ADVM Acoustic Beam Calibration - Phase 2

October 19, 2020

Presented to:

Federal Interagency Sedimentation Program (FISP)
Technical Committee Meeting

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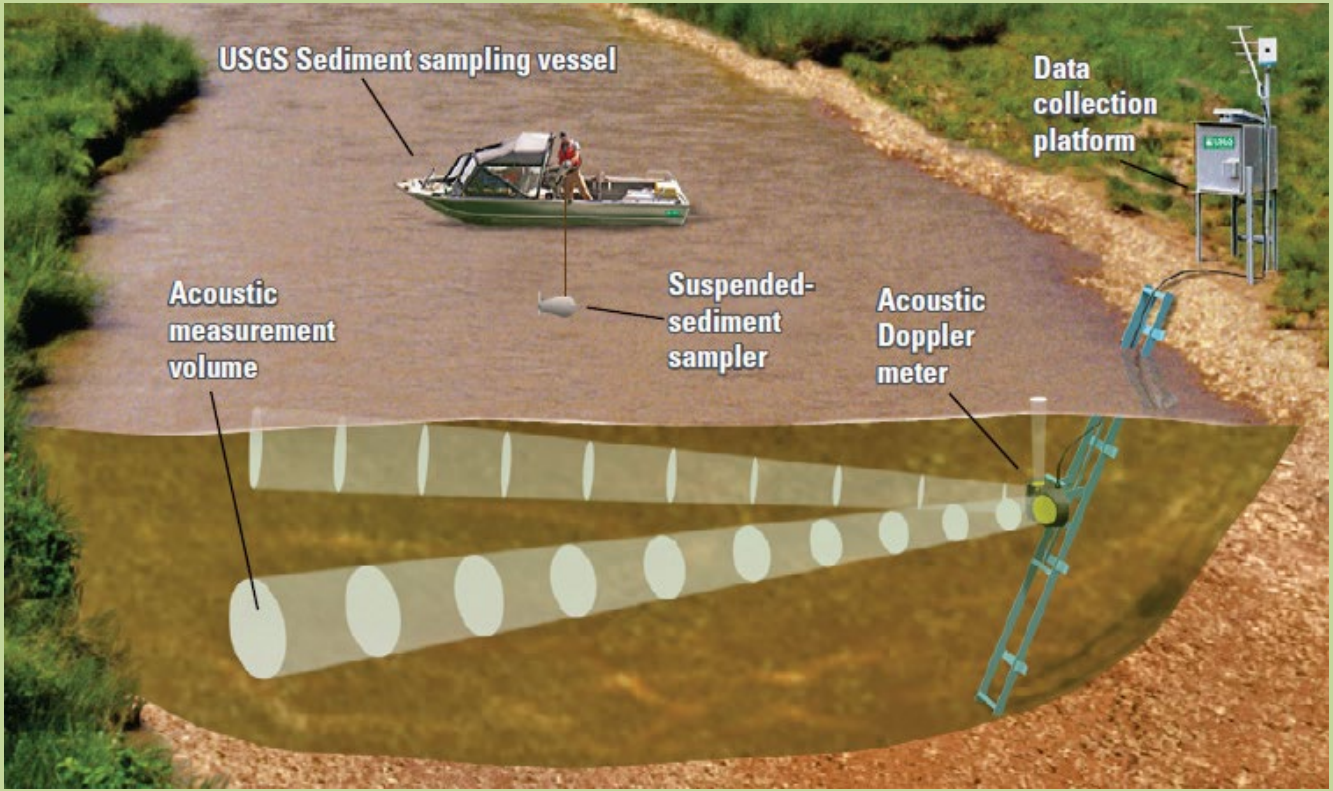
Presentation Overview

- The Application – ADVM for Sediment Acoustic Index Rating
- The Problem – Variation in ADVM Backscatter Data
- Phase 1 (2019): Calibration Method Review and Selection
- Phase 2 (2020-2022): Calibration Implementation

ADVM for Sediment Acoustic Index Rating



The Sonar Equation

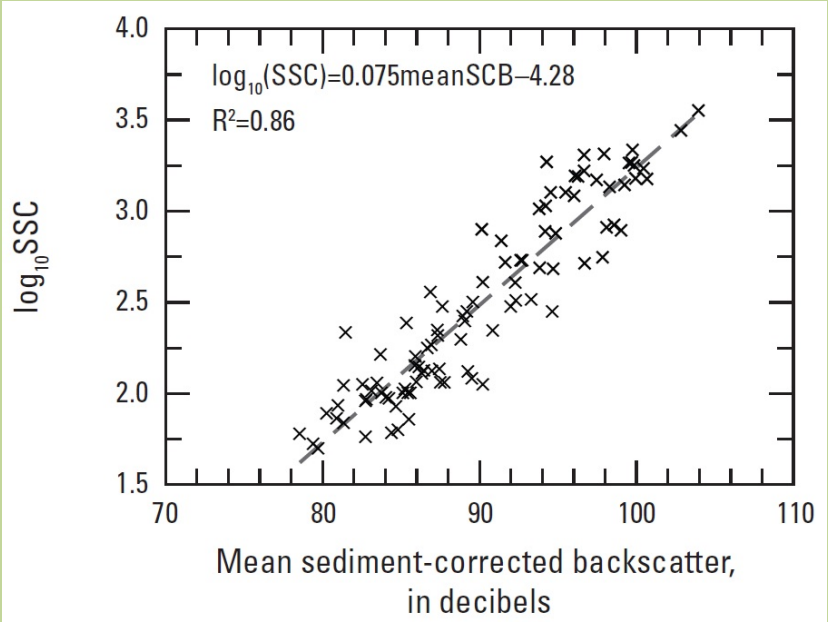
$$SL - 2*TL + TS = RL$$

- SL = Source level = strength of the acoustic pulse
- TL = Transmission losses = geometric spreading, water absorption, sediment absorption
- TS = Target strength = function of reflective particles and the size of the ensonified water volume
- RL = Receive level = measured backscatter intensity data

ADVM for Sediment Acoustic Index Rating

Developing a Rating

- Site selection and installation
- Data collection over a range of conditions
- SCB: Sediment Corrected Backscatter
- Rating development and error analysis

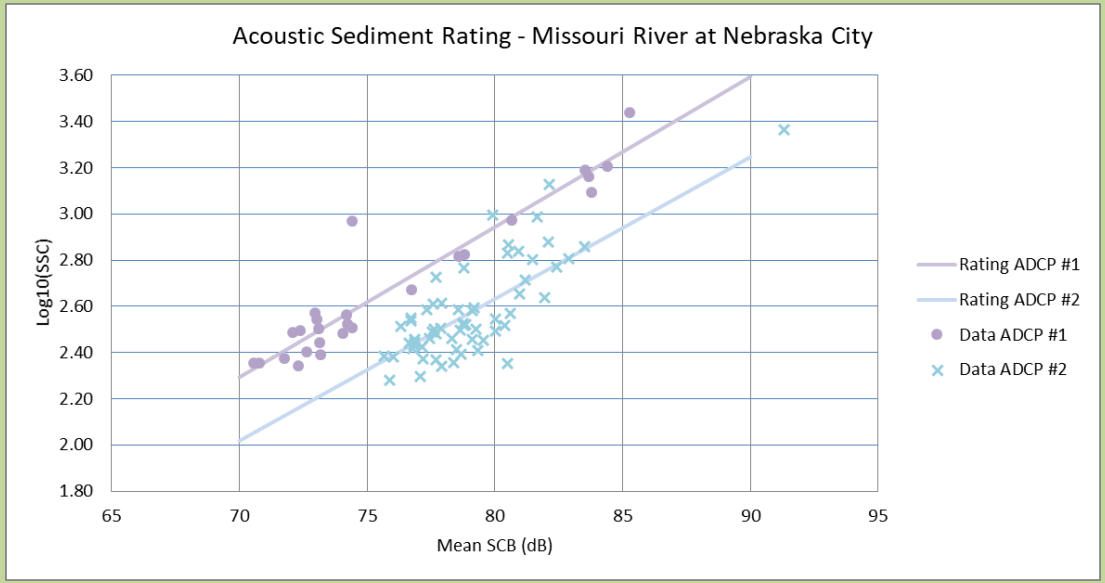


The Problem – Variation in ADVM Backscatter Data

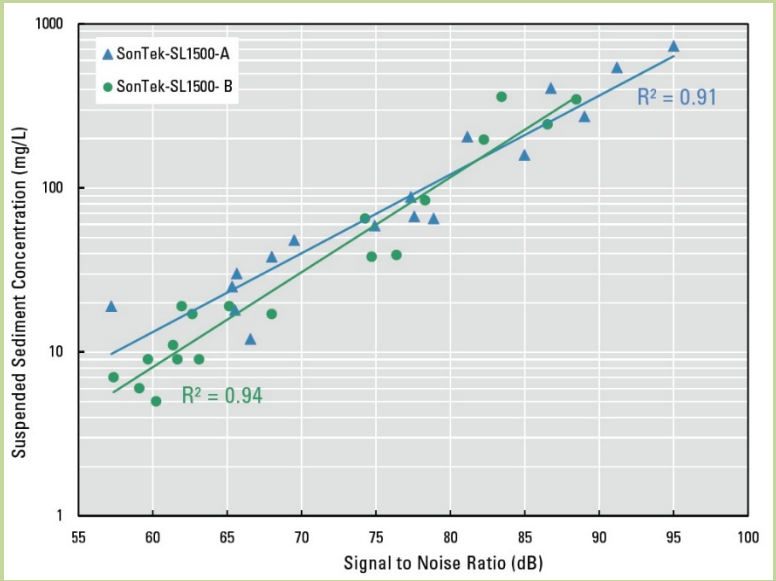
- ADVMs are designed for velocity measurement
- Backscatter is secondary data primarily used for QA/QC
- Manufacturer's do not precisely calibrate backscatter – data will vary from instrument to instrument
- Error sources
  - Variation in transmit strength
  - Variation in transducer / receiver sensitivity
  - Variation in receiver linearity

The Problem – Variation in ADVM Backscatter Data

A new instrument may require a new rating



SSC Error ~100%



SSC Error -20% to +80%

Phase 1 (2019): Calibration Method Review and Selection

- The Goal: Select a calibration protocol so that any calibrated ADVM can be replaced by one of the same frequency without changing the sediment index rating

- Minimum: relative calibration
  - Account for offset in transmit power and receive sensitivity between systems
  - Account for variations in receiver linearity

- Ideal: absolute calibration
  - Convert measured data to absolute backscattering (pressure)
  - This may offer additional benefits as techniques improve with time

Method	Quality	Absolute?	Advantages	Disadvantages
Suspended sediment tank	Offset: fair Slope: fair	No	Direct calibration from sediment Control sediment type/size	Difficult design/operation Inherently noisy Time consuming
In-situ	Offset: good Slope: fair	No	Direct calibration from sediment No need to remove ADVM	Time consuming Requires reference system
Discrete target	Offset: fair/good Slope: poor	Theoretical	Direct calibration of backscatter	Difficult design/operation Limited range of backscatter
Electronics only	Offset: fair Slope: good	No	Easy to measure/control Full receiver range	Ignores transducers Requires opening system
Test transducer	Offset: fair/good Slope: fair/good	No	Simple Full receiver range	Test transducers vary Mechanical coupling can vary Unproven
Reference hydrophone	Offset: good Slope: good	Yes	Direct pressure measurement Full receiver range Beam pattern, near field	Larger tank and hydrophone Special mounting/electronics Longer procedure Concerns above 2000 kHz

Phase 1 Results – November 2019

Selected Method: Reference Hydrophone

- Best overall performance
- Most likely to provide reliable results
- Provides absolute calibration
- USGS HIF would be an excellent facility
- Calibration should require 1 person 1 day of work

Reference Hydrophone Calibration Procedure

- Large tank of still water
  - HIF “Jet” tank for most systems, tow tank for lowest frequencies
- Mount and align ADVM and hydrophone
  - Distance between systems 0.5-4.0 m
  - Precise beam alignment is essential
- Transmit calibration:
  - ADVM transmits as in normal field operation
  - Hydrophone receives, electronics measure output to determine pressure
- Receive calibration
  - Hydrophone transmits at a range of driving voltages
  - ADVM receives transmitted signal, logs reported signal strength
- Data analysis to determine all key calibration parameters
- Additional data (beam pattern, near field) for limited number of systems

Phase 2: Implement Calibration Procedure

Year 1 – August 2020 through July 2021

Task	Details	Schedule
1: Facility evaluation	2 days on-site at HIF	November 5-6, 2020
2: Mechanical system design	Hydrophone and ADVM mounting, transducer damping	Design by February 2021 Fabrication details TBD
3: Electrical system design	Hydrophone transmit and receive control and measurement	
4: ADVM data acquisition system design	Automatic control and data logging	
5: Sediment processing software proposal	Scope to replace existing Matlab code, expand capabilities	Proposal by April 2021

Phase 2: Implement Calibration Procedure

Year 2 – August 2021 through July 2022

Task	Details	Tentative Schedule
6: Processing software	Analyze and output data in format to be used for rating development	Alpha version: November 2021 Beta version: February 2022 Final version: April 2022
7: Initial calibrations	2 trips of 1 week each at HIF	Trip 1: November 2021 Trip 2: February 2022
8: Ongoing support	Address issues that arise during the first year of operations	Existing contract covers through July 2022