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Measuring methane emission from small water body with eddy covariance method

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1. Background

1.1 GHG emissions of small water body

High perimeter to surface area

Shallow depth

Frequent mixing

Small ponds only comprise **8.6% of total area** of global water distribution, but account for **15.1% for CO_2 emission** and **40.6% of diffusive CH_4 emissions**. (Holgerson et al., *2016*)

Temporary ponds ≠ Aquacultural ponds (In China： 43.7%) ?

1.2 Previous work and objectives

Location	Latitude and Longitude	Area	Water depth	Method	Time
Puhao Ecological Garden	32.24° N , 118.68° E	3720 m^2	1.5 m	Flux Gradient	2015.07.15 - 2015.07.24

Based on the measurement, the small pond was the source of CO_2 and CH_4 for the atmosphere, the mean emission flux of CO_2 and CH_4 was **0.03 mg·(m²·s)⁻¹** and **0.89 μg·(m²·s)⁻¹**, respectively in summer.

Objectives

1 Documenting the temporal variation and local drivers of CH_4 flux from small water body.

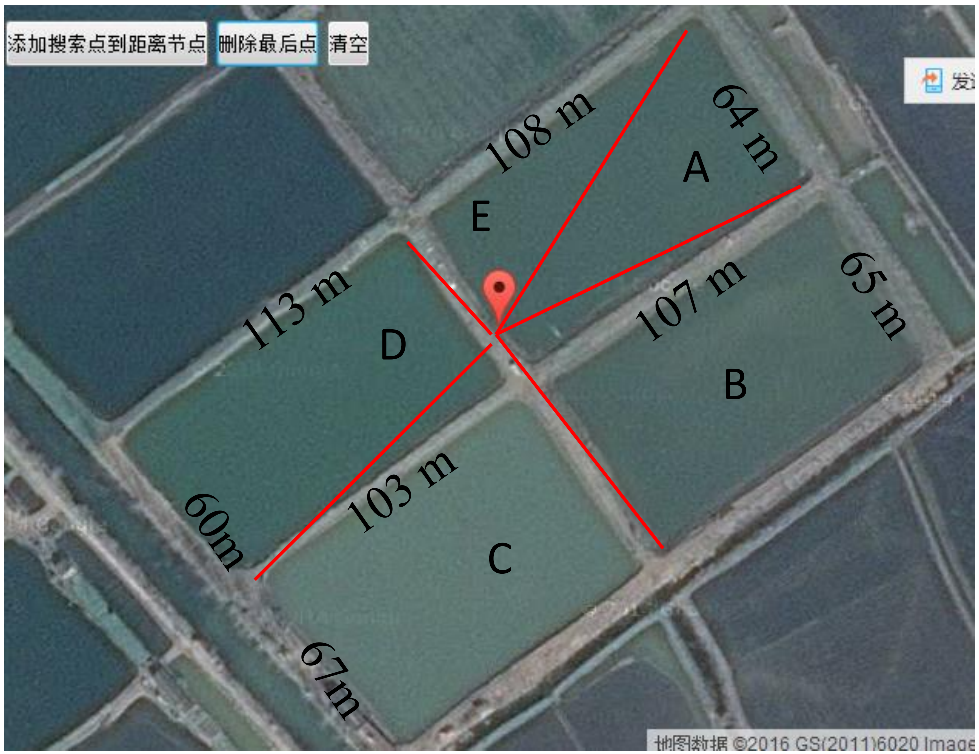
2 Quantifying the flux of CH_4 in small water body.

3 Evaluating the contribution of ebullition and diffusive components to the total CH_4 flux.

2. Experimental design

2.1 Study Site

Latitude and Longitude	Area (A)	Water Depth (A, m)	Temperature
31.97° N , 118.25° E	6912 m^2	Winter: **0**; Spring: **0**; Summer: **0.98**; Autumn: **1**	（-9.2 °C , 37.6 °C）



Pond A: (35° , 67°)

Pond B: (88° , 120°)

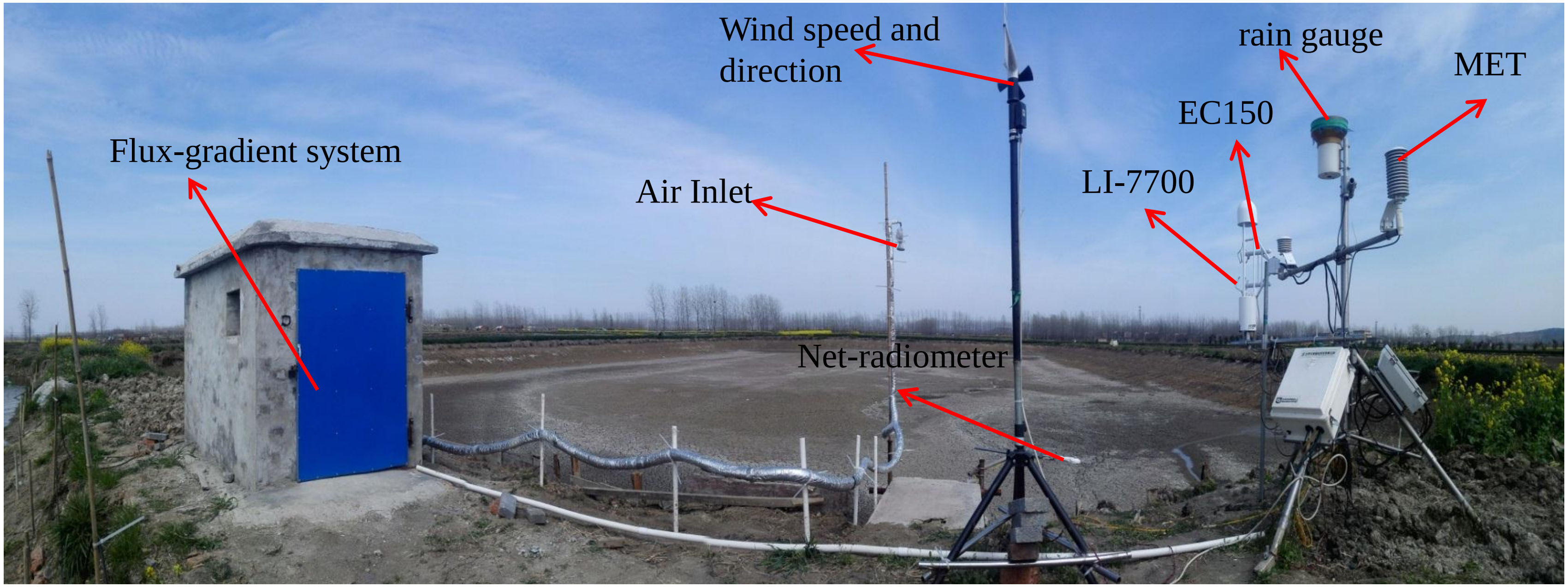
Pond C: (160° , 196°)

Pond D: (237° , 312°)

EC150: 2016.01.07 – till now

LI7700: 2016.03.24 – till now

2.1 Study Site — Instrument



Flux-gradient system (UGGA)

Eddy covariance system (EC150, LI-7700)

MET system

2.2 Micrometeorological Method

Flux-gradient Method

$$F = -c\rho_a K \frac{r_2 - r_1}{z_2 - z_1}$$

- F : flux of CO_2 (mg m^{-2} s^{-1}), CH_4 (μg m^{-2} s^{-1}), or H_2O (g m^{-2} s^{-1})
- c : unit conversion constant (44/29 for CO_2, 16/29 for CH_4, and 18/29 for H_2O)
- K : eddy diffusivity (m^2 s^{-1})
- ρ_a : air density (kg m^{-3})
- r : the half-hourly mean dry air mixing ratios

Eddy Covariance Method

$$F = \overline{\rho_a}\,\overline{\omega'\chi'}$$

- w : vertical wind component
- χ : gas mixing ratio

Inverted-funnel Method

$$F = \frac{C_{CH4} \times V \times M}{A \times t \times V_m} \times \frac{1}{1000}$$

2.3 Data processing

Experimental Record

↓

Instrument Status
(samples, diagnostic value, and signal value)

↓

Deleting the EC data when it rains

↓

Five point moving average
(standard deviation:1.5 except:CH_4)

↓

2-D coordinate rotation

↓

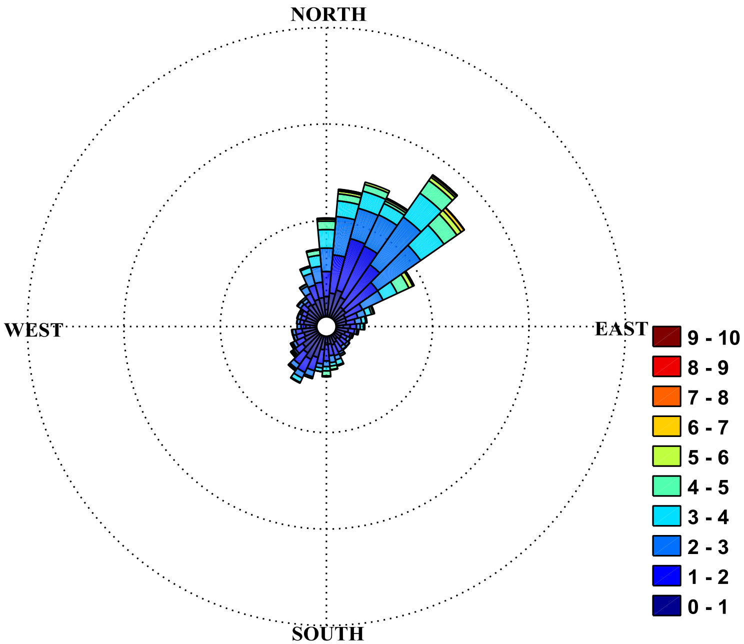
WPL correction

↓

Spectral correction(F_m)

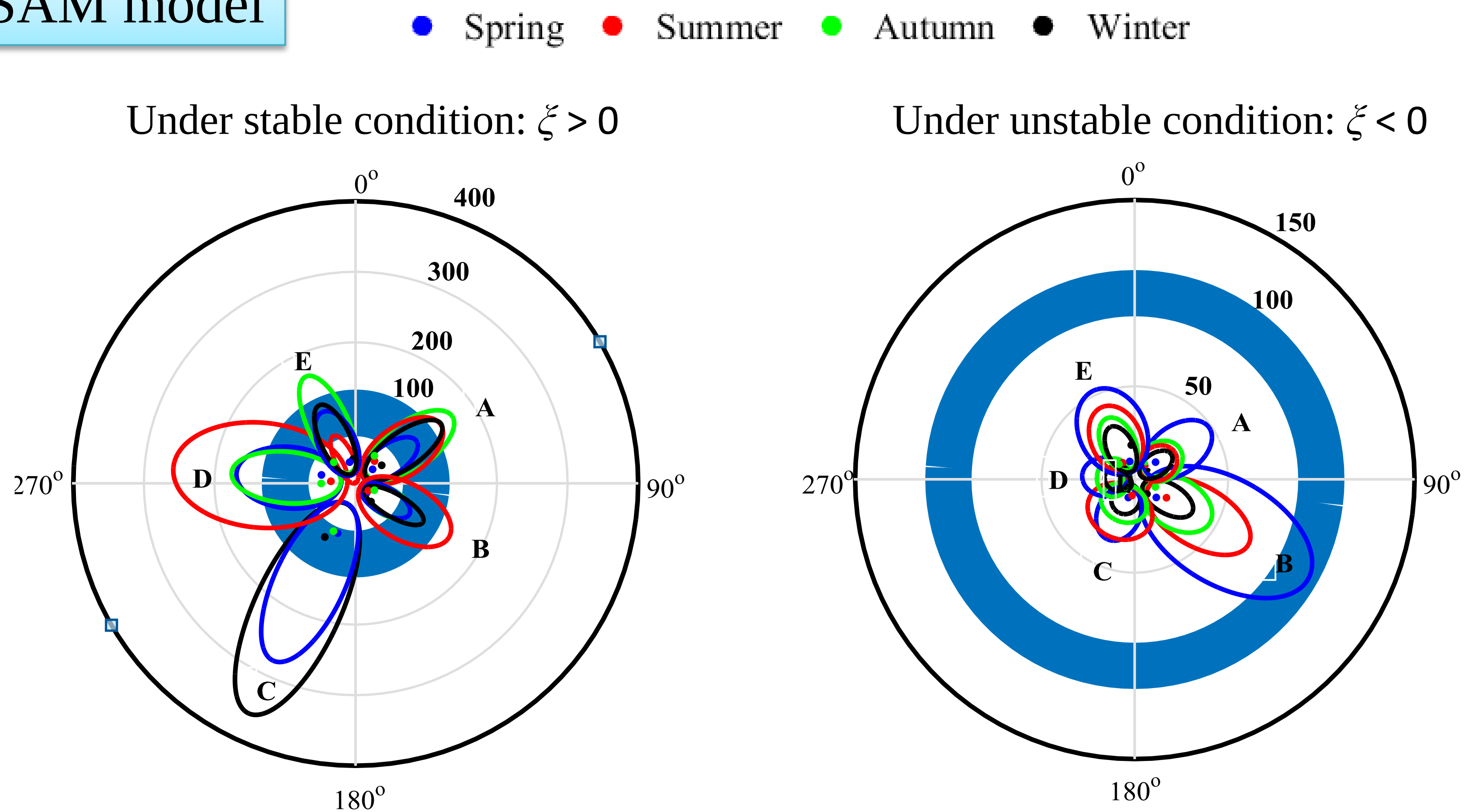
↓

Footprint



2.3 Data processing — Flux Footprint

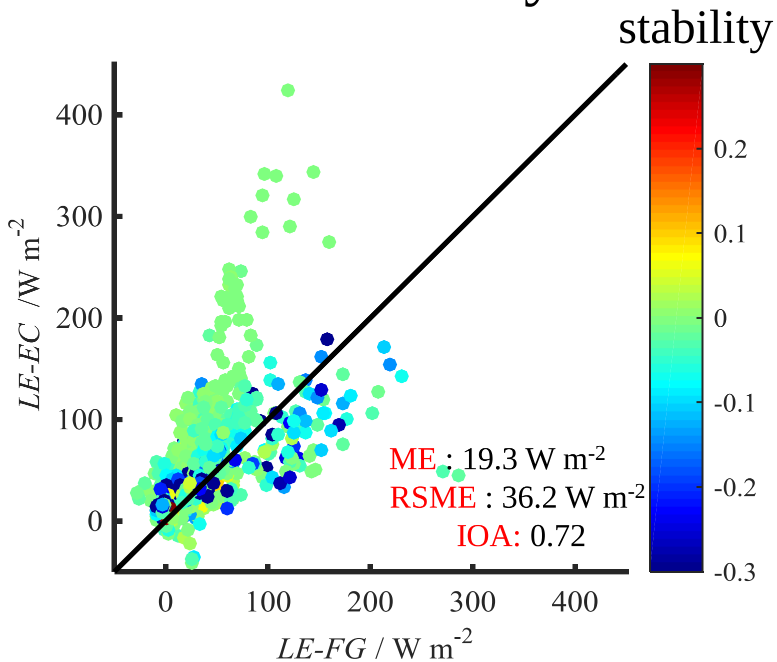
FSAM model

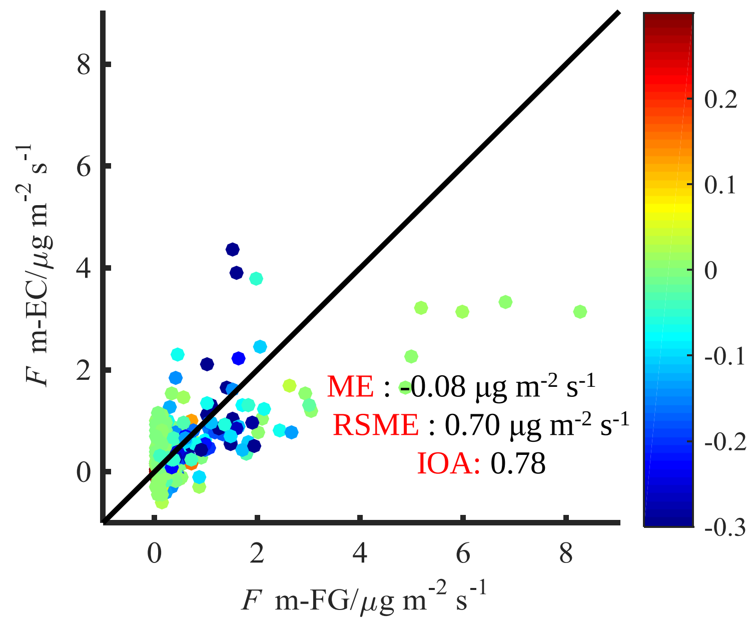


Valid data: 19%

3. Results and Discussion

3.1 Flux Gradient vs Eddy covariance



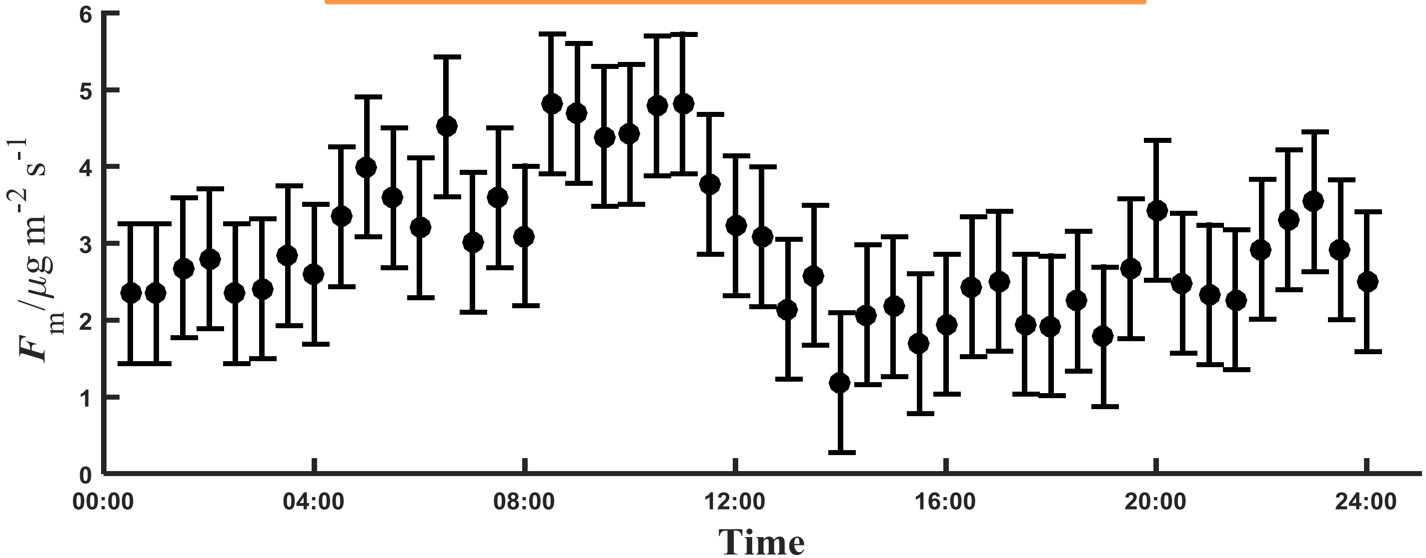


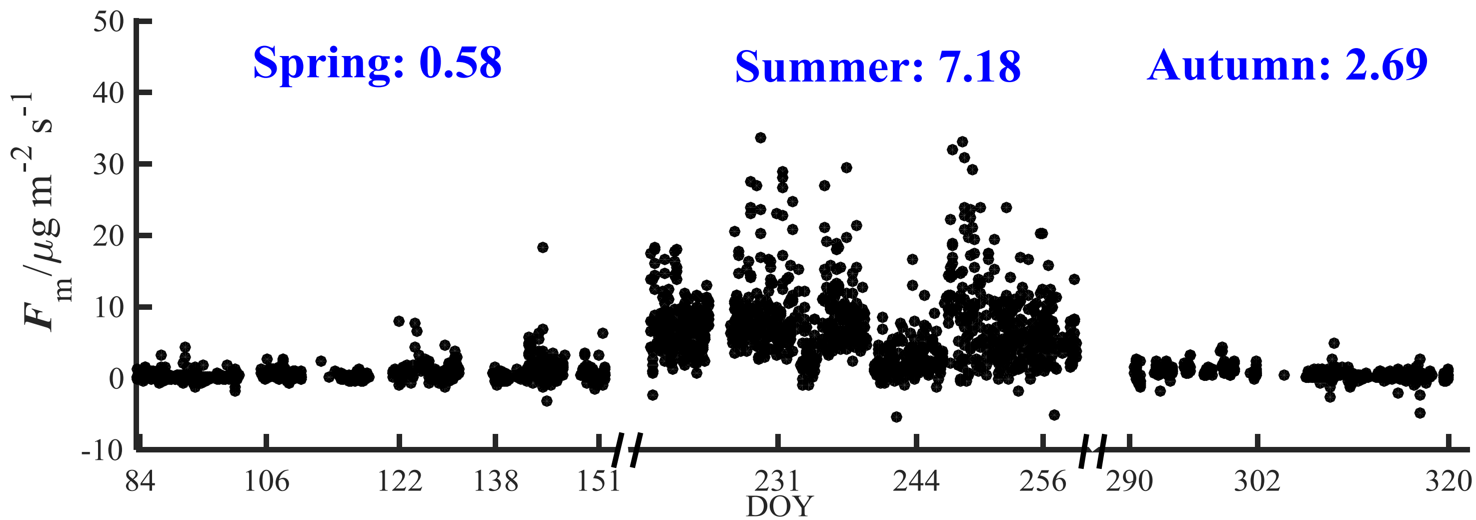
Season	*LE* _FG / W m^{-2}	*LE*_EC / W m^{-2}
Winter	15.2 (15.5)	36.6 (36.1)
Spring	40.1 (47.1)	57.7 (62.5)
Autumn	29.3 (29.0)	49.0 (32.5)

Season	F_m _FG / μg m^{-2} s^{-1}	F_m_EC /μg m^{-2} s^{-1}
Spring	0.30 (0.57)	0.29 (0.42)
Autumn	1.02 (0.99)	1.03 (0.90)

3.2 Temporal variation of CH_4 flux — EC

Mean value: 2.96 (4.25) μg m^{-2} s^{-1}



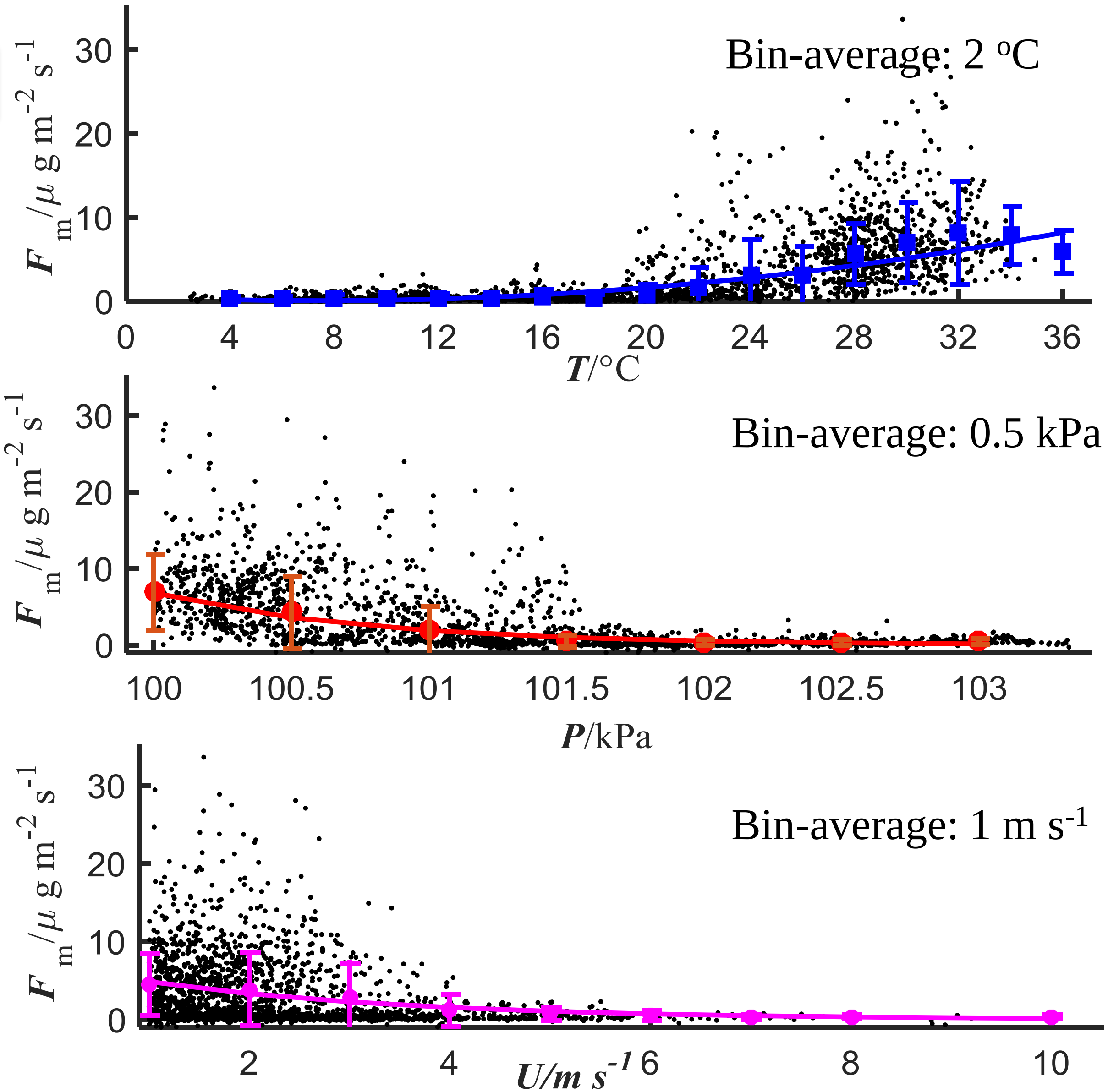


3.3 Environmental Factors

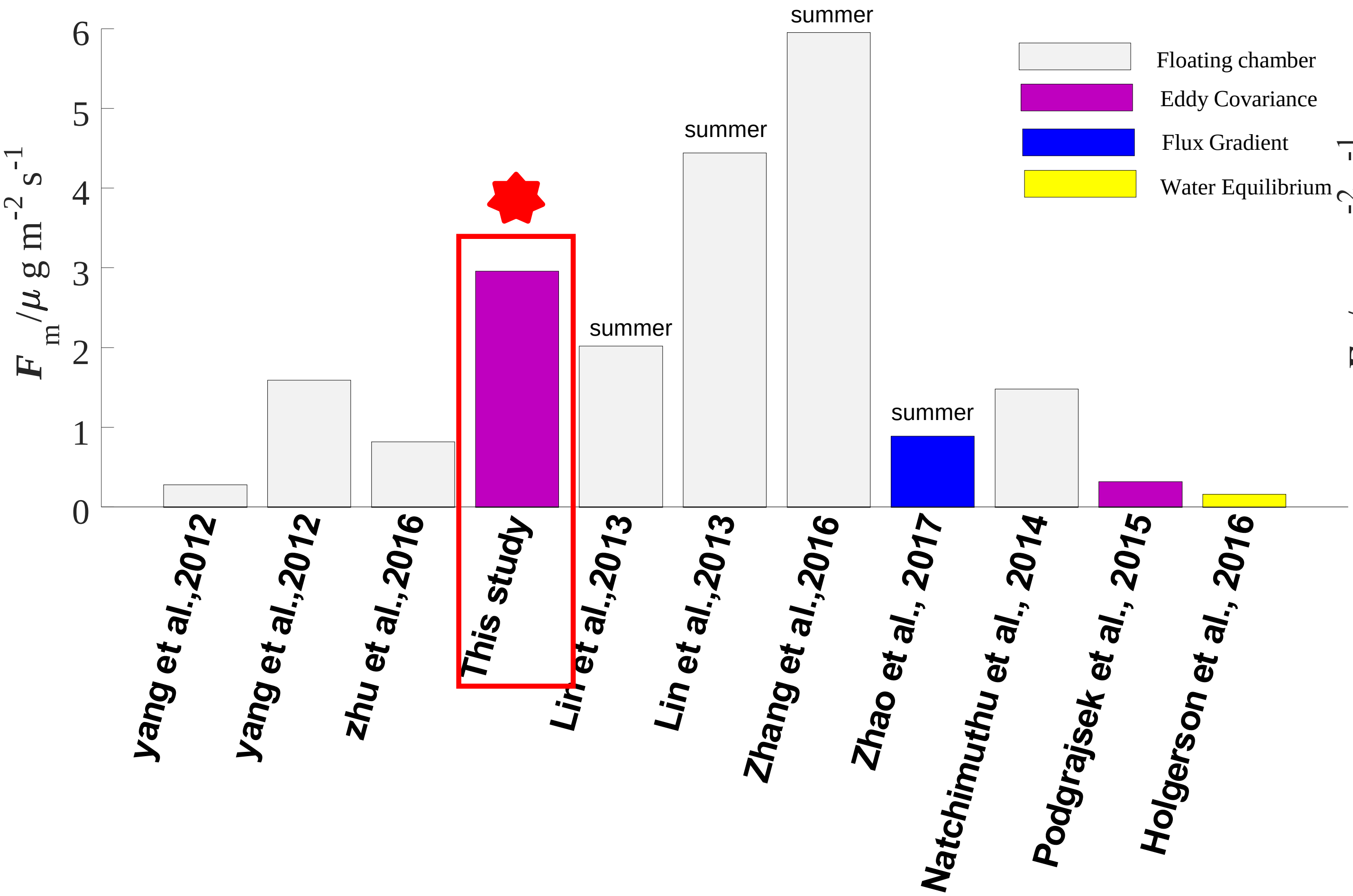
Air Temperature

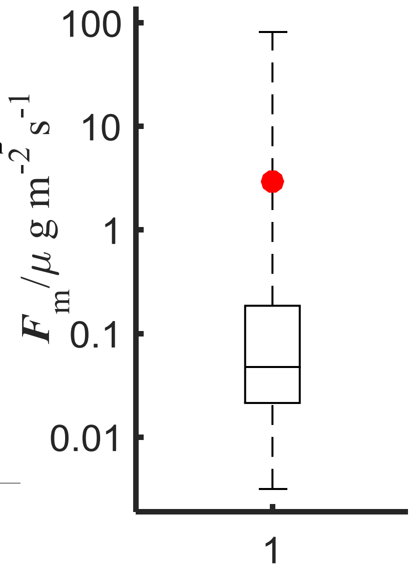
Pressure

Wind speed



3.4 Compared with other literature results

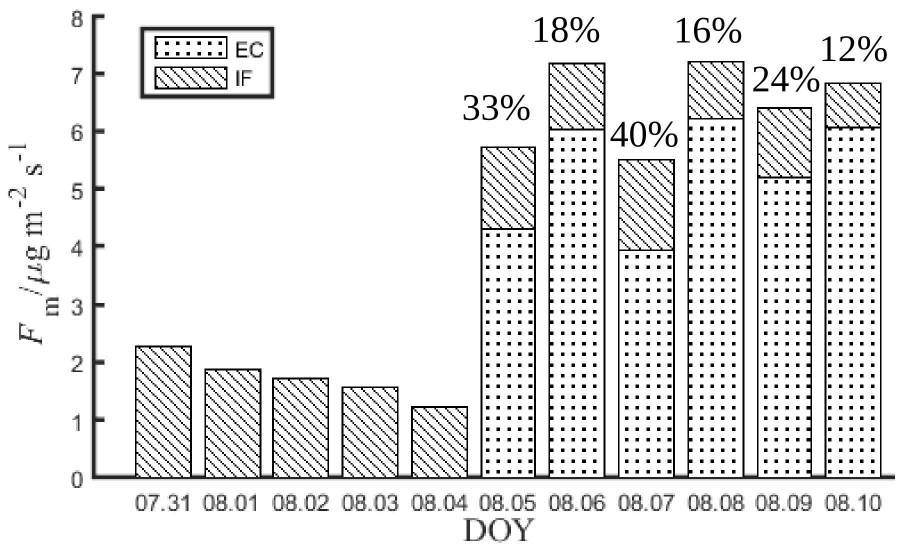




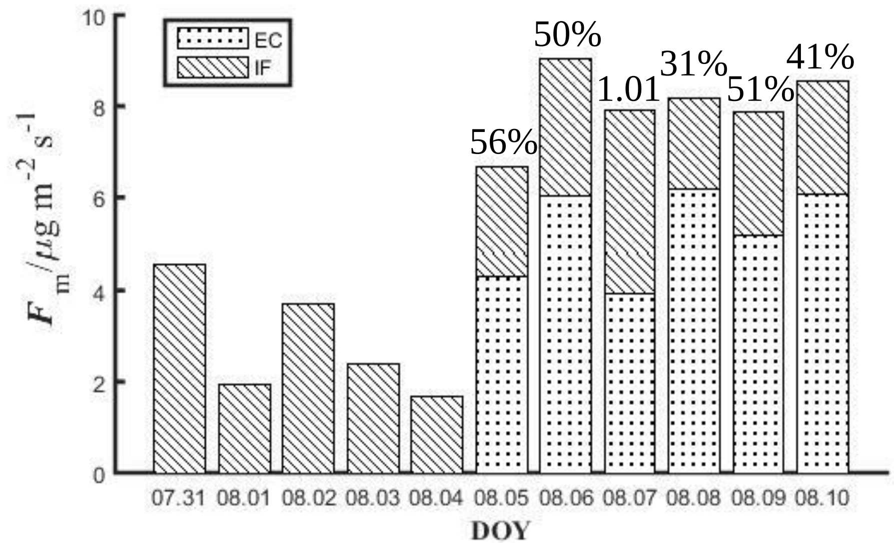
Data Source:
(Xiao et al., 2014)

3.5 Eddy Covariance vs Inverted Funnel

Ebullition Contribution: 24%
(IF(mean value) / EC)



Ebullition Contribution: 46 %
(IF(maximum) / EC)

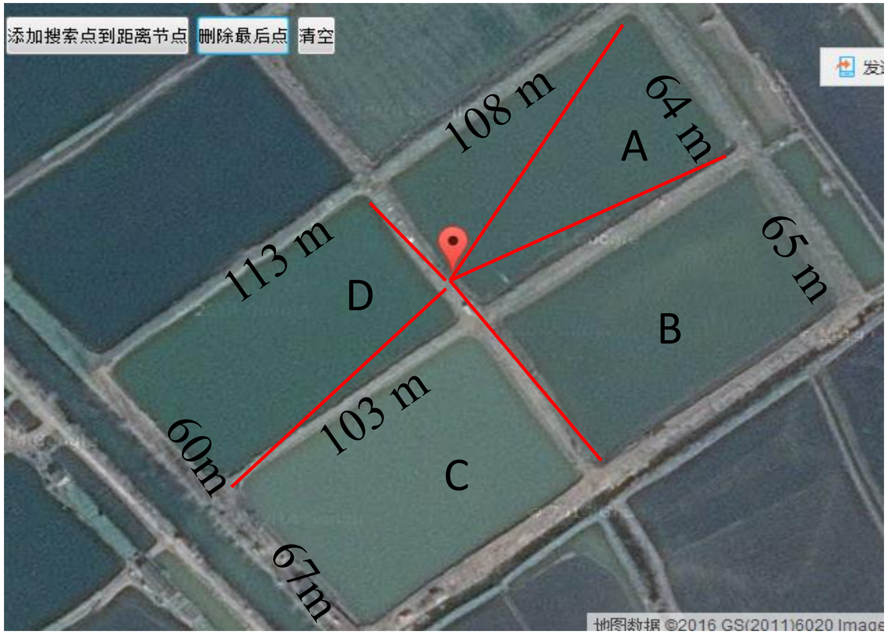


IF Observation time: 2016.07.31 – 2017.08.10

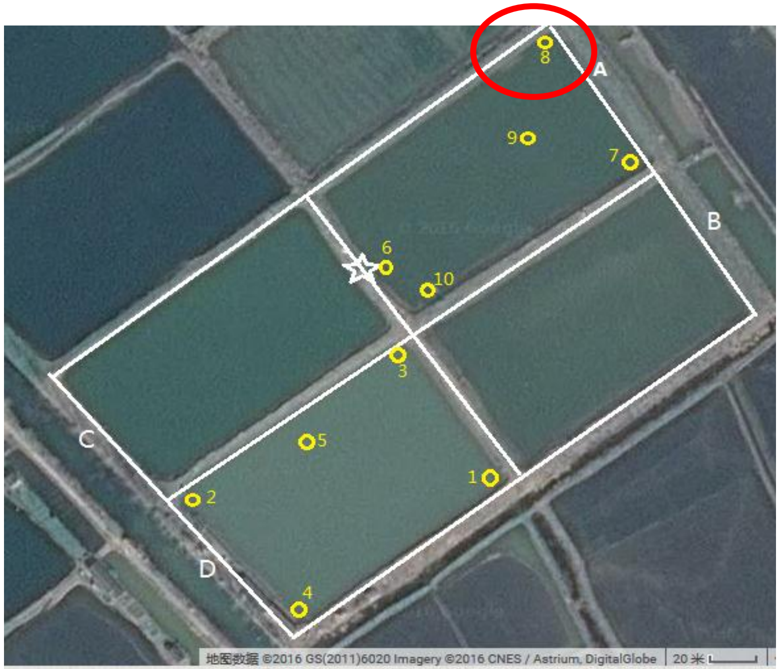
Data Source: (Zhang et al., 2017)
Manuscript in preparation

3.5 Eddy Covariance vs Inverted Funnel

EC observation



IF observation



Conclusion

- 1 CH_4 flux has obvious diurnal cycle with high values during daytime ($F_m \approx$ 3.12 μg m^{-2} s^{-1}) and low values during nighttime ($F_m \approx$ 2.79 μg m^{-2} s^{-1}); The maximum seasonal flux occurred in summer ($F_m \approx$ 7.18 μg m^{-2} s^{-1}) and corresponded to the highest water temperature.

- 2 Air temperature, air pressure and wind speed have significant correlation with the half-hourly CH_4 fluxes.

- 3 The average CH_4 flux from Guandu small water body ($F_m \approx$ 2.96 μg m^{-2} s^{-1}) was much higher than that reported from other small water body.

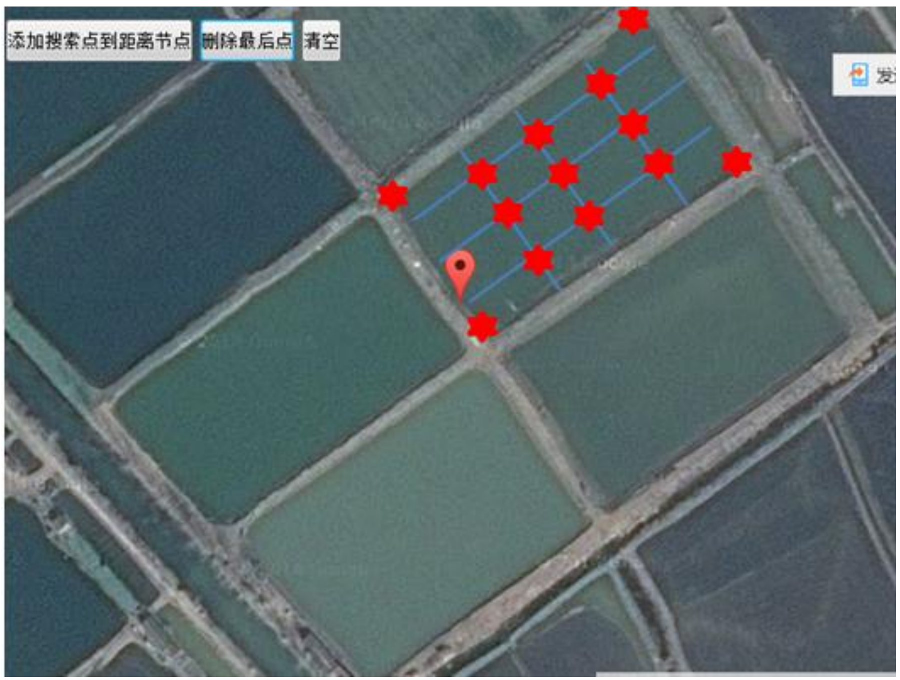
Spring Experimental Design:

- Measuring the water quality parameters of small ponds

  1. Instrument: YSI water quality analyzer-----DO, pH (frequency: three hours)

  2. DOC measurement --- bring water sample to Institute of Geography

- Measuring the spatial distribution of CH_4 concentration in small ponds



Sampling design
(✱ :sampling point)

Thank you