Measuring river planform changes from remotely sensed data: A Monte Carlo approach to assess the impact of spatially variable geometric error

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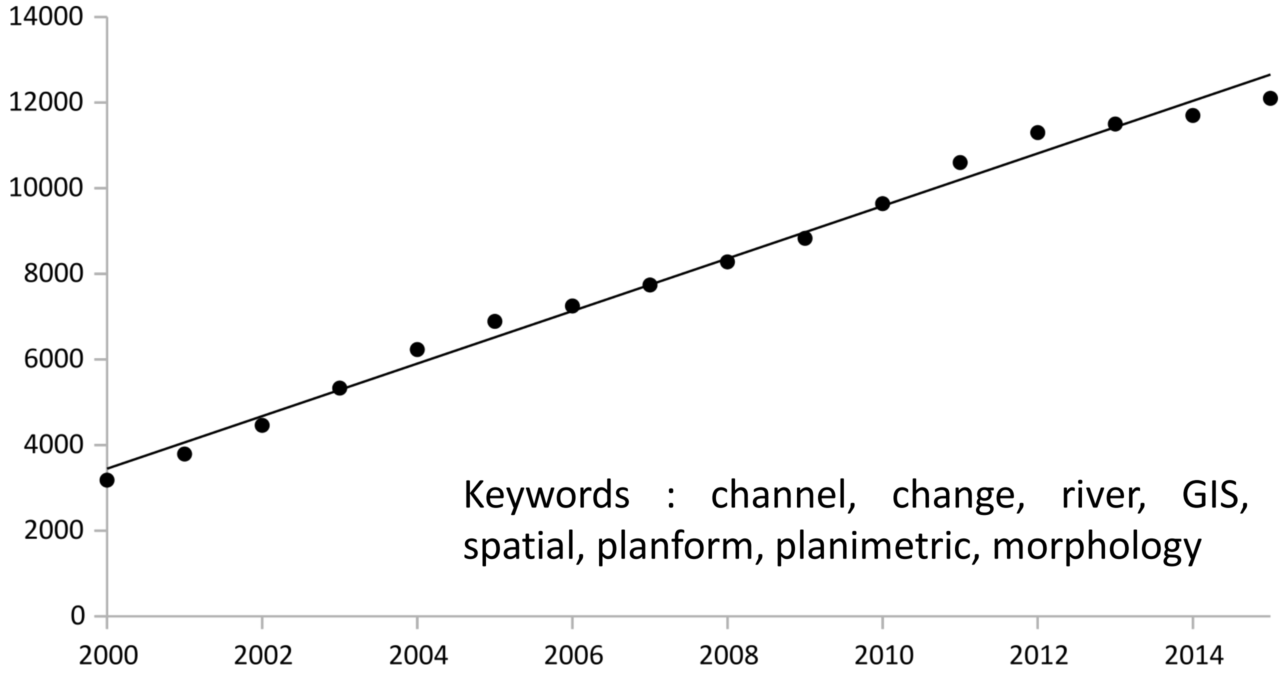
RESEARCH CONTEXT

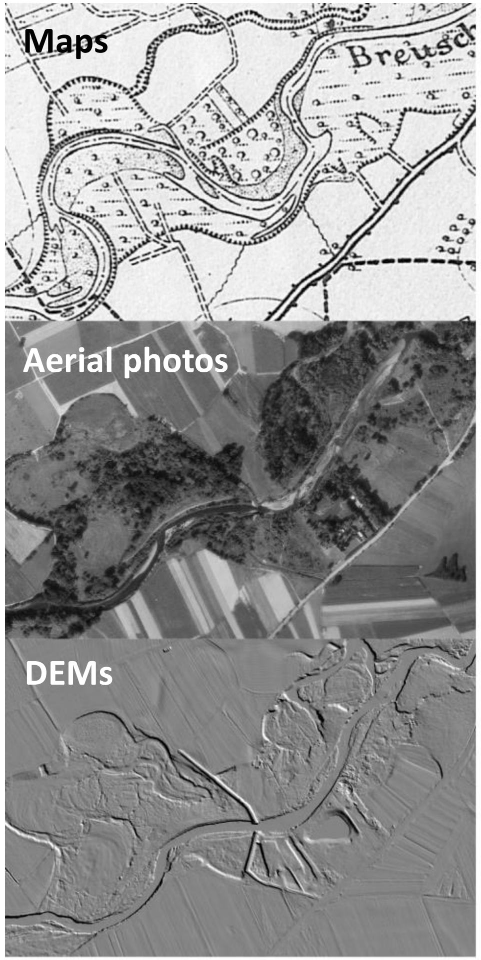
- Remotely sensed planimetric data in the fluvial context
- Affordable and easy, only need data and GIS

➔ Widely used

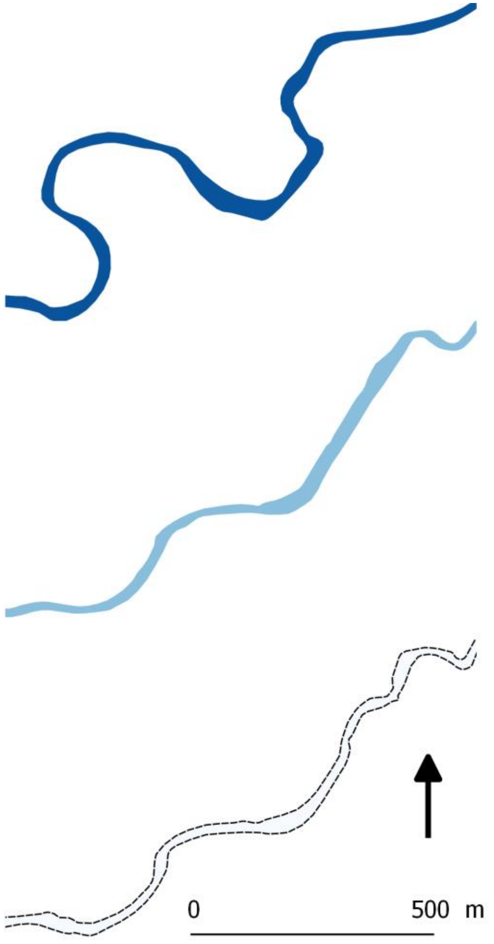
Yearly number of publications using planform data in the fluvial context.



Processed remotely sensed data example



Channels delineation (GIS)



Ready for quantification !

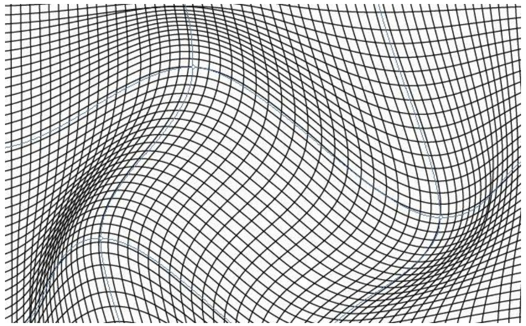
RESEARCH CONTEXT

Many use and metrics extracted from remotely sensed data in the fluvial context :
- Delineation of historical *mobility space*
- Quantification of lateral migration rates
- Quantification of morphometric variables

→ Useful in river restoration projects

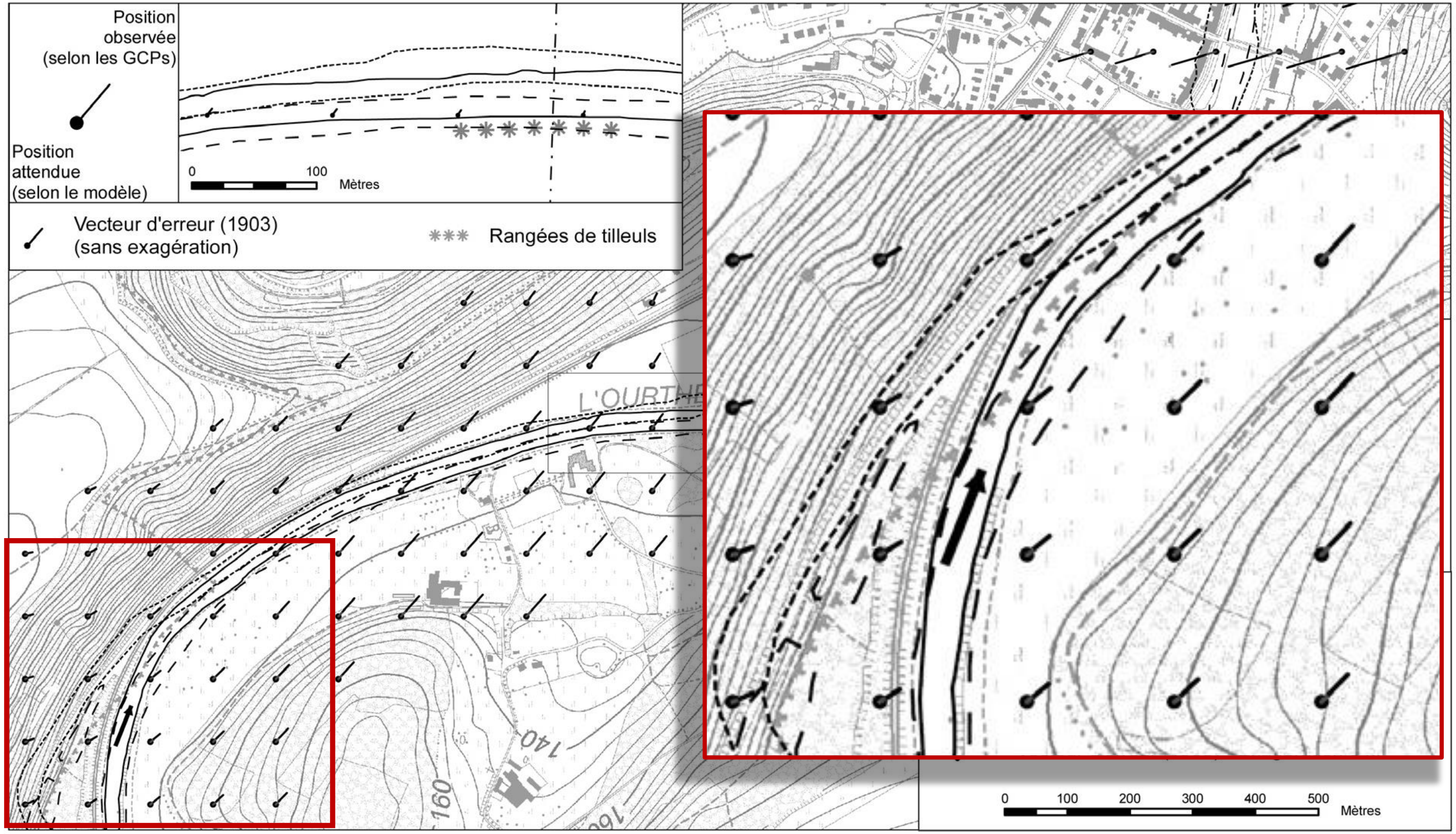
REMOTELY SENSED DATA ARE AFFECTED BY SPATIALLY VARIABLE (SV) ERRORS
(Lea & Legleiter, 2016; Donovan et al., 2019)

Due to coregistration or orthorectification
(GEOMETRIC)



Opposed to uniform error (RMSE)

Geometric error example



Channel in the mountain ?

Map of superposition of diachronic active channels of the Ourthe River (Belgium). From Snijders et al. (2005).

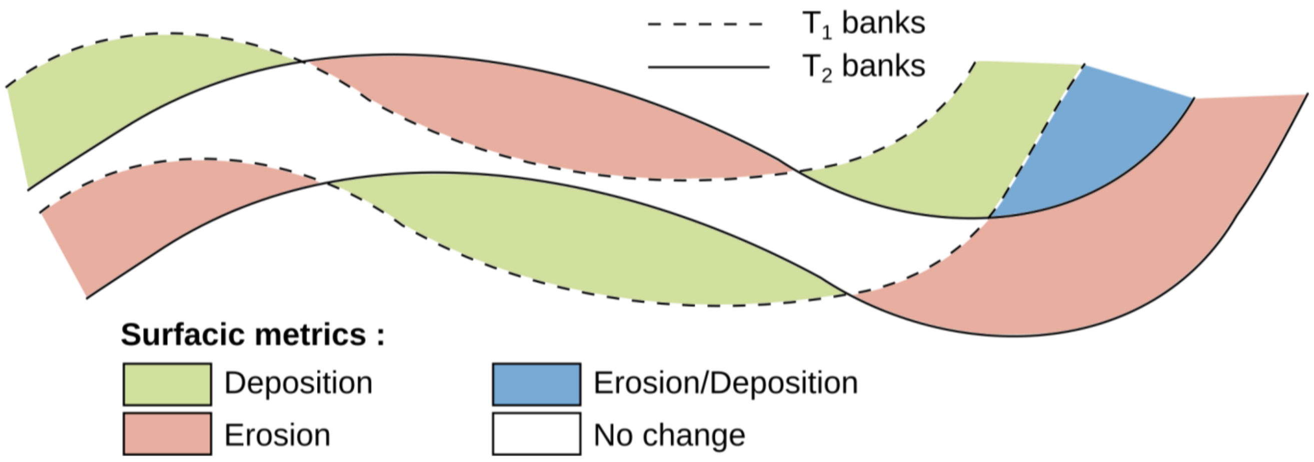
RESEARCH GOAL

- Use of metrics extracted from remotely sensed data, which are affected by SV error…
- Misinterpretation of planform changes and geomorphic processes

➔ How to deal with SV error? What about results significance?

Study goal: To design a method evaluating the impact of SV error on quantification of surficial river changes.

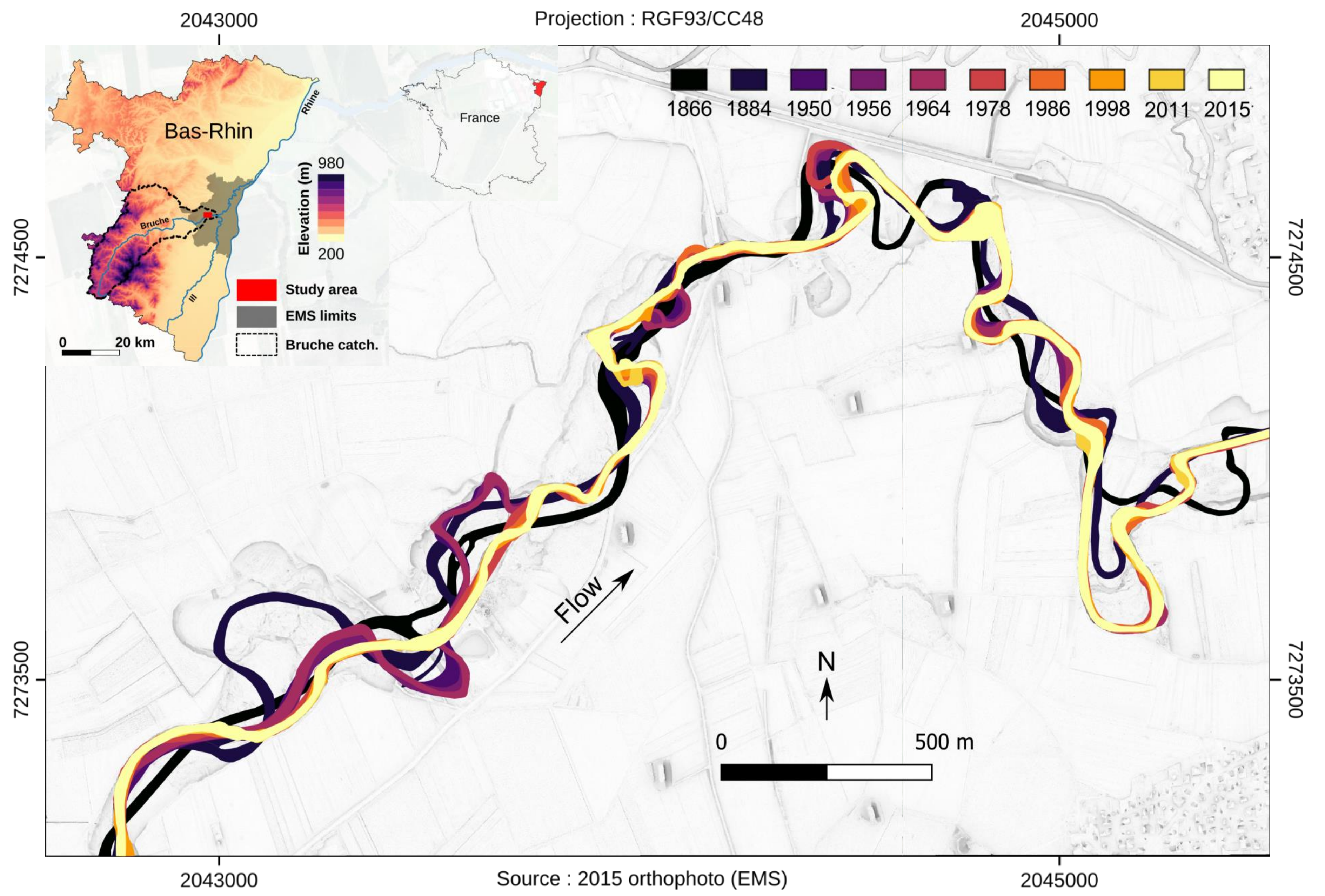
Specific metric used: Channel Polygon Overlay



➔ Comprehensible metric

➔ High transferrability to different channel patterns

STUDY AREA and DATA



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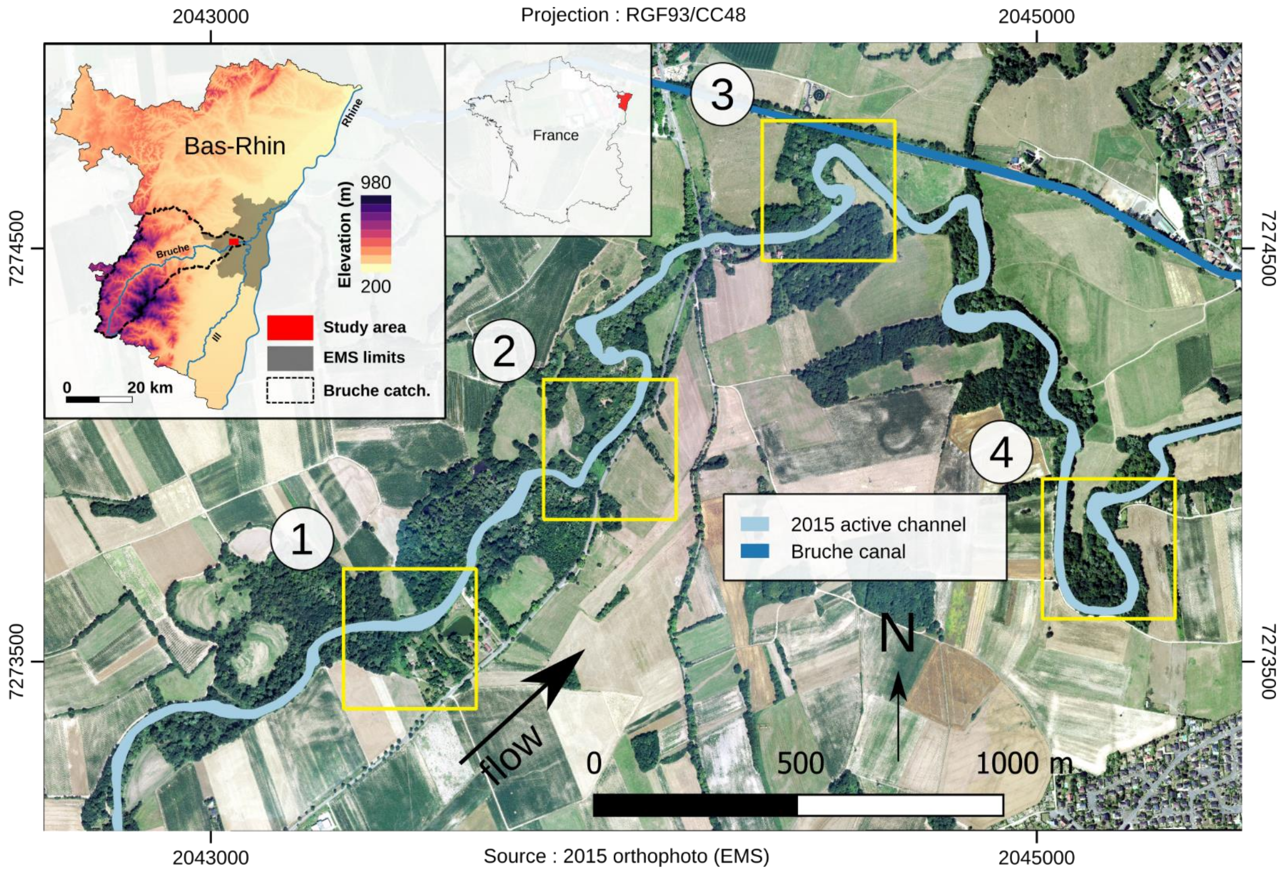
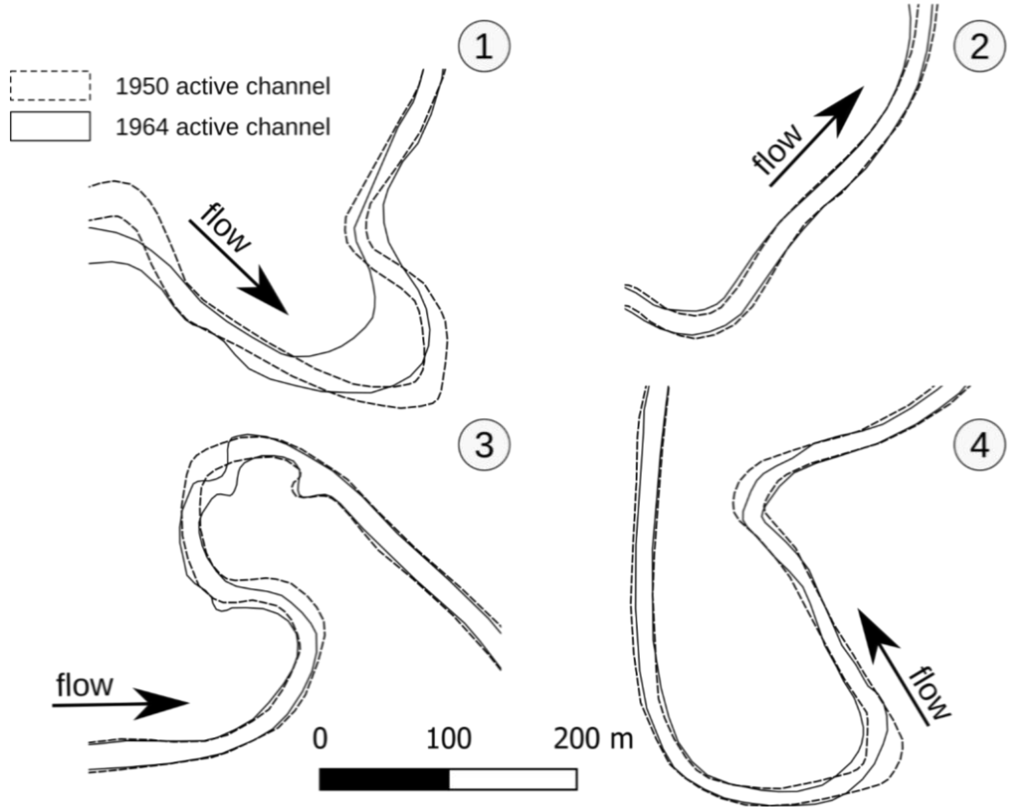




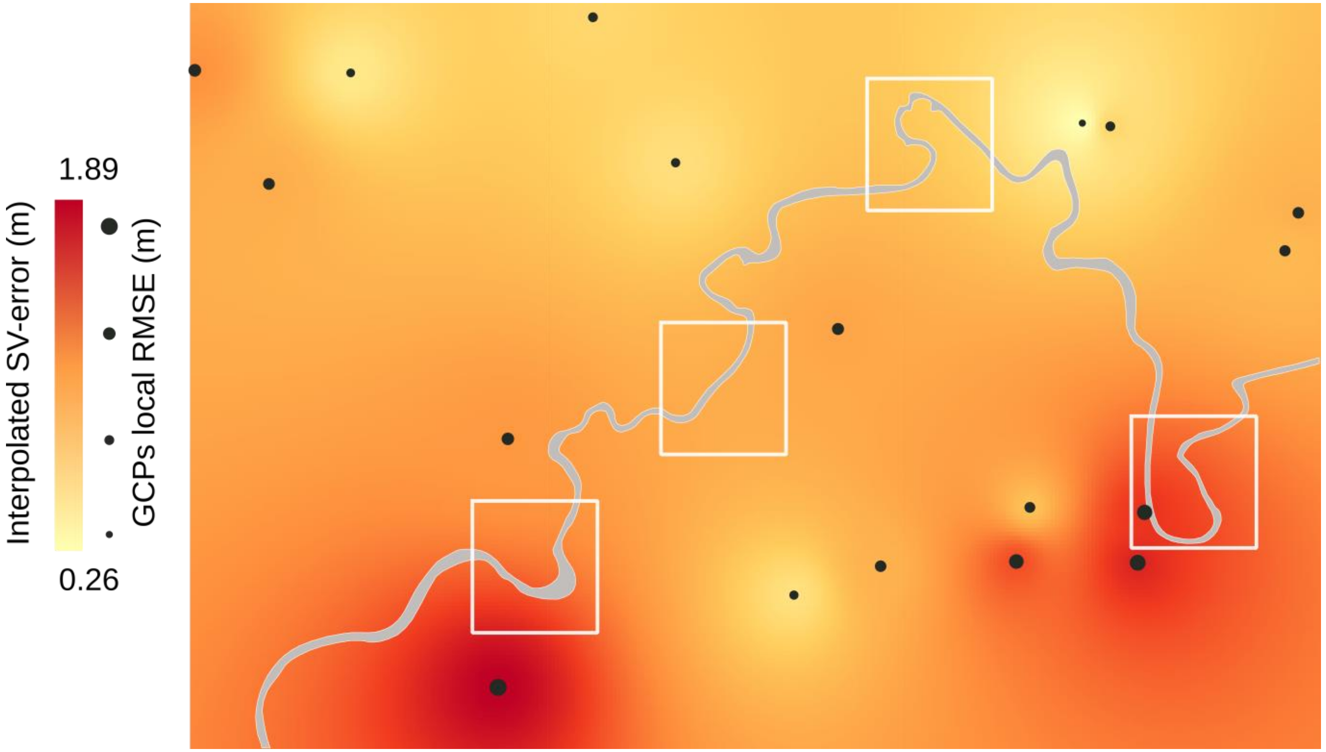
- 6km long sub-tributary of the Upper Rhine
- Laterally active mid-sized river (~20m width)

- 2 orthophotos (1950; 1964)
- 4 different fluvial situations
- 3 processes : erosion, deposition and both

METHODS: SV error interpolation

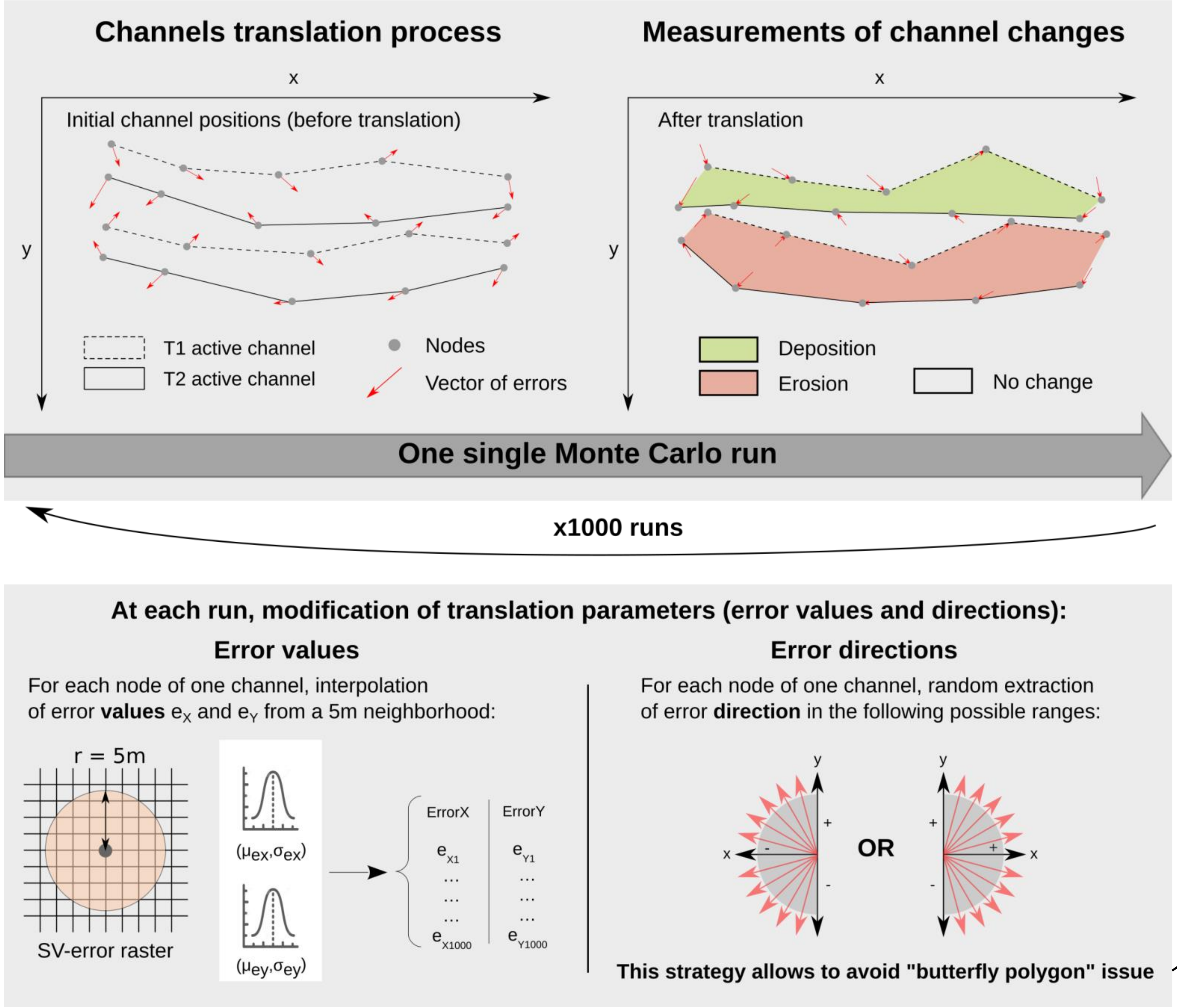
- Selection of 18 ground control points (GCPs) on the reference orthophoto (2015)
- GCPs localization on the 1950 and 1964 orthophoto

- Local RMSE
- Inverse Distance Weighting interpolation



<u>Each pixel (bank nodes) get a specific geometric error</u>

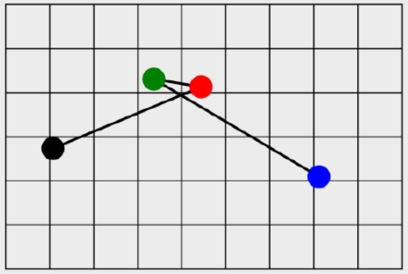
METHODS: Monte Carlo simulation



- According to its geometric error, each bank node is randomly translated
- Then, planform changes are measured

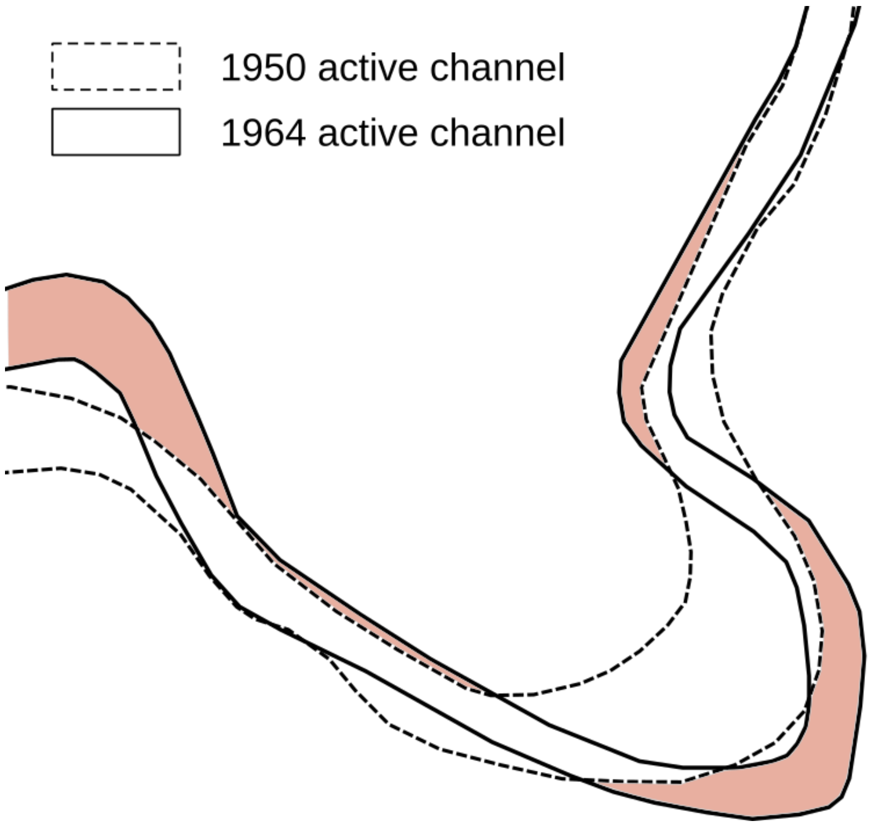
At each run:

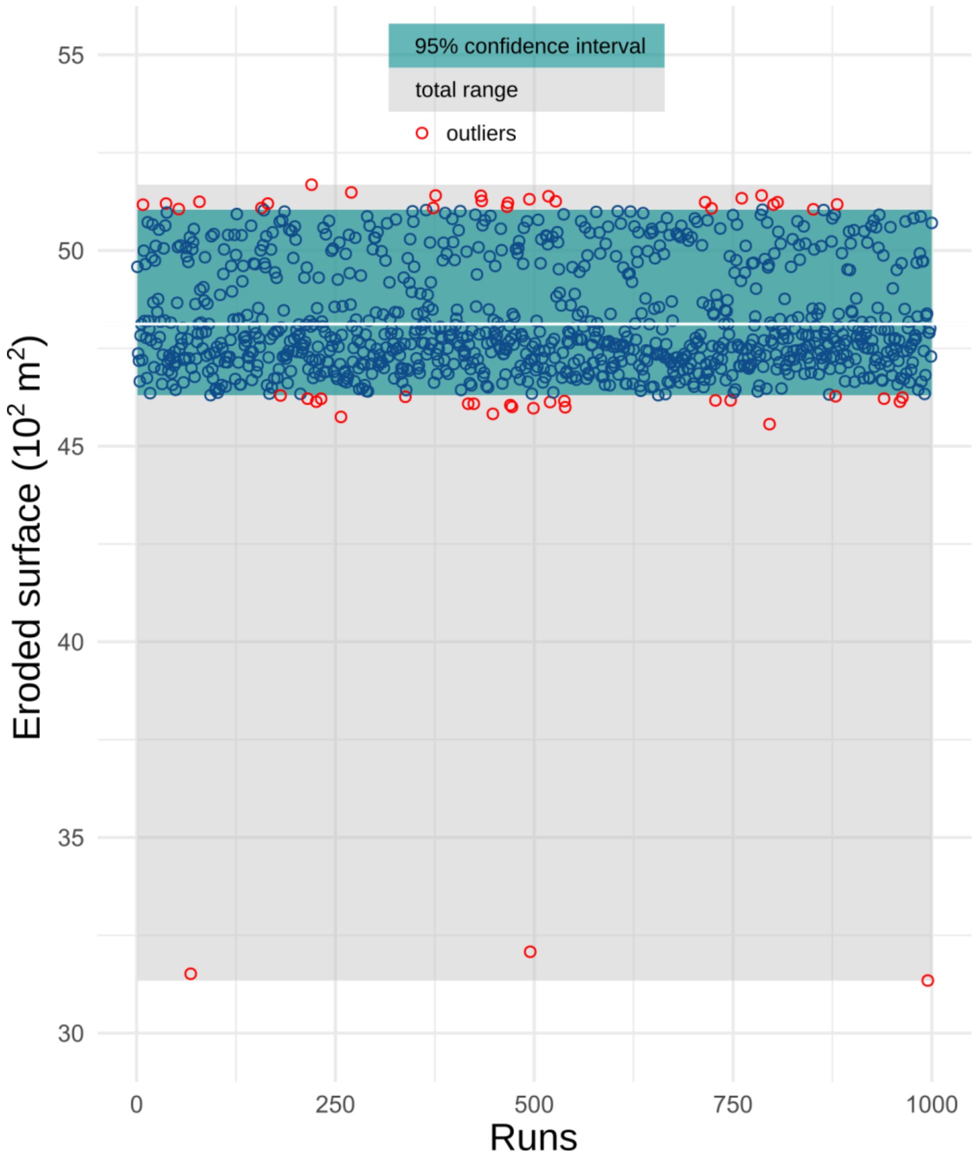
- the error value is re-extracted
- the error direction is reset



Simulated line with butterfly polygon

RESULTS: measurements variability

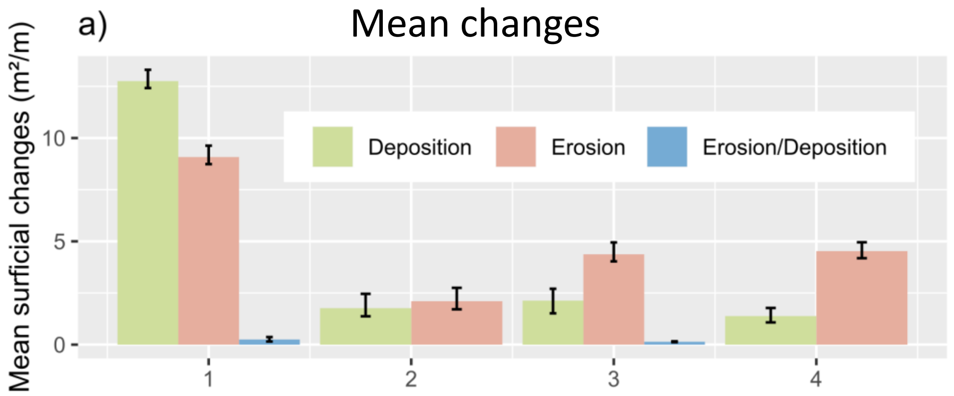




- Example for eroded surface in sub-reach 1
- Induced variability of the measurements
- Presence of outliers

DISCUSSION: measurements uncertainty

What confidence can we have with the measurements ?



The higher the change the lower the uncertainty ?

DISCUSSION: measurements uncertainty

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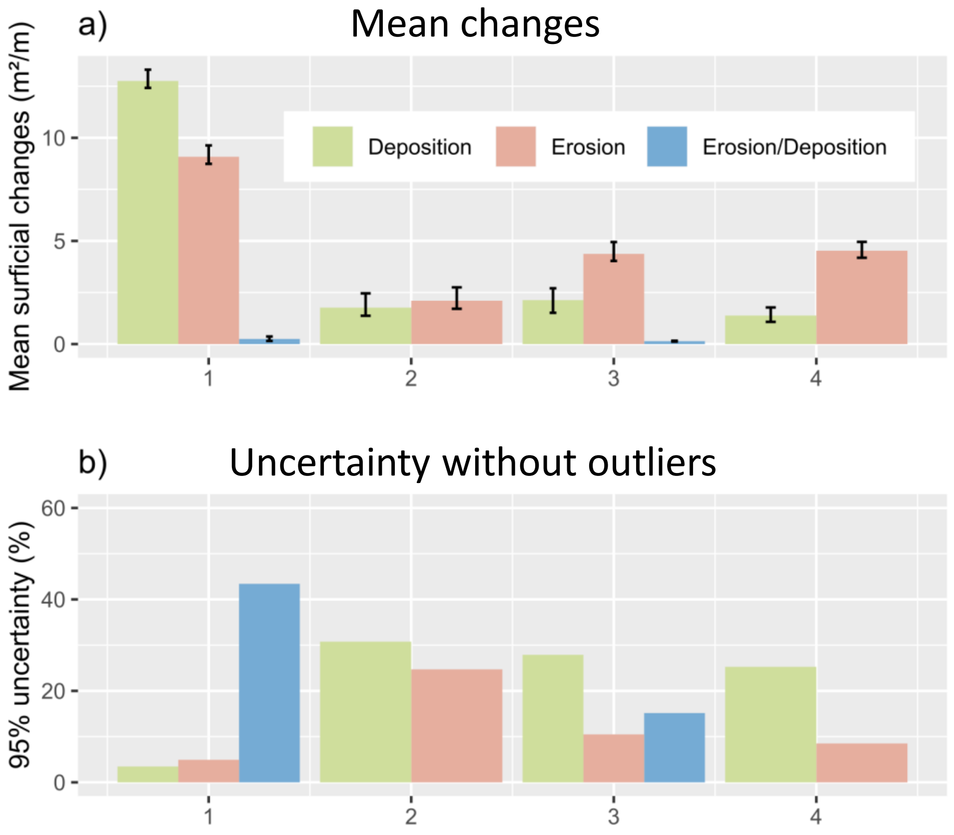
Compute percentage of uncertainty:

$$95\%\ uncertainty = \frac{\frac{1}{2} \times 95\%\ confidence\ interval\ width}{mean} \times 100$$



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Not as easy !

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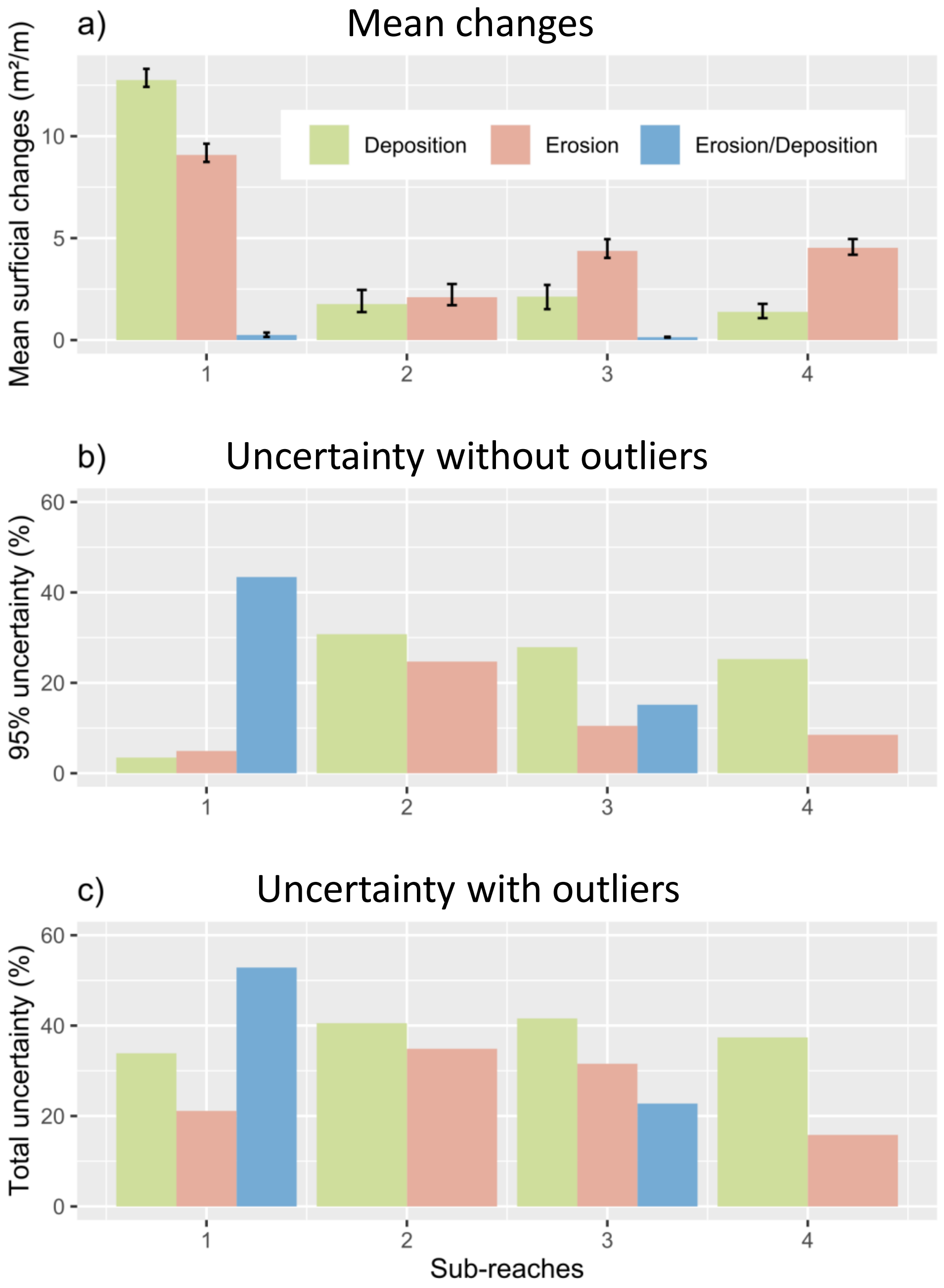

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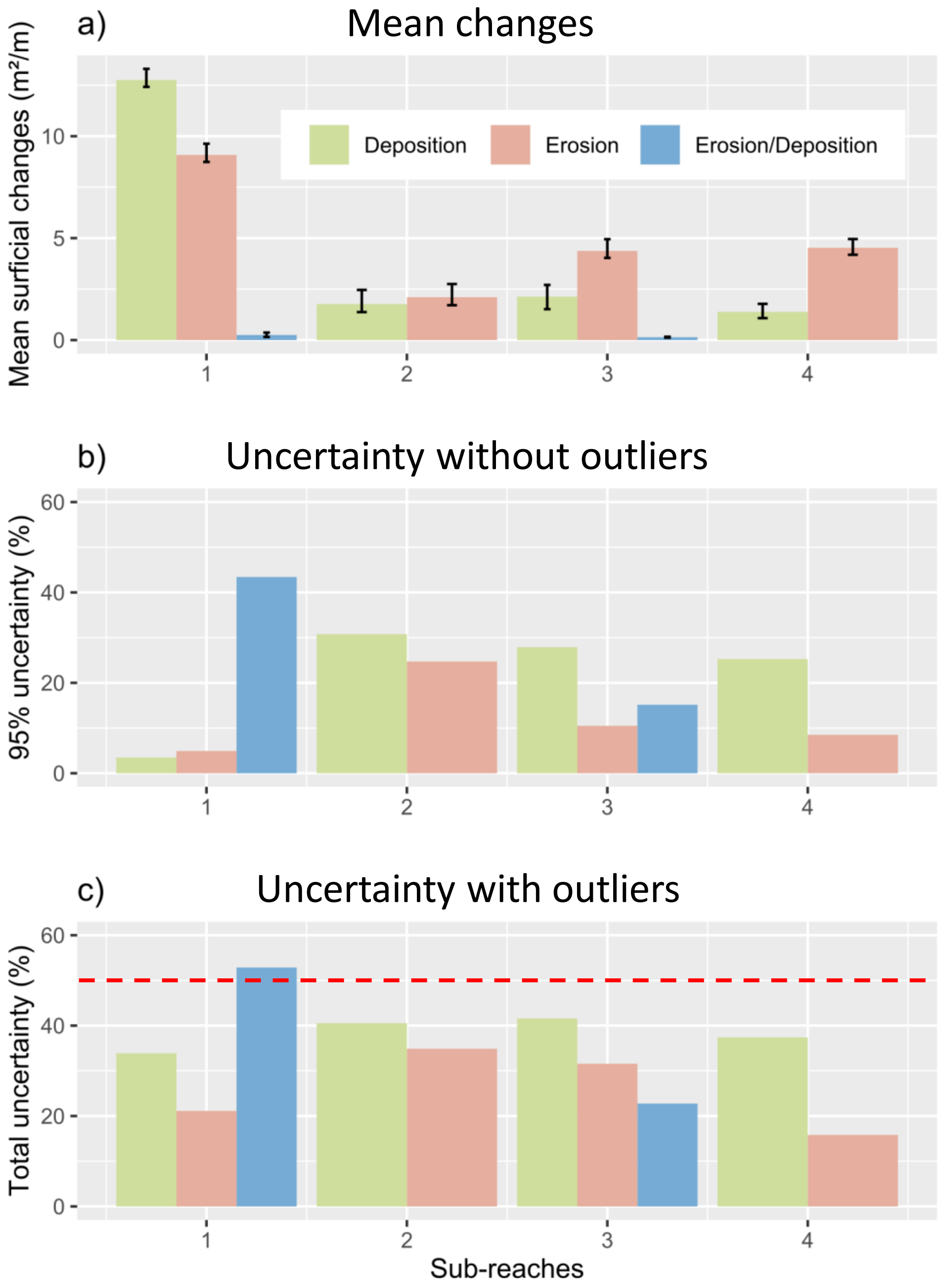

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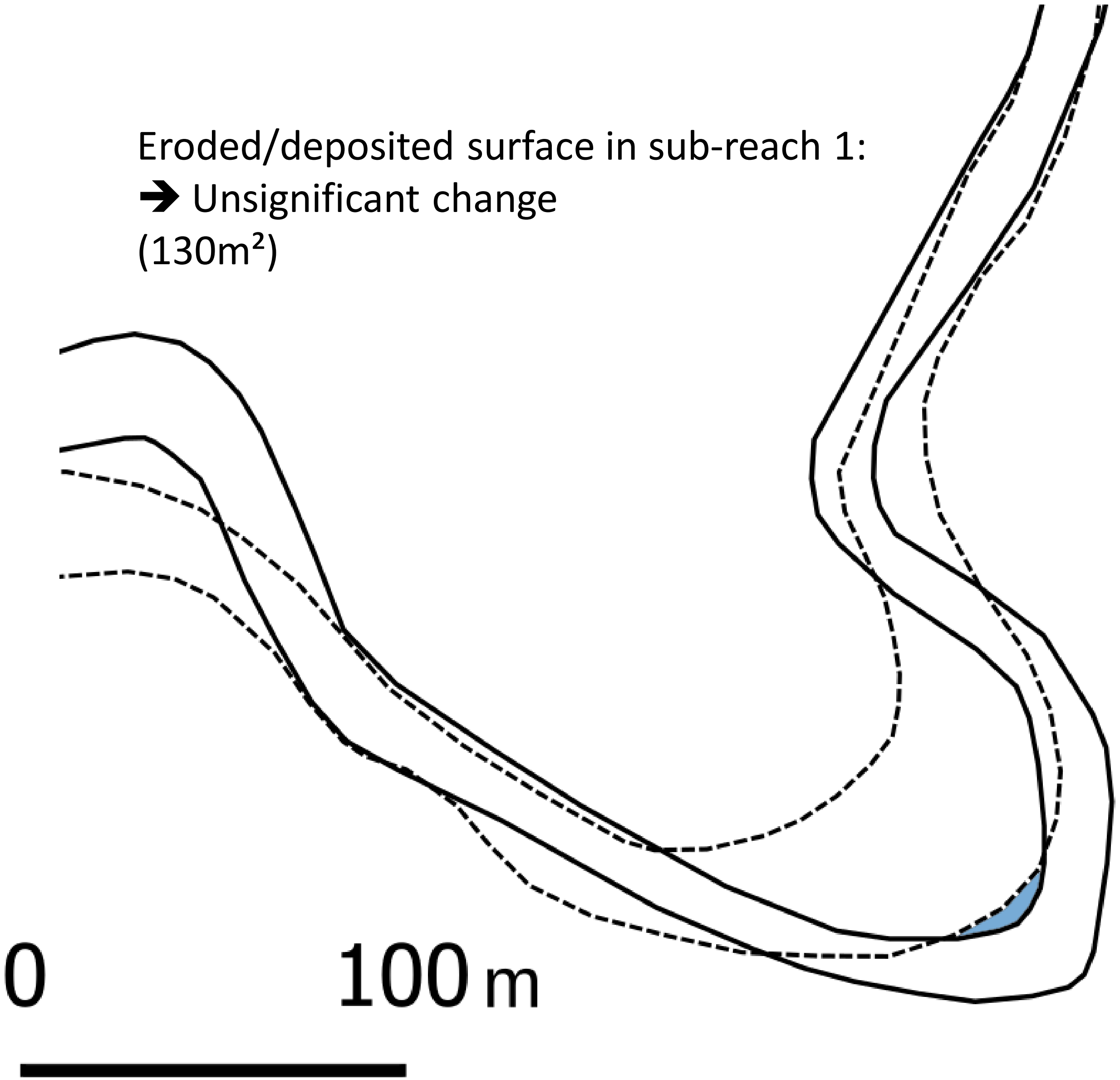
Not as easy !

When is a change unsignificant ?

When total uncertainty > 50%

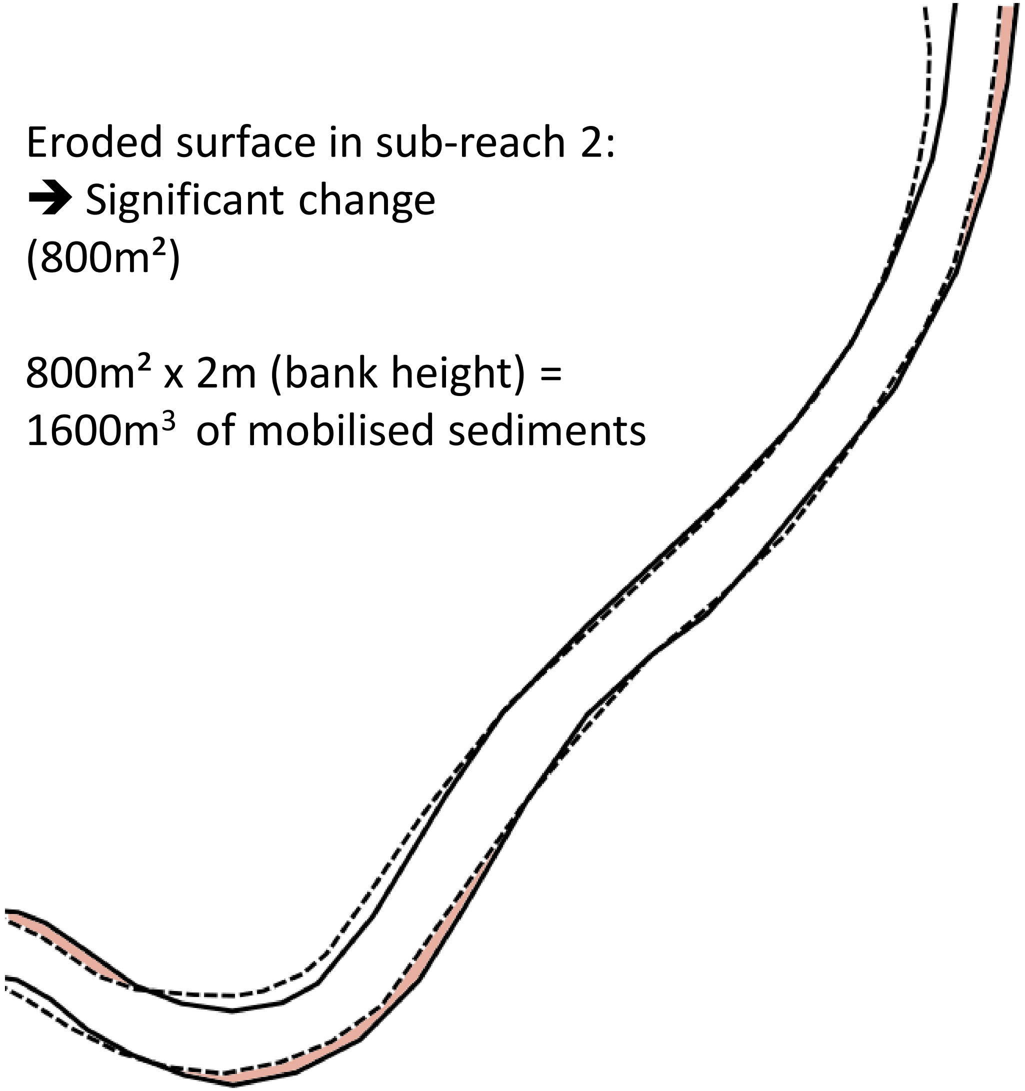
DISCUSSION: (un)significant examples

Eroded/deposited surface in sub-reach 1:
➔ Unsignificant change
(130m²)



Eroded surface in sub-reach 2:
➔ Significant change
(800m²)

800m² x 2m (bank height) =
1600m³ of mobilised sediments



CONCLUSIONS

- Orthophotos do are affected by SV error
- MC simulation allows to quantify SV error impact on a surficial metric
- SV error strongly affects uncertainty (significance) of measurements of the channel lateral mobility
- Uncertainty might be dependent **not only on the magnitude of changes, but also on their shapes**

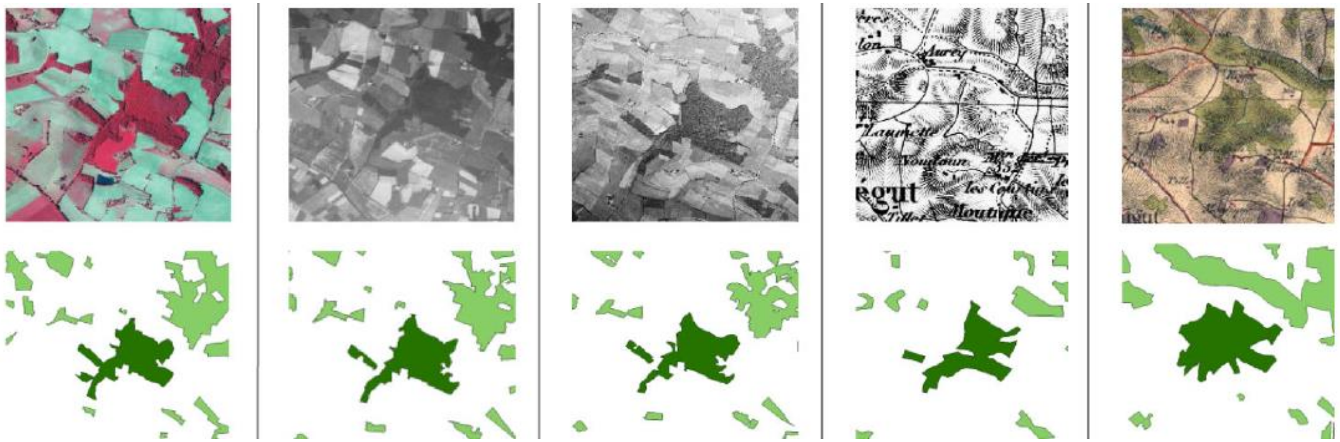
RECOMMENDATIONS AND PERSPECTIVES

- **Taking SV error into account is strongly recommended, regardless of the remotely sensed data used**

- Methodology easily transferrable to any channel patterns

- Methodology transferrable to other geographic issues

Forest evolution



(Herrault et al., 2015)

Braided river (Sunwapta river, Canada)