

## **UpTempO:**

Measuring the **U**pper Layer **T**emperature of the Arctic **O**cean  
(ARC-0856177)

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## **1. Project Summary**

The surface layer (0-60 m) of the Arctic Ocean has in recent years experienced unprecedented summertime warming. The causes are still under investigation, but are undoubtedly related to extreme summer sea ice retreat, which allows more atmospheric heating and northward advection of warm sub-arctic waters. Warming surface waters in turn melt more sea ice (“ice-albedo feedback”) and delay fall ice growth. They also affect marine ecosystems, atmospheric boundary layer characteristics, and water mass formation. Presently, we can observe ocean surface temperatures by satellite, although these data need more validation and do not tell us about the vertically integrated heat content of the upper ocean. Hydrographic cruise data can measure sub-surface warming, but provide only a “snapshot” view of the warming at one time during summer. Ice-based buoys exist that can measure temperature profiles, but these are not optimized for observing the open sea.

This project is designed to fill this gap in the Arctic Observing Network measurement strategy, i.e., to measure the time history of summer warming and subsequent fall cooling of the seasonally open water areas of the Arctic Ocean. We are focusing on those areas with the greatest ice retreat, i.e., the northern Beaufort, Chukchi, East Siberian, and Laptev Seas. We are doing this by building relatively inexpensive ocean thermistor string buoys, to be deployed in the seasonally ice-free regions of the Arctic Ocean.

## **2. Technology Highlights**

The main idea is to build a buoy with a surface float that contains:

- ARGOS or Iridium antenna,
- sea level pressure sensor, and
- batteries and electronics.

Hanging down from this float is a string of thermistors with higher resolution near the surface (depths = 2.5 m, 5 m, 7.5 m, 10 m, 15 m, 20 m, 25 m, 30 m, 35 m, 40 m, 50 m, and 60 m) that measure temperature every two hours with 0.05°C accuracy. A few pressure sensors are also added, which with a cable model provides thermistor depths when the cable swings off the vertical owing to ocean current shear. In the longer term, we also plan to add a higher accuracy thermistor plus conductivity cell at 5 m depth for calibration purposes. Battery life is estimated at 2 years.

The buoys can be deployed in open water during summer, or possibly in a lead or simply left on the ice during spring. Deployment is by “ship/aircraft of opportunity.” We will generally rely on the kindness of our colleagues to deploy these simple buoys, similar to the strategy employed by the International Arctic Buoy Program. We will pay for shipping and logistics costs to get the buoys to the deployment vessel.

We received funding at the start of summer 2009, which we used to build 4 buoys in a very short time. Two buoys had a traditional spherical hull, while the other two had a strengthened hull with a new inverted, tiered shape manufactured by LBI Corporation. The buoys were manufactured by Clearwater Instrumentation in Watertown, MA. Three of the buoys were deployed by icebreakers in August and September (2 off the US Coast Guard icebreaker Healy and 1 off the Canadian Coast Guard icebreaker Louie St. Laurent. Unfortunately, all failed within a couple of days, eventually sending no signals at all. The fourth was not deployed when it was found to be malfunctioning while on board the Canadian Coast Guard icebreaker Sir Wilfred Laurier. Our best guess is that the antenna failed, as a new ARGOS3 antenna was used in these buoys.

We are now planning deployments for 2010. Clearwater will contribute 2-3 buoys, and we have placed a new order for 6 more with MetOcean Data Systems of Dartmouth, NS, Canada. These will be deployed by ships in the summer, and possibly by helicopter north of Alaska in the spring, if the manufacturing time line will allow this.

### 3. Science Highlights

None yet; however, we did obtain some temperature profiles from a buoy before it died this past summer, which looked “reasonable” compared to recent hydrographic profiles obtained via summer cruises.

### 4. Lessons Learned

From our experience this past summer, we are focused this year on providing ample time for testing of equipment before deployment. We had discussions with both Clearwater and a representative of the ARGOS company about the antenna, which it turns out is somewhat tricky to manufacture properly. ARGOS is interested in motivating the community to transition to their new ARGOS3 system, which like Iridium provides the ability for 2-way communication. Thus, they may provide a buoy for us at no cost to deploy this summer that uses this new system.

The two buoys we manufactured this summer contained lithium batteries. We had to ship on a very tight schedule, and this presented some severe shipping problems since these batteries are “hazardous cargo.” We are inclined now to use alkaline batteries in our buoys, which provide more shipping flexibility. This is important, given our “opportunistic” deployment strategy.

## 5. Interactions with other projects

Given our “opportunistic” deployment strategy, we rely on a number of other projects.

- *IABP*: The UpTempO buoys will be part of the International Arctic Buoy Program; e.g., their data will be reported on the IABP web site (in addition to CADIS).
- *BGOS*: This past summer, a buoy was deployed via the Louie St. Laurent, whose mission also includes Andrey Proshutinsky’s BGOS project. We hope to deploy again on this cruise in 2010, so that the “snapshot” temperature profiles taken in open water by the CTD survey can be extended through the rest of the summer and into the winter by looking at our buoy data.
- *NABOS*: We have contacted Igor Polyakov about the deployment of a buoy on this cruise, in the deep water to the north of the Laptev or East Siberian Seas.
- *SIZONET*: We have contacted Hajo Eicken about a possible springtime deployment north of Alaska. The advantage of this opportunity, if it works, is that the buoy would measure the entire summer warming and then fall cooling in the first year of observation.
- *IMBs*: How much heat is in the upper ocean, and what effect does this have on ice melting? We can address this question by looking at data collected by our buoys and any nearby IMBs. CRREL is now developing a “seasonal” IMB that can float, which we hope can be deployed near our buoys in the near future.
- *ITPs*: These buoys obtain temperature profiles from about 7 m depth down to 800 m. WHOI is now manufacturing a version that can float. We anticipate a close collaboration in the future between these larger, more expensive buoys and our smaller, cheaper buoy.

## 6. Data use

None yet.

## 7. Publications

None yet.

## 8. Web site

Eventually, our data will be on the IABP web site: <http://iabp.apl.washington.edu/>

## 9. International Cooperation

We will be deploying our buoys on US, Canadian, and Russian icebreakers this summer.

## 10. Education/Outreach

I give many outreach talks to K-12 and college classes in the Seattle area. I have been recently including information about Arctic Ocean warming and the ways we are and plan to measure it. I include a schematic of our UpTempO buoys (**Figure 1**) and how ocean temperature varies with depth. The most recent example was a 1.5 hour talk and demonstration at a “Science Night” at Roosevelt High School in Seattle on January 14, 2010.

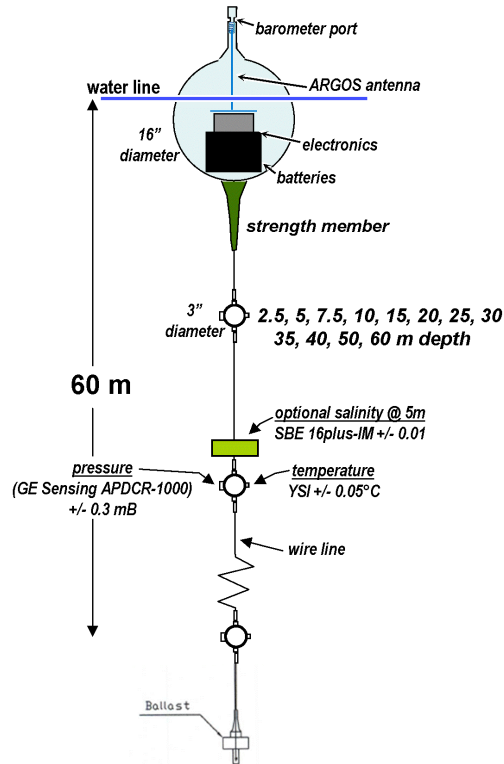


Figure 1. Schematic of the UpTempO buoy. The hull contains an antenna, electronics, batteries, and a barometer. Below the hull hangs a 60 m string of 12 thermistors. Some buoys will include a Seabird temperature/conductivity pair at 5 m depth for calibration of the other sensors.