Use of Profiling Floats for Real-time \textit{in-situ} Observations in the Arctic

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Website: alamo.whoi.edu
All Argo Floats are Profiling Floats
Not All Profiling Floats are Argo Floats

- Argo is an international program to survey blue-water global ocean. Initial design did not include coverage of:
  - marginal seas
  - continental shelves
  - high-latitude oceans

- Primary characteristics of an Argo float mission
  - Profile depth to 2000 dbar
  - Park (passive drift) at 1000 dbar
  - 10-day repeat cycle

- Key strength of Argo program: nearly all floats are programmed with common mission and use a common sensor (Seabird SBE41 cp)
Essential components of a Profiling Float:

- **Buoyancy Engine** – Ability to change volume displacement of the instrument - typically achieved by pumping fluid from internal reservoir into external bladder. Must be energy efficient and capable of pumping against maximum pressure at profile depth (2000 dbar)

- Sensor package
- Satellite communications system (ARGOS, Iridium)
- Geo-location system (i.e. GPS)
- **Central controller (CPU) and firmware**
ALAMO  Air-Launched Autonomous Micro-Observer

A-sized profiling floats were originally developed under funding from ONR, and redeveloped under NOAA Sandy Supplemental funding. Initial use was collecting *in-situ* observations for improving hurricane forecasts and rapid-sampling of ocean response to hurricane-force winds.

- A-sized case
- Weight <9 kg
- 1000-meter depth rating
- 1 meter bin-averaged data
- Iridium Short-Burst Data communication
The ALAMO floats have been tested and deployed in cooperation with US Air Force 53rd Weather Reconnaissance Squadron.
Primary design constraint was ability to launch through A-sized tube.

Previous air-deployed profiling floats have required opening tail ramp.
Mixture of RBR T/P and RBR CTD sensors

Data reported in real-time on GTS for use by forecast models

Goal: manage float to last over duration of hurricane season

2015-2017
47 ALAMO deployed from Hurricane Hunter WC-130J aircraft.
Atlantic Ocean: 2015 Hurricane Season

- #9040 Deployed in the Tongue Of The Ocean (TOTO) in Bahamas Bank, trapped as a virtual mooring.
- Daily cycle to 1000m but when hurricanes passed over, float switched to burst sampling of rapid, shallow cycles

9040: Profile Positions

9040: Temperature °C

HOI TEMPESTS: 2018-Feb-25

Erika Joaquin Kate
ALAMO sensor package variants:

- RBR Temperature/Pressure
- RBR CTD - compact, low-power inductive conductivity cell
- RBR CTD w/ PAR (Photosynthetically active radiation)
- (RBR CTD w/ $O_2$-Optode)

- Seabird SBE 41cp CTD (extended case)

Programmed to repeatedly profile from 0-300 dbar (10 profiles per day)
Each cycle: 2 hrs submerged, 20 minutes on surface.
Vertical Speed ~10 cm/s (ascent speed controlled by CPU)

Average Duration: 50 days (37-58 days)
Average # of Profiles: 496 (368-573)
Average distance profiled: 158 km (127-179 km)
Internal Waves!
Reported Positions of ALAMO floats deployed in Chukchi Sea: 2016-2018

Bathymetry contours at 50m and 100m isobaths

Chukchi Sea

RV Sikuliaq

Barrow Canyon

Barrow

Point Hope

Alaska

GPS fixes only

Float #: Year of Deployment
9058: 2016
9115: 2016
9076: 2016
9085: 2016
9119: 2017
9150: 2018
9152: 2018
9153: 2018
Air-launched deployments from NOAA DeHavilland Twin Otter

Deployment videos at alamo.whoi.edu
#9085-PT: 245 profiles over 77 days, Fall 2016

**Heat Loss**
- $-0.04^\circ C$ /day
- $-85 \text{ W/m}^2$

**9085: Temperature °C**

**Heat Loss**
- $-0.24^\circ C$ /day
- $-500 \text{ W/m}^2$
Rapid sampling 245 profiles collected in 77 days

Winter Iced over

Surfaced April 24 2017 but was only able to offload a few SBD messages

Deployed Sept 16 2016

Sampling rate reduced to once per 5 days to conserve batteries over winter

(Missing Data)
Challenges for profiling floats in the Arctic

1. Sea Ice - float needs to be able to surface in order to:

• Communicate with satellite – Offload data, receive commands to change mission

• Determine Location via GPS. (*Location can be determined while submerged by acoustic methods if an appropriate network of sound sources is available)

Ice Avoidance Algorithms:

• Measure near-surface water temperature to determine likelihood of the presence of sea ice (supplement with calendar date). If water at freezing point then high likelihood of sea-ice => bail out of ascent before striking ice. Decision-making loop has to happen quick in Arctic

• If possibility of broken ice or open leads, have option to make repeated surfacing attempts in effort to find open water. (Choices: How many attempts?, how long to wait between?, how long to remain at surface?)
Challenges for profiling floats in the Arctic

2. High density stratification due to surface freshwater layers.

Measure of a float’s ability to overcome density stratification: $\frac{\Delta V}{V}$
(fractional change in volume divided by total volume)

<table>
<thead>
<tr>
<th></th>
<th>VOLUME (LITERS)</th>
<th>$\Delta V^*$ (ml)</th>
<th>$\Delta V / V$</th>
</tr>
</thead>
<tbody>
<tr>
<td>APEX / SOLO-1</td>
<td>~24</td>
<td>260-280</td>
<td>1.2%</td>
</tr>
<tr>
<td>SOLO-2 / S2A</td>
<td>~19</td>
<td>650</td>
<td>3.4%</td>
</tr>
<tr>
<td>ALAMO</td>
<td>9 to 10.5</td>
<td>400</td>
<td>3.8%</td>
</tr>
</tbody>
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*Fluid moved by hydraulic system. Additional factors determine the overall ability to overcome stratification: hull compressibility, thermal expansion, and inclusion of ‘compresssee’ compensator.
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 RV Sikuliaq

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Bathymetry contours at 50m and 100m isobaths

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- 9058: 2016
- 9115: 2016
- 9076: 2016
- 9085: 2016
- 9119: 2017
- 9085: 2016
- 9150: 2018
- 9152: 2018
- 9153: 2018
Float #9119 equipped with RBR CTD w/ PAR

Based on satellite imagery and observed water temperature, it appears float became lodged in sea-ice and was unable to descend.
#9119: RBR CTD with PAR sensor
Photosynthetically Active Radiation

Diurnal cycle, weakening into winter
Float #9152-SBE CTD

Deployed June 17, 2018 from RV Sikuliaq

Temperature Profiles - Last cycle #28 at 2018-06-26 09:54 GMT

Raw Salinity

Point Hope
Summary

- ALAMO: compact, air-deployable instruments offer increased opportunity for deployment from multiple types of platforms. Small size also advantageous when stowage space is limited.

- Rapid profiling frequency provides capability to resolve internal waves and diurnal processes.

- Two-way Iridium satellite communications supports real-time transmission of data and ability to reprogram float mission.


- Future work: SODA (Stratified Ocean Dynamics of the Arctic) plans to deploy a “float garden” in Barrow Canyon. A cluster of ALAMO will be anchored to sea floor, every two weeks one will release and start mission. Goal: monitor pathways of Pacific Summer Water flowing into Arctic interior.