

# Finite Mixture Models for Sub-pixel Coastal Land Cover Classification

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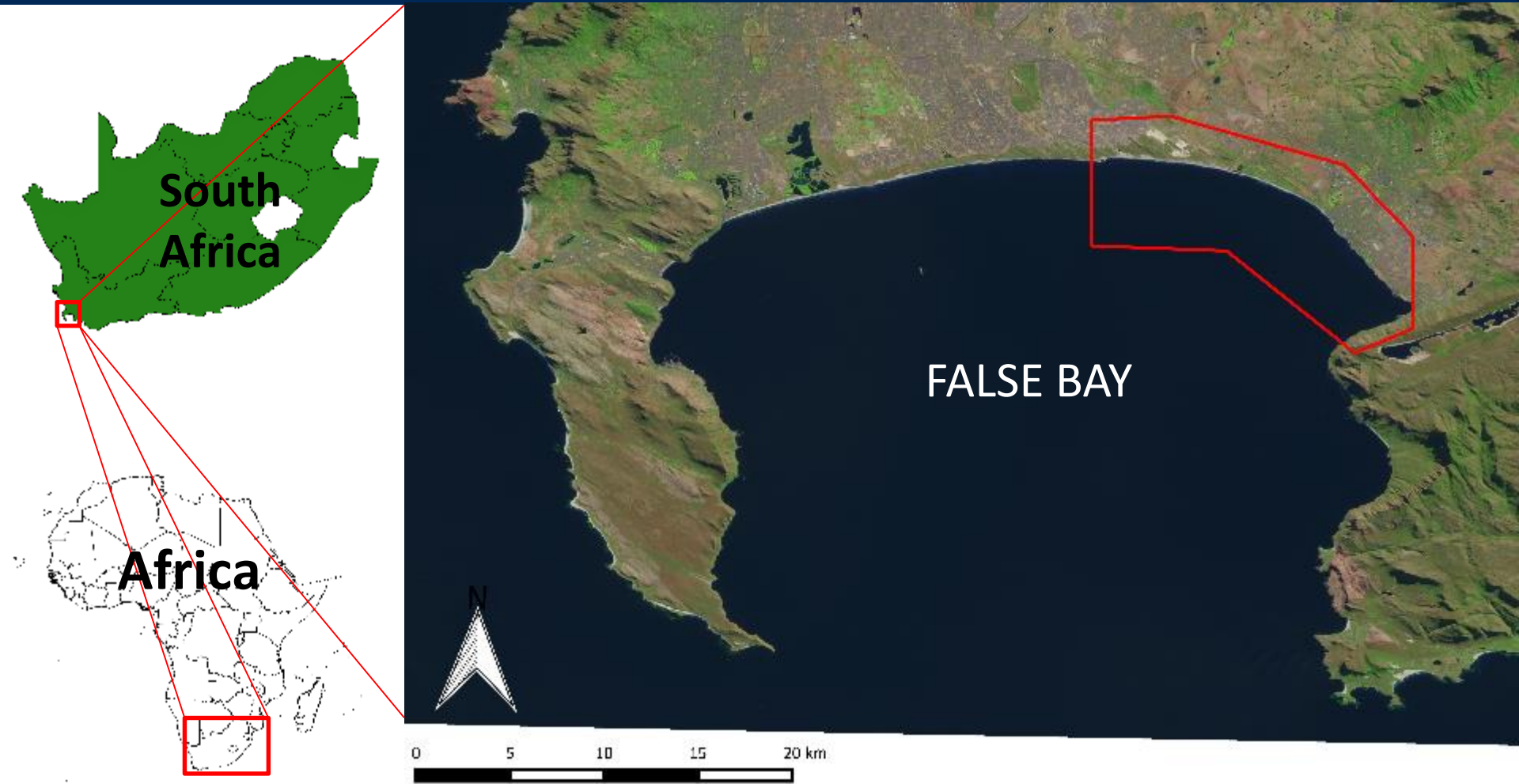
Dr. V. Goodall

ISRSE - 37

Tshwane, South Africa

10 May 2017

# Study Area



# Study Area

18°41.40'E

18°45.90'E

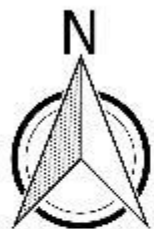
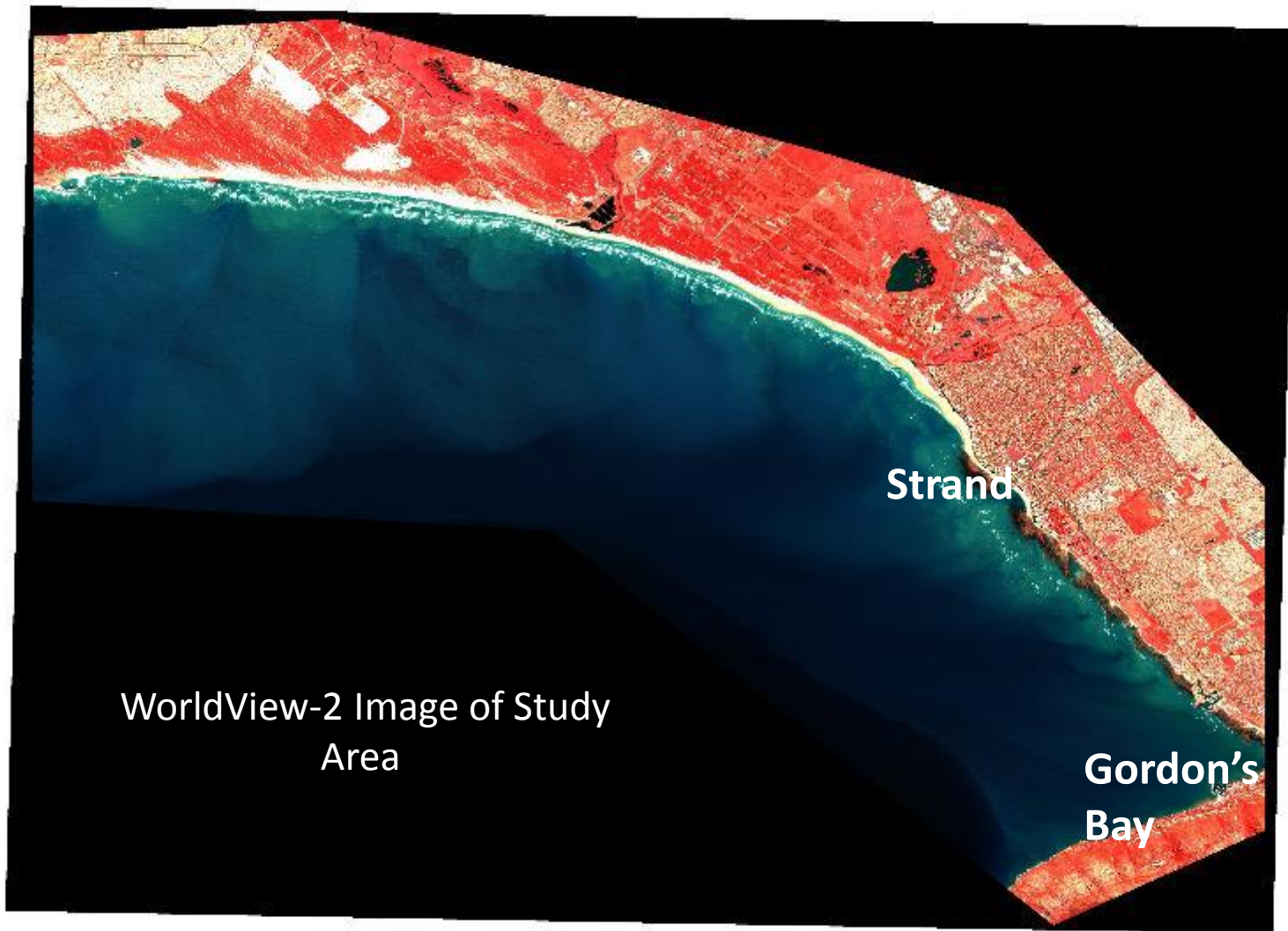
18°50.40'E

-34°2.40'S

-34°5.40'S

-34°8.40'S

-34°11.40'S



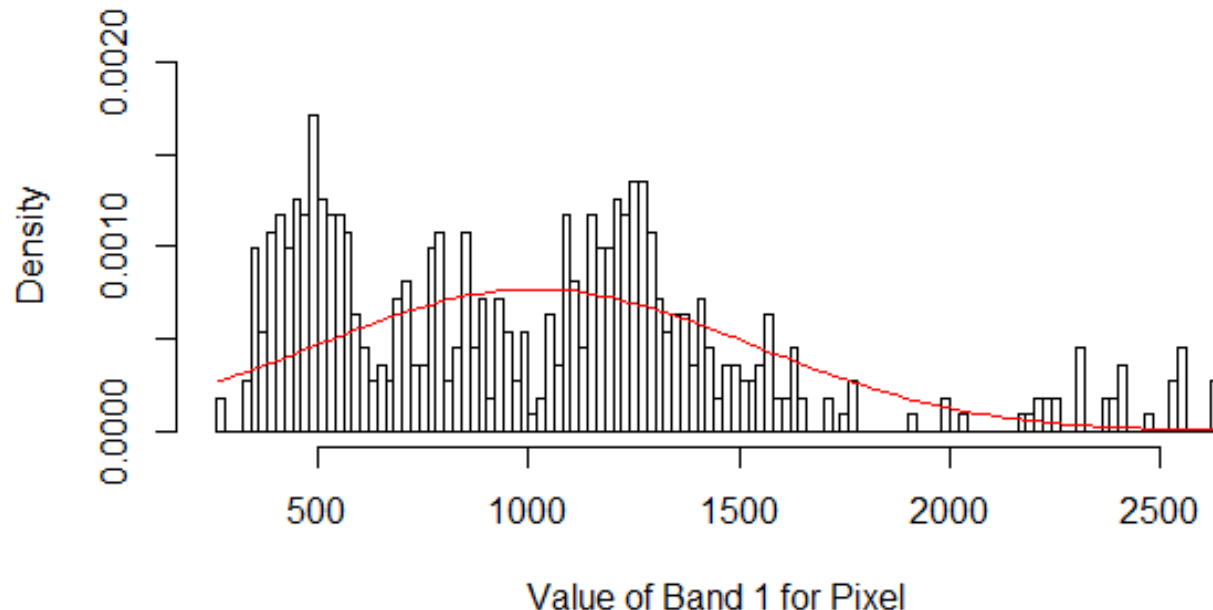
# Classes

Class	Description
Algae	Any vegetation growing on beach rock (partly submerged or not)
Bare Ground	Any kind of uncovered soil excluding beach rock and beach sand
Beach Rock	Non-vegetated rocky cliffs found along the beaches
Beach Sand	Unvegetated and unconsolidated ground found along the beach
Built Up/Urban	Any man-made structure including but not limited to buildings, roads and bridges
Herbaceous Vegetation	Grass and other herbaceous i.e. non-woody vegetation
Shadow	Shadow caused by tall buildings and steep relief
Sparse Vegetation	Mixture of herbaceous and/or woody vegetation and bare ground and/or built up/urban and/or beach sand
Water	Any kind of open water bodies
Woody Vegetation	Trees and shrubs

# Maximum Likelihood Classification

- Popular method
- Single Gaussian distribution fitted per class
- Non-informative priors
- Bayes' rule to generate posterior probabilities
- Maximum posterior probability gives class
- Parametric method
- Uni-modal and Gaussian assumptions

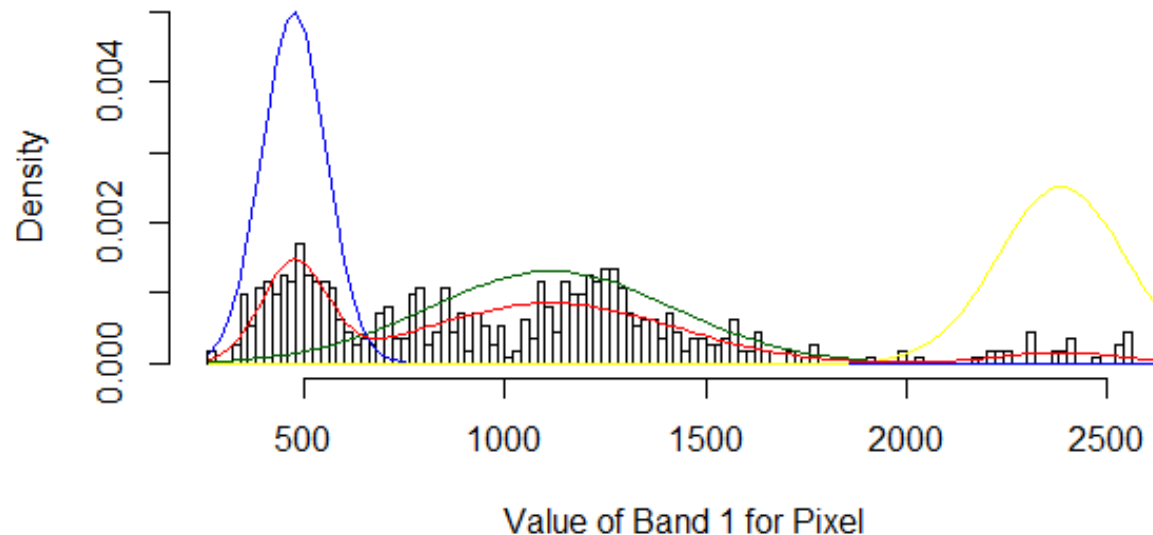
**Gaussian distribution for Bare Class Band 1**



# Mixture Discriminant Analysis

- Fits multiple distributions per class
- Uses mixture of these to give full distribution of class
- Non-informative priors
- Bayes' rule to generate posterior probabilities
- Maximum posterior probability gives class
- Multi-modal and not only Gaussian distributions
- Semi-parametric method

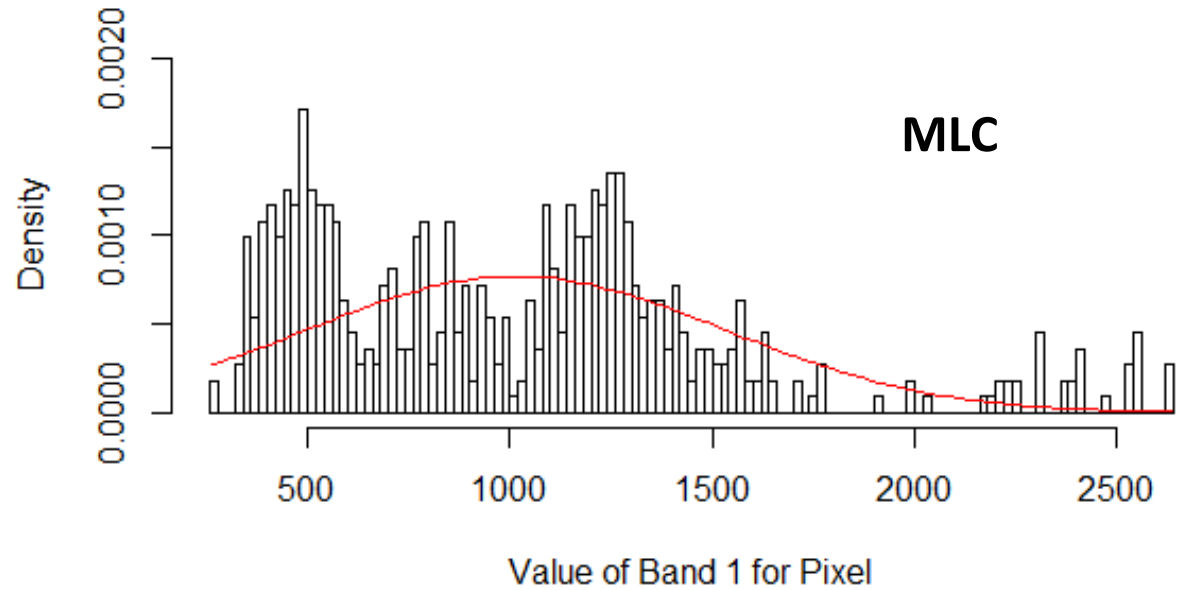
**Mixture of 3 Gaussian distributions for Bare Class Band 1**



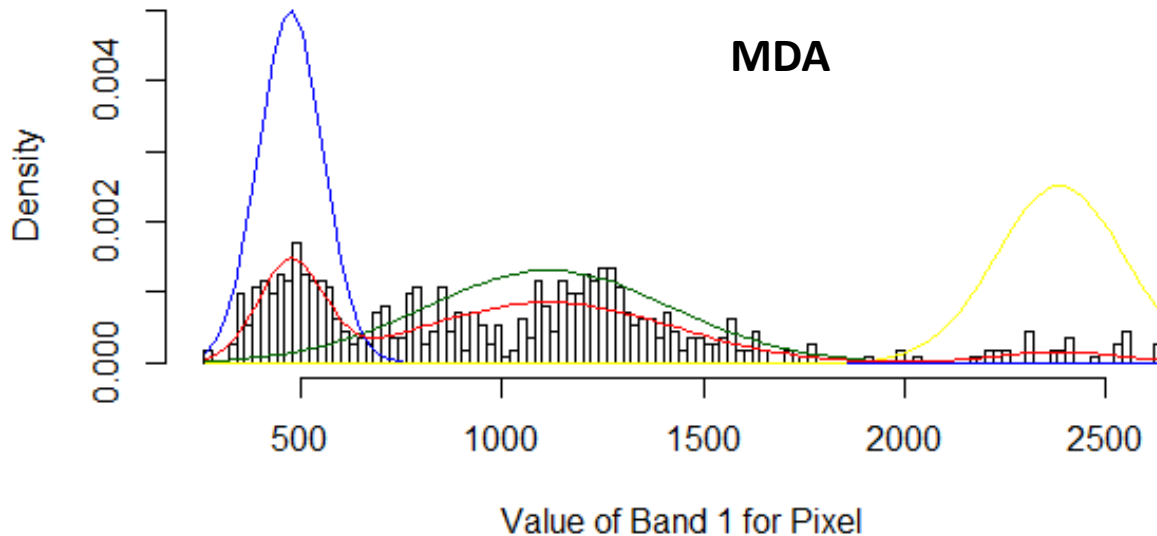


# MLC VS MDA

## Gaussian distribution for Bare Class Band 1



## Mixture of 3 Gaussian distributions for Bare Class Band 1



# MLC vs MDA

**Maximum Likelihood  
Classification**

**Mixture Discriminant  
Analysis**

**Image Preprocessing**

**Acquisition of Training Data for all Classes**

**Fit single Gaussian distribution per  
class**

**Fit 1-10 distributions of choice per class**

**Use integrated complete likelihood  
criterion to determine optimal number  
of classes**

**Classification of image using fitted distribution(s), non-informative priors and Bayes' Rule**

**Acquisition of Validation Data**

**Accuracy Assessment**



# Training Data

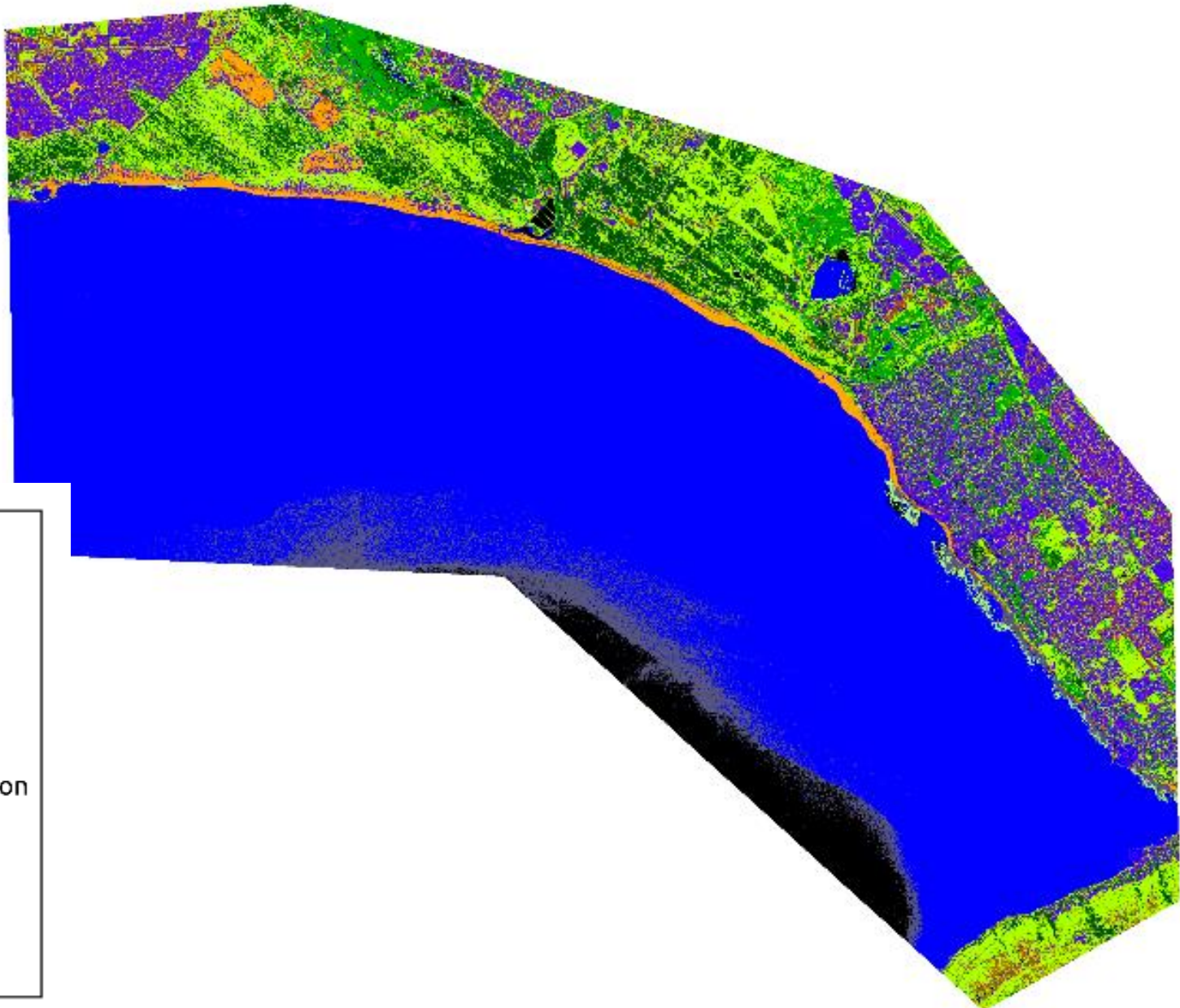
- Screen digitisation
- Based off GPS assisted fieldwork
- Varying number of training points per class

Class	Number of training samples
Algae	888
Bare Ground	1205
Beach Rock	1021
Beach Sand	4842
Built Up/Urban	9976
Herbaceous Vegetation	1777
Shadow	1444
Sparse Vegetation	1192
Water	2788
Woody Vegetation	1632

# Optimal Number of Sub-classes

	Maximum Likelihood	Gaussian	<i>t</i> -distribution
Algae	1	7	5
Bare Ground	1	8	7
Beach Rock	1	5	3
Beach Sand	1	10	10
Built Up/Urban	1	10	10
Herbaceous Vegetation	1	5	5
Shadow	1	8	8
Sparse Vegetation	1	3	3
Water	1	10	10
Woody Vegetation	1	5	5

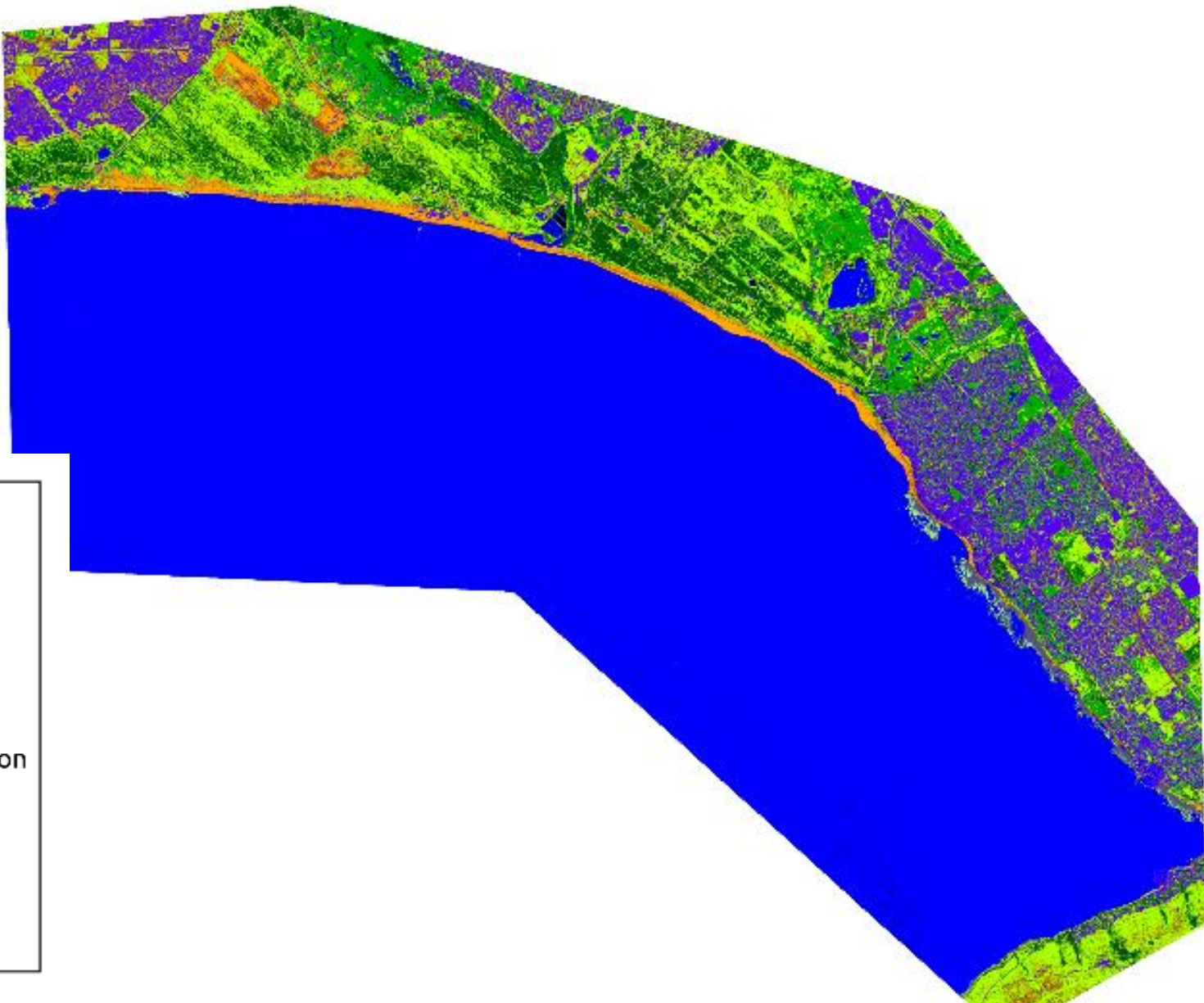
# Maximum Likelihood Classification (MLC)



## Legend

- Unclassified
- Algae
- Bare Ground
- Beach Rock
- Built Up/Urban
- Herbaceous Vegetation
- Beach Sand
- Shadow
- Sparse Vegetation
- Water
- Woody Vegetation

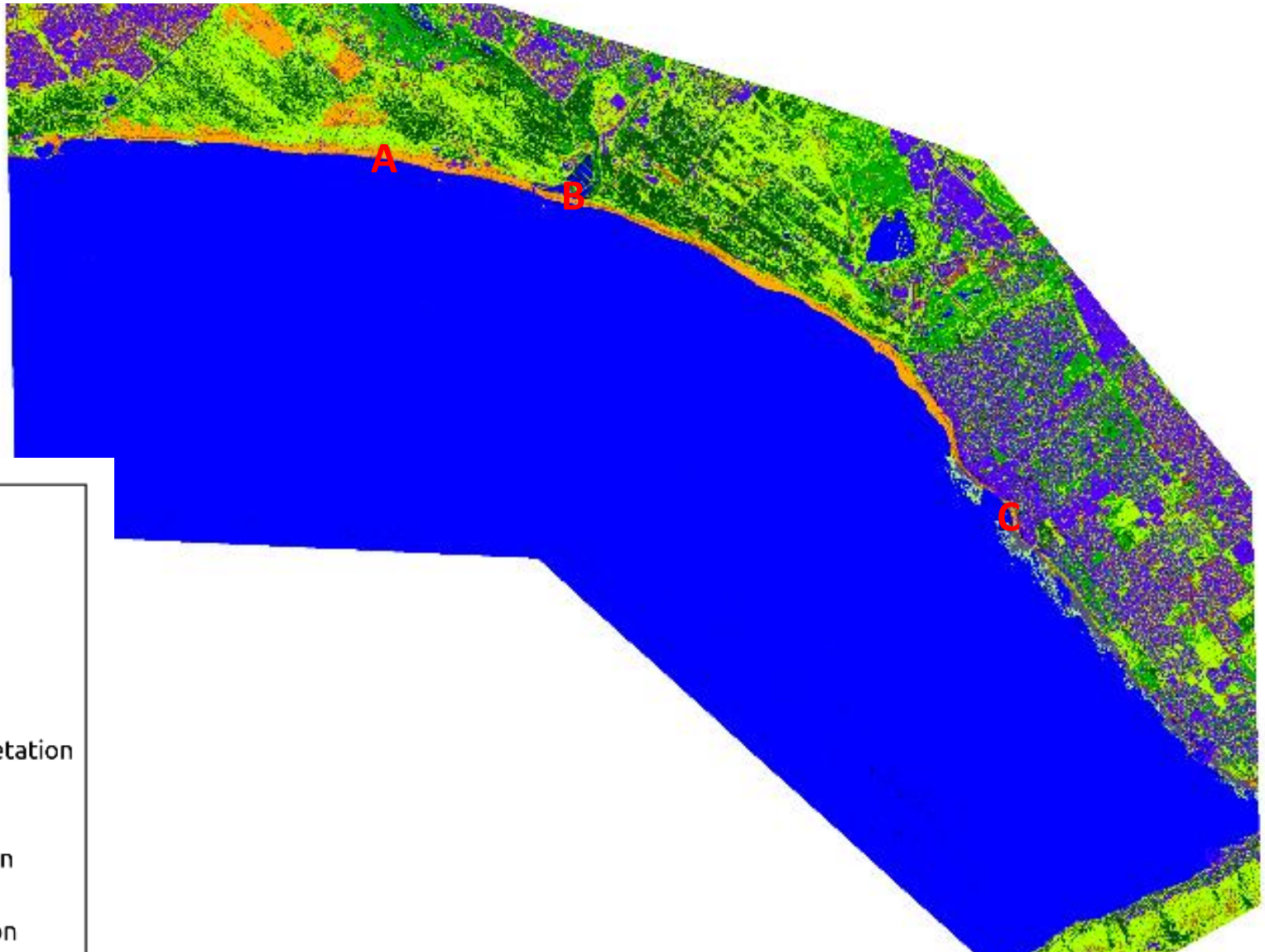
# Gaussian Mixture Discriminant Analysis (GMDA)



- Legend**
- Unclassified
  - Algae
  - Bare Ground
  - Beach Rock
  - Built Up/Urban
  - Herbaceous Vegetation
  - Beach Sand
  - Shadow
  - Sparse Vegetation
  - Water
  - Woody Vegetation



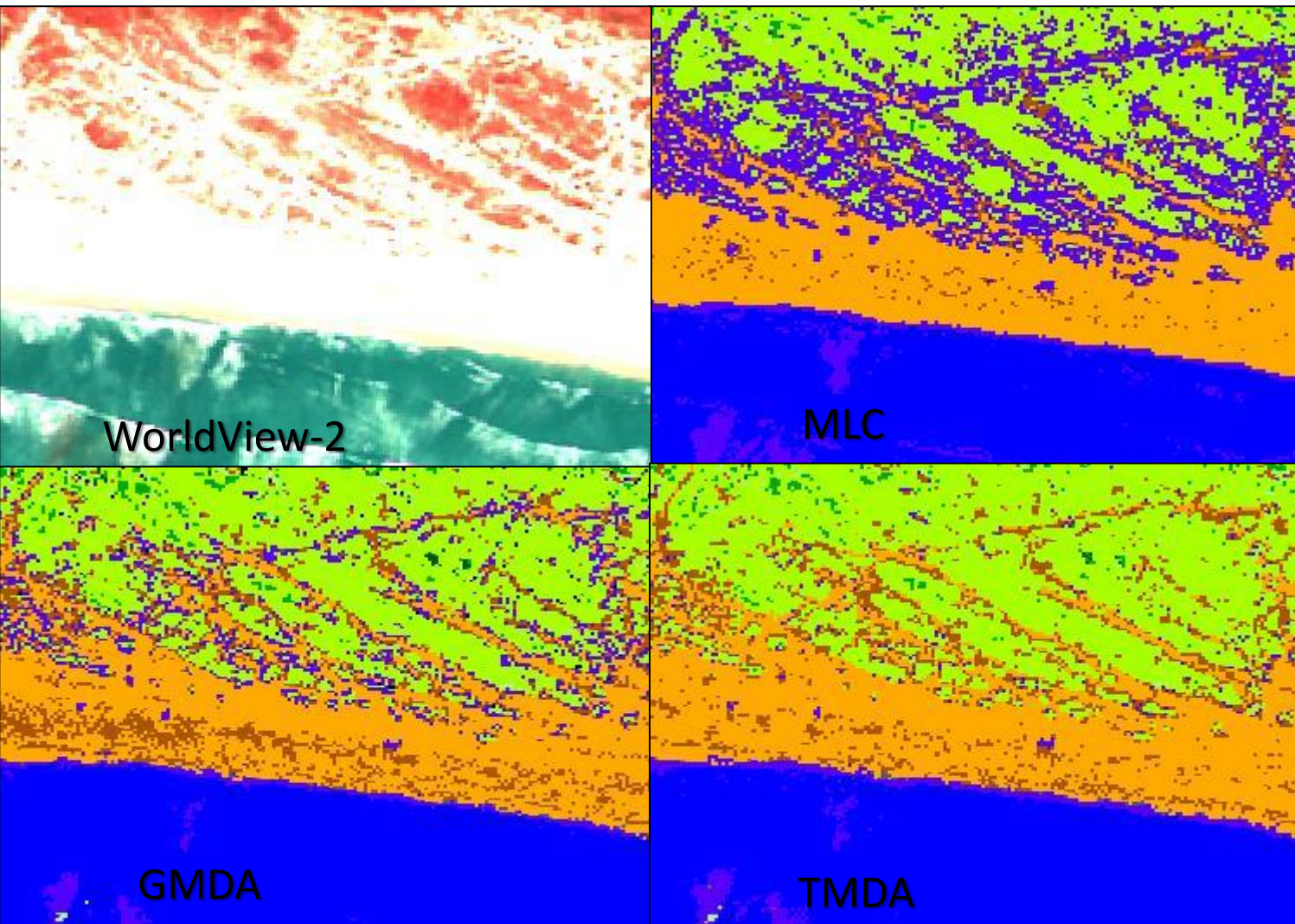
# t-distribution Mixture Discriminant Analysis (TMDA)



## Legend

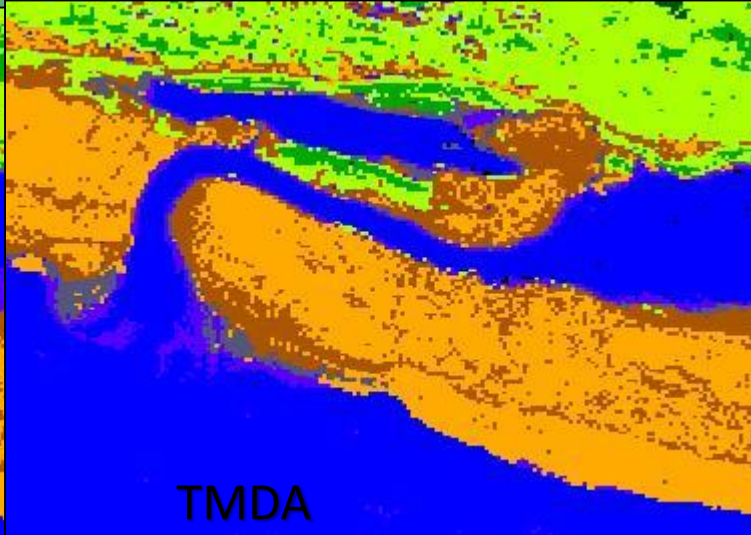
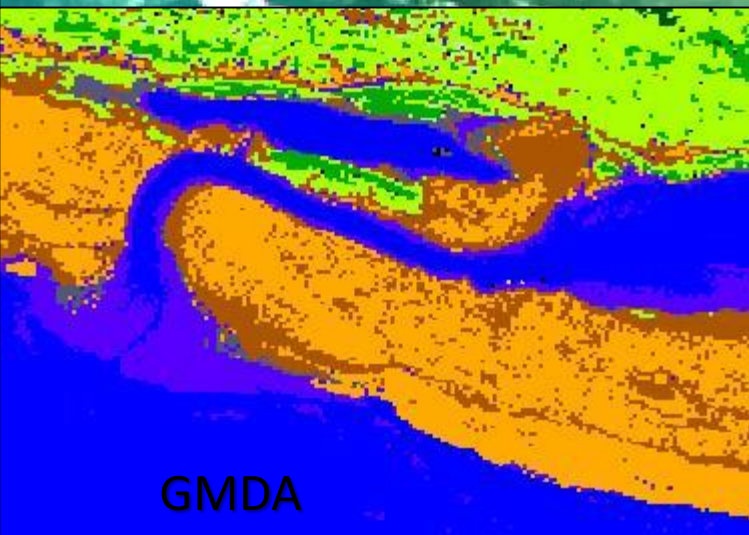
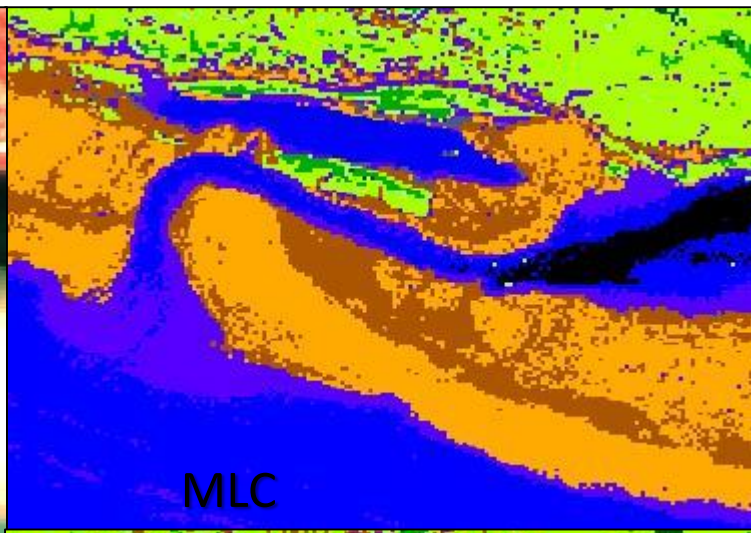
- Unclassified
- Algae
- Bare Ground
- Beach Rock
- Built Up/Urban
- Herbaceous Vegetation
- Beach Sand
- Shadow
- Sparse Vegetation
- Water
- Woody Vegetation

# Results for Area A





# Results for Area B

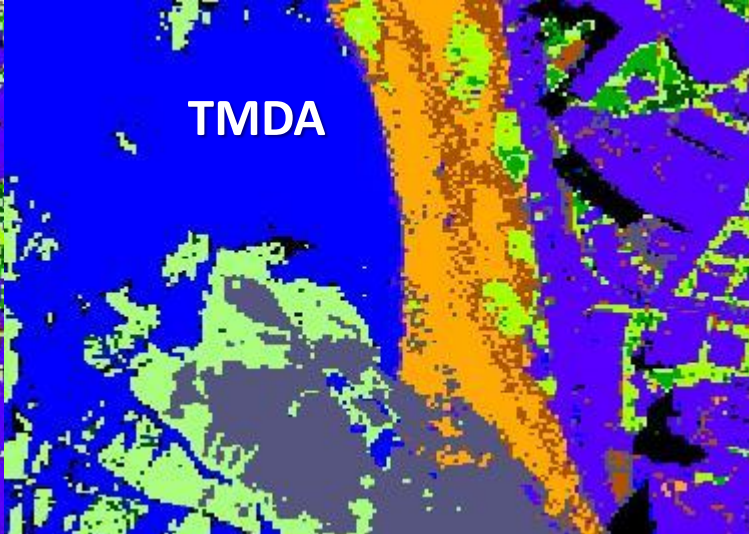
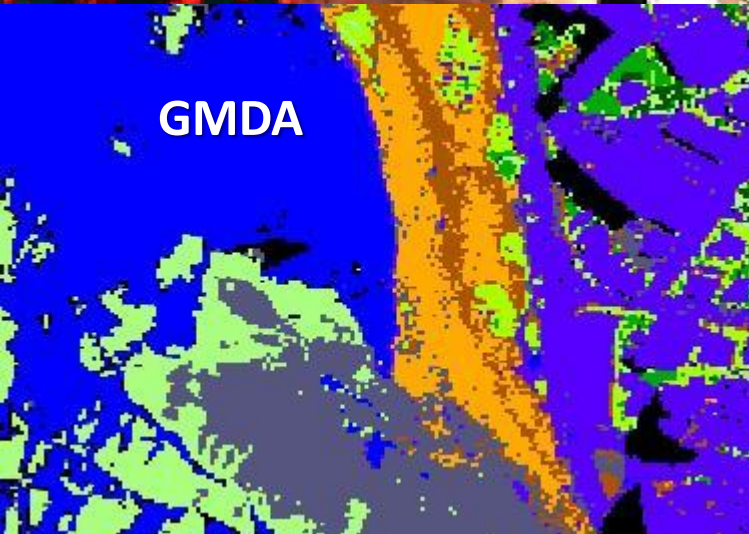
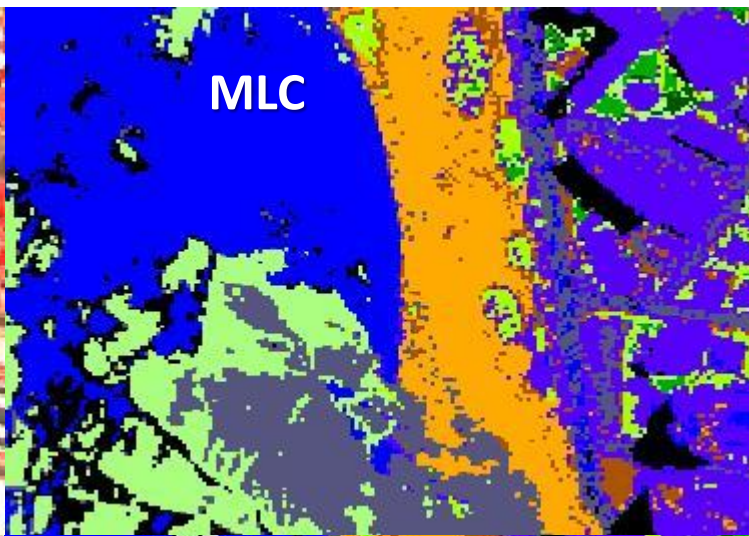


## Legend

- Unclassified
- Algae
- Bare Ground
- Beach Rock
- Built Up/Urban
- Herbaceous Vegetation
- Beach Sand
- Shadow
- Sparse Vegetation
- Water
- Woody Vegetation



# Results for Area C



## Legend

- Unclassified
- Algae
- Bare Ground
- Beach Rock
- Built Up/Urban
- Herbaceous Vegetation
- Beach Sand
- Shadow
- Sparse Vegetation
- Water
- Woody Vegetation

# Validation Areas and Data

- 9154 stratified random points over the entire area from previous Gaussian MDA classification map
- Minimum 48 points per class
- ‘Ground truth’ classes assigned to the pixels by inspection of the WorldView-2 imagery and Google Earth

# Accuracy Assessment

	Maximum Likelihood	Gaussian	<i>t</i> -distribution
Kappa	78.12%	78.99%	79.09%
Overall Accuracy	85.82%	86.27%	86.32%
Quantity Disagreement	3.01%	2.61%	2.27%
Allocation Disagreement	11.16%	11.12%	11.42%
Total Disagreement	14.18%	13.73%	13.68%

# Conclusions

- Classification using MLC, MDA (Gaussian and  $t$ -distributions) was performed
- $t$ -distribution MDA shows accuracies slightly higher than others
- However, visual inspection show  $t$ -distribution MDA performs much better
- May be due to low validation point coverage
- Advantage: MDA requires no time consuming splitting of classes

# Way Forward

- Consideration of skew distribution mixtures
- Automated optimisation of number sub-classes
- Sub-pixel consideration using Sentinel or Landsat imagery
- Multi-date imagery for change detection

**Thank you**



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