Ice-tethered Instruments: History and Future Development

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Since the 1980s, Arctic drifting buoys with subsurface instrumentation have acquired unattended data on the surface air, ice, and upper ocean.
### Specifications:

<table>
<thead>
<tr>
<th></th>
<th>POP (SALARGOS)</th>
<th>IOEB</th>
<th>J-CAD</th>
<th>ITP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Developer</td>
<td>PSC</td>
<td>WHOI/JAMSTEC</td>
<td>JAMSTEC</td>
<td>WHOI</td>
</tr>
<tr>
<td>Lifetime</td>
<td>3 years</td>
<td>3 years</td>
<td>&gt;2 years</td>
<td>2.75 years</td>
</tr>
<tr>
<td>Length</td>
<td>300m</td>
<td>110-165m</td>
<td>260m</td>
<td>200-800m</td>
</tr>
<tr>
<td>Communications &amp; locs.</td>
<td>ARGOS</td>
<td>ARGOS</td>
<td>ORBCOMM/GPS</td>
<td>Iridium/GPS</td>
</tr>
<tr>
<td>CTDs</td>
<td>6</td>
<td>4</td>
<td>6</td>
<td>profiler</td>
</tr>
<tr>
<td>Frequency</td>
<td>12 min.</td>
<td>2 hour</td>
<td>1 hour</td>
<td>1-2 daily</td>
</tr>
<tr>
<td>Other sensors</td>
<td>Baro., Air T</td>
<td>Baro., Air T, Wind</td>
<td>Baro., Air T, Wind</td>
<td>interface for external</td>
</tr>
<tr>
<td></td>
<td>150kHz ADCP</td>
<td></td>
<td>300 kHz ADCP(s)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Ice thermistors</td>
<td></td>
<td>SST</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Trap, Fluoro., Trans.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hardware costs</td>
<td>$40,000</td>
<td>$250,000</td>
<td>$150,000</td>
<td>$40,000</td>
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<tr>
<td>Expendable</td>
<td>yes</td>
<td>no</td>
<td>yes</td>
<td>yes</td>
</tr>
</tbody>
</table>

The vertical resolution of the T & S observations from conventional systems has been limited to only a few depths due to the costs associated with outfitting multiple sensors on a single package.
Between 1985 and 1994, the Polar Science Center, APL/UWASH, deployed 24 Polar Ocean Profiler (or SALARGOS) data buoys in the Arctic Ocean. These data were incorporated into the US-Russian Environmental Working Group Atlas.

http://iabp.apl.washington.edu/
• Models are needed to account for depth changes of the discrete conductivity and temperature sensors on the SALARGOS buoys due to shoaling of the mooring system from the ice drift.
• Parameterizations are relied upon to reconstruct the upper ocean profiles from the discrete measurements.

From Steele and Morison, 1992
Simultaneous air, ice, and upper ocean observations from sensors on Ice-Ocean Environmental Buoys (IOEBs) deployed in the Beaufort Sea provide a column of environmental data along the drift track.

1996-97 BGY

1997-98 SHEBA

http://www.whoi.edu/ioeb
Halocline eddy from IOEB ADCP data

Top: Current vectors at depth of eddy center (104 m) are superimposed on the IOEB drift (top panel). Bottom: Contours of current velocities relative to the background (cm/s) by depth and radius from the eddy center (bottom panel).
Eddies from IOEB ADCP data

Drift tracks of IOEBs with ADCP data with locations of subsurface anticyclonic eddy encounters (66) indicated by circles, cyclonic eddy encounters (14) indicated by triangles, one eddy encounter of indeterminate sense by a square, and unconfirmed encounters by crosses (14). Filled symbols denote encounters within the eddy cores (29).
Since 2000, JAMSTEC Compact Arctic Drifter (J-CAD) Buoys have been measuring the structure of upper-ocean currents and water properties under the multi-year ice of the Arctic Ocean for a better understanding of the role of the Arctic Ocean in global climate.

http://www.jamstec.go.jp/arctic/J-CAD_e/jcadindex_e.htm
When compared to climatological data, the time series data at discrete depths indicate changes in the upper ocean, as is apparent in this data from a J-CAD deployed at the North Pole in 2000.

Figure 5. Horizontal distributions of (a) salinity at 25m deep and (b) potential temperature at 250m deep around the North Pole. Note that the data along the trajectories is observed by J-CAD and the background describes the EWG winter climatological (1948-1993) data.
Metocean Ice Beacons with CTDs at 10, 25 and 40m drifting in the Beaufort Gyre since August 2004

http://www.whoi.edu/beaufortgyre
Climatological anomalies of temperature and salinity at 5 depths from ice camps and buoys deployed in the Beaufort Sea indicate significant mixed layer freshening and halocline warming in the late 1990s and 2000s.
Long-term drifting platform observations of the Arctic mixed layer

Drift tracks of SALARGOS (blue) and IOEB (red) buoys and ice camps (green).

T above freezing (10m)

Ice-ocean friction velocity
Annual cycle of $Taf$ from drifting observations (blue), climatology (green), and parameterization (red)

**Beaufort Gyre**

**Transpolar Drift**
Summary

• Ice-tethered platforms are a proven means of acquiring unattended high quality air, ice, and ocean time series data from the Arctic Ocean during all seasons.

• Development of automated profiling instruments will overcome the limitations of discrete depth systems.

• For climate variability studies, arrays of platforms are needed to better account for the spatial and temporal variability of the data from individual drifters.
An Ice-tethered Profiler for Sustained Observation of the Arctic Ocean

Mooring length: 800 m or less
Profiling range: 1,060,000 m
Duration: 3 years for one profile per day
Temperature specification: -40° C
Data telemetry: up to 150 kbytes per day
Sensors: FSI EMCTD or Seabird CP-41 (same as ARGO floats)
Telemetry: Seabird inductive link from profiler to surface unit; Iridium link to shore
Power: lithium “DD” battery packs
Size: Profiler fits through an 11-12 inch hole in the ice
ITP Profiler with SeaBird CTD
ITP Surface Buoy and Controller

[Images of the ITP Surface Buoy and Controller]