DRAGON 4 ID. 32405

Monitoring Dynamics of Coastal Wetlands and Suspended Sediment with High (Temporal/Spatial/Spectral) Resolution Satellite Images(32405)

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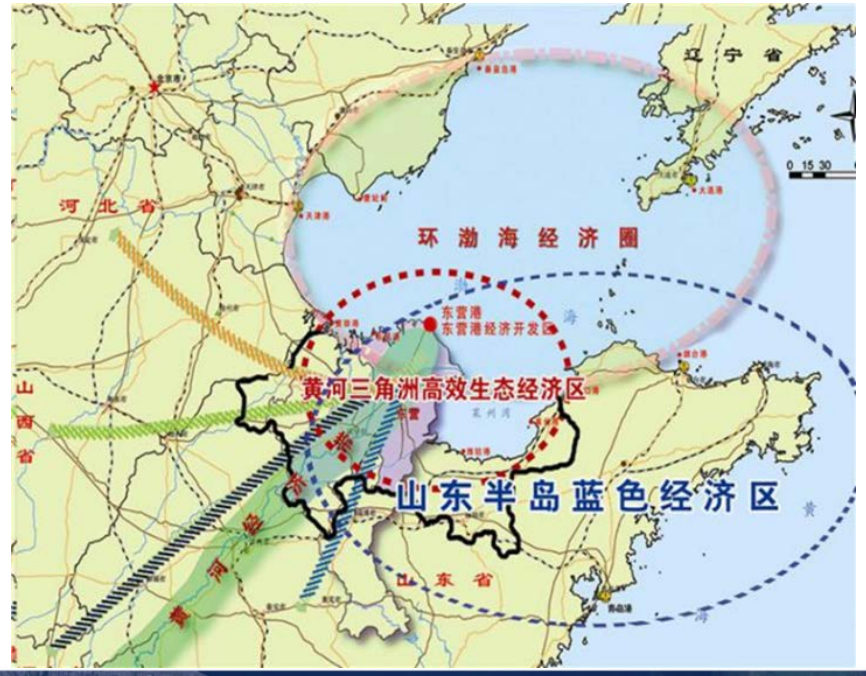
- Atmosphere correction of ENVISAT MERIS over European coastal turbid waters
- Coastal wetland classification based on high resolution SAR and optical images
- Estimation of coastal wetland carbon storage capacity by GF-1 WFV satellite image
- Coral reef bleaching monitoring based on WorldView-2 and GF-2 satellite images

Part I : Overview of the project

Motivation

China's coastal zone is now experiencing fast changes due to the significant socio-economical implications and the intense human activity, requiring high resolution data, in the temporal, spatial or spectral dimensions to derive more subtle and detailed information from the earth observation data.



Objective

- To explore and demonstrate the technical possibility and capability of high resolution remote sensing for monitoring:
  - coastal wetlands of the Yellow River estuary
  - suspended sediment in the Bohai Sea
- To develop new multi- and hyperspectral remote sensing methods to derive estuarine wetlands biomass, SPM, and carbon storage.

Sub-projects

32405_1: Synergistic ocean color observation based on polar-orbiting and geostationary satellite images

a). Validating the SPM ocean color products from polar orbiting and geostationary satellite images

b). Developing SPM retrieval method based on synergistic utilization of polar orbiting and geostationary satellite images

c). Characterizing the spatio-temporal pattern and variability of SPM in the Bohai Sea by time series of satellite images

32405_2: Wetlands monitoring using high resolution remote sensing images in Yellow River estuary

a). Estuarine wetlands classification using hyper-spectral remote sensing imagery

b). Estuarine wetlands carbon storage monitoring using hyper-spectral remote sensing imagery

c). Estuarine wetlands change monitoring using high resolution remote sensing images

Project's Partners and Roles

Dr. Shubha Sathyendranath(LI), Merit Scientist, Plymouth Marine Laboratory,UK (Remote sensing, ocean optics).

Dr. Tingwei CUI(LI), Professor, First Institute of Oceanography (FIO), State Oceanic Administration (SOA), China. Major: ocean optics and ocean color remote sensing;

Dr. Yi MA(PI), Professor, First Institute of Oceanography (FIO), State Oceanic Administration (SOA), China, Major: coastal zone optical remote sensing.

Dr. Stefan Simis, Plymouth Marine Laboratory, Senior scientist, Plymouth Marine Laboratory(Remote sensing of inland waters, phytoplankton ecology)

Dr. Guifen Wang Plymouth Marine Laboratory

Dr. Guangbo REN, First Institute of Oceanography (FIO), State Oceanic Administration(SOA), China, PhD Candidate, Major: optical remote sensing.

Dr. Yanfang Xiao, First Institute of Oceanography (FIO), State Oceanic Administration (SOA), China. Major: ocean color remote sensing.

Dr. Rongjie Liu, Associate professor, First Institute of Oceanography (FIO), State Oceanic Administration (SOA), China. Major: ocean color remote sensing.

Dr. Bing Mu, Ocean University of China. Major: ocean color remote sensing.

Dr. Ping Qin, Ocean University of China. Major: ocean color remote sensing.

Satellite data

ESA

- Sentinel-2/3, SPOT-5, SPOT-6, PROBA CHRIS……

CHINESE

- GF-1/2/3/4, HJ-1 CCD, FY,……

TPM

- GOCI, Landsat-8 OLI, Landsat TM/ETM+, ALOS, ……

Expected outcome

- New method of monitoring SPM by synergistic use of geostationary and polar-orbiting optical images.
- New ocean color products (e.g. SPM concentration) with high spatial and temporal resolutions will be developed for turbid waters along China coast.
- Uncertainties of ocean color products from Sentinel-2/3 products in the turbid waters along China coast.
- New biomass/carbon storage hyper-spectral retrieval model of estuarine wetlands types using new hyper-spectral remote sensing images.
- Automatic wetland classification method using high resolution remote sensing images.

Research progress

1. Evaluation, processing and application of China's geostationary optical satellite GF-4

2. Atmosphere correction of ENVISAT MERIS over European coastal turbid waters

3. Coastal wetland classification based on high resolution SAR and optical images

4. Estimation of coastal wetland carbon storage capacity by GF-1 WFV satellite image

5. Coral reef bleaching monitoring based on WorldView-2 and GF-2 satellite images

Publications

1. Qin et al., MERIS atmosphere correction, submitted to RSE
2. Chen et al., GF-4 monitoring of macro-algal bloom, submitted to JRS
3. Cui et al., GF-4 evaluation and application, in prep.
4. Chen et al., Long-term changes of Chla in the Bohai Sea, in prep.
5. Cui et al., Environment issue of the Bohai Sea and its demands on optical remote sensing, in prep.
6. Liu et al., GF-4 monitoring of red tide in Bohai Sea, in prep.

Summary on progress and collaboration

- All works have been carried out as scheduled, exploring the satellite images from the Chinese and European sides, from the geostationary and polar orbits, and from the optical and microwave sensors.
- Collaboration mechanism between European and Chinese scientists has been built. Chinese young scientist (Dr. Qin Ping) has taken a one-year visit to PML for collaboration.

Plans for the next 2 years

- Collect the field and satellite data;
- Validate the ocean color products derived from Sentinel-3 and GOCI and GF-4 over the turbid waters along China coast.
- Improve the results and publish co-authored papers.
- Invite British colleagues to China to give lectures.
- Send Chinese young scientist to PML for a short visit.

Part II： Specific research progresses

1. Preliminary evaluation, processing and application of China's geostationary optical satellite GF-4

GF-4 specifications

	ID	Spectral range（μm）	Spatial Resolution（m）	Imaging swath（km）	Time between two images
Pan	1	0.45~0.90	50	400	20s
Visible & NIR	2	0.45~0.52			
	3	0.52~0.60			
	4	0.63~0.69			
	5	0.76~0.90			
MWIR	6	3.5~4.1	400		

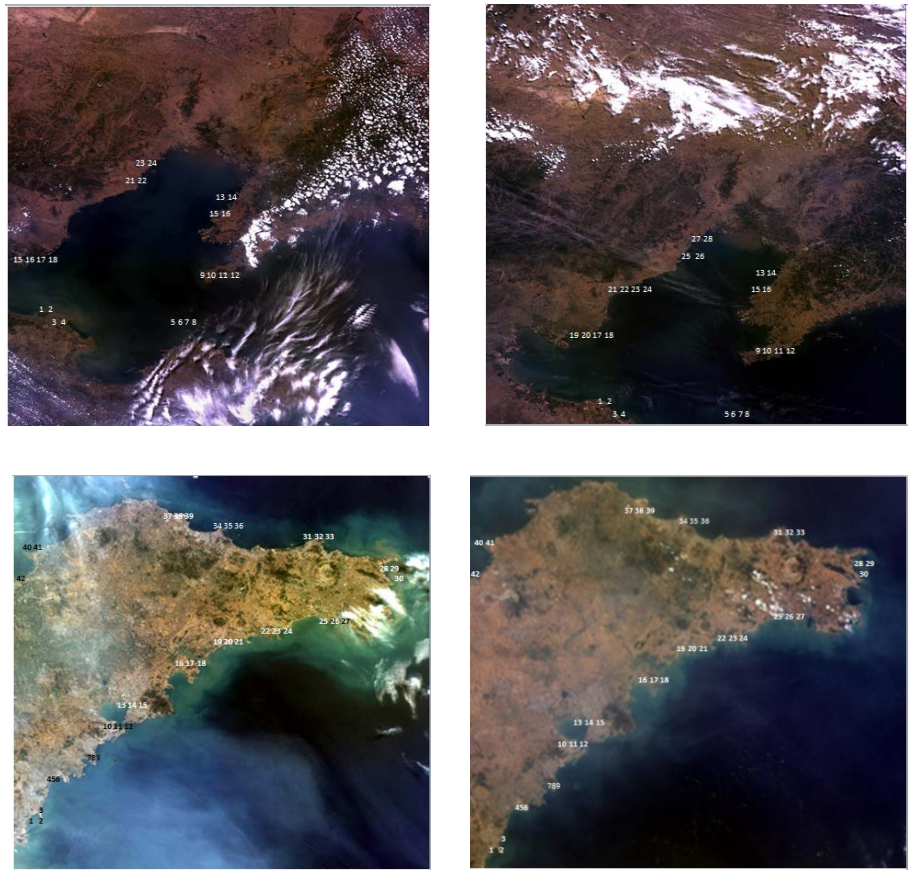
Evaluation of GF-4 image autonomous positioning accuracy

Study area：Bohai Sea and Yellow Sea

Method： using 70 homonymous points derived from georeferenced HJ-1A-CCD images as ground truth.

Positioning error：160-4400m，average 2284±2124m

Images covering the same area at different time have similar positioning accuracy.

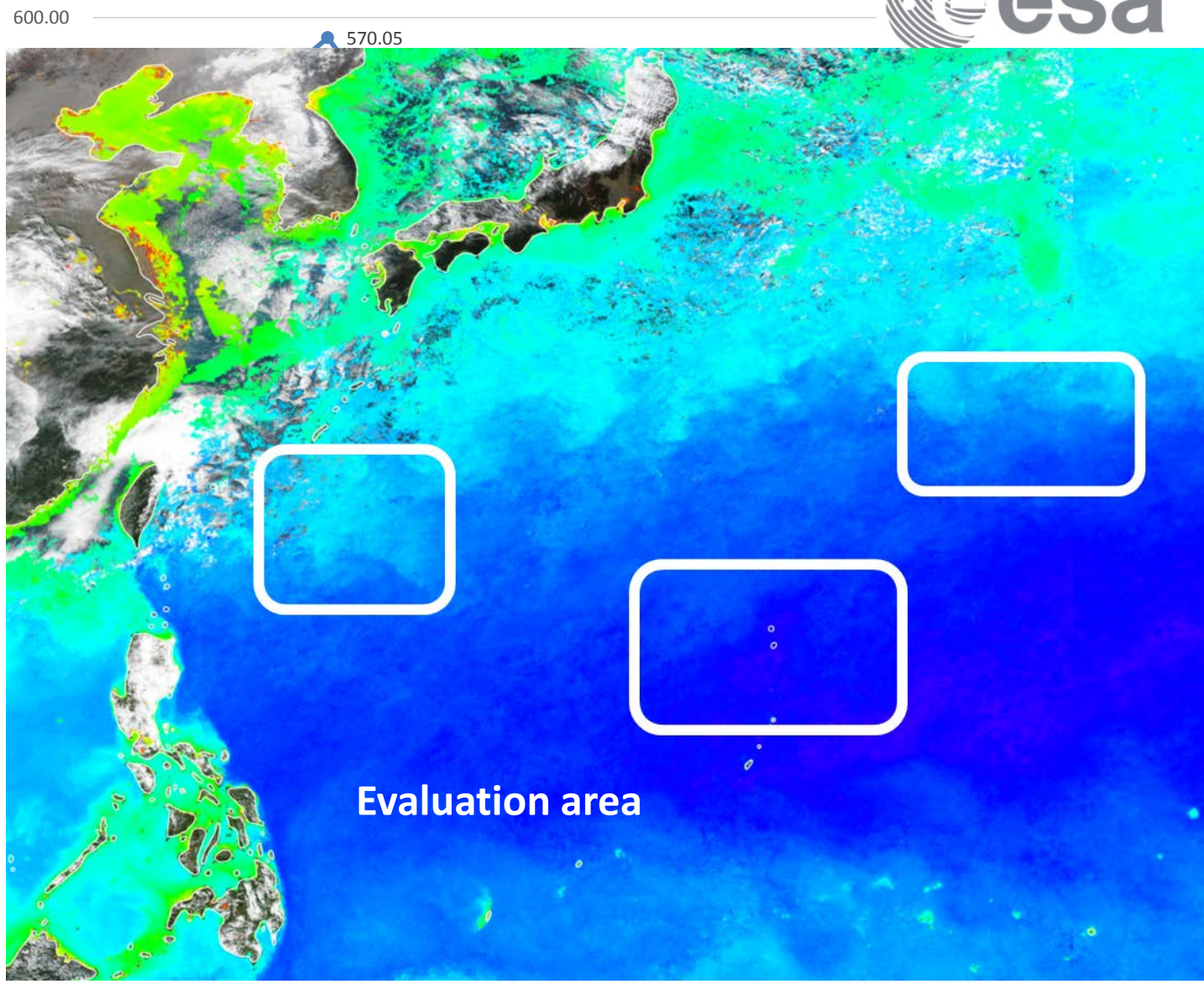


GF-4 images and positioning point distribution

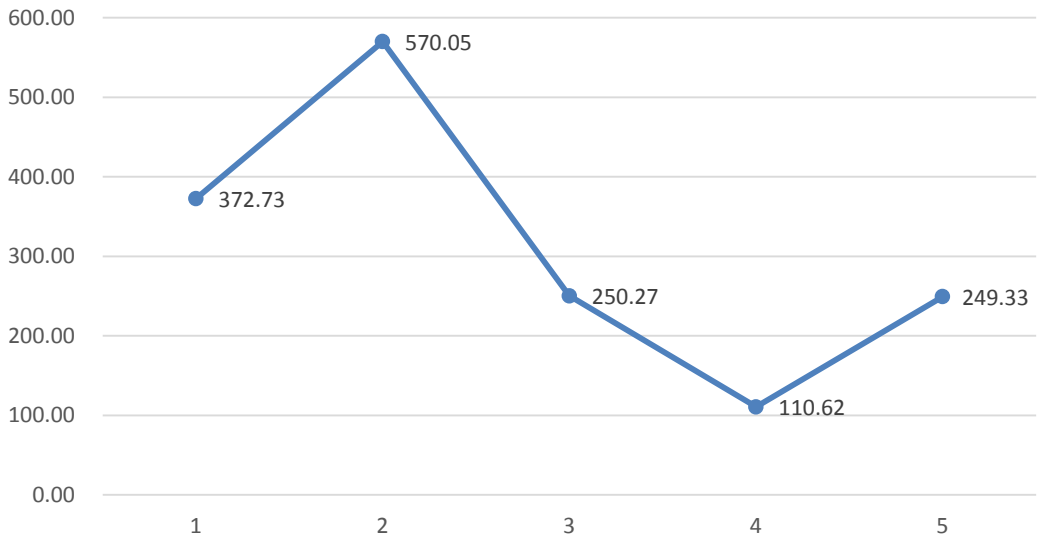
SNR evaluation of GF-4

Method:

- 4 Cloud-free (Level 1b) GF-4 images were selected.
- The “clearest” water were identified.
- The spectral radiances of 3×3 pixel boxes were extracted.
- The mean and standard deviation (STD) were calculated.
- The SNR was calculated using the following formula: **SNR = Mean / Stdev**



SNR evaluation results

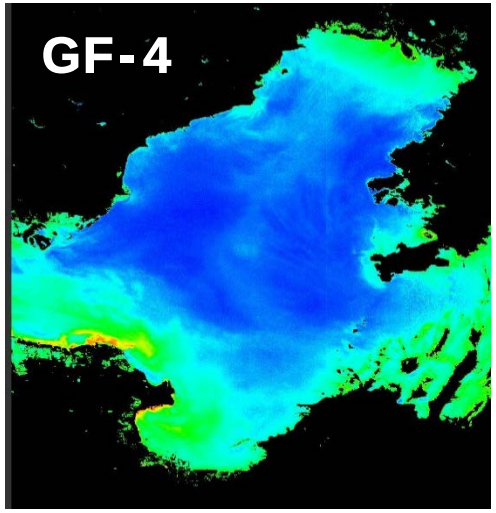


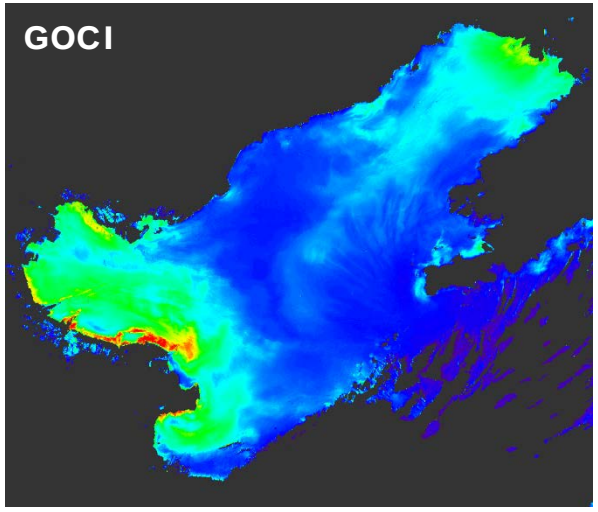
Band	Spectral range（μm）	SNR
1	0.45~0.90	372
2	0.45~0.52	570
3	0.52~0.60	250
4	0.63~0.69	110
5	0.76~0.90	249

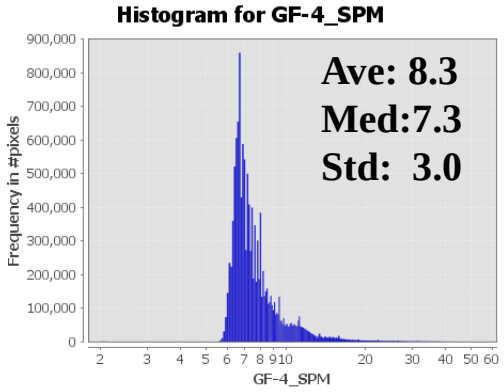
- The blue band has the highest SNR.
- More images are needed for further test.

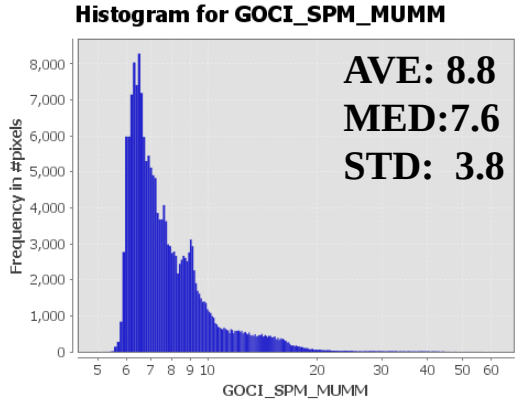
SPM estimation

GF-4 vs. GOCI

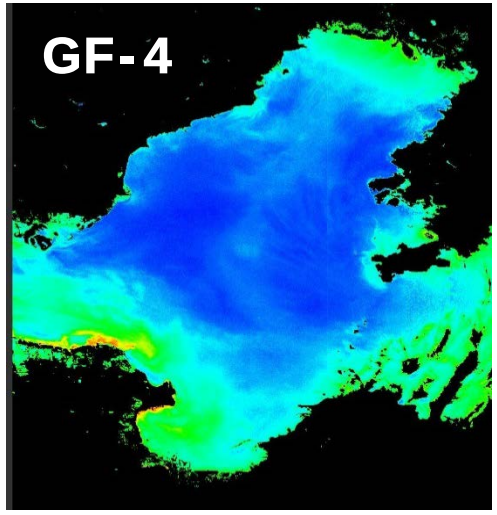


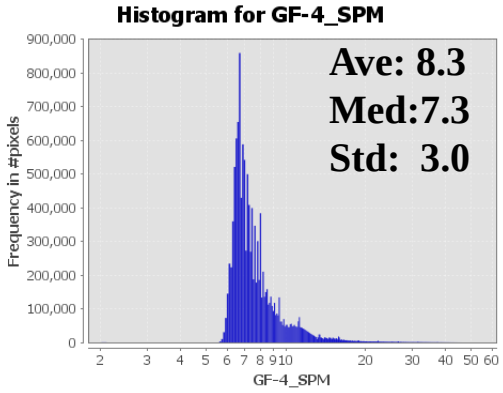


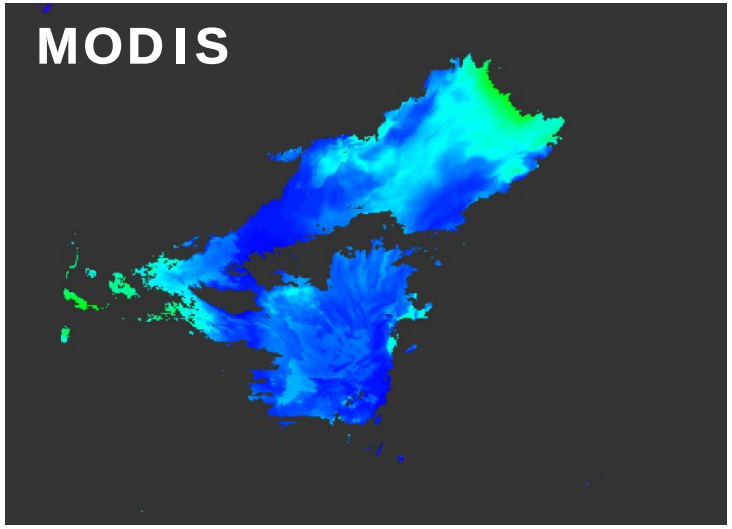


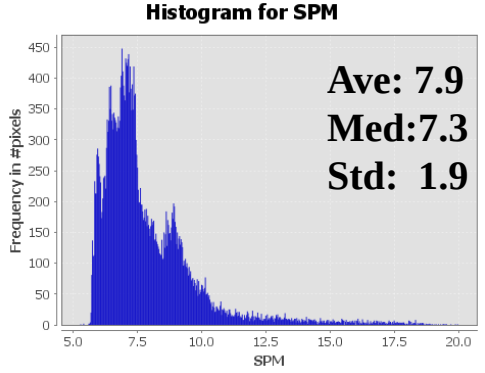


GF-4 vs. MODIS

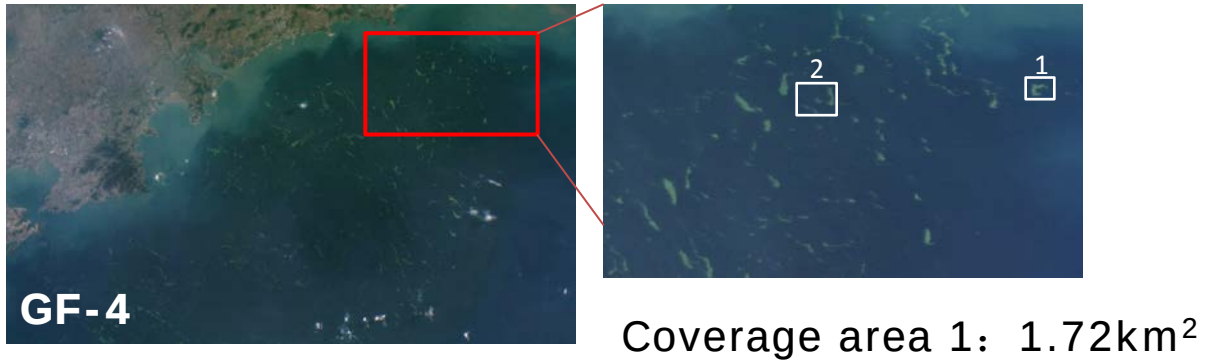

GF-4


Histogram for GF-4_SPM
Ave: 8.3
Med:7.3
Std: 3.0
Frequency in #pixels
GF-4_SPM


MODIS


Histogram for SPM
Ave: 7.9
Med:7.3
Std: 1.9
Frequency in #pixels
SPM

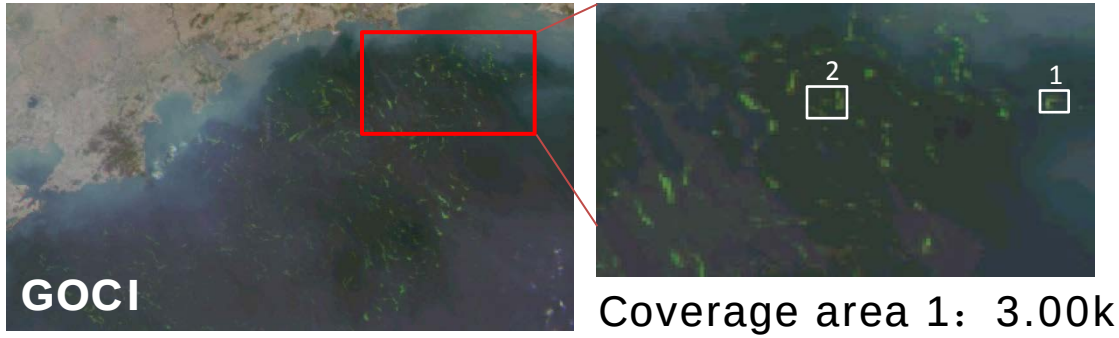
Green tide monitoring



2016.6.25

Coverage area 1：1.72km²

Coverage area 2：2.62km²

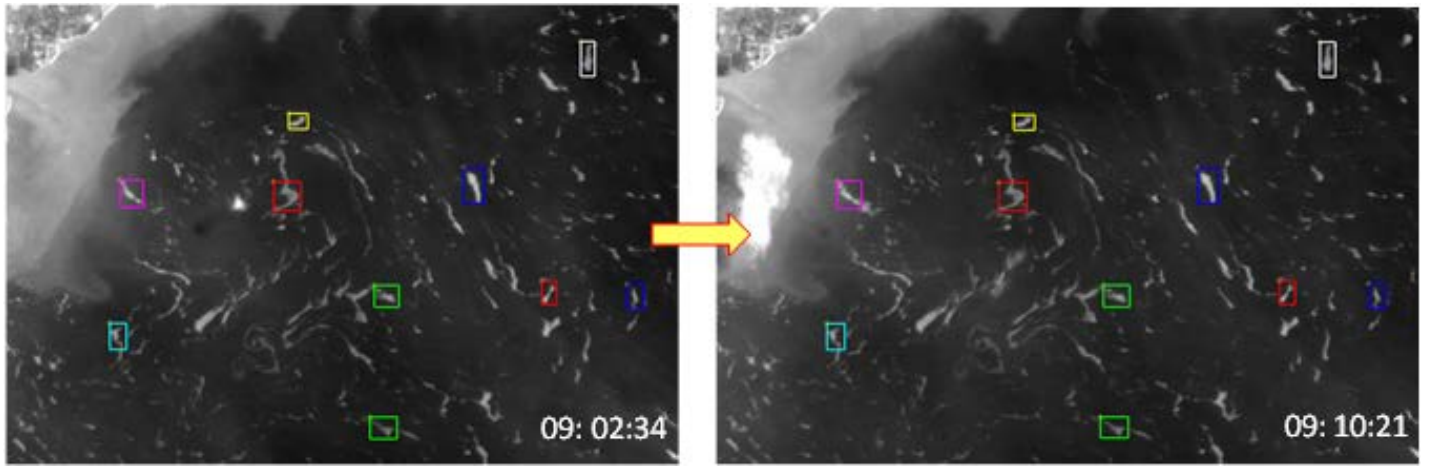


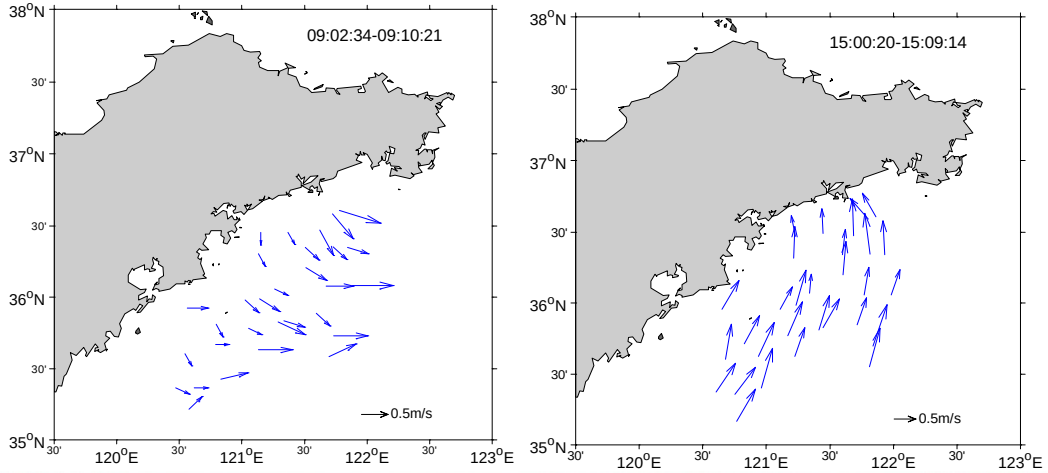
Coverage area 1：3.00km²

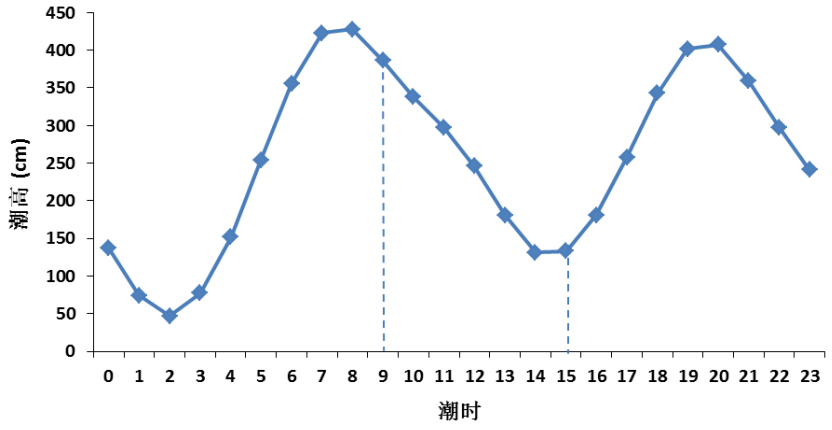
Coverage area 2：6.75km²

- **Shape features of macro-algal patches are clear in GF-4 images, but difficult to identify in GOCI images;**
- **GOCI derived green tide area overestimated those from GF-4.**

Estimation of movement velocity of green tide using GF-4 images







Red tide detection

- The red tide stripes are clearly visible in the GF-4 image of 50m resolution, but invisible in the GOCI image of 500 m resolution.
- The high spatial resolution of GF-4 makes up for the deficiency of its band configuration.

2. Atmosphere correction algorithm for ENVISAT MERIS over European coastal turbid waters

Study area:

The Baltic Sea is a semi-enclosed sea and optically dominated by the absorption of CDOM and has a weak scattering signal from particles.

***In situ* data:**

- two AERONET-OC sites

  Gustaf Dalén Tower & Helsinki Lighthouse

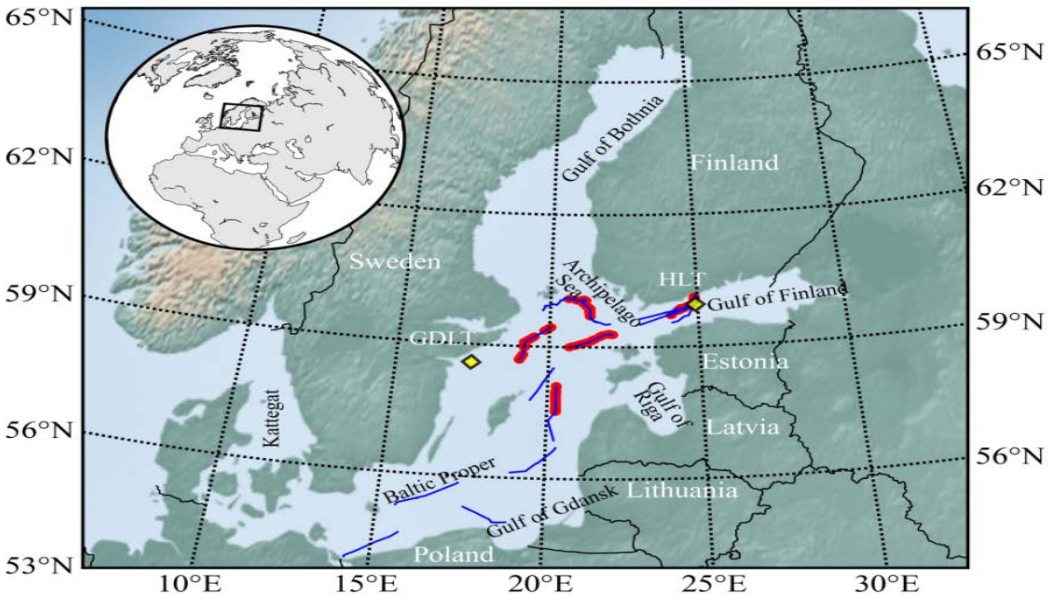
- the shipborne autonomous platform

Six algorithms:

CC(v1.8.3), C2R-Lakes (v1.6),

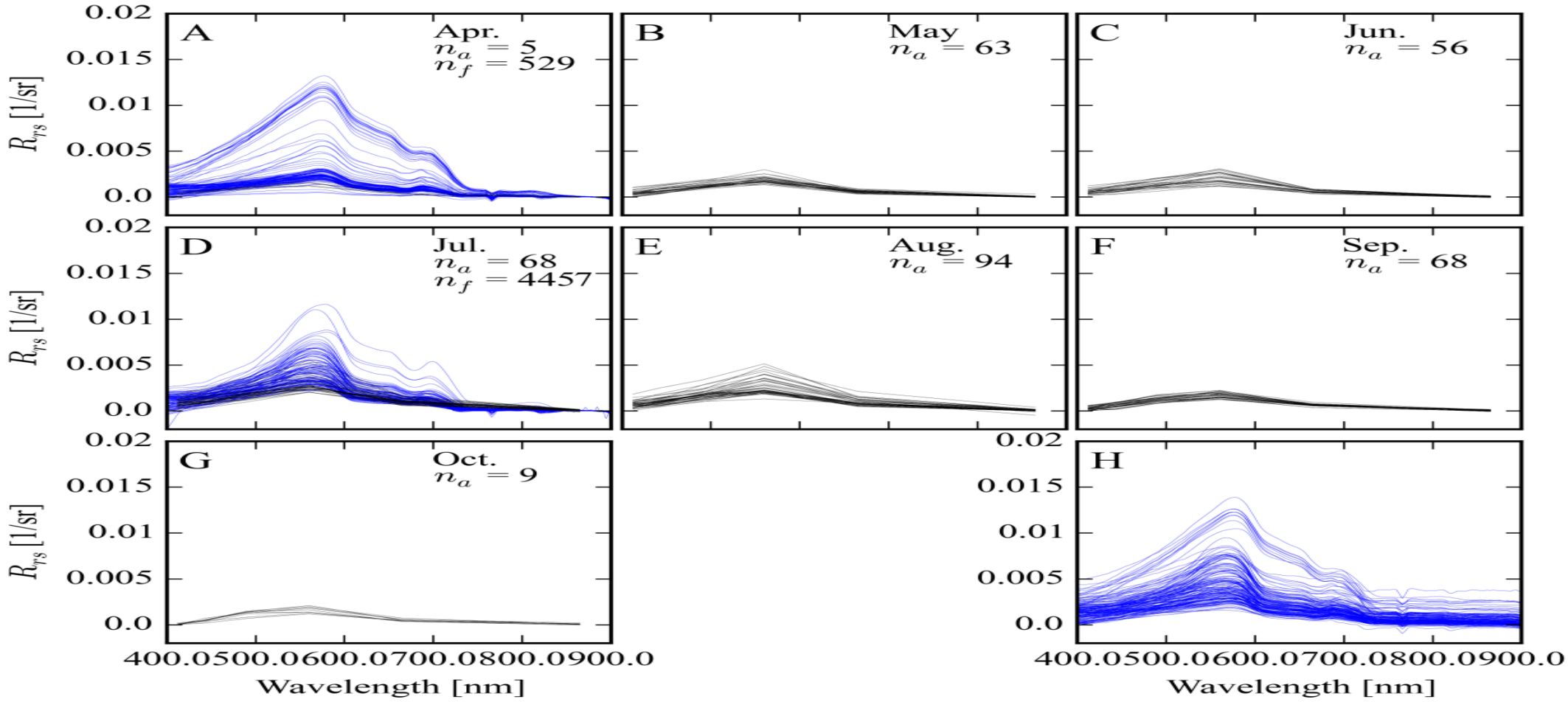
C2R-CC (v 0.15), FUB (v 2.2),

MEGS (v 8.1), POLYMER (v 3.5)



Blues lines are the trajectories of the research vessel, red points represent shipborne matchups and yellow diamonds are the two AERONET-OC sites.

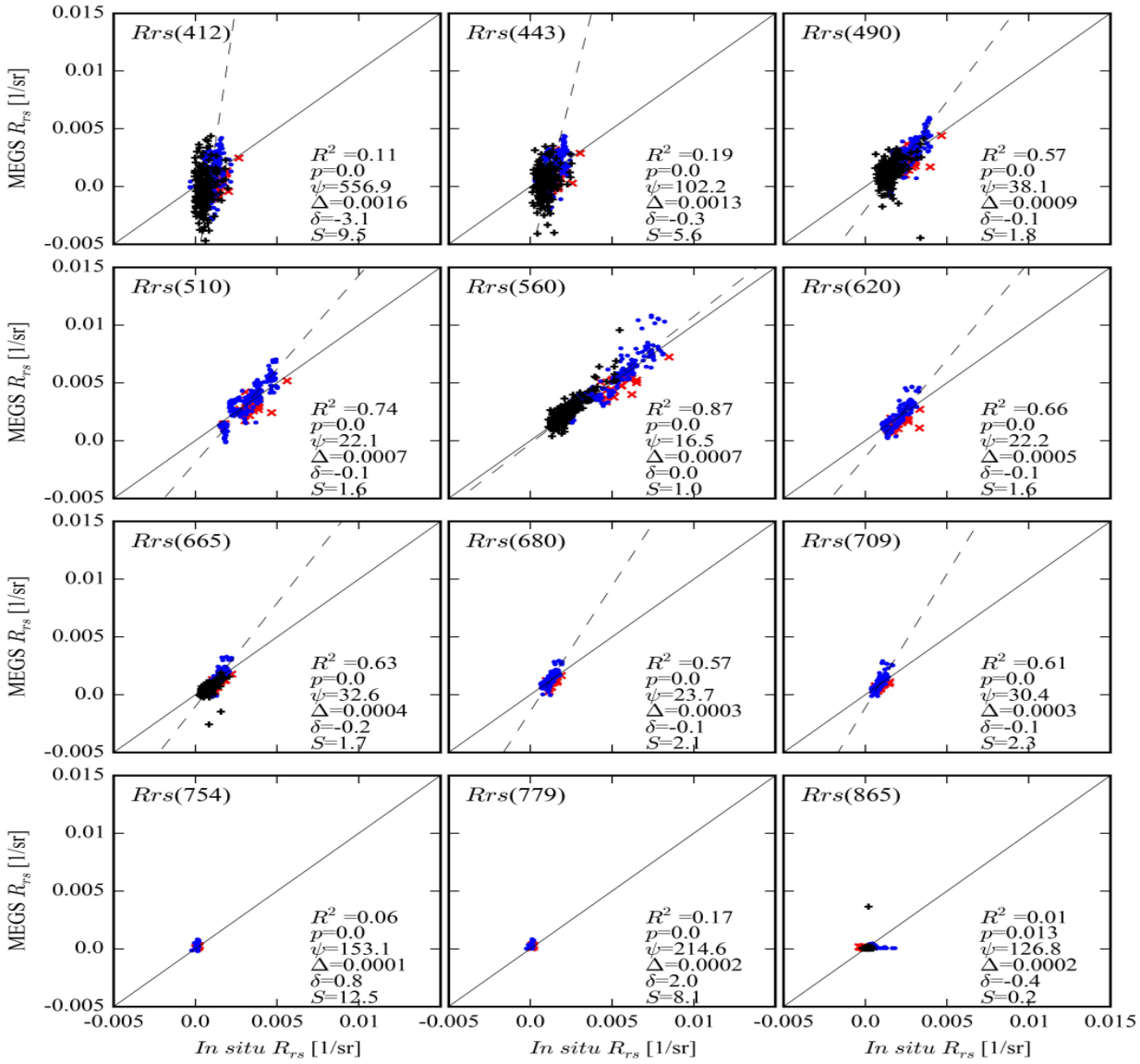
in situ R_{rs} spectra



the ship (blue curves) and AERONET-OC (black curves)

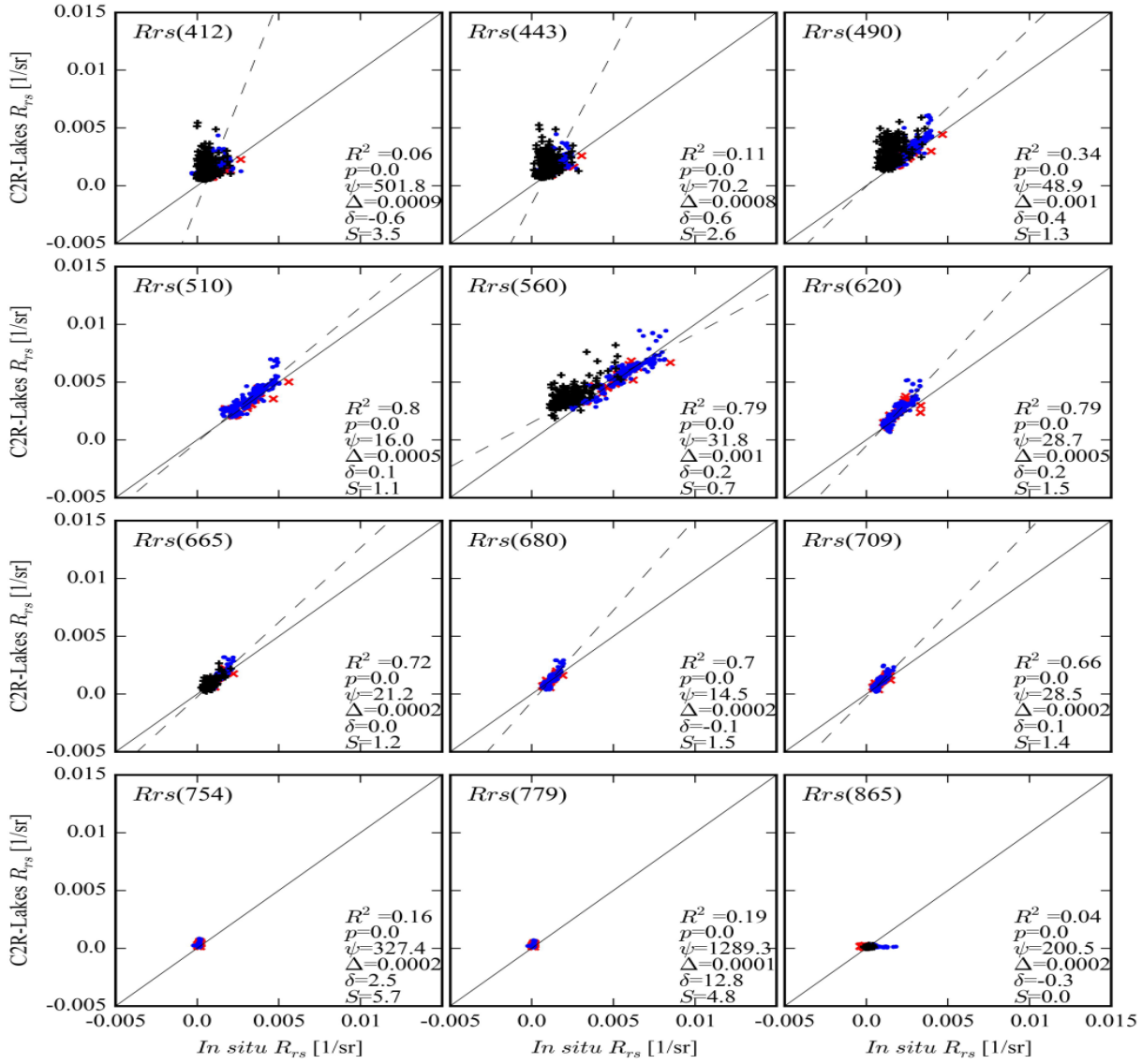
Results

MEGS algorithm



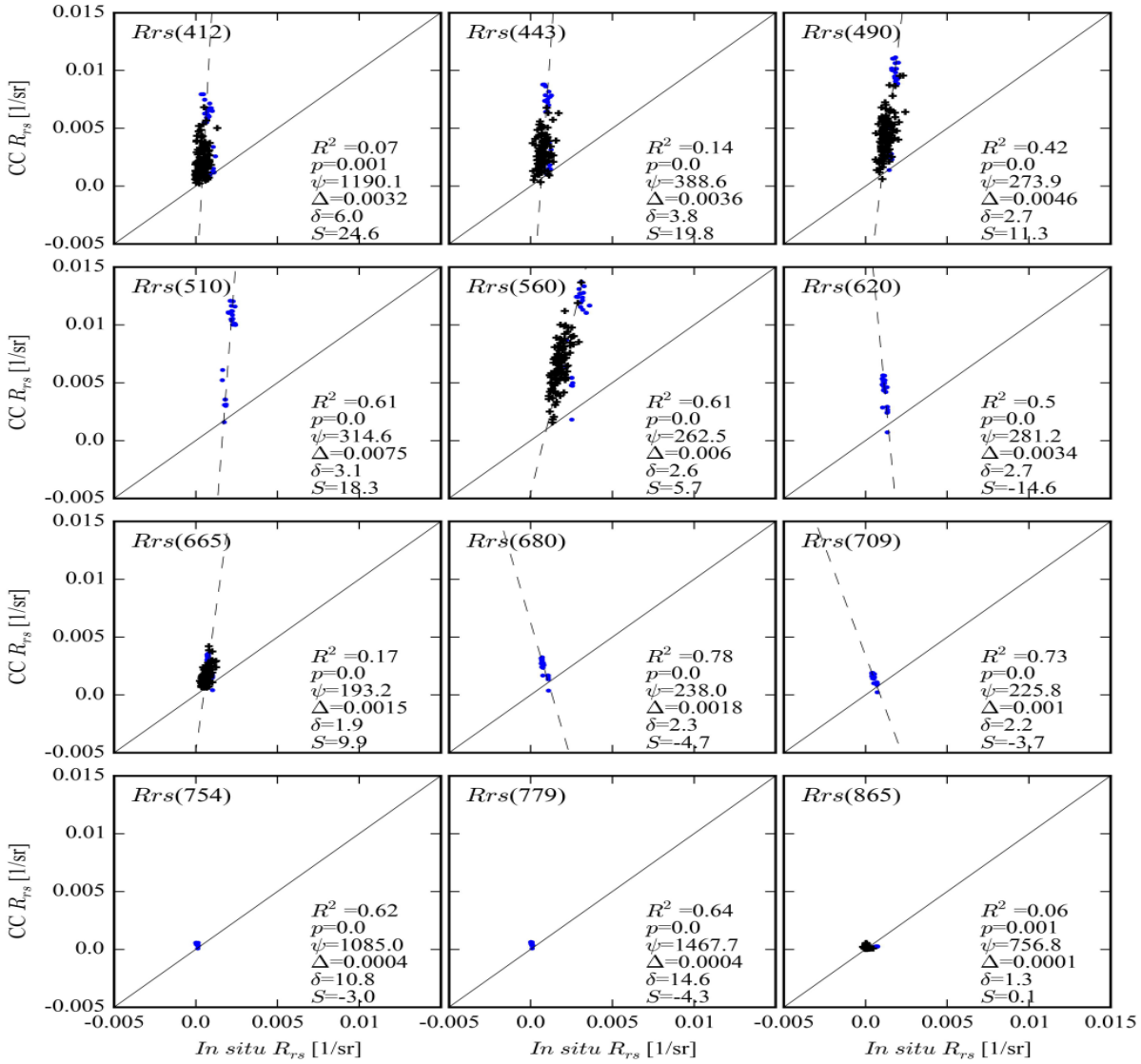
- Cruise
- AERONET-OC
- negative

C2R-Lakes algorithm



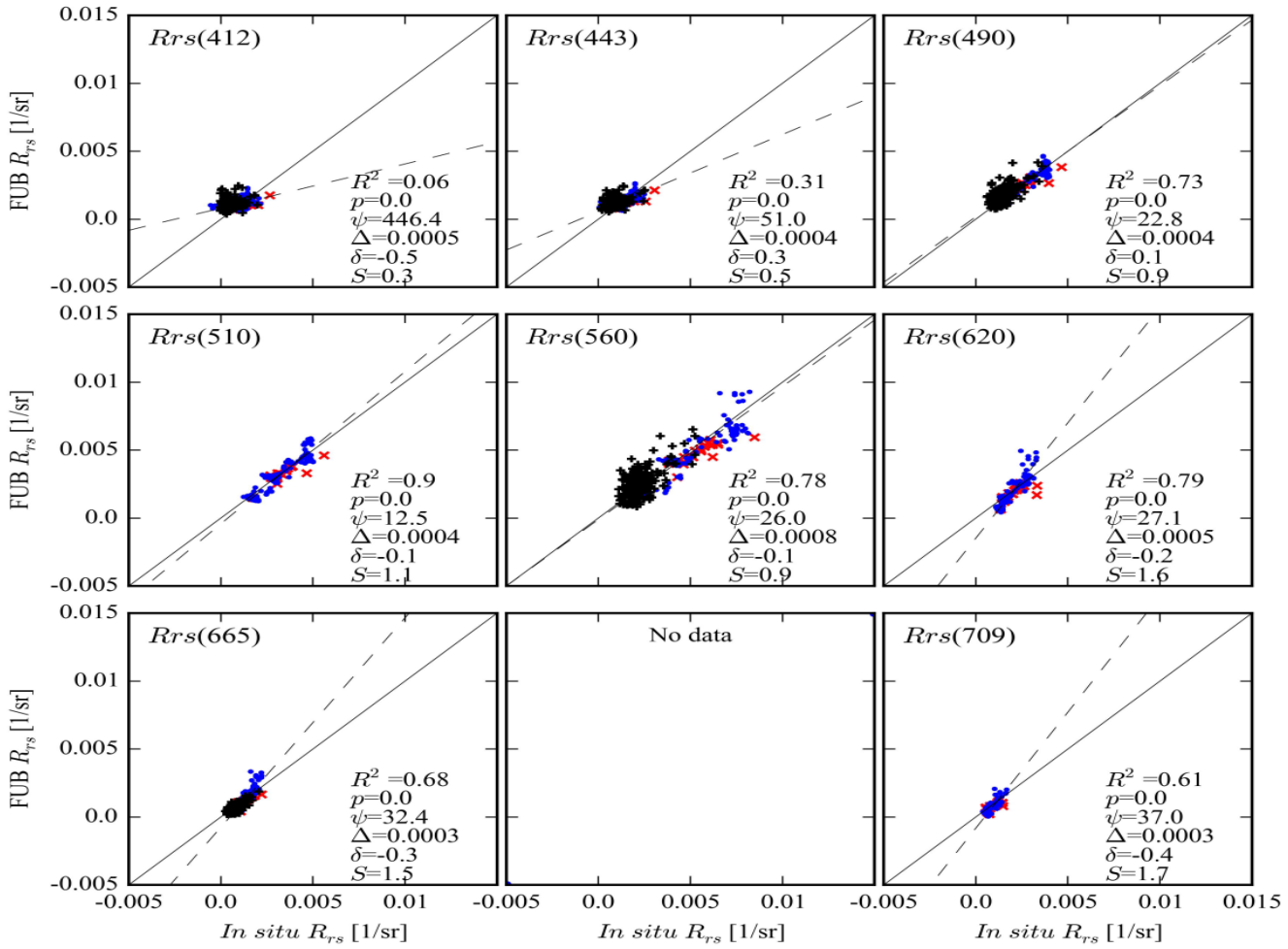
- Cruise
- AERONET-OC
- negative

CC algorithm



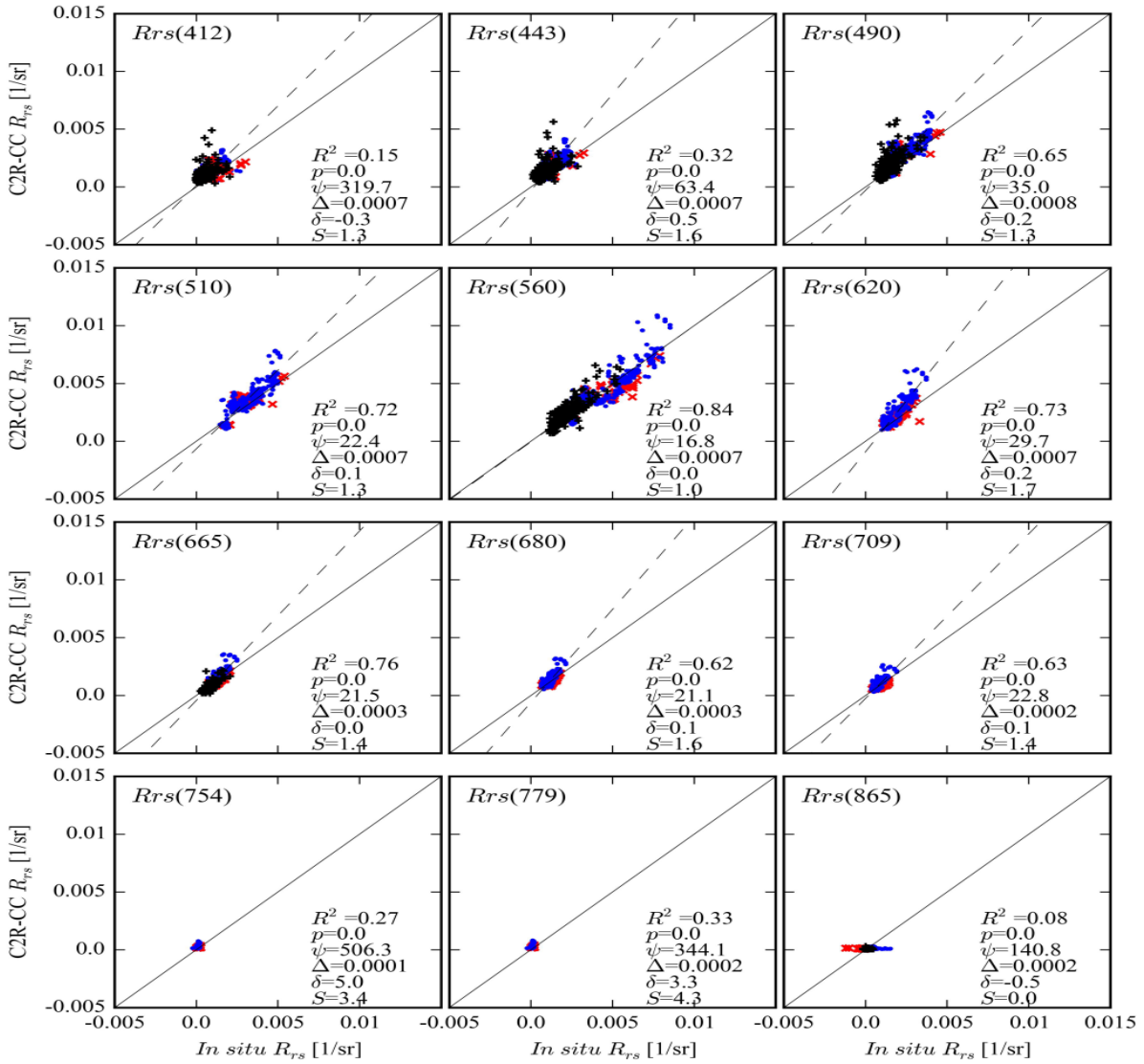
- Cruise
- AERONET-OC
- negative

FUB algorithm



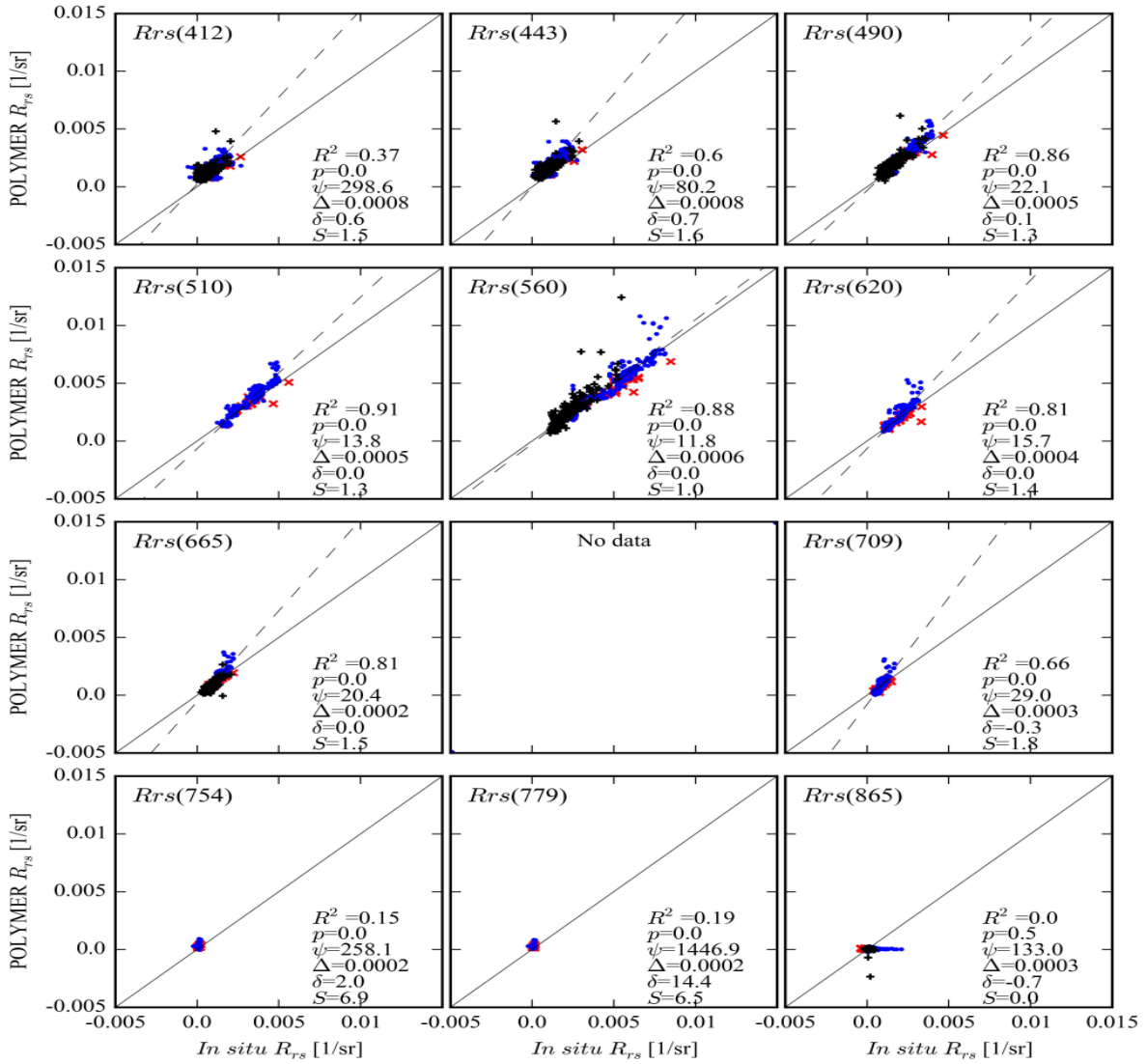
- Cruise
- AERONET-OC
- negative

C2R-CC algorithm



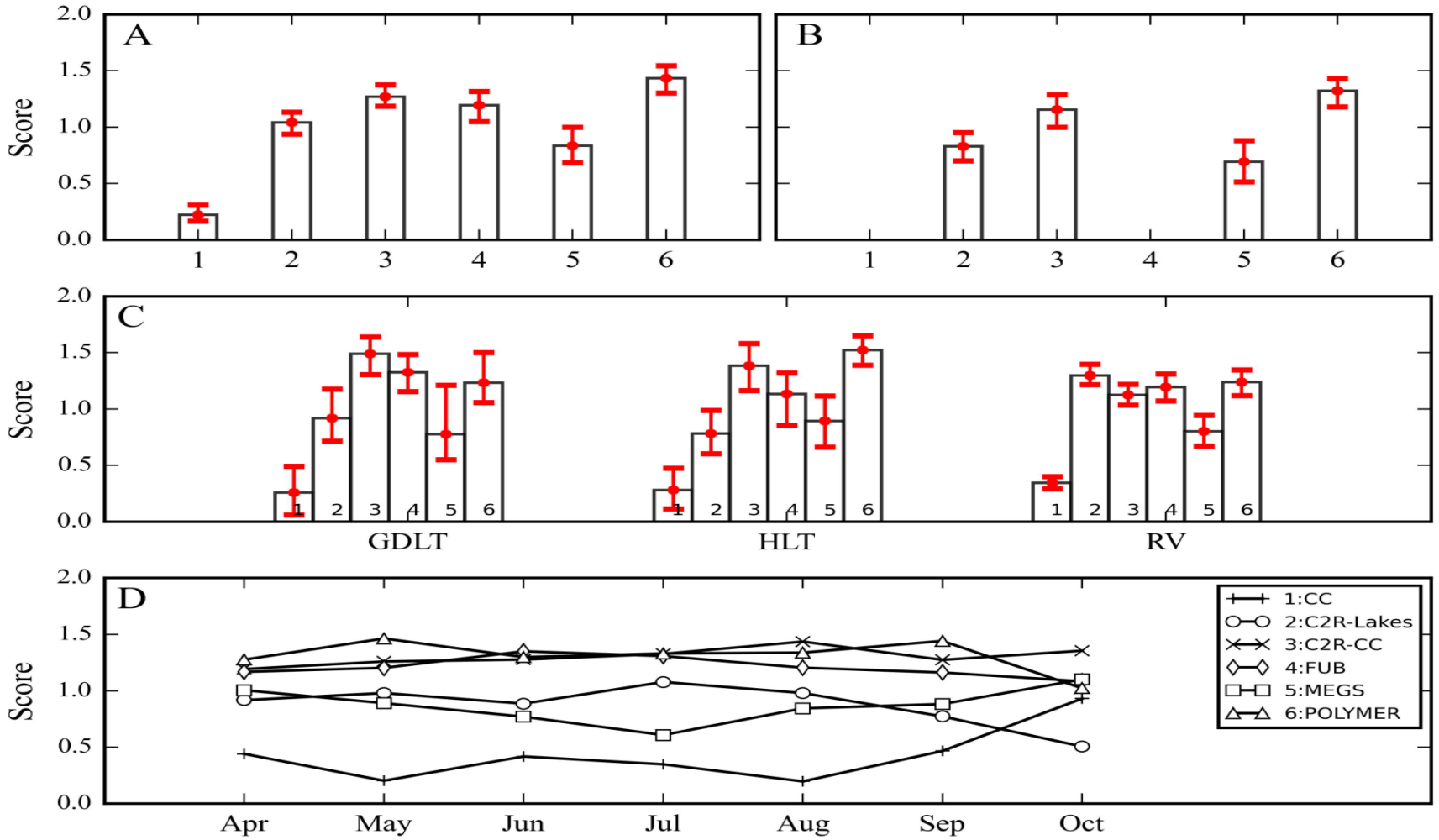
- Cruise
- AERONET-OC
- negative

POLYMER algorithm



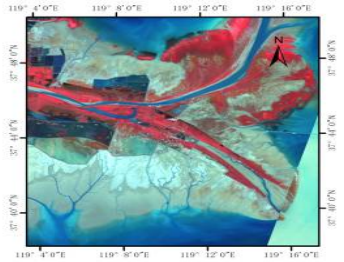
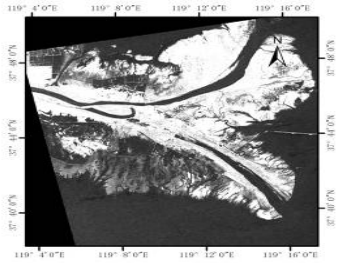
- Cruise
- AERONET-OC
- negative

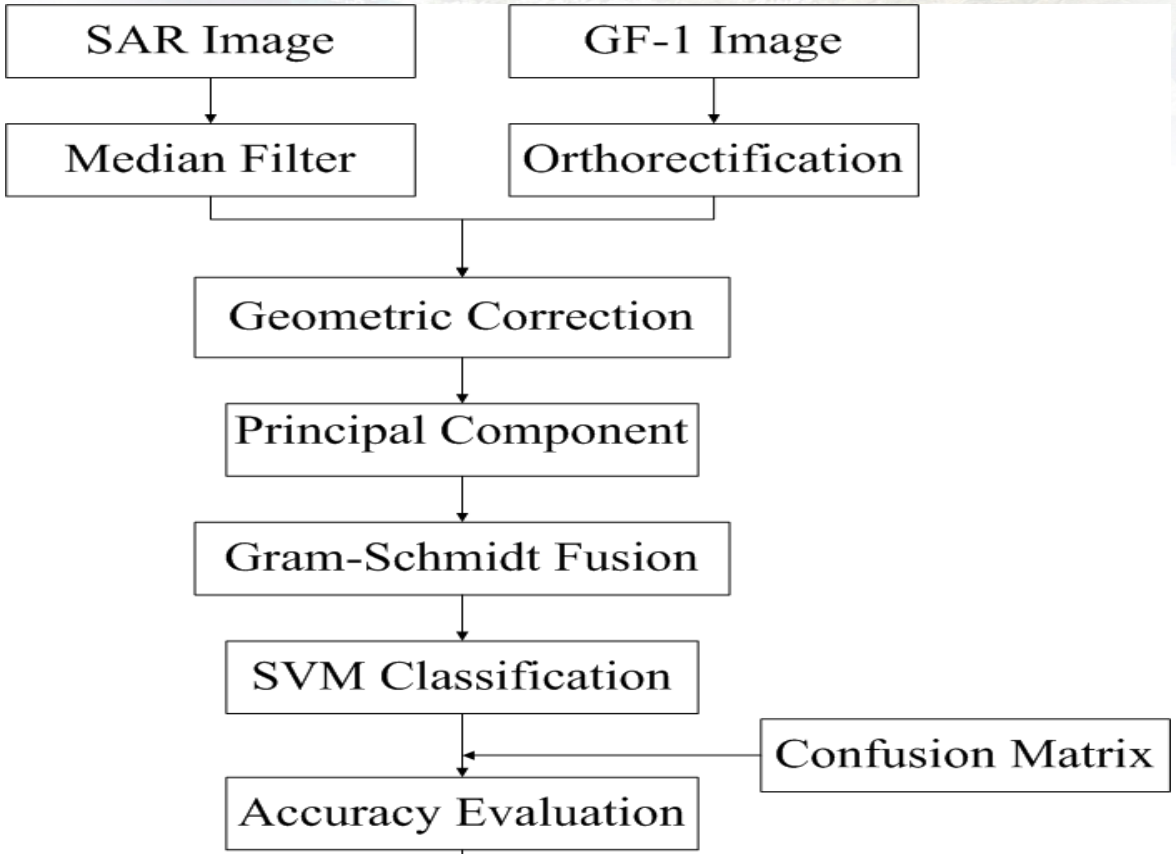
Score



- **POLYMER exhibited the best performance at MERIS from 490–709 nm.**
- **C2R-CC was the second most accurate algorithm.**
- **CC exhibited the worst accuracy for all wavebands.**

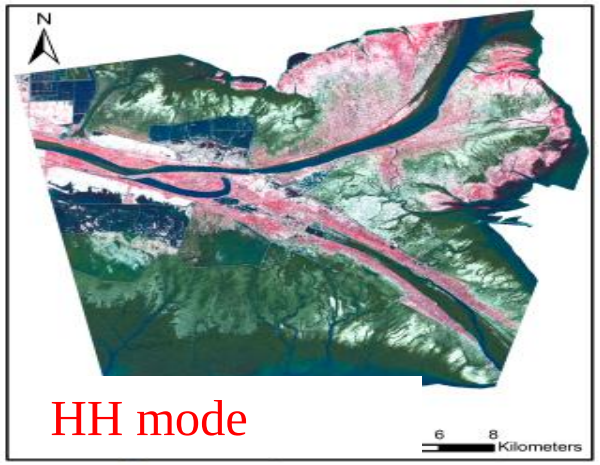
3. Coastal wetland classification based on high resolution SAR and optical image fusion

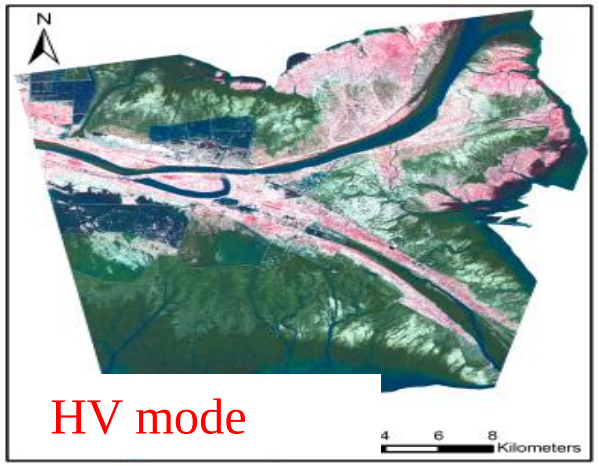
Sensor	Image	Resolution	Date	Repeating Period
GF-1 WFV		16m	2015.9.26	4 days
Radarsat-2 SAR (Fine Quad Polarization)		8m	2015.9.23	24 days

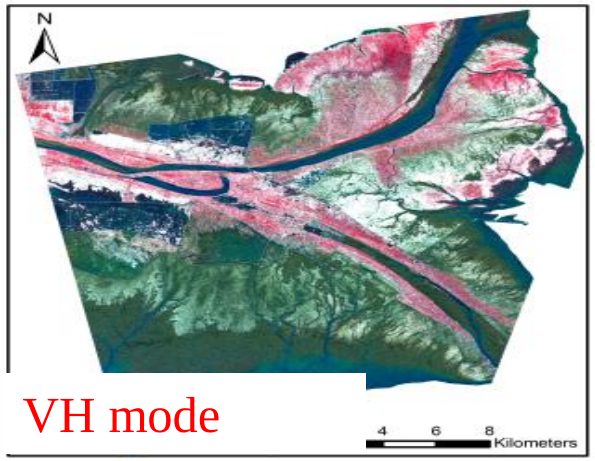


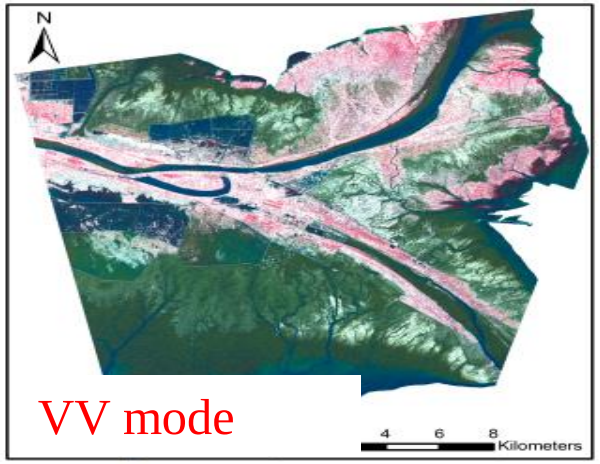
Flow chart of automatic information extraction of coastal wetland

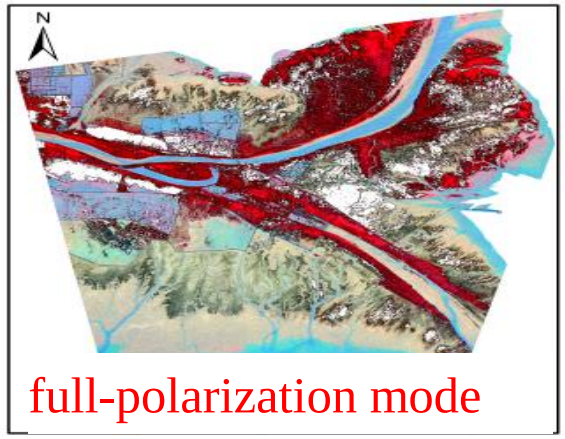
Fusion results of GF-1 and SAR images



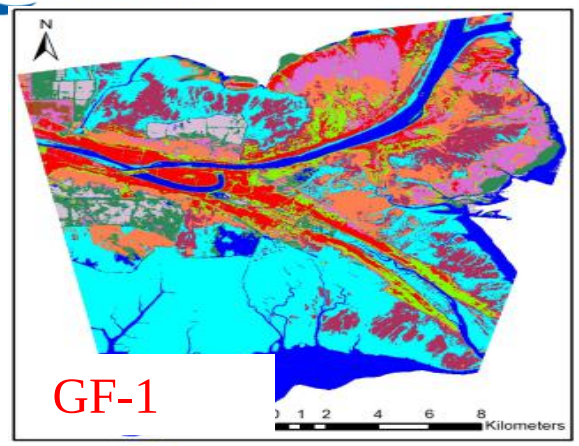


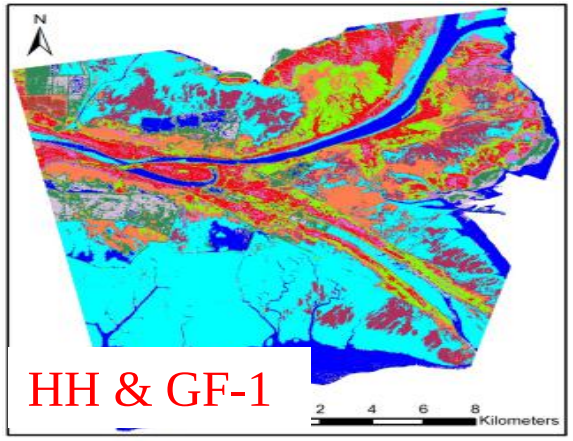


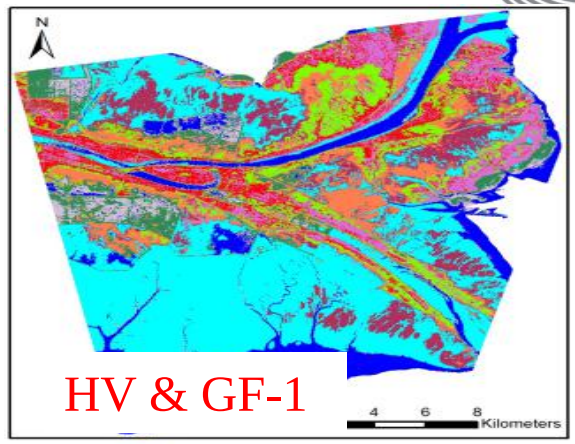


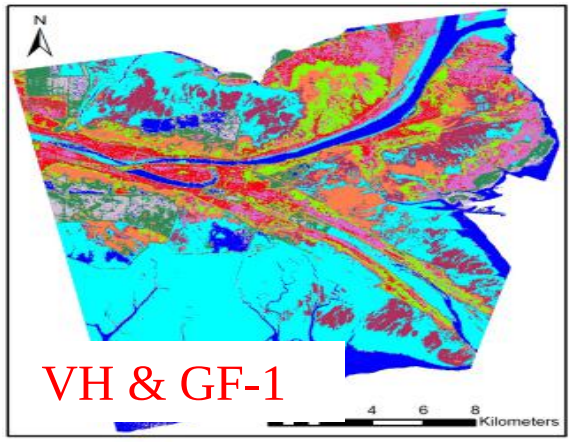


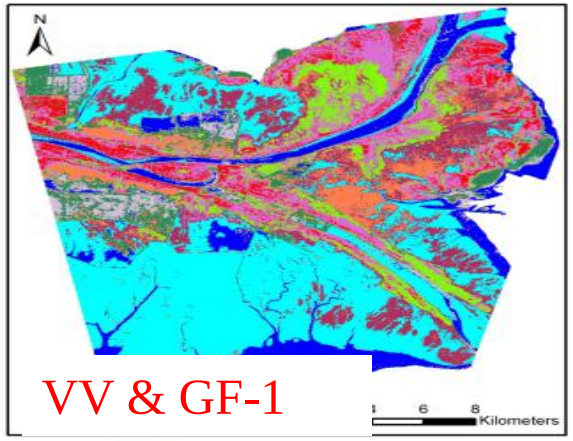
The classification results

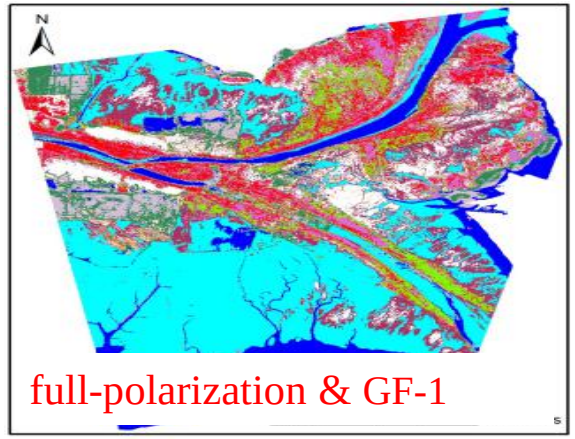












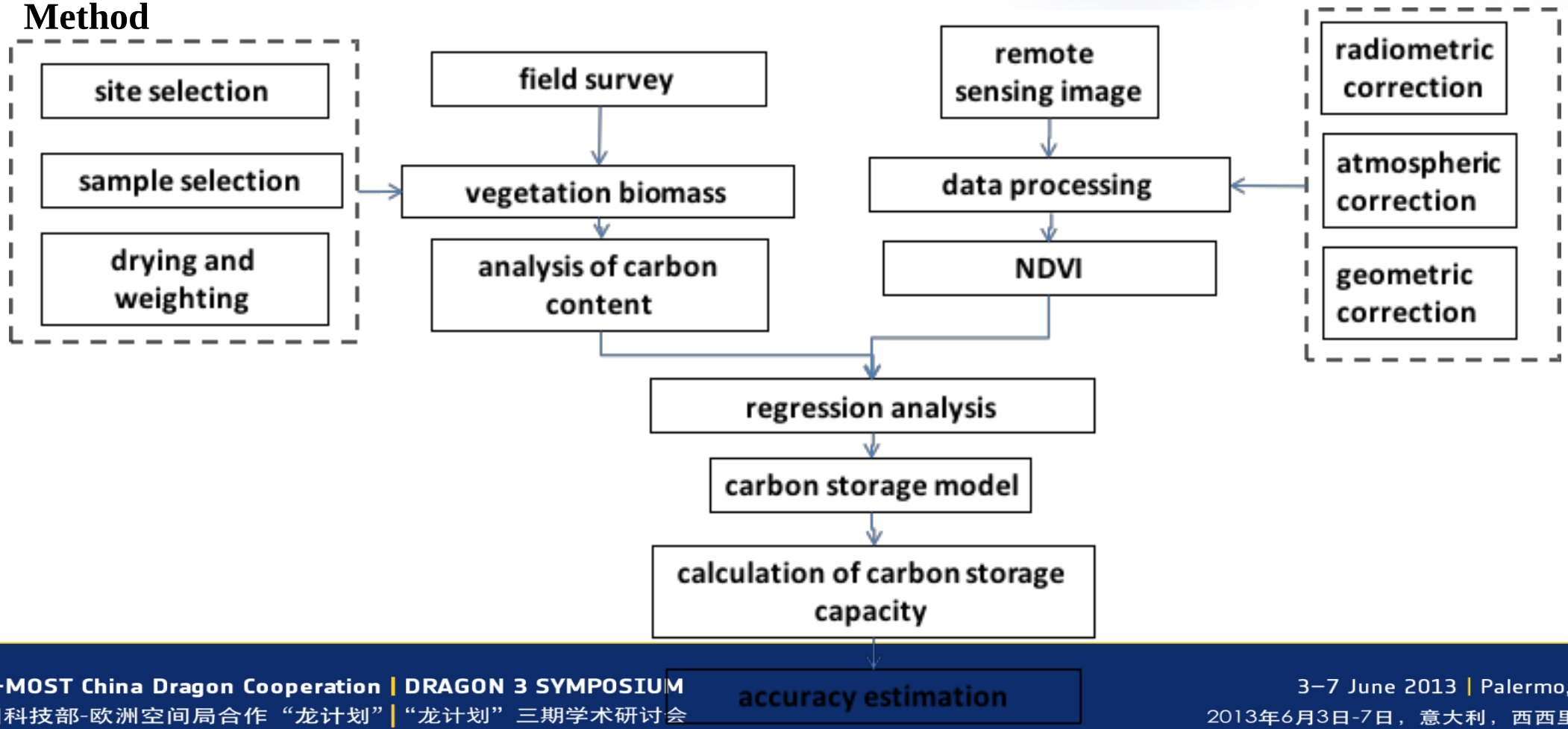
tidal flat
suaedasalsa
river
aquaculture pond
paddy field
tamarisk
tidal flat reed
swag
terrestrial reed
spartina alterniflora loisel

CONCLUSIONS

- **The classification accuracy of tidal flat reed in the fusion image VV polarimetric SAR and GF-1, is better (3.6% higher) than that of original GF-1 images (57.6%).**
- **In all the fusion images, the classification accuracy of river, tidal flat and aquaculture pond have (>80%) are higher than other targets, possibly due to the SAR sensitivity to the water.**

4. Estimation of Coastal wetland carbon storage capacity by GF-1 WFV remote sensing image

Method



Field work

- The study area is the *tamarix chinesis* shrub in the city of Changyi of Shandong Province.
- Sample area (10m×10m square) was selected to represent the local vegetation growth characteristics.
- Certain percentage of the sample vegetation was derived and dried at 80℃ until the weight did not change, and then analyzed with burning method to obtain the carbon content .
- With the data quality control, 12 samples were used to establish the carbon storage capacity model and 6 samples were used for accuracy assessment.

Remote sensing data

Parameters of GF-1 WFV2 multispectral satellite image

Bands	0.45-0.52 μm 0.52-0.59 μm 0.63-0.69 μm 0.77-0.89 μm
spatial resolution	16m
swath	800km
Repeated period	four days

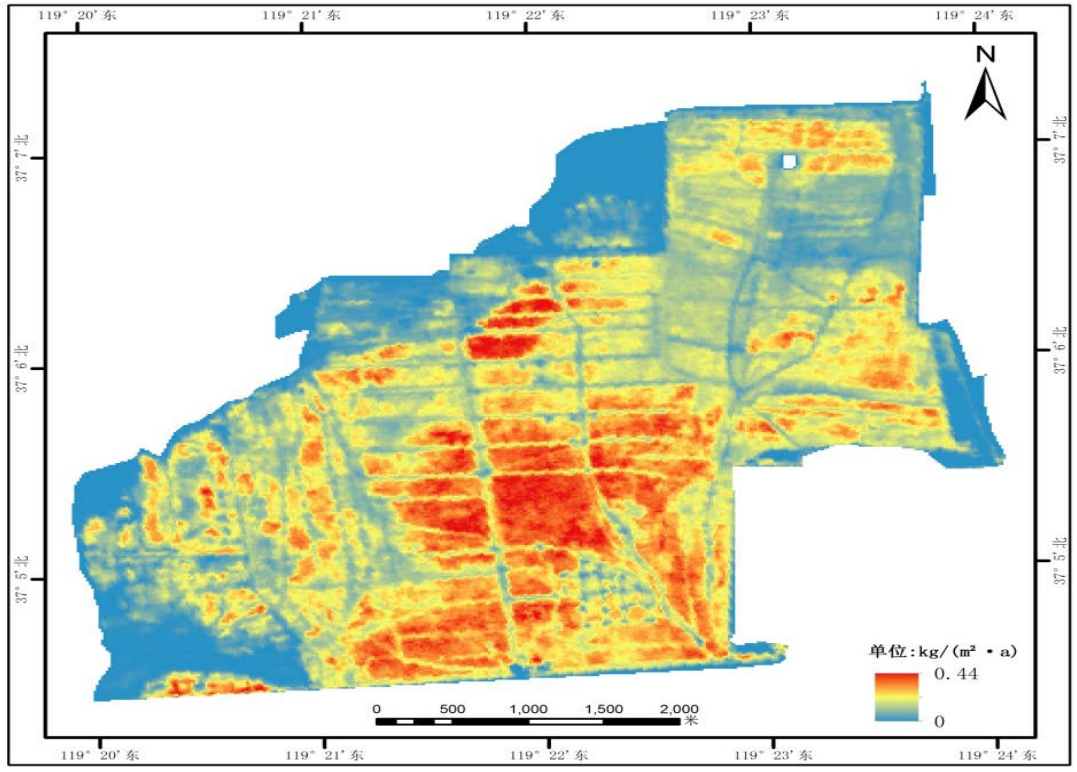
Result

- The developed carbon storage capacity model:

$$y=2014NDVI^{3.810}$$

R^2 is 0.898，and RMSE is 3.9%.

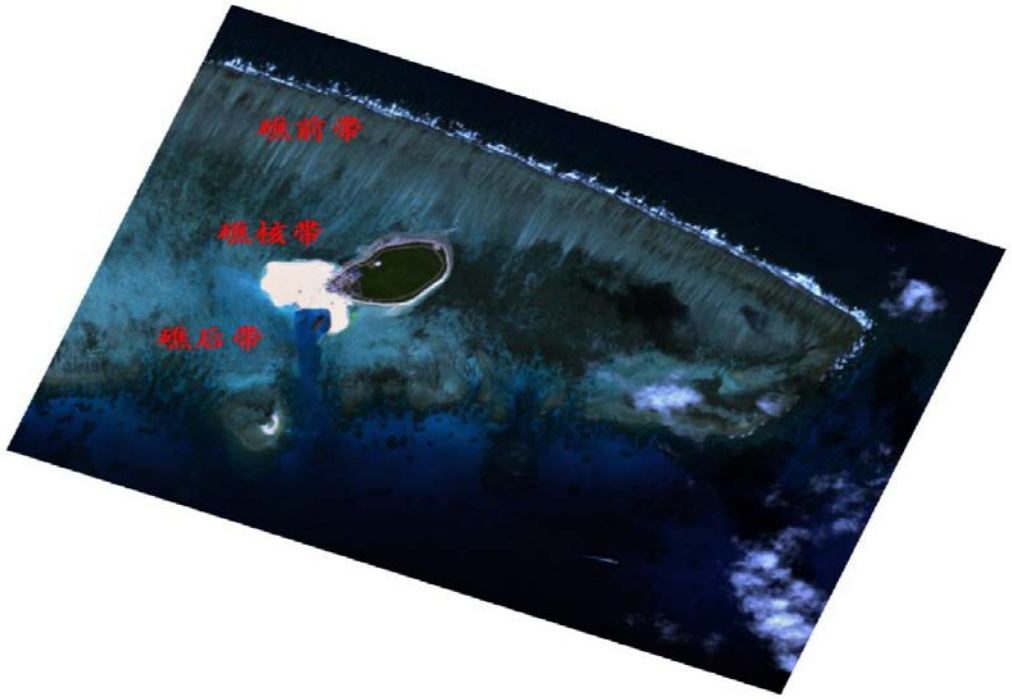
- The carbon storage capacity of the study area is 2.98×10^3t every year.



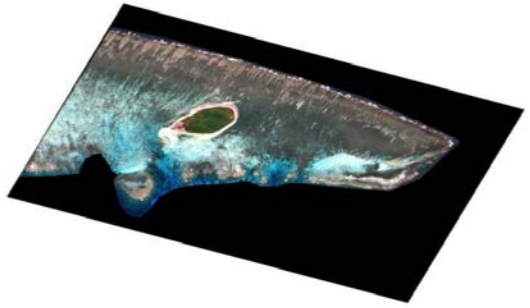
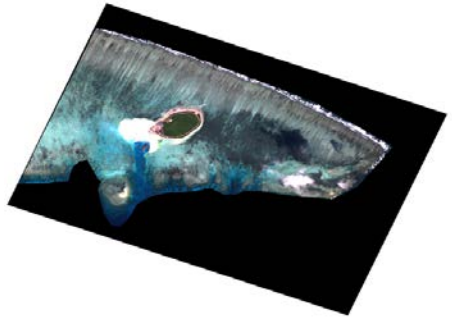
5. Coral Reef Bleaching Monitoring Based on WorldView-2 and GF-2 Remote Sensing Images

Study area

- The study area is the Zhaoshu Island and its adjacent waters in the Xisha Islands of South China Sea.
- The reef plate of the Zhaoshu Island is about 10km long and the widest part is 3km .



Remote sensing image

Satellite Sensor	Image	Resolution	Date
WorldView-2		0.5m	2010.02.07
GF-2		4m	2015.12.14

Field data

Photos and videos as well as the GPS data of coral reefs were collected.

Field sites location

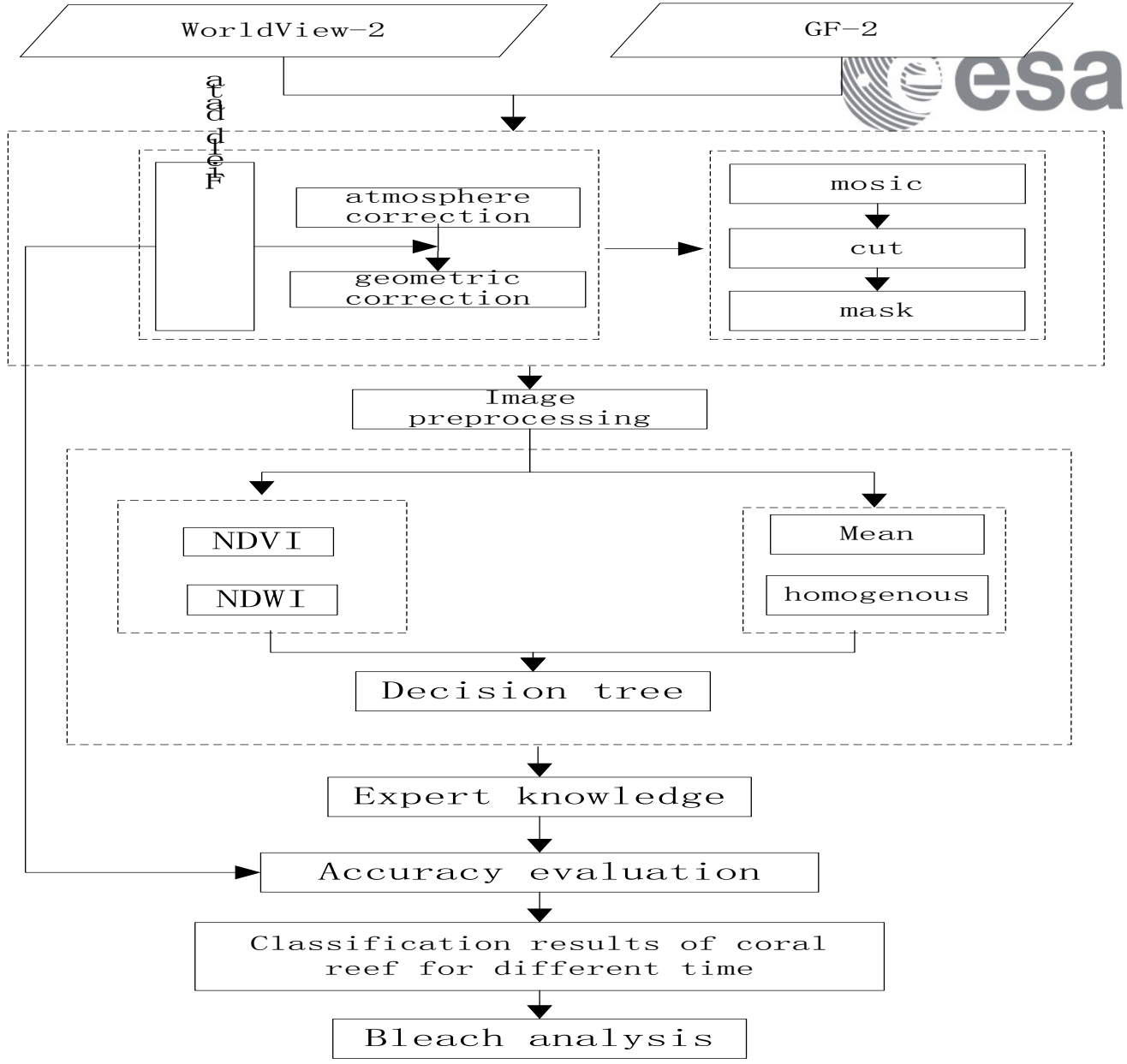
In situ image and video

Method

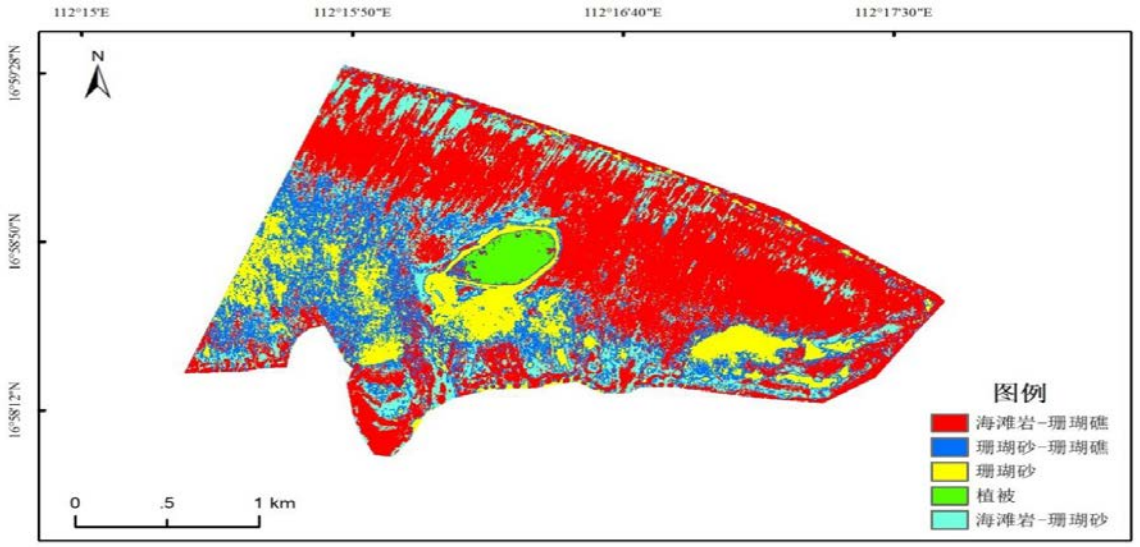
① **Remote sensing data processing**

② **Classification model establishment**

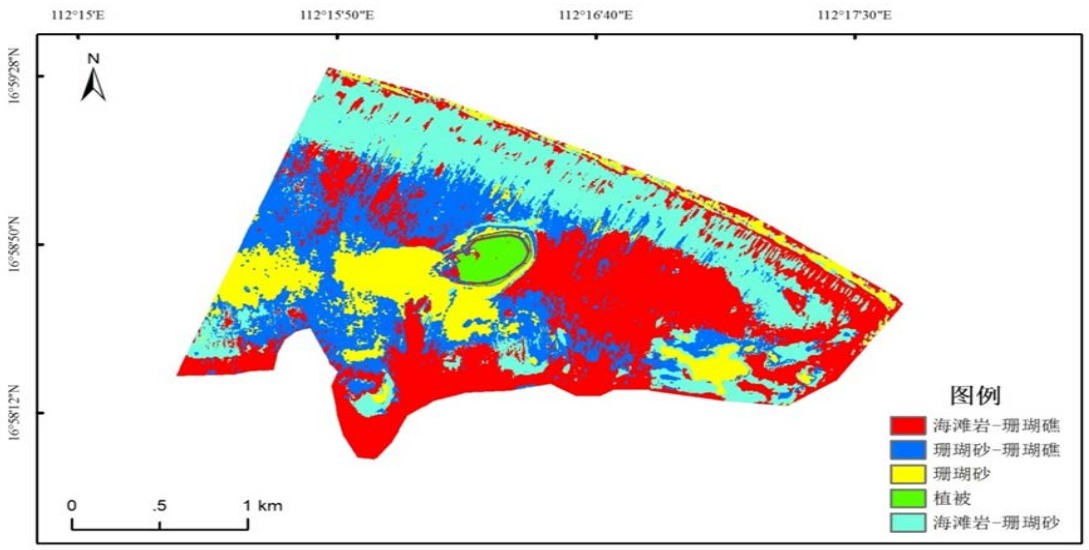
③ **Coral reef bleach monitoring**



Classification results



Classification results for 2010

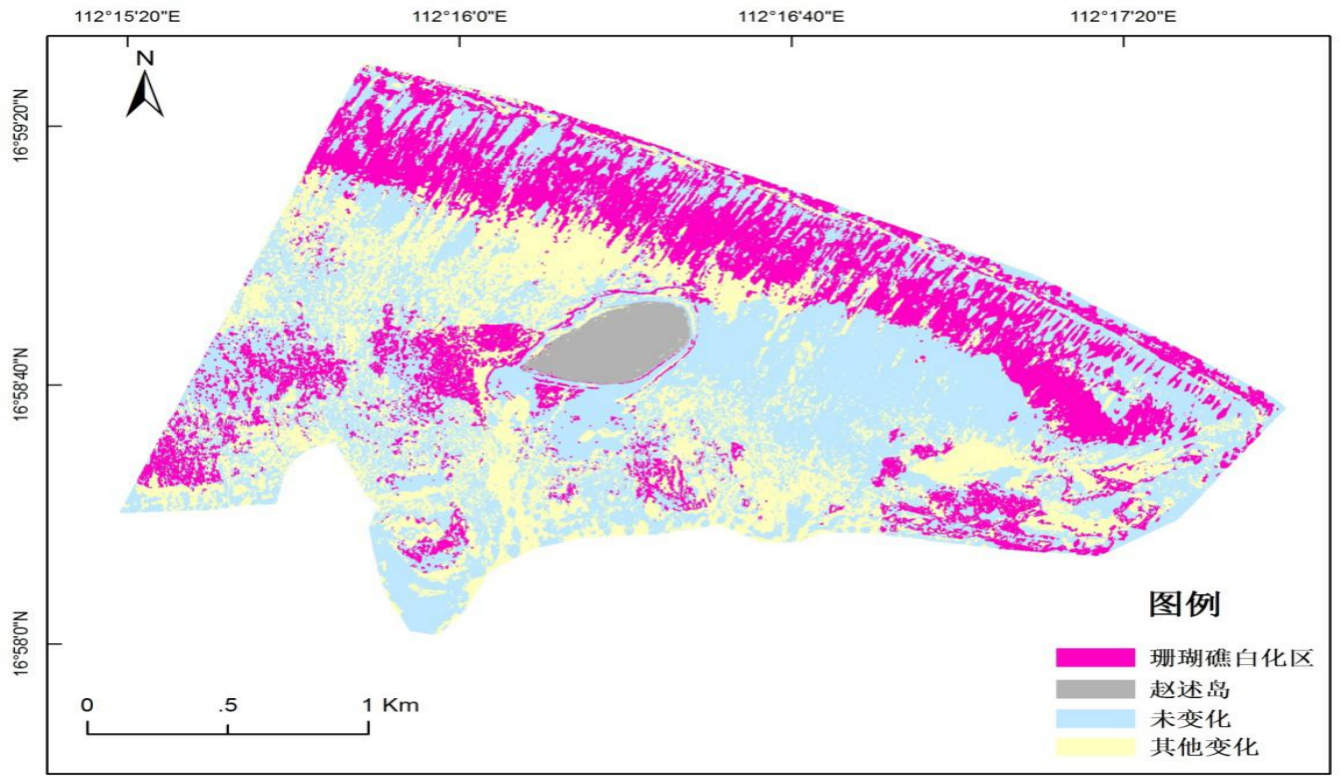


Classification results for 2015

The overall classification accuracy for the two images are better than 90%。

Coral reef bleach monitoring

About 1/4 of coral reef in the study area was bleached during 2010 and 2015, the total area of which was 152.29 hm^2 .



Coral reef bleach monitoring result during 2010 and 2015

Any question, please contact with

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