Federal Interagency Sedimentation Project

FY2021 Call for Ideas

Idea Title: Development and testing of a prototype field apparatus to track calibration drift of field-deployed LISST-ABS sensors.

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Additional Investigators: Tristan Austring**;** Jonathan O'Connell
PI Location: New Mexico Water Science Center (WSC), Albuquerque, NM; Wyoming-Montana WSC, Helena, MT;
Study Location(s): New Mexico WSC Sediment Laboratory; Wyoming-Montana WSC Sediment Laboratory.

Introduction: This study supports the FISP mission to develop standardized, consistent, and accurate quantification of sediment characteristics and transport in surface waters. The objective of the proposed research will be to develop a prototype apparatus to test and track calibration drift in Sequoia's LISST-acoustic back scatter (LISST-ABS) sensor. The research will use laboratory and field apparatus in the Helena and Albuquerque Sediment Laboratories to determine the potential of field staff to adequately and efficiently determine if a LISST-ABS sensor has drifted from factory calibrations.

Background: The LISST-ABS sensor was developed by Sequoia Scientific (Sequoia) as an alternative to turbidimeters (optical) for estimating suspended-sediment concentrations (SSCs) in surface waters. Because of its smaller size, the ABS sensor is easier to deploy than other acoustic instrumentation such as acoustic doppler profilers (ADPs) and acoustic doppler current profilers (ADCPs), which typically require hard attachment to infrastructure or the river bank (Topping and Wright, 2016; Landers and others, 2016). One of the main advantages of the ABS described by Sequoia is the lack of sensitivity to biofouling, which can be a problem in optical sensors, particularly during warm summer months with low-flow conditions when algae growth is prolific.

Initial testing by the USGS indicates the ABS sensor shows promise as a novel, cost-effective, off-the-shelf tool for monitoring SSC (Snazelle, 2017; Manaster and others, 2020). However, these initial tests did not account for the potential of instrument drift over long deployments. To meet the quality standards typically required for USGS Water Mission Area records available on the National Water Information System (NWIS), field staff perform checks every 2 to 6 weeks on deployed instrumentation to assure adequate performance. In the case of optical instruments, fouling and calibrations checks are done every visit to track the influence of biofilms and transducer drift on the transmitted signal. Despite the ABS's lower sensitivity to biofouling, uncertainty regarding the sensor's drift from factory calibrations remains undocumented.

The ABS sensor differs from ADP and ADCPs because a transducer is used to convert the strength of the acoustic backscatter signal to a unitized value (sediment concentration in mg/l). While this conversion is one of the benefits of the sensor, it also presents a dilemma because there is currently no method for users to check transducer drift in the field or laboratory. Instead, calibrations must be done by sending the sensors to Sequoia, who use a specialized apparatus for checking calibrations and proprietary software to upload raw voltage values that re-calibrate the transducer. Sequoia calibrates each instrument across different concentrations of 75

to 90 µm glass spheres (1.0, 3.0, 10.1, 100, 1000, and 10,000 mg/l). Comparison of factory calibration checks in four ABS units deployed by the USGS Wyoming-Montana Water Science Center (WY-MT WSC) indicated average calibration drifts ranging from 5 to 61 percent per year, with maximum drifts from individual concentration bins ranging from 10 to 92 percent (Table 1). Of the four sensors, only one stayed within 10 percent per year across all concentration bins (Serial no. 6083). These magnitudes of calibration drift suggest a need to develop methods for checking calibration drift in LISST-ABS sensors deployed in the field.

***Table 1**. Basic statistics of rates of drift from factory calibrations for four LISST-ABS sensors used by the USGS WY-MT WSC.*

LISST-ABS Unit (serial no.)	Avg. Calibration Drift (%/year)[a]	Max. Calibration Drift (%/year)[b]	Min. Calibration Drift (%/year)[c]	Deployment location (USGS Gage no.)
6083	-5%	-10%	4%	06284010 - Shoshone R. bl. Willwood Dam nr. Ralston, WY
6122	-19%	-40%	1%	12324400 - Clark Fork abv. Little Blackfoot R. nr. Garrison, MT.
6127	-21%	-34%	-3%	12324200 - Clark Fork nr. Deer Lodge, MT.
6149	-61%	-92%	-33%	06283995 - Shoshone R. abv. Willwood Dam nr. Ralston, WY

[a] Average of percent deviation across 6 concentrations of 75 to 90 micron glass spheres (1.0, 3.0, 10.1, 100, 1000, and 10000 mg/l).

[b] Maximum (in absolute magnitude) of percent deviation across 6 concentrations of 75 to 90 micron glass spheres (1.0, 3.0, 10.1, 100, 1000, and 10000 mg/l).

[c] Maximum (in absolute magnitude) of percent deviation across 6 concentrations of 75 to 90 micron glass spheres (1.0, 3.0, 10.1, 100, 1000, and 10000 mg/l).

Purpose and Scope: The purpose of the proposed research is to develop and test a prototype apparatus to document calibration drift of LISST-ABS sensors deployed at USGS real-time SSC monitoring locations. The research will be split between the WY-MT WSC and the New Mexico Water Science Center (NM-WSC). Initial calibration checks on the sensors by each WSC will be performed using laboratory methods (Snezell, 2017), after which each WSC will develop portable apparatus and methods. The proposed benefits of the study will be to improve the quality and confidence in data records produced by the LISST-ABS at USGS and other agency monitoring stations across the Nation.

Technical Requirements: The proposed study will primarily be laboratory-based but, if confidence in the methods is realized early, the methods will be applied to LISST-ABS monitors currently deployed at USGS gaging stations. The purpose of two different WSCs working on the same problem is to increase the potential for learning from different approaches to the same problem, thus increasing the chance for success of a final design. The basic steps of the proposed study are as follows:

1. Develop prototype of apparatus used to create suspension of standardized particle sizes in specific concentrations (based on basic re-circulation design of Figure 1).
2. Use existing laboratory methods (i.e. Snezell, 2017 and/or stir-plate + beaker) to test ability of personnel at each WSC to reproduce results of Sequoia. These tests will be

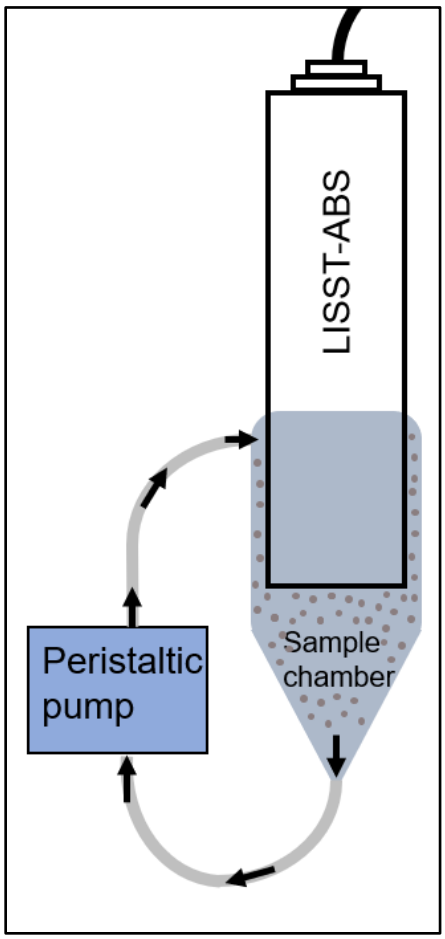

Figure 1. *Schematic showing basic design of portable apparatus used to check calibrations on the LISST-ABS suspended sediment sensor manufactured by Sequoia Scientific.*

done using LISST-ABS sensors that have been recently calibrated by Sequoia. Additionally, the WSCs will work with Sequoia to obtain the same standard material to assure any differences are methodological.

3. Test potential of prototype apparatus to reproduce concentrations from task 2. Note that, regardless of success of task 2 at reproducing results of Sequoia, the apparatus should, at minimum, be able to closely mimic conditions in the laboratory by each operator at each WSC.

4. If necessary, alter apparatus design and/or standardized material to better reproduce factory or laboratory concentrations. If such modifications are unsuccessful, test potential of apparatus to produce stable concentrations over a range of concentrations (1, 10, 100, 1000) using standardized materials of different particle sizes. The purpose here is to use grain sizes that are as close to the factory calibrations as possible (75 to 90 µm) yet maintain a stable suspension.

5. If tasks 3 and 4 are successful, use the apparatus to test calibration drift of LISST-ABS sensors currently deployed at USGS gaging stations.

Because there is a need to understand how well operators can re-produce the calibrated concentrations after receipt of calibrated sensors from Sequoia, the study will initiate after each center receives a sensor that has been factory calibrated by Sequoia. The two centers will work off a basic initial design (Figure 1) and will each use at least two different standardized particle materials (glass spheres and Arizona test dust) in their testing.

FISP funding would support the cost of labor, Sequoia factory calibrations, and materials costs (apparatus and standard test particles), and basic shipping costs incurred by the WSCs.

Deliverables: A formal presentation during FISP's annual research results meeting is proposed, with potential for additional future funding toward a written product (USGS Open-File Report) with FISP committee approval.

Timeline: The proposed timeline for the project is 1 year (2021). The major activities and scheduled completion dates are presented in table 1.

Table 1. Timeline of major activities and completion dates.

Activities and Components	Completion Date
1. Send two LISST-ABS sensors to Sequoia for factory calibration.	Late March, early April 2021
2. Receive factory-calibrated LISST-ABS sensors.	May-June 2021

3. Test center laboratory methods to reproduce Sequoia calibration results.	June-July 2021
4. Develop and test portable apparatus.	June-September 2021
5. Improvements to apparatus or testing methods	July-October 2021
6. Test apparatus in the field (if applicable).	September – November 2021
7. Present results to FISP committee	TBD

Budget: The proposed budget is to support a 1-year study. This project leverages previous funding provided by the Wyoming Department of Environmental Quality, National Park Service, and U.S. Army Corps of Engineers (funding used to purchase LISST-ABS sensors and pay for previous calibrations which exposed need to understand drift). Additionally, this project will benefit from in-kind salary and equipment costs from an upcoming project at NMWSC involving a LISST-ABS. The total cost of the project using FISP funding is $23,915 including labor, equipment, and lab supplies. The centers will cover the cost of labor and travel to any field-deployed sensors (Task 5).

Table 2. Itemized budget.

Budget Category	Cost FY 21	Explanation and Comments
Personnel – WY-MT WSC Personnel – NM WSC	$12,315 $7,500	Tasks 1-5
Equipment/Supplies	$4,100	Cost of calibrations for 2 LISST-ABS sensors. Purchase of materials/pumps for prototype apparatus. Purchase of industrial test grains (glass spheres and test dust); lab equipment;
Total Project Costs	$23,915	FISP funding

Unique Qualifications: USGS staff assigned to this project will be Jason Alexander, PhD, and Jeb Brown, M.S. as principal investigators. Jason Alexander is a USGS hydrologist with expertise in field geomorphology and sedimentology. Jeb Brown is a USGS hydrologist with research focuses in suspended sediment and metals transport, and suspended sediment surrogate instrumentation for 14 years at NMWSC. Jonathan O'Connell, B.S. is a hydrologic technician and has 8 years of experience collecting suspended-sediment samples and maintaining turbidimeters in California, Montana, and Wyoming.

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References:

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