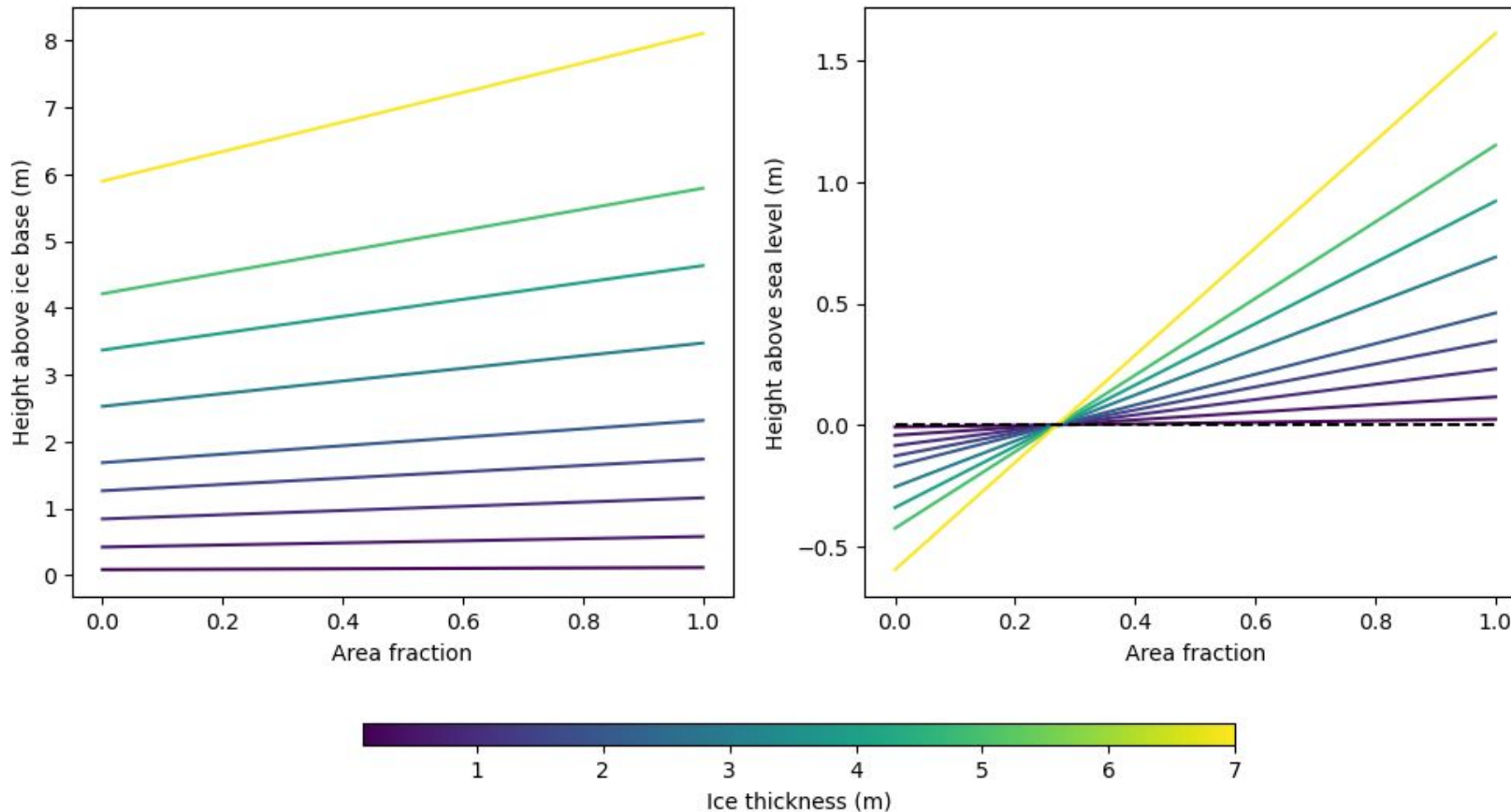

Landy et al., 2014

Proposed Changes

Assume linear hypsometric curve which is a function of ice thickness, such that when **pond surface is at sea level, pond area is constant**.
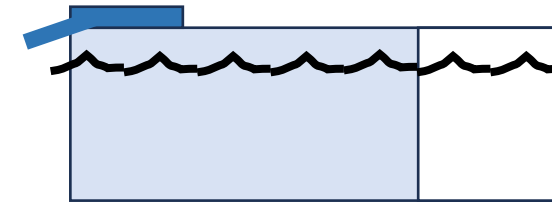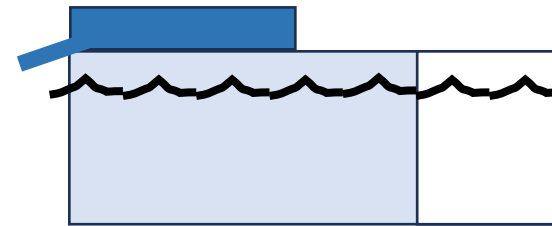
Proposed changes

<u>Icepack proposed</u>

<u>Icepack currently</u>

1. Explicitly represent hypsometry -> controls depth-area changes and enables sea level ponds.

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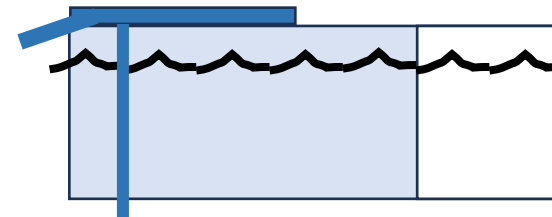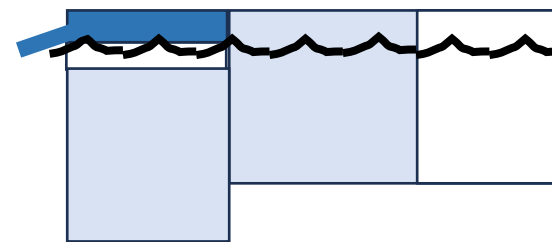4. Freeboard constraint applied to entire category.

Ponds are perched above the ice surface and exponentially decay.

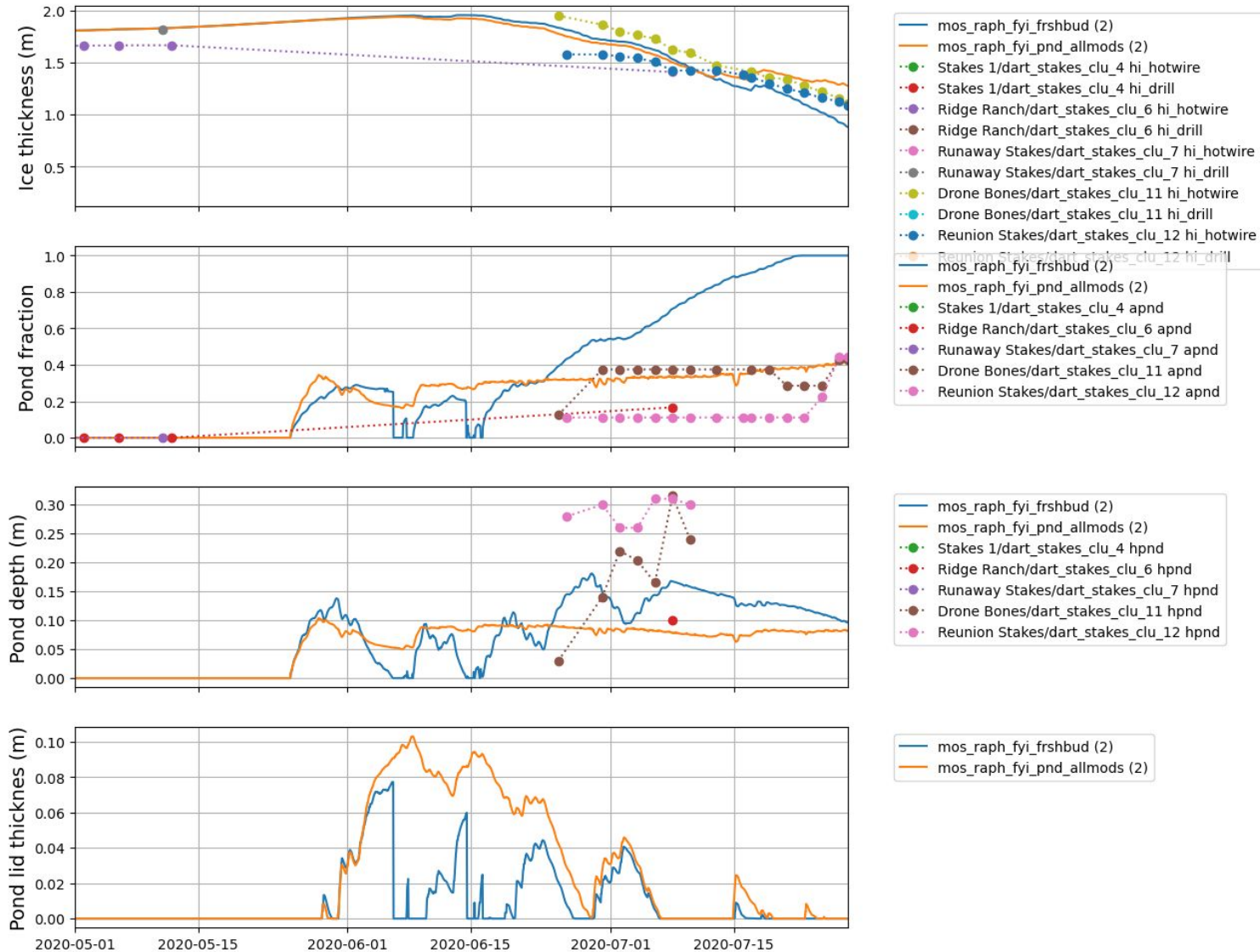Pond area and depth grow by fixed ratio. Drainage only reduces depth.

The pressure head for percolation drainage assumes perched ponds.

If pond mass would depress ice locally below freeboard, instantaneous drainage.

Icepack vs. MOSAiC Observations

Ongoing work

- Apply logistic hypsometry instead of linear
- Detailed comparison with transect observations
- Implementation in CICE and testing in standalone and CESM

Contact: dcsewall@ucar.edu