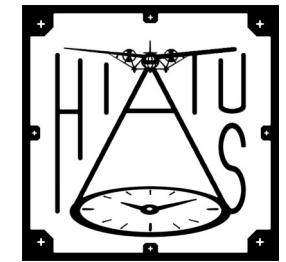




Liberté
Égalité
Fraternité



GEOMETRIC AND RADIOMETRIC PROCESSING OF HISTORICAL AERIAL PHOTOGRAMMETRIC CAMPAIGNS



HIATUS ANR PROJECT "HISTORICAL IMAGE ANALYSIS FOR TERRITORY EVOLUTION STORIES"

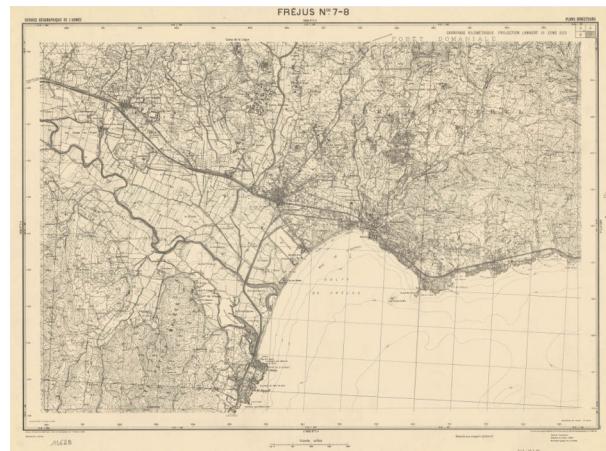


<https://anr-hiatus.github.io/>

arnaud.le-bris@ign.fr

Context

Which data to analyze des **long-term spatio-temporal evolution of territories** ?



Topographic maps



Archival aerial images



Archival satellite images

Context

Which data to analyze des **long-term spatio-temporal evolution of territories?**



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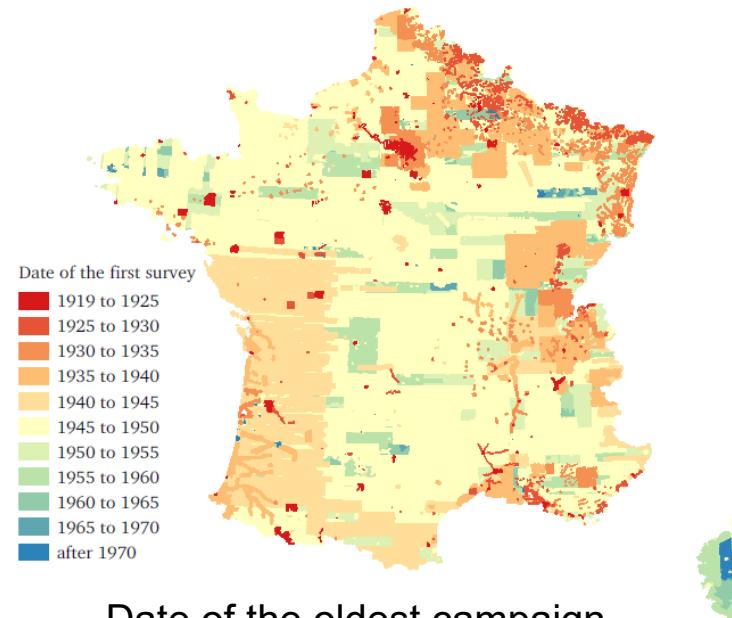
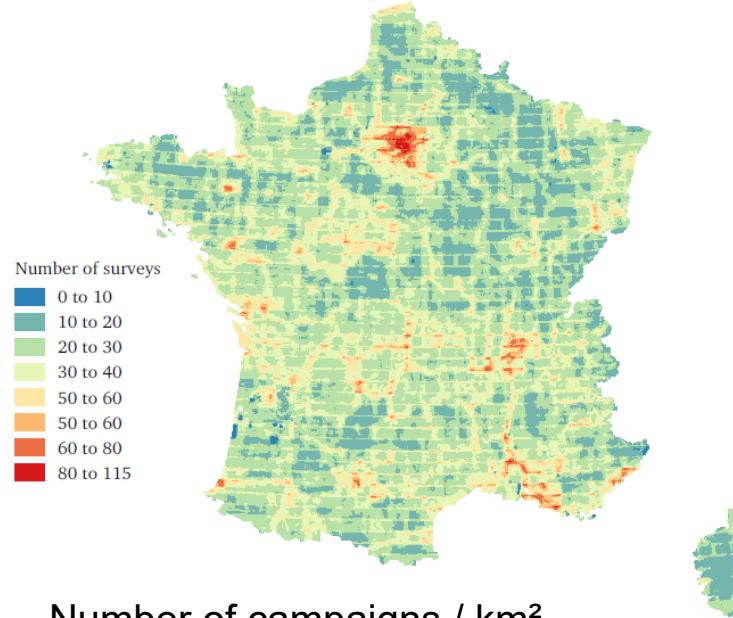


Archival satellite images

→ **Archival aerial images** : a unique and still not widely used source :

- to observe the evolution of territories
- to detect (geometric / semantic) changes
- to produce historical land cover maps

Archival aerial images in France

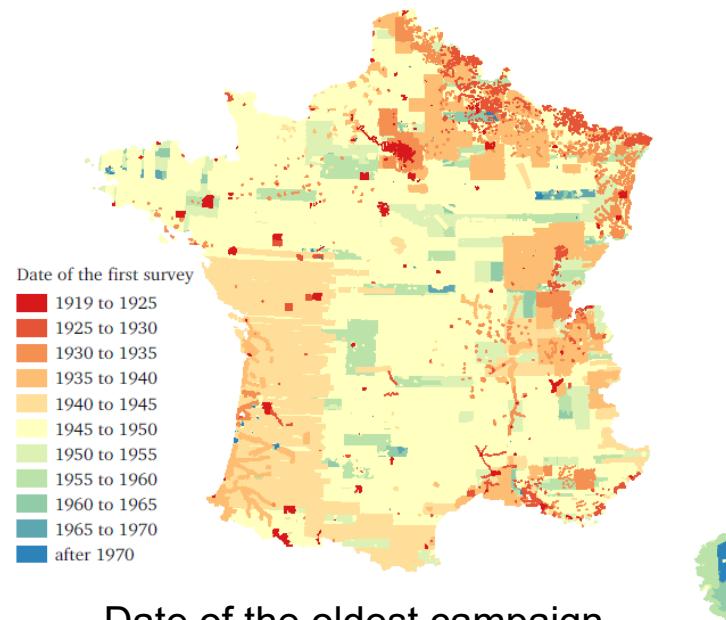
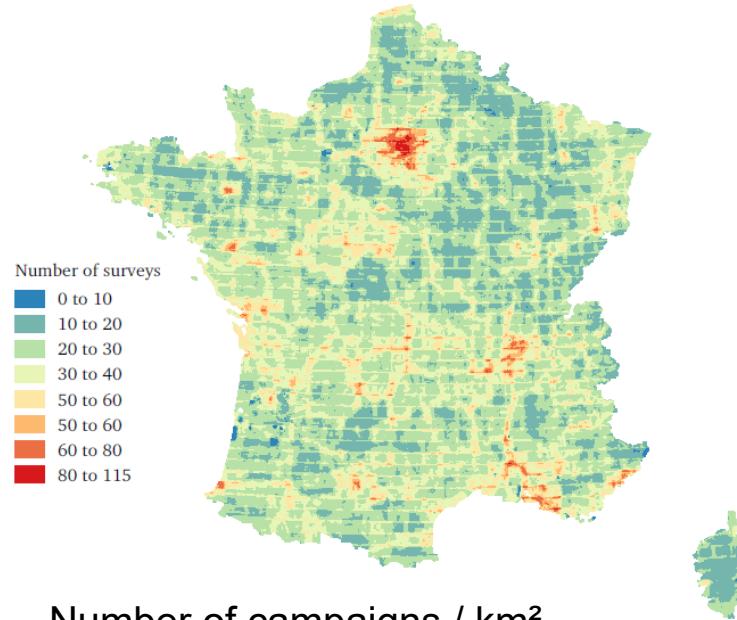


→ Archival aerial images:

- Available everywhere
- Long time series



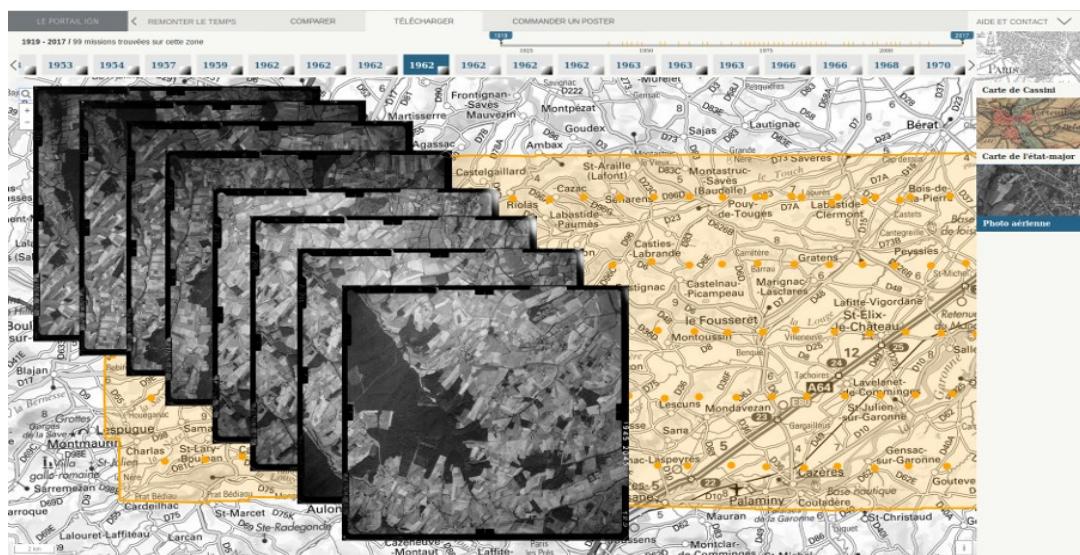
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→ Archival aerial images:

- Available everywhere
- Long time series
- Scanned and available through web services

<https://remonterletemps.ign.fr>



Possible use cases?

- Many possible use cases
 - Artificialization



Possible use cases?

- Many possible use cases
 - Artificialization
 - Forest extension



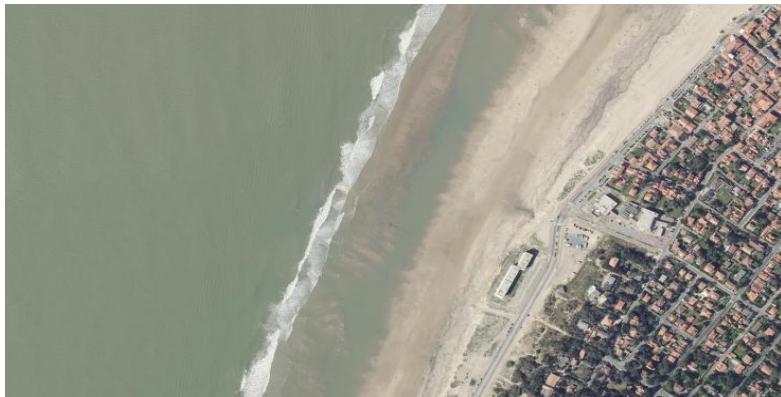
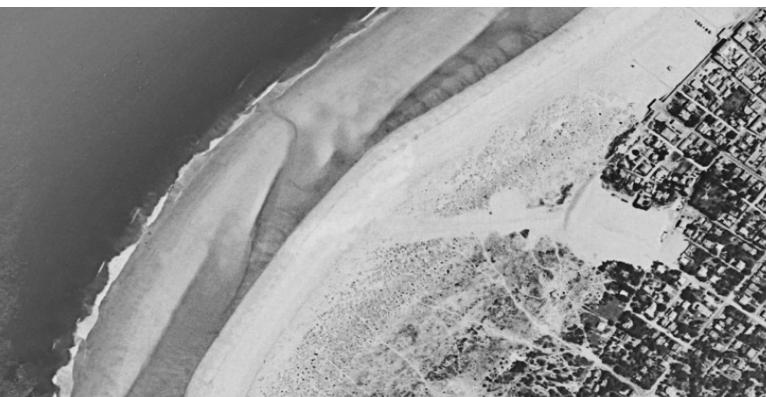
Possible use cases?

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 - Agricultural practices:
 - parcels evolution
 - removal of hedges



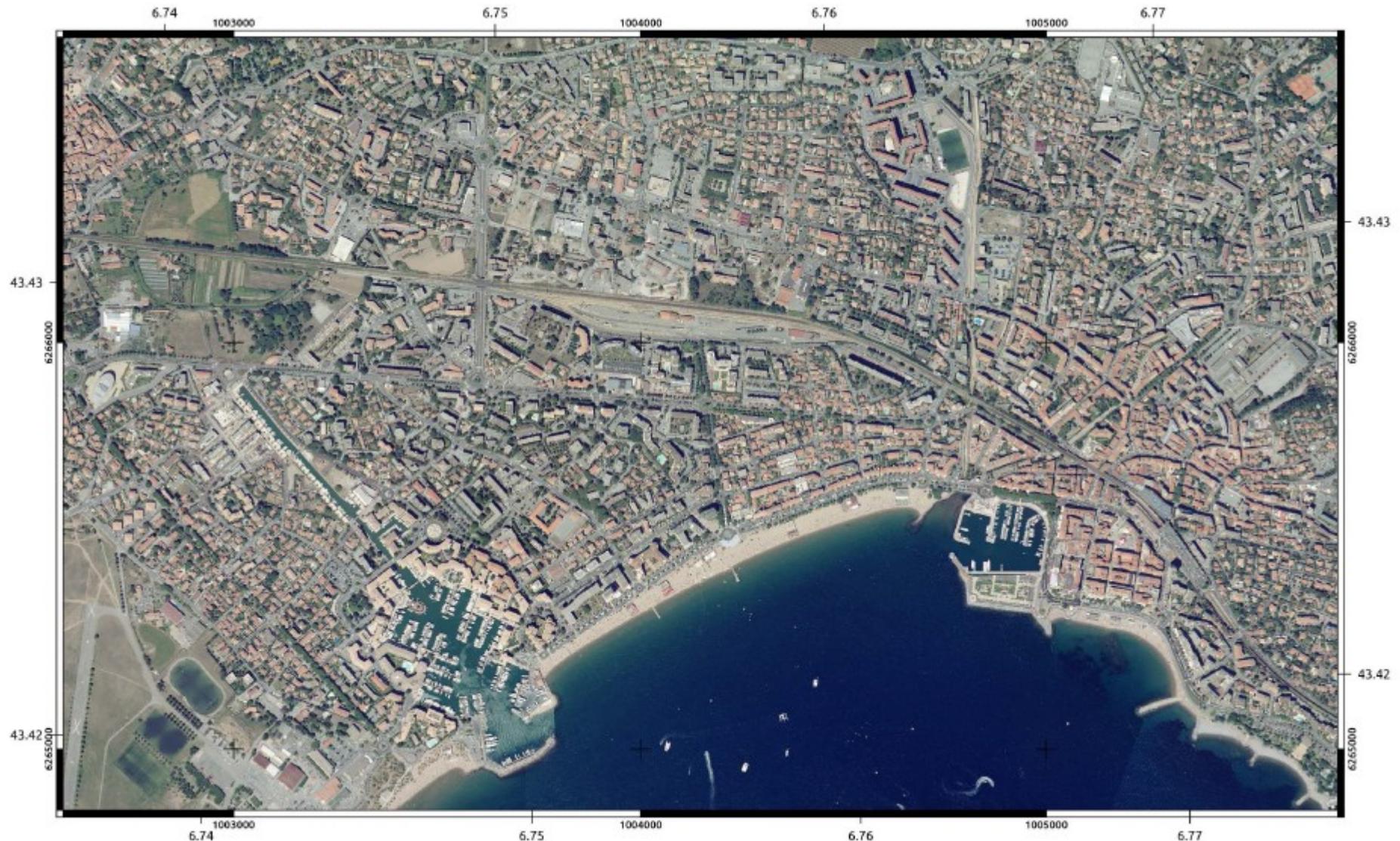
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 - Agricultural practices:
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 - removal of hedges
 - Littoral erosion



Archival aerial images?

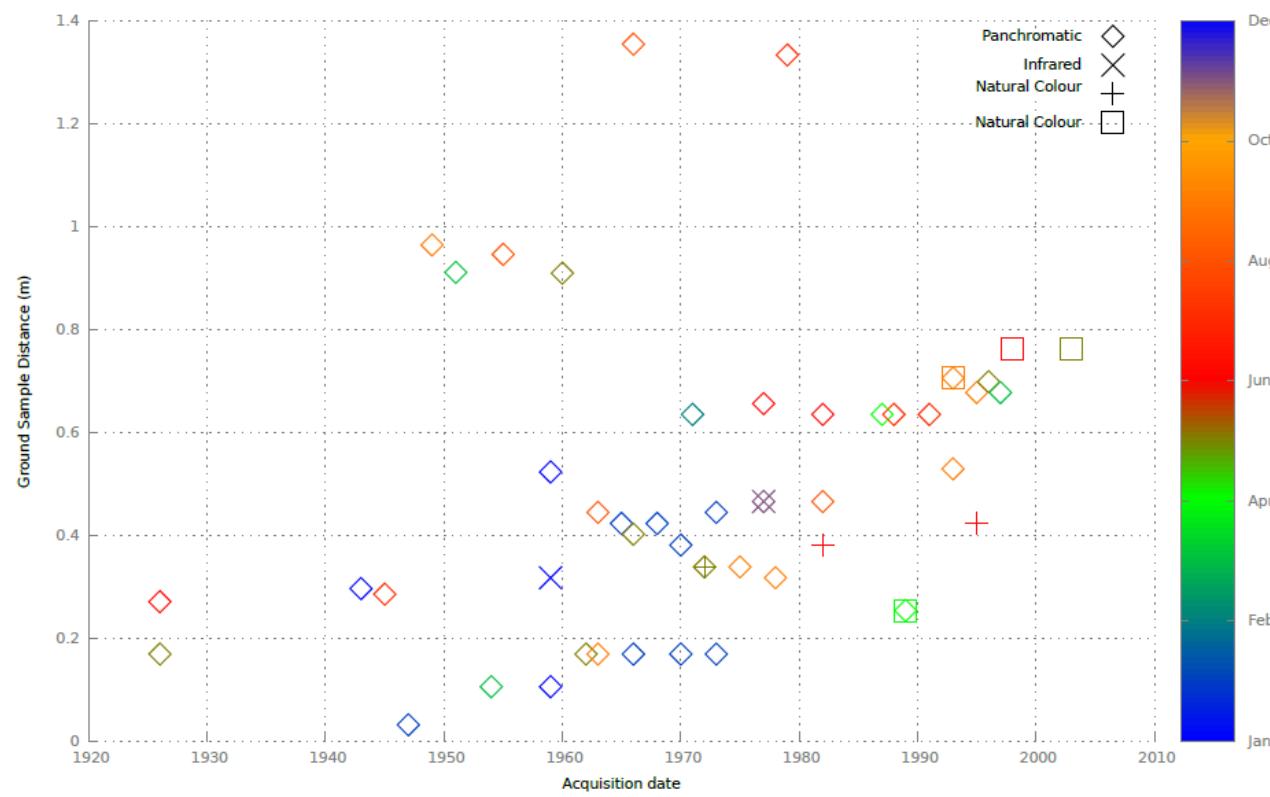
- Very heterogeneous data
(spatial resolution, spectral configuration, season, network structure. ...)



Fréjus study area ; urban area ; 3 km x 2 km

Archival aerial images?

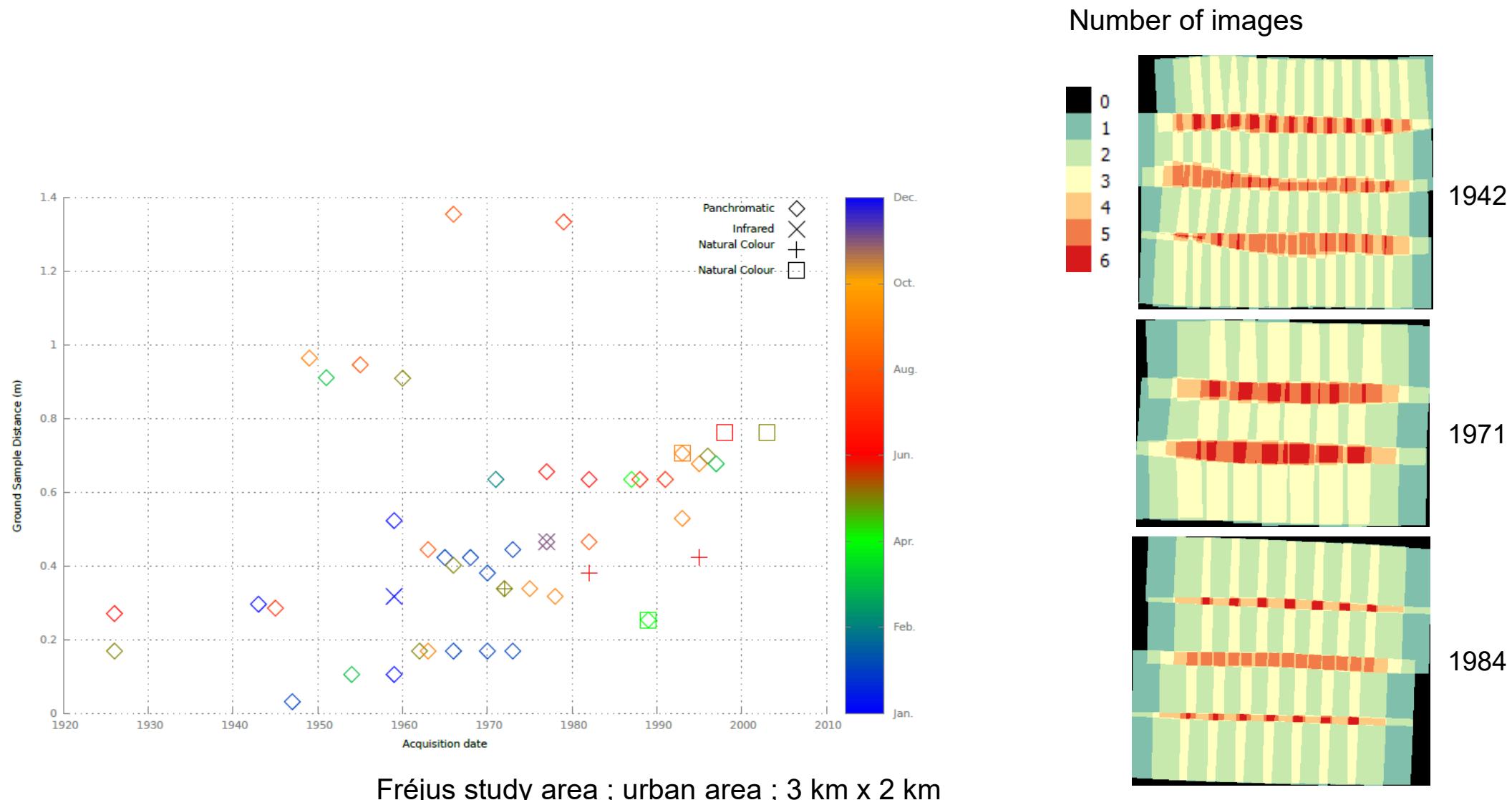
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Archival aerial images?

- Multi-view acquisitions → 3D information...



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Archival aerial images?

- Multi-view acquisitions → 3D information...
but require pose estimation / internal and external calibration



Fréjus study area ; urban area ; 3 km x 2 km

HIATUS project



"Historical Image Analysis for Territory evolUtion Stories"

- Geometric and radiometric processing

HIATUS project



"Historical Image Analysis for Territory evolUtion Stories"

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- **Data analysis**

- Pbs: heterogeneity, quality and imprecise data and lack of reference data

HIATUS project



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- **Change detection and image+DSM time series analysis**
 - Robust clustering wrt noise and data heterogeneity
 - Constrained collaborative clustering taking into account prior knowledge related to use cases

HIATUS project



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- **End user interaction:**

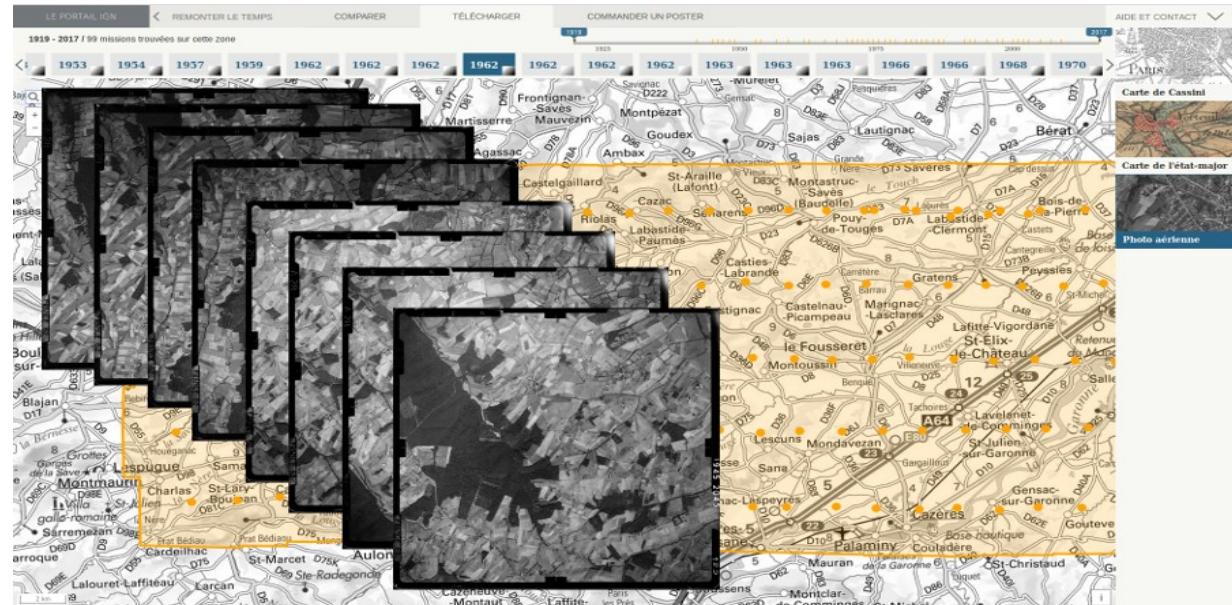
- Develop an online viewer to show the evolution of territories for some land cover use cases and an interactive change detection tool

GEOMETRY

Archival aerial images?

In France, scanned image are available at :

<http://remonterletemps.ign.fr>



Some **metadata** are available:

- Coarse flight plan
- Focal
- Physical size of images
- Scan parameters (dpi)
- Calibration [rarely]

Usual photogrammetric pipeline

- **Image orientation:**

- Interior orientation [image per image]
- Relative orientation: "en l'air" model [all images + camera metadata]
- Absolute orientation: georeferenced model [all images + position metadata + GCPs]

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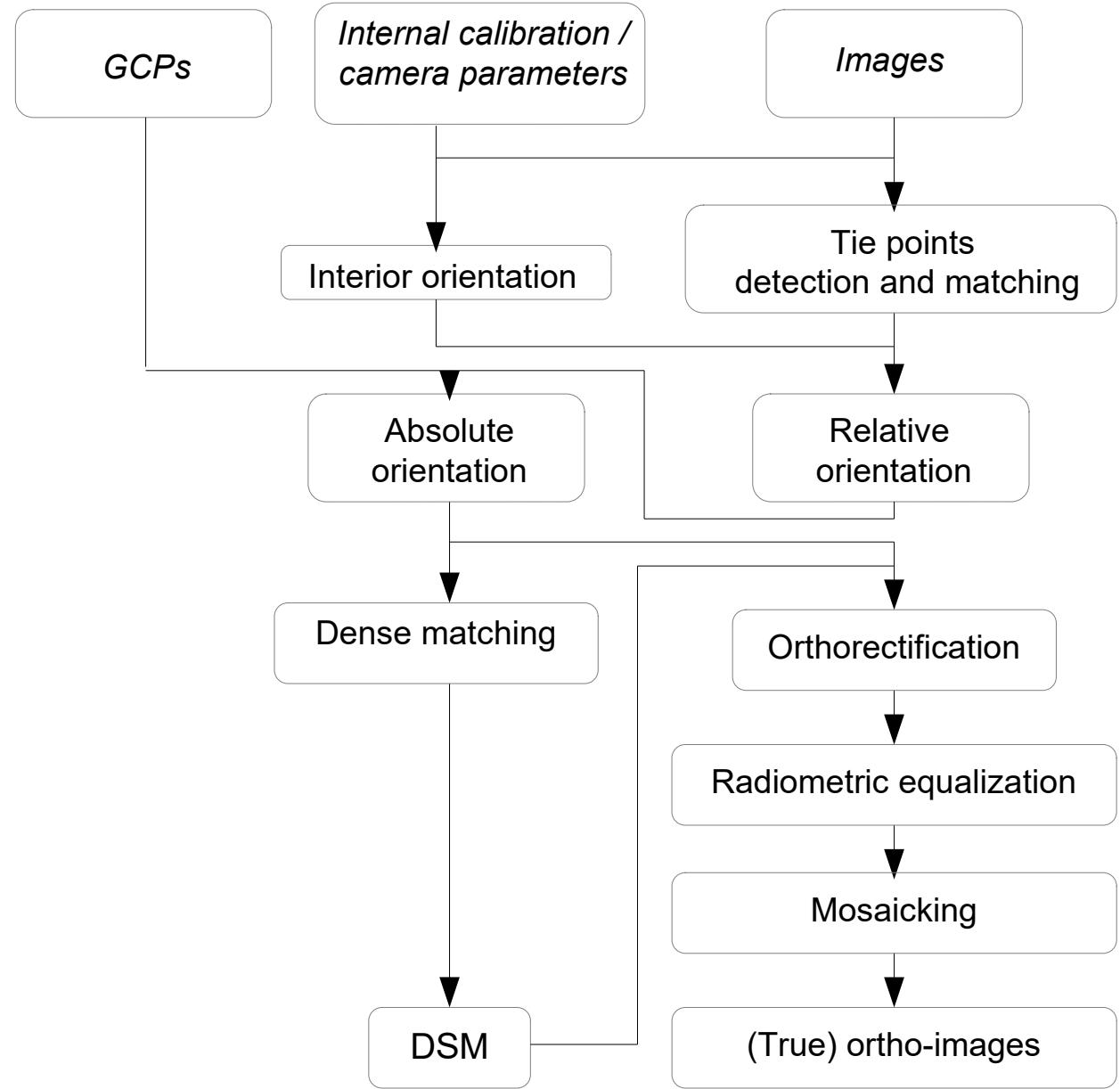
- **Final products:**

- Dense matching – DSM
- Orthoimage (orthorectification + mosaicing)

Some **metadata** are available:

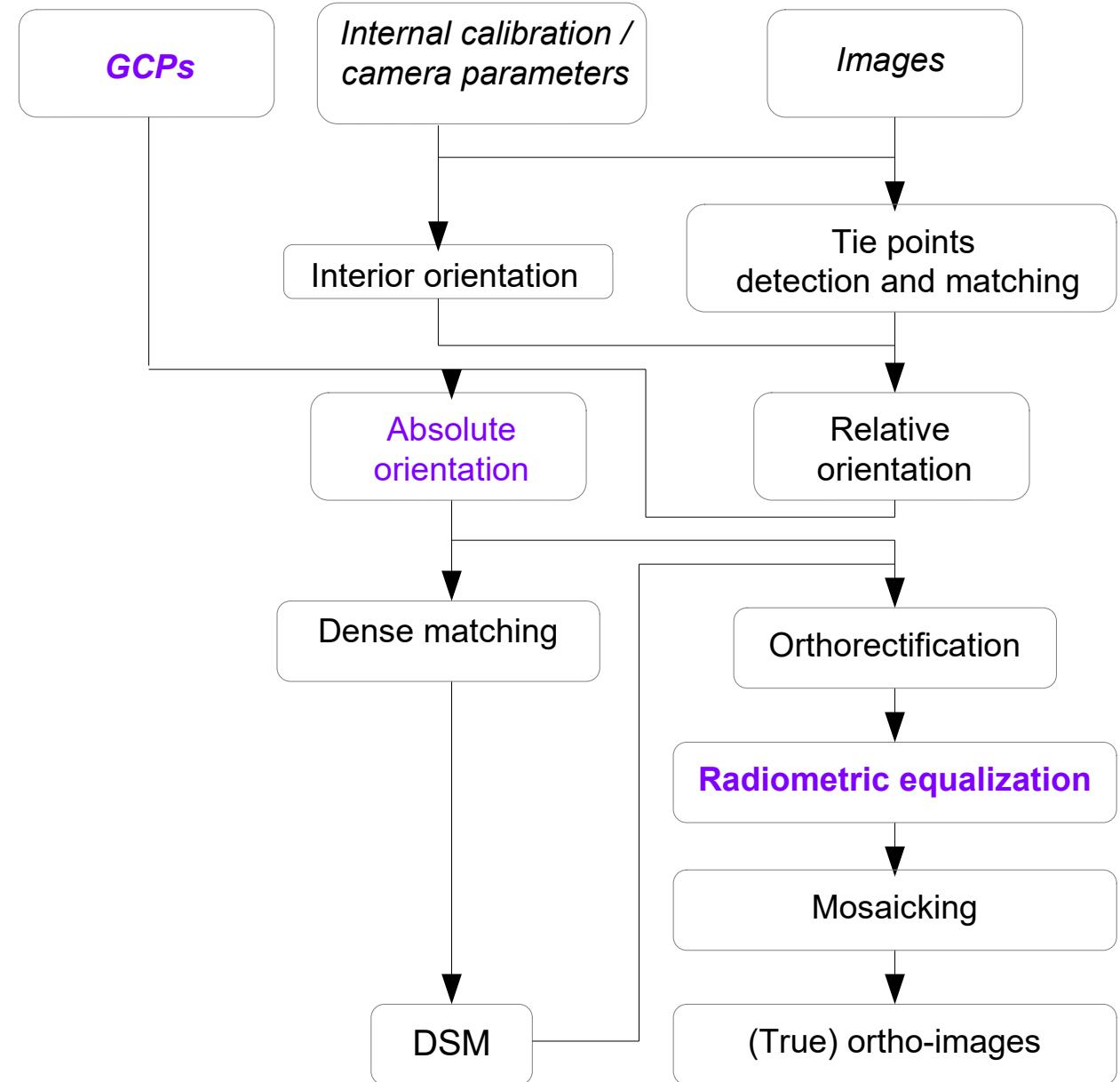
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Usual photogrammetric pipeline

Main issues



Using only available data...



Fabas study area ; 12 km x 10 km ; **recent ortho-image (IGN BDOrtho)**

Using only available data...



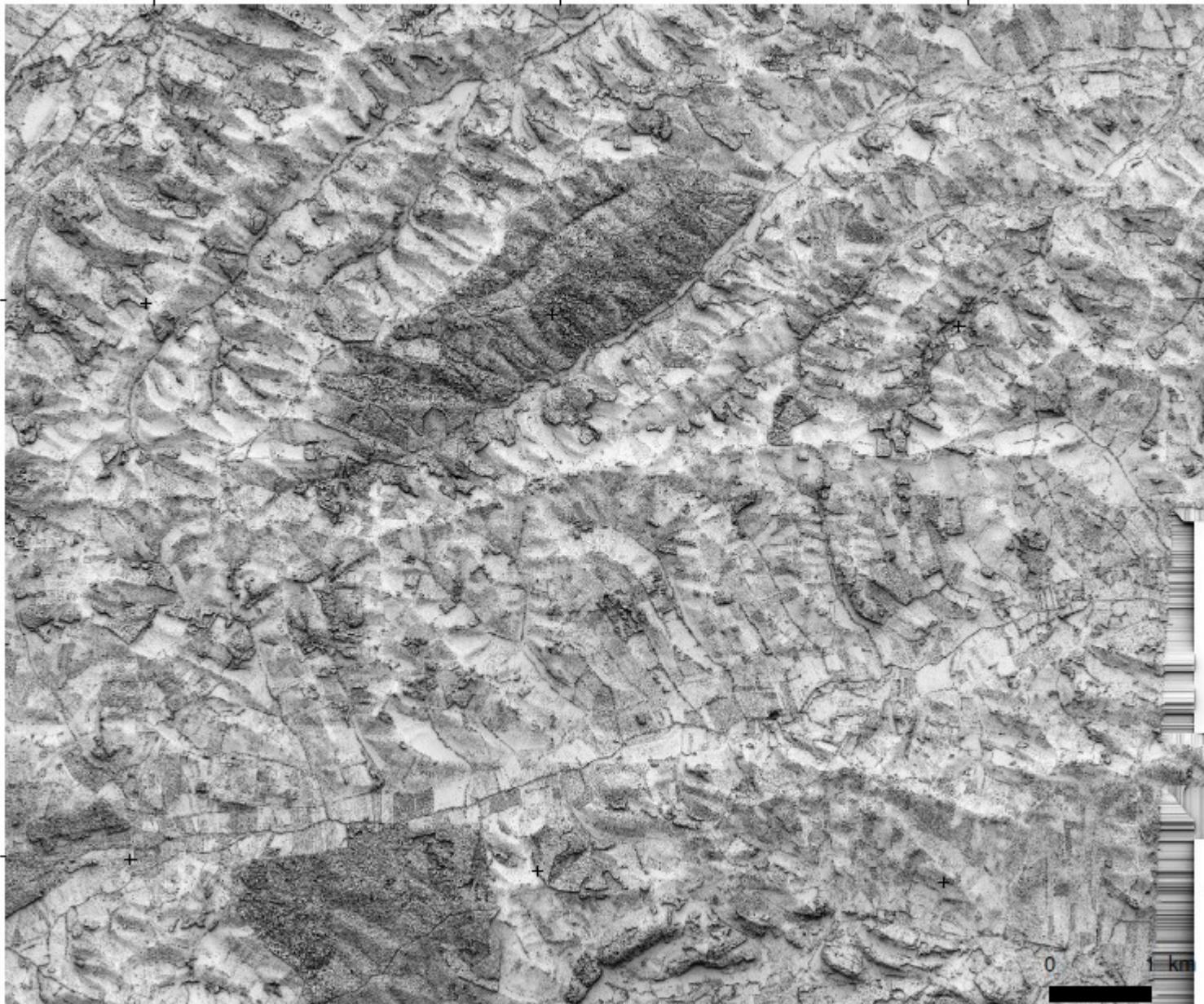
Fabas study area ; 12 km x 10 km ; ortho-image from an acquisition of 1984
pose+calibration directly out of available metadata

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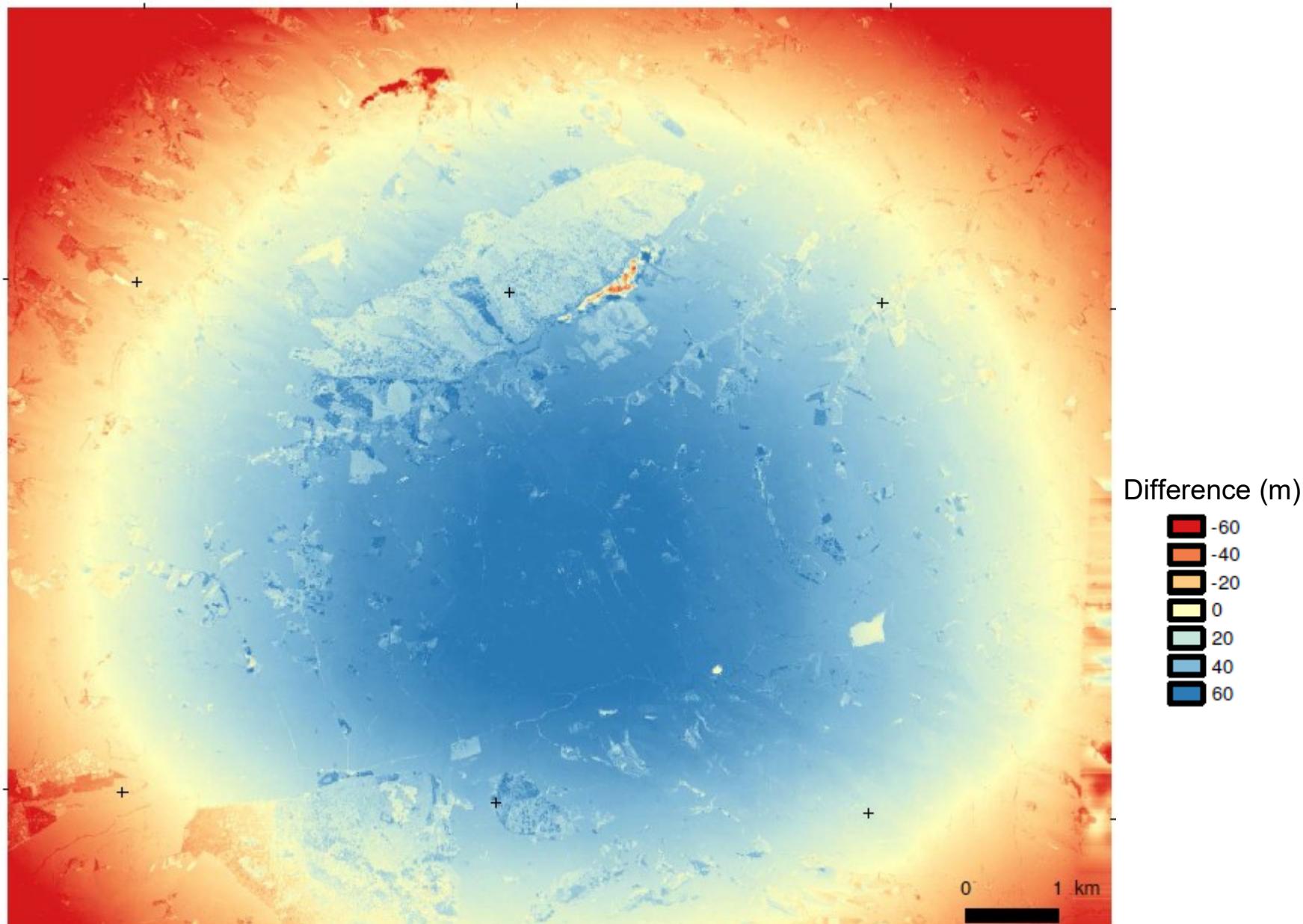
Fabas study area ; 12 km x 10 km ; **ortho-image from an acquisition of 1984**
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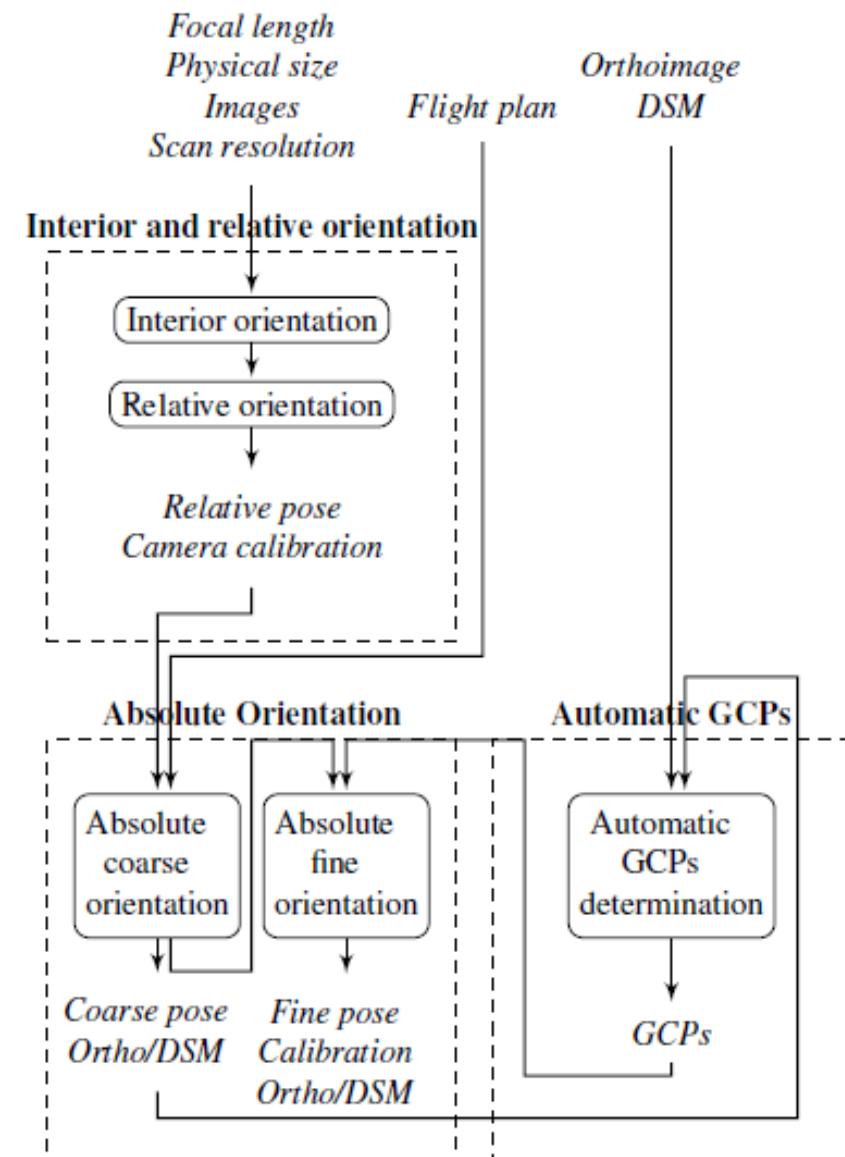
Fabas study area ; 12 km x 10 km ; DSM from an acquisition of 1984
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Using only available data...



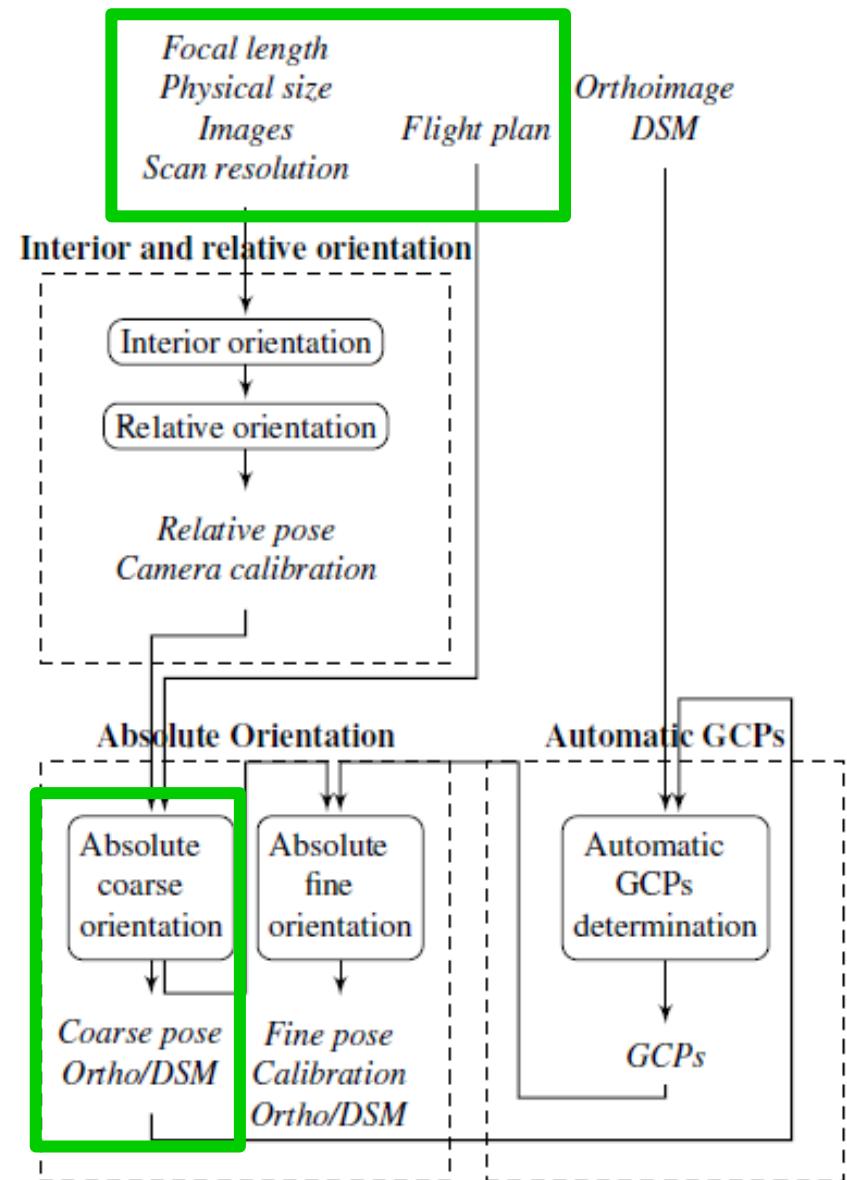
Fabas study area ; 12 km x 10 km ; altimetric difference between "1984" DSM and present "reference" DSM

Proposed approach



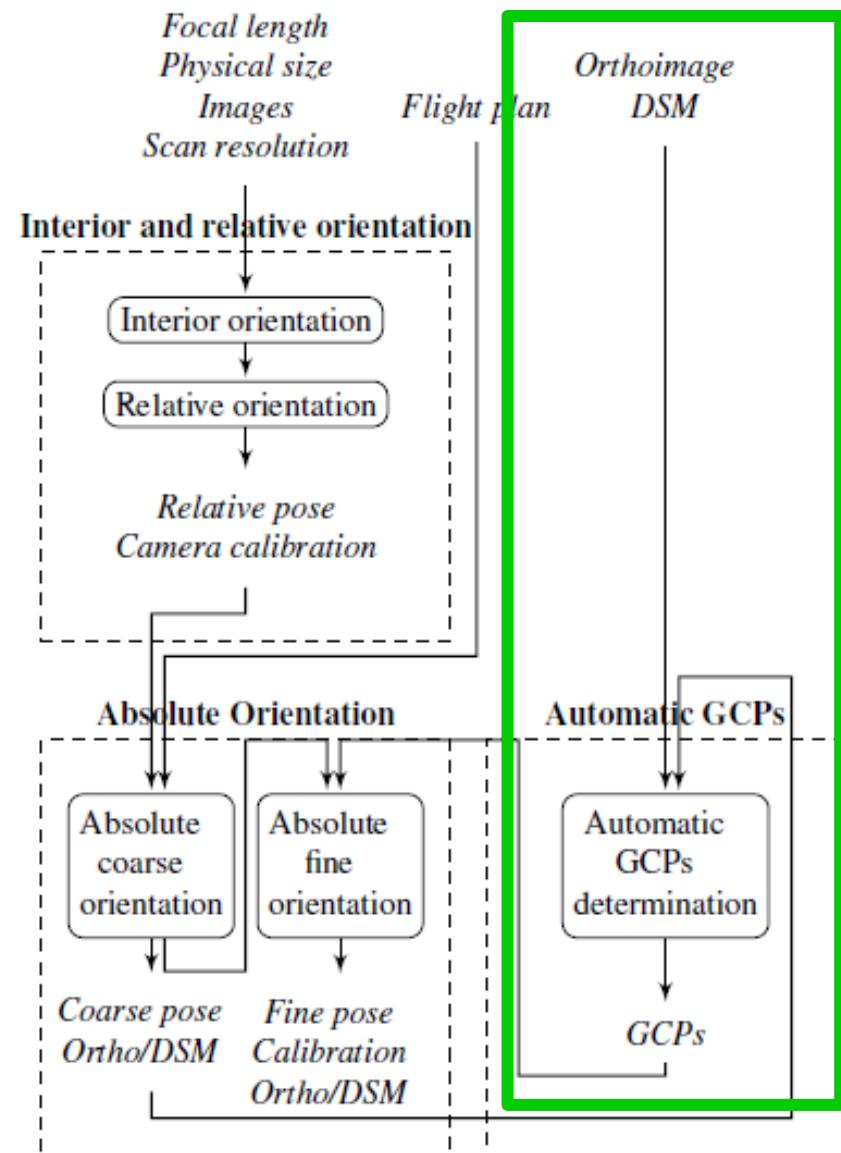
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- Use metadata provided with images :
→ "Coarse" initial solution



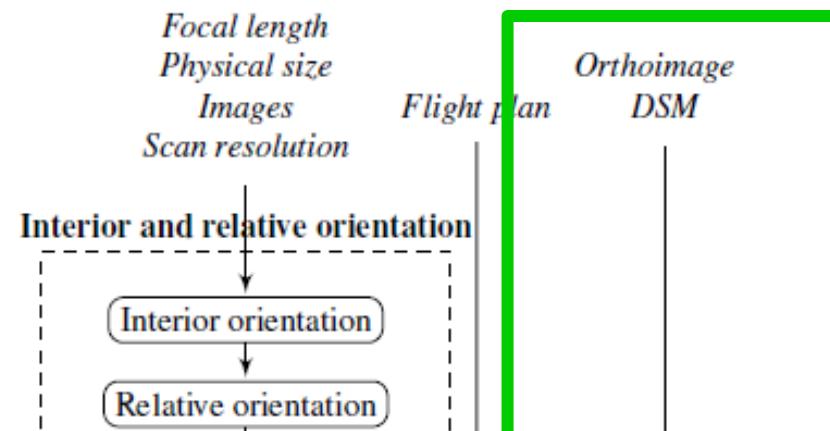
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Detect and match homologous points between archival "coarse" ortho-images/DSM and recent reference ones



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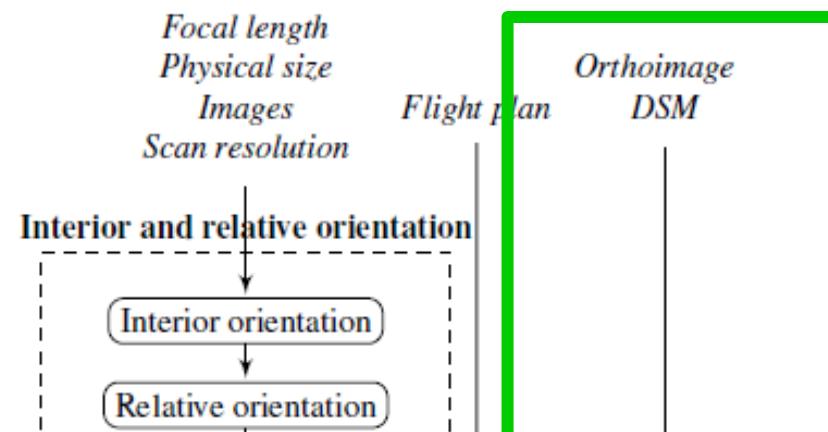
Inter-date homologous point detection → need for a method robust to diachronism...

- Cross-domain approaches adapted to multimodal data ? DASC [Kim et al. , 2017]
- Learning based approaches:
 - *TILDE* [Verdié et al. , 2015]
 - *LIFT* [Yi et al. , 2016] (deep learning)
 - [Aubry et al., 2014] → designed to detect homologous points

between recent images and historical paintings
→ multi-modal and multi-temporal !

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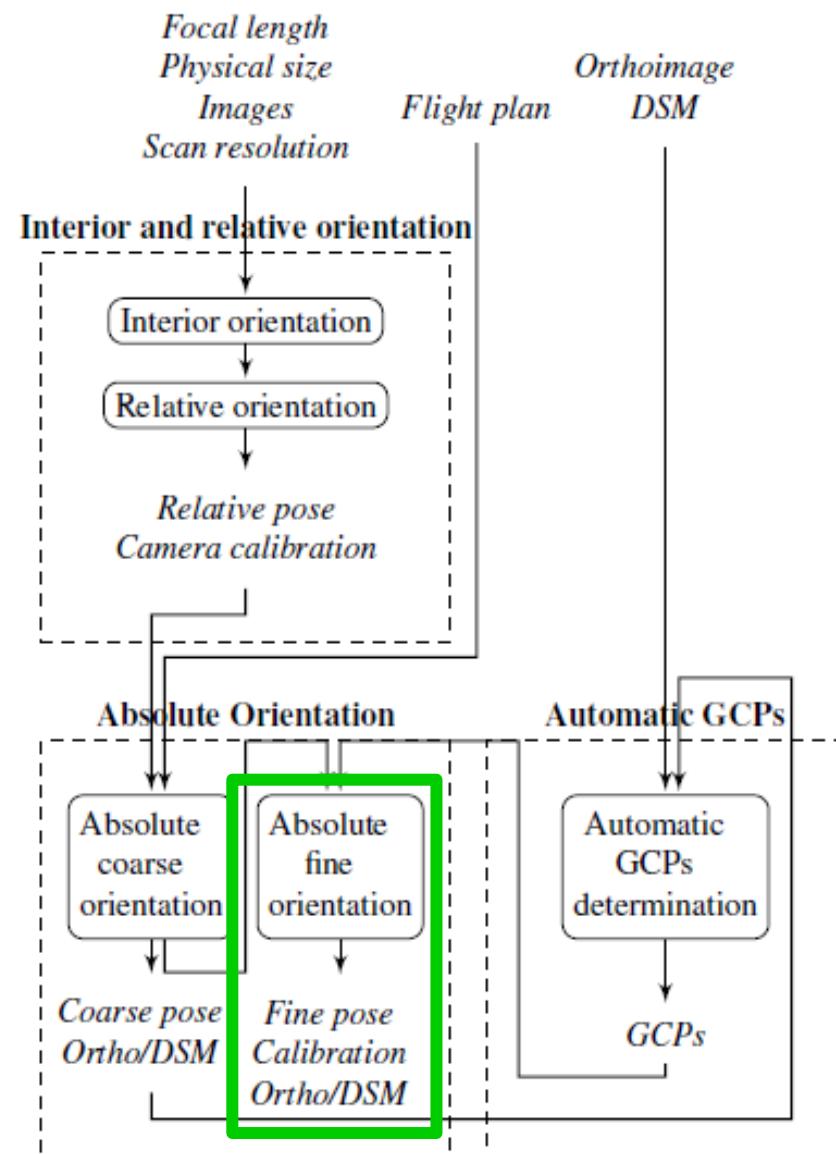


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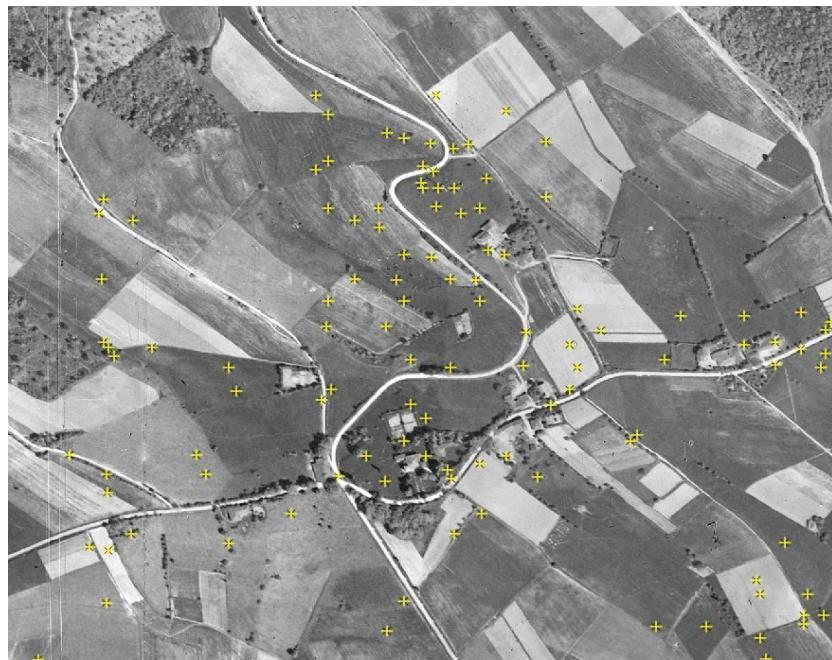
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Automatic GCPs: results



Fabas
1942



Fréjus
1954



Visual assessment

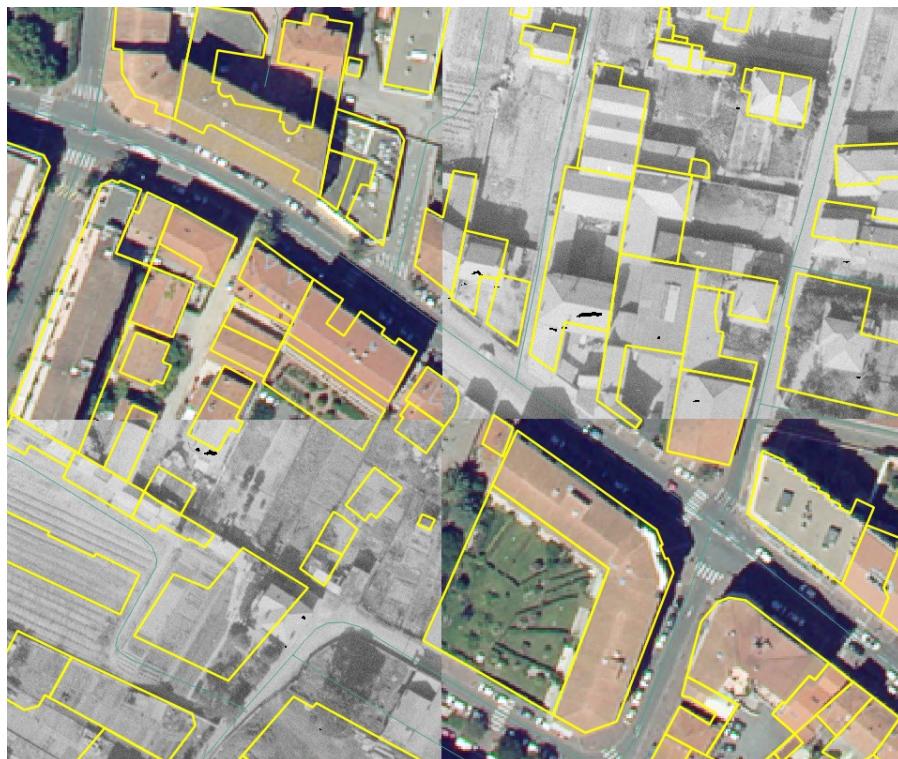


Fréjus (1954, coarse calibration)



Fabas (1942 , coarse calibration)

Visual assessment

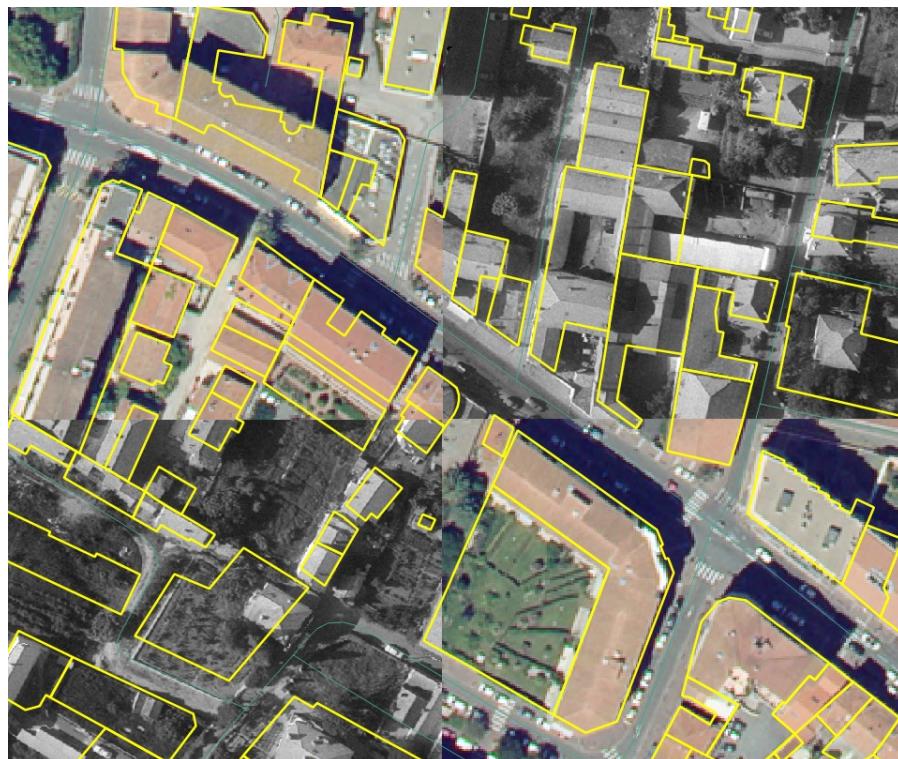


Fréjus (1954)



Fabas (1942)

Visual assessment

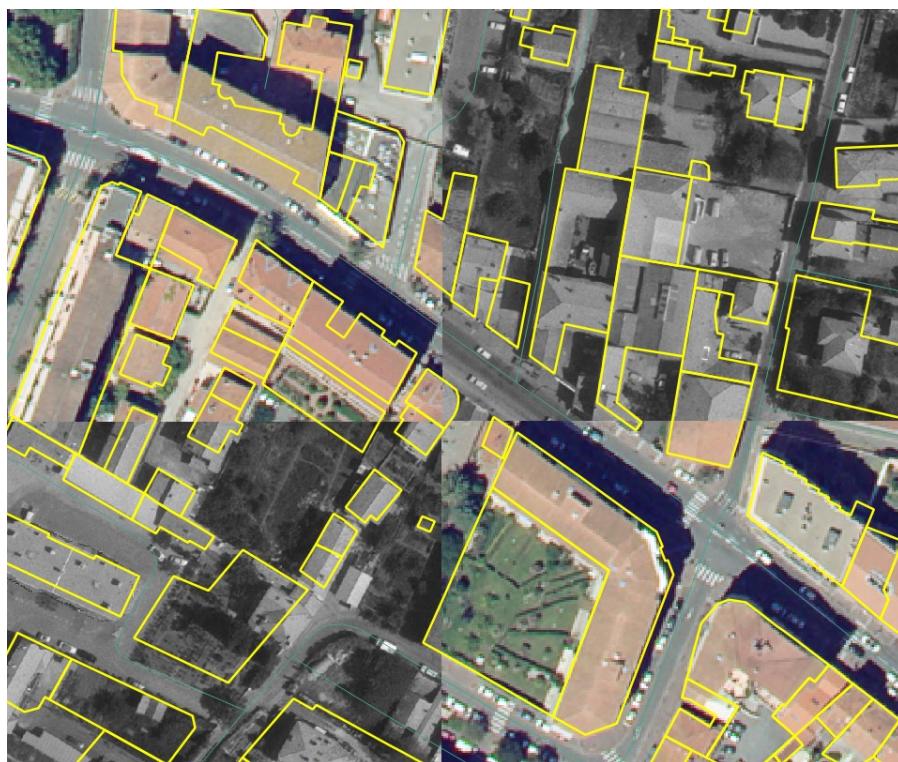


Fréjus (1966)



Fabas (1962)

Visual assessment

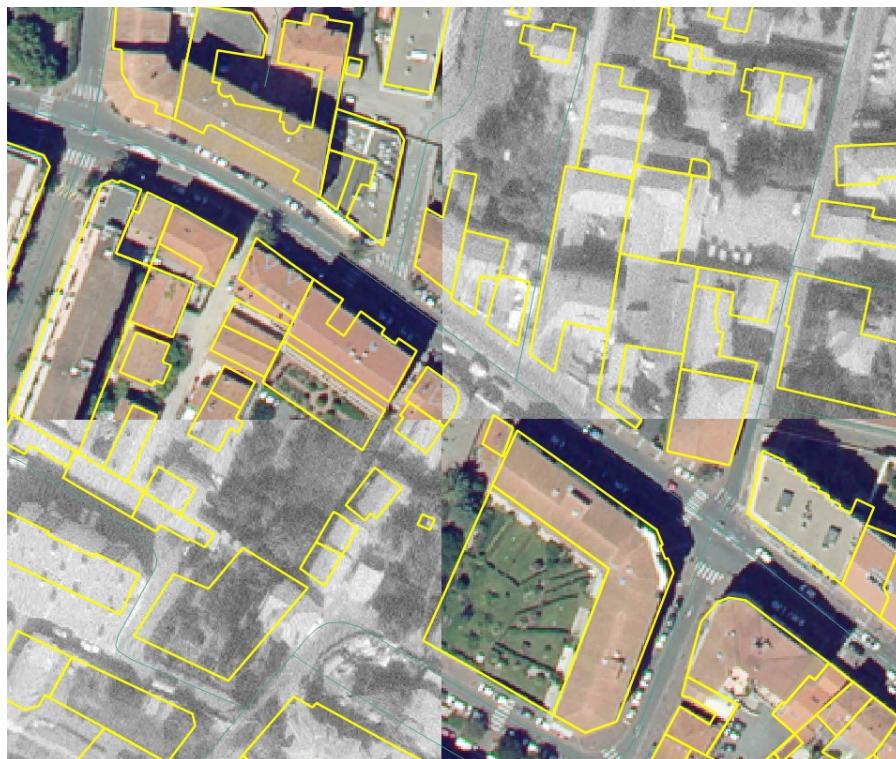


Fréjus (1970)



Fabas (1971)

Visual assessment

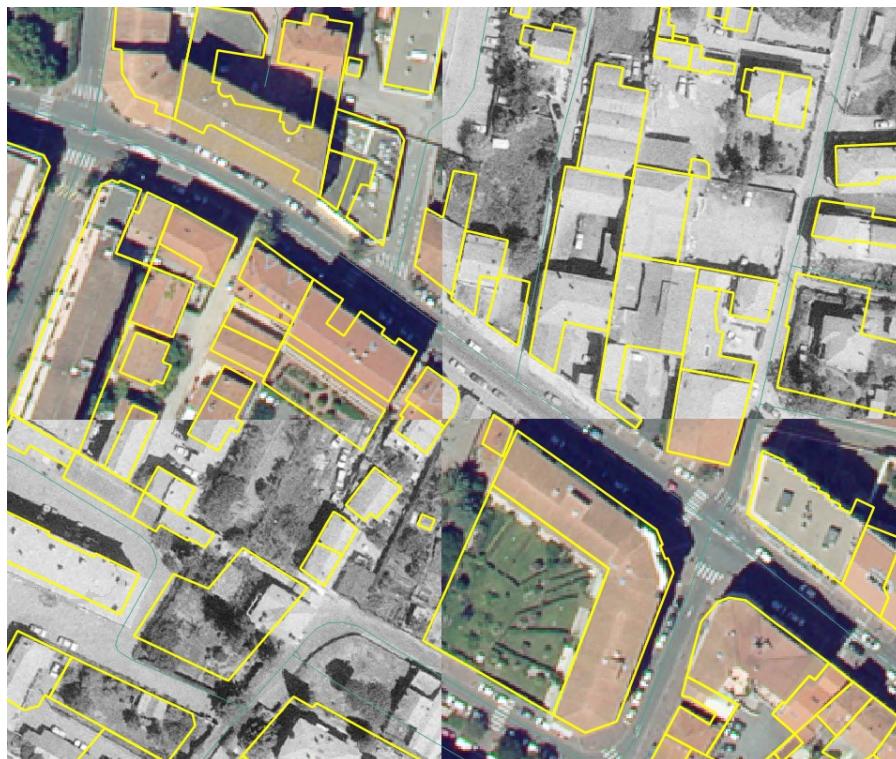


Fréjus (1978)



Fabas (1984)

Visual assessment



Fréjus (1989)

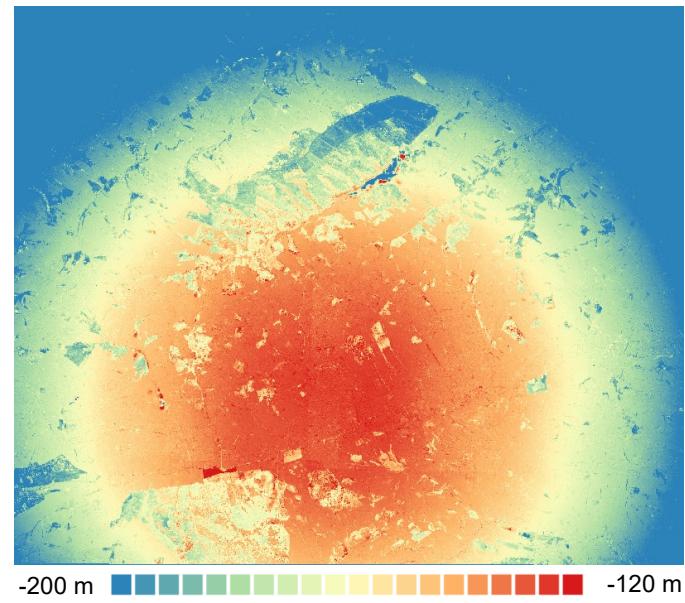


Fabas (1992)

Automatic GCPs: results

Altimetric differences between obtained old DSM and reference DSM

Fabas (1971)

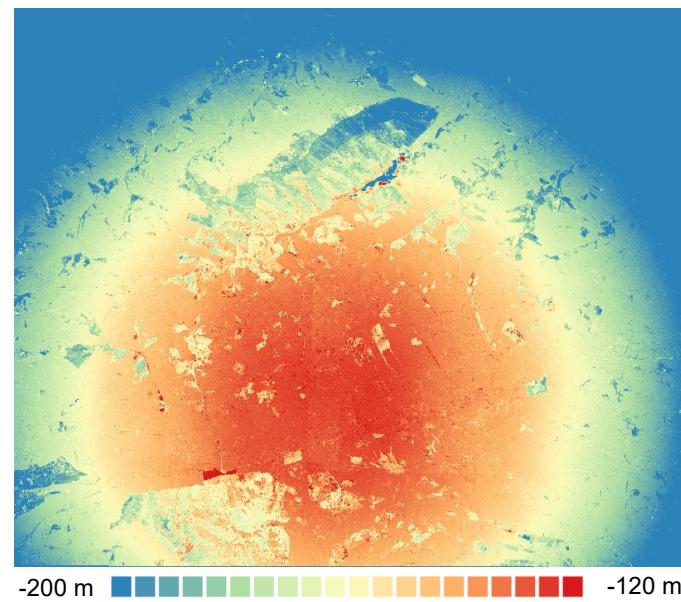


DSM "coarse calibration"

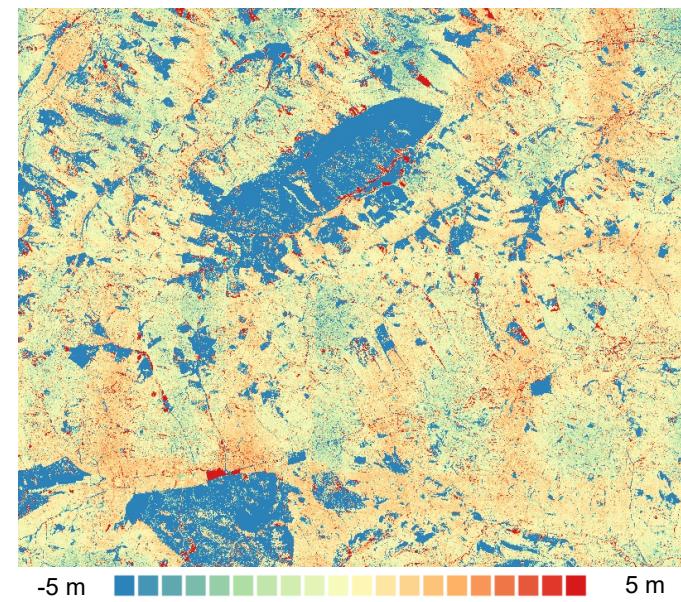
Automatic GCPs: results

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Fabas (1971)



DSM "coarse calibration"

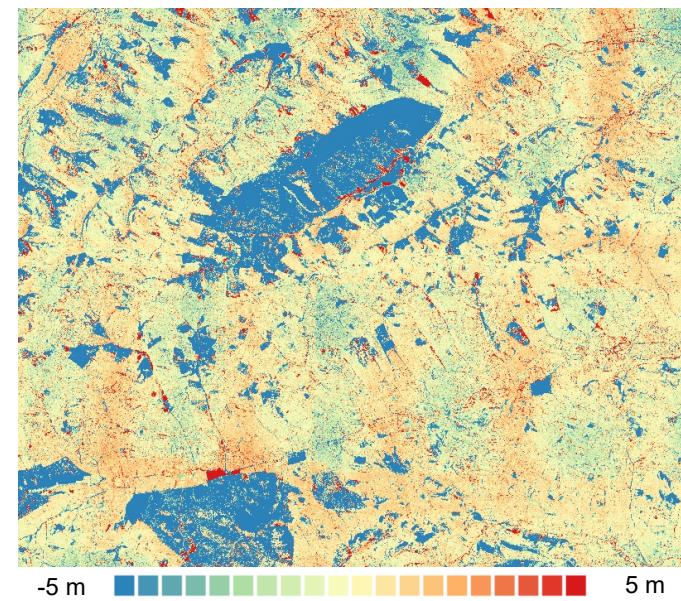
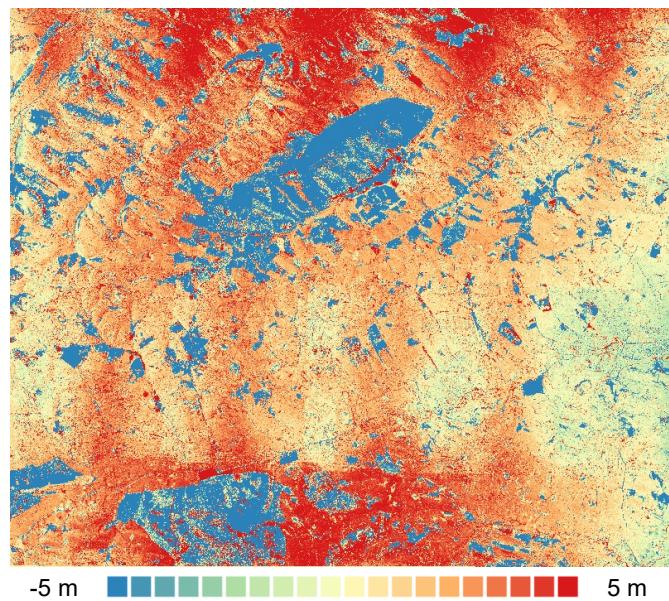
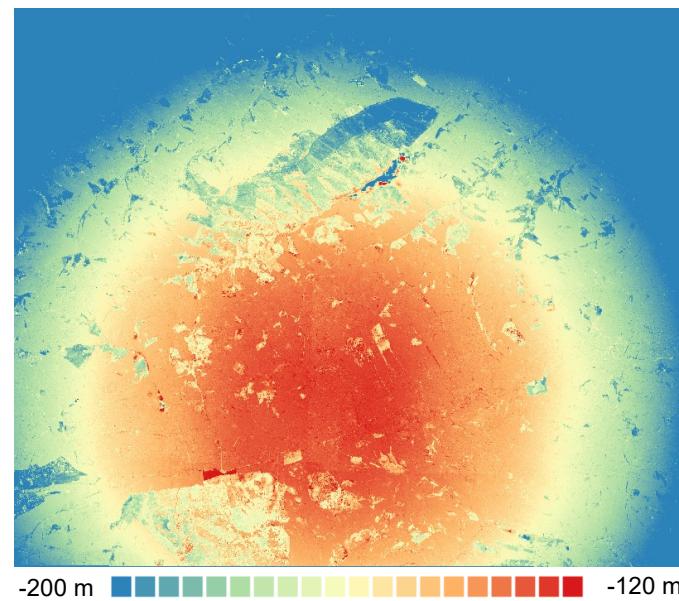


DSM "final calibration"
automatic control points
taken into account in bundle
adjustment

Automatic GCPs: results

Altimetric differences between obtained old DSM and reference DSM

Fabas (1971)



DSM "coarse calibration"

DSM "coarse calibration"
polynomial model applied to
correct altimetric
deformations

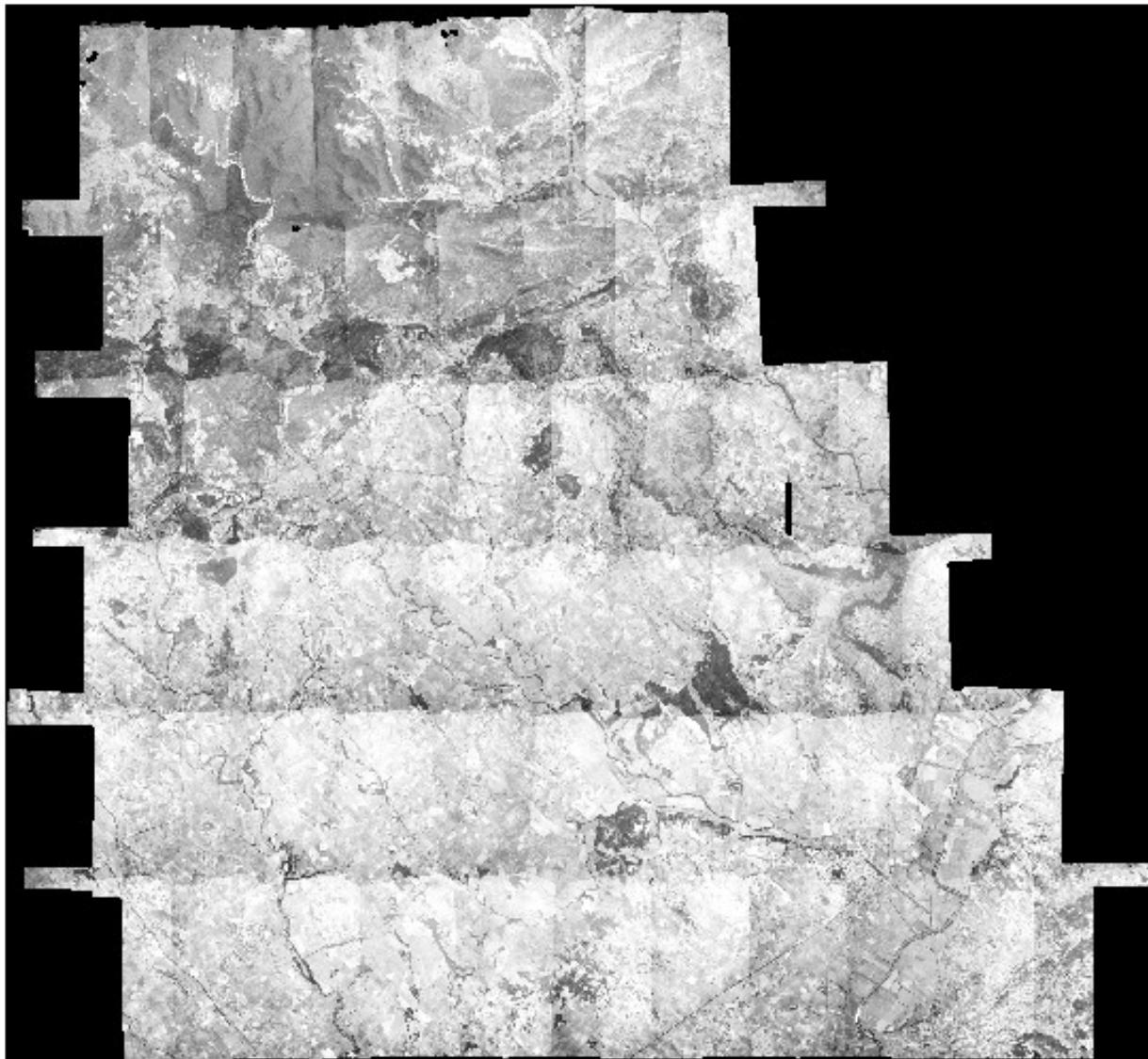
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RADIOMETRY

Radiometric issues

How to perform radiometric corrections to obtain homogeneous mosaics?

→ main phenomena to consider : vignetting, hot spot, fog, ...



Radiometric issues

How to perform radiometric corrections to obtain homogeneous mosaics?

→ main phenomena to consider : vignetting, hot spot, fog, ...

2 considered methods:

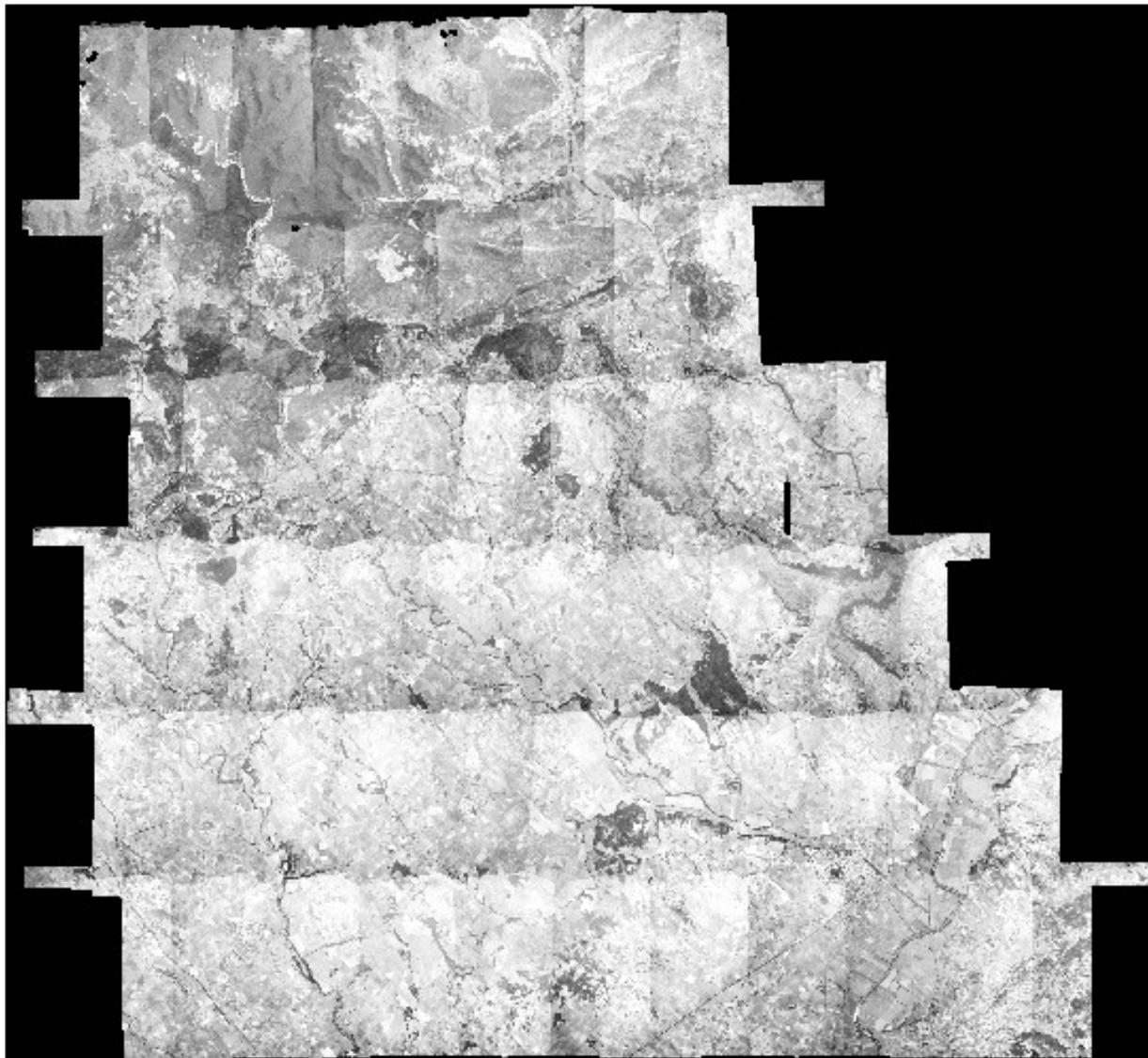
- Parametric model:

- An additive polynomial correction model for each image
- Minimize differences between ortho-images in overlapping areas
- Computed at low resolution

Radiometric issues

How to perform radiometric corrections to obtain homogeneous mosaics?

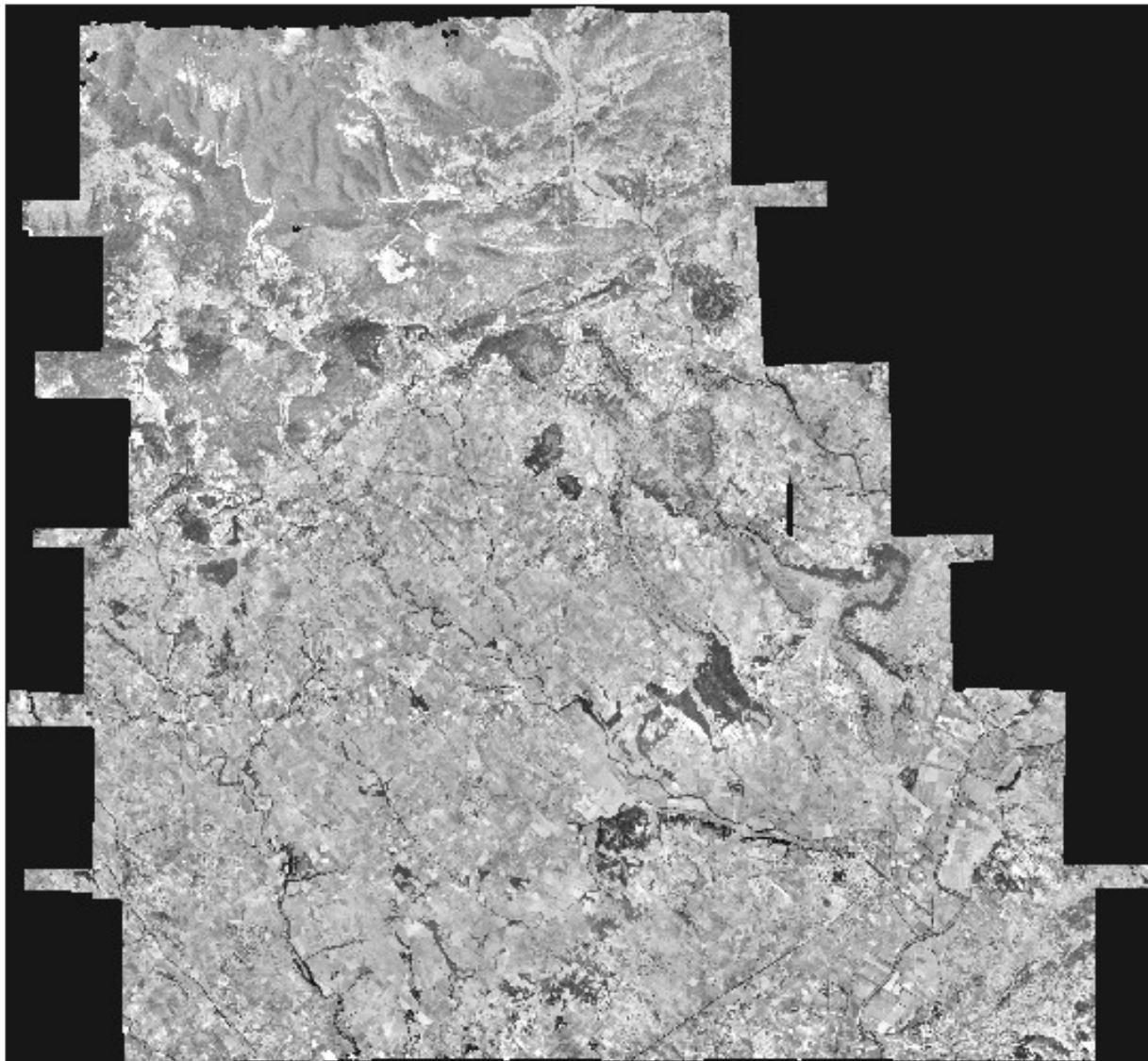
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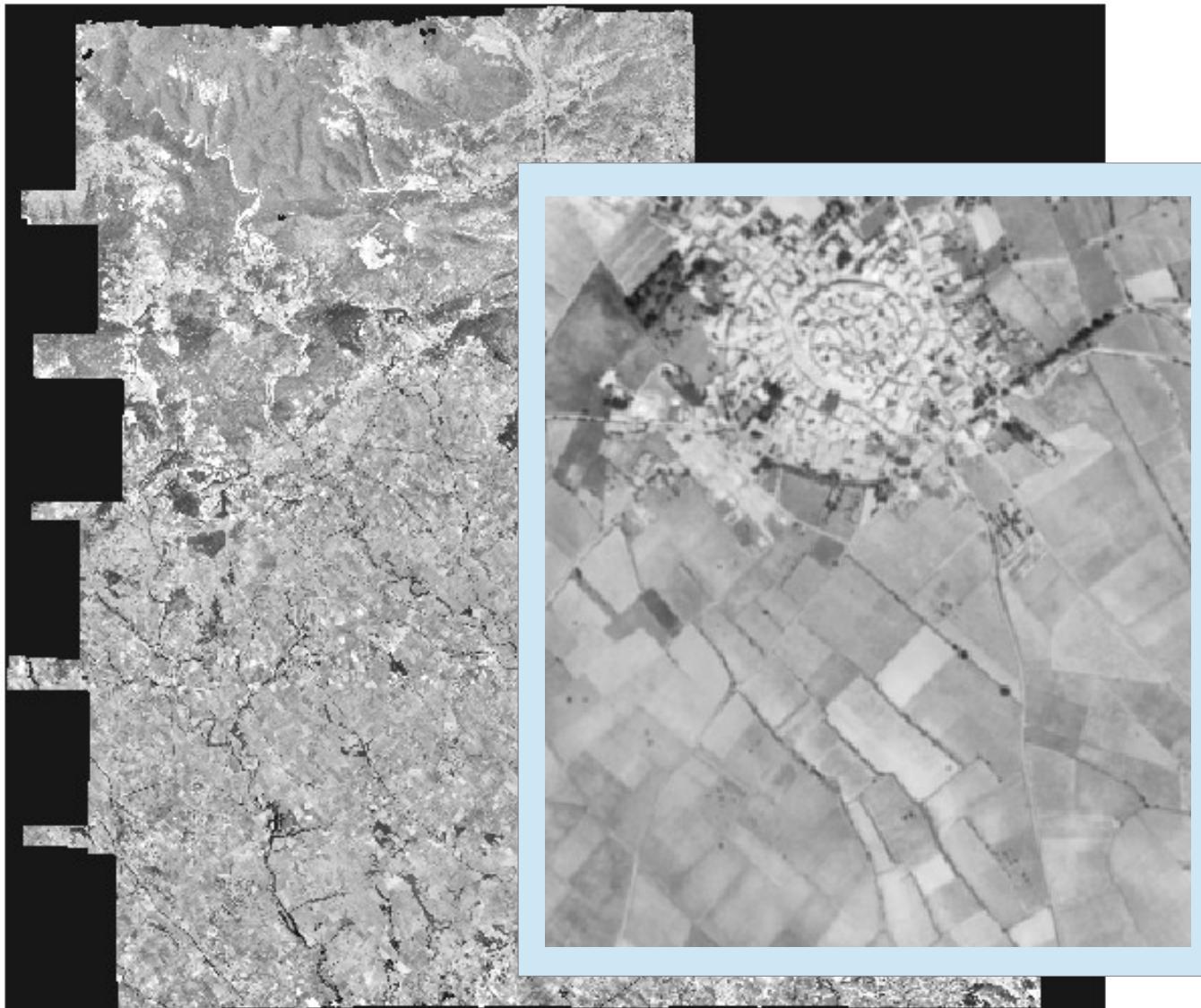


- Parametric model
- Additive polynomial model
- Sometimes tends to smooth images

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Radiometric issues

[Lelégard et al., 2020 , 2022]

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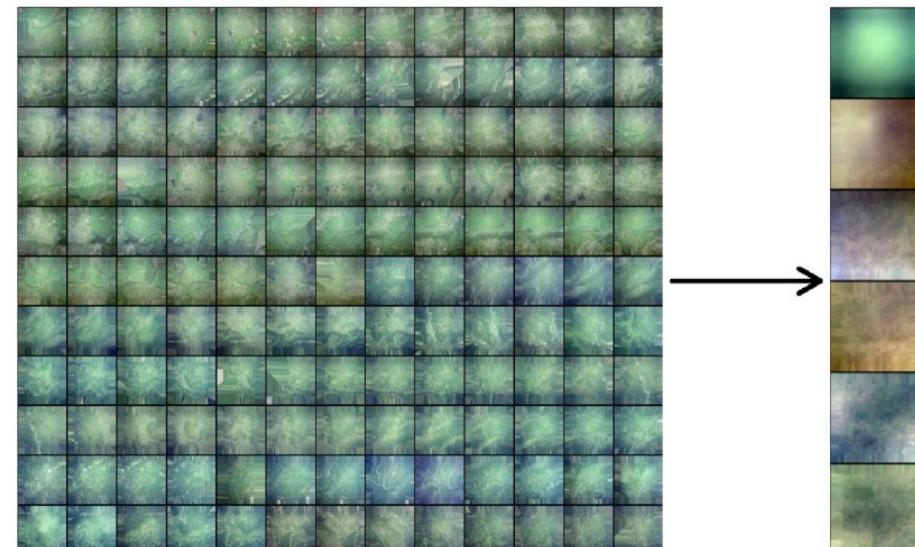
→ main phenomena to consider : vignetting, hot spot, fog, ...

- Non parametric model:

- Estimate at low resolution a gain and offset correction grid for each image
- Apply Walis filtering to each image
 - gain and offset estimated for each pixel = correction grid

$$Img'(x, y) = \frac{\sigma_0}{\sigma_w(x, y)} \cdot (Img(x, y) - \mu_w(x, y)) + \mu_0$$

- Obtain a low frequency correction model:
 - PCA decomposition applied the whole set of correction grids



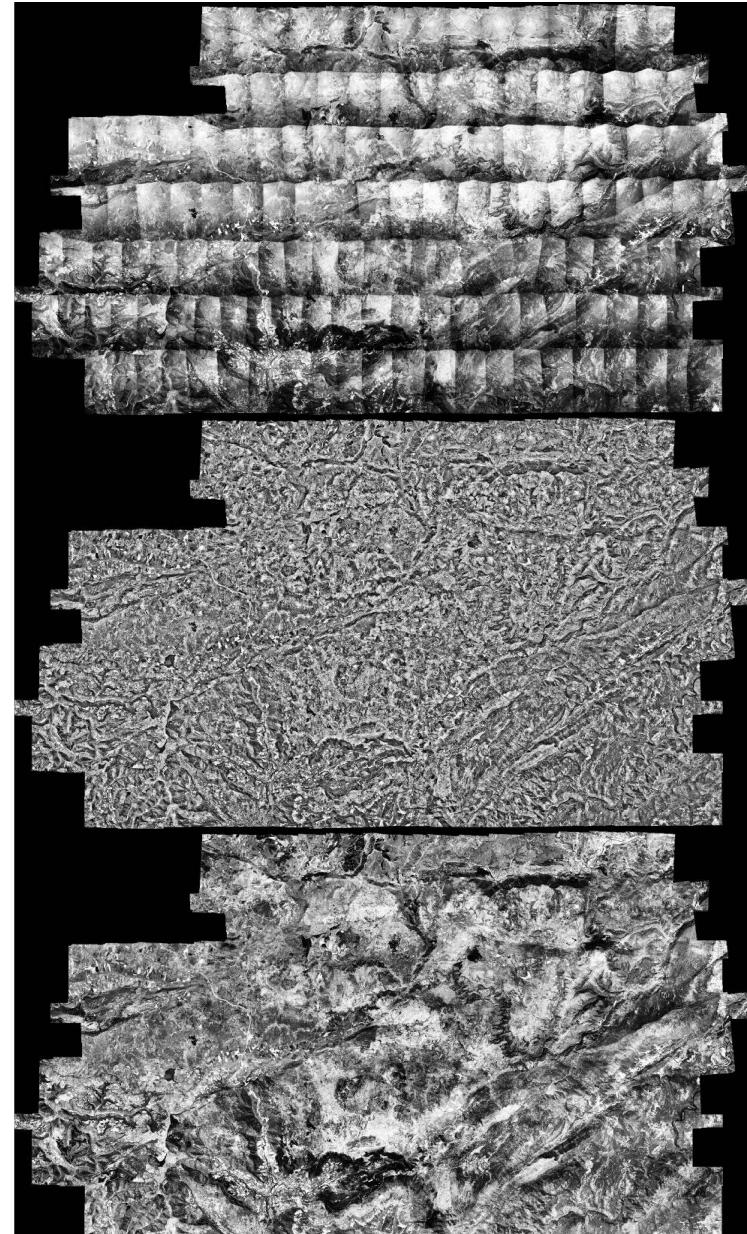
Radiometric issues

[Lelégard et al., 2020 , 2022]

How to perform radiometric corrections to obtain homogeneous mosaics?

- Non parametric model

Statistical gain / offset correction



Raw
orthophotomosaic

Raw statistical
equaization
(Walisi filtering)

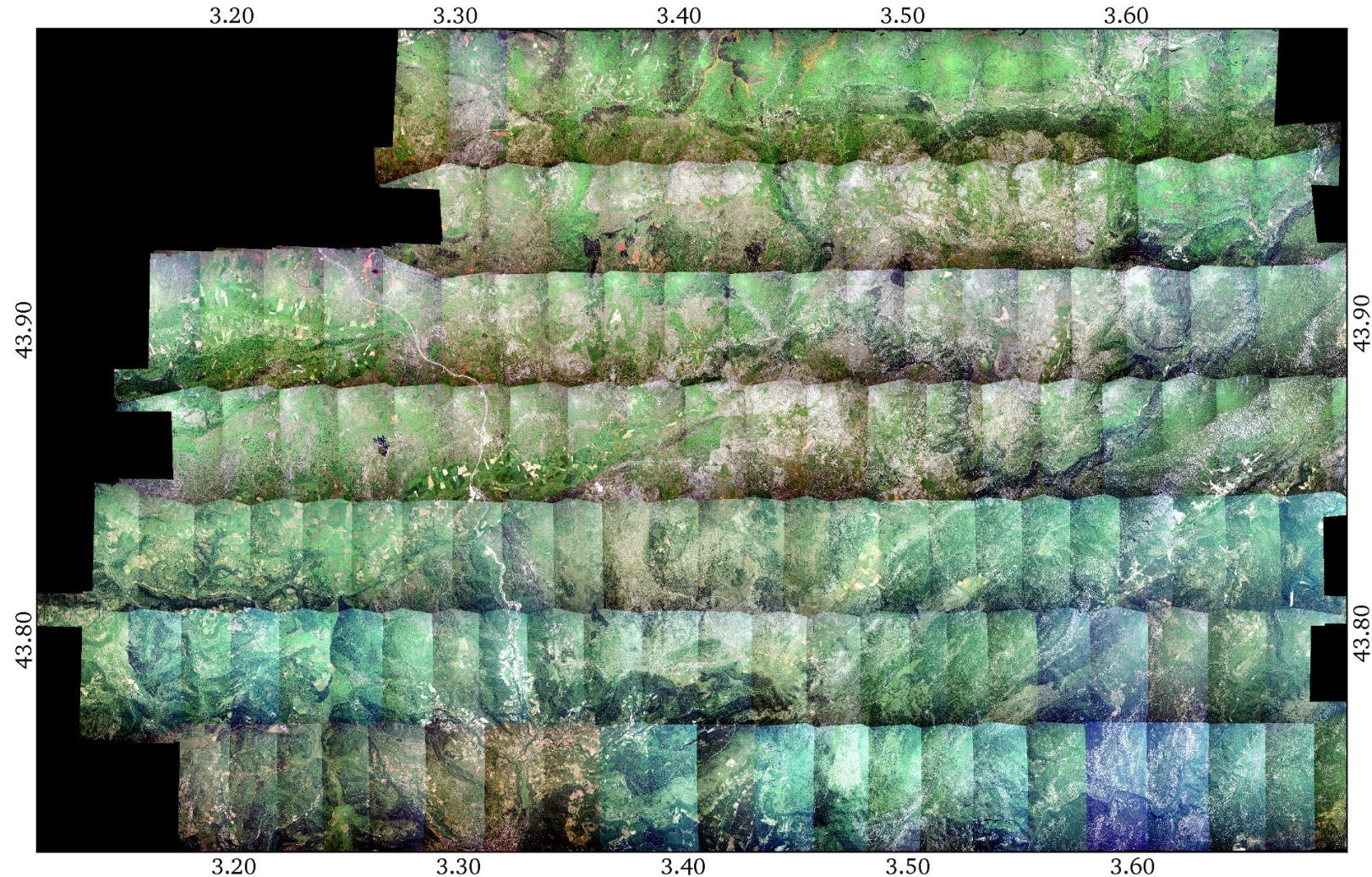
Proposed
correction

Radiometric issues

[Lelégard et al., 2020 , 2022]

How to perform radiometric corrections to obtain homogeneous mosaics?

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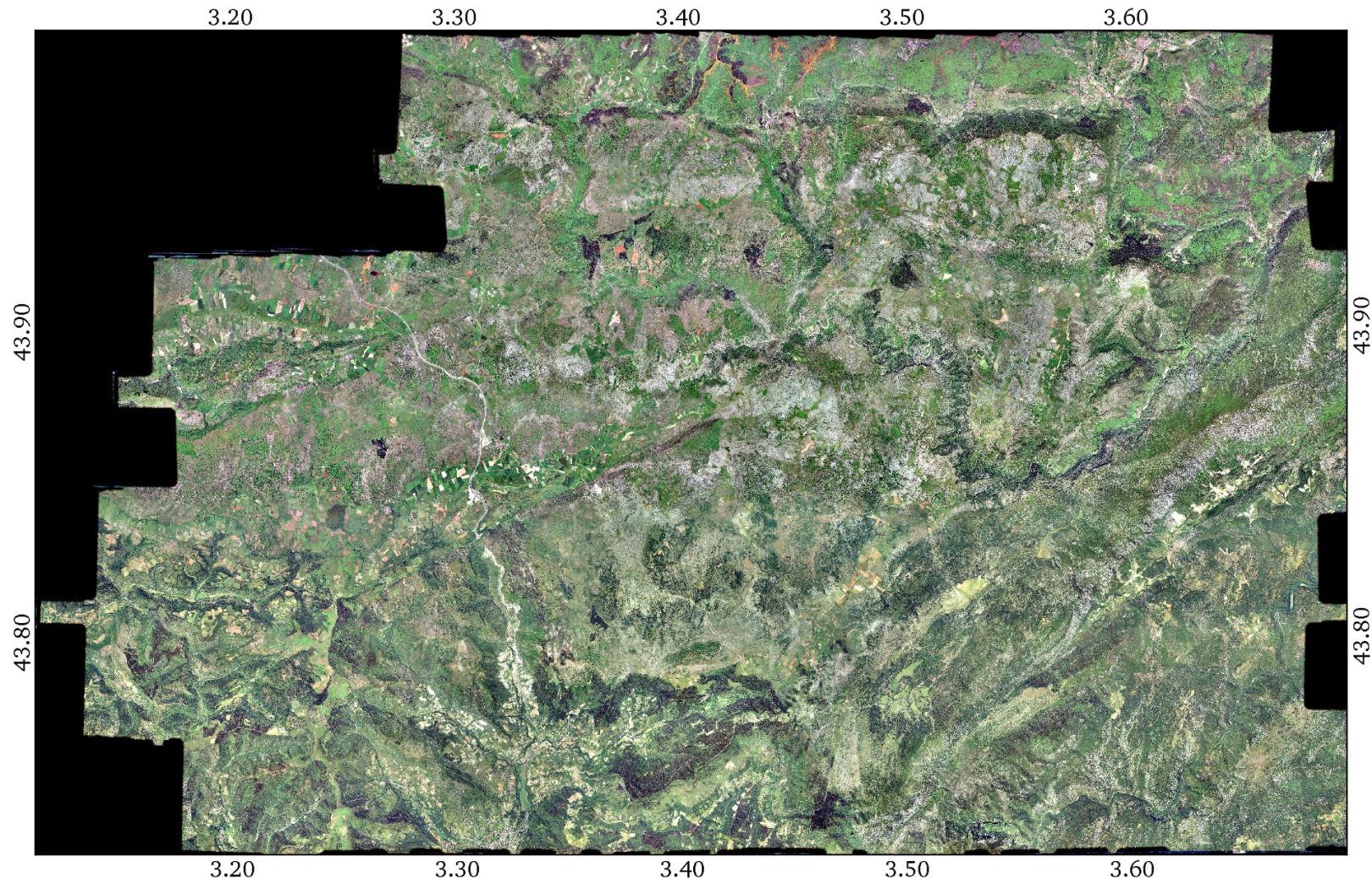
Larzac : raw mosaic

Radiometric issues

[Lelégard et al., 2020 , 2022]

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Larzac : non parametric model

Radiometry : non parametric model

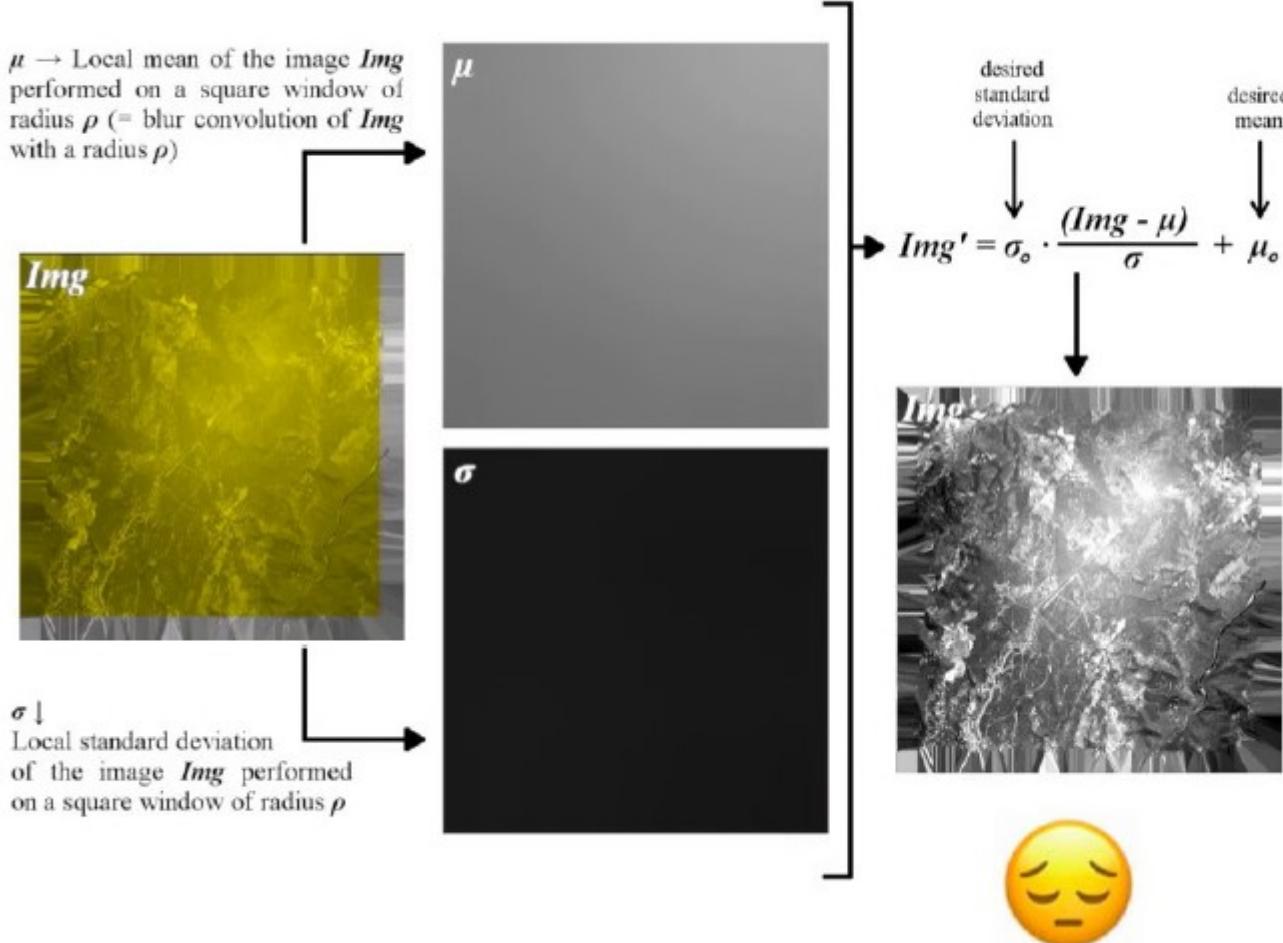
[Lelégard et al., 2020 , 2022]

Needs to define :

- the size of the Walis filter
- the number of PCs to keep

→ Develop metrics to help to define these parameters.

Impact of the filter size on the Walis correction : how to have a correction suitable at different scales?



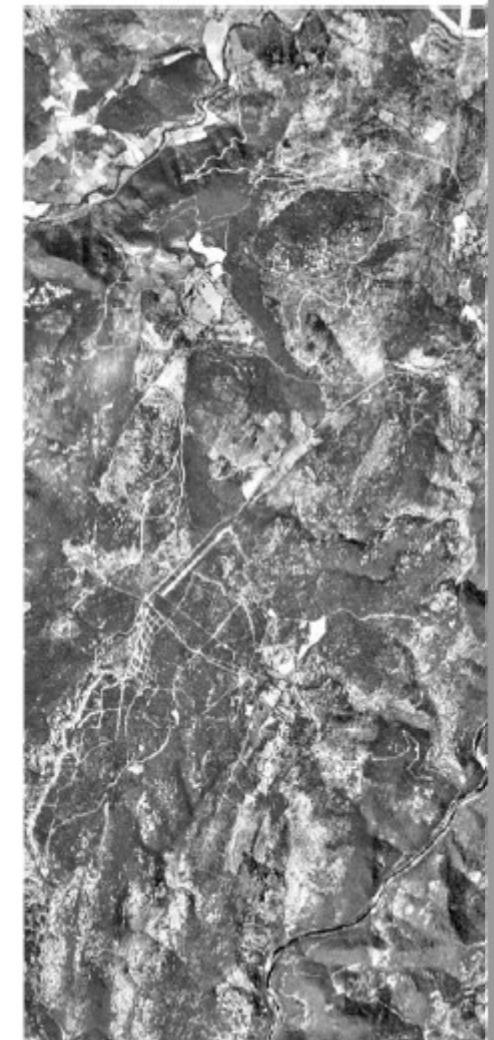
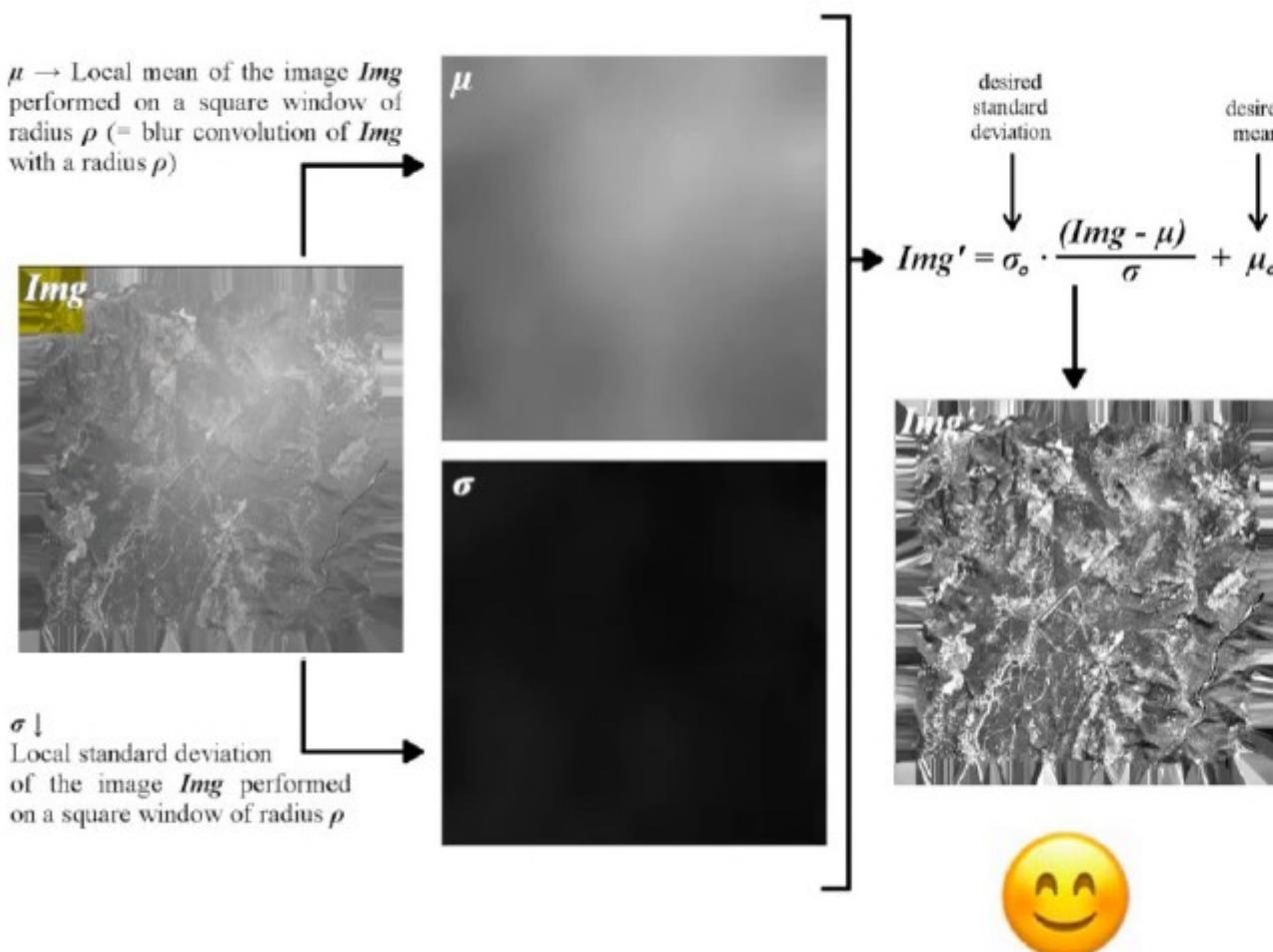
Radiometry : non parametric model

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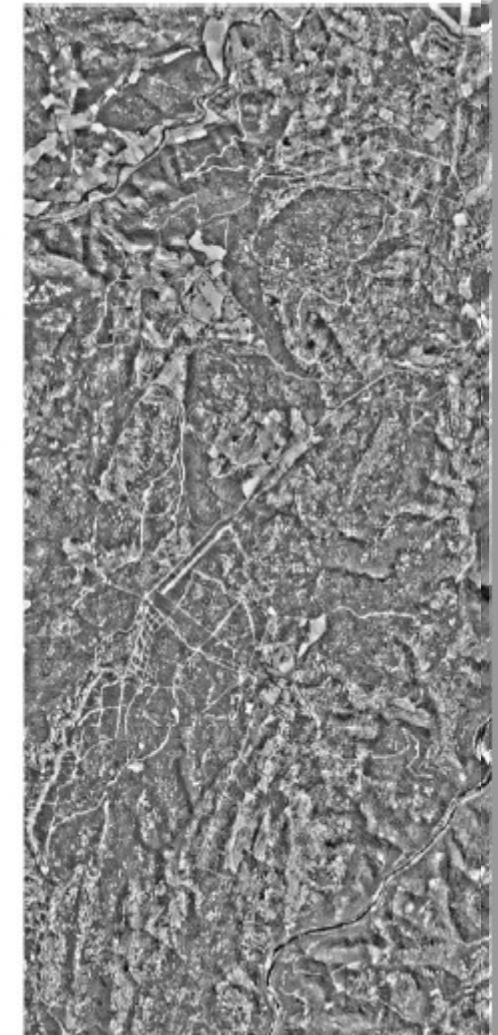
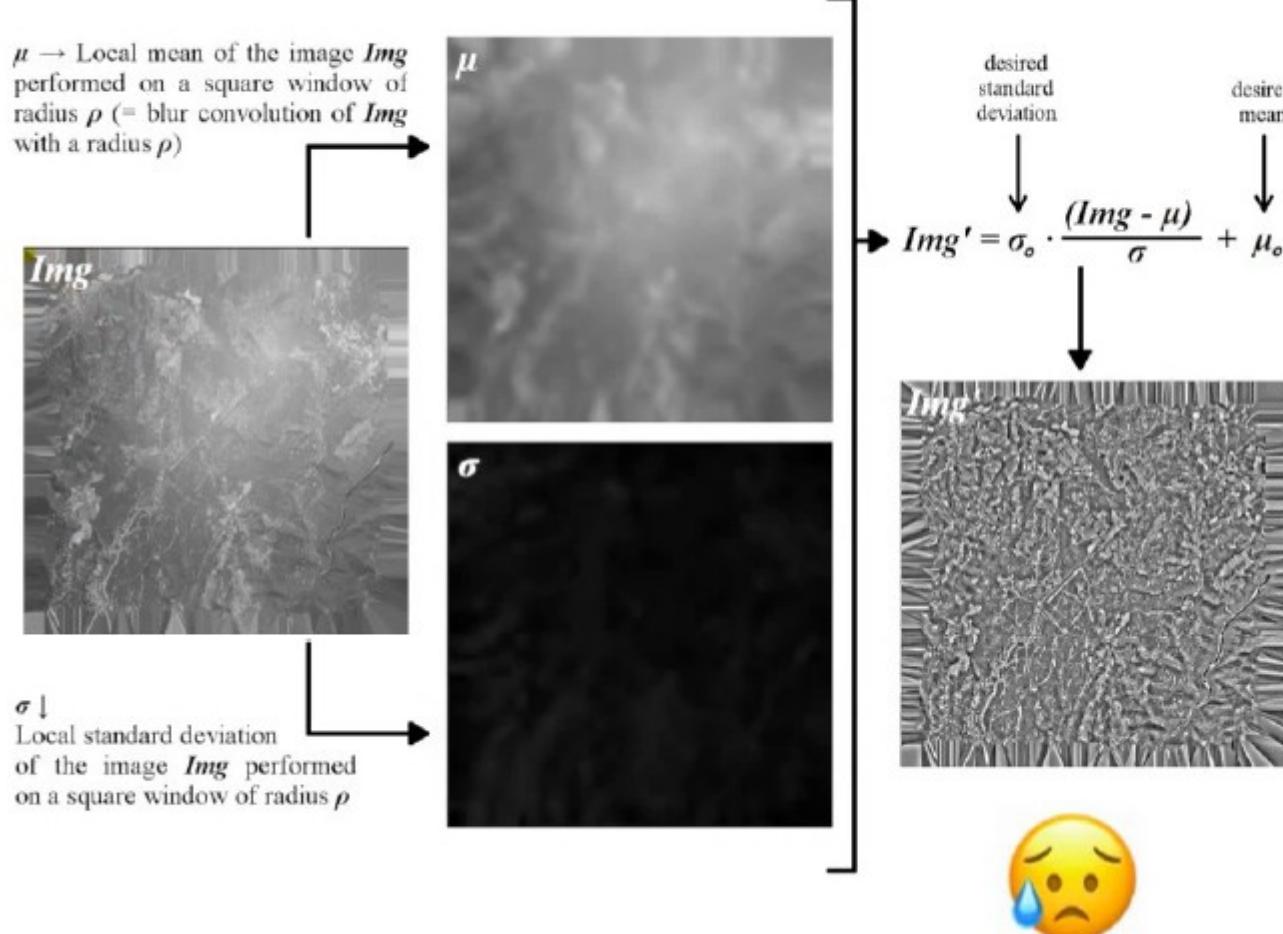
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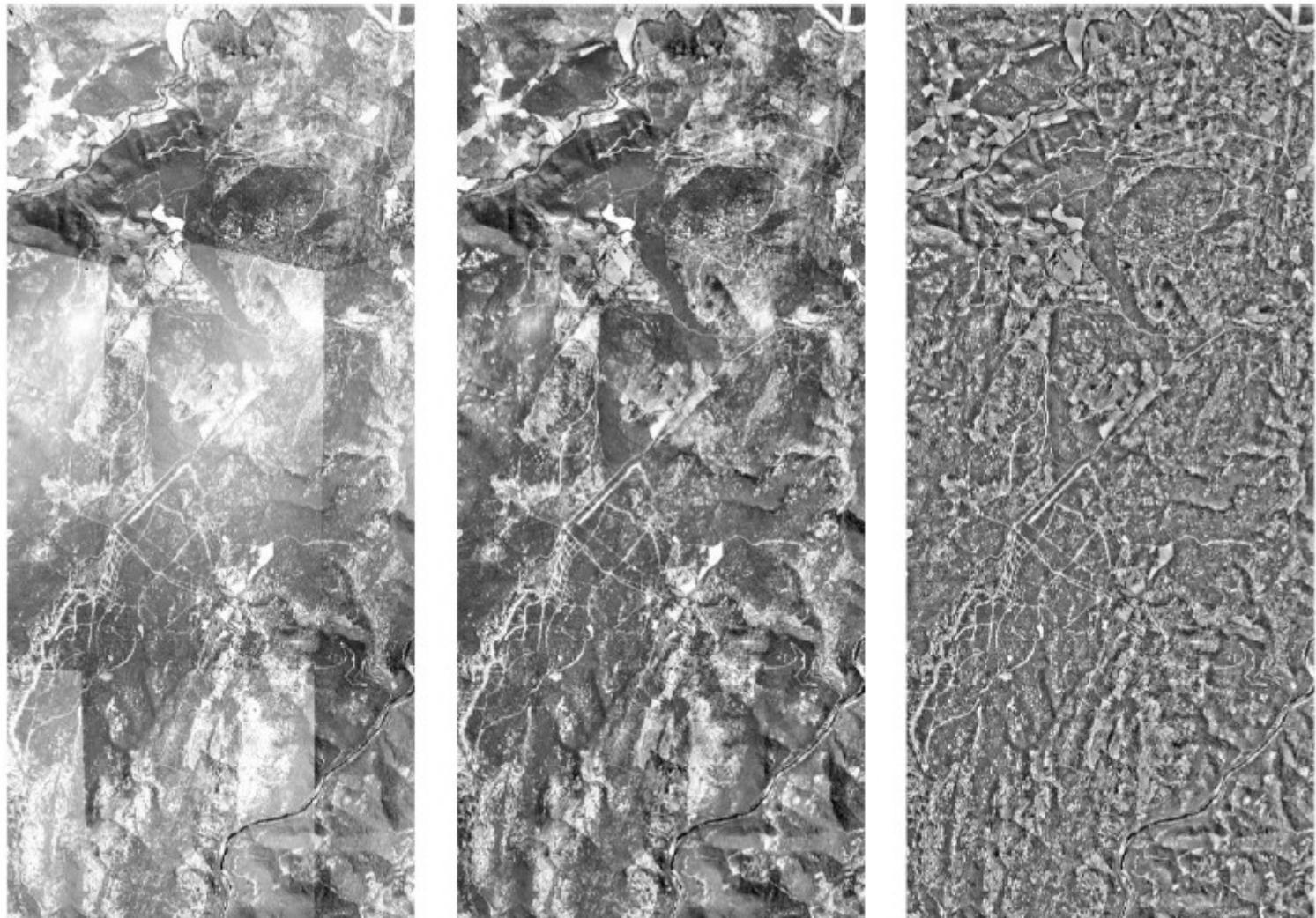
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Radiometry : non parametric model

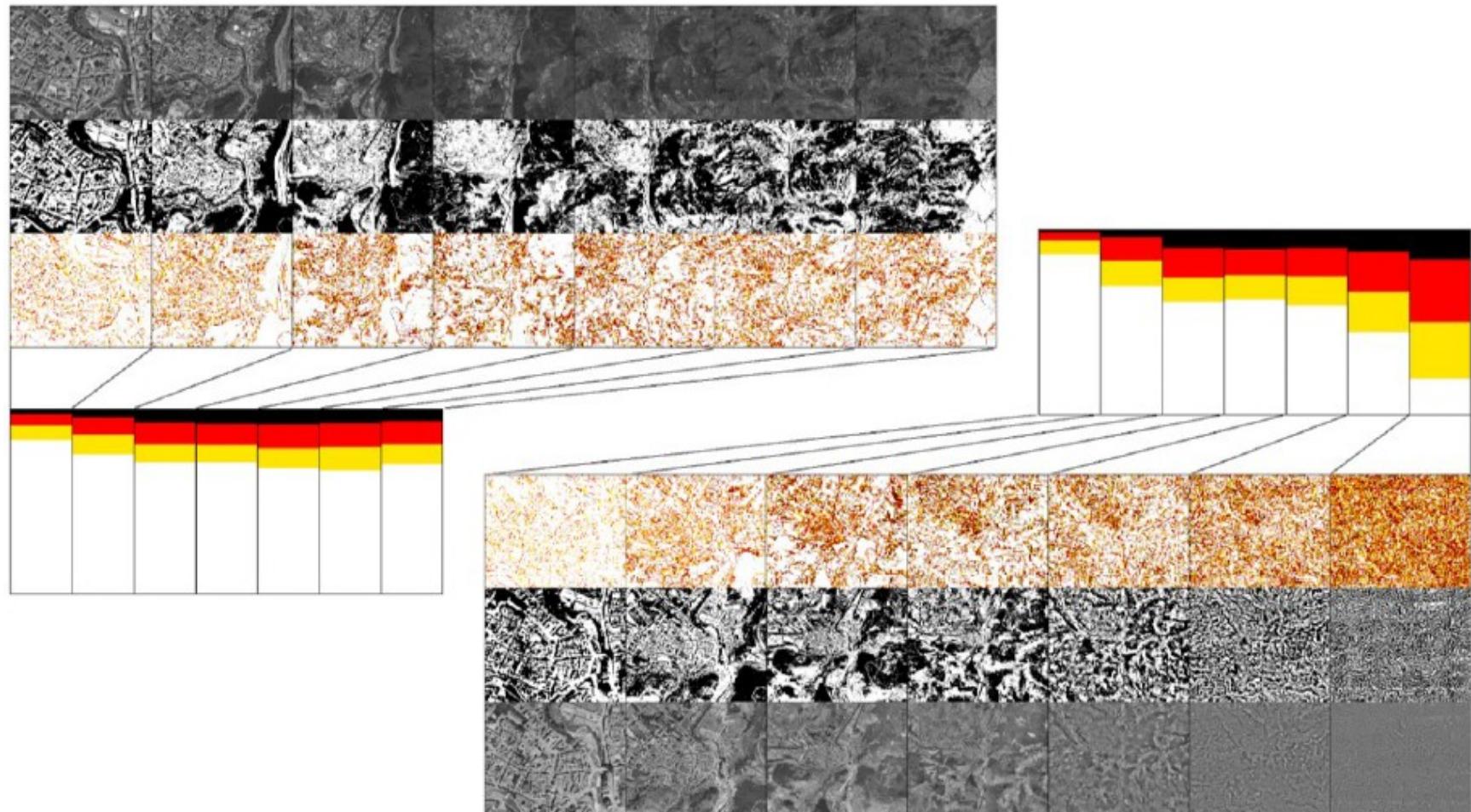
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Impact of the filter size on the Walis correction : how to have a correction suitable at different scales?



An invariance by closing and opening metric score is considered

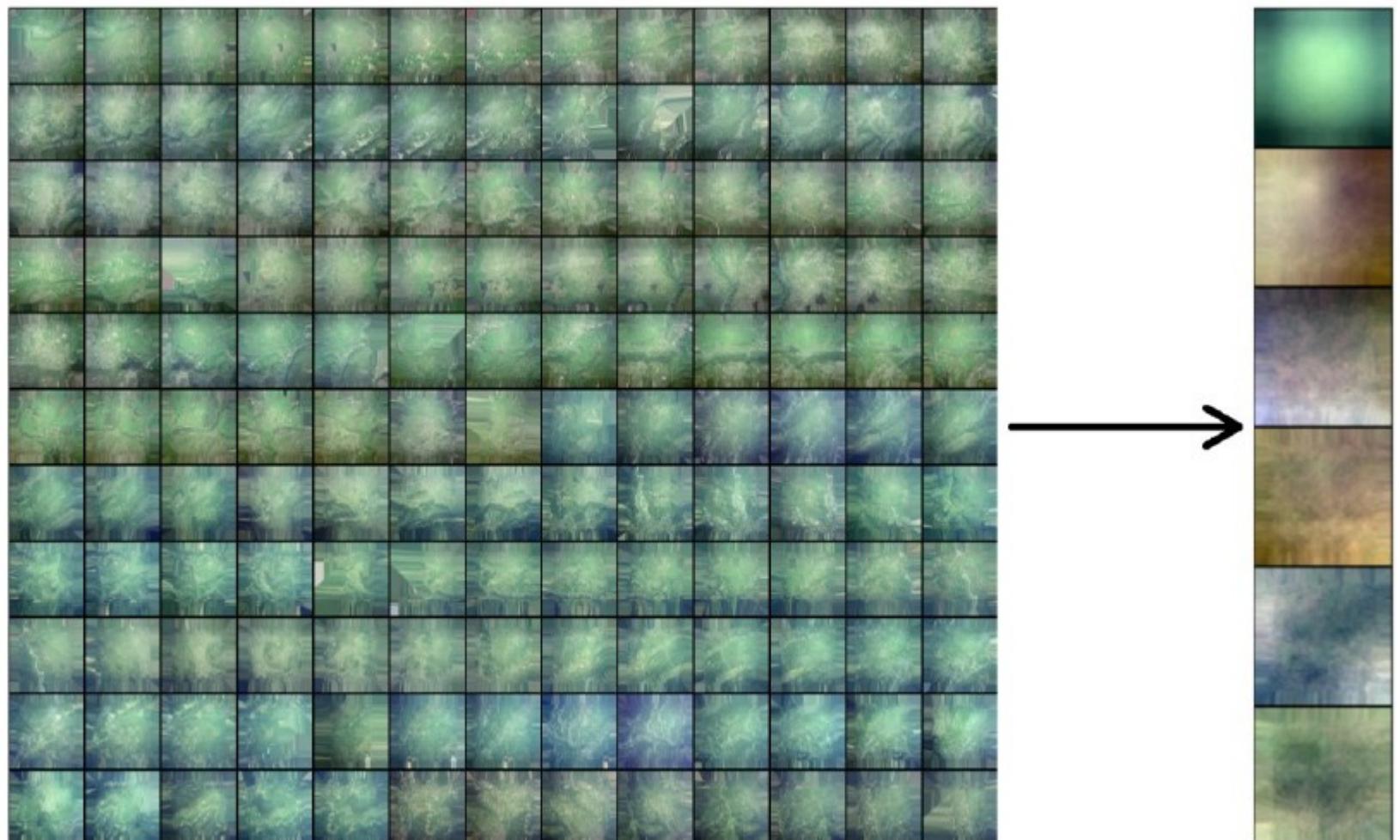
Radiometry : non parametric model

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- the number of PCs to keep

Impact of the number of kept PCs on the final correction?



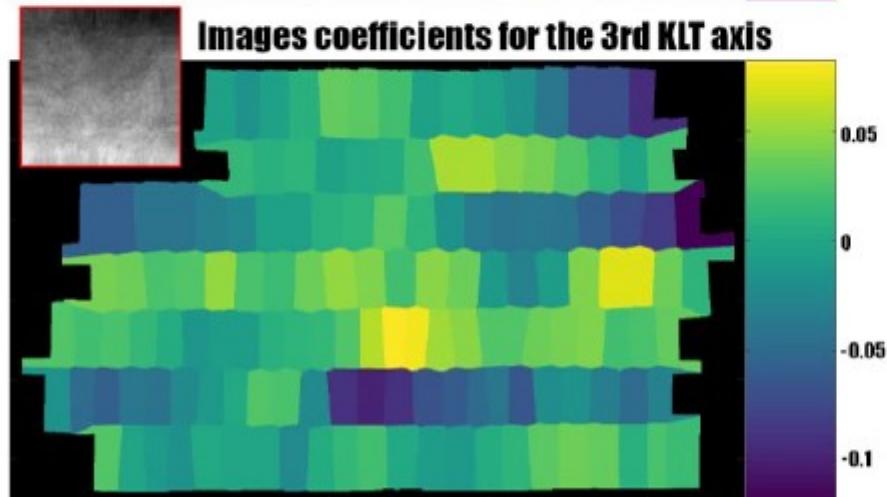
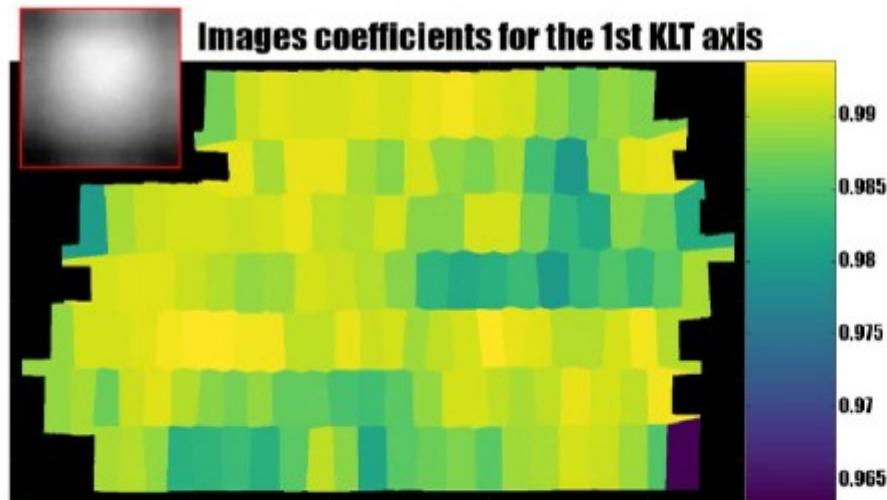
Radiometry : non parametric model

[Lelégard et al., 2020 , 2022]

Needs to define :

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Radiometry : non parametric model

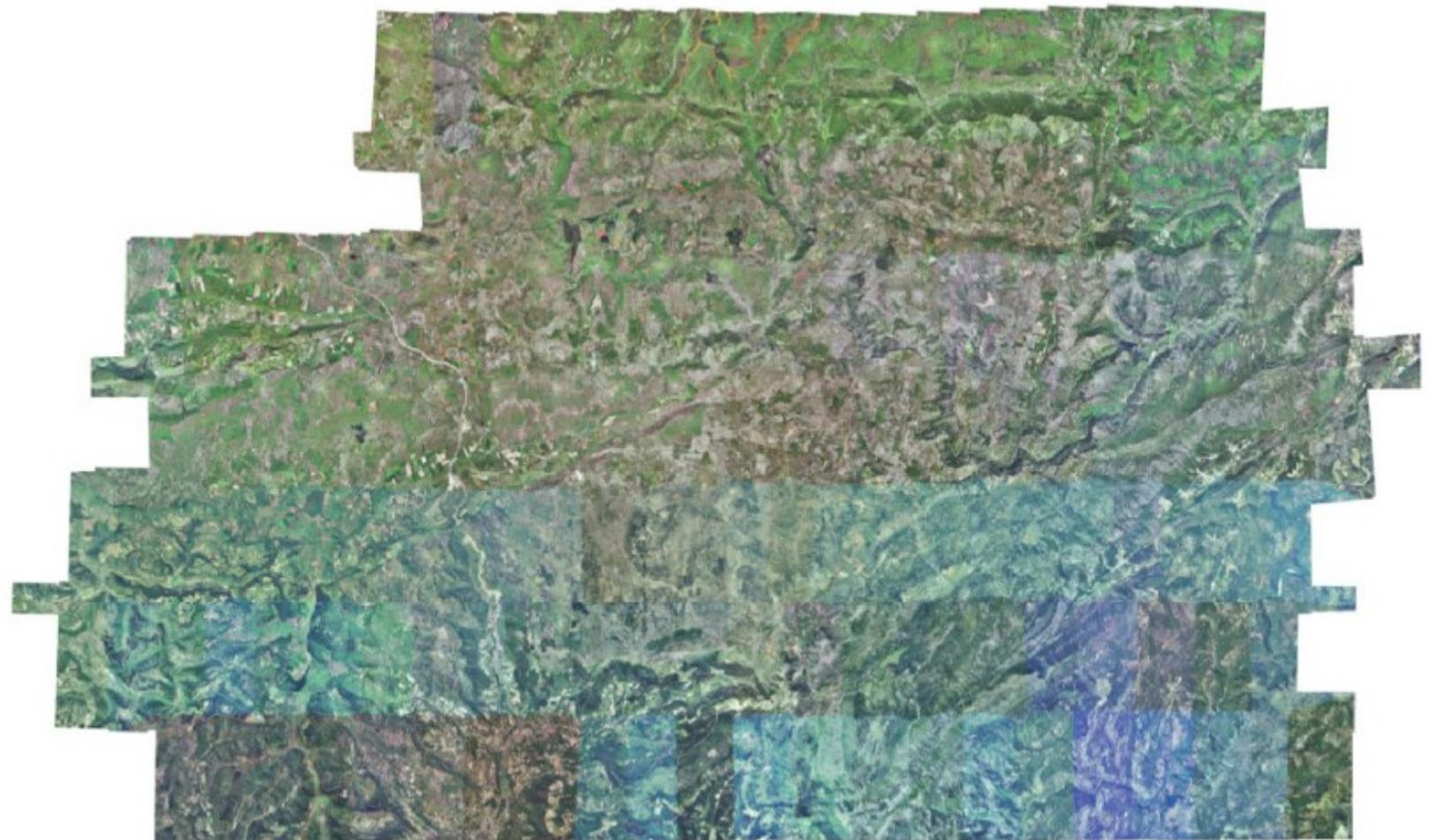
[Lelégard et al., 2020 , 2022]

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→ Develop metrics to help to define these parameters.

Impact of the number of kept PCs on the final correction?



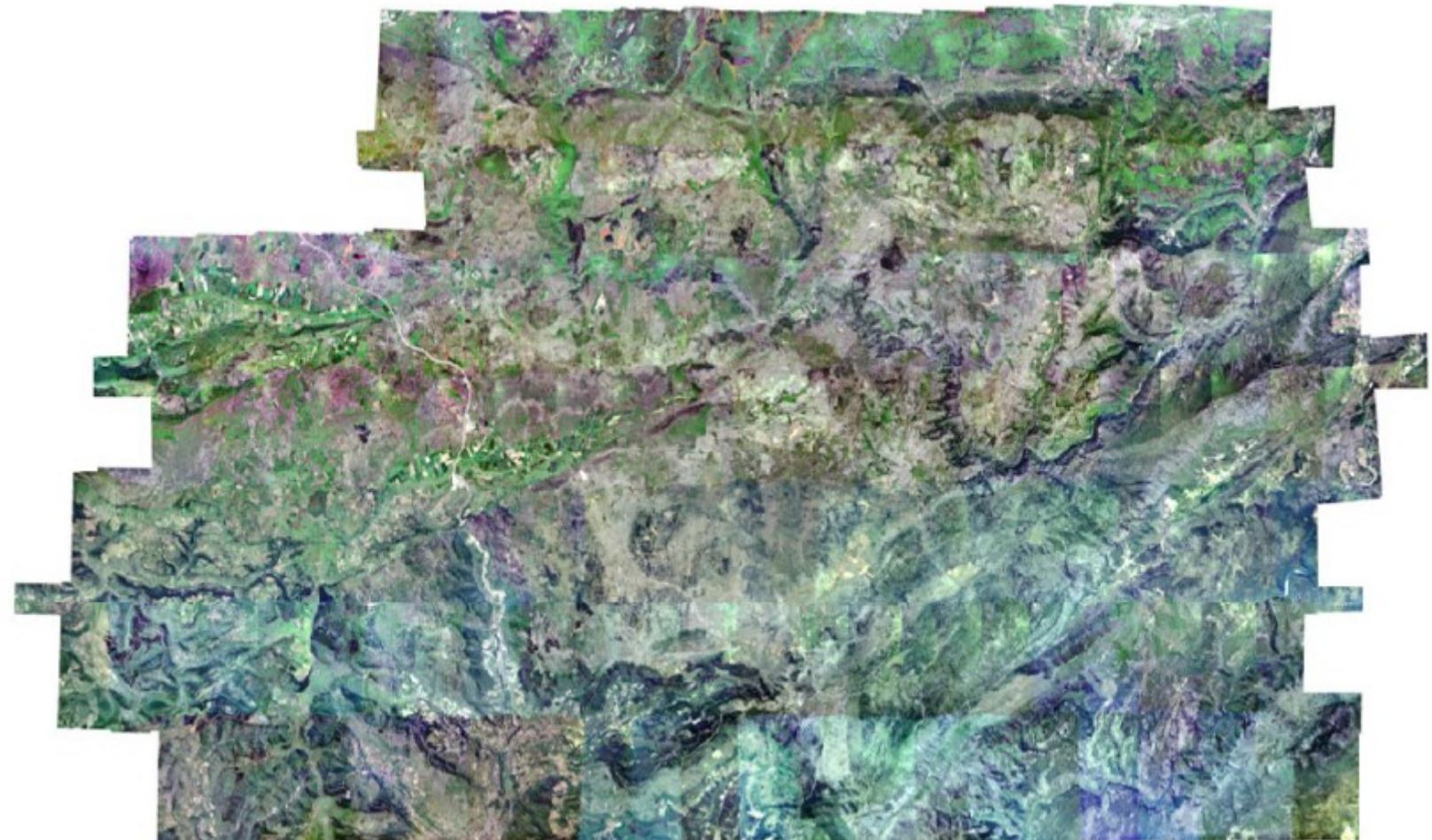
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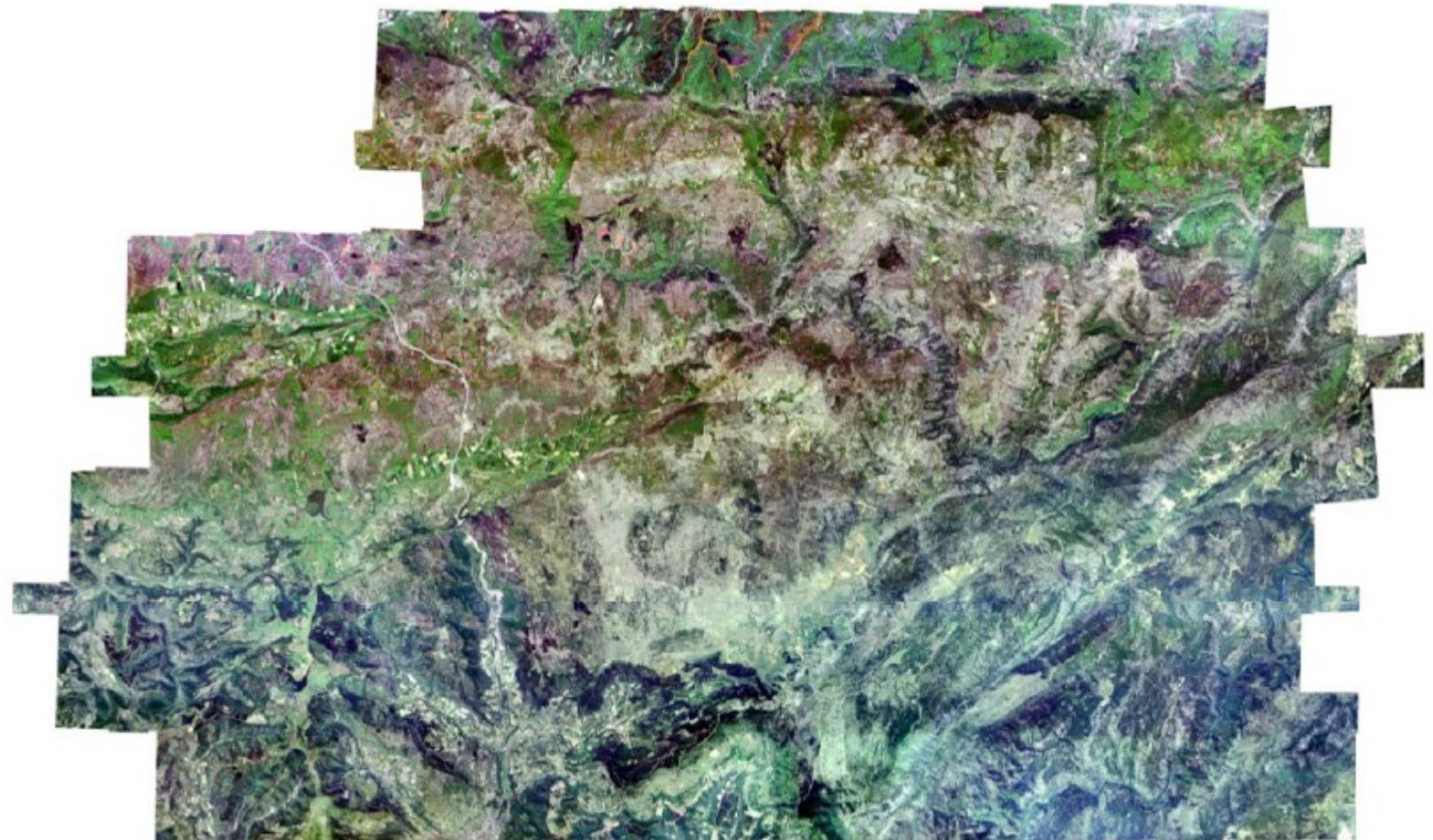
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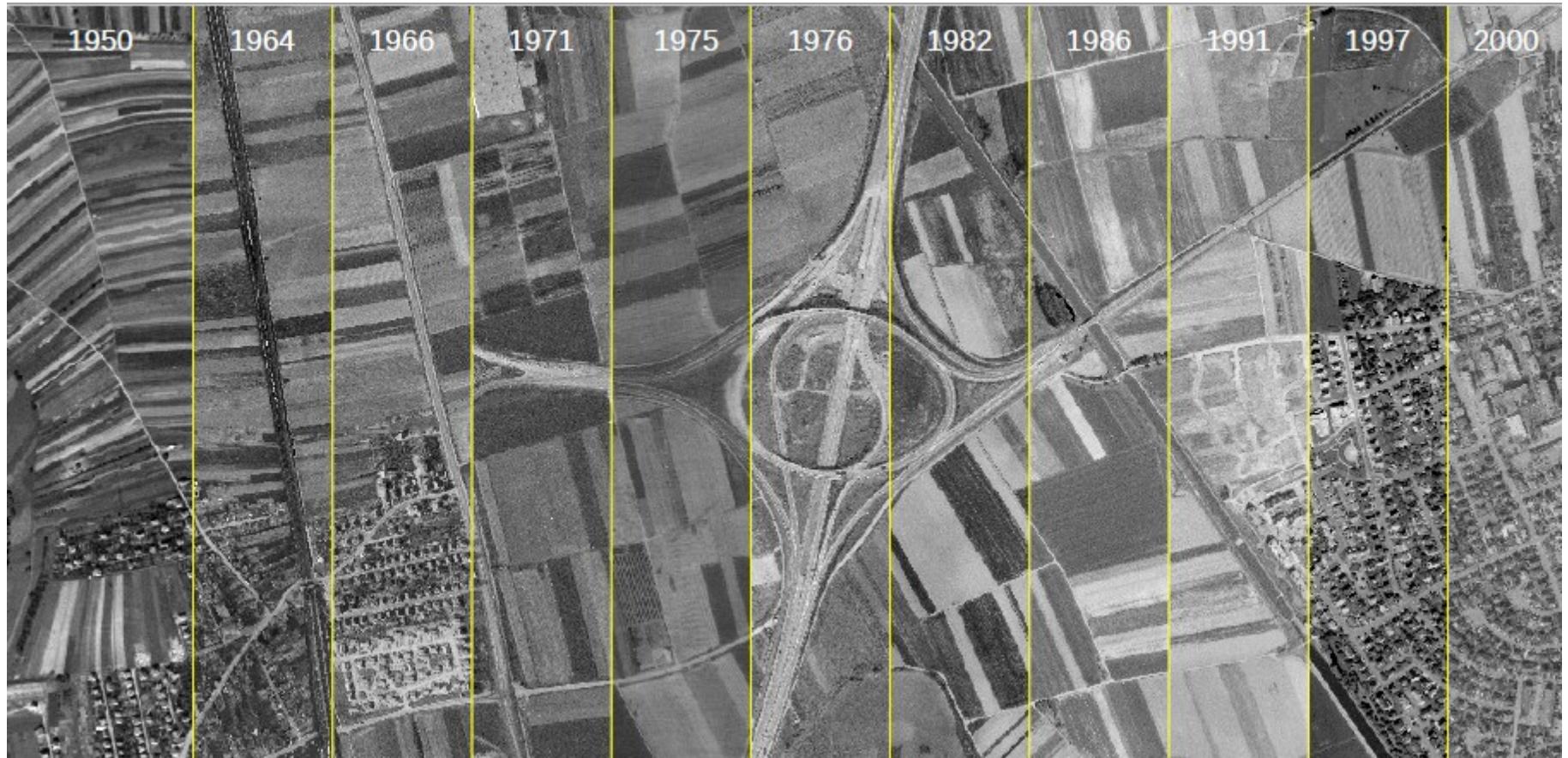
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TOWARDS OPERATIONAL

Results / perspectives: geometry

- Fully automatic method to generate orthoimage+DSM time series
- Perfectible results but generally compatible with remote sensing analysis



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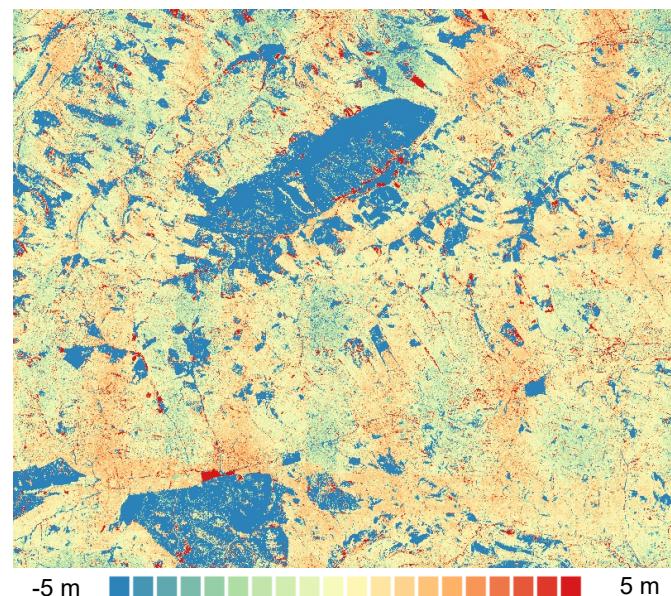


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But still some difficulties / limits...

- How to cope with areas where huge changes occurred
- Reduced errors for DSMs, but can still lead to problems when calculating differences between DSMs .

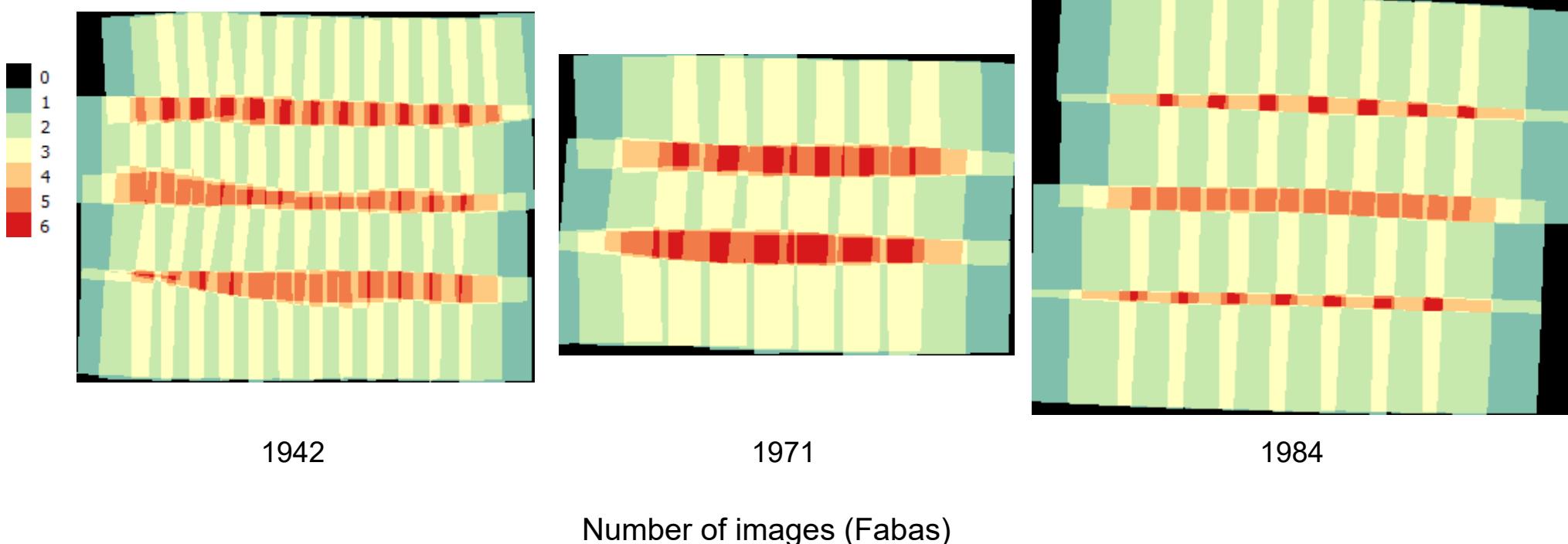


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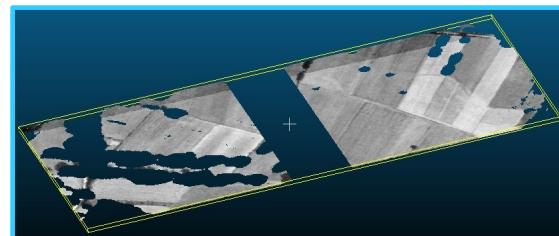
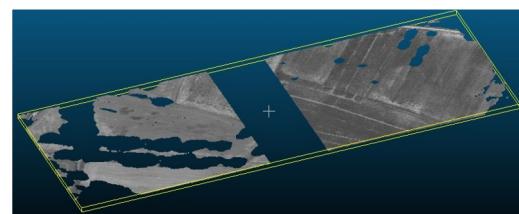
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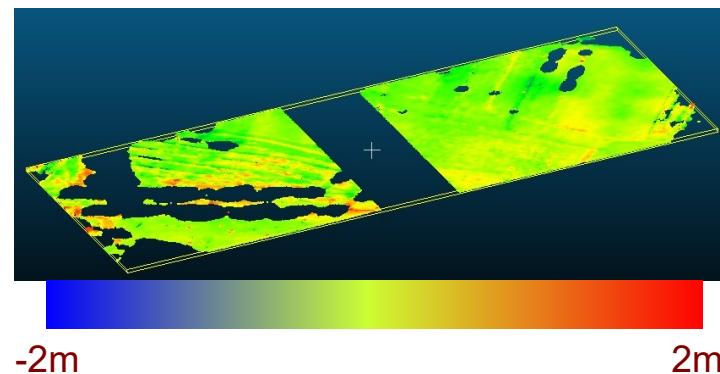
Results / perspectives: geometry

[Craciun et al., 2022]

- Current work, especially to have better landmarks in rural / natural areas
- 2D/2D registration of image patches (HoG)
- Overground filtering (DSM texture)



- DSM registration (first at patch level)

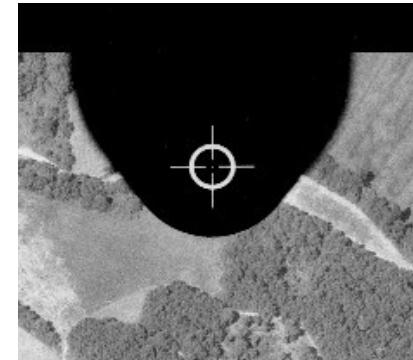


TOWARDS OPERATIONAL?

OTHER CHALLENGES RAISED ESPECIALLY BY
FOREIGN (AFRICAN 1940S, 1950S, 1960S)
COLLECTIONS OF IGN

Other challenges

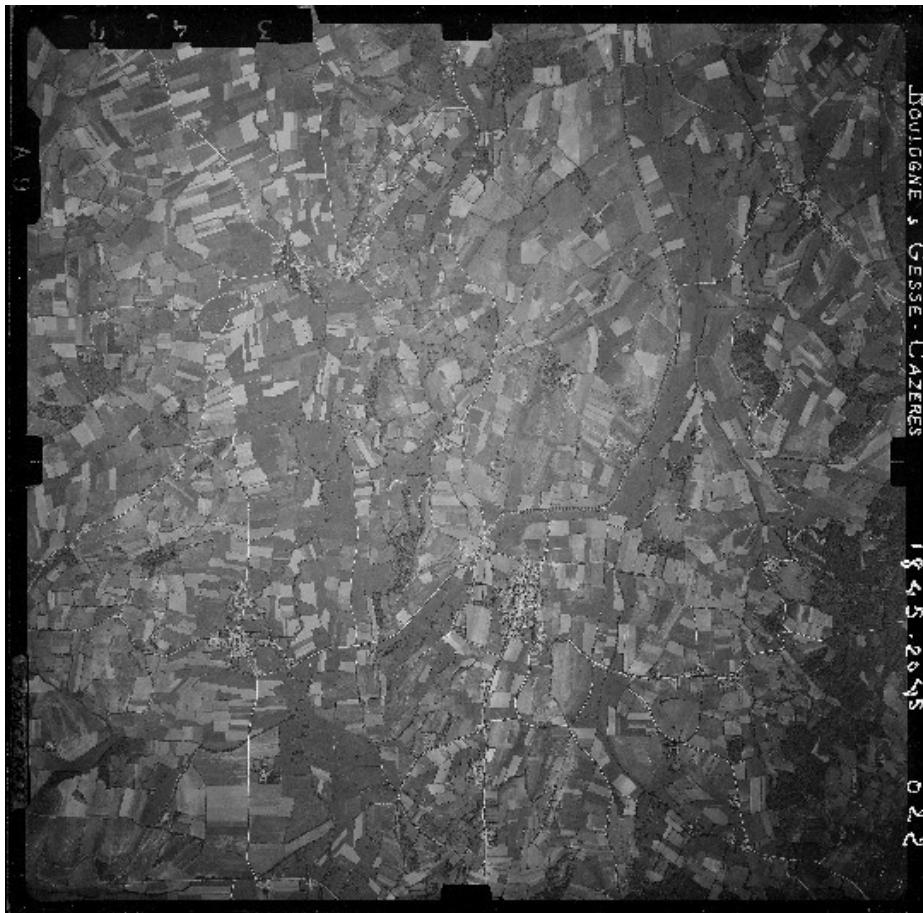
- Everything can stop at early steps : interior orientation sometimes not so easy...
→ **various fiducial marks**



easy

Other challenges

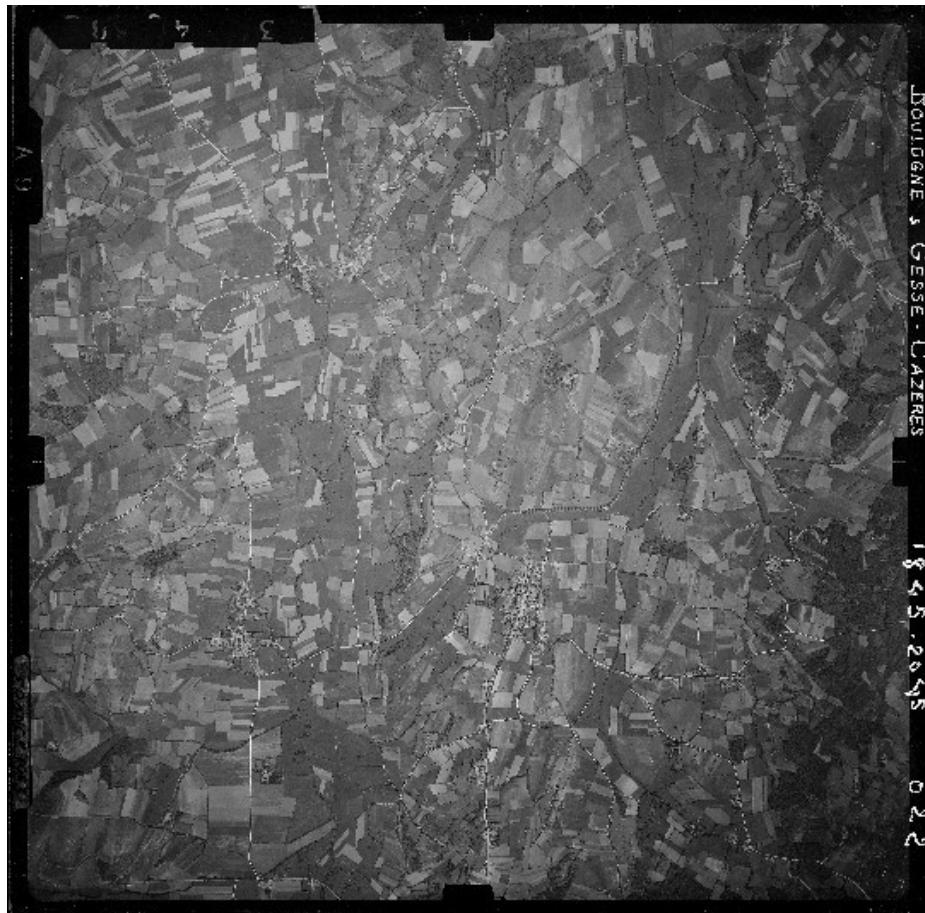
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sometimes easy

Other challenges

- Everything can stop at early steps : interior orientation sometimes not so easy...
→ **various fiducial marks**



sometimes difficult when
- superimposed with dark image
- misleading image texture

Other challenges

- Everything can stop at early steps : interior orientation sometimes not so easy...
→ missing **fiducial marks**



difficult

Other challenges

- Everything can stop at early steps : interior orientation sometimes not so easy...
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difficult

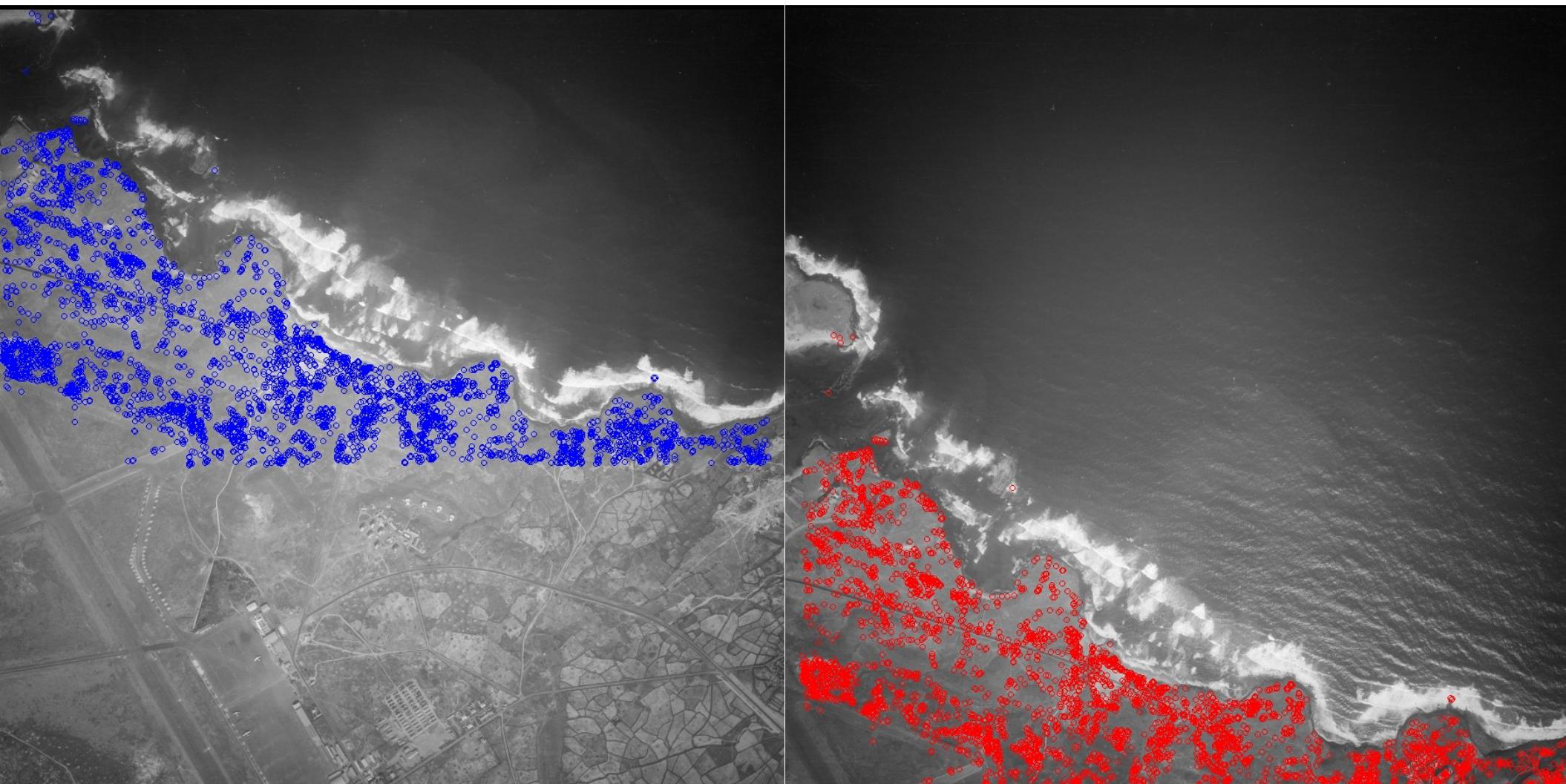
Other challenges

- Images undergo physical deformation (due to conservation conditions)



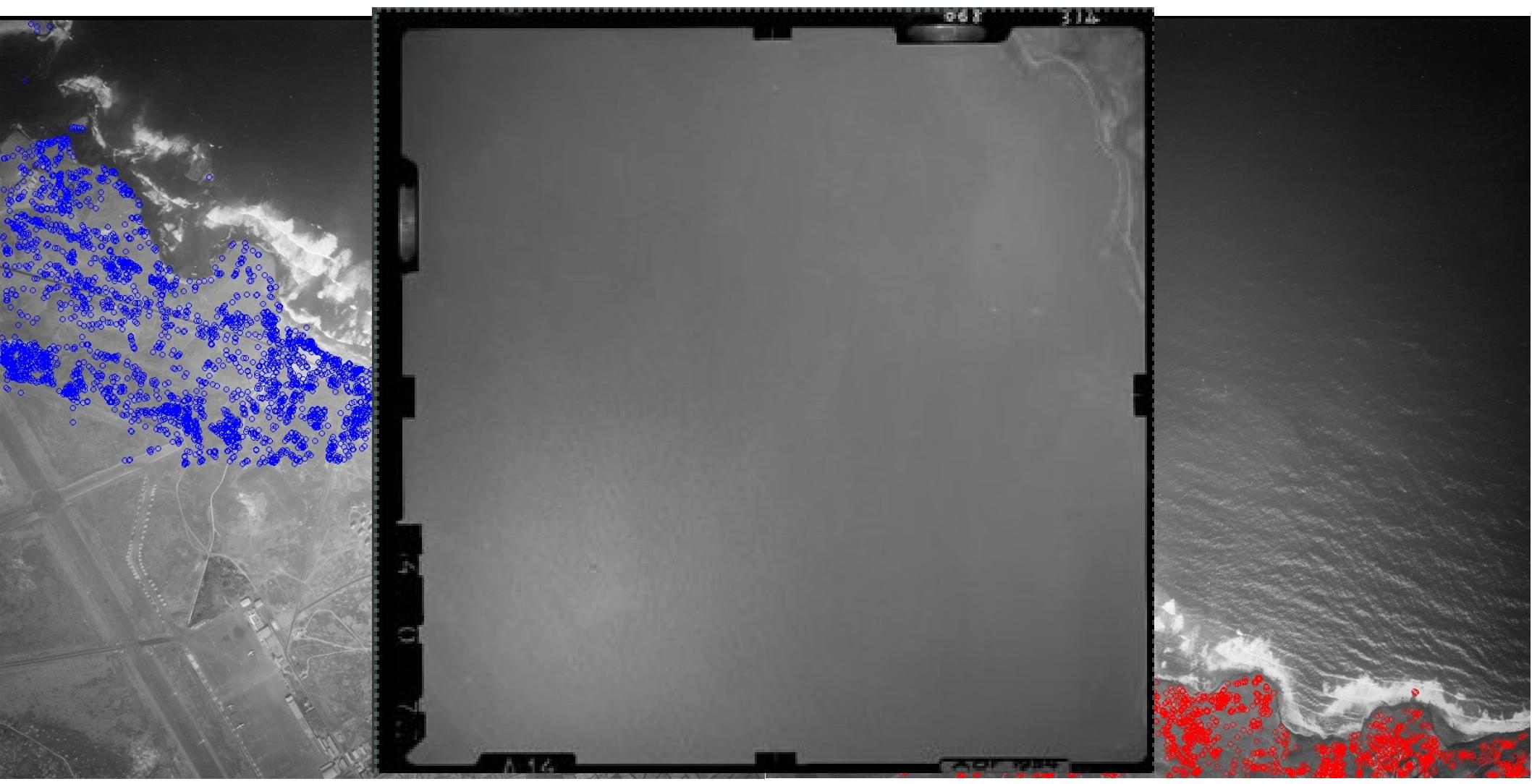
Other challenges

- Everything can stop at early steps : no relative orientation when **tie points extraction fails**
→ Problems for specific landscapes...



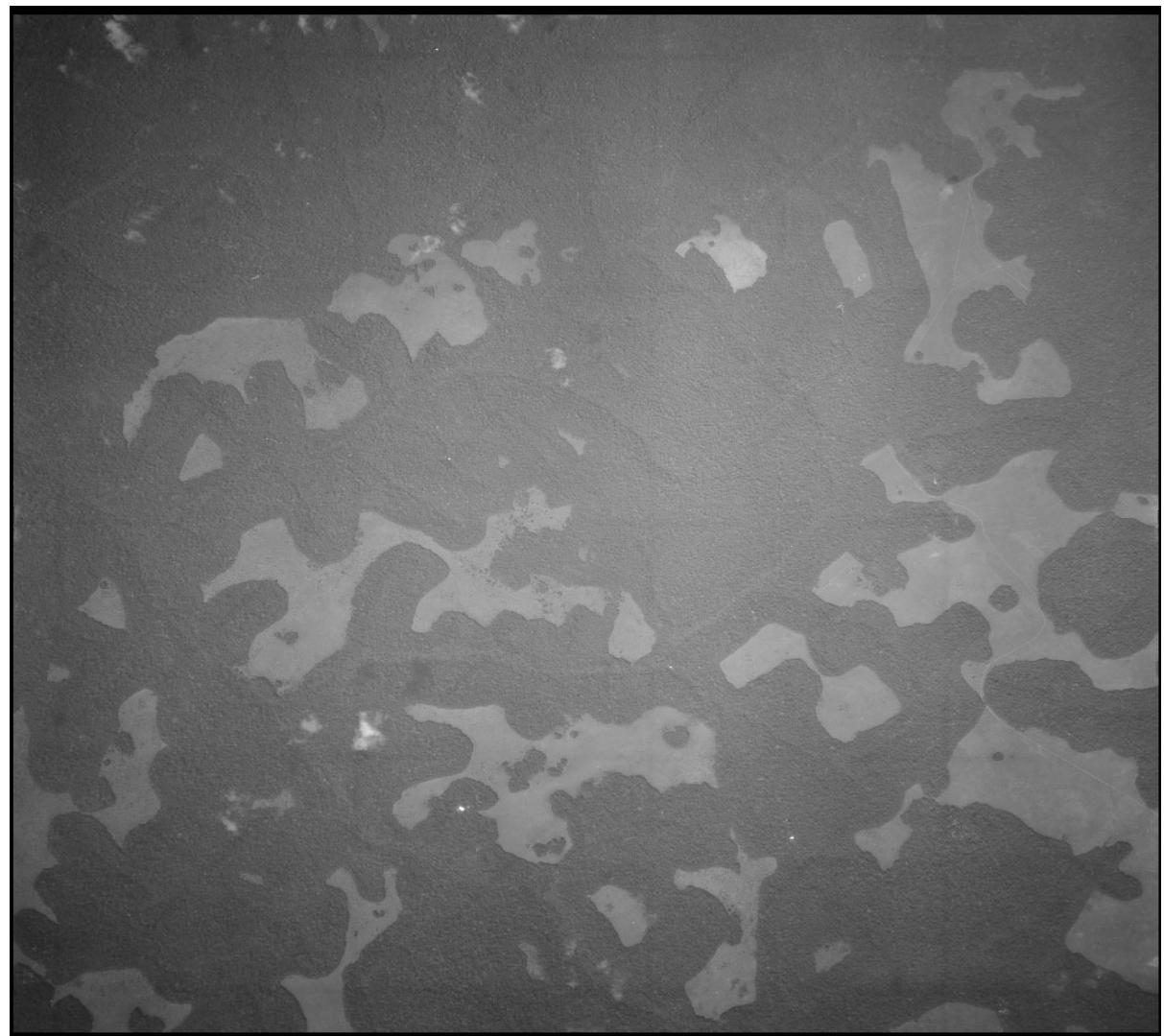
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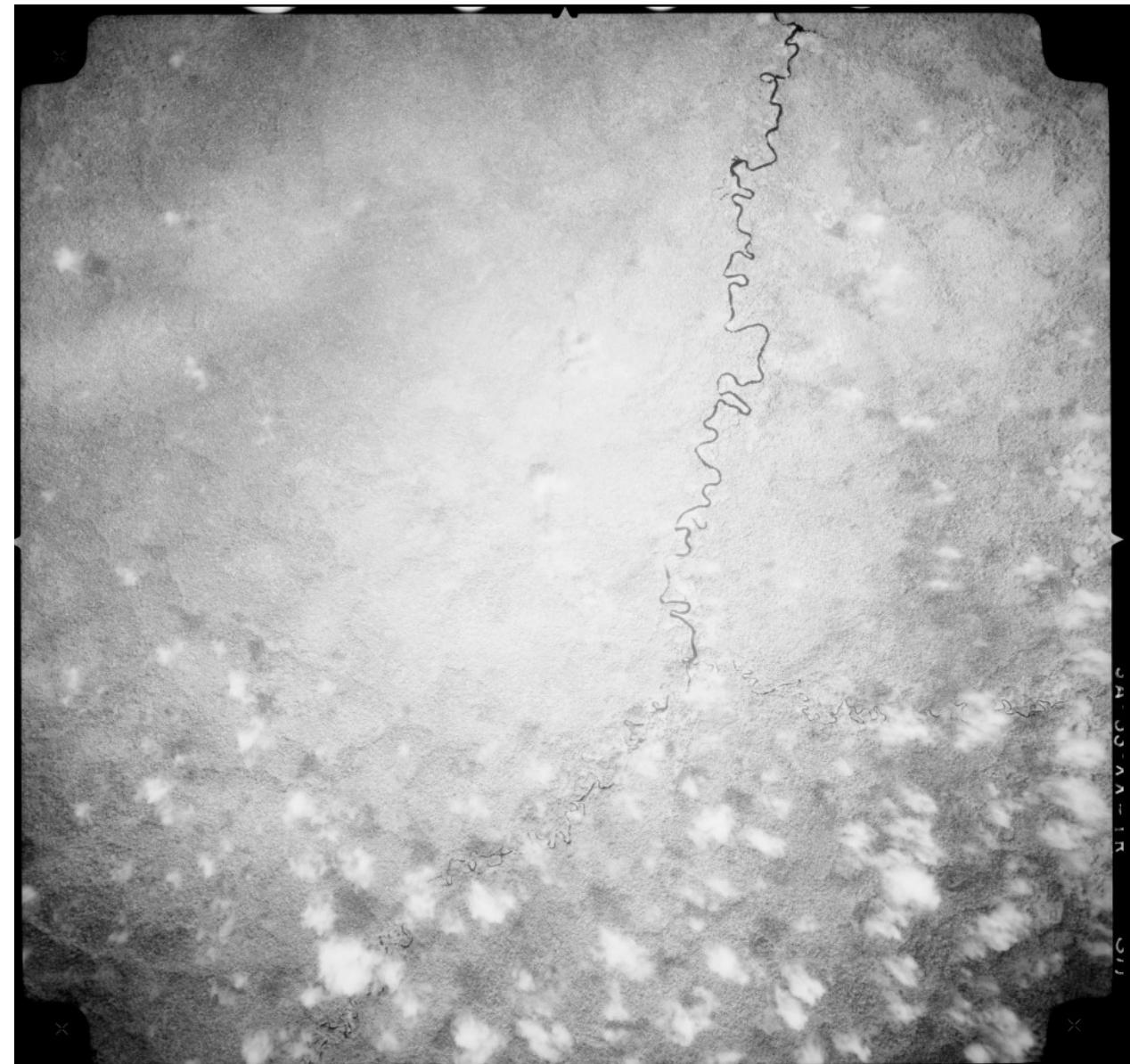
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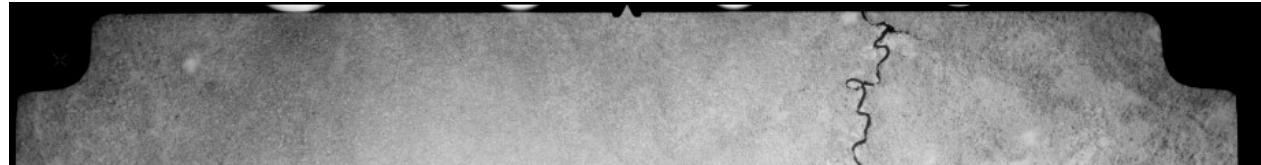
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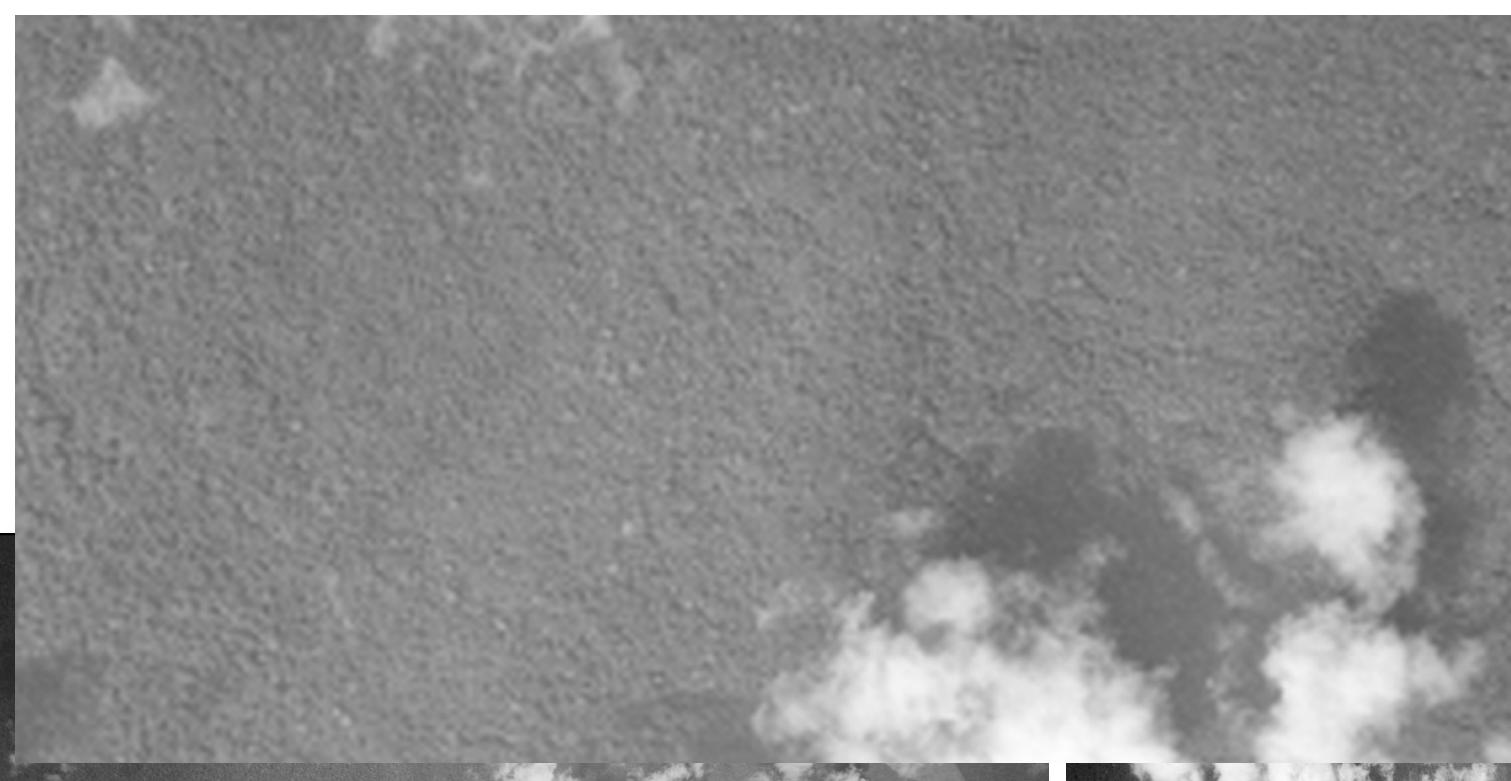
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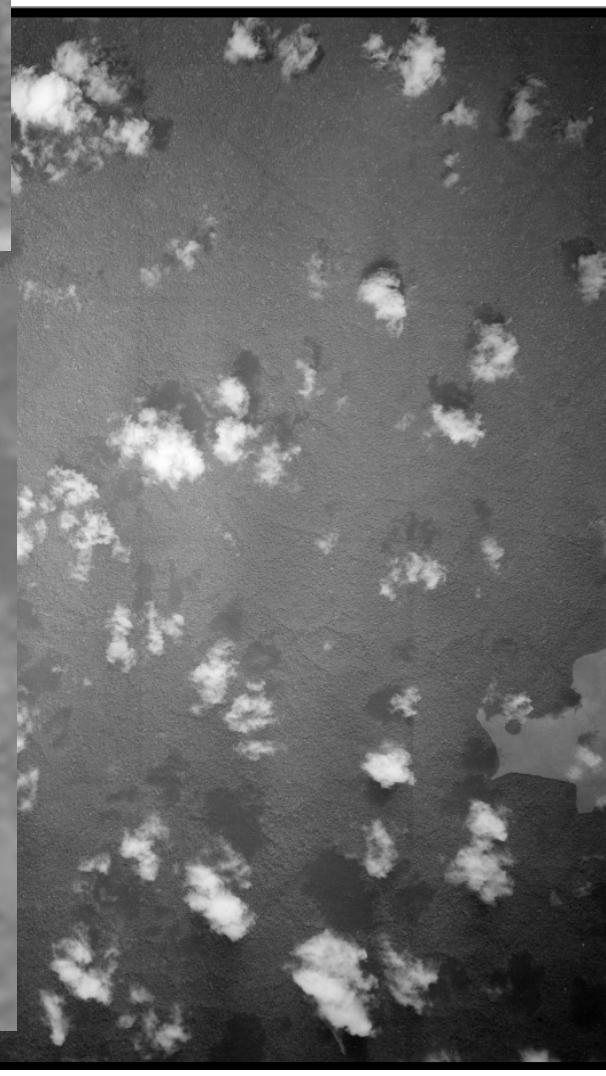
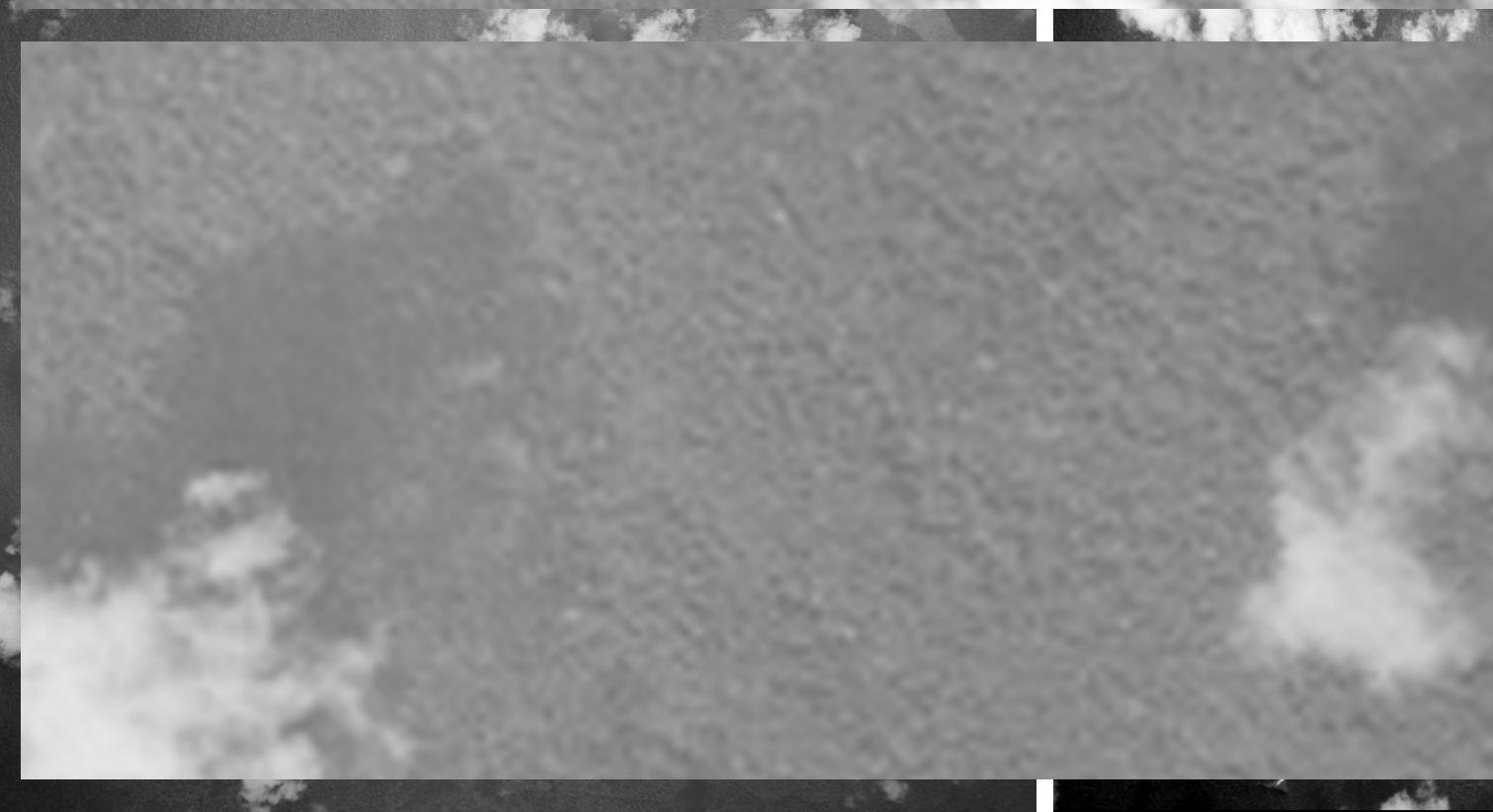
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extraction fails



Other challenges

- Clouds vs. Radiometric equalization...



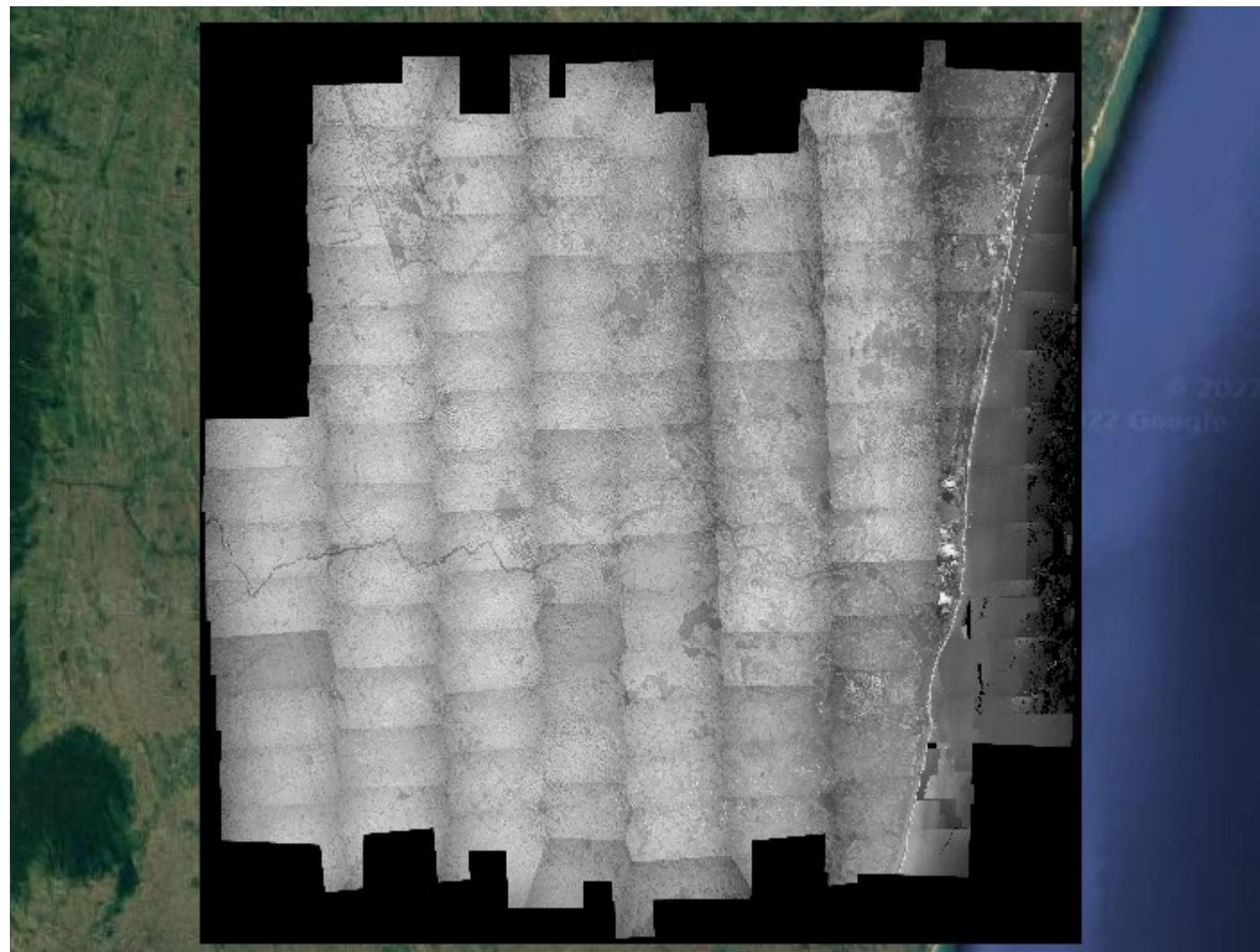
Other challenges

- Later : correlation problems for dense matching (related to image scale, noise, texture, conservation state and landscape...)



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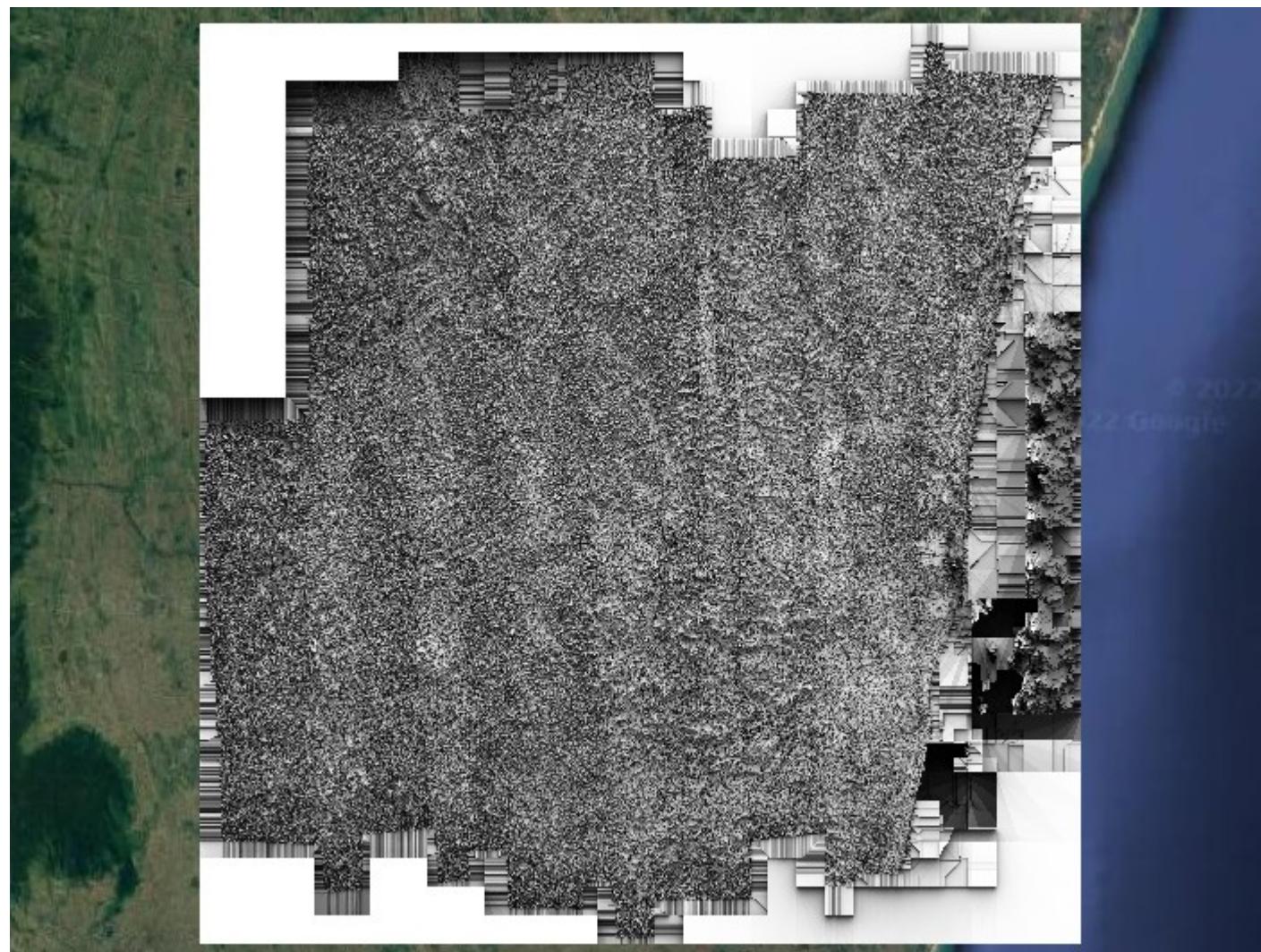
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Coarse ortho-image
(coarse georeferencing,
raw radiometry)

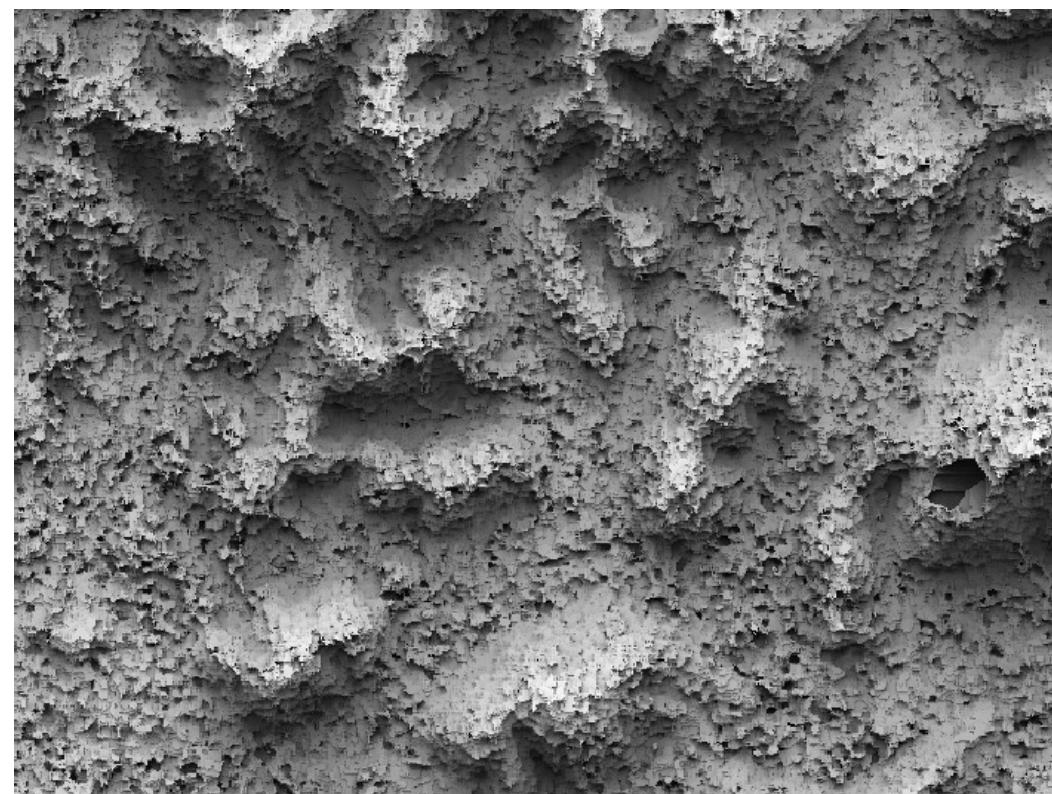
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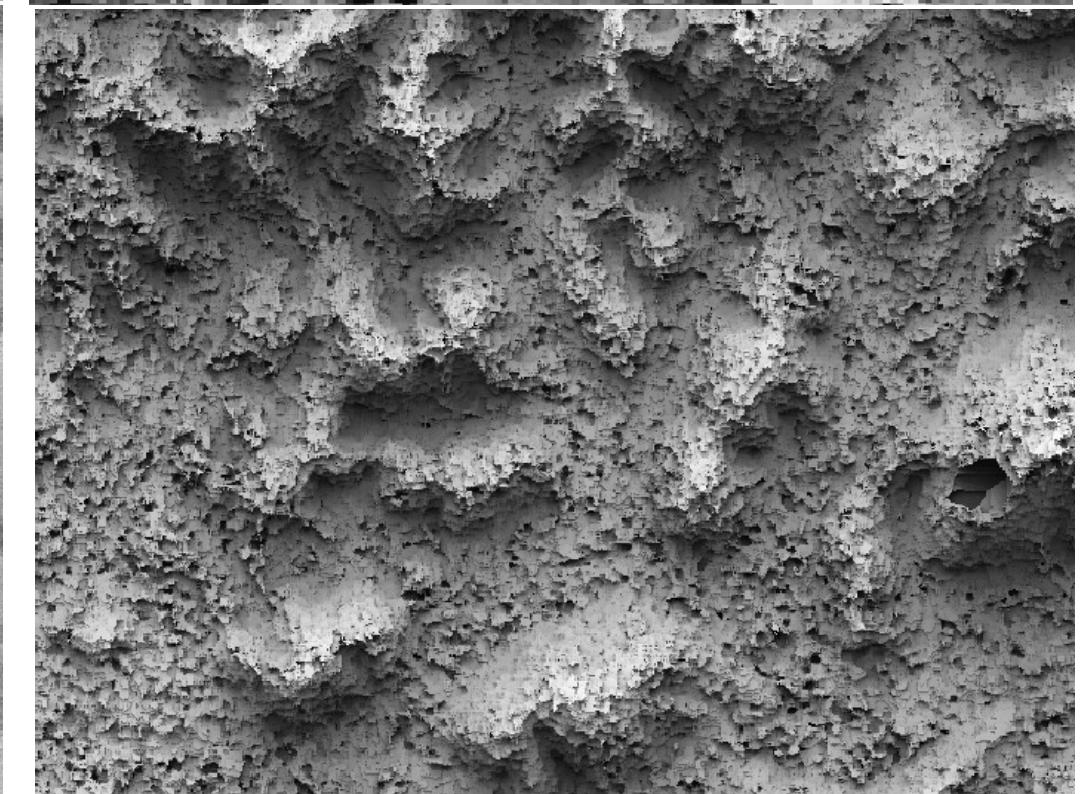
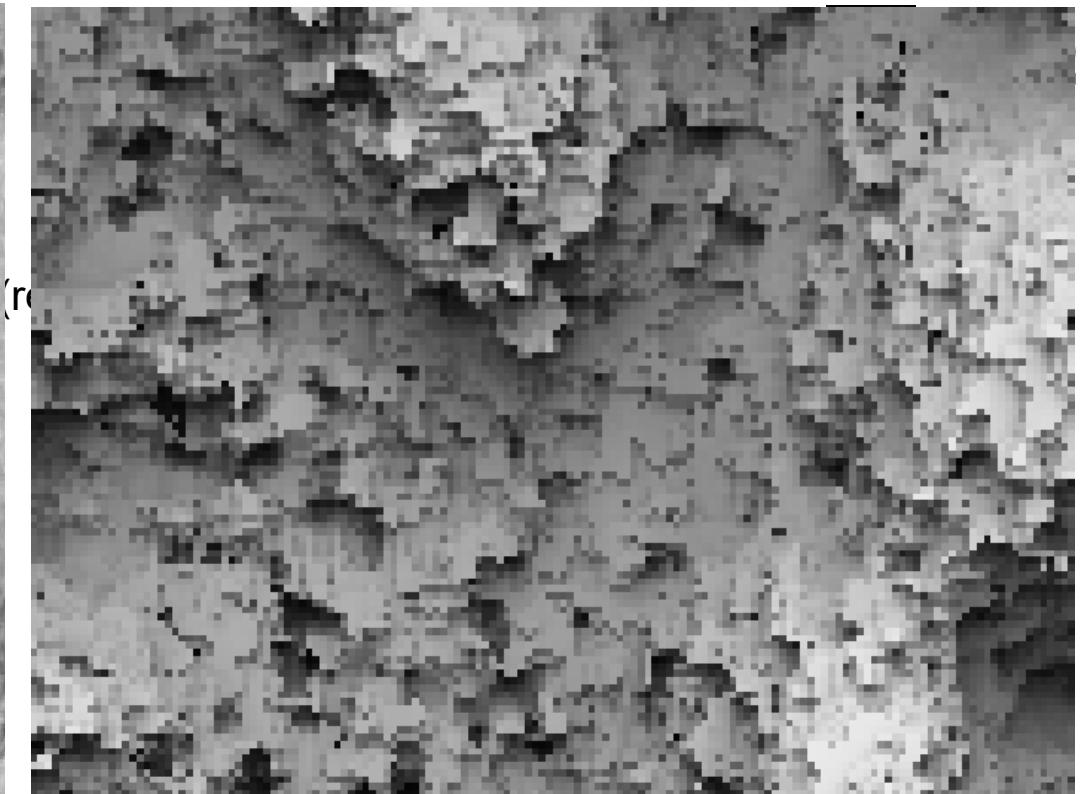
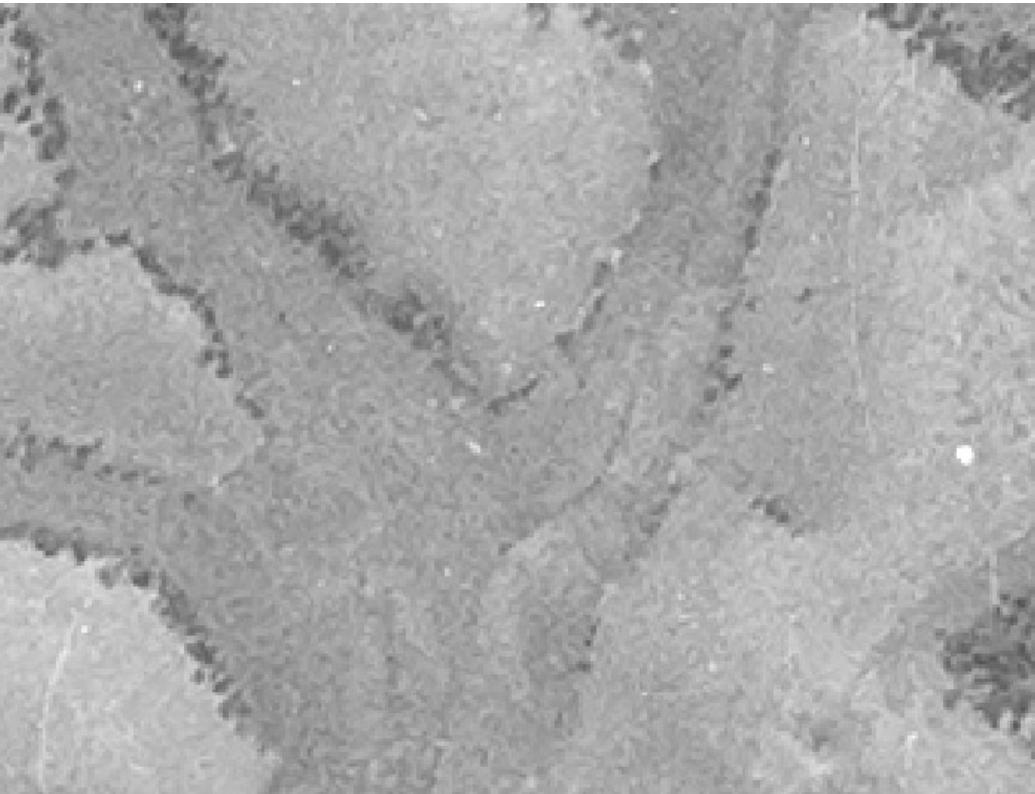
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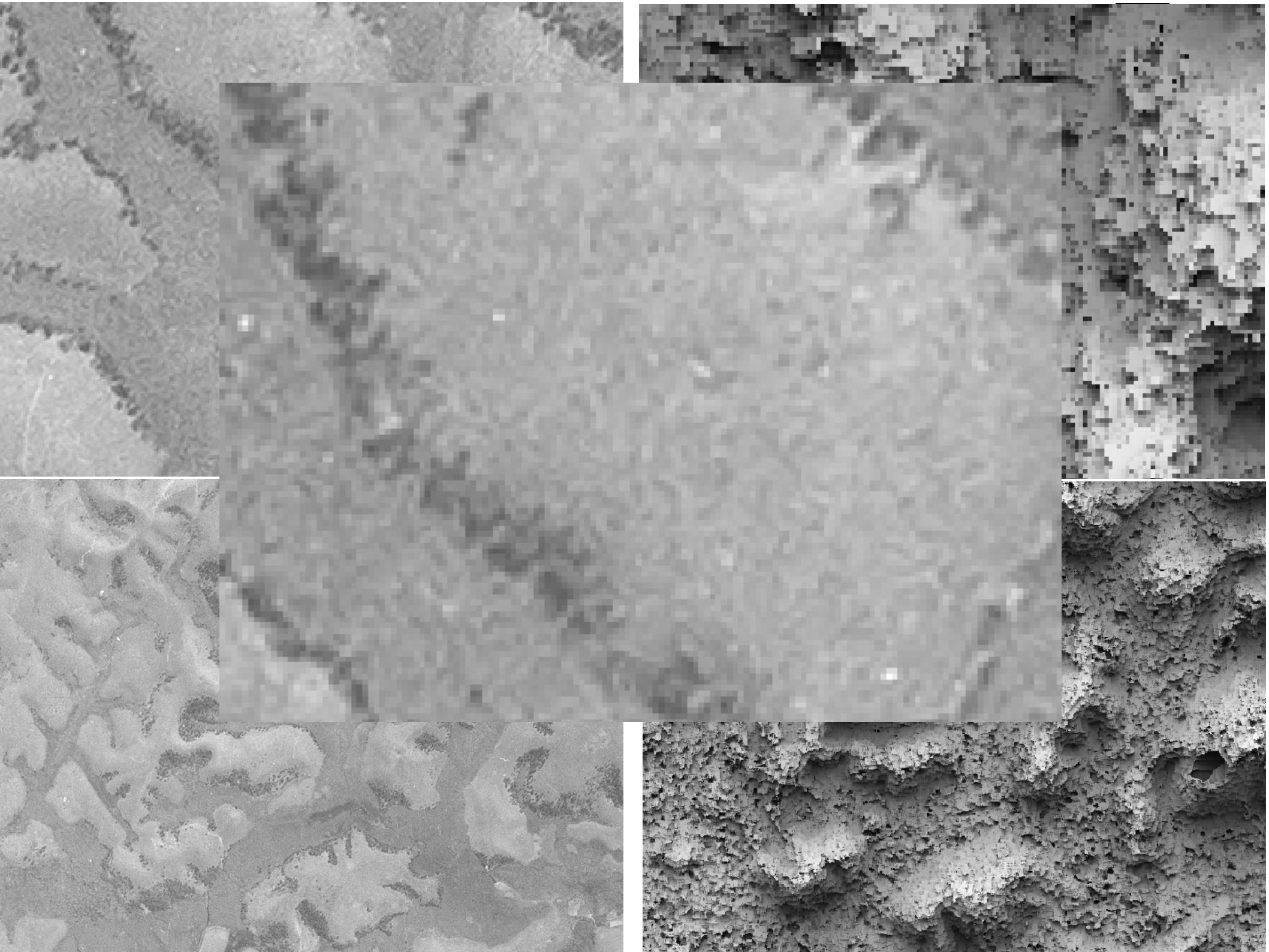


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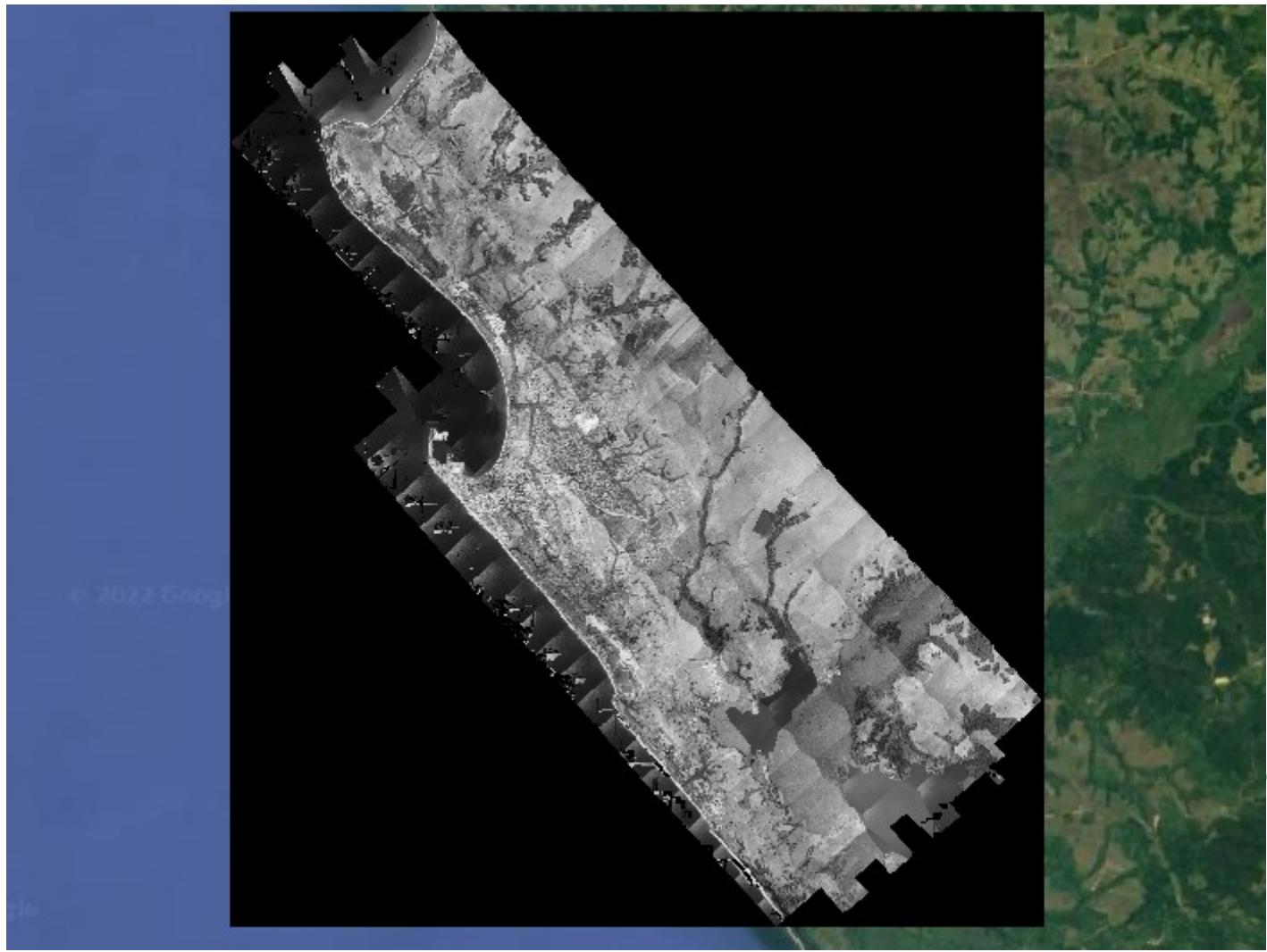






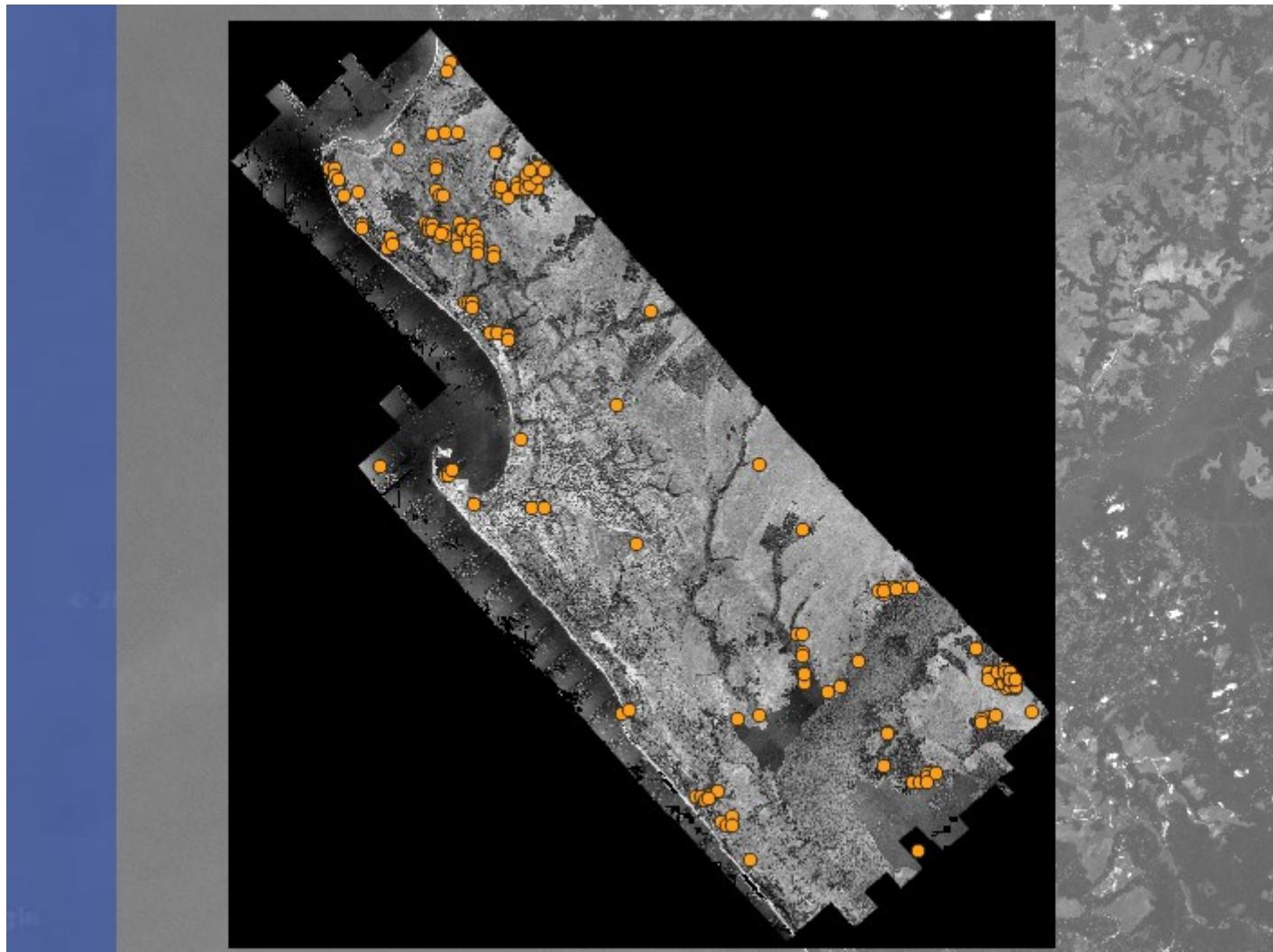
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→ experiments using Sentinel-2 date to perform 2D ortho-image registration, rather than fine image pose estimation...



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Sentinel-2 L2A

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RÉPUBLIQUE
FRANÇAISE

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DE L'INFORMATION
GÉOGRAPHIQUE
ET FORESTIÈRE

1950

1964

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1971

1975

1976

1982

1986

1991

1997

2000

Thank you for your attention.

<https://anr-hiatus.github.io/>

arnaud.le-bris@ign.fr



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