Simultaneous measurements of N_2O and CO in urban air: calibration, data quality and preliminary interpretation

Yale-NUIST center on Atmospheric Environment

Yale Univ. and Nanjing Univ. of Infor. Sci. & Tech.

www.yale.edu www.nuist.edu.cn

Hu Cheng

2015.5.22

Outline

- Background and Objectives
- Methods
- Results
- On-going work

Background

- N_2O has 297 times the global temperature potential (GTP_{100}) of CO_2 , The atmospheric N_2O concentration was 324 ppb in 2011 and has increased by approximately 20% since 1750 [*IPCC. 2013*].

- The increase N_2O is caused by anthropogenic emissions from the use of fossil fuel as a source of energy and from land use and land use change, in particular agriculture.

- Carbon monoxide(CO) plays a key role in tropospheric photochemistry, it is involved in the formation of tropospheric ozone, and the interaction of CO with Hydroxyl controls the oxidation capacity of the atmosphere and leads to the formation of carbon dioxide which is a key greenhouse gas of the atmosphere.[*Crutzen et al., 2008*]

IPCC 2013

TgN $(N_2O) yr^{-1}$

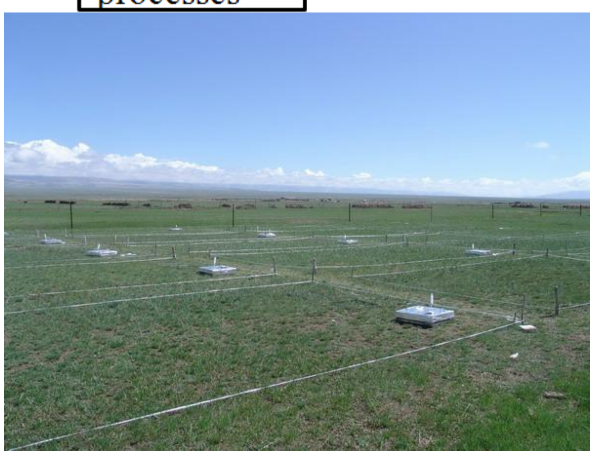
Global N_2O emission in 2006

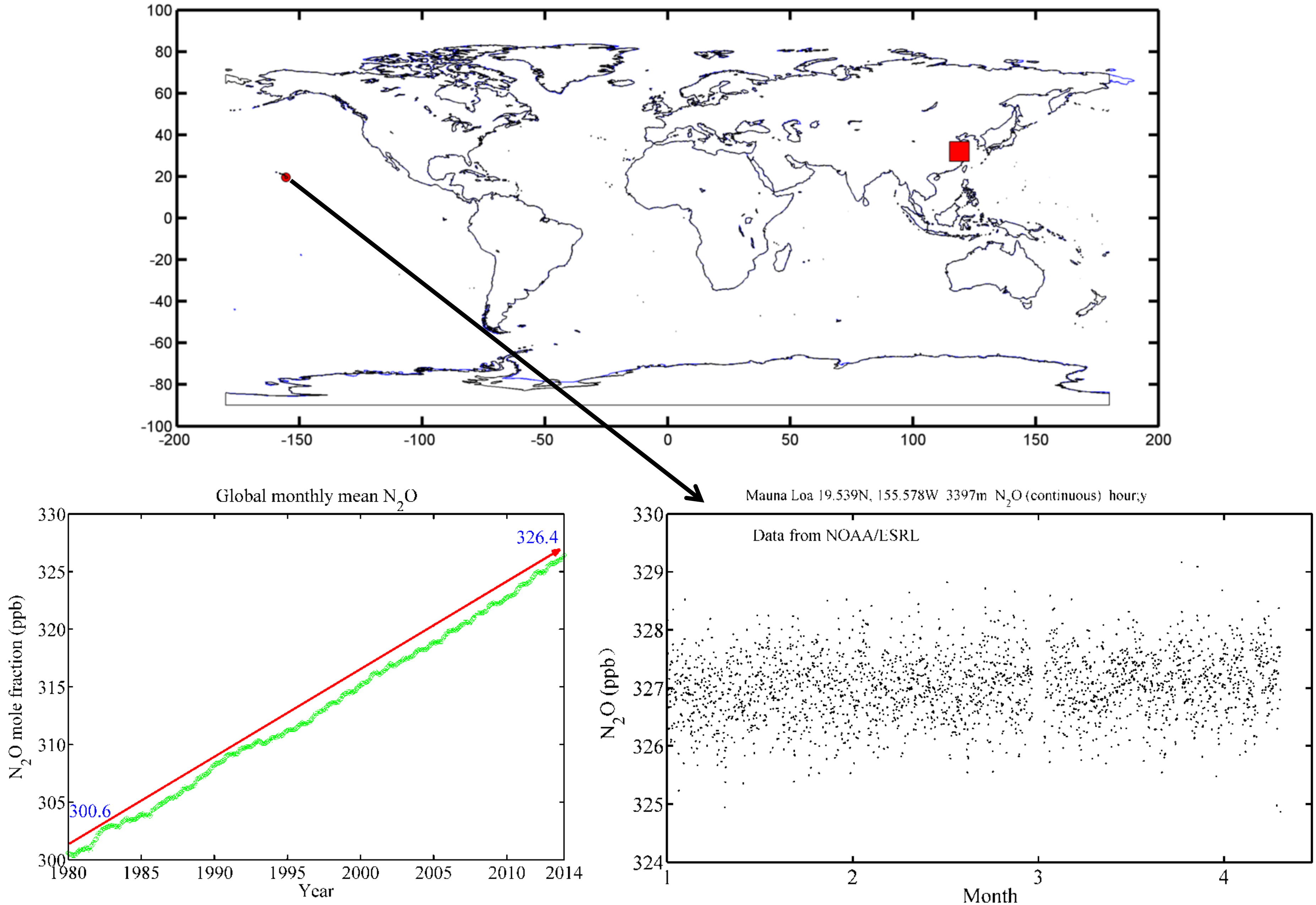
Anthropogenic N_2O emissions 6.9(2.7-11.1)

- Fertilizers in agriculture 4.1 (1.7-4.8)
- Fossil fuel use and industrial processes 0.7 (0.2-1.8)
- Biomass burning 0.7(0.2-1)
- Land emissions due to atmospheric nitrogen deposition 0.4-1.3

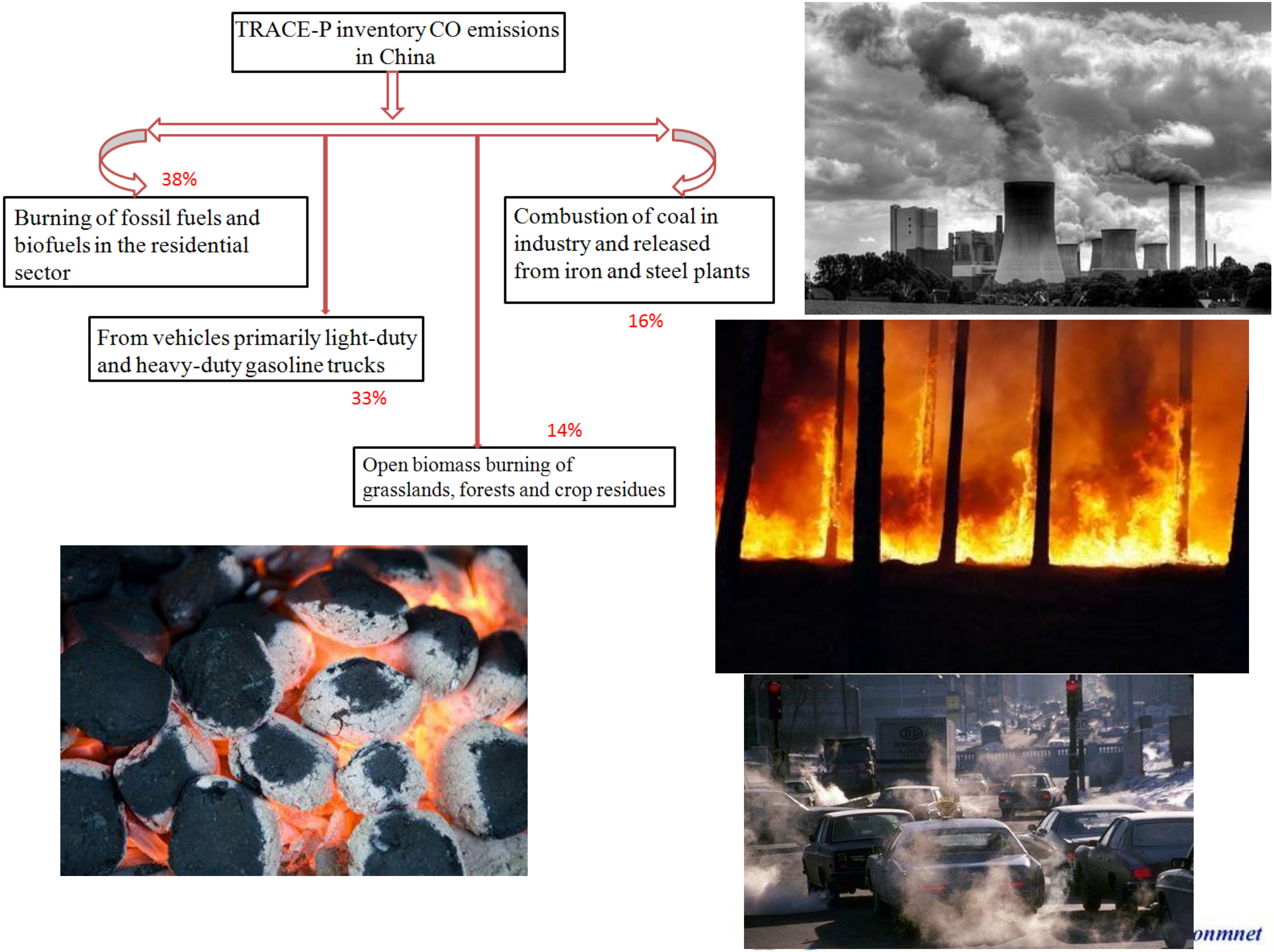
Natural N_2O emissions 11.0（5.4-19.6）

- Soils, oceans, and a small atmospheric source





Global monthly mean N_2O
326.4
300.6
N_2O mole fraction (ppb)
Year
Mauna Loa 19.539N, 155.578W 3397m N_2O (continuous) hour;y
Data from NOAA/ESRL
N_2O (ppb)
Month


TRACE-P inventory CO emissions in China
38%
Burning of fossil fuels and biofuels in the residential sector
From vehicles primarily light-duty and heavy-duty gasoline trucks
33%
Combustion of coal in industry and released from iron and steel plants
16%
14%
Open biomass burning of grasslands, forests and crop residues

N_2O/CO emission methods

- Soil chamber observations. → N_2O

- Flux-gradient method.

$$F_{N_2O} = -K\frac{\partial c}{\partial z} \qquad K = \frac{ku_*(z-d)}{\phi_h}$$

- Boundary layer approaches(including several methods).

- Eddy covariance.

- IPCC methods

$$F_{N_2O} = \sum_{i=1}^{n} EF_i \times F_i$$

CO/N_2O

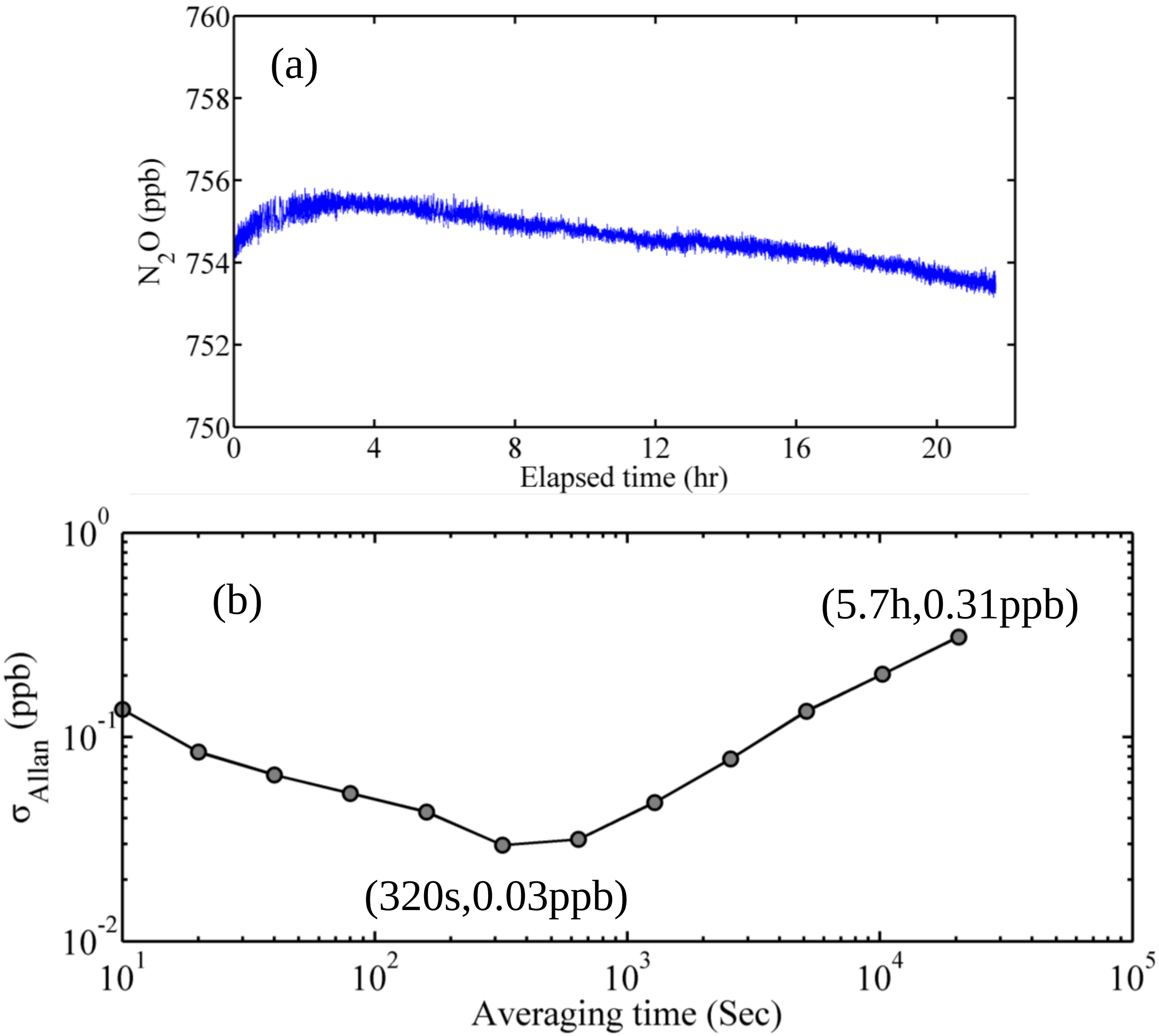
Objectives

- Data quality control and calibration.

- Determine the N_2O:CO emissions ratio (to evaluate this value calculated by IPCC inventory method).

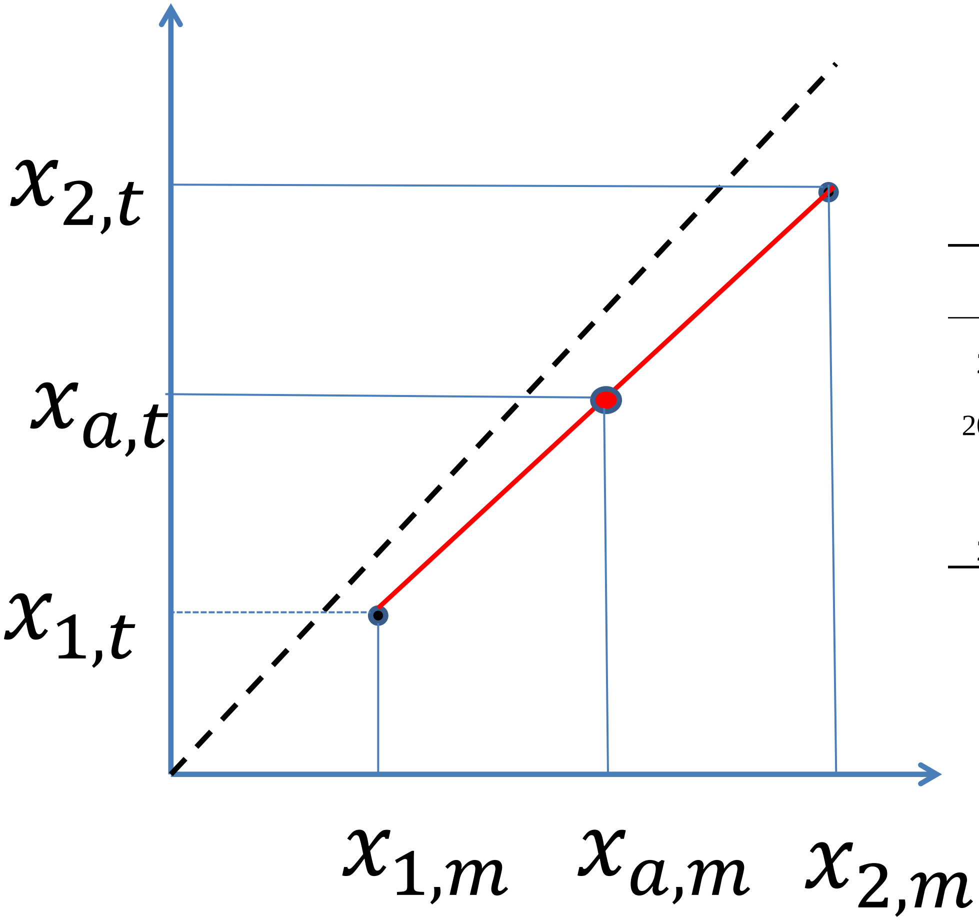
Methods and Results

Simultaneous measurements of N_2O and CO
From April 2014 to April 2015.



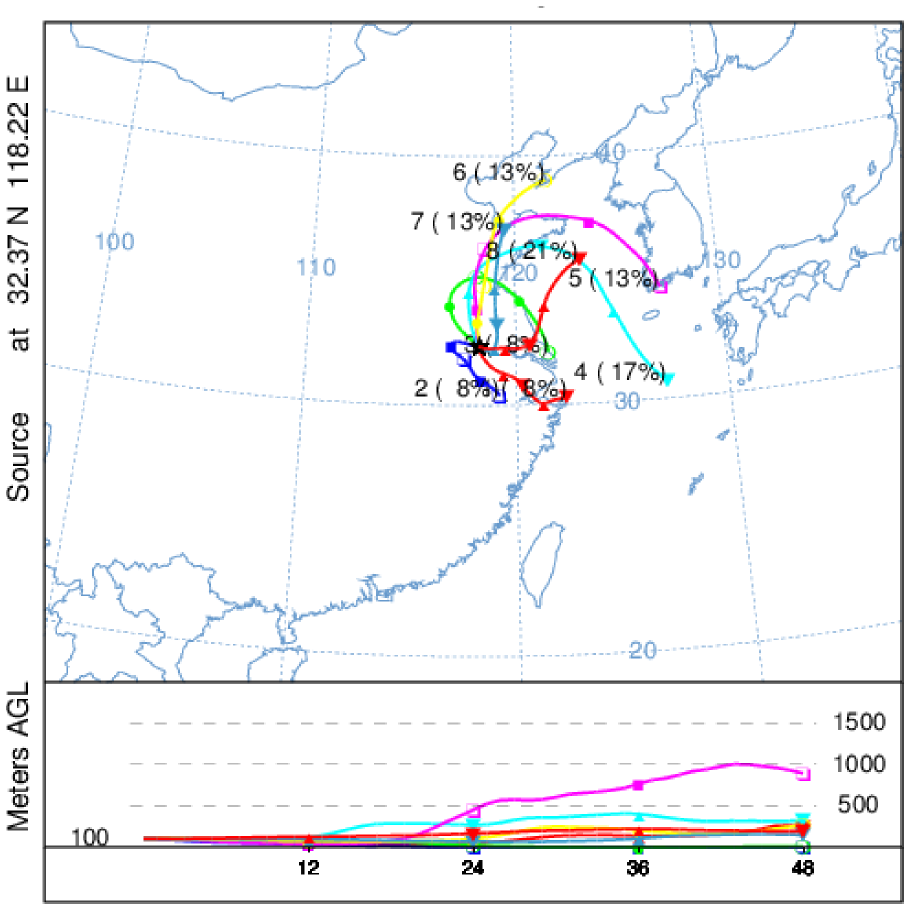
Time series of (a) N_20 standard gas concentration and (b) Allen deviation.

Calibrating method



	A standard gas (750.4ppb)	B standard gas (299ppb)	C standard gas (766ppb)
2014-6-16	540.2	**312.6**	**778.7**
2014-11-19	534.2	309.1	**770.2**
2015-3-8	525.2	303.5	757.2
2015-5-10	534.0	308.5	769.9

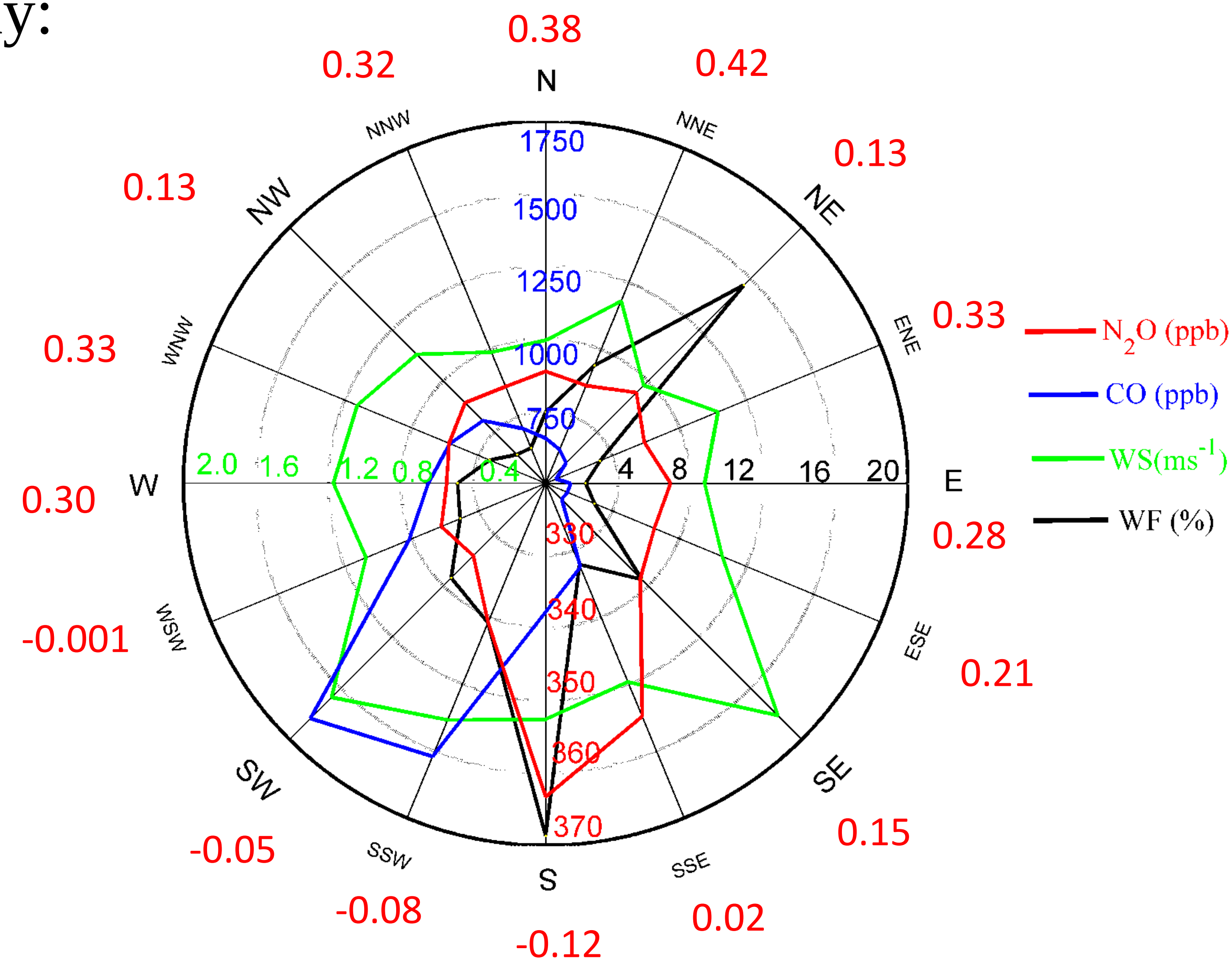
$$x_{a,t} = \frac{x_{2,t} - x_{1,t}}{x_{2,m} - x_{1,m}}(x_{a,m} - x_{1,m}) + x_{1,t}$$



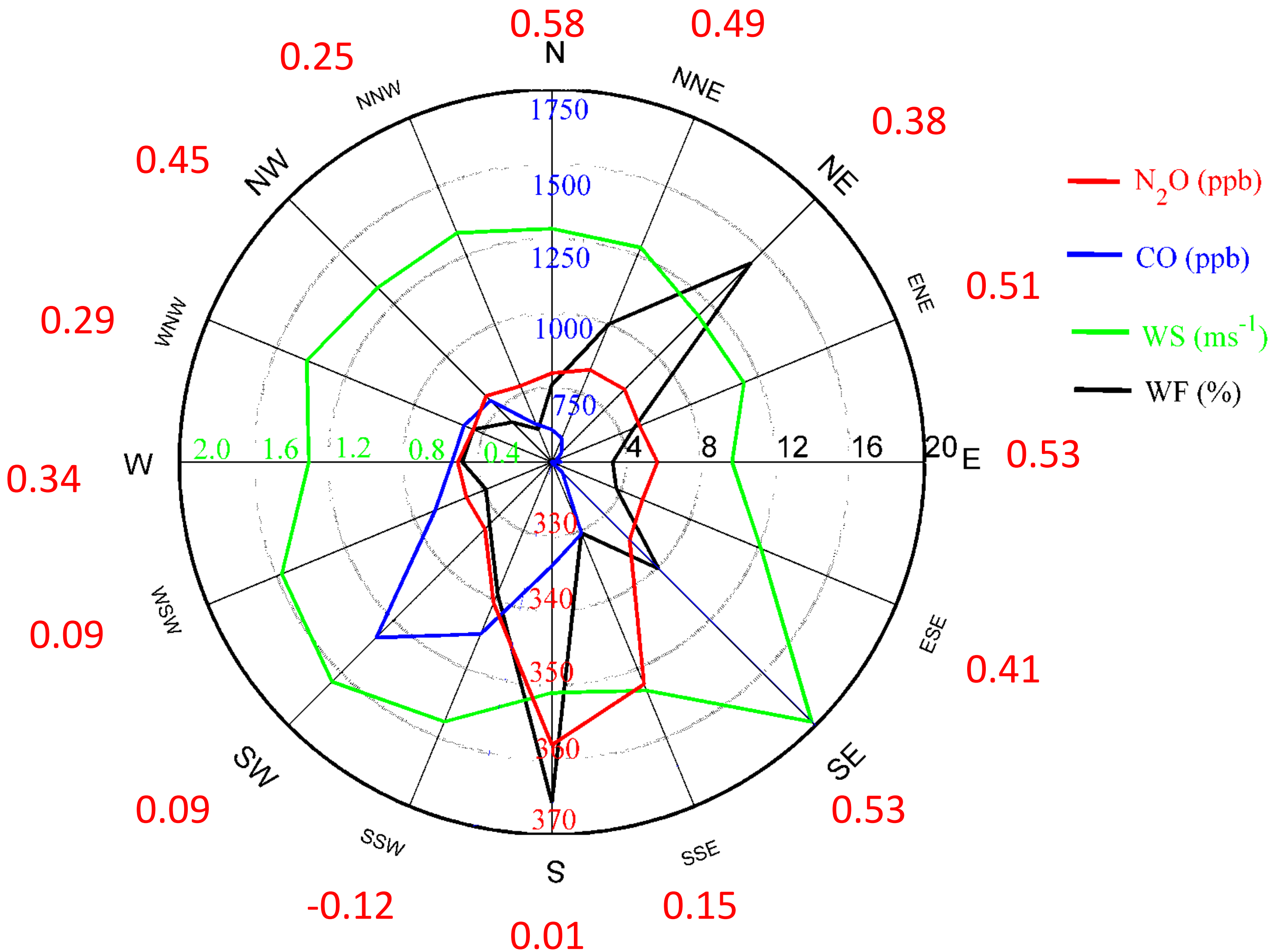
Eight sources paths from backward trajectory analysis in 4th June, 2014.

Draw by Baomengying

Allday:

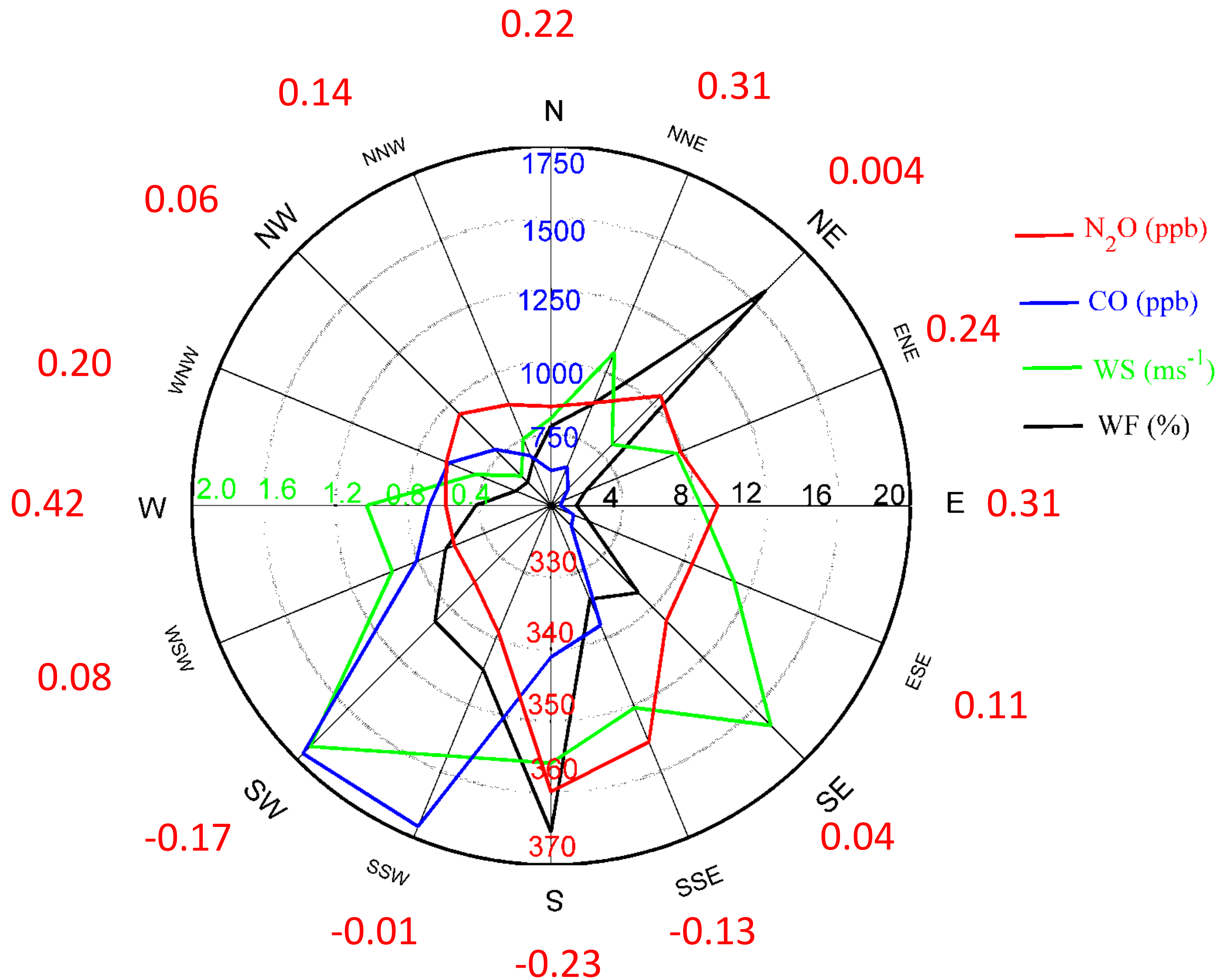

0.38
0.32
0.42
N
NNW
NNE
0.13
NW
NE
0.13
WNW
ENE
0.33
0.33
W
E
0.30
0.28
WSW
ESE
-0.001
0.21
SW
SE
-0.05
0.15
SSW
SSE
S
-0.08
0.02
-0.12
1750
1500
1250
1000
750
2.0
1.6
1.2
0.8
0.4
4
8
12
16
20
330
340
350
360
370
N_2O (ppb)
CO (ppb)
WS(ms^{-1})
WF (%)

Midday: 10:00-17:00 LT

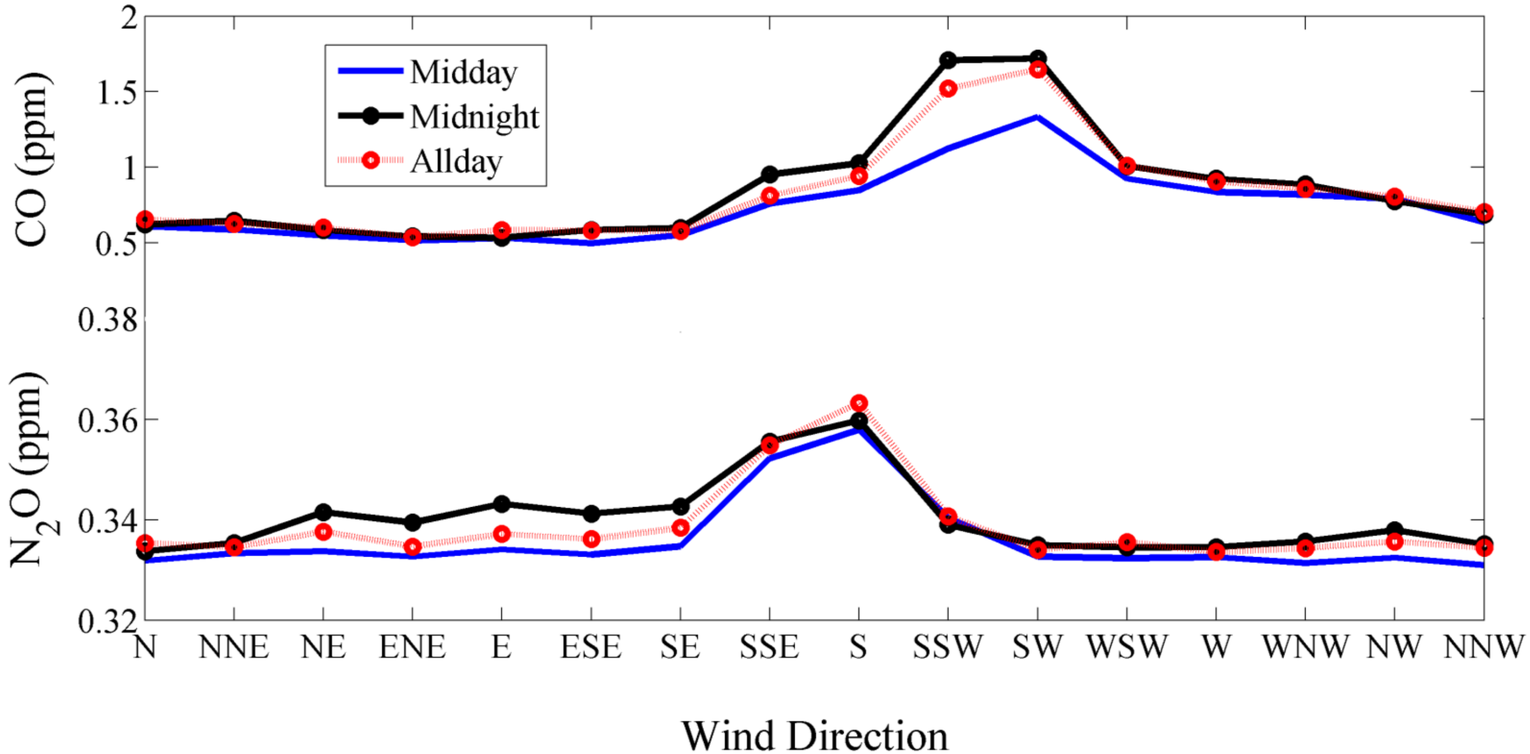


In the midday, the atmospheric boundary mixes well, and the concentration can represent a source size around 100 to 1000km[Lee et al., 2001; Wunch et al., 2009]. We assume that the midday N_2O:CO ratio can represent emissions information in YRD[Yang et al 2014].

Midnight: 23:00-05:00 LT



We assume that the midnight N_2O:CO ratio could represent emissions information in Nanjing[Zimnoch et al., 2010; Yang et al 2014].



Midday
Midnight
Allday
CO (ppm)
2
1.5
1
0.5
0.38
0.36
0.34
0.32
N2O (ppm)
N
NNE
NE
ENE
E
ESE
SE
SSE
S
SSW
SW
WSW
W
WNW
NW
NNW
Wind Direction

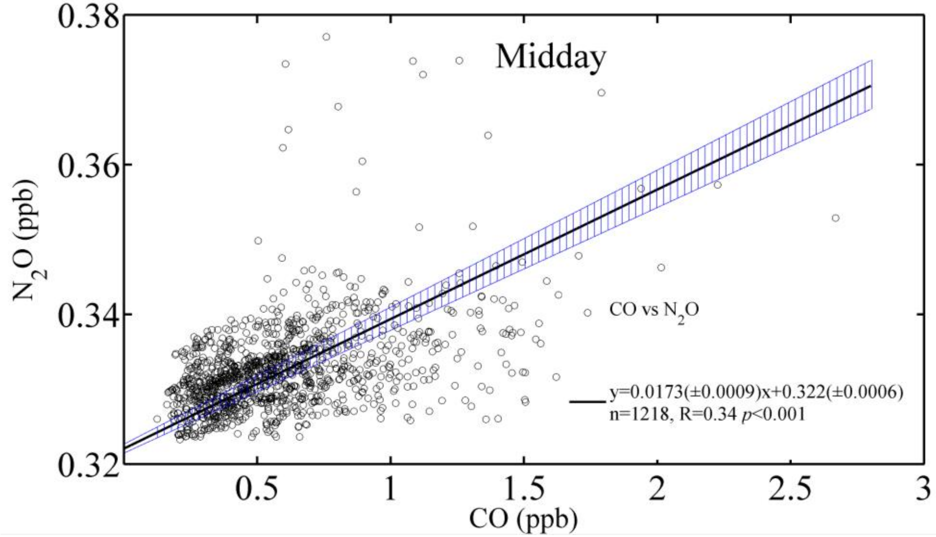
	Direction	W	WNW	NW	NNW	N	NNE	NE	ENE	E
Allday	r(p)	0.30 (***)	0.33 (***)	0.13	0.32 (***)	0.38 (***)	0.42 (***)	0.13 （***）	0.33 （***）	0.28 （***）
	a	0.013 (0.001)	0.026 (0.003)	0.023 (0.003)	0.021 (0.003)	0.023 （0.002）	0.019 （0.001）	0.055 （0.003）	0.026 （0.003）	0.055 （0.008）
	b	0.32 (0.001)	0.31 (0.002)	0.32 (0.003)	0.32 (0.002)	0.32 （0.002）	0.32 （0.0001）	0.30 （0.002）	0.32 （0.002）	0.31 （0.004）
Midday	r(p)	0.34 (***)	0.29 (***)	0.45 (***)	0.25	0.58 (***)	0.49 (***)	0.38 (***)	0.51 (***)	0.53 (***)
	a	0.011 (0.002)	0.015 (0.003)	0.008 (0.002)	0.012 (0.0006)	0.015 (0.002)	0.017 (0.002)	0.027 (0.003)	0.017 (0.003)	0.036 (0.007)
	b	0.32 (0.002)	0.32 (0.002)	0.33 (0.001)	0.32 (0.002)	0.32 (0.001)	0.32 (0.001)	0.32 (0.001)	0.32 (0.001)	0.31 (0.004)
Midnight	r(p)	0.42 (***)	0.2	0.06	0.14	0.22 (*)	0.31 (***)	0.004	0.24	0.31
	a	0.016 (0.003)	0.018 (0.005)	0.046 （0.015）	0.022 （0.006）	0.026 (0.005)	0.020 (0.003)	0.080 (0.0083)	0.045 (0.014)	0.091 (0.034)
	b	0.32 (0.003)	0.32 (0.005)	0.30 (0.001)	0.32 （0.004）	0.32 (0.003)	0.32 (0.002)	0.30 (0.005)	0.32 (0.007)	0.29 (0.018)

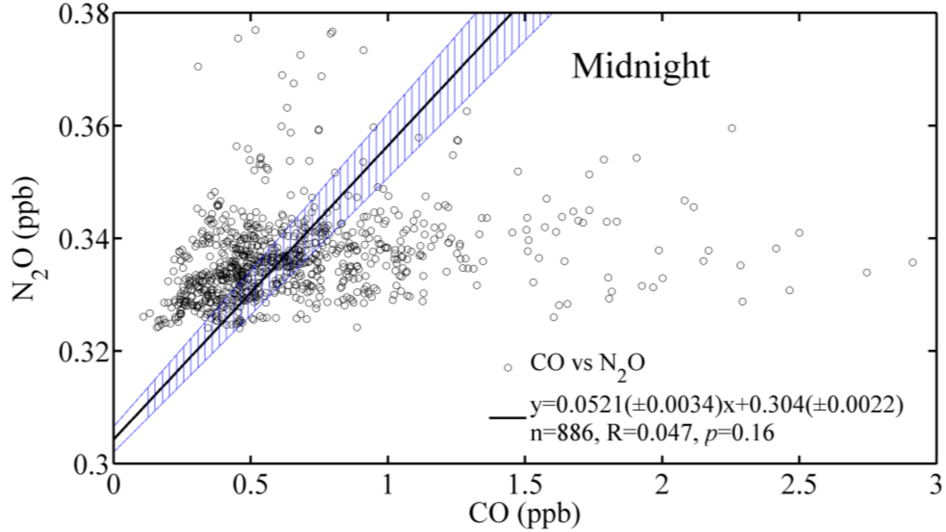
*, **, and *** denote 95%, 99% , and 99.9% confidence level, respectively.

All regressions are by geometric linear regression.

a is the slope; b is the intercept; r: correlation coefficient.

	Direction	WSW	SW	SSW	S	SSE	SE	ESE
Allday	r(*p*)	-0.002	-0.05	-0.08(*)	-0.12(***)	0.02	0.15(***)	0.21(***)
	a	-0.037 (0.004)	-0.014 （0.001）	-0.037 （0.004）	-0.063 （0.003）	0.037 （0.005）	0.061 （0.005）	0.037 （0.005）
	b	0.37 (0.004)	0.36 (0.002)	0.38 （0.003）	0.42 （0.003）	0.30 （0.007）	0.30 （0.003）	0.31 （0.003）
Midday	r(*p*)	0.09	0.09	-0.12	0.01	0.15	0.5 （***）	0.41 （***）
	a	0.02 （0.004）	0.012 （0.002）	-0.033 （0.048）	0.056 （0.005）	0.0195 （0.004）	0.026 （0.003）	0.032 （0.006）
	b	0.31 （0.004）	0.32 （0.003）	0.38 （0.005）	0.31 （0.004）	0.31 （0.008）	0.32 （0.002）	0.32 （0.003）
Midnight	r(*p*)	0.08	-0.17	-0.1	-0.23	-0.13	0.037	0.11
	a	0.009 （0.002）	-0.009 （0.001）	-0.026 （0.004）	-0.061 （0.006）	-0.052 （0.009）	0.082 （0.013）	0.05 （0.015）
	b	0.33 （0.009）	0.35 （0.003）	0.38 （0.006）	0.42 （0.006）	0.4 （0.009）	0.29 （0.008）	0.31 （0.009）





Scatter plot (April, 2014 - April, 2015, wind direction from South is removed) of N_2O and CO, regression equation is shown in black line, with 95% confidence level, data number(n), and regression coefficient (R) are also shown.

Results

- We find this LGR N_20/CO analyzer a precision of 0.4‰ with 5.7 hours averaging intervals.

- The N_2O to CO emission ratio by using observed atmospheric N_2O and CO concentrations measured at a suburban site of Nanjing is 0.0173(representing YRD) and 0.0521 (representing Nanjing).

On-going work

- CO standard gas calibration.
- Estimate CO and N_2O emissions using IPCC method and compare the N_2O:CO ratio with results in this study.
- Evaluate whether CO can be used to calculated N_2O emissions.

Thank you