Sediment Management Workshop
Bolzano, 8th November 2018

Interreg Alpine Space
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HyMoCARES

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Benefits from sediment reintroduction schemes in rivers

Case studies on the Upper Drac and Büech Rivers

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Generalities about sediment recharge and its context

- Context of sediment depletion and its causes
- The restoration of alpine rivers requires the restoration of sediment continuity
- One possible solution is to reinject artificially sediment
- Few feedbacks on sediment recharge operations in the literature

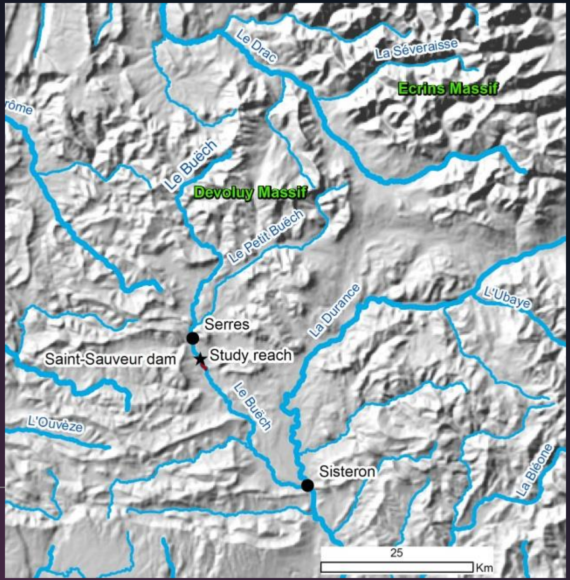
Case studies

TWO ALTERED RIVERS STUDIED IN THE FRENCH ALPS

Case studies

Two altered rivers studied in the French Alps

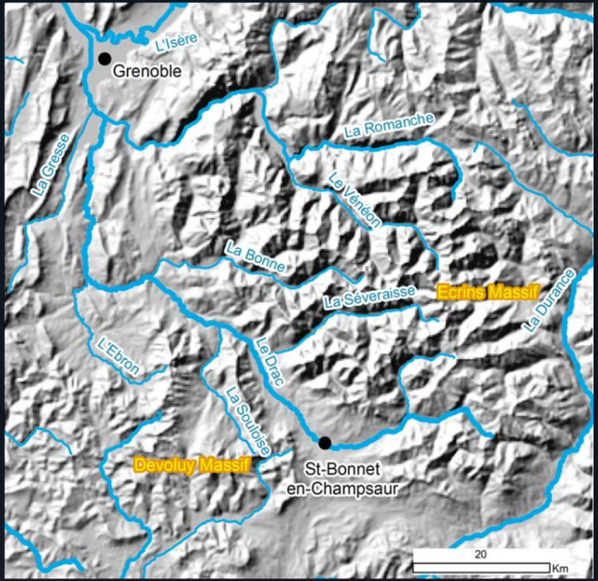
Buëch River



Durance catchment

Tributary of the Durance River

Drac River



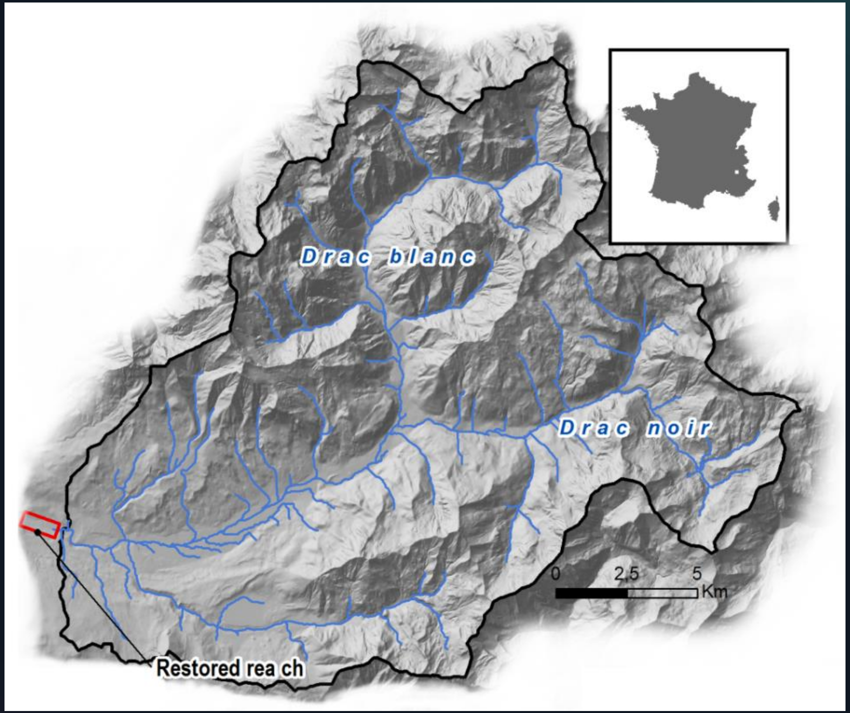
Rhône catchment

Tributary of the Isère River

Upper Drac River

The Upper Drac River and its catchment

Drainage area (in km²)	340
Location	44°39′17″N, 6°6′23″E
Length of the study reach (in km)	3.6
Active channel width (in m)	110
Channel slope (in m/m)	0.01
Planform morphology	Braided pattern
Mean discharge Q2	9 m³/s 90 m³/s



Study reach and its context

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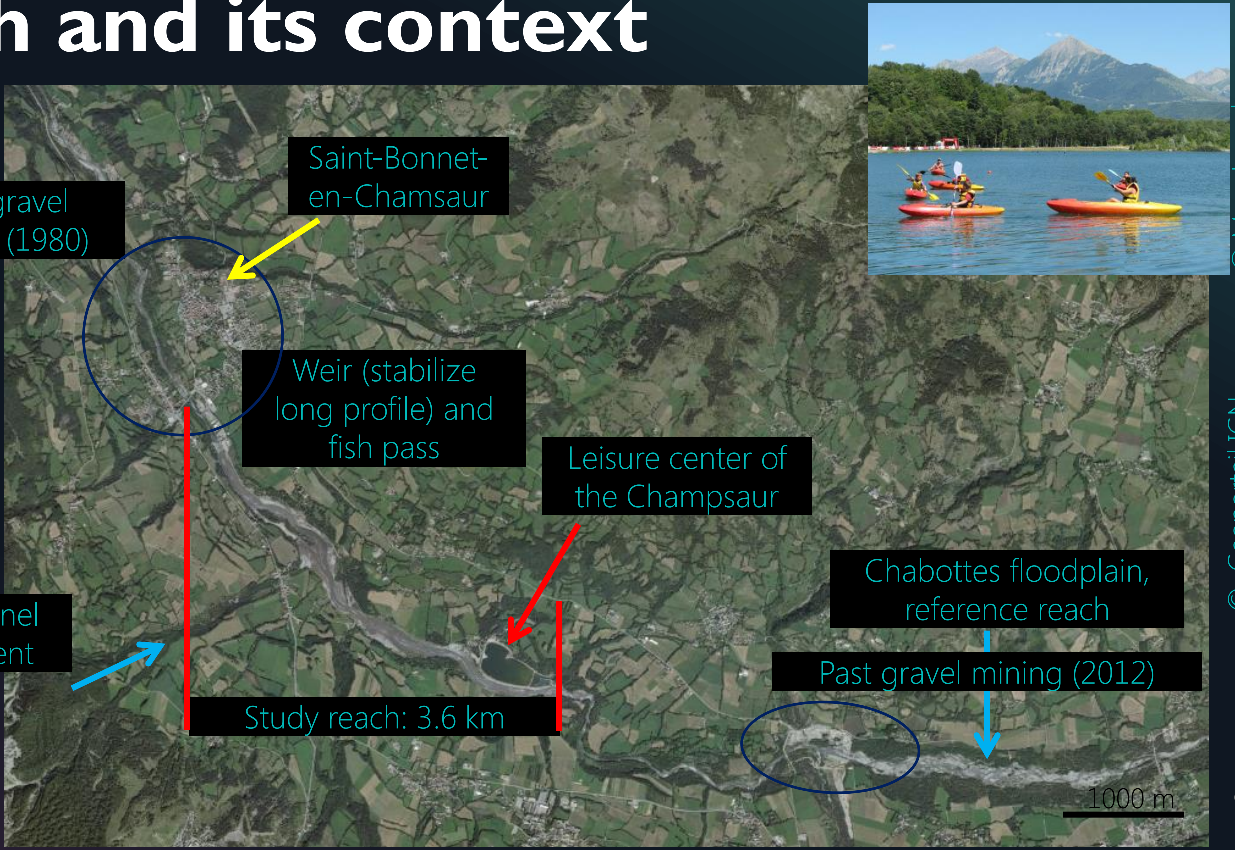

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Human alterations of the hydromorphology

- Dramatic channel incision into lacustrine clay deposits under the effect of gravel mining
- Intense regressive erosion and marked narrowing of the active channel
- A threat for the artificial pond of the Champsaur leisure center
- Lowering of the water table and subsequent alteration of the riparian forest
- Alteration of aquatic habitats related to the loss of gravel substrate and to the expanding clay outcrops

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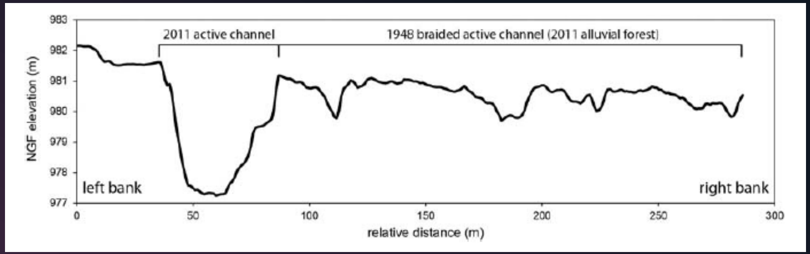
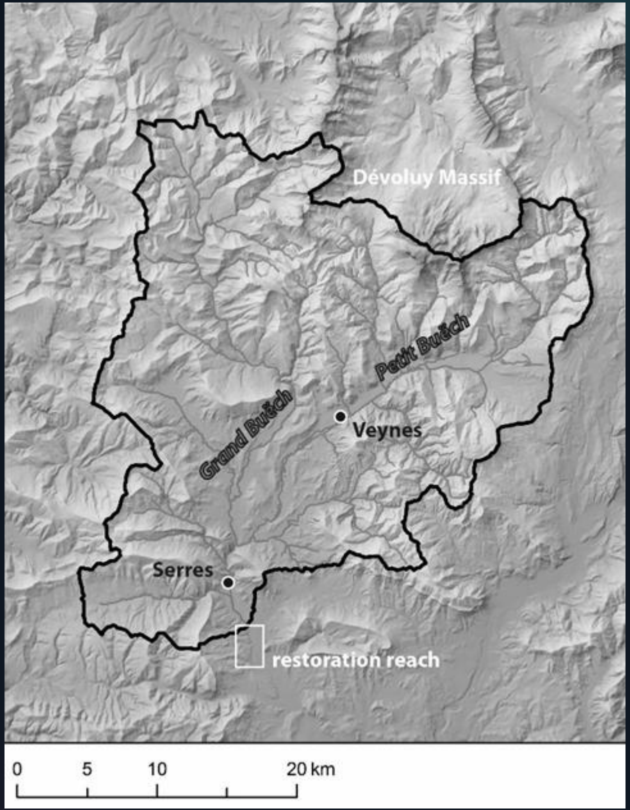


Buëch River

The Buëch River and its catchment

Drainage area (in km²)	836
Location	44°23′48″N, 5°43′51″E
Length of the study reach (in km)	2,2
Active channel width (in m)	180
Channel slope (in m/m)	0.009
Planform morphology	Braided / wandering patterns



Study reach and its context

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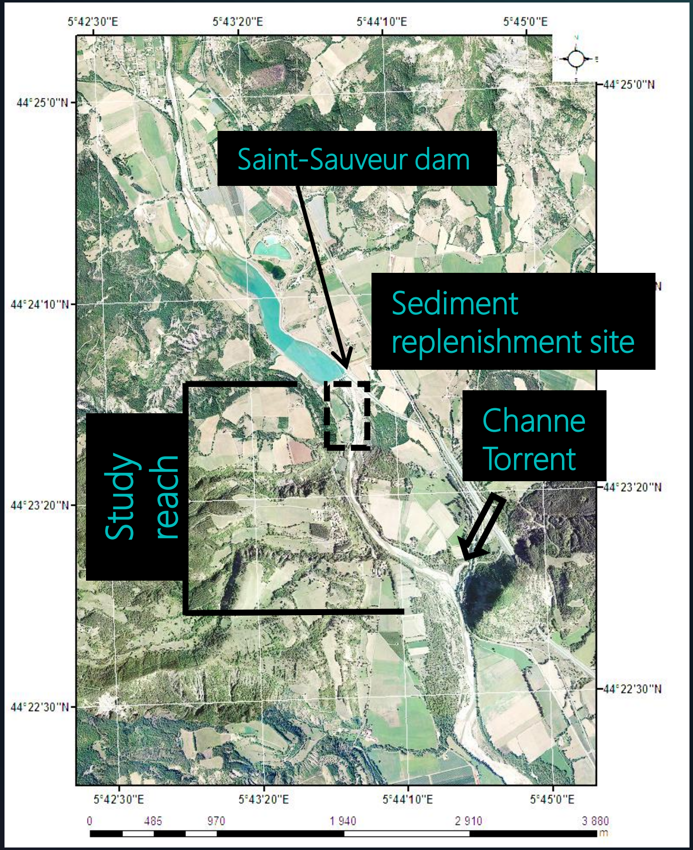

Brousse G. 2017, IAG 9th ICG

Human alterations of the hydromorphology

- Gravel mining > 3 millions of m^3 in the upper catchment
- Dam built between 1991 and 1992: dredging of 600,000 m^3 of sediment
- Sediment transport continuity strongly impacted
- Narrowing of the active channel
- Channel incision (marly bedrock outcrops)
- A shift from a braided to a wandering pattern

1956 2006

Restoration actions

SEDIMENT REPLENISHMENT AND POST RESTORATION REMOBILIZATION

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Upper Drac River

Hydromorphological restoration project

Between 11/2013 and 04/2014

355,000 m^3 of sediment from alluvial terrasses reintroduced

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Rectangular cross-section

to form a wide active channel like it was before degradation with a general rise of the bed-level to stop regressive erosion


©EDF

Buëch River

Hydromorphological restoration project

8 weeks – 09/2016

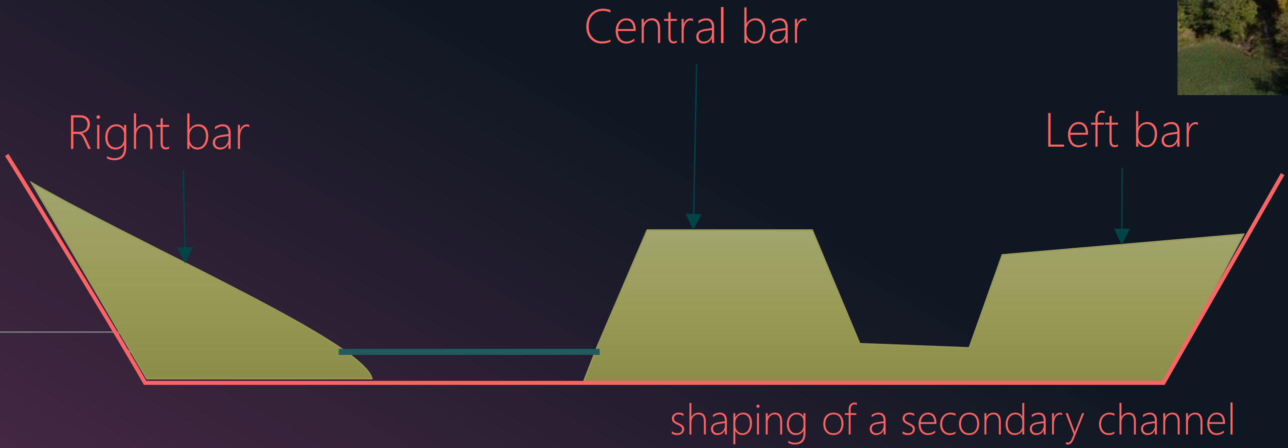
Dredging the alluvial fan of the Saint Sauveur reservoir

Sediment replenishment downstream of the dam

44,000 m^3

EDF ©

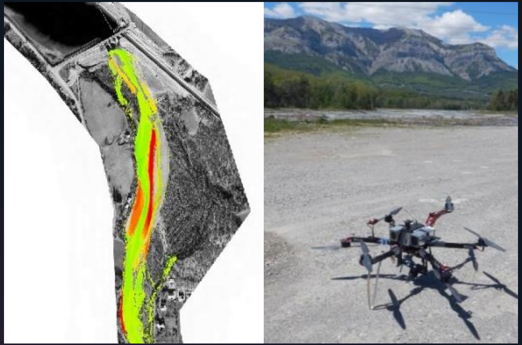
Schematic cross section of the replenishment operation



Brousse G. 2017, IAG 9th ICG

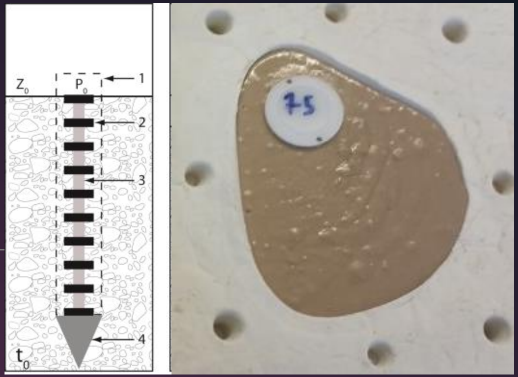
Monitoring design and first results

Monitoring of the restoration projects



Repetitive high-resolution topographic surveys of the restored reach

High-frequency qualitative survey of channel changes using time-lapse cameras



Bedload tracing program using active ultra-high frequency RFID technology

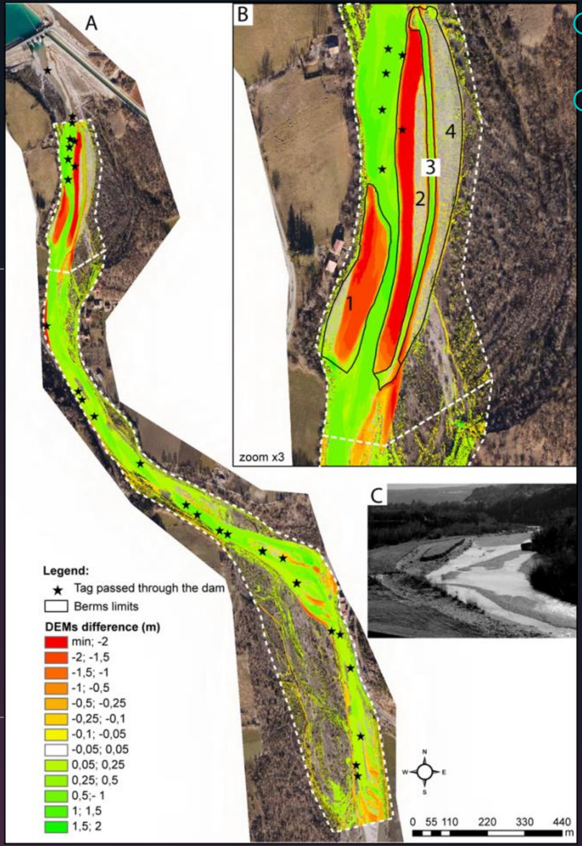
Ancillary field surveys for specific data analysis

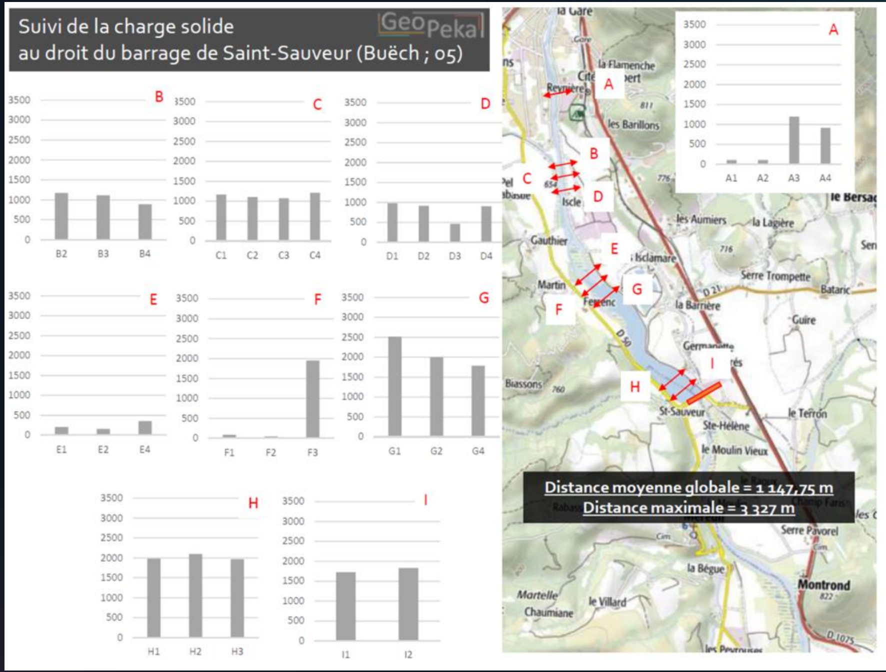
Buëch River

Effects observed after a Q10 flood:
50% of injected volume remobilized

Post-restoration sediment remobilization

- Aggradation downstream of the recharge site
- RFID tags have moved up to 2km downstream of the dam



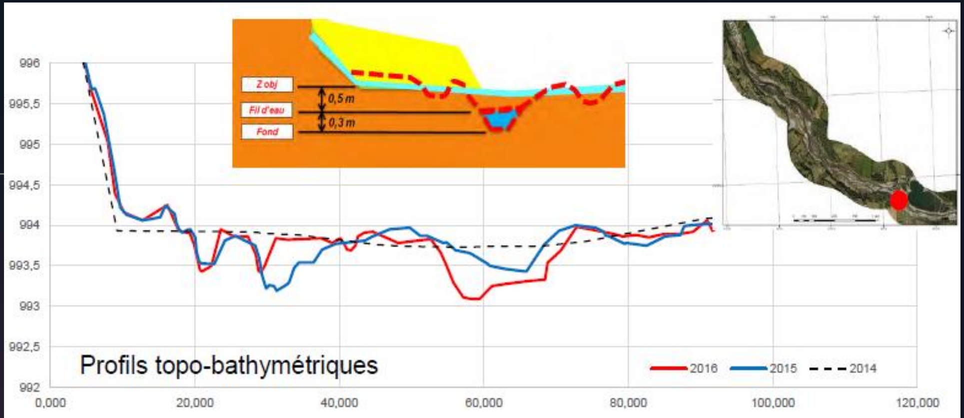


Upper Drac River

Formation of low-flow channels on the upstream part of the restored reach

Post-restoration sediment remobilization

- Effects observed on the first post-restoration campaign



On the bed elevation

Two sectors showed preferential adjustement on the 2014 and 2015 long profiles (Brousse et al. 2017)

On the distances of bedload transport

75 RFID Tags deployed on the reference reach (upstream of the restored reach) which covered a maximal distance of 2.9km (after 11 months of monitoring)

Brousse et al. 2017

First results

On the Upper Drac site

- A promising trend towards spontaneous braiding recovery
- A rapid transfer of gravels from the first upper sediment source (the braided Chabottes plain)
- Diversity of flow facies and habitat recovery

On the Buëch site

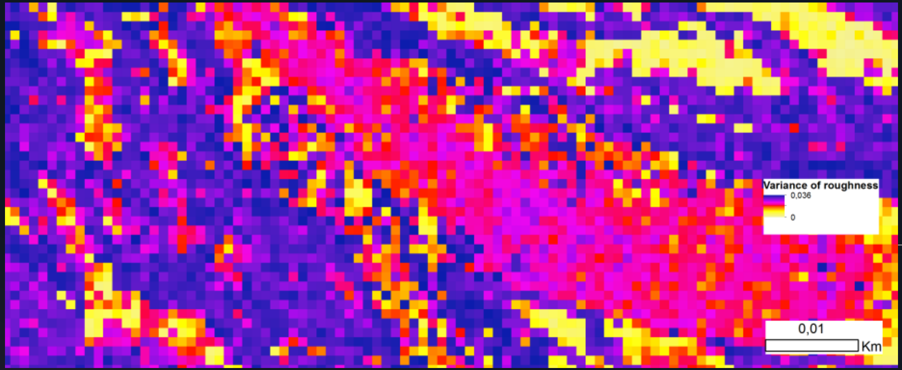
- Global aggradation and scour limitation but no braided pattern observed yet
- A transfer of gravels from upstream of the dam
- Recharge in a context of flood: what will be the evolution of the morphology without big flood event ?

Benefits of photogrammetry technics for the monitoring of sediment replenishment

DEM and ortho xy resolution is very high (1-5cm) and errors very low

Point clouds are extended under water (compared to limited LiDAR technics) but have to be corrected

Surficial grain size distribution on gravel bars and under water: parameters (based on manual measurements of the visual gravel sizes on the orthophotos) are correlated with a roughness index of the point cloud → Spatially continuous map of substrate size



Work in progress

A multivariate analysis conducted at the reach scale, to produce a map of the diversity of flow facies and physical habitats which is reproducible every field campaign to assess benefits of restoration actions

- The water features
- The water depths and relative elevation to the water level
- The roughness indicator (correlated to the surface grain size)
- The relative elevation to the thalweg

Conclusion

Monitoring design adapted to the assessment of morphological changes

Successful operations of sediment replenishment (spontaneous braiding recovery)

Limitation of incision in both sites and associated risks

Tools developed and validated on both sites

Multivariate analysis promising

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Thanks for your attention

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