An aerial photograph of a dense urban landscape, likely in the Netherlands, showing a complex network of streets, buildings, and a winding river. The terrain is a mix of urban development and agricultural fields. The text is overlaid on the upper left portion of the image.

**How to build a dense geospecific urban
VBS2 terrain of 250 km²
in just a few clicks...**

**Frido Kuijper
TNO
The Netherlands**

An aerial photograph of a rural landscape, likely in the Netherlands, showing a dense network of roads and fields. A prominent river or canal winds through the lower right portion of the image. The terrain appears flat with a mix of agricultural fields and some built-up areas.

Automated Terrain Extraction from Aerial Imagery A Case Study

**Frido Kuijper
TNO
The Netherlands**



Police Training Mission Dutch MoD



MoD requirement

VBS2 terrain database
for mission training support

5000 km² terrain with 250 km² detailed urban inset





Workflow

› 20 cm aerial imagery with derived DSM

source
data



(courtesy German MoD / DLR)



Workflow

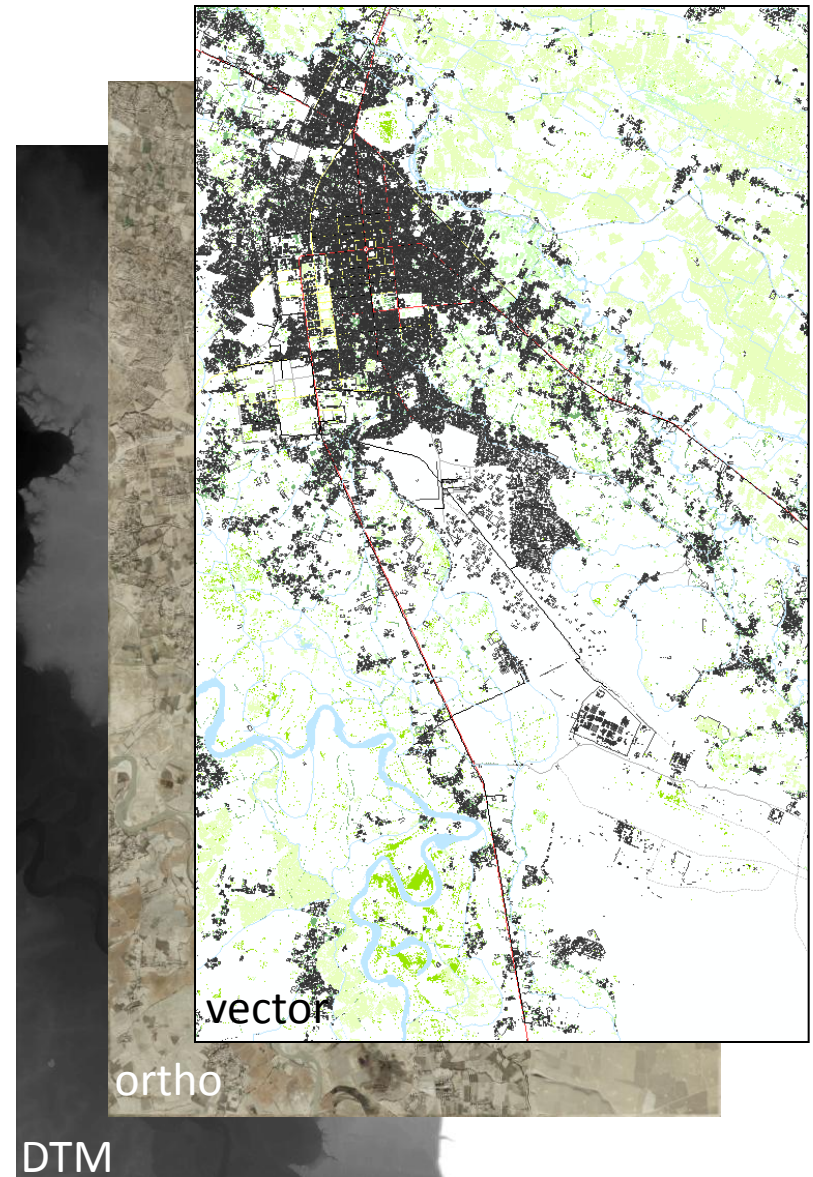
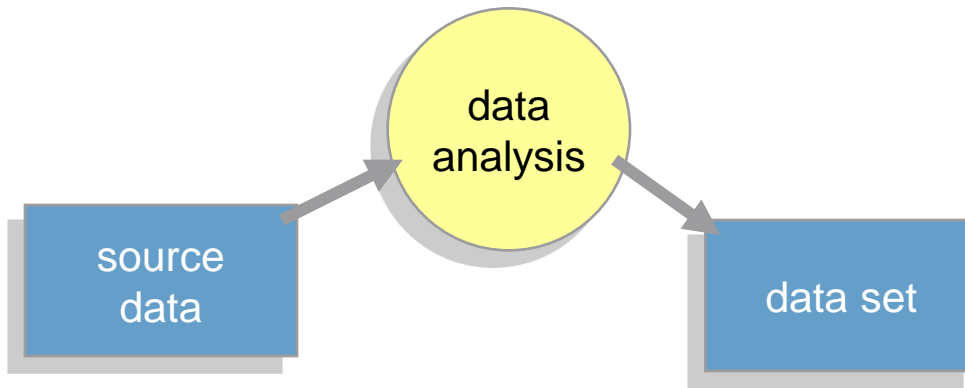
› Ground imagery for landmarks

source
data





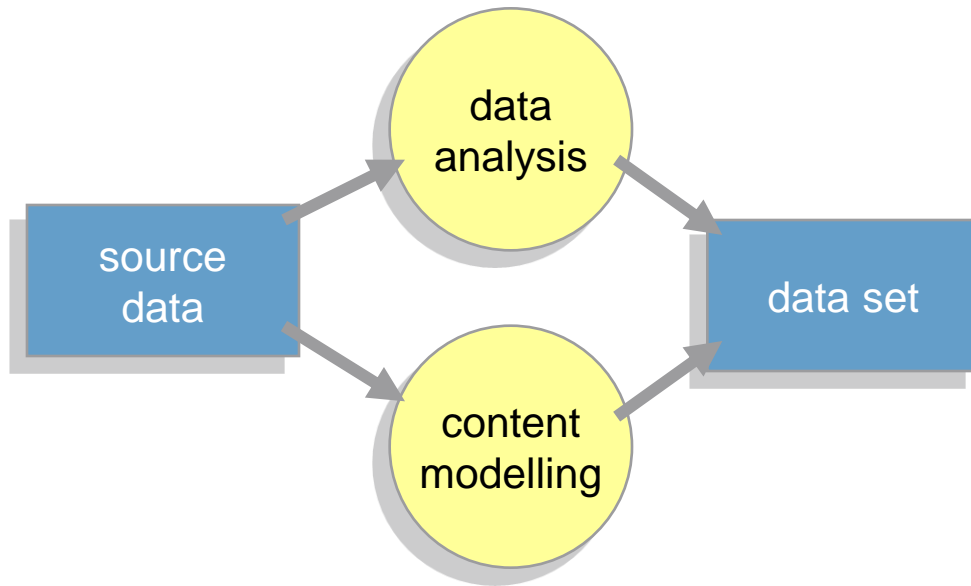
Workflow





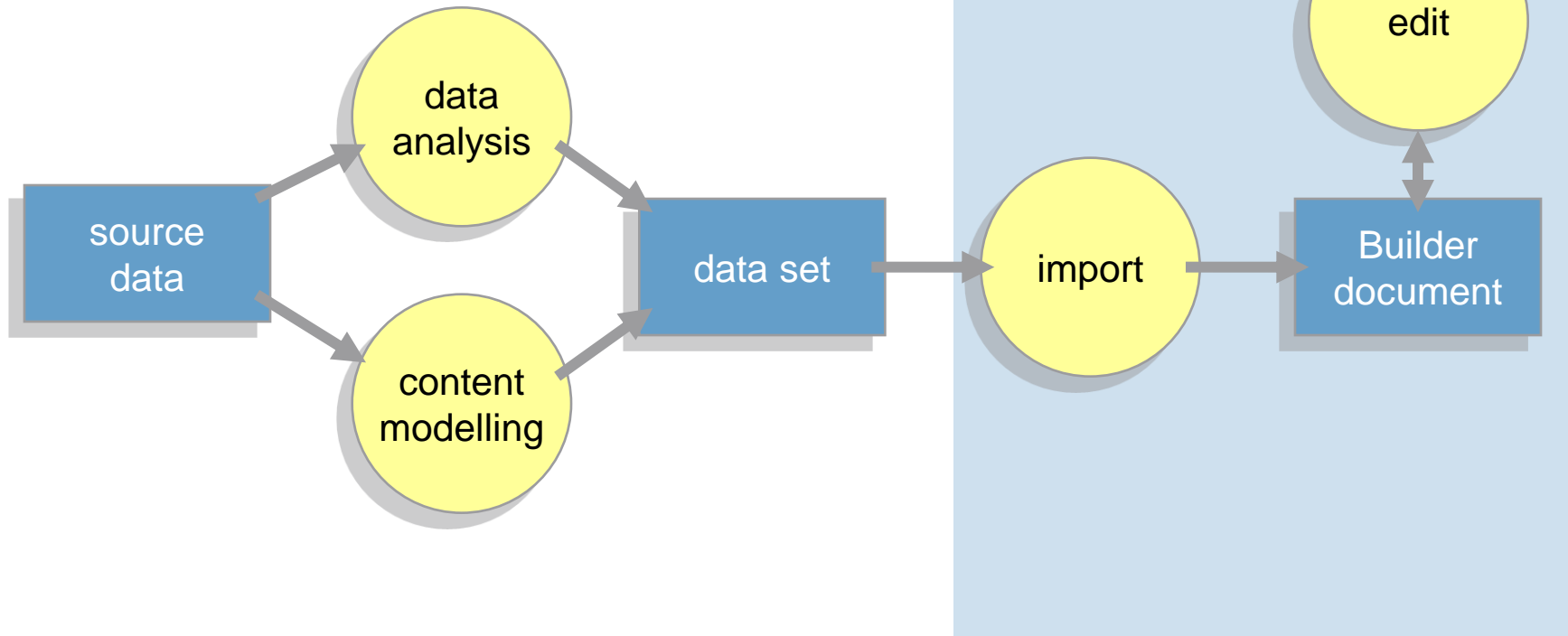


Workflow



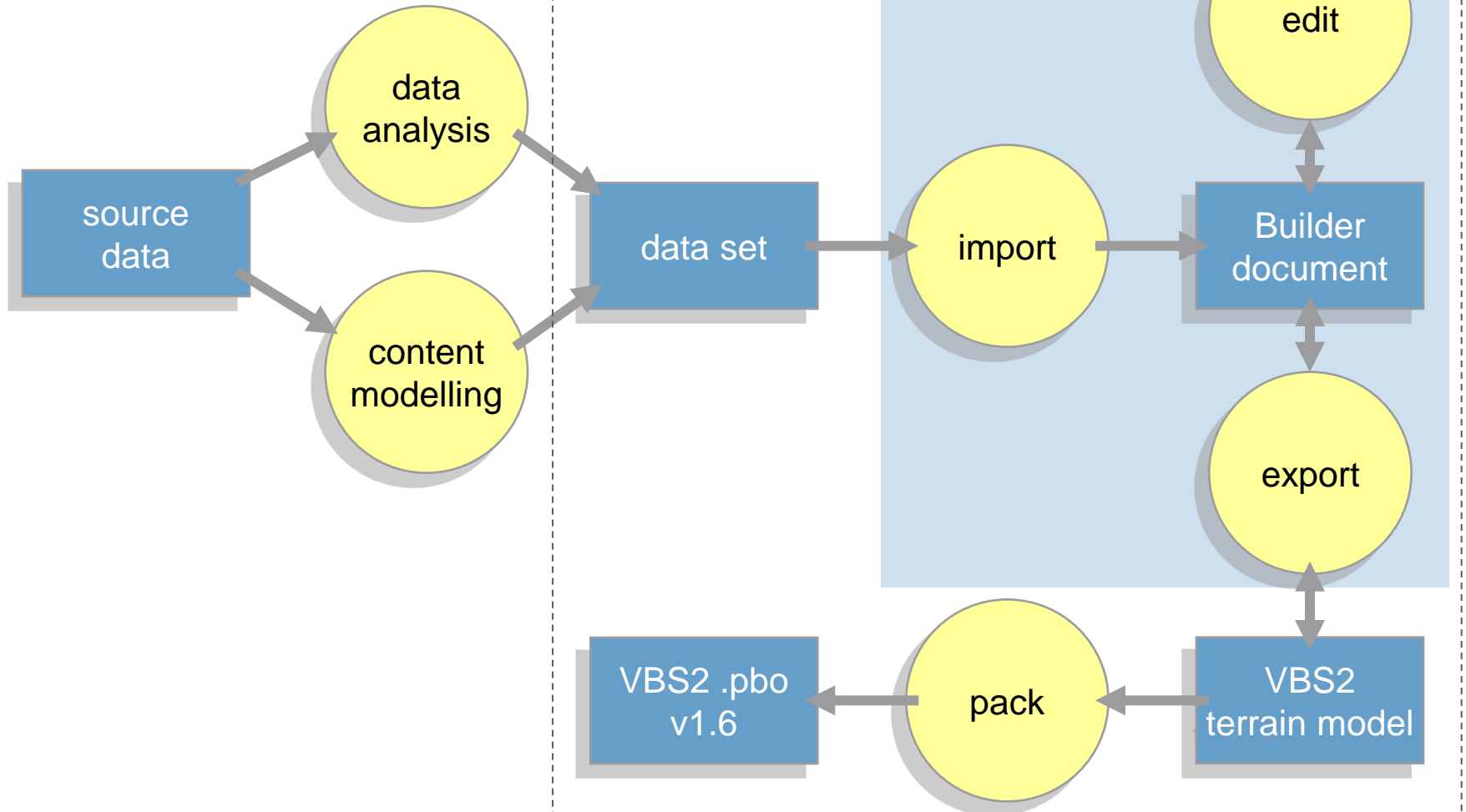


Workflow





Workflow





Overview presentation

- › Technical approach
 - › Data analysis
 - › automatic DTM generation
 - › automatic feature extraction
 - › VBS2 model generation
 - › model preparation and VBS2 export

- › Results

- › Lessons learned



Automatic DTM generation

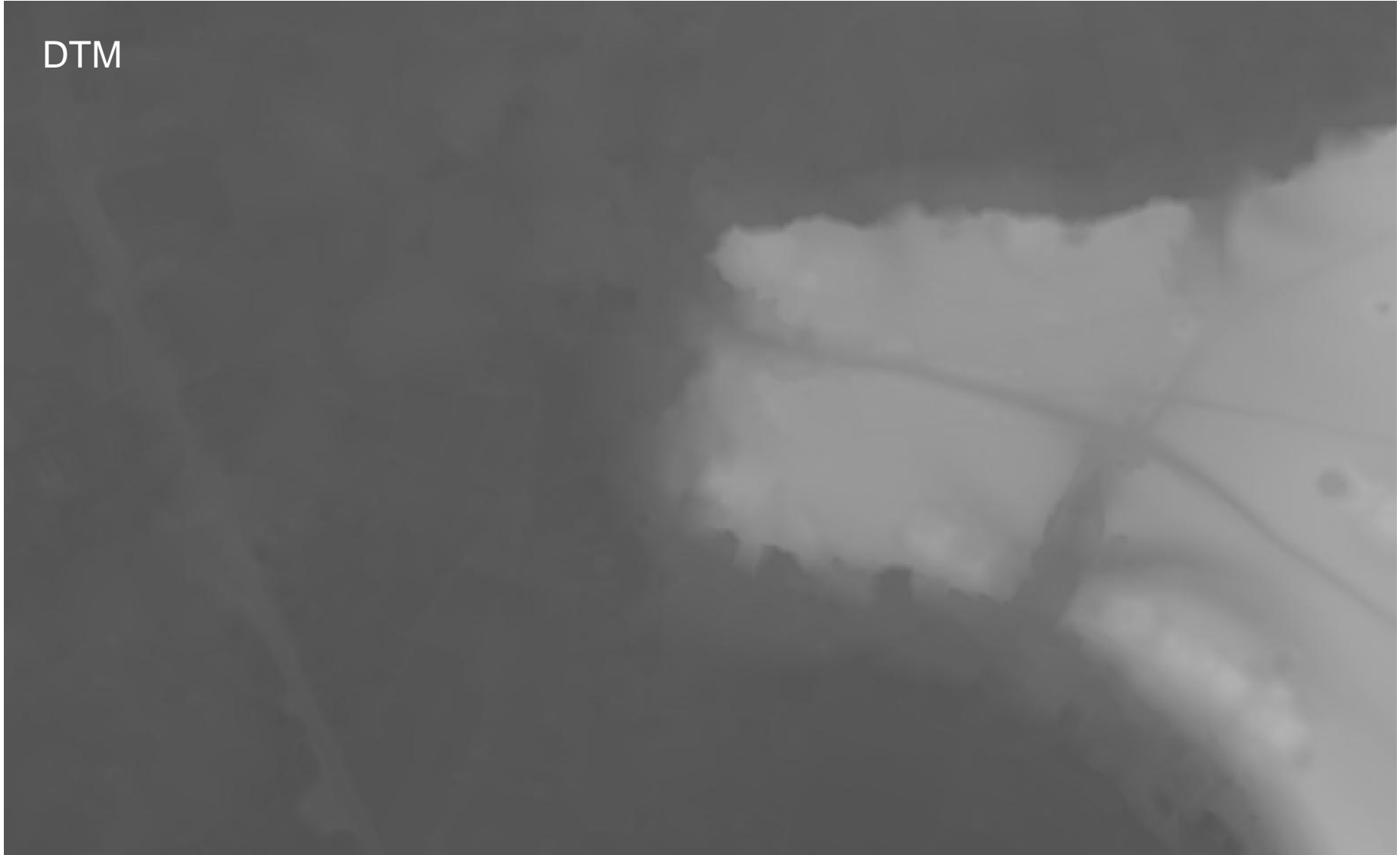


DSM





DTM





› Compute shadow



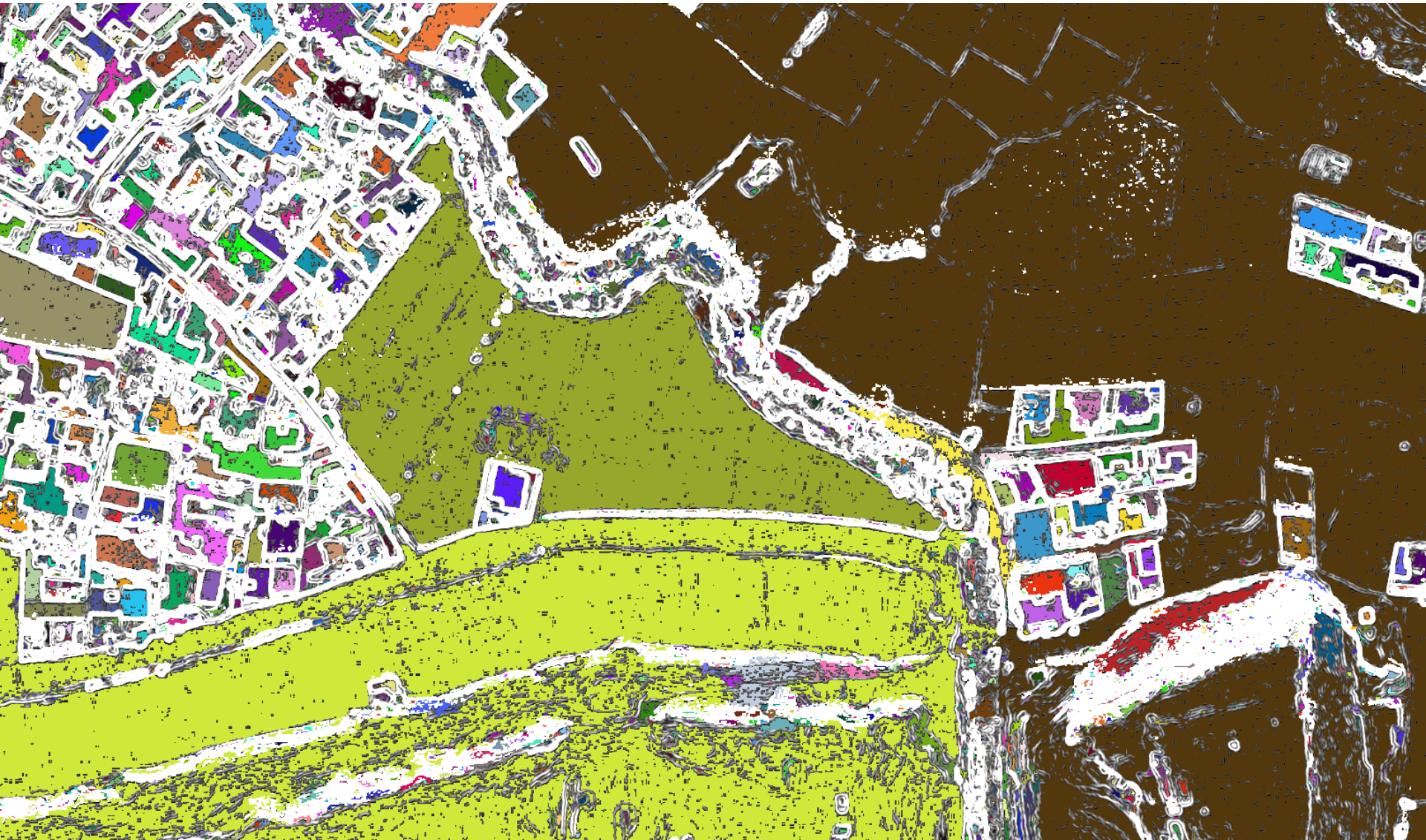


› Compute 2nd order gradient



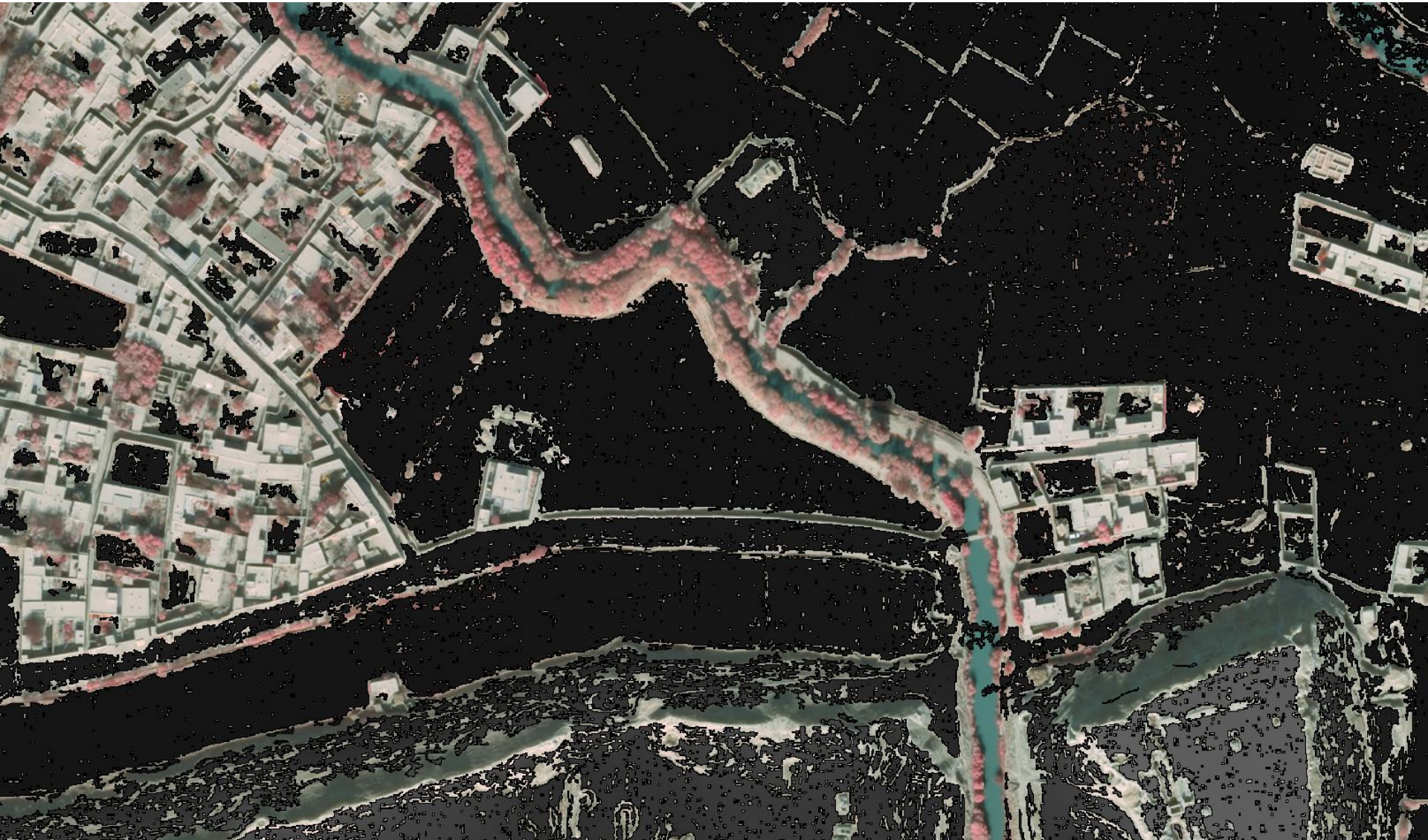


- Find segments of low 2nd order gradient





› Classify segments to find DTM points





› Interpolate DTM points



Automatic feature extraction – walls

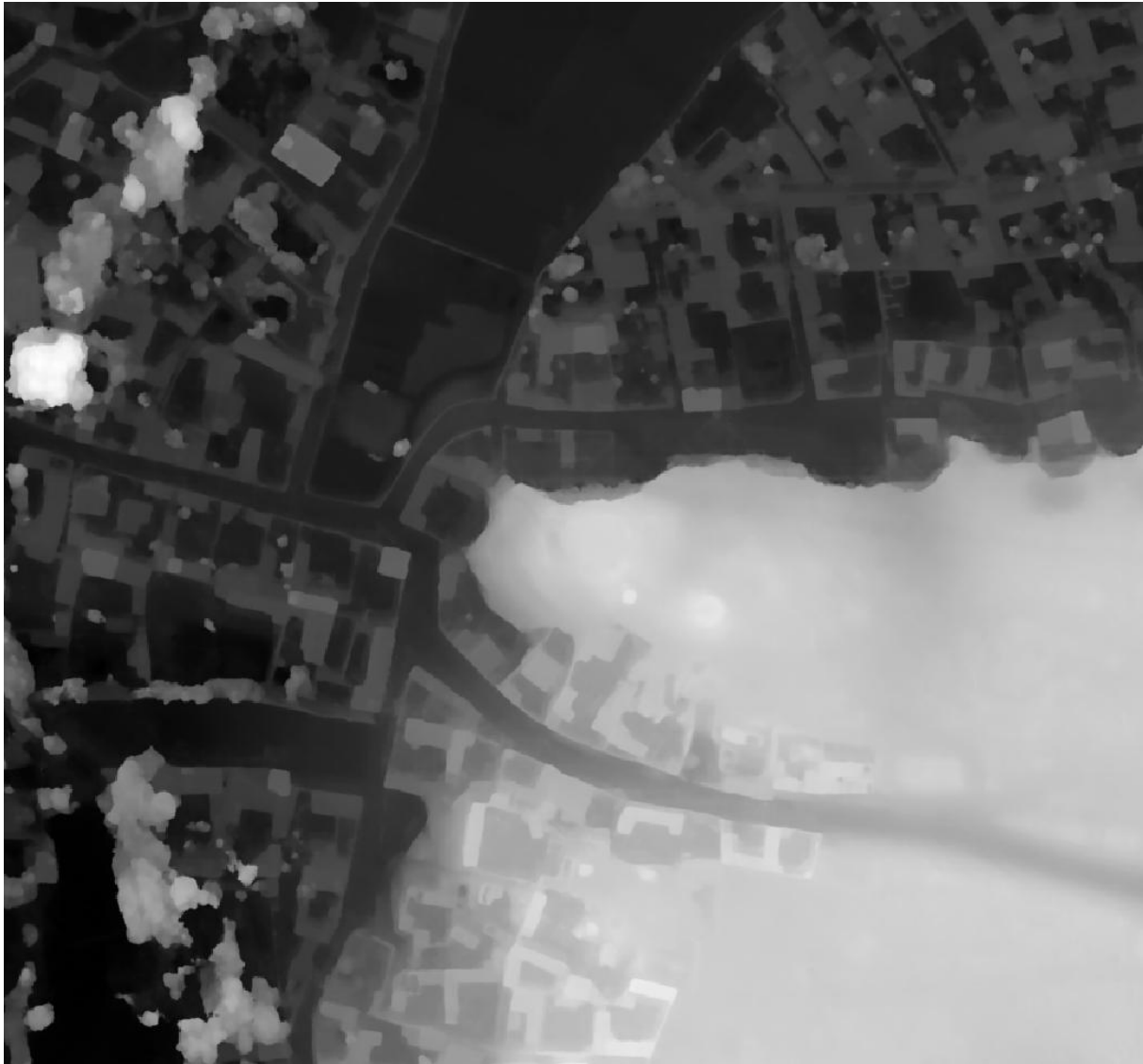


➤ Find walls





- › Work on normalized DSM = DSM - DTM





- › Work on normalized DSM = DSM - DTM



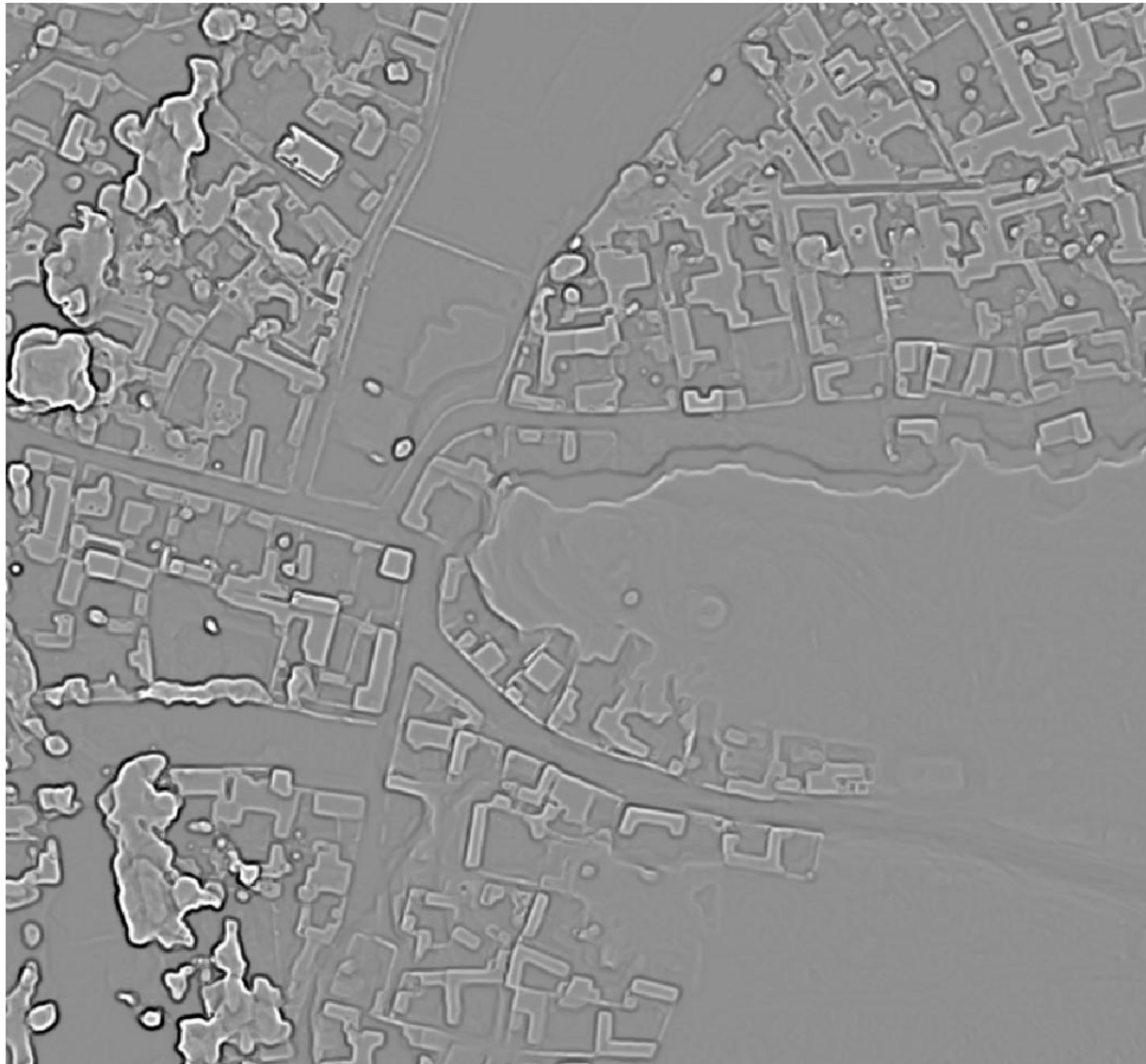


- › Work on normalized DSM = $DSM - DTM$



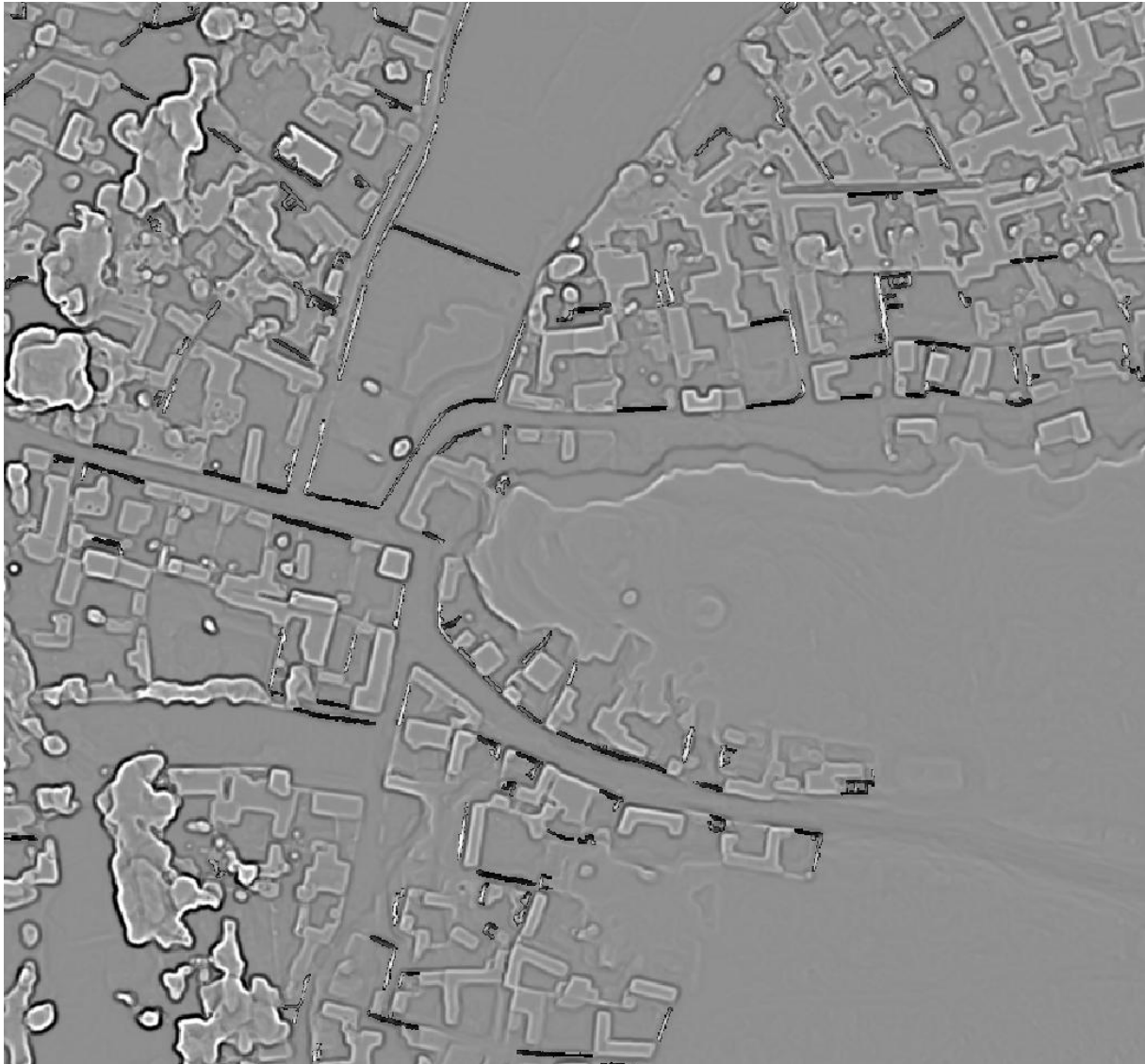


› Compute second order gradients



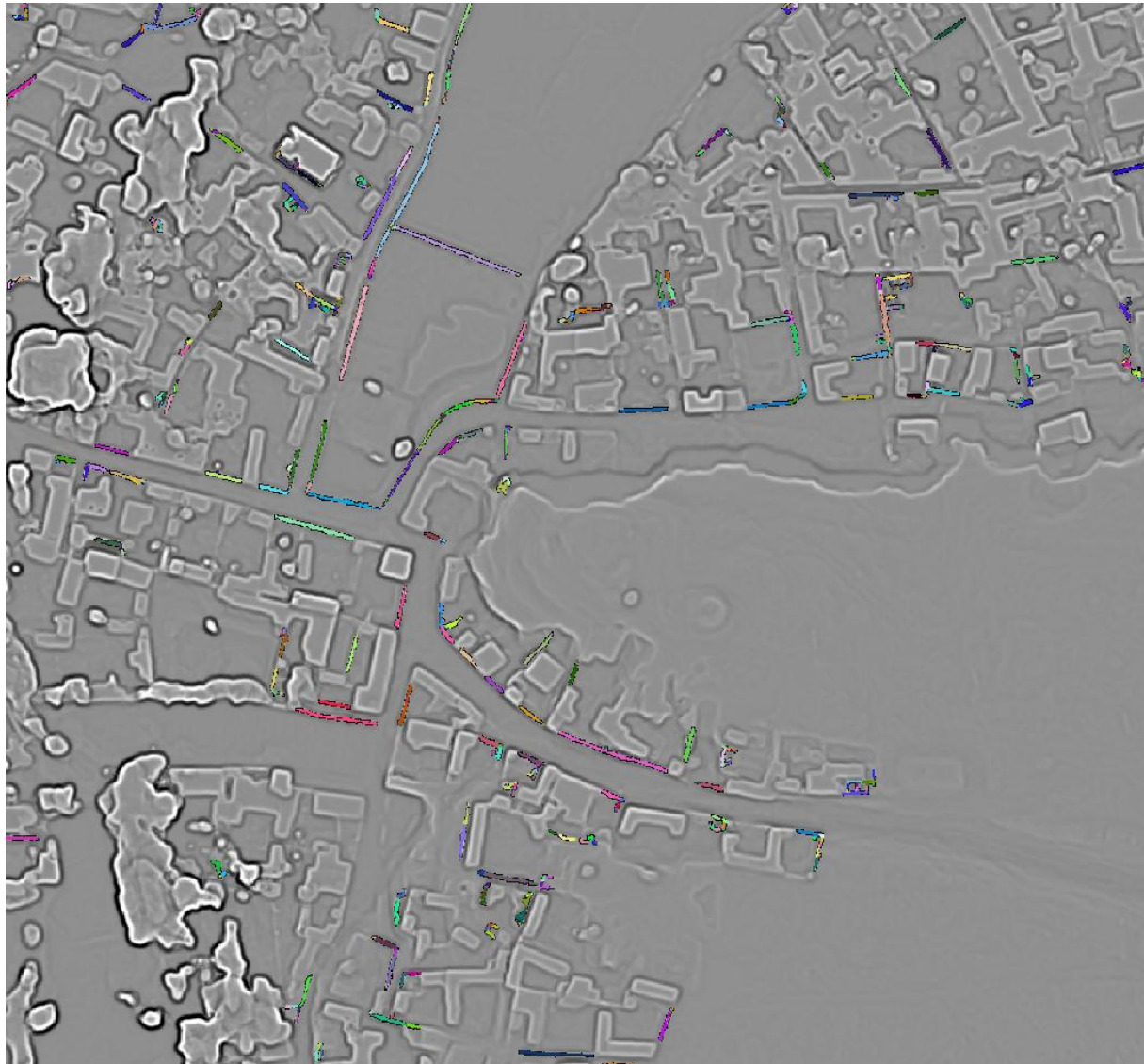


- › Find local extrema in gradient direction, check gradient in orthogonal direction





- › Cluster selected pixels that have similar gradient orientation





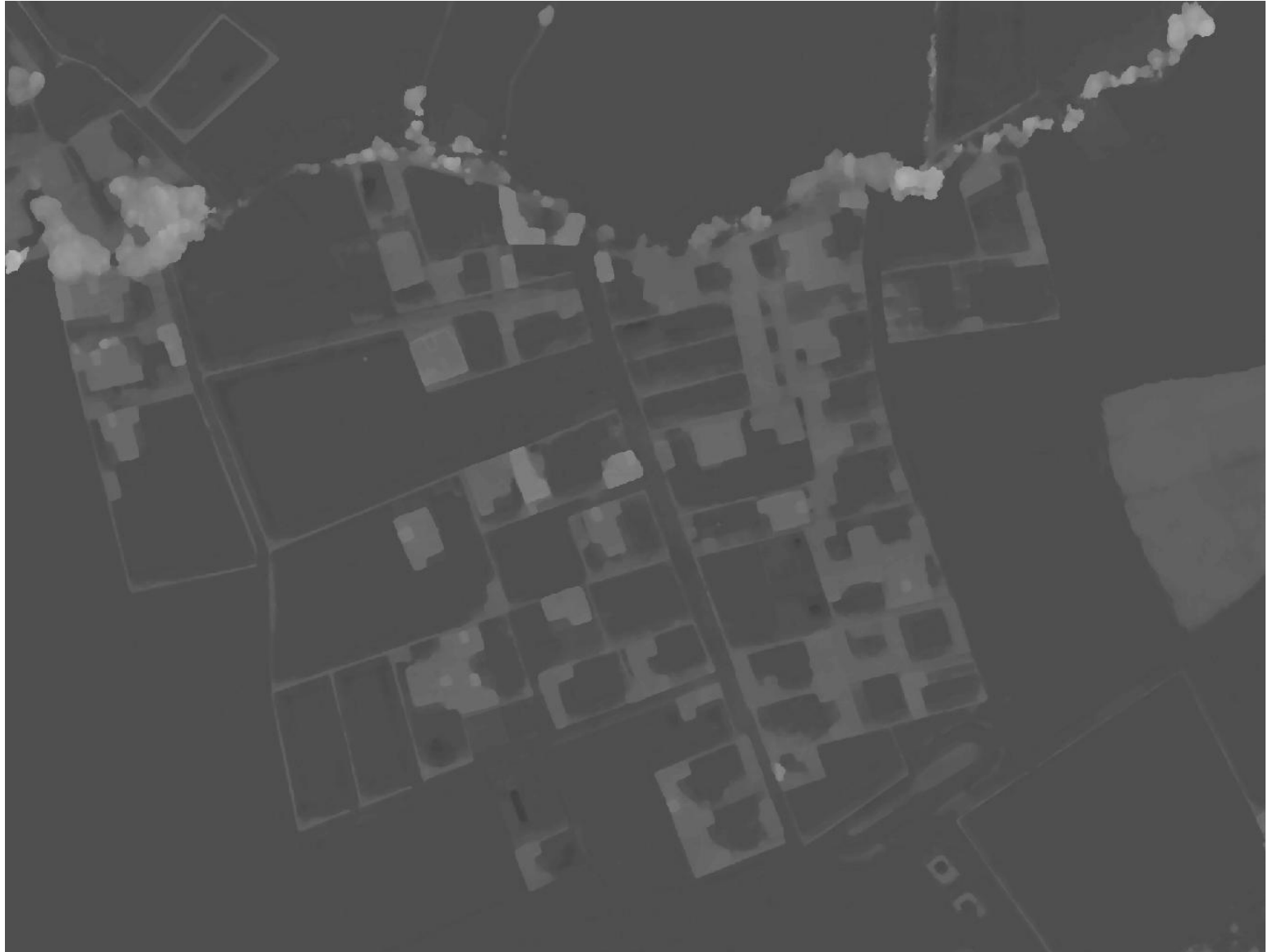
› Vectorize segments and clean-up





Automatic feature extraction – buildings



















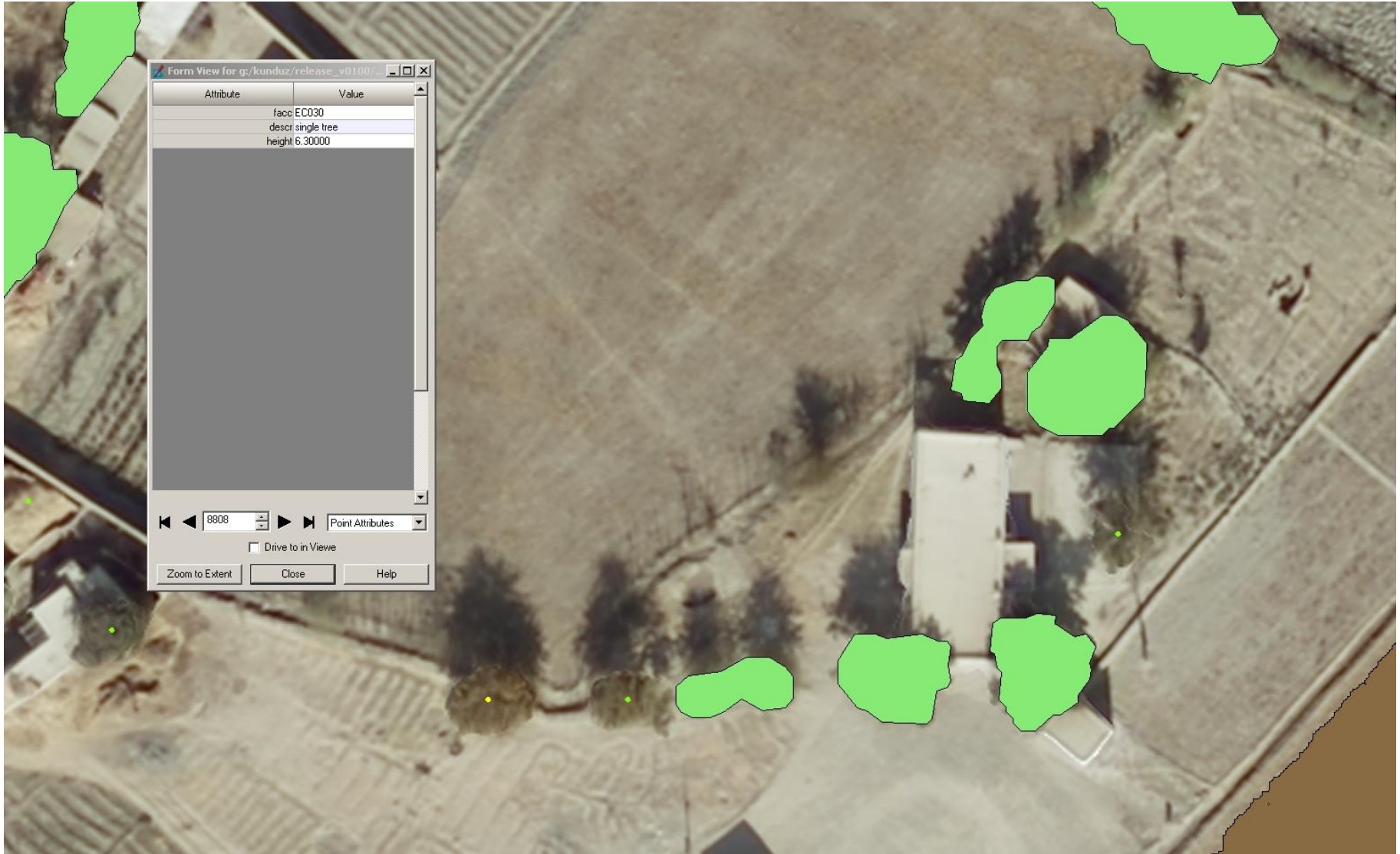


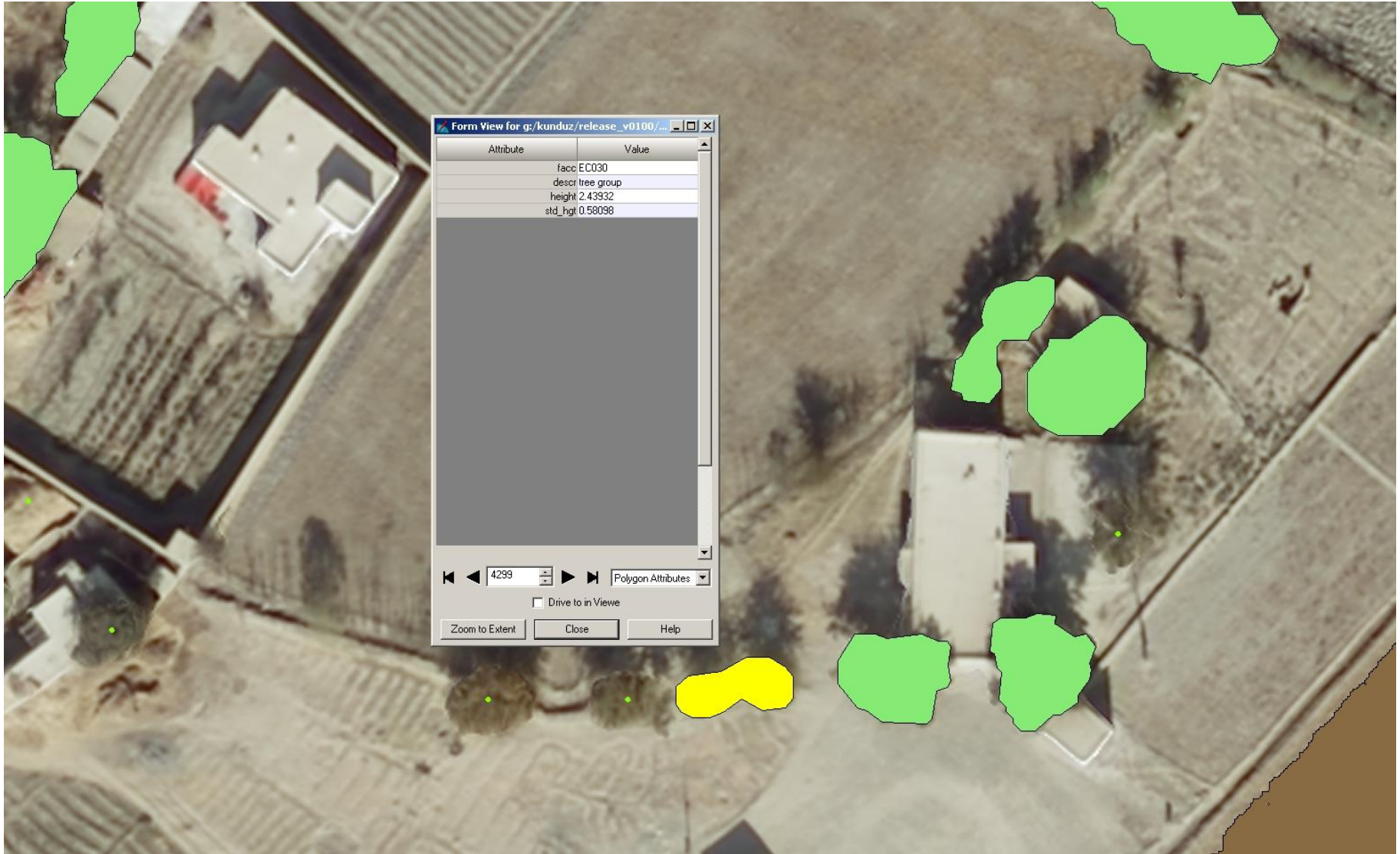
Automatic feature extraction - vegetation













VBS2 model generation

- › Using re-lion Builder
- › WYSIWYG 3D terrain editor
- › Export to VBS2 capability



Bestand Bewerken Beeld Voorkeuren Help



Plaatsing

Positie Oriëntatie UTM

Globale Positie Locale Positie

X: X:

Y: Y:

Z: Z:

Koppelingsinstellingen

Radius (pixels)

Eigenschappen

Meshbron

T1 loam 6.913x11.739 grey

Toolconfiguratie

Afkappen

Afkap hoogte:

Footprinting

Footprinting

Overzichtskaart



Zoeken

Hoogte Oppervlakte Begroeiing Gebouwen Interieur Transport + Infra Alles Document

Tool Verzameling

Afvlakken (gemiddeld)	Afvlakken (groot)	Afvlakken (smal)	Level (gemiddeld)	Level (groot)	Level (smal)	Snel Verhogen (extra groot)	Snel Verhogen (gemiddeld)	Snel Verhogen (groot)	Snel Verhogen (smal)



Results

- › Vector data
 - › built-up
 - › vegetation



Results

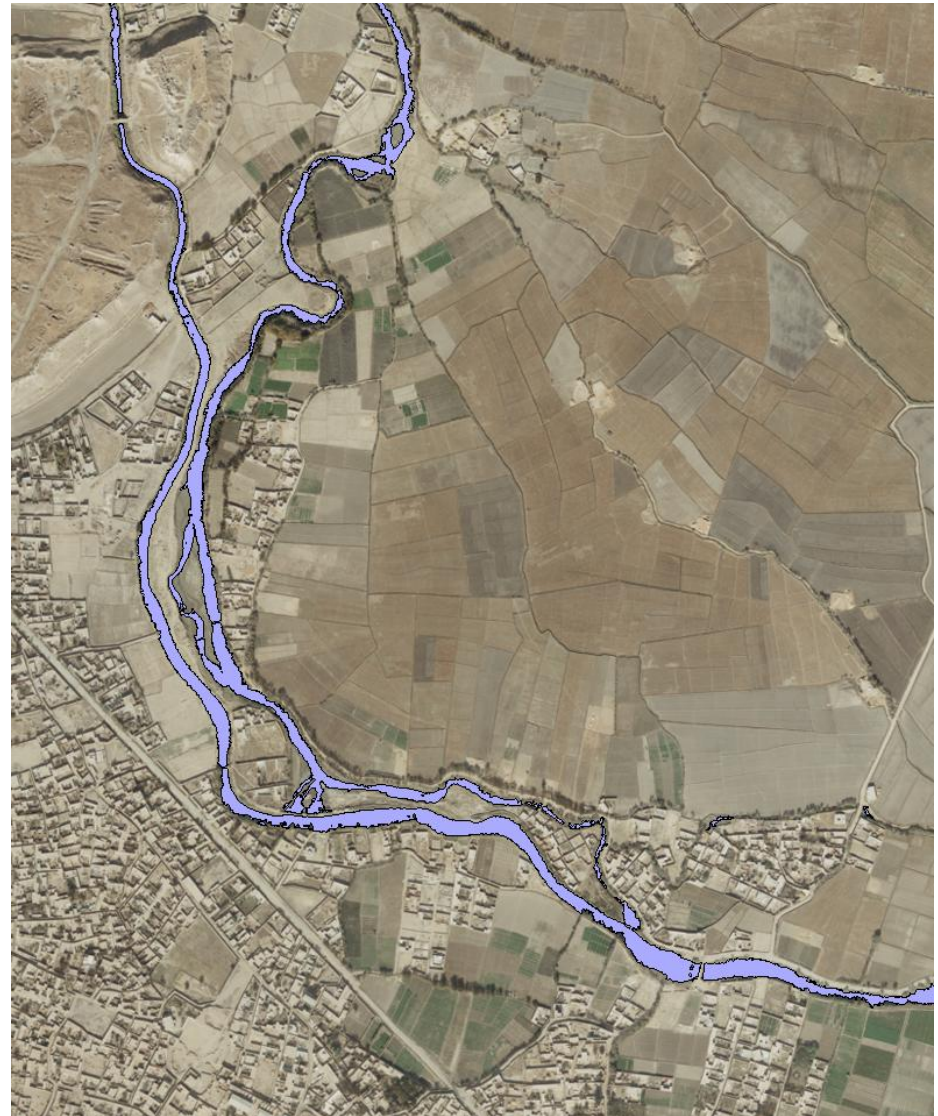
- › Vector data
 - › built-up
 - › vegetation
 - › transportation





Results

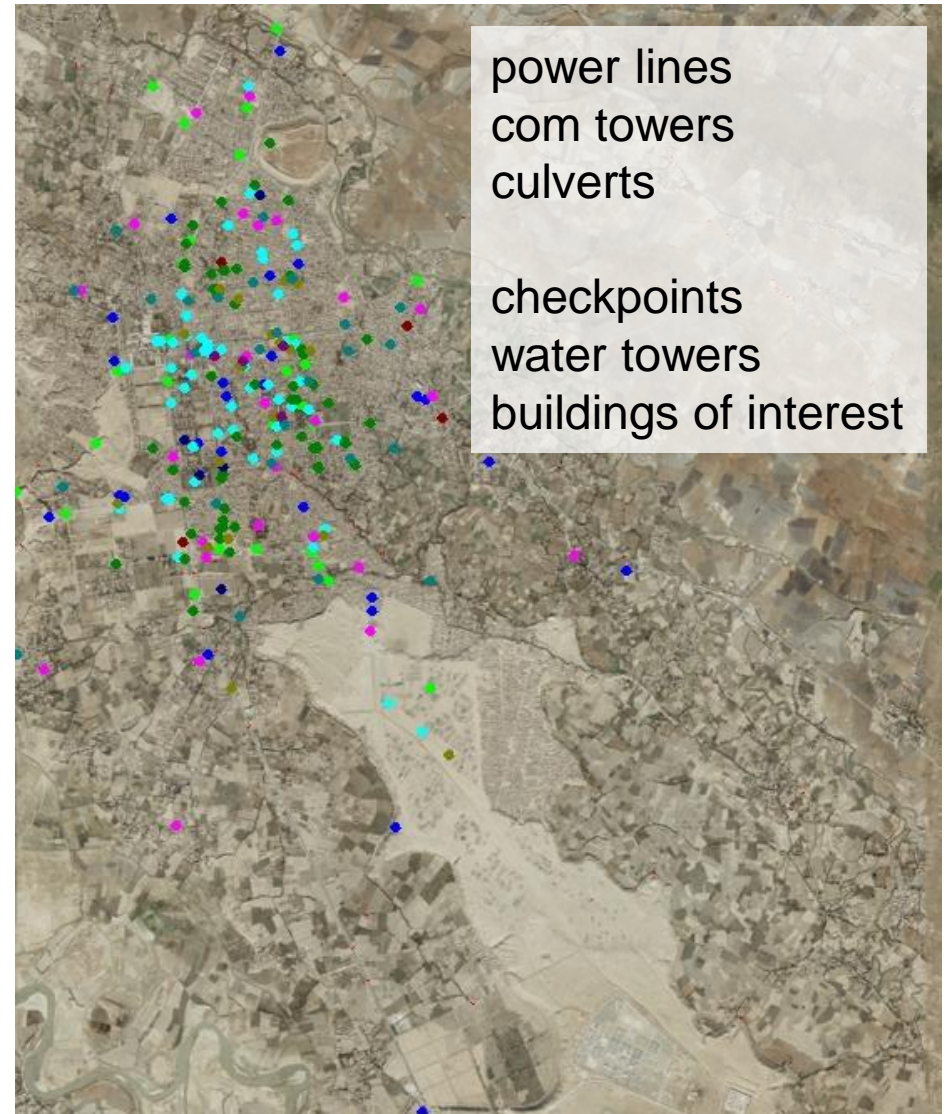
- › Vector data
 - › built-up
 - › vegetation
 - › transportation
 - › hydrography





Results

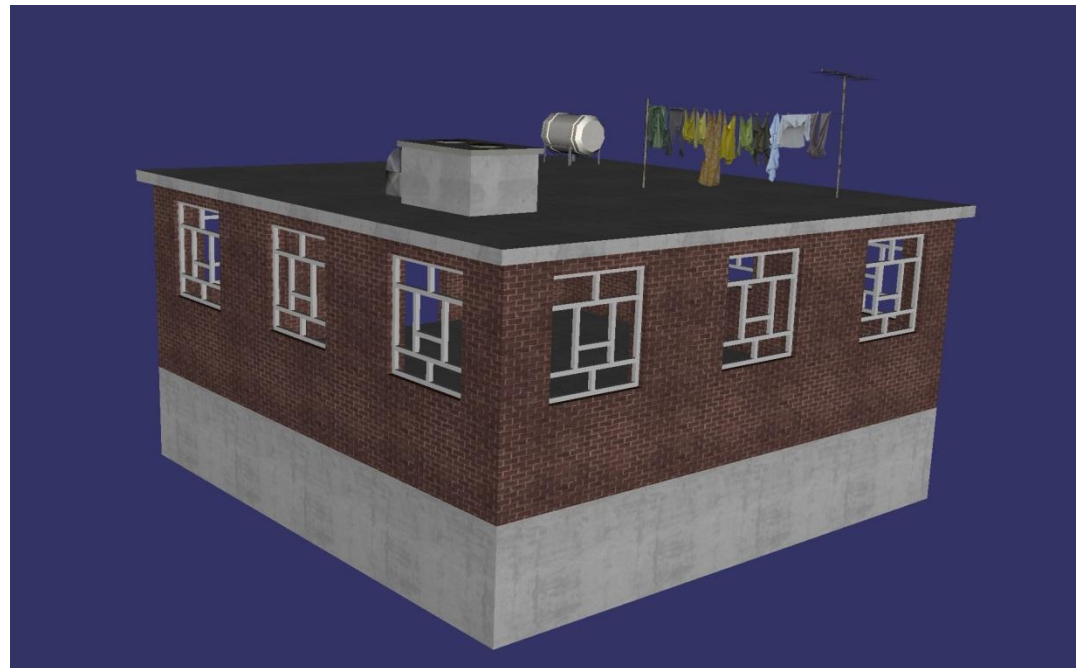
- › Vector data
 - › built-up
 - › vegetation
 - › transportation
 - › hydrography
 - › other





Results

- › Vector data
 - › built-up
 - › vegetation
 - › transportation
 - › hydrography
 - › other
- › Content
 - › 400+ models







Lessons learned

- › Automatic analysis from 20 cm stereo aerial imagery
 - › Impressive DSM, but not as accurate as LIDAR
 - › Shadow problems cause inaccuracies in automatic analysis
 - › Good results for training and general situation awareness
 - › Need more quality control for detailed intelligence support
 - › DTM generation is key – and difficult

- › VBS2 model generation
 - › Accessible end-user export capabilities through WYSIWYG editing
 - › pre-v2.0 limitations

- › COTS tools = bugs, bugs, bugs ☹️

Acknowledgments

Customer

Dutch MoD - Simulation Center Land

Project team

TNO
re-lion

Source data

Dutch MoD Geographic Office
German MoD Geographic Office
DLR