Assessing the summer mass balance and freshwater storage of Arctic sea ice

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Photo: Lianna Nixon

Funding: NSF OPP 2138787

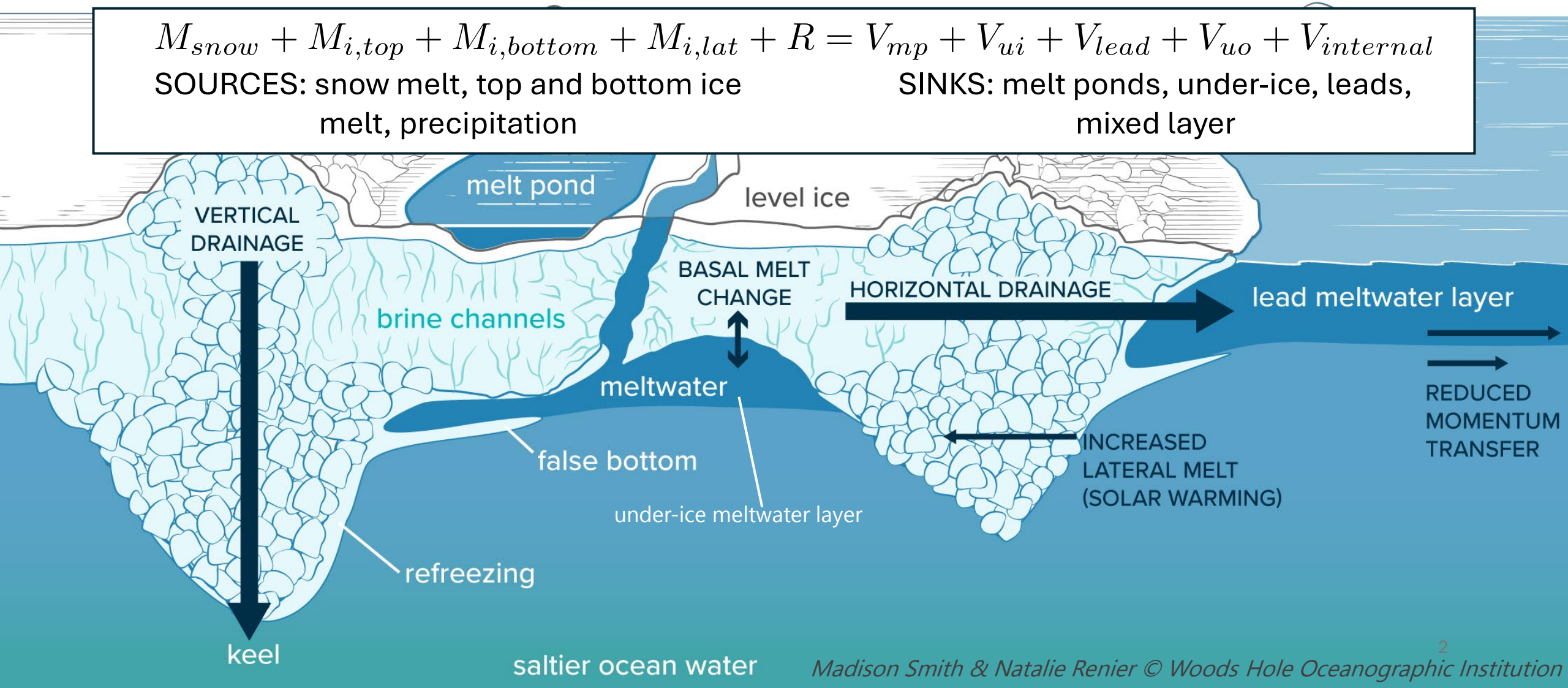
CESM PCWG meeting – June 12, 2024

Freshwater budget – sea ice and upper ocean

$$M_{snow} + M_{i,top} + M_{i,bottom} + M_{i,lat} + R = V_{mp} + V_{ui} + V_{lead} + V_{uo} + V_{internal}$$

SOURCES: snow melt, top and bottom ice melt, precipitation

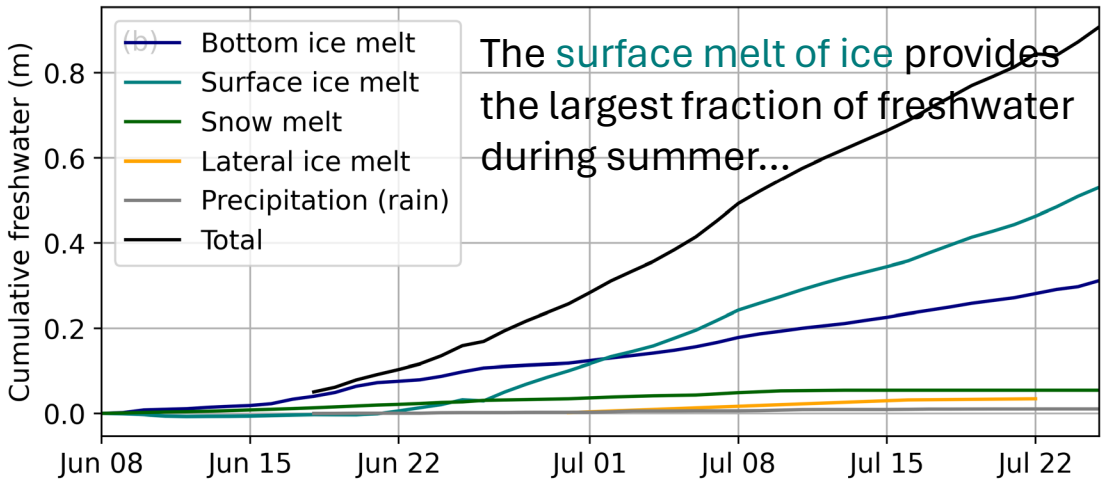
SINKS: melt ponds, under-ice, leads, mixed layer



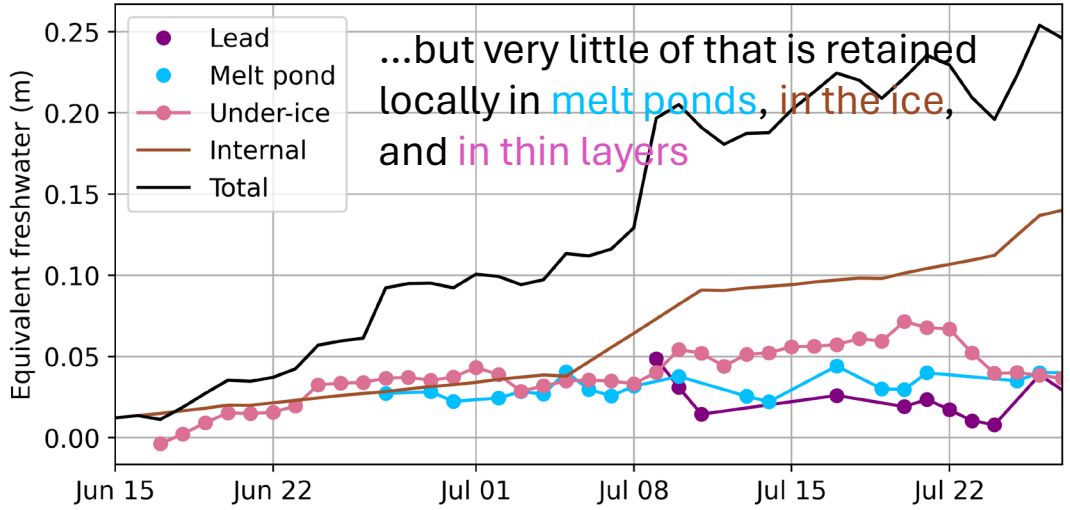
Freshwater budget – observations

$$M_{snow} + M_{i,top} + M_{i,bottom} + M_{i,lat} + R = V_{mp} + V_{ui} + V_{lead} + V_{uo} + V_{internal}$$

SOURCES:



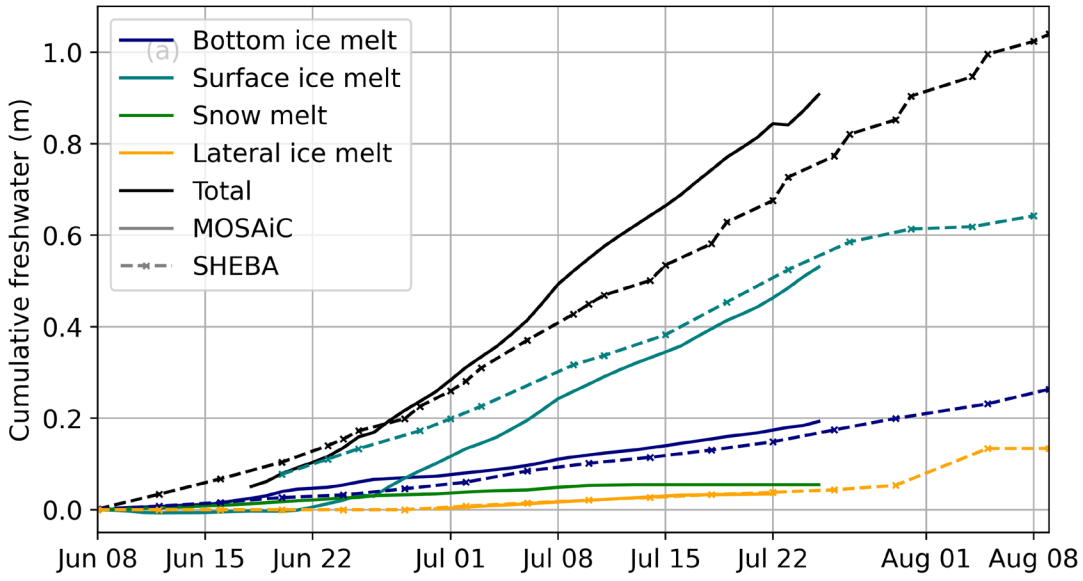
SINKS:

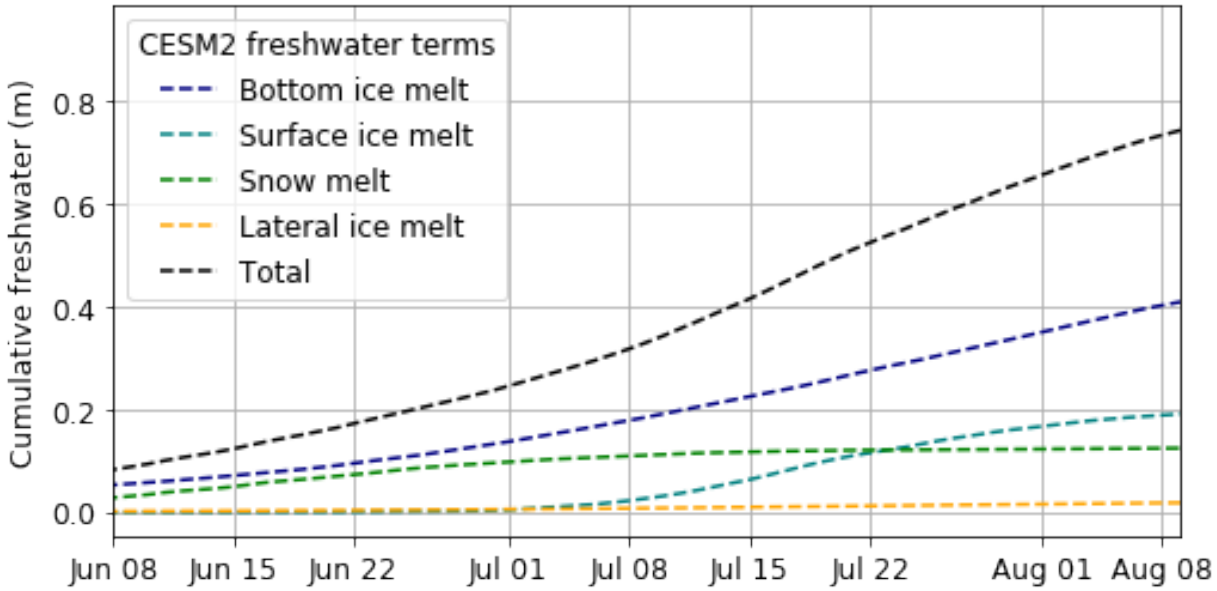


- The residual (V_{uo}) is about 75% of total freshwater sources
  - Most of sea ice and snow meltwater makes it into the ocean
- Freshwater that is retained in other sinks (melt ponds, thin meltwater layers) is likely important to capture well

Comparison of freshwater sources

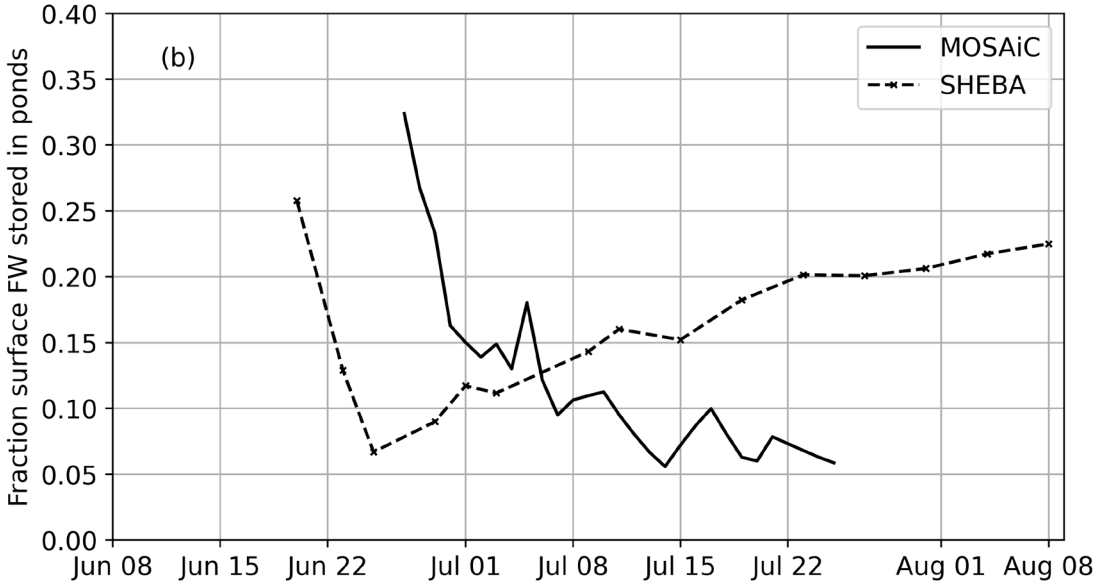
- Total meltwater sources are about 30% lower in the model compared to observations
- Bottom melt is a higher fraction in the model, while surface melt is a lower fraction



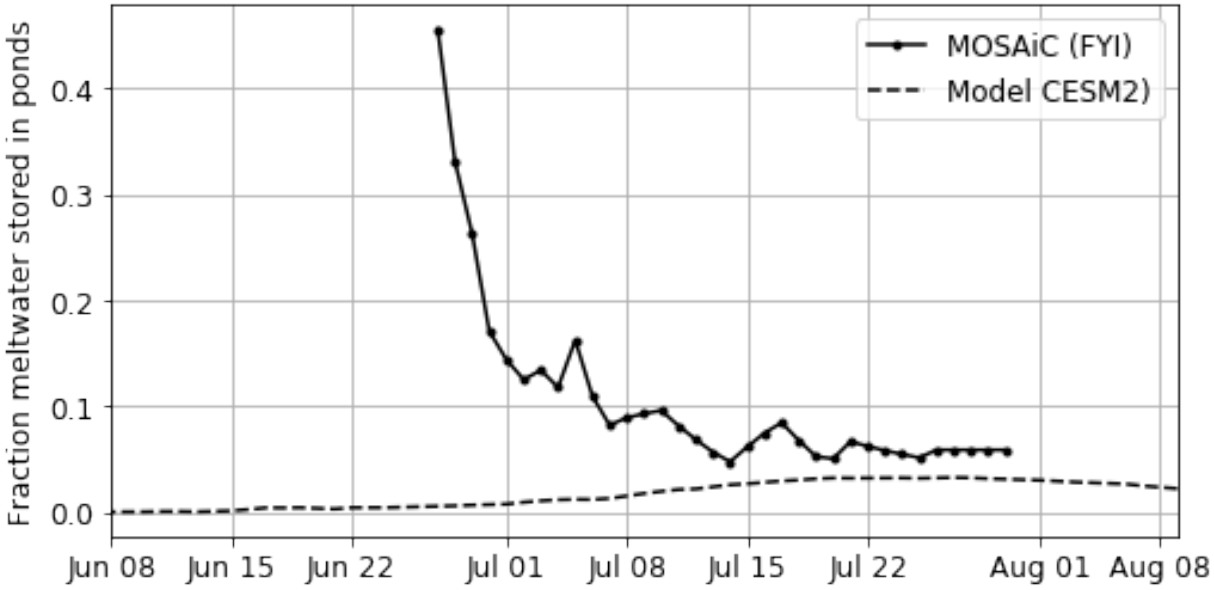


Comparison of freshwater storage in melt ponds

Pond storage fractions are fairly similar between MOSAiC (2020; FYI/SYI) and SHEBA (1998; MYI), though with different temporal evolution



CESM2 substantially underestimates melt pond storage for both, though especially for MYI/SYI



Diagnosing differences in freshwater production and storage

↓Total surface meltwater about 30% less than in observations

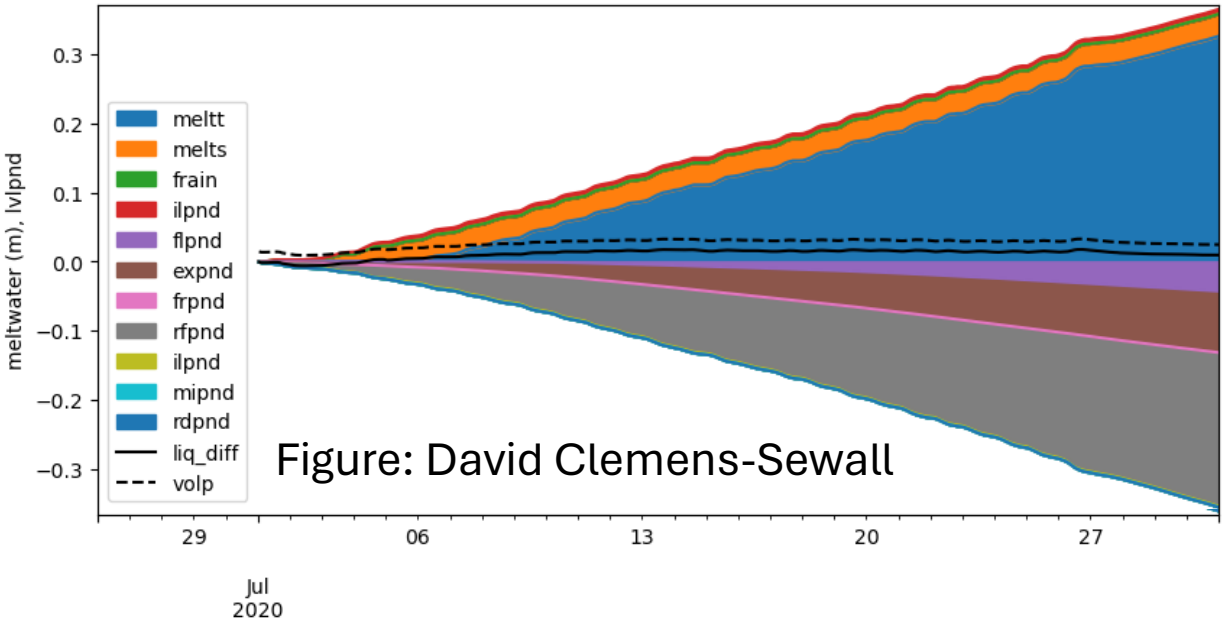


Figure: David Clemens-Sewall

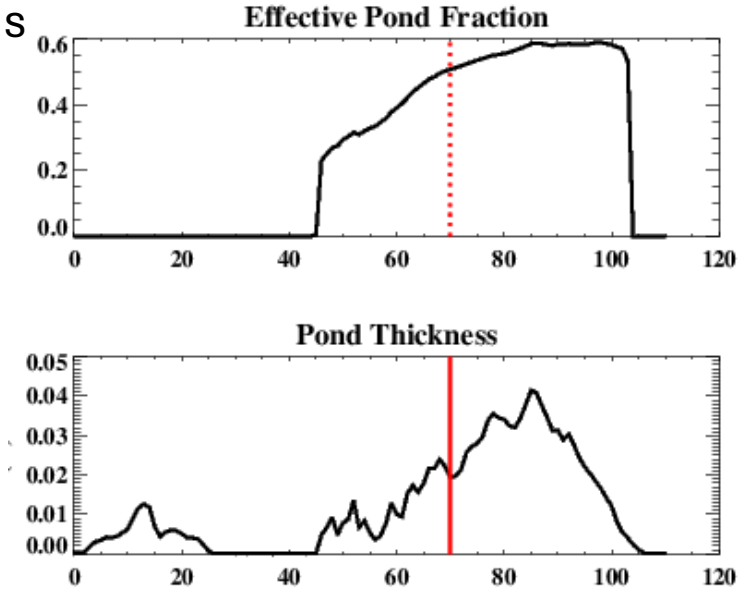


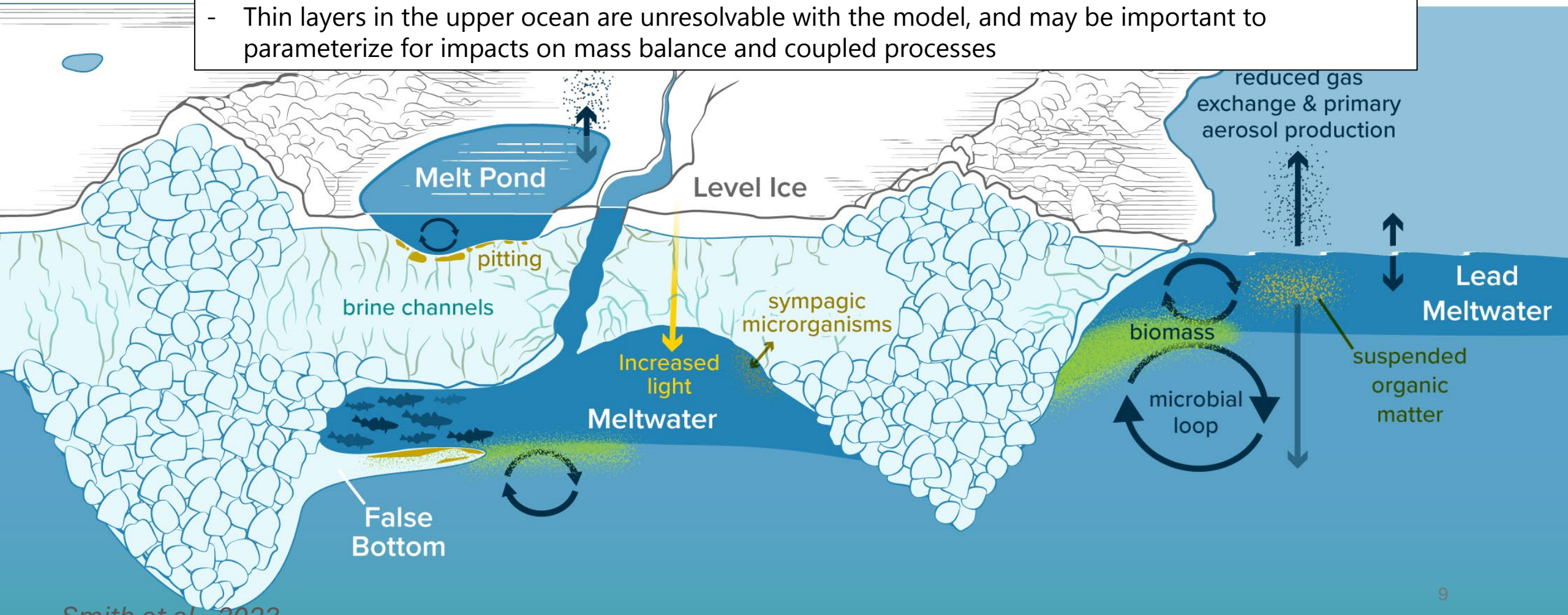
Figure: David Clemens-Sewall

← Melt ponds peak at 0.02 m equivalent depth, compared to 0.05-0.45 m in observations

- In forced 1D comparisons, meltwater production compares pretty well, but melt ponds don't
- Differences in freshwater sources may be a result of the climate, but **melt ponds are likely a result of processes**

Local freshwater has far-reaching impacts in the Arctic system

- The under-representation of melt ponds is a key target for improvement (Clemens-Sewall, in prep)
- Thin layers in the upper ocean are unresolvable with the model, and may be important to parameterize for impacts on mass balance and coupled processes



Smith et al., 2023