Modeling Sediment Transport in the Puyallup River Watershed

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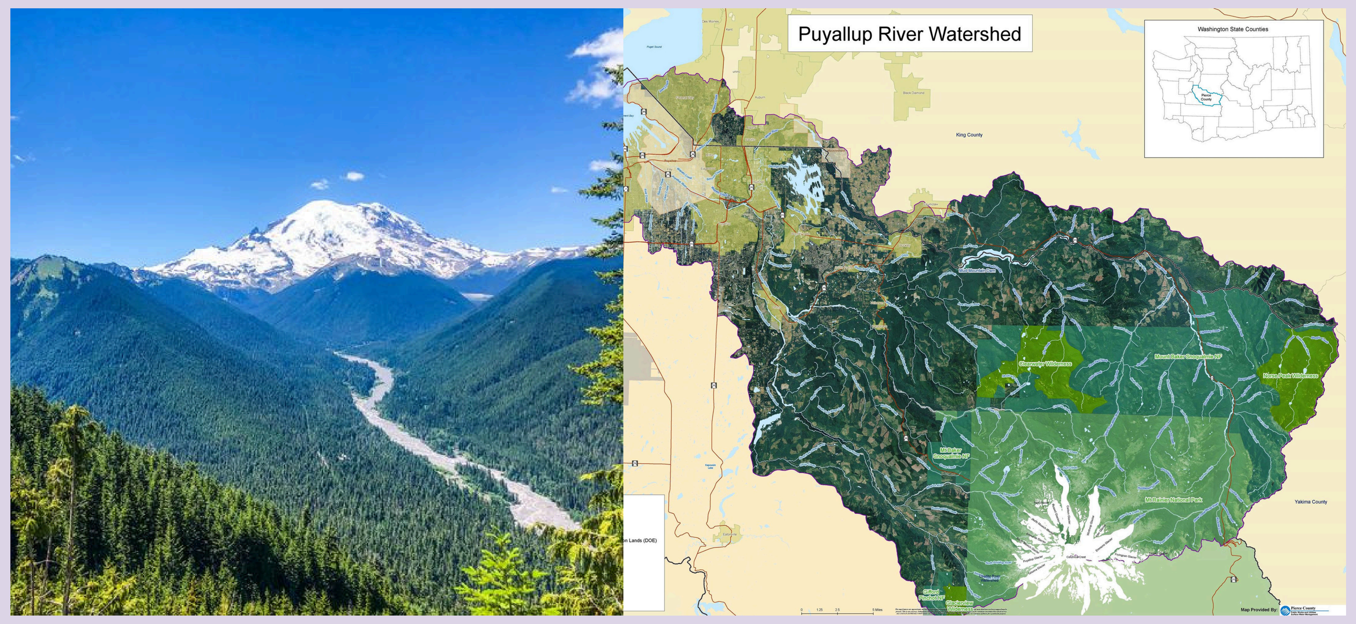
Introduction

- Glacial headwaters can deliver an abundance of alluvial sediment to a watershed, and fluxes in soil aggradation often perpetuate flood risks to populated areas downstream.
- As climate change amplifies precipitation and accelerates glacial retreat, tracking shifts in sediment derived from glaciers becomes essential.
- To understand the factors that influence the fate of glacial sediment, we developed a sediment transport model of the Puyallup River Watershed using LandLab, an open-source geomorphic modeling package written in Python.



Methods

The Network Sediment Transport feature in LandLab tracks sediment parcels through the Puyallup River Watershed as they are transported, eroded, and buried over time. Using Digital Elevation Models (DEMs) and local USGS channel measurements, we modeled the transport of coarse, mixed sized sediments, mainly derived from Emmons Glacier.

Parameters used:

- 0.1-10mm grain diameters
- Flow depth was set to 4 m (Czuba et al 2010).
- Channel width set to 85 m (Czuba et al 2010).

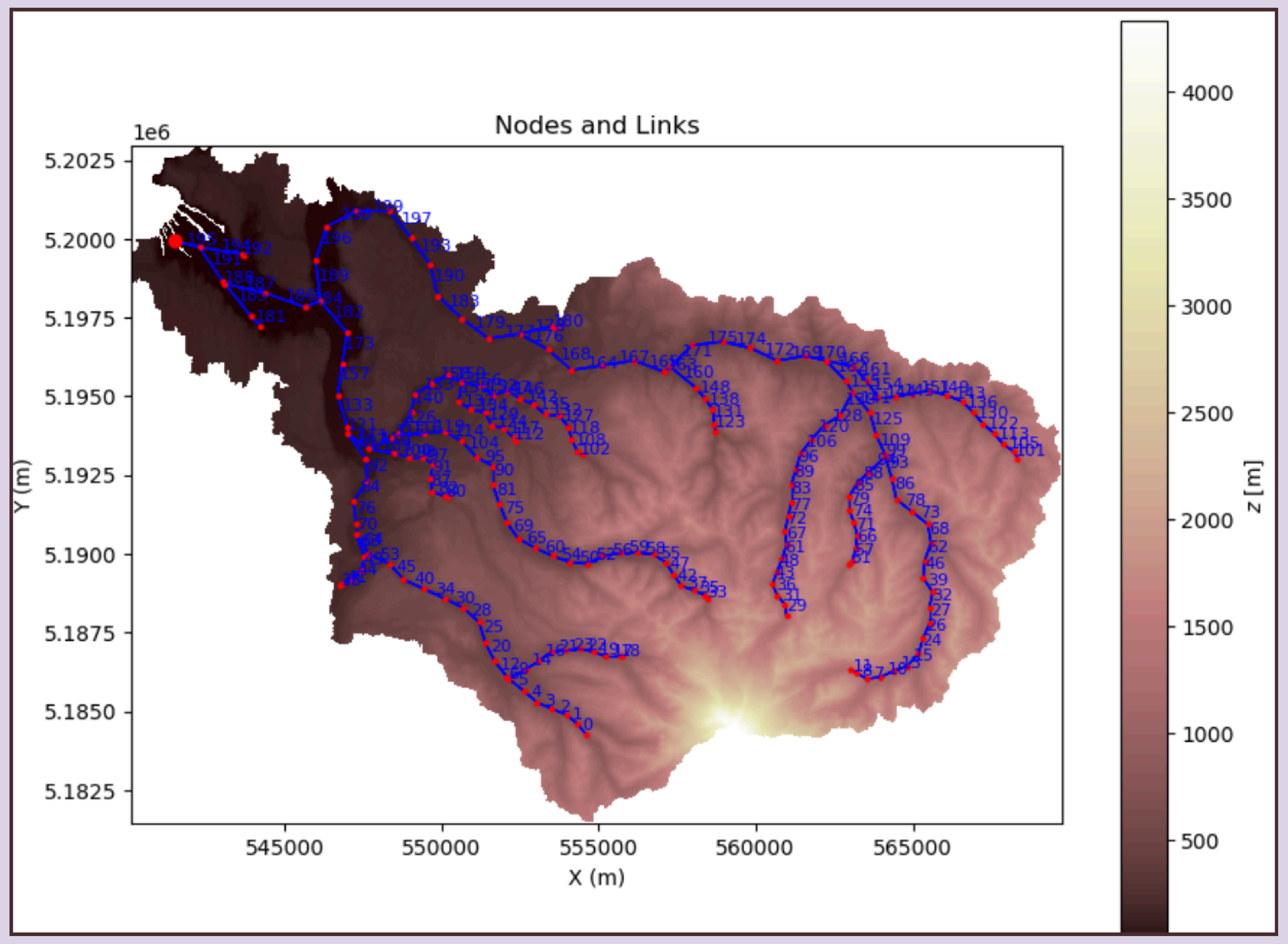


Fig 1. Map of links and nodes of Puyallup River Watershed. Network Model Grid assumes drainage flow direction based on topographic data. Red dot marks drainage outlet, Commencement Bay.

Results

Observing Impacts on Sediment Transport

- Smaller channel widths decreased the speed of transport for all grain sizes
- Higher quantity of parcels per link also slowed transport
- Parcels derived from Link 11 (Emmons Glacier) get trapped after traveling for over 5 hours, indicating that coarse sediment in the outlet may not be primarily sourced by Emmons
- Other glacial sources (Carbon Glacier) make it to the outlet within 24 hours

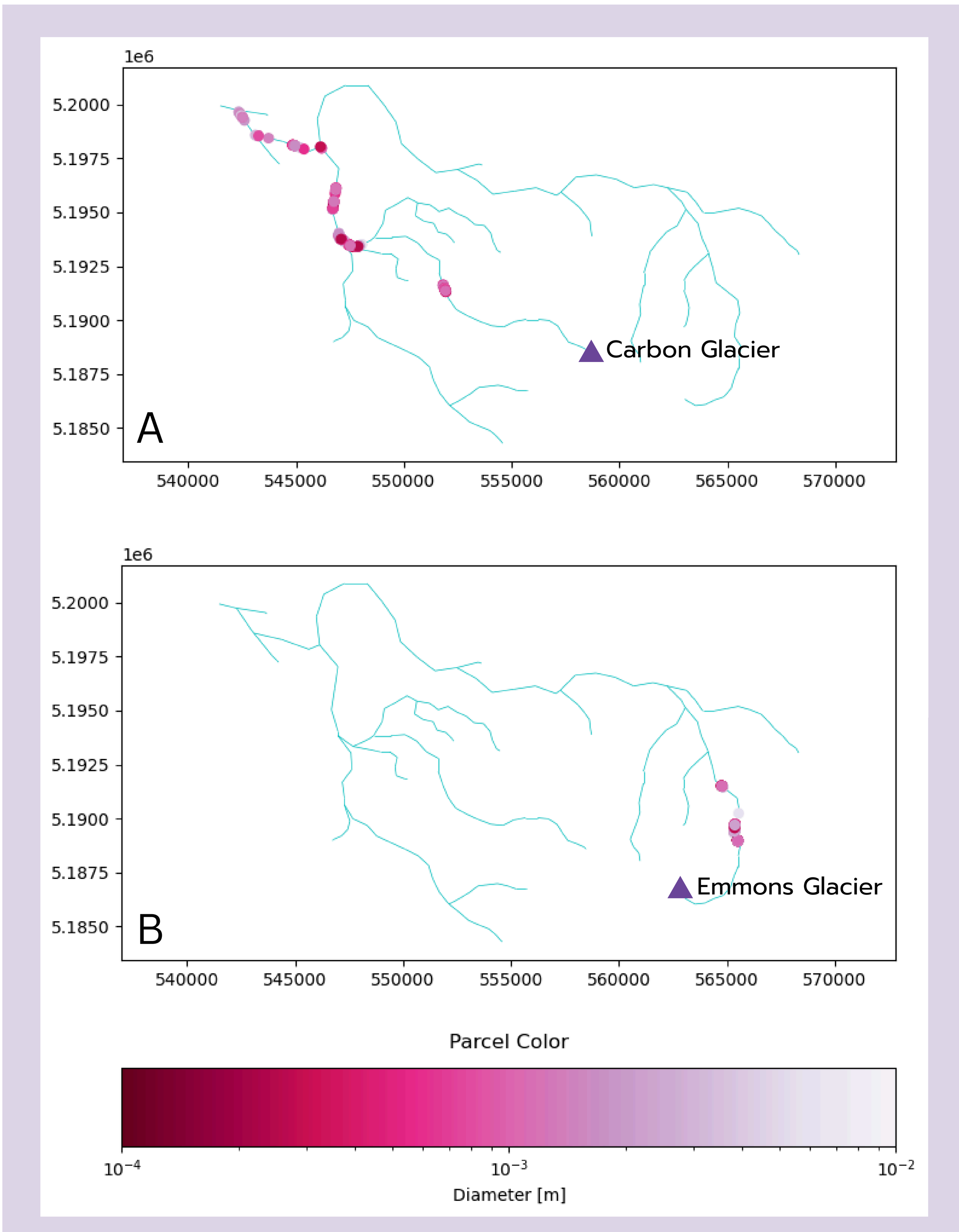


Fig 2. A) Network Sediment Tranporter plots all sediment parcels originating at Carbon Glacier after 24 hours. **B)** Network Sediment Transporter plots all sediment parcels originating at Emmons Glacier after 4.5 hours. Parcel color represents grain size.

Comparing Outputs to Local Data

- We compared grain size distributions within the same link (Fig 3, Fig 4).
- Rates of Volume Changes in the Emmons Proglacial Basin (Fig 5) were also compared

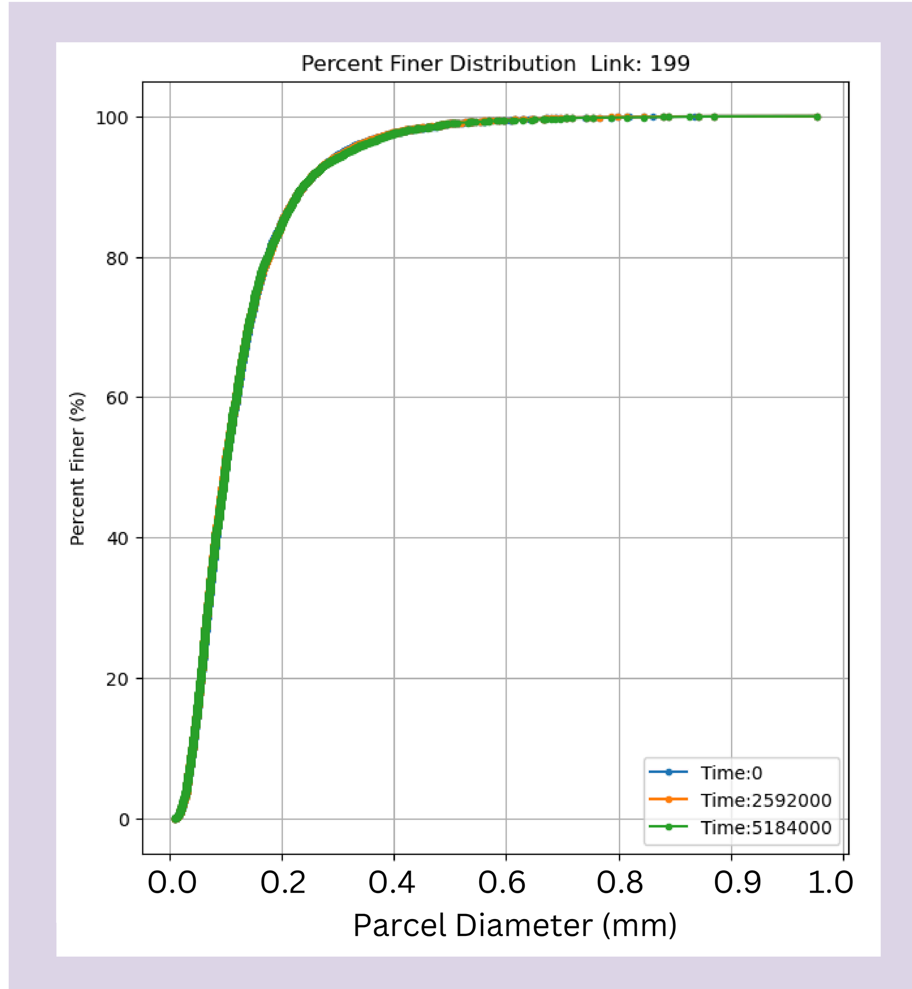


Fig 3. Distribution of sediment size distance travel (m) over time (hours). Parcels with smaller grain diameter, on average, traveled farther than larger grains with corresponding proximity

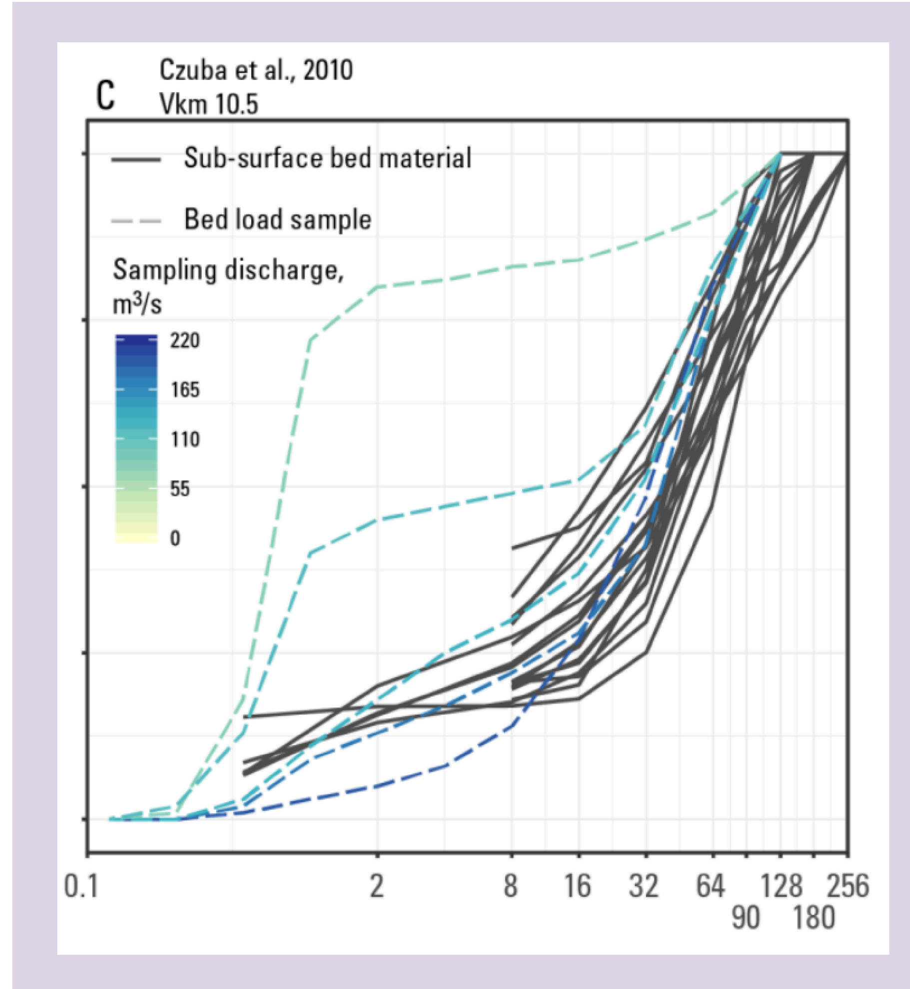


Fig 4. Field data for grain size percent finer distribution located at USGS Vkm 10.5 (Link 199). Adapted from: Anderson & Jaeger 2020.

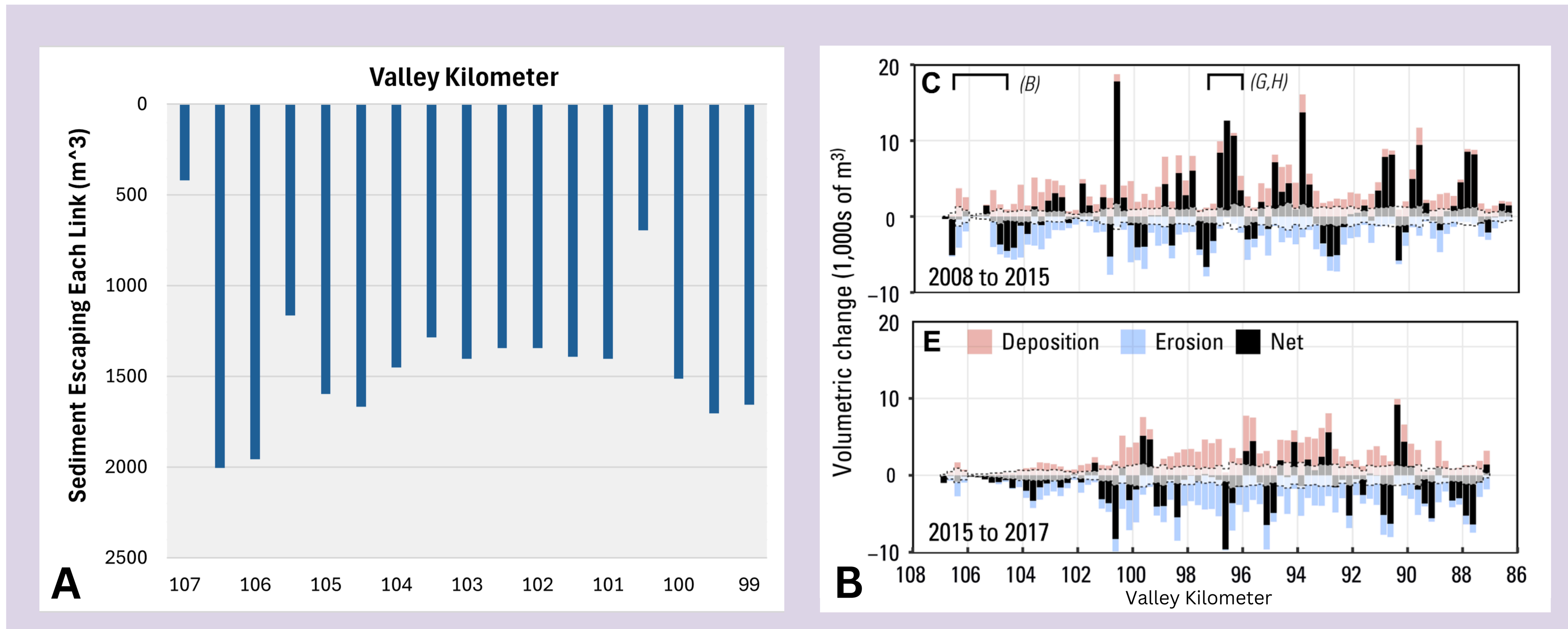


Fig 5. A) Modelled data showing Annual Volume of Sediment escaping each link using its corresponding Valley Kilometer (VKM). VKM 107 represents Emmons Glacier. **B) Real field data showing volumetric change of bed material in Emmons proglacial basin.** Adapted from: Anderson & Jaegar 2020. Coarse sediment escaped its link at a much faster pace in model simulations compared to observed annual erosion rates by volume. However, sediment eroding directly from Emmons proglacial basin occured slower than its downstream sections, similar to the reference data.

Discussion

Our model is not capable of representing every dynamic of sediment transport in local watersheds to an exact scale, but that was neither the goal of this project, nor is it for most models. We were able to observe how certain changes to a watershed impacts sediment transport, and how can that help us understand where and when we get fluxes of sediment throughout the basin.

Next Steps

Our watershed model is accessible to use and modify through GitHub. Since glacial sediment transport in our local watersheds is an emerging record, we hope to apply more relevant parameters to the model.

Works Cited

Acknowledgements

Thank you Mark Piper at University of Colorado Boulder and CSDMS for troubleshooting code!

GitHub Repository to Acess Model: