DATA PRODUCT SPECIFICATION FOR LOW FREQUENCY ACOUSTIC PRESSURE WAVES

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Document Control Sheet

Version	Date	Description	Author
0-01	2012-08-15	Initial Release	S. Denny
0-02	2012-08-19	Update after focused review	S. Denny, with F. Vernon, M. Vardaro, J. Fram, O. Kawka
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1-00	2013-02-14	Initial Release	E. Chapman

Signature Page

This document has been reviewed and approved for release to Configuration Management.

OOI Senior Systems Engineer: ______________________________

Date: 2013-02-14

This document has been reviewed and meets the needs of the OOI Cyberinfrastructure for the purpose of coding and implementation.

OOI CI Signing Authority: ______________________________

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Table of Contents

1 Abstract

This document describes the computation used to calculate the OOI Level 1 Low Frequency Acoustic Pressure Waves (HYDAPLF) core data product, which is the time-series acoustic signal sensed from the Low Frequency Hydrophone (HYDLF) attached to the Broadband Seismometer (OBSBB and OBSBK) instruments. This DPS applies to instrument classes of HYDLF only. This document is intended to be used by OOI programmers to construct appropriate processes to create the L1 HYDAPLF core data product.

2 Introduction

2.1 Author Contact Information

Please contact Skip Denny (denny@apl.washington.edu) or the Data Product Specification lead (DPS@lists.oceanobservatories.org) for more information concerning the computation and other items in this document.

2.2 Metadata Information

2.2.1 Data Product Name

The OOI Core Data Product Names for these products are

- HYDAPLF

The OOI Core Data Product Descriptive Names for these products are

- Low Frequency Acoustic Pressure Waves

2.2.2 Data Product Abstract (for Metadata)

The OOI Level 1 Low Frequency Acoustic Pressure Waves core data product, HYDAPLF, is the time-series acoustic signal sensed by a low frequency hydrophone (HYDLF) and digitized by a channel of the seismometer digitization system onboard the co-located broadband seismometer (OBSBB and OBSBK) instruments. The acoustic signal is obtained in conjunction with the seismic time series to identify the waterborne component of the seismic signal and facilitate the isolation of a pure seafloor structure signal. The acoustic signal is digitized at the same rate(s), and with the same time-stamp, as the seismic signal for greater correlation. The transformation of the L0 acoustic signal to L1 will consist of converting digital counts into physical units and correction for the applied gain.

2.2.3 Computation Name

N/A

2.2.4 Computation Abstract (for Metadata)

The OOI Level 1 Low Frequency Acoustic Pressure Waves core data product is computed by decoding binary format data digitized by the broadband seismometer instruments into Acoustic Pressure Wave data. The data will be parsed from the OBSBB and OBSBK instruments that it is attached to, both physically and electrically. After the data is parsed and decoded, a linear calibration factor, Gain, will be applied to transform the L0 digital counts into the L1 core data product HYDAPLF.

2.2.5 Instrument-Specific Metadata

See Section 4.4 for instrument-specific metadata fields that must be part of the output data.

2.2.6 Data Product Synonyms

Synonyms for this data product are

- Acoustic Time Series

2.2.7 Similar Data Products

Broadband Acoustic pressure waves (HYDAPBB) for Broadband Hydrophones
Broadband Frequency (HYDFRBB) for Broadband Hydrophones

Additional information regarding these similar products can be found in OOI Data Product Specifications for HYDAPBB (DCN 1341-00820) and HYDFRBB (DCN 1341-00810).

2.3 Instruments

For information on the instruments from which the L1 Low Frequency Acoustic Pressure Waves (HYDAPLF) core data product inputs are obtained, see the HYDLF Processing Flow document (DCN 1342-00821). This document contains information on the instrument class and make/models; it also describes the flow of data from the HYDLF instruments through all of the relevant QC, calibration, and data product computations and procedures.

HYDLF instruments are deployed as a component of the OBSBB/OBSBK instruments on the RSN system at Hydrate Ridge (Site PN1A and PN1B) and Axial (PN3A and PN3B) subsites.

Please see the Instrument Application in the SAF for specifics of instrument locations and platforms.

2.4 Literature and Reference Documents

The electronic files of the reference documents are stored on Alfresco under REFERENCE>Data Product Specification Artifacts (1341-00821_HYDAPLF).

Urick, Robert J., “Principles of Underwater Sound”, 3rd Ed., 1983, pg 44-53.

http://www.lubell.com/Hydrophone_Info_By_Dr._Joe_Blue.pdf “HYDROPHONES FOR MONITORING MARINE MAMMAL SOUNDS”.

http://www.fdsn.org/seed_manual/SEEDManual_V2.4.pdf	SEED format manual.
http://www.seiscomp3.org/wiki/doc/applications/seedlink	Seedlink Manual
slink2orb.1.pdf	slink2orb man page
orbserver.5.pdf	orbserver interface man page
dbbuild.5.pdf	Antelope dbbuild parameter file description
packets.5.pdf	Antelope packet description
dm24_mk3.pf.pdf	Datalogger configuration description
css30.pdf	css3.0 schema description
tar_data	tar file of test data

http://www.guralp.com/fir-filter-configuration-of-the-cmg-dm24-mk3/ Guralp fir filters (This file is not stored in Alfresco. Please consult the website directly.)

Of Poles and Zeros: Fundamentals of Digital Seismology (Modern Approaches in Geophysics) by F. Scherbaum. Publisher: Springer; 2nd edition (January 19, 2007). Language: English. ISBN-

10: 0792368355 ISBN-13: 978-0792368359 (This text is not stored in Alfresco.)

2.5 Terminology

2.5.1 Definitions

Definitions of general OOI terminology are contained in the Level 2 Reference Module in the OOI requirements database (DOORS). The following terms are defined here for use throughout this document.

OCVR – Open Circuit Voltage Response, the calibration constant that transforms the measured voltage into pressure. OCVR has units of decibels relative to 1 micro-Pascal (dB/1 μPa) as it is a compressed ratio compared to a standard.

Transfer Function - A transfer function is a mathematical representation, in terms of temporal frequency, of the relation between the input and output of a linear time-invariant system with zero initial conditions and zero-point equilibrium.

Poles and Zeros – solutions for Laplace’s transform in a linear time-invariant system.

FIR Filter - a finite impulse response (FIR) filter is a filter whose impulse response (or response to any finite length input) is of finite duration, because it settles to zero in finite time.

Sensor Sensitivity – Nominal conversion factor from ground velocity in the middle of the seismometer passband to Volts.

ADC – Analog to Digital Converter, hardware that provides a conversion at a specified rate and bit-depth. For example in this case, the analog signal will be digitized by the Guralp DM24S3EAM at 24-bit depth at 1000 Samples per second.

2.5.2 Acronyms, Abbreviations and Notations

General OOI acronyms, abbreviations and notations are contained in the Level 2 Reference Module in the OOI requirements database (DOORS).

2.5.3 Variables and Symbols

N/A

3 Theory

3.1 Description

The ultimate output of a transducer, e.g. hydrophone, is a calibrated sound pressure level relative to a measured response to a known signal. To do this, any gain applied outside of the calibrated unit needs to be removed so that the calibration factor, the OCVR or Sensitivity, can be applied. Calibration is affected by cable length, temperature and pressure and internal signal conditioning (e.g. filtering and preamp gain). The calibration results in a set of values that provide a transfer function between the output voltage of the transducer to absolute pressure, called OCVR or Sensitivity, which is a function of frequency. Often OCVR is presented as a graph (see Figure 1). As such, it cannot be applied to a time-series unless that time-series is filtered and then only that one calibration point can be used to convert volts to dB re: pressure. Therefore, only any external gain will be accounted for in this data flow.

An ADC will convert the analog voltage output from the hydrophone into a digital stream at a maximum rate of 1000 Samples per second with a depth of 24-bits. This digital binary stream will represent the time-series acoustic energy at the hydrophone.

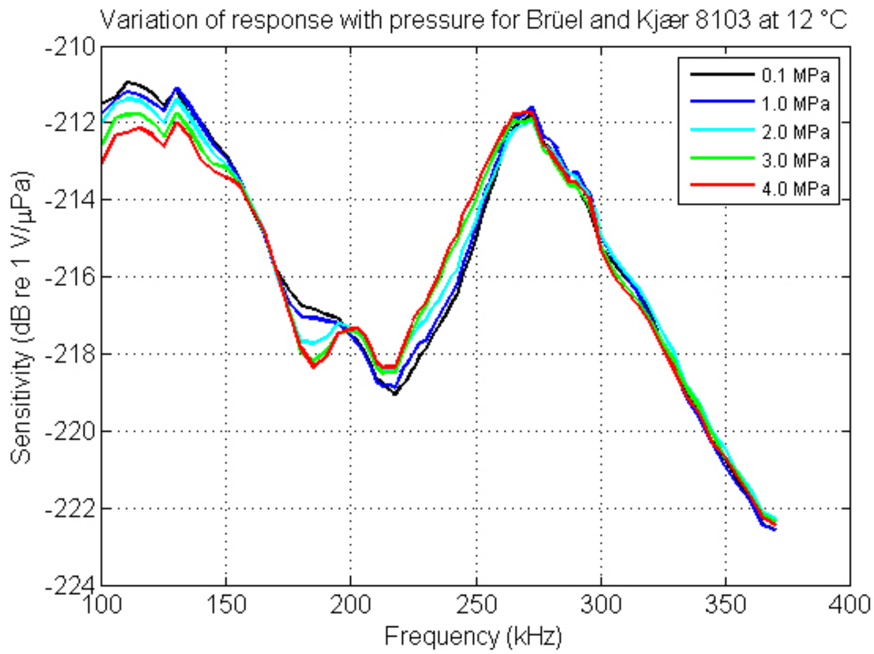

Figure 1. Typical Calibration Curve (OCVR), Conducted as a family of pressure curves

3.2 Mathematical Theory

The output signal will be amplified and filtered by the digitization system. To return to the output level of the hydrophone, this gain must be removed from the signal. Mathematically, this is:

$$S(t) = \frac{x(t)}{G}, where\ G = Gain\ set\ at\ digitizer, x(t) is\ input\ time - series\ and\ S(t) is\ corrected\ output\ signal$$

3.3 Known Theoretical Limitations

None

3.4 Revision History

No revisions to date.

4 Implementation

4.1 Overview

The output of the OBSBB/OBSBK instruments includes the seismic data and is formatted for transmission via SEEDlink protocol and diverted by the US Navy for inspection using Antelope Orb. After Navy inspection of the data, it is returned, with its time-stamps, to the OOI ION system for storage. Some data may not be returned, for security reasons. The output of the OBSBB/OBSBK instrument comprises SEED blockettes using the SEEDlink protocol. Data are acquired using slink2orb, which takes SEEDlink packets and inserts into an import BRTT Antelope Orb in the US Navy data diversion switch and is not accessible to OOI. Data are exported from the US Navy data diversion switch from another Orb that makes these data available to the OOI. The original SEED blockettes (L0 data) can be pulled from the above mentioned export orb and converted to standard OOI format for L1 data.

All reference documents are listed in section 2.4 above.

This is the same data stream process as for the broadband ground acceleration, broadband ground velocity and short period ground velocity data products. See OOI Data Product Specifications for GRNDACC (DCN 1341-00100) and GRNDVEL (DCN 1341-00090) and SGRDVEL (DCN 1341-00110) for additional details.

4.2 Inputs

Inputs are: Miniseed packets acquired from an Antelope Orbserver.
Dbbuild parameter file for metadata

Input Data Format

- See observer.5.pdf, packets.5.pdf, css3.0.pdf, and the SEED manual referenced in Section 2.4

4.3 Processing Flow

The specific steps necessary to create all calibrated and quality controlled data products for HYDLF core instruments are described in the instrument-specific Processing Flow document (DCN 1342-00821). This processing flow document contain flow diagrams detailing all of the specific procedures (data product and QC) necessary to compute all levels of data products from the instrument and the order in which these procedures occur.

The processing flow for the computation is as follows:

1. Build seismic metadata using command
   dbbuild -b rsnsp rsnsp-dbbuild
2. Generate dataless seed using command
   mk_dataless_seed rsnsp
3. Send *rsnsp_dataless_seed* to IRIS Data Management Center
4. Establish connection to diversion switch export orb at ip_address:port_number
5. Write data to disk using command
   orb2wf -dbm dbmaster/rsnsp ip_address:port_number rsnsp

4.4 Outputs

The output of the calibration computation is

- L1 HYDAPLF Time-series in cycles/sec (Hertz).
- Attachment – dataless seed file named rsnsp_dataless_seed

See Appendix B for a discussion of the accuracy of the output.

Automated QC algorithms are performed using range checks, which will generate QC flags for HYDAPLF. See Data Processing Flow Diagram for HYDLF (DCN 1342-00821) for details.

4.5 Computational and Numerical Considerations

4.5.1 Numerical Programming Considerations

These codes and APIs depend on the Antelope software.

4.5.2 Computational Requirements

Linux platform with Antelope installed.

4.6 Code Verification and Test Data Set

Gain = 1500 Volts/meter/sec * 787401.57 counts/volt;

1) Untar the file tar_data
2) Cd data
3) Run program trsample to show L0 data values for first 10 data points

```
trsample -T -n 10 rsn
 SUM1   LHZ    10 (calib=0.503809)  1/15/2013 (015)  0:00:00.000

1/15/2013   0:00:00.000 3371
1/15/2013   0:00:01.000 3113
1/15/2013   0:00:02.000 2378
1/15/2013   0:00:03.000 2130
1/15/2013   0:00:04.000 2649
1/15/2013   0:00:05.000 3419
1/15/2013   0:00:06.000 2988
1/15/2013   0:00:07.000 2382
1/15/2013   0:00:08.000 2413
1/15/2013   0:00:09.000 2627
```

4) Run program trsample to show L1 data values for first 10 data points in units of nanometers/sec

```
palapa% trsample -c -T -n 10 rsn
 SUM1   LHZ    10 (calib=0.503809)  1/15/2013 (015)  0:00:00.000

1/15/2013   0:00:00.000 1698.339444574
1/15/2013   0:00:01.000 1568.356775722
1/15/2013   0:00:02.000 1198.057312132
1/15/2013   0:00:03.000 1073.11273122
1/15/2013   0:00:04.000 1334.589495306
1/15/2013   0:00:05.000 1722.522266686
1/15/2013   0:00:06.000 1505.380676472
1/15/2013   0:00:07.000 1200.072547308
1/15/2013   0:00:08.000 1215.690619922
1/15/2013   0:00:09.000 1323.505701838
```

Appendix A Example Code

None.

Appendix B Output Accuracy

The time-series voltage is digitized at 24-bits resolution, and has an accuracy of better than the 0.1 dB specified for the hydrophone.

Relevant requirements from the OOI requirements database (L2_Science_Requirements_ReferenceOnly_Baseline_Version_2.29_(NSF-CCB-2012-07-03)) are listed below.

The low frequency passive acoustic instrument shall measure acoustic pressure waves with a resolution of 0.1 dB// 1 μPa.

The low frequency passive acoustic instrument shall measure acoustic pressure waves with an accuracy of ±1 dB// 1 μPa.

Appendix C Sensor Calibration Effects

None.