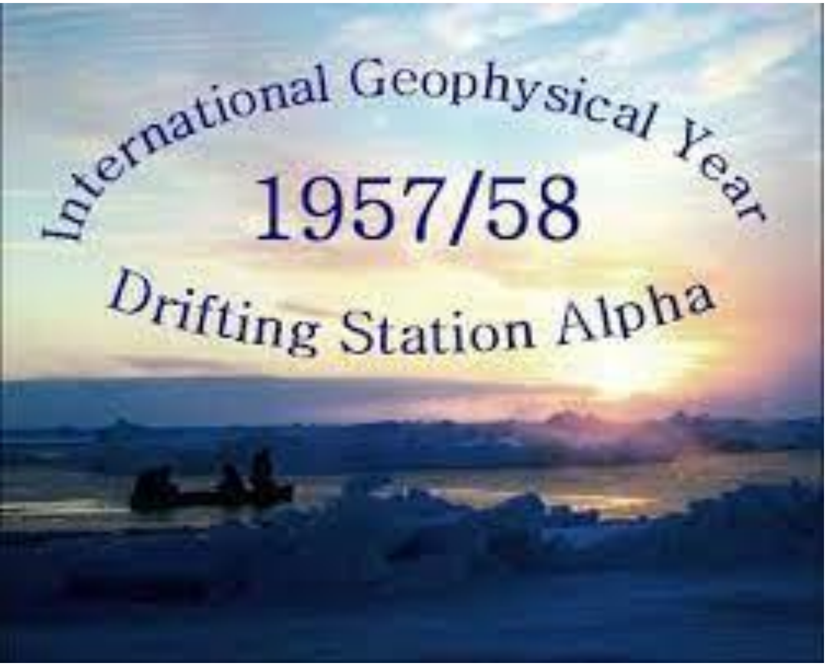
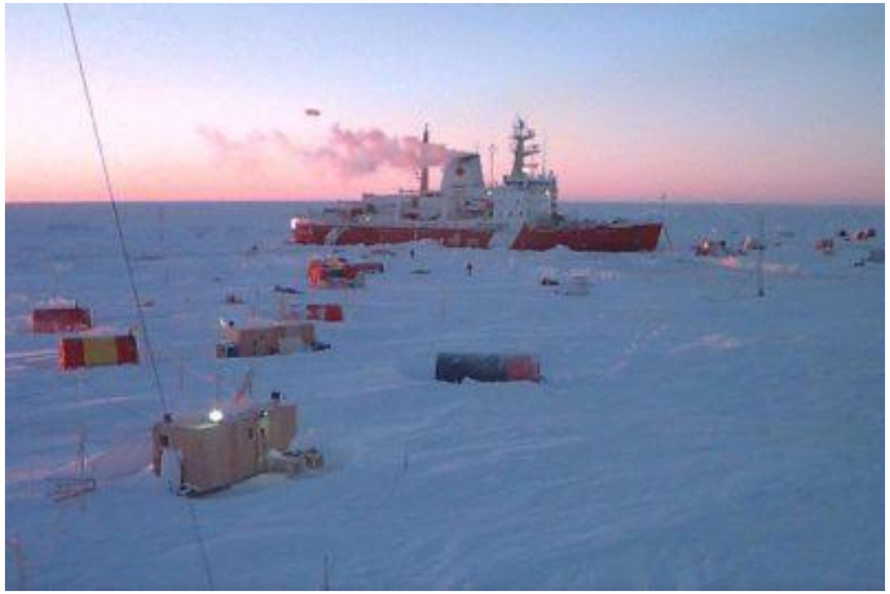
Sea ice sensitivity in the New Arctic





David Clemens-Sewall[1], Marika Holland[1], Ian Raphael[2], Michael Gallagher[3]
[1]NSF NCAR, [2]Dartmouth College, [3]CIRES

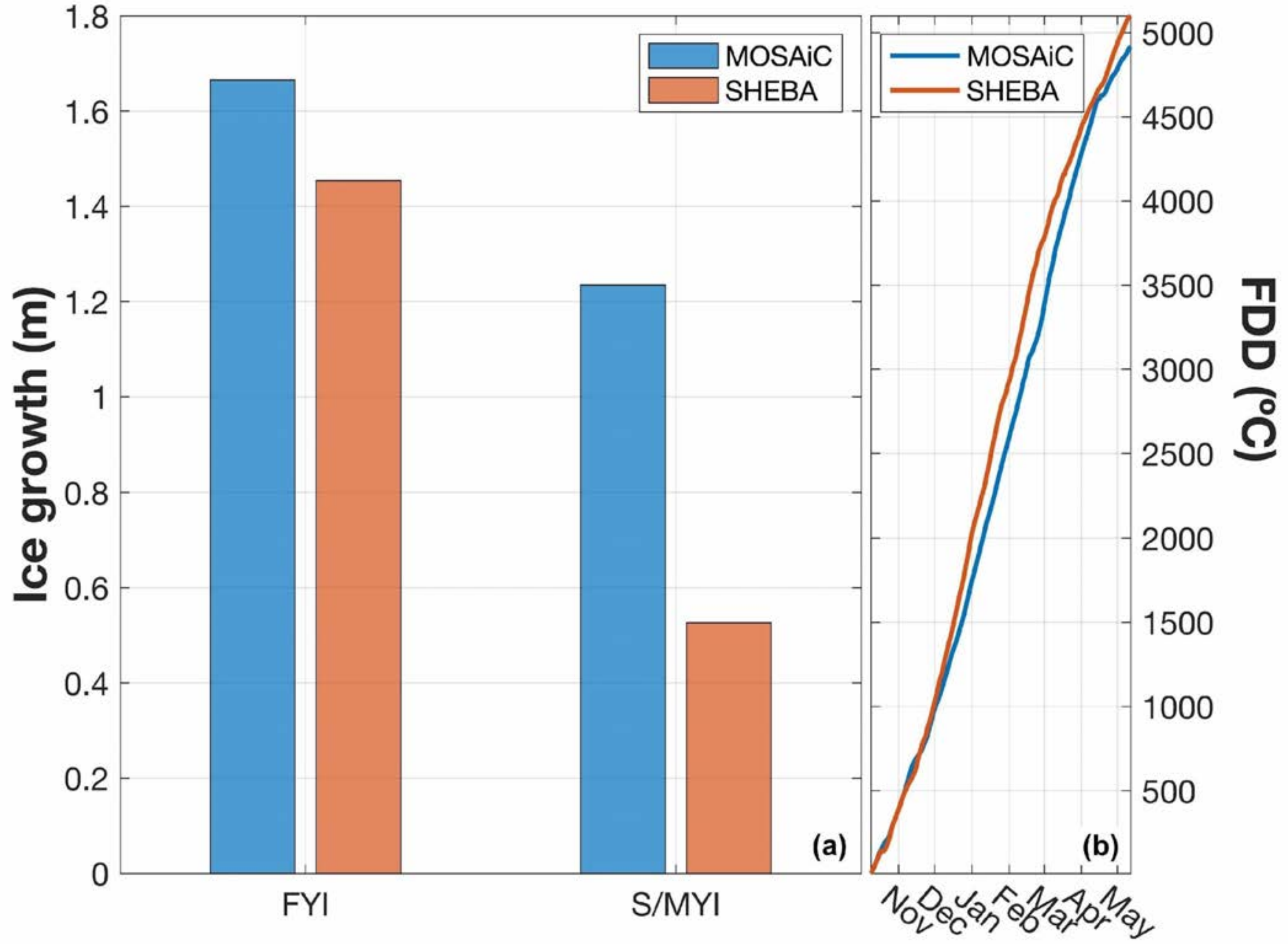
Photos: NSIDC, DoE ARM, M. Ernst

Outline

- **Inspiration & Goals**
- Methods
- Results
- Conclusions

Photo: Monica Votnik

Inspiration & Goals



Raphael et al. in review

- 2m air temperature at MOSAiC and SHEBA were similar.
- FYI growth was similar, and single column modeling suggested differences could be largely explained by snow thickness, **not differences in forcing or parameterizations**.
- S/MYI growth discrepancies were only 46% explained by initial snow and ice thickness and precip.

Goal

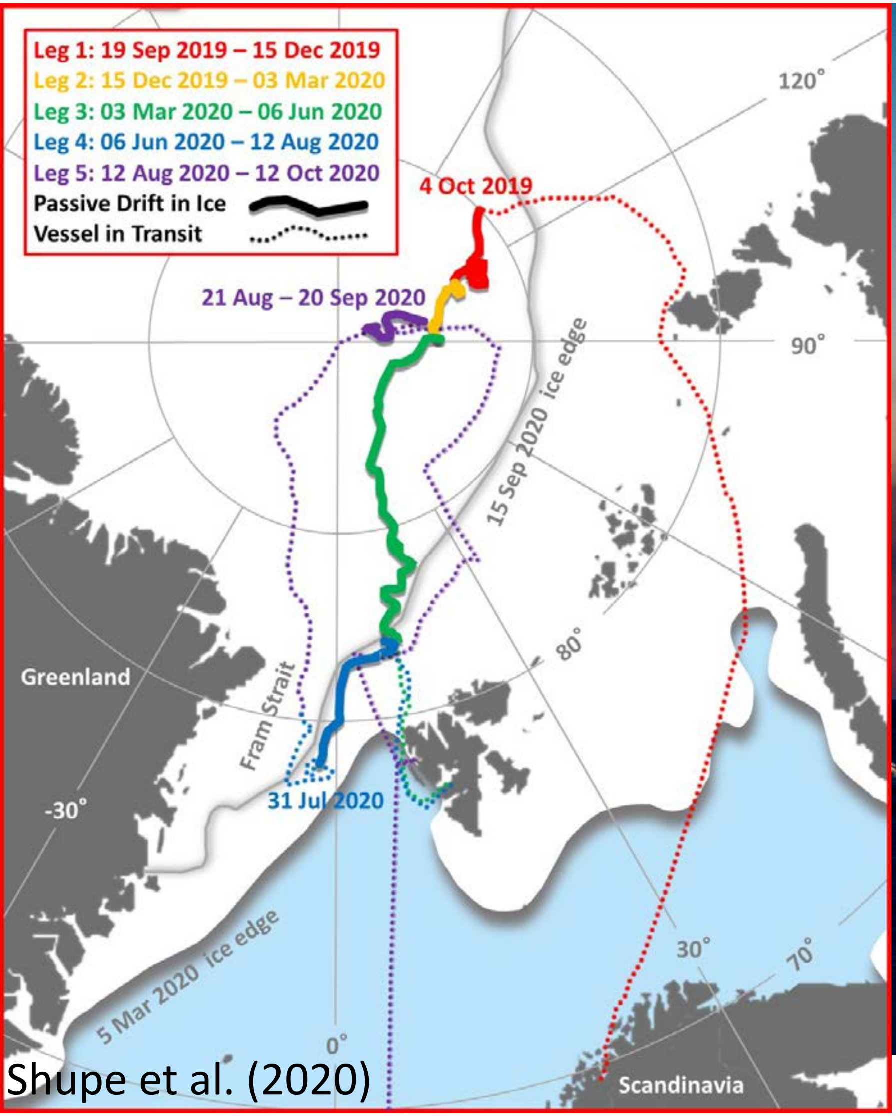
Explore how the sea ice sensitivity to different processes is impacted by the ice state, considering the transition from the thicker, perennial ice (the ‘Old Arctic’) to thinner, seasonal ice (the ‘New Arctic’).

Outline

- Inspiration & Goals
- **Methods**
- Results
- Conclusions

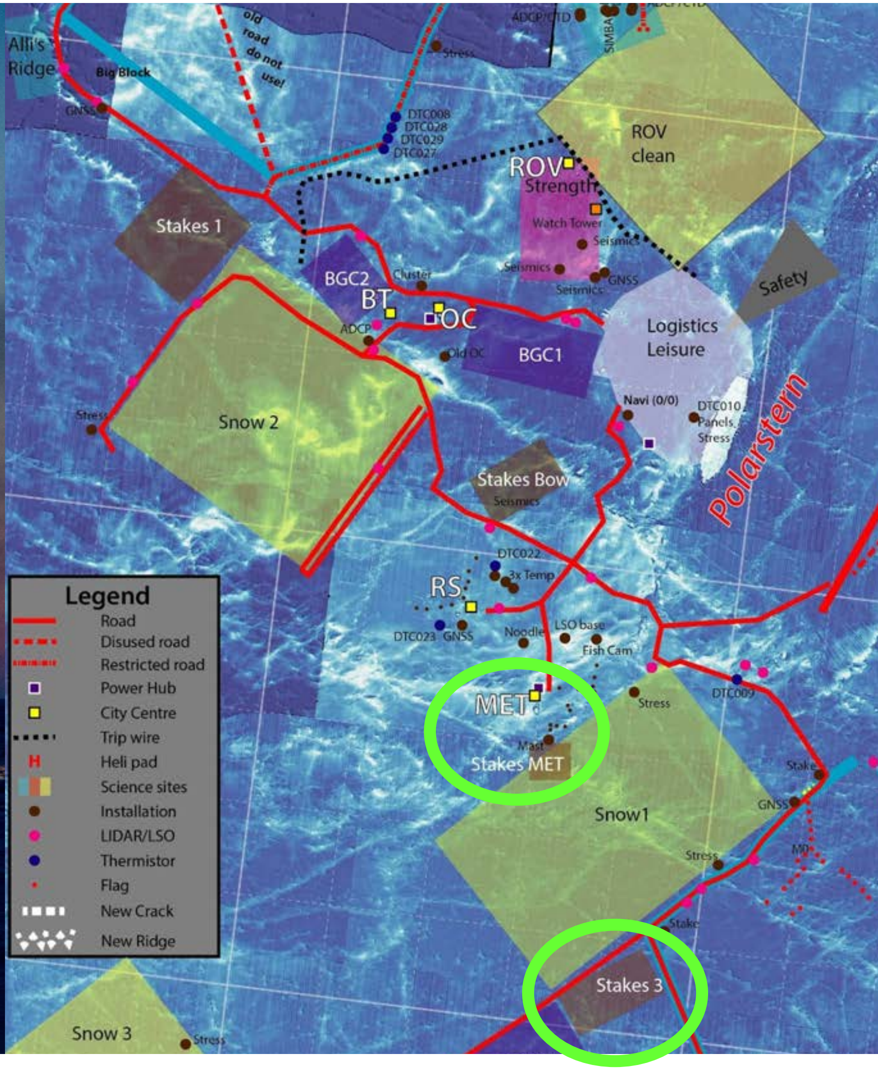
Photo: Eric Brossier

Methods – MOSAiC Expedition

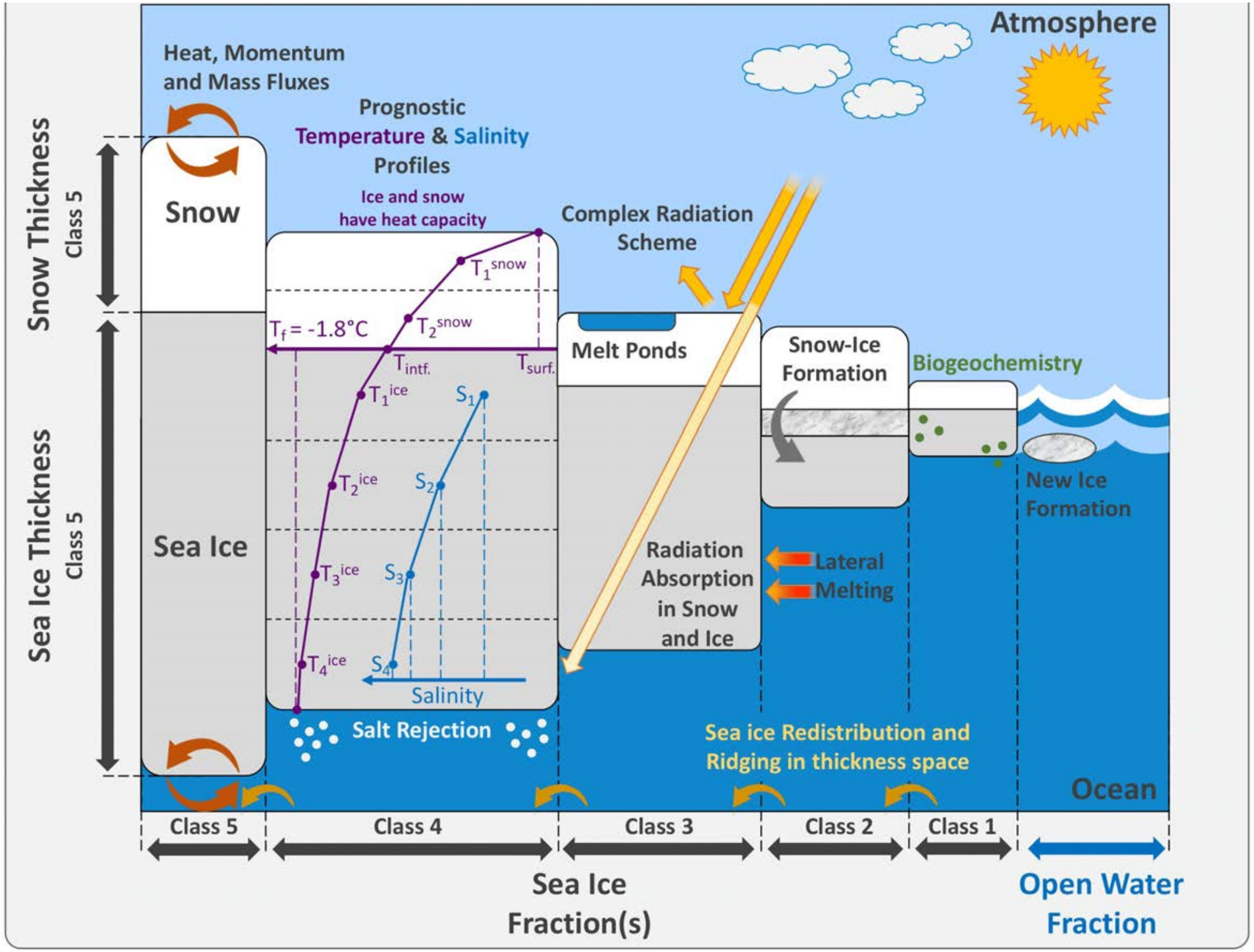


Shupe et al. (2020)

Photo: C. Rohleder



Methods – Icepack sea ice model



Zampieri (2021)

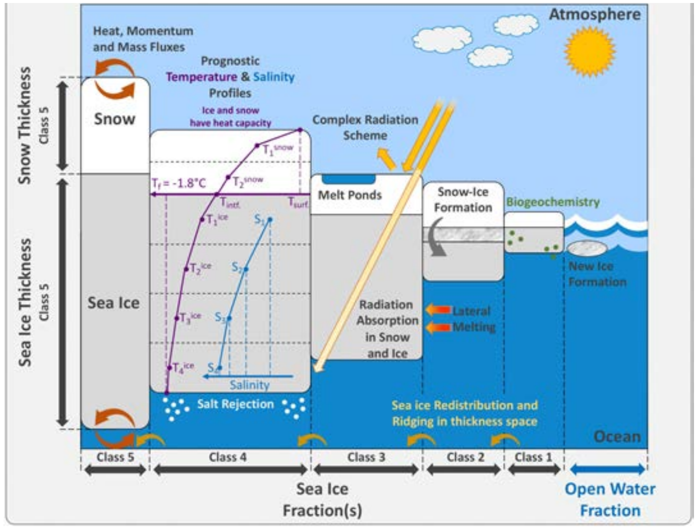
Methods – Single Column Modeling

Atmosphere Measurements

Ocean Measurements

Photo: J. Schaffer

Icepack SCM

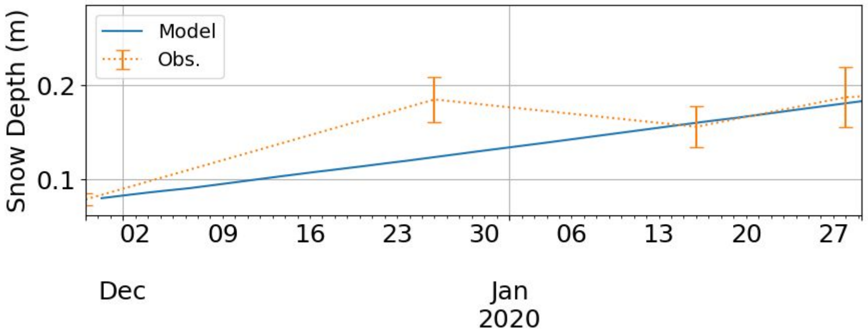


Zampieri (2021)

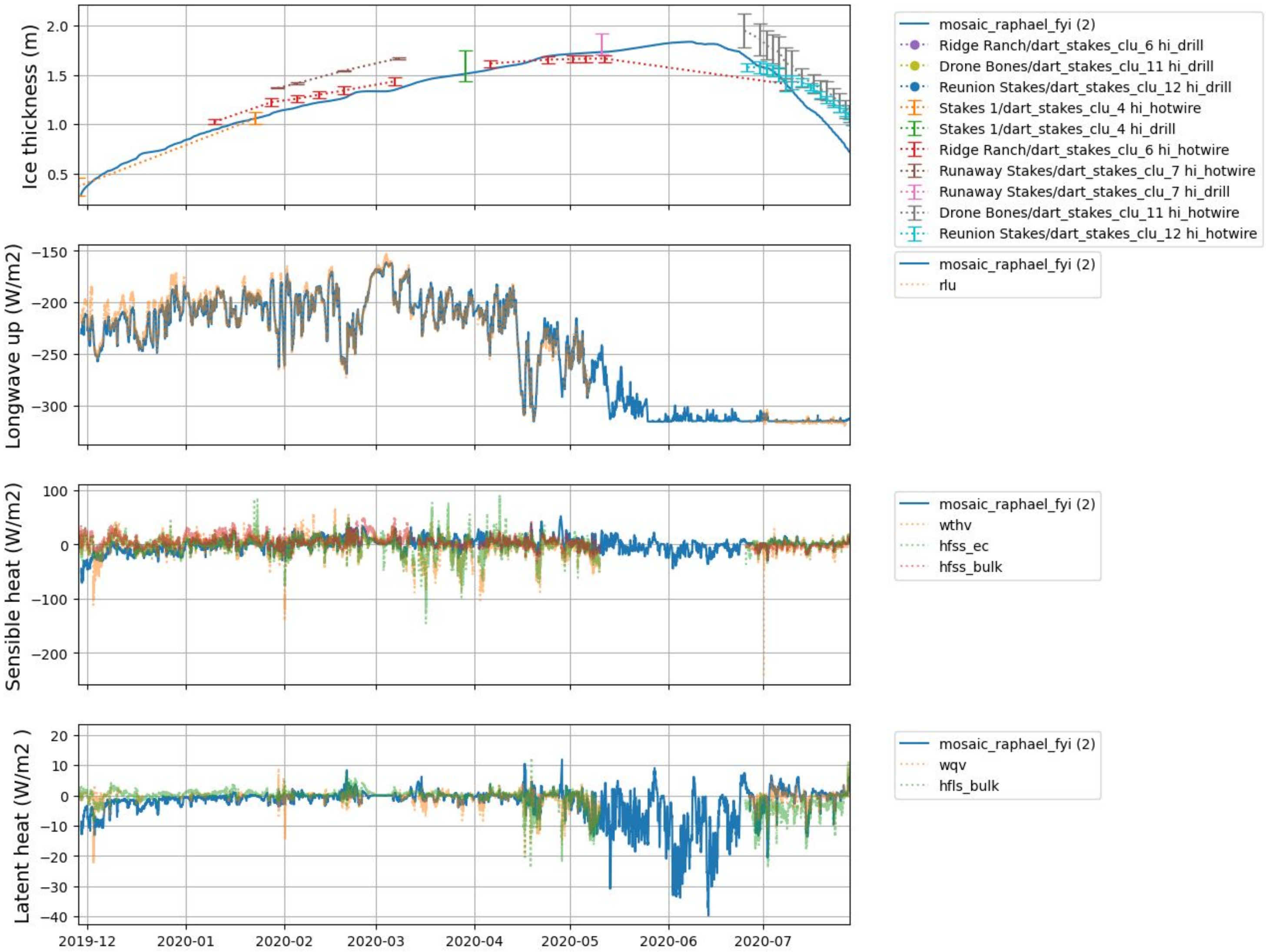
Snow and Ice Measurements

Photo: D. Clemens-Sewall

Model Validation



Methods – Validation



Outline

- Inspiration & Goals
- Methods
- **Results**
- Conclusions

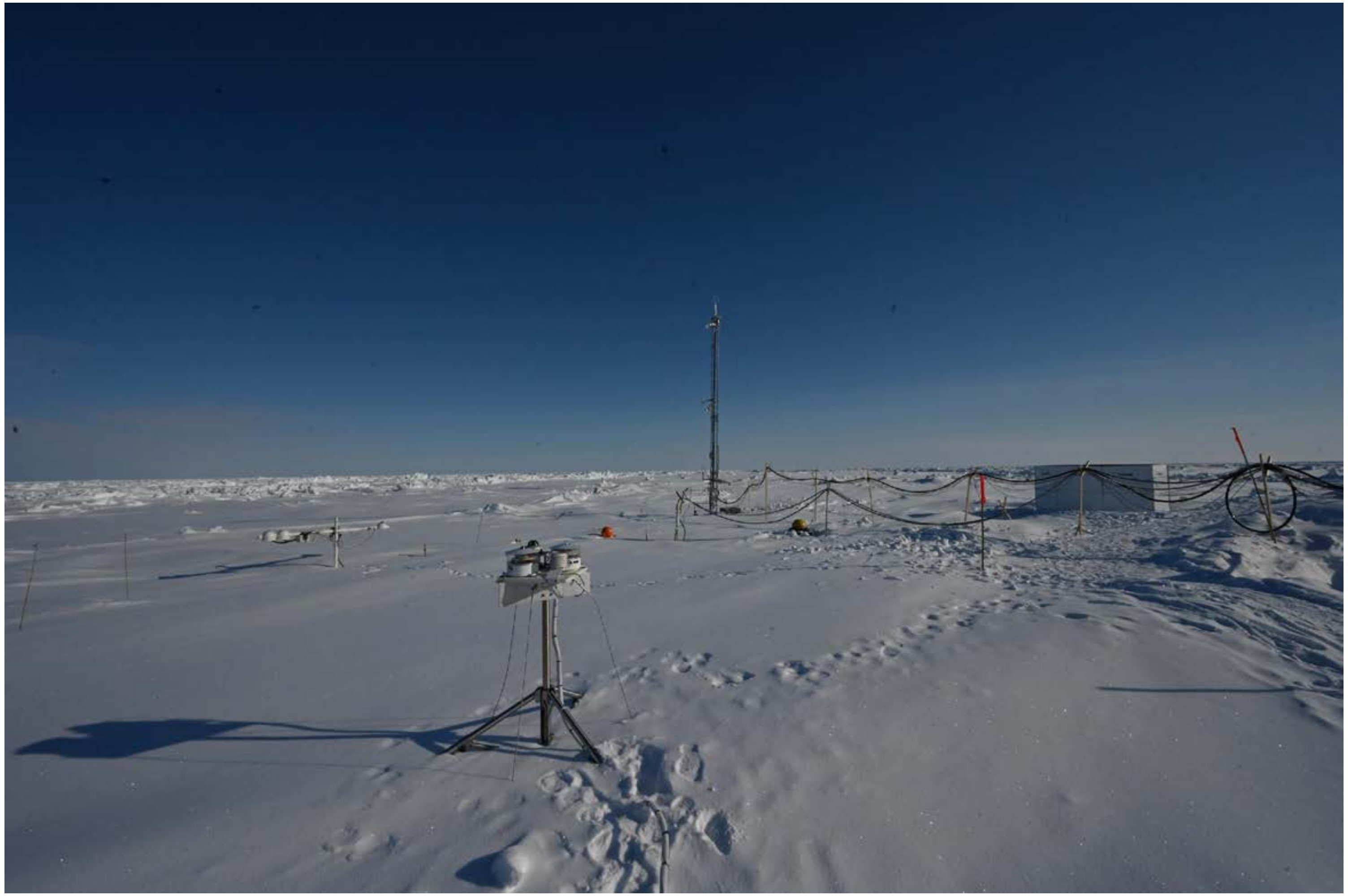


Photo: Martin Radenz

Results

Nov. 28 ice (snow):

CHARLIE 2.79 m (8 cm)

SHEBA 1.76 m (8 cm)

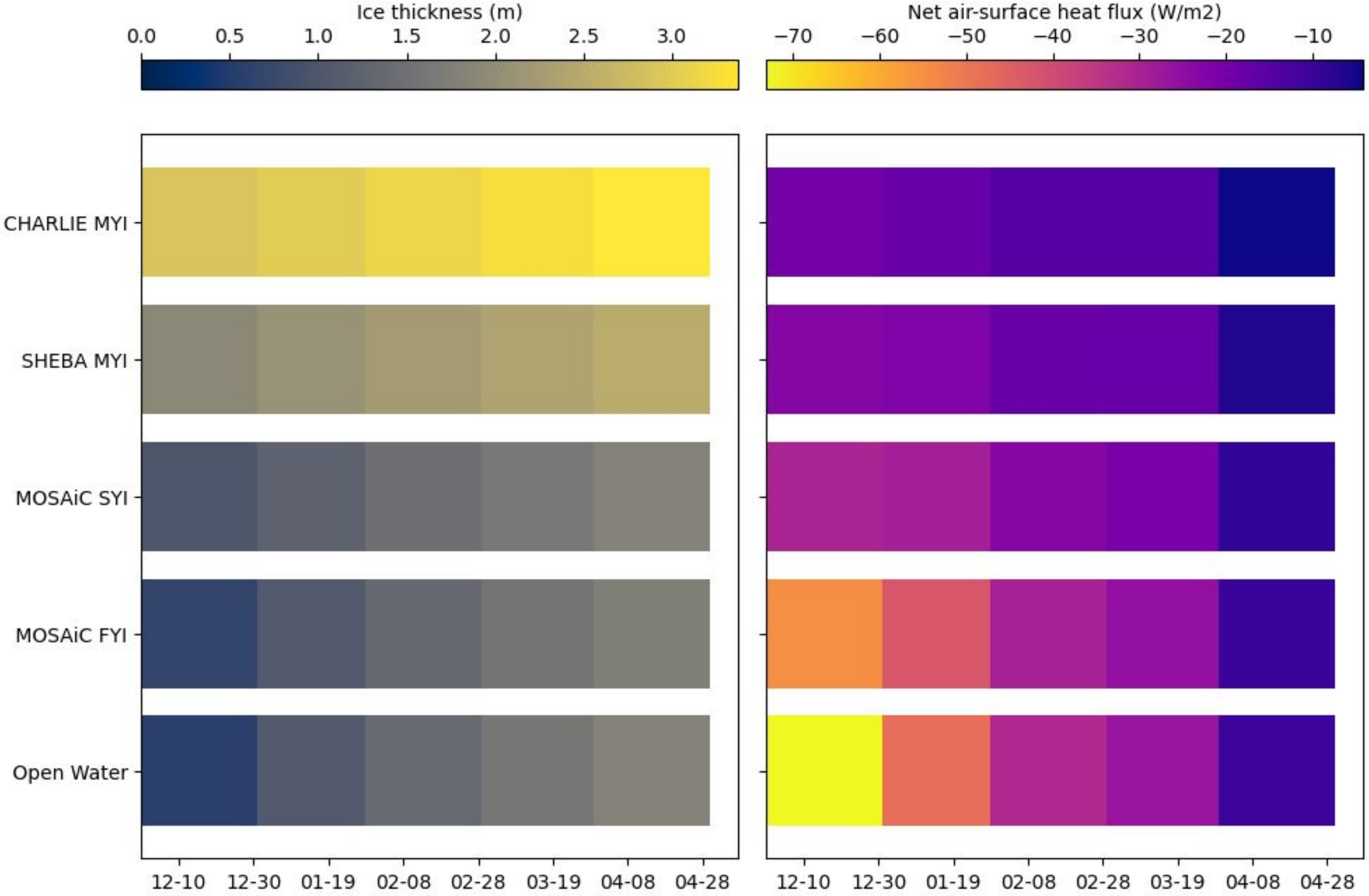
MOS SYI 0.80 m (8 cm)

MOS FYI 0.28 m (2 cm)

Open Water 0 m (0 cm)

Oceanic heat flux convergence: 1 W/m^2

Mixed layer: 32 PSU, 45 m thick



Results

Nov. 28 ice (snow):

CHARLIE 2.79 m (8 cm)

SHEBA 1.76 m (8 cm)

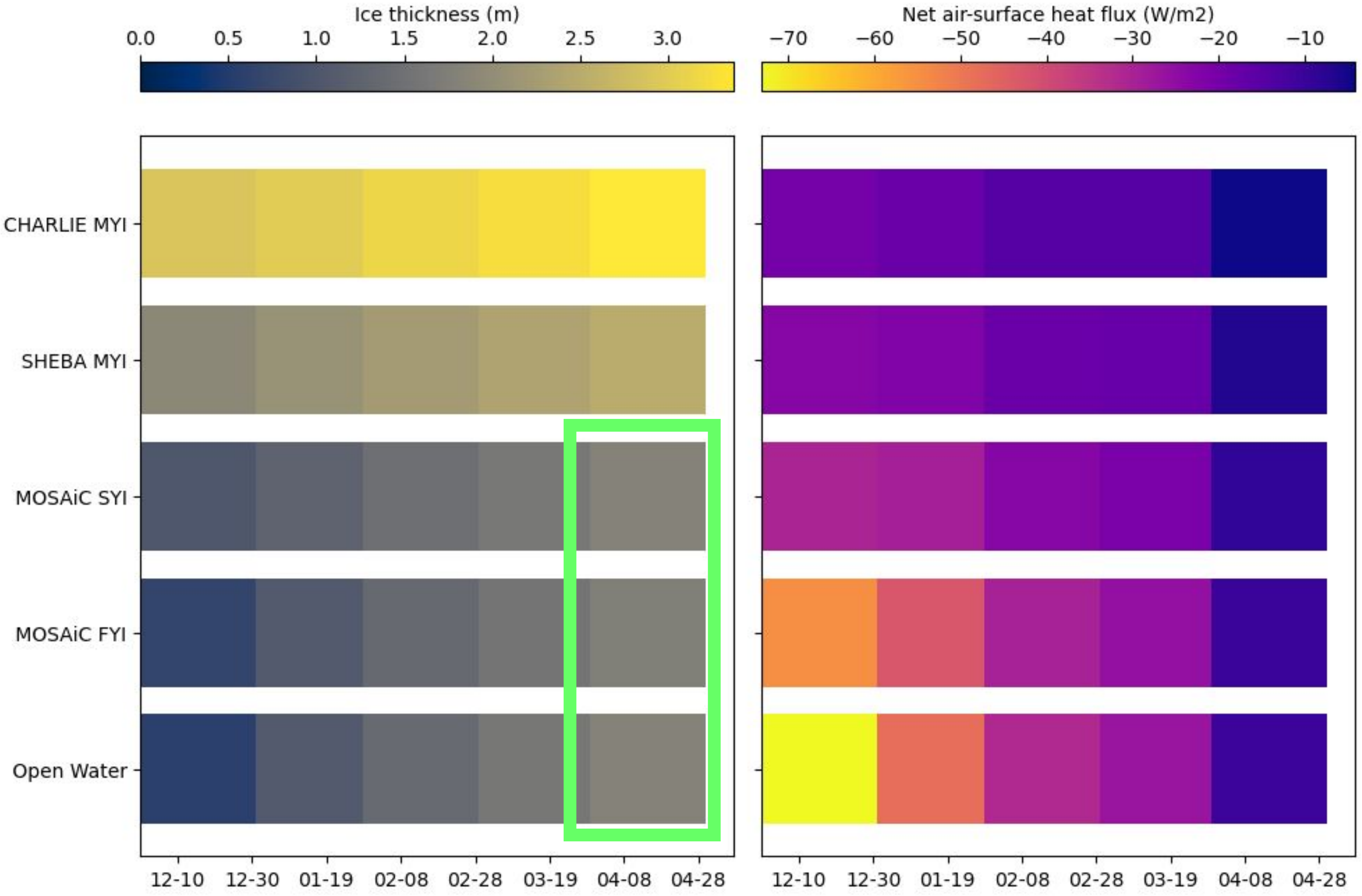
MOS SYI 0.80 m (8 cm)

MOS FYI 0.28 m (2 cm)

Open Water 0 m (0 cm)

Oceanic heat flux convergence: 1 W/m^2

Mixed layer: 32 PSU, 45 m thick

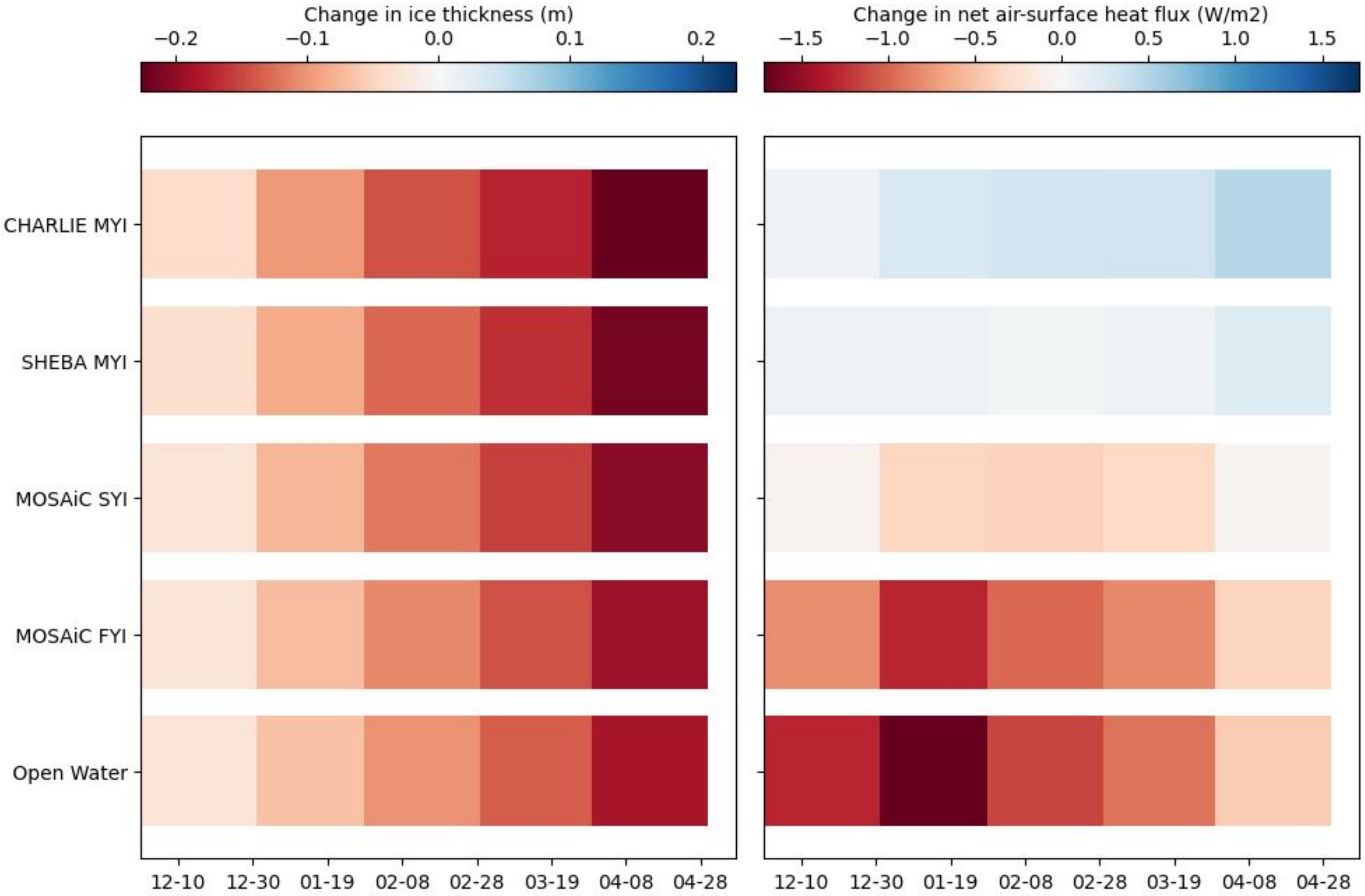


Results

- Oceanic heat flux convergence:

1 W/m^2 □ 7 W/m^2

- Greatest impacts on ice thickness (and growth) are on thickest ice.
- Greatest impacts on air-surface heat flux on thinnest ice.

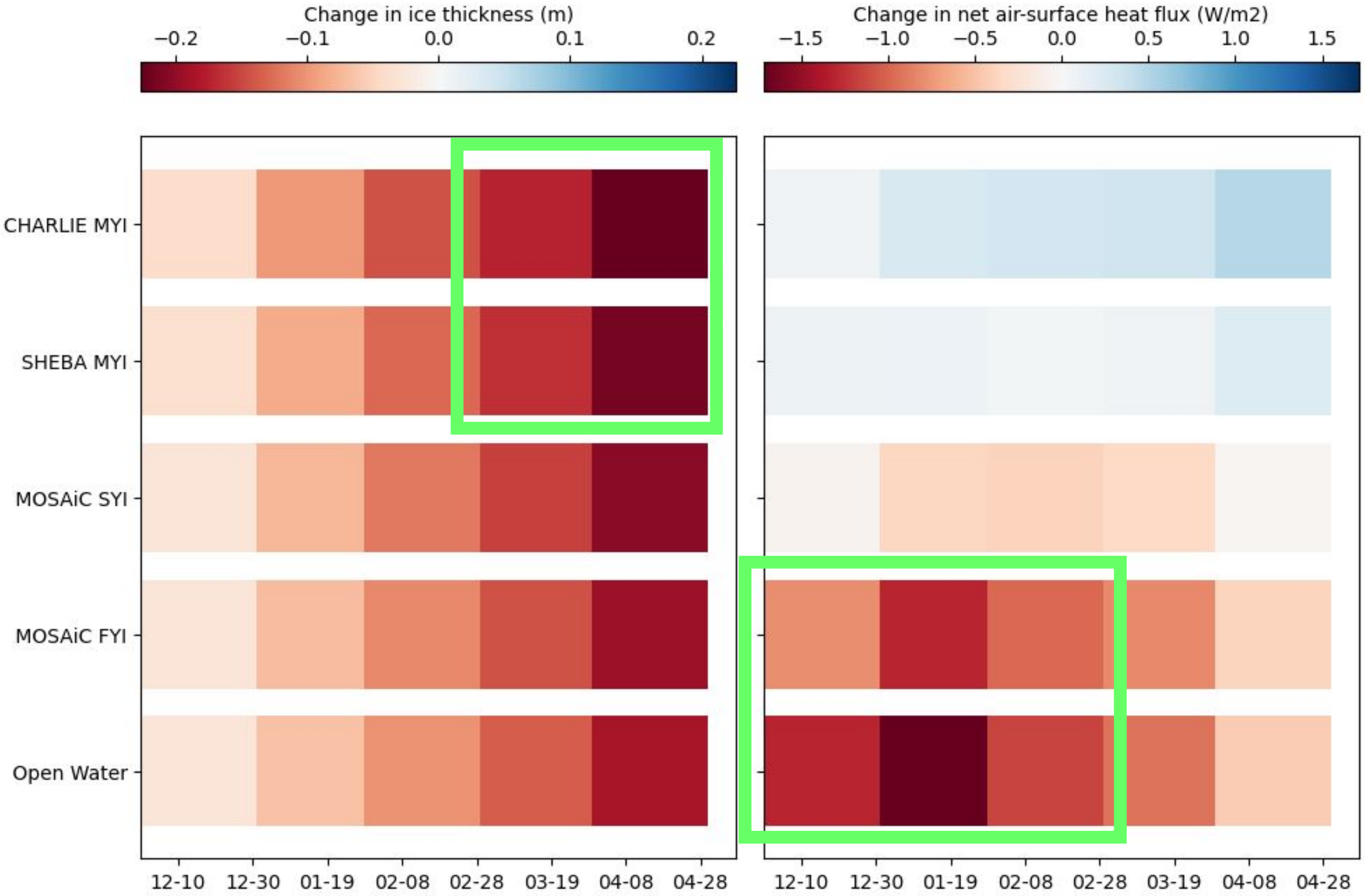


Results

- Oceanic heat flux convergence:

1 W/m^2 □ 7 W/m^2

- Greatest impacts on ice thickness (and growth) are on thickest ice.
- Greatest impacts on air-surface heat flux on thinnest ice.



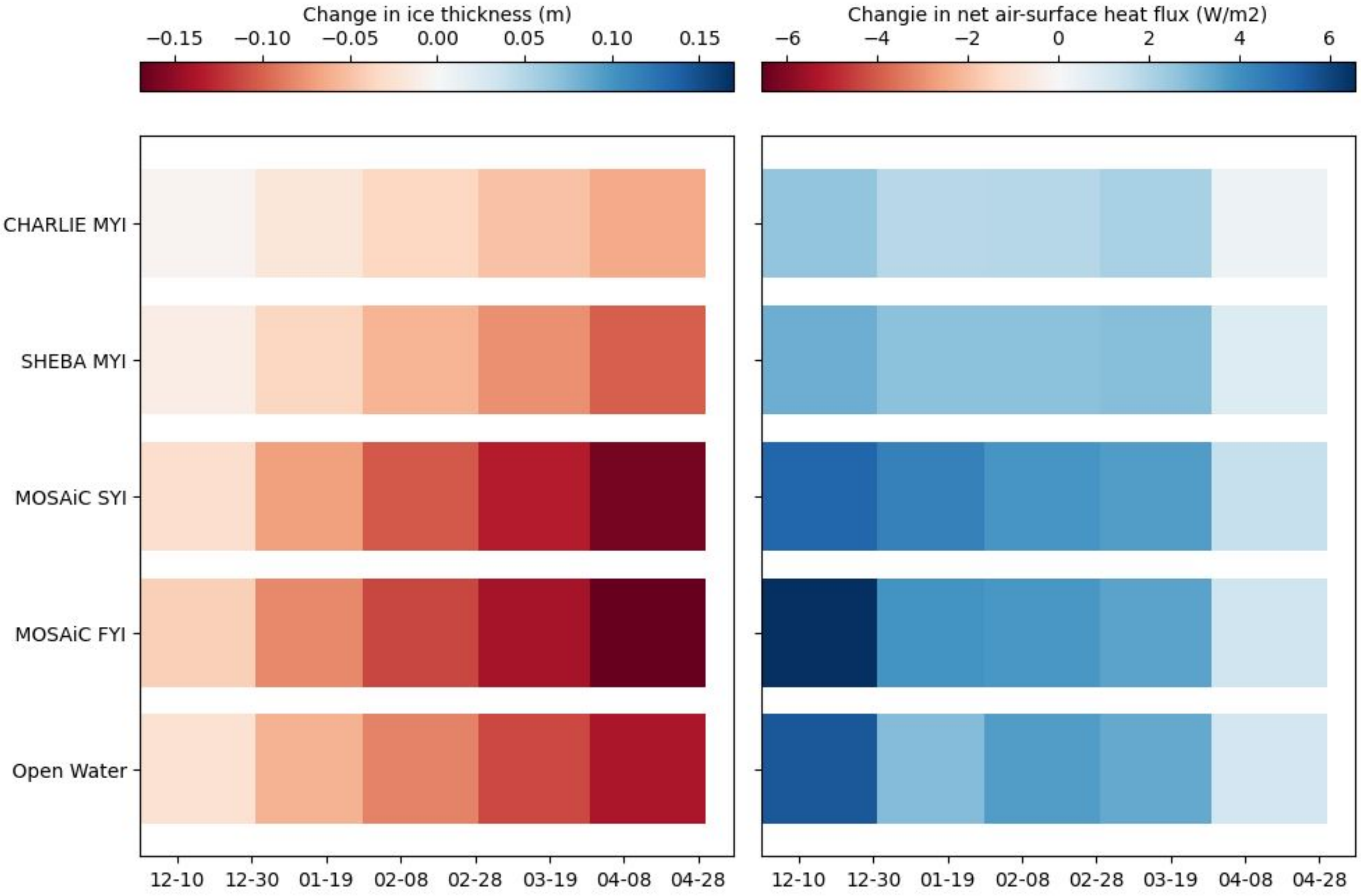
Results

- Snow thermal conductivity:

0.3 W/m K □ 0.2 W/m K

- Greatest impacts* on ice thickness (and growth) are on thinnest ice.
- Greatest impacts* on air-surface heat flux on thinnest ice.

*Slightly reduced on OW



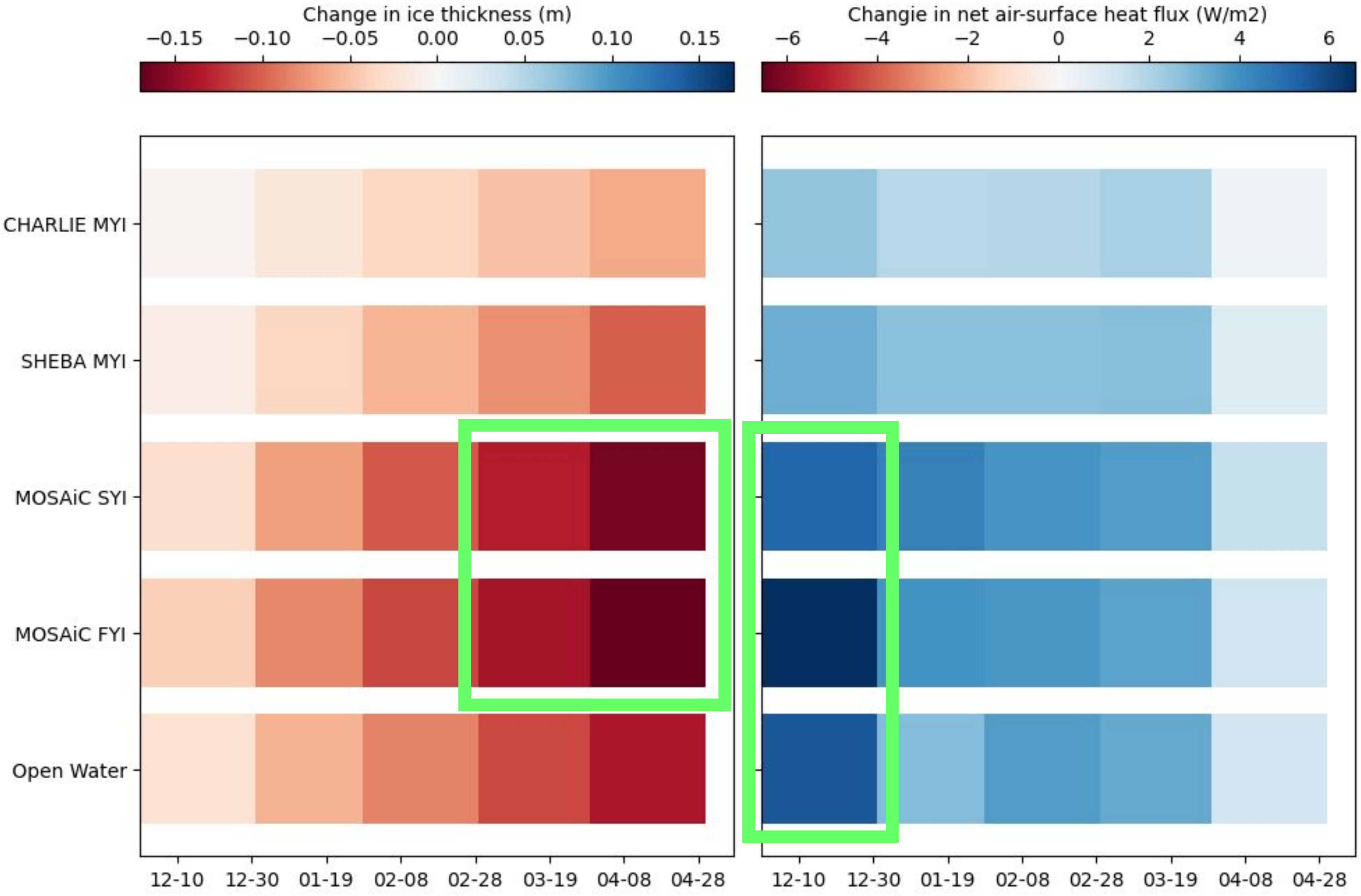
Results

- Snow thermal conductivity:

0.3 W/m K □ 0.2 W/m K

- Greatest impacts* on ice thickness (and growth) are on thinnest ice.
- Greatest impacts* on air-surface heat flux on thinnest ice.

*Slightly reduced on OW



Outline

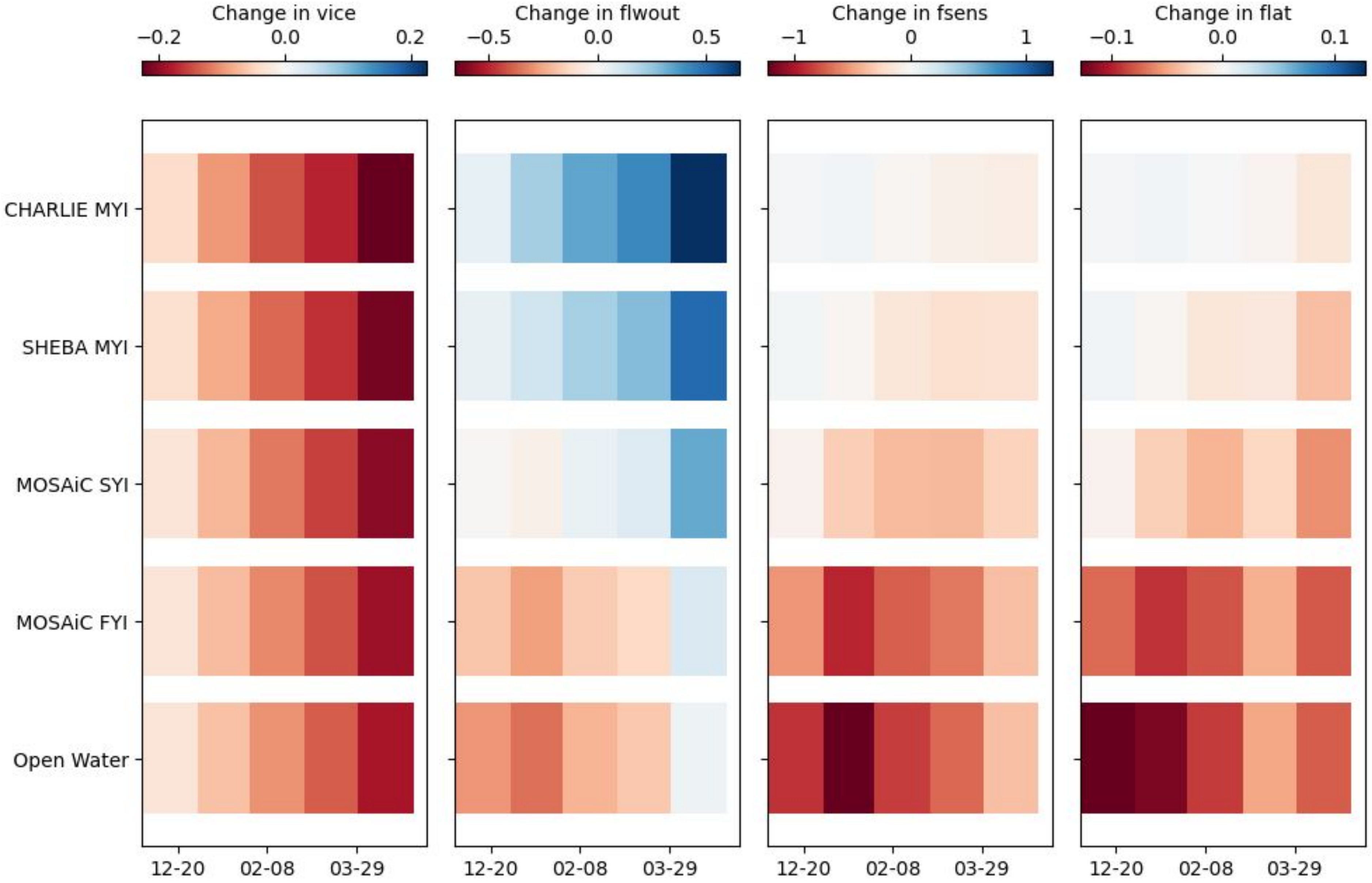
- Inspiration & Goals
- Methods
- Results
- **Conclusions**

Conclusions

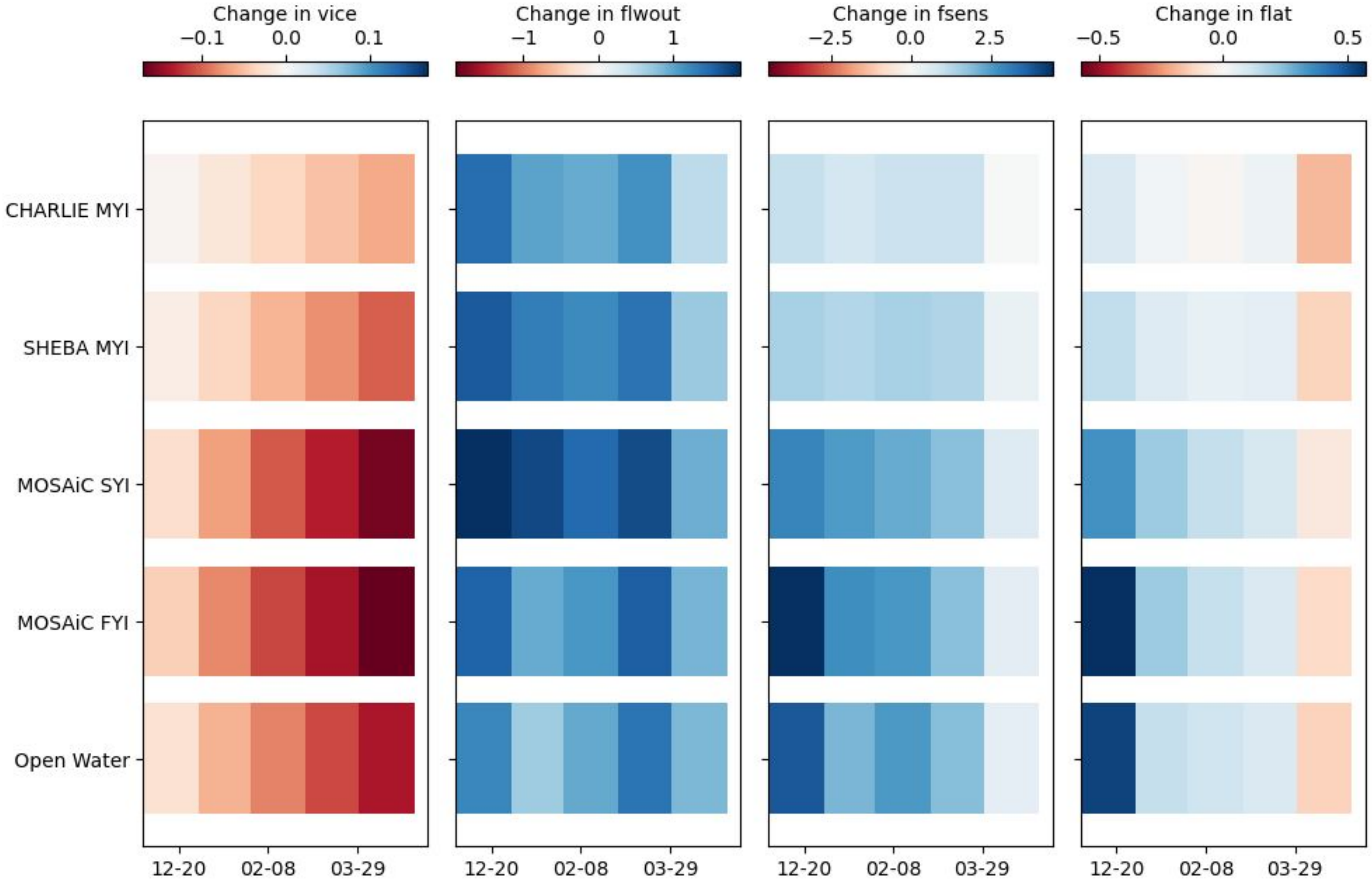
- The sea ice state impacts the modeled sensitivity. E.g., the thickness (and growth) of thicker ice is more sensitive to changing oceanic heat flux. Whereas thinner ice is more sensitive to changing snow thermal conductivity.
- Which metric we use matters too. E.g., net air-surface heat flux sensitivity has a different dependence on ice state than thickness.
- Single column modeling is a tool that can help investigate these sensitivities for planning measurement campaigns and model tuning.
- Need more forcing datasets from different ice states (e.g., SHEBA, AIDJEX)
- Polar amplification studies should consider changes in the ice state.

Contact: dcsewall@ucar.edu

Backup


Change in vice
−0.2
0.0
0.2
Change in flwout
−0.5
0.0
0.5
Change in fsens
−1
0
1
Change in flat
−0.1
0.0
0.1
CHARLIE MYI
SHEBA MYI
MOSAiC SYI
MOSAiC FYI
Open Water
12-20
02-08
03-29

qdp


Change in vice
−0.1
0.0
0.1
Change in flwout
−1
0
1
Change in fsens
−2.5
0.0
2.5
Change in flat
−0.5
0.0
0.5
CHARLIE MYI
SHEBA MYI
MOSAiC SYI
MOSAiC FYI
Open Water
12-20
02-08
03-29

ksno