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Methane bubble flux from small ponds measured using the inverted-funnel method in summer

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Outline

- Background
- Materials and Methods
- Results and Discussion
- Conclusion
- Future Work

1. Background

- **CH_4** is an important greenhouse gas with warming potential globally about 20 times than CO_2 (Cicerone and Oremland, 1988; Wuebbles and Hayhone, 2002).
- **0.583PgC/yr^{-1}** were omitted from very small ponds globally, and small ponds make up only 8.6% of the global surface area, yet comprise 15.1% of CO_2 diffusion and 40.6% of diffusive CH_4 emissions (Holgerson and Raymond, 2016).
- There are four pathways for methane transportation from lake sediment to atmosphere: ebullition, diffusion, aquatic vegetation, storage in water column, where ebullition is the major (Bastviken et al., 2004).
- This study aims to **quantify the bubble ratio** in small ponds, CH_4 ebullition and diffusive fluxes were measured.

2. Materials and Methods

Figure 1 Location of the sampling sites.

- Mean water depth：

Pond A: 0.97 m

Pond B: 0.48 m

- Experimental period:

2016/07/27-2016/08/13

- Gas sampling:

Frequency:

Intense sampling:

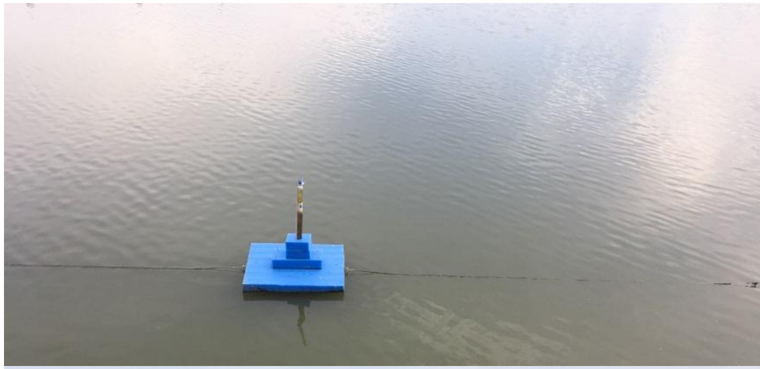
6:00,12:00,18:00,24:00

Daily sampling: 7:00 LST

- Water sampling:

Frequency: 12:00 LST

2. Materials and Methods



Inverted-funnel method

$$F = \frac{C_{CH_4} \times V \times M}{A \times t \times V_m} \times \frac{1}{1000}$$

F is the flux (mg CH_4 m^{-2} d^{-1});

C_{CH4} is the CH_4 concentration(μL L^{-1});

V is the accumulated gas volume (L);

M is the molar weight of CH_4 (16.04 g mol^{-1});

A is the funnel area (0.053 m^2);

t is the measurement period (d);

V_m is the molar volume od gas at standard conditions (22.4 L mol^{-1}).

(Wik et al., 2013)

2. Materials and Methods

- Water equilibrium method

$$F = K(C_w - C_{eq})$$

C_w is the dissolved gas concentration;
C_{eq} is the gas concentration in water that is in equilibrium with the atmosphere at the in-situ temperature;
K is the gas transfer coefficient.

(Blees et al., 2015)

3.1 Meteorological variables

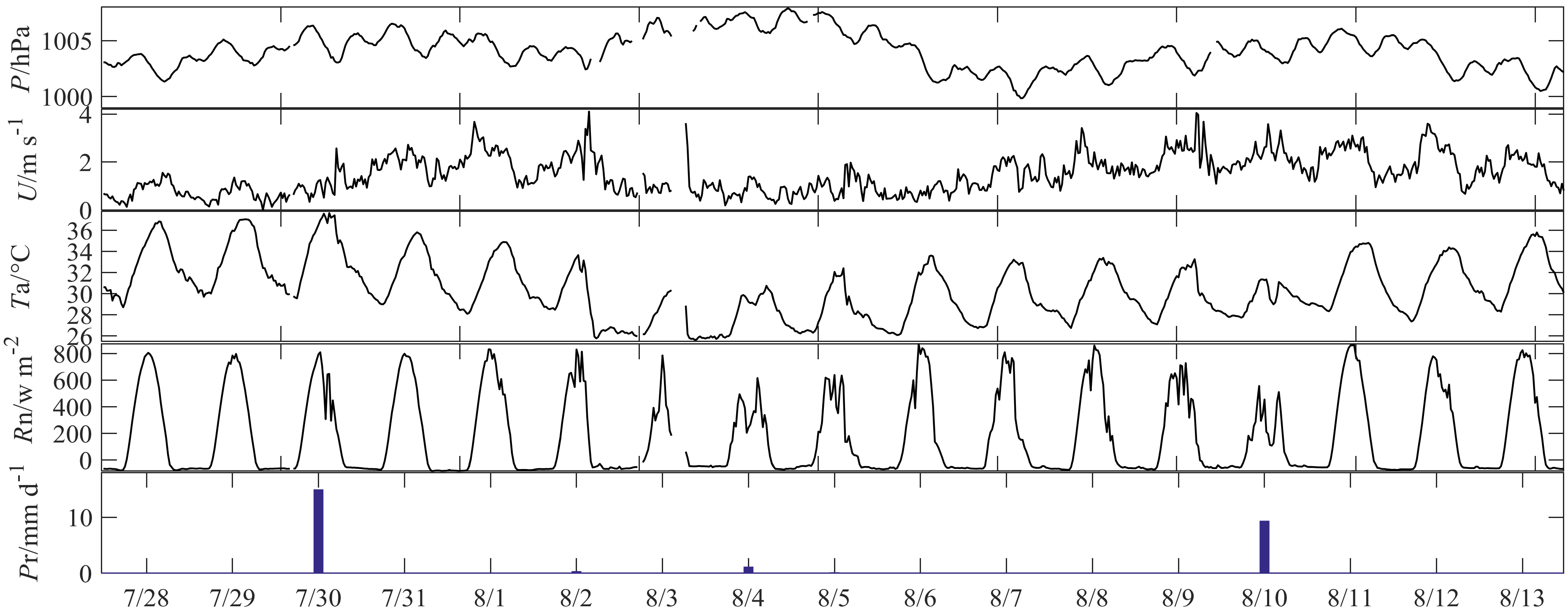


Figure 2 Time series of meteorological factors.

3.2.1 Diurnal ebullition rate (1)

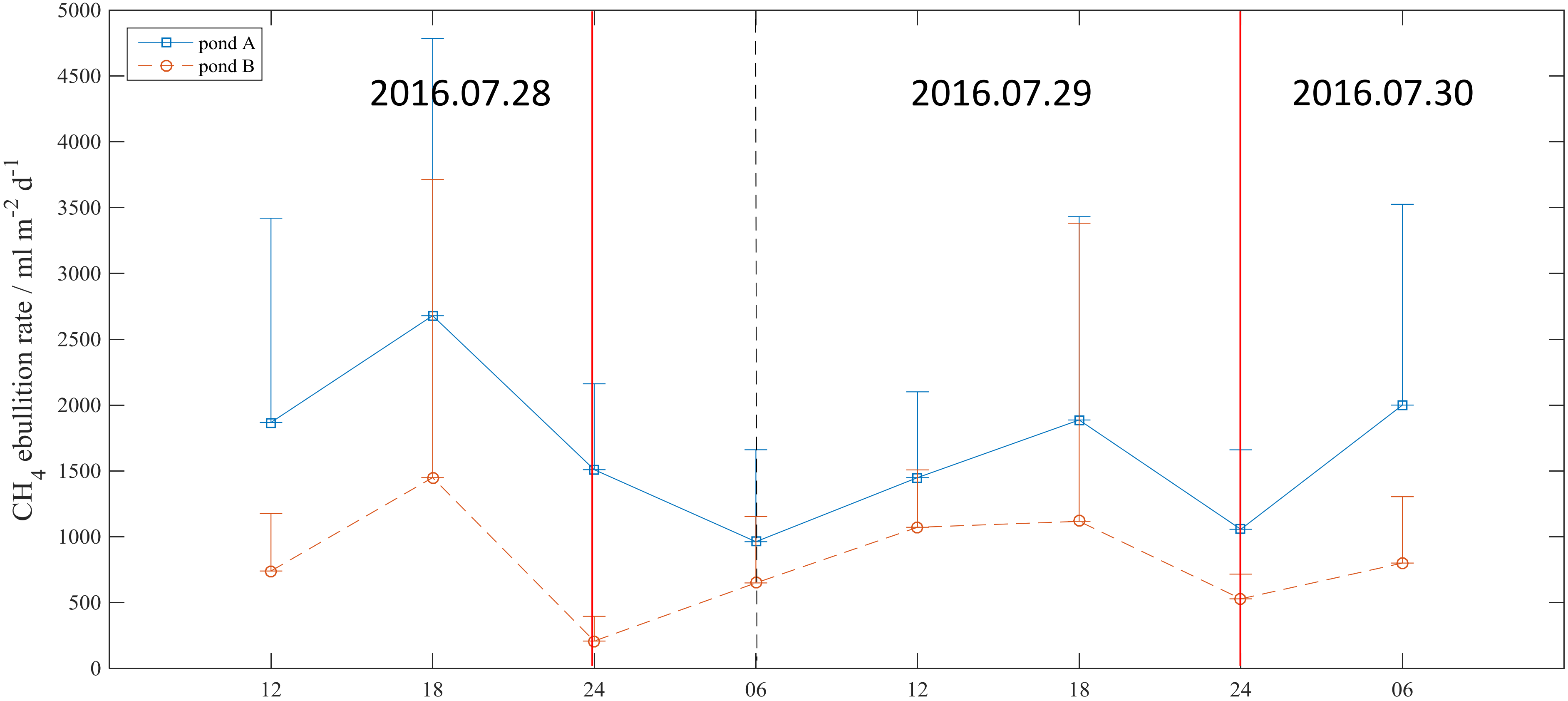


Figure 3 Time series of CH_4 ebullition rate during the two-day intensive compaign.

3.2.2 Diurnal ebullition rate (2)

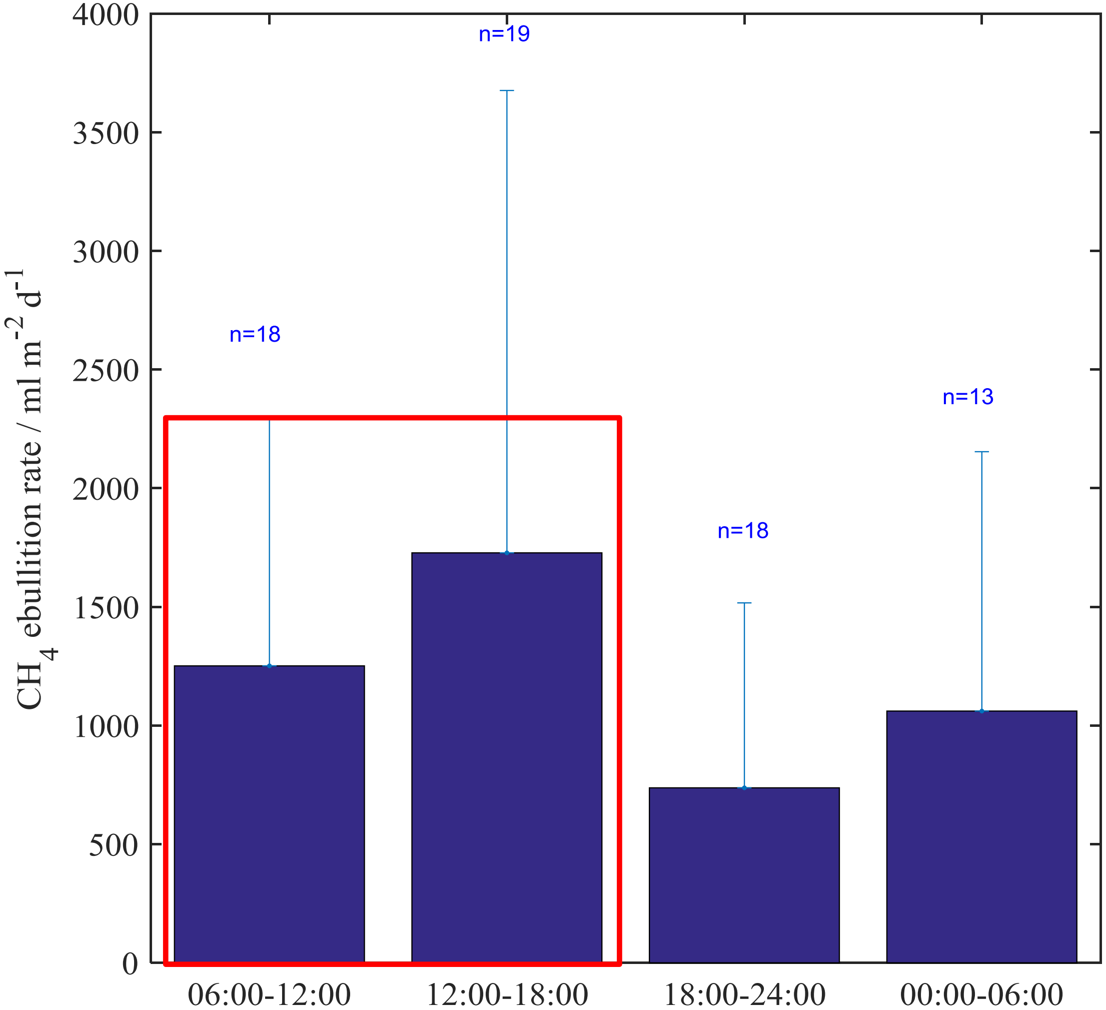


Figure 4 Diurnal composite of CH4 ebullition rate.

3.3 Temporal variabilities of methane fluxes

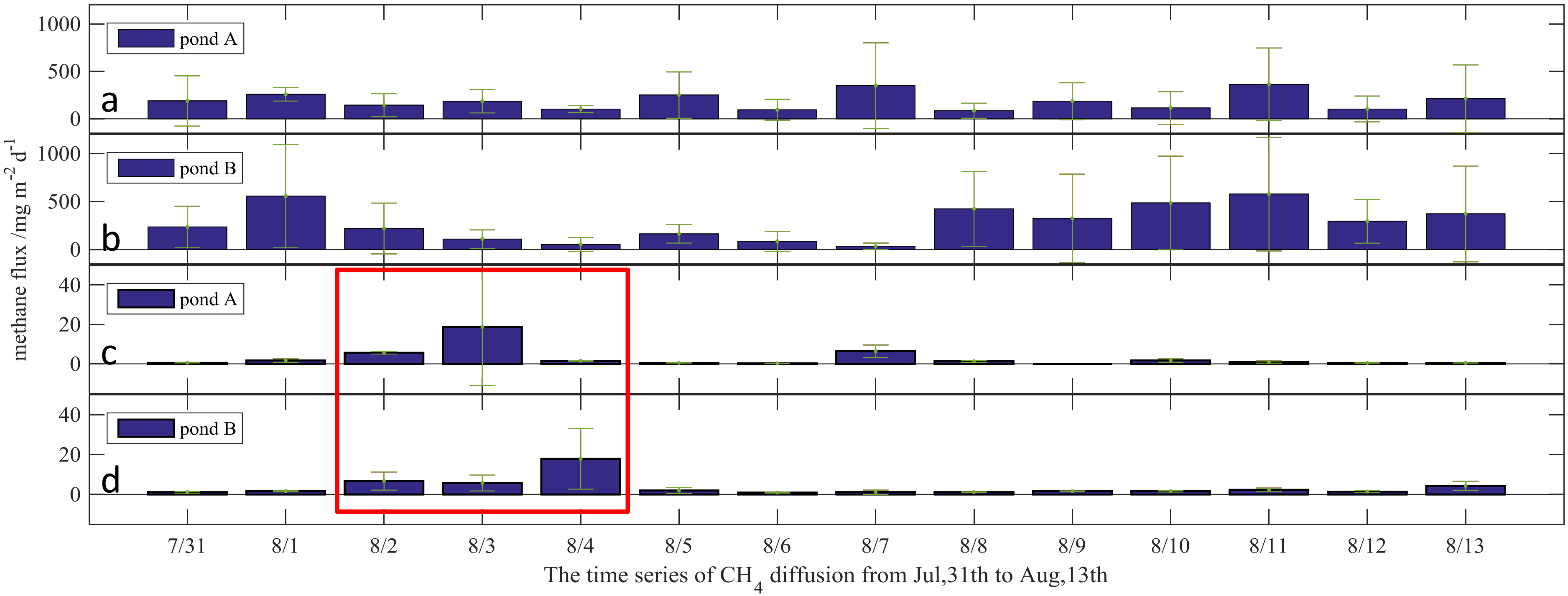
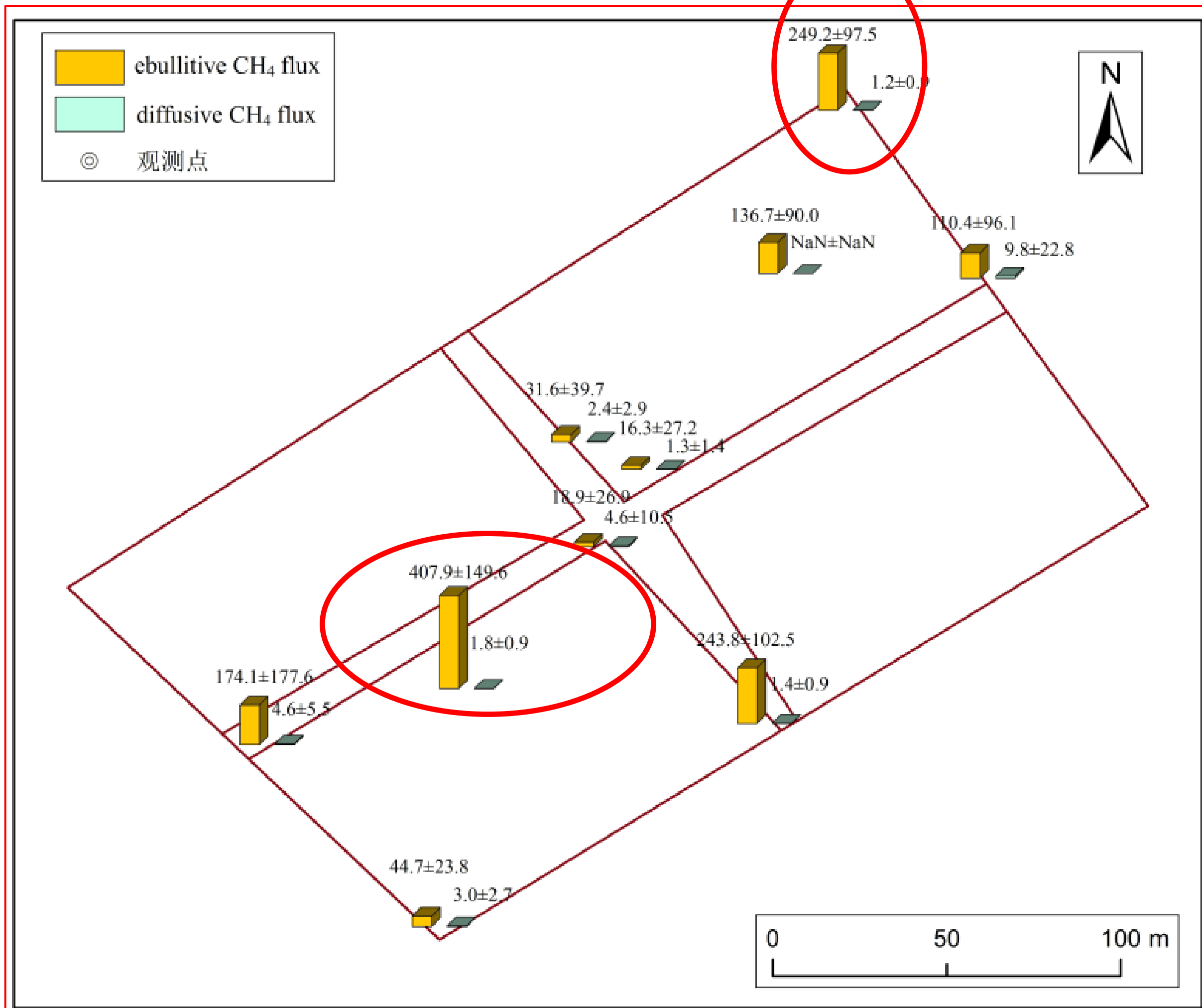


Figure 5 Time series of daily methane fluxes during 14 days.

3.4.1Spatial patterns of methane fluxes



Maximum bubble flux:

Pond A:

A4 249.2 mg $m^{-2}d^{-1}$

Pond B:

B5 407.9 mg $m^{-2}d^{-1}$

Unit is mg $m^{-2}d^{-1}$

Figure 6 Spatial patterns of methane fluxes in the two ponds.

3.4.2 Spatial mean value of methane fluxes in the two ponds

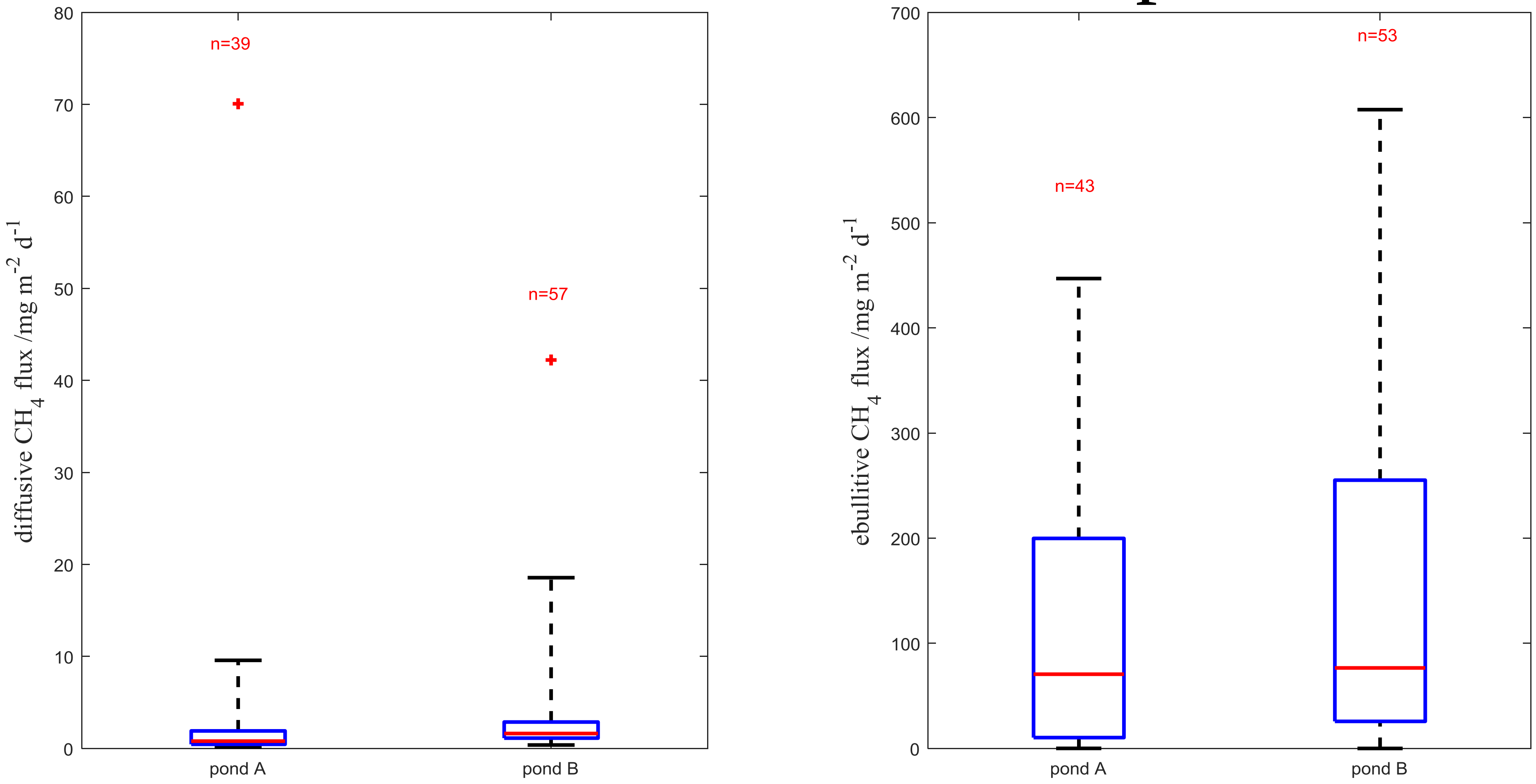


Figure 7 Spatial mean value of methane fluxes variations in ponds A and B.

Table 1 The ratio of bubble methane flux to total methane flux.

date	Pond A				Pond B			
	bubble	diffusion	total	Ratio	bubble	diffusion	total	Ratio
	mg $m^{-2}d^{-1}$	mg $m^{-2}d^{-1}$	mg $m^{-2}d^{-1}$	%	mg $m^{-2}d^{-1}$	mg $m^{-2}d^{-1}$	mg $m^{-2}d^{-1}$	%
7/31	190.29	0.5	190.79	99.74	234.93	1.07	236	99.55
8/1	155.34	1.65	156.99	98.95	129.86	1.59	131.45	98.79
8/2	143.3	5.6	148.9	96.24	219.24	6.71	225.95	97.03
8/3	130.27	18.66	148.93	87.47	108.79	5.7	114.49	95.02
8/4	102.27	1.47	103.74	98.58	52.27	0.16	52.43	99.69
8/5	118.41	0.49	118.9	99.59	100.09	1.92	102.01	98.11
8/6	94.61	0.2	94.81	99.79	85.11	0.88	85.99	98.98
8/7	131.56	6.39	137.95	95.36	33.62	1.09	34.71	96.85
8/8	84.98	1.27	86.25	98.53	203.55	1.07	204.62	99.48
8/9	101.65	NaN	NaN	---	160.55	1.58	162.13	99.02
8/10	62.93	1.7	64.63	97.37	266.82	1.59	268.41	99.41
8/11	214.05	0.9	214.95	99.58	291.62	2.27	293.89	99.23
8/12	102.9	0.41	103.31	99.61	215.98	1.39	217.37	99.36
8/13	73.32	0.43	73.75	99.42	154.27	4.28	158.55	97.3
Ave	121.85	3.05	126.45	97.71	161.19	2.24	163.43	98.42

Table 2 The correlation coefficient in influencing methane bubble flux.

	Water depth	Wind speed	Water temperature	pressure
Pond A	-0.18	0.03	0.52	0.21
Pond B	-0.592*	0.740**	0.28	-0.25

* $p<0.05$
** $p<0.01$

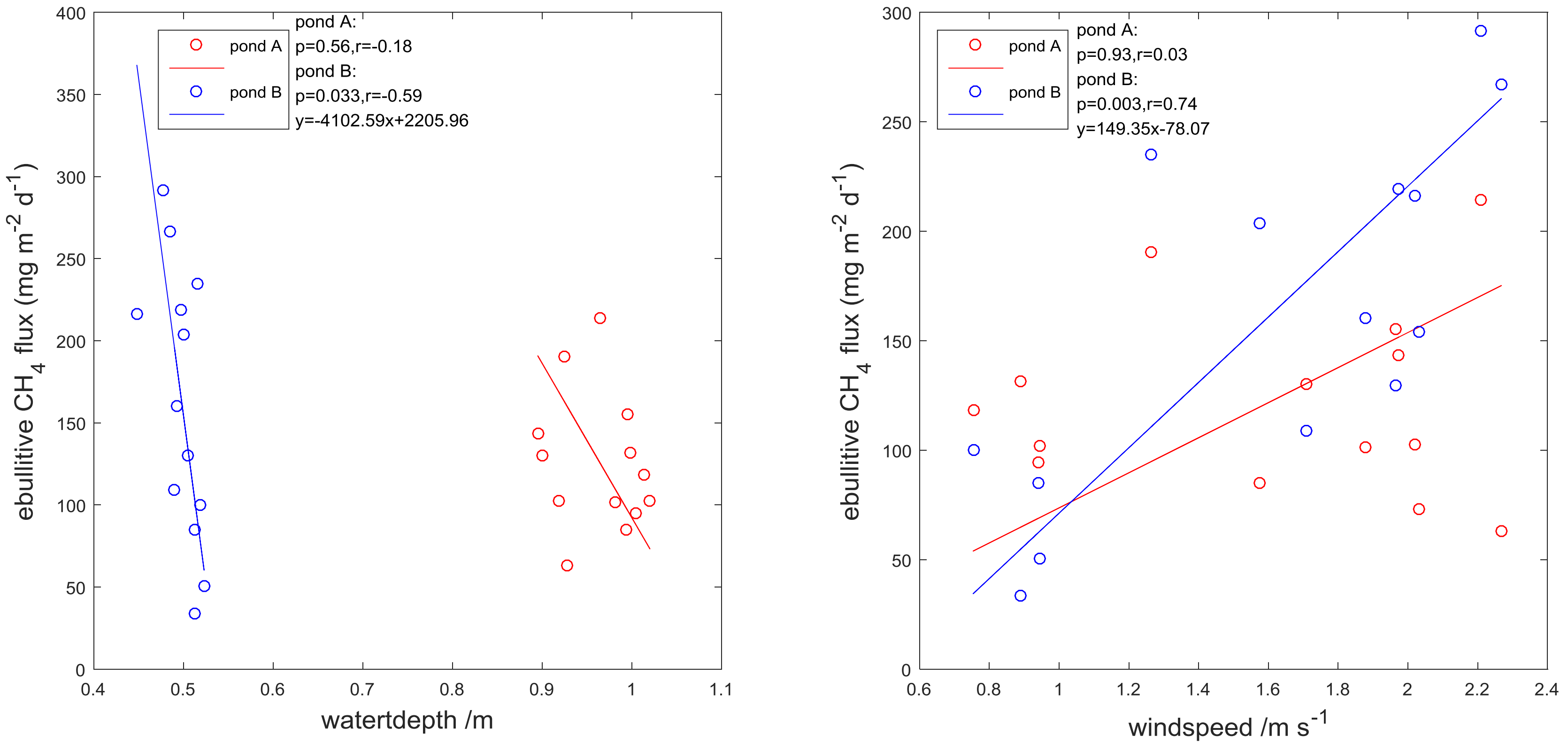


Figure 8 Environmental factors on methane ebullition.

Wetland system	region	Sampling time	Bubble flux $mg\cdot(m^2\cdot d)^{-1}$	Sampler number n	Bubble ratio (%)	reference
Floodplain lake	Amazon	7-8	120	35	85	50
Floodplain lake	Amazon	7-9	27.2	41	68	51
Floodplain lake	Amazon	4-5	73.6	116	-	52
Floodplain lake	Amazon	11-12	40	40	-	53
Near Manaus lake	Amazon	annual	44.8	90	59-73	53
Calaro lake	Amazon	9	164.8	-	69	54
Macrophyte mats	Amazon	annual	192	-	-	55
Near Miranda River	Pantanal	3,6,9,12	142.4	-	90	56
15 lakes	Pantanal	9,11	131.8	-	91	38
Lake L1	Pantanal	9,11	216	24	-	38
Floodplain Orinoco River	Venezuela	5	114	-	65	55
Macrophyte mats	Venezuela	5	25.6	-	-	55
Priest Pot	English, UK	5-10	192	-	96	2
Headwater catchment	Siberia	8-10	15.36	-	-	57
Thermokarst lakes	Siberia	2003.4-2004.5	46.7	-	-	58
Gatun lake	Panama	2-5	1m:884±212 3m:1088±240 10m:5±16	-	-	33
Huahu lake	Qinghai-Tibet	6-8	362.4	-	-	59
Pond_Site F	Hubei	7/10	-	-	99.7	60
Pond_Site N	Hubei	7/10	-	-	91.67	60
This study_pond A	Anhui	7-8	118.04	44	97.71	-
This study_pond B	Anhui	7-8	170.02	54	98.42	-

Conclusion

- Ebullition is the main pathway in the small shallow and productive ponds account for more than **87%** of methane emission in summer.
- Methane emission by bubbling occurred episodically, with greatest rates primarily in the afternoon of **1200 to 1800** LST.
- Obvious temporal and spatial variabilities were found.
- Methane bubble flux was influenced by water depth in the two ponds.

Future Work

- Methane concentration of bubble emissions.
- Bubble trap / sample frequency / gas sample store.
- Annual methane emissions in ponds or lakes even to a region or global methane emissions.

$$F = K(C_w - C_{eq})$$

THANK YOU FOR YOUR TIME AND ANY SUGGESTION IS WELCOMED!