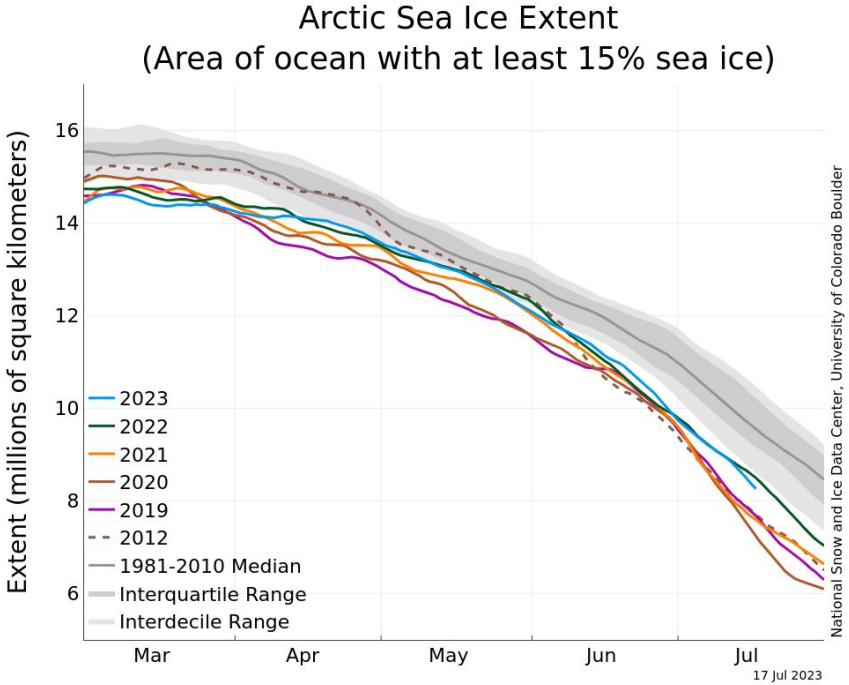
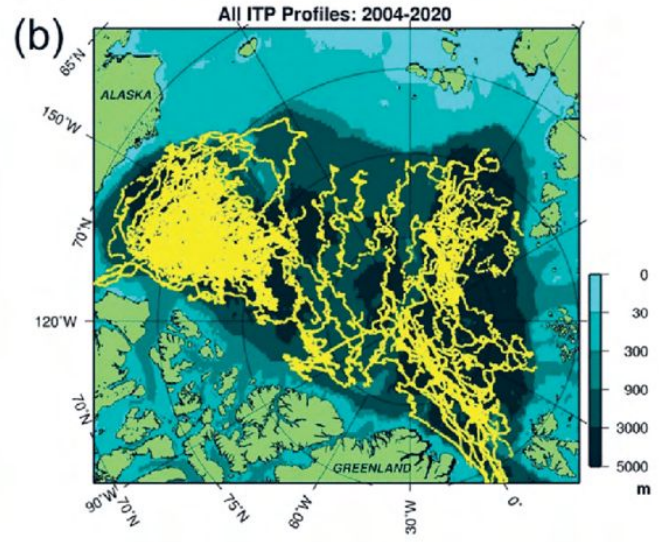
Towards an Arctic Ocean profiling array

Steve Jayne, Alex Ekholm,Susan Wijffels and WHOI float group

Rapidly changing Arctic



- The summer ice extent in the Arctic is decreasing rapidly
- This creates the ability for profiling floats to operate effectively there
- However, it diminishes the ability of Ice-Tethered Profilers (NSF)



Environmental Challenges

- Seasonal sea ice cover **prevents floats from surfacing**
  - No GPS positions for under ice profiles
- Ice can **damage floats** in numerous ways:
  - Breaking antennas
  - Crushing floats in ice floes
  - Ice forming on floats while at the surface increasing the buoyancy
- The **ice avoidance** algorithm was originally designed for the **Southern Ocean** which has relatively thick wintertime mixed layers which gives the floats time to detect likely ice conditions and turn around
- The Arctic has a **much different** stratification which makes the likely presence of ice harder to predict, and requires much shallower temperature observations

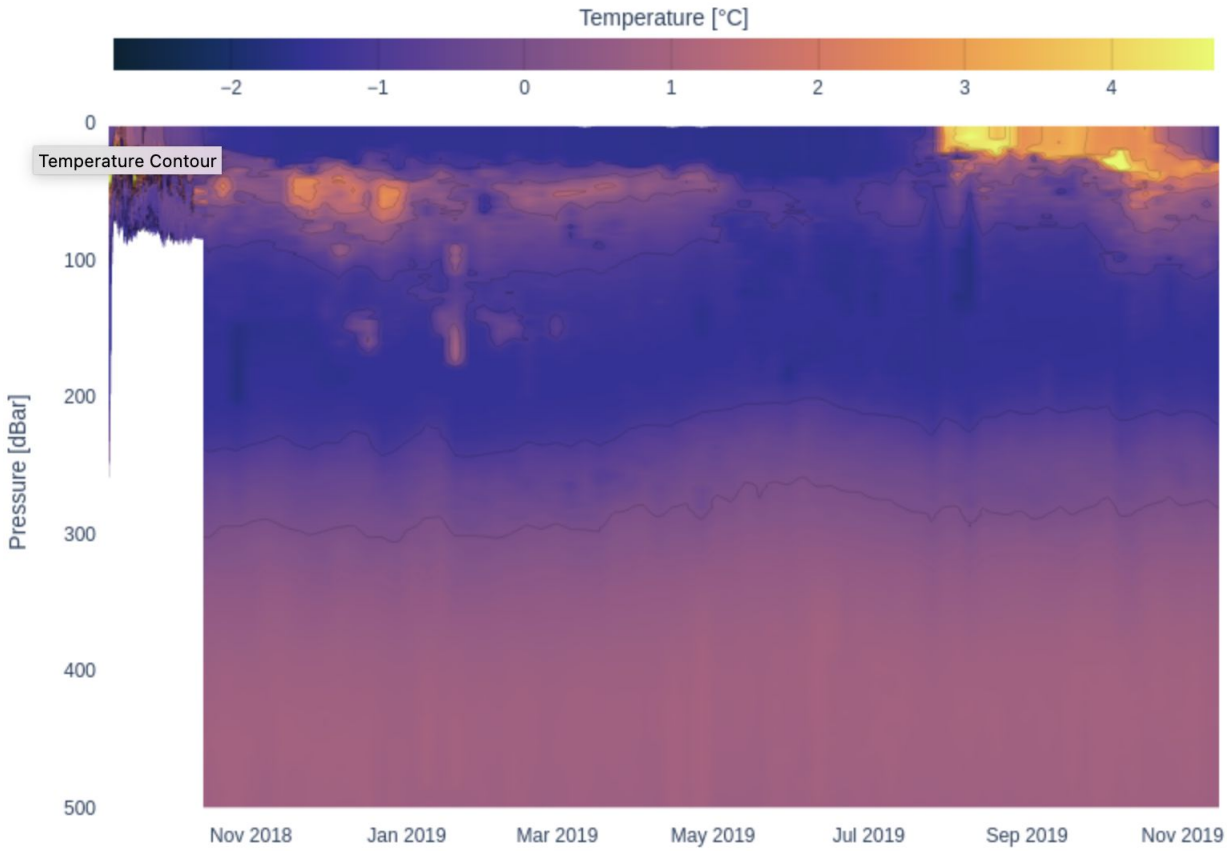
Technical Challenges

- APEX floats have a small change in volume ($\Delta V/V \sim 1\%$), and therefore can not overcome the strong surface stratification in the Arctic Ocean
- S2A ($\Delta V/V \sim 3.4\%$) and ALTO/ALAMO ($\Delta V/V \sim 4.2\%$) have **sufficient buoyancy** to operate in the Arctic surface stratification
- While ALTO/ALAMO floats operate well in the Arctic and some have overwintered under the ice, the floats from MRV have been plagued with **firmware and hardware issues**, including an incorrect and buggy implementation of the ice avoidance algorithm.

Previous Arctic Ocean profiling float efforts

- Under various ONR-sponsored research initiatives, profiling floats have been deployed in the Beaufort Gyre. Under the Stratified Ocean Dynamics of the Arctic, floats were deployed in both the Barents Canyon and in the open Arctic Ocean:
  - Boury et al., 2020, JPO, DOI: 10.1175/JPO-D-19-0273.1
- In collaboration with NOAA/PMEL, WHOI deployed floats for the Arctic Heat Open Science Experiment, focused primarily on the Chukchi Sea. Many of these were air-deployed by the NOAA Twin Otter:
  - Wood et al., 2018, BAMS, DOI: 10.1175/BAMS-D-16-0323.1

Stratified Ocean Dynamics of the Arctic (SODA) experiment – ALTO float 11012

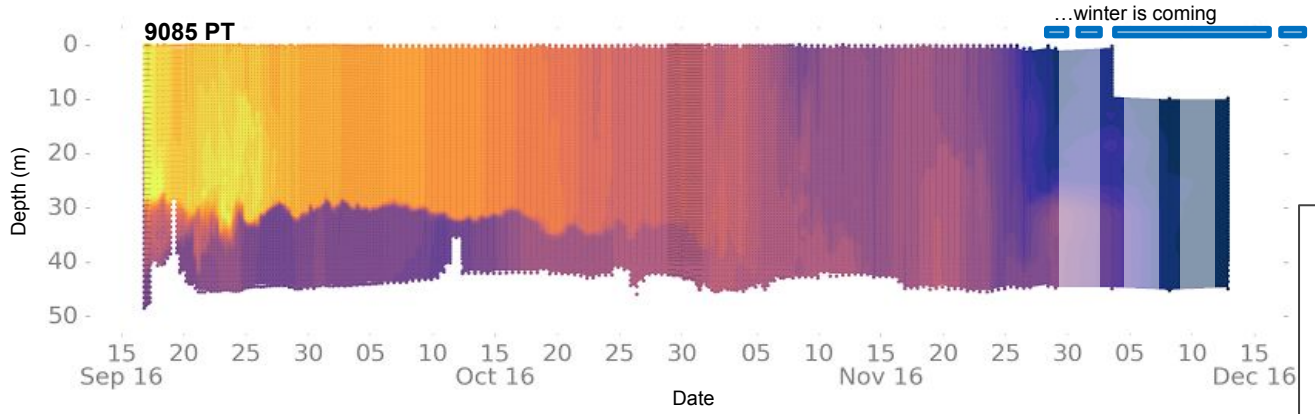


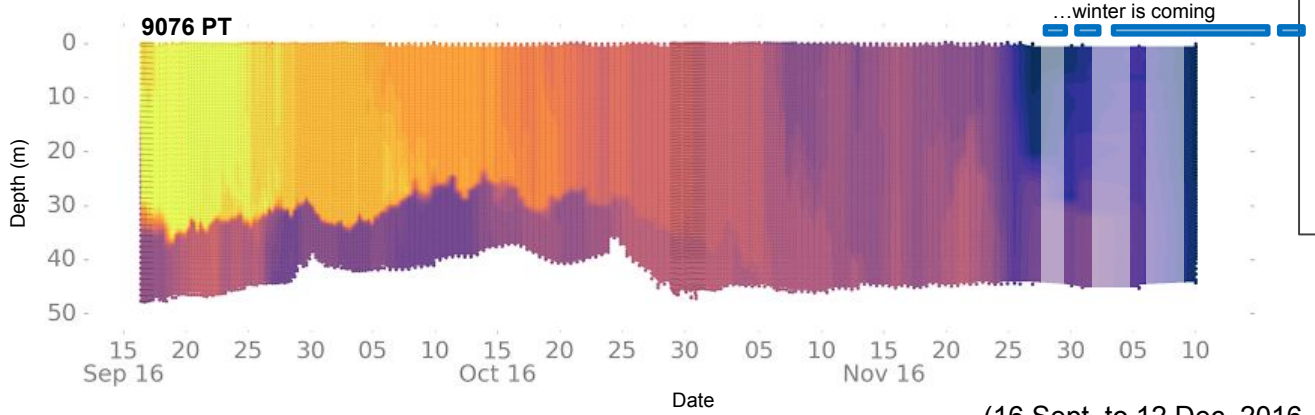
Float deployed with 4 others to trace the Chukchi Slope Current

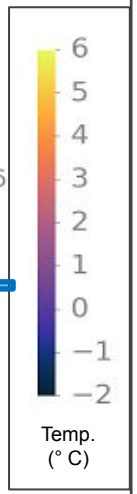
Successfully overwintered and returned data for over a year.

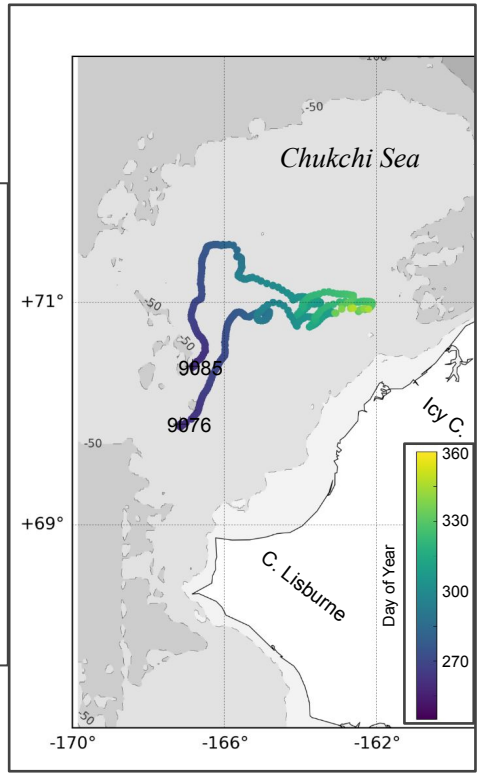
Data available at: argo.whoi.edu/alamo

Arctic Heat Open Science Experiment (NOAA)









ALAMO Tracks
(mostly bottom)

(16 Sept. to 12 Dec. 2016 – 500 profiles)

Improving Arctic Ice Avoidance Methods

Lucas Herron and Steven Jayne, WHOI

- Using **historic** CTD **profiles** in the Arctic we apply a **machine learning** to seek optimal Instruction Set Architecture policies for predicting the presence of ice based on upper ocean temperature and salinity
- Arctic hydrographic & ice data used to train the system:
  - Argo – 24,960 profiles
  - Ice Tethered Profilers (ITP) – 60,528 profiles
  - MASIE-NH daily sea ice extent (4 km) – Matched with profiles to determine presence of ice
- Methods determine a **probability of ice above a surfacing float**
  - Allows users to determine risk tolerance for desired mission
- Optimal temperature threshold across the full Arctic dataset:
  - **-0.5°C at 20 dbar for best prediction** of presence of surface ice

Current work

- Experimenting with **acoustic receivers on ALTO** floats to listen for timed transmissions from surface buoys in the Arctic Mobile Observing System (ONR sponsored) to geolocate floats under ice (as is done with RAFOS)
  - 4 ALAMO floats are currently under the ice awaiting this summer's melt
  - Craig Lee (UW/APL) is developing a similar system using the SOLO-2 platform
- Continuing to work with MRV System to **fix the firmware** and improve the ice avoidance autonomy
- There is strong interest from the Naval Oceanographic Office to **deploy more floats** in the Arctic
  - 4 ALTO floats are on the USCGC Healy about to be deployed
  - 4 ALTO floats will be air-deployed later this summer

Future Opportunity: As the multiyear ice retreats, there is an opportunity for sustained deployments to build an **Arctic Argo array** that tracks subsurface changes, complementing the ITP program (multiyear ice regions)