Inverting fluvial network topology to understand landscape dynamics

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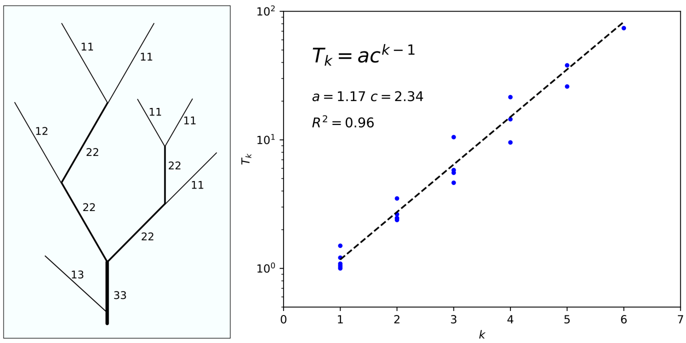
Tokunaga self-similarity

Tokunaga self-similarity describes the side-branching structure of networks, each network link records its order [i] and the order of link it flows into [j]. Ratios of branch counts can be calculated as:

$$T_{ij} = \frac{N_{ij}}{N_i}, \tag{1}$$

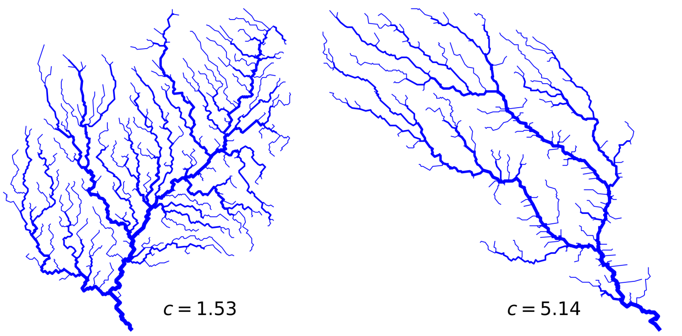
which allows us to calculate the Tokunaga parameters a, c:



Can this simple metric yield insight into geomorphic process at a global scale?

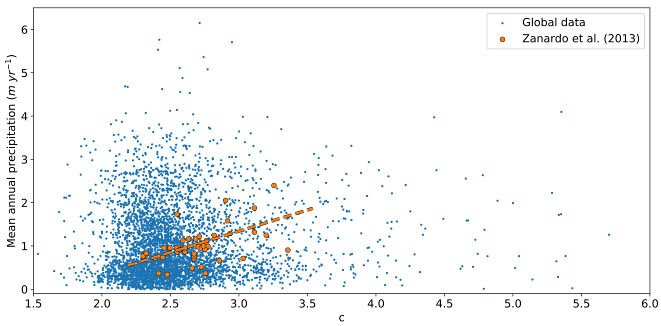
What is c?

A large value of c corresponds to a network with many low order channels flowing into high order channels.



Climate

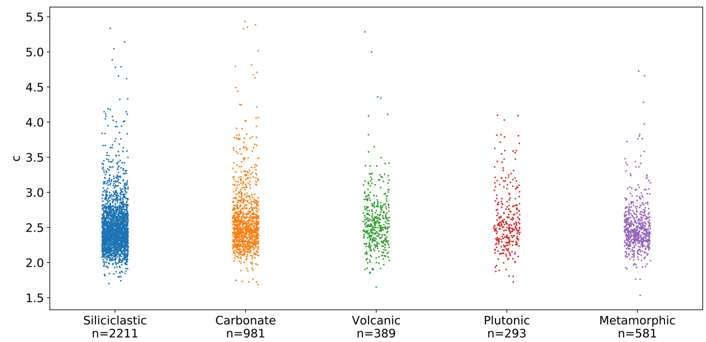
Zanardo et al. (2013) suggested a correlation between c and precipitation for 50 sites across the USA:



A global analysis of over 9000 drainage basins does not replicate this finding. What drives variation in c?

Lithology

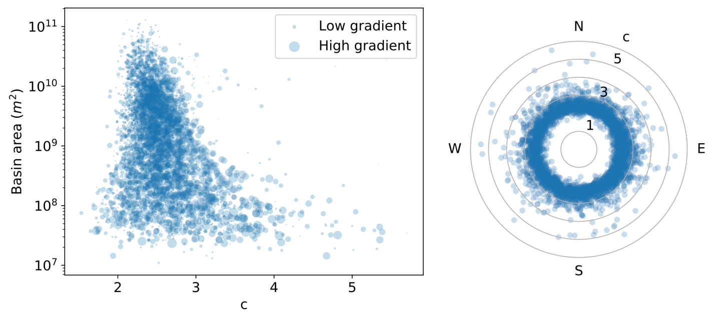
Using the GLiM dataset (Hartmann & Moosdorf, 2012), we can identify the dominant lithology of each of our drainage basins:



Catchment lithology is often a control on landscape form, but does not appear to influence fluvial network branching structure.

Basin morphology

Do we see patterns in basin area, gradient or aspect and network branching structure?



Small basins appear most likely to have a high c value, with no clear bias towards gradient or aspect.

Summary

- **Tokunaga parameters can be used to describe fluvial network branching structure.**
- **The majority of global fluvial networks fall within a narrow range of c values.**
- **There is no clear correlation between Tokunaga parameters and traditional geomorphic metrics at the global scale.**

References

Zanardo, S., Zaliapin, I., & Foufoula-Georgiou, E. (2013), Are American rivers Tokunaga self-similar? New results on fluvial network topology and its climatic dependence, doi:10.1029/2012JF002392.

Hartmann, J., & Moosdorf, N. (2012), The new global lithological map database GLiM: A representation of rock properties at the Earth surface, doi:10.1029/2012GC004370.