EGU General Assembly 2020

HS4.1 Flash floods and rainfall induced hydro-geomorphic hazards: from observation to forecasting and warning

Flash-flood hazard hydro-geomorphic characterization and mapping: analysis of the 2019 and 1994 Francolí river flood effect

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Image: Oscar Riera

CGL2017-84720-R

INTRODUCTION

On October 22, 2019, intense rains took place in Catalonia (292,6 mm in 24 hours at Prades). These rains caused a sudden discharge increase and a major flash flood in the Francolí river. Around 4 km upstream of the studied area, the pick flow was of 1.330 $m^3.s^{-1}$ (Balasch et al., this session). As a result, the river swept along a large quantity of vegetation, crops and infrastructures. It caused a considerable economic damage (exceeding 100 million euros) and loss of six human lives.

Francolí is a typical Mediterranean river with frequents floods. There are records of major floods in 1874 (Santa Tecla), in 1930 (Sant Lluc) and, in 1994 the last one before 2019, when there were 10 fatalities and economic losses of 17.000 million euros.

1994 Flood
Arxiu Comarcal de la Conca de Barberà

2019 Flood
ACN - Núria Torres

LOCATION OF THE STUDIED RIVER AND EXAMPLE OF THE AREA PRESENTED HERE

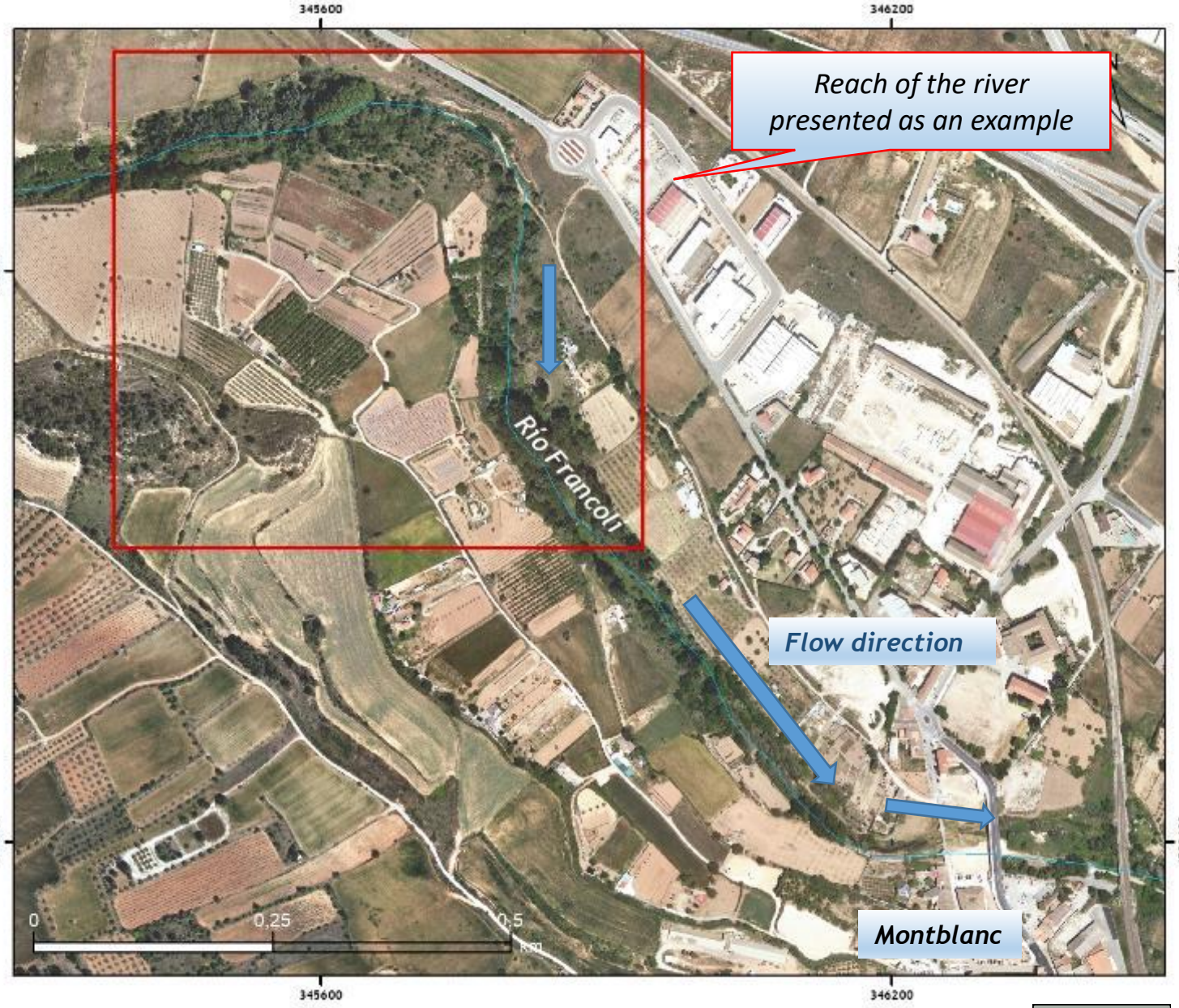
LOCATION

Francolí watershed (in blue).
Catalonia (in green)

Area presented:
analysis example

Sources: ICGC. IDEE.
CC by 4.0 [on line]

Reference System: ETRS 89/UTM 31N



ORTHOPHOTO PRE FLOOD. FLIGHT DATE: MAY 2019 (ICGC)

OBJETIVE AND METHODOLOGY

The main objective of the study is to carry out a hydro-geomorphic analysis of the 2019 flood and to establish and map the Active Band and the Preferential Flow Zone (PFZ). We define the Active Band as the zone affected by the particular flood of 2019. The PFZ define by the Spanish legislation, is the envelope of the areas where the flow defined by concentrates during major floods, as well as the most frequently flooded areas in minor floods.

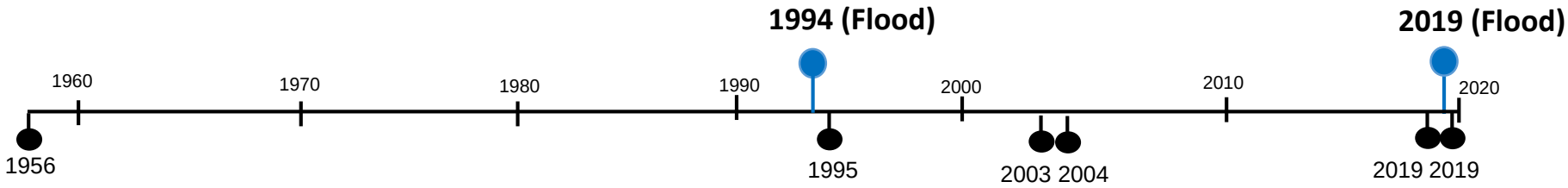
As a result, we expect to acquire information to analyze and characterize the fluvial dynamics of the Mediterranean rivers.

The employed methodology carried out is mostly based on classical aerial photo-interpretation and GIS technology image and data comparison.

In order to detect and assess the floods effects, the morphological changes and the stretch evolution, this study compares of the 2019 (post-flood event), with 2019 (pre-flood event), as well as 1995 (after the 1994 flood), and 1956 orthophotographs, and 2003 Digital Terrain Model of 1x1m of ICGC.

Morphological effects (such a channel migration, significant erosive and sedimentary morphologies, extension of the flooded areas through ephemeral evidence, avulsion phenomena, channel widening or bank erosion), are detected trough photo-interpretation.

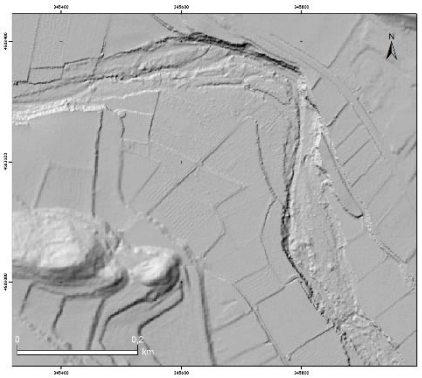
AERIAL PHOTOS, ORTHOPHOTOS AND DTM USED IN THIS STUDY



1956

1995 POST FLOOD

2003 DTM



2004

2019 PRE FLOOD

2019 POST FLOOD

Source: ICGC. CC by 4.0 [on line]
Reference System: ETRS 89/UTM 31N

GEOMORPHOLOGICAL CHARACTERIZATION 1st STEEP: ANALYSIS CRITERIA EXAMPLES

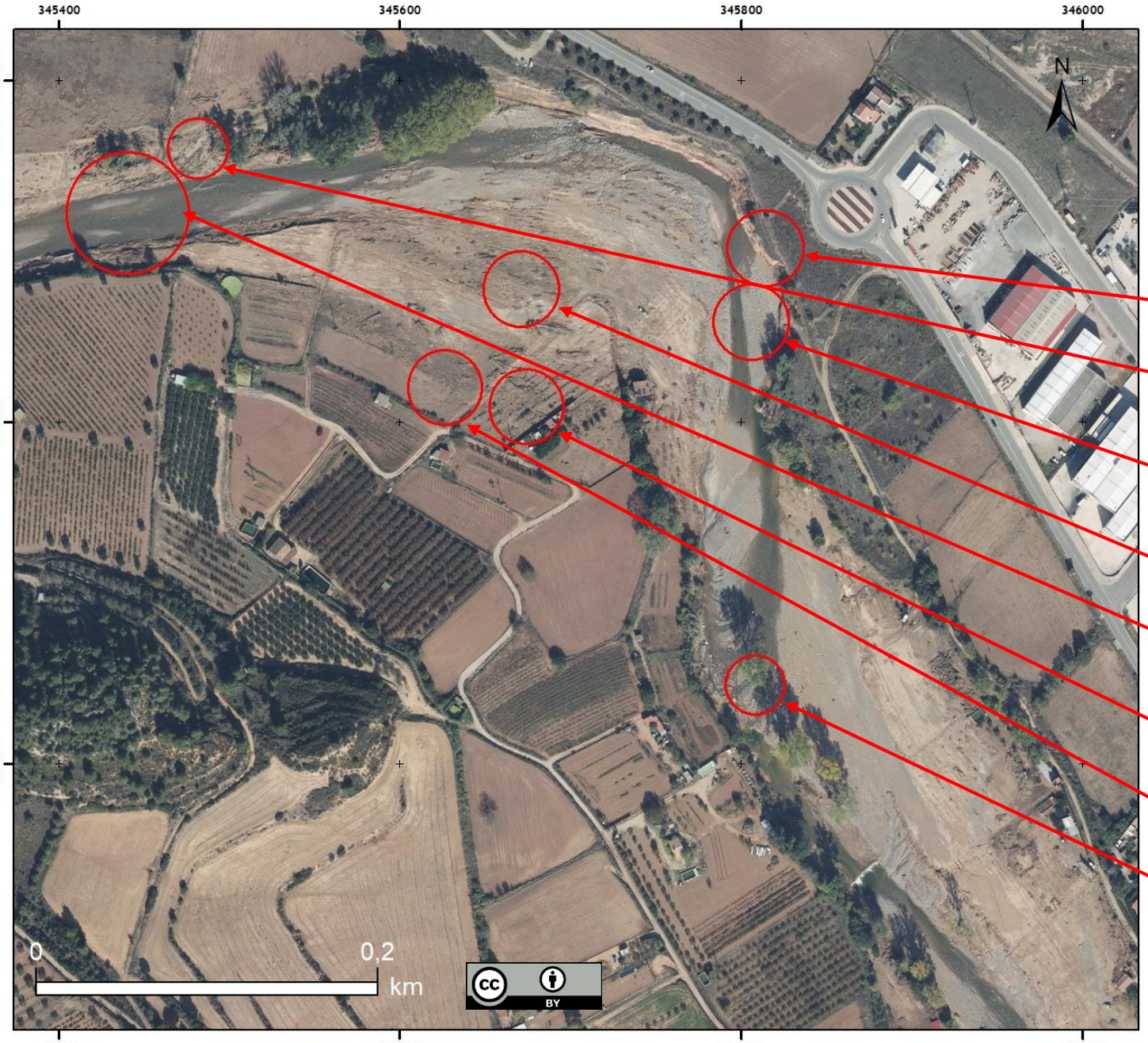
2019
ORTHOPHOTO POST FLOOD

ANALYSIS CRITERIA

- Bank erosion
- Large wood acumulation
- Gravel bars
- Water marks
- Channel widening
- Affected crops
- Vegetal drifted ephemeral evidence
- Affected riparian trees

Source: ICGC. CC by 4.0 [on line]
Reference System: ETRS 89/UTM 31N

GEOMORPHOLOGICAL CHARACTERIZATION 1st STEEP: ANALYSIS CRITERIA EXAMPLES



2019
ORTHOPHOTO POST FLOOD

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Source: ICGC. CC by 4.0 [on line]
Reference System: ETRS 89/UTM 31N

GEOM. CHARACTERIZATION 2nd STEEP: INTERPRETATION OF THE FLOODED AREA

2019

ORTHOPHOTO POST FLOOD

Legend

2019 FLOODED AREA: ACTIVE BAND

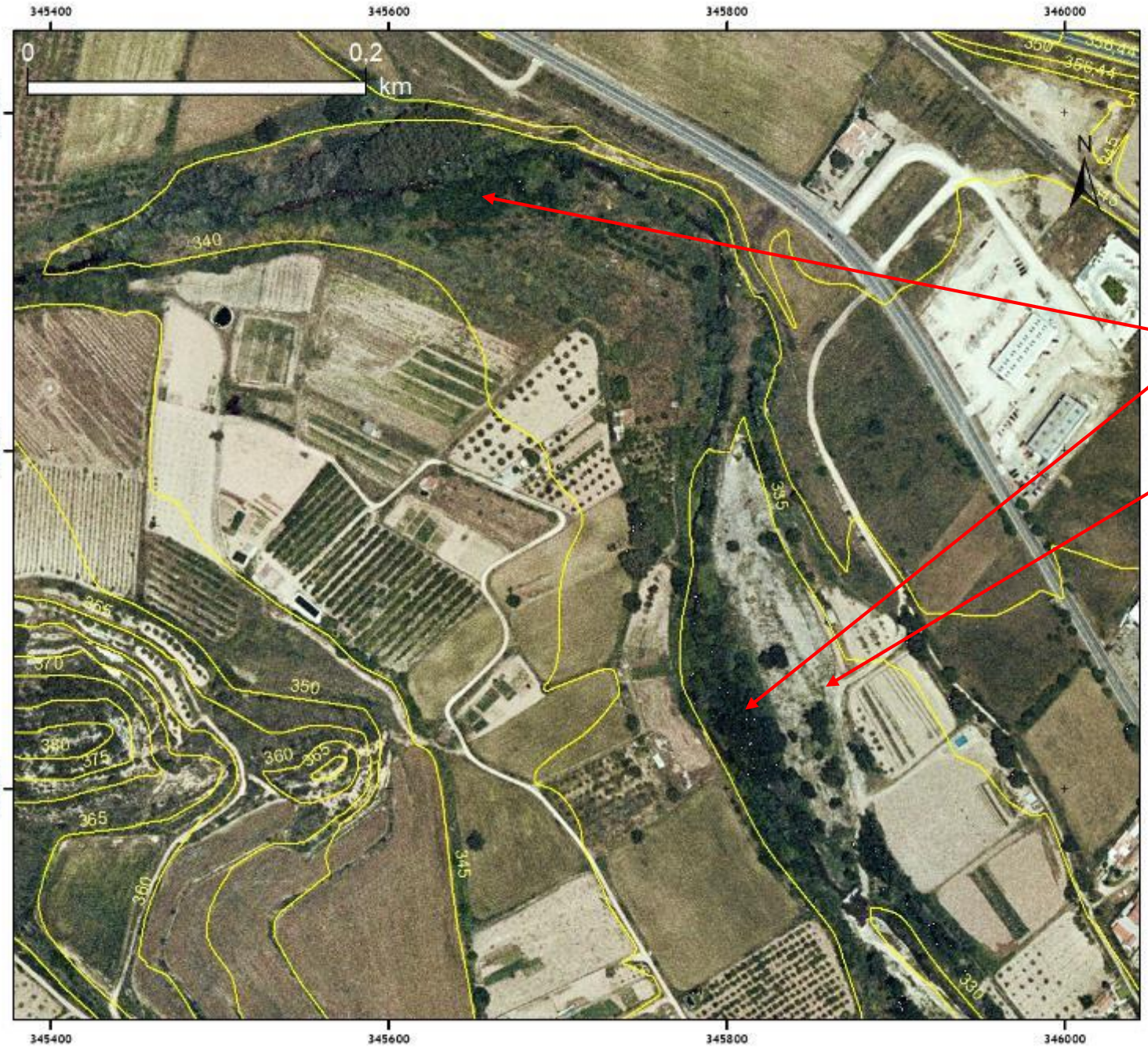
This area has been determined from the visualization of ephemeral evidence such as deposited drifted vegetation, tilted and flattened vegetation, watermarks, affected crops, bank erosion, etc.

2019 HIGH ENERGY FLOW AREA

This area, that is part of the Active Band, has been determined from the functional channel, gravel deposits and bars and significant erosion.

Source: ICGC. CC by 4.0 [on line]
Reference System: ETRS 89/UTM 31N

GEOM. CHARACTERIZATION 3st STEEP: PREVIOUS SITUATIONS



2004
ORTHOPHOTO

PRE FLOOD SITUATION

Note the riparian vegetation.

This orthophoto shows rough texture and gravel deposits in some sectors.

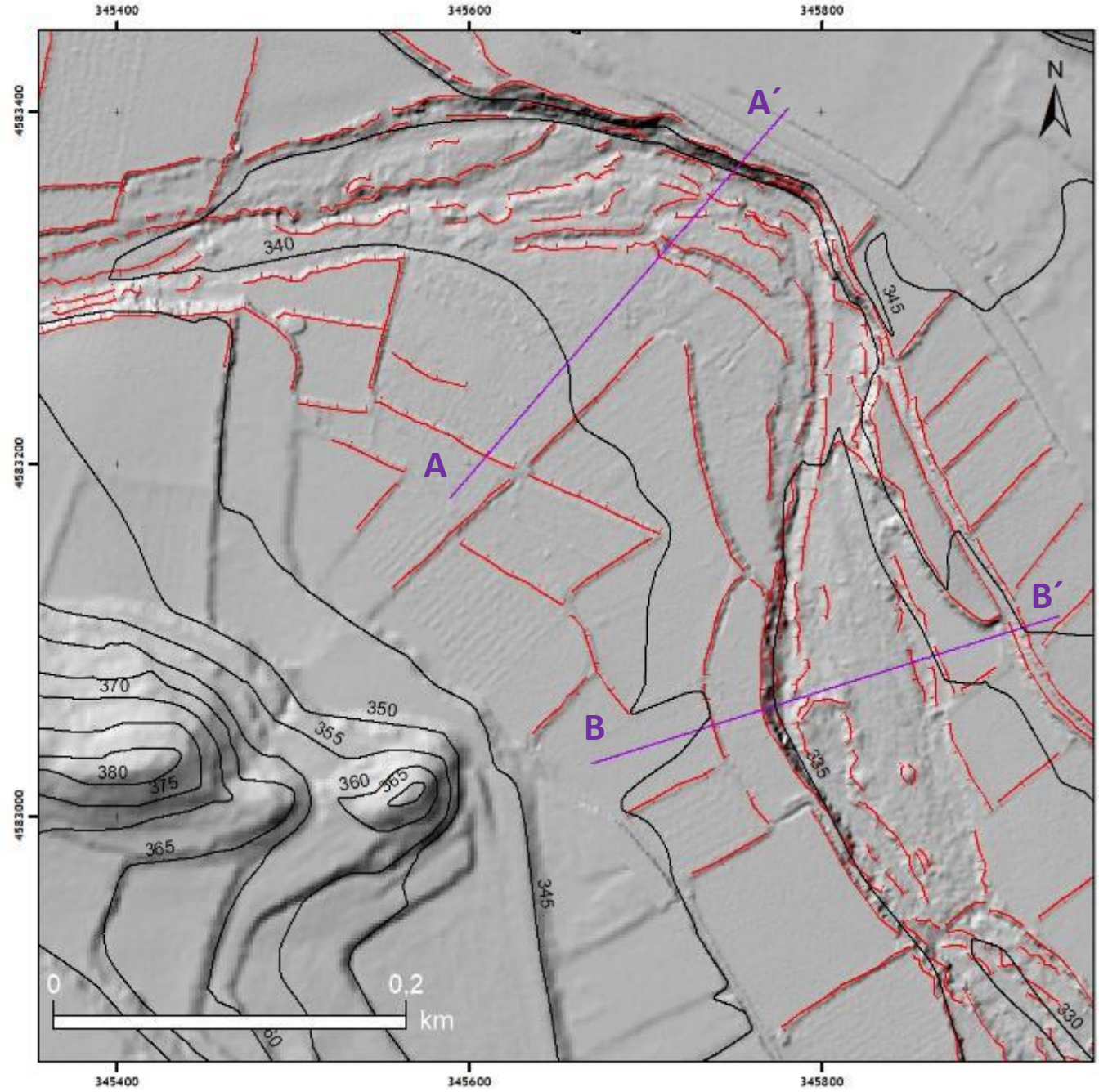
Legend

Contour Line (5 m interval)

Sources: ICGC. IDEE. CC by 4.0 [on line]

Reference System: ETRS 89/UTM 31N

GEOM. CHARACTERIZATION 3st STEEP: PREVIOUS SITUATIONS

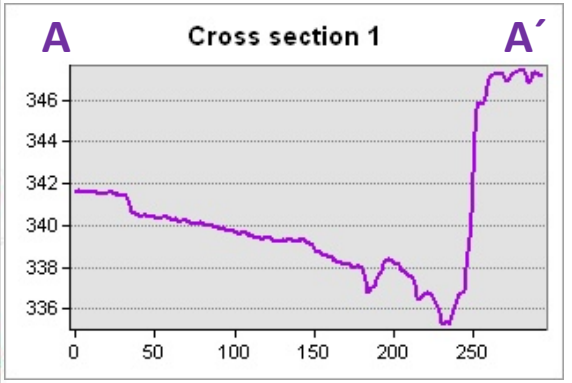


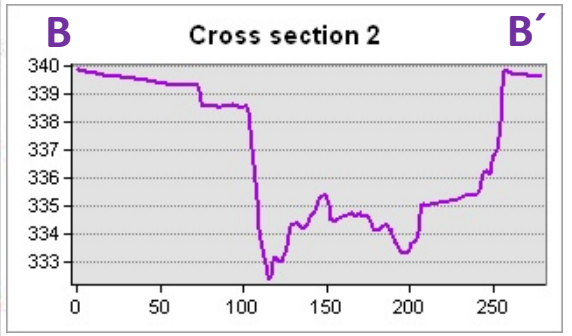
2003

DTM 1X1
SCARPS ANALYSIS

Legend

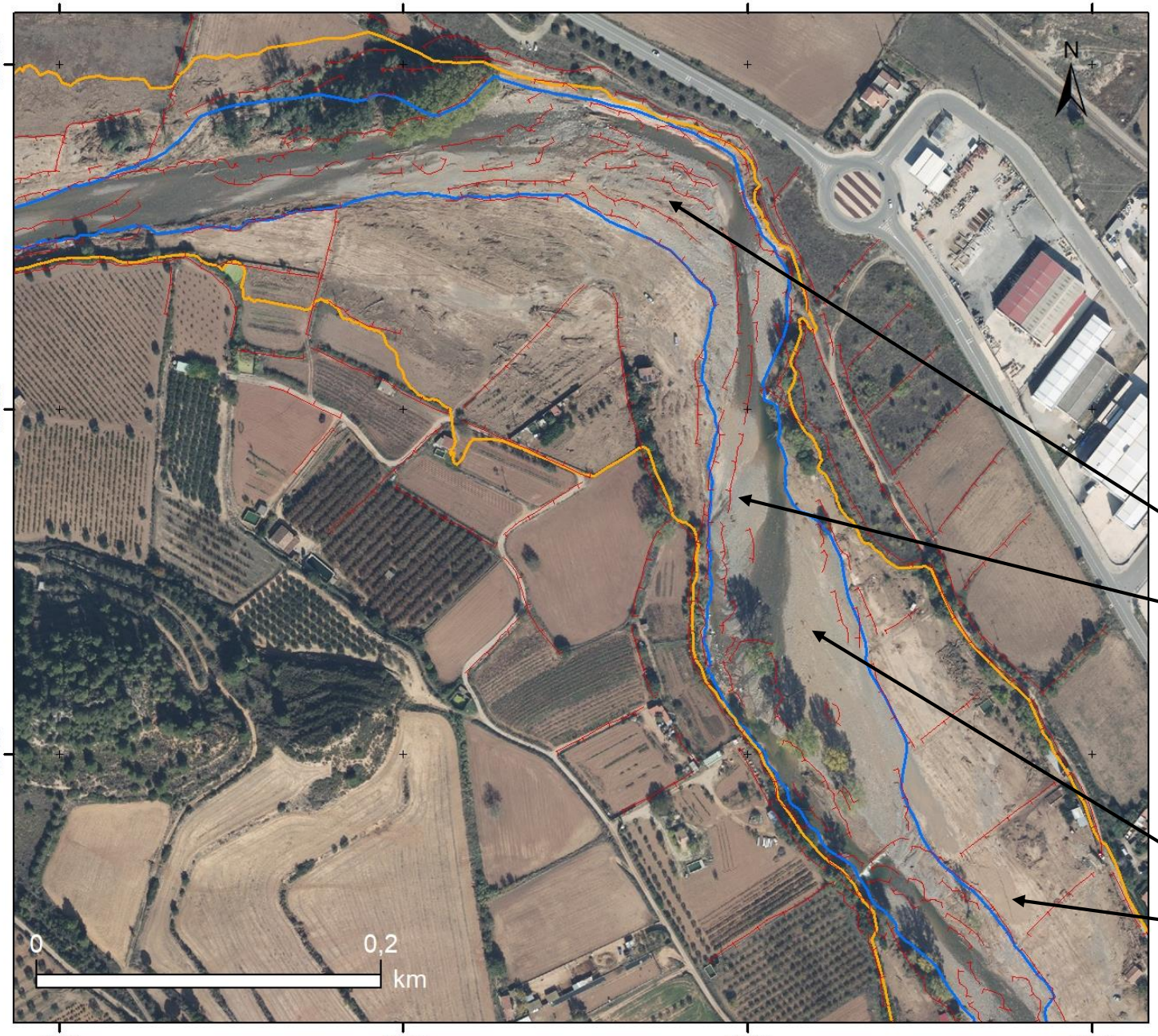
- SCARPS 2003
- CONTOUR LINE (5 M INTERVAL)
- CROSS SECTION





Reference System: ETRS 89/UTM 31N

RESULTS AND COMPARISON



2019
ORTHOPHOTO POST FLOOD

Legend

2019 FLOODED AREA: ACTIVE BAND

2019 HIGH ENERGY FLOW AREA

SCARPS 2003

Some scarps condition the High Energy Flow area.

Other scarps have been eroded.

Channel migration.

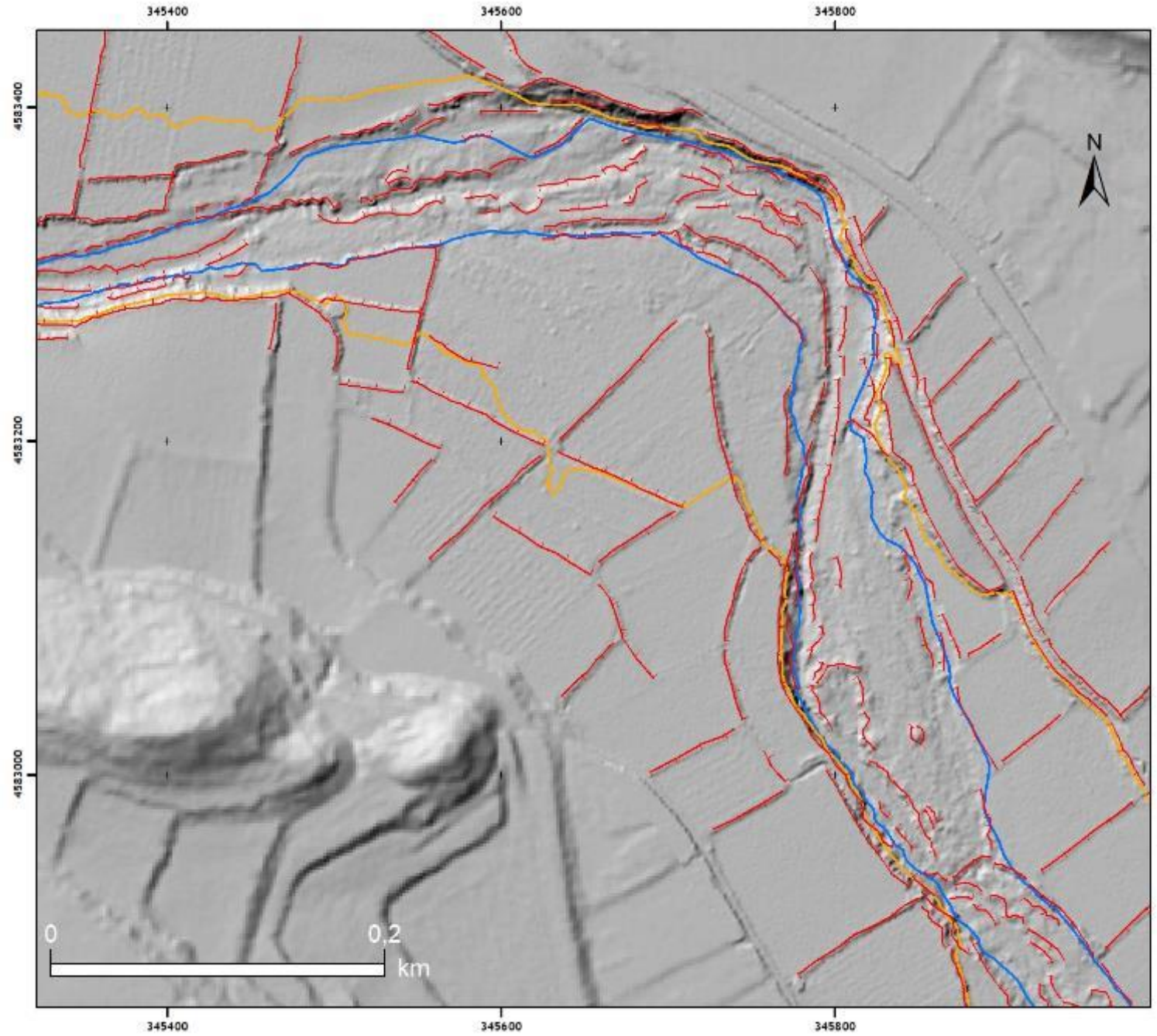
Areas with rough textures on the 2003 DTM correspond to areas where the flow reached high speed and energy during the 2019 flood.

Gravel bars.

Fine sediment accumulations.

Source: ICGC. CC by 4.0 [on line]
Reference System: ETRS 89/UTM 31N

RESULTS AND COMPARISON



2003

DTM 1X1

Legend

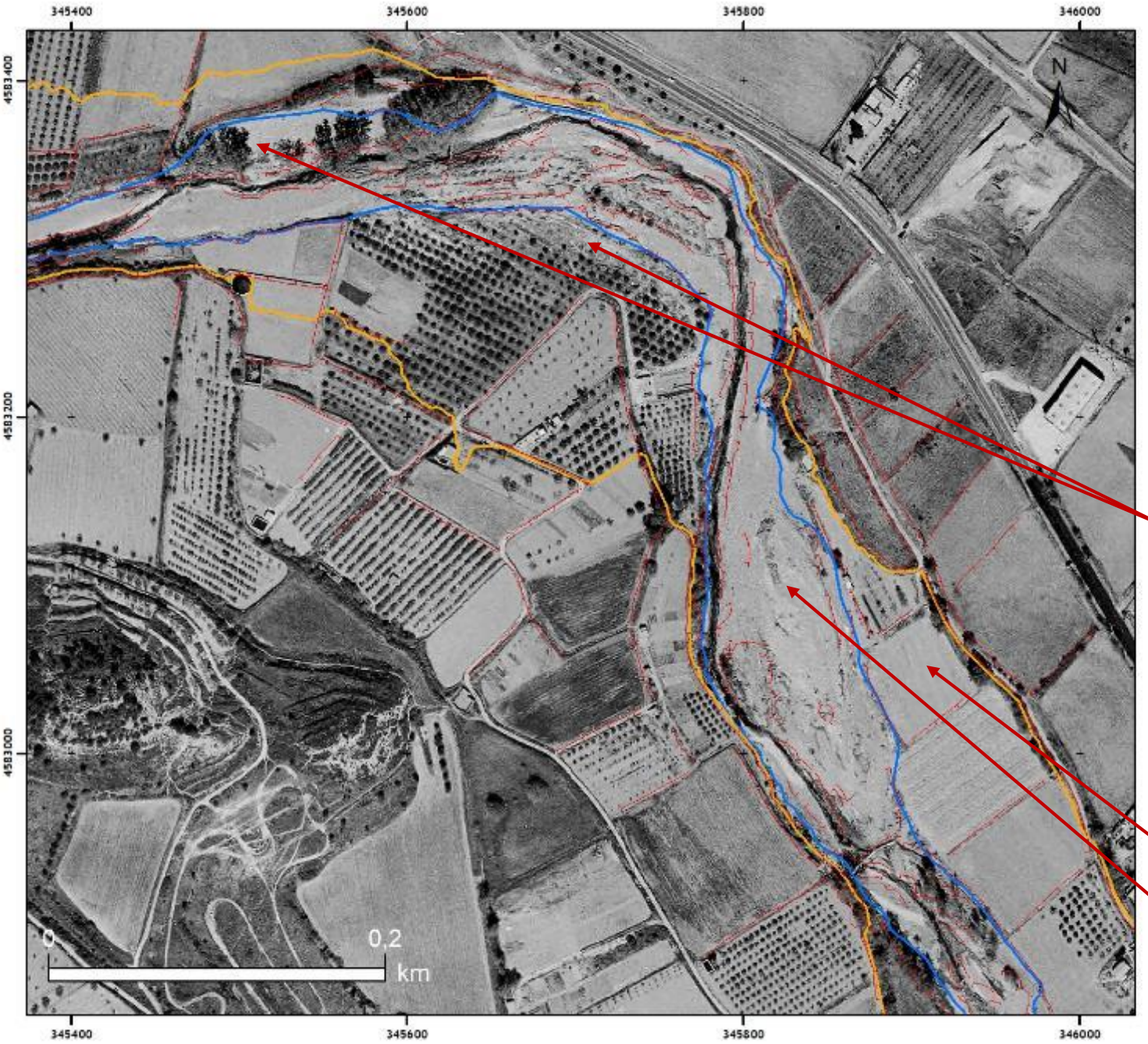
- 2019 FLOODED AREA: ACTIVE BAND
- 2019 HIGH ENERGY FLOW AREA
- SCARPS 2003

Some scarps limited the area with High Energy Flow (HEF) in 2019.

Furthermore, HEF corresponds to the roughest texture likely modelled by the effects of previous floodings.

Source: ICGC. CC by 4.0 [on line]
Reference System: ETRS 89/UTM 31N

RESULTS AND COMPARISON



1995
ORTHOPHOTO
POST 1994 FLOOD

Legend

- 2019 FLOODED AREA: ACTIVE BAND
- 2019 HIGH ENERGY FLOW AREA
- SCARPS 2003

Some effects of the 1994 overflow can be observed

The High Energy Flow area of 2019 corresponds to the HEF of 1994.

Rough textures correspond to areas where the flow reached high speed and energy.

Fine sediment accumulation, low energy.

Gravel bars, high energy.

Source: ICGC. CC by 4.0 [on line]
Reference System: ETRS 89/UTM 31N

RESULTS AND COMPARISON

1956-57
AMERICAN FLIGHT B SERIE

Legend

2019 FLOODED AREA: ACTIVE BAND

2019 HIGH ENERGY FLOW AREA

At this time, land use was more intensive. There was more crops near the channel.

Bend of the meander is a widening area in the following floods.

Source: ICGC. CC by 4.0 [on line]
Reference System: ETRS 89/UTM 31N

DISCUSSION AND PRELIMINAR CONCLUSIONS

- The geomorphological effects of the 2019 flood allow us to define the Active Band. Some of these effects, as avulsion, channel widening, channel migration, gravel accumulation and bank erosion, leads to characterize a High Energy Flow area.

- Determining the morphologic effects of the High Energy Flow area in successive floods, permits the definition of the Preferential Flow Zone (PFZ) in this case study.

- This zoning allows us to discriminate areas with high and low flow energies during flood, and to identify the margins which are most prone to erosion.

- Characterization of the type and magnitude of geomorphological effects is crucial and has implications for the definition of flood hazard areas.

- This characterization highlights that the Francolí river is very active from a hydro-geomorphological point view.

- Morphological effects in flash flood events and the comparison with other overflows can help understand the fluvial dynamics in the Mediterranean rivers.

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