ESA - MOST Dragon 2 Programme

2011 DRAGON 2 SYMPOSIUM

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"龙计划"二期2011年学术研讨会

Land-use Land-cover classification of SAR Images by means of Segmentation Techniques exploiting Ancillary Optical Data

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Outline

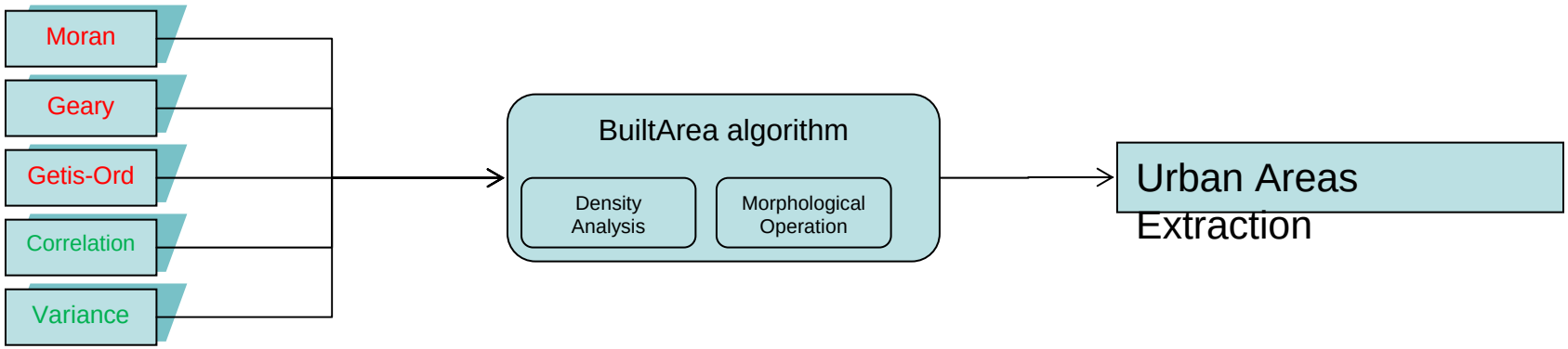
- Introduction
- Problem Analysis
- Proposed Methods
  - Segmentation Techniques
  - Exploitation of Ancillary Optical Data
- Case Study: ENVISAT/ASAR, Shanghai
- Conclusions

Introduction

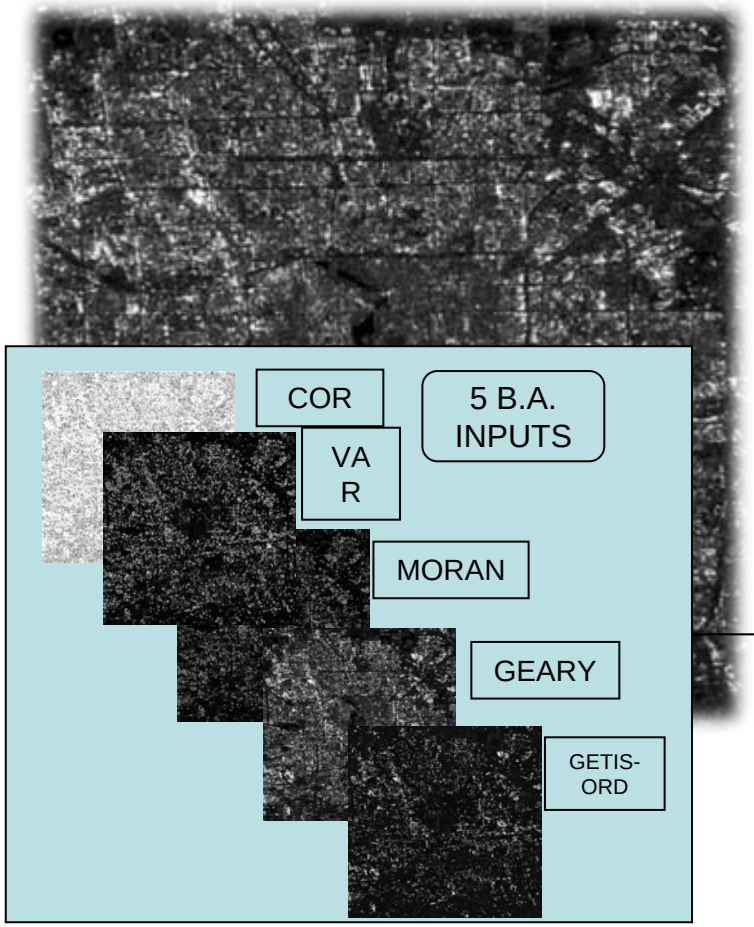
- The work is subdivided into two different tasks:
  - the first one is the extraction of the human settlement extents for different sensors;
    - implementation of “BuiltArea” procedure
  - the second one requires instead the characterization of different land use classes using the same SAR data sets.
  - Different segmentation techniques are compared and exploited in order to identify statistically homogeneous regions and eventually a supervised classification of the selected features allows assigning each region to a class;
  - Tests on the areas of Shanghai show potentials for the use of these techniques in urban area monitoring using moderate resolution SAR;
  - A preliminary study on the exploitation of ancillary optical data for segmentation.

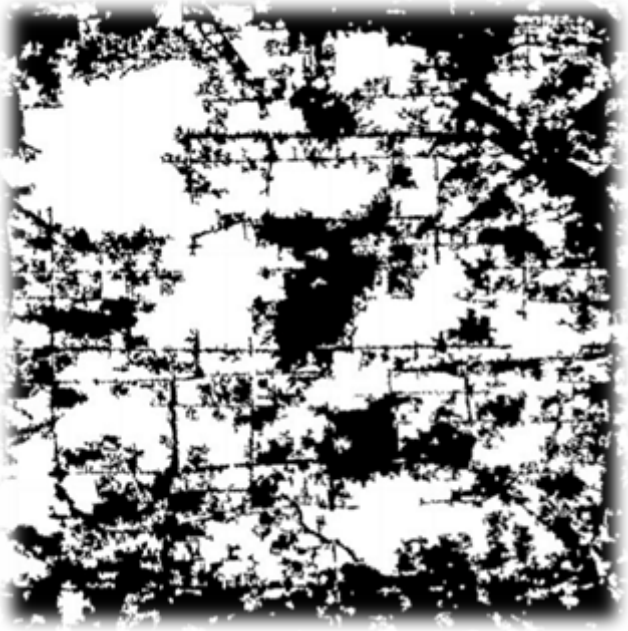
U. A. Extents Extraction - BuiltArea

- The first step is aimed to focus the analysis on human settlements only
- We rely on the more precise version of the “Built-Area” algorithm
- All of the most recent approaches developed for SAR images rely on spatial indexes and/or a combination to extract human settlements
- The indexes considered in this work belong to two major categories: Local Indicators of Spatial Associations (LISA) and co-occurrence textural features:
  - **Moran’I index,**
  - **Geary’c index,**
  - **Getis-Ord’Gi index,**
  - **Correlation**,
  - **Variance**.



U. A. Extents Extraction - BuiltArea





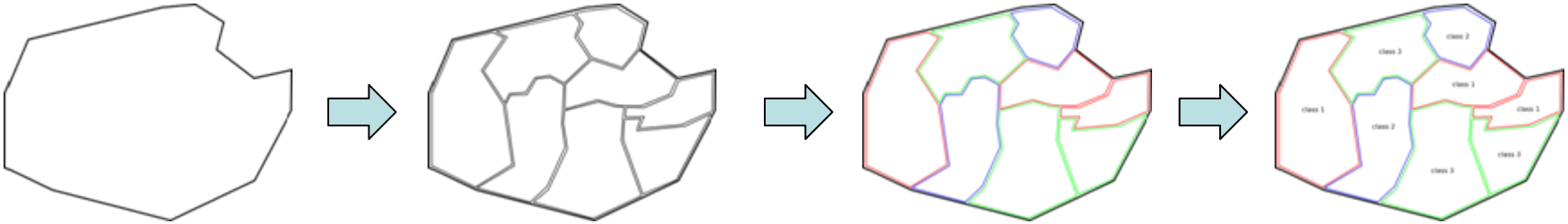
3-PARAMETERS SET ACCORDING TO THE ACQUISITION SENSOR (ENVISAT/ASAR):

SCALE_LISA: 0.6
SCALE_TEXT: 0.4
SCALE_URB: 0.1

ENVISAT/ASAR APP - Geocoded
12,5 m spatial resolution
Acquired on August 8° 2009

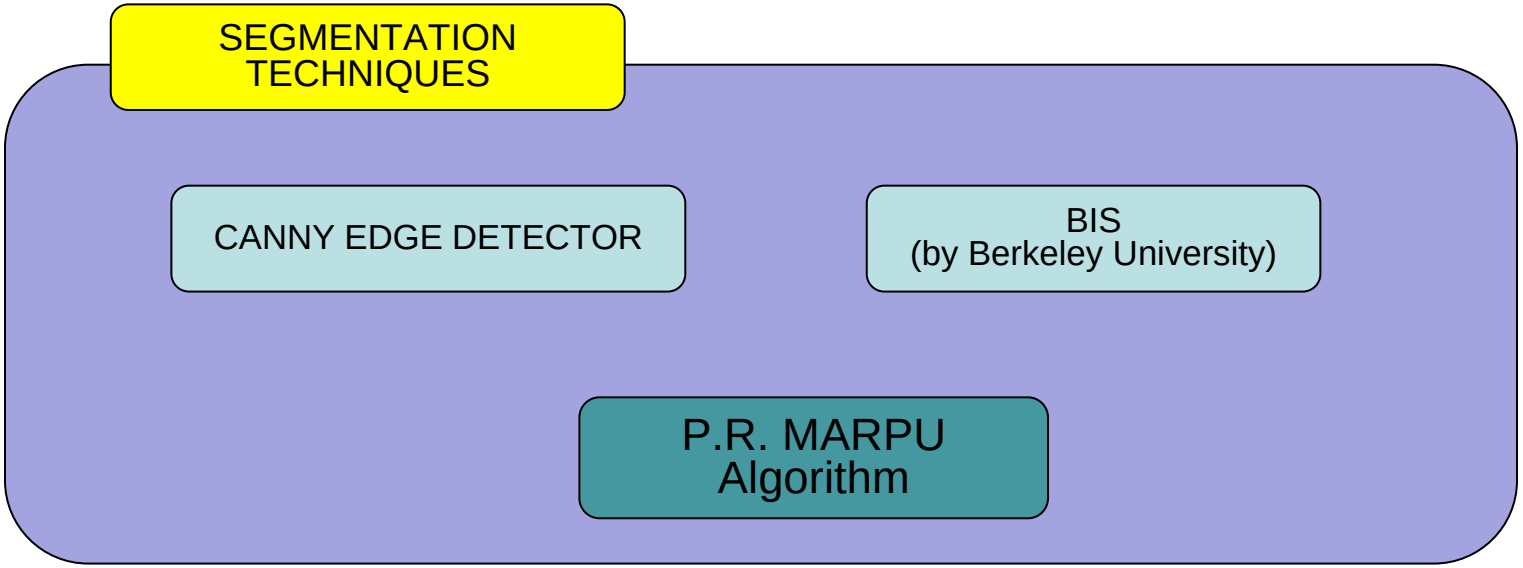
II° Phase: Land Use / Land Cover Classification

- Besides the use of spatial features, the second pillar of this research work is the use of regions instead of single pixels in the final LULC classification.
- Urban environments show a natural structural organization, and they can be seen as block agglomerates rather than building units.
- It makes sense to segment a SAR image into statistically homogeneous areas and use these regions as a spatial proxy to urban blocks.
- This operation can be seen as a clustering process in which each object may be eventually labelled as part of a specific urban land cover class, according to specific criteria.



Segmentation Algorithms

In our work, three different segmentation techniques, based on different methodologies, have been compared in order to establish which segmentation approach is more suited for SAR images.



Segmentation Algorithm: Canny Edge Detector

CANNY EDGE DETECTOR (CED)

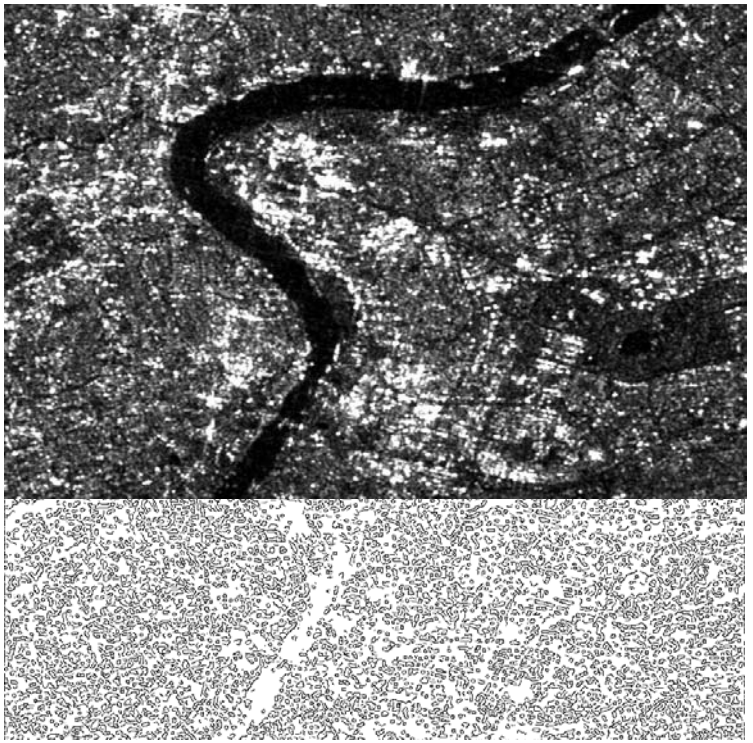
+ it doesn't need a-priori statistical knowledge on regions
+ limited number of parameters estimation
+ valid for every segment orientation

•It is based on four different phases:

1. Image Smoothing,
2. Edge Enhancement,
3. Non-maxima suppression,
4. Hysteresis Thresholding.

•PROCESSING CHAIN based on:

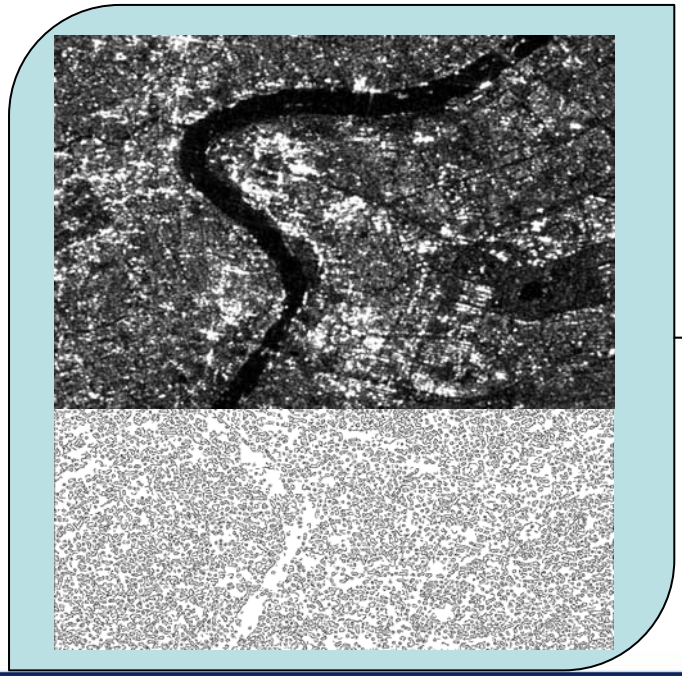
– a denoising algorithm,
– an edge detection step,
– a region merging technique



Land Use / Land Cover Classification: Region Merging

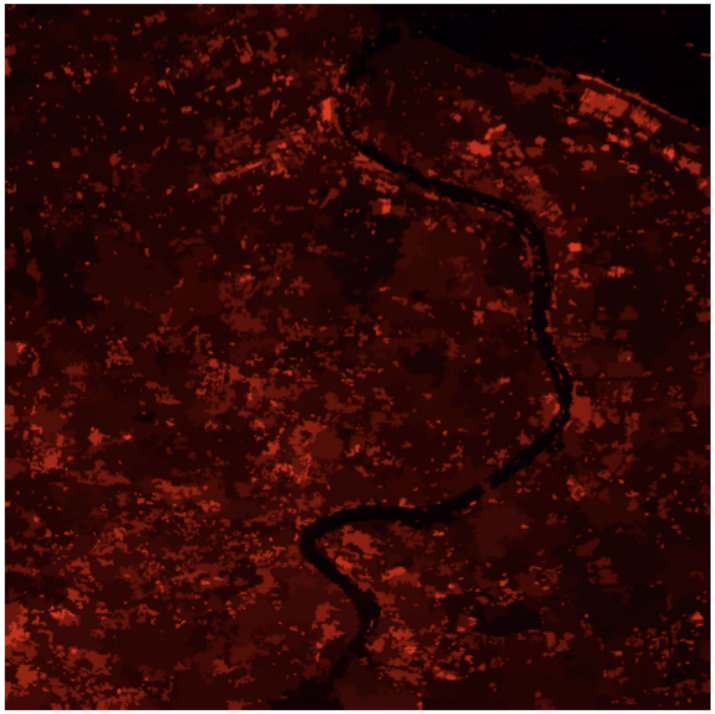
REGION MERGING

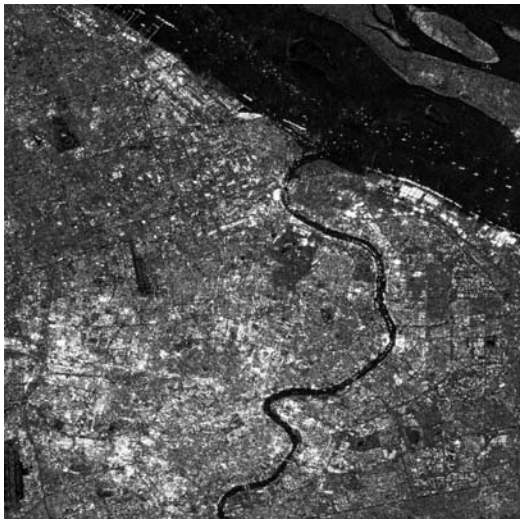
It uses the output of the canny edge detector in order to generate, from the original edge detected image, well-defined closed regions corresponding to statistically homogeneous areas.



Segmentation Algorithm: BIS

The Berkeley ImageSeg algorithm is an object-based image analyzer algorithm, where compactness, shape and scale parameters may be adjusted in order to obtain the desired level of segmentation.





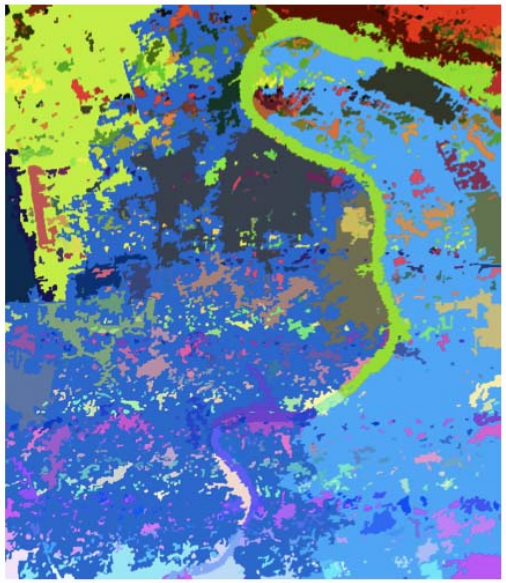
ASAR/ENVISAT
APP IMAGE
VV-POLARIZATION
PIXEL POSTING: 12.5 m

Segmentation Algorithms: P.R. Marpu

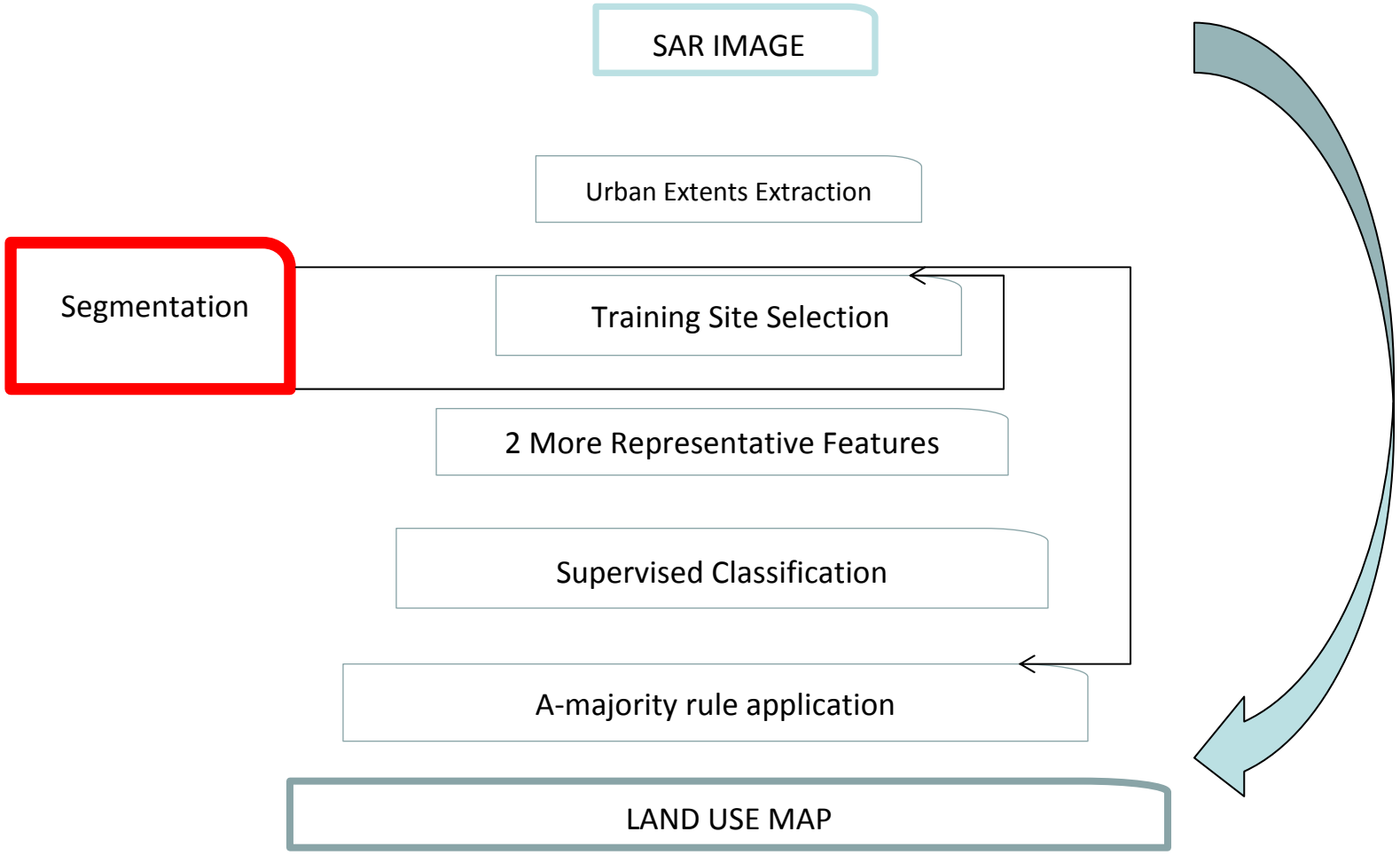
The Marpu algorithm is based on a graph theoretic approach together with a region growing technique where the graph is used to guide the merging process.

The algorithm is based on building a graph over the image connecting all the objects.

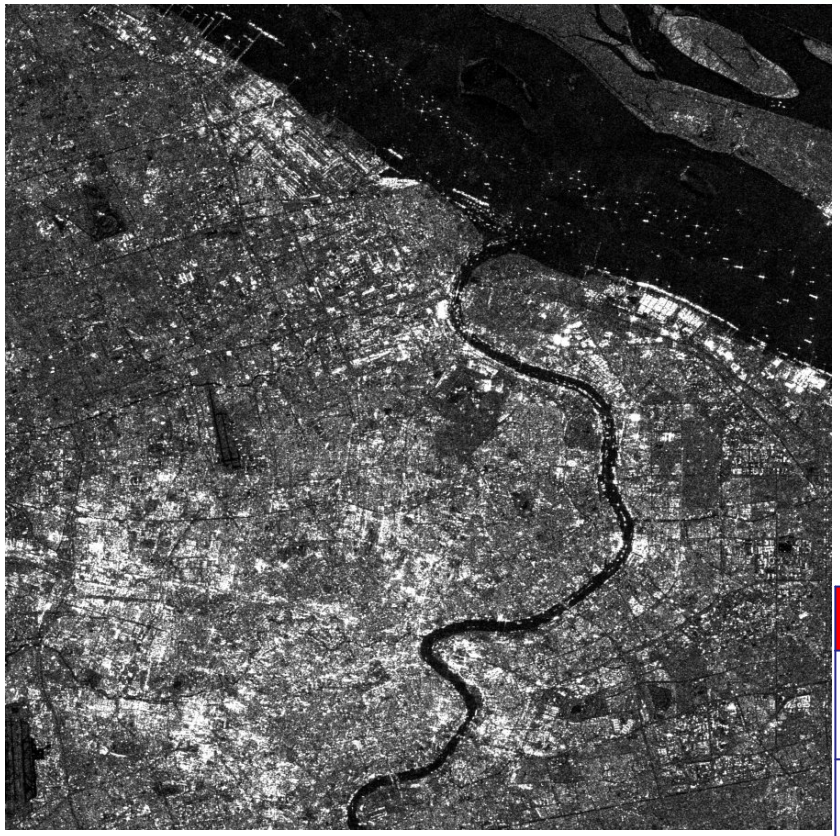
The Standard deviation to Mean Ratio (SMR) is used as the homogeneity criterion while merging the objects. Higher value of this ratio will yield bigger objects and vice-versa.



Land Use / Land Cover Classification: Processing Chain



CASE STUDY: SHANGHAI CITY ACQUIRED FROM ENVISAT/ASAR



Area: Shanghai, Pudong

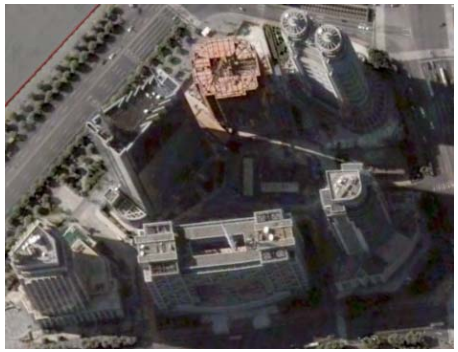
Acquisition Date: 2-Aug-08

SATELLITE	ENVISAT
SENSOR	ASAR
IMAGE TYPE	APP (Alternating Polarization mode Precision image)
BAND	C
PIXEL SPACING	12.5 m x12.5 m

Land Use / Land Cover Classification: Classes Selection

Three different land use classes have been chosen among the CORINE nomenclature and according to the typical Chinese urban environment:

•commercial areas (CA) (including commercial sites as well as apartment buildings),
•residential continuous dense urban fabric (RDF),
•green urban areas (GUA) inside the urban extents.



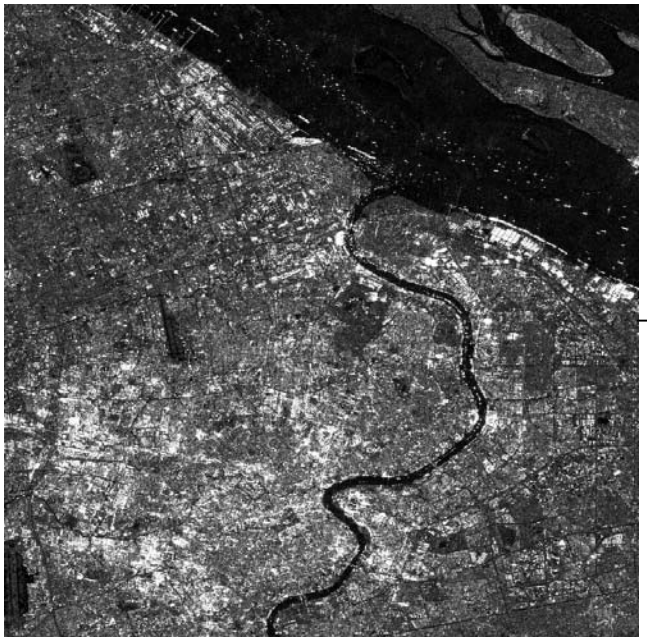
Commercial Areas

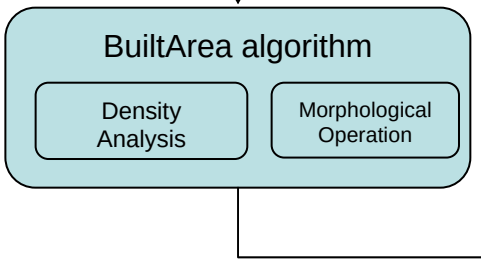
Residential Continous Dense Urban Fabric

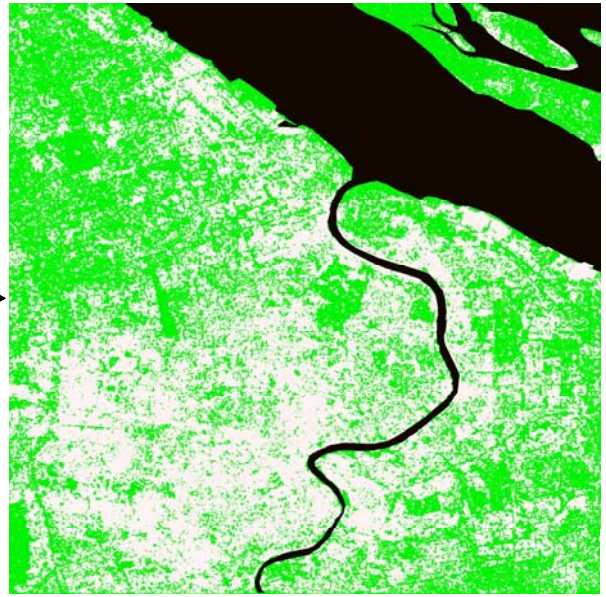
Green Urban Areas

CASE STUDY: SHANGHAI CITY ACQUIRED FROM ENVISAT/ASAR

BUILTAREA Urban Extents Extraction:

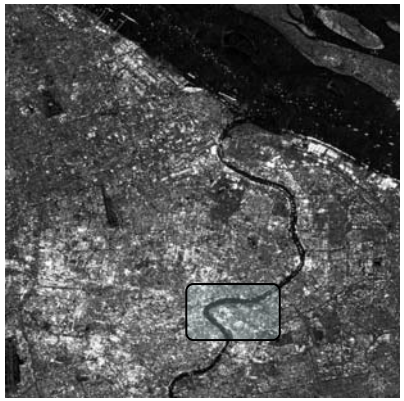




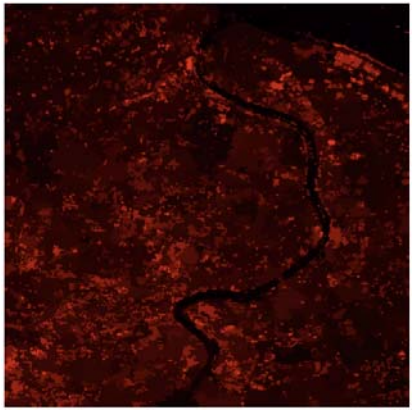


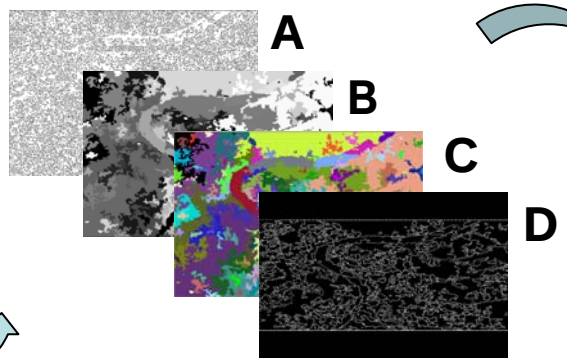
CASE STUDY: SHANGHAI CITY ACQUIRED FROM ENVISAT/ASAR

Canny Edge Detector and Region Merging



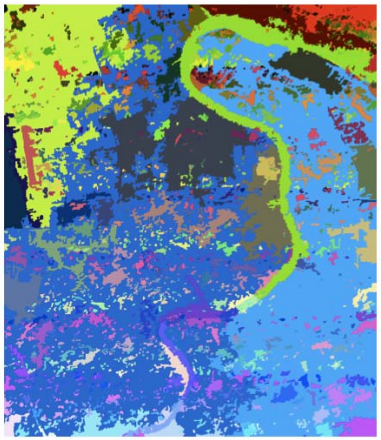
BIS Algorithm





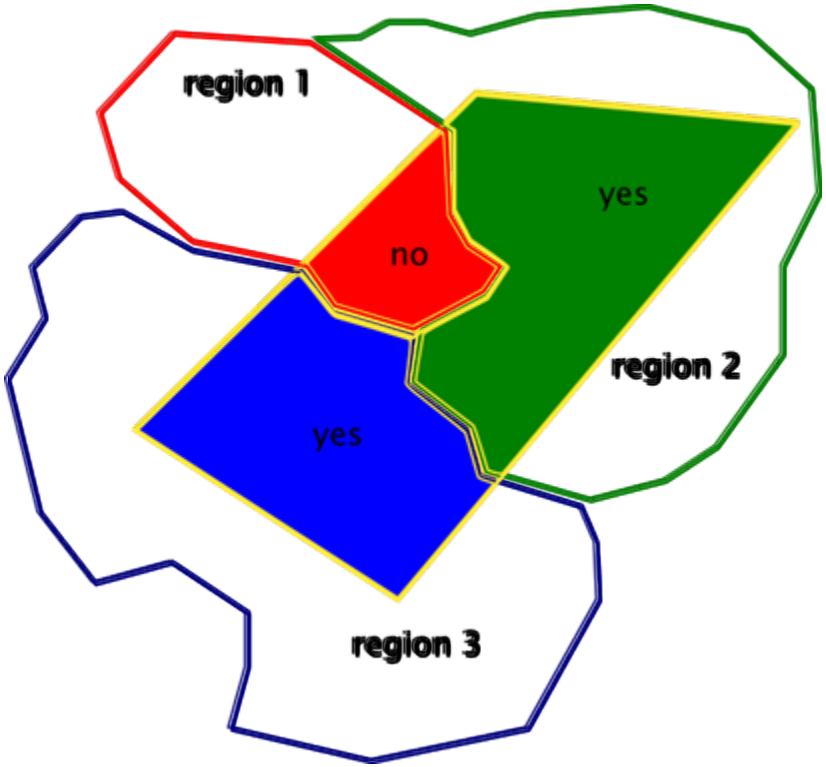
A. Edge Detection
B. Edge Map
C. Region Merging
D. Shape Files

Marpu Algorithm



TRAINING SET MODIFICATIONS

Training set is modified according to the segmentation.
Only the two widest regions belonging to it are maintained.



CLASSES SEPARABILITY

In order to maintain the number of features as small as possible, the two more representative feature are used for the classification step.

- *Moran Index*
- *Geary Index*
- *Getis- Ord Index*
- *Correlazione*
- *Varianza*
- *LISA Density*
- *Original Values*
- *Speckle Divergence*
- *L.D.I.*

→ Jeffrey – Matusita Index →

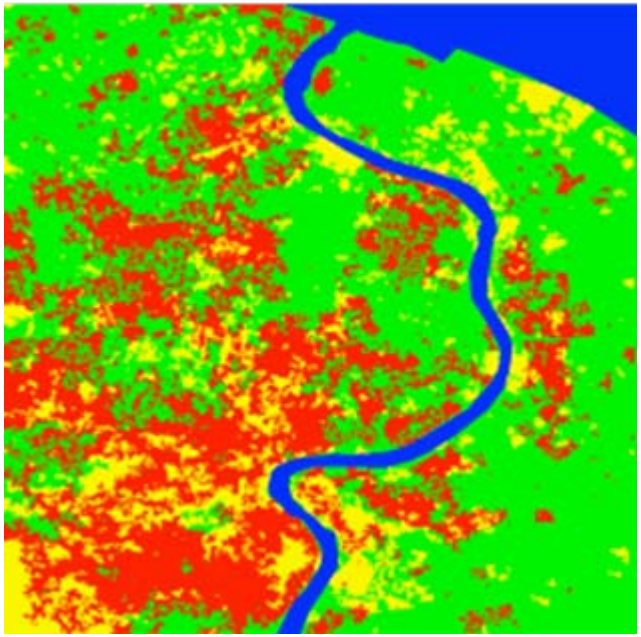
CLASSES	JEFFREY-MATUSITA INDEX	BEST INDEX PAIR
RESIDENTIAL CONTINOUS DENSE VS COMMERCIAL AREAS	1.95	GETIS_ORD + Speckle Divergence
GREEN URBAN AREAS VS COMMERICAL AREAS	1.87	MORAN + Speckle Divergence
GREEN URBAN AREAS VS RESIDENTIAL CONTINOUS DENSE	0.57	CORRELATION + Getis-Ord

$$JM_{cd} = \sqrt{2(1 - e^{-B_{cd}})}$$

$$B_{cd} = \frac{1}{8}(M_c - M_d)^T \left(\frac{\Sigma_c + \Sigma_d}{2}\right)^{-1} (M_c - M_d) + \frac{1}{2}\ln\left(\frac{\frac{1}{2}|\Sigma_c + \Sigma_d|}{\sqrt{|\Sigma_c||\Sigma_d|}}\right)$$

Segmentations Comparison

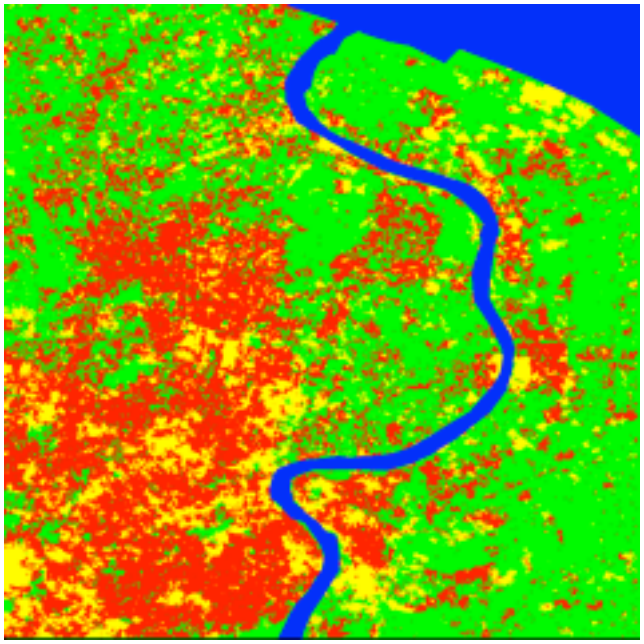
Final Output of the processing chain, after the Minimum Distance classification and the application of the majority rule.



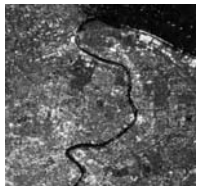
BIS – Final Output

LEGEND

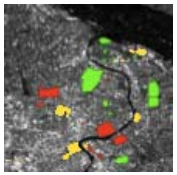
BLUE:
water
YELLOW:
Commercial
Areas
RED:
Residential
C.D.



Marpu - Final Output



ASAR/ENVISAT Image



Ground Truth

Accuracy Assessment

CONFUSION MATRIX		
Overall Accuracy	70.20 %	
K-Coeff.	0.41	
	Producer Accuracy	User Accuracy
Commercial Areas	67.22 %	79.70%
Residential C.D.	56,45 %	43,34 %
Green Urban Areas	87,36 %	79, 53 %

CED + RM - Algorithm Accuracy Assessment

CONFUSION MATRIX		
Overall Accuracy	80.76 %	
K-Coeff.	0.62	
	Producer Accuracy	User Accuracy
Commercial Areas	67.22 %	79.70%
Residential C.D.	47.80 %	64.18 %
Green Urban Areas	94.50 %	84.07 %

BIS - Algorithm Accuracy Assessment

CONFUSION MATRIX		
Overall Accuracy	83.84 %	
K-Coeff.	0.69	
	Producer Accuracy	User Accuracy
Commercial Areas	66.01 %	80.64 %
Residential C.D.	66.26 %	69.01 %
Green Urban Areas	94.79 %	88.35 %

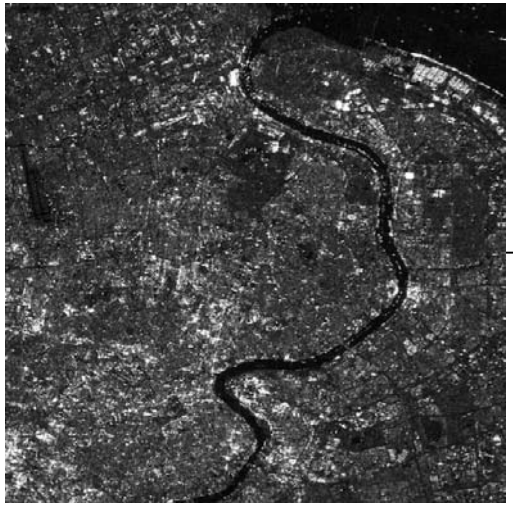
Marpu - Algorithm Accuracy Assessment

Increasing accuracy

DATA FUSION

- The idea is to perform the segmentation task on the optical images, taking advantage of the characteristics of the segmentation algorithms, originally conceived for optical data.

- The optical data has been acquired by the Beijing-1 stellite in june 2009



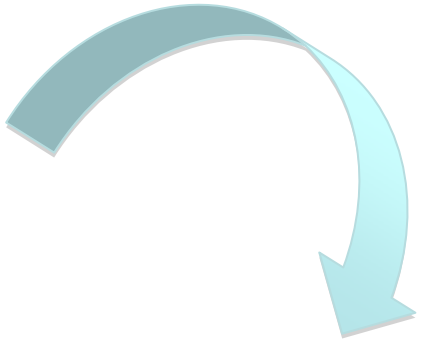
SAR
ASAR/ENVISAT

FUSION

OPTICAL
BEIJING-1

Marpu Algorithm Over Optical

CONFUSION MATRIX		
Overall Accuracy	83.84 %	
K-Coeff.	0.69	
	Producer Accuracy	User Accuracy
Commercial Areas	66.01 %	80.64 %
Residential C.D.	66.26 %	69.01 %
Green Urban Areas	94.79 %	88.35 %



~ +6 overall accuracy
~ 0.07 k-coeff

CONFUSION MATRIX		
Overall Accuracy	89.89 %	
K-Coeff.	0.76	
	Producer Accuracy	User Accuracy
Commercial Areas	71.01 %	83.23 %
Residential C.D.	69.26 %	70.01 %
Green Urban Areas	96.79 %	92.35 %

CONCLUSIONS

- A methodology for LU/LC classification of SAR images using a segmentation approach has been proposed and applied to a case study of Shanghai;

- Three different segmentation algorithms have been compared over the same area; two of them specific for remote sensed images;

- A preliminary analysis of fusion of SAR and optical data (ASAR/ENVISAT + BEIJING-1) has been carried out, showing how the segmentation over optical images provides better results.

FUTURE

- Research is ongoing and polarimetric features (Wishart Classification) are under study as a valid to improve the accuracy by means of the dual polarimetric (HH and VV) ASAR data available.

Thanks for your attention