ESA–MOST Dragon Cooperation

中国科技部-欧洲空间局“龙计划”合作

2017 DRAGON 4 SYMPOSIUM

2017年“龙计划”四期学术研讨会

New Earth Observation tools for biogeochemical studies of Yangtze Valley lakes (BioGeoLakes)

26–30 June 2017 | Copenhagen, Denmark

2017年6月26-30日，丹麦 哥本哈根

New Earth Observation tools for biogeochemical studies of Yangtze Valley lakes (BioGeoLakes)

Project researchers (in collaboration with WaRYWeBio)

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- Univ. Siena – Steven Loiselle, Claudio Rossi, Alessandro Donati
- Wuhan Univ. – Xiaoling Chen, Jianzhong Lu, Lian Feng, Jian Li, Liqiong Chen
- IREA-CNR – Paolo Villa, Mariano Bresciani
- Nanchang University - Haiming Qin
- DLR - Juliane Huth
- Jiangxi Normal University - Shuhua Qi, Li Zhang
- RADI - Junsheng Li

Bio-optical Algorithms	• Algorithm development for complex optical conditions
Spatial and temporal	• Spatio-temporal analysis of biogeochemical and hydrological dynamics → primary productivity, carbon and vegetation conditions
Modelling and EO tools	• EO modelling and EO tools of Yangtze lake ecosystems for management and monitoring

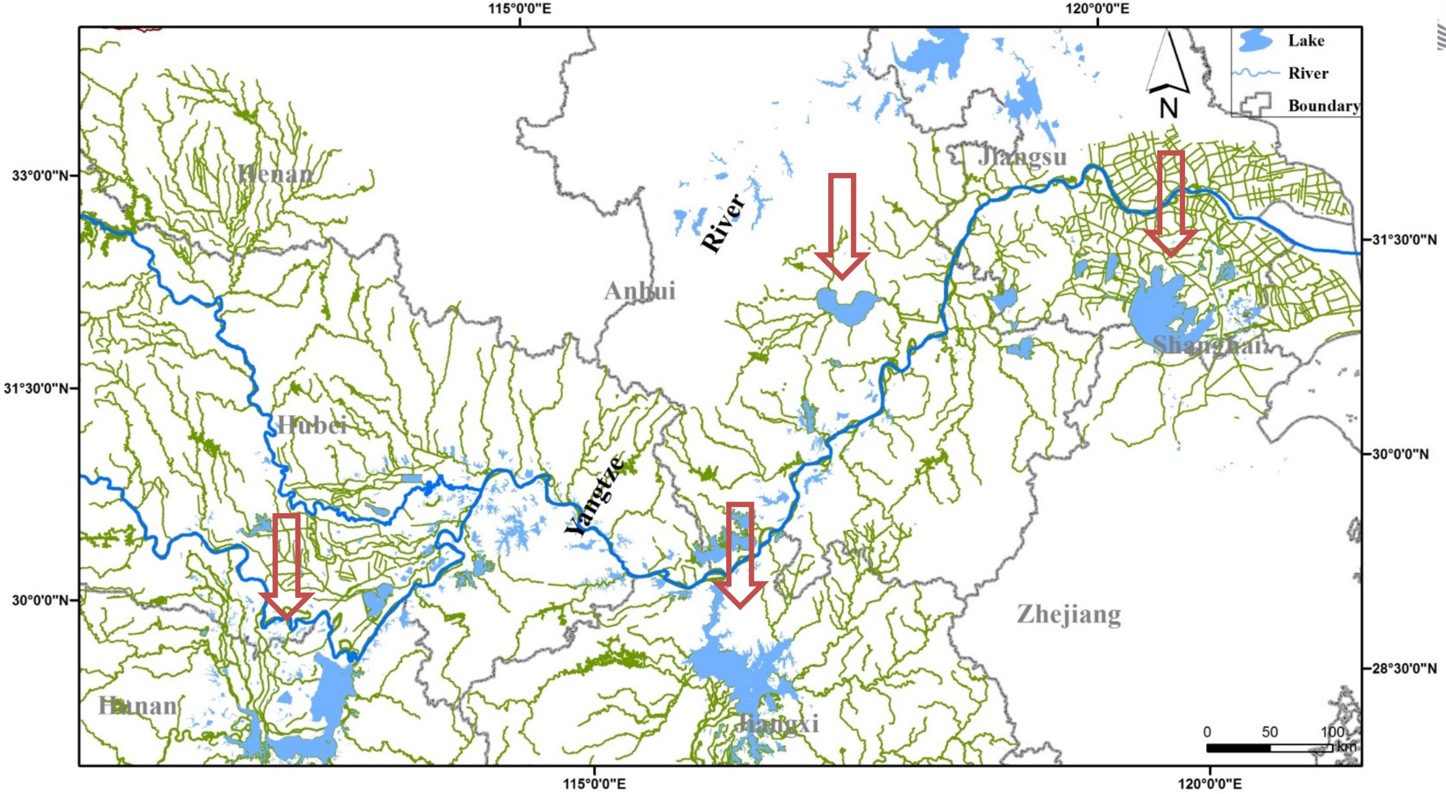

Chaohu

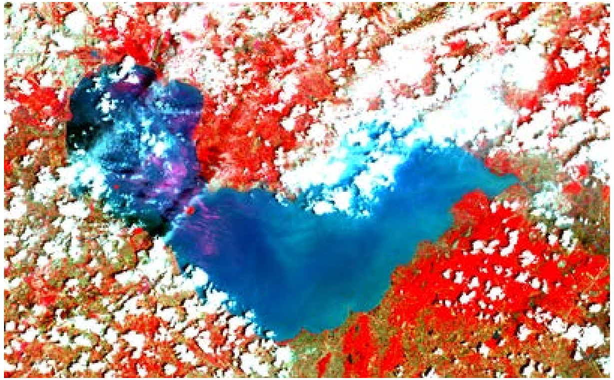

Taihu


Dongting

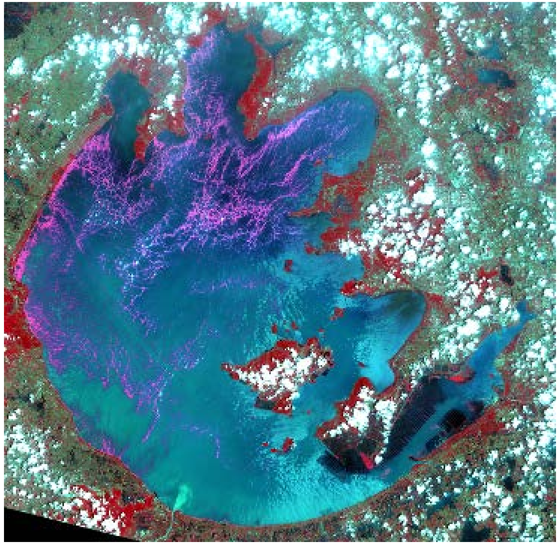

Poyang

4 of the 8 largest freshwater lakes in China



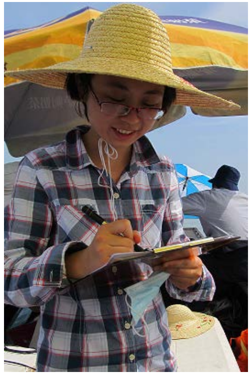


Sentinel 2A – 13 June 2016



Sentinel 2A – 16 June 2016

Sentinel-1/2/3, Cryosat-2, SMOS, HJ-1-A/B CCD and HSI, HY-1B CZI, Beijing-1/2 MSI, GaoFen -1/2, Suomi NPP VIIRS, COMS-1 GOCI, Landsat, MODIS, VIIRS



BioGeoLakes – Expected results

- Calibration and validation of new algorithms
- Multi-source and multi-platform approaches to identify key spatial and temporal lake dynamics
- Identification of hydrodynamic–water quality links with respect to hydrological, land cover and climate change;
- Assessment of new and upcoming EO sensors;
- Support for provincial and national stakeholders and managers
- Enlarge and enforce the cooperation between European and Chinese researchers
- Initiatives for training and knowledge building

Water resource and quality monitoring in Poyang wetlands and lakes, linking MERIS and Sentinel 2

Chen Xiaoling, Chen Liqiong

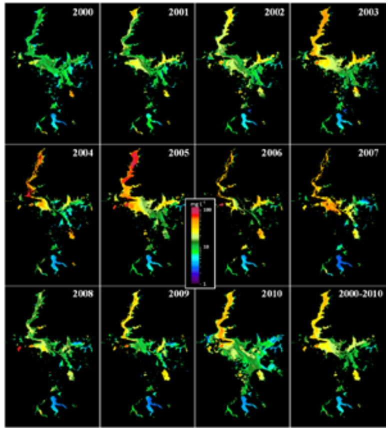
Feng Lian, Li Jian, Lu Jianzhong, Tian Liqiao

Wuhan University

Thematic Goals

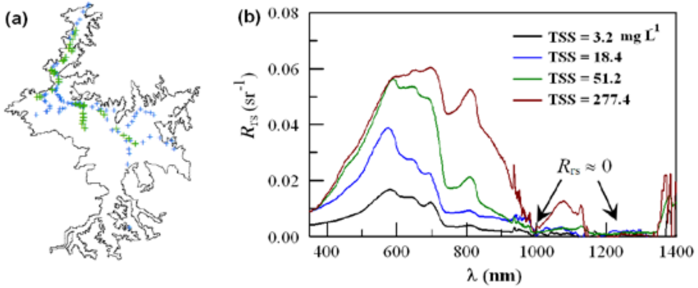
- Water quality monitoring
  - ✓ Suspended sediments
  - ✓ Chlorophyll_a
  - ✓ Nutrient index: water age
- Water quantity monitoring
- Wetland and wetland vegetation monitoring

We succeed in retrieval TSS from MODIS images in Dragon 3

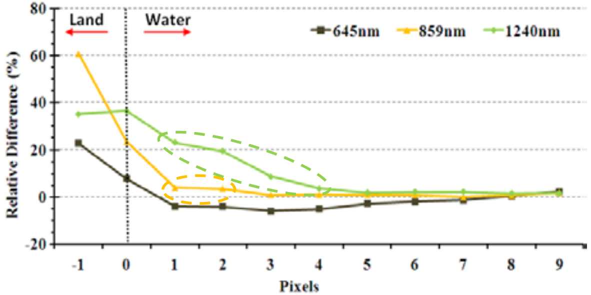


Spatio-temporal Pattern of Suspended Sediments, MODIS, 2000-2010

Water reflectance ~0 at >1000 nm

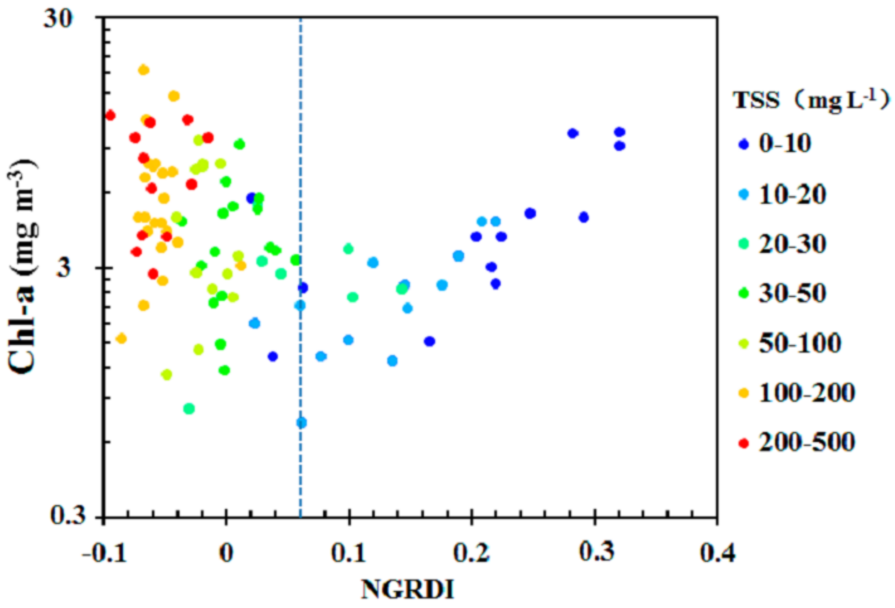


645 nm "immune" to land adjacency effect



Dragon 4： New retrieval algorithms of TSS and Chla in Poyang Lake are performed for ESA and China EO data

Remote Sensing for Chlorophyll-a

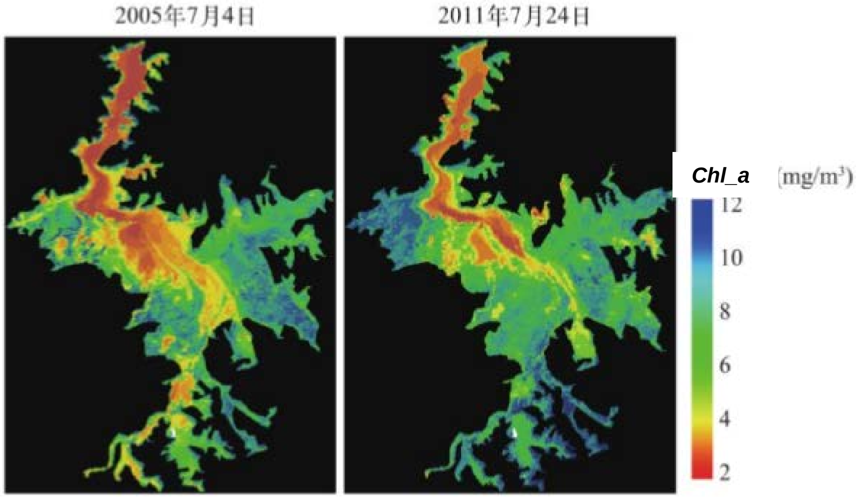


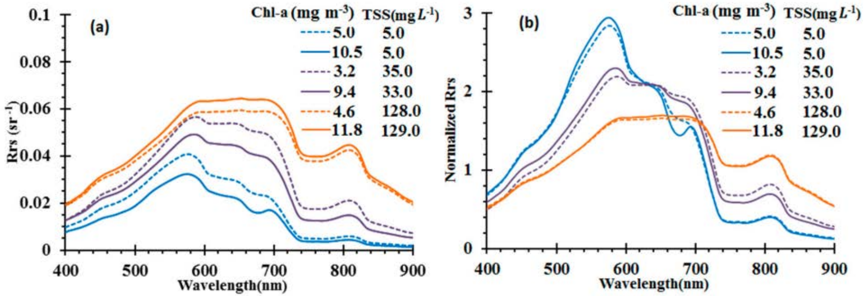
A positive correlation exists between Chl-a and NGRDI (Normalized Green-Red Difference Index) in relatively sediment-poor waters.

$$NGRDI = (Rrs,560 - Rrs,681)/(Rrs,560 + Rrs,681)$$

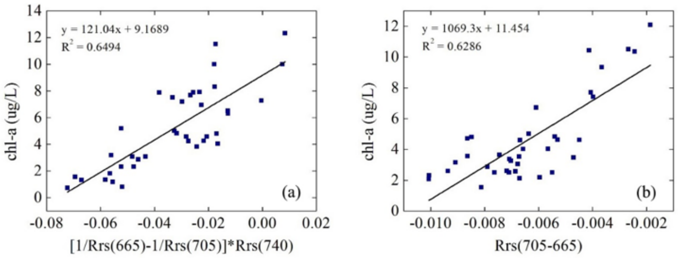
Remote Sensing for Chlorophyll-a, Using MERIS

Using NGRDI to classify waters in North and South Lakes, and modify Chla retrieval models separately



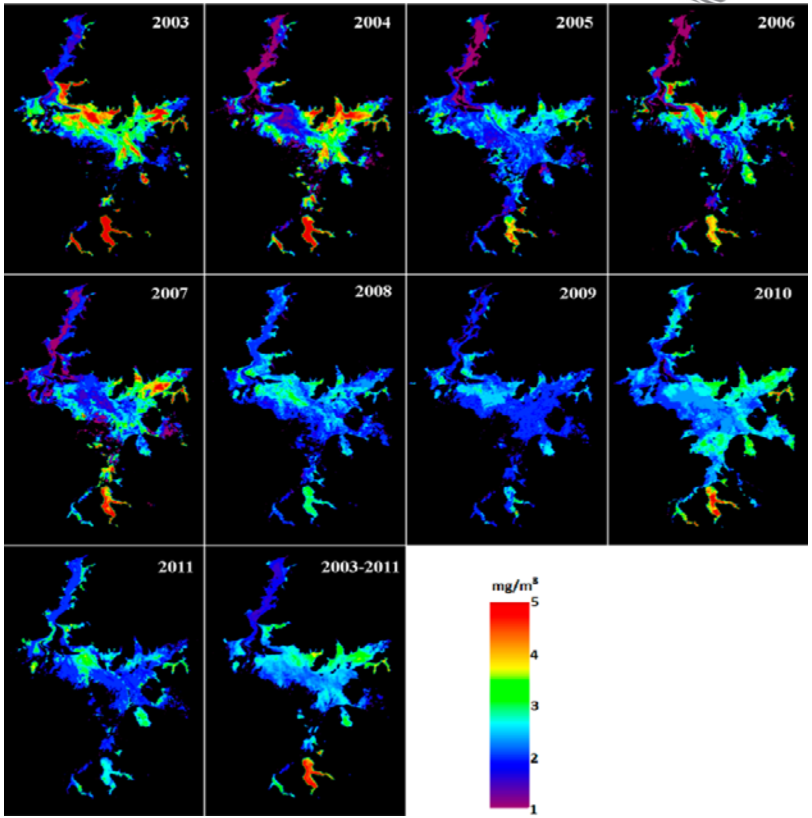


North Lake *South Lake*



Spatio-temporal Pattern of Chla, MERIS

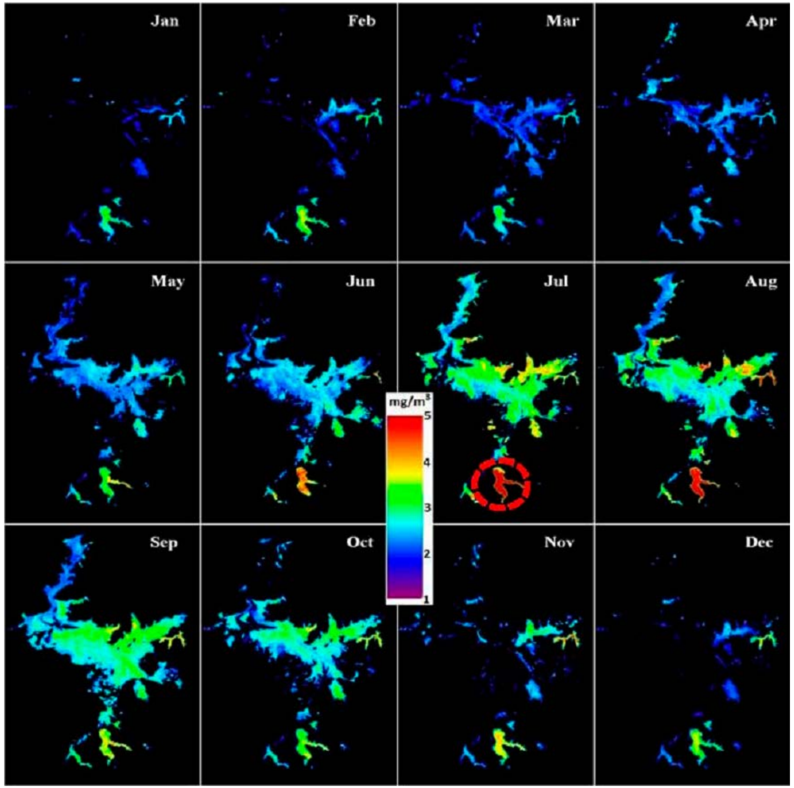
- ✓ Mean Chl-a distributions of Poyang Lake between July and September from 2003 to 2011.
- ✓ Higher Chl-a was observed in the small sub-lake in the south and in the astern Poyang Lake.
- ✓ Chl-a was found to be the highest in 2003 and 2004.



Spatio-temporal Pattern of Chla, MERIS

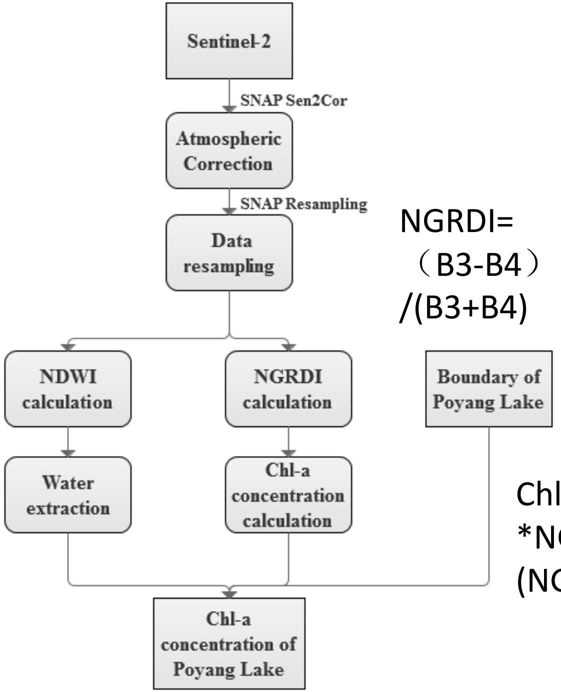
- ✓ Chl-a distributions during each climatological month between 2003 and 2012.
- ✓ Higher Chl-a was observed in the south, especially for the small sub-lake.
- ✓ Chl-a in the summer months appeared higher than in other months.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Mean
Mean	2.6	2.9	2.5	2.4	3.0	3.4	4.4	4.2	3.5	3.3	3.3	2.9	3.2
Std.	0.5	0.6	0.4	0.2	0.4	0.8	1.0	1.0	0.3	0.3	0.6	0.6	0.6



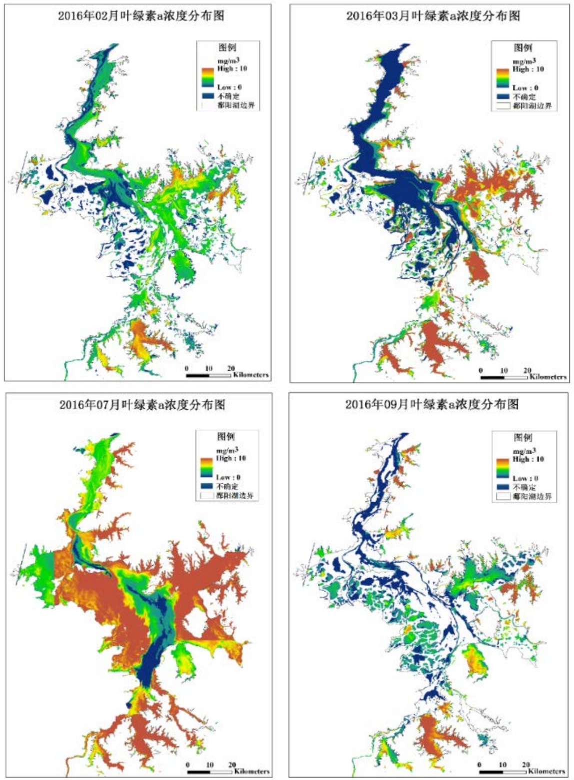
Chl_a retrieval from Sentinel 2A

Data： Sentinel-2A (20160207，20160331， 20160726， 20160924)

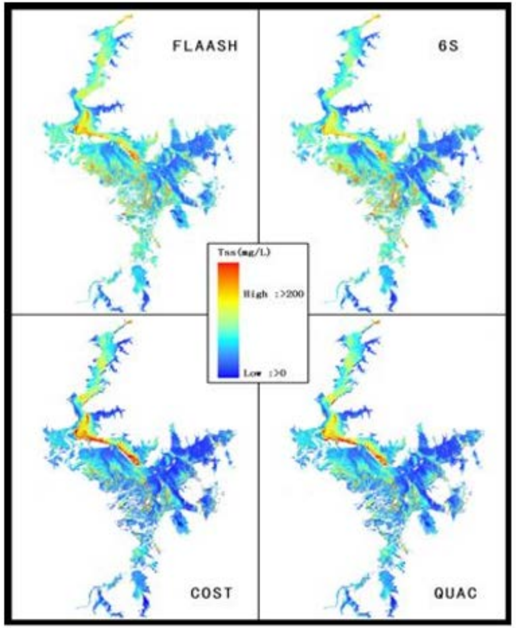


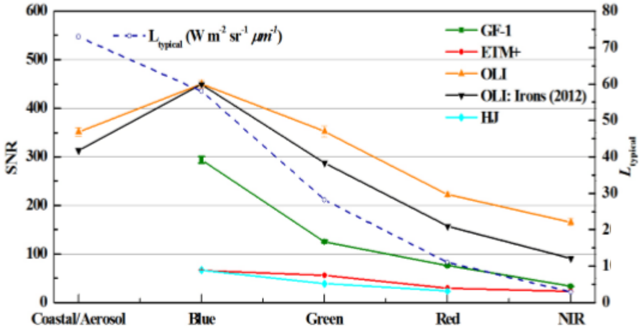
NGRDI=（B3-B4）/(B3+B4)

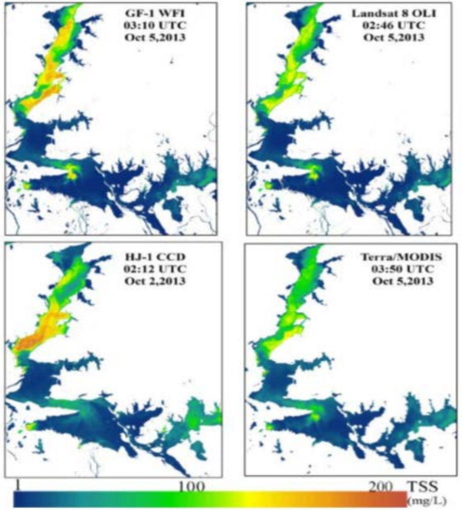
Chla=0.87exp*(7.05 *NGRDI)*1.25 (NGRDI>0.06)



TSS retrieval of HJ and GF series

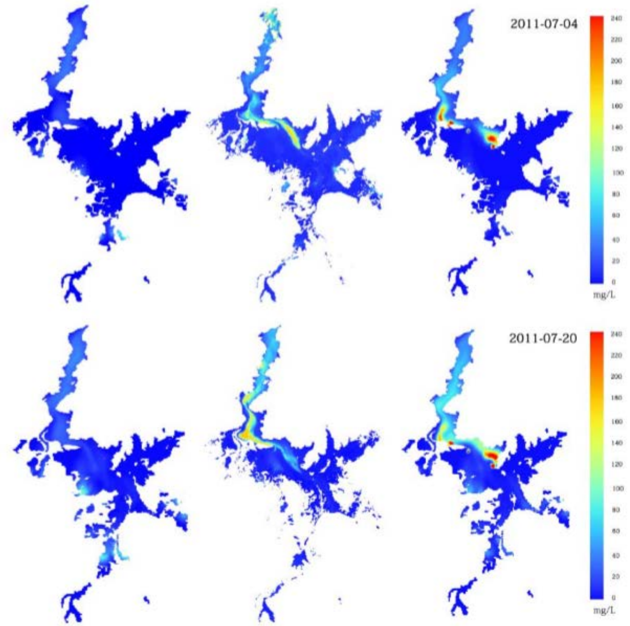




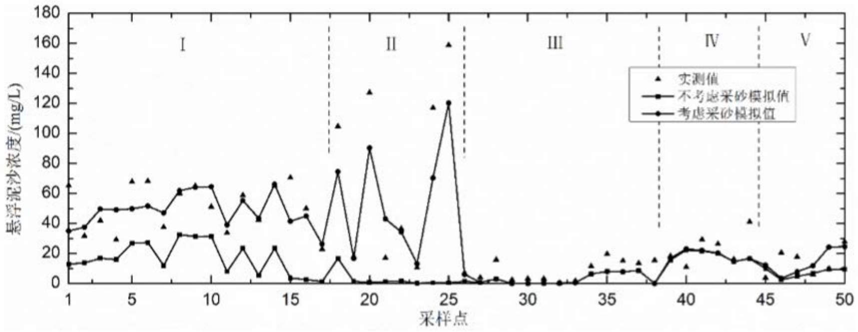


- ✓ Compare different AC methods on HJ 1A/B images
- ✓ Discuss how SNR differences in GF,landsat ETM+,OLI and HJ series influence the SST retrieval results

Data assimilation for TSS

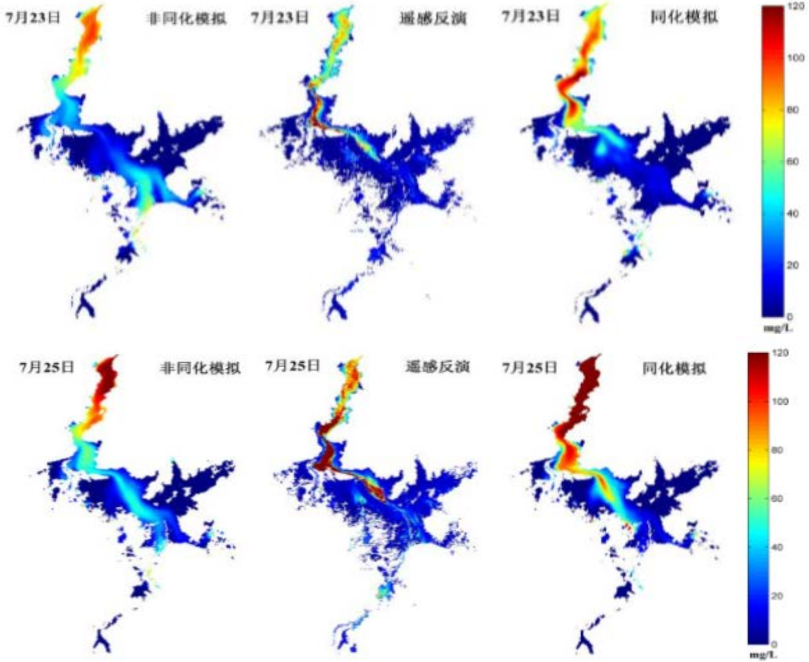


Simulation RS retrieval Simulation with dredging detection

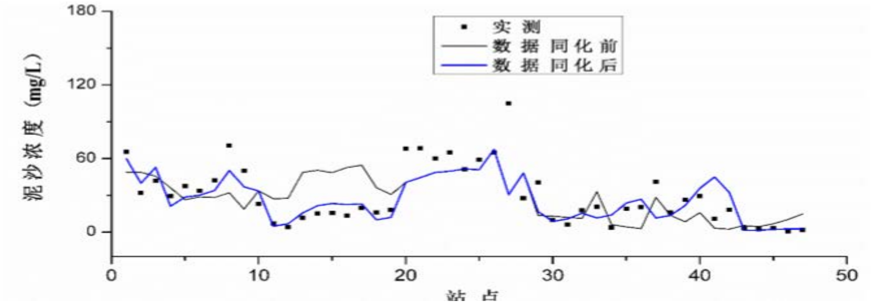


- ✓ Using Landsat dredging area detection results, reset the boundaries of hydrologic simulation,
- ✓ TSS simulation with dredging detection has a similar pattern with TSS remote sensing retrieval results, and performs a better accuracy than simulation without dredging detection .

Data assimilation for TSS

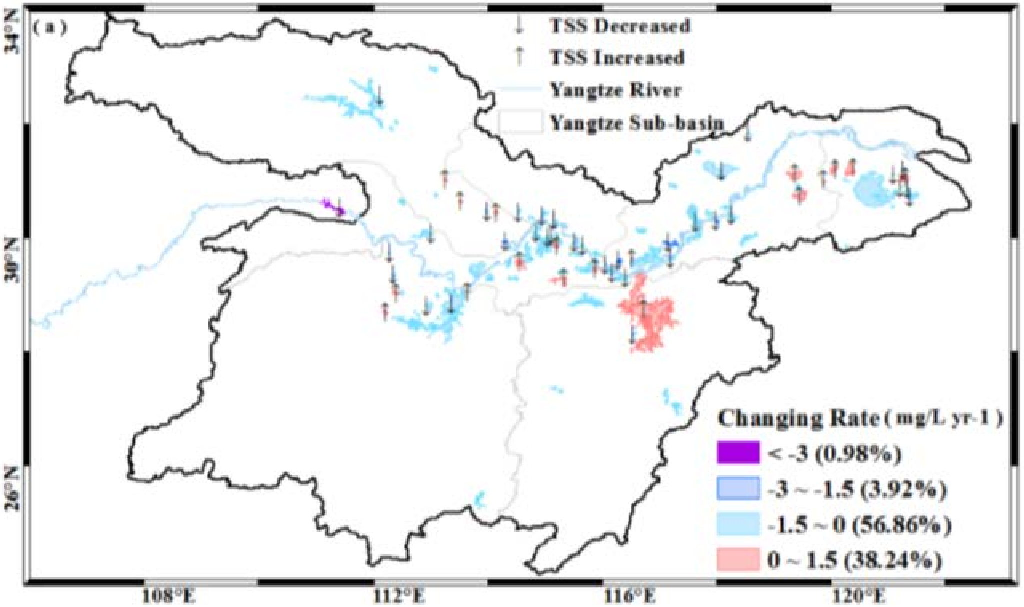


Simulation RS retrieval Assimilation



With the aid of remote sensing data and in-situ data, a better hydrodynamic simulation results of Total Suspended sediments achieved.

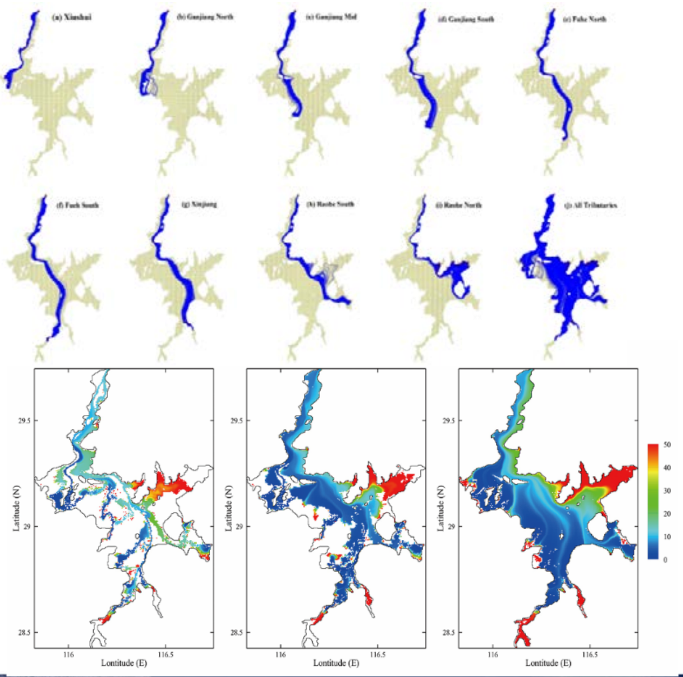
TSS various in 102 lakes in Yangtze basin from 2000 to 2014

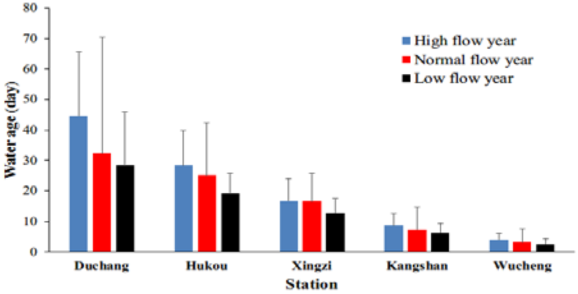


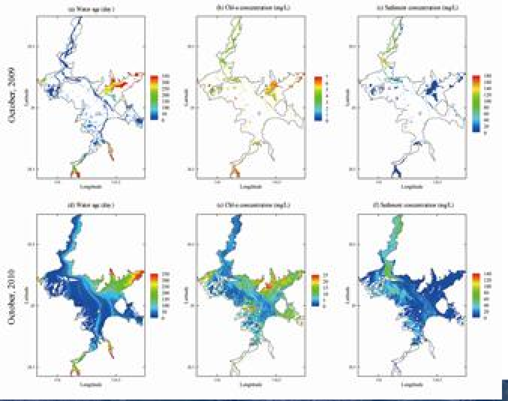
In river-connected lakes such as Dongting Lake and the Three Gorges Reservoir TSS is decreasing
64.5% of the TSS in river non-connected lakes is decreasing.

Nutrient index : Water age

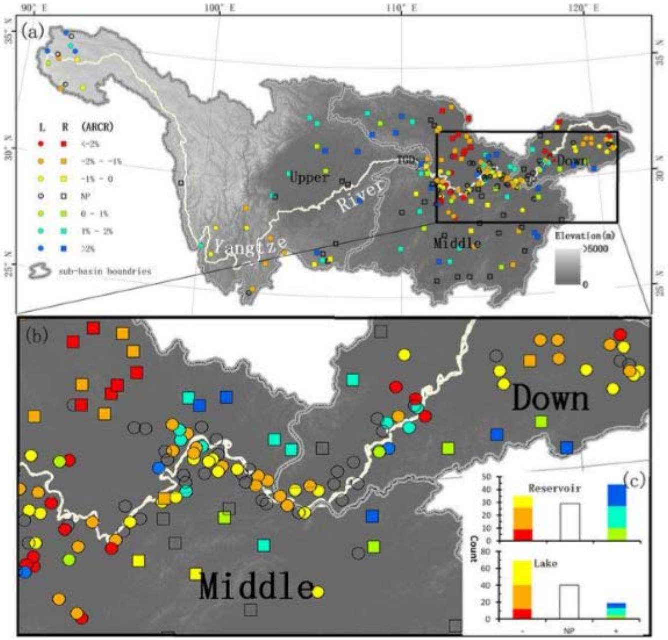
Water age ranges from 10 to 30 days in most regions of lake. The spatial distribution of water age is highly related to the pattern of satellite images derived chlorophyll-a and sediment concentration.





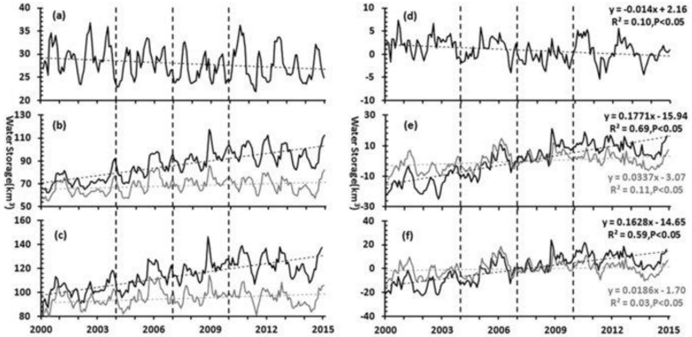


Water quantity
128 lakes and 108 reservoirs in Yangtze basin

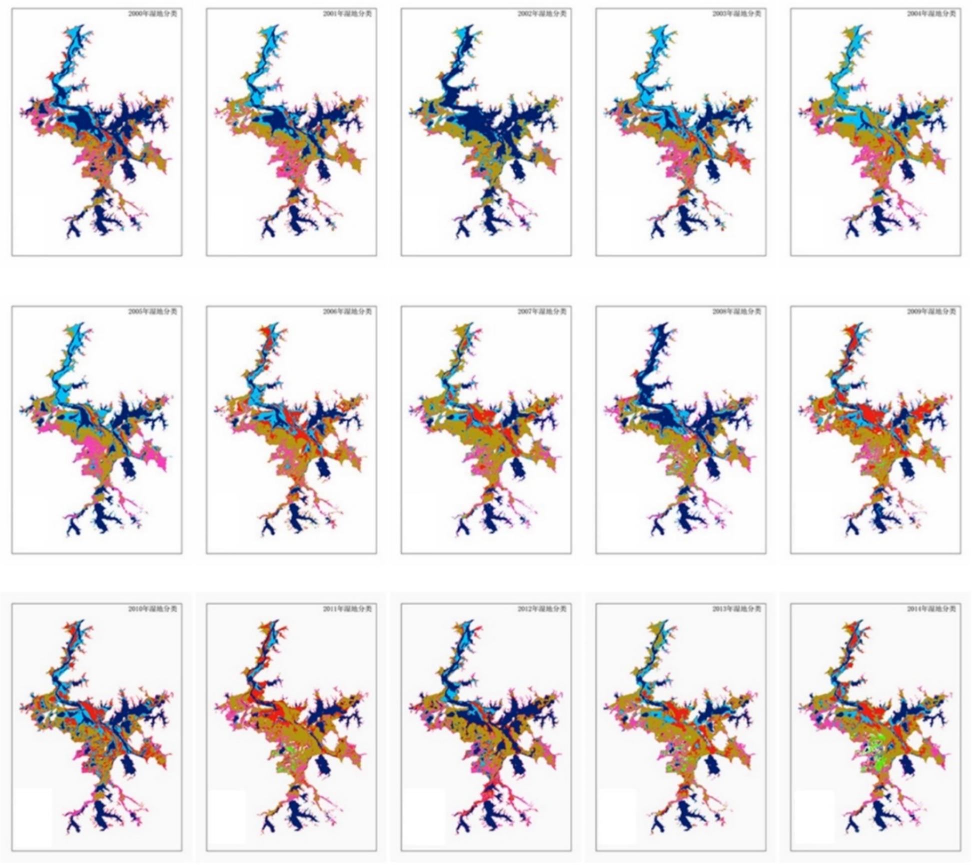


- Monthly various trends of water quantity of lakes and reservoirs in Yangtze basin from 2000-2014

- 8 days composite products of MODIS data was involved



Wetland vegetation Classification



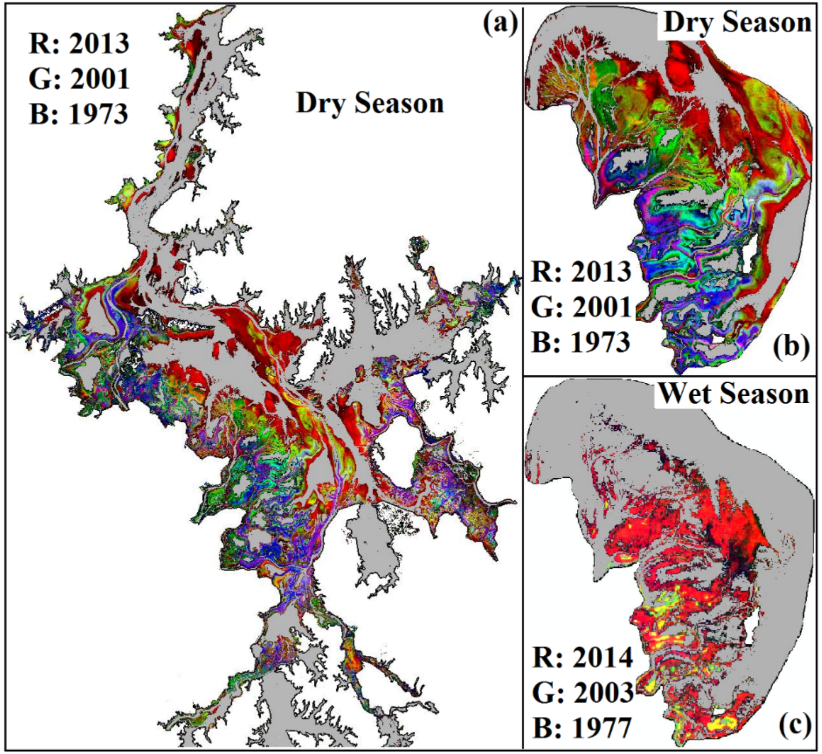
- ✓ Time series MODIS NDVI data was employed in vegetation classification in Poyang Lake Wetland

图例

- Unknown
- Water
- Mud
- Aquatic macrophytes
- Sedges
- Hygrophilous vegetation
- Emergent Plants

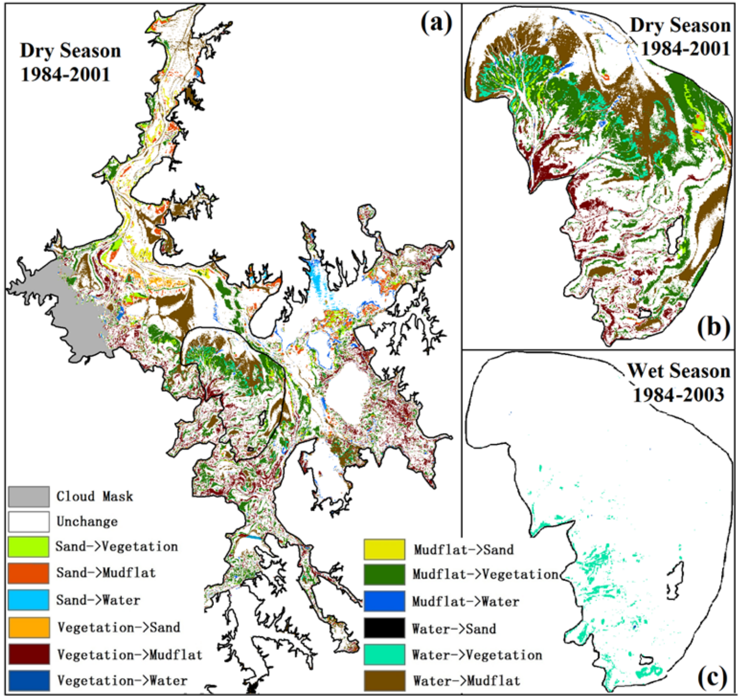
Long-term NDVI Changes

- **Entire Poyang Lake**
  - ✓ Wetland vegetation spread to near-shore regions from 2001 to 2013
  - ✓ Vegetation in Offshore regions showed better growth in the 1970s
- **NWNNR for the dry seasons**
  - ✓ High NDVI values (red) in near-water regions
  - ✓ High NDVI values (blue) along the lake boundary
- **NWNNR for the wet seasons**
  - ✓ Coverage of vegetation was dramatically expanded in the most recent year

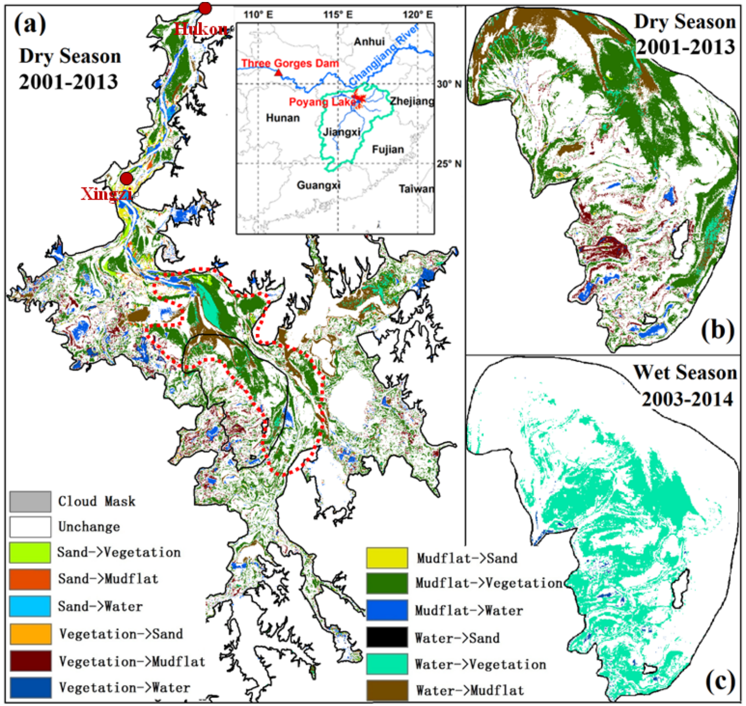


Reddish color indicates higher NDVI and better wetland vegetation growth!

Wetland Changes before and after TGD

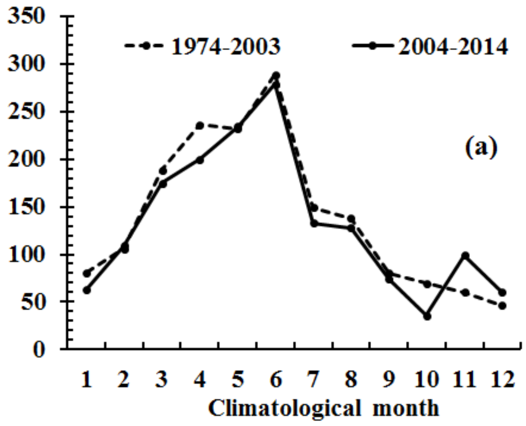


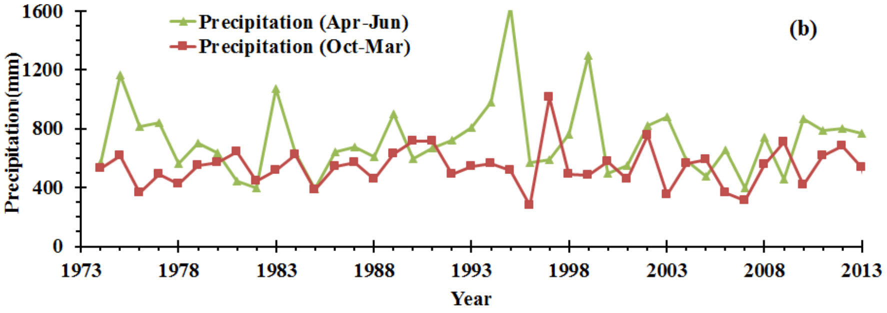
Pre-TGD Period



Post-TGD Period

Local Precipitation Rather Than The TGD ?





a) No significant changes between pre- and post-TGD periods' meteorological data

b) No significant decreasing trend could be identified when a four decades period was considered

Low water level of Poyang Lake in recent years is unlikely to be caused by the variations of the local precipitation.

Plan for next 2 years

- ✓ Coupling RS and hydrodynamic simulation and data assimilation
- ✓ Get a better understanding of water quality variation in Poyang Lake using Higher spatial resolution imageries
- ✓ Make a whole map of water quality in Yangtze river lakes
- ✓ More scientific visits and in deep cooperation.

New EO approaches to monitor and manage shallow lakes under the influence of human activities

Hongtao Duan, Steven Loiselle

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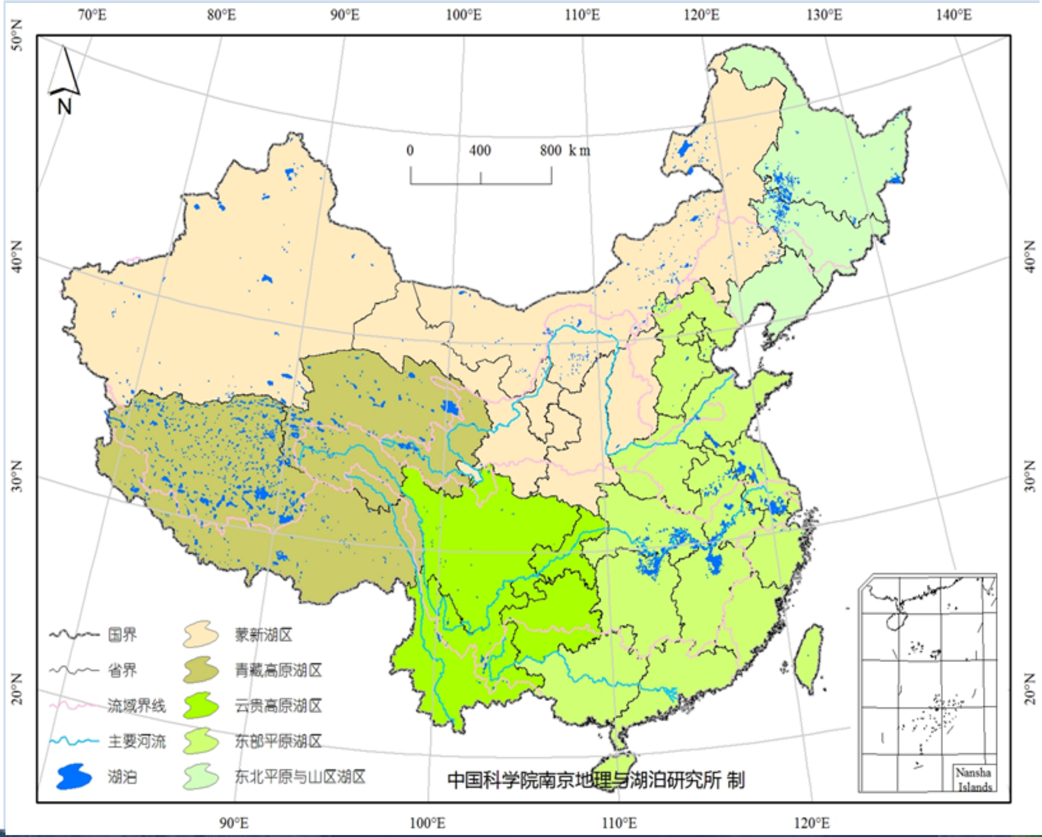
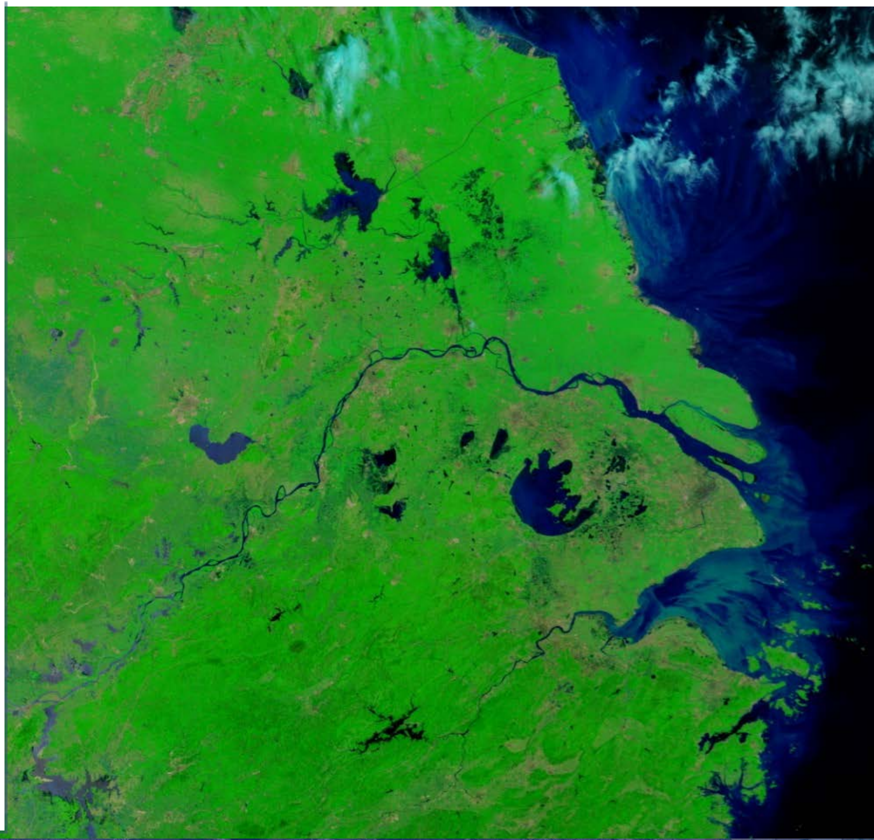
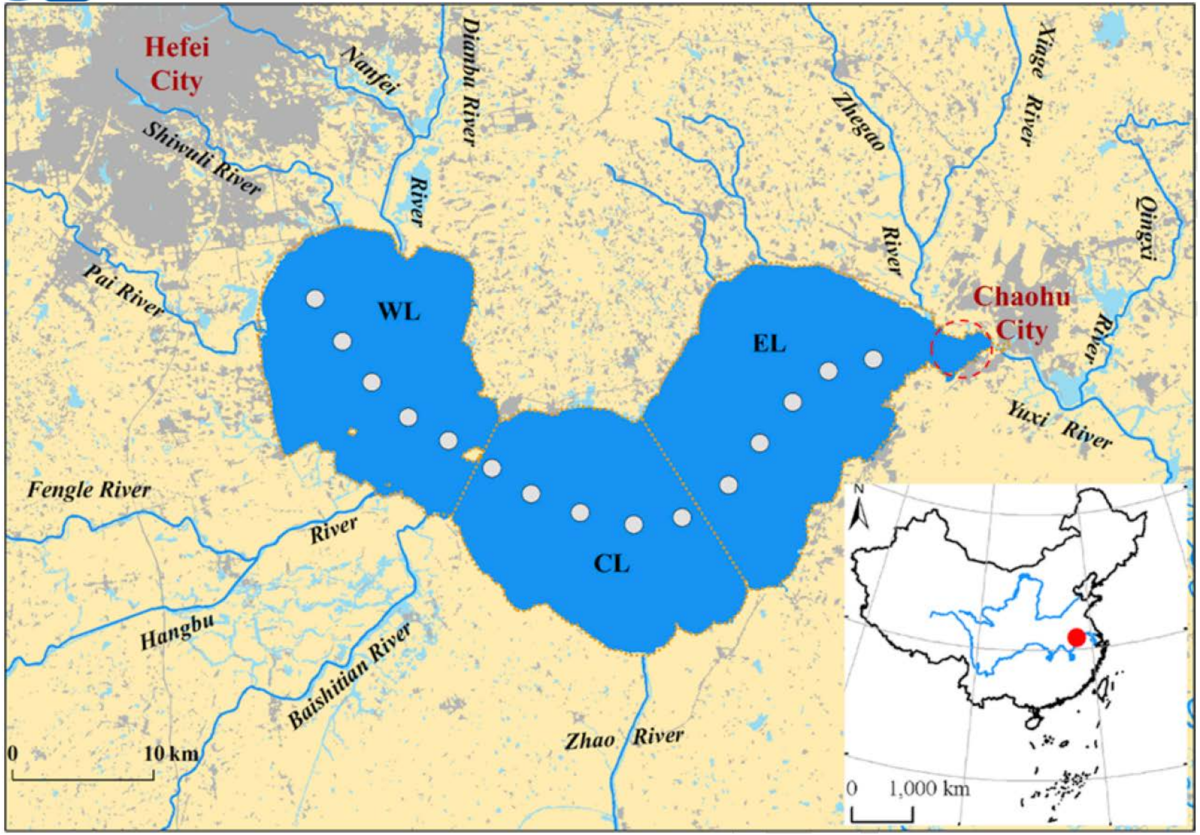
Chinese Lakes Map

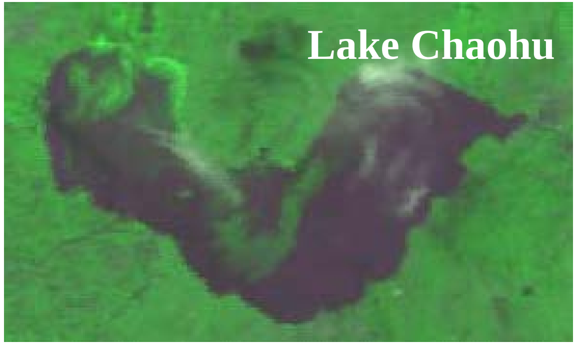
MODIS RGB Images





Case I: MODIS observations of cyanobacterial risks

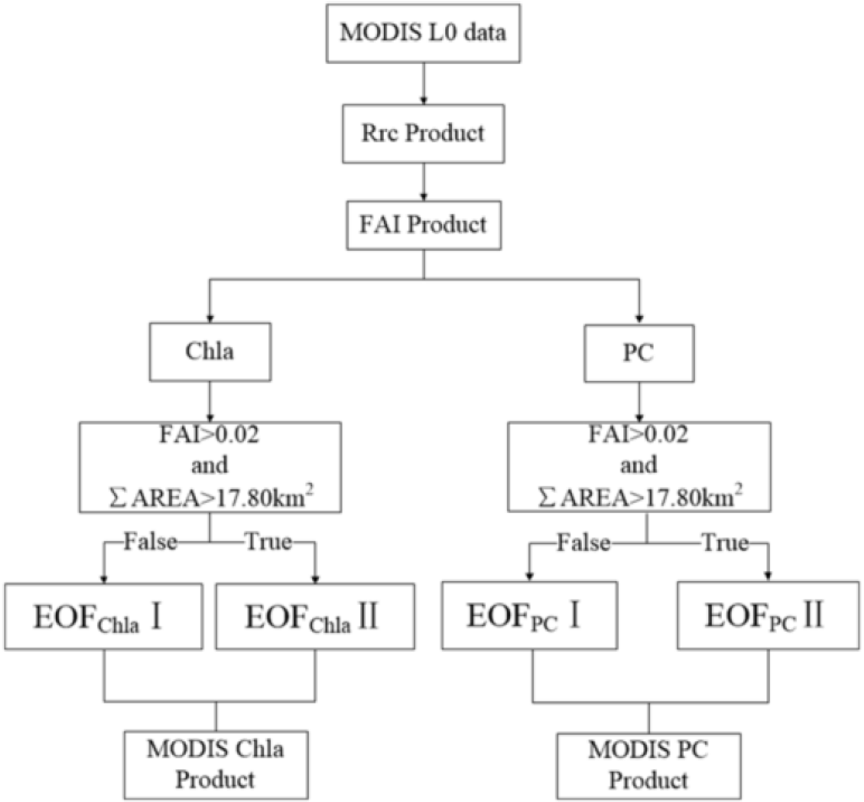


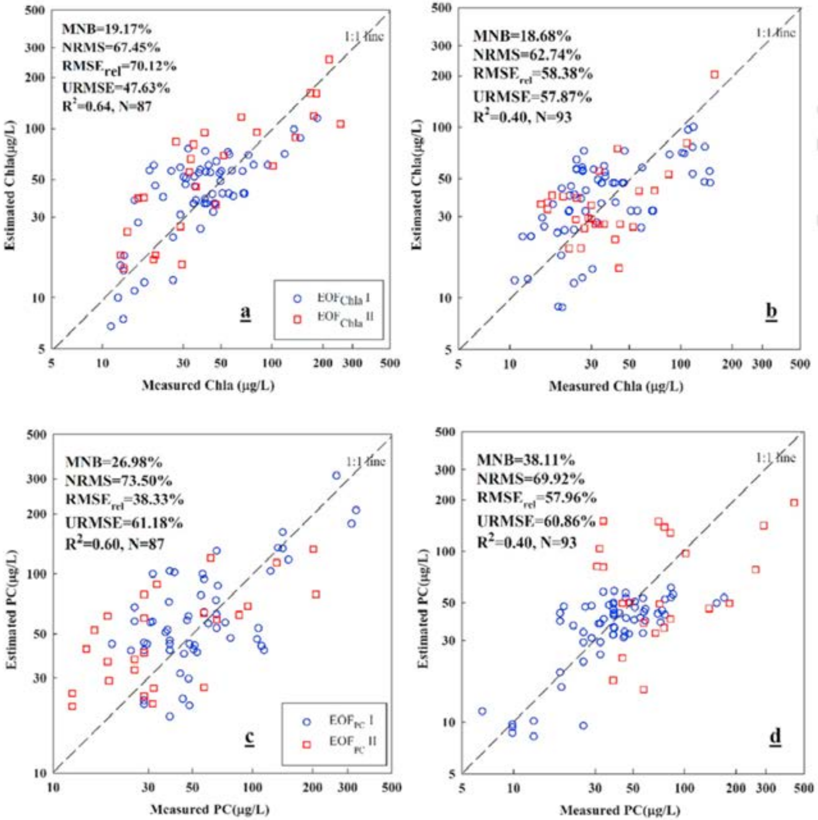


Tao, Duan*, Loiselle, et al., A novel practical algorithm to estimate phycocyanin pigment. IEEE JSTAR, 2017, in revision

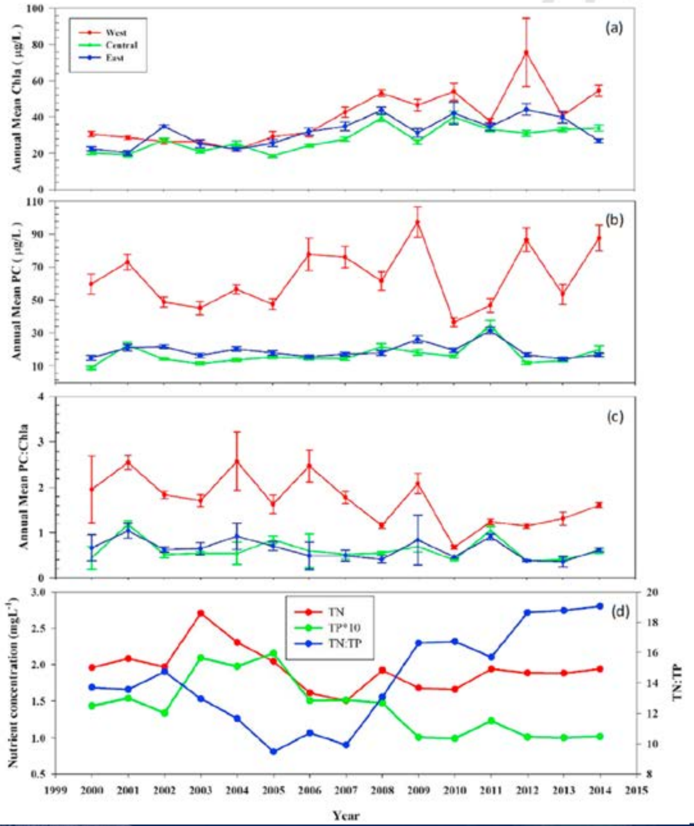
Duan, Tao, Loiselle, et al., MODIS observations of cyanobacterial risks in a eutrophic lake: implications for long-term safety evaluation in drinking-water source. Water Research, 2017, in press

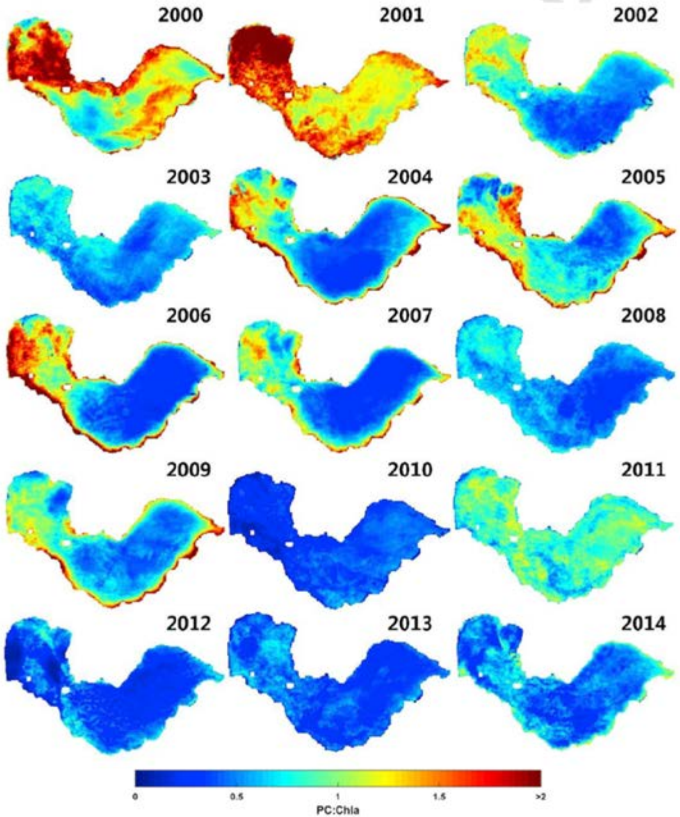
MODIS EOF-based Algorithms: Chla and PC



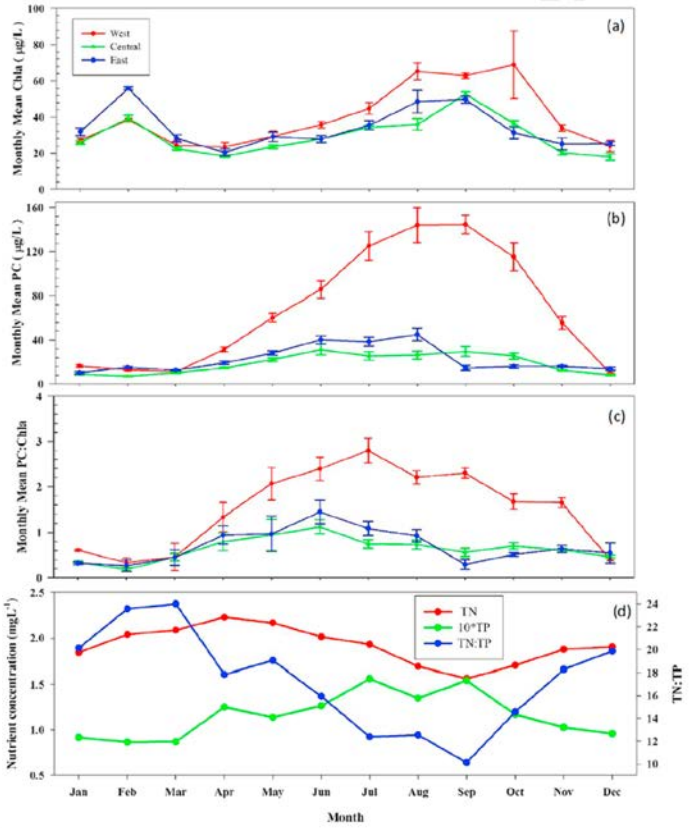


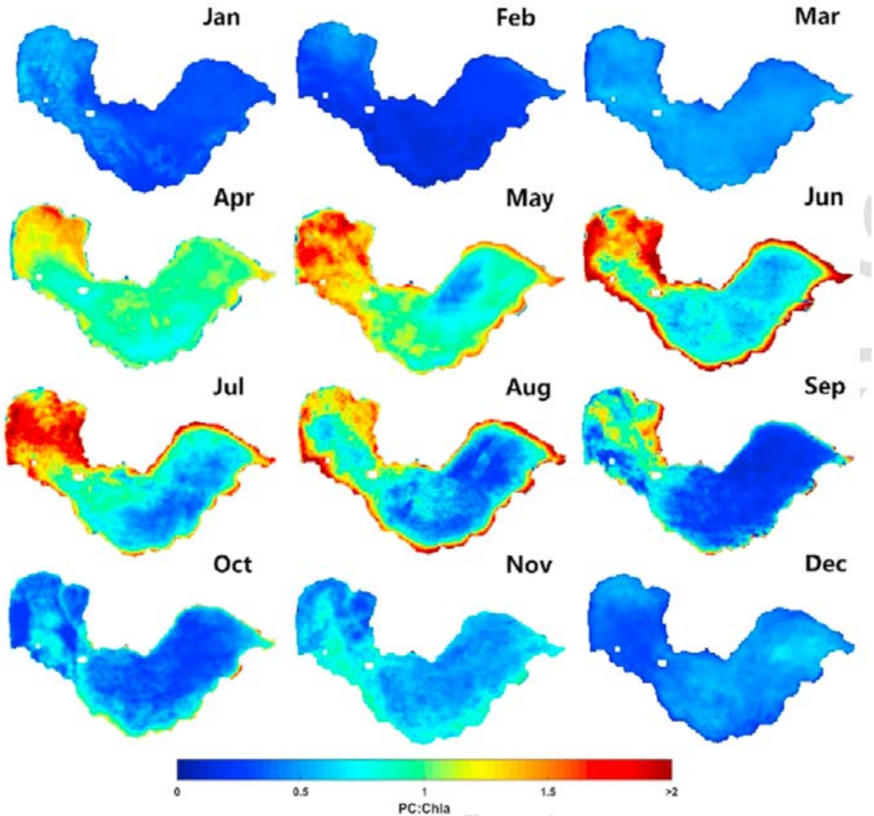
Annual mean of Chla, PC and their ratio



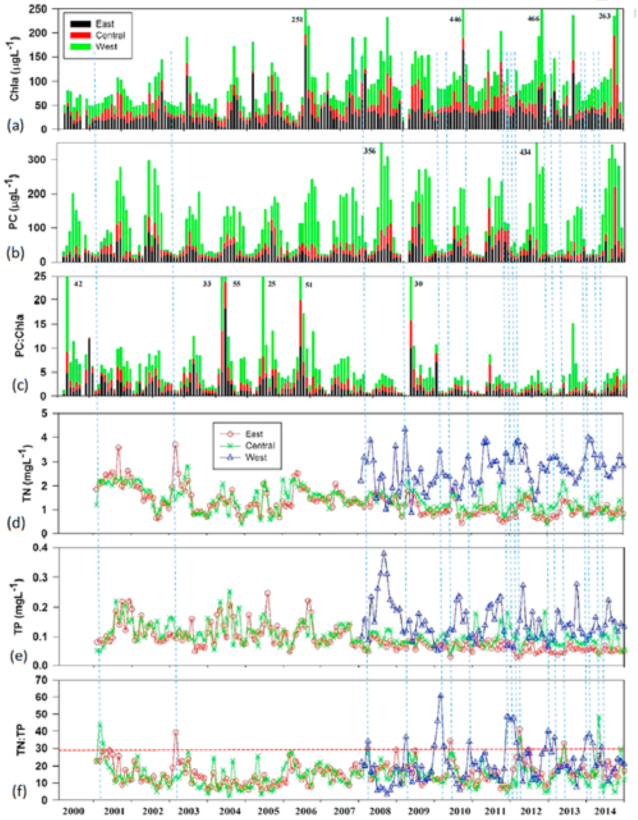


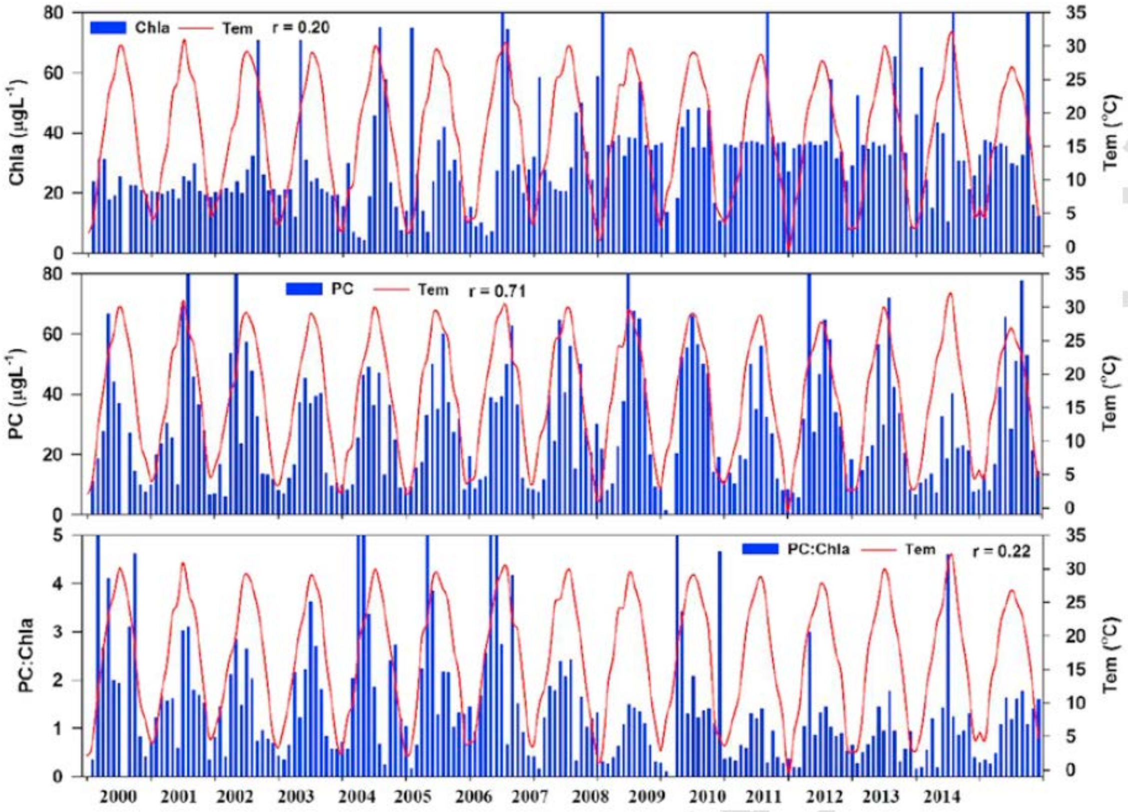
Monthly mean of Chla, PC and their ratio





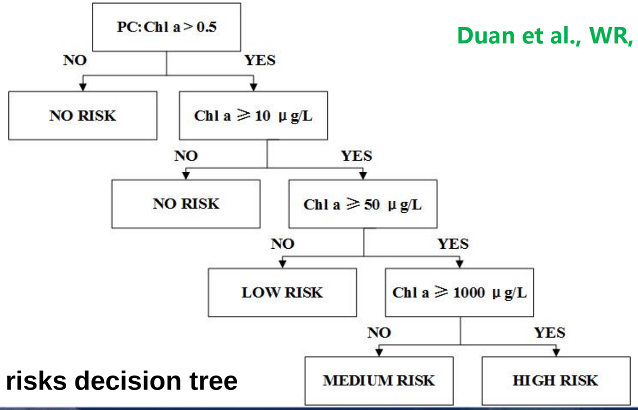
Driving factors: Nutrients and Temperature





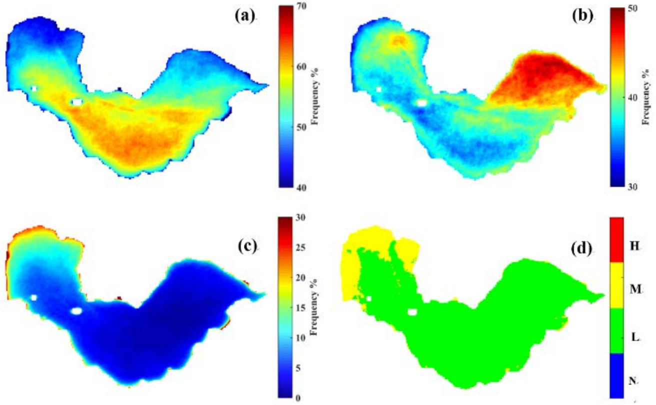
MODIS observations of cyanobacterial risks

Year / Month	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14
Jan.	\														
Feb.															
Mar.										\					
Apr.															
May															
Jun.															
Jul															
Aug.	\														
Sep.															
Oct.															
Nov.															
Dec.															



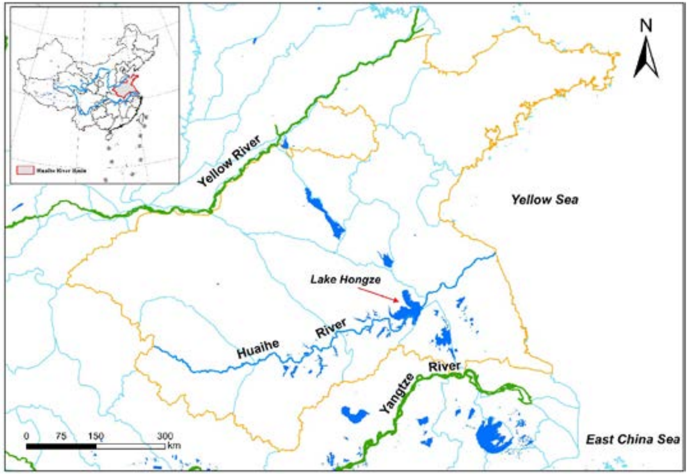
Cyanobacterial risks decision tree

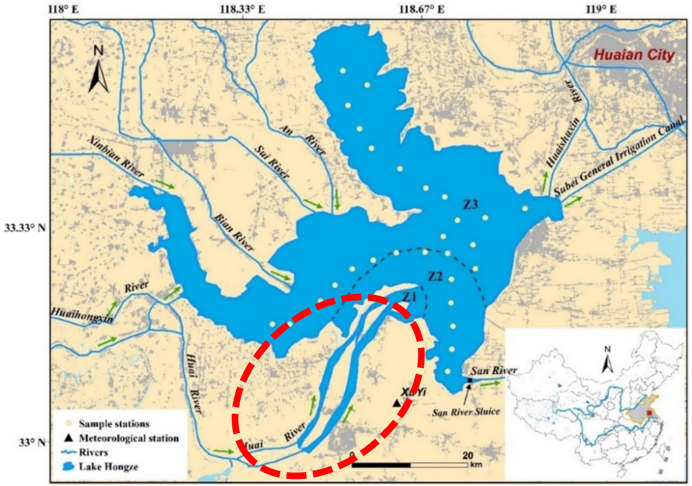
Duan et al., WR, 2017



The frequency (a–c) and mean (d) of risk rank distributions derived from MODIS (2000–2014) in Lake Chaohu

Case II: Human induced turbidity in Lake Hongze





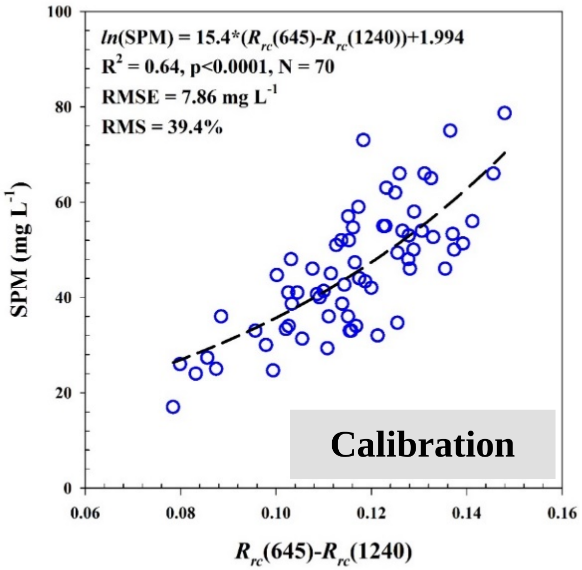
- **Lake Hongze**, the largest lake in the Huai River Basin and the fourth largest freshwater lake in China; The runoff of the Huai River into Lake Hongze: >70%.
- The normal water storage level is 12.5 m, the maximum area is 1597 km^2, and the capacity is 3.04 billion m^3.

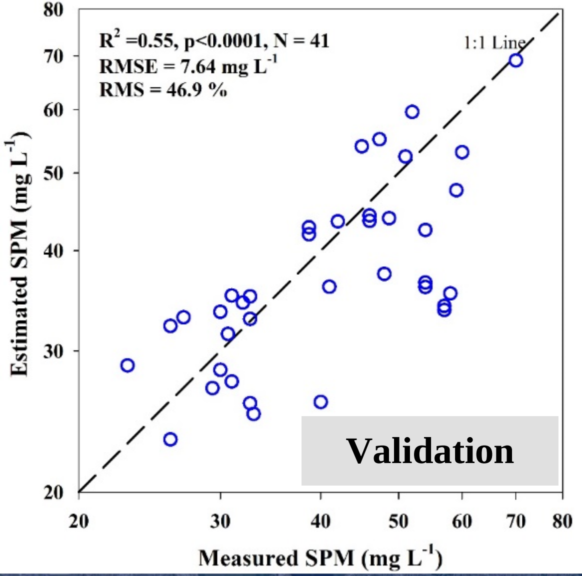
Cao, Duan*, et al., RSE, 2017

□ SPM Algorithm: 111 concurrent dataset of MODIS/Aqua R_{rc} data and in situ SPM measurements using a time window of ±3 hours

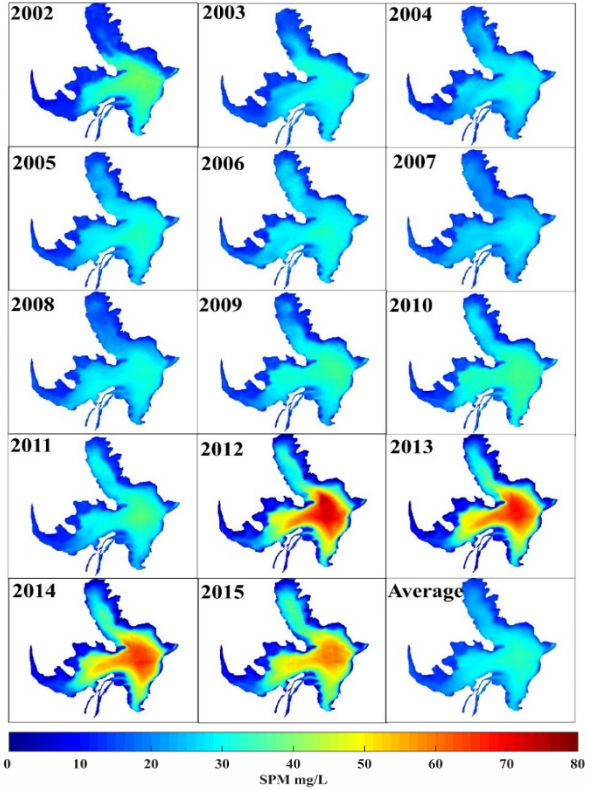
$$R_{rc}(\lambda) = \rho_t(\lambda) - \rho_r(\lambda) = \rho_a(\lambda) + \pi t(\lambda) t_0(\lambda) R_{rs}(\lambda)$$

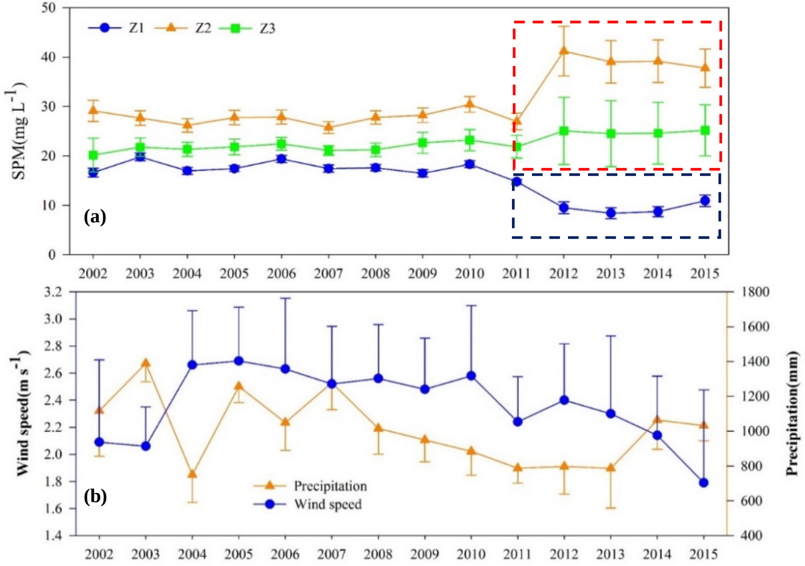
$$[\mathrm{SPM}] = exp\left(15.4 * R_{rc}(645) - R_{rc}(1240)\right) + 1.994$$





Long-term trends: SPM inter-annual variability





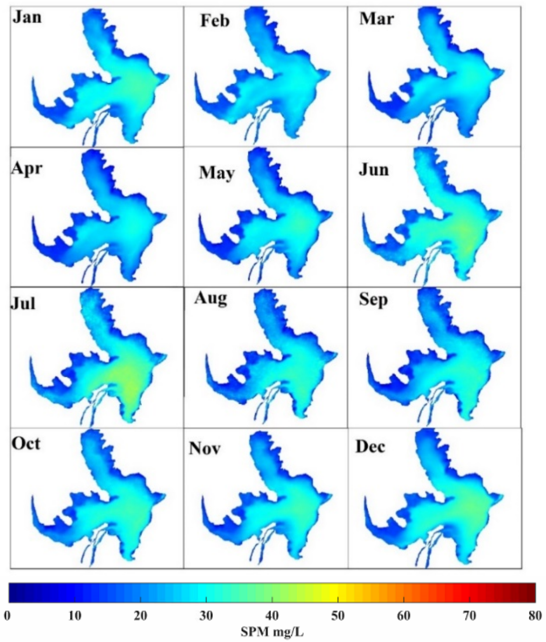
(1) Since 2012, the SPM concentration significantly increases in most of Lake Hongze;

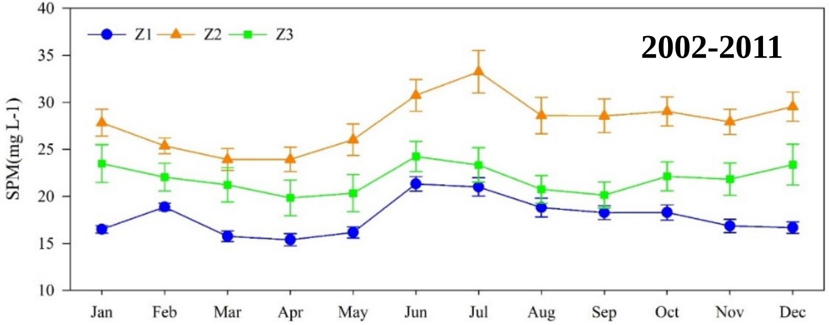
(2) The concentration exhibits a downward trend in the inlet estuary region of the Huai River.

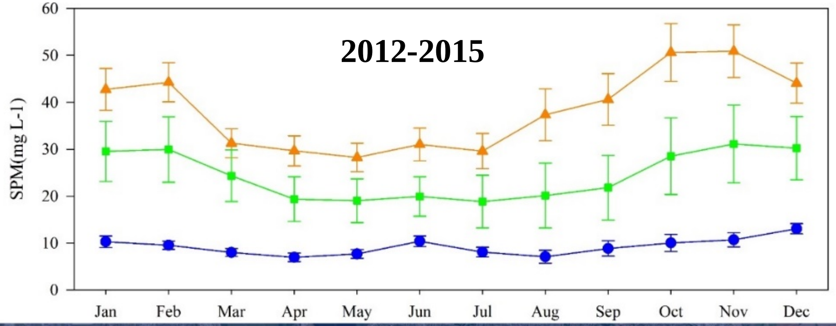
Long-term trends: SPM intra-annual variability

- 2002-2011: highest in Summer and lowest in Spring;
- 2012-2015: high in the fall and winter seasons, low in the spring and summer seasons.

2002-2011

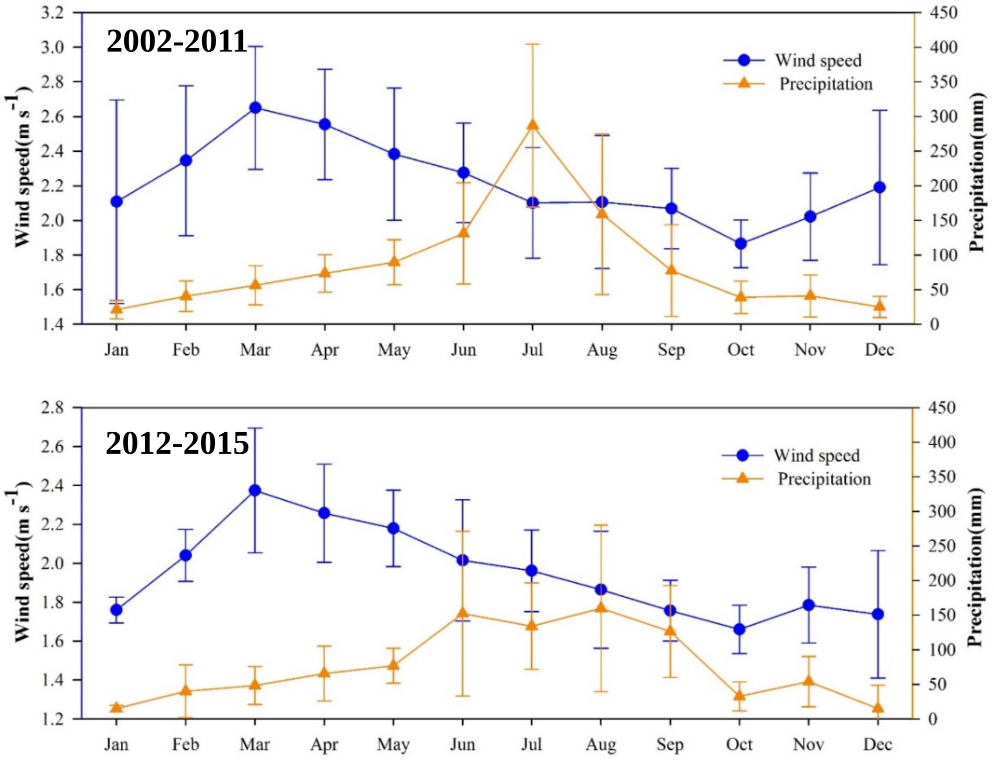




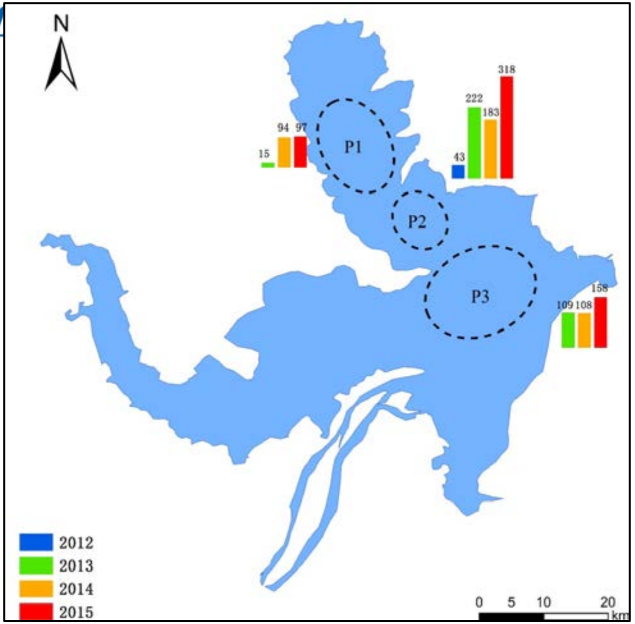


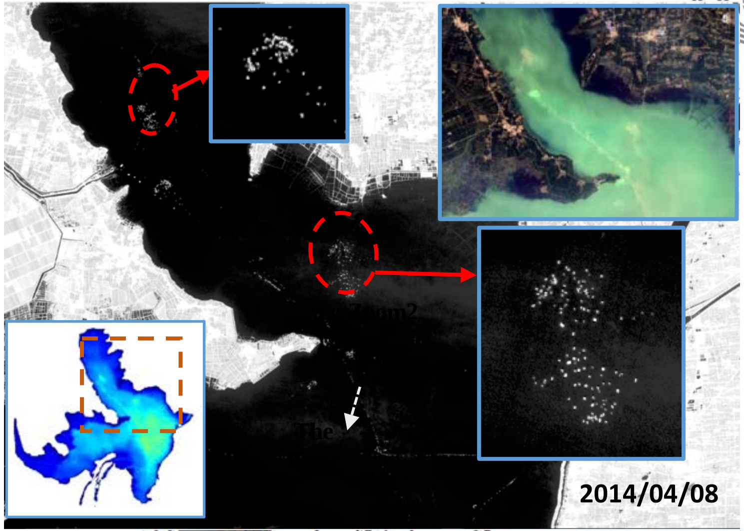
Why a significant increase of SPM since 2012?

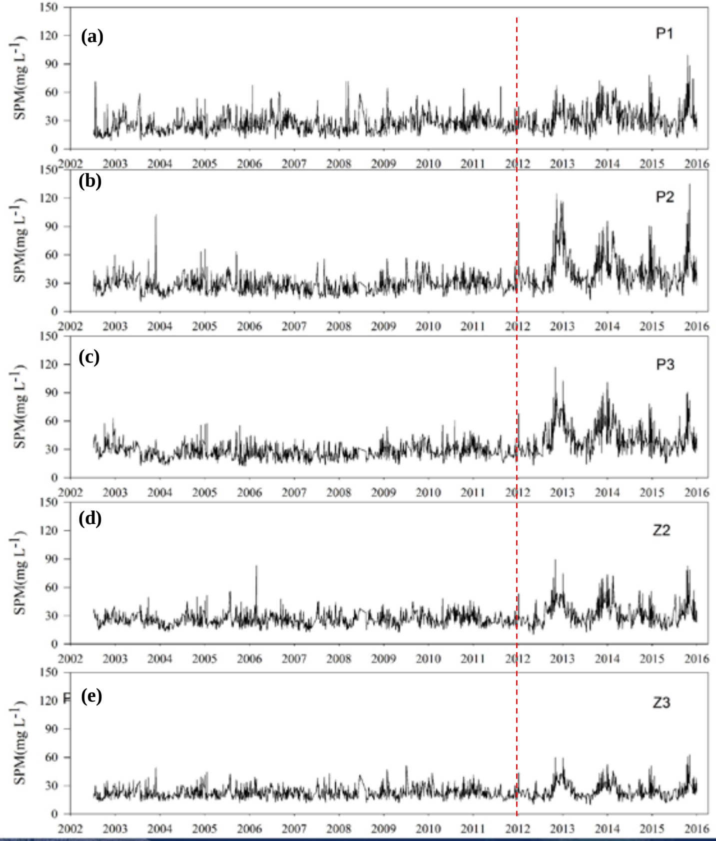
- Precipitation and wind speed have not changed significantly in 15 years.



Dredging activities in Lake Hongze


N
P1
P2
P3
15
94
97
43
222
183
318
109
108
158
2012
2013
2014
2015
0
5
10
20
km


2014/04/08



2002-2011 2012-2015

P1:25.49±9.57 mg/L→33.10±13.10 mg/L, +29.85%

P2:30.04±8.33 mg/L→43.87±18.35 mg/L, +46.04%

P3:29.04±6.47 mg/L→43.06±4.89 mg/L,+48.27%

Z2:25.47±6.70 mg/L→32.87±12.35 , +29%

Z3:21.75±5.60 mg/L→24.82±8.48 mg/L, +14%

- **Since 2012, the average SPM concentration is equivalent to an increase by 21.07%.**
- **For the normal water level of 12.5 m, 15.048 billion tons of sediments from dredges contribute to Lake Hongze every year.**


THANK YOU!