

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

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

Samuel Brenner<sup>1</sup>, Luc Rainville<sup>1</sup>, Jim Thomson<sup>1</sup>, Jennifer MacKinnon<sup>2</sup>, Craig Lee<sup>1</sup>

<sup>1</sup> Applied Physics Laboratory, University of Washington, Seattle, WA

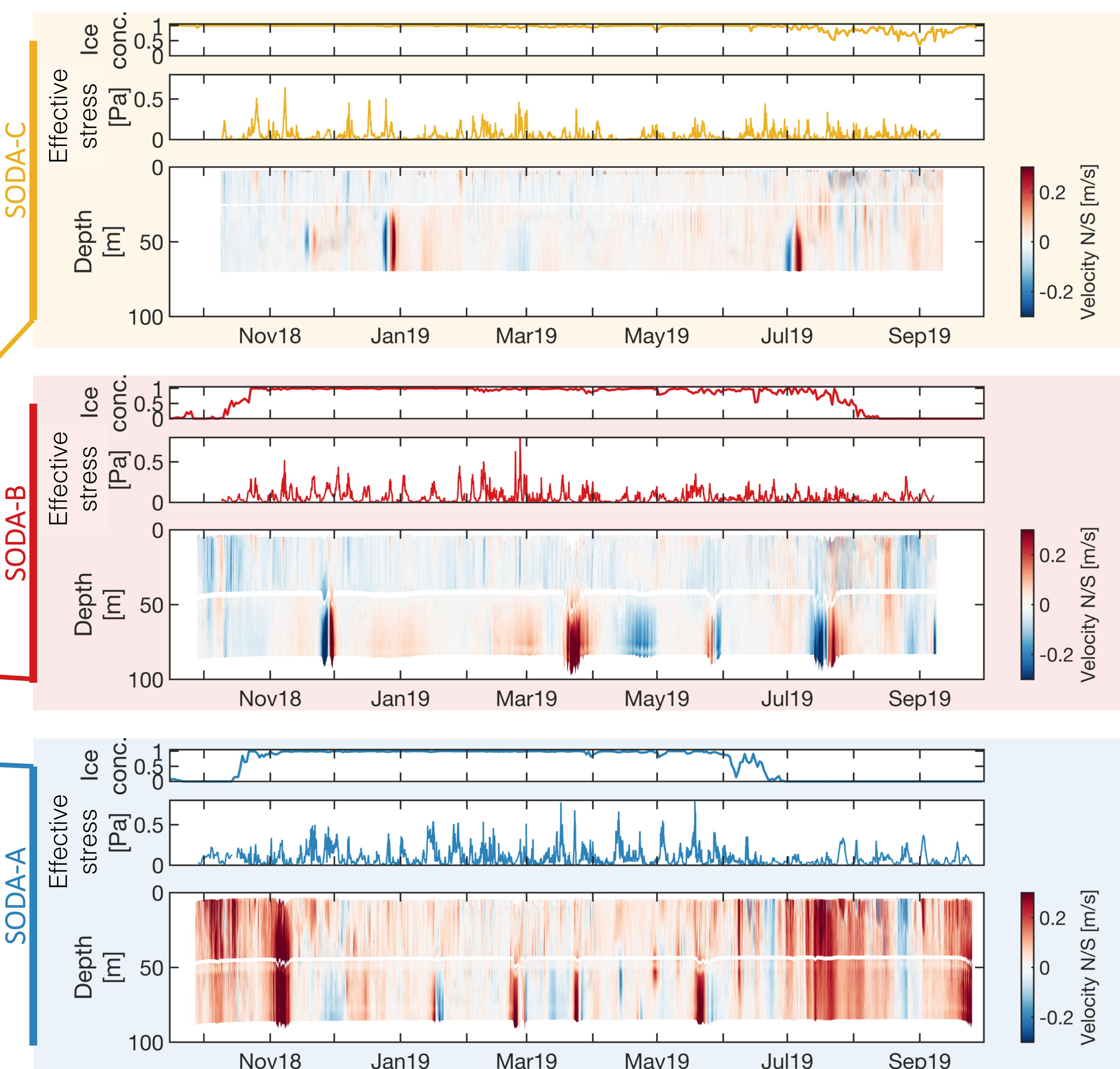
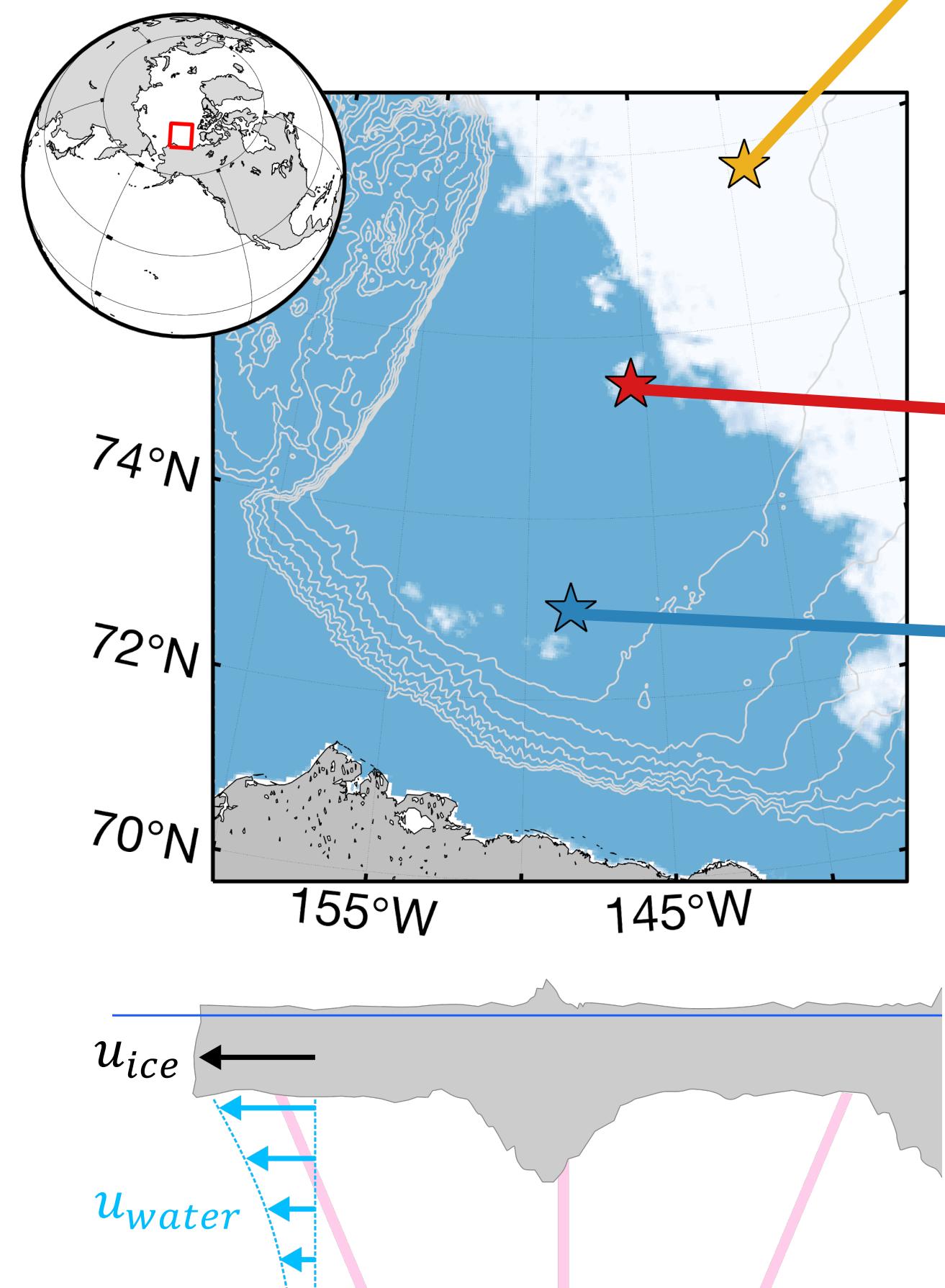
<sup>2</sup> Scripps Institution of Oceanography, La Jolla, CA

## Key ideas

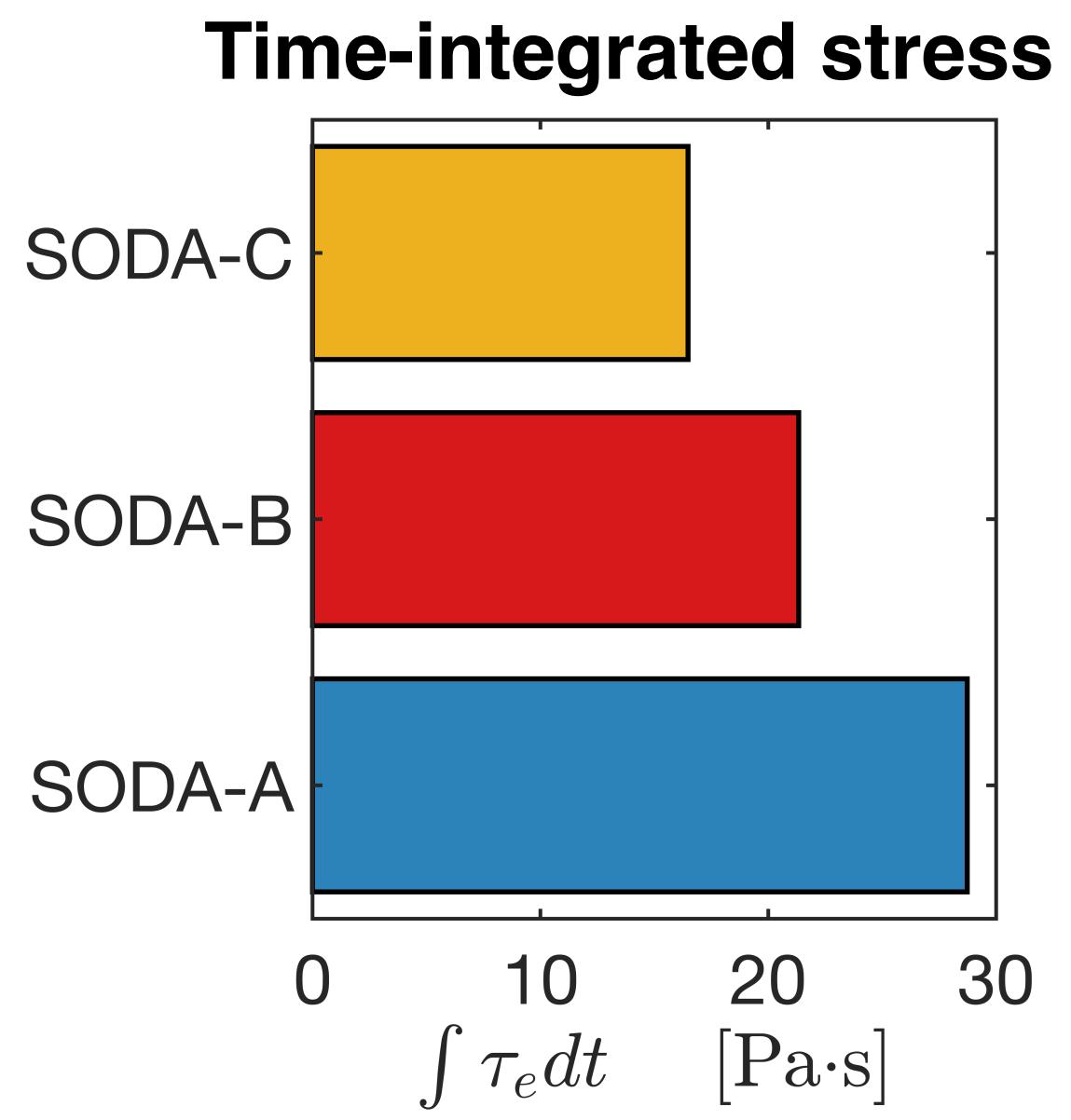
1. We can recover estimates of ice-ocean drag from moorings
2. Ice draft bursts allow ice geometry characterization for use in parameterizations
3. Differences in the upper-ocean momentum match differences in surface stress

## 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 ( $A$ ):  

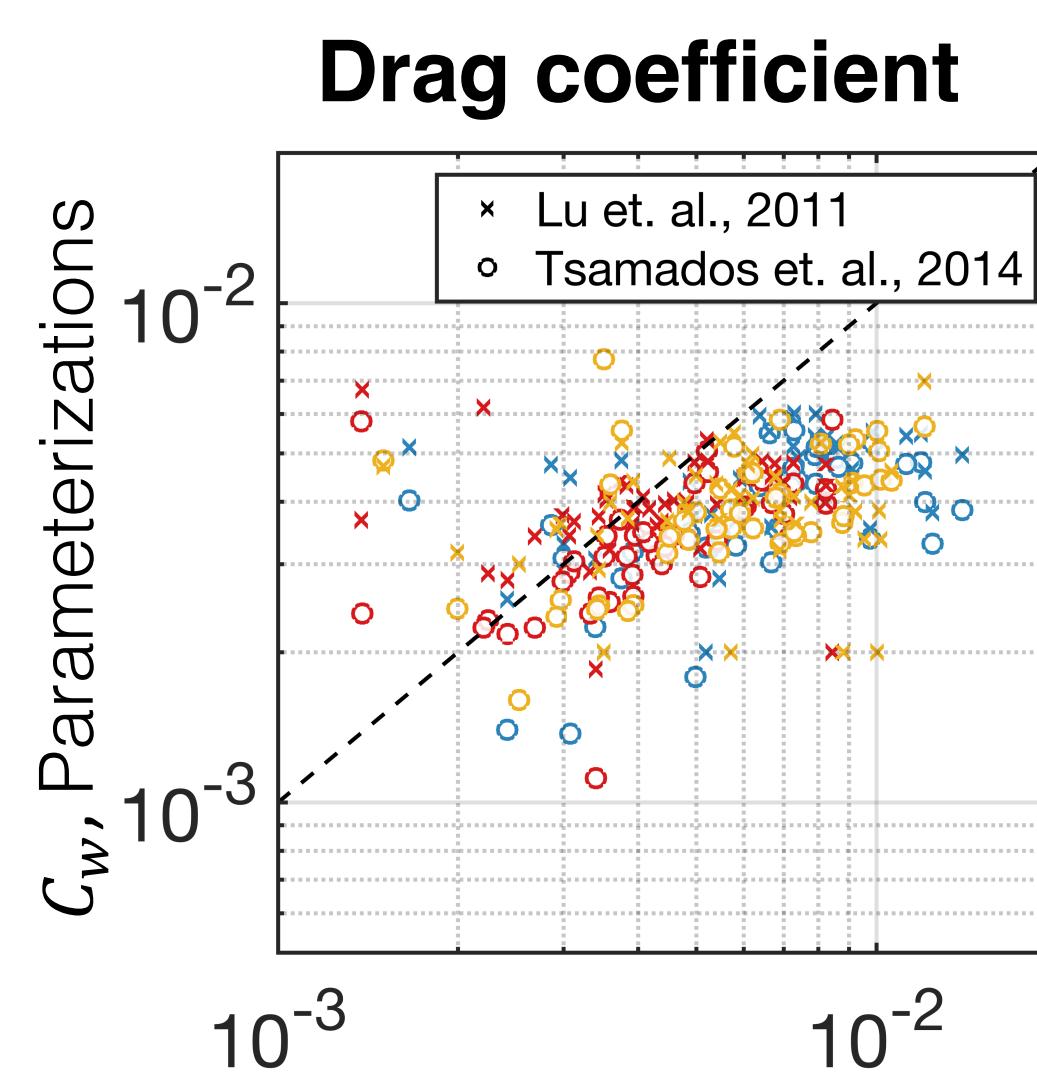
$$\tau_e = (1 - A)\tau_{ao} + A\tau_{oi}$$

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

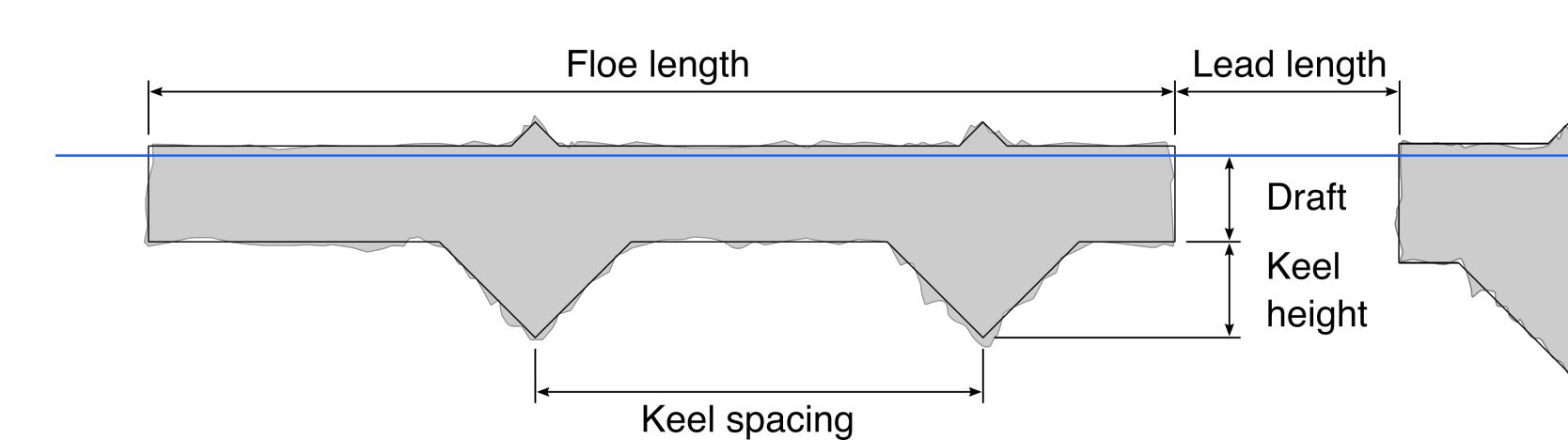
$$\tau_{oi} = \rho_w C_w (\mathbf{u}_i - \mathbf{u}_w) |\mathbf{u}_i - \mathbf{u}_w|$$
  

$$\tau_{ao} = \rho_a C_{ao} \mathbf{U}_{10} |\mathbf{U}_{10}|$$

## 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.



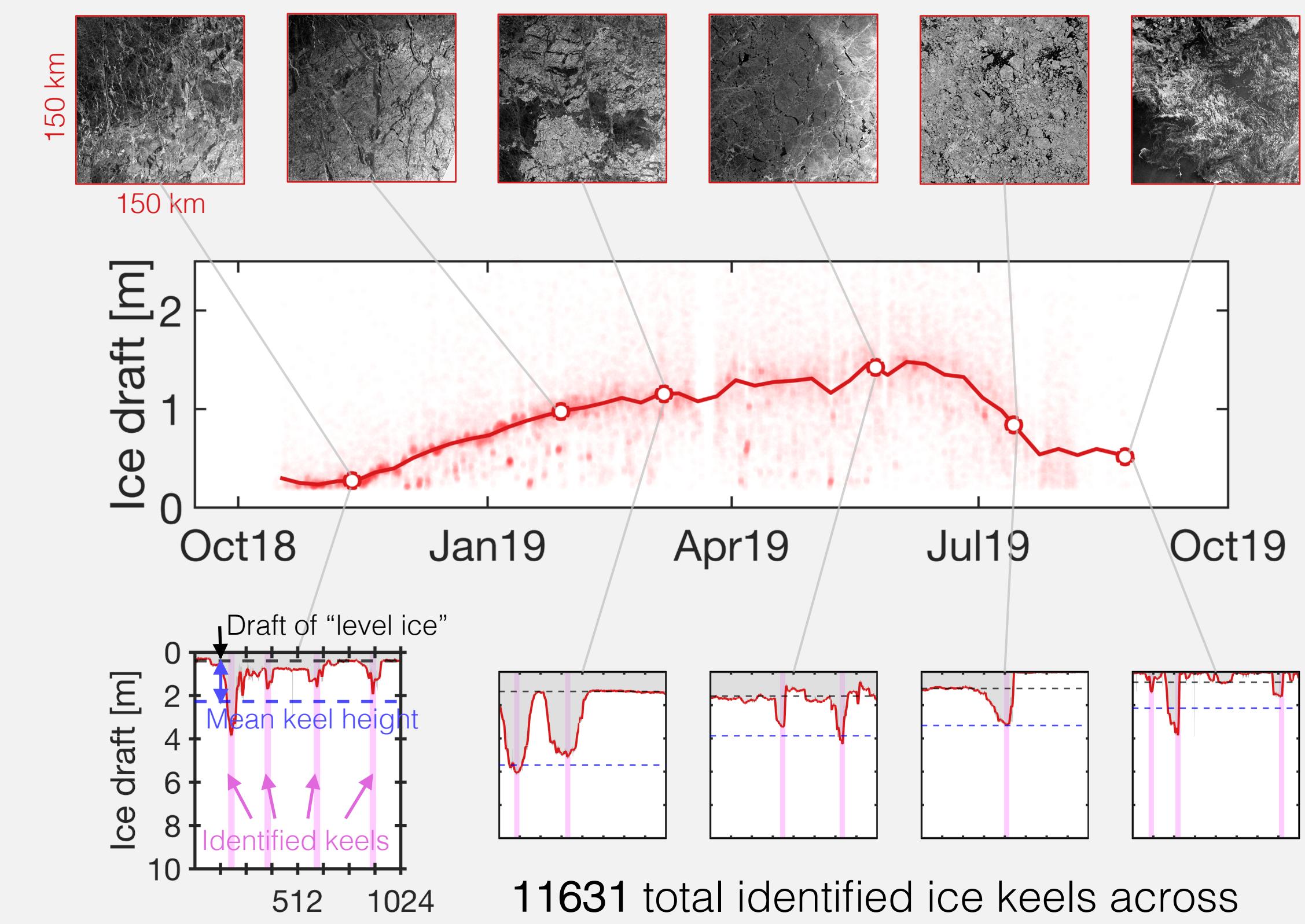
## Acknowledgements:

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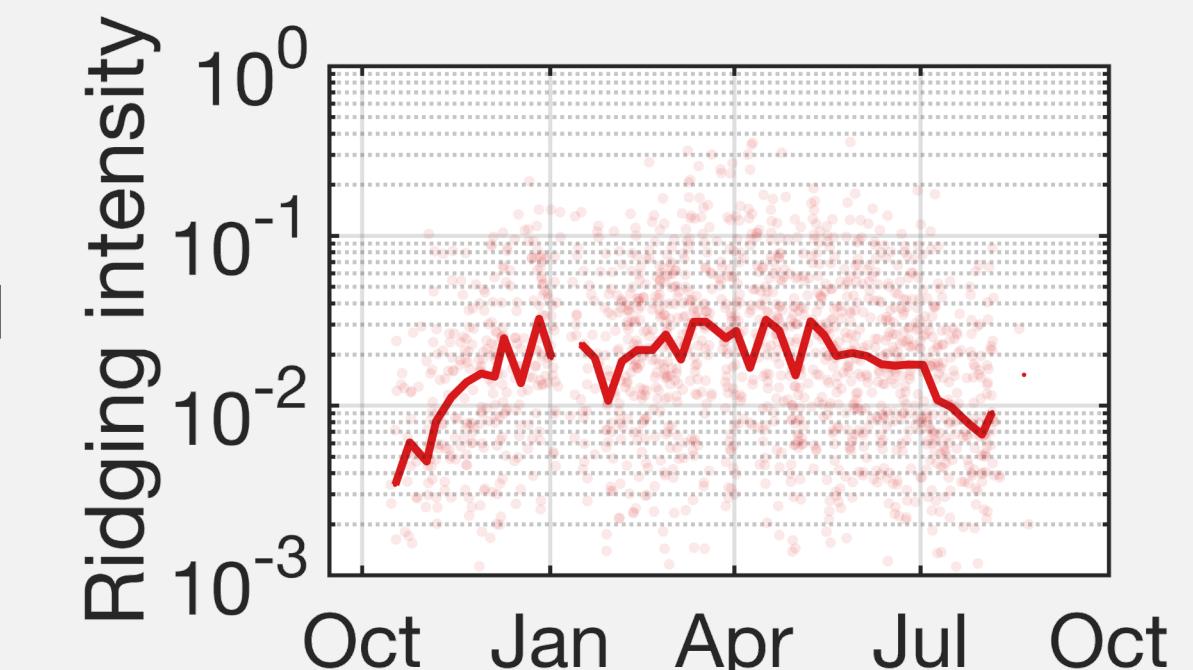
## Methods

### 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



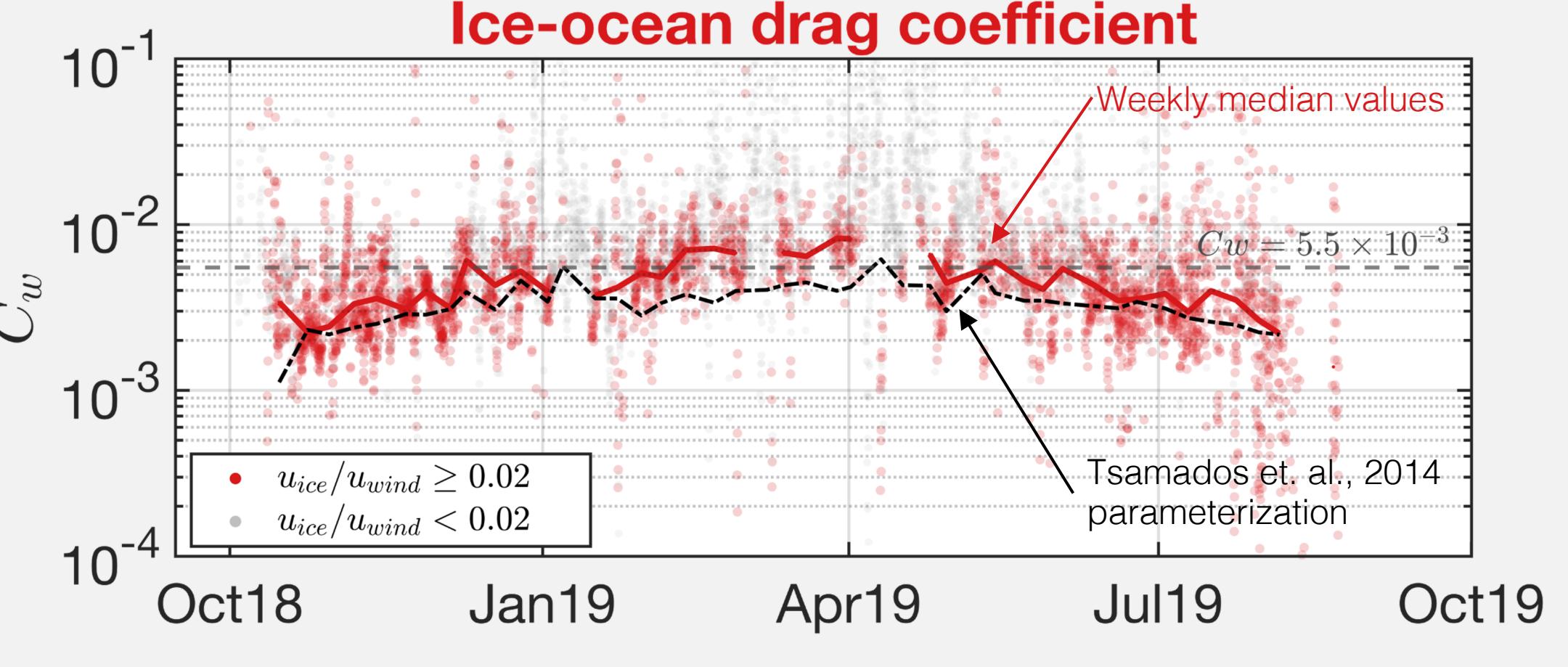
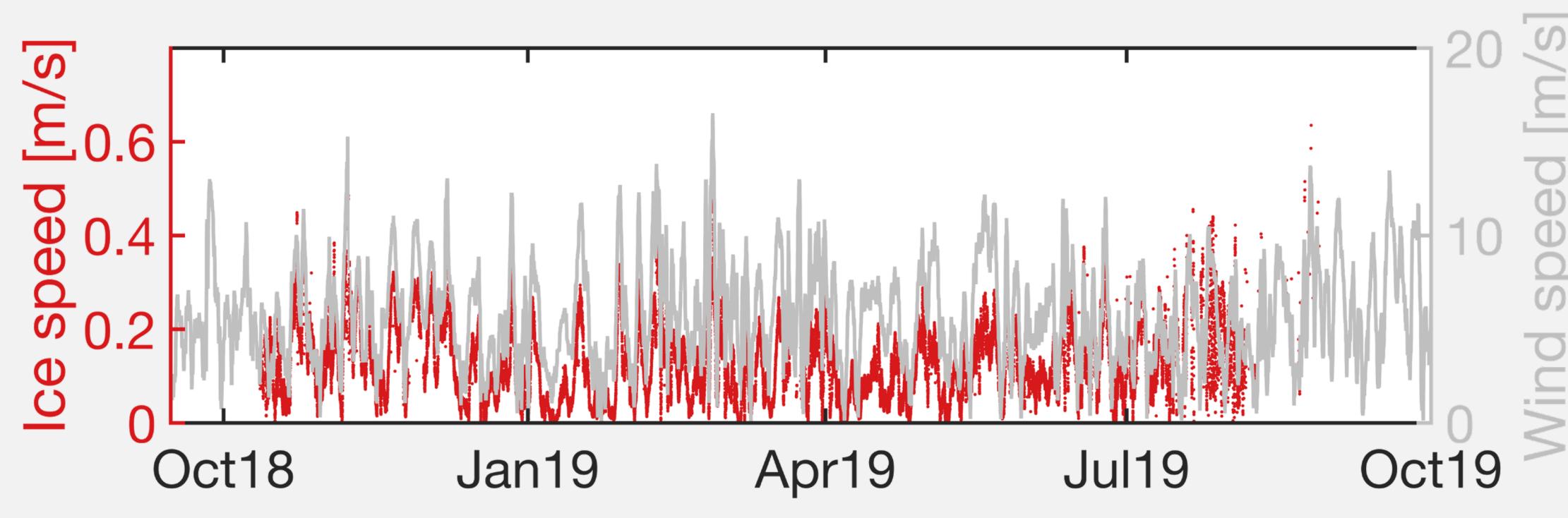
### Ice-ocean momentum transfer

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

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

- 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:  $C_w = \left| \frac{\tau_{ai} - \rho_i h_i (\mathbf{f} \times \mathbf{u}_i)}{\rho_w (\mathbf{u}_w - \mathbf{u}_i)^2} \right|$



### 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>

To learn more about the SODA research program, visit: [www.apl.washington.edu/soda](http://www.apl.washington.edu/soda)



Corresponding author:  
**Samuel Brenner**  
 Applied Physics Lab  
 University of Washington  
[sdbren@uw.edu](mailto:sdbren@uw.edu)

