

## **Final Report: Wind Stress Inversion for the Arctic Ocean**

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Award Number: N00014-16-1-2349  
<http://www.apl.uw.edu/soda>

### **LONG-TERM GOALS**

The long-term goal of this project has been to improve understanding of the Arctic ice-ocean-atmosphere using using persistent, autonomous measurements of surface forcing throughout an annual cycle.

### **OBJECTIVES**

The specific objectives have been to use observations to

- Infer the wind input to the Arctic Ocean in the presence *and* absence of sea ice cover
- Estimate the modulation of this wind input by surface waves
- Understand the associated changes to stratification
- Improve parameterizations of these processes for use in forecast models

### **APPROACH**

A large collaborative team funded under the Stratified Ocean Dynamics Arctic (SODA) Department Research Initiative developed a coordinated science plan (Lee et al, 2016). The field components were conducted in 2018-2019, and collaborative analysis has been ongoing since then. A PhD student, Sam Brenner, has been leading much of the analysis.

### **WORK COMPLETED**

Autonomous Wave Glider and SWIFT buoy missions in summer 2018 mapped the surface temperature and salinity anomalies related to remnant sea ice in the Beaufort Sea, as well as heat transported from the Bering Strait (MacKinnon et al, 2021). The SWIFT measurements were further used to diagnose wave-driven transport along the edge of the marginal ice zone (Thomson et al, 2021).

Year-long mooring observations using uplooking Nortek Signature 500 profilers mounted on Stablemoor platforms from 2018-2019 recorded the ice draft and drift, along with wave activity and [inferred] wind forcing (Brenner et al, 2021). These measurements compliment an ongoing effort to measure surface waves and ice on the BGOS moorings, including a new data archive developed under this award (Thomson, 2020).

## RESULTS

The Wave Glider and SWIFT observations showed that remnant sea ice in the summer can cause strong near surface stratification and pre-condition the surface for freezing the the autumn (Figure 1). The observations also showed the strong influence of lateral advection in transporting ocean heat (MacKinnon et al, 2021) and the strong influence of surface waves in transporting ice (Thomson et al, 2021).

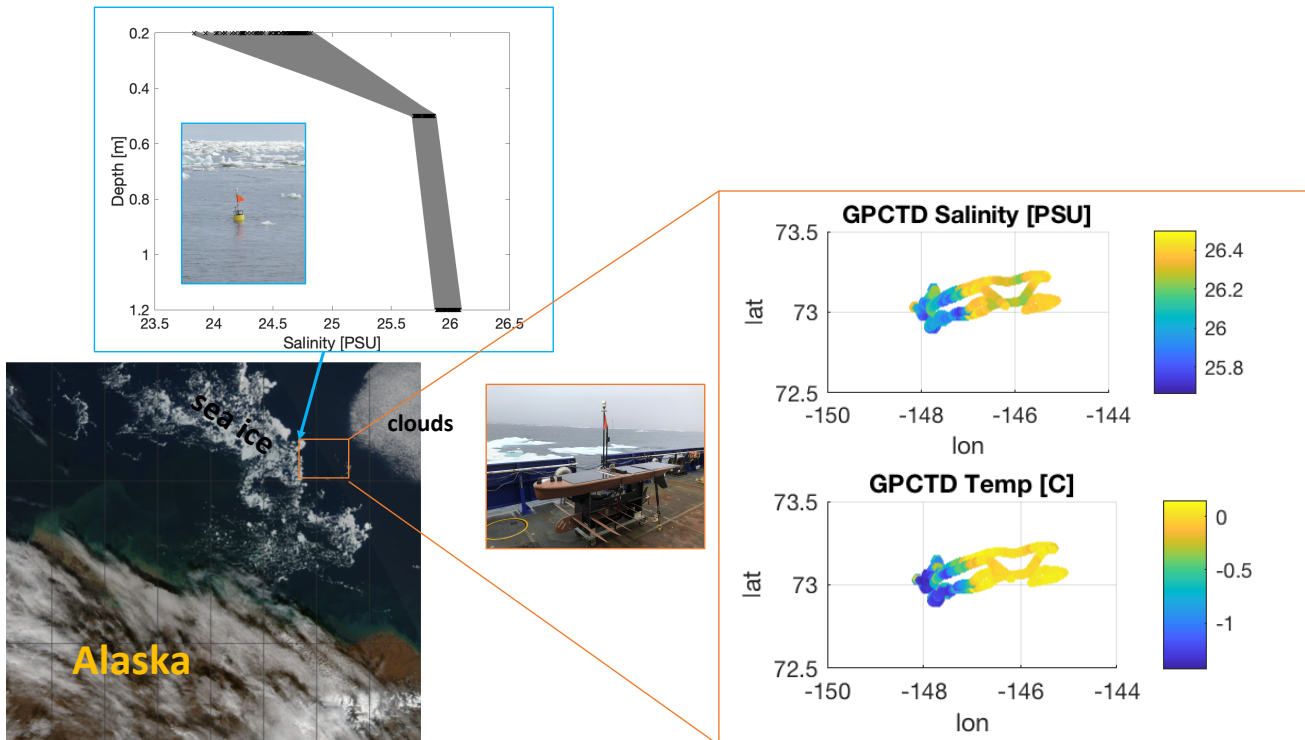


Figure 1: Wave Glider and SWIFT observations during in September 2018.

The mooring observations show that surface wave conditions are consistent with reanalysis products (ERA5) at the southern mooring (SODA A) but not at the middle mooring (SODA B) where sea ice conditions are more varied (Figure 2). These conditions reflect the combined effects of wind forcing and partial ice cover, with the implications for ocean evolution parameterized in a drag coefficient (Brenner et al, 2021).

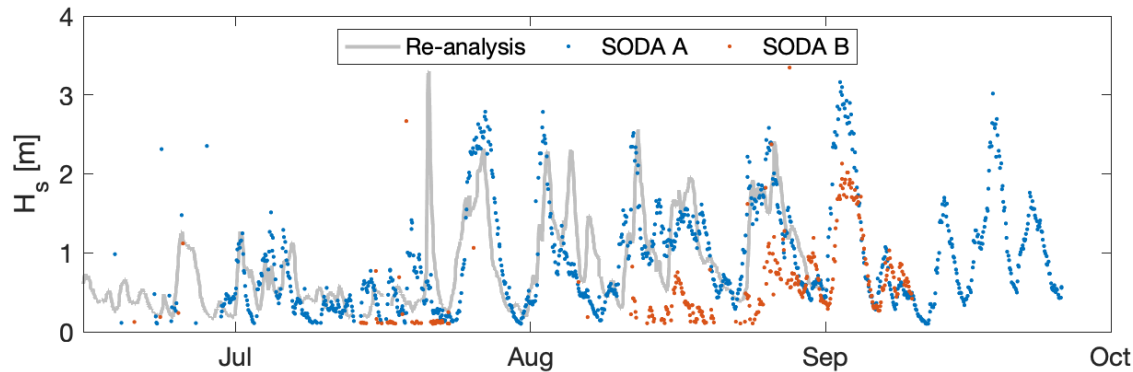


Figure 2: Surface wave heights observed at SODA A and B moorings in autumn 2018, along with ERA5 reanalysis wave heights.

## IMPACT/APPLICATIONS

These results are being applied to improve forecast skill for the Arctic ice-ocean-atmosphere system. The drag coefficients and related parameterizations determined from the mooring observations are key to the coupling of the ice-ocean-atmosphere. The wave-driven transport at the ice edge demonstrates the need for a wave model in the fully couple system. The ongoing wind analysis indicates that reanalysis products (i.e., ERA5) are accurate for large-scale applications, but lack the resolution necessary to specific local dynamics.

## PRODUCTS

Publically archived datasets:

<https://digital.lib.washington.edu/researchworks/handle/1773/46602>

<https://digital.lib.washington.edu/researchworks/handle/1773/46260>

<https://digital.lib.washington.edu/researchworks/handle/1773/46919>

## PUBLICATIONS

- Thomson et al, Wave-driven flow along a compact marginal ice zone, *Geophys. Res. Let.* (2021). <https://agupubs.onlinelibrary.wiley.com/doi/10.1029/2020GL090735> [published, refereed]
- Brenner et al, Comparing observations and parameterizations of ice-ocean drag through an annual cycle across the Beaufort Sea, *J. Geophys. Res.* (2021). <https://agupubs.onlinelibrary.wiley.com/doi/10.1029/2020JC016977> [published, refereed]
- Mackinnon et al, A warm jet in a cold ocean, *Nature Communications* (2021). <https://doi.org/10.1038/s41467-021-22505-5> [published, refereed]
- Thomson, J. (2020), Long-term Measurements of Ocean Waves and Sea Ice Draft in the Central Beaufort Sea, Technical Memorandum APL-UW TM 1-20. Applied Physics Laboratory, University of Washington, Seattle, October 2020, 19 pp. [published]
- Lee et al, Science and Experiment Plan: Stratified Ocean Dynamics of the Arctic, Technical Report APL-UW 1601. Applied Physics Laboratory, University of Washington, Seattle, September 2012, 48 pp (2016). [published]

# REPORT DOCUMENTATION PAGE

*Form Approved*  
OMB No. 0704-0188

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<b>1. REPORT DATE (DD-MM-YYYY)</b> 28/06/2021		<b>2. REPORT TYPE</b> Final Technical		<b>3. DATES COVERED (From - To)</b> 4/1/2016 - 3/31/2021	
<b>4. TITLE AND SUBTITLE</b> Wind Stress Inversion for the Arctic Ocean				<b>5a. CONTRACT NUMBER</b>	
				<b>5b. GRANT NUMBER</b> N00014-16-1-2349	
				<b>5c. PROGRAM ELEMENT NUMBER</b>	
<b>6. AUTHOR(S)</b> James Thomson				<b>5d. PROJECT NUMBER</b>	
				<b>5e. TASK NUMBER</b>	
				<b>5f. WORK UNIT NUMBER</b>	
<b>7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)</b> University of Washington – Applied Physics Laboratory 4333 Brooklyn Avenue NE Seattle, WA 98105-6613				<b>8. PERFORMING ORGANIZATION REPORT NUMBER</b>	
<b>9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)</b> Office of Naval Research/ 322 875 North Randolph Street Arlington, VA 22203-1995				<b>10. SPONSOR/MONITOR'S ACRONYM(S)</b> ONR	
				<b>11. SPONSOR/MONITOR'S REPORT NUMBER(S)</b>	
<b>12. DISTRIBUTION / AVAILABILITY STATEMENT:</b>  Distribution Statement A: Approved for public release; distribution is unlimited.					
<b>13. SUPPLEMENTARY NOTES</b>					
<b>14. ABSTRACT</b> Autonomous Wave Glider and SWIFT buoy missions in summer 2018 mapped the surface temperature and salinity anomalies related to remnant sea ice in the Beaufort Sea, as well as heat transported from the Bering Strait (MacKinnon et al, 2021). The SWIFT measurements were further used to diagnose wave-driven transport along the edge of the marginal ice zone (Thomson et al, 2021). Year-long mooring observations using uplooking Nortek Signature 500 profilers mounted on Stablemoor platforms from 2018-2019 recorded the ice draft and drift, along with wave activity and [inferred] wind forcing (Brenner et al, 2021). These measurements compliment an ongoing effort to measure surface waves and ice on the BGOS moorings, including a new data archive developed under this award (Thomson, 2020).					
<b>15. SUBJECT TERMS</b> Arctic Ocean, Sea Ice, Surface Waves, Autonomous Sampling					
<b>16. SECURITY CLASSIFICATION OF:</b>			<b>17. LIMITATION OF ABSTRACT</b>  UU	<b>18. NUMBER OF PAGES</b>  4	<b>19a. NAME OF RESPONSIBLE PERSON</b> Jim Thomson
<b>a. REPORT</b> Unclassified	<b>b. ABSTRACT</b> Unclassified	<b>c. THIS PAGE</b> Unclassified			<b>19b. TELEPHONE NUMBER (include area code)</b> (206) 543-1300