FEDERAL INTERAGENCY SEDIMENTATION PROJECT

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Proposal Title: ADCP/LISST-SL/SSC data analysis and surrogate testing

Project Chief: Jon Czuba (WA), Tim Straub (IL), and Chris Curran (WA)

Project Chief Location: USGS Washington and Illinois Water Science Centers

Proposed Start Date: January, 2012 Proposed End Date: September 30, 2012

1. Relation to FISP goals –

The Illinois and Washington Water Science Centers (IL-WSC and WA-WSC) of the U.S. Geological Survey tested a stream-lined (SL) Laser In-Situ Scattering and Transmissometry (LISST) surrogate technology as part of a FISP-funded project in FY11 called *LISST-SL Testing*. The FY11 LISST-SL field testing focused on side-by-side comparisons of the LISST-SL (concentration and particle size) with physical samples of suspended-sediment concentration (SSC) and particle size to determine the LISST-SL's efficacy for collecting reliable concentration and particle-size distribution data.

In addition to the side-by-side collection of LISST-SL and SSC data, the IL- and WA-WSCs collected three-dimensional (3-D) water-velocity and acoustic-backscatter data with a down-looking acoustic Doppler current profiler (ADCP). Analysis of the ADCP data was not included in the FY11 proposal.

We propose to collect 2-5 additional ADCP/LISST/SSC datasets in Washington and Illinois or Missouri, and analyze these new datasets along with those collected previously, as part of FY11 LISST-SL testing, to (1) supplement testing of the emerging LISST surrogate technology for quantifying SSC and grain-size distributions, (2) evaluate down-looking ADCPs as acoustic surrogates for quantifying SSC and grain-size distributions, and if funding allows (3) provide insight into the temporal and spatial variation of SSC and grain-size distributions.

During field testing, it was noted that the LISST-SL lacked sufficient weight to maintain horizontal position in the river cross-section and showed a tendency to move from side to side as river velocities increased. This problem was rectified by designing a harness system which allowed standard USGS sounding weights to be suspended below the instrument. Other design issues and pre-deployment calibration protocols were improved by the manufacturer, Sequoia, as a result of USGS field testing in FY11. While gains were made in improving the deployment of the LISST-SL in natural river conditions, more data collection opportunities and comparison analyses are needed for an accurate assessment of this promising technology.

Data collected, as part of the FY11 LISST-SL testing, and available for analysis include 13 IL-WSC sets of ADCP/LISST/SSC data (over 170 samples) at 11 sites and 4 WA-WSC datasets (over 100 samples) at

3 sites. These datasets consist of a discharge measurement, following standard USGS procedures using a tethered-boat ADCP (1,200 and 600 kHz; with a differential global-positioning system in Washington) including a loop moving-bed test and at least 4 transects, used to determine sediment flux and sometimes equal-discharge increment (EDI) stationing. During side-by-side comparisons of the LISST and SSC measurements at point-sample locations and at EDI verticals, stationary profiles of 3-D water velocity and acoustic backscatter were collected at the same locations. For the stationary profiles, the ADCP sampled the flow at 3 Hz with the total sampling time for each profile ranging from at least 10 minutes to several hours. A cursory review of these ADCP measurements and considering observations of boils (upwellings of water and sediment) in the field suggests that there was considerable spatial and temporal variation in the SSC similar to what was observed by Czuba et al. (2009).

Most streamflow measurements made today use ADCPs, and each of these measurements record acoustic backscatter. Qualitative information about the distribution of suspended sediment can be inferred from acoustic-backscatter measurements. A better understanding of the utility of acoustic-backscatter measurements from down-looking ADCPs as surrogates for suspended-sediment concentrations has the potential to revolutionize sediment measurements by providing rapid measurements of sediment flux and sediment distribution in space and time.

2. Technical merit (Scientific merit) –

The purpose of our proposed work is to compare temporal and spatial variations in sediment flux measured by the down-looking ADCP, LISST-SL, and physical sampler and to evaluate the utility of using down-looking ADCPs as a surrogate for measuring suspended-sediment concentrations. Additionally, we will collect 2-5 new ADCP/LISST/SSC datasets targeting sediment and hydraulic conditions not covered in the existing datasets. These new datasets will strengthen our comparisons and provide additional testing of the LISST-SL, building upon the comparisons made as part of the FY11 LISST-SL testing.

The ADCP data will be analyzed using code that can be easily incorporated as a module in the Velocity Mapping Toolbox (VMT; Parsons et al., submitted), which is a free program that provides advanced processing and plotting of down-looking ADCP measurements. Currently, VMT only processes transect data, but an extension is being developed to include stationary profiles. We will use VMT to aid in processing the ADCP data, and then take the analysis and processing further using acoustic-backscatter and acoustic-attenuation data to compute SSC in space and time.

The researchers have much experience in sediment-data collection, testing the LISST-SL, and advanced analysis of 3-D water-velocity and acoustic-backscatter intensity data from ADCPs (Czuba et al., 2011; Czuba et al., 2009; Parsons et al., submitted).

3. Technical context (Relevance and importance) –

Previous work in rivers with acoustics as a surrogate for suspended-sediment concentration has primarily relied on side-looking ADCPs to characterize variations in suspended sediment across a fixed profile of the channel. Down-looking ADCPs, which are used for routine discharge measurements, provide detailed measurements of acoustic backscatter throughout the entire cross section. This rapid, detailed measurement can provide spatial and temporal resolution of suspended-sediment flux throughout the cross section that is not possible with a fixed deployment. Several studies have used acoustic backscatter from down-looking ADCPs as a qualitative surrogate for suspended sediment, but SSC was not computed from the acoustic data or compared to simultaneous SSC data (Czuba et al., 2011; Czuba et al., 2009).

The datasets collected by the IL- and WA-WSCs as part of the FY11 LISST-SL testing contain the data necessary to more fully understand the spatial and temporal variability of sediment flux by grain size and the utility of these emerging surrogate technologies (ADCP and LISST-SL). The combined ADCP/LISST/SSC datasets represent diverse geographical locations across the U.S.A. with different sizes of sediment in suspension. In Illinois, sediment in suspension from agricultural fields is clay and silt. Variability in glacial deposits also results in sand in suspension for some river systems. In Washington, most sediment in suspension is sand, silt, and clay, derived from denuding mountains and generated through the glacial grinding of sediment and bedrock into glacial flour. Since some data has already been collected, additional funding for the analysis is all that is needed to fully explore these datasets. Collecting additional datasets will supplement testing of these emerging surrogate technologies and provide a more robust comparison of these different technologies over a wide range of conditions.

4. Timeline, budget (Feasibility), and partners -

The project will be completed by the end of FY12. The results will be summarized in a USGS director-approved report (such as an Administrative Report or an Open-File Report) and the data will be made available to FISP at the end of the project.

The first 3 months (January – March) will be used to collect additional datasets and begin processing existing data. The second 3 months (April – June) will be used to process additional data collected and begin analyzing the combined data. The third 3 months (July – September) will be used to fully analyze the data, perform additional analyses, and draft the report.

The budget assumes a direct appropriation of funds and zero overhead for the sediment samples processed at Cascades Volcano Observatory (CVO) Sediment Laboratory.

We propose to collect 2-5 additional ADCP/LISST/SSC datasets in Washington and Illinois or Missouri and analyze these new ADCP/LISST/SSC datasets along with those collected previously as part of FY11 LISST-SL testing. The total funding requested is **$30,000**, which includes $23,000 for labor and travel and $7,000 for analysis of sediment samples by CVO. The allocation of the total funding is $15,000 to the WA-WSC and $15,000 to the IL-WSC.

The USGS is providing all of the equipment except for the LISST-SL being used by the IL-WSC, which has been loaned from FISP. In addition, the IL- and WA-WSCs will be collecting SSC data at several sediment-monitoring stations during FY12. As appropriate, we will leverage these data-collection efforts to obtain additional datasets for comparing ADCP/LISST/SSC data-collection techniques.

References

Czuba, J.A., Best, J.L., Oberg, K.A., Parsons, D.R., Jackson, P.R., Garcia, M.H., and Ashmore, P., 2011, Bed morphology, flow structure, and sediment transport at the outlet of Lake Huron and in the upper St. Clair River: Journal of Great Lakes Research, v. 37, no. 3, p. 480-493, doi: 10.1016/j.jglr.2011.05.011.

Czuba, J.A., Oberg, K.A., Best, J.L., Parsons, D.R., Simmons, S.M., Johnson, K.K., and Malzone, C., 2009, Temporal Characteristics of Coherent Flow Structures generated over Alluvial Sand Dunes, Mississippi River, revealed by Acoustic Doppler Current Profiling and Multibeam Echo Sounding: *in* Proceedings of River, Coastal, and Estuarine Morphodynamics 2009, Santa Fe, Argentina, September 21-25, 2009.

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