University of Washington
Applied Physics Lab
1013 NE 40th Street
Seattle, WA 98105

Final Report

Processing of SCICEX ULS data for 2011-2014

May 29, 2018

Reporting Period:
12/23/2015 - 03/31/2018

Prepared for:
Office of Naval Research
875 North Randolph Street
Arlington, VA 22203-1995

Award Number: N00014-4-12-G-0078/N00014-16-F-3007
http://nsidc.org/data/g01360.html

Submitted by:
Axel Schweiger
phone: (206) 543-1312 fax: (206) 543-3521 email: axel@apl.uw.edu

LONG-TERM GOALS

Arctic sea ice thickness is critical to geophysical research into climate change, shipping, biological productivity and other things. The overall goal of this work is to produce a public archive of ice draft data for research. The data is meant to span the largest time range possible and be of the highest possible quality. In addition the data must include detailed and accurate documentation.

OBJECTIVES

The goal of this work is the production of publically releasable upward looking sonar (ULS) data from SCICEX cruises 2011-2014.

APPROACH

The work includes multiple processing routes. 1) Reconstruction of 2011 SCICEX ULS data that were recorded as "Peak Return" rather than the "First Return" to make compatible with the existing data based on "First Return". This was done using a stastically approach trained using 2014 data for which both "First" and "Peak" were available. 2) Process data delivered from NUWC to APL in full wave form as well as retrieve First and Peak return, these data are available only for the Hampton 2014 and the Topeka 2012 cruises, 3) reprocessing and calibration of 2014 New Mexico data previously processed by ASL which was not recorded at NUWC.

WORK COMPLETED

All work to be completed under this contract has been completed. Data that are not subject to declassification are available for delivery to NSIDC. We are still currently awaiting instructions regarding the process of declassifying Topeka 2012 and Hampton 2014 data. Part of the work included the training of a new analysis/programmer (Beth Kirby) to transfer and document knowledge about the processing steps and approaches from the previous analyst PI (Mark Wensnahan).

Software Development

Previously developed software was adapted to processes new data streams and allow for the ingest, calibration, and output formatting of new data streams processed under this contract.

Processing of 2011 data: Reconstructing First Return Draft from Peak Return observations:

Since original wave form data for SCICEX 2011 are considered lost, we opted to correct 2011 peak-return data to "first return" data. The correction was done as follows:

From the 2014 Hampton cruise, full wave form as well as "peak" and "first" return values are simultaneously available (See below). Following experimentation with different methods to convert between peak and first return we selected the following method:

$$D_{first} = a + b\overline{D}_{peak} + c\sigma_{peak} + d\overline{D}_{peak}\sigma_{peak}$$

Where D_{first} is the corrected "first" return and $\overline{D}_{peak}$ and σ_{Peak} refer to the mean and standard deviation of the peak draft over a sequence of points. Coefficients *a* through *d* are determined by linear regression. The underlying reasoning is that the relationship between first and peak draft depends on both the mean ice thickness as well as the variability of ice thickness. Experimenting with

different window size and computing the correlations and RMS errors for independent test samples, we selected a sliding window size of 500 points. This window size corresponds to approximately 2.5 km in distance. Using this window size, the correlation and draft RMS errors between reconstructed first return and actual first return are 0.97 and 0.169m respectively. This window size represents a compromise between maintaining the structure of the under ice profiles while minimizing the error in the conversion.

Since the correction depends on the interpretation of adjacent values, large gaps in the input data needed to be eliminated. Prior to applying these above correction to the 2011 data, originally delivered sections with peak returns were further inspected for gaps. Gaps of size larger than 2000 m were used to break the original sections to yield contiguous sections that had no gaps larger than 2000m. The peak to first conversion was then applied to generate corrected output draft files. End and start points of sections were shifted to account for the data loss that occurs at the beginning and end of each section due to the sliding window. *It is critical to note that the generated "first" return data represents a "smoothed" product with different statistical properties and inherent resolution than the input return data. Users are advised to consider this difference. Nevertheless, for applications such as model or satellite algorithm validation, the smooth, corrected first return should be useful.*

Classified Topeka 2012, and 2014 Hampton Data from NUWC

Data Source

Data were provided from NUWC in the form of Matlab files. Geolocation data were obtained from the NSIDC SCICEX archive (bathymetry data). Note that some segments from the Hampton are currently not available because the classification level did not allow providing the full return data to APL/UW.

First and Peak Return Draft Retrievals

NUWC provided Matlab formatted files with course, speed, and depth for the course for the submarine at each timestep. Matlab files include full return as well as retrieved first and peak returns. The algorithm for the retrieval of first and peak returns was developed by NUWC and is as follows:

1. Correlate the return signal with the transmitted signal to find the portion of the return signal that is similar to the transmitted signal. This identifies the echo of the ping in the return signal.
2. Extract a sample from the full data set that represents a window around the echo that is large enough to encompass the return pulse plus a representative buffer of ambient noise.
3. Establish a background signal level for the ambient noise by finding the maximum of the absolute value of the signal strength from a sample of 500 points at the end of the sample data.
4. Use the Matlab function findpeaks to pull the points with the largest values from the correlated sample, using parameters that set the min distance between peaks of 50 samples & the heights of the peaks at least 2.75 times the background peak level.
5. The value for the first return was the draft at the location for the first peak from the findpeaks function.
6. The value for the peak return was the draft at the location for maximum value of the return within the cross-correlated sample data.

Editing and Open Water Correction

First (and Peak) returns in the Matlab data from were merged with latitude and longitude data from NSIDC. The data were then interactively edited and open water corrections applied using the same procedure as described above.

2014 New Mexico Data

Data Source

Data from the New Mexico were not successfully recorded on digital tapes and original values are not available from NUWC. Since ASL delivered data from the New Mexico mission to NSIDC, they must have been recorded somewhere but the processing history is currently somewhat uncertain. Based on inspection of the data and communication with NUWC and ASL, our best estimate is that the data were recorded on a separate recording system (SLOGGER) from which ASL produced the data delivered to NSIDC. NUWC states that SLOGGER recorded data are "first return" drafts but the details of the processing algorithm are currently unknown. Using the assumption that 2014 New Mexico data provided to NSIDC by ASL are equivalent first return value, we apply the usual interactive editing and open water correction steps. Since the input data has already been declassified, no additional declassification is needed.

Editing and Open Water Correction

Using the same interactive editing procedure as for other cruises, New Mexico data were broken into sections and open water corrections applied. Sections contain the full section data,

RESULTS

We trained a new analyist/programmer to manage data editing and processing of SCICEX data from different data streams. We have established a working pathway to process future SCICEX missions. We have reconunstructed sea ice draft from "Peak Return" measurments from the 2011 cruises. We have generated sea ice drafts for SCICEX cruises from 2012 through 2014. .

IMPACT/APPLICATIONS

Ice thickness data is used for a large variety of research. The data is useful for the development and validation of sea ice models and for the validation other methods of determining ice thickness, particularly satellite-based measurements. Relatively high spatial resolution sea ice thickness measurement, providing a subgrid scale ice thickness distribution are particularly useful for the development of next generation sea ice models.

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. REPORT DATE *(DD-MM-YYYY)*	**2. REPORT TYPE**	**3. DATES COVERED** *(From - To)*
30-05-2018	Final Technical	12/23/2015 - 3/31/2018

4. TITLE AND SUBTITLE
SCICEX Topsounder Data Processing Transition

5a. CONTRACT NUMBER
N00014-12-G-0078

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)
Axel Schweiger

5d. PROJECT NUMBER

5e. TASK NUMBER
N00014-16-F-3007

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
University of Washington – Applied Physics Laboratory
4333 Brooklyn Avenue NE
Seattle, WA 98105-6613

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)
Office of Naval Research
875 North Randolph Street
Arlington, VA 22203-1995

10. SPONSOR/MONITOR'S ACRONYM(S)
ONR

11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION / AVAILABILITY STATEMENT:

DISTRIBUTION STATEMENT A. Approved for public release; distribution is unlimited.

13. SUPPLEMENTARY NOTES

14. ABSTRACT

Arctic sea ice thickness is critical to geophysical research into climate change, shipping, biological productivity and other things. The overall goal of this work is to produce a public archive of ice draft data for research. The data is meant to span the largest time range possible and be of the highest possible quality.

15. SUBJECT TERMS
NUWC, SCICEX, data, ice, ice thickness

16. SECURITY CLASSIFICATION OF:			**17. LIMITATION OF ABSTRACT**	**18. NUMBER OF PAGES**	**19a. NAME OF RESPONSIBLE PERSON**
					Axel Schweiger
a. REPORT	**b. ABSTRACT**	**c. THIS PAGE**	SAR	5	**19b. TELEPHONE NUMBER** *(include area code)*
UL	UL	UL			(206) 543-1300