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# How does channel pattern generate unsteady bedload transport?


Trevor Hoey, **Richard Williams**, Laura Quick, Richard Boothroyd, Pamela Tolentino, and Carlos Primo David

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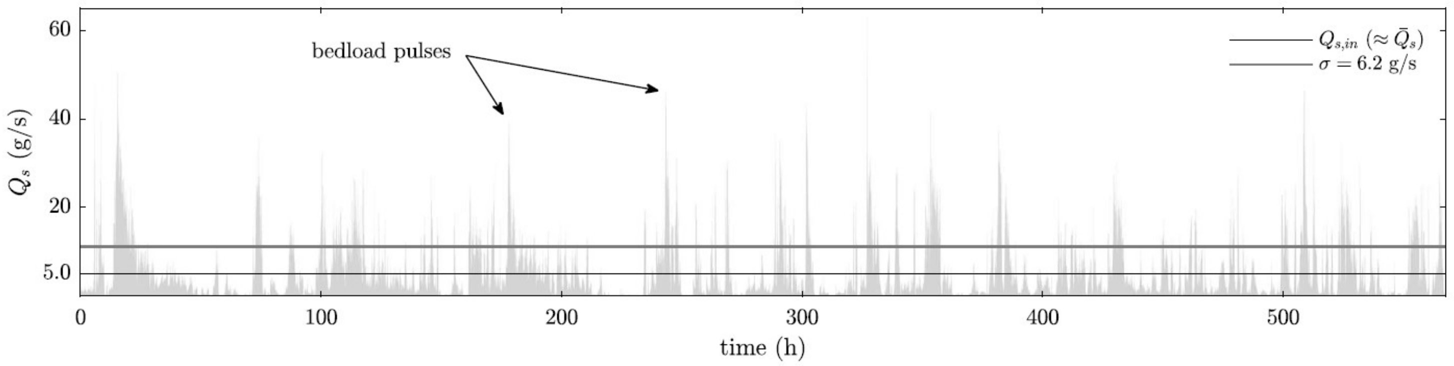
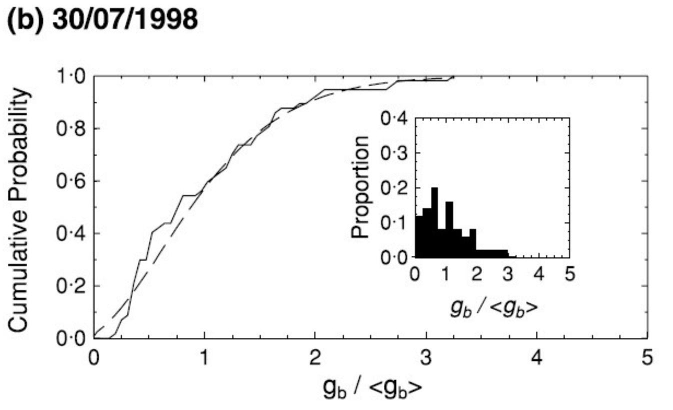
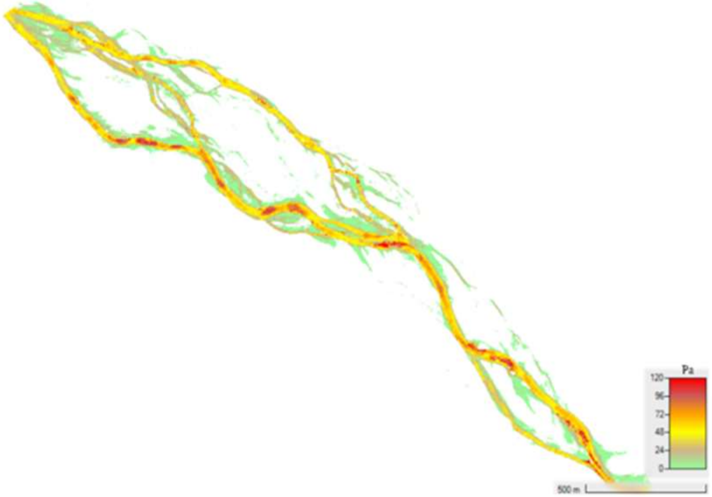
# Unsteady bedload transport




Laboratory flume, 5.5 mm gravel Dhont & Ancey, *GRL*, 2018




Field (Arolla), D50 = 50 mm, poorly sorted
Cudden & Hoey, *ESPL*, 2003



Numerical (HECR-RAS 2D) model Devoll, Albania
D50 = 19 mm; Balouchi et al., *RRA*, 2024

- Pulses occur over a range of scales
- Described by skewed frequency distributions
- Causal mechanisms at all scales:
  - turbulence
  - grain sorting
  - bedform dynamics
  - reach-scale stress variability
  - advection-diffusion of sediment inputs

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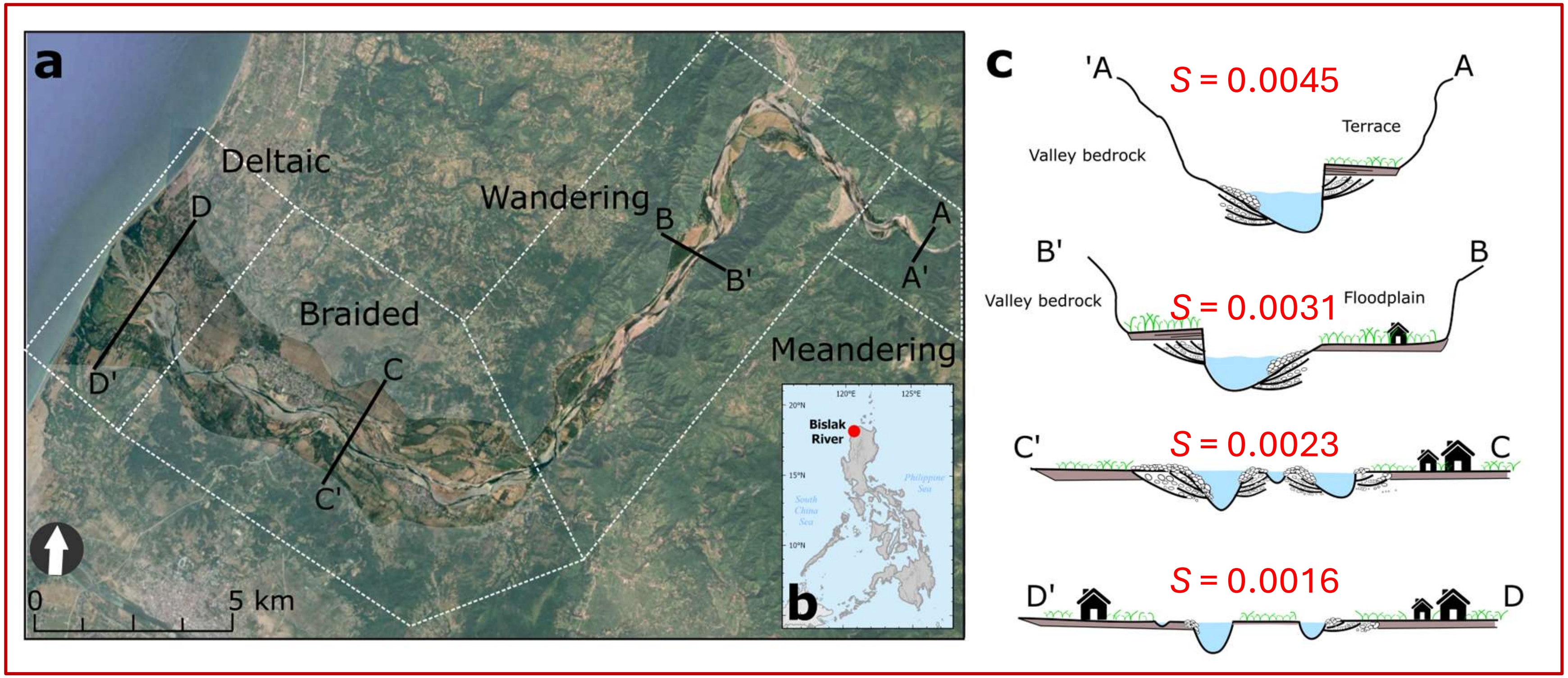
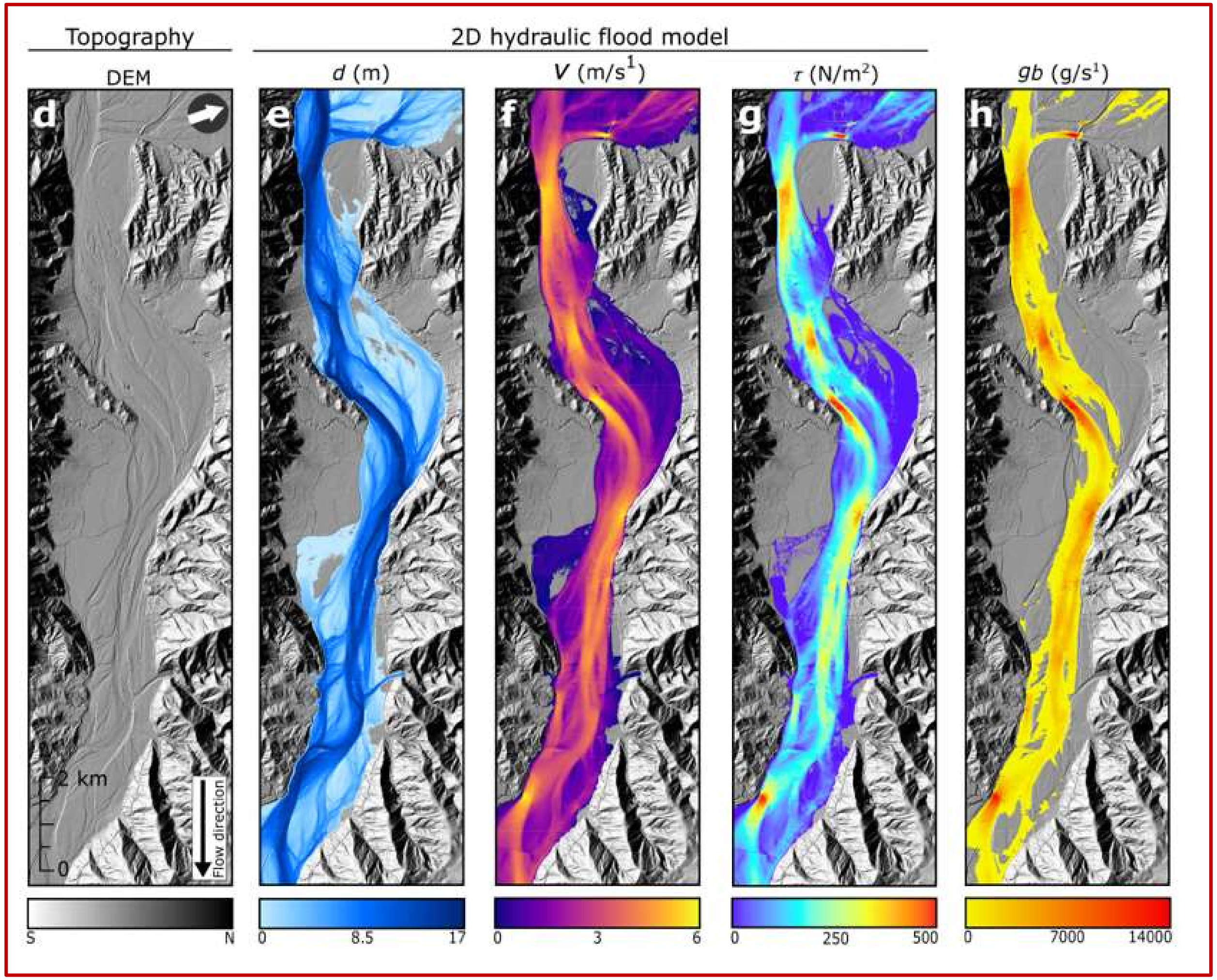
# Hypothesis: channel pattern controls bedload variability



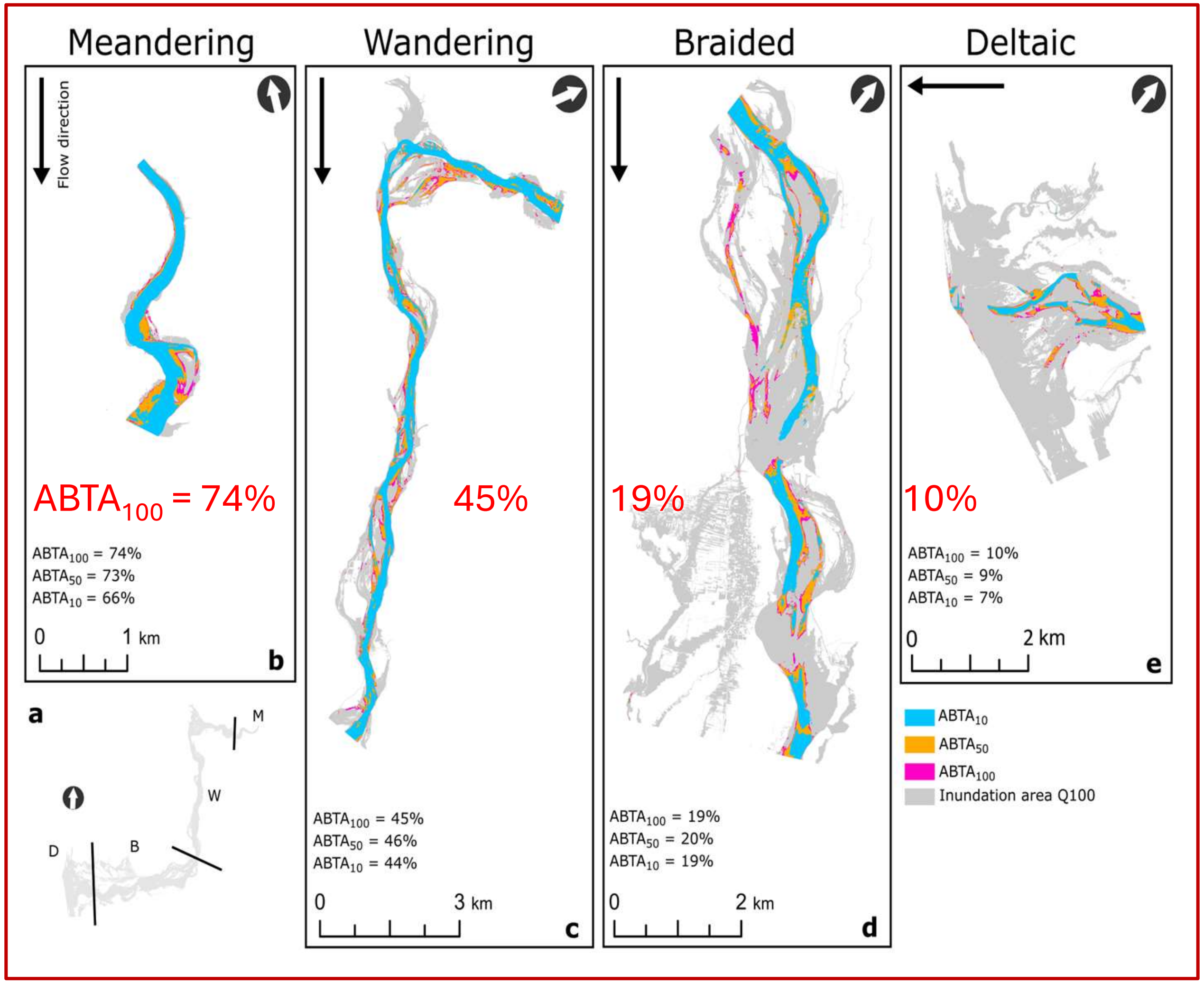

- Bislak River, N Luzon, the Philippines
- Four adjacent reaches – from confined meandering to unconfined deltaic
- Seasonal flow (Dry season Nov – March; wet season peak June – August)

# Summary methodology



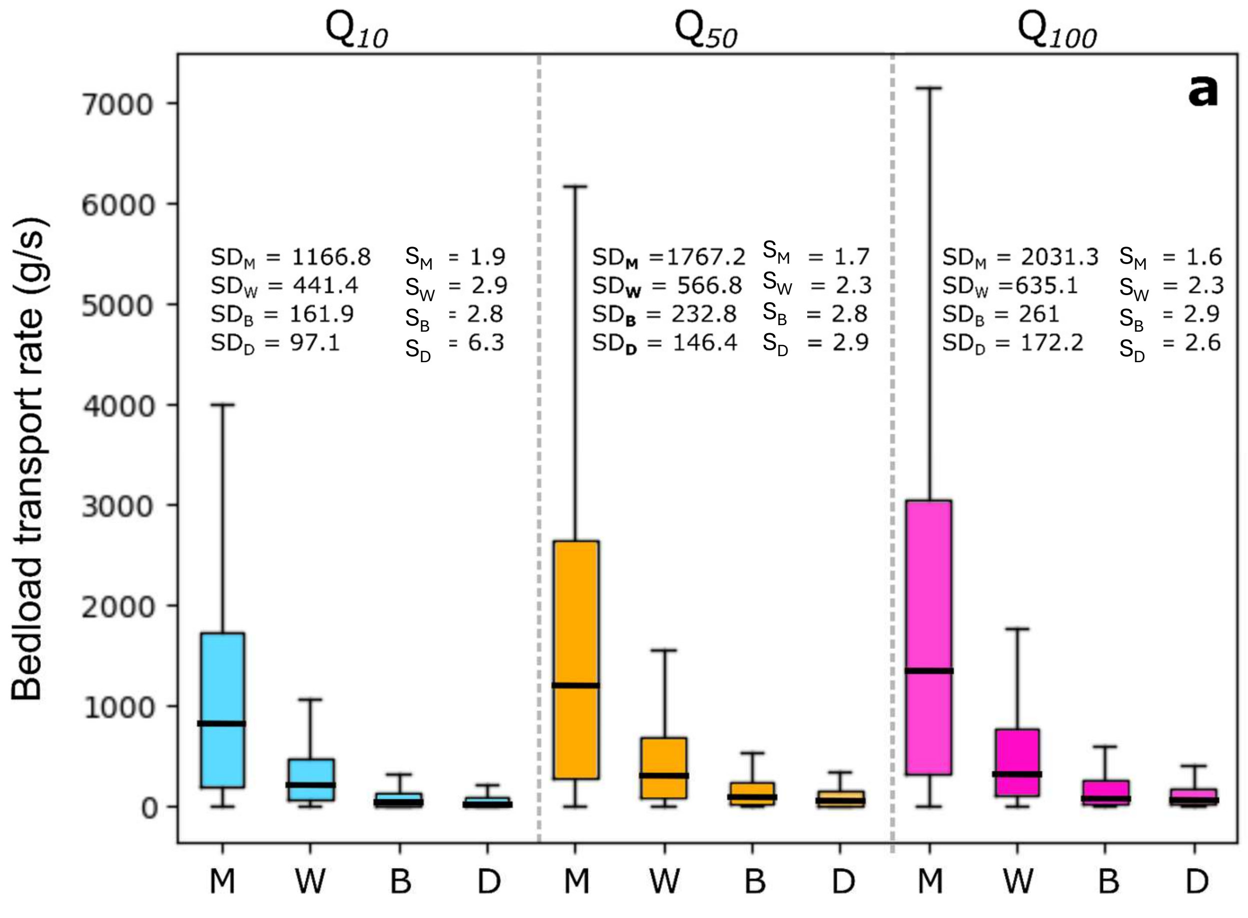

- 0.5m resolution DEM
- HEC-RAS predictions of hydraulics and bedload transport ($Q_{100}$ event)
- Bedload uses constant grain-size distribution and generalised Meyer-Peter and Müller equation
- Statistics extracted for each of the 4 reaches

# Bedload transport locations



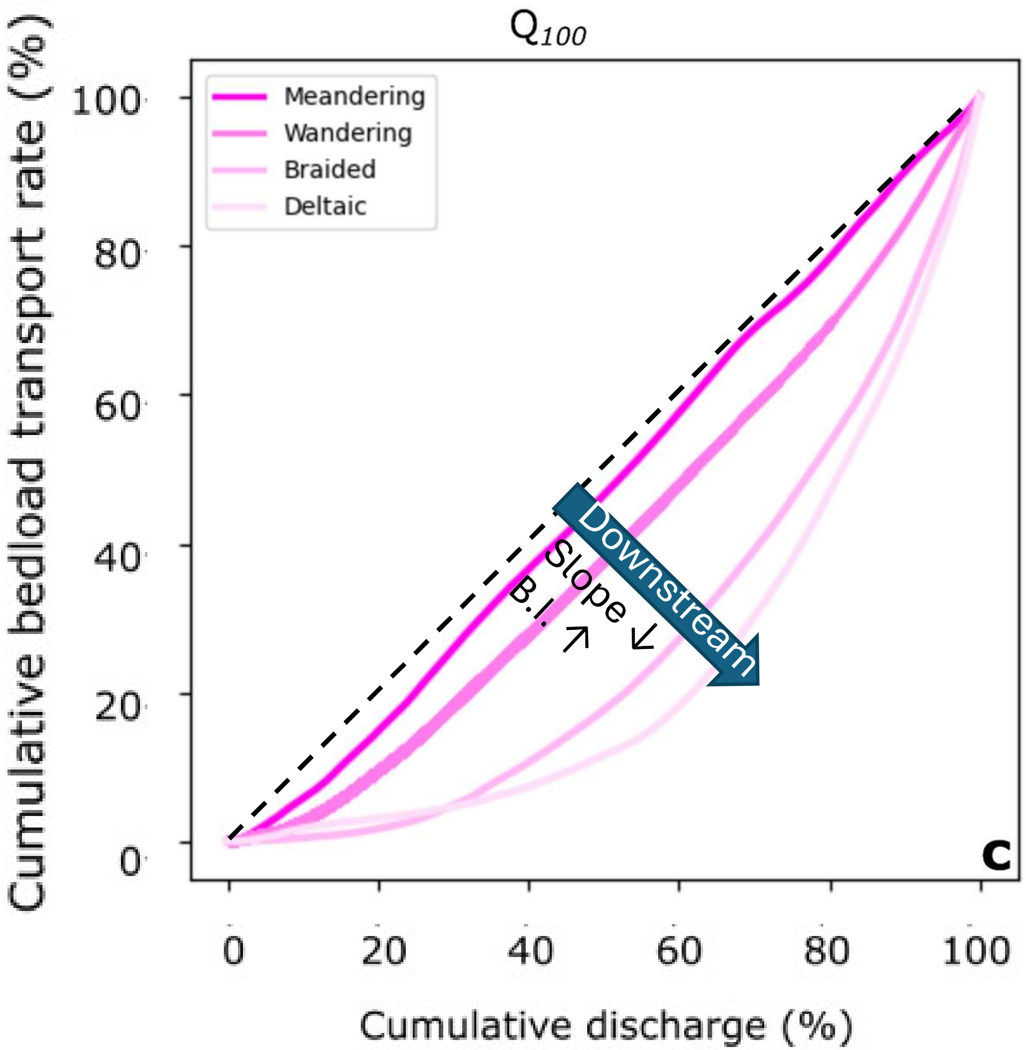

- Areas with $\tau > \tau_c$ shown
- Coloured areas are for $Q_{10}$, $Q_{50}$, $Q_{100}$
- Proportion of bed with active transport (ABTA) stable with increasing $Q$
- ABTA decreases as flow spreads (74% to 10% for $Q_{100}$)

# Frequency distributions of bedload



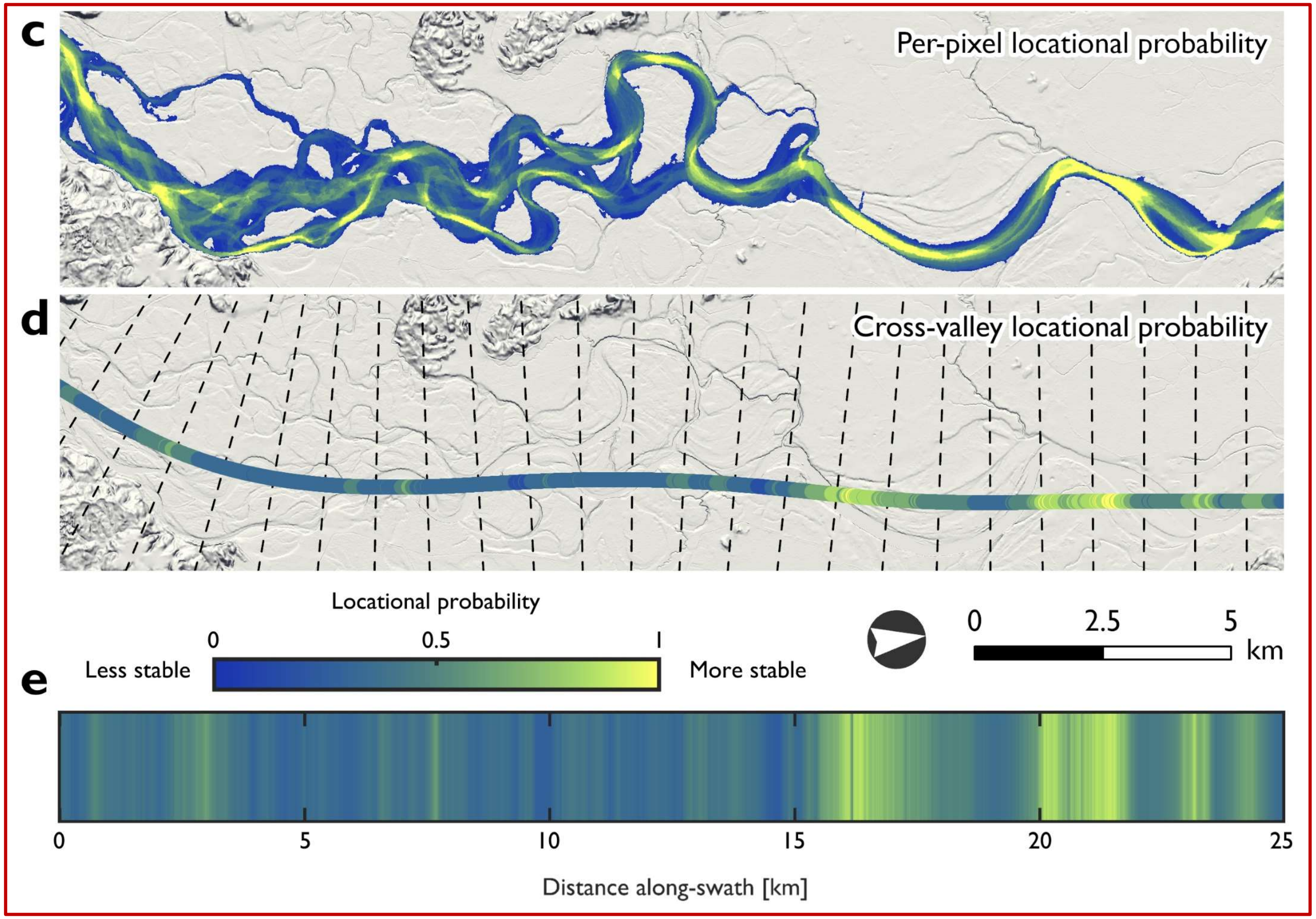

- Mean, Median and s.d. all decrease downstream
- Skew low in confined meandering reach
- Results change little for different *Q* values
- Also change little if $D_{50}$ is varied

# Cumulative frequency distributions



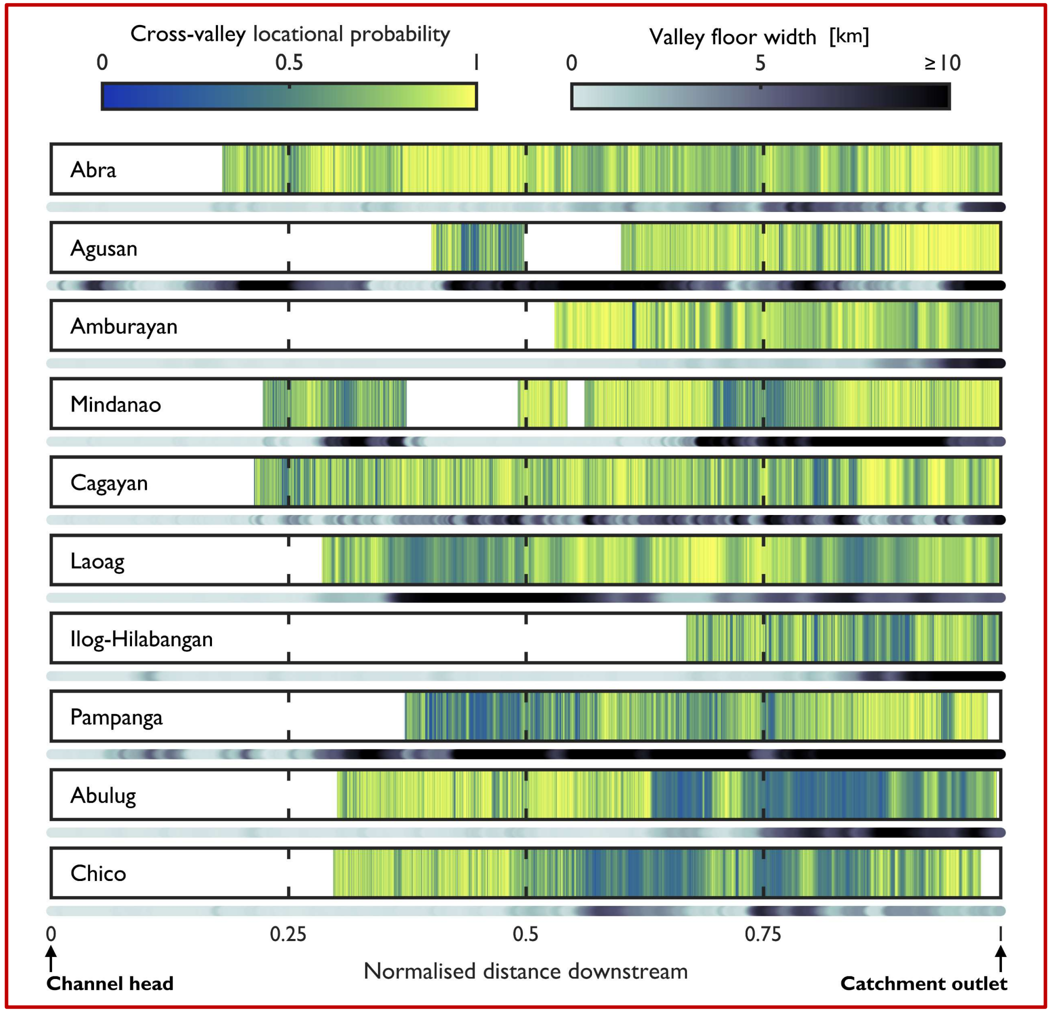

- Data converted to cumulative form
- Dashed line for bedload in proportion to discharge in all cells
- More concave curves show greater spatial variability in bedload
- Variability increases as slope falls and braiding index rises downstream
- What does this imply for river channel change and temporal dynamics?

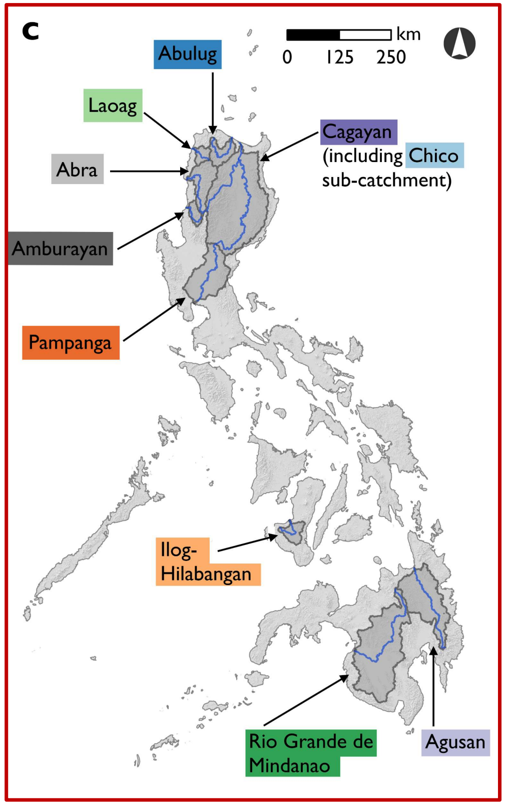
# Locational probabilities reveal hotspots of change


Boothroyd et al, 2025, *Nature Communications* doi.org/10.1038/s41467-025-58427-9

# Spatially heterogeneous nature of river planform mobility




Boothroyd et al, 2025, *Nature Communications* doi.org/10.1038/s41467-025-58427-9

# Conclusions

- Reach-scale hydraulic properties determine reach-scale distributions of bedload transport
- Less confined, braided and deltaic patterns show much greater spatial variability than more confined meandering and wandering reaches
- Spatially variable bedload transport controls morphological dynamism, which we can now assess at whole-catchment scales
- Assuming that temporally unsteady bedload follows from spatial heterogeneity, braided reaches will experience more variable transport through time, although at lower unit rates, than meandering reaches
- These results have theoretical implications, but also can inform how rivers are managed

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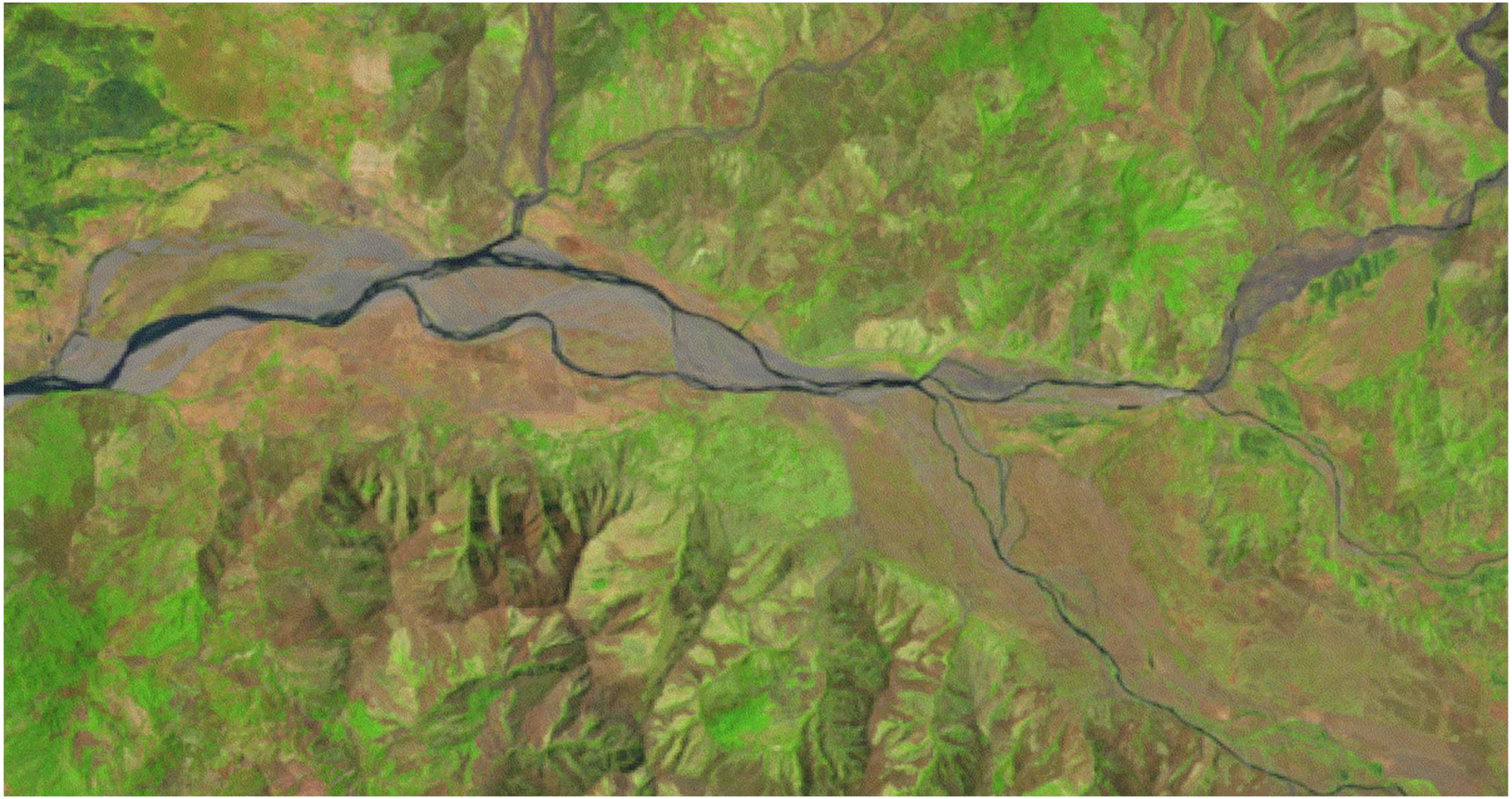
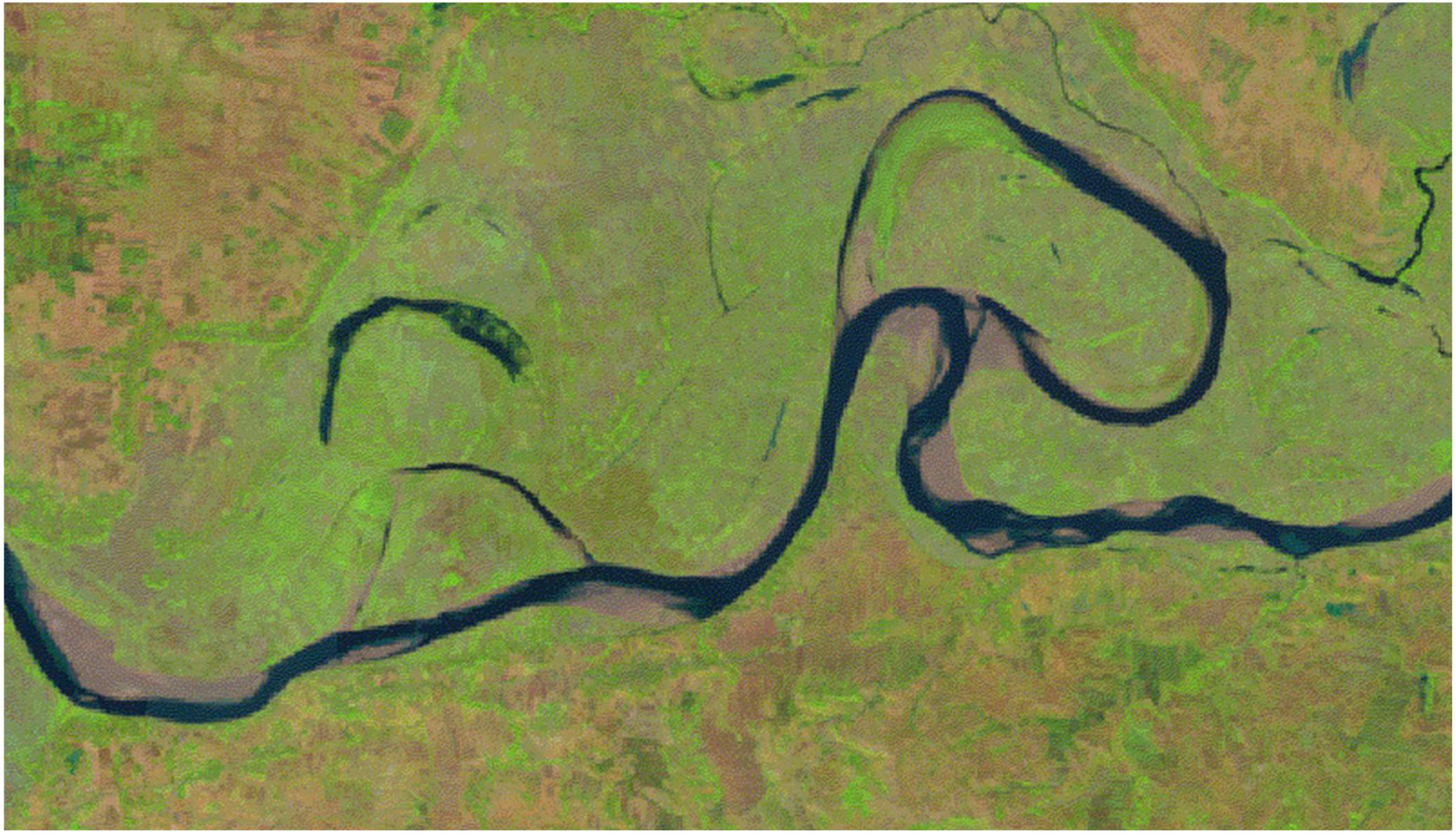
# Braided river adjustment – Bucao River



# Meandering river adjustment – Cagayan River



# Wandering gravel bed river adjustment – Abulug River