

## **Seasonal Ice Zone Reconnaissance Surveys Coordination**

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Award Number: N00014-12-1-0231

<http://psc.apl.washington.edu/northpole/>

### **LONG-TERM GOALS**

This grant is for the coordination of the Seasonal Ice Zone Reconnaissance Surveys (SIZRS) program of repeated ocean, ice, and atmospheric measurements across the Beaufort-Chukchi sea seasonal sea ice zone (SIZ) utilizing US Coast Guard Arctic Domain Awareness (ADA) flights of opportunity. The individual observational components of SIZRS are covered in separate reports. Our long-term goal is to track and understand the interplay among the ice, atmosphere, and ocean contributing to the rapid decline in summer ice extent that has occurred in recent years. The SIZ is the region between maximum winter sea ice extent and minimum summer sea ice extent. As such, it contains the full range of positions of the marginal ice zone (MIZ) where sea ice interacts with open water.

### **OBJECTIVES**

The overarching objectives for SIZRS are to:

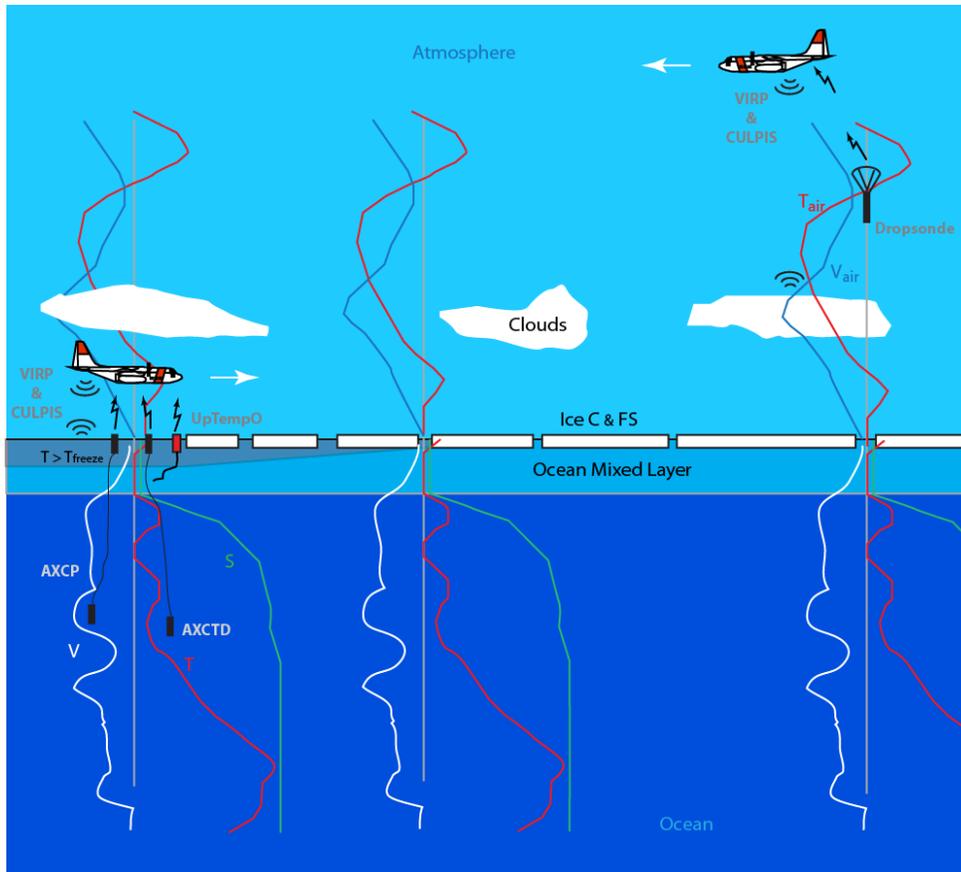
- Determine seasonal variations in air-ice-ocean characteristics across the BCSIZ extending over several years and for a variety of SIZ conditions.
- Investigate and test hypotheses about the physical processes that occur within the BCSIZ that require data from all components of SIZRS.
- Improve predictive models of the SIZ through model validation and through the determination of observing system requirements.

### **APPROACH**

This grant coordinates the various SIZRS observations on the ADA flights, assure integration with modeling efforts, maintain the SIZRS website, serve as the SIZRS point of contact, and help gain the necessary Coast Guard approvals for the SIZRS instruments.

The U.S. Coast Guard Arctic Domain Awareness (ADA) flights offer the way to make regular measurements over long ranges in the Beaufort and Chukchi seas at no cost for the platform. SIZRS includes a set of core measurements needed to, make complete atmosphere-ice-ocean column measurements across the SIZ, make a section of ice conditions across the SIZ, and deploy drifting buoys to give time series of surface conditions. These measurements are illustrated in Figure 1.

Specifically, the core elements (Table 1) are aircraft expendable CTD (AXCTD) vertical profiles of ocean temperature and salinity plus aircraft expendable current profiler (AXCP) ocean velocity shear (Morison), UpTempO buoy measurements of sea surface temperature (SST), sea level atmospheric pressure (SLP), and velocity (Steele), and dropsonde measurements of atmospheric properties (Schweiger et al.), in-flight, and inflight laser profiling for ice thickness using the CU Laser Profiler Instrument-extended (CULPIS-X) (Tschudi, University of Colorado collaborating with Lindsay and Chickadel, UW). In addition, atmospheric modeling and ice-ocean modeling components (Schweiger et al.) will tie the SIZRS observations together. Other collaborating projects (Table 2) have come forward to participate in or collaborate with SIZRS, including buoy deployments for the International Arctic Buoy Program (Rigor, UW).



**Figure 1. Schematic of the SIZRS core measurements. The column measurements (AXCTD & AXCP at low altitude outbound & dropsonde at high altitude inbound) will be made in five locations (3 shown) with at least one column each in open water, MIZ, and pack ice. The aircraft remote sensing (CULPIS-X) will give sea ice concentration, floe size, and thickness and surface temperature profiles across the SIZ. Buoy deployments (core UpTempO and other IABP buoys) will provide time series at several locations across the SIZ. Missions will be flown monthly during the April-Oct time frame for three years**

ADA flights are conducted twice per month from March through November. On ADA flights, we will conduct atmosphere-ice-ocean observations at least once per month. These will include lines of about 5 stations across the SIZ with profile measurements through the complete air-ice-ocean column (Fig. 1).

Several times each season we will repeat station locations along a frequently studied longitude line (e.g., 150°W and 140 °W). Other stations will be made to examine particularly active regions of ice retreat or advance.

Ultimately, three UpTempO buoy deployments will be made in June and the buoy sites revisited with column measurements several times per season.

Flight paths will be based on science priorities and on remote sensing estimates of ice conditions at the time of the flights. Remote sensing resources include MODIS visible and IR imagery, NSIDC ice extent charts based on a composite of passive microwave products (<http://nsidc.org/data/masie/>), and daily updated Oceansat-2 (OS2) scatterometer (a clone of QuikSCAT) from Son Nghem at the Jet Propulsion Laboratory. Starting in 2013, we began a new component of SIZRS (Harry Stern, PI) to collect and analyze Arctic sea ice satellite visible imagery from the USGS Global Fiducials Library (GFL). These are provided a few days prior to flights for every degree of latitude from the Alaska coast up the 150°W longitude line into the ice up to about 80°N. These provide a record of ice conditions across the MIZ and help with preflight planning. We also receive regular images from any AXIB or UpTempO buoys we deploy.

**Table 1: Core Projects of the SIZ Reconnaissance Survey Flights**

<b>Project</b>	<b>PI</b>	<b>Co-PIs</b>	<b>Observations/Activity</b>
<i>Ocean Profile Measurements During the SIZRS</i>	<b>Morison</b>		Ocean expendable probes AXCTD & AXCP for T, S, V, internal waves/mixing
<i>Clouds and the Evolution of the SIZ in Beaufort and Chukchi Seas</i>	<b>Schweiger</b>	<b>Lindsay, Zhang, Maslanik, Lawrence</b>	Atmospheric profiles (dropsondes, micro-aircraft), cloud top/base heights
<i>UpTempO buoys for understanding and prediction....</i>	<b>Steele</b>		UpTempO buoy drops for SLP, SST, SSS, & surface velocity
<i>Visible and Thermal Images of the SIZ from the Coast Guard Arctic Domain Awareness Flights</i>	<b>Lindsay</b>	<b>Chickadel</b>	Analysis of visible and IR profiles using CULPIS-X (below) . Remote sensing for analysis and flight planning.
<i>High Resolution Satellite Visible Imagery for SIZRS</i>	<b>Stern</b>	<b>Schweiger</b>	Collect and analyze GFL visible imagery
<i>Ice thickness and character using CULPIS-X</i>	<b>Tschudi</b>	<b>Maslanik</b>	CULPIS-X Laser profiler for ice thickness, reflectance, skin temperature, visible imagery
AXCTD= Air Expendable CTD, AXCP= Air Expendable Current Profiler, SLP= Sea Level atmospheric Pressure, SST= Seas Surface Temperature, A/C= aircraft, SIC=Sea Ice Concentration			

## **WORK COMPLETED**

SIZRS has nearly completed its second season working with USCG Air Station Kodiak. The coordination effort assembled documentation needed for USCG approval of all the originally proposed UW SIZRS instruments to be used on the ADA flights. The required Safety of Flight Tests (SOFT)\* were successfully completed in February 2013, and the approvals were obtained in advance of the 2013 field season. These instrument systems include the AXCTD and AXCP (Morison), dropsondes (Schweiger), and UpTempO buoys (Steele). The AXIB buoy of the IABP (Ignatius Rigor), which we deploy on some of our flights, had received approval prior to SIZRS. The CULPIS-X instrument from Tschudi at the University of Colorado has been in a complicated and long approval process since before SIZRS began. The process is lengthy for CULPIS-X because it requires temporary modification of the aircraft airframe. Given the uncertainty in the CULPIS-X approval process, the Lindsay and Chickadel infrared imagery project has purchased a commercial infrared video camera, and we have designed and built a mount that allows us to gather ice-ocean imagery from inside the aircraft when the rear loading ramp is down for the expendable probe and buoy deployments. This camera system is only starting the approval process now, but because the camera is a commercial unit, and nothing will be mounted outside the airplane, we think approval will proceed relatively rapidly.

Using the AXCTDs, AXCPs, and the atmospheric Dropsondes we have conducted 8 SIZRS flights in 2013. These were on June 18, 19, and 20, July 16, and August 13, 15, and 16. The June and August ADA flights were expanded by the Coast Guard, largely to better accommodate our sampling. These operations began with flights originating in Kodiak on Tuesdays. During these we tested Dropsondes, and in August dropped an AXIB buoy and an UpTempO buoy. Also, in those months a second and third day were added based out of Eielson Air Force Base in Fairbanks. Operating from Fairbanks has allowed longer missions sampling with AXCTD, AXCP and Dropsonde on both 140°W and 150°W up to 76°N and potentially farther north. The August operation was delayed one day at Eielson due to mechanical problems with the C-130. In a tremendous display of commitment and determination, the USCG replaced one of the aircraft's engines and extended the schedule one day to complete our flights. In these flights at least some sea ice was encountered at most stations, and along with poor visibility, presented the challenge of finding ice free leads into which we could drop the expendable probes. The USCG crews have been exceedingly good at meeting these challenges.

We coordinated with the ONR MIZ DRI to obtain various images in support of operations and SIZRS research. GFL high-resolution optical images were provided by the SCITOR Corporation and helped guide deployment. SAR imagery, providing detailed information about the evolution of the seasonal ice zone in the SIZRS region were obtained.

\*(The SOFT is performed with a USCG C-130 on the ground at the USCGAS Kodiak ramp. The aircraft is run on the ground and all engine instruments and avionics readings are recorded. The test is repeated with all scientific gear connected as needed to the aircraft antennas and receiving and recording data. The SOFT is successful if the aircraft engine instruments and avionics instruments are not affected by the operation of the science equipment.)

## **RESULTS**

The scientific results are described in the report for the various science components of SIZRS including for this PI "Ocean Profile Measurements During the Seasonal Ice Zone Reconnaissance Surveys", grant number N00014-12-1-0236.

## **IMPACT/APPLICATIONS**

The SIZRS effort is a pioneering program in the use of aircraft expendable ocean and atmosphere sensor probes in tracking changes in the sea-ice environment of the Arctic. It will lead to greater availability of synoptic snapshots of environmental properties over extended ranges.

## **RELATED PROJECTS**

See Table 1.