ISSDOTv2 Methodology, Uncertainty, and Applications for Measuring Bed-Load Transport

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Introduction

Bed-load transport is an important physical process impacting river management. Bed load impacts riverine geomorphology, dredging, navigation, flood control, and habitat suitability. Even with the recognized importance of bed-load transport, limited measurements are available on larger riverine systems due to the expense and difficulty in obtaining accurate measurements. The Integrated, Section Surface Difference Over Time, version 2 (ISSDOTv2) method utilizes sequential multi-beam bathymetric measurements to determine both the total bed load and the lateral variability in bed load across a river section (Abraham et al 2011; McAlpin et al 2022). The method includes estimates of uncertainty to allow river managers to consider the accuracy of the measurements in the decision-making process. The ISSDOTv2 method and code have been validated using flume measurements at the USDA National Sedimentation Laboratory in Oxford, MS. These flume results provided validation data during the development of the uncertainty propagation process to ensure reasonable uncertainty limits were computed. The ISSDOTv2 method has been utilized by the U.S. Army Corps of Engineers on a number of river systems for various purposes.

Methods

The ISSDOTv2 method is implemented in a MATLAB numerical code. Some modifications to the original method (Abraham et al. 2011) were required to obtain accurate results with a consistent numerical scheme in a timely and efficient manner. These modifications primarily consisted of adjustments required to apply the ISSDOTv2 equation, which was developed to compute the transport of a single wave, to multi-beam datasets with varying wave sizes laterally and various wave lengths/heights longitudinally. Additional smaller modifications were also incorporated into the method and are detailed in McAlpin et al. 2022. The numerical scheme was validated with flume measurements which indicated increasing accuracy for higher transport conditions (transport>30 kg/h/m). The flume comparisons indicate an expected accuracy of approximately ±10% for transport rates greater than 30 kg/h/m with reduced accuracy at lower transport rates (transport<10 kg/h/m) (McAlpin et al. 2022).

The uncertainty in the ISSDOTv2 results is obtained by identifying and propagating the individual sources of uncertainty through the computational process. Sources of uncertainty include the time difference between surveys, wave identification, bathymetry measurements, the regression accuracy required to include unresolved scour/deposition areas between discrete multi-beam measurements (Shelley et al. 2013), particle density, sediment porosity, and sand wave shape factor. The importance of each individual component of uncertainty varies in magnitude and also varies across locations and applications.

Results

The ISSDOTv2 method has been applied across a range of river sizes with the greatest data collection focus on the Missouri and Mississippi Rivers as shown in Figure 1. The measurements are typically collected in a river crossing, and thalweg measurement locations are avoided. The rating curve for the Mississippi River measurements is shown in Figure 2. The rating curve is consistent across a wide range of locations and flow rates, and it indicates that the primary mechanism impacting the bed load is the discharge.

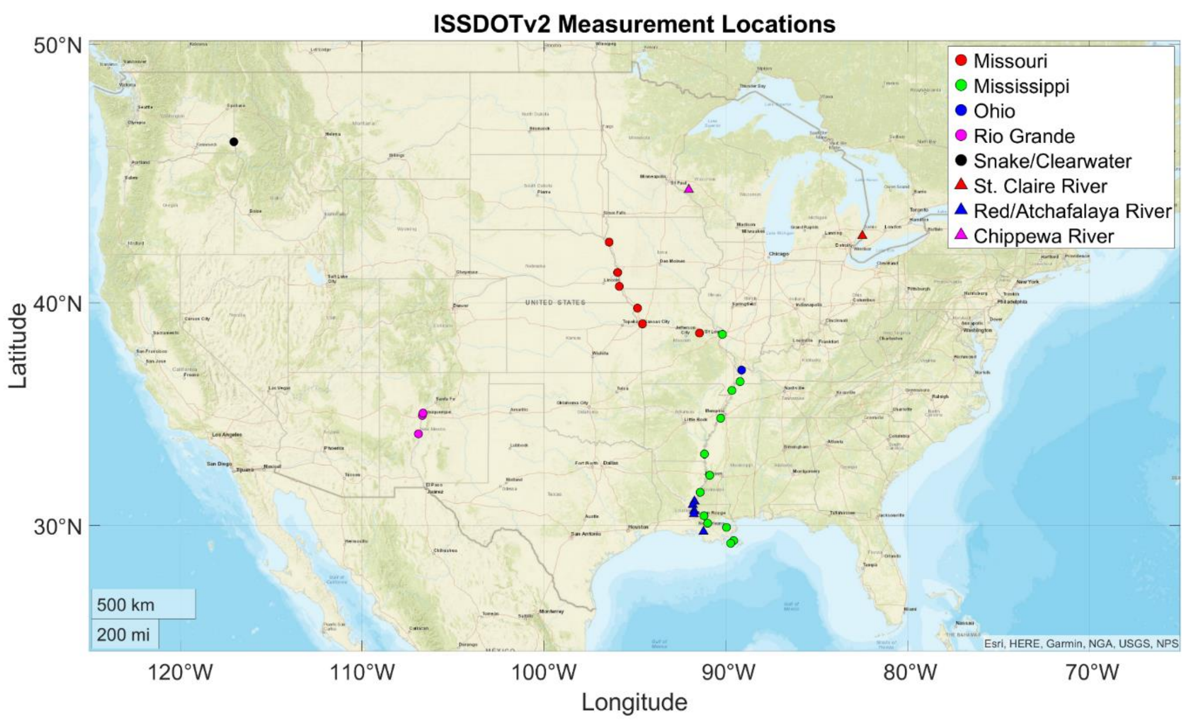

Figure 1. ISSDOTv2 bed-load measurement locations.

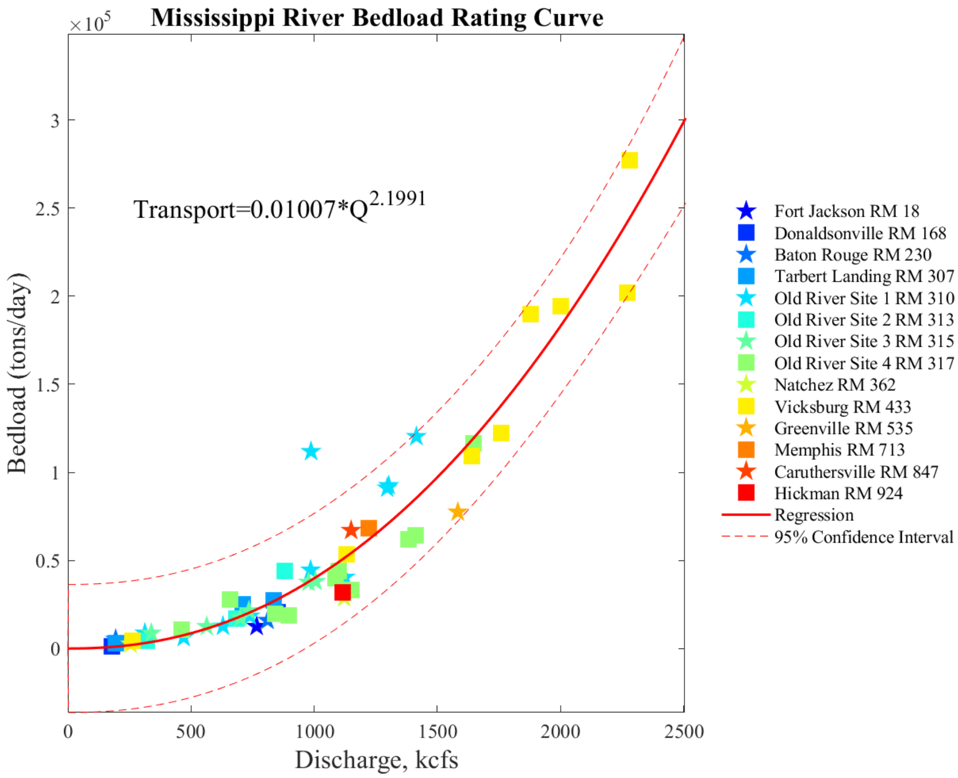

Figure 2. Mississippi River bed-load rating curve.

Conclusions

The ISSDOTv2 numerical code measures bed-load transport rates on large, sand bed rivers. The results are consistent and repeatable and include uncertainty bounds. The uncertainty estimates can be utilized to better describe the discharge versus bed-load relationship. These measurements are useful for applications including the development of sediment budgets, verification of sediment transport functions, numerical model validation, and determination of habitat suitability.

References

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