

Modeling changes in subglacial hydrology and ice dynamics of the Greenland Ice Sheet corresponding to surface elevation changes between the ICESat and ICESat-2 eras

Aleah Sommers, Colin Meyer, Lauren Andrews, Aaron Stubblefield

Context

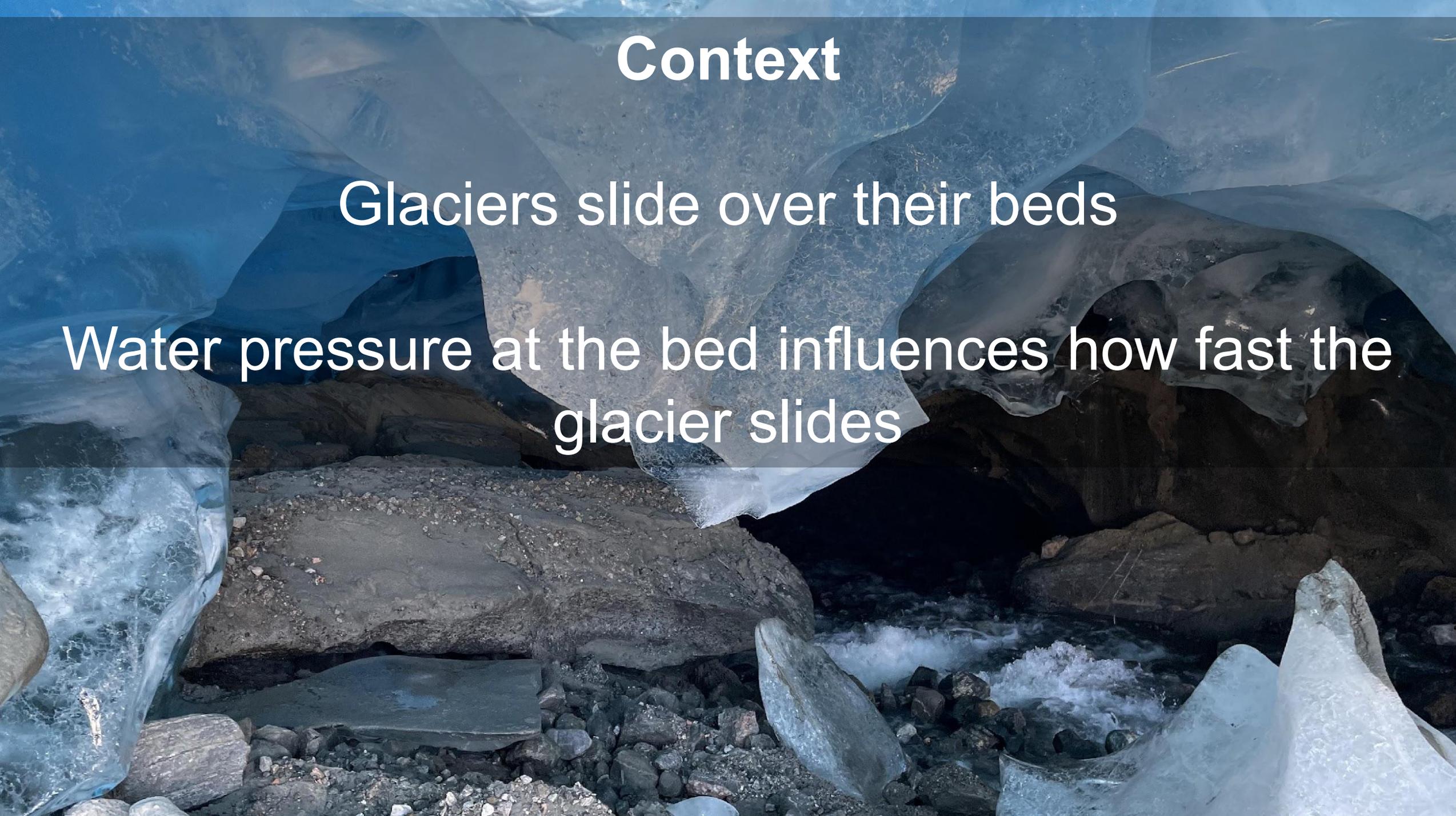
Glaciers slide over their beds



Context

Glaciers slide over their beds

Water pressure at the bed influences how fast the glacier slides

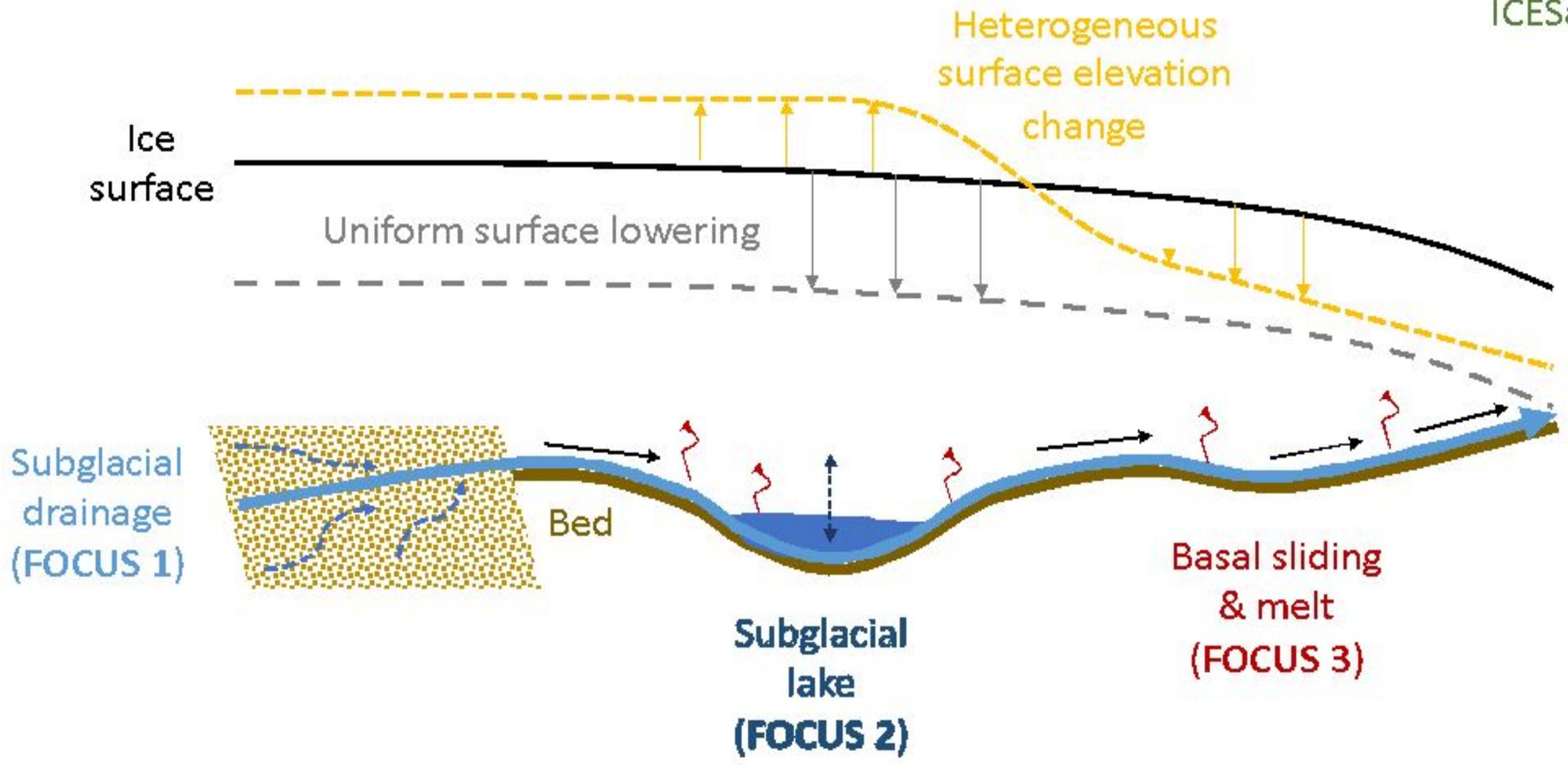


Context

Glaciers slide over their beds

Water pressure at the bed influences how fast the glacier slides

How fast the ice moves determines how quickly ice goes into the ocean, impacting sea level rise



Ice surface

Uniform surface lowering

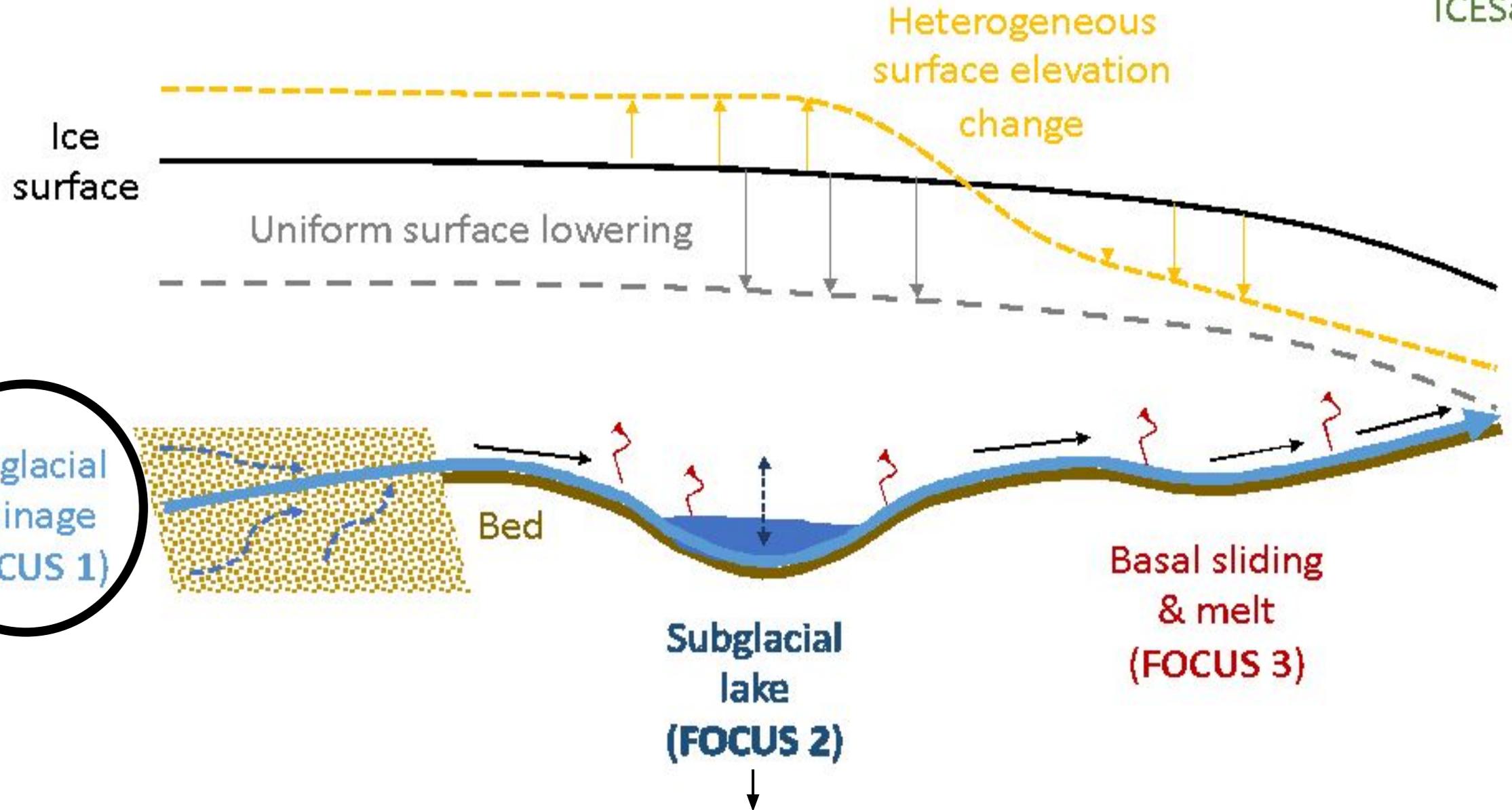
Heterogeneous surface elevation change

Subglacial drainage (FOCUS 1)

Bed

Subglacial lake (FOCUS 2)

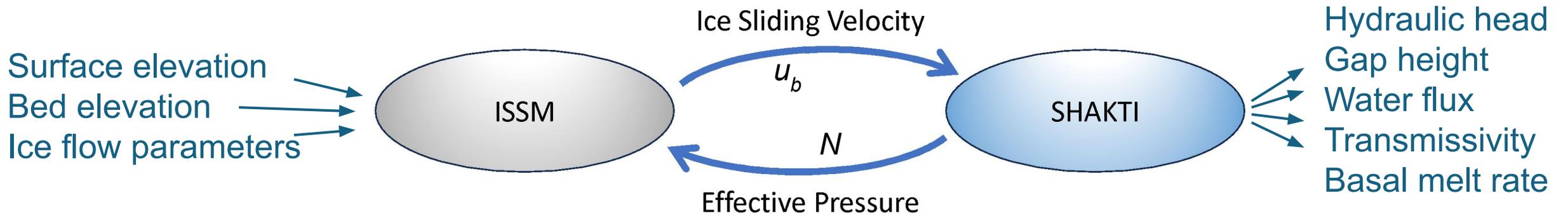
Basal sliding & melt (FOCUS 3)



* See Aaron Stubblefield's poster! *

Method

- Use ICESat and ICESat-2 gridded DEMs to constrain SHAKTI model to simulate subglacial drainage and dynamics of Greenland glaciers
- Subglacial hydrology two-way coupled to ice dynamics



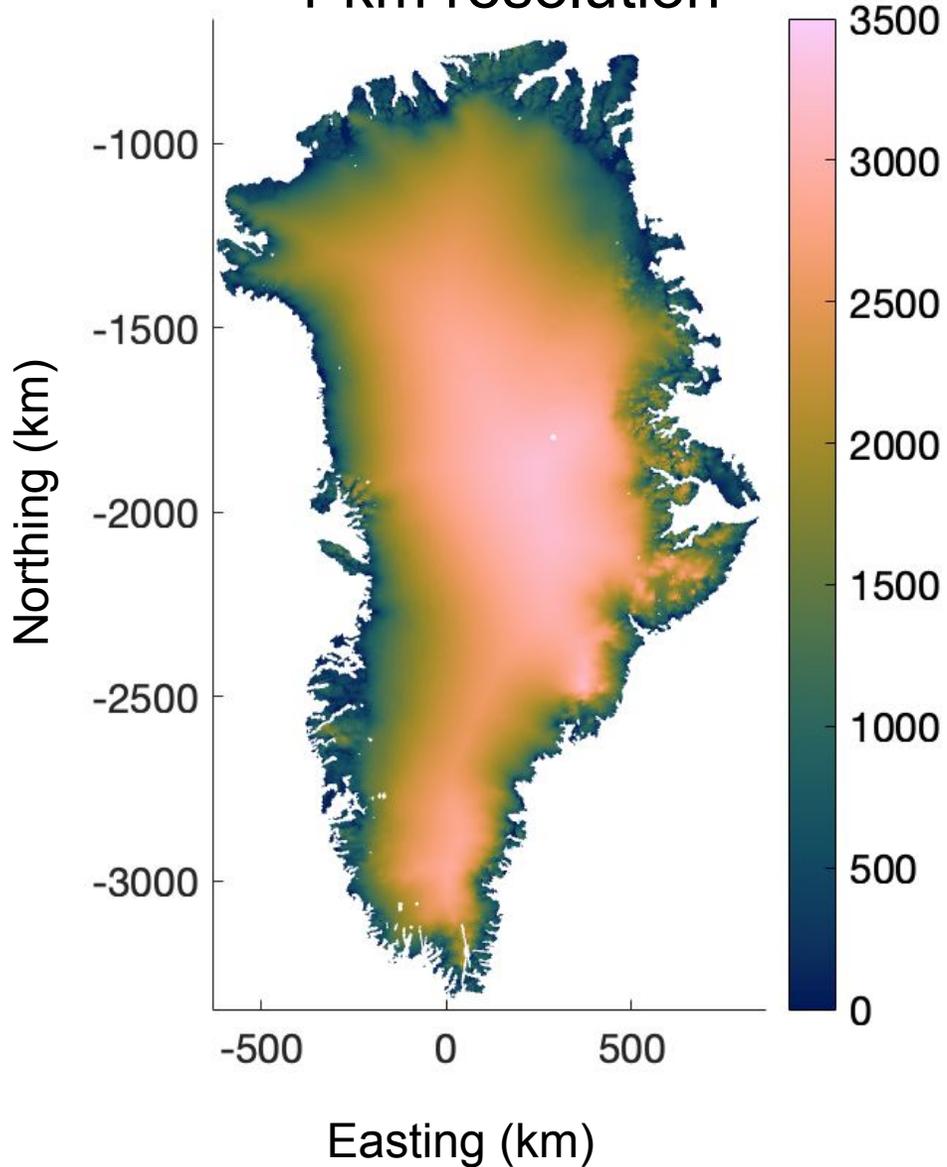
Basal Stress (aka Friction or Sliding Law)

$$\tau_b = f(u_b, N)$$

ICESat

(NSIDC-0305)

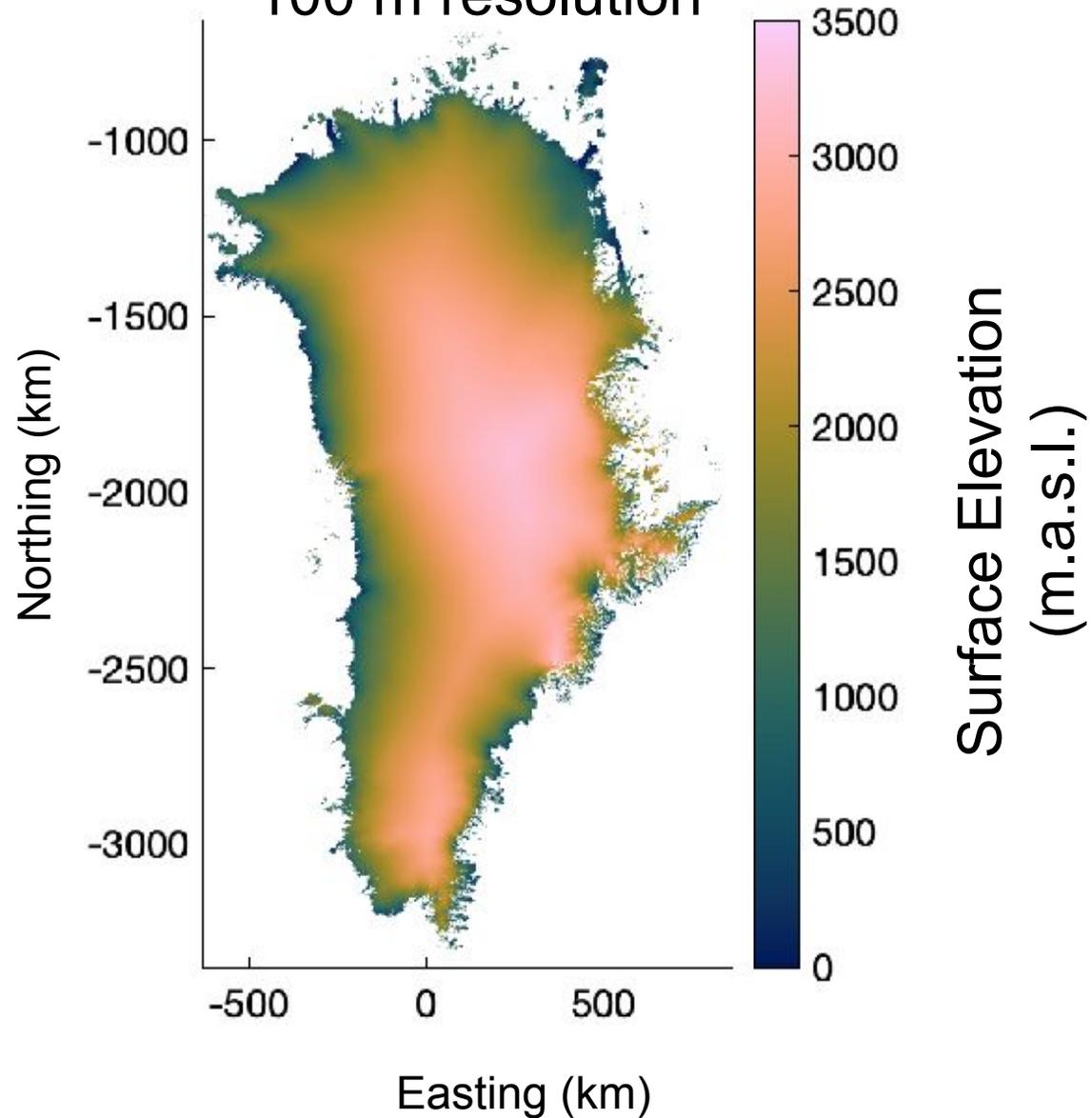
1 km resolution



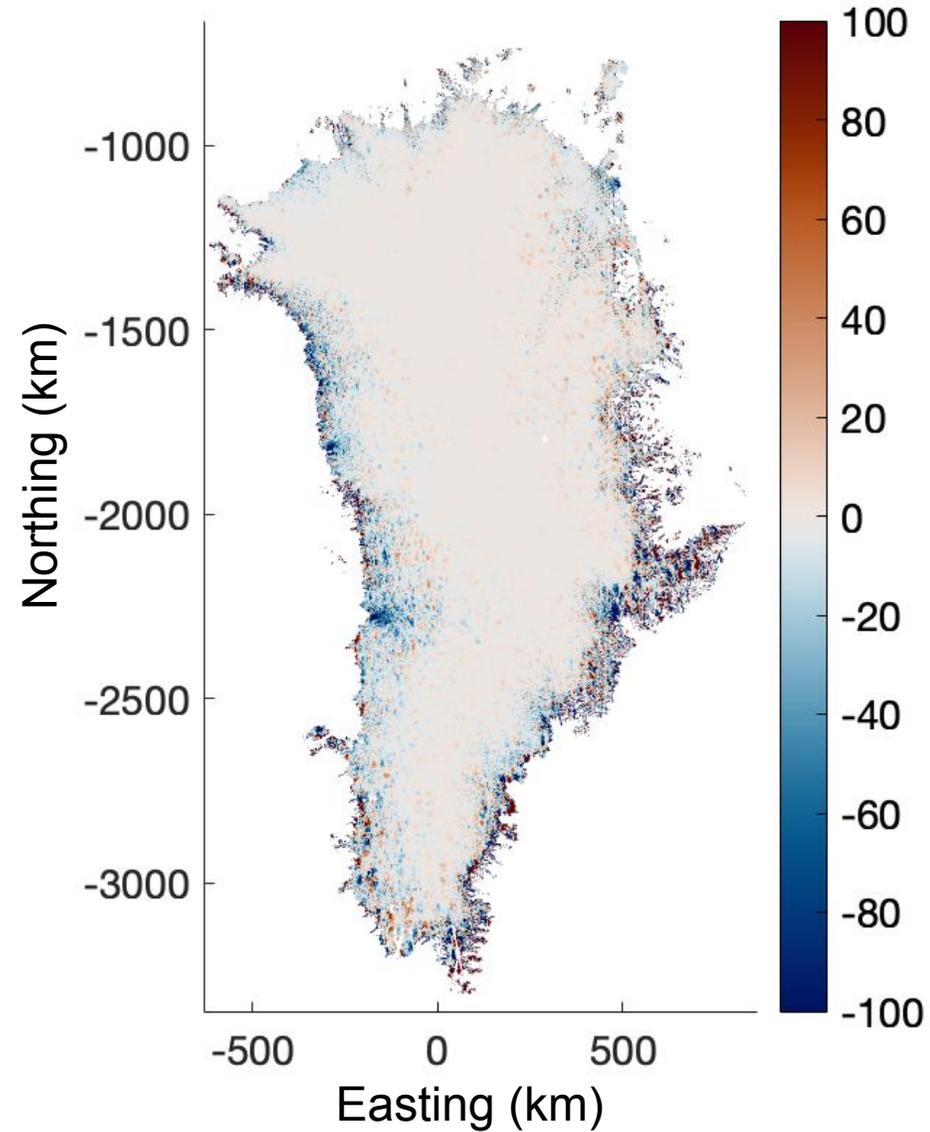
ICESat-2

(ATL14, Version 3)

100 m resolution

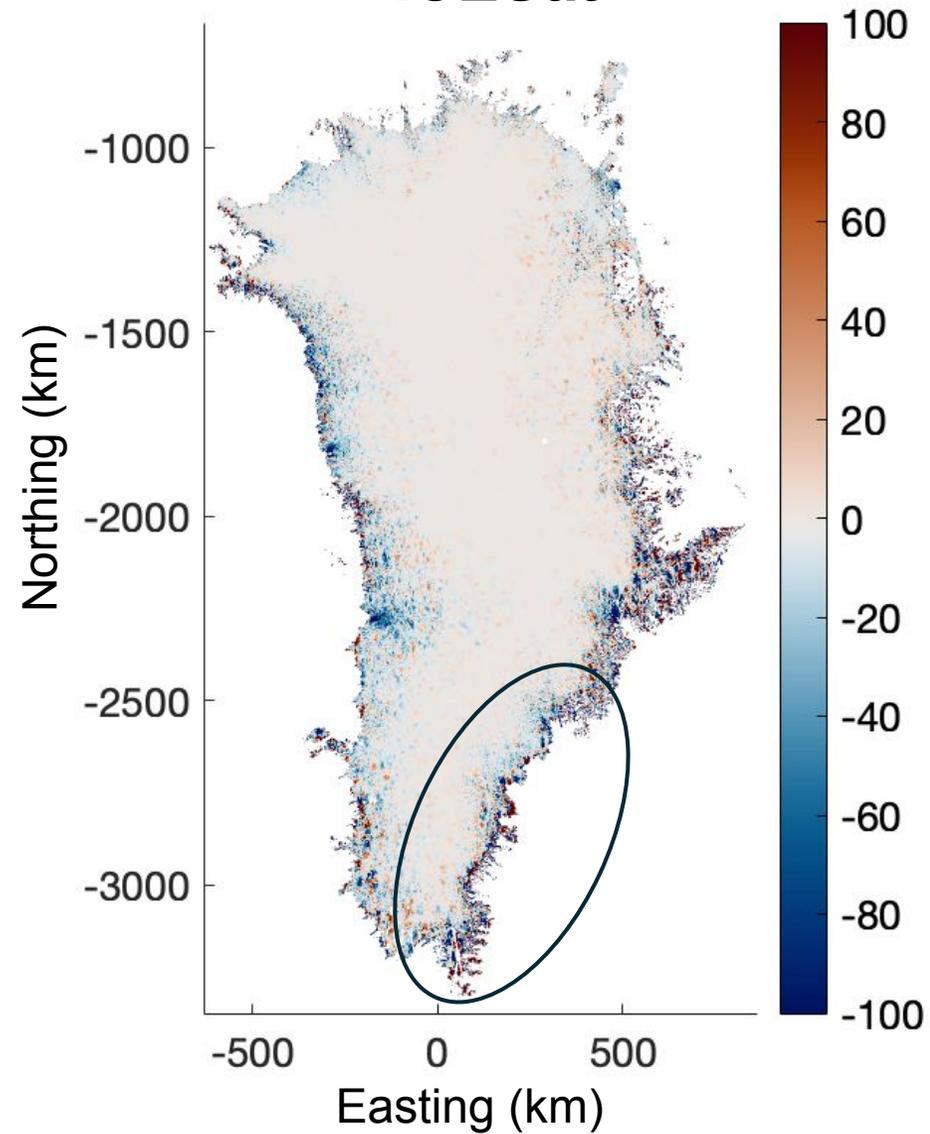


ICESat-2 – ICESat

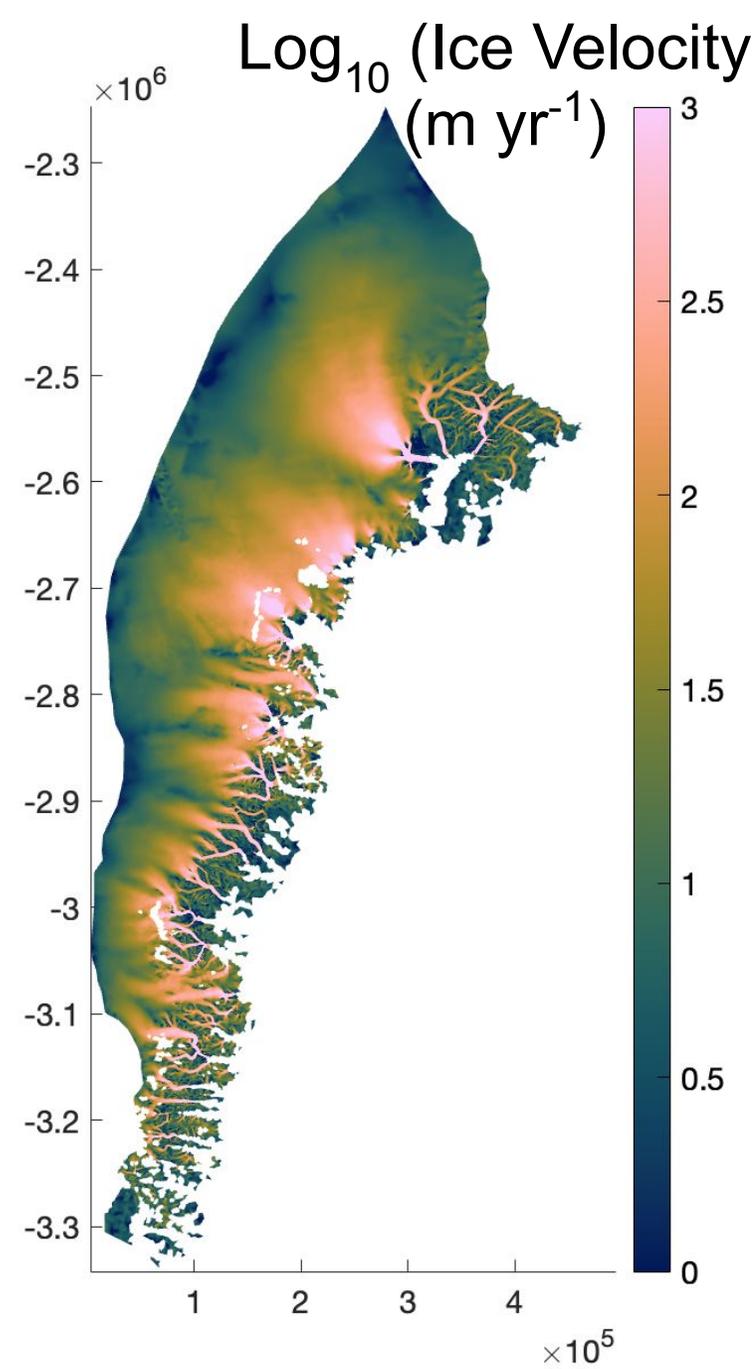
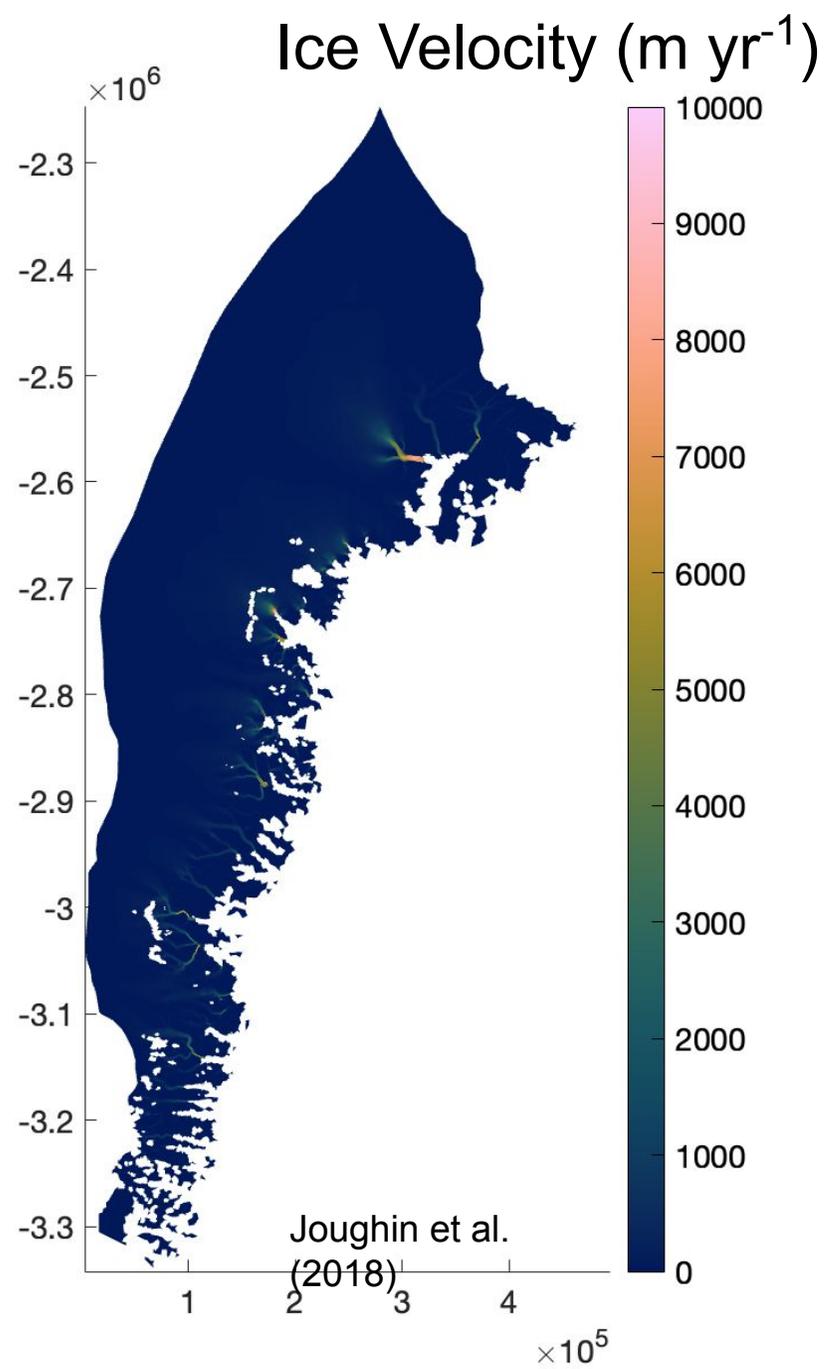
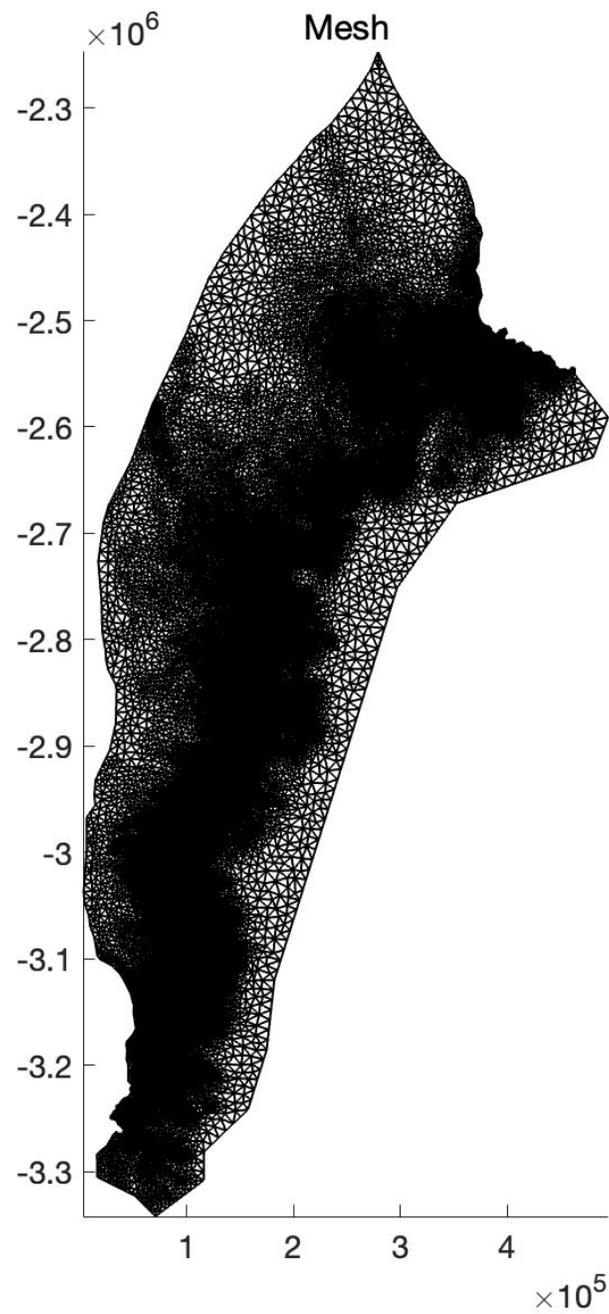


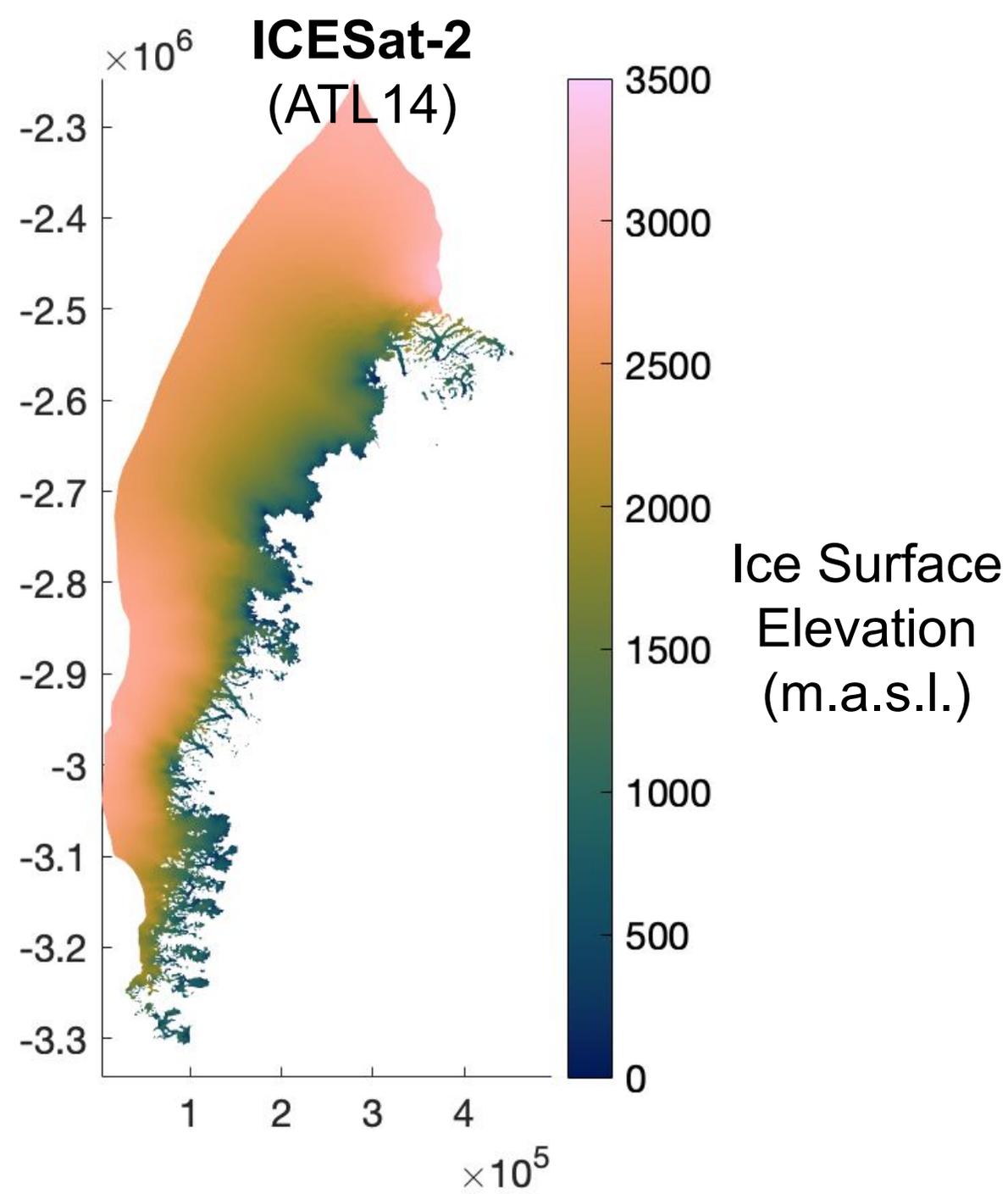
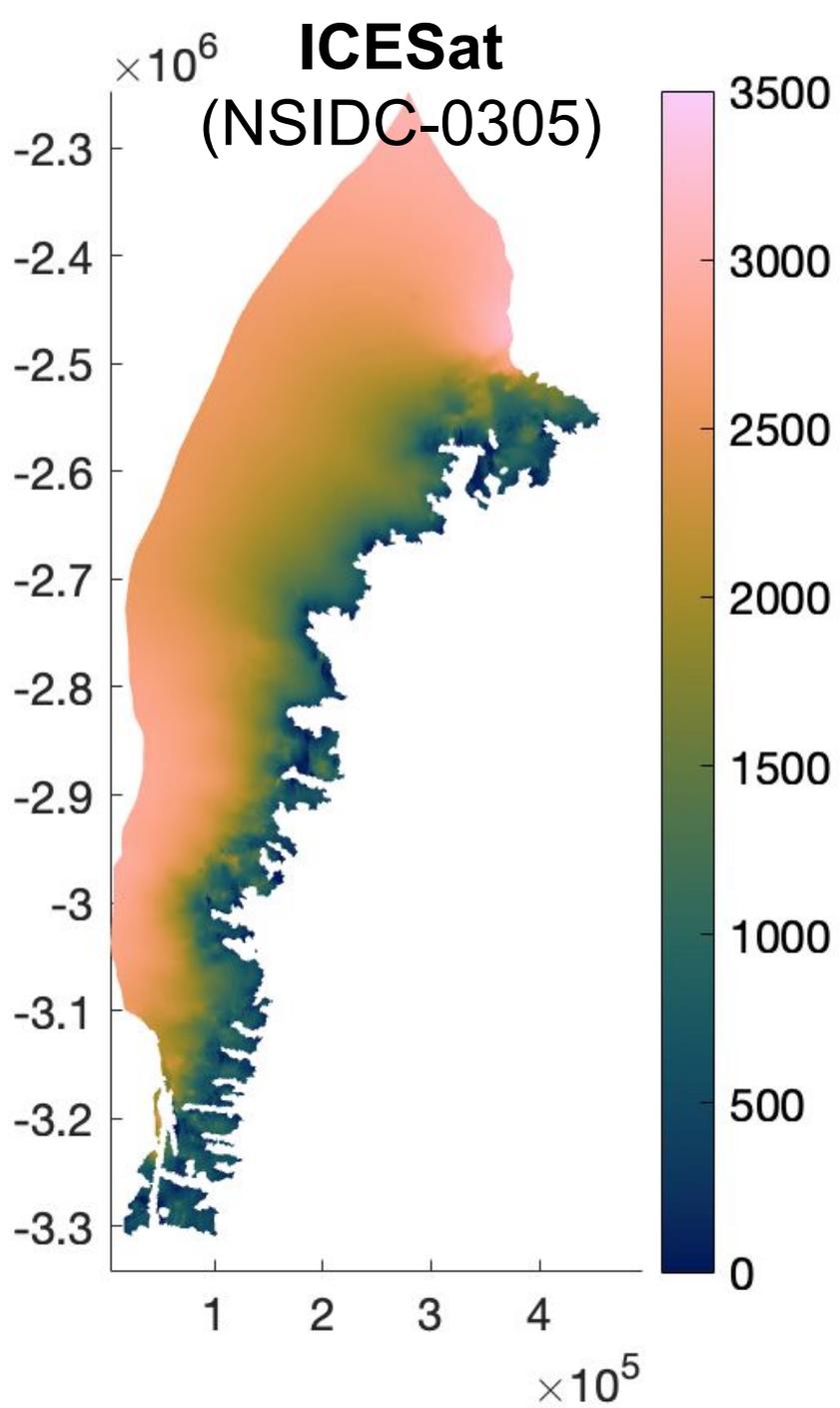
Change in Ice
Surface
Elevation (m)

ICESat-2 – ICESat

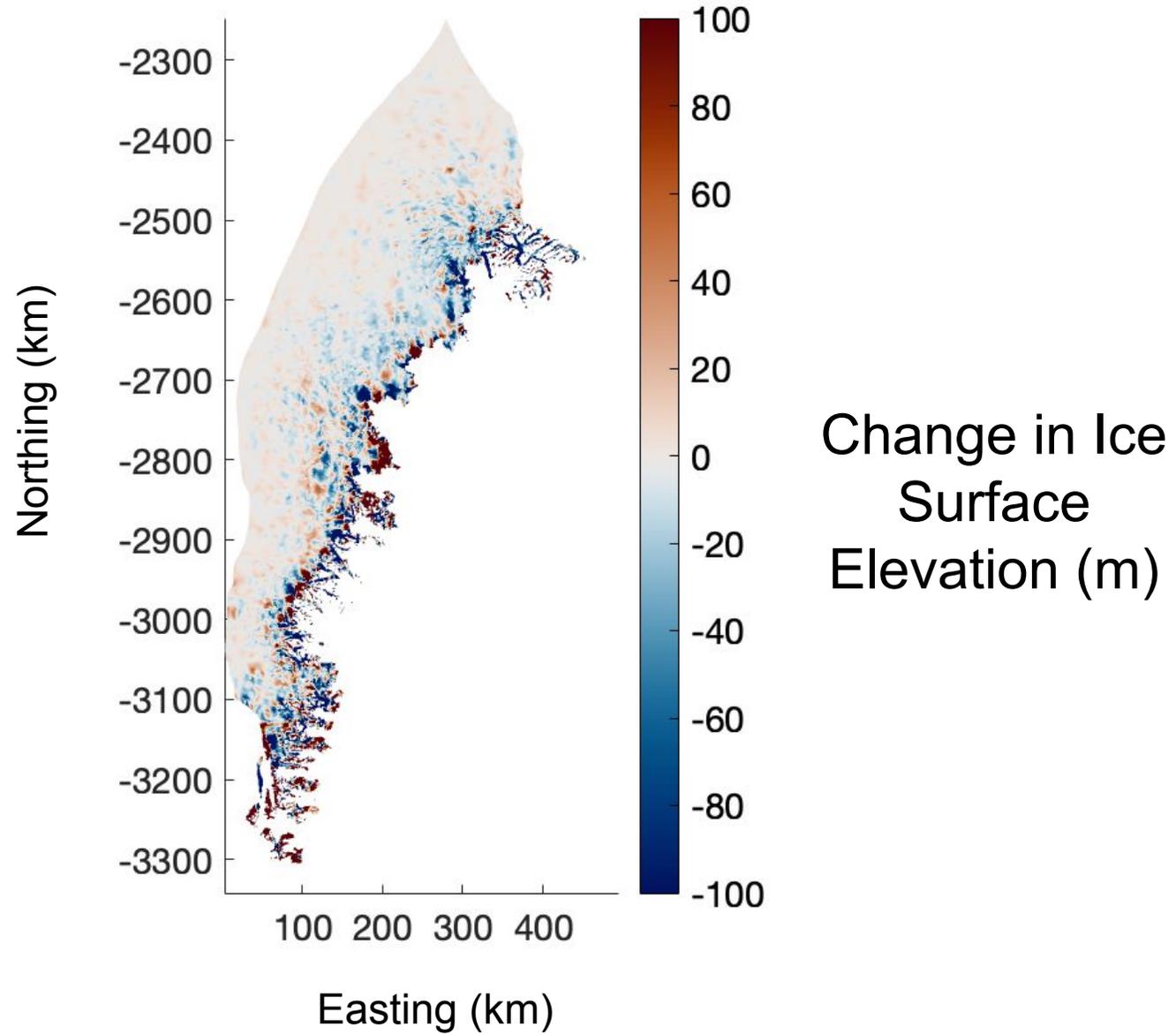


Change in Ice
Surface
Elevation (m)





ICESat-2 – ICESat



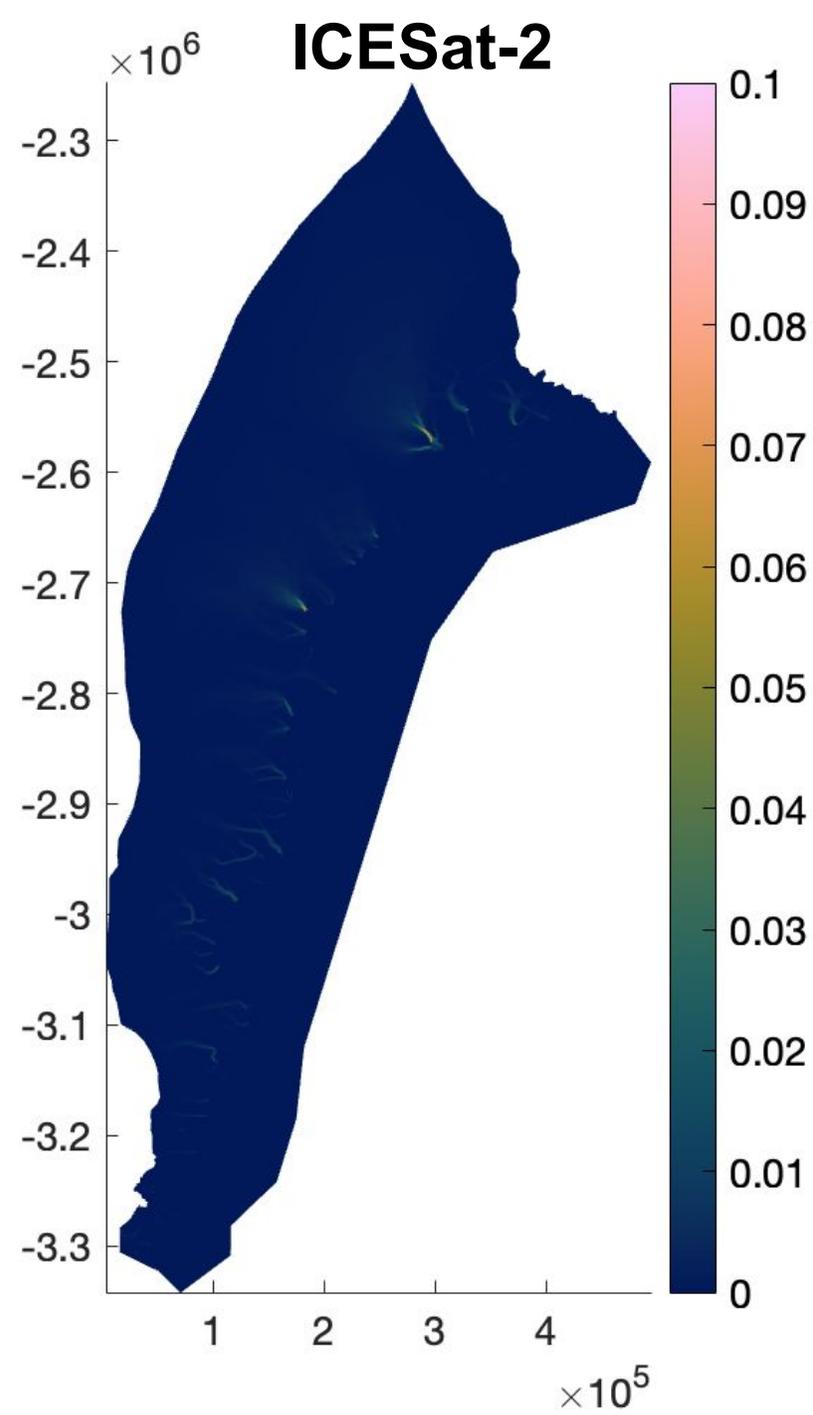
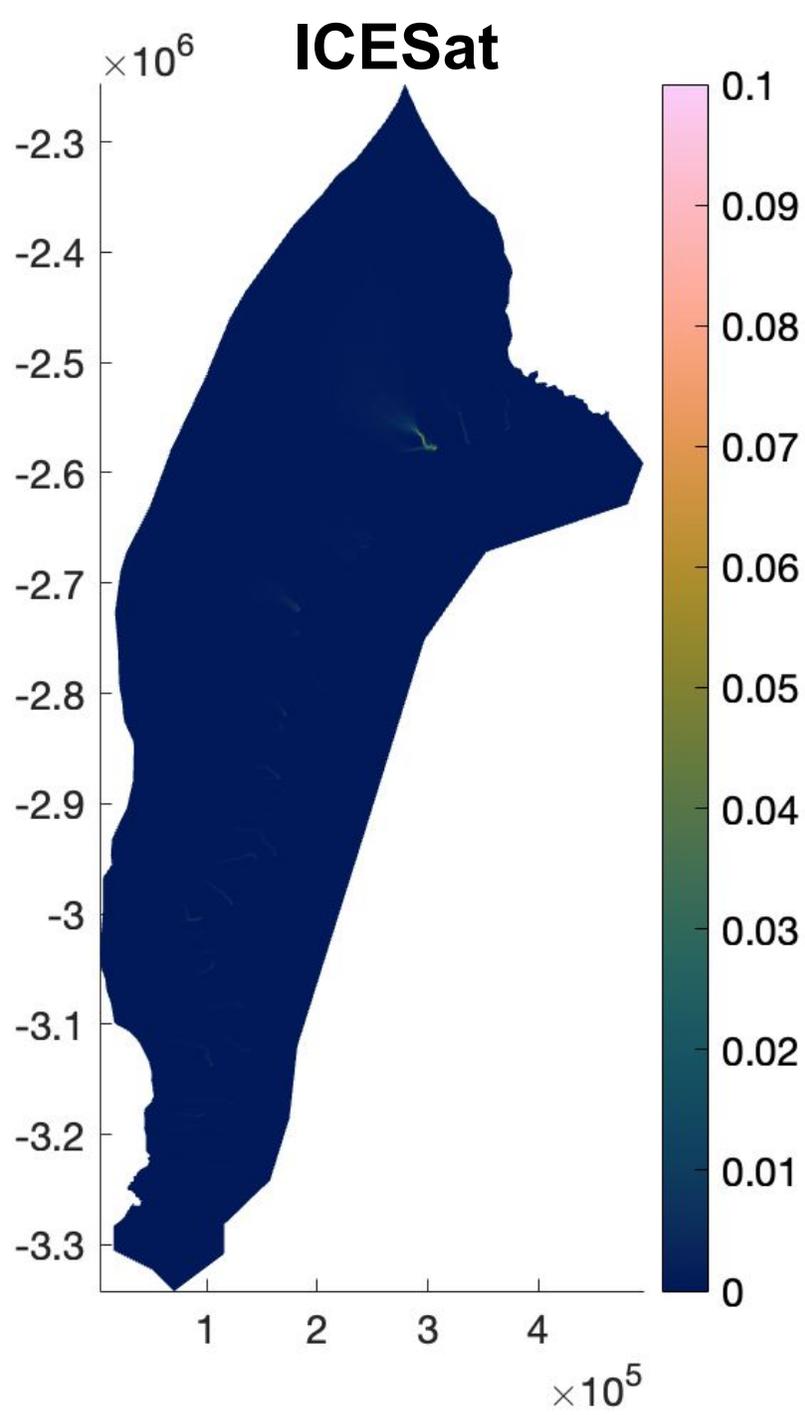
Challenges:

- To smooth geometry or not?
- Ice masks and appropriate general boundary conditions in SHAKTI for large-scale simulations
- Choice of sliding law and other parameter values

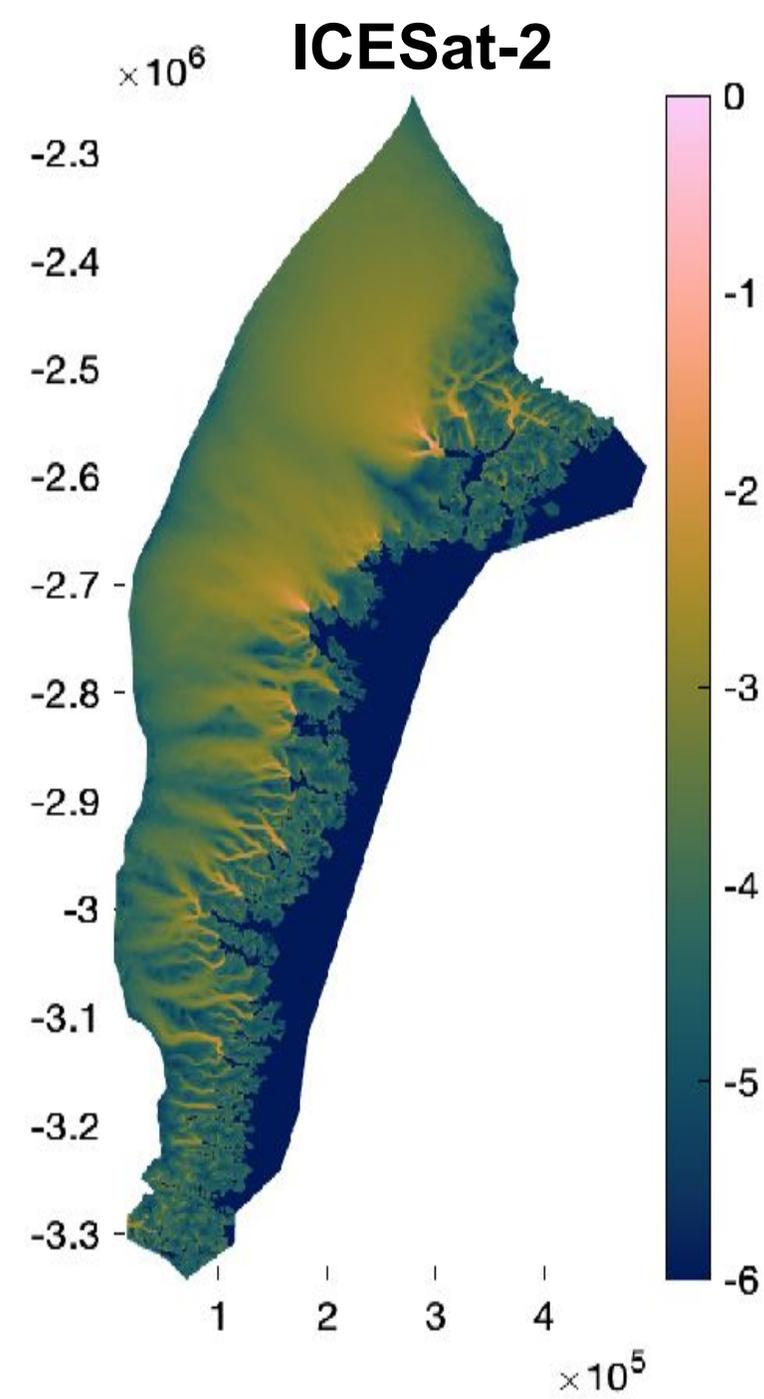
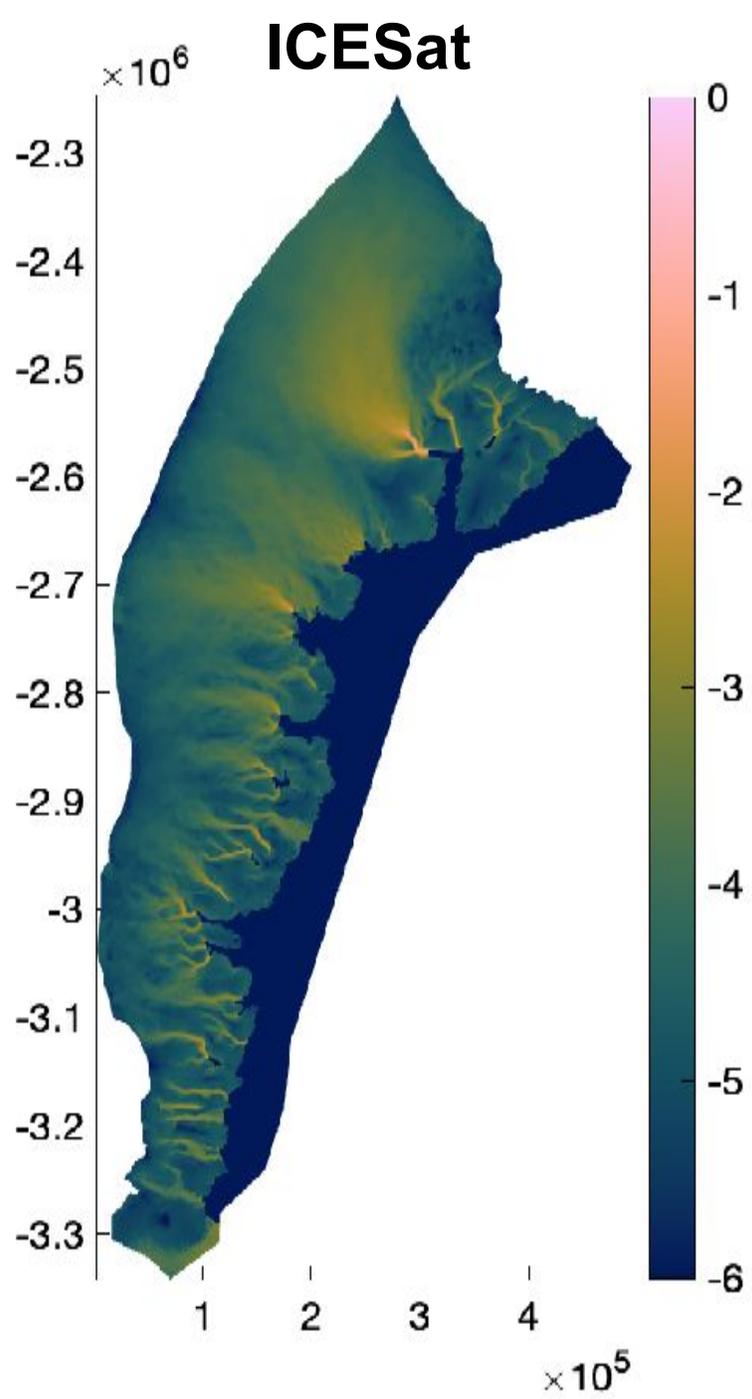


Preliminary Results

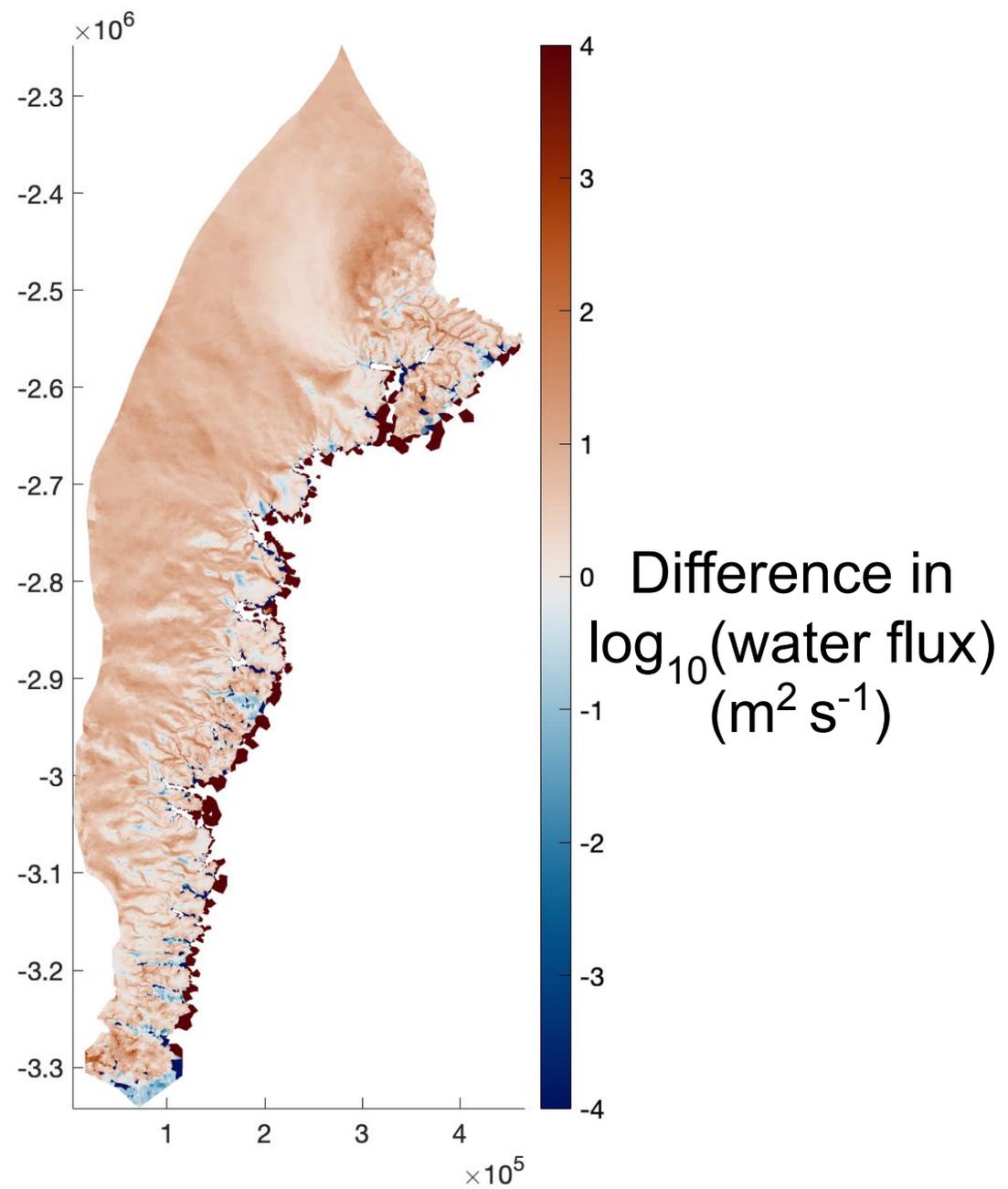
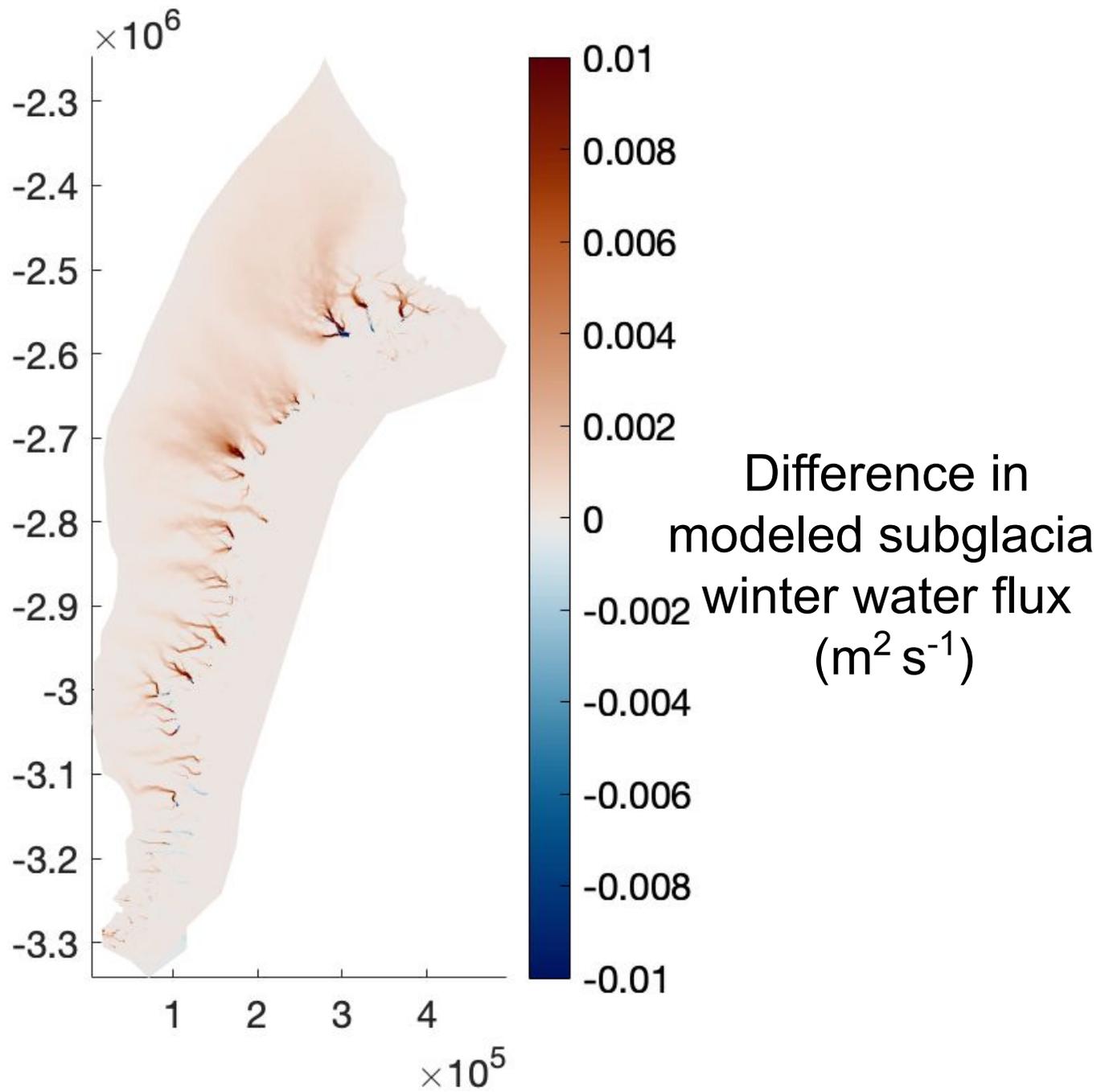
Winter "base state" hydrology

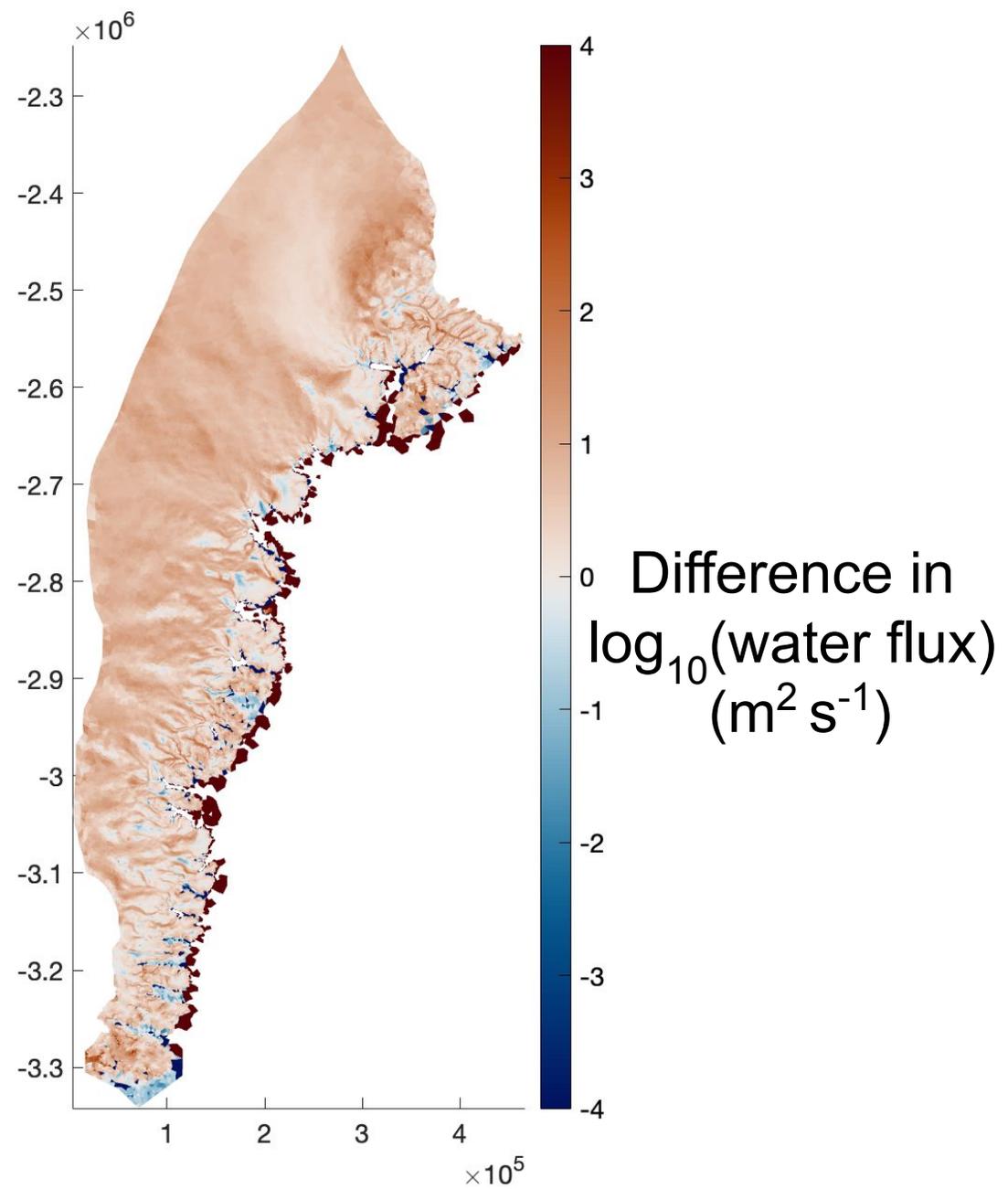
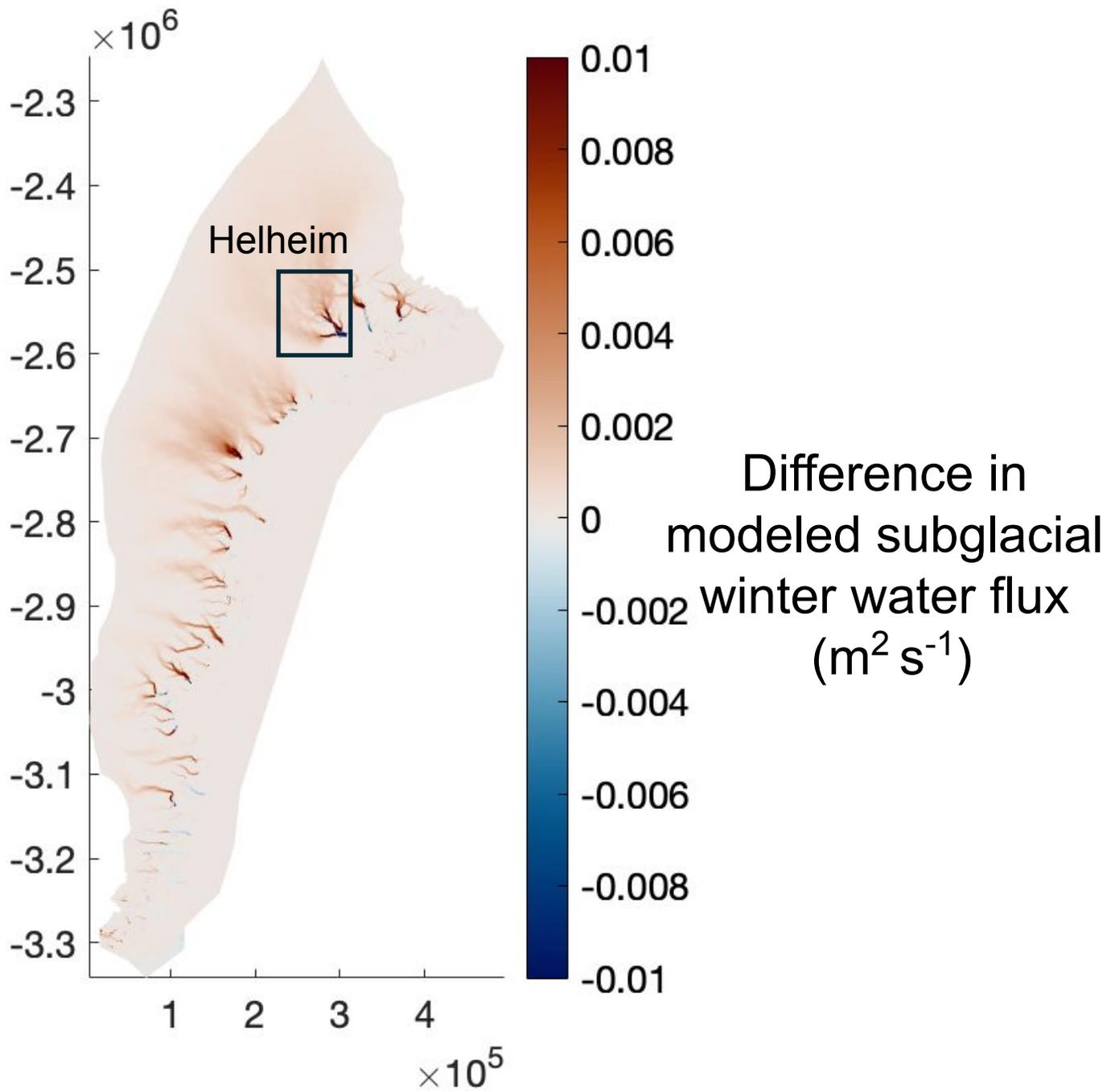


Modeled
subglacial
water flux
($\text{m}^2 \text{s}^{-1}$)

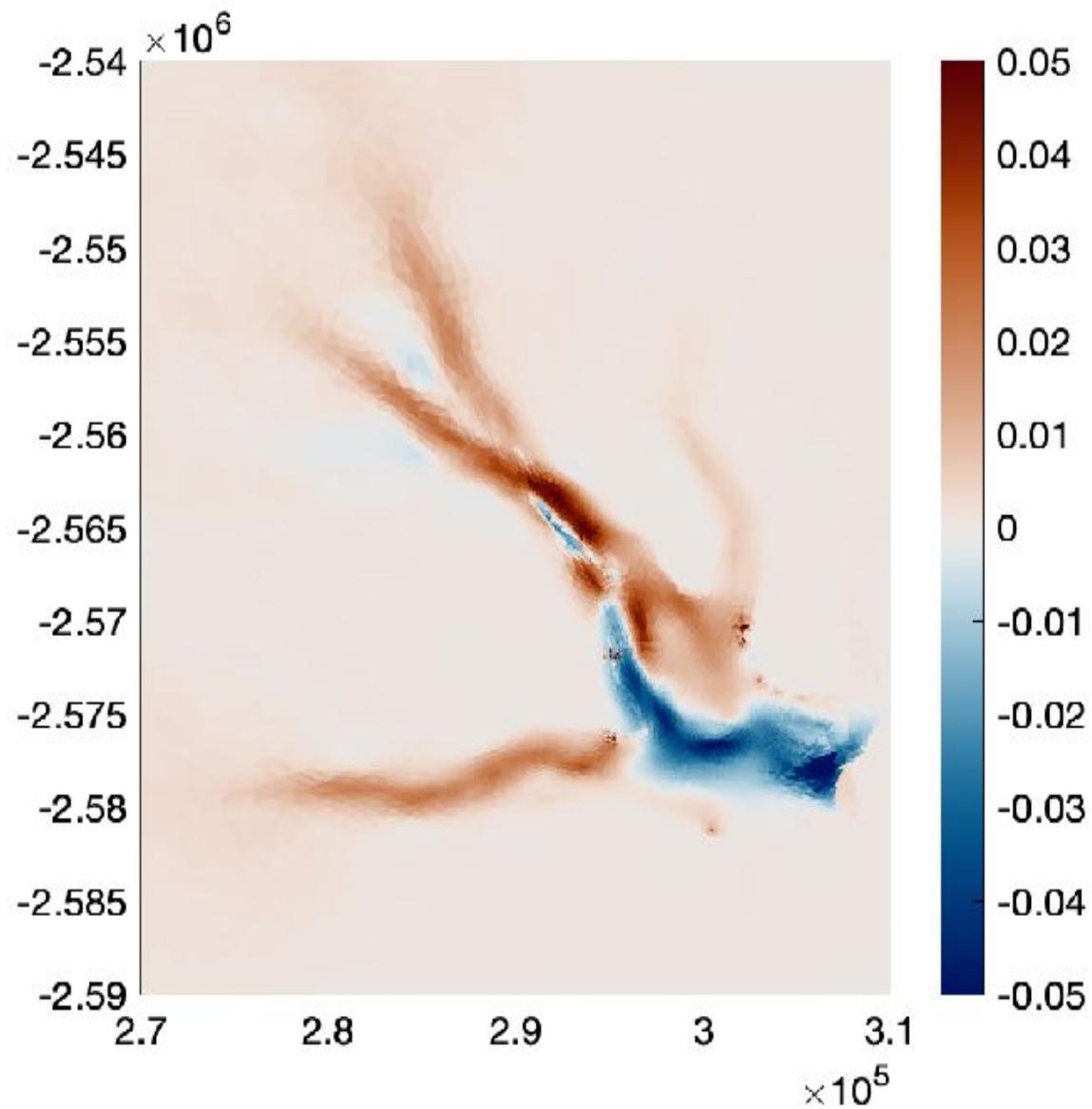


Log_{10} (Modeled
subglacial
water flux)
($\text{m}^2 \text{s}^{-1}$)

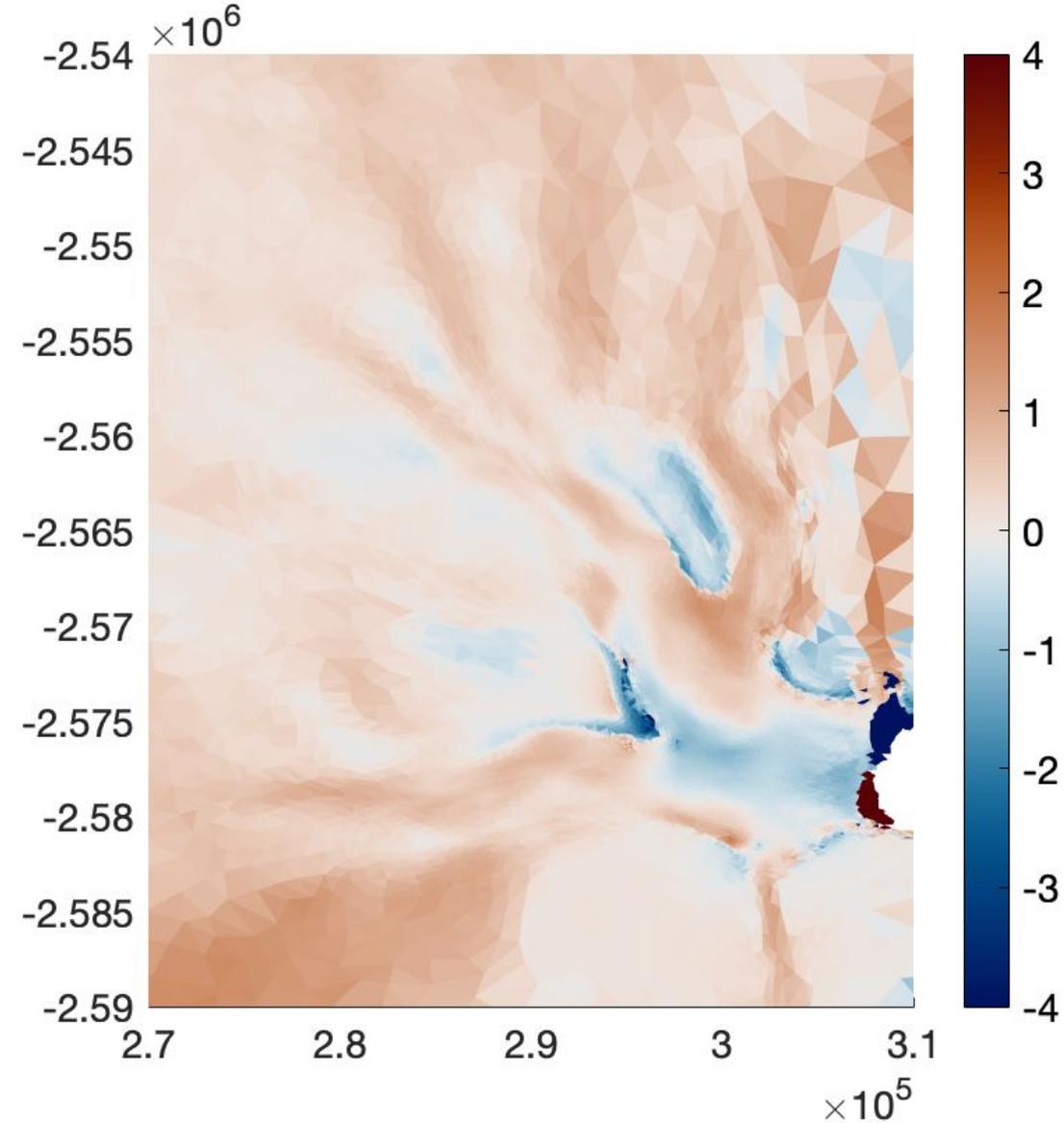


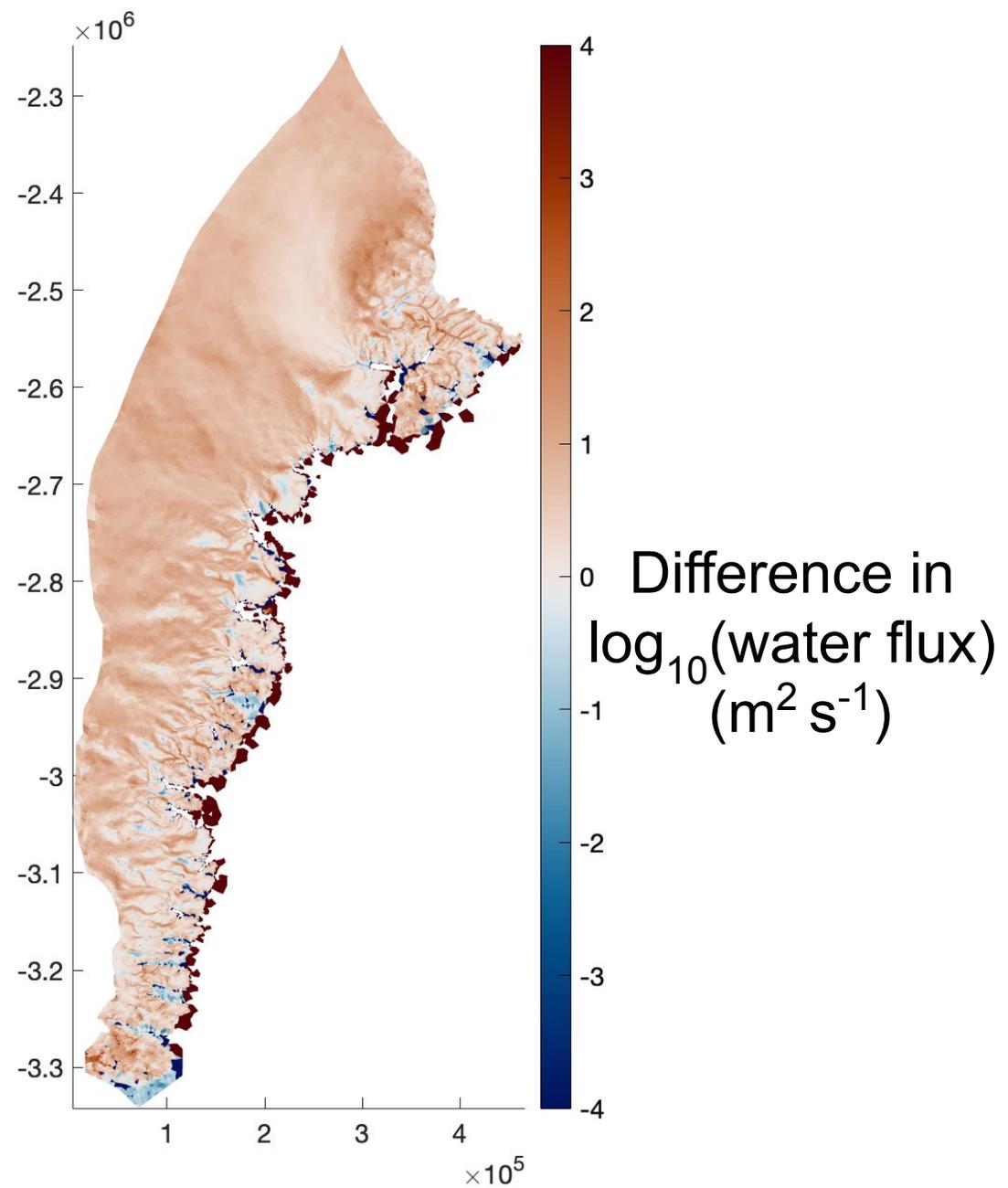
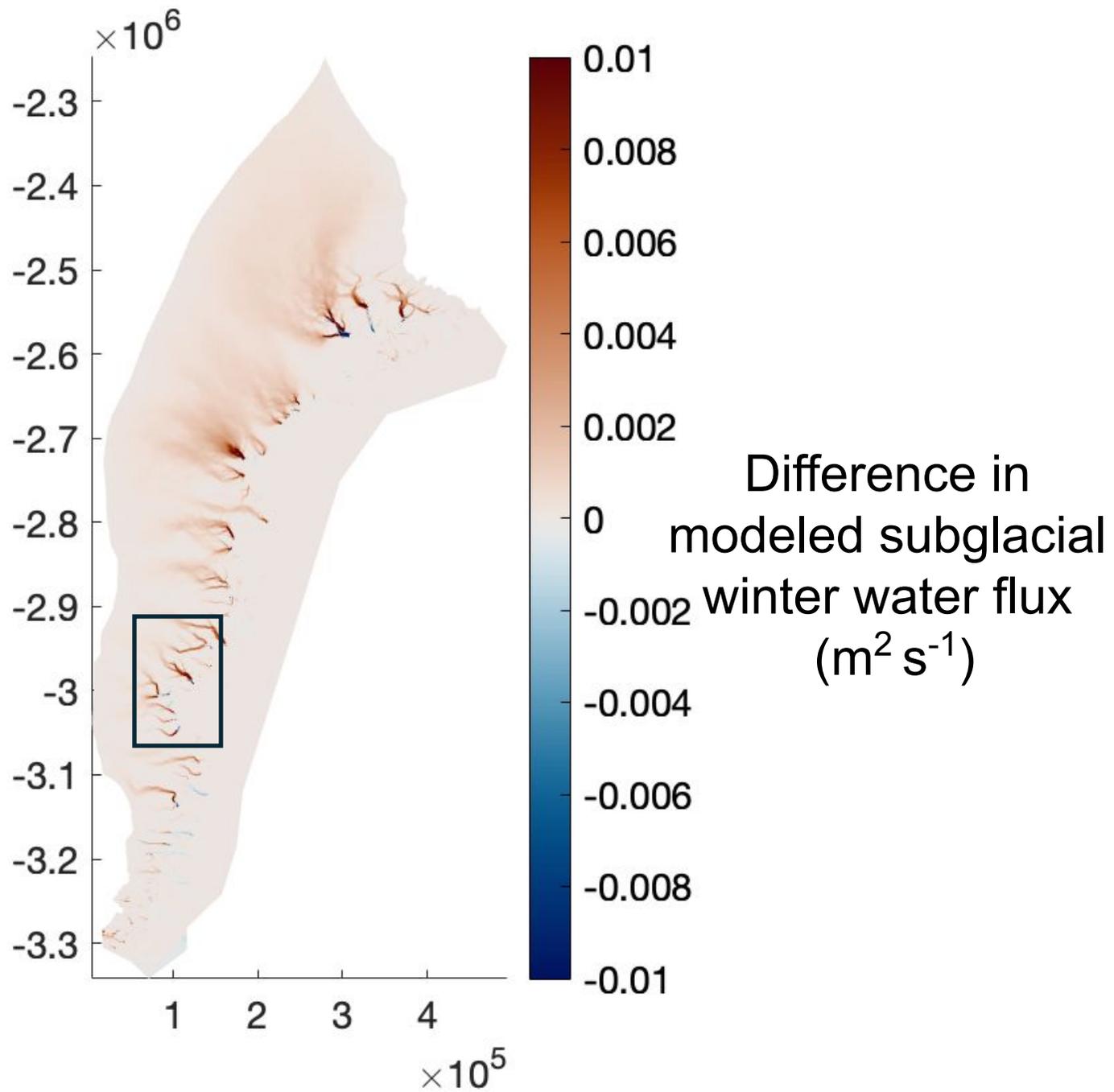


Difference in modeled
subglacial winter water flux
($\text{m}^2 \text{s}^{-1}$)

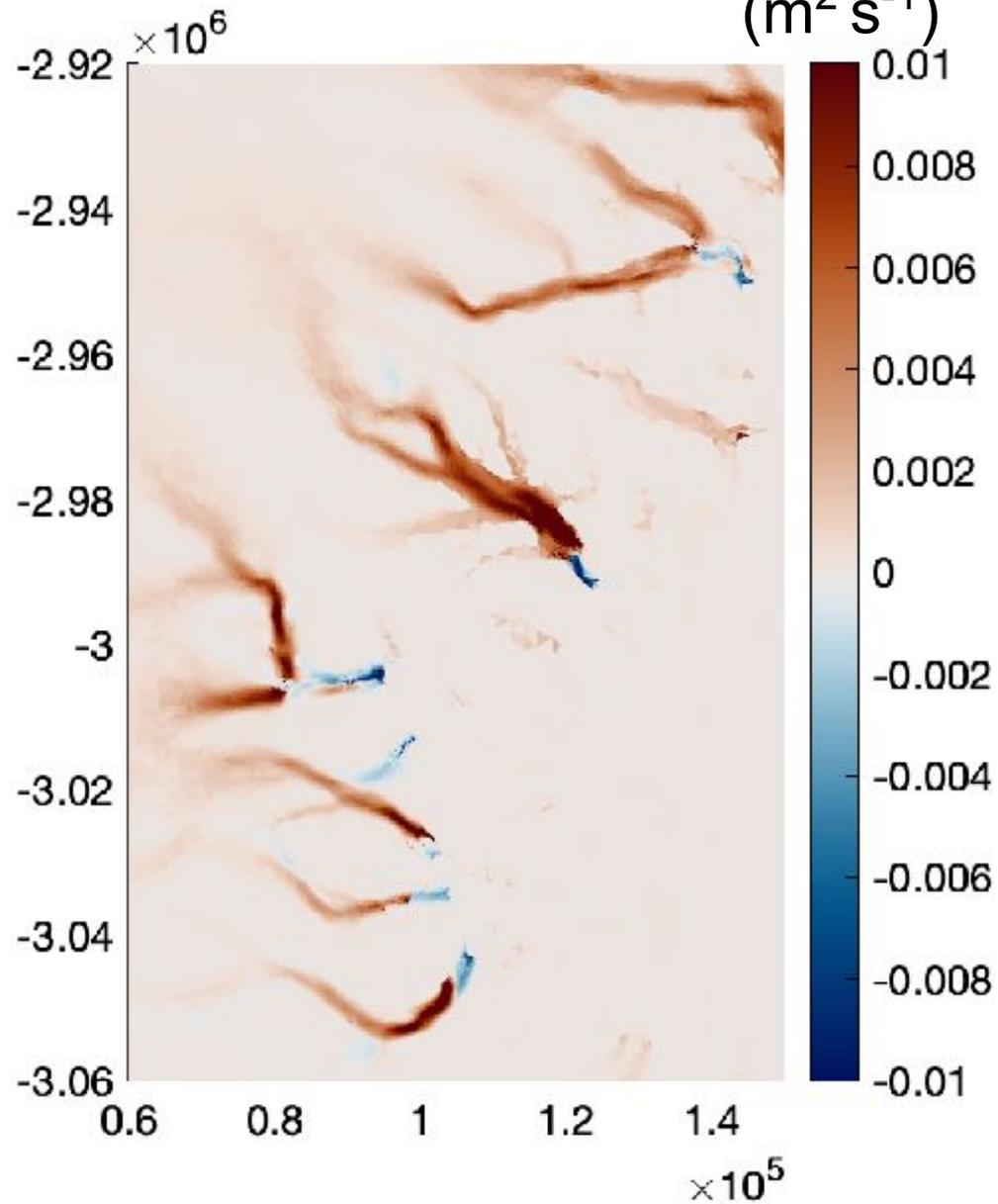


Difference in
 $\log_{10}(\text{water flux})$
($\text{m}^2 \text{s}^{-1}$)

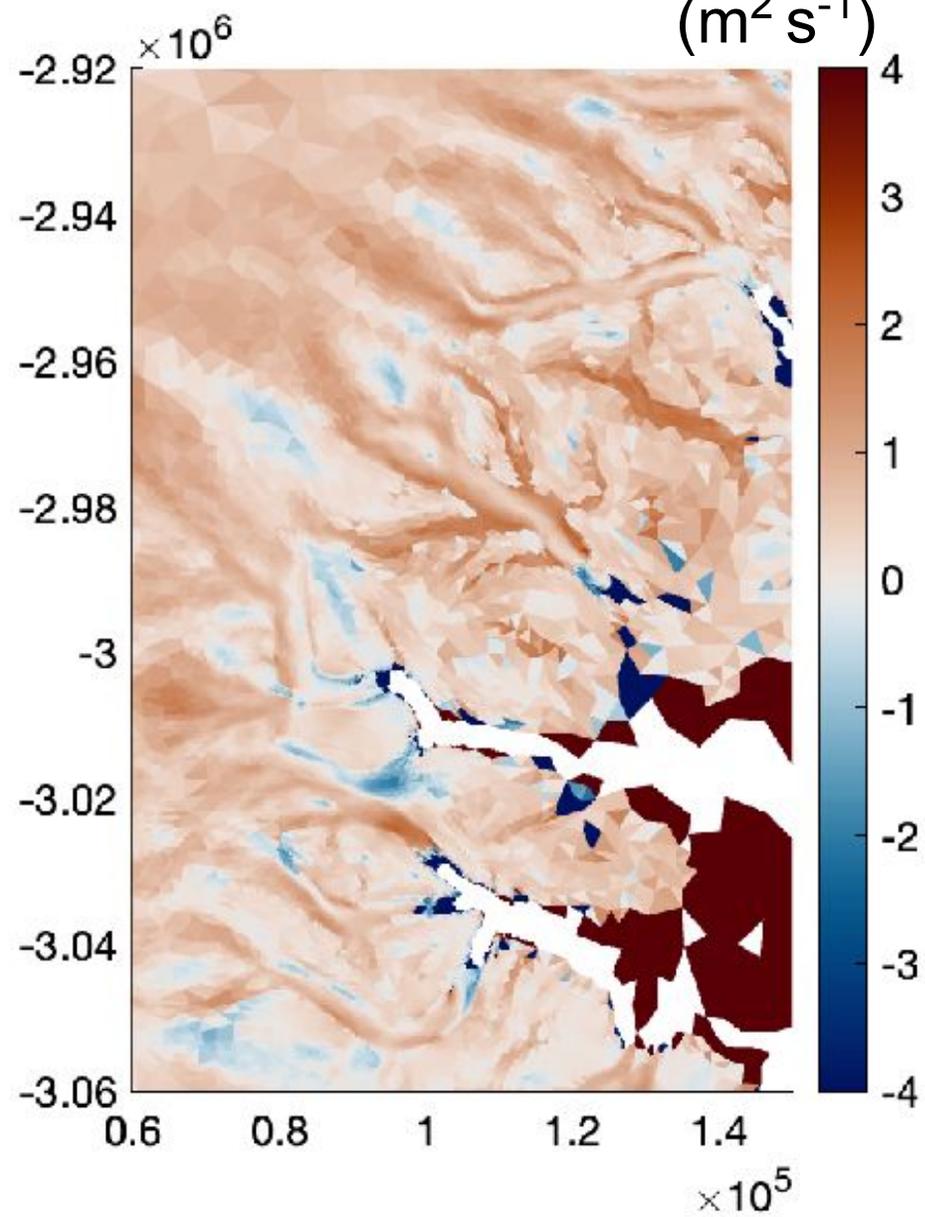


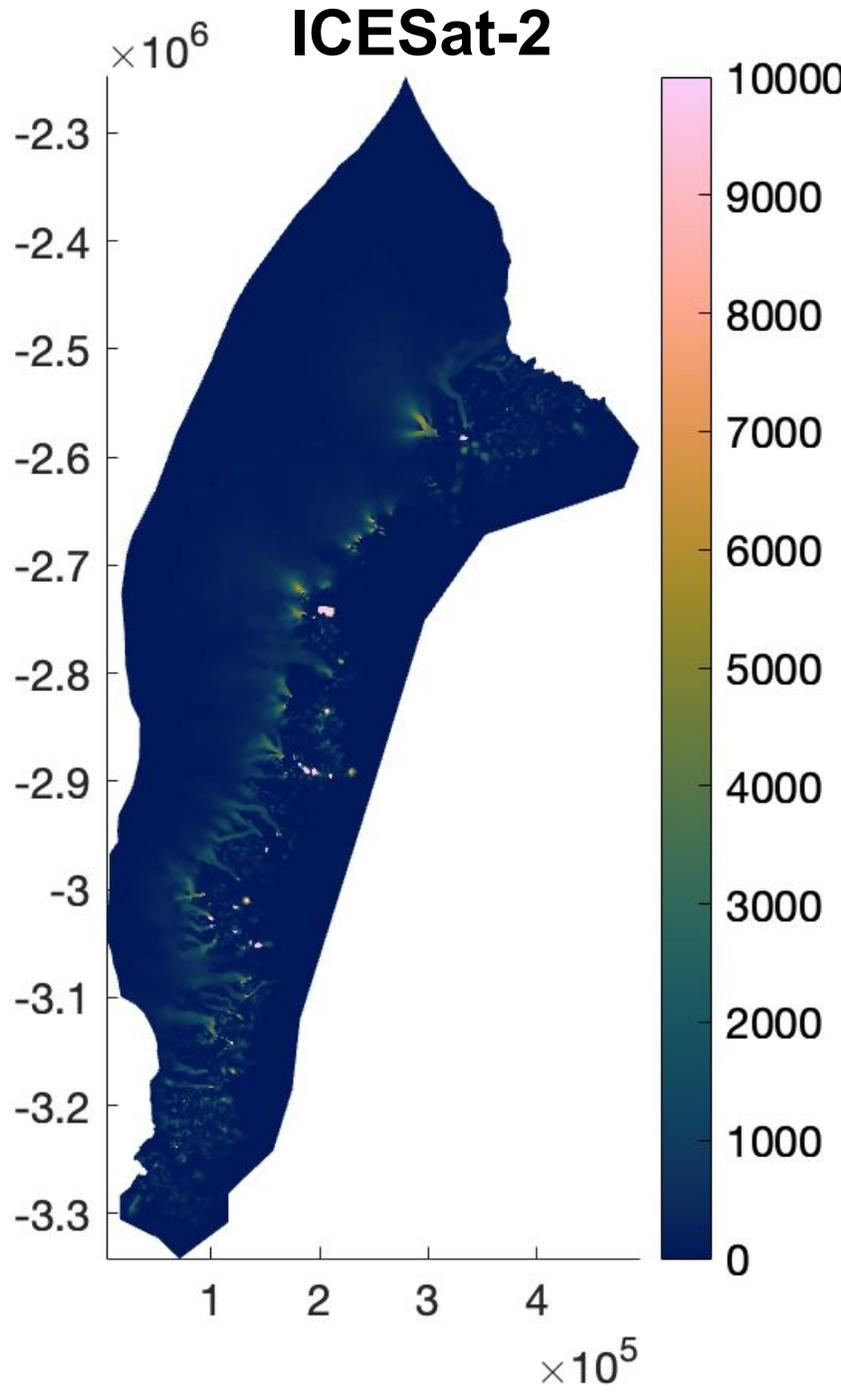
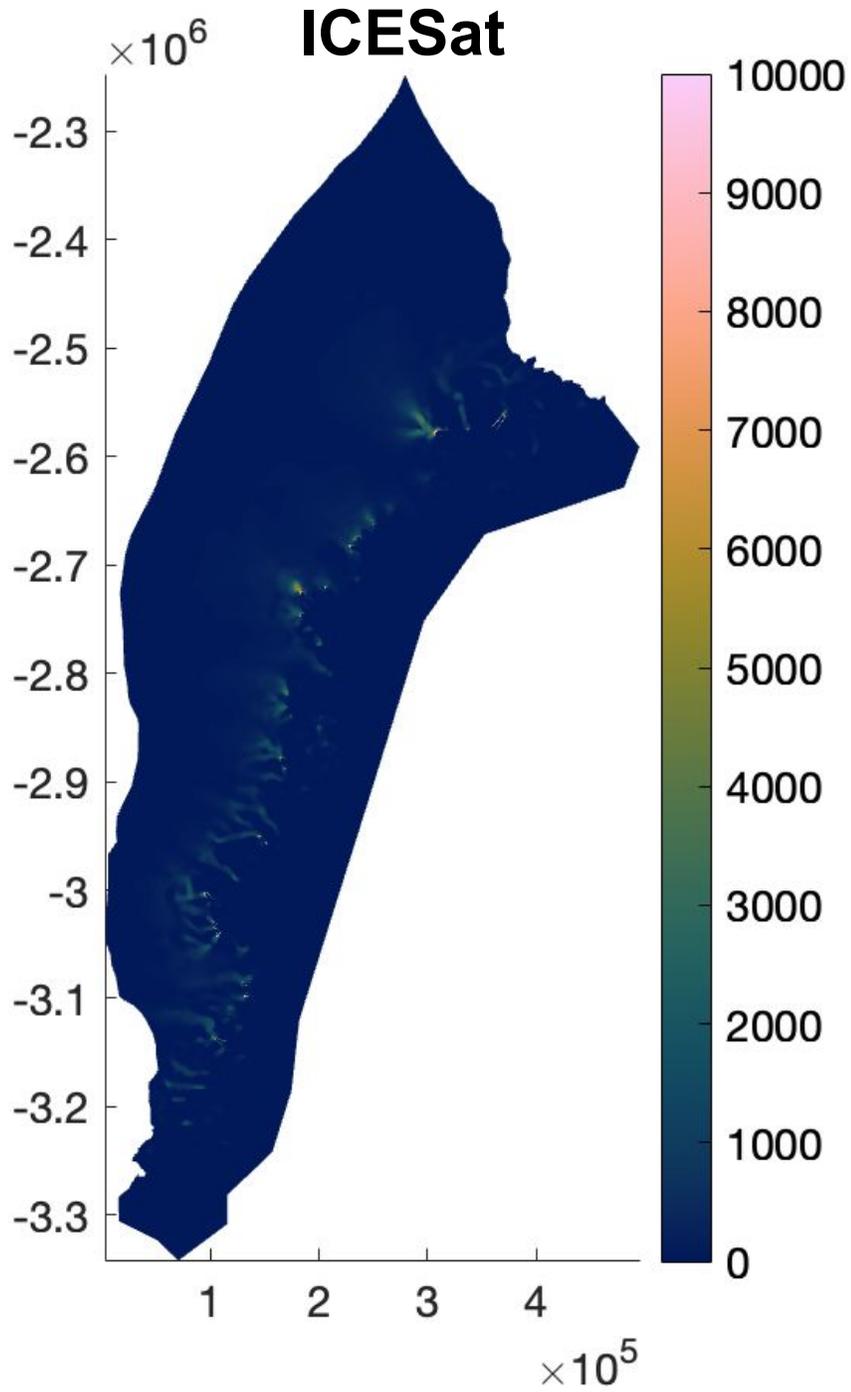


Difference in modeled
subglacial winter water flux
($\text{m}^2 \text{s}^{-1}$)



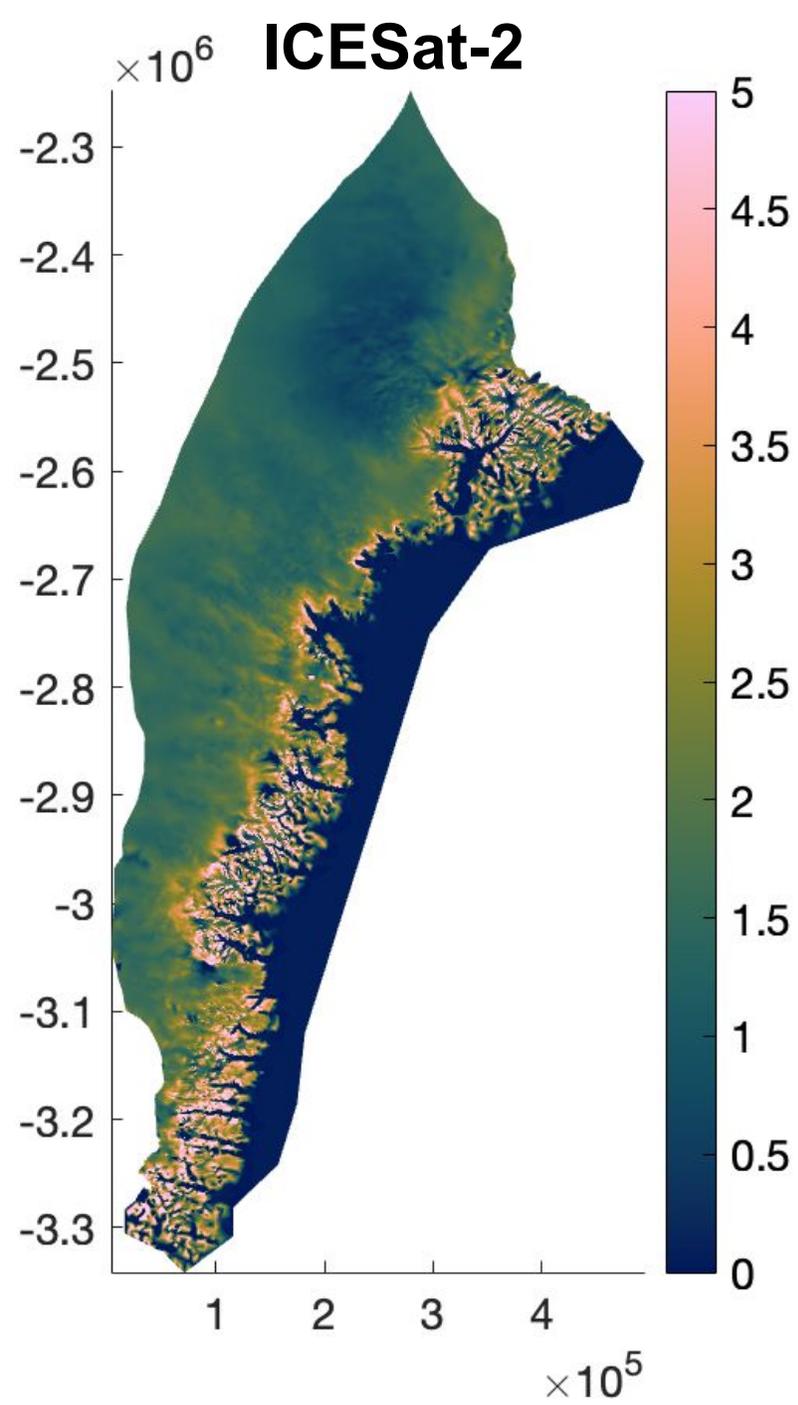
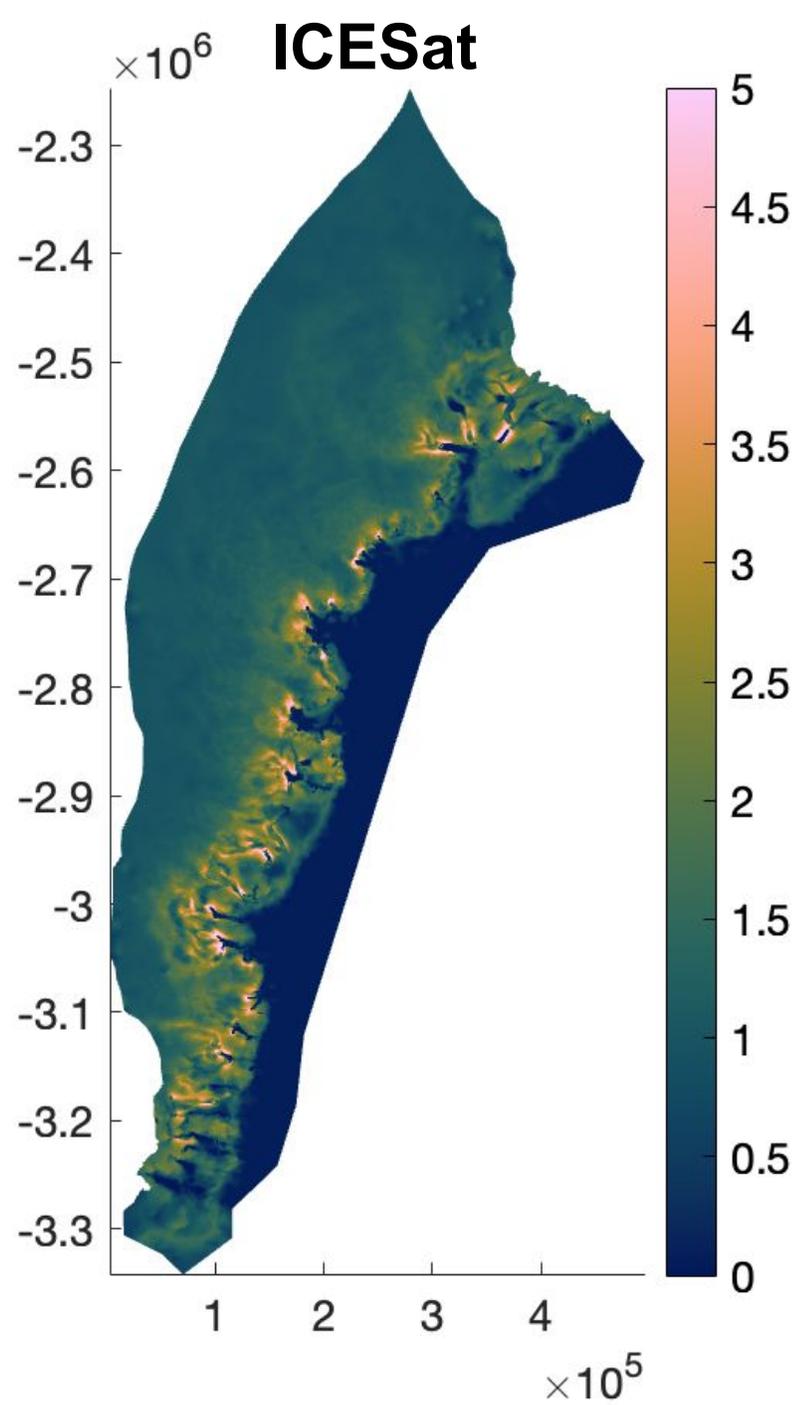
Difference in
 $\log_{10}(\text{water flux})$
($\text{m}^2 \text{s}^{-1}$)





Modeled ice velocity (m yr^{-1})

□ *Potential for validation!*



Modeled effective
pressure
(MPa)

Heterogeneous
surface elevation
change

Ice
surface

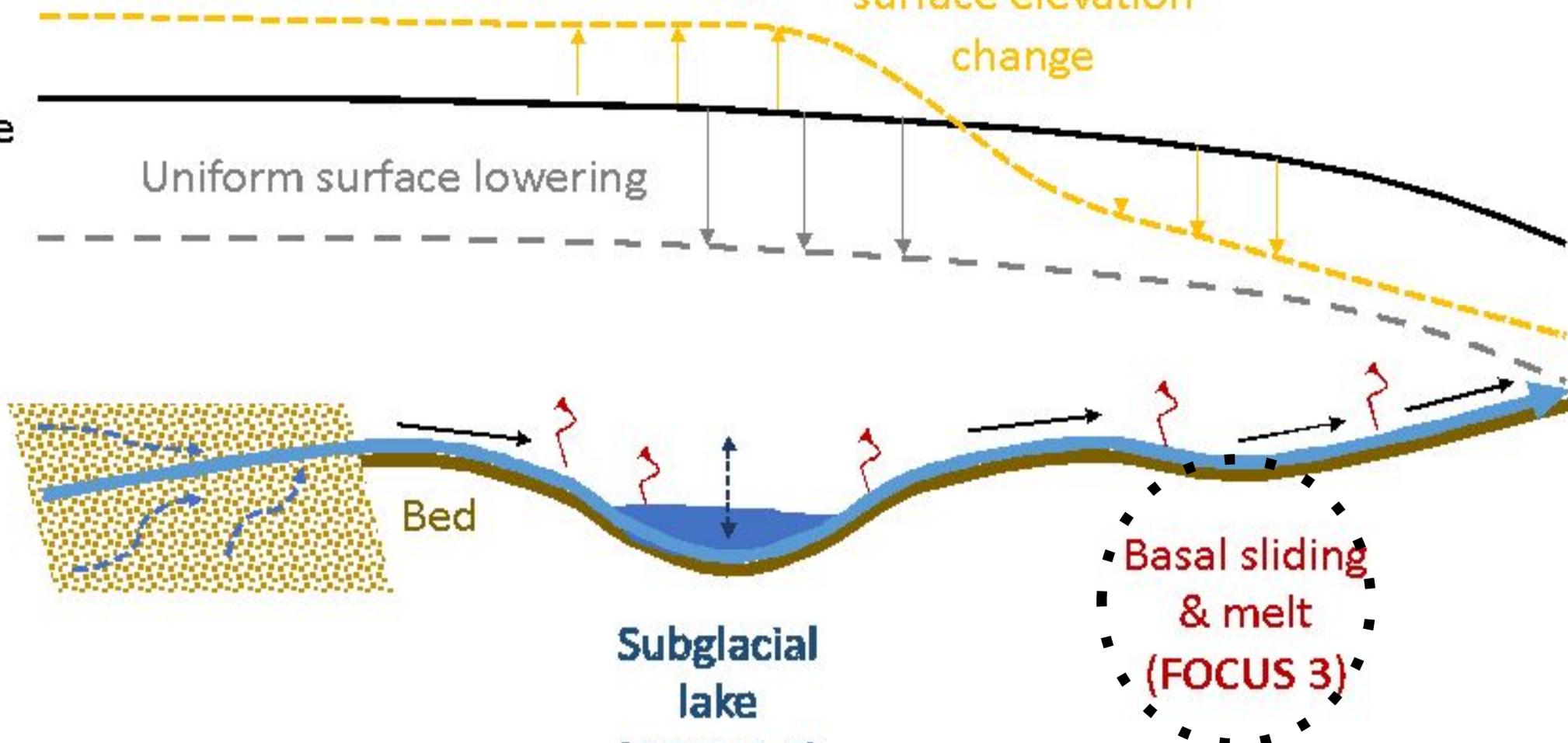
Uniform surface lowering

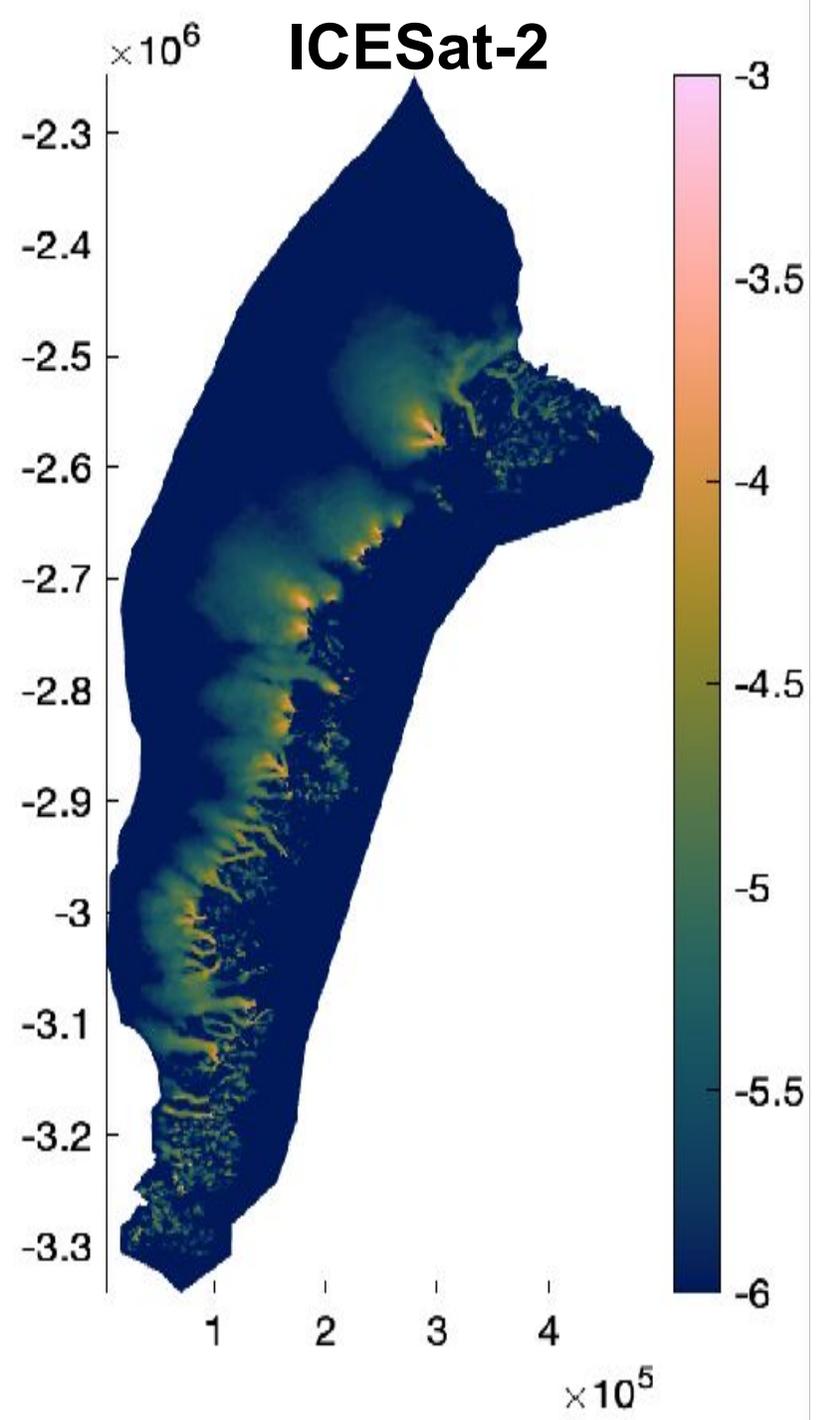
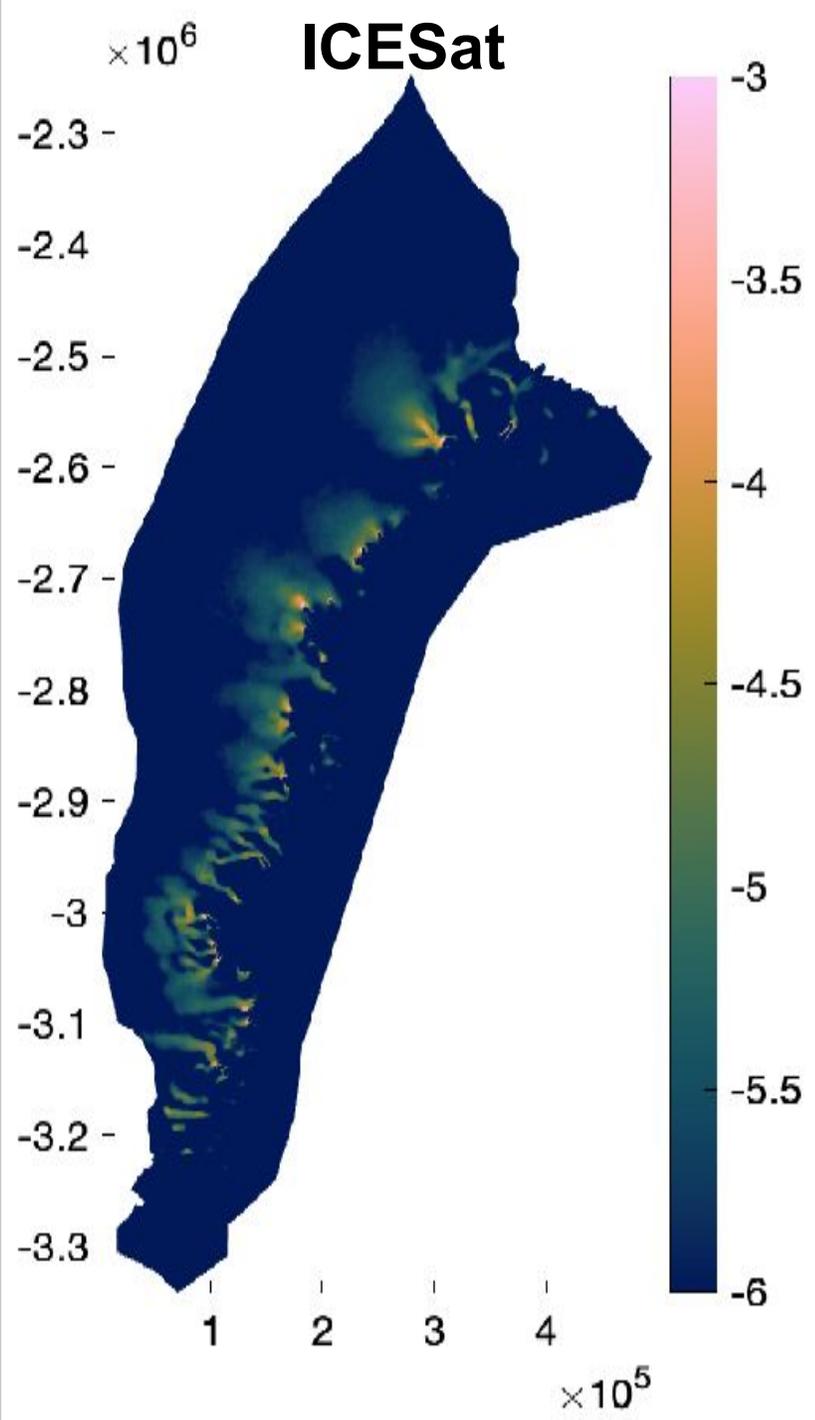
Subglacial
drainage
(FOCUS 1)

Bed

Subglacial
lake
(FOCUS 2)

Basal sliding
& melt
(FOCUS 3)





$\text{Log}_{10}(\text{Modeled basal melt rate})$
 $(\text{kg m}^{-2} \text{s}^{-1})$

Next steps:

- Other sectors and/or ice-sheet-wide simulations
- Seasonal changes using ATL15

Conclusions:

- Decadal-scale changes in ice surface elevation influence subglacial hydrology, ice velocity, and basal melt
- SHAKTI-ISSM coupled modeling – understand and quantify basal processes and dynamics
- More to come!

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