Remote sensing flood-scale and annual-scale erosion and deposition patterns in a wide braided river

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- AAM Geodan for ALS survey
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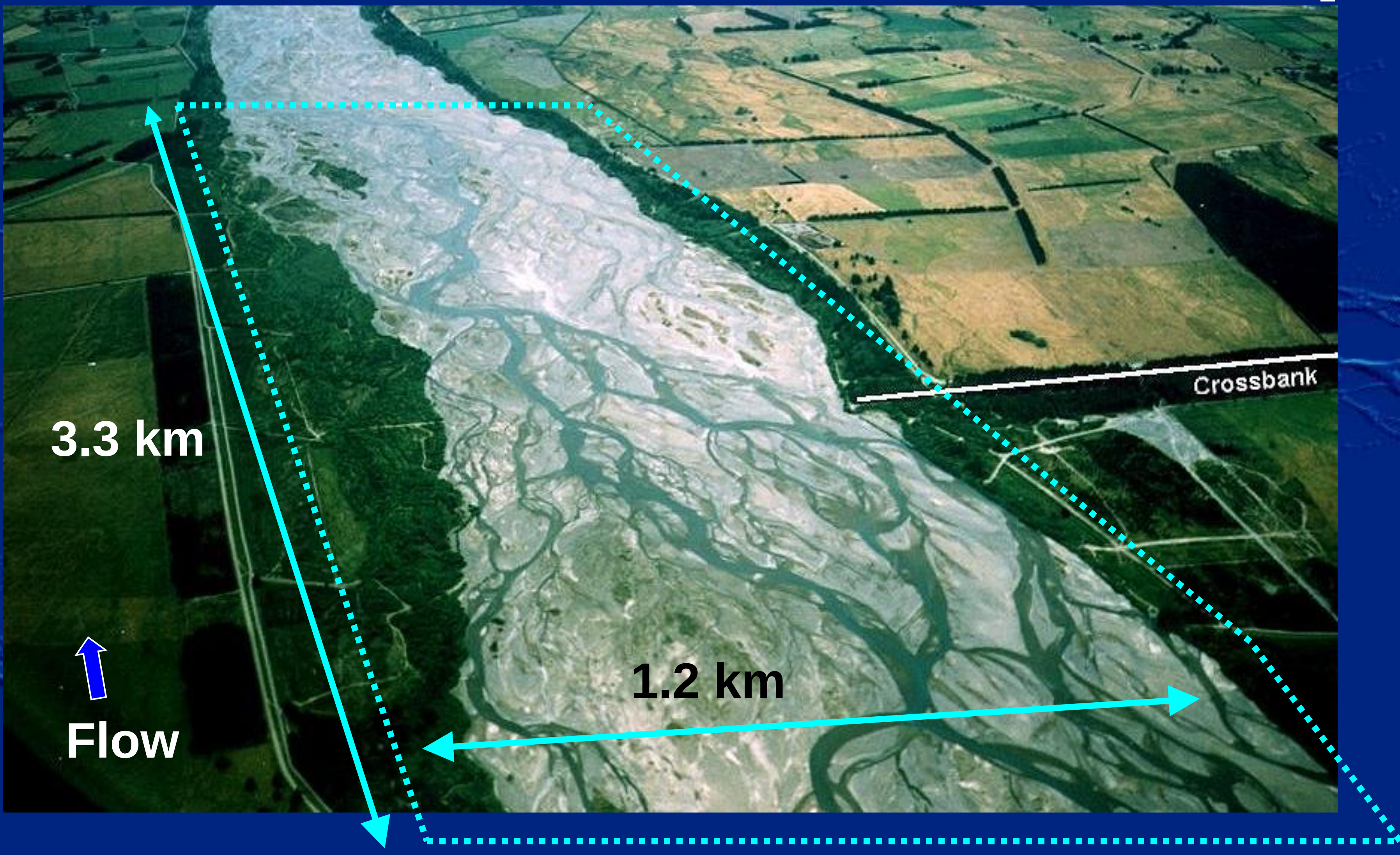
Context: Why are erosion and deposition important?

- Most visually apparent consequence of mutual feedback adjustment between channel process and channel form
- Observation of river channel changes allow assessment (‘classification’) of channel change and likelihood of occurrence
- Measurement of river channel form and its change through time may lead to better estimates of certain river channel processes than direct process measurement (e.g. bedload transport)

Waimakariri study reach

Christchurch ~5km



Waimakariri time-lapse video (NIWA, 2000)

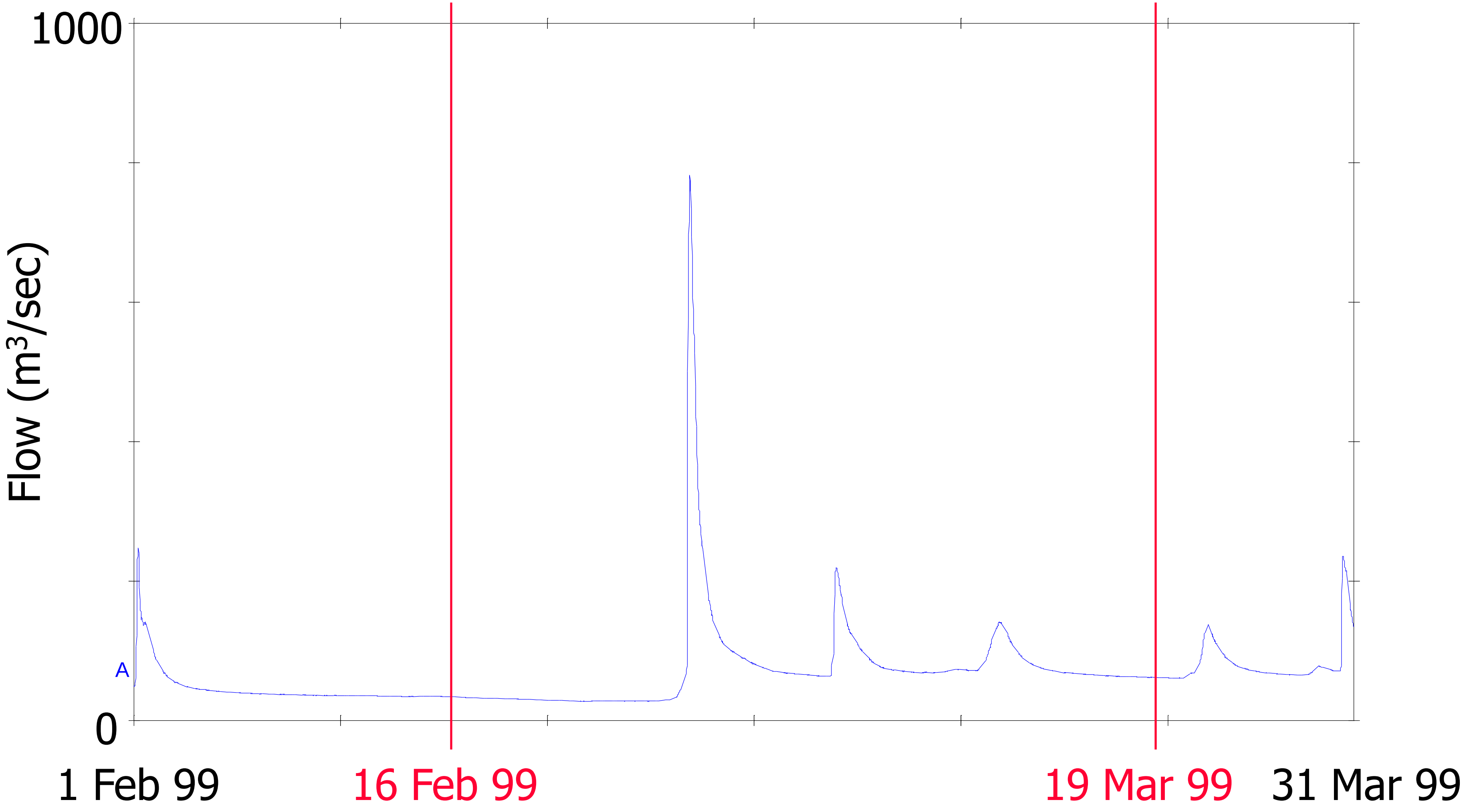
- Part of Cam-Era project (www.niwa.cri.nz/cam-era)
- Using camera situated on electricity pylon in study reach
- One image per day: 1st April to 2nd May 2000

Photogrammetric surveys

- February 1999: 1:5000 (= 16 photos)
- March 1999: 1:5000 (= 18 photos)
- February 2000: 1:4000 (= 24 photos)
- May 2000: ALS survey

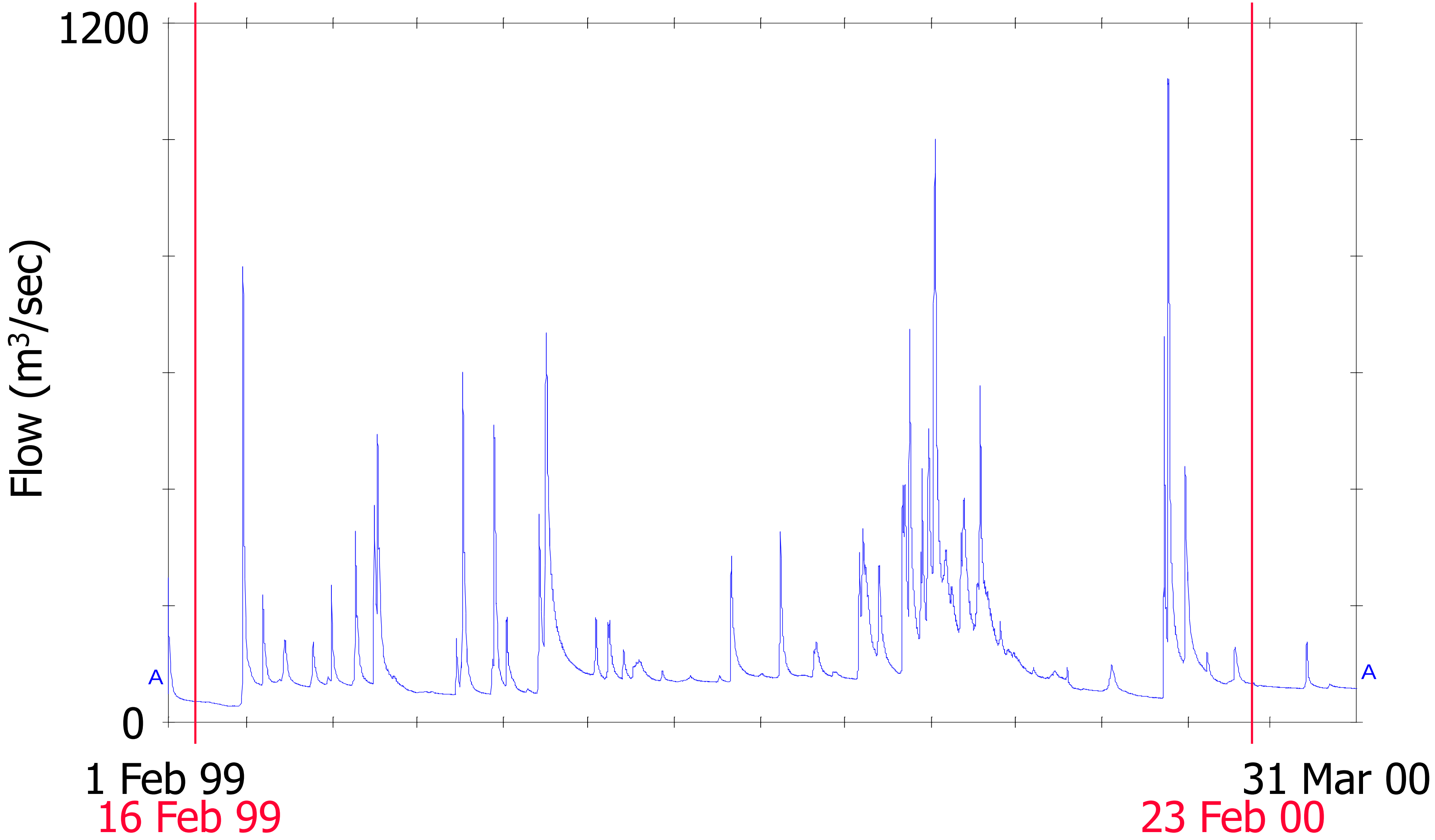
February 1999 to March 1999: Flood-scale change

Data from Environment Canterbury



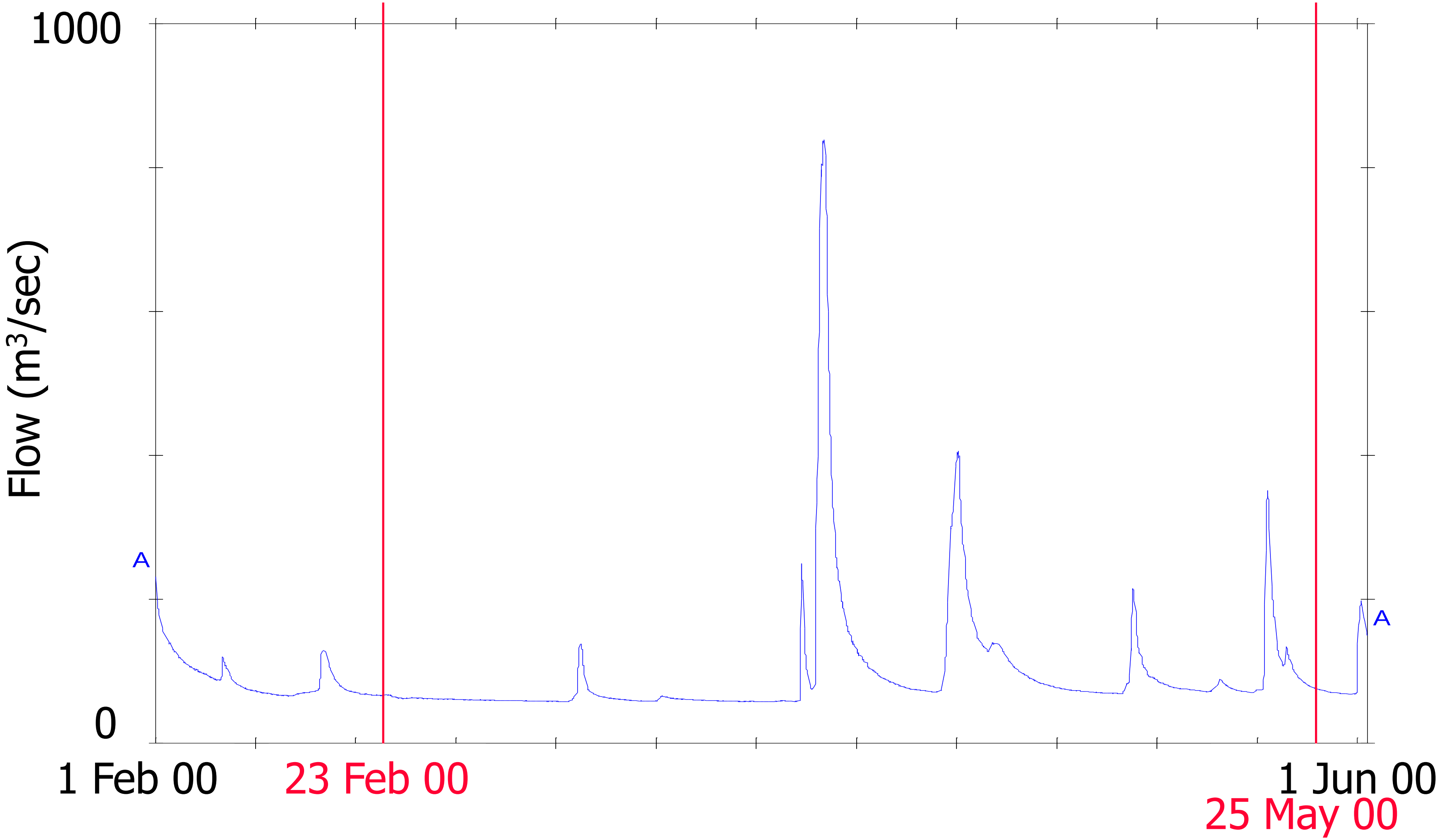
February 1999 to February 2000: Annual-scale change

Data from Environment Canterbury

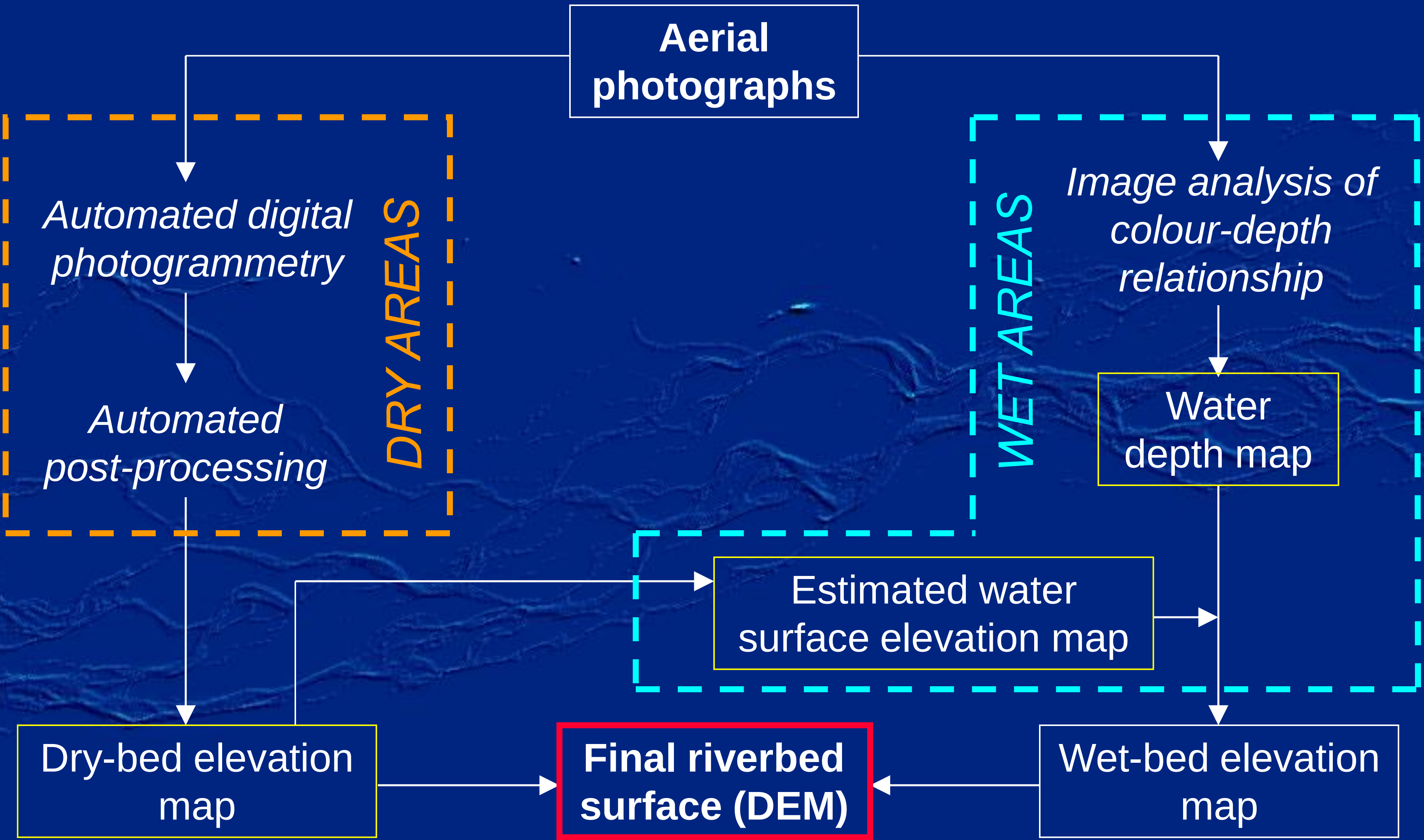


February 2000 to May 2000: Flood-scale change

Data from Environment Canterbury

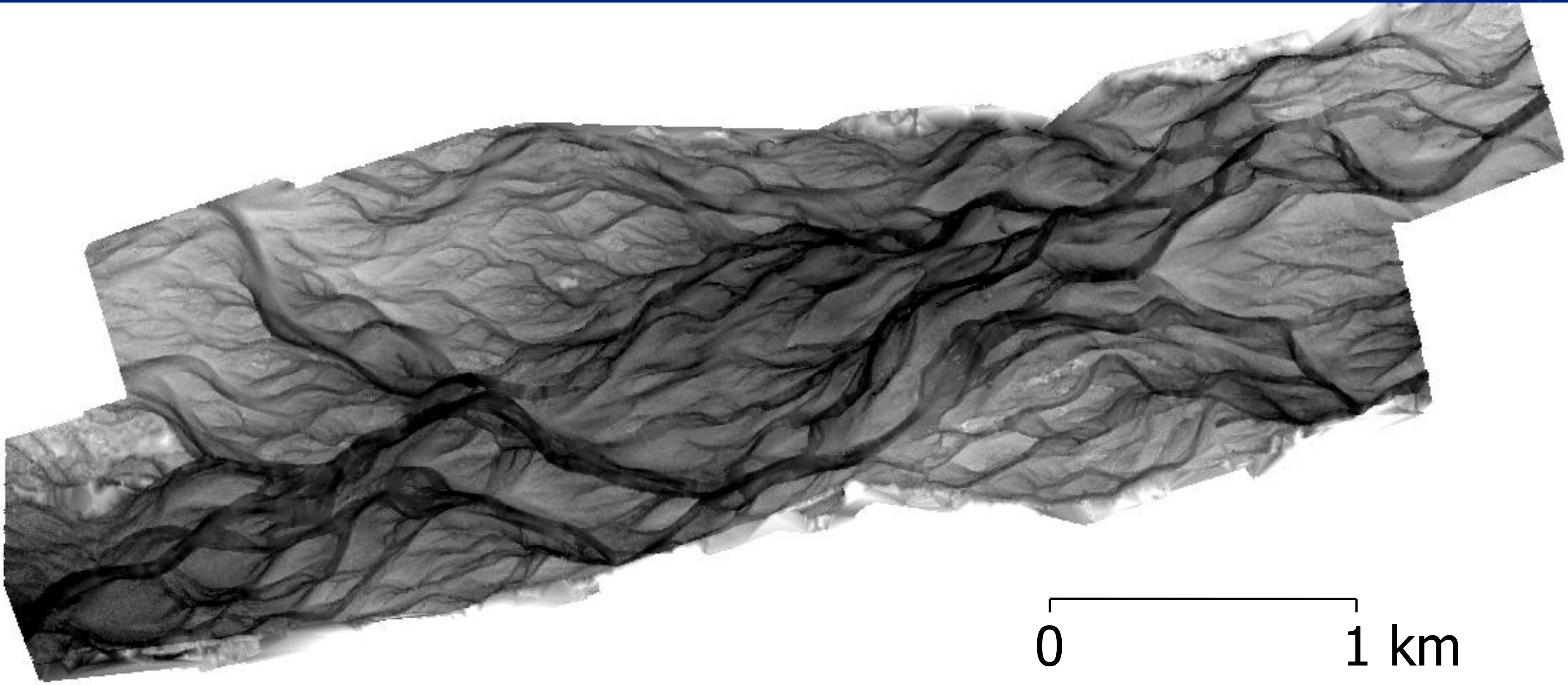


Method

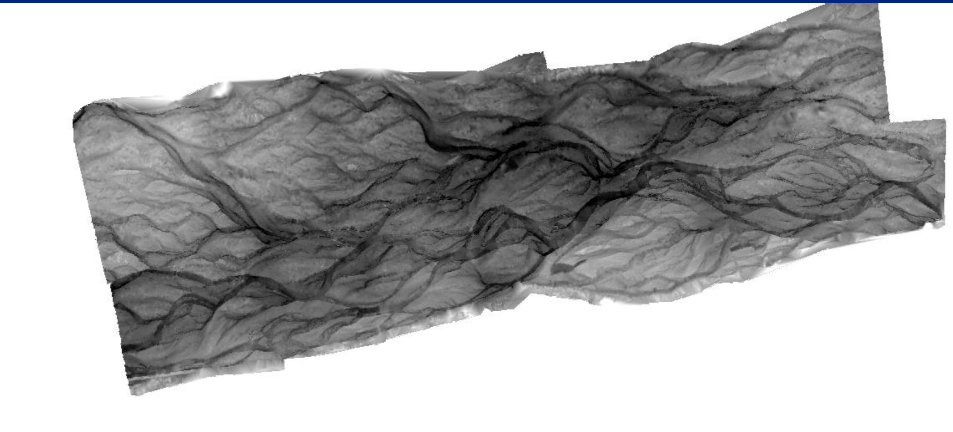


Aerial photographs
Automated digital photogrammetry
Automated post-processing
DRY AREAS
Image analysis of colour-depth relationship
WET AREAS
Water depth map
Estimated water surface elevation map
Dry-bed elevation map
Final riverbed surface (DEM)
Wet-bed elevation map

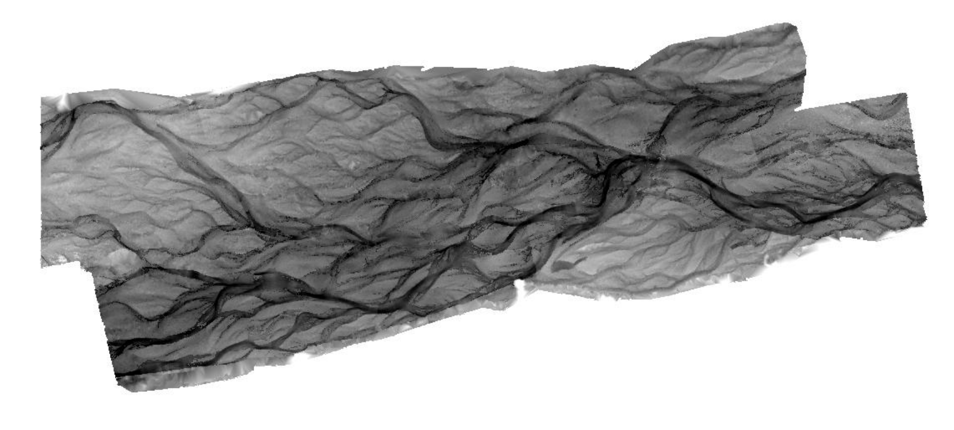
Final DEM surface - Feb 2000



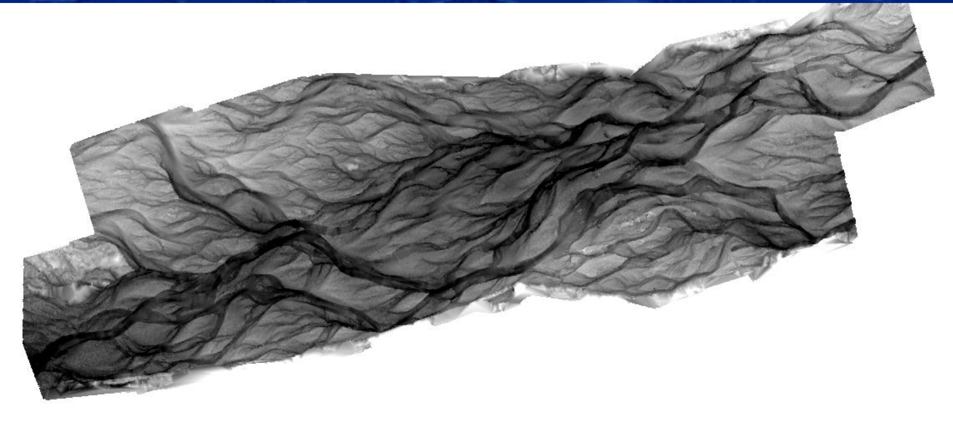
DEM surfaces compared



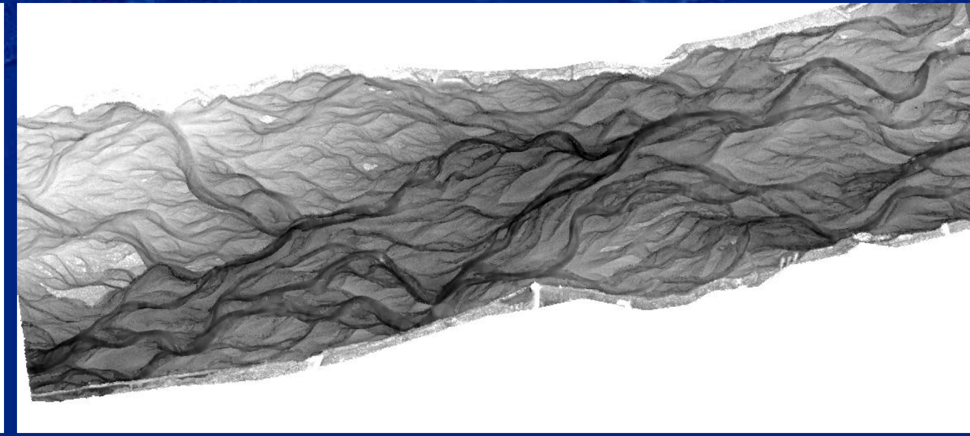
February 1999



March 1999



February 2000



May 2000

Calculation of morphological change

- Elevation change at each pixel:

$$\Delta h = h_{t2} - h_{t1}$$

- However, since both surfaces will contain errors, it becomes necessary to define the "minimum level of detection" (Brasington *et al*., 2000), or minimum elevation change, that can be distinguished from background noise (Δh_{min})

Minimum height change (Δh_{min})

- Propagated error from linear combination of two surfaces is given by:

$$E = \sqrt{[(e_1)^2+(e_2)^2]}$$

- For DEM surfaces, error is calculated in terms of precision, often as standard deviation of errors (SDE) as compared with ground-survey check points.
- With an absence of systematic error, change between two surfaces is deemed significant at a given significance level (t) when:

$$\Delta h > t \sqrt{[(SDE_1)^2+(SDE_2)^2]}$$

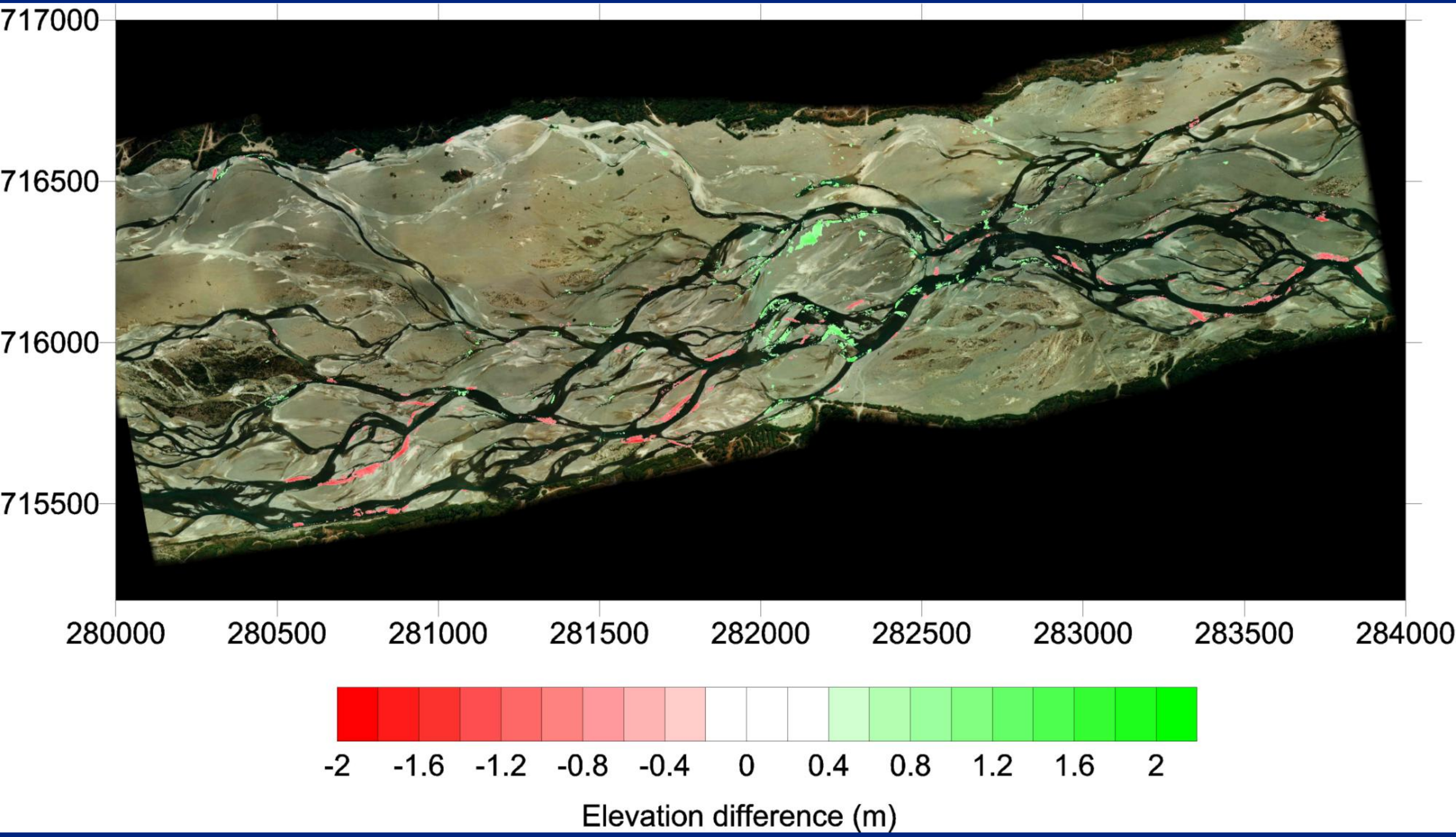
Δh_{min} values used

- Calculation of Δh_{min} complicated by:
  - different precision of wet and dry areas of riverbed
  - change in location of wet and dry areas during epochs
  - e.g. Δh_{min} for 0299 to 0200 using t_α of 0.05:
    - Dry > Dry = $1.96 \times \sqrt{[(0.261)^2+(0.131)^2]}$ = **0.57 m**
    - Dry > Wet = $1.96 \times \sqrt{[(0.261)^2+(0.219)^2]}$ = **0.67 m**
    - Wet > Dry = $1.96 \times \sqrt{[(0.318)^2+(0.131)^2]}$ = **0.67 m**
    - Wet > Wet = $1.96 \times \sqrt{[(0.318)^2+(0.219)^2]}$ = **0.76 m**
- Thereafter it becomes a trade-off between confidence level and magnitude of change: We can be less confident that smaller changes are 'real'

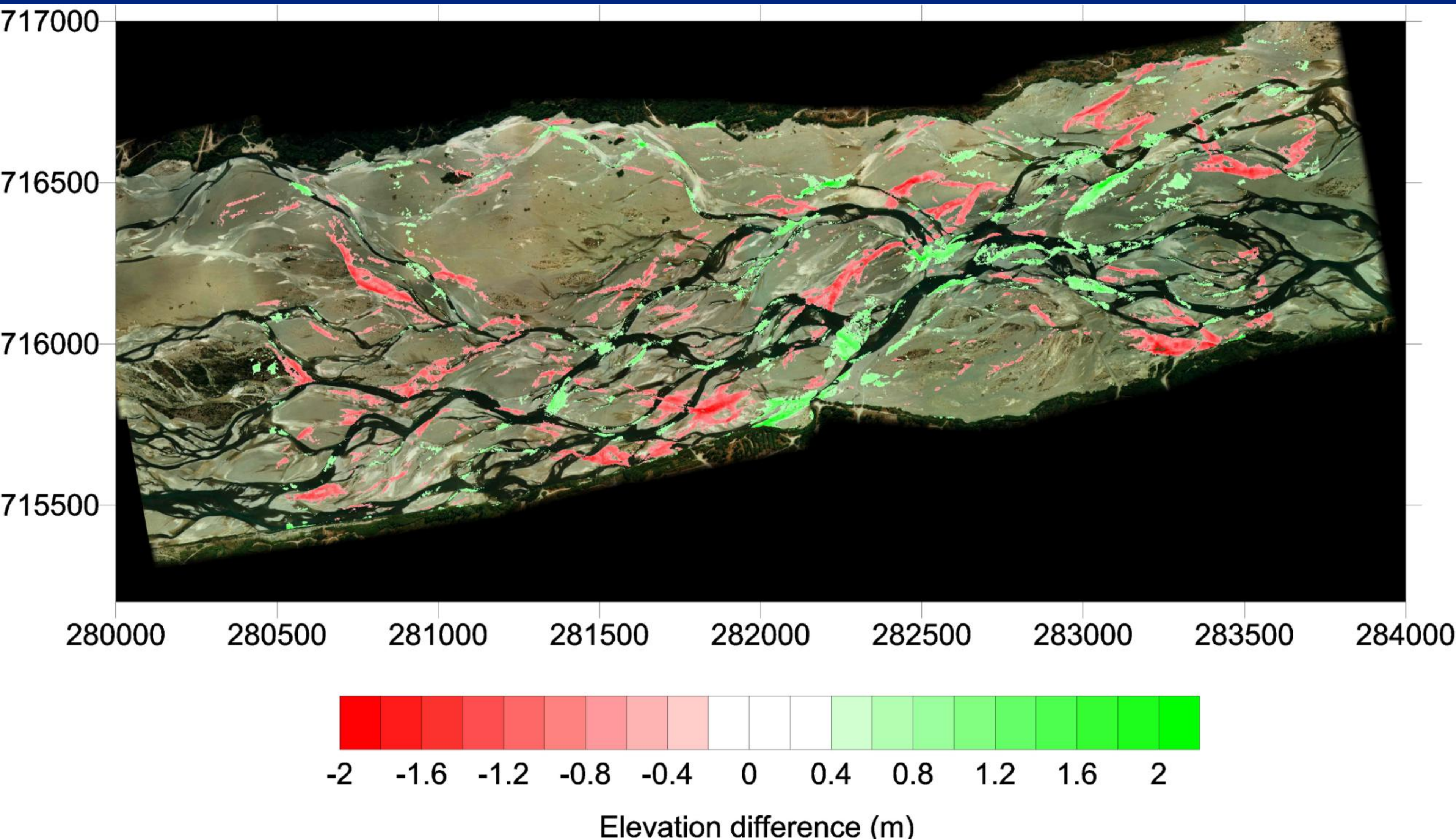
Maps of difference

- Maps show significant change at 95% confidence level for three epochs:
  - February 1999 to March 1999 (Flood-scale)
  - February 1999 to February 2000 (Annual-scale)
  - February 2000 to May 2000 (Flood-scale)
- In each case the changes are superimposed on the photo-mosaic of the reach at the start of the epoch

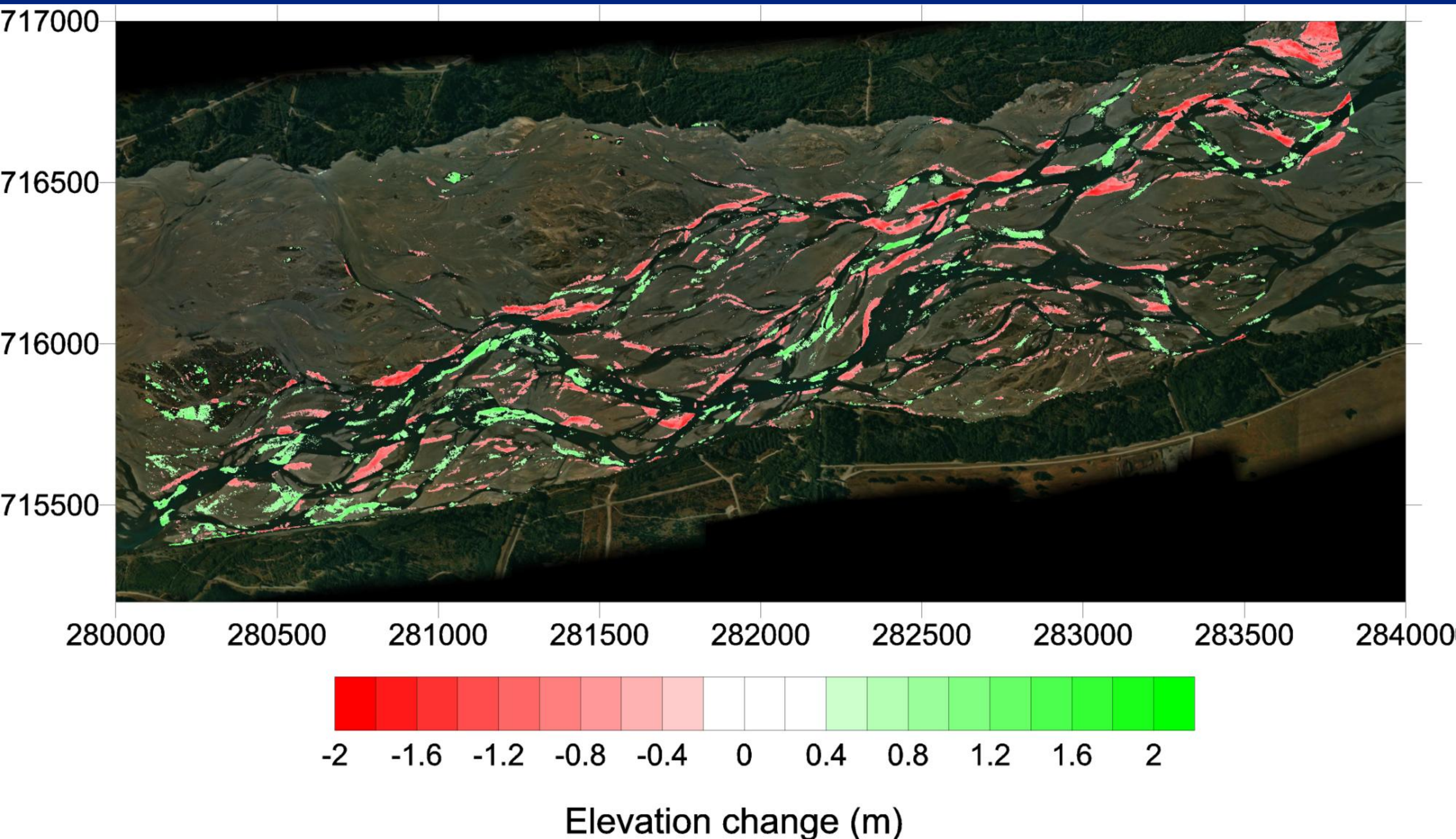
February 1999 to March 1999



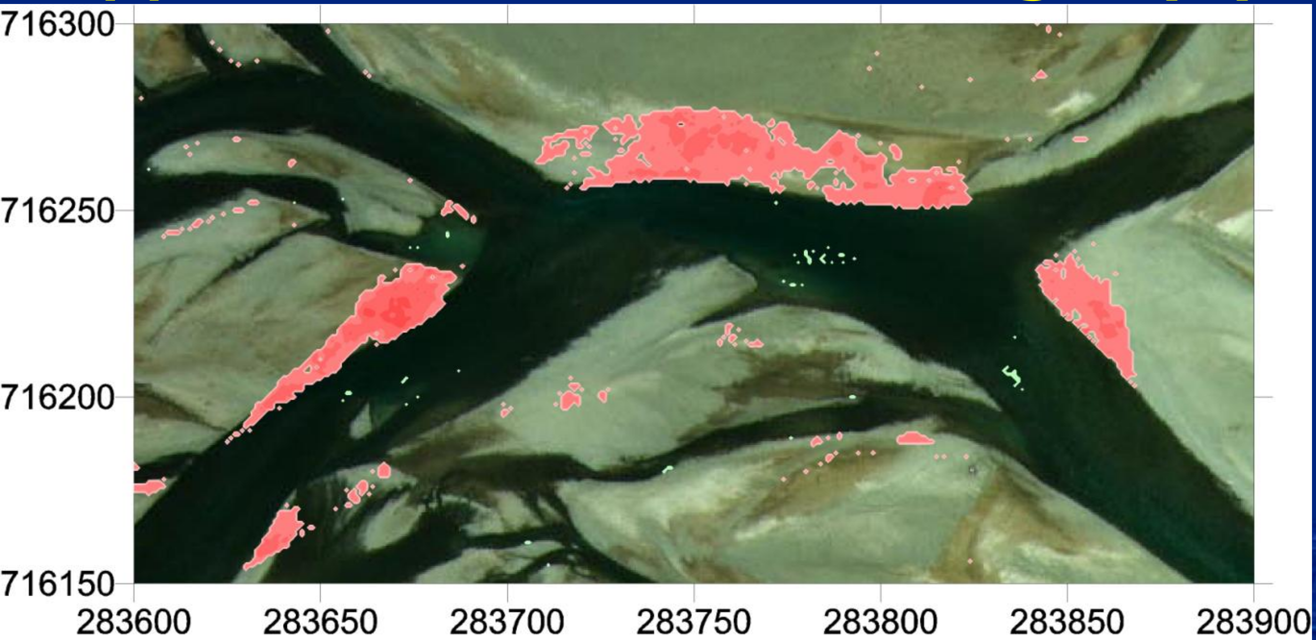
February 1999 to February 2000



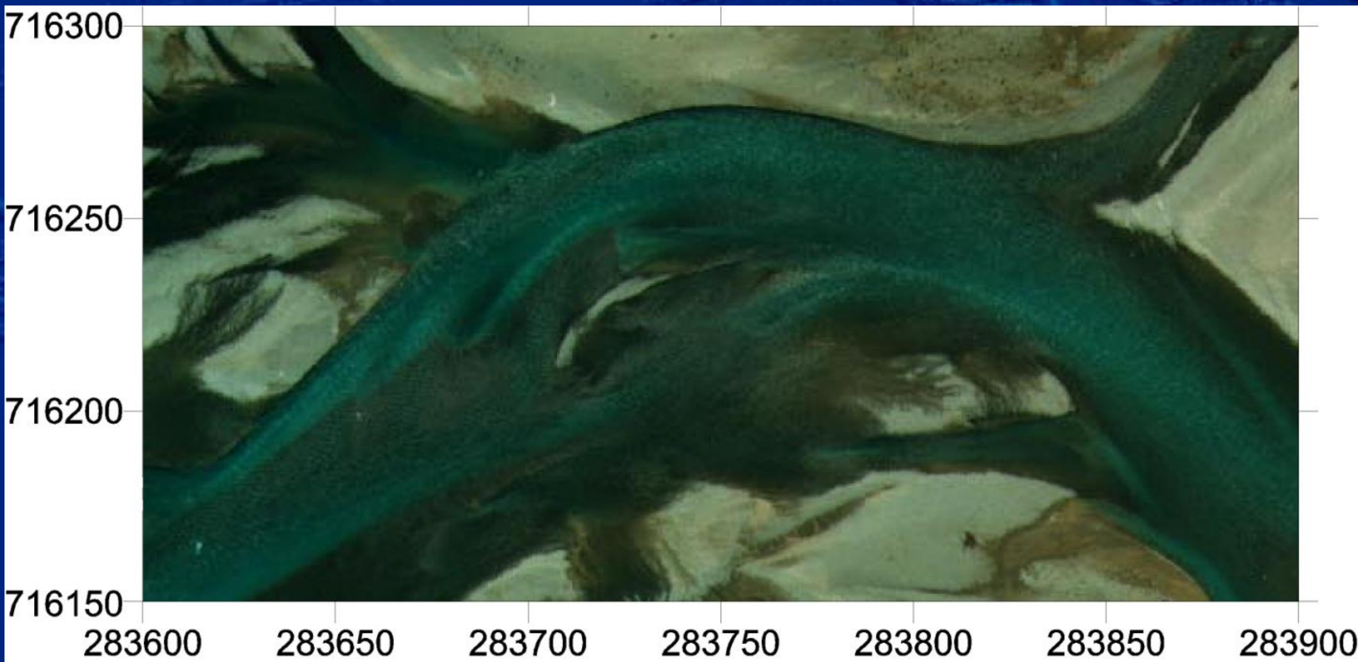
February 2000 to May 2000



Types of riverbed change (1): Bank erosion

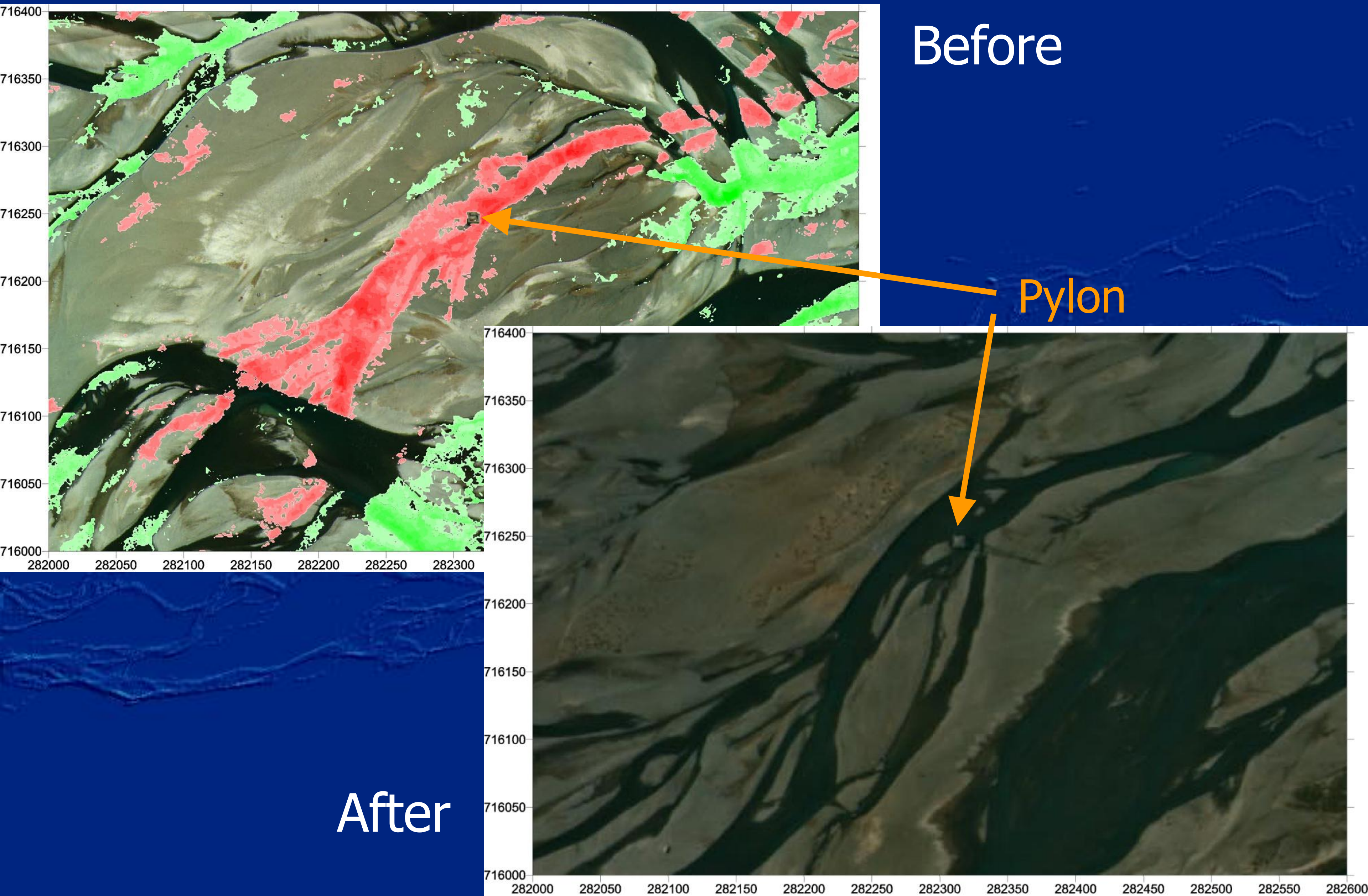


Before

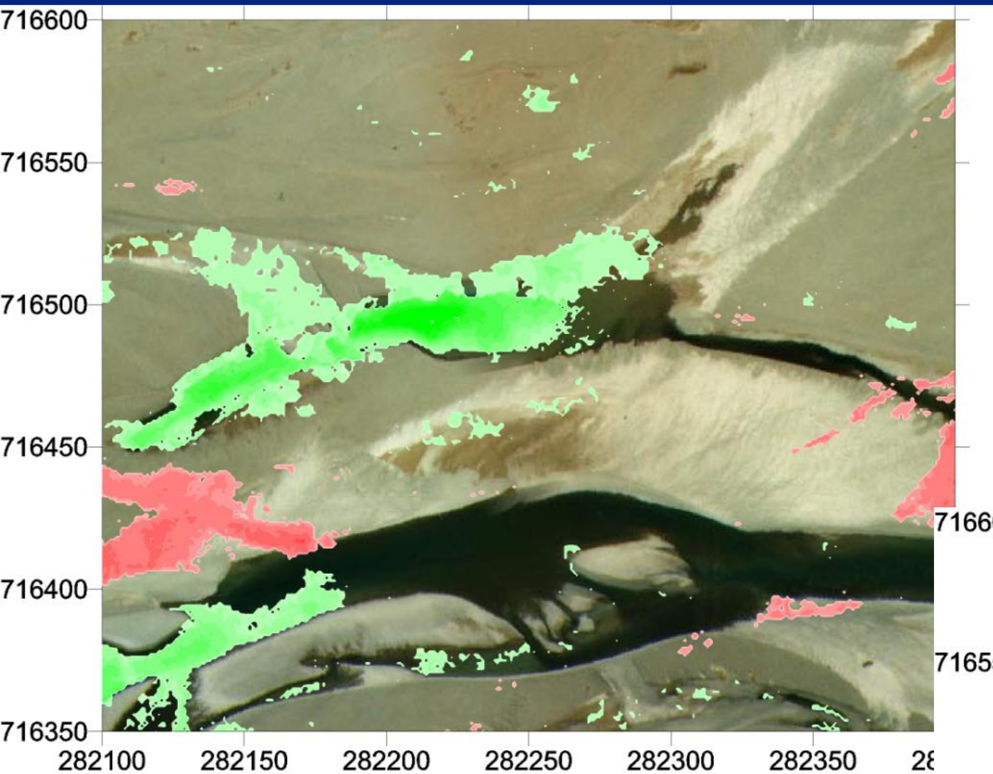


After

Types of riverbed change (2): Avulsion



Types of riverbed change (3): In-channel fill



Before

After

Types of riverbed change (4): Bar-top erosion/deposition

Conclusions

- First attempt at studying 3D morphological change for such a large and dynamic (yet flat) braided river channel
- Early results are encouraging:
  - discrete, ordered(?) areas of cut and fill present, not just random noise
  - Different mechanisms of change can be hypothesised
- Minimum detectable height change sensitive to precision (SDE) of surfaces, which will limit findings in areas of little change
- Next, quantitative data to back up qualitative patterns