

Momentum fluxes across the air-ice-ocean interface in the Beaufort Sea

How does ice cover mediate momentum transfer into the Arctic Ocean?

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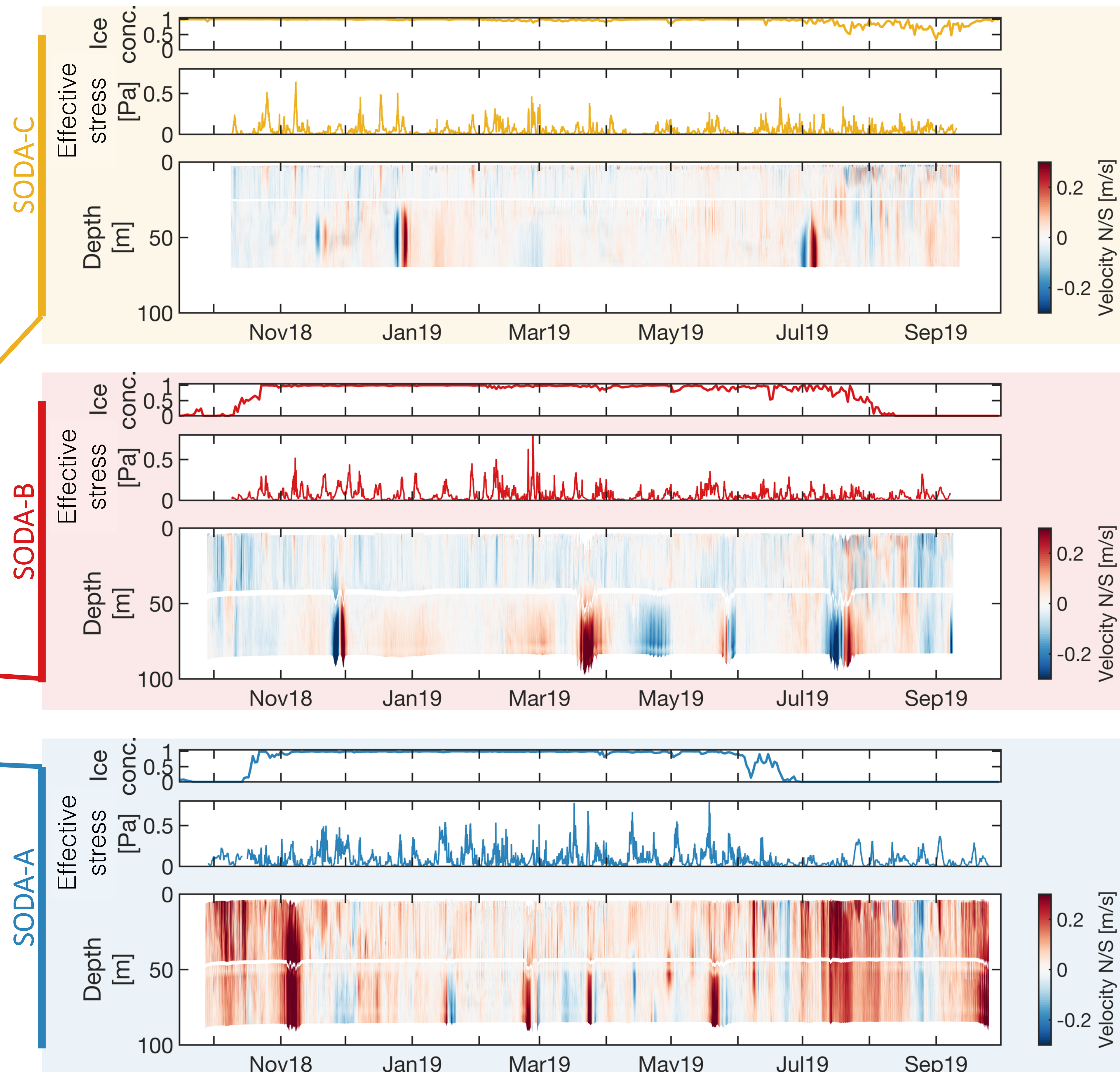
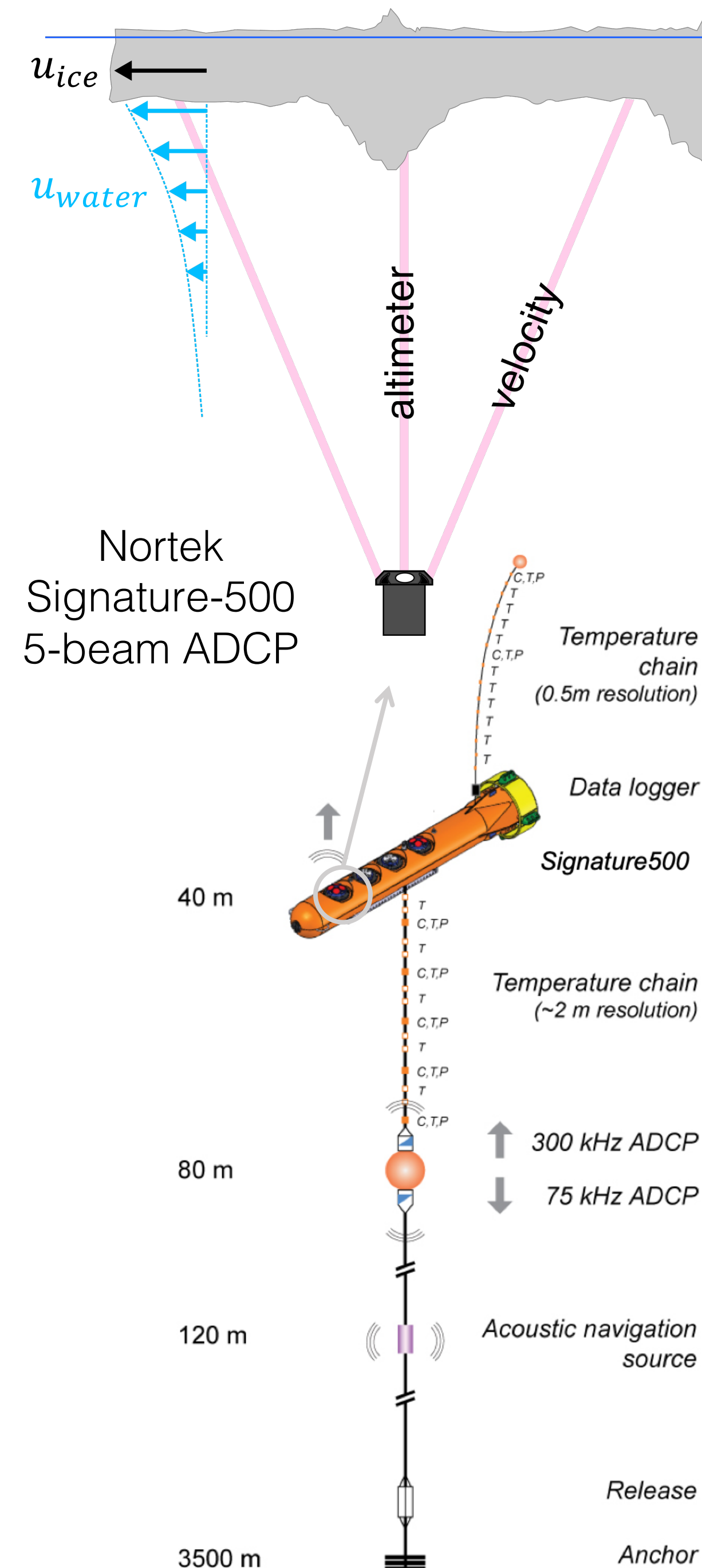
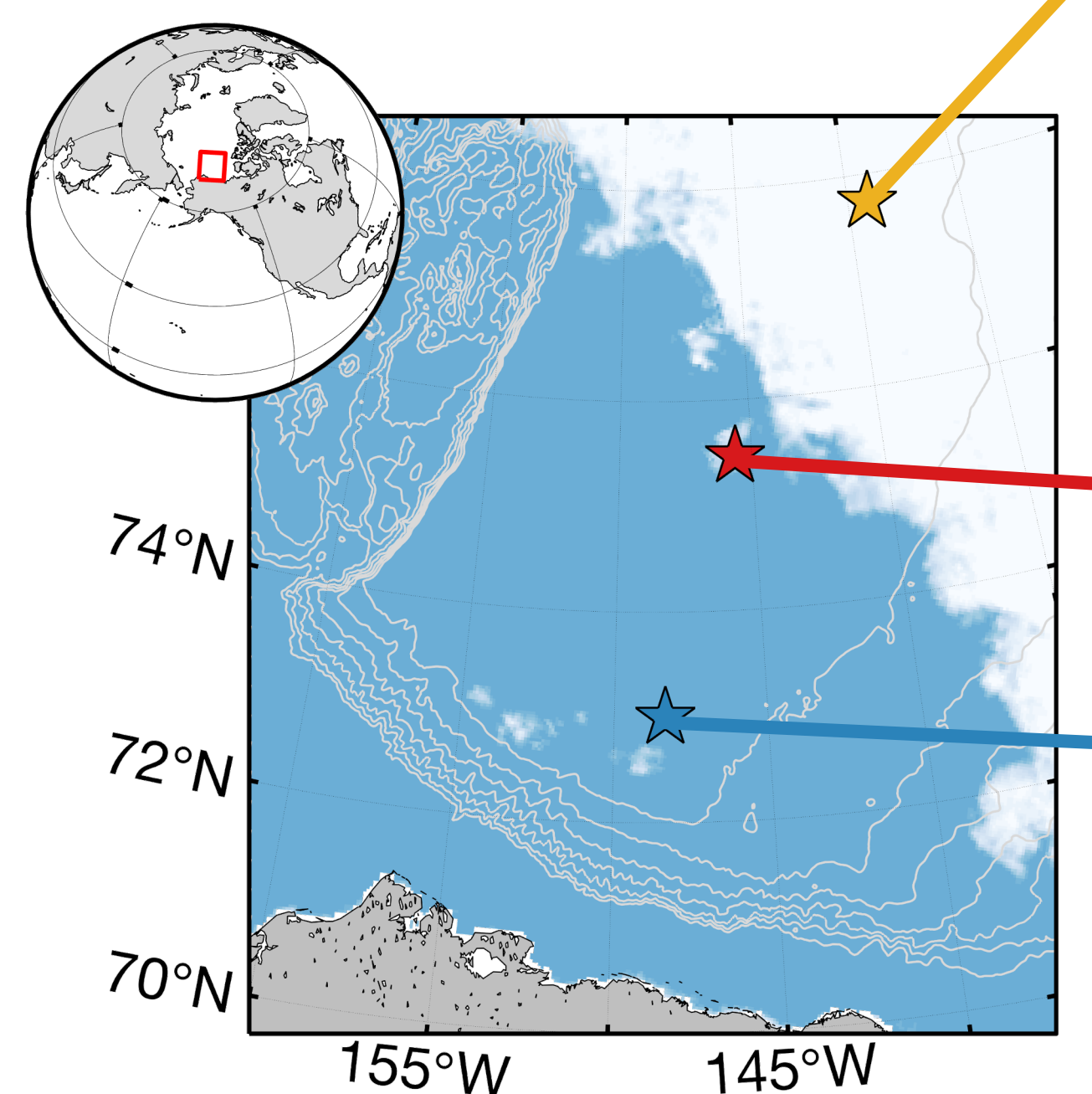
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Key ideas

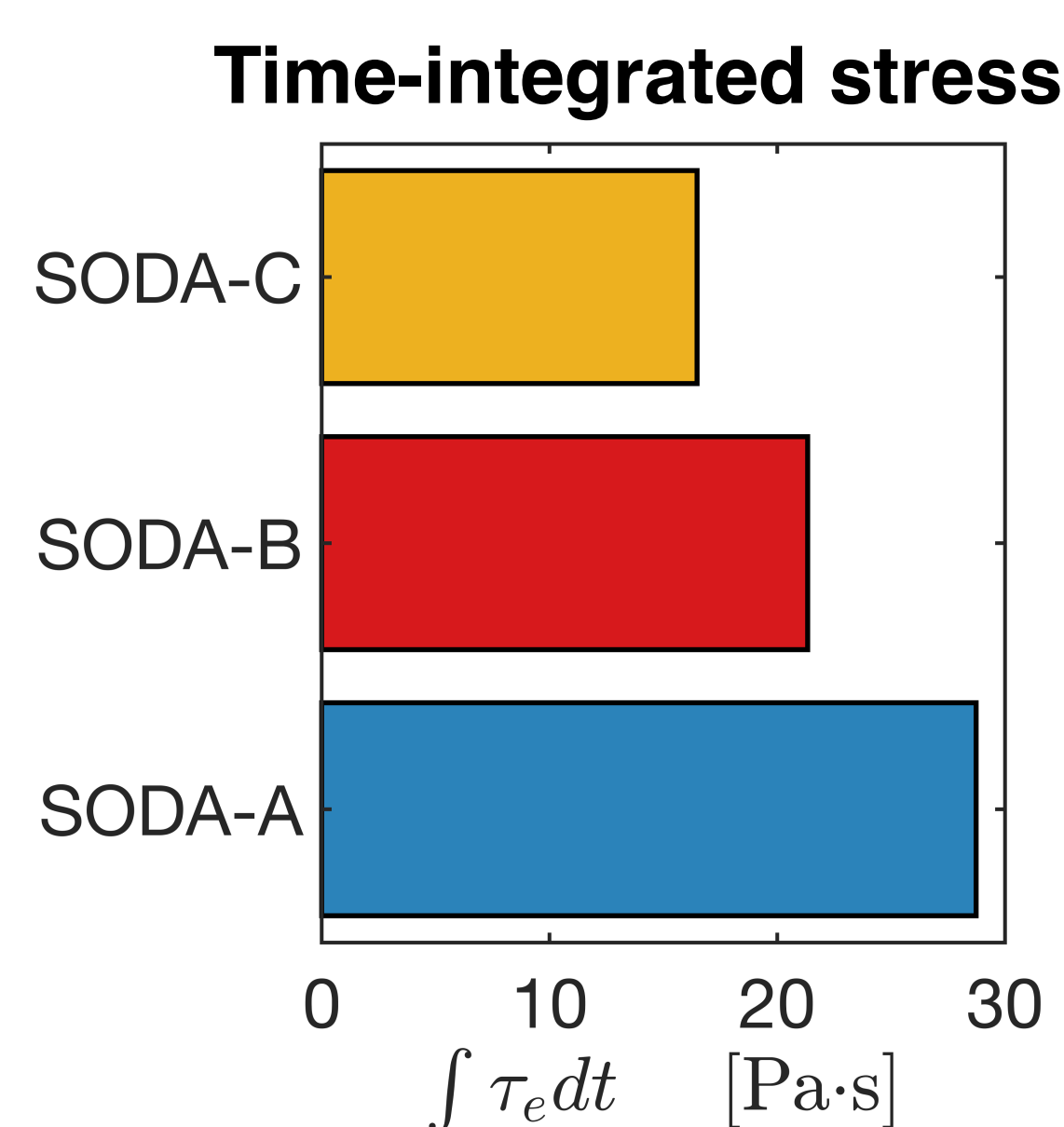
1. We can recover estimates of ice-ocean drag from moorings
2. Ice draft bursts allow ice geometry characterization for use in parameterizations
3. Differences in the upper-ocean momentum match differences in surface stress

Study description

The Stratified Ocean Dynamics of the Arctic (SODA) program took place in the Beaufort Sea, including 3 moorings deployed for a year from Sept. 2018 to Sept. 2019.



Effective surface stress input



Changes in effective stress are driven by both the individual atmosphere and ice stresses and sea ice concentration (A):

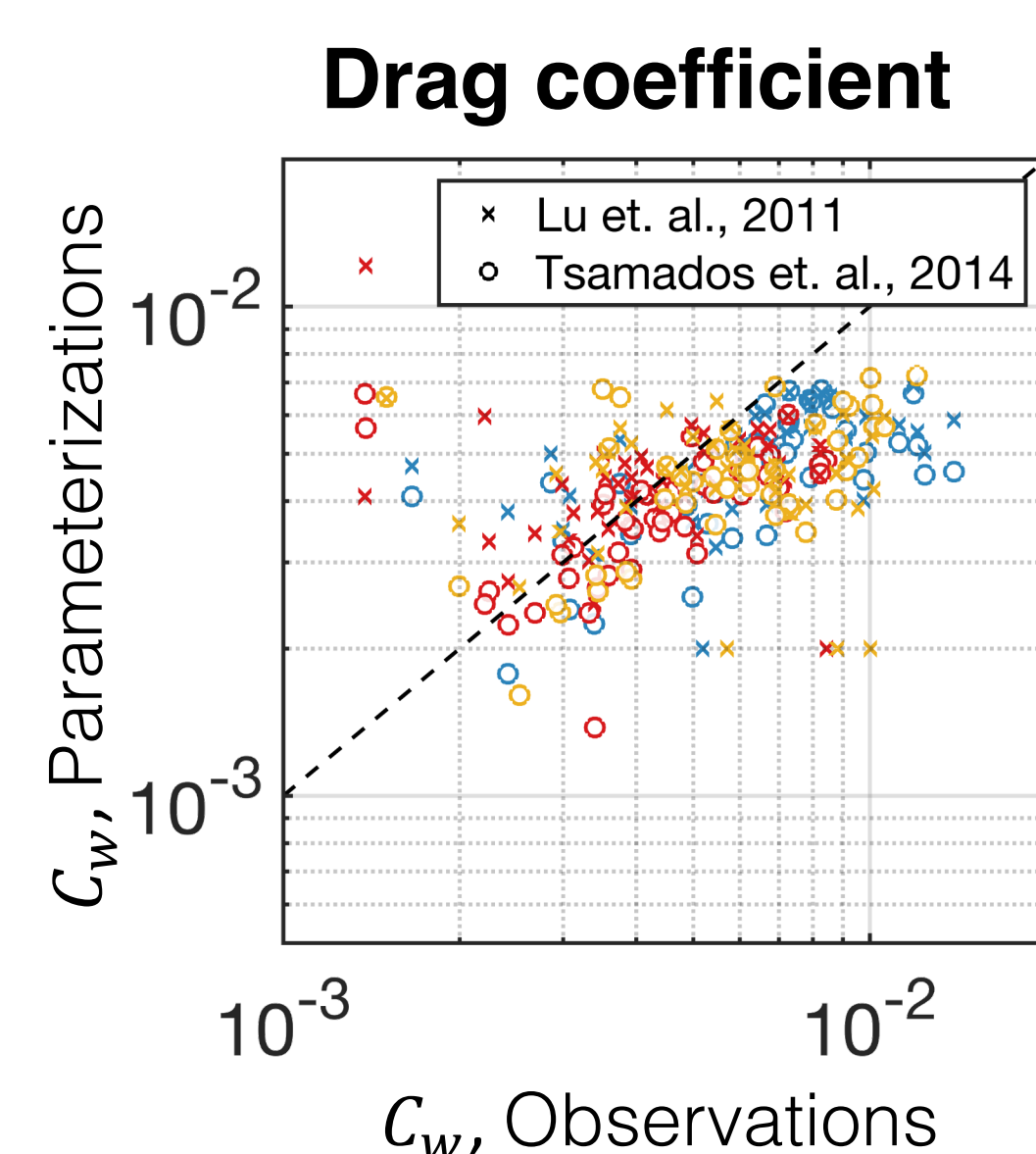
$$\tau_e = (1 - A)\tau_{ao} + A\tau_{io}$$

Differences in upper-ocean momentum across moorings matches with differences in effective surface stress input

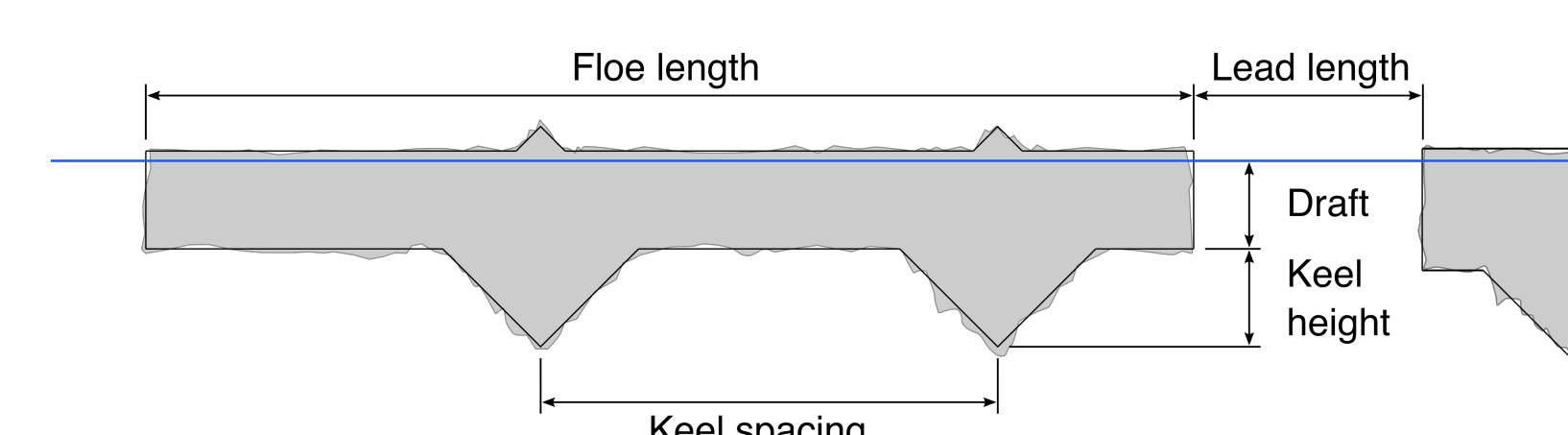
Ice-ocean stress: $\tau_{io} = \rho_w C_w (u_i - u_w) |u_i - u_w|$

Atmosphere-ocean stress: $\tau_{ao} = \rho_a C_{ao} U_{10} |U_{10}|$

Ice-ocean drag parameterization



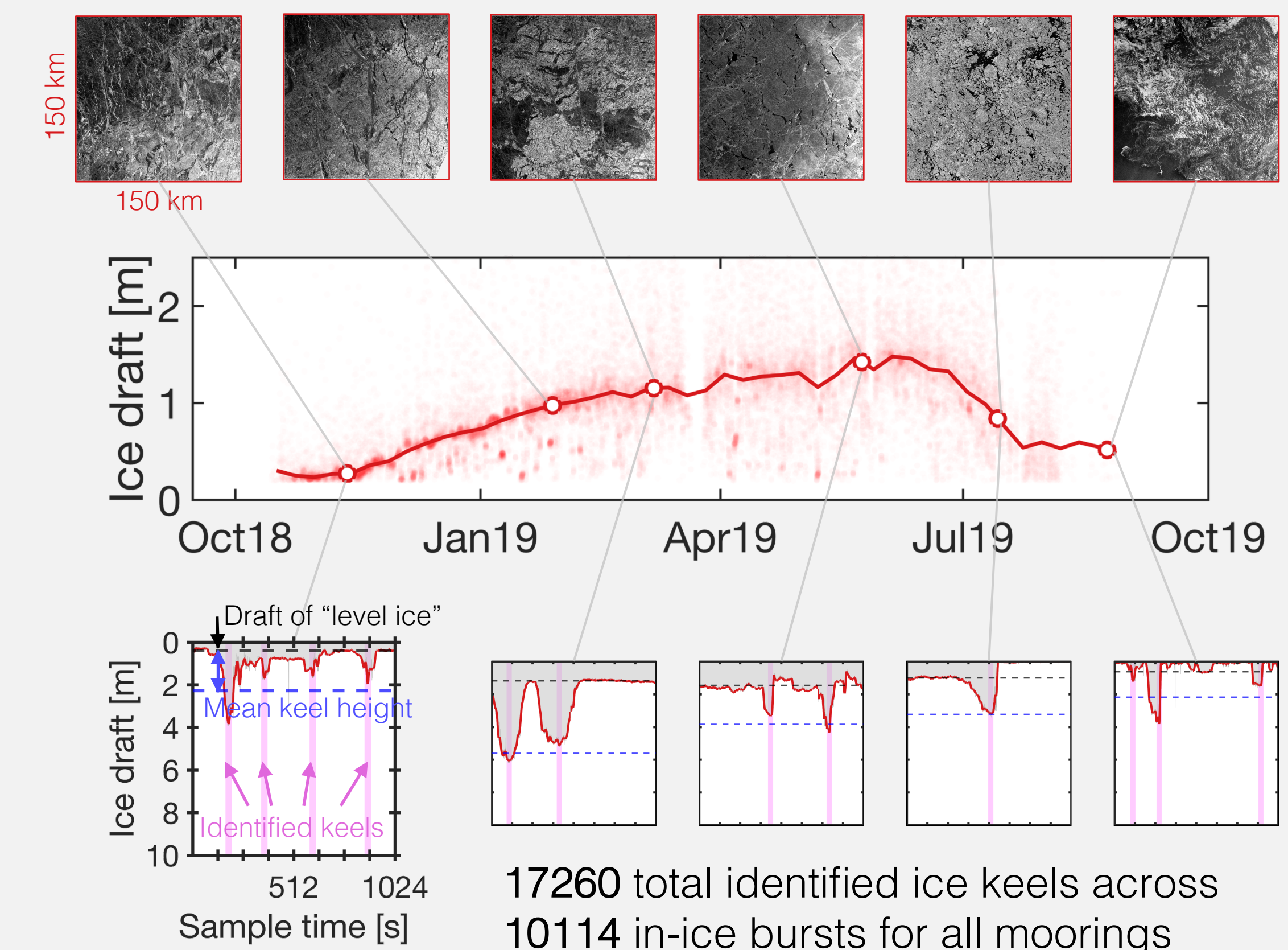
Tsamados et. al. (2014), and Lu et. al. (2011) parameterize the ice-ocean drag coefficient, C_w , in terms of idealized geometric features. We test the parameterizations against estimates from our observations with known ice geometry.



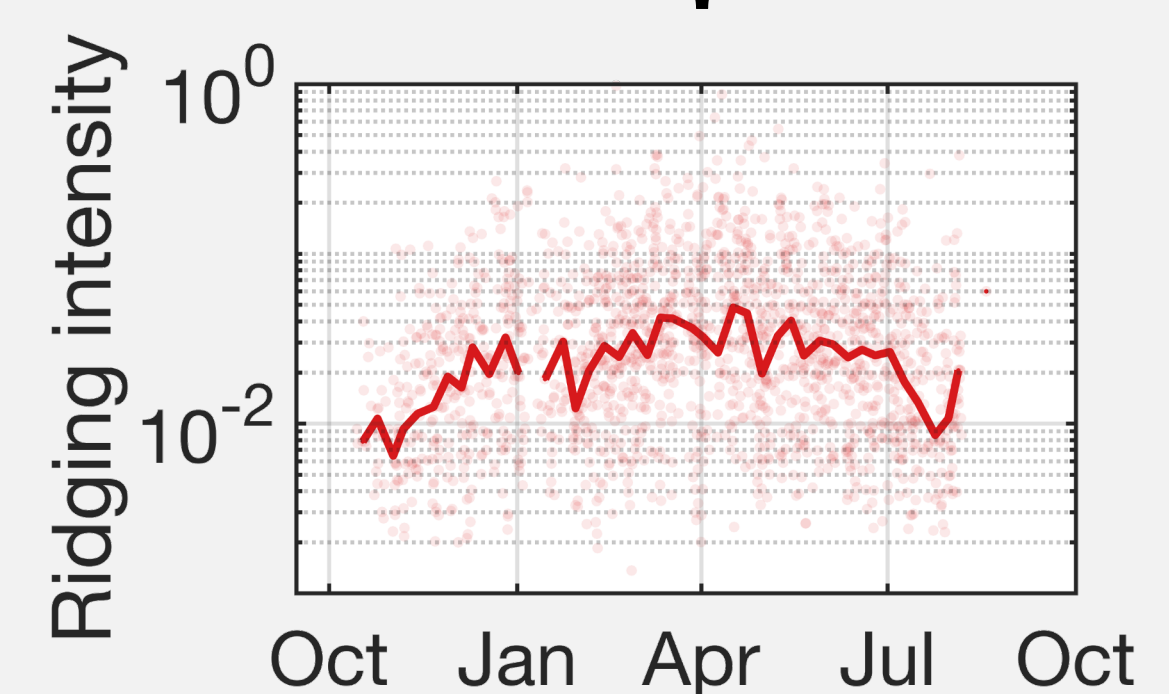
Methods

Ice Geometry

- Burst altimetry data from Signature-500 ADCPs (1024 s @ 2Hz collected every 2 hours) allows for identification and assessment of ice keels and leads
- SAR imagery provides additional context



- Bursts give temporal variation in keel height & spacing, and can be used to derive additional geometric properties



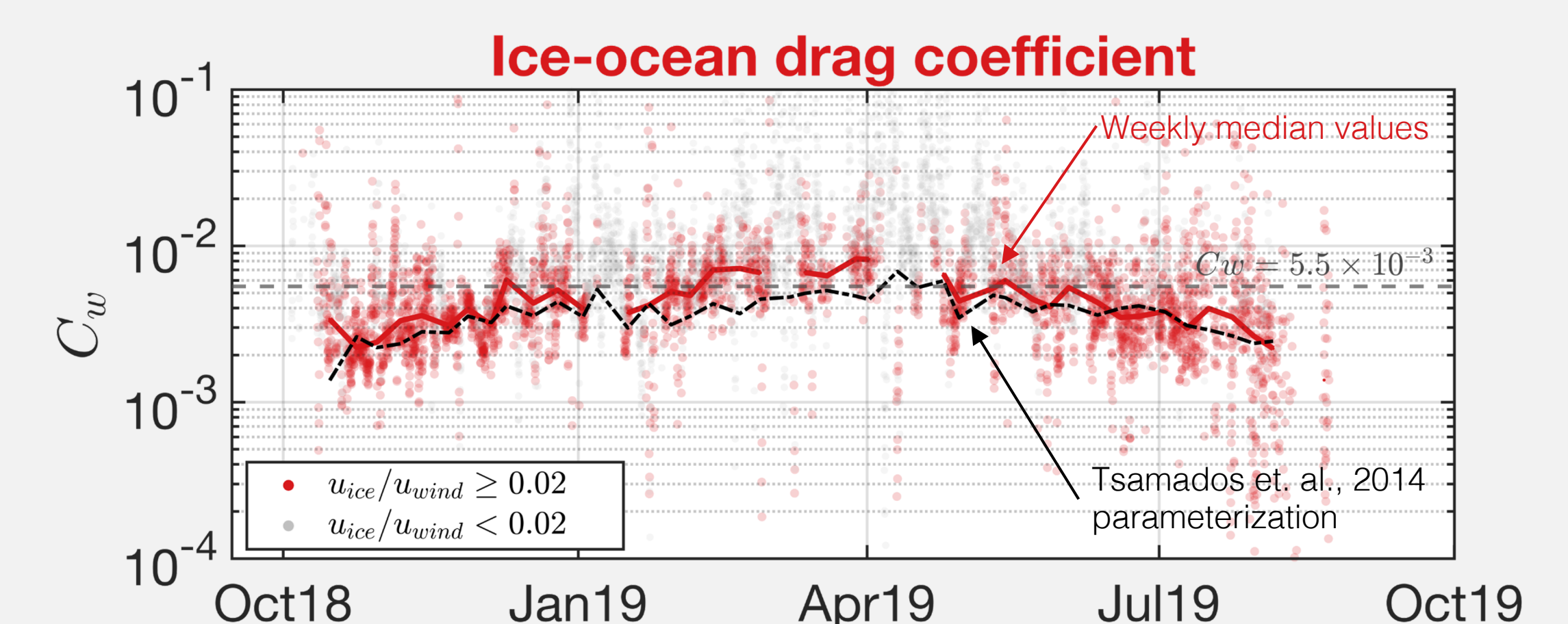
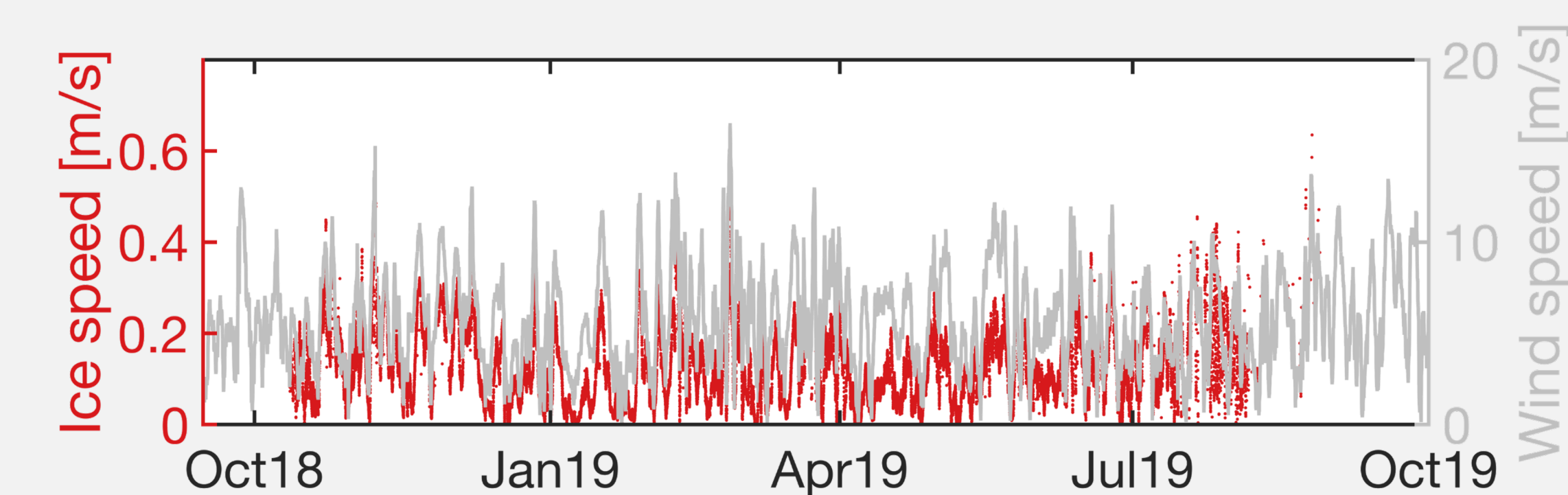
Ice-ocean momentum transfer

Ice momentum equation: $\rho_i h_i \left[\frac{du}{dt} + f \times u_i \right] = \tau_{ai} + \tau_{oi} + \nabla \cdot \sigma$ if $u_{ice}/u_{wind} \geq 0.02$

Ocean-ice stress: $\tau_{oi} = \rho_w C_w e^{i\beta} (u_w - u_i) |u_w - u_i|$

- We estimate the ice-ocean drag coefficient by inverting ice ice momentum in terms of the ocean-ice stress
- This is only valid if internal ice stresses are negligible, which we assume occurs for a high enough ice/wind speed ratio
- Results are sensitive to the inclusion of water velocity u_w

Ice-ocean drag coefficient: $C_w = \left| \frac{\tau_{ai} - \rho_i h_i (f \times u_i)}{\rho_w (u_w - u_i)^2} \right|$



References

- Lu, P, Li, Z, Cheng, B and Leppäranta, M 2011 A parameterization of the ice-ocean drag coefficient. *J Geophys Res*, 116(C07): 019. DOI: <https://doi.org/10.1029/2010JC006878>
- Tsamados, M, Feltham, D, Schroeder, D, Flocco, D, Farrell, SL, et al. 2014 Impact of variable atmospheric and oceanic form drag on simulations of Arctic sea ice. *J Phys Oceanogr*, 44: 1329–1353. DOI: <https://doi.org/10.1175/JPO-D-13-0215.1>

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