Basal melting and moderately complicated box models

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This work is based on

(Law et al., 2022)

EARTHARXIV COVERSHEET

Complex motion of Greenland Ice Sheet outlet glaciers with basal temperate ice

This manuscript has been submitted to Science Advances and has not been peer-reviewed.

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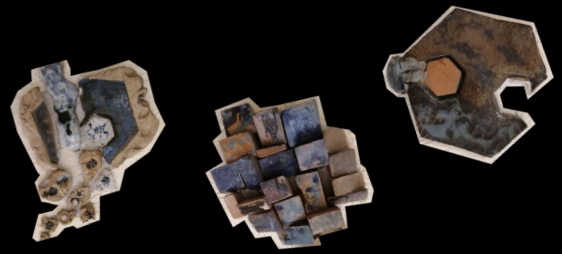
Basal melting

-Fairly simple



Basal melting

Basal melt (kg m^{-2} a^{-1})

Frictional heating ($u_b \tau_b$, J m^{-2} a^{-1})

Hydrological storage

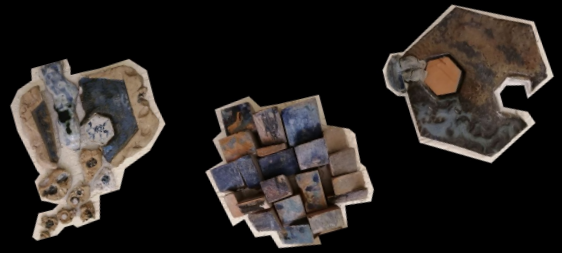
Normal vector

$$M_b = \frac{1}{H}(F_b + Q_b + \boldsymbol{G}_b \cdot \boldsymbol{n} - \boldsymbol{q} \cdot \boldsymbol{n})$$

Enthalpy (J kg^{-1})

Geothermal heat flux (J m^{-2} a^{-1})

Energy flux into ice (J m^{-2} a^{-1})



Basal melting

USF_basal_melt.F90

```
!same treatment for GHF
GHF_vector(1) = 0.0_dp
GHF_vector(2) = 0.0_dp
GHF_vector(3) = GHF
GHF = DOT_PRODUCT(Normal, GHF_vector)
```

```
MbNode = (FrictionHeatNode + GHF + IceFluxNormal)/EnthNode
```

Basal melting

-Uses the output of **`getFrictionHeat`** *function -not-* **`GetFrictionHeating`** *function as output in W* m^{-2} *makes the former easier to work with here*

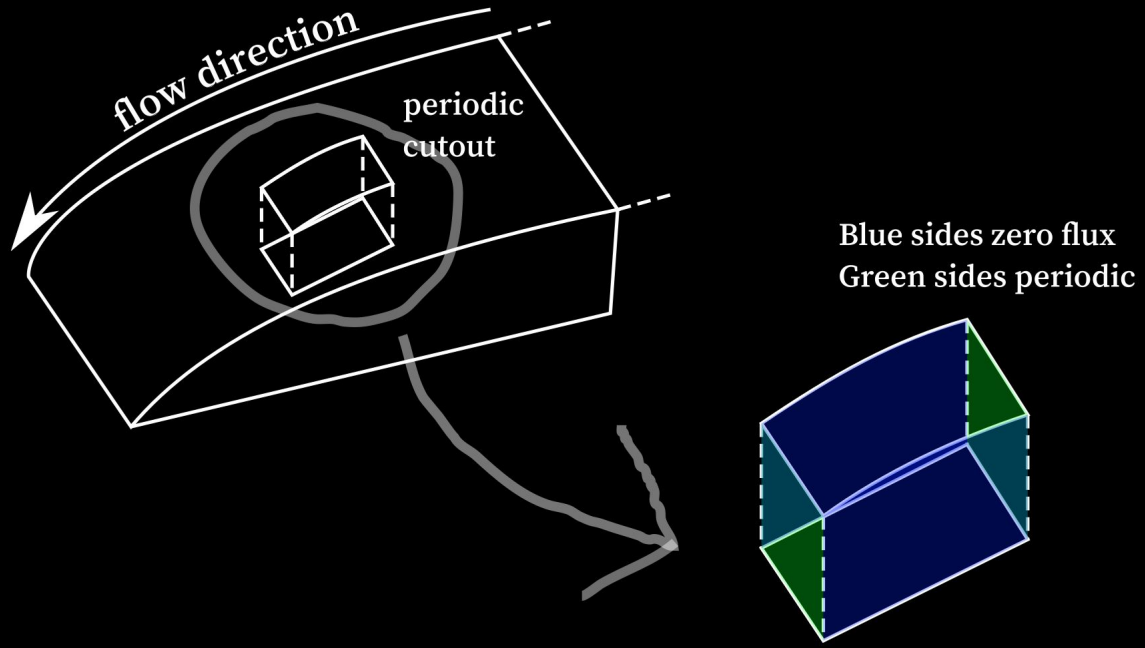
Problem: how to model just a chunk of glacier?

-Initially just tried a "sensible" velocity field input for a cuboid from plane strain assumptions.

-This didn't work .

-(free surface blows up, model doesn't like a fixed surface, hard to know if the velocity field is reasonable).

Answer: make the chunk periodic first



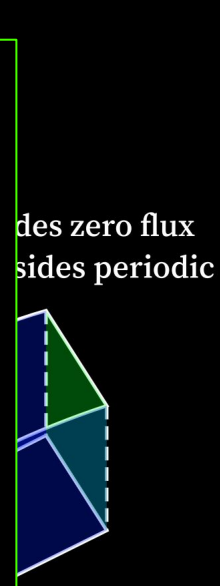
Answer: make the chunk periodic first

Then set “best-guess” parameters for:

Rheology (Duval, 1977; Duval, 1987; Haseloff et al., 2019; Adams et al., 2021).

Sliding (Helanow et al., 2021).

Swing the gravity vector as a crude inversion method.



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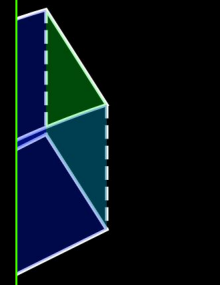


However! *Thermomechanically coupled modelling is incompatible with periodic boundary conditions.*

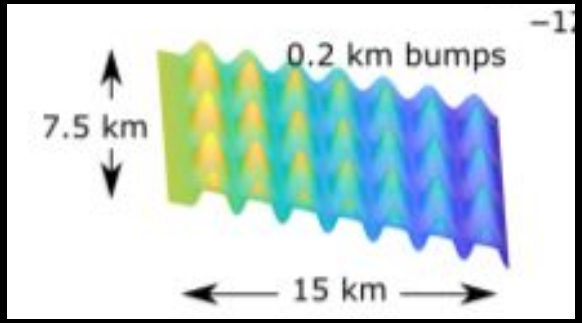
So: *Run with a constant enthalpy field first to obtain the input velocity field and free surface value.*

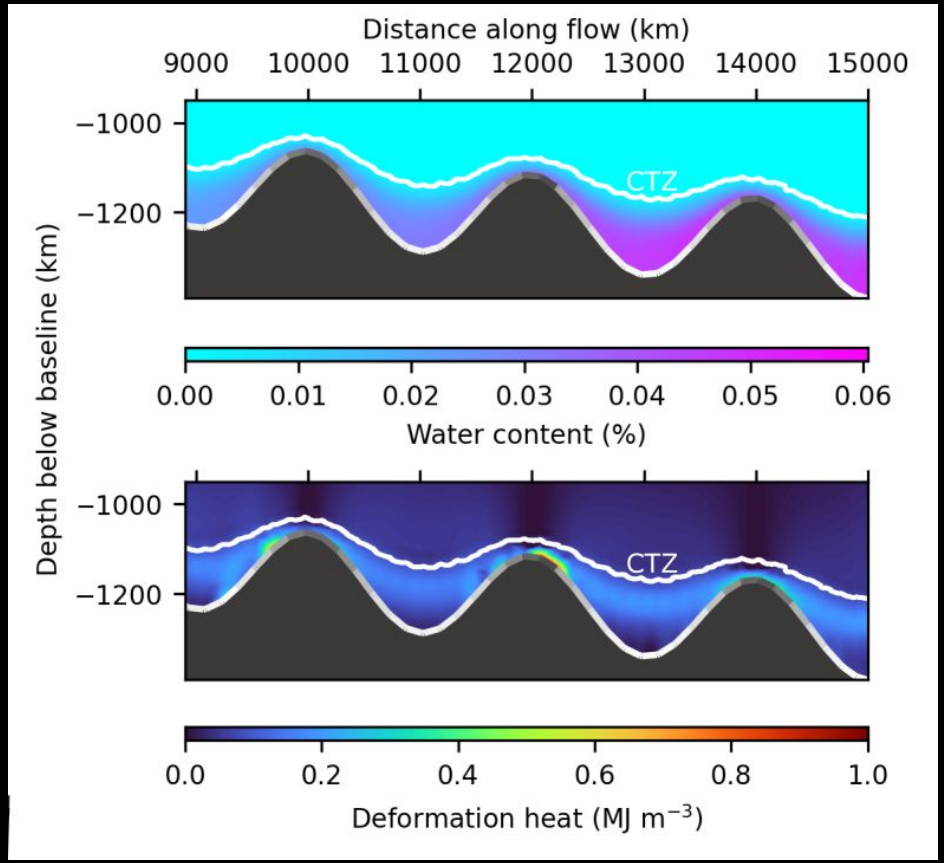
Then: *A thermomechanical run can be obtained under the assumption that this doesn't greatly affect the free surface.*

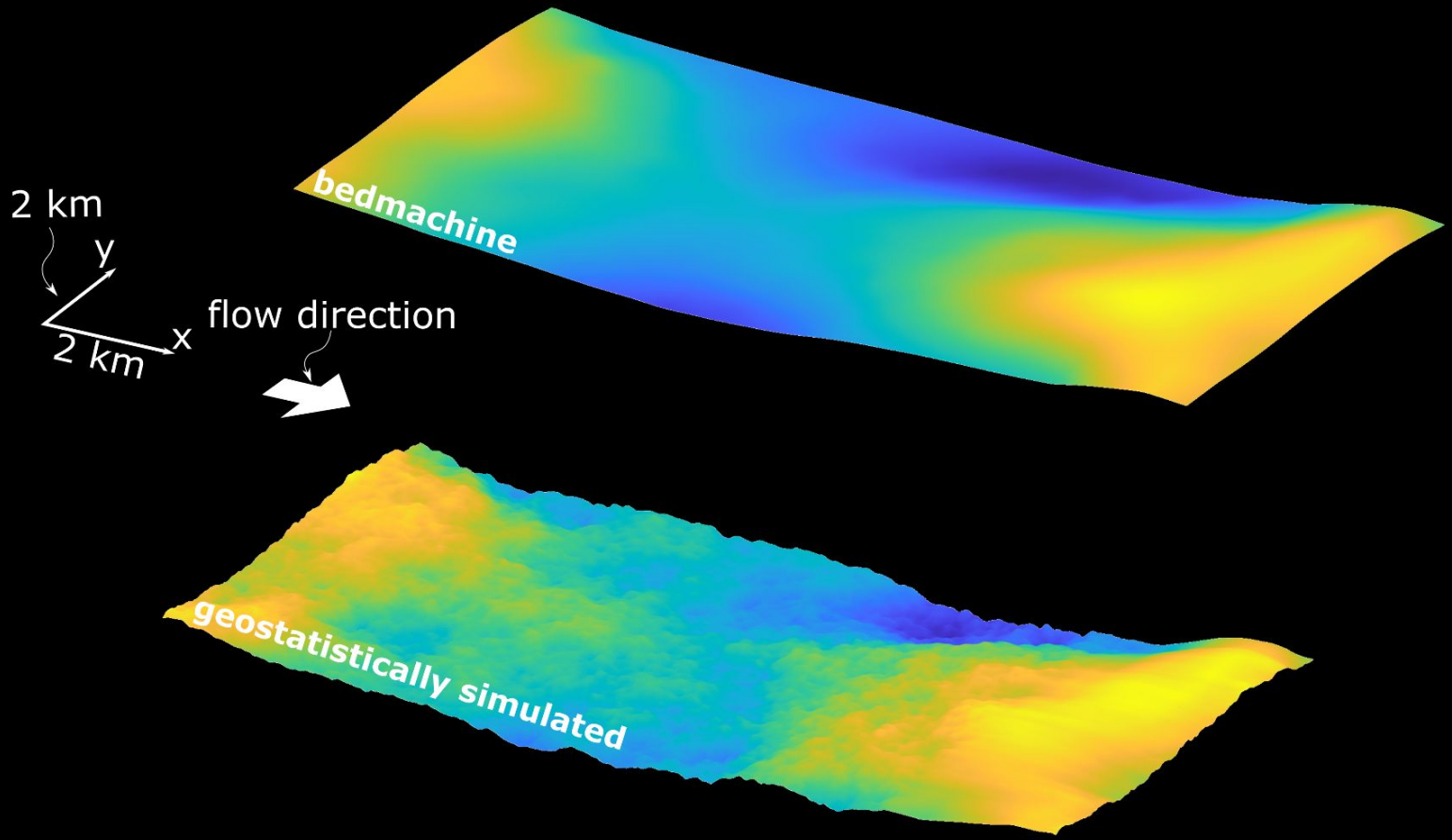
Note that there were some issues regarding normal vector continuity at periodic boundary conditions, but this was addressed a year or so ago.

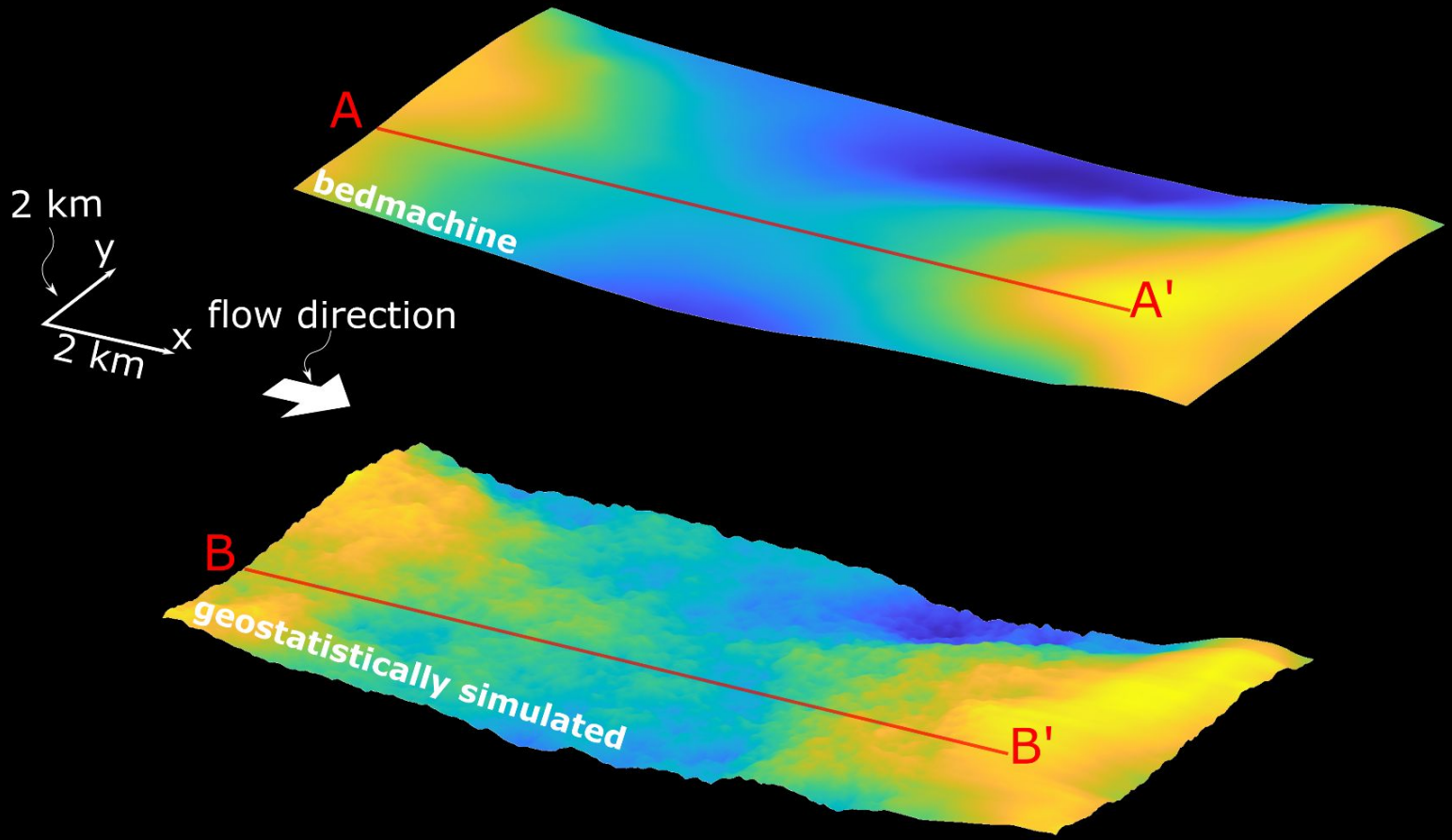
EGU results

-These are for synthetic sinusoidal DEM.

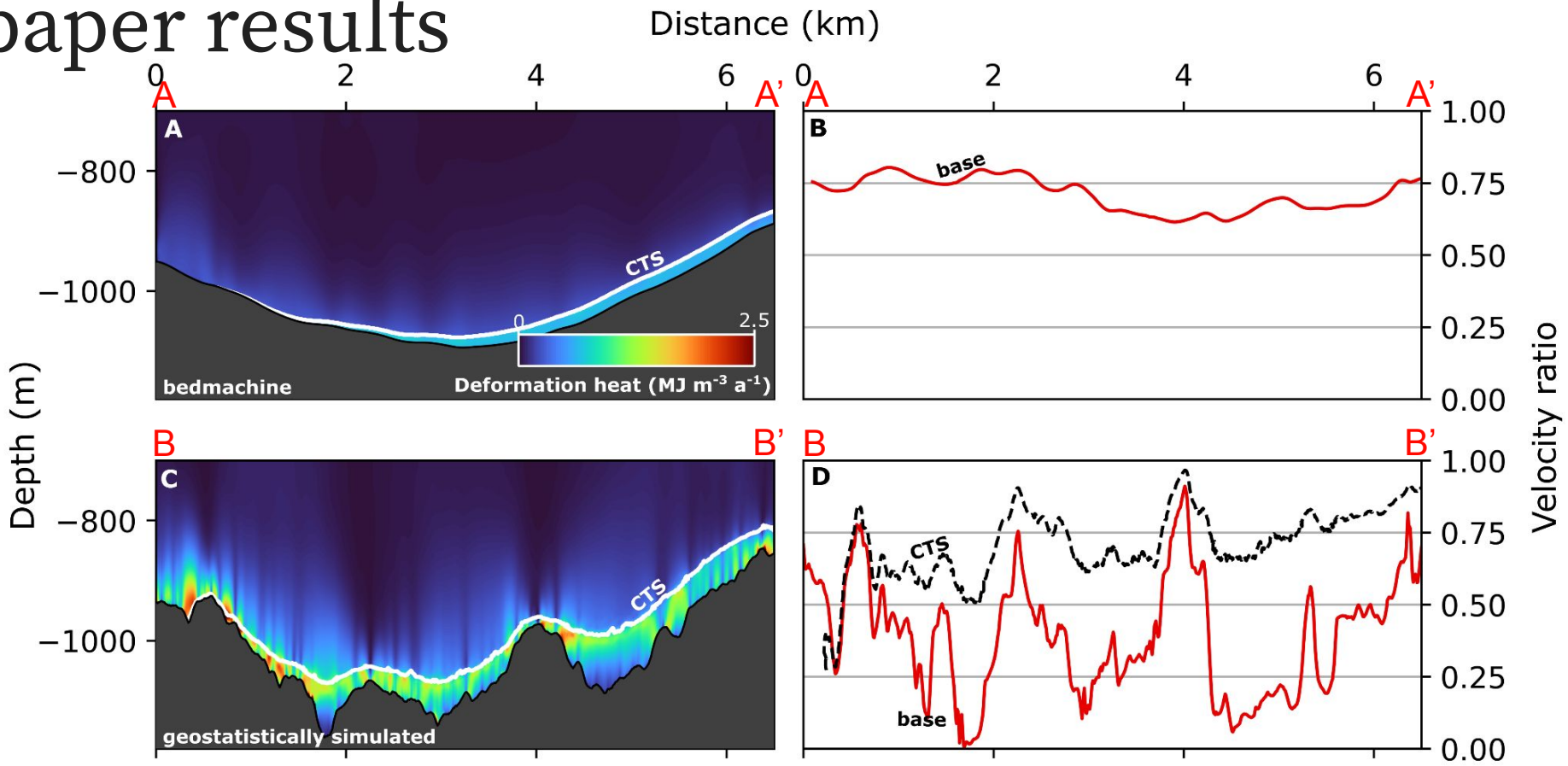





2 km
y
x
2 km
flow direction
bedmachine
geostatistically simulated

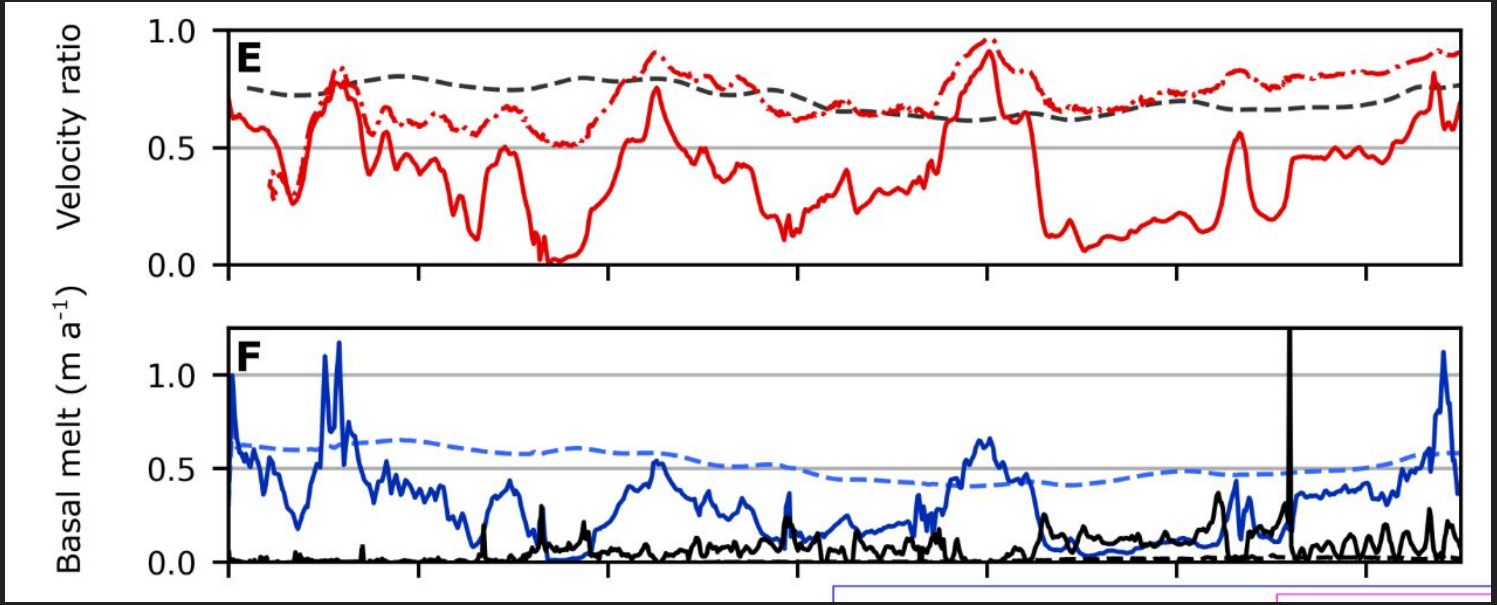

A
bedmachine
A'
2 km
y
x
2 km
flow direction
B
geostatistically simulated
B'

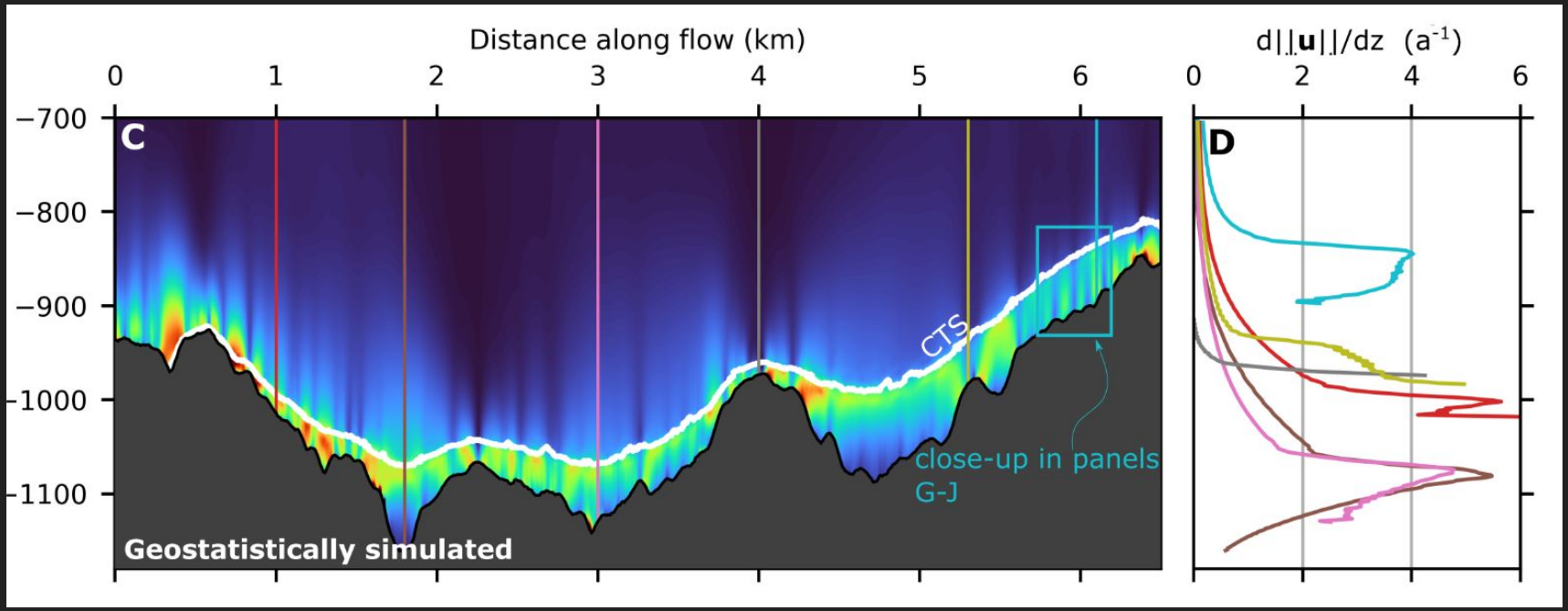
paper results



Law et al. (*in prep*)

paper results





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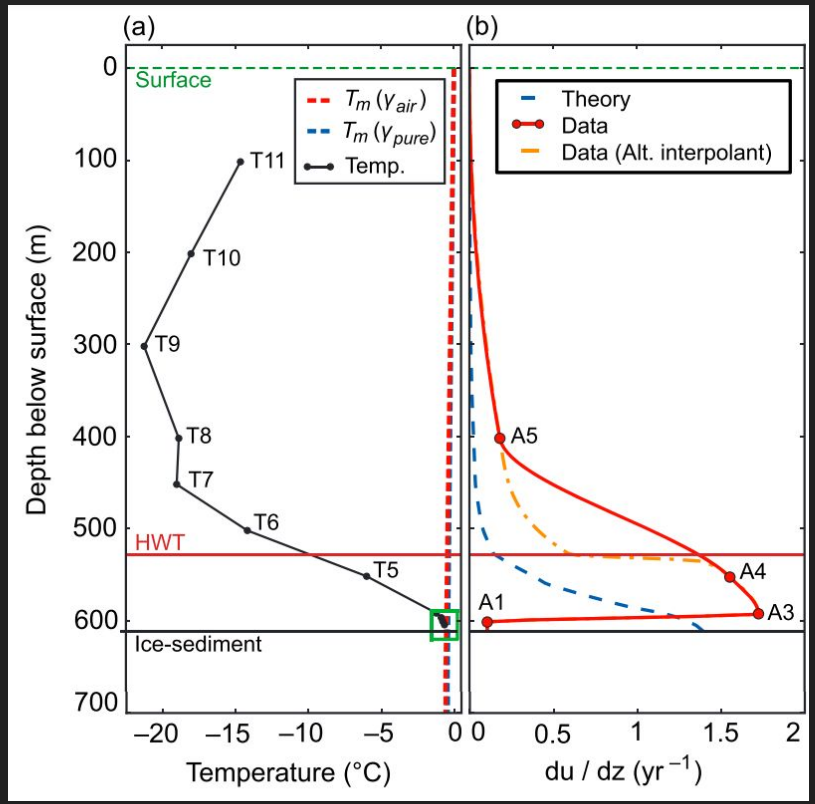
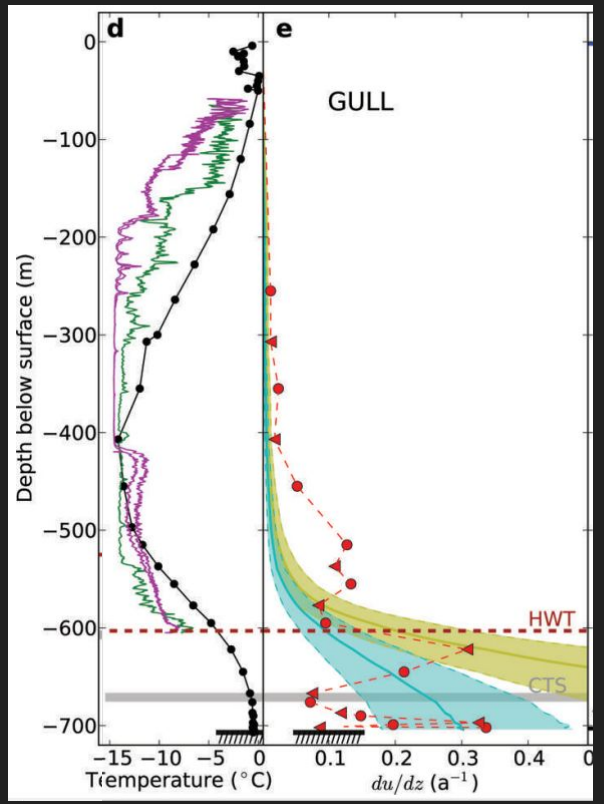


Doyle et al. (2018)



Ryser et al. (2014)

Law et al. (*in prep*)

Thanks :]