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Yale-NUIST Center on Atmospheric Environment

A discussion on the paper “Fluxes of methane and carbon dioxide from a small productive lake to the atmosphere”

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Outline

- Background
- Objective
- Materials & Methods
- Results & Discussion
- Conclusion

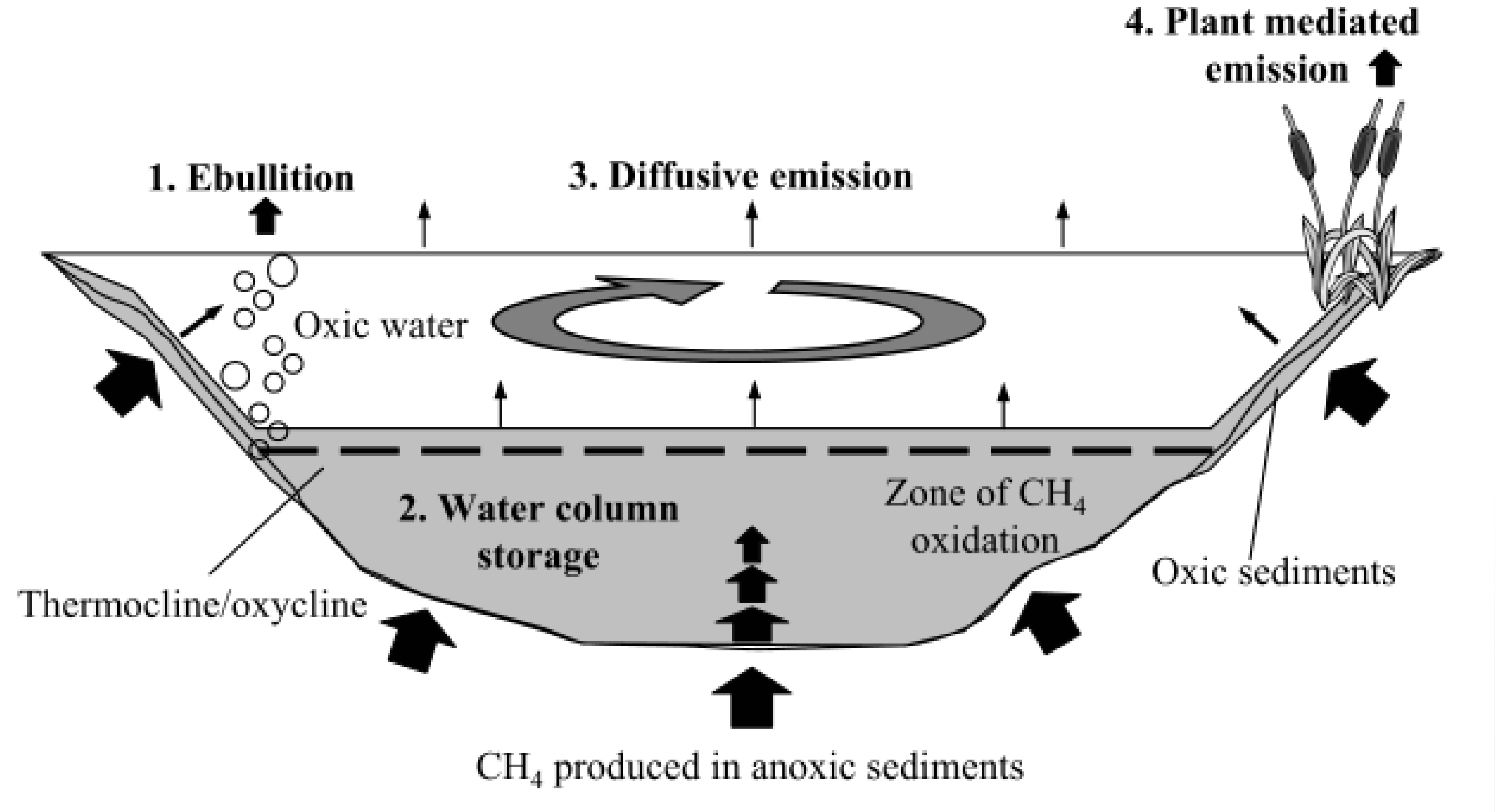
Background: why is CH_4 from lake?

- Increasing the concentrations of gases CH_4 and CO_2 have stimulated research on their emission from terrestrial and aquatic environments (Conrad, 1996; Segers, 1998).

- On a global scale, freshwater environments account for more than 20% of the total CH_4 flux to the atmosphere, and because of the large area, the wetlands are the most important source (Khalil & Shearer, 1993).

- The importance of lakes in the global emissions of CH_4 and CO_2 may have been underestimated from the estimates of the emission of CH_4 and CO_2 from freshwater lakes (Ehhalt, 1974; Rudd & Hamilton, 1978).

Background: CH_4 exchange pathway



(David Bastvikon et al., 2004).

Objective

- To quantify the rates of emission of CH_4 and CO_2 by molecular diffusion and ebullition from a small hypertrophic lake.

- A high resolution sampling regime was used to estimate the temporal and spatial variation of loss processes.

Materials and Methods

Study site: Priest Pot

Characteristic:

Small hypertrophic

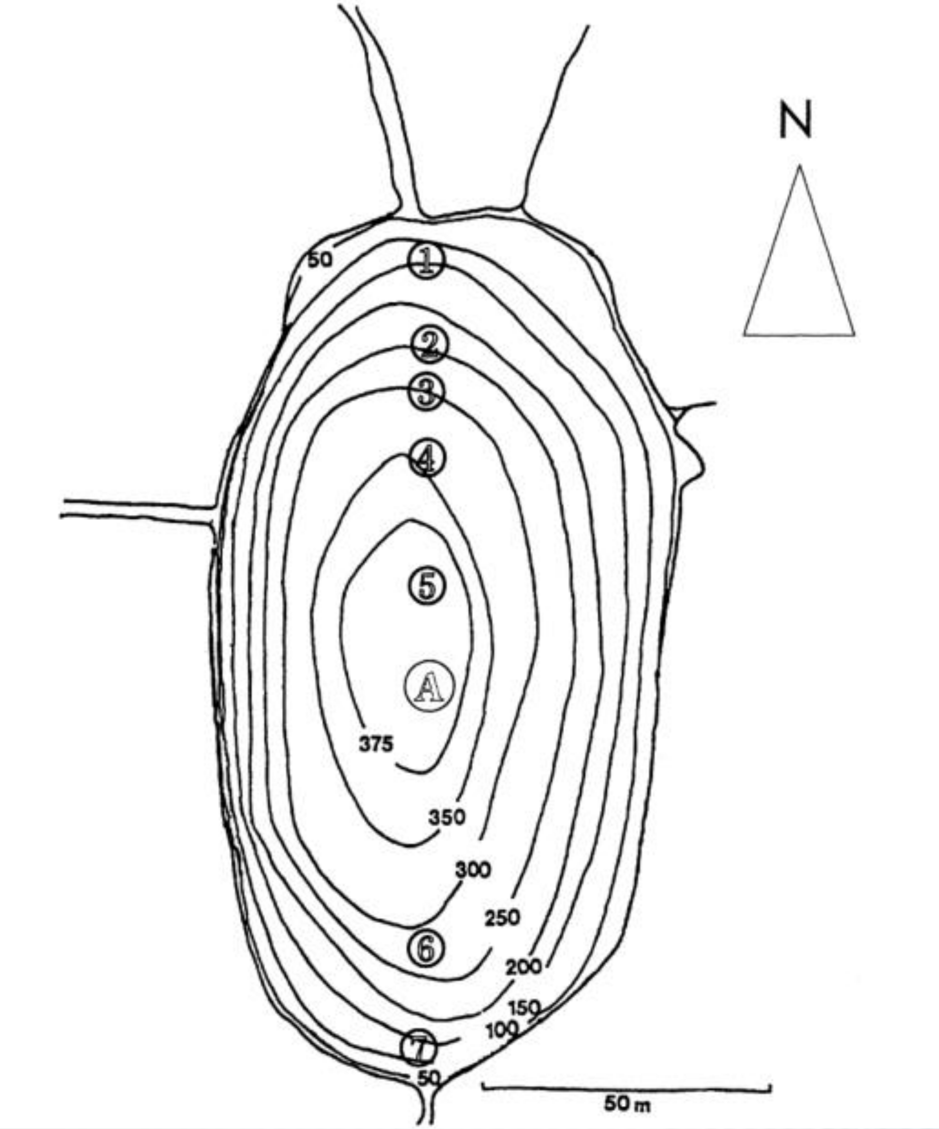
TP: 600 ug/ L

Chlorophyll a: 300 ug/ L

Maximum depth: 3.9 m

Mean depth: 2.3 m

Gas sampling



- using inverted-funnel method.
- Covering a depth range from 1.6 m to 3.5 m.
- All samples were transport to the laboratory in a cool box and analyzed gas composition within 4 hours.

Water sampling

- Using the multi-syringe sampler sometimes using a 0.5 liter bottle sample (Heaney, 1974).

- Taking water from the deepest points at every 10 cm intervals.

Gas analysis

- Gas-trap samples: Hewlett Packard 5710A gas chromatograph.

- Dissolved CH_4: a gas chromatograph with a FID.

- Dissolved inorganic carbon: by conversion to CO_2.

- pH: a calibrated combination eletrode.

Results & Discussion: Dissolved CH_4 and CO_2

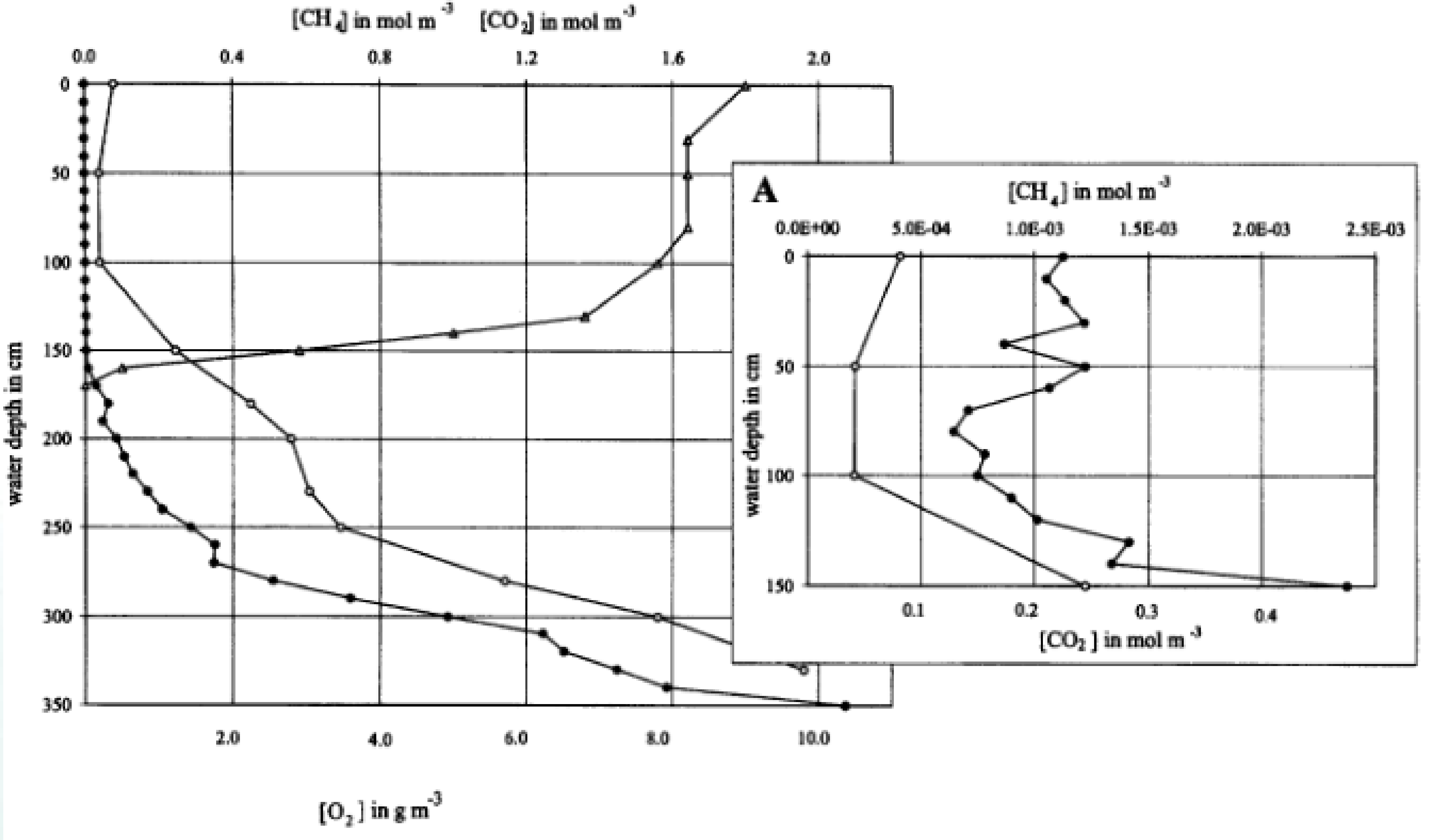


Fig.1 Example of high resolution depth profiles of CH_4 (closed circles) and CO_2 (open circles) and O_2 (triangles) concentration.

Results & Discussion: Rates of diffusive flux

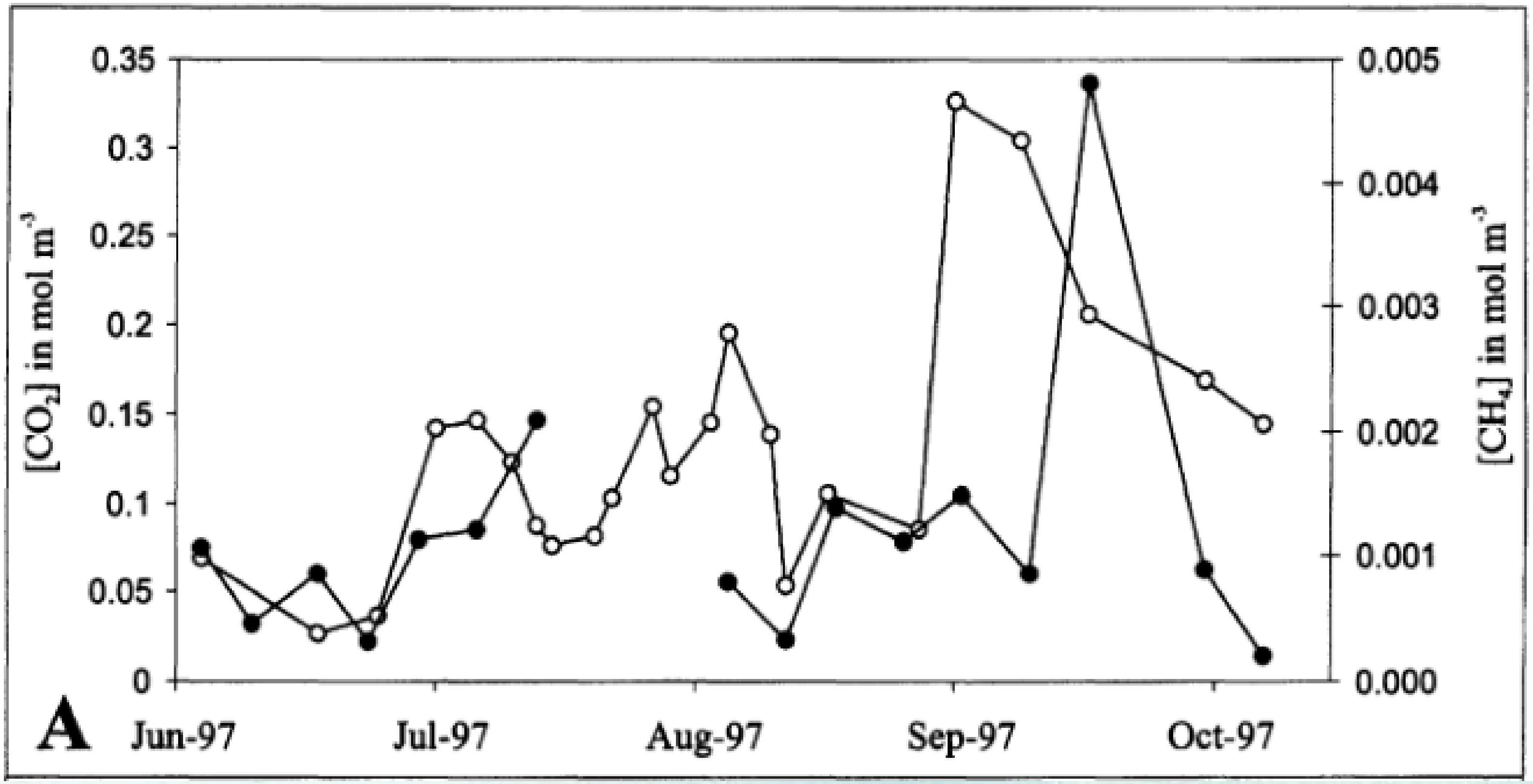


Fig.2 Seasonal variations for CH_4 (closed circles) and CO_2 (open circles) of concentrations in the surface water.

Results & Discussion: Rates of diffusive flux

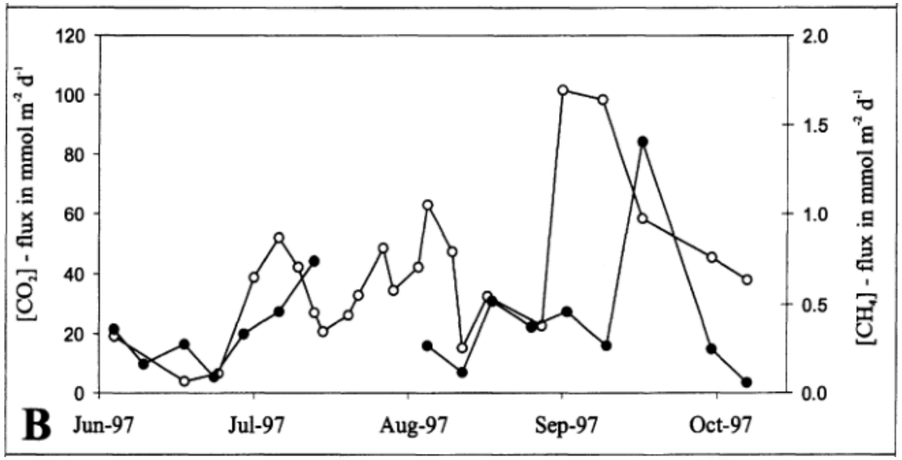
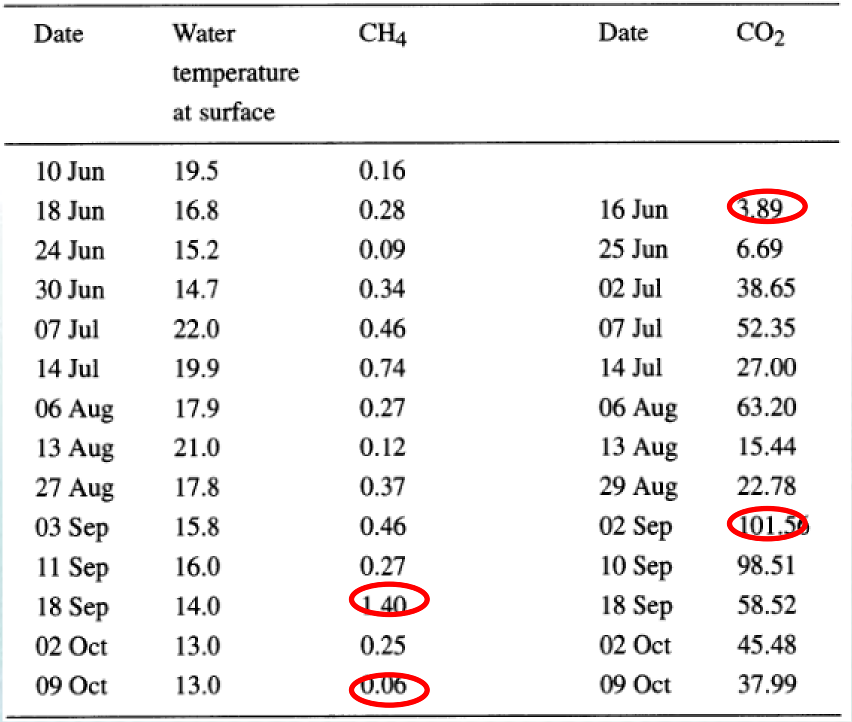


Fig.3 Flux for CH_4 and CO_2 to the atmosphere for a boundary layer 400 um thick.

Table 1. Diffusive fluxes of CH_4 and CO_2 measured at central point.



Date	Water temperature at surface	CH_4	Date	CO_2
10 Jun	19.5	0.16		
18 Jun	16.8	0.28	16 Jun	3.89
24 Jun	15.2	0.09	25 Jun	6.69
30 Jun	14.7	0.34	02 Jul	38.65
07 Jul	22.0	0.46	07 Jul	52.35
14 Jul	19.9	0.74	14 Jul	27.00
06 Aug	17.9	0.27	06 Aug	63.20
13 Aug	21.0	0.12	13 Aug	15.44
27 Aug	17.8	0.37	29 Aug	22.78
03 Sep	15.8	0.46	02 Sep	101.56
11 Sep	16.0	0.27	10 Sep	98.51
18 Sep	14.0	1.40	18 Sep	58.52
02 Oct	13.0	0.25	02 Oct	45.48
09 Oct	13.0	0.06	09 Oct	37.99

Results & Discussion: Rates of diffusive flux

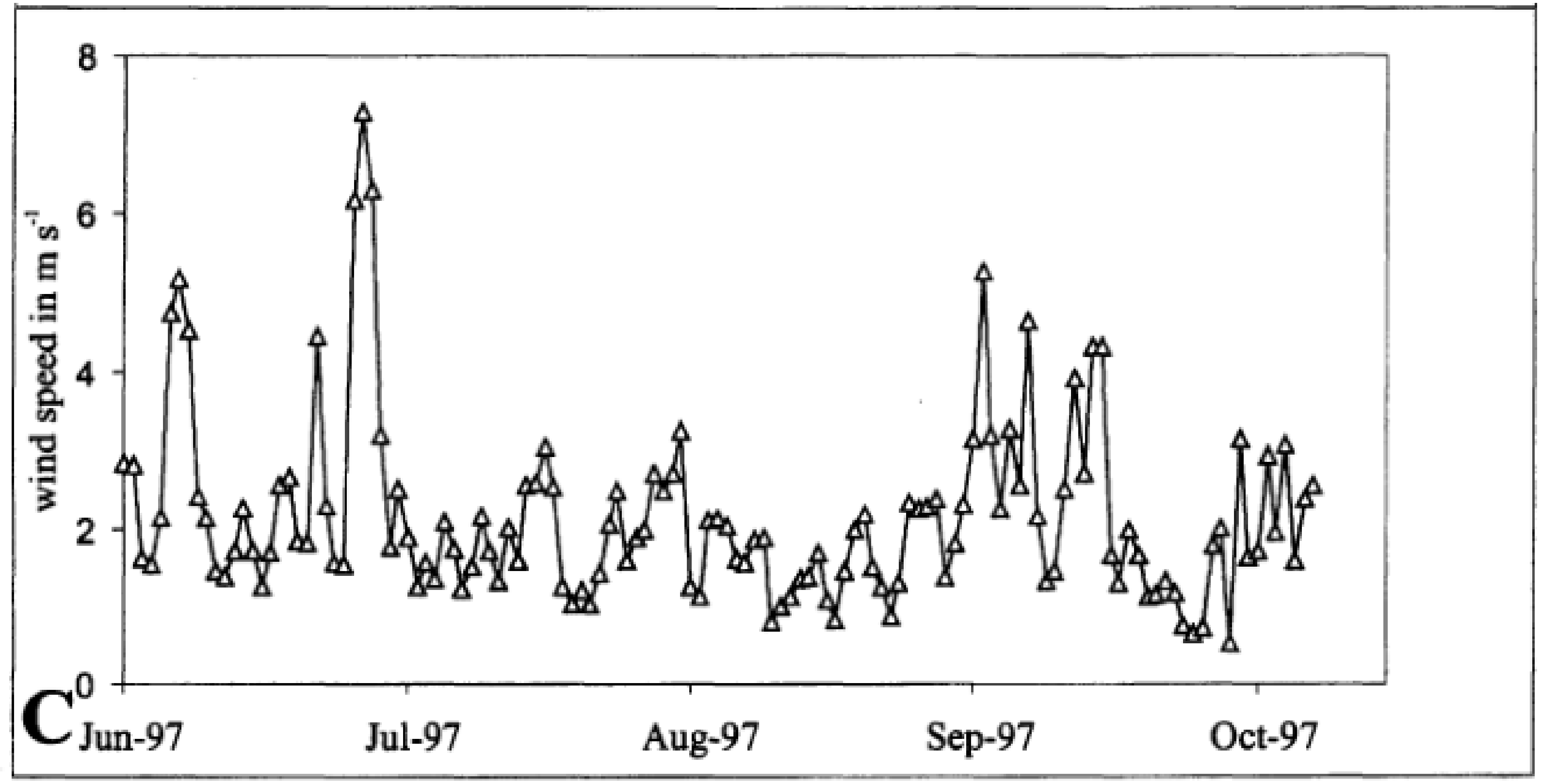


Fig.4 Wind speed measured at the neighbouring Esthwaite Water is given as daily averages.

Results & Discussion: Spatial variation in gas ebullition and composition

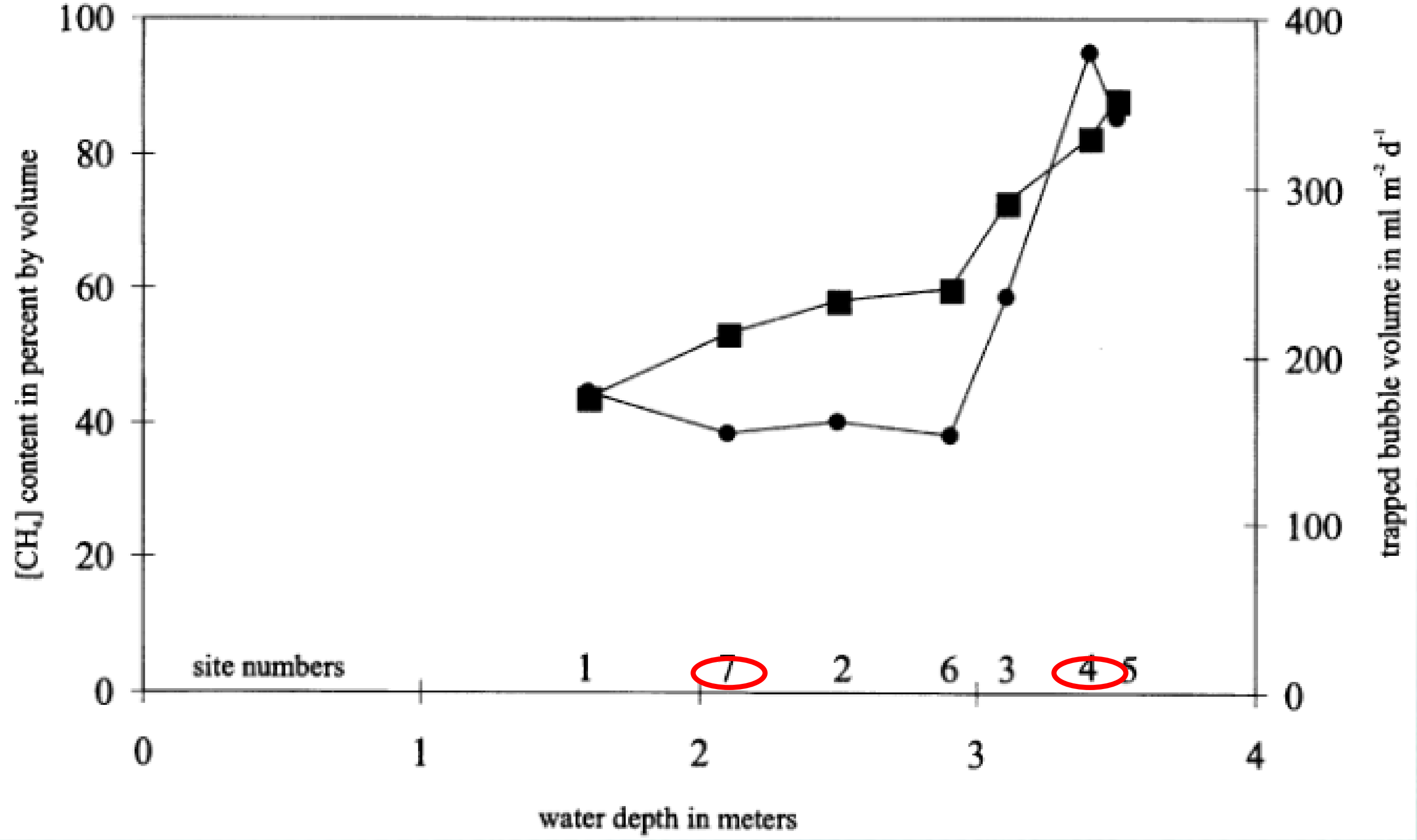


Fig.5 Average total gas ebullition (black dots) and CH_4 content (black boxes) for the seven sites over the study period as a function of water depth.

Results & Discussion: Temporal variation in gas ebullition and composition

average:1-7

deep:4

shallow:7

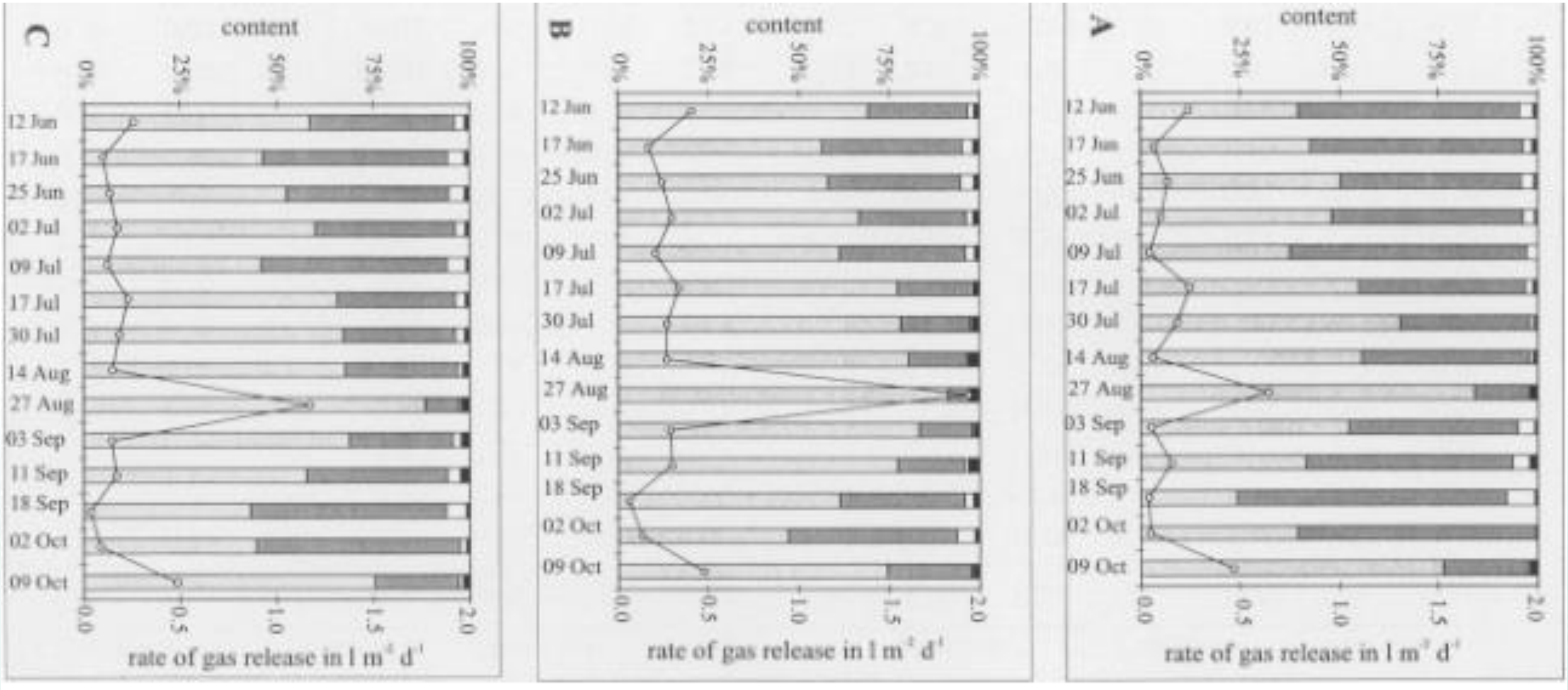
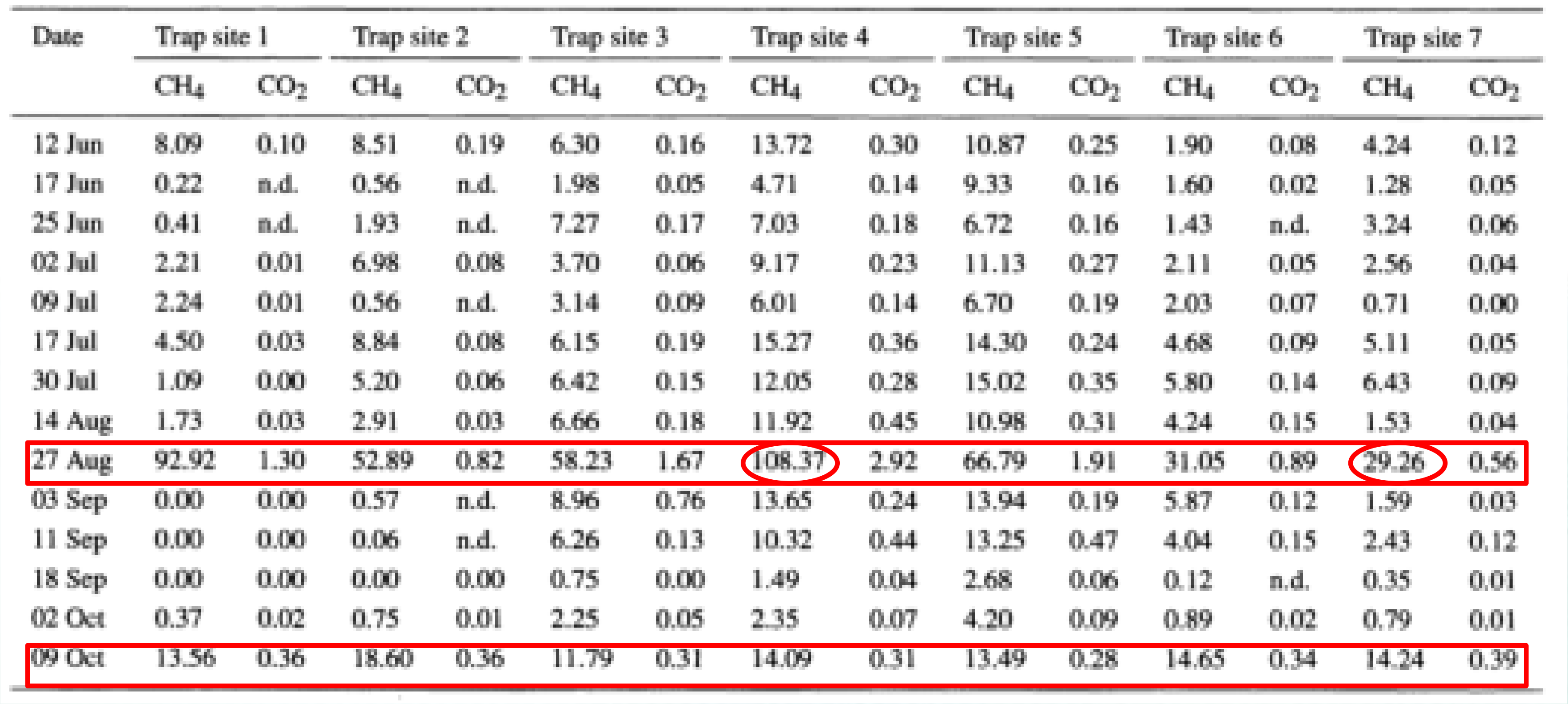


Fig.6 Seasonal variations in composition and rate of gas released, (A) at shallow site(trap site 7), (B) at deep site (trap site 4) and (C) average over all trap sites.

Results & Discussion: Temporal variation in gas ebullition and composition

Table 2. Ebullition fluxes of CH_4 and CO_2 from all sites.



Date	Trap site 1		Trap site 2		Trap site 3		Trap site 4		Trap site 5		Trap site 6		Trap site 7	
	CH_4	CO_2	CH_4	CO_2	CH_4	CO_2	CH_4	CO_2	CH_4	CO_2	CH_4	CO_2	CH_4	CO_2
12 Jun	8.09	0.10	8.51	0.19	6.30	0.16	13.72	0.30	10.87	0.25	1.90	0.08	4.24	0.12
17 Jun	0.22	n.d.	0.56	n.d.	1.98	0.05	4.71	0.14	9.33	0.16	1.60	0.02	1.28	0.05
25 Jun	0.41	n.d.	1.93	n.d.	7.27	0.17	7.03	0.18	6.72	0.16	1.43	n.d.	3.24	0.06
02 Jul	2.21	0.01	6.98	0.08	3.70	0.06	9.17	0.23	11.13	0.27	2.11	0.05	2.56	0.04
09 Jul	2.24	0.01	0.56	n.d.	3.14	0.09	6.01	0.14	6.70	0.19	2.03	0.07	0.71	0.00
17 Jul	4.50	0.03	8.84	0.08	6.15	0.19	15.27	0.36	14.30	0.24	4.68	0.09	5.11	0.05
30 Jul	1.09	0.00	5.20	0.06	6.42	0.15	12.05	0.28	15.02	0.35	5.80	0.14	6.43	0.09
14 Aug	1.73	0.03	2.91	0.03	6.66	0.18	11.92	0.45	10.98	0.31	4.24	0.15	1.53	0.04
27 Aug	92.92	1.30	52.89	0.82	58.23	1.67	108.37	2.92	66.79	1.91	31.05	0.89	29.26	0.56
03 Sep	0.00	0.00	0.57	n.d.	8.96	0.76	13.65	0.24	13.94	0.19	5.87	0.12	1.59	0.03
11 Sep	0.00	0.00	0.06	n.d.	6.26	0.13	10.32	0.44	13.25	0.47	4.04	0.15	2.43	0.12
18 Sep	0.00	0.00	0.00	0.00	0.75	0.00	1.49	0.04	2.68	0.06	0.12	n.d.	0.35	0.01
02 Oct	0.37	0.02	0.75	0.01	2.25	0.05	2.35	0.07	4.20	0.09	0.89	0.02	0.79	0.01
09 Oct	13.56	0.36	18.60	0.36	11.79	0.31	14.09	0.31	13.49	0.28	14.65	0.34	14.24	0.39

Results & Discussion: Temporal variation in gas ebullition and composition

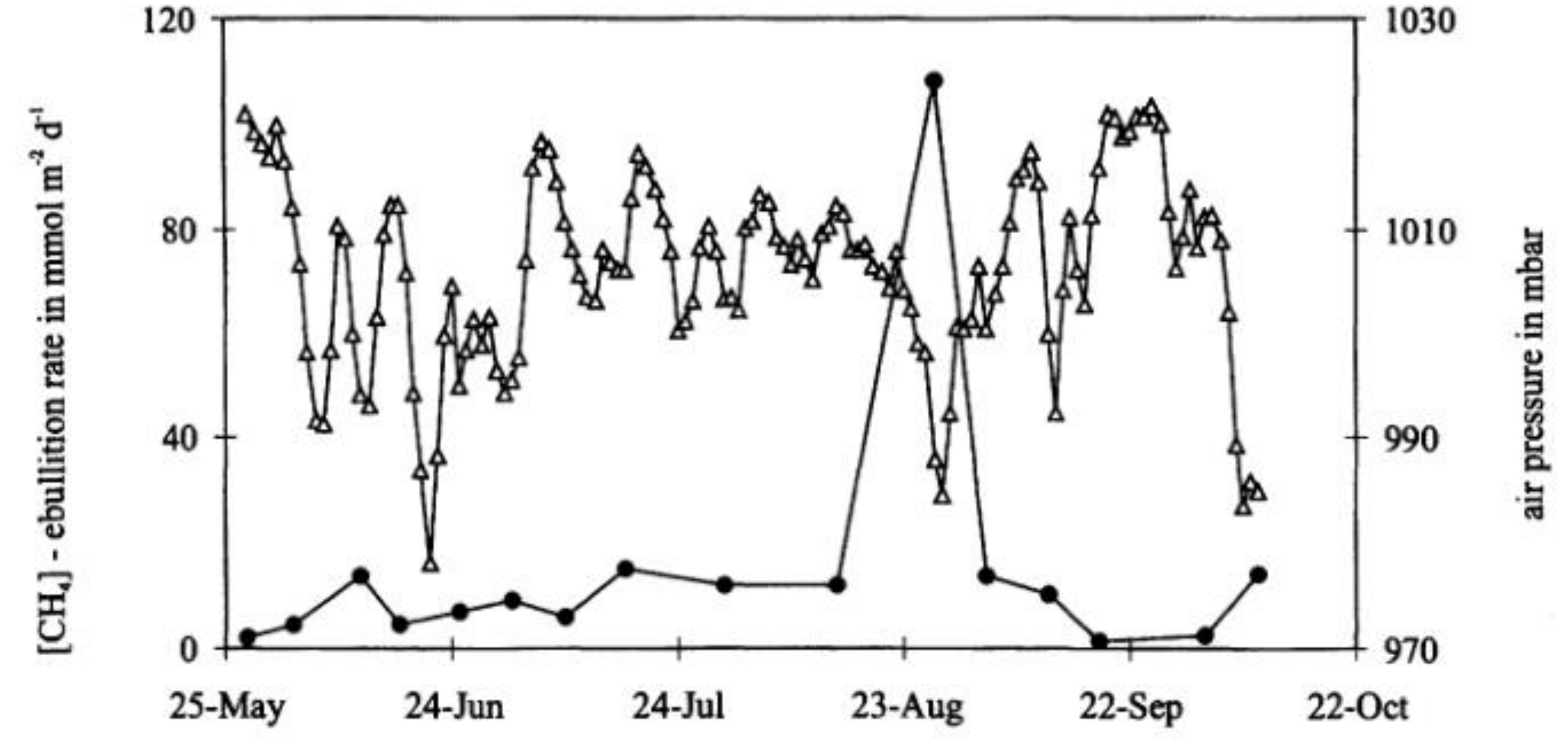


Fig.7 Means of methane ebullition rate (black dots) and daily means of atmospheric pressure (open triangles) over the study period.

Conclusion: the flux of CH_4 and CO_2

- The average flux of CH_4 and CO_2 was 12 and 40 mmol m^{-2} d^{-1} respectively, of which diffusion across the air-water interface apportioned 0.4 and 40 mmol m^{-2} d^{-1} whilst the corresponding losses of ebullition were 12.0 mmol m^{-2} d^{-1} for CH_4 and 0.23 mmol m^{-2} d^{-1} for CO_2.
- Most CH_4 (96%) was lost by ebullition, and most CO_2 (99%) by diffusive process.

Conclusion: the nature of flux for CH_4 and CO_2

- The ebullition of gas showed high spatial and temporal variation.
- The CH_4 content of the trapped gas varied and was highest at the deepest points (88%).
- Pulses of gas ebullition were detected at the same time falling barometric pressure.

Thank you for your attention