# The effects of rheological parameters on ice-shelf flow on centennial time scales

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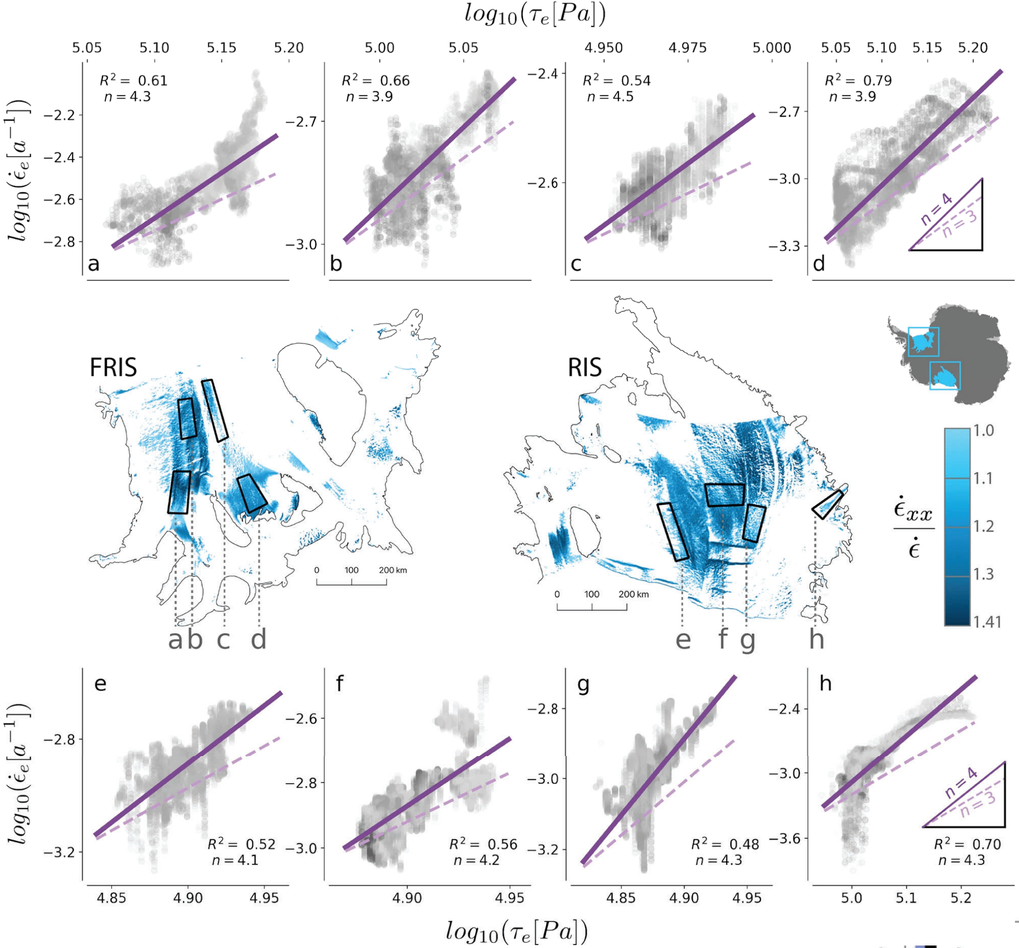
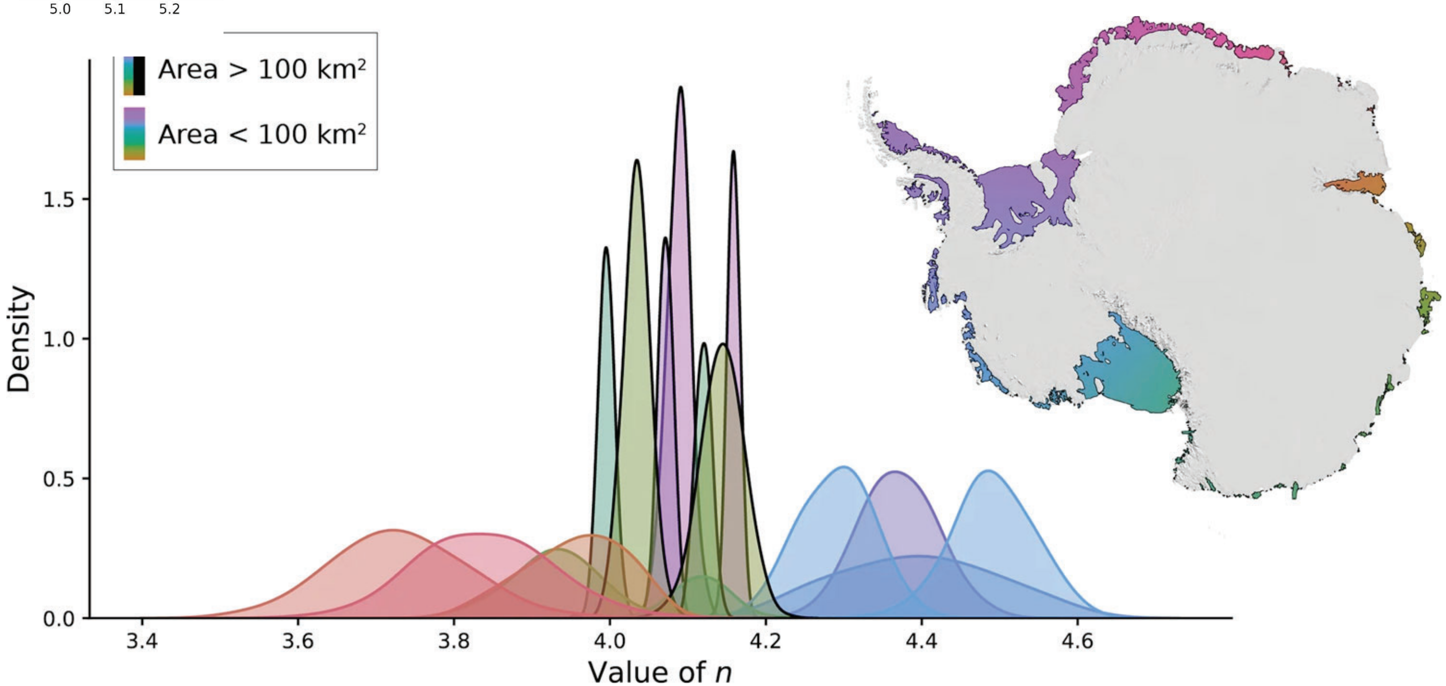
# $n$ inferred from observations



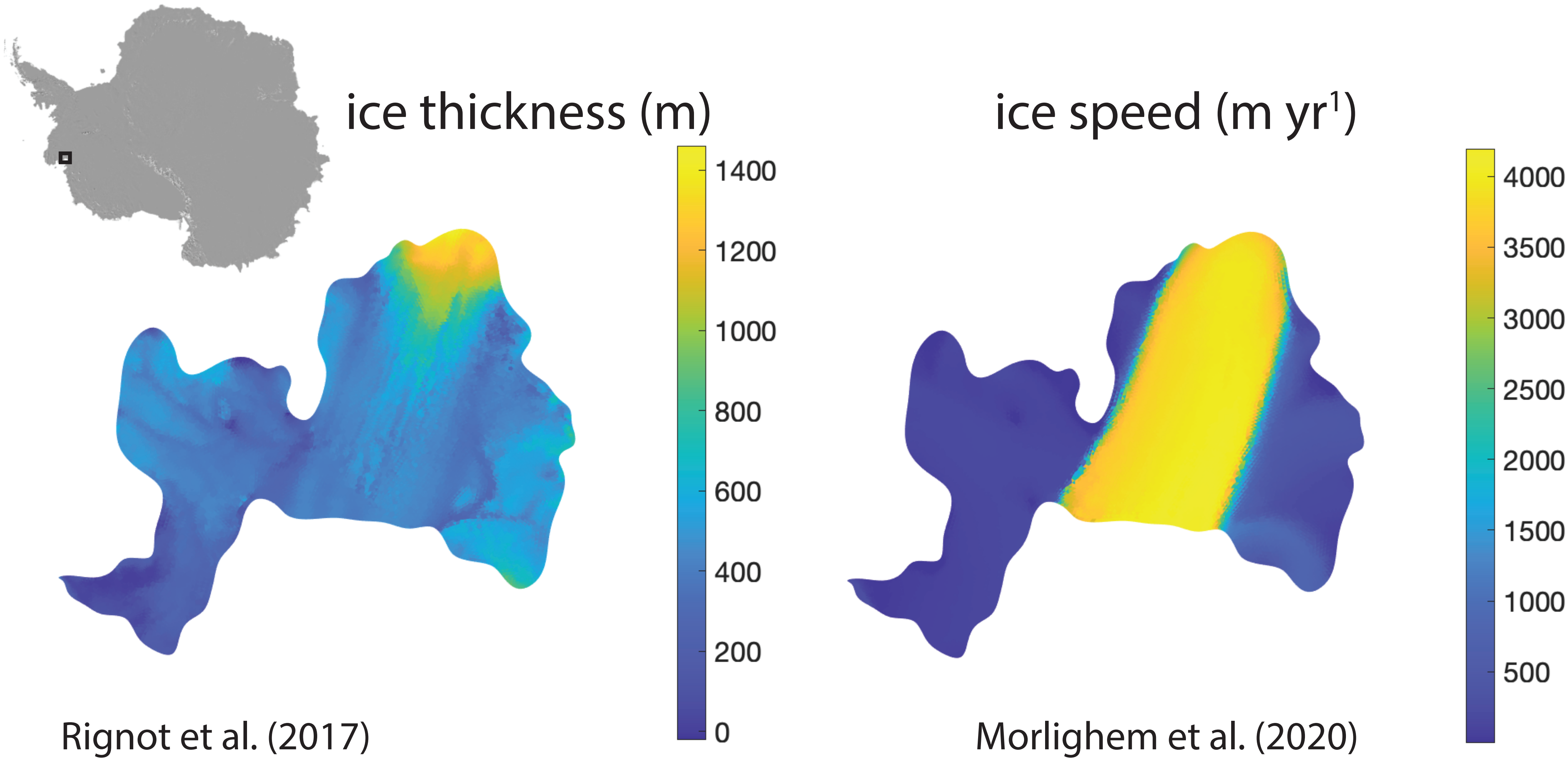

## On ice shelves

$$\log \dot{\epsilon} \propto n \log \tau_e$$



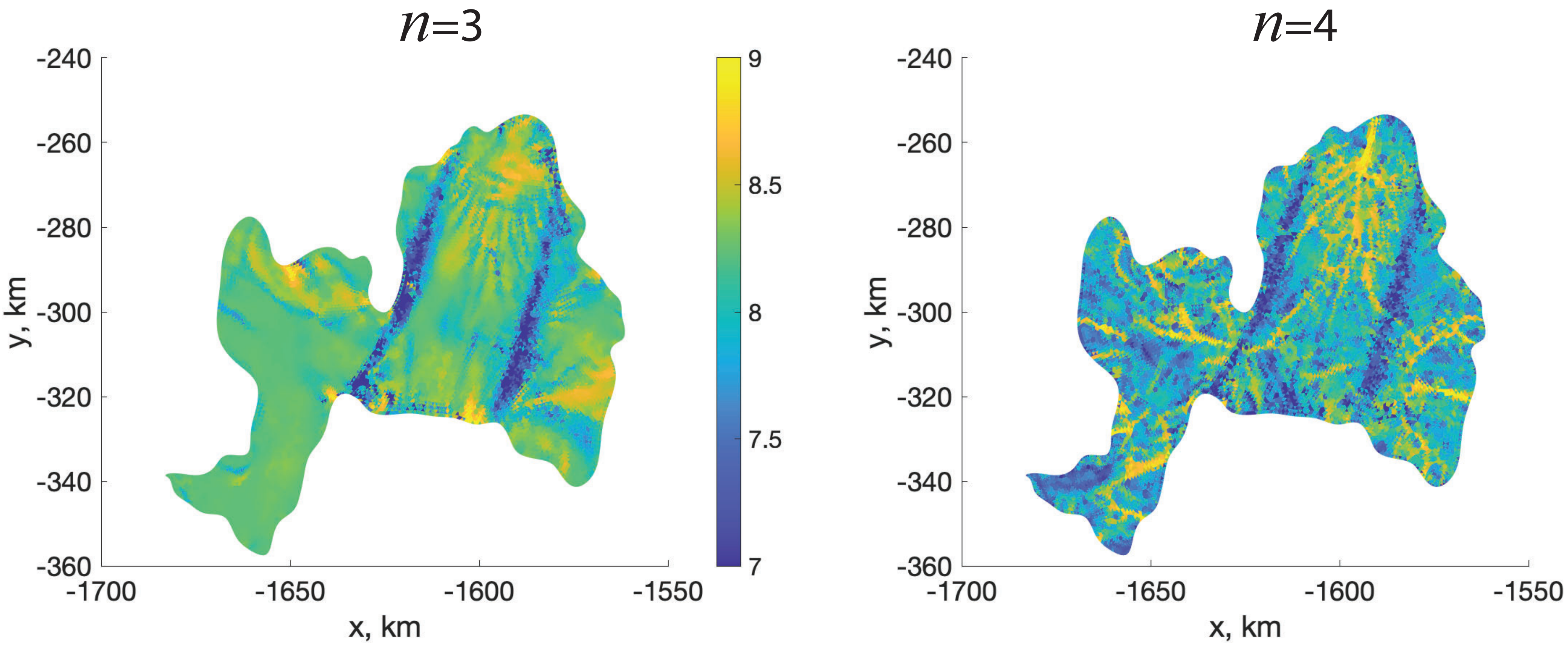

Millstein et al. (2022)

# Pine Island Glacier Ice Shelf



# Inverted ice-stiffness parameter






Control method (e.g. Rommelaere & MacAyeal, 1997)

# 100 yr simulation

momentum balance

$$[2\nu H(2u_x + v_y)]_x + [\nu H(u_y + v_x)]_y = \rho g' H H_x$$

$$[\nu H(u_y + v_x)]_x + [2\nu H(u_x + 2v_y)]_y = \rho g' H H_y$$

$$g' = \frac{\rho_w - \rho}{\rho_w} g$$

reduced gravity

mass balance

$$H_t + H(u_x + v_y) + uH_x + vH_y = -\dot{m}$$

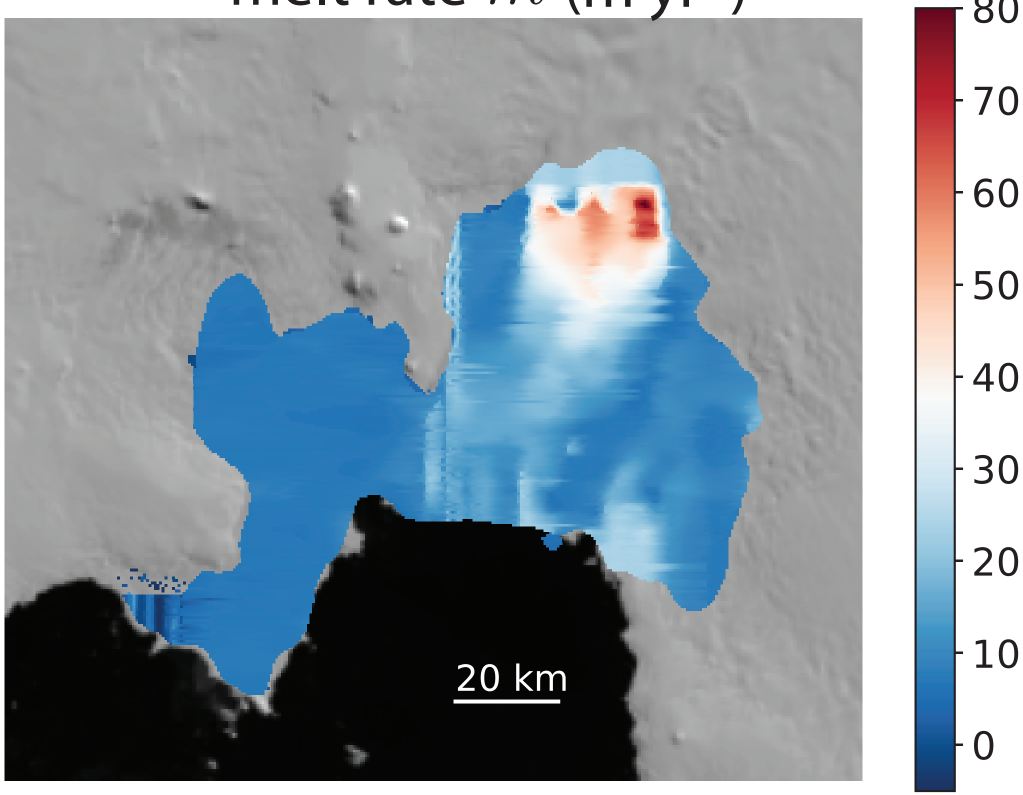
ice thickness ($H$); velocity components ($u$, $v$)

ice-stiffness parameter ($\bar{B}_n$)

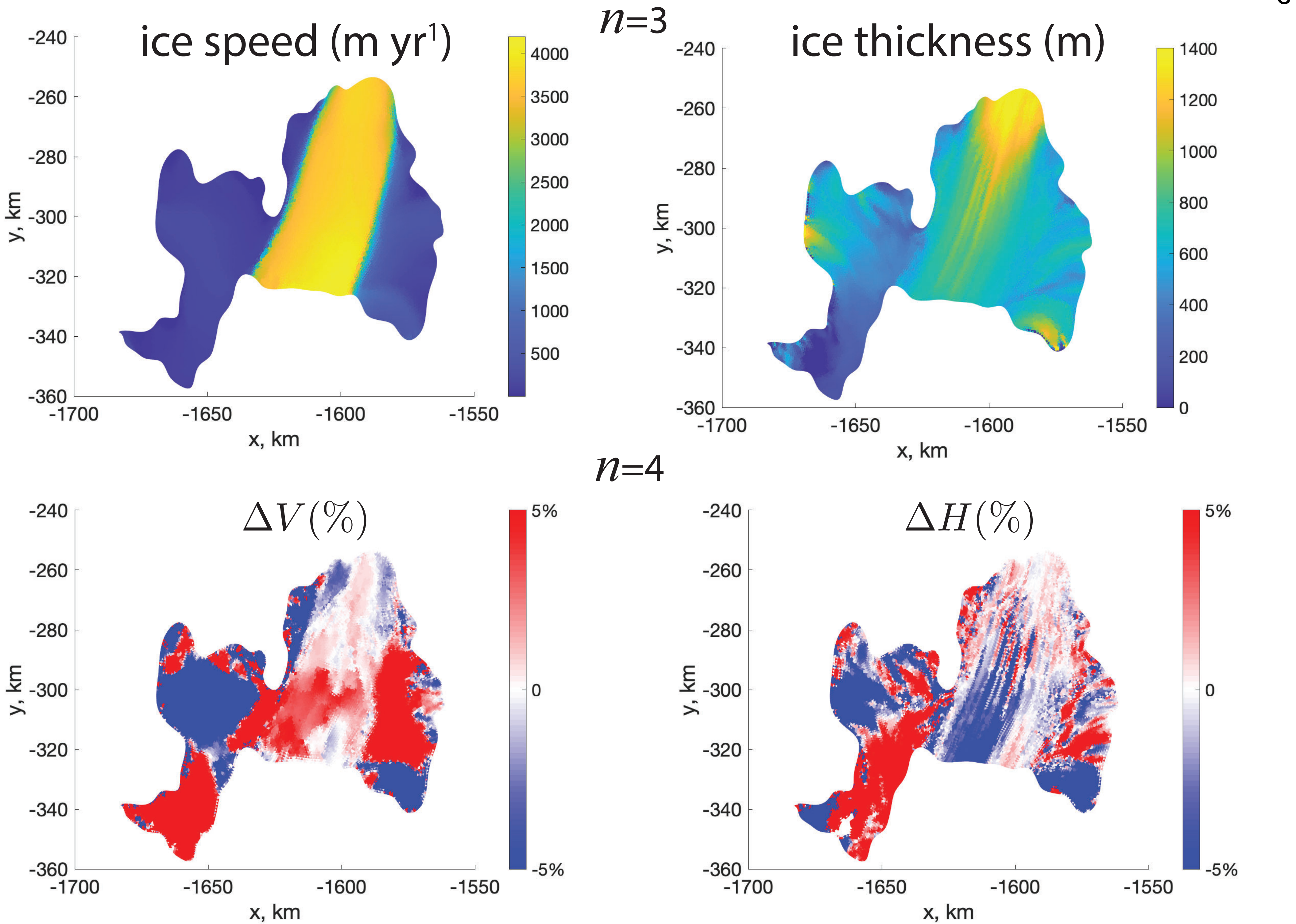
$$\nu = \frac{\bar{B}_n}{2} \dot{e}_{II}^{\frac{1-n}{2n}}$$

viscosity

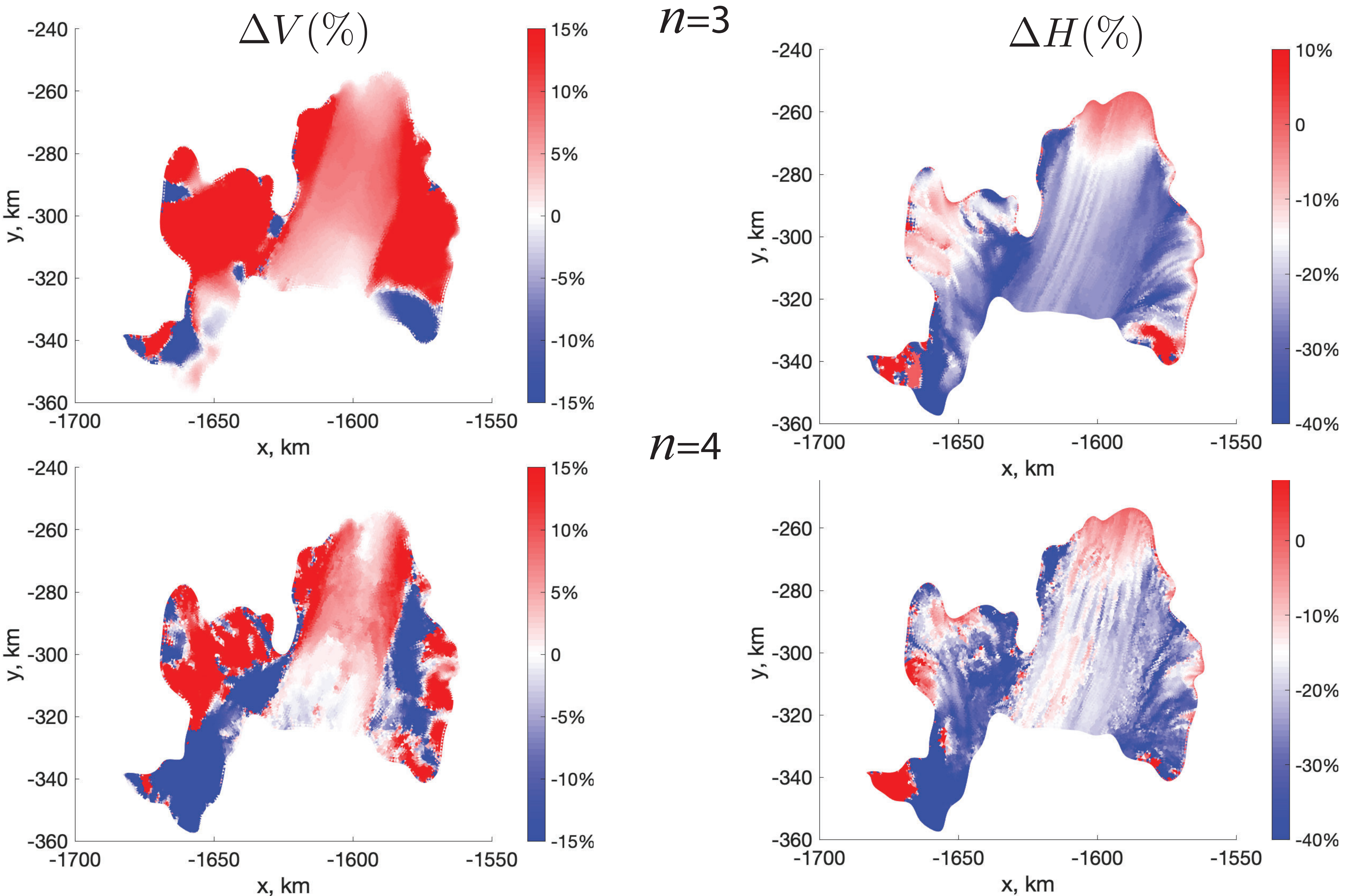
melt rate $\dot{m}$ (m yr$^{-1}$)




Adusumilli et al. (2020)


n=3
ice speed (m yr1)
ice thickness (m)
n=4
ΔV (%)
ΔH (%)
y, km
x, km
-240
-260
-280
-300
-320
-340
-360
-1700
-1650
-1600
-1550
4000
3500
3000
2500
2000
1500
1000
500
1400
1200
1000
800
600
400
200
0
5%
0
-5%

# Difference between simulations with Cryosat-derived melt rate and consant melt rate (0.3 m $yr^{-1}$)



# Summary

— Ice-stiffness parameter inferred for $n$=3 and $n$=4 have similar spatial pattrens:

lower values along the shear margins,
higher values along melt channels.

— After 100 yrs simulations, the difference in melt rates has stronger effects (~15-40%) than the difference in rheologica parameters (~ 5%).