Methane flux at a submerged macrophyte habitat and relations to carbon dioxide flux

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1 Background

Methane is an important greenhouse gas, and the growth rate of methane concentration has become stronger since 2007 , but the reason is still uncertain (Kirschke et al,2013; Nisbet et al, 2014)

Lake is one of the most important sources of atmosphere methane, and it has significantly effect on the atmospheric methane concentration and global carbon cycle(Borges et al, 2011; Bastviken et al, 2011; Van Huissteden et al, 2011).

Methane emission is temperature-dependent, and global warming may have a large impact on methane emission from aquatic ecosystems et al (Durocher et al, 2014)

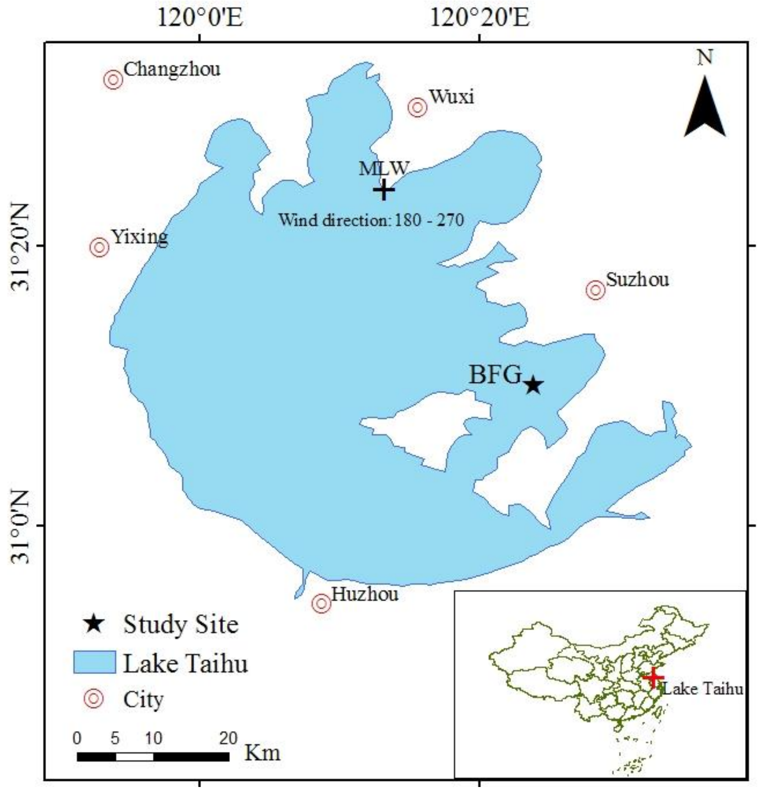
The effect of aquatic vegetation on CH_4 emission

(1) supply the labile carbon in the root zone (Chanton et al ,1995)

(2) supply the organic matter for CH_4 production

(3) increase the methane emission through the stomatal conductance

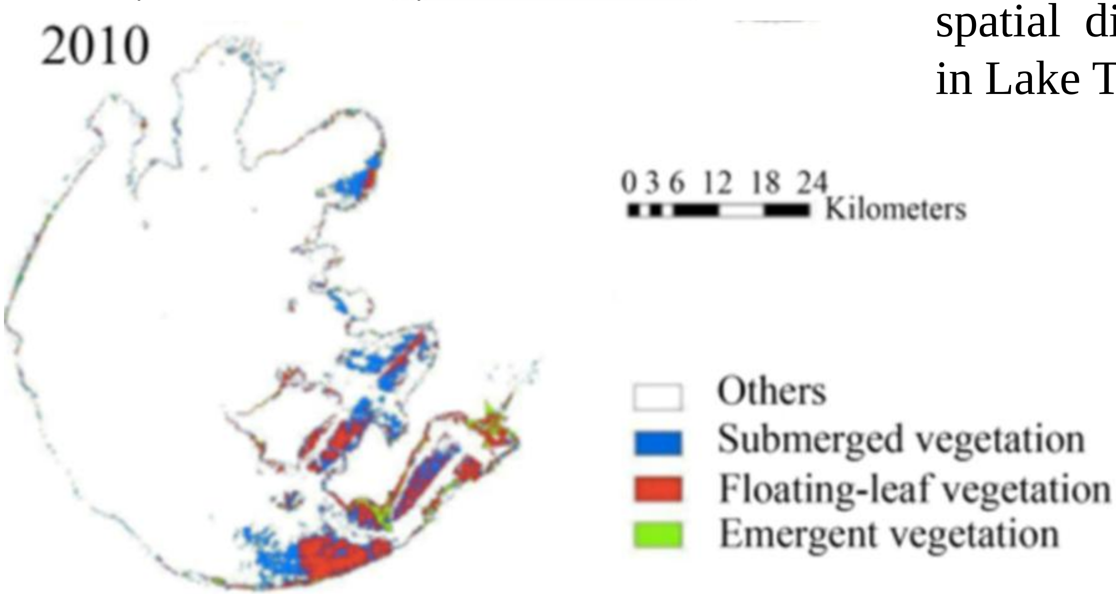
(4) reduce the bubble emission (Schimel et al, 1995)



MLW site: Eddy Covariance system
Flux-gradient system(CO_2/CH_4/H_2O)

BFG study site : Water quality monitor system
Eddy Covariance system
Open-path CH_4 analyzer

Figure.1 The introduction of study site and the spatial distribution of aquatic vegetation in Lake Taihu



Zhao et al, 2013

2 CH_4 flux measured by Eddy Covariance at BFG

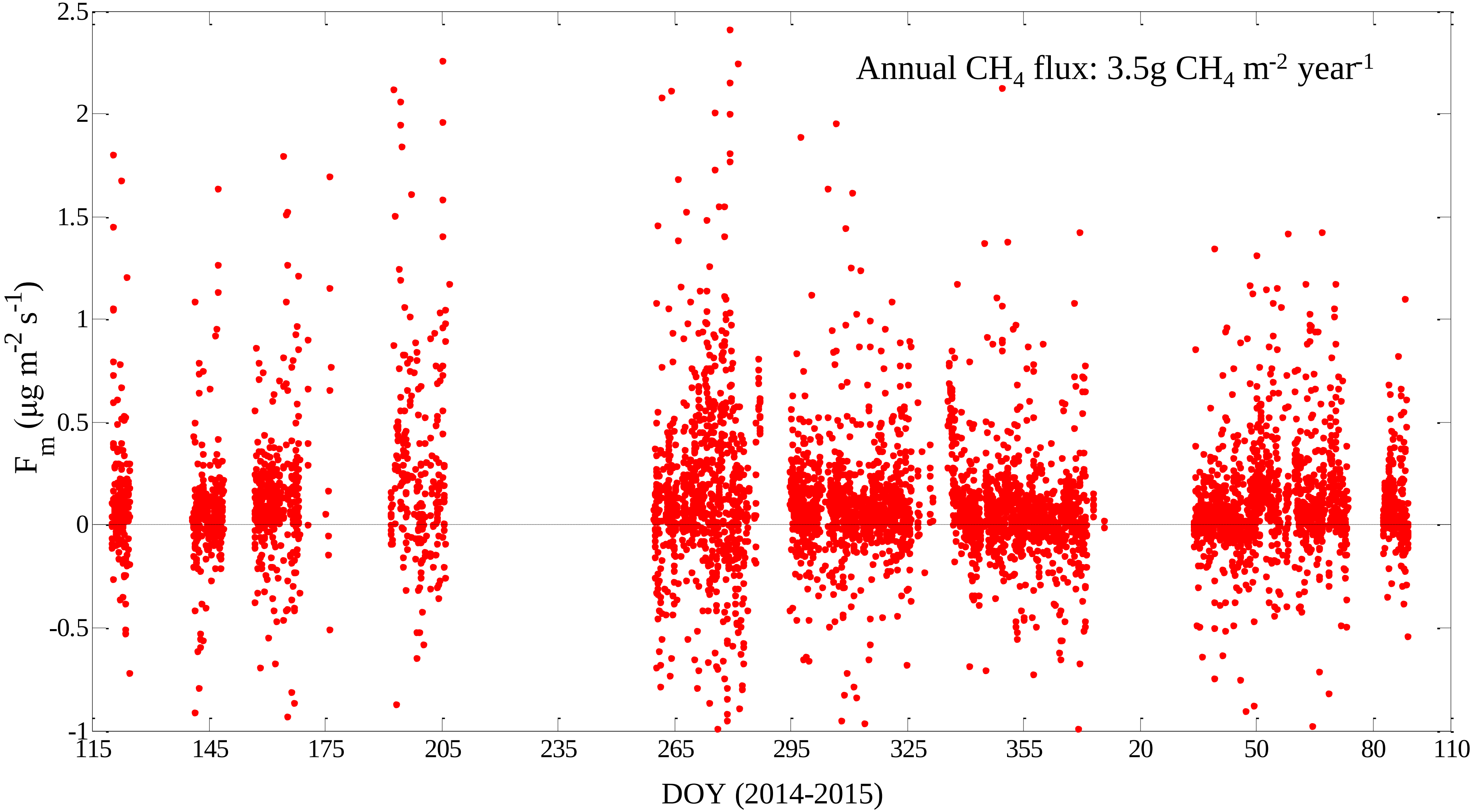


Fig.2 The temporal variation of CH_4 flux

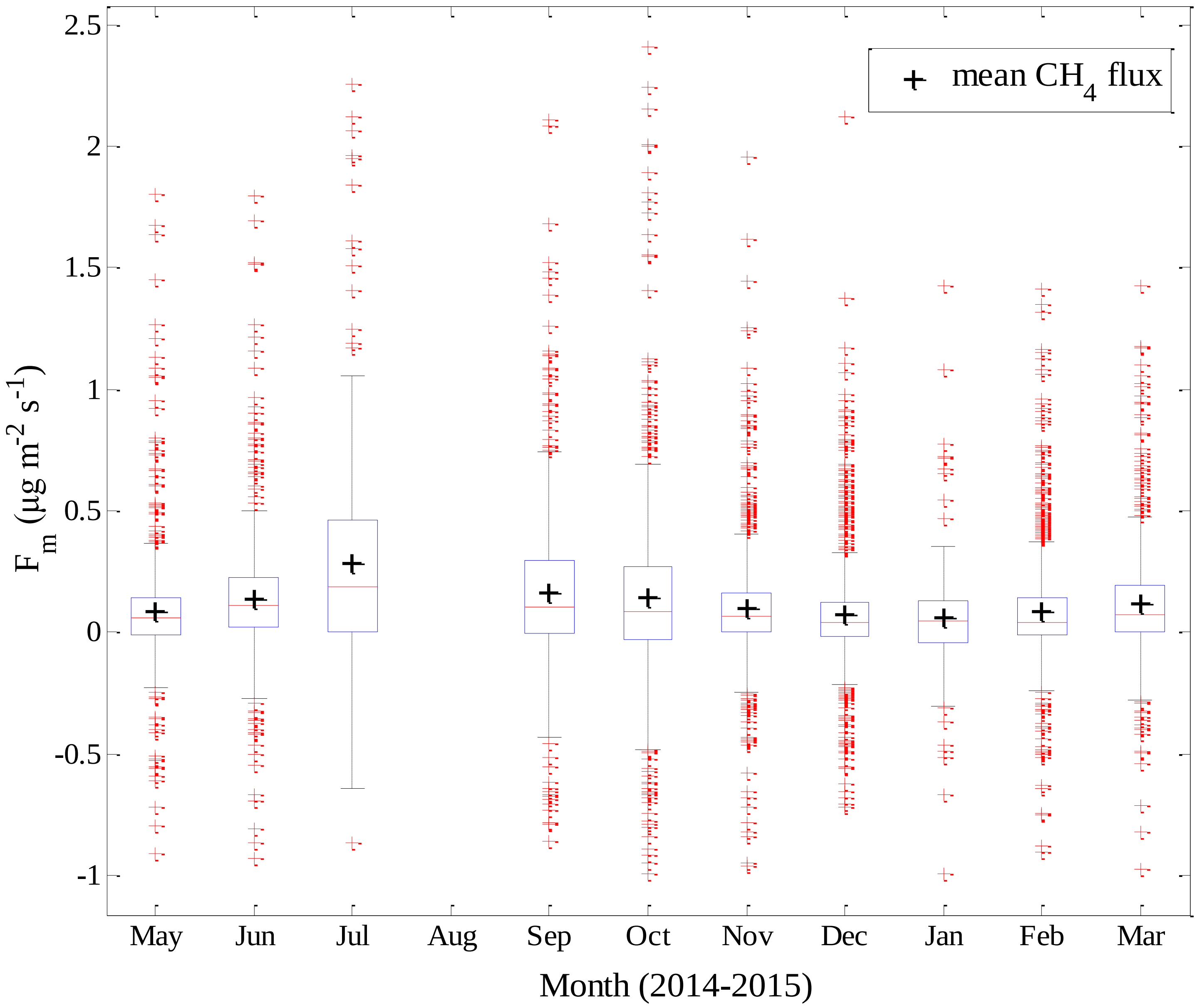


Fig.3 The seasonal variation of CH_4 flux

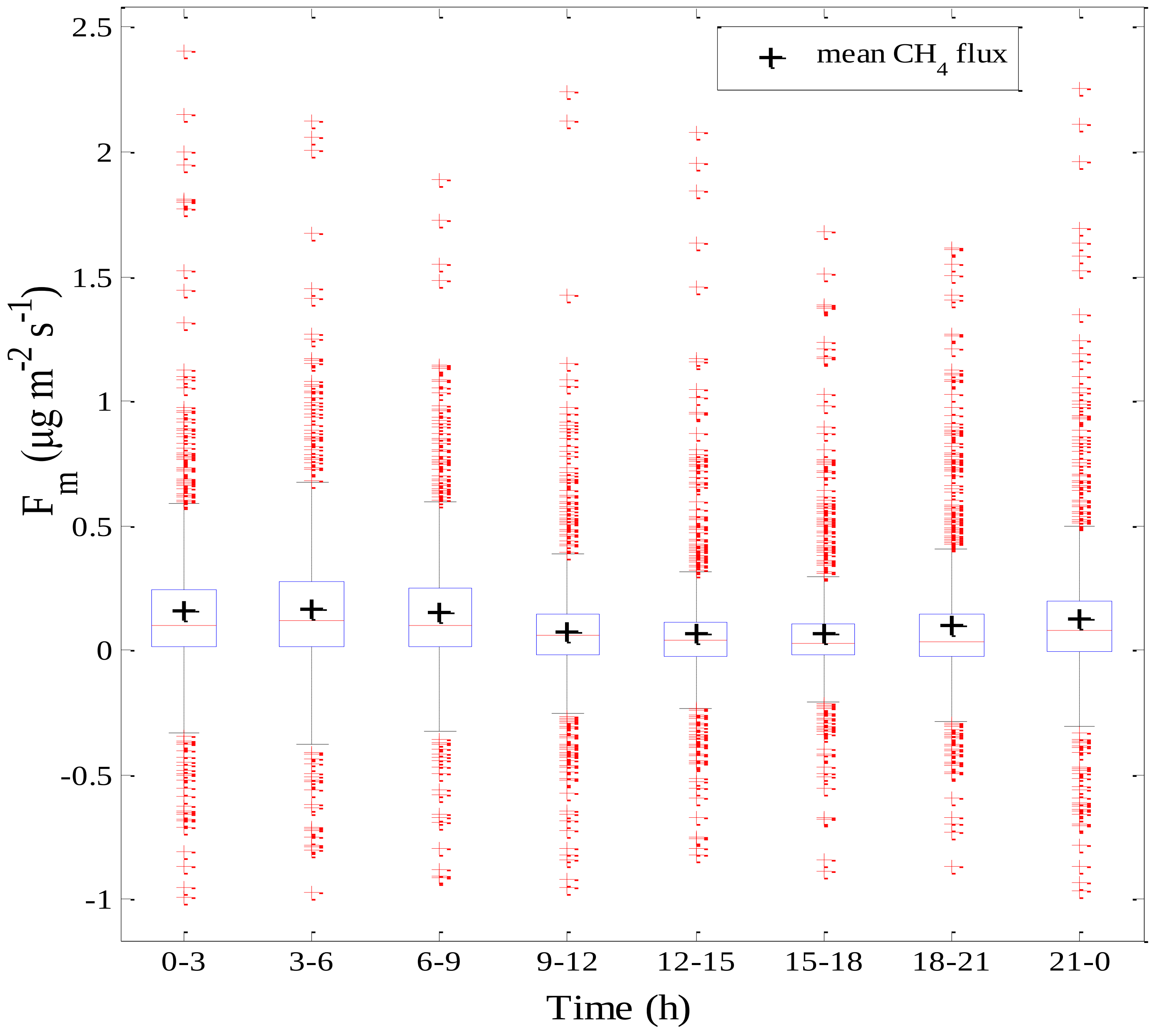


Fig.4 The diurnal cycle of CH_4 flux

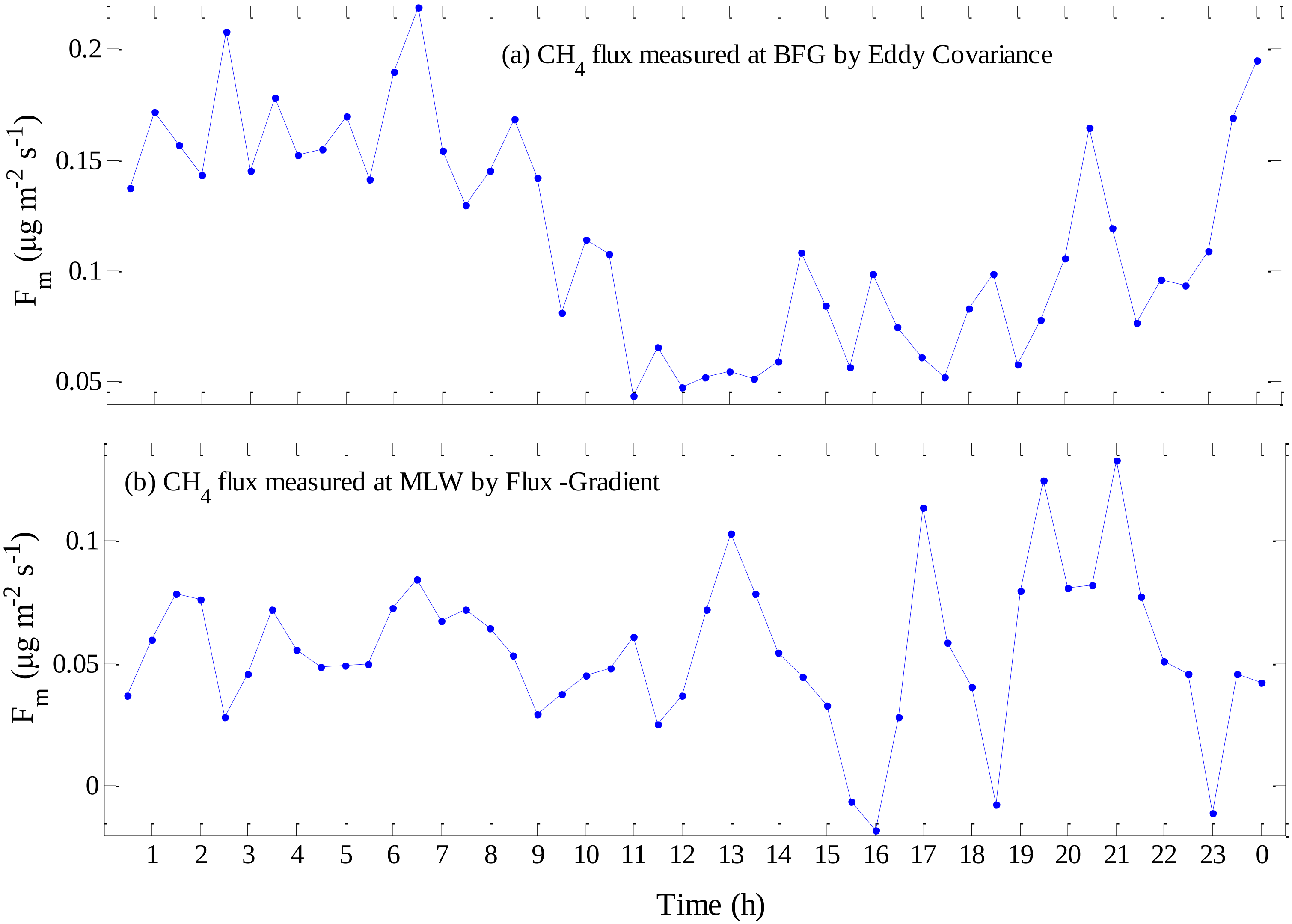


Fig.5 The diurnal variation of CH_4 flux at (a)BFG with amount of submerged vegetation and (b) MLW with no aquatic vegetation

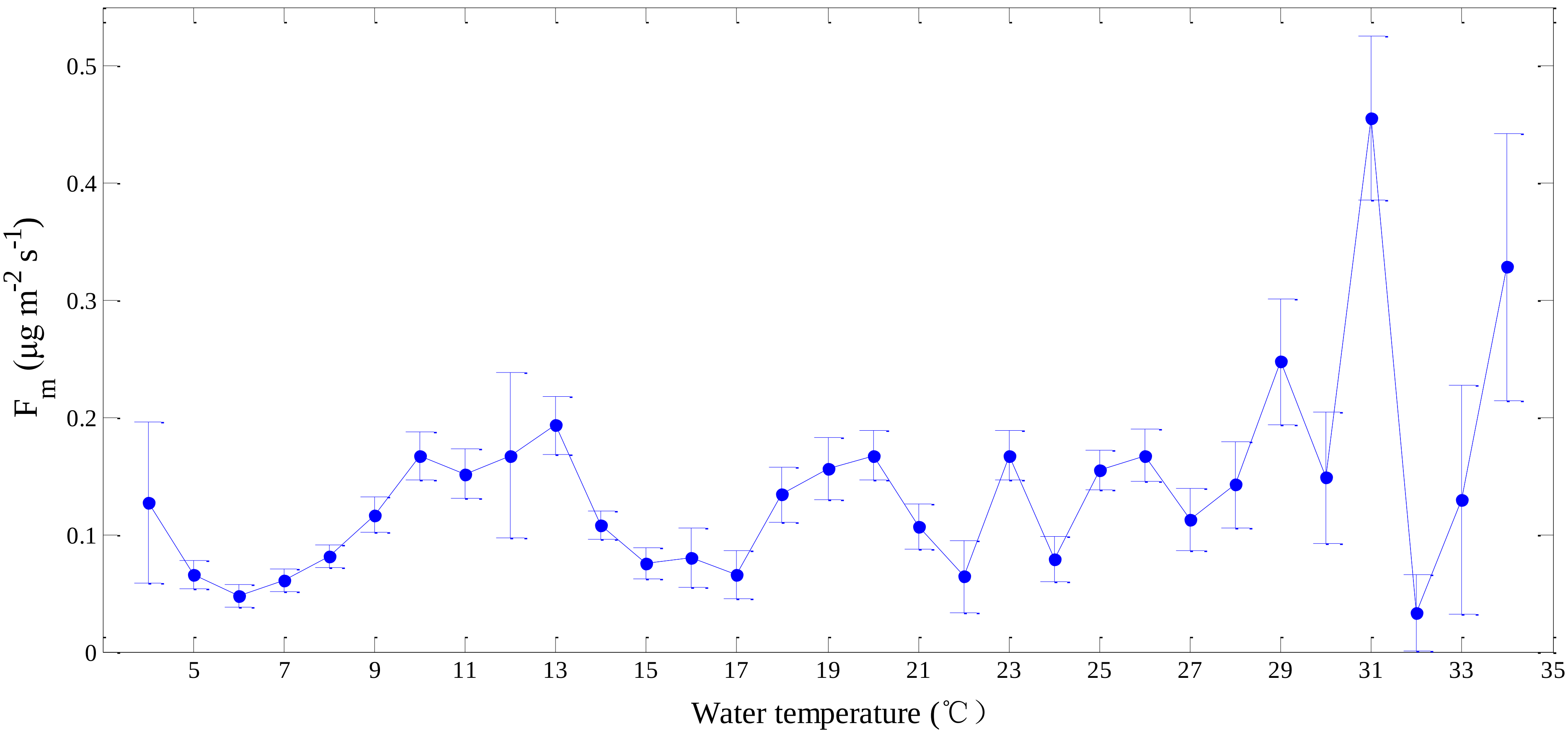


Fig.6 Relationship between CH_4 flux and water temperature

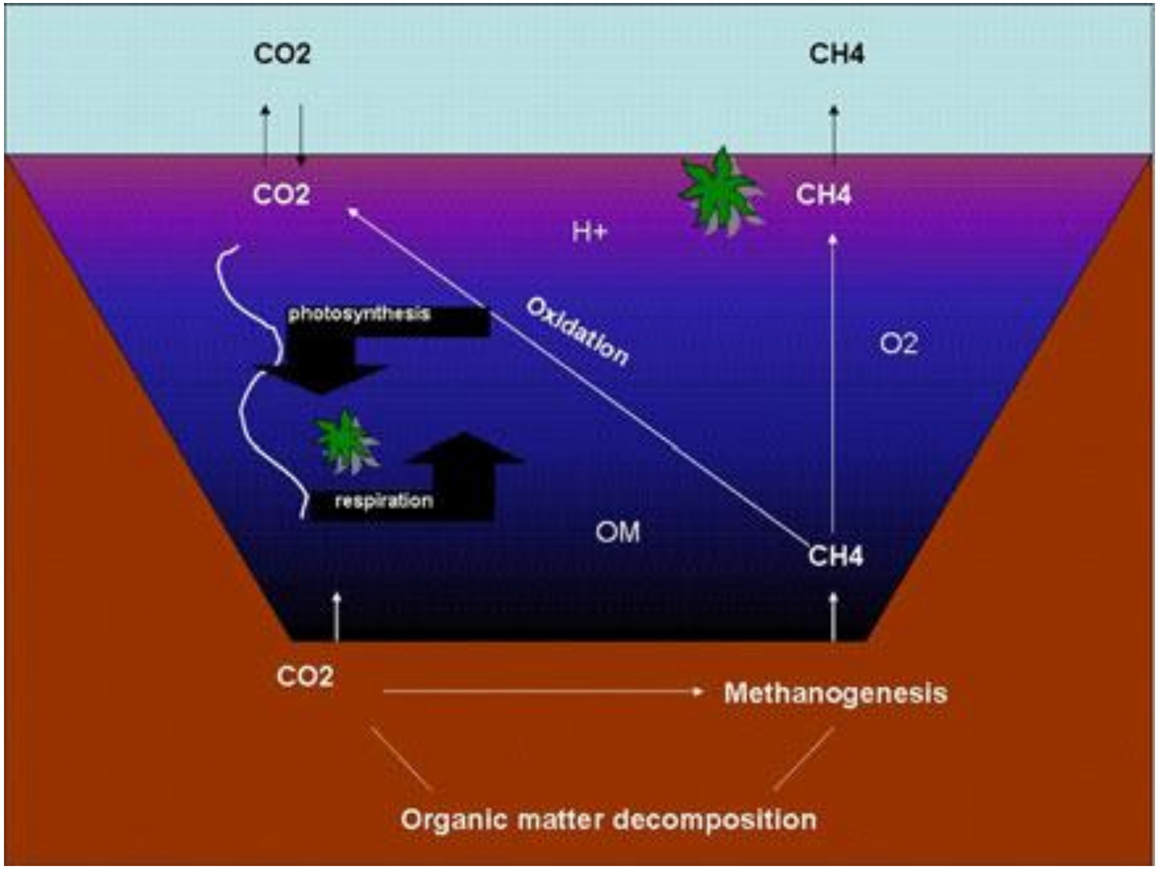
Table. The correlation coefficient (r) between CH_4 flux and environmental factor

	half- hour	**daily mean**
Dissolved Oxygen	-0.124*	-0.267
Chl-a	-0.182**	-0.21
Water Depth	-0.05**	-0.16*

*, ** Correlation is significant at the 0.05, and 0.01 level, respectively

3 The relationship between CH_4 flux and CO_2 flux at BFG

The negative relationship between CO_2 flux and CH_4 flux indicates that the greater the carbon uptake, the more methane is emitted; the positive correlation suggests that they are both the predominantly result of microbial metabolism, and they are affected by similar environmental drivers, such as temperature and availability of carbon (Morin et al, 2014).



Simplified illustration of CO_2 and CH_4 dynamics in water bodies (Schrier-Uijl et al ,2011)

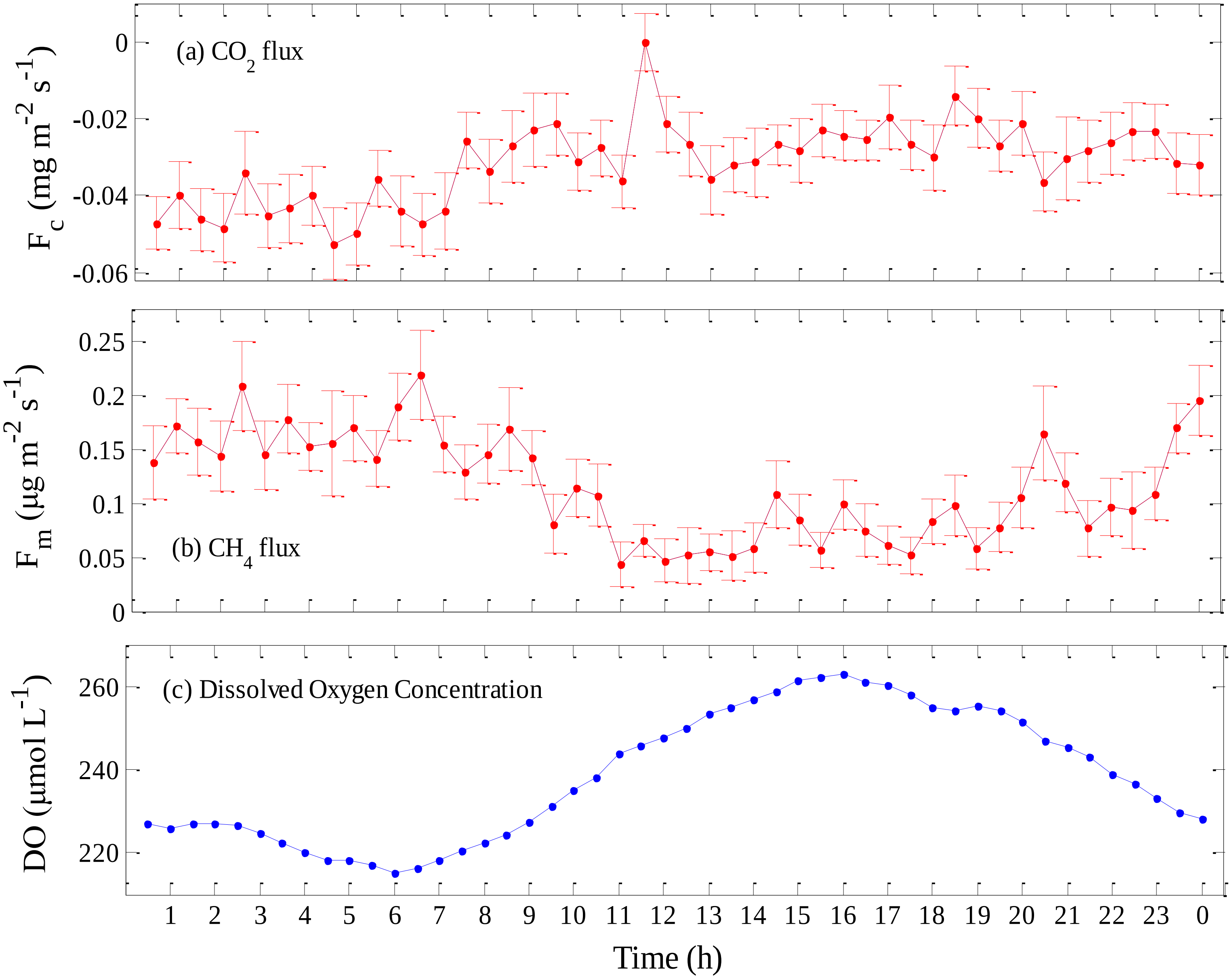


Fig.7 The diurnal variation comparison of (a) CO_2 flux, (b) CH_4 flux, (c) dissolved oxygen concentration at BFG

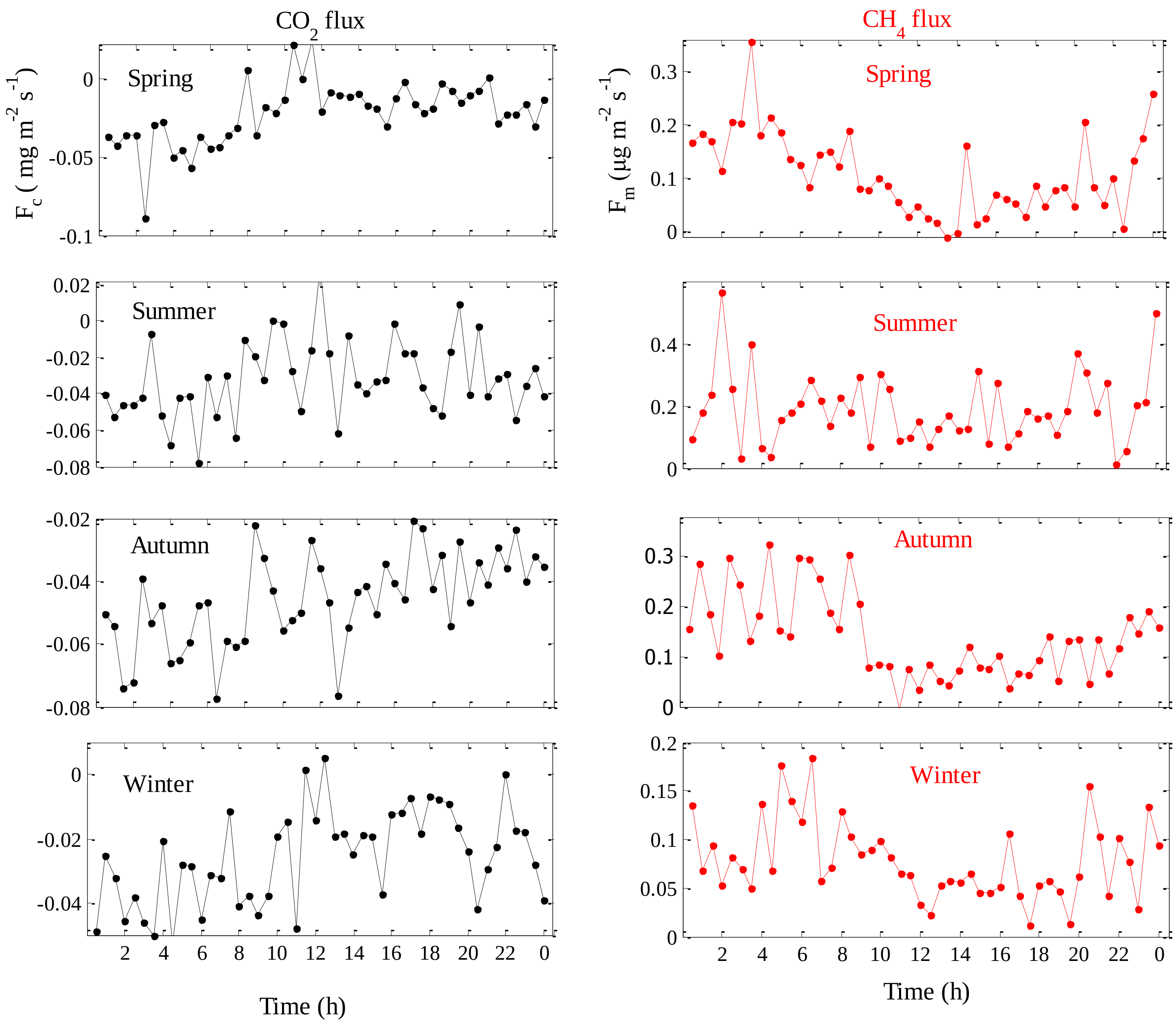


Fig.8 The diurnal variation of CO_2 flux and CH_4 flux at spring, summer, autumn, and winter

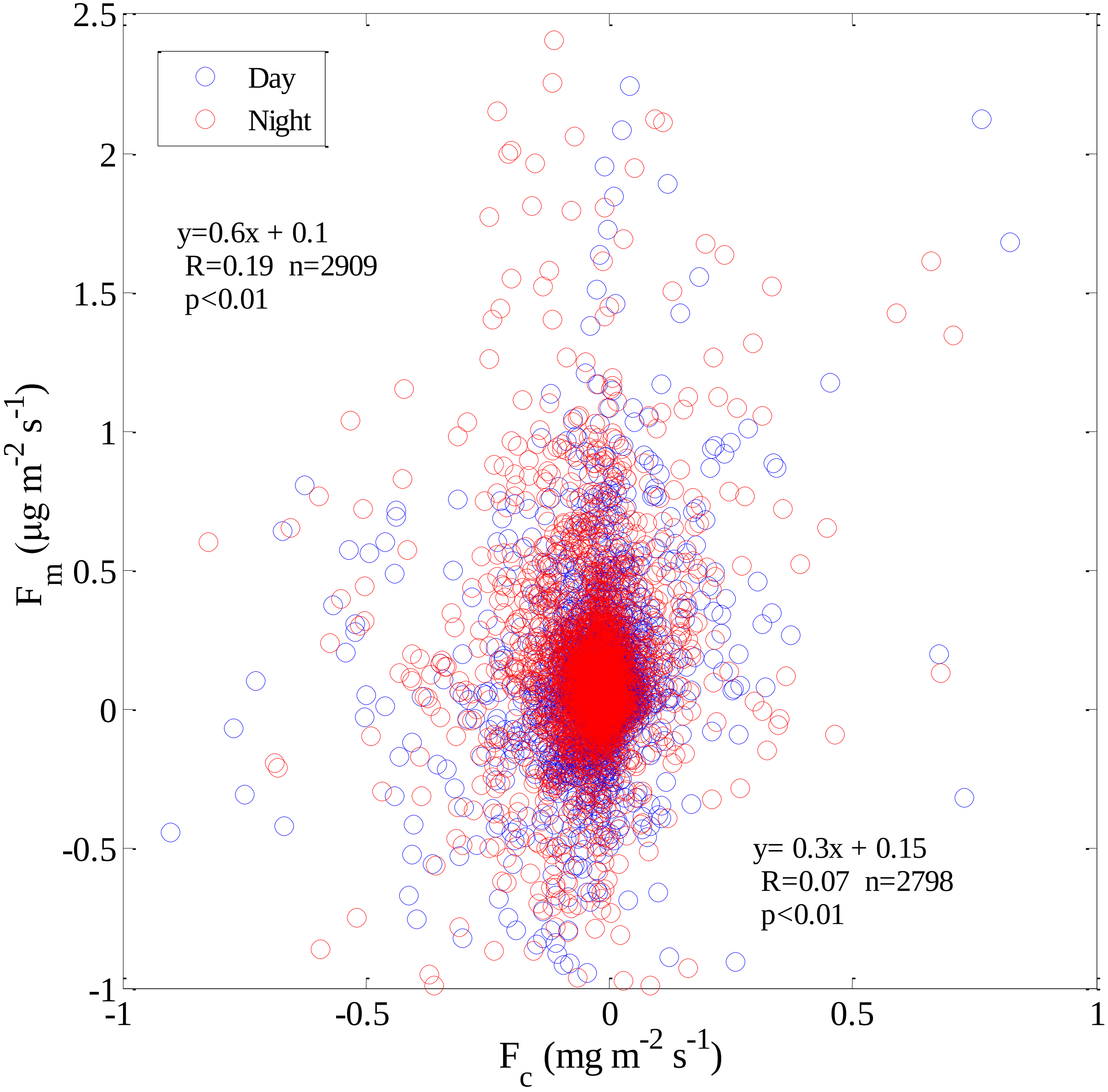


Fig.9 Relationship between CO_2 flux and CH_4 flux at the time scale of half-hour

Table2. The correlation coefficient (r) between CH_4 flux and CO_2 flux (Fc), latent heat flux (LE), and sensible flux (H)

		Fc	LE	H
Spring	day	0.416**	0.128*	0.172**
	night	0.248**	0.009	0.157**
Summer	day	0.366**	0.07	0.098
	night	-0.007	0.312**	0.198**
Autumn	day	0.118**	0.229**	0.078*
	night	0.025	0.128**	0.148**
Winter	day	0.181**	0.344**	0.25**
	night	0.123**	0.238**	0.309**

*, ** Correlation is significant at the 0.05, and 0.01 level, respectively

4 The correction factor of CH_4 flux measured by water equilibrium, flux-gradient, and eddy covariance

(1) Water equilibrium

$$F = k \times (C_w - C_e)$$

(2) Flux-gradient theory

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

(3) Eddy covariance

Schubert et al (2012) have a conclusion: water equilibrium estimates were 5-30 times lower at calculating CH_4 emission flux of aquatic system.

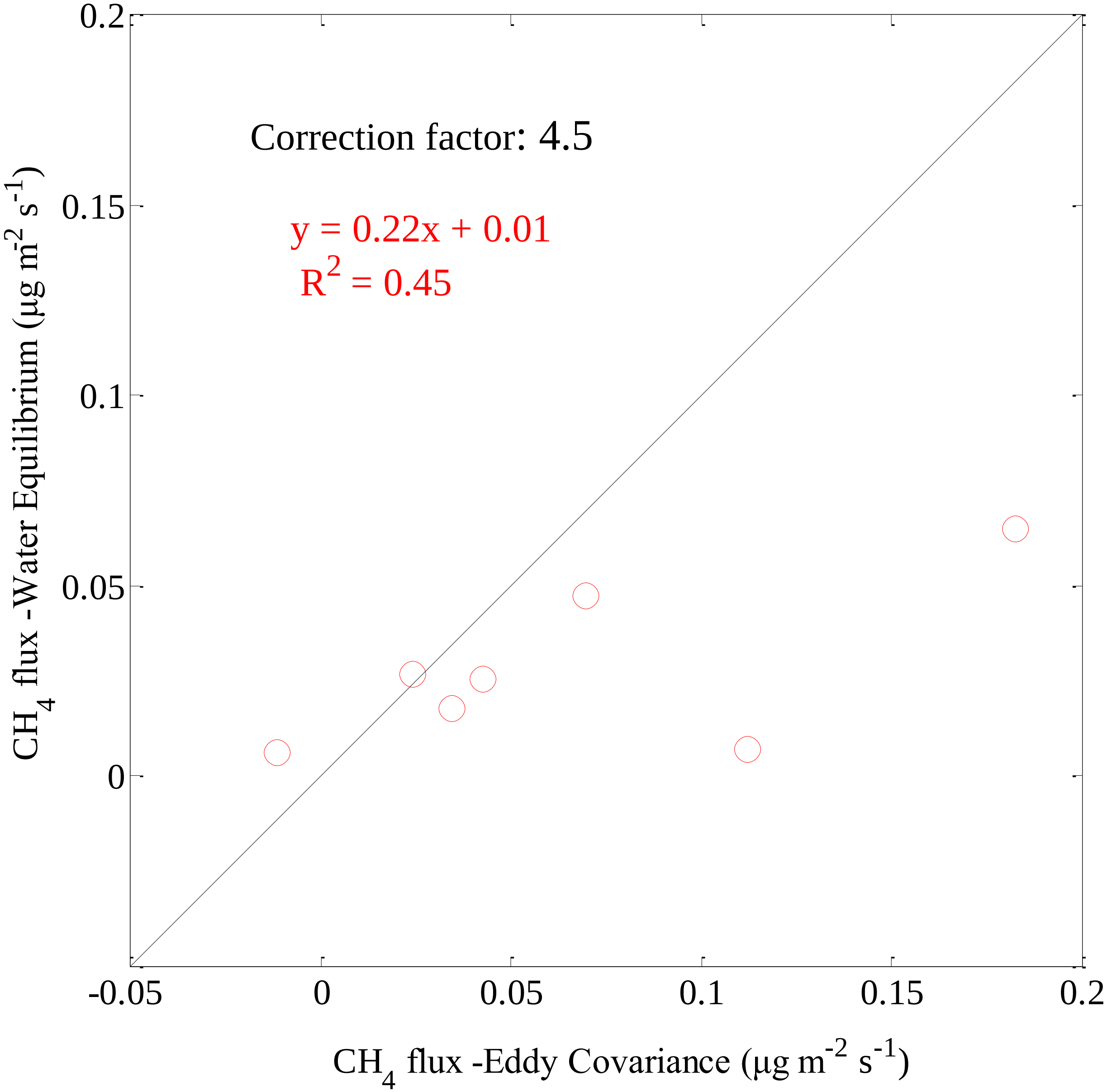


Fig.10 The correction factor of CH_4 flux between water equilibrium and eddy covariance

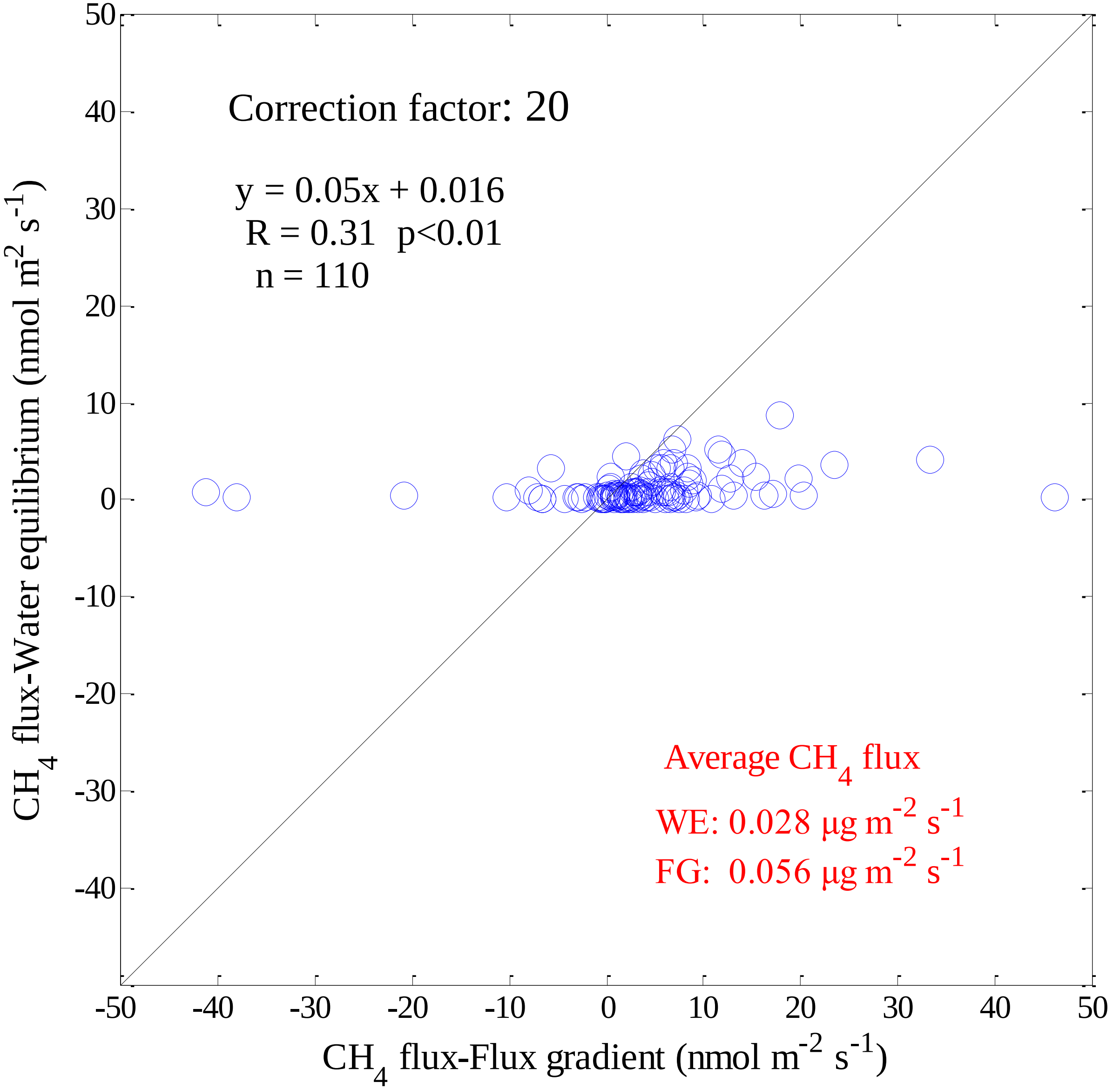


Fig.11 The correction factor of CH_4 flux between water equilibrium and flux-gradient

Table3. The correction factor of CH_4 flux between water equilibrium and flux-gradient at different environmental condition

Data Select		y (WE) = ax(FG) + b	Correction factor
Water temperature (Tw_℃)	≥10	y=0.08x+0.02 r=0.4 p<0.01 n=42	12.5
	≥ 20	y=0.112x+0.006 r=0.44 p<0.01 n=38	8.9
	< 10	y=0.006x+0.005 r=0.163 p>0.05 n=42	-
Wind speed (WS_m s^{-1})	≥ 3.7	y=0.075x+0.013 r=0.303 p>0.05 n=26	13.3
	<3.7	y=0.046x+0.016 r=0.316 p<0.01 n=84	21.7
	≥6	y=-0.03x+0.02 r=0.08 p>0.05 n=11	-
Tw ≥ 10℃ WS ≥3.7 m s^{-1}		y=0.04x+0.03 r=0.124 p>0.05 n=14	25
3.7 m s^{-1} ≤ WS ≤ 6 m s^{-1}		y=0.102x +0.01 r=0.493 p=0.062 n=16	9.8

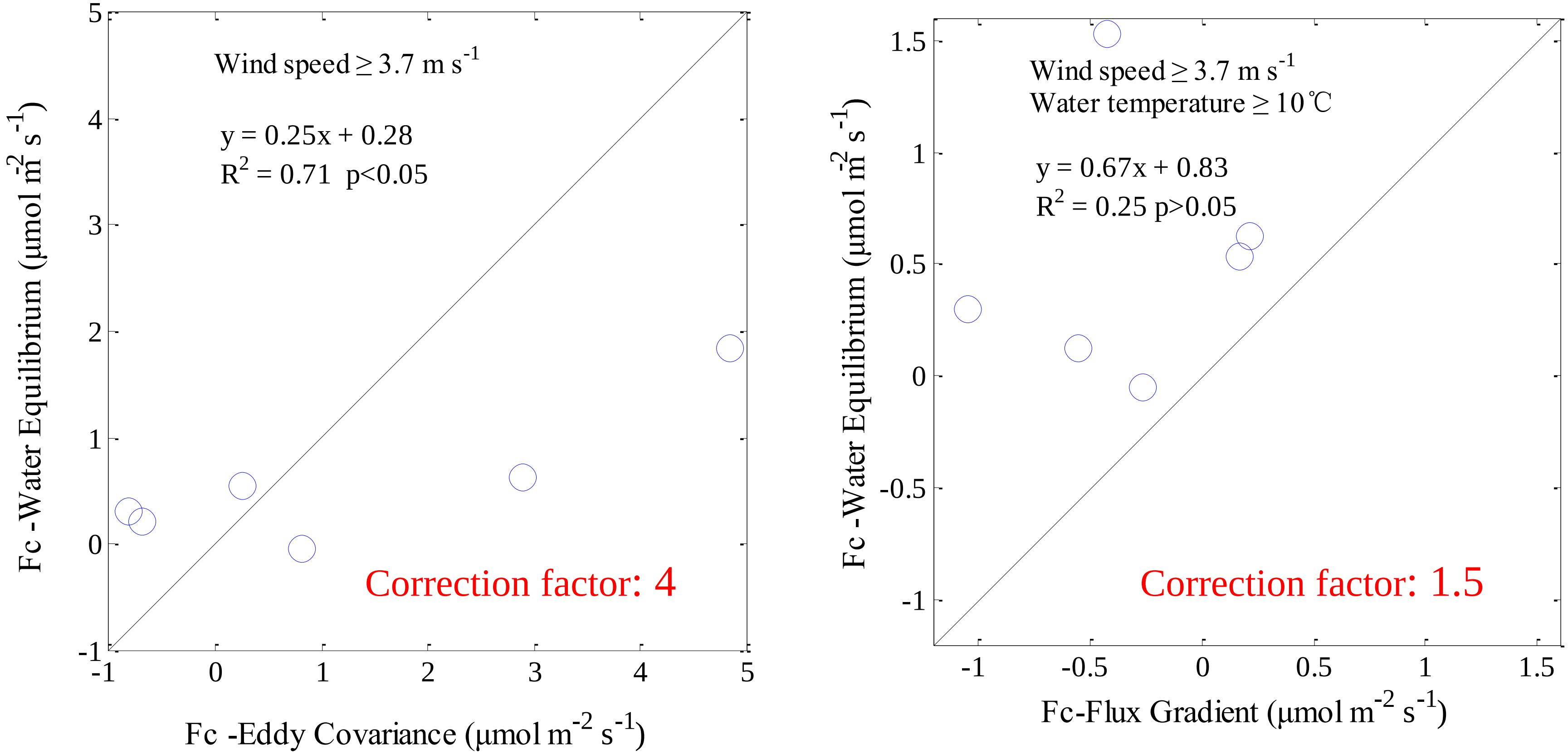


Fig.12 The validate of bubble effect on correction factor of CH_4 flux by comparing the CO_2 flux

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