Topic : Advanced Remote Sensing III - Monitoring

Coastal Wetland Monitoring by High-Resolution Satellite Imagery

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4:40 pm, June 6, 2012, Room: Curacao 5 & 6, Orlando, Florida, USA

Outline

- Introduction
- Scope of Works
- Study Area and Materials
- Methodology
  - ✓ Spatial Autocorrelation
  - ✓ Local Spatial Autocorrelation
  - ✓ Image Classification
- Results and Discussions
- Conclusions

(a)

(b)

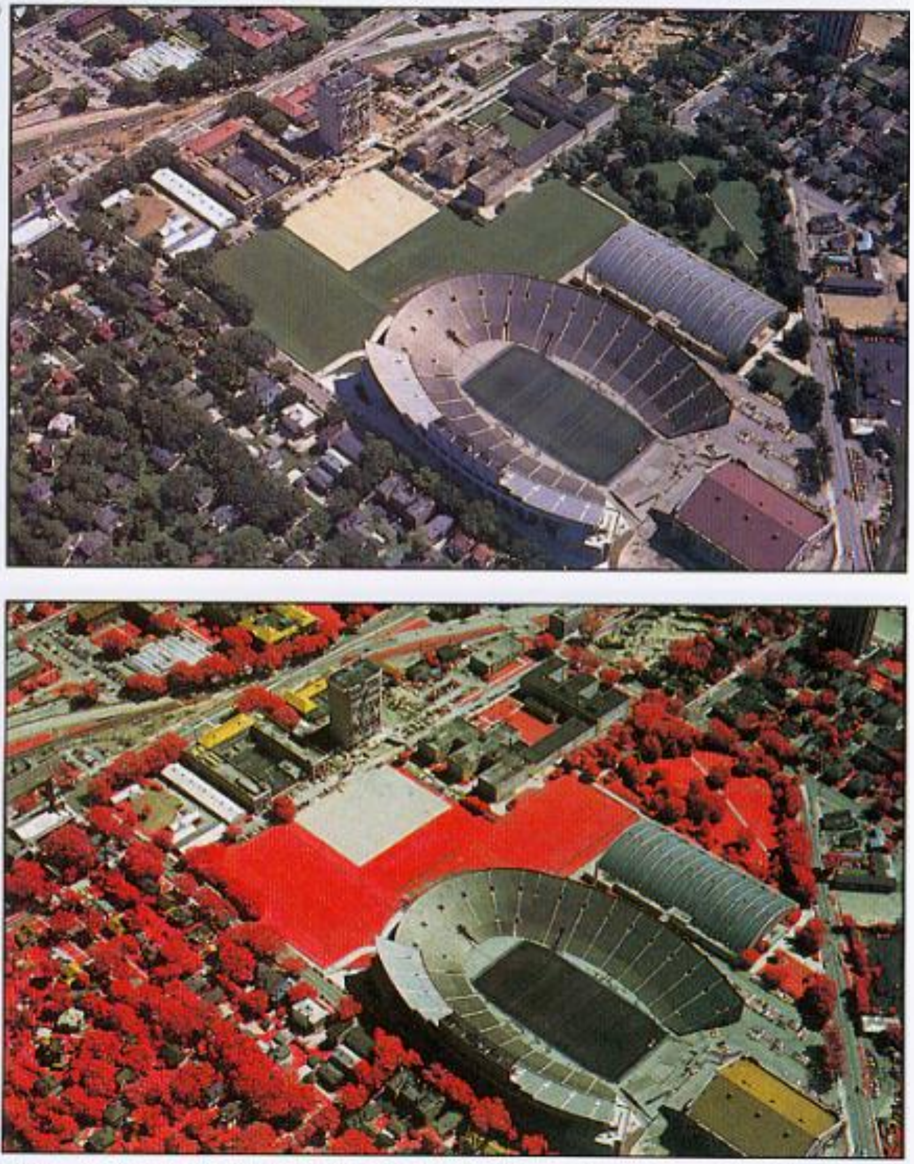


Plate 3 Oblique normal color (a) and color IR (b) aerial photographs showing a portion of the University of Wisconsin-Madison campus. The football field has artificial turf with low near-IR reflectance. (For major discussion, see Section 2.9.)

(a)

(b)

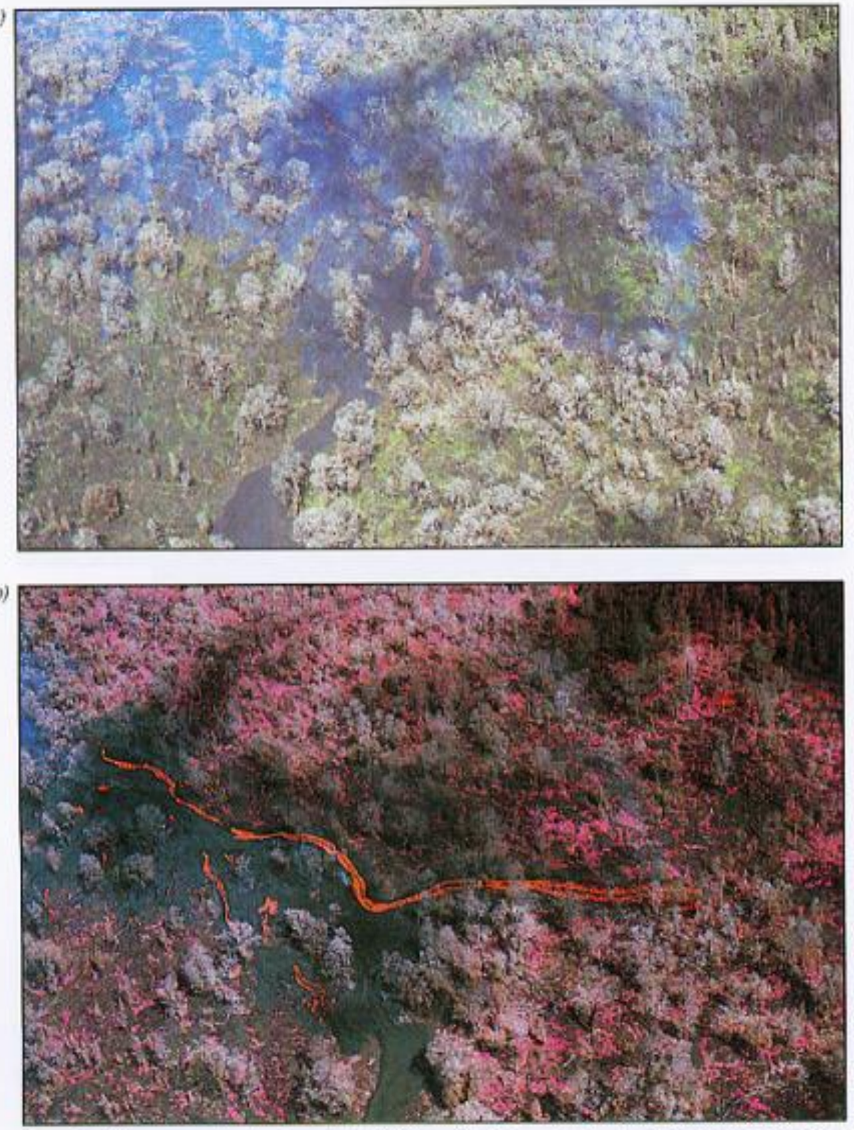


Plate 4 Oblique normal color (a) and color IR (b) aerial photographs showing flowing lava on the face of Kilauea Volcano, HI. The orange tones on the color IR photograph represent IR energy *emitted* from the flowing lava. The pink tones represent sunlight *reflected* from the living vegetation. (For major discussion, see Section 2.8.)

Introduction

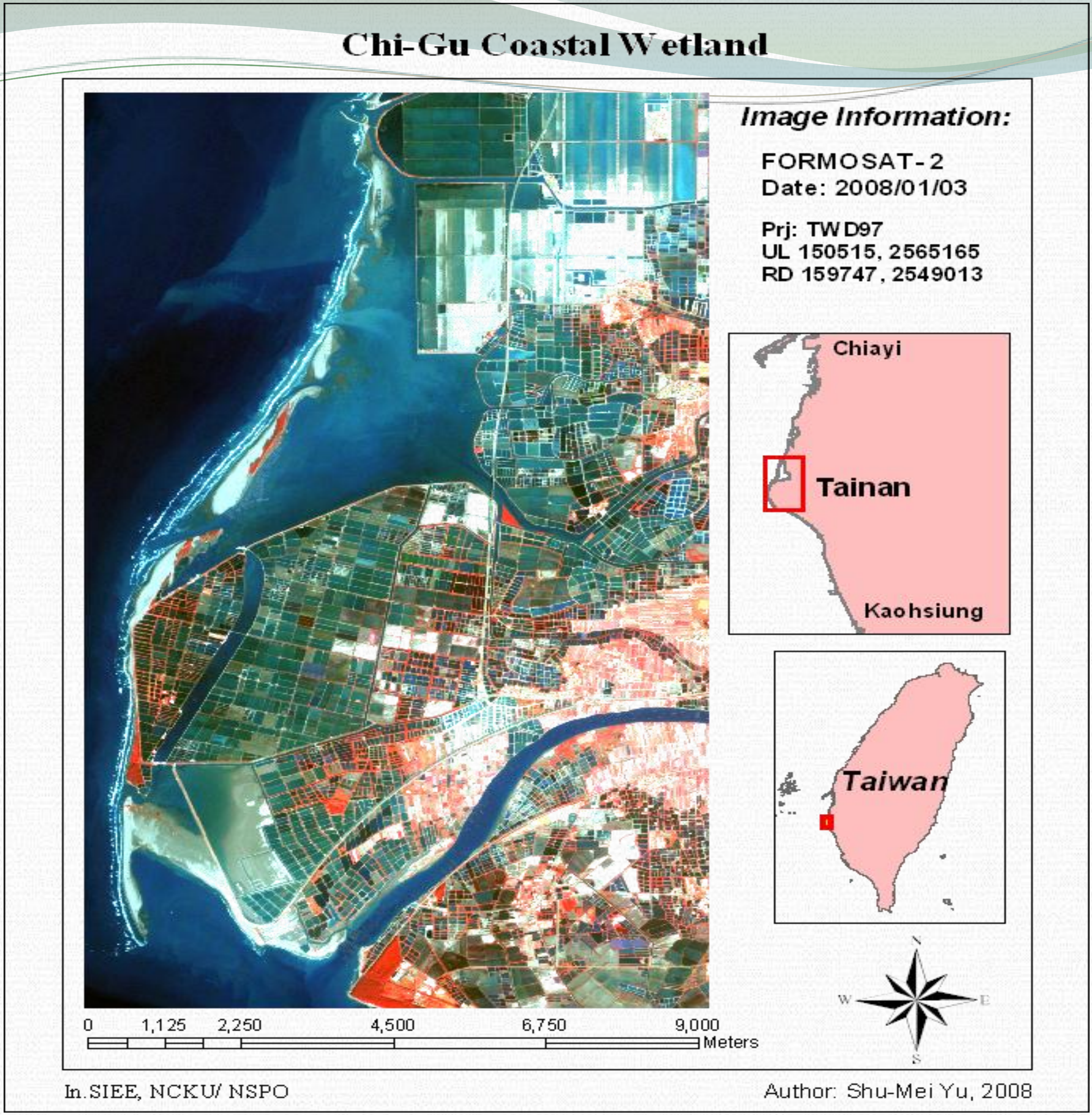
- Wetland is an ecosystem locating between the water and continent with high primary production.
- The net production of a costal wetland is better than any other kinds of ocean system.
- Monitoring and evaluation are the basic work for environmental protection and management.

Scope of Works

- Monitor and evaluate environment change of coastal wetland
- Multi-temporal satellite image process and Geographic Information System (GIS) are adapted to perform the investigation
- Wetland environmental changes and spatial statistical analyses

Study Area and Materials (1/2)

- The study area, the Chi-Gu Coastal Wetland, is located in the southwestern part of Taiwan. It is the largest wetland in Taiwan.
- The complex ecosystem includes the sandbars, the lagoon, and the estuary.
- The area is known for the habitat of the endangered water bird, the Black-faced Spoonbills.


Chi-Gu Coastal Wetland
Image Information:
FORMOSAT-2
Date: 2008/01/03
Prj: TWD97
UL 150515, 2565165
RD 159747, 2549013
Chiayi
Tainan
Kaohsiung
Taiwan
0
1,125
2,250
4,500
6,750
9,000
Meters
N
W
E
S
In.SIEE, NCKU/ NSPO
Author: Shu-Mei Yu, 2008

Study Area and Materials (2/2)

- Multi-temporal satellite images were used for spatial statistical analyses.
- Geographic Information System (GIS) are adapted to perform the measurement for environmental changes.
- Establish the Wetland Evaluation Indices (WEI) based on the remote sensing and GIS techniques.

Season	Date	Time	Season	Date	Time
Winter (Dry)	2004-12-10	09:46:17	Summer (Wet)	2005-07-23	09:52:26
	2006-02-05	09:57:23		2006-08-12	10:01:52
	2006-12-06	10:03:49		2007-07-04	10:08:52
	2008-01-03	10:15:39			

Methodology (1/9)

Spatial Autocorrelation

- Most of geo-features would have shown a spatial autocorrelation.
- A non-random spatial pattern may show either positive or negative spatial autocorrelation.
- Negative spatial autocorrelation is characterized by a tendency for dissimilar values to cluster in proximate locations.

Methodology (2/9)

- Spatial autocorrelation provided with some physical meanings in statistics.
- It provides analysis in remote sensing image classification without subjective training data collection.

Methodology (3/9)

- The distance between core and neighborhood extent was depending upon the kernel size or the spatial lag. A 3x3 kernel size was employed to process the spatial autocorrelation.

Methodology (4/9)

Local Spatial Autocorrelation

- Anselin (1995) subsequently proposed *Local Indicators of Spatial Autocorrelation* (LISA) as a general means for decomposing global autocorrelation measurements
- The individual contribution of each observation can be assessed, as well as the local “hot spots”.

Methodology (5/9)

Local Spatial Autocorrelation

- The local *Getis-Ord Gi* can be used to identify the negative autocorrelation. However, this property is rather rare in images.

Methodology (6/9)

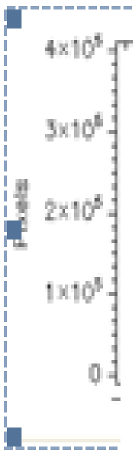
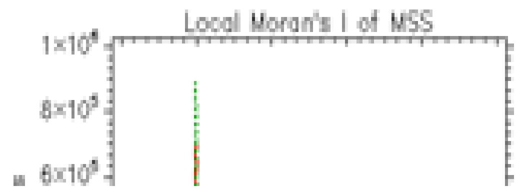
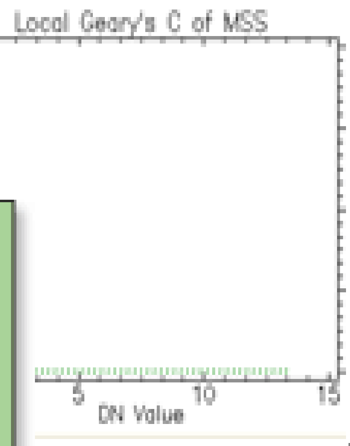
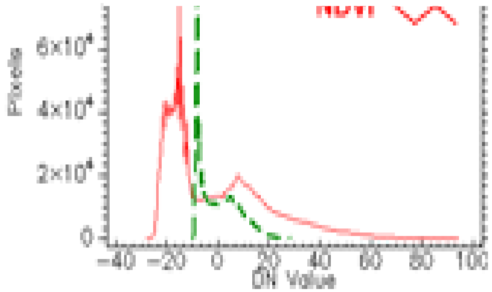
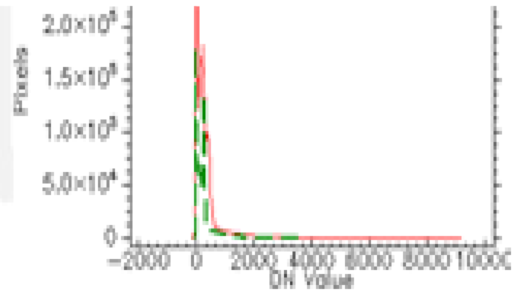
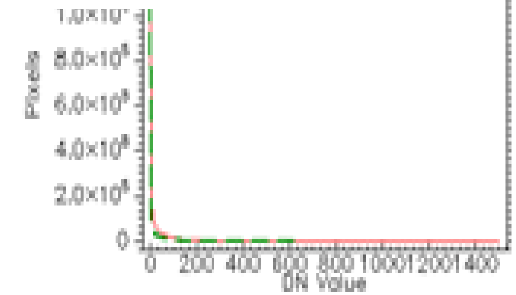
- The purpose of local spatial autocorrelation in image processing was to enhance the difference between the geo-features on image as well as to improve the classification accuracy.

$$G_i(d) = \frac{\sum_j w_{ij}(d)x_j - W_i x}{s[W_i(n - W_i)/(n-1)]^{1/2}}, \; j \neq i$$

Where: $W_i = \Sigma_j w_{ij}(d)$

$w_{ij}(d)$ is the weighted spatial lag distance "d" between pixels *i* and *j*

and x_i and x_j are the DN values of pixels i and j.

Methods	Getis Gi	Local Moran's I	Local Gery's C
Histograms MS			
Histograms Ratio Images			
Pattern Extraction	Hot Spots	Cluster	Variability

Methodology (7/9)

Image Classification

- Classification procedures were usually employed for the multi-spectrum images directly.
- The *Getis-Ord Gi* spatial autocorrelation images and extract local spatial autocorrelation layers
- Integrated NDVI and GNDVI is to enhance the pattern of vegetation and water-body on image.

Methodology (8/9)

- Extract the geo-feature parameters, including NDVI and GNDVI.
- Extract the spectrum image layers which were produced from spatial autocorrelation:

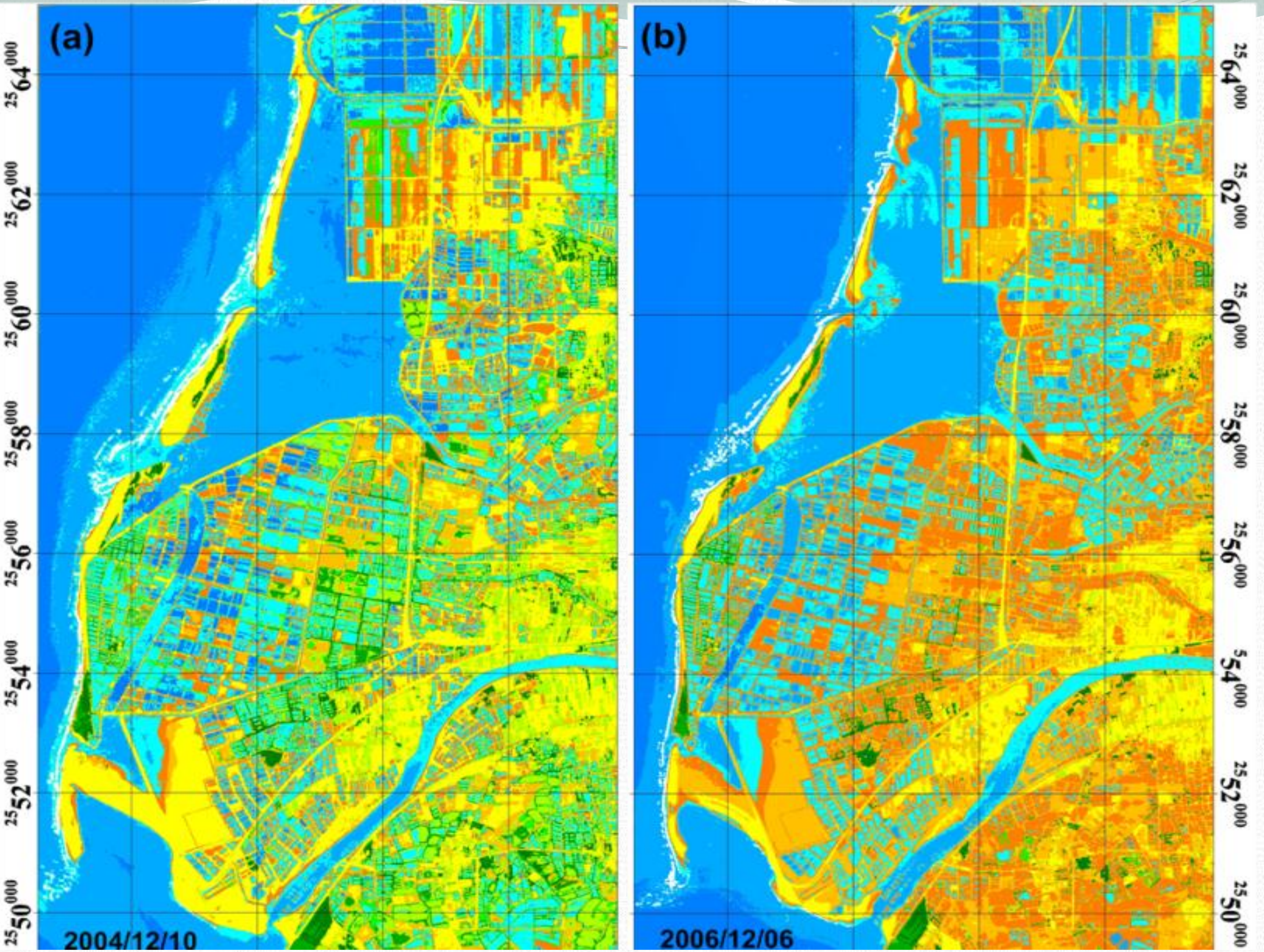
(1) R Getis-Ord Gi

(2) G Getis-Ord Gi

(3) NIR Getis-Ord Gi.

Methodology (9/9)

- Integrate the NDVI, GNDVI and three spatial autocorrelation spectrum images for K-means classification.

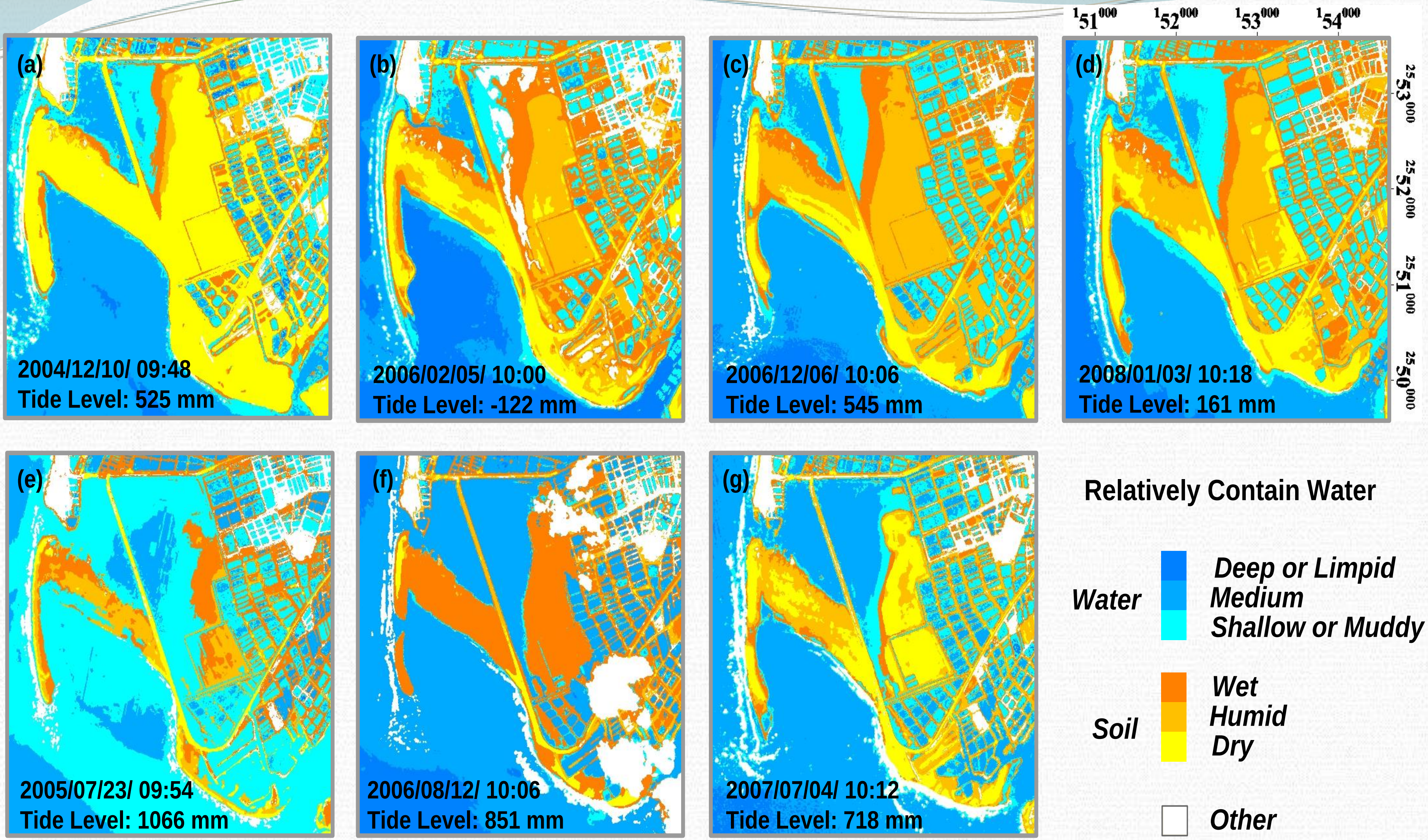


(a)
(b)
2004/12/10
2006/12/06
$^{25}64^{000}$
$^{25}62^{000}$
$^{25}60^{000}$
$^{25}58^{000}$
$^{25}56^{000}$
$^{25}54^{000}$
$^{25}52^{000}$
$^{25}50^{000}$

Results and Discussions

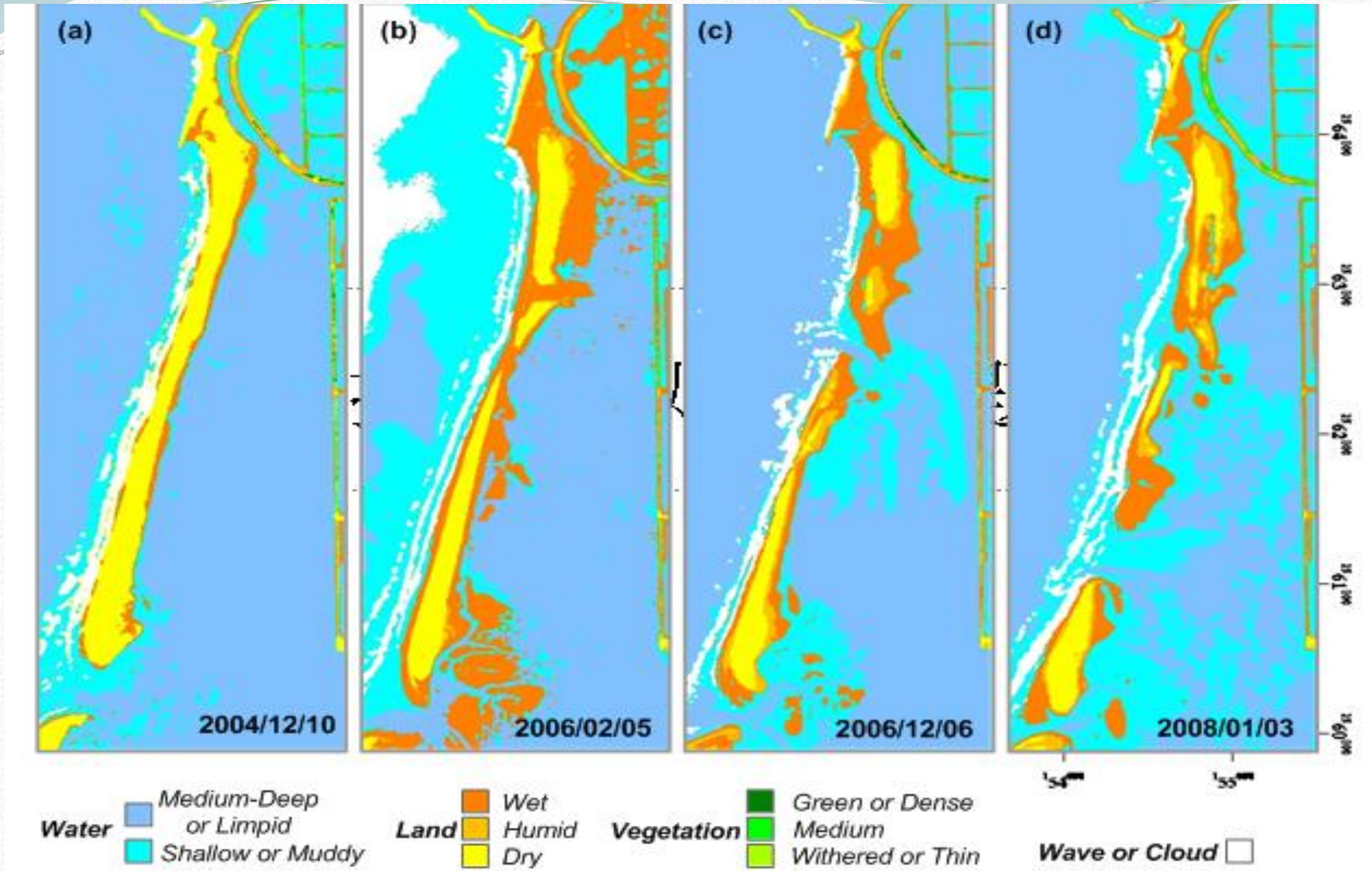
Wetland Soil Moisture Investigation

- In winter, the rainfall and rainy days are fewer than summer.
- The soil moisture is controlled by elevation, and the area of dry soil will be greater than summer days.
- Dry soil can to be regarded as stable soil body.



* Dry soil decrease

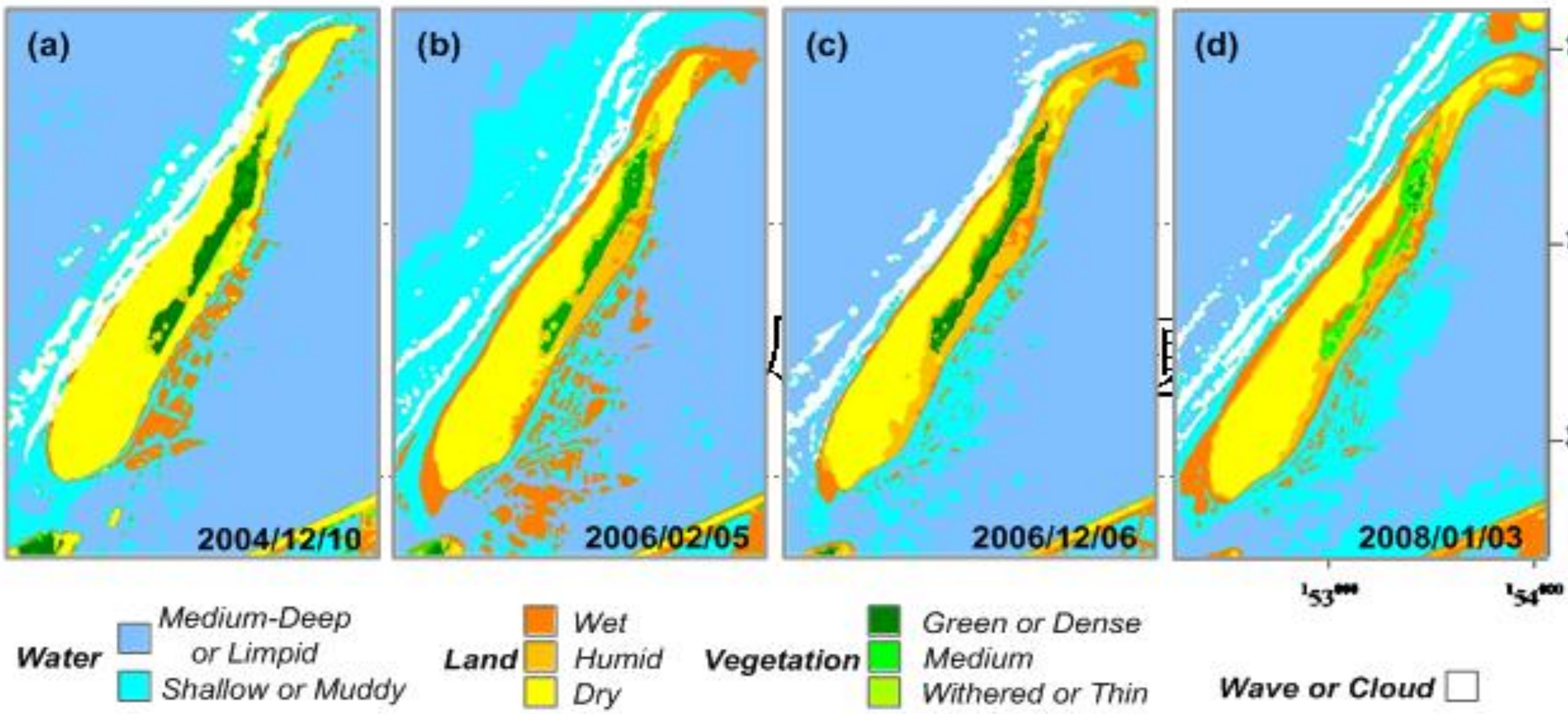
* Shallow water increase



* Dry soil decrease

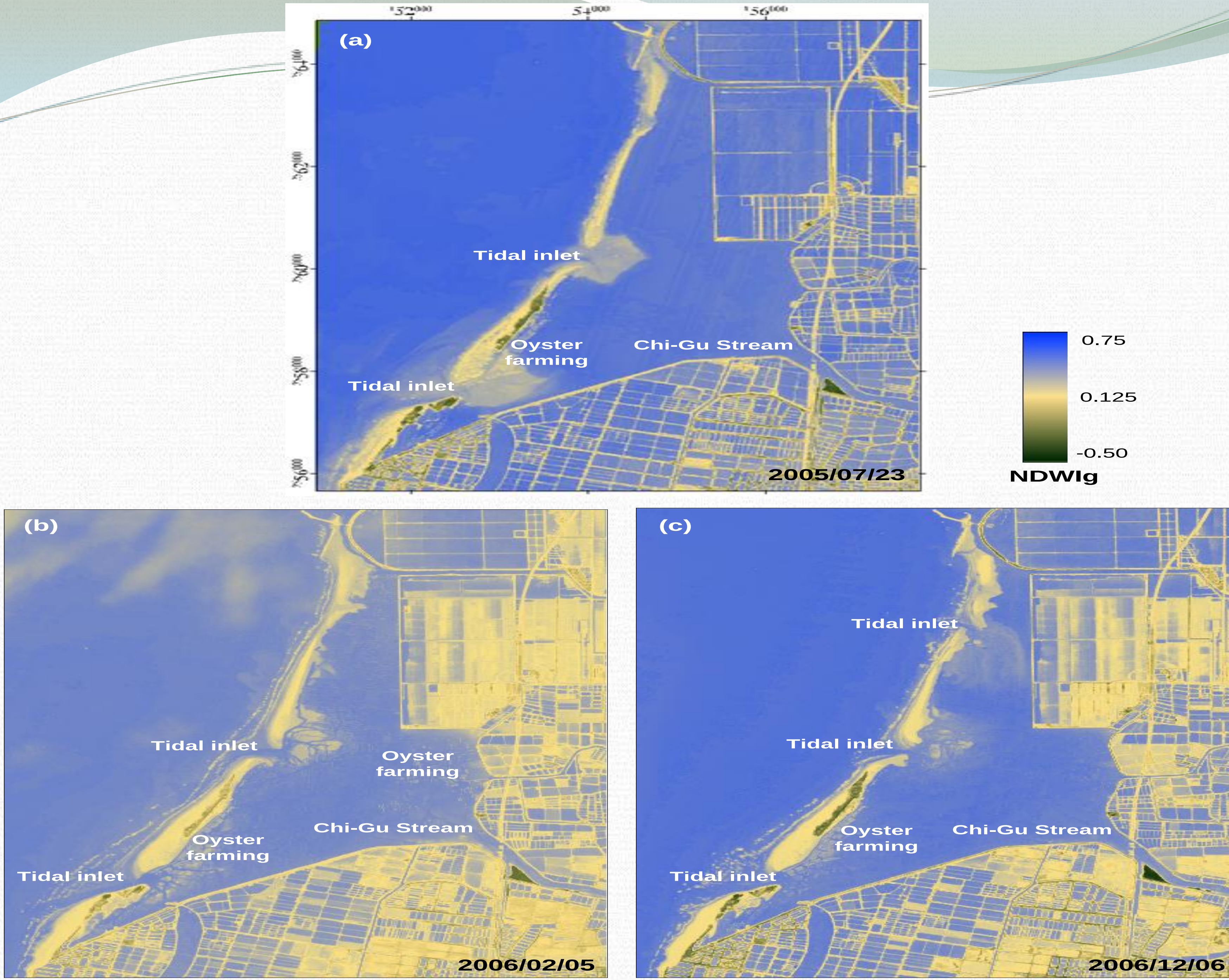
* Shallow water increase

- The vegetation was controlled by erosion process, the vegetation density was controlled by land area, and the stable soil body was also reduced from 2004 to 2008.

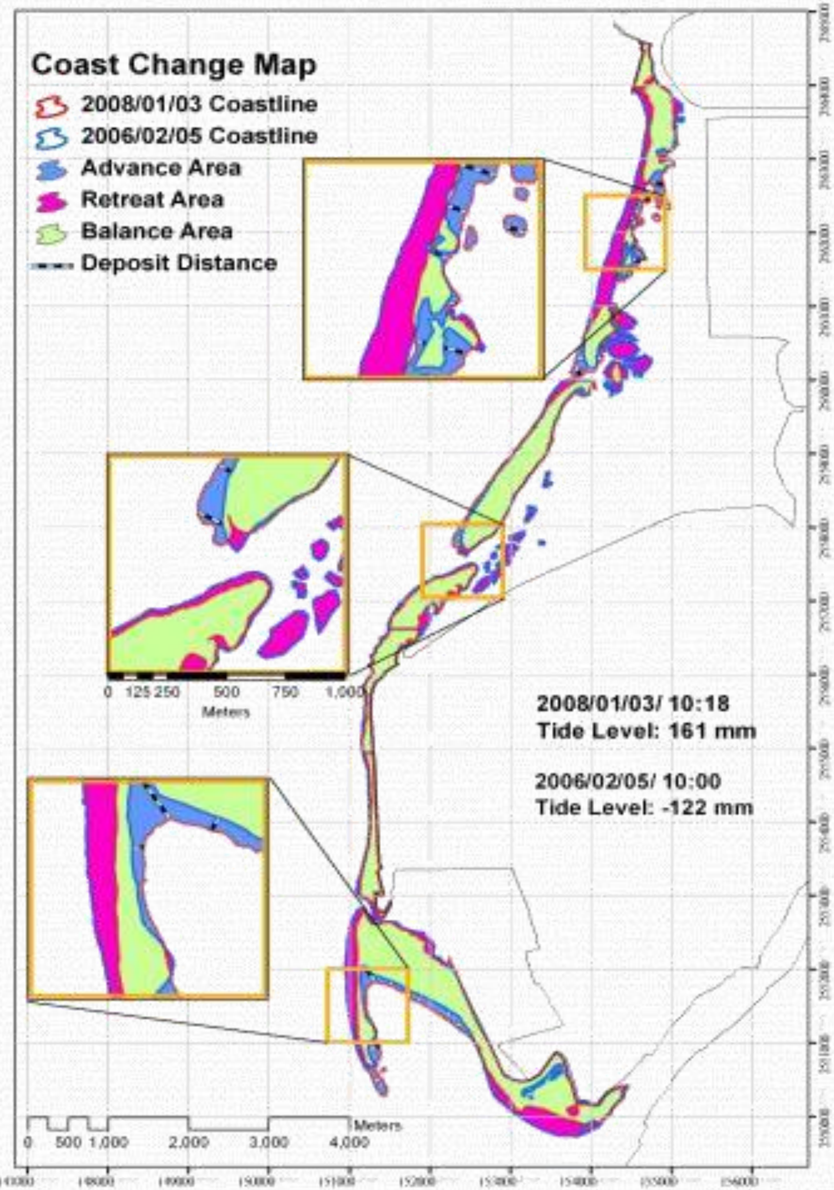


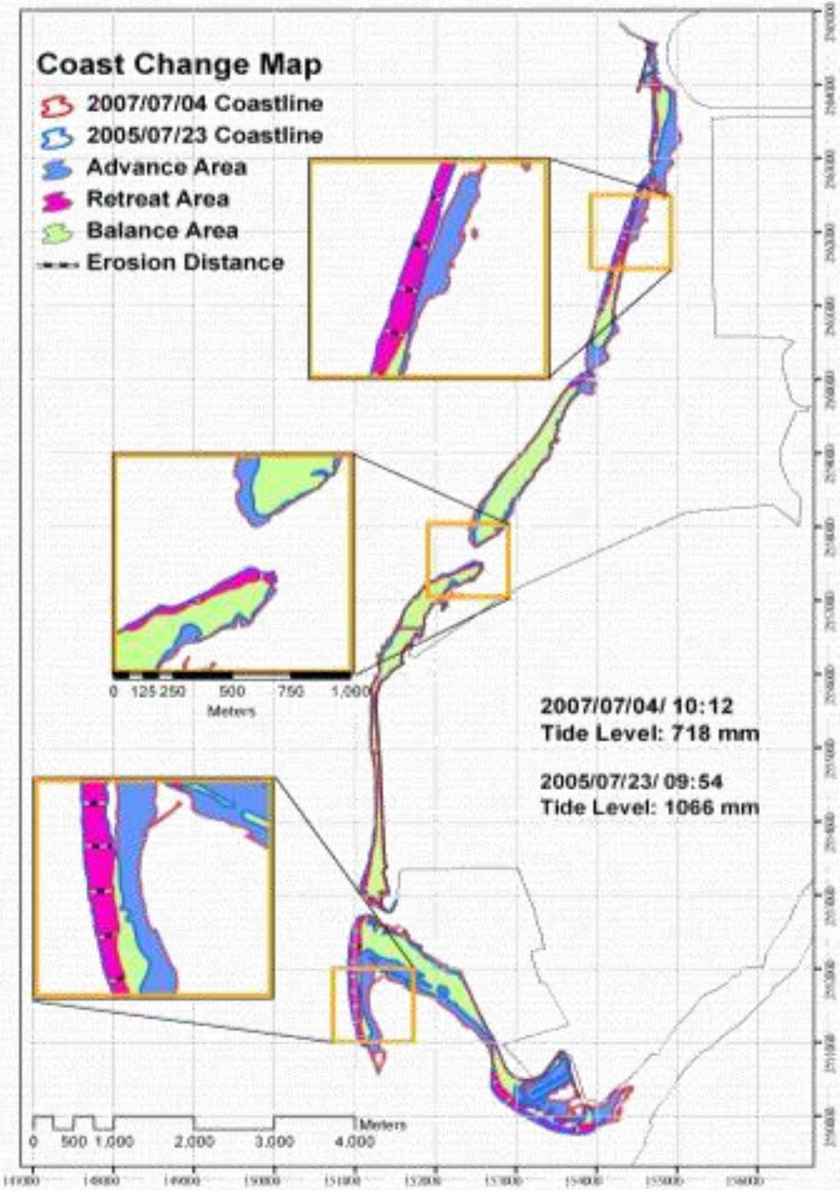
The Stagnate Source of Lagoon

- The environmental changes in this area have given the evidence of differences at the seasonable shaking and the spatial location.
- There are also the influence factors of changes: rainfall, typhoon, tide, vegetation distribution, and human activities.



(a)
Tidal inlet
Oyster farming
Chi-Gu Stream
Tidal inlet
2005/07/23
0.75
0.125
-0.50
NDWIg
(b)
Tidal inlet
Oyster farming
Chi-Gu Stream
Oyster farming
Tidal inlet
2006/02/05
(c)
Tidal inlet
Tidal inlet
Oyster farming
Chi-Gu Stream
Tidal inlet
2006/12/06


Coast Change Map
2008/01/03 Coastline
2006/02/05 Coastline
Advance Area
Retreat Area
Balance Area
Deposit Distance
0 125 250 500 750 1,000
Meters
2008/01/03/ 10:18
Tide Level: 161 mm
2006/02/05/ 10:00
Tide Level: -122 mm
0 500 1,000 2,000 3,000 4,000
Meters


Coast Change Map
2007/07/04 Coastline
2005/07/23 Coastline
Advance Area
Retreat Area
Balance Area
Erosion Distance
0 125 250 500 750 1,000
Meters
2007/07/04/ 10:12
Tide Level: 718 mm
2005/07/23/ 09:54
Tide Level: 1066 mm
0 500 1,000 2,000 3,000 4,000
Meters

Conclusions

- Satellite images can be used for short-term investigation to realize the wetland changes caused by hazardous event.
- Local spatial autocorrelation should provide objective classification in training stage.
- Spatial autocorrelation also enhances the pattern of the vegetation as well as the water-body on the image.

Thank You !

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