Preliminary Analysis of a Horizontal Multifrequency Hydroacoustic Device Designed for Surrogate Measurements of Suspended Sediment Concentration: the Horizontal Acoustic Sediment Current Profiler

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Abstract

Single frequency active hydroacoustic measurements have been correlated with suspended sediment concentration. In river systems that include widely varying suspended sediment particle sizes, a multi-frequency hydroacoustic approach has increased predictive capabilities. However, the multi-frequency approach requires installation and operation of multiple sensors in a river channel and relies on technology previously designed for measuring water velocity. The Horizontal Acoustic Sediment Current Profiler (HASCP) is a single unit multi-frequency (500, 1,500, and 2,000 mHz) hydroacoustic sensor that was designed to target suspended sediment concentrations. The HASCP was briefly deployed in the Rio Grande at Albuquerque, NM, USGS gage in 2021 and is currently (2022) in operation at the Colorado River near Cameo, CO gage. Results of preliminary testing of the HASCP are presented in this paper.

Introduction

Measurement of suspended-sediment concentration (SSC) requires collection of discrete samples, which can be difficult, hazardous, and/or costly to collect. Several continuous sensors have been identified as successful surrogates for estimating SSC (Rasmussen et al., 2009; Landers et al., 2014; Brown et al., 2015). Hydroacoustic backscatter has become one of the most robust surrogates to estimate SSC (Landers et al., 2016) as well as estimating particle size fractions (Topping and Wright, 2016). In rivers with complex sediment transport, particularly widely varying particle size ranging from coarse sands to fine clays, measurements using a single acoustic frequency can bias estimations of SSC. To circumvent this challenge, a multifrequency acoustic approach can be applied (Topping and Wright, 2015). Acoustic Doppler velocity meters (ADVMs) have been used to measure stream velocity but also record acoustic backscatter as quality assurance data. A prototype instrument, the Horizontal Acoustic Sediment Current Profiler (HASCP) manufactured by Rowe Technology in 2019, is a multi-frequency ADVM designed expressly as an instrument optimized for estimating SSC, in rivers with widely varying particle sizes. The USGS acquired a prototype HASCP and tested the instrument in the laboratory, Rio Grande, and Colorado River. This extended abstract informs the SSC surrogate community on a new multi-frequency instrument packaged in one device.

HASCP Instrument Details

The HASCP operates with three frequencies (nominally: 600 kHz, 1200 kHz, and 2400 kHz) in one unit (Figure 1). Two 1200 kHz (rectangular transducer), one 2400 kHz (piston transducer), and one 600 kHz (piston transducer) beam(s) are horizontally oriented, while one 1200 kHz beam is located at the top of the instrument pointed towards the water surface and can be used for measuring the depth of the instrument from the water surface. The two 1200 kHz beams are used for both backscatter and velocity data, whereas the 600 kHz and 2400 kHz beams are used only for backscatter measurements. The transducers are contained in one acetal material housing and require external power but can log data internally (up to 32 gigabytes). Power supply and communication protocol for the instrument is through Recommended Standard (RS) 485 or RS 232 from a cable located at the top of the instrument.

Figure 1. Temporary deployment of the Horizontal Acoustic Sediment and Current Profiler (HASCP) at the Rio Grande at Central, Albuquerque, NM (USGS ID 08330000) in July 2021. Tyson Hatch (U.S. Geological Survey) is shown here with the HASCP which was mounted to a solid aluminum pole and secured to existing infrastructure for 4 hours during operational testing. Maximum depth in the channel during deployment was approximately 3 feet.

HASCP Deployments

The HASCP was first evaluated in the office setting for connectivity, hardware inspection, manual review, and basic software navigation. Feedback was documented for the manufacturer, and the instrument was prepared for deployment in a river. The HASCP was deployed in the Rio Grande at Central Bridge in Albuquerque, NM for approximately 4 hours in June 2021. The focus of this review was on general operation in a mock deployment setting. While the instrument was secured in the Rio Grande, the software was tested for instrument durability, deployment options, file downloads, data file structure, and general data review.

As part of the USGS Next Generation Water Observing System (NGWOS) Upper Colorado project, the HASCP was installed in the Colorado River at Cameo, CO (the Cameo gage) in October 2021 to evaluate long term deployment and potentially build a regression equation to estimate SSC. The instrument was removed from the Colorado River in December to avoid damage from ice. The HASCP had collected data for half of the deployment, but stopped for an unknown reason. Operation of the instrument was documented for feedback to the manufacturer.

In April 2022, the HASCP was installed upstream of the Cameo gage at a location allowing for more depth to collect data at lower flows. An Argonaut SL1500 was also installed next to the HASCP. The instrument was set to profile a similar cross section as the HASCP and collected data with a delay to avoid cross-talk between instruments with similar frequencies. The instrumentation was removed in November 2022 ahead of potential ice in the river.

Preliminary Findings and Discussion

Evaluation of the HASCP in the office setting showed that the manual and software needed improvements. The connection between cable and HASCP body had a loose fitting when fully tightened which the manufacturer verified was watertight despite our concern. This was verified to be accurate in later field deployments. The manual included basic information, however it required some improvements for clarity; suggestions were provided to the manufacturer. The software was the component which needed most improvements. The biggest software limitations were lack of deployment verification notice (could never tell if the instrument was actually collecting data), as well as file management (downloading data was cumbersome).

The brief evaluation of the HASCP in the Rio Grande showed the collected data were in a range of what was to be expected, and the instrument functioned without issue. Later, a lengthy deployment in the Colorado River showed deployment challenges. Some challenges were due to site specific difficulties (shallow channel, solar-battery regulator failure), while others were due to the software (missing data when the instrument was not deployed despite field technician's careful analysis during site visits). Future work will include telemetered data to verify deployments are successful and data are collected, software improvement feedback to the manufacturer, velocity comparison between HASCP and an Argonaut SL-1500, and development of an SSC surrogate model.

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