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Multitemporal Multisensor Spaceborne SAR Data for Urban Land Cover Mapping & Change Detection: Preliminary Results

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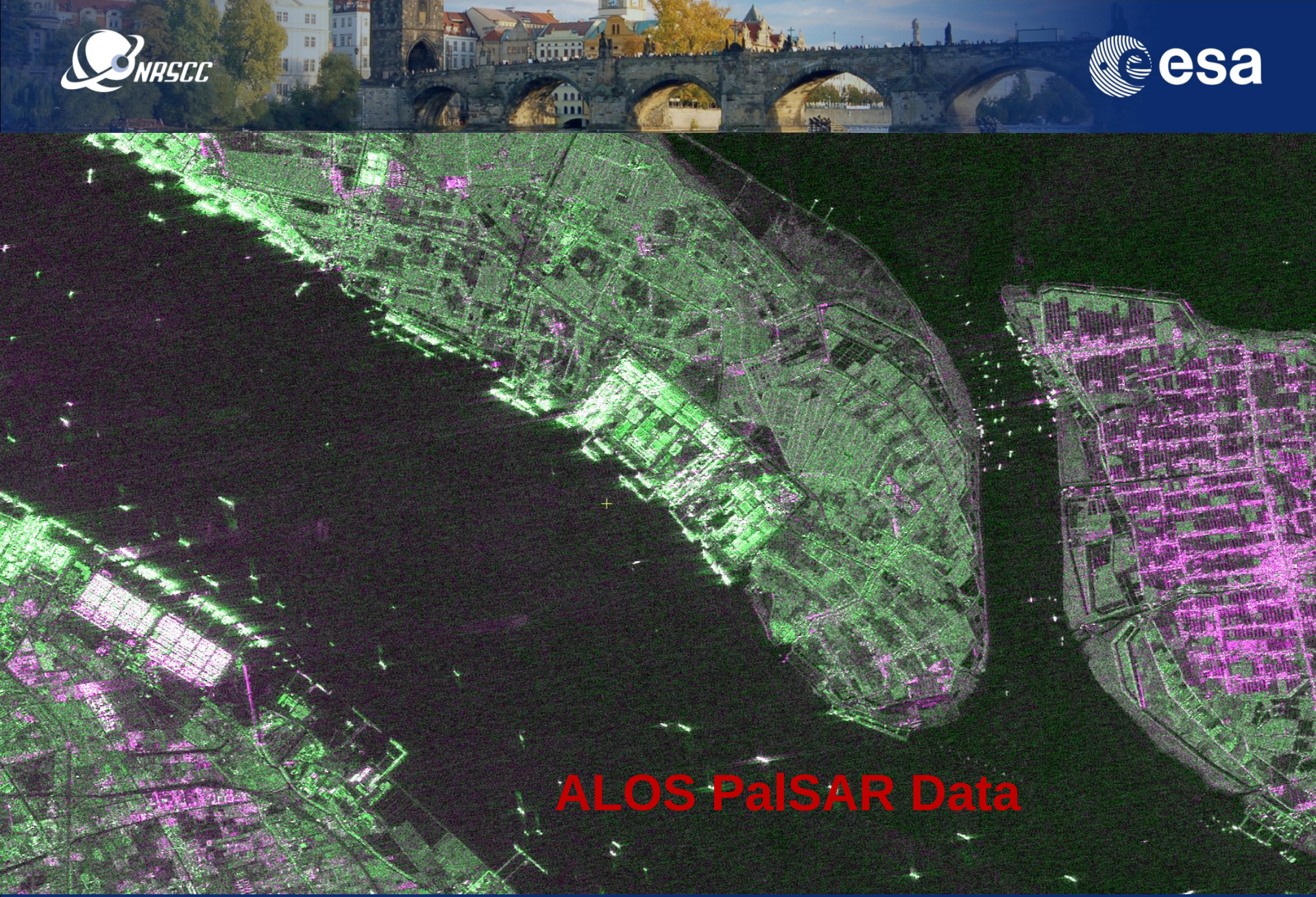
Introduction

- This research is part of the project *'Satellite Monitoring of Urbanization in China for Sustainable Development'*
- Multitemporal Multisensor Spaceborne SAR Data: Opportunities and challenges
  - ENVISAT ASAR, ERS-1/2 SAR
  - ALOS PalSAR, JERS-1 SAR
  - Terra SAR-X, COSMO-SkyMed
  - RADARSAT-1/2
  - HJ-1C S-SAR, etc.


ENVISAT ASAR Data

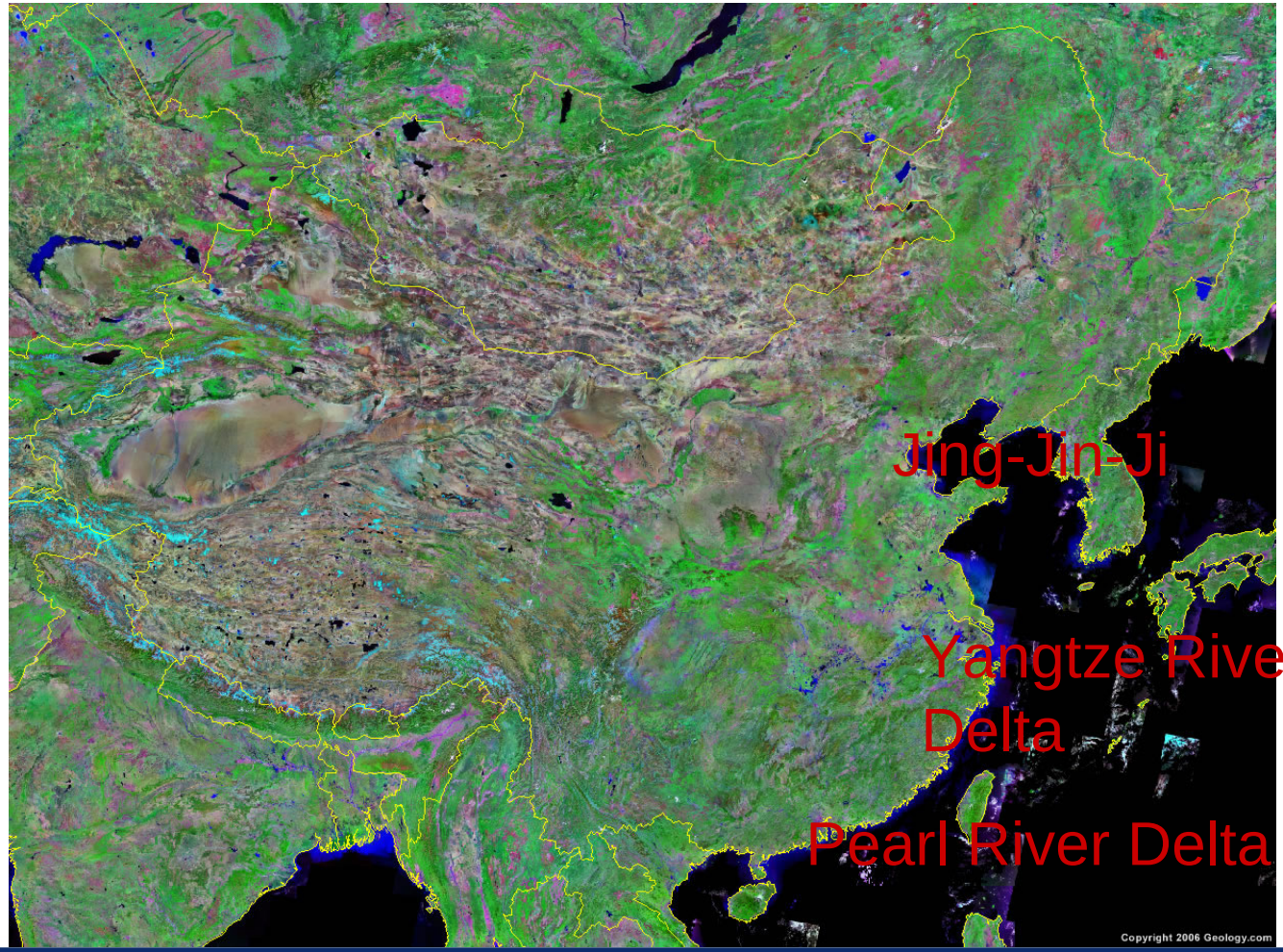

ALOS PalSAR Data


Terra SAR-X Data
Click here to begin

Research Objectives

- The overall objective is to investigate Multitemporal Multisensor Spaceborne SAR Data for urban land cover mapping and change detection in China.
  - Evaluate X-band SAR, C-band SAR and L-band SAR data and their synergy for urban land-cover mapping,
  - Investigate object-based rule-based SVM for classification of multisensor SAR data
  - Develop effective methods for change detection using multitemporal SAR data

Study Area


Jing-Jin-Ji
Yangtze River Delta
Pearl River Delta
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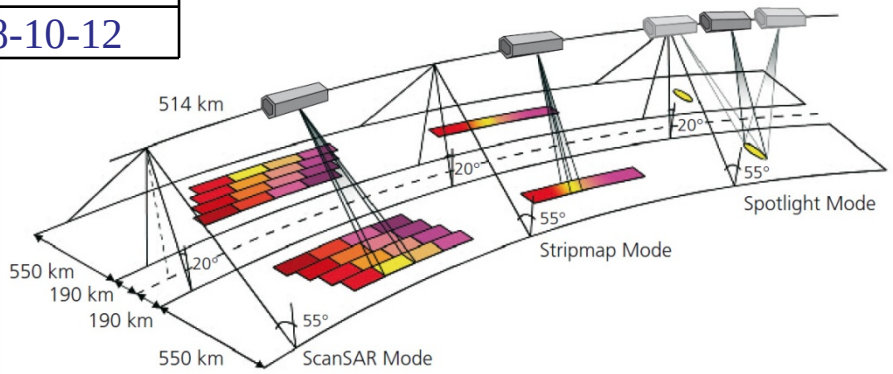
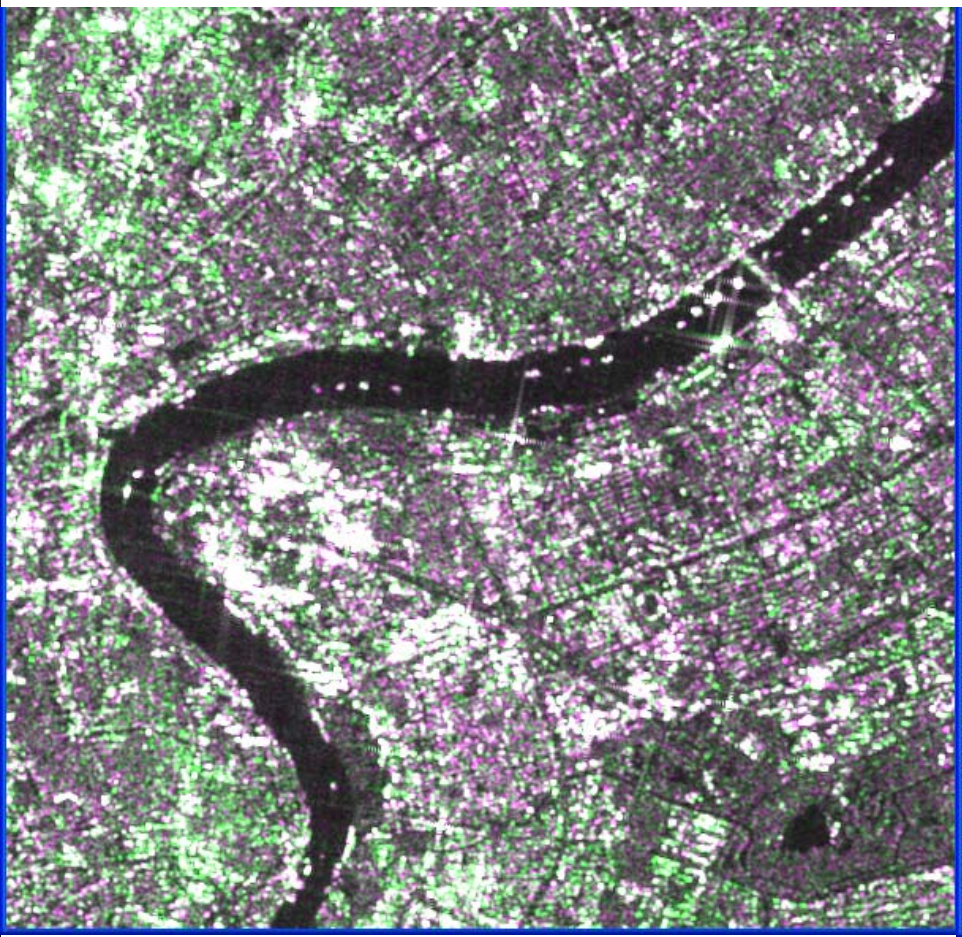
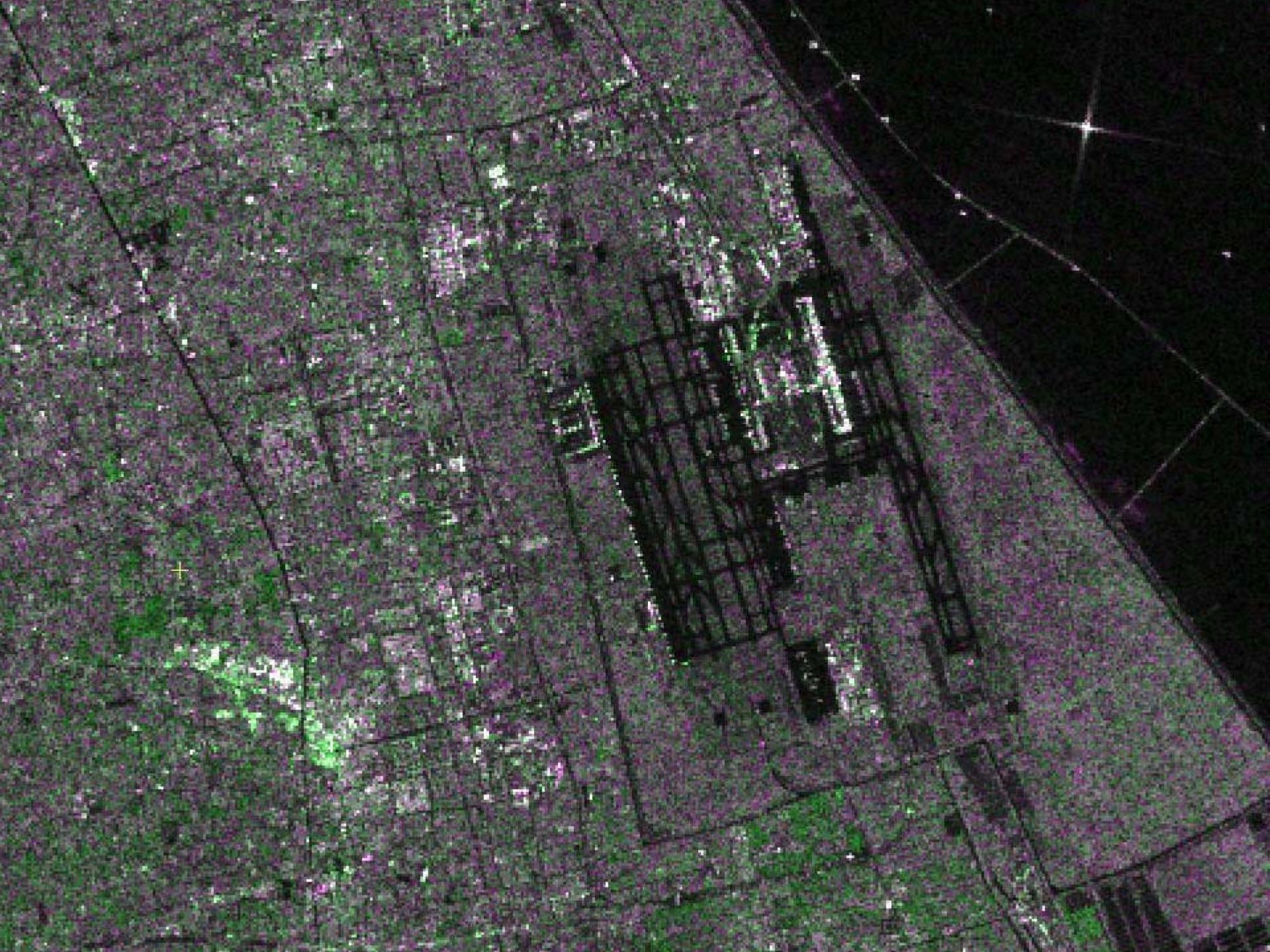
Data Description

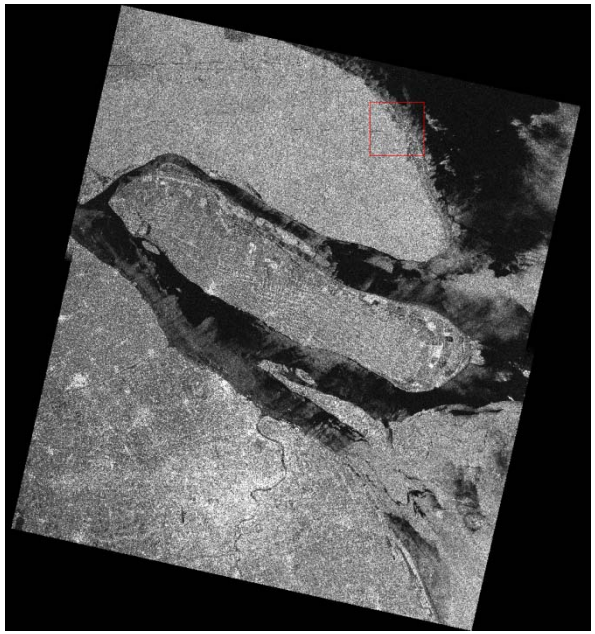
	Polarizations	Resolution	Orbit	Acquisition Date
Terra SAR-X	VV	1m x 1m	DES	2008-08-09
			DES	2008-08-20
			ASC	2008-05-04
			ASC	2008-05-15
ENVISAT ASAR	HH/VV	30m x 30m	DES	2008-08-02
			DES	2008-08-15
			DES	2008-09-03
			DES	2008-09-19
ALOS PalSAR	HH/HV	19m x 10m	ASC	2008-07-12
			ASC	2008-08-27
			ASC	2008-10-12



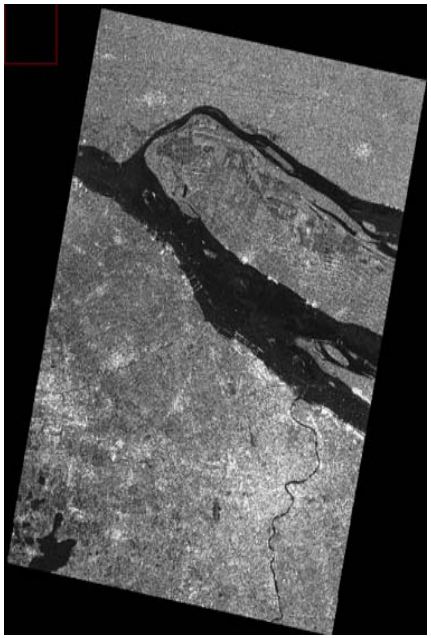




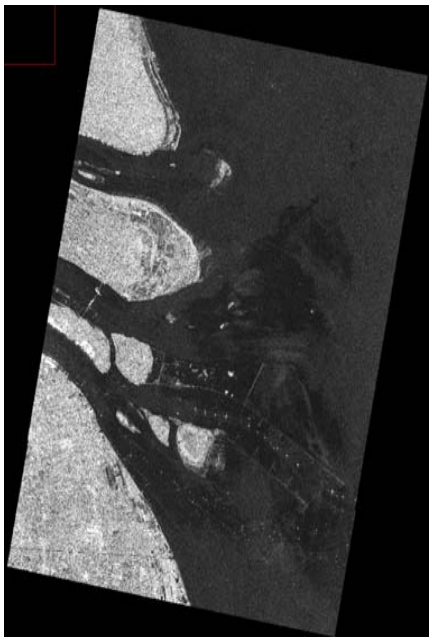
Multitemporal SAR Data



ERS-2 SAR Image 1999/09/07



ENVISAT SAR Image 2008/09/03



ENVISAT SAR Image 2008/09/19

Field Data Collection

Public Green Space

Lake in Century Park

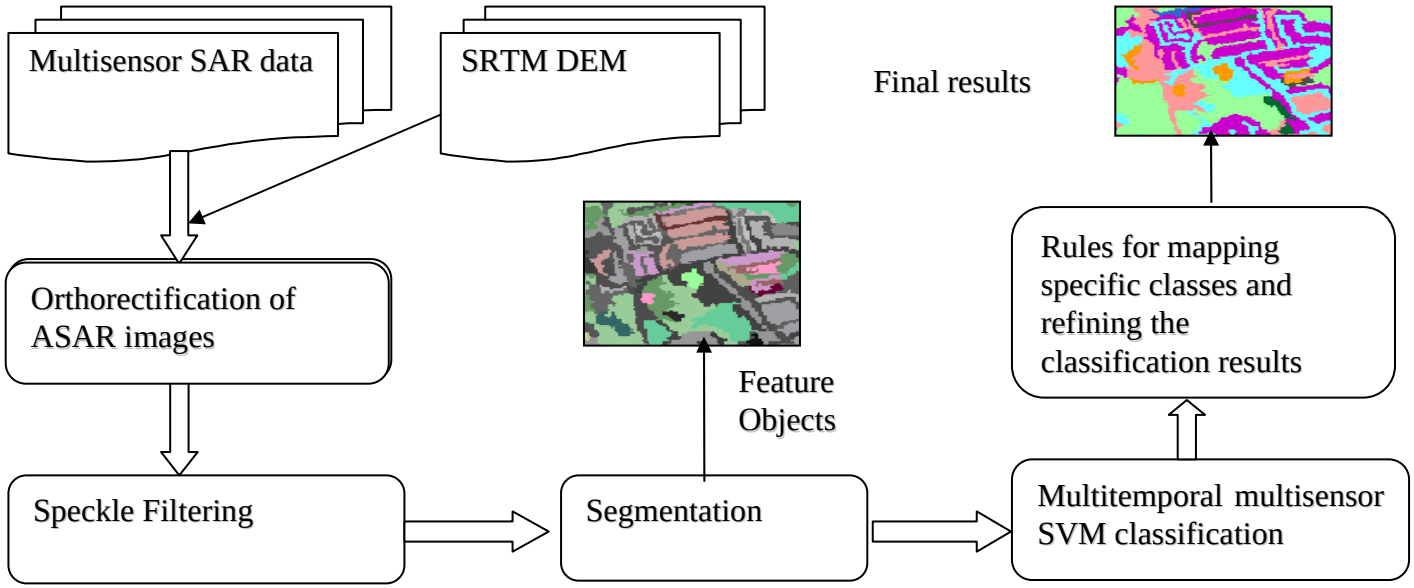
NO	Longitude	Latitude	Ground Truth	Classification Result
1	121°24'57"	31°13'17"	Grass	4
2	121°26'31"	31°13'28"	Platanus	3
3	121°28'08"	31°14'06"	Granite	5
4	121°28'12"	31°14'14"	Pine	4
5	121°28'55"	31°14'33"	Built-up areas	3
6	121°28'52"	31°14'27"	Marble	5
7	121°28'57"	31°14'25"	Built-up areas	3
8	121°29'07"	31°14'27"	Built-up areas	3
9	121°29'07"	31°14'28"	Road	3
10	121°32'41"	31°12'54"	Poplar, willow	5
11	121°32'42"	31°12'57"	Lake water	1
12	121°36'15"	31°11'54"	Bamboo, pine	5
13	121°36'16"	31°11'38"	Buildings	3
14	121°35'12"	31°20'12"	Wasteland	6
15	121°36'00"	31°19'24"	Unused land	3
16	121°35'58"	31°19'08"	Newroad	4
17	121°35'53"	31°19'02"	Wasteland	6
18	121°35'46"	31°18'28"	Factory	3
19	121°36'09"	31°18'03"	New Buildings	6
20	121°36'41"	31°18'12"	Greenhouse	5

Buildings

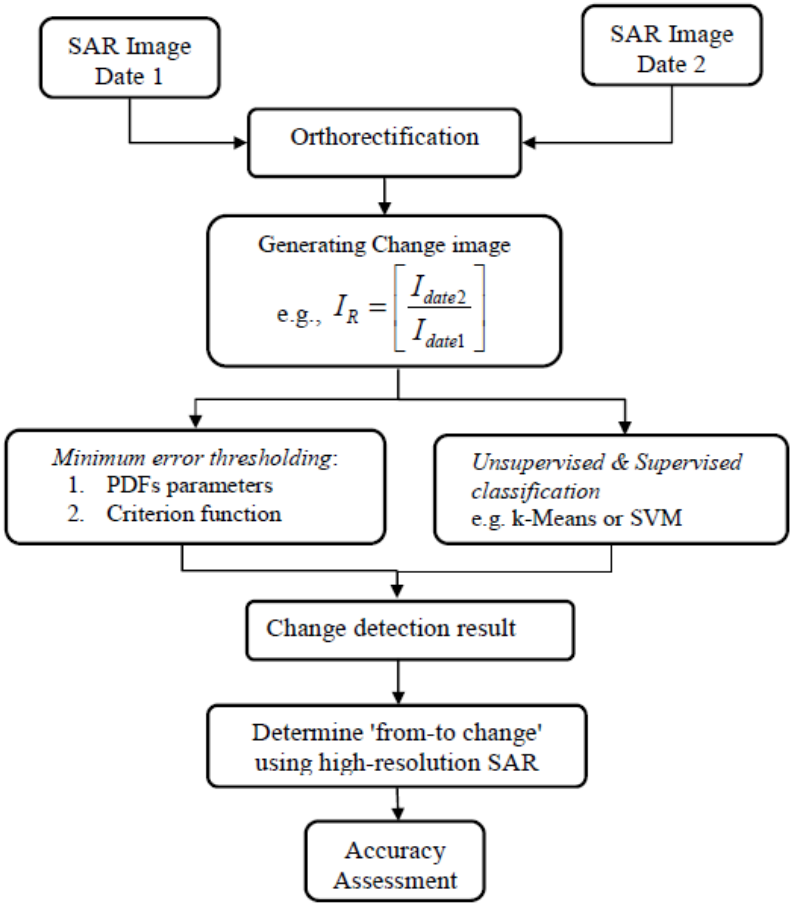
Construction Site

Methodology: Classification

- Object-based SVM combined with rules

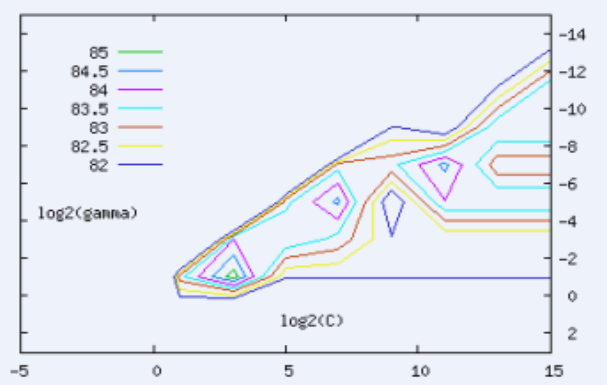


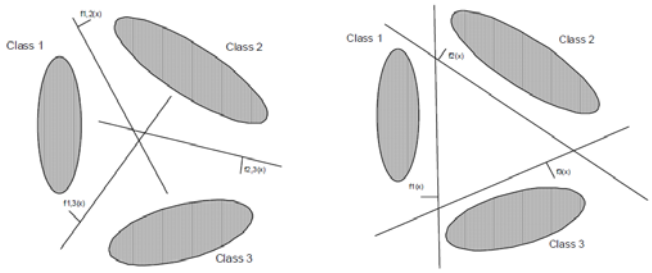
Methodology: Change Detection



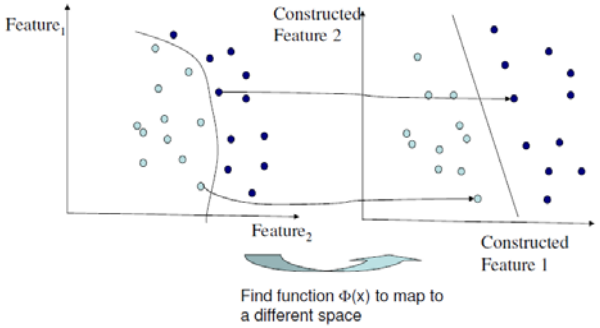
SVM Classification

- SVM is an advanced concept of a binary classifier.
- RBF kernel is used to map features into the high dimension space.
- For multi-class classification, one-against-one approach is used.
- LIBSVM is used as experiment plantform.



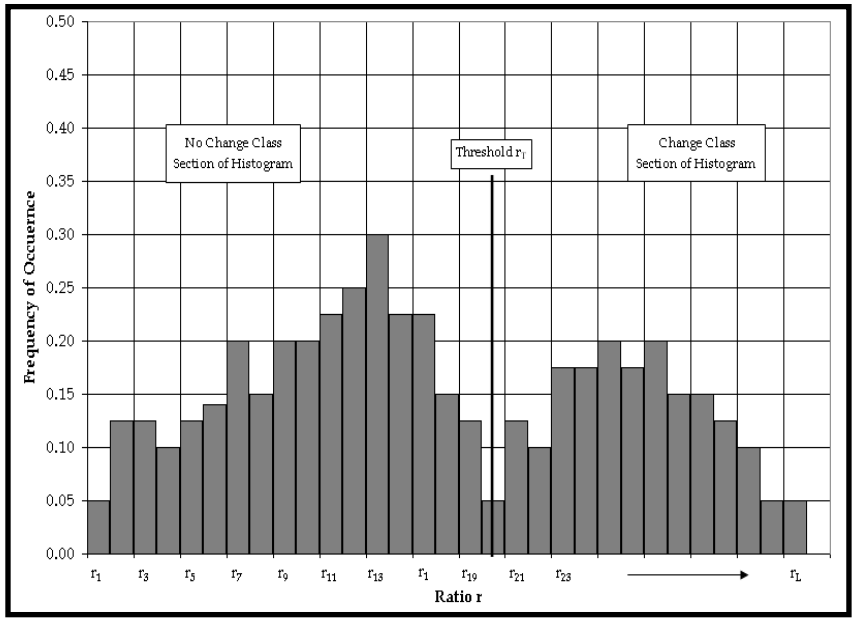


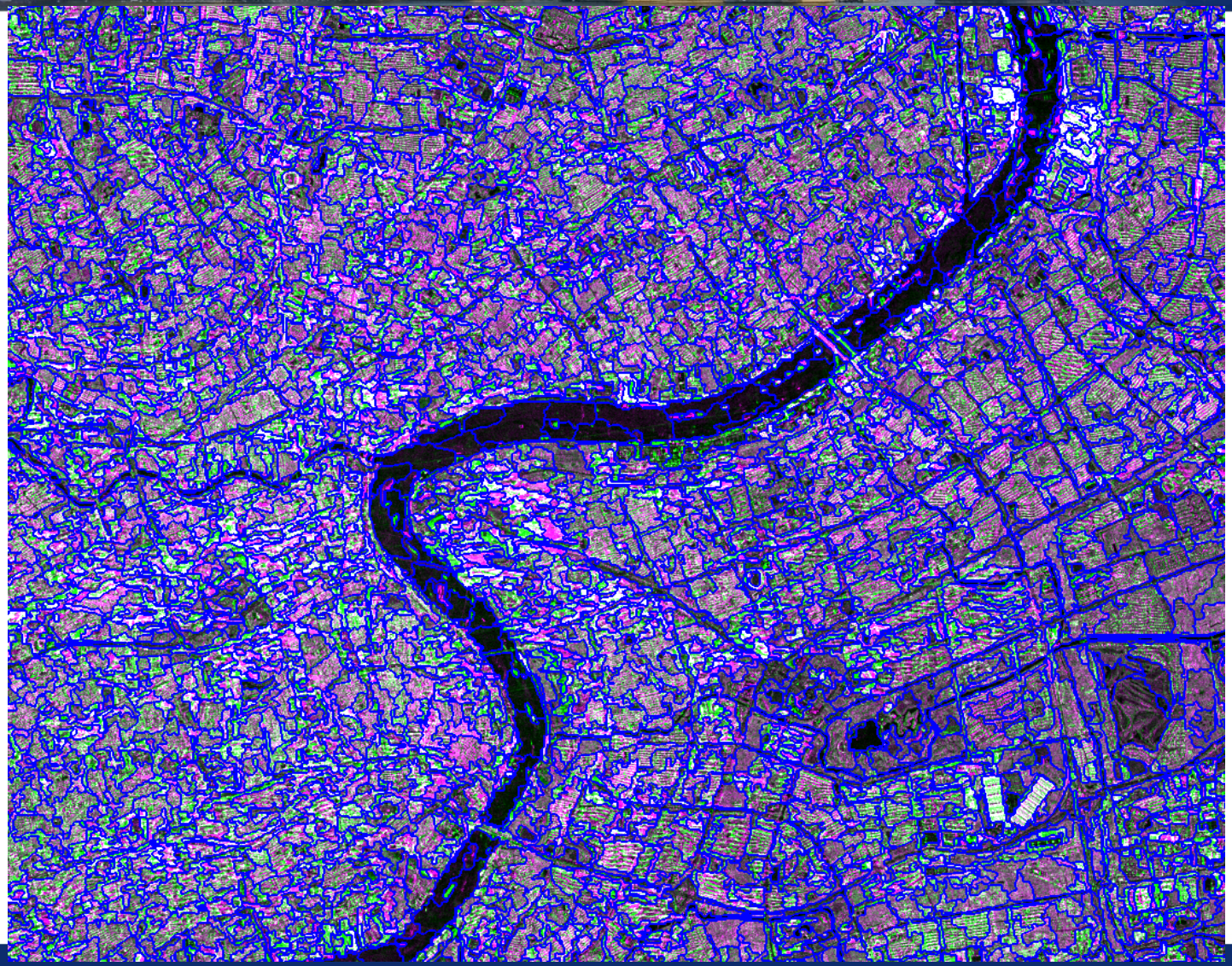
"one against one" and "one against all" scheme

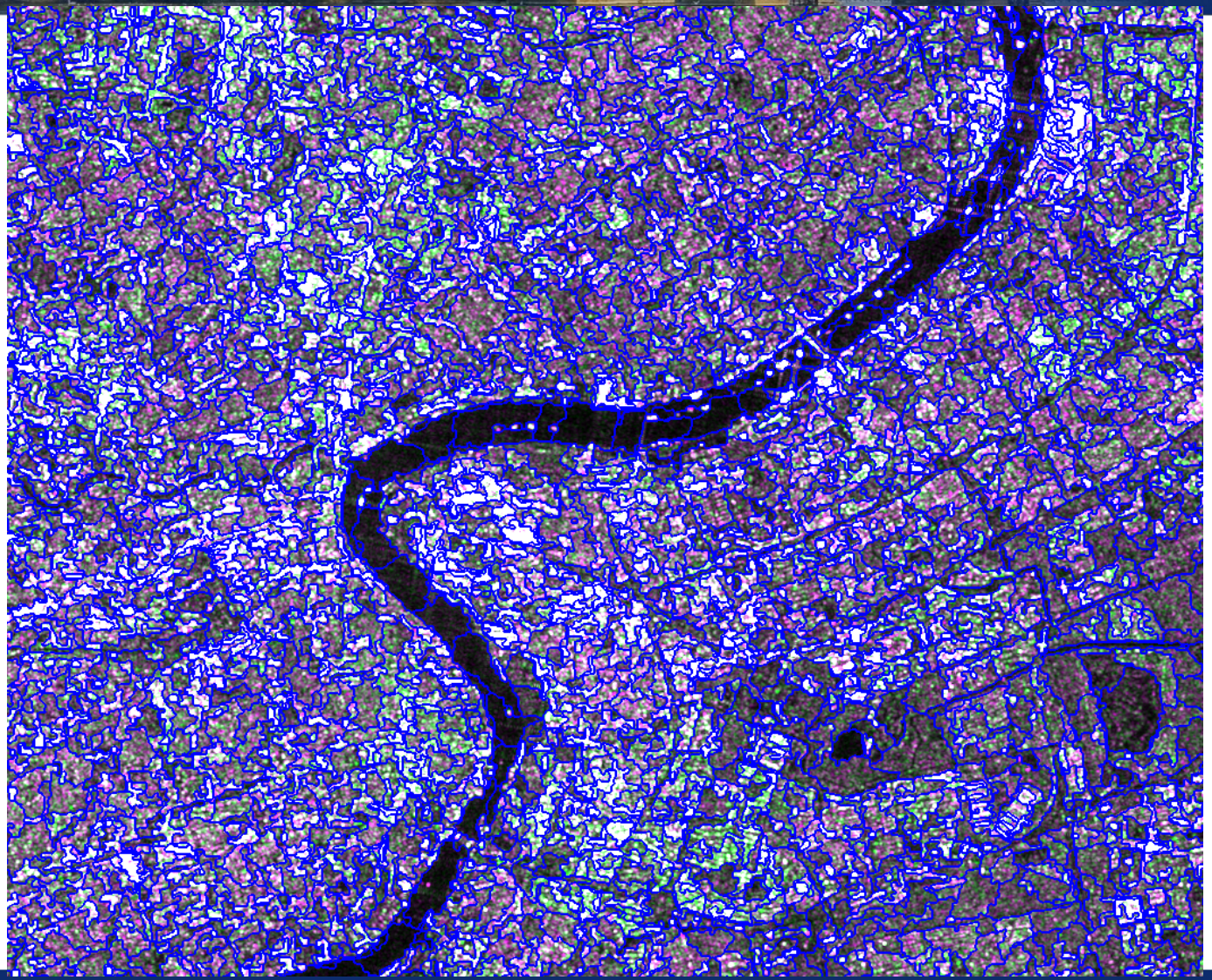


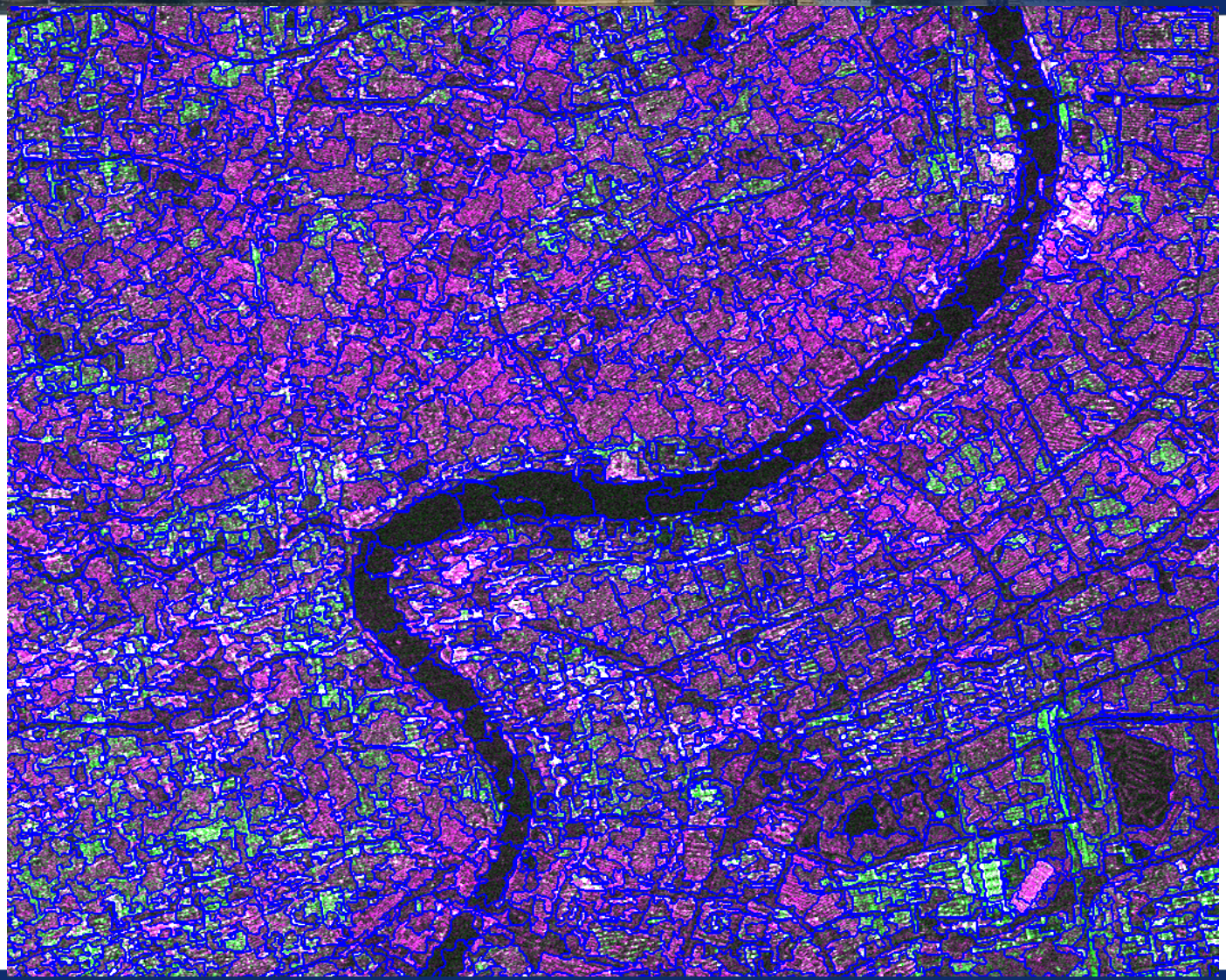
Unsupervised Change Detection

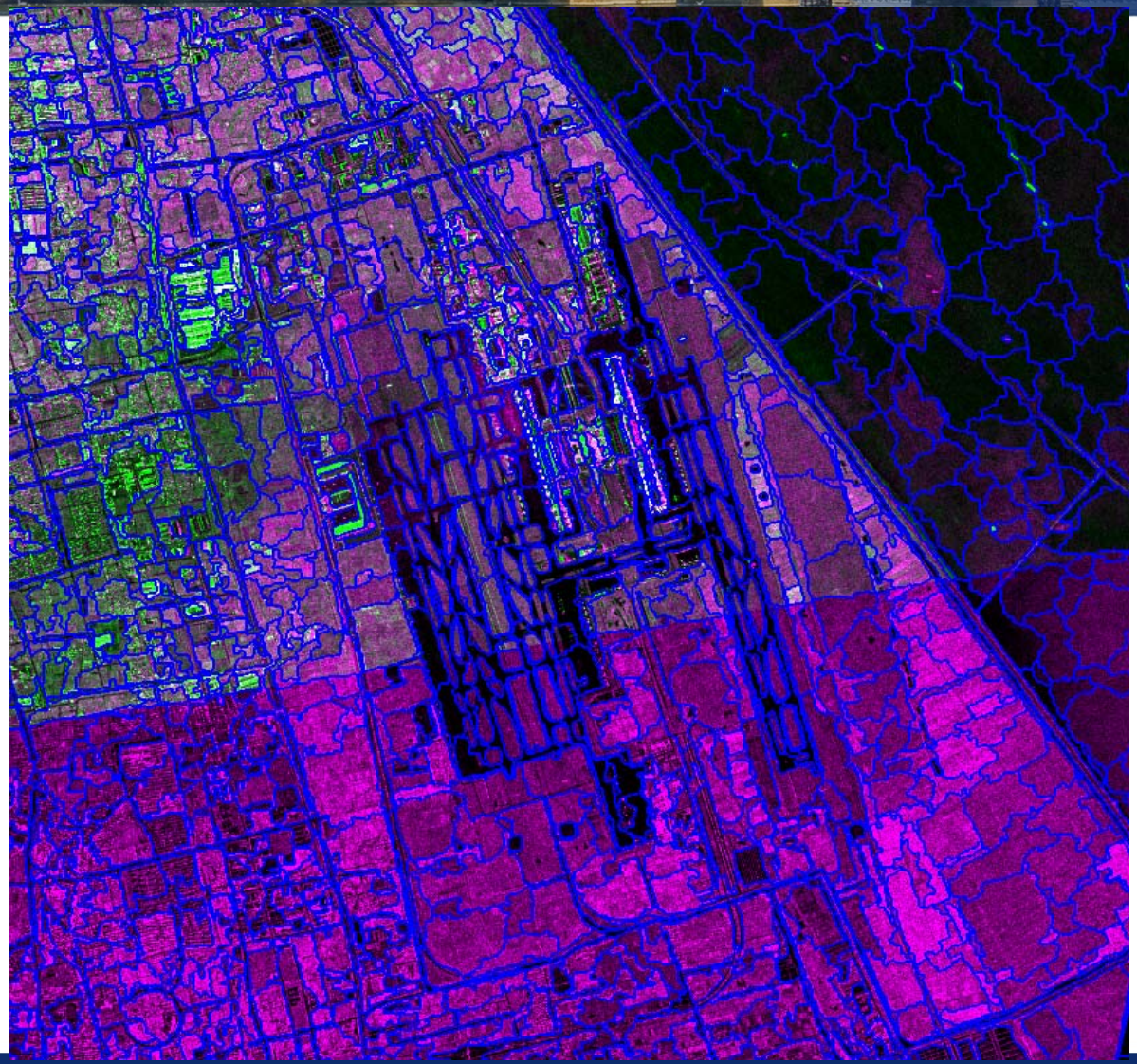
- Change detection as a binary classification problem
  - No change class having a density function $p_1(r)$ and prior probability P_1
  - Change class having a density function $p_2(r)$ and prior probability P_2.
- Kittler-Illingworth Algorithm
  - Unknown probabilities estimations using histogram fitting techniques for a given threshold value r_T.
- Alternative Models:
  - Generalized Gaussian
  - Log normal
  - Nakagami Ratio
  - Weibull Ratio

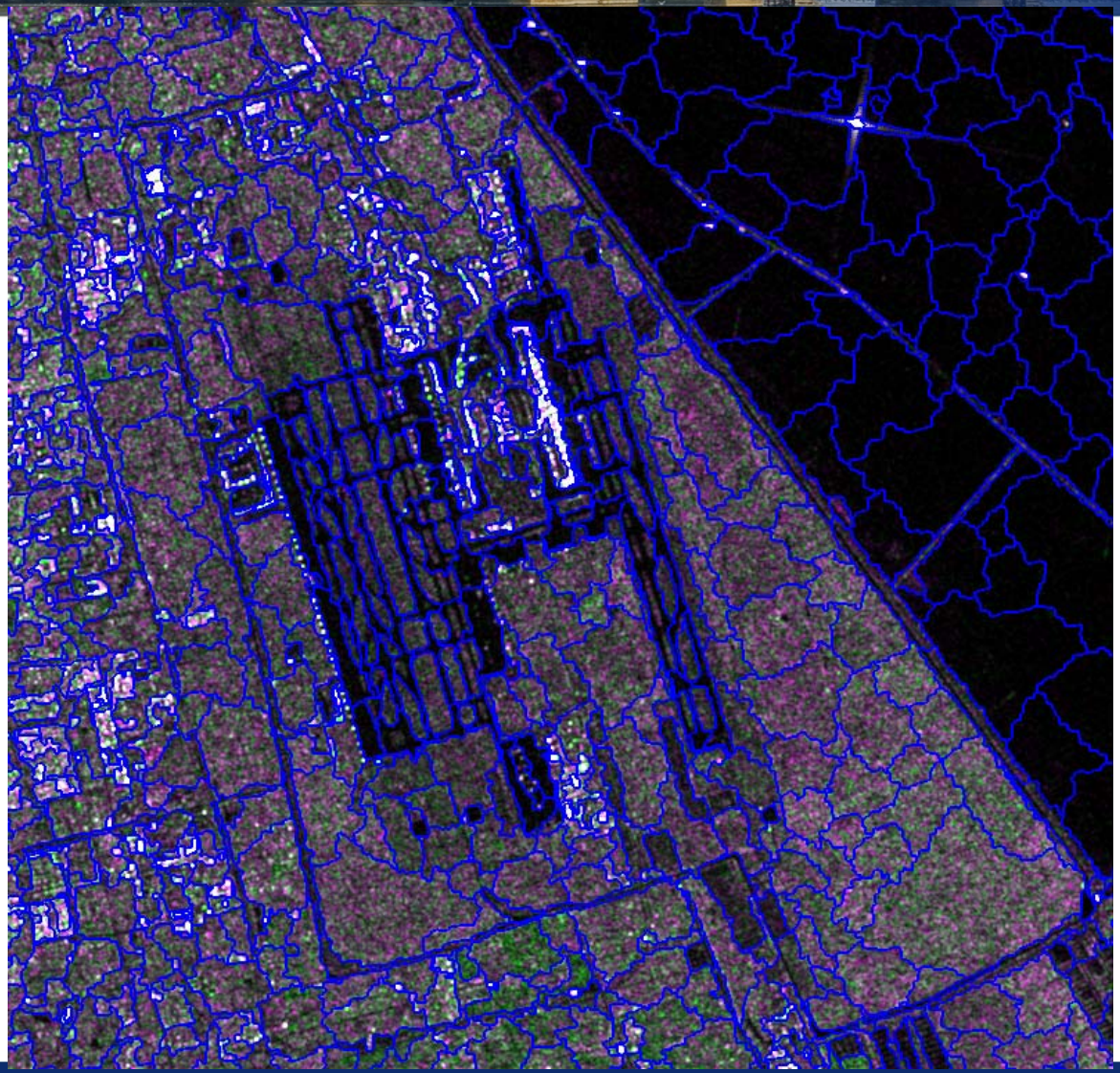


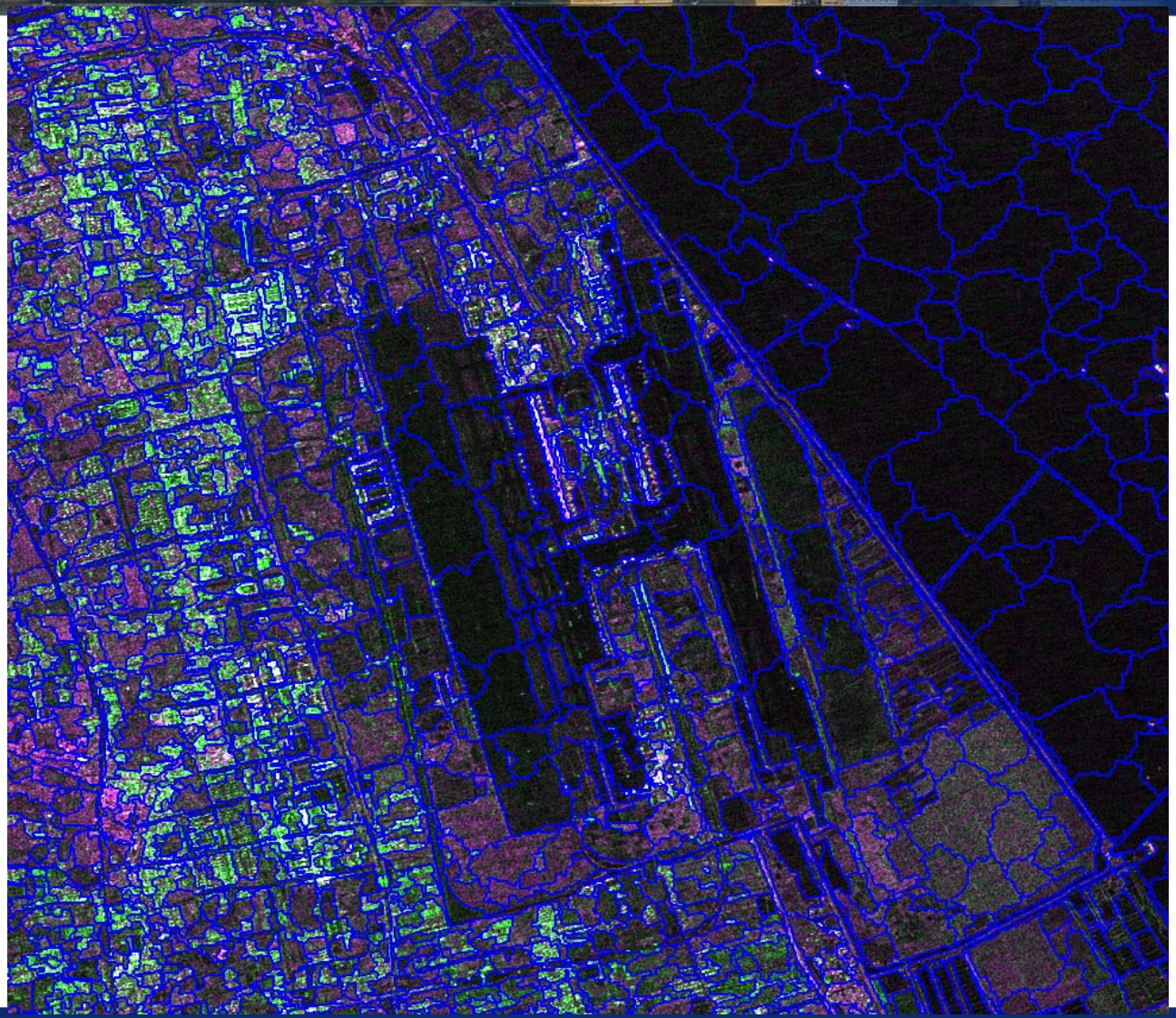










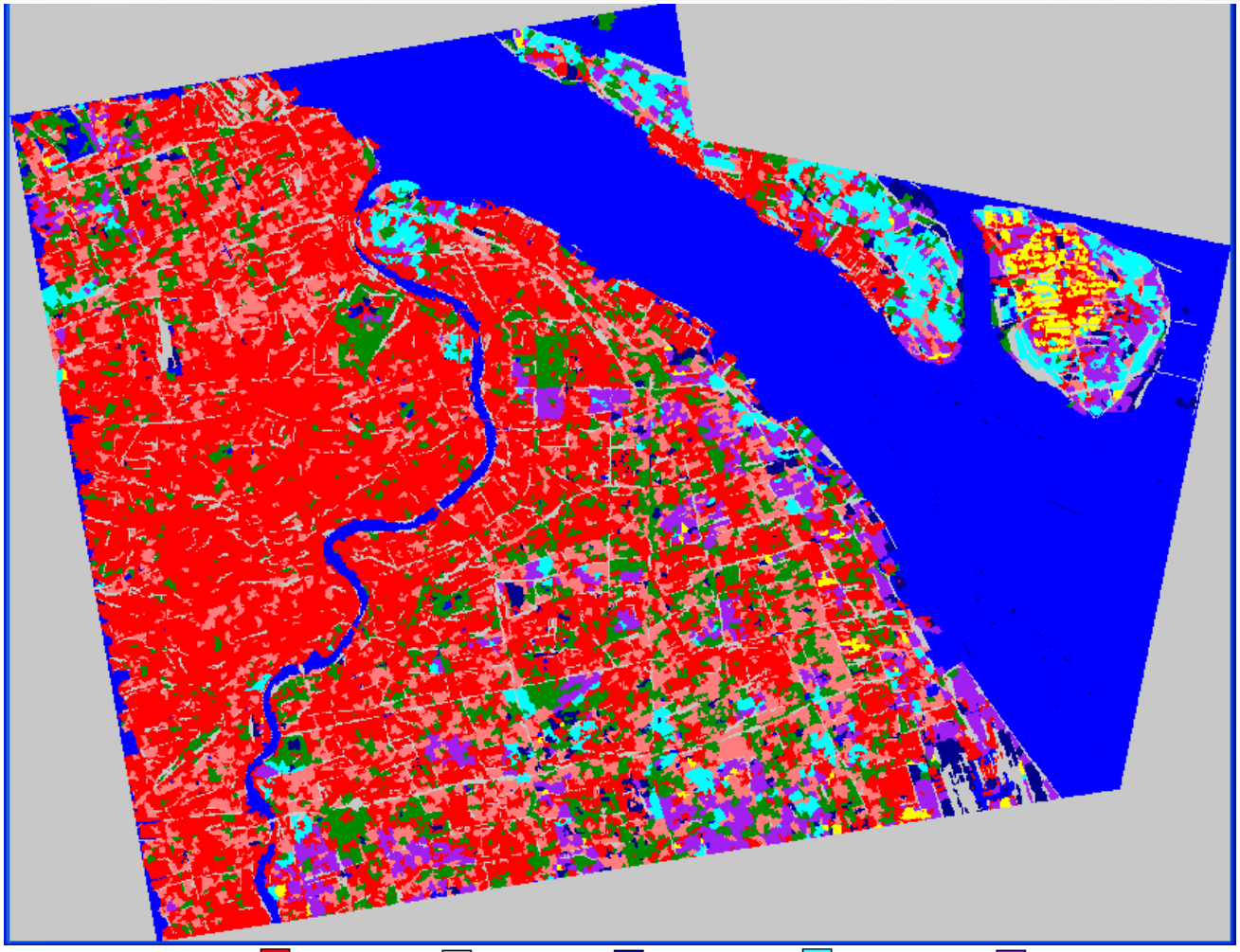


Results & Discussion

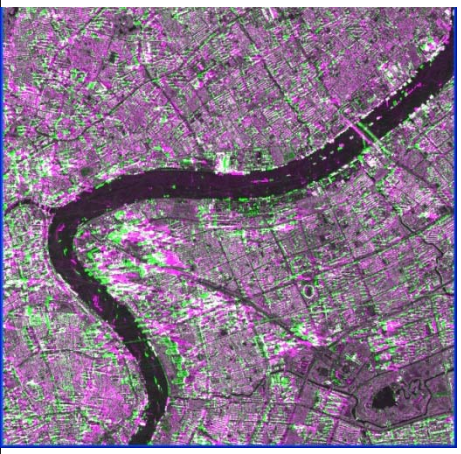
	L+C+X	C+X	L+X	L+C	X	L	C
Kappa	0.75	0.66	0.74	0.72	0.69	0.71	0.61
Overall	0.83	0.77	0.83	0.81	0.79	0.80	0.73
Results with rules							
Kappa	0.80	0.70	0.77	0.75	0.69	0.72	0.67
Overall	0.86	0.79	0.84	0.83	0.79	0.81	0.78

Results & Discussion

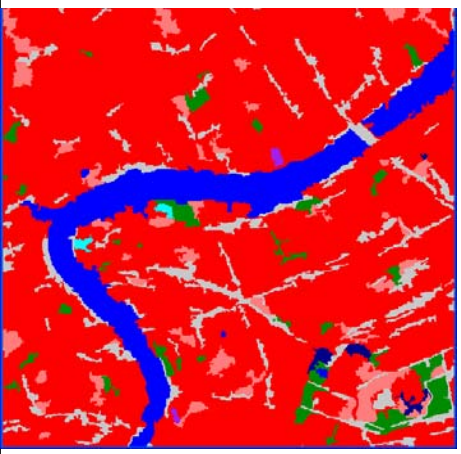
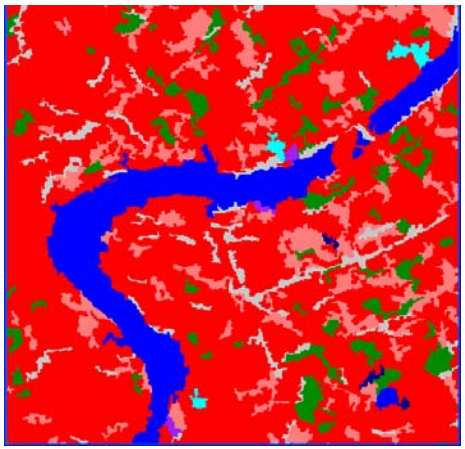
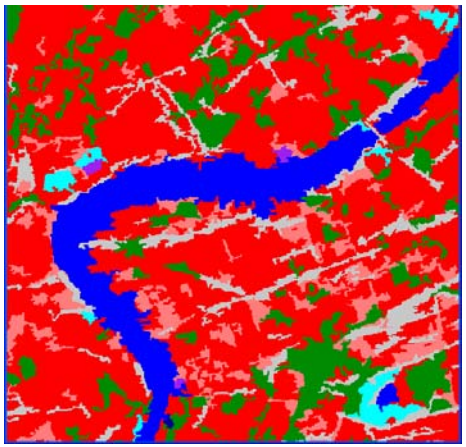
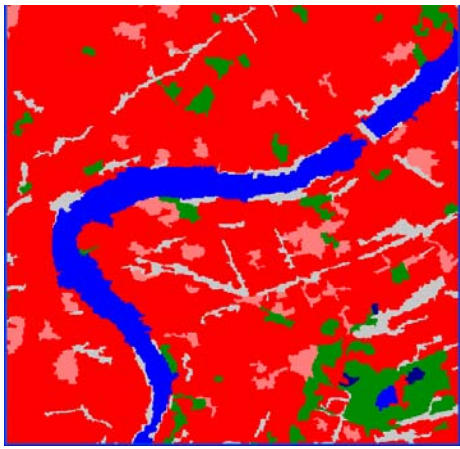
Class	LD	road	crop1	crop2	crop3	bare	park	water	HD	Prod.	User.
LD	60.97	0.13	5.18	0	2.16	0	14.45	0	8.65	60.97	38.11
road	0.42	74.94	0	0	0.33	3.72	0.85	0.7	1.58	74.94	71.02
crop1	6.98	0	74.59	1.11	0.03	0	7.72	0	0	74.59	78.01
crop2	0	0	0	77.48	0.49	0	0	0	0.03	77.48	97.76
crop3	2.85	1.1	7.15	6	66.89	0	11.67	0	0.1	66.89	65.57
bare	0	3.6	0	0	9.54	65.01	3.5	0.09	0.09	65.01	60.73
park	11.74	5.13	11.36	0	19.9	30.81	54.47	0	1.06	54.47	62.15
water	0	2.04	0.69	0	0	0	4.45	97.51	0.33	97.51	98.89
HD	17.05	13.06	1.03	15.41	0.66	0.46	2.89	1.7	88.16	88.16	89.06


Legend:
HD
LD
Road
Bare
Water
Park
Crop1
Crop2
Crop3

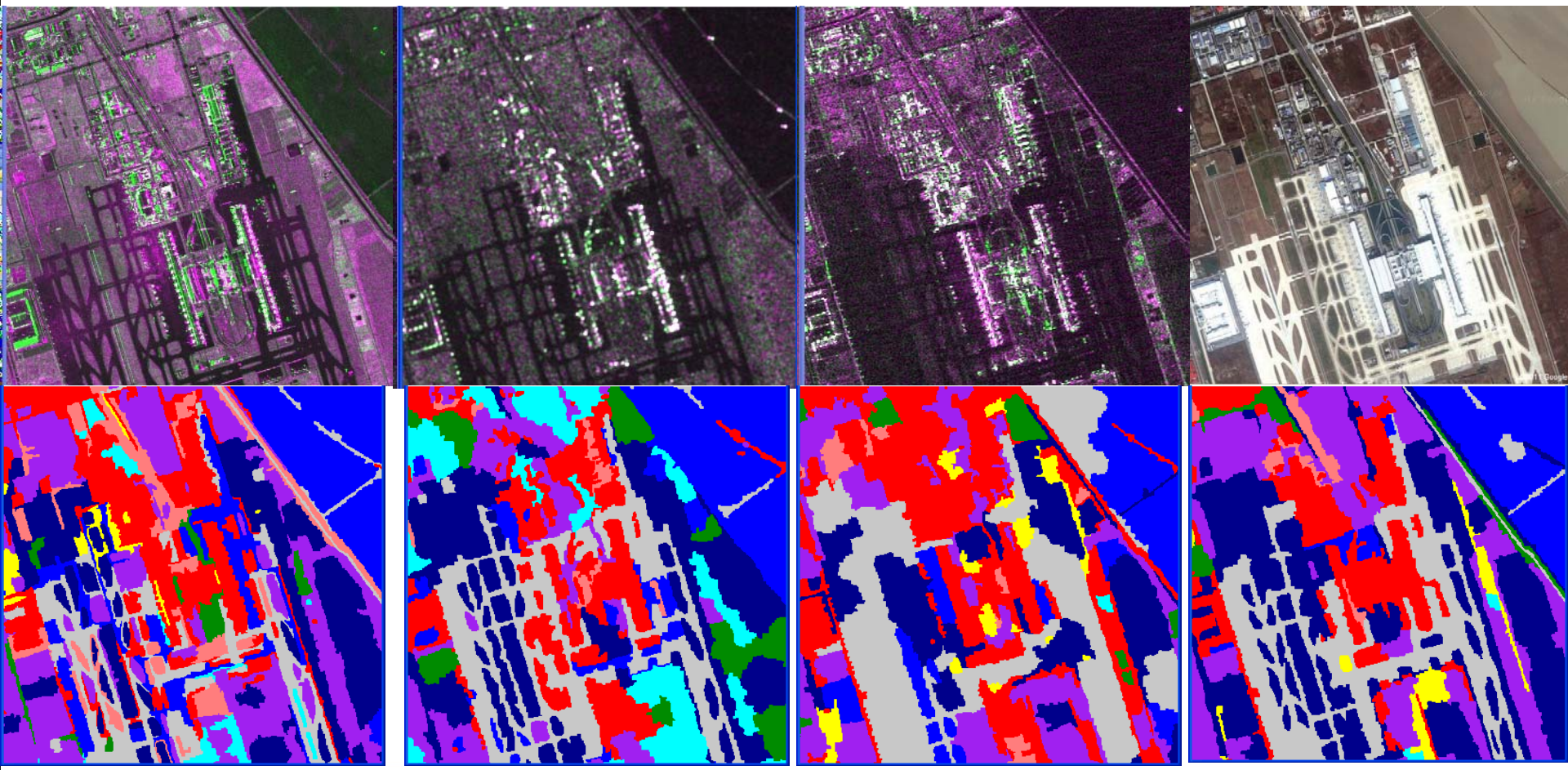
Results & Discussion



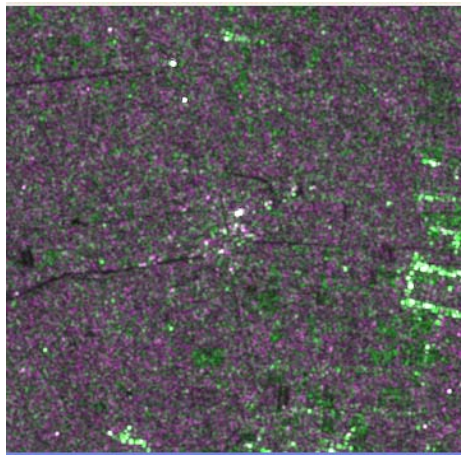
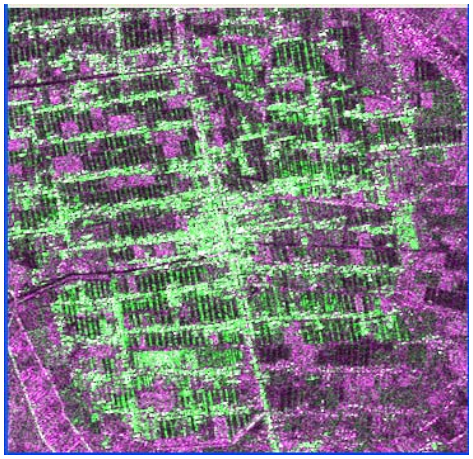


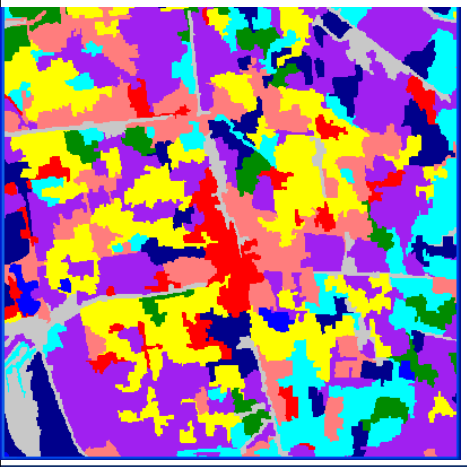
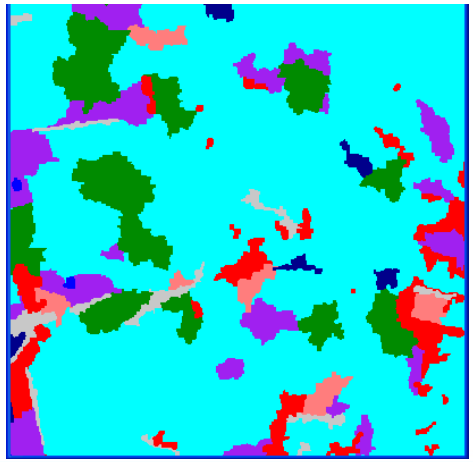
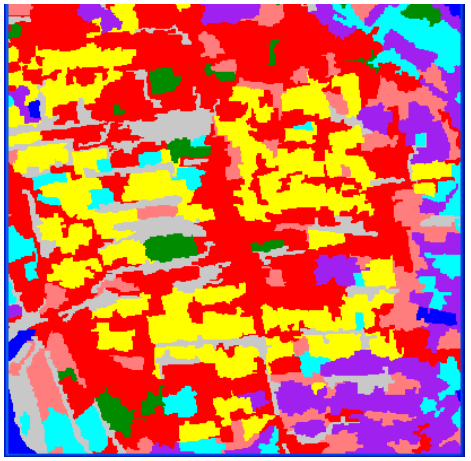
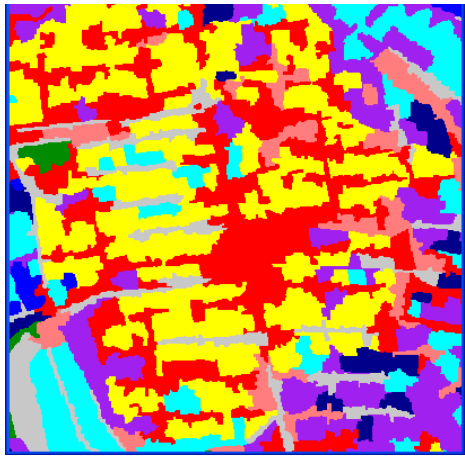





Results & Discussion

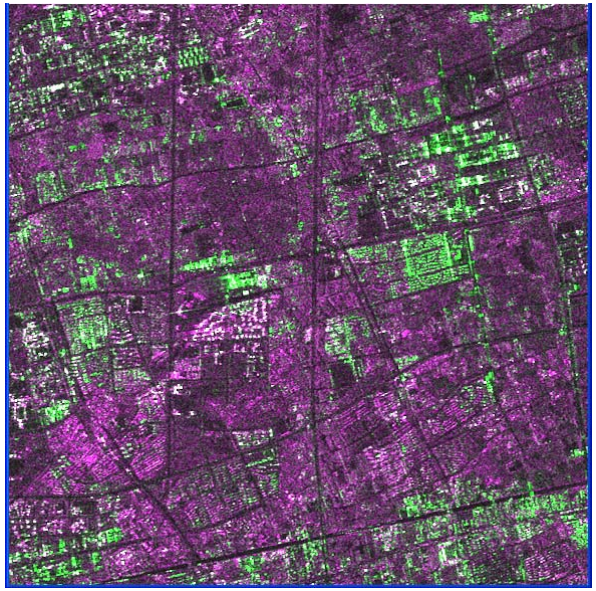


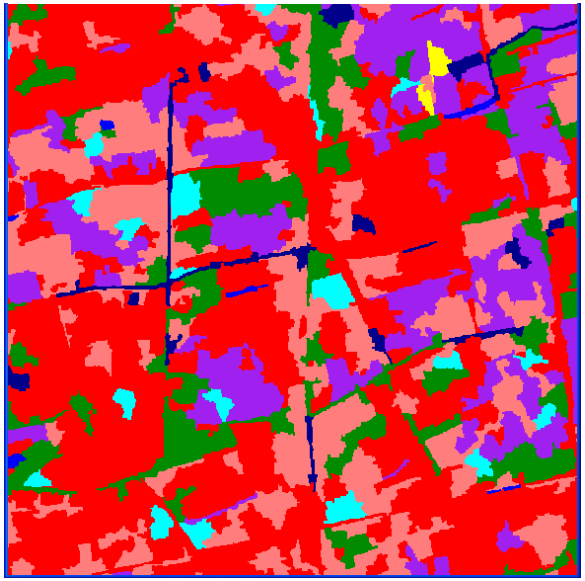
Results & Discussion

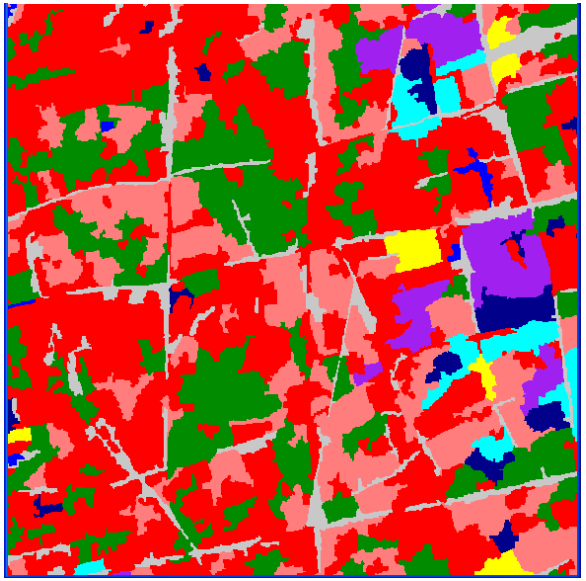




Results & Discussion

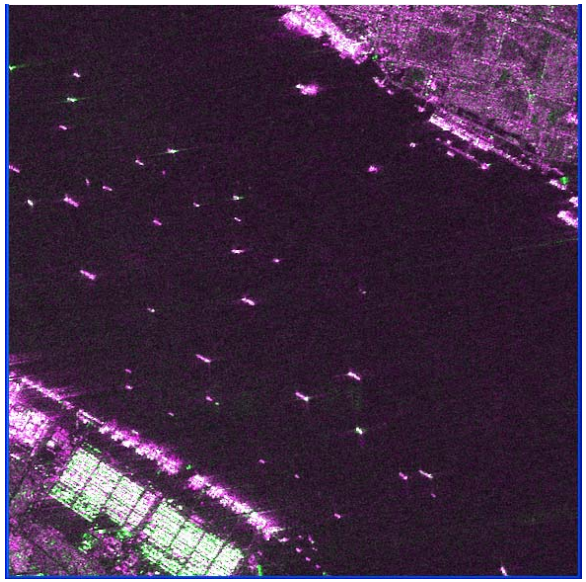


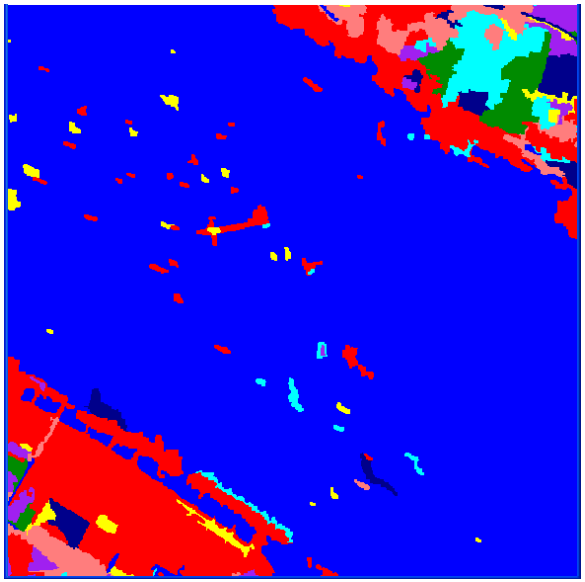


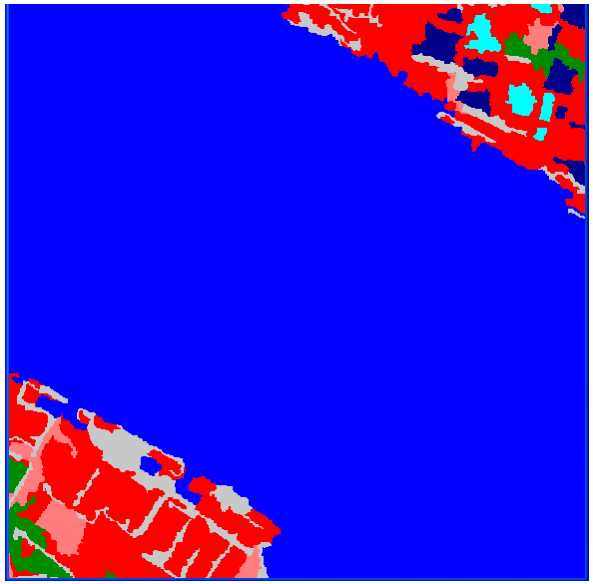


Legend: HD, LD, Road, Bare, Water, Park, Crop1, Crop2, Crop3

Results & Discussion





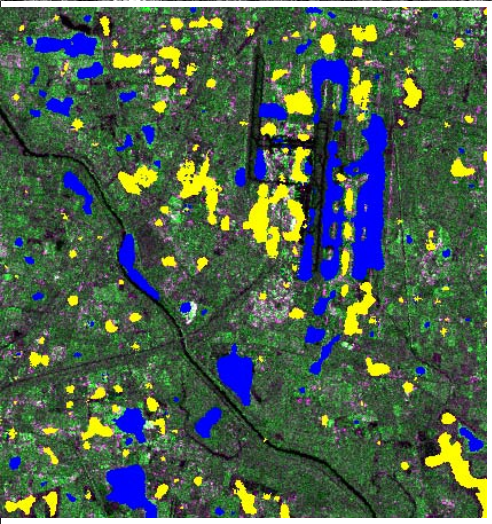


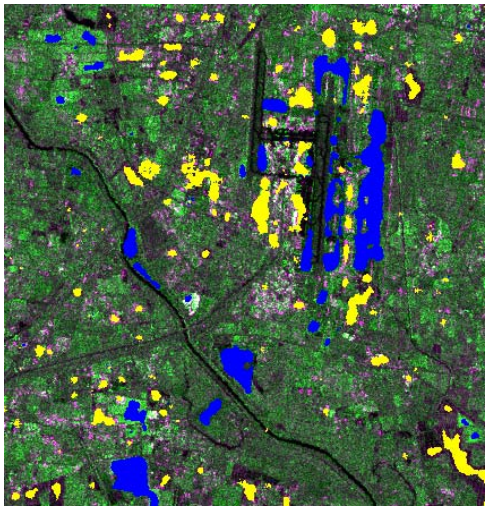
Legend: HD, LD, Road, Bare, Water, Park, Crop1, Crop2, Crop3

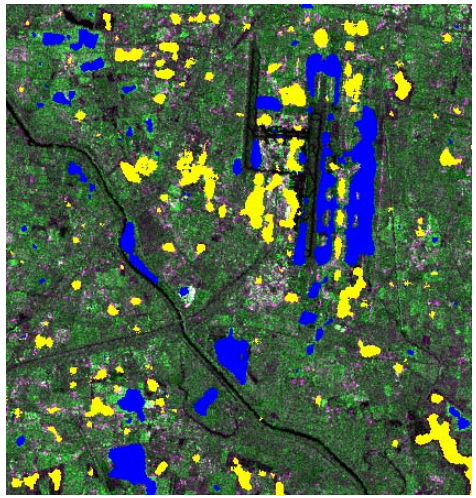
Results & Discussion

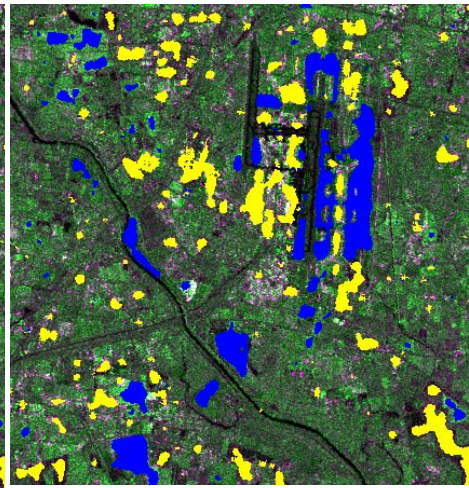
Density Model	GG	LN	NR	WR	LogRatio SVM	Ratio SVM
Positive Change	98.49	92.19	92.19	79.71	98.50	97.68
Negative Change	84.53	61.32	61.32	52.60	78.21	77.93
False Alarm	11.23	2.70	2.70	0.18	7.92	10.74
Overall Error	8.18	11.34	11.34	16.80	8.36	9.31
Kappa coefficient	0.87	0.82	0.82	0.72	0.87	0.85
Change %	10.90	5.10	5.10	2.63		

Change Detection

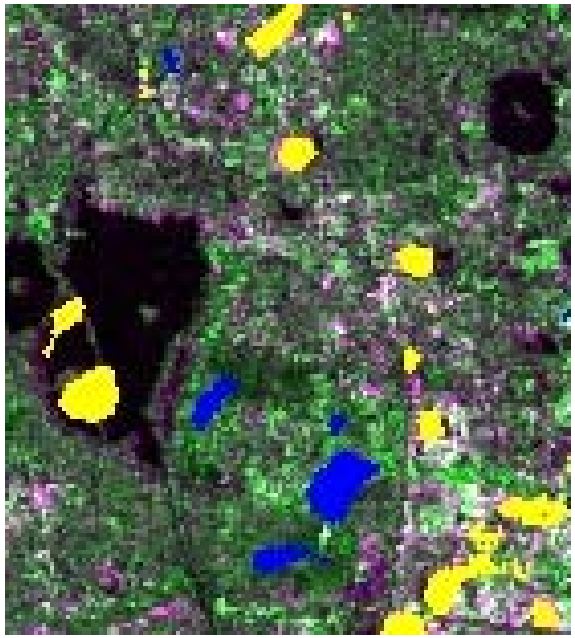


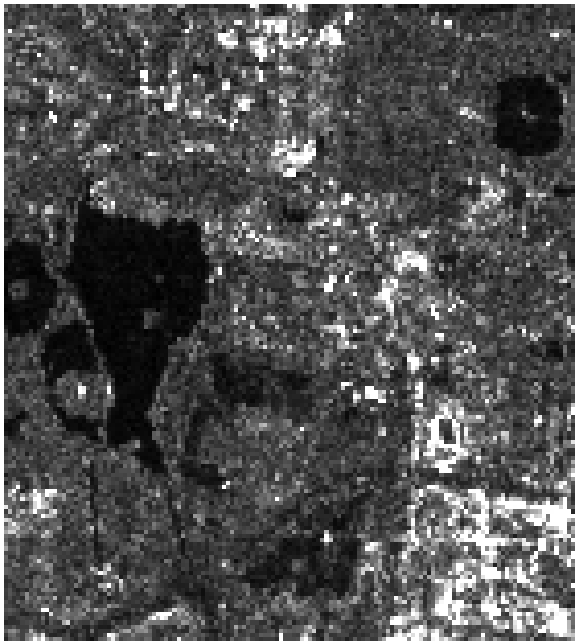


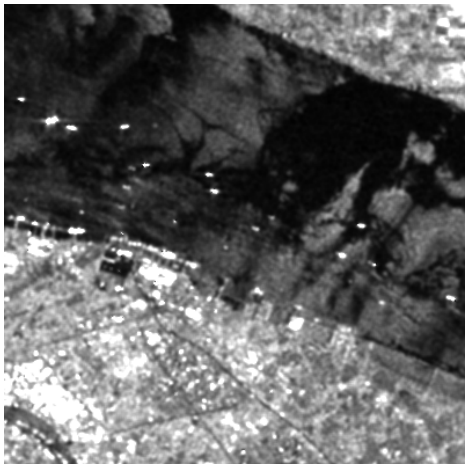




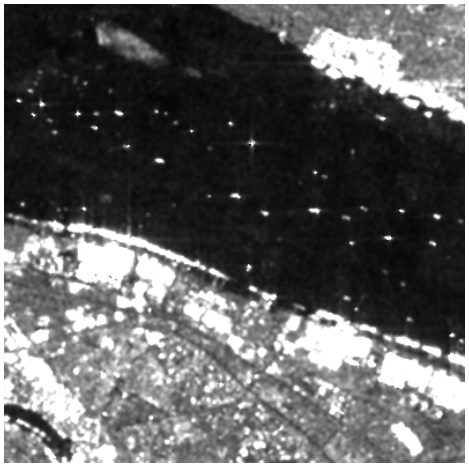
Results & Discussion







1999 ERS-2 Image



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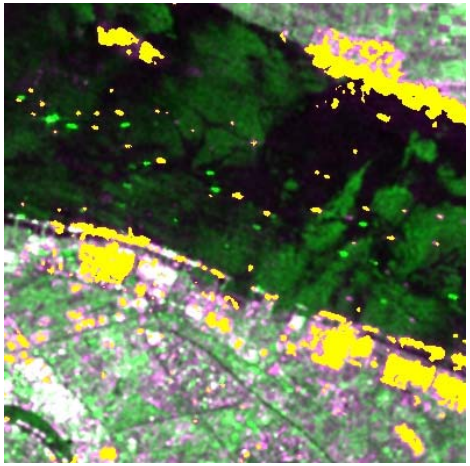
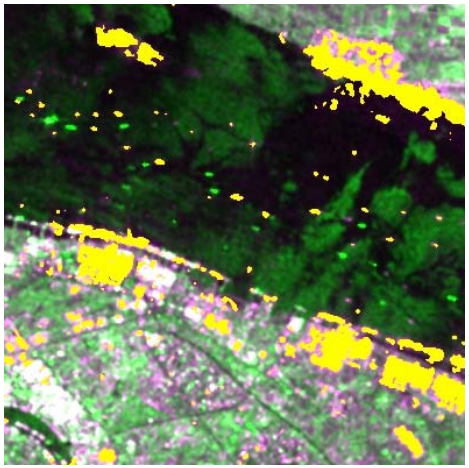


Log-Normal PDF



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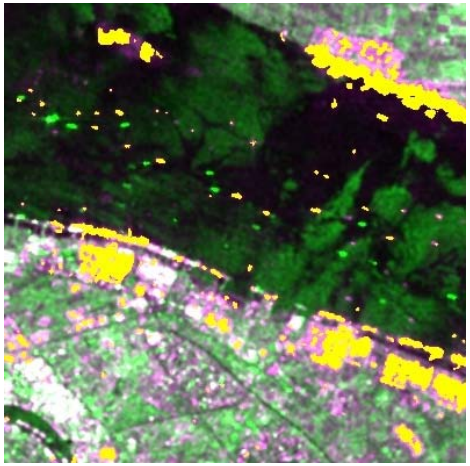
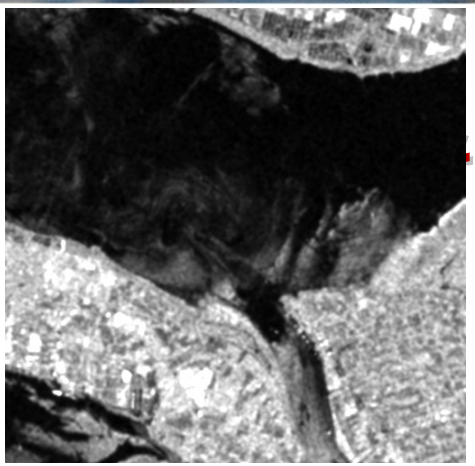


Weibull Ratio PDF



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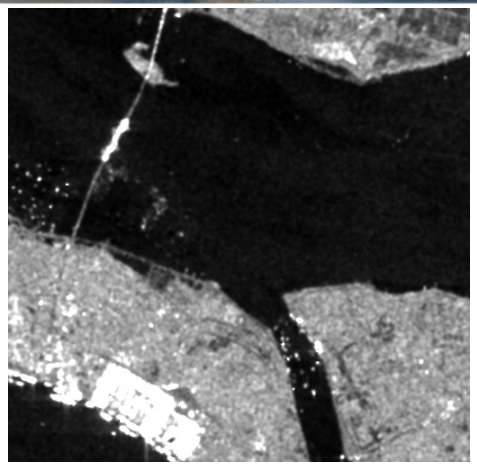

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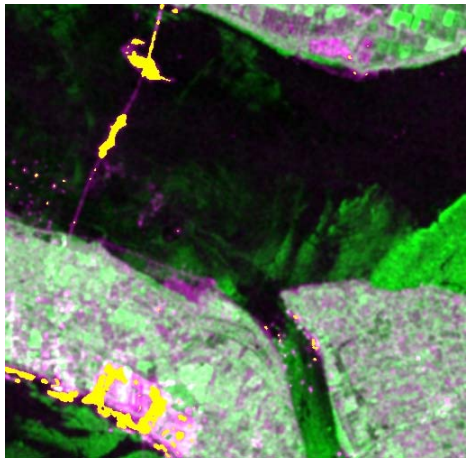

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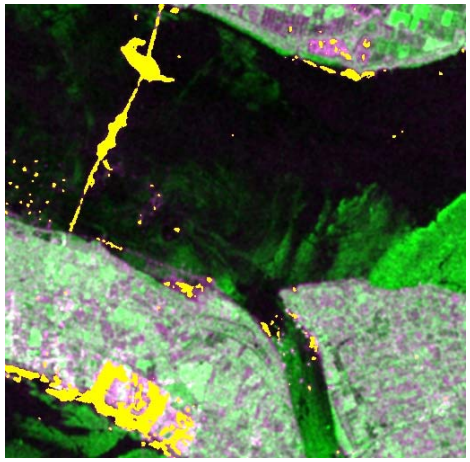

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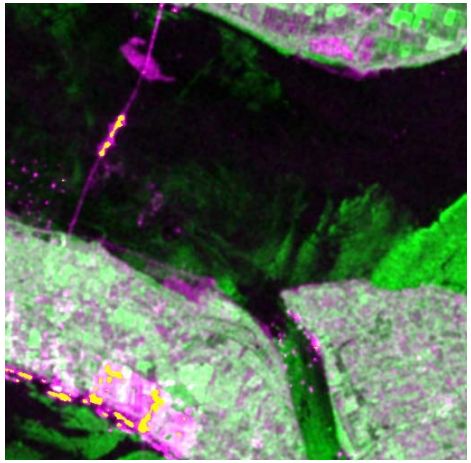

Weibull Ratio PDF

Conclusions

- Object-based SVM combined with rules is effective for classification of multisensor SAR data.
  - Rule-based approach was able to improve the object-based SVM classification accuracy
- For comparison of multisensor SAR data for urban Land cover classification
  - Single frequency: PalSAR (L-band) yielded high accuracy than X- and C-SAR
  - Dual frequency: L+X or L+C produced higher accuracy than C+X or single frequency SAR
  - L+C+X yielded the highest classification accuracy

Conclusions

- Unsupervised Kittler-Illingworth algorithm is fast change detection method.
  - The best change result is obtained by using either log normal or Nakagami ratio to model the change /no-change classes.
  - The positive change detection accuracies were very good in general except for the Weibull ratio model while negative change accuracies were poor.
- Log ratio or ratio with supervised SVM is also very effective in detecting changes