Yale

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Eddy covariance measurement of CH_4 flux at Lake Taihu

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August 29, 2014

◆Outline

1 Background

2 Method and material

3 Results

- CH_4 flux measured by Eddy covariance
- Comparison between the new and old EC system

4 Discussion

1 Background

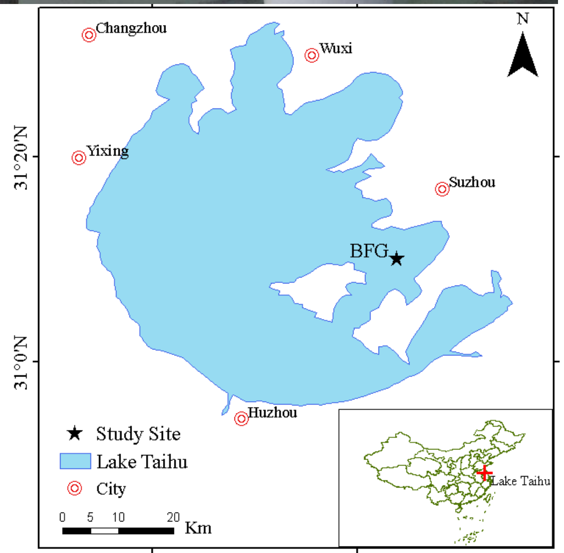
- Methane is one of the most important greenhouse gas, contributing 0.48W m^{-2} to anthropogenic radiative forcing, second only to CO_2.

- For methane, lakes are of significant importance , and recent studies have shown that lakes may offset the global terrestrial carbon sink by about 25% (Bastviken et al, 2011).

- Eddy covariance measurement of methane exchange are possible over peatlands and wetlands (Detto et al, 2010; Hendriks et al, 2008; Rinne et al, 2007), only a few EC studies have measured CH_4 from inland waters (Eugster et al, 2011; Schubert et al, 2012).

- Papers state that methane fluxes measured with LI-7700 agree well with methane fluxes measured with closed path sensors and that LI-7700 is the best choice for measurements on remote sites.

◆ 2 Method and material



Li-7700: open-path methane analyzer

Length: 0.47m

Weight: 5.2kg

Low- power

◆Computing Flux (online & offline)

□ CH_4 flux calculated by online

$$F_c = A\left\{\overline{w'q'_{cm}} + B\mu\frac{\overline{q_{cm}}}{\overline{q_d}}\overline{w'q_v'} + C(1+\mu\sigma)\frac{\overline{q_{cm}}}{\overline{T}}\overline{w'T'}\right\}$$

✓Spectroscopic corrected is simultaneously WPL corrected.

✓ A account for spectroscopic effects of temperature, pressure, and water vapor on methane density.

✓ B provides spectroscopic corrections to the latent heat flux term for pressure and water vapor.

✓ C provides spectroscopic corrections to the sensible heat flux term for temperature, pressure and water vapor.

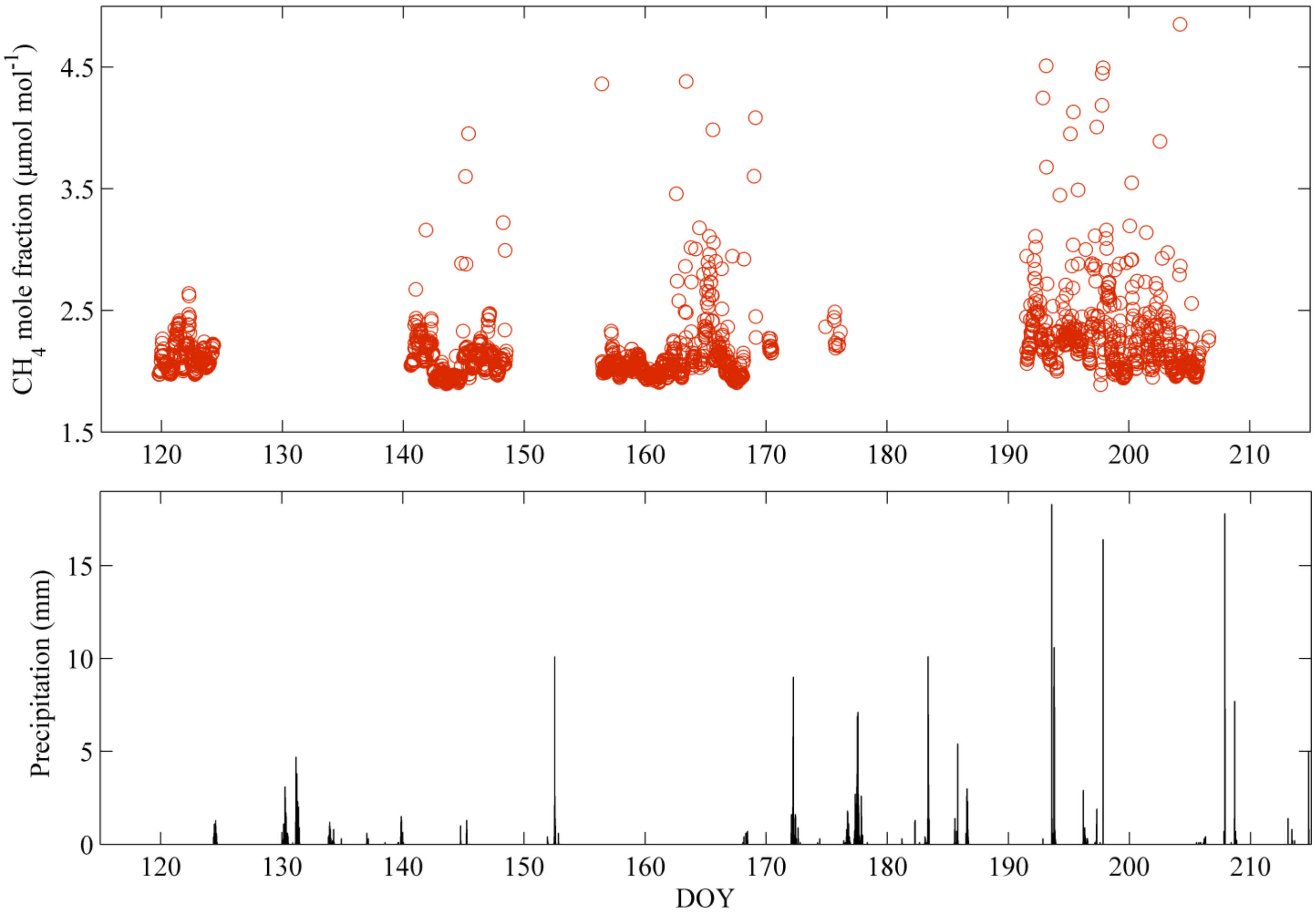
◻ CH_4 flux calculated by offline

- ✓ Raw data processing
  - axis rotations for tilt correction: double rotations
  - detrending method: block average
  - time lags compensation: covariance maximization with default
- ✓ Compensate density fluctuations: WPL correction
- ✓ Spectral correction: low frequency rang & high frequency range
- ✓ Spectroscopic corrections

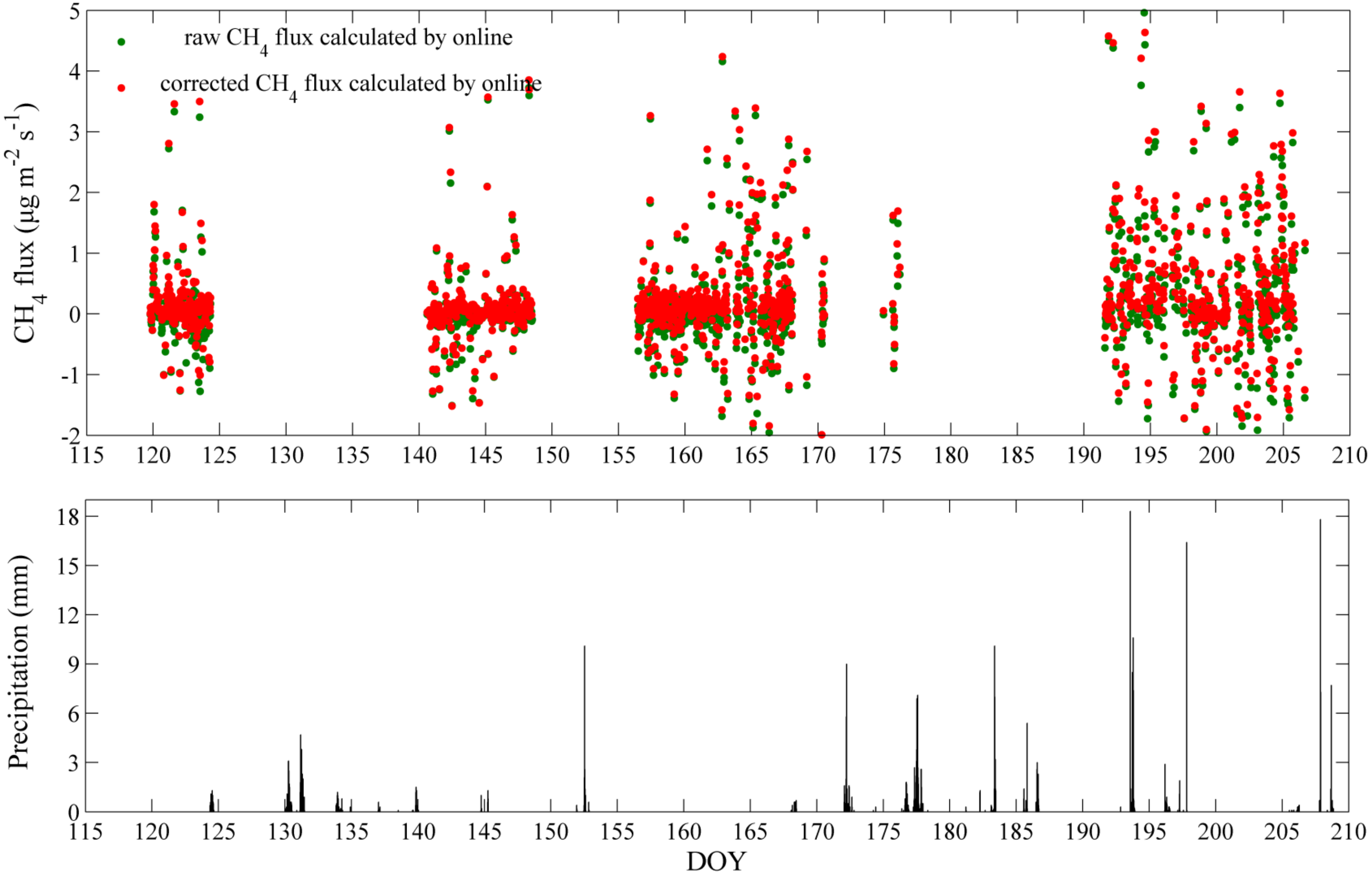
Webb et al, 1980; Moncrieff et al, 1997; Moncrieff et al, 1997; McDermitt et al, 2010

◆3.1 CH_4 flux measured by Eddy covariance

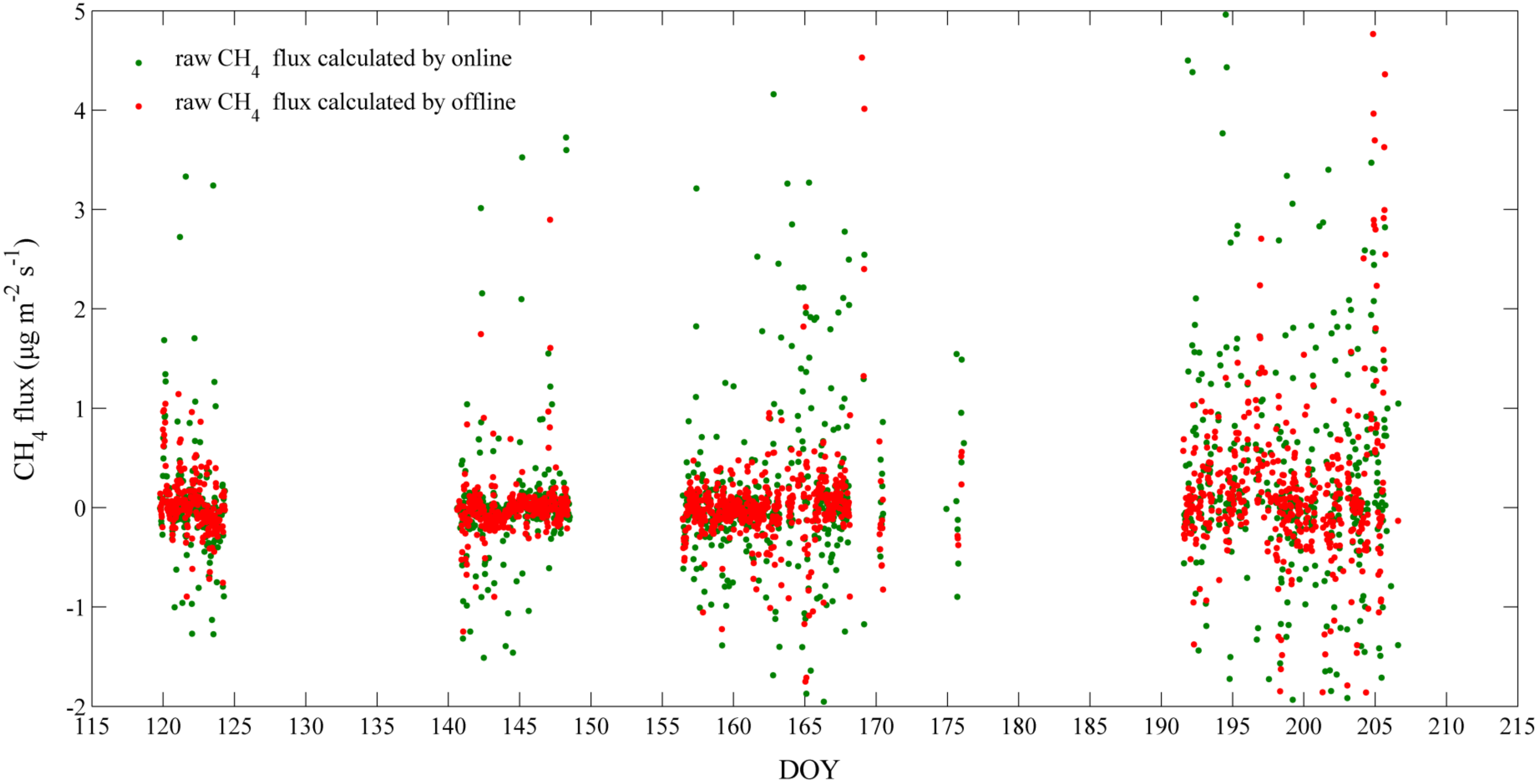
- The CH_4 concentration of atmosphere at BFG site



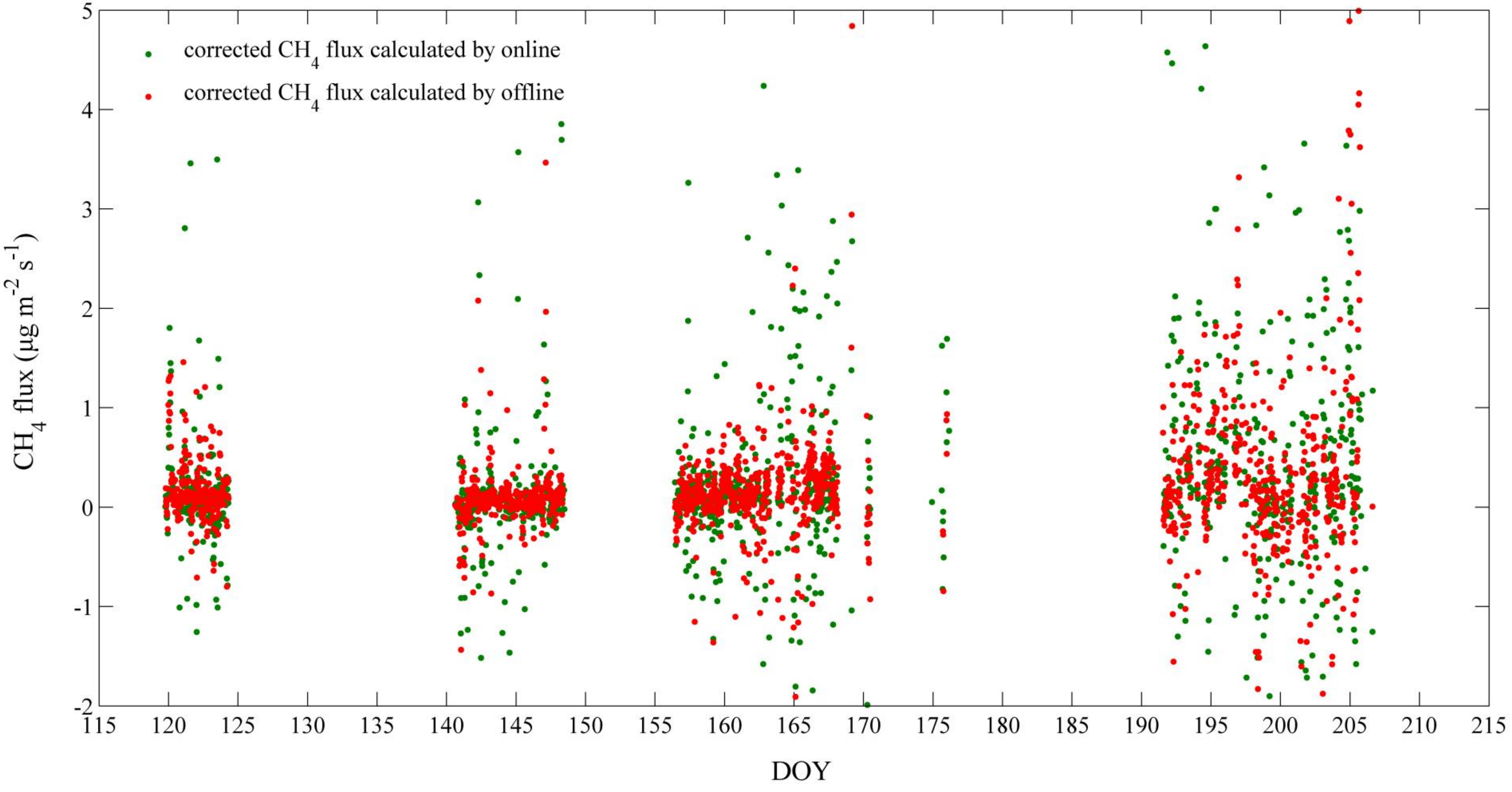
Comparison of raw CH_4 flux and corrected CH_4 flux calculated by online



Comparison of raw CH_4 flux



Comparison of corrected CH_4 flux



The average CH_4 flux

Date (2014)	Average CH_4 emission flux ($\mu g\ m^{-2}\ s^{-1}$)			
	Calculated by online		Calculated by offline	
	raw	corrected	raw	corrected
4.29~ 5.28	0.314±0.627	0.373±0.642	0189±0.309	0.302±0.383
6.5~ 7.10	0.492±0.742	0.606±0.743	0.228±0.453	0.411±0.540
7.10~ 8.5	0.818±0.948	0.963±0.970	0.564±0.756	0.816±0.924

The average CH_4 emission flux: 0.367±0.550 $\mu g\ m^{-2}\ s^{-1}$

Day: 0.310±0.491 $\mu g\ m^{-2}\ s^{-1}$

Night: 0.415±0.590 $\mu g\ m^{-2}\ s^{-1}$

☐ Data quality check

	Day	Night
Data (points)	764	826
Flag0 (%)	8.6	5.9
Flag1 (%)	66.5	65.6
Flag2 (%)	24.9	28.5

Flag 0: best quality fluxes
Flag 1: fluxes suitable for general analysis
Flag 2: fluxes should be discarded

Mauder and Foken, 2004

Compared with the related research

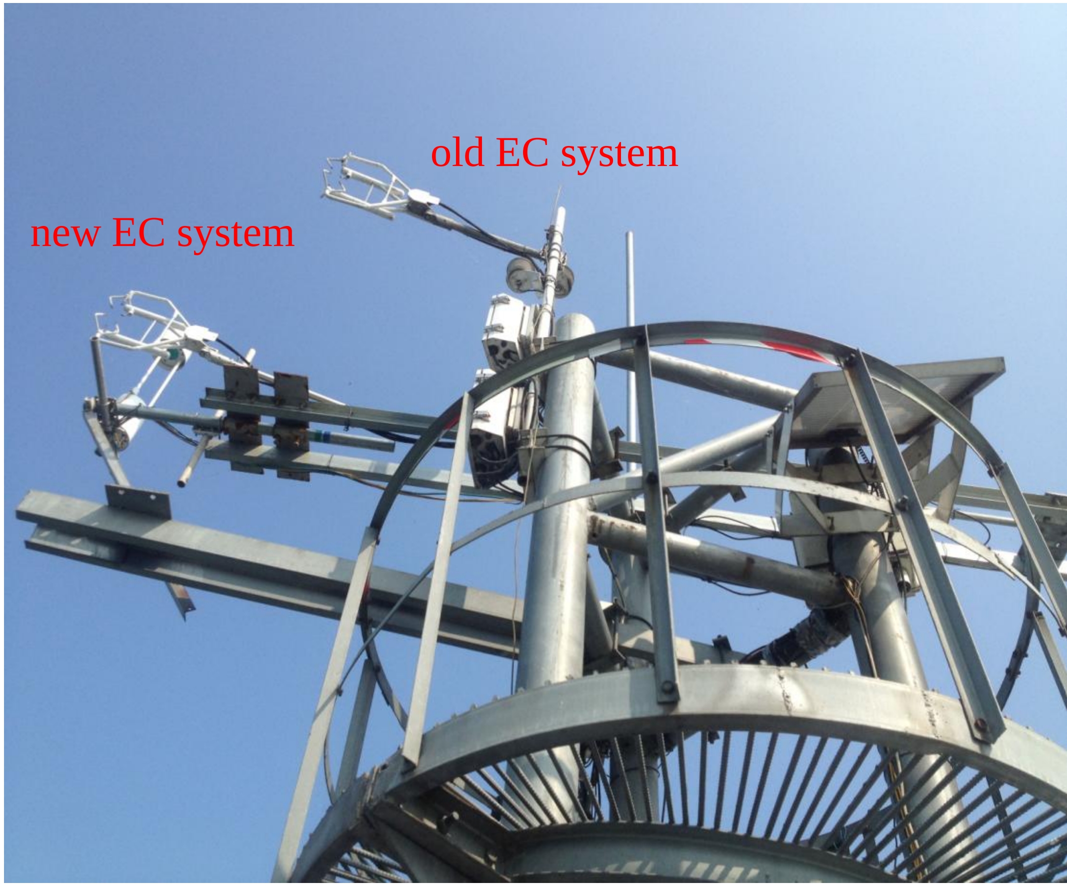
Study site	Method	CH_4 emission flux ($\mu g\ m^{-2}\ s^{-1}$)	Reference
BFG(2014.5~2014.8)	EC (Model Li-7700)	0.367	This study
MLW(2012.5~2012.8)	Gradient diffcusion	0.223	This study
MLW(2011.8~2013.12)	Water equilibrium	0.031	This study
Lake Tamnaren	EC (Model Li-7700)	0.112	Podgrajsek et al, 2014
Wuliangsu Lake	Static chamber	0.6	Duan et al, 2005
Boreal lake (total: 177)	Water equilibrium	0.149	Juutinen et al, 2009
Wetland lake	Floating chambers	1.08	Schrier-Uijl et al, 2011

Compared with other ecosystem

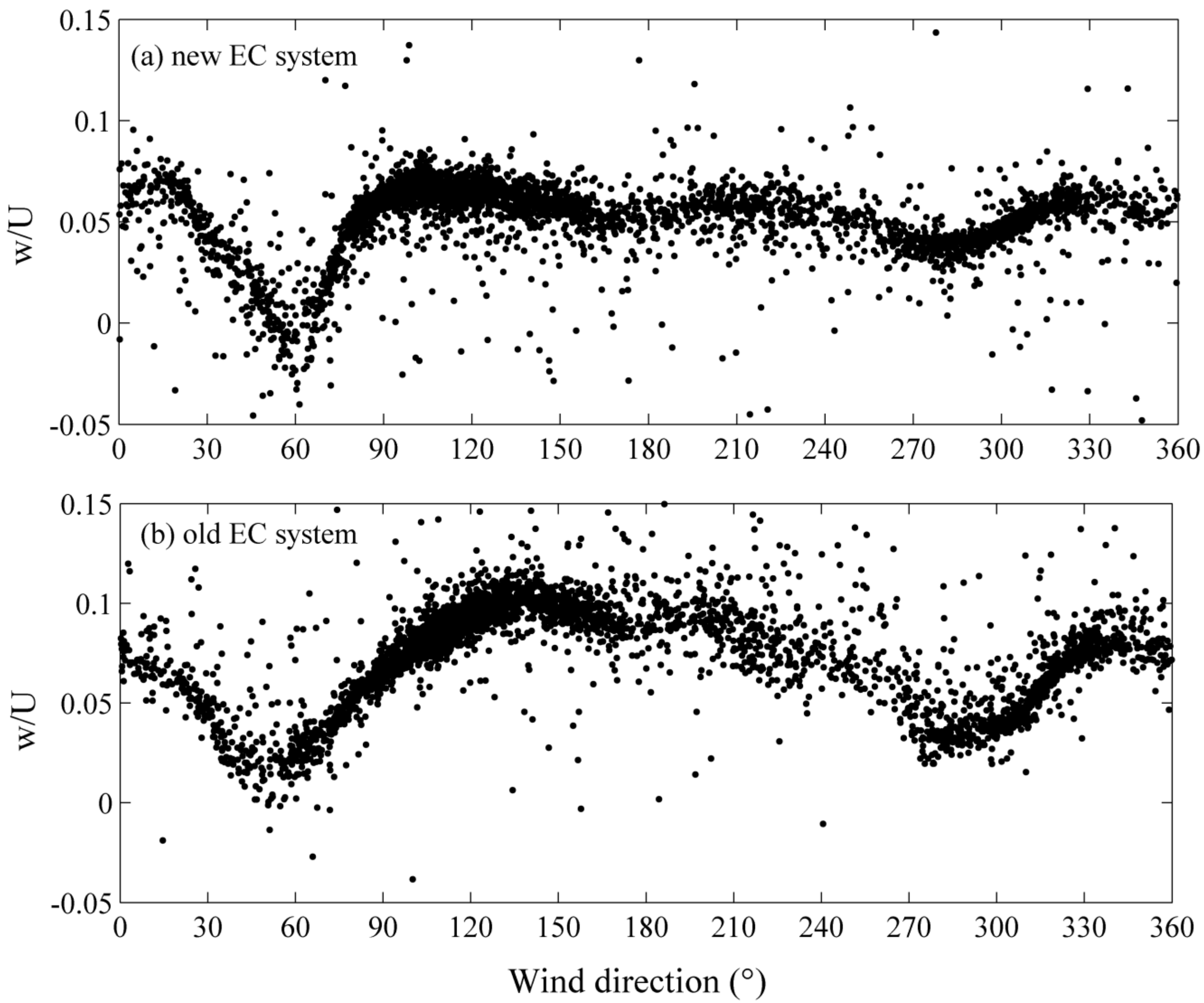
Study site		Method	CH_4 emission flux ($\mu g\ m^{-2}\ s^{-1}$)	Reference
BFG(2014.5~2014.8)		EC (Model Li-7700)	0.367	This study
Urban wetland		EC (Model Li-7700)	0.16~0.64	Morin et al, 2013
Rice field		EC (Model Li-7700)	1.312(peak)	Alberto et al, 2014
Sheep pasture		EC (Model Li-7700)	0.288	Dengel et al, 2011
Poor fen		EC (Model Li-7700)	0.81~2.55	Pypker et al, 2013
Wet coastal tundra		EC (Model Li-7700)	1.91	Ikawa et al, 2012
Heterogeneous wetland		EC(Model Li-7700)	1.24~7.41	Matthes et al, 2014
Wetland ditch		Floating chambers	9.36	Schrier-Uijl et al, 2011
Delta	River	Static chamber	8.69	Gondwe et al, 2014
	Floodplain	Static chamber	5.66	
	lagoons	Static chamber	4.69	

◆3.2 Comparison between the new and old EC system

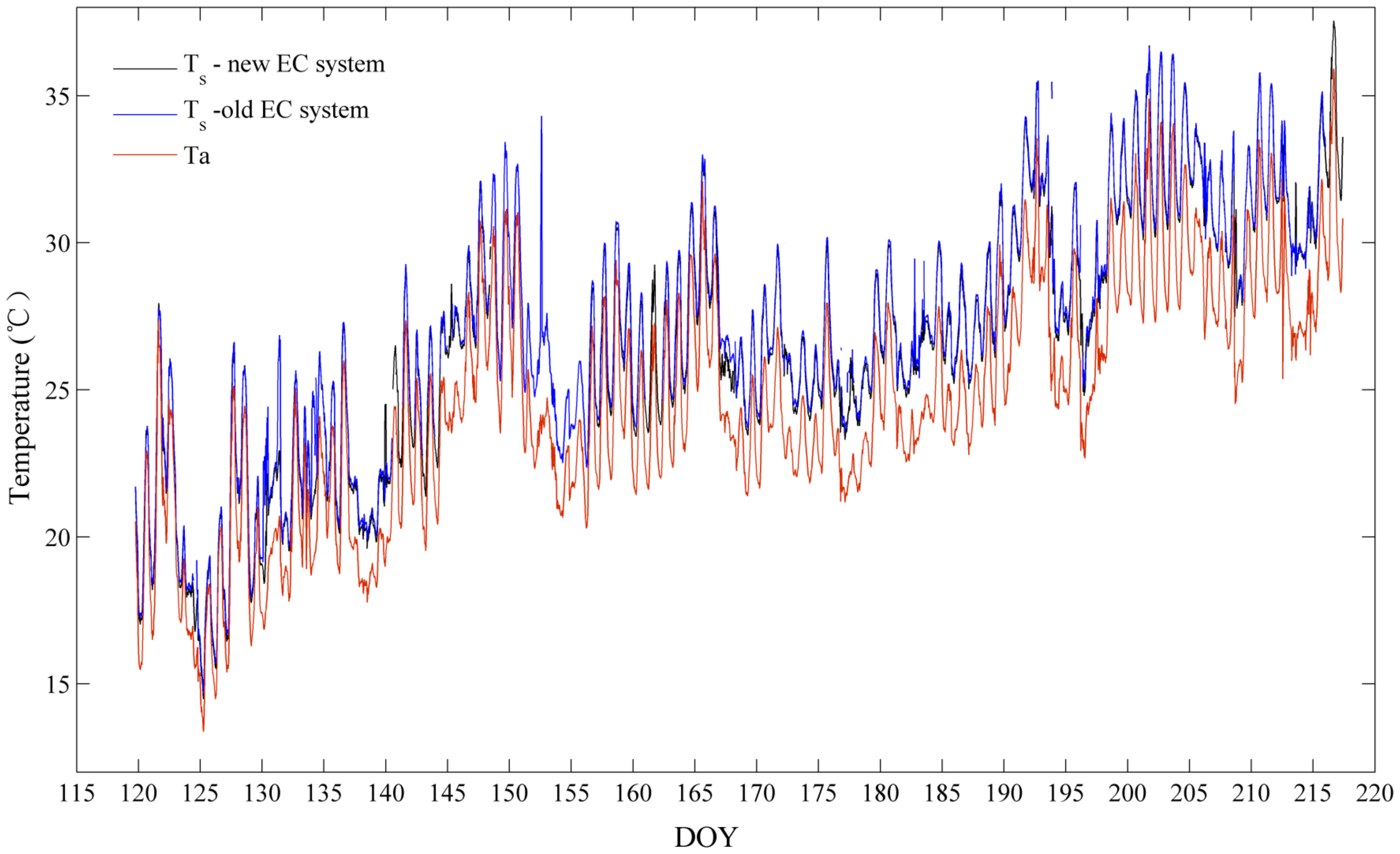
- CO_2/H_2O concentration and Ts
- friction velocity
- sensible heat flux
- latent heat flux
- CO_2 flux
- wpl correction for CO_2 flux and Latent heat flux



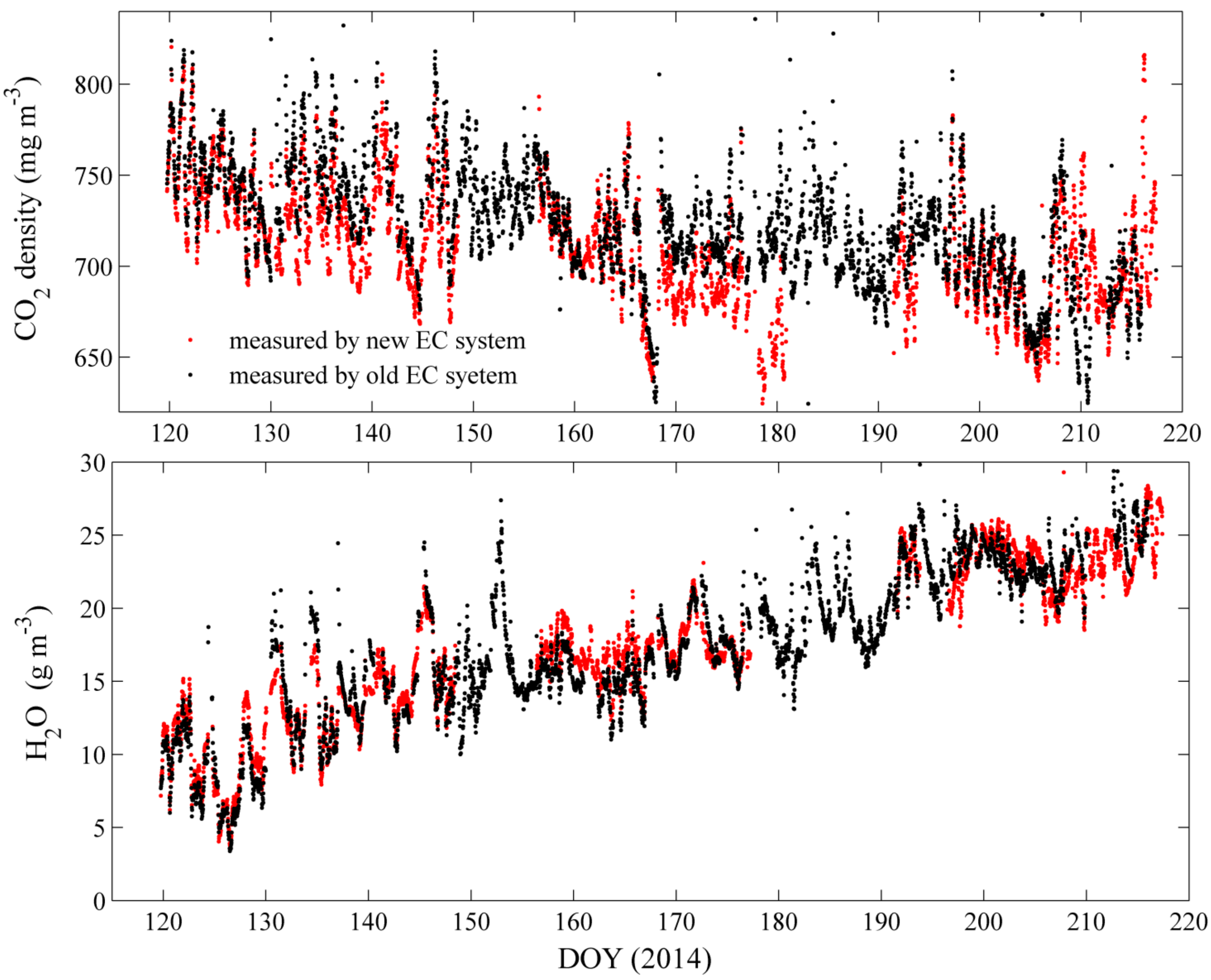
Tilt as a function of wind direction



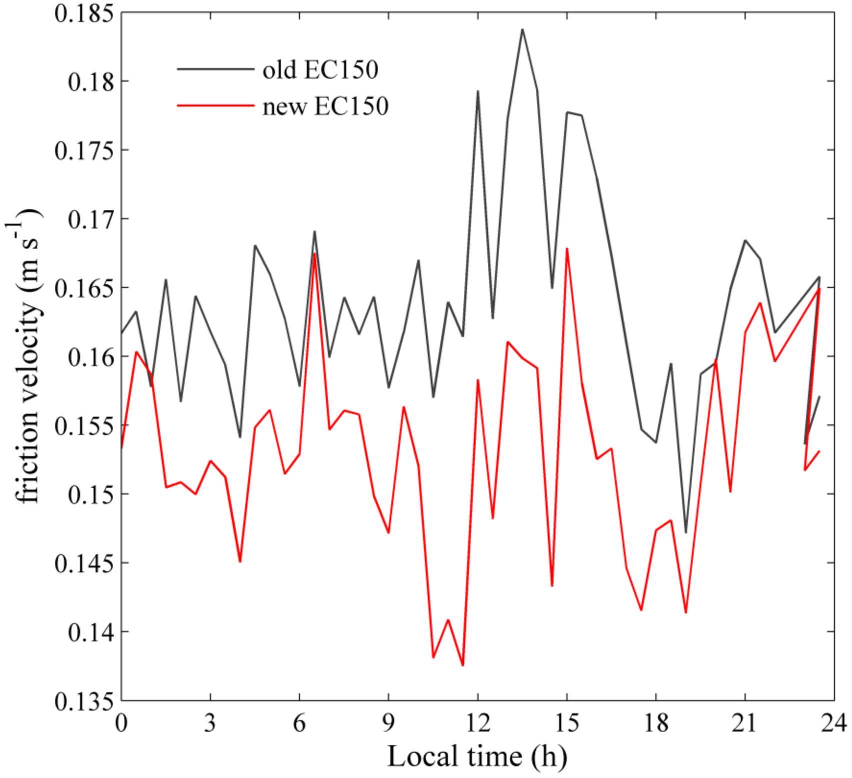
Time series of temperature

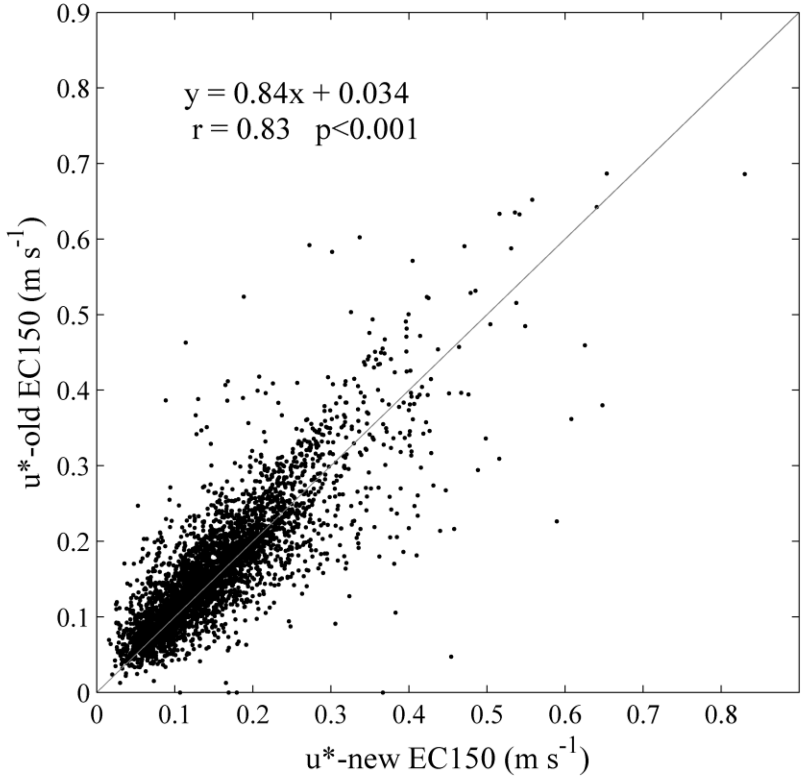


Time series of CO_2 density and H_2O concentration

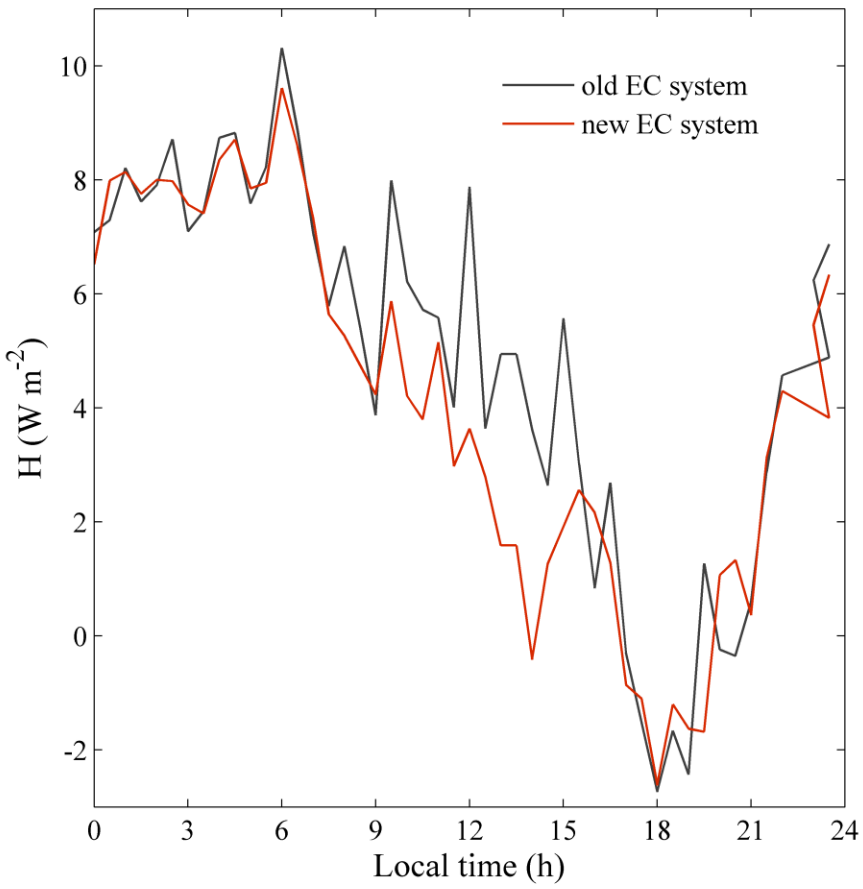


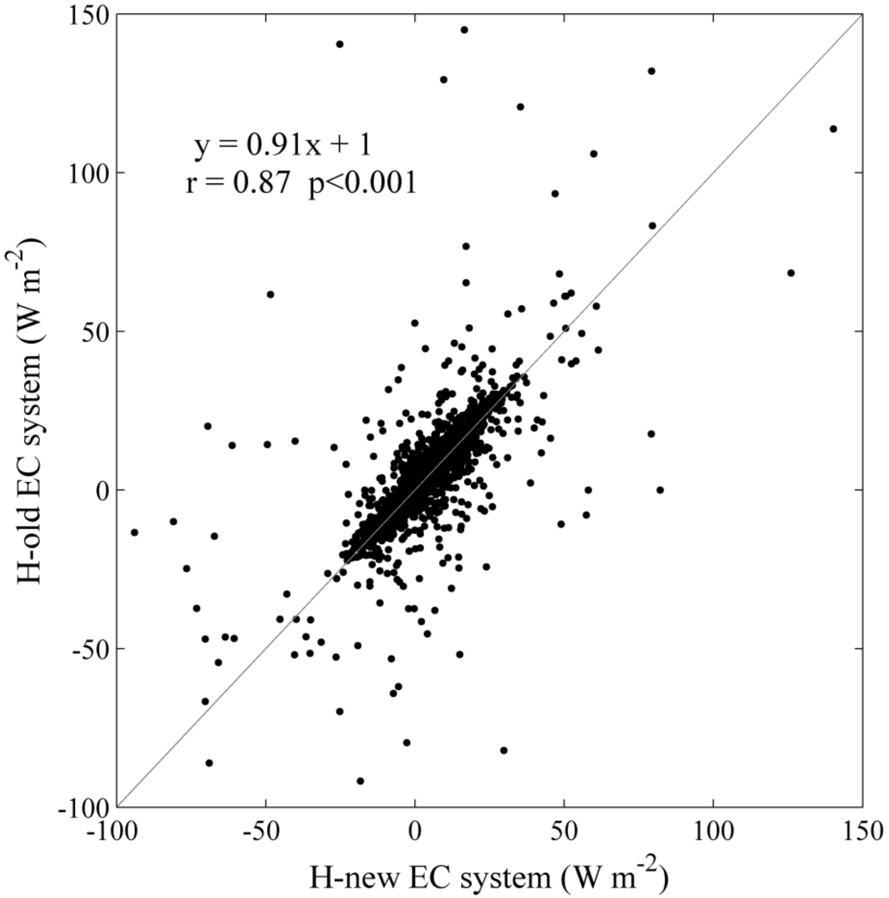
Comparison of friction velocity



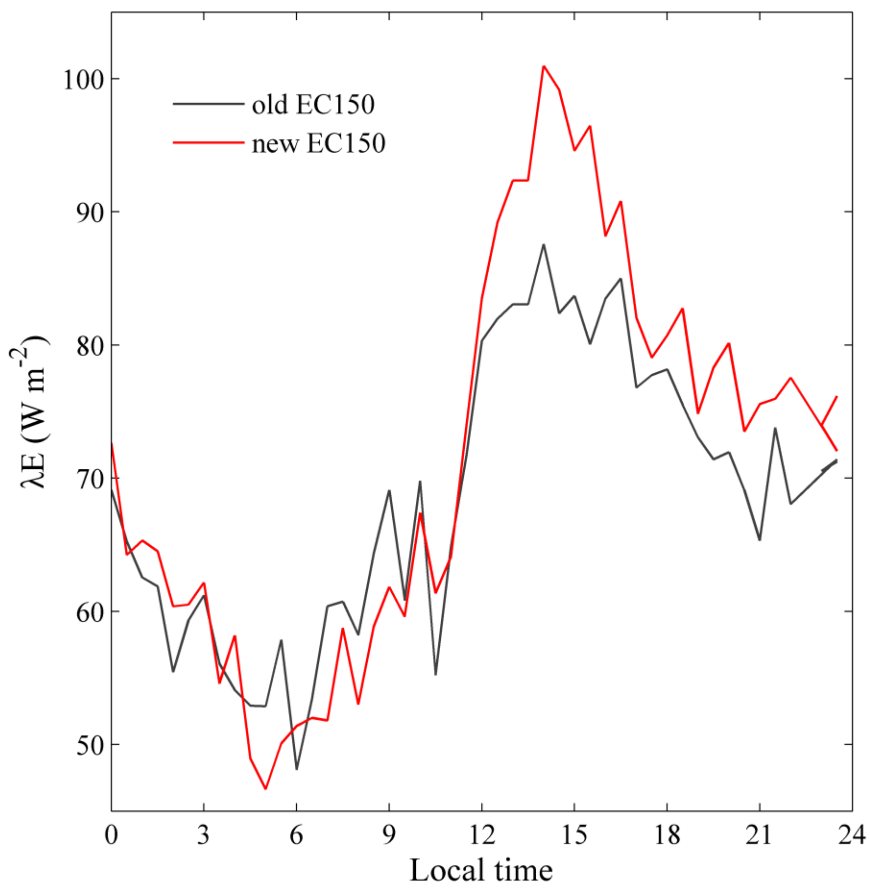


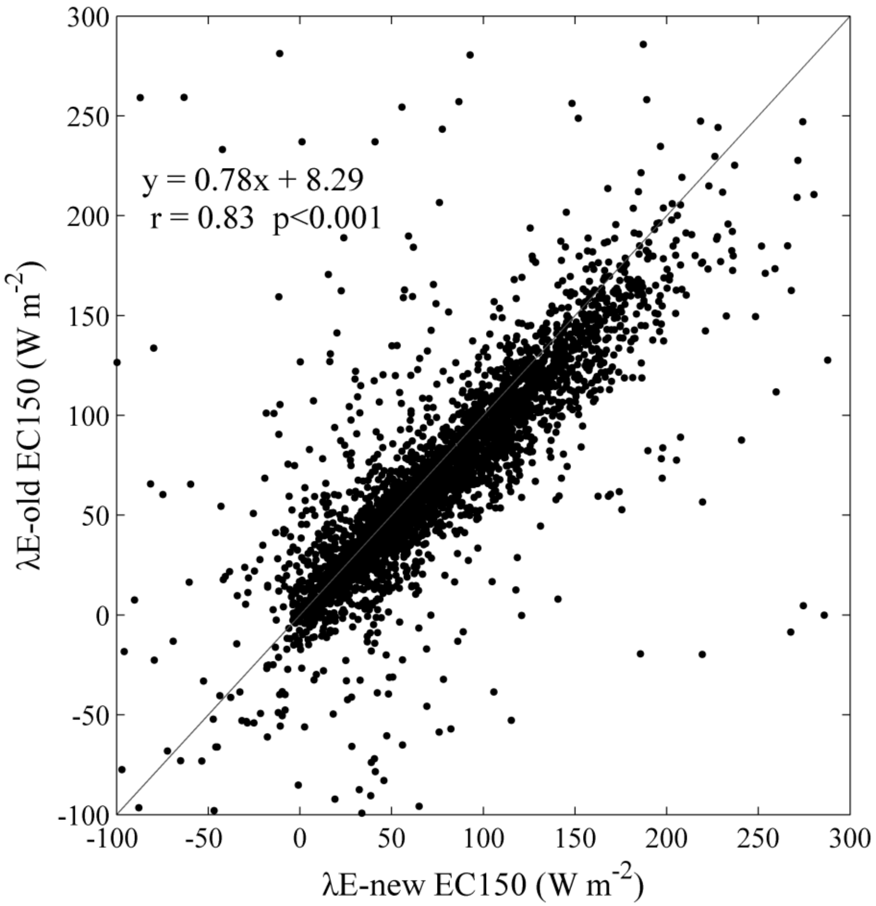
Comparison of sensible heat flux



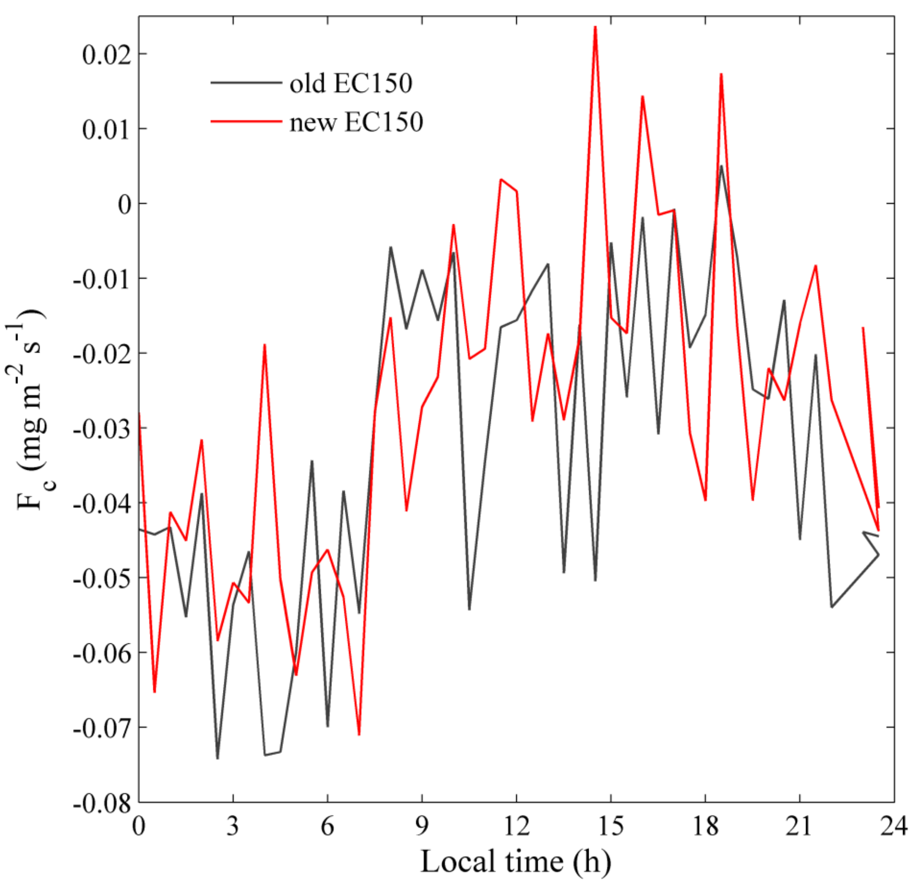


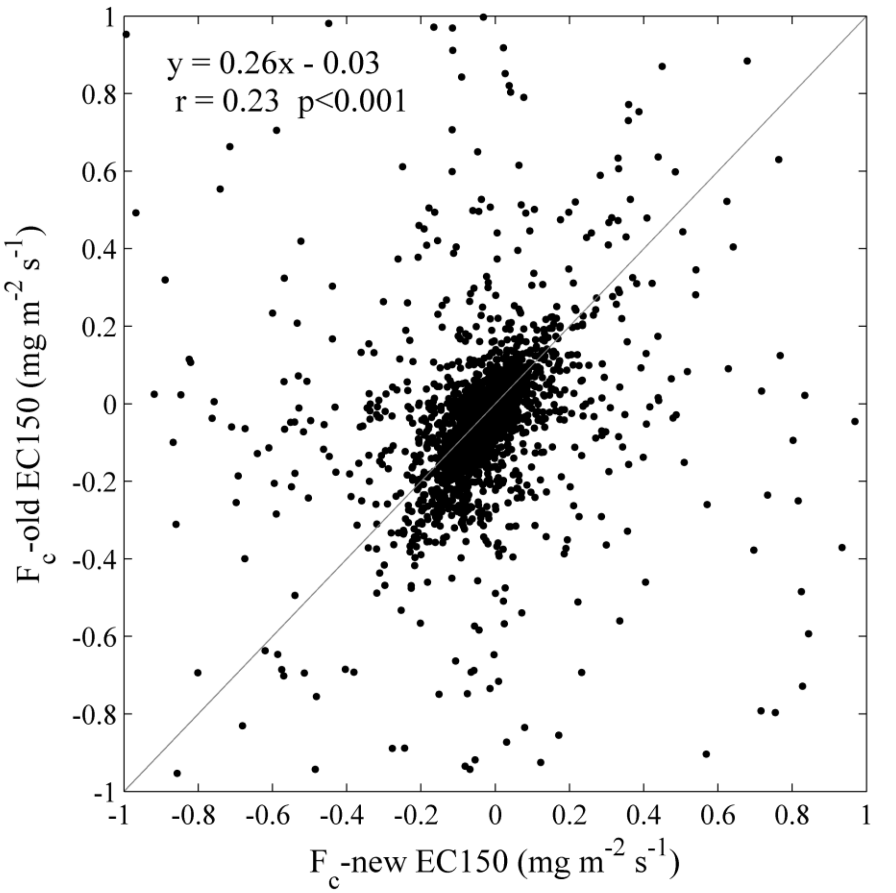
Comparison of latent heat flux



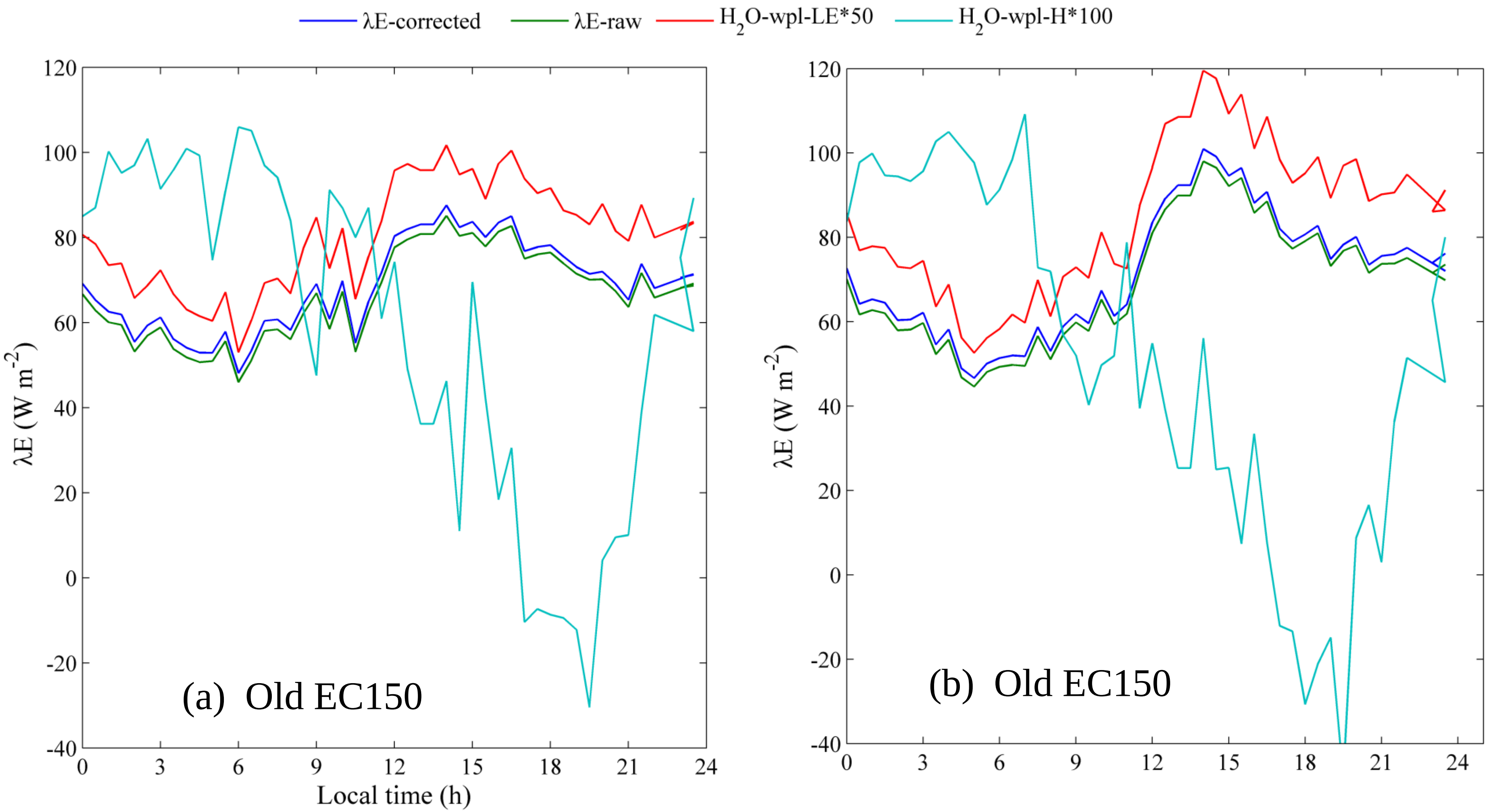


Comparison of CO_2 flux

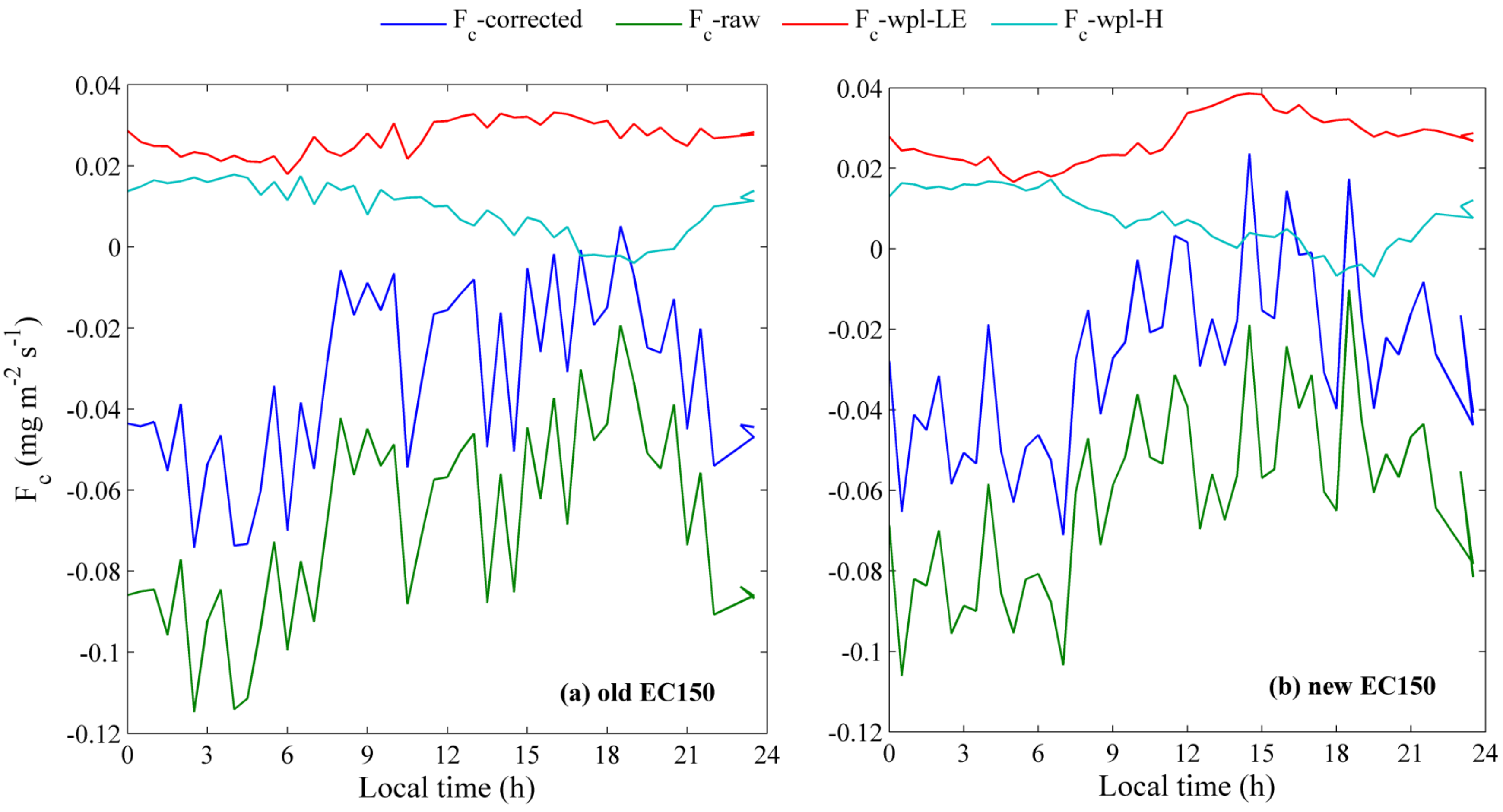




WPL correction for latent heat flux

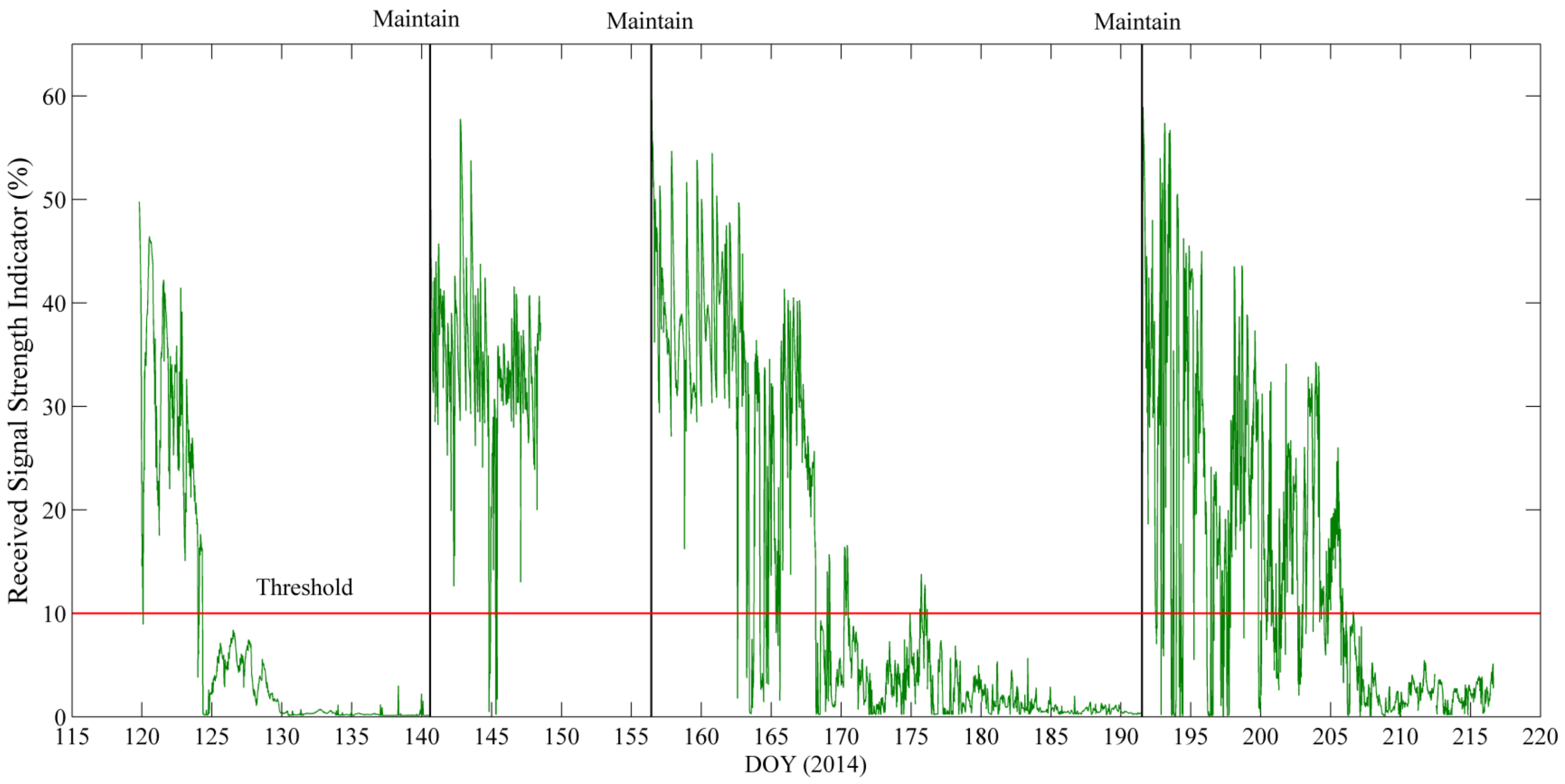


WPL correction for CO_2 flux

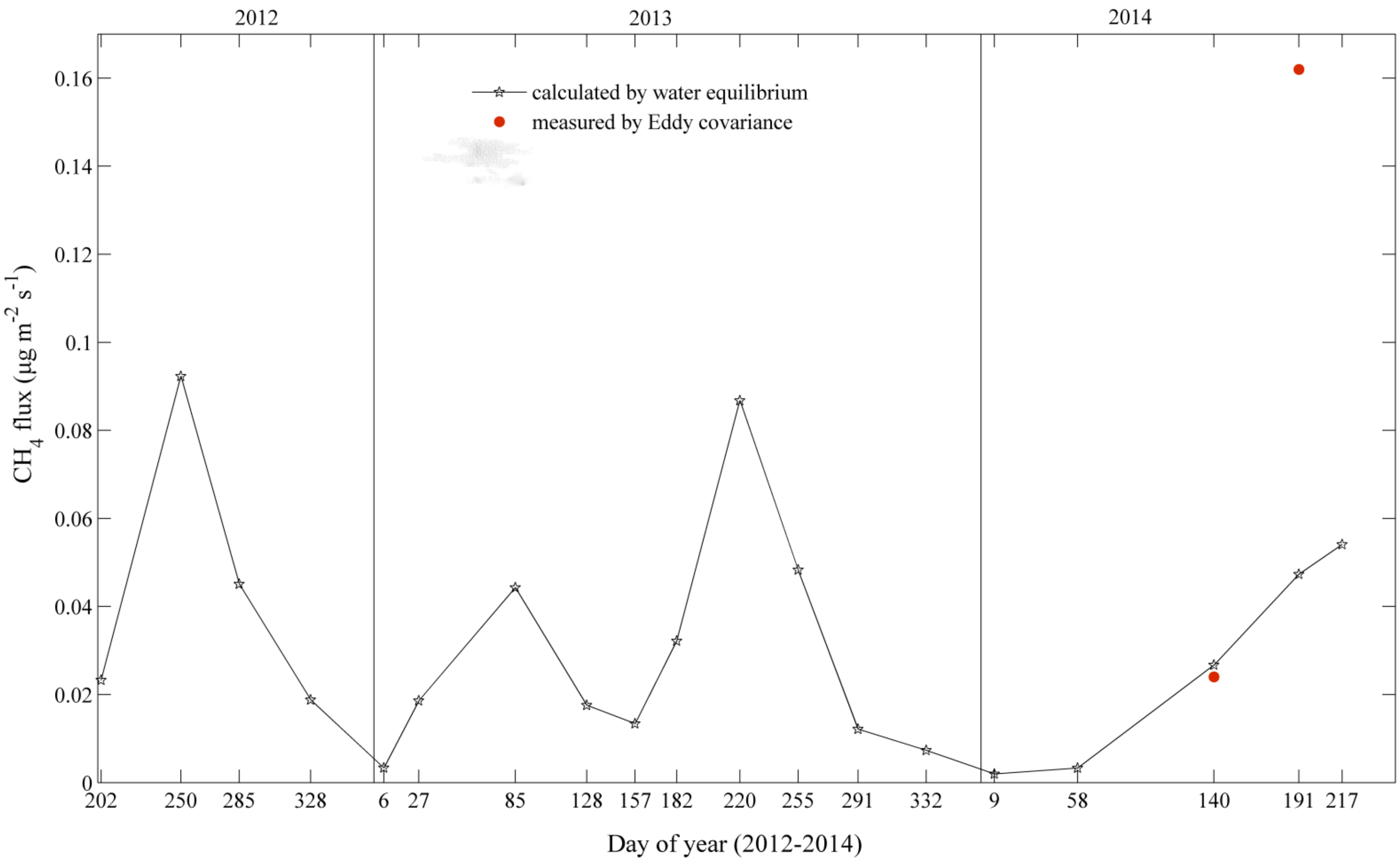


◆ 4 Discussion

□ The open path CH4 analyzer should be maintained frequently: ten days is the threshold



The CH_4 emission flux calculated by water equilibrium method at BFG site



The CH_4 flux will reach a high level: 0.1μg m^{-2} s^{-1} *10 = 1 μg m^{-2} s^{-1}

Schubert et al (2012) have a conclusion: boundary model estimates were 5-30 times lower at calculating CH4 emission flux of aquatic system.

The impact of ebullition

- Ebullition is an important path that transport CH_4, Shakhova et al (2014) estimate that bubble inject 100-630 mg CH_4 m^{-2} d^{-1}(about 1.16-7.29 μg CH_4 m^{-2} s^{-1}) into the overlying water at the Arctic Shelf *(published at Nature*).

- The impact of ebullition on eddy covariance measurement of CH_4 flux .
- CH_4 bubble emission level at BFG site

Thank You