TLC &RS Lab

TOLOMEO
TOoLs for Open Multi-risk assessment using Earth Observation data

CBERS AUTOMATIC CO-REGISTRATION

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Overview

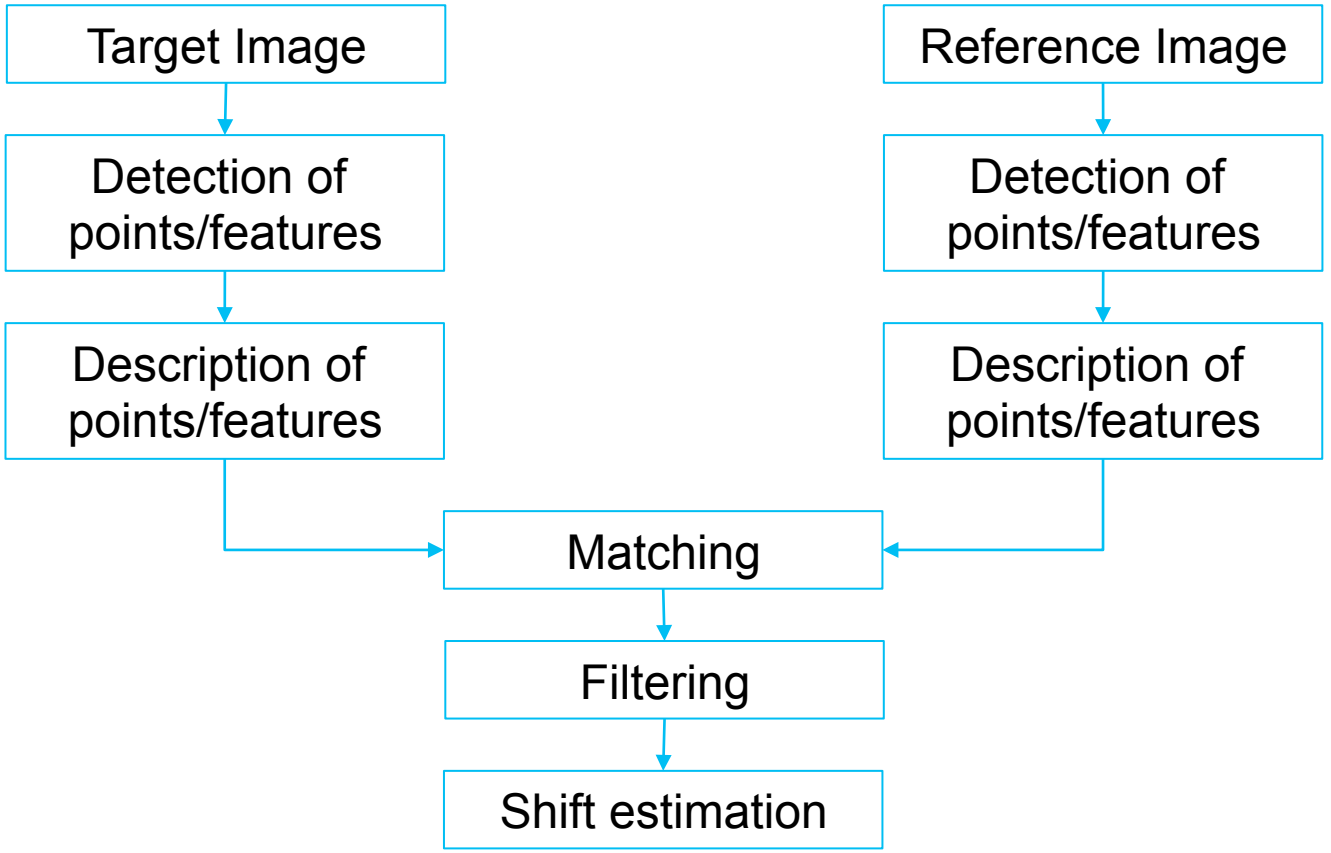
- Main concept
- Automatic subset selection
  - Grid-based
  - Unsupervised-classification-based
- CCD-to-CCD co-registration
- CCD-to-HRC co-registration
- Implementation
- Application

MAIN CONCEPT

Starting Point

- A method was developed in Pavia to co-register Landsat images
  - *Harb, M., De Vecchi, D., Dell'Acqua, F., Iannelli, G. C., "A novel approach in refining the geometrical accuracy of Landsat images in the context of temporal tracking of Built-up areas as physical vulnerability indicator", in progress*
- Detection of points using SURF
- Correction of translational shift
- Evolution of the method used for mosaicking of HRC CBERS images

Starting Point



Main Idea

- Use the same method to fix the shift among panchromatic and multispectral bands for CBERS-2B CCD images

- Match HRC panchromatic with CCD bands
  - Interesting for urban area monitoring purposes

Issues of the original method

- Not capable to run on the complete image
  - Errors in point extraction
  - Time consuming
- Determination of a single point not the best solution
  - Noise affected
  - Unstable

AUTOMATIC SUBSET SELECTION

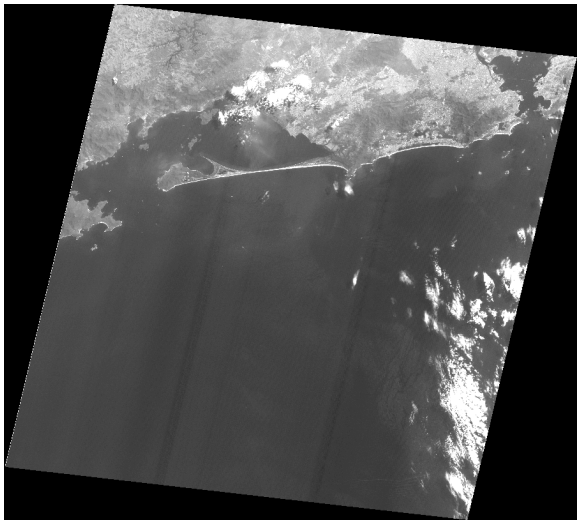
Subset selection

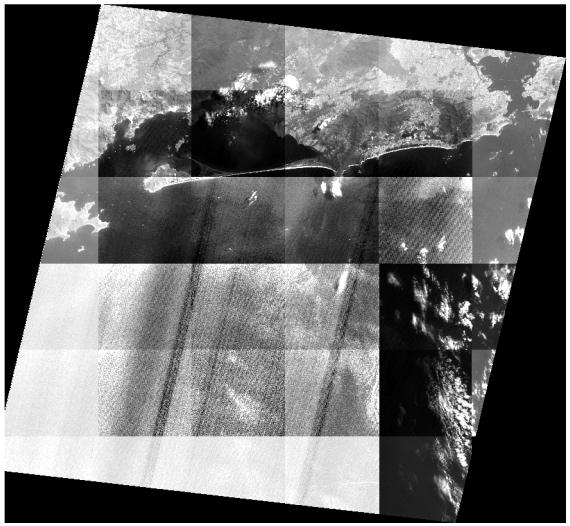
- Automatic method for subset extraction
  - Try to avoid clouds
  - High variability of the scene → improve point selection
  - Reduced processing time

- 2 different methods developed
  - Grid-based
  - Unsupervised-classification-based

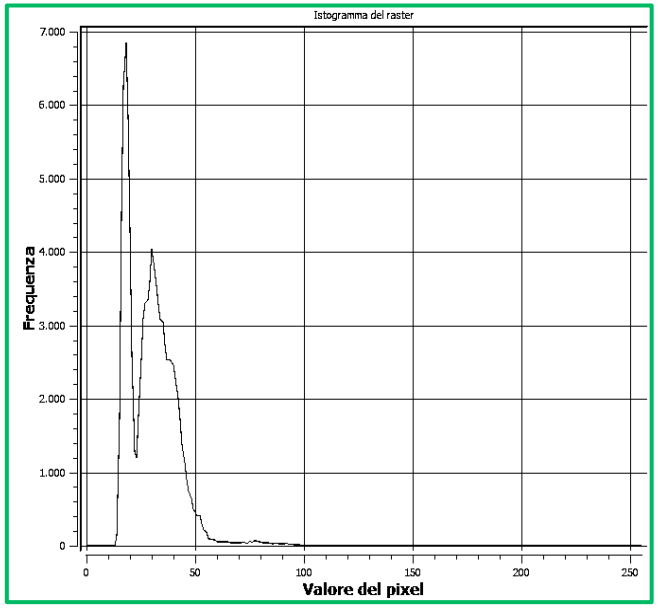
Grid-based

- Division in regular tiles (6x6)
- Statistics for each tile
  - Frequency of max and min values (among the 20 most common values)
  - Distance between min and max
  - Frequency standard deviation





Grid-based


Istogramma del raster
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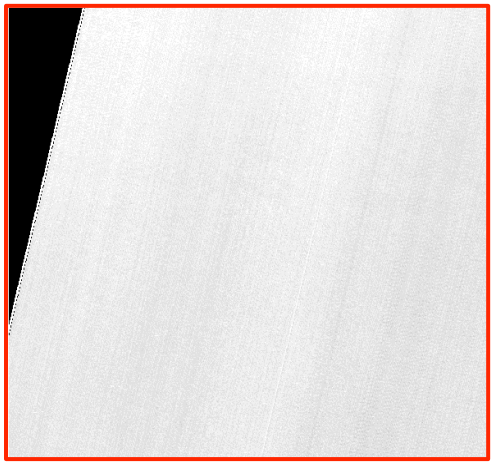
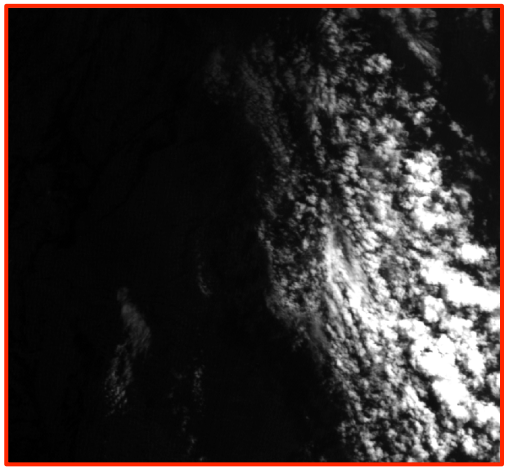
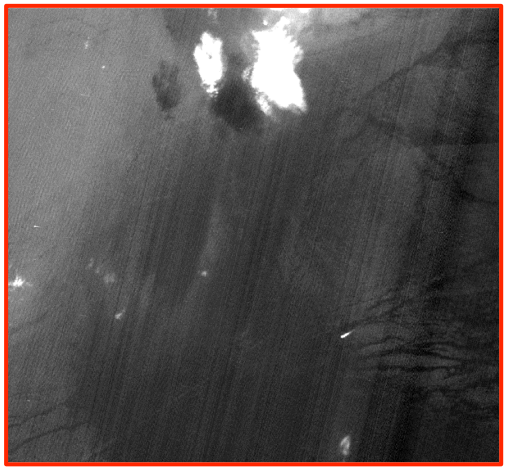
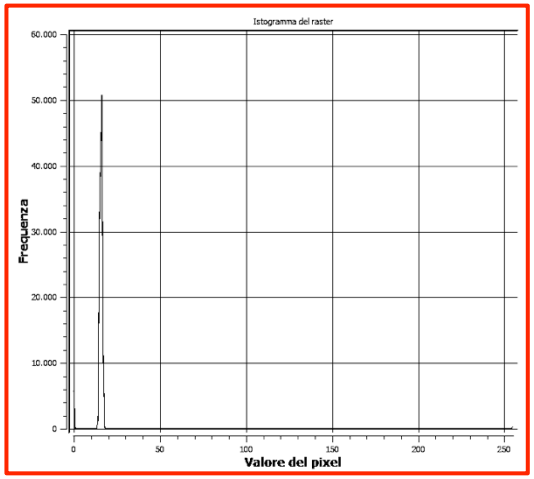
Valore del pixel

Grid-based





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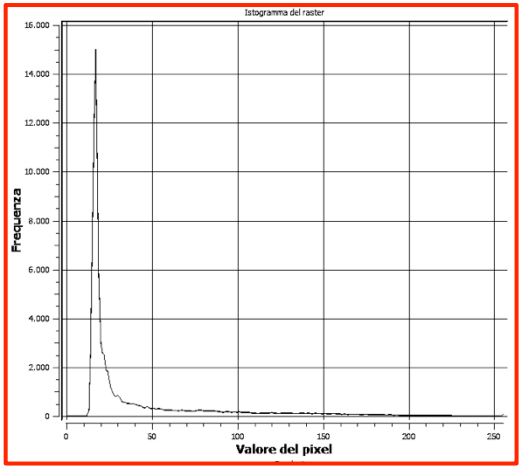
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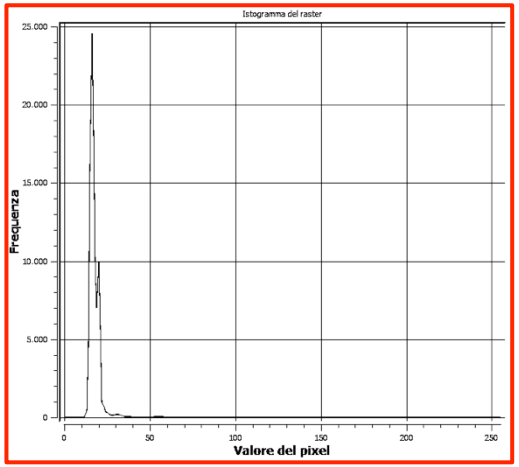
Istogramma del raster
Frequenza
Valore del pixel
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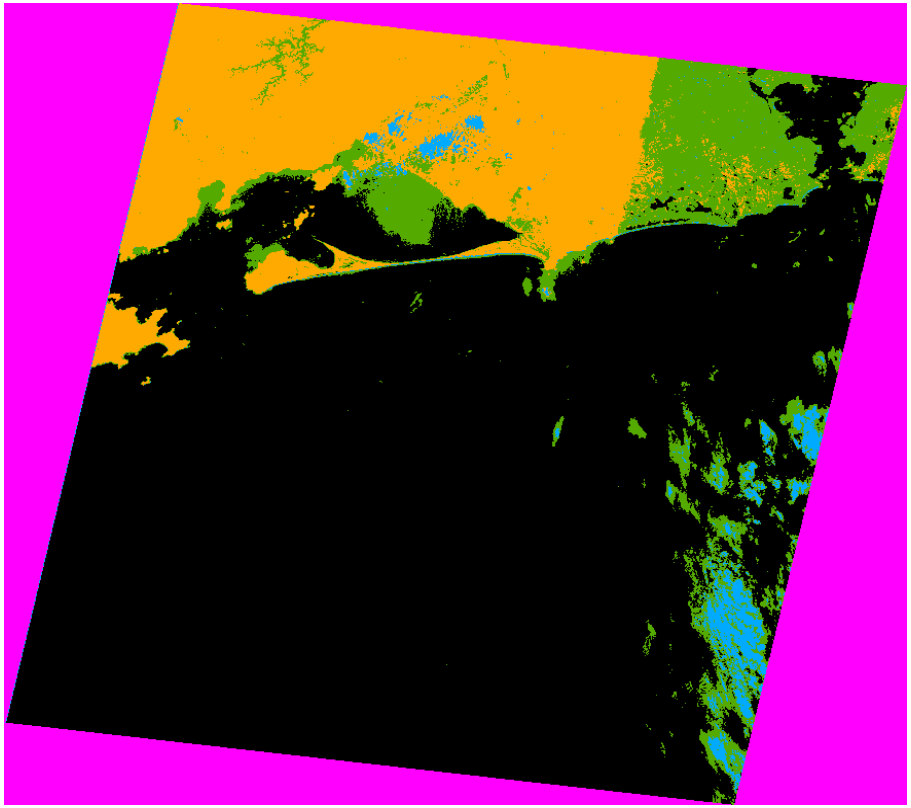
250

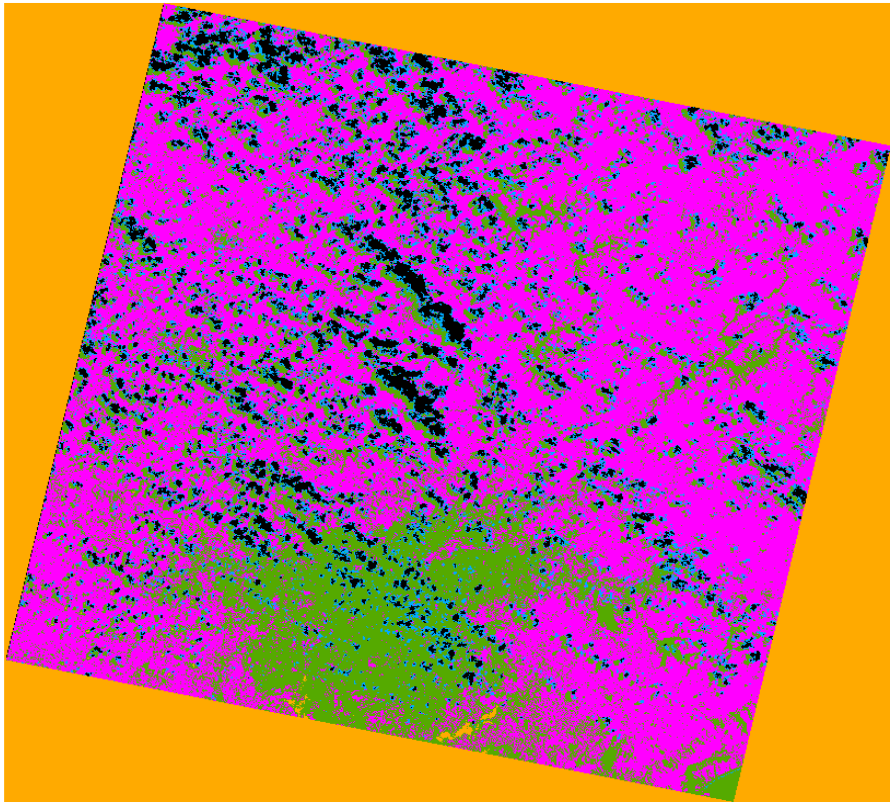
Unsupervised-classification-based

- Combination of multispectral bands
- Unsupervised classification
- Statistics for each class
  - Min and max value
  - Distance between min and max
  - Standard deviation
  - Min and max value frequency
  - Total number of value

Unsupervised-classification-based

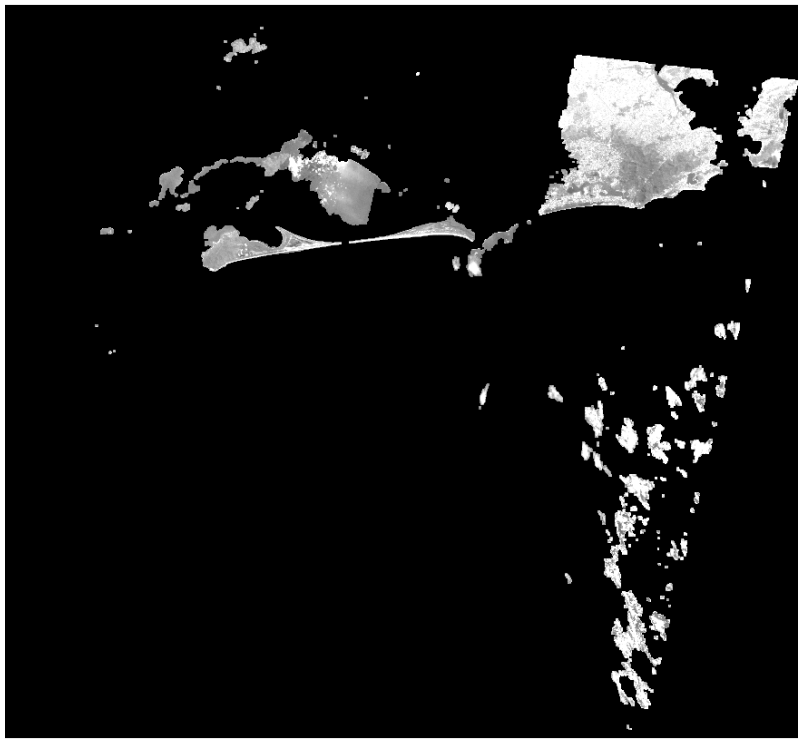
- Green class to be selected

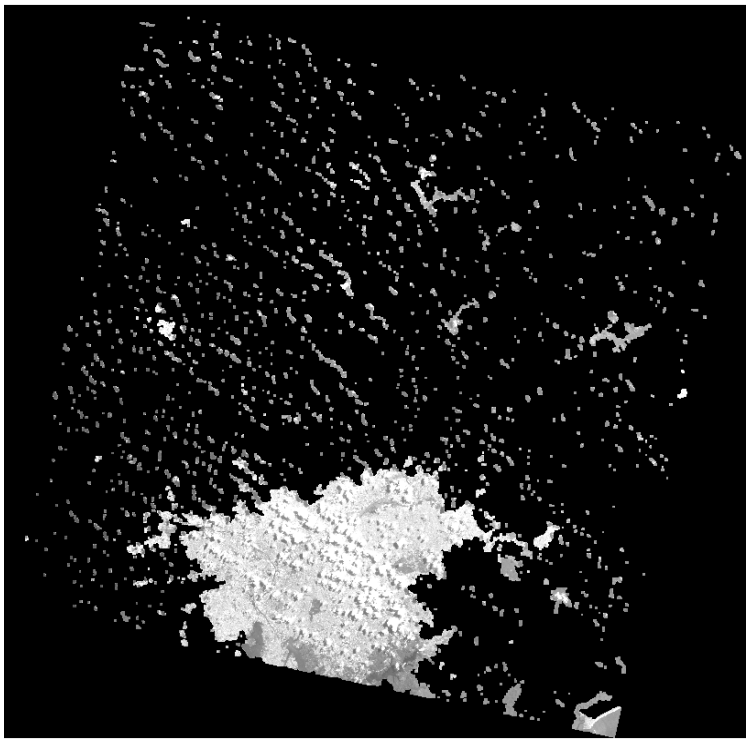




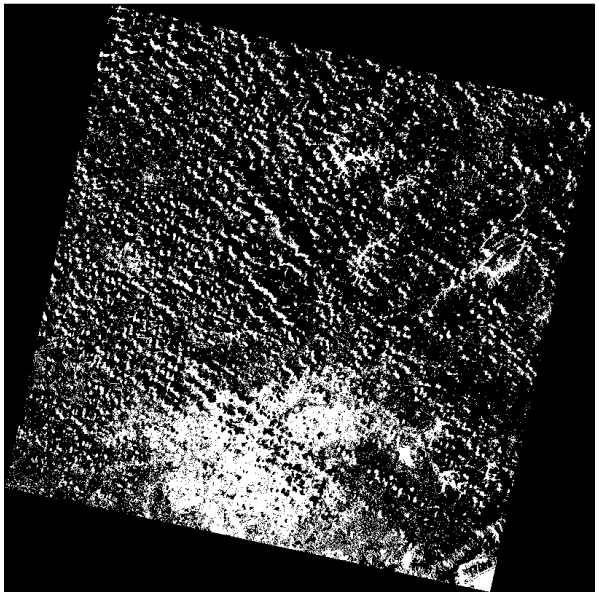
Unsupervised-classification-based

- Selected class can't be used directly → errors

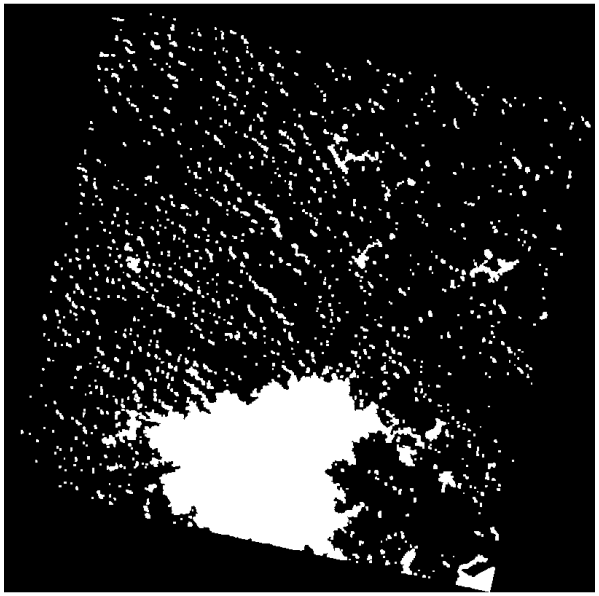




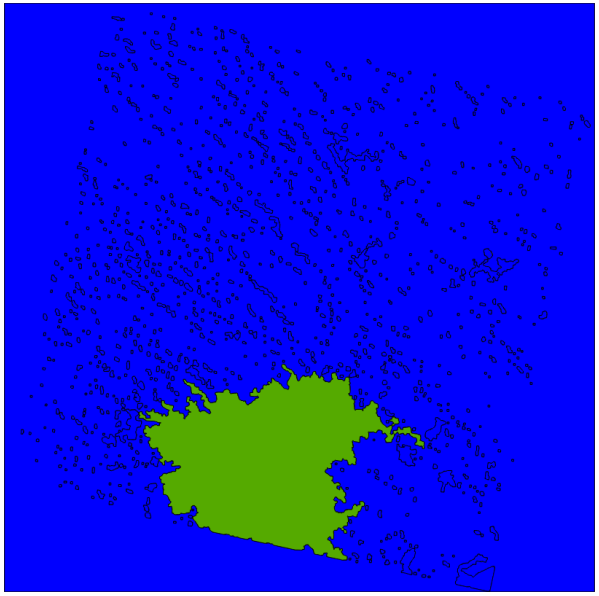
Unsupervised-classification-based



Mask from classification



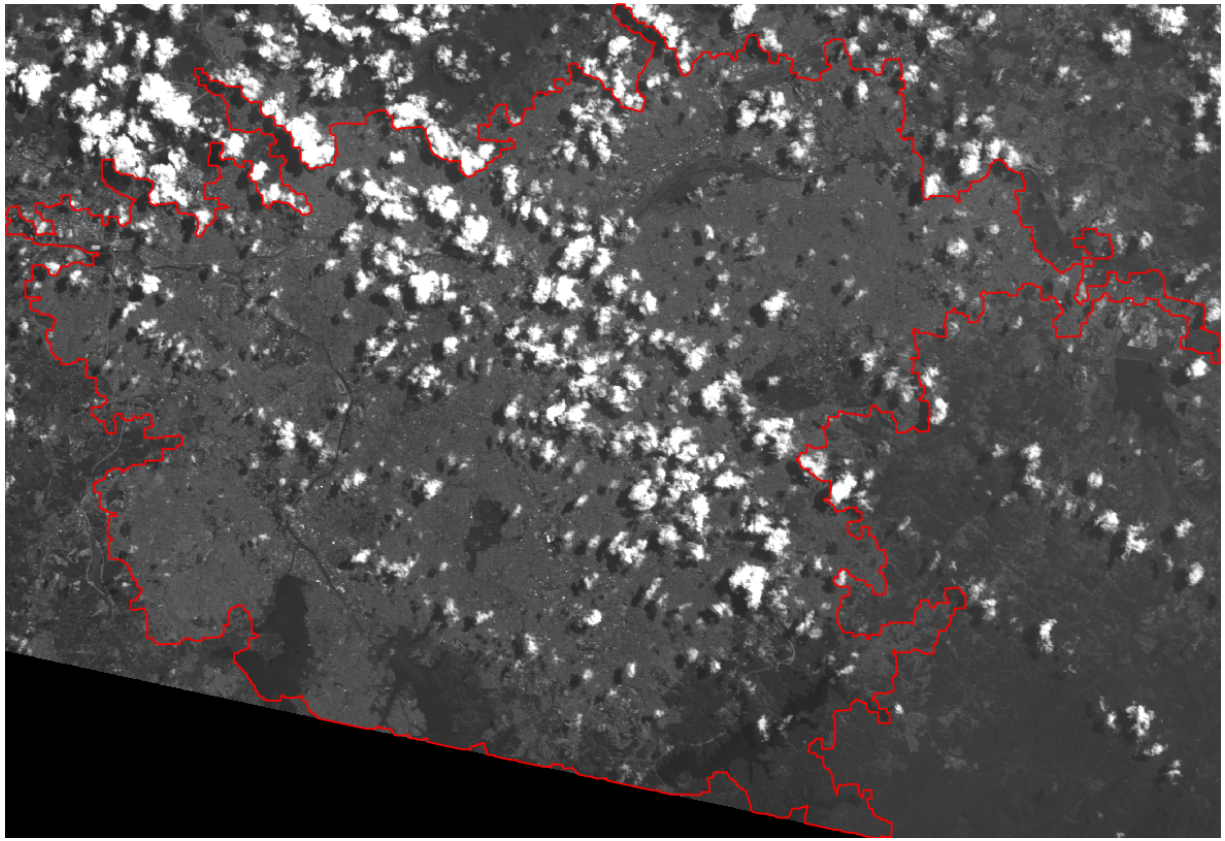
Morphologica filter



Max area selection

Unsupervised-classification-based

- Regular tile



CCD-TO-CCD CO-REGISTRATION

CCD-to-CCD co-registration

- Target: fix the shift between panchromatic (BAND 5) and all the other bands (BAND 1, 2, 3 and 4)
- Assumption of linear shift
- Used as preliminary test for the method

CCD-to-CCD co-registration

Point N	Dist. before (m)	Dist. after (m)	Dist. before (pix)	Dist. after (pix)
1	127,579	17,978	6,37895	0,8989
2	126,41	12,539	6,3205	0,62695
3	135,469	12,225	6,77345	0,61125
4	122,714	13,592	6,1357	0,6796
5	142,027	20,836	7,10135	1,0418
6	128,01	12,888	6,4005	0,6444
7	134,098	21,837	6,7049	1,09185

RMSE = 16,43916101 meters / 0,821958051 pixels

Average Euclidean Error (AEE) = 15,985 meters / 0,79925 pixels

CCD-TO-HRC CO-REGISTRATION

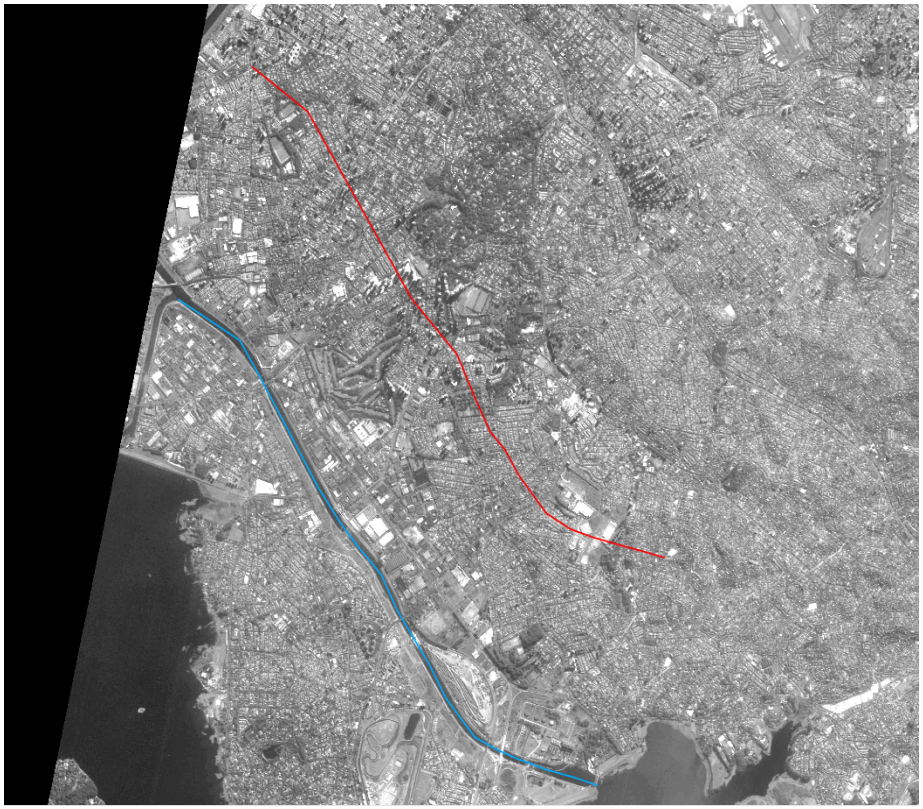
CCD-to-HRC co-registration

- Target: fix the shift between panchromatic HRC and all the CCD bands (BAND 1, 2, 3 and 4)

- Assumption of linear shift

CCD-to-HRC co-registration

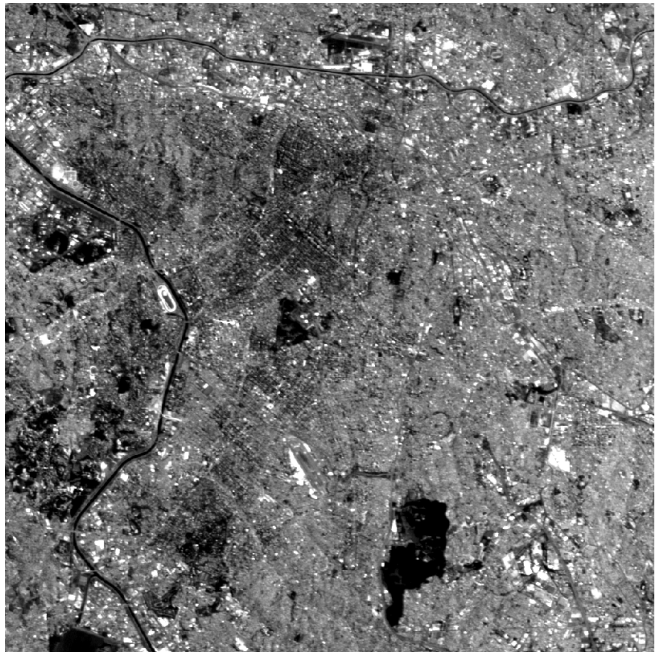
CCD

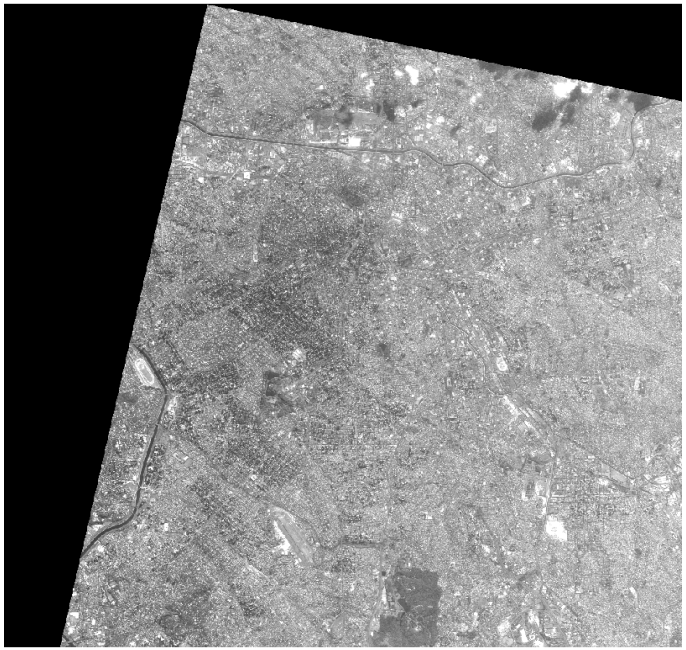


HRC

CCD-to-HRC co-registration

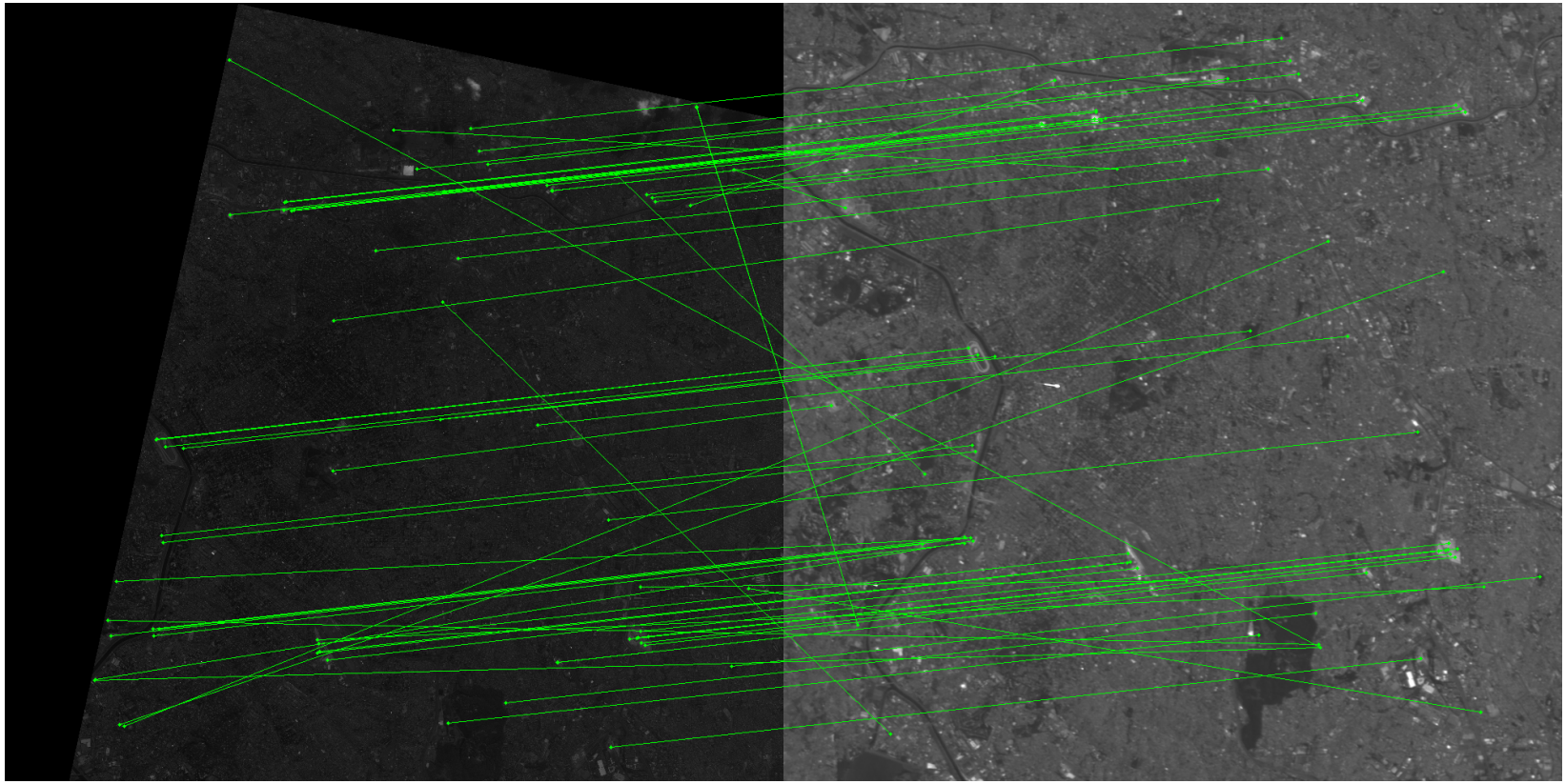
- Match CCD resolution
  - Resample HRC 2.5m to 20m
- Extract subset using the unsupervised-classification approach





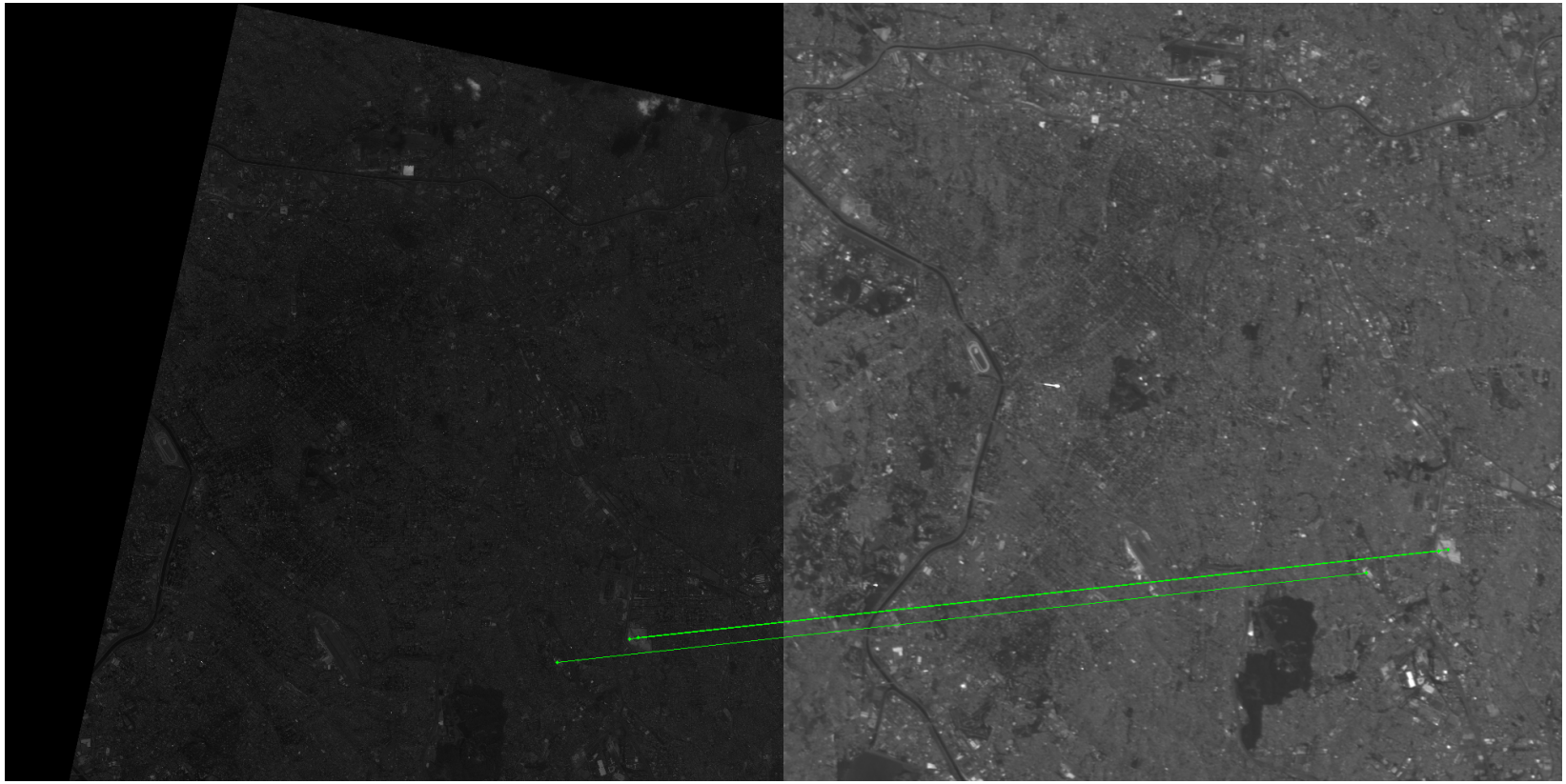
CCD-to-HRC co-registration

- Output of detection, description and matching

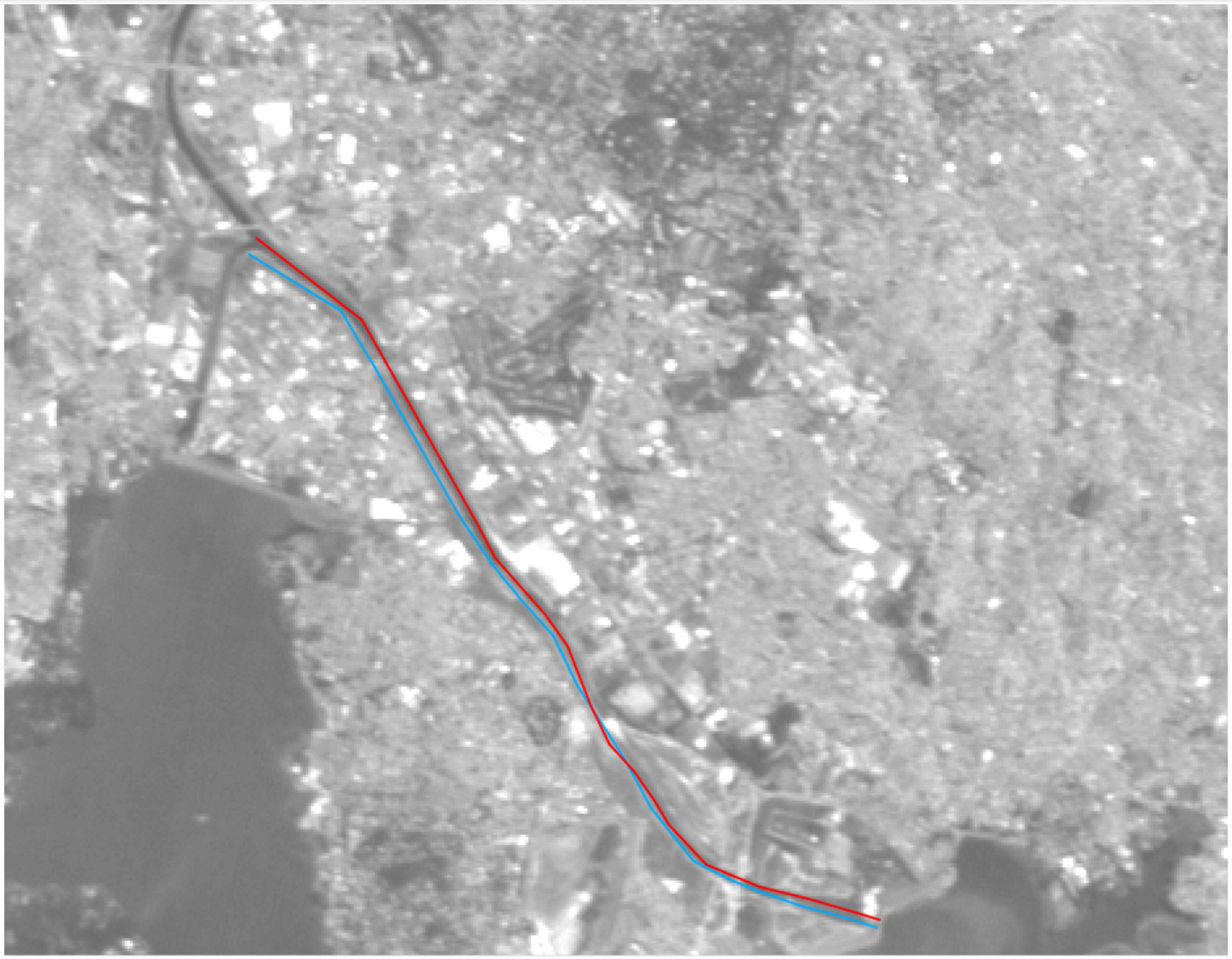


CCD-to-HRC co-registration

- Output after filter



CCD-to-HRC co-registration



CCD-to-HRC co-registration

- Original shift

ID	Delta X	Delta Y	Deviation X	Deviation Y
1	-5439,46	3920,38	-34,6787143	-32,8086
2	-5431,62	3902,1	-26,8477143	-51,0886
3	-5387,25	3983,02	17,52428571	29,83143
4	-5408,13	3967,36	-3,35671429	14,17143
5	-5371,59	3951,69	33,18628571	-1,49857
6	-5408,13	3946,48	-3,35371429	-6,70857
7	-5387,25	4001,29	17,52628571	48,10143
AVG	-5404,78	3953,189		

CCD-to-HRC co-registration

- After correction with single HRC

ID	Delta X	Delta Y	Deviation X	Deviation Y
1	-120,671	-134,74	-4,49371429	15,65714
2	-84,397	-98,16	31,78028571	52,23714
3	-129,417	-169,62	-13,2397143	-19,2229
4	-113,728	-144,64	2,449285714	5,757143
5	-142,199	-229,38	-26,0217143	-78,9829
6	-101,539	-108,64	14,63828571	41,75714
7	-121,29	-167,6	-5,11271429	-17,2029
AVG	-116,177	-150,397		

RMSE = 13.80036 meters

AEE = 190.4499 meters

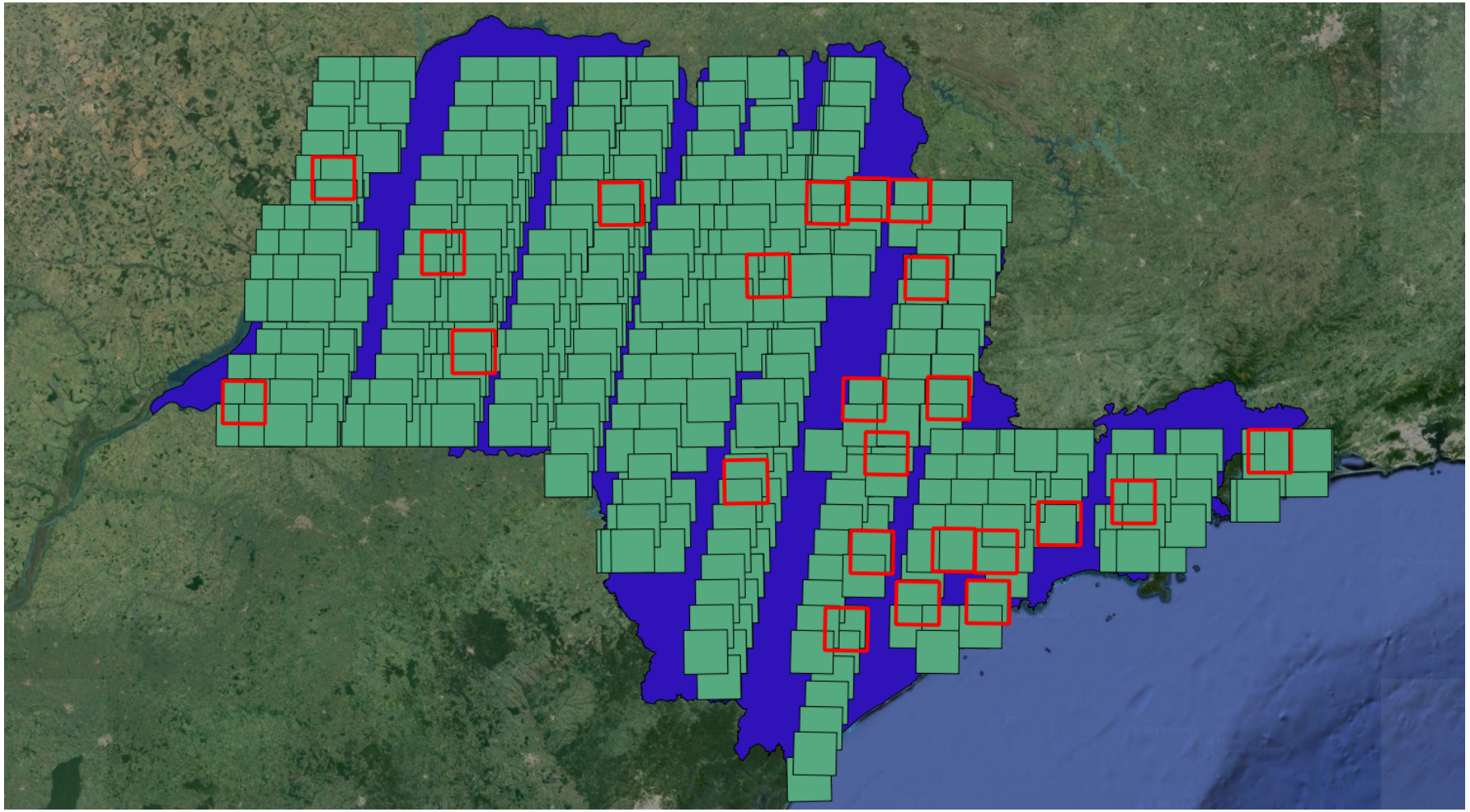
CCD-to-HRC co-registration

- A method for HRC co-registration was also developed in Pavia

- Semi-automatic approach
  - Registration of a few images manually
  - Automatic registration of the others taking advantage of the overlapping area

- Developed by Gianni Cristian Iannelli and Mostapha Harb

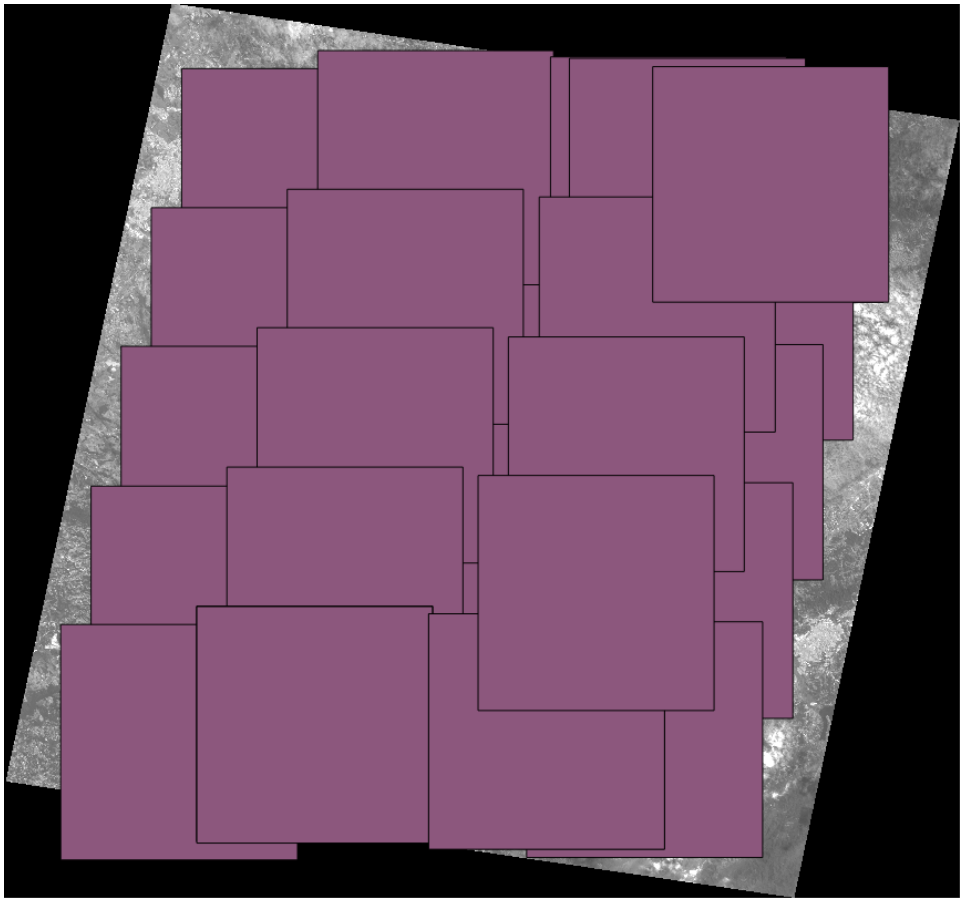
CCD-to-HRC co-registration



CCD-to-HRC co-registration

- Consider all the HRC images within the area covered by the CCD image

- Pick 5 random HRC



CCD-to-HRC co-registration

- Determine the points for each intersection
- Filter extracted points according to the slope
- Weighted average using frequency of detected points

CCD-to-HRC co-registration

- After improved correction

ID	Delta X	Delta Y	Deviation X	Deviation Y
1	-51,58	-50,84	1,15	5,79
2	-75,13	-75,85	-22,40	-19,22
3	-15,31	-29,07	37,42	27,56
4	-68,17	-145,49	-15,44	-88,86
5	-15,03	-85,42	37,70	-28,79
6	-91,67	78,89	-38,94	135,52
7	-52,20	-88,64	0,53	-32,01
AVG	-52,7271	-56,6314		

RMSE = 9.879638 meters

AEE = 97.60725 meters

IMPLEMENTATION

Implementation

- Python language
- Libraries:
  - OpenCV
  - GDAL/OGR
  - Numpy
  - Scipy
  - Orfeo Toolbox
- Code released with open source license
- Easy to implement as QGIS plugin

Implementation

- 5-HRC method
  - CCD image size: 6800 x 6300
  - Processing time: 190.28 sec/CCD image

APPLICATIONS

Applications

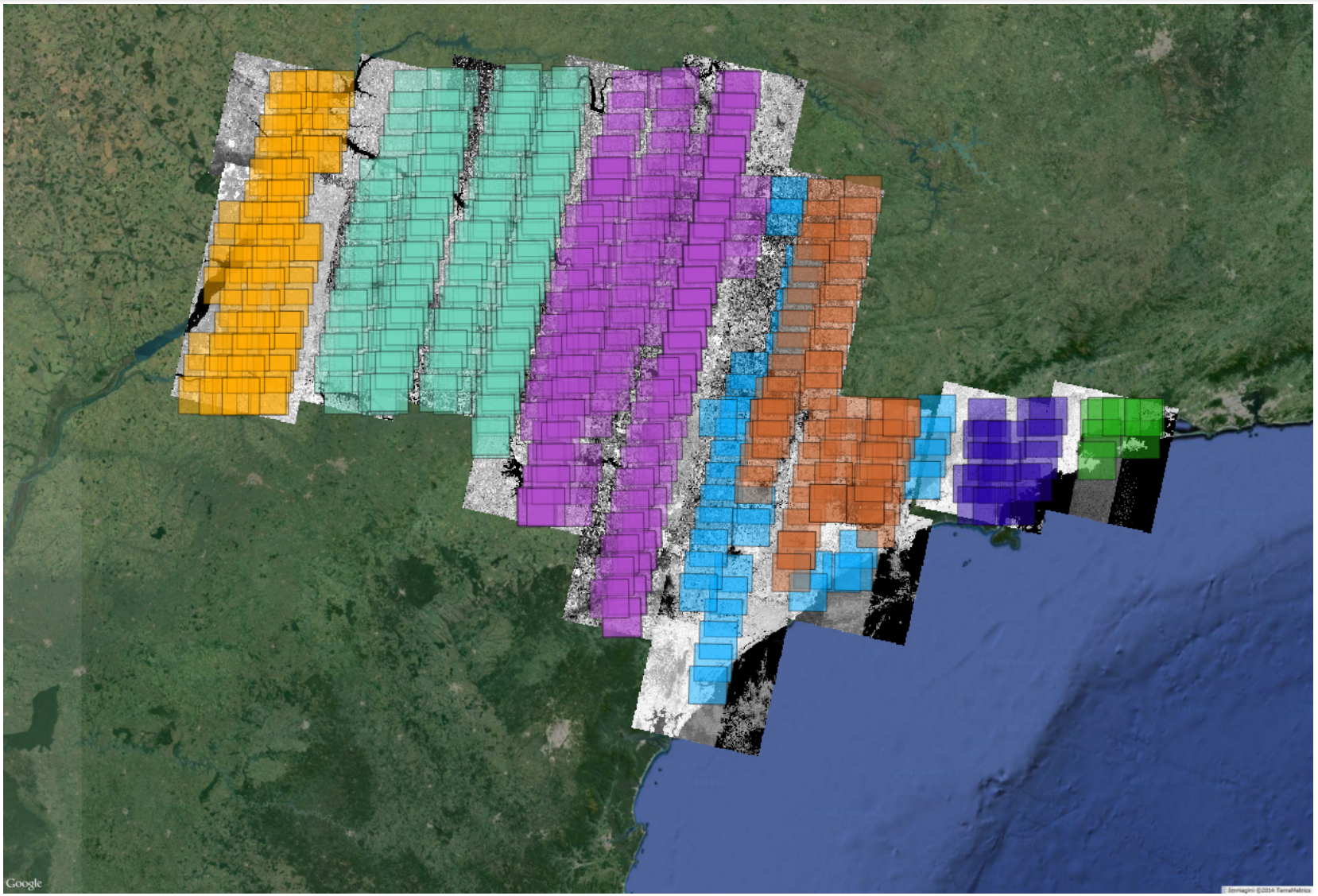
- Pan-sharpened image

Applications

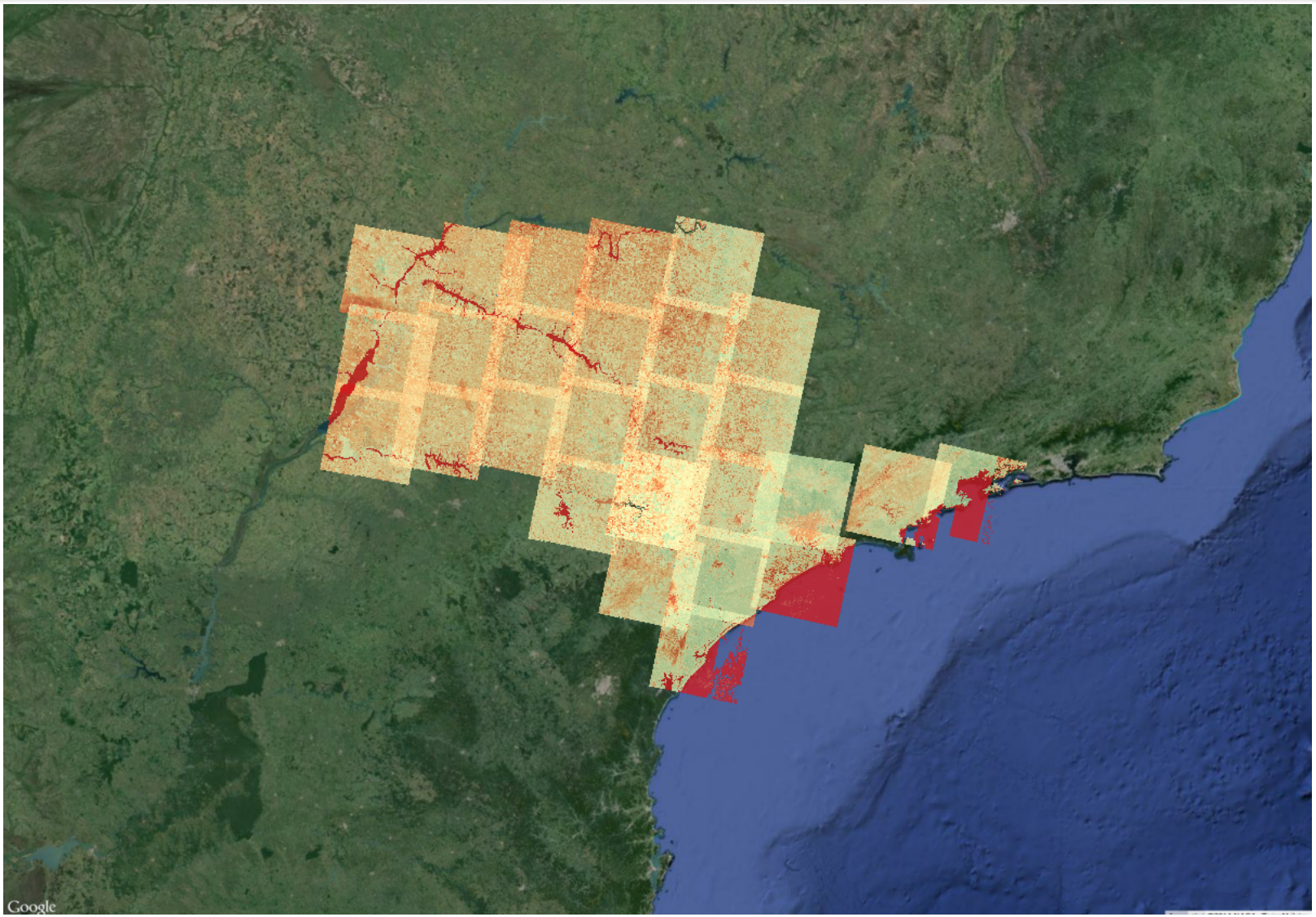
- Combine
  - spatial information from panchromatic
  - spectral information from multispectral CCD

- Urban Area monitoring purposes
  - NDVI layer generated from CCDs
  - Improve the extraction from HRC-only designed in Pavia

Applications



Applications



THANK YOU!