Effect of forest and check dams on water surface, bedload input and debris earth flow in alpine watersheds

- SOME EXAMPLES OF FRENCH EXPERIENCE -

4th Workshop of the WPMMW Working Group 2
Traunkirchen – Austria – June 11-13, 2018

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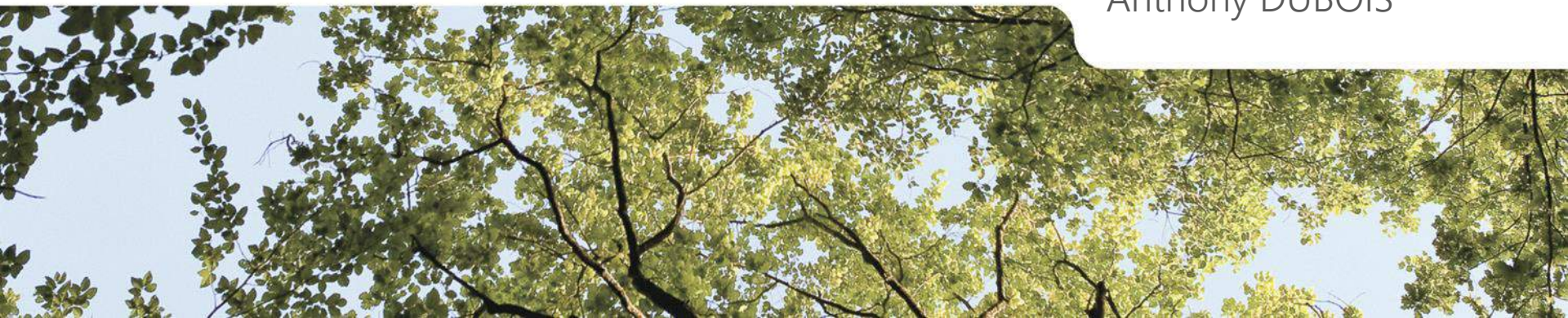


A long history of reforestation and torrent control works

National context

- Early and Mid 19th century : 'Forester' lobby + pioneering work on check-dams
- Mid to late 19th century : 3 laws (1860, 1864, 1882)
- Late 19th century -> Early 20th century : « Golden » age of RTM works
- Now : 14 000 check dams maintained, 10 tunnels, 736 km of drainage netwoks, 74 km of avalanche barriers

Some examples

Grollaz watershed (Savoie)
Béoux watershed (Drôme)

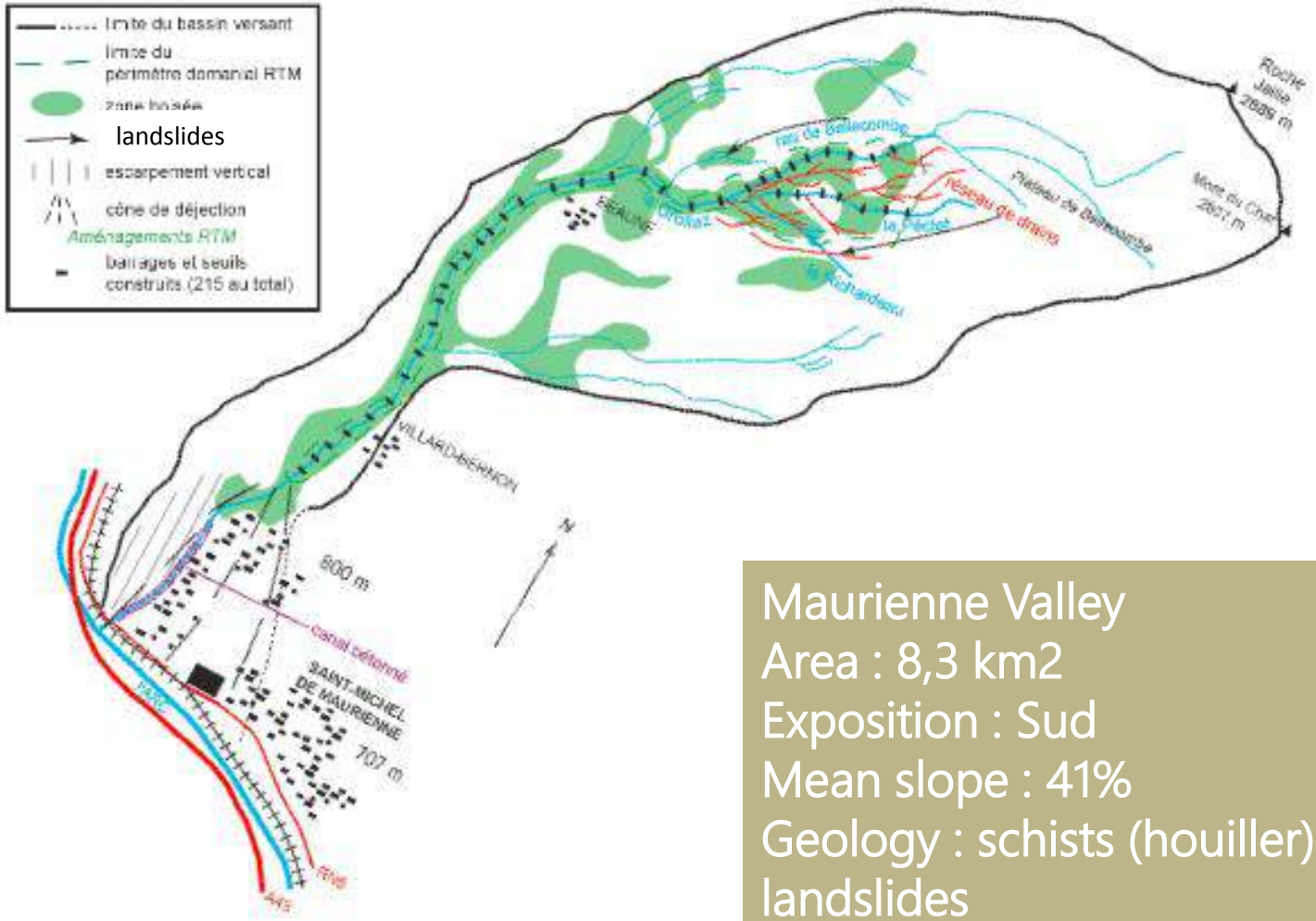
A long history of reforestation and torrent control works

Grollaz (Savoie)

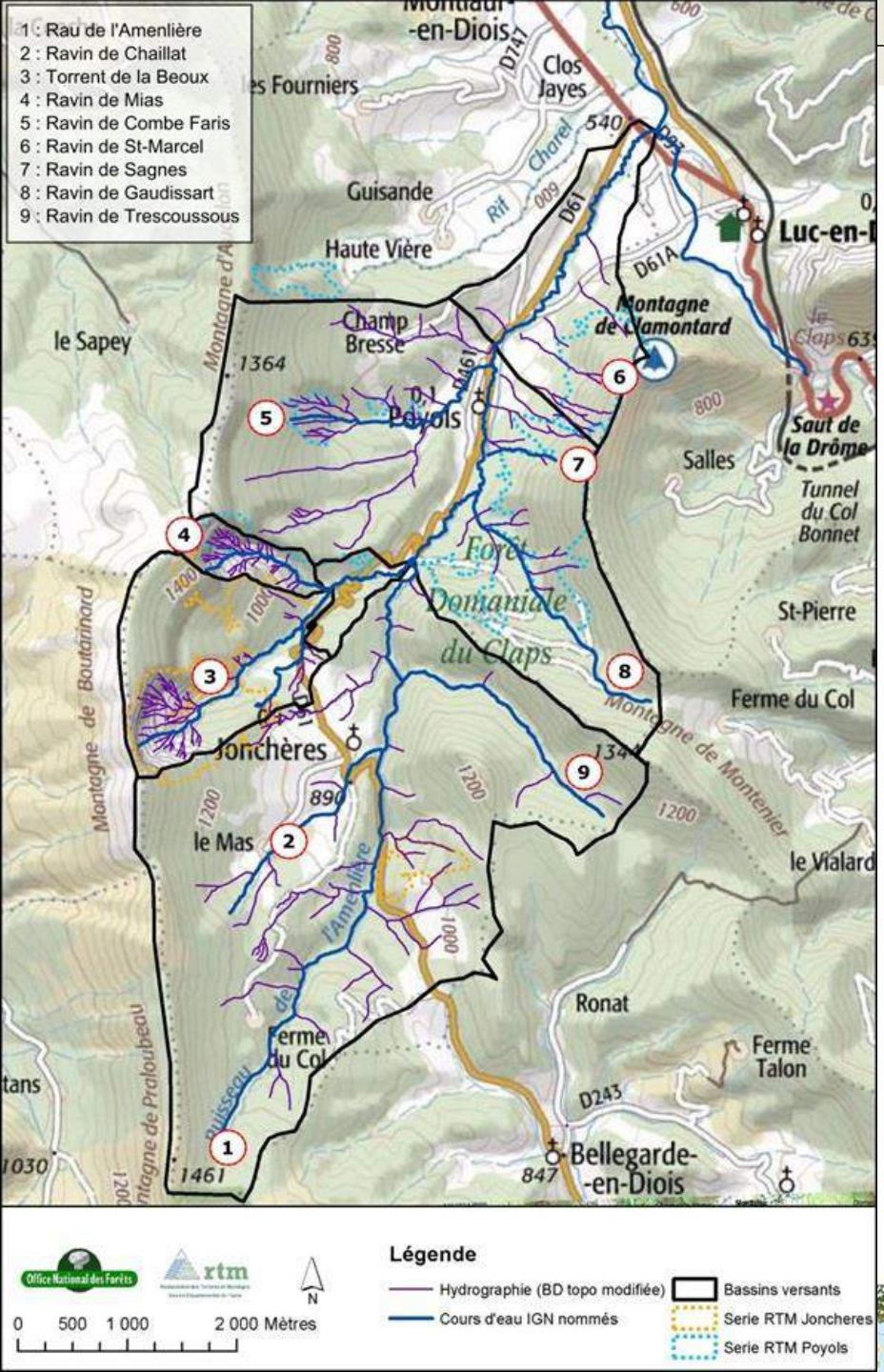
Béoux (Drôme)

Torrent of Grollaz

Main features



Maurienne Valley
Area : 8,3 km2
Exposition : Sud
Mean slope : 41%
Geology : schists (houiller) -> prone to landslides



Béoux river

- Main tributary of Drome river
- 2 main streams : Béoux et Bourdiole
- Area : 28,4 km2
- Geology : sedimentary rocks (jurassic and cretaceous)
- Erosion only in Beoux and Mias upper catchments
- Intense torrent control/reforestation intervention in the catchment

EFFECT OF FOREST AND CHECK DAMS ON WATER SURFACE, BEDLOAD INPUT AND DEBRIS EARTH FLOW IN ALPINE WATERSHEDS

1- Effect of reforestation

2- Effect of check dams

1- Effects of reforestation

A- Morphological evolutions

↘ Eroded areas -> ↘ sediment loads -> ↘ bedload transport

➔ Morphological changes

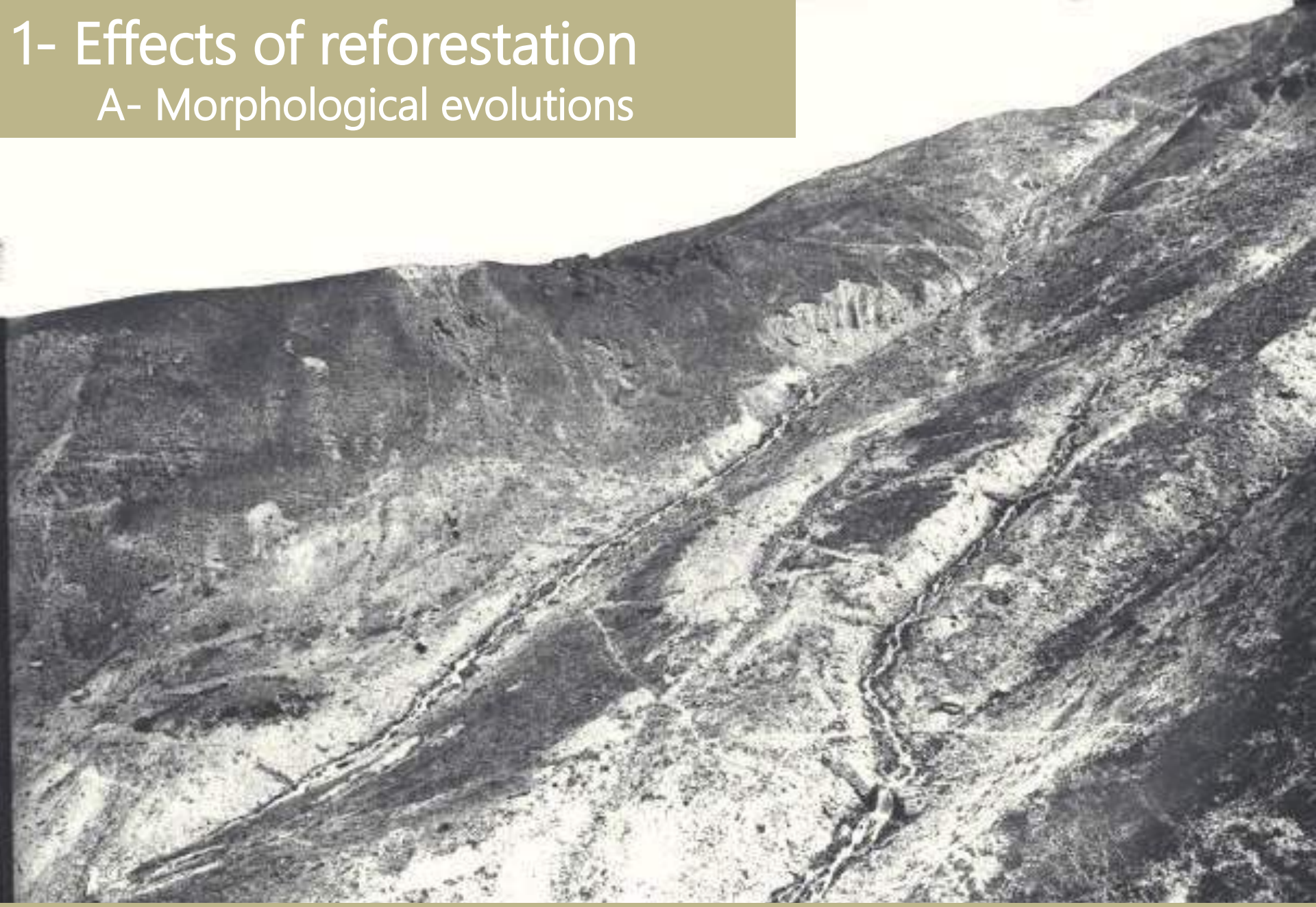
B- Potential source of woody debris during floods and landslides

+ Regulation of flow discharge

→ Difficult to measure
Capacity of regulation varies according to vegetation type/species ?

1- Effects of reforestation

A- Morphological evolutions



> Grollaz watershed

Success of reforestation during the XIXth century


30 years later

Alluvial fan – before RTM works

Grollaz Watershed, 1880

Alluvial fan - 2002

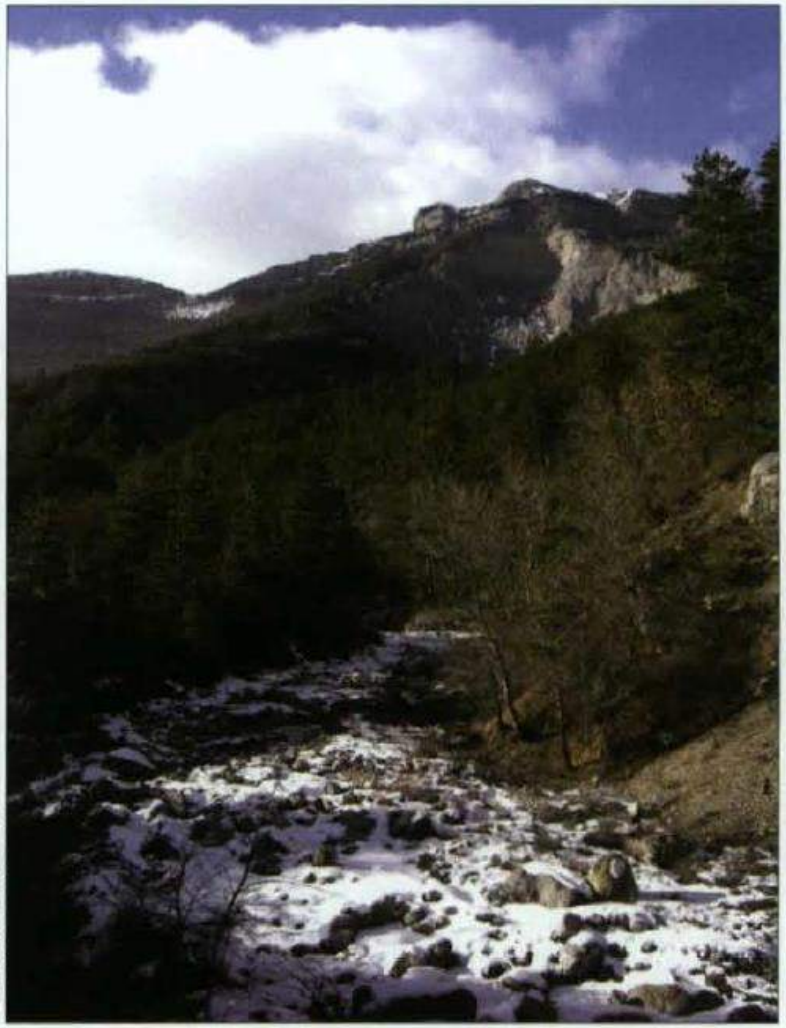
Source : archives RTM


The torrent now
RTM 73

1- Effects of reforestation

A- Morphological evolutions

La Béoux - 1899



La Béoux - 2005

> Béoux watershed

19th century

Forest : 405 ha (24%)

Eroded lands : 553 ha (32 %)

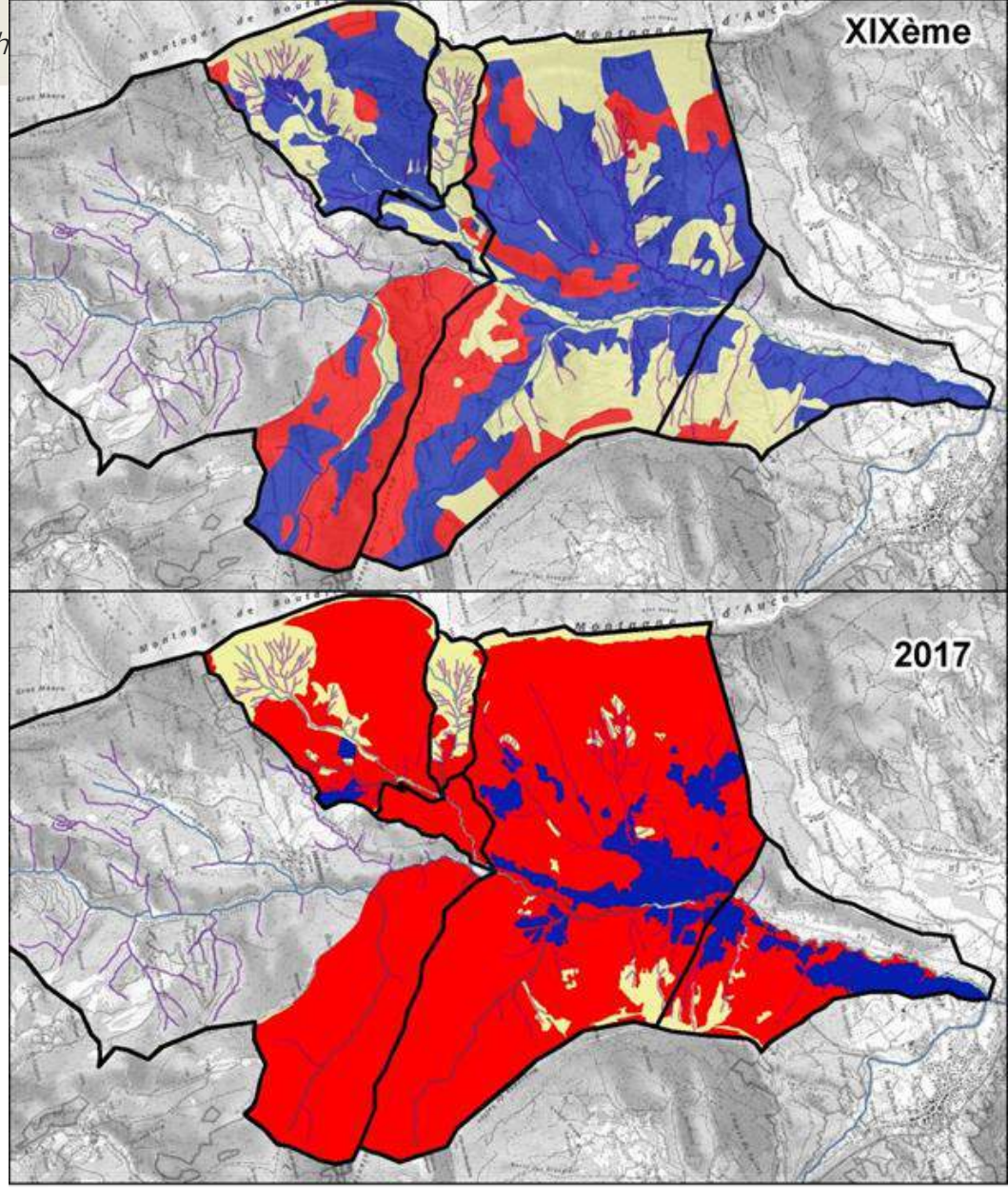
Uncultivated lands : 744 ha (44 %)

2017

Forest : 1345 ha (79%)

Eroded lands : 190 ha (11 %)

Uncultivated lands : 167 ha (10 %)



0 500 1 000 2 000 Mètres

Légende

Hydrographie

Bassins versants

Occupation du sol

formations boisées

zones en érosion

autres formations (landes, friches,...)

Office National des Forêts

rtm

Effect on bedload transport

During floods

ECSTREM Method (Peteuil et Liebault, 2010)

$$V_{100} = 112700.A_{er}^{0,93}.S^{0,75}$$

Formula for torrents prone to bedload AND debris flows
Aer : area of eroded lands connected to the streams (km2)
S : slope of the stream (m/m)

Période de retour	Période actuelle	XIXème siècle	
		Hypothèse basse	Hypothèse haute
T = 10 ans	3 890 m³	11 750 m³	13 170 m³
T = 100 ans	6 990 m³	25 170 m³	28 630 m³

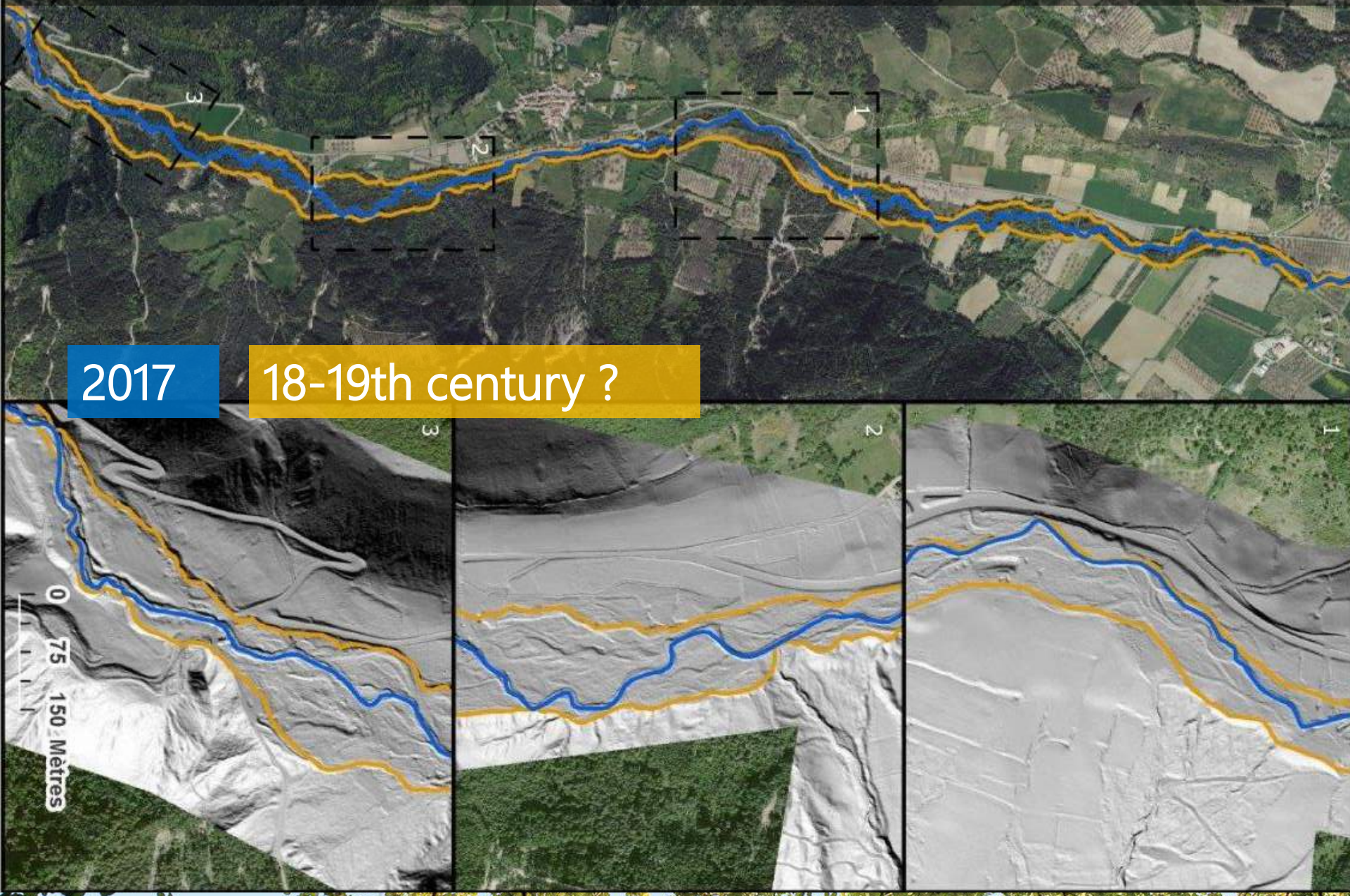
Tableau 23 : Volumes mobilisables par charriage – méthode ECSTREM

→ Diminution of sediment loads by 3 to 4

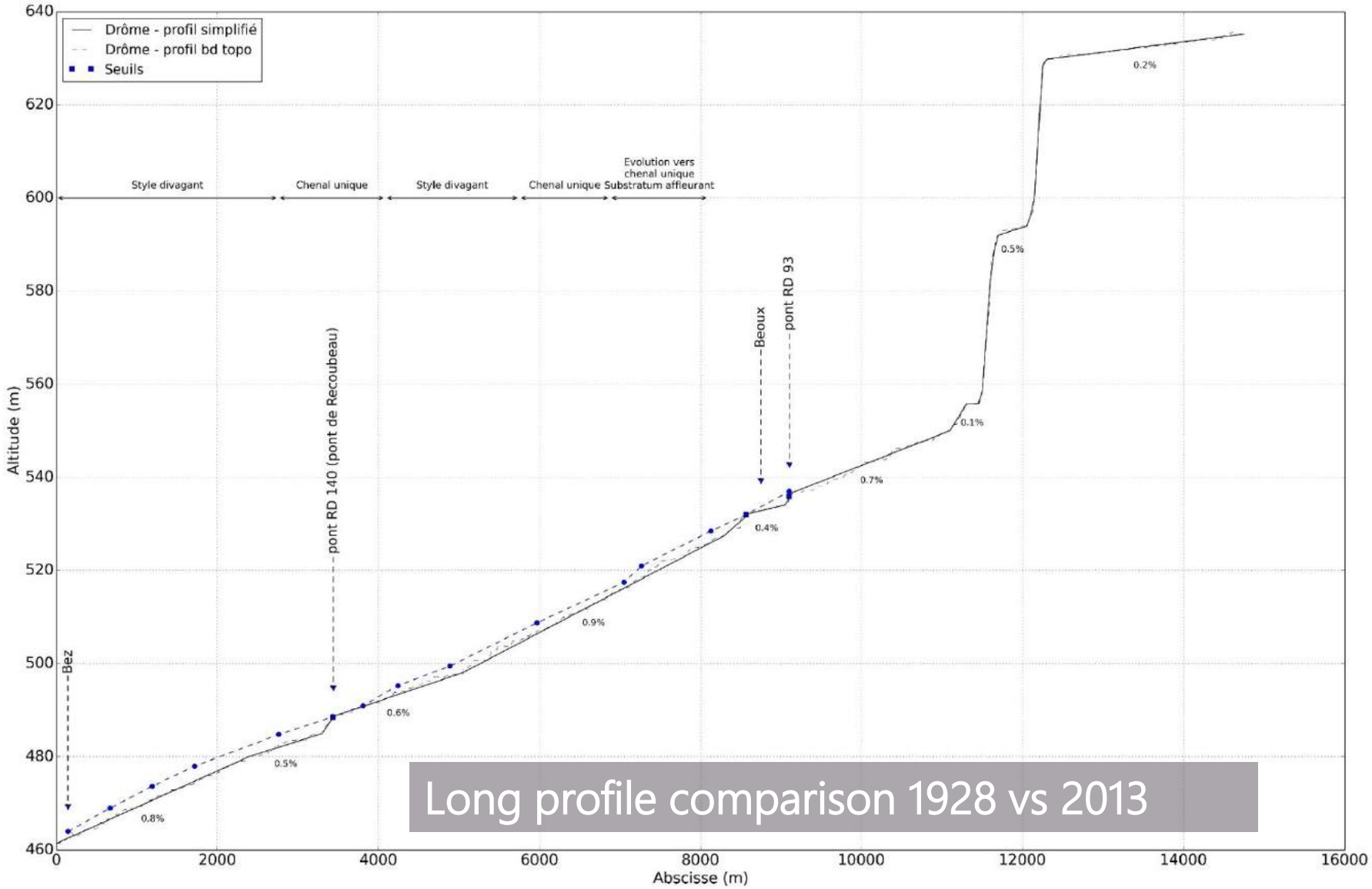
Narrowing of active channel width

Old footbrige on the Béoux river

Narrowing of active channel width

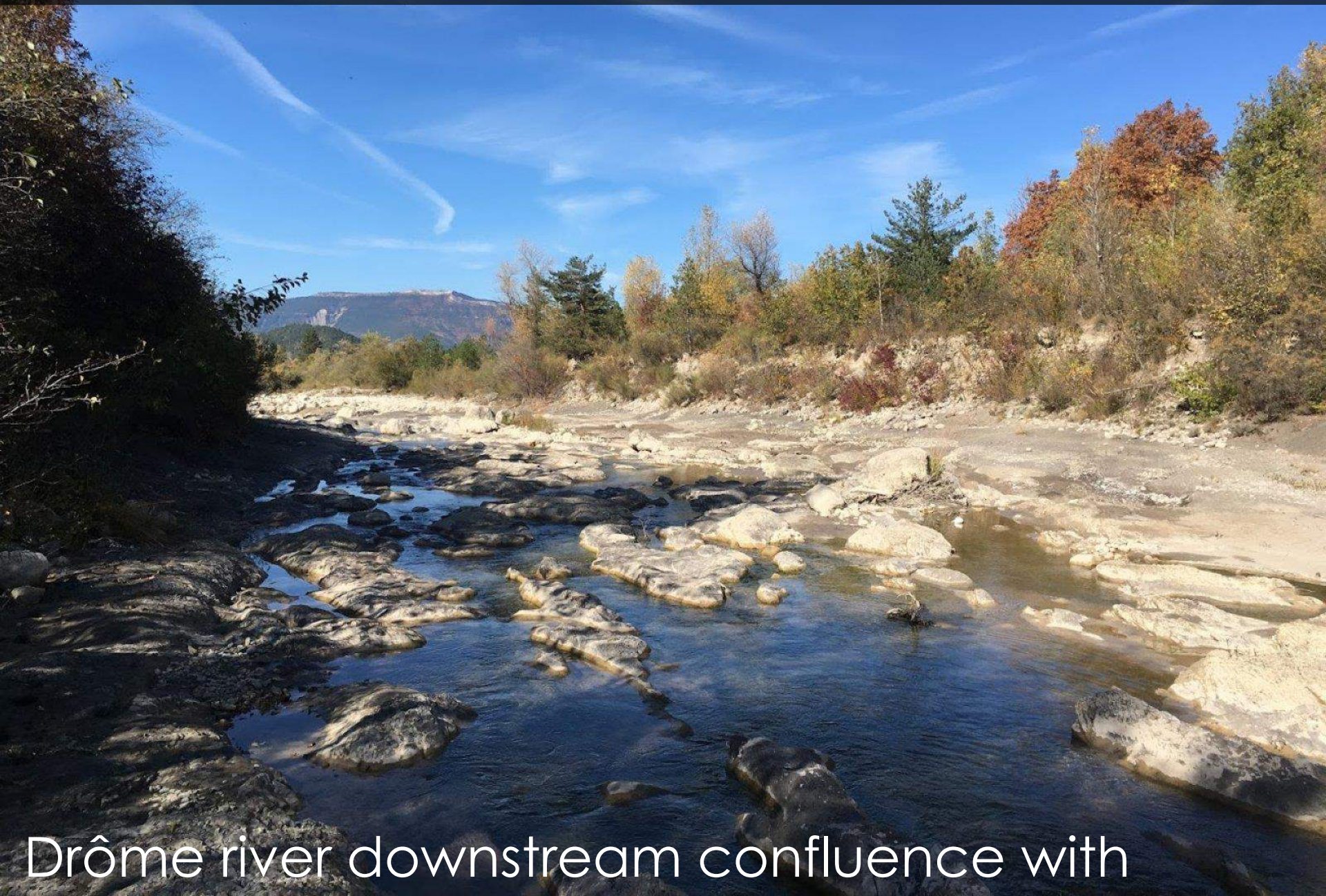


Drôme incision : -3,0 m !



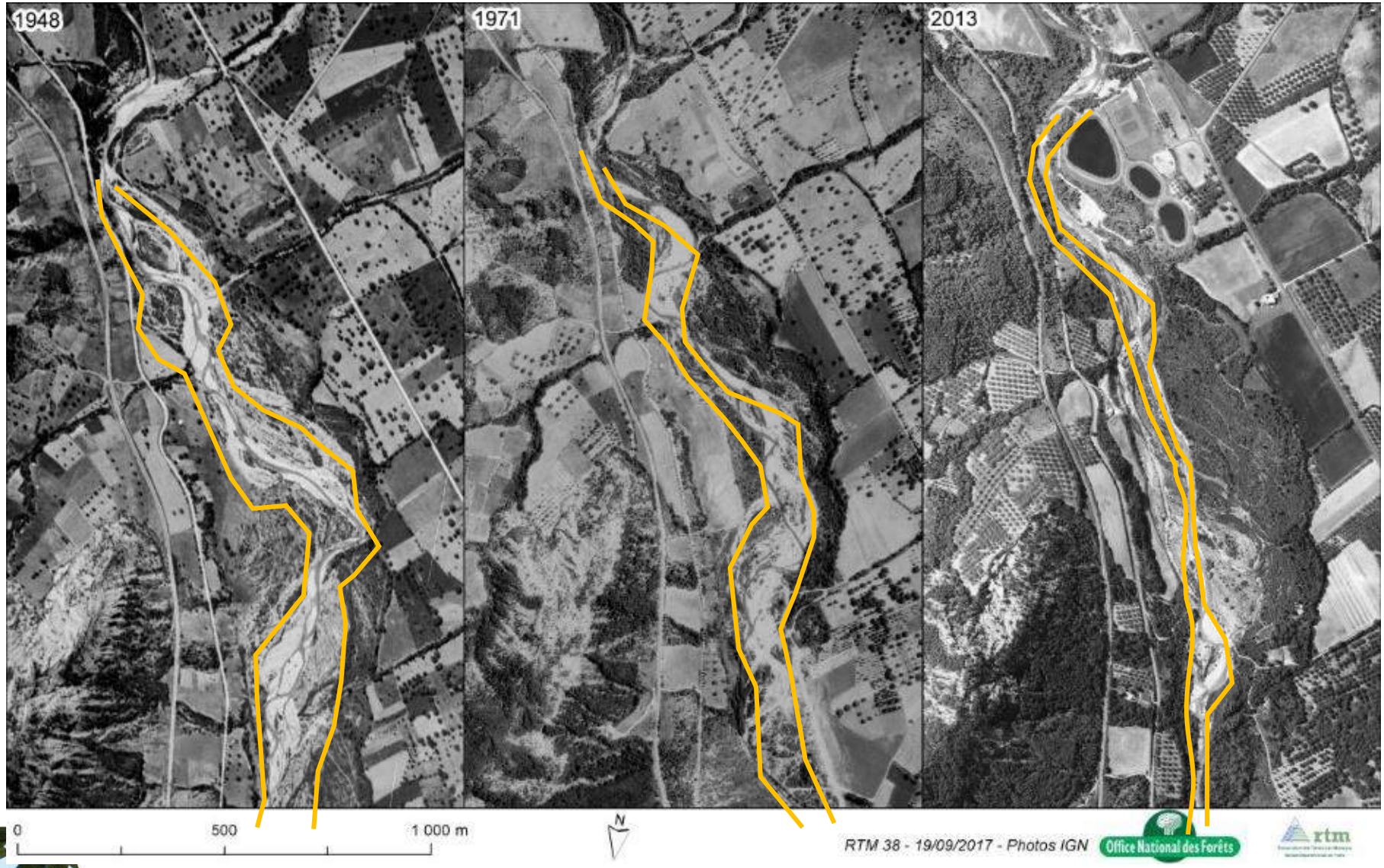
Long profile comparison 1928 vs 2013

Drôme incision : -3,0 m !



Drôme river downstream confluence with

Braided to straight



1- Effects of reforestation

B- Woody debris during floods

Torrent de la Malsanne, Le Perrier (38),

Ruisseau de Malafossant –Saint-Jean d'Avelanne (2002)

2- Effects of checks dams

What are their objectives ?

Initially, stabilization works implanted to support reforestation actions

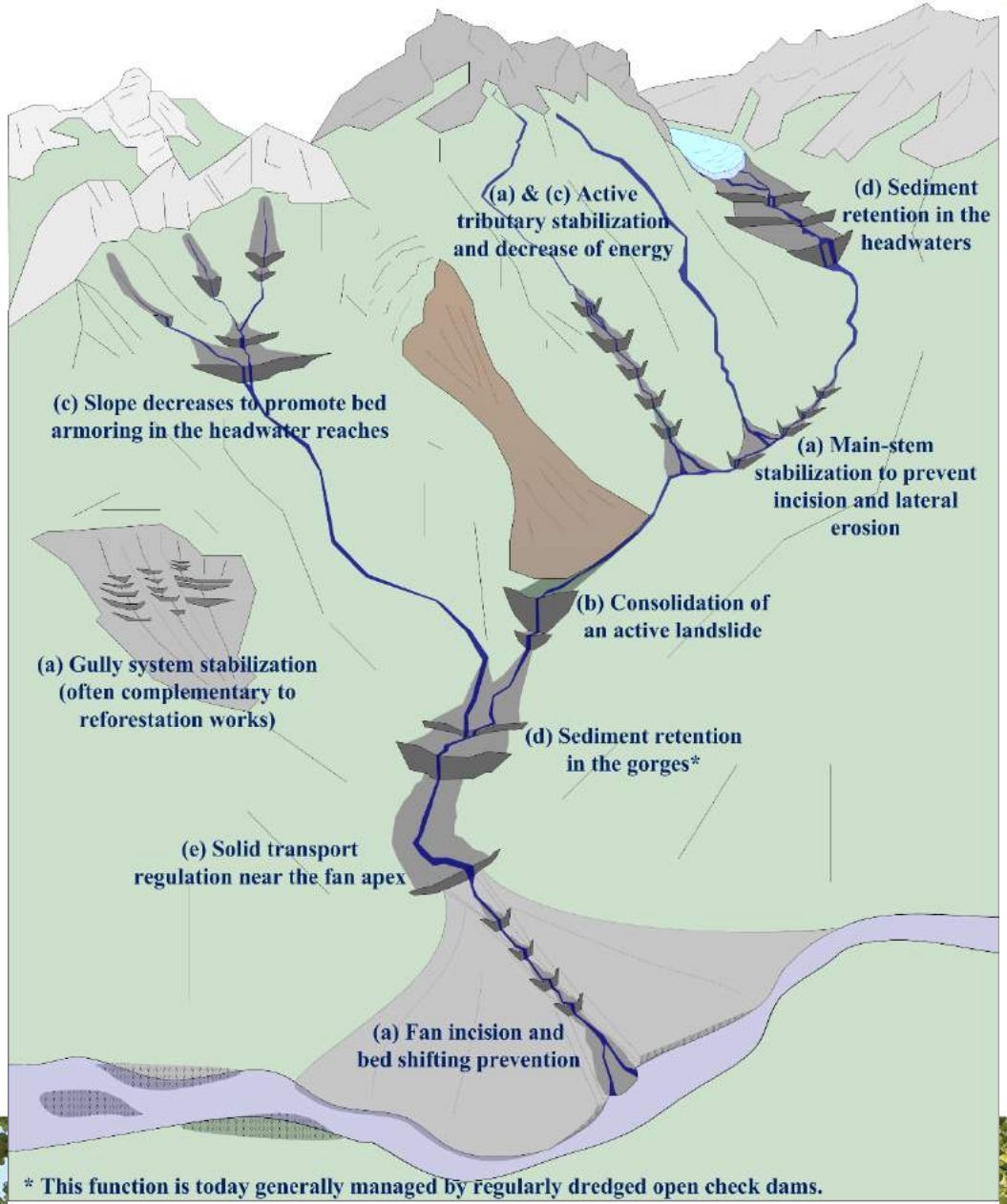
Main functions

- Stabilization:
  - Longitudinal stabilization : prevent incision
  - Transversal stabilization : prevent lateral erosion
- Consolidation downstream landslides
- Retention (very rare)

Associated functions

- Régulation of bedload transport
- Decrease of flow energy

Functions of checks dams



From: G. Piton et al, 2016

Stabilization check dams

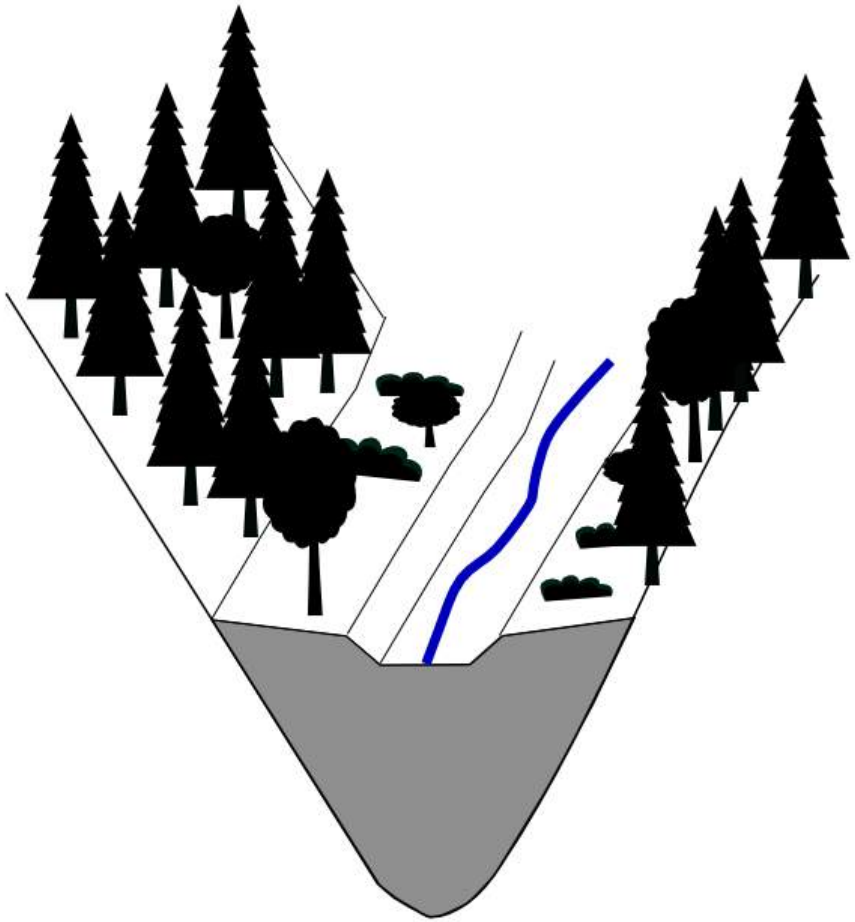
Stabilization check dams

Stabilization =

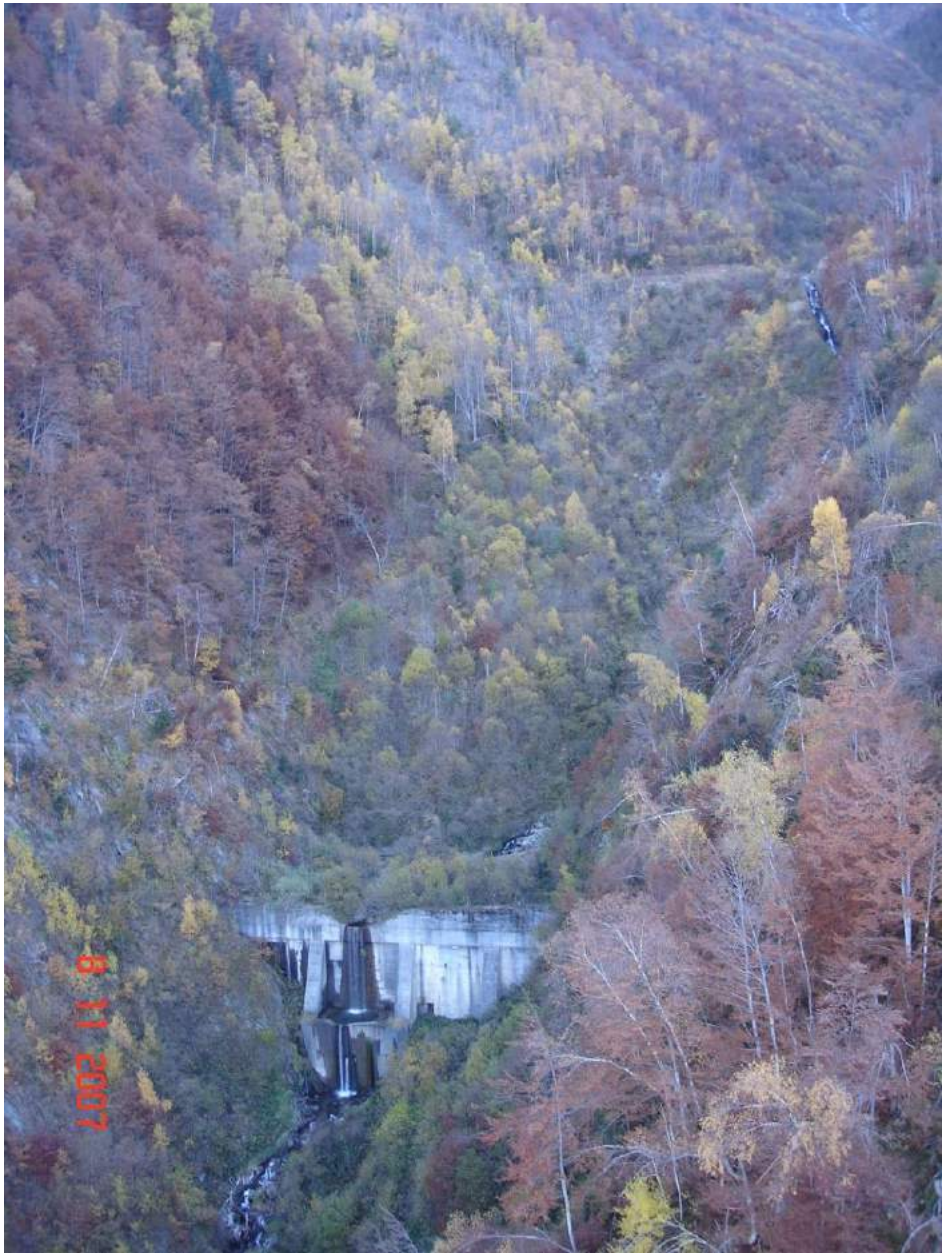
Lateral deposit upstream dam (a)
+

Recentering channel (b)
+

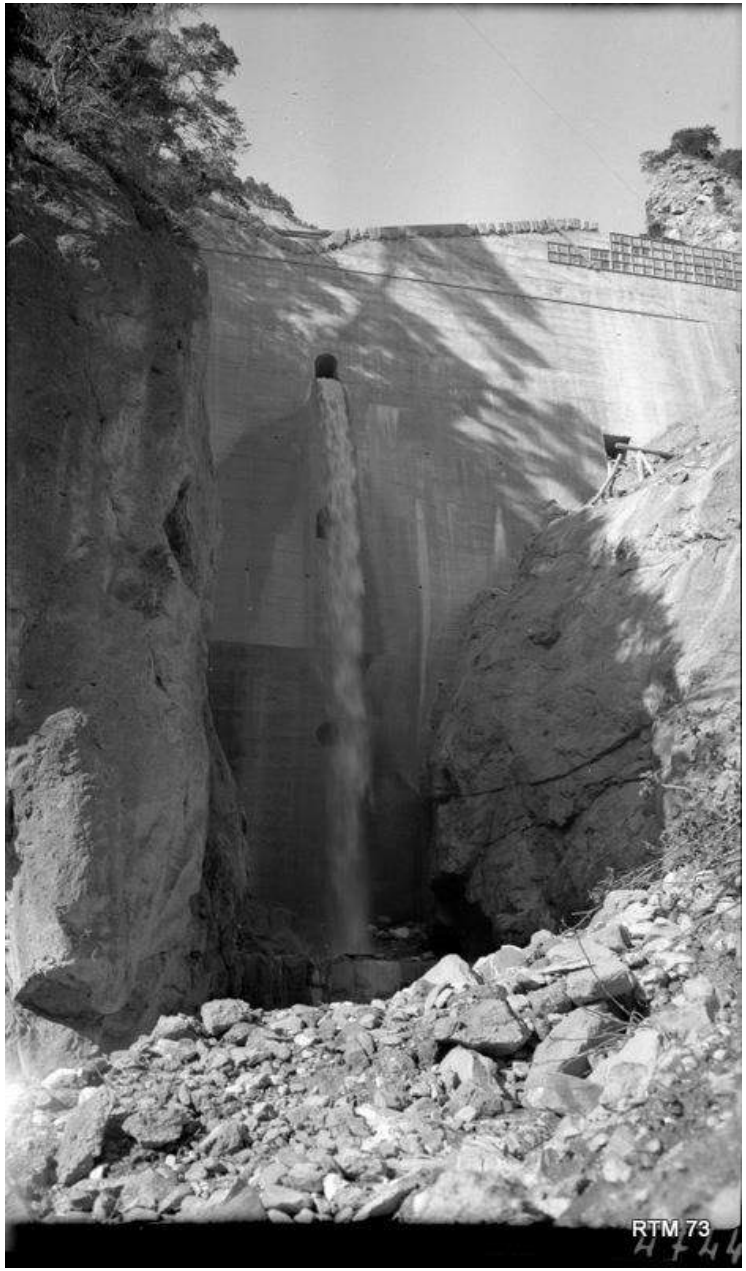
Long profile stabilization (c)

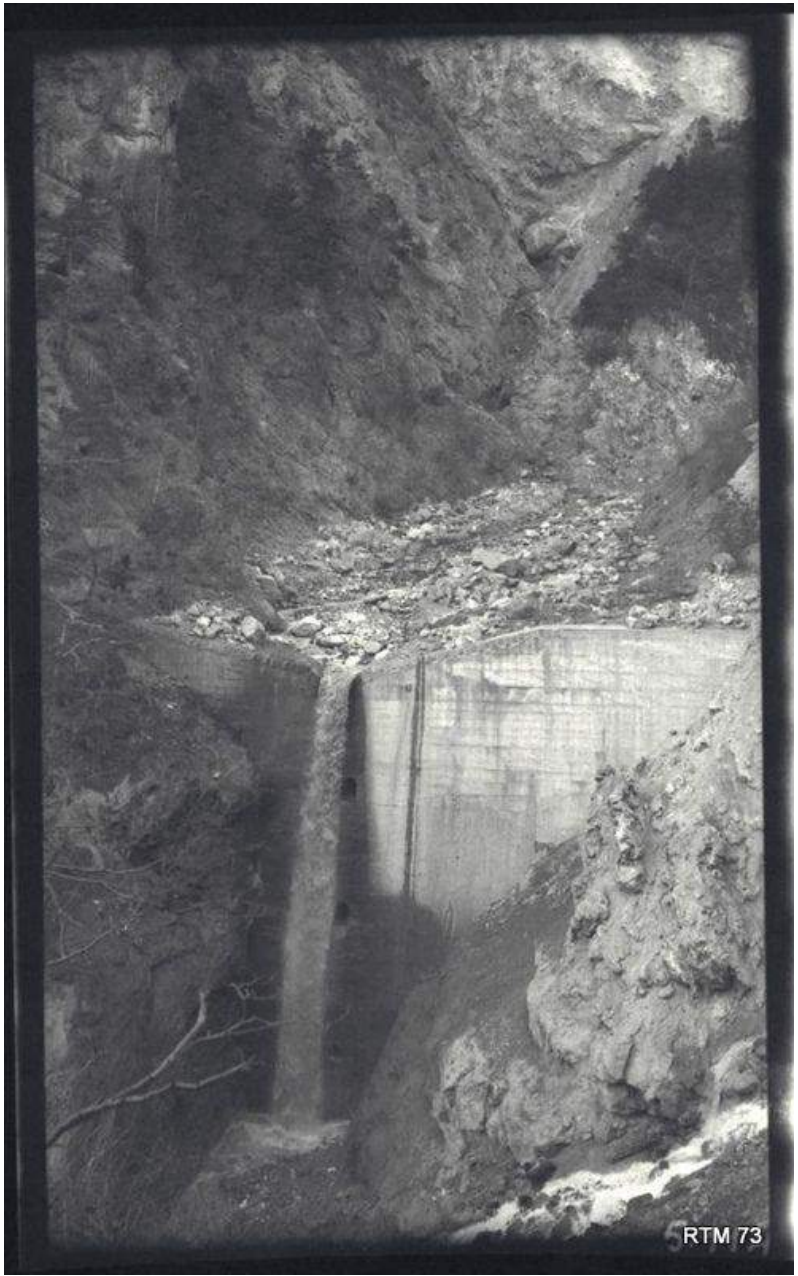


Consolidation check dams

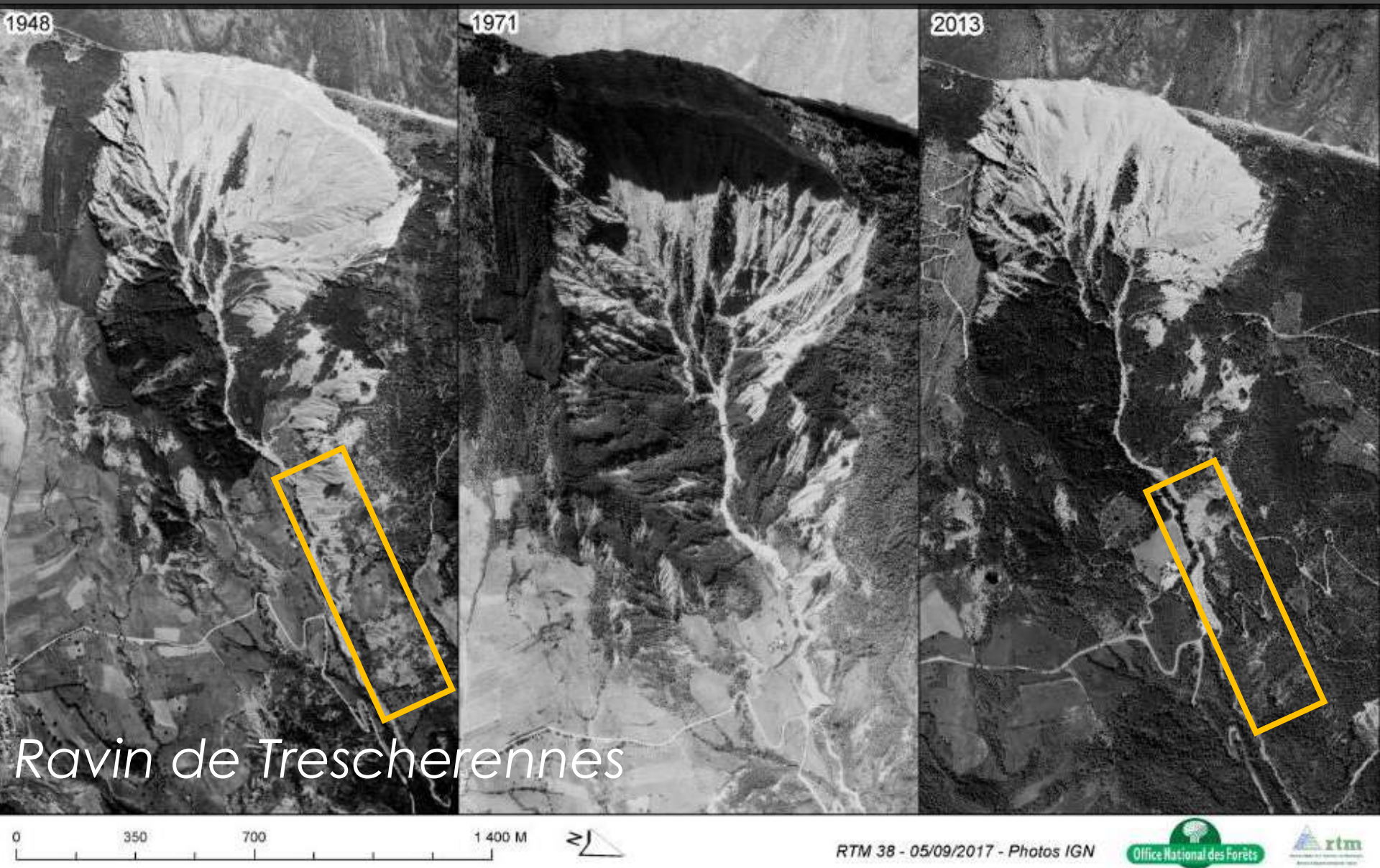


Retention check dams

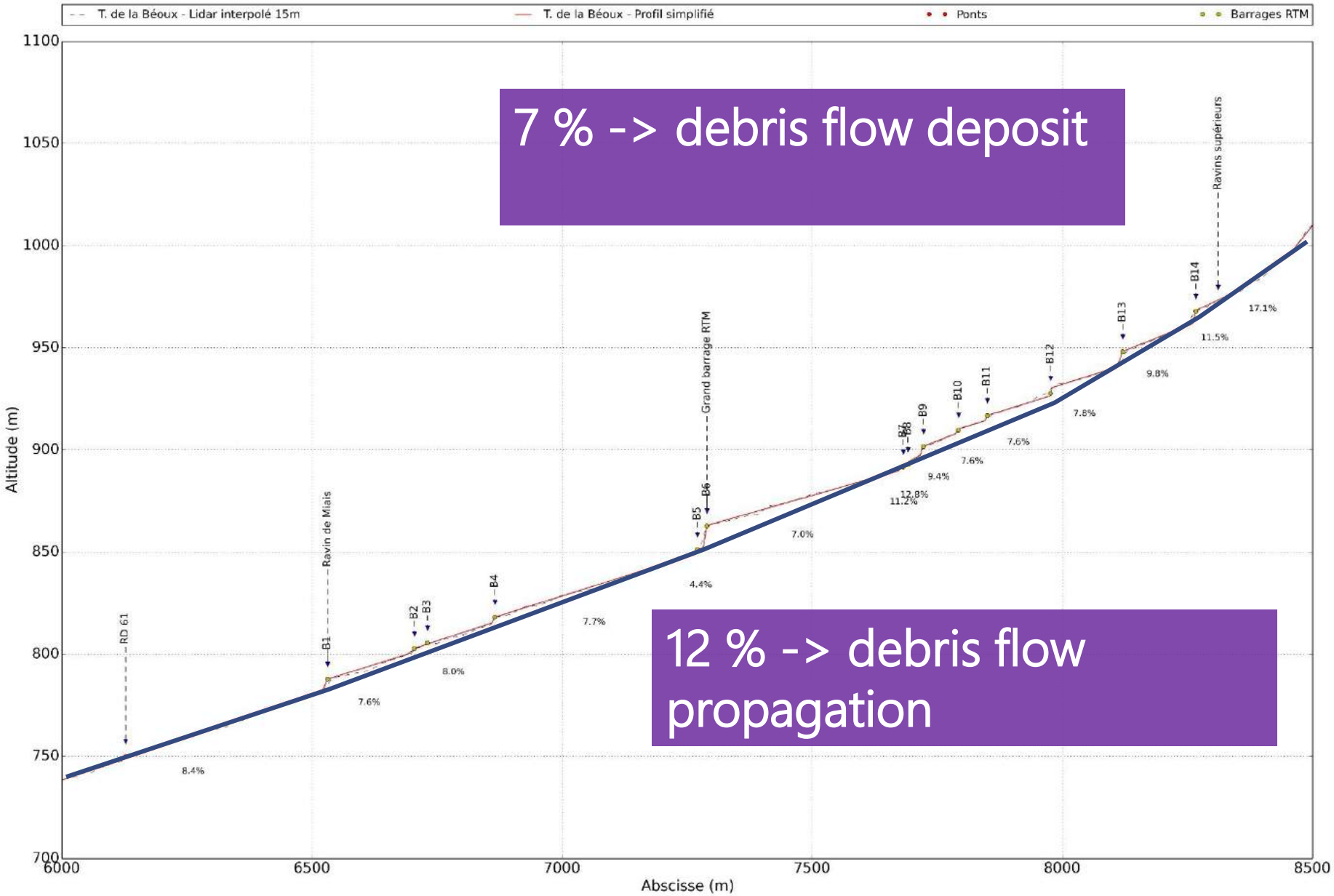




Transitory effect downstream consolidation or retention check dams



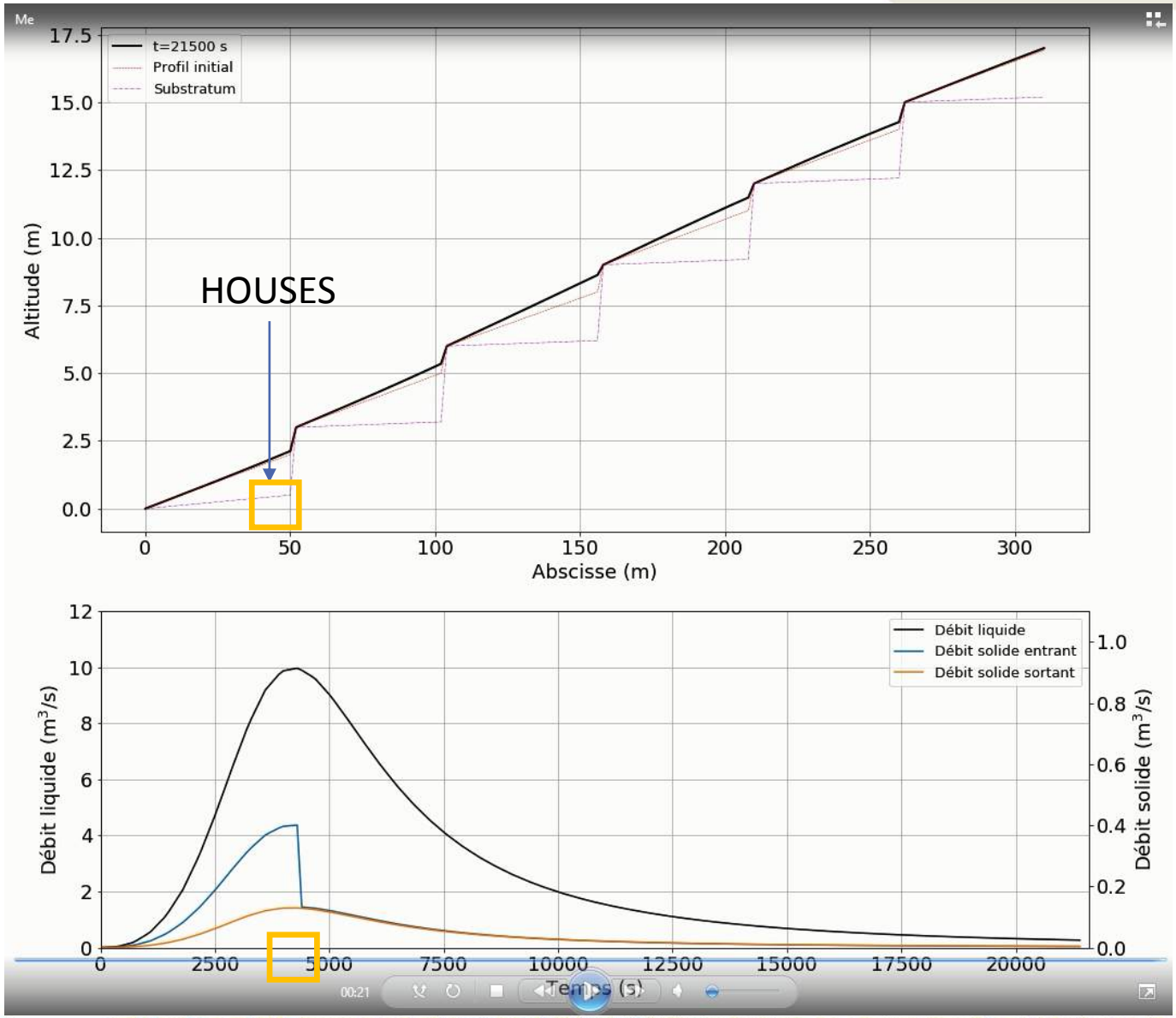
Decrease of flow energy



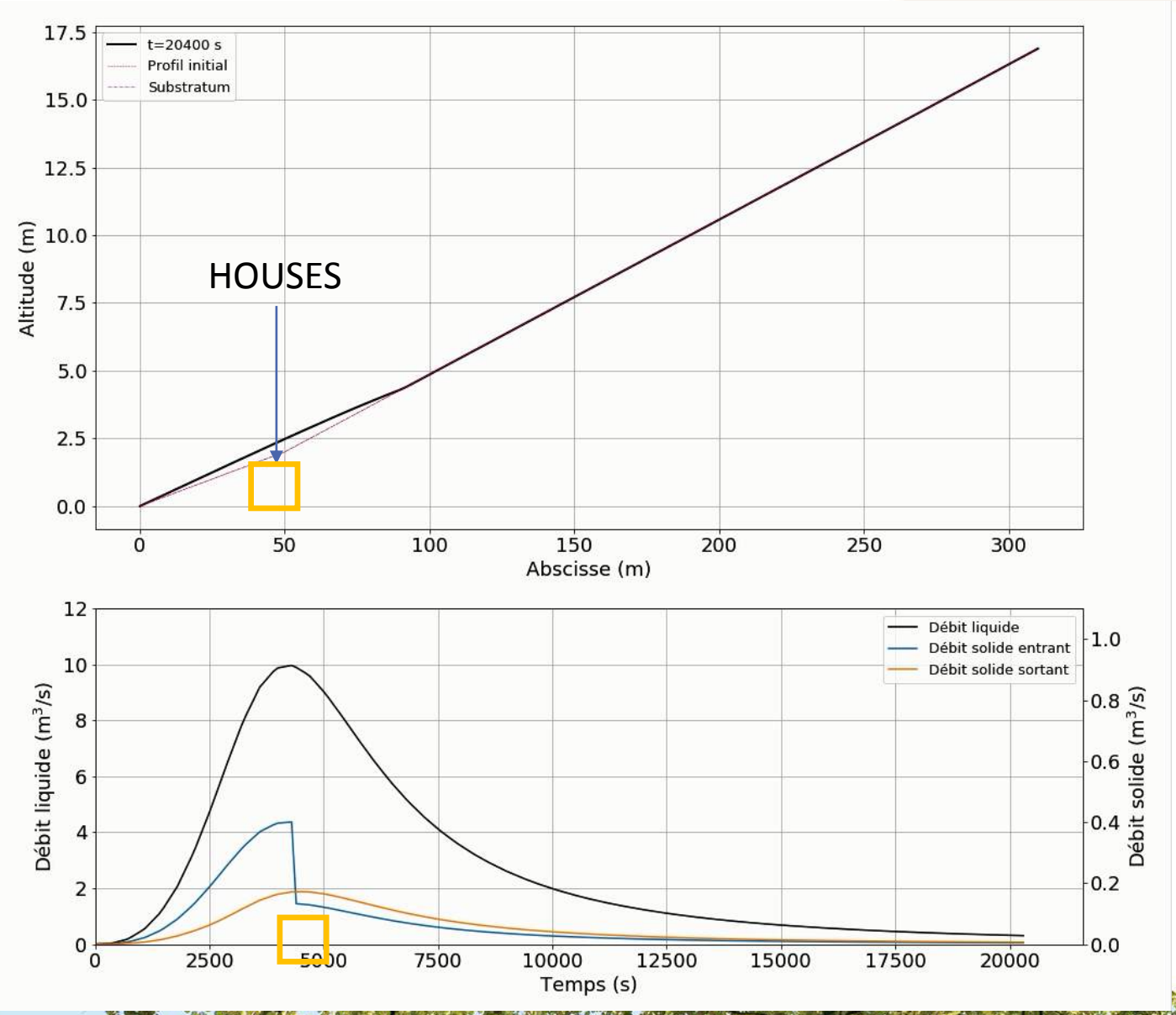
7 % -> debris flow deposit

12 % -> debris flow propagation

Regulation of sediment loads



Regulation of sediment loads



- Thanks for your attention -

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