Estimating urban net CO_2 flux using a box model

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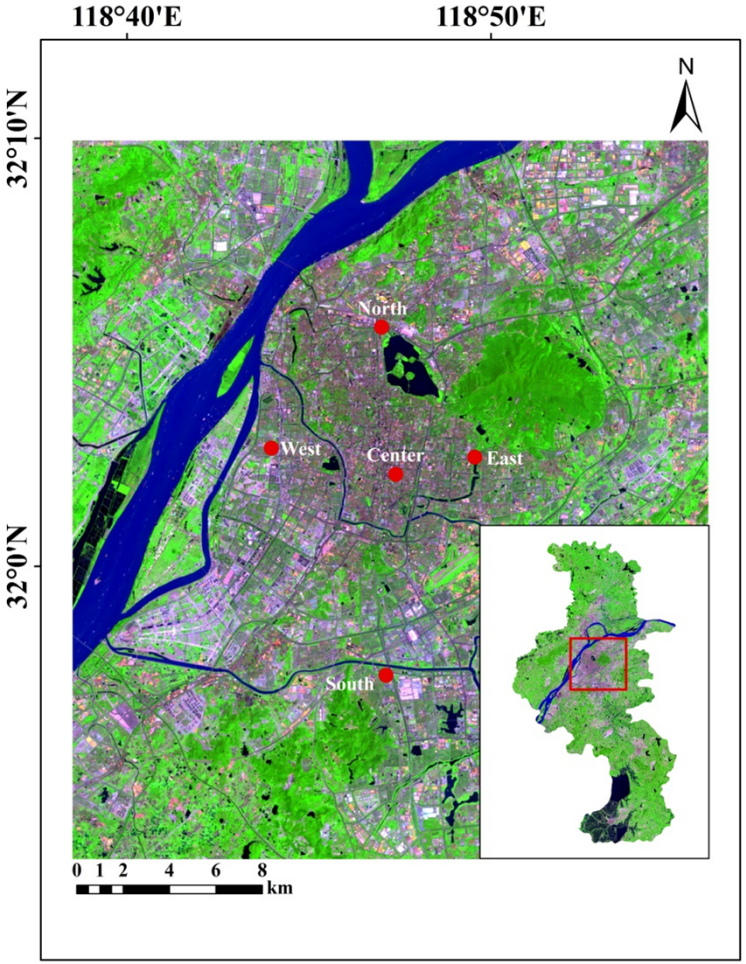
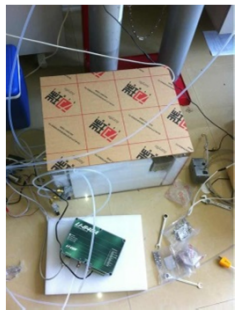
Background

- 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.

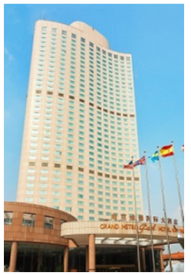
- In this study, we measured CO_2 in the city of Nanjing, China. The data were used with a box model to determine the spatial and temporal variation of the urban surface CO_2 source strength.

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. 15km distance from north to south, and 8.8 km distance form west to west.

Tab.1 Summary of the dates of the experiments

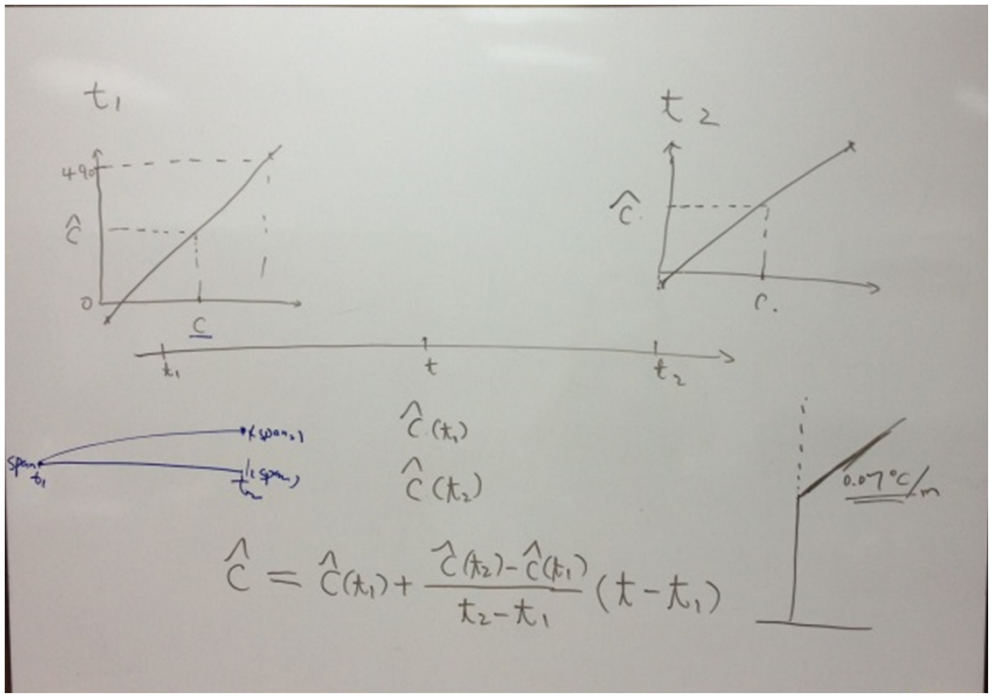
	Time	Status
Winter	20140112-20140118	conducted
April	20140420-20140426	conducted
Summer	20140717 00:00-20140725 17:00	conducted
Autumn	20141007 17:00-20141016 12:00	conducted
Winter	201501**	plan to conduct

linear interpolation

$$C(t) = \frac{C_{st1} - 0}{C_{st3} - C_{st2}} C_{obs}(t) - \frac{C_{st1} - 0}{C_{st3} - C_{st2}} C_{st2}$$

$$C = C(t_1) + \frac{C(t_2) - C(t_1)}{t_2 - t_1}(t - t_1)$$

- **t**: observed time
- **t_1, t_2**: calibration time, t1<t<t2
- **C**:calibrated concentration
- **C_{st1}**: value of standard gas of CO_2
- **C_{st2}, C_{st3}**: value of 840A measured standard N_2, CO_2



Results

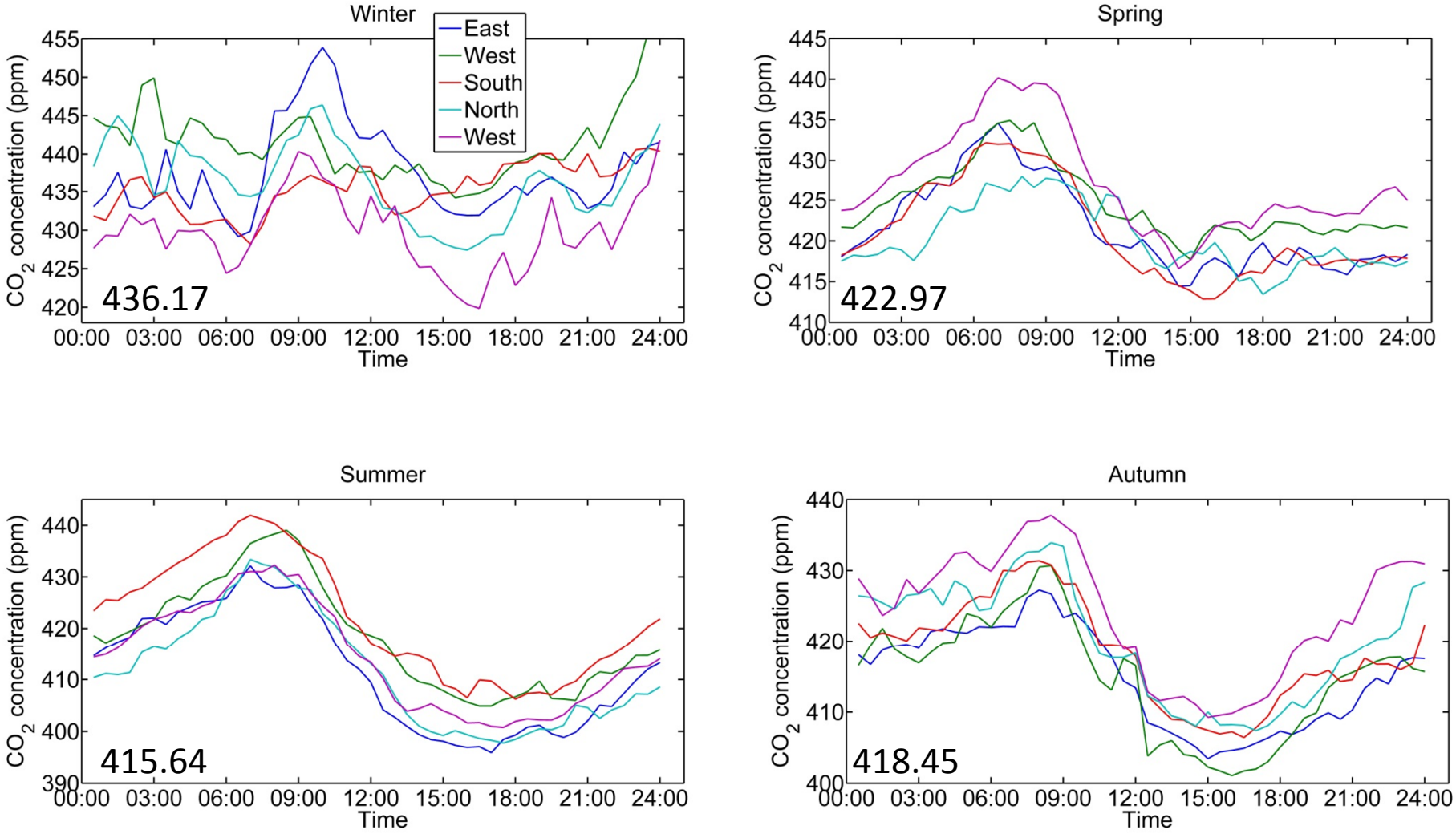
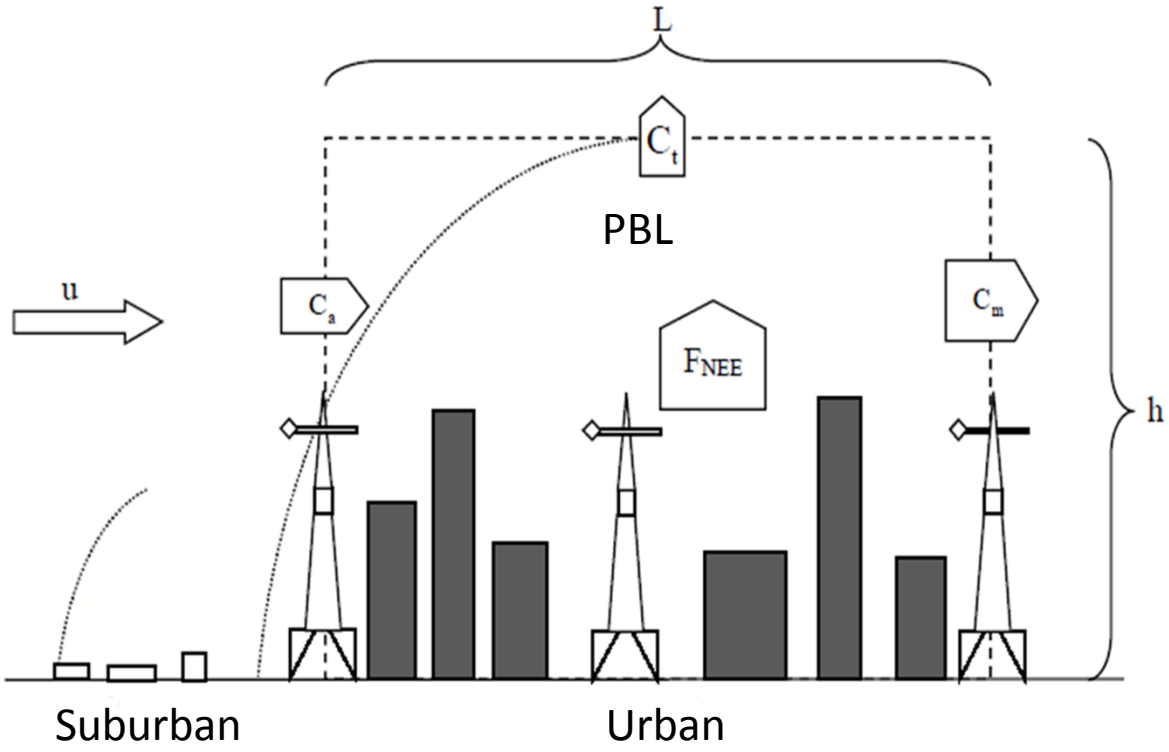


Fig.1 Diurnal pattern of CO_2 concentration

- Box Model



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

- Main equation

$$\mathrm{F}_{NEE} = \rho h \frac{\partial C_m}{\partial t} + \rho \mathrm{h} \frac{u}{\mathrm{L}} \left(C_{down} - \mathrm{C}_{up} \right) + \rho \frac{\partial \mathrm{h}}{\partial \mathrm{t}} \left(C_t - \mathrm{C}_m \right)$$

time variation **advective term** **vertical turbulency**

$$\frac{dh}{dt} = \frac{\mathrm{Hv}}{\rho c_p h \gamma_v}$$

(McNaughton, 1989)

$$\mathrm{Hv} = \mathrm{H} + 0.07\lambda E$$

γ_v Gradient of virtual potential temperature at height h+, immediately above the PBL.

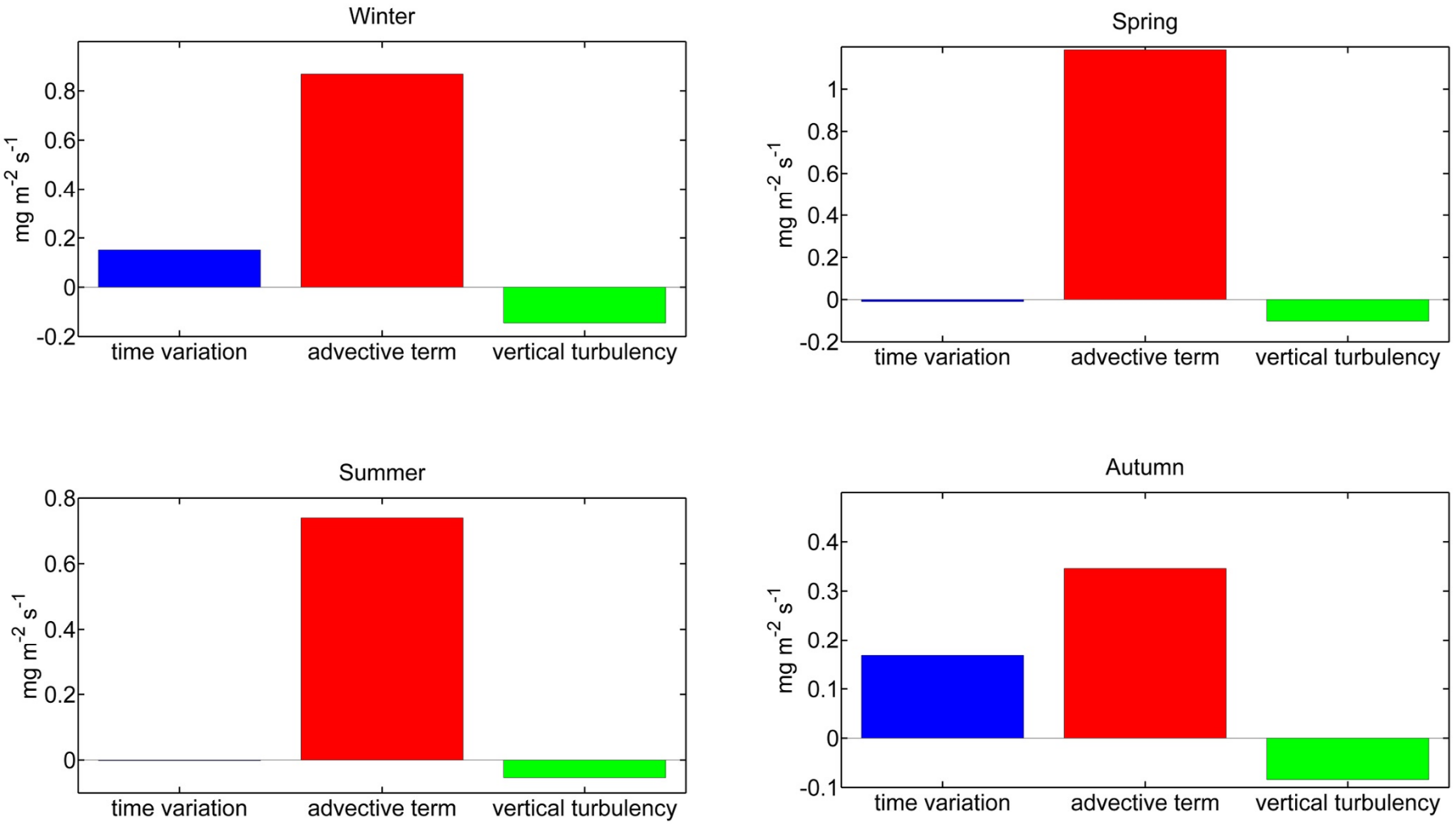


Fig.2 Calculation of three components of NEE in different seasons

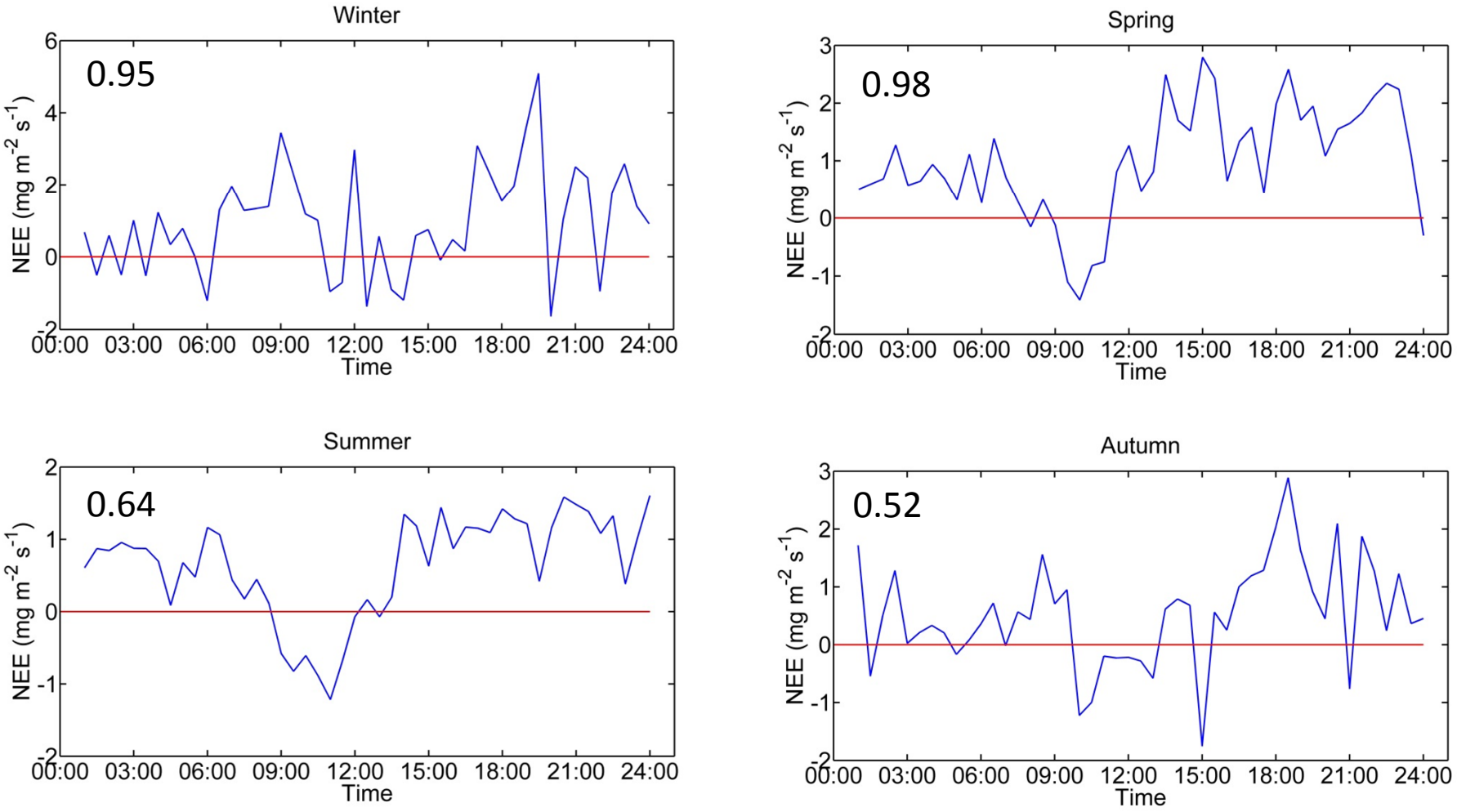


Fig.4 Diurnal variation of calculated NEE in different season

Carbon tracker

- CarbonTracker is a CO_2 measurement and modeling system developed by NOAA to keep track of sources (emissions to the atmosphere) and sinks (removal from the atmosphere) of carbon dioxide around the world.
- CarbonTracker uses atmospheric CO_2 observations from a host of collaborators and simulated atmospheric transport to estimate these surface fluxes of CO_2.
- The current release of CarbonTracker, CT2013, provides global estimates of surface-atmosphere fluxes of CO_2 from January 2000 through December 2012.
- http://www.esrl.noaa.gov/gmd/ccgg/carbontracker/

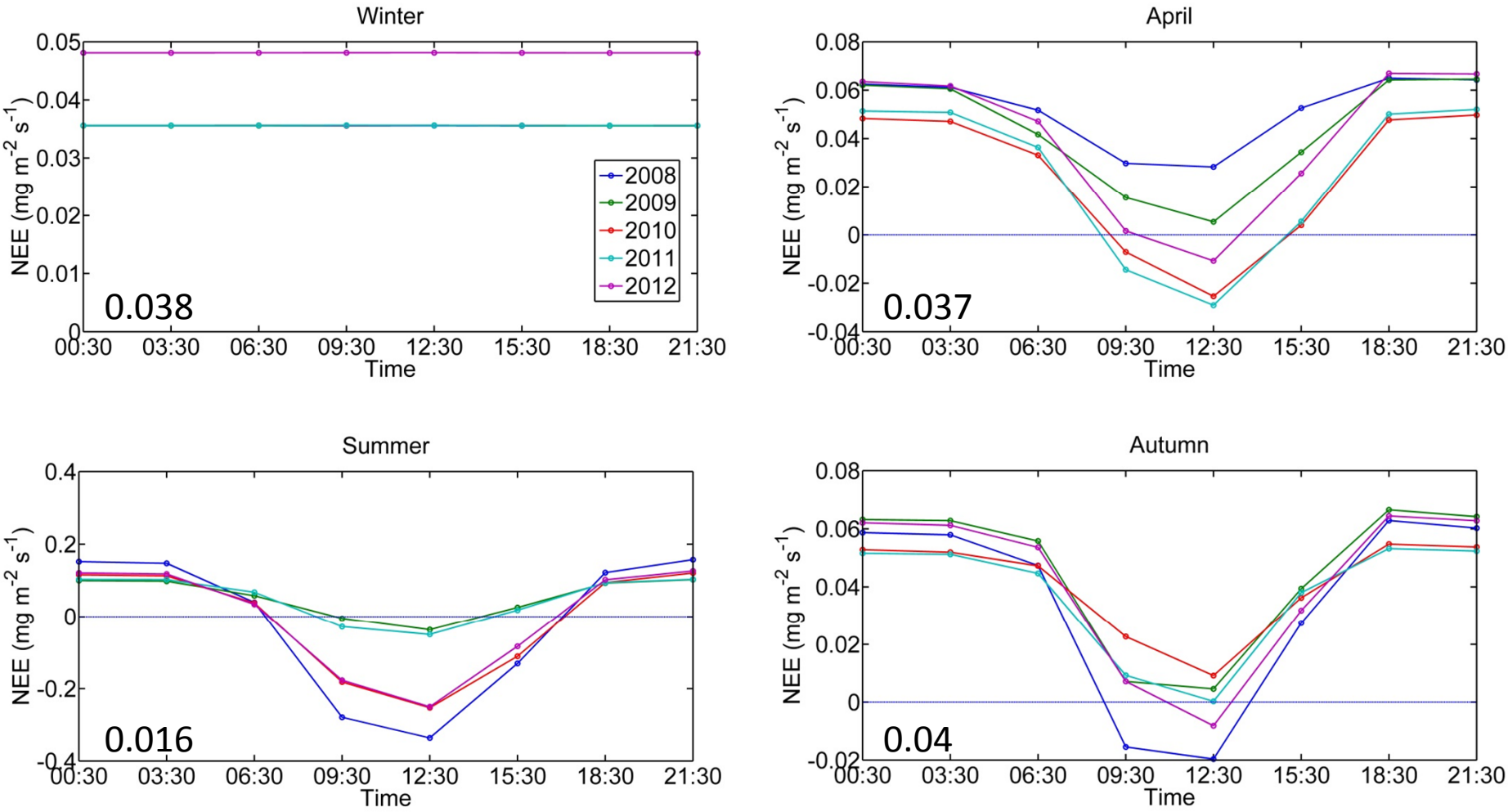


Fig.5 The diurnal composite flux derived from Carbon Tracker (3-hourly data) for the grid point that corresponds to Nanjing (grids of 118°E, 31.5°N and 118°E, 32.5°N, then make an average) for the five most recent years (2008-2012). The flux has four components: fossil flux, bio flux, fire flux and ocean flux and add them up to get the composite flux.

The sensitivity test

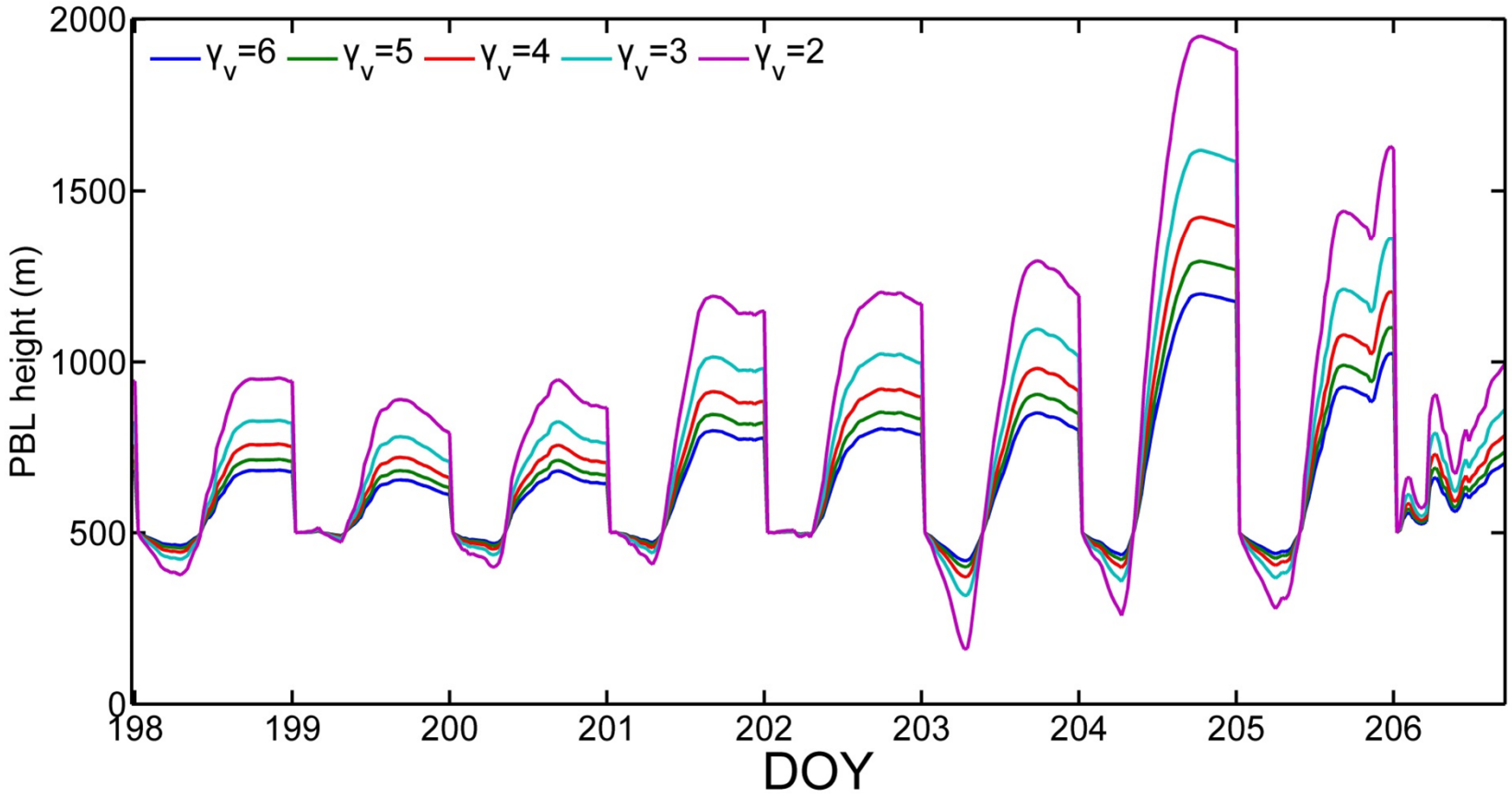


Fig.6 Time series of PBL heights

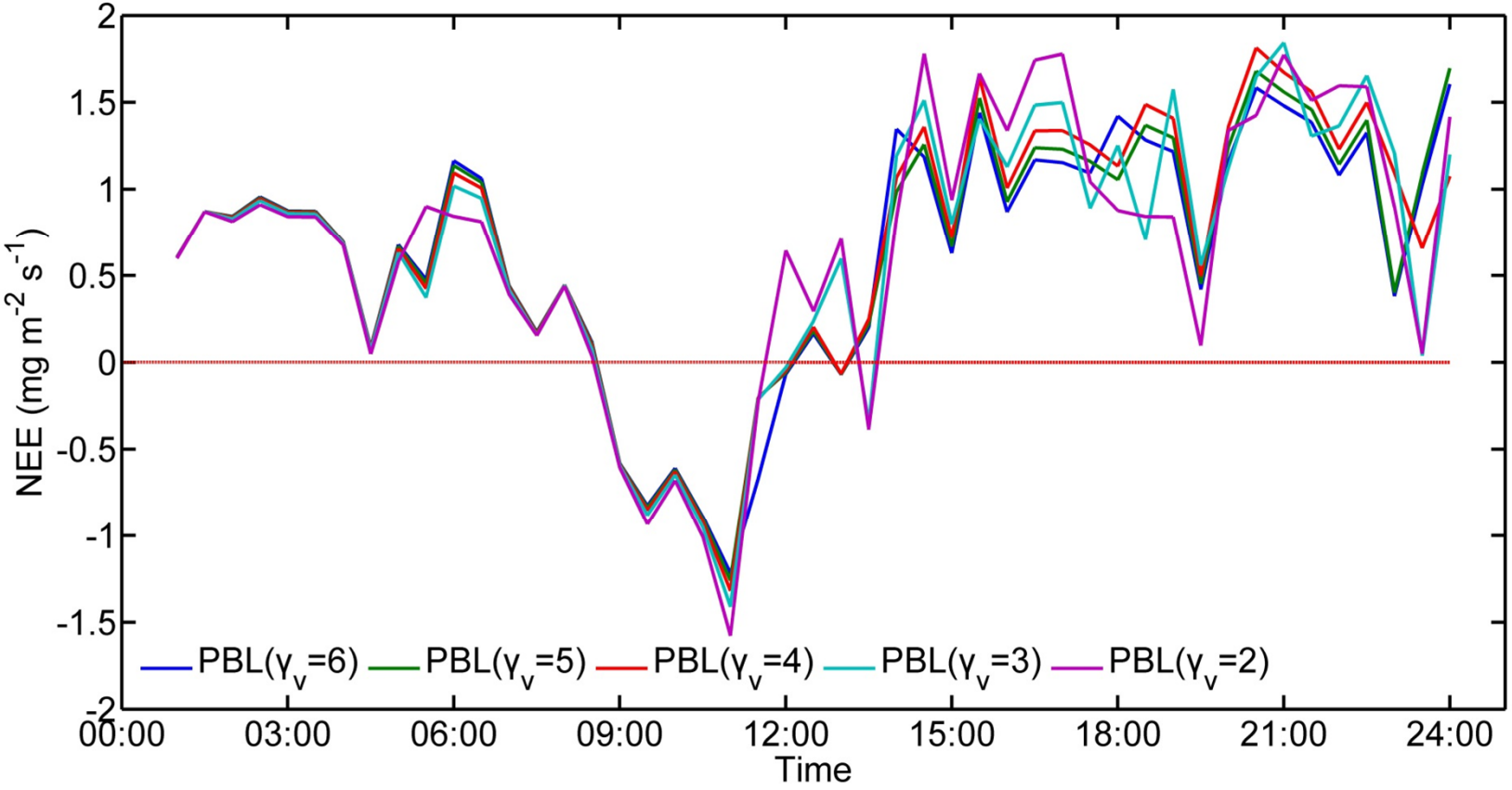


Fig.7 Diurnal pattern of NEE (summer)

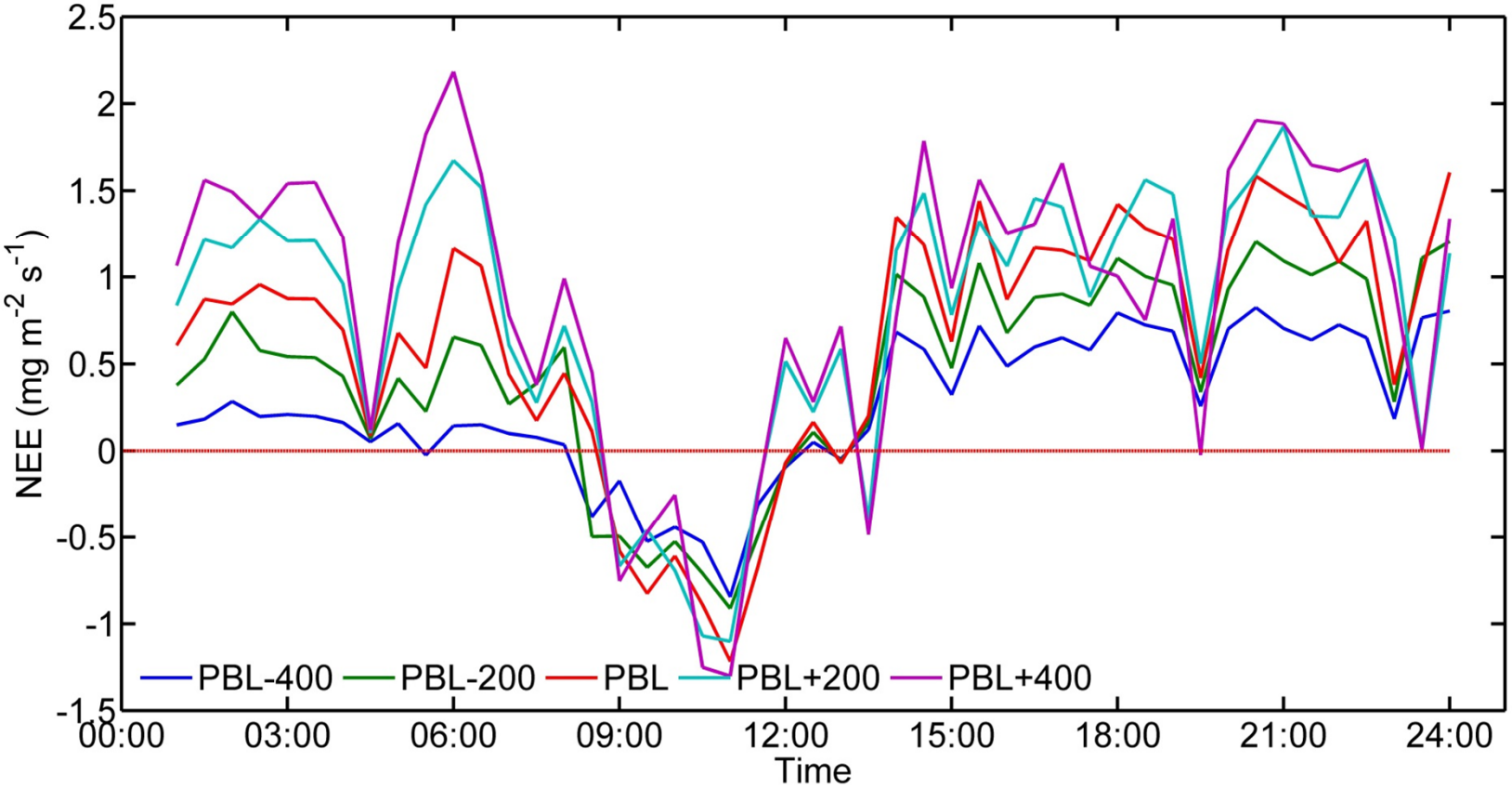


Fig.8 Diurnal pattern of NEE (summer)

Summary and on-going work

- Yang Dong's paper indicated CO_2 emission for Nanjing in 2009 is 66.49×10^9Kg (*Shen, 2014*). Convert it to flux is about 0.32 mg $m^{-2}s^{-1}$.And my result is 0.77 mg $m^{-2}s^{-1}$.

- My results provide evidence for box model where, on average, advection was the most important CO_2 reduction process in Nanjing. The same as Strong et al (2011).

- My results showed the same change trend with Carbon Tracker's, but the values were much higher.

- PBL height is an important parameter in the equation. I need find some more ways to calculate it.

- The data need to be dug deeper, like data pre-processing, pick out typical case and so on.

Thank you