Abstract number: EP31D-1896

Dimensions and shapes of tidal-fluvial meanders – are the final meanders of a river disproportionally large?

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Introduction

Many river mouths reputedly have one or a few excessively large meanders in the tidal-fluvial transition (e.g. Thames, Salomon, see Fig. 1). Relations for meander size are either derived from rivers or small tidal creeks. Here we present data of 72 fluvial-tidal transitions to test whether meanders at the transition are indeed much larger than the upstream fluvial meanders.

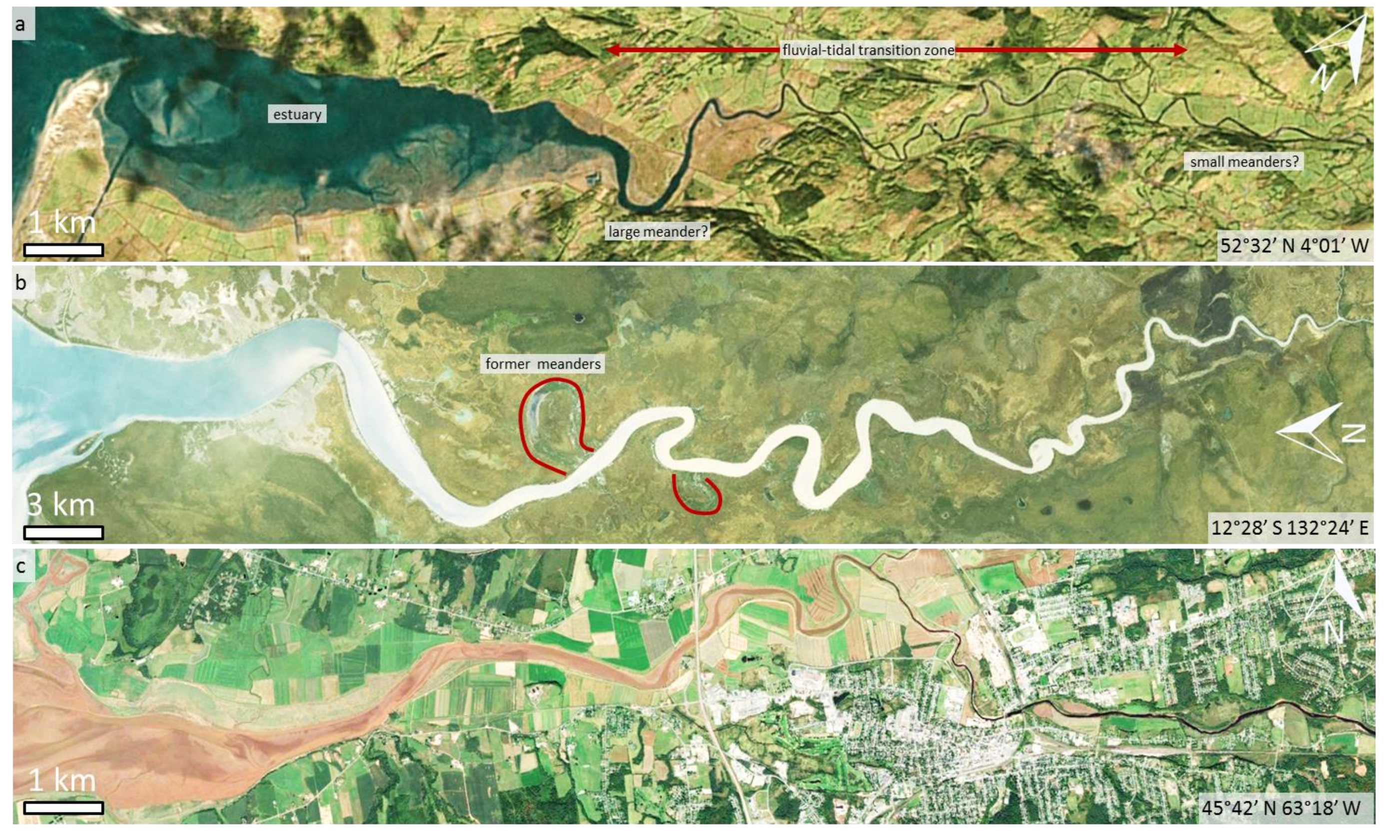


Fig. 1: Aerial photographs of fluvial-tidal meanders. (a) Dovey, UK; (b) Kakadu, northern Australia; (c) Salomon river, Cobequid bay, USA.

Methods

- **Digitized the outline of 800 meanders in 72 rivers that transition from land into the sea;**
- **Extracted the channel centerlines and calculated inflection points;**
- **Derived meander dimensions: wavelength, amplitude, sinuosity;**
- **In multi-channel estuaries, the main meandering channel was used.**

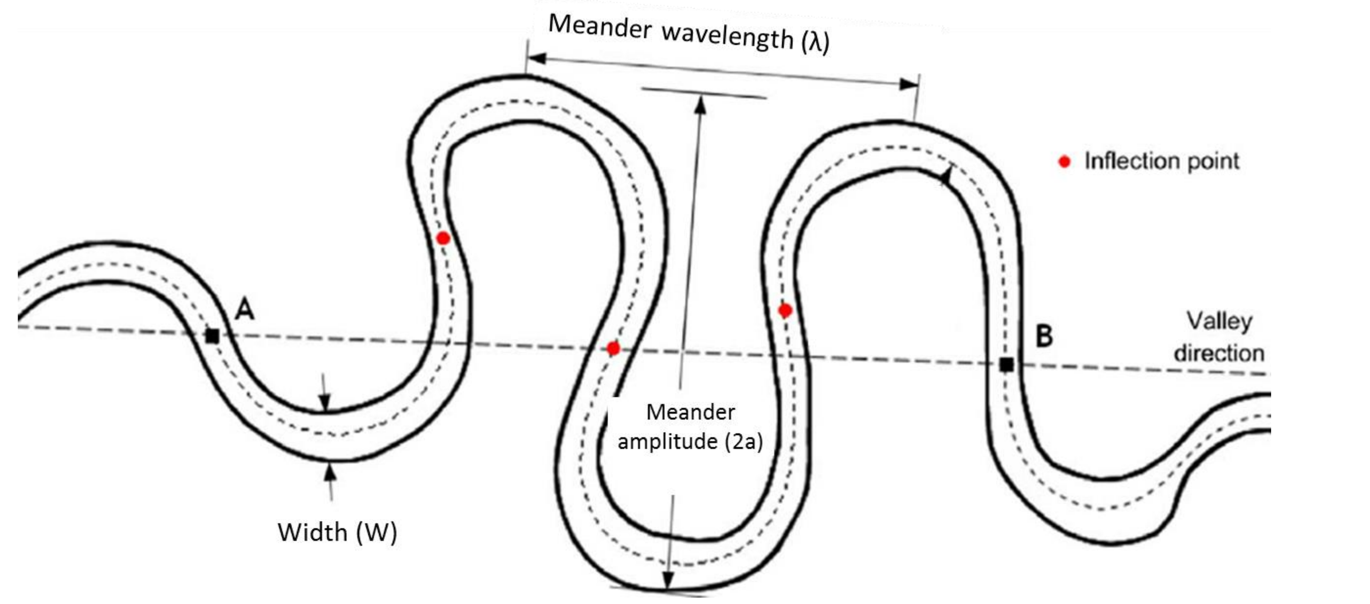


Fig. 2: Definitions of channel width (W), meander wavelength (λ), meander amplitude (2a) and inflection points. Inflection points are determined as the locations where the curvature changes from positive to negative or vice versa. (Modified from Güneralp and Marston, 2012)

Meander dimensions

- **Wavelength and amplitude increase in seaward direction (Fig. 3 & 4);**
- **Estuarine meanders are on average 4 times larger than their landward counterpart (Fig. 3);**
- **Landward meanders set the minimum meander dimensions and correspond to Leopold and Wolman (1960) and Struiksma et al. (1985).**

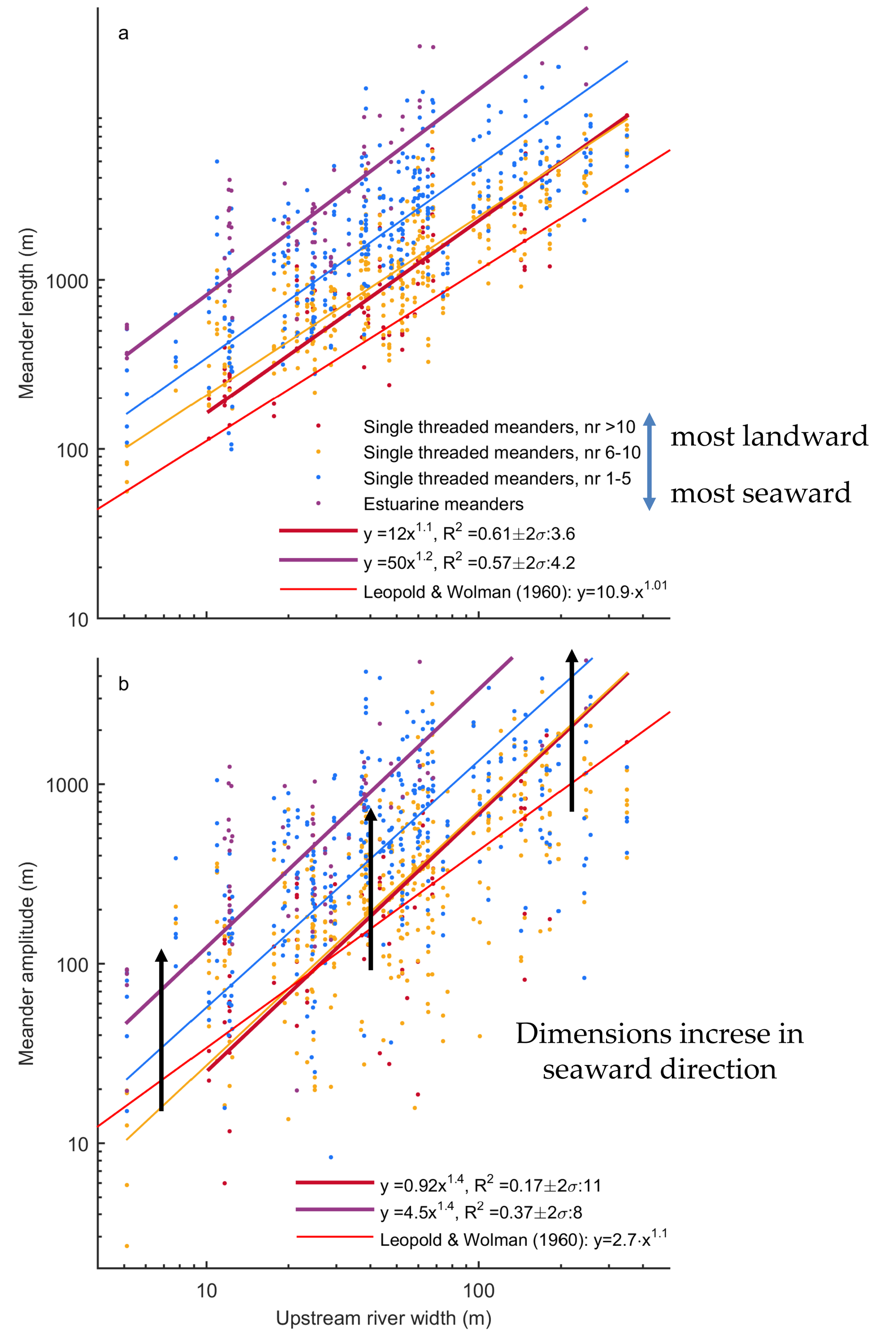


Fig. 3: Meander dimensions increase in seaward direction. Meander length (a) and amplitude (b) as a function of upstream river width.

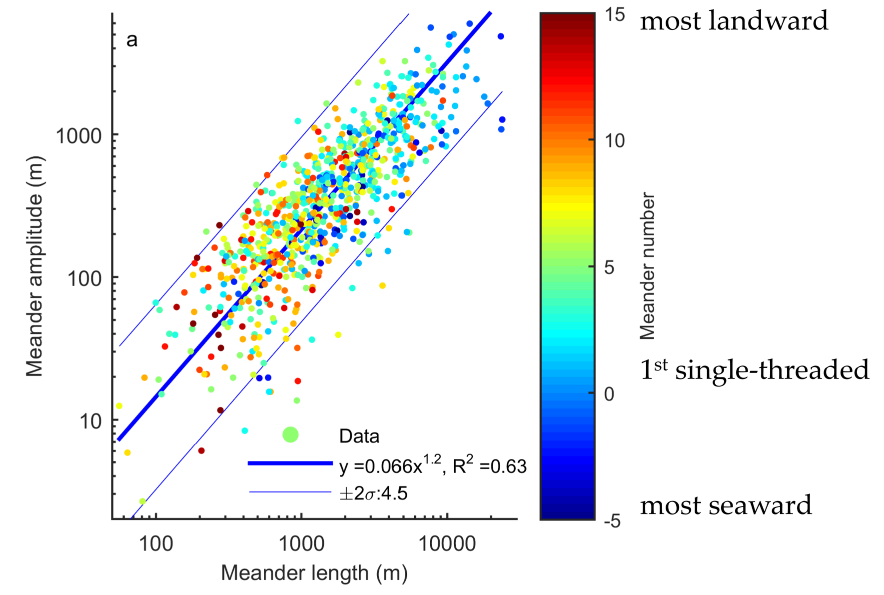


Fig. 4: Good correlation between meander amplitude and length, but lack of correlation with position in the fluvial-tidal transition.

Proportionality to channel dimensions

- **Meander dimensions scale with local channel width (Fig. 5);**
- **Meander dimensions are not disproportionally large when compared to the local channel dimensions (Fig. 5);**
- **Increase in meander dimensions scales with the channel width convergence length (Fig. 6).**

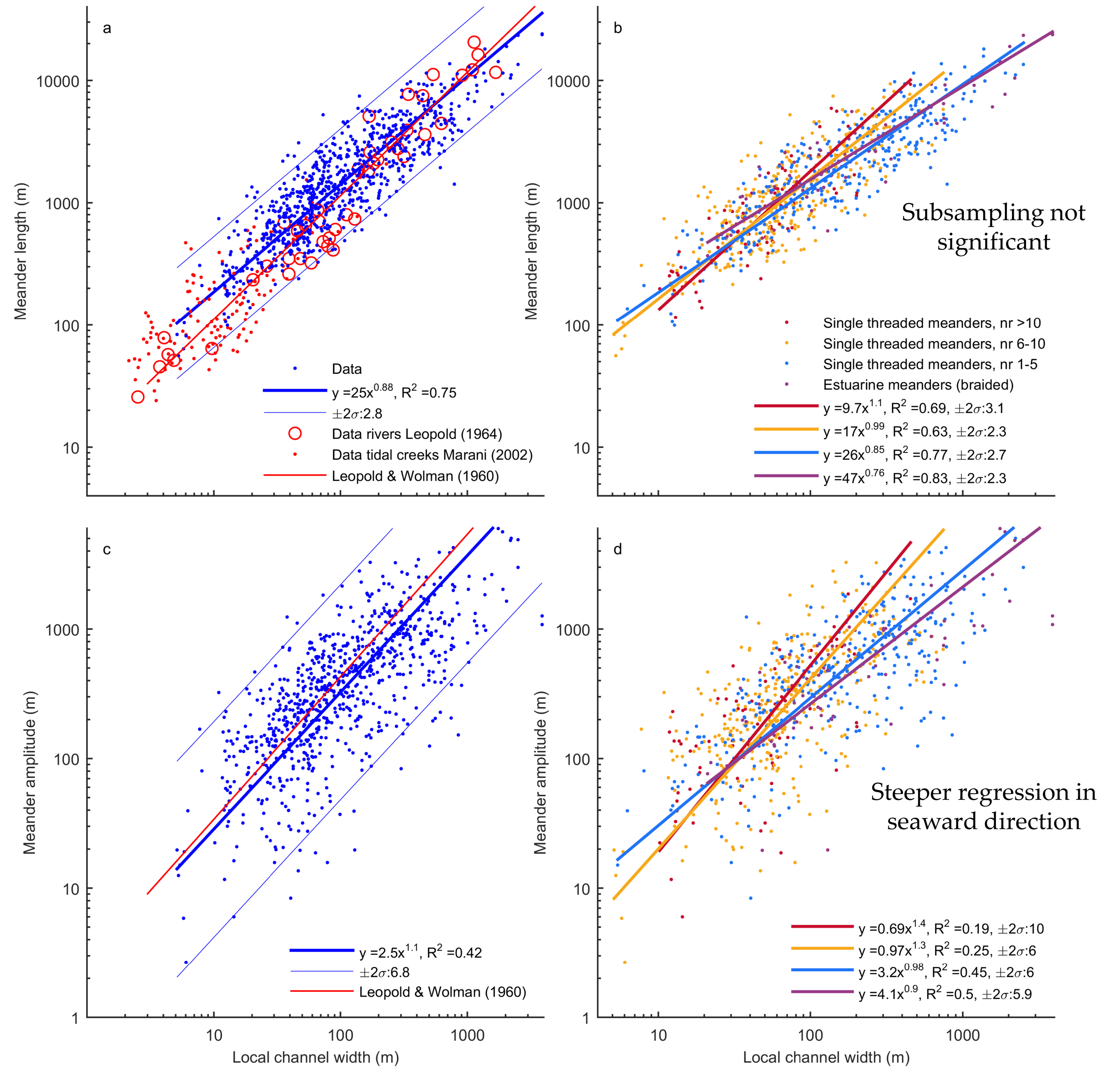


Fig. 5: (a,c) Meander dimensions scale with local channel width. (b,d) Subsampling shows that the relations are independent on the position along the transition zone.

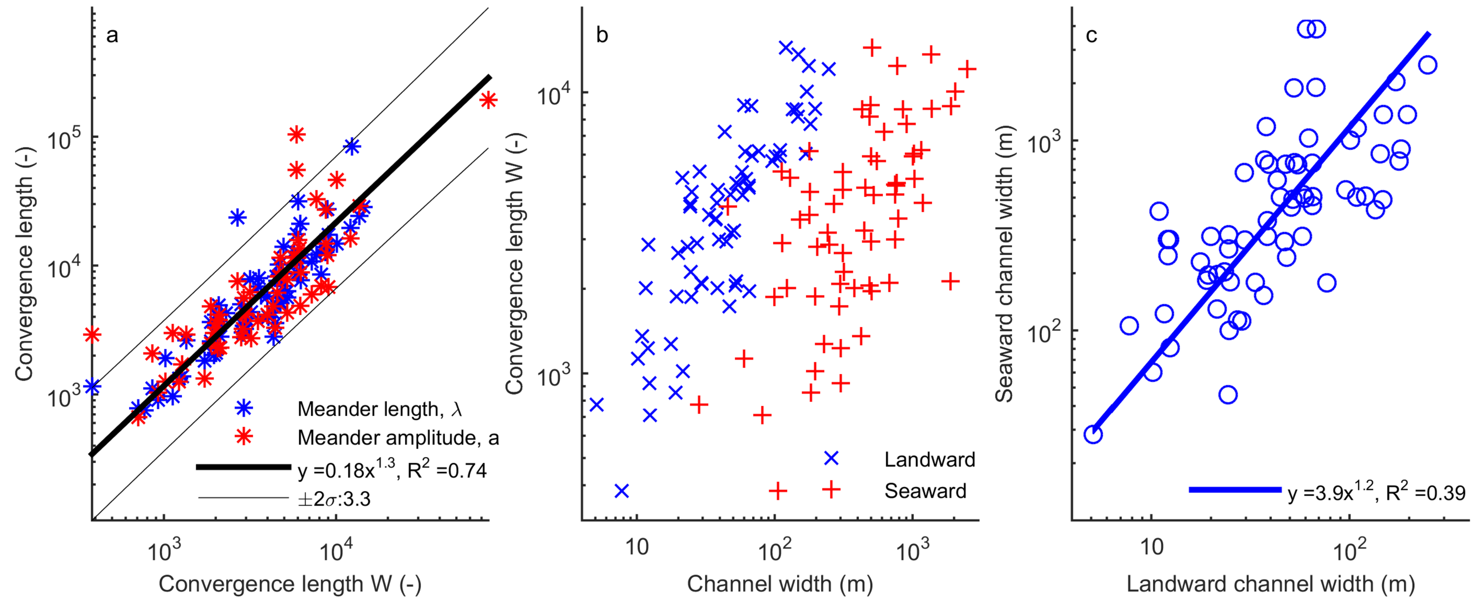
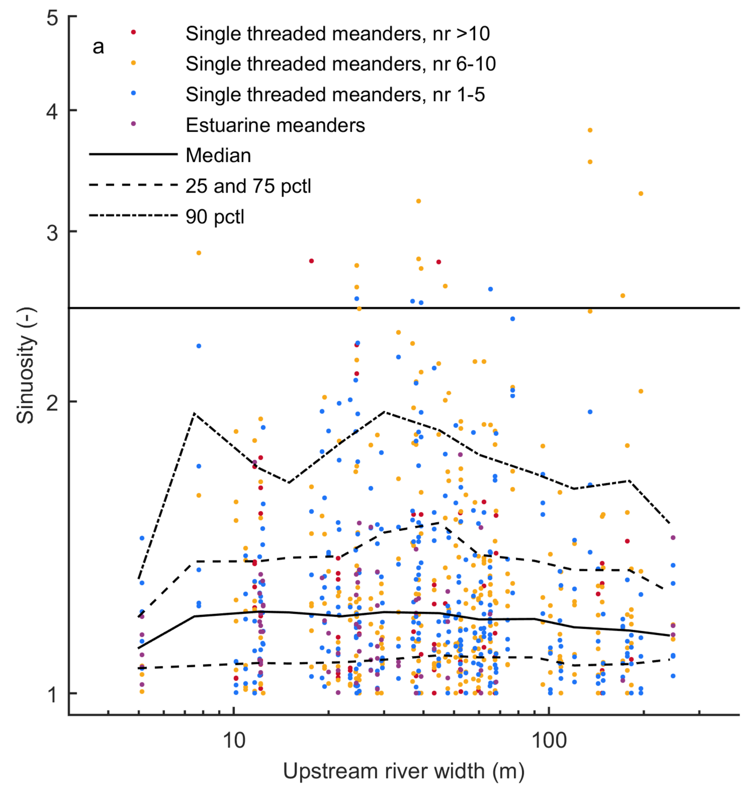


Fig. 6: The degree to which meander dimensions increase in seaward direction scales with the width convergence length (a), defined as the distance over which the width increases with a factor e (≈2.72). (b) The width convergence length scales better with upstream channel width than with seaward channel width. (c) Smaller river systems generally transition into smaller channels at the mouth and larger systems vice versa, but scatter is relatively large.

Sinuosity peaks above 2.5?

Literature suggests that channel sinuosity systematically peaks above 2.5 in the fluvial-tidal transition zone (Dalrymple et al., 2012).

Fig. 7: Meander sinuosity as a function of upstream river width, showing that only 11 systems out of 72 have meanders with a sinuosity that peaks above 2.5.



- **Only 11 of the 72 systems peak above 2.5;**
- **Highest values mostly meander numbers between 6-10;**
- **Degree of sinuosity lacks correlation with the size of the tidal system.**

Conclusions

- **Meander dimensions increase in seaward direction;**
- **Increase in dimensions is proportional to the channel width;**
- **The landward river width sets the minimum dimensions and the downstream dimensions scale with the upstream river;**
- **The main meanders in the multi-channel estuary are typically 4 times larger;**
- **Sinuosity peaks above 2.5 are rather an exception than a rule for tidal-fluvial meanders;**
- **Meanders in the transition zone are not excessively large beyond the usual spread and seaward change.**

References

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NWO Applied and Engineering Sciences

Dec 2017