Overview of Research on PLEIADES at MATIS laboratory : Potential of PLEIADES Images for Mapping Applications

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Introduction

- Outline :
  - 3D building reconstruction
  - Change detection

- Work ordered by CNES

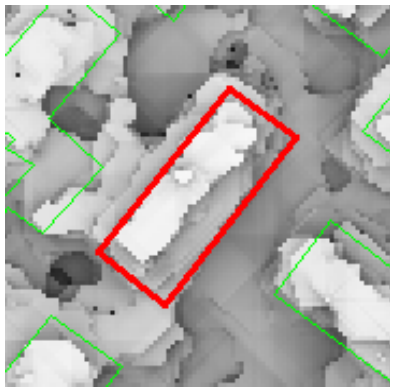
- Adapting methods for aerial images to PLEIADES simulations

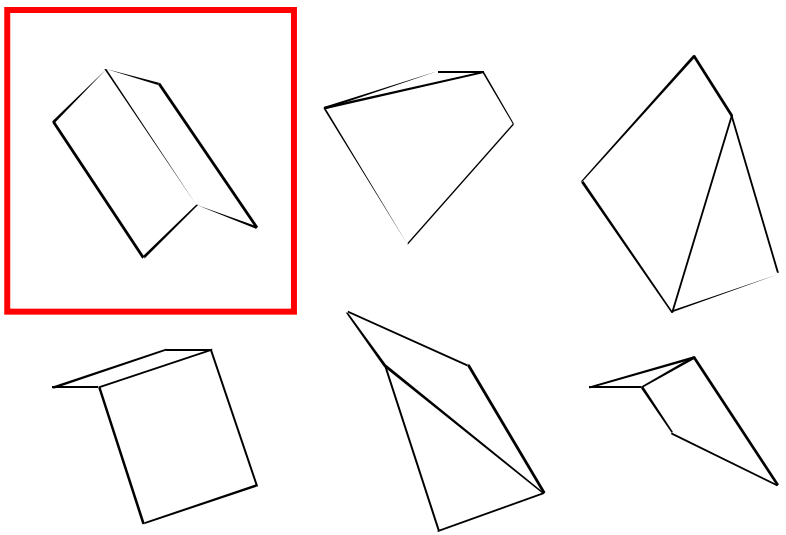
I - 3D building reconstruction

3D building reconstruction

Semi automatic approach

- Designed for very high resolution images, multiscopy
- Data : Correlation DSM, cadastral map (outline of buildings) and true orthophoto
- Integration in an interactive system
  - Correction of the outline
  - Constraints on the type of building to reconstruct





Semi automatic approach – Results

- Quality of reconstruction in relation with data quality (altimetric accuracy <1/2 level)
- Productivity quite good (at least 100b/h), 90% of the building correctly reconstructed
- Adapted for not too dense urban area

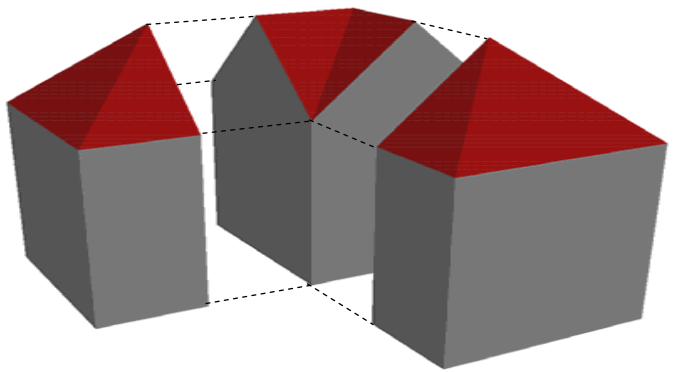
3D building reconstruction

Automatic approach

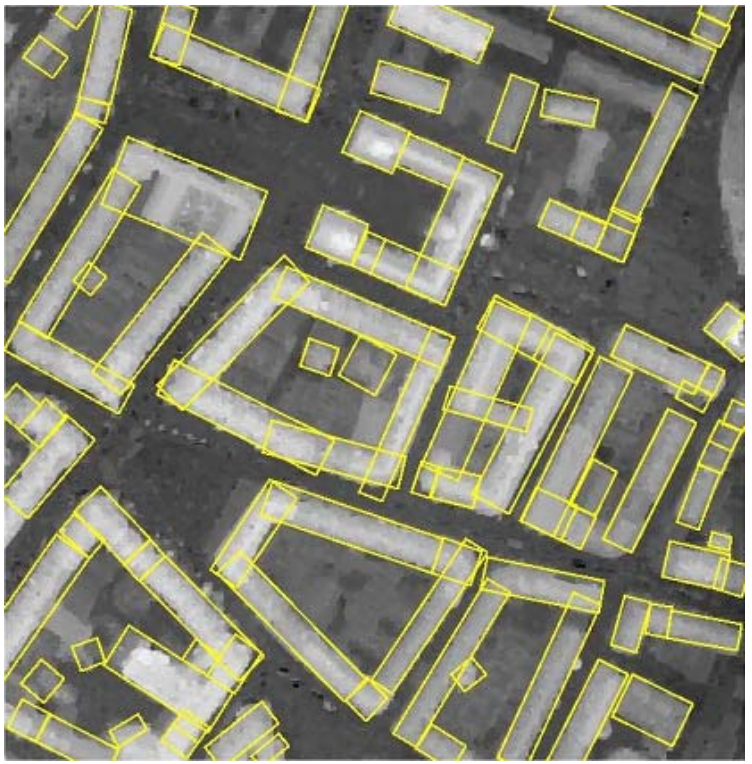
F. Lafarge PhD 2007 : Modèles stochastiques pour la reconstruction tridimensionnelle d'environnements urbains

- Designed for high resolution satellite images
- **Fully automatic**
- Data : **Only a correlation DSM**
- Adapted for dense urban area
- 2 steps :
  - Extraction of a pseudo cadastre : rectangles from the DSM
  - 3D building reconstruction

A building = an assembling of simple urban structures



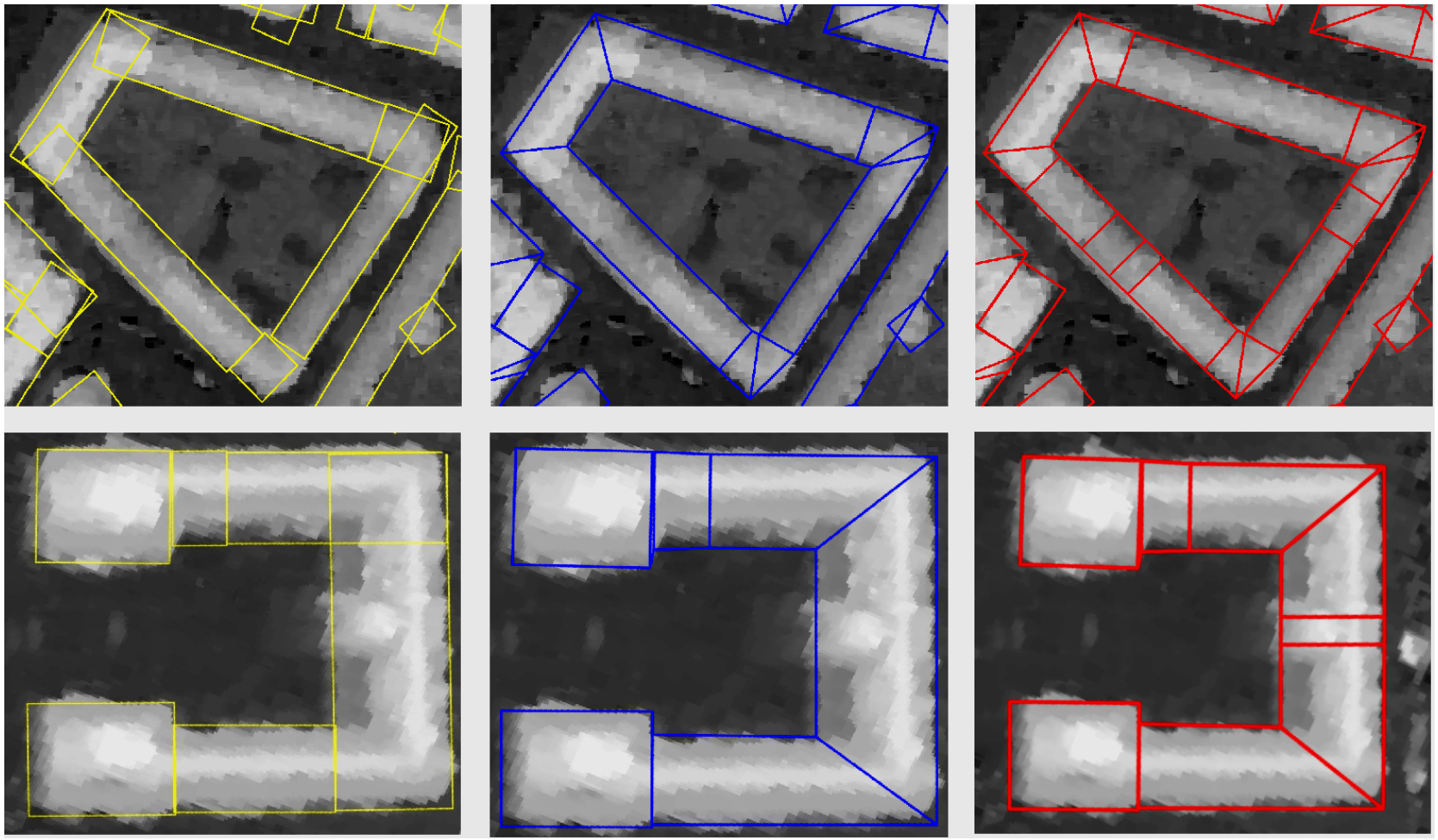
2D Extraction



Amiens

3D building reconstruction

2D Extraction



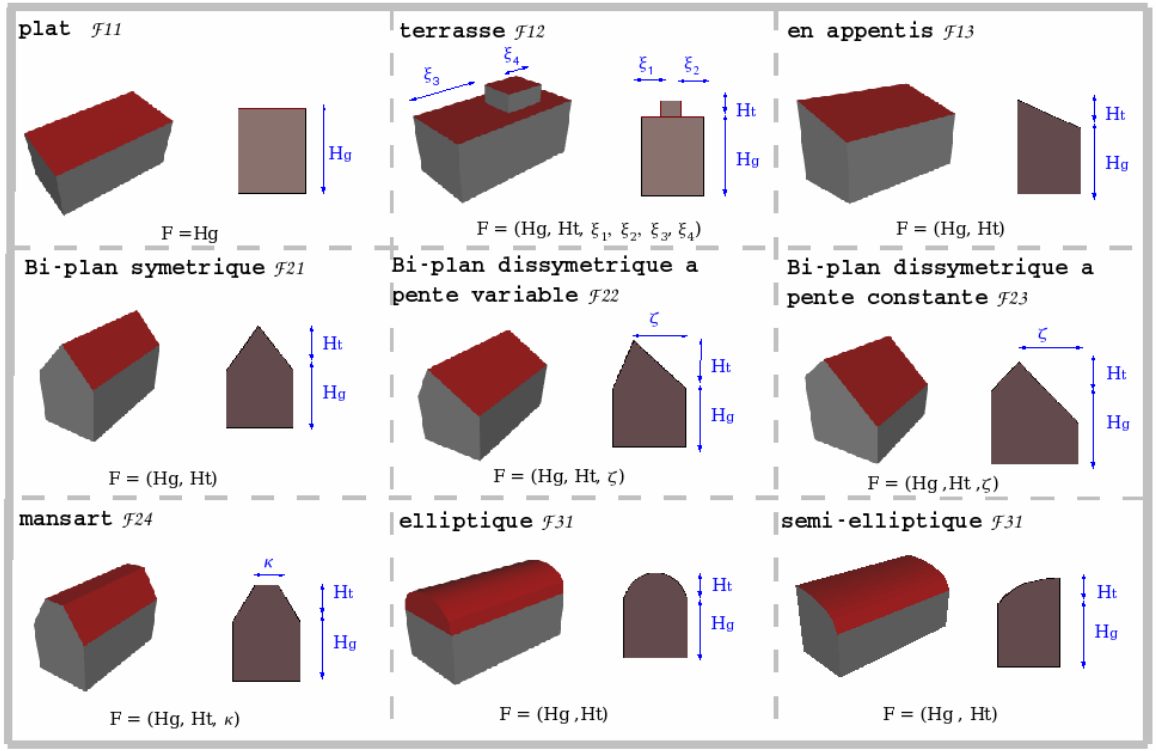
rectangular supports “connected” supports structural supports

Amiens

3D building reconstruction

Library of 3D model

- 9 forms
- 1 to 6 parameters
- included curved roofs



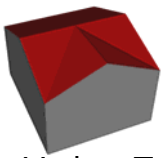
- Variants :
  - ends and junctions
  - orientation of the object


Variant **-**

Variant **V**

Variant **2V**


Variant **L**


Variant **T**


Variant **+**

3D building reconstruction

Bayesian framework

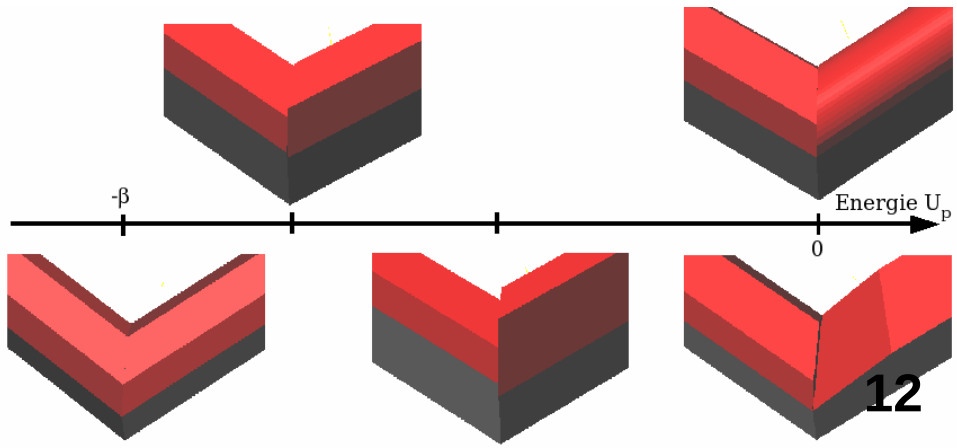
- Finding the configuration of models x which maximizes the posterior density *h:*

$$h(x) = h(x/\mathcal{D}) \propto h_p(x)\mathcal{L}(\mathcal{D}/x)$$

a priori

likelihood

- *Likelihood :* Linked to Z-error between the DSM and the proposed 3D-models
- *A priori :* Introduce knowledge on the assembling of the objects :
  - to compensate for the lack of information contained in the DSM
  - to have realistic buildings



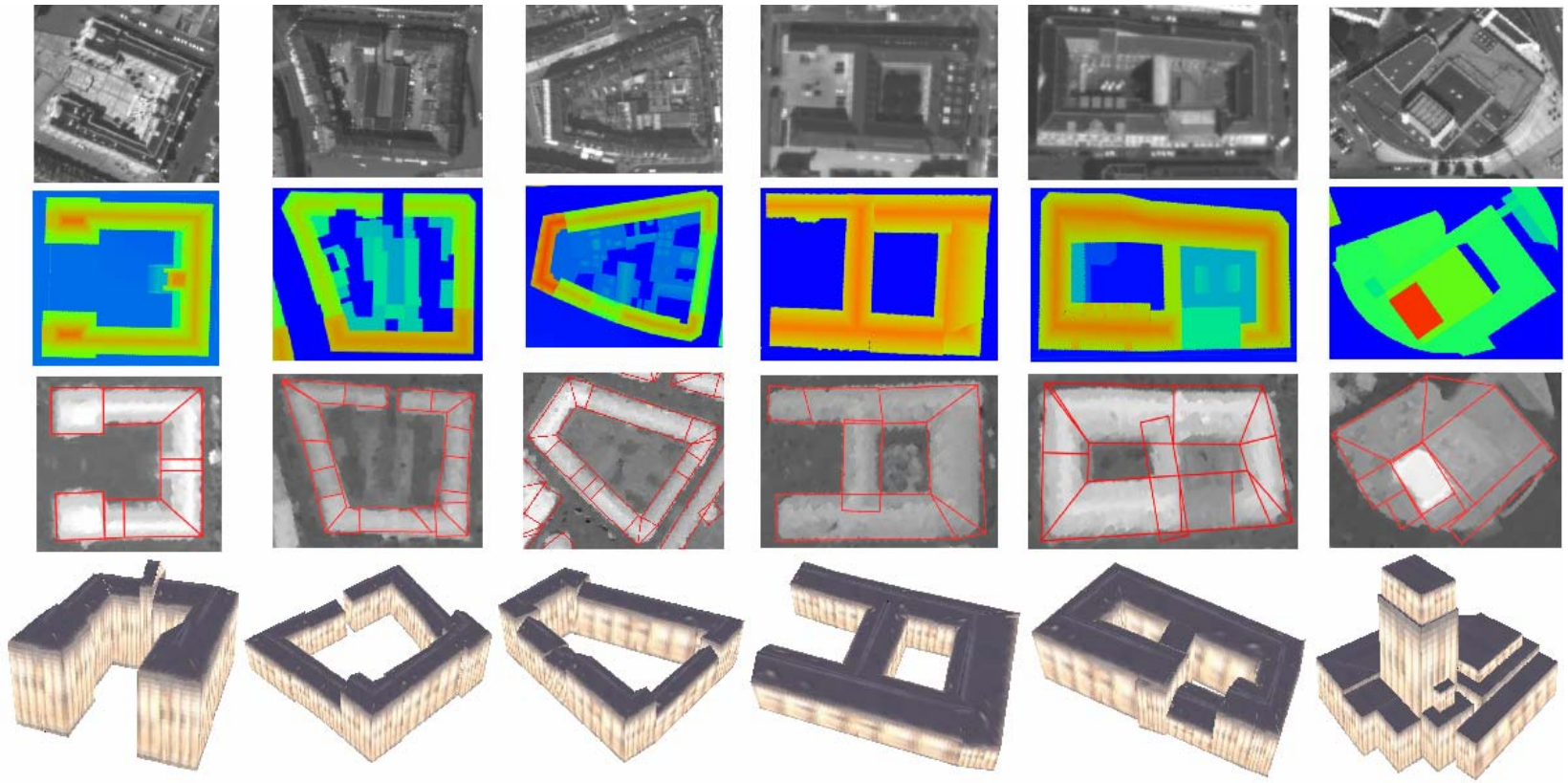
3D building reconstruction

PLEIADES simulations ©CNES

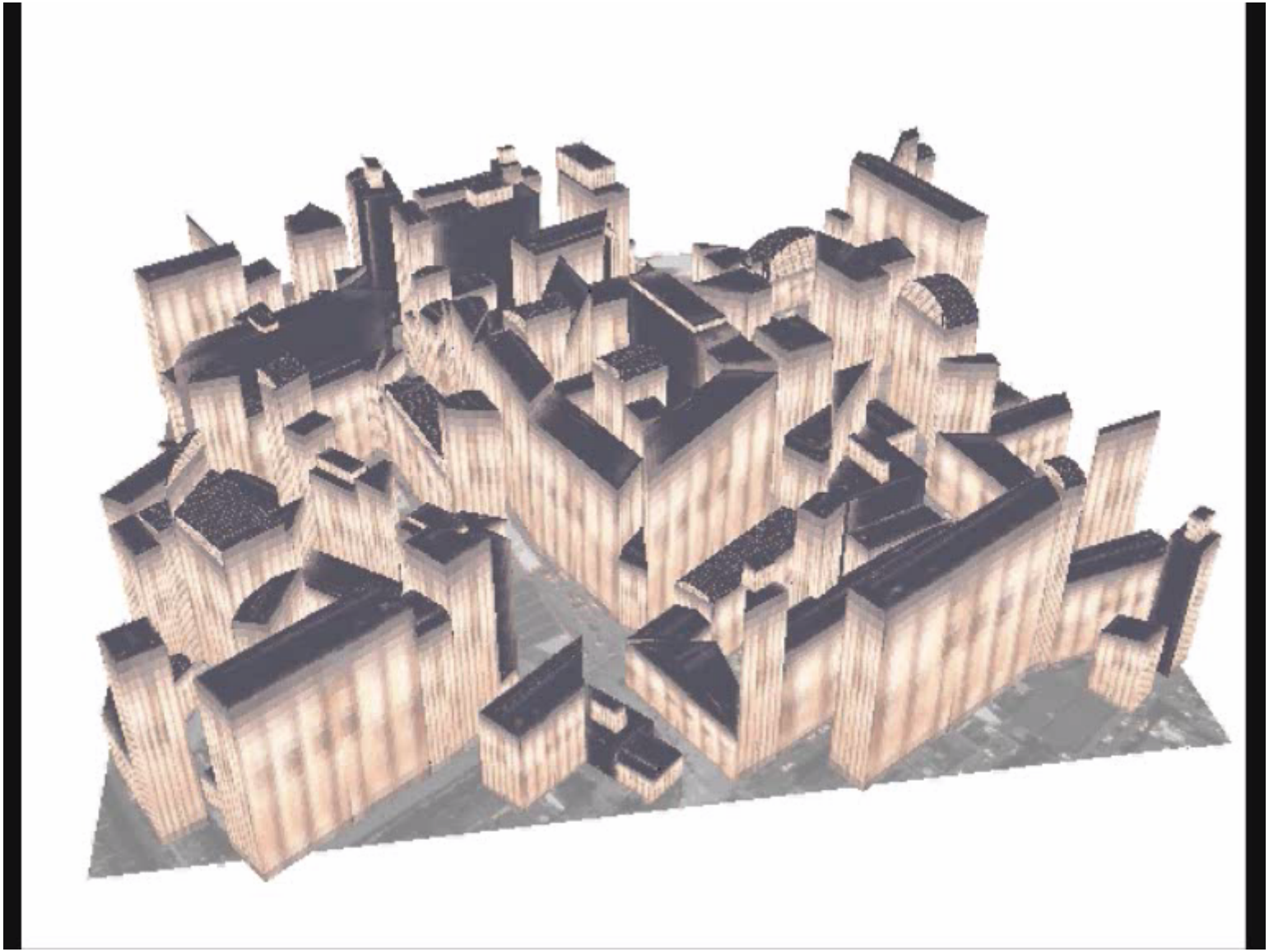
Ground truth ©IGN

Buiding Extraction

3D Reconstruction

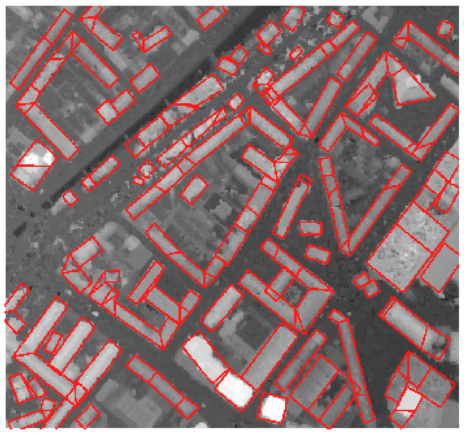


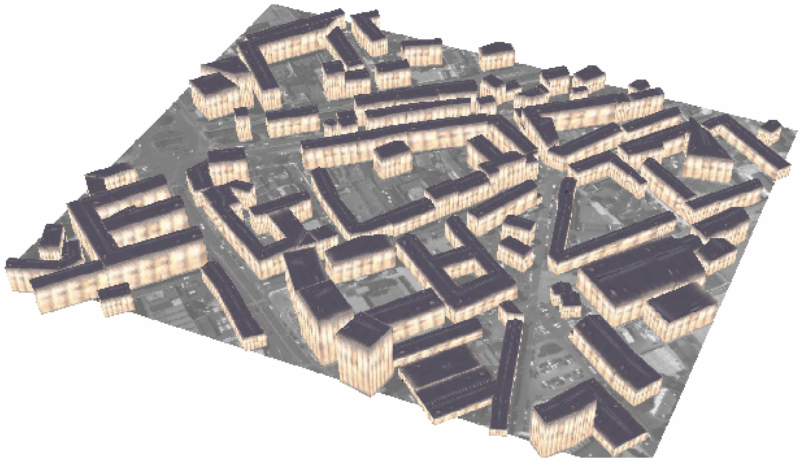
3D building reconstruction

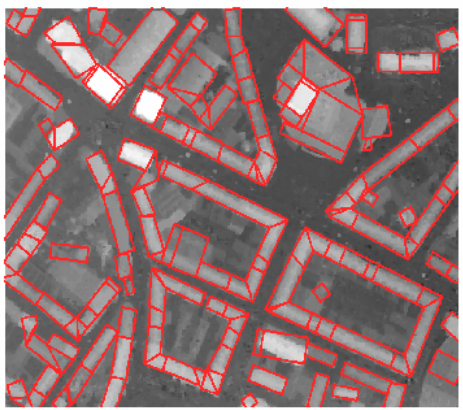


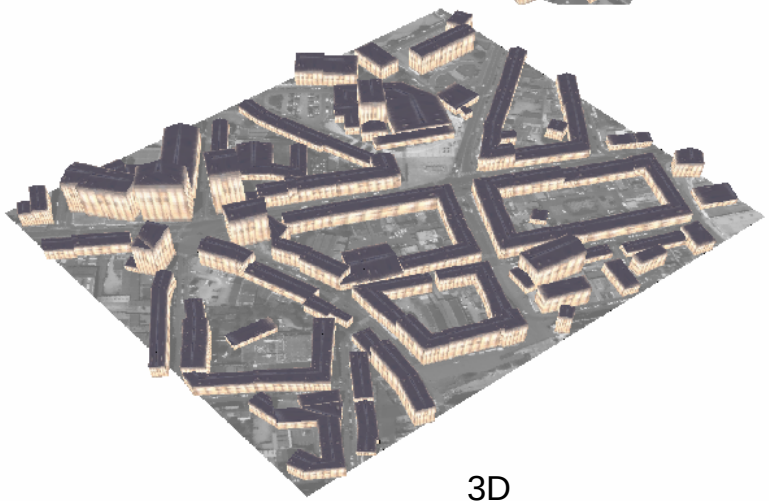
Reconstruction of a dense urban area (Amiens) from a PLEIADES DSM (0.7m resolution)

3D building reconstruction









PLEIADES simulations ©CNES

Building Extraction

3D Reconstruction

3D building reconstruction

- Interesting characteristics :
  - Original and difficult context : satellite data – a single DSM – automatic without cadastral maps – dense urban areas
  - Adaptive method (different roof models, various data resolutions)

- Limits :
  - Restricted use in some situations (discontinuities in DSMs, vegetation, inner courtyards)
  - No 2D correction between extraction and reconstruction stages
  - Computing time

II - Change Detection

Change Detection : Context

- 2D topographic databases completed → revision
- Updating maps is tedious, time-consuming and expensive
- Semi-automatic tools : detect changes in a database from recent data (PLEIADES images)
- An operator verifies only the changes detected

Change Detection : Principles

2 approaches tested

- First approach : 3D approach, focused on buildings
- Second approach : Classification approach

Change Detection : 3D approach

N. Champion et al. : Automatic Revision of 2D Building Databases from High Resolution Satellite Imagery: A 3D Photogrammetric Approach. Agile , Hanover, Germany , May-June 2009.

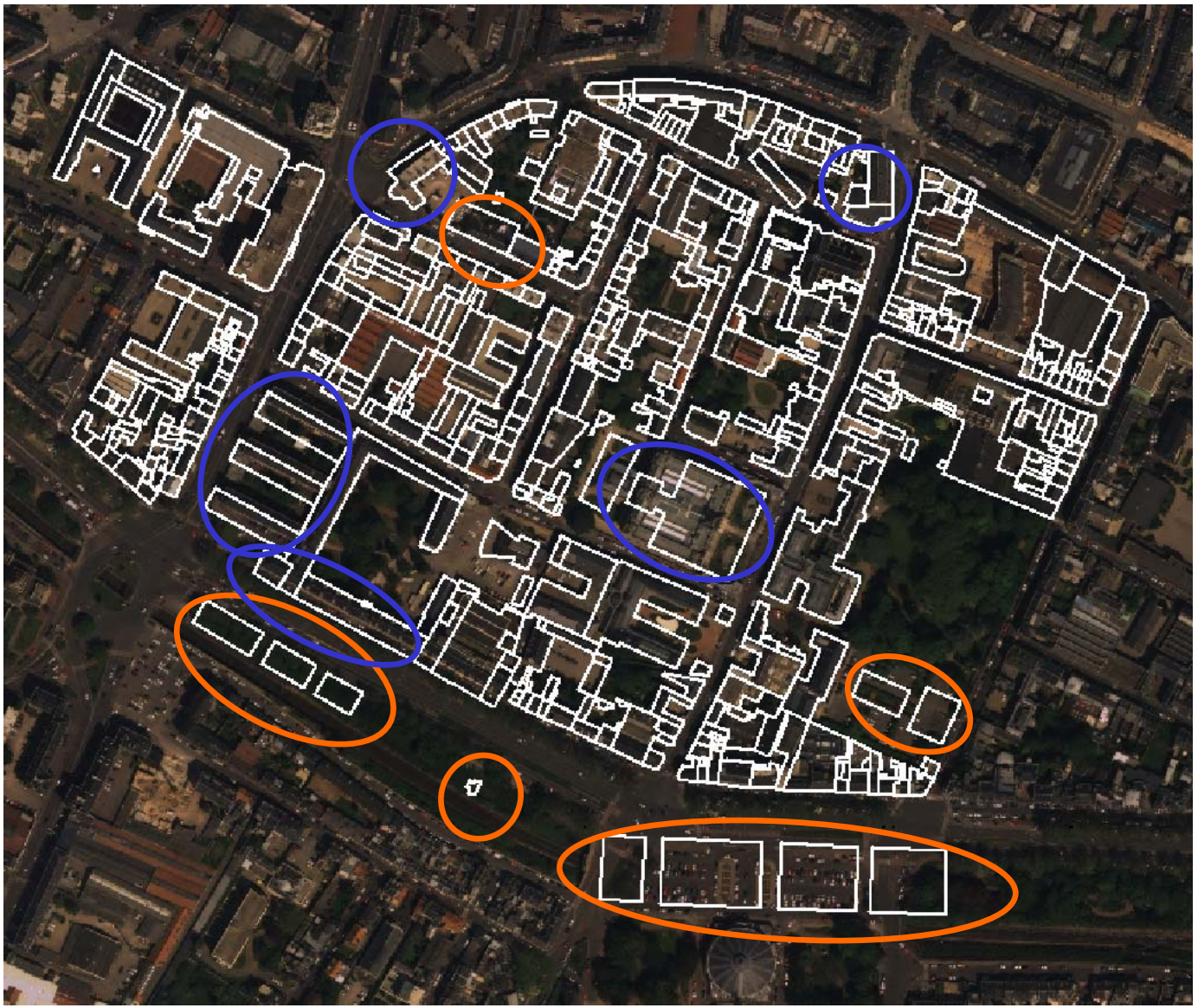
Data

- Correlation DSM
- DTM, derived from the DSM
- Vegetation mask, derived from NDVI

Principle

- Automatic verification of the database : comparison between geometric primitives extracted from the DSM and images and vector database → suppressed buildings
- Detection of new buildings : comparison of above ground mask (DSM-DTM, vegetation) with the existing database

Change Detection : 3D approach - Results



Amiens

Change Detection : 3D approach - Results

Real changes

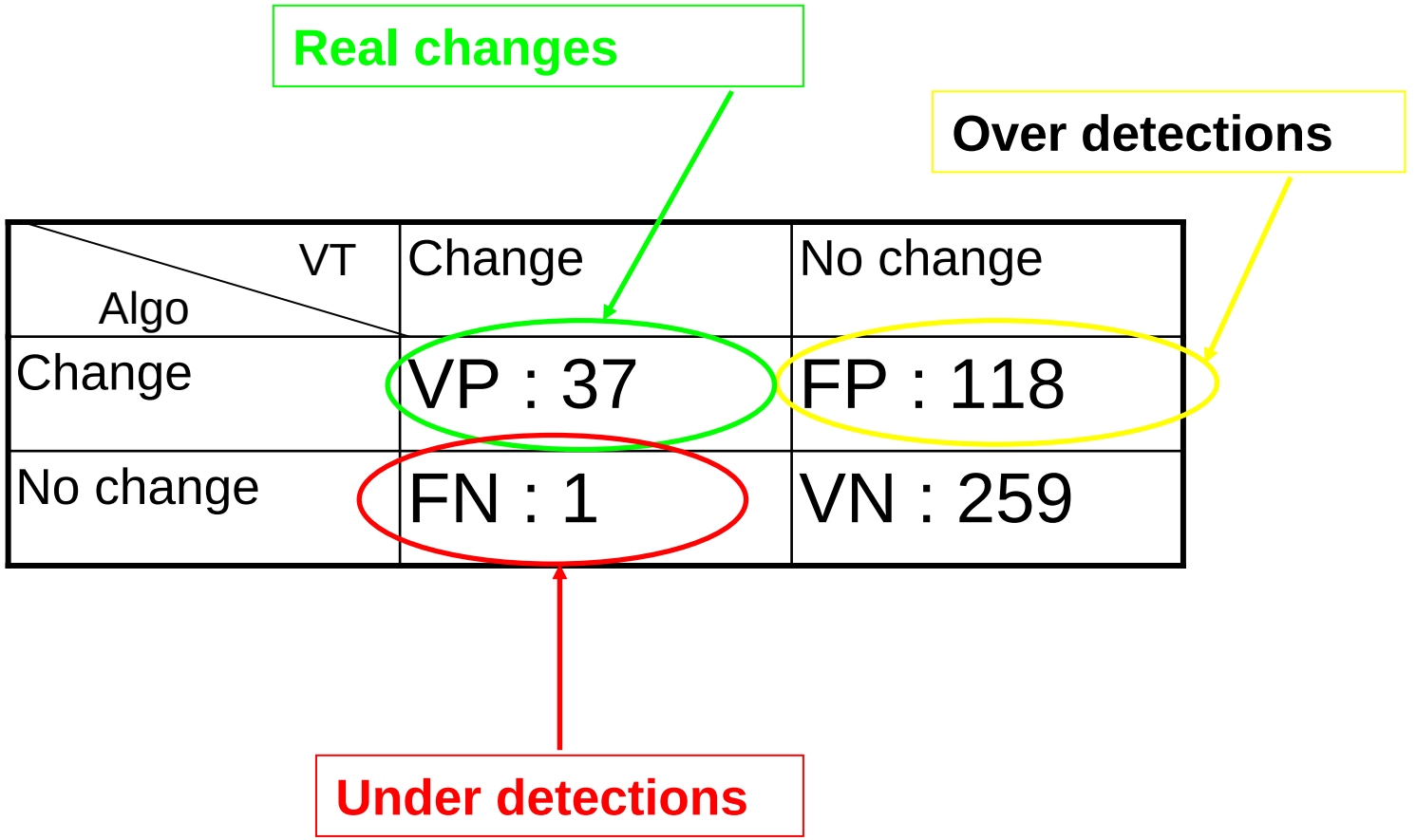
Under detections

Over detections

Amiens

Change Detection : 3D approach - Results

Amiens



35% of the database to verify
Completeness : 97 %
Correctness : 24%

Change Detection : 3D approach - Results

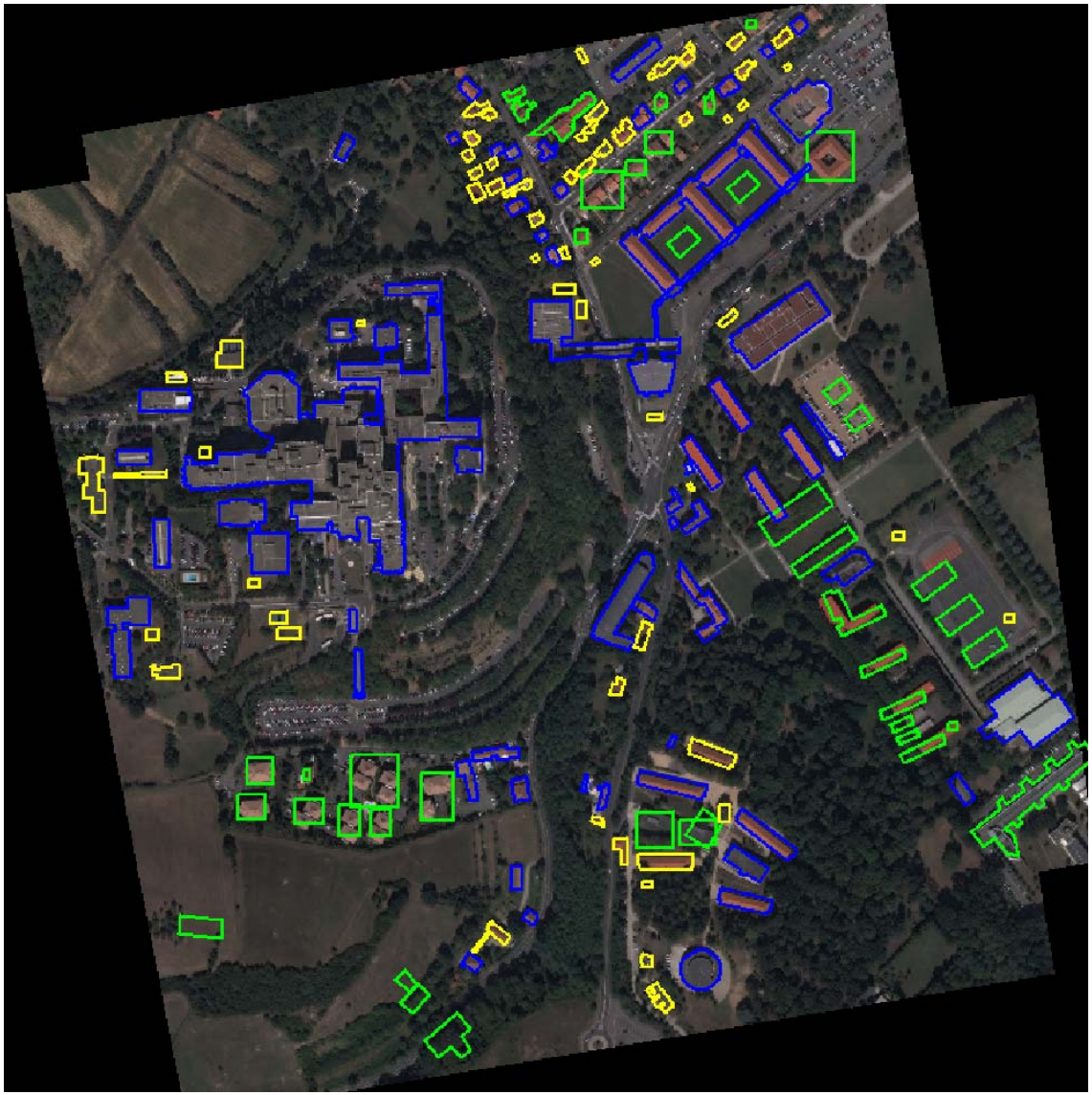
Toulouse

Change Detection : 3D approach - Results

Real changes

Under detections

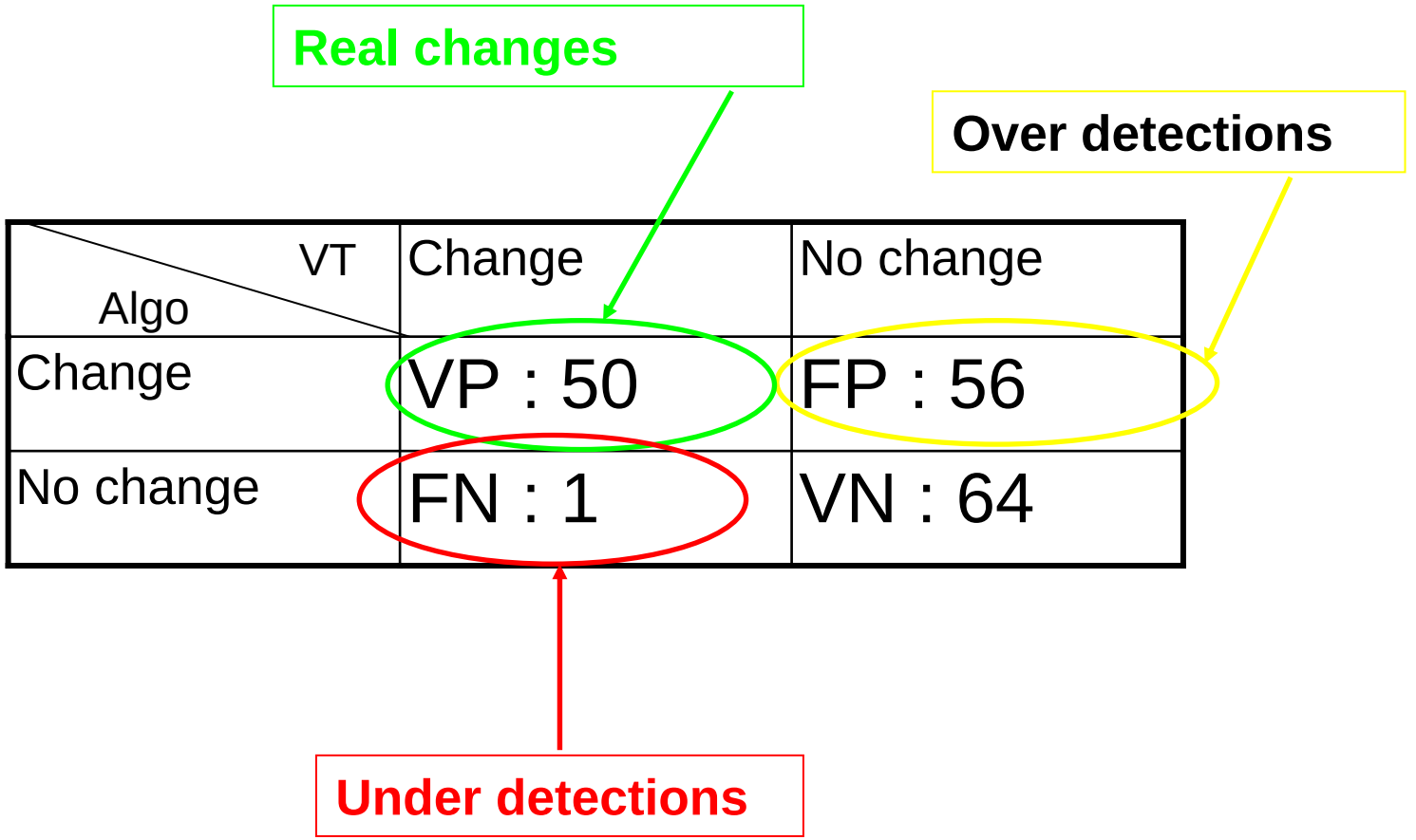
Over detections



Toulouse

Change Detection : 3D approach - Results

Toulouse



62% of the database to verify
Completeness : 98 %
Correctness : 47%

Change Detection : Classification approach

Data

- Orthoimage RGB + NIR
- Database to update : buildings, roads, vegetation…
- Options : Correlation DSM, DTM

Principle

- Estimation of a model from the existing database : training data
- Classification of images following the model
- Differences between classification and database → changes
- Classification mistakes between roads and grey roof buildings → DSM & DTM
- …

Change Detection : Classification approach

New buildings

Buildings suppressed

Toulouse 1

Change Detection : Classification approach

buildings

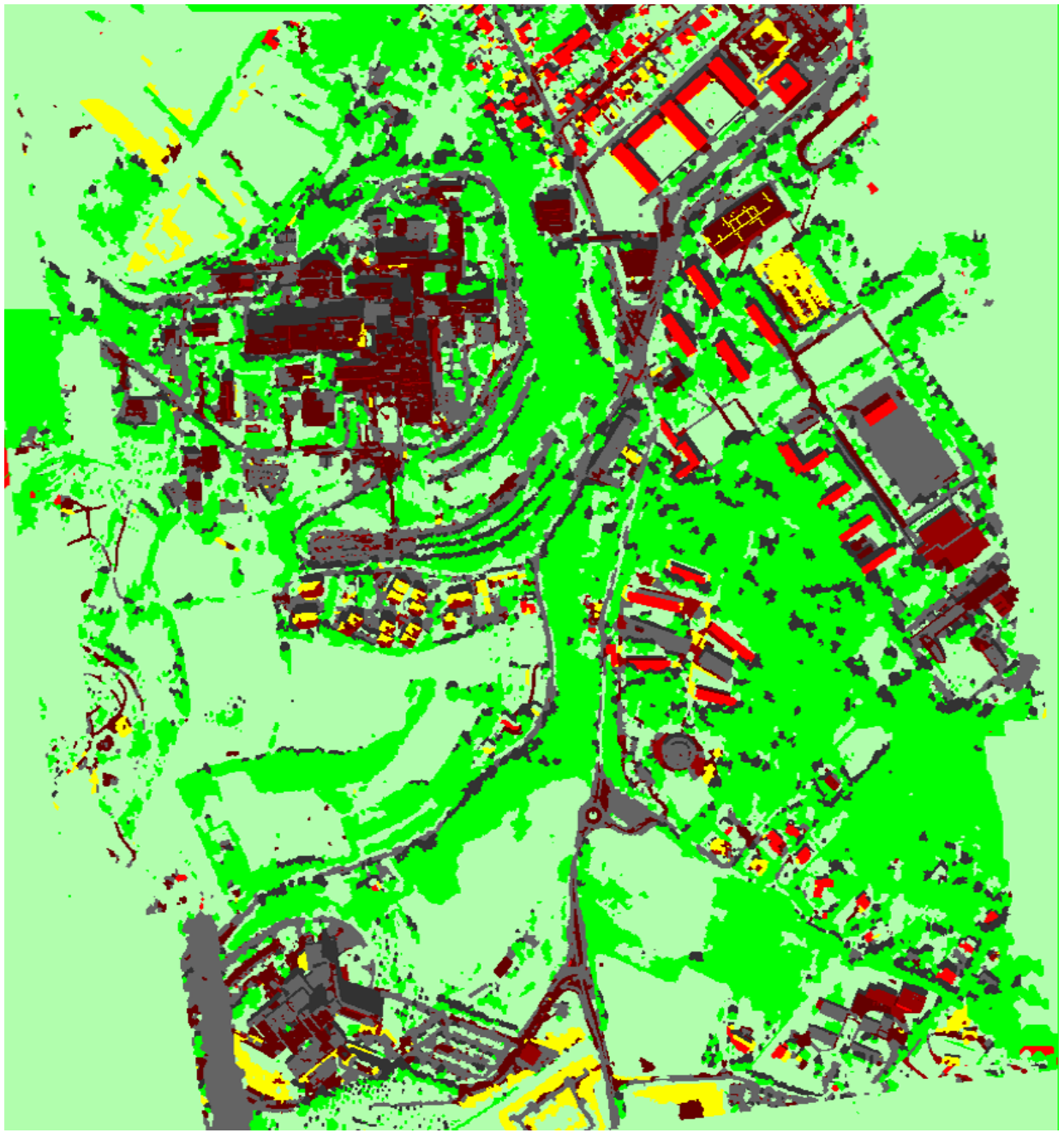
bare soil

trees

grass

roads

shadows



Classification : only radiometry

Results Toulouse 1

Change Detection : Classification approach

buildings

bare soil

trees

grass

roads

shadows

Classification : radiometry and database and DSM/DTM

Results Toulouse 1

Change Detection : Classification approach

New buildings

Results
Toulouse 1

Change Detection : Classification approach

Buildings suppressed

Results Toulouse 1

Change Detection : Classification approach

Toulouse 1

New buildings :

- Simulations : 16
- Completeness : 88% (14/16)
- Correctness : 31%

Suppressed buildings :

- Simulations : 7
- Completeness : 86% (6/7)
- Correctness : 7% (86 overdetections)

Change Detection : Classification approach

New buildings

Buildings suppressed

Toulouse 2

Change Detection : Classification approach

buildings

bare soil

trees

grass

roads

shadows

Classification : only radiometry

Results Toulouse 2

Change Detection : Classification approach

buildings

bare soil

trees

grass

roads

shadows

Classification : radiometry and database and DSM/DTM

Results Toulouse 2

Change Detection : Classification approach

New buildings

Results Toulouse 2

Change Detection : Classification approach

Buildings suppressed

Results Toulouse 1

Change Detection : Classification approach

Toulouse 2

New buildings :

- Simulations : 29
- Completeness : 100%
- Correctness : 31%

Suppressed buildings :

- Simulations : 15
- Completeness : 87% (13/15)
- Correctness : 21%

Conclusion

- 2 promising methods
- Work in progress…
  - Cooperation between these methods
  - Comparison 3D / 3D

Thank you for your attention !