FACULTY OF SCIENCES

geography department Ghent University

From Forest Monitoring to Cultural Heritage:

Reanalyzing LiDAR Data with Deep Learning to Map Ancient Structures in Yucatan, Mexico

Rune Van Severen, Jana Ameye, Mario Hernandez, Tim Van de Voorde

belspo

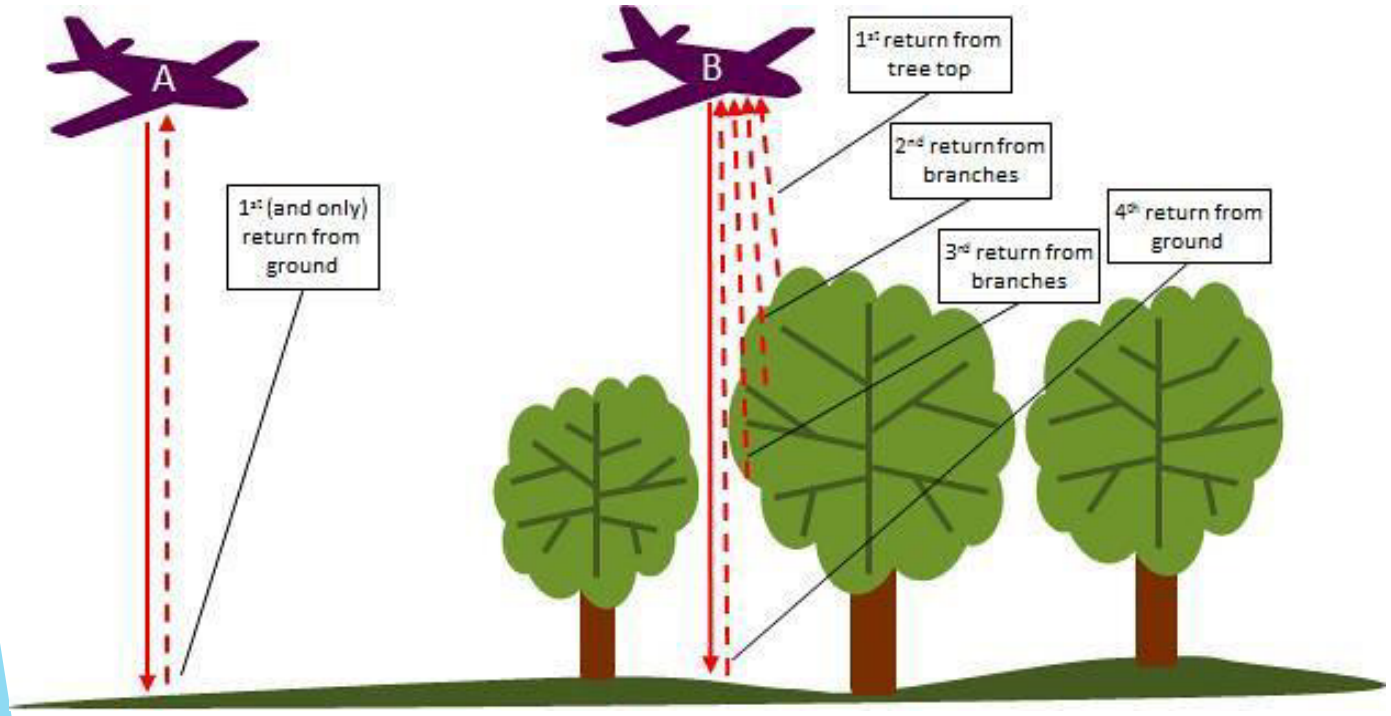
Funded by Belgian Science Policy Office (BELSPO SR/02/212).

Objective

Investigate the applicability of deep learning models, particularly Mask R-CNN, for detecting and segmenting archaeological structures based on airborne LiDAR data in the Puuc region of Yucatan, Mexico.

Studiegebied, Puuc-regio, Yucatan, Mexico

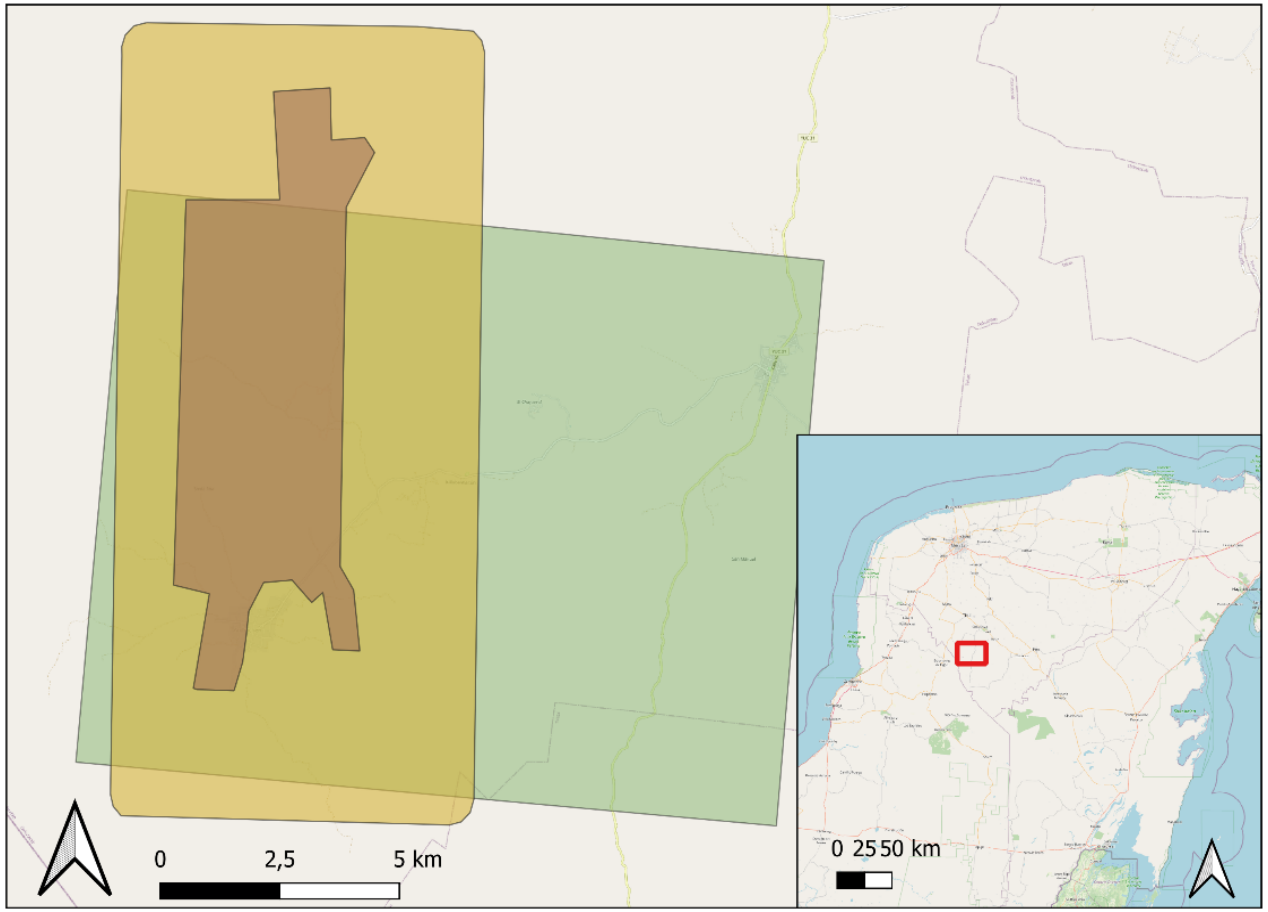
LiDAR data



LIDAR

- Active Sensor
- Provides 3D point clouds
- Detailed 3D information (DTM/DSM/CHM)
- Penetrates forest canopies

LiDAR data



De Alianza en G-LiHT data is airborne lidar data afkomstig van het México REDD+ en NASA's Goddard's Lidar, Hyperspectral and Thermal Imager.
De Pléaides, hoge resolutie satellietbeelden zijn afkomstig van Airbus Defence and Space.

Kaart gemaakt door Rune Van Severen via QGIS 3.16

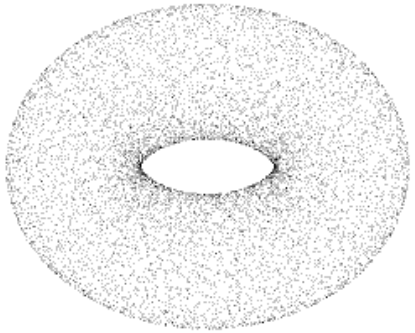
LIDAR

- AlianzaRedd+ LiDAR data
- Woodwell Climate Center
- Funded by USAID (Cartodata)
- 29/03/14 – 22/4/14
- 175km² - 8p/m² - >100Gb

OTHER DATA

- G-LiHT Data (NASA)
  - April/May 2013
- Pléiades Tri-stereo data
  - 15/01/2022

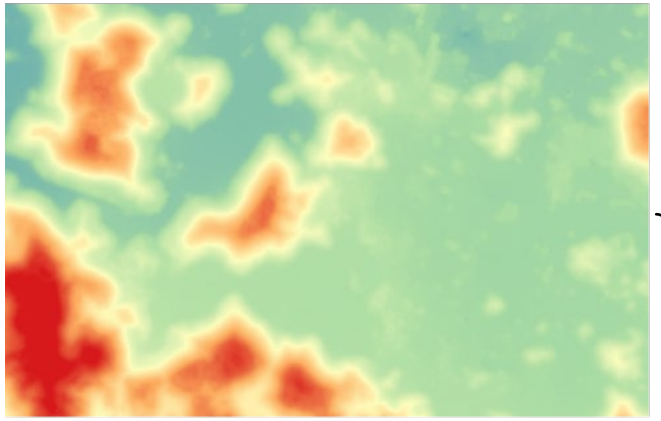
METHODS



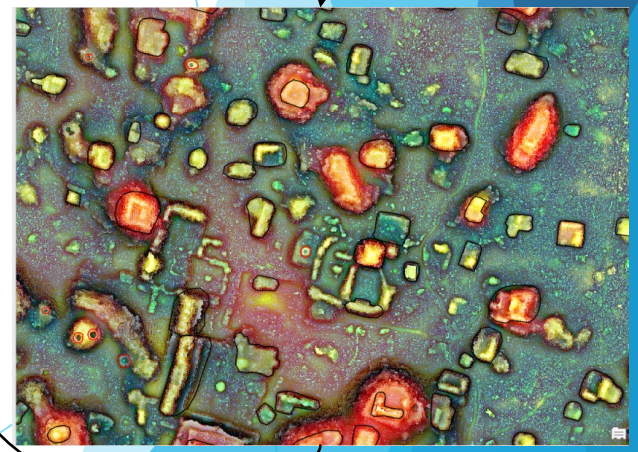
LIDAR POINT CLOUD

PREPROCESSING
CLASSIFICATION
GROUND/NON-GROUND

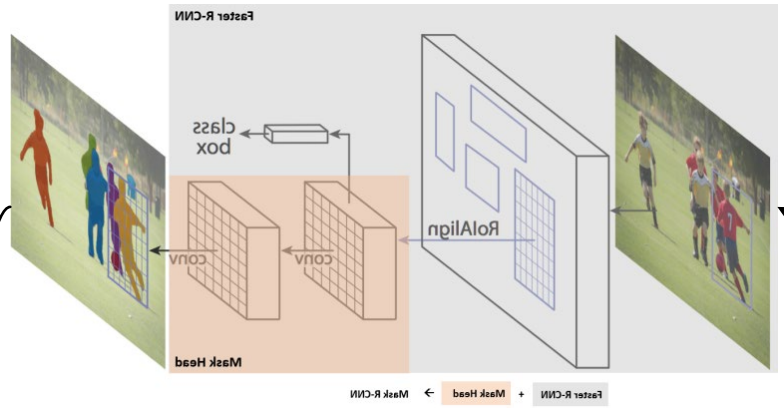
GENERATE DTM



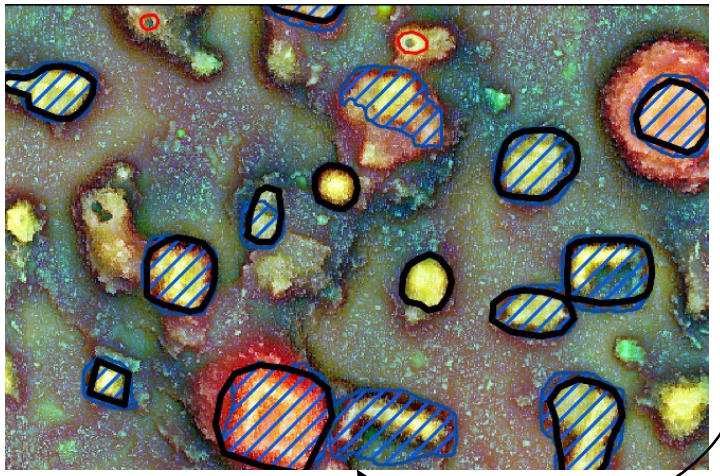
TERRAIN VISUALISATIONS



VISUAL SAMPLING



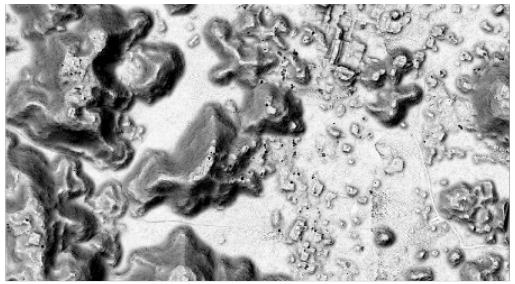
MASK-R CNN



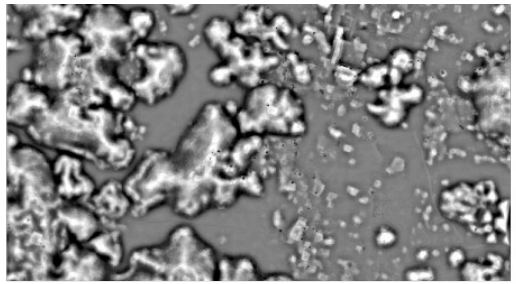
OBJECT INSTANCE SEGMENTATION

ACCURACY ASSESSMENT

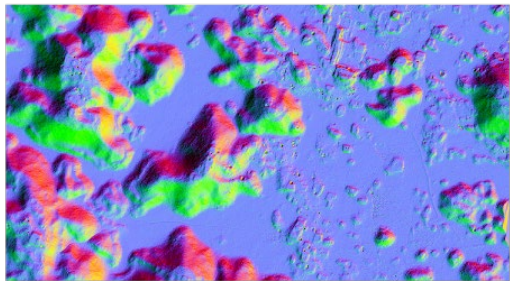
Enhanced v3 Multi-scale topographic position (e3MSTP)



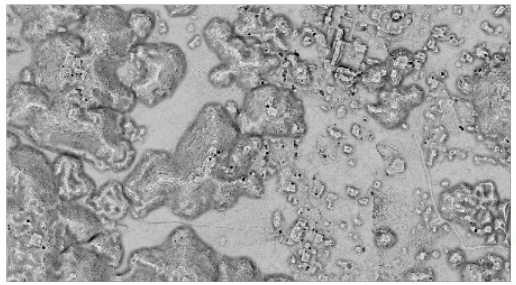
Sky view factor



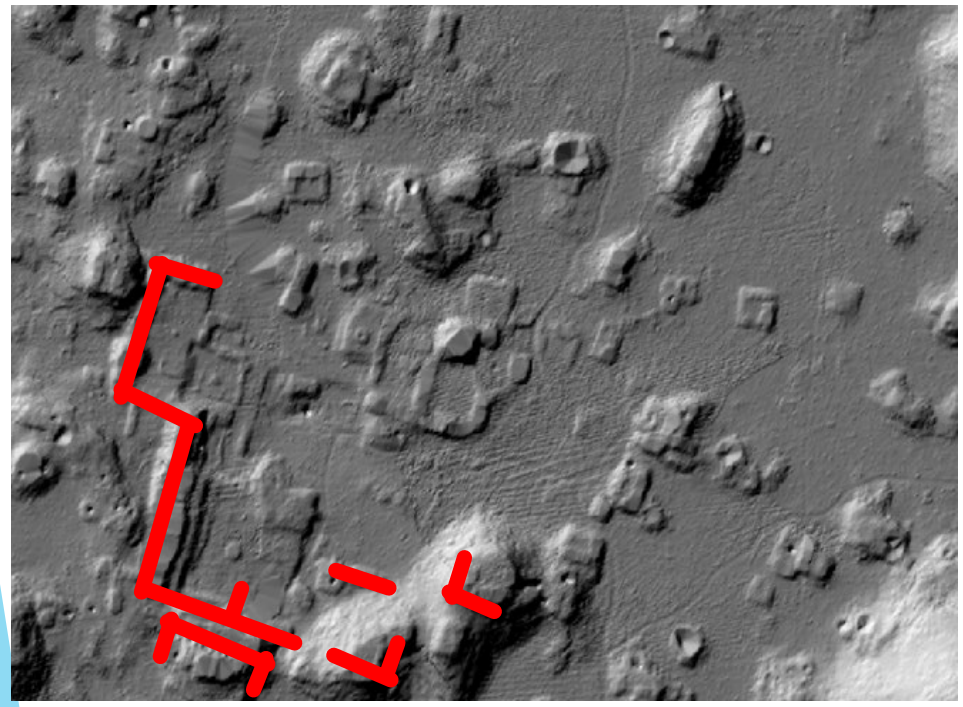
Simple local relief model

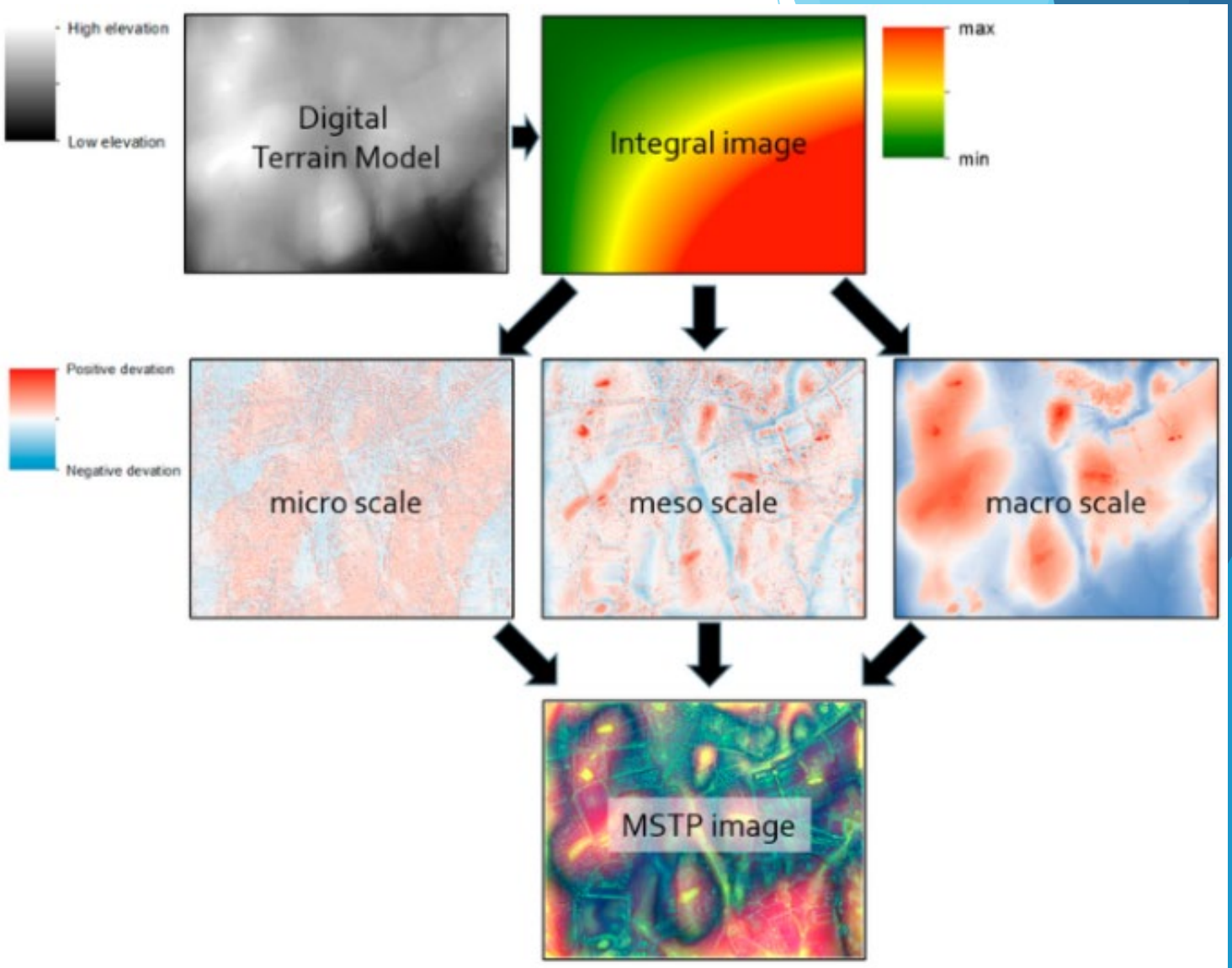


PCA of hillshading



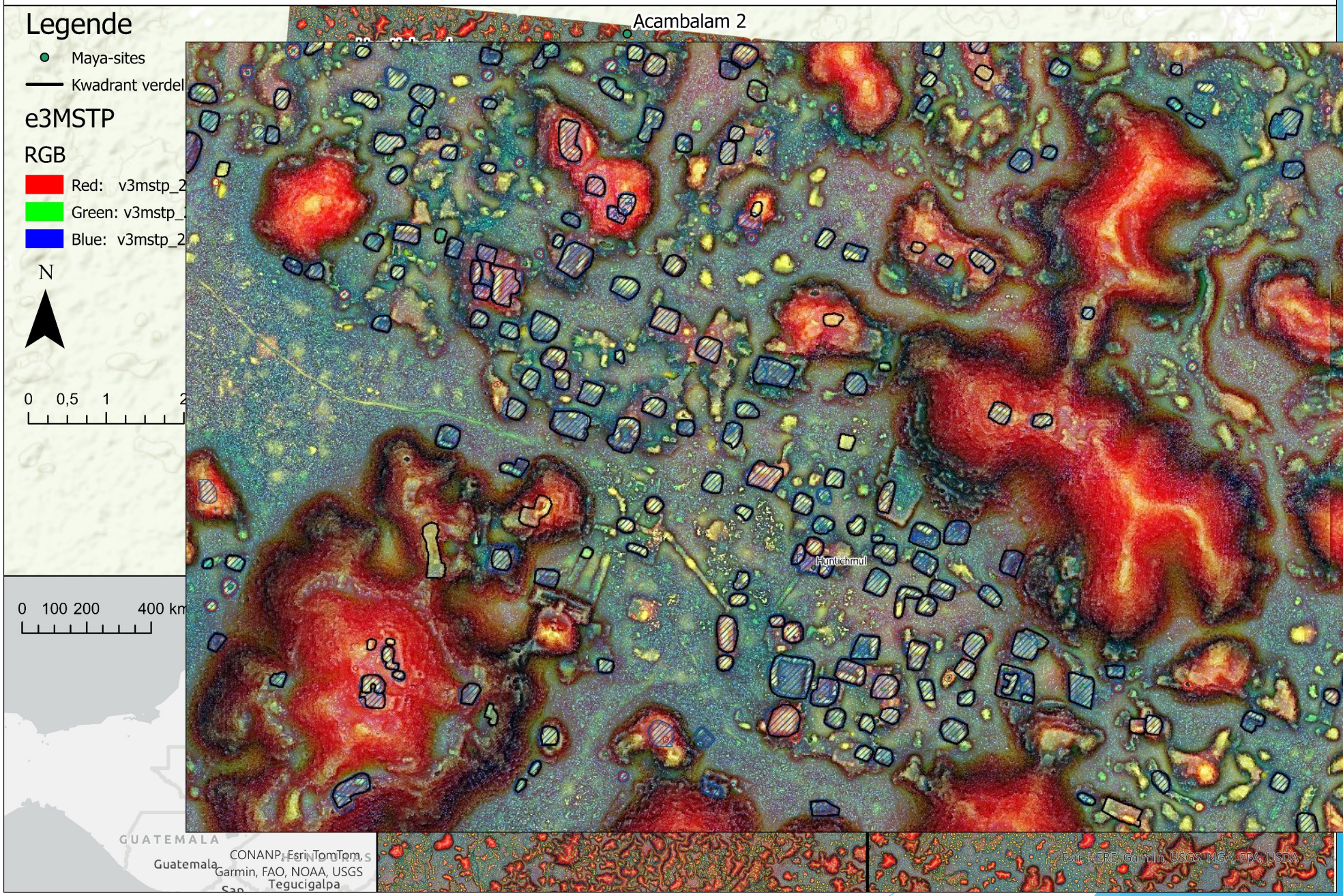
Positive openess

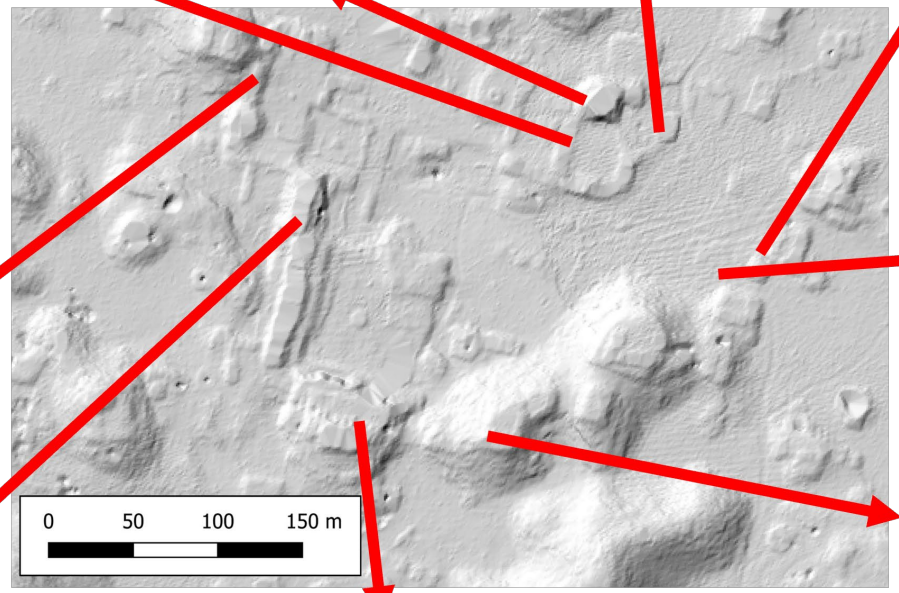




Adapted from "Combined detection and segmentation of archaeological structures from LiDAR data using a deep learning approach," door A. Guyot, M. Lennon, T. Lorho, & L. Hubert-Moy, (2021), Journal of Computer Applications in Archaeology, 4(1), p. 1. DOI: 10.5334/jcaa.64

e3MSTP van het studiegebied verdeelt in 4 kwadranten




0
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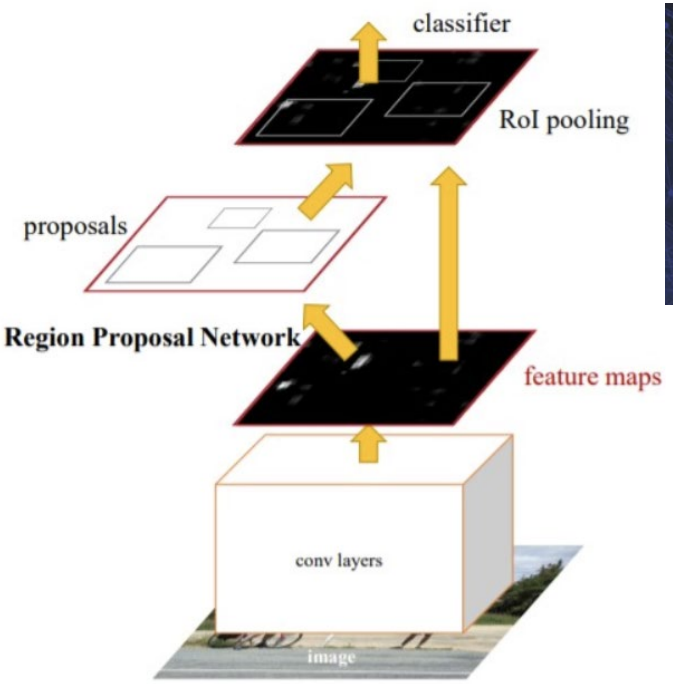
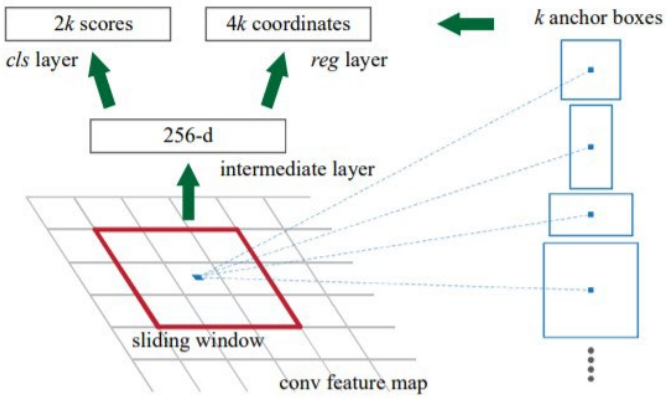
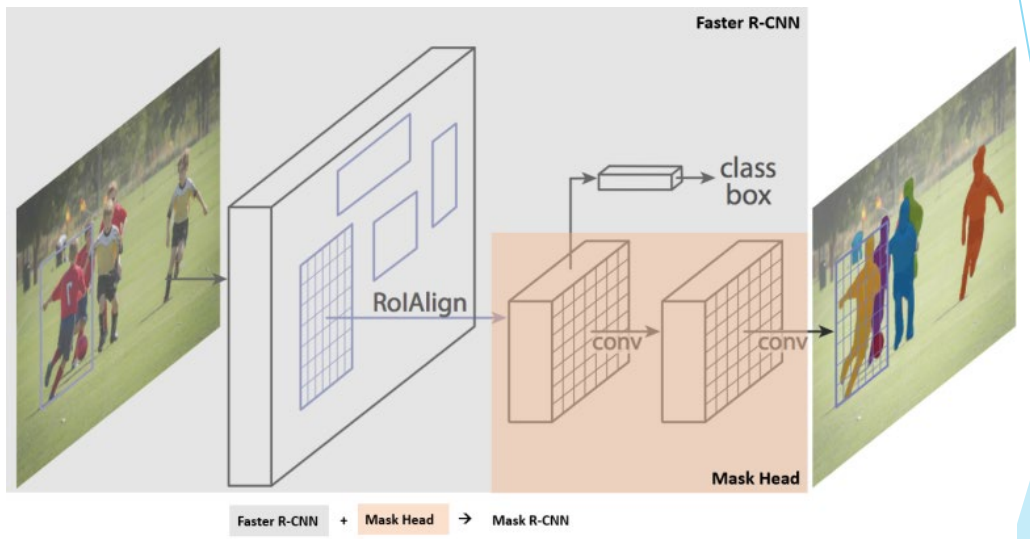



```
pc.fit(epochs=100, lr=myLR, early_stopping=True)
```

74.00% [74/100 1:48:40<38:10]

epoch	train_loss	valid_loss	average_precision	time
0	2.939283	2.338507	0.144679	01:51
1	2.139708	1.730215	0.322651	01:45
2	1.726137	1.465050	0.342089	01:32



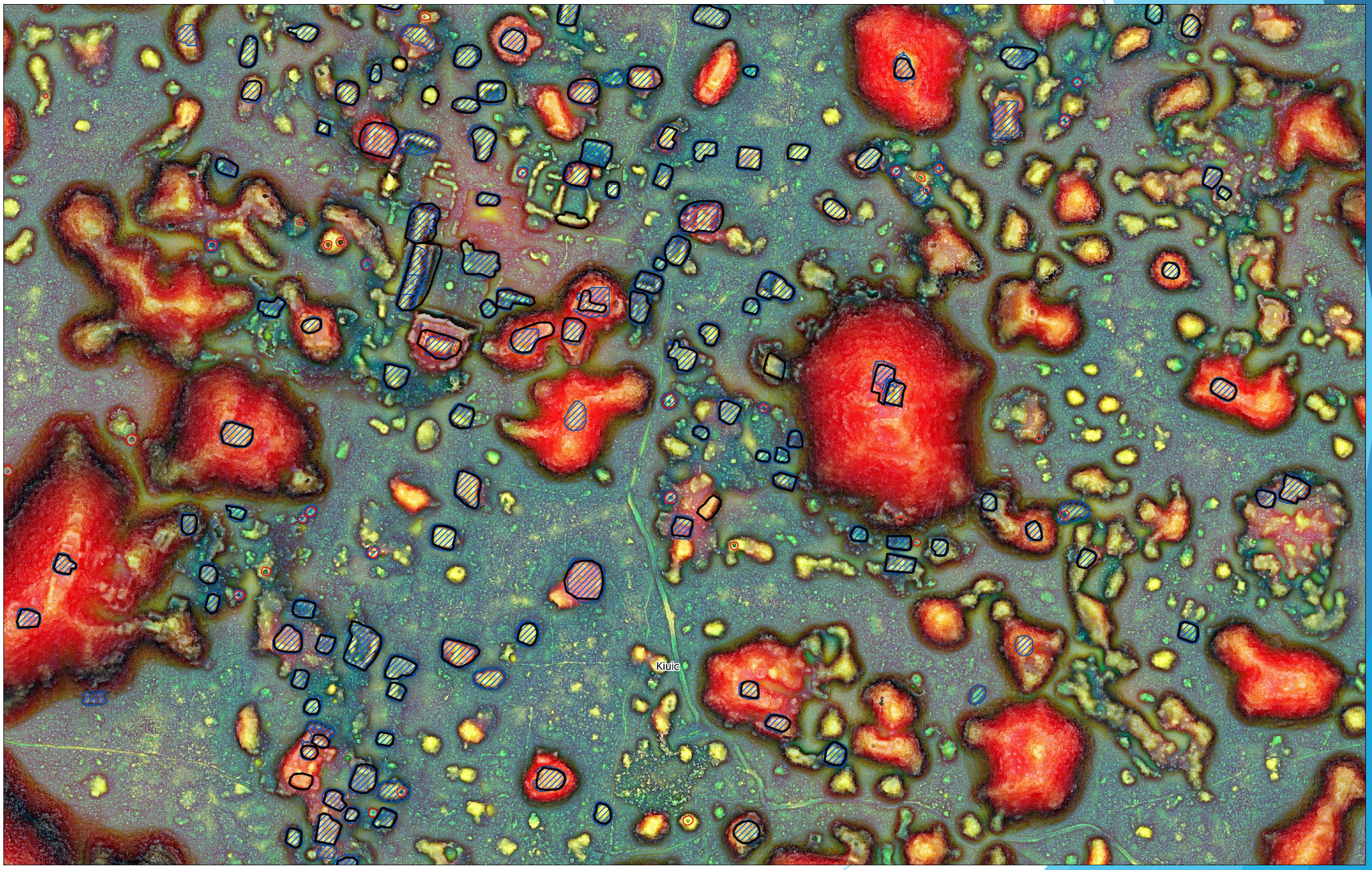


MASK-R CNN ➔ Object instance segmentation

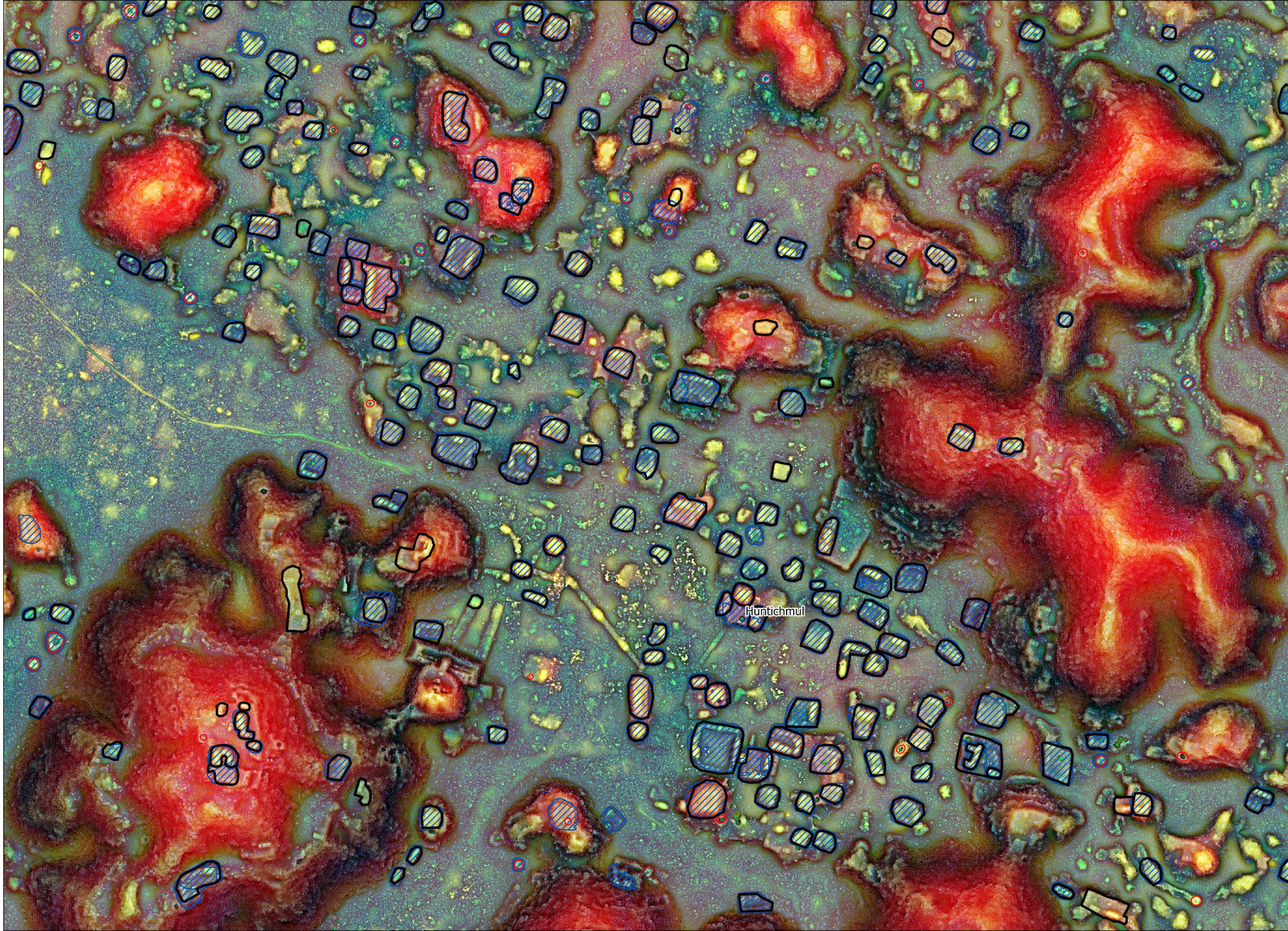
Adapted from "Faster R-CNN Object Detector | ArcGIS API for Python," (z.d.). Geraadpleegd via https://developers.arcgis.com/python/guide/faster-rcnn-object-detector/

Results

KIUIC



HUNTICHMUL



- 6 → Buildings: good balance between precision and recall
- 1 → Ring-shaped structures: High precision but lower recall

IoU >= 0,3000

IoU >= 0,3000	Precision	Recall	F1 Score	AP	True Positive	False Positive	False Negative
All Classes	0,6696	0,8343	0,7430	0,6269	685,0000	338,0000	136,0000
6	0,6386	0,9213	0,7544	0,6731	585,0000	331,0000	50,0000
1	0,9346	0,5376	0,6826	0,5025	100,0000	7,0000	86,0000

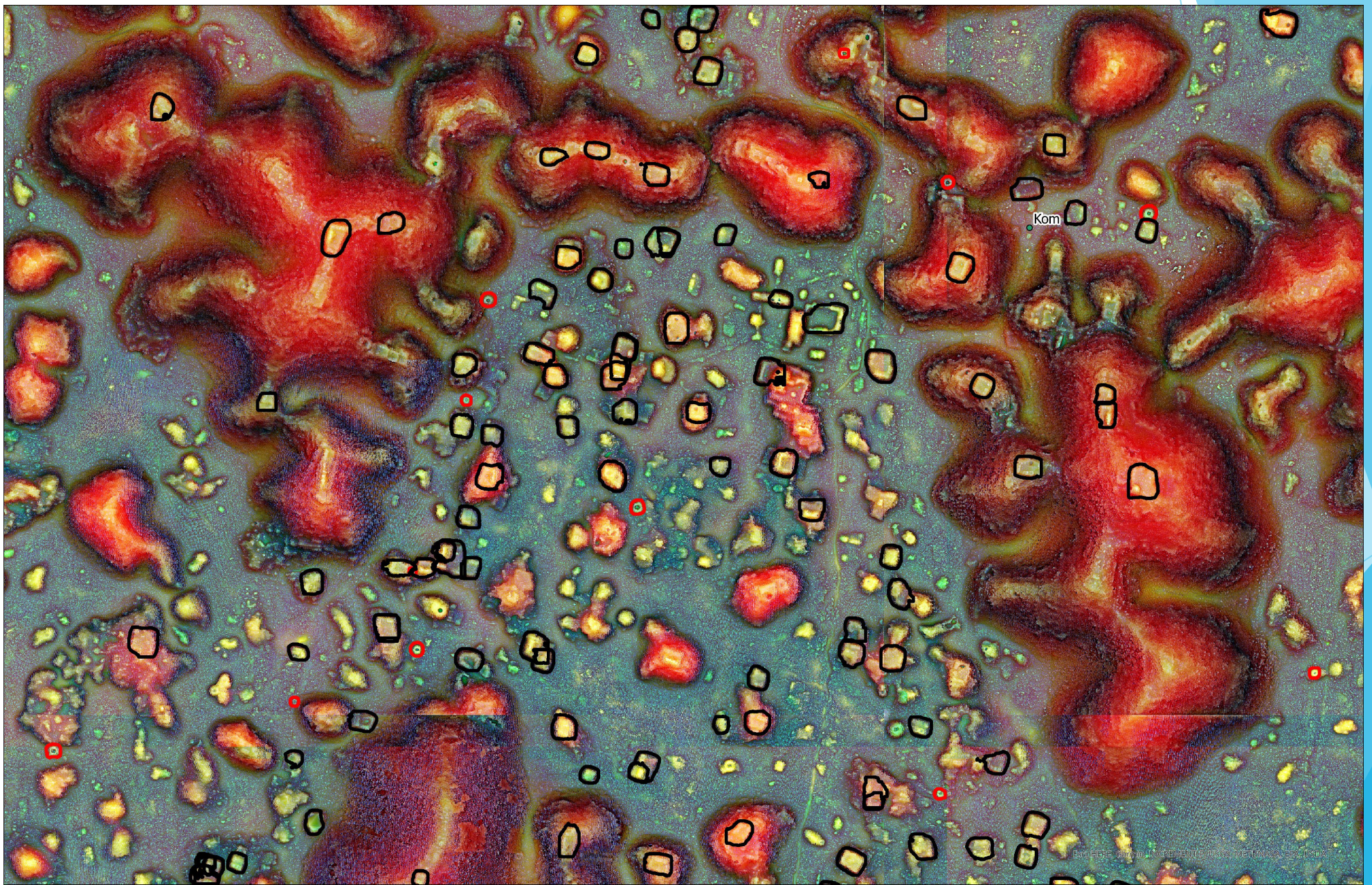
- Post-processing

IoU >= 0,3000

IoU >= 0,3000	Precision	Recall	F1 Score	AP	True Positive	False Positive	False Negative
All Classes	0,7167	0,8343	0,7711	0,6559	683,0000	270,0000	136,0000
6	0,6891	0,9213	0,7885	0,7082	583,0000	263,0000	50,0000
1	0,9346	0,5376	0,6826	0,5025	100,0000	7,0000	86,0000

Segmentation in “Unseen” Areas

KOM site



GROUND TRUTH MANUALLY ANNOTATED → OBJECTIVE METHODS

EXPAND THE TRAINING DATASET FOR BETTER MODEL TRAINING

TEST DATASET

EXPLORE MORE DEEP LEARNING ARCHITECTURES AND BACKBONES

Buildings

- Good balance between precision and recall
- Robust for building segmentation

Ring-shaped structures

- High precision, low recall
- Model is cautious, few mistakes but many missed positives

Evaluation and Optimization

- Current approach effective for identifying archaeological structures
- Further optimization needed to increase recall of ring-shaped structures

Key Insights

- Accelerates the discovery and analysis of archaeological sites hidden under dense vegetation
- Enhanced techniques for cultural heritage preservation