

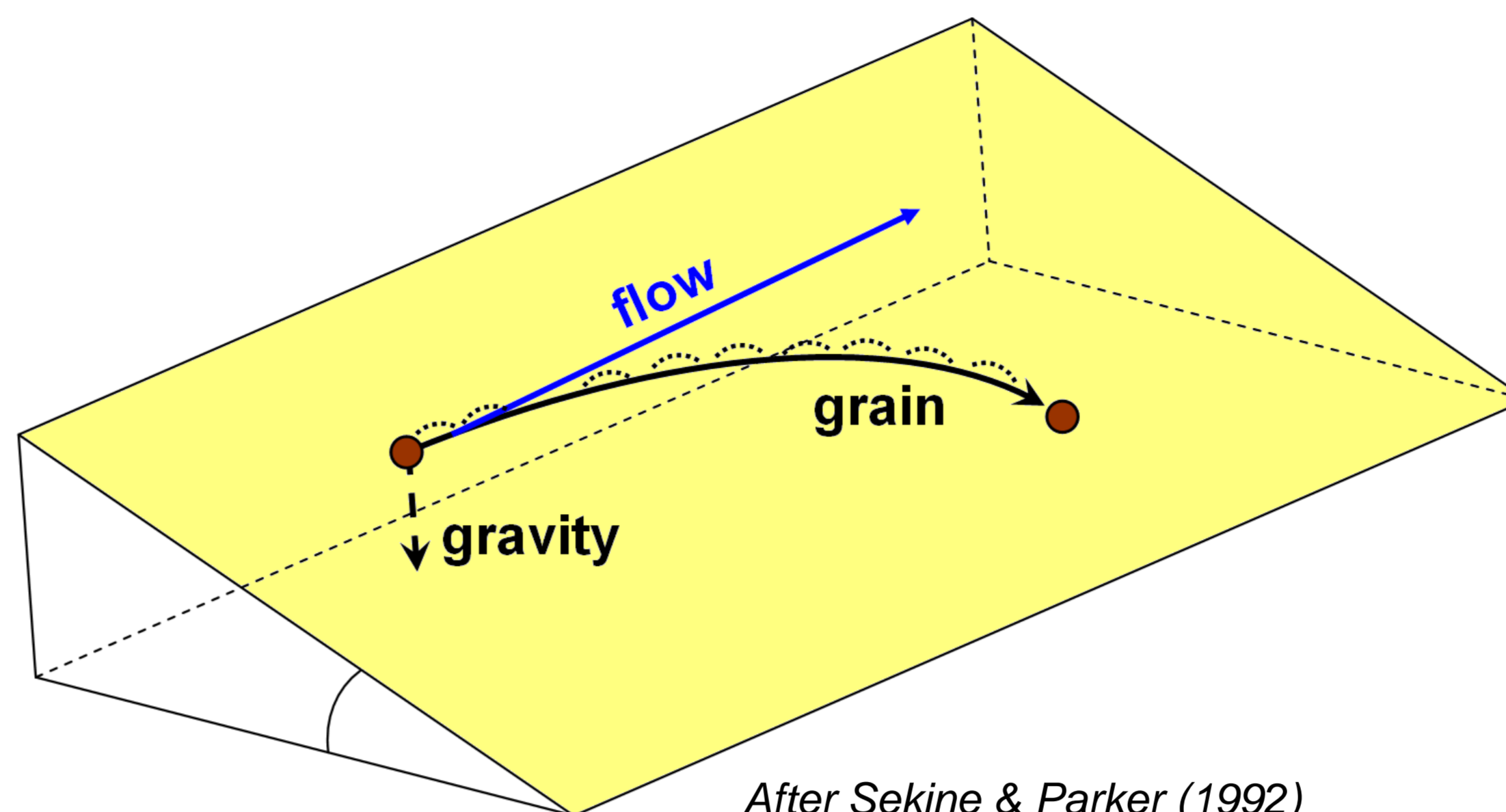
Major bed slope effects in all river morphodynamics models



Background

River and coastal morphodynamics is the result of sediment transport primarily induced by flowing water. Gravity affects the bed load transport on bed slopes, e.g. the transverse slope in meander bends or along bar edges. Gravity steers grain paths to downslope direction (see figure), rotating the bed load vector. This process is essential in morphodynamic models.

Quantification methods for effect of gravity in morphodynamic models like Delft3D, Mike21 and Nays are based on flume experiments (e.g. Hasagawa 1981, Talmon 1995). Large scatter and fundamental differences between quantification methods exist, significantly reducing the reliability of physics-based morphodynamic models. Furthermore, current methods need calibration.

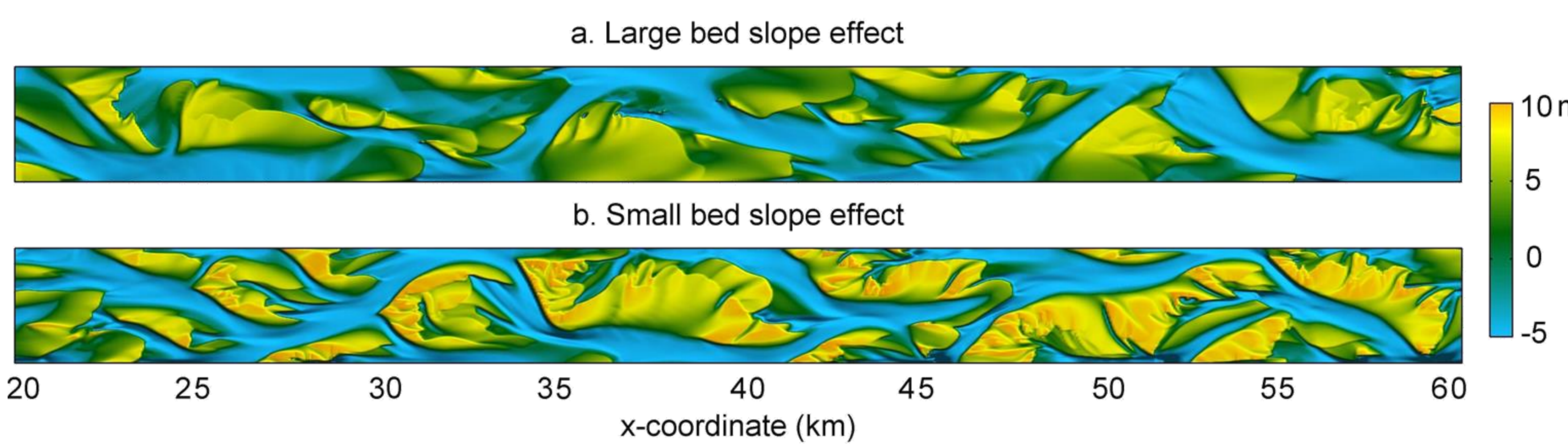
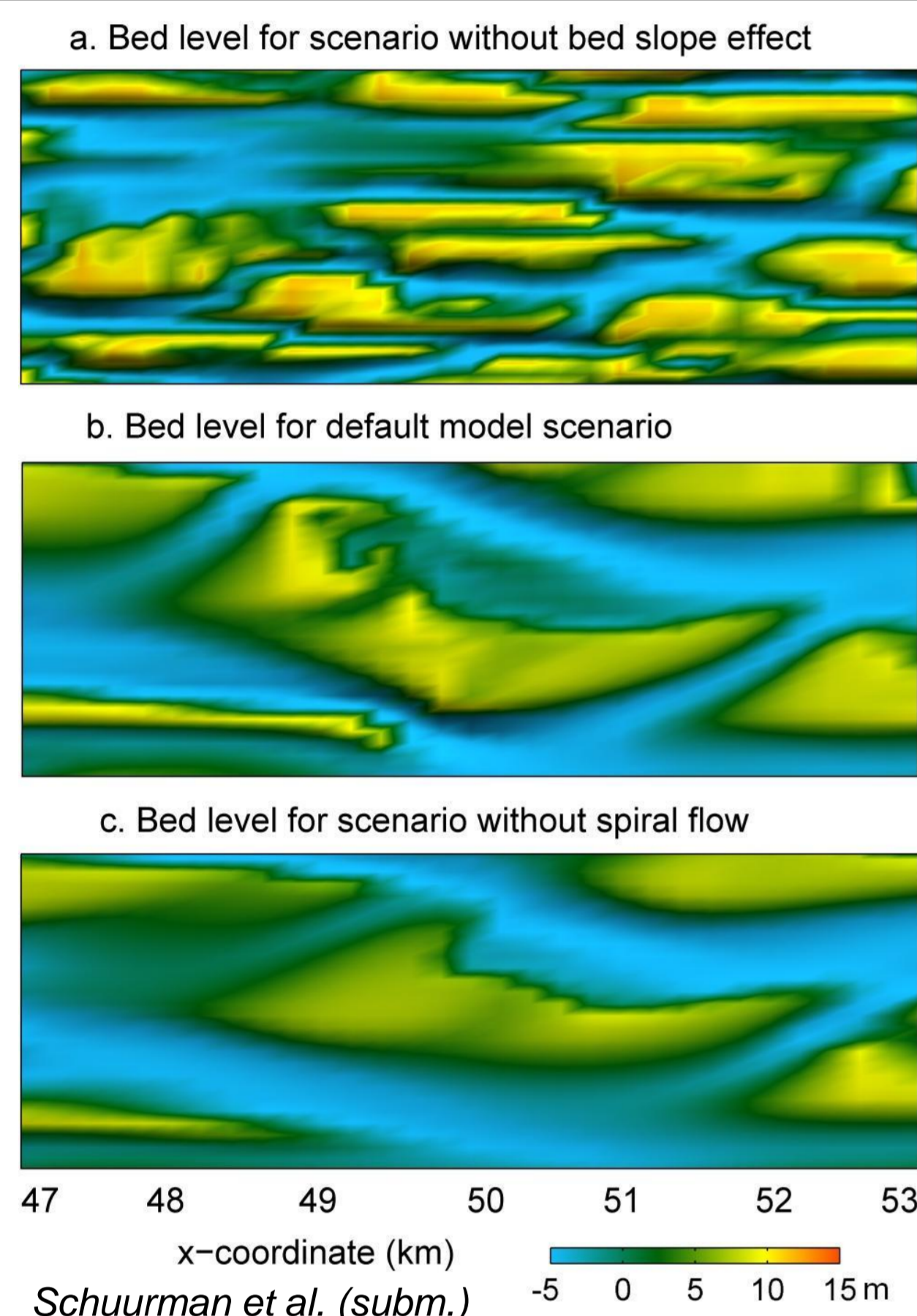


Research question:
How does bed slope effects influence bed topography, morphodynamics and sorting in physics-based morphodynamic models?

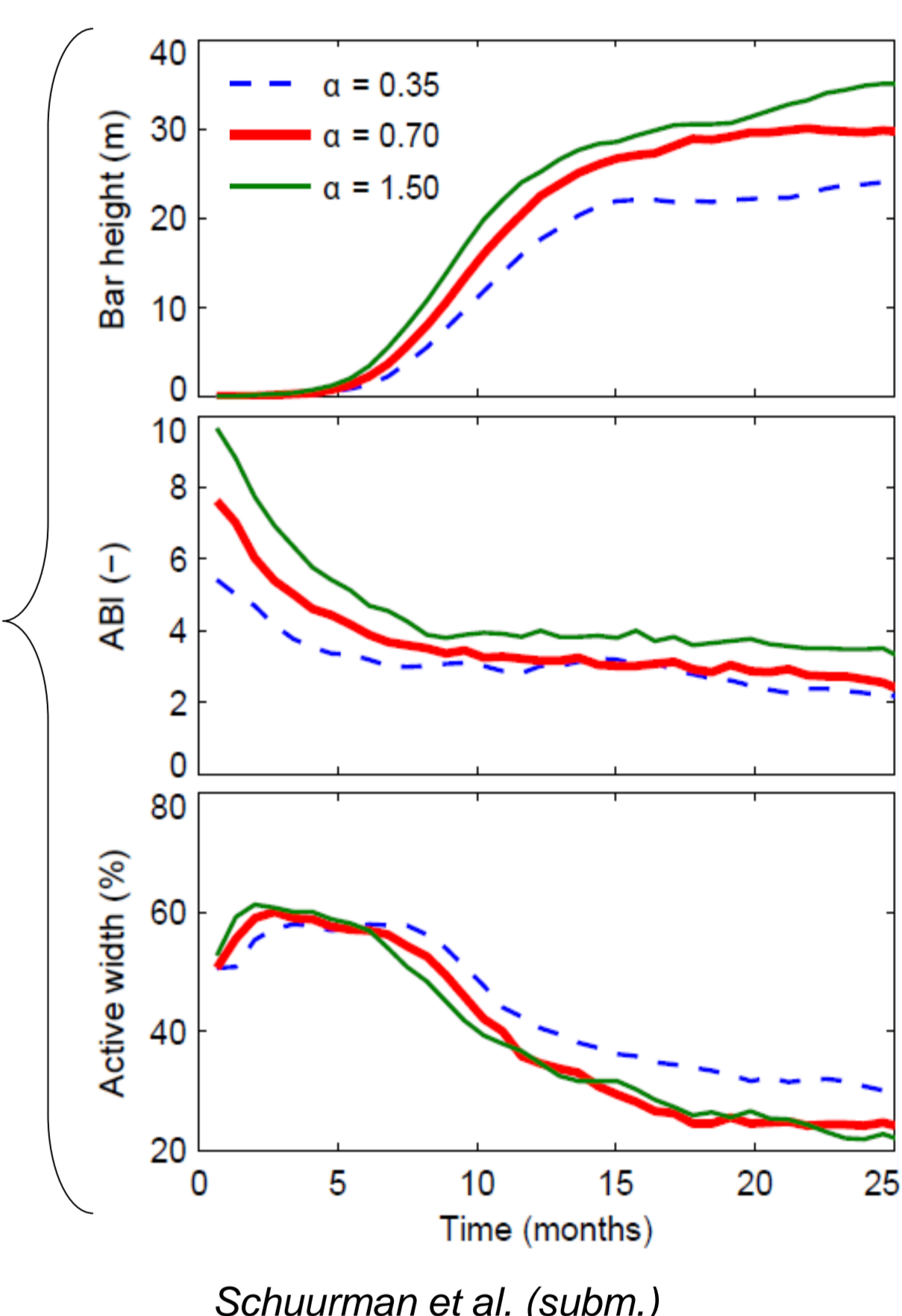


Results

Modeling of braid-bar morphology

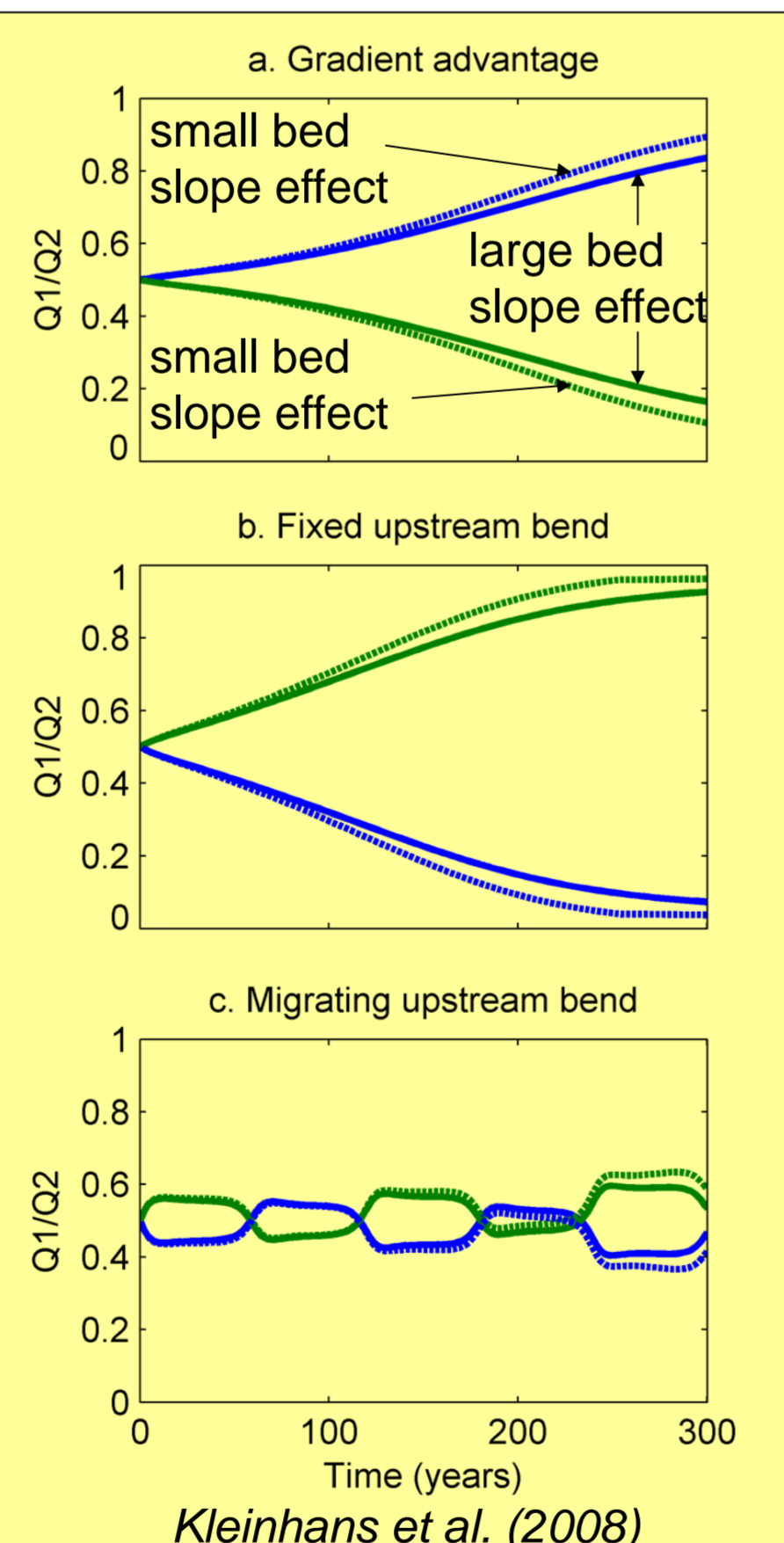


- Slope of bar edges is highly affected by bed slope effect
- Unrealistic bar shapes without bed slope effect!
- Larger scale bar pattern, e.g. braiding intensity, active channel width and bar height, is affected by bed slope effect
- In our braided river simulations, bed slope effect has much larger influence than spiral flow



Bifurcations

- Bifurcation stability affected by bed slope effect
- Non-uniformity, e.g. upstream bend (partly) counterbalanced by bed slope effect
- Large bed slope effect → slow bifurcation evolution



Quantification

Rotation of bed load vector by bed slope effect, using Koch & Flokstra (1981):

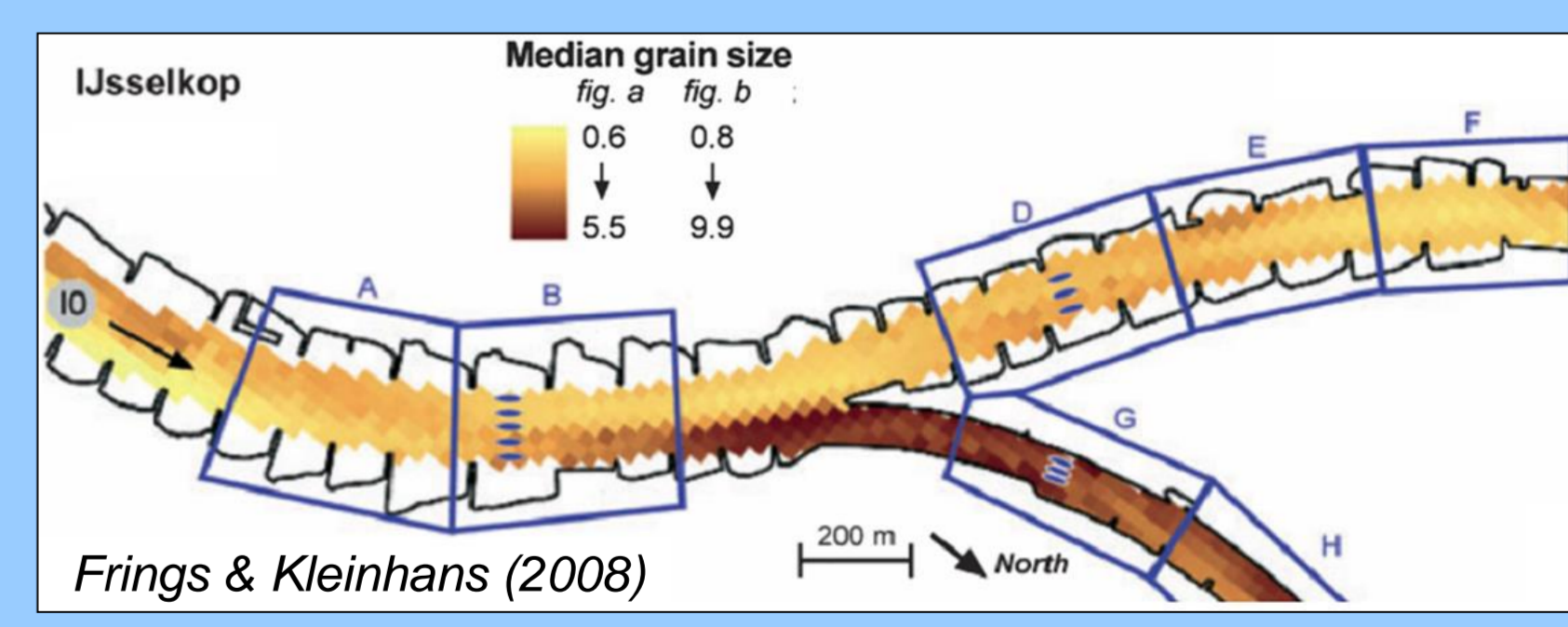
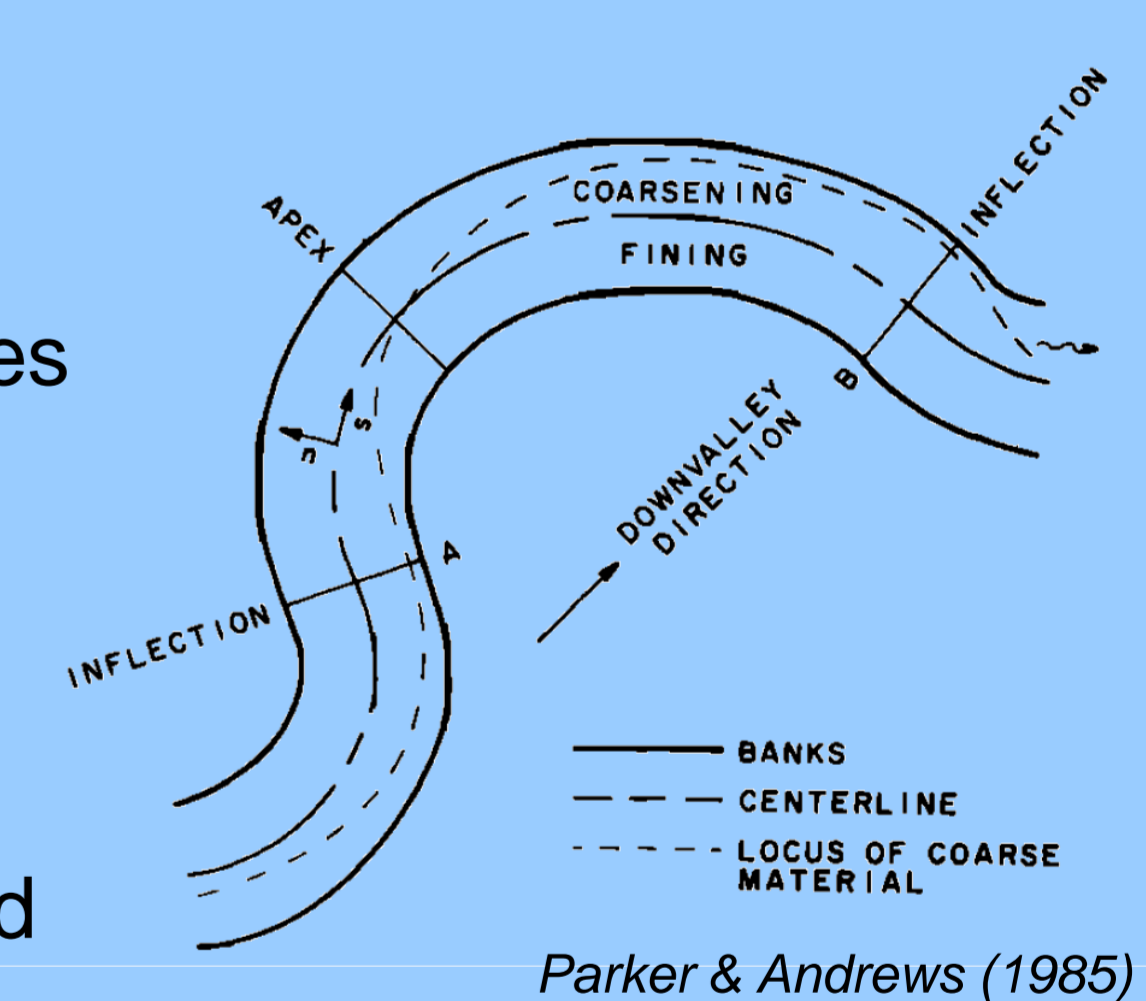
$$\tan(\varphi_s) = \frac{\sin(\varphi_r) \frac{1}{\alpha \theta^\beta} \frac{\partial z_b}{\partial n}}{\cos(\varphi_r) \frac{1}{\alpha \theta^\beta} \frac{\partial z_b}{\partial s}}$$

Parameters α is empirically derived $O(1)$, based on bar properties β is usually 0.5.

Struikma et al. (1985)

Grain sorting

- Bed slope affects grain sorting on transverse slopes
- Large grains → large bed slope effect
- In meander bends: fine grains in inner bend and coarse grains in outer bend



Conclusions

- Bed slope affects bar pattern, grain sorting and bifurcations
- Larger bed slope effect:
 - Low braiding intensity
 - Low bars
 - Fine grained inner bend
 - Slow evolution of bifurcations
- Bed slope effect is a indispensable process in physics-based morphodynamic models
- Effect not understood well enough, fundamental research is needed

Acknowledgements

- Netherlands Organisation of Scientific Research (NWO) (grant ALW-Vidi-864.08.007 to MGK)
- Technical support from Deltares: C.J. Sloff, E. Mosselman and B. Jagers
- Cooperation with Royal HaskoningDHV

Applications

- Scour depth has implications for subsurface architecture and stability of structures
- Morphodynamic modeling for maintenance of navigation channel and river measures

