

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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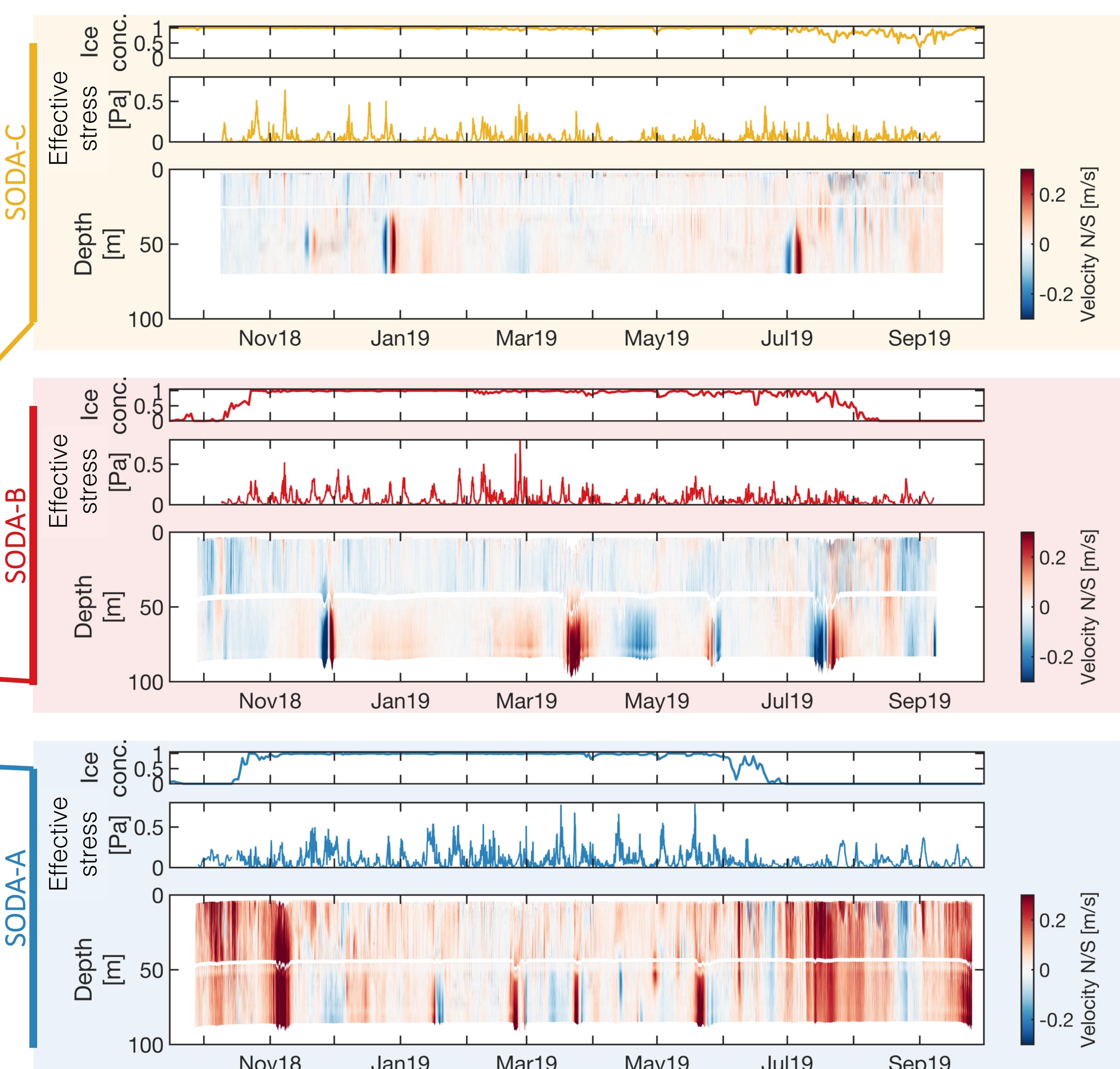
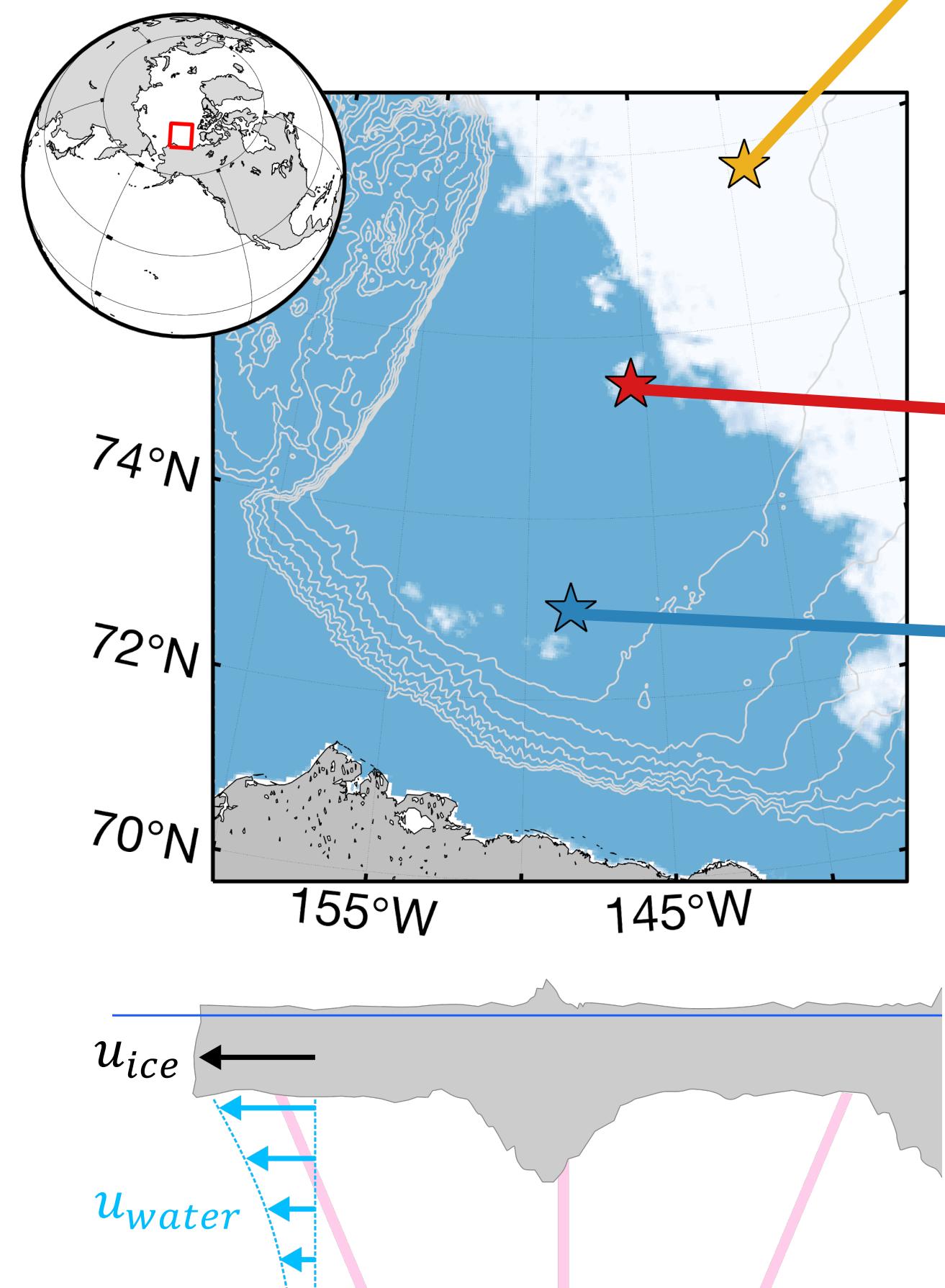
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Key ideas

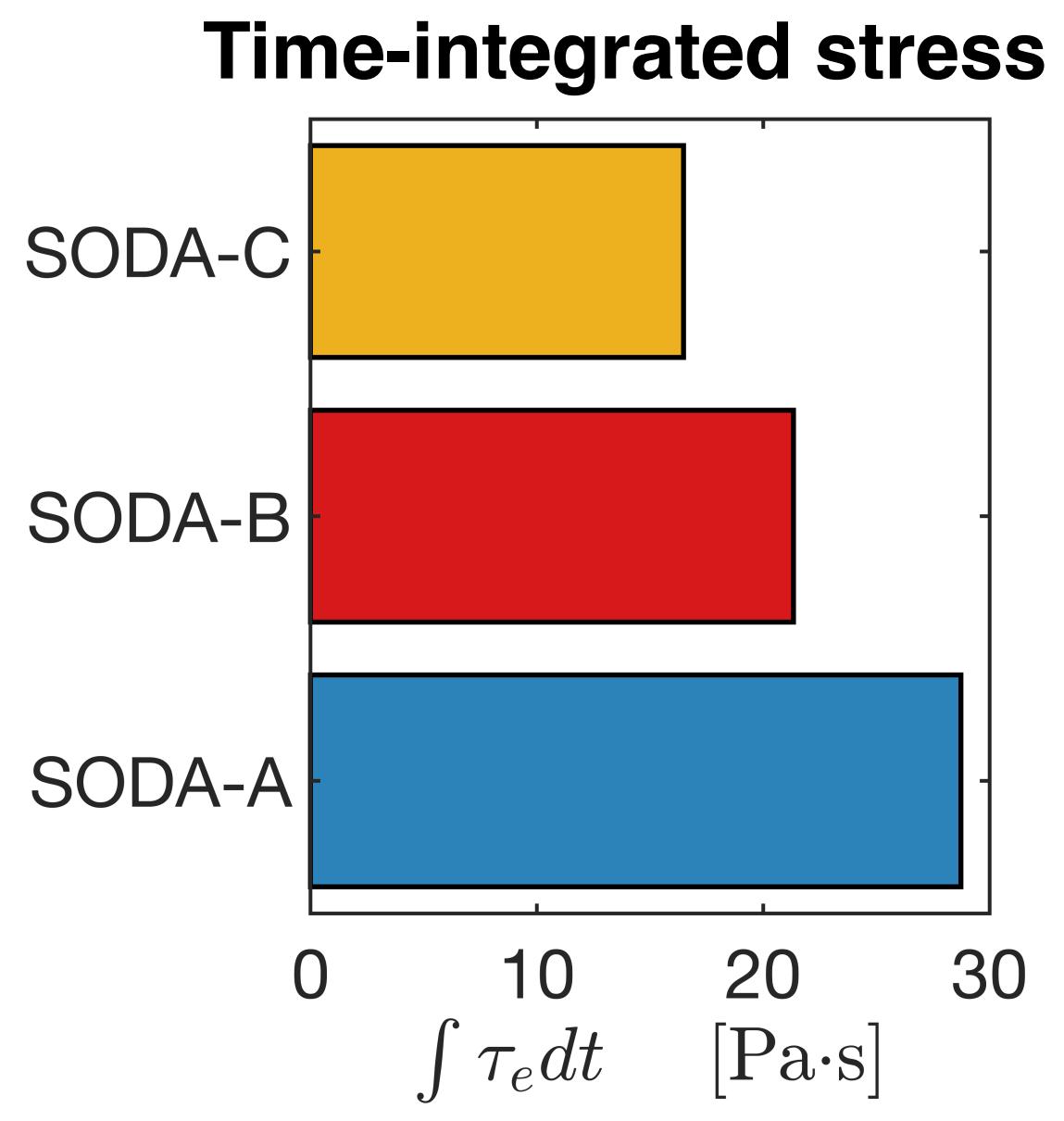
1. We can recover estimates of ice-ocean drag from moorings
2. Ice draft bursts allow ice geometry characterization for use in parameterizations
3. Differences in the upper-ocean momentum match differences in surface stress

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.



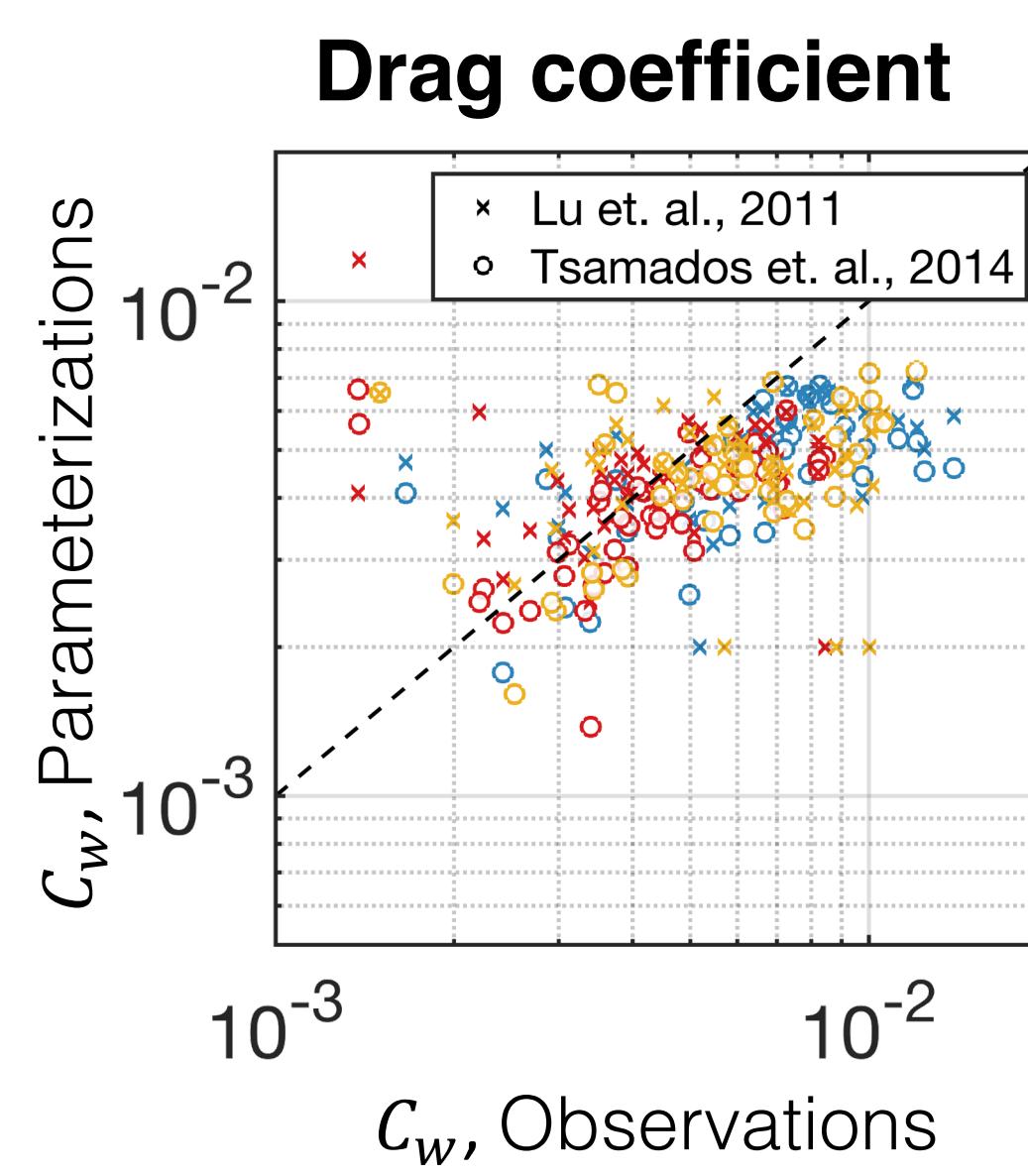
Effective surface stress input



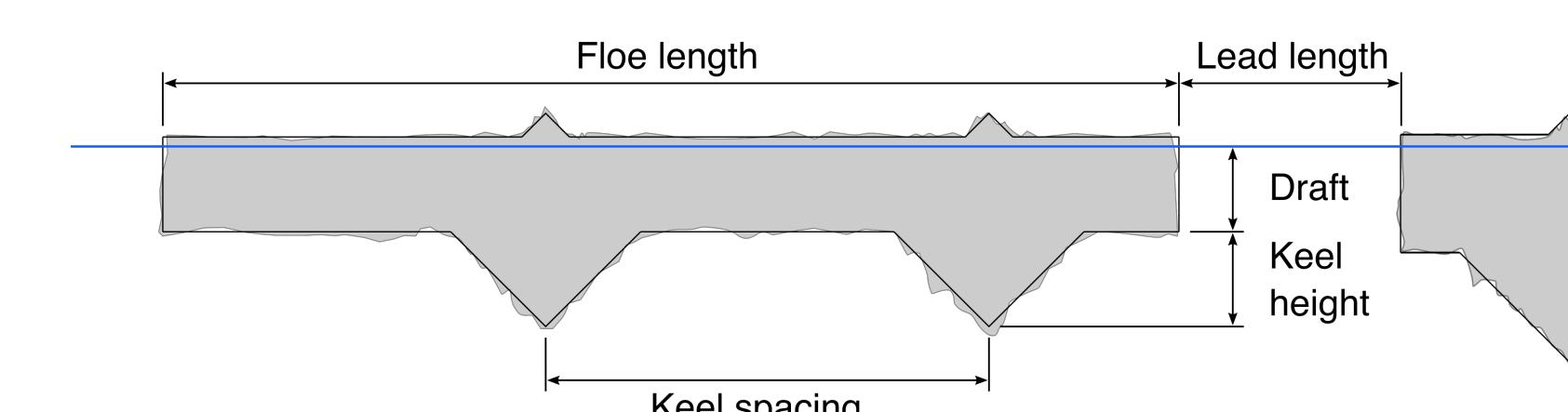
Changes in effective stress are driven by both the individual atmosphere and ice stresses and sea ice concentration (A):
 $\tau_e = (1 - A)\tau_{ao} + A\tau_{oi}$

Differences in upper-ocean momentum across moorings matches with differences in effective surface stress input
 $\tau_{oi} = \rho_w C_w (\mathbf{u}_i - \mathbf{u}_w) |\mathbf{u}_i - \mathbf{u}_w|$
 $\tau_{ao} = \rho_a C_{ao} \mathbf{U}_{10} |\mathbf{U}_{10}|$

Ice-ocean drag parameterization



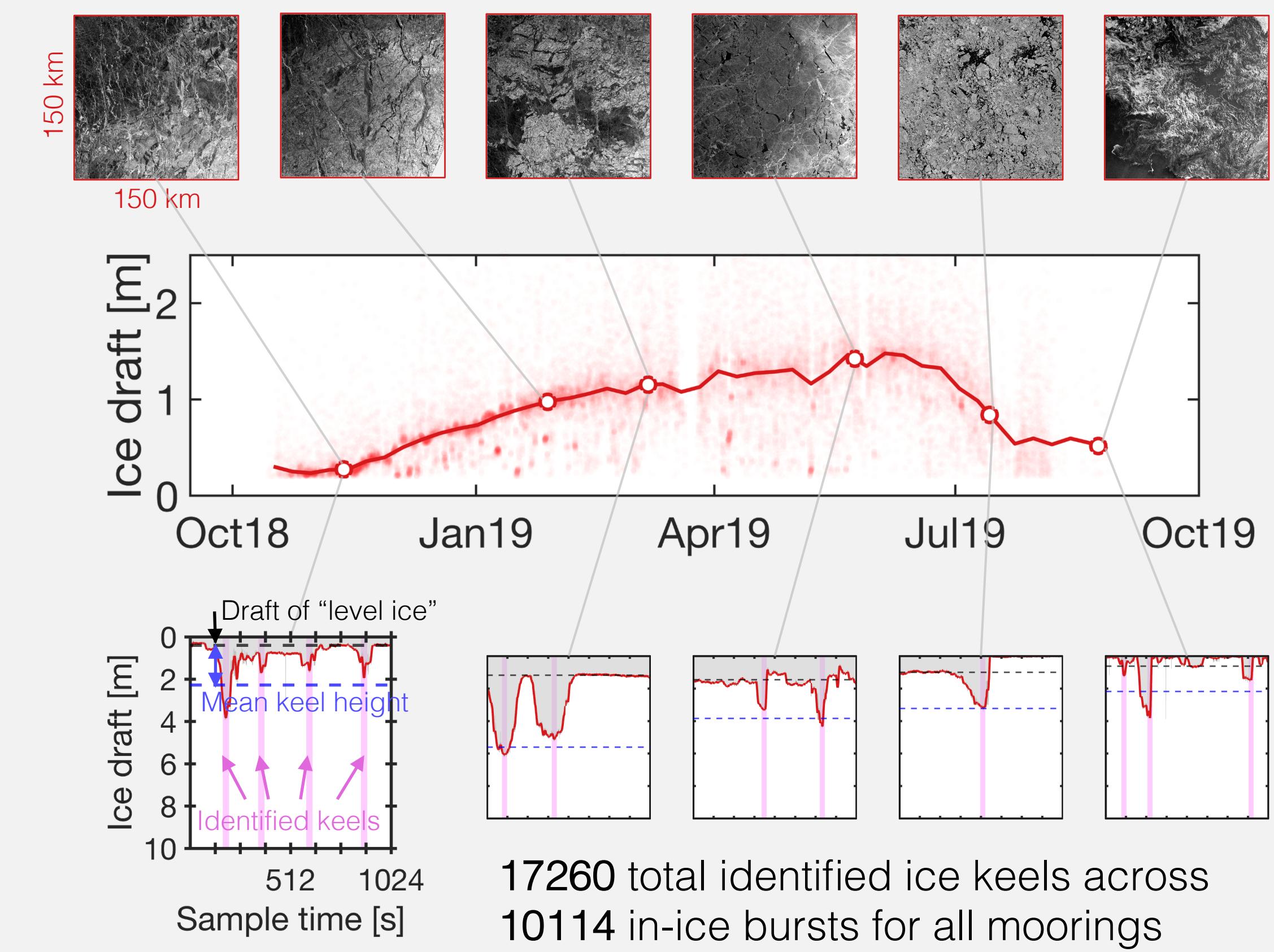
Tsamados et. al. (2014), and Lu et. al. (2011) parameterize the ice-ocean drag coefficient, C_w , in terms of idealized geometric features. We test the parameterizations against estimates from our observations with known ice geometry.



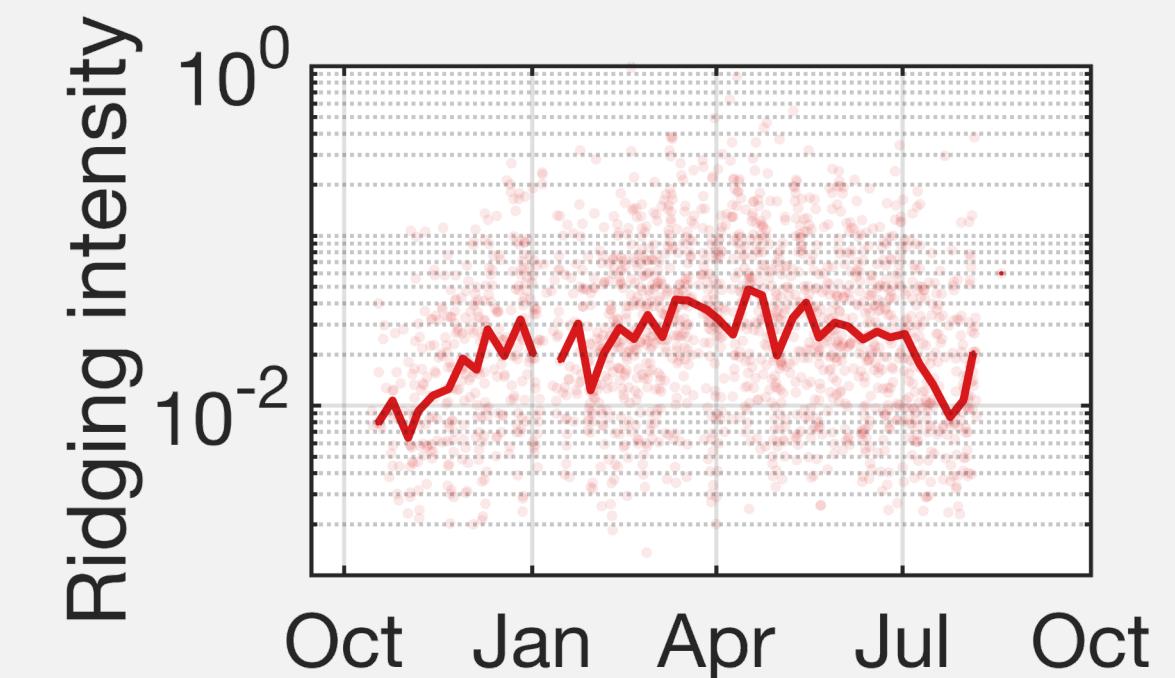
Methods

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



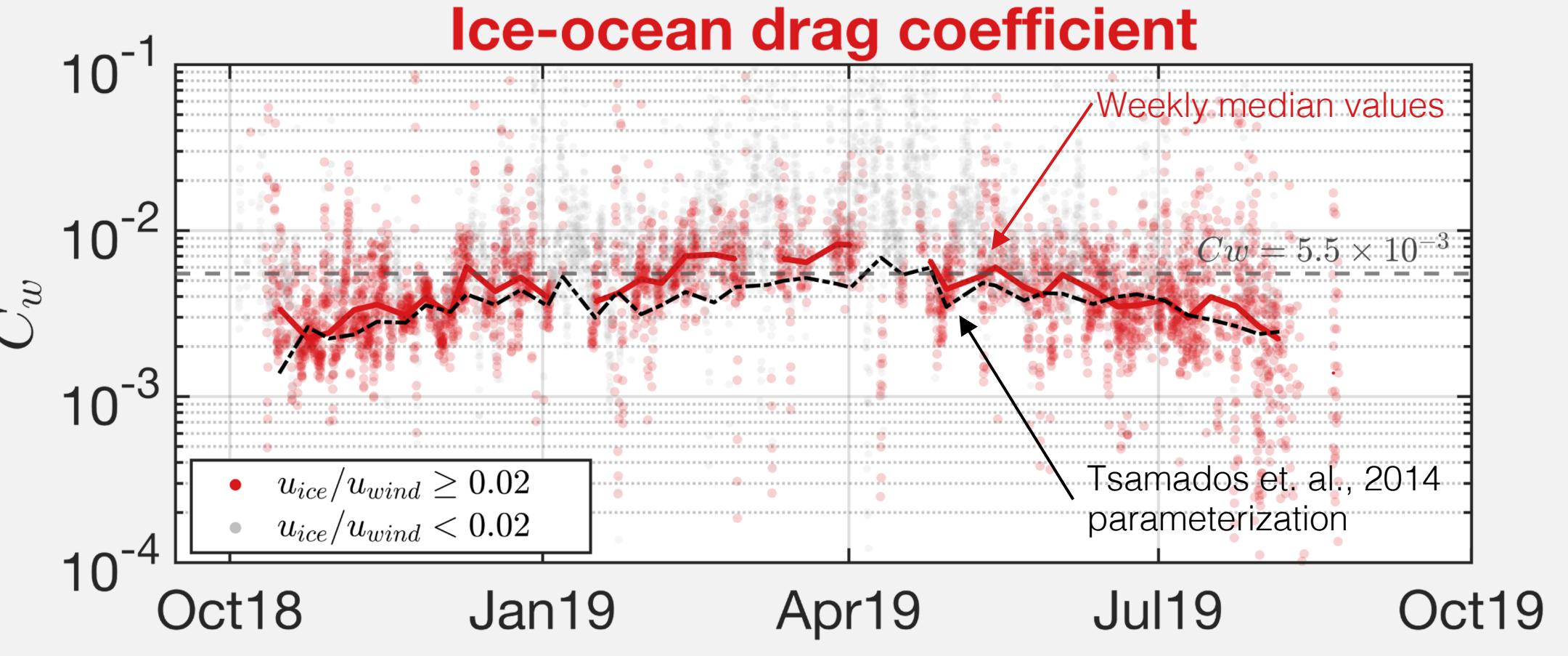
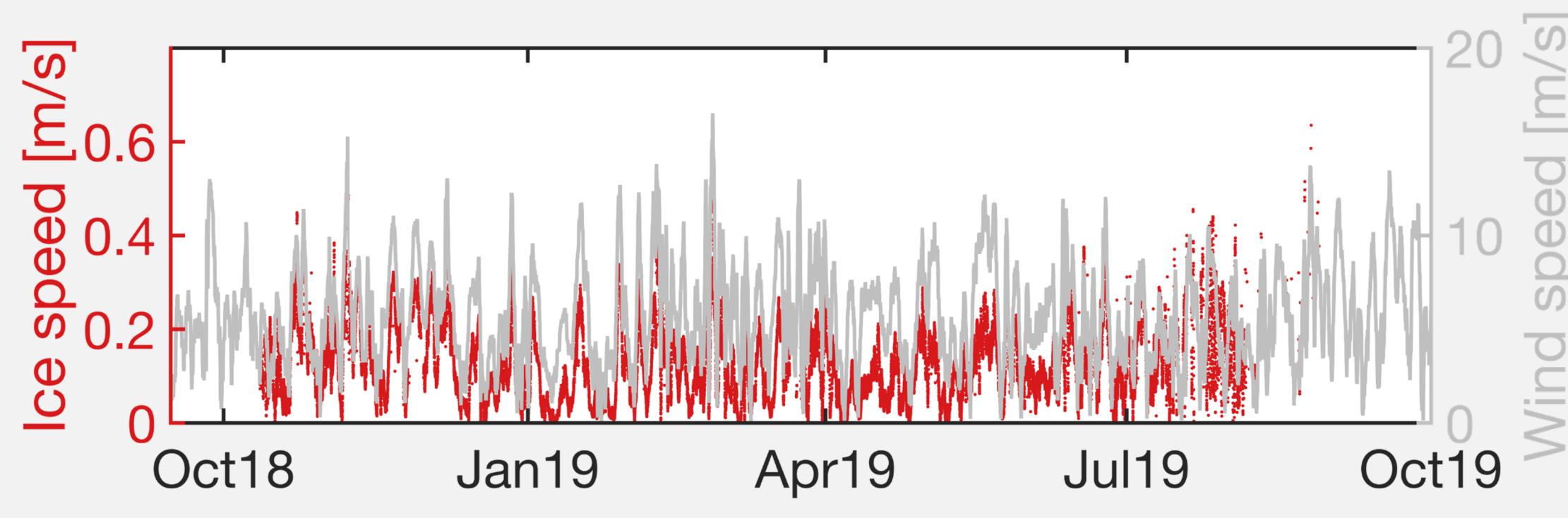
Ice-ocean momentum transfer

Ice momentum equation: $\rho_i h_i \left[\frac{d\mathbf{u}}{dt} + \mathbf{f} \times \mathbf{u}_i \right] = \boldsymbol{\tau}_{ai} + \boldsymbol{\tau}_{oi} + \nabla \cdot \boldsymbol{\sigma}$

Ocean-ice stress: $\boldsymbol{\tau}_{oi} = \rho_w C_w e^{i\beta} (\mathbf{u}_w - \mathbf{u}_i) |\mathbf{u}_w - \mathbf{u}_i|$

- We estimate the ice-ocean drag coefficient by inverting 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 \mathbf{u}_w

Ice-ocean drag coefficient: $C_w = \left| \frac{\boldsymbol{\tau}_{ai} - \rho_i h_i (\mathbf{f} \times \mathbf{u}_i)}{\rho_w (\mathbf{u}_w - \mathbf{u}_i)^2} \right|$



References

- Lu, P, Li, Z, Cheng, B and Leppäraanta, 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>



Acknowledgements:

We would like to thank the Office of Naval Research (ONR) for funding support, the National Ice Centre (NIC) for providing satellite imagery, the captain and crew of the USCGC Healy for operational support, and SODA project team members.

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