Modèle Numérique de Surface (MNS) et Applications

Digitaal oppervlaktemodel (DOM) en toepassingen

Digital Surface Model (DSM) and Applications

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Digital Surface Model (DSM) and Applications

Plan

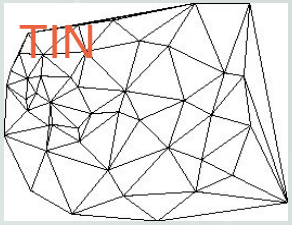
1. *DigitalSurfaceModel : Generalities*
2. *DSM from stereoscopic pairs*
3. *DSM from LIDAR data*
4. *DSM from vectors*
5. *DigitalTerrainModel from DSM*
6. *Automatic Change Detection*
7. *Road Network*
8. *Roof Orientation*

1. Digital Surface Model : Generalities

DSM == 3D surface (e.g. the earth's surface)

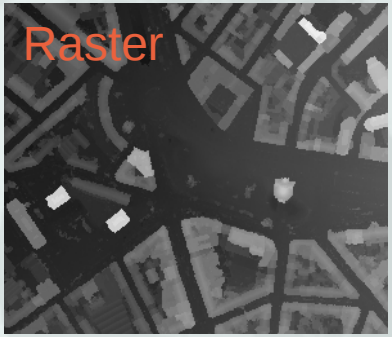
Common Representations

- Triangulated Irregular Network : XYZ points



- **Raster** : 2-D regular grid of Z values

  Handled like an image



2. DSM from Stereoscopic pairs

Stereo Matching of an image pair

Correlation between 2 images : disparity D (x,y)

Surface reconstruction : (x,y) + D → XYZ (= DSM)

- Position and orientation of camera
- Camera parameters (focal length, pixel size, ...)

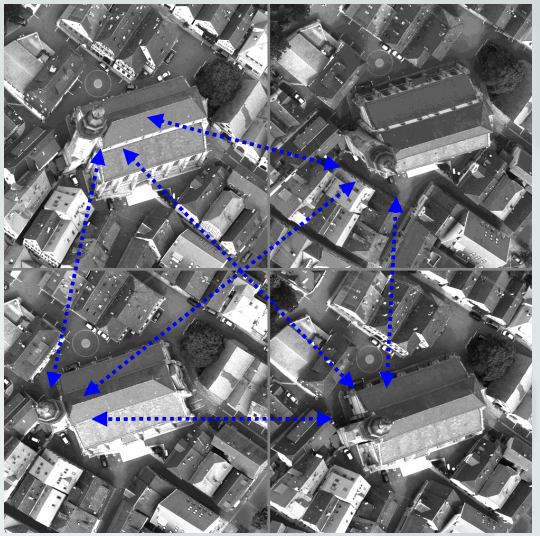
Multi-view : more than 2 views

Several image pairs

Several Z for each XY: median

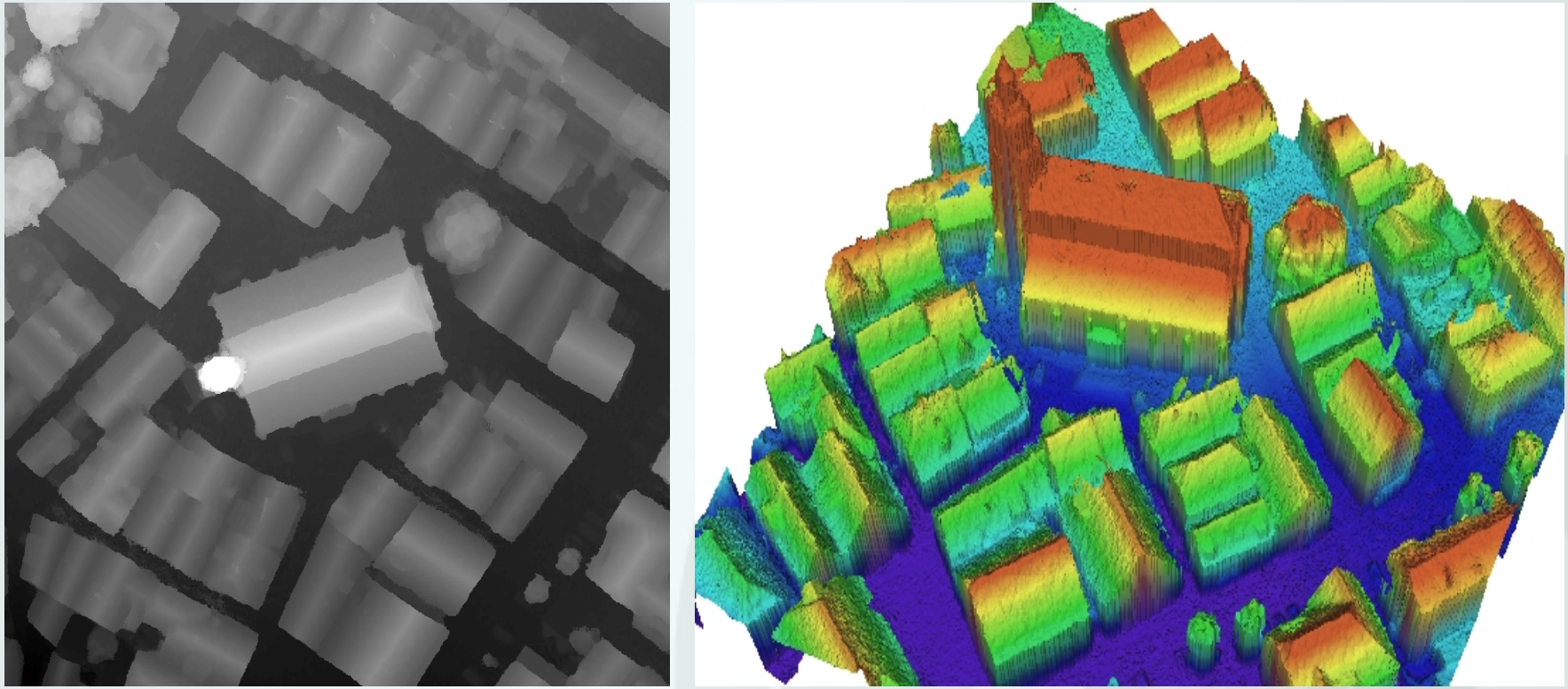
→ Less occluded areas

→ Higher accuracy



Multi-view

2. DSM from Stereoscopic pairs



DSM and oblique view

2. DSM from Stereoscopic pairs

UrbIS Photogrammetric Flight 2014

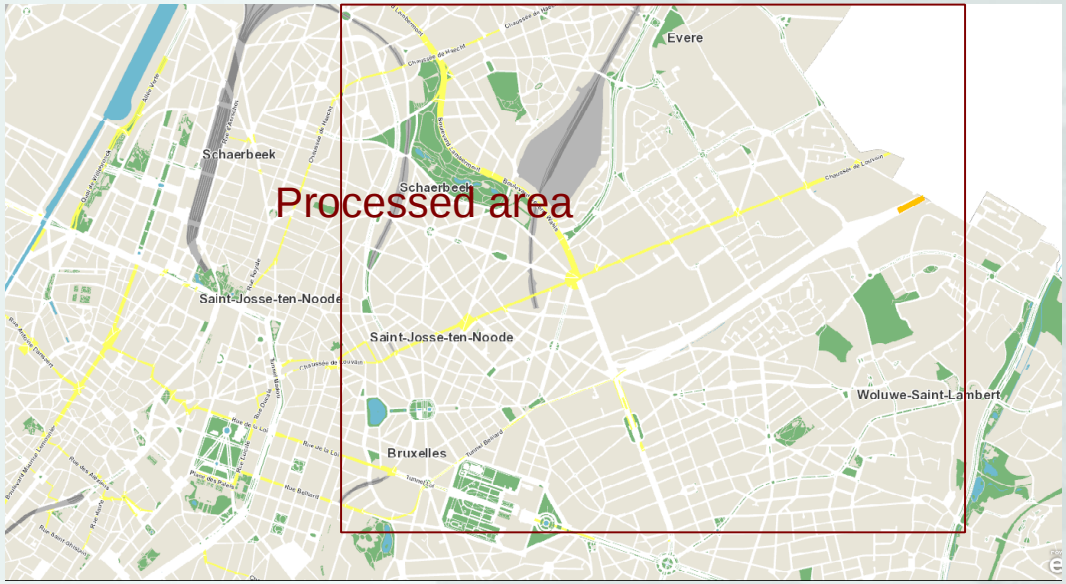
Camera: Vexcel UltraCamEagle , 13080 x 20010, Ground resolution: 7.5cm

Total of 1092 images in 30 strips – Image overlaps: 60% / 60%

DSM_RMA extraction on large area

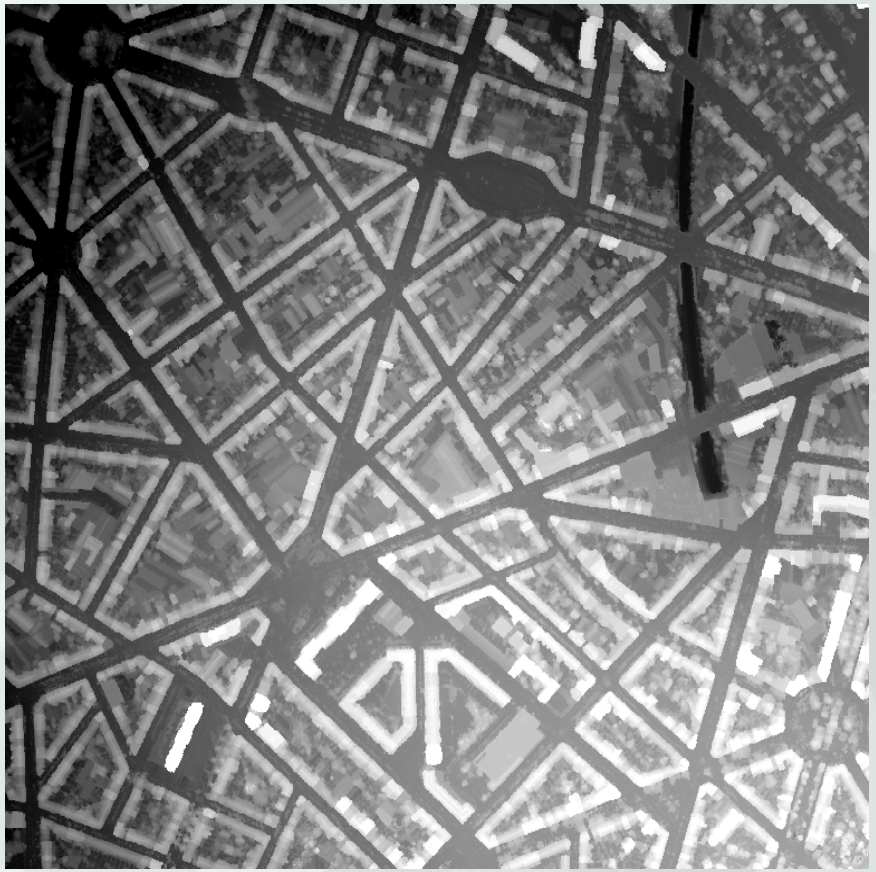
About 18 km^2 (117 images)

80 hours on 100 CPUs (parallel computing)



Area for large test

2. DSM from Stereoscopic pairs



A sample (1km^2) of the generated DSM

2. DSM from Stereoscopic pairs

DSM evaluation

By visualization

(Vector superposition)

Rather complete surface

Good superposition

! Difficult shadow areas

A sample (1km²) of the generated DSM

3. DSM from LIDAR

LIDAR

Measurement of distance to objects by LASER

Converted into points with geo coordinates

Very precise :

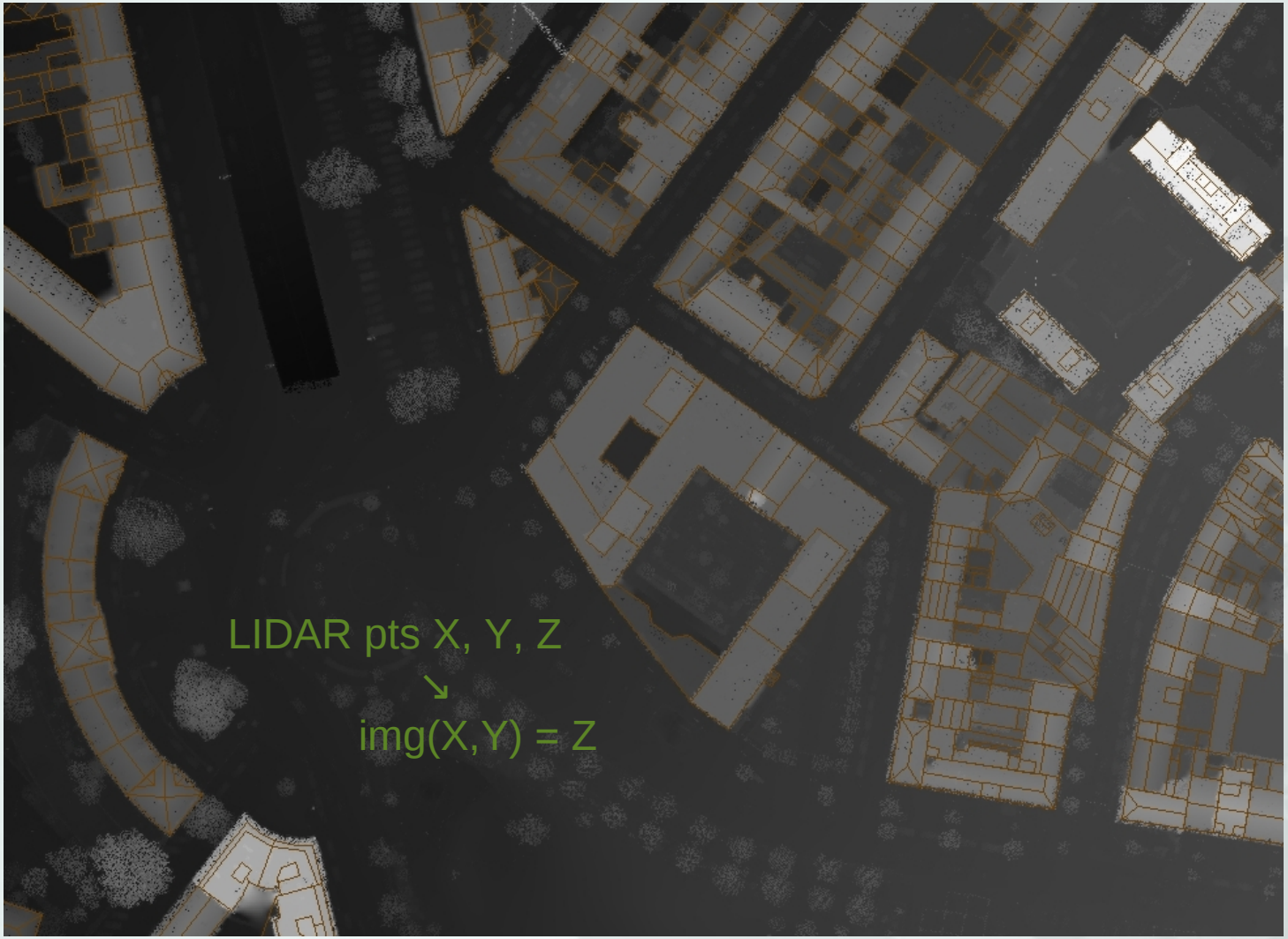
- CIRB : 30 pts per m^2
- Precision : A few cm in Z

Applications

Replace/Complement the traditional photogrammetry

Good reference to evaluate image-based DSM

3. DSM from LIDAR : rasterization



Raster from LIDAR acquired for CIRB

4. DSM from Vectors

Database vectors

Buildings, roads, trees, ...

Encoded from image, field survey, …

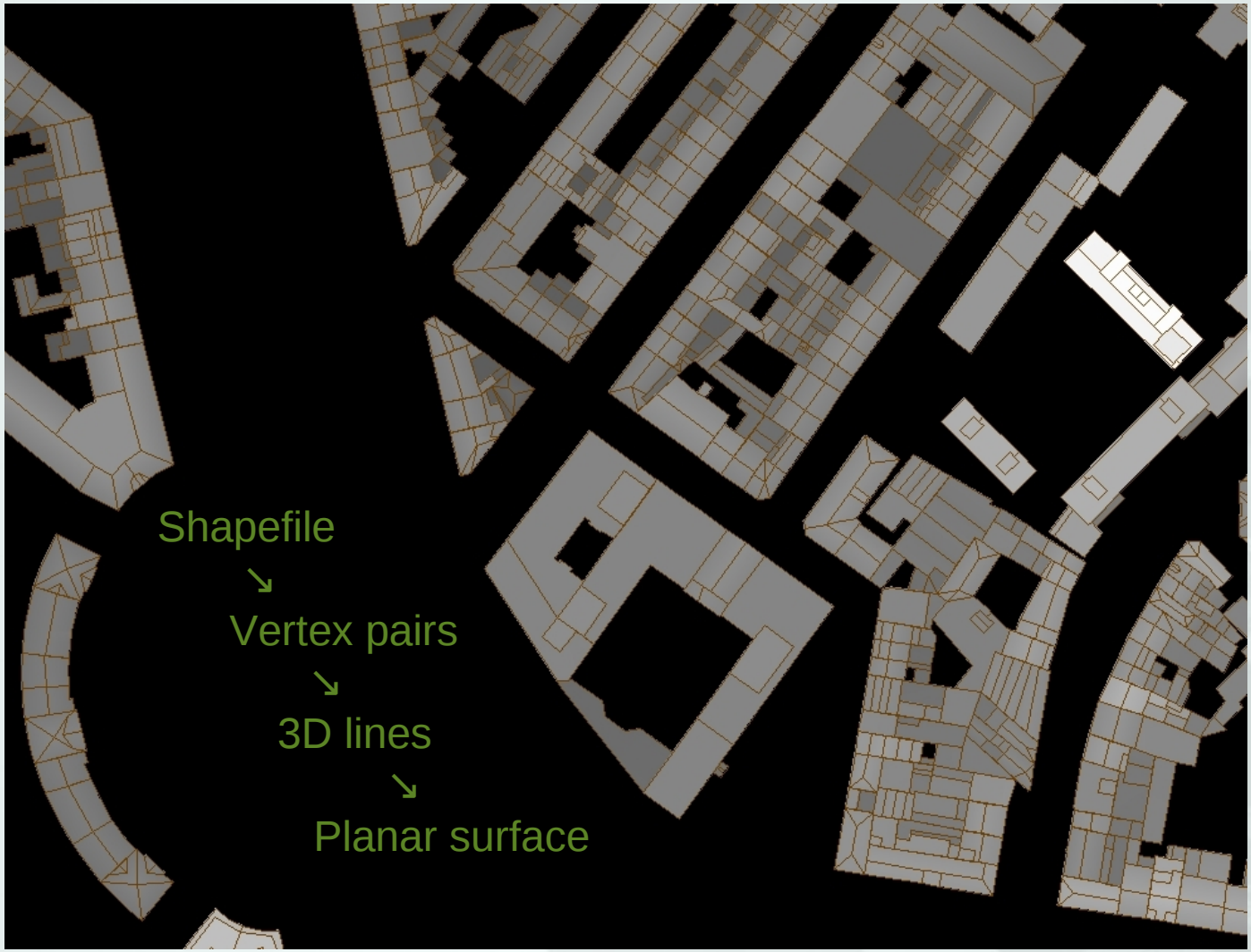
and more and more automatically

Applications

The vectors have to be updated

→ Automatic Change Detection

4. DSM from Vectors



Raster from Urbis-Adm 3D vectors (UrbAdm_Bu_Roof_3D)

(2.) DSM_RMA - DSM (LIDAR & Vectors)

DSM evaluation
By Difference

Trees
- No leaves in images
- Echoes in LIDAR

Houses
- ! Close to facade
- ! Shadows

DSM_RMA - DSM (LIDAR & Vectors)

5. Deriving a DTM from a DSM by Uniform Regions and Context

5.1 Introduction

5.2 Region detection

5.3 Region filtering

5.4 Interpolation

5.5 Results

5.6 Conclusions

5.1 DTM : Introduction

Digital Terrain Model

Bare earth (No building, No tree, ...)

Applications

Ortho-rectification

Flood risk evaluation

Vehicle navigation, ...

Production

From field survey !

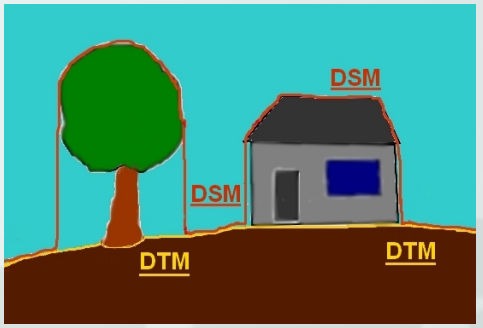
Derive DTM from DSM

Our Approach (automatically)

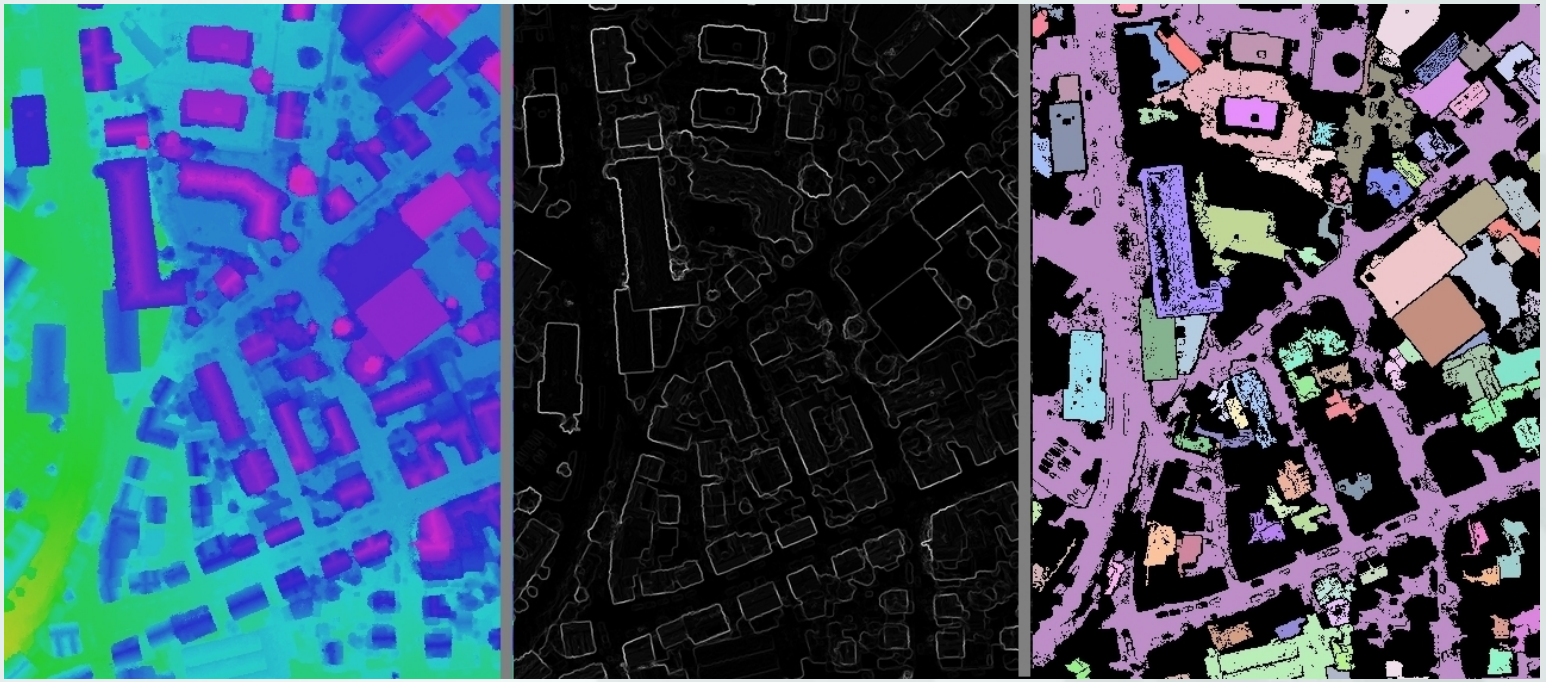
Get uniform regions of DSM

Reject locally elevated regions

Interpolate between kept regions



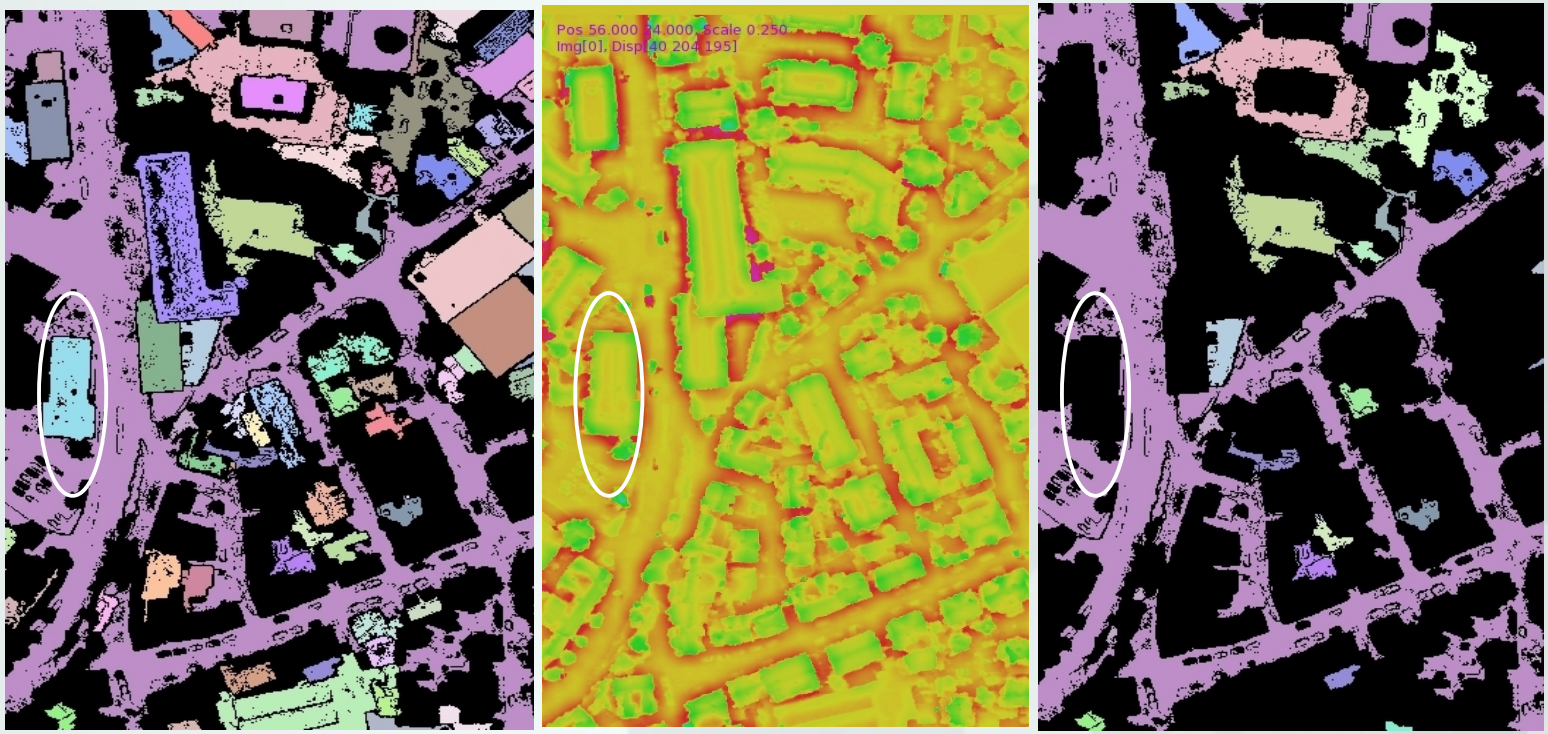
5.2 Region Detection



a) DSM in colour. b) Gradients. c) Regions of limited slope

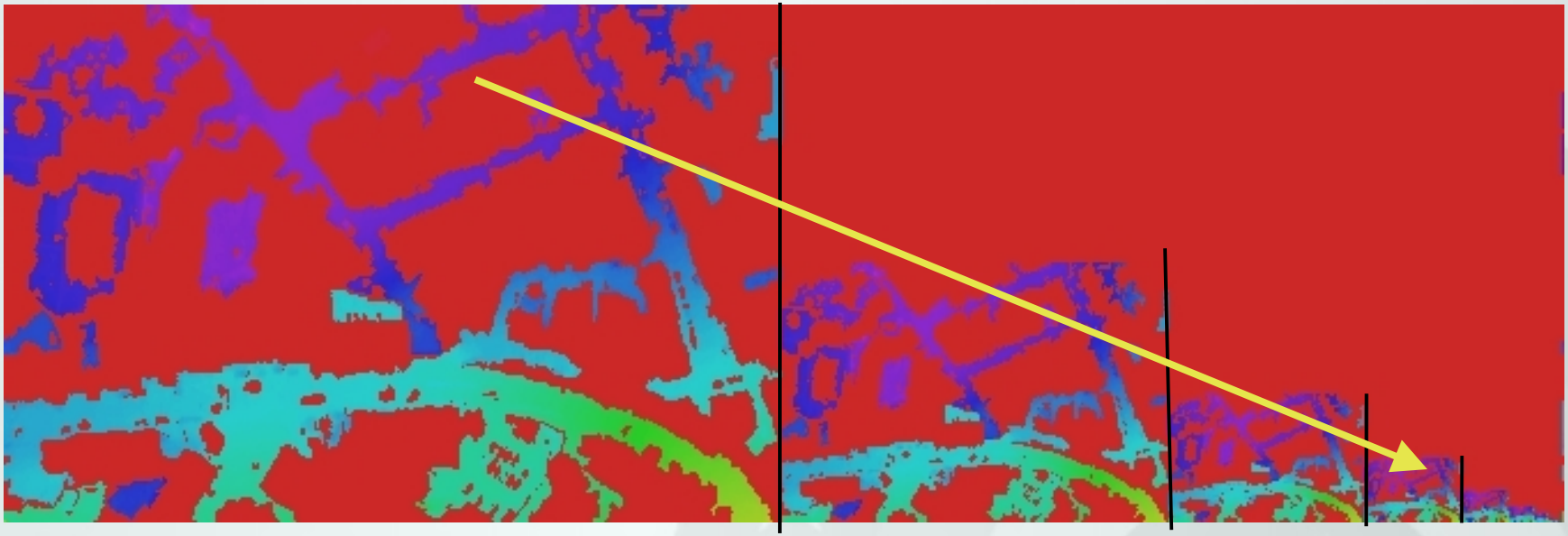
(Test case Vaihingen, 9cm)

5.3 Region filtering



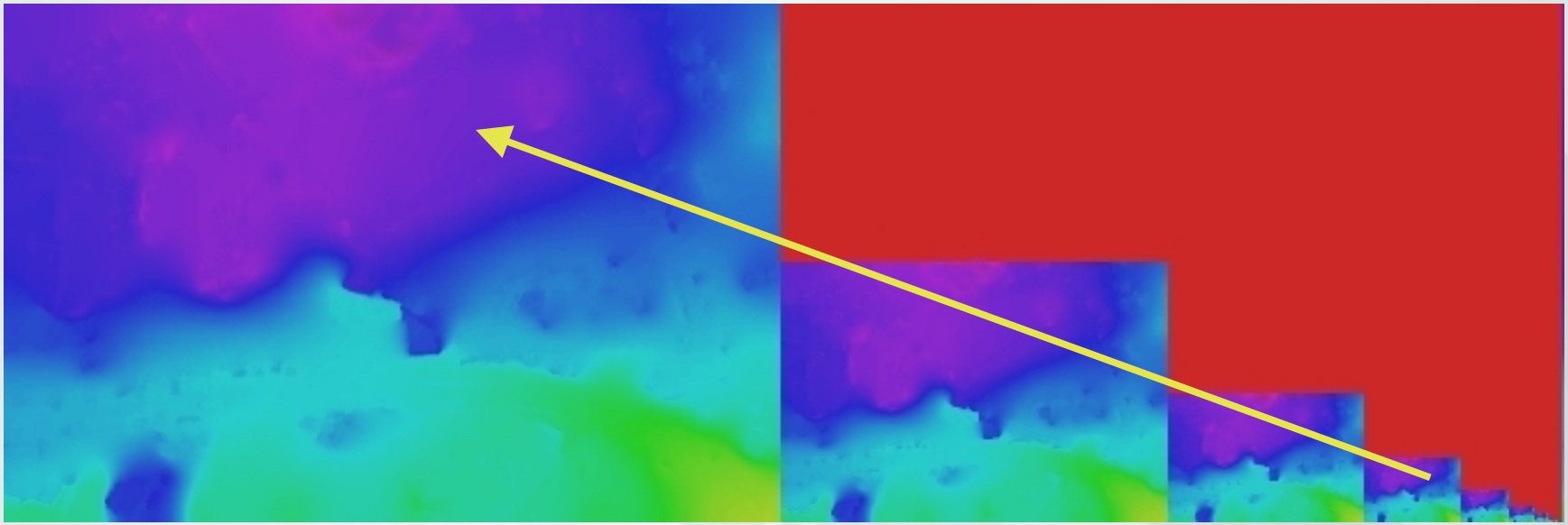
a) Regions of limited slope. b) DSM - LowPass. c) Lower regions

5.4 Interpolation



Pyramid of sparse DTM

5.4 Interpolation



Filled Pyramid: Level 0 Level 1 Level 2 Level 3 ... N

5.5 Results (DTM from DSM)

Stereo imagery (GSD=7.5 cm) → DSM_RMA → **DTM**

LIDAR data (30 pts/m2)

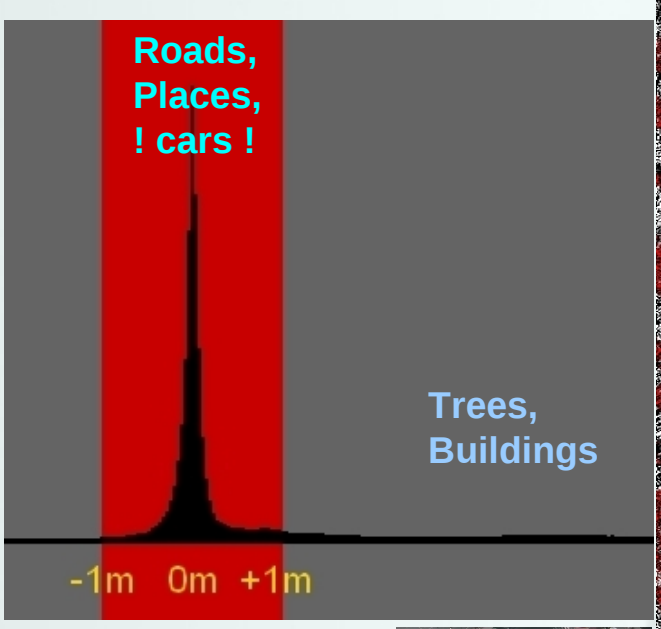
Qualitatively:
Difference DTM and LIDAR, highlighting [-1m..1m]:

- Roads, places well detected
- Some errors inside block of houses

Quantitatively: Histogram

- RMS value of [-1m..1m] = 0.24m (3.2 x GSD)
- But includes !cars!, benches, bushes, ...
- DEPENDS on DSM precision

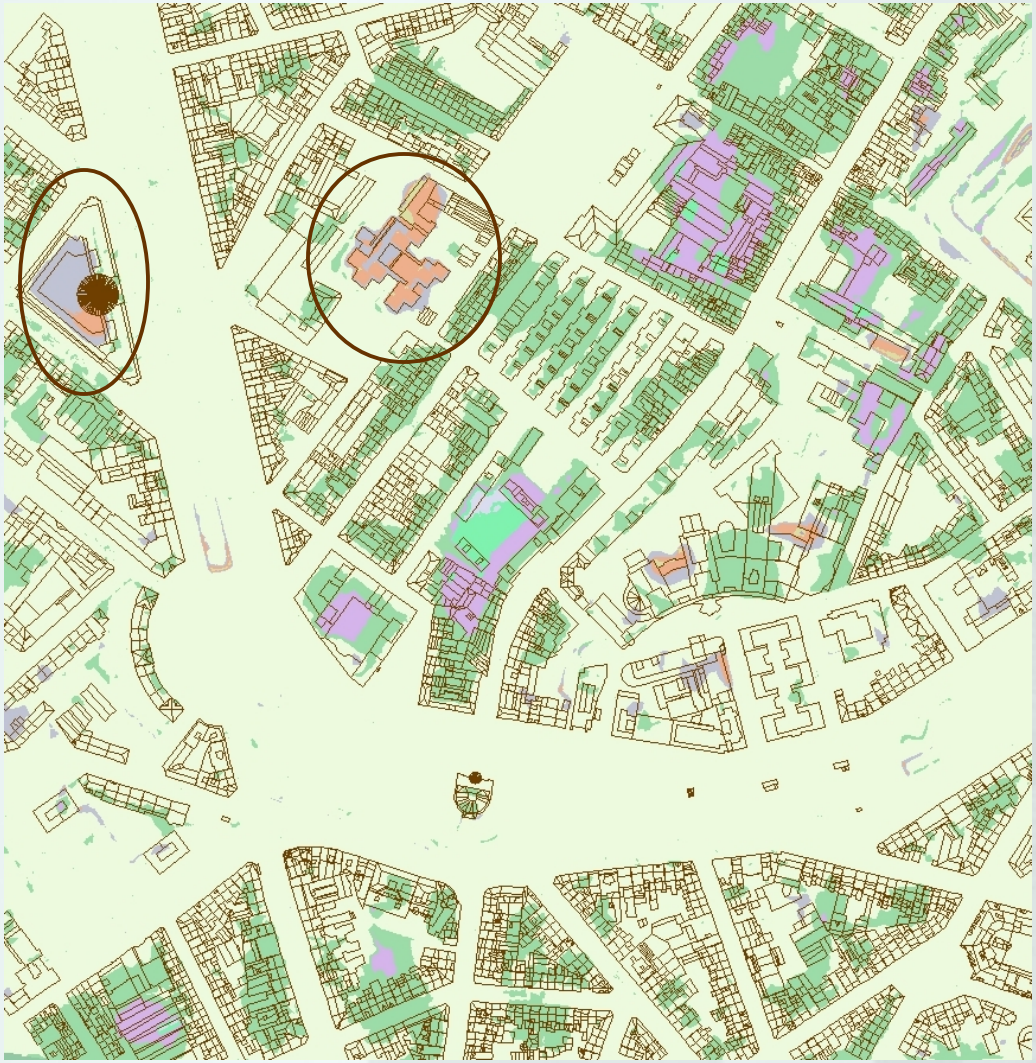
5.5 Results (DTM from DSM)



Difference LIDAR – DTM : Distribution and raster

5.5 Results (DTM from DSM)

Grey [-2..-1]m
White [-1..1]m
Green [1..2]m
Violet [2..3]m
Orange [3..4]m



RMA_DTM - UrbIS_DTM

5.6 Conclusions (DTM from DSM)

New DTM from DSM method

* Designed for urban areas
* Suited to UHR (0.1m) images

  Enough uniform regions

\+ Image processing tasks optimized (1s / Mpix)

! Interior of city blocks should be filtered

! Woods

Possible Future

? Integrate spectral features for classification

6. Change Detection

Objectives

Detect changes in buildings automatically

DSM is the most valuable info

Approach : nDSM (Normalised DSM)

nDSM = DSM -DTM

Constant threshold (e.g. 2m)

! But vegetation (NDVI is useful but requires near IR)

In development ...

6. Change Detection

Previous development

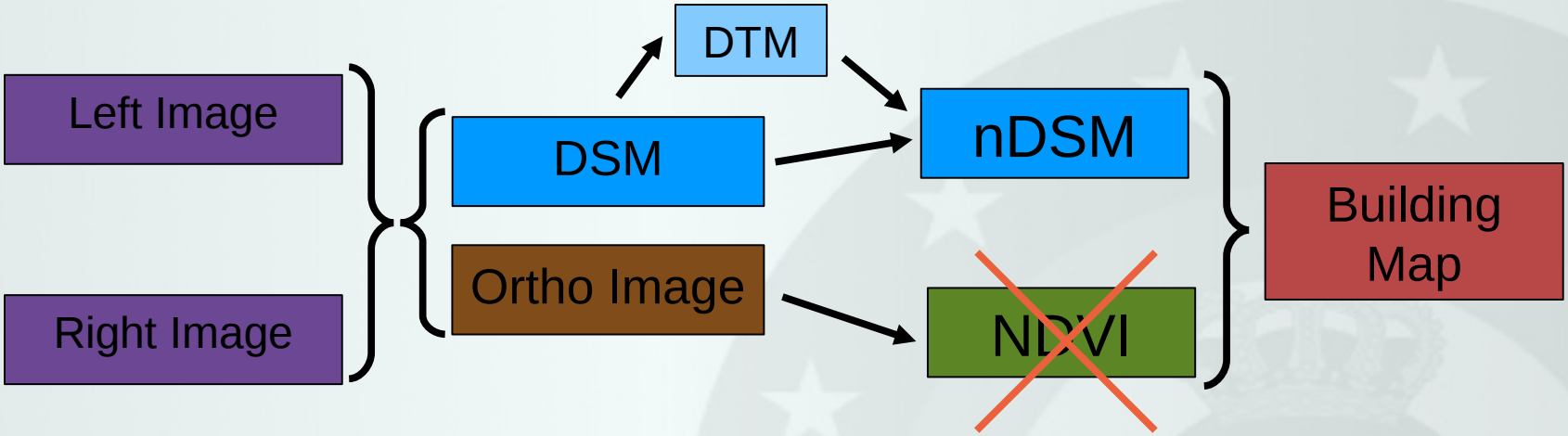


Image Data (nIR, R, G)

Stereo Computation

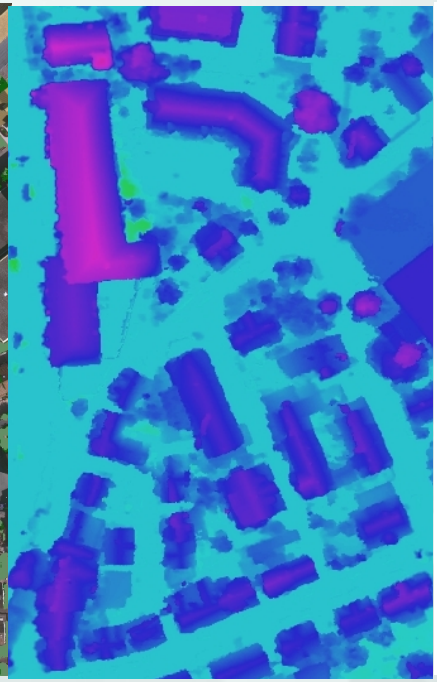
Image Processing:
nDSM = DSM – DTM
NDVI = Vegetation index

6. Change Detection

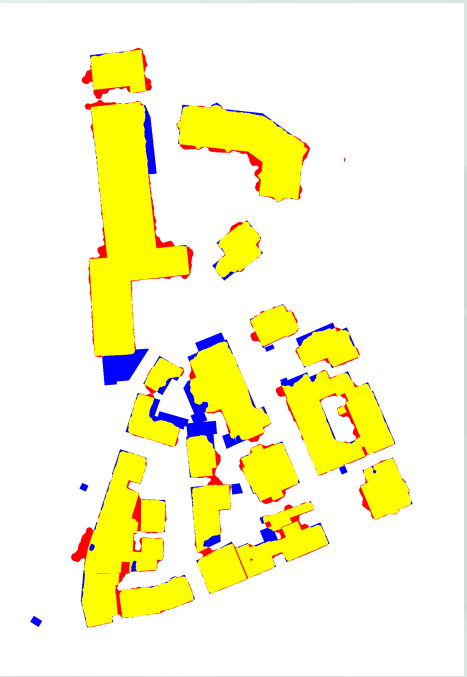
Previous development

NearIR_R_G

Vegetation detected

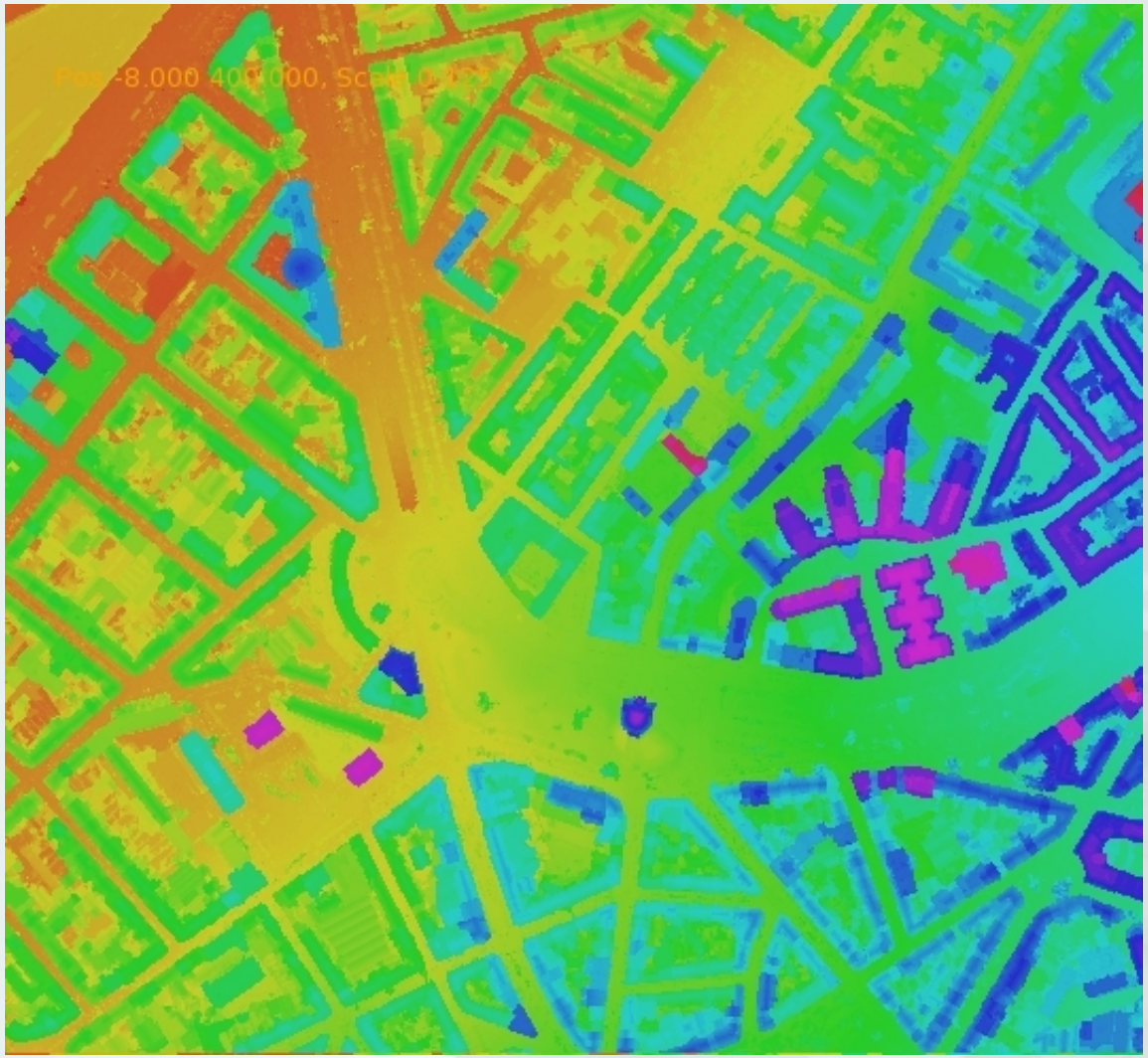


nDSM



Yellow=buildings

6. Change Detection



DSM in false colour

6. Change Detection

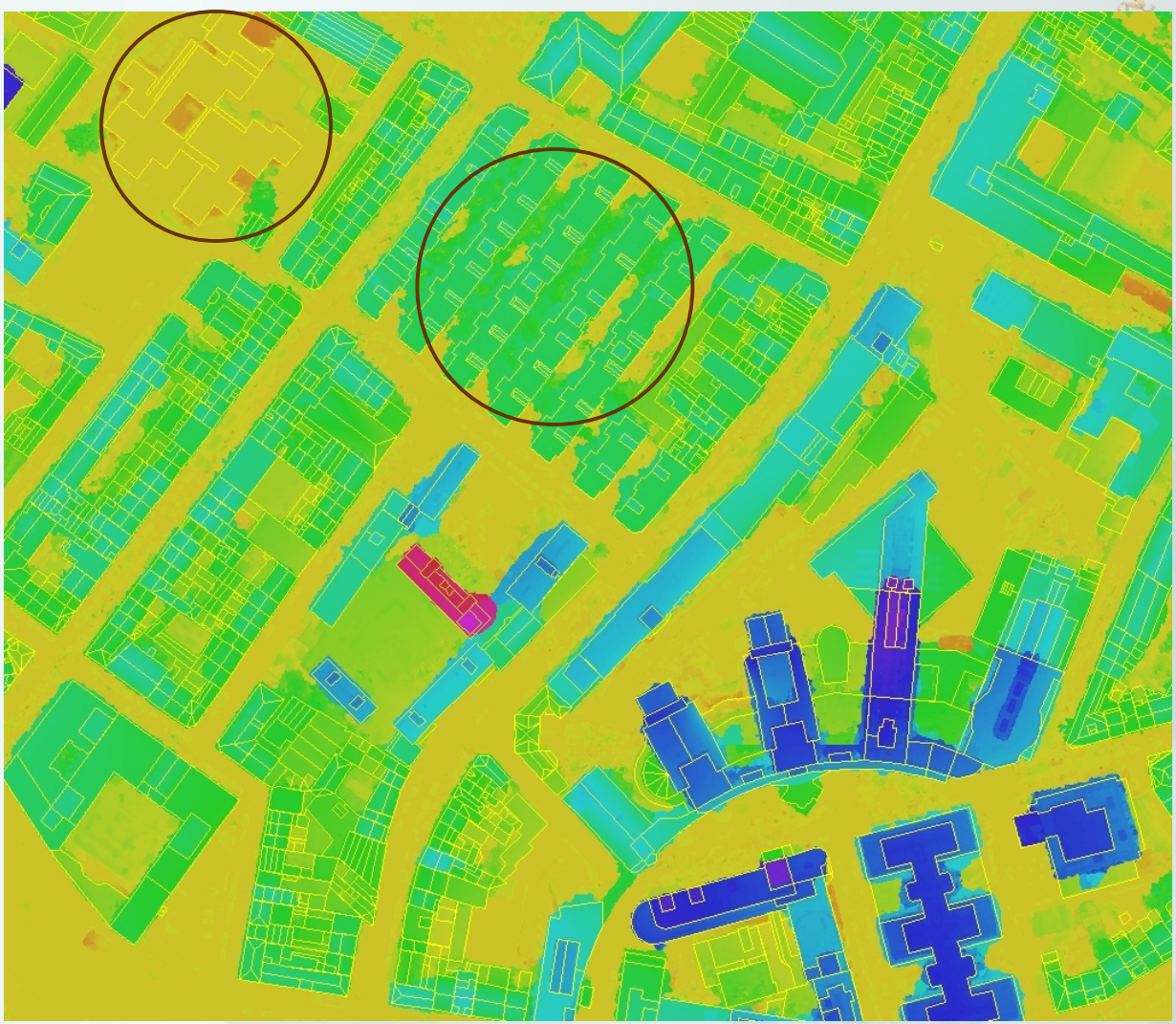
nDSM in false colour

6. Change Detection

Yellow = Ground
Rest should be Buildings
(Few trees)

No change here

! DTM errors
(False change)



nDSM and building vectors

7. Road Network from DSM

Objectives

Find roads automatically

In Urban Areas

Centre line ?

Approach : DSM

Road from optical images difficult → 3D

diversity, occlusion, shadow

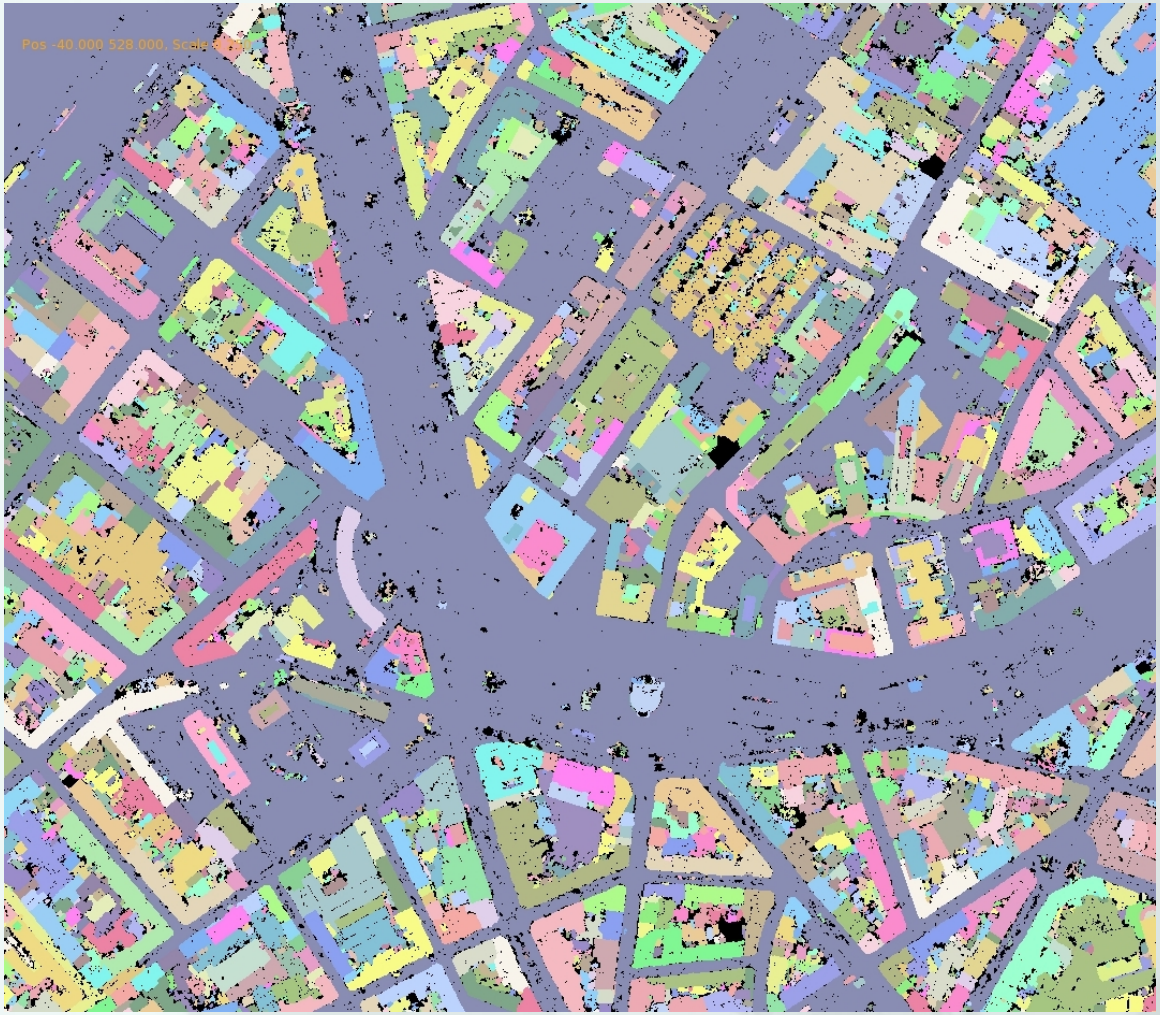
!!! Trees, Cars, Open areas

7. Road Network from DSM

Method

DSM segmentation

Into regions



Uniform regions (Porte de Halle)

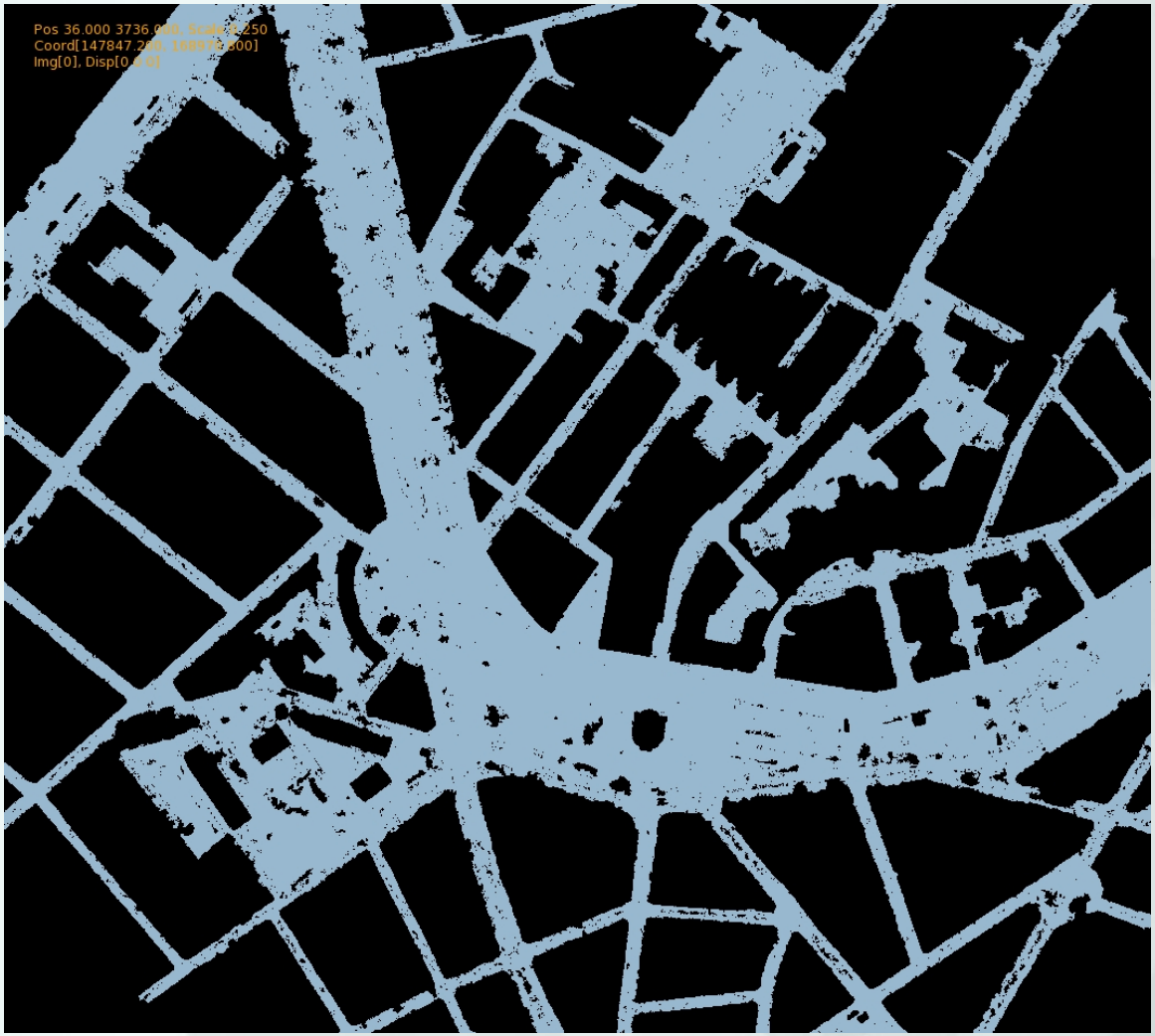
7. Road Network from DSM

Method

DSM segmentation

Keep the largest region

(lower)



Road region

7. Road Network from DSM

Method

DSM segmentation

Keep the largest region

Morphological filter

to fill gaps

Distance transfo and gap filling

7. Road Network from DSM

Method

DSM segmentation

Keep the largest region

Morphological filter

Local maxima (ridges) as centre lines

7. Road Network from DSM

Conclusions

Easy/Fast implementation

Registration potential

Interest for DTM (no city block)

Possible Future

Consider the ridges as a graph -> nodes and edges

Compare with existing network (database)

8. Roof orientation

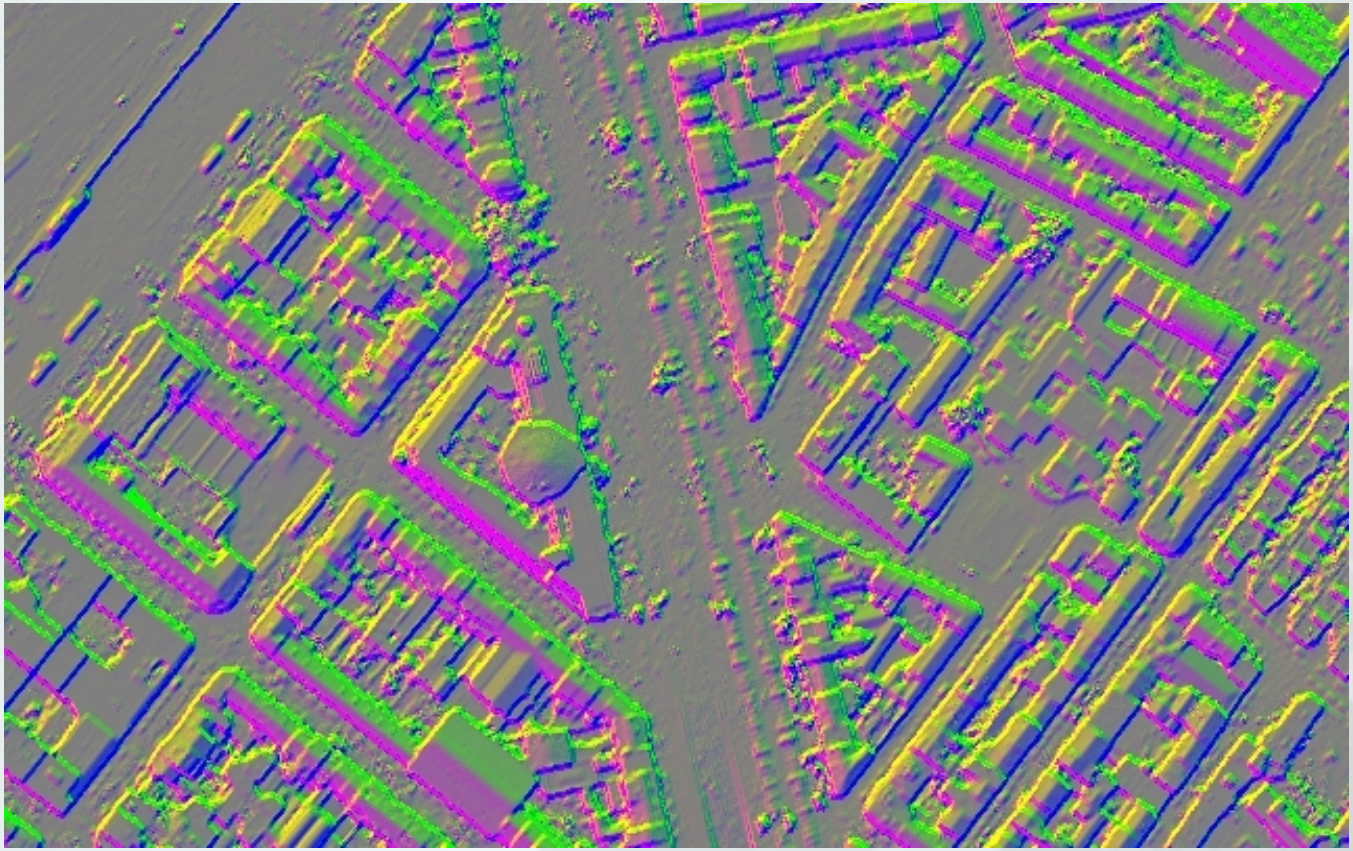
Interest for sun factor (photovoltaics)

Direct derivation from DSM

(Paris : la carte d'ensoleillement des toits en ligne (04/07/2013))

© www.ef4.be		inclinaison par rapport à l'horizontale (°)						
		0	15	25	**35**	50	70	90
orientation	est	88%	87%	85%	83%	77%	65%	50%
	sud-est	88%	93%	95%	95%	92%	81%	64%
	sud	88%	96%	99%	**max 100%**	98%	87%	68%
	sud-ouest	88%	93%	95%	95%	92%	81%	64%
	ouest	88%	87%	85%	82%	76%	65%	50%

8. Roof orientation



Roof orientation in false colour from DSM
(No analysis of occluding neighbours)

Conclusions

DSM_RMA extraction is mature

- Future: error quantification
- Future developments for Satellite imagery

DTM from DSM (urban) achieved a 'plateau'

- Inherent errors from image-based DSM (shadows)
- Difficulties inside building blocks
- ? Spectral info + a priori data (vectors, old DTM)

Change Detection

- Good potential, but vegetation
- Ground truth of change for evaluation

Road Network

- To help DTM