Using the box model to constrain anthropogenic CO_2 emission in the city of Nanjing

Yale-NUIST Center on Atmospheric Environment
Yale Univ. and Nanjing Univ. of Infor. Sci. & Tech.

Gao Yunqiu

Outline

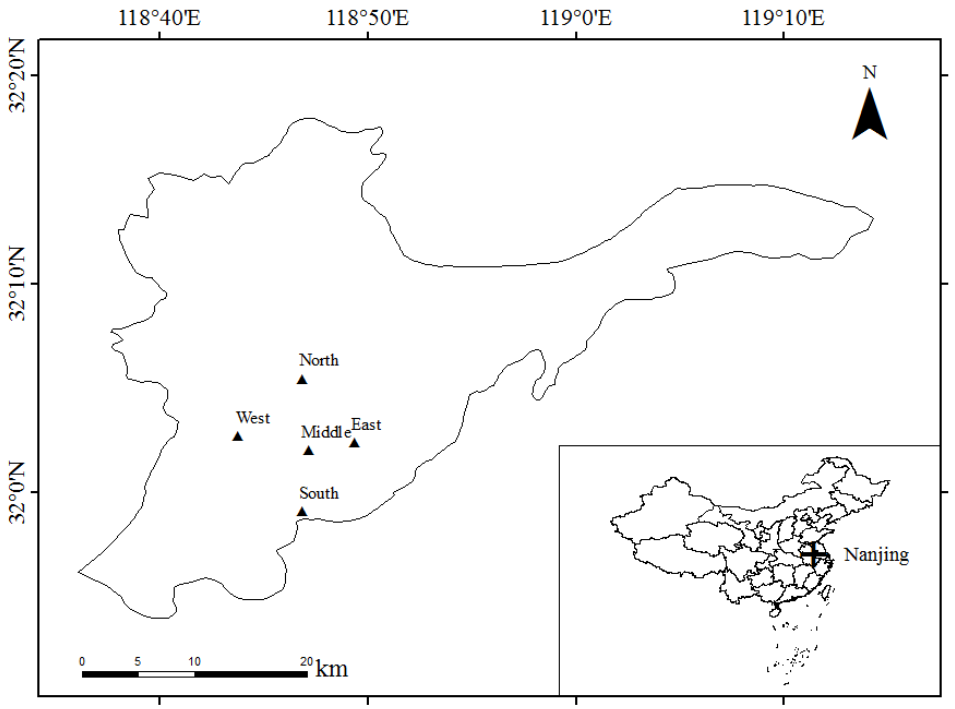
- Background
- Methods and materials
- Results
- Conclusion and on-going work

Background

- Urban areas are important sources of GHGs. Globally, much more CO_2 is emitted from anthropogenic sources in urban area with comparison to suburbs and the natural landscapes.

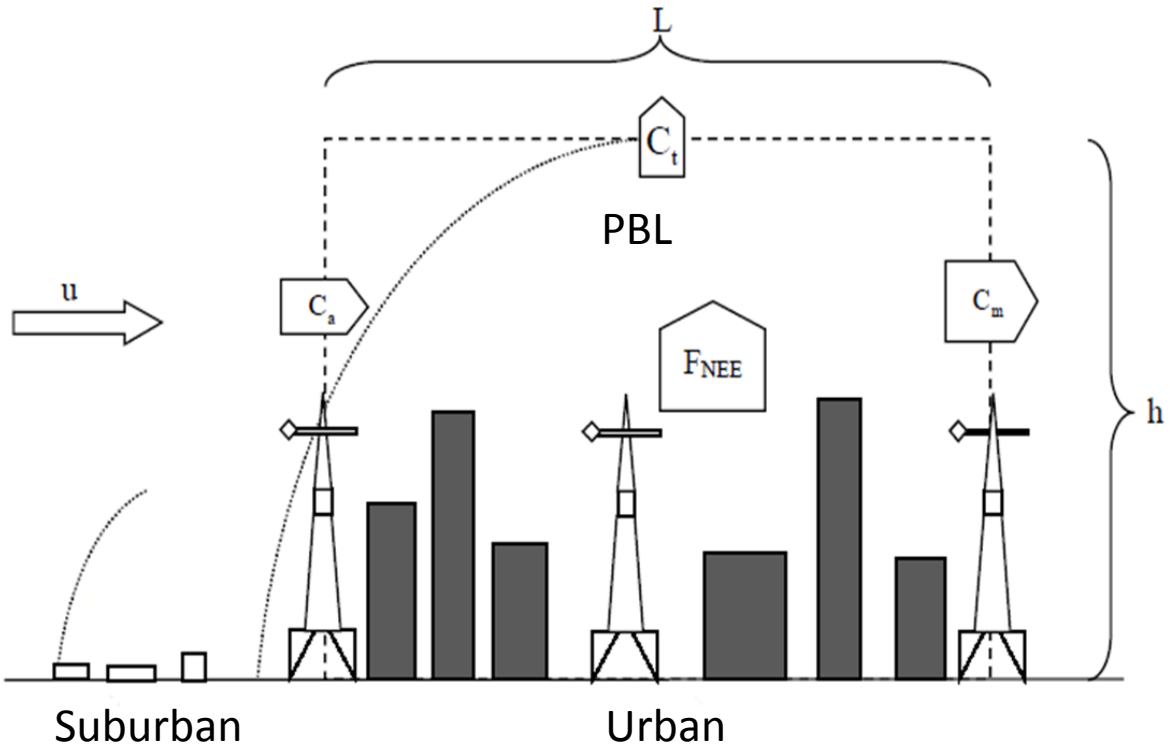
- In this study, we measured CO_2 in the city of Nanjing, China. The data were used with a box model to determine the spatial and temporal variation of the urban surface CO_2 source strength.

Methods and materials



We made measurements on the roof of 5 tall buildings (100-120 m tall) located in the north, east, south, west and middle of the Nanjing City (April 20-26 2014).

- Box Model



C_m, C_a and C_t represent urban, suburban and free atmospheric CO_2 concentration.

- Main equation

PBL height

$$F_{NEE} = \rho h \frac{\partial C_m}{\partial t} - \rho h \frac{u}{L}(C_a - C_m) + \rho \frac{\partial h}{\partial t}(C_t - C_m)$$

Free atmospheric CO_2 concentration

- PBL height

(1) This data come from Nanjing Weather Bureau

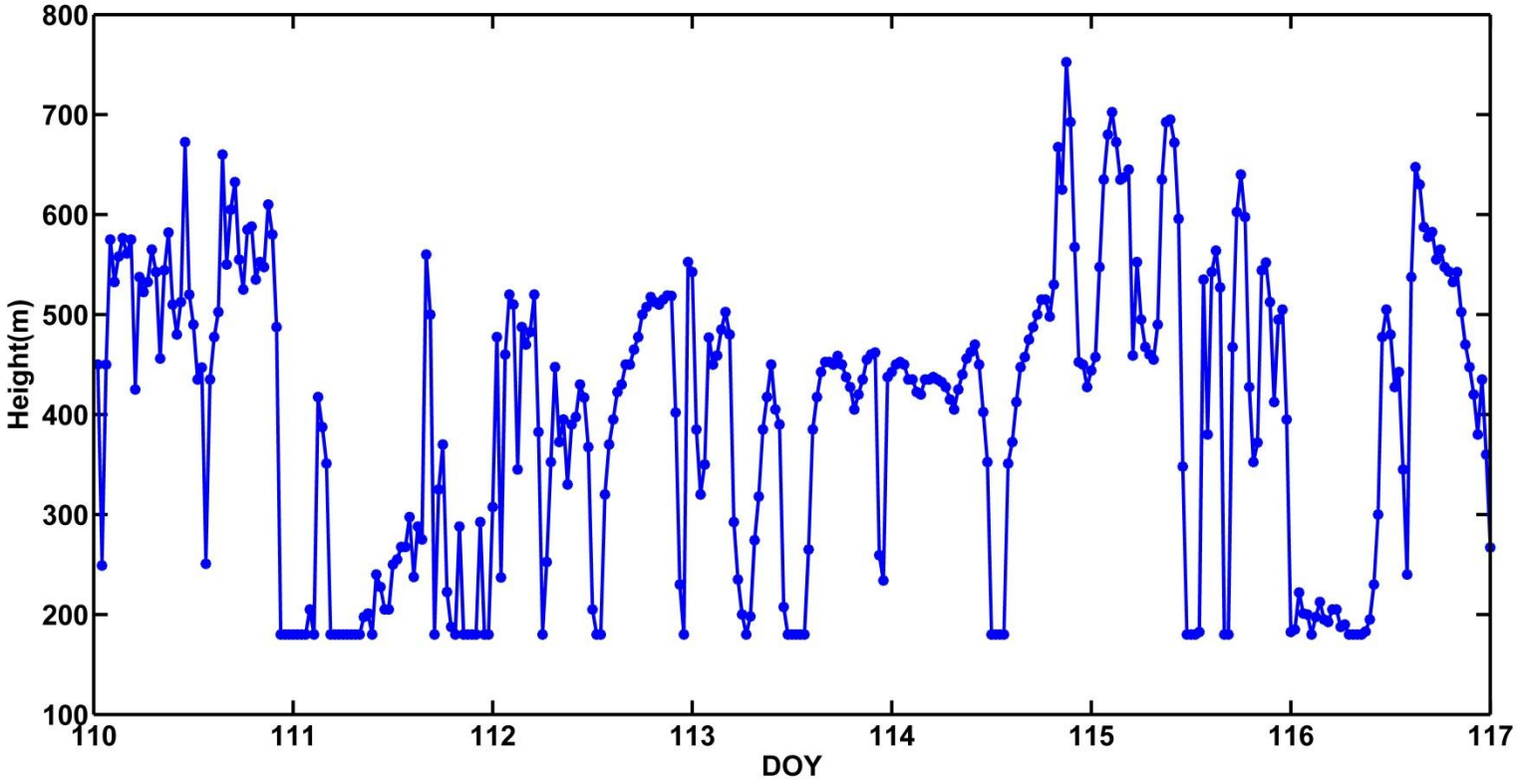


Fig.1. Heights of PBL in Nanjing

(2) Empirical equation $h = c(u^*|L|/|f|)^{\frac{1}{2}}$ (Zilitinkevich,

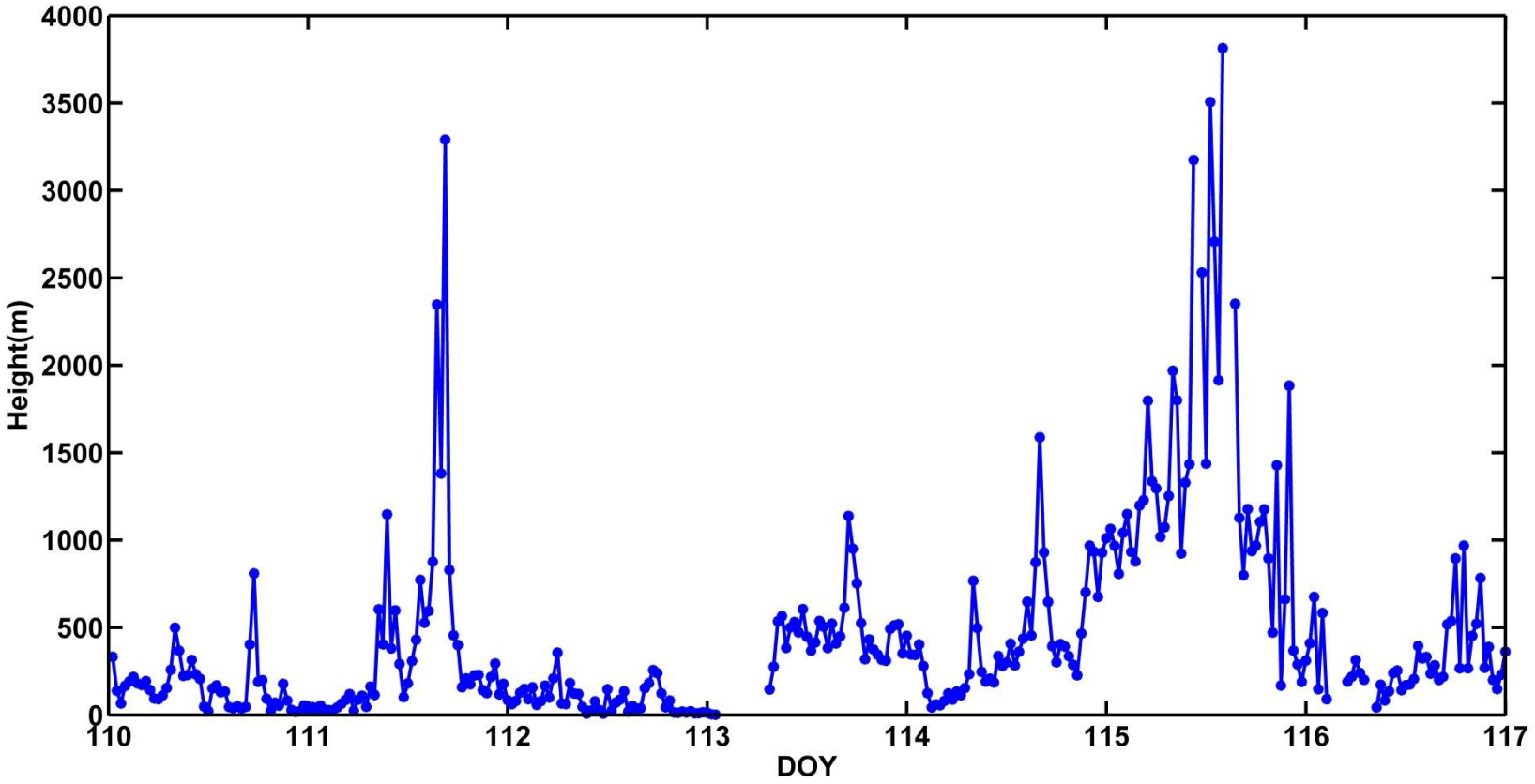


Fig.2. Heights of PBL in Nanjing

- $C_t \longrightarrow (C_t - C_m)$

Tab.1. Monthly Means and Standard Error of ABL and Free-Tropospheric Mixing for CO_2

Month	C_t, ppmv	C_m, ppmv
Jan.	371.9 ± 0.2	376.4 ± 0.5
Feb.	372.4 ± 0.2	376.8 ± 0.4
Mar.	373.1 ± 0.2	377.9 ± 0.6
Apr.	374.4 ± 0.2	376.6 ± 0.2
May	373.9 ± 0.2	372.5 ± 0.8
June	370.8 ± 0.1	365.6 ± 0.7
July	366.8 ± 0.3	357.6 ± 0.7
Aug.	363.9 ± 0.2	358.3 ± 0.9
Sep.	363.7 ± 0.3	366.1 ± 0.7
Oct.	366.9 ± 0.1	371.9 ± 0.8
Nov.	370.7 ± 0.2	375.9 ± 0.4
Dec.	372.8 ± 0.2	375.6 ± 0.4

In April, C_t-C_m=-2.2ppm.
(Heliker B R., et al, 2004)

- C_t

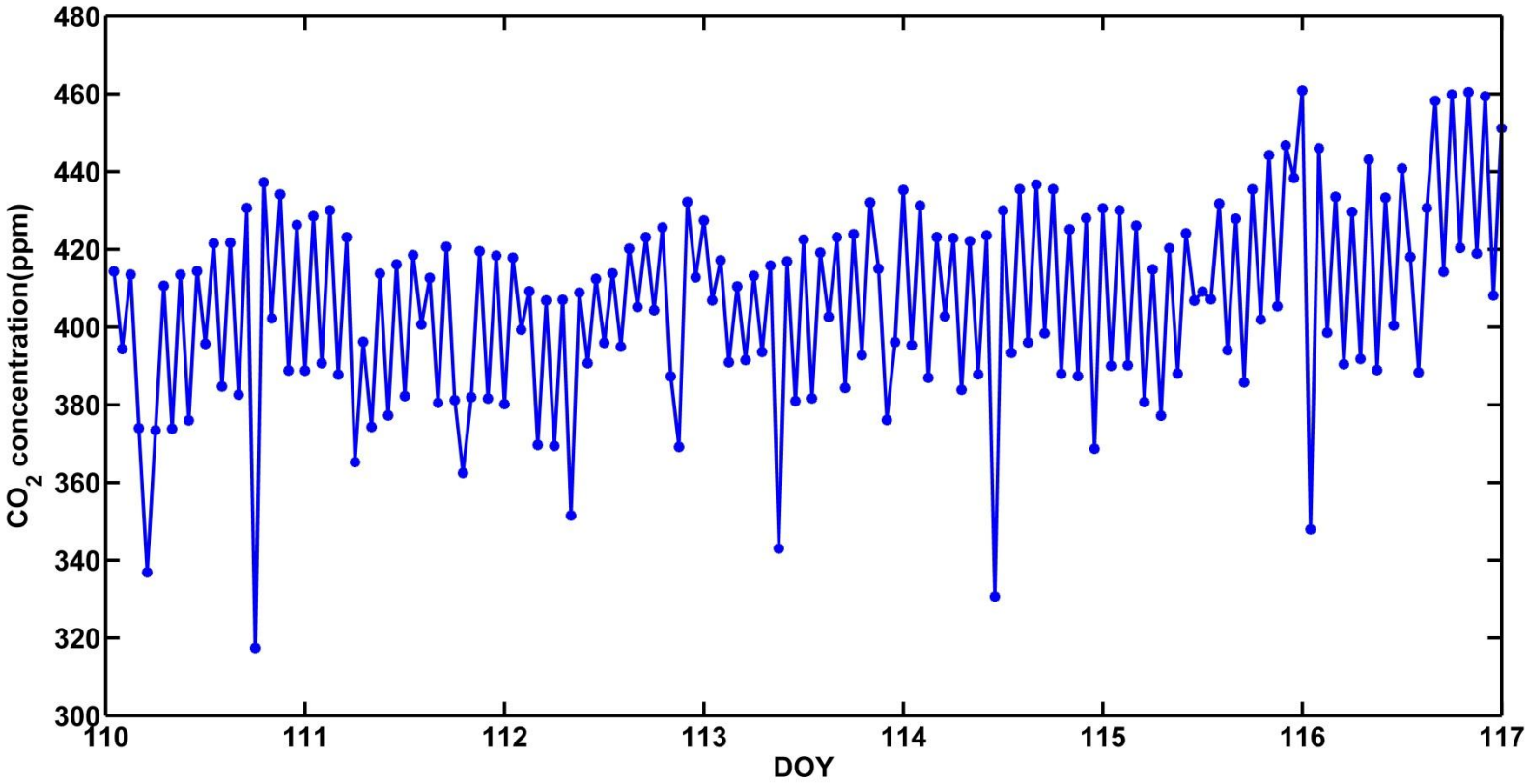


Fig.3. CO_2 concentration observed at Lin'an regional background station from 2014-04-20 to 2014-04-26

Results

- Noon $F_{NEE} = \rho h \frac{u}{L}(C_m - C_a)$ (C_m: downwind, C_a: upwind)

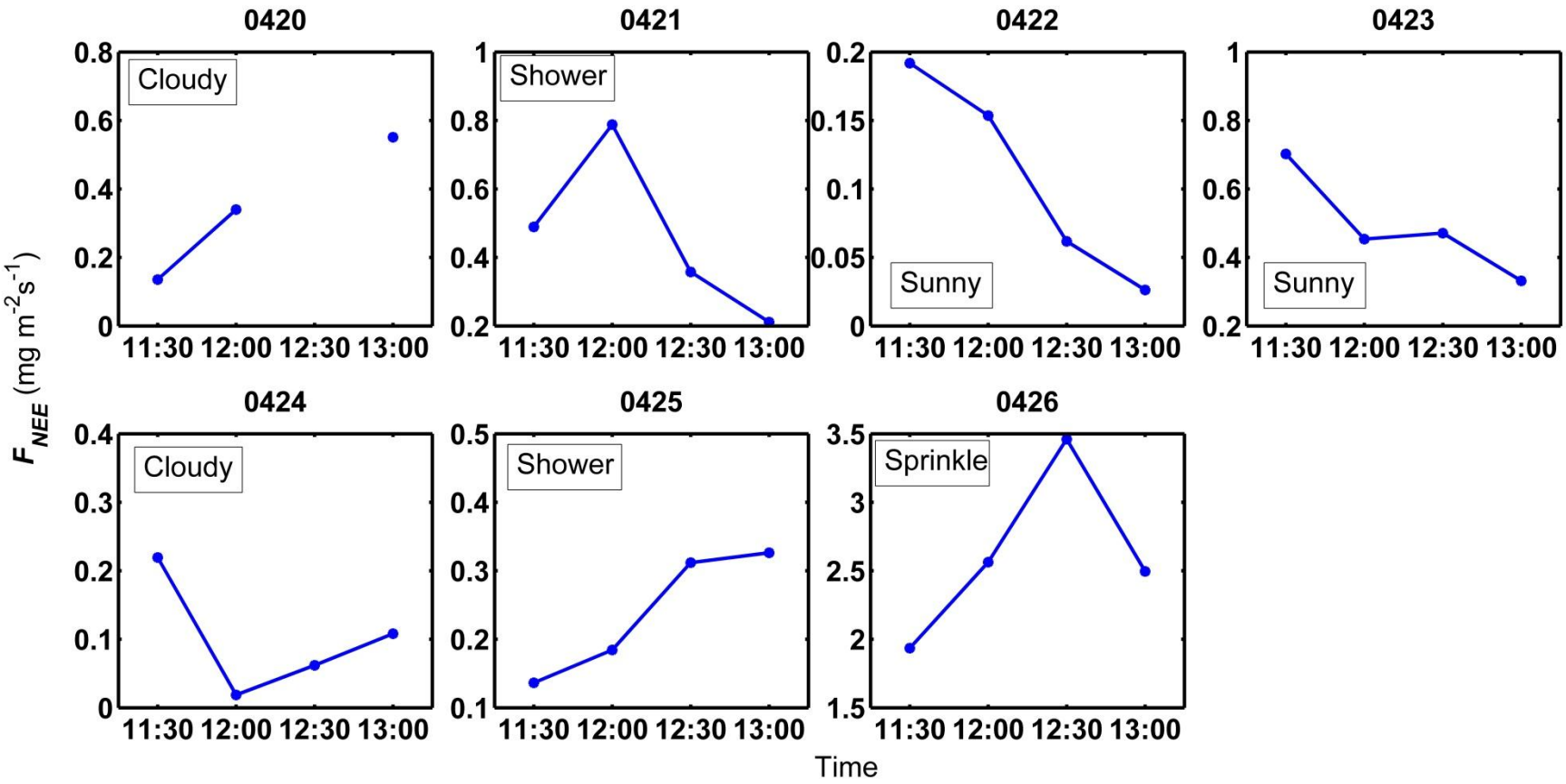
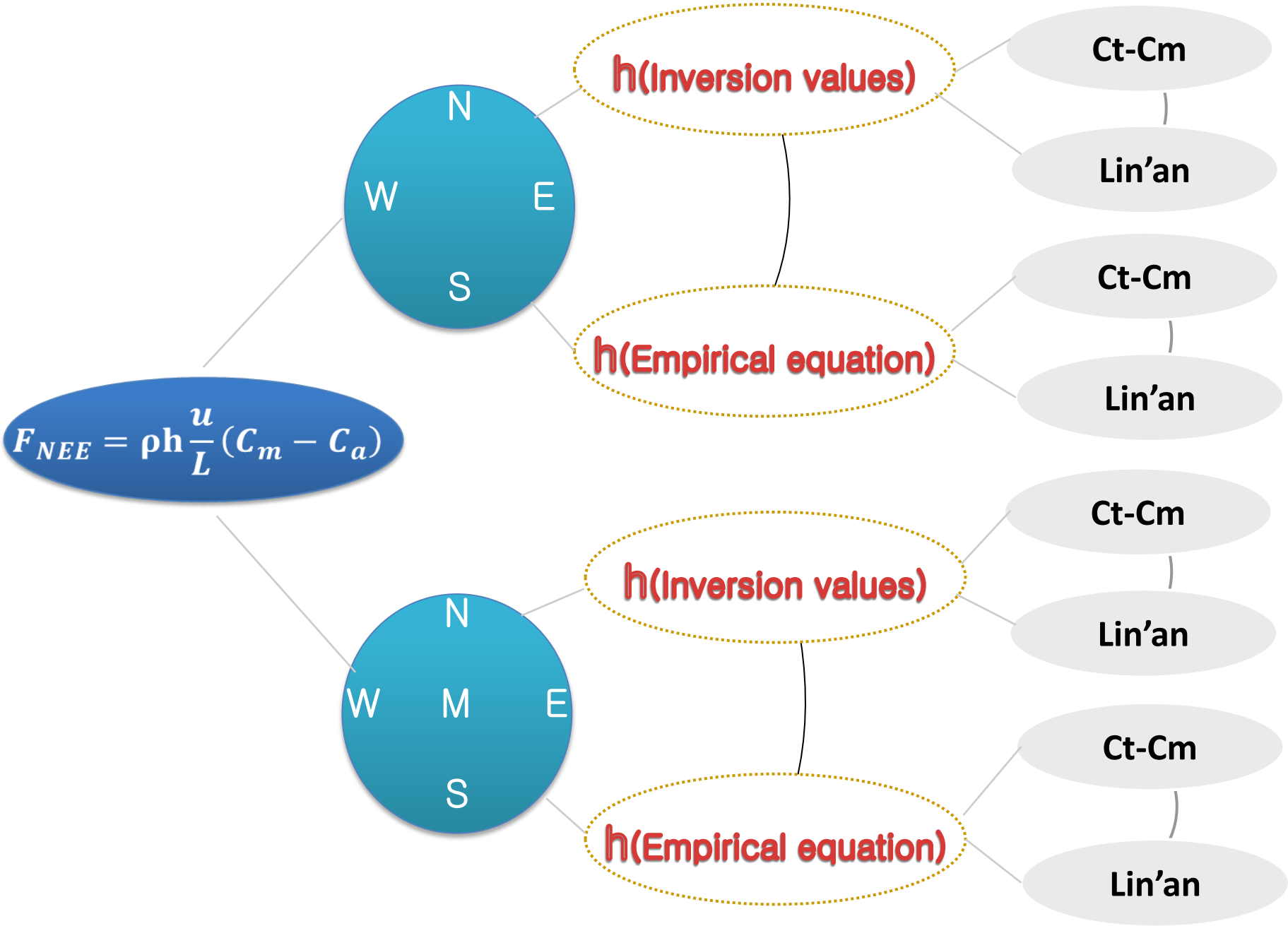
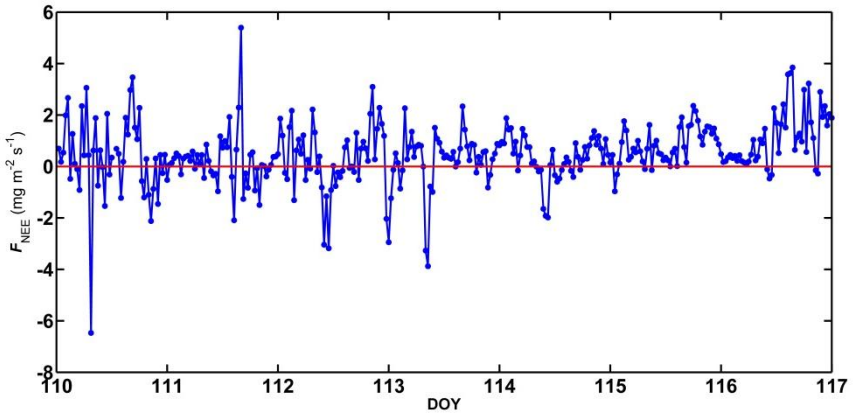


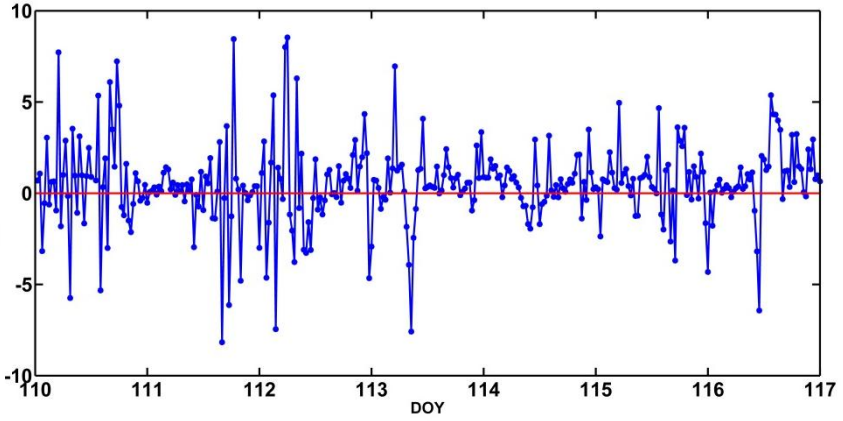
Fig.4. F_{NEE} during the noon


$F_{NEE} = \rho h \frac{u}{L}(C_m - C_a)$
N
W
E
S
h(Inversion values)
h(Empirical equation)
Ct-Cm
Lin'an
Ct-Cm
Lin'an
N
W
M
E
S
h(Inversion values)
h(Empirical equation)
Ct-Cm
Lin'an
Ct-Cm
Lin'an

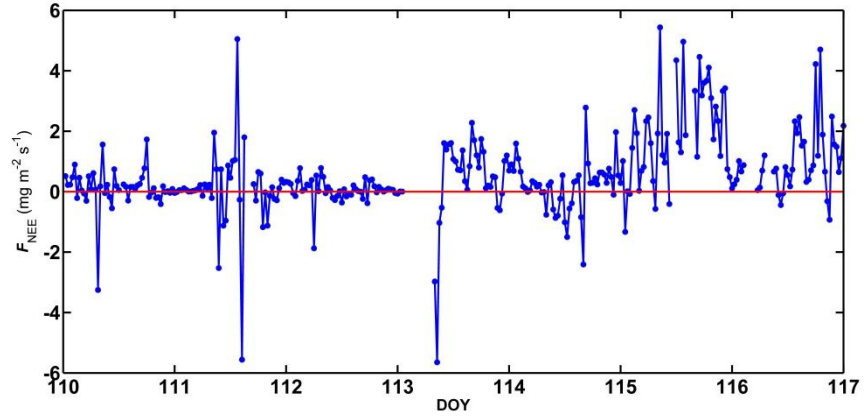
- Four sites



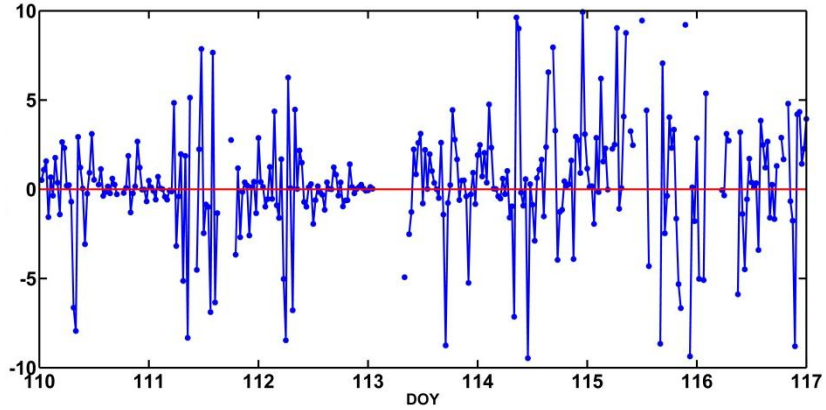
a. Four sites, h(inversion values) and C_t-C_m



b. Four sites, h(inversion values) and Lin'an



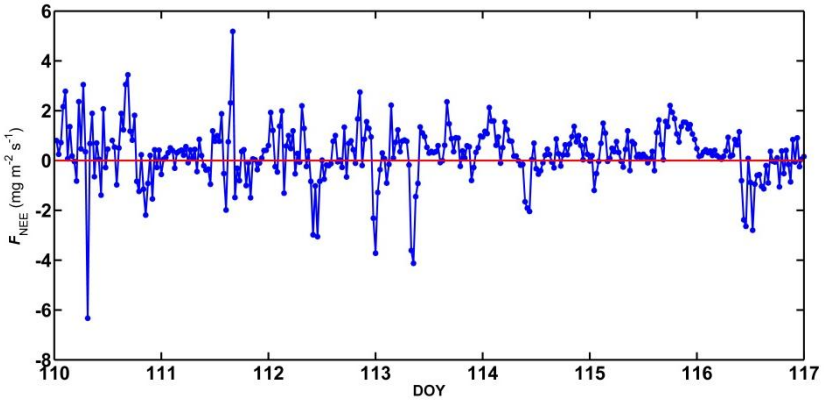
c. Four sites, h(empirical equation) and C_t-C_m



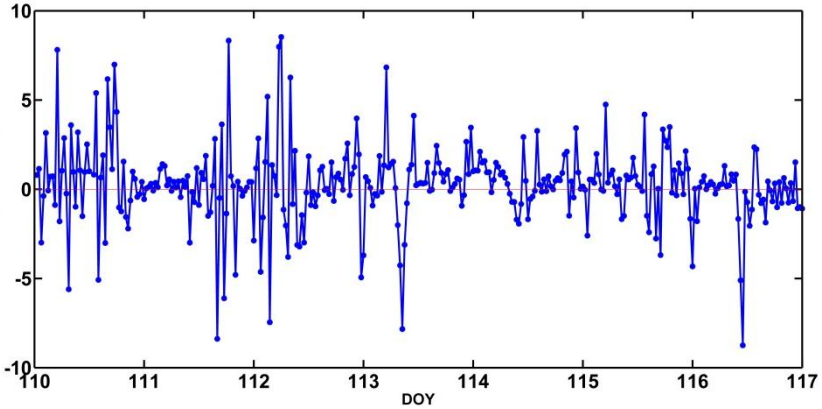
d. Four sites, h(empirical equation) and Lin'an

Fig.5. Time series of F_{NEE}

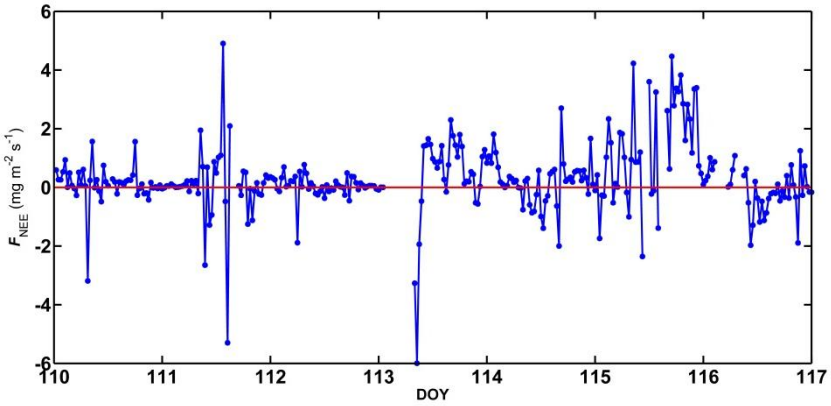
- Five sites



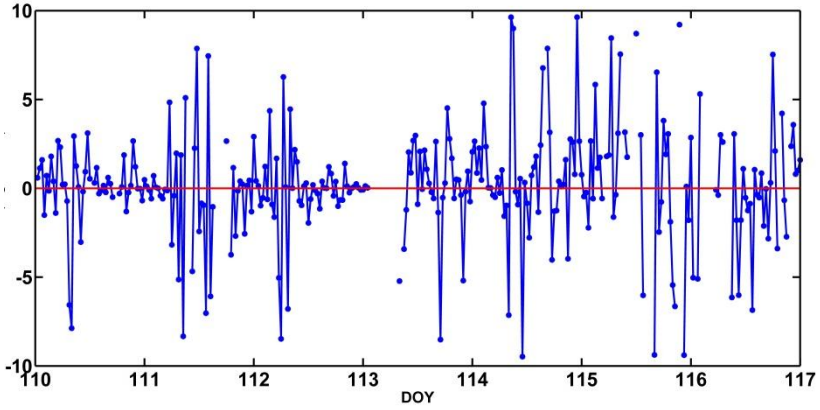
a. Five sites, h(inversion values) and C_t-C_m



b. Five sites, h(inversion values) and Lin'an



c. Five sites, h(empirical equation) and C_t-C_m



d. Five sites, h(empirical equation) and Lin'an

Fig.6. Time series of F_{NEE}

Tab.1. Average F_{NEE} for the entire study (mg m^{-2} s^{-1})

	h(inversion values) and C_t-C_m	h(inversion values) and Lin'an	h(empirical equation) and C_t-C_m	h(empirical equation) and Lin'an
Four sites	0.49	0.51	0.52	0.31
Five sites	0.26	0.28	0.29	0.18

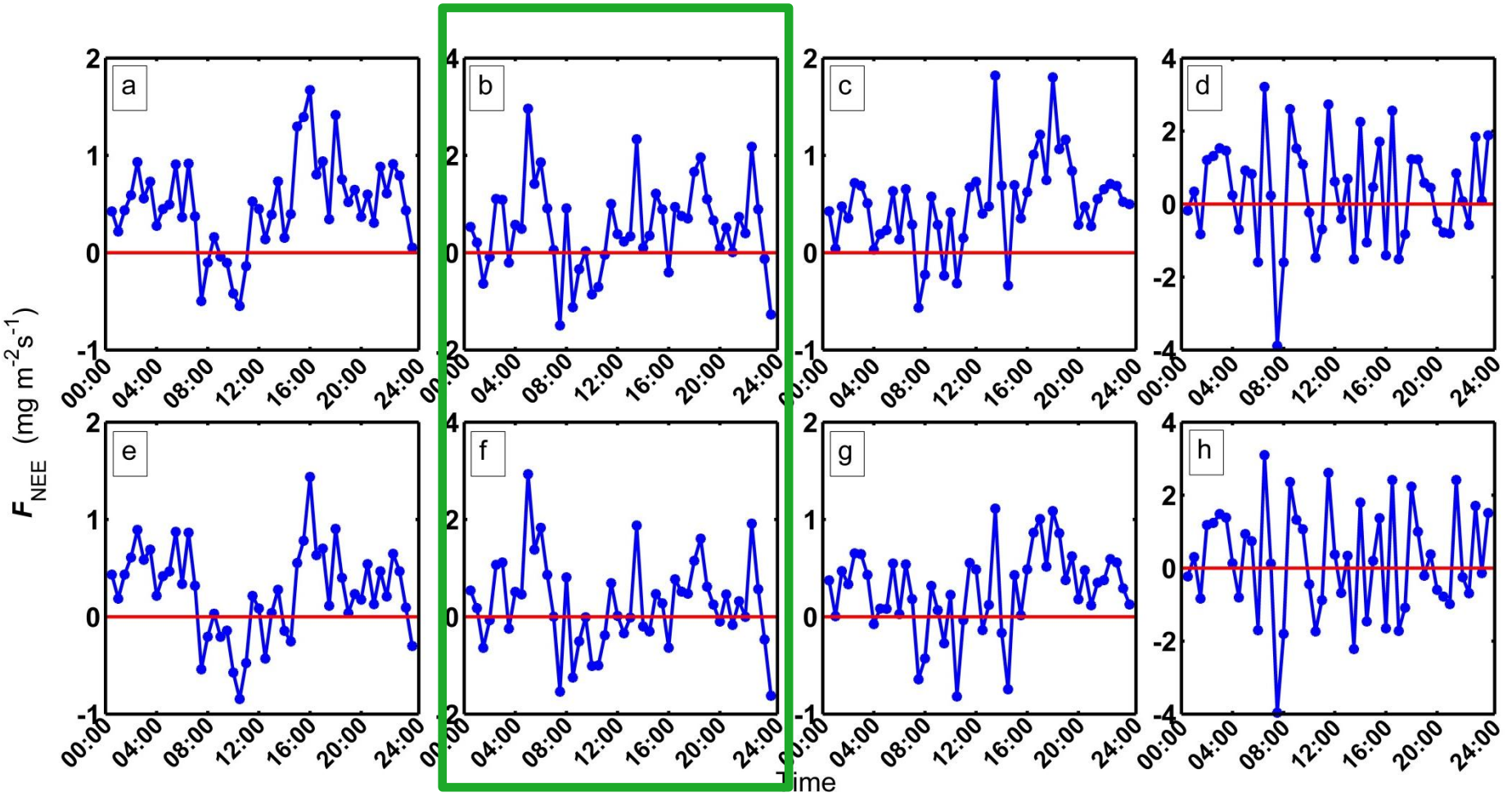


Fig.7. Average diurnal pattern of F_{NEE} for the entire study

a. Four sites, h(inversion values) and C_t-C_m, b. Four sites, h(inversion values) and Lin'an, c. Four sites, h(empirical equation) and C_t-C_m, d. Four sites, h(empirical equation) and Lin'an , e. Five sites, h(inversion values) and C_t-C_m, f. Five sites, h(inversion values) and Lin'an, f. Five sites, h(empirical equation) and C_t-C_m, h. Five sites, h(empirical equation) and Lin'an

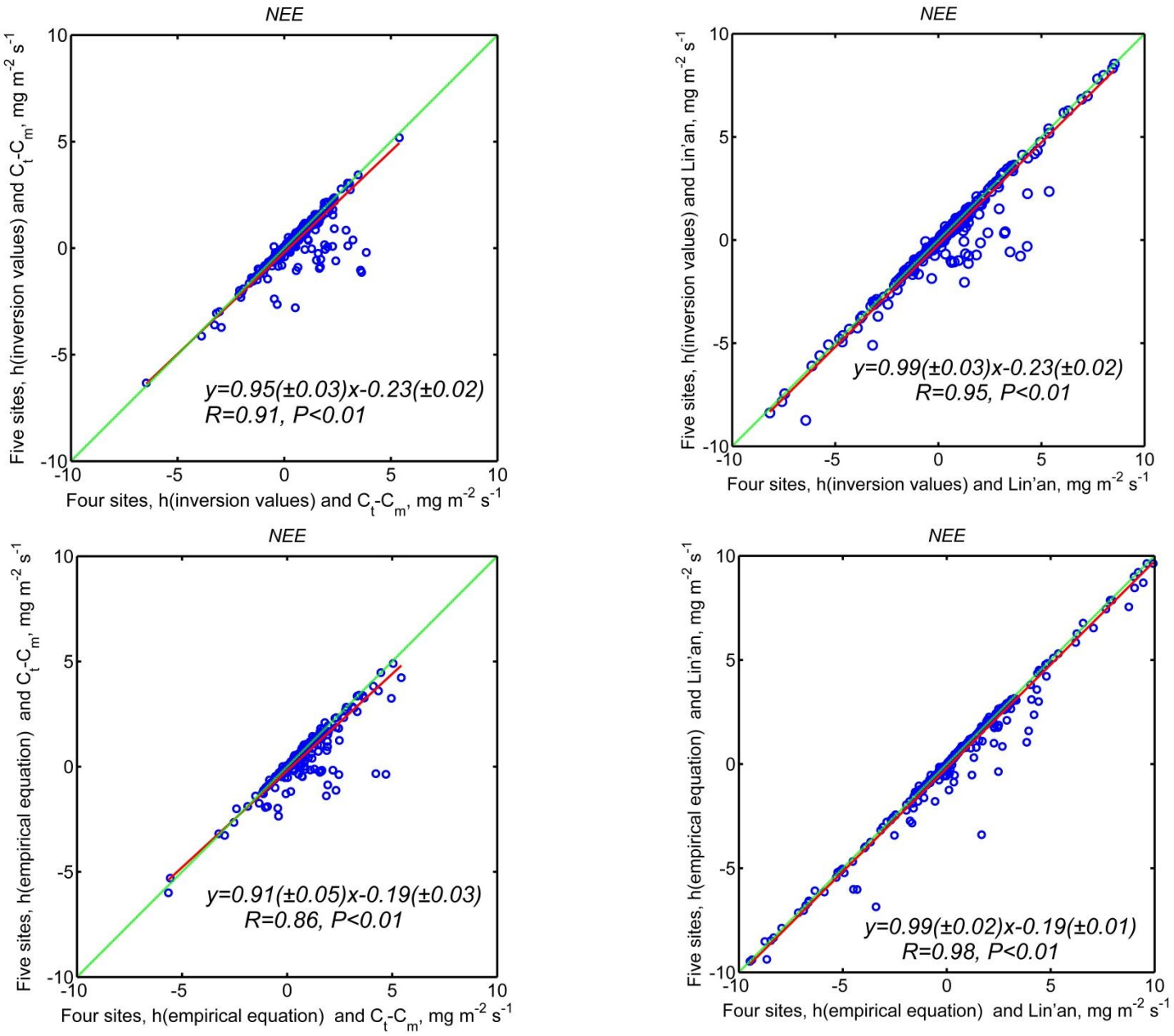


Fig.7. Correlation between four sites and five sites

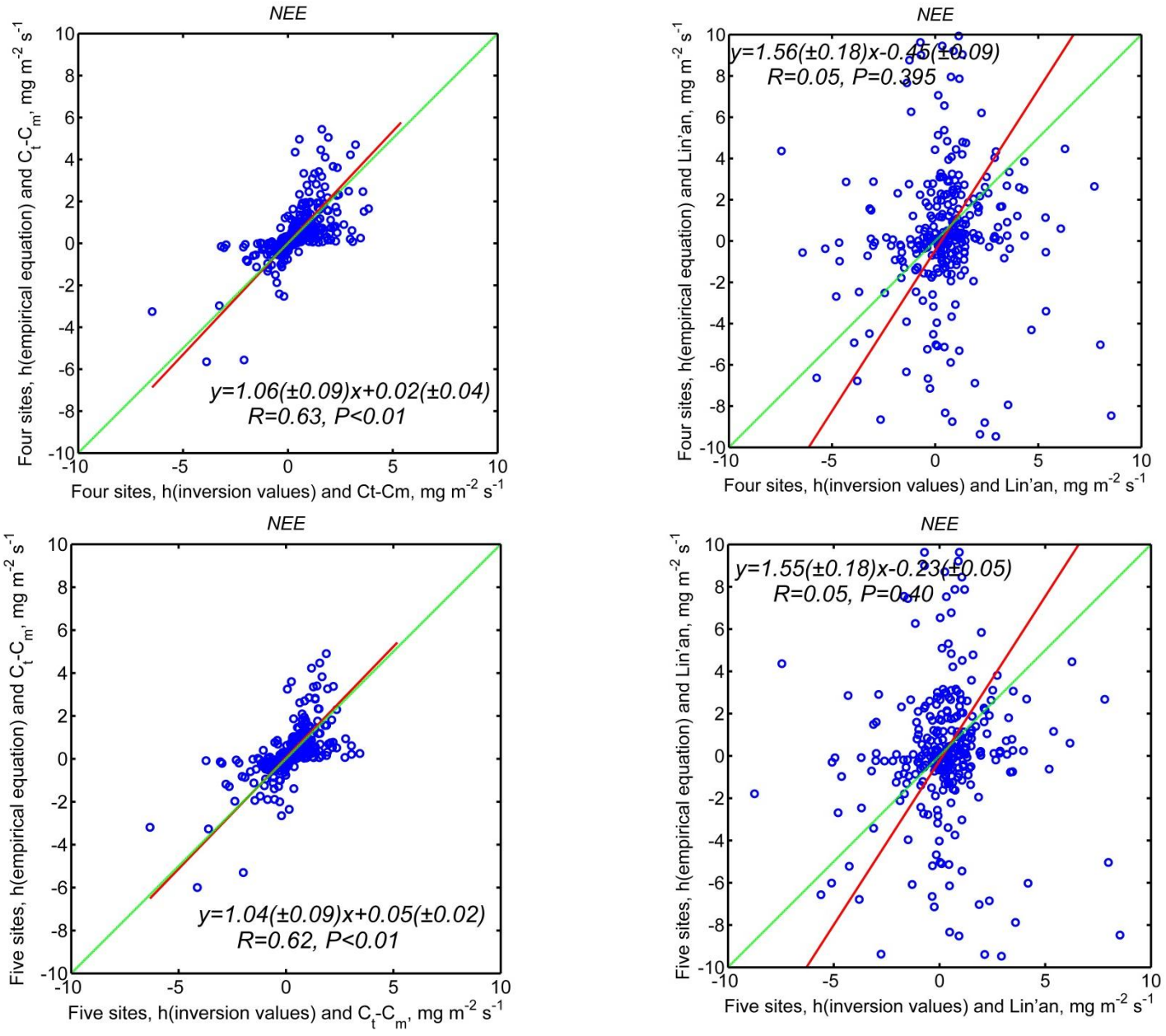


Fig.8. Correlation between h(inversion values) and h(empirical equation)

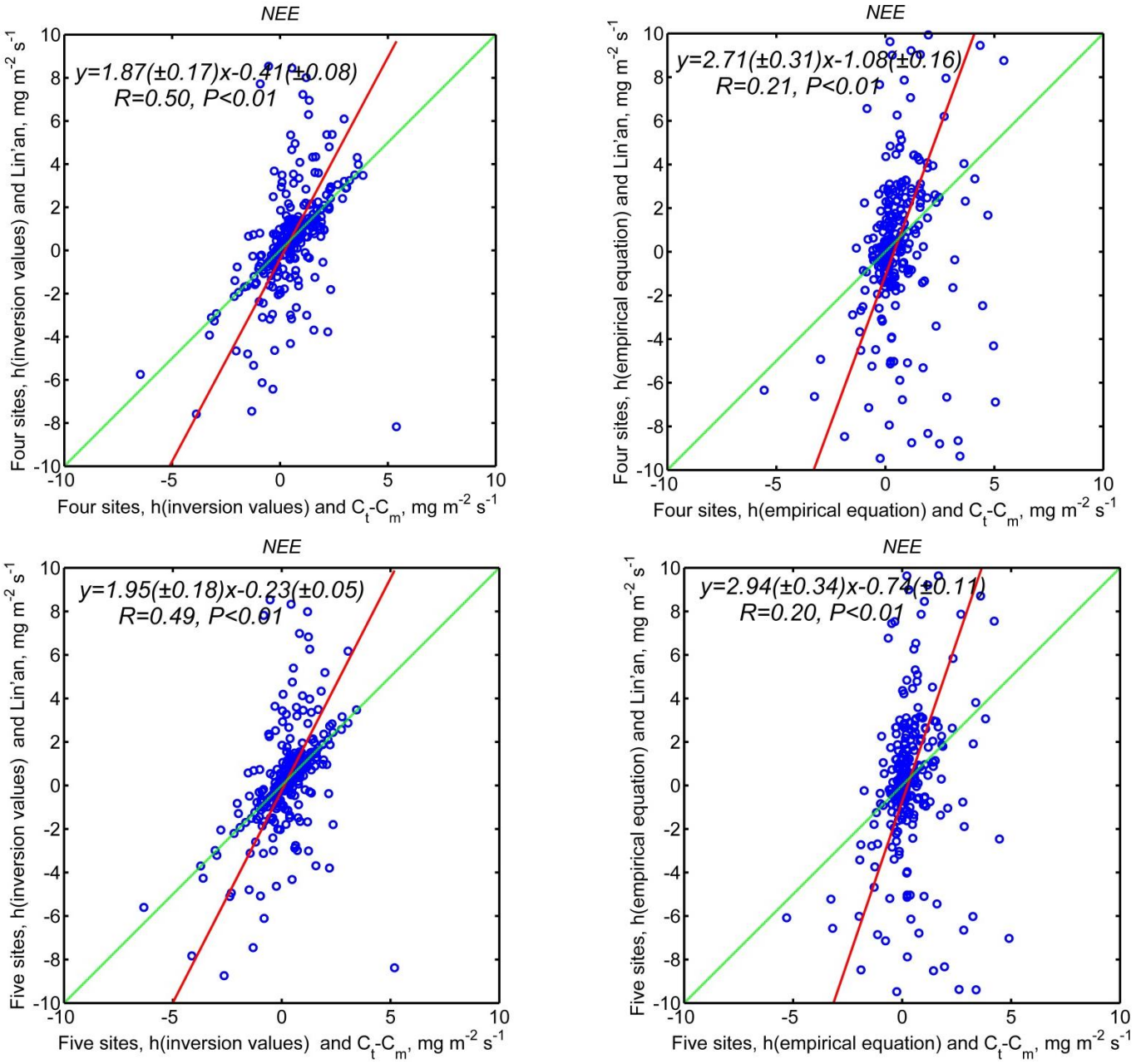


Fig.8. Correlation between C_t-C_m and Lin'an

Conclusion and on-going work

- On the whole, the result shows that Nanjing is carbon source.

- I still need to find more appropriate parameters to improve the estimation of CO_2 flux.

Thank you