Assessment and Guidance for using Laser In-Situ Scattering and Transmissometry–Stream-Lined 2 (LISST-SL2)

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Extended Abstract

Quantifying suspended sediment in streams is an important step to estimate the threat to riverine environments posed by fluvial sediment and sorbed material. Suspended sediments not only carry chemicals and pollutants, but also interact with the river bed to affect the geomorphology of streams (e.g., Ahammad et al., 2021; Castro, 1995; Rehg et al., 2005). Measurement of suspended-sediment concentration and particle-size distribution is critical for many engineering, ecological, and geomorphological issues, but obtaining an accurate measurement of sediment quantity and size distribution in a river is challenging. Apart from traditional in-situ sampling and subsequent lab analysis, sediment-surrogate technologies have been developed that operate on turbidity, laser diffraction, pressure difference, and acoustic backscatter principles to measure certain characteristics of river sediment.

The Laser In-Situ Scattering and Transmissometry–Stream-Lined 2 (LISST-SL2) is a second-generation isokinetic river sediment monitoring device that uses laser diffraction to measure suspended-sediment concentration and particle size between 1 and 500 microns in 36 log-spaced bins at a point in a river every second. The LISST-SL2 is deployed from a B-reel (Figure 1), which both suspends the instrument and serves as a communications cable from the instrument to a topside box, which further connects to a computer for instrument control, data collection, and data visualization. This second-generation device has been redesigned to address limitations, noted by the Federal Interagency Sedimentation Project, and described by Czuba et al. (2015). However, further testing of this device is needed to determine the extent of the modifications on determining suspended-sediment concentration (SSC) and particle-size distribution (PSD).

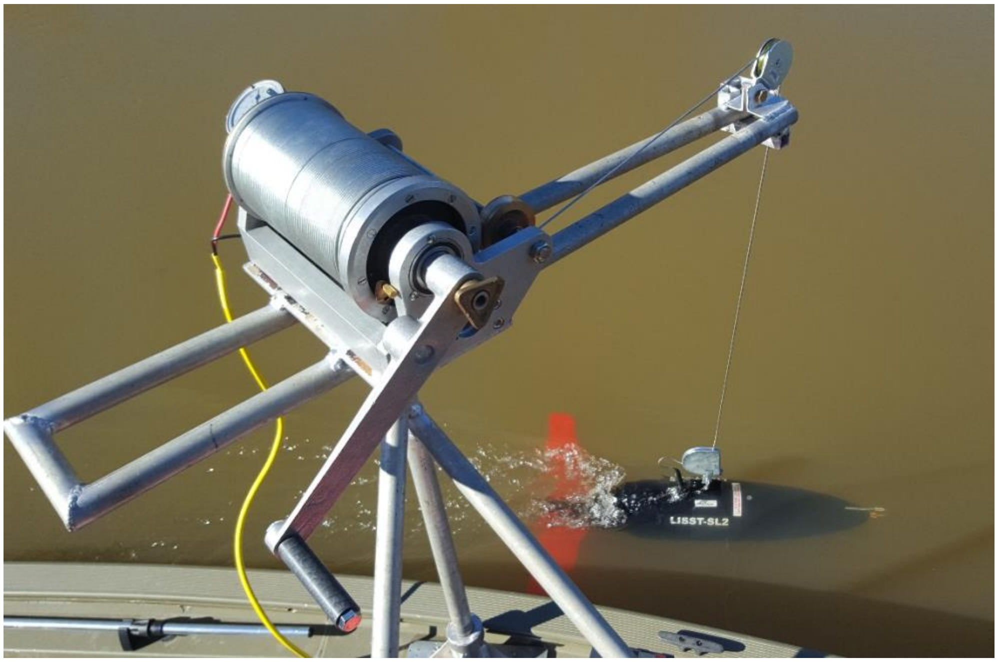

Figure 1. Deployment of the LISST-SL2 (87 cm in length) from a B-reel. The LISST-SL2 is deployed just below the water surface in the New River near Whitethorne, Virginia.

This study evaluates the LISST-SL2 with concurrent physical measurements of suspended-sediment concentration (SSC) and particle-size distribution (PSD) with P-6 and D-74 samplers as well as velocity measurements by an acoustic Doppler current profiler (ADCP). We collected 136 LISST-SL2 samples along with 61 physical samples for SSC measurement, of which 24 physical samples included PSD measurement during 2018–20 from 11 sites in Washington state and Virginia (Figure 2). These 136 samples included both point- and depth-integrated data, where depth-integrated samples were collected by lowering the LISST-SL2 gradually from the water surface to the river bottom and then raising the instrument from the river bottom back to the water surface. An effective density is required to convert the measured volumetric SSC by the LISST-SL2 into a reported mass SSC, and by default the LISST-SL2 assumes a value of 2.65 g/mL. From our data set, we computed effective densities (mass SSC/volumetric SSC) that ranged from 0.5 to 5.4 g/mL, with a best-fit value of 2.05 g/mL (Ahammad et al., 2023). Additionally, the LISST-SL2 was not able to measure the finest sediment sizes in suspension, which affects the resulting PSD. Therefore, we proposed some adjustments of the LISST-SL2 data with a supporting physical sample to account for these effective density and PSD issues. The physical measurement is used to determine a site-specific and sampling-date-specific effective density for calculating SSC, and rescale the PSD from the LISST-SL2 (Ahammad et al., 2023). When doing so, we were able to reduce the root-mean square relative error (RMSRE) from 117% to 18% for SSC, and from 78% to 26% for PSD (Ahammad et al., 2023). LISST-SL2 velocities were generally higher than ADCP velocities with a 21% RMSRE. Our results and guidance will allow for more accurate sampling by the LISST-SL2, which has potential for studying spatial and temporal variation of suspended-sediment characteristics in rivers.

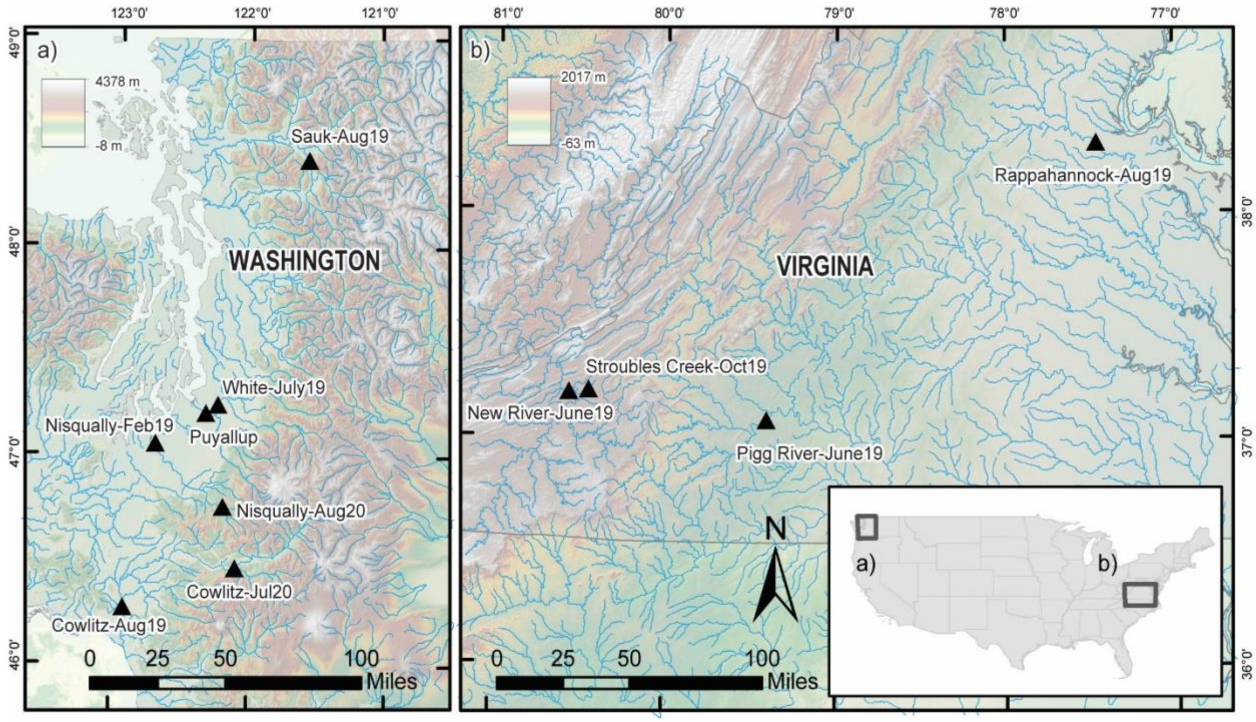

Figure 2. Map of the stations (shown with triangles) where samples were collected in (a) Washington and (b) Virginia. (Puyallup was sampled in Dec18, Aug19, Oct19, and Aug20)

References

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