



LIDAREXPRESS

AN HYBRID PROCESSING CHAIN FOR
AUTOMATIC LIDAR DATA CLASSIFICATION
AND DIGITAL MODELS GENERATION

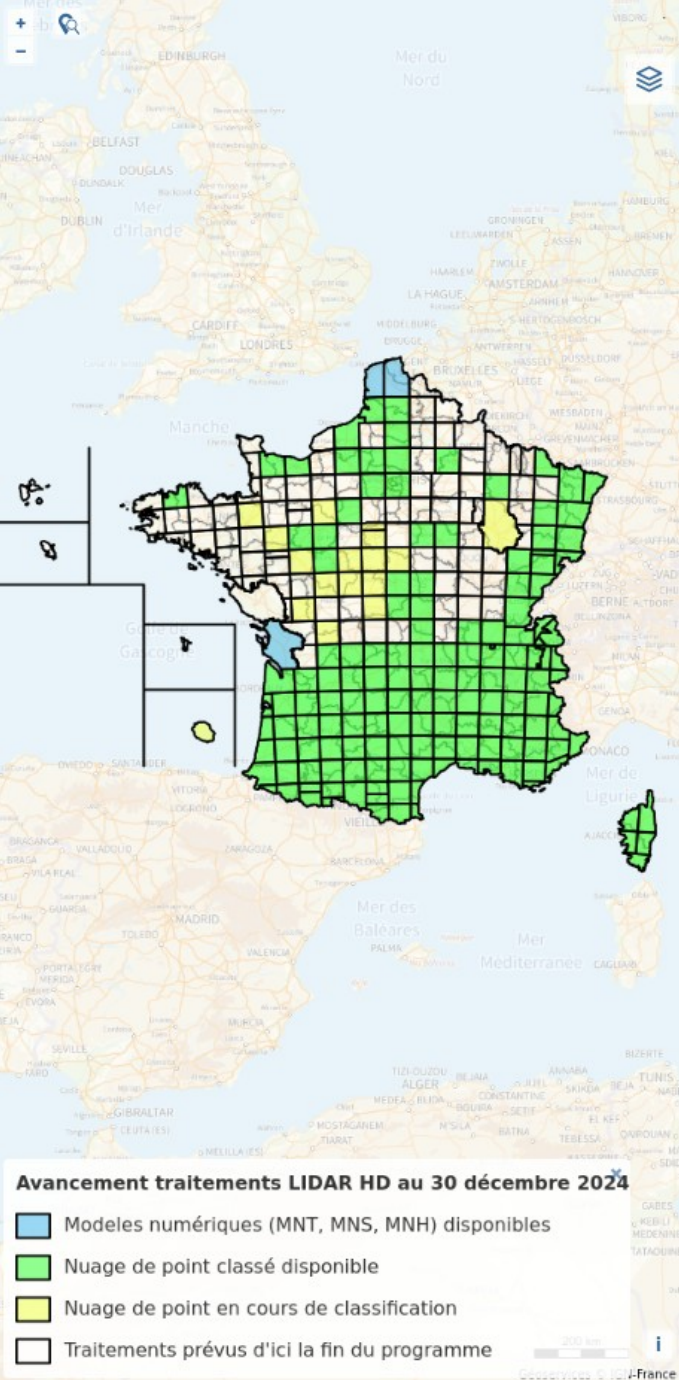
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LEAD DEVELOPER @ IGN

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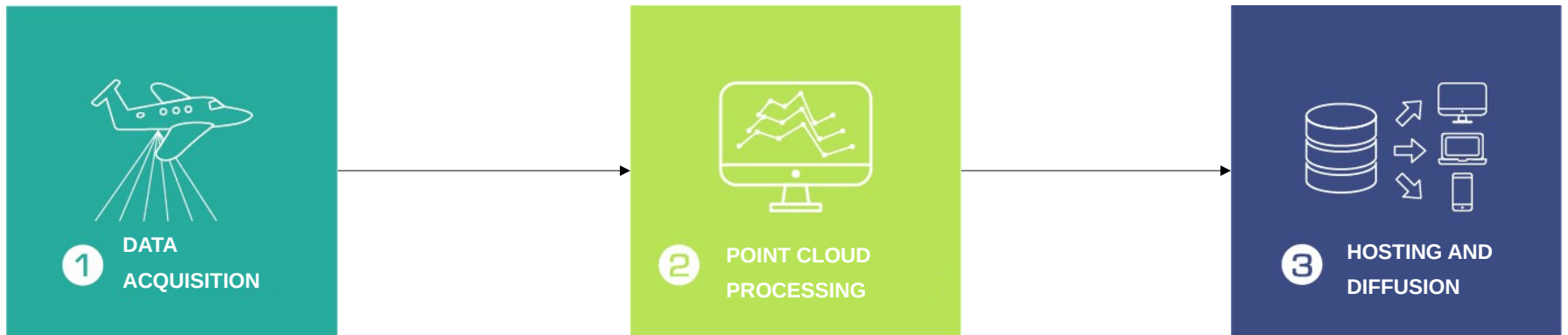
1. THE LIDARHD PROGRAM



THE LIDAR HD PROGRAM

- A countrywide 3D cartography, with point clouds and digital models
- ≥ 10 points / m^2
- ~ 300 Gb of (laz) classified point clouds per acquisition block (50km edge)
- A 5 years program (2020 – 2025)
- Open data shared at <https://geoservices.ign.fr/lidarhd>

AN OVERVIEW ON THE PROCESS



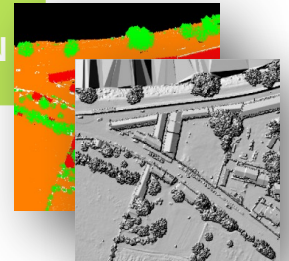
LAS TILES
PREPARATION



CLASSIFICATION



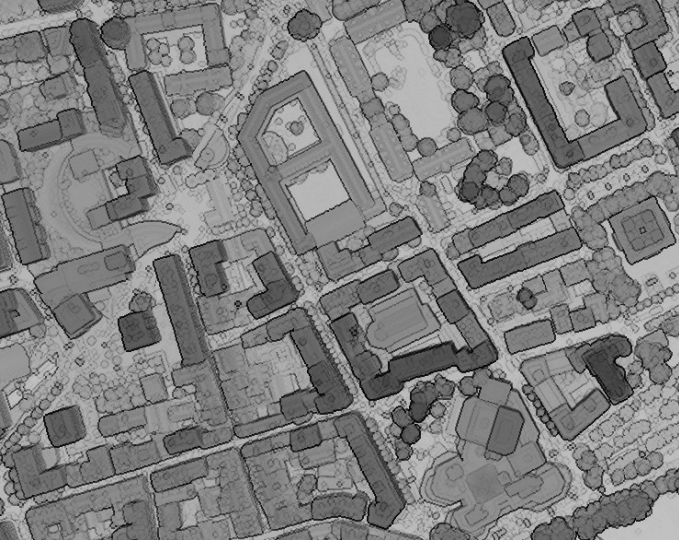
RASTERS
GENERATION



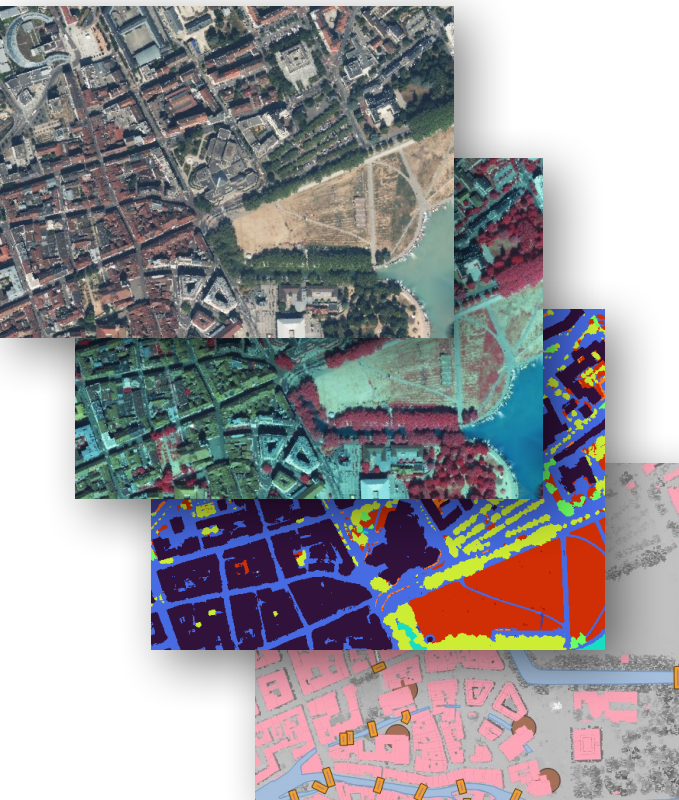
Scope of LidarExpress






2. LIDAREXPRESS INSIGHT

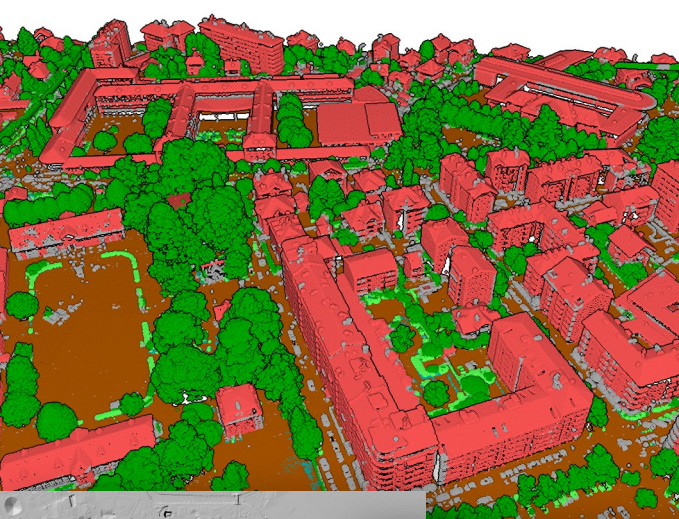


LIDAREXPRESS IO

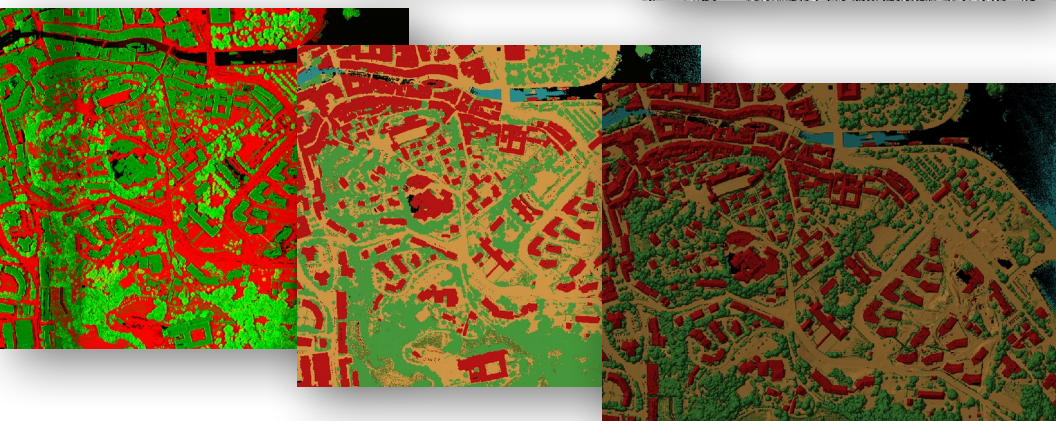
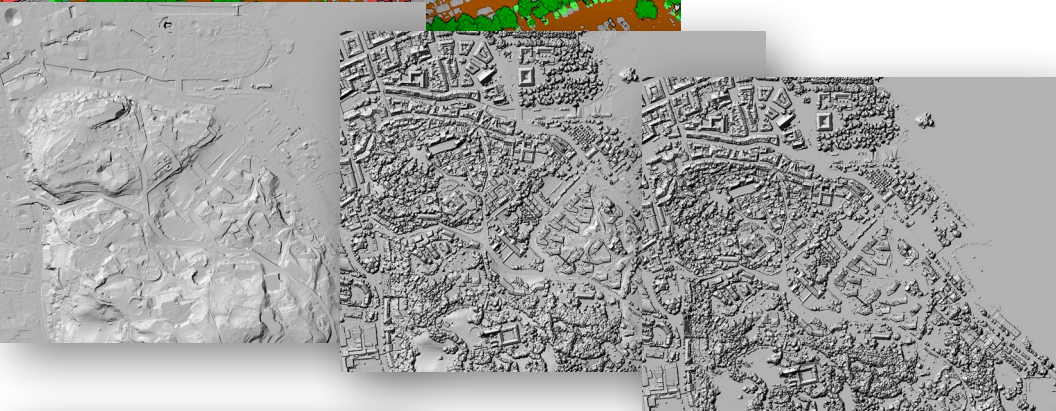


INPUT

- 1km² tiles in las 1.4 format without classification (except for artefacts)
- Batches of 2500 tiles (50 * 50 km)
- Additionnal information from other IGN sources:
 - Orthoimages RGB and NIR (BDORTHO):
<https://geoservices.ign.fr/bdortho> 
 - 2D Semantic segmentation (OCSGE):
<https://geoservices.ign.fr/ocsge> 
 - Vector data (BDTOPO):
<https://geoservices.ign.fr/bdtopo> 



LIDAREXPRESS IO



OUTPUT

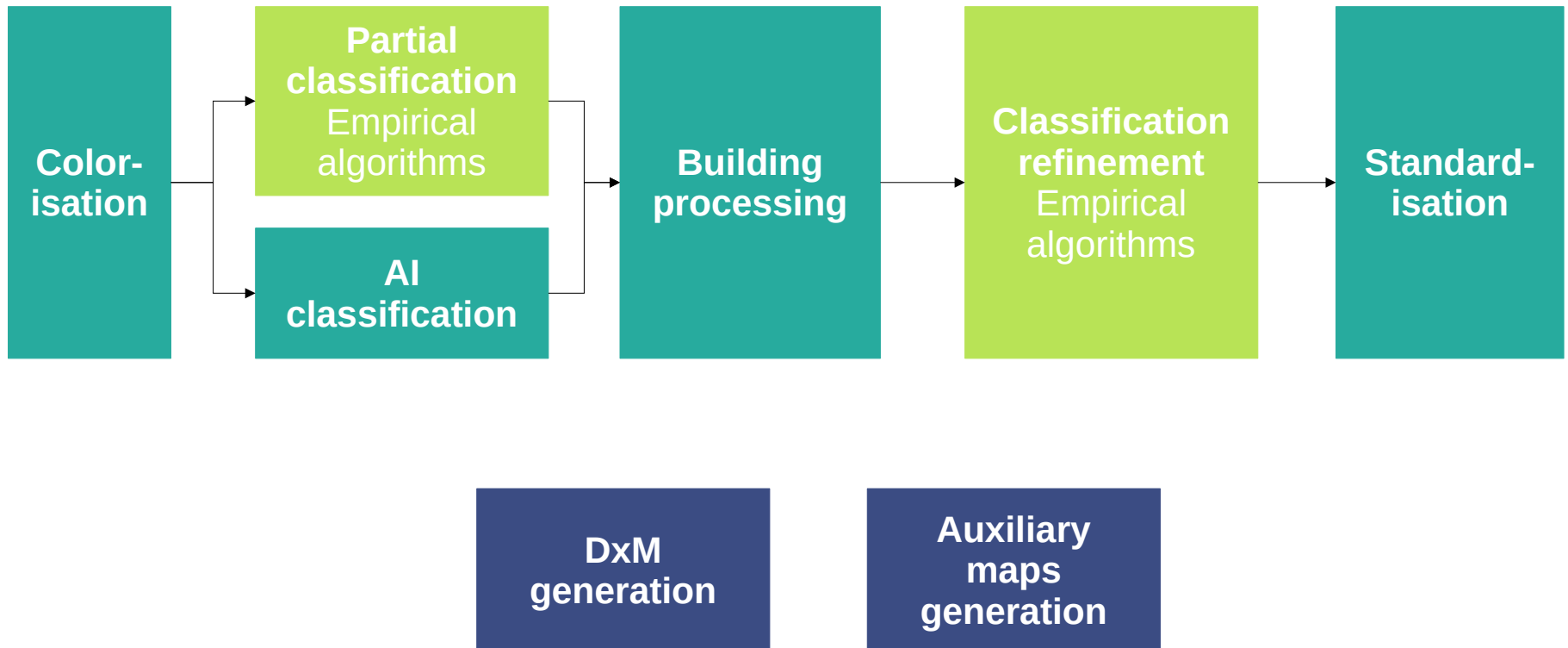
- LAS 1.4 with classification
- Digital Terrain Model (50 cm)
- Digital Surface Model (50 cm)
- Digital Height Model (50 cm)
- Raster metadata:
 - Density map (1 m)
 - Classification maps (50 cm)

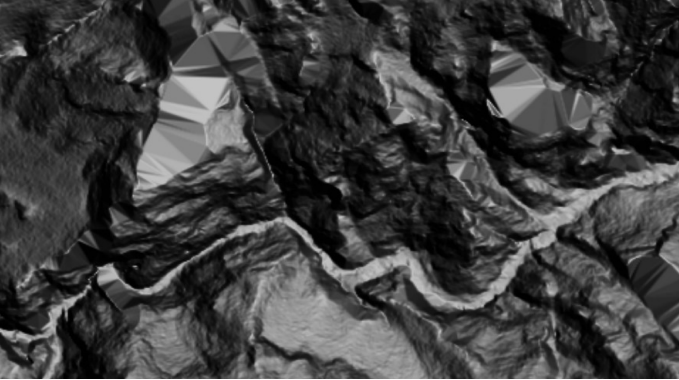
Open source tools

Tools expected to become open

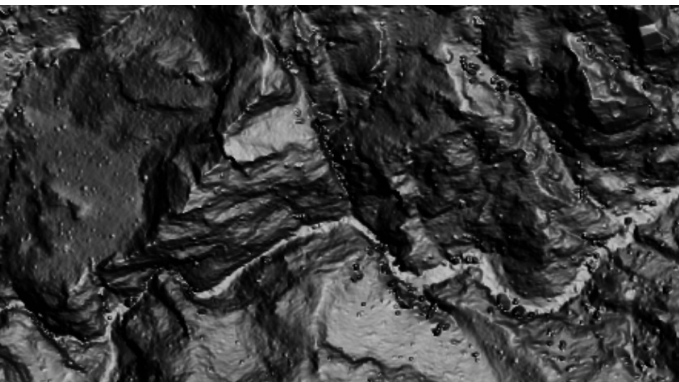
Closed source tools

PROCESSING STEPS

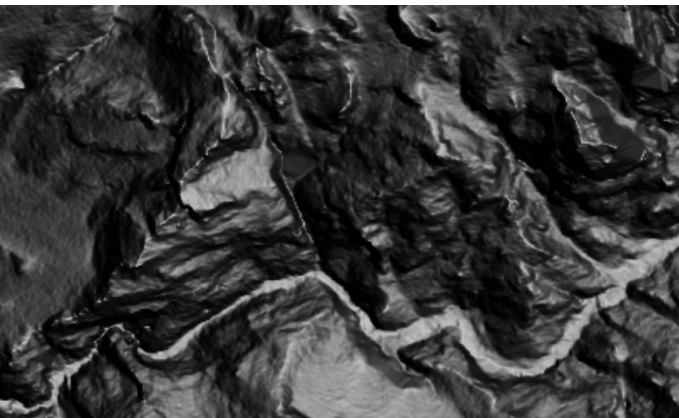




Classical method only



AI only

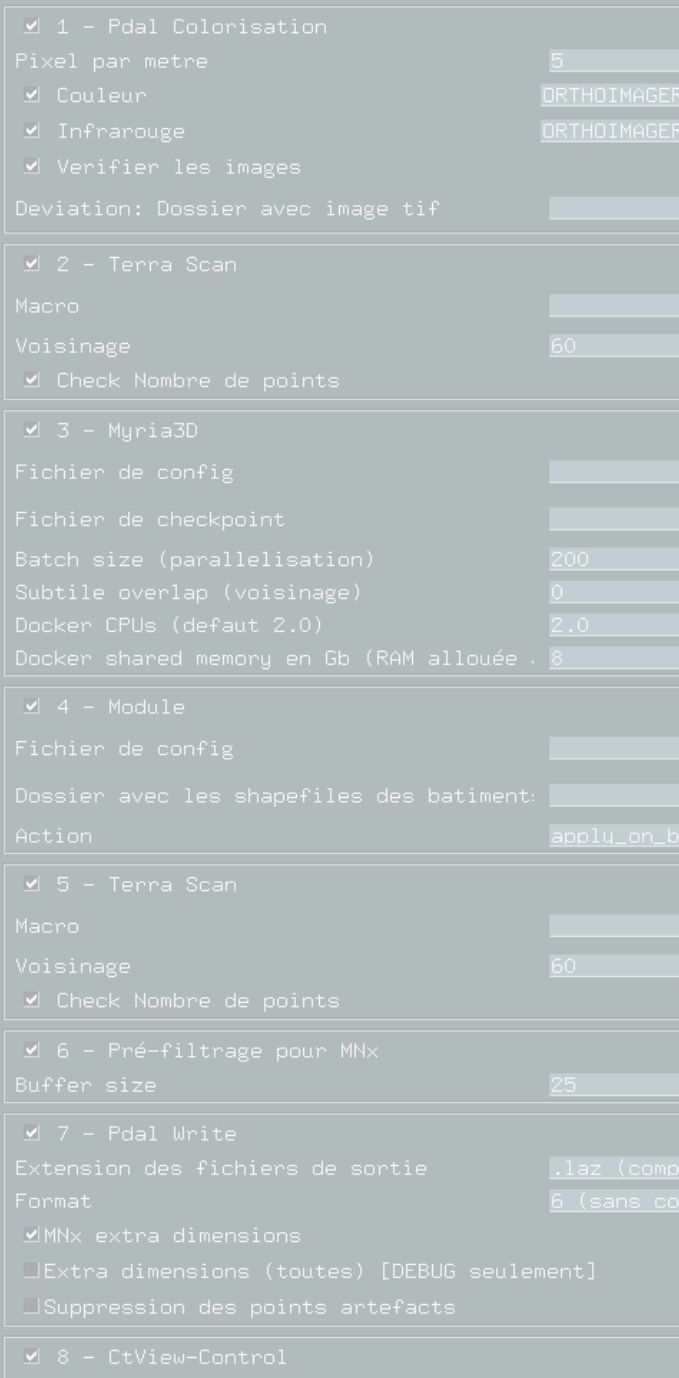


Combination

CHALLENGES

ALGORITHMIC CHALLENGES

- 3 sources of knowledge:
 - 3D deep learning
 - empirical algorithms
 - External knowledge (OCSGE, BDTOPO)
- How to combine results?
 - For Water, Vegetation and Greenhouses, combination is “handmade” (in the Classification Refinement module)
 - For buildings: a building processing module

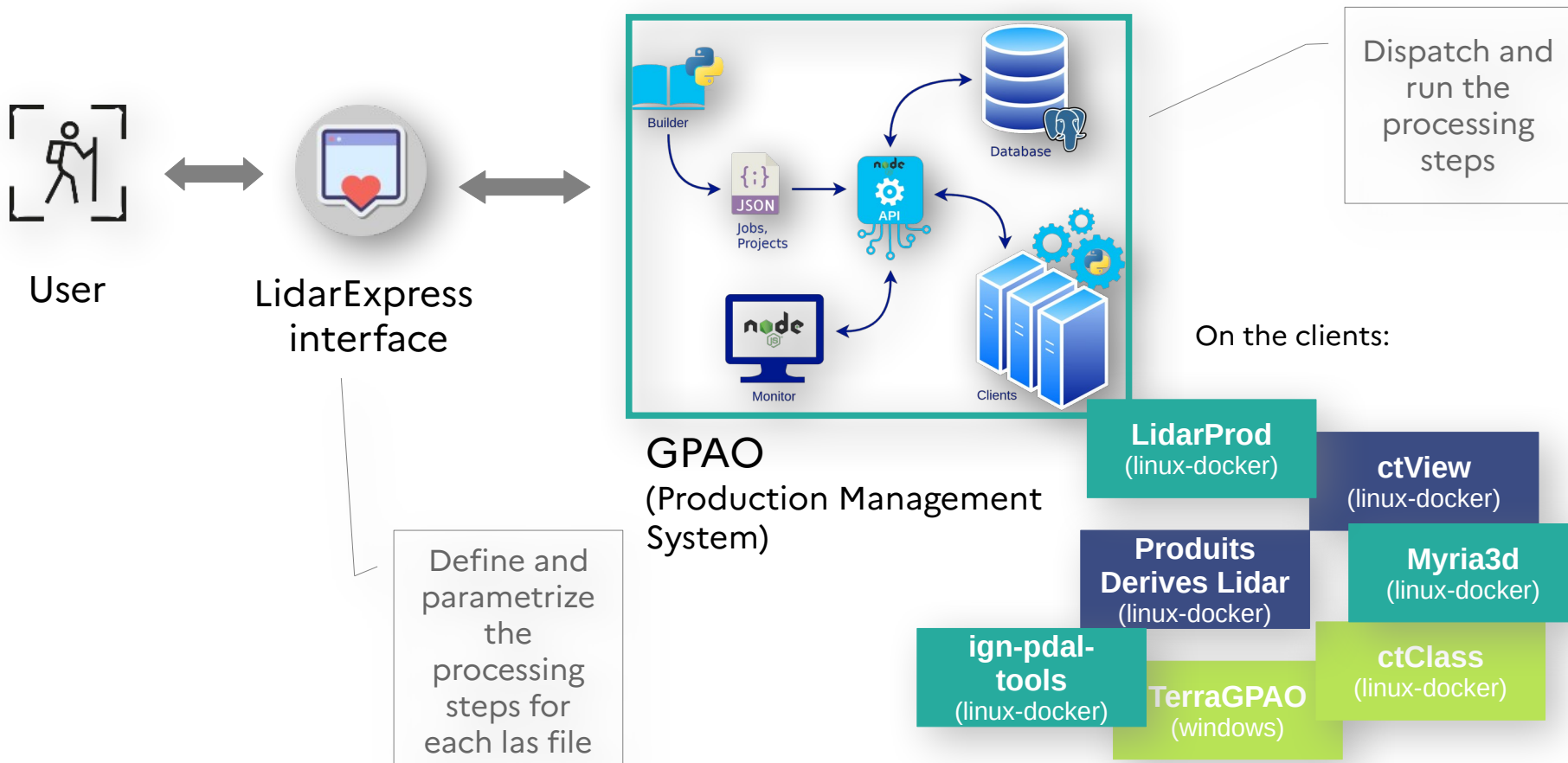


CHALLENGES

SOFTWARE/INFRASTRUCTURE CHALLENGES

- Massive amount of data
- Massive computation => Can't be handled by the operator's computer
- Windows / Linux modules
- Steps depend on each other
- Need to be flexible (possibility to replace steps or add new ones)

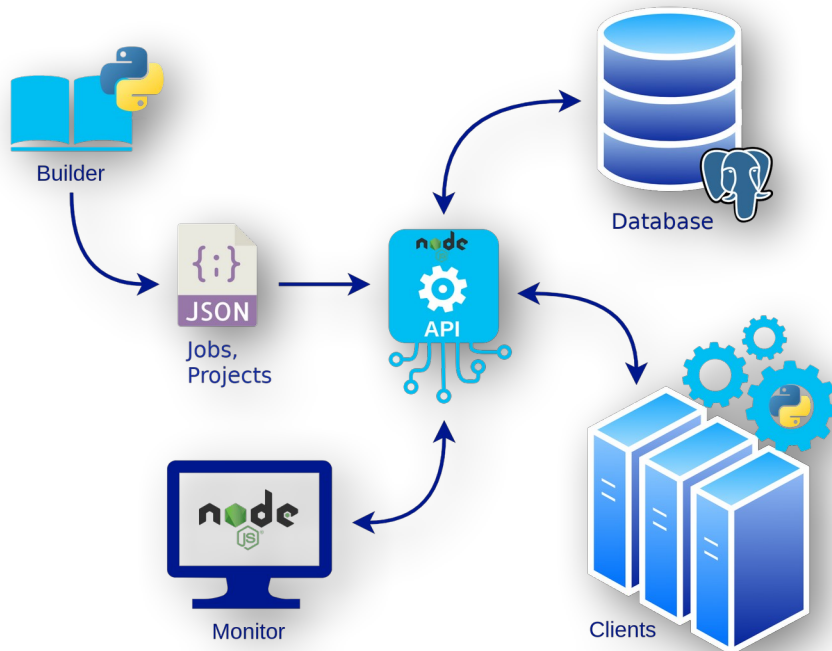
ARCHITECTURE





An aerial 3D map showing a city area with buildings and terrain. The buildings are colored in shades of red and pink, while the surrounding terrain and vegetation are colored in shades of green, yellow, and blue. A large white box is overlaid on the map, containing the text '3. OPEN SOURCE COMPONENTS'.

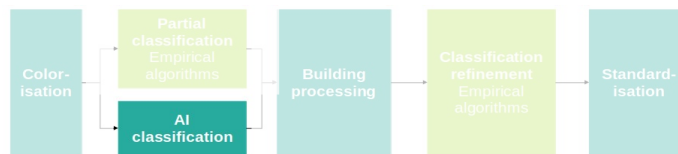
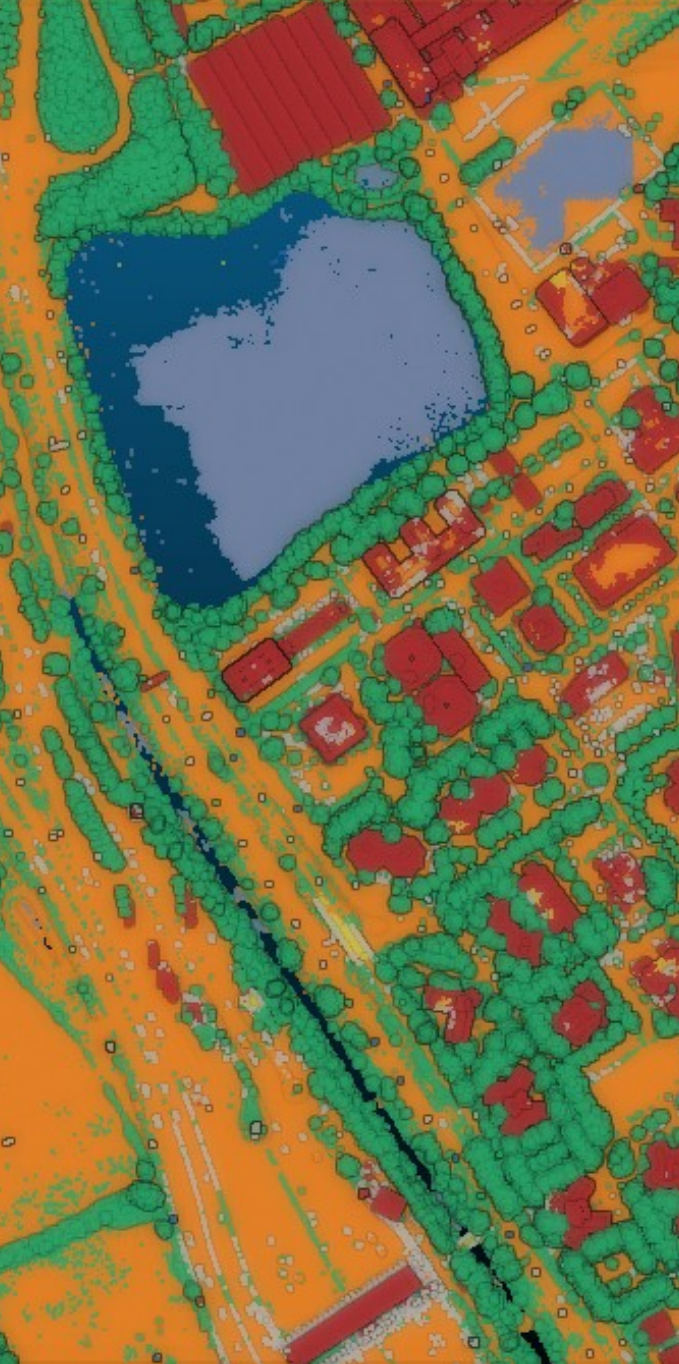
3. OPEN SOURCE COMPONENTS

IGN-GPAO PRODUCTION MANAGEMENT



- Platform for distributed computing on several nodes
- Docker-compose deployment 
- Node.js API
- Node.js web interface
- Python library to build workflows
- PostgreSQL database to store workflows



- Used for several projects at IGN
- <https://github.com/ign-gpao/> 
- Cecill-B license (BSD-like)

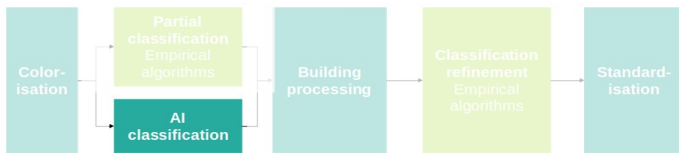


MYRIA3D

3D DEEP LEARNING FOR CLASSIFICATION

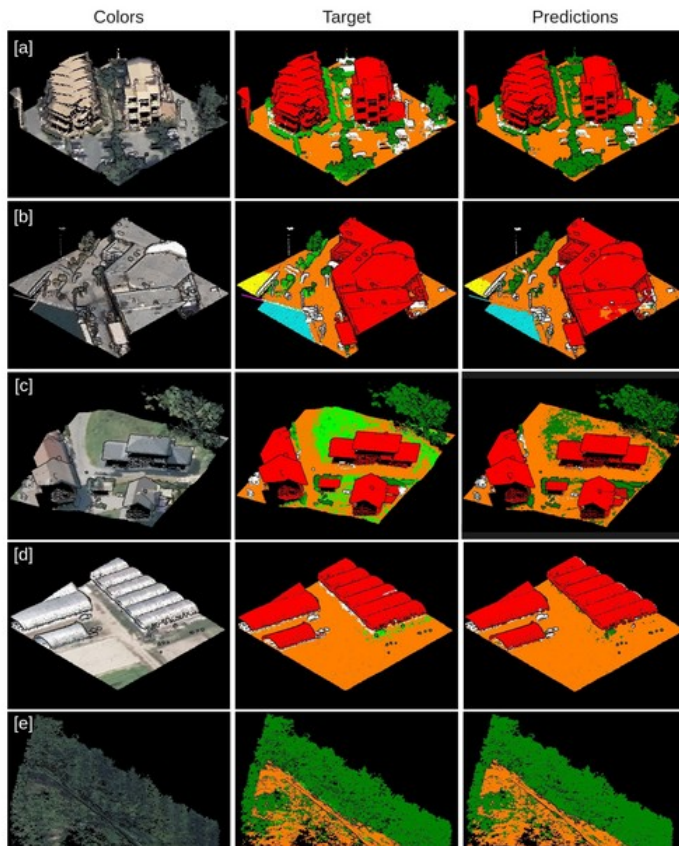
Aerial Lidar HD Semantic Segmentation with Deep Learning

- <https://github.com/IGNF/myria3d> (MIT license, based on pytorch) 
- 7 classes: ground, vegetation, building, water, bridge, permanent structure, other
- Model architecture: RandLa-Net
- Docker image available 



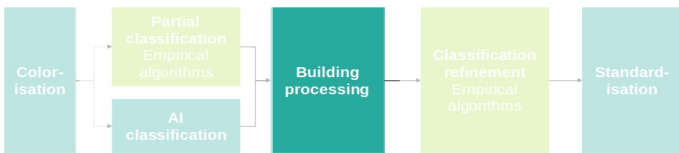
MYRIA3D

3D DEEP LEARNING FOR CLASSIFICATION

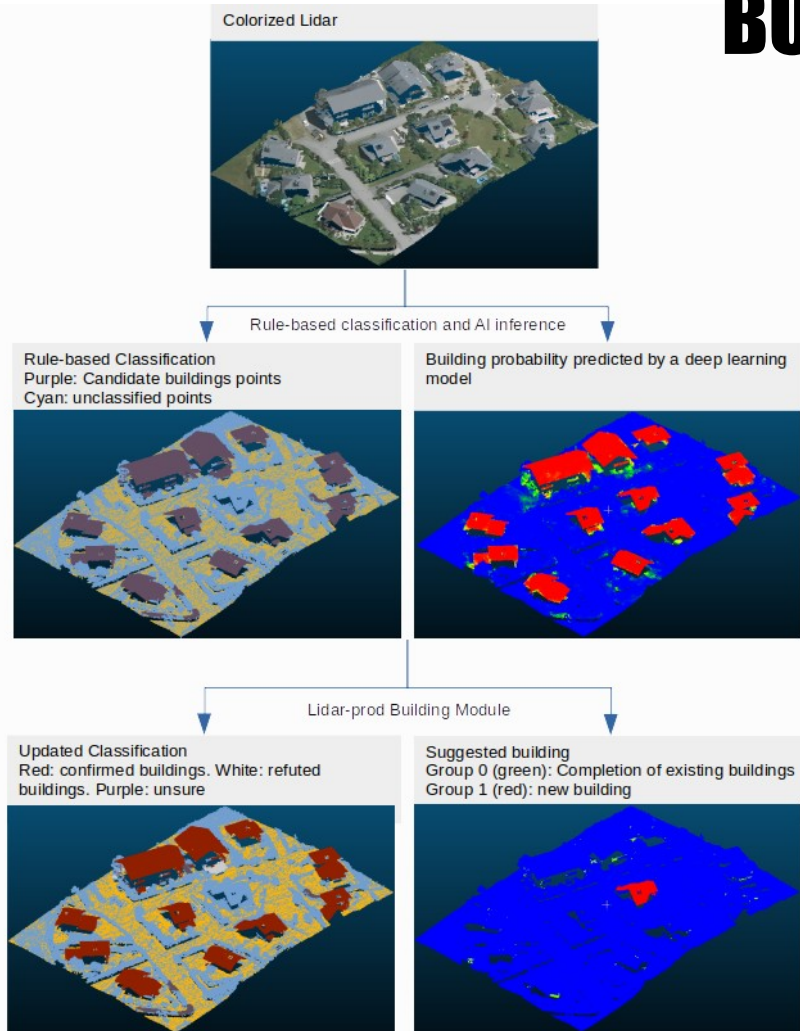


- Data: FRACTAL dataset available at <https://huggingface.co/datasets/IGNF/FRACTAL> 🙌 (etalab-2.0 license)
- Dataset Sampler (PACASAM: Patch Catalog Sampling) available at <https://github.com/IGNF/pacasam> 🐙 (BSD3-License)
- Pretrained model at https://huggingface.co/IGNF/FRACTAL-LidarHD_7cl_randlnet 🙌 (etalab-2.0 license)


Input point cloud, target classification and model prediction for a subset of patches from the test set of FRACTAL



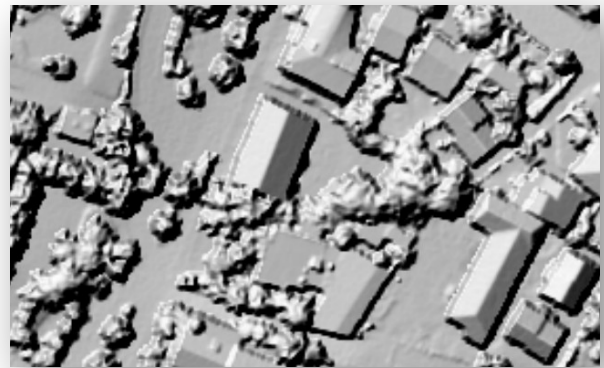
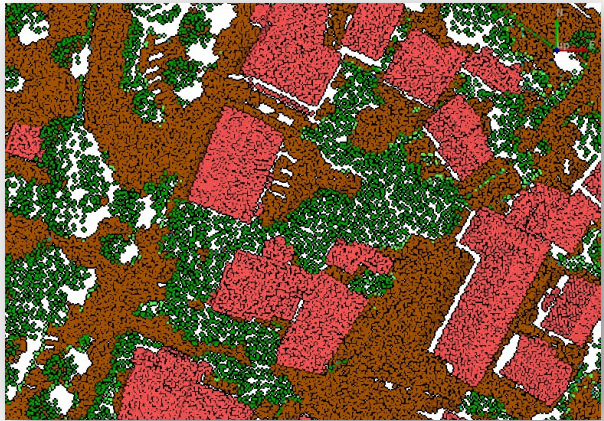
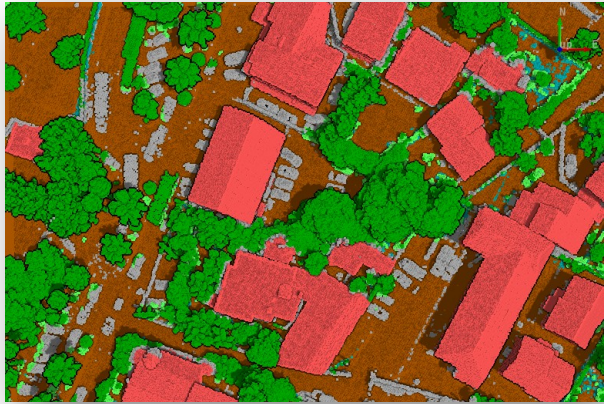
LIDAR-PROD BUILDING MODULE



Specific tool to combine:

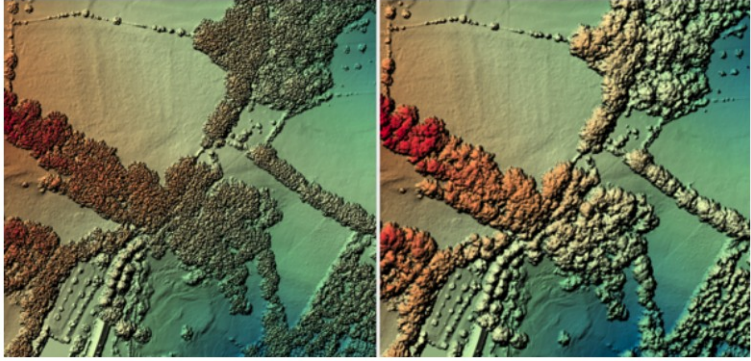
- AI predictions
- Initial + Refined BDTOPO classifications
- <https://github.com/IGNF/lidar-prod> (BSD-3 license) 
- **BUILDING VALIDATION:**
 - Confirm or refute groups of candidate building points (from geometric algorithms)
 - Focused on geometric algorithm overdetection
 - Thresholds from optimisation on a dataset (AI model dependent)
 - Create **uncertain** points to be checked by a human
- **BUILDING COMPLETION:**
 - Confirm points that have high-enough probability
- **BUILDING IDENTIFICATION:**
 - Highlight potential buildings that were missed by the rule-based algorithm, for human inspection. (Clusters identified as **uncertain**)

DIGITAL MODELS GENERATION

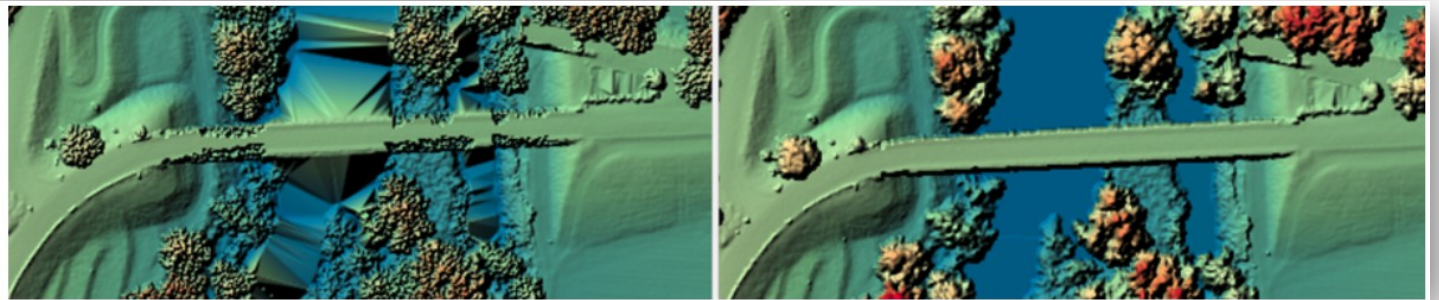
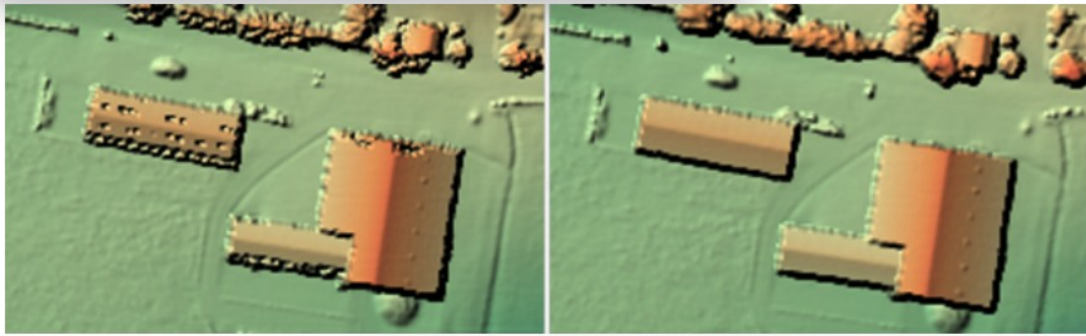


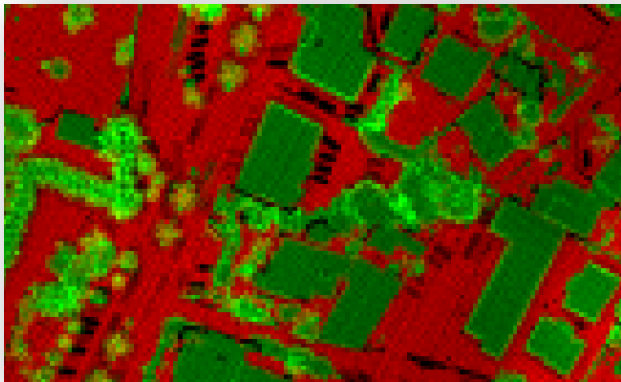
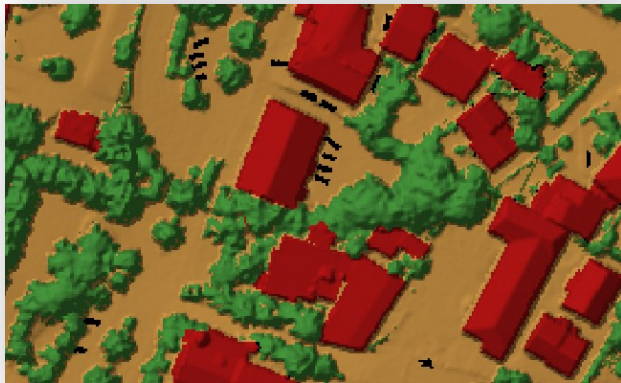
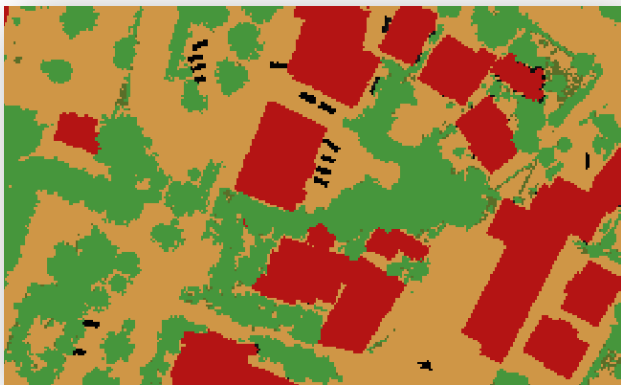
- Points pre-selection based on geometrical rules:
 - Vegetation canopy
 - Building limits
 - ...
- 2D Delaunay triangulation
- Interpolation on a regular grid
- Based on pdal / gdal
- Digital Terrain Model, Digital Surface Model, Digital Height Model
- To be released soon...

DIGITAL MODELS GENERATION



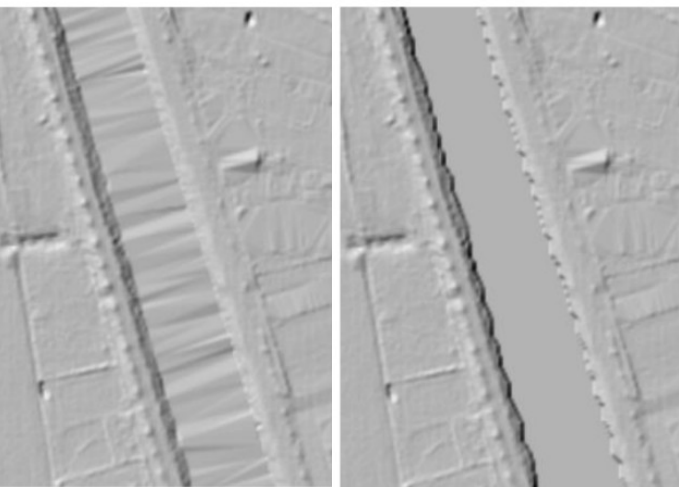
EFFECTS OF POINT PRE-SELECTION





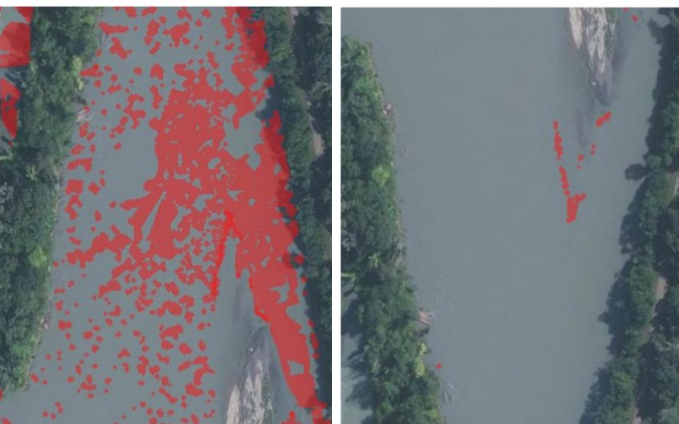
CTVIEW : 2D MAPS GENERATION

- Generate thematic 2D map view from LAS Files
 - Classification maps
 - Density maps
 - Can be extended to other maps
- Highly configurable using a yaml file
- Based on pdal / gdal
- To be released soon...




Before

After



In red, holes in the water surface

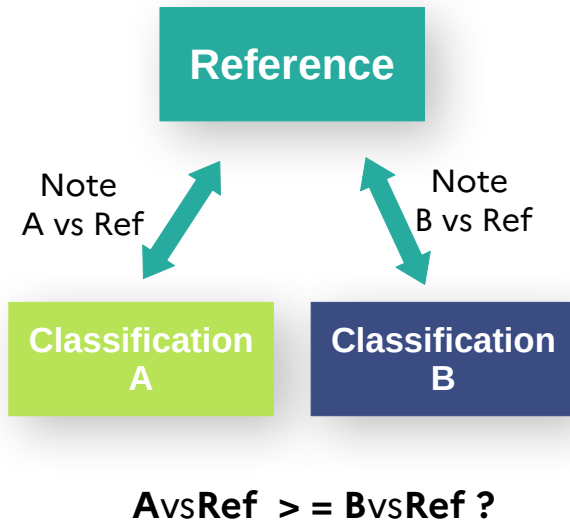
LIDRO: WATER SURFACES FLATTENING

- Requirement specific to water: water should flow downwards
- Issues:
 - Missing points on the river edges
 - Almost no points in water
- Use information from BDTOPO + water masks (information of missing points) to create water skeletons
- Available at <https://github.com/IGNF/lidro> 
(MIT license)

An aerial 3D map showing a landscape with buildings, trees, and terrain. The buildings are colored in shades of red and pink, while the trees are green. The terrain is colored in shades of blue, purple, and yellow. A white box is overlaid on the map, containing the text '4. EVALUATION TOOL'.

4. EVALUATION TOOL

COCLICO: CLASSIFICATION EVALUATION



- **CO**mparaison de **CL**assification par rapport à une référence **CO**mmune (Compare classification results to a common reference)
- Compare classifications independently of the classification method
- No single metric was representative of the quality of the classification
=> Combination of several metrics
- Note without a unit, **only used to say which classification is best**



Credit: Karen Arnold
(publicdomainpictures.net)

Reference

VS

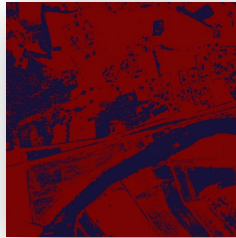
Classification
A

Class Ref / Class A	1	2	3, 4, 5	6
1	15	1	21	1
2	2	1540	0	1
3, 4, 5	0	0	5641	0
6	15	1	15	5464

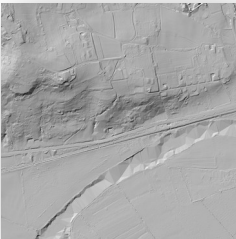
COCLICO: CLASSIFICATION EVALUATION



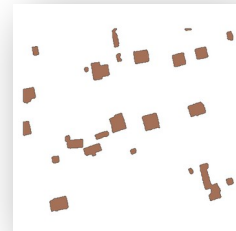
VS



VS



VS



CURRENT METRICS (CLASS BY CLASS)

- Point to point metrics: points count difference, confusion matrix
- Planimetric metrics: using a classification map
- Altimetric metrics: using digital models for each class
- Objectwise metrics: eg. check that all buildings are detected
- Aim to add new metrics!
- Available at <https://github.com/IGNF/coclico> (MIT License)
- Still under development





5. CONCLUSION



CONCLUSION

Bunch of open source tools (or soon to be) integrated in our process:

- Distributed computing platform
- Classification Tools
- 2d Maps generation tools
- AI training helpers
- Evaluation Tool

Different levels of maturity to these tools.

Eg:

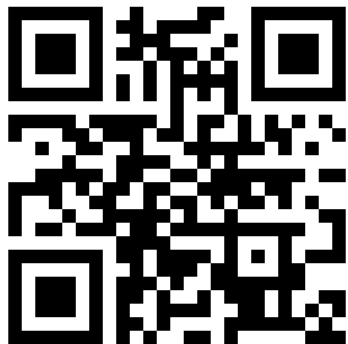
- Myria3d already used outside IGN, a few external pull requests
- Coclico still under development
- CtView not yet released



THANK YOU FOR YOUR ATTENTION

OUR OPEN DATA

[https://
geoservices.ign.fr/](https://geoservices.ign.fr/)



géoservices

OUR OPEN SOFTWARE

<https://github.com/ignf/>



OUR OPEN AI MODELS

[https://huggingface.co/
IGNF/](https://huggingface.co/IGNF/)

