

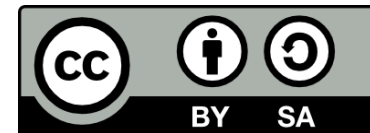
# Barrows beyond borders: how far can an Irsih model see?

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ZRC SAZU

Session 2

From Point Clouds to Patterns: Machine Learning in Landscape Archaeology

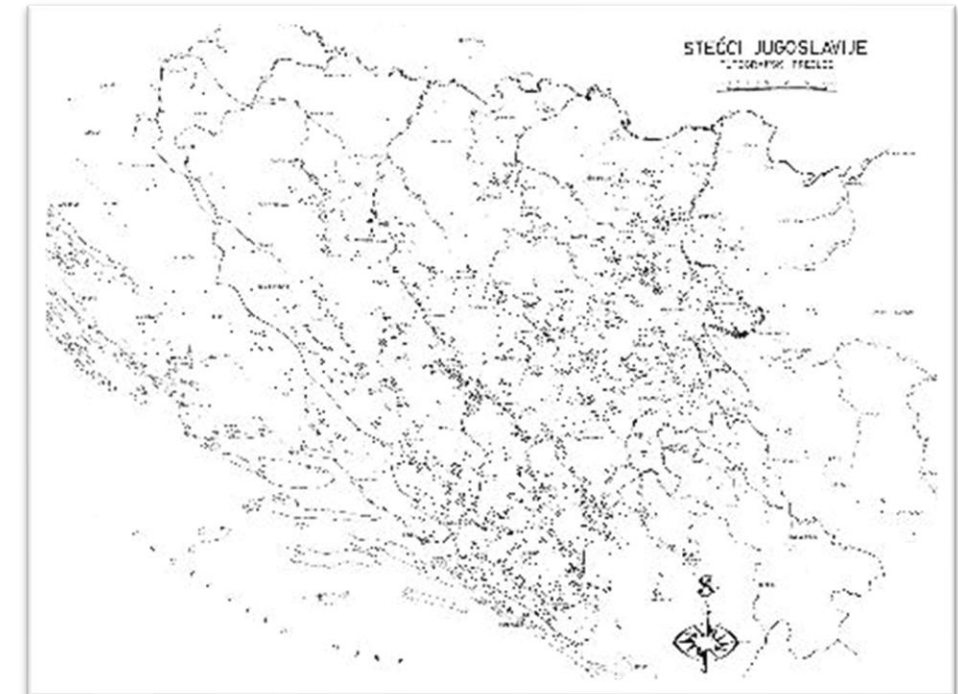
LAC 2026, Bamberg





# Project STONE

**"Unde venis?" Unravelling the enigma of the stećci tombstones (ERC)**







# Project STONE



Is it possible to use *remote sensing* data to *reliably detect* prehistoric *burial mounds* and hillforts to reconstruct the prehistoric funerary landscape?





# Project STONE

Challenges of mapping burial mounds in eastern Herzegovina

- thousands of small, densely clustered prehistoric barrows
- karstic landscape







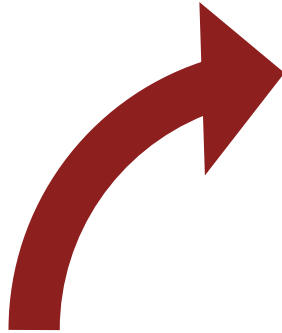
# ADAF / background

- Why machine learning?
  - **Early identification** of previously unknown or potentially significant monuments at **large scale**
- Main outcomes:
  - Standardised ML-ready data
  - Thoroughly tested (ready-to-use) ML models
  - Software for detection - ADAF
  - Python code for training/retraining





DEM



**Input data options:**

Select input file:

☒ DEM (\*.tif / \*.vrt)

☐ Visualization (\*.tif / \*.vrt)

Select file ☐ Tiles are from same dataset (create VRT)

Output folder: **not selected**

Change output folder

☐ Save visualizations

**Machine learning options:**

Select machine learning method:

☒ segmentation

☐ object detection

Select model: ADAF model

Select classes for inference:

☒ All archaeology ☐ Barrow ☐ Ringfort ☐ Enclosure

**Post-processing options:**

Select min area [m<sup>2</sup>]: 40

Select min roundness: 0.50

Roundness examples: 0.50 0.95

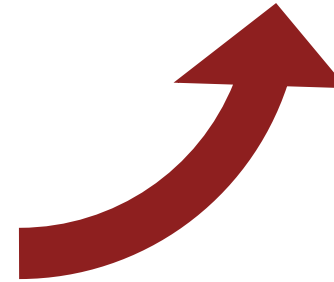
☐ Keep probability masks (raw segmentation results)

Run ADAF

# ADAF / software



Polygons



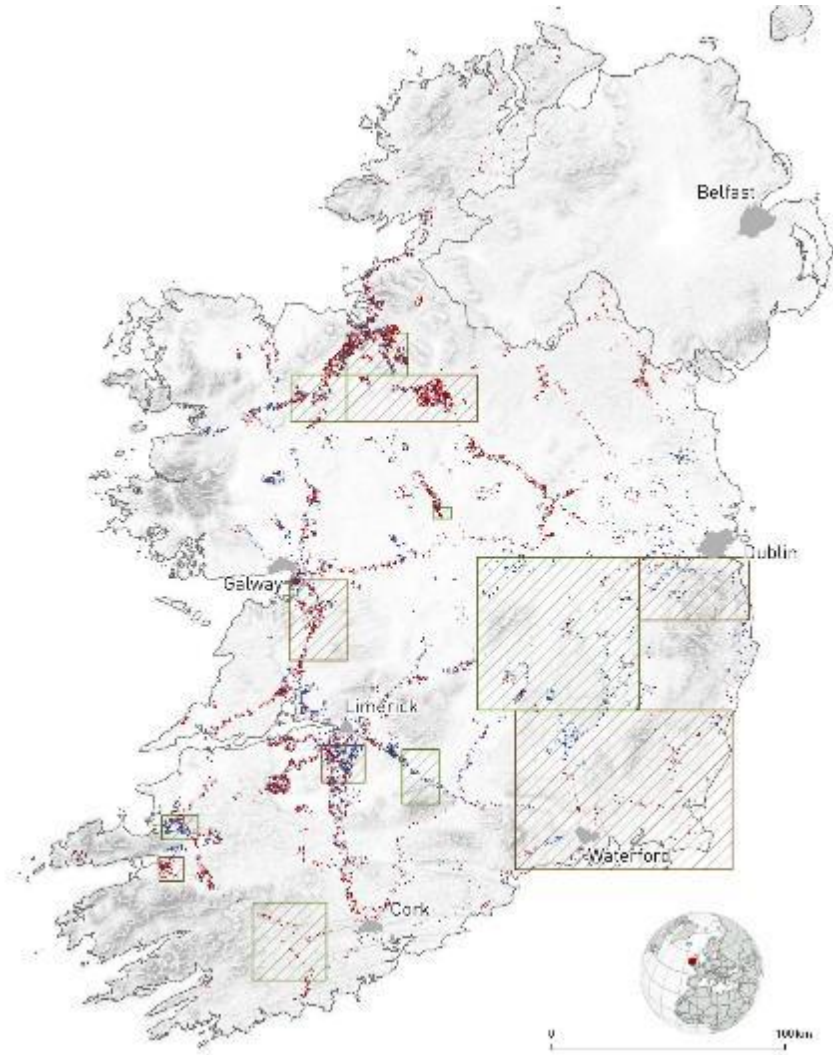
EarthObservation/adaf





# ADAF / ML model

- HRNet
- SLRM
- Expertly labelled data
- From >200 datasets
- Train : Validation : Test = 60% : 20% : 20%



training class	count
barrow	*2,461
enclosure	2,324
ringfort	5,933
<b>total</b>	<b>10,718</b>



# Barrows



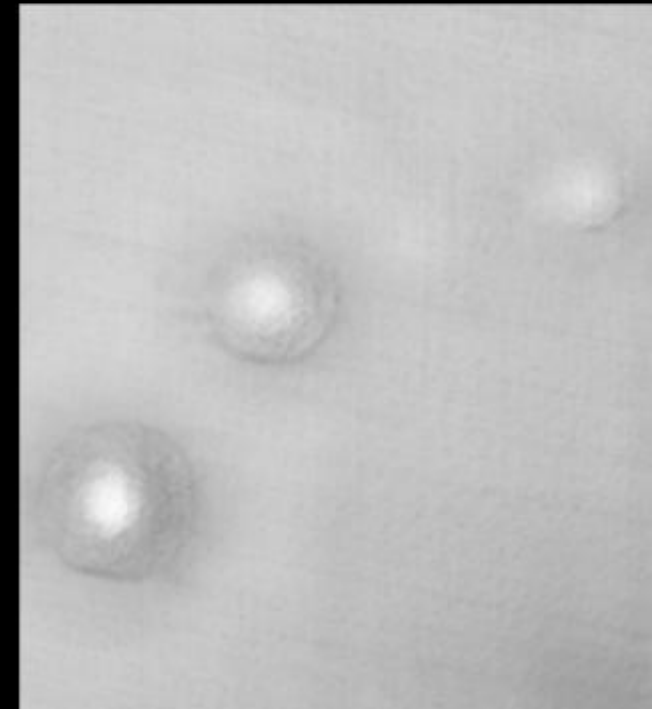
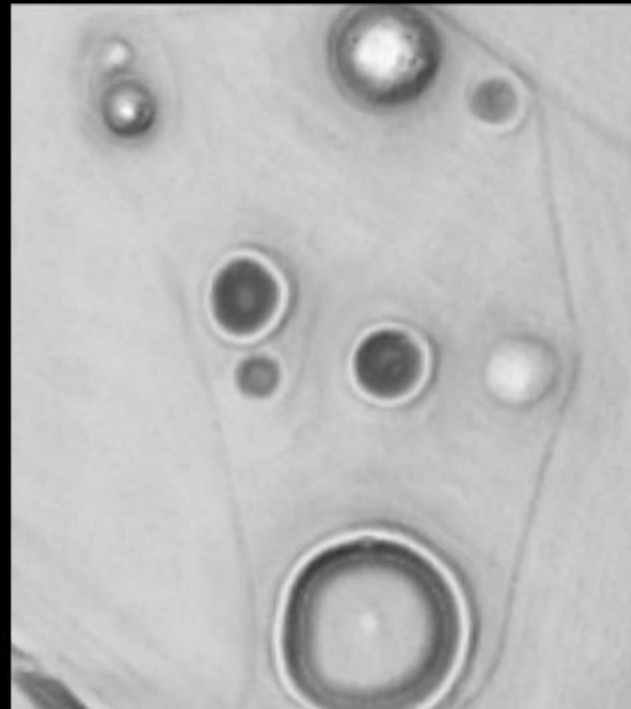
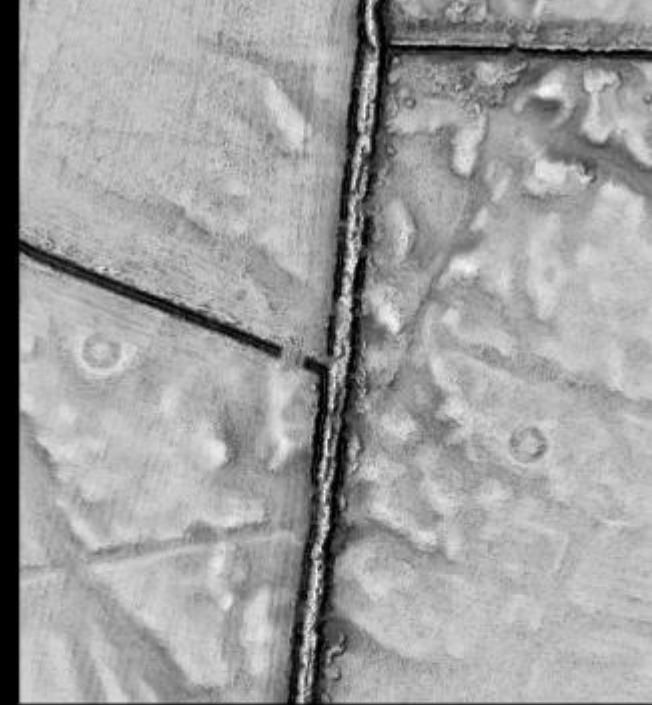
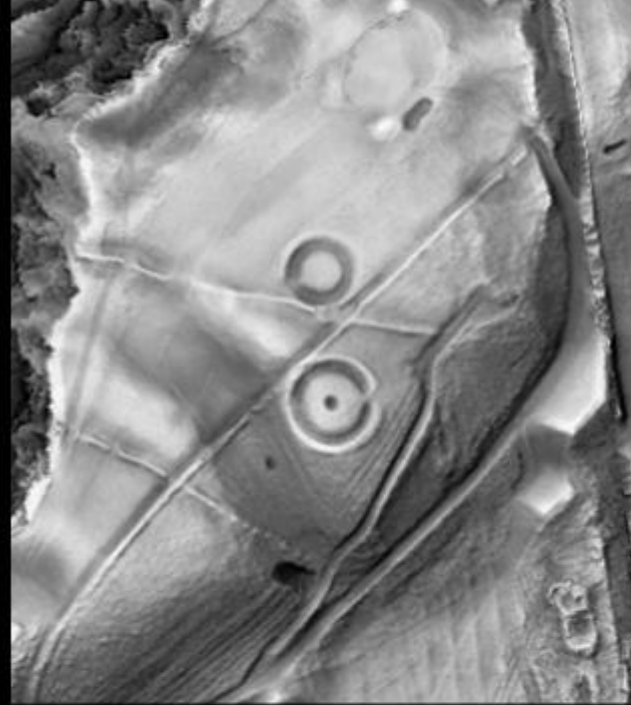
Photo: Aristodemo De Cesaris



# Barrows

- bowl-barrow
- ditch barrow
- embanked barrow
- mound barrow
- pond barrow
- ring-barrow
- stepped barrow
- unclassified

0 100 m





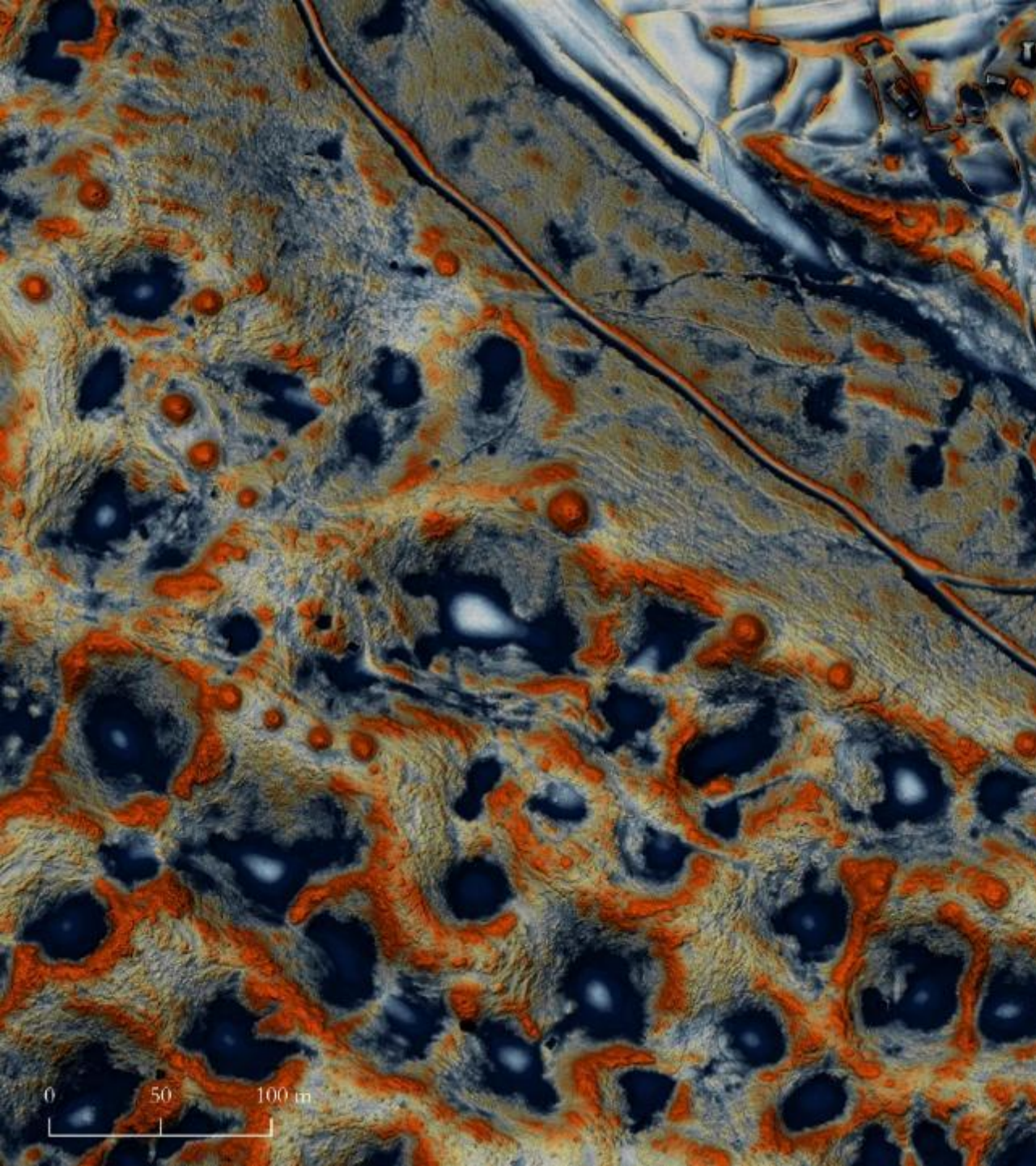


Photo: Luka Škerjanec

















# Domain adaptation

Preliminary results showed that ADAF successfully identified around half of the known burial mounds in east Herzegovina.

What can we do to make it better?



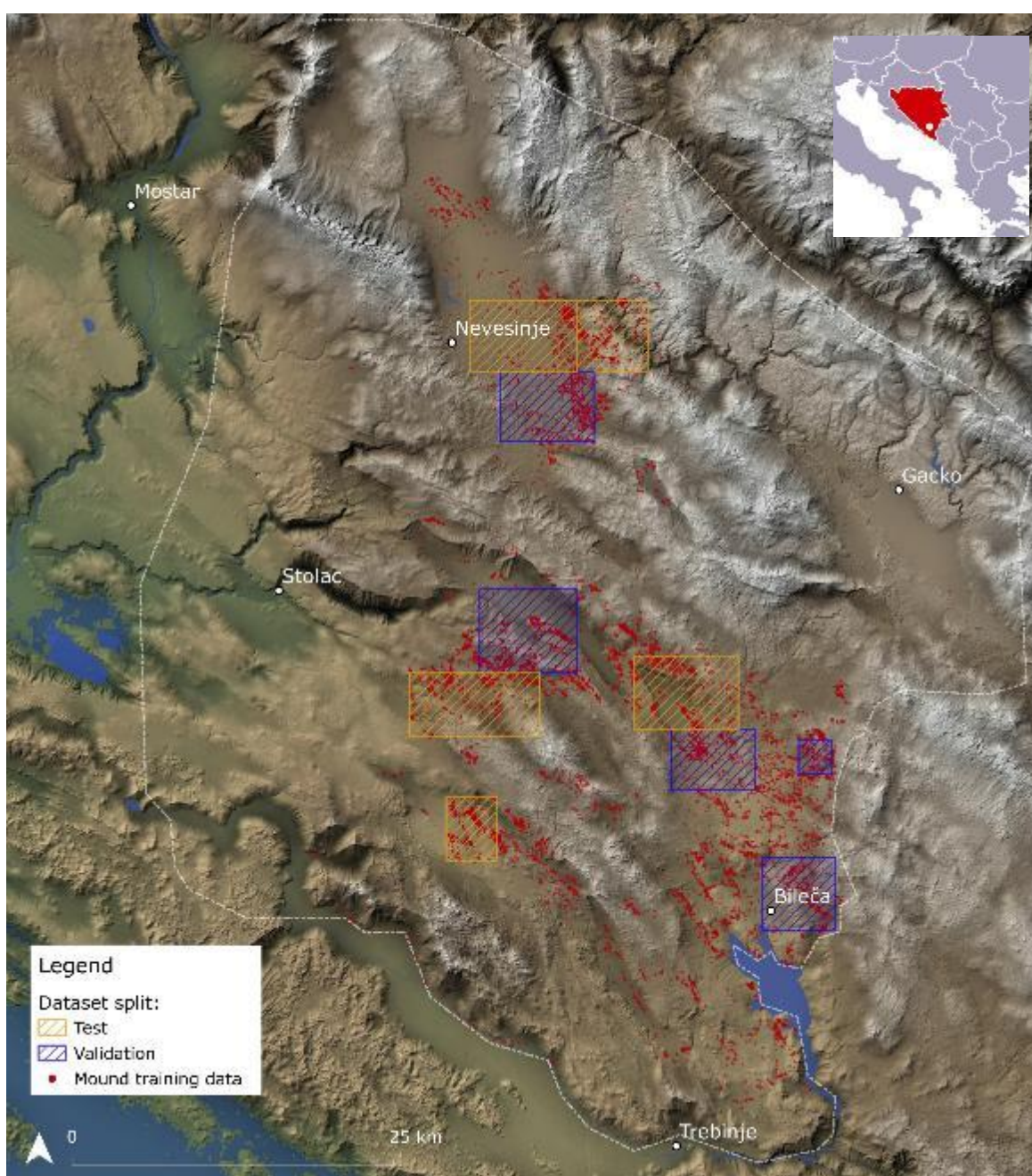
# Retraining

Training data:

- study area 4000 km<sup>2</sup>
- 8616 samples
- data split = 60/20/20

ML models:

name	domain	tile size
adaf	Ireland	512px
adaf-retrained	Ireland + BIH	512px & 256 px
stone	BIH	512px & 256 px





# Results

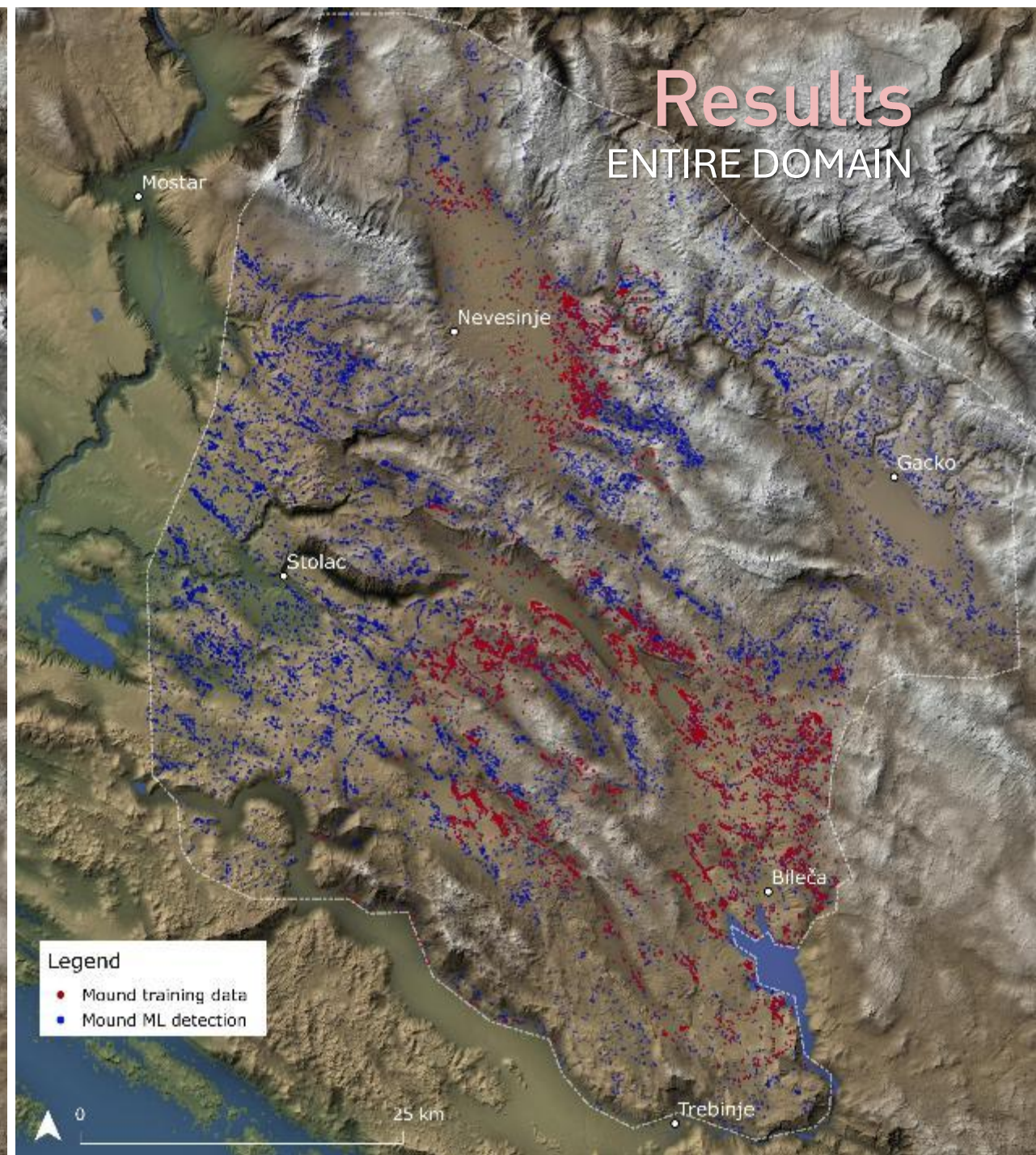
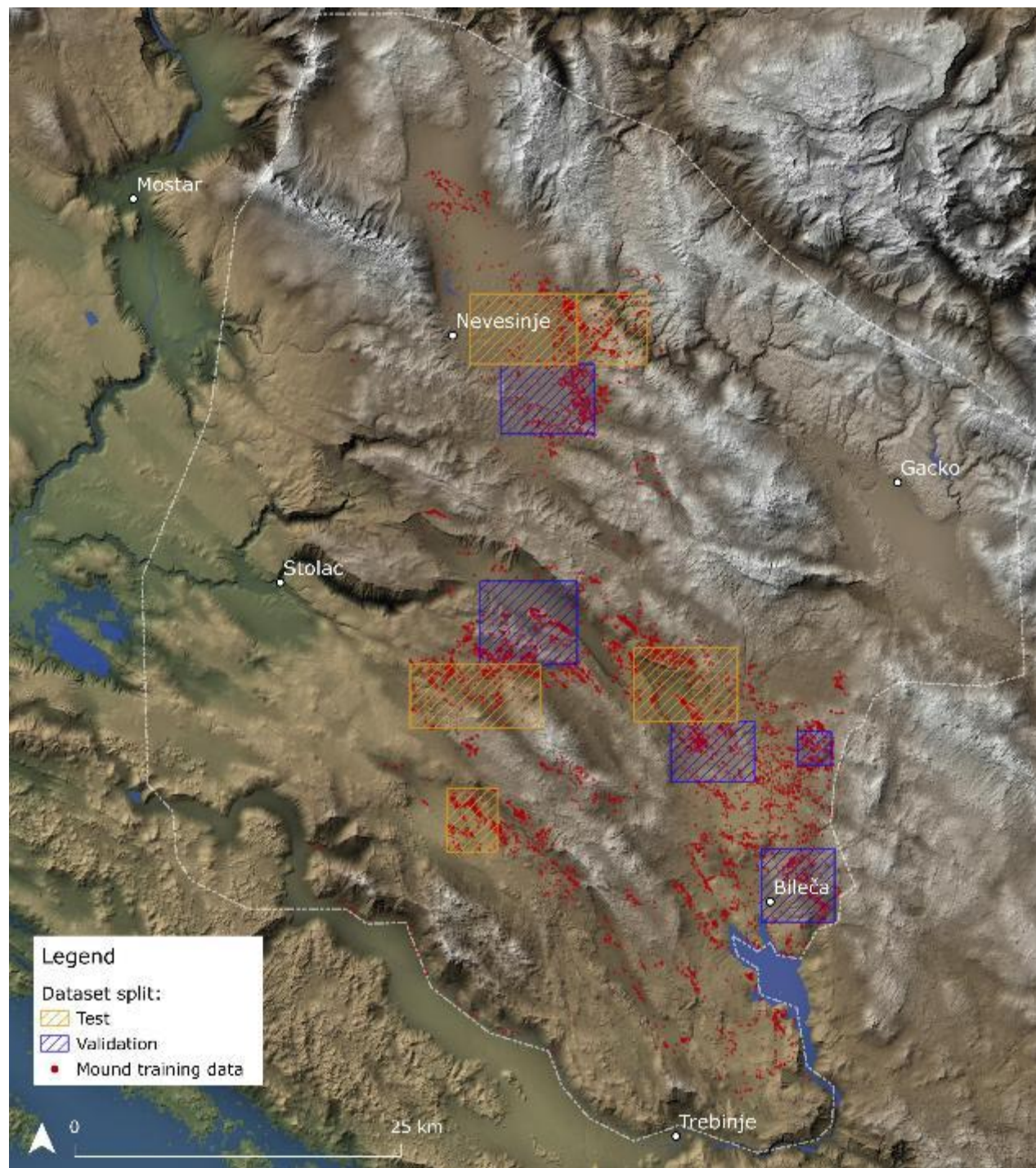
## ANALYSIS ON TEST AREA

No. of instances in reference data (RD) = 1917

experiment	tile size	detections	TP	FP	FN	% of detections		% of RD		f1	lou
						TP	FP	FN	FN		
adaf	512 px	891	742	149	1175	83%	17%	61%		0.528	0.280
adaf-retrained	512 px	1930	<b>1508</b>	422	<b>409</b>	78%	22%	<b>21%</b>		0.784	<b>0.591</b>
stone	512 px	1819	1474	<b>345</b>	443	<b>81%</b>	<b>19%</b>	23%		<b>0.789</b>	0.562
adaf-retrained	256 px	1958	1364	594	553	70%	30%	29%		0.704	0.500
stone	256 px	2060	1466	594	451	71%	29%	24%		0.737	0.507





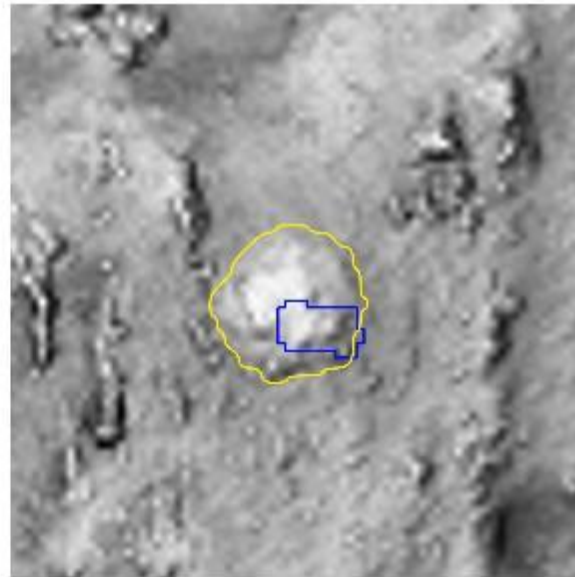
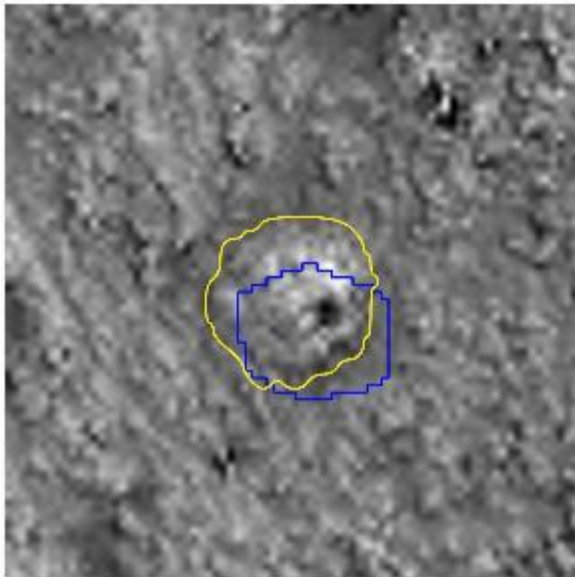
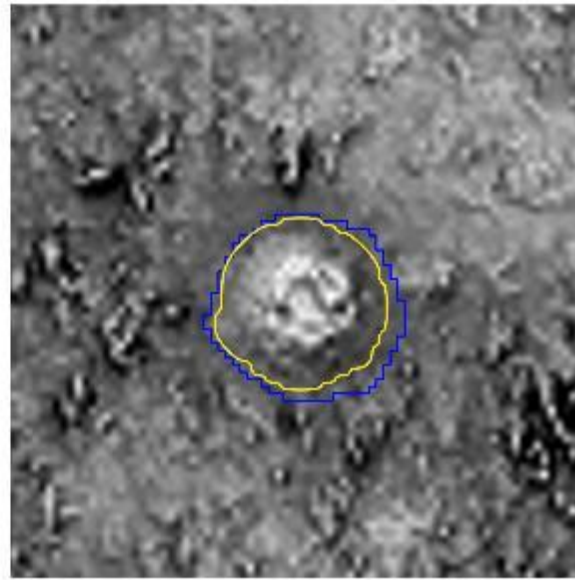
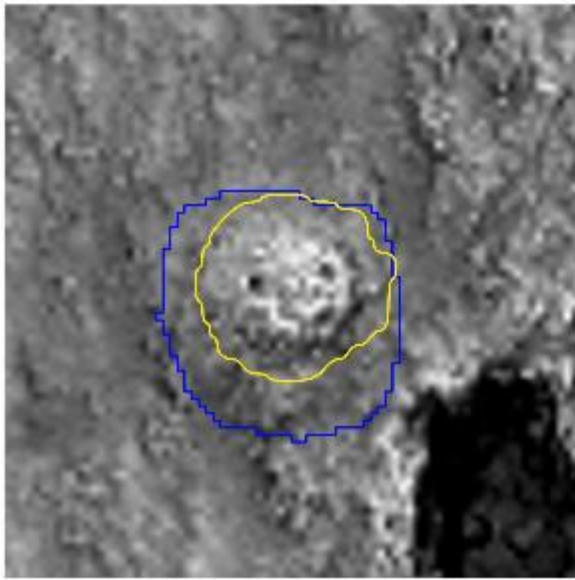




# Challenges / Discussion

Results are polygons BUT – what can we do with them?

- Luka needs better segmentation to do his analysis
- ADAF used to **localise only** – use a different method for accurate segmentation



0 25 m







# Challenges / Discussion

## What next?

Strugled to detect burial mounds on sloped terrain

- Limitation of using SLRM; a different visualisation could improve this

What about other regions?

- A long path ahead to a generalised model
- Slovenia, Croatia, ...







# Thank you for your attention!

EarthObservation/adaf



Photo: Luka Škerjanec