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Temporal and Spatial Variations of Methane Emission in a Large and Shallow Eutrophic Lake in Subtropical Climate

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Outlines

- Introduction
- Objective
- Materials and Methods
- Results and Discussion
- Conclusions

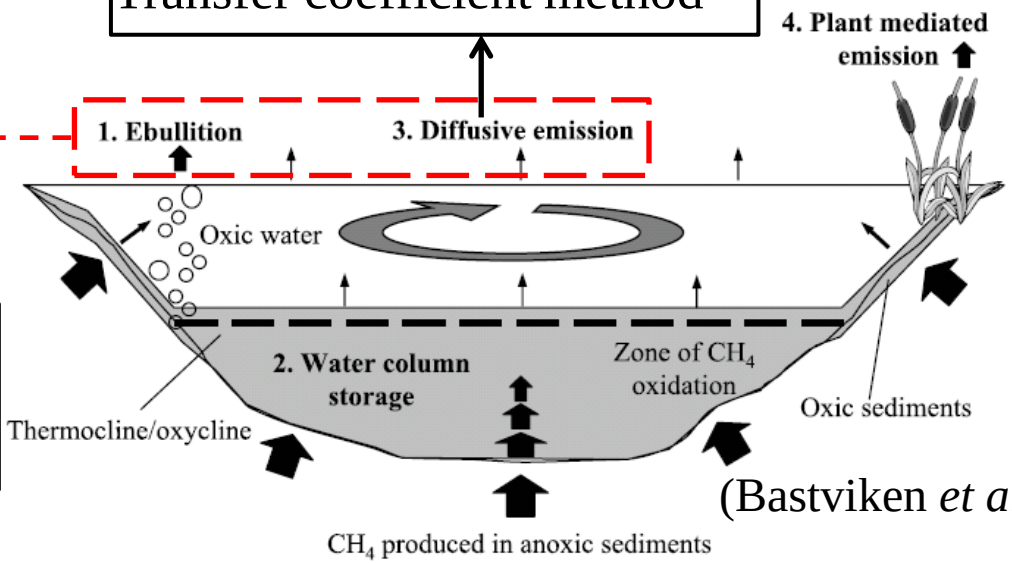
Introduction

- Shallow lakes with algal bloom or vegetation growth are an importance source of atmospheric CH_4.
- Lake Taihu, a large (area 2400 km^2) and shallow (mean depth 1.9 m) subtropical freshwater lake in eastern China, exhibits high spatial heterogeneity in terms of pollution level, macrophyte vegetation abundance and algal growth.

Transfer coefficient method

Eddy covariance method

Flux-gradient method



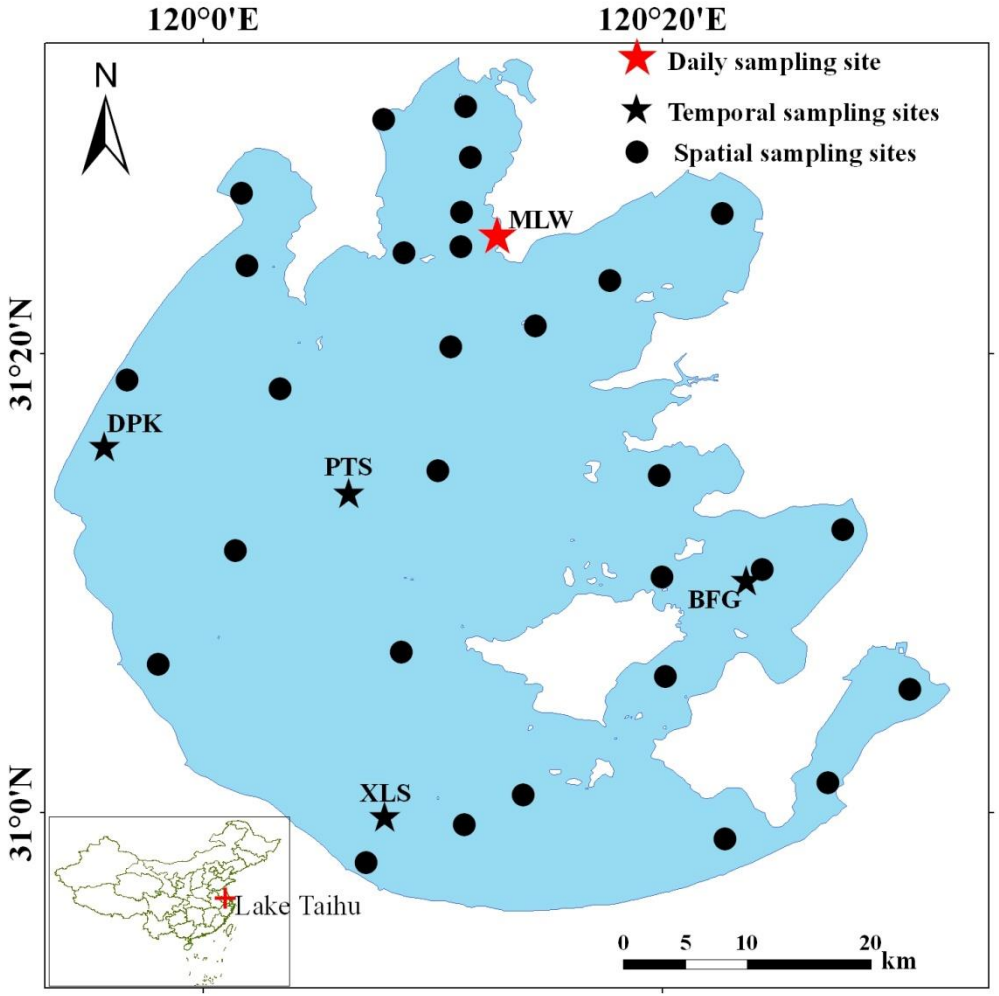
(Bastviken *et al.*, 2004)

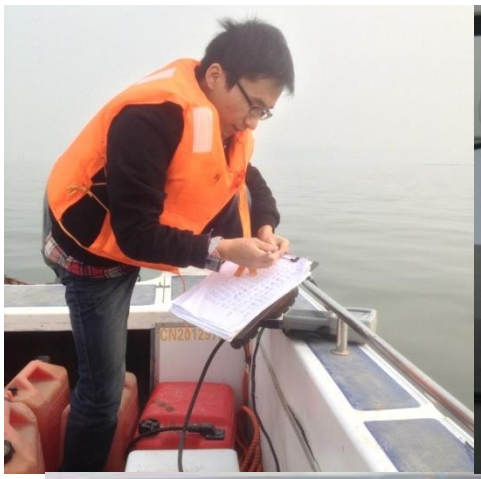
Objectives

- Characterizing temporal and spatial variability of the CH_4 flux in the lake;
- Investigating the biological, chemical and physical controls of the observed variabilities;
- Quantifying the roles of submerged vegetation and algal growth in the lake-air methane exchange;
- Determining the relative contributions of diffusion and ebullition to the total flux.

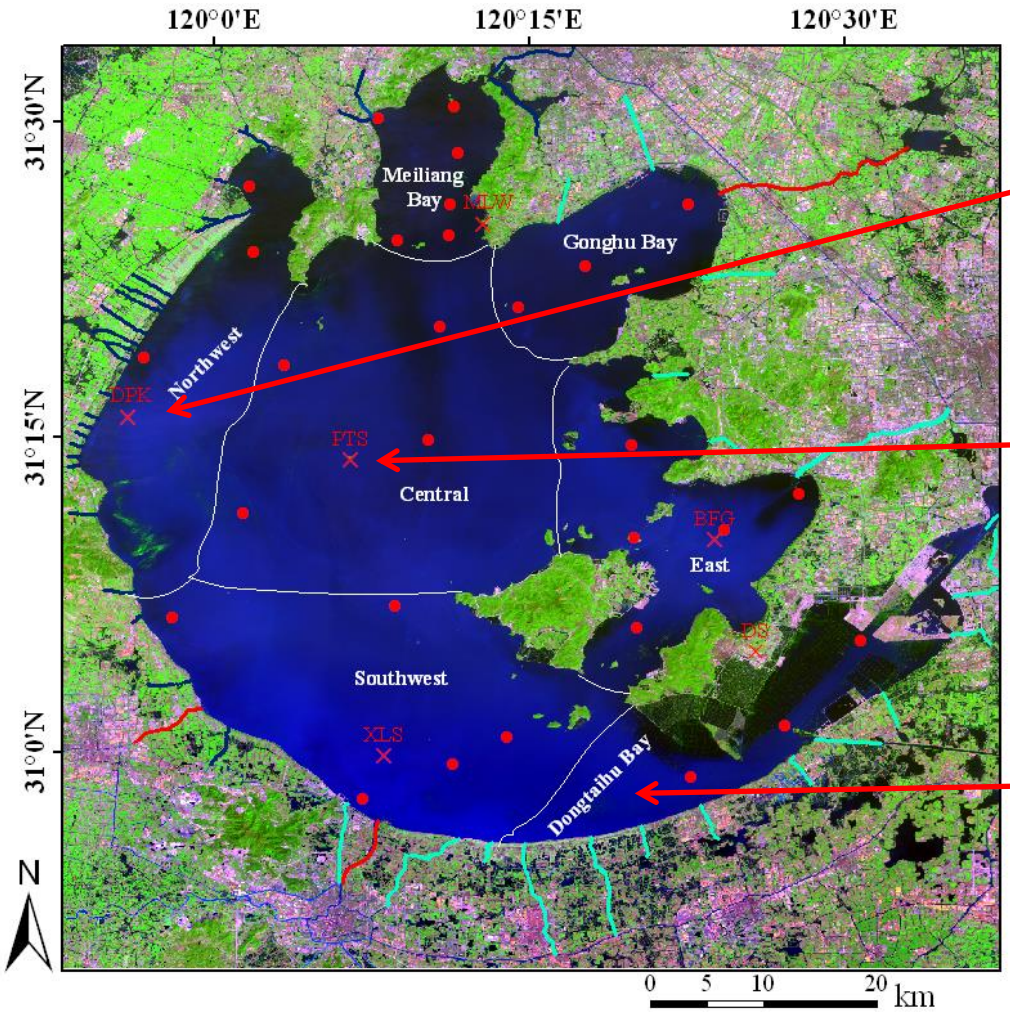
Materials and Methods

The CH_4 diffusion flux at the sampling sites was determined with the transfer coefficient method: $F_{m,d} = k \times (C_w - C_e)$





Seven biological zones



Eutrophic

Low photosynthetic activity

Submerged macrophyte

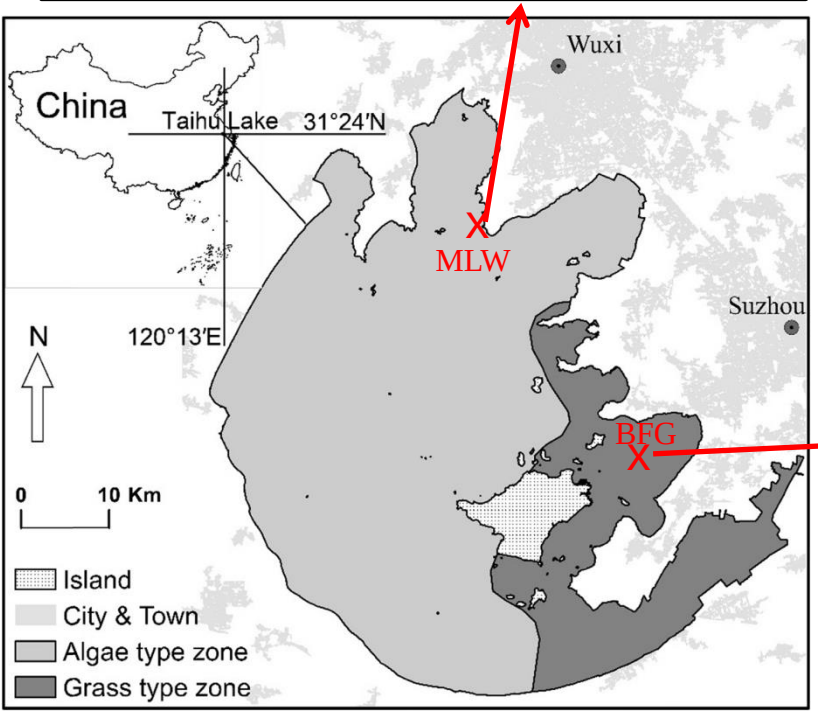
The measurement of total CH_4 flux ($F_{m,}$ diffusion plus ebullition)

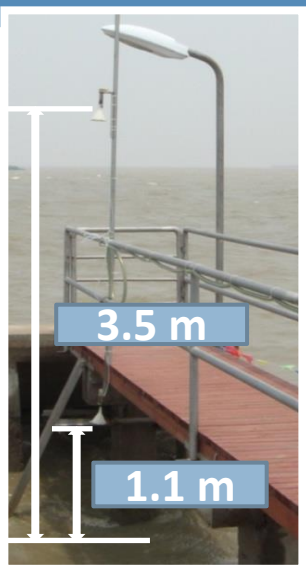
Flux-gradient method determines the total CH_4 flux (F_m) at MLW site

$$F_m = -0.55\,\rho_a\,K\,\frac{r_2 - r_1}{z_2 - z_1}$$

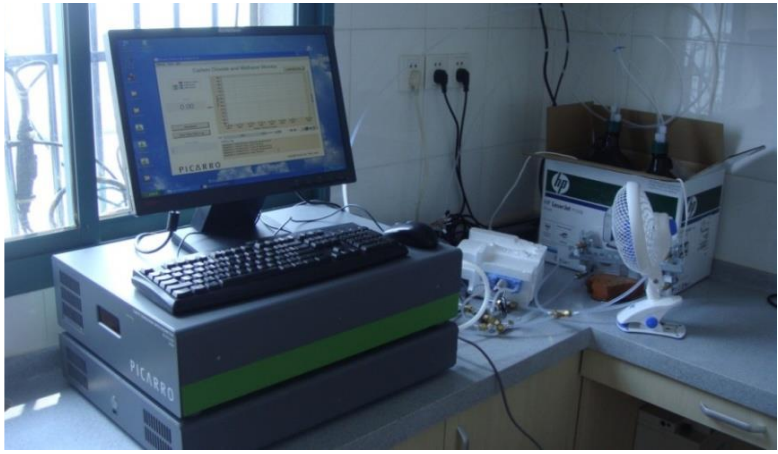
r_2-r_1: vertical concentration gradient

K: eddy diffusivity





Flux-gradient CH_4 flux system



Eddy CH_4 flux tower

Xiao *et al.*, 2014; Luo *et al.*, 2016

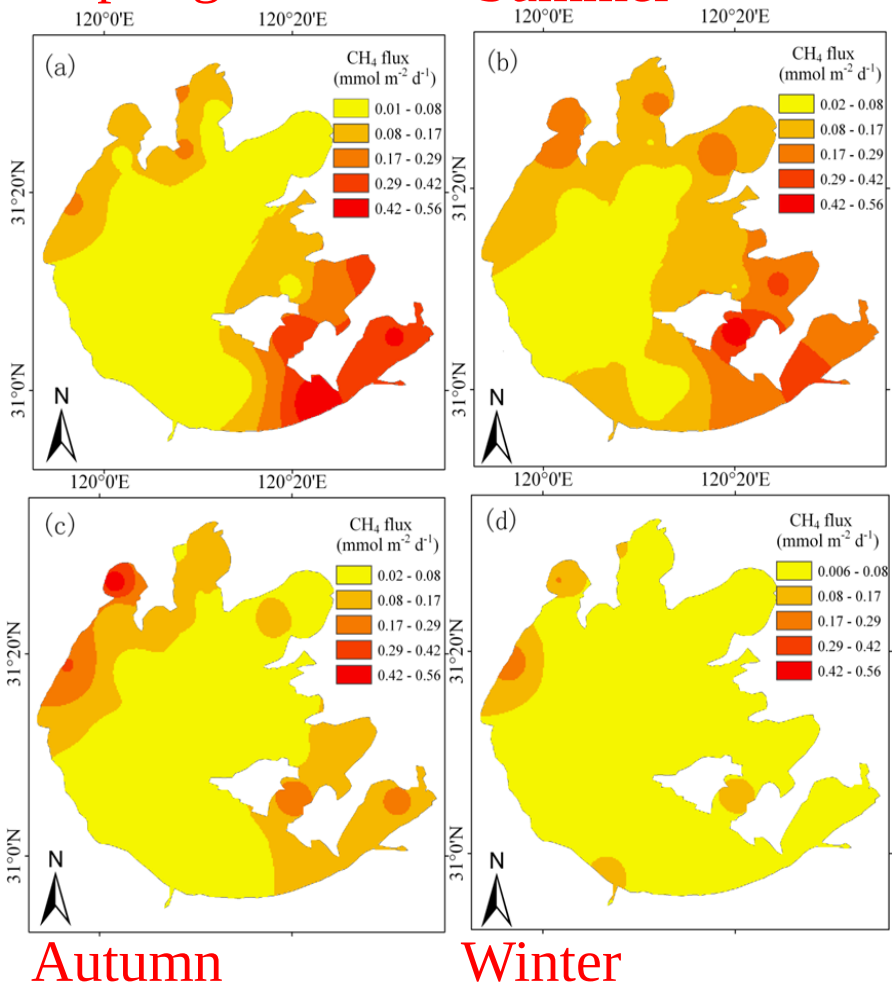
Results and Discussion

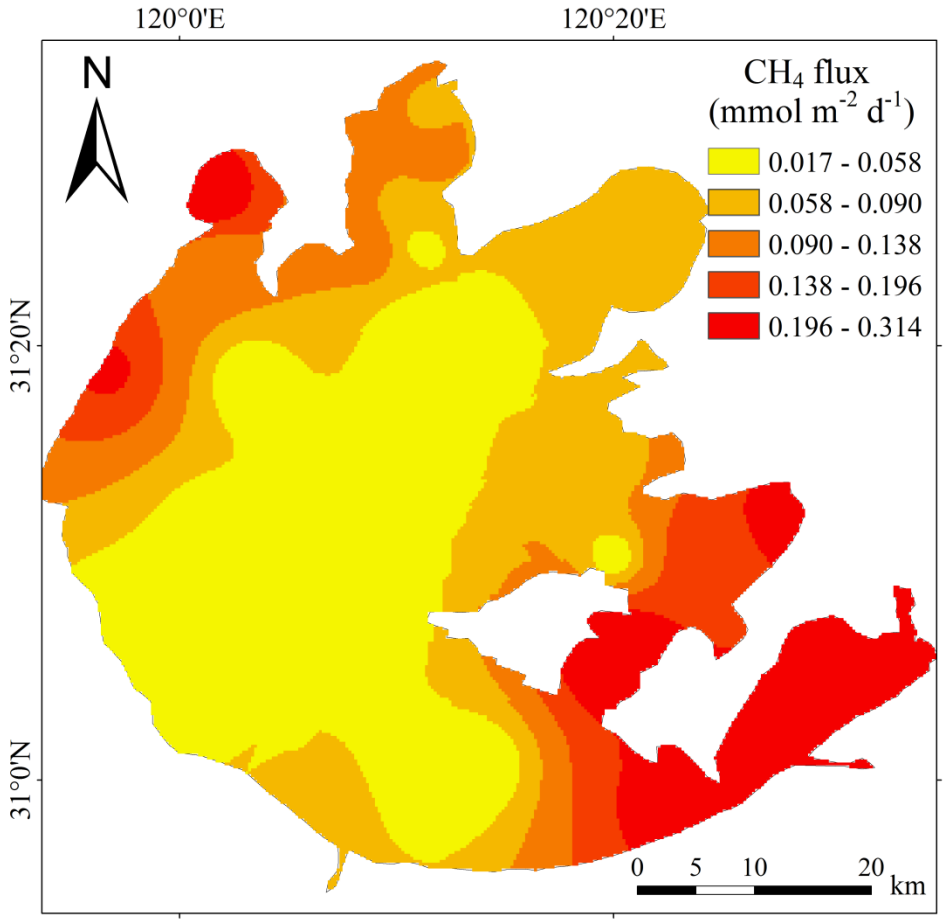
Spatial variations of CH_4 diffusion flux

Spring

Summer

Annual mean CH_4 diffusion flux





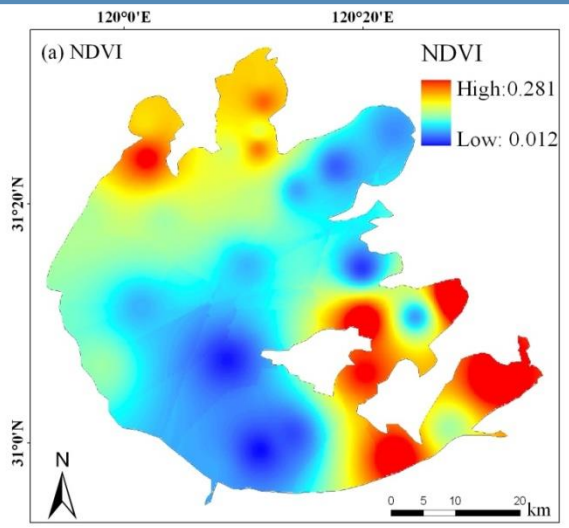
Autumn

Winter

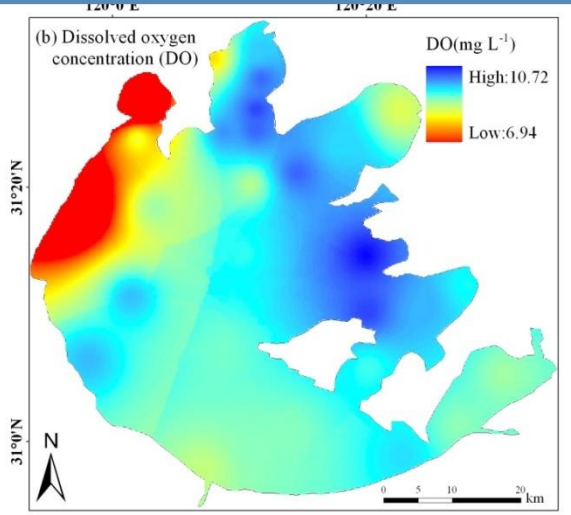
The annual mean CH_4 diffusion flux of whole lake was 0.094 mmol m^{-2} d^{-1}.

Spatial variations of environment factors

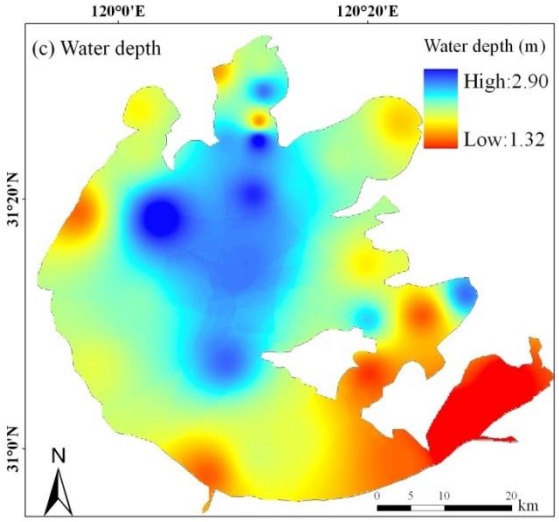
NDVI



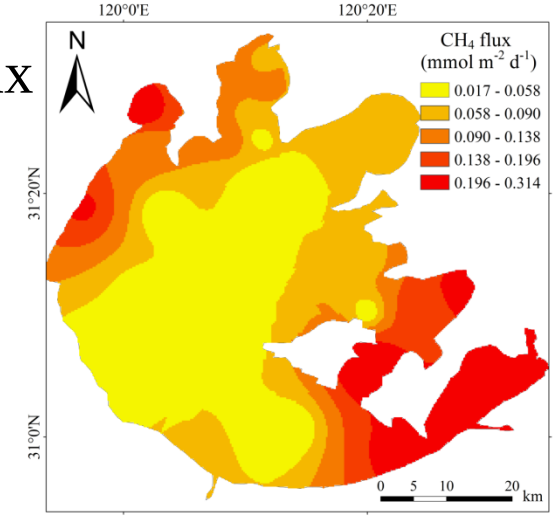
DO



Water depth

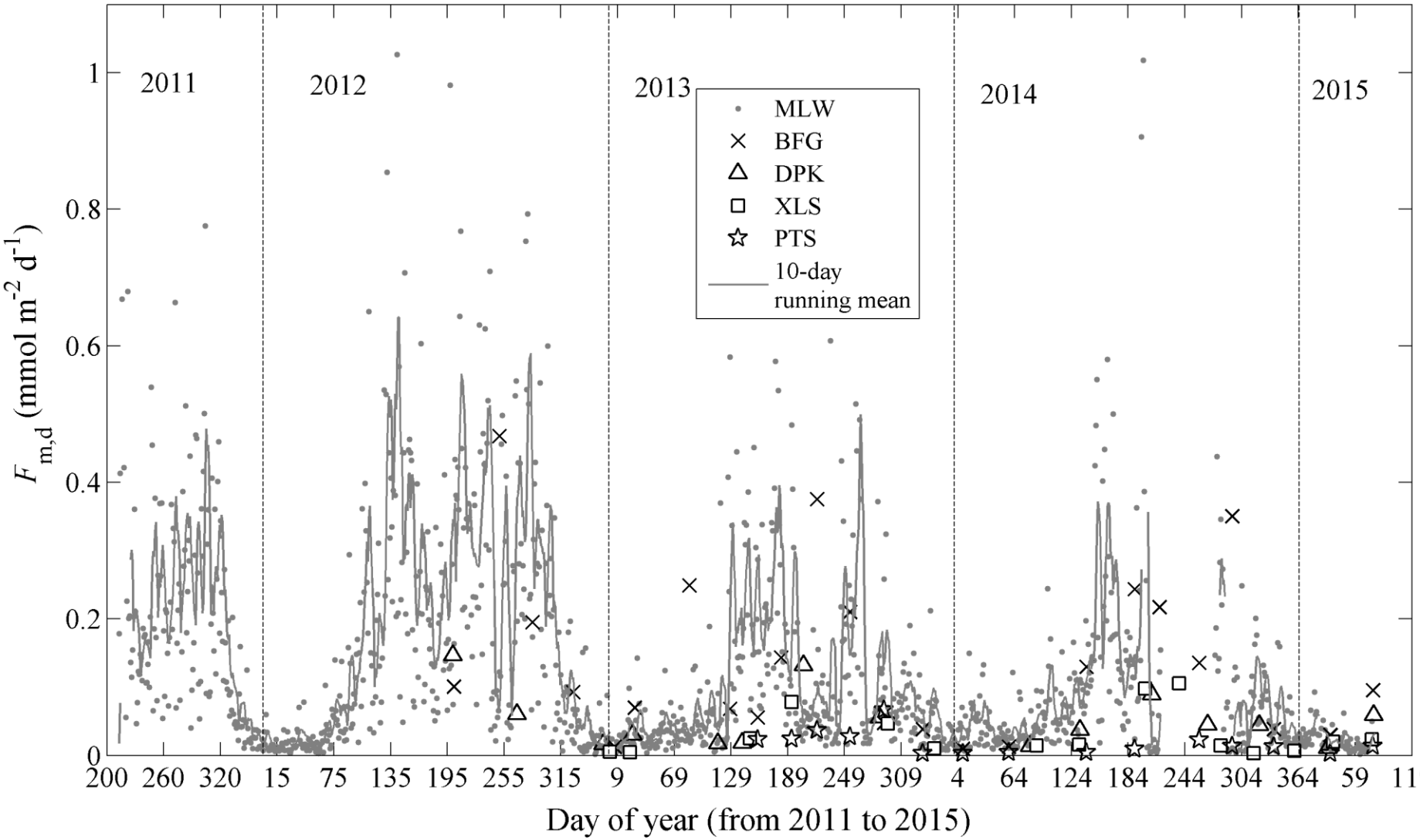


CH_4 flux



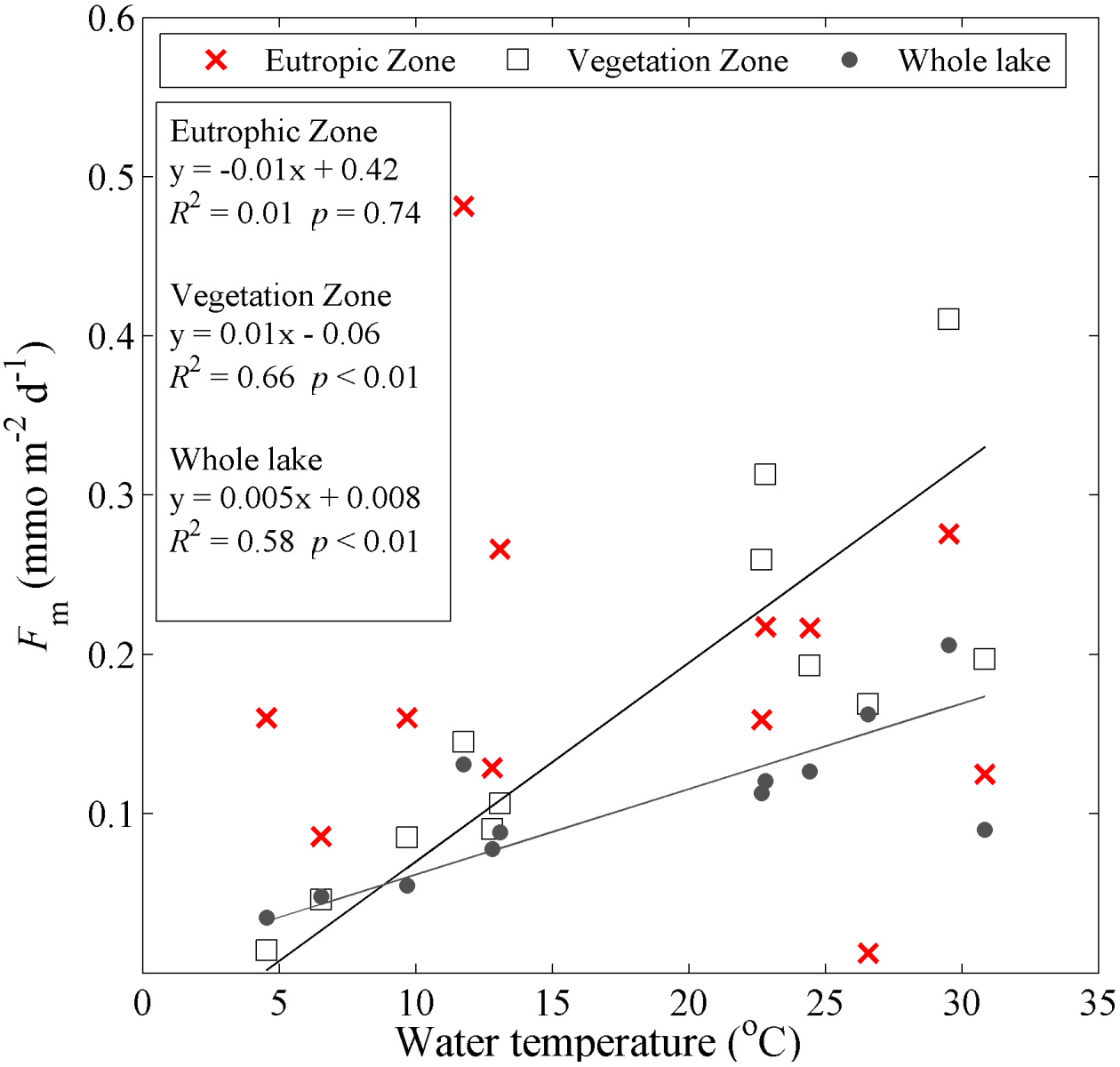
NDVI, dissolved oxygen concentration (DO), and depth explained 78% of the observed spatial variability in the methane flux ($p < 0.01$).

Temporal variations of CH_4 diffusion flux

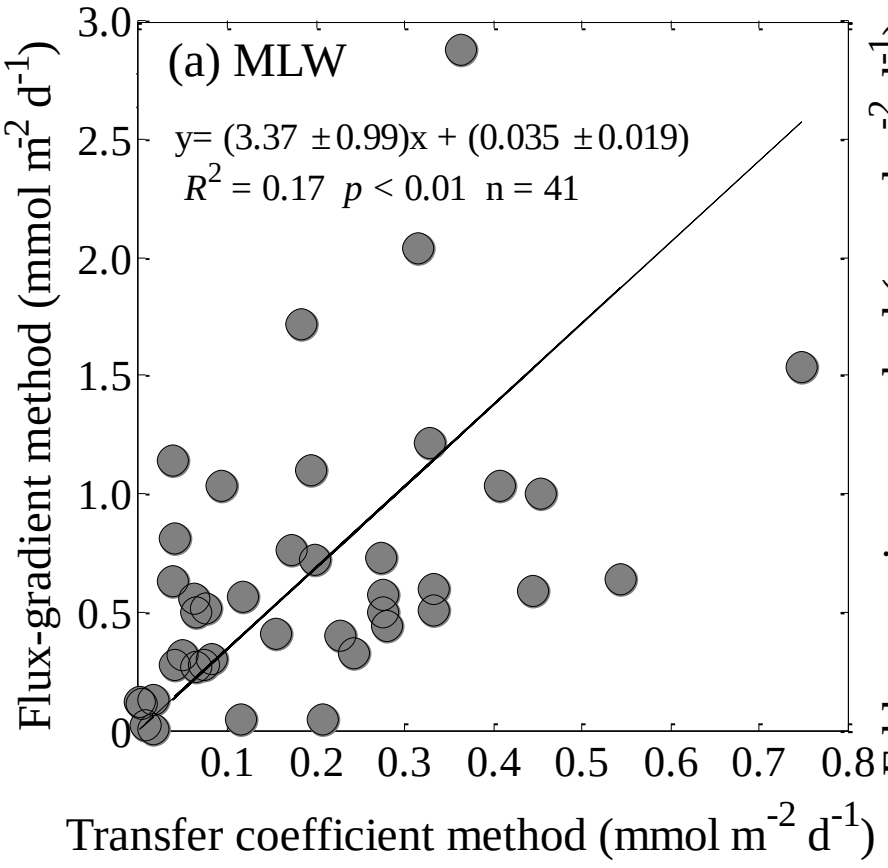


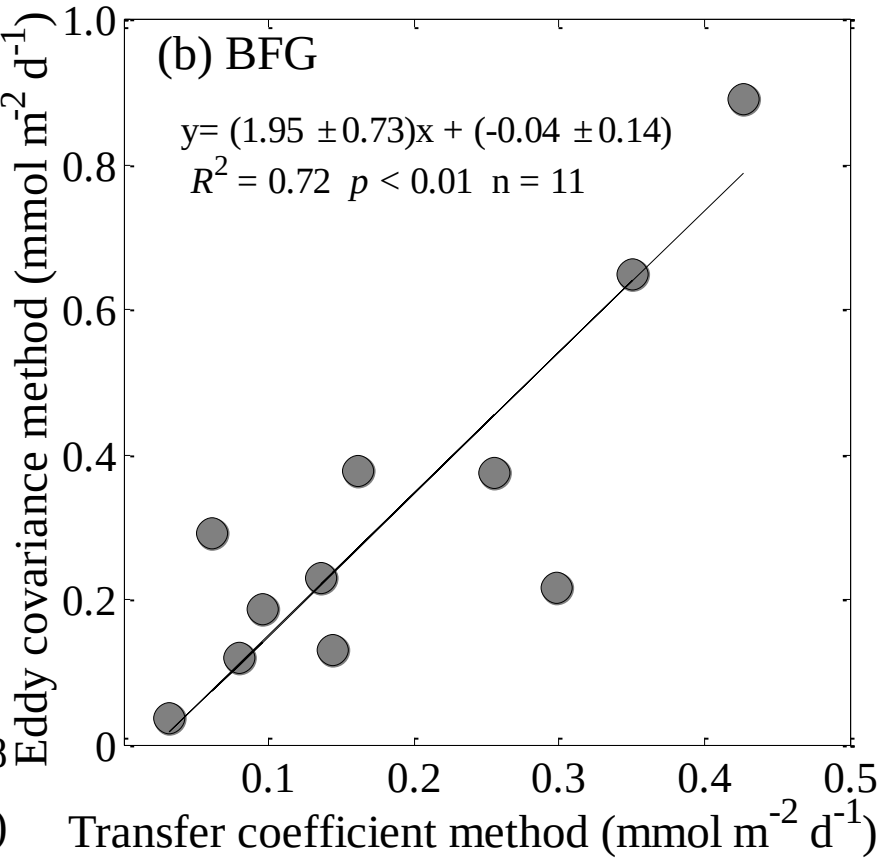
At all sampling sites, the highest CH_4 flux appeared in summer, and the lowest appeared in winter.

Control factor on CH_4 flux temporal variations



Total CH_4 flux versus diffusion flux





	CH_4 flux (mmol m^{-2} d^{-1})			Ebullition
	Total	Diffusion	Ebullition	percentage
MLW: open water zone	0.707	0.120	0.507	72%
BFG: macrophyte zone	0.319	0.184	0.135	41%

CH_4 flux in the seven zones of Lake Taihu

Zones	Surface area (km^2)	CH_4 flux (mmol m^{-2} d^{-1})		
		Total flux	Diffusion flux	Ebullition flux
Meiliang Bay	100	0.306	0.085	0.224
Gonghu Bay	215.6	0.216	0.064	0.156
East Zone	316.4	0.265	0.177	0.109
Dongtaihu Bay	131	0.405	0.227	0.167
Southwest Zone	443.2	0.144	0.039	0.104
Northwest Zone	394.1	0.688	0.191	0.497
Central Zone	737.5	0.277	0.026	0.200
Whole lake	2338	0.269	0.094	0.175

Macrohytes

Eutrophic

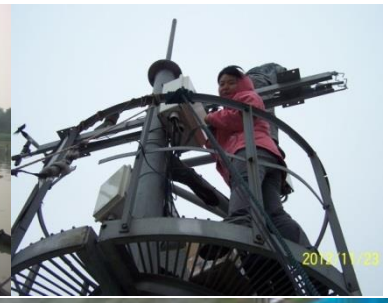
The CH_4 flux of the lake (0.269 mmol m^{-2} d^{-1}, or 1.57 g m^{-2} $year^{-1}$) was similar to the medium value (1.6 g CH_4 m^{-2} $year^{-1}$) in inland waters (Bastviken *et al.*, 2011; Ortiz-Llorente *et al.*,2012).

Conclusions

- The seasonal pattern of the CH_4 flux was mostly regulated by water temperature.
- The spatial variations of the CH_4 emission resulted mostly from uneven growth of algae and from spatial variability in aquatic vegetation.
- The annual mean lake CH_4 emission flux after correction for the ebullition contribution (1.57 g CH_4 m^{-2} $year^{-1}$) was comparable to the mean flux of global lakes.





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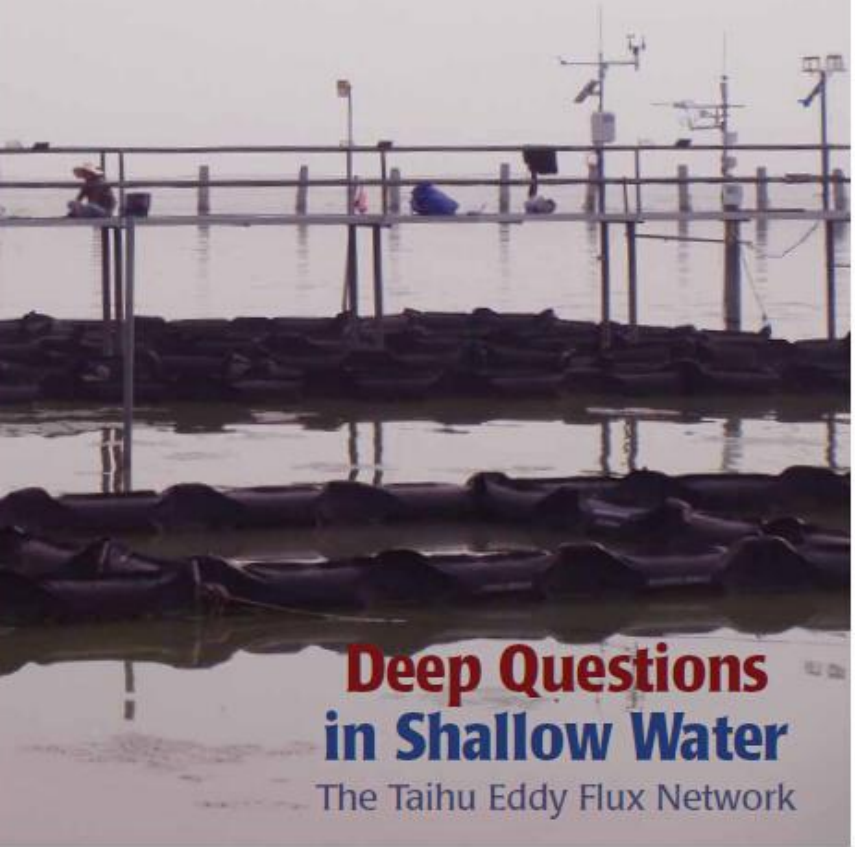
MOORE EF5 TORNADO ANALYZED

FIELD WORK FOR UNDERGRADUATES

LAND-CHANGE EFFECTS ON CLIMATE



Deep Questions in Shallow Water

The Taihu Eddy Flux Network

Thank you for your attention !