Linear Inverse Modelling and Scaling Analysis of Drainage Networks

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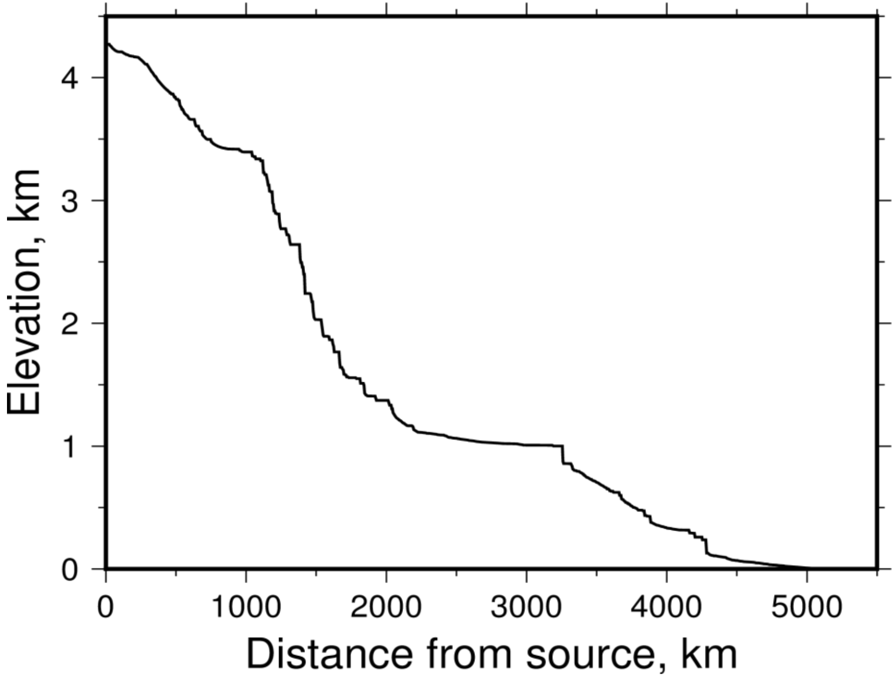
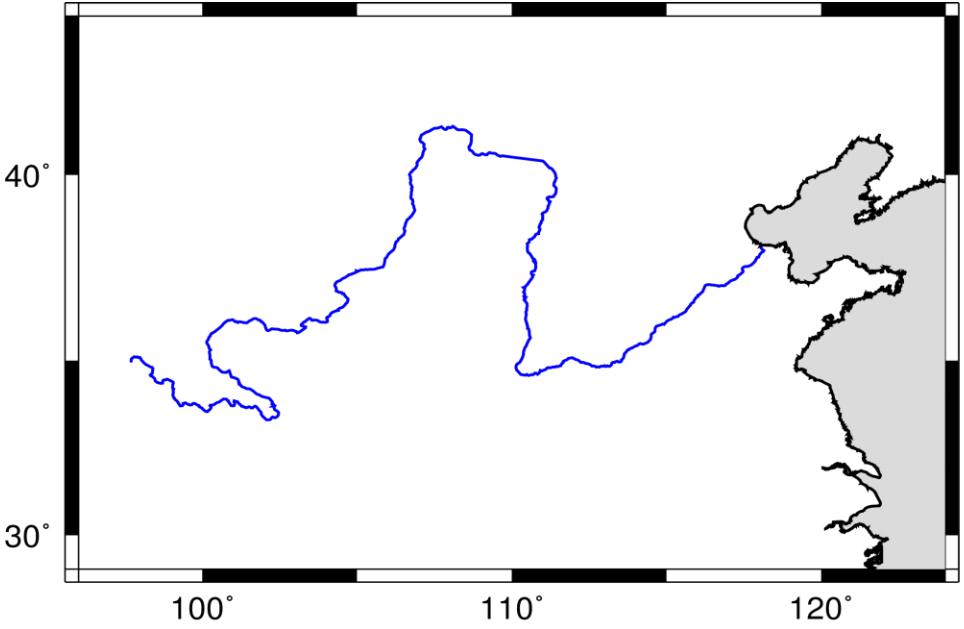
Overview

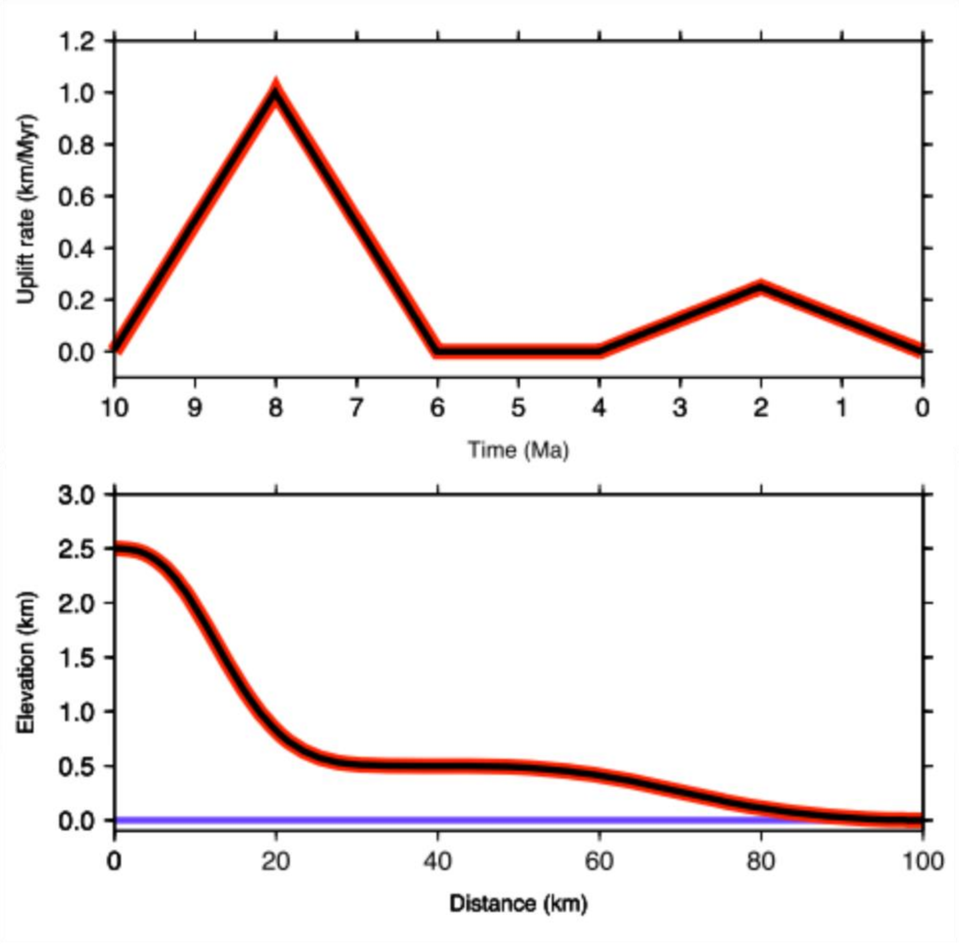
- Introduction
- Theory behind river profile behaviour
- Formulating an inverse problem
- Results and calibration
- Scaling analysis
- Future work and conclusions

Introduction



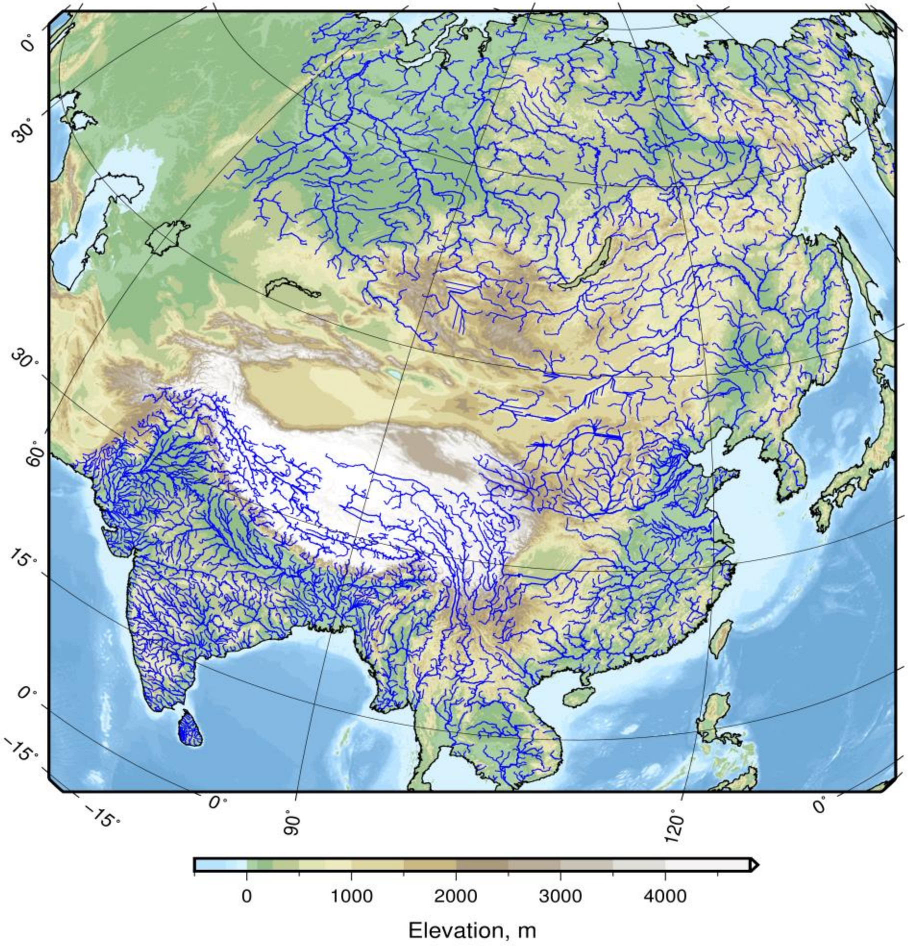


Introduction

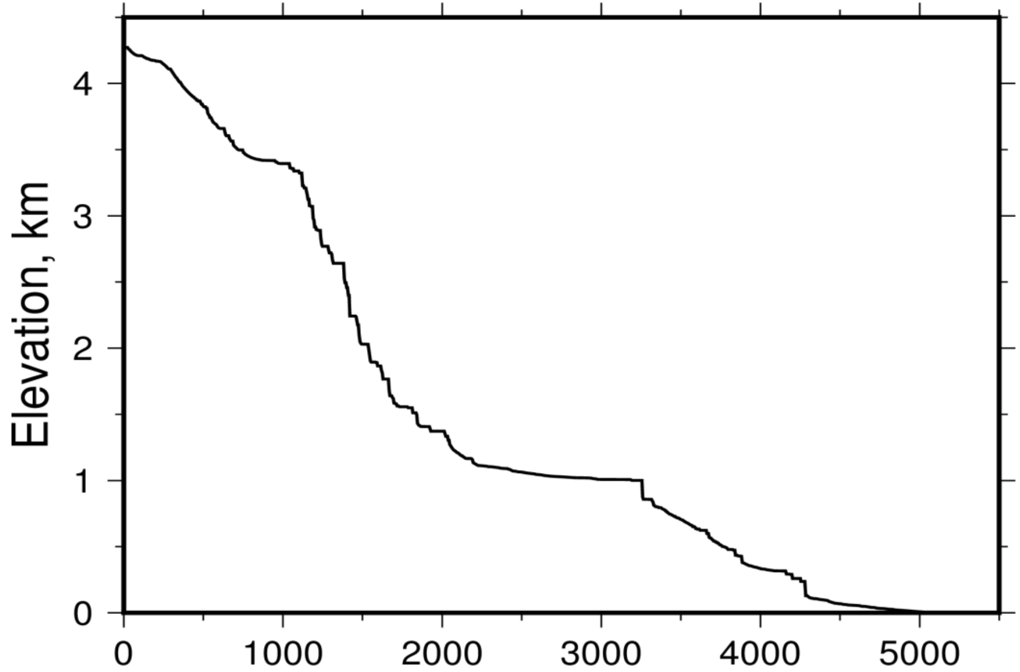


Roberts & White 2010, JGR

Introduction



River Profile Theory



$$\frac{\partial z}{\partial t} = U(x,t) + E(x,t)$$

River Profile Theory

$$E(x,t) = -v[PA(x)]^m \left(\frac{\partial z}{\partial x}\right)^n + \kappa \left(\frac{\partial^2 z}{\partial x^2}\right)$$

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Formulating an Inverse Problem

$$-\frac{\partial z}{\partial t} + vA^m \frac{\partial z}{\partial x} = U(x,t)$$

Formulating an Inverse Problem

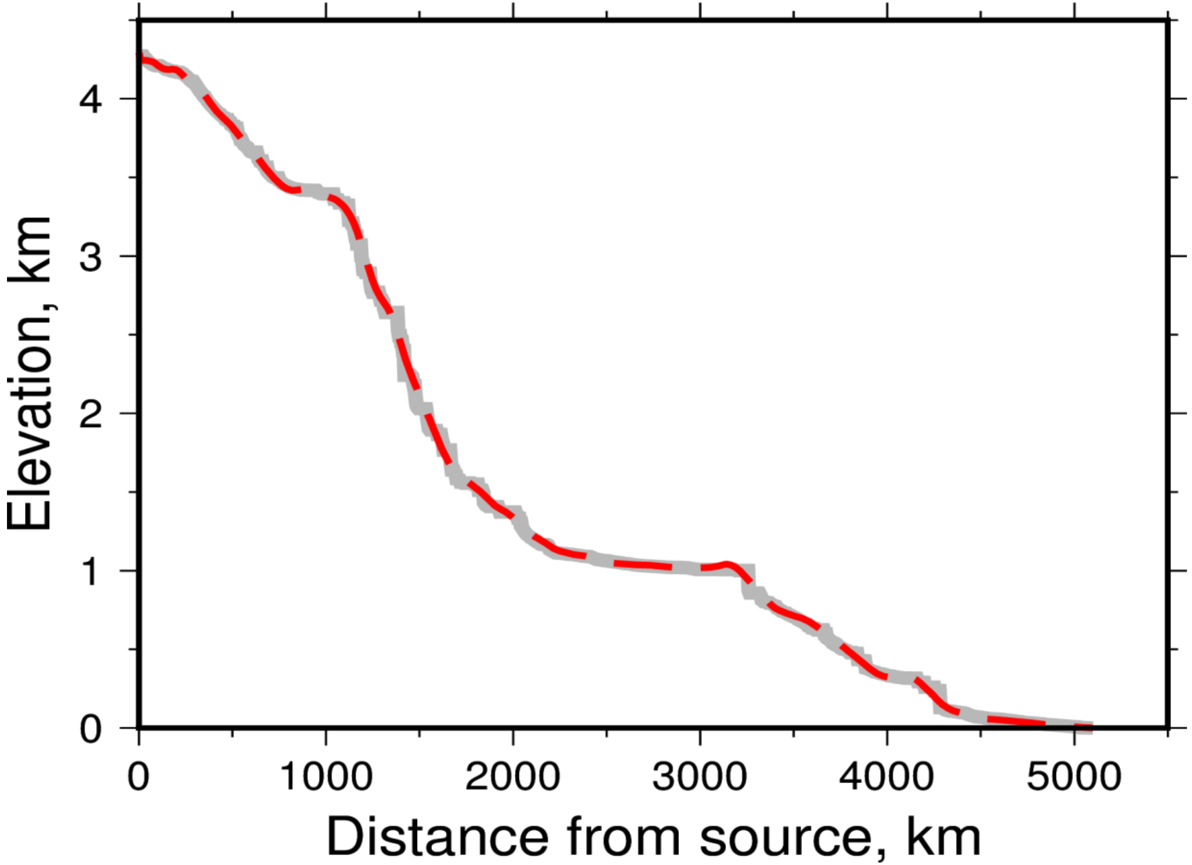
$$\frac{dx}{dt} = -vA^m$$

$$\frac{dz}{dt} = -U(x(t), t)$$

Formulating an Inverse Problem

$$z* = \int_{0}^{\tau_G} U(x(t), t).dt$$

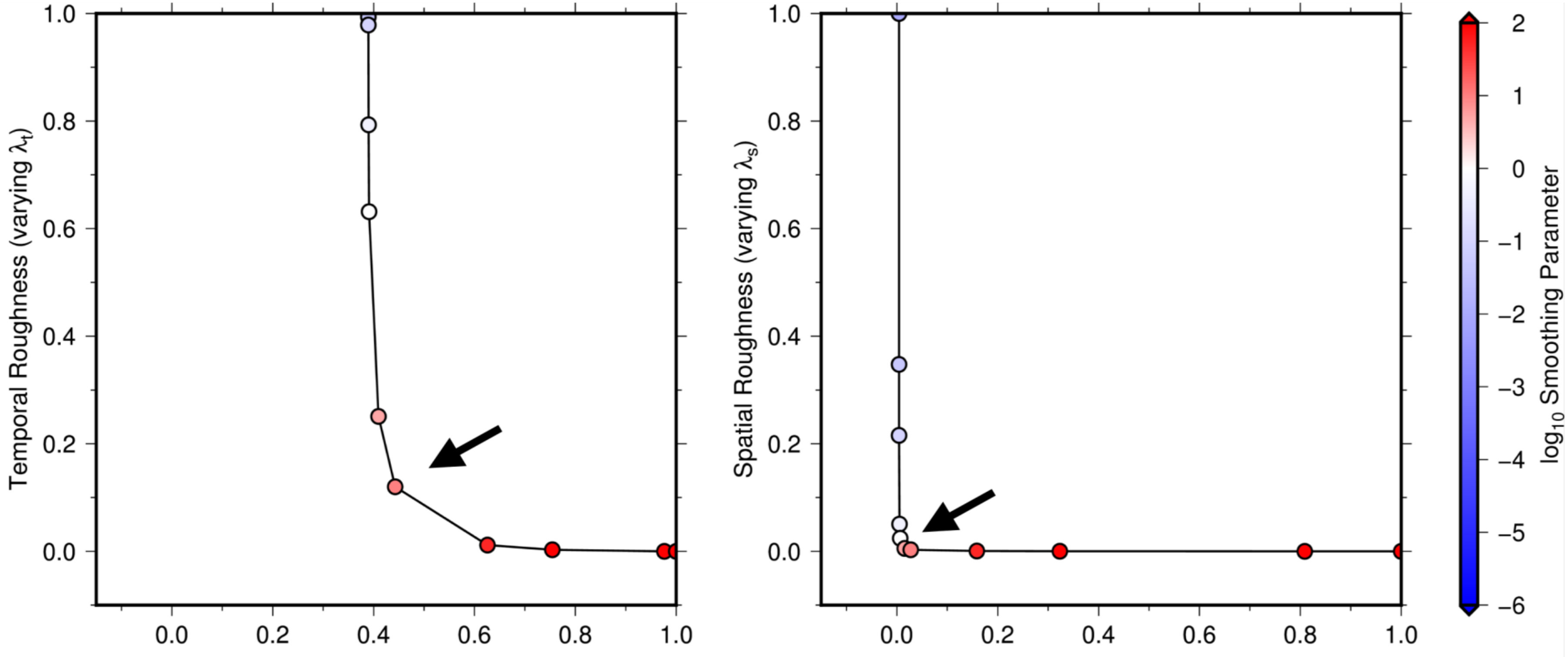
Calibration



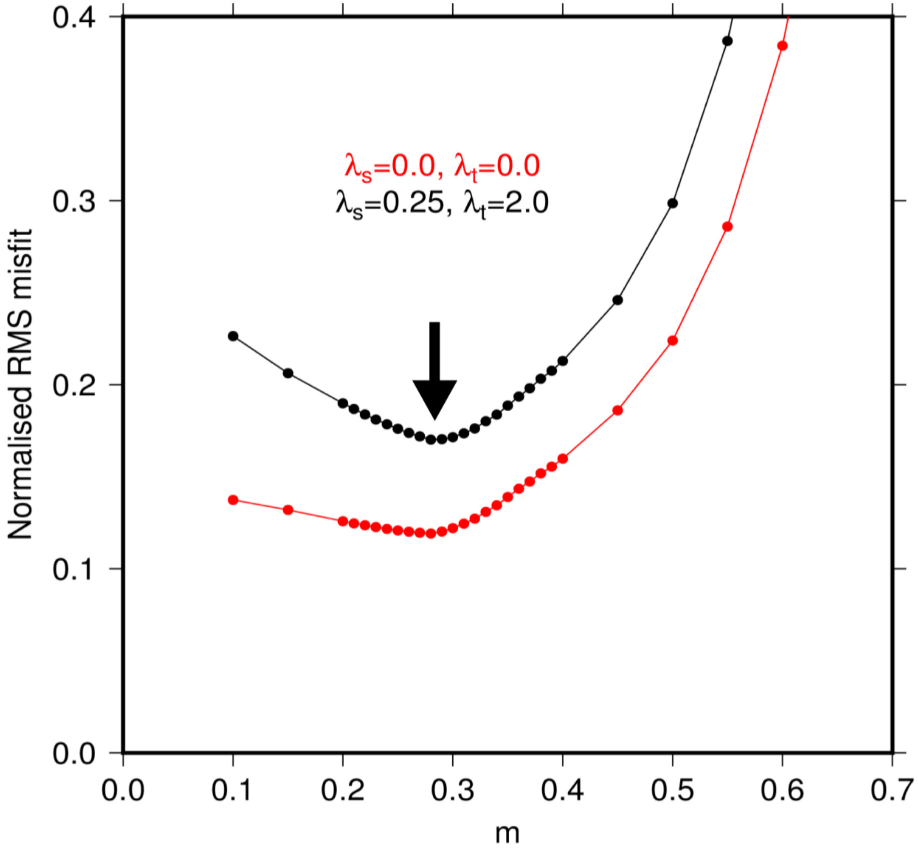
Calibration

$$-\frac{\partial z}{\partial t} + vA^{m}\frac{\partial z}{\partial x} = U(x,t)$$

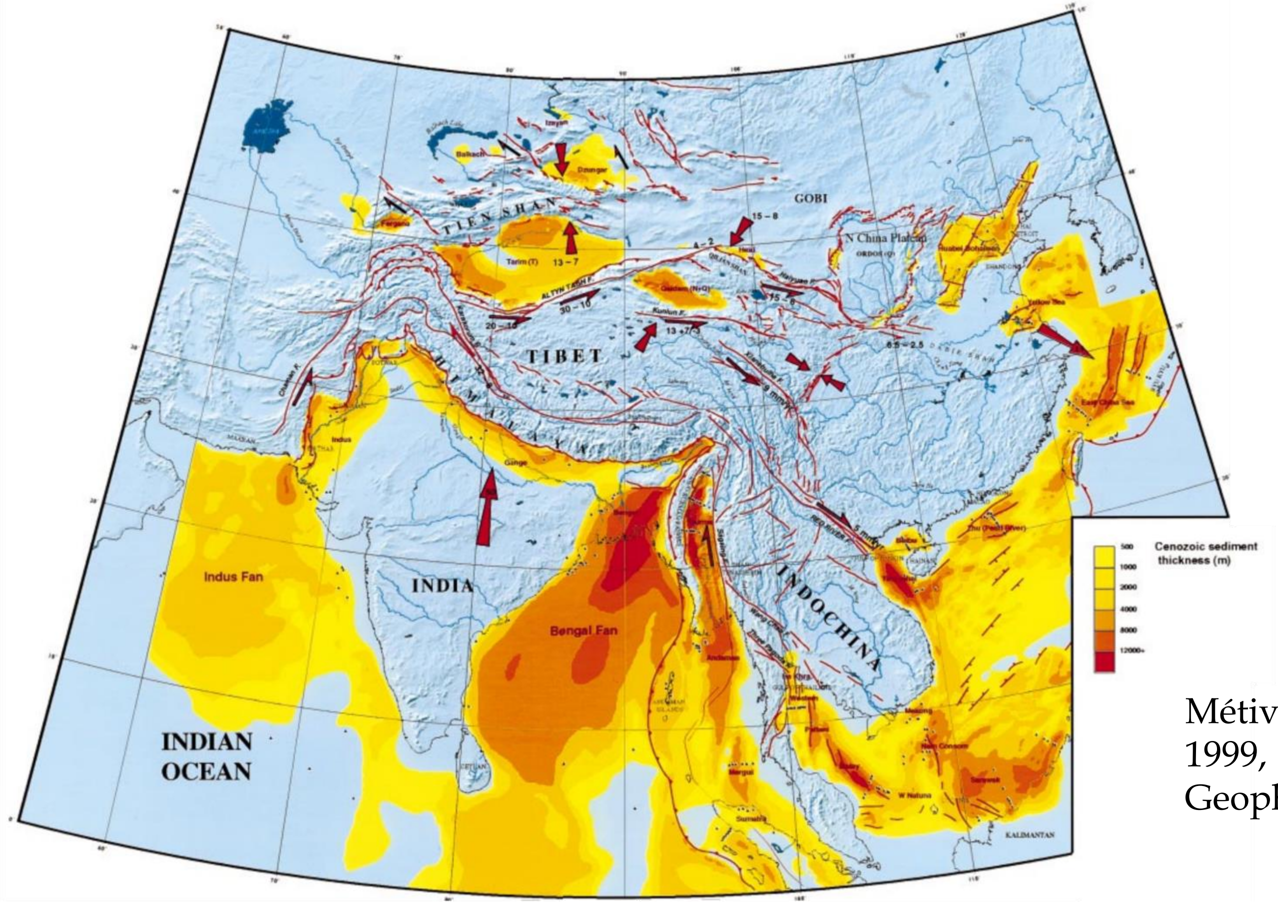
Calibration



Calibration

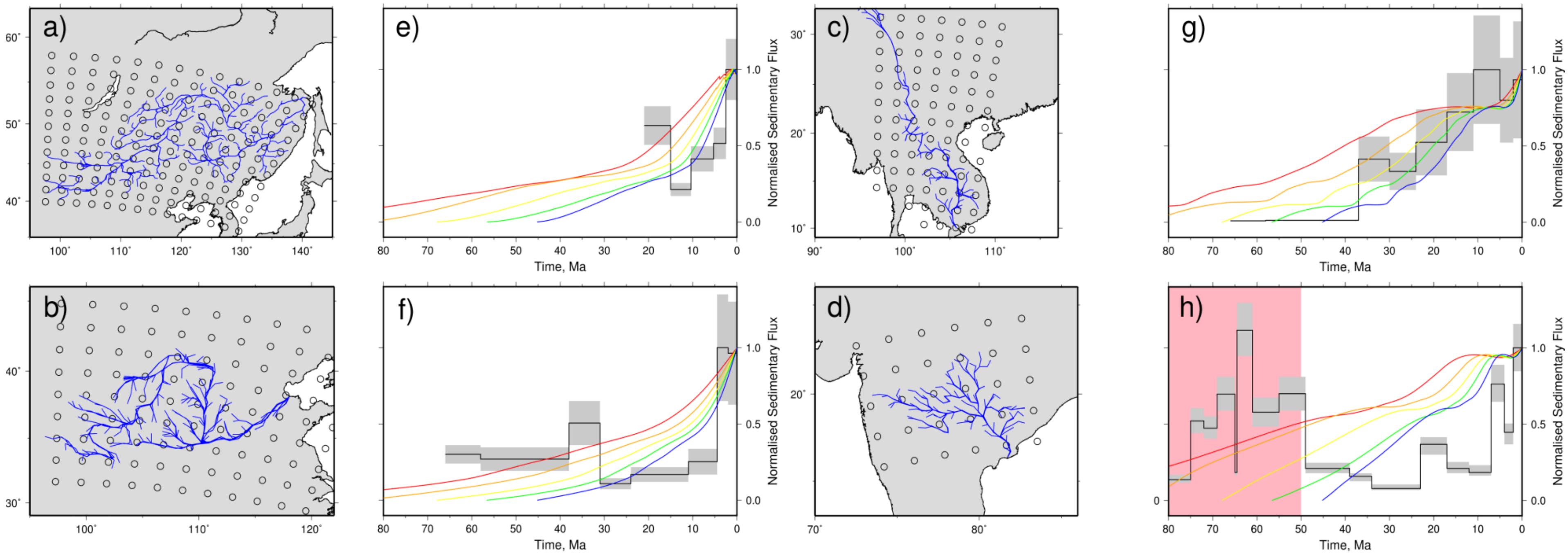


Calibration



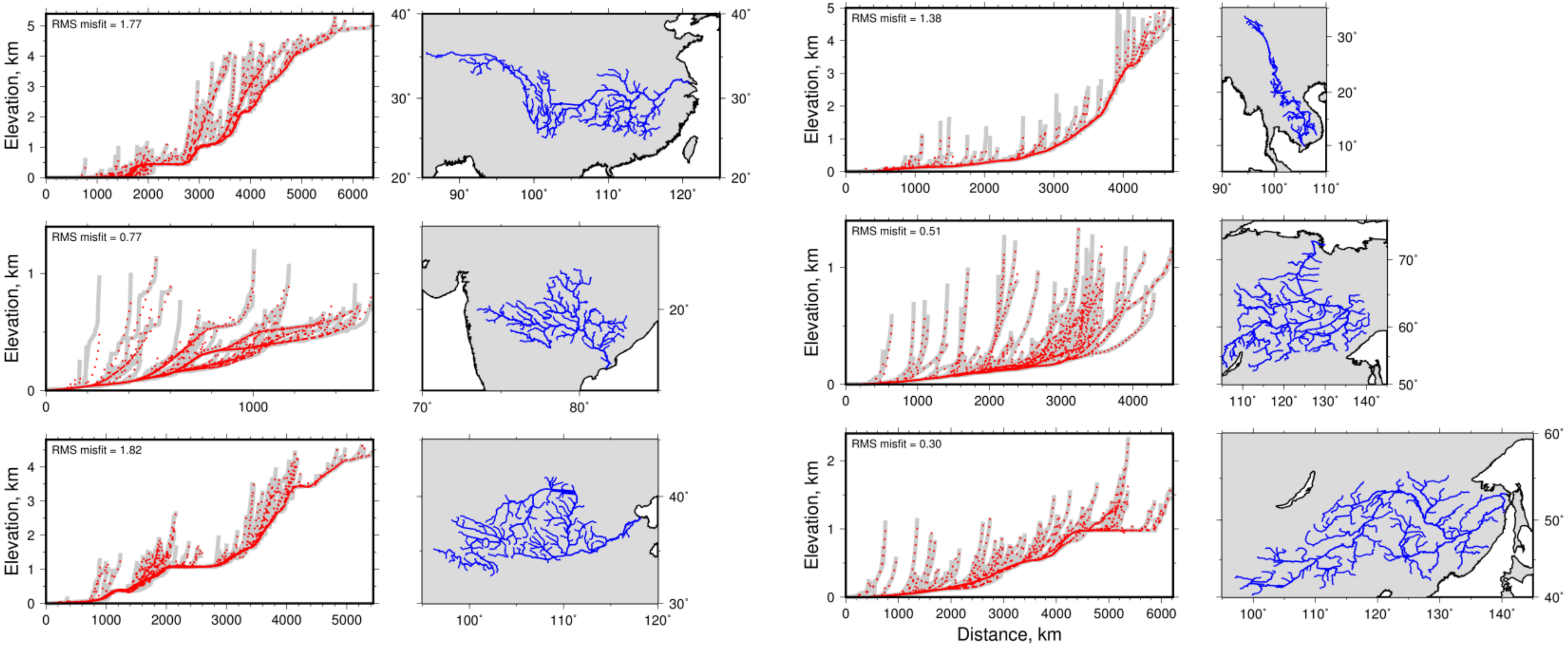
Métivier et al. 1999, Geophys. J. Int.

Calibration

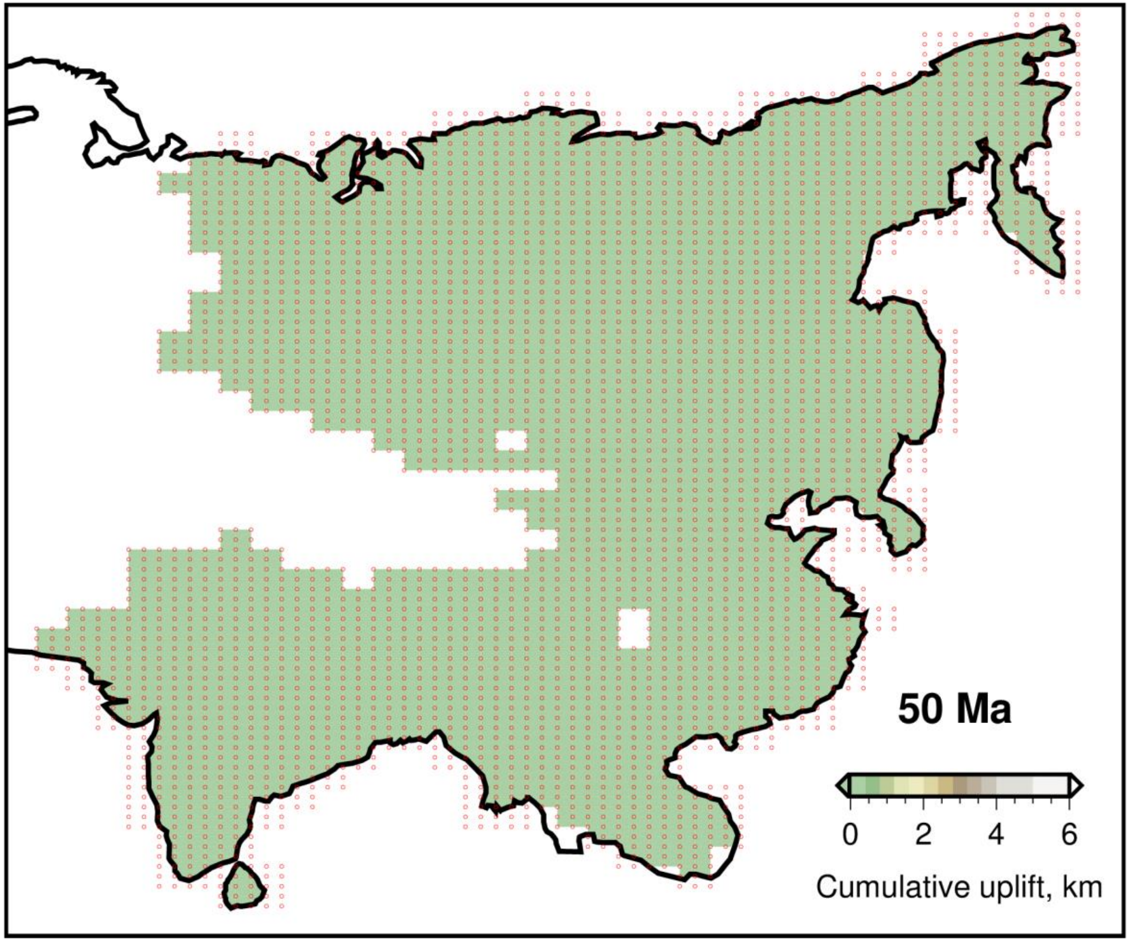


Métivier *et al.* 1999 (Geophys. J. Int.), Nicholson *et al.* 2015 (Basin Research), Richards *et al.* 2016 (G3, under review)

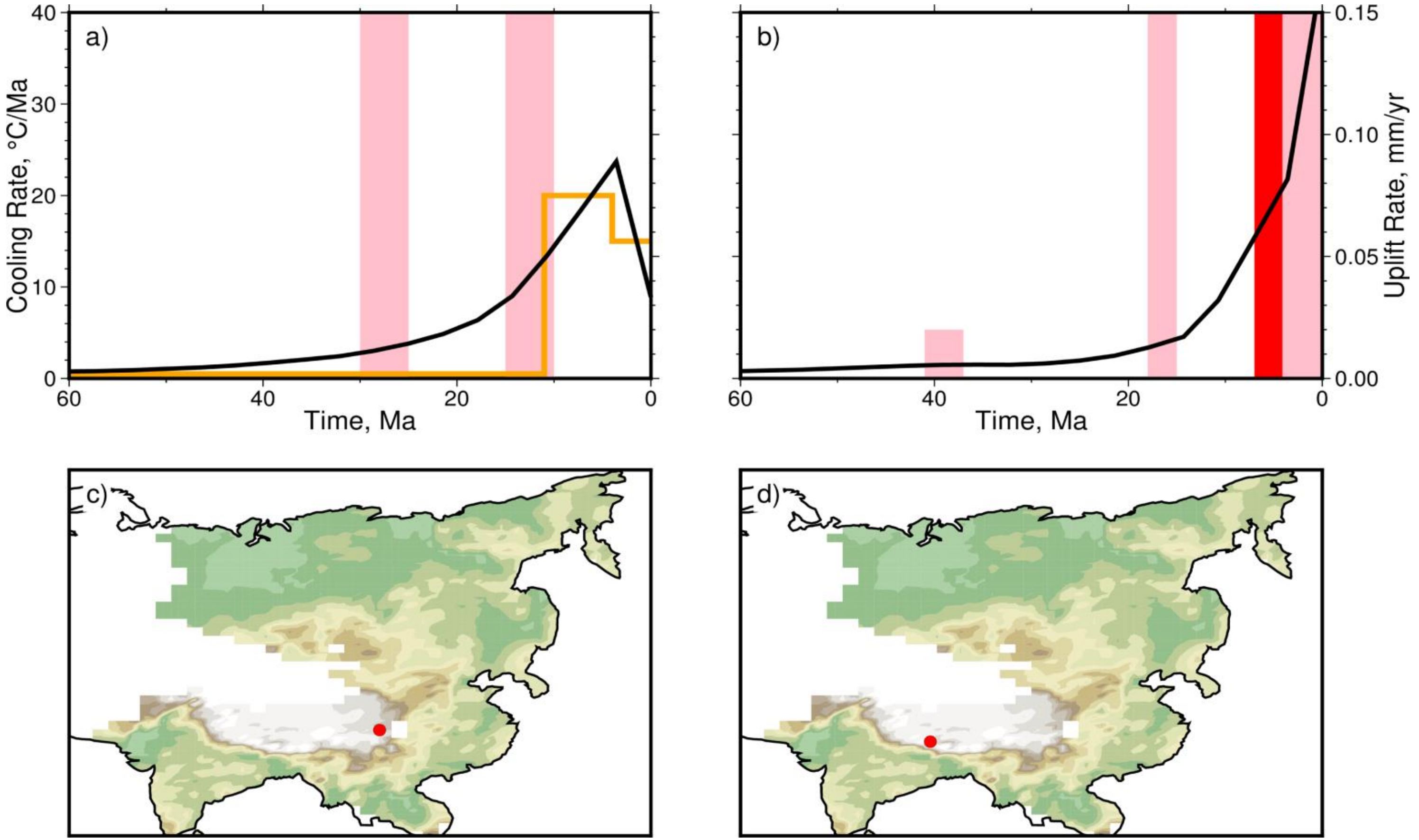
Results for Asian Rivers



Results for Asian Rivers



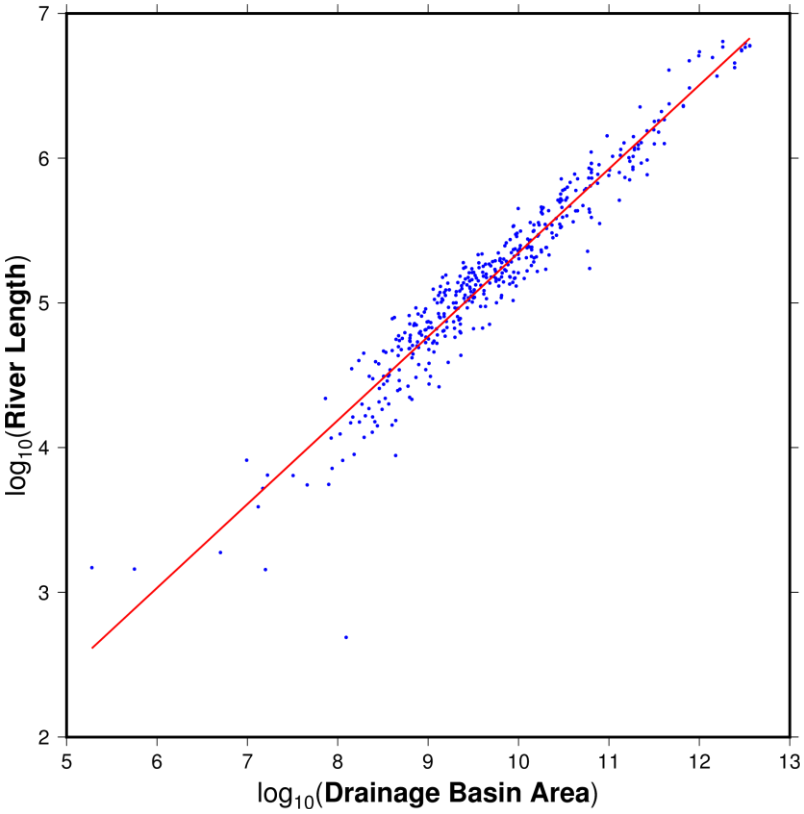
Results for Asian Rivers



Values of Erosional Constants

- v and m vary
- Why?
- What length- and time-scale?

Scaling Analysis



$$L = CA^h$$

$$C = 0.359$$

$$h = 0.579$$

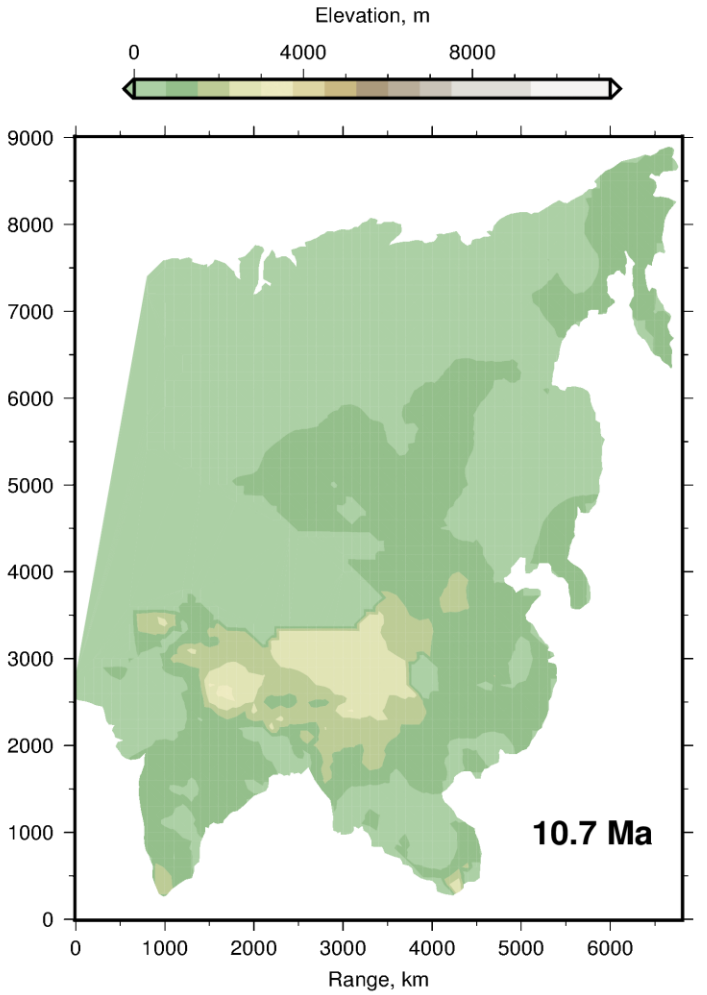
Conclusions & Future Work

- Calculated uplift history recreates Asian river profiles well, using single values of erosional constants.
- History agrees with constraints on uplift and sediment flux.
- Asian rivers record of uplift to earliest Cenozoic times.

Future Work

- Do erosional constants vary significantly globally/within Asia?
- Do erosional constants correlate with geomorphic indices?
- Link landscape evolution with river profile evolution.

Future Work



Elevation, m
0
4000
8000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
0
1000
2000
3000
4000
5000
6000
Range, km
10.7 Ma