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River-landslide erosion interaction assessed through LiDAR and UAV SfM high-resolution DEMs, SAR and photogrammetry

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INTRODUCTION

- In landslide research an important part is dedicated to the reconstruction of past landslide events and activity. This is an important aspect regarding the posibility to understand both landslide evolutions mechanisms and factors.
- For the last 100 years, cartographic, and for the last 50 years, remote sensing (RS) data is of crucial importance for such approaches.
- The spatial and temporal resolution of this data is increasing toward the present day.
- The information that can be used is both quantitative and qualitative.
- We present a study case of the usage of various RS data and methods to characterize river and landslide interactions in the hilly area of NE Romania.

STUDY AREA – Moldavian Plateau

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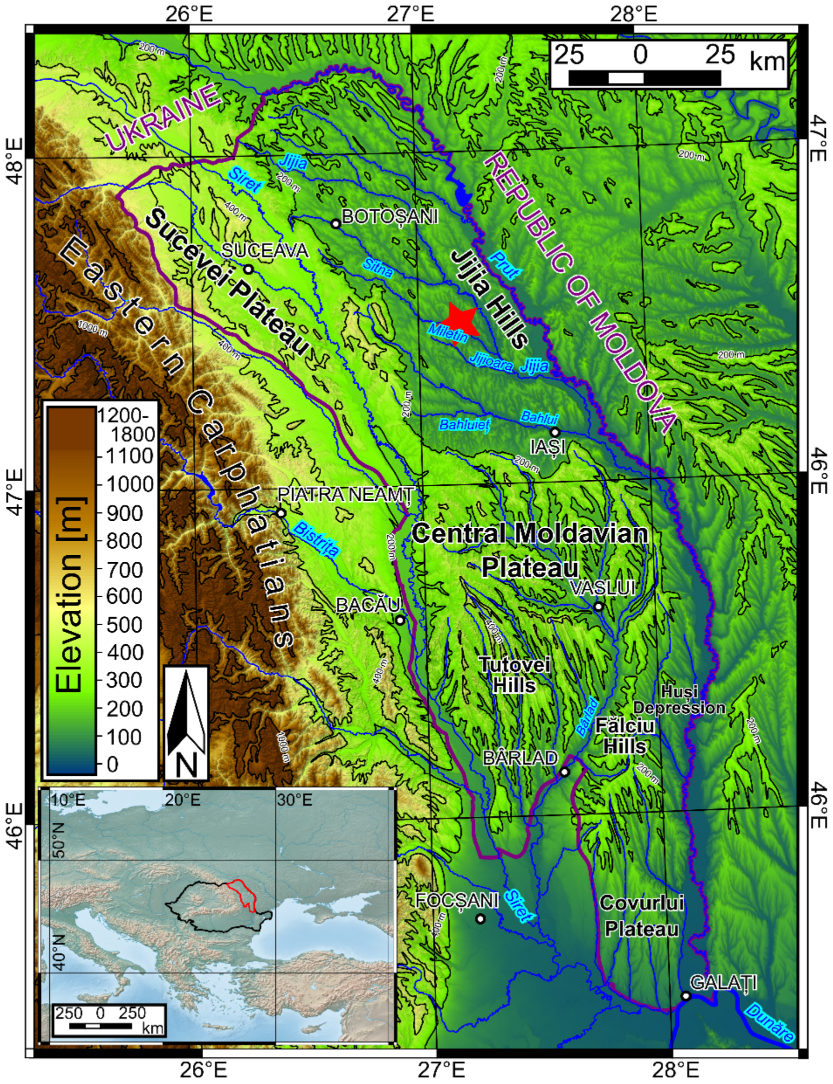
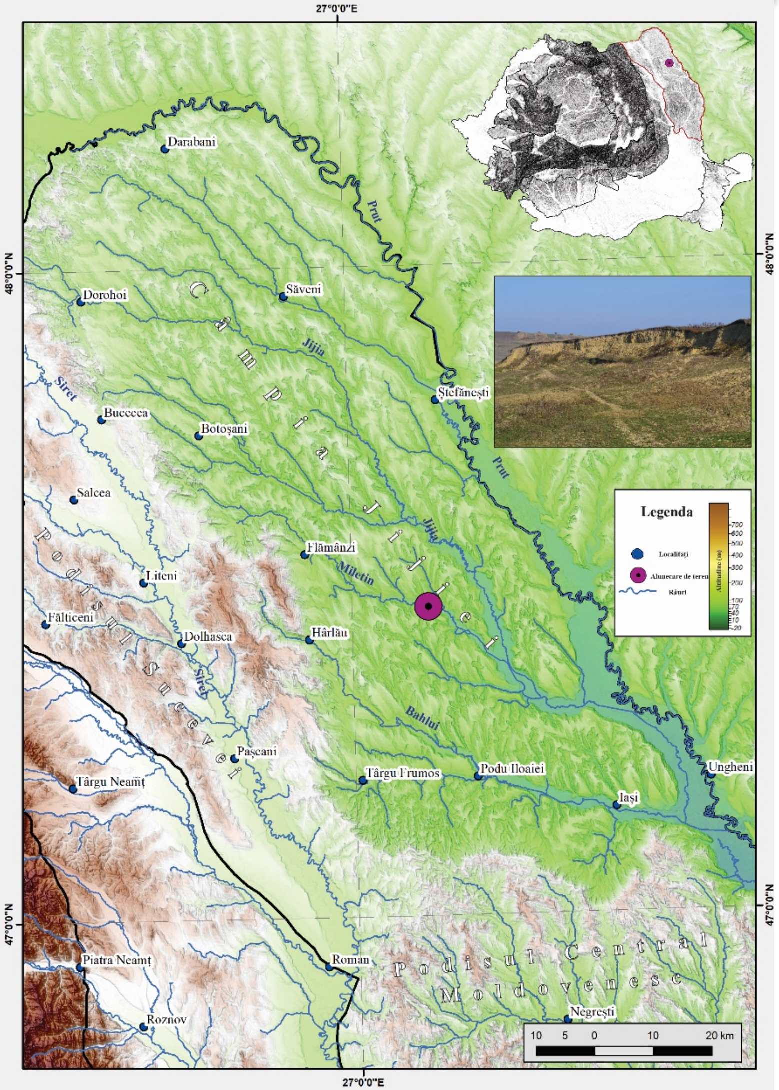


Hilly area, with elevation range between 70 and 180 m;
Subhorizontal intercalations of Miocene musdtones and sands;
Dry climate, with 450 to 500 mm rainfall, falling predominantly during spring.

Mărgărint and Niculiță, 2017



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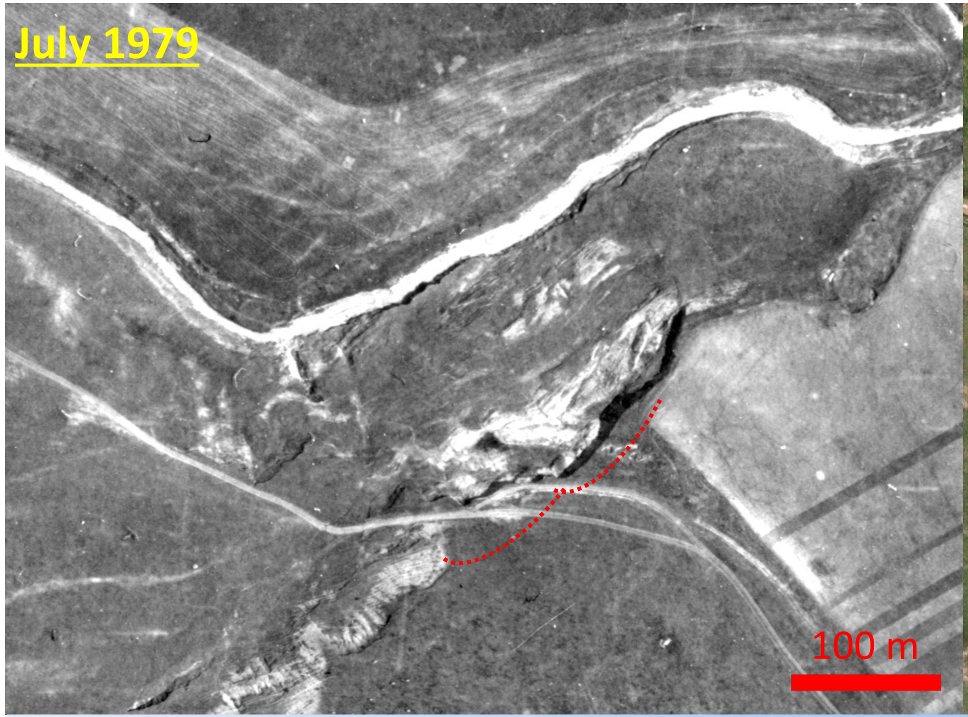

- Topographic maps and optic imagery show that the river Miletin created the instability at least at the begining of the XXth century, in 1980 the landslide appearing laterally to an old dormant landslide, and showing transgresive evolution trough scarp slumping.
- Between 1980 and 2005, the landslide has shown important scarp reactivation and Miletin river channel sinuosity increased .

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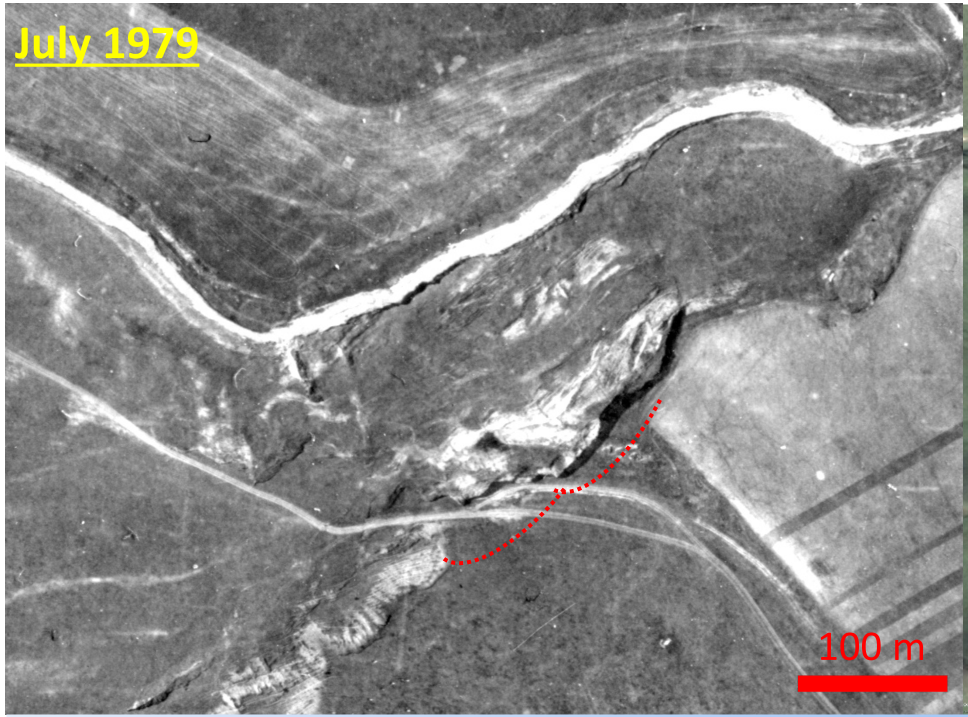

- After 2005, the scarp slumping continued, but in the same time the increased Miletin river channel sinuosity started to erode the basal part of the landslide. The evolving channel sinuosity and erosion has created stability of the landslide body, the previous scarp slump deposits being mobilised. The scarp has shown new signs of slumping.

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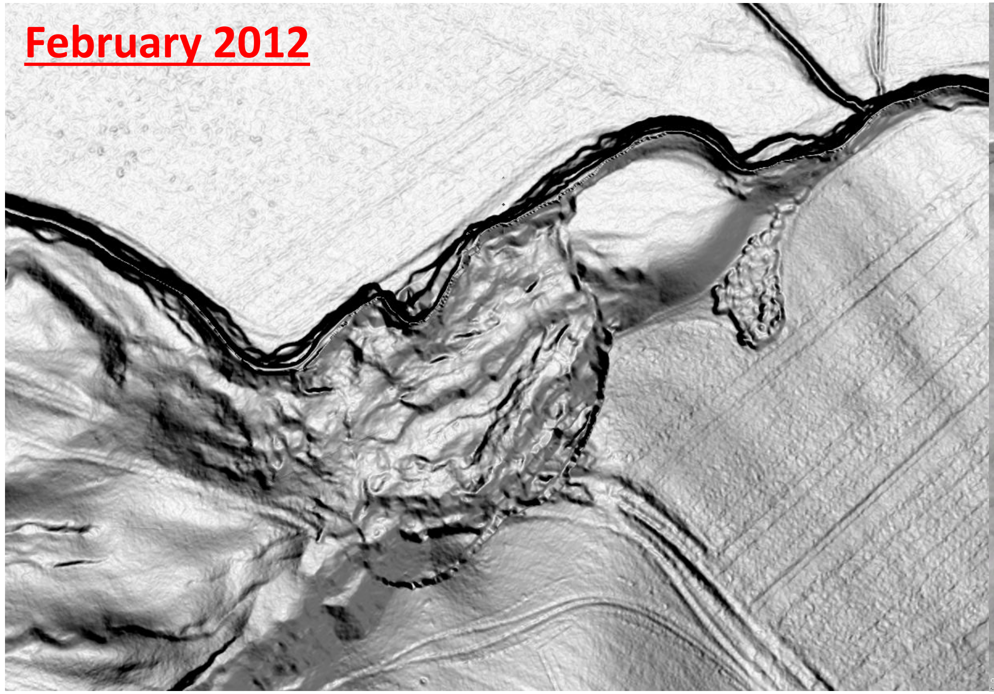

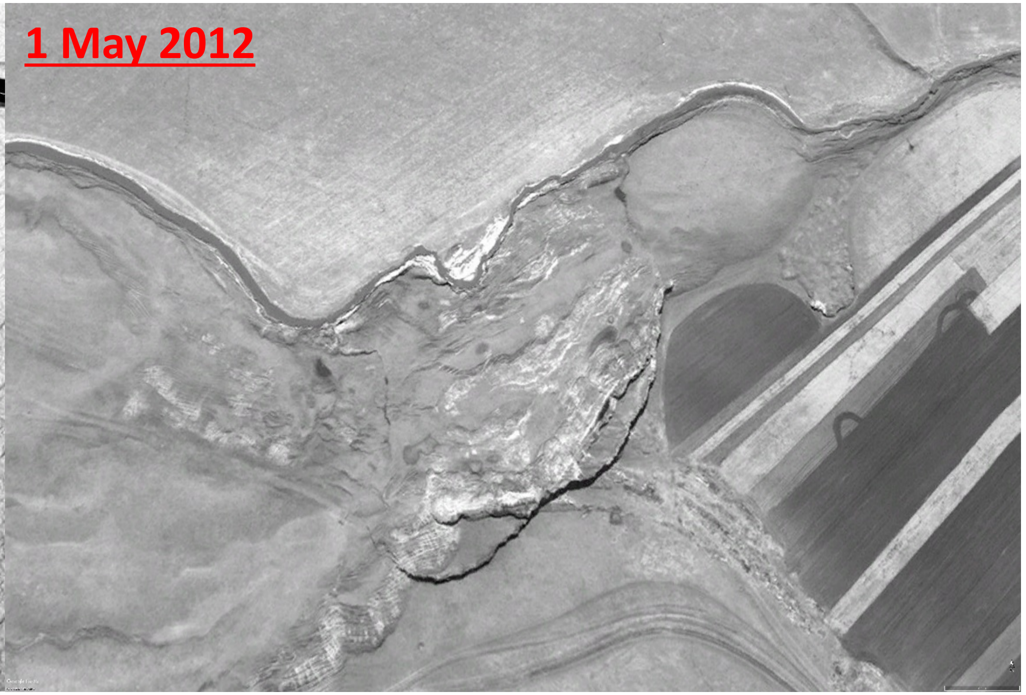

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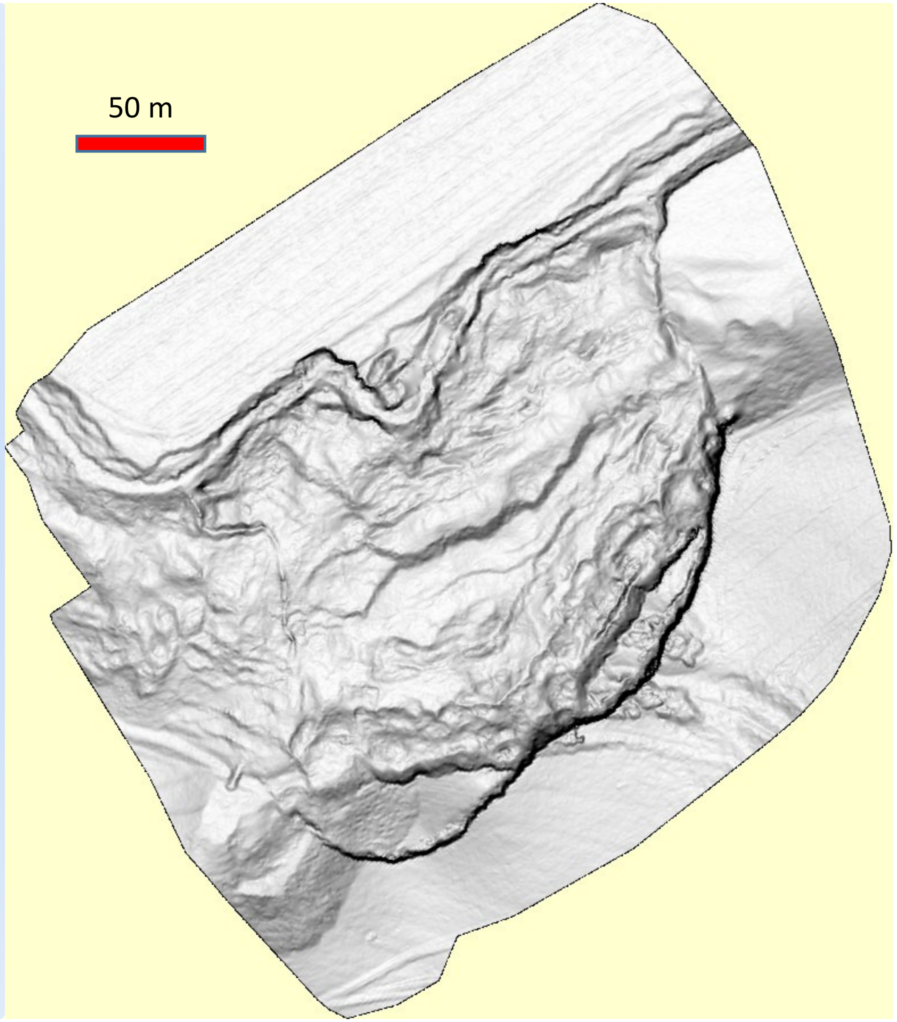
LiDAR data

- LiDAR data aquired in February 2012 with 4-6 points per meter density and was classified in Cloud Compare with the CANUPO (Brodu and Lague, 2012) and CSF (Zhang et al., 2016) plugins.
- The DEM was obtained through interpolation in SAGA GIS using Multilevel B-spline (for a detailed description of the methodology see Niculiță et al., 2020) at a resolution of 0.25 m.
- Geomorphic Change Detection (Wheaton 1998, Wheaton et al., 2010a, 2010b) in it’s simplest setup (through thresholding of ±0.15 m) was used to asses the changes.



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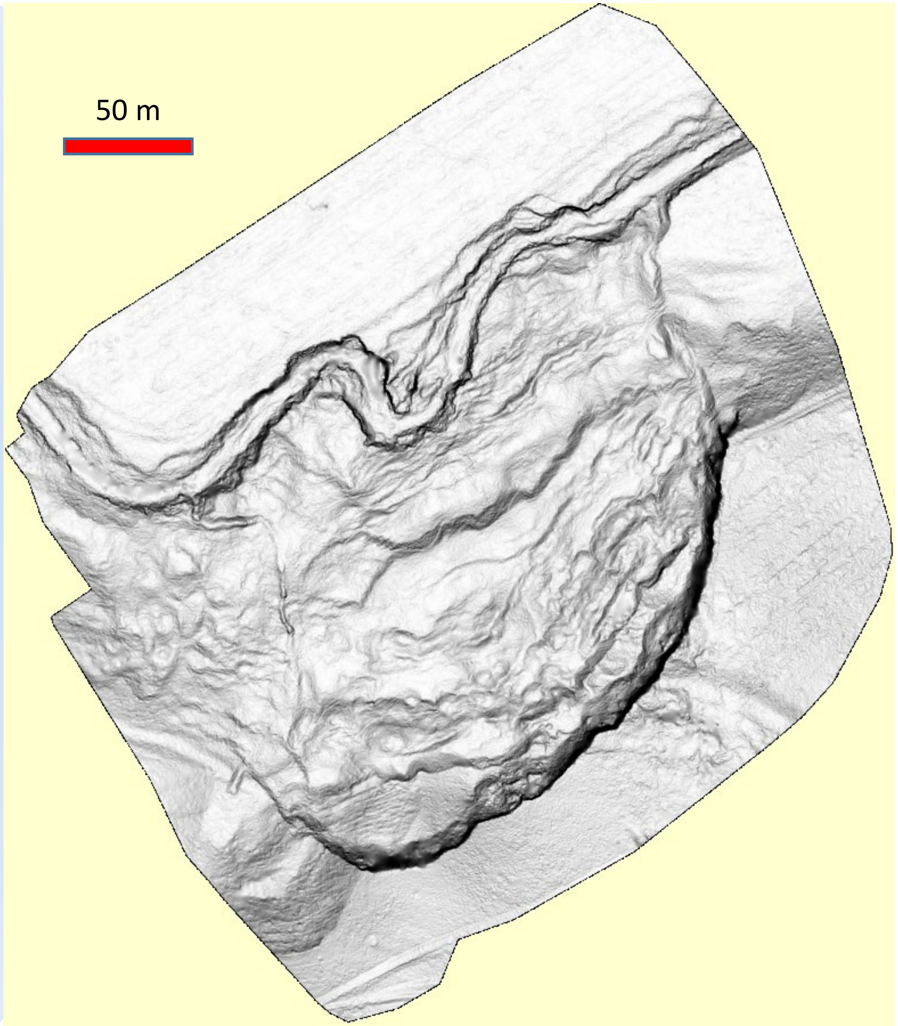
Structure from Motion from UAV images

- The Phantom 4 Pro quadcopter was used to capture the images in stereo pairs (models) as a string & block photogrammetric flight path with 80% side and forward (end) overlap. The altitude of the flight was 50 m relative to the terrain surface, the flight plan being computed and executed by UgGS software. The camera acquired images at 20 MP resolution, in 3:2 Aspect Ratio with a size of 5472x3648 pixels per image and RAW format. The nominal pixel size was ~ 0.012 m.
- SfM was performed in Visual SFM, the point cloud being georeferenced using 14 GCPs measured in the field with a Trimble GeoExplorer 6000 GPS and the ROMPOS differential correction service.



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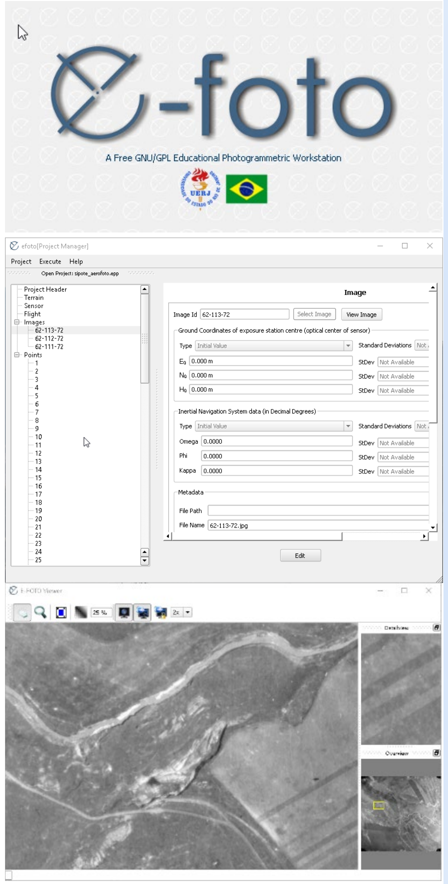
Digital Photogrammetry



- E-Foto photogrammetry software (http://www.efoto.eng.uerj.br/en - Ribeiro et al., 2018) was used to perform a digital photogrammetry workflow .
- Two photogrammetric images aquired in July 1979, in stereo pair with 60% overlap; interior orientation > photo-triangulation > exterior orientation by spatial resection > vector points generated through stereo plotter.
- Unfortunately since the point cloud was sparse a DEM could not be obtained, and five topographic profiles were extracted by stereoscopic measurements.

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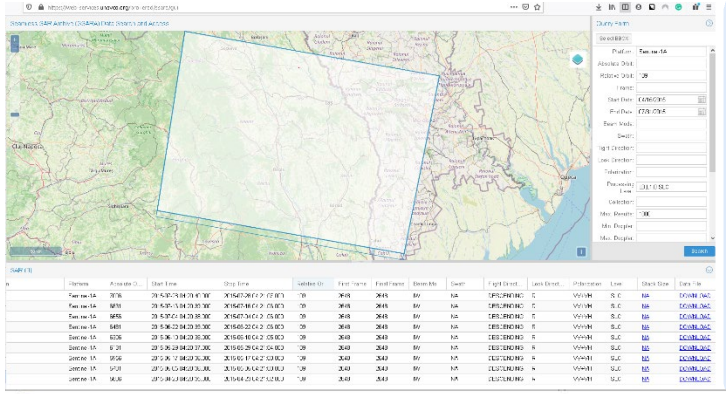
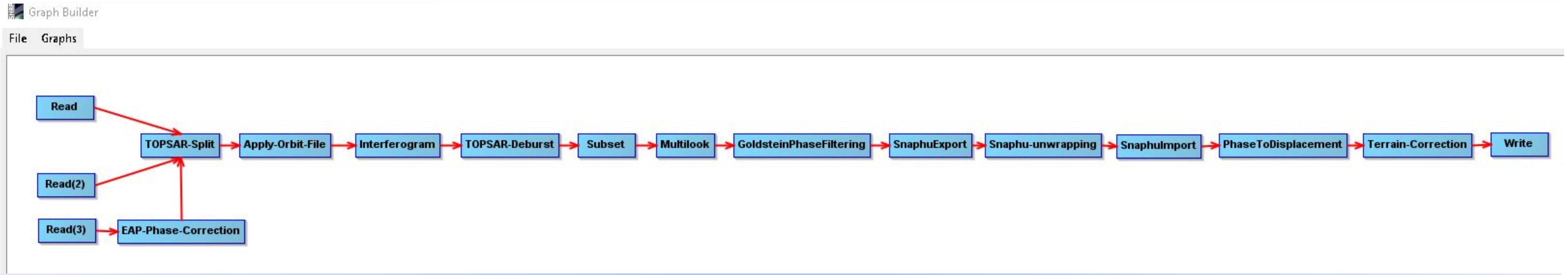
DInSAR of SENTINEL-1A



- DESCENDING SENTINEL-1A data from SSARA Archive (https://web-services.unavco.org/brokered/ssara/gui) from October 2014 to October 2019 (167 images)



- SNAP Phase processing and SNAPHU unwrapping to estimate displacement from Phase.
- Future approach will try a SBAS DInSAR since PS is not suitable, and displacement from Phase results are promising.

RESULTS – GCD 2012-2019

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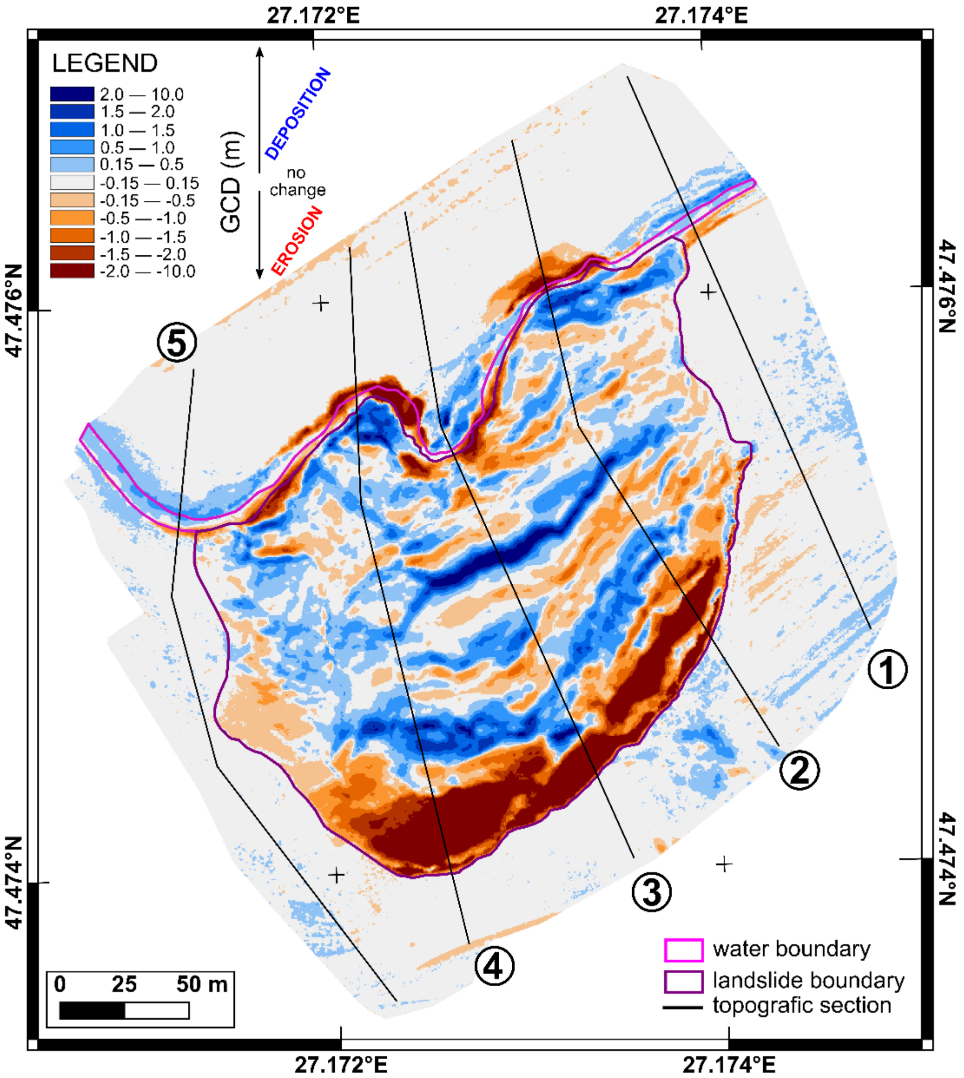
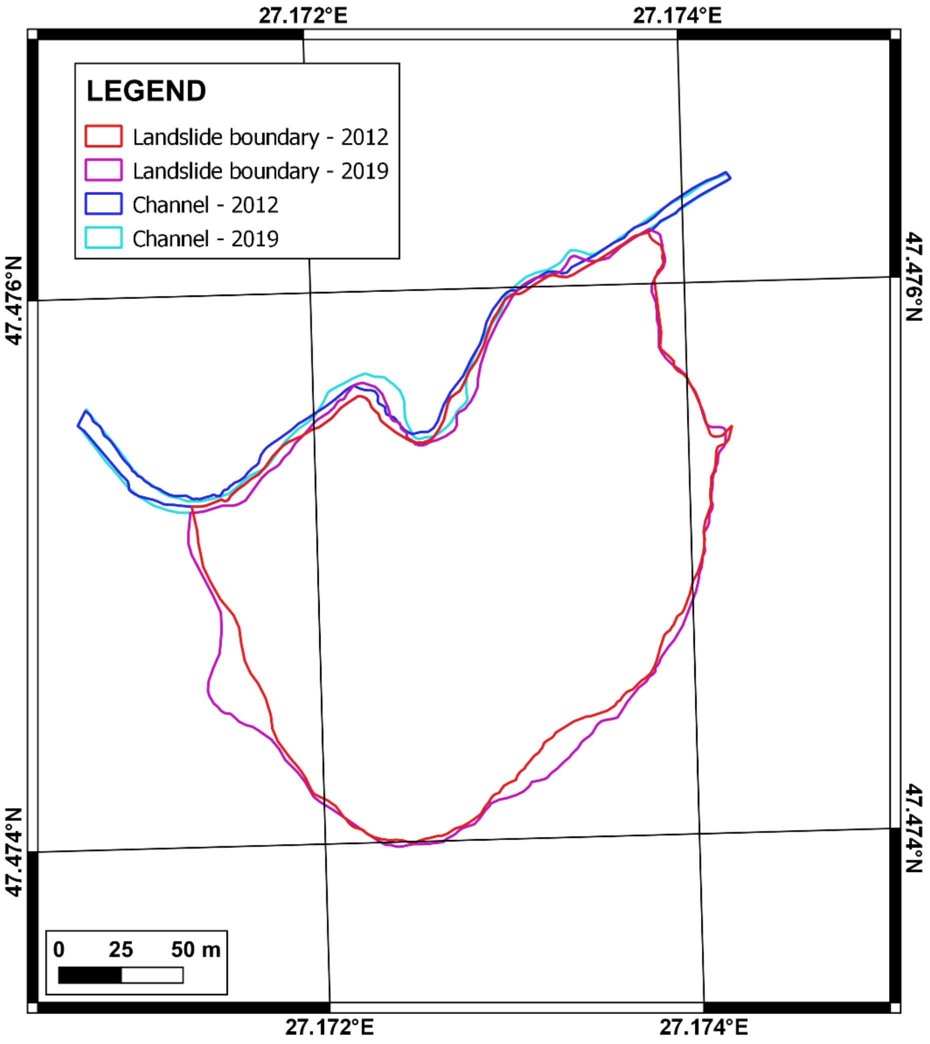
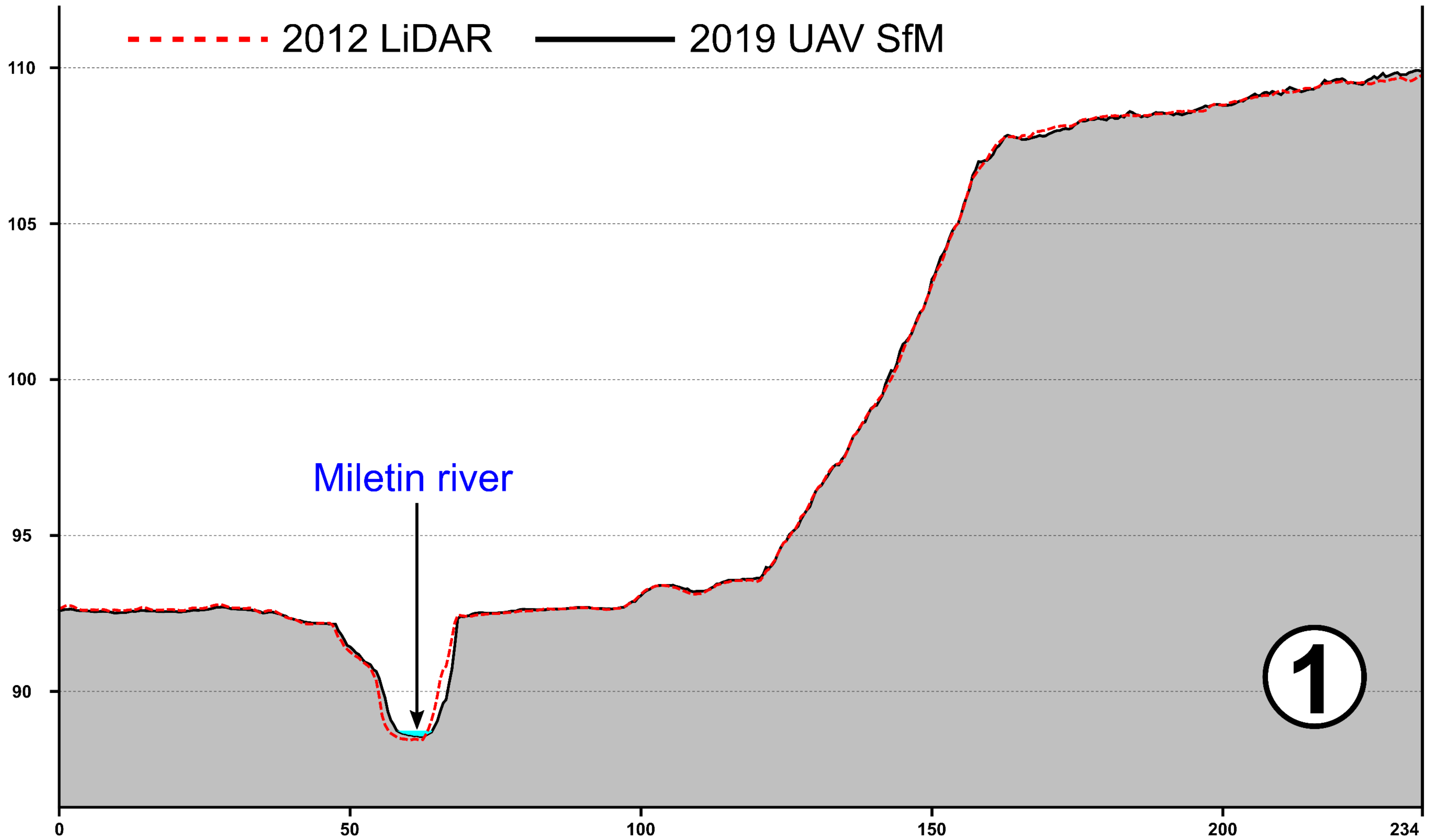
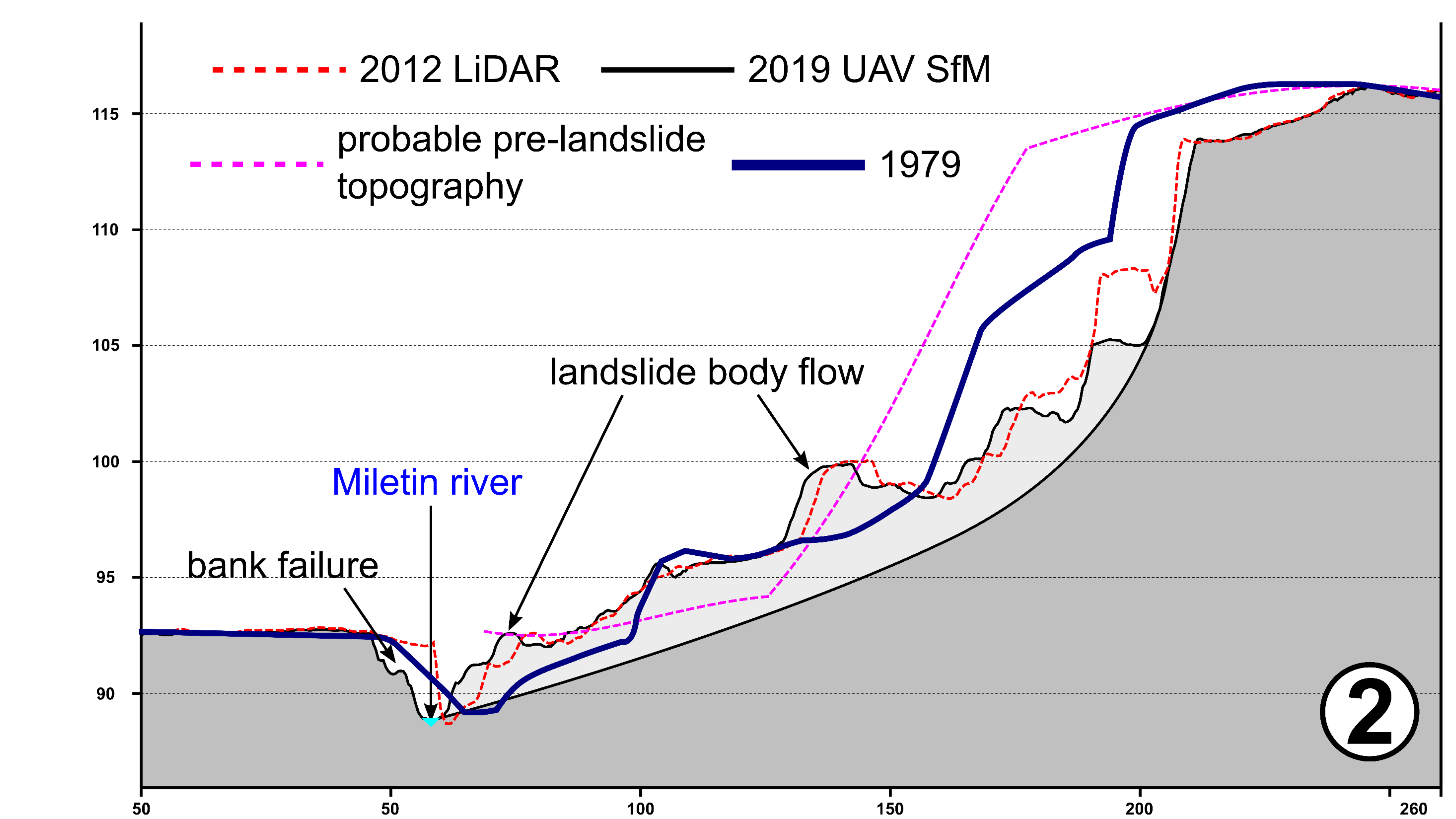
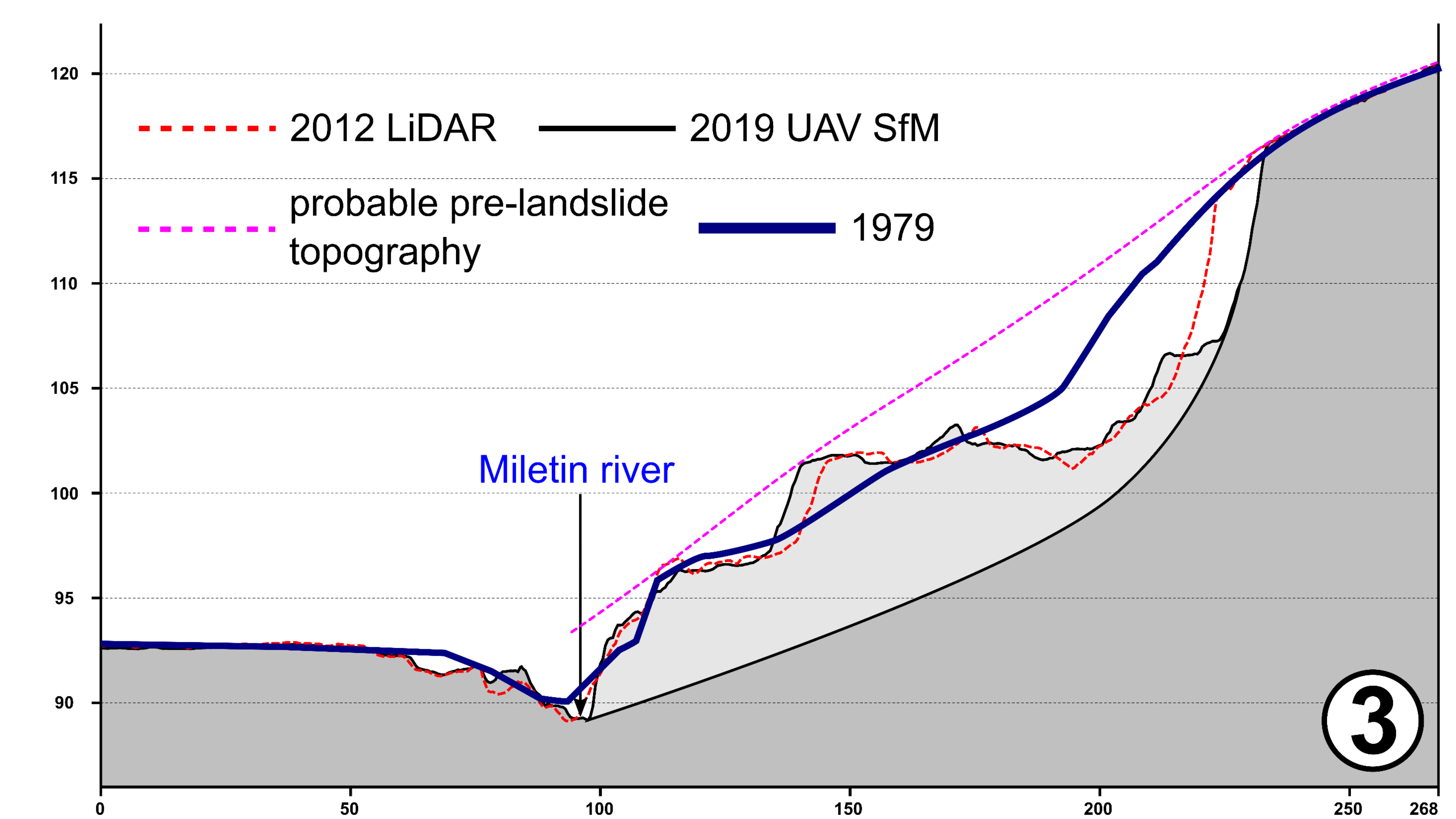




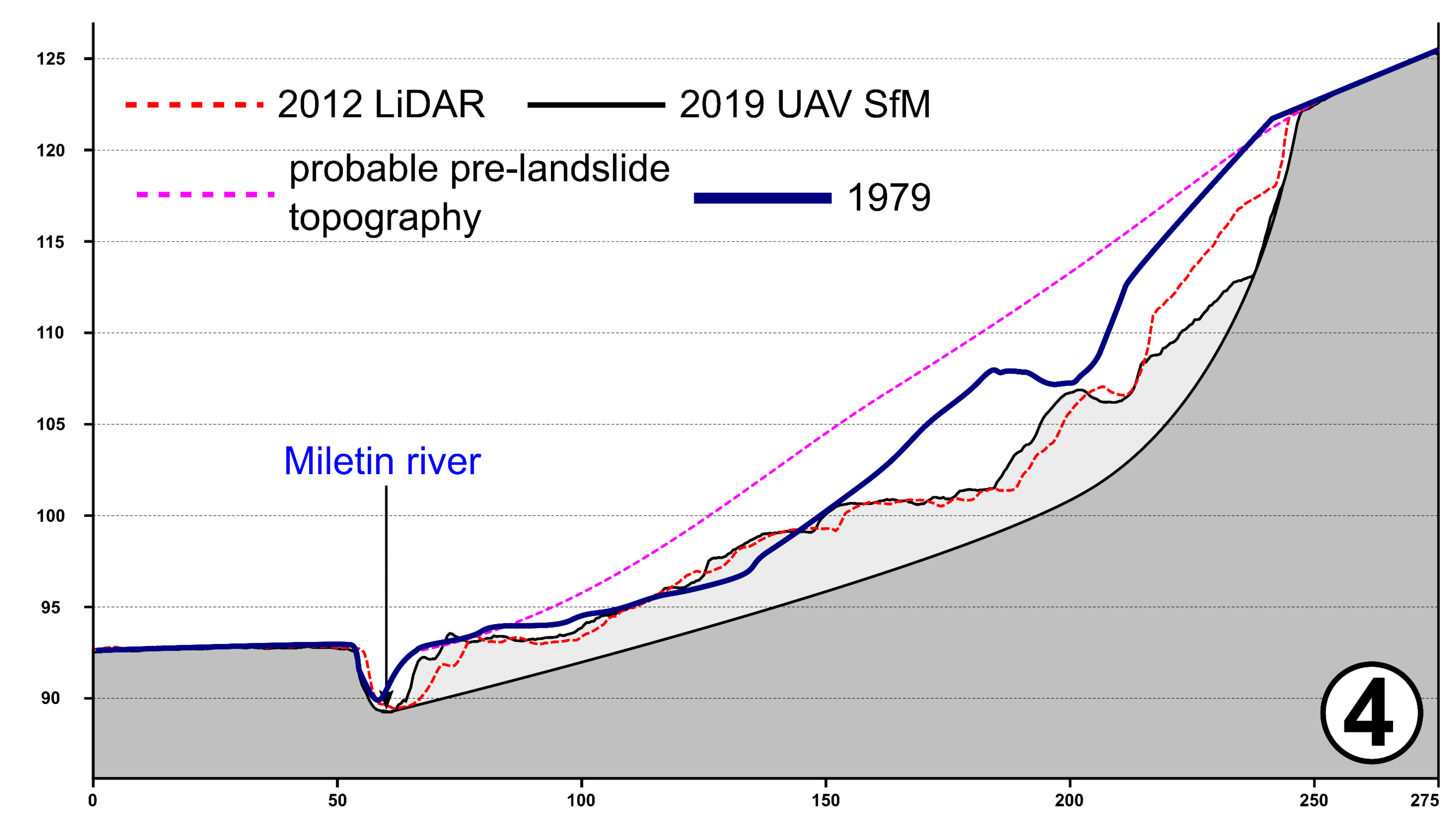

2012 LiDAR
2019 UAV SfM
110
105
100
95
90
Miletin river
1
0
50
100
150
200
234



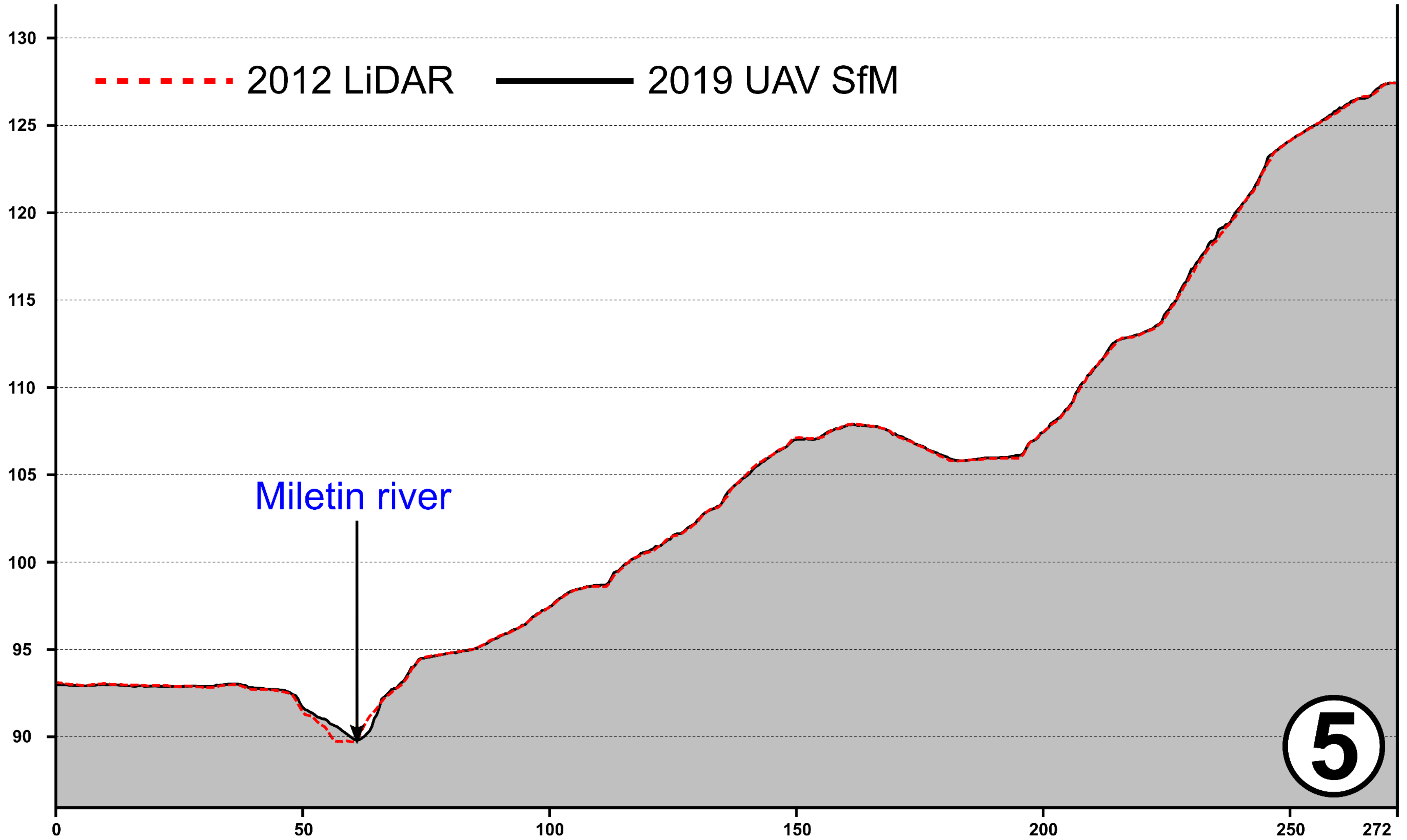
2012 LiDAR
2019 UAV SfM
probable pre-landslide topography
1979
landslide body flow
Miletin river
bank failure
115
110
105
100
95
90
50
50
100
150
200
260
2

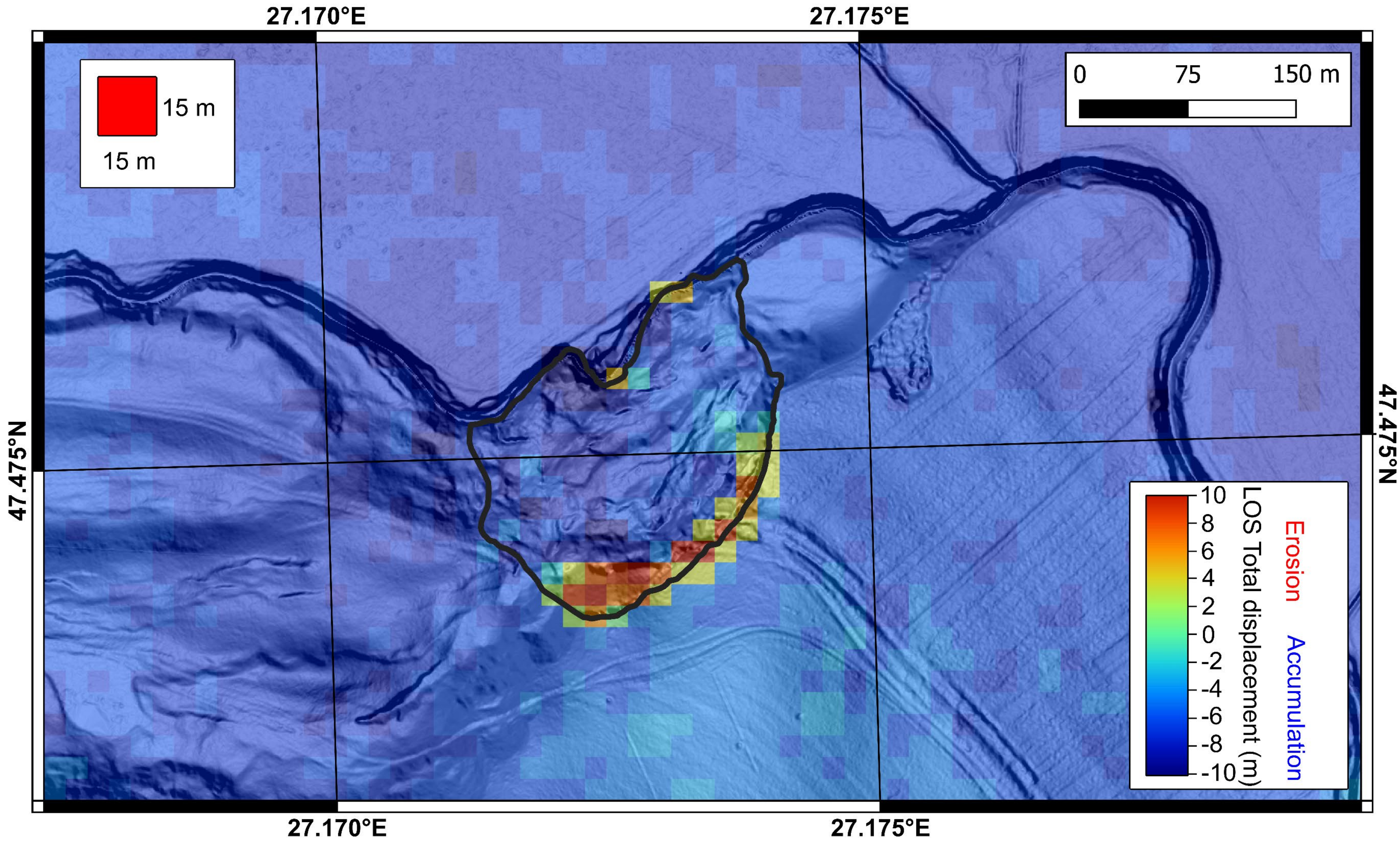


2012 LiDAR
2019 UAV SfM
probable pre-landslide topography
1979
Miletin river
120
115
110
105
100
95
90
0
50
100
150
200
250
268
3



2012 LiDAR
2019 UAV SfM
probable pre-landslide topography
1979
Miletin river
4
125
120
115
110
105
100
95
90
0
50
100
150
200
250
275


130
125
120
115
110
105
100
95
90
2012 LiDAR
2019 UAV SfM
Miletin river
5
0
50
100
150
200
250
272



27.170°E
27.175°E
15 m
15 m
0
75
150 m
47.475°N
47.475°N
10
8
6
4
2
0
-2
-4
-6
-8
-10
LOS Total displacement (m)
Erosion
Accumulation
27.170°E
27.175°E

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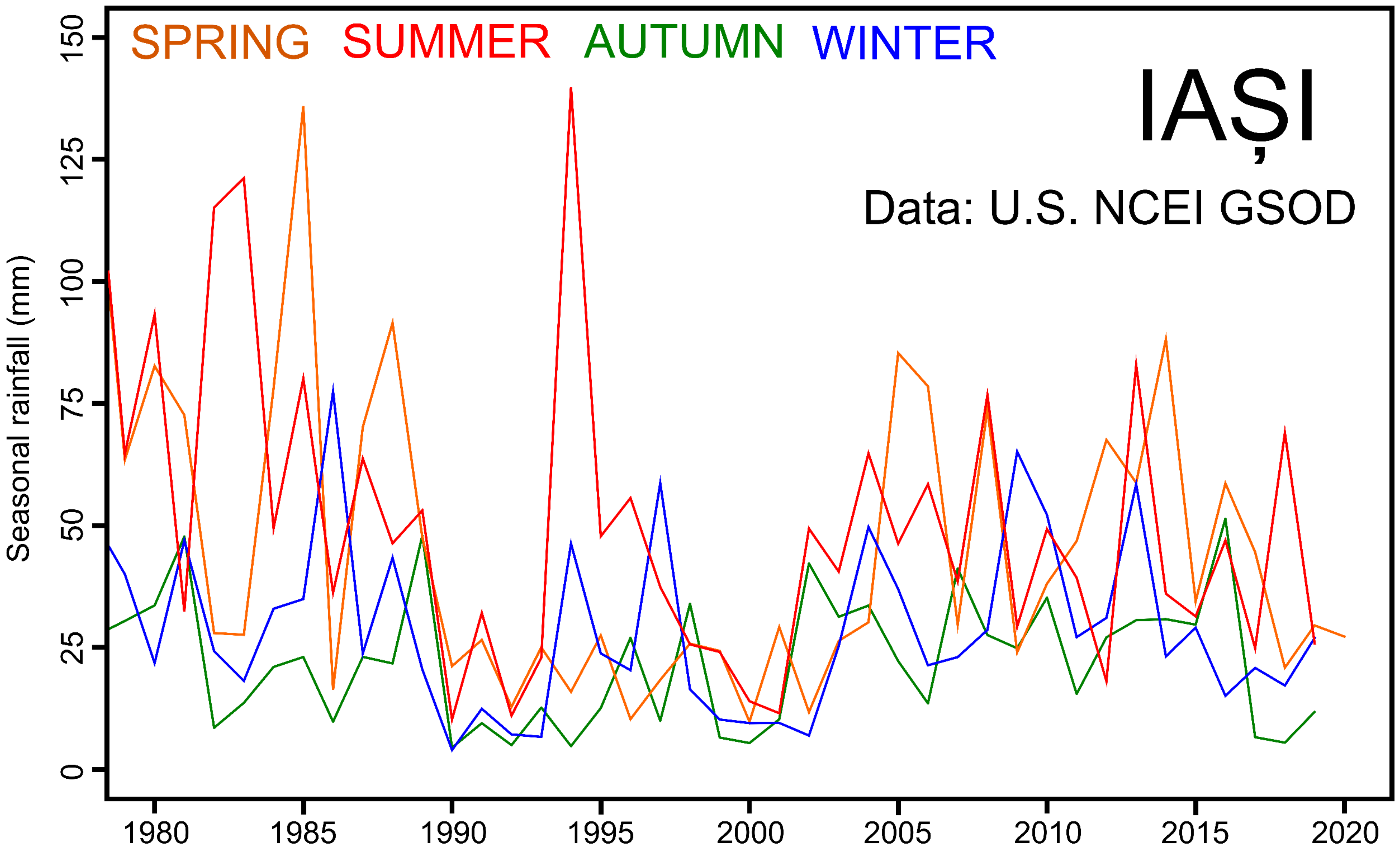
DISCUSSIONS

- The RS data and methods are able to show the following aspects regarding the Șipote-Chișcăreni landslide:

- The landslide triggered before 1920, evolved trough retrogressional scarp slumping as the river incised and migrated toward the base of the hillslope.
- The incision of the river and it's ability to evacuate the basal part of the landslide body maintained the instability , the flow of the body material and the scarp slumping.
- The intensification of fluxes of landslided material generate the increasing of channel sinuosity;
- Erosion and accumulation, both for river channel, banks and landslide elements are spatially assessed;
- SAR displacement estimates are in good agreement with the GCD rates, and an SBAS temporal assessment of the rates could provide a temporal characterization of landslide activity;
- The landslide scarp reactivated after the 2005, 2008 and 2010 wetter years and it's retreat has stopped in the last five years which are dry during the winter.


SPRING SUMMER AUTUMN WINTER
IAȘI
Data: U.S. NCEI GSOD
Seasonal rainfall (mm)
0
25
50
75
100
125
150
1980
1985
1990
1995
2000
2005
2010
2015
2020

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- The availability of historic and active RS data and of RS techniques is proving beneficial to natural hazard studies.
- By merging the qualitative and quantitative information gathered about geomorphological processes and changing topography the neaf future evolutiong can be estimated.
- We have shown that in the case of Șipote-Chișcăreni landslide, channel incision and fluvial erosion are linked with landside trigerring and dynamics. In it’s present state the landslide is inactive during dry seasons, but it is re-activated during wet seasons.

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- We thank to the Aerial Survey Section of the Ministry of National Defense and to the Flight Operation section of Romanian Aeronautical Authority for the support in obtaining all the required authorizations for performing the flights.


Thank you for your attention ☺

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