

MicroSWIFT Buoys Measure SST and SSS in the Alaskan Arctic

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Suzanne
Analysis



Jiaxu
Arctic AIR

...in preparation for submission

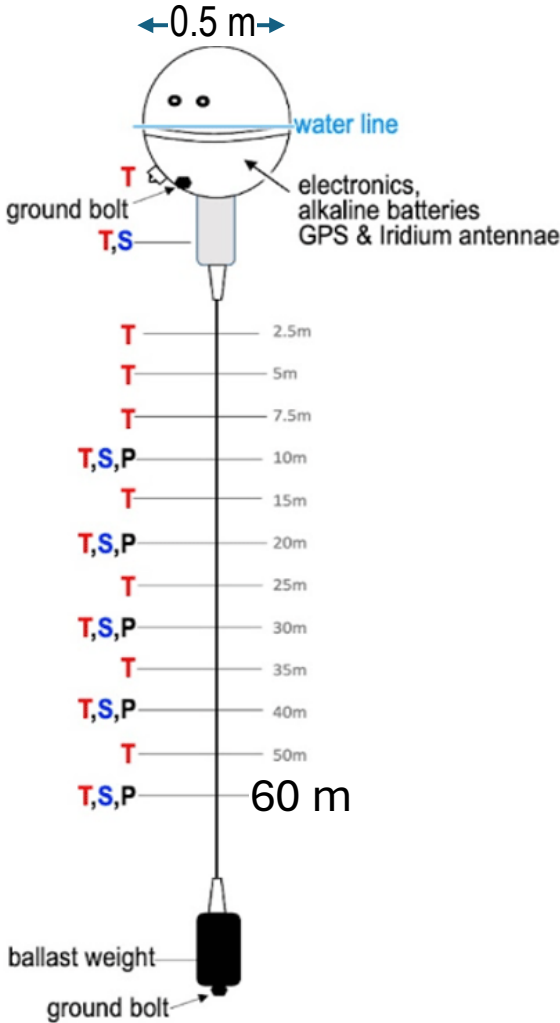
UpTempO / Hydrobuoys

Coast Guard C130



Seasonal Ice Zone Reconnaissance Surveys

Beaufort Sea, 2010-present, ONR
monthly June-October



Pacific Gyre Co.
Oceanside, CA

UpTempO / Hydrobuoys

Coast Guard C130



Seasonal Ice Zone Reconnaissance Surveys

Beaufort Sea, 2010-present, ONR
monthly June-October

- Drushka et al. (ESSD, 2024)
- Hondegnonto et al. (JAOT, 2025)

Salinity & Stratification at the Sea Ice Edge

Beaufort Sea, September 2022, NASA

PALS
N34AH

SMAP et al

UAS

Wave Glider

Jet-SSP

Remote sensing

Ship-based

Piloted

Drifting

Flux mast

Salinity snake

Underway CTD

R/V Woldstad

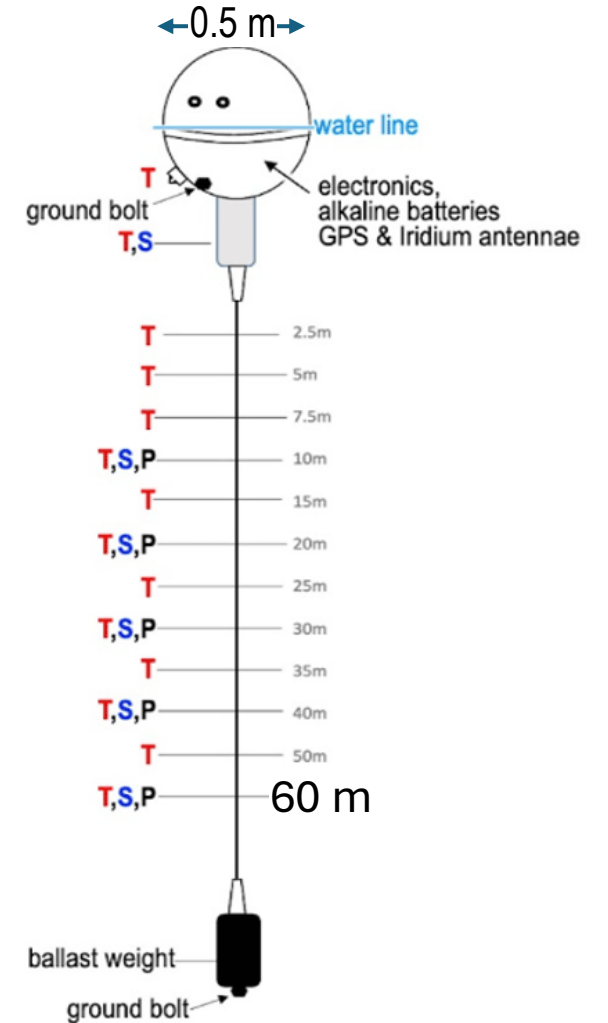
UpTempO buoy

SWIFT

Under Ice Float

Ice mass balance buoy

SVP(S) drifter



Pacific Gyre Co.
Oceanside, CA

UpTempO / Hydrobuoys

Coast Guard C130



Seasonal Ice Zone Reconnaissance Surveys

Beaufort Sea, 2010-present, ONR
monthly June-October

Salinity & Stratification at the Sea Ice Edge

Beaufort Sea, September 2022, NASA

Good:

- T & S profiles
- Winter (*i.e.* ice) survival

PALS
N34AH

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Flux mast

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Ice mass balance buoy

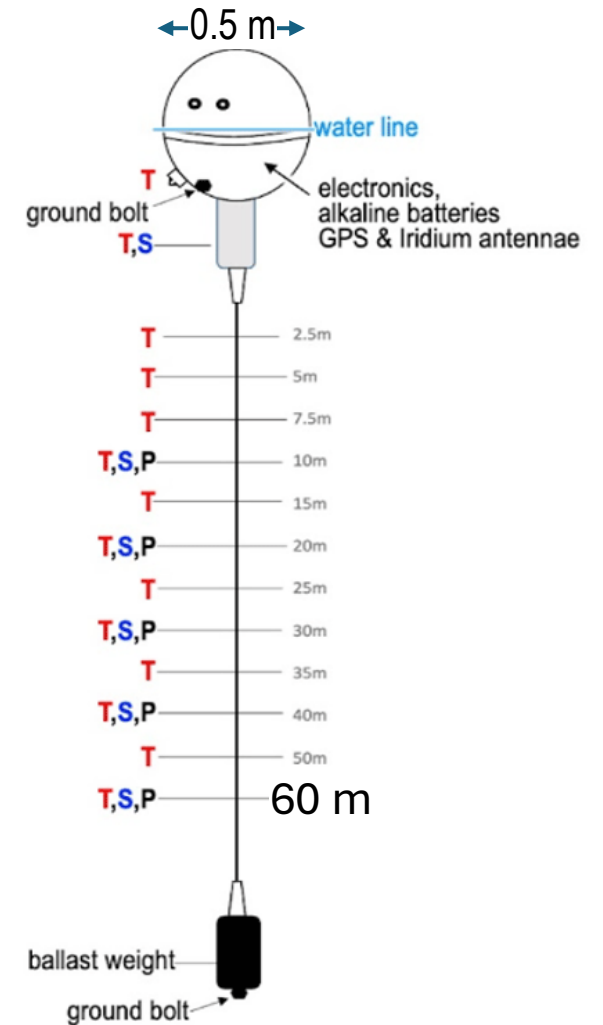
SVP(S) drifter

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Ship-based

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Drifting



Pacific Gyre Co.
Oceanside, CA

UpTempO / Hydrobuoys

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Seasonal Ice Zone Reconnaissance Surveys

Beaufort Sea, 2010-present, ONR
monthly June-October

Good:

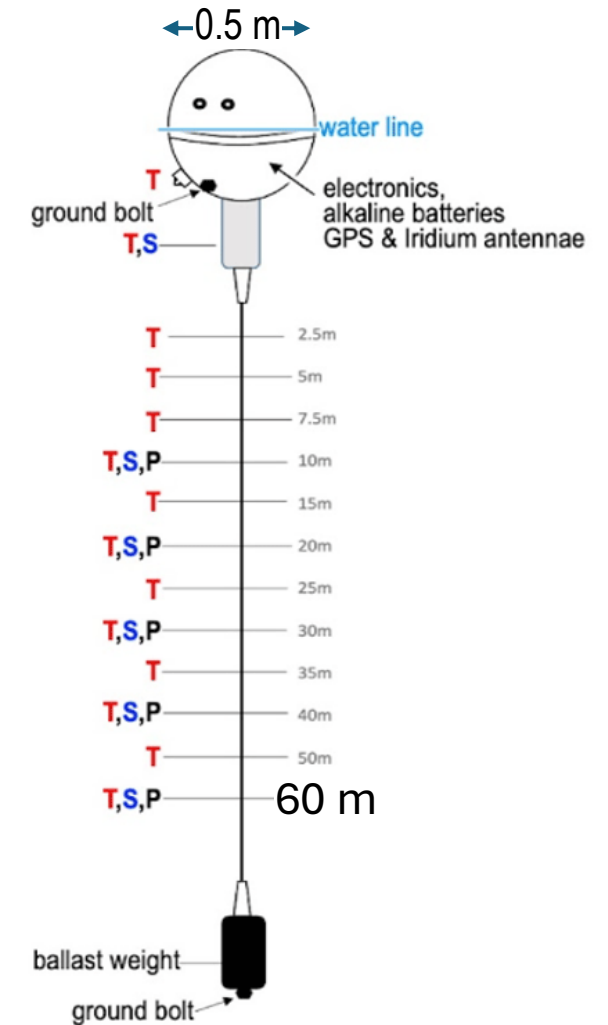
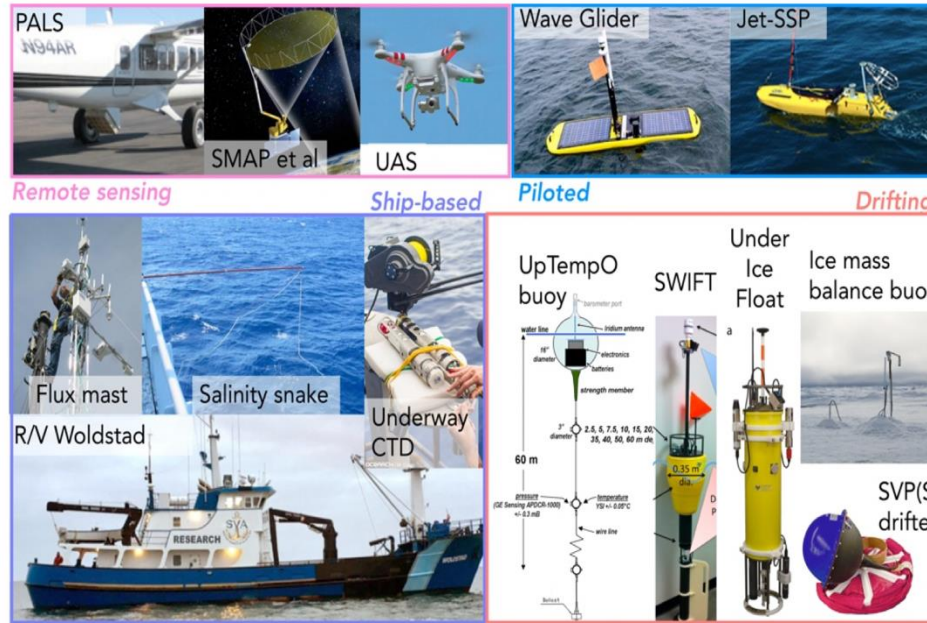
- T & S profiles
- Winter (i.e. ice) survival

Bad:

- Big & \$\$ (up to \$60k)
- Deployment not simple
- So much trash...

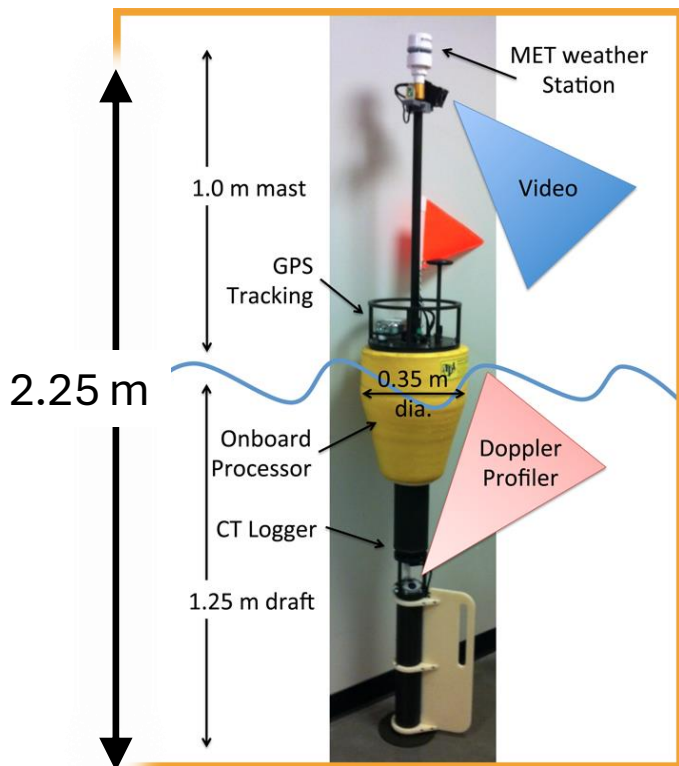
Salinity & Stratification at the Sea Ice Edge

Beaufort Sea, September 2022, NASA



Pacific Gyre Co.
Oceanside, CA

SWIFT = Surface Wave Instrument Float with Tracking

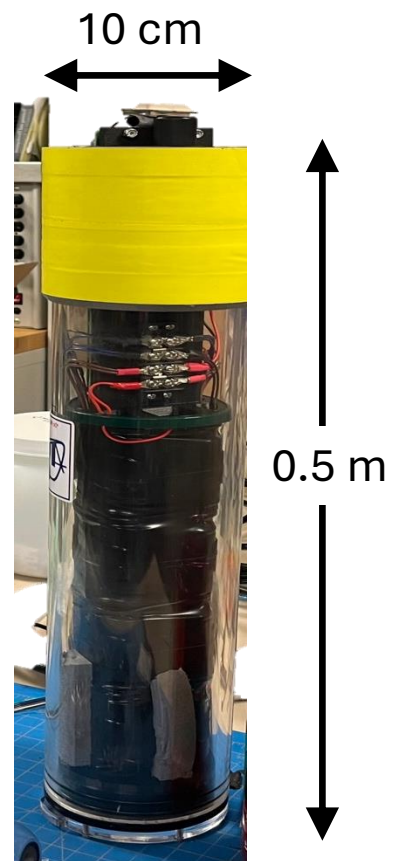


A big, expensive “wave+” buoy

- **Jim Thomson**
- **Alex deKlerk**
- **APL engineers**



microSWIFT buoys



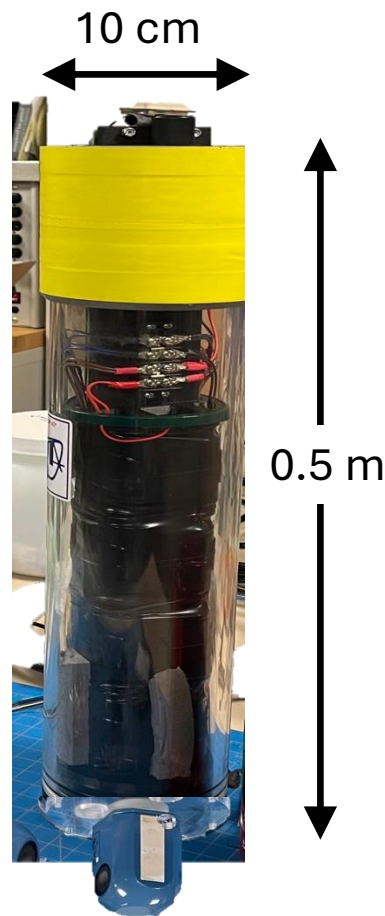
- Iridium
- GPS
- Surface waves

- Jim Thomson
- Alex deKlerk
- APL engineers



microSWIFT buoys

parachute



CT cell:
Aanderaa 5819c

Smaller & cheaper

up to \$6k

- Iridium
- GPS
- Surface waves
- SST
- SSS
- 2-month lifetime

- Jim Thomson
- Alex deKlerk
- APL engineers



Arctic AIR (Airborne Investigations & Research)

NOAA Twin Otter



Bering,
Chukchi, **2023-2025**
Beaufort Seas

2 flight periods: summer & fall



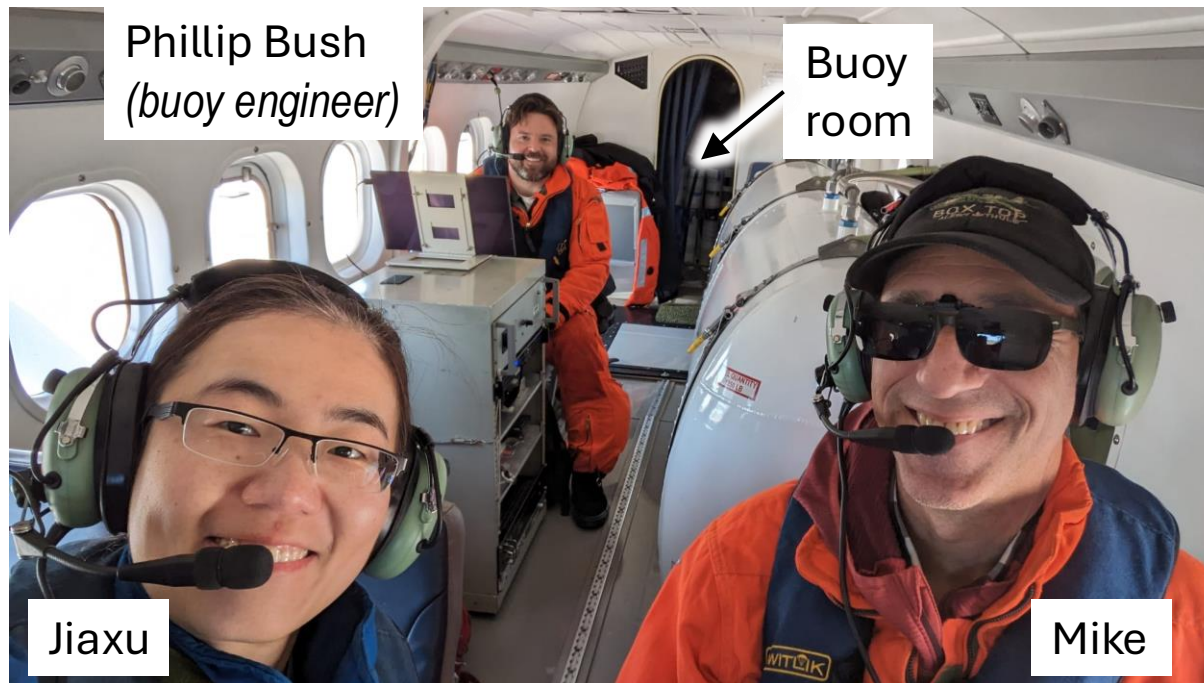
Jiaxu Zhang
lead PI
NOAA/PMEL/UW

Arctic AIR (Airborne Investigations & Research)

NOAA Twin Otter



Bering,
Chukchi, 2023-2025
Beaufort Seas



Phillip Bush
(buoy engineer)

Buoy
room

Jiaxu

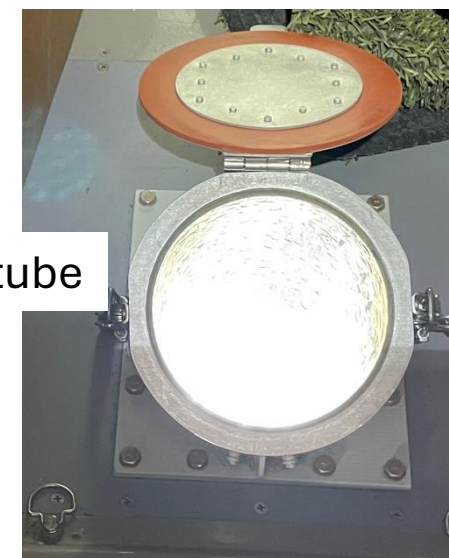
Mike



Jiaxu Zhang
lead PI



buoys ready to go



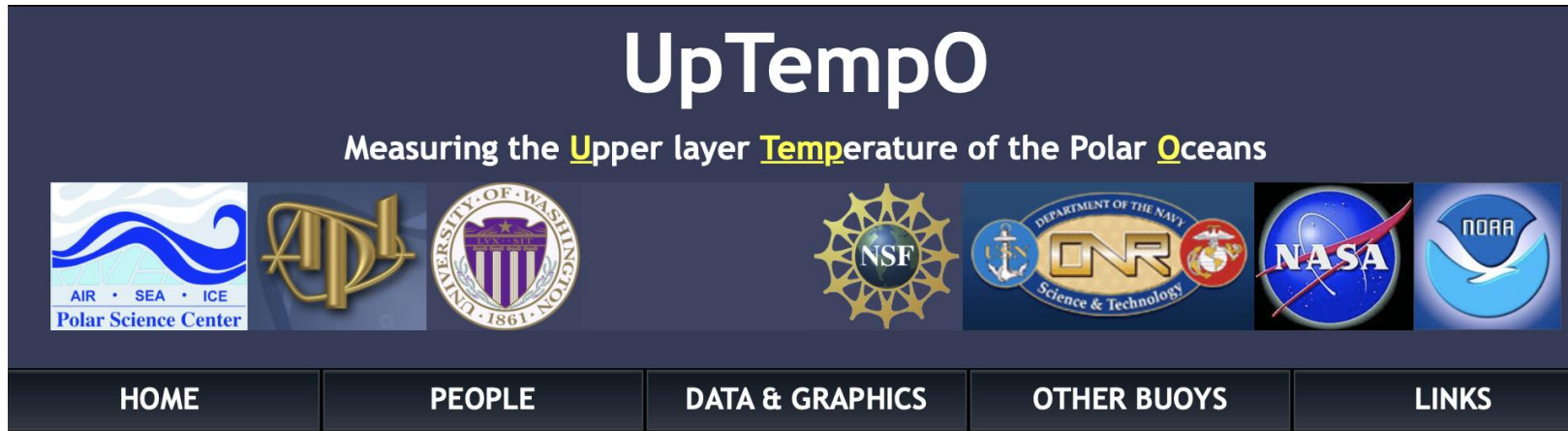
deployment tube

Arctic AIR microSWIFT buoy deployment



west of Nome, AK
June, 2024

Buoy Websites



UpTemp0
Measuring the **U**pper layer **T**emperature of the Polar **O**ceans

AIR · SEA · ICE
Polar Science Center

APL

UNIVERSITY OF WASHINGTON
1861

NSF

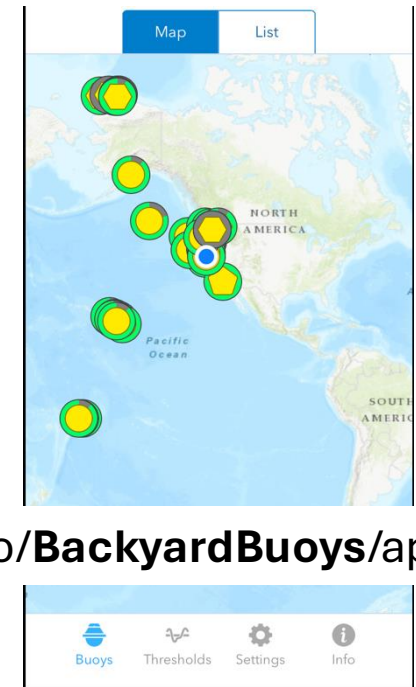
DEPARTMENT OF THE NAVY
ONR
Science & Technology

NASA

NOAA

HOME PEOPLE DATA & GRAPHICS OTHER BUOYS LINKS

<http://psc.apl.washington.edu/UpTemp0>

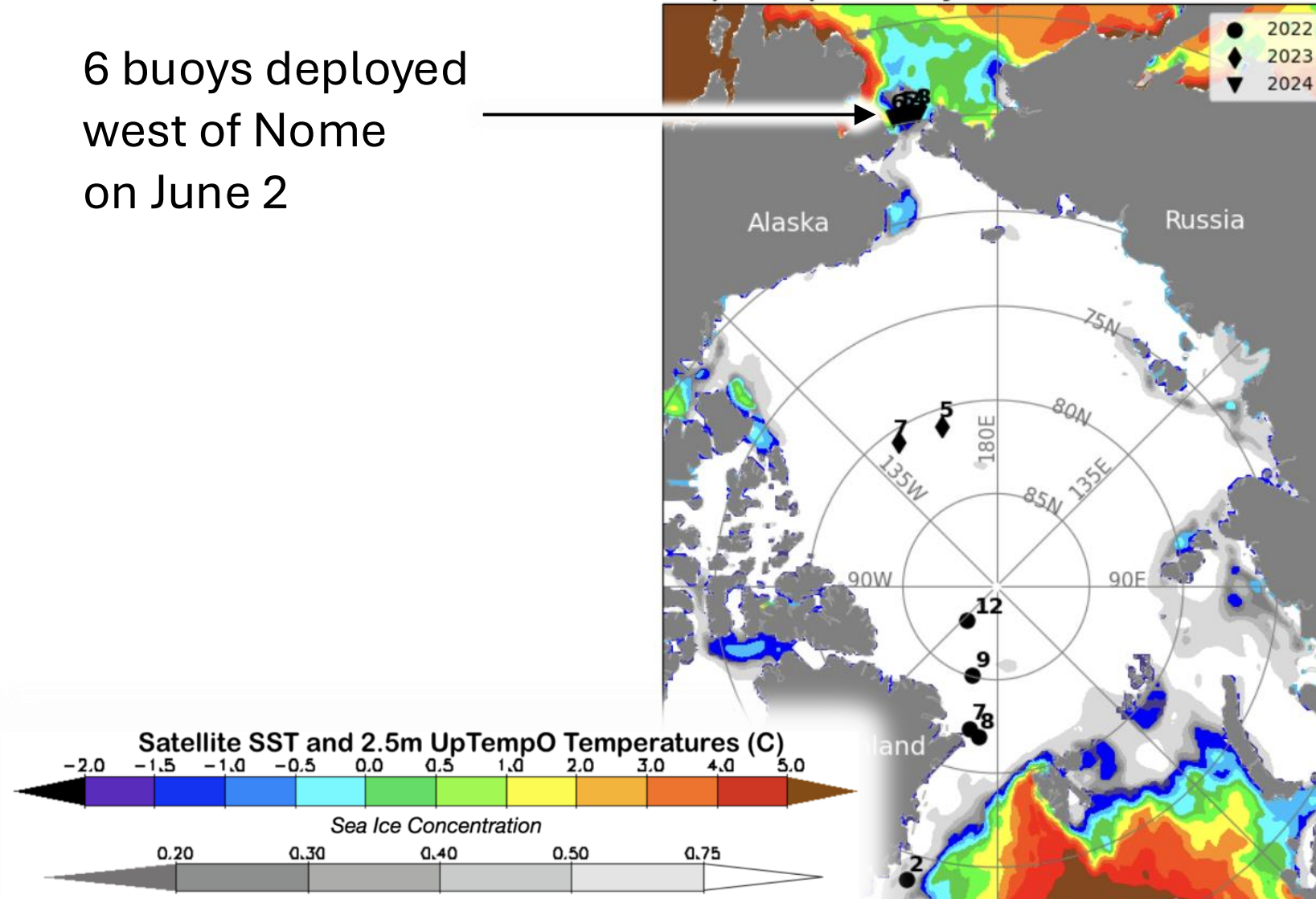


<https://software.apl.uw.edu/proto/BackyardBuoys/app.php>

Buoy Website

UpTempO Buoy Positions 6/2/2024

6 buoys deployed
west of Nome
on June 2



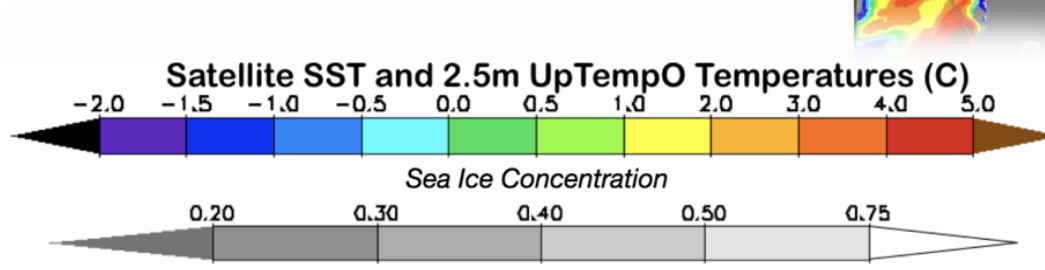
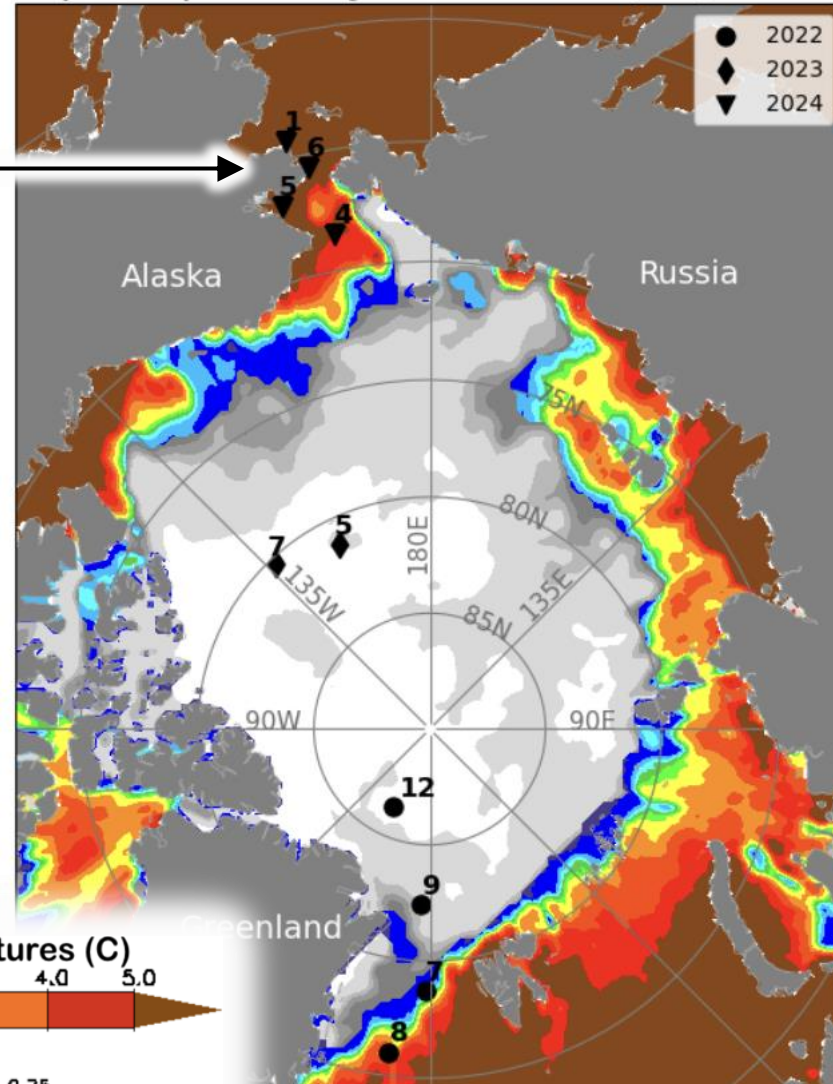
Buoy Website

UpTempO Buoy Positions 7/28/2024

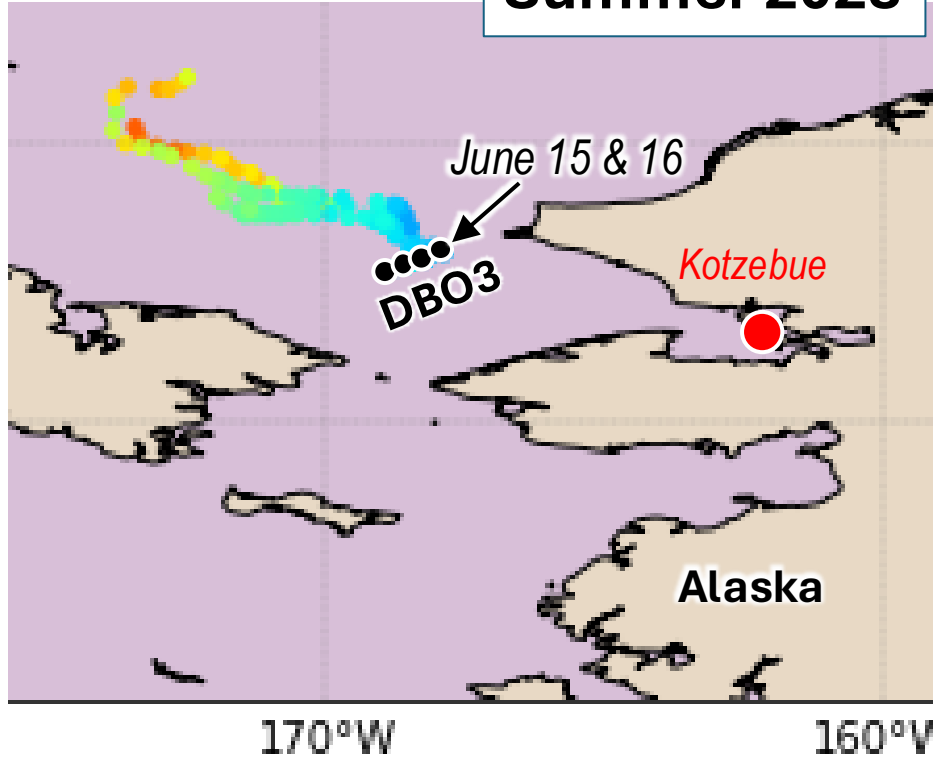
Two months later:

- 2 died early (*ice!*)
- 2 made it north through Bering St.
- 3 sampled western Norton Sound
- 1 made a circuit of Norton Sound

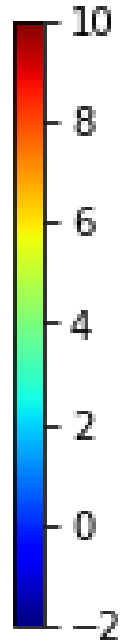
Click through week by week...



Summer 2023

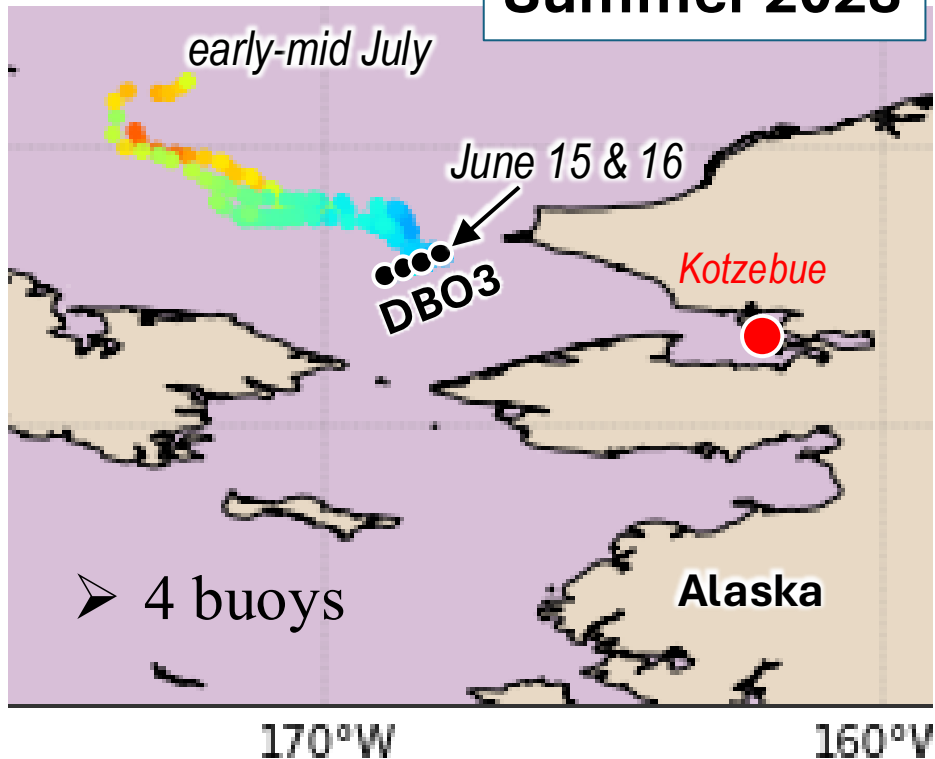


SST (°C)

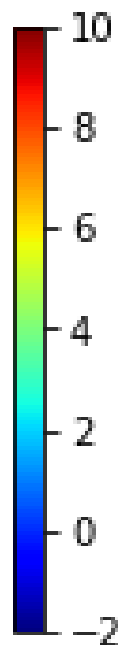


DBO:
Distributed Biological Observatory

Summer 2023



SST (°C)

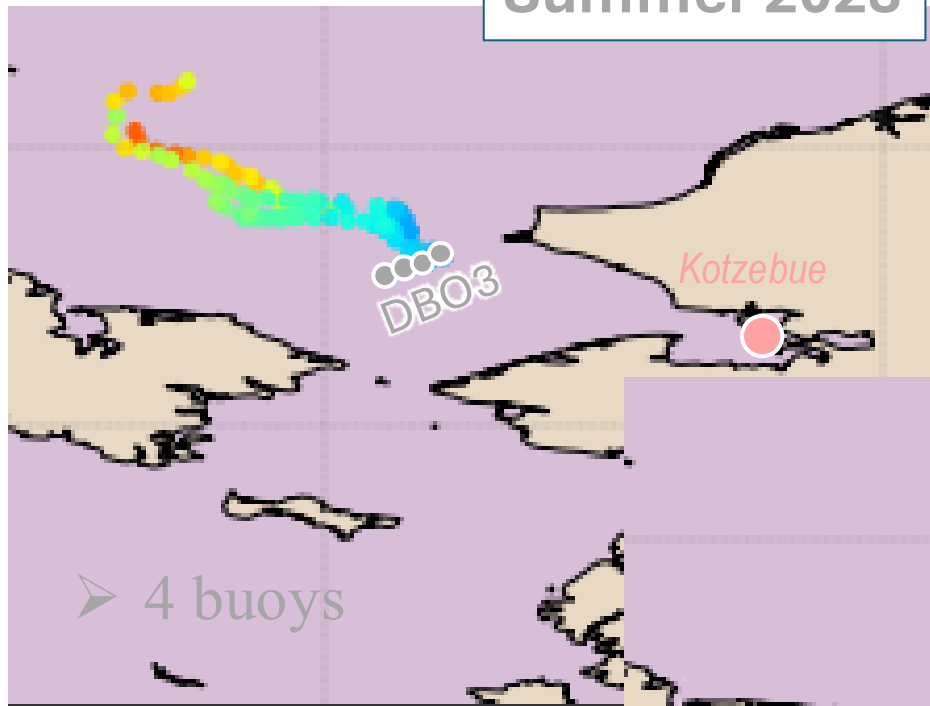


DBO:
Distributed Biological Observatory

Getting **warmer** to the north!?

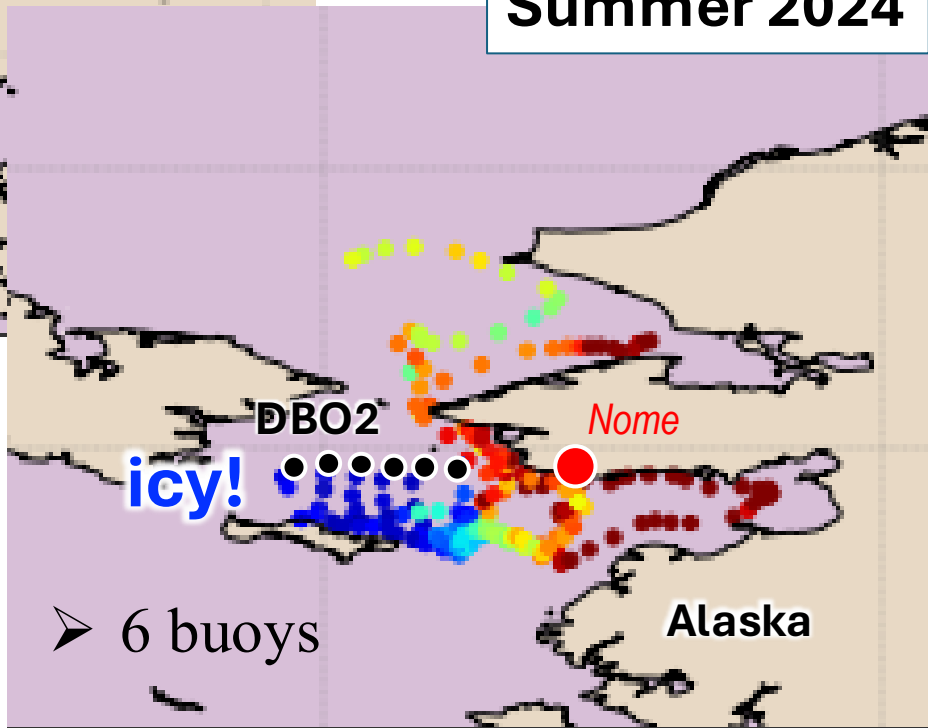
June → July!

Summer 2023

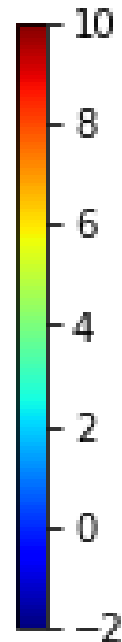


start June – end July

Summer 2024



SST (°C)



➤ 4 buoys

➤ 6 buoys

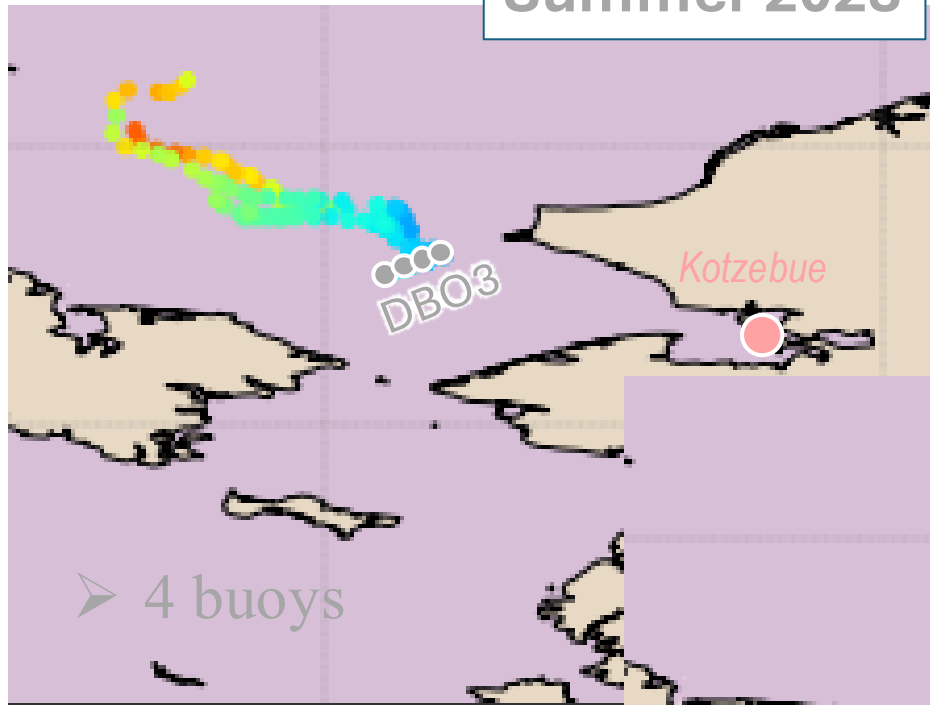
170°W

170°W

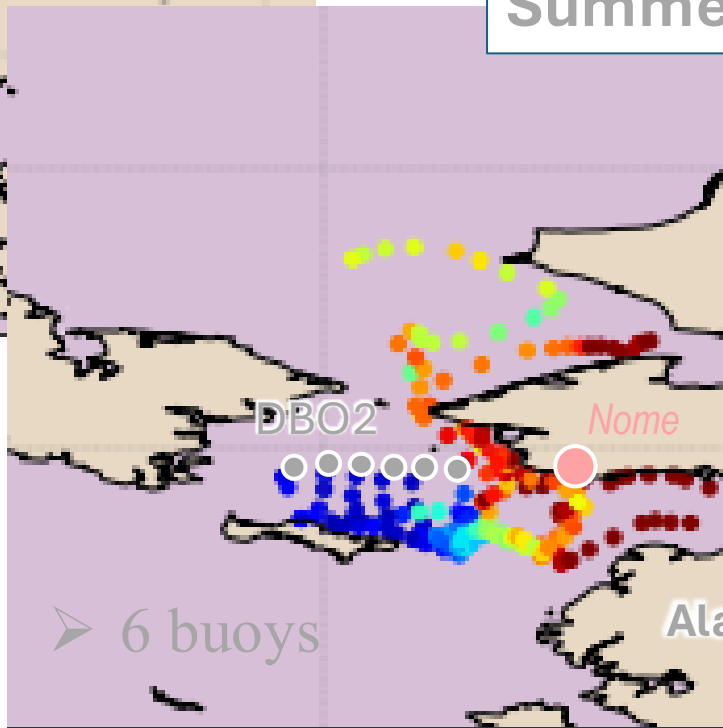
160°W

Alaska

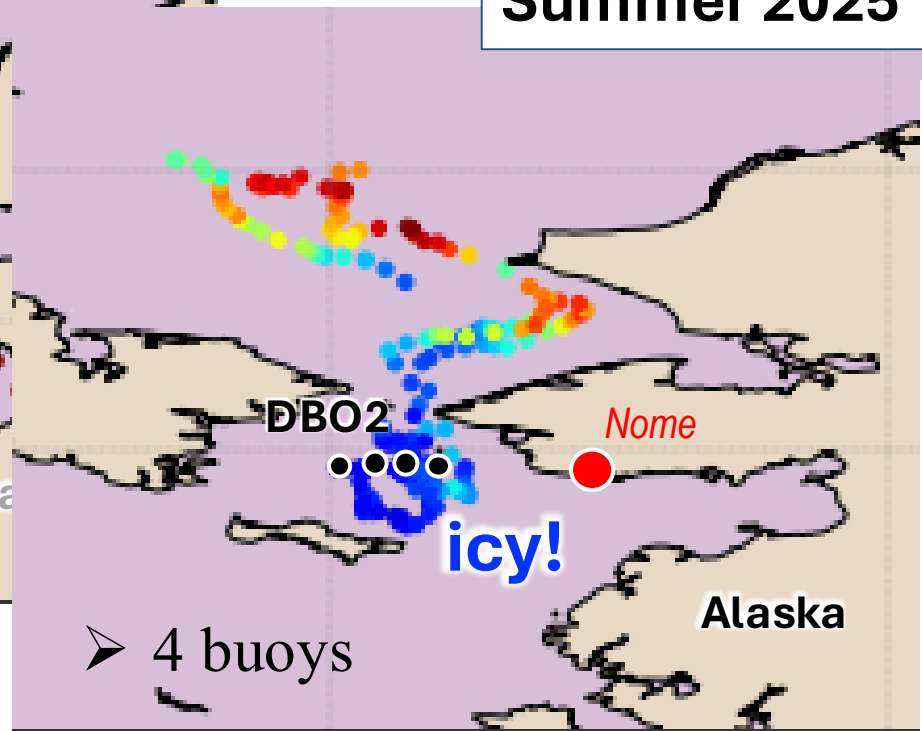
Summer 2023



Summer 2024

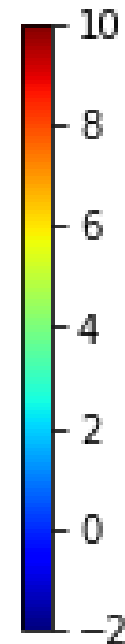


Summer 2025



Late May – end July

SST (°C)



170°W

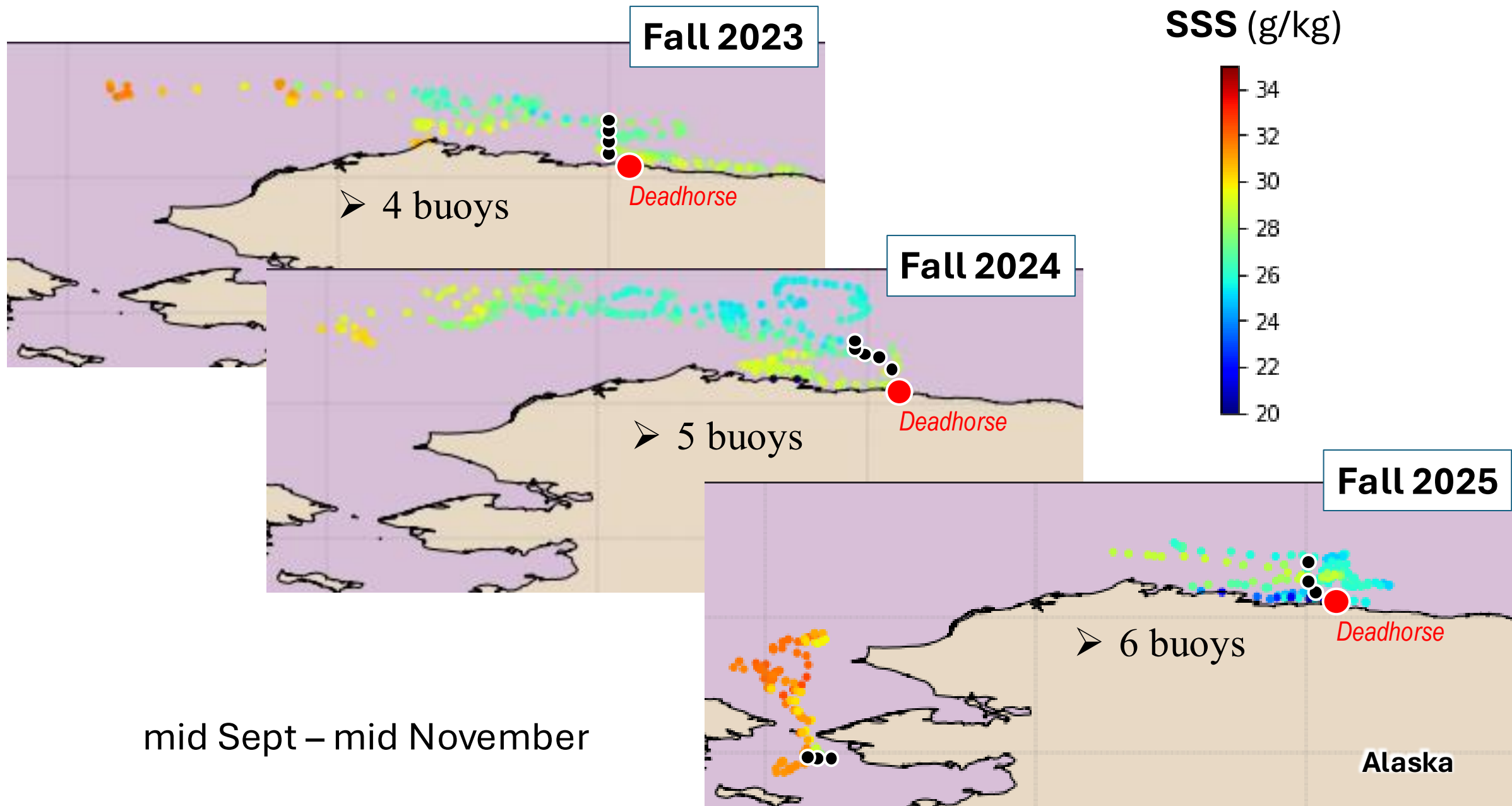
170°W

170°W

160°W

Ala

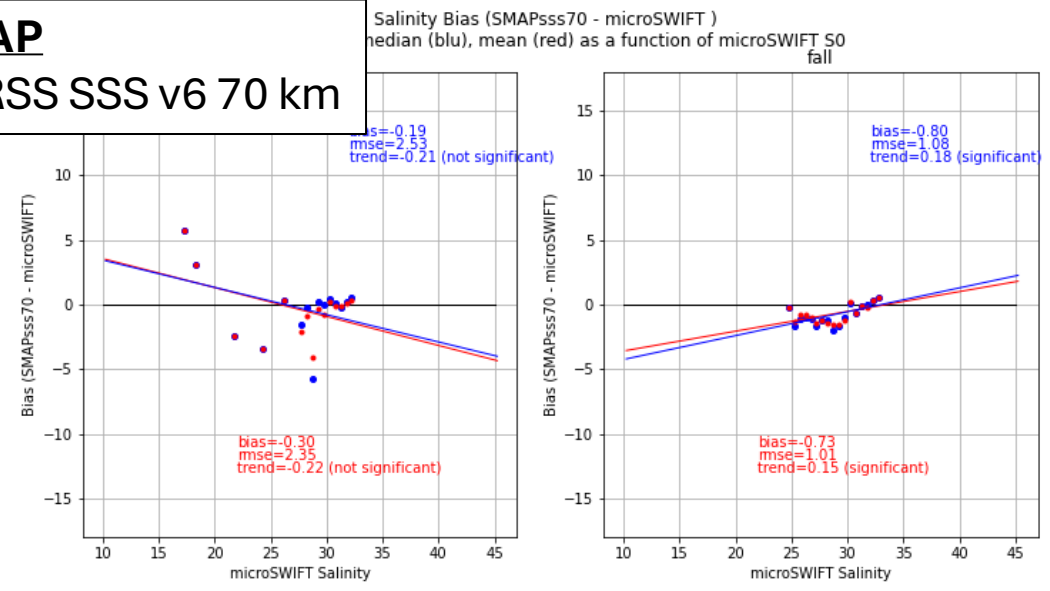
Alaska



Salinity error (satellite – buoy) vs. Salinity

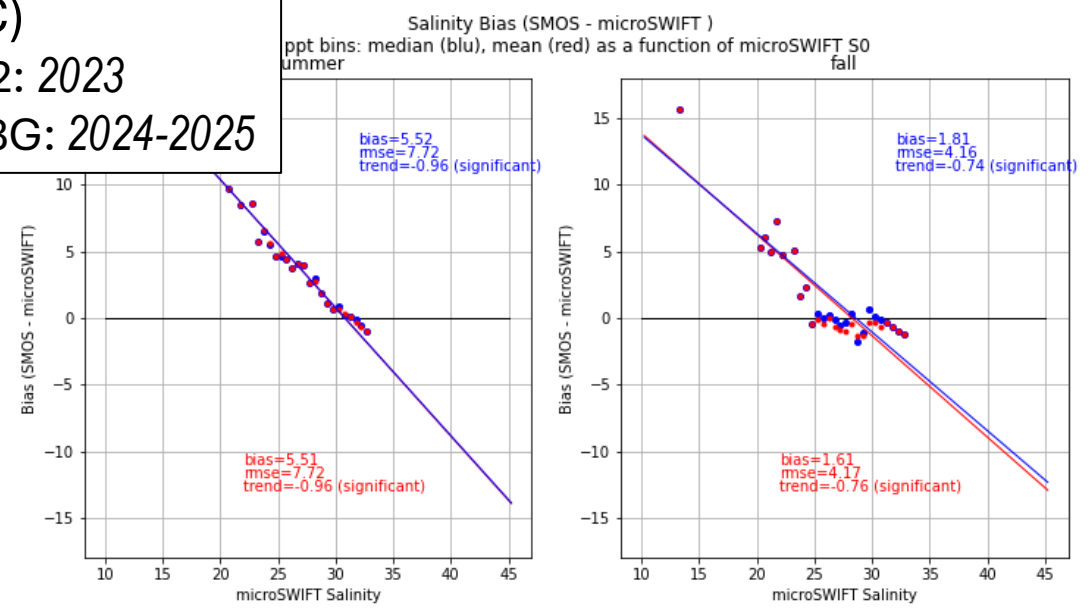
SMAP

- RSS SSS v6 70 km



SMOS (CEC)

- ARCTIC V2: 2023
- ARCTIC L3G: 2024-2025



At low SSS:

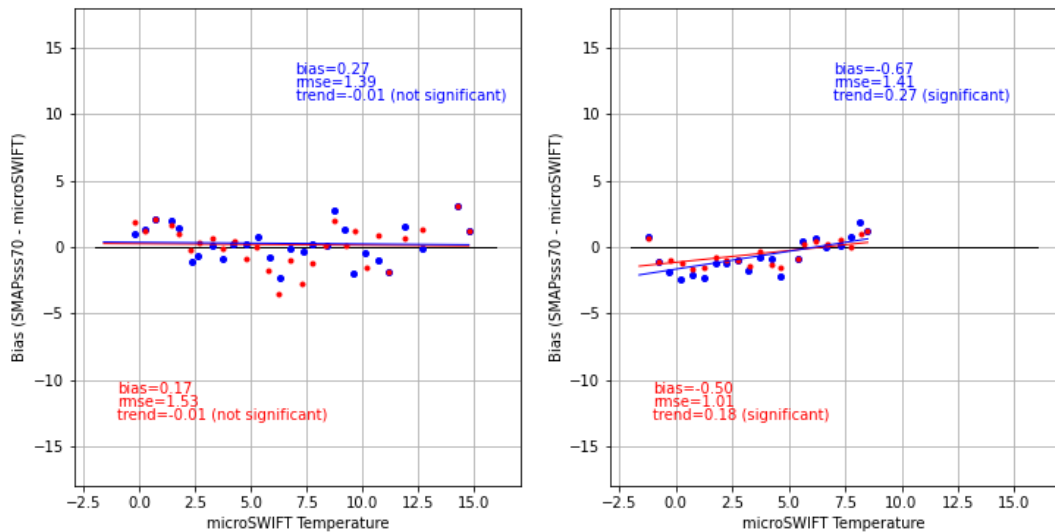
SMAP underestimates (slightly)
SMOS overestimates

➤ Fournier et al. (2019) same result

SMOS isn't getting low SSSs (coastal/icy)

Salinity error vs. Temperature

Salinity Bias (SMAPsss70 - microSWIFT)
 0.5 deg bins: median (blu), mean (red) as a function of microSWIFT TO

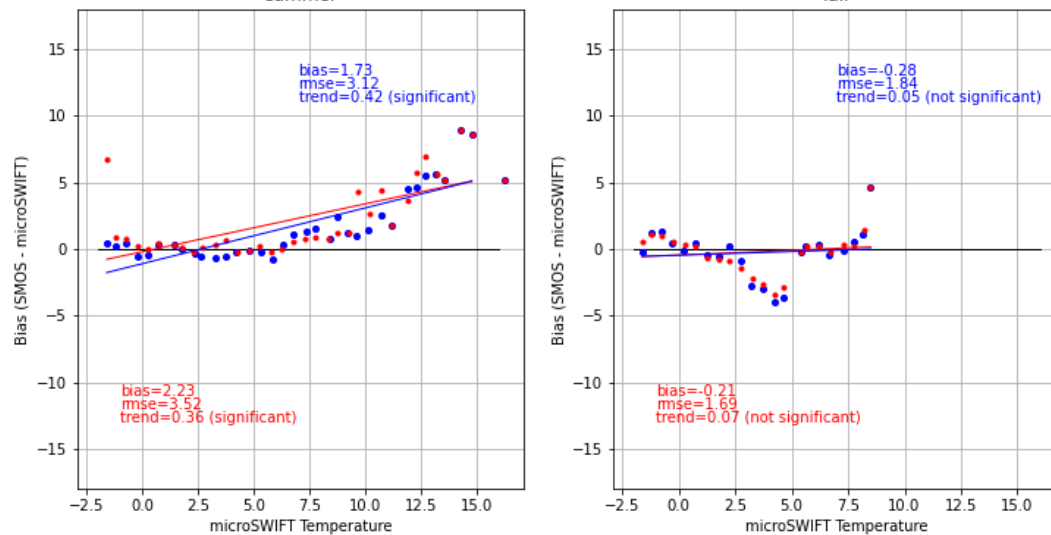


At low SST:

SMAP underestimates (*slightly*)

SMOS not bad

Salinity Bias (SMOS - microSWIFT)
 0.5 deg bins: median (blu), mean (red) as a function of microSWIFT TO



SSS: The bottom line

(satellite – buoy)

	<u>bias</u>	<u>RMSE</u>	
SMAP 70km	-0.53	1.78	<i>smallest bias & RMSE</i>
SMOS (25km)	3.61	6.23	
SMAP 40km	1.60	5.27	<i>noisier than 70km</i>
OISSSv3 (25°)	2.97	5.02	<i>meh, but better than SMOS!</i>

SSS: The bottom line

(satellite – buoy)

SST: The bottom line

(satellite – buoy)

	<u>bias</u>	<u>RMSE</u>	
SMAP 70km	-0.53	1.78	<i>smallest bias & RMSE</i>
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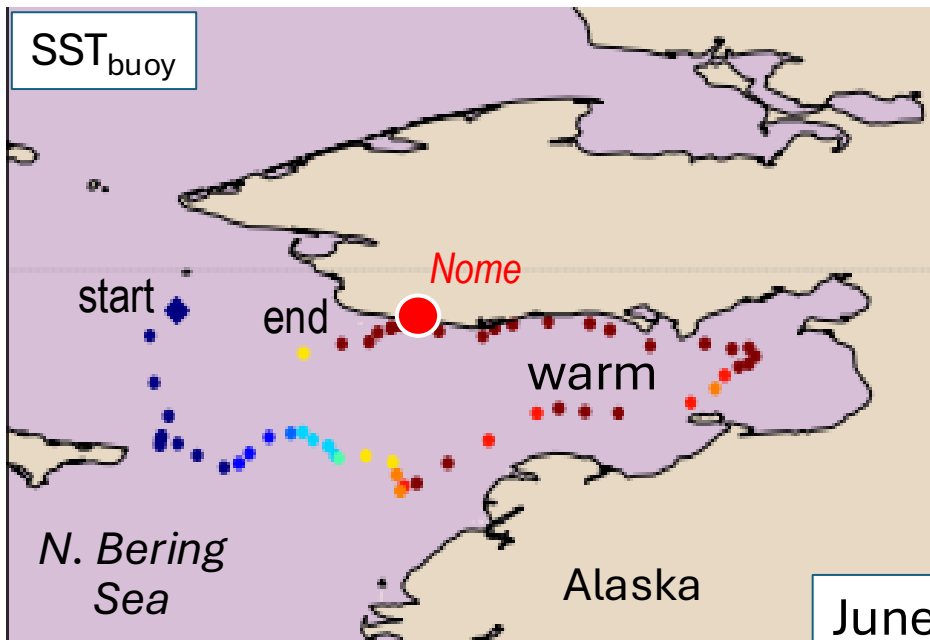
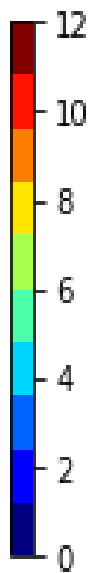
	<u>bias</u>	<u>RMSE</u>
OISST (0.25°)	-0.91	1.45
OSTIA (0.05°)	-0.22	0.91

SMAP 40km 1.60 5.27 *noisier than 70km*

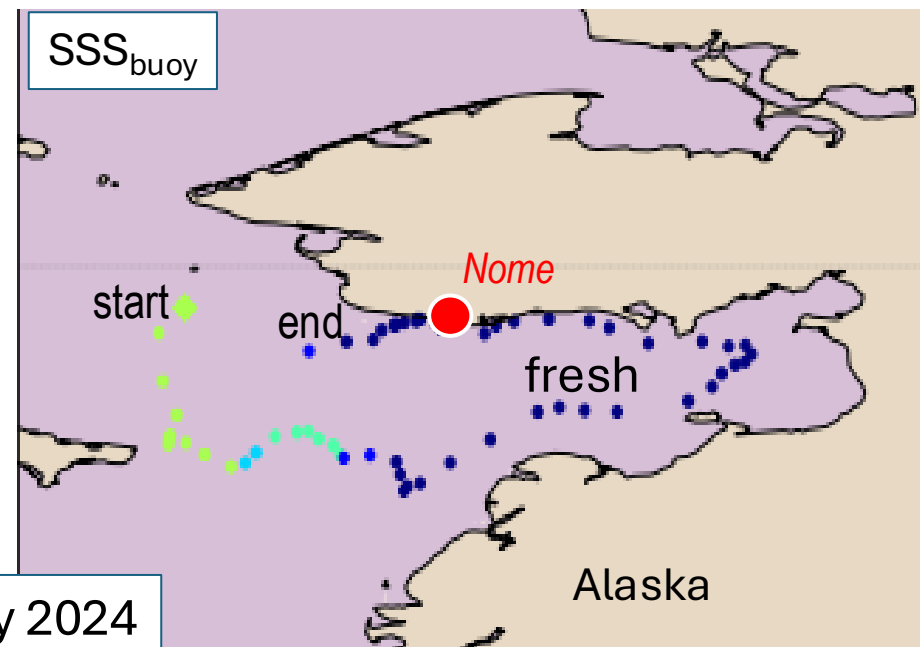
OISSSv3 (25°) 2.97 5.02 *meh, but better than SMOS!*

River water signal

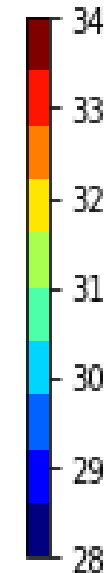
SST (°C)



SSS_{buoy}



SSS (g/kg)



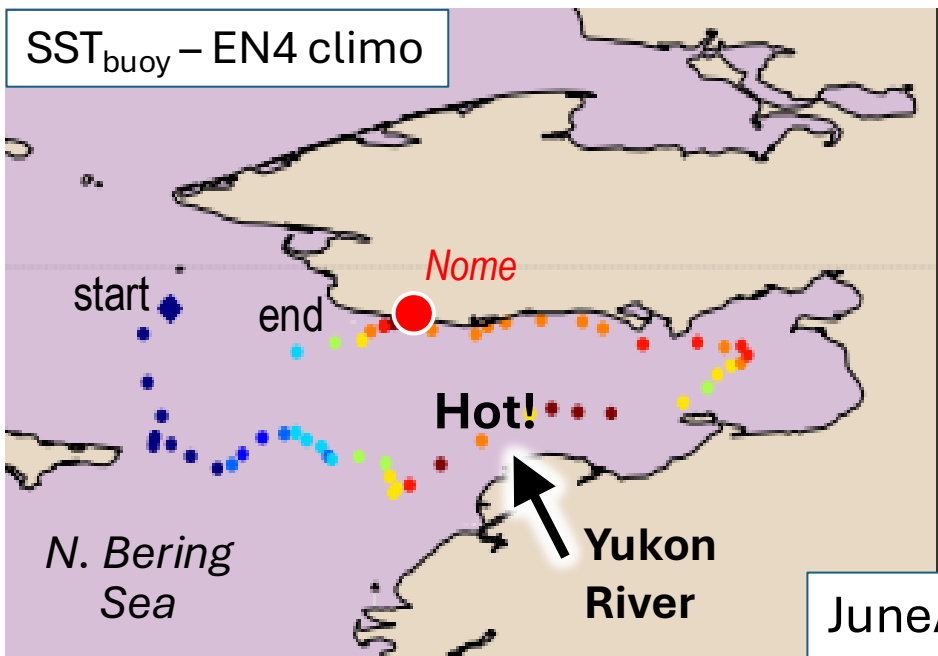
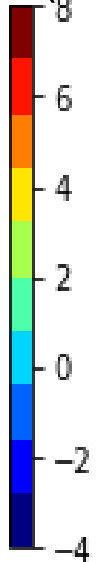
June/July 2024

Summer:

Norton Sound is generally warmer & fresher than the N. Bering Sea

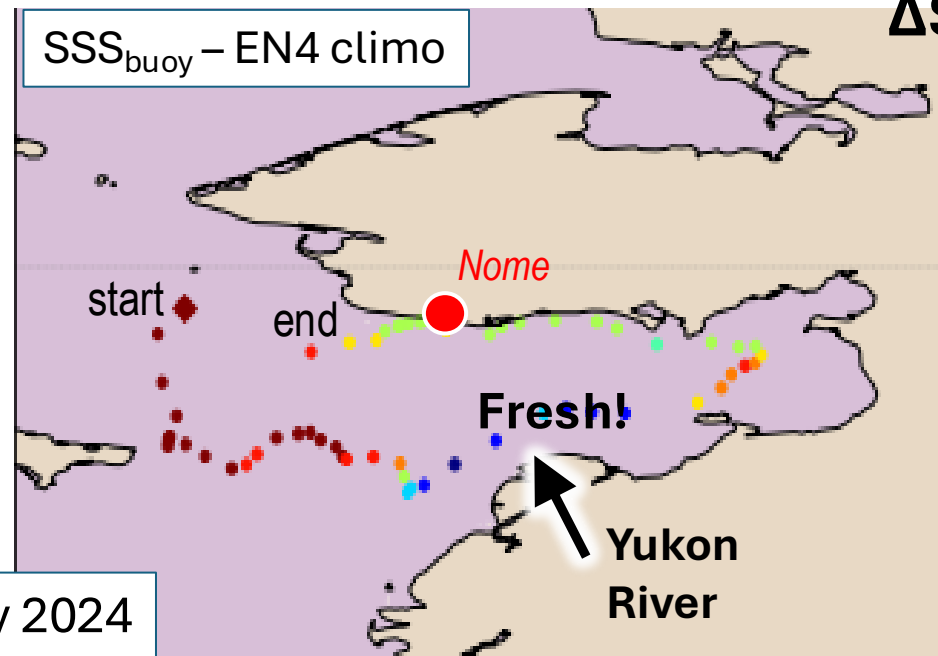
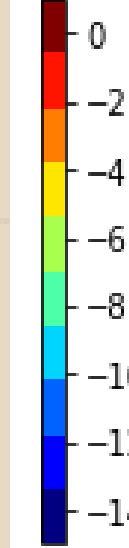
River water signal

ΔSST ($^{\circ}C$)



SSS_{buoy} - EN4 climo

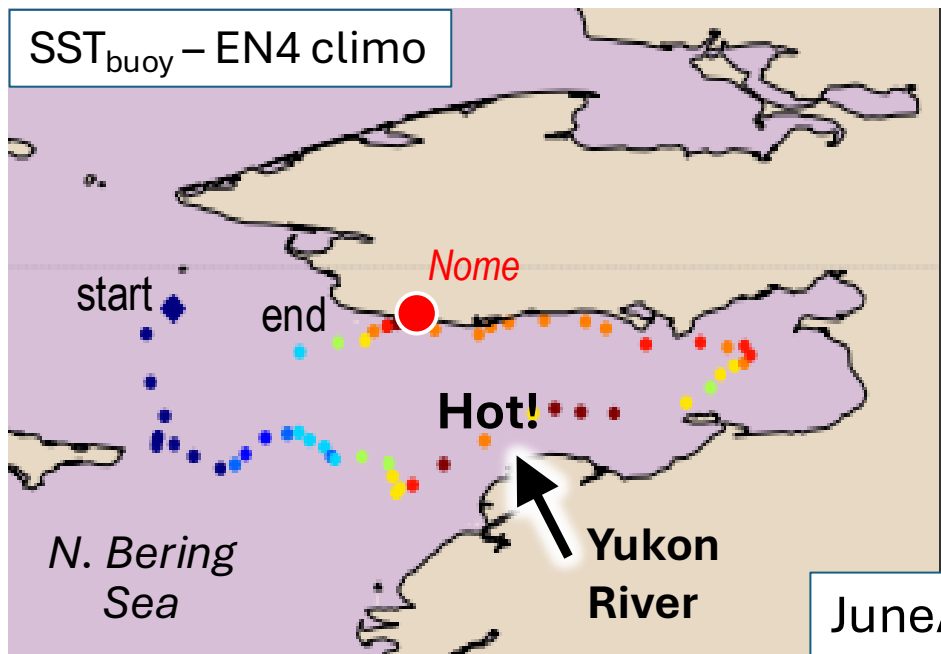
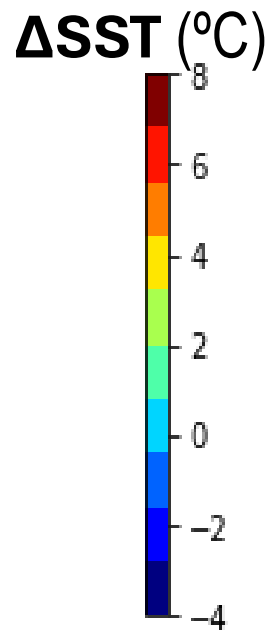
ΔSSS (g/kg)



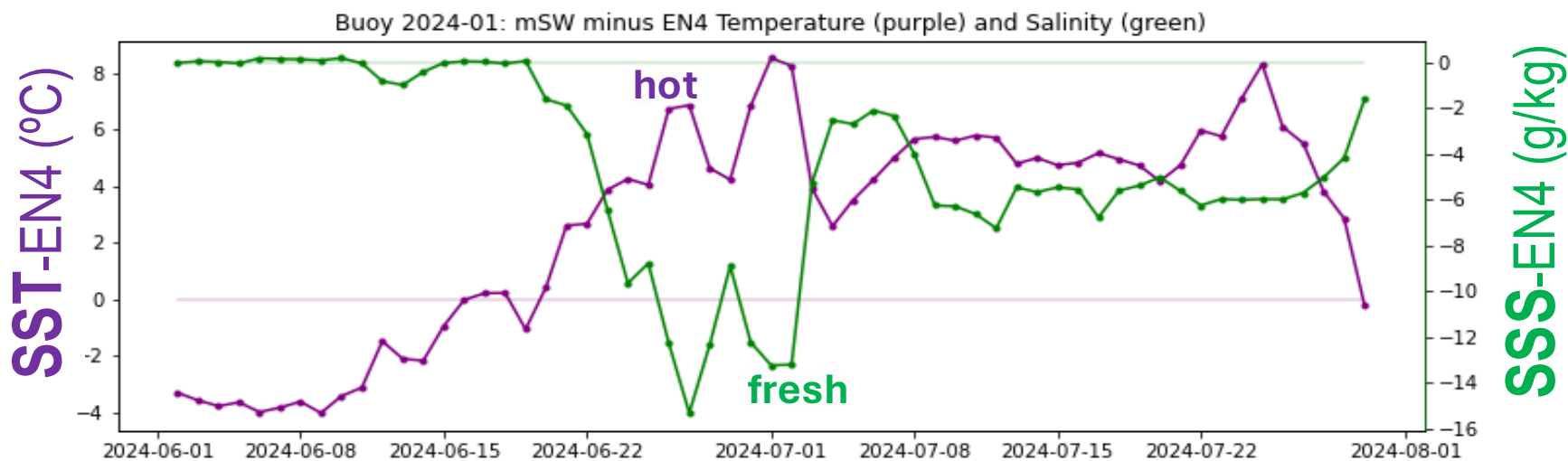
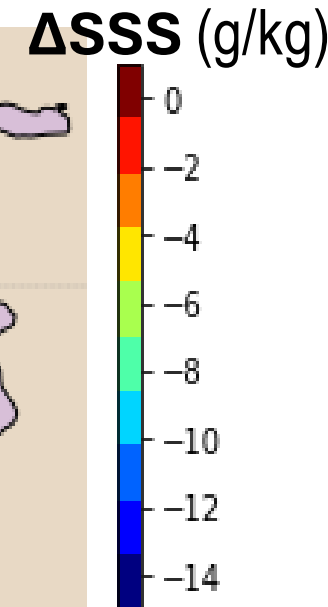
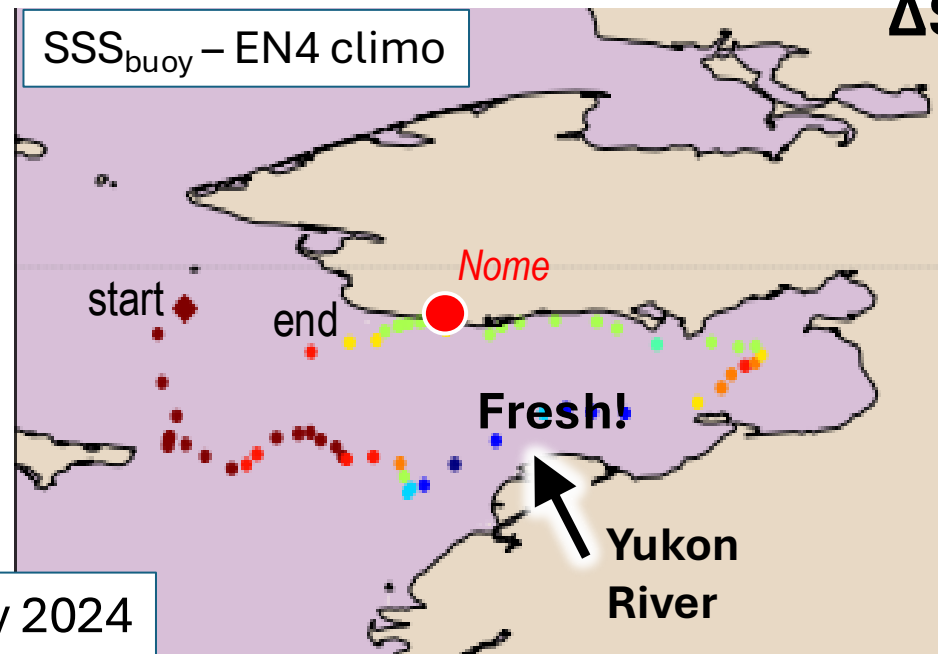
EN4 climatology

Monthly mean (2000-2025) global gridded $1^{\circ} \times 1^{\circ}$ 3D ocean T & S

River water signal

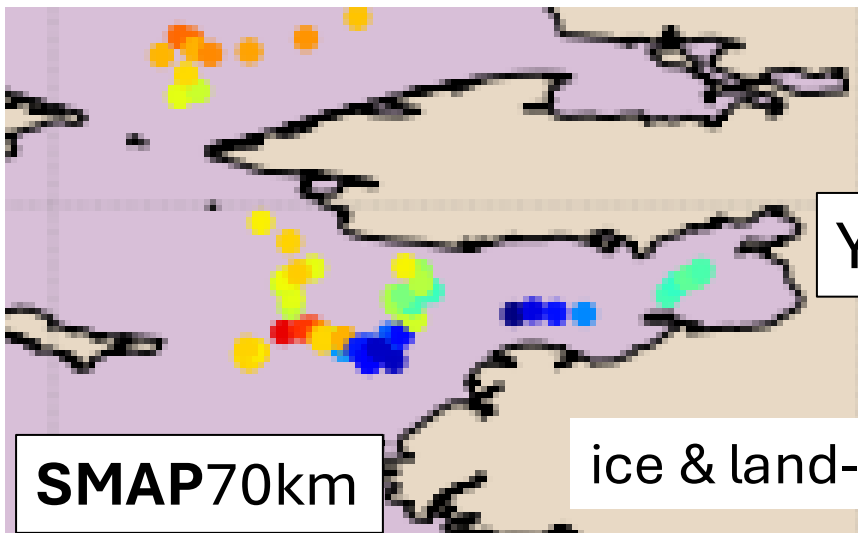


June/July 2024

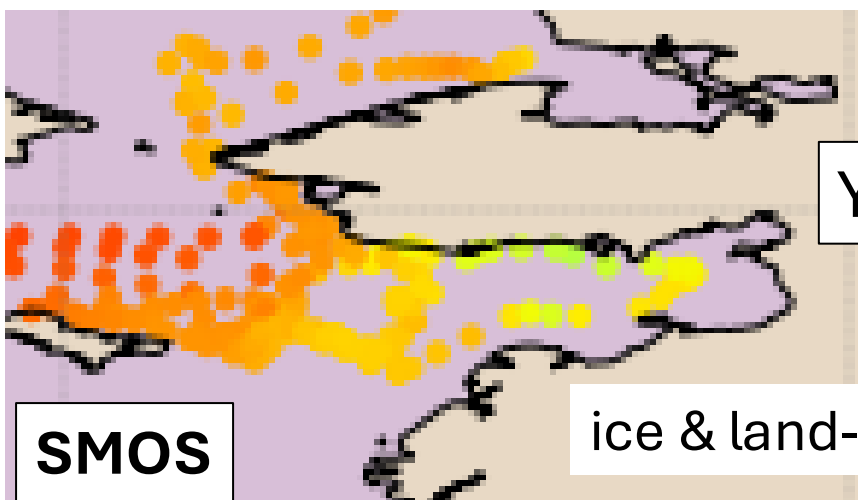
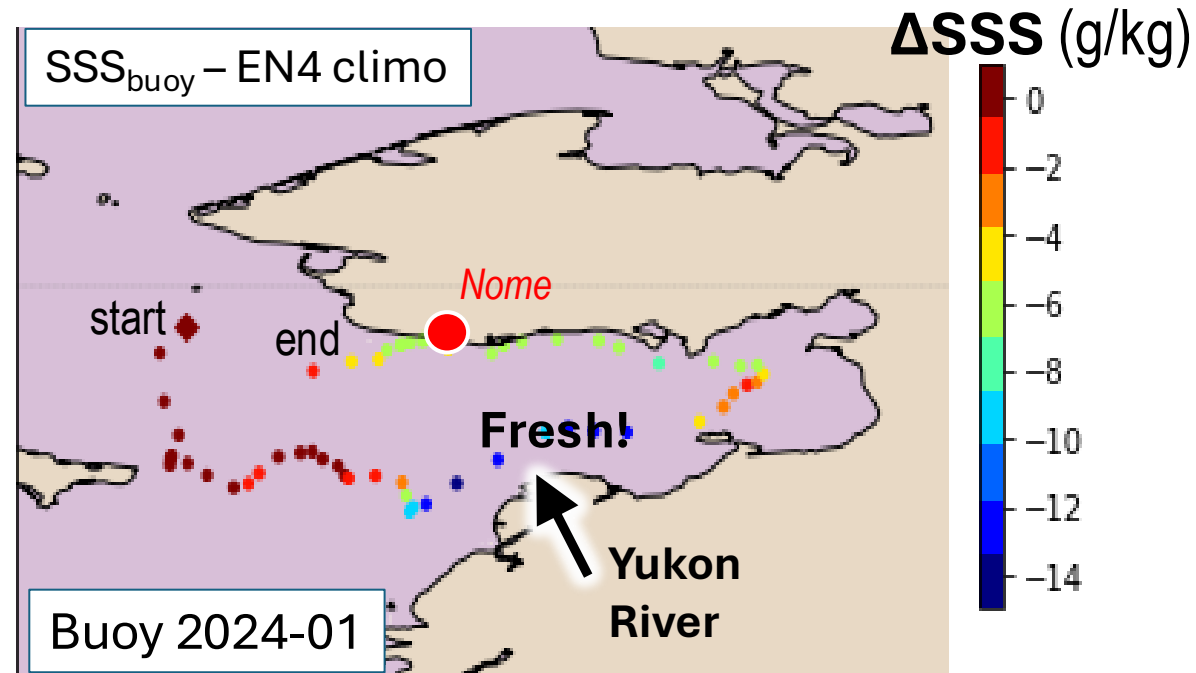


River water signal: Did **SMAP** or **SMOS** get it?

All summer 2024 buoys



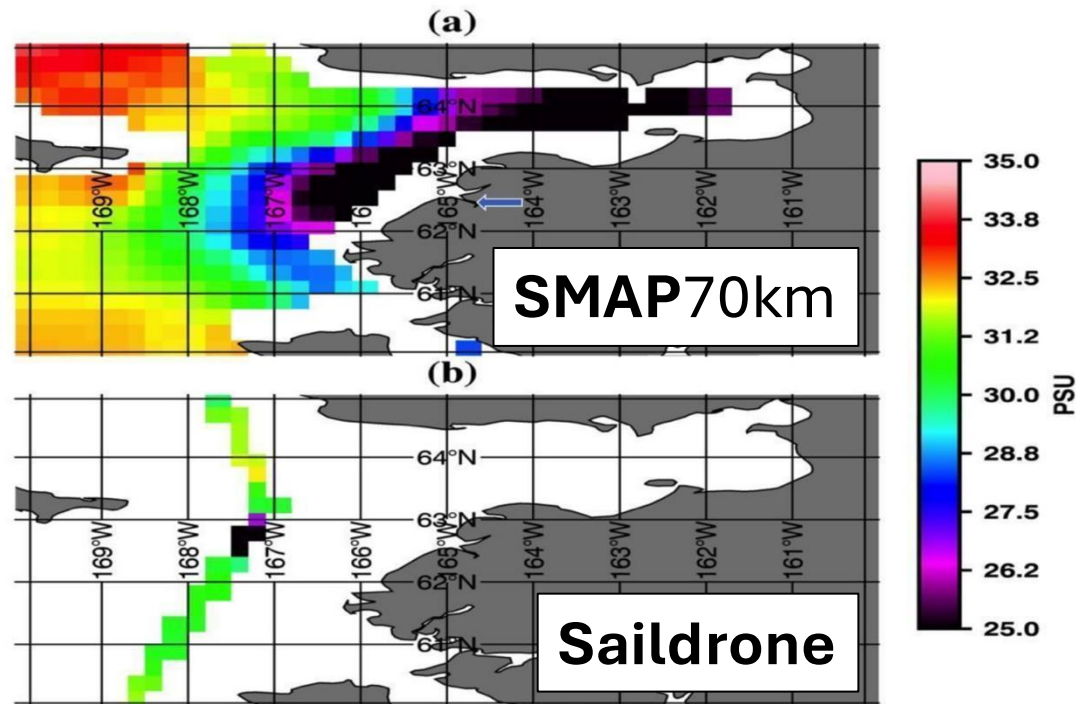
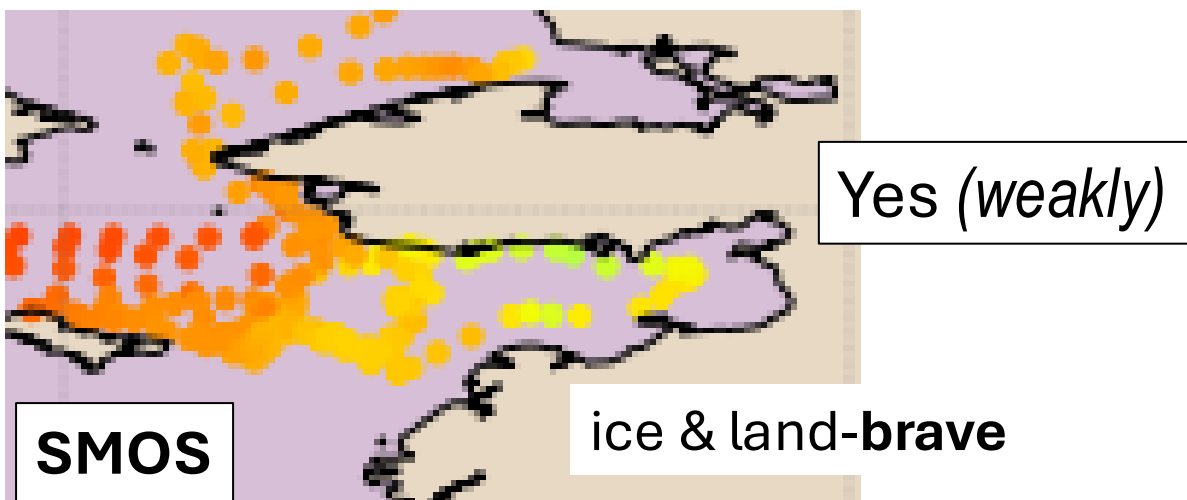
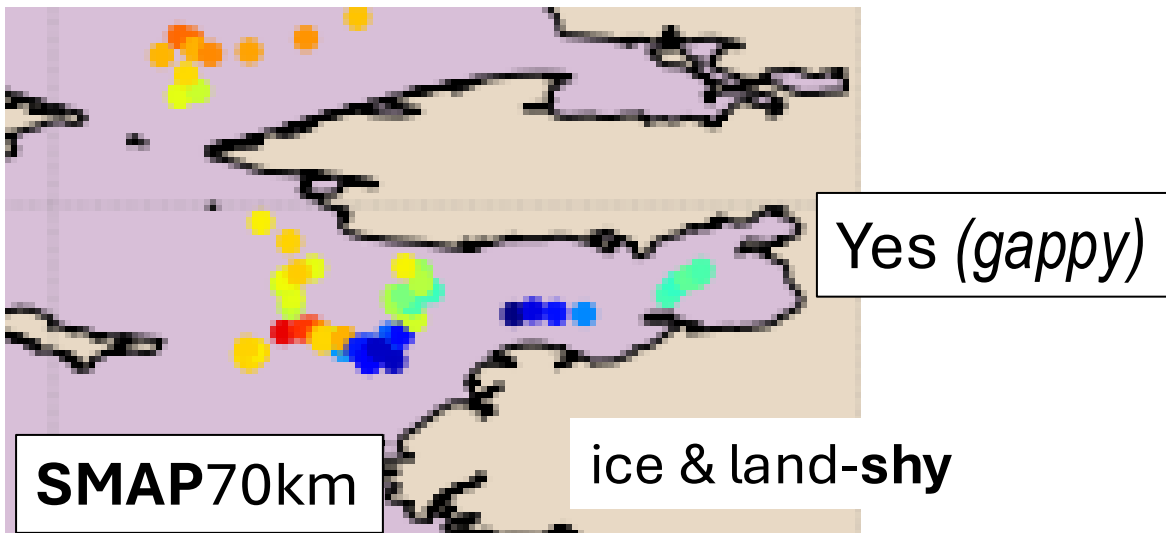
Yes (*gappy*)



Yes (*very weakly*)

River water signal: Did **SMAP** or **SMOS** get it?

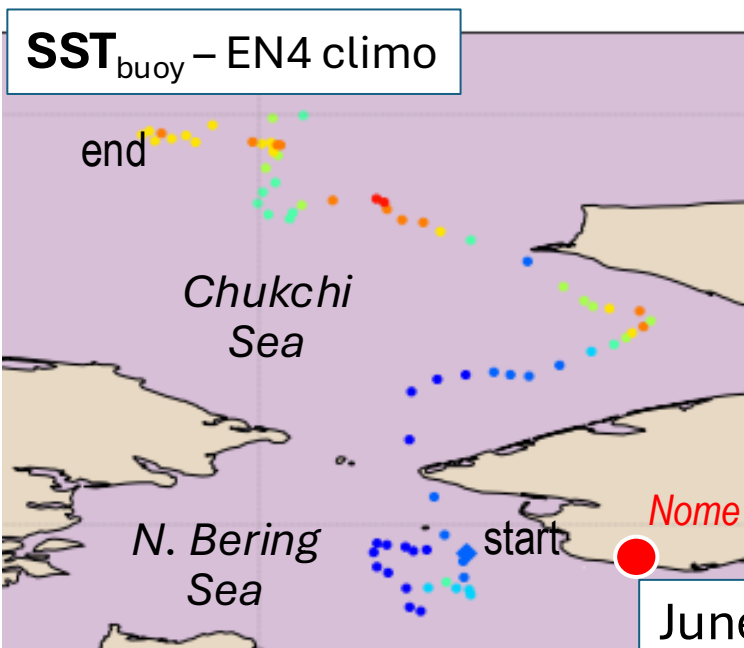
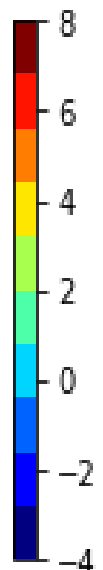
All summer 2024 buoys



Vazquez-Cuervo et al. (*Rem. Sens.*, 2021)

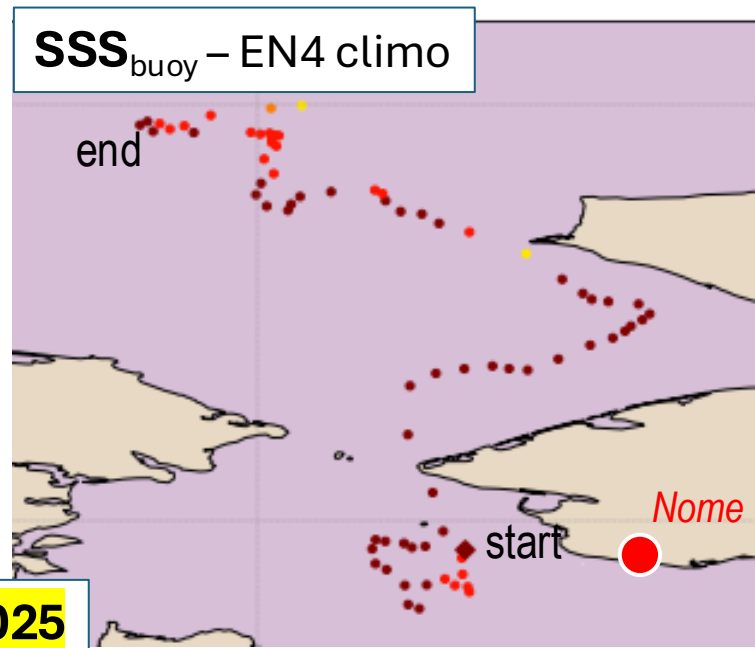
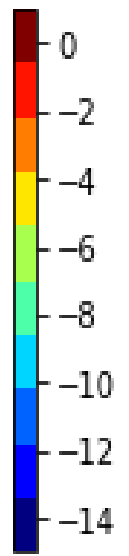
Ice Melting Signal

ΔSST ($^{\circ}C$)



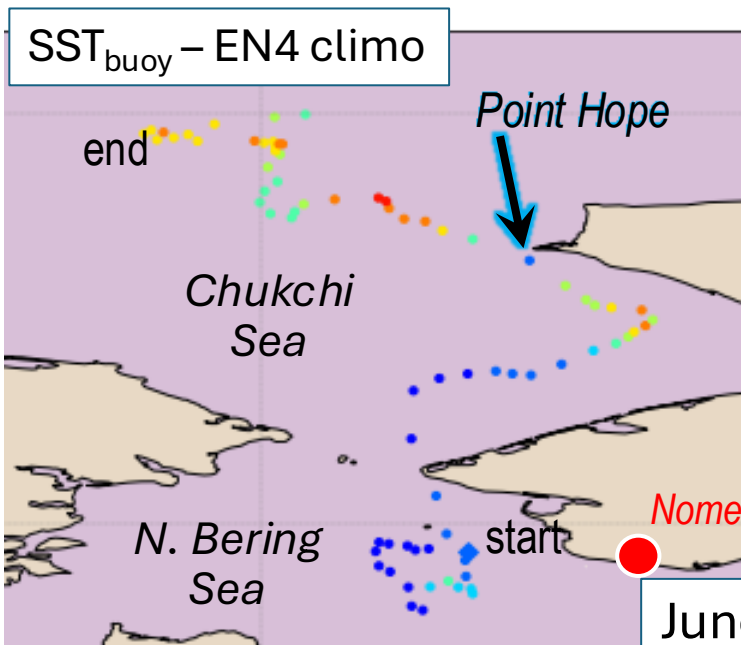
June/July 2025

ΔSSS (g/kg)

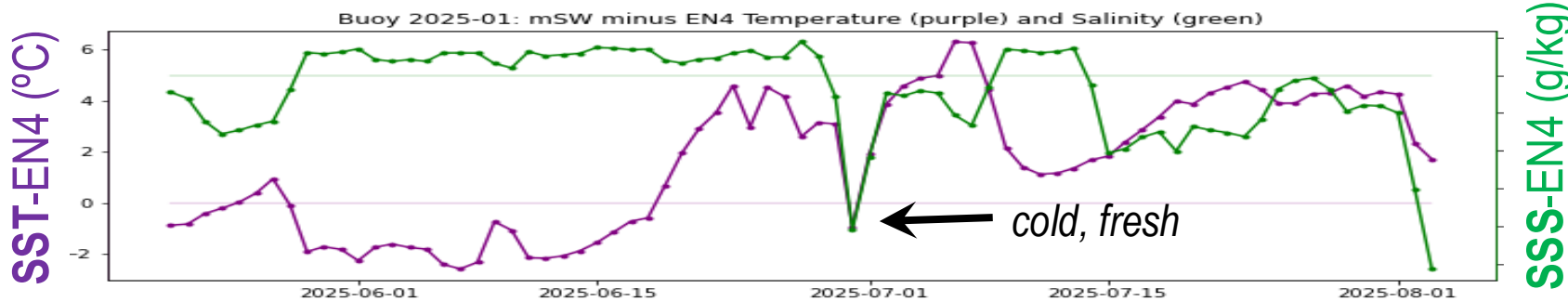
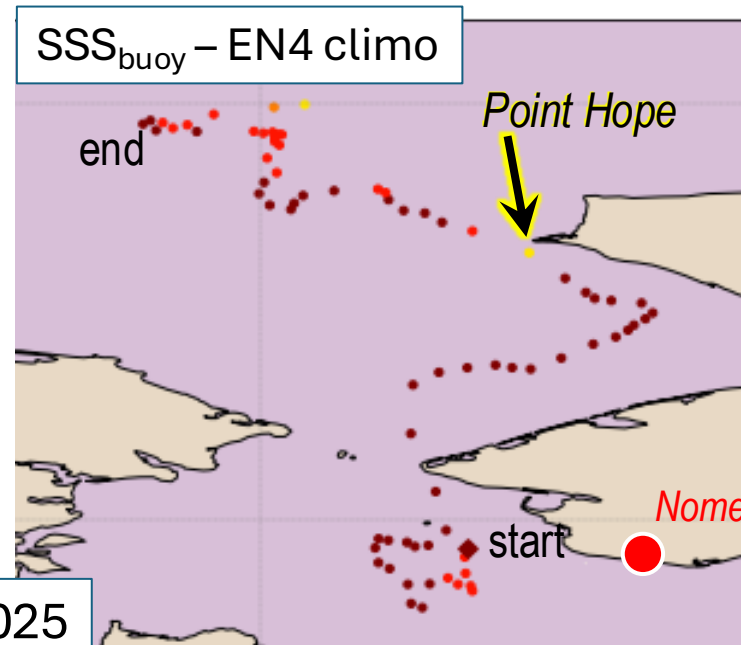
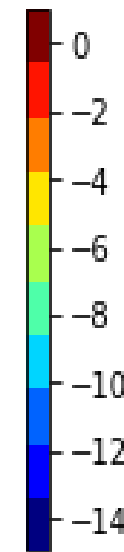


Ice Melting Signal

ΔSST ($^{\circ}C$)

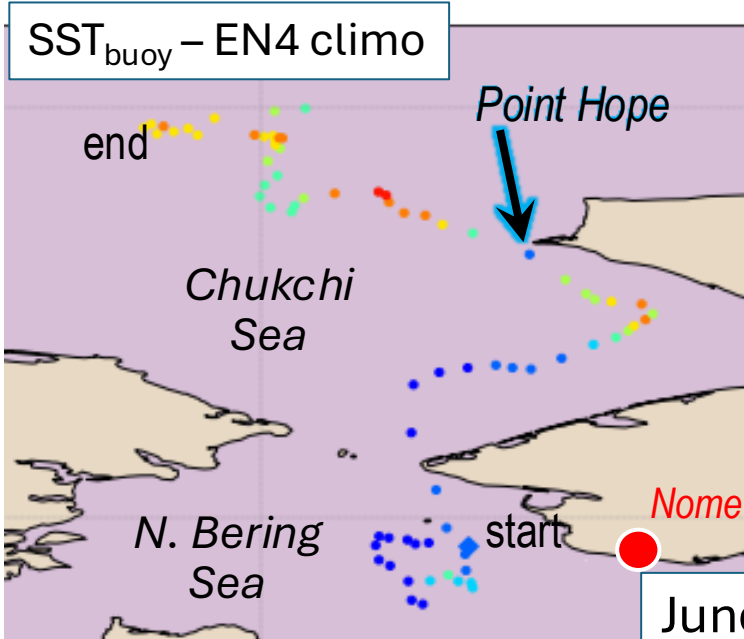


ΔSSS (g/kg)

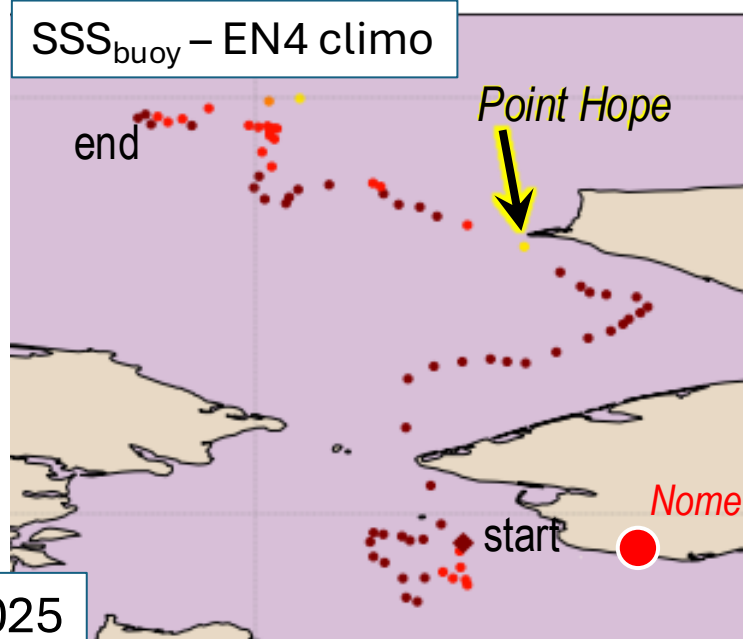
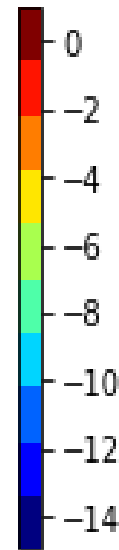


Ice Melting Signal

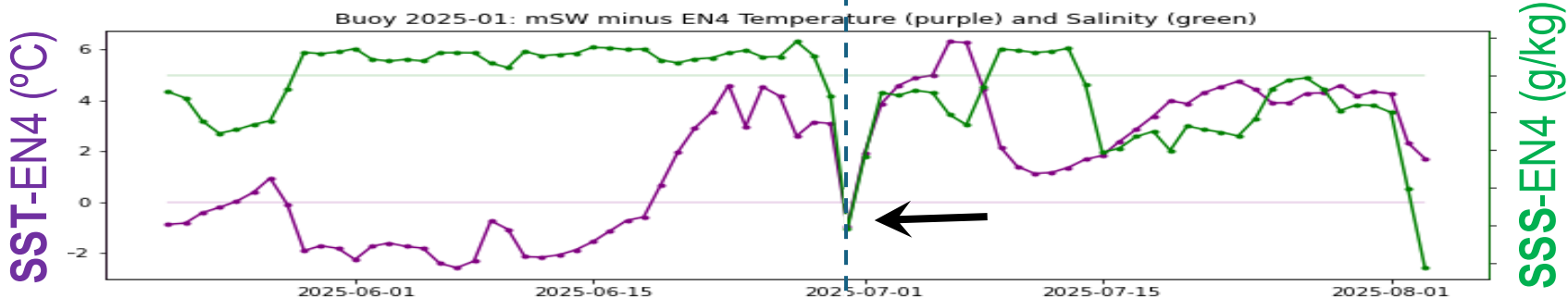
ΔSST ($^{\circ}C$)



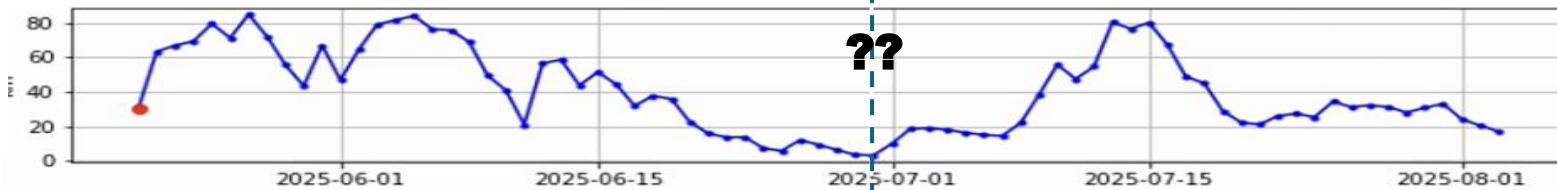
ΔSSS (g/kg)



June/July 2025



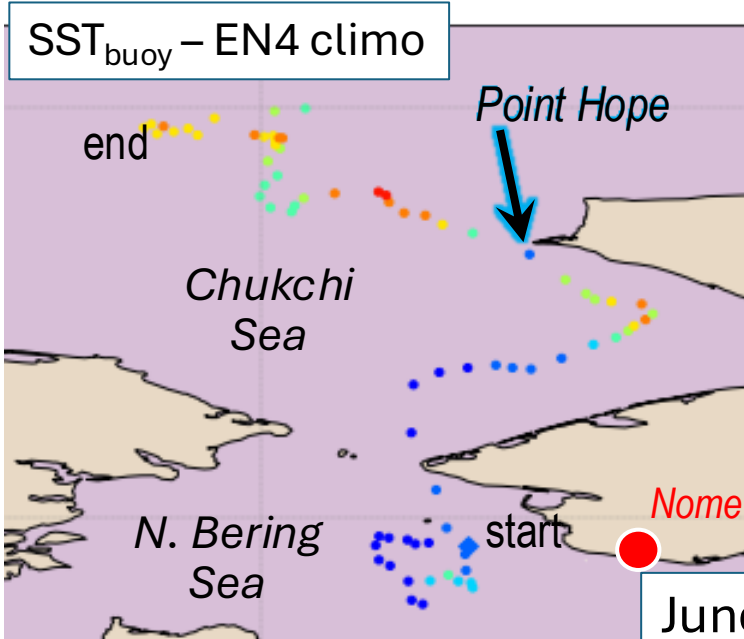
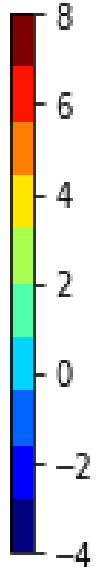
Distance to ice edge (km)



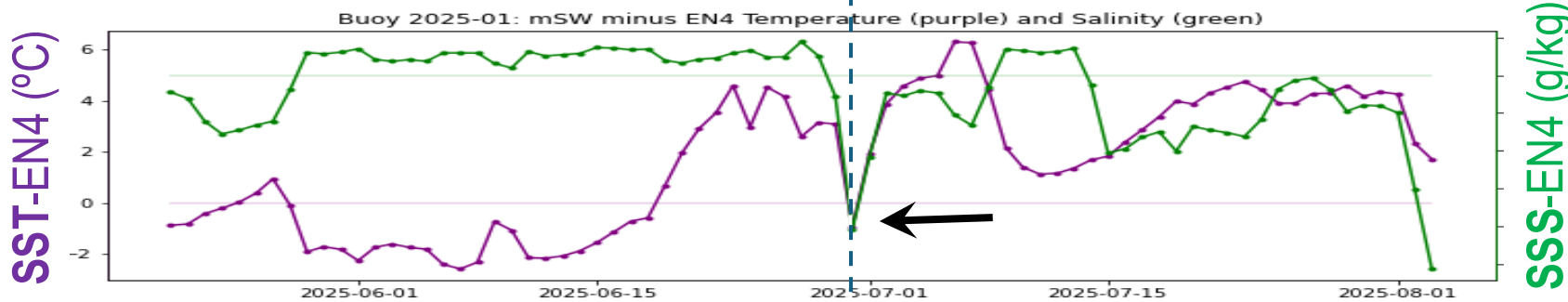
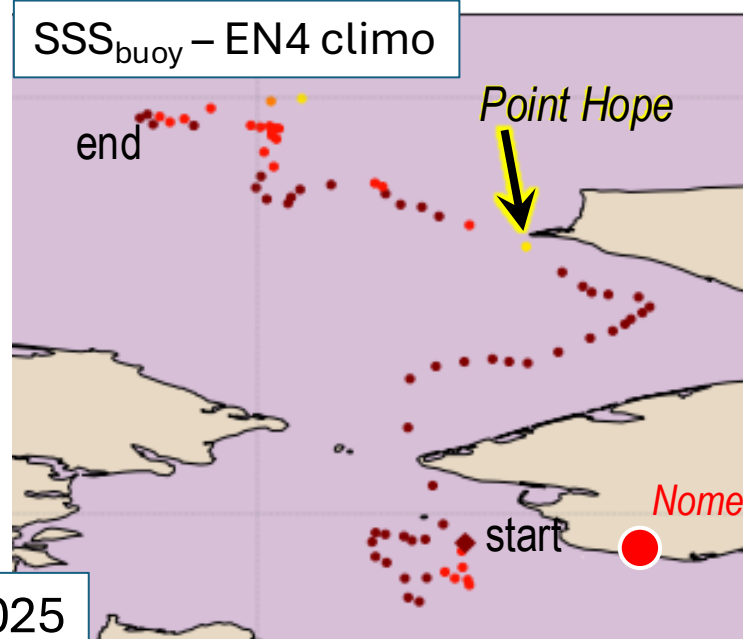
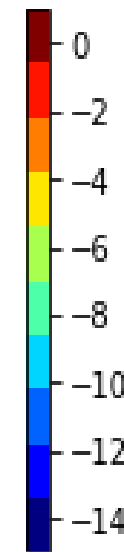
Ice melt signal closer to ice edge?
 A bit...

Ice Melting Signal

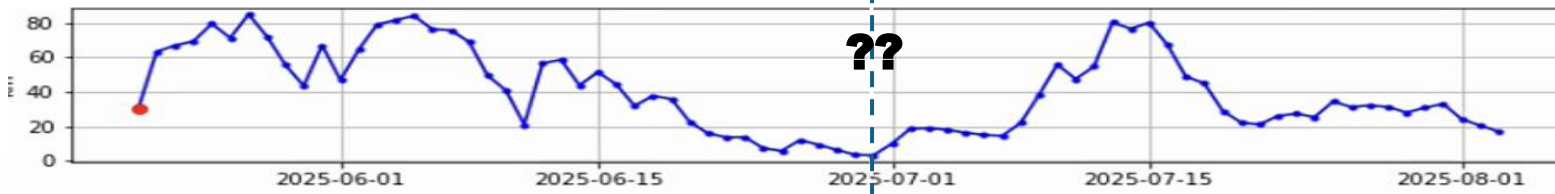
ΔSST ($^{\circ}C$)



ΔSSS (g/kg)



Distance to ice edge (km)



using grASIP
(Pacini et al., 2025)

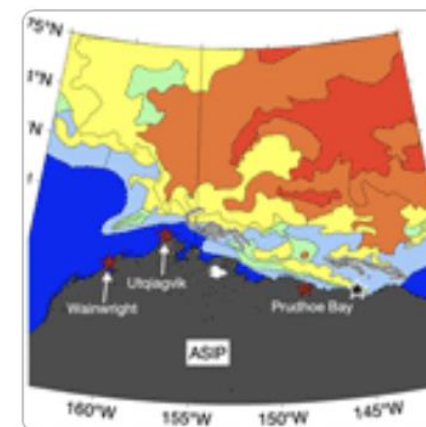
gridded Alaska Sea Ice Program Sea Ice Concentration

Research article |  The Cryosphere

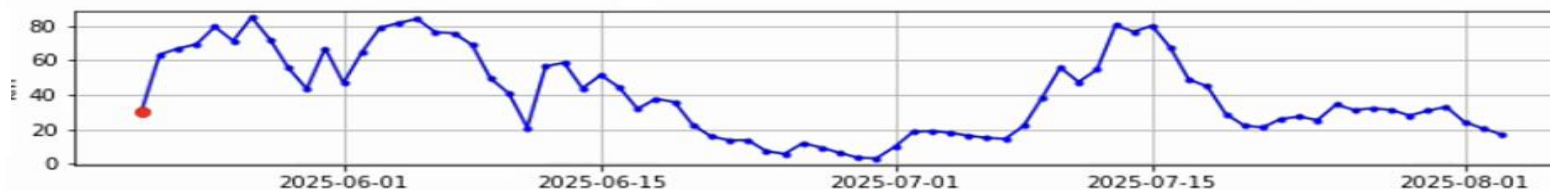
28 Mar 2025

National Weather Service Alaska Sea Ice Program: gridded ice concentration maps for the Alaskan Arctic

Astrid Pacini , Michael Steele, and Mary-Beth Schreck



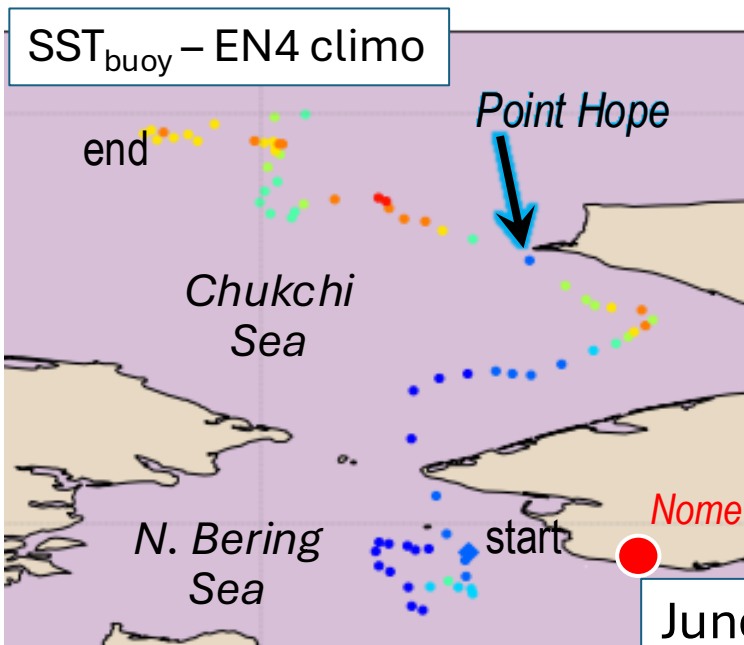
Distance to
ice edge (km)



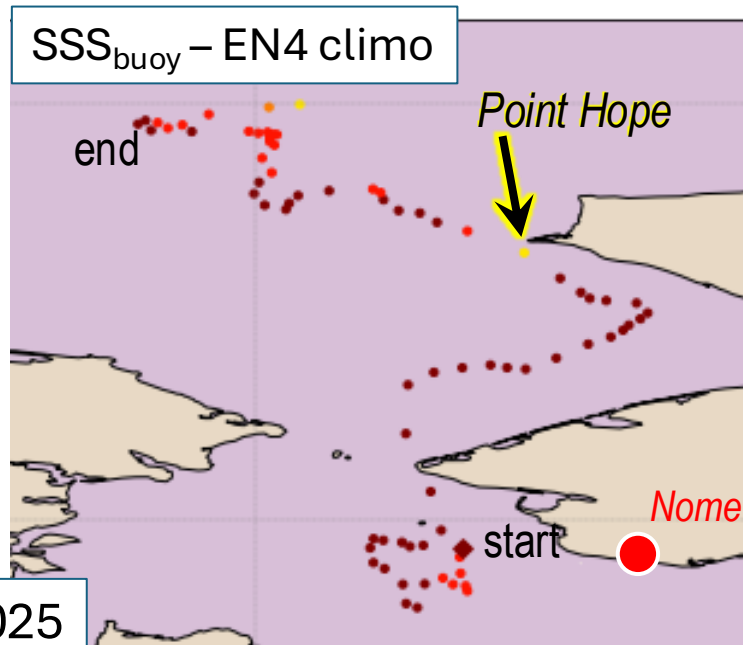
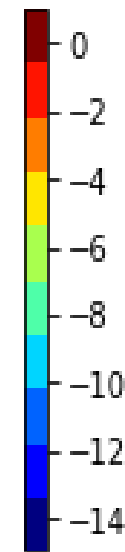
using grASIP
(Pacini et al., 2025)

Ice Melting Signal

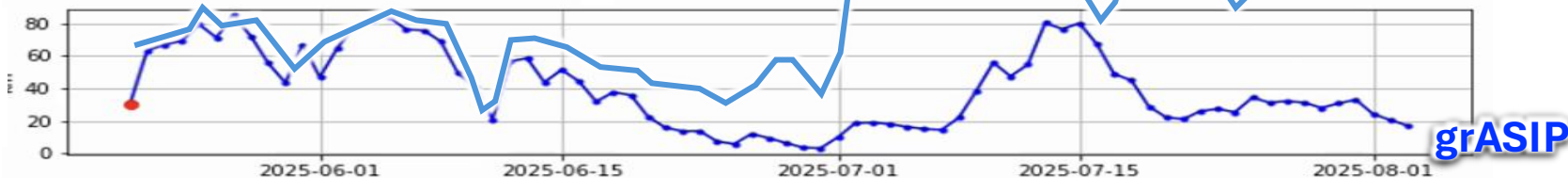
ΔSST ($^{\circ}C$)



ΔSSS (g/kg)



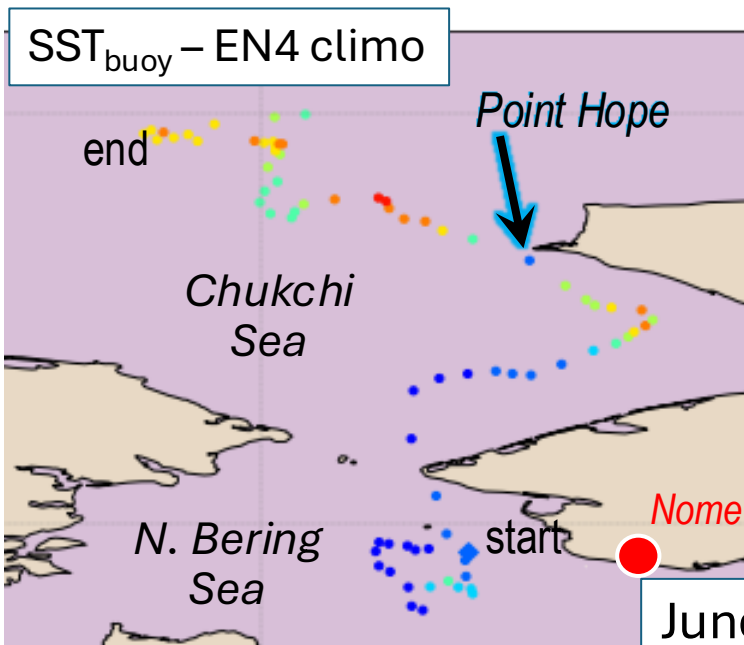
Distance to ice edge (km)



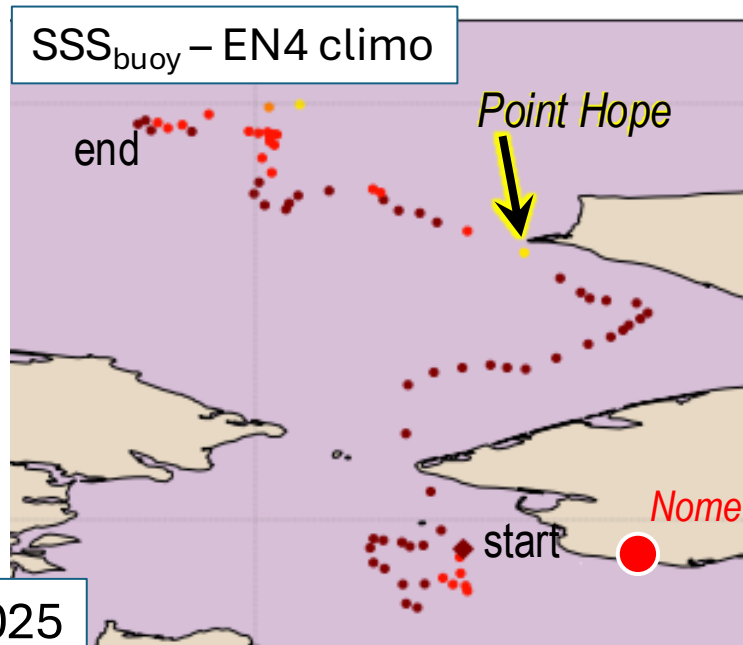
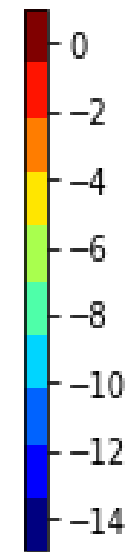
(high resolution!!)
 Passive μ wave
 ice edge
 is too far north
 in summer.

Ice Melting Signal

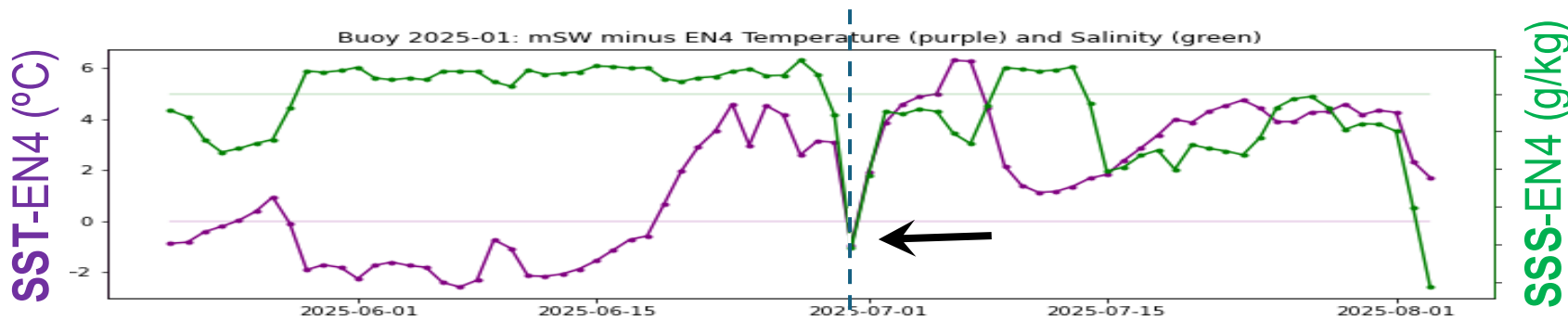
ΔSST ($^{\circ}C$)



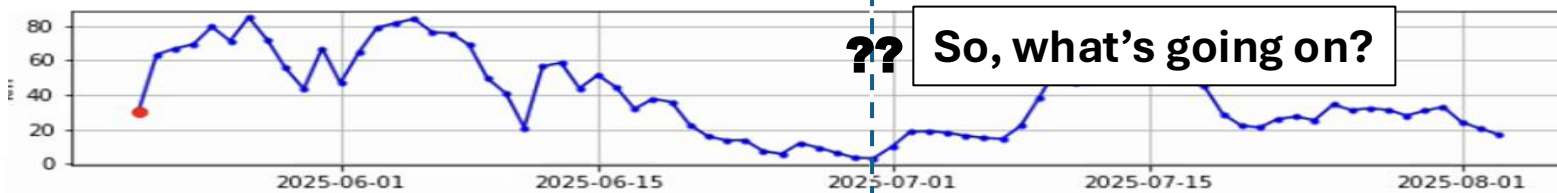
ΔSSS (g/kg)



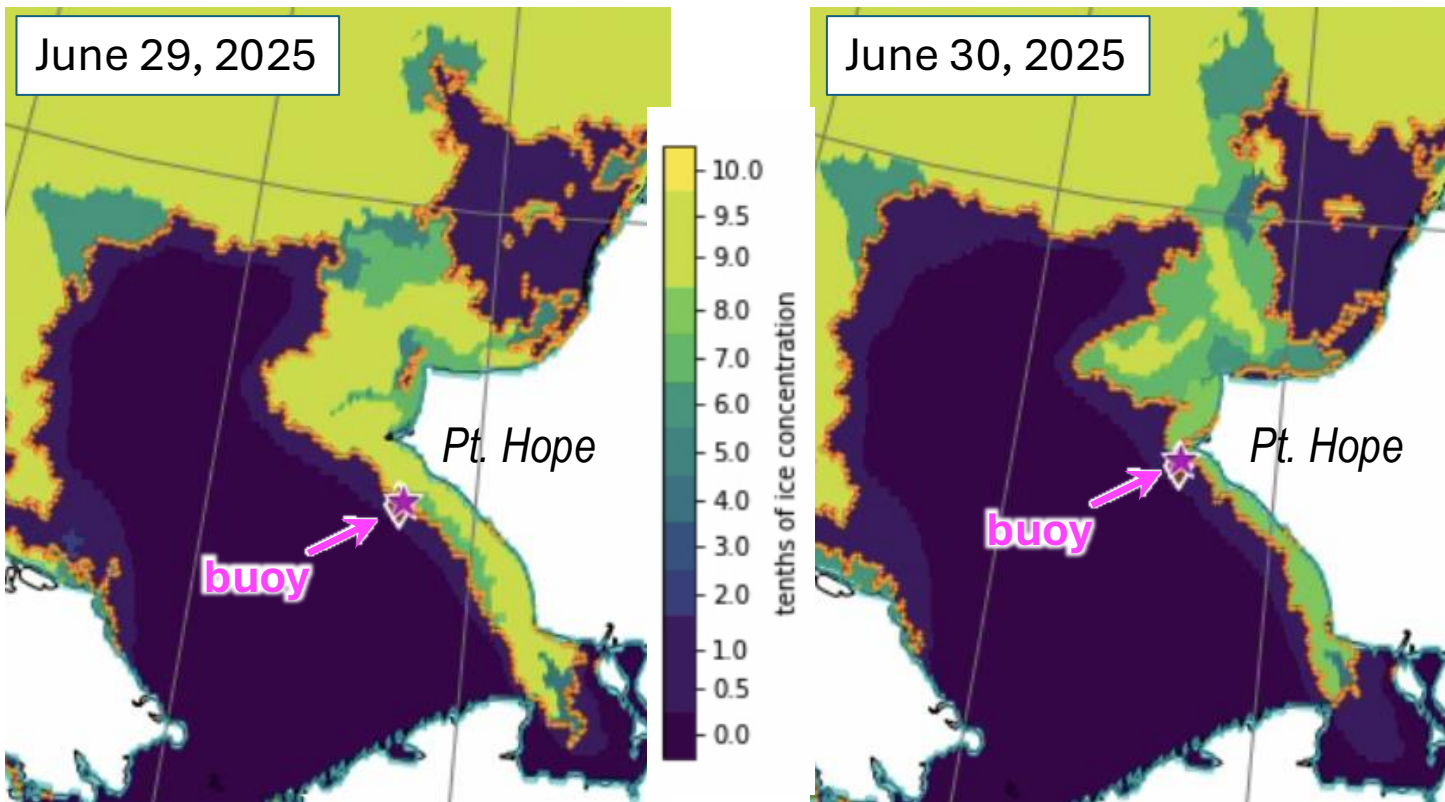
June/July 2025



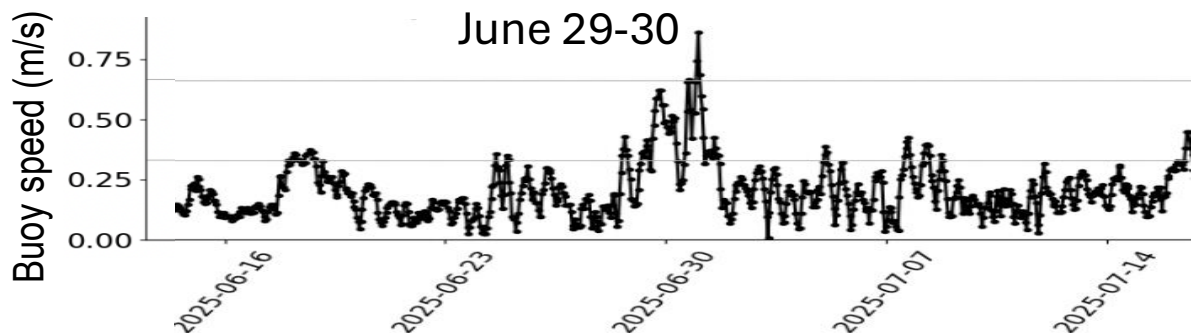
Distance to ice edge (km)



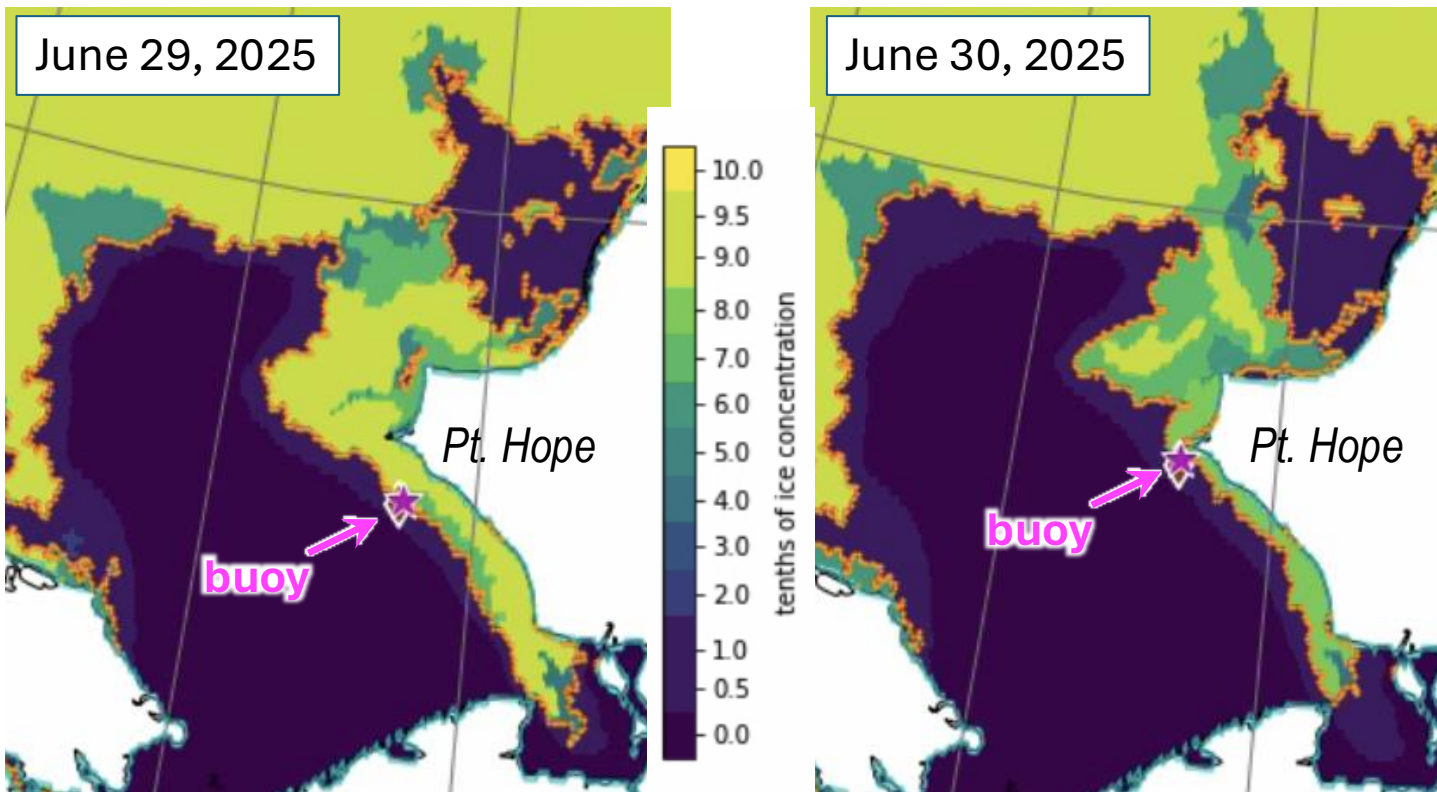
Ice Melting Signal



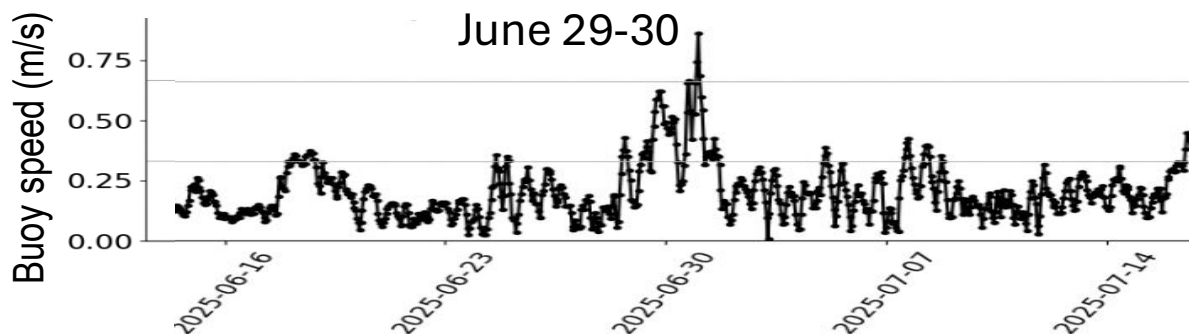
- Buoy hugs the ice edge,
- ... which retreats dramatically northward, leaving behind **cold, fresh meltwater**,
- ...which the buoy samples!



Ice Melting Signal



- Buoy hugs the ice edge,
- ... which retreats dramatically northward, leaving behind **cold, fresh meltwater**,
- ...which the buoy samples!



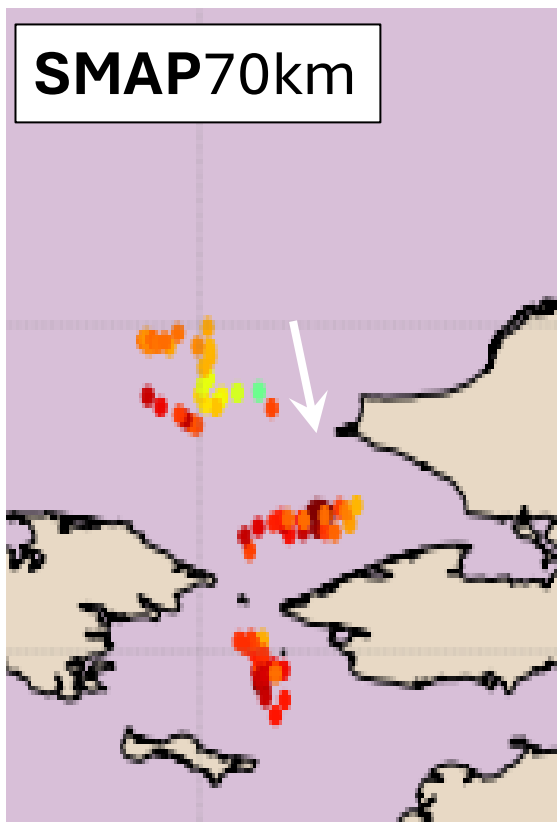
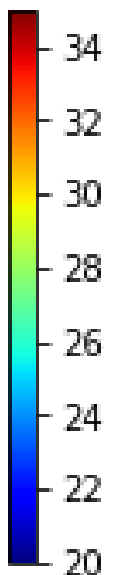
See Bingham et al. (JGR 2026 in review):

“Fossil Marginal Ice Zone”

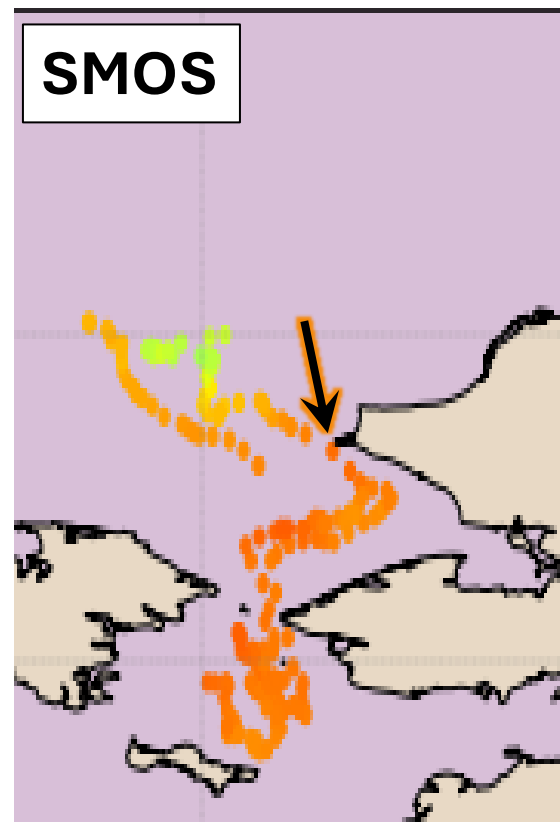
Ice Melting Signal: Did **SMAP** or **SMOS** get it?

All summer 2025 buoys

SSS (g/kg)



Large ice &
land masks



Weak
signals

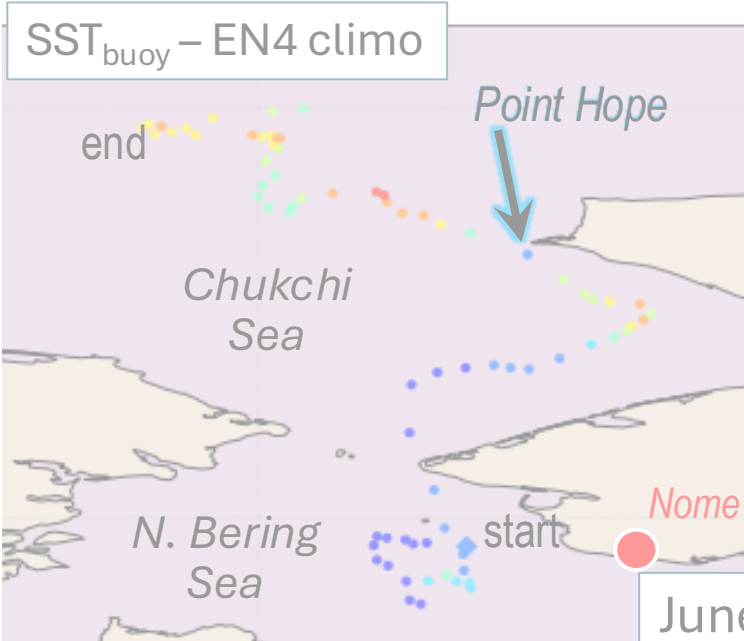
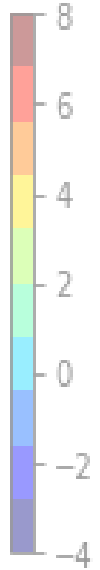
Nope.

Sea ice meltwater from SMOS:

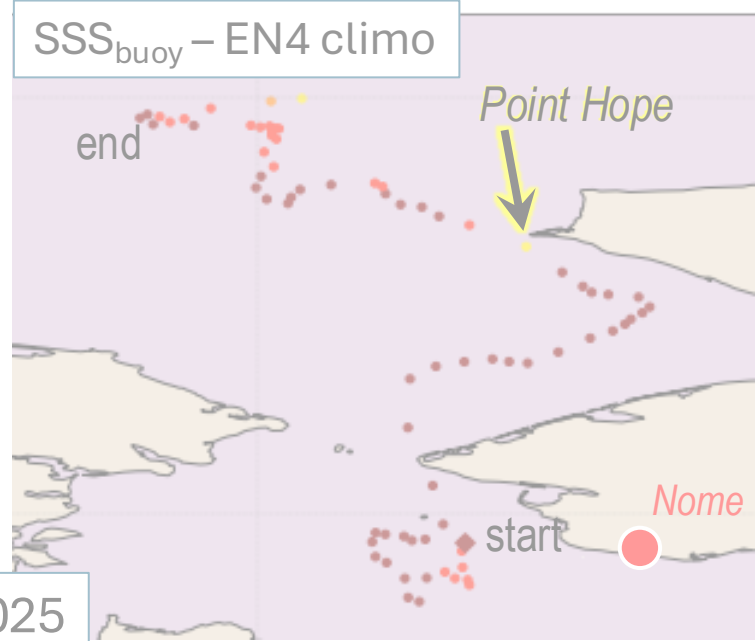
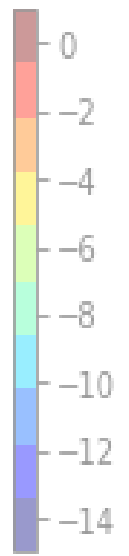
- *Supply et al. (JGR, 2022)*
- *De Andres et al. (JGR, 2025)*

Ice Melting Signal

ΔSST ($^{\circ}C$)

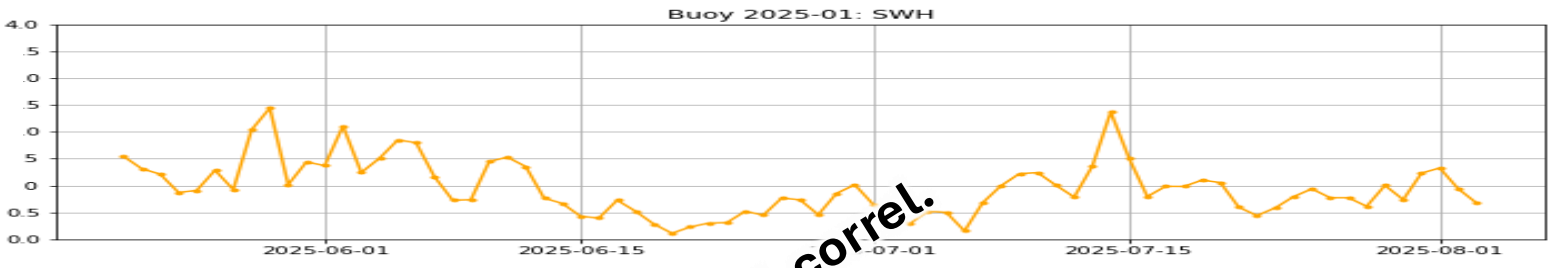


ΔSSS (g/kg)

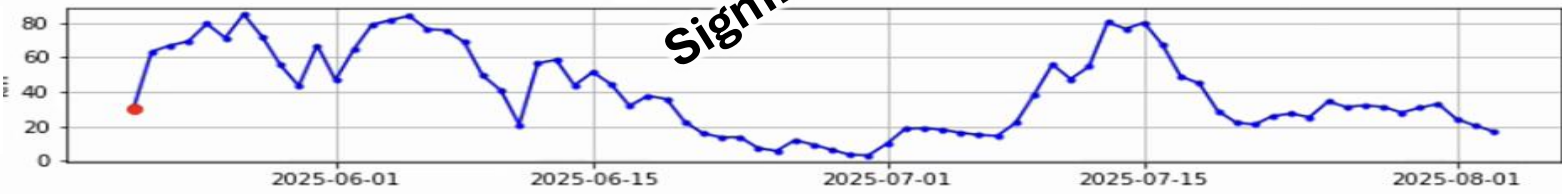


June/July 2025

Signif.
 wave height (m)



Distance to
 ice edge (km)

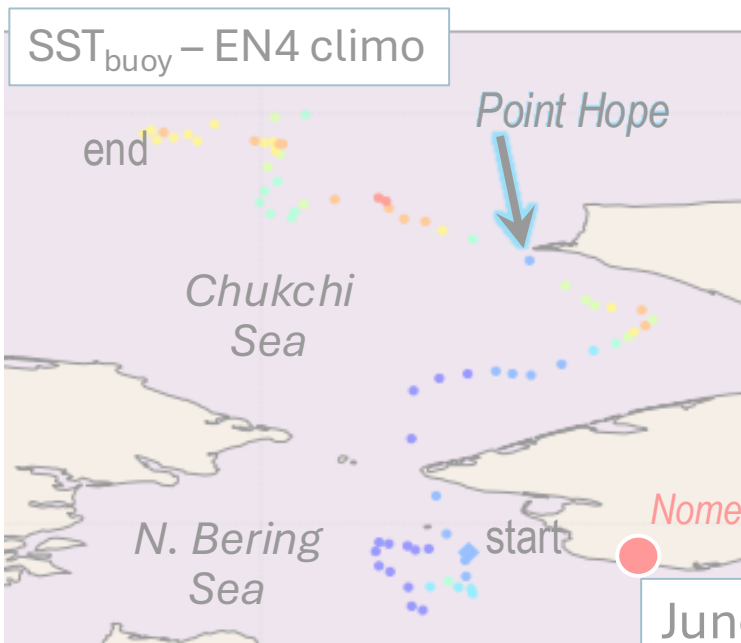
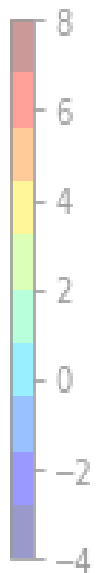


Signif. correl.

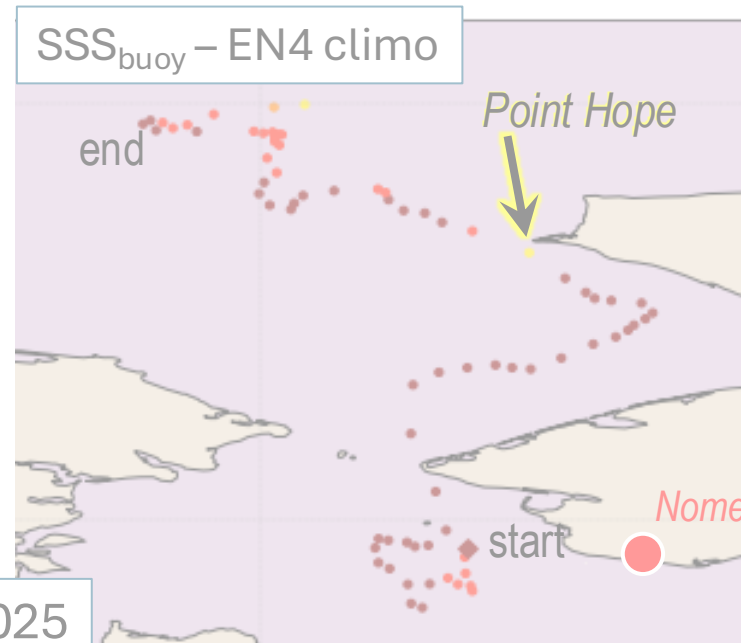
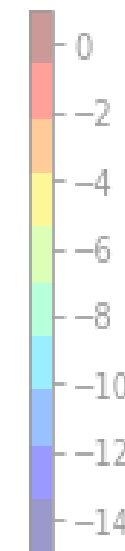
Ice damps
 waves...

Ice Melting Signal

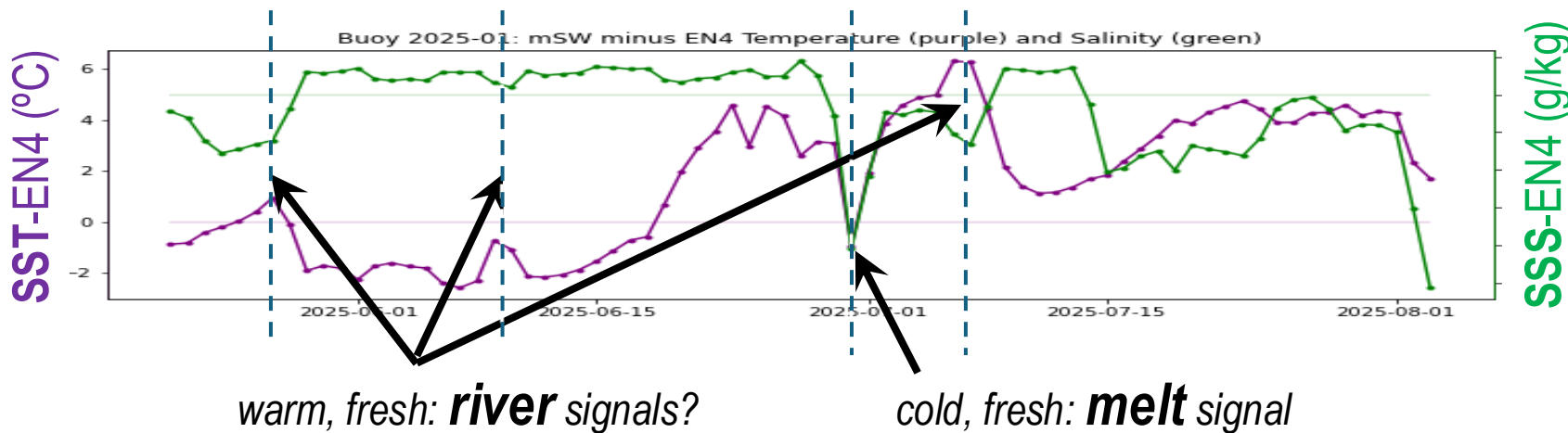
ΔSST ($^{\circ}C$)



ΔSSS (g/kg)

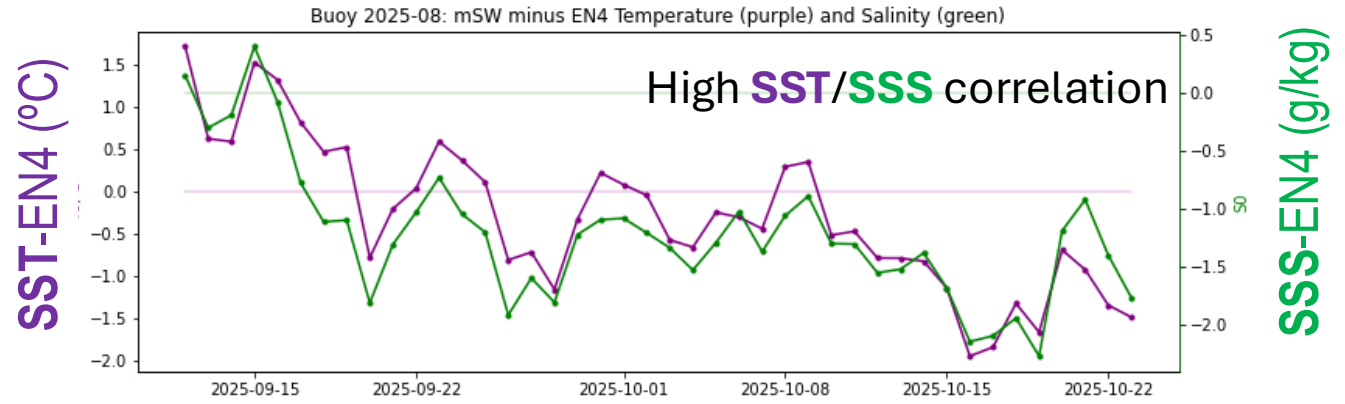
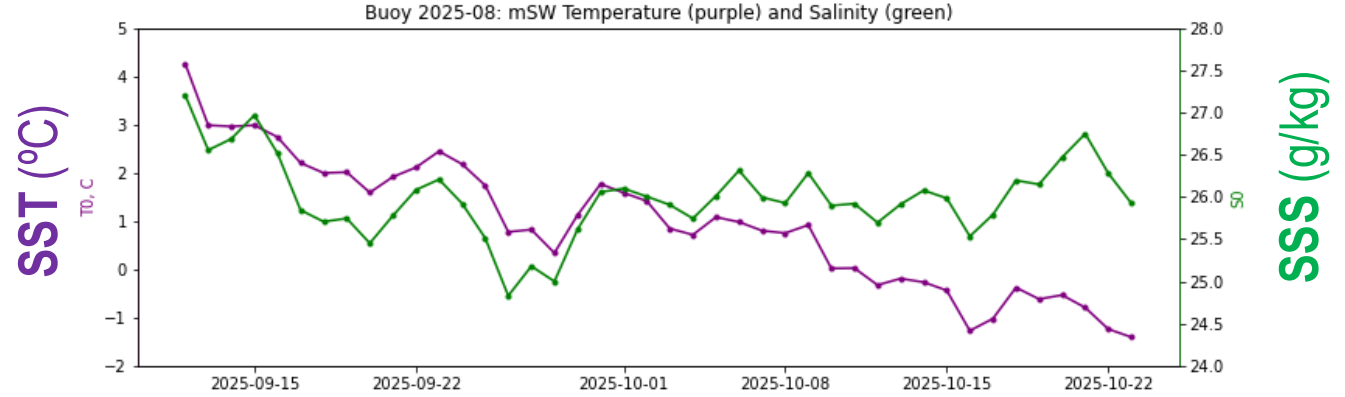
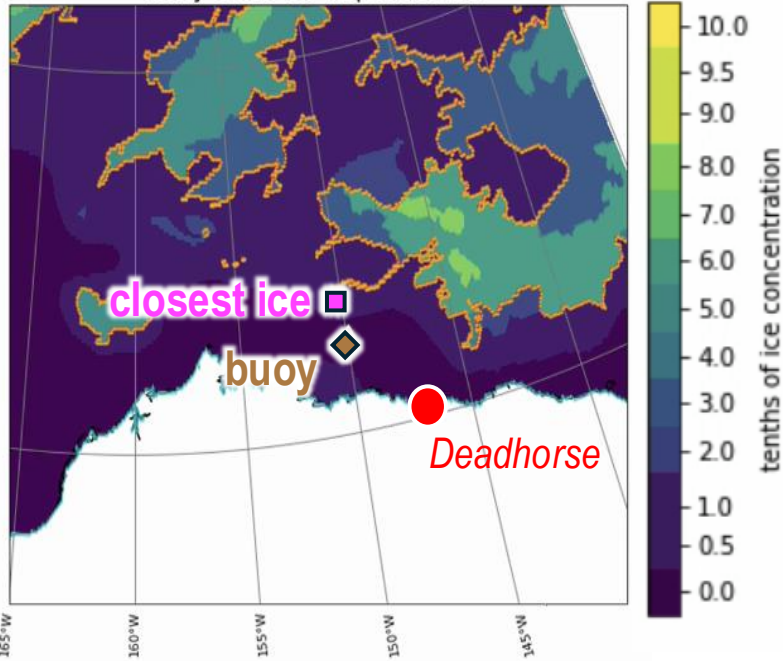


June/July 2025



Southern Beaufort Sea: FRESH Arctic

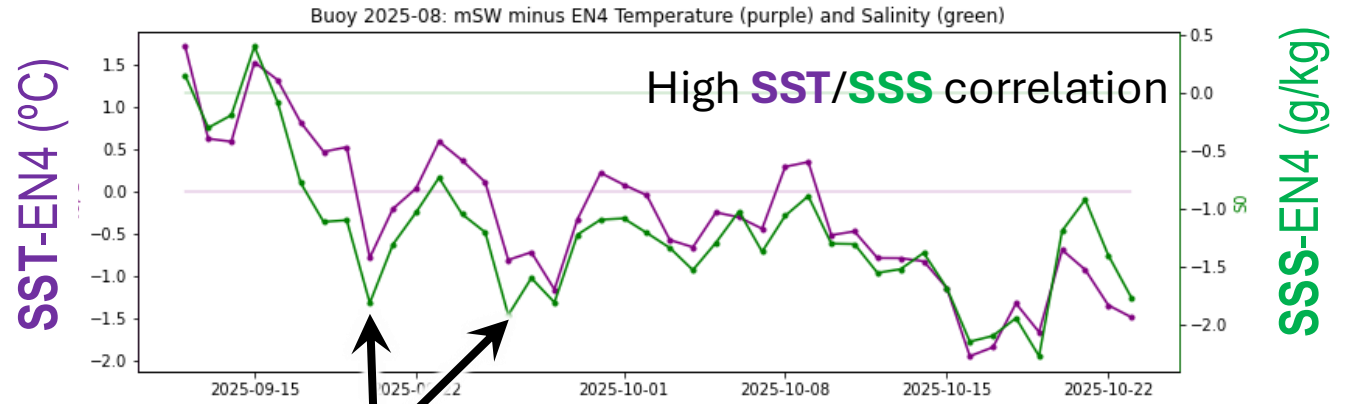
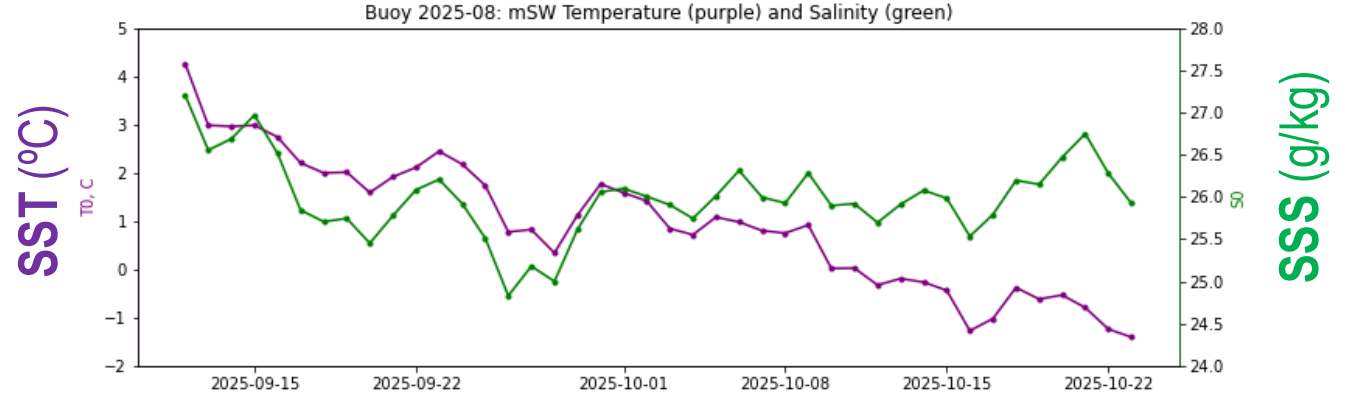
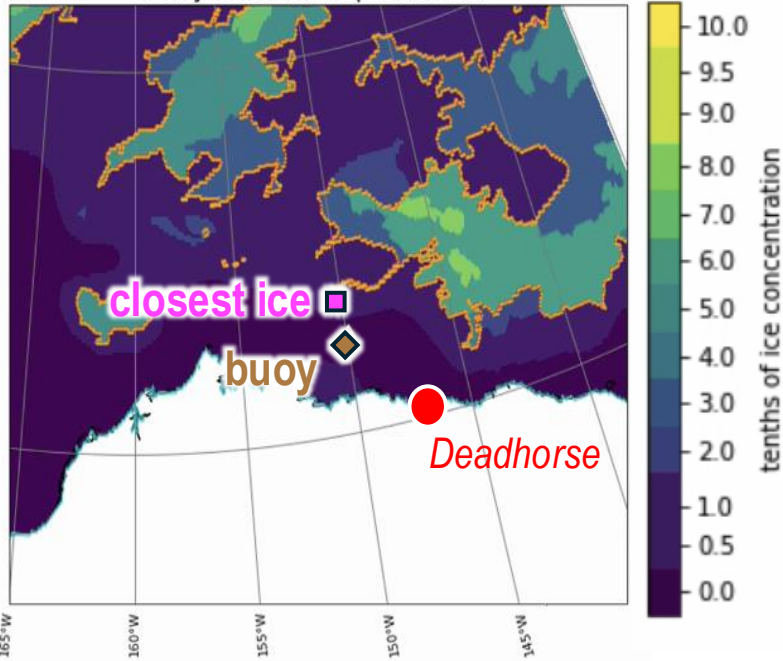
Sept 12, 2025



Subtracting out the climatology 😊

Southern Beaufort Sea: FRESH Arctic

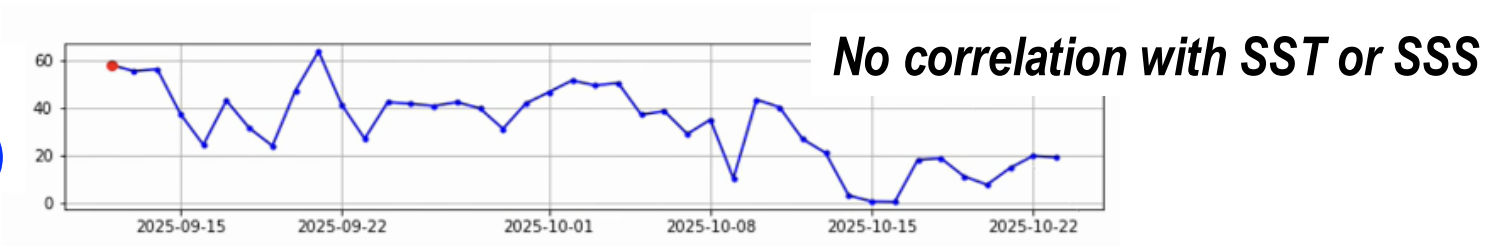
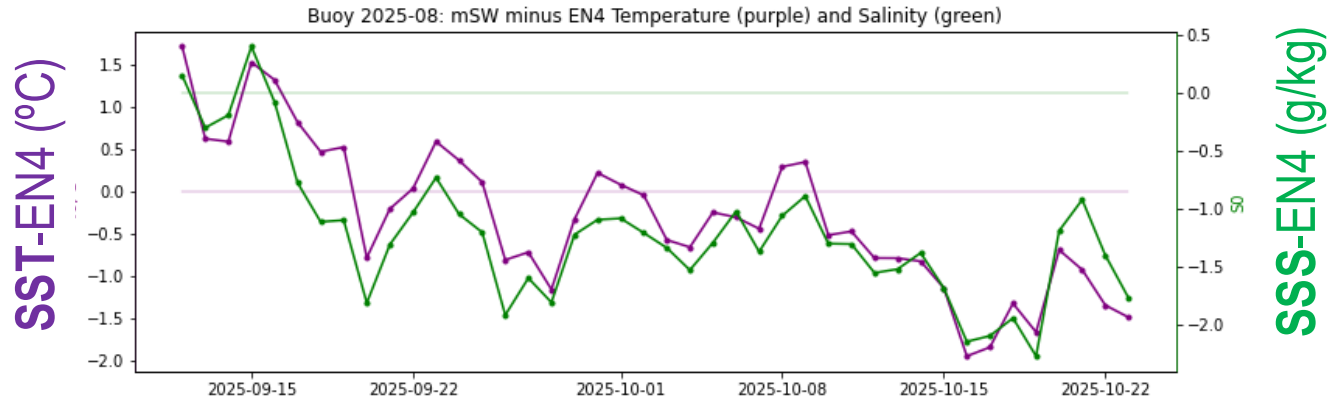
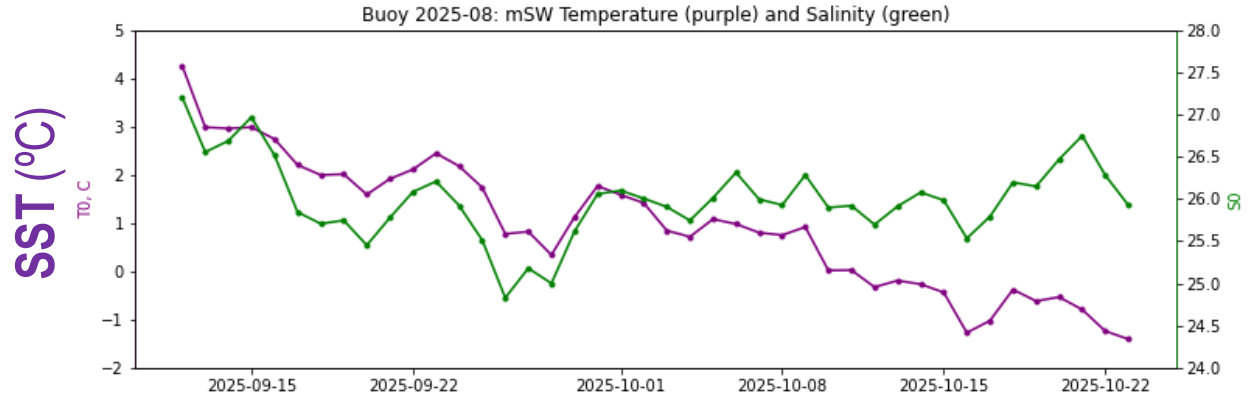
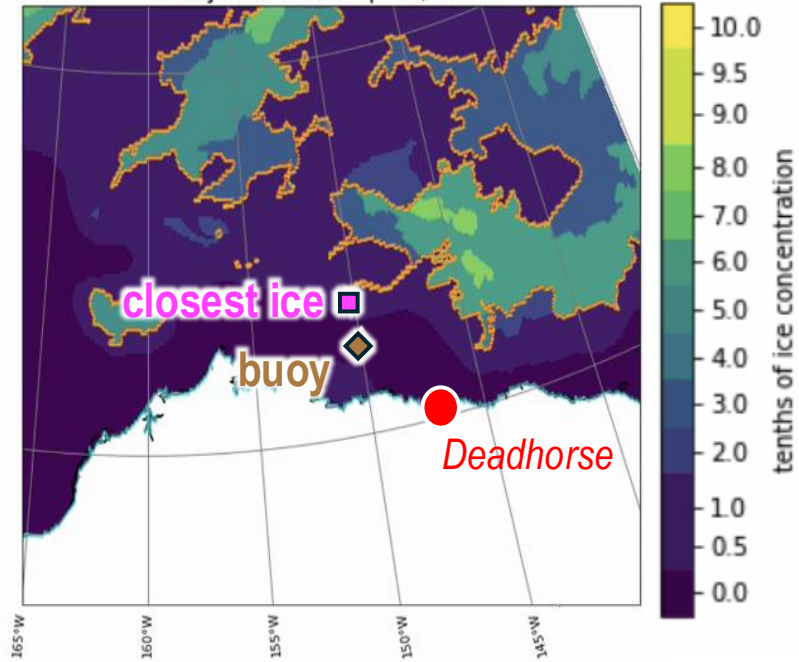
Sept 12, 2025



ice melt?

SST & SSS high correlation

Sept 12, 2025



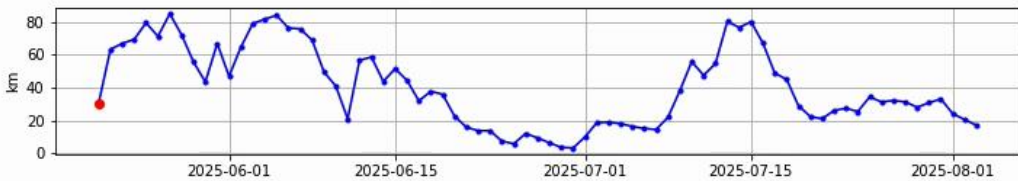
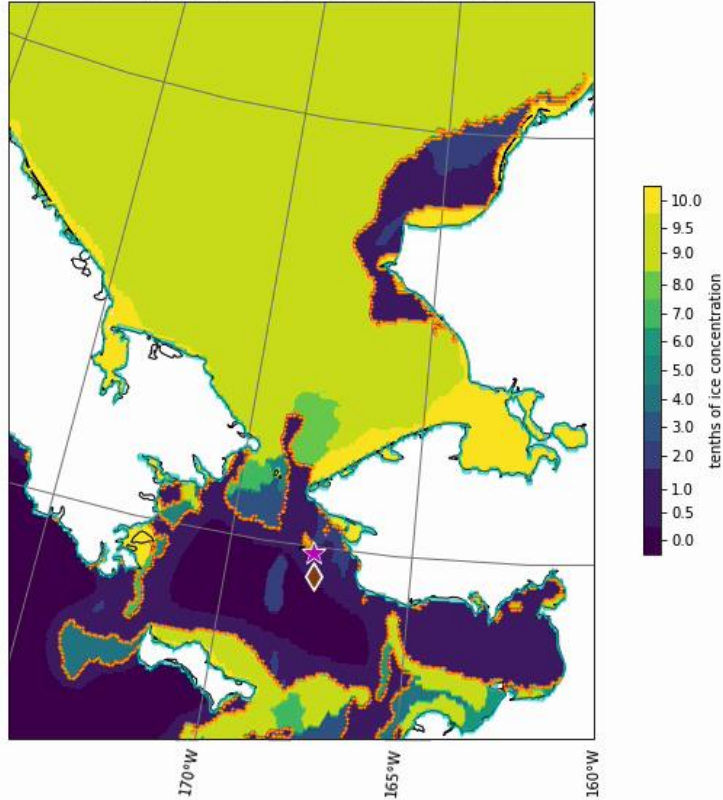
More analysis necessary...

Distance to ice edge (km)

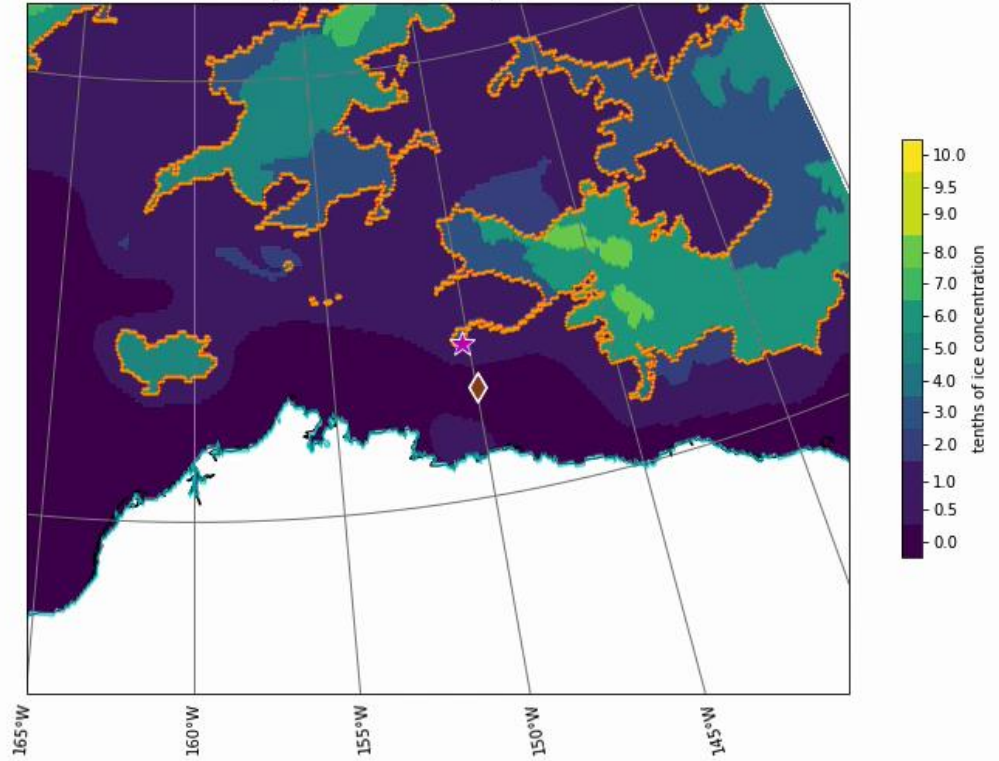
No correlation with SST or SSS

The geometry of the summer sea ice pack is complicated

Buoy 2025-01 May 21, 2025



Buoy 2025-08 Sep 12, 2025



Summary

- **microSWIFT buoys** for ocean surface obs.
- **SMAP**-RSS70km: few data near land & ice ...*but closer to obs.*
- **SMOS**-CECArctic: data near land & ice! ...*but signals are damped*
- River vs. ice melt signals: We're working on it
- The “**Fossil MIZ**”

Thank you!

Supplementary Figures

