# Remote Sensing Monitoring of Suspended Sediment Concentration in the Pearl River Estuary and Deep Bay

*Dr. Li-Qiao TIAN* [a,b], *Prof. Onyx Wing-Hong WAI* [a], *Prof. Xiao-Ling CHEN* [b]

[a] Department of Civil and Structure Engineering, the Hong Kong Polytechnic University, HKSAR, China

[b] State Key Laboratory of Information Engineering in Surveying, Mapping and Remote Sensing, Wuhan University, Wuhan, China

**Abstract:** Total suspended sediment (TSS) in the water column is one of the major parameters that regulates the penetration of light into water, which impacts the primary production in coastal waters especially in bays and estuaries. In this study, a combined approach using both the Chavez (1996) COST image-based atmospheric correction procedure and the pseudo-invariant features (PIF) method was implemented to remove the atmospheric effects of the HJ-1A/1B satellite CCD images of Deep Bay. Then a practical robust retrieval model was created between the satellite corrected reflectance band ratio of Band3 and Band2 (Rrs3/Rrs2) and the in-situ measured TSS concentration on August 29, 2012. Finally, the influence of the flood-ebb tidal cycles and wind factors (directions and speeds) on the TSS spatial pattern was also analyzed for the period from September through November in 2008. The results showed that HJ-1A/1B CCD imagery could be used to estimate TSS in the study area over synoptic scales without the support of simultaneous in-situ atmospheric parameters and spectrum data. This would be a very useful information for numeric simulation studies in Deep Bay. In addition, we also analyzed the variability of total suspended sediment concentration based on the satellite images taken by Moderate Resolution Imaging Spectroradiometer (MODIS) from 2003 to 2010 in the Pearl River estuary. A band ratio retrieval algorithm for estimating concentrations of total suspended sediments was developed based on the in-situ data collected on June 5, 2012. Long-term TSS distribution maps derived from MODIS data onboard Aqua satellite showed significant variations in both space and time. The factors should be further investigated.

**Keywords:** *suspended sediments, remote sensing, MODIS, Pearl River Estuary, Deep Bay*

# Remote Sensing Monitoring of Total Suspended Sediment Concentration in the Pearl River Estuary and Deep Bay

Liqiao TIAN[1,2], Onyx W.H. WAI[1,*] and Xiaoling CHEN[2]

*Email: ceonyx@polyu.edu.hk

[1]Department of Civil and Environmental Engineering, the Hong Kong Polytechnic University, Kowloon, Hong Kong, China

[2]State Key Laboratory of Information Engineering in Surveying, Mapping and Remote Sensing, Wuhan University, Wuhan, 430079, China

Hong Kong, Nov. 17, 2012

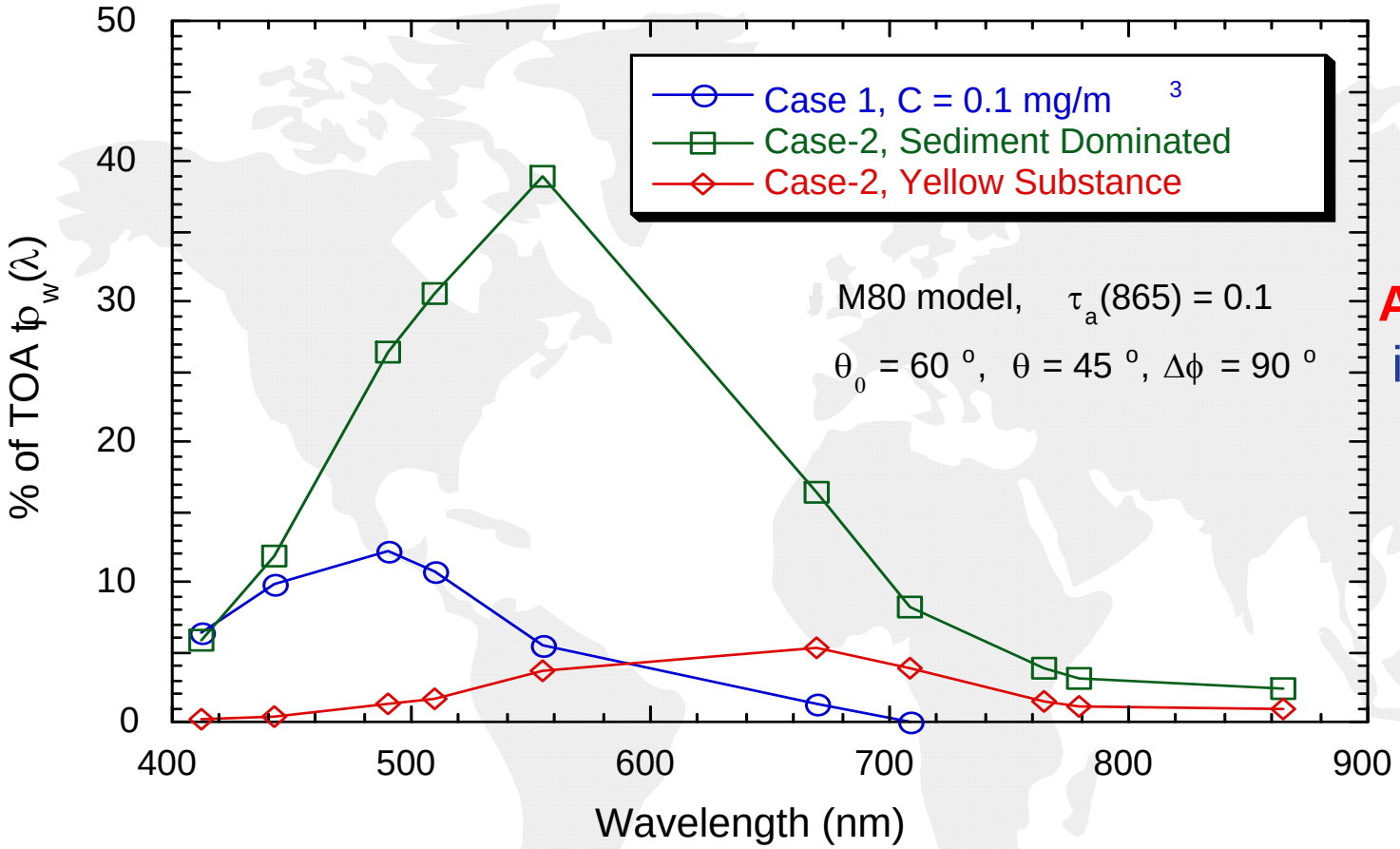
# Outline

- Introduction
- Theory basis
- Cases：Pearl River Estuary & Deep Bay
- Conclusion

# Introduction

- Plays an important role in water quality Total Suspended Sediment (TSS)
  - nutrient and pollutant carrier
  - transparence/turbidity/color
  - the construction of port
  - and so on
- Traditional approach
  - time consuming
  - labor extensive
  - high price
  - discrete in temporal and spatial distribution
- Remote sensing
  - large-scale observations
  - frequently revisit

# Theory basis-atmospheric correction



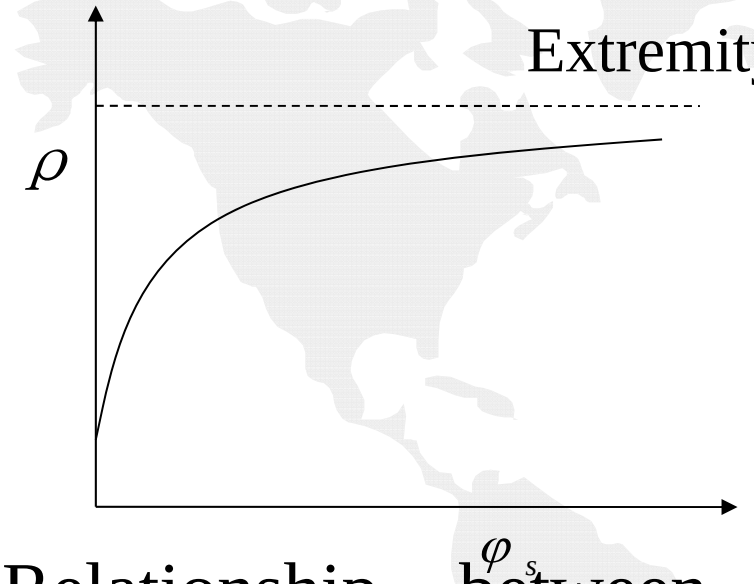

**Aerosol influence** is hard to remove

At satellite altitude ~**90%** of sensor-measured signal over ocean comes from the **atmosphere & surface**! (Wang Menghua)

It is crucial to have accurate **atmospheric correction!**

# Theory basis—TSS Retrieval

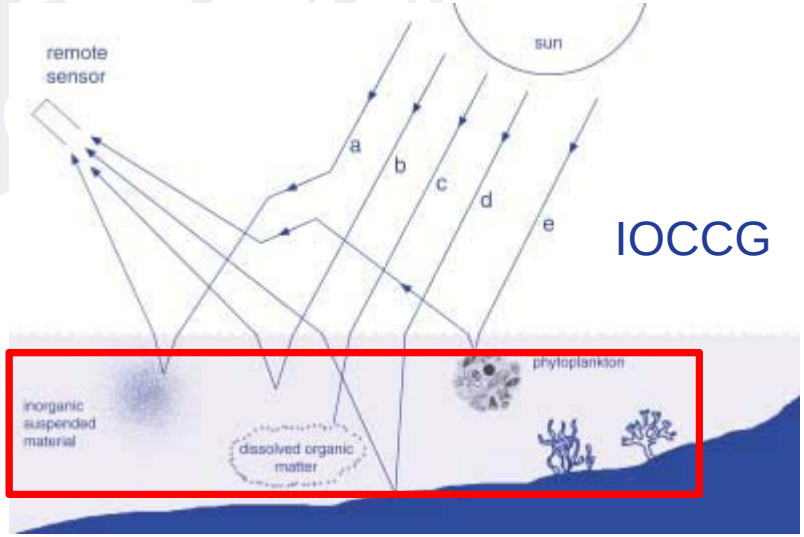
## Reflectance spectra with different TSS concentrations




- $\frac{d\rho}{d\varphi_s} > 0$, reflectance increases as the increase of SS level
- $\frac{d^2\rho}{d^2\varphi_s} > 0$, change rate decreases when SS level increases
- it fits to a log relationship

Relationship between spectral reflectance and SS concentration, Where $\rho$ is the RS reflectance, is the SS concentration

Retrieval is another key procedure




IOCCG

# Case 1: Pearl River Estuay

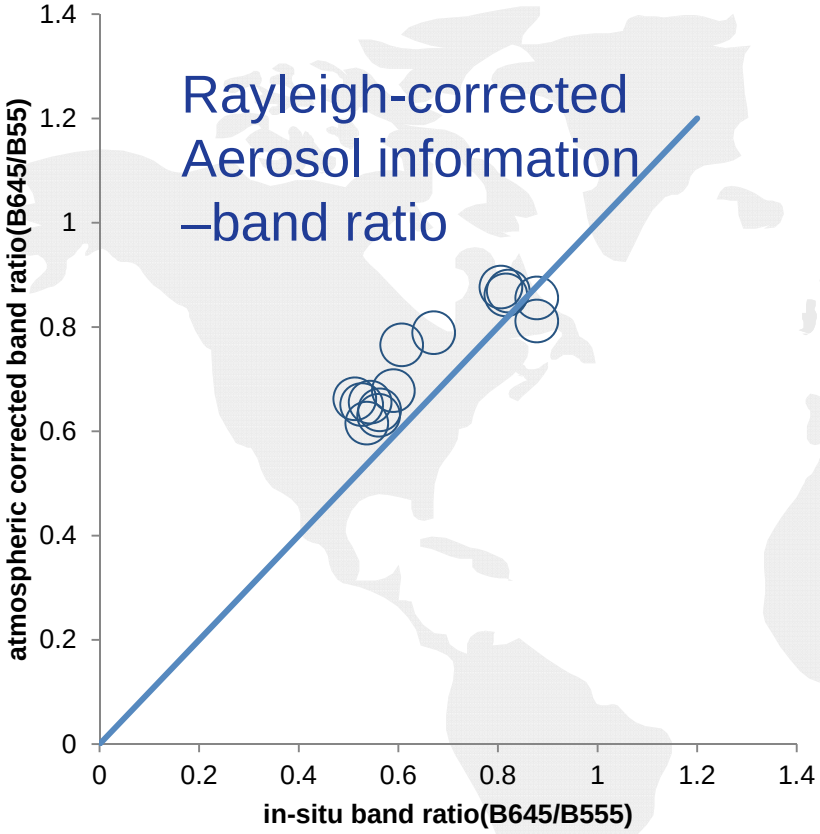


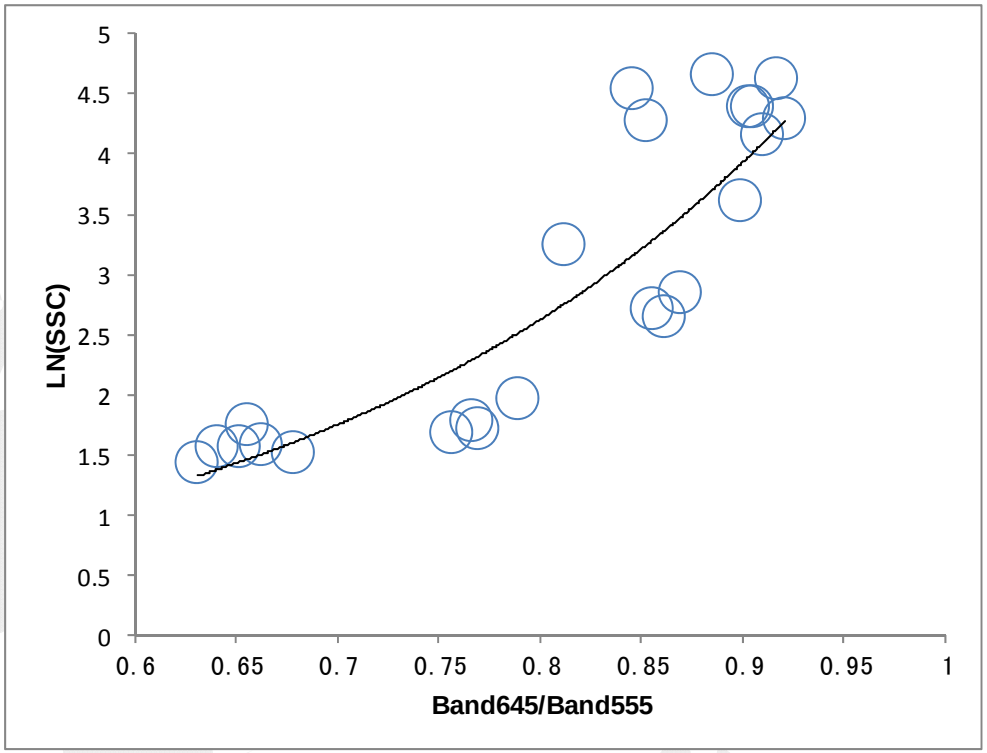
- **2012-6-5 PRE, 16 stations ;**

  (Thanks for the field investigation)

- **2004-10-17, 18 Deep Bay, 16 stations**

# Atmospheric correction& TSS Retrieval




Atmospheric correction
Band ratio
R.E. =13.1788%

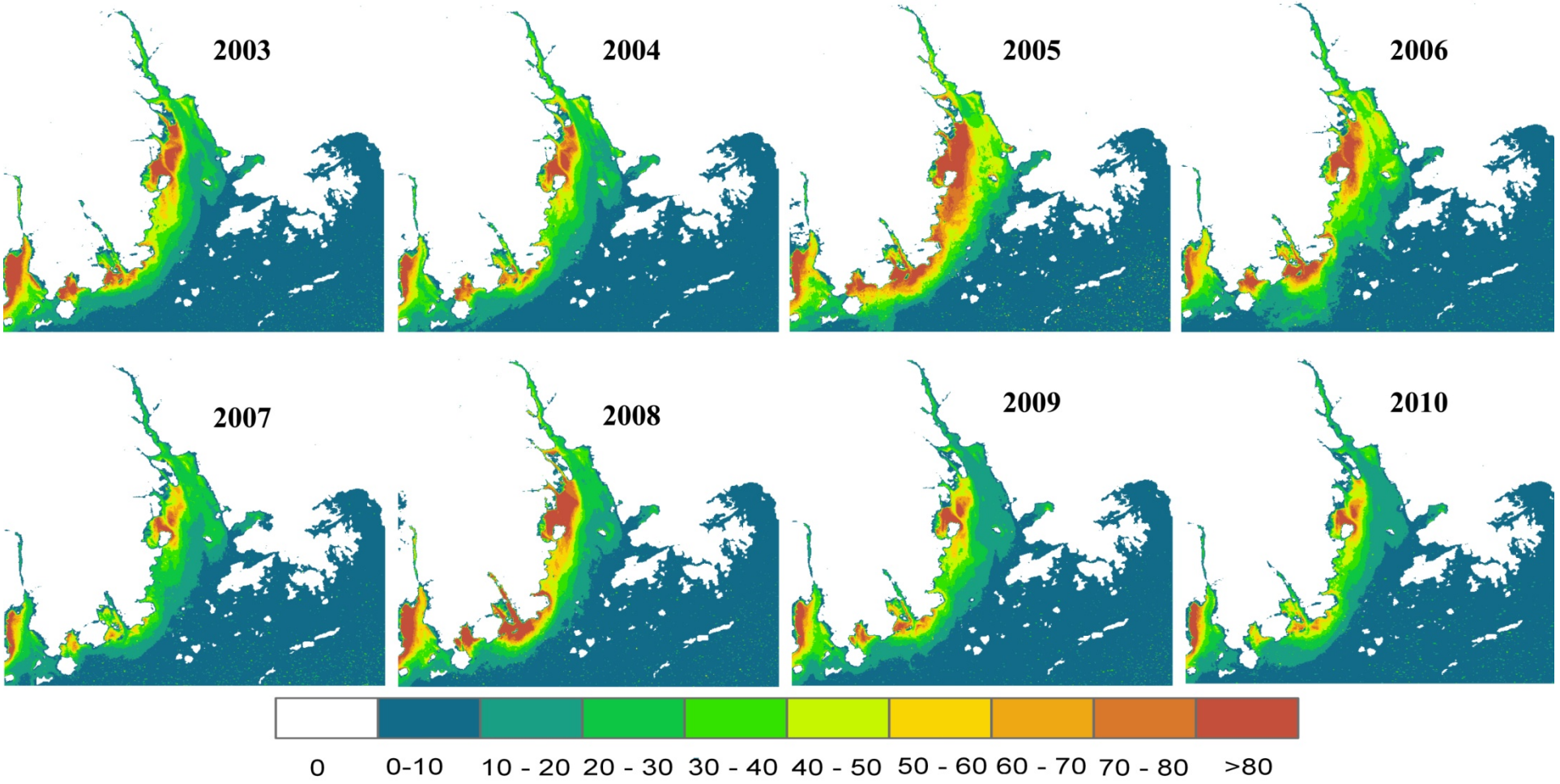
TSS：4.16-106 mg/L
N=32; RE=22.31%

MODIS 645, 555nm ratio
Spatial resolution: 250、500m

# Atmospheric correction& TSS Retrieval

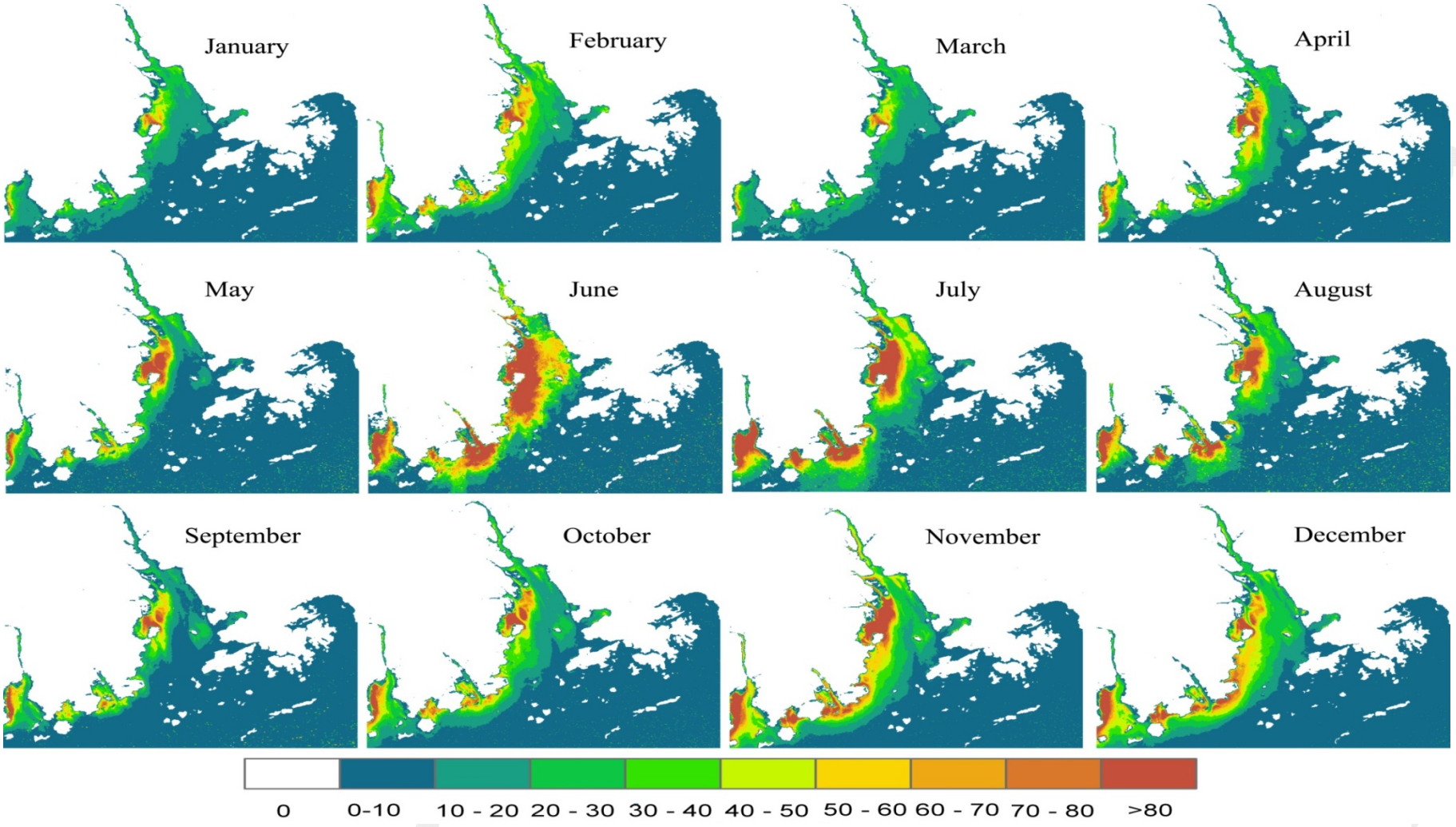
| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 总计 |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | - | 7 | 5 | 7 | 5 | 9 | 6 | 12 | 5 | 56 |
| 2 | - | 3 | 5 | 1 | 2 | 5 | 2 | 6 | 1 | 25 |
| 3 | - | 4 | 2 | 8 | 0 | 0 | 3 | 3 | 6 | 26 |
| 4 | - | 5 | 2 | 0 | 1 | 2 | 2 | 2 | 1 | 15 |
| 5 | - | 3 | 4 | 0 | 3 | 6 | 2 | 7 | 5 | 30 |
| 6 | - | 2 | 3 | 0 | 3 | 3 | 1 | 0 | 2 | 14 |
| 7 | 9 | 11 | 2 | 2 | 7 | 10 | 3 | 6 | 11 | 61 |
| 8 | 10 | 5 | 2 | 2 | 7 | 4 | 7 | 2 | 5 | 44 |
| 9 | 5 | 2 | 5 | 0 | 5 | 4 | 4 | 5 | 2 | 32 |
| 10 | 8 | 5 | 10 | 3 | 6 | 3 | 4 | 9 | 7 | 55 |
| 11 | 6 | 10 | 7 | 7 | 5 | 9 | 6 | 2 | 9 | 61 |
| 12 | 6 | 11 | 6 | 6 | 12 | 7 | 12 | 0 | 13 | 73 |
| Total | 44 | 68 | 53 | 36 | 56 | 62 | 52 | 54 | 67 | **492** |

# Inter-annual variation

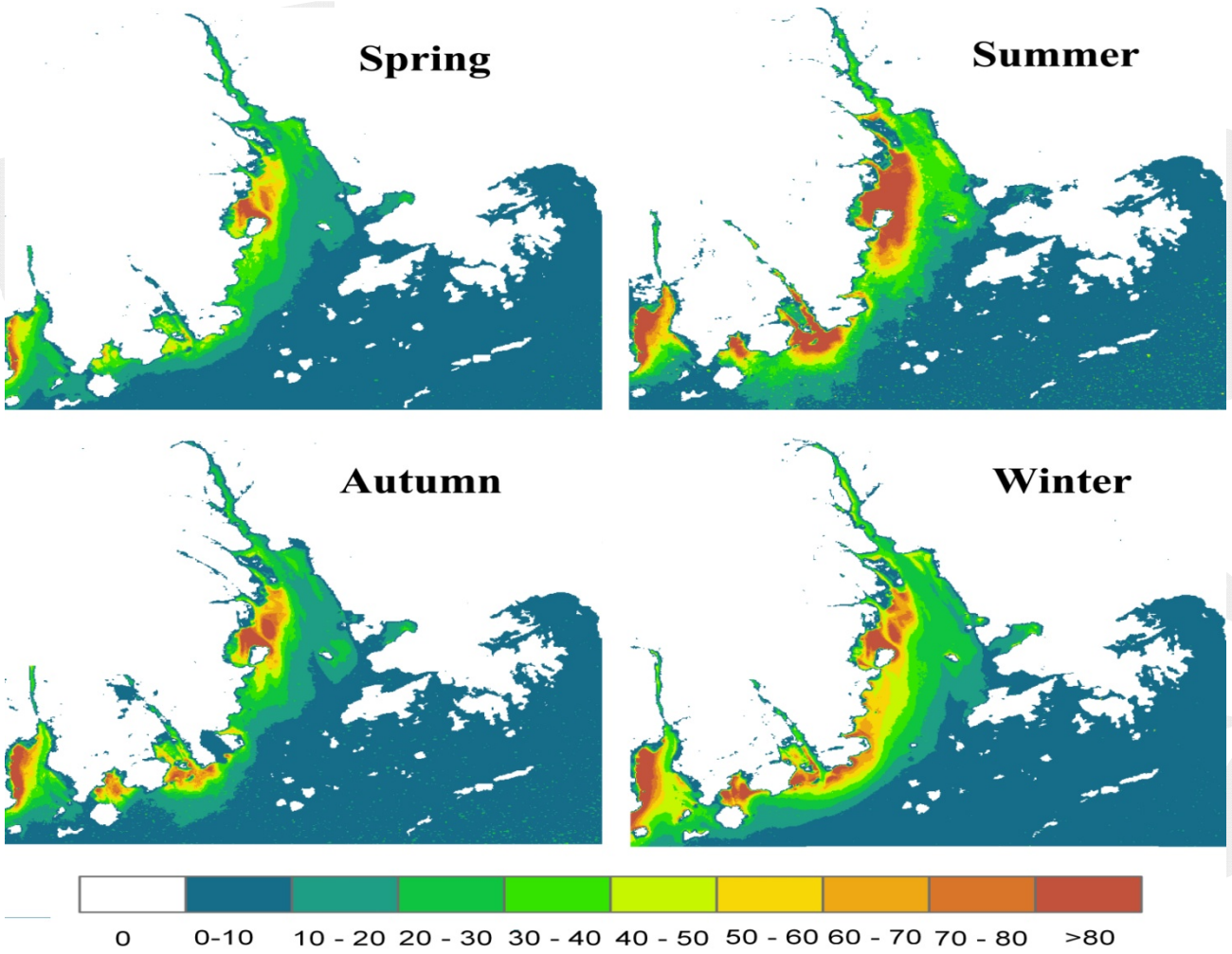



TSS (mg/L)

# Monthly change

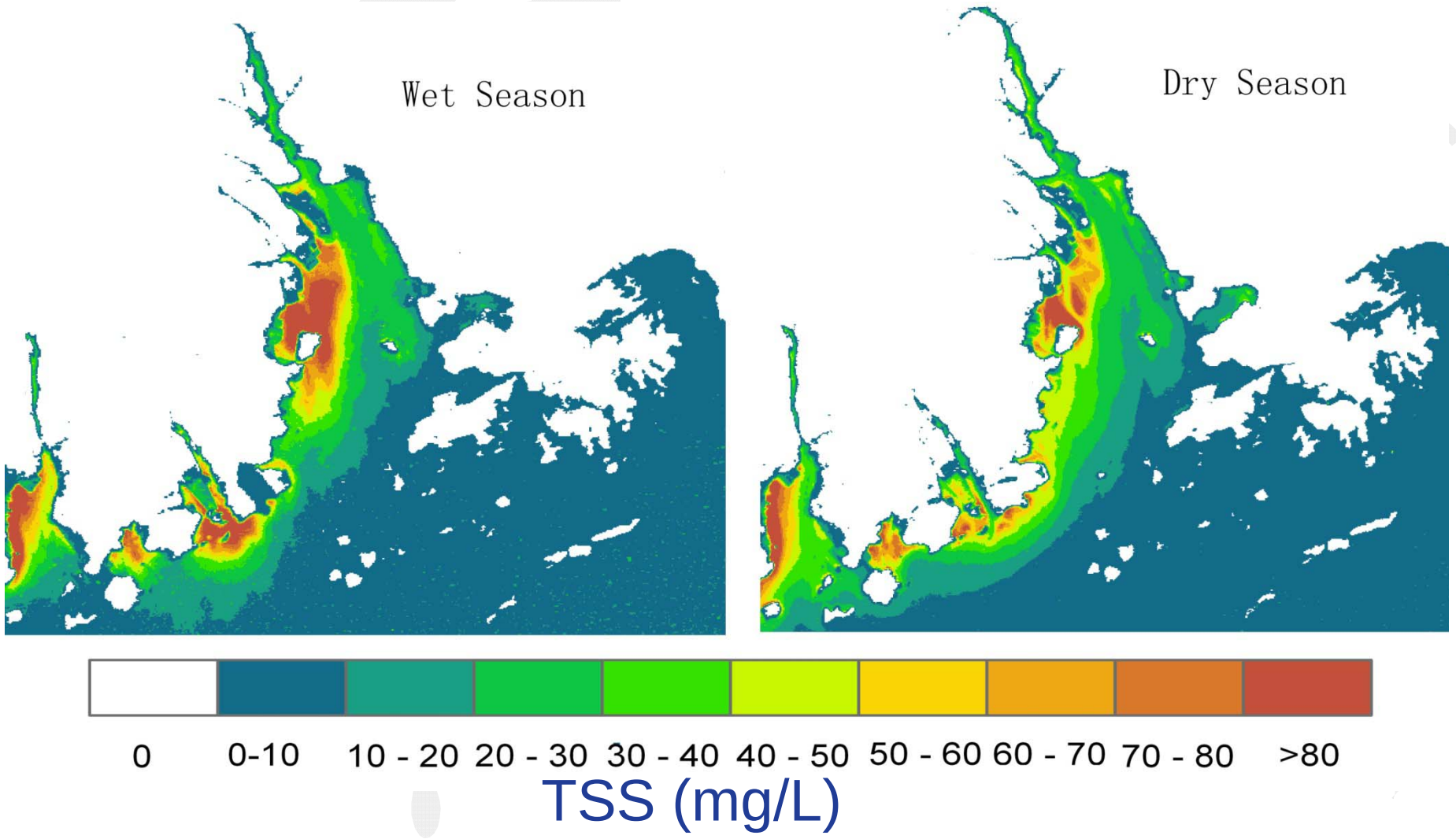


# Seasonal change

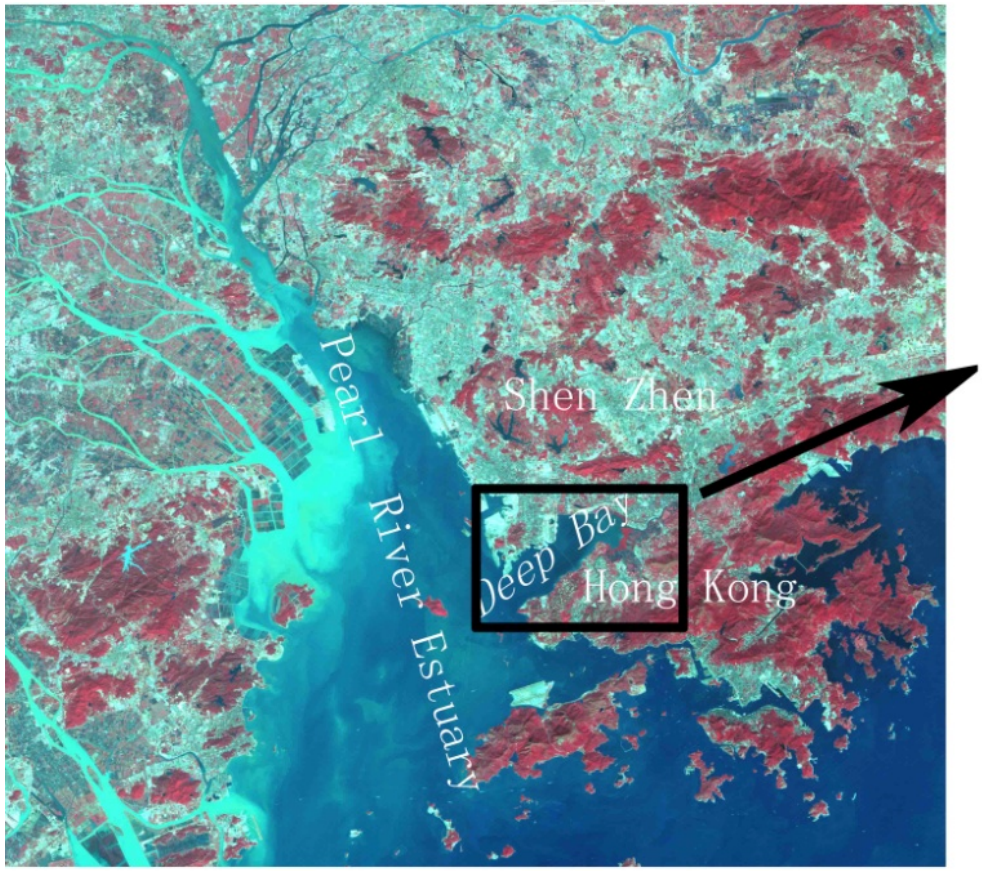


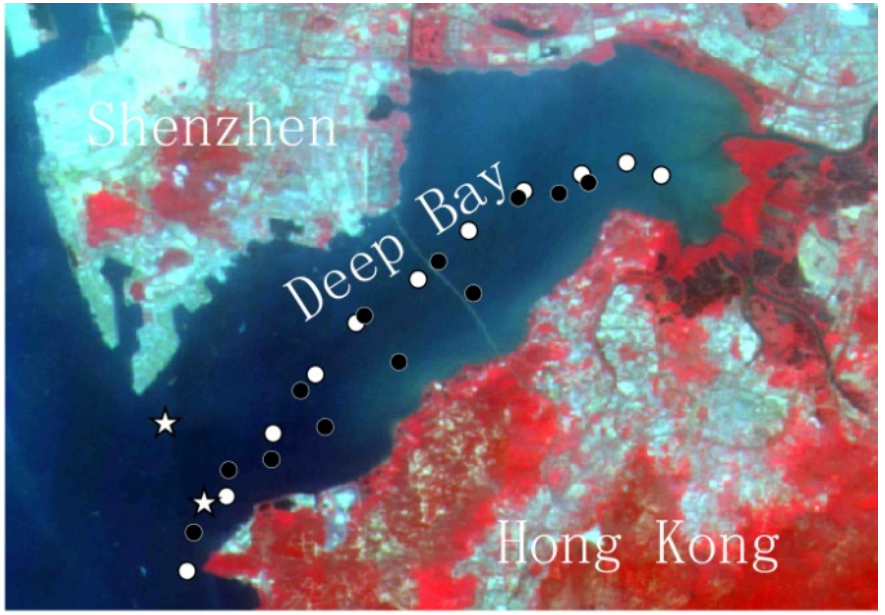

TSS (mg/L)

# Wet-Dry season Change



# Case 2: Deep Bay




☆ Stations in September through November, 2008

○ Stations on August 29, 2012

● Stations on October 26, 2012

MODIS Resolution: 250m---- Pearl River Estuary

HJ-1A/1B CCD:30m----Deep Bay

# Case 2: Atmospheric correction

Atmospheric correction

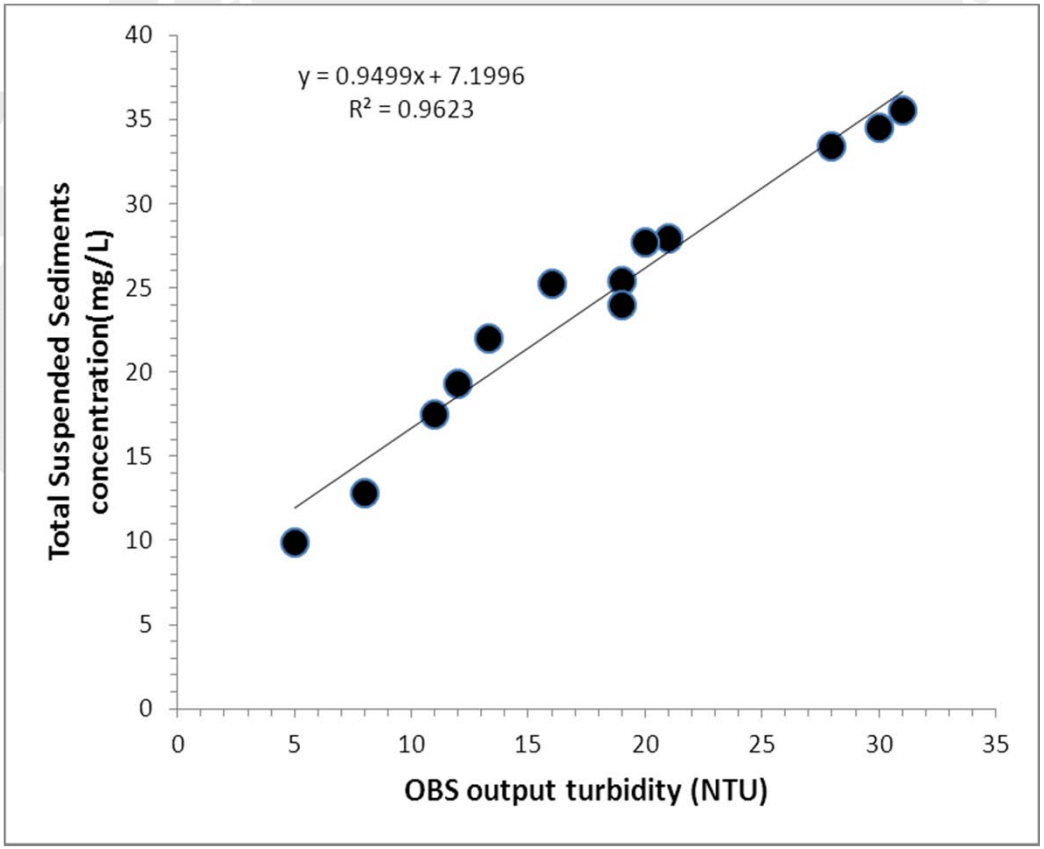
- Combined COST& PIF method

- Image-based information was employed
- Pseudo-Invariant Features were selected to do the radiation standardization for long-term monitoring

Avoid the aerosol influence

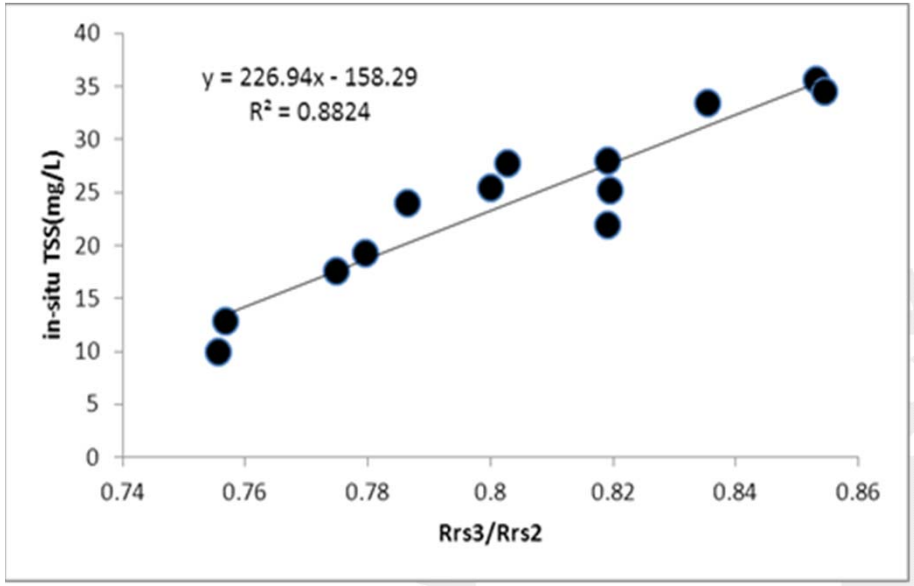
TSS from lab analysis is believable

OBS measurements

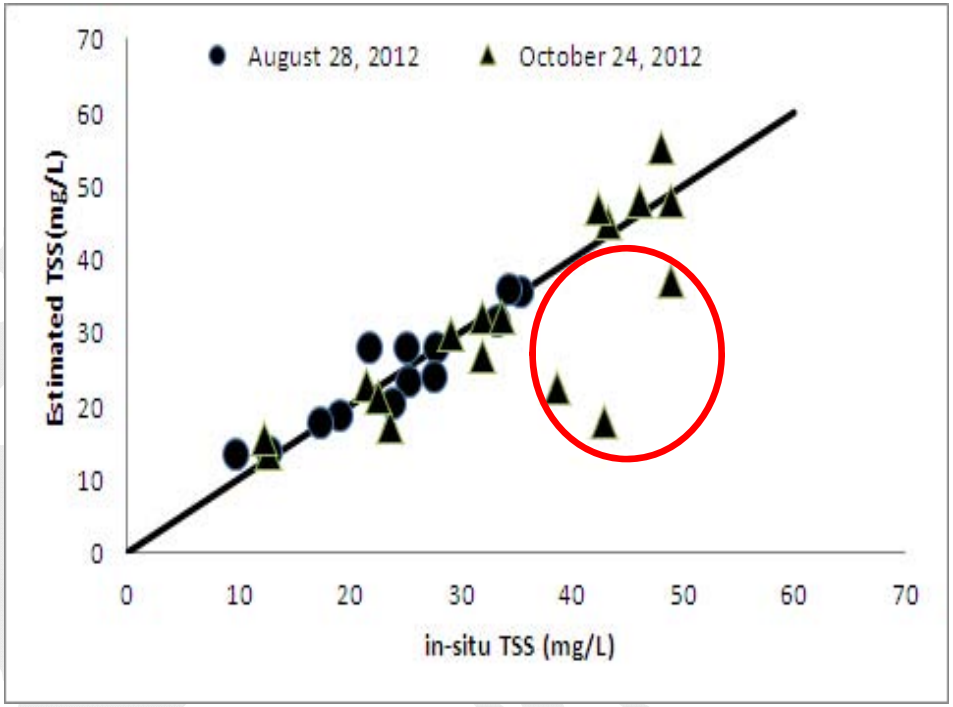



OBS calibration using the in-situ mass in water samples

# TSS retrieval & Validation

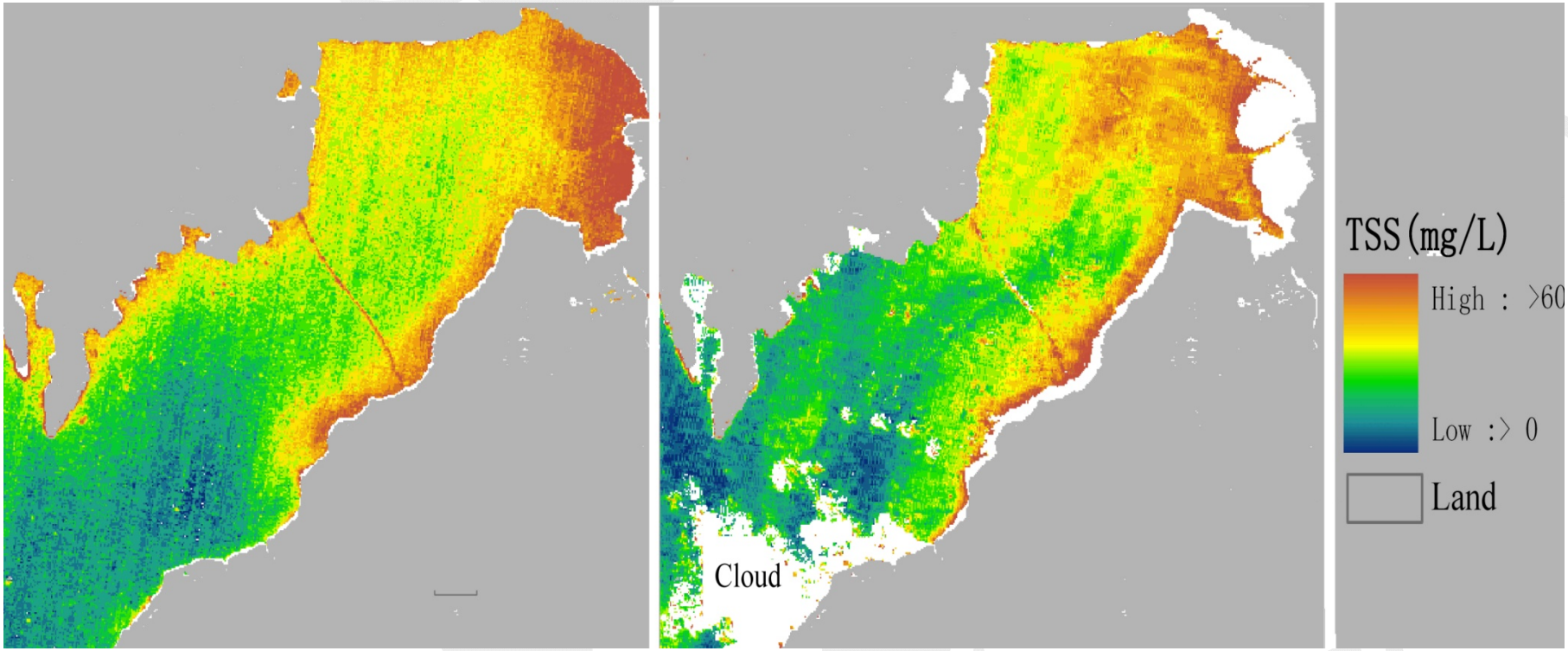



**Regression relationship between TSS concentration and the reflectance ratio (Rrs3/Rrs2) of band 2 and band 3 of HJ-1A/1B satellite CCD imagery**



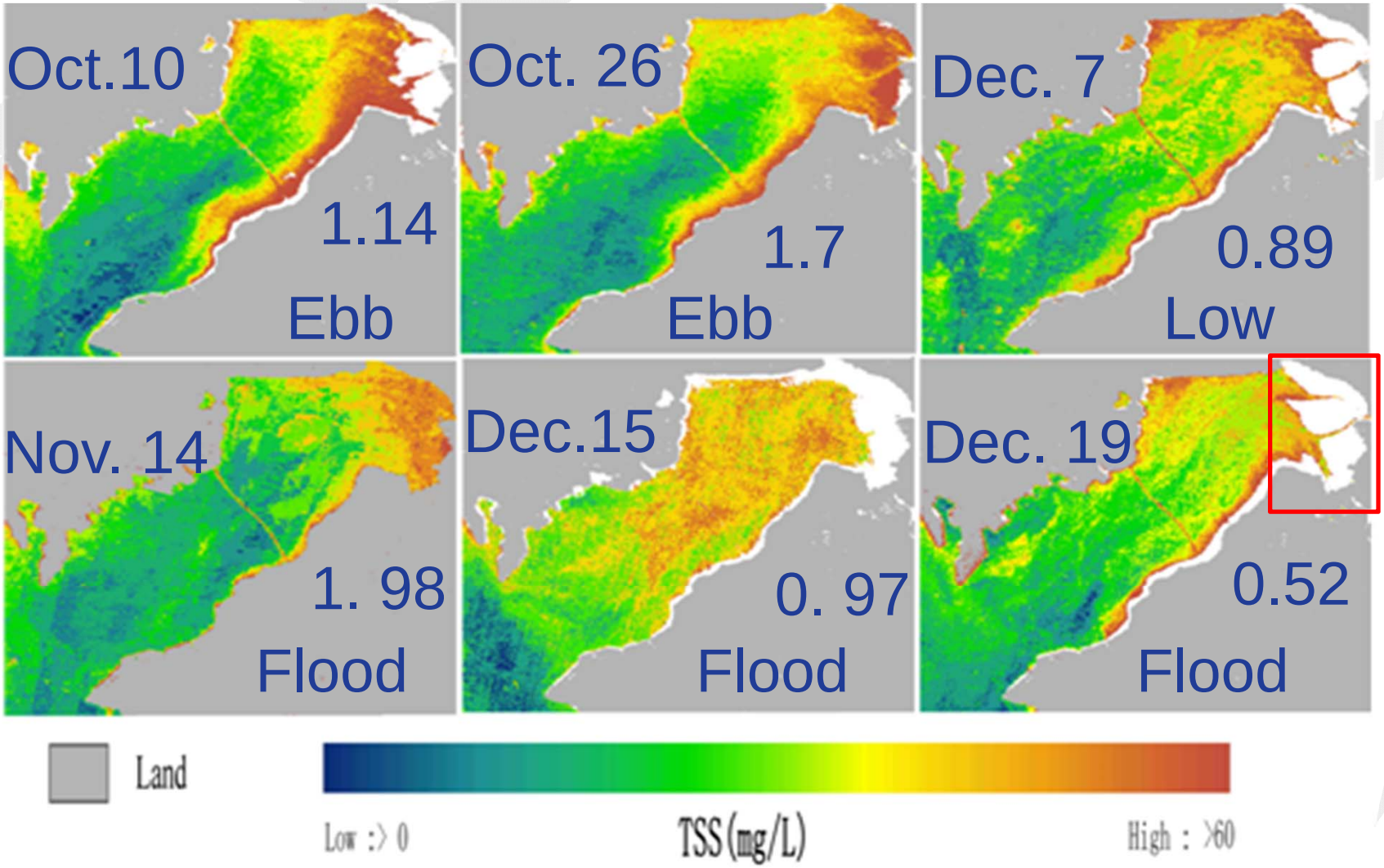

**Comparison of TSS concentration between the retrieval values from the in-situ data and the HJ-1A/1B CCD images collected on August 28, and October 24, 2012**

# TSS spatial pattern

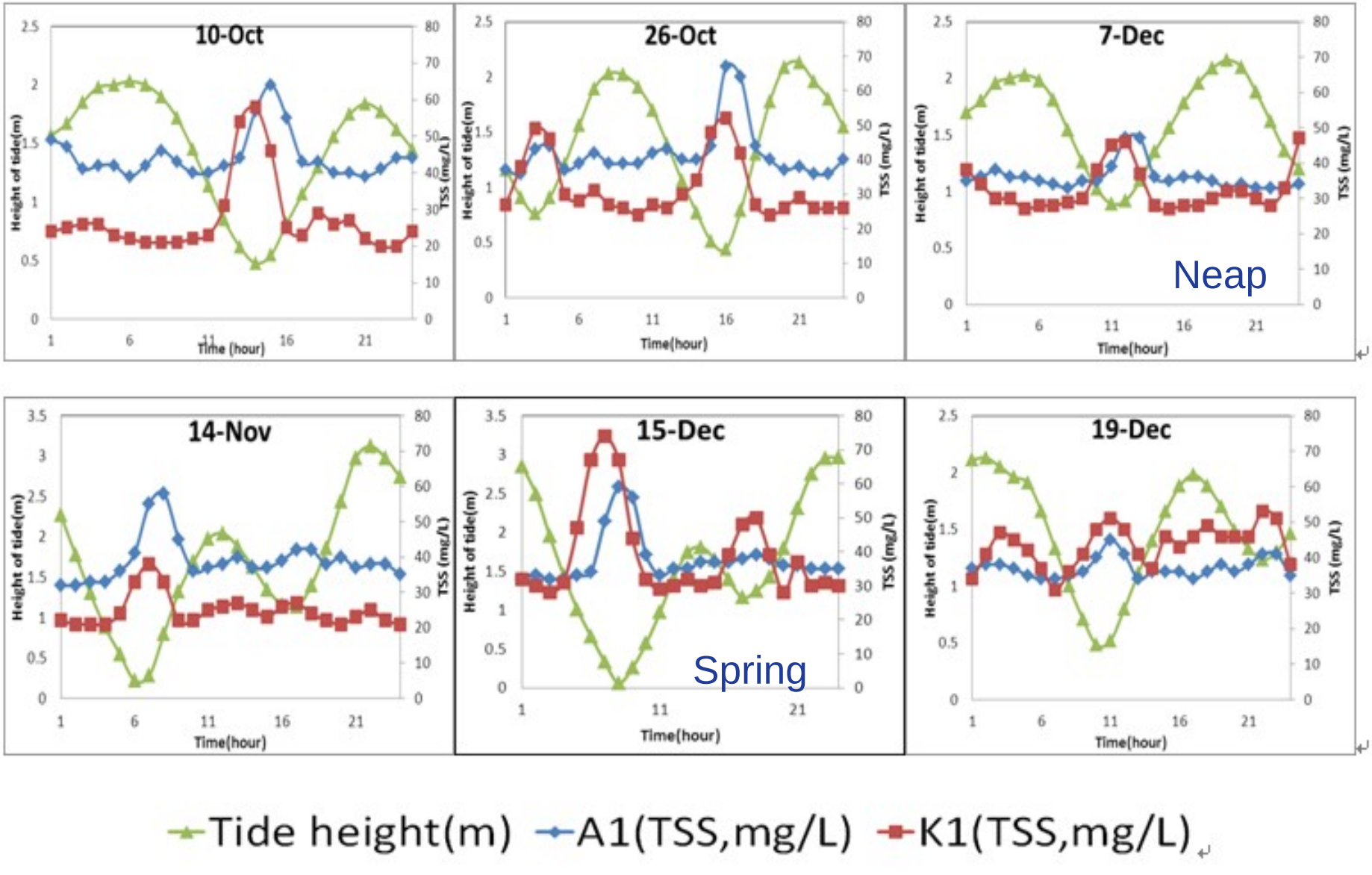



TSS concentration maps from HJ-1A/1B satellite CCD images on August 28, and October 24, 2012

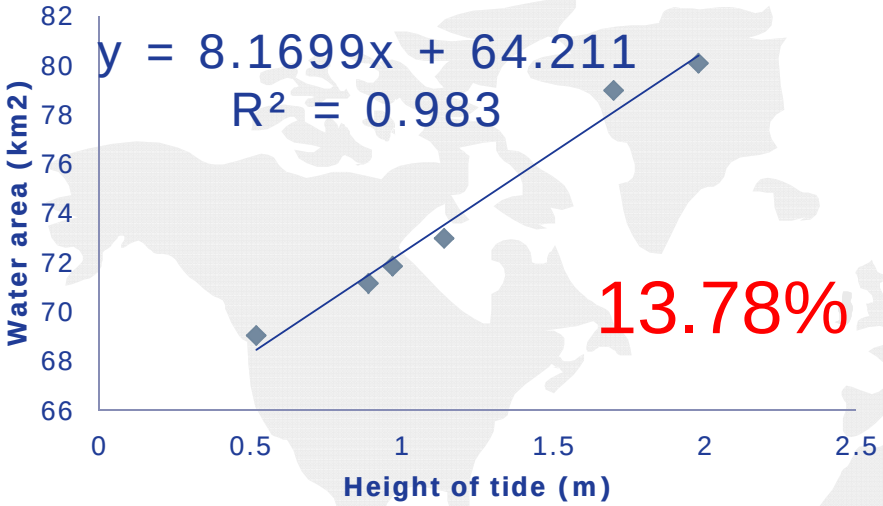
# TSS variation



# OBS measurements & tide circle



# Water area variation




13.78%

| Date | measured height of tide (m) | water area ($km^2$) | exposed tidal zone ($km^2$) | Percent of the exposed tidal zone (%) |
|---|---|---|---|---|
| 10- Oct | 1.14 | 72.9783 | 7.0992 | 8.87 |
| 26- Oct | 1.7 | 78.9795 | 1.098 | 1.37 |
| 14- Nov | 1.98 | 80.0775 | 0 | 0 |
| 7- Dec | 0.89 | 71.1558 | 8.9217 | 11.14 |
| 15- Dec | 0.97 | 71.8524 | 8.2251 | 10.27 |
| 19- Dec | 0.52 | 69.0435 | 11.034 | 13.78 |

# Conclusion

- **Some effective atmospheric correction methods were applied to process MODIS and HJ-1A/1B CCD data.**
- **TSS retrieval models suitable for PRE and Deep Bay were established.**
- **TSS information and its variation are focused on in this work.**
- **Influence of meteorological-hydrological data would be focused on in the future.**

I got the information, but the reasons need **further investigation**

I think, numeric simulation is needed in the future study!

THE HONG KONG POLYTECHNIC UNIVERSITY
香港理工大學

# Thank you