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USGS ADCP~SSC Work

Research Directions and Highlights of the 2016 "Summit"

Molly Wood, P.E.
Office of Surface Water
U.S. Department of the Interior
U.S. Geological Survey

Get a Suspended-Sediment Estimate While Measuring Flow…..

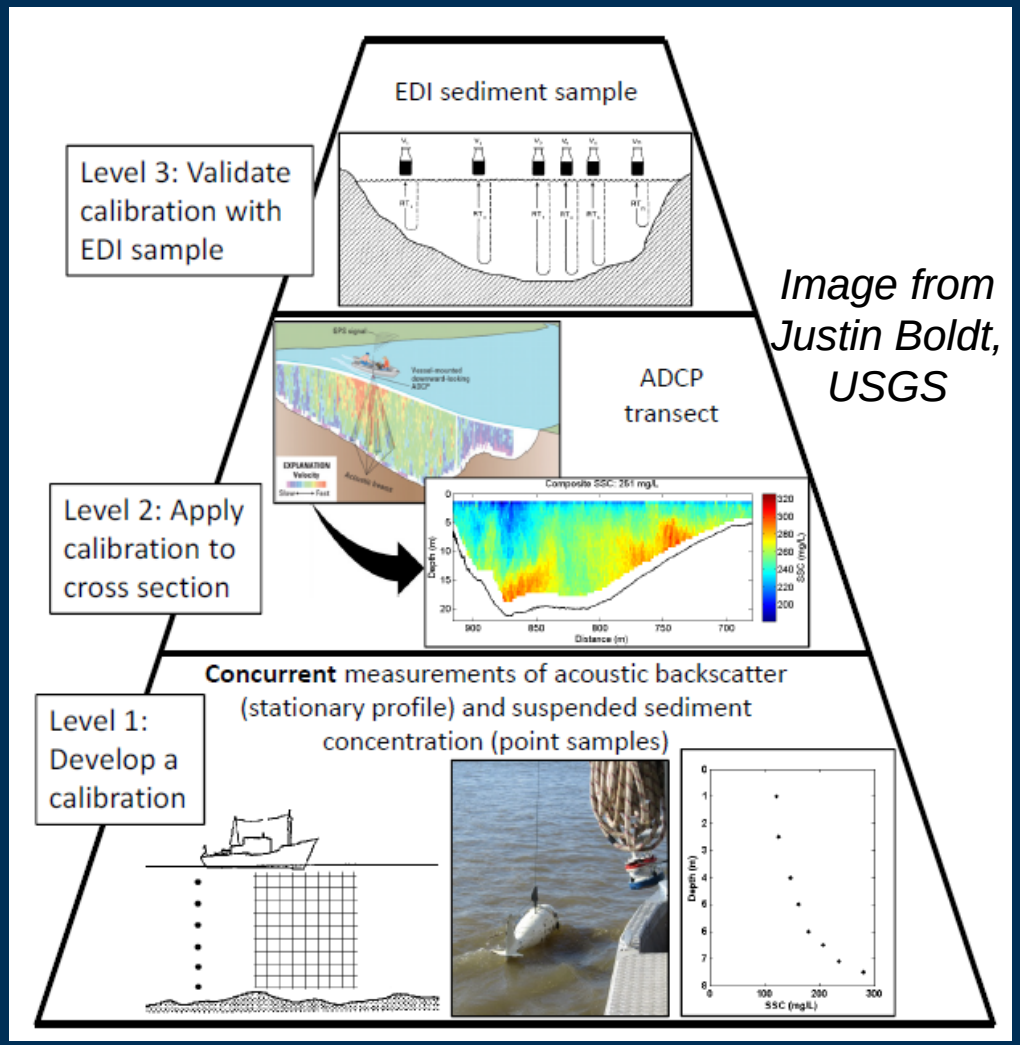
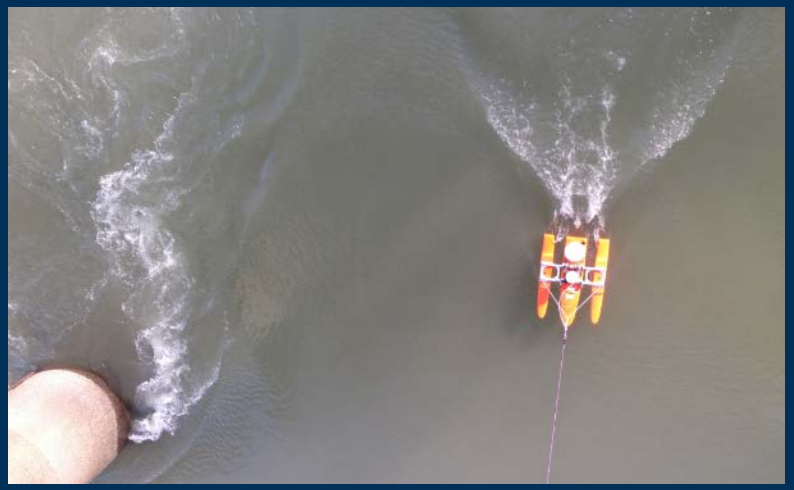
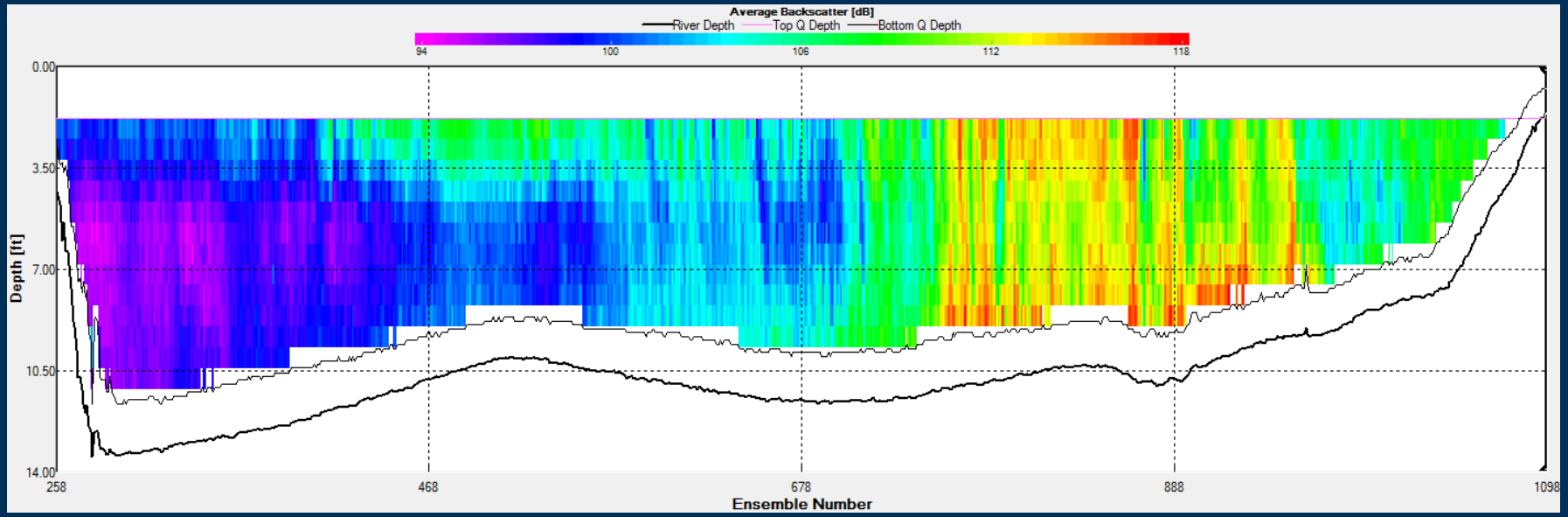


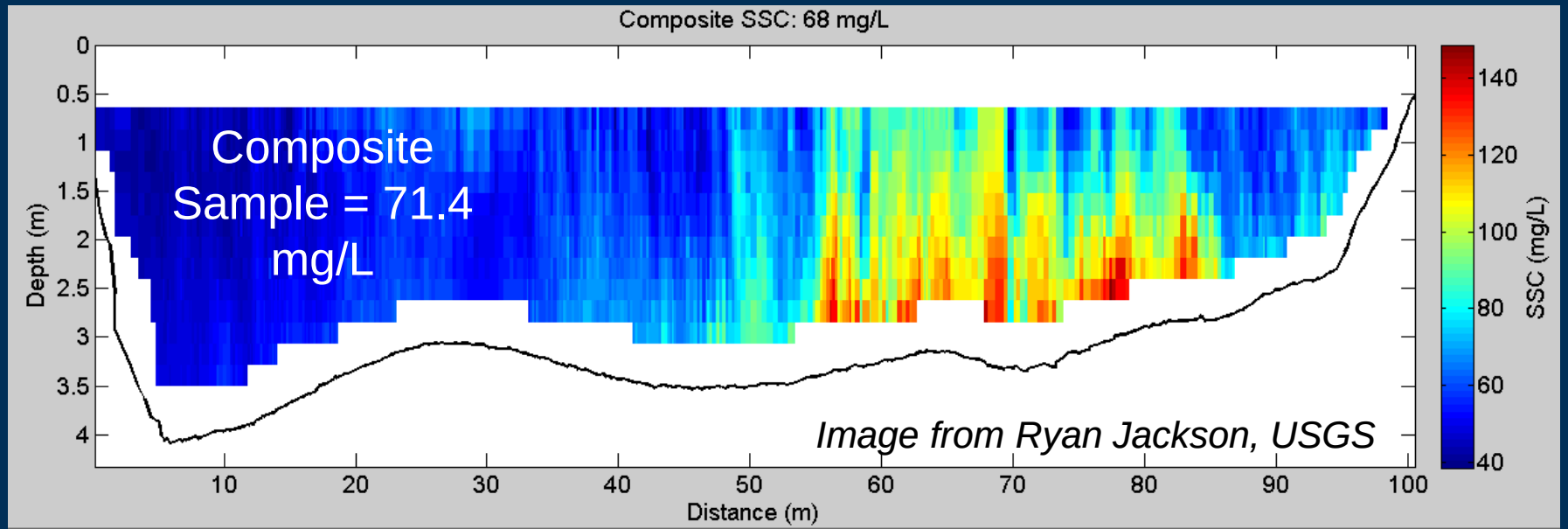
Image from Justin Boldt, USGS



Measured Backscatter (dB)



Suspended Sediment Concentration (mg/L)



Benefits

- Would leverage 1000s of measurements made across the country each year
- High spatial resolution SSC data not possible with samples alone
- Potentially rapid assessments after calibration developed
- If calibration could be developed for a river, could quickly evaluate sediment transport along a reach

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Why Can't We Use These Techniques?

- Assumption that sediment characteristics are fairly homogeneous with horizontal acoustic measurement volume does not hold in the vertical
- Calibrations don't necessarily hold spatially and temporally

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2016 USGS “Summit”

- July 18-22, 2016
- Urbana, IL and St. Louis, MO
- Goals:
  - Bring together sediment acoustics experts
  - Discuss steps for making the technique more operational
  - Collect a test dataset

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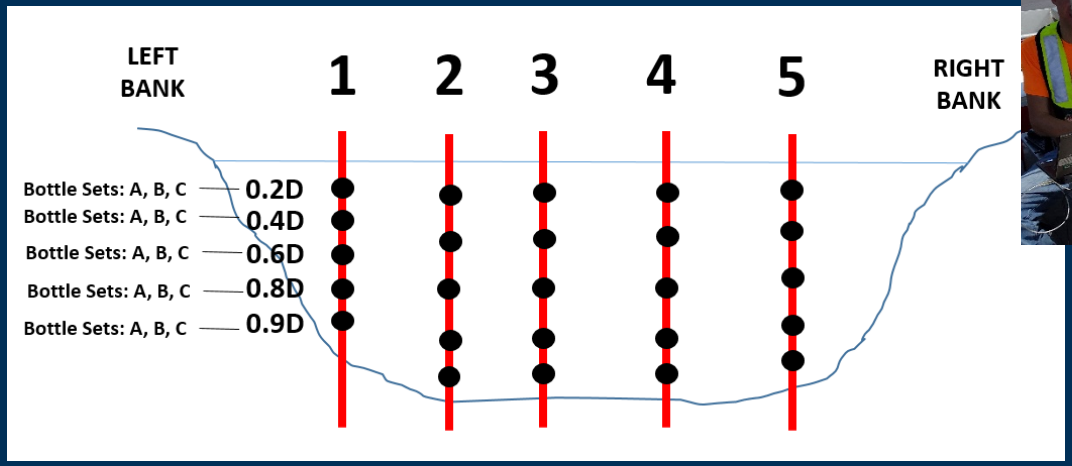
“Summit” Test Dataset – Missouri River



“Summit” Test Dataset

Data Collected During 2016 ADCP~SSC Summit		
Station ID:	06935965	
Station Name:	Missouri River at St. Charles, MO	
Date:	7/20/16	
Point Samples		
	Set A	1 sample each at 0.2, 0.4, 0.6, 0.8, 0.9D at 5 verticals
	Set B	1 sample each at 0.2, 0.4, 0.6, 0.8, 0.9D at 5 verticals
	Set C	1 sample each at 0.2, 0.4, 0.6, 0.8, 0.9D at 5 verticals
Bed Material Samples		1 sample from bed at each of 5 verticals
ADCP Discharge Measurements		
	M9	2 transects "before"
	RiverPro	2 transects "before"
	Rio Grande 600	2 transects "before"; 4 transects "after"
	Rio Grande 1200	2 transects "before"; 4 transects "after"
ADCP Stationary Profiles		
	M9	5 verticals; 3 "replicate" measurements at vertical 3
	RiverPro	Vertical 1 only
	Rio Grande 600	5 verticals
	Rio Grande 1200	5 verticals
ADCP Longitudinal Transects		
	Rio Grande 600	
	Rio Grande 1200	
Turbidity Profiles	YSI 6920 V2 Sonde	Verticals 2, 3, 4, 5 complete; Vertical 1 at 0.2, 0.6, 0.8D
LISST ABS Profiles		Verticals 3, 4, 5

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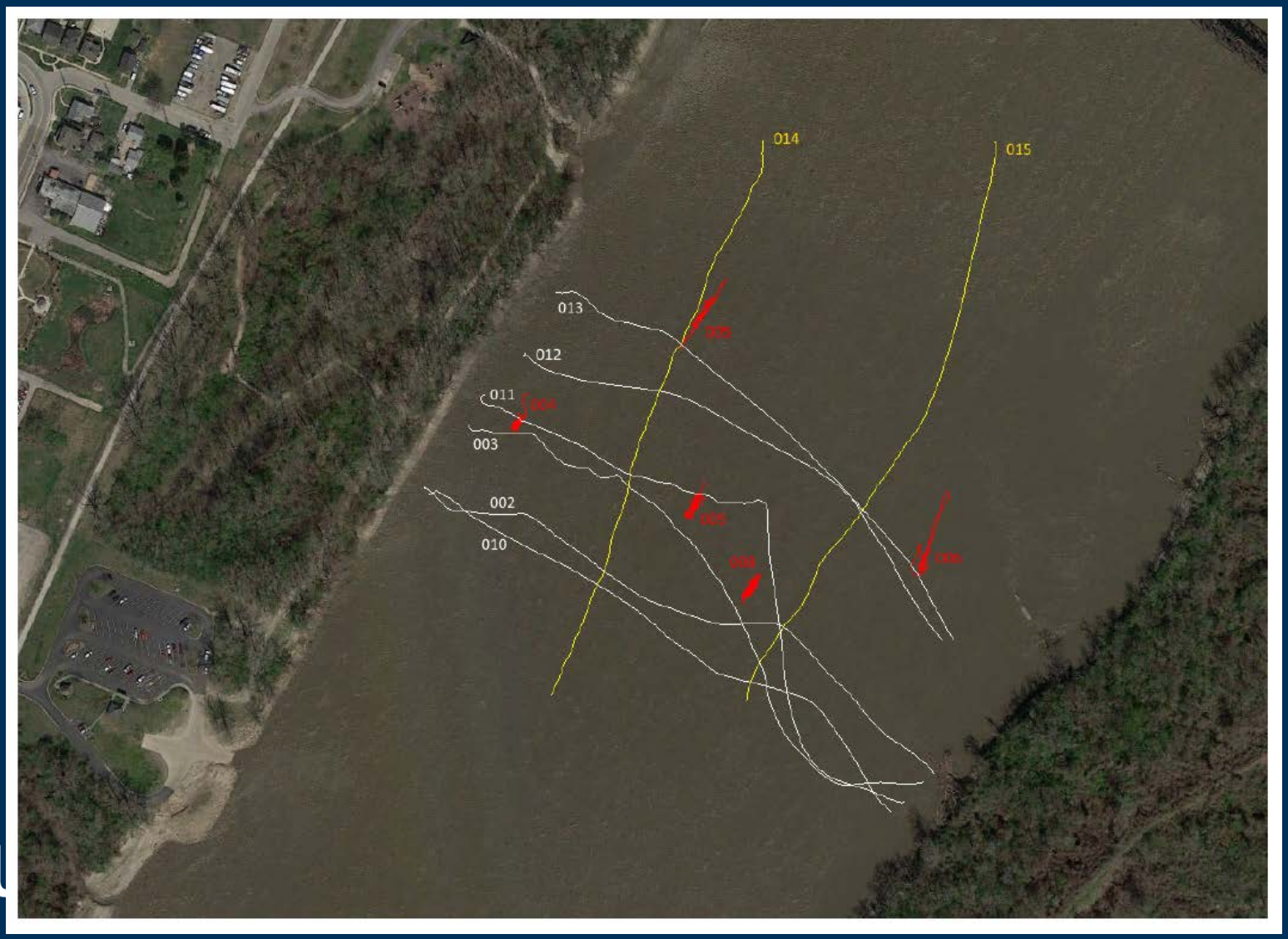
“Summit” Test Dataset



Sample Analyses

Sample Set	Analysis - CVO	Analysis - KY	Unit Cost	No. Samples	Total Cost
Set A		Conc, Sand/Fine Split	50	25	$1,250.00
Set B		PSD of Sand and Fines (composite by vertical)	214	5	$1,070.00
Set C	PSD of Sands; Conc; Sand/Fine Split		135	25	$3,375.15
Bed material		PSD of sands only	122	5	$610.00
Rush					$280.75
				TOTAL	**$6,585.90**

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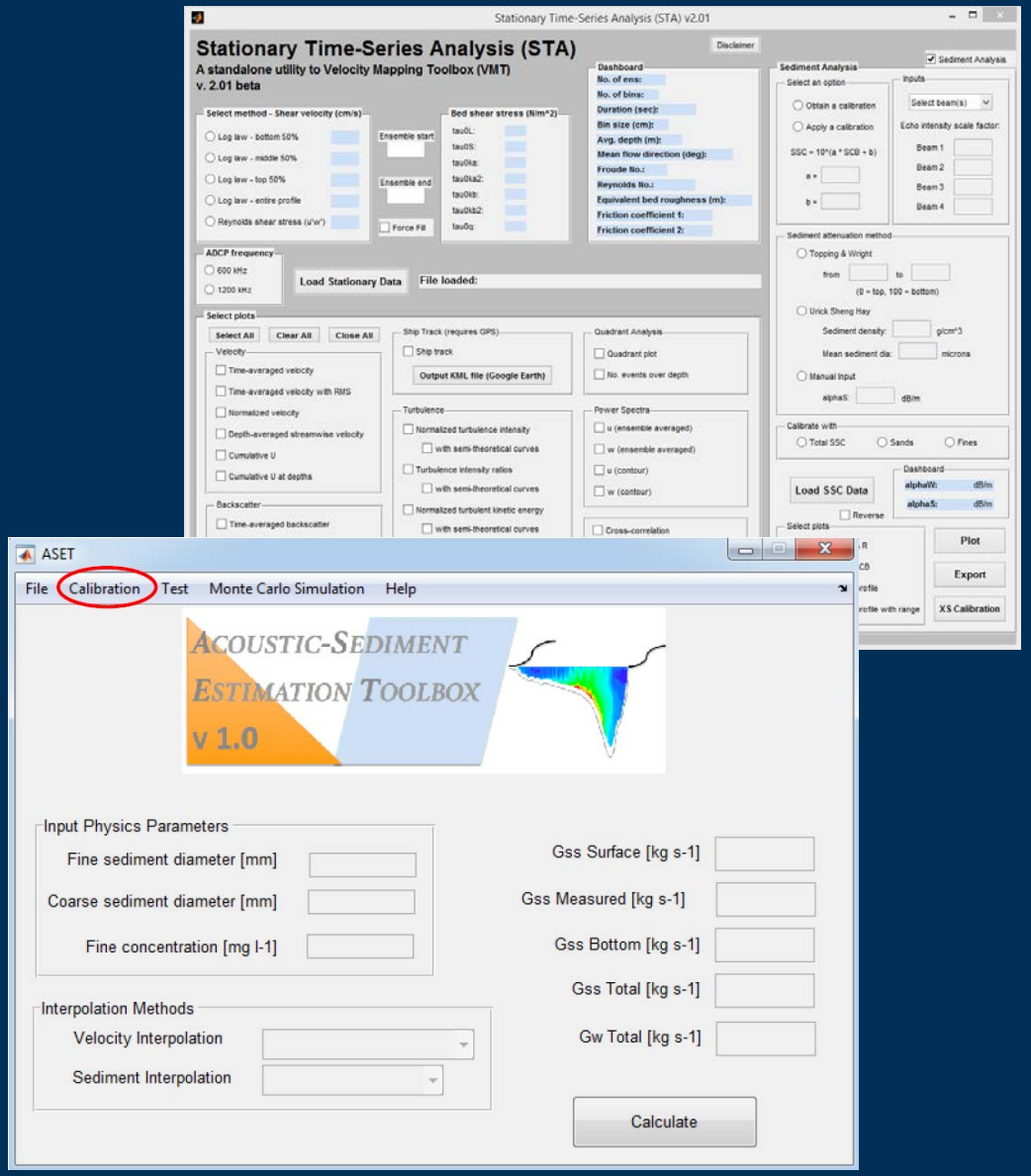
Processing Software

- STA (developed by Justin Boldt, USGS)
- ASET (developed by Ricardo Szupiany's team, Universidad de Litoral



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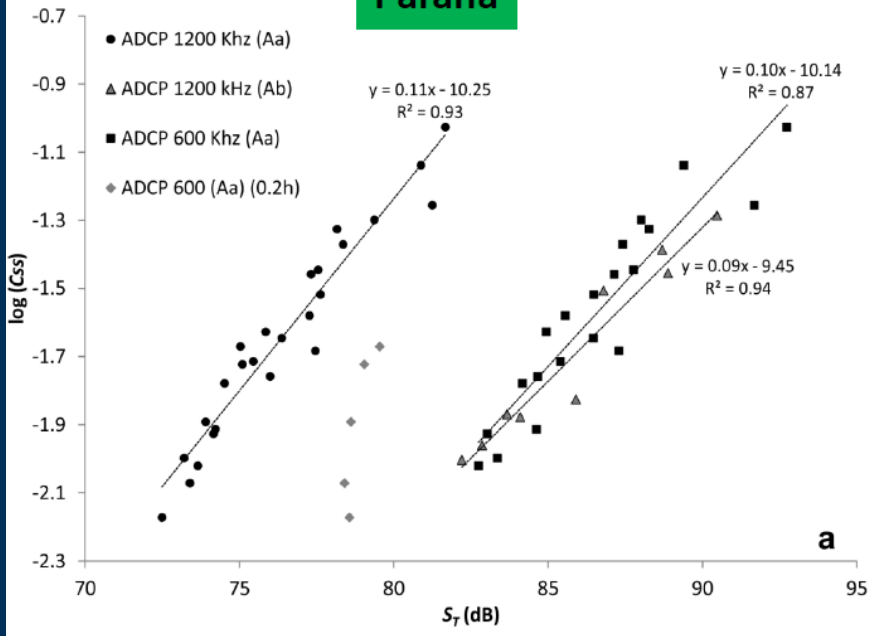
Results to Date

Differences *ST* and *Css* regressions between Paraná and Missouri Rivers

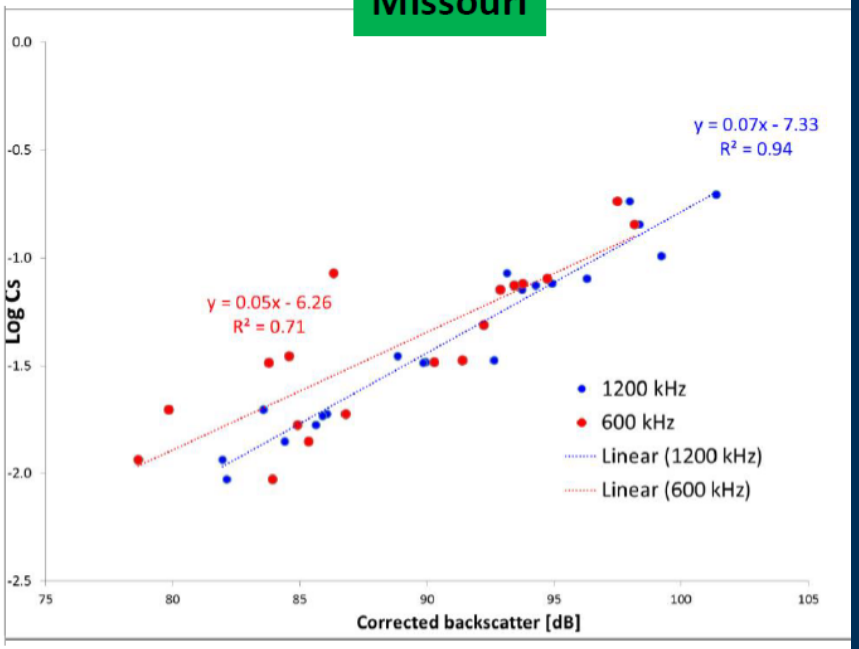
$$Log_{10}(Css) = 0.1(ST) + K_T$$

beam spreading, fluid and sediment attenuation

Paraná



Missouri



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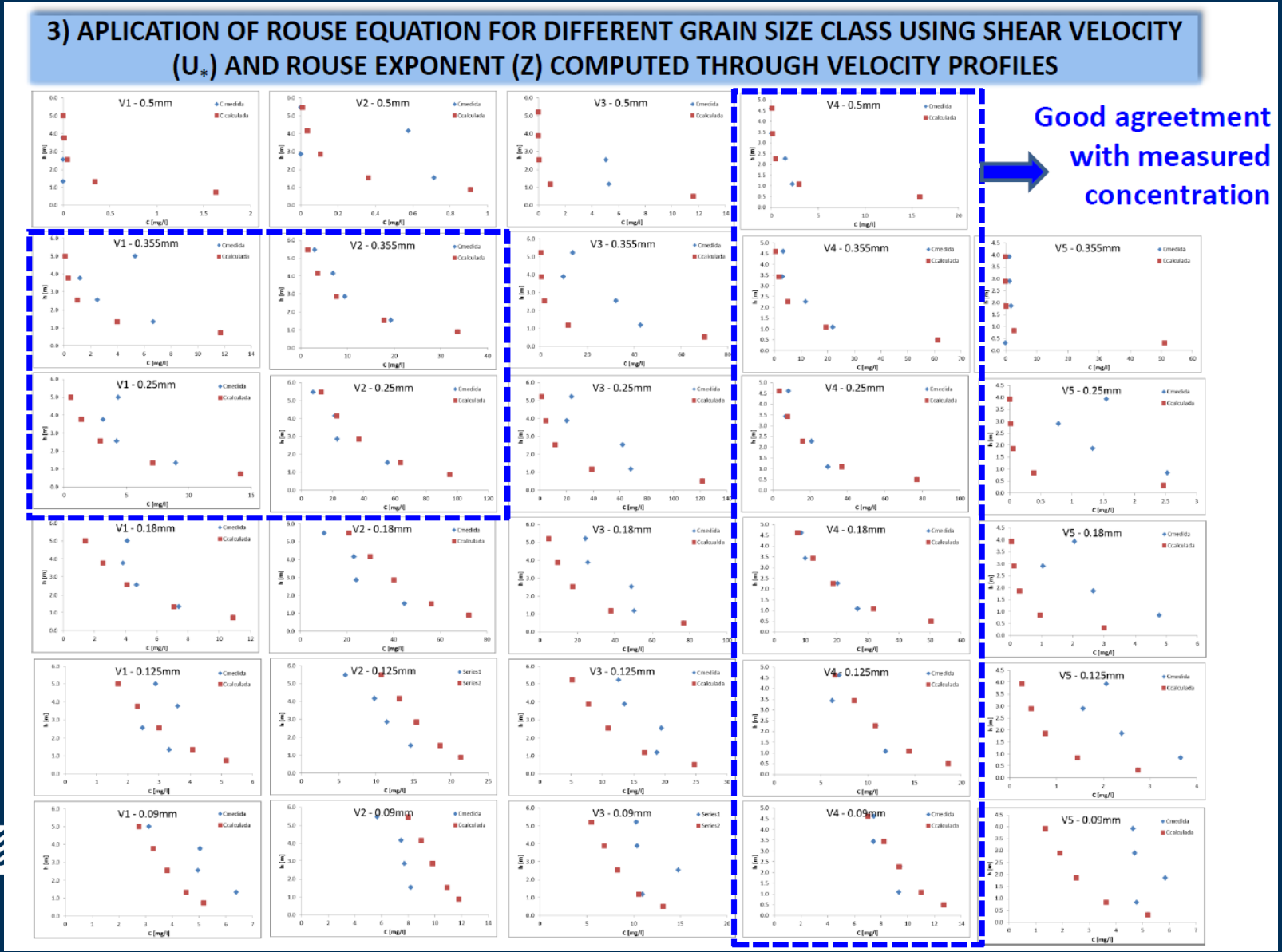
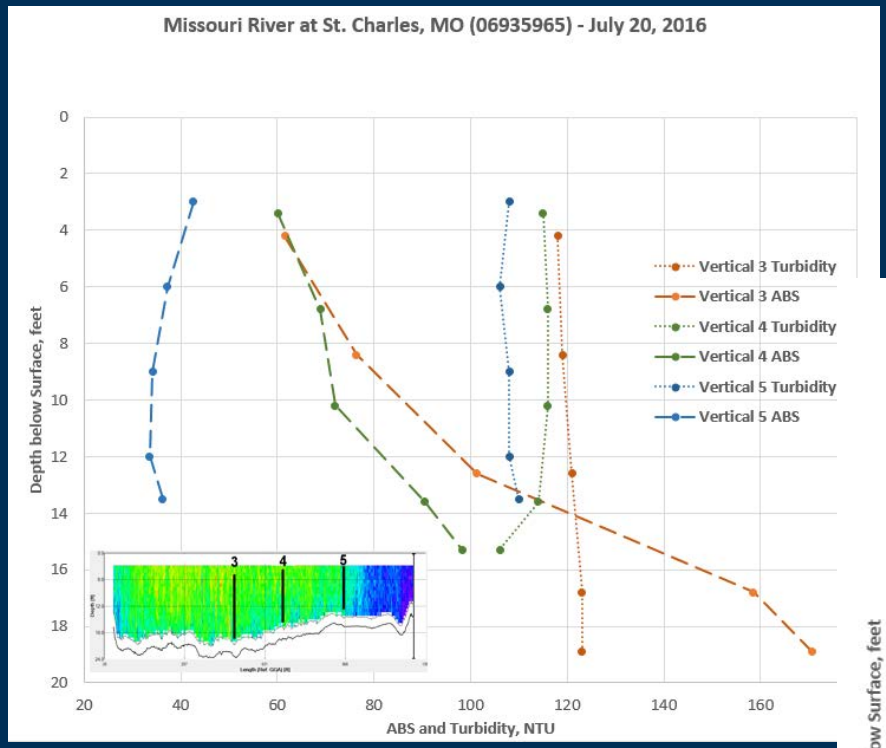
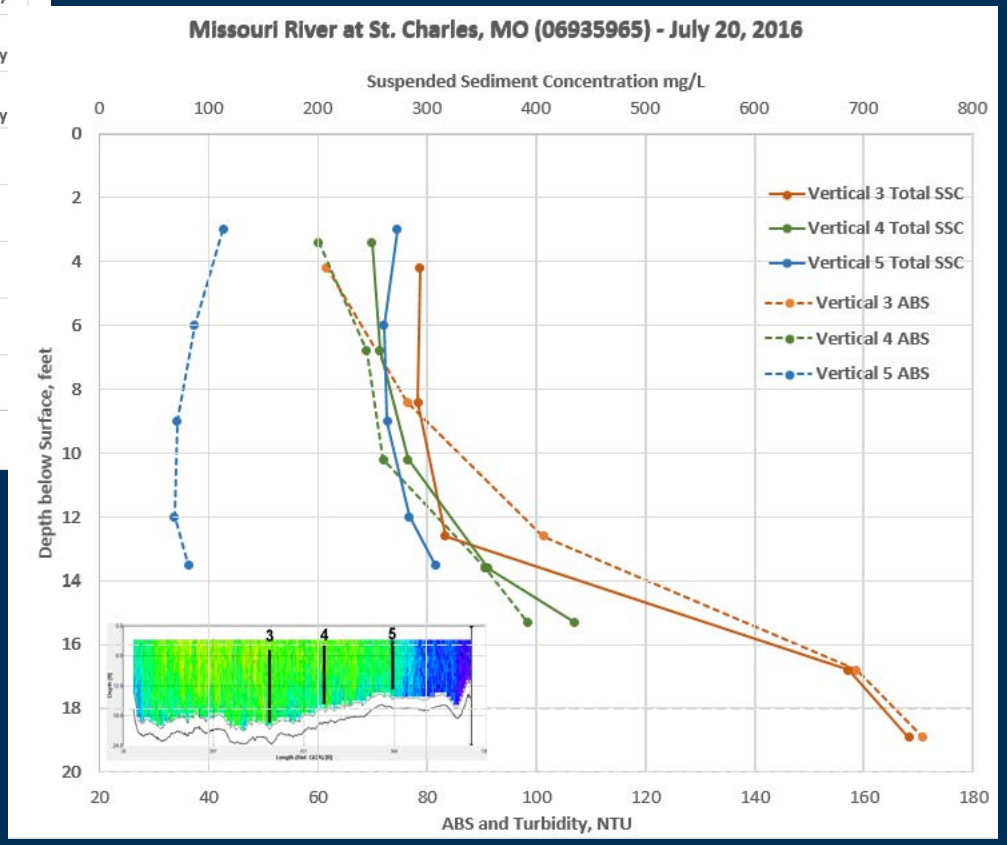
Results – Rouse Curves



Results – Turbidity and ABS





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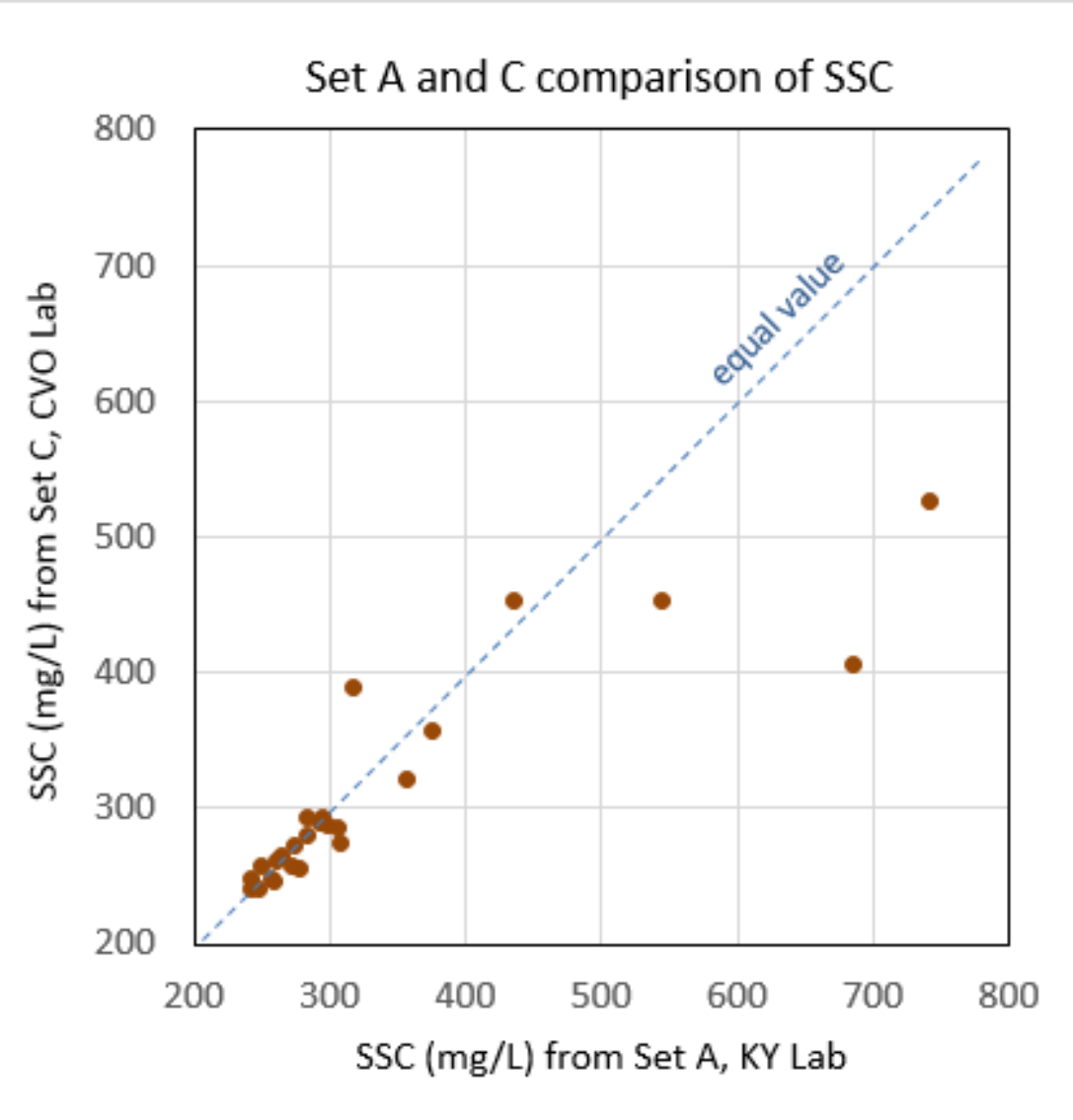
Results – Lab Comparison



Highlights

- Lower slopes and higher dispersion (w/ 600kHz) with Missouri River vs Parana River
- So far fairly good agreement in transport estimates computed from samples and ASET
- Rouse curve uncertainties - analysis may benefit from sampling closer to bed where practical
- Some difference between lab results – due to variability in system or in lab methods?

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OSW Note

OSW Informational and Technical Note 2016.33 *September 8, 2016*

SUBJECT: Announcement of OSW Summit to Advance the Use of ADCPs to Estimate Suspended Sediment

The purpose of this OSW Note is to announce an initiative coordinated by OSW to advance the use of down-looking acoustic Doppler current profilers (ADCPs) to estimate suspended-sediment transport in rivers. This Note presents 1) a summary of a recent OSW Summit to strategize and collect a test dataset and 2) an invitation for USGS Water Science Centers to collaborate with OSW on the collection of future test datasets.

Background

Various OSW and Water Science Center initiatives have advanced the use of side-looking acoustic Doppler velocity meters (ADVMs) to estimate suspended-sediment concentrations, resulting in the publication of the Techniques and Methods Report 3-C5 (Landers and others, 2016). A key assumption in the successful application of the methods described in T&M 3-C5 is that sediment characteristics (particularly grain size distribution) do not substantially vary across the measurement volume ensonified by the ADVM. This assumption is almost never met in the measurement volume ensonified by a down-looking ADCP because sediment concentration and grain size commonly vary with depth in a river channel (García, 2008). The use of ADCPs to estimate suspended sediment has been investigated (Boldt and others, 2012; Latosinksi, 2014; Boldt, 2015; Szupiany and others, 2016) but is not yet considered an operational technique. Additional datasets are needed to define methods that are appropriate for a wide range of sediment and hydrologic conditions and that account for sediment variations with depth in acoustic data corrections. OSW staff in the Hydroacoustics and Sediment programs has recognized the need to advance this technique, which would greatly leverage and provide value to existing sediment monitoring programs where ADCPs are used to measure streamflow.

OSW Summit

OSW staff held an "ADCP Sediment Summit" during the week of July 18-22, 2016, in Urbana, Illinois, and St. Louis, Missouri, to discuss steps for advancing the use of down-looking ADCPs for estimating suspended-sediment transport. The summit included a series of meetings and seminars in Urbana and a comprehensive field data collection effort on the Missouri River near St. Louis. Summit participants included Justin Boldt (Indiana-Kentucky WSC), Mark Landers (OSW), Amanda Manaster (Illinois-Iowa WSC), Kevin Oberg (OSW), Tim Straub (Illinois-Iowa WSC), Molly Wood (OSW), and Ricardo Szupiany (Universidad Nacional de Litoral in Santa Fe, Argentina). Ryan Beaulin (Illinois-Iowa WSC), Gary Johnson (Illinois-Iowa WSC), and Ben Rivers (Missouri WSC) also participated in the field data collection effort on the Missouri River. The Missouri River dataset included the collection of three replicate sets of point suspended-sediment samples at 25 locations in the river, bed material samples, backscatter profiles at five locations using four ADCPs with differing frequencies, and backscatter and turbidity profiles using fixed-point monitoring sensors.

Summit participants processed some existing ADCP and sediment datasets in the Stationary Time-Series Analysis (STA) program, developed by Justin Boldt, and the Acoustic-Sediment Toolbox (ASET) program, developed by Ricardo Szupiany and his colleagues at the Universidad Nacional de Litoral. Participants also documented next steps for analyzing the Missouri River dataset and will continue efforts to make the technique more operational through discussions during monthly conference calls, testing additional datasets, and publishing results.

Request for Datasets from Water Science Centers

Summit participants are requesting information from Water Science Centers on available or planned datasets that could be used to test assumptions and answer key questions in the use of down-looking ADCPs to estimate suspended sediment. OSW *may* be able to fund additional analyses or data collection as part of existing monitoring programs to support data needs for this effort.

The required dataset would include (see figure 1):

- ***Point, isokinetic sediment samples*** (such as those collected with a P-6, P-61, P-63, or P-72 sediment sampler) - Sample locations determined using EDI techniques, 5 samples per vertical (e.g., 0.2, 0.4, 0.6, 0.8, and 0.9 depths); minimum 3 verticals (ideally 5) that cover a range of sediment and acoustic backscatter conditions for the river cross section. Each point sample must be individually analyzed for suspended-sediment concentration and sand/fine break. Some level of full particle size information is needed; ideally for each bottle if sufficient sediment is present for the analysis. At a minimum, full particle size information is needed on a composite sample at each vertical. Replicate samples (A and B sets) are recommended. Samples collected during high sediment and flow events are of particular interest. See contact information below to discuss the best plan for your site.
- ***Concurrent ADCP stationary profiles at each sampling vertical*** - Stationary profiles collected using 600kHz and/or 1200kHz Teledyne RD Instruments Rio Grande ADCPs are preferred, but data from other ADCPs are welcome as long as cell size is kept constant for a given ADCP. ADCP positioning relative to GPS is desirable. External sources of instrument noise (particularly external echosounders/"fish finders") should be turned off during the measurement, and exposure to nearby boats should be limited.
- ***Moving-boat ADCP measurements*** - Moving-boat streamflow measurements using the same ADCPs used for the concurrent ADCP stationary profiles, made at the same cross section and reasonably close to the time of sediment samples collection. Ideally, moving-boat ADCP measurements should be made before *and* after the concurrent point sediment samples and ADCP stationary profiles.
- ***Depth-integrated, isokinetic EDI samples*** - For validating calibrations developed using point samples; can be collected concurrently or sequentially with other samples and ADCP measurements.
- ***Field notes*** - Notes documenting locations of verticals, times and time zones of each sample and ADCP measurement, field conditions, and other observations.

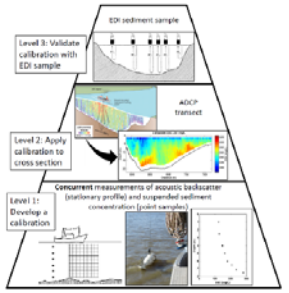

Figure 1. Data requirements for developing calibrations to estimate suspended sediment using down-looking ADCPs.

Please contact Molly Wood (mswood@usgs.gov) or Mark Landers (landers@usgs.gov) if you have existing monitoring programs with sediment and ADCP datasets that meet or can be adapted to meet these requirements with additional support from OSW. OSW can provide additional information to interested Water Science Centers on ADCP configuration and sediment sample analyses to guide future data collection efforts.

/signed/

Molly Wood
For the Office of Surface Water

References

Boldt, J.A., 2015, From mobile ADCP to high-resolution SSC: a cross-section calibration tool: Proceedings of the 3rd Joint Federal Interagency Conference on Sedimentation and Hydrologic Modeling, April 19-23, 2015, Reno, Nevada, pp. 1258-1260.

Boldt, J.A., Czuba, J.A., Straub, T.D., Curran, C.A., Szupiany, R.N., and Oberg, K.A., 2012, Estimation of suspended-sediment concentration from down-looking acoustic Doppler current profilers using an acoustic backscatter calibration procedure and MATLAB-based tool: Proceedings of the American Society of Civil Engineers Hydraulic Measurement and

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Outstanding Questions

- Noise – what influences, how sensitive are results?
- Will Rouse curve evaluations be improved with samples closer to bed?
- Can we make more assumptions with fines dominated rivers?
- What needs to be done to get calibrations to hold over time and space?

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Next Steps

- Finish Missouri River analysis
- Investigate effect of noise/interference
- Investigate lab result differences in more detail
- Continued workgroup meetings
- Collect additional datasets over range of conditions; possibly repeat datasets at same site(s)
- Publication(s)
- Continue to push for sediment acoustic improvements with vendors

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Questions?

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Submitted Candidate Sites

- **Sacramento River**
- Missouri River @ Hermann, @Kansas City, @ St. Joseph, @ Nebraska City
- Mississippi River @ Grafton, @ St. Louis, @ Belle Chasse
- Illinois River @ Florence
- Columbia River @ Beaver Army Terminal
- Green River @ Mineral Bottom
- Colorado River @ Potash

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