Drivers of temporal variations of CO_2 flux at a submerged macrophyte habitat in Lake Taihu

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YNCenter Weekly Video Conference
2016.04.01

Outline

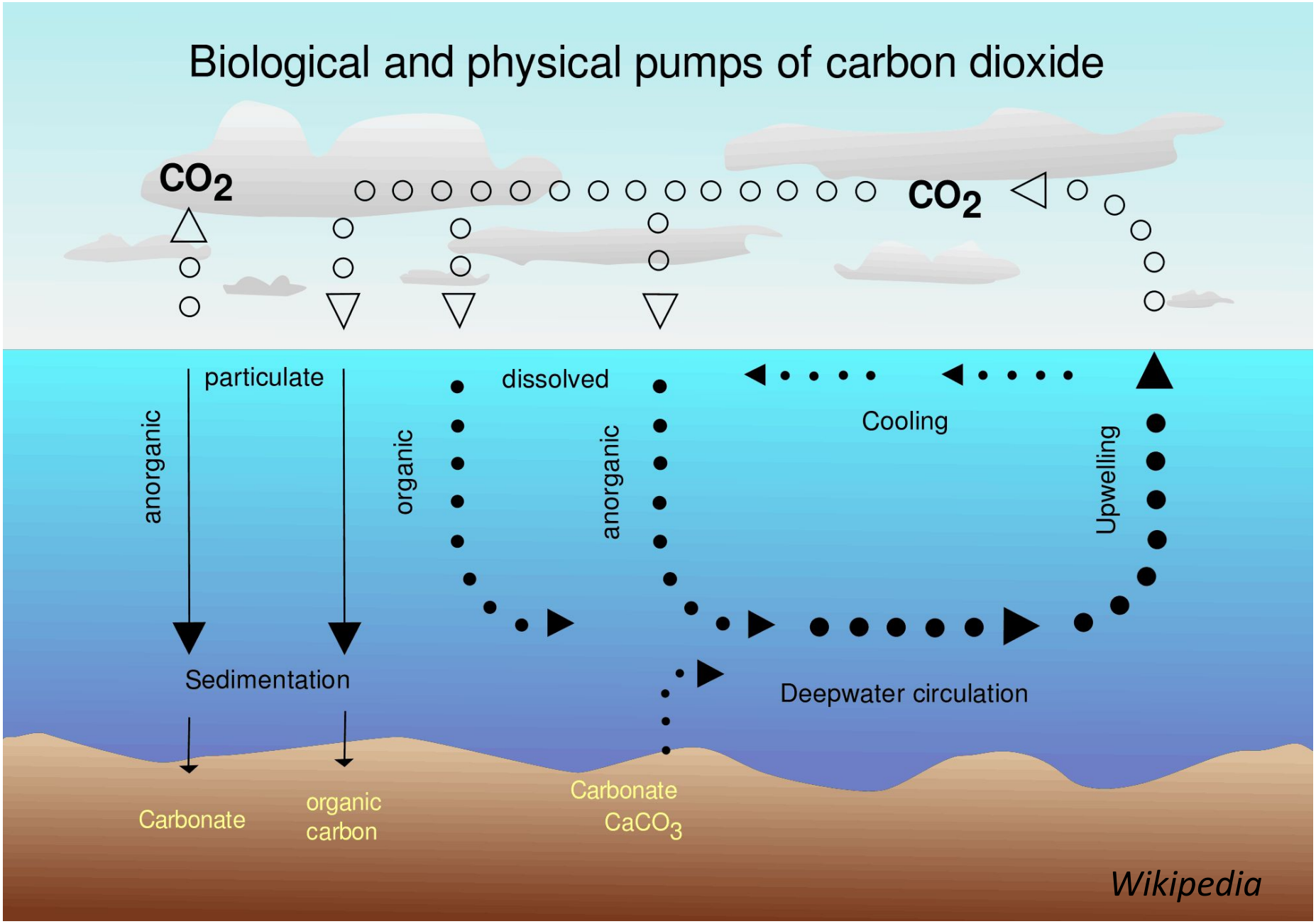
- Background
- Site description
- Data post-processing method
- Results
- Conclusions
- On-going work

Background

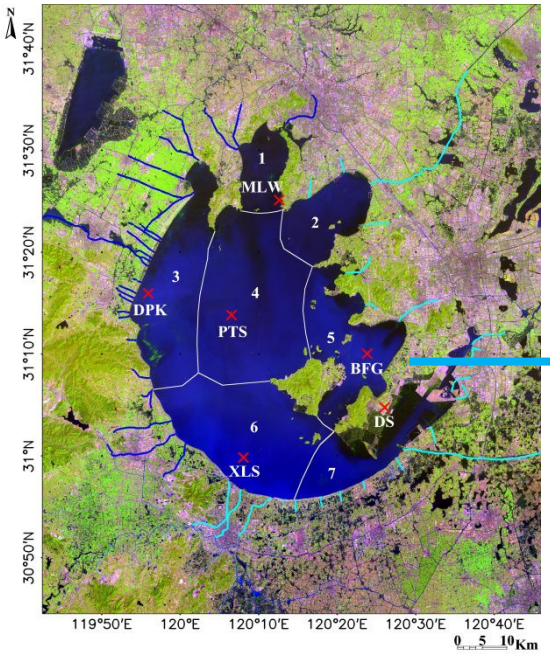
- Lakes play crucial roles in global carbon cycle (Tranvik et al, 2009) and their social importance cannot be ignored as they have impacts on local climate (Cole et al, 1994).

- Freshwater lakes usually act as sources of atmospheric carbon with CO_2 supersaturated (Cole et al, 1994), except for some high algal activities (Balmer and Downing, 2011).

- Lake Taihu located in Yangtze River Delta, the 3rd largest freshwater lake in China with average depth of 1.9m. Is this eutrophic lake a source or sink of atmospheric CO_2 (Lee et al, 2014).?


Biological and physical pumps of carbon dioxide
CO2
CO2
particulate
dissolved
anorganic
organic
anorganic
Cooling
Upwelling
Sedimentation
Deepwater circulation
Carbonate
organic carbon
Carbonate CaCO3
Wikipedia

Site description



Bifenggang site避风港站

(BFG, 31°10′28"N, 120°24′01"E)

- Dominated by submerged macrophytes
- Started on 15 December 2011
- Water depth: 1.7 m
- EC height: 8.5 m above water surface.
- EC gas analyzer: Campbell EC150

Data post-processing method

2-D coordinate rotation

↓

Sonic temperature correction for sensible heat flux

↓

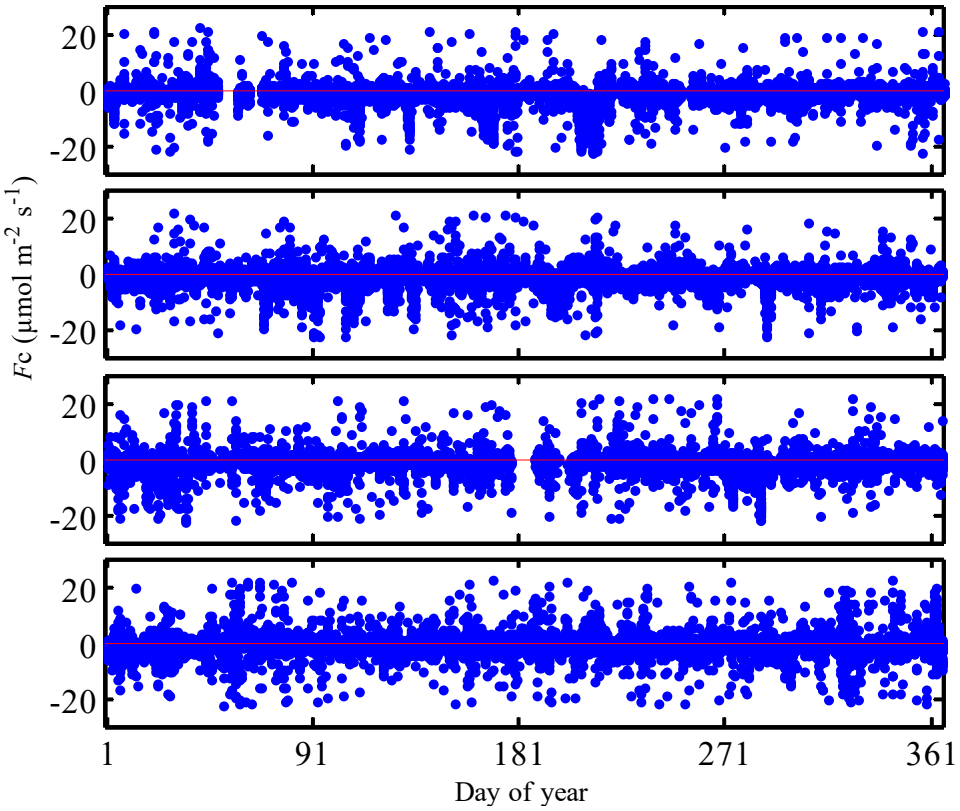
WPL correction

↓

Eliminating the EC data when it rains

↓

Half hourly post-processing data



Time series of post-processing CO_2 flux

Results

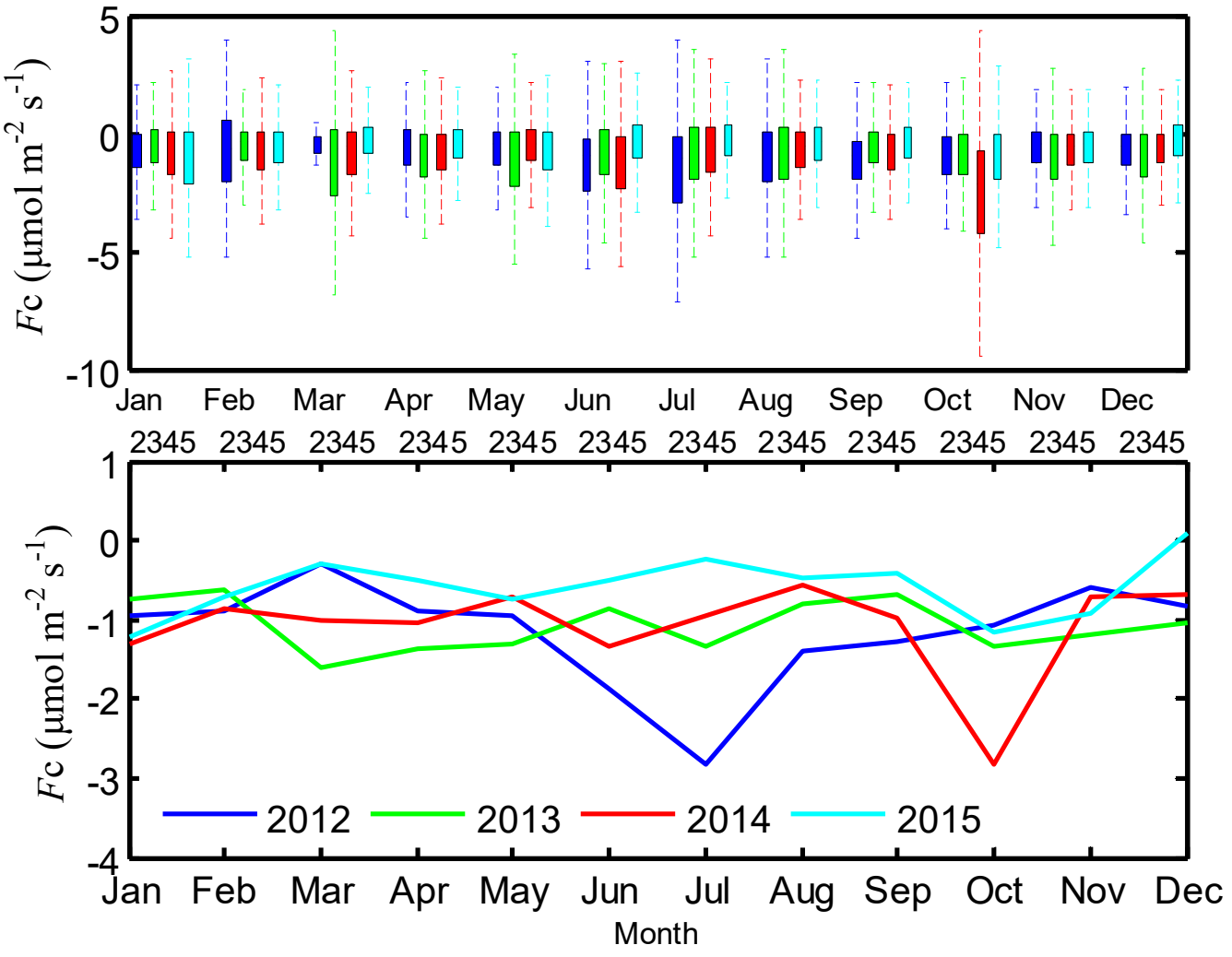


Fig.1 Monthly mean time series of CO_2 flux

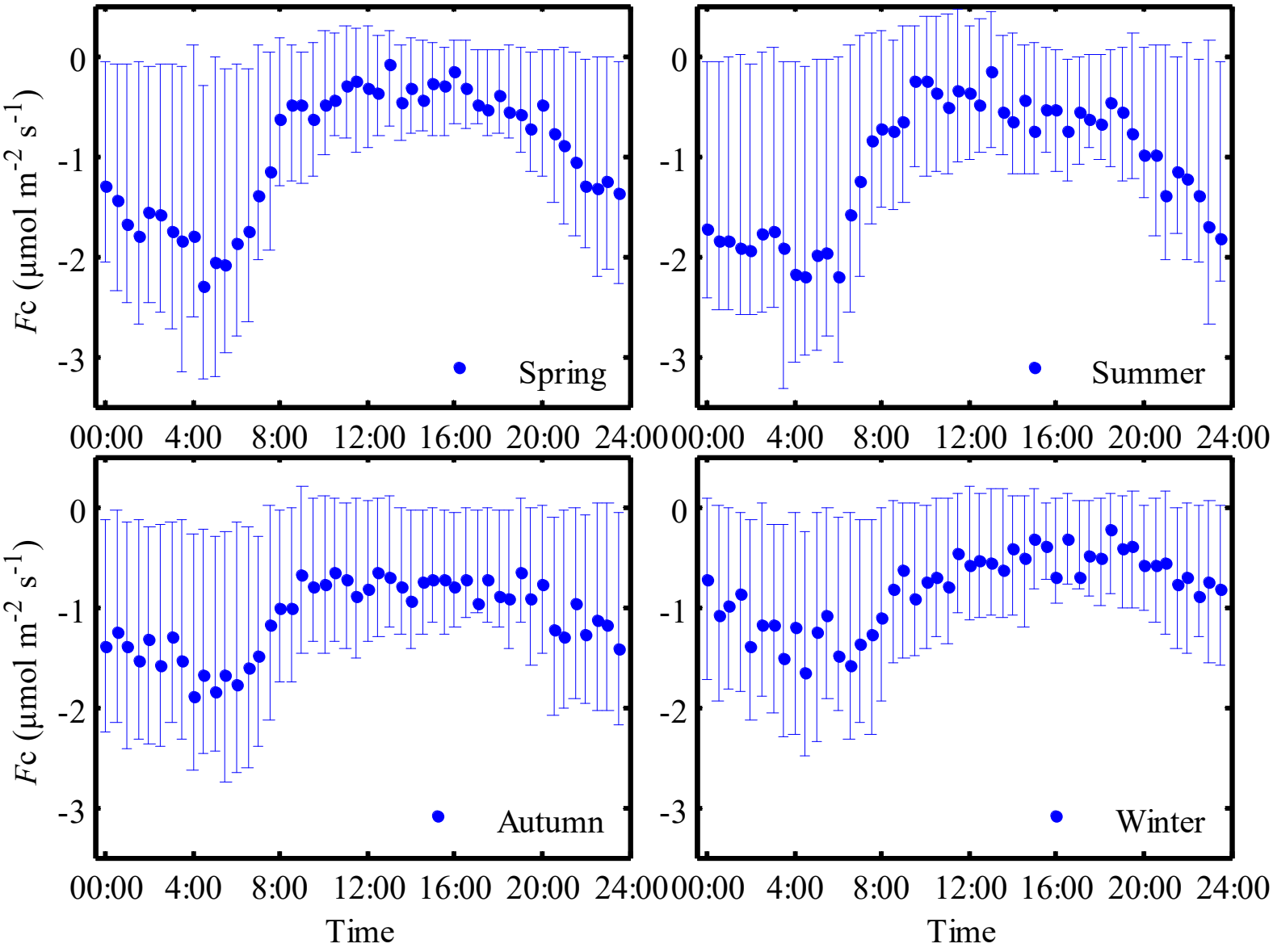


Fig.2 Diurnal pattern of CO_2 flux in different seasons from 2012 to 2015. The error bars indicate the 25th and 75th percentiles.

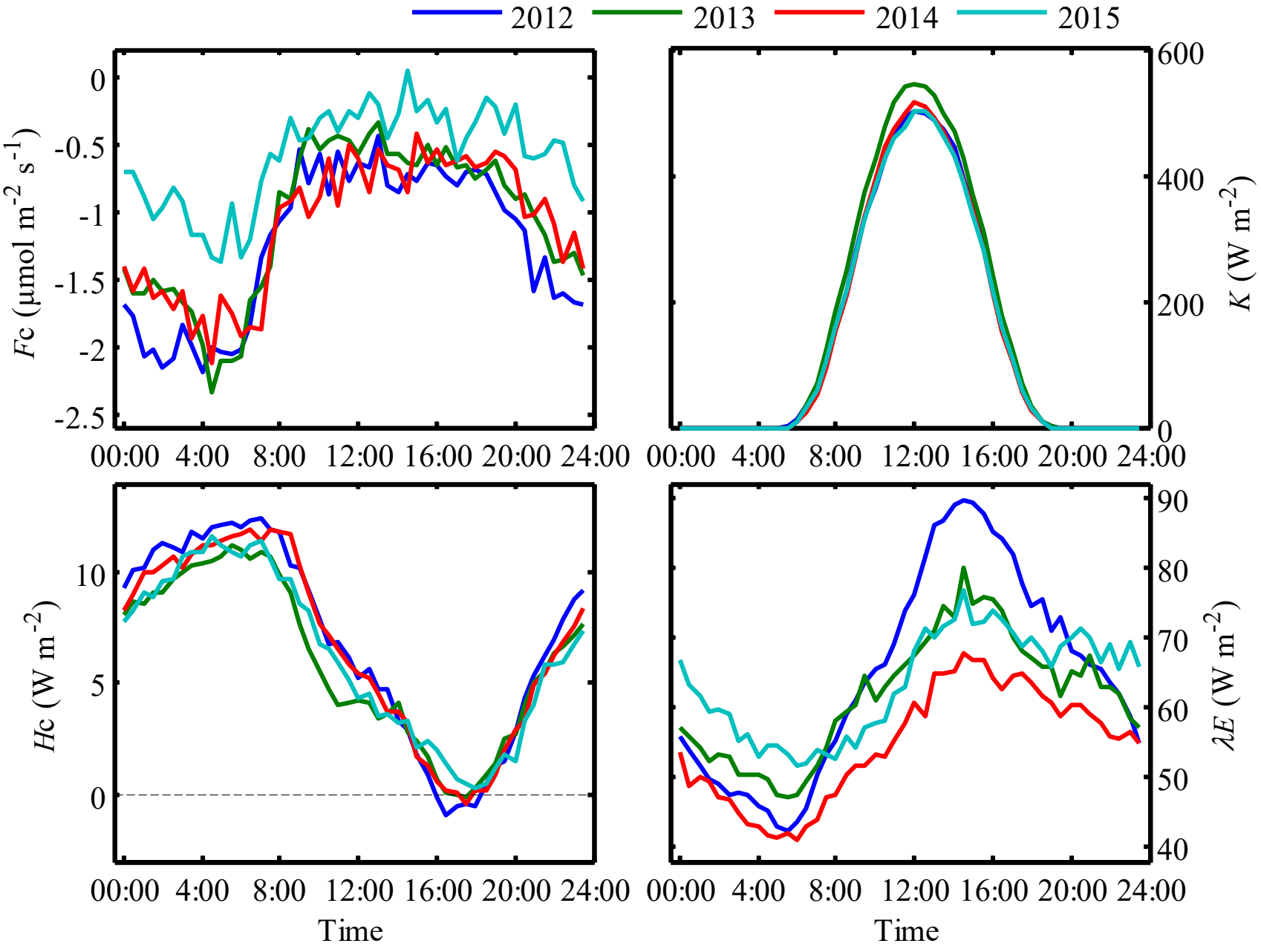
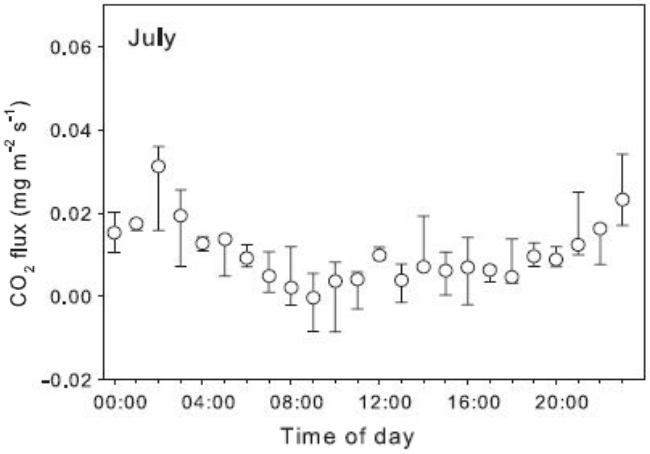


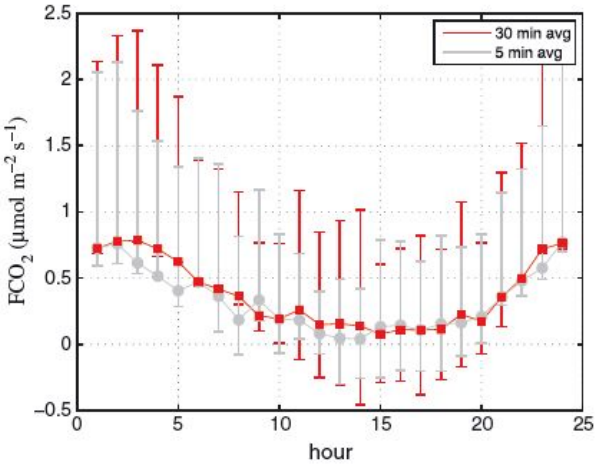
Fig.3 Diurnal pattern of *Fc*, *K*, *Hc* and *LE* from 2012 to 2015

Tab.1 Yearly carbon emission and yearly mean *K*, *Hc* and *LE*

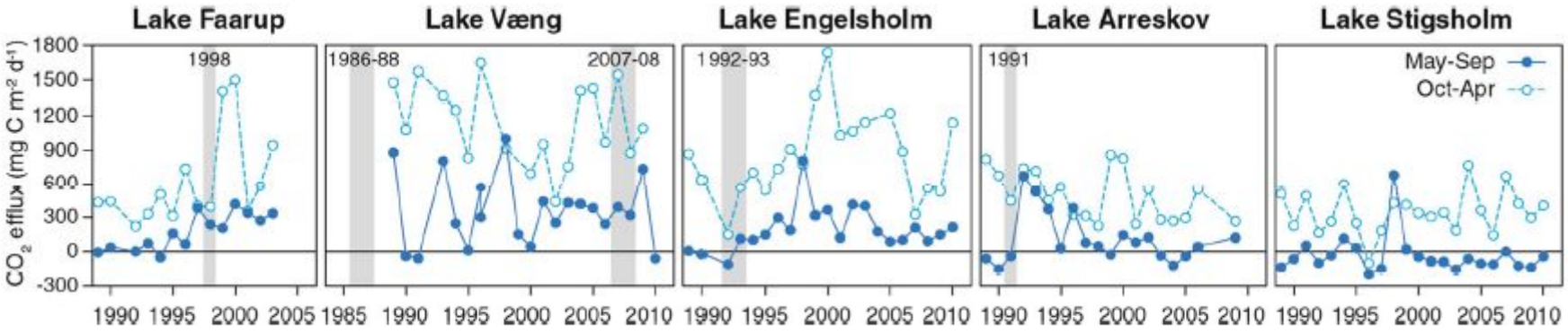
	2012	2013	2014	2015
C (t $m^{-1}y^{-1}$)	-0.4615	-0.3989	-0.4051	-0.2180
K (W m^{-2})	145.5	158.4	143.7	142.8
Hc (W m^{-2})	7.0	6.0	6.7	6.3
LE (W m^{-2})	64.6	61.5	54.7	63.5



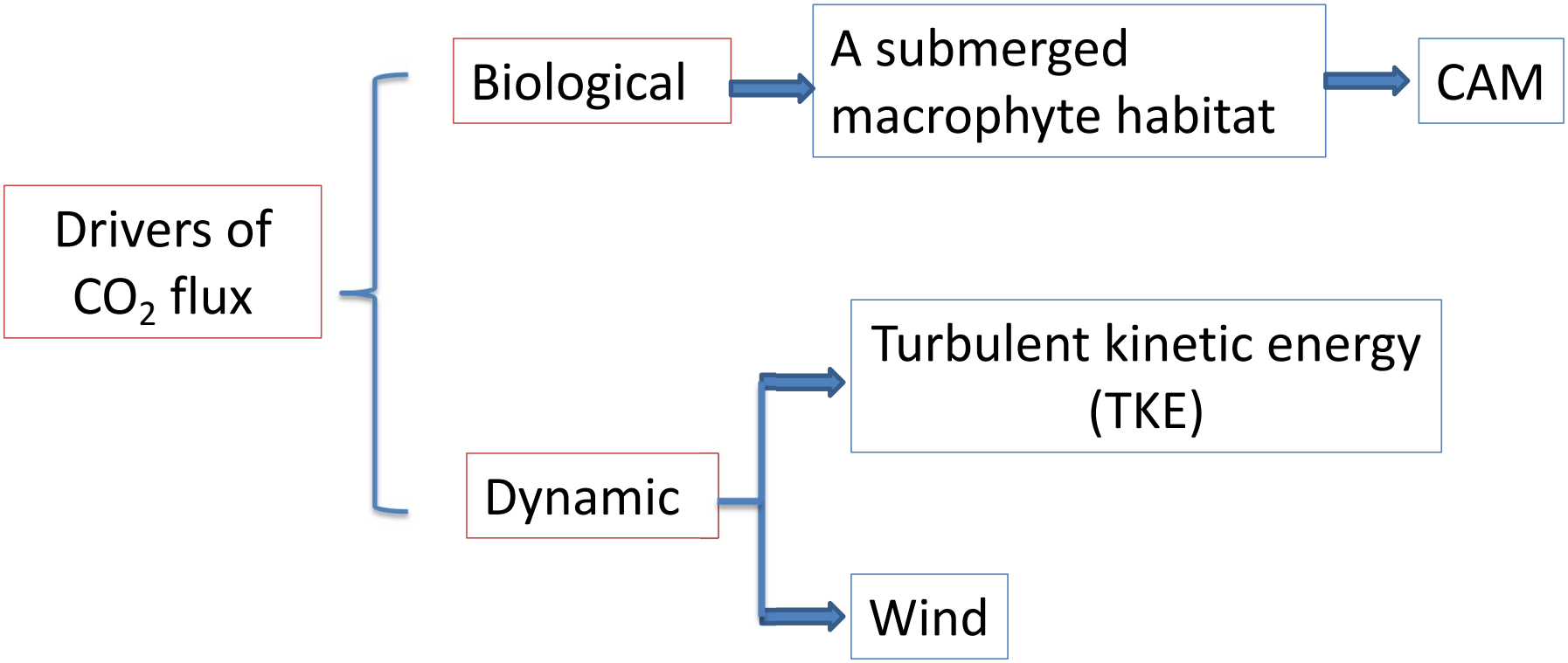
(1) Lake Pallasjärv, northern Finland, mean depth: 9 m, two streams have a peatland-dominated drainage Area, time period: 2013. (Lohila et al,2015)



(2) Lake Tämnaren, east central Sweden, mean depth: 1.3 m, time period: 2010-2012. (Podgrajsek et al,2015)



(3) Five eutrophic, shallow and polymictic lakes, Danish (Keppesen et al,2015).

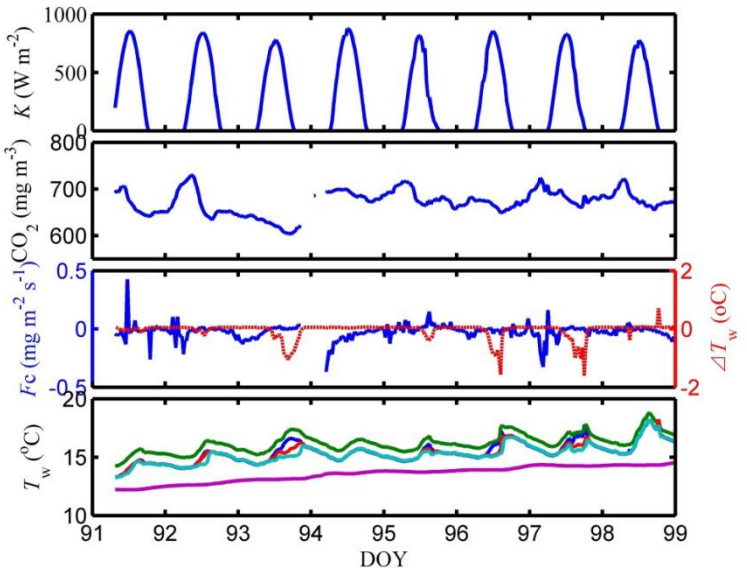


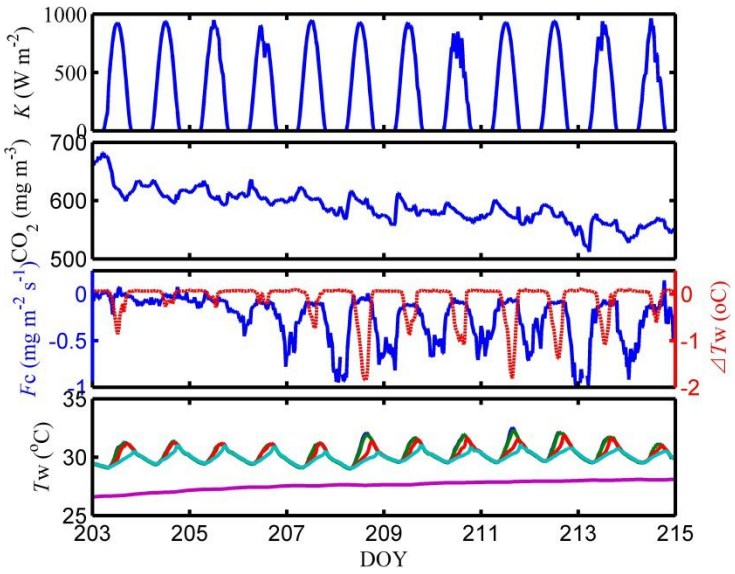
CAM: the Crassulacean acid metabolism

- The most interesting feature regarding the CO_2 flux (*F*c) data is the negative flux in darkness. These nocturnal uptake events usually persist through the whole. They tend to occur in the night following a daylight period of strong solar radiation (Lee et al, 2014).

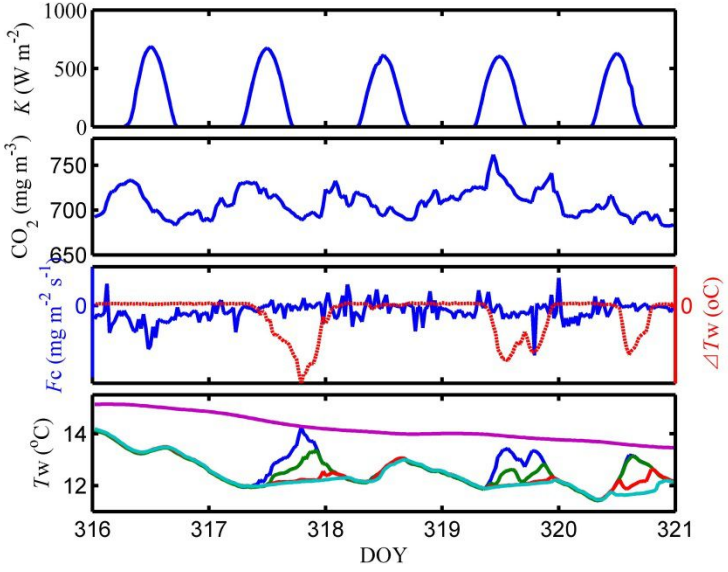
- In this way, I find all the continue sunny and cloudless days from 2012 to 2015 by taking incoming shortwave radiation (K) as judgment criterion. Taking a 5 days or longer time period as a case, there are 3, 5,6 and 4 cases in 2012 to 2015 respectively.

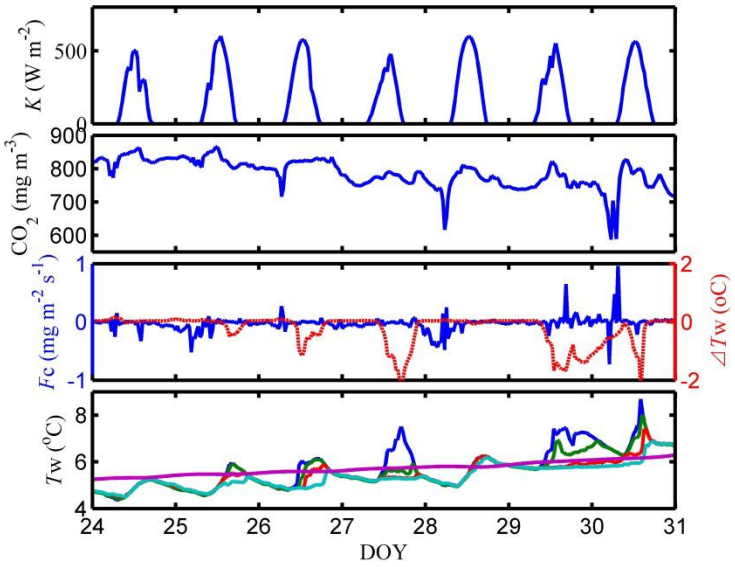
2012 cases

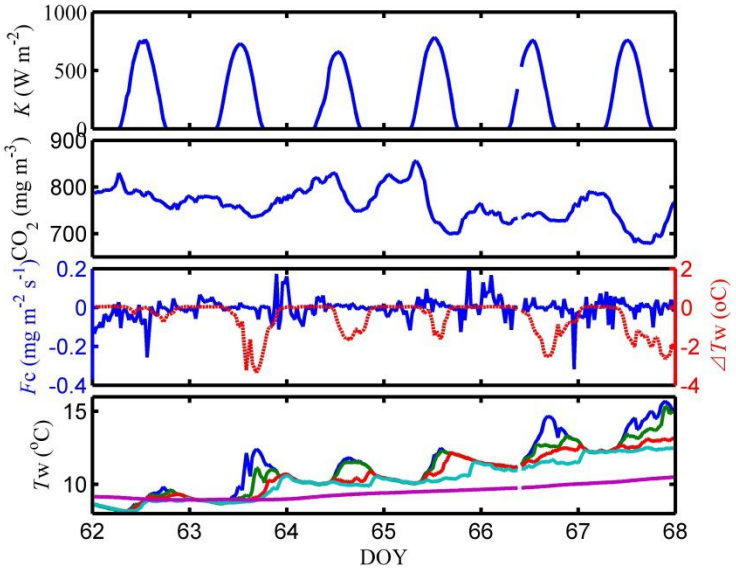


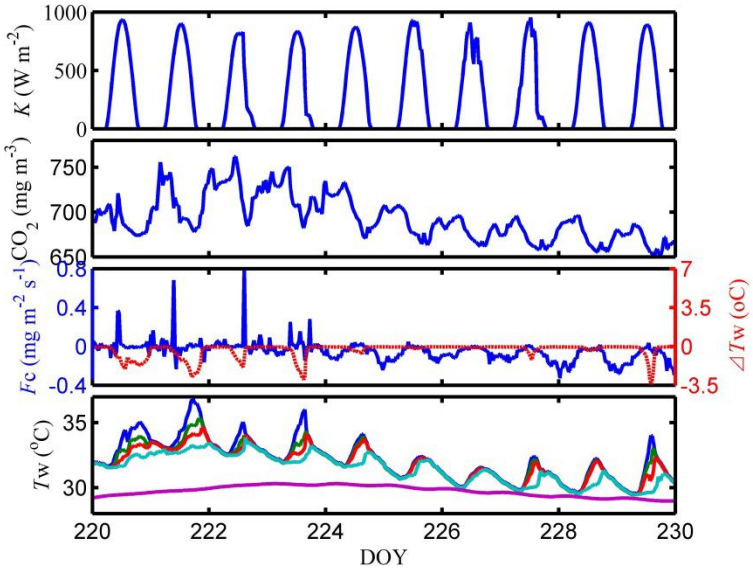


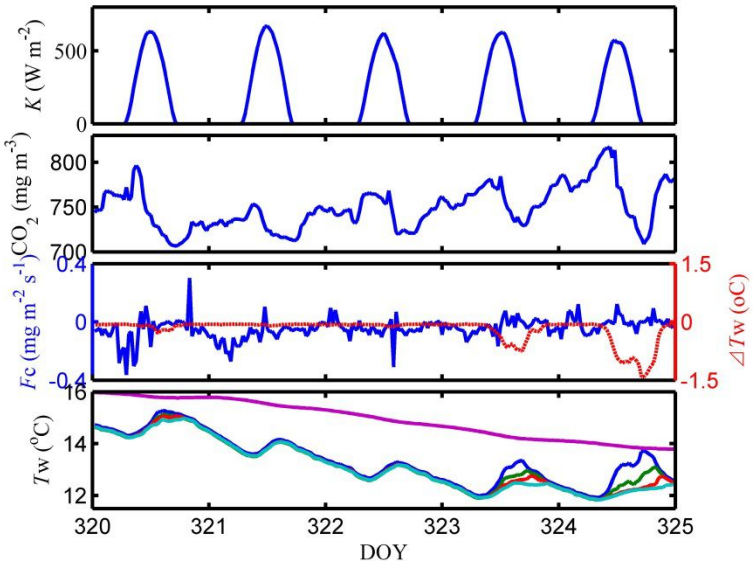
2013 cases

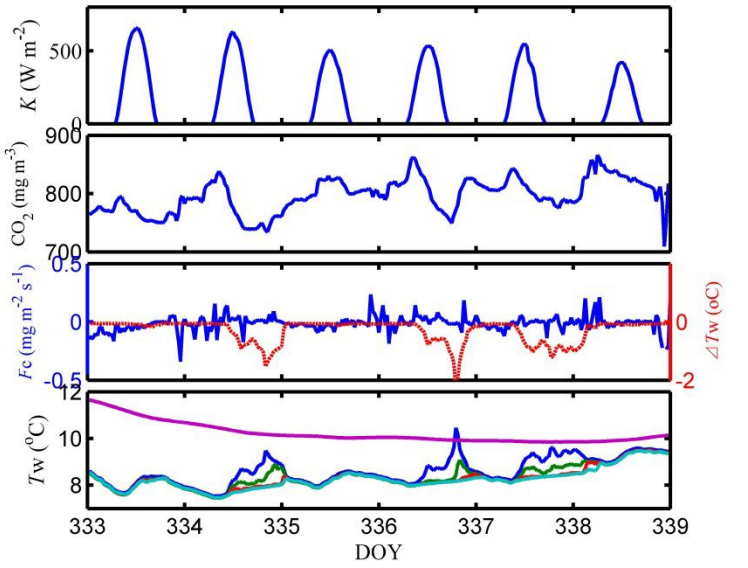




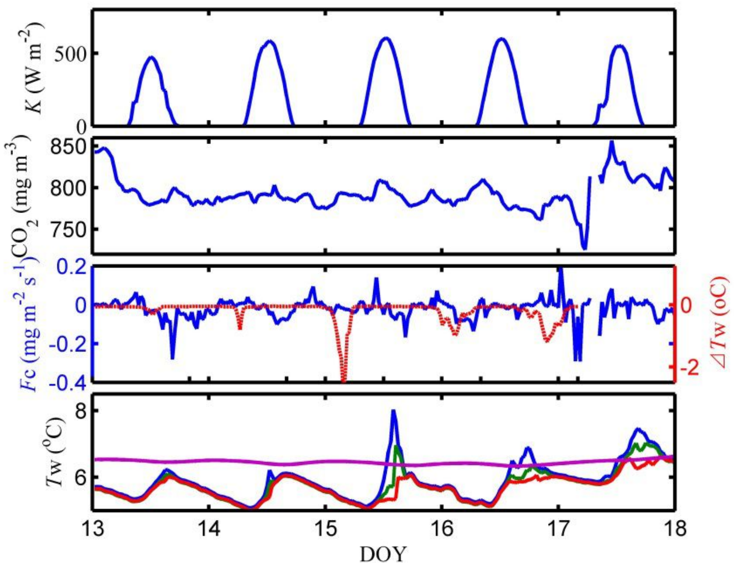

K (W m-2)
CO2 (mg m-3)
Fc (mg m-2 s-1)
ΔTw (oC)
Tw (oC)
DOY

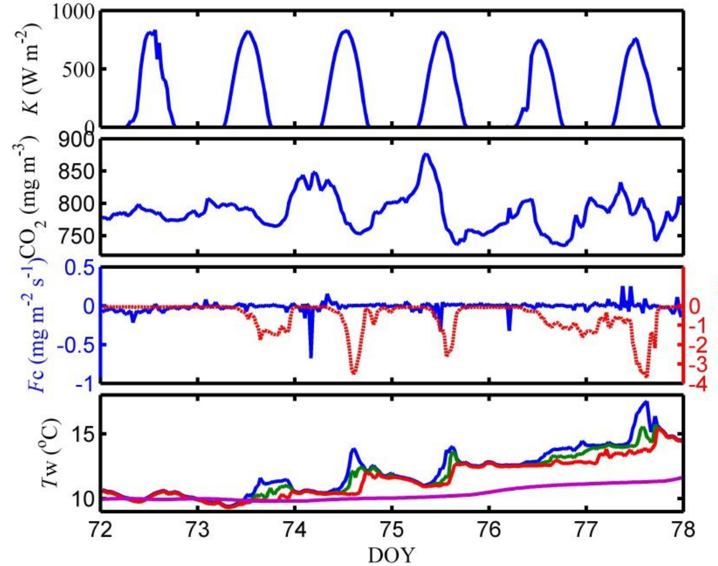

K (W m-2)
CO2 (mg m-3)
Fc (mg m-2 s-1)
ΔTw (oC)
Tw (oC)
DOY

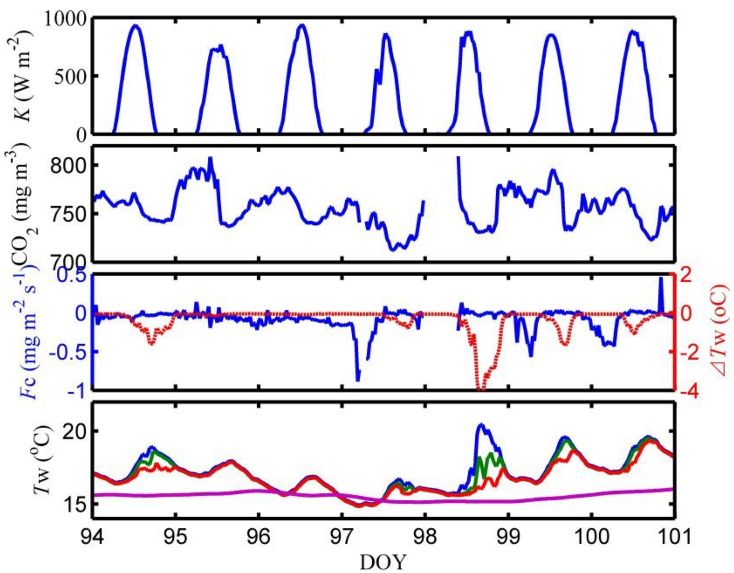

K (W m-2)
CO2 (mg m-3)
Fc (mg m-2 s-1)
ΔTw (oC)
Tw (oC)
DOY

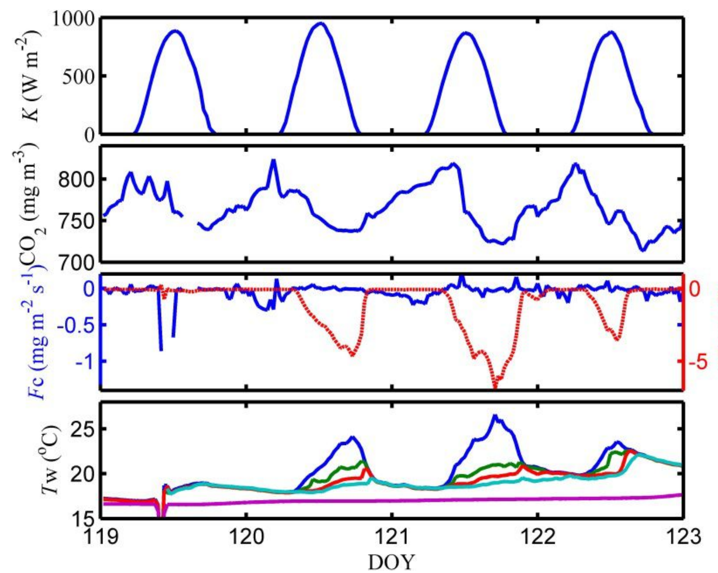

K (W m-2)
CO2 (mg m-3)
Fc (mg m-2 s-1)
ΔTw (oC)
Tw (oC)
DOY

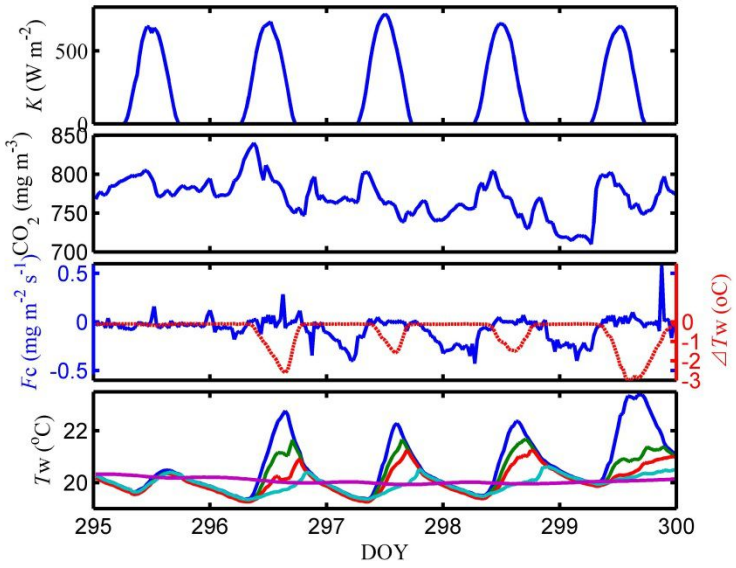
2014 cases

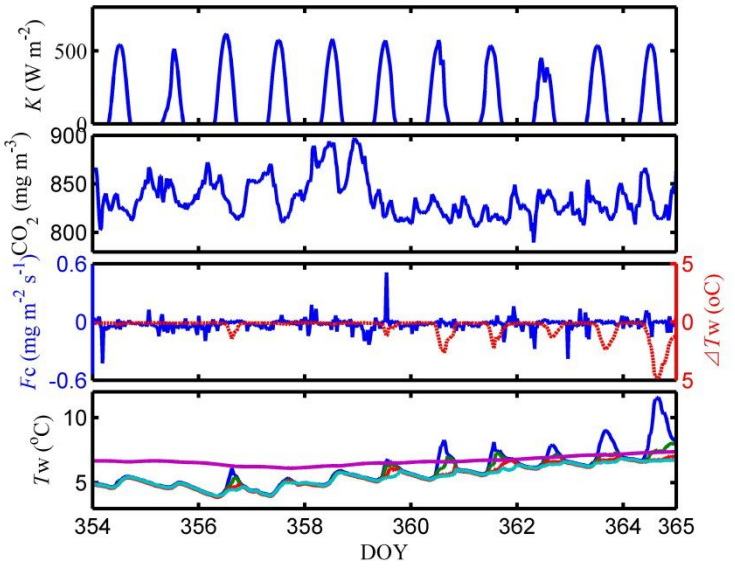

K (W m-2)
CO2 (mg m-3)
Fc (mg m-2 s-1)
ΔTw (oC)
Tw (oC)
DOY


K (W m-2)
CO2 (mg m-3)
Fc (mg m-2 s-1)
ΔTw (oC)
Tw (oC)
DOY

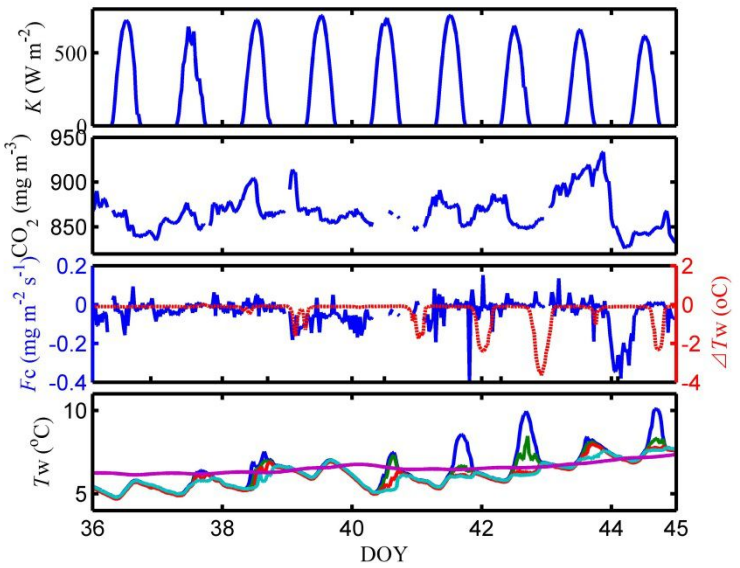

K (W m-2)
CO2 (mg m-3)
Fc (mg m-2 s-1)
ΔTw (oC)
Tw (oC)
DOY

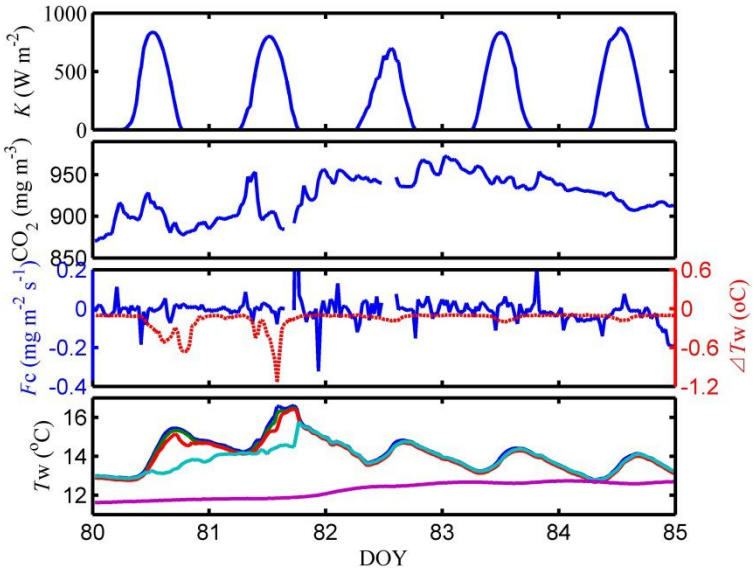

K (W m-2)
CO2 (mg m-3)
Fc (mg m-2 s-1)
ΔTw (oC)
Tw (oC)
DOY

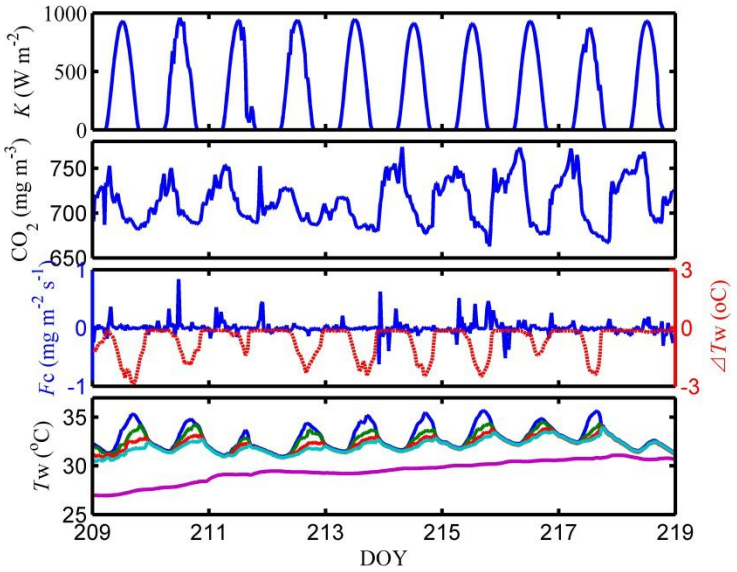

K (W m-2)
CO2 (mg m-3)
Fc (mg m-2 s-1)
ΔTw (oC)
Tw (oC)
DOY

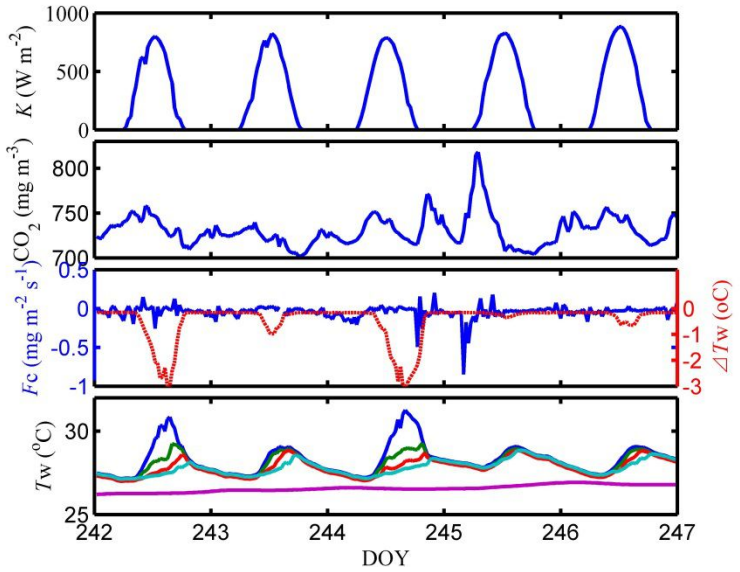

K (W m-2)
CO2 (mg m-3)
Fc (mg m-2 s-1)
ΔTw (oC)
Tw (oC)
DOY

2015 cases


K (W m-2)
CO2 (mg m-3)
Fc (mg m-2 s-1)
ΔTw (oC)
Tw (oC)
DOY


K (W m-2)
CO2 (mg m-3)
Fc (mg m-2 s-1)
ΔTw (oC)
Tw (oC)
DOY


1000
500
0
K (W m-2)
750
700
650
CO2 (mg m-3)
1
0
-1
Fc (mg m-2 s-1)
3
0
-3
ΔTw (oC)
35
30
25
Tw (oC)
209
211
213
215
217
219
DOY


1000
500
0
K (W m-2)
800
750
700
CO2 (mg m-3)
0.5
0
-0.5
-1
Fc (mg m-2 s-1)
0
-1
-2
-3
ΔTw (oC)
30
25
Tw (oC)
242
243
244
245
246
247
DOY

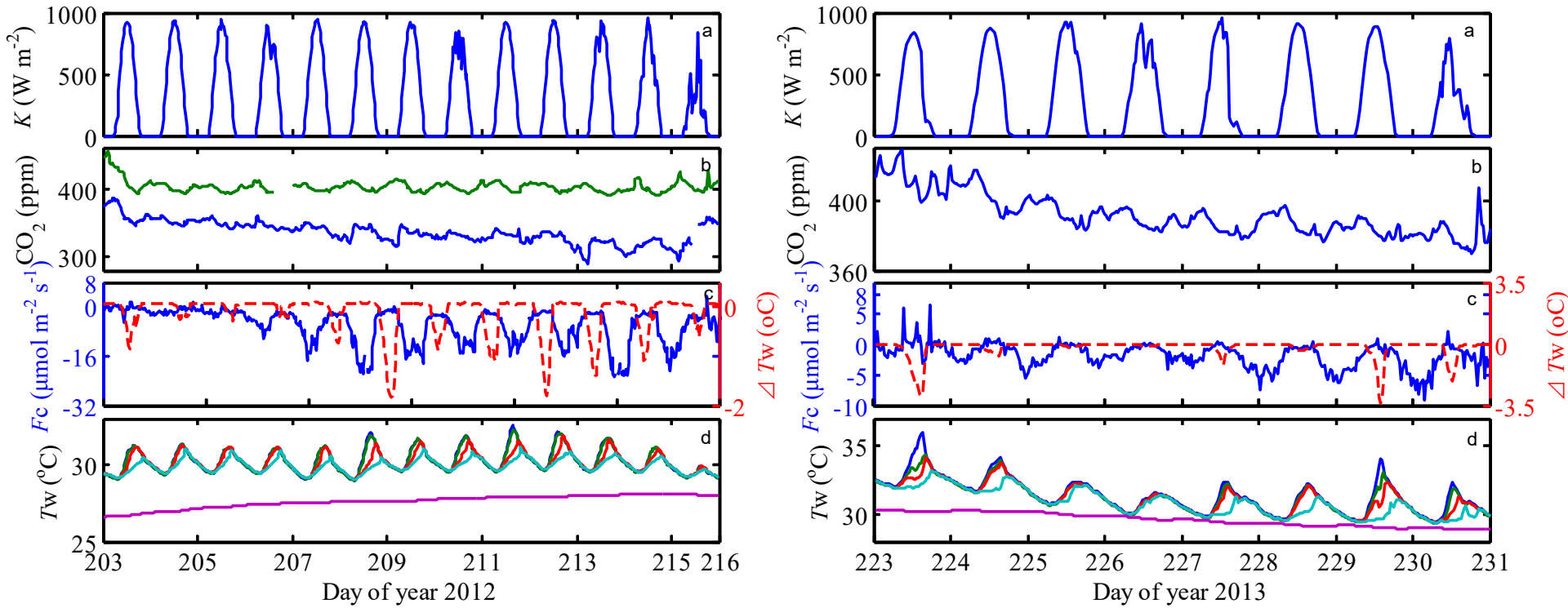


Fig.5 Time series at BFG. (a) Incoming shortwave radiation, (b) CO_2 mixing ratio at BFG (blue line) and at MLW (green line), (c) CO_2 flux (blue solid line) and ⊿ *T*w means water temperature difference between 100cm and 20 cm, (d) water temperature at 20cm (blue), 50cm (green), 100cm (red), 150cm (blue) and 200cm (purple).

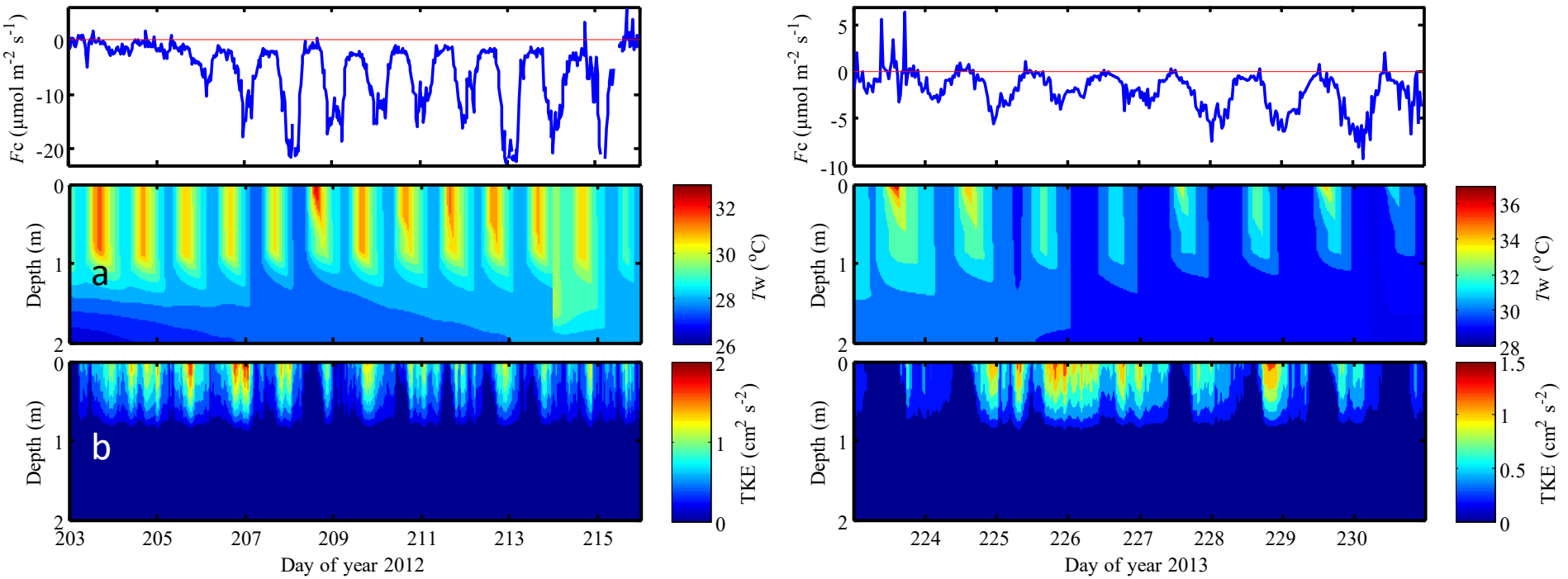


Fig.6 Time series at BFG. (a) CO_2 flux , (b) Water temperature, (c) TKE.

K-ε model A model for vertical turbulent diffusion and stratification in a shallow lake with submersed macrophytes is formulated on the basis of a one-dimensional equation for production, transport, and dissipation of turbulent kinetic energy, coupled with a vertical heat transfer equation.

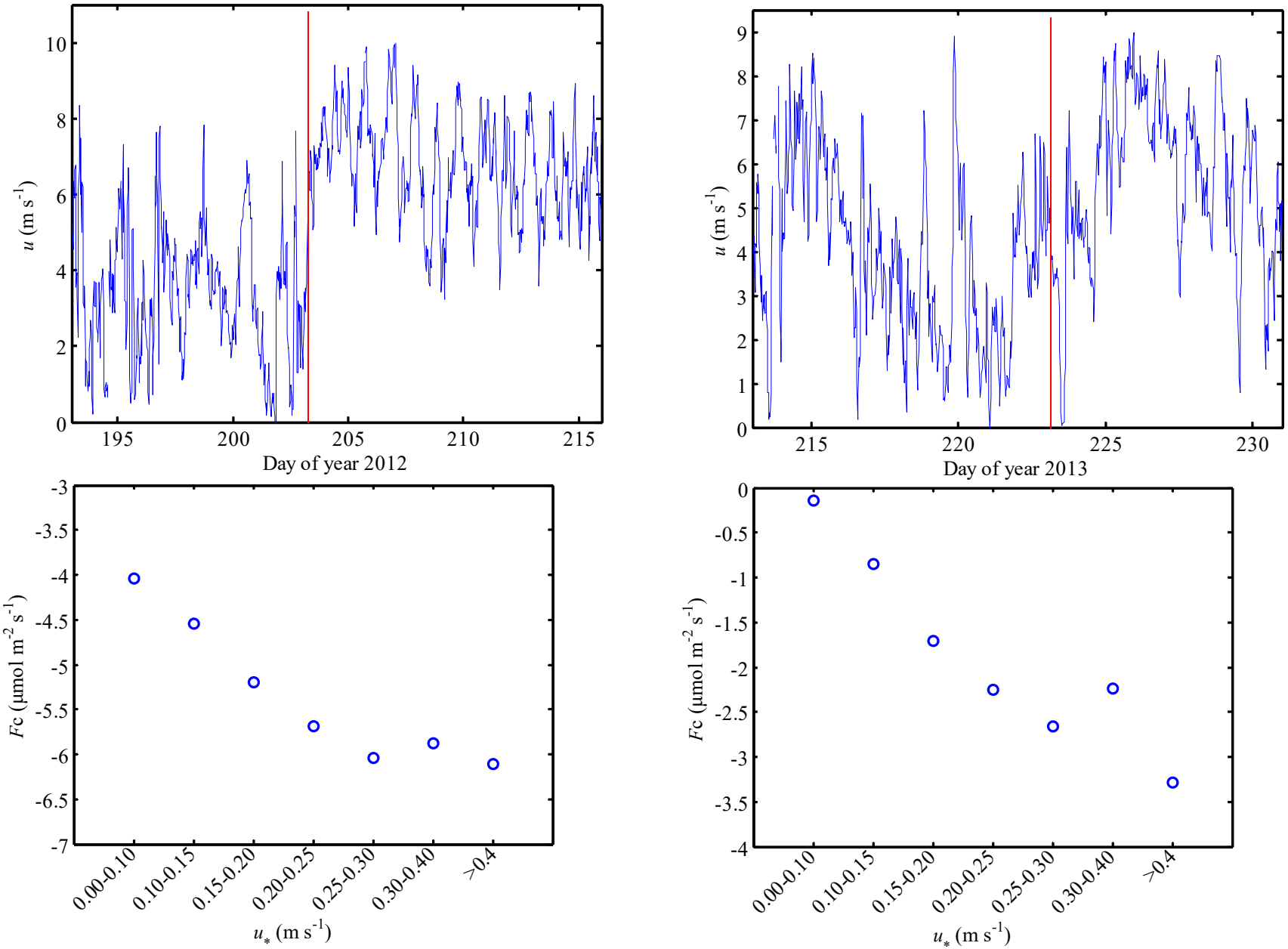


Fig.7 CO_2 flux in different friction velocity (u_*) classes.

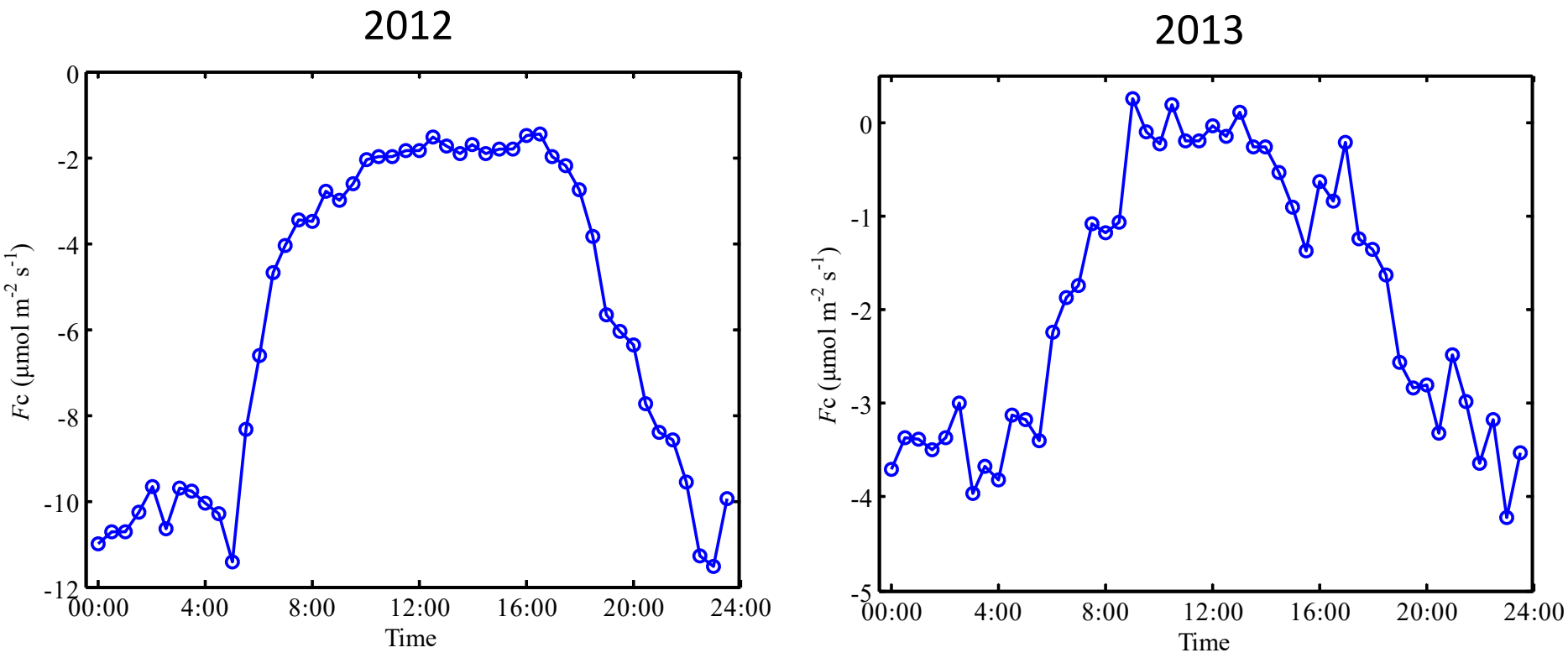


Fig.8 Diurnal pattern of CO_2 flux

Yearly averaged nighttime flux ranges from -1 to 0 μmol m^{-2} s^{-1} and is 3 to 4 times the midday flux (Fig. 3). In the 2012 case, nighttime flux is about -10 μmol m^{-2} s^{-1} and is 5 times the midday flux, similar phenomenon displays in the 2013 case.

Conclusions

- This submerged macrophyte habitat in Lake Taihu is a atmospheric CO_2 sink. Diurnal pattern of *F*c is quite different with other researches.

- Drivers of CO_2 flux at this area can be the CAM of aquatic plants and dynamic forces like TKE and friction velocity.

On-going work

- Reading more papers about lake CO_2 flux and do literature summary.

- As only 2 cases were analyzed, I will continue analyzing other data and determine the drivers of CO_2 flux.

Thank you!