Coordination, Data Management and Enhancement of the International Arctic Buoy Programme (IABP)
A US Interagency Arctic Buoy Programme (USIABP) contribution to the IABP

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LONG-TERM GOALS

Our ability to predict weather and sea ice conditions requires *in situ* observations of surface meteorology and ice motion. These observations are assimilated into Numerical Weather Prediction (NWP) models that are used to forecast weather on synoptic time scales, and into the many long-term atmospheric reanalyses (e.g. NCEP/NCAR Reanalysis) that are used for innumerable climate studies. The impact of these *in situ* observations can be seen in Fig. 1 where Inoue et al. (2009) shows that the standard deviation in gridded sea level pressure (SLP) reanalyses fields over the Arctic Ocean was over 2.6 hPa in areas where there were no buoy observations to constrain the reanalyses, and this uncertainty in the SLP fields spreads to cover the entire Arctic when the observations from buoys are removed from the reanalyses. The buoy observations also help constrain of estimates of wind and heat. *In situ* observations of sea ice motion are also important for estimating the drift of various areas and types of sea ice, and for understanding the dynamics of ridging and rafting of this ice, which changes the thickness distribution of sea ice. Over the Arctic Ocean, this fundamental observing network is maintained by the IABP, and is a critical component of the Arctic Observing Network (AON).

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OBJECTIVES

Maintain a network of drifting buoys on the Arctic Ocean to provide meteorological and oceanographic observations for real-time operational requirements and research purposes including support to the World Climate Research Programme, the World Weather Watch Programme, and the Arctic Observing Network (AON).

APPROACH

The IABP is a collaborative effort of 32 different research and operational institutions from many different countries (http://iabp.apl.washington.edu/Participants.htm). No single institution or agency can maintain the AON. The IABP is funded and managed by the Participants of the program. Management of the IABP is the responsibility of the Executive Committee, of which Co-PI Dr. Pablo Clemente-Colón is a member, and operation of the program was delegated to the Coordinator of the IABP, PI Dr. Ignatius Rigor.

The United States contribution to the IABP is coordinated through the United States Interagency Arctic Buoy Program (USIABP), which is managed by Co-PI Lt. Bethany McDomand at the NAVICE and PI Dr. Rigor at the PSC/APL/UW. The USIABP is also a collaborative program that draws operating funds and services from a number of U.S. government organizations and research programs, which include the Office of Naval Research (ONR; this grant and prior Grant # N00014-10-1-0506), the International Arctic Research Center, the National Aeronautics and Space Administration, the National Oceanic and Atmospheric Administration, the National Science Foundation, the Naval Oceanographic Office, the NAVICE, the and the U.S. Coast Guard. From these contributions the USIABP acquires and deploys buoys on the Arctic Ocean, and supports the Coordination, Data Management and Enhancement for the IABP by the PSC/APL/UW.

WORK COMPLETED

During the past year we purchased 5 large (4 AXIB, 1 PAWS), and 20 smaller meteorological buoys (SVP) using funds contributed to the USIABP. Ten SVP buoys were purchased from MetOcean, who has been providing reliable buoys for many years, and also builds the PAWS buoy; and we purchased 10 more SVP buoys from a new supplier, Pacific Gyre in California.

These buoys were deployed during various field campaigns as follows:

1) During the Bromide Ozone Mercury Experiment (BROMEX) in March 2012, the USIABP deployed 5 buoys in and around Barrow to support the weather fields and analysis of the air chemistry measurements. Figure 2 shows a portable weather station (PWS) and 3 SVP buoys that we were testing at an inland site before deployment. The surface temperature measurements taken by the SVP buoys manufactured by MetOcean, that we first tested in 2006 and have been deploying since, matched the air temperature measurements of the PWS quite well, however, the new Pacific Gyre SVP buoy showed a diurnal warm bias compared to the measurements taken by the PWS and compared to the measurements taken by the National Weather Service (NWS) station at Barrow (Fig. 3). The Pacific Gyre SVP buoy was shielded (with aluminum foil) on March 23, which reduced the bias, confirming that the exaggerated diurnal cycle was due to solar heating of the hull. However, there were still alarming differences between all the measurements taken in the Barrow area. Comparison of the NWS station and the NOAA Climate Reference Network (CRN) station were different by as much as 20C.

We expected some differences across the 10 km. domain, but not this large. Since the AON requires accurate measurements of pressure, temperature, and wind, we plan to perform a rigorous assessment of the sensors we use to measure these variables. We can perform an Arctic Observing eXperiment (AOX) in Spring 2013 using funds already provided to the USIABP, however, we may request additional logistics support from NSF to perform the AOX at Barrow, Alaska.

We are planning to perform AOX at either the DOE/ARM or NOAA/CRN station near Barrow, for which we are seeking permission and complimentary support to deploy a cluster of buoys, and other instruments that we routinely use for the AON. This cluster of buoys will be collected using funds already provided to the USIABP, and contributions from our international partners in the IABP. In particular, Chris Marshall who heads the MetAreas program for Environment Canada, has agreed to provide Minimet SVP Buoys, and an Automatic Voluntary Observing Ships System (AVOS) system to assess during AOX. We will solicit other instruments from our collaborators in the IABP so we may perform a thorough assessment, with the overarching goal of understanding the performance and quantify the errors of our fundamental AON instruments. And we will collaborate with Dorothy Hall and Son Nghiem at NASA to compare the retrievals of temperature from satellites.

2) The PAWS and 4 SVP were deployed at the PSC/APL/UWs North Pole Environment Observatory (http://psc.apl.washington.edu/northpole) in April 2012, along with other buoys purchased by collaborators in the IABP to establish an "Automated Drifting Station (ADS)" which measures a myriad of physical parameters.

3) PI Rigor deployed 2 AXIB buoys from the Arctic Domain Awareness flights in August and September 2012 (Fig. 4). These were deployed with AXCTD probes for the Seasonal Ice Zone Reconnaisance Surveys (SIZRS, ONR grant N00014-12-1-0231 to Dr. Morison)

4) Co-PI Clemente-Colón is currently onboard the Coast Guard ice breaker Healy overseeing the deployment of the IABP buoys. One AXIB was deployed in September 2012, however, the second AXIB failed predeployment tests and will be returned to the manufacturer for repair and deployed during the summer of 2013. We also collaborated with LCDR John Woods to develop the Naval Academy "IceGoat" buoy (Fig. 5) which was tested at Barrow and recently deployed by Co-PI Clemente-Colón from the Healy. The remaining SVP buoys will be deployed in the large expanses of open water of the Beaufort, Chukchi and Bering seas.

The data from all USIABP buoys are released to the research and operational communities in near real-time through the WMO Global Telecommunications System. As part of this grant we QA/QC the data from the Arctic buoys for the WMO/GTS. All the meteorological, and oceanographic data posted on to the GTS by the IABP may be viewed at http://www.jcommops.org/dbcp/network/maps.html .

Research quality fields of ice motion, sea level pressure (SLP) and surface air temperature are also analyzed and produced by the APL-UW; these fields can be obtained from the IABP web server at http://iabp.apl.washington.edu/ , and have been archived at various data centers.

RESULTS

The IABP currently has 80 buoys reporting in the Arctic (Fig. 6), of which 26 were purchased using funds contributed to the USIABP (1 PAWS, 8 AXIBs, 1 IceGoat, and 16 SVPs). The AXIB buoy has

proven its ability to survive in the rougher conditions of the increasing seasonal ice zone, e.g. the oldest buoy in the IABP AON is an AXIB deployed in open water 2008.

IMPACT/APPLICATIONS

The observations from the IABP have been essential for: 1.) Monitoring Arctic and global climate change (many of the changes in Arctic climate were first observed or explained using data from the IABP); 2.) Forecasting weather and sea ice conditions; 3.) Forcing, assimilation and validation of global weather and climate models; 4.) Validation of satellite derived estimates of sea ice motion, surface temperature, sea ice thickness, etc.

Since the inception of the program, over 600 publications have been written using data from the IABP. A list of these citations through 2008 can be viewed at http://iabp.apl.washington.edu/publications_citations.html . We are currently in the process of updating this list through the present, however, and simple query http://scholar.google.com of "Arctic buoys – Antarctic" yields over 6000 results in the peer reviewed and popular literature.

RELATED PROJECTS

The USIABP/IABP is collaborative effort that leverages existing field campaigns to maintain the fundamental observations required for AON, e.g. the primarily NSF funded North Pole Environmental Observatory, and in turn the observations collected by the USIABP/IABP is used for operational forecasting of weather and ice conditions, and for research. For example, the surface temperatures from the IABP complement the measurements of upper ocean temperature by Dr. Steele (ONR Grant # N00014-12-1-0224), and are being used by Dr. Schweiger (ONR Grant # N00014-12-1-0232) to validate the Weather Research Forecasting model. We also collaborate with Dr. Morison in SIZRS (ONR Grant # N00014-12-1-0231) and assist each others projects on the Coast Guard Arctic Domain Awareness flights.

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FIGURES

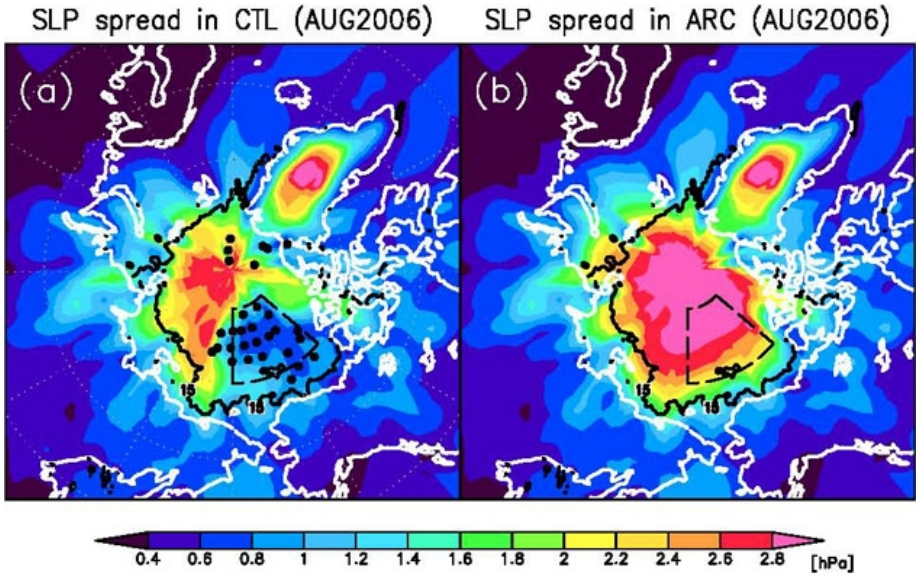

Figure 1. Standard deviation (SD) of sea level pressure measurements from various atmospheric reanalyses. The SD is low in areas where there are buoy observations (left). The spread increases to cover the whole Arctic when the observations from the buoys are removed from the reanalyses (right). [Inoue et al. 2009].

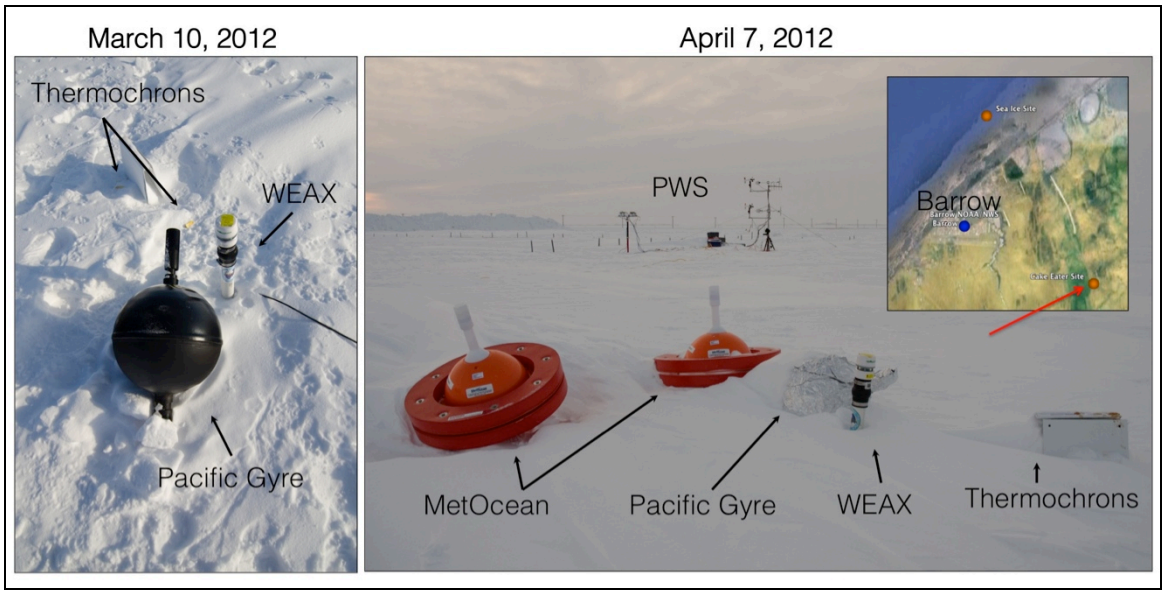

Figure 2. Weather station and buoys deployed during the Bromide, Ozone, Mercury Experiment in Barrow, Alaska, March 2012. We also tested a portable weather station (WEAX), and Thermochrons used by NASA to groundtruth retrievals of surface temperature by aircraft and satellites.

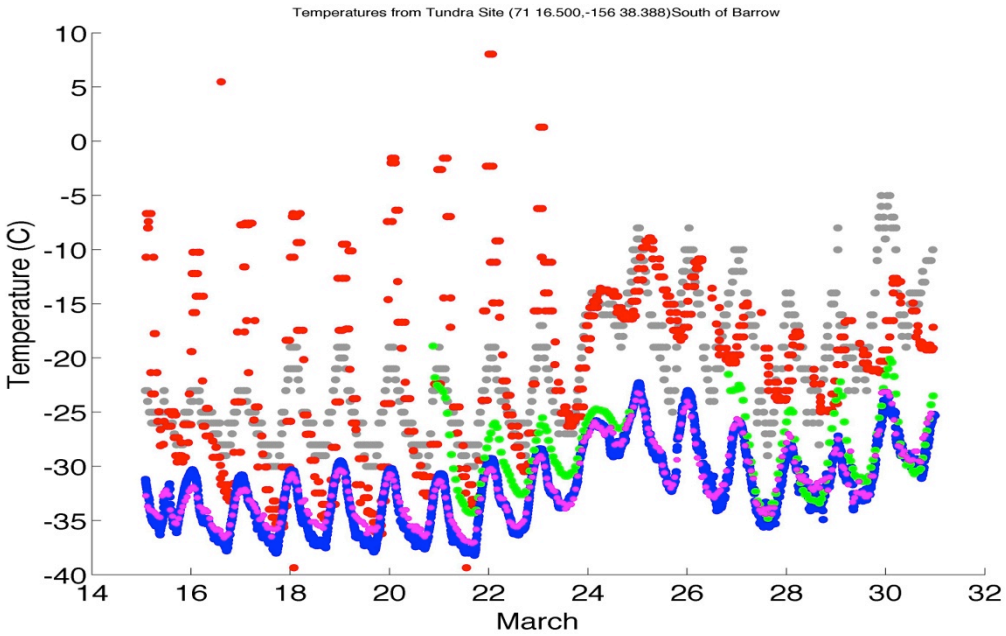

Figure 3. Time series of temperature from the various sensors. This figures show that the measurements from NWS station at Barrow (grey), are as much as 20 degrees warmer than the measurements from the Barrow Climate Reference Network (CRN) station at Barrow (pink). The observations from the Portable Weather Station (PWS, blue), MetOcean SVP (green), and Pacific Gyre SVP (grey) are also shown.

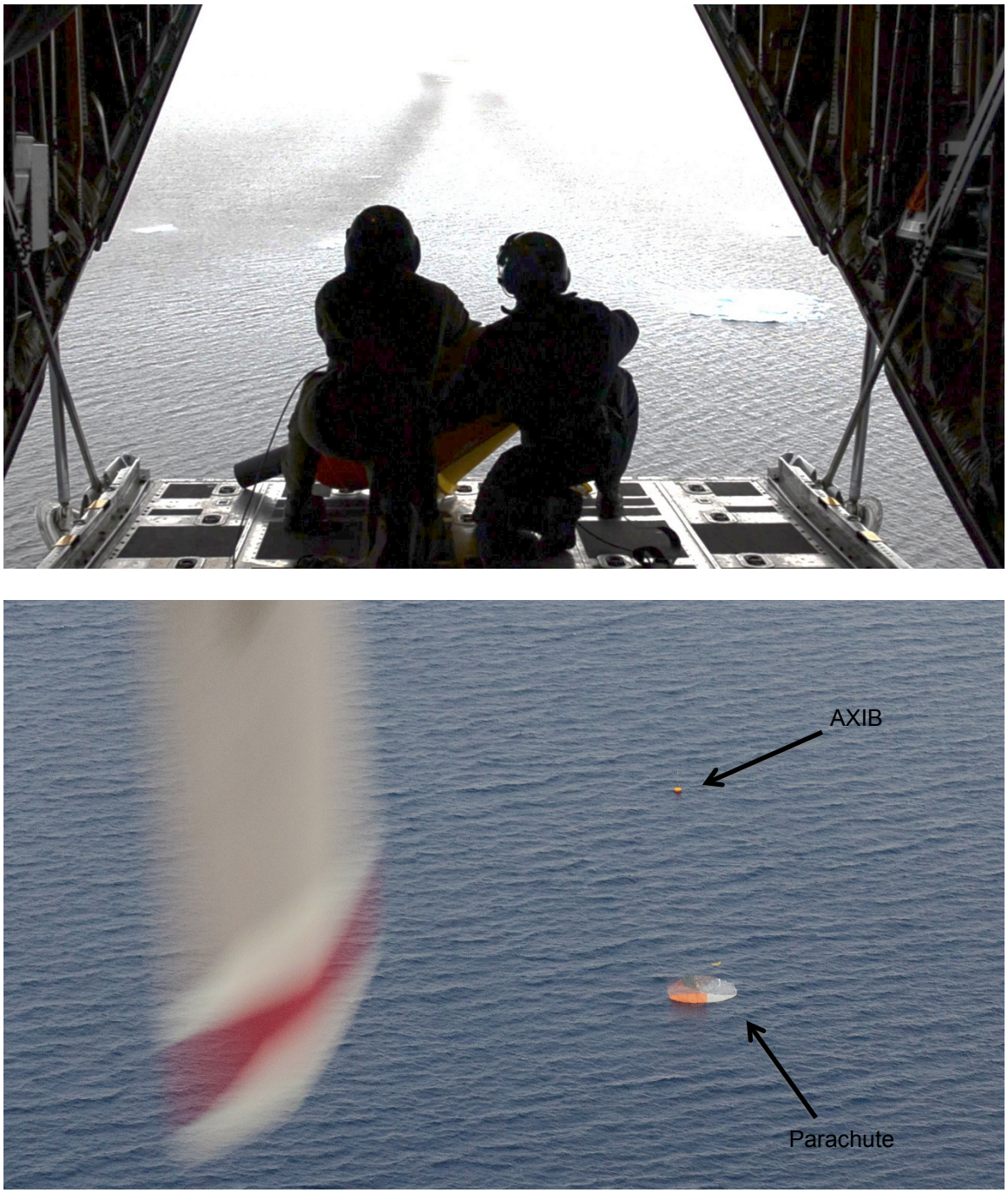

Figure 4. Deployment of the Airborne eXpendable Ice Beacon (AXIB) buoy 100181 from an Arctic Domain Awareness flight in August, 2012 (top). The picture below shows the AXIB deployed in open water at 78N 150W, and the parachute which separates from the buoy during deployment. The AXIB was developed by the USIABP specifically to survive annual freeze/thaw cyles in the harsher, dynamic conditions of the seasonal ice zone. Our ability to air drop AXIB makes it possible to fill holes in the IABP AON where we may not have deployment opportunities from ice breakers.

Figure 5. Pictures showing the development of the Naval Academy IceGoat. This buoy measures air pressure, temperature and reports by Argos. It also has 2 webcams which transmit pictures every 15 minutes, and GPS via Iridium. This buoy was deployed at BROMEX, and was redeployed by the Healy. Courtesy of LCDR John Woods, USNA.

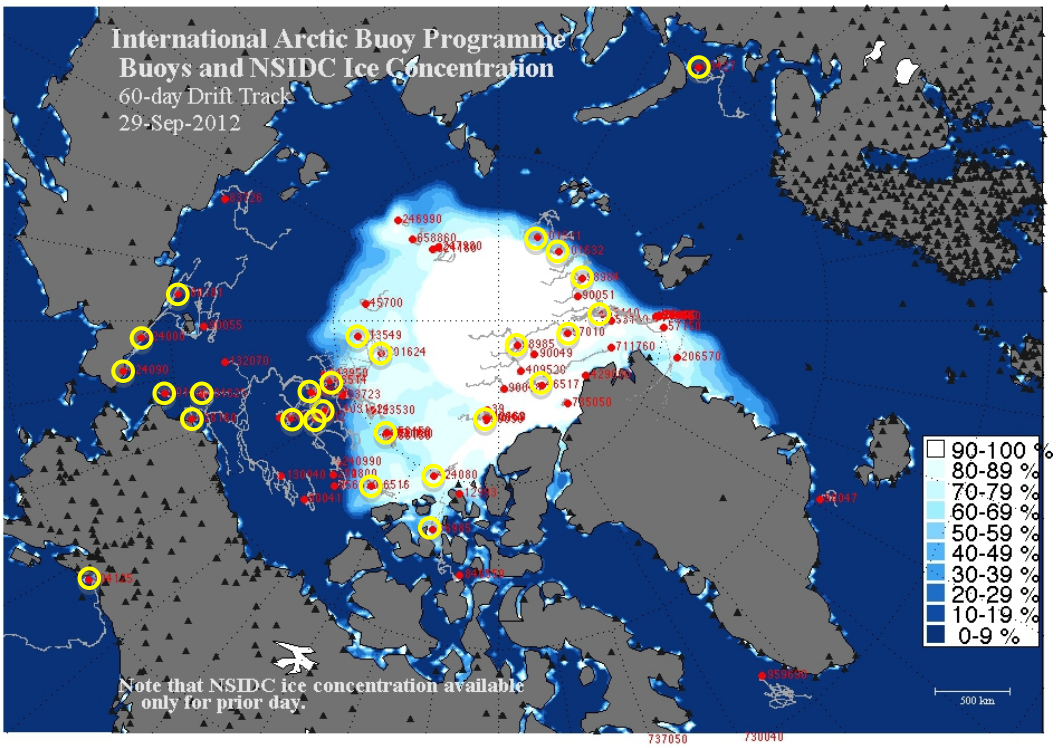

Figure 6. Map of all IABP buoys reporting (80) on Sep. 29, 2012. Buoys circled in yellow (26) were purchased by the USIABP, including funds from this grant. These buoys were deployed using the North Pole Environmental Observatory, the CG icebreaker Healy, and the CG Arctic Domain Awareness flights.