A Global Bedload and River Slope Dataset for Modeling and Analysis of Large Rivers

Md Tazmul Islam[1], Sagy Cohen[1], James Syvitski[2]

[1] The University Of Alabama, Department of Geography

[2]University of Colorado-Boulder, CSDMS, INSTAAR

Introduction

- Quantification of sediment flux has long been an area of interest for scientist and engineers.
- Sediment transport data are essential for monitoring rivers e.g. during dam construction, to maintain marine ecology, for nutrient measurement, for food security and other similar works.
- Bedload flux measurements are relatively expensive and time-consuming, and includes significant spatial and temporal uncertainties.
- We present a new bedload and river slope database to support our global scale riverine modeling efforts.
- Analysis of bedload and slope values is provided.
- River slope values are used here to validate our new Global River Slope (GloRS) layer .

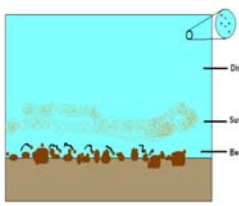


Fig 1: Different sediment movement in rivers (Ritter, 2006)

Bedload and Slope dataset

- Bedload data from 86 sites on large rivers (basin area >1000 square km), and 34 slope measurements has been collected so far.
- The compiled dataset presented here (Fig: 2) is a unique product because bedload and river slope observations are typically reported for small rivers and streams.
- This compiled bedload dataset for large rivers includes thirteen sites for Alaska, one for Arizona, four for Colorado, twenty five for California, one for Nevada, two for New Mexico, eighteen for Idaho, two for Iowa, five for Wyoming, four for Wisconsin, four for Washington, one for Utah, and one for South Dakota.
- This dataset will be used to build a global bedload model using the modified Bagnold (1966) equation within the WBMsed (Cohen et al. 2013, 2014) computational framework, a global scale sediment flux modeling framework.

Hinton et al. (2016):

- This database are compiled from published sources and through author's personal communications.
- Sample description such as site name, coordinate, bedload measurement methods, discharge and transport data, grain size distribution, slope, channel, bankfull characteristics, and even stream classification descriptors where possible.
- Website: http://worldwater.byu.edu/app/index.php/sediment

Surface Dynamics Modeling Lab

Comprehensive Bedload Data Sources

Table 1. Number of Data Sets and Observations by State or Region (Hinton et al., 2016)

Location	Number of data sets	Number of observations
Outside the United States	15	505
Alaska	23	489
Arizona	1	34
California	161	4,270
Colorado	130	3,051
Idaho	51	4,240
Indiana	6	61
Iowa	1	13
Michigan	1	7
Mississippi	1	358
Nebraska	3	30
Nevada	10	251
New Mexico	3	7
North Carolina	3	15
North Dakota	2	12
Oregon	9	279
South Dakota	4	17
Utah	4	108
Washington	4	184
Wisconsin	1	4
Wyoming	51	1,143
Total	484	15,081

Williams and Rosgen (1989) & Graf (1984):

- Williams and Rosgen (1989) provide first comprehensive data for total sediment loads for 93 streams across the United States.
- Data were collected through filed measurements by many different individuals and organizations
- They reported the water slope for many sites.
- Graf (1984) reported both bedload transport and slope data. It includes information for nine Illinois Rivers. The main focus of that research was to estimate the volume of the sand-size materials into Mississippi River and its tributaries.

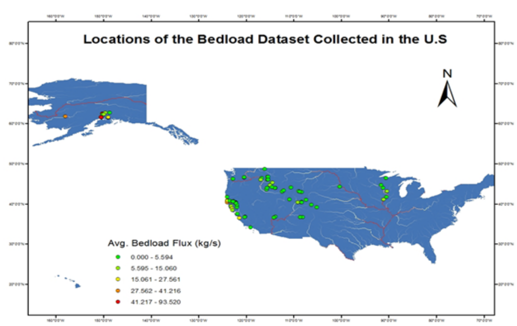


Fig 2: Locations of bedload data Collected in the U.S

Global River Slope (GloRS) layer Analysis

- Slope is calculated for a given river segment length based on the difference between its highest and the lowest elevation (derived from an underlying DEM) which ideally (absent errors) corresponds to its most upstream and downstream locations respectively.
- Calculation of global river slope procedure has been done for relatively course resolution global scale products at 15arc-sec resolution (approximately 460x460m), obtained from the USGS HydroSHEDS website (http://hydrosheds.cr.usgs.gov/index.php), and upscaled to 6 arc-minute resolution, suitable for global scale modeling.

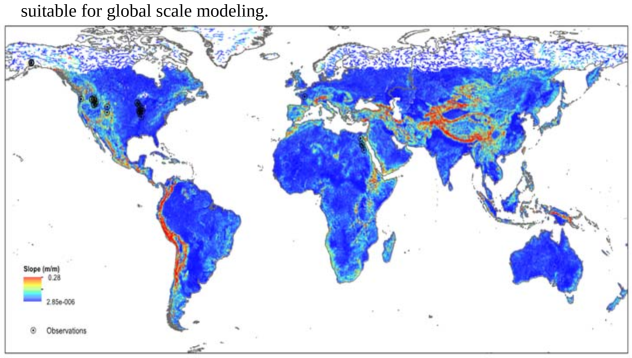


Figure 3. Global River Slope (GloRS) map at 6 arc-minute resolution and location of observed river slope data

$$\text{slope} = \frac{\text{Elevation Depression}}{\text{Segment Length}} \qquad \text{Elevation Depression} = \text{Maximum Elevation} - \text{Minimum Elevation}$$

GloRS Validation

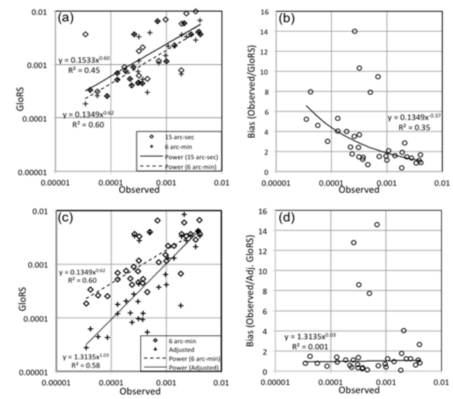


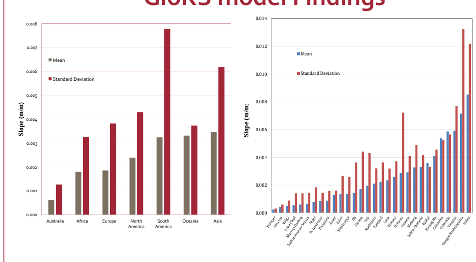
Fig 4: Relationship of GloRS with observed Slope value

- The correlation between GloRS and observed data is highest for the 6 arc-min layer. The 15 arc-sec layer yielded a lower correlation but only because of miscalculation in one data point
- An adjustment equation was developed by fitting a linear regression between the highest an lowest data points for which an adjustment value of 1 was set to the high slope point (0.0041) and an adjustment value of 0.15 was set to the lowest slope data point (0.00018). The adjustment equation applied to the 6 arc-min GloRS layer is:

$$\mathbf{S_a = S_o(216.84S_o + 0.111)}$$

- Here S_a is adjusted and S_o is original slope values

GloRS model Findings



- At continental-scale, average river slope values range by a factor of 5.7 between Australia, with lowest average, to Asia, with highest average river slope .
- Basin-scale analysis reveals a fairly heterogenetic mosaic of average river slopes. Of the world's large river basins Central Asian basins yielded the highest standard variability (Ganges-Brahmaputra).

Conclusion and Future Research

- The dataset presented here for bedload and slope provides prospective for global river analysis and modeling.
- In future, this slope layer and bedload data will be used for the development of new global bedload model using modified Bagnold equation (1966).

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