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Sediment Acoustics

Real-Time Continuous Suspended Sediment Data in the Lower Columbia River

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U.S. Geological Survey

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Sediment Acoustics

Imagine a real-time acoustic sediment network…..

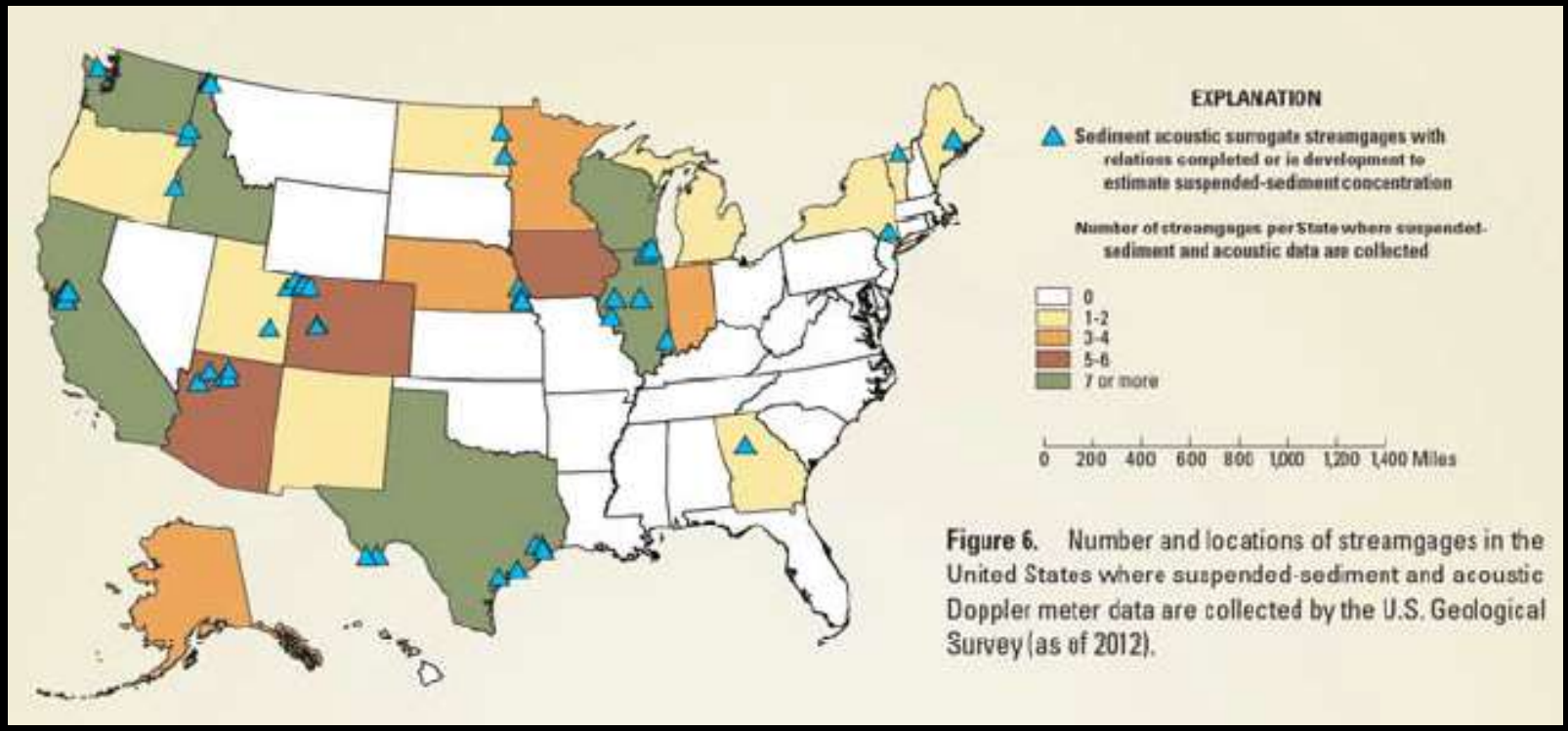

Figure 6. Number and locations of streamgages in the United States where suspended-sediment and acoustic Doppler meter data are collected by the U.S. Geological Survey (as of 2012).

Wood, M.S., 2014, Estimating suspended sediment in rivers using acoustic Doppler meters: U.S. Geological Survey Fact Sheet 2014-3038, 4 p.

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Why Real-Time SSC Data is Needed

- Determine sediment loads
- Determine timing of sediment transport
- Define seasonal and event transport mechanisms

Sediment Effects

- Navigation
- Habitat restoration
- Beach restoration
- Reservoir/bay infilling
- Water Quality

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Sediment Acoustics

- ADVM's Deployed at Many Sites to Compute Discharge
- One Instrument, Lots of Uses:
  - Discharge
  - SSC
  - Sediment Flux
  - Velocity
  - Future Applications…
- Limited Instrument Fouling
- Limited Calibration Drift
- Large Measurement/Sample Volume
- Reduced Costs

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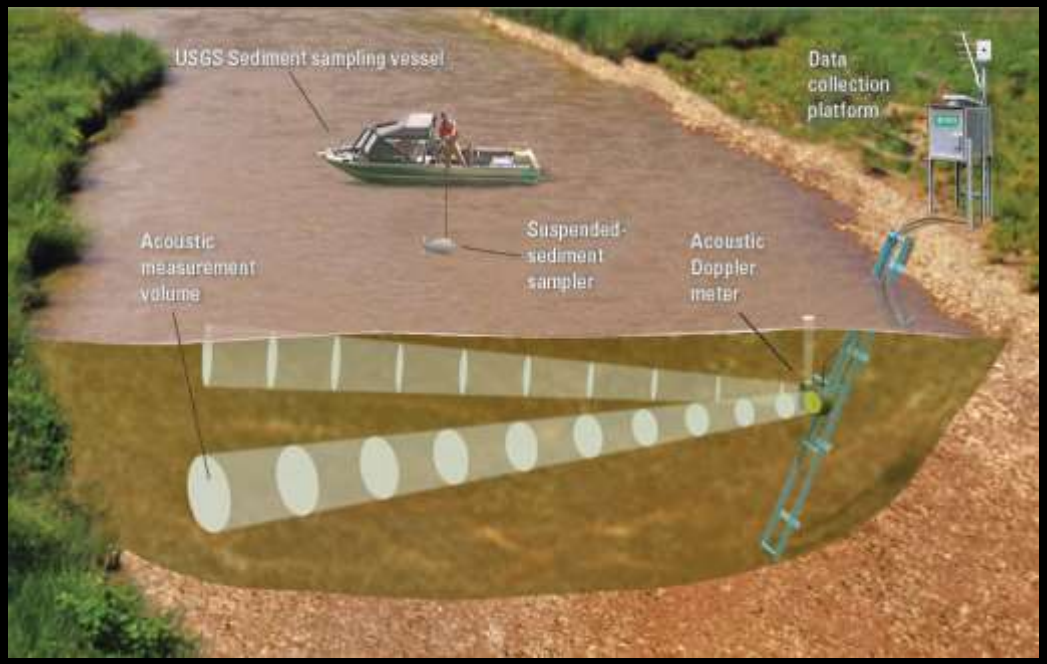
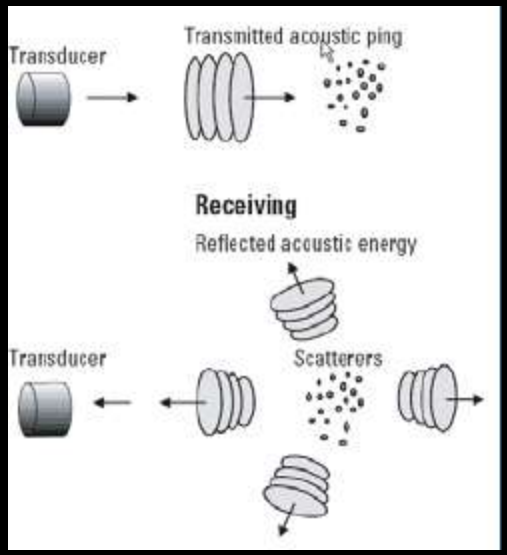
Sediment Acoustics

- Transmit acoustic energy of known f (frequency)
- Measure shift in f from return signal to compute velocity
- Acoustic backscatter intensity is measured for QA purposes.





Images from Wood, M.S., Modified from Sontek

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Acoustic Site Instrumentation

- Multi-cell configuration needed to compute SAC (sediment attenuation coefficient).
- Need LOTS of data transmitted to compute real-time
  - 20 SS values
  - 20 velocity values
  - 15 other

  } Every Measurement Interval
- SDI-12 not sufficient
- Serial data
- Two way data communication.
- 12 volt DC to DC converters used to keep ADVM power constant.

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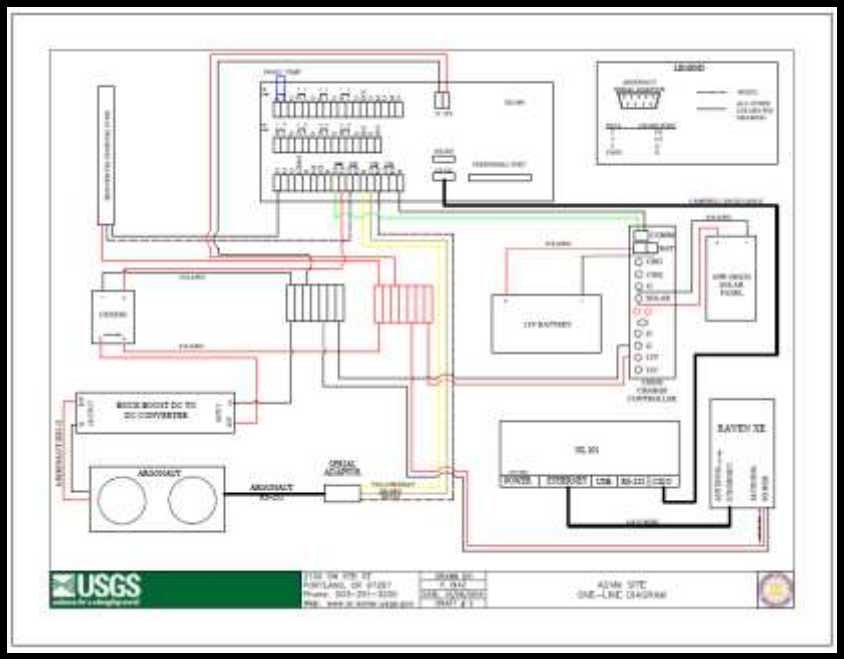
Acoustic Site Instrumentation



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Surrogate Acoustics Parameter Processing

- Processing is Done Using SAID (Surrogate Analysis and Index Developer Tool)
  - Acoustic Parameter Processing
    - Raw Measured Acoustic Backscatter needs to be corrected for the effects of:
      - Beam Spreading
      - Water Absorption
    - Normalized Acoustic Parameters
      - SCB (sediment corrected backscatter)
      - SAC (sediment attenuation coefficient)
  - Data Transformations
  - Regression Models

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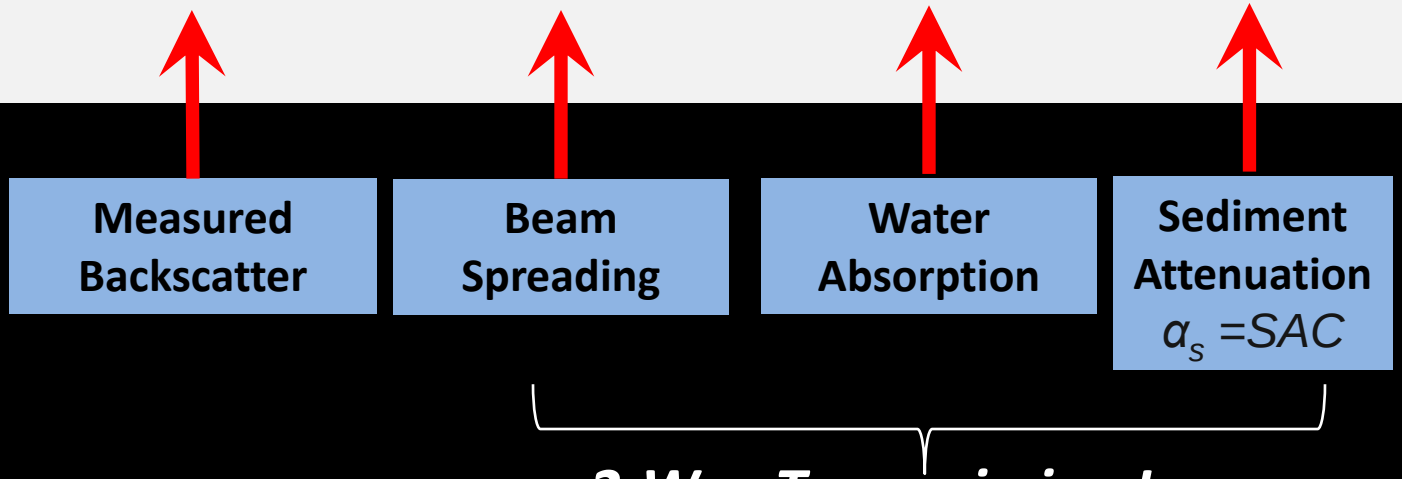
Surrogate Acoustic Parameter Processing

$$WCB = MB + 20log_{10}(\psi r) + 2r(\alpha_w)$$

$$SCB = WCB + 2r\alpha_s$$

$$SCB = MB + 20log_{10}(\psi r) + 2r(\alpha_w) + 2r\alpha_s$$



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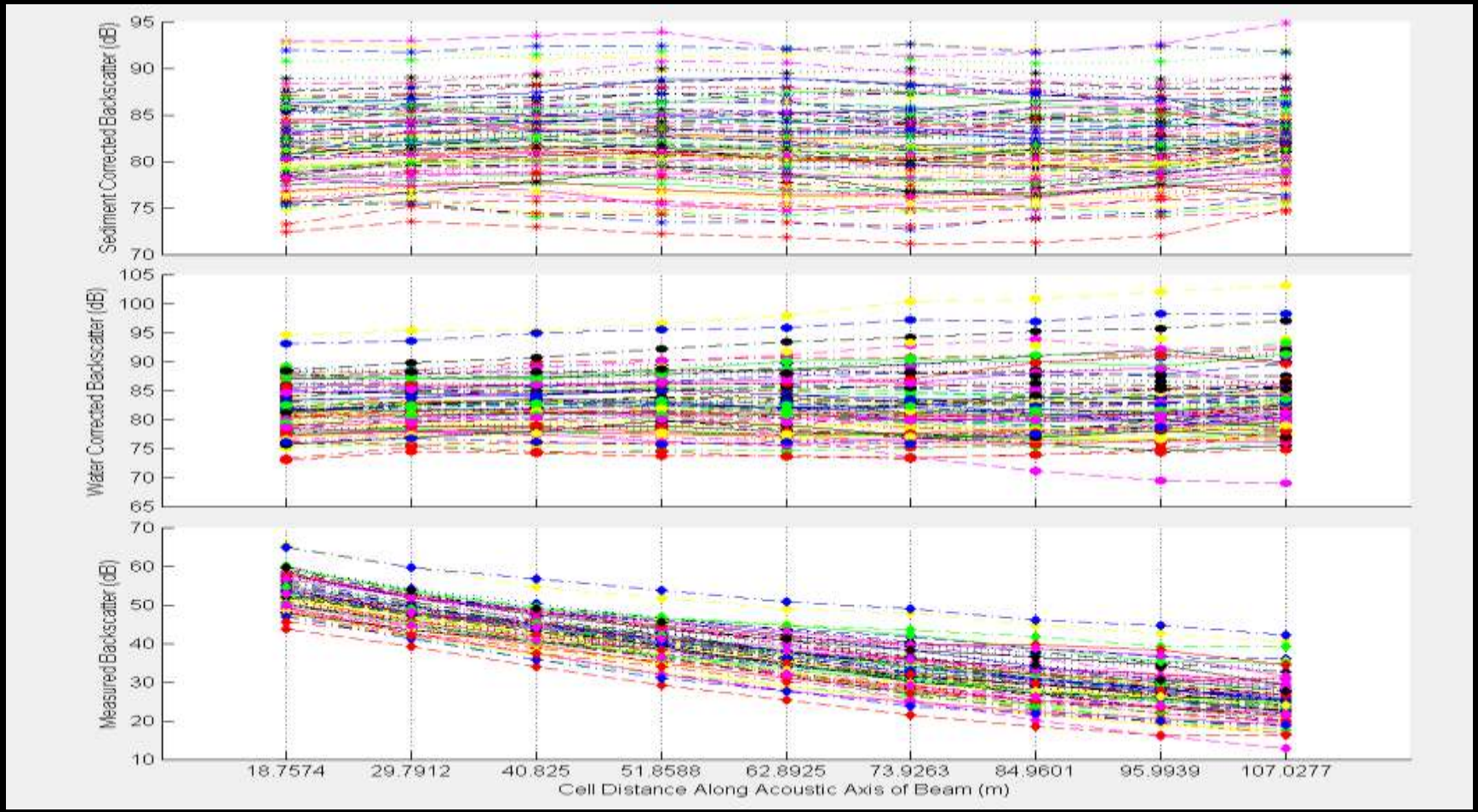
Surrogate Acoustic Parameter Processing



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Signal Strength Cell Data output from SAID model
Provisional, subject to revision.

Lower Columbia Acoustic Sites

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14144700
Columbia at Vancouver, WA

- Existing NWS tide gage (I-5 bridge)
- NSIP funded in 2015 for discharge
- USACE funding for SSC data.
- Key point for Lower Columbia River (LCR) SSC budget
- New station installed on a USCG dolphin January 2016.
- Data collection commenced in winter 2016.

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14211720
Willamette @ Portland, OR

- Site being relocated in spring/summer 2016
- NSIP funded for discharge
- Key point for LCR SSC budget
- Ongoing sediment sampling funded by NAWQA.

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14246900
Columbia River @ Beaver Army Terminal nr Quincy, OR

- Used SAID Model
- Calibration Data - 55 samples collected from WY 2009-2015
- Used Multi-linear Regression to predict SSC
- Predictor Variables Used:
  - SCB (Sediment Corrected Backscatter)
  - Discharge
  - Gage Height
- Model Results .89 R^2

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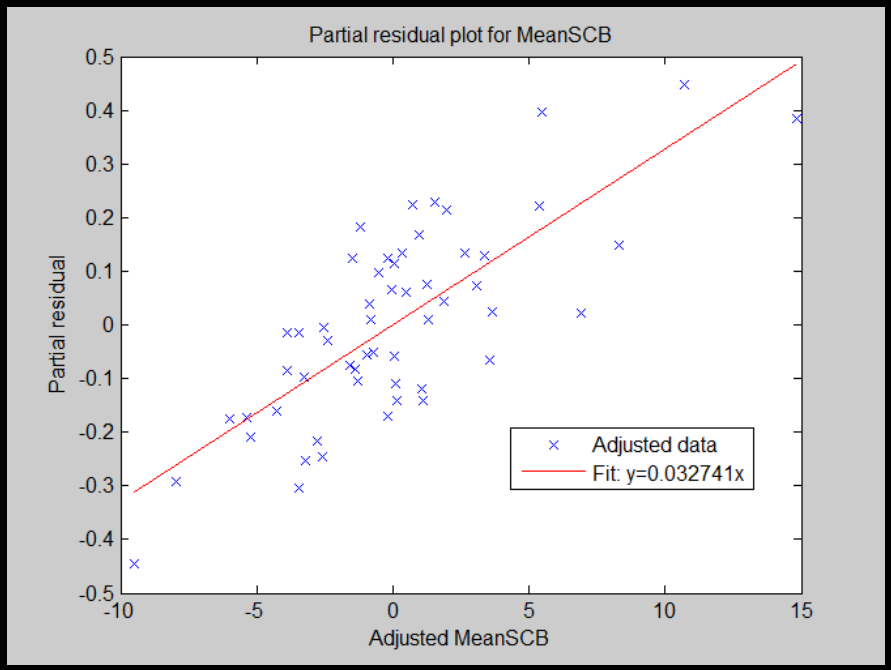
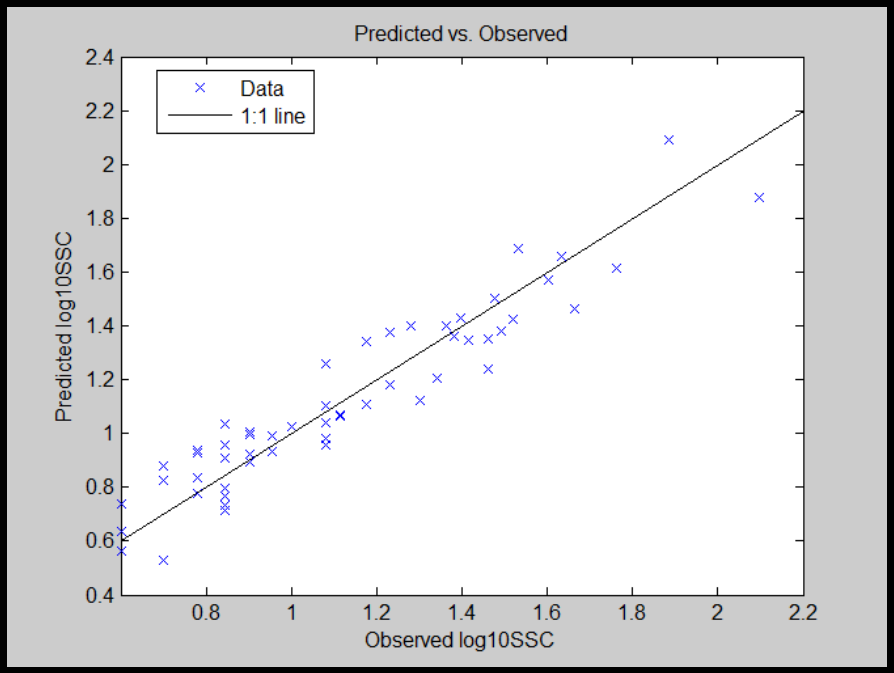
14246900
Columbia BAT Model Results





Statistics output from SAID model
Provisional, subject to revision.

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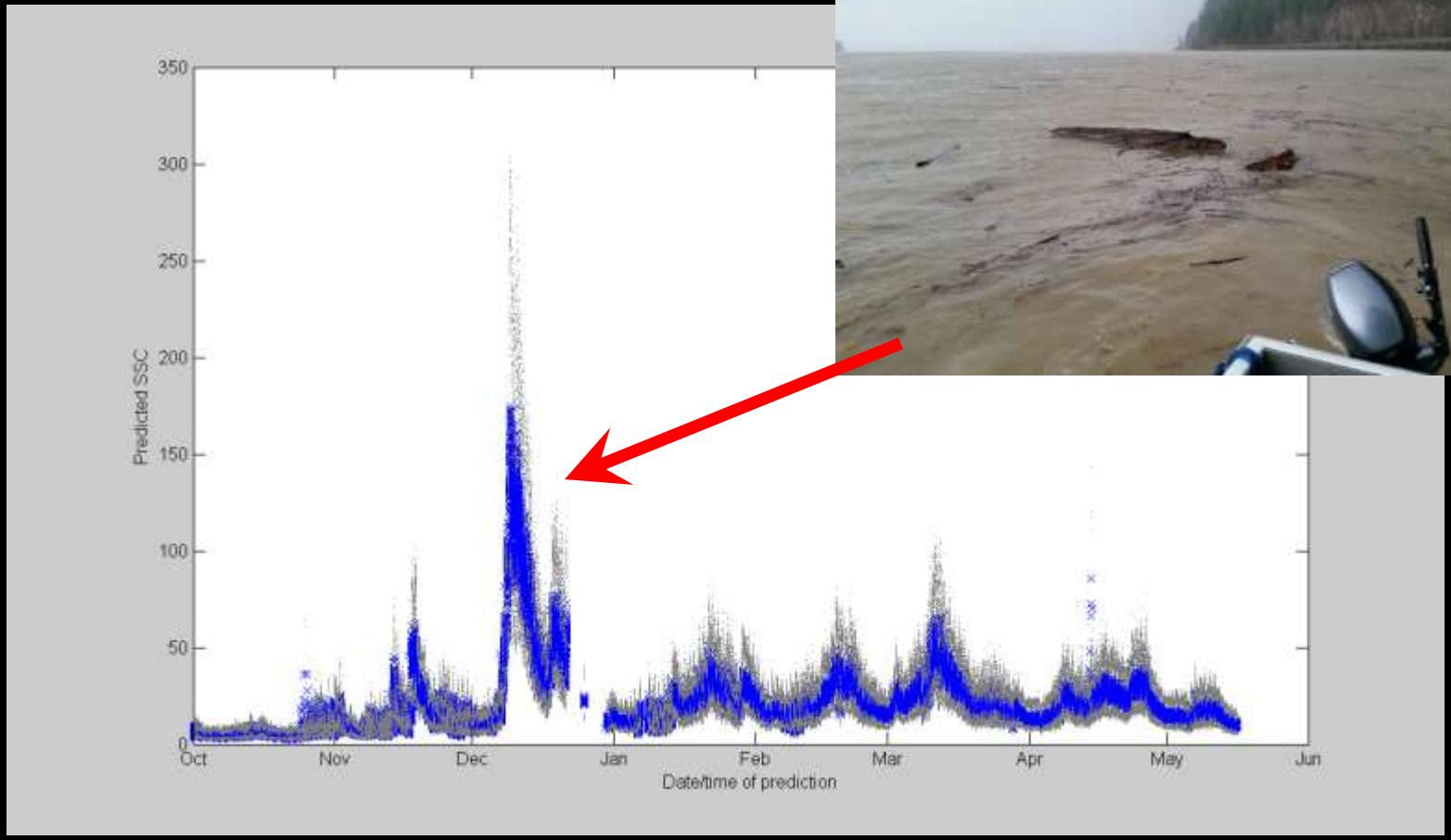
Time Series Data (WY 2016)



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Time Series SSC output from SAID model
Provisional, subject to revision.

Next Steps

- Install mechanism to compute real-time SCB from multi-cell backscatter data (Aquarius).
- Real-Time data on NWIS WEB
- Continue collecting SSC verification/calibration samples
- Develop Sediment Acoustic Model for Columbia Vancouver.
- Add additional sites:
  - LCR sites
  - Existing sites
  - Other

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Acknowledgements

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