Theoretical Challenges for Ocean Dynamics Ice-Ocean Interactions
A Jupyter Notebook

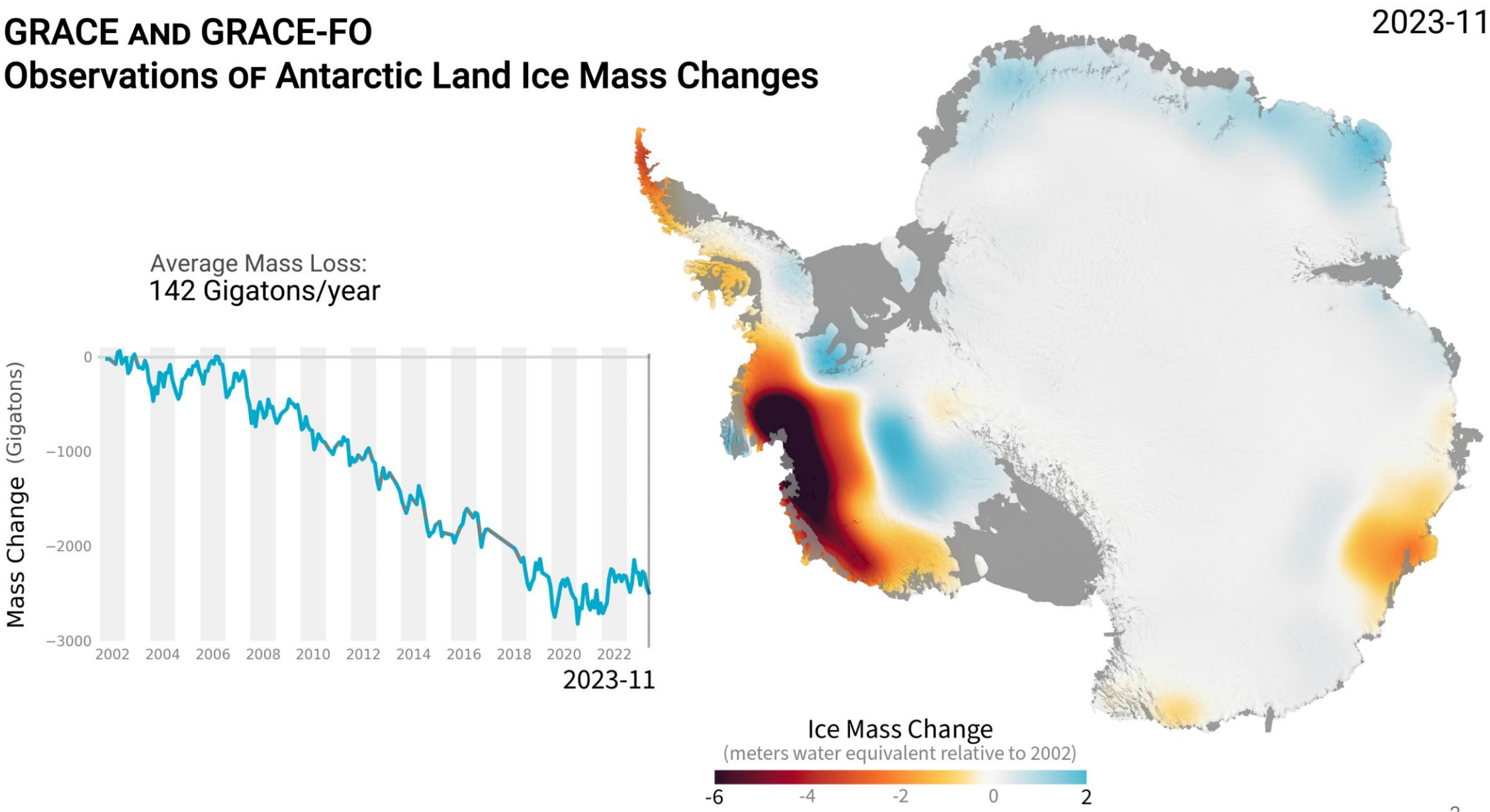
Louis-Alexandre Couston, Louis Saddier

ENSL, UCBL, CNRS, Laboratoire de physique, F-69342 Lyon, France

louis.couston@ens-lyon.fr, louis.saddier@ens-lyon.fr

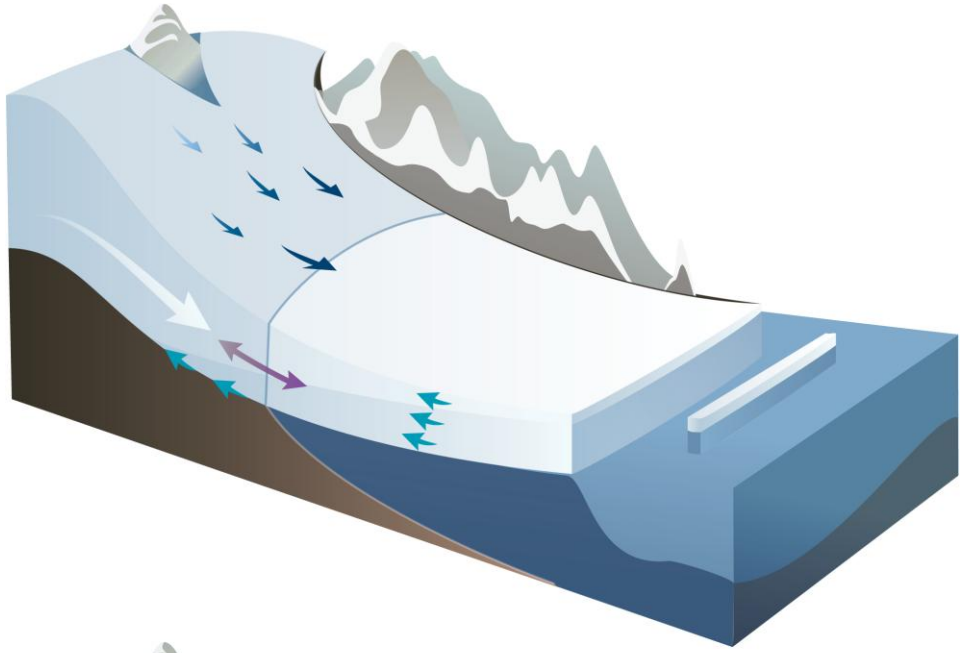
www.climatephysics-ensl.fr

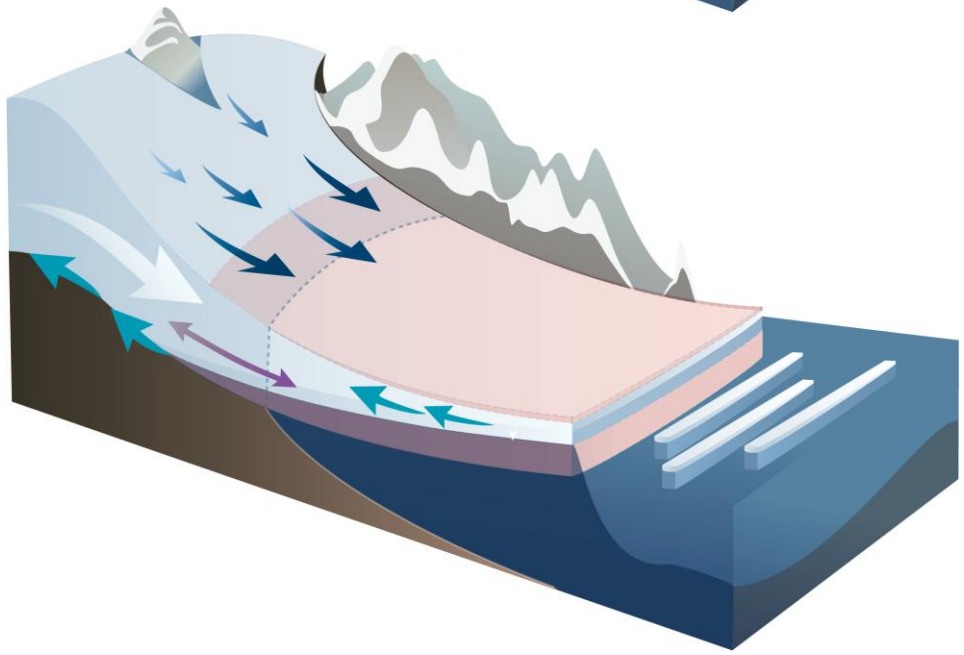
Ice losses globally, with large regional differences



https://svs.gsfc.nasa.gov/31158

Ocean-driven ice-shelf thinning increases ice losses

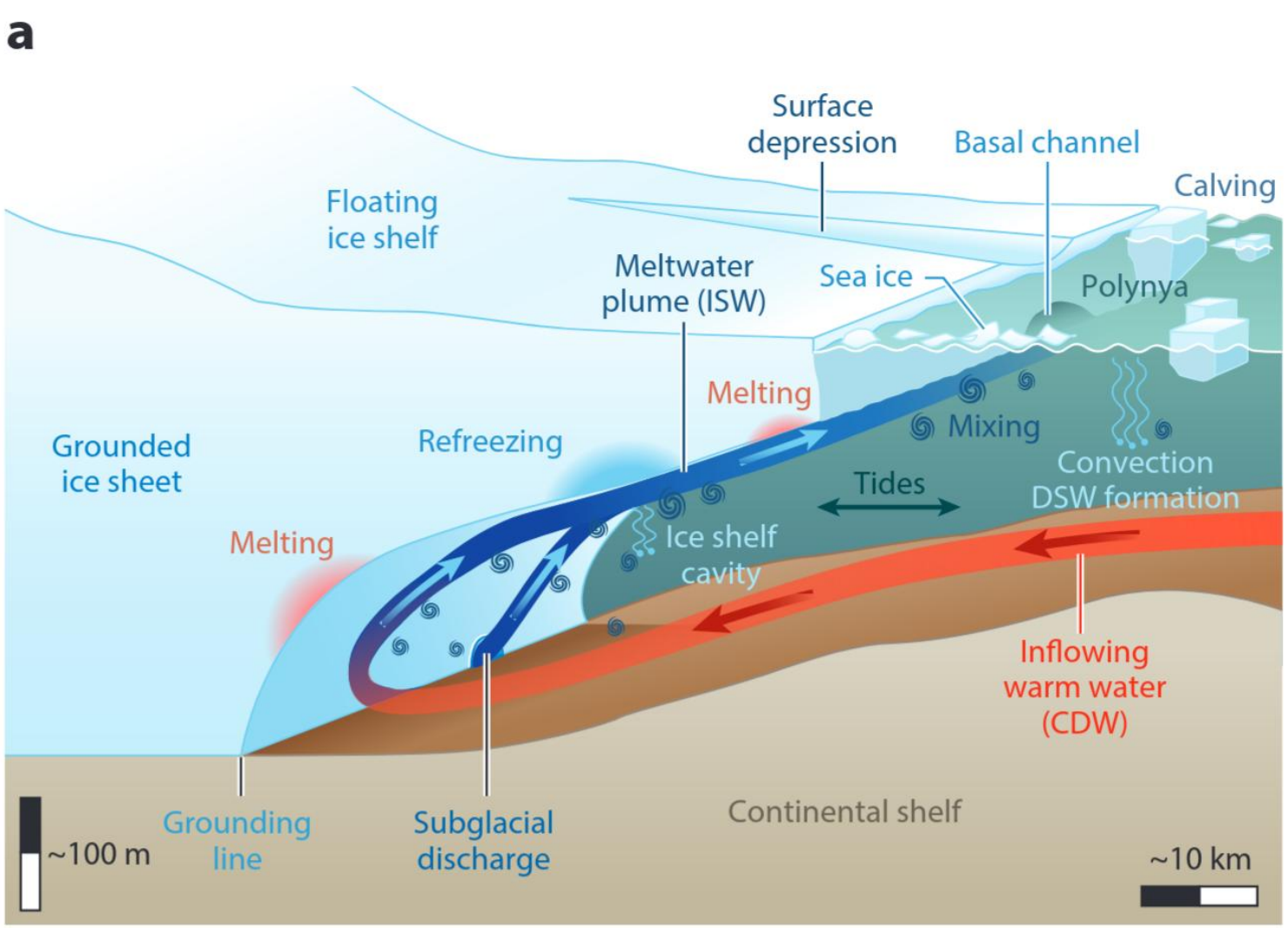


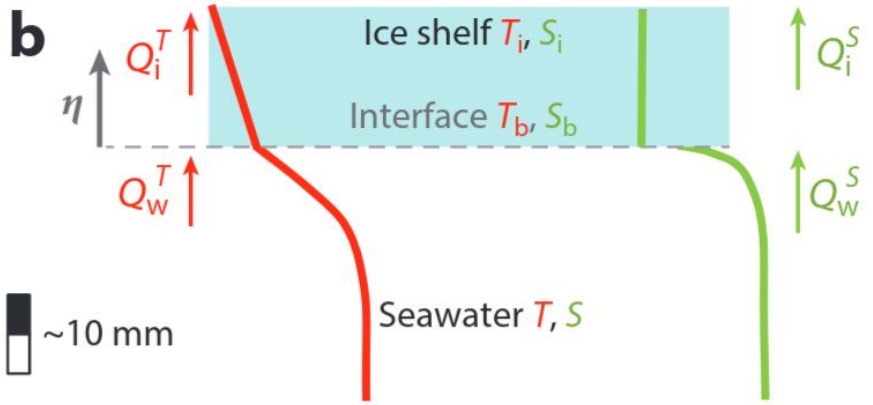


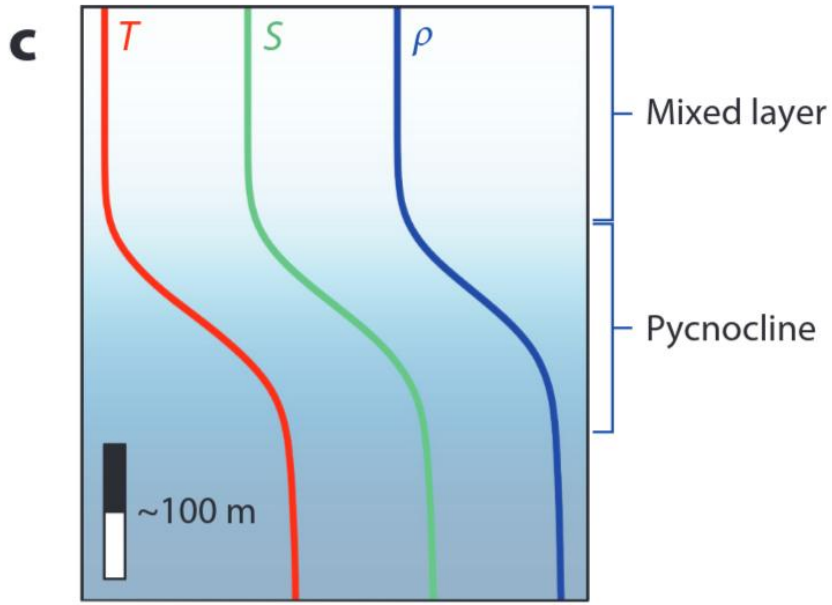
- Ice sheets are viscous gravity-driven flows
- Ice shelves (often) provide buttressing against the flows of continental ice upstream depending on the stress budget
- Ice-shelf thinning reduces side friction, enabling faster grounded ice discharge into the ocean

Gudmundsson 2019

Melting and stratification in the ice-ocean boundary layer

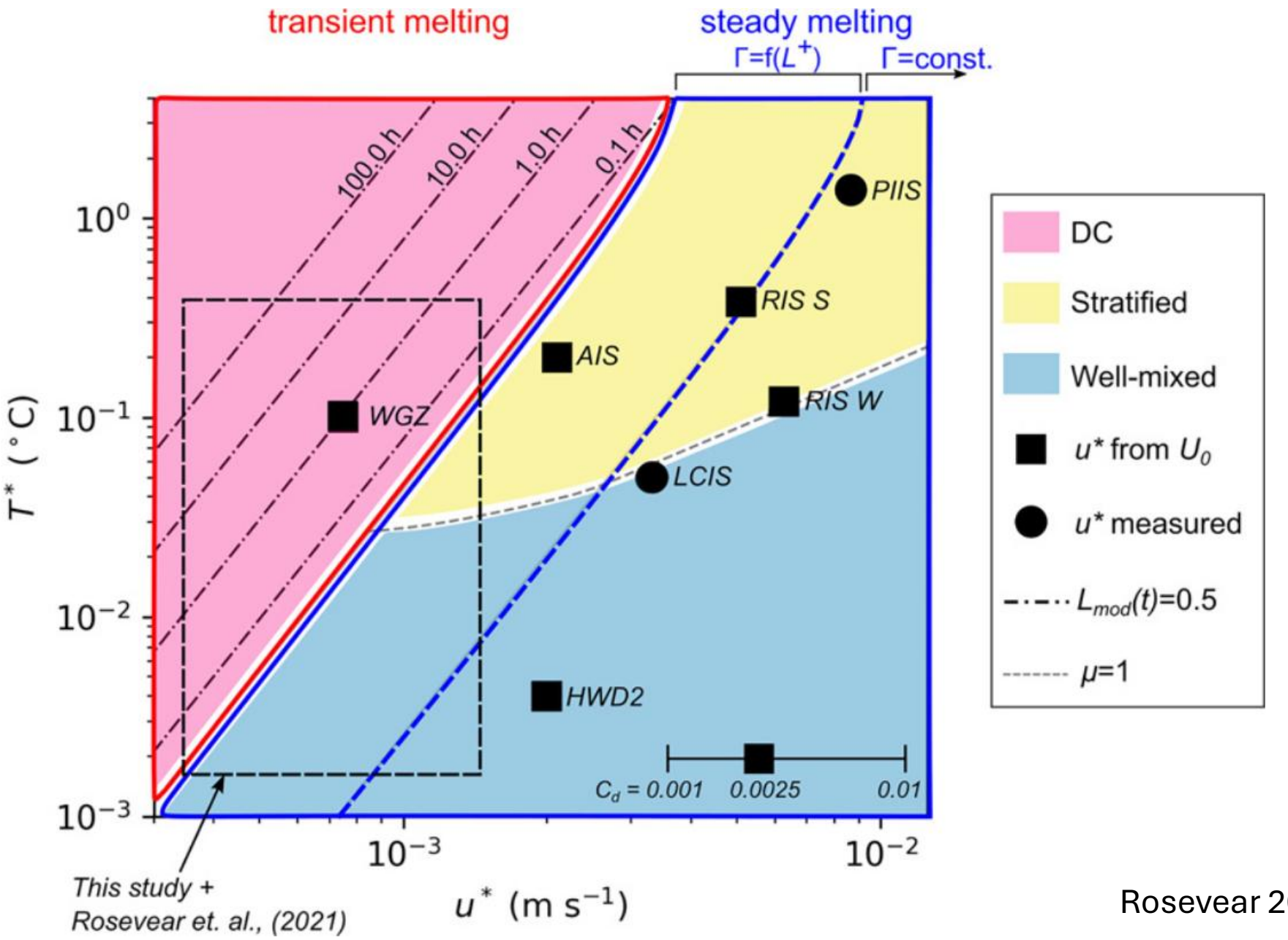






Rosevear 2025

Multiple regimes



Rosevear 2021

One parameterization to govern them all

$$\rho_i a_b L_i = \rho_i c_i a_b (T_i - T_b) - \rho_w c_w u_* \Gamma_T (T_b - T_w), \tag{11}$$

$$\rho_i a_b (S_b - S_i) = -\rho_w u_* \Gamma_S (S_b - S_w), \tag{12}$$

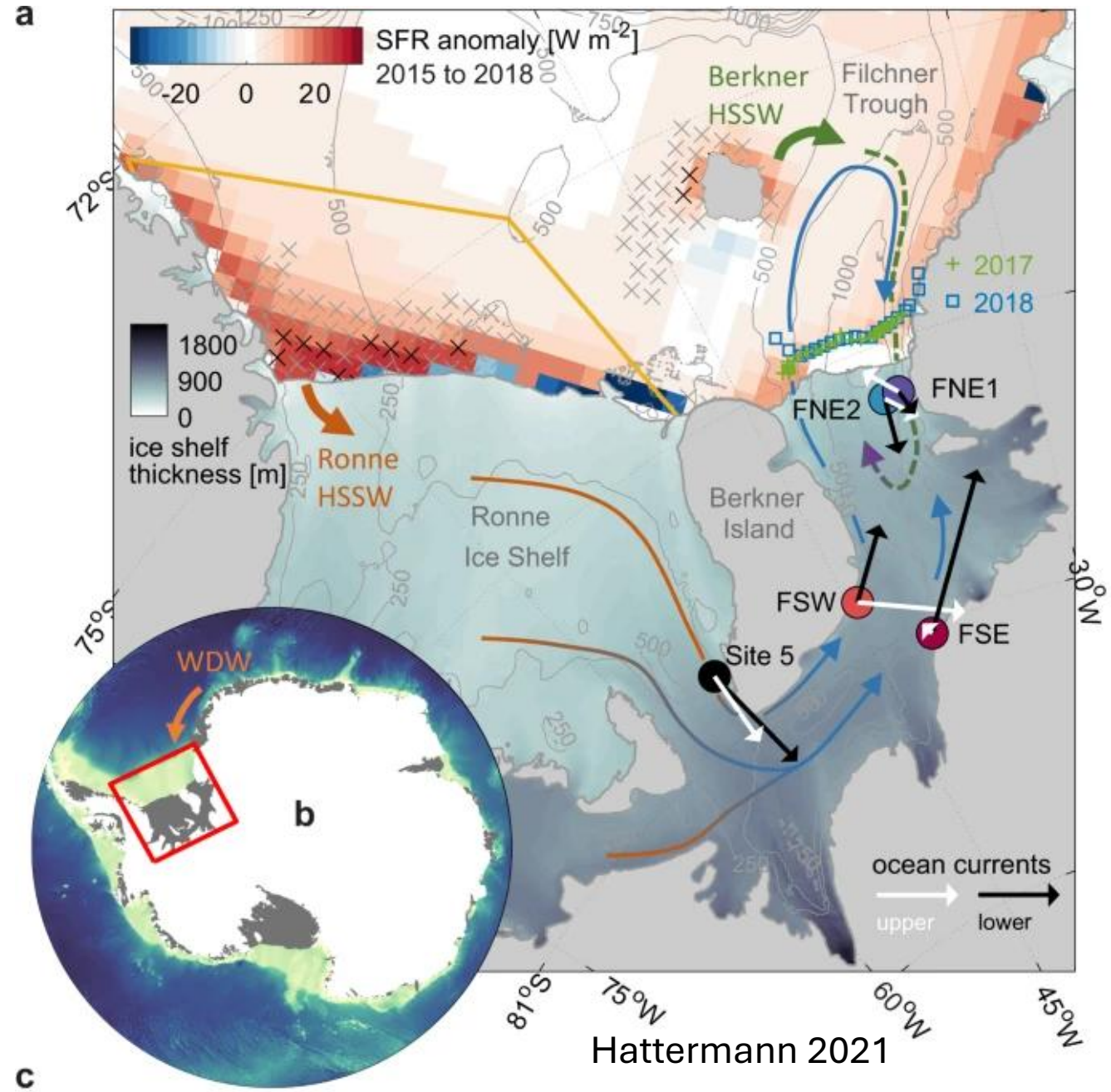
and

$$T_b = \lambda_1 S_b + \lambda_2 + \lambda_3 P_b \tag{13}$$

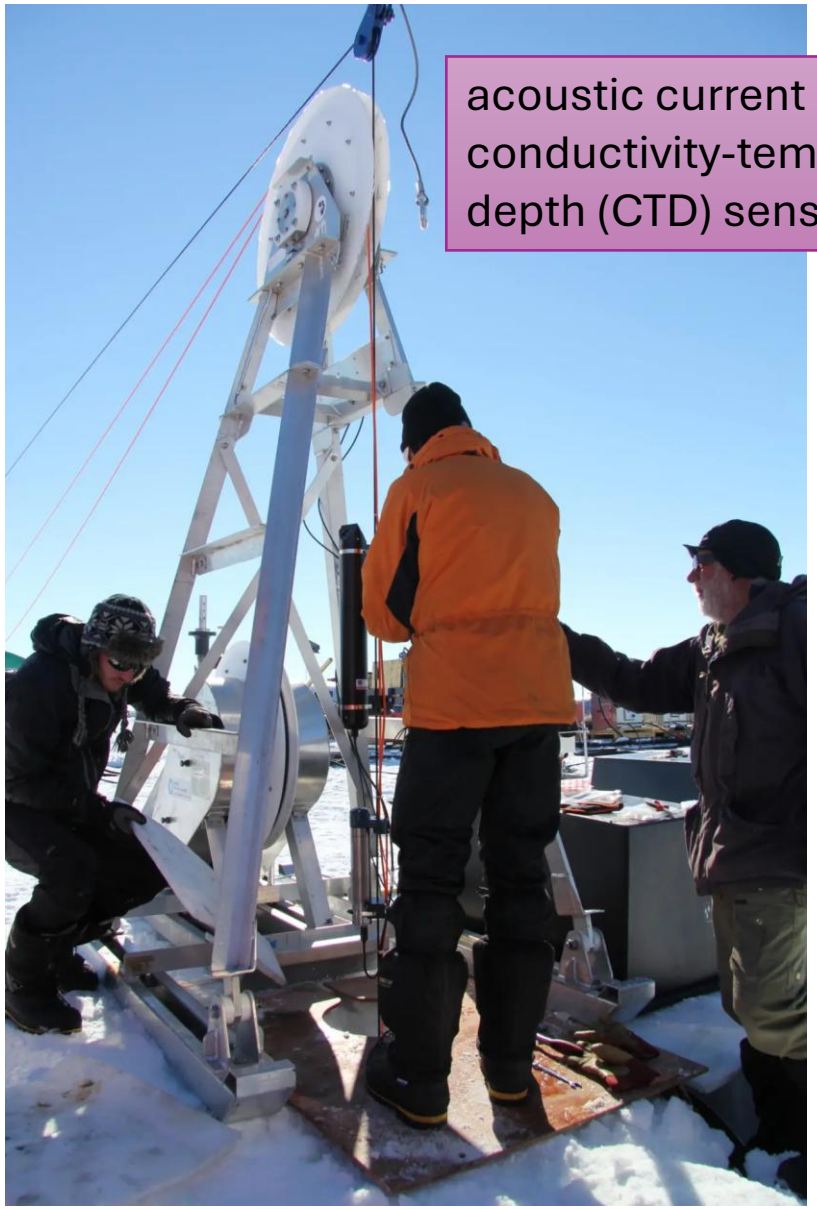
$$u_*^2 = C_d U^2, \tag{3}$$

Jenkins 2010

How is that going to work? The Ronne ice shelf test case



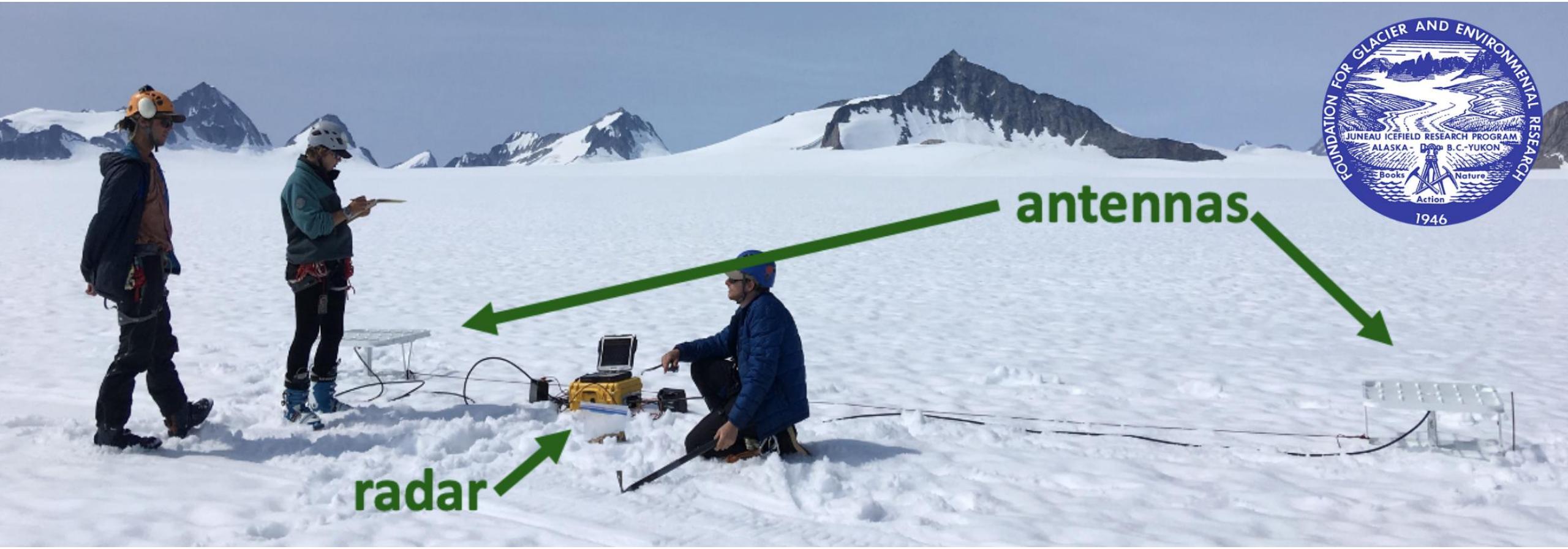
Hattermann 2021



acoustic current meters
conductivity-temperature-depth (CTD) sensors

Hot water drilling - 770m (Keith Makinson)

The truth. Autonomous phase-sensitive Radio Echo Sounder (ApRES)



The Glaciology Data Analysis and Modeling book (Elizabeth Case)