Global Incised Valley Filling During the Holocene Sea-Level Highstand - Implications for Carbon Burial

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Introduction

The efficiency of fluvial sediment and particulate organic carbon (POC) burial in river deltas strongly depends on their depositional environment, which can range from protected incised valleys to exposed active margins. We hypothesize the formation and infilling of incised valleys from Holocene sea-level rise led to increased fluvial sediment burial, and, consequently, POC burial. To test this, we developed a new incised valley fill model that estimates incised valley volume and fill rates. We apply this model to all river deltas globally (n=10,848), some of which are filled already but many still infilling since Holocene sea-level rise slowed ~6ka BP. The rate of incised valley infilling is determined based on global model estimates of fluvial sediment and POC supply. We use our model to explore the magnitude of POC burial during the Holocene, including its potential for global climate regulation.

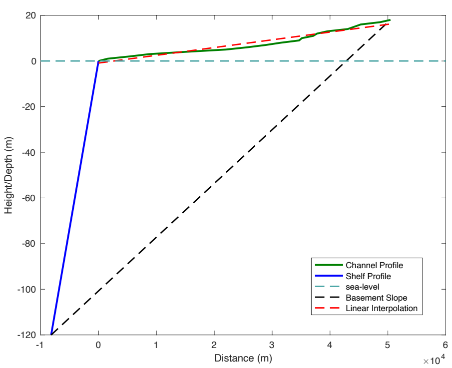


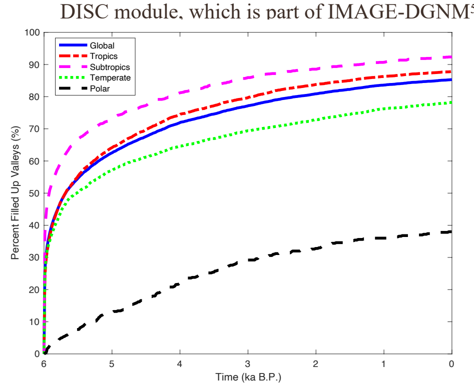
Figure 1. Example of a model estimating incised valley volume.

Objectives

- Build a model that incorporates fluvial sediment flux, incised valley dimensions, and POC to predict fluvial valley infilling and POC burial.
- Provide a global map of incised valley infilling time and of POC burial.

Methods

- Located deltas/valleys below 60° latitude using HydroSheds[1]. For latitudes greater than 60°, valleys located using ETOPO1[2]. Resulting dataset consisted of 10,848 incised valleys (see Figures 4-6).
- Volume modeled for a subset of incised valleys (n=100) to generate an empirical relationship between volume and both river discharge and channel slope. This model is then applied to all incised valleys. To model volume, we used the equation for half a cone (volume=[pi*radius²*height/3]/2) where the radius is the width of a river's mouth (measured on Google Earth) and the height is where the basement slope (created when sea-level was 120m below present during the Last Glacial Maximum) crosses the linear interpolation of the channel profile (0m; Figure 1).
- To estimate fluvial sediment flux to valleys, used the WBMSed 2.0 distributed global-scale sediment flux model[3].Sediment discharge estimated using the BQART model[4]. To estimate POC fluxes, used the CARBON-DISC module, which is part of IMAGE-DGNM[5].



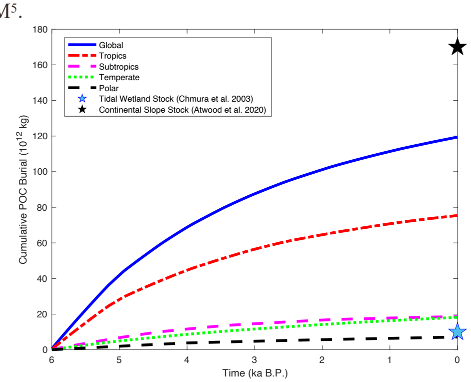


Figure 2 (left). Percent of incised valleys that have filled up over time, separated by climate zones.

Figure 3 (right). Cumulative amount of POC buried within incised valleys over time, separated by climate zones. Final POC burial estimates compared to carbon stocks in tidal wetlands[6] and in continental slope sediments[7].

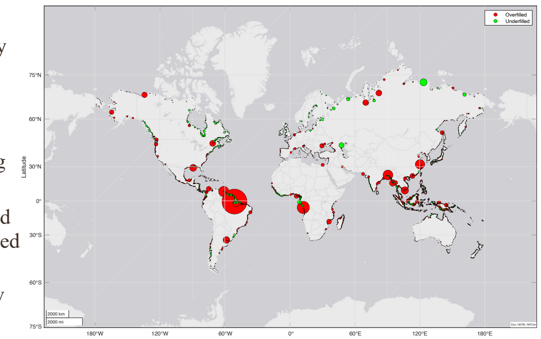
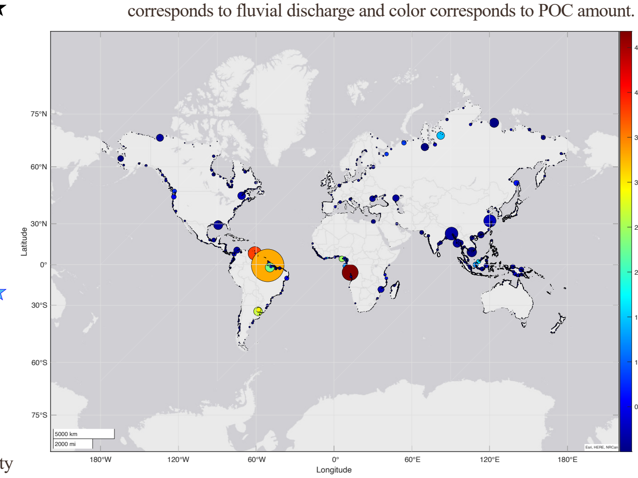


Figure 4 (top). All incised valleys classified as either underfilled (green) or overfilled (red) based on sediment burial over 6ka. Symbol size corresponds to individual river fluvial discharge.

Figure 5 (bottom). POC buried within valleys after 6ka. Symbol size corresponds to fluvial discharge and color corresponds to POC amount.



References

1 Lehner et al. 2008, EOS, 89(10); 2 Amante and Eakins 2009, NOAA Memorandum; 3 Cohen et al., 2013, Comput. Geosci, 53; 4 Kettner and Syvitski, 2008, Comput. Geosci. 34(10); 5 Vilmin et al., 2019, Glob. Planet Change 163; 6 Y Chmura et al., 2003, GBC, 17(4); 7 Atwood et al. 2020, Front Mar Sci, 7

Acknowledgements

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