

CBERS automatic co-registration

WP2: Tools for human exposure (HUEX)
to multiple risks

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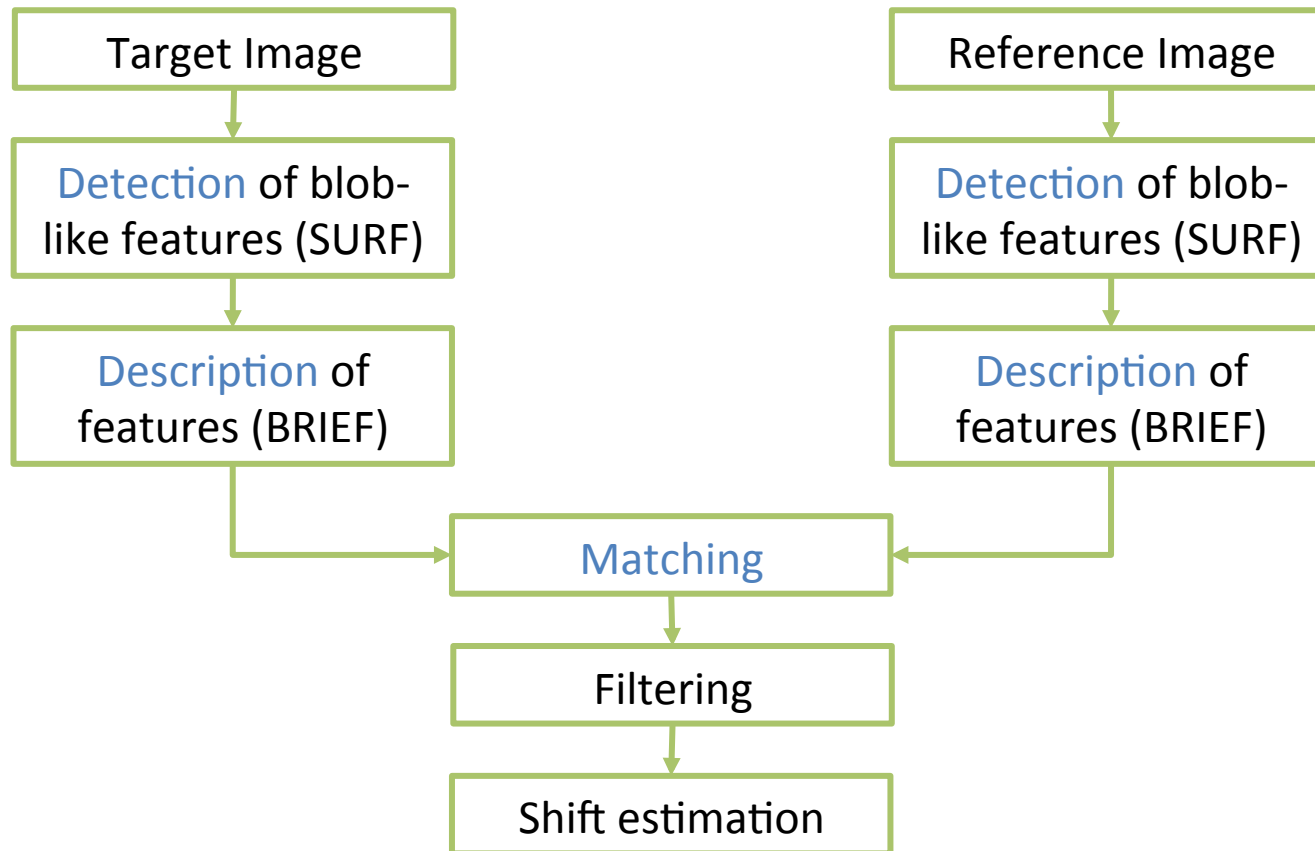
Overview

- Main Concept
- Automatic Tile Selection
- CCD-to-CCD co-registration
- CCD-to-HRC co-registration
- Implementation
- Application

Main Concept

- Method originally developed in Pavia to co-register Landsat images
- Feature-based
- Correction of translational shift

Main Concept



Issues of the original method

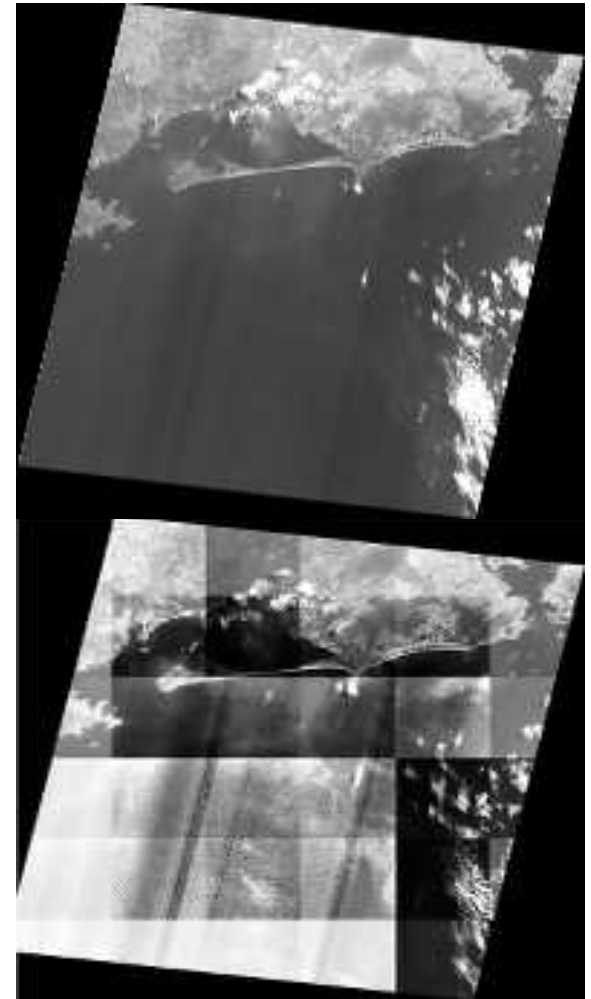
- Not capable to run on the entire image
 - Errors in point extraction
 - Time consuming
- Best single point
 - Affected by noise
 - Unstable solution

Automatic Tile Selection

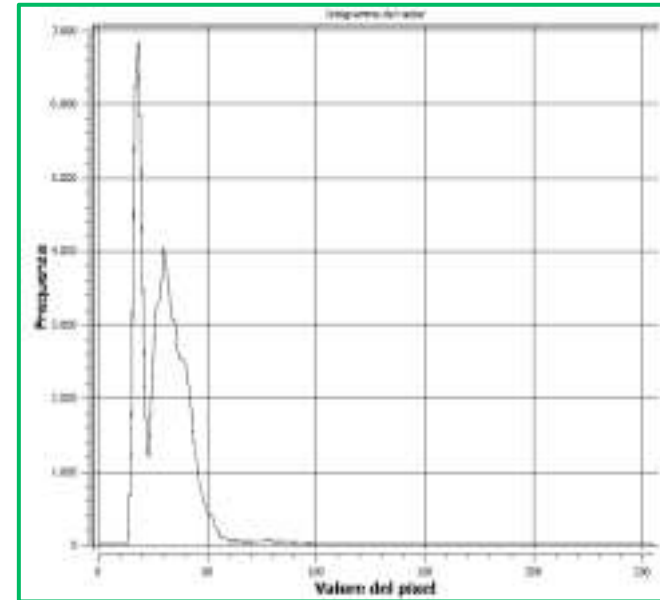
- Automatic method for **subset extraction**
 - Try to avoid clouds
 - High variability of the scene improve point selection
 - Reduced processing time
- 2 different methods developed
 - **Grid-based**
 - **Unsupervised-classification-based**

Grid-based

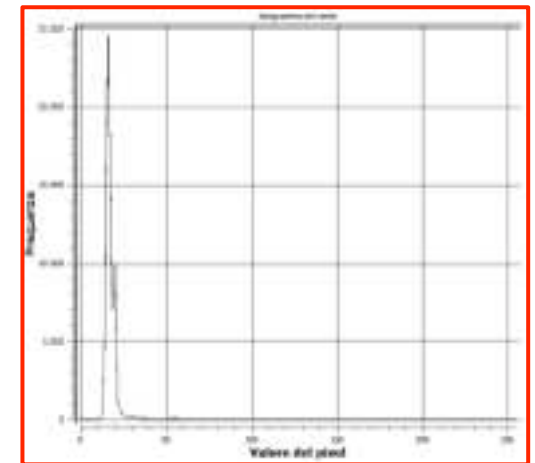
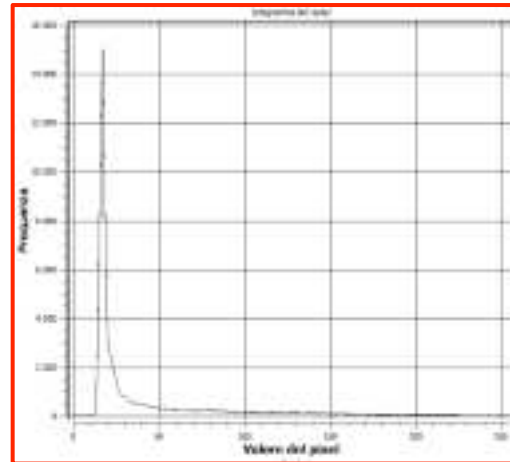
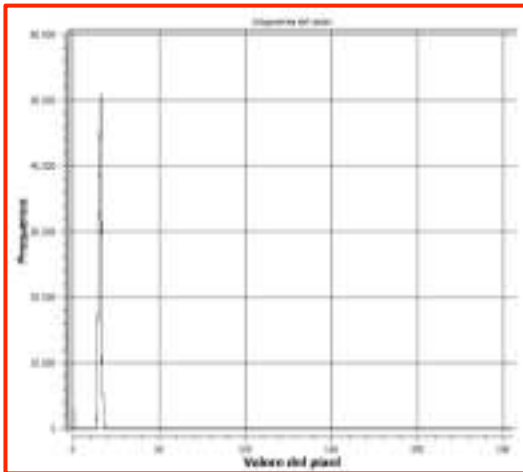
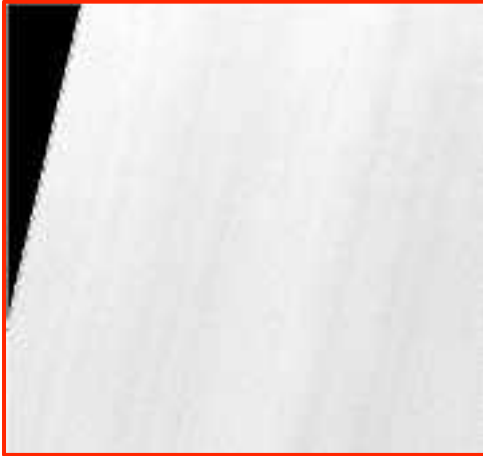
- Division in **regular tiles** (6x6)
- Statistics for each tile
 - Frequency of max and min values (among the 20 most common values)
 - Distance between min and max
 - Frequency standard deviation



Grid-based



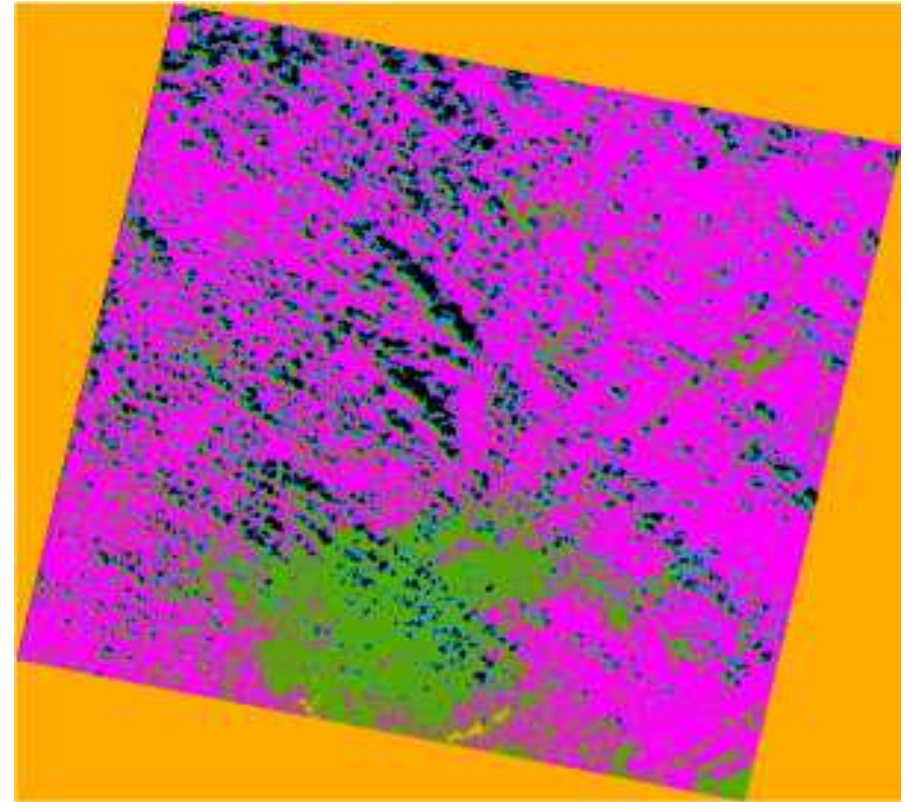
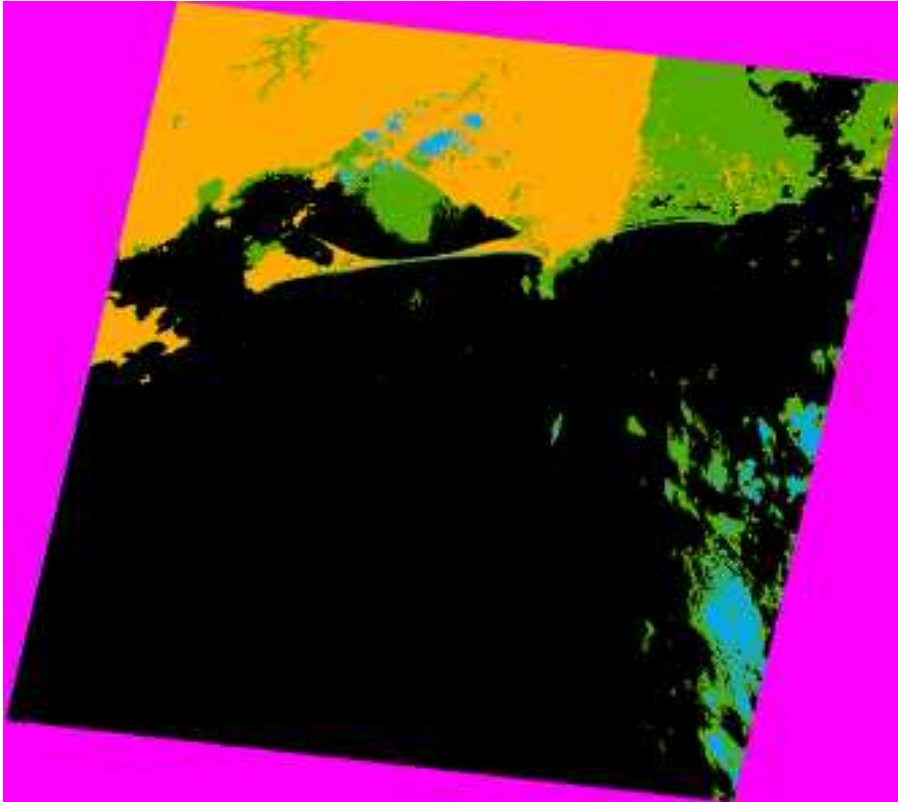
Grid-based



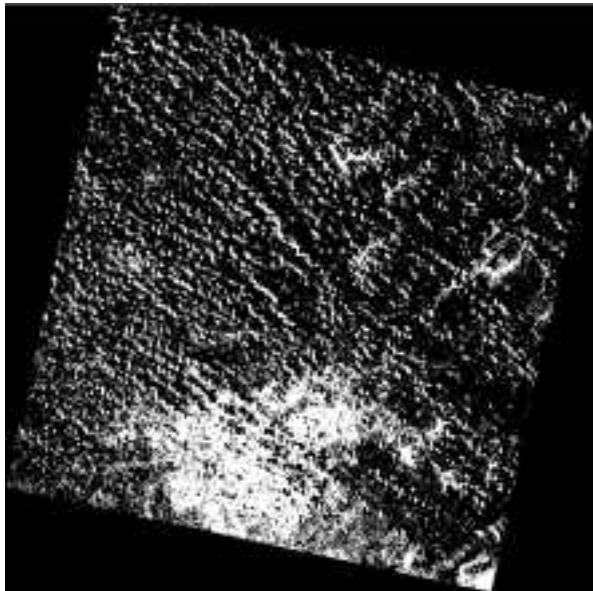
Unsupervised- classification-based

- 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

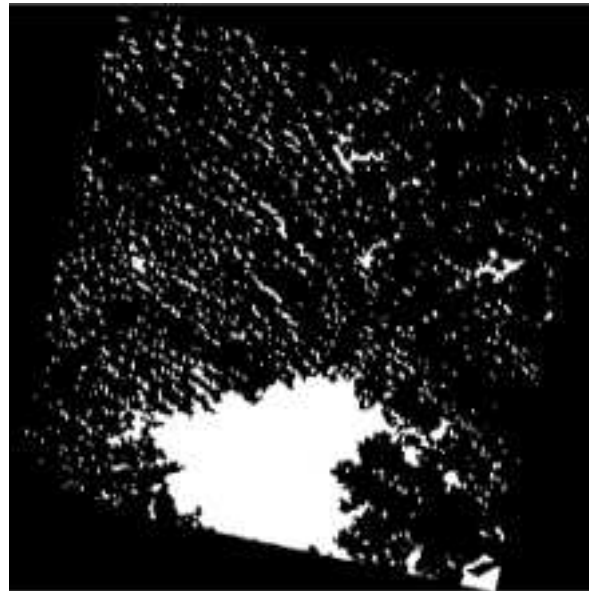
Unsupervised- classification-based



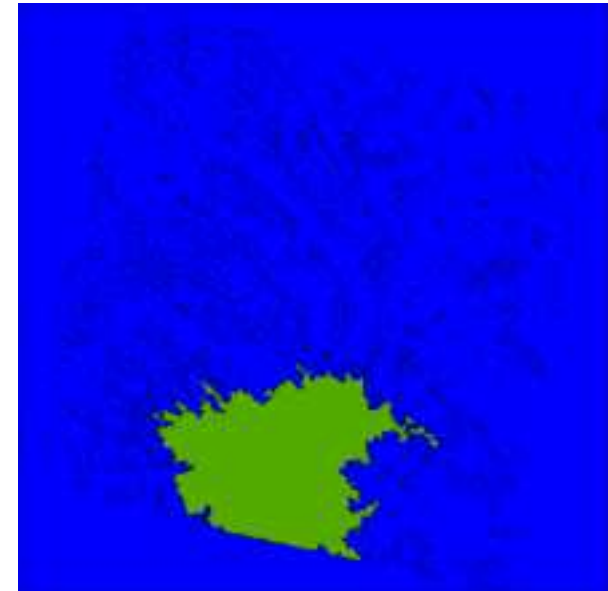
Unsupervised- classification-based



Mask from classification

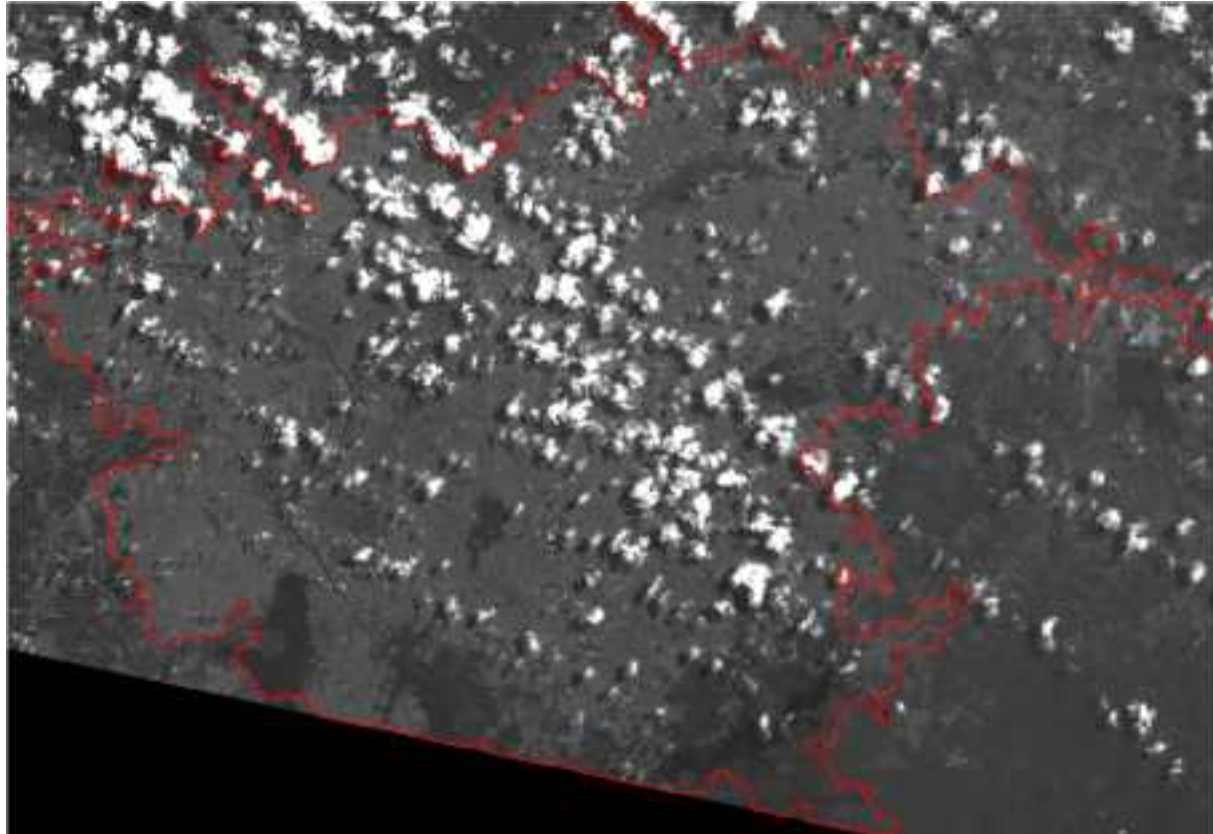


Morphologica filter



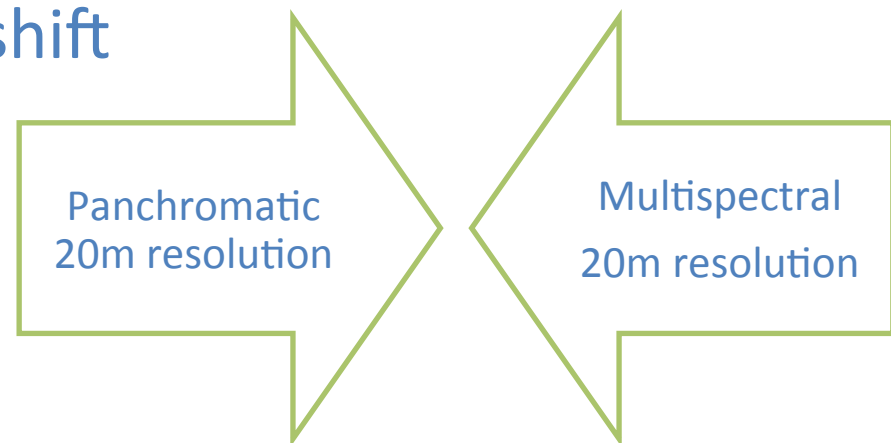
Max area selection

Unsupervised- classification-based



CCD-to-CCD co-registration

- Fix the shift between **panchromatic** (BAND 5 @ 20 meters) and all the **other bands** (BAND 1, 2, 3 and 4 @ 20 meters)
- Assumption of **linear shift**



CCD-to-CCD co-registration

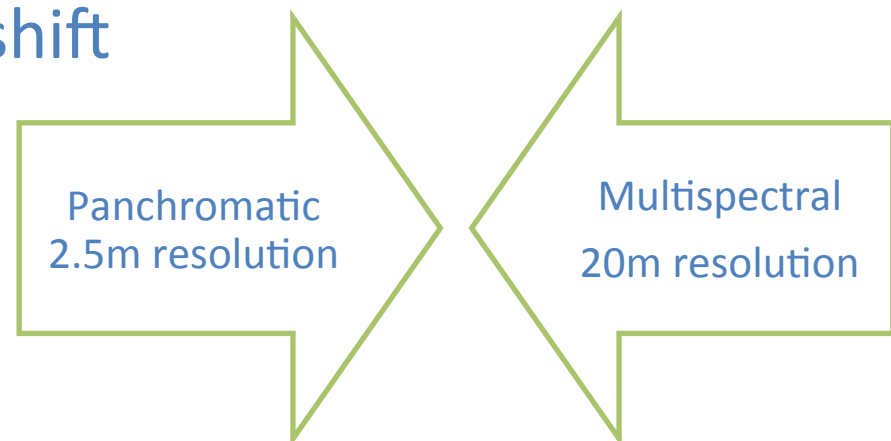
Point N	Dist. before (m)	Dist. after (m)	Dist. before (pix)	Dist. after (pix)
1	127,579	17,978	6,37895	0,8989
2	126,41	12,539	6,3205	0,62695
3	135,469	12,225	6,77345	0,61125
4	122,714	13,592	6,1357	0,6796
5	142,027	20,836	7,10135	1,0418
6	128,01	12,888	6,4005	0,6444
7	134,098	21,837	6,7049	1,09185

RMSE = 16,43916101 meters / 0,821958051 pixels

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

CCD-to-HRC co-registration

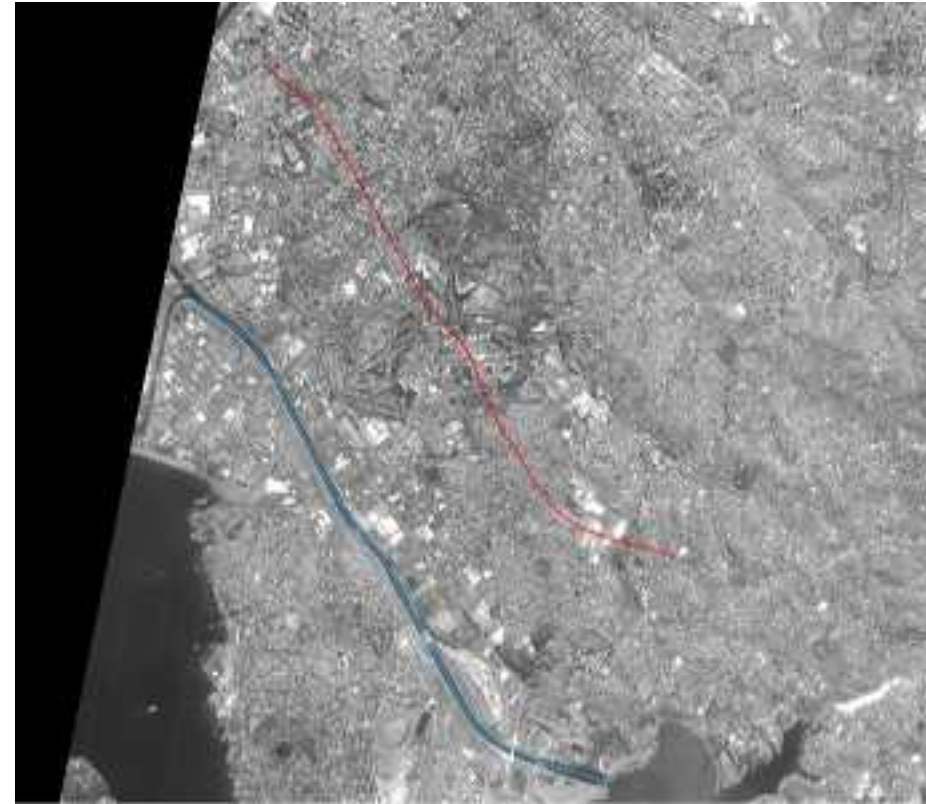
- Fix the shift between **panchromatic HRC (@ 2.5 meters)** and all the **CCD bands (BAND 1, 2, 3 and 4 @ 20 meters)**
- Assumption of **linear shift**



CCD-to-HRC co-registration



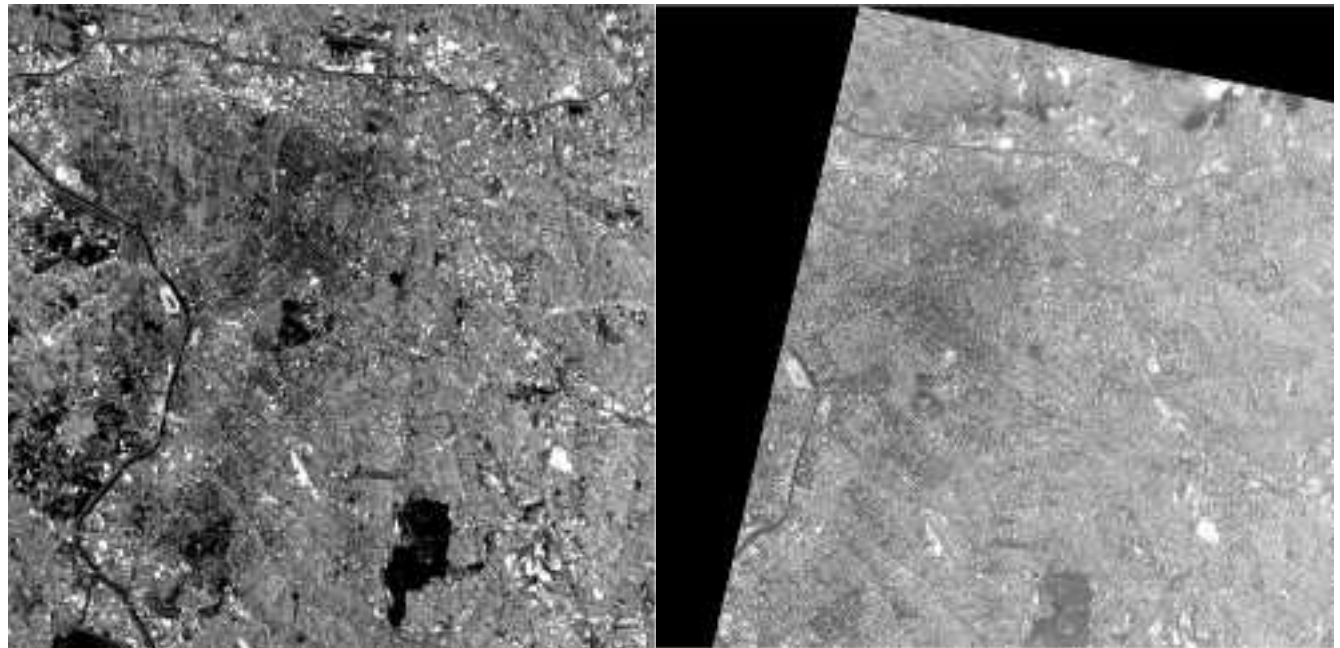
CCD



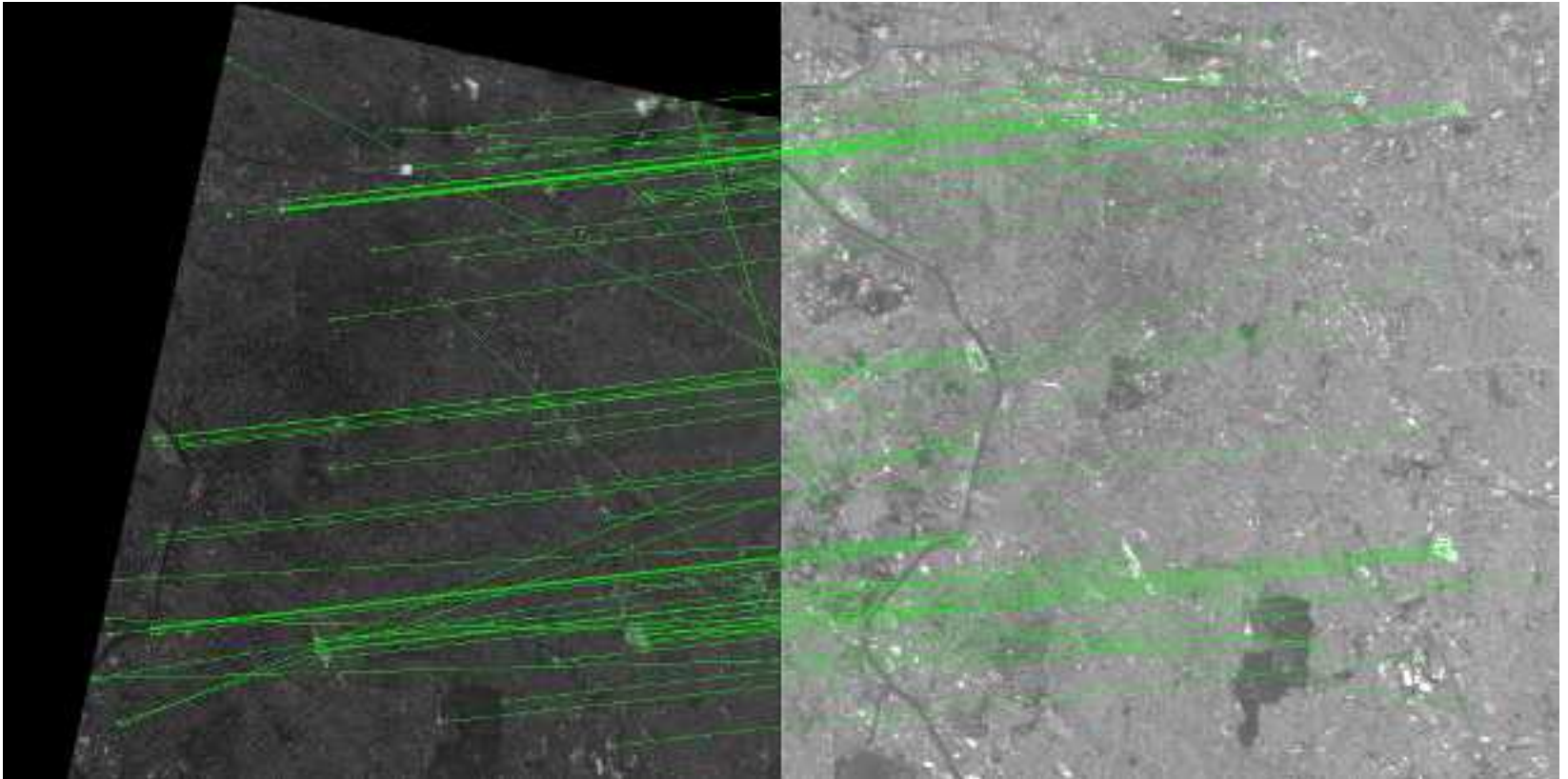
HRC

CCD-to-HRC co-registration

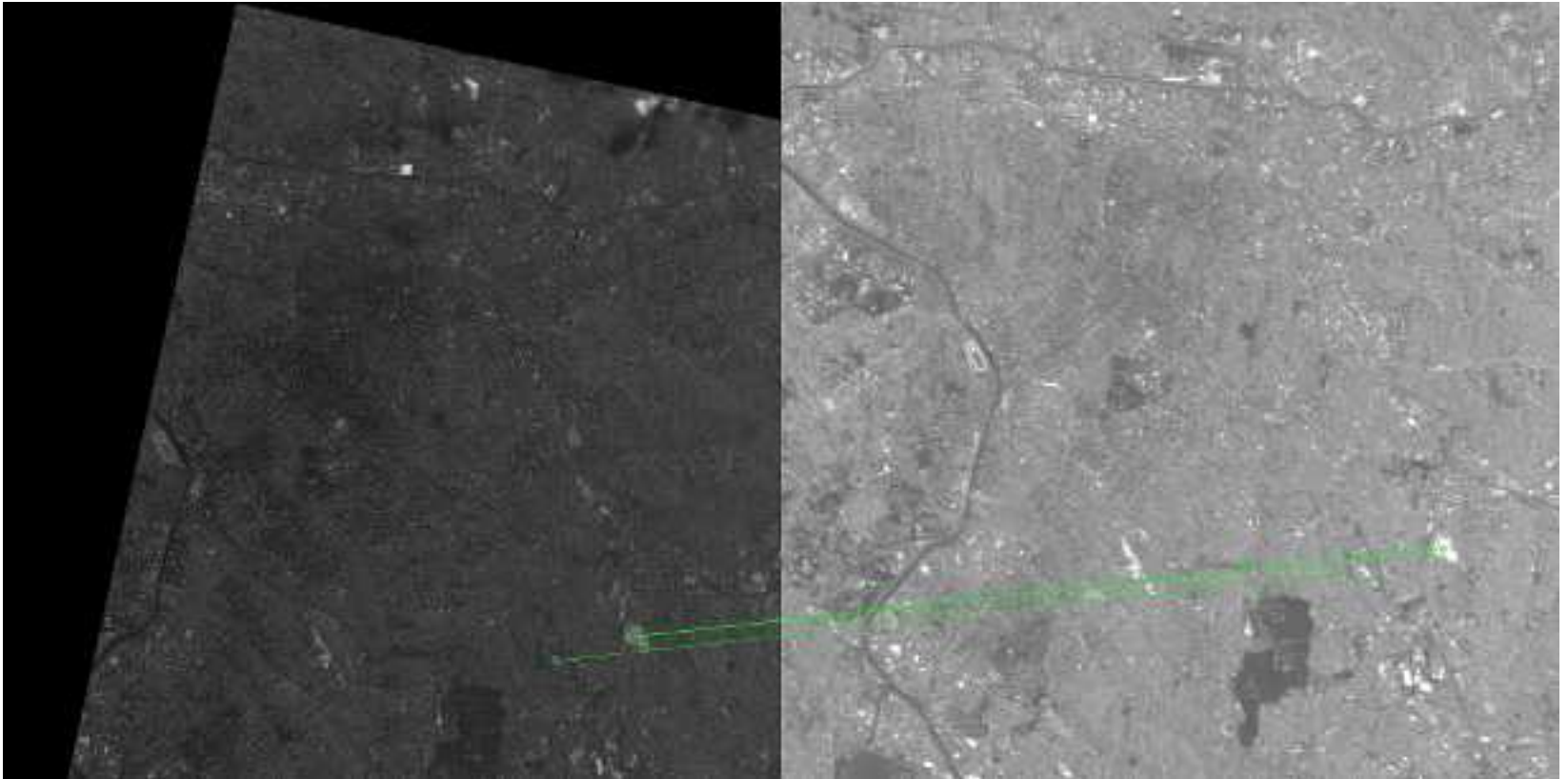
- Match CCD resolution
 - Resample HRC 2.5m to 20m
- Extract subset using the **unsupervised-classification** approach



CCD-to-HRC co-registration



CCD-to-HRC co-registration



CCD-to-HRC co-registration



CCD-to-HRC co-registration

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

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		

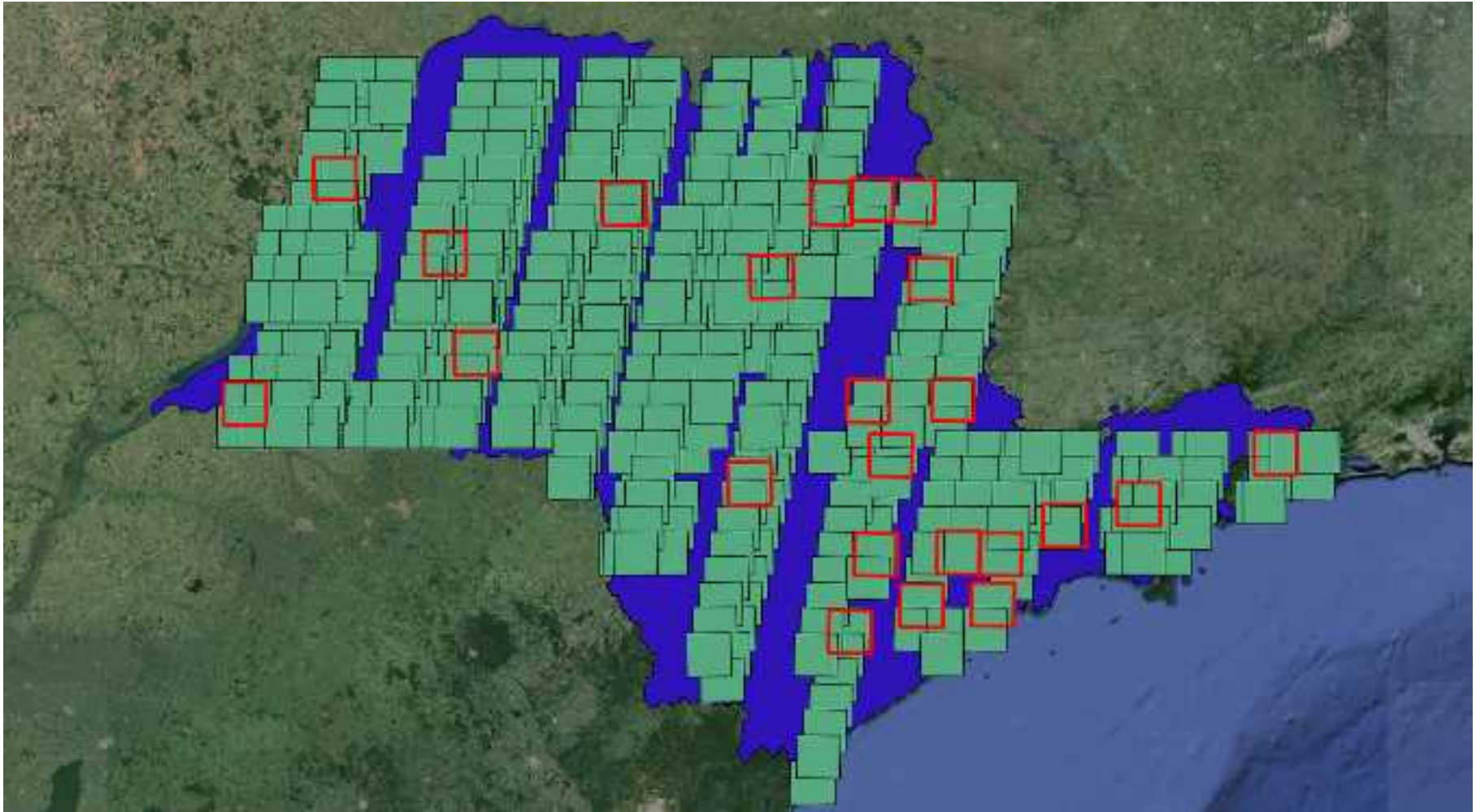
RMSE = 13.80036 meters

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 using the overlapping area
- Developed by *Gianni Crisan*, *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

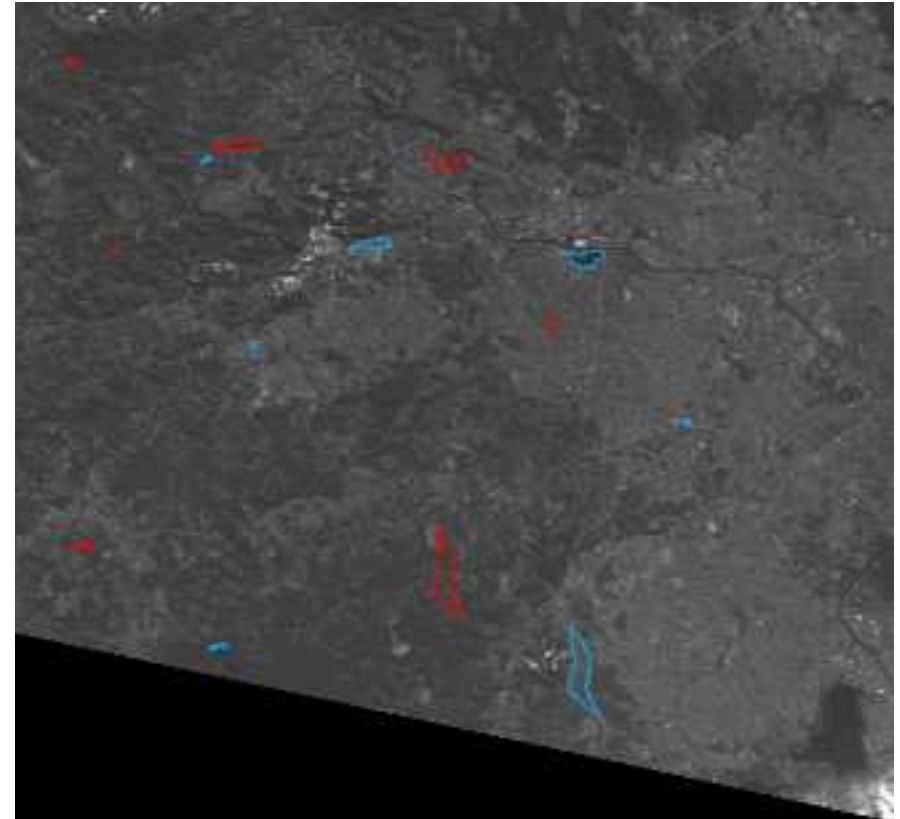
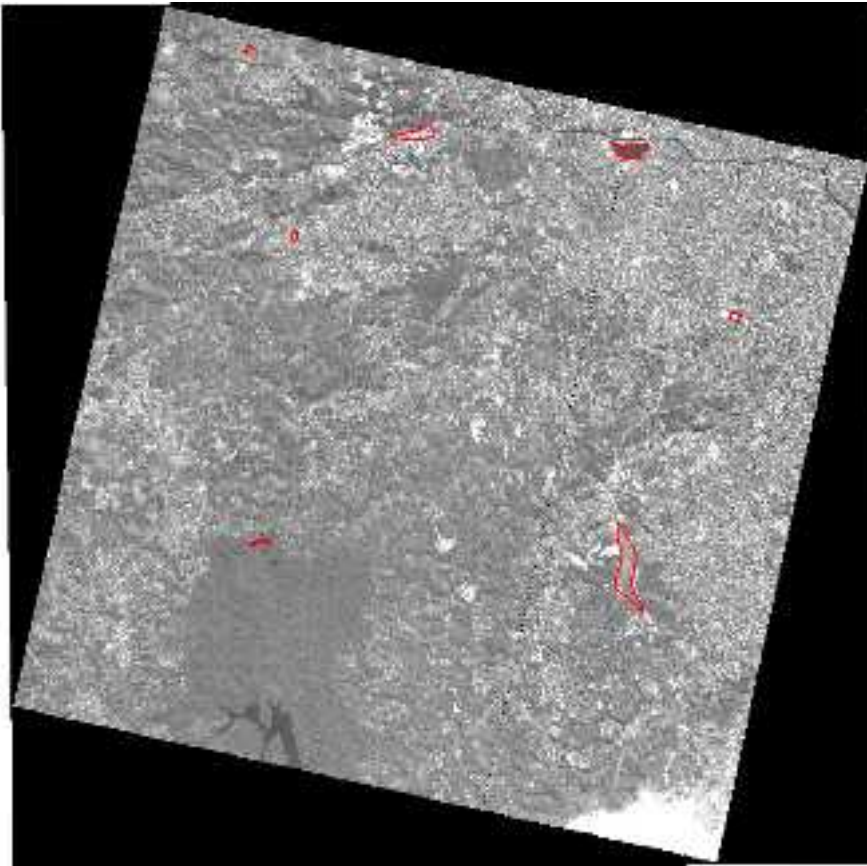
CCD-to-HRC co-registration

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		

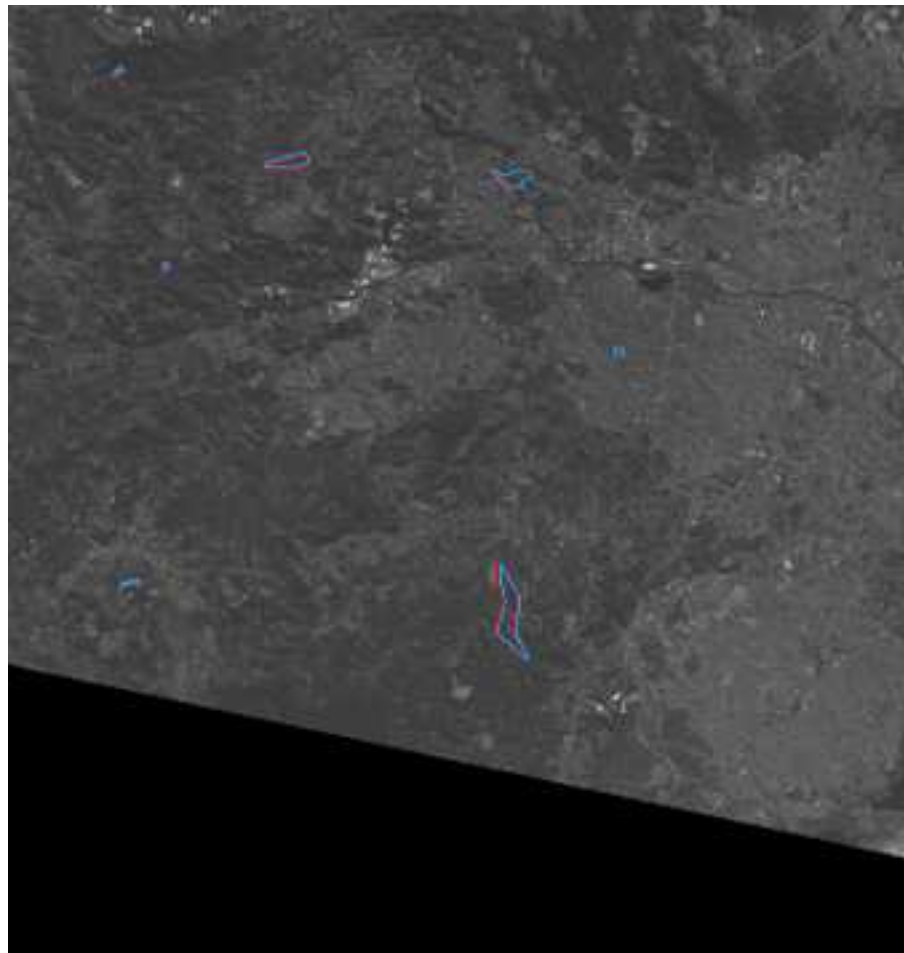
RMSE = 9.879638 meters

AEE = 97.60725 meters

CCD-to-HRC co-registration



CCD-to-HRC co-registration



Implementation

- Python language
- Libraries: OpenCV, GDAL/OGR, Numpy, Scipy, Orfeo Toolbox
- Code released with open source license



Implementation

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

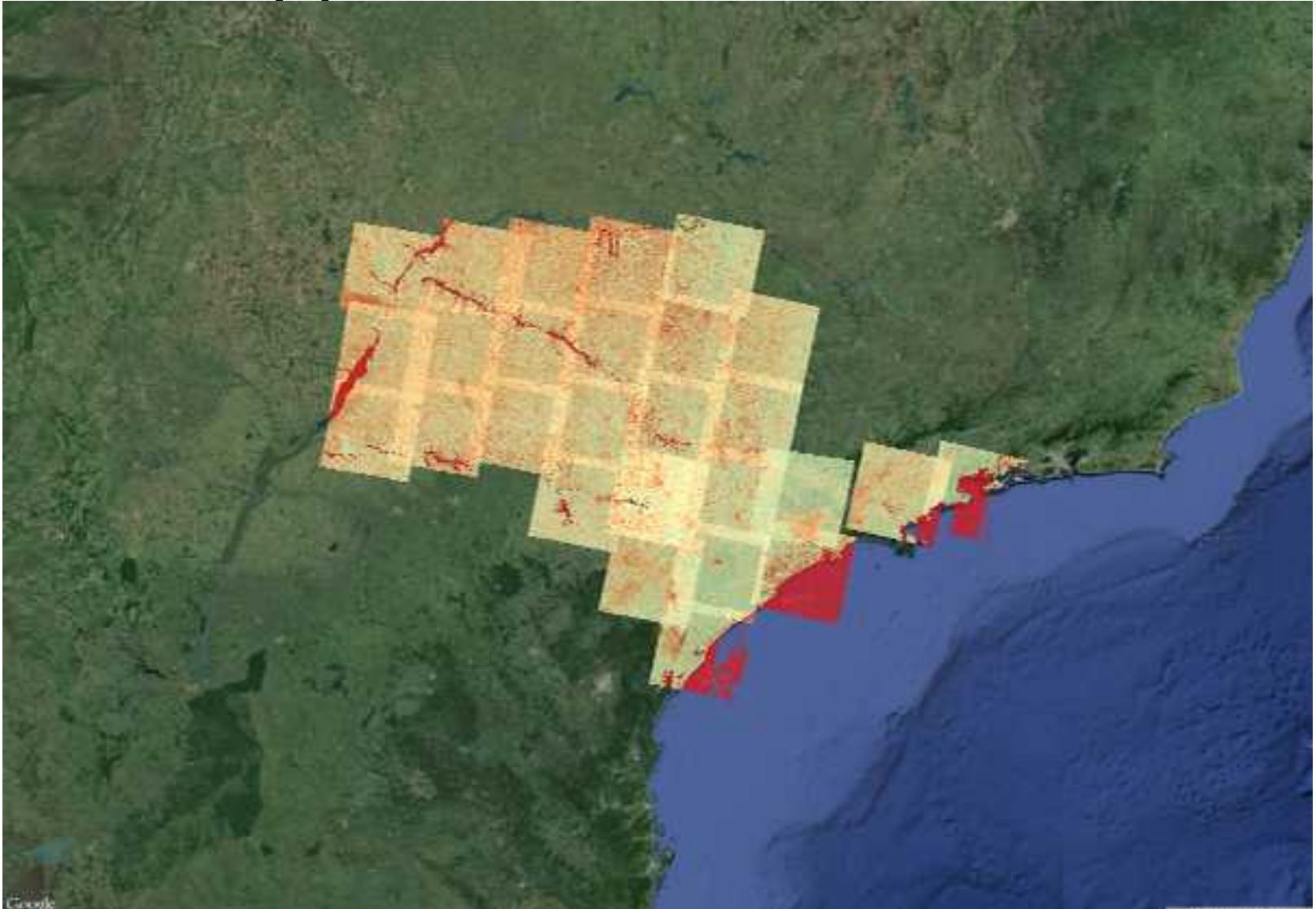
Applications

- Combine
 - spatial information from panchromatic
 - spectral information from multispectral CCD
- Urban Area monitoring purposes
 - NDVI layer generated from CCDs
 - Improve the extraction from HRC imagery designed in Pavia

Applications



Applications



Applications

Test case	Overall Accuracy (before)	Kappa coefficient (before)	Overall Accuracy (after)	Kappa coefficient (after)
1	99.6151	0.882	99.5723	0.8522
2	98.8622	0.6037	99.6878	0.8196
3	98.6585	0.6718	99.5579	0.837
4	99.8694	0.8998	99.7176	0.7335
5	99.2665	0.5595	99.7099	0.6727

