CH_4 flux from an aquaculture zone in a subtropical lake

PU Yini

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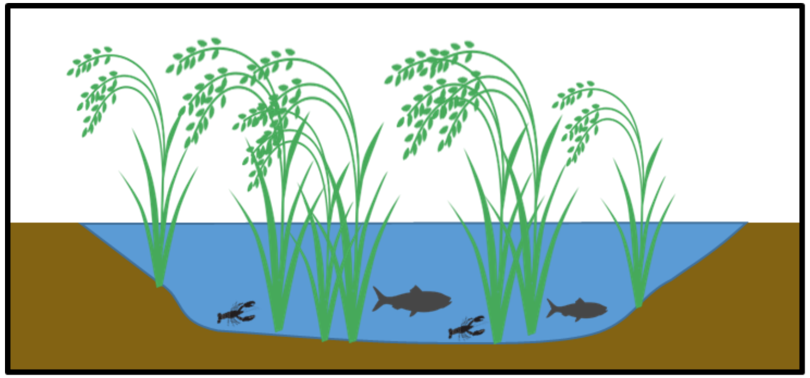
Outline

- Introduction
- Methods
- Results and discussion
- Conclusions

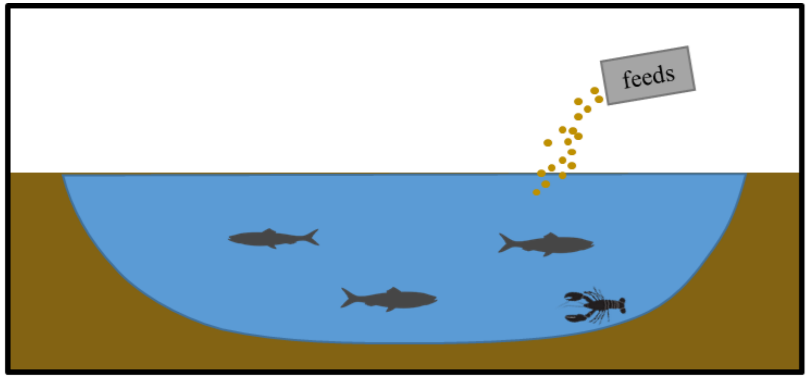
01 Introduction

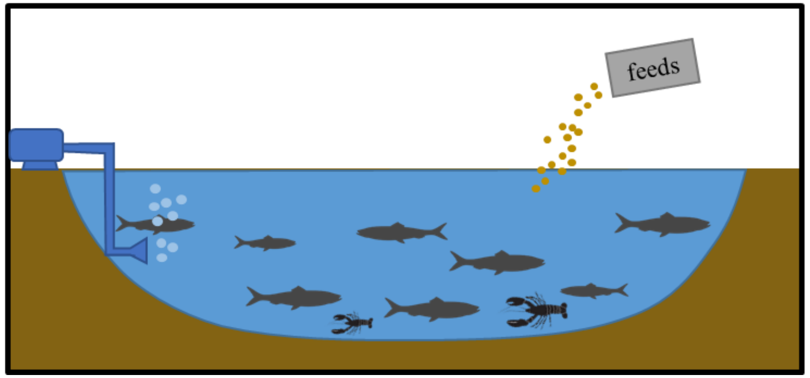
Aquaculture systems are major anthropogenic sources of CH_4 emission: 6.04 ± 1.17 Tg CH_4 yr^{-1}, and China contributes 68% of global budgets (Yuan *et al*., 2019).

Rice-fish systems

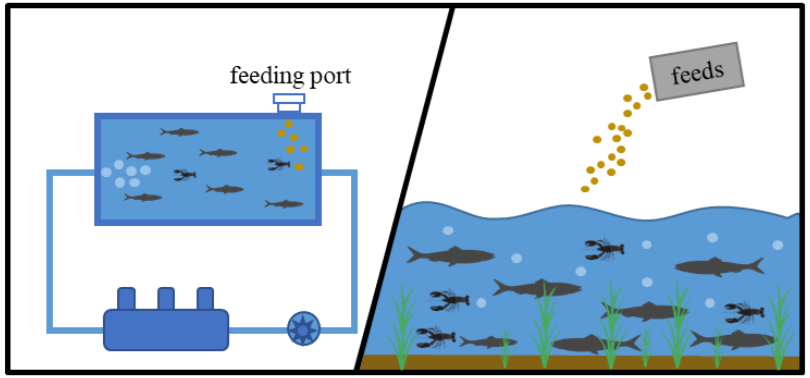


Extensive systems

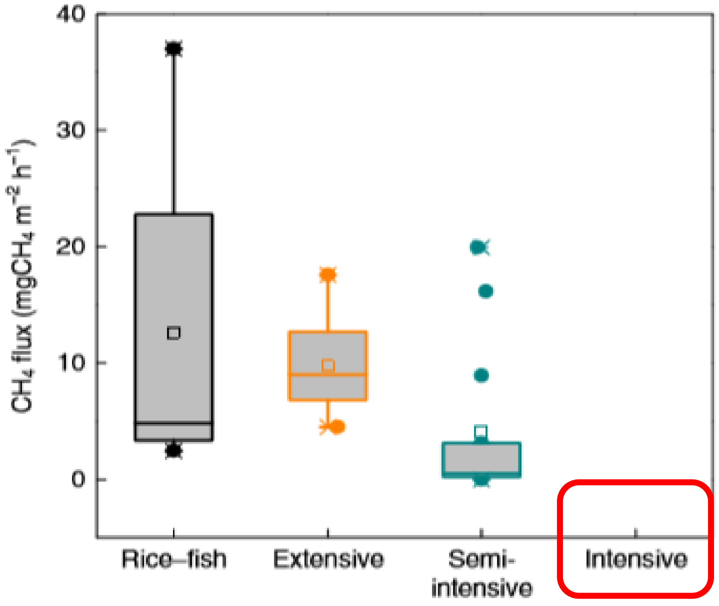




Semi-intensive systems



Intensive systems



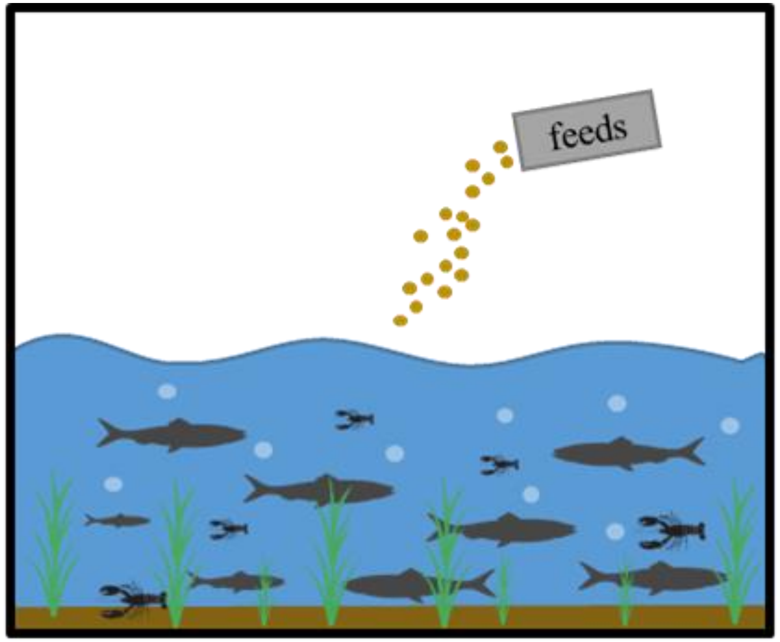
CH_4 emission from intensive systems is negligible ?

Yuan *et al*., 2019

- aquaculture site
- stocking density
- management practices (aeration)

- The presence of aquatic plants in aquaculture systems will increase CH_4 emission by 14% ~ 128% (Ma *et al*., 2018; Hu *et al*., 2016; Liu *et al*., 2016).

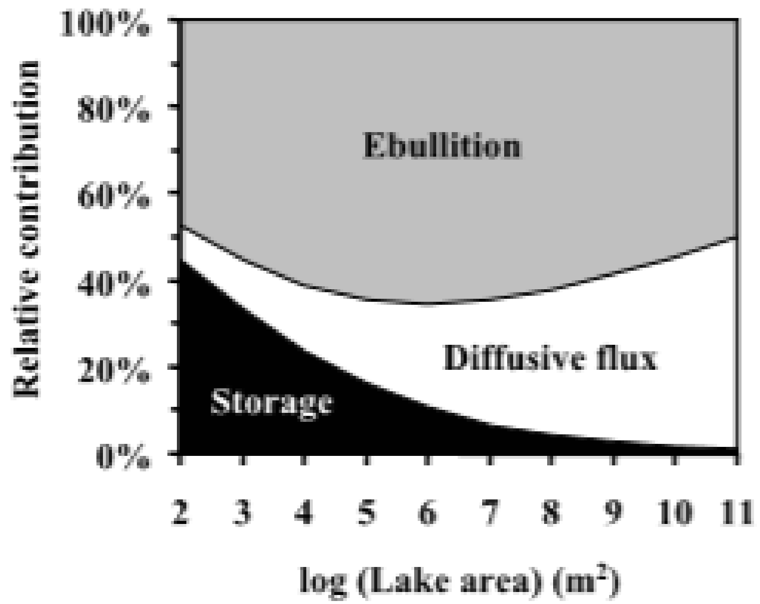
- Dredging will greatly reduce the sediment C substrate for CH_4 production, and drainage will destroy the anaerobic environment in sediments (Hu *et al*., 2016).



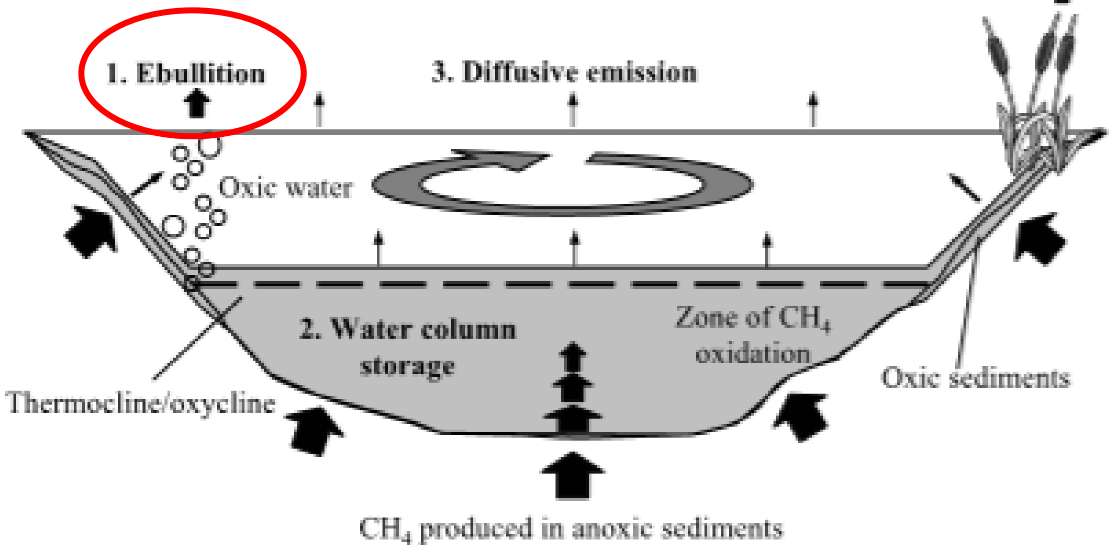
Hot spot

Objective 1: To investigate CH_4 emission from aquaculture zones of lakes

For lakes, ebullition ratio: 40%~60% (Bastviken *et al*., 2004)



CH_4 transfer efficiency largely depends on ebullition



Bastviken *et al*., 2004

Whether the disturbance of intensive aquatic animal activities will affect the pathway of CH_4 emission?

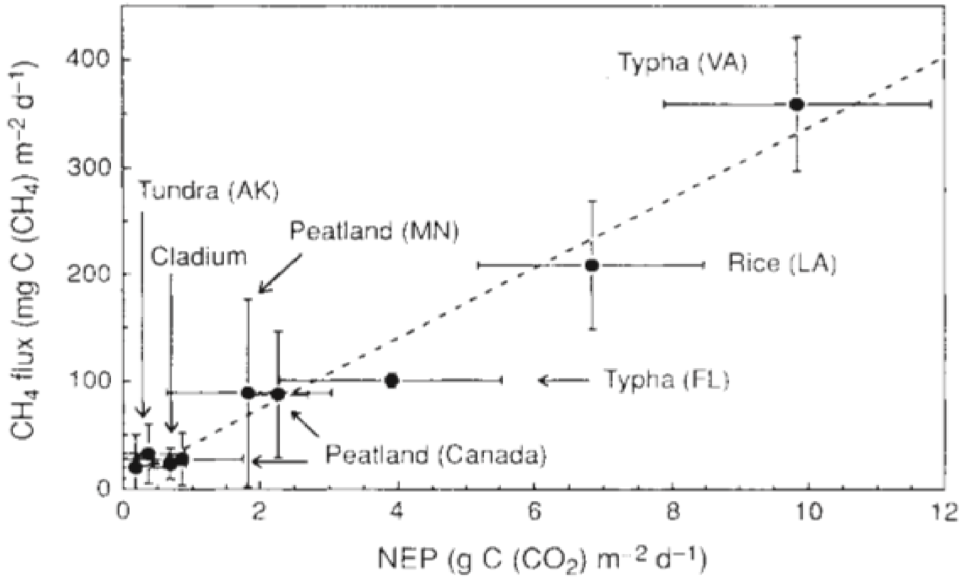
Objective 2: To determine the ratio of CH_4 ebullition from aquaculture zones of lakes

The water DO concentration in aquaculture systems: >5 mg L^{-1}

In small closed aquaculture ponds, DO dynamics caused by artificial aeration is the key factor affecting CH_4 emission.

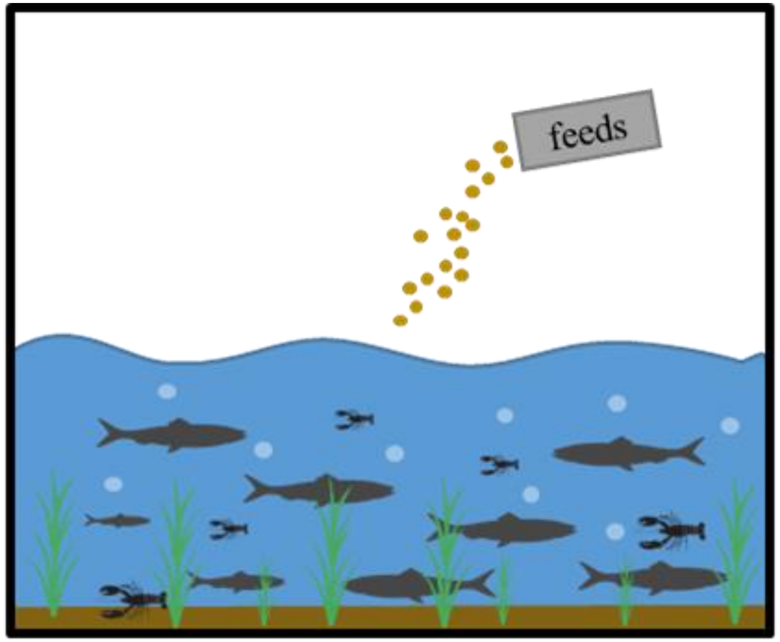
In aquaculture zones of lakes, there is no need to aerate because of sufficient DO.

Objective 3: To examine the driving factors that control CH_4 dynamics



Whiting *et al*., 1993

For natural wetlands, CH_4/NEP: 3.3%

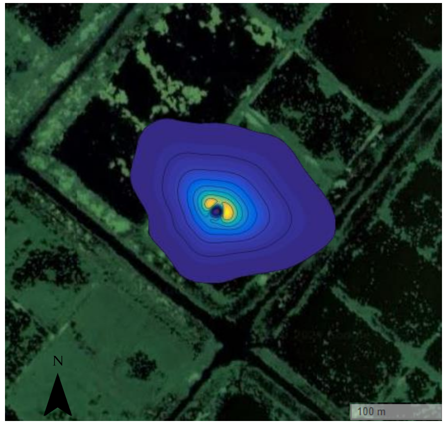


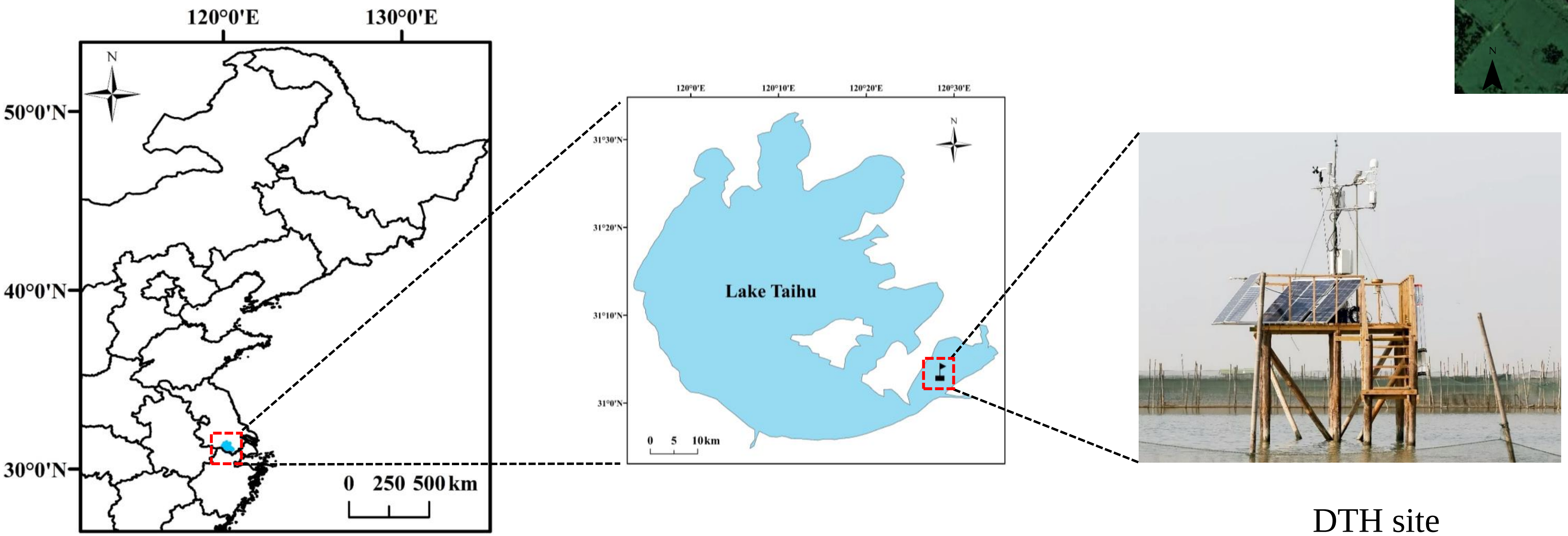
Carbon inputs:
NEP + feeds input

CH_4/C inputs

Objective 4: To quantify the ratio of CH_4 emission to total carbon inputs from aquaculture zones of lakes

2.1 Site description





DTH site
31°03’40"N 120°28’14"E

Observation time: 2018.04~2018.12

2.2 Aquaculture management practices

Management practices	Time
Quicklime sterilization	Mid January
Young crabs stocking	Mid January
Freshwater prawn fry stocking	Late January
Plant *Elodea nuttallii*	May
Harvest freshwater shrimps	June
Giant river prawn fry stocking	July
Harvest crabs and shrimps	Mid September-late December

Feeds	Application rate (t ha^{-1})	Contents of C and N	
		C（%）	N（%）
Pellet feed	3	21.4	5.12
Trash fish	54	8.41	2.69
Corn seeds	9	46.4	1.35

The crabs were fed once daily at 4:00~6:00 a.m.

2.3 Eddy covariance data processing

(1) Data correction for CO_2

2-D coordinate rotation

↓

Sonic temperature correction

↓

WPL correction

↓

Spectroscopic correction

(2) Data correction for CH_4

2-D coordinate rotation

↓

Sonic temperature correction

↓

Frequency correction

↓

WPL correction

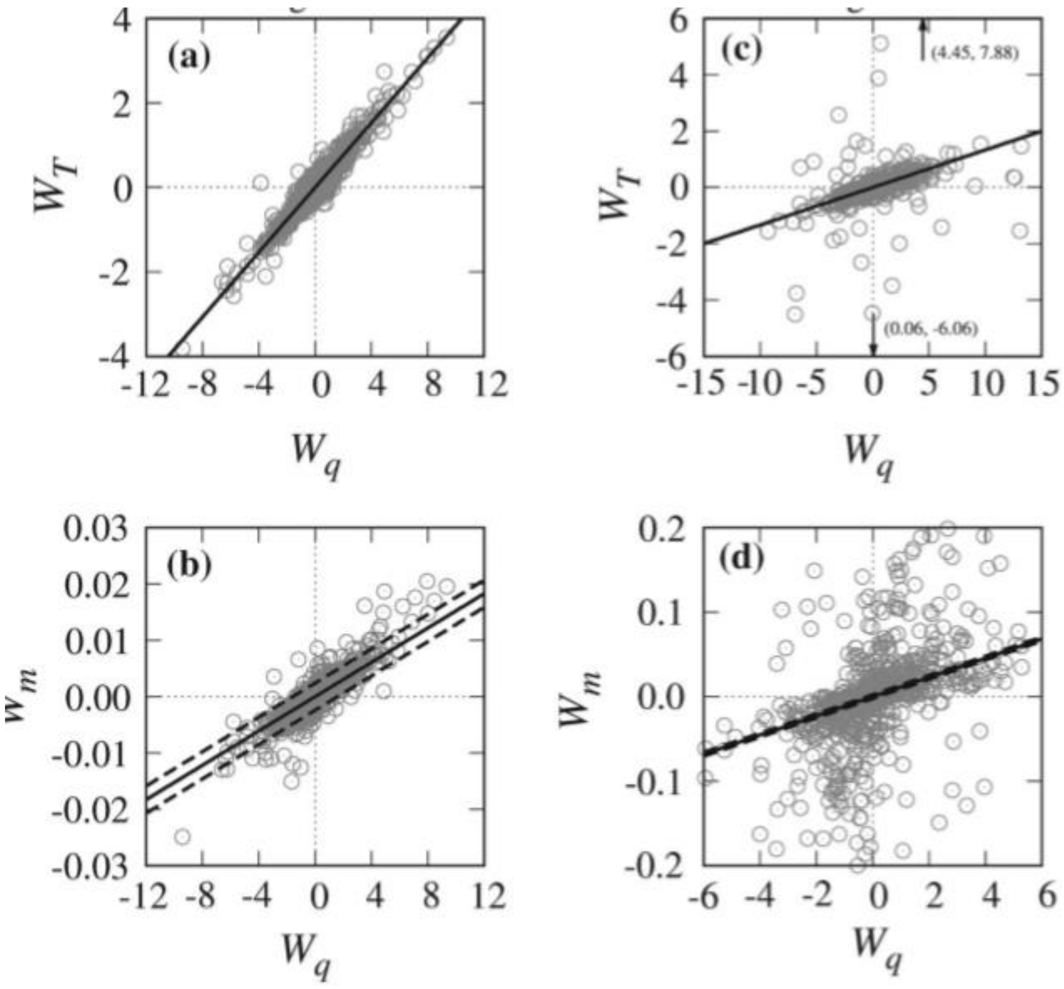
2.4 CH_4 ebullition partitioning

Principle

- **Local scalar similarity** between the CH_4 concentration and other reference scalars, eg: Ta or q.

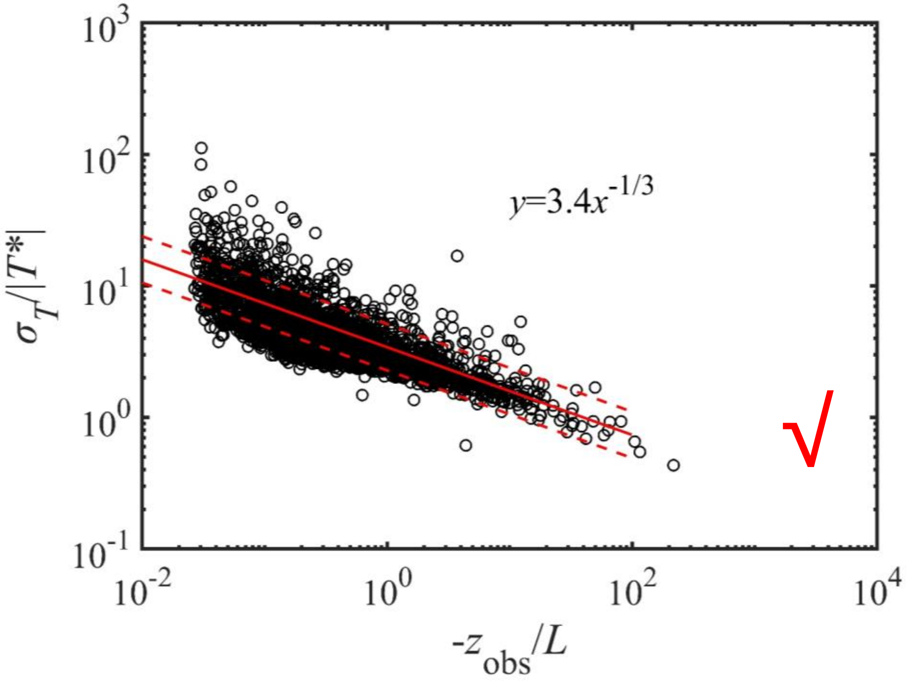
- Similar and dissimilar fluctuation components are related to diffusive and ebullitive CH_4 fluxes, respectively.

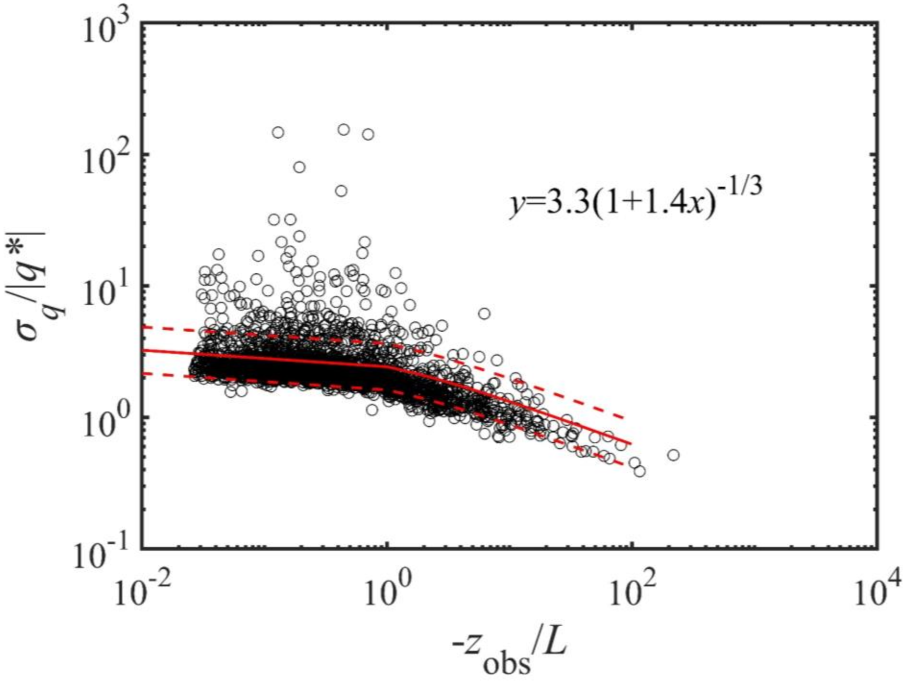
$$W_x^{j,i} = \int_{-\infty}^{\infty} x(t)\psi_{j,i}(t)\mathrm{d}t,$$



Iwata *et al*., 2018

Choice of the reference scalar

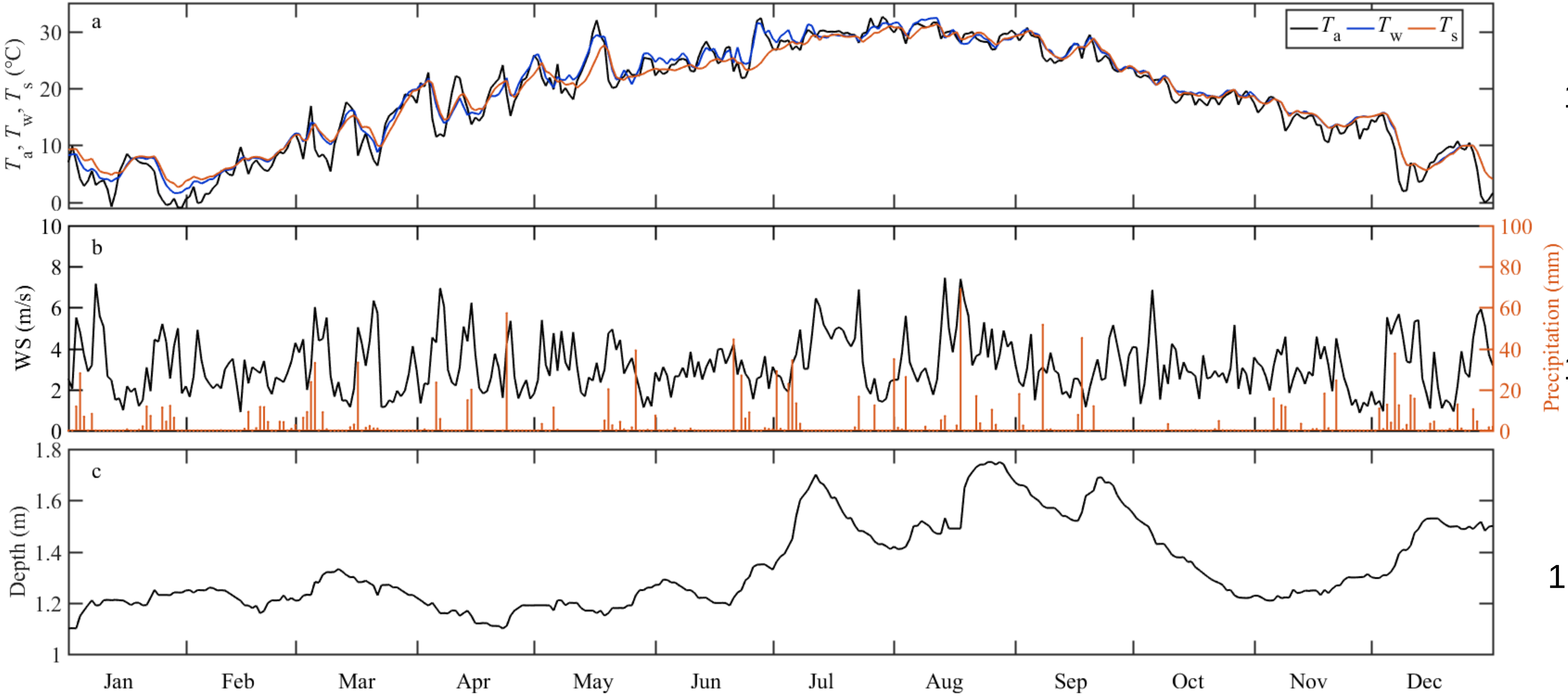




03 Results and discussion

(1) Environmental condition

	Area (km^2)	DOC ($mg \cdot L^{-1}$)	TN ($mg \cdot L^{-1}$)	TP ($mg \cdot L^{-1}$)	DO ($mg \cdot L^{-1}$)
Dongtaihu Bay	131	7.09	1.12	0.06	9.95



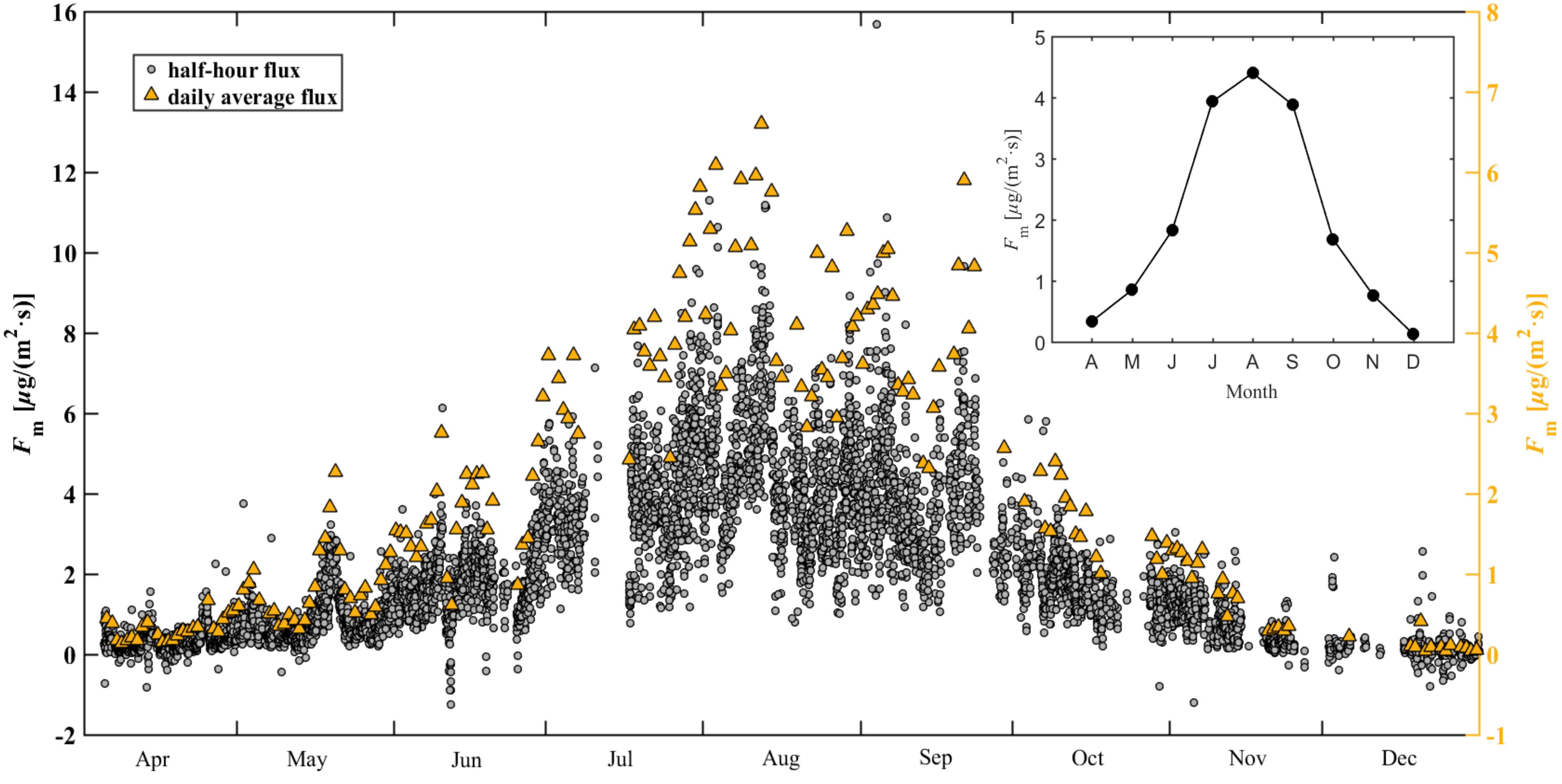
18.0 ℃

3.2 m/s

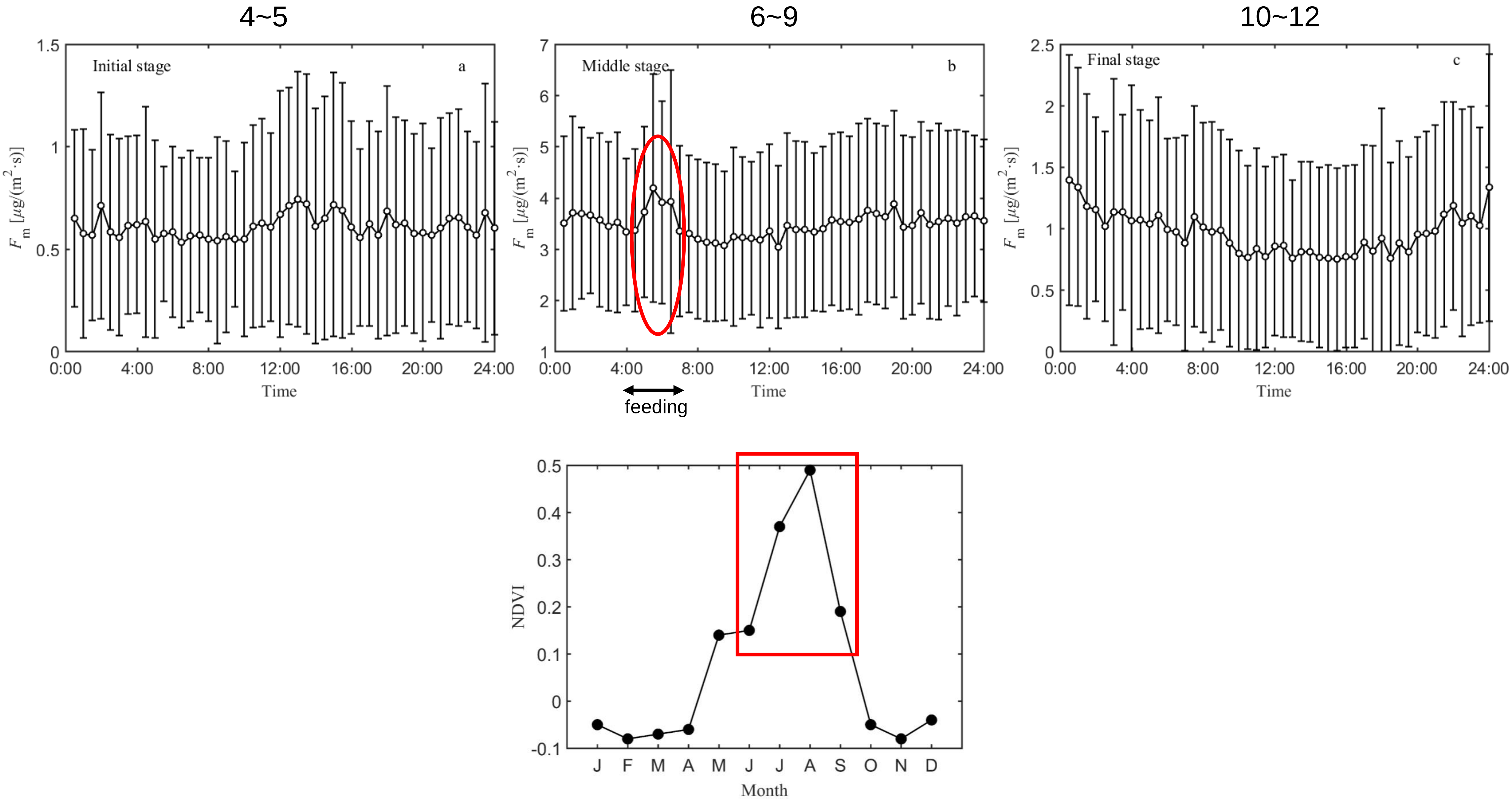
1294 mm

1.3 m

(2) CH_4 emission

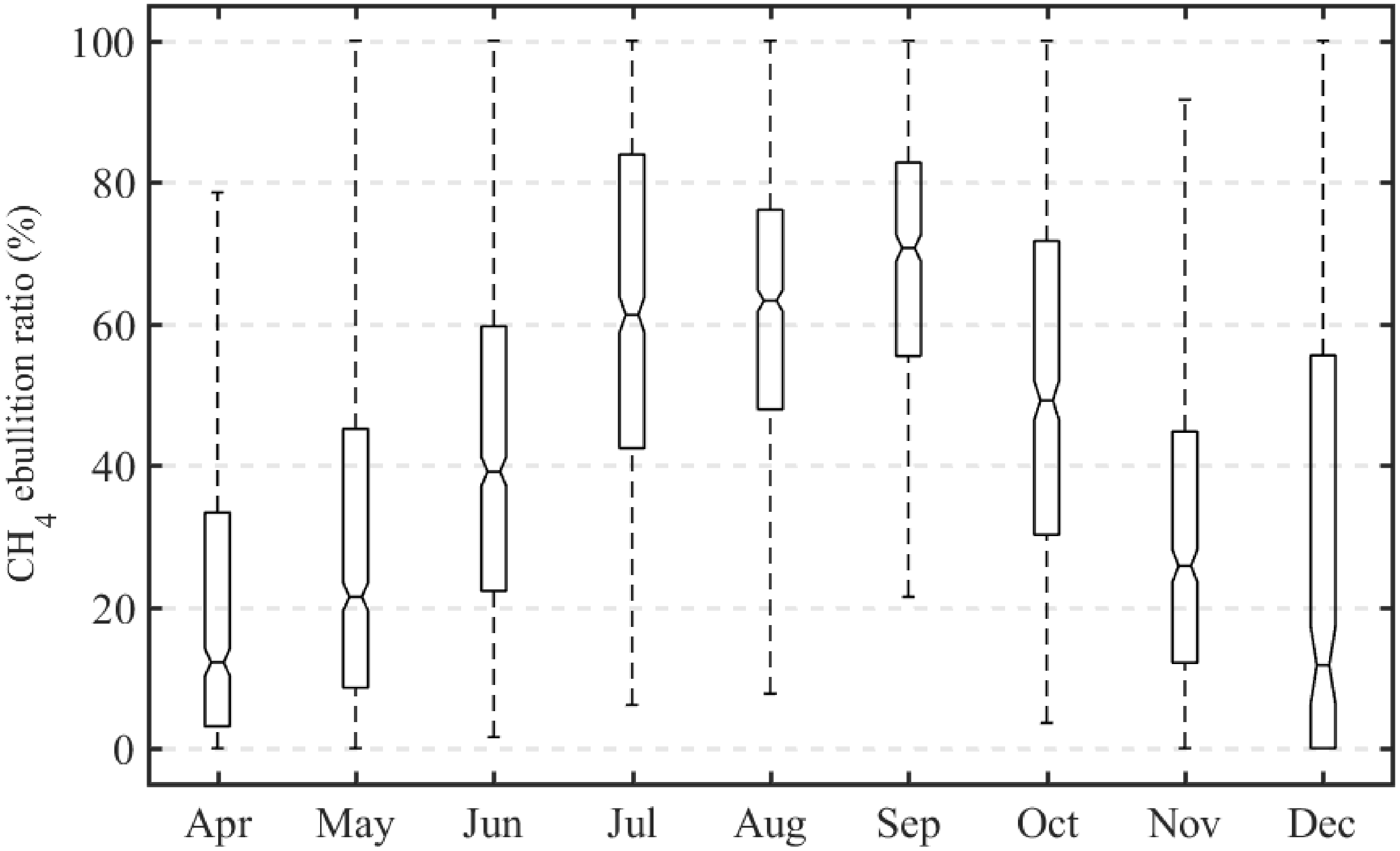


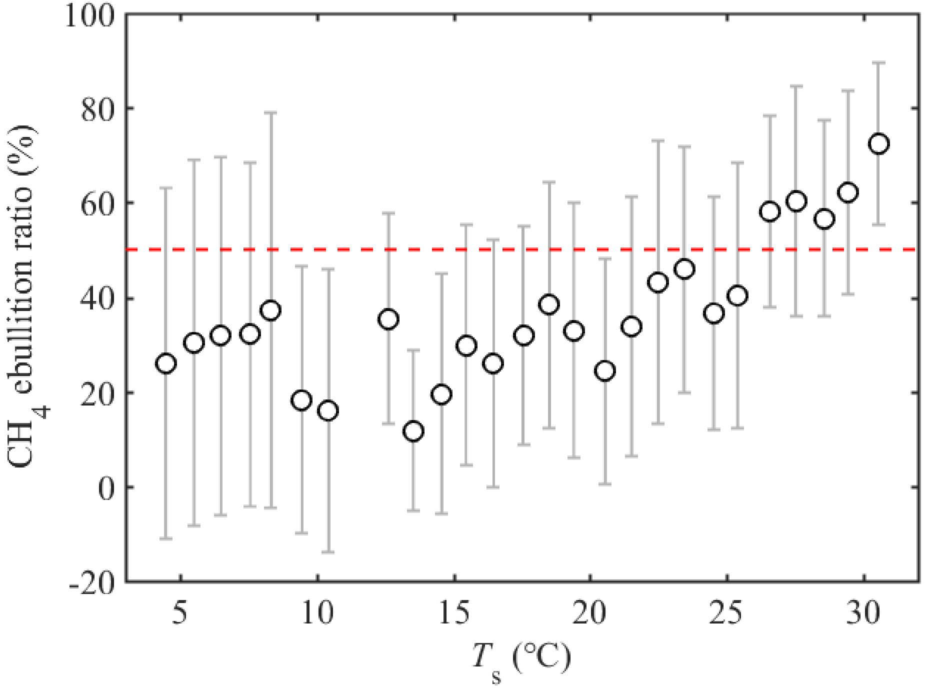
CH_4 flux: 2.07 μg/(m²s)



4~5
6~9
10~12
Initial stage
a
Middle stage
b
Final stage
c
F_m [$\mu g/(m^2 \cdot s)$]
Time
feeding
NDVI
Month
J F M A M J J A S O N D

(3) CH_4 ebullition ratio



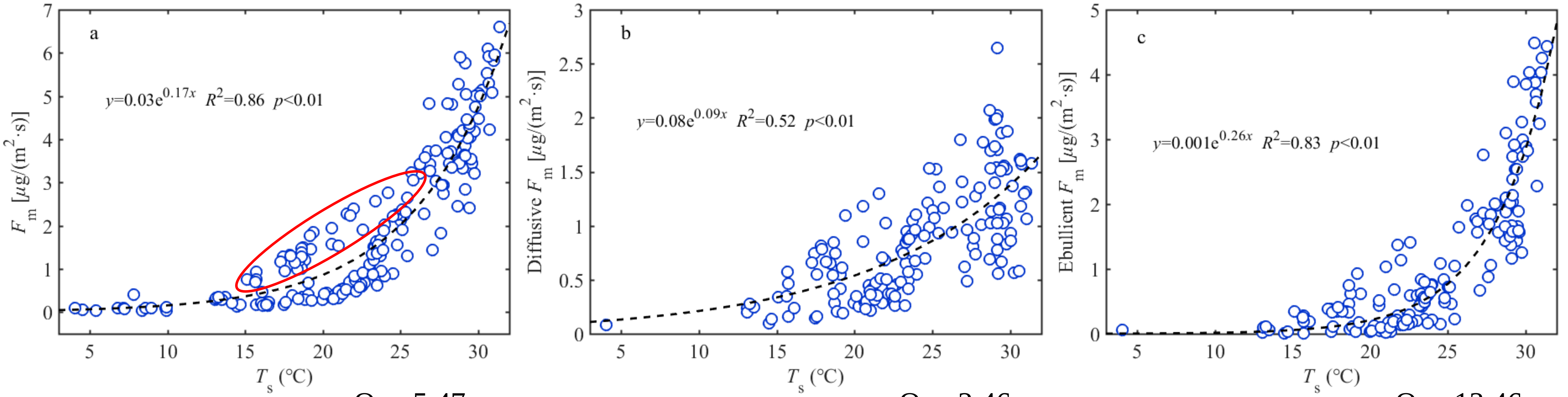


Overall: 57.3%

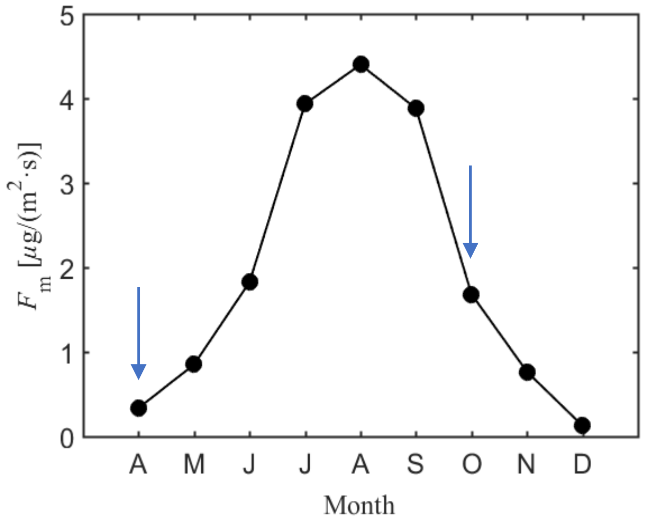
BFG: 49% (Xiao *et al.*, 2017)

(4) Factors influencing CH_4 flux

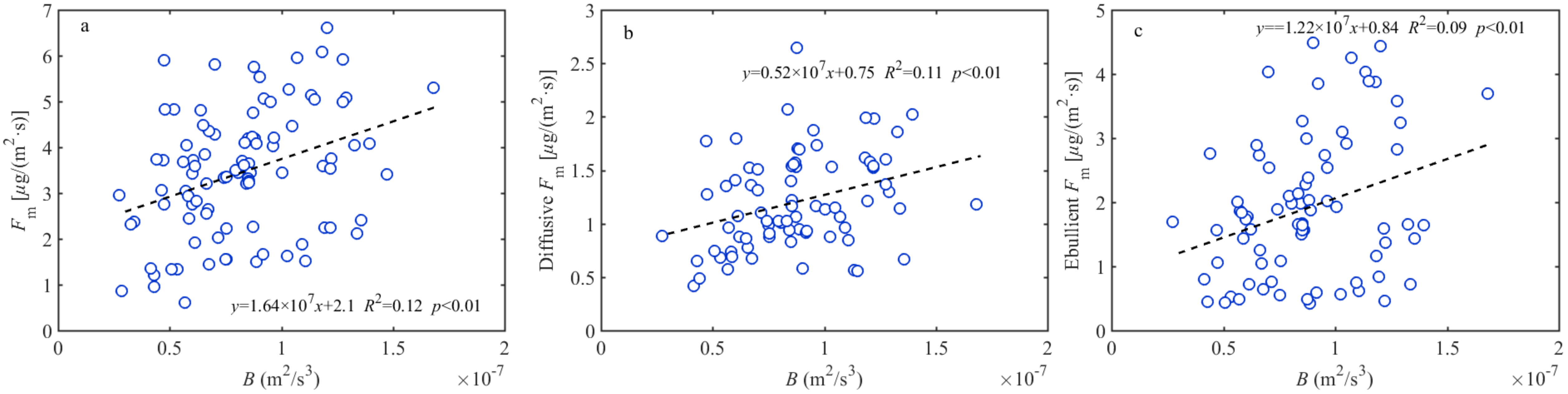
Production

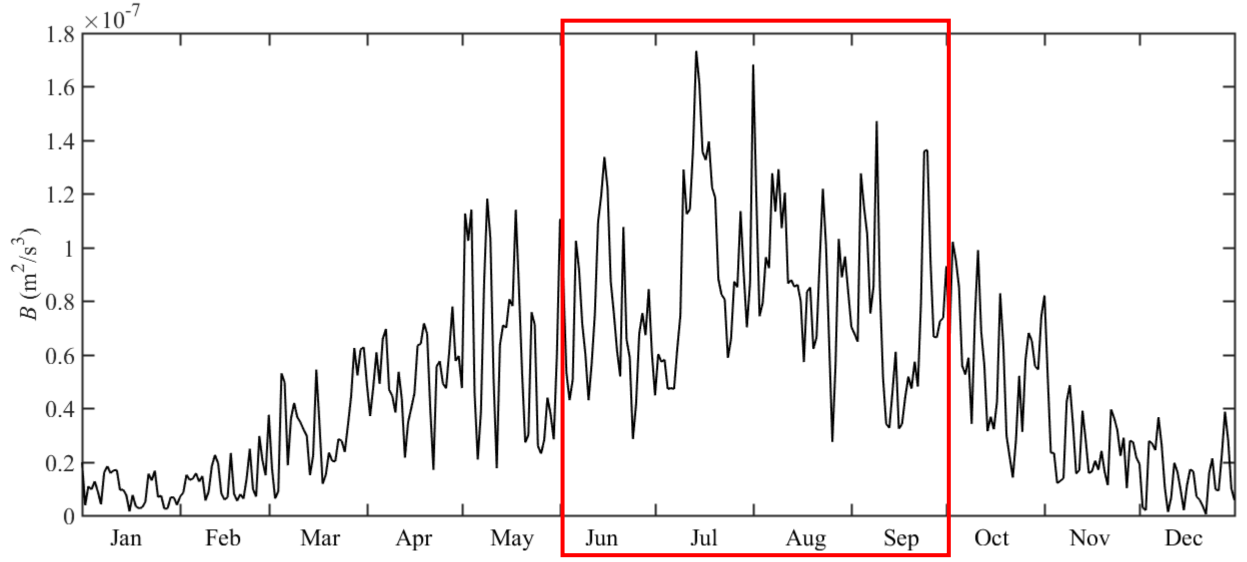


$Q_{10}=5.47$ $Q_{10}=2.46$ $Q_{10}=13.46$



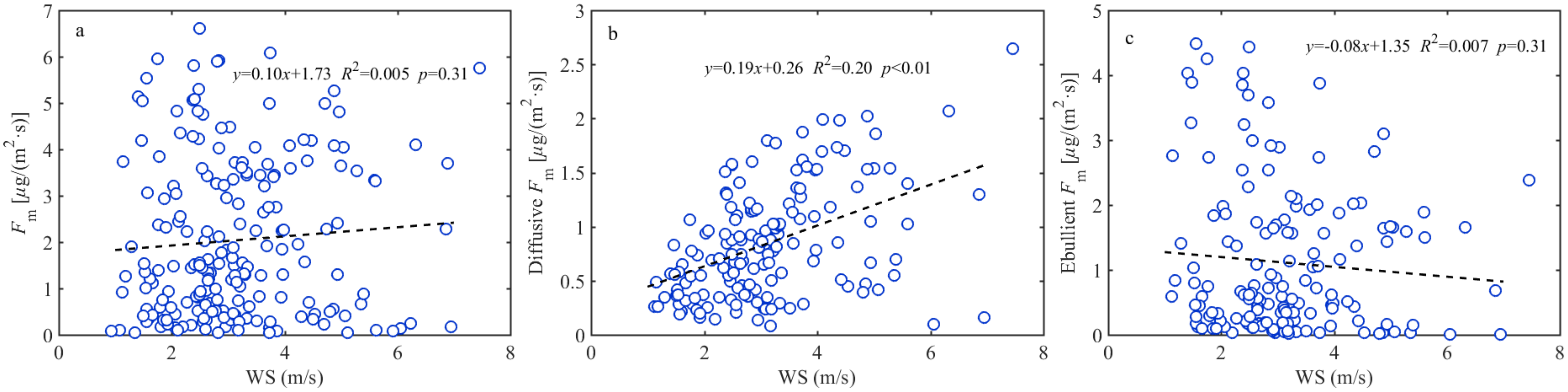
Thermal disturbance (water-side convection)



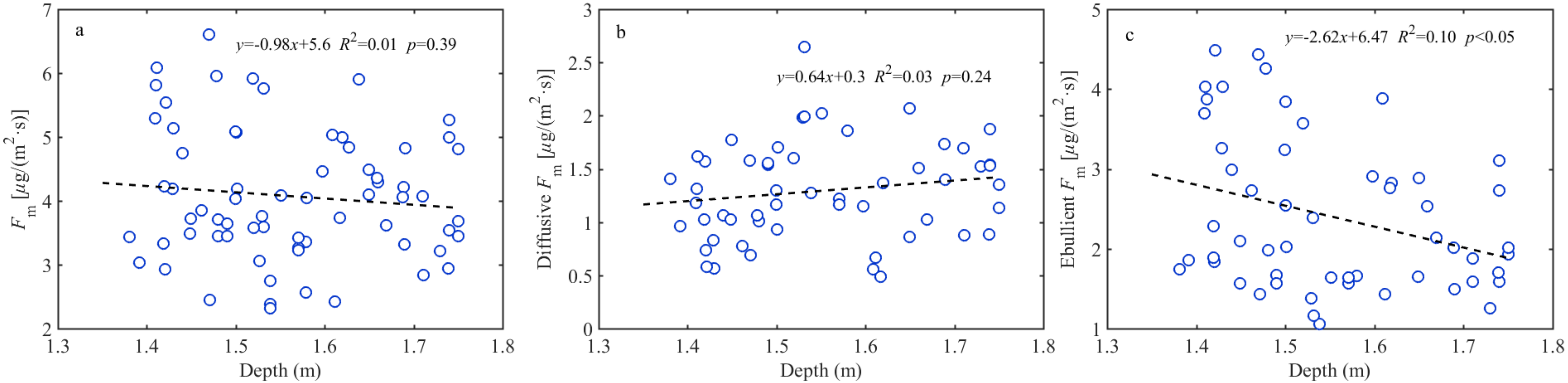


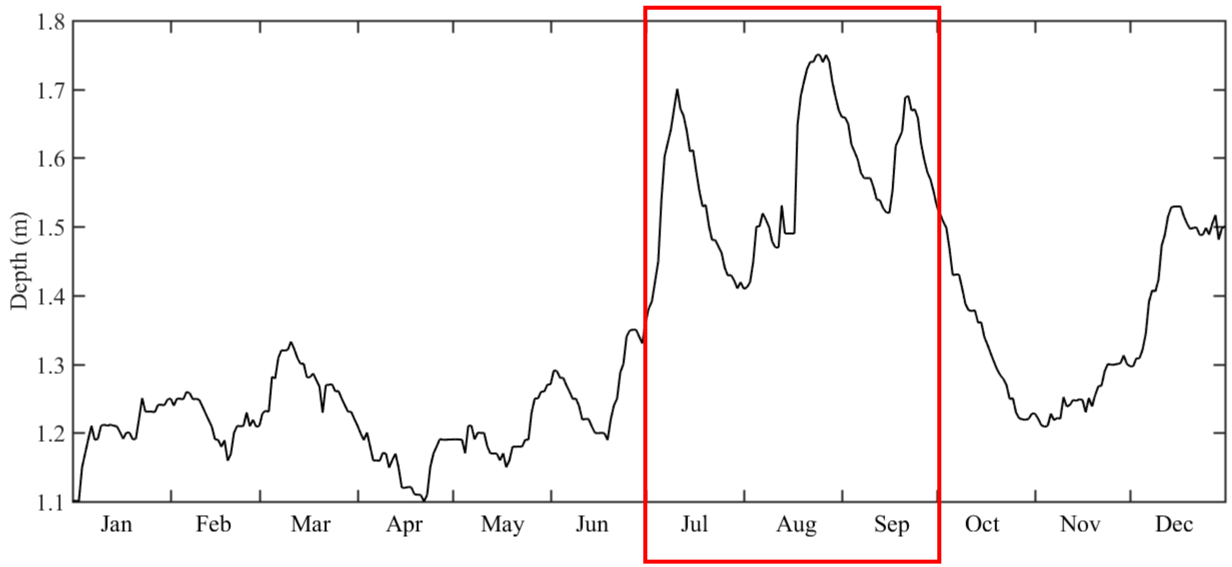
$$B = \frac{g a Q_{eff}}{c_{pw} \rho_w}$$

Mechanical disturbance (wind forcing)

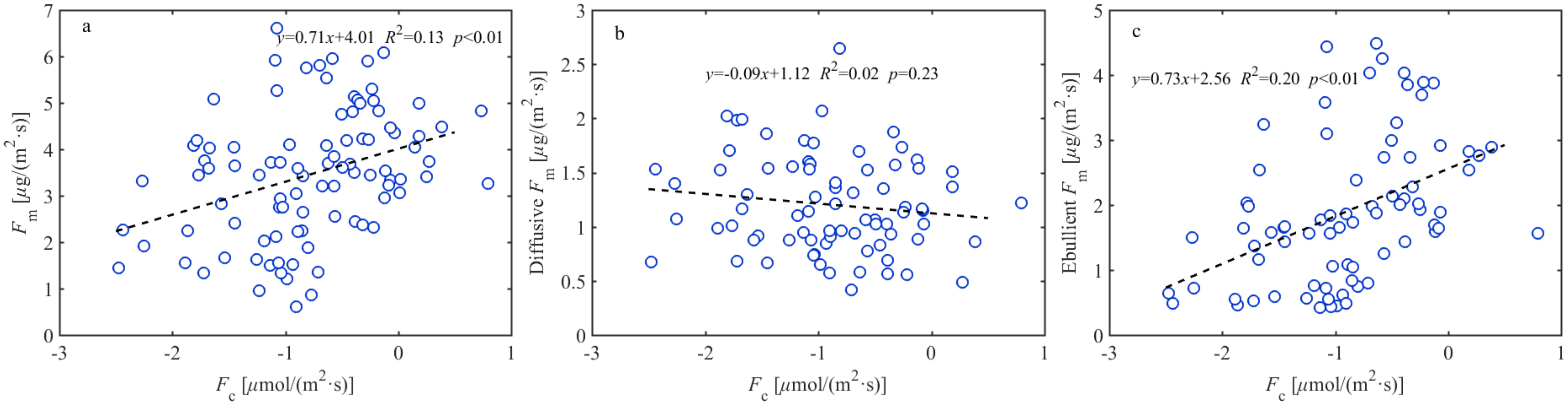


Water depth

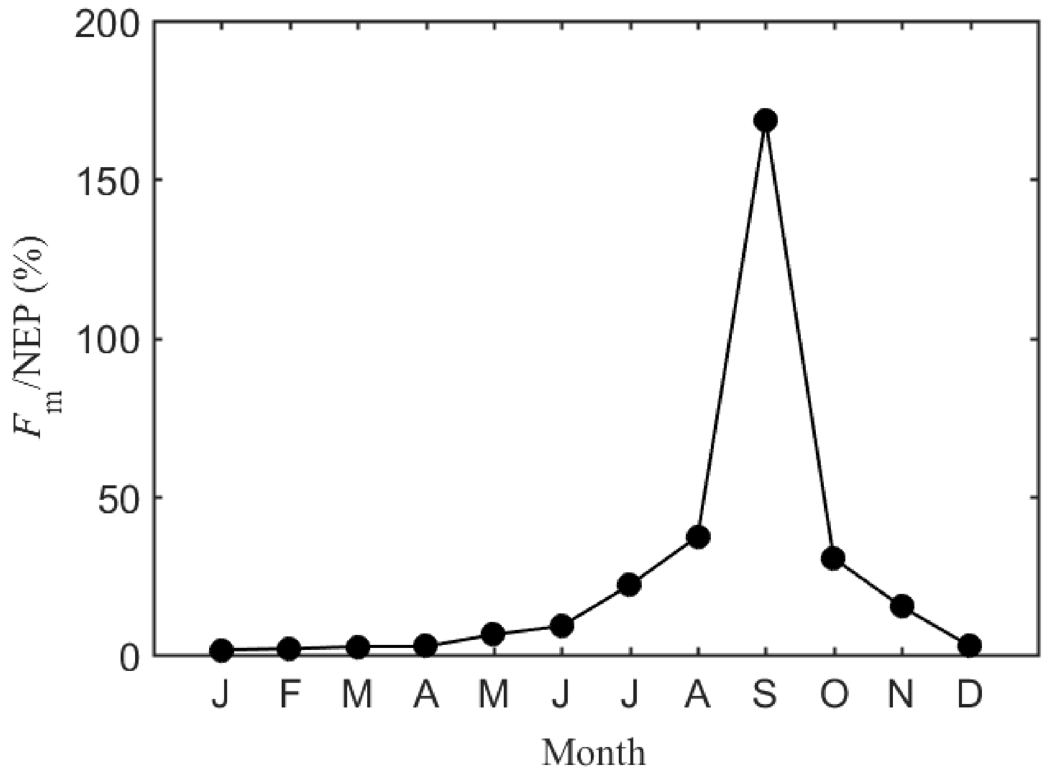

a
y=-0.98x+5.6 R2=0.01 p=0.39
Fm [μg/(m2·s)]
Depth (m)
b
y=0.64x+0.3 R2=0.03 p=0.24
Diffusive Fm [μg/(m2·s)]
Depth (m)
c
y=-2.62x+6.47 R2=0.10 p<0.05
Ebullient Fm [μg/(m2·s)]
Depth (m)


Depth (m)
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec

Photosynthesis



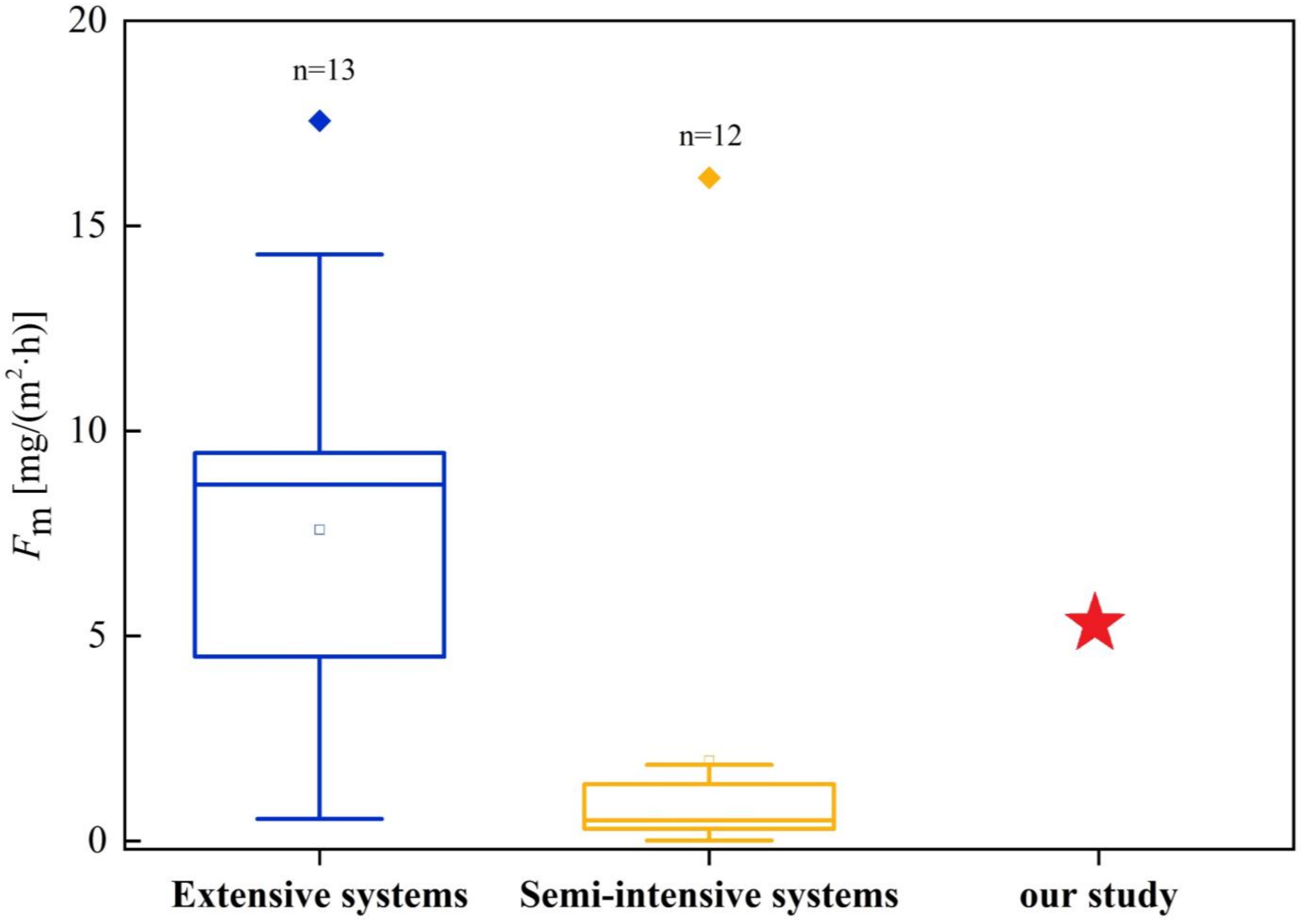
(5) C budgets



System	CH_4 (g C m^{-2})	NEP (g C m^{-2})	Feeds input (g C m^{-2})	Harvest (g C m^{-2})
Dongtaihu Bay	34.21	233.80	935.94	26.85

CH_4/C inputs: 2.99%

(6) Comparison with other published literatures



0.34 Tg CH_4 yr^{-1}

04 Conclusions

- The CH_4 flux from the aquaculture zone of East Lake Taihu was 1.45 $\mu g/(m^2 \cdot s)$, which is between the values of semi-intensive systems and extensive systems.

- The ratio of CH_4 ebullition from the aquaculture zone of East Lake Taihu was about 57%, which means the disturbance of intensive aquatic animal activities will not affect the pathway of CH_4 emission.

- Different CH_4 emission process is influenced by different environmental variables. The superposition effect made sediment temperature and thermal disturbance become the driving factors of CH_4 dynamics. Besides, O_2 produced by photosynthesis of aquatic plants may have a greater impact on CH_4 emission compared to productivity.

- In spite of large amount of organic C input, the ratio of CH_4 to total carbon inputs from the aquaculture zone of East Lake Taihu was still close to that of natural wetlands.

Thanks for your attention!