Estimation of Anthropogenic CH_4 Emissions in the Yangtze River Delta Based on Top-Down Method

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- Materials & Methods
- Results & Discussion
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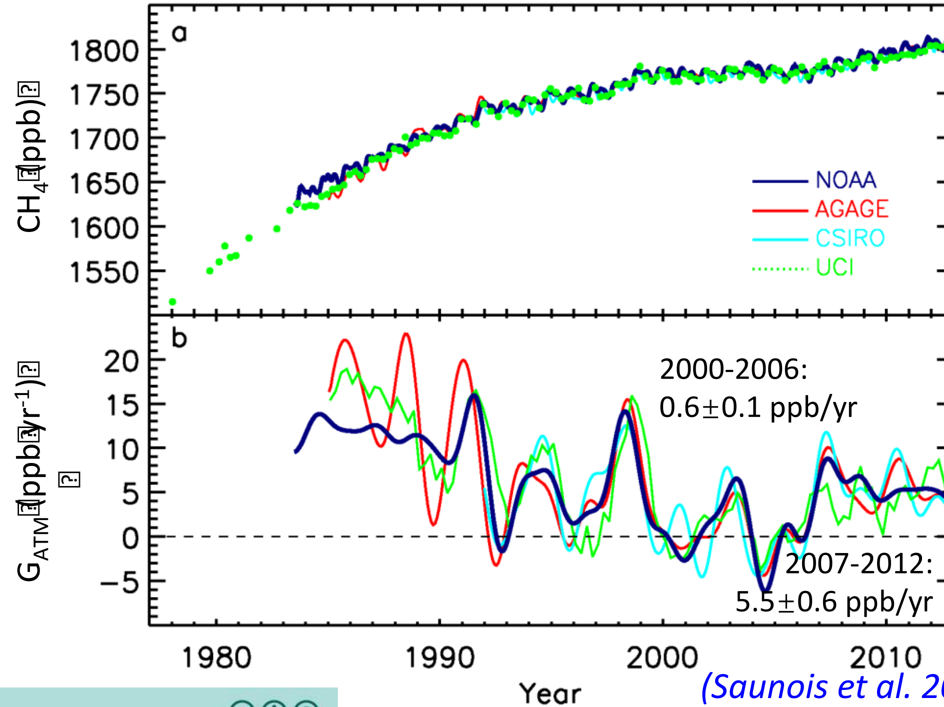
1. Introduction

CH_4 vs. CO_2

(1) Growth: 150% vs. 45%

(2) Life time: 9~11 yr vs. 50~200 yr

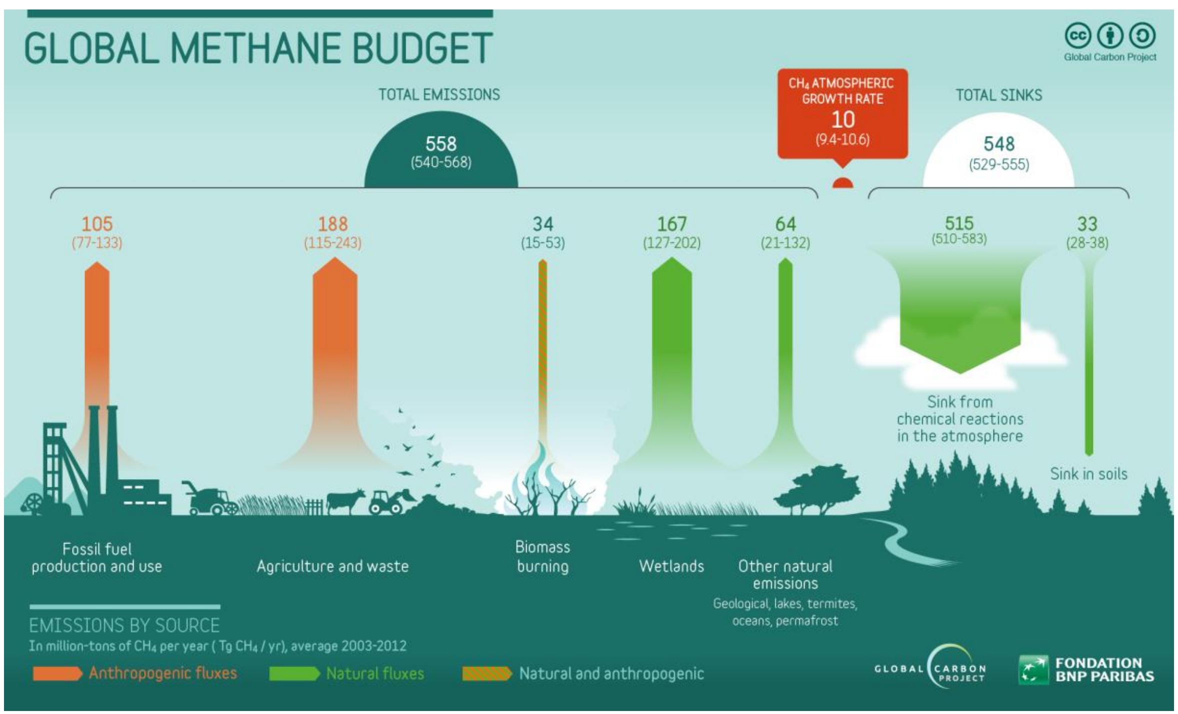
(3) GWP_{100}: 28 vs. 1



(Saunois et al. 2016)

- +12.5 ppb/yr in 2014
- +10.0 ppb/yr in 2015

(*Courtesy, Ed Dlugokencky, NOAA)*



Anthropogenic sources/world total

60%

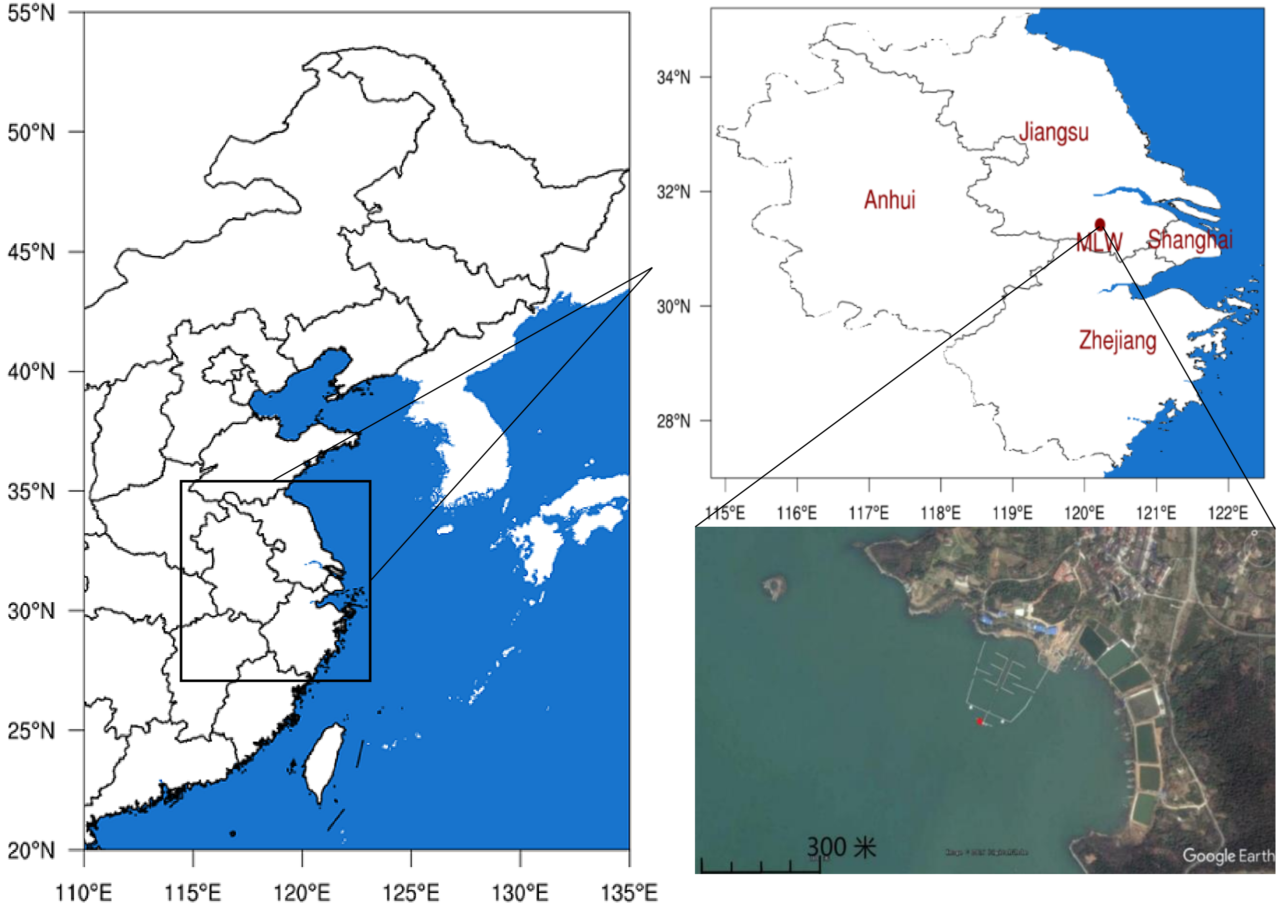
China emission/world total

(EDGAR v4.2, 2012)

22%

2. Materials & Methods

2.1 Site description

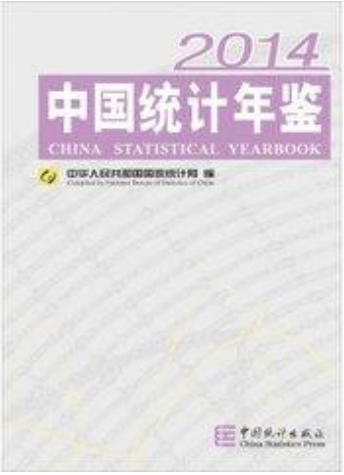


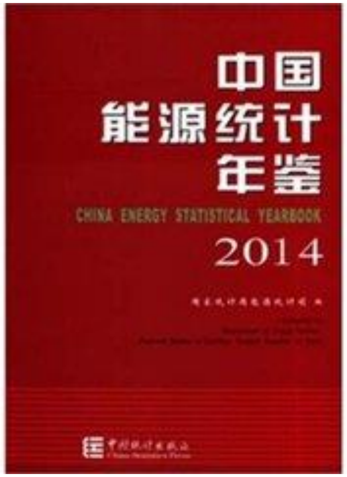
2.2 Data collection

- Observation period: 2012.5~2017.3

$CO_2/CH_4/H_2O$

- Statistical data: 2012~2015





2.3 Method

- IPCC inventory (bottom-up)

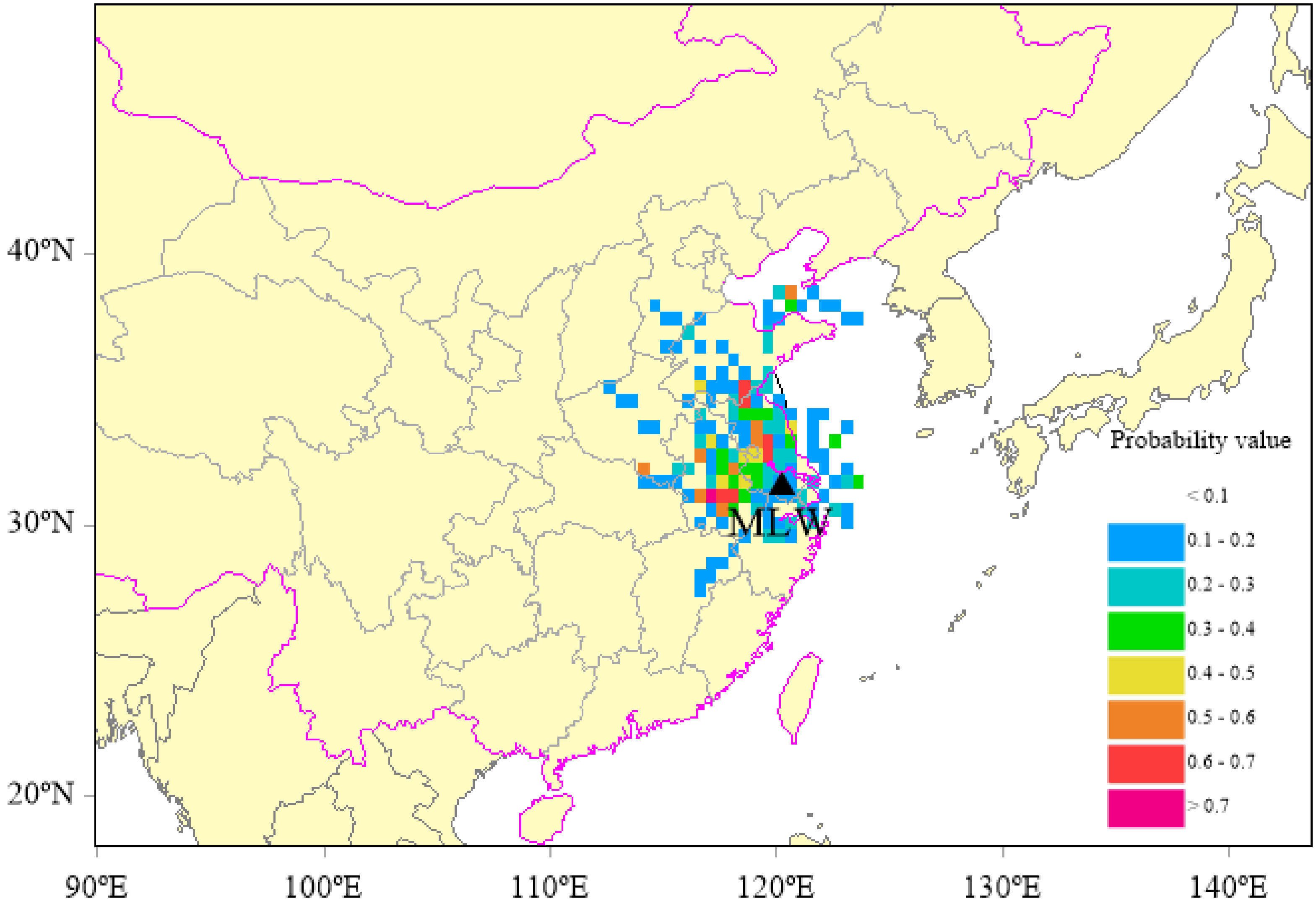
$$F_A|_{b-u} = \sum_1^n f_A \, E_A \qquad (1)$$

A: CH_4, CO_2 etc.
n: types of emission sources
f_A: emission factor for gas A
E_A: consumption

- Atmospheric method (top-down)

Source area?

$$F_{CH_4}|_{t-d} = F_{CO_2}|_{b-u} \times \frac{CH_4}{CO_2}\Big|_{slope} \times \frac{M_{CH_4}}{M_{CO_2}} \qquad (2)$$



81%

76%

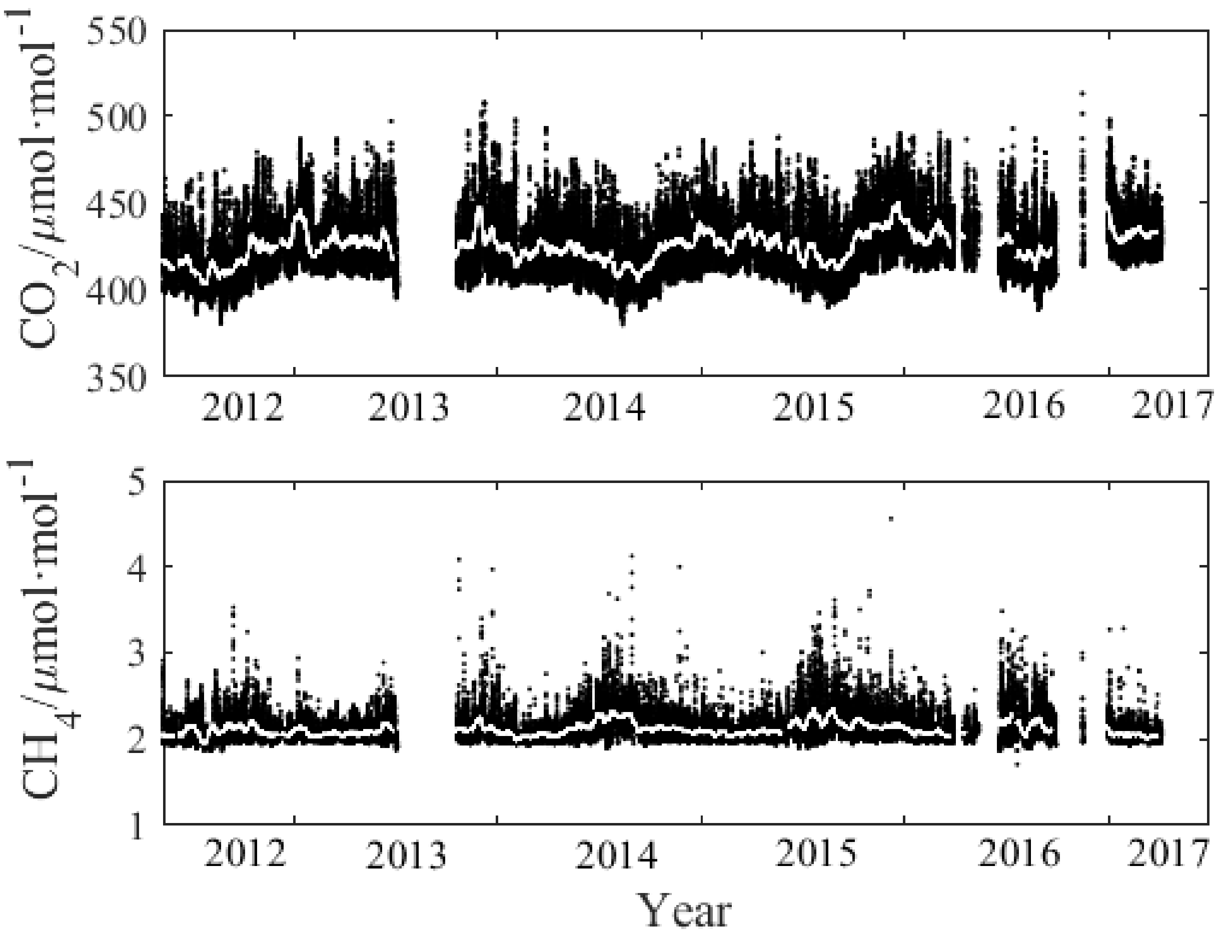
Source area=3.8×10^5 km^2

Inland area

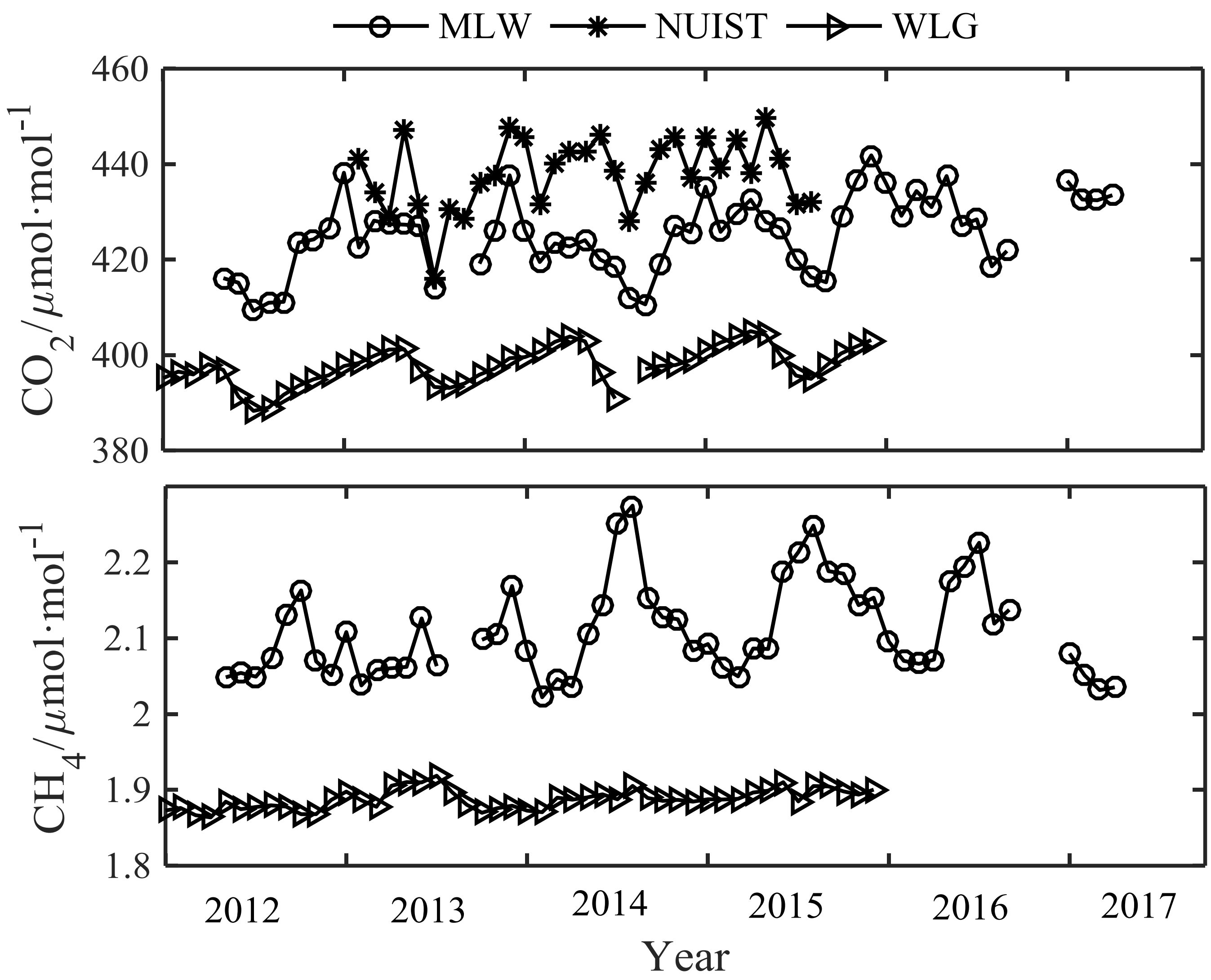
Yangtze River Delta
(YRD)

3. Results & Discussion

3.1 Atmospheric CO_2 and CH_4 concentration



3.1 Atmospheric CO_2 and CH_4 concentration



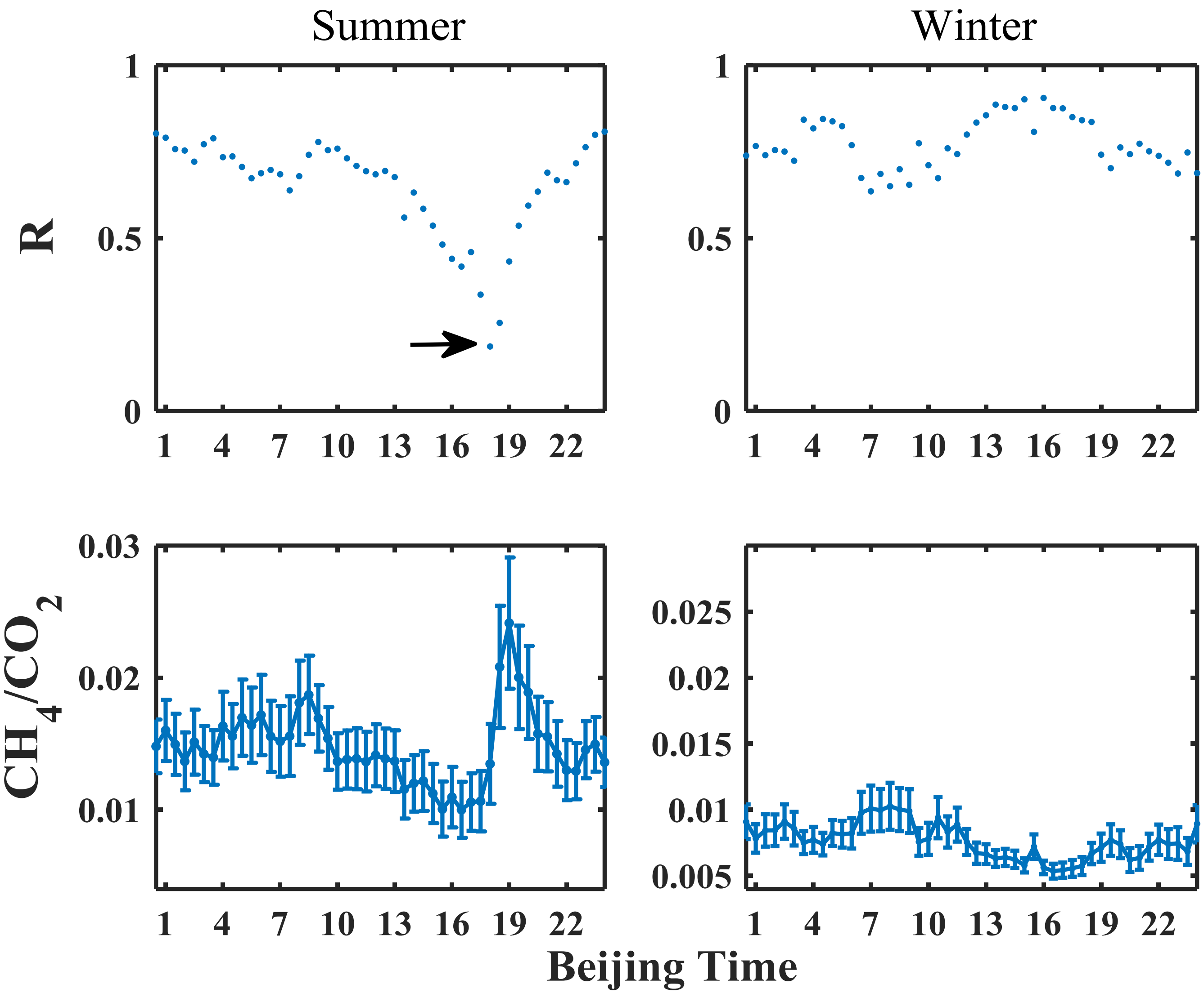
MLW: 3.3±0.5 ppm/yr
WLG: 2.2±1.2 ppm/yr

MLW: 22.1±3.5 ppb/yr
WLG: 7.3±3.8 ppb/yr

	Period	CO_2 (ppm/yr)	CH_4 (ppb/yr)	Reference
WLG	2012-2015	2.2±1.2	7.3±3.8	This research
LAN	2009.1-2011.12	3.7±1.2	8.0±1.2	Fang et al., 2013; Fang et al., 2014
LFS		2.7±0.8	7.9±0.9	
SDZ		3.5±1.6	-	
WLG		2.2±0.8	9.4±0.2	
SDZ	2009-2013	3.8±0.01	10±1	Fang et al., 2016
Qinghai-Tibet Plateau	2003-2014	-	4.7	Feng et al., 2017
Northern Hemisphere mid-latitude	1983-2014	-	9.1±7.8	Sun et al.,2017
Antarctic	1983-2014	-	8.7±6.9	
MHD	2005-2009	2	-	Vermeulen et al., 2011
	2005-2010	-	7.4	
Beijing	1985-1989	-	35	Wang et al., 2001
	1990-1997		10	
	1993-2002	2.3	-	Liu et al., 2005
Xi'an	2011-2013	3.3	-	Wang et al., 2015
MLW	2012.5-2017.3	3.3±0.5	22.1±3.5	This research

3.2 Relationship between CO_2 and CH_4

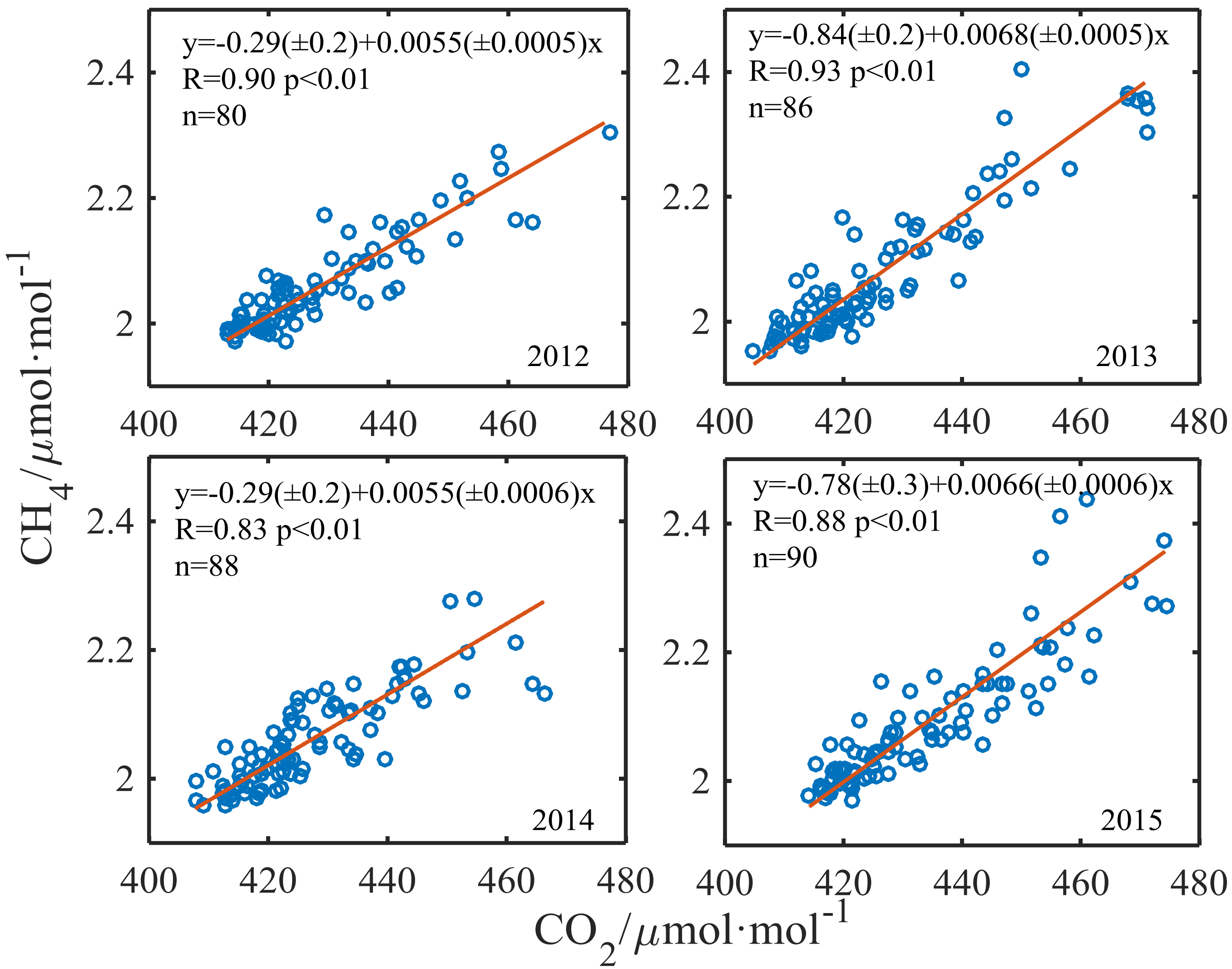
2015



3.2 Relationship between CO_2 and CH_4

Winter

Midday



Location	Type	Time	CH_4/CO_2 ($\times 10^{-3}$)	Reference
Boulder, Colorado	Surface, in situ	1985.12	7.6±0.7	*Conway et al., 1989*
Barrow, Alaska	Surface, in situ	1986.03	21.2±0.4	
Barrow, Alaska	Surface, in situ	1986.04	13.5±0.9	
Arctic troposphere, lower stratosphere	Aircraft, flasks	1986.03~1986.04	17.5±0.6	
Alert, NWT, Canada	Mountain, in situ	1986.04	20	*Trivett et al., 1989*
Ocean Station M (66°N, 2°E)	Surface, flasks	1983-1989, winter	9.3±1.7*	*Conway et al., 1993*
Barrow, Alaska	Surface, flasks	1989.03	11.0	
Arctic troposphere, lower stratosphere	Aircraft, flasks	1989.03	13.5	
Barrow, Alaska	Surface, in situ	1989~1990	9.14±3.27	*Jaffe et al., 1995*
Alert, NWT, Canada	Mountain, in situ	1992.01~1992.04, BC>100 ng/m^3	13.0±2.2*	*Worthy et al., 1994*
lack Forest, Germany	Mountain, in situ	1991~1995, winter (hourly & daily)	7.8±1.0	*Schmidt et al., 1996*
		1991~1995, winter, monthly	6.5±1.1	
NASA LAB	Surface, in situ	1986~1997, winter, midnight	12.8±0.3	*Harris et al., 2000*
Tatra Mountains, southern Poland	Mountain, in situ	1997, winter	10.7±0.3	*Necki et al., 2010*
Pasadena, LA	Aircraft, in situ	2007.08~2008.06	7.8±0.8	*Wunch et al., 2009*
LA,	Aircraft, in situ	2008.06	6.74±0.58	*Wennberg et al., 2012*
LA,	Aircraft, in situ	2010.05~2010.06	6.55-6.7	*Wennberg et al., 2012; Peischl et al., 2013*
Pasadena, LA	Surface, in situ	2012.02~2012.08	6.30±0.01	*Wong et al., 2015*
Pasadena, LA	Surface, in situ	2011.09~2013.06	6.10±0.10	
LA	Column(FTS)	2011.09~2013.10	6.40±0.50	
NUIST	Building, in situ	2010, winter, midday	4.3±0.7	*Shen et al., 2014*
MLW	Surface, in situ	2012~2015, winter, midday	6.1±0.5*	*This research*

3.3 CH_4 and CO_2 emissions based on the IPCC method

Anthropogenic CO_2 emissions (2012)

	YRD	
	Emission ($\times 10^{11}$ kg)	Percent of total (%)
Industrial energy consumption*	13.03 (±6%)	67.9
Industrial processes	4.40 (±8%)	23.0
Transportation	1.35 (±17%)	7.0
Household	0.40 (±5%)	2.1
Total	19.18 (±7%)	100

*. This section also covers energy emissions in construction, commercial and manufacturing industries.

Anthropogenic CH_4 emissions (2012)

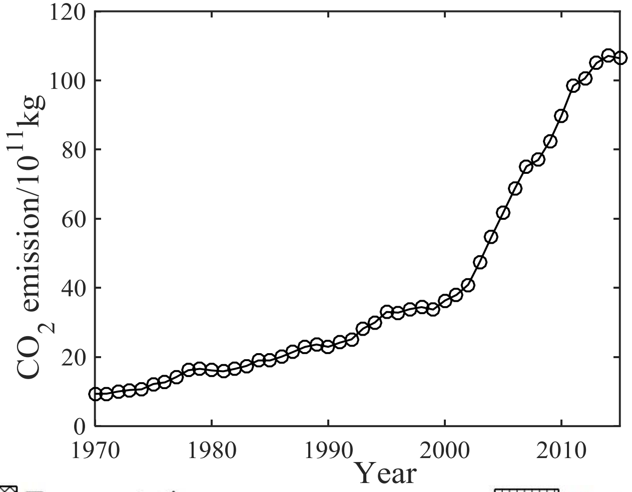
	YRD	
	Emission ($\times 10^{9}$ kg)	Percent of total (%)
Rice cultivation*	2.68 (±6%)	46.3
Landfill	0.50 (±28%)	8.7
Wastewater treatment	0.28 (±29%)	4.8
Livestock	0.31 (±12%)	5.4
Fuel and Biomass burning	0.32 (±14%)	5.6
Coal mining	1.69 (±8%)	29.2
Total*	5.78 (±17%)	100

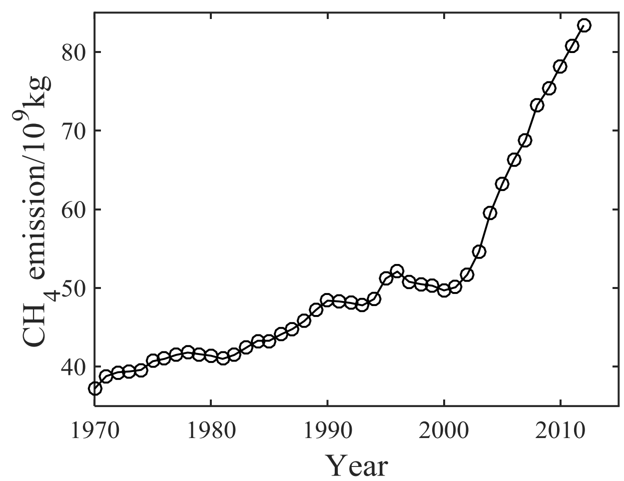
*. CH_4 emissions from rice cultivation were not included in the anthropogenic total as the analysis was limited to wintertime.

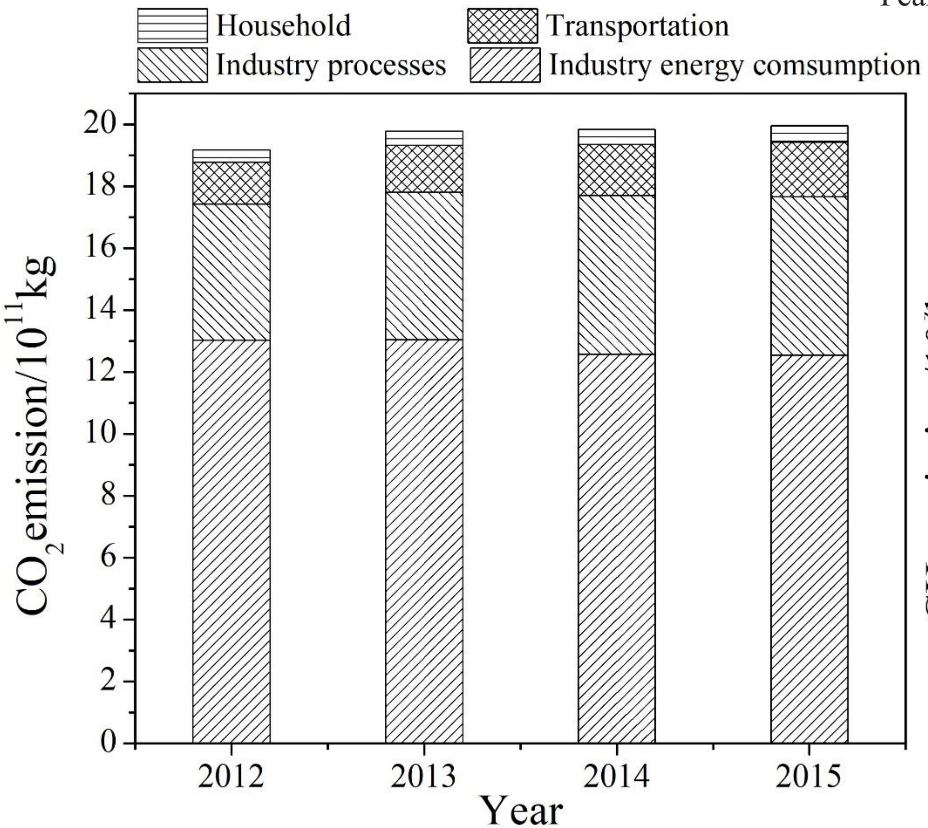
3.3 CH_4 and CO_2 emissions based on the IPCC method

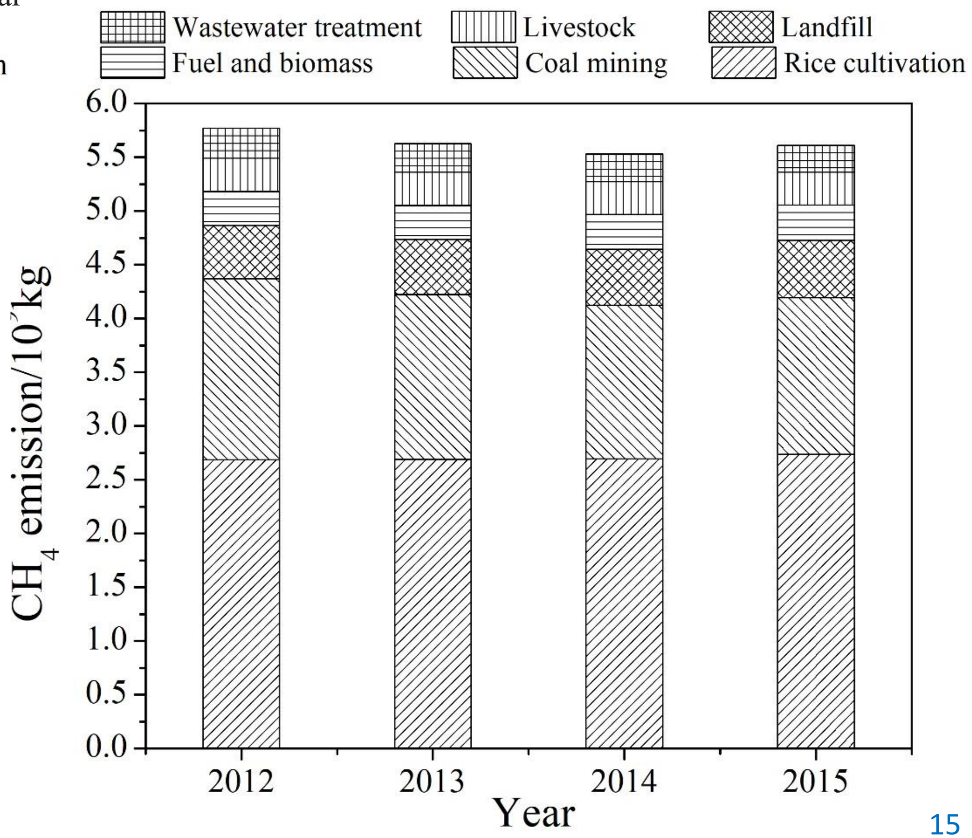
China

(EDGAR v4.2, 2012)



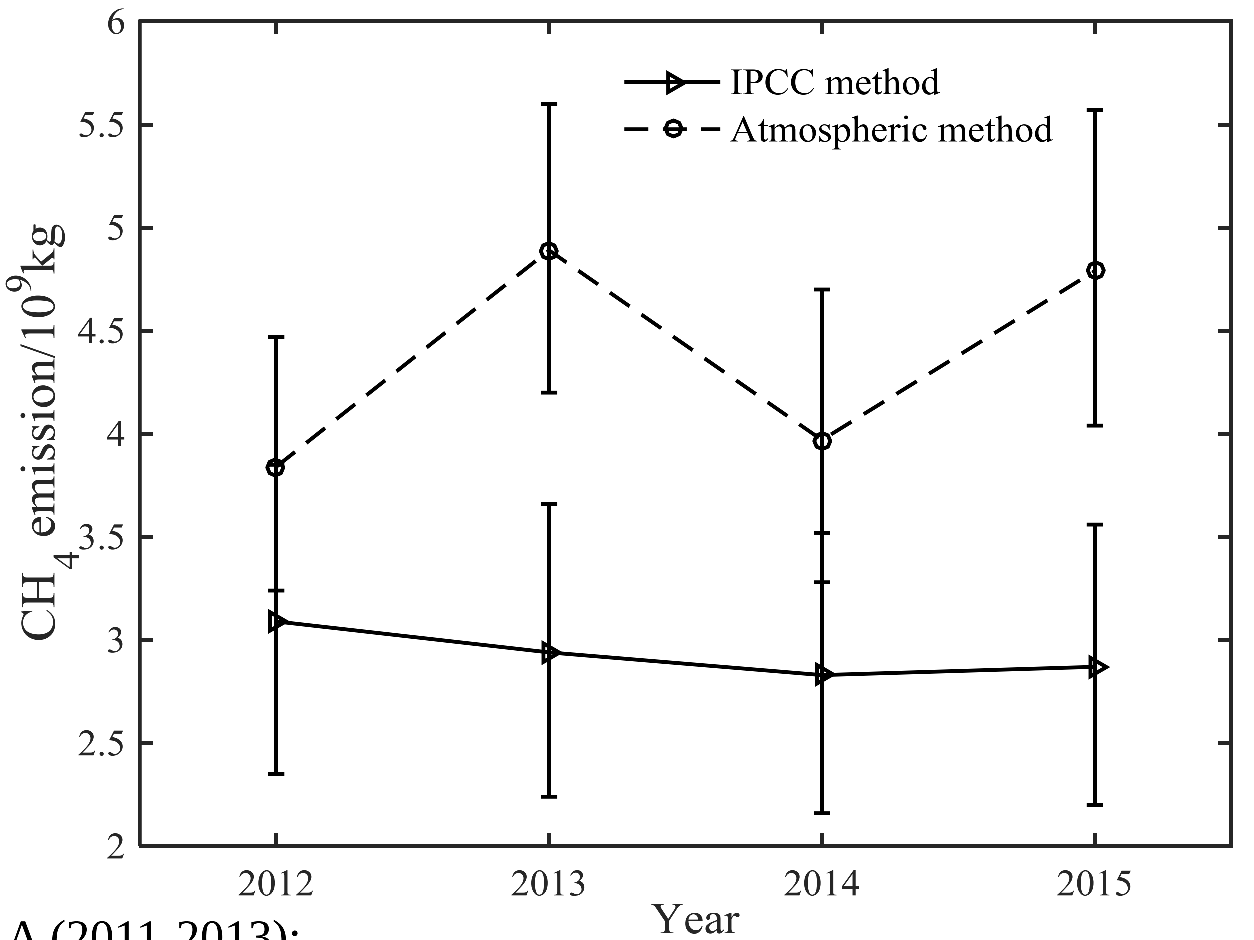






3.4 Comparison of CH_4 emissions by two methods

1.2~1.7 times



LA (2011-2013):

$F_{CH_4}|_{t\text{-}d}$ is 1.2-1.6 times as large as $F_{CH_4}|_{b\text{-}u}$ *(Wong et al., 2015).*

California (2010-2011)

$F_{CH_4}|_{t\text{-}d}$ is 1.3-1.8 times as large as $F_{CH_4}|_{b\text{-}u}$ *(Jeong et al., 2013).*

4. Conclusions

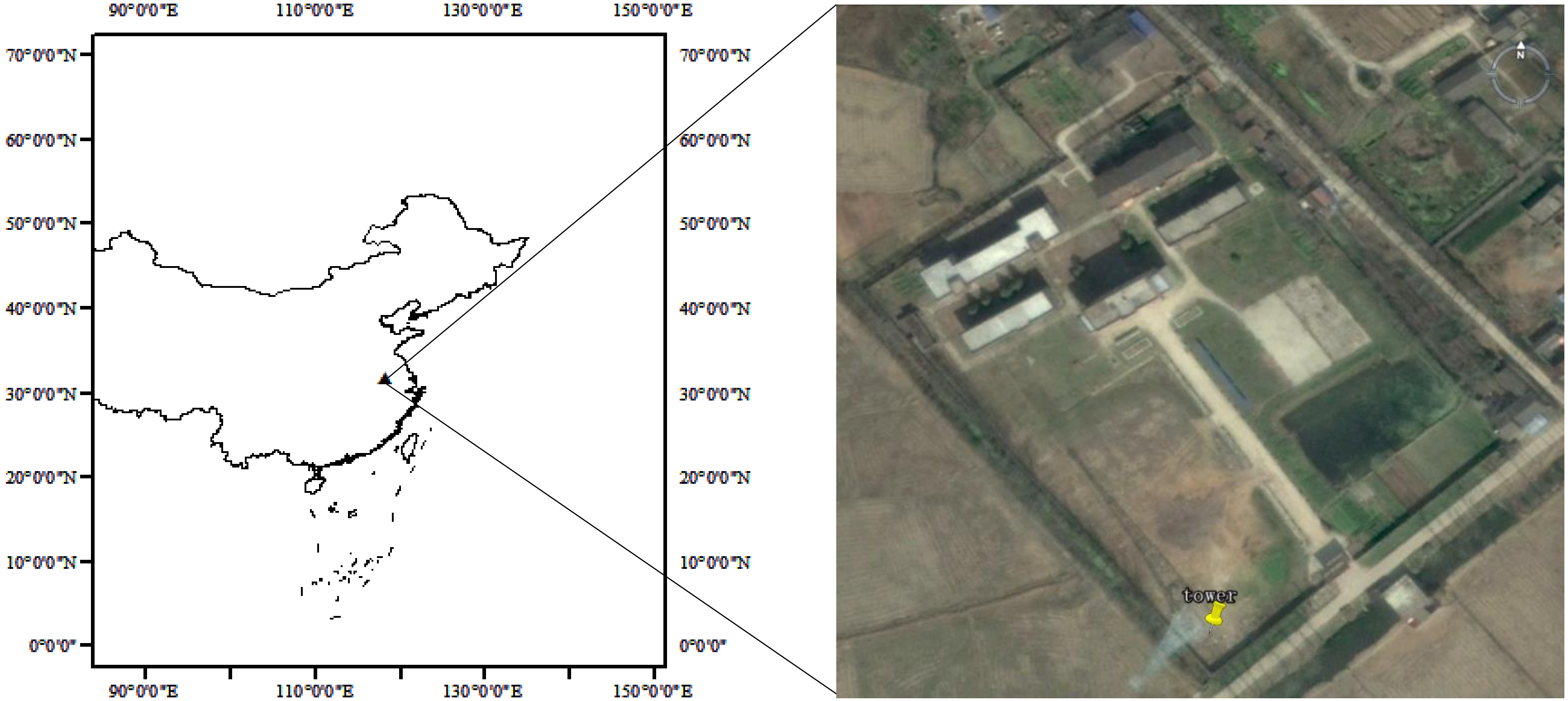
- The annual growth rate of CO_2 and CH_4 in the atmosphere were 3.3 ± 0.5 ppm yr^{-1} and 22.1 ± 3.5 ppb yr^{-1} respectively which were significantly higher than that in Waliguan station;

- The top-down CH_4 emission is 20-70% larger than bottom-up CH_4 emission inventory and consistent with previous studies;

- The average annual anthropogenic CH_4 emissions (excluding emission from rice cultivation) were 4.37×10^9 kg in the YRD area.

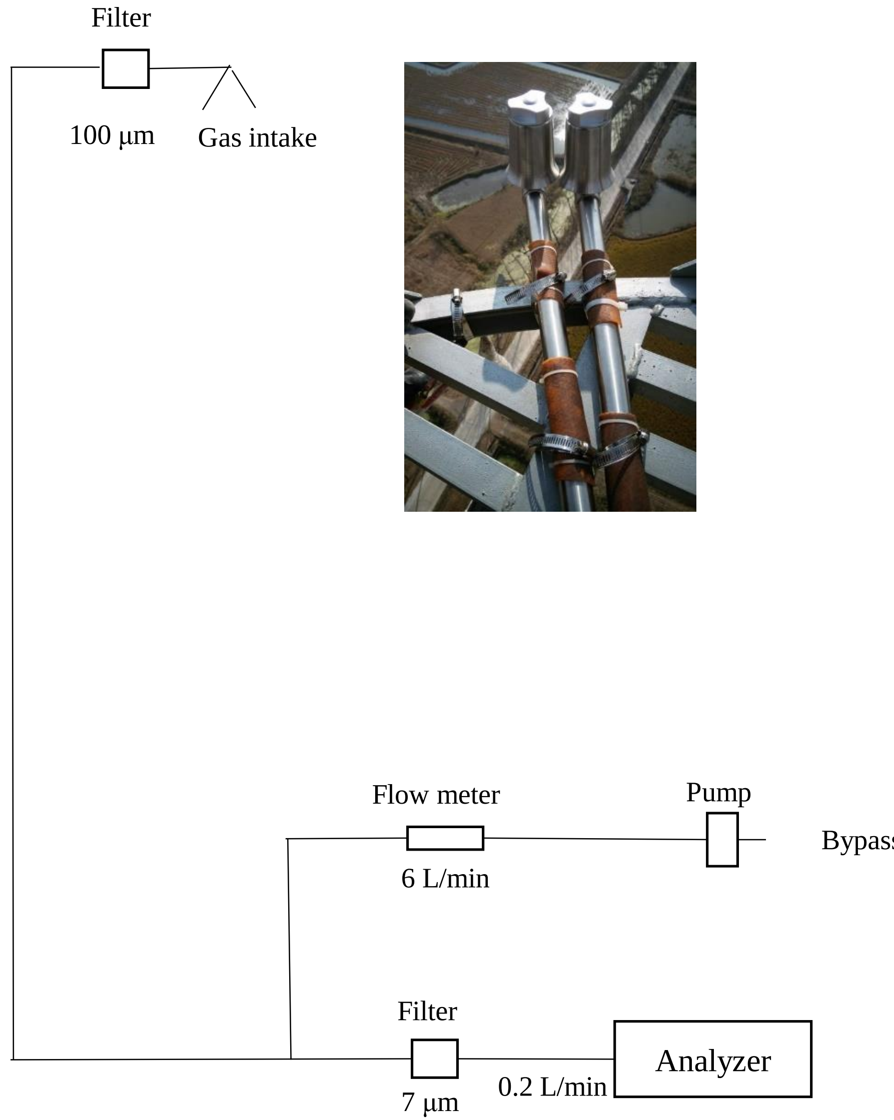
5. Next work

5.1 Site description



5.2 Experiment setup

Length of tube: 100m



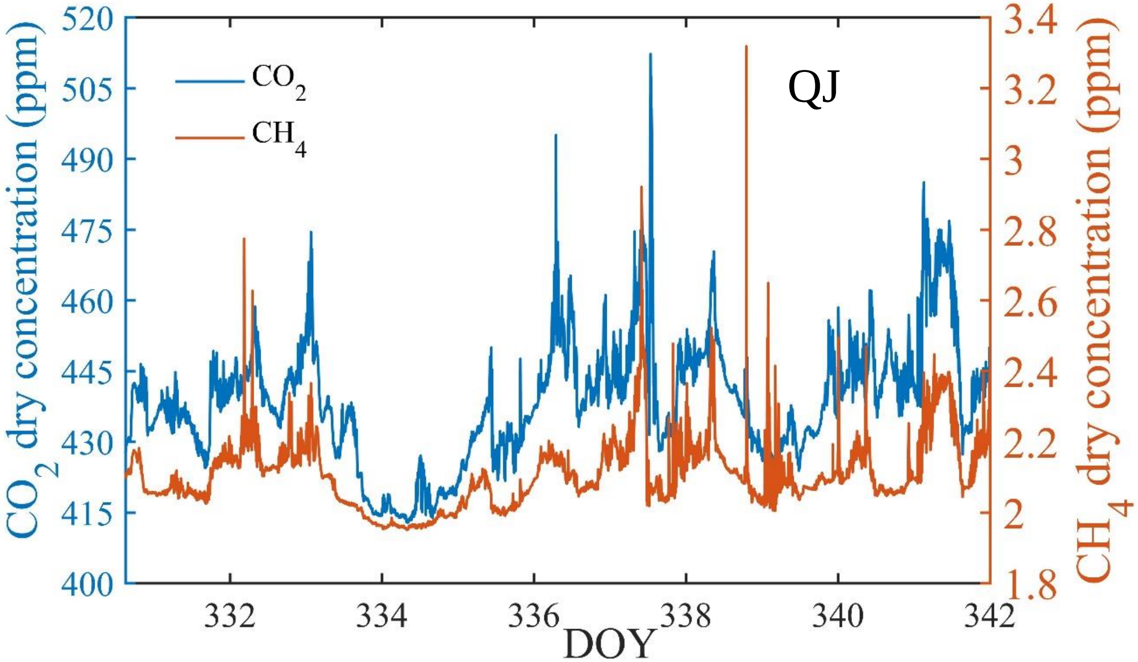
Delay time 47 s

5.3 Initial analysis

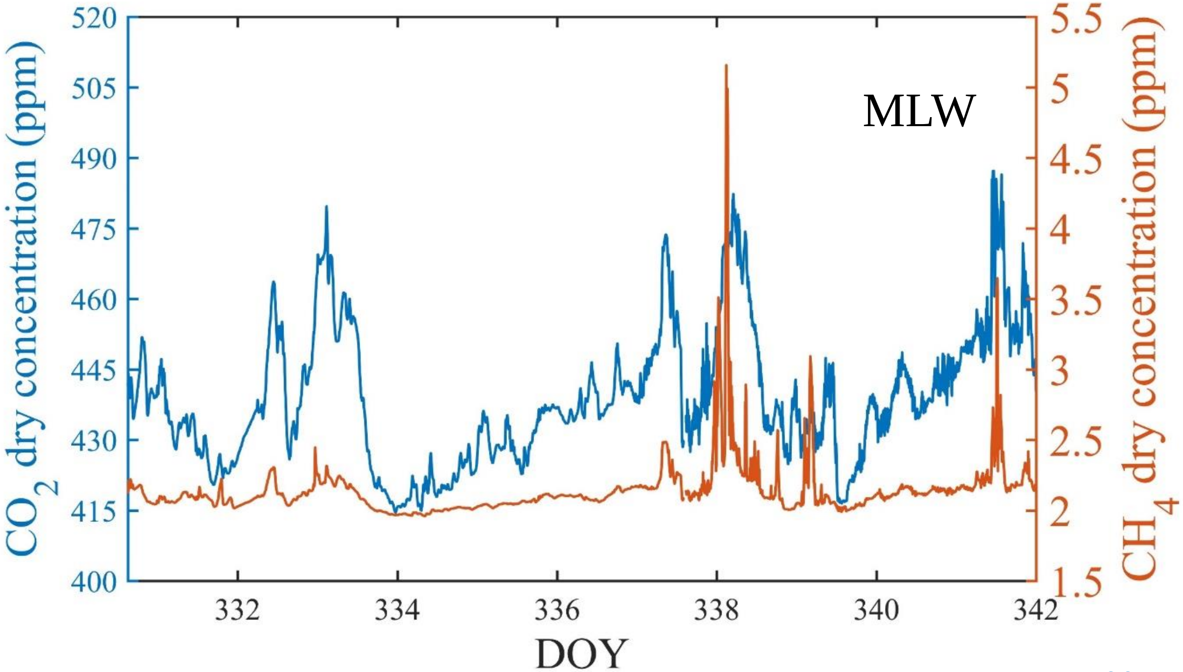
Period:

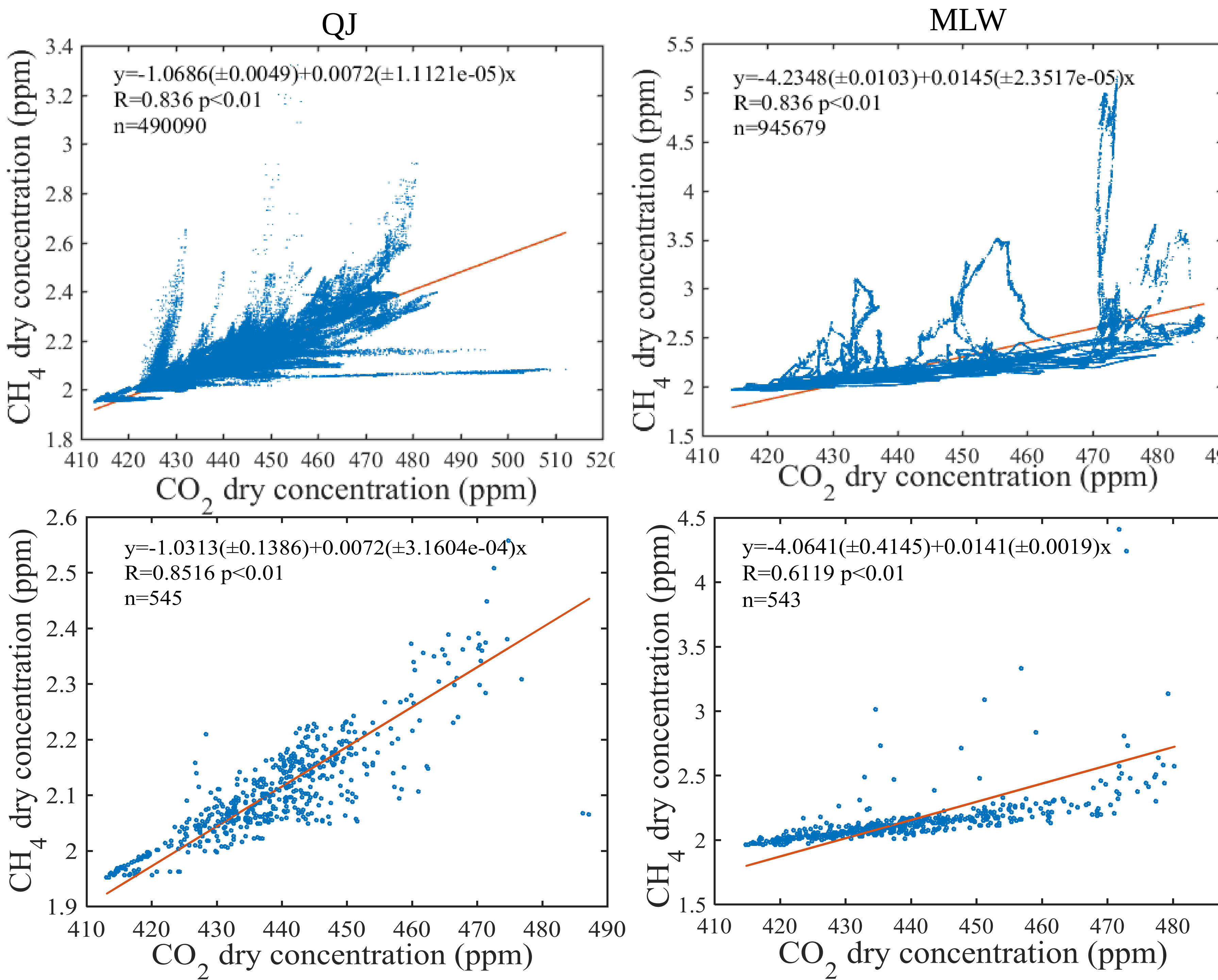
11.26 15:00~12.08 00:00

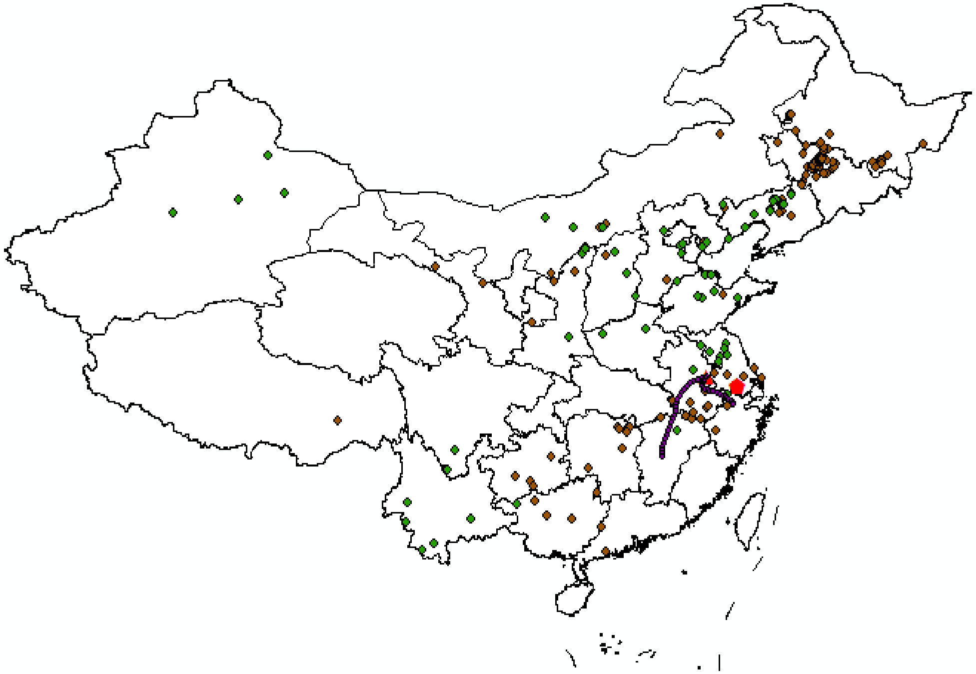
QJ
2017.11.28
2017.12.03
2017.12.04
2017.12.05



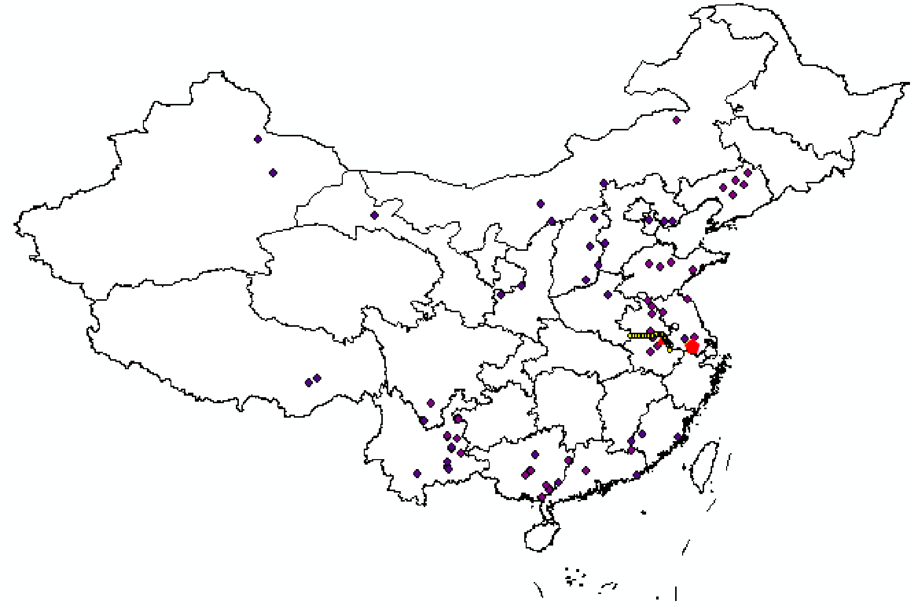
MLW
2017.12.04
2017.12.05
2017.12.07



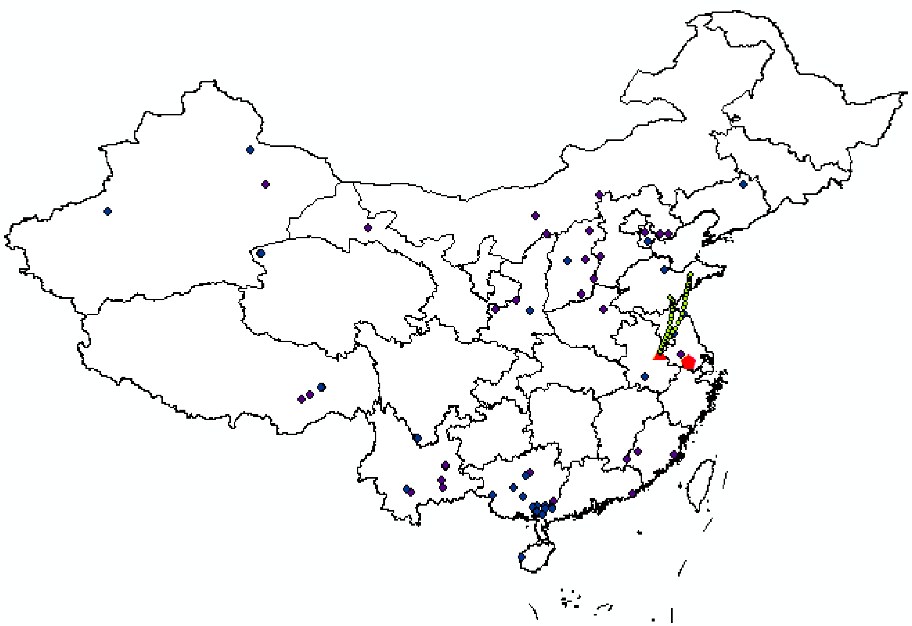

QJ
MLW
y=-1.0686(±0.0049)+0.0072(±1.1121e-05)x
R=0.836 p<0.01
n=490090
y=-4.2348(±0.0103)+0.0145(±2.3517e-05)x
R=0.836 p<0.01
n=945679
y=-1.0313(±0.1386)+0.0072(±3.1604e-04)x
R=0.8516 p<0.01
n=545
y=-4.0641(±0.4145)+0.0141(±0.0019)x
R=0.6119 p<0.01
n=543
CH4 dry concentration (ppm)
CO2 dry concentration (ppm)



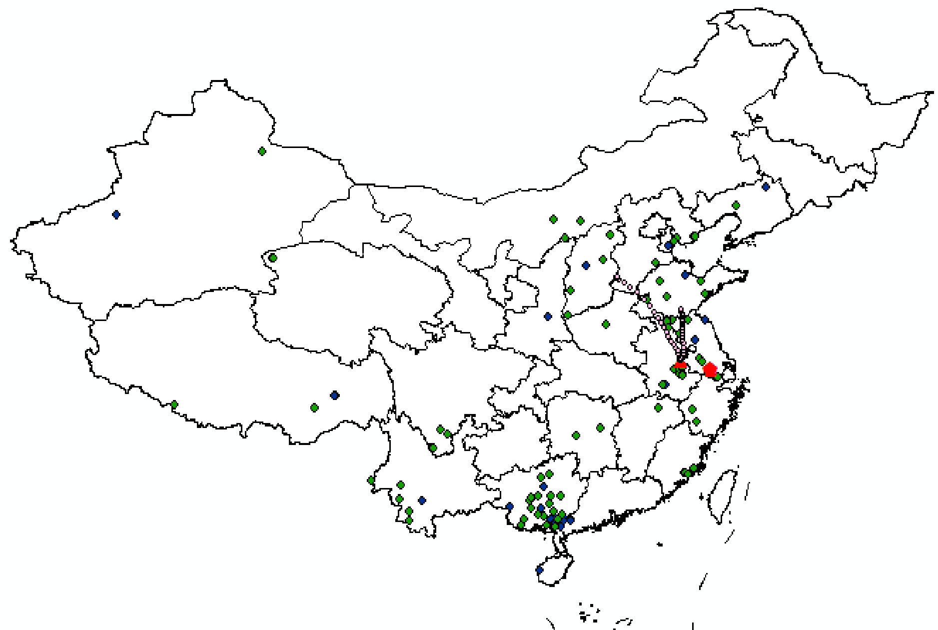
11.27 06:00-11.28 06:00



12.02 12:00-12.03 12:00



12.03 12:00-12.04 12:00



12.04 12:00-12.05 12:00

Thank you
for your attention!