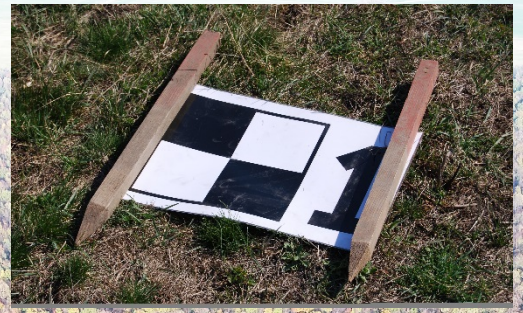
EGU General Assembly 2020

Online | 4–8 May 2020



Using RPAS derived images and LiDAR DEM's for the assessment of geomorphic changes in a cultural heritage site affected by recent landslides

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INTRODUCTION

- Remote sensing, and especially LiDAR and RPAS SfM, are now basic method used in natural hazard evaluation.
- If a LiDAR DEM reference dataset are available, DEMs obtained from RPAS images and SfM, can be used to asses the geomorphological processes rate and dynamics through the geomorphic change detection approach (GCD).
- The availability of a detailed GCD analysis can be used to derive the following:

- detailed geomorphological mapping;

- detailed rate of process;

- recent past geomorphological evolution;

- near future possible geomorphological evolution.

- These elements are of crucial importance in the case of cultural heritage sites that are in danger due to natural hazards.

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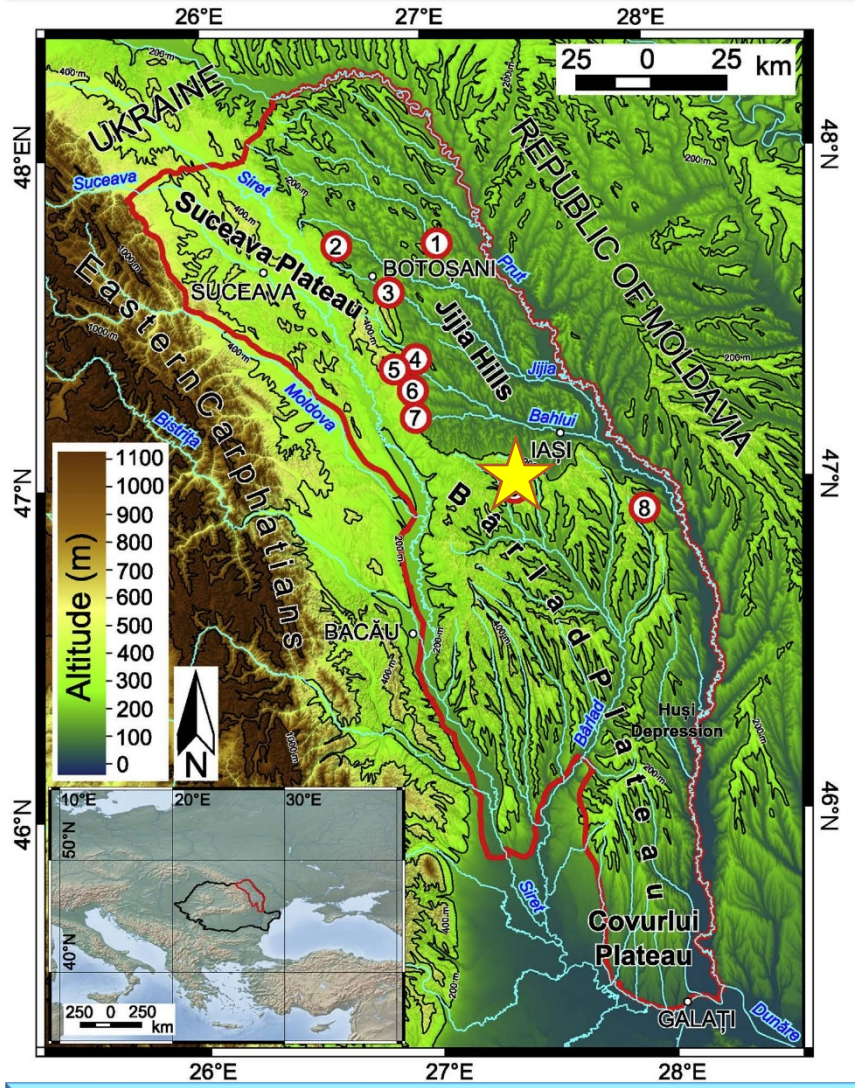
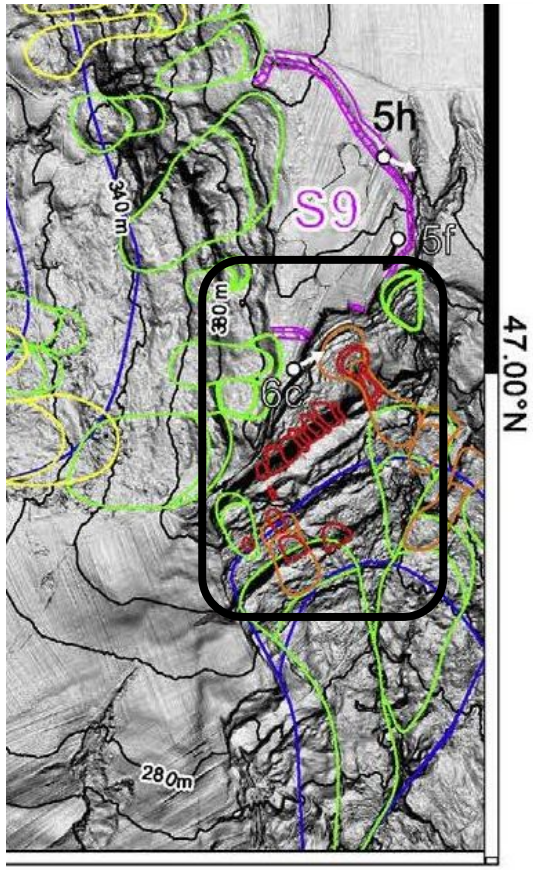
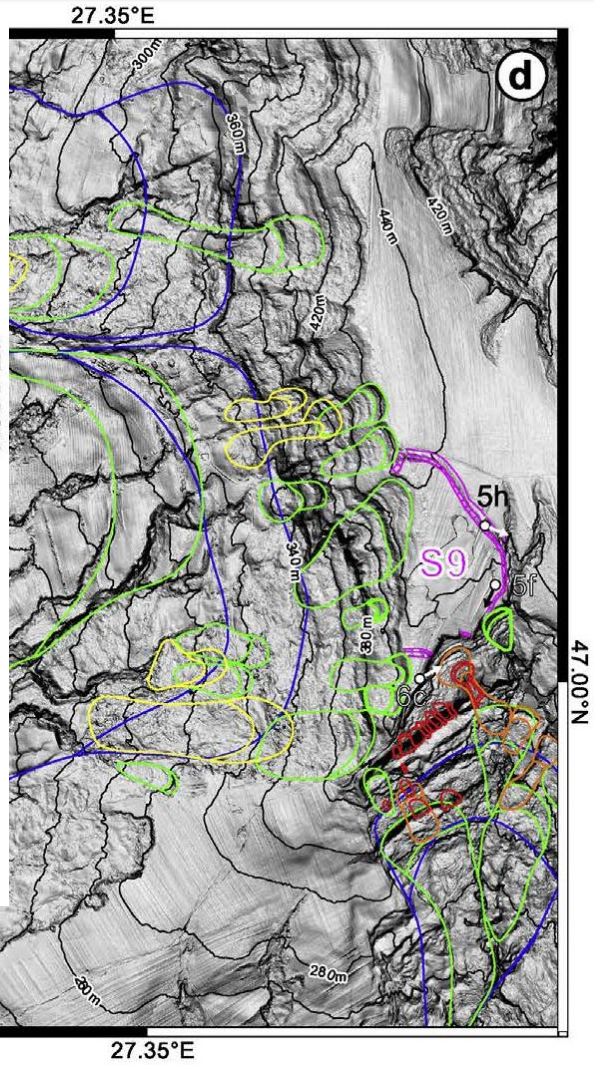
STUDY AREA – Poiana Mănăstirii iron age hillfort







Niculiță et al., 2016

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STUDY AREA – Niculiță et al., 2016

- This study focus on the area of Poiana Mănăstirii Thraco-Getic hillfort (2550-2050 yr BP), located in the central part of Moldavian Plateau, Romania. Covering a surface of 12 ha, the fortress is surrounded by a 2-3 m high wall, with a 10 m wide base, and a 1 m deep and 4-6 m wide trench.
- In its southern part, the landslides destroyed these remnants, and due to the deforestation of the slope in the last 30 years, these processes recorded almost yearly reactivations. The main landslide scarp is affected by a gully system that contributes to the archaeological site degradation.

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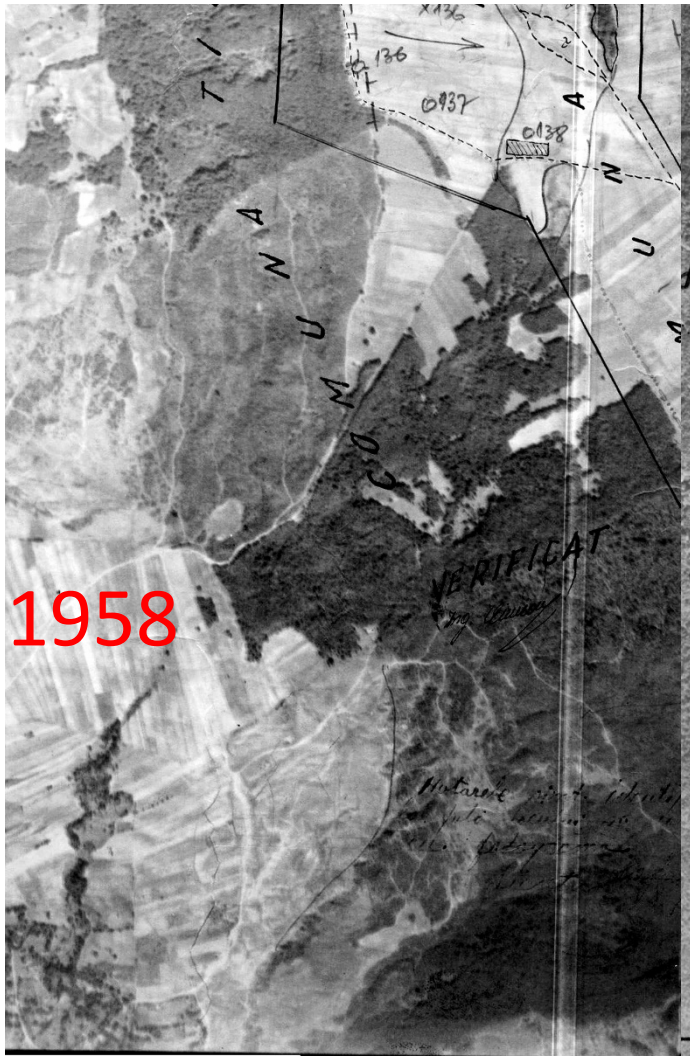
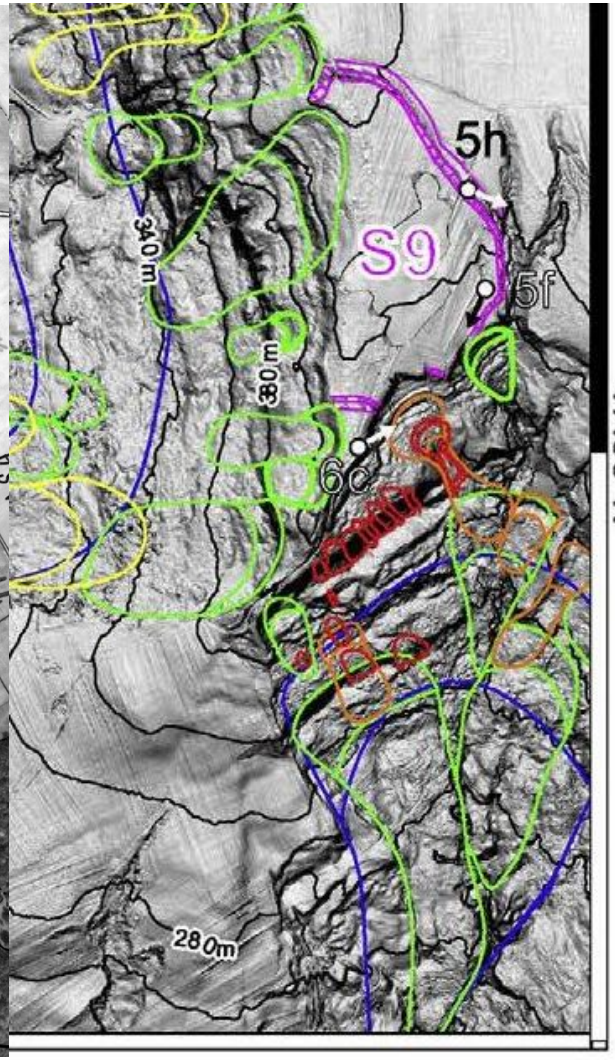
LAND USE HISTORY - Deforestation after 1984





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METHODOLOGY

- The usage of a quadcopter allow the coverage of up to 15 ha per battery in a framework that allow high accuracy and precision of the topographic data.
- 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 image and RAW format. The nominal pixel size was ~ 0.012 m. SfM was performed in Visual SFM.

Structure from Motion

Visual SFM

Bundle adjustment to estimate the 3D geometry of the point cloud, and the interior and exterior camera orientation

Feature matching on photos

Sparse point cloud

Multi-view stereo (MVS) image matching algorithm to densify the cloud

GCPs used to scale and georeference the point cloud

Trimble GeoExplorer 6000 GPS

Georeferenced point cloud

Dense point cloud

Mesh

Textured mesh (3D model)

Ortophoto-imagery

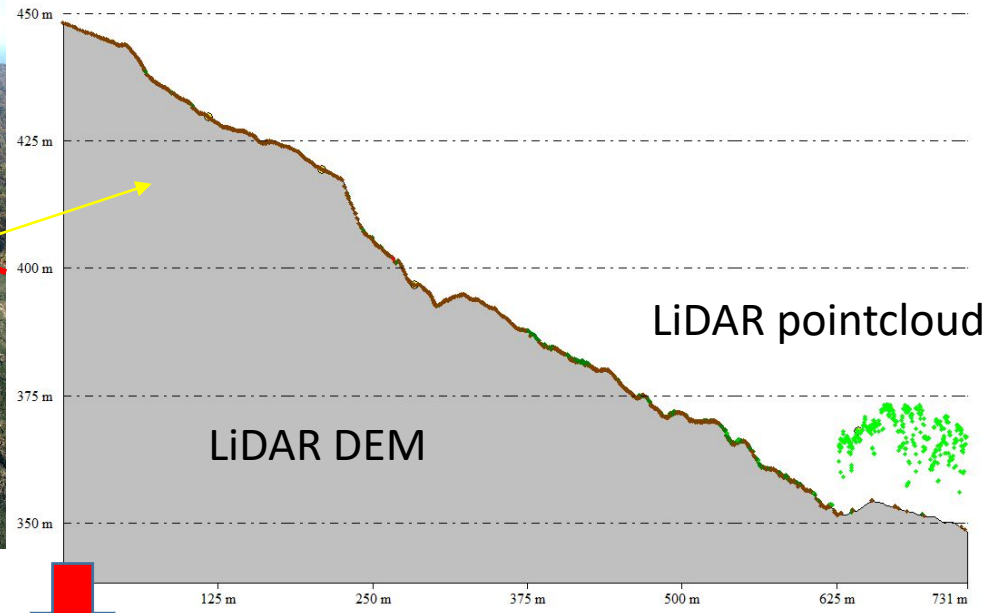
DTM

classification

CSF - Zhang et al., 2016

Brodu & Lague, 2012

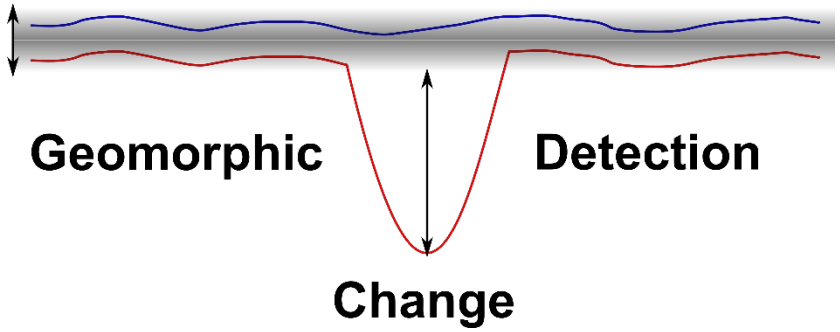
DEM



DEM

Geomorphic Change Detection

Wheaton, 2008; Wheaton et al., 2010a, 2010b



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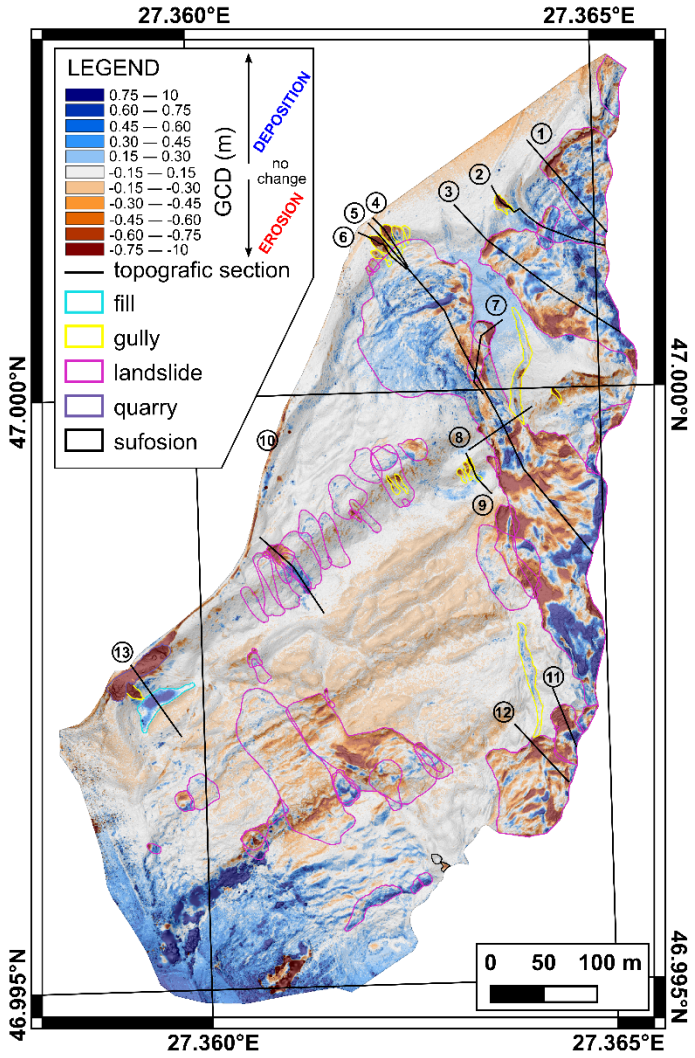
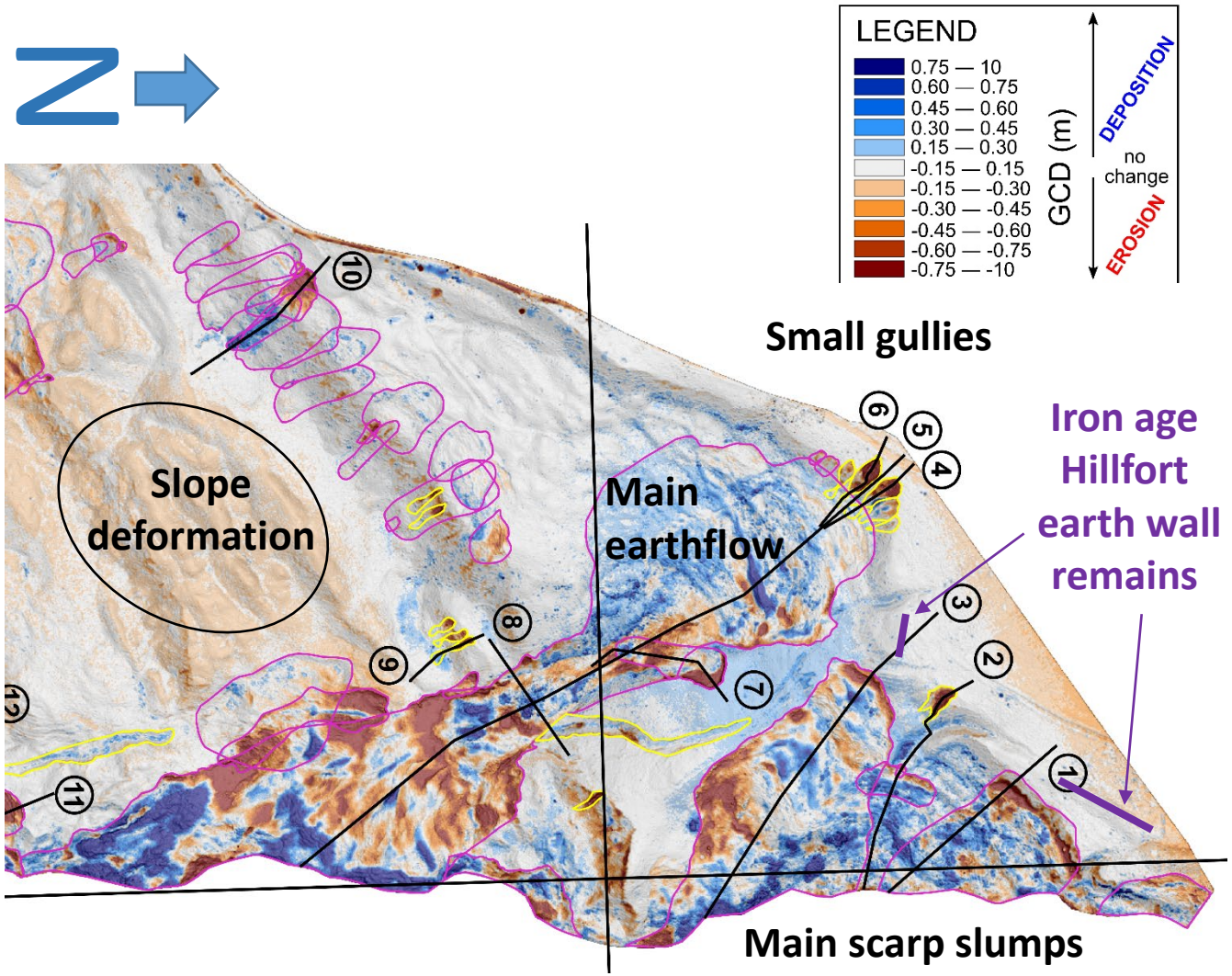
RESULTS





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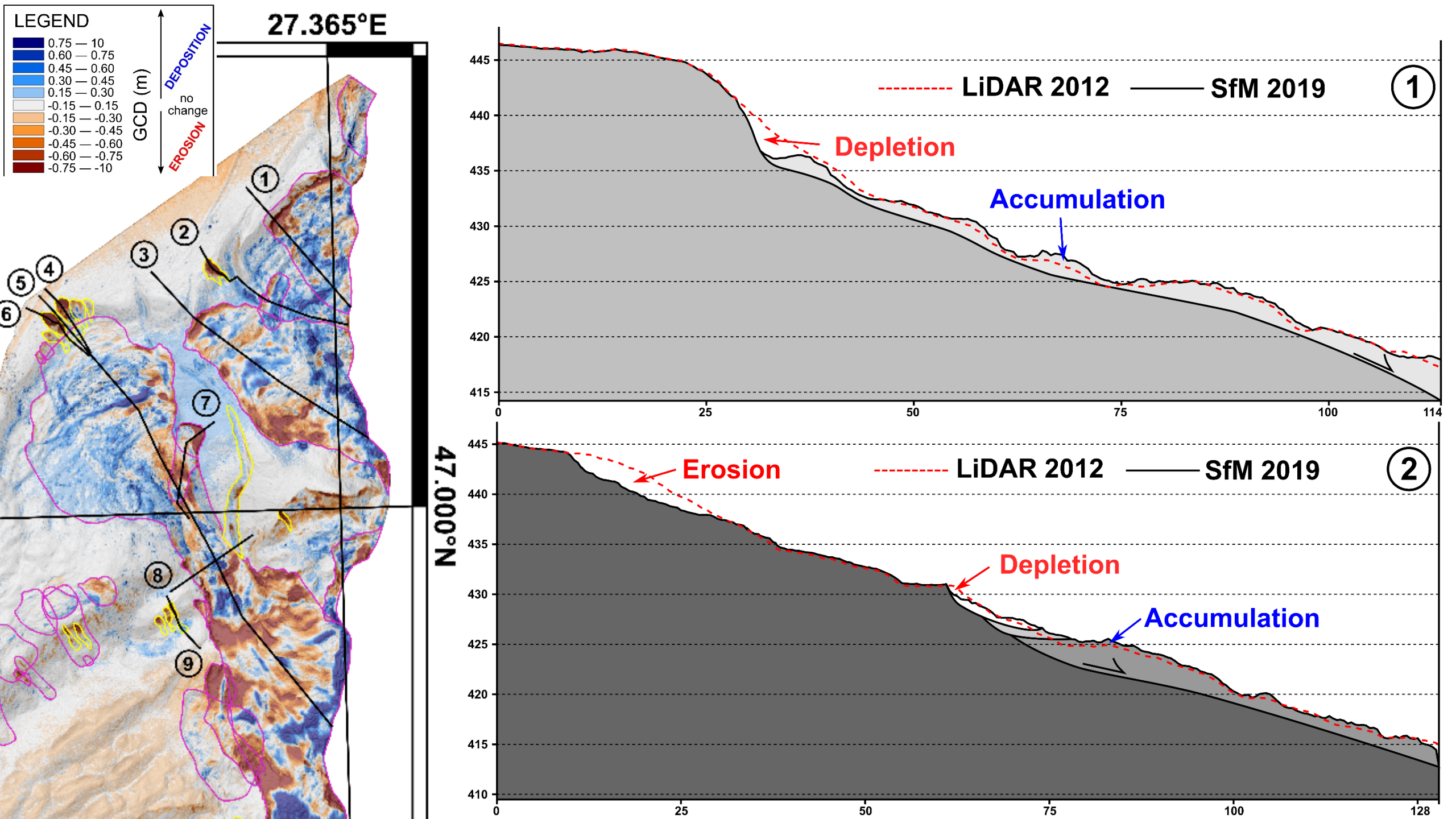
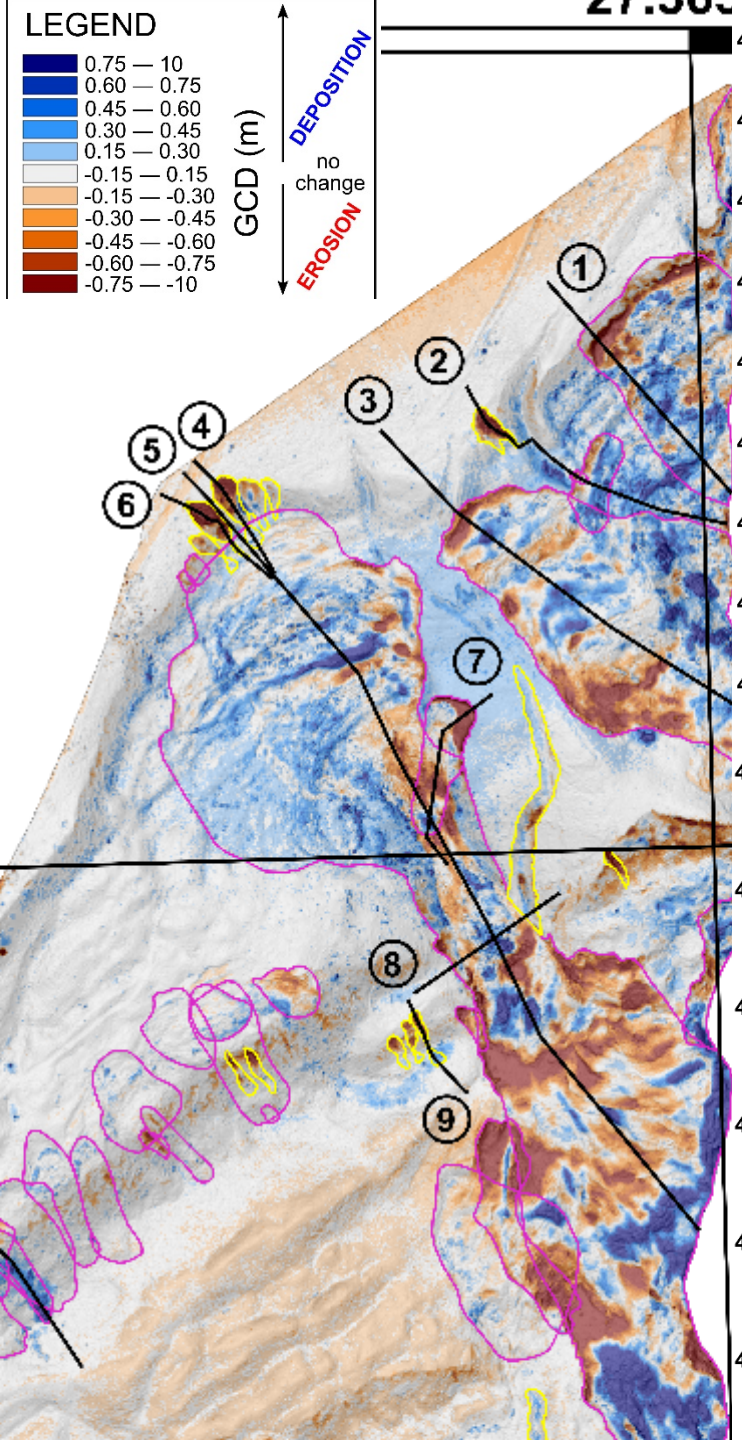
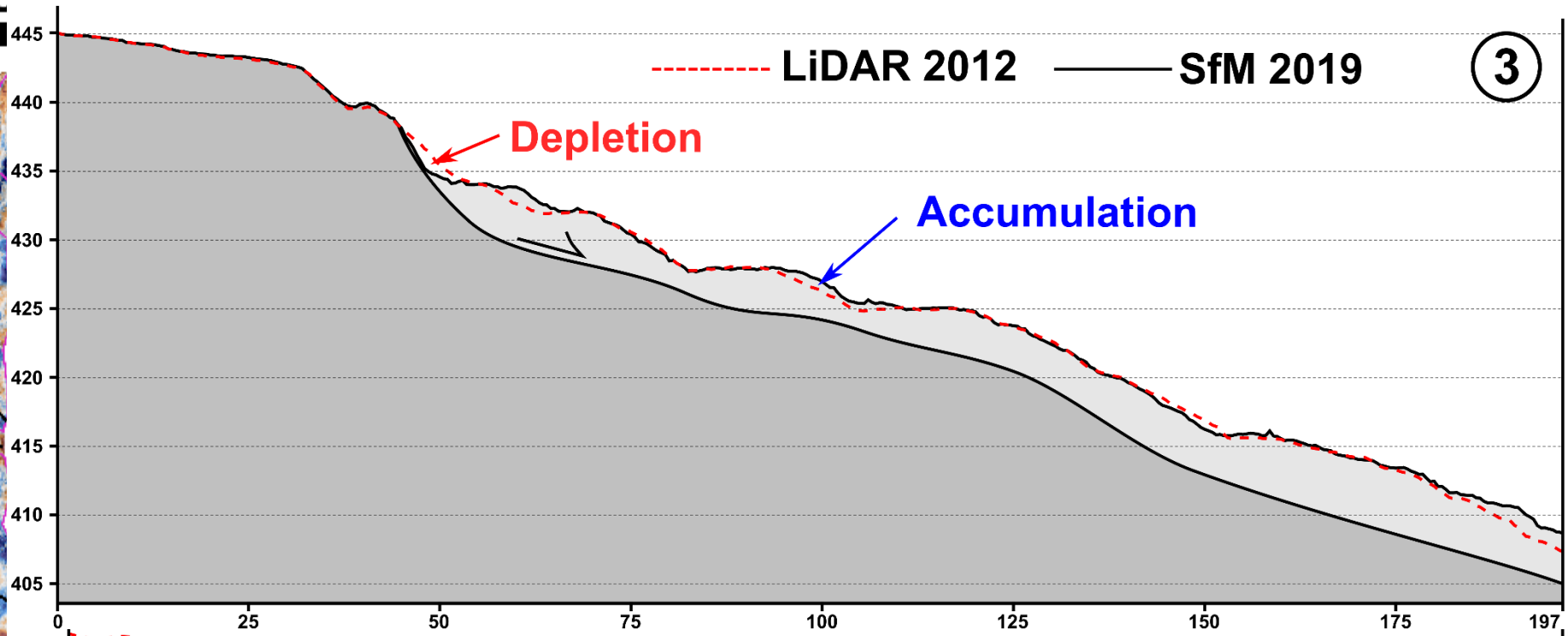
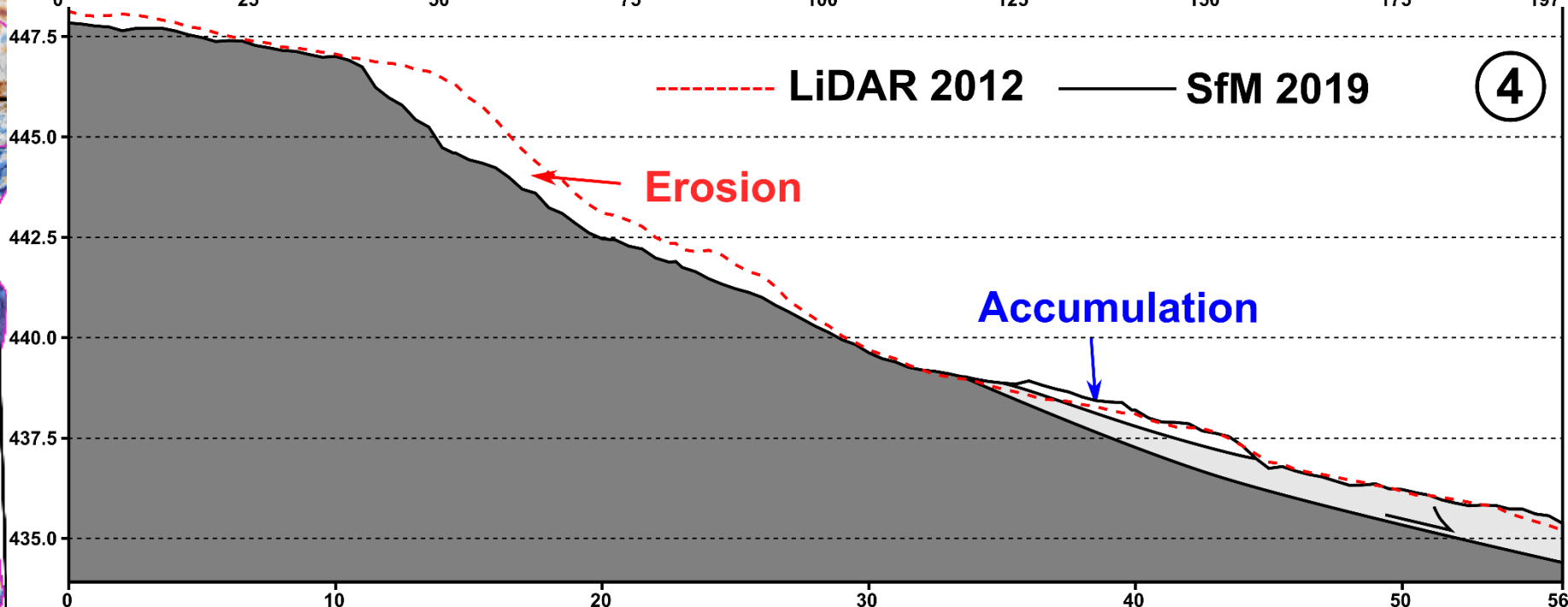
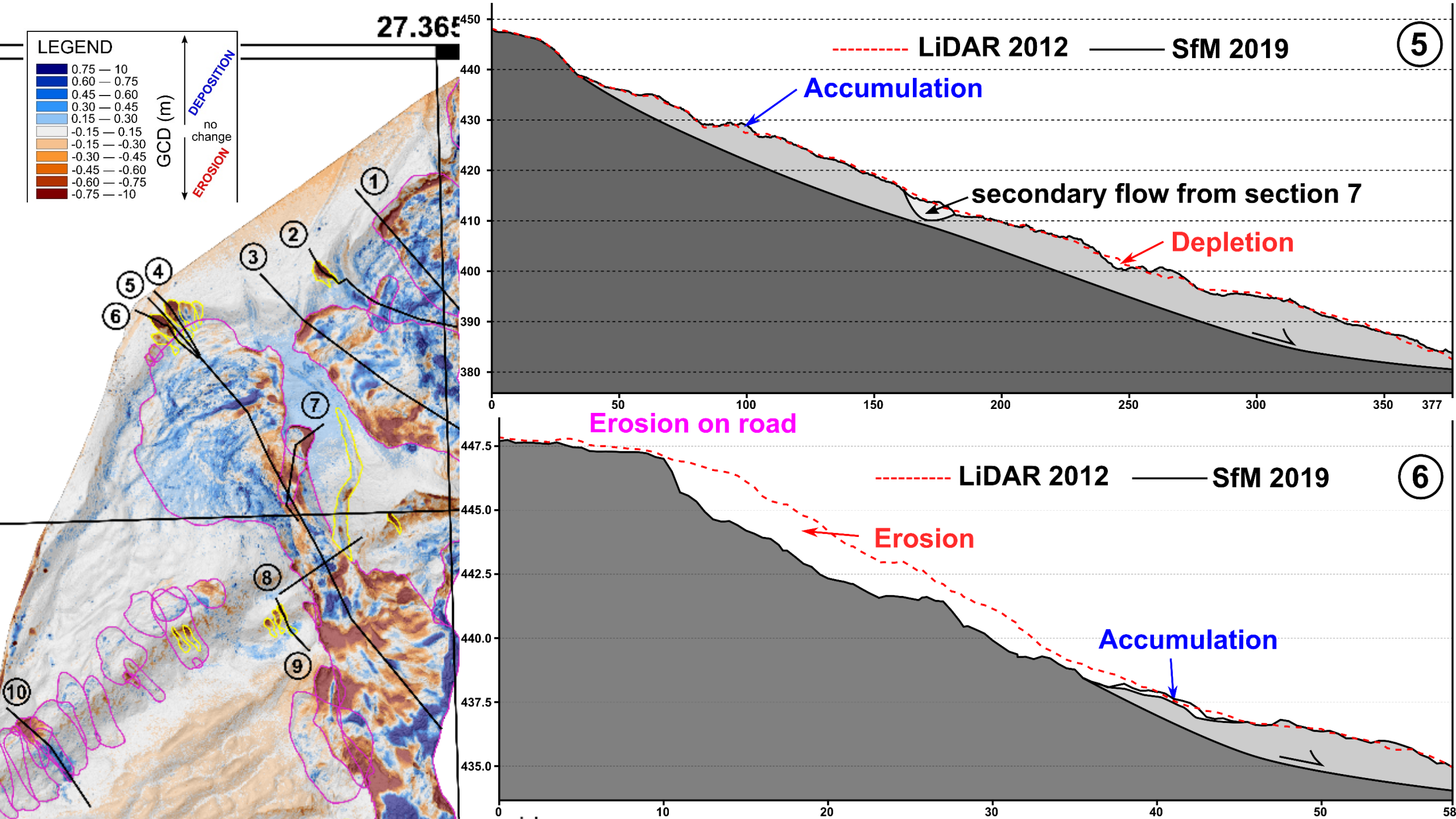
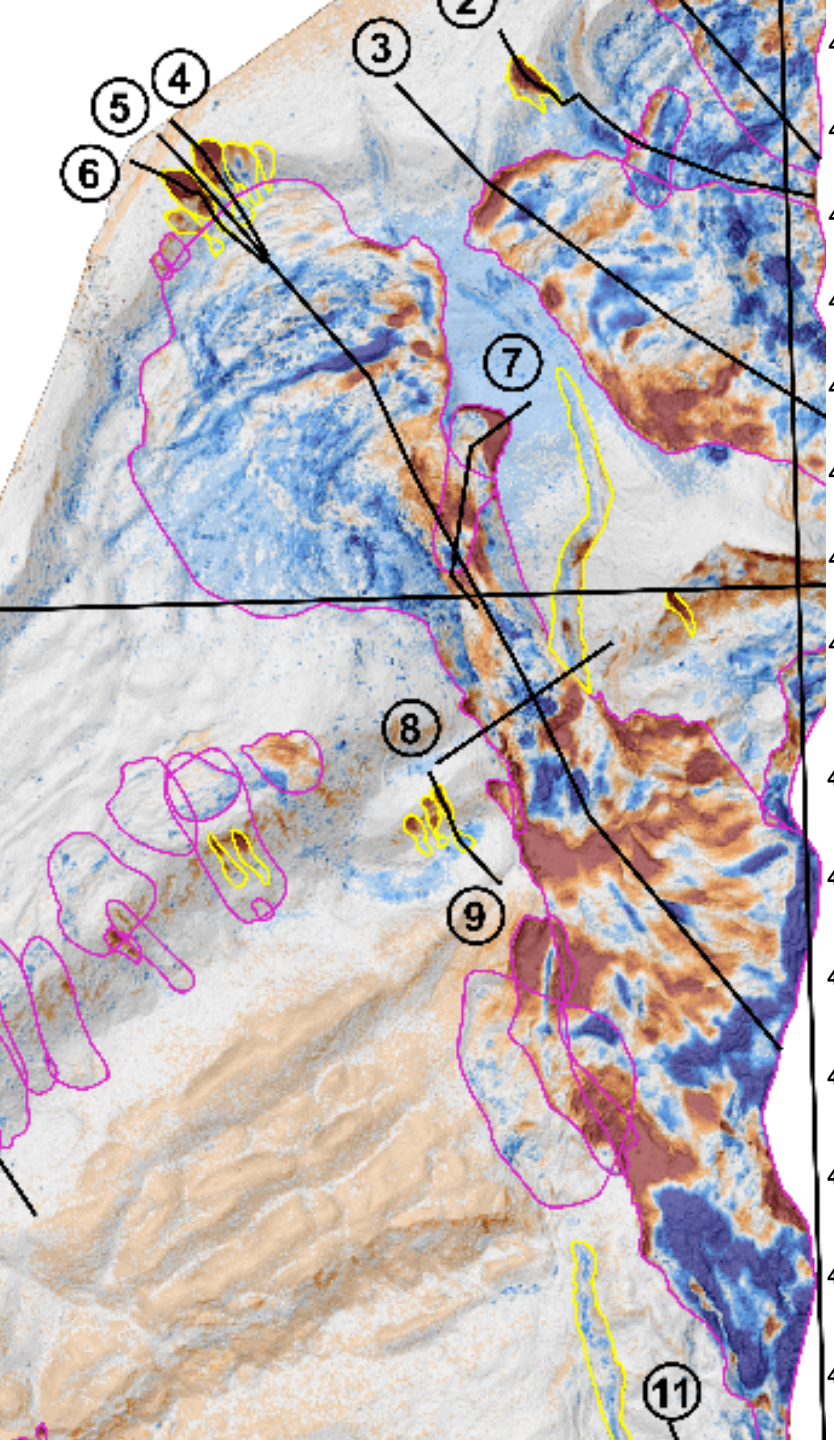

LEGEND
0.75 — 10
0.60 — 0.75
0.45 — 0.60
0.30 — 0.45
0.15 — 0.30
-0.15 — 0.15
-0.15 — -0.30
-0.30 — -0.45
-0.45 — -0.60
-0.60 — -0.75
-0.75 — -10
GCD (m)
DEPOSITION
no change
EROSION
27.365°E
47.000°N
1
2
3
4
5
6
7
8
9
LiDAR 2012
SfM 2019
Depletion
Accumulation
Erosion
445
440
435
430
425
420
415
410
0
25
50
75
100
114
128


LEGEND
0.75 — 10
0.60 — 0.75
0.45 — 0.60
0.30 — 0.45
0.15 — 0.30
-0.15 — 0.15
-0.15 — -0.30
-0.30 — -0.45
-0.45 — -0.60
-0.60 — -0.75
-0.75 — -10
GCD (m)
DEPOSITION
no change
EROSION
1
2
3
4
5
6
7
8
9


LiDAR 2012
SfM 2019
3
Depletion
Accumulation
445
440
435
430
425
420
415
410
405
0
25
50
75
100
125
150
175
197


LiDAR 2012
SfM 2019
4
Erosion
Accumulation
447.5
445.0
442.5
440.0
437.5
435.0
0
10
20
30
40
50
56


LEGEND
0.75 — 10
0.60 — 0.75
0.45 — 0.60
0.30 — 0.45
0.15 — 0.30
-0.15 — 0.15
-0.15 — -0.30
-0.30 — -0.45
-0.45 — -0.60
-0.60 — -0.75
-0.75 — -10
GCD (m)
DEPOSITION
no change
EROSION
27.365
1
2
3
4
5
6
7
8
9
10
LiDAR 2012
SfM 2019
5
Accumulation
secondary flow from section 7
Depletion
450
440
430
420
410
400
390
380
0
50
100
150
200
250
300
350
377
Erosion on road
LiDAR 2012
SfM 2019
6
Erosion
Accumulation
447.5
445.0
442.5
440.0
437.5
435.0
0
10
20
30
40
50
58


2
3
4
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6
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8
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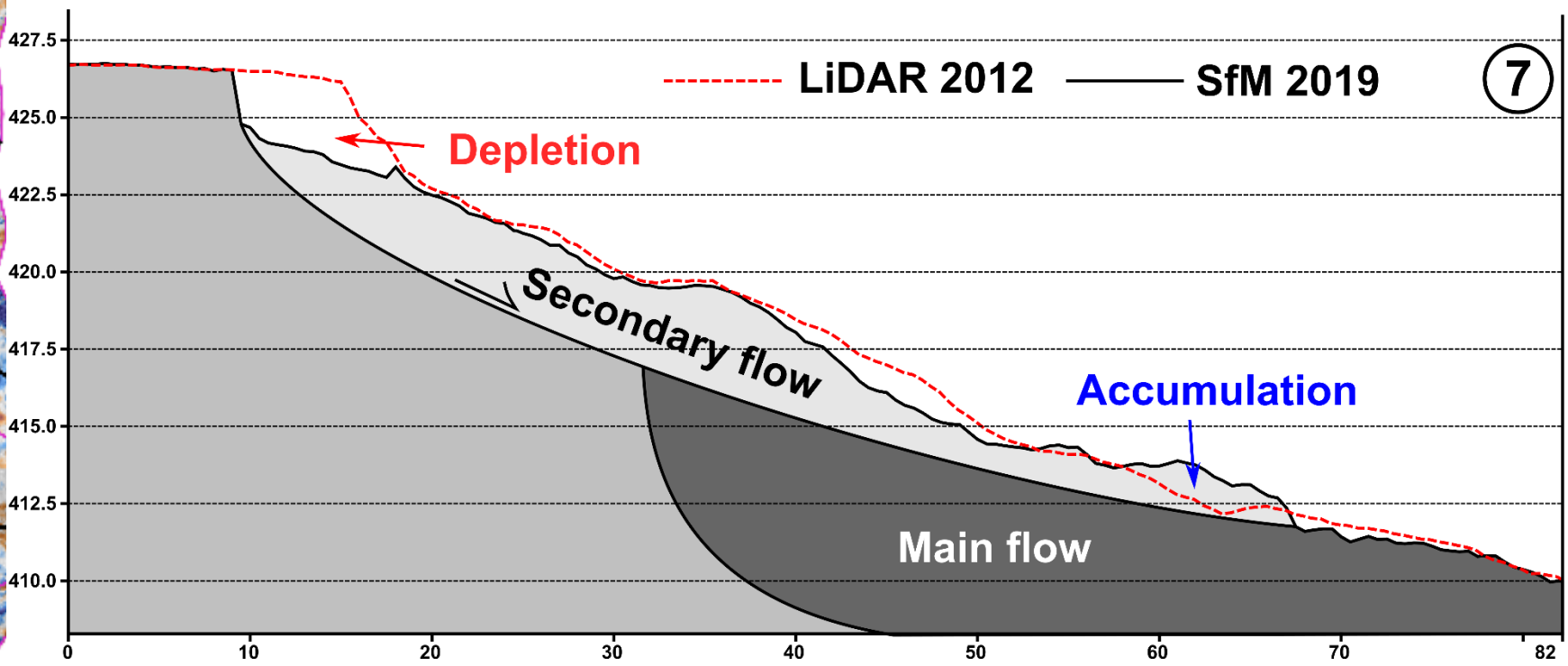
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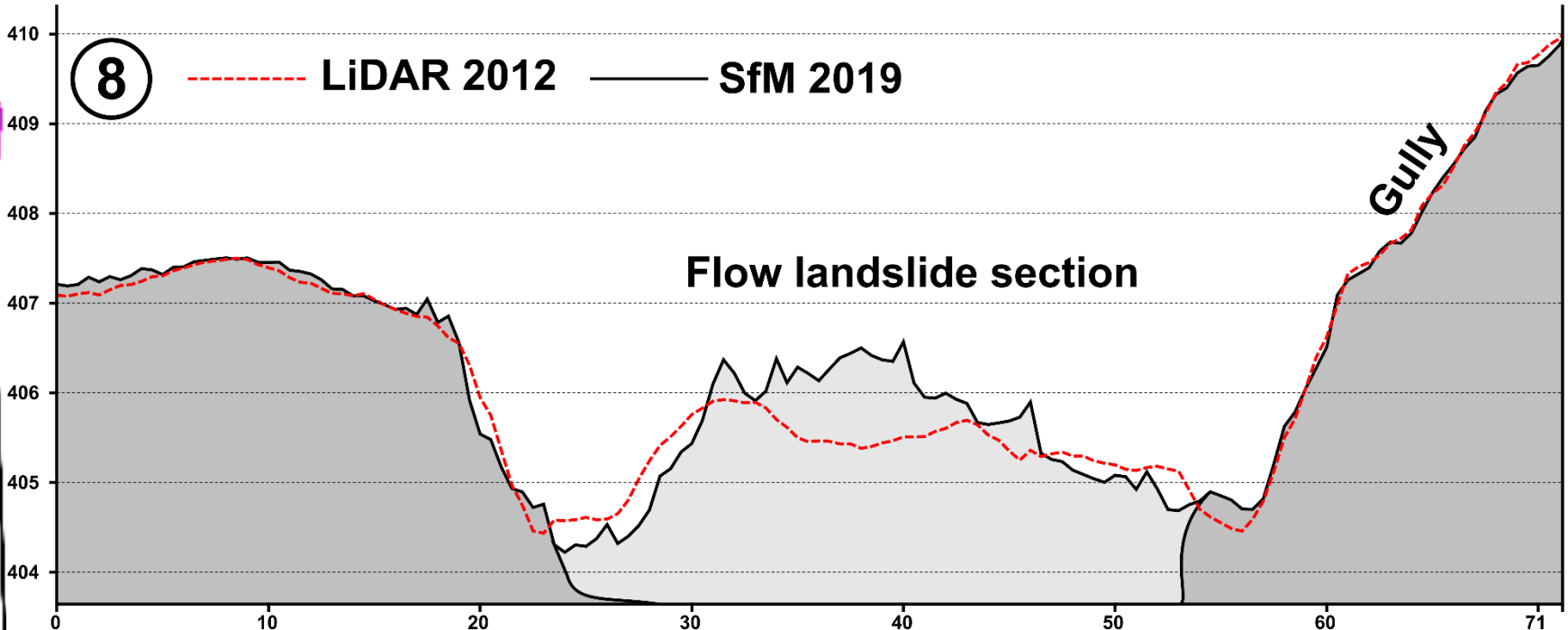
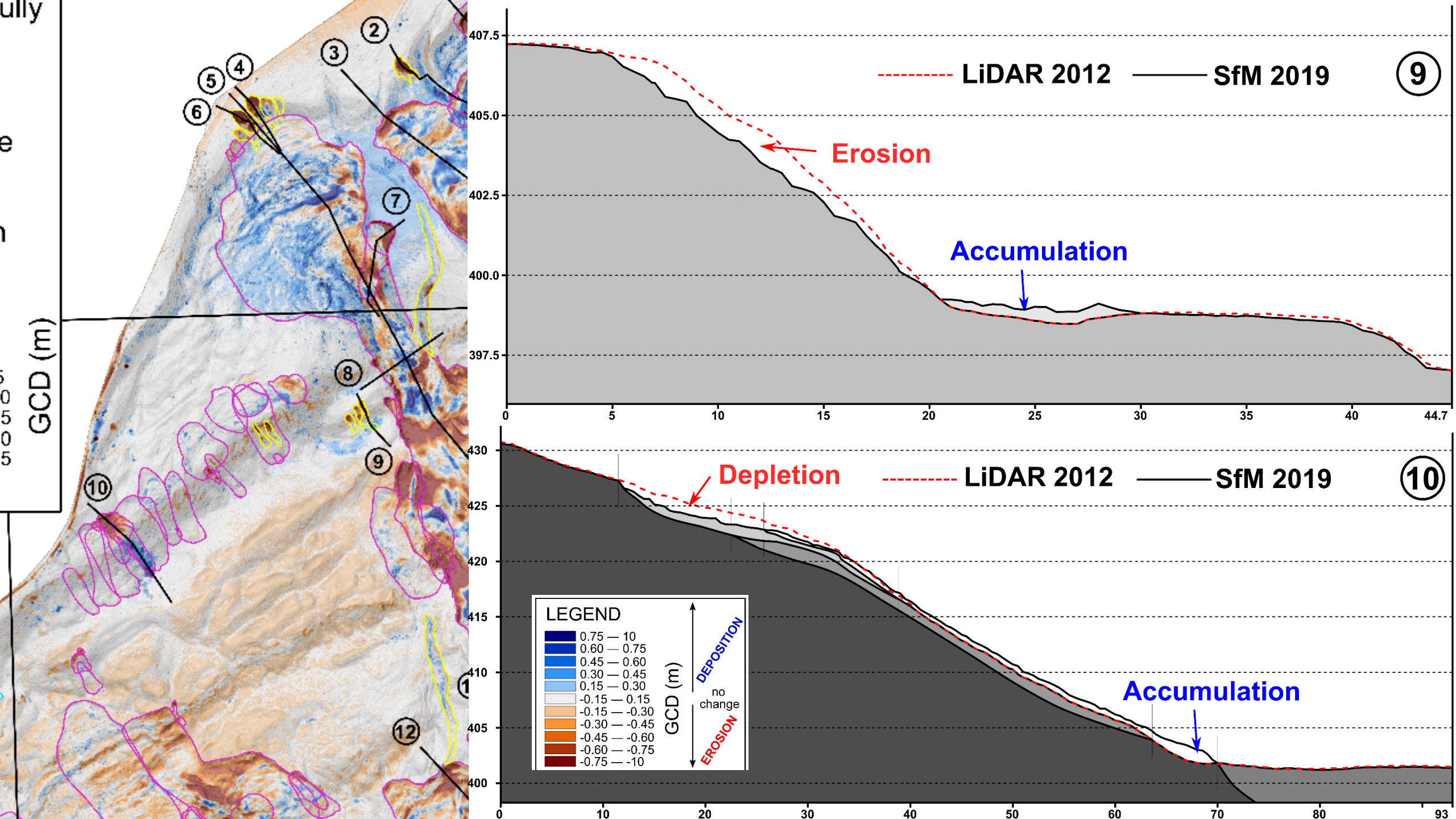
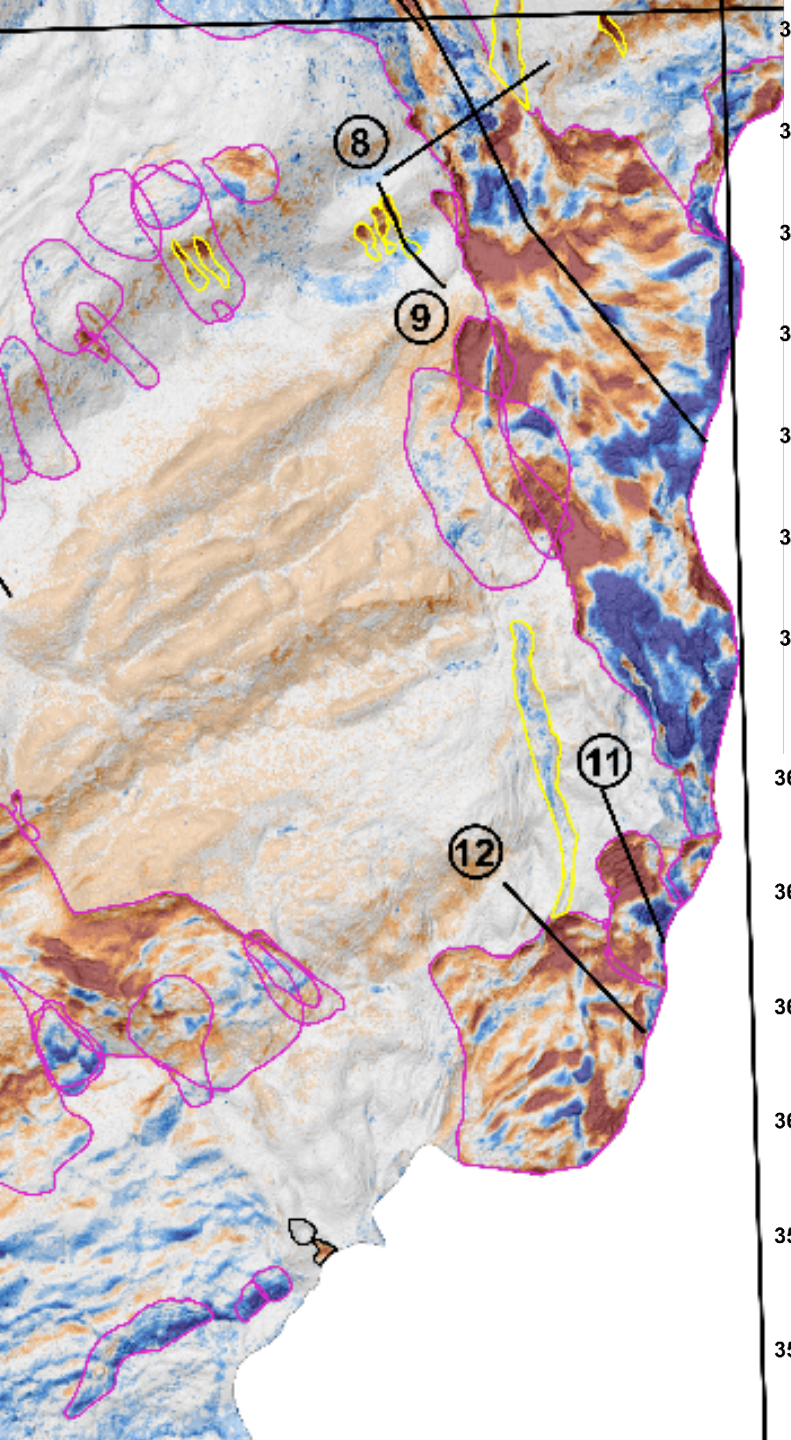
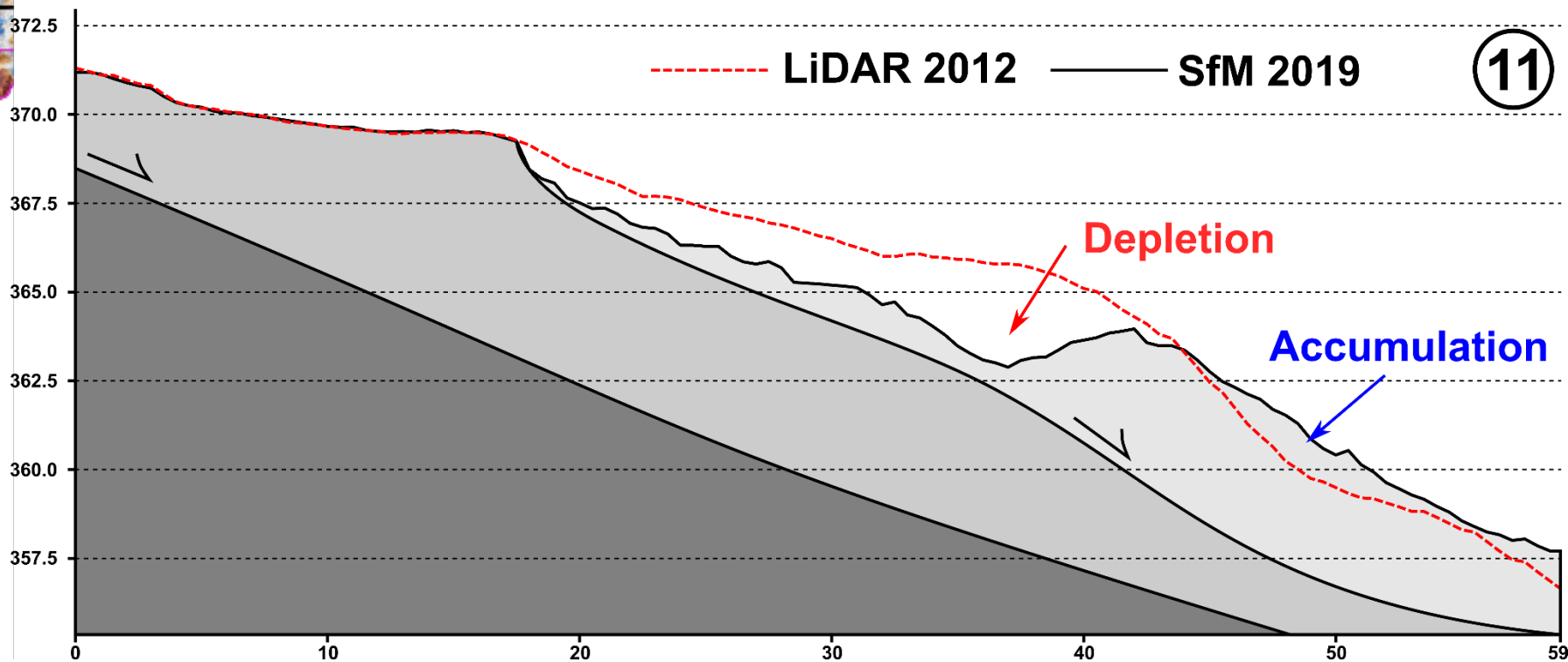
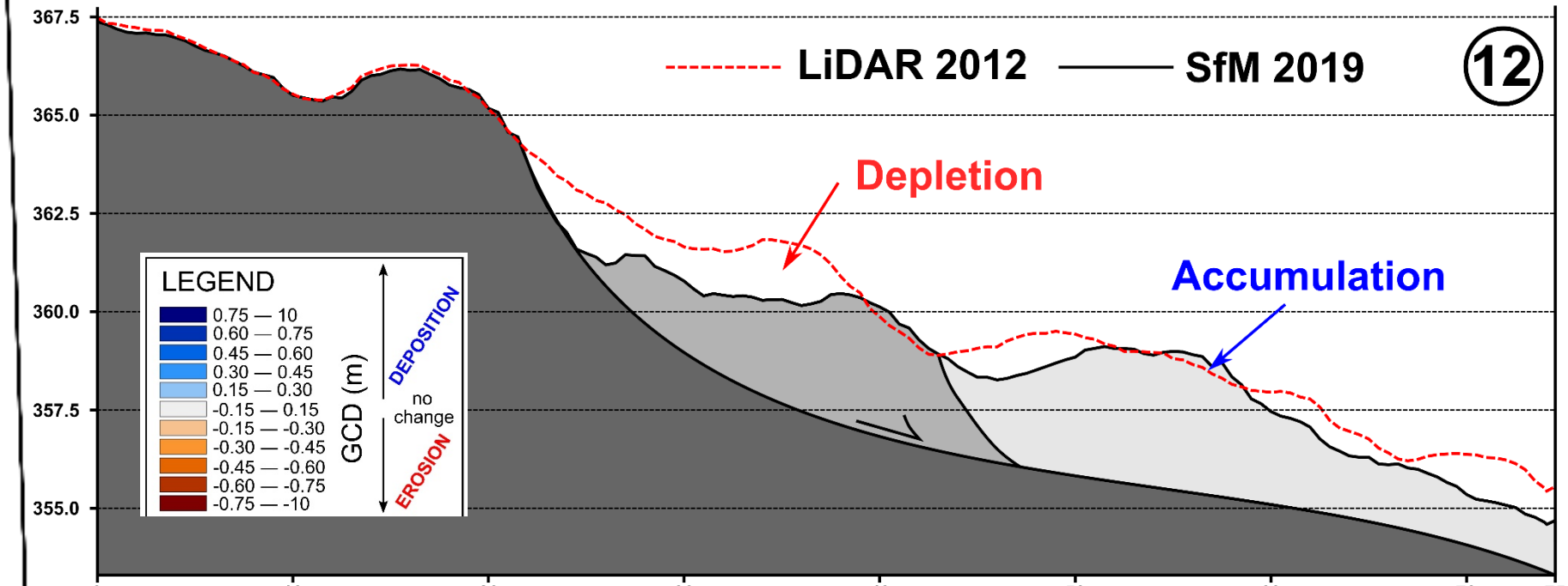
LiDAR 2012
SfM 2019
Depletion
Secondary flow
Accumulation
Main flow
427.5
425.0
422.5
420.0
417.5
415.0
412.5
410.0
0
10
20
30
40
50
60
70
82


8
LiDAR 2012
SfM 2019
Flow landslide section
Gully
410
409
408
407
406
405
404
0
10
20
30
40
50
60
71


GCD (m)
LEGEND
0.75 — 10
0.60 — 0.75
0.45 — 0.60
0.30 — 0.45
0.15 — 0.30
-0.15 — 0.15
-0.15 — -0.30
-0.30 — -0.45
-0.45 — -0.60
-0.60 — -0.75
-0.75 — -10
DEPOSITION
no change
EROSION
LiDAR 2012
SfM 2019
Erosion
Accumulation
9
Depletion
Accumulation
10


8
9
11
12


LiDAR 2012
SfM 2019
11
Depletion
Accumulation
372.5
370.0
367.5
365.0
362.5
360.0
357.5
0
10
20
30
40
50
59


LiDAR 2012
SfM 2019
12
Depletion
Accumulation
LEGEND
0.75 — 10
0.60 — 0.75
0.45 — 0.60
0.30 — 0.45
0.15 — 0.30
-0.15 — 0.15
-0.15 — -0.30
-0.30 — -0.45
-0.45 — -0.60
-0.60 — -0.75
-0.75 — -10
GCD (m)
DEPOSITION
no change
EROSION
367.5
365.0
362.5
360.0
357.5
355.0

DISCUSSIONS

- The GCD method is able to show:

- the development of existing gullies and of new gullies on the bedrock steps and landsldie scarps;

- the development of new landslide events and the evolution of suspended landslides through reactivation;

- possible very slow deformations that need to be validated through DinSAR or DGPS monitoring.

- Unfortuatelly, due to the forest cover (which limit the DEM results of the RPAS SfM), the main hillslope gully, which is triggering the basal hillslope instability cannot be fully detailed.

CONCLUSIONS

- A detailed map showing the changes in topography between 2012 and 2019 has been carried out, supplementing a geomorphological mapping.
- The most dynamic portions of the landslide are accompanied by dense micro-topographic features like secondary scarps, longitudinal and transversal cracks, which have been mapped using the ortophotoimage.
- The most dynamic parts of the hillslope are an earthflow, shallow and slumps along with the eastern gully system, piping sinkholes, and the main scarp gullies.
- The evolution of the landslides and gullies indicate that the southern part of the fortress will be affected in the near future.
- Alongside the identification of the most active parts of the landslide, we conclude that the entire recently deforested area must return as quick as possible to the initial land use (forest).

Acknowledgements

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Thank you for your attention ☺