The evolving anatomy of a gravel-bed river

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Acknowledgements:

- NERC (UK) & FRST (New Zealand) for funding
- NIWA (particularly Maurice Duncan, Ian Halstead & Jeremy Walsh)
- Environment Canterbury (formerly Canterbury Regional Council)
- Air Logistics (NZ) & Precision Aerial Surveys for aerial photography
- AAM Geodan for ALS survey

Remote sensing = New views of landforms

- Remote sensing technologies allow synoptic measurement of large areas
- For large gravel riverbeds, this potentially represents a huge increase in morphological information (compared to 'conventional' x-section surveys)
- Gravel riverbeds offer important test of remote sensing methods due to large spatial extent with small vertical relief
- This paper shows some of the key findings from a remote sensing monitoring programme of a large gravel-bed river

The Waimakariri River

Method

(1) Digital Photogrammetry:
- 3 surveys (Feb 99, Mar 99 & Feb 00)
- 16 / 22 photos at 1:5000 / 1:4000
- ERDAS Imagine OrthoMAX
- Ground point spacing = 1m

(2) Airborne laser scanning:
- 1 survey (May 00); 3 passes
- Processed inhouse by AAM Geodan
- Ground point spacing = 1m

(a) Dry point elevations

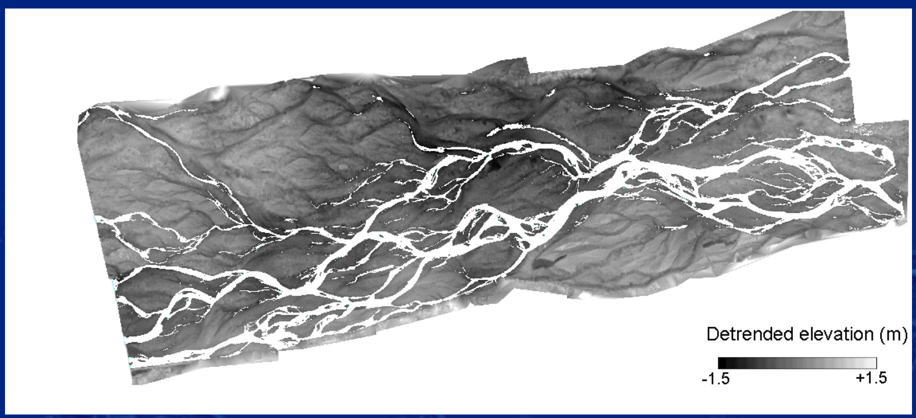
(+ water edge elevations ⇒ estimated water surface elevations)

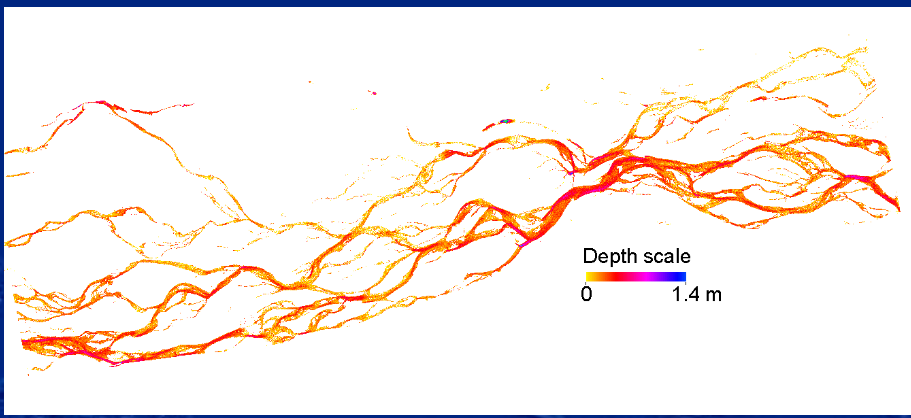
(3) Image Analysis:
- Empirical relationship derived using PCI
- Depth = *f*(ln[water colour]) (Lyzenga, 1981; Winterbottom & Gilvear, 1998)
- Ground point spacing = 1m
- Estimated water depth subtracted from estimated water surface map

(b) Wet point elevations

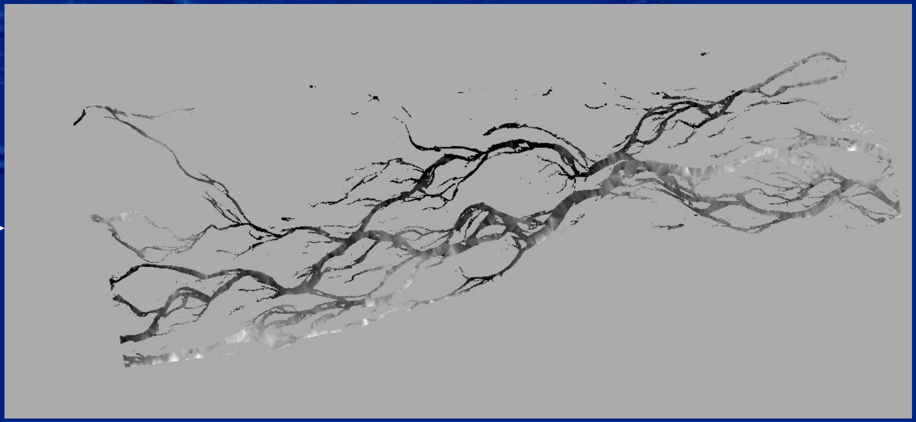
Photogrammetry / ALS

Image analysis





Interpolation across wetted channels



Subtracted from

Merged to give...

Results

- 4 riverbed digital elevation models (DEMs):
  - 3300 x 1300 m study reach
  - Ground spacing of 1m
  - Almost 3000000 point elevations!!
- 3 difference DEMs:
  - Flood-scale (Feb 99 to Mar 99; Feb 00 to May 00)
  - Annual-scale (Feb 99 to Feb 00)

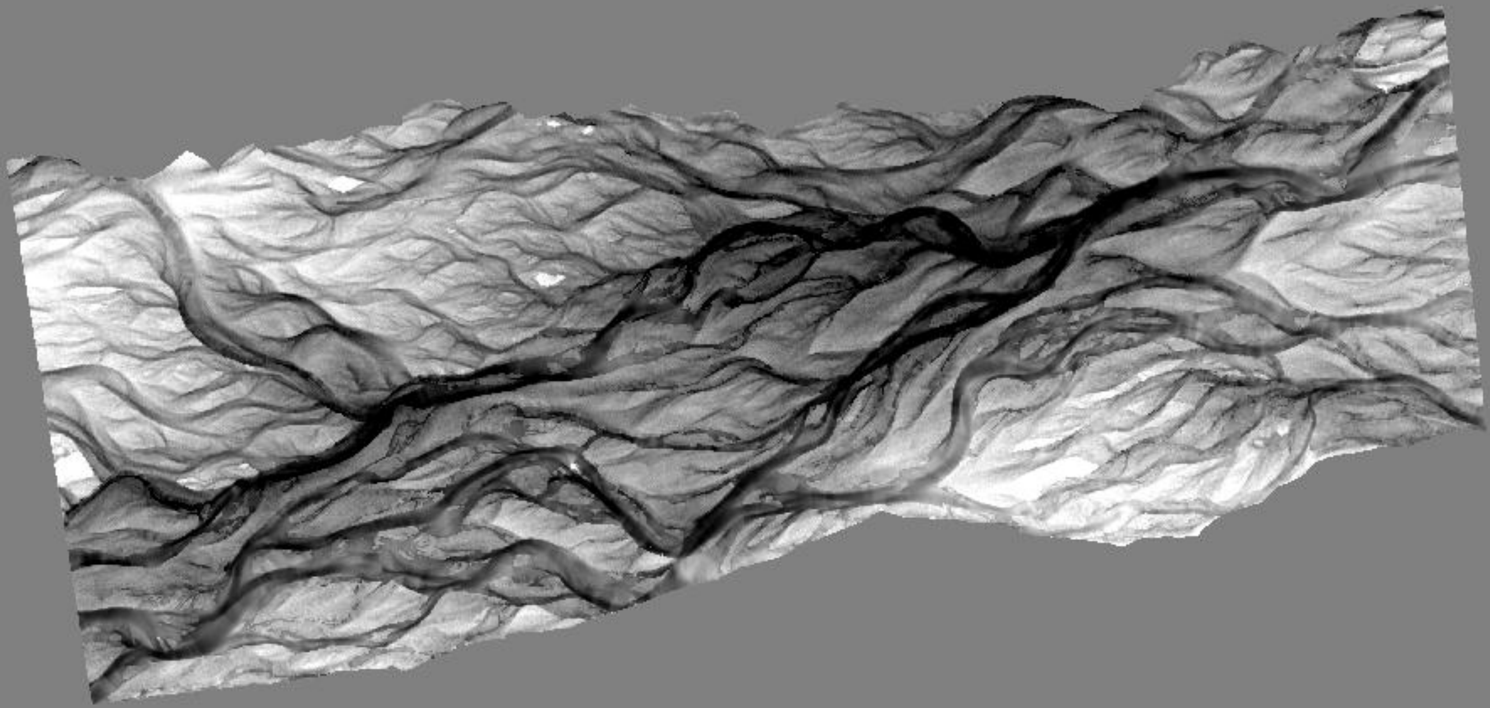
DEM quality

- Assessed in terms of accuracy (mean error, ME) and precision (standard deviation of error, SDE) - after Cooper (1998)
- Estimated by comparing DEM elevations with check data

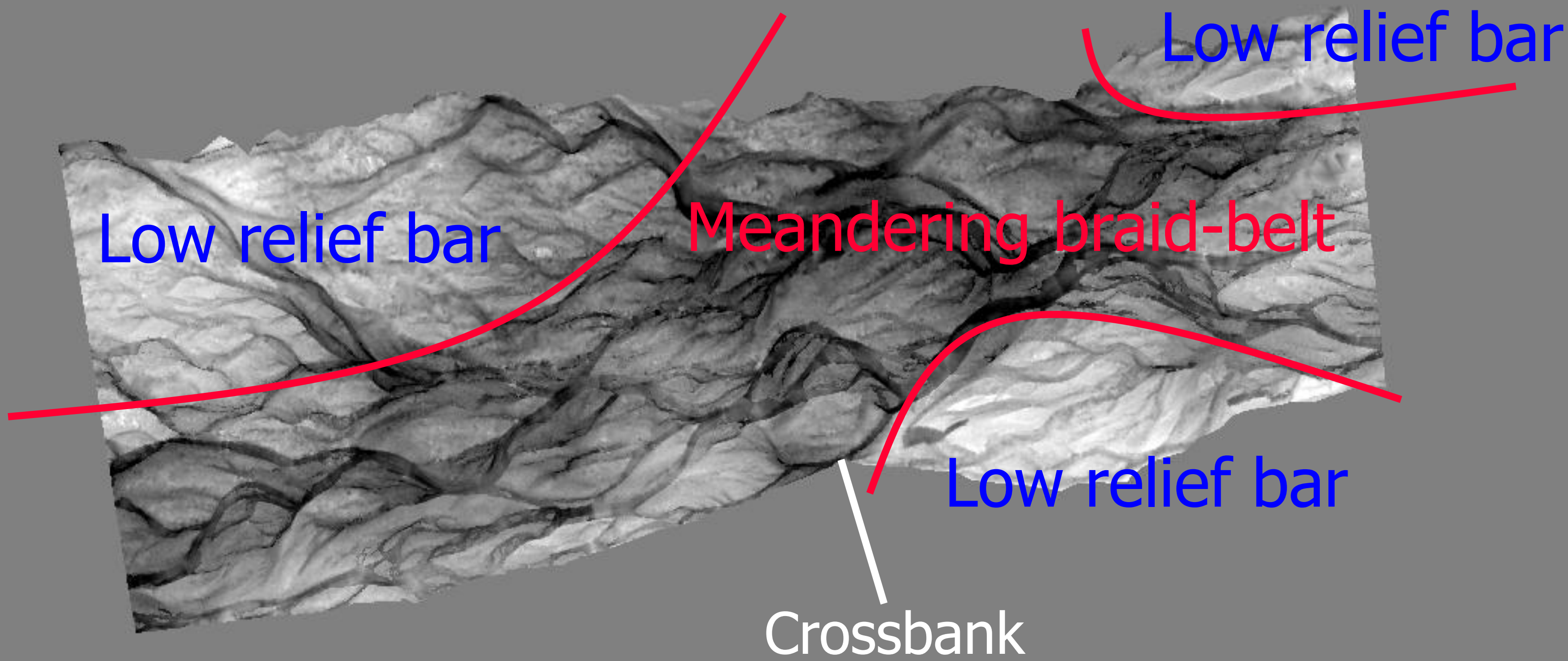
		Dry areas		Wet areas	
Survey	Method	ME (m)	SDE (m)	ME (m)	SDE (m)
Feb 99	1:5000 photogrammetry	+0.084	0.261	+0.260	0.318
Mar 99	1:5000 photogrammetry	+0.010	0.261	+0.168	0.264
Feb 00	1:4000 photogrammetry	+0.088	0.131	+0.101	0.219
May 00	ALS survey	–0.019	0.100	+0.037	0.250

Final DEM surfaces

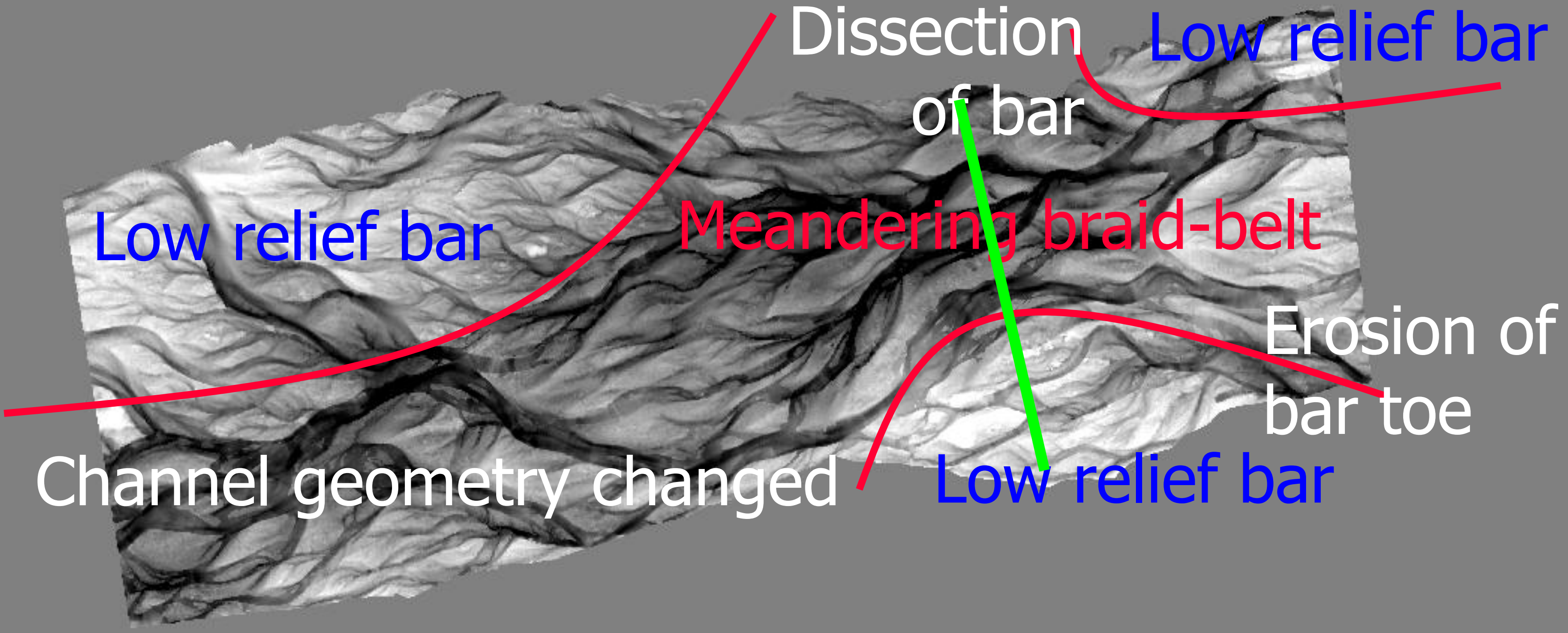
May 2000



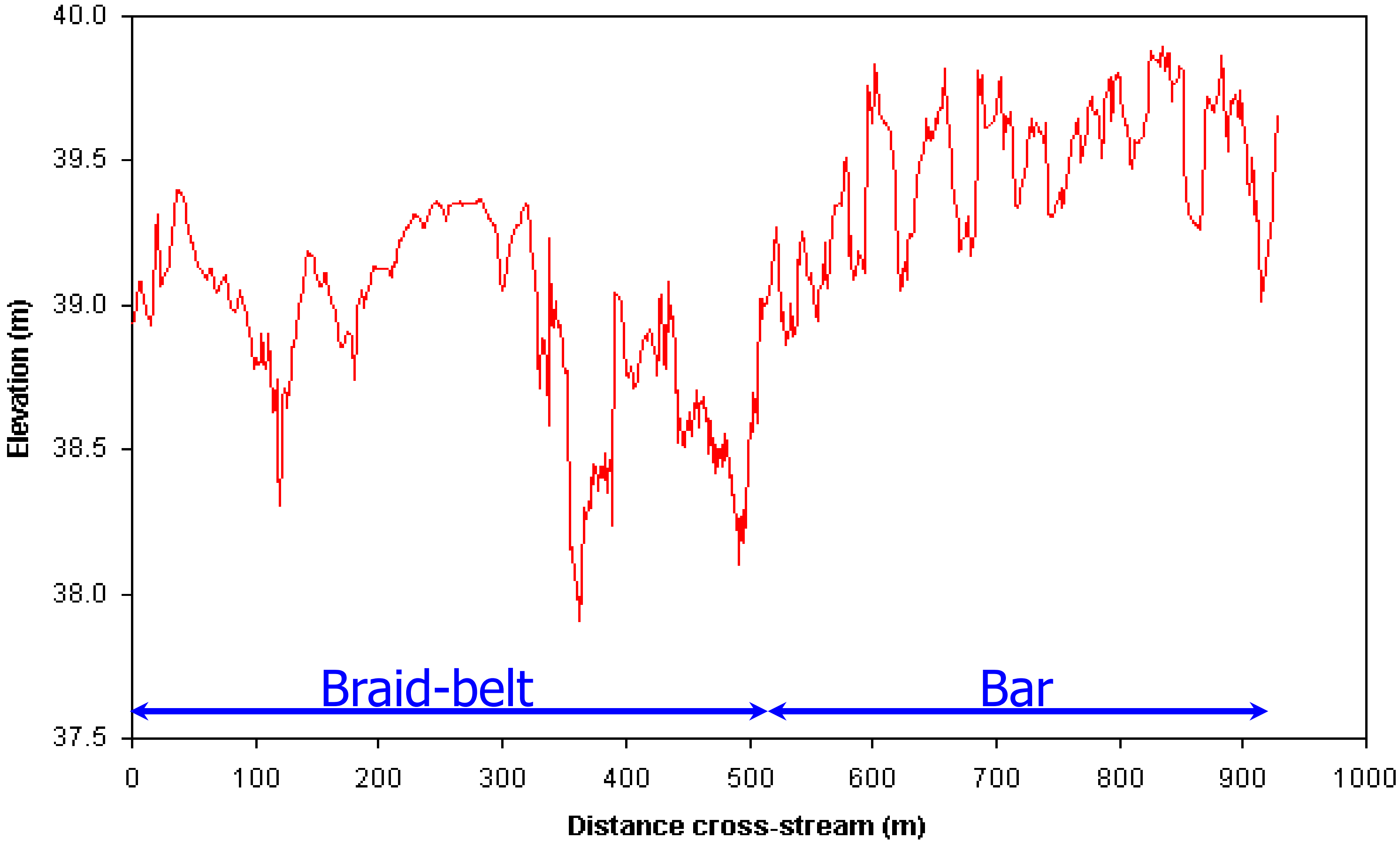
Reach-scale morphology: Feb 1999 and Mar 1999



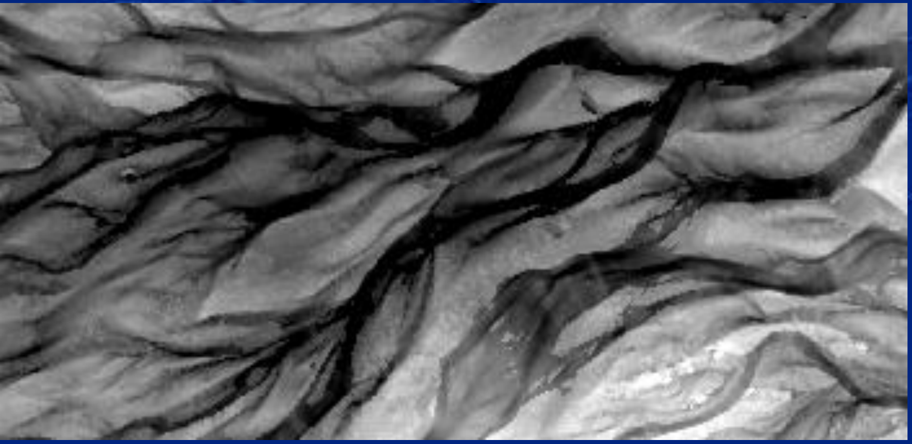
Reach-scale morphology: Feb 2000 and May 2000



Cross-section

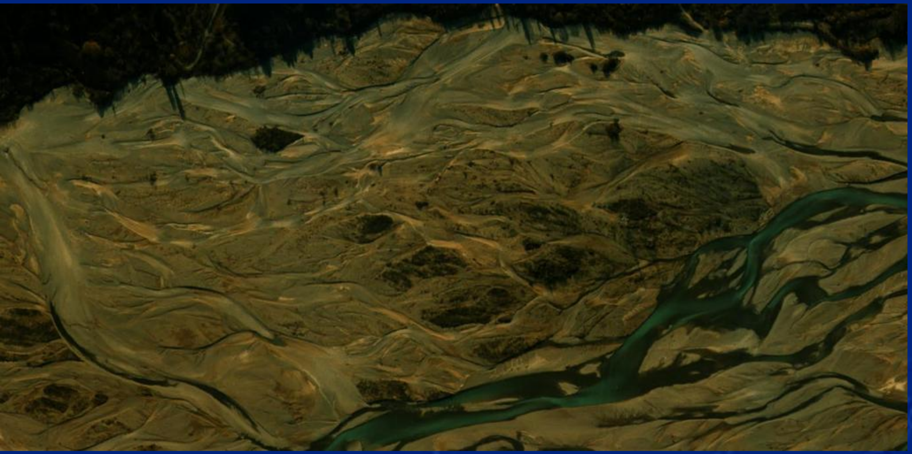


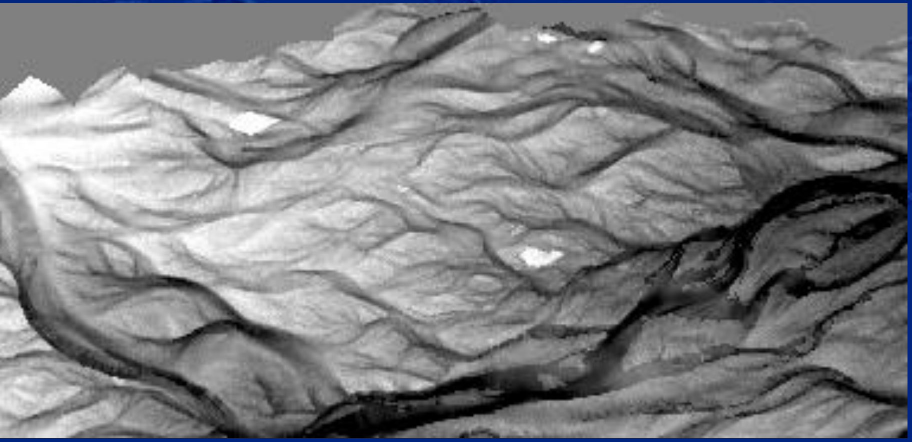
Braid-belt



- Complex braided form
- Meandering pattern
- Concentration of flow
- Remains actively braided at low flows
- Activity $\neq$ elevation
- Very dynamic, even at flood time-scale

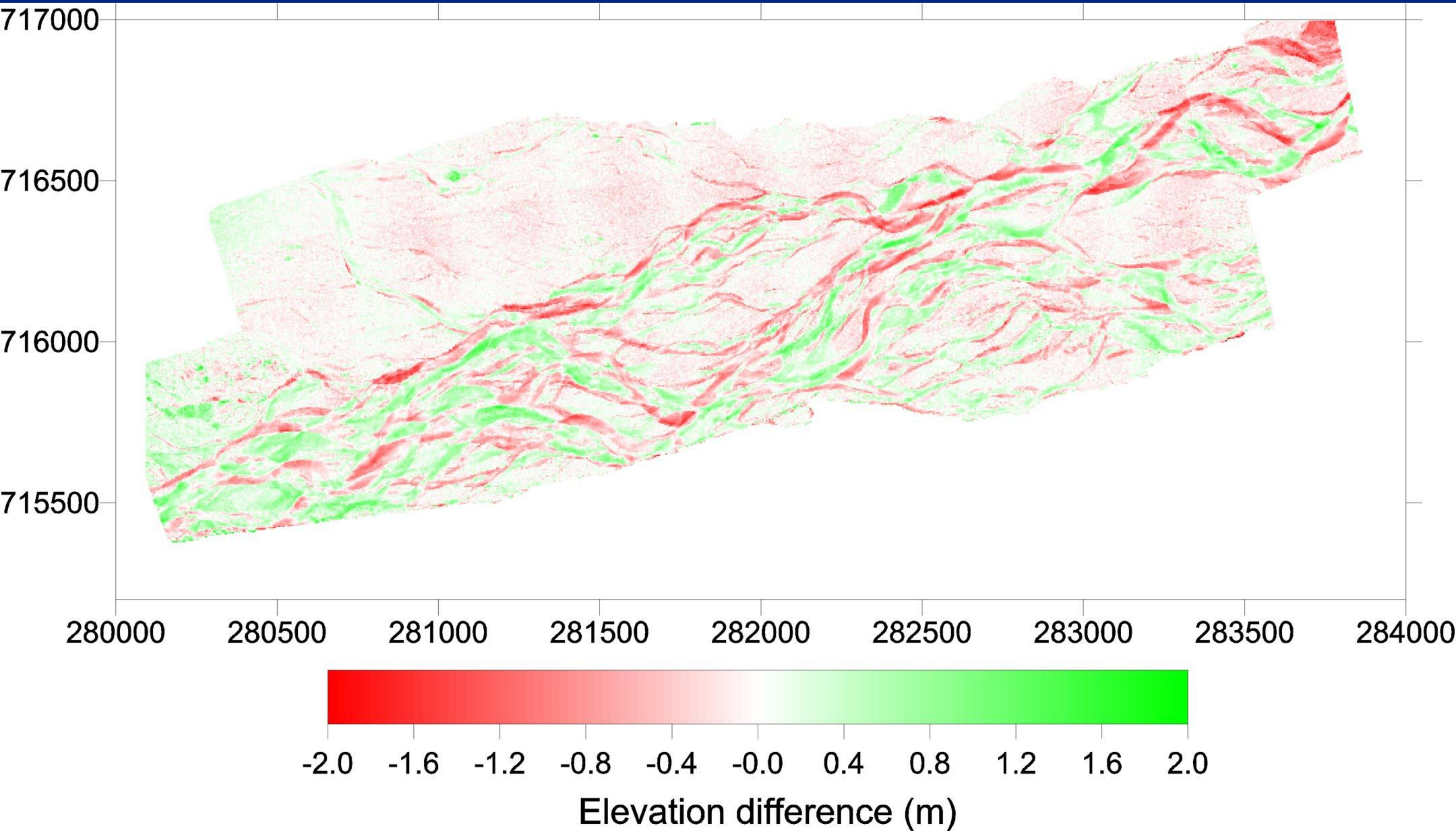
Low relief bars



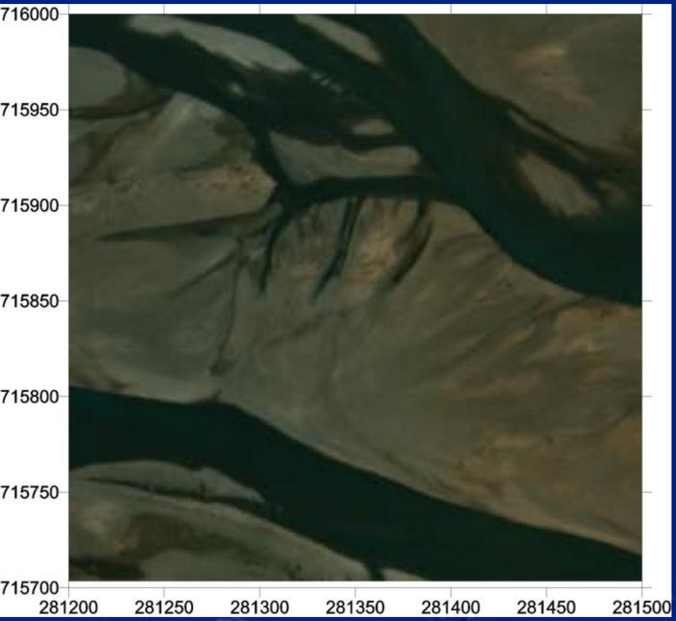


- Higher mean elevation than braid-belt
- Alternating(?)
- Dendritic drainage
- Relatively stable over time ($\Rightarrow$ vegetation)
- However, evidence of upstream migration and dissection

Difference DEMs

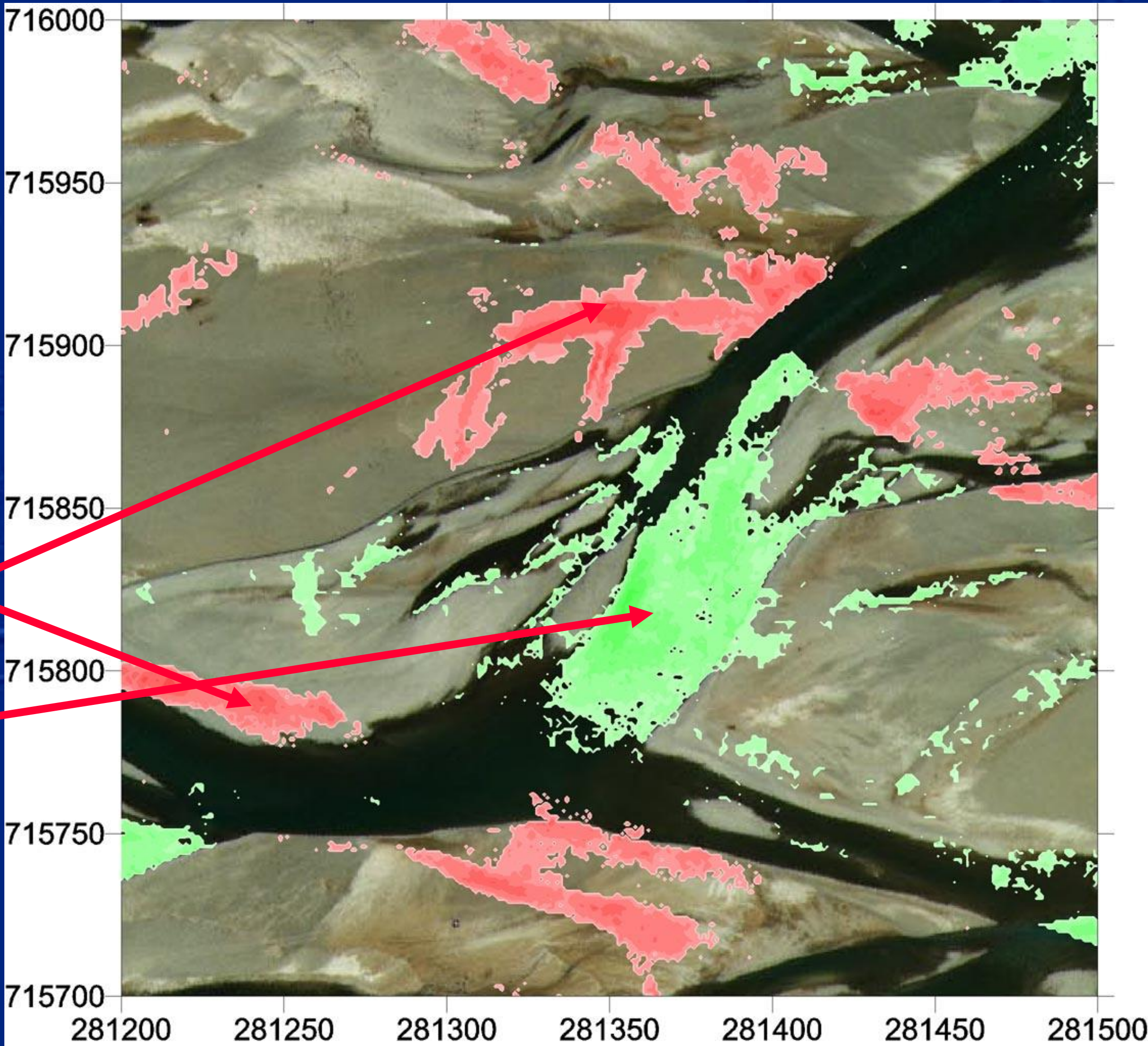


Patterns of change



After

Before



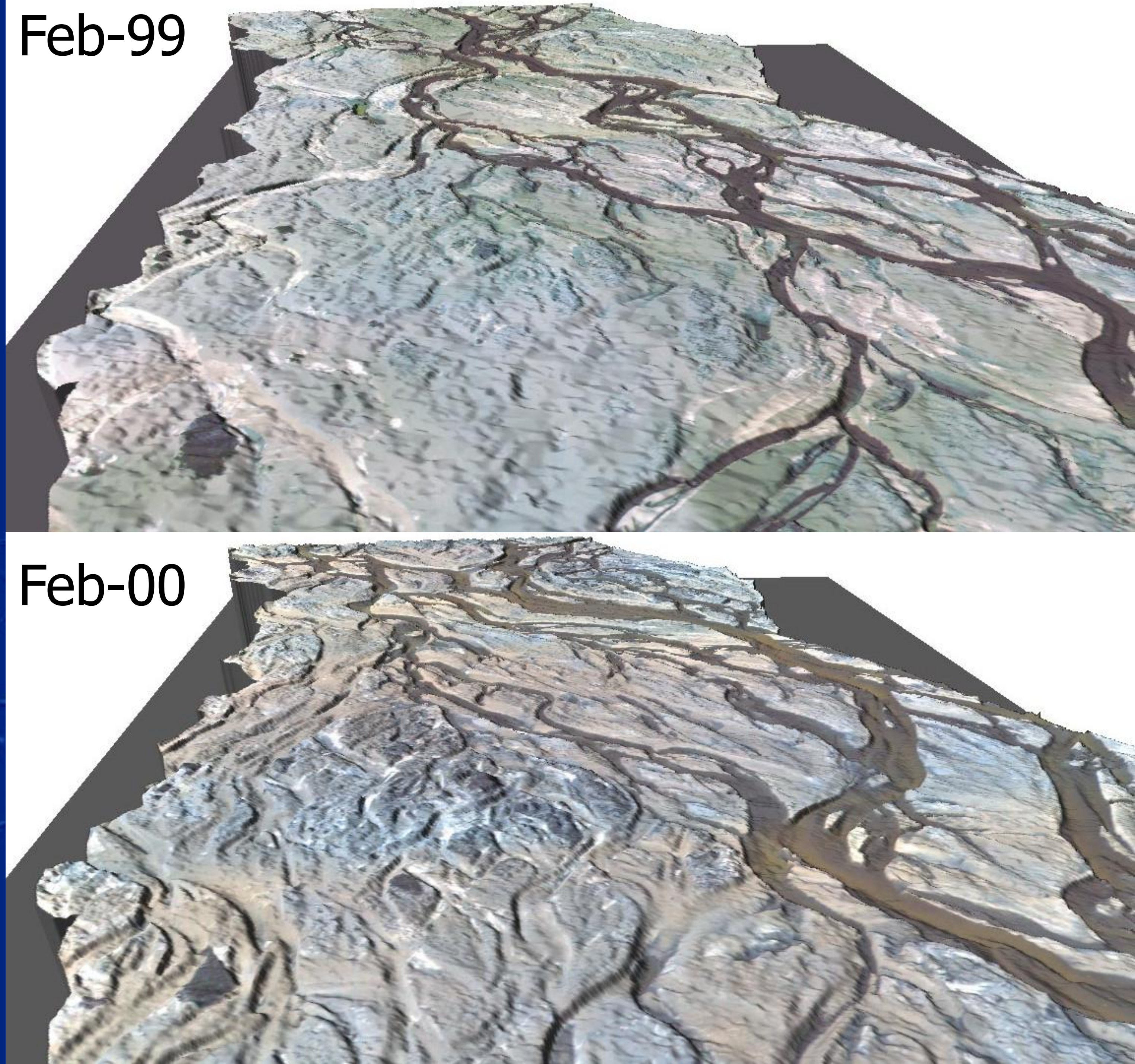
Bank erosion

Avulsion

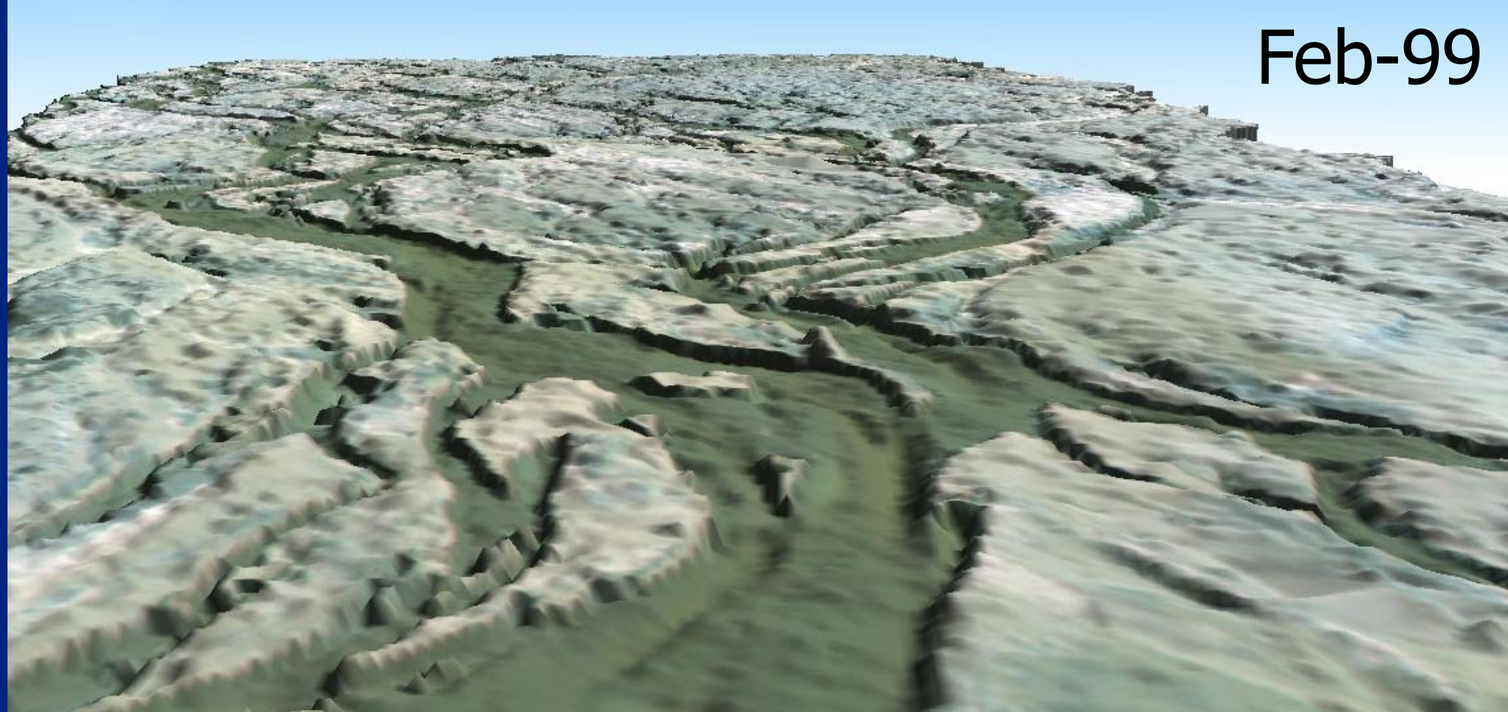
In-channel fill

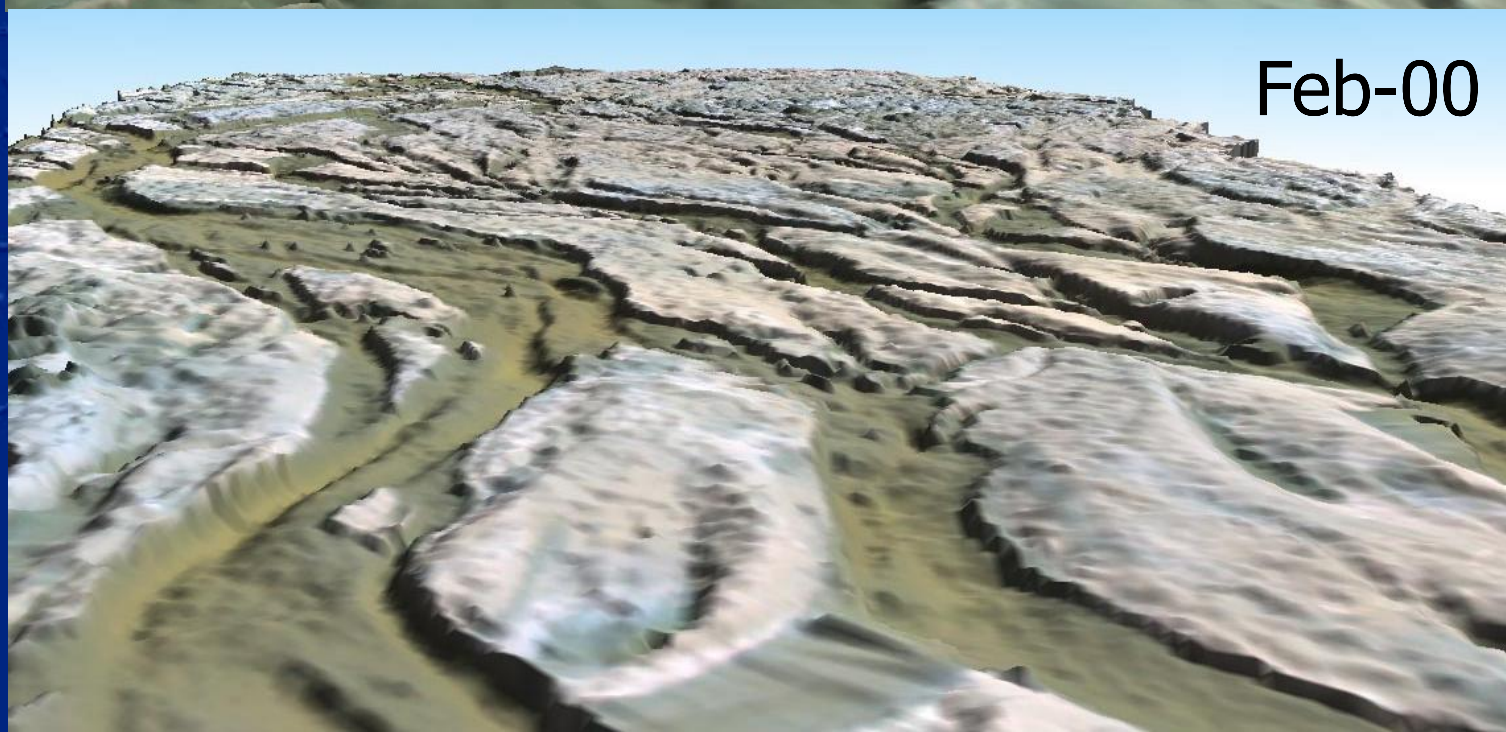
Bar-top change?

3D visualisation: Study reach

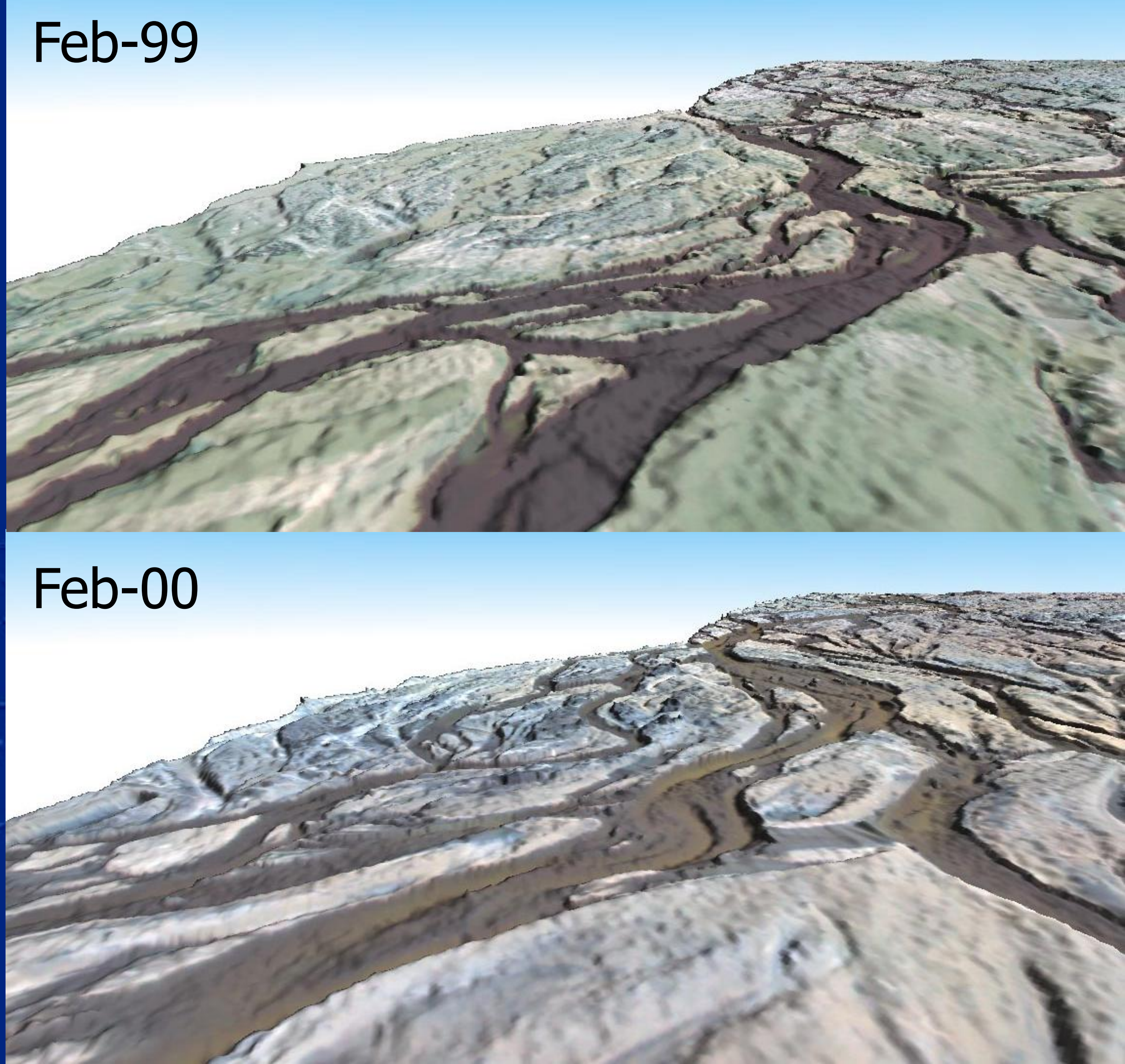


3D visualisation: Braid-belt





3D visualisation: Bar top



Problems: (a) Methodological

- Surface quality:
  - DEM accuracy - systematic error, especially in wetted channels
  - DEM precision - higher than expected; linked to low matching success in areas of low surface texture
- Propagation of errors in derived parameters:
  - Mean bed level
  - Slope
  - Morphological scaling
  - Patterns/volumes of morphological change
- Allows identification of pattern and/or process rate, but <u>not</u> identification of process mechanism

Problems: (b) Operational

- Cost:
  - Acquisition of imagery
  - Processing/post-processing software
- Data volume:
  - 1 DEM = 30Mb in image format
  - 1 DEM = 300Mb in (x,y,z) ASCII format
- Development of surface/morphological analysis techniques appears slower than the development of the remote sensing technologies themselves

Conclusions

- Remote sensing clearly has much to offer river science
- Photogrammetry/ALS are providing a new view of large gravel-bed braided rivers:
  - Static picture (riverbed morphology)
  - Dynamic picture (patterns of change)
- Quality of morphological information obtained wholly dependant on data quality
- Hence, analysis and improvement of DEM quality must be a priority