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Application of the Keeling Plot Method to Determining the Isotopic Composition of Surface Water Vapor Flux Using High-Frequency Observations

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2018.7.6

Outline

- Introduction
- Data and Methods
- Results and Discussion
- Conclusions

Introduction

- The isotopic composition of evapotranspiration and evaporation can provide us a unique insight in the study of water cycle (Gat, 1996).

- Keeling plot method has been widely used in the calculation of δ_E. And the result of Keeling plot can be affected by the choose of regression method (Wehr and Saleska, 2017) and the sample size N (Zobitz et al., 2006; Good et al., 2012).

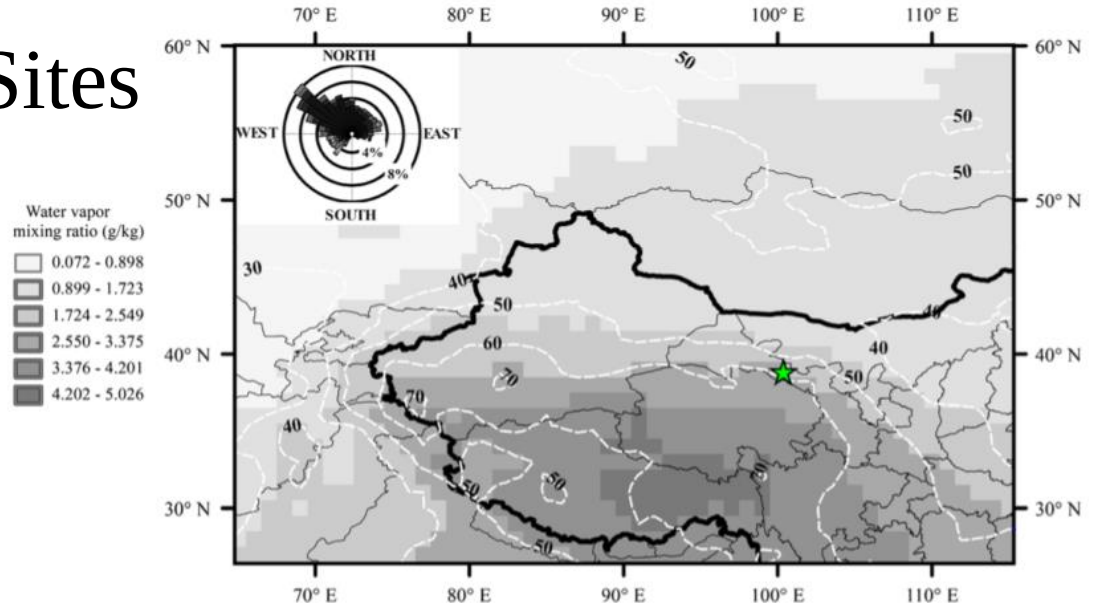
Objectives

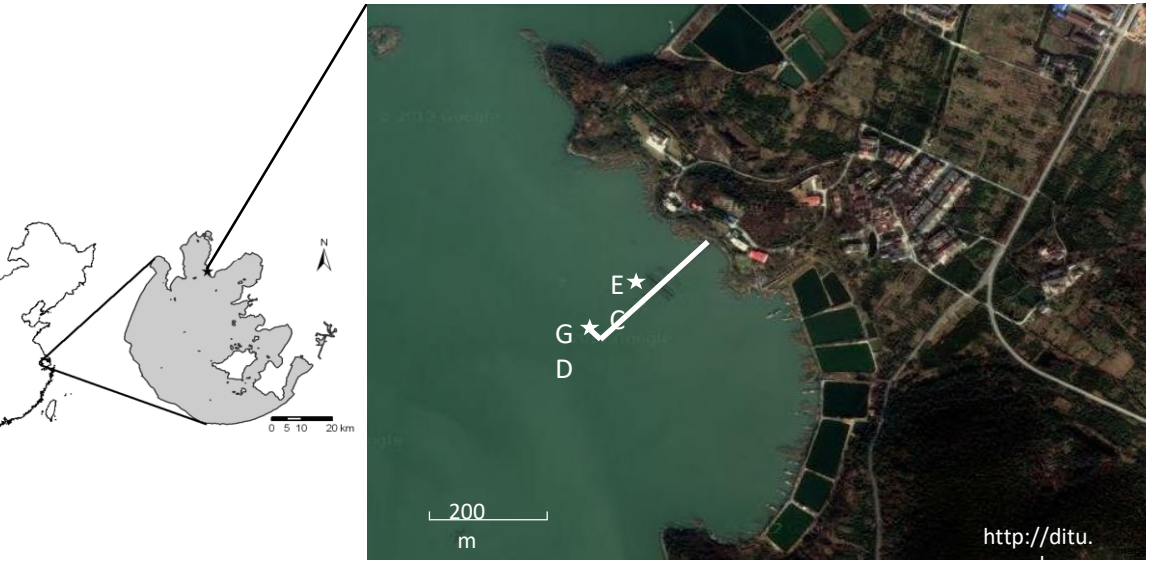
- To calculate δ_E using Keeling plot method based on high-frequency data.

- To find a better regression method for Keeling plot method, through comparing δ_E calculated by Keeling plot method with flux gradient method.

Data and Methods

Sites





Sites	Heihe	Lake Taihu
Latitude Longitude	38°15′N 100°22′E	31°24′N 120°13′E
Underlying Surface	Corn	Lake
Instrument	Picarro L1102-i	LGR-WVIA
Precision for $\delta^{18}O$	0.2‰	0.1‰
Data Frequency	0.2 Hz	2 Hz
Inlets Height	0.5 and 1.5 m	1.1 and 3.5 m

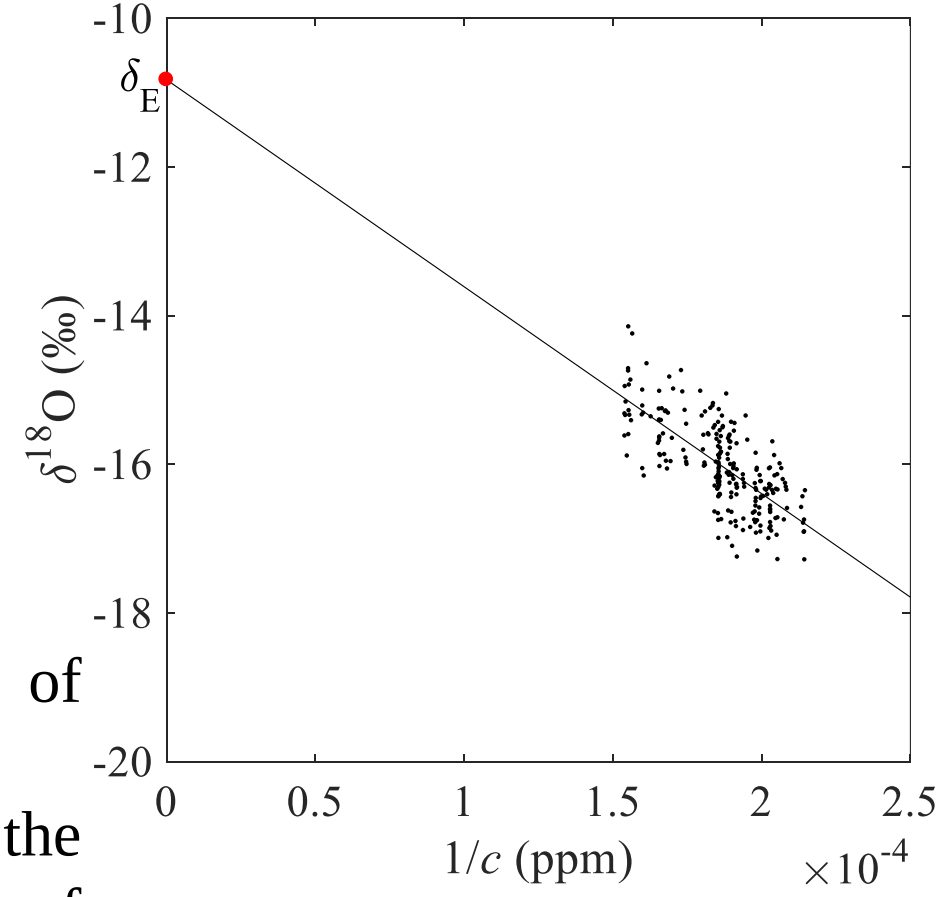
(Huang and Wen, 2014
Xiao et al., 2014, 2017)

Keeling Plot

$$c_o = c_b + c_s$$

$$c_o\delta_o = c_b\delta_b + c_s\delta_s$$

$$\delta_o = \frac{1}{c_o}\left(c_b\delta_b - c_b\delta_s\right) + \delta_s$$



c: concentration of trace gas

δ:the stable isotopic composition of trace gas

Subscripts o, b and s refer to the isotopic composition information of the observed, background and source.

Regression Methods

- Ordinary Least-Squares Regression (OLS)

In OLS, the error in x is negligible and the error variance for the $\widehat{y_i}$ does not vary with i.

- Geometric Mean Regression (GMR)

In GMR, the x error divided by the variance of the $\widehat{x_i}$ is equal to the variance of the y error divided by the variance of the $\widehat{y_i}$.

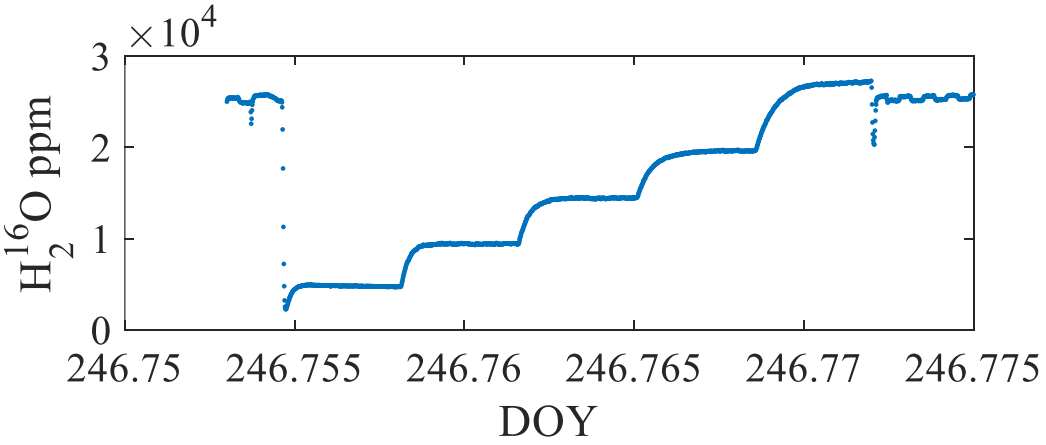
- York's Solution (YS)

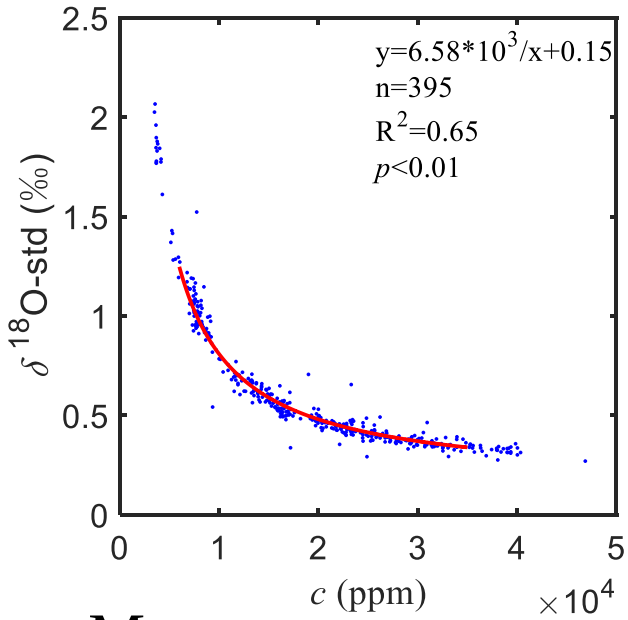
In YS, independent points have normally distributed errors in both x and y.

(York, 1968, 2004; Wehr and Saleska, 2017)

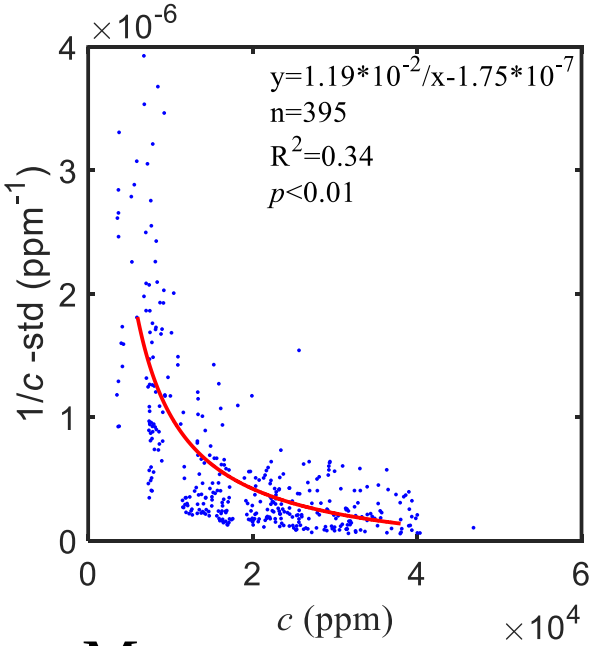
Determining of the parameters in YS

Lake Taihu

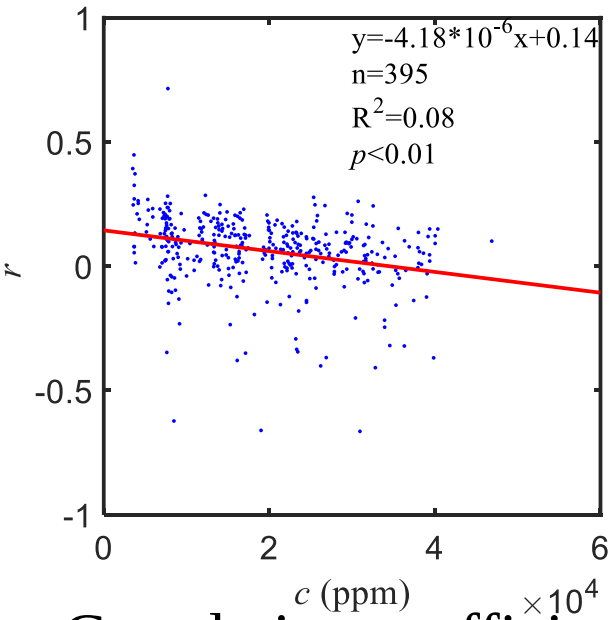




Measurement error standard deviations of δ ^{18}O

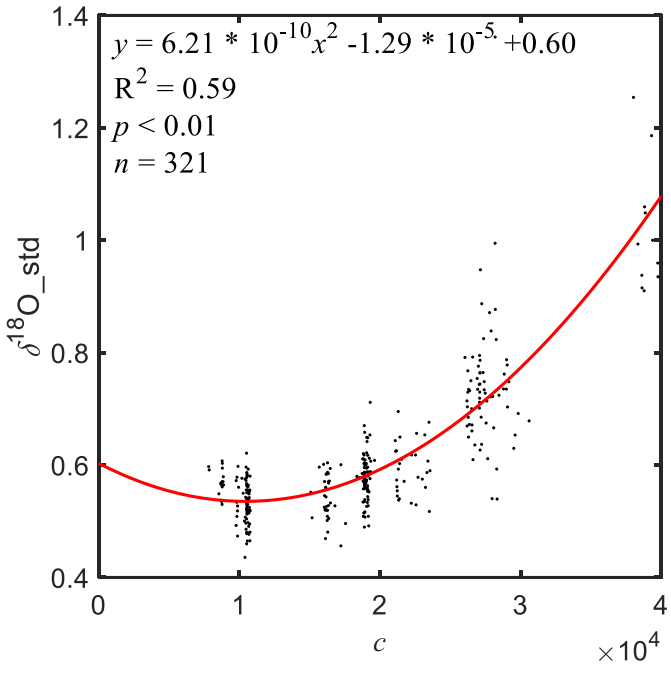


Measurement error standard deviations of 1/*c*

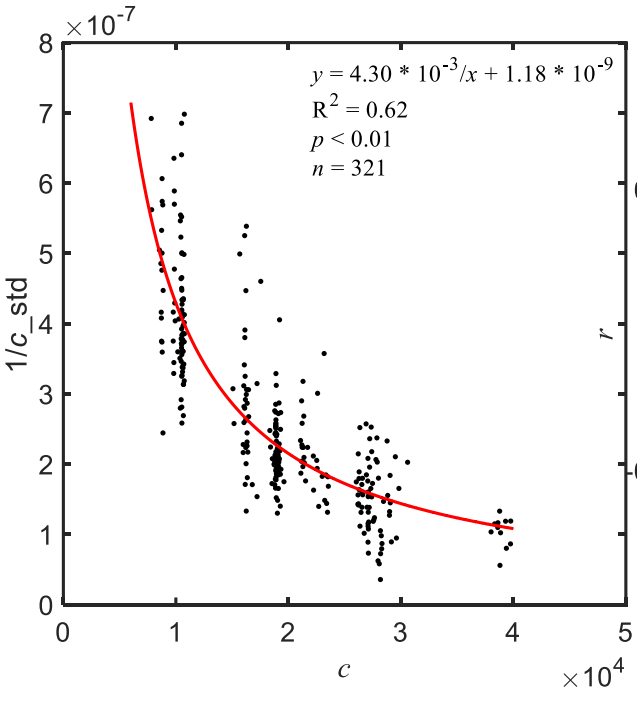


Correlation coefficient between δ^{18}O errors and 1/c errors

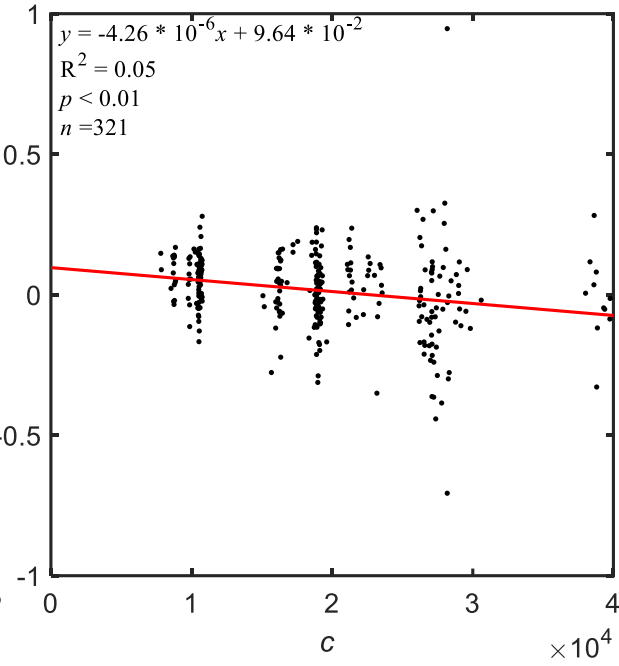
Heihe



Measurement error standard deviations of δ ^{18}O



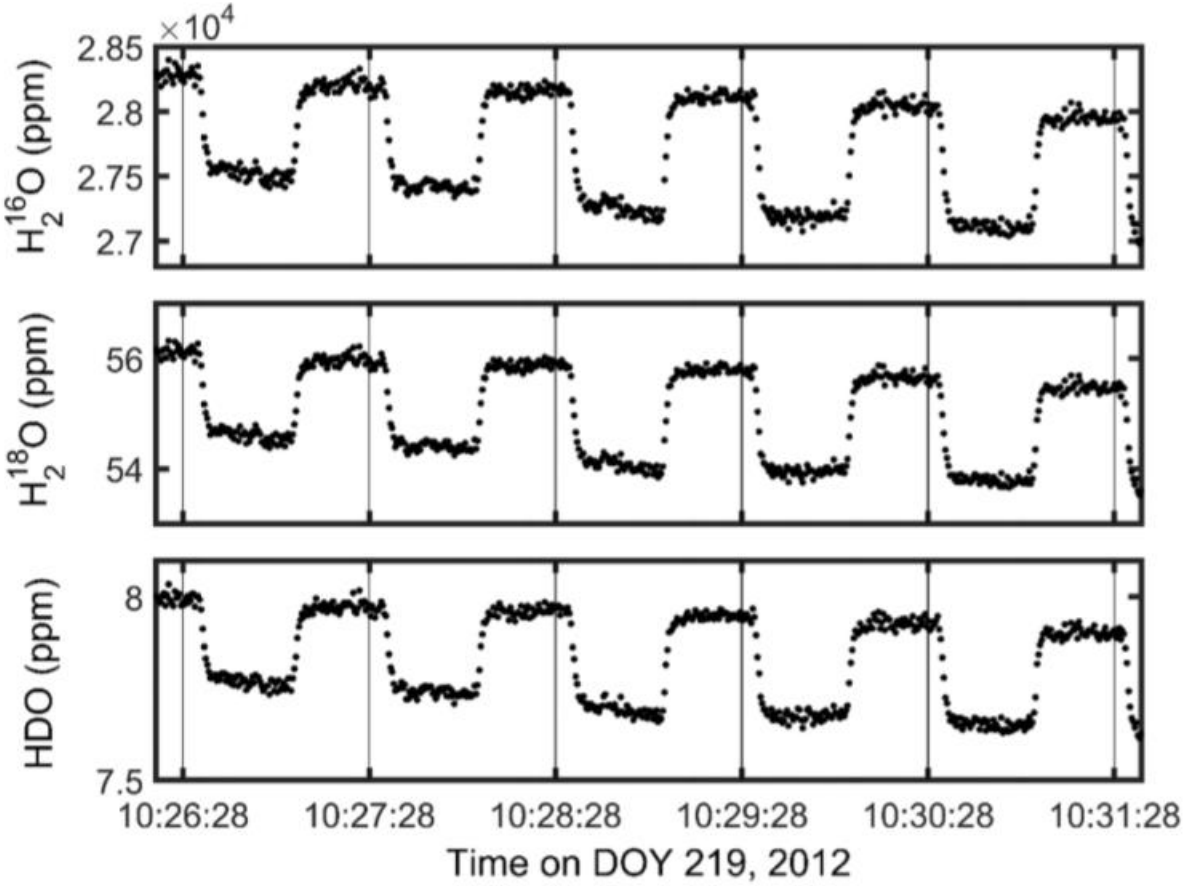
Measurement error standard deviations of 1/*c*



Correlation coefficient between $\delta^{18}O$ errors and 1/c errors

Flux Gradient

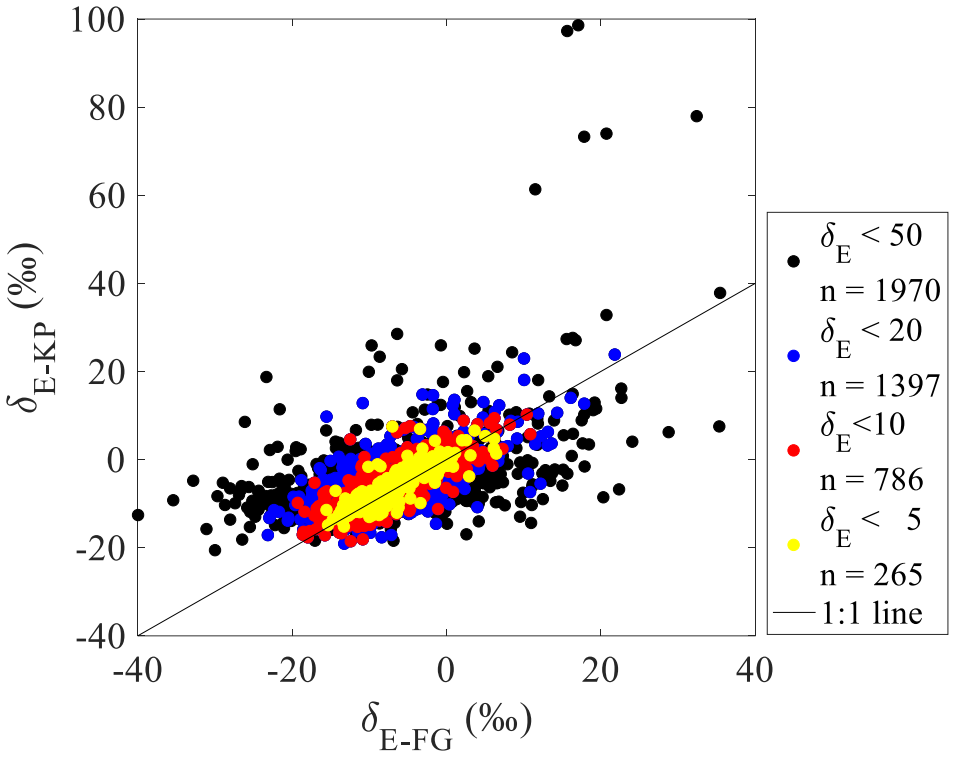
$$R_E = \frac{x'_{a,1} - x'_{a,2}}{x_{a,1} - x_{a,2}}$$

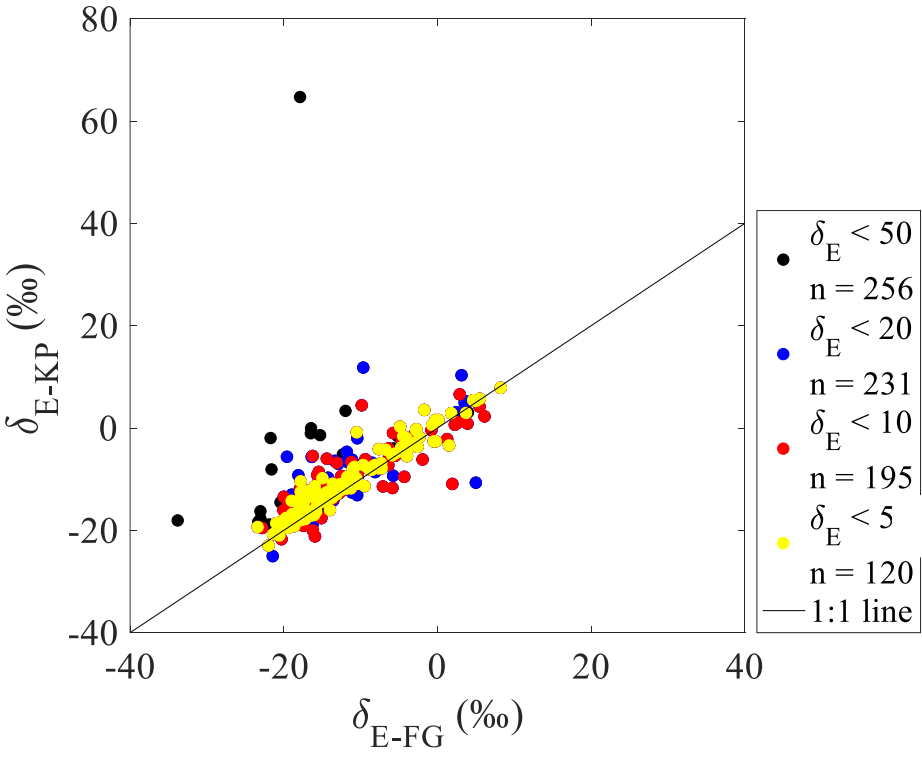


(Xiao et al., 2017)

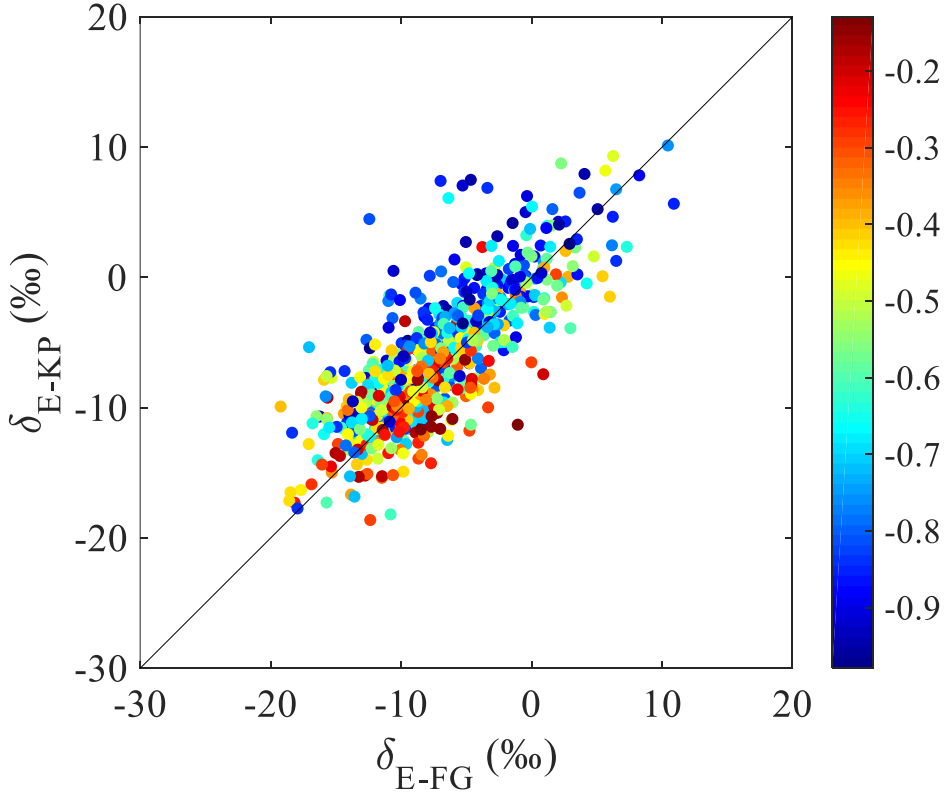
Data selection

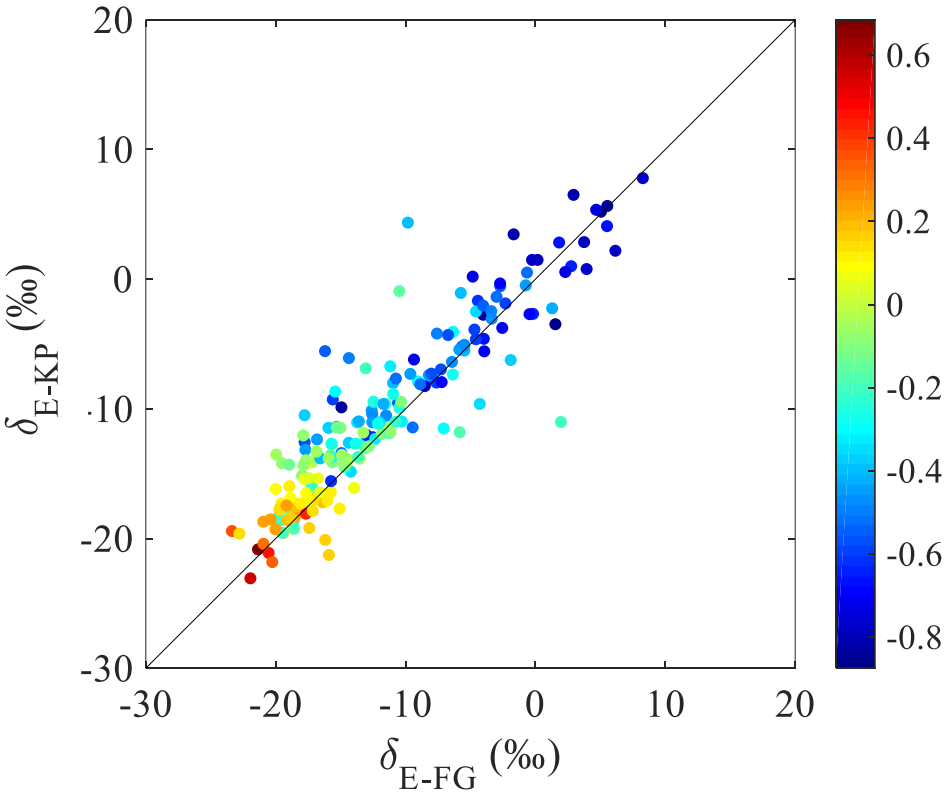
Different δ_E_std





Different r


20
10
0
-10
-20
-30
-30
-20
-10
0
10
20
δE-KP (‰)
δE-FG (‰)
-0.2
-0.3
-0.4
-0.5
-0.6
-0.7
-0.8
-0.9


20
10
0
-10
-20
-30
-30
-20
-10
0
10
20
δE-KP (‰)
δE-FG (‰)
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8

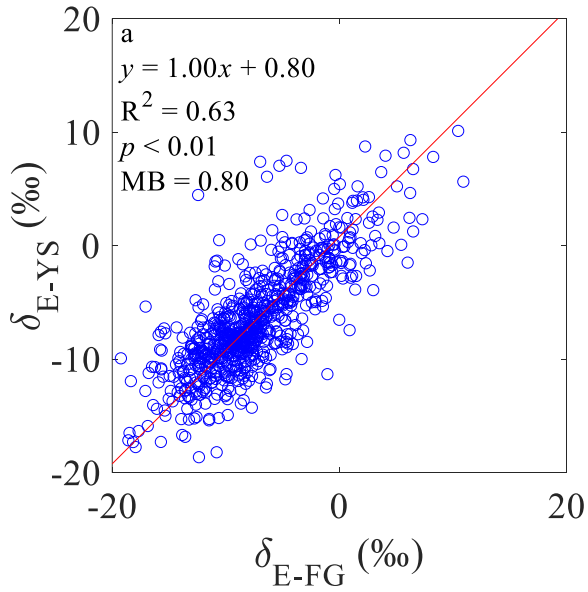
Selection criteria:

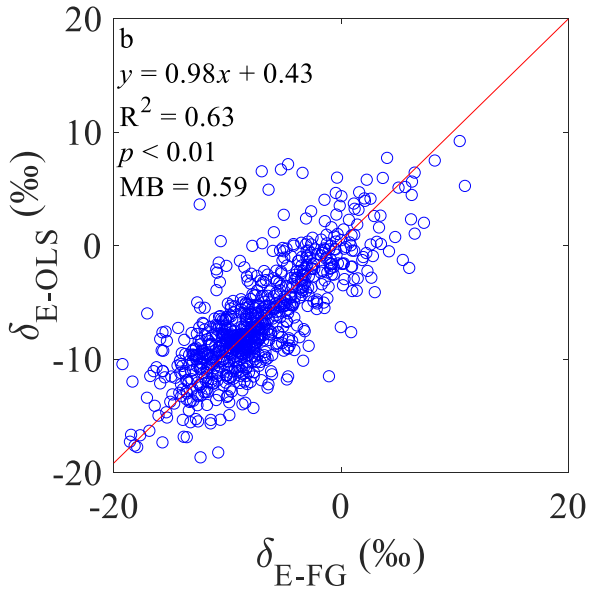
- δ_E_std < 10
- $p < 0.05$
- Wind Direction Selection: [140 315) for Lake Taihu

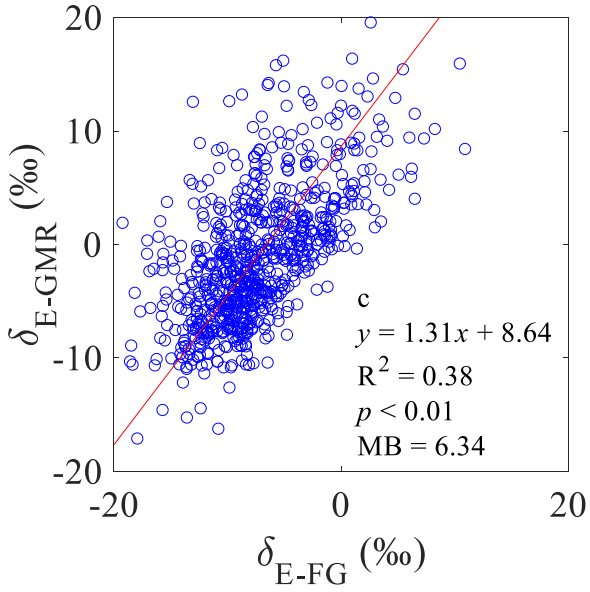
	Heihe	Lake Taihu
Total Hour	3026	1525
After WD Selection	3026	349
After Selection	786	195
Percentage	26.0%	55.9%

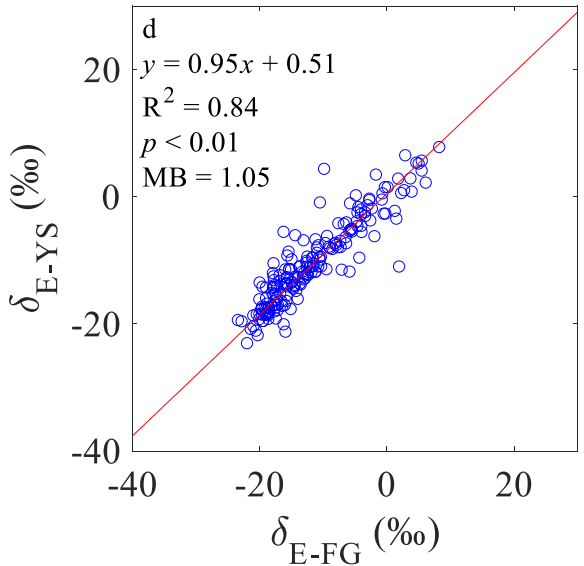
Results and Discussion

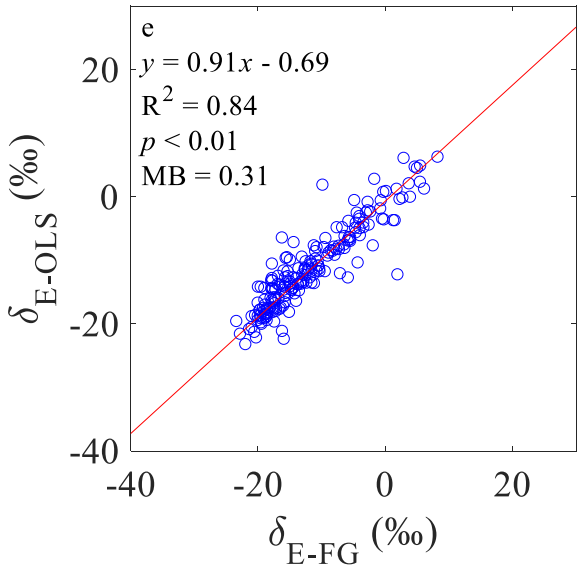
Comparison of the three regression methods

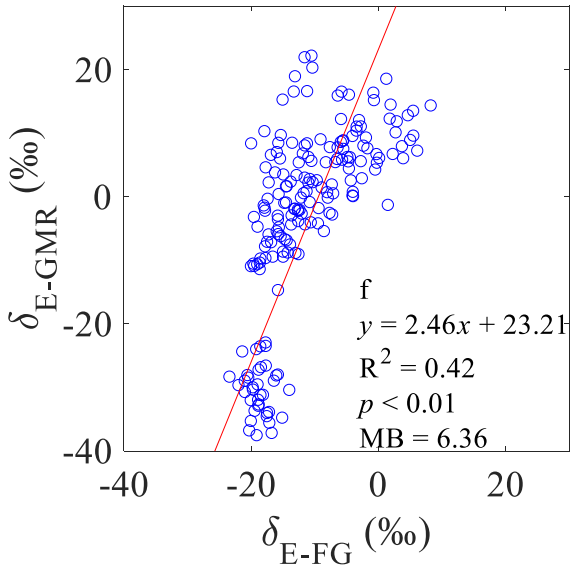












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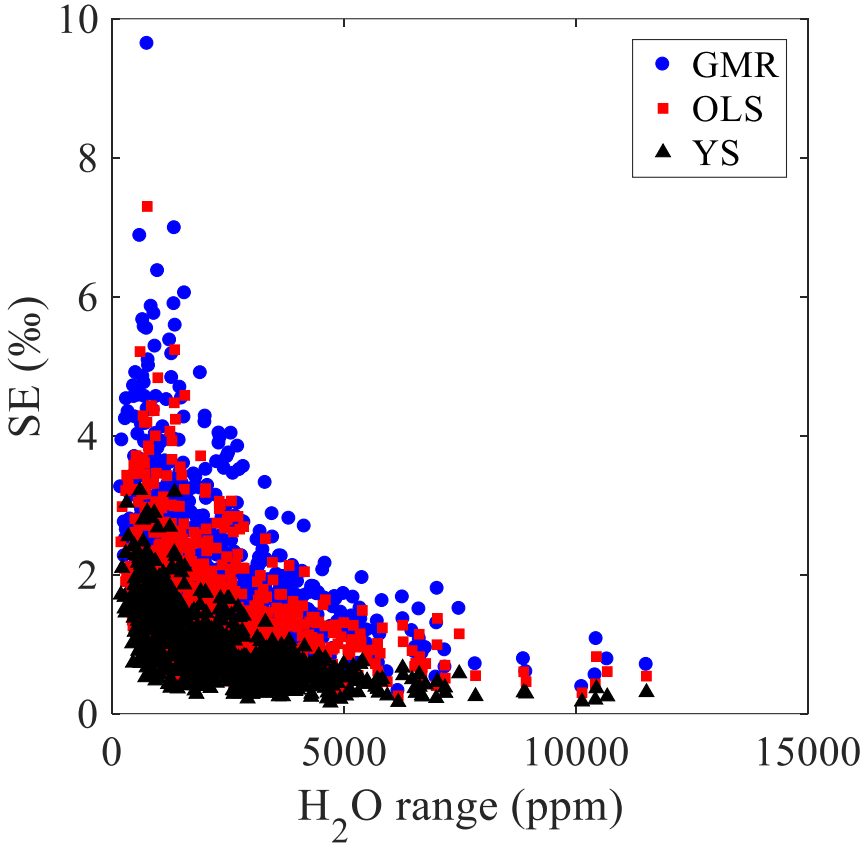

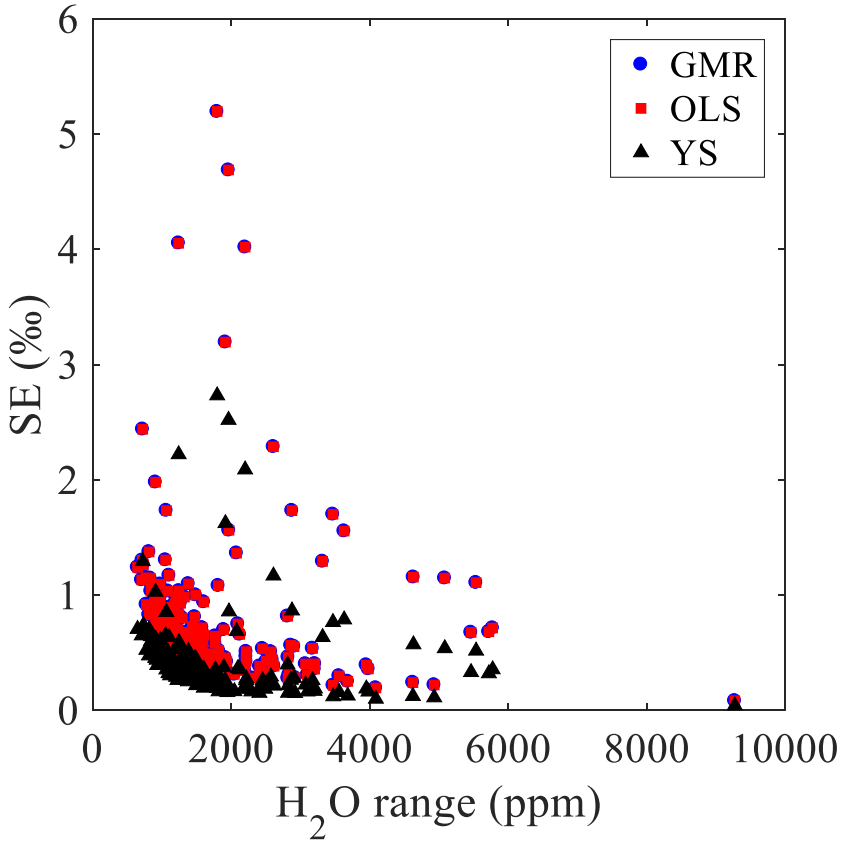

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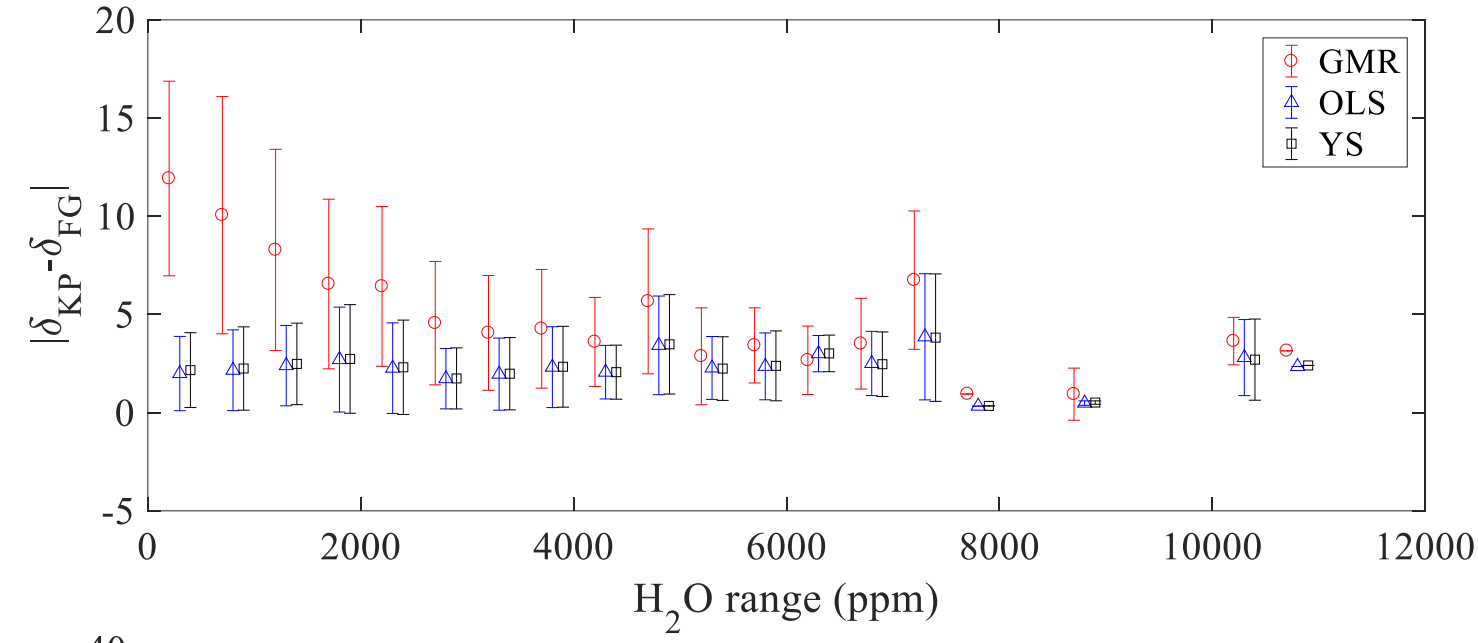
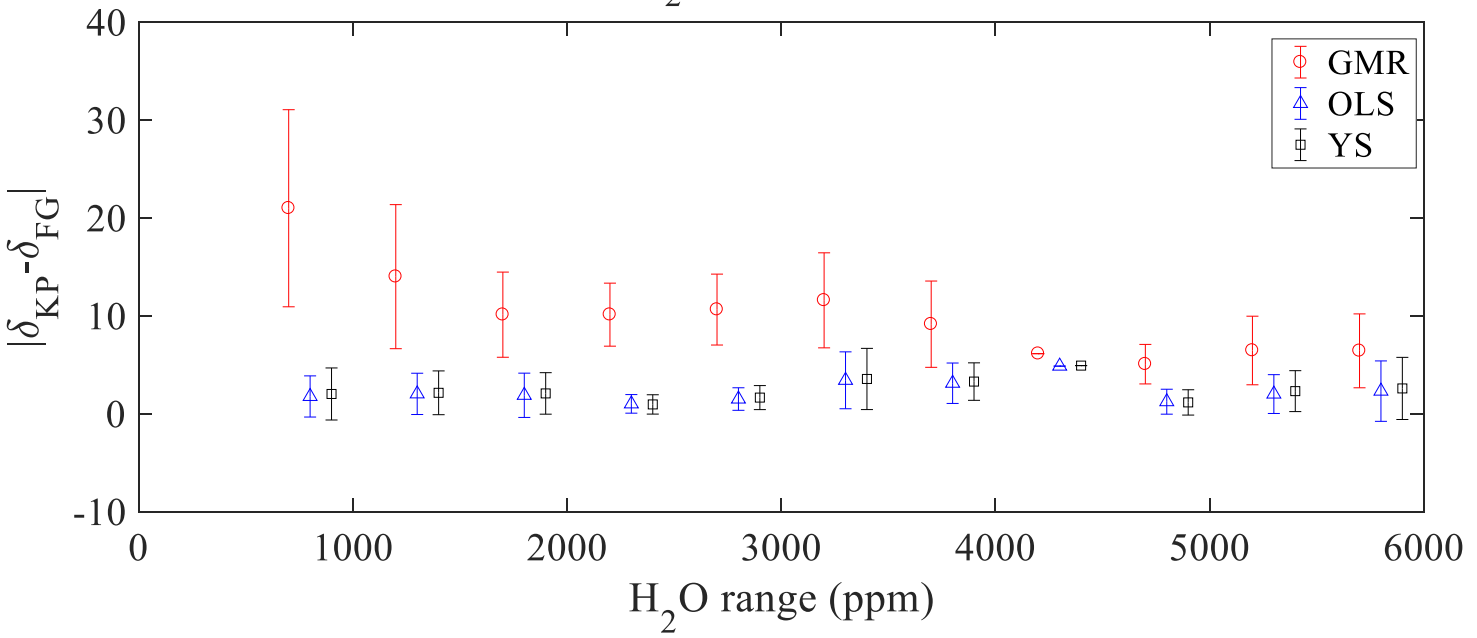
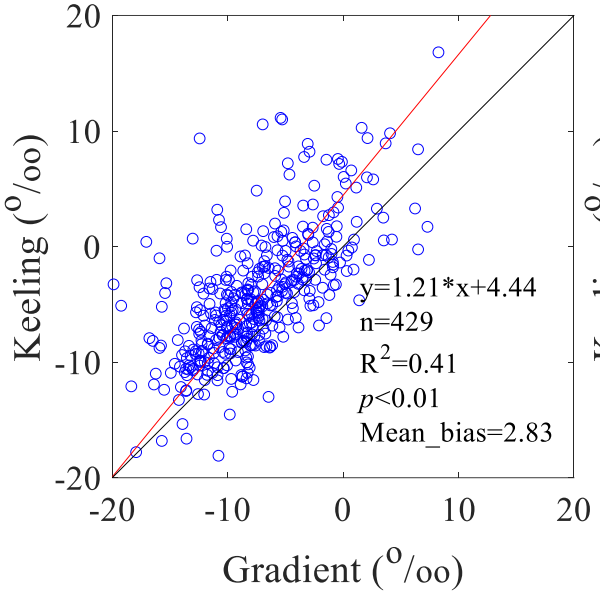
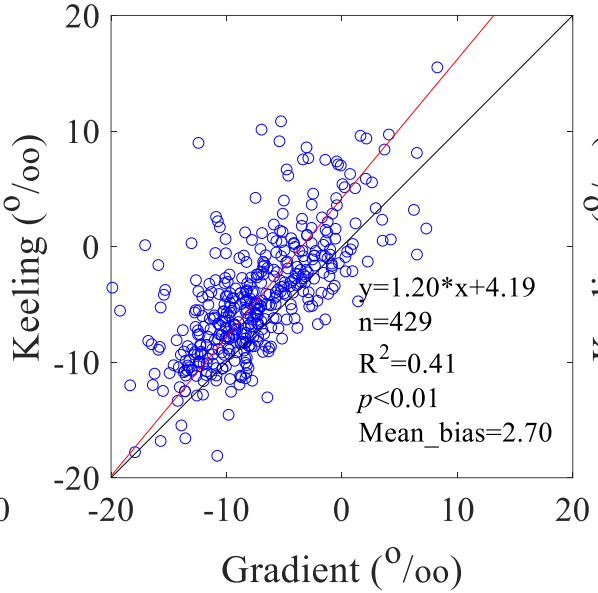


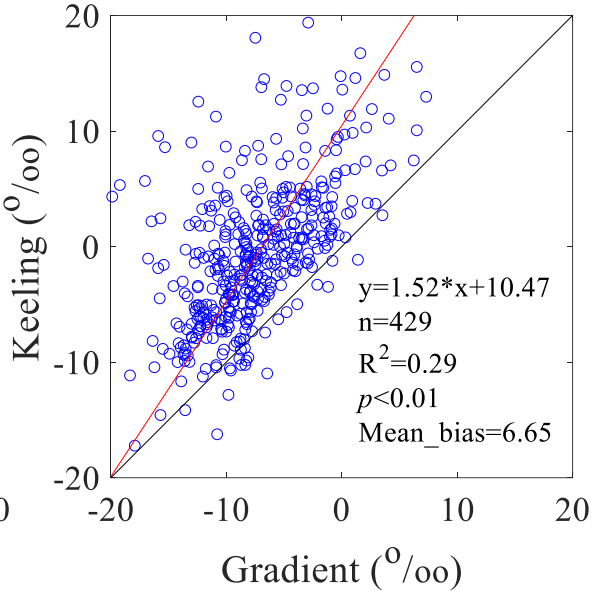


Inlet selection (Heihe)

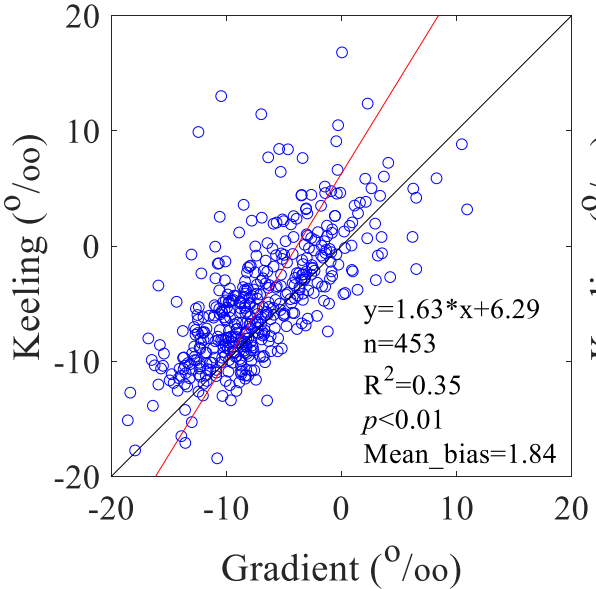
Lower level

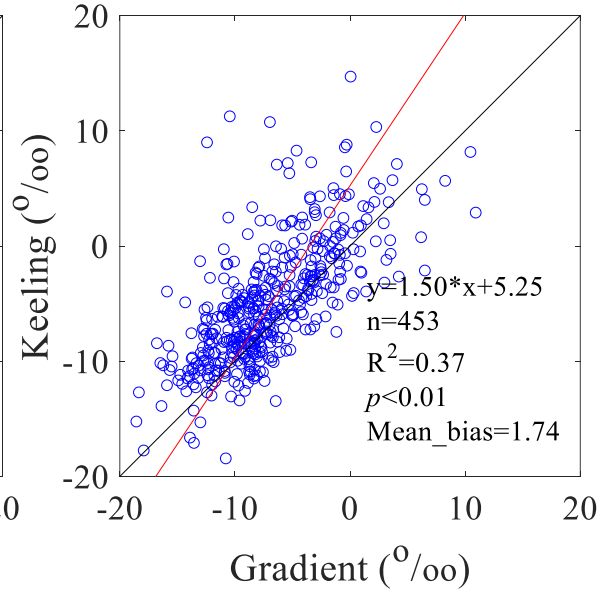


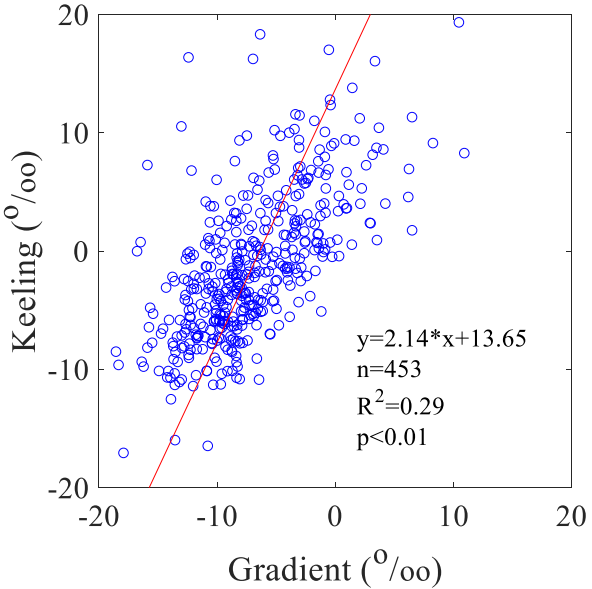




Upper level

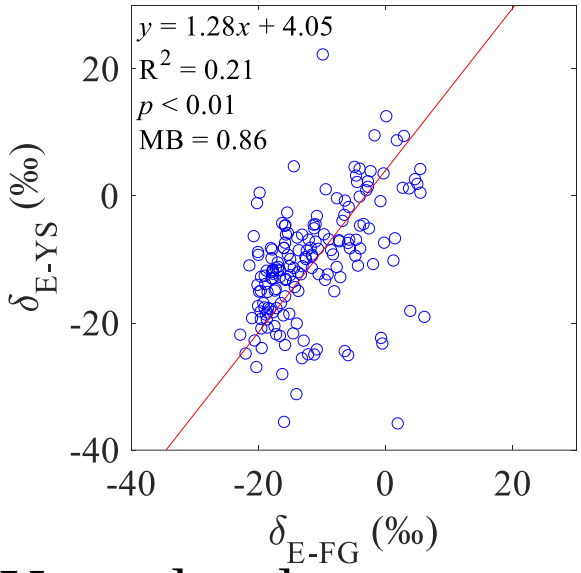


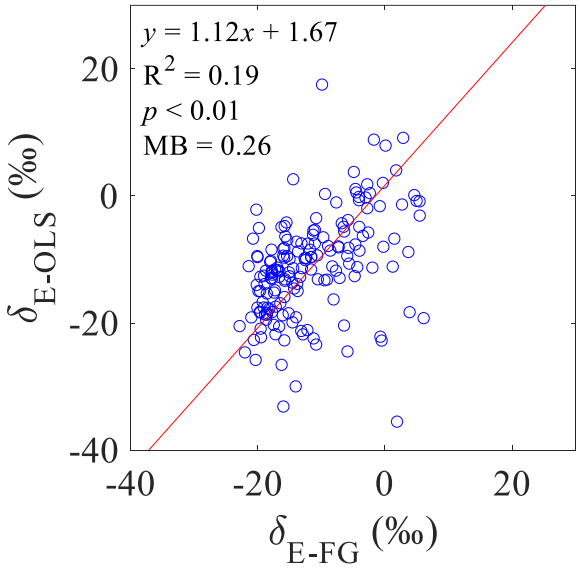


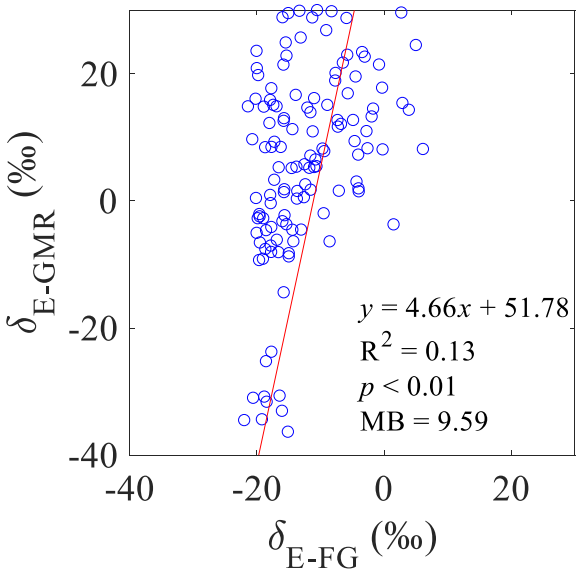


Inlet selection (Lake Taihu)

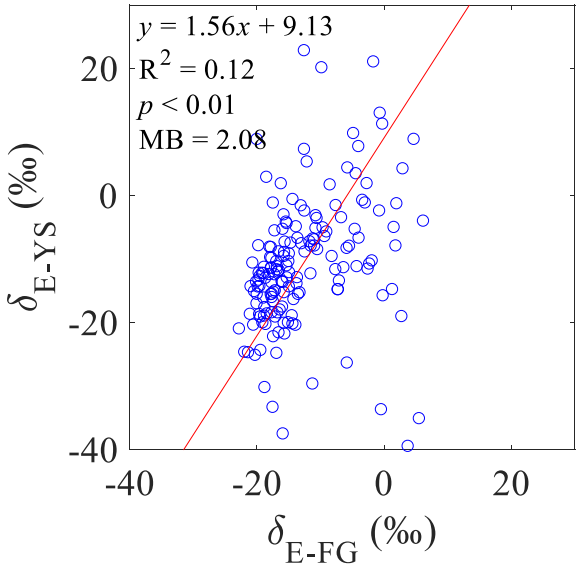
Lower level

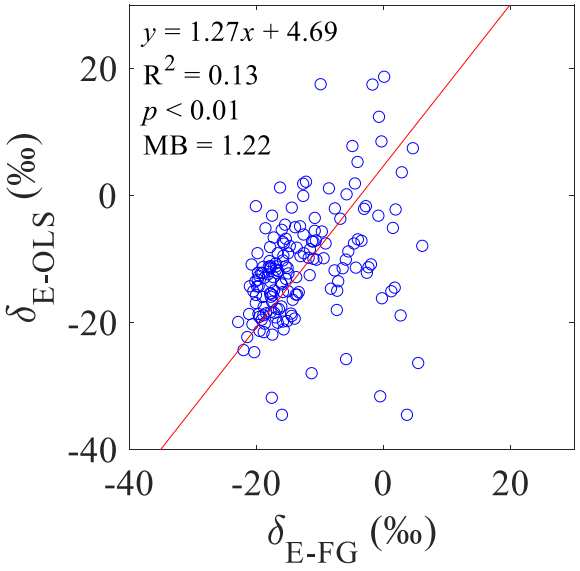


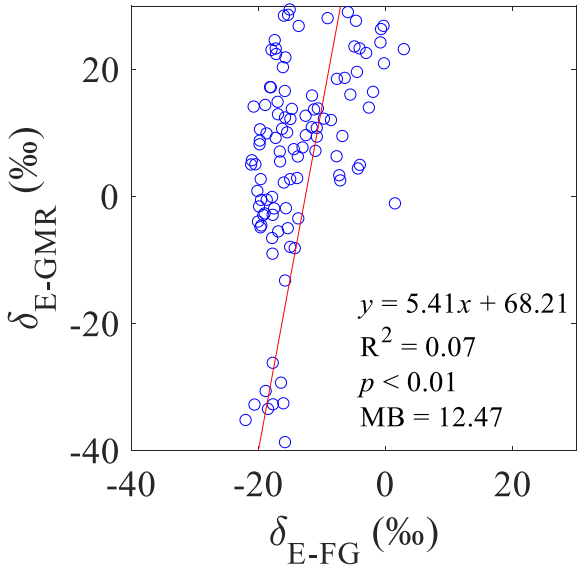




Upper level







Conclusions

- High-frequency data can be used to calculate δ_E in Keeling plot method.
- Using two levels observed data can get better KP results.
- Using OLS or YS regression method in Keeling plot can get consistent results with flux gradient method.

Thanks for your attention!