

# EURO-SDR Project

## **Benchmarking of Image Matching processes for DSM Computation**

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**1 – Presentation of the project**

**2-Technical aspect IGN's participation**

**3-First results of the project**

**Future and conclusion**

# 1 – Presentation of the project

# Objective of the project

## Motivation :

**At the beginning of 2000's laser scanning was thought to make photogrammetry useless.**

**Then came digital camera :**

**High image quality**

**Image is “cheap” : redundancy  
(multiple correlation).**

**Then came algorithms improvements :**

**Optimization (SGM, Graph Cut)**

**Multi resolution, multi scale**

**At end of years 200X some convergent opinion that image matching may be an alternative to Laser. For example :**

**Halla's paper in phowo 2009 (come back of digital image matching)**

**Leberl's show in phowo 2009 ("throw away your expensive useless scanner" )**

**Development of new commercial solution (inpho, LPS)**

**IGN France experience on Bati 3D project (3D city model using MicMac's DEM).**

## It was time to make tests and evaluation :

- Test different algorithms and software solutions
- On a limited number of data sets:
  - Maybe 3 or 4 areas of 1 or 2 Km<sup>2</sup>
- Evaluation based on Reference data from
  - higher resolution images
  - LiDAR data
  - Manual measurements



State of the art

Pros / cons of the available solutions

Find new perspectives for research on image matching

## **Data Set**

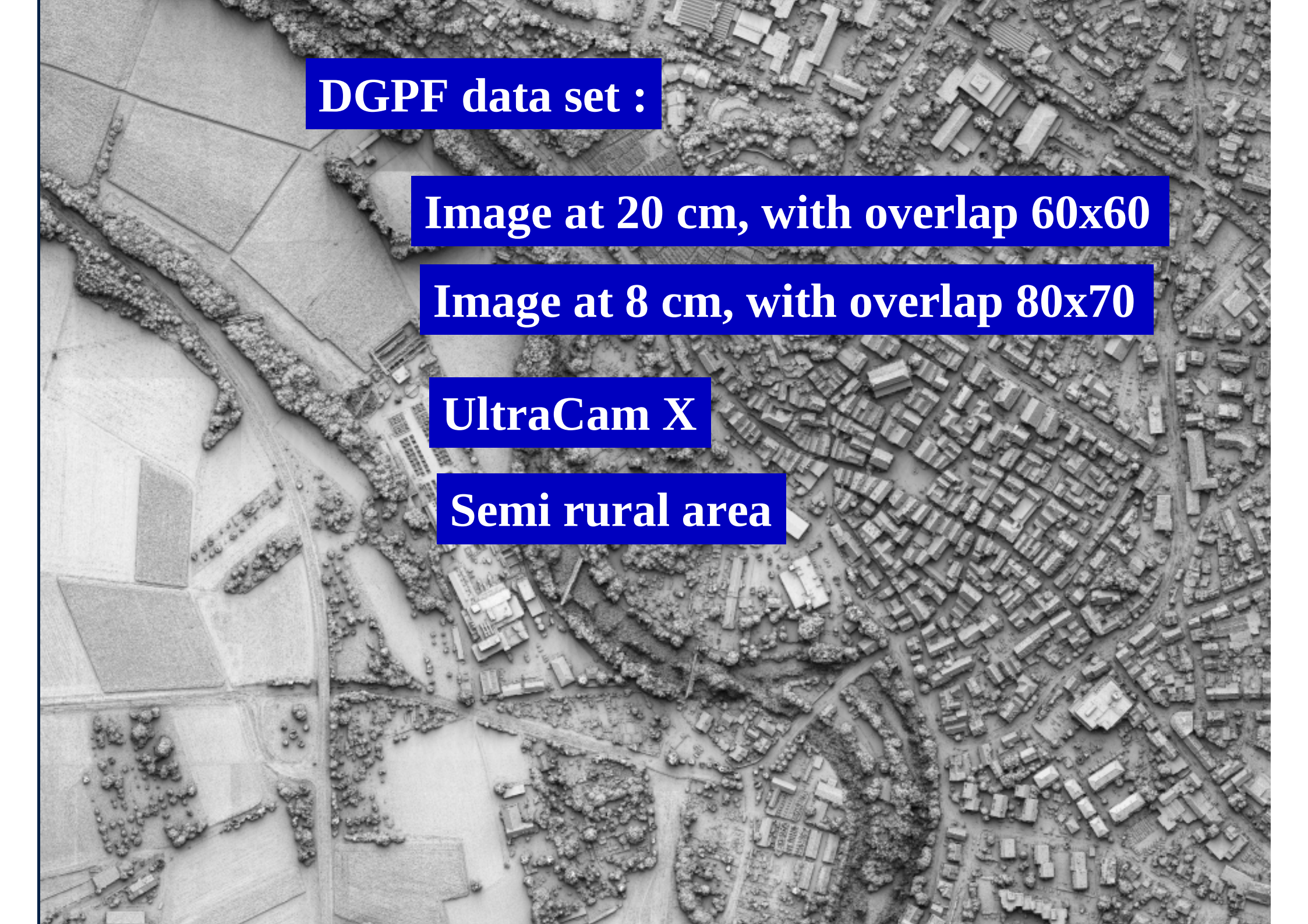
**Four data set have been collected :**

**DGPF data set by IFP**

**Algorta Data set by IGN Spain**

**Ticino data set by Swiss Topo**

**Marseille data set by IGN France**



DGPF data set :

Image at 20 cm, with overlap 60x60

Image at 8 cm, with overlap 80x70

UltraCam X

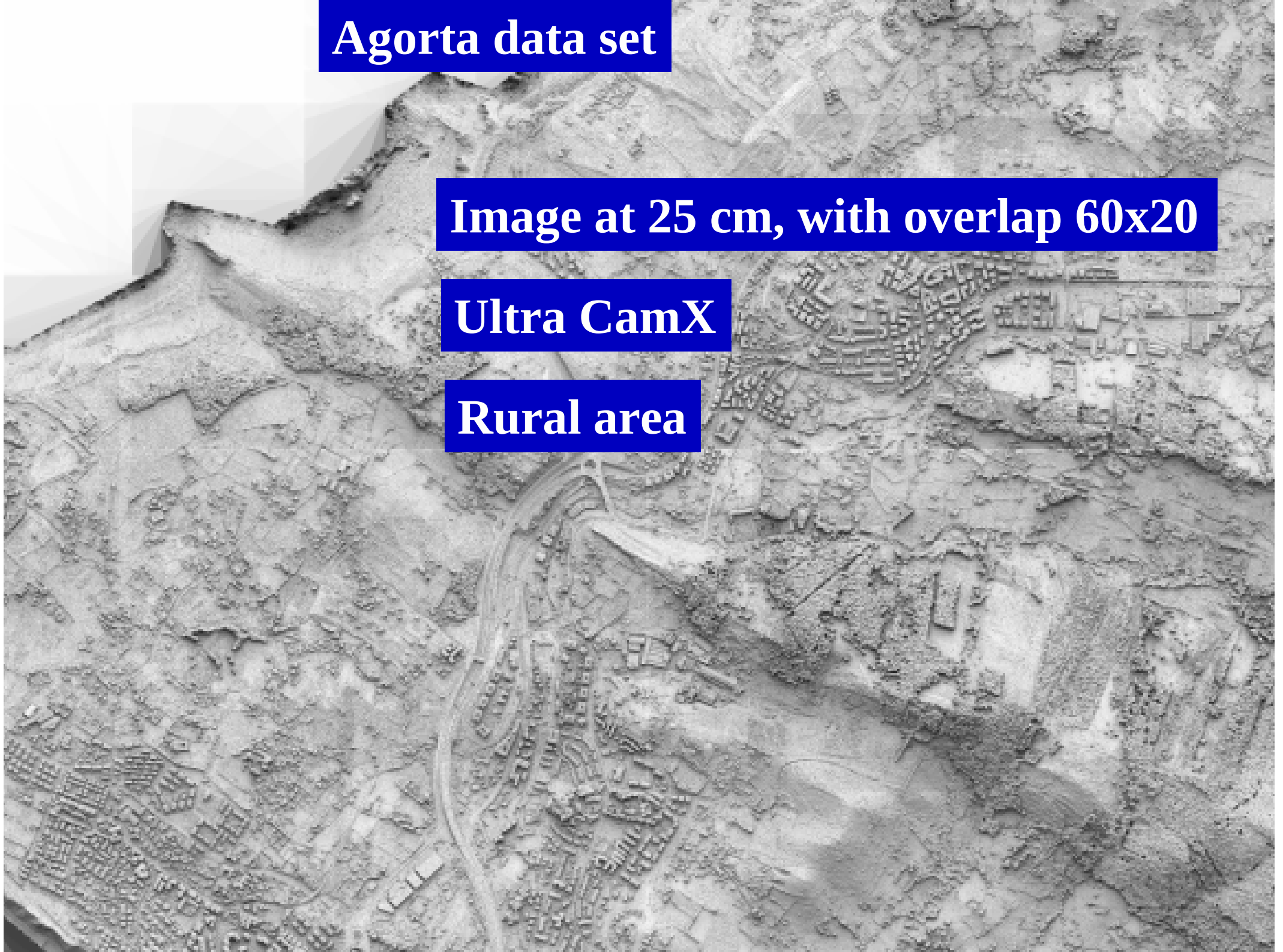
Semi rural area

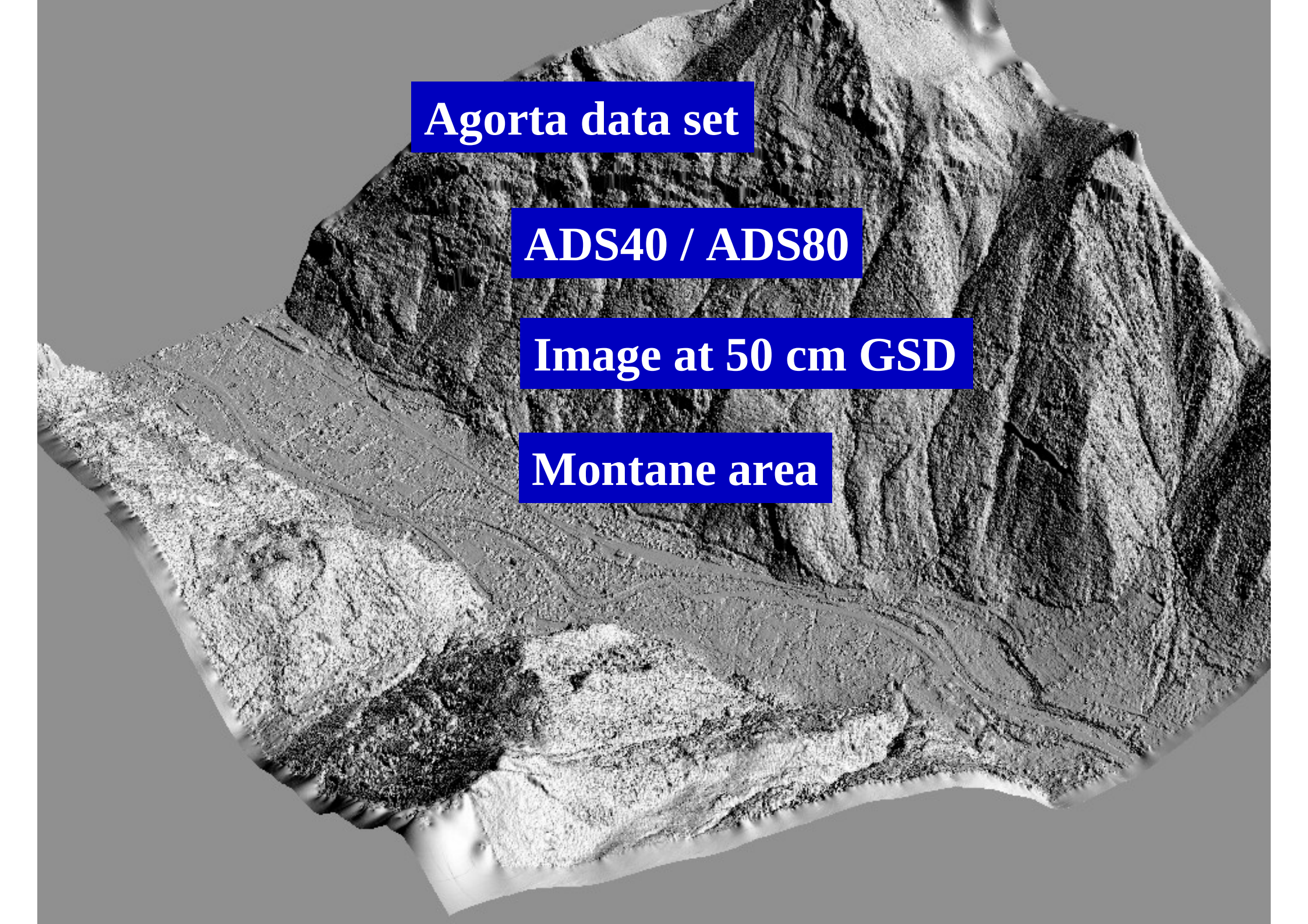
**Agorta data set**

**Image at 25 cm, with overlap 60x20**

**Ultra CamX**

**Rural area**



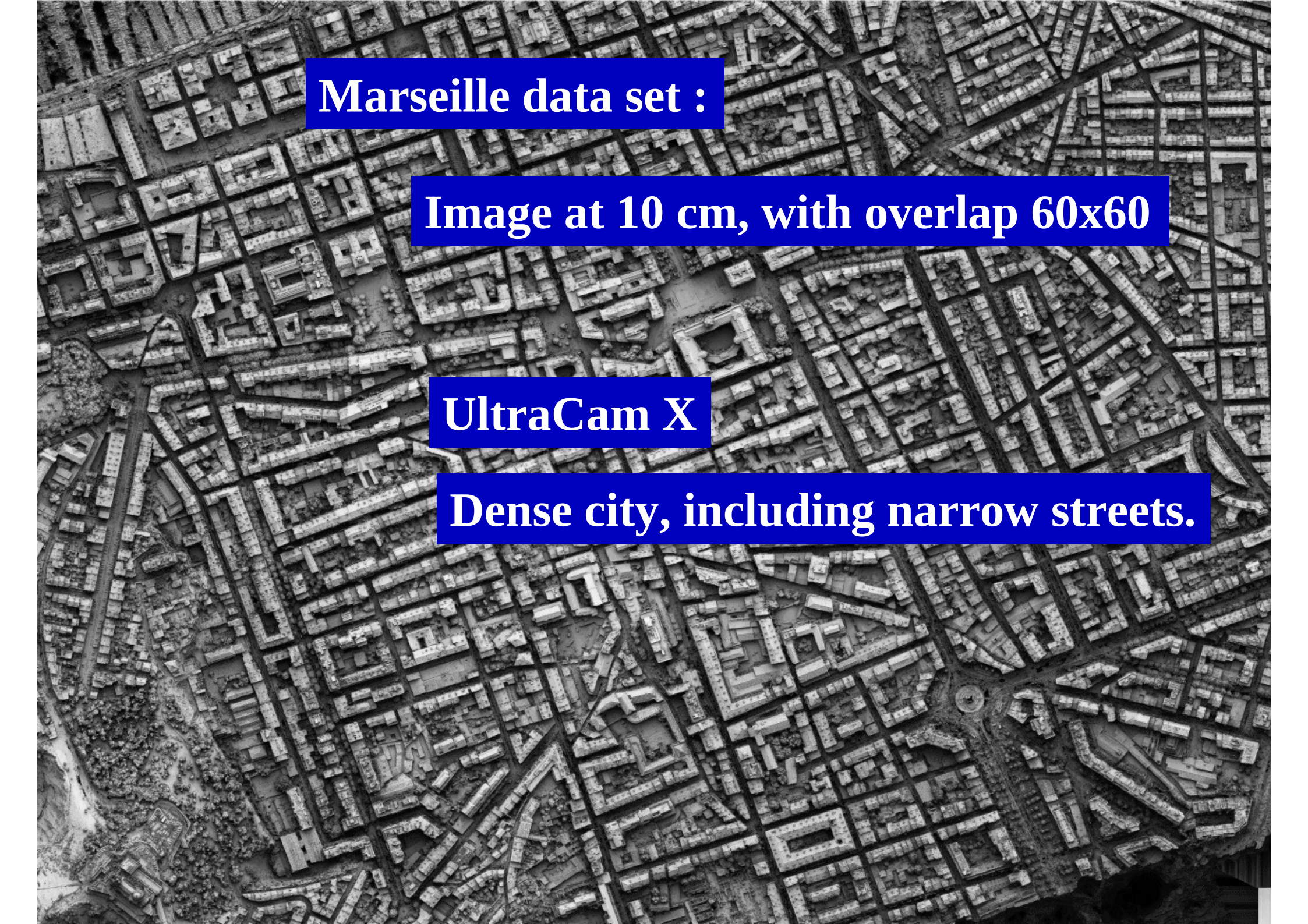


**Agorta data set**

**ADS40 / ADS80**

**Image at 50 cm GSD**

**Montane area**



**Marseille data set :**

**Image at 10 cm, with overlap 60x60**

**UltraCam X**

**Dense city, including narrow streets.**

**Not a perfect data set but :**

**Variety of resolution and overlapping**

**Variety of landscape**

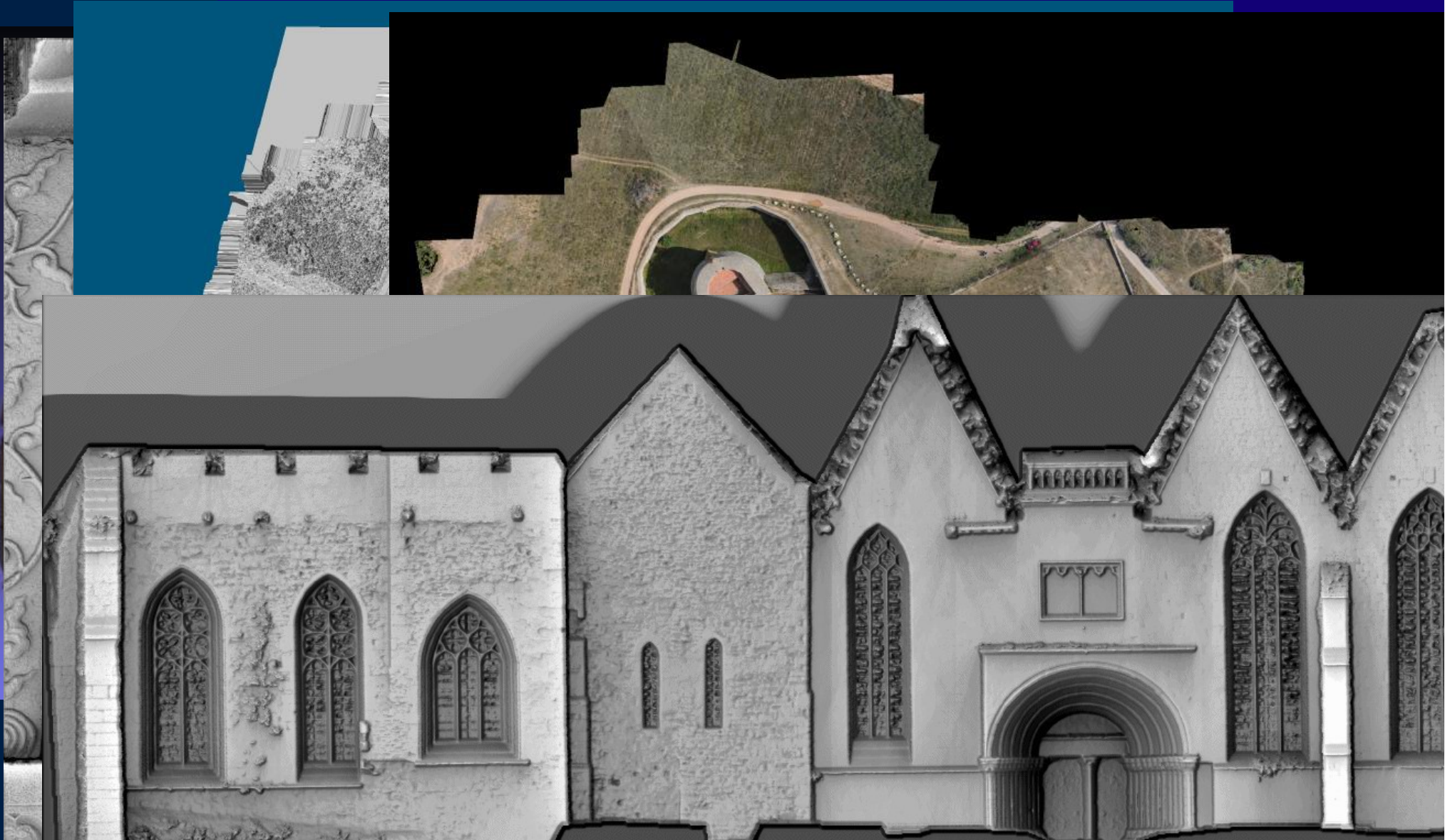
**Variety of camera**

**And already a huge set of data to  
download !**

**It was decided to limit to these 4 data set.**

## 2-Technical aspect IGN's participation

# Based on IGN's open source photogrammetric pipeline for image based 3D modelisation:



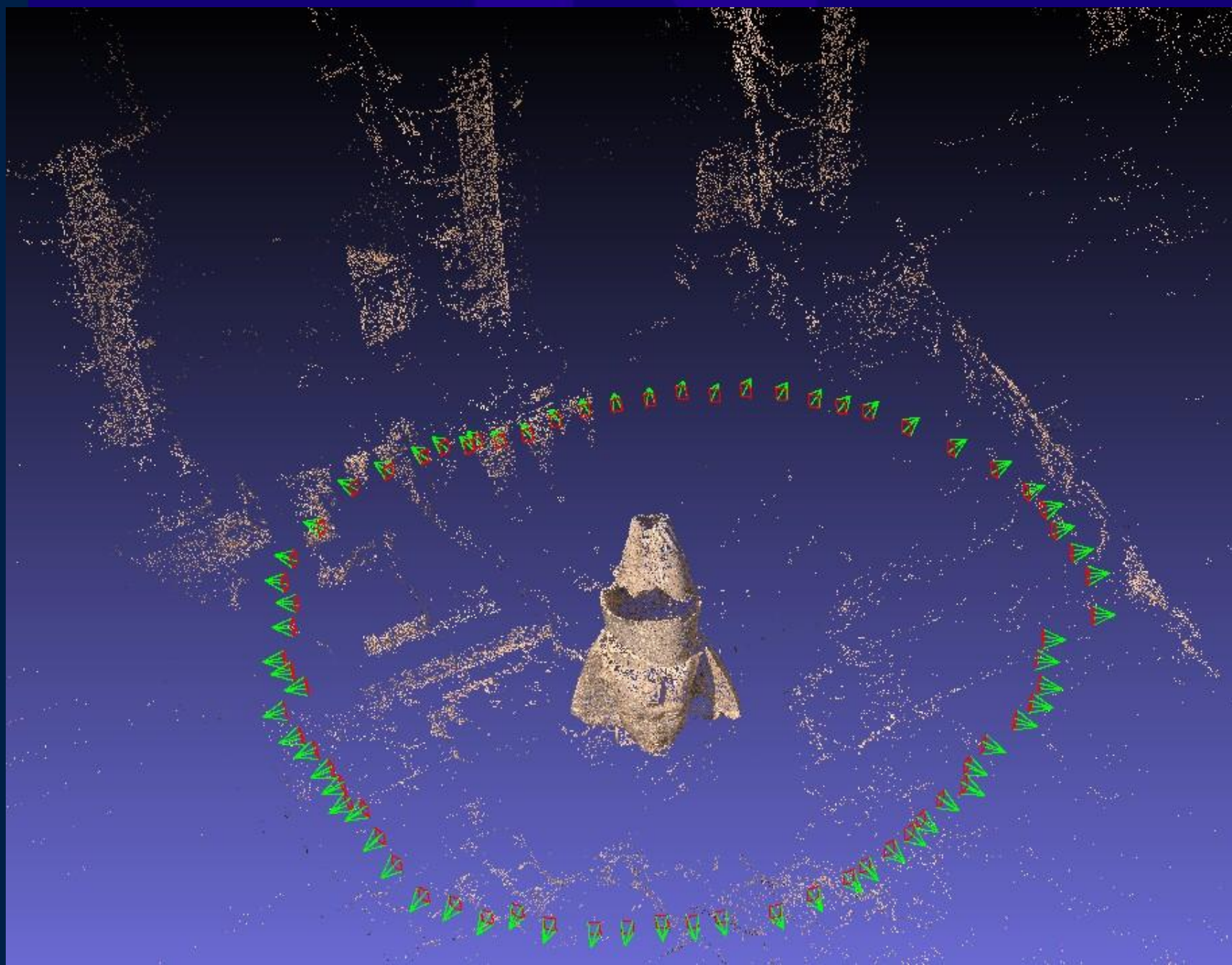
# First, get images



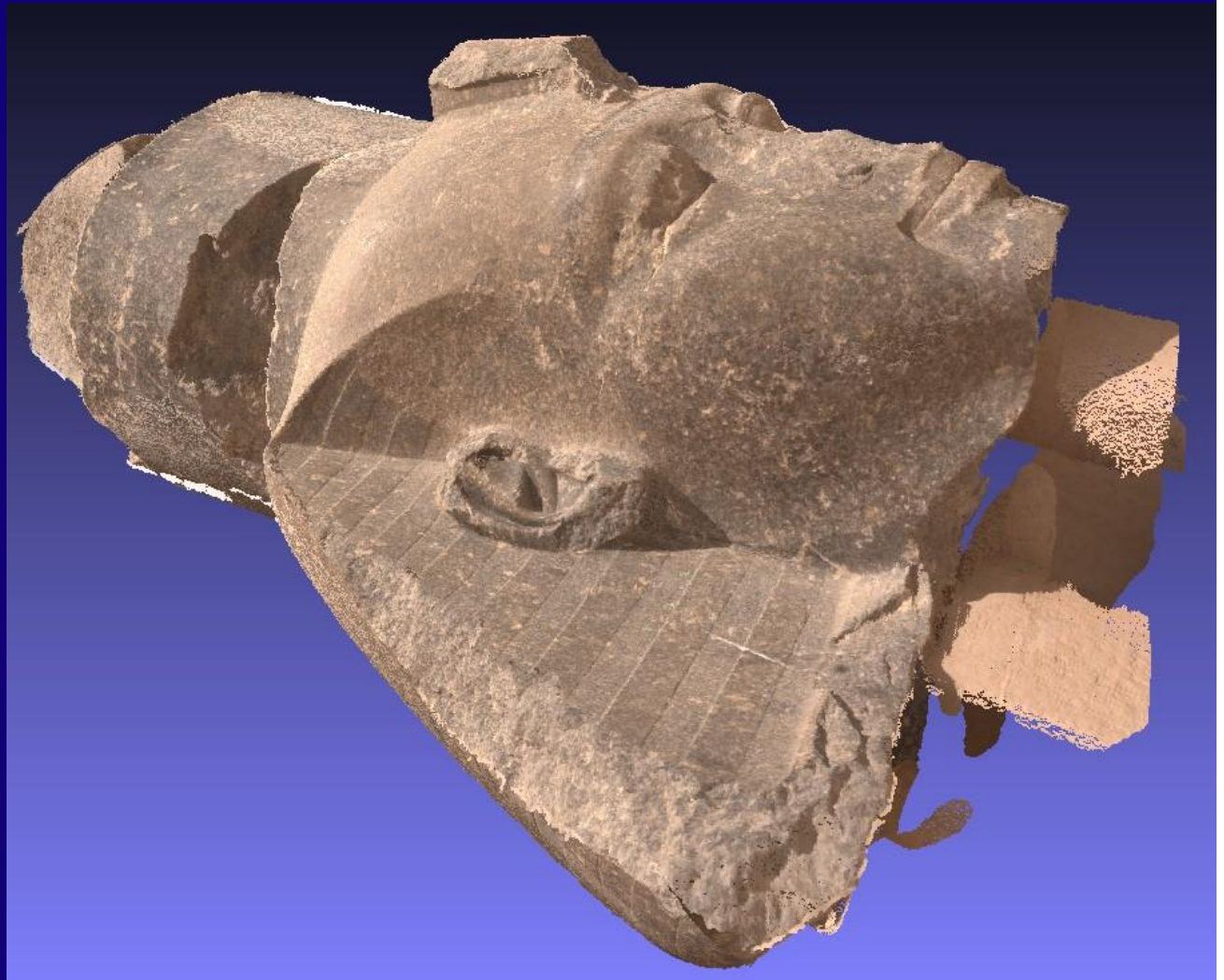
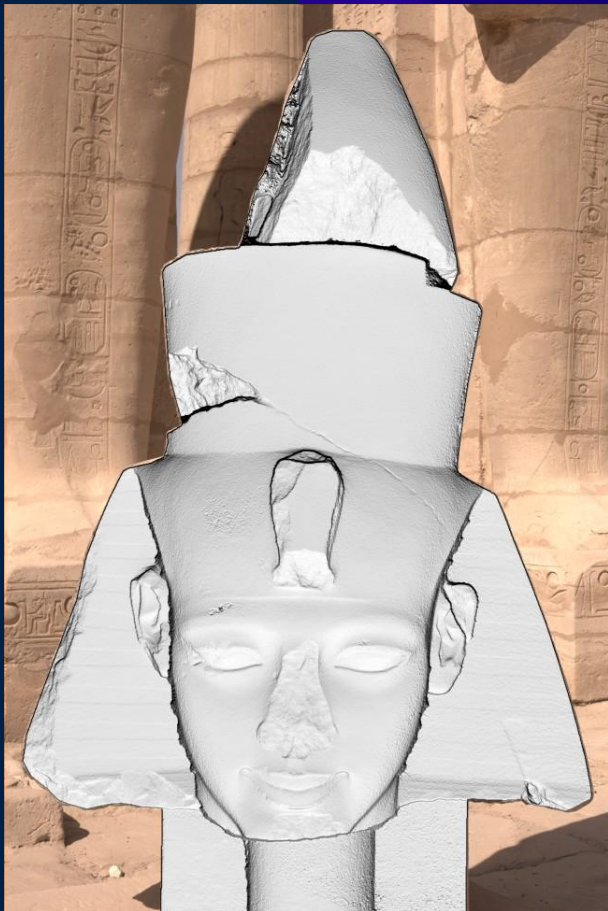
# From image to tie points



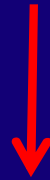
# From tie points to pose and calibration estimation



# From oriented images to 3D model by dense matching



**Images**



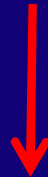
*Sift*

**Ties points**



*Apero*

**Orientation**



*MicMac*

**Depth maps and 3D model**

# MicMac parameters for this benchmark :

**Ground geometry;**

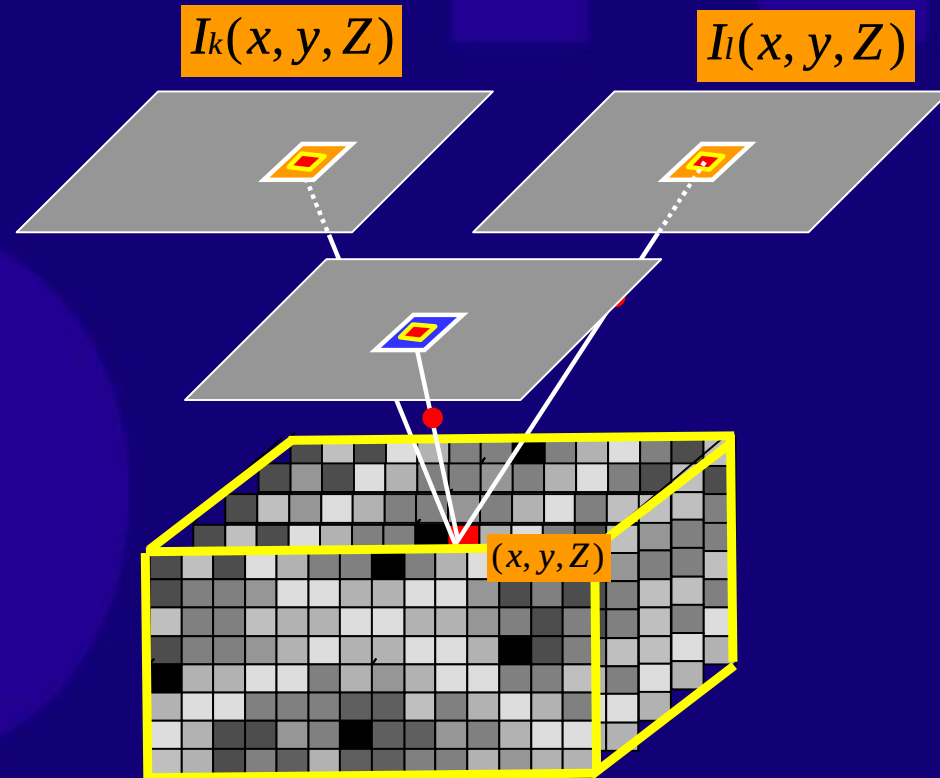
**Multi-correlation**

**Multi-resolution;**

**Energy minimization (SGM);**

**Hidden part prevision.**

# Ground geometry and multi correlation

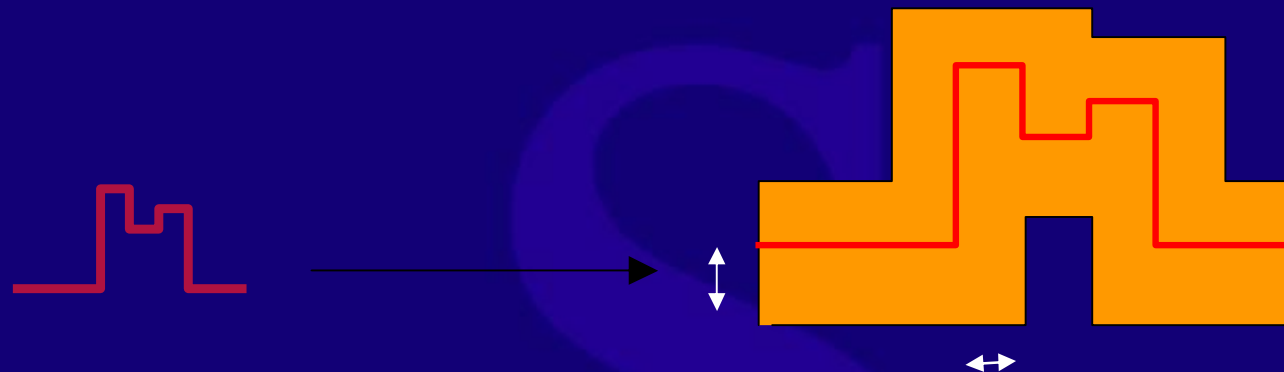


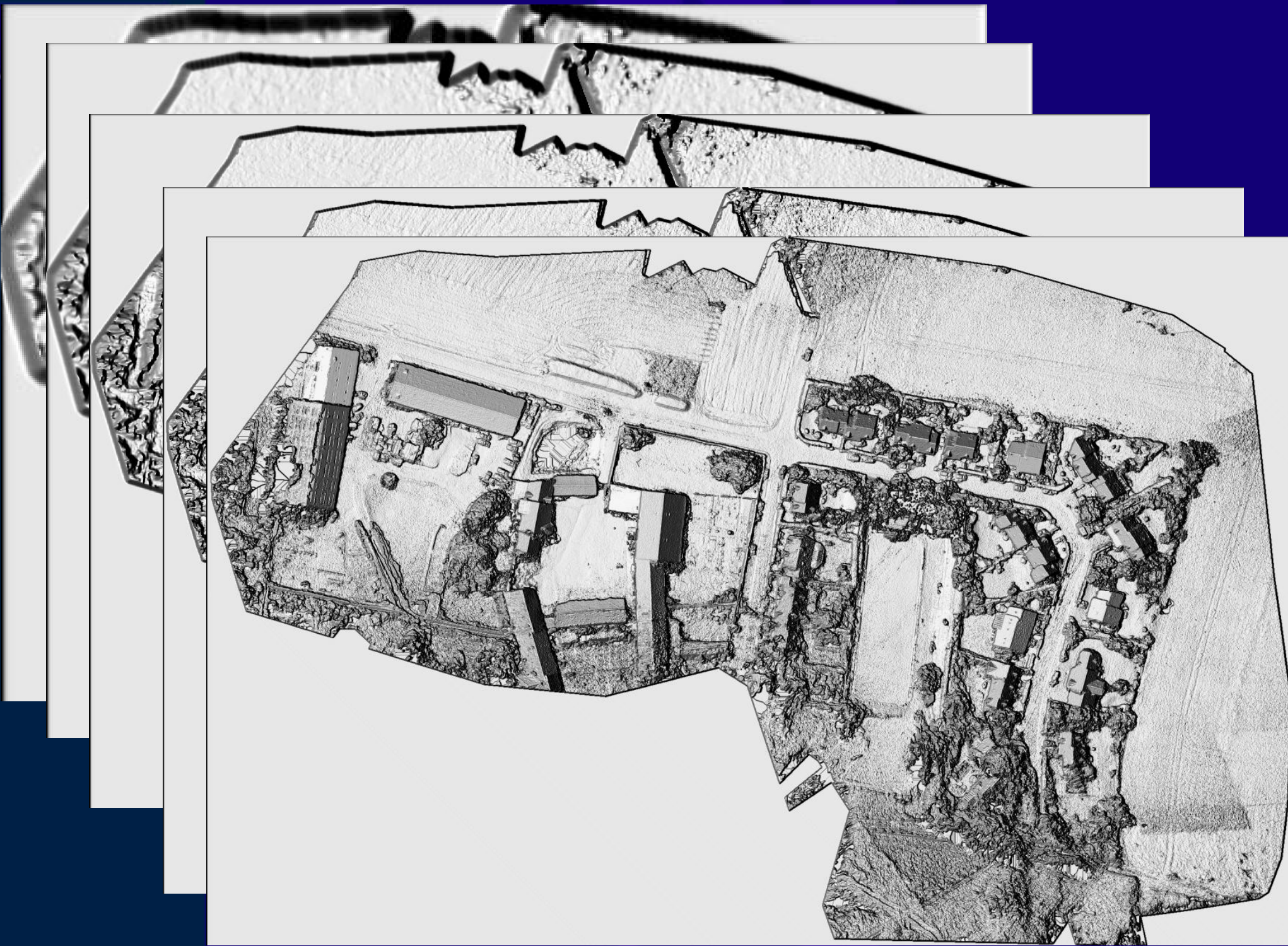
# Multi-resolution:

Initial step, résolution  $2^N$ , the complete interval of depth is explored.

Current step, résolution  $2^K$ , initialized from previous step at resolution  $2^{K+1}$ ;

Dilatation threshold in x,y and depth to define the new space to explore.





## Energy minimization :

To penalize variation of  $Z$ , we try to compute a function  $Z(x,y)$  minimizing:

$$\sum Corr(x, y, Z(x, y)) + F(|Z(x+1, y) - Z(x, y)|) \dots$$

Two minimization algorithms are available :

Graph Cut (global)

SGM (semi global) by multiple  
directionnal dynamic programming

What is the “good” function for  $F$  ?

“Standard” (L1 function)

For smooth terrain (convex)

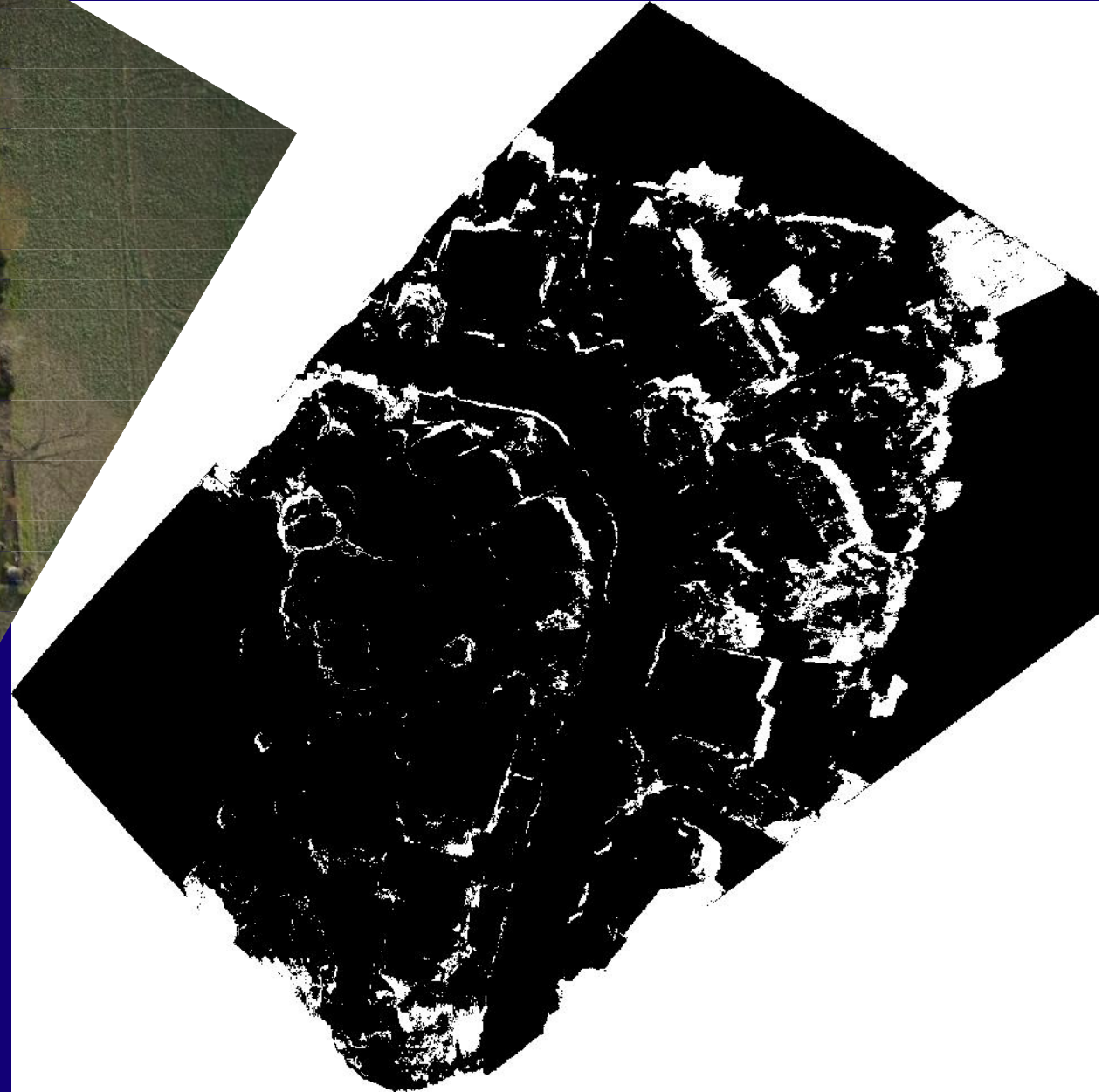
For DEM in city (concave : favour discontinuity)

F

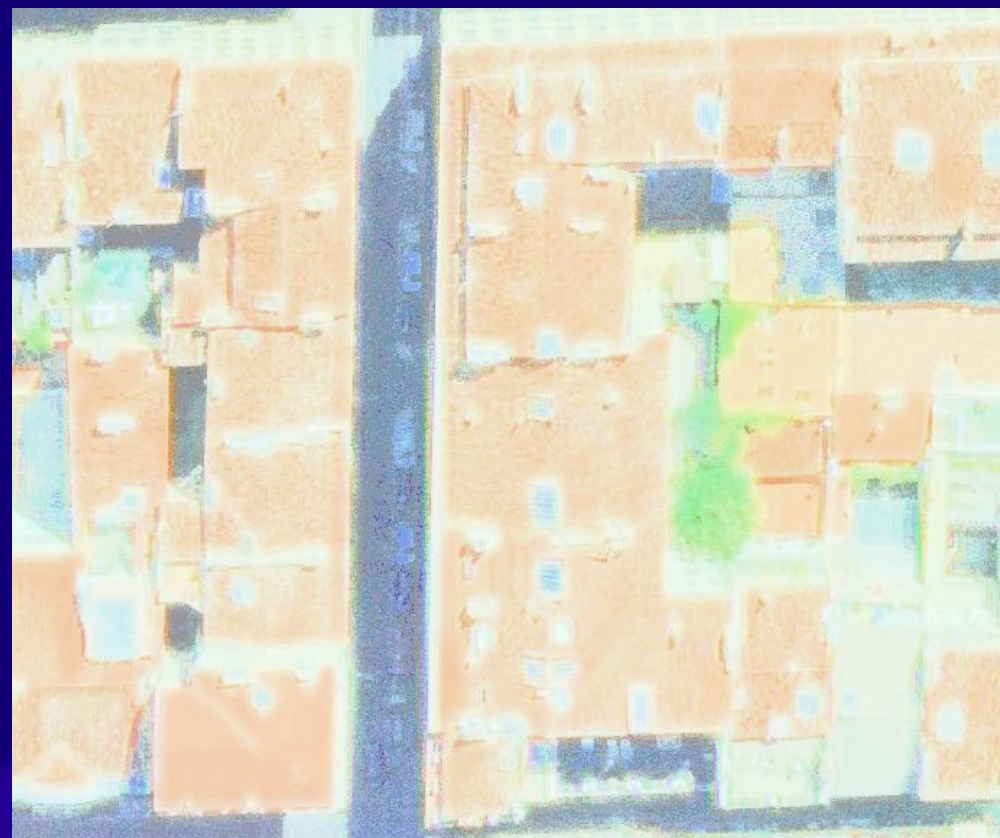
Graph cuts cannot deal with non convex  
function : use SGM

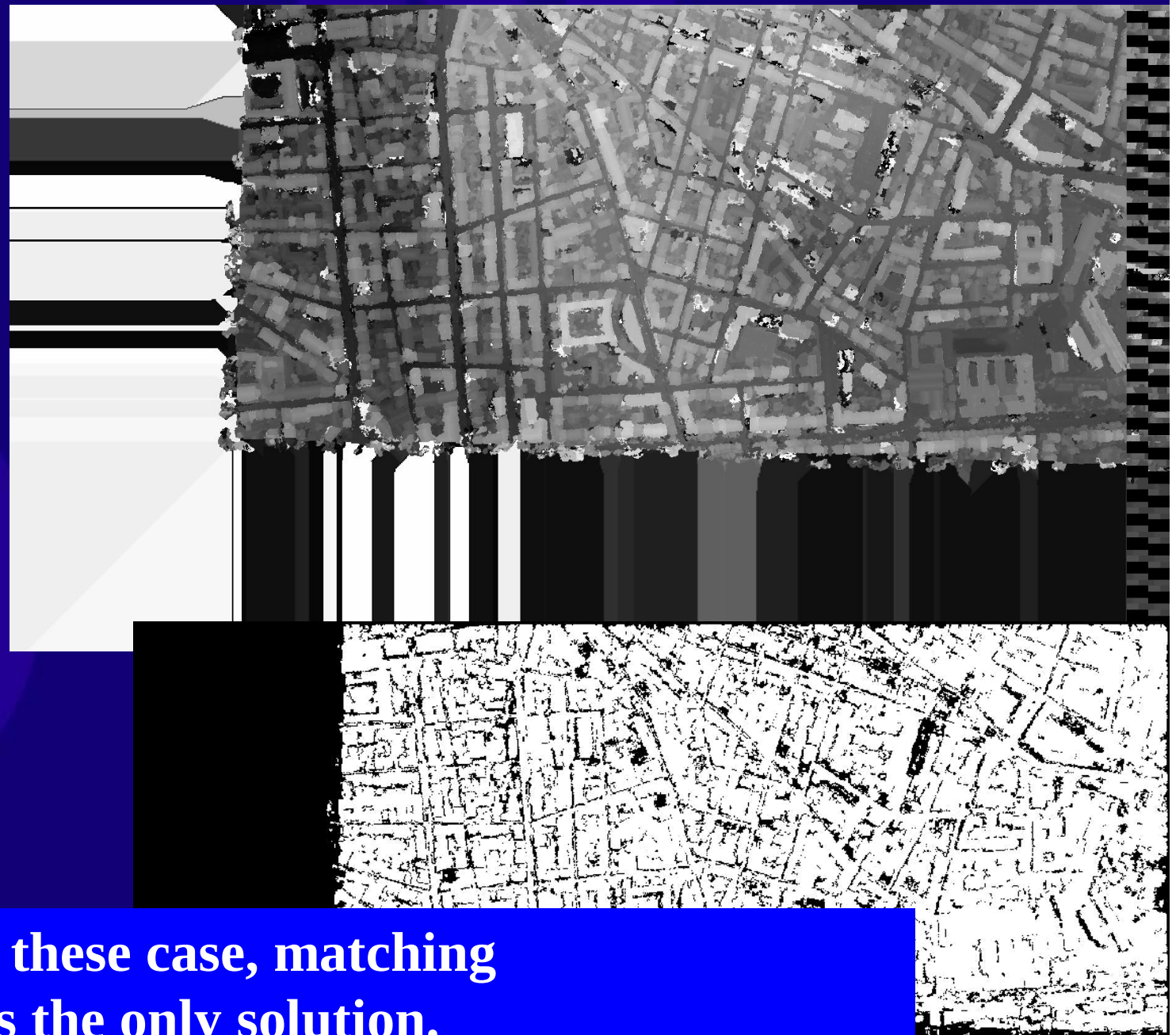
Z

# Hidden part prevision using ZBufer.



## Still problem with narrow shaded streets :





**Probably to handle these case, matching  
by pair of images is the only solution.  
Test on this way, still unfinished.**



**MicMac and Aperro can be downloaded at :**

**[www.micmac.ign.fr](http://www.micmac.ign.fr)**

**Free open source software on a LGPL-like  
licence.**

## 3-First results

# Organisation that volunteered to participate :

|                                         |                                                            |
|-----------------------------------------|------------------------------------------------------------|
| <b>DLR</b>                              | <b>Heiko Hirschmueller</b>                                 |
| <b>Freiburg University</b>              | <b>Barbara Koch</b>                                        |
| <b>IAPG</b>                             | <b>Heidi Hastedt</b>                                       |
| <b>ICG (graz)</b>                       | <b>Horst Bischof</b>                                       |
| <b>IAPG</b>                             | <b>Heidi Hastedt</b>                                       |
| <b>IESSG (university of Nottingham)</b> | <b>Martin J Smith</b>                                      |
| <b>IFP</b>                              | <b>Michael Cramer<br/>Norbert Haala</b>                    |
| <b>IGN Belgium</b>                      | <b>Valéry Lemaire</b>                                      |
| <b>IGN France</b>                       | <b>Marc Pierrot Deseilligny<br/>Grégoire Maillet</b>       |
| <b>IGN Spain</b>                        | <b>Javier Hermosilla</b>                                   |
| <b>Joanneum Research</b>                | <b>Gutjahr Karlheinz</b>                                   |
| <b>LVG</b>                              | <b>Stöbel Wolfgang</b>                                     |
| <b>Pavia University</b>                 | <b>Vittorio Casella</b>                                    |
| <b>FGI</b>                              | <b>Juha Hyyppä<br/>Kimmo Nurminen<br/>Mika Karjalainen</b> |
| <b>Swiss Topo</b>                       | <b>Roberto Artuso</b>                                      |



## **Proposed solution by different participant :**

### **Commercial**

**Match AT, inpho**

**Dense Matcher, vexcel (prototype ?)**

**eATE, Leica**

**NGATE, Socet-Set**

### **Non Commercial**

**Semi Global Matching (DLR own's code)**

**MicMac (IGN own's code)**

**For now only two volunteer's data set  
have been collected.**

**DLR :**

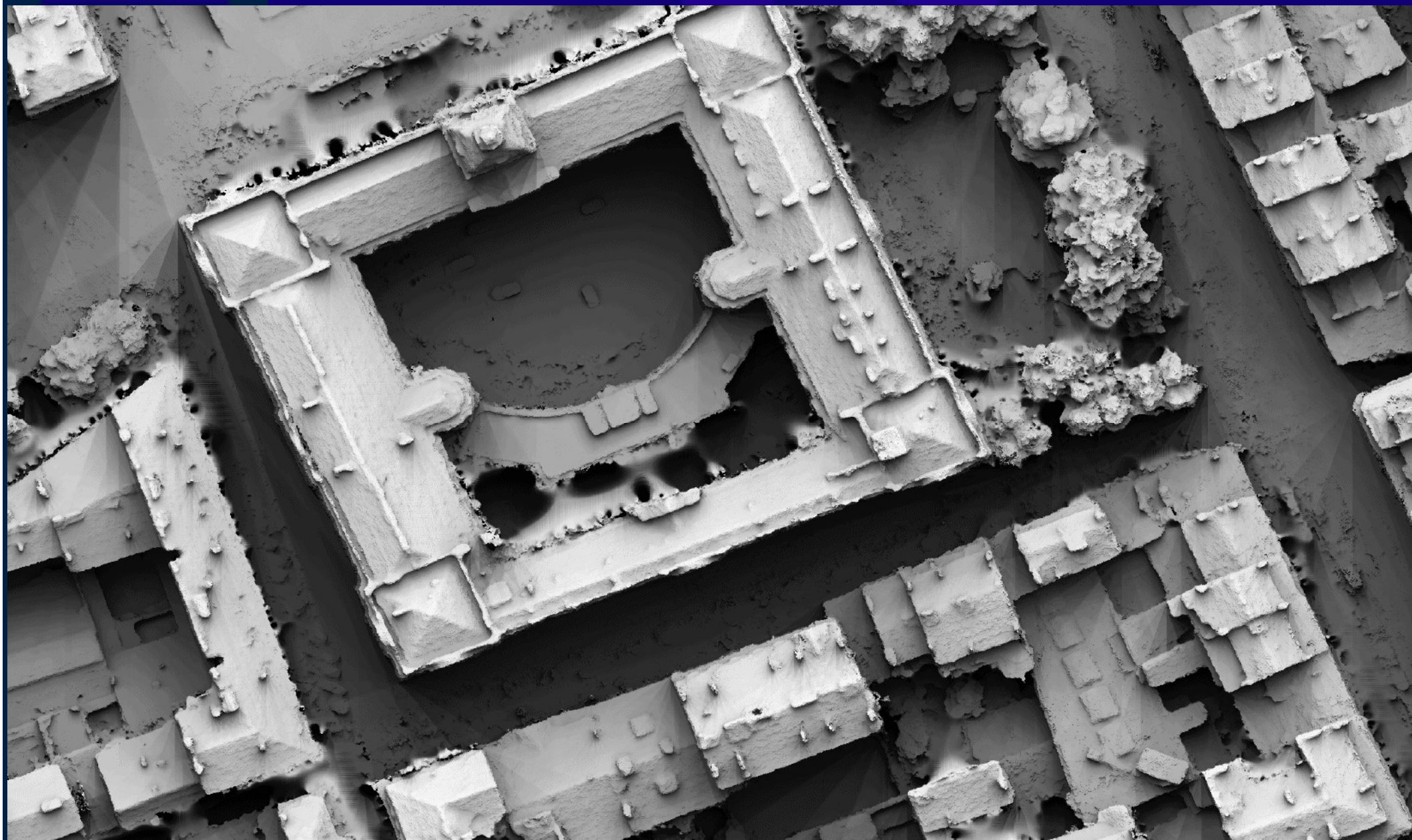
**Has run four dataset**

[http://eurosdrrbenchmarkofimagematching.ign.fr/Results\\_DLR.pdf](http://eurosdrrbenchmarkofimagematching.ign.fr/Results_DLR.pdf)

**IGN (france) :**

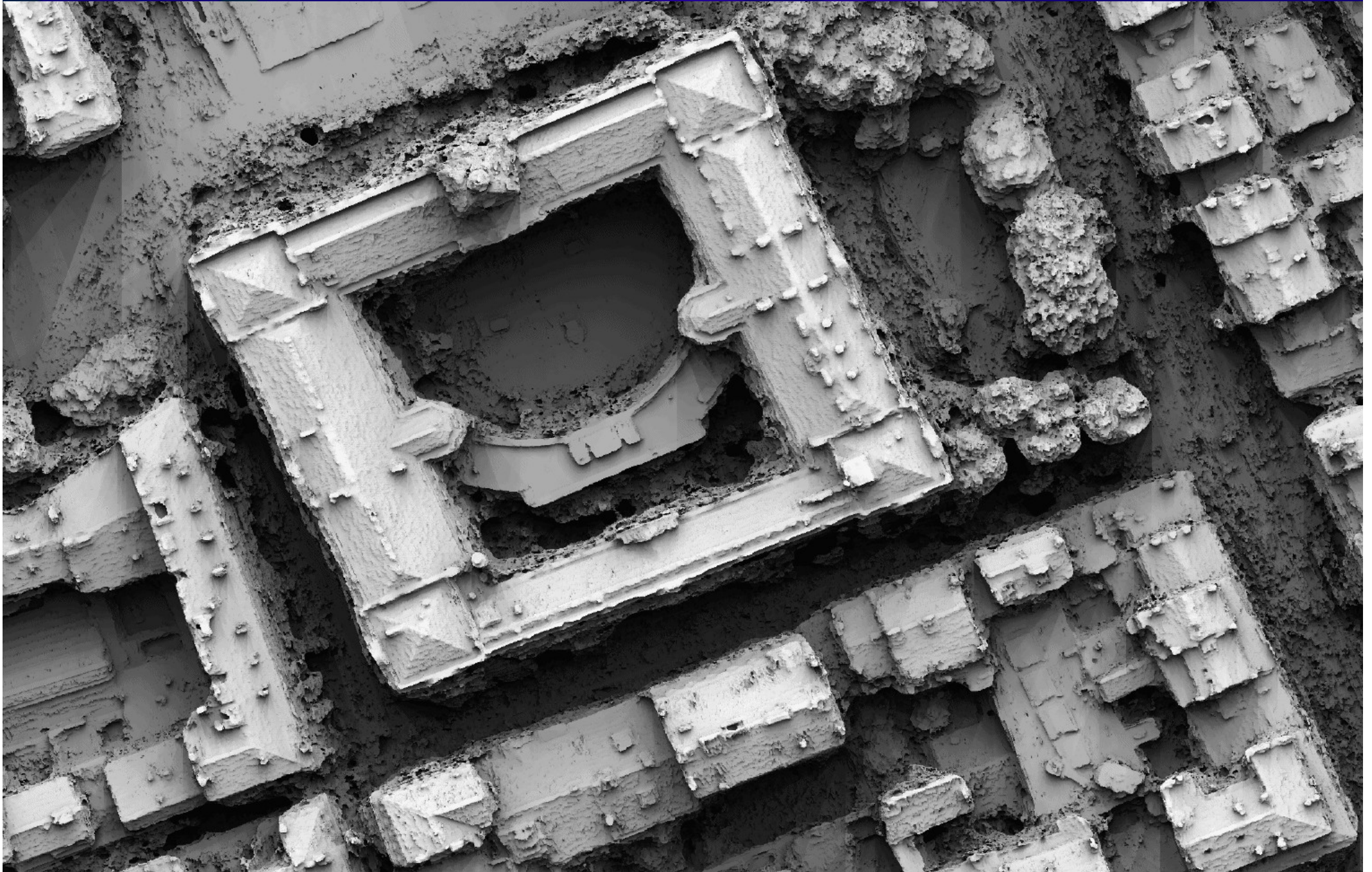
**Has run three dataset .**

[http://eurosdrrbenchmarkofimagematching.ign.fr/Results\\_IGN.pdf](http://eurosdrrbenchmarkofimagematching.ign.fr/Results_IGN.pdf)





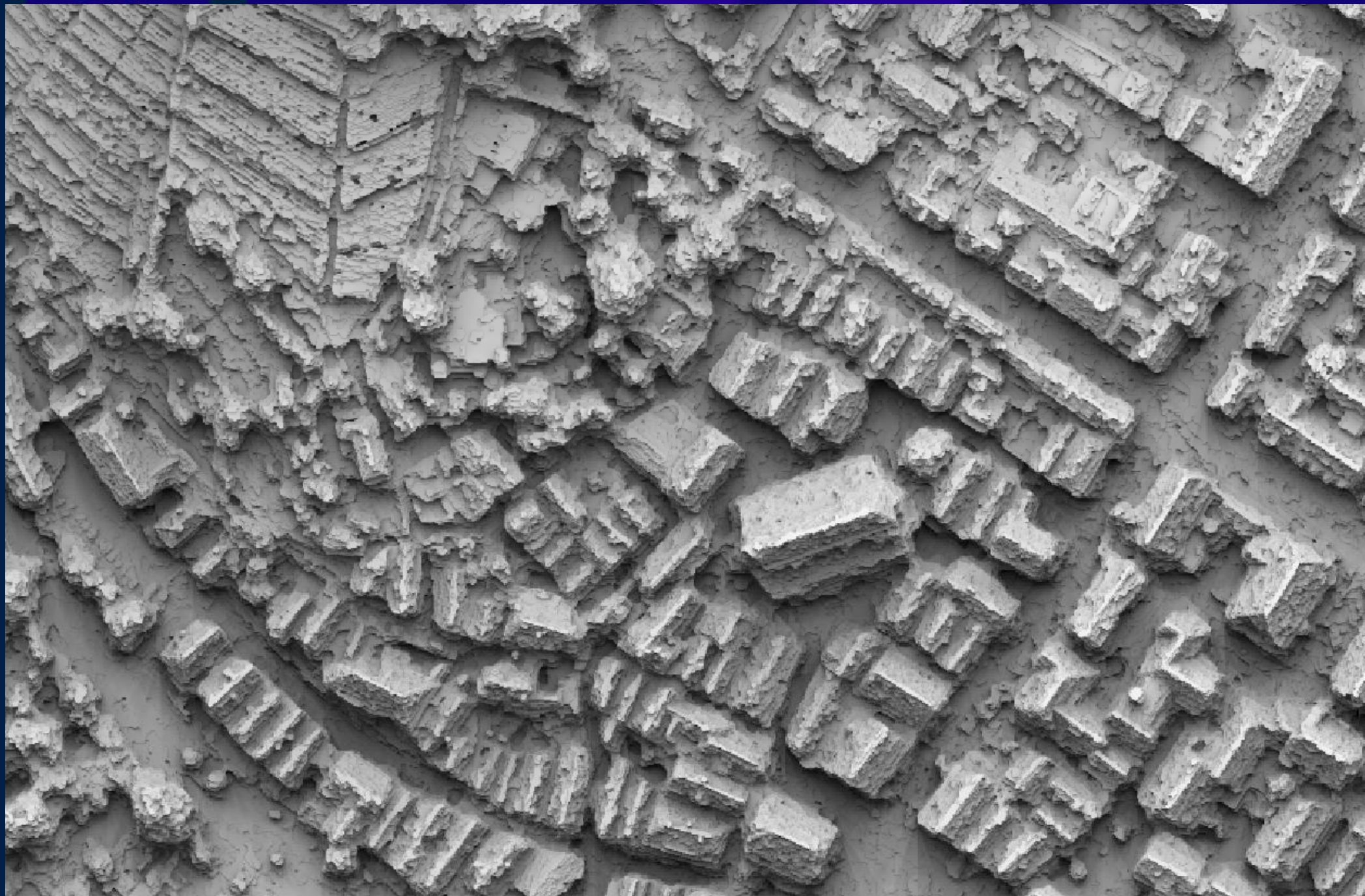
Marseilles- IGN





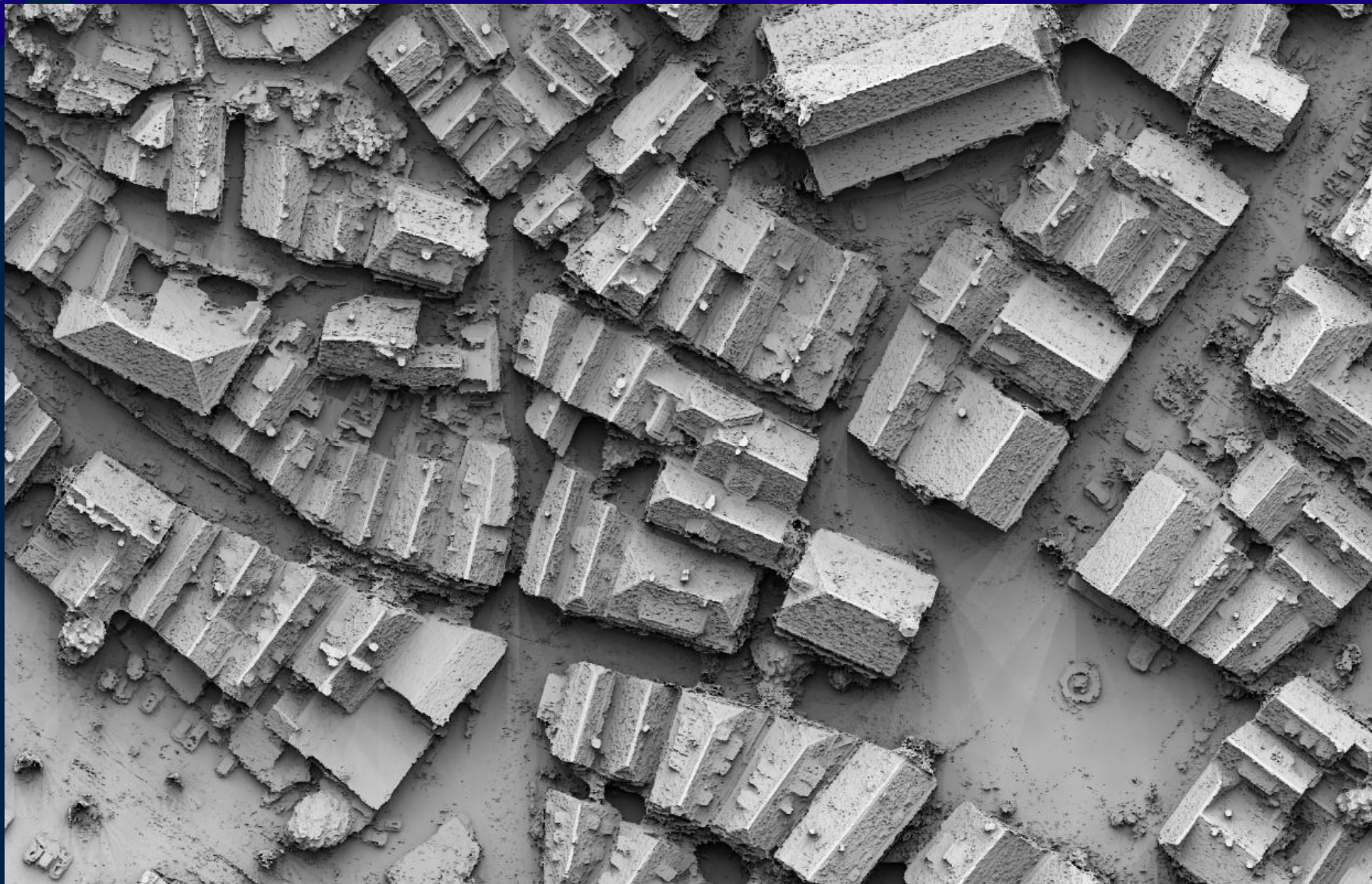


## DGPF 20 cm- IGN



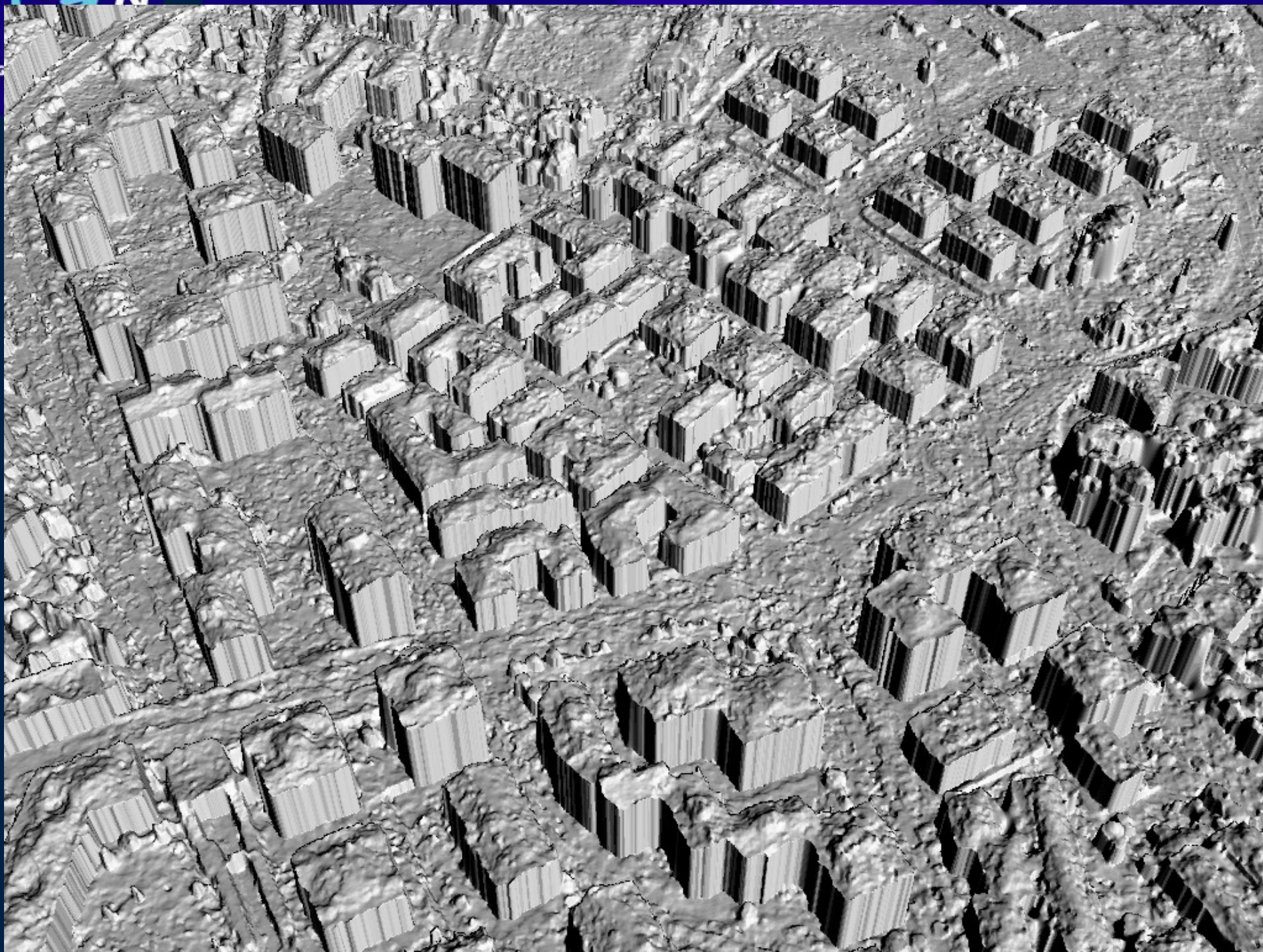


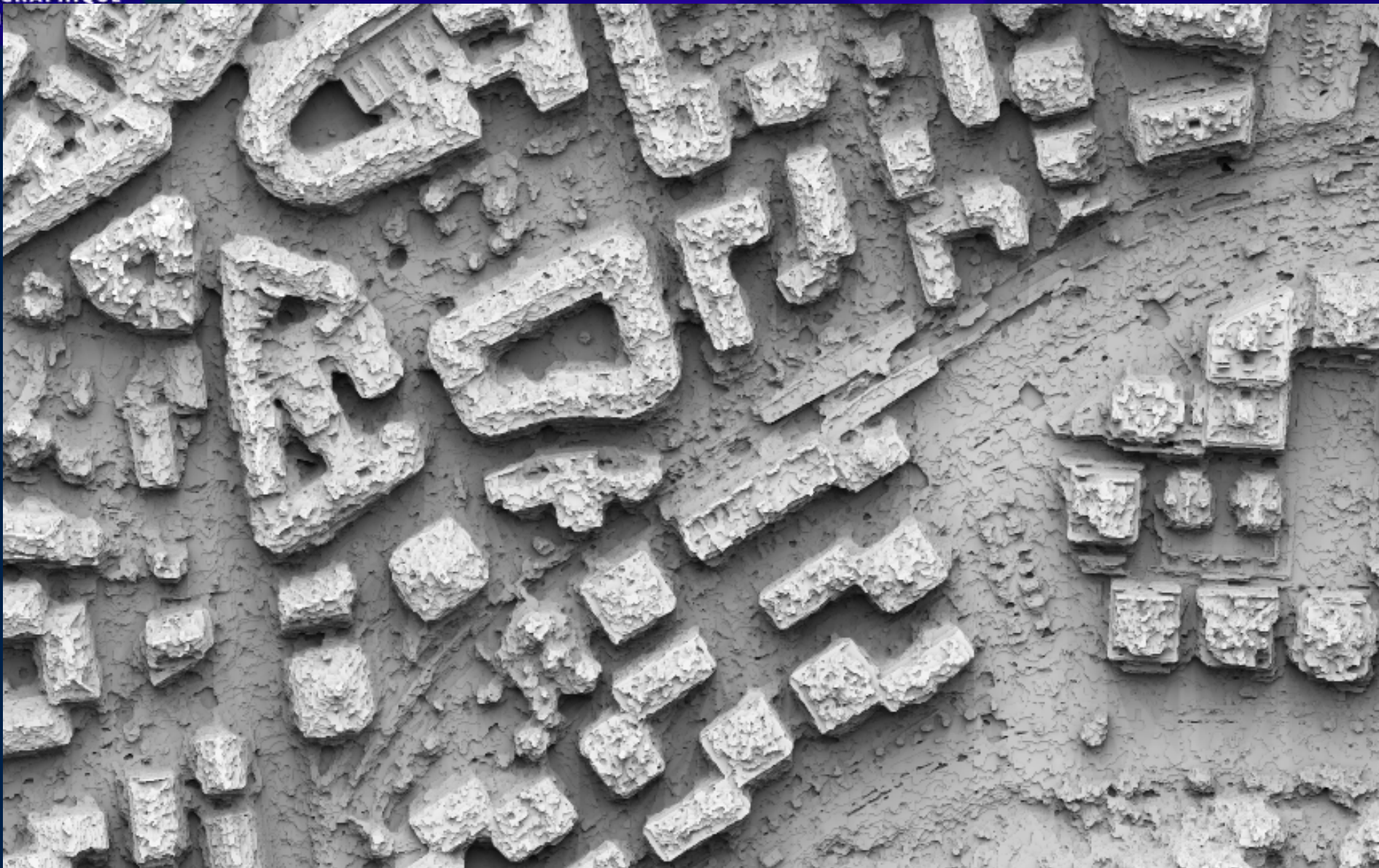
# DGPF 8 cm- IGN

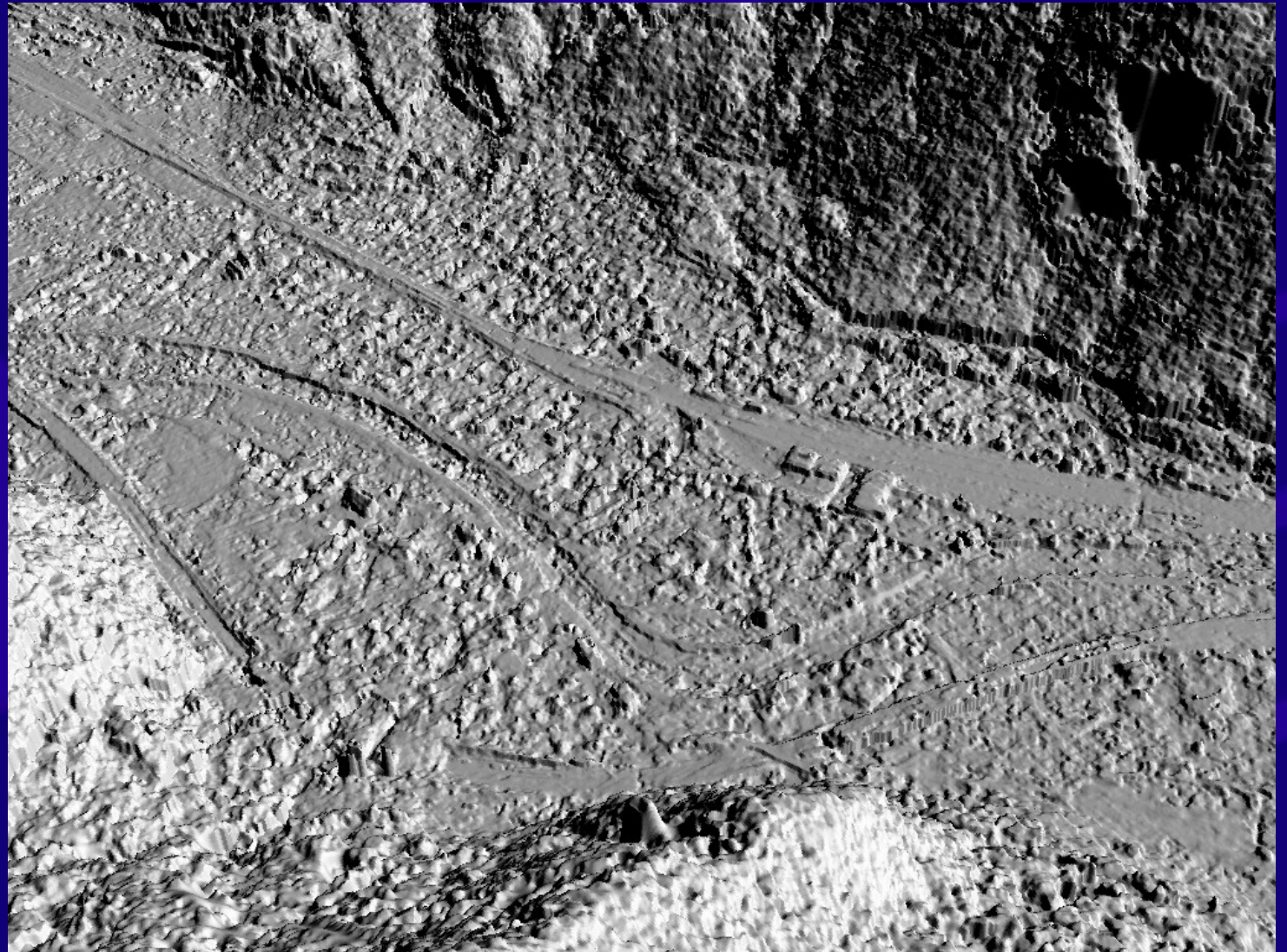




AGORT-DLR







**Matching stopped at 1m because of 2-3 pixel error in geometry interpretation.**

**Not run because of 2-3 pixel  
error in geometry interpretation.**

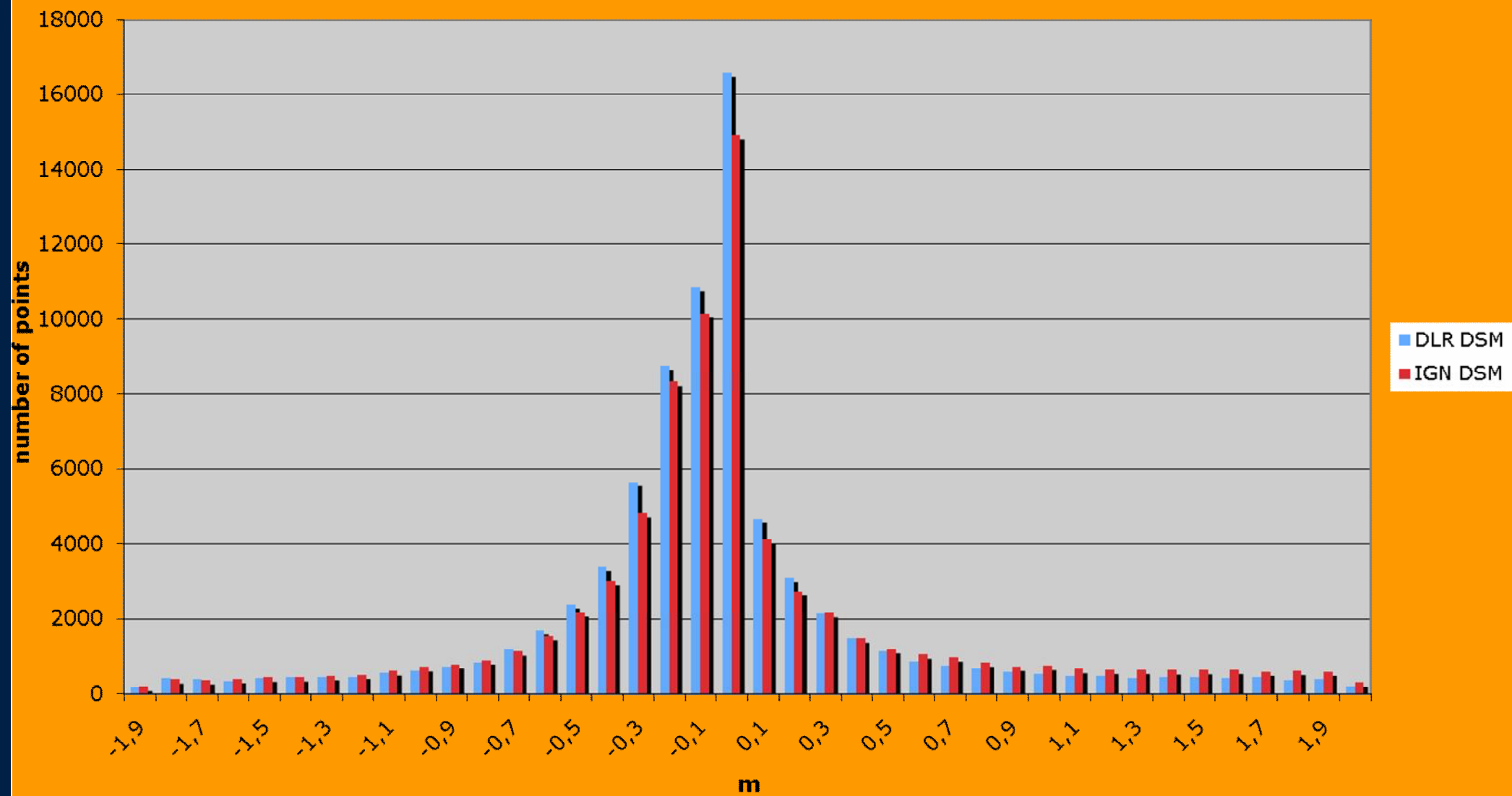
# Quantitative evaluation

**Programs for statistical comparison with laser data are ready.**

**First test on Marseille data-set are coherent with qualitative evaluation (DLR's are more acute)**

# Marseille

## DSM / others (non ground) LiDAR points



## Future and conclusion

## Future of the project ?

**2 participant are not enough for a benchmark, but there are new proposals.**

**IGN will not continue to lead the project.**

**Is an organisation volunteer to take back the project?**

**If yes, what has be done can be transmitted (if legal owners agree):**

**Data set collected;**

**Ground truth**

**Results of 2 participants.**

**Program for ground truth comparison**

**Thank you for your attention.**