Determining morphological stability of tidally-influenced bifurcations

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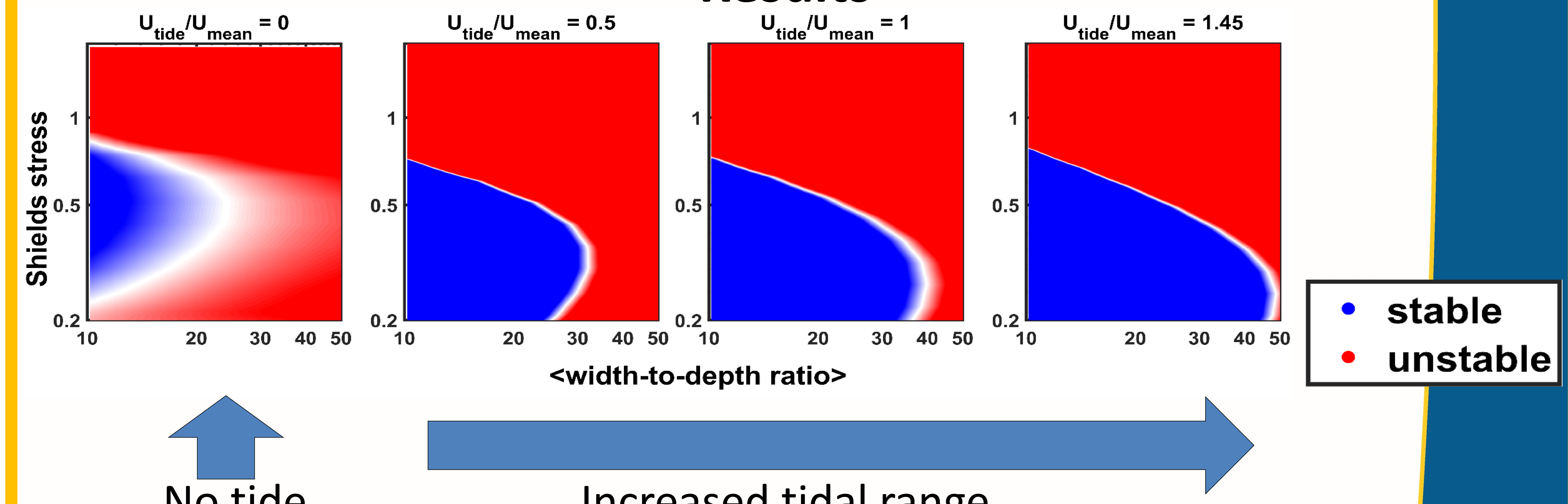
Introduction

The morphology of river bifurcations often evolves asymmetrically, resulting in an avulsion (unstable bifurcation). Observations suggest that bifurcations in tidally influenced systems are stable; however, the stability theory has not been applied to tidal systems. This is because of the presence of bi-directional flows induced by tides, suspended load dominated condition, and typical low channel slopes in tidal deltas and estuaries.

Objective

we aim to study the morphological stability of bifurcations in the range from river- to tide-dominated systems.

Results



Methods

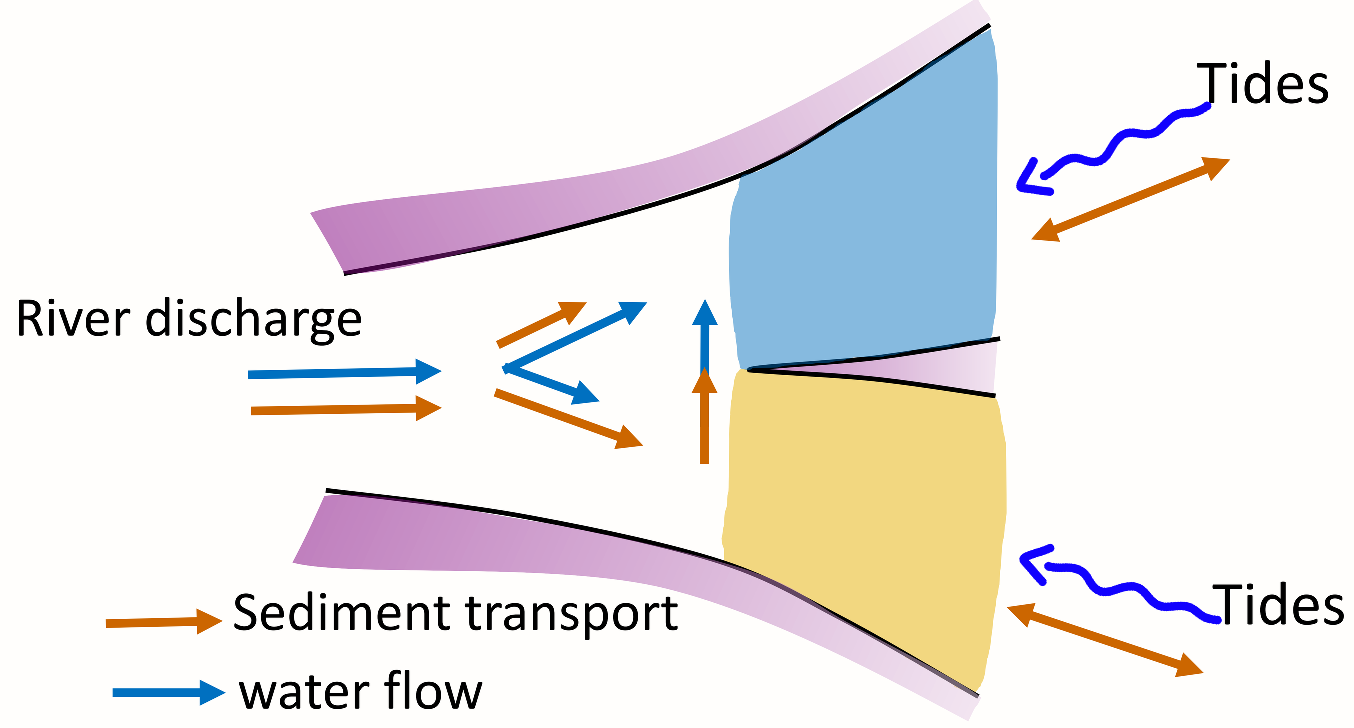
Develop 1D numerical model that solves

- the 1D shallow water equations: mass and momentum balance
- sediment transport: van Rijn 1984
- Sediment division: Bolla Pittaluga et al. (2015)
- Mophological update: Exner equation

Perturb symmetric bifurcation by deepening one of the branches

Does asymmetry grow?

$$depth\ ratio = \frac{h_1 - h_2}{h_1 + h_2}$$



Conclusion

- Tides can counteract the avulsion process that would occur in river-dominated deltas.
- Increasing tidal range drives a stable bifurctaion for larger range of Shields numbers and width/depth ratios.

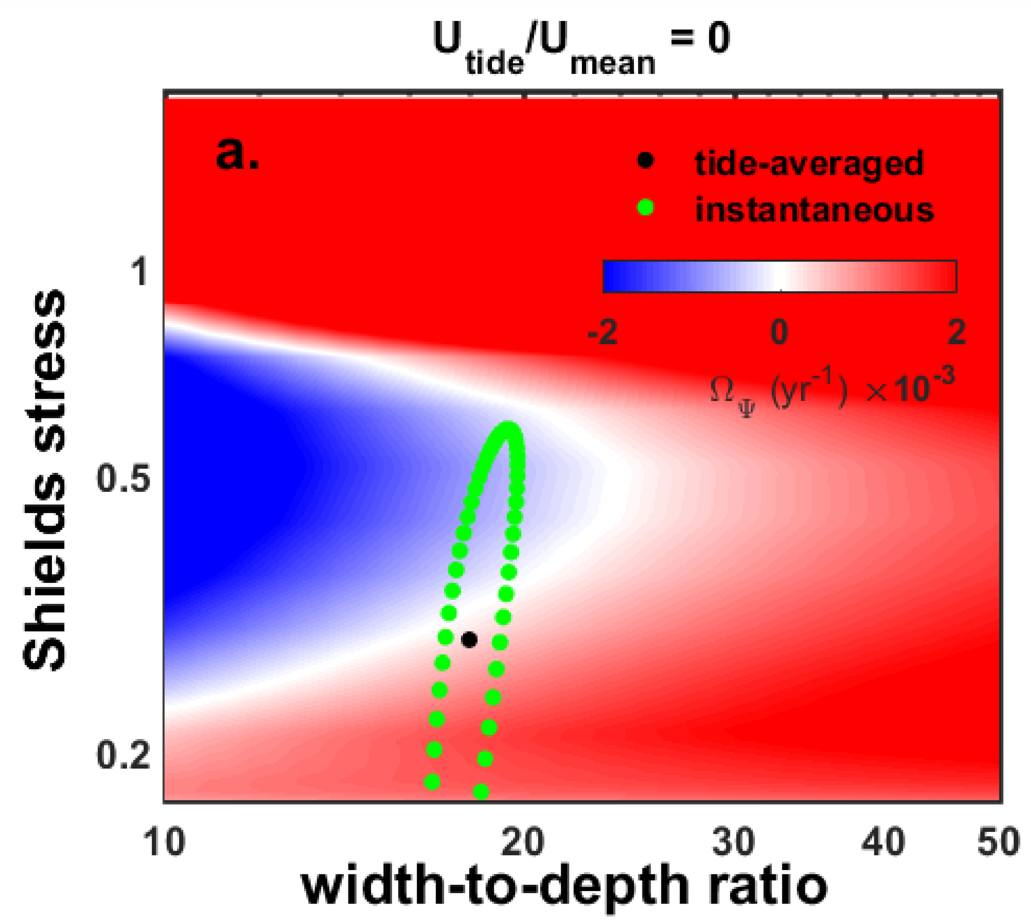
Reference

Bolla Pittaluga, M., Coco, G., & Kleinhans, M. G. (2015). A unified framework for stability of channel bifurcations in gravel and sand fluvial systems. *Geophysical Research Letters*, *42*(18), 7521–7536. http://doi.org/10.1002/2015GL065175

van Rijn, L. C.: Sediment transport, part I: Bed load transport, J. Hydraul. Eng., 110(10), 1431–1456, doi:10.1061/(ASCE)0733-9429(1984)110:10(1431), 1984a.

van Rijn, L. C.: Sediment transport, part II: Suspended load transport, J. Hydraul. Eng., 110(11), 1613–1641, doi:10.1061/(ASCE)0733-9429(1984)110:11(1613), 1984b.

Why?



We analyse the case with small tides and observe a condition that is unstable for U_{tide}/U_{mean} = 0 but stable for U_{tide}/U_{mean} = 0.5. The instantaneous Shields stress and width-to-depth ratio in one tidal cycle are observed and overlaid in river-only diagram. The growth of asymmetry changes in one tidal cycle and determines the tide-averaged growth.