Temporal-Spatial Variations and influencing factors of Transfer Coefficients of Momentum, Heat and Water Vapor in Lake Taihu

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Outline

- Background
- Materials and method
- Temporal-spatial variations of transfer coefficients
- Influencing factors of transfer coefficients
- Conclusions

Background

- Difference of oceans and lakes make transfer coefficients of momentum, heat and water vapor markedly different, while most lake models are still using results from oceans to calculating fluxes.

- Due to huge area of Lake Taihu, different regions may have different characteristics, which might lead to the difference of transfer coefficients.

Materials and methods

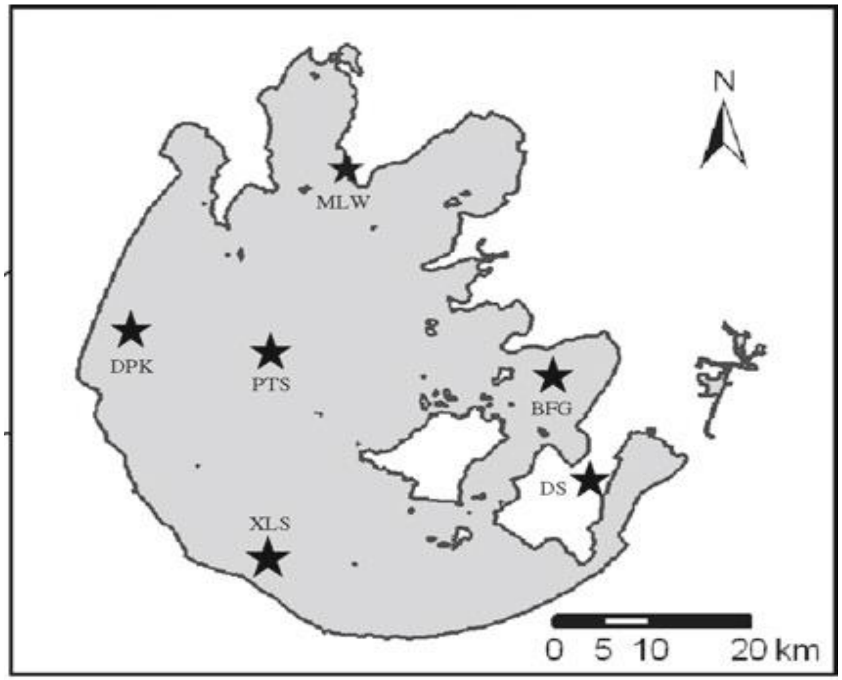


Fig.1 The introduction of study sites in Lake Taihu.

Data time: 2014.1.1-12.31

MLW site:
WD(Wind Direction): 200-315°

DPK site:
WD: 110-280°

BFG site:
135-315°

XLS site:
WD: 45-225°

PTS site:
45-225°

Materials and methods

Bulk transfer relationships

$$\tau = \rho_a C_D u^2$$

$$H = \rho_a c_p C_H u(T_s - T_a)$$

$$LE = \rho_a L_v C_E u(q_s - q_a)$$

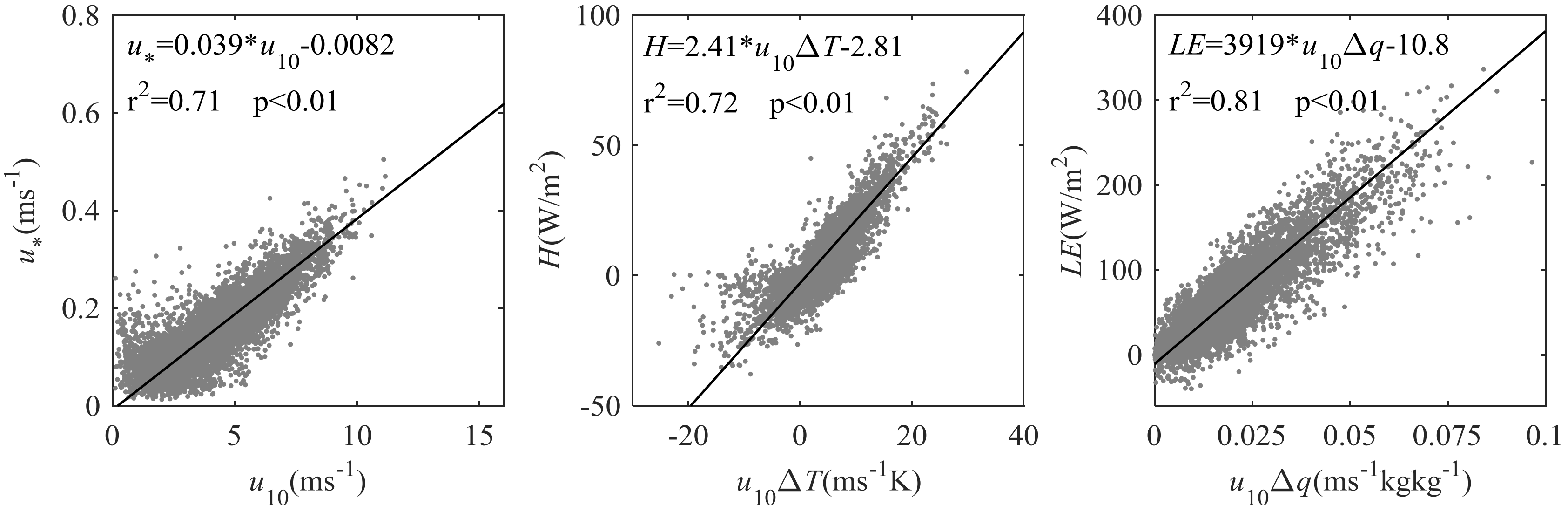


Fig.2 Bulk transfer relationships for the PTS site.

Materials and methods

Relationships between roughness lengths and transfer coefficients

$$C_{\mathrm{D}} = \kappa^2 / [\ln(z / z_0) - \psi_m(\zeta)]^2$$

$$C_{\mathrm{H}} = \kappa^2 / ([\ln(z / z_0) - \psi_m(\zeta)][\ln(z / z_{\mathrm{h}}) - \psi_{\mathrm{h}}(\zeta)])$$

$$C_{\mathrm{E}} = \kappa^2 / ([\ln(z / z_0) - \psi_m(\zeta)][\ln(z / z_{\mathrm{q}}) - \psi_{\mathrm{q}}(\zeta)])$$

For the standard reference height of 10 m and neutral stability

$$C_{\mathrm{D10N}} = \kappa^2 / [\ln(10 / z_0)]^2$$

$$C_{\mathrm{H10N}} = \kappa^2 / [\ln(10 / z_0)][\ln(10 / z_{\mathrm{h}})]$$

$$C_{\mathrm{E10N}} = \kappa^2 / [\ln(10 / z_0)][\ln(10 / z_{\mathrm{q}})]$$

Materials and methods

Wave height

$$H = \frac{0.07u_{10}^{\ 2}\left(gD/u_{10}^{\ 2}\right)^{\frac{3}{5}}}{g}$$

(Davidan et al. 1985)

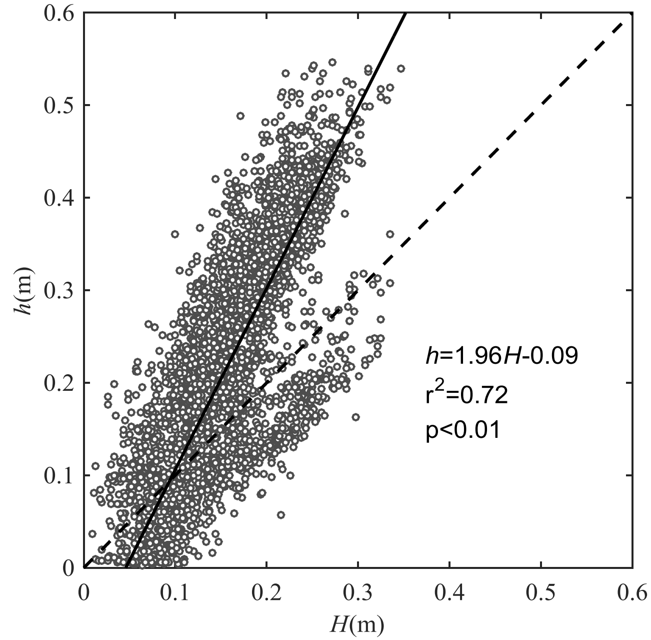


Fig.3 Diagram of simulated wave height and observed wave height

Temporal variations of transfer coefficients

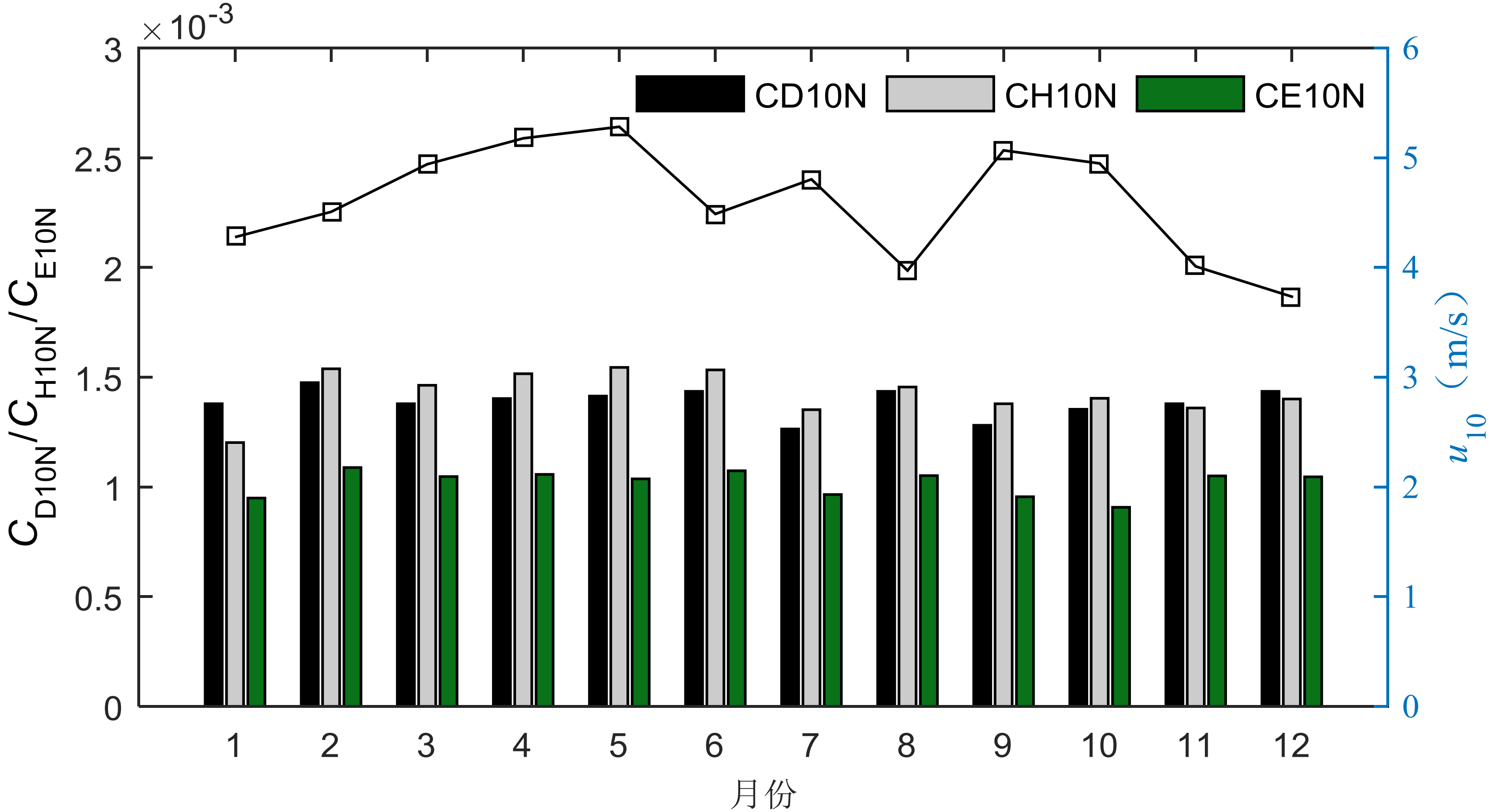


Fig.4 The seasonal variation of transfer coefficients at 10-m height for the PTS sites.

Spatial variations of transfer coefficients

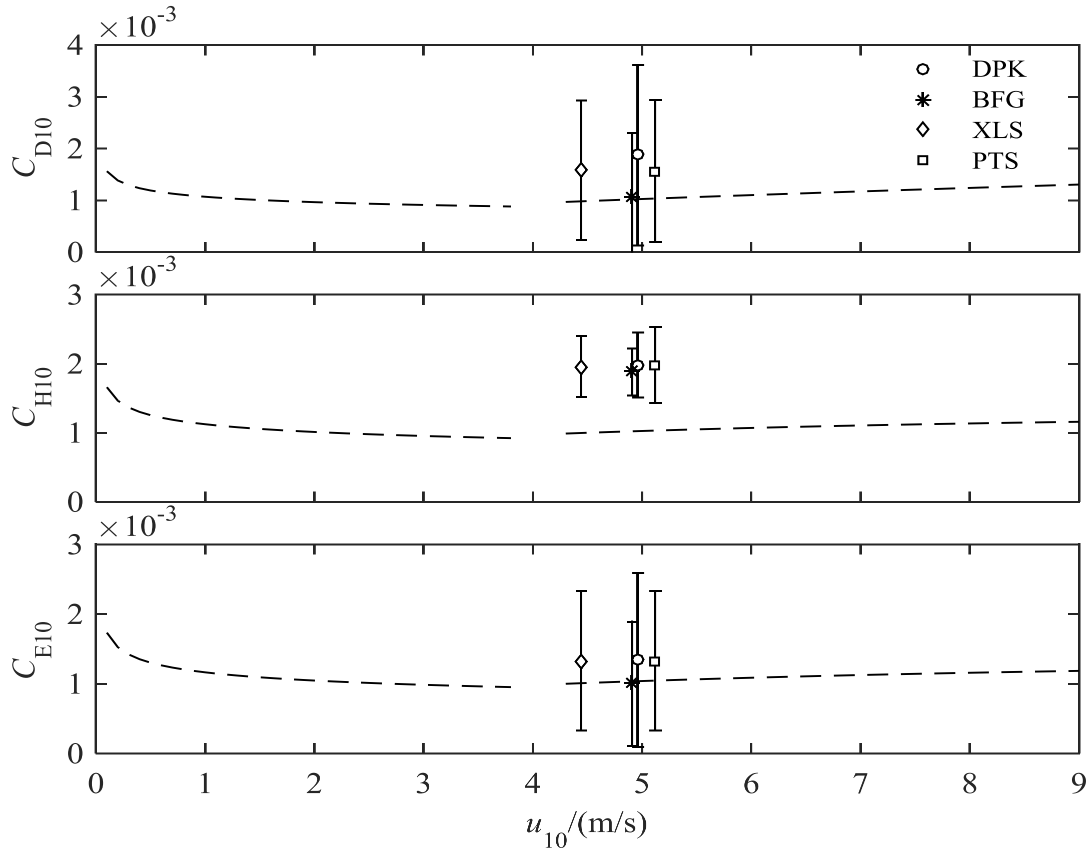


Fig.5 The bulk transfer coefficients at 10-m height versus the mean values of u_{10} for the DPK, BFG, XLS, PTS sites.

Spatial variations of transfer coefficients

Table.1 The bulk transfer coefficients at 10-m height and the mean values of u_{10} for the DPK, BFG, XLS, PTS sites.

	DPK	BFG	XLS	PTS
10^3C_{D10}	1.87	1.08	1.58	1.57
10^3C_{H10}	1.98	1.88	1.96	1.98
10^3C_{E10}	1.34	1.0	1.33	1.33
u_{10}	4.96	4.91	4.44	5.12

Transfer coefficients vs. wind

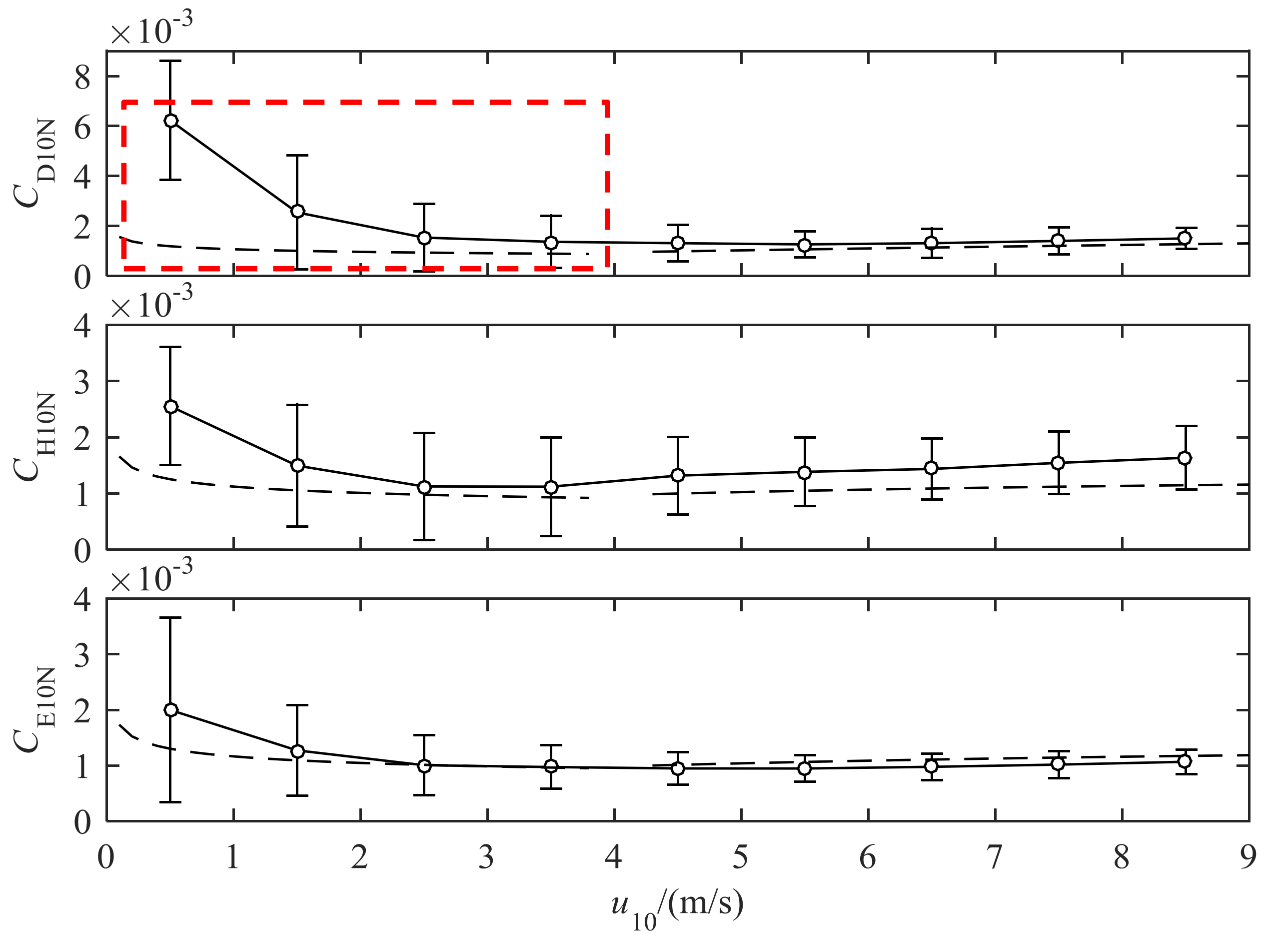


Fig.6 Transfer coefficients at 10-m height versus u_{10} for the PTS sites.

Transfer coefficients vs. wave height

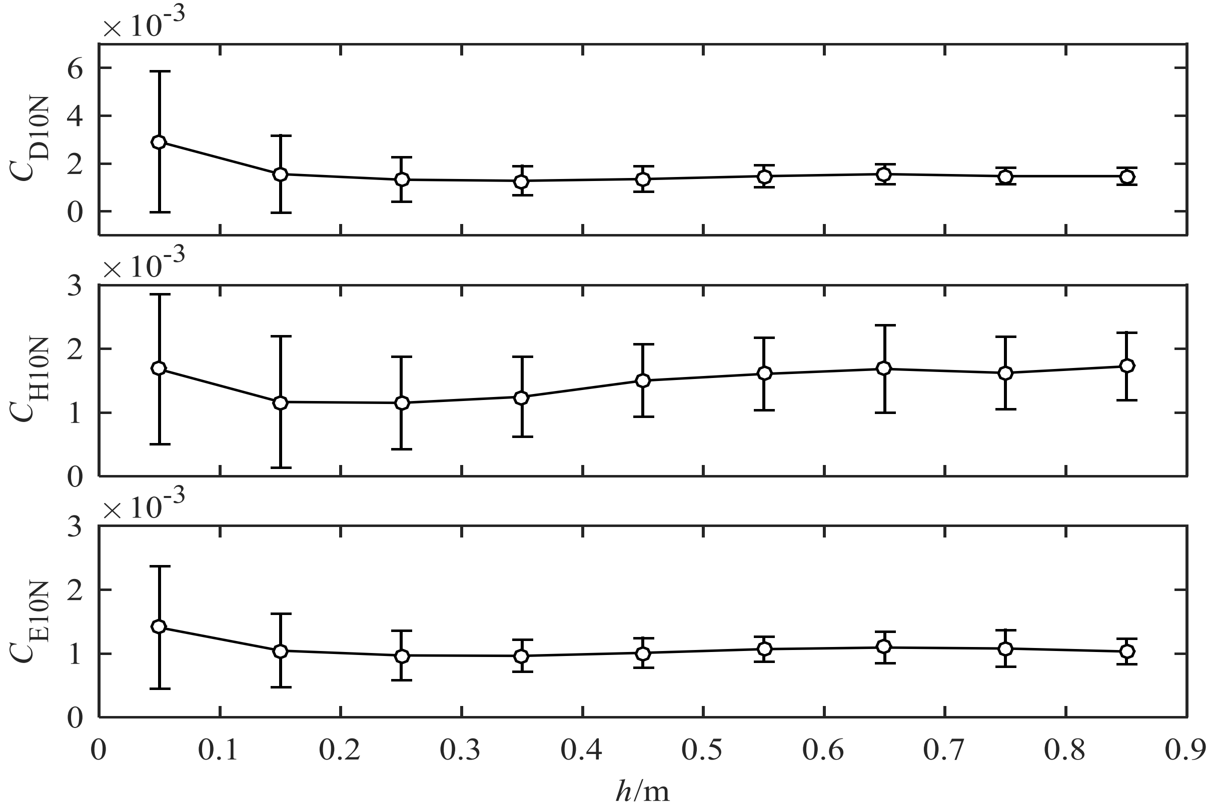


Fig.7 Transfer coefficients at 10-m height versus wave height for the PTS sites.

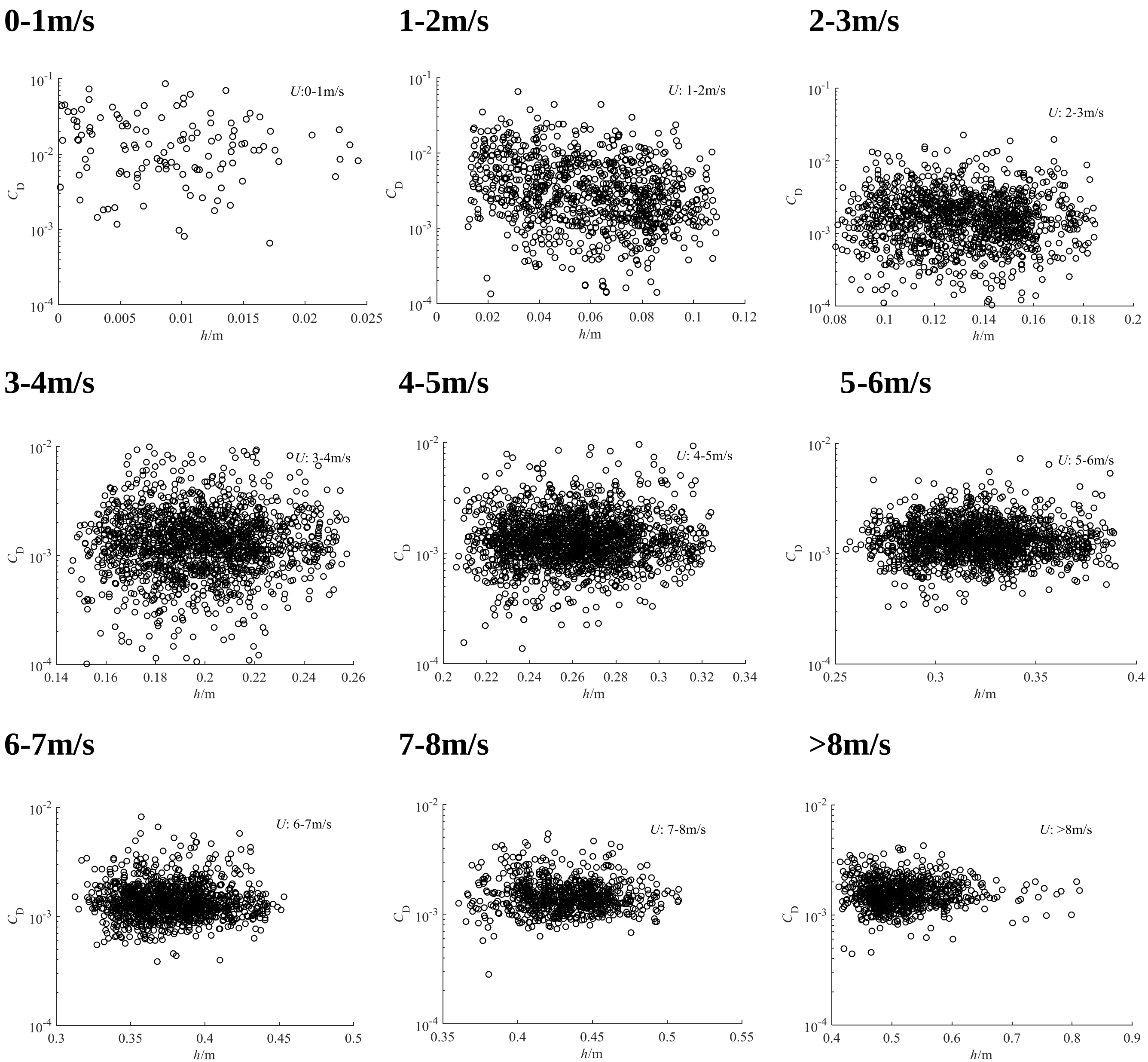
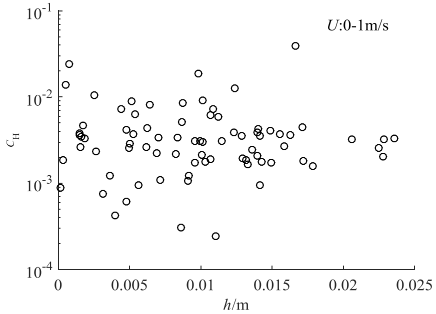
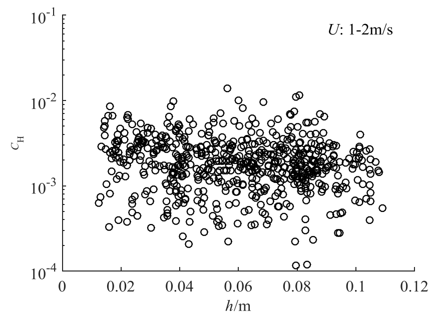


Fig.8 C_{D10N} versus wave height under different wind-speed ranges for the PTS sites.

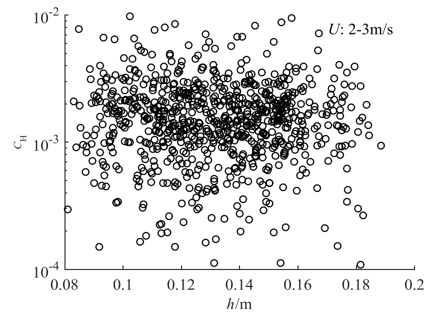
0-1m/s



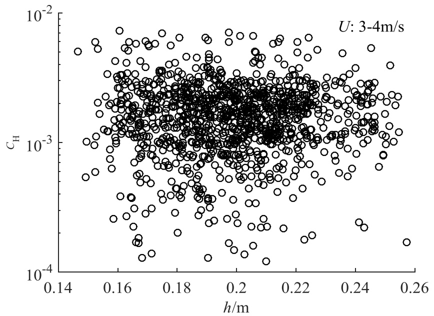
1-2m/s



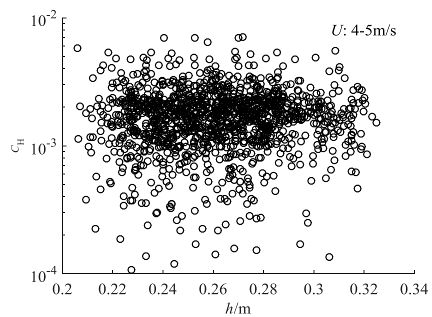
2-3m/s



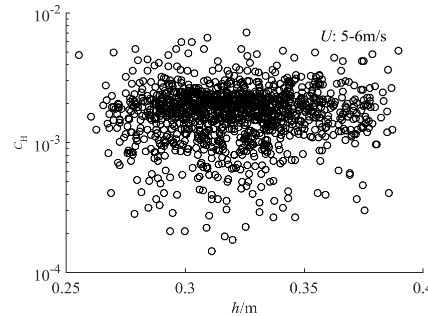
3-4m/s



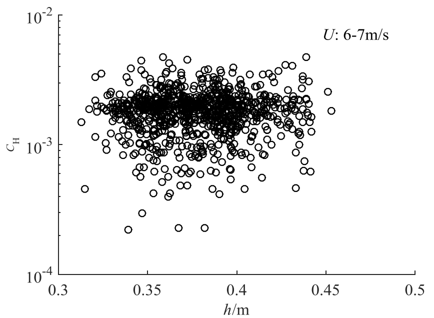
4-5m/s



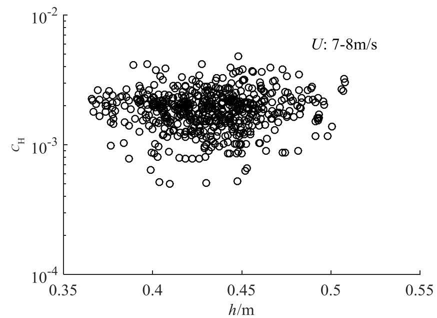
5-6m/s



6-7m/s



7-8m/s



>8m/s

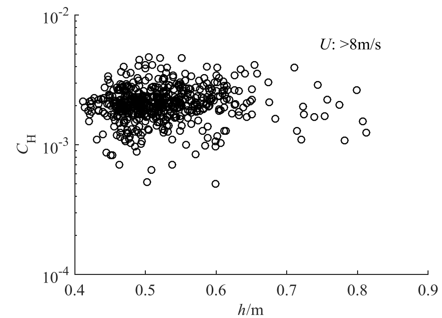


Fig.9 C_{H10N} versus wave height under different wind-speed ranges for the PTS sites.

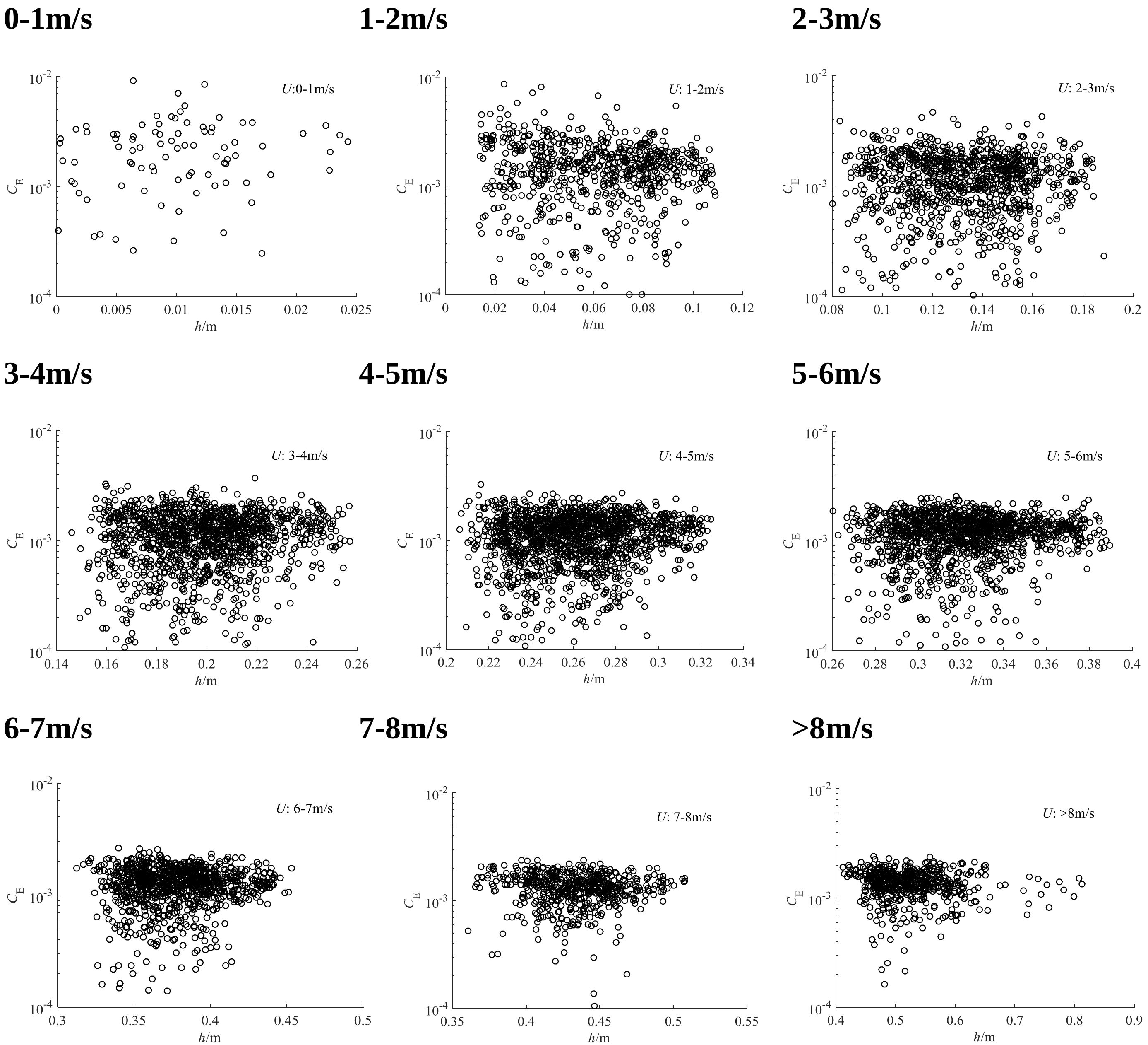


Fig.10 C_{E10N} versus wave height under different wind-speed ranges for the PTS sites.

Transfer coefficients vs. stability

Table.2 The mean values and one standard deviation of transfer coefficients under different stability conditions

	Unstable(ζ <-0.04)	Neutral（-0.04≤ ζ ≤0.04）	Stable（ζ >0.04）
10^3C_D	1.56±0.17	1.62 ± 0.03	1.25 ± 0.28
10^3C_H	1.78±0.28	1.45 ± 0.03	1.41 ± 0.32
10^3C_E	1.19 ± 0.14	1.12 ± 0.02	0.95 ± 0.2

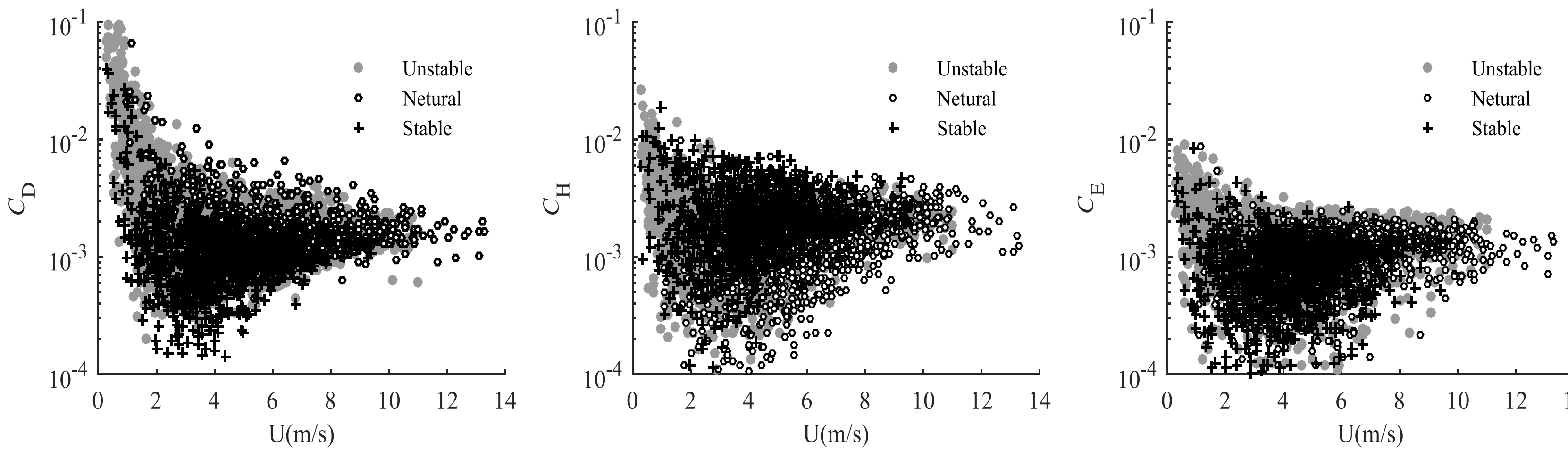


Fig.11 Transfer coefficients at reference height for the PTS sites.

Table.3 The mean values and one standard deviation of transfer coefficients under different stability conditions

Sites		Unstable	Netural	Stable
MLW	10^3C_D	1.9	2.12	1.33
	10^3C_H	1.7	1.59	1.25
	10^3C_E	1.17	1.12	0.81
DPK	10^3C_D	1.89	1.86	1.17
	10^3C_H	1.59	1.12	0.82
	10^3C_E	1.34	1.22	0.83
BFG	10^3C_D	1.28	1.86	0.86
	10^3C_H	1.11	1.04	0.72
	10^3C_E	0.88	0.85	0.6
XLS	10^3C_D	1.5	1.49	0.94
	10^3C_H	1.46	1.31	0.87
	10^3C_E	1.18	1.1	0.73
PTS	10^3C_D	1.56	1.62	1.25
	10^3C_H	1.78	1.46	1.41
	10^3C_E	1.19	1.12	0.95

Conclusions

- (1) There were less marked seasonal variations of transfer coefficients of momentum, heat and water vapor in the PTS site: slightly higher in spring and winter, lower in summer and autumn. Other sites had similar characteristics.

- (2) Different regions of Lake Taihu were not the same on transfer coefficients. The BFG site was obviously lower than other sites because of submerged vegetation. The DPK site was slightly higher than the XLS and PTS sites.

- (3) Transfer coefficients of momentum, heat and water vapor all rapidly decreased with increasing wind speed under 4 m/s of wind speed, reached a minimum values and then tend toward a constant or increased slowly as wind speed increased further. The relationship between transfer coefficients and wave height was similar, due to limit water depth, wave development was restricted with wind speed increasing.

- (4) C_H and C_E increased with increasing atmospheric instability. Due to the continuous change of roughness , variations of C_D with atmospheric stability was not clear.

Thank you