Toward a unified model for sediment transport from terrestrial source to abyssal-plain sink

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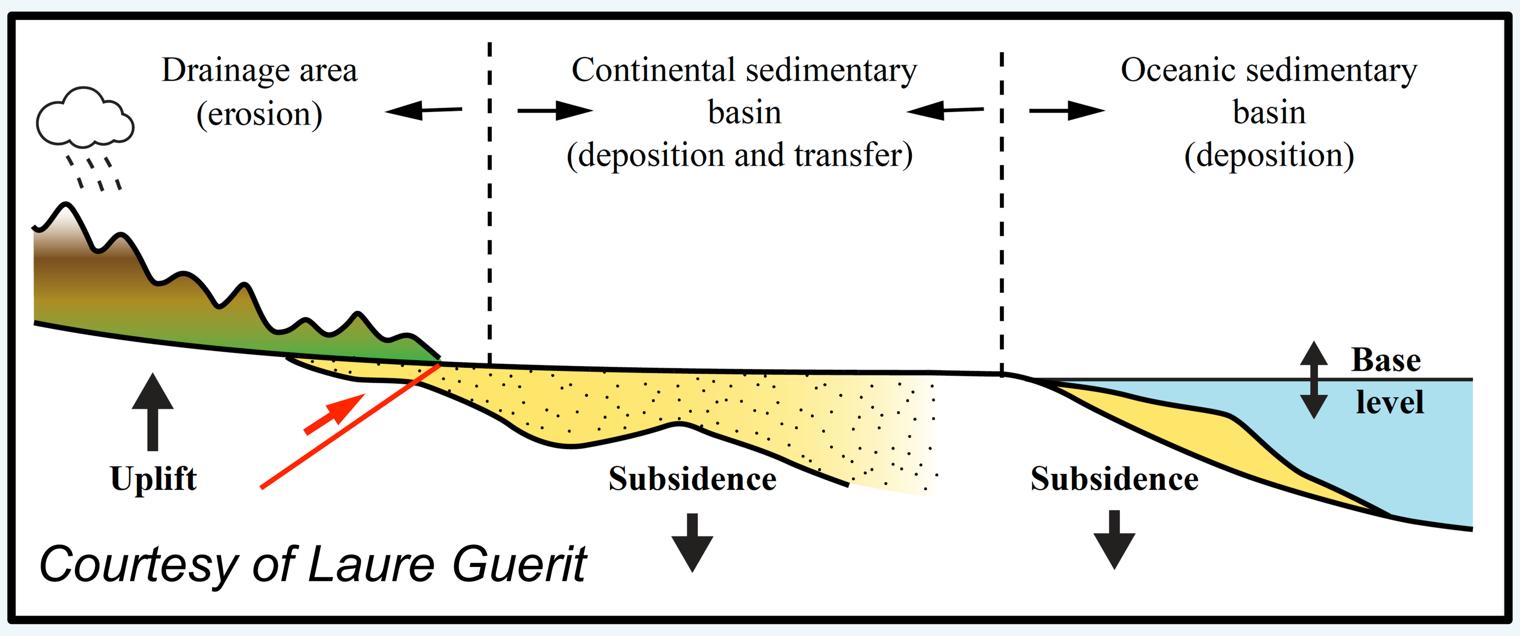
Introduction, conceptual approach, and numerical model



Courtesy of Laure Guerit

- Stratigraphic forward models are increasingly coupled with landscape evolution models to quantitatively constrain continental exhumation histories from stratigraphy.
- Many stratigraphic models perform well on the continental shelf and upper slope, but rely on local diffusion approaches that prevent long-distance transport of sediment over basin floors.
- We propose a nonlocal approach to modeling erosion, sediment transport, and deposition in the marine environment. The new marine model is coupled to an existing fluvial erosion model.

Landscape and seascape evolution occur within the erosion-deposition framework, with deposition dependent on a transport length scale L.
e.g. Kooi and Beaumont, 1994

U: uplift/subsidence rate
E: erosion rate

$$\frac{\partial h}{\partial t} = U - E + \frac{Q_s}{WL}$$

Q_s: sediment flux
W: unit width

Terrestrial (river):

(after Yuan et al., 2019)

$$L = \frac{A}{WG}$$

L is set by water discharge and a deposition term G.

$$\frac{\partial h}{\partial t} = U - K_f A^m S^n + \frac{G Q_s}{A}$$

Marine Basin:

$$L = \frac{\lambda}{1 - (S/S_c)^2}$$

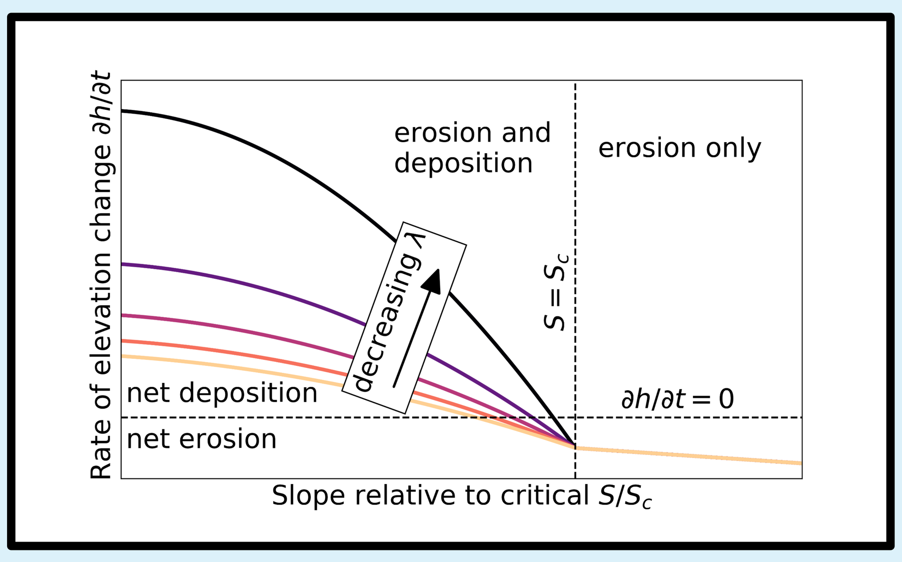
(after Carretier et al., 2016).

L is set by slope S relative to a slope of no deposition S_c and a transport distance λ.

$$\frac{\partial h}{\partial t} = U - KS + \frac{Q_s\left(1 - (S/S_c)^2\right)}{W\lambda}$$

Sensitivity Analysis

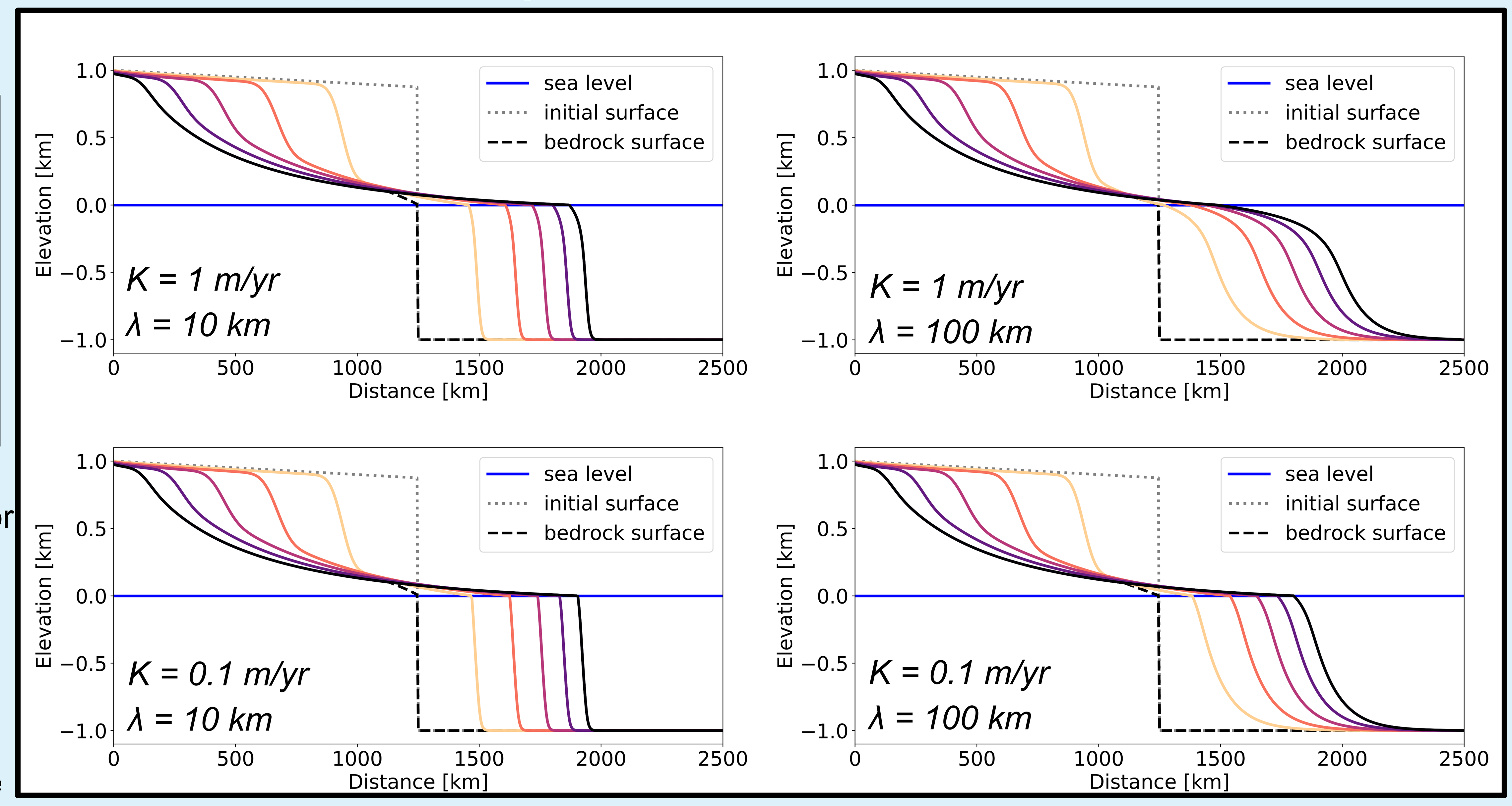
Below: rate of elevation change in the marine environment as a function of slope and transport length scale.



Right: Examples of stratigraphy produced under a constant sea level for different values of the marine erosion efficiency and marine sediment transport length scale. Long transport distances, with which the model diverges from the local diffusion approximation, are required to produce realistic deep marine deposits.

Short transport length scale

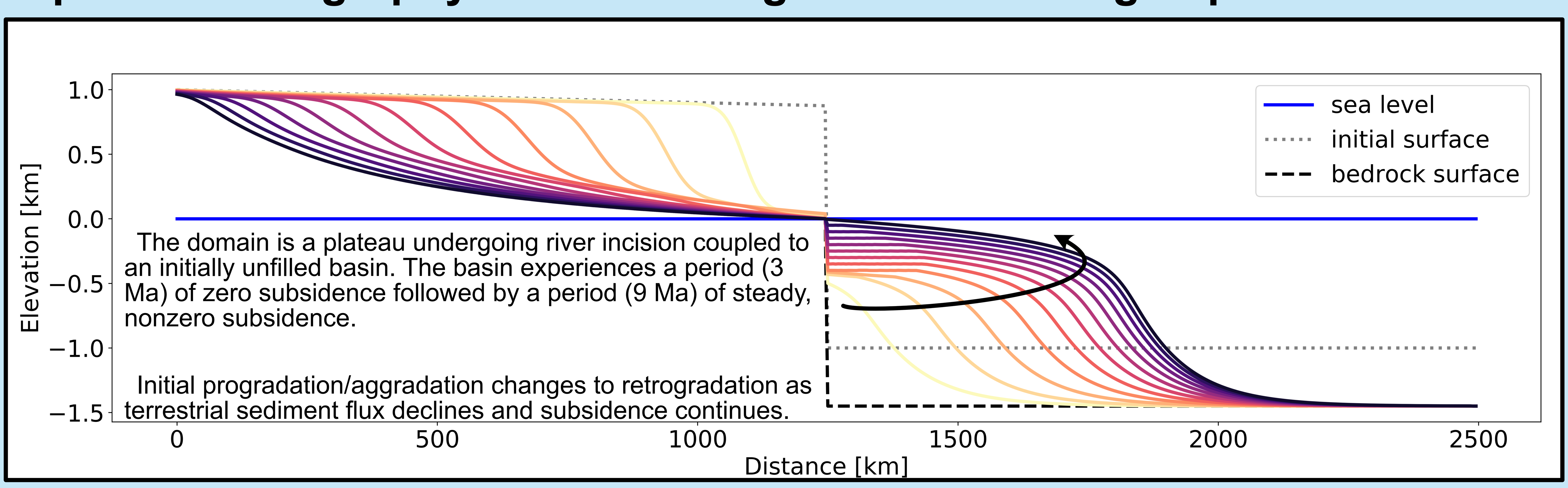
Long transport length scale



Fast marine erosion

Slow marine erosion

Sequence Stratigraphy in a Subsiding Basin over Large Space/Time Scales



- The new formulation enables modeling of the deep marine environment where slopes become vanishingly small and nonlocal, momentum-driven transport dominates.
- Efficient, large-scale models coupling continental erosion and marine deposition will allow for the inversion of long-term seismic datasets to constrain past tectonics, climate, and landscape evolution.
- **We are looking for case studies/datasets on passive margins that could be used for model calibration and validation. Any suggestions would be much appreciated!**

References: Kooi and Beaumont, 1994, *JGR*; Carretier et al., 2016, *ESurf*, 10.5194/esurf-4-237-2016; Yuan et al., 2019, *JGR: ES*, 10.1029/2018JF004867; Castelltort and van den Driessche, 2003, *Sed Geol*, 10.1016/S0037-0738(03)00066-6. Thanks to Guillaume Baby, Delphine Rouby, and Brendan Simon for helpful discussions. This project has received funding from the European Union's Horizon 2020 research and innovation programme under the Marie Skłodowska-Curie grant agreement number 833132.