Street level CO_2 concentrations in the city of Nanjing: an update

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1. Introduction

- Urban area is less than 2.4% of the world's total land area *(Potere,D. et al,2007)*, but it contributes more than 80% of the global CO_2 emission*(Turner,I.I. et al,1994*).
- In 1998, Idso,C.D. et al. found "urban CO_2 dome" phenomenon for the first time in Phoenix, United States*(Idso,C.D. et al,1998).*
- Koerner,B. et al. found vehicles were the largest contributor (79.9%) of "CO_2 dome" in Phoenix*(Koerner, B. et al,2002).*

- Nanjing is the capital city of Jiangsu Province, the city's chief area is 6,587,02 square kilometers, total household population is 6,384,792*(Nanjing Statistical Yearbook,2013)*. Nanjing is next to Suzhou in the total carbon emission in Jiangsu Province*(Xiao xiang,2011*), it is imminent to develop a low-carbon economy.
- Therefore, quantitative interpretation the street-level CO_2 spatial and temporal patterns in Nanjing is benefitial to the city emission reduction.

2. Method

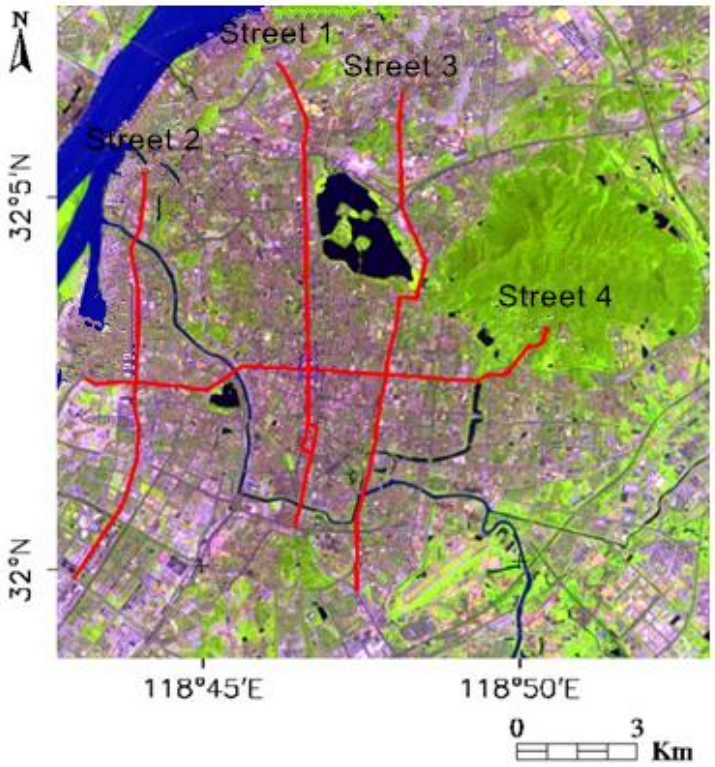


Fig. 1. Map of Nanjing city showing the streets of data obtained

Instrument: LI -840A CO_2 /H_2O gas analyzer

Time: Jun 6, 9, 14, 15, 17, 2013 (Summer)
Dec 20, 21, 23, 26, 2013 (Winter)
Apr 4, 5, 8, 9, 2014 (Spring)

06:00 07:30 11:30 17:30(17:00) 22:00

Speed: 30km/h

3. Results

3.1 Spatial and temporal patterns

3.1.1 CO_2 concentration of urban traffic trunk

Table. 1. Mean CO_2 concentrations (ppm) for different seasons

Season	Time	Ave±1σ	Min	Max
Summer	Weekday	457.9±51.9	382.4	1403.2
	Weekend	467.8±53.5	387.0	1276.4
	Total	461.9±52.8	382.4	1403.2
Winter	Weekday	506.3±61.6	411.4	1306.4
	Weekend	482.4±42.5	418.2	1023.9
	Total	500.7±58.6	411.4	1306.4
Spring	Weekday	487.7±50.4	395.9	997.6
	Weekend	456.2±35.5	396.0	756.3
	Total	480.6±49.2	395.9	997.6

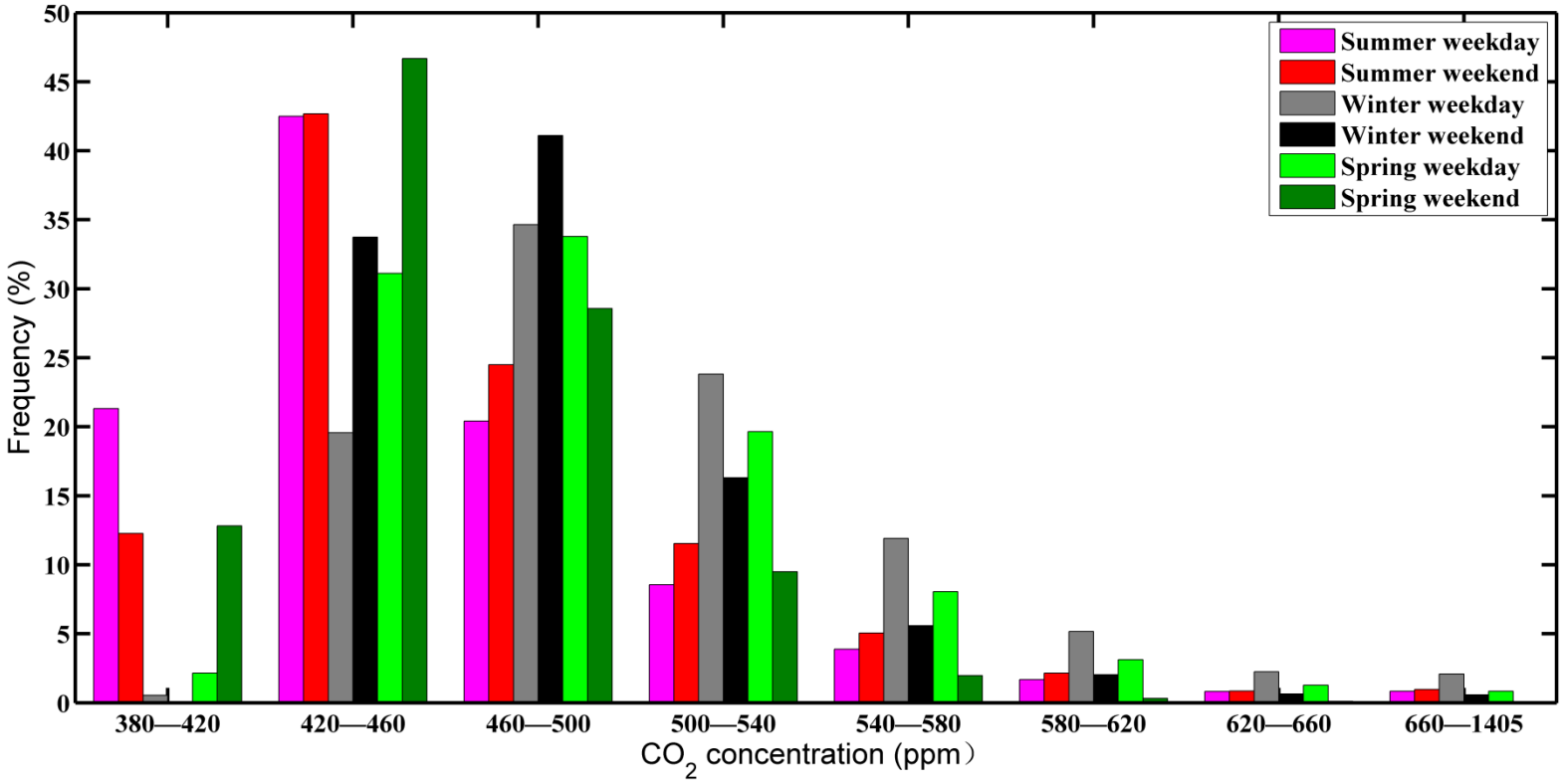


Fig. 2. Frequency distributions of CO_2 concentrations (ppm) for different seasons

Table. 2. Mean CO_2 concentrations (ppm) for different streets

Street	Summer Ave±1σ		Winter Ave±1σ		Spring Ave±1σ	
	Weekday	Weekend	Weekday	Weekend	Weekday	Weekend
Street 1	464.7±54.8	480.9±55.5	507.7±53.6	490.5±48.1	491.2±51.4	459.5±34.6
Street 2	442.7±44.1	454.0±53.1	483.8±48.1	463.8±32.8	466.4±43.9	442.9±30.1
Street 3	462.8±52.9	466.4±56.6	518.6±61.6	493.4±44.2	498.1±47.5	464.0±39.3
Street 4	461.7±52.2	469.7±46.1	511.6±73.1	477.3±34.6	487.9±52.0	458.6±34.1

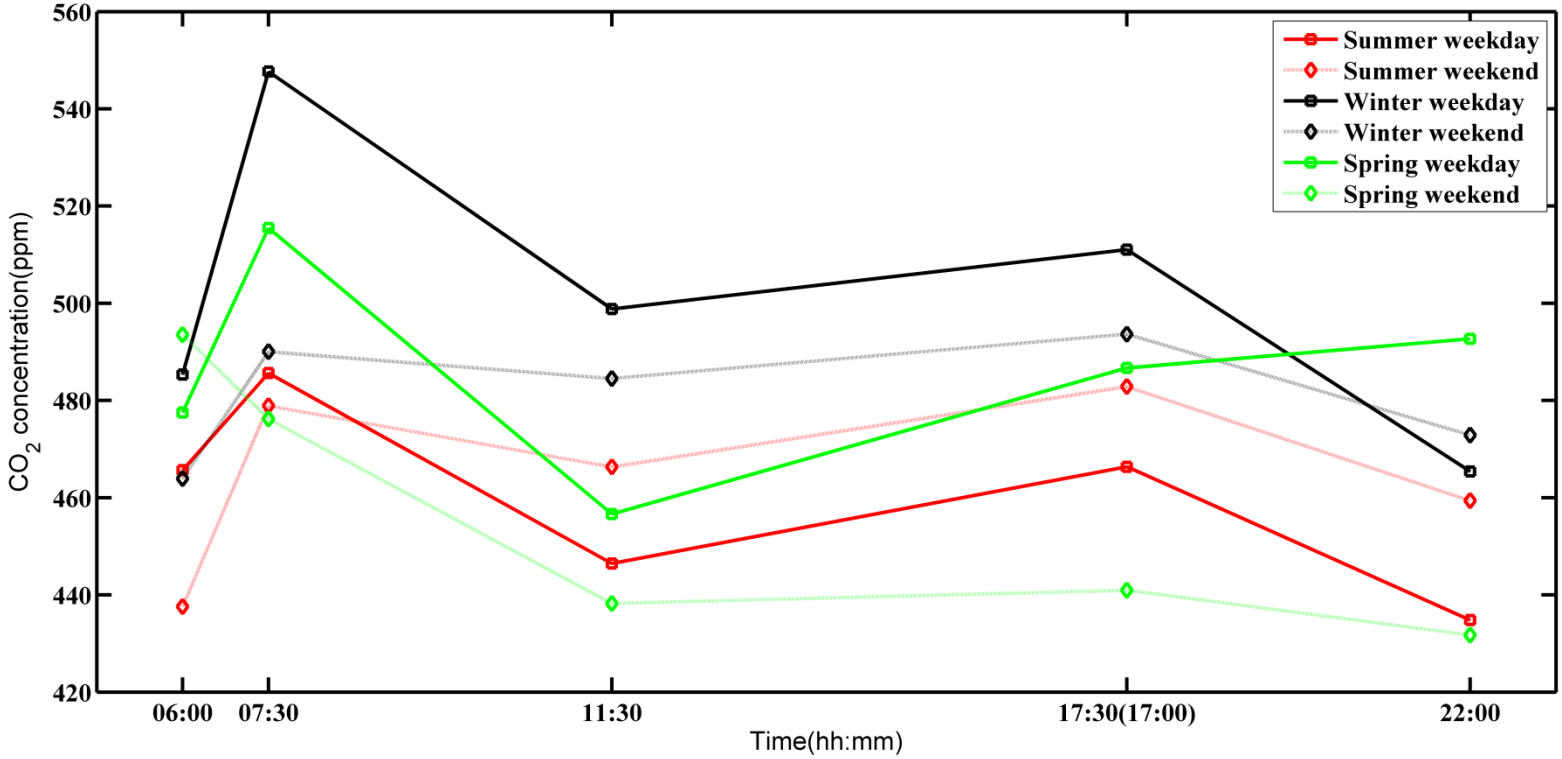


Fig. 3. Diurnal variation of CO_2 concentrations (ppm) for different seasons

3.1.2 CO_2 concentration of urban center and urban forest

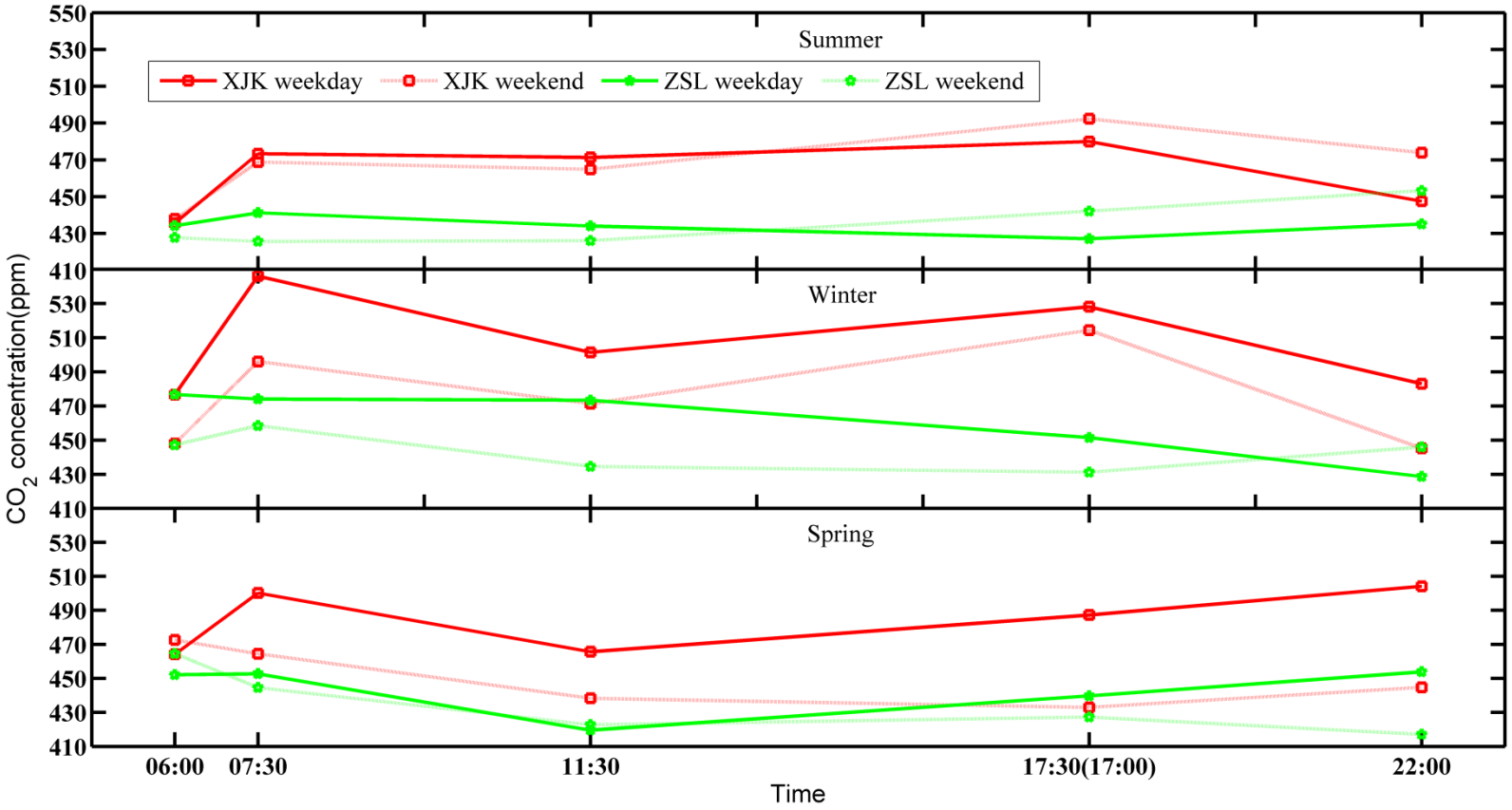


Fig. 4(a). Diurnal variation of CO_2 concentrations (ppm) of XJK and ZSL in different seasons

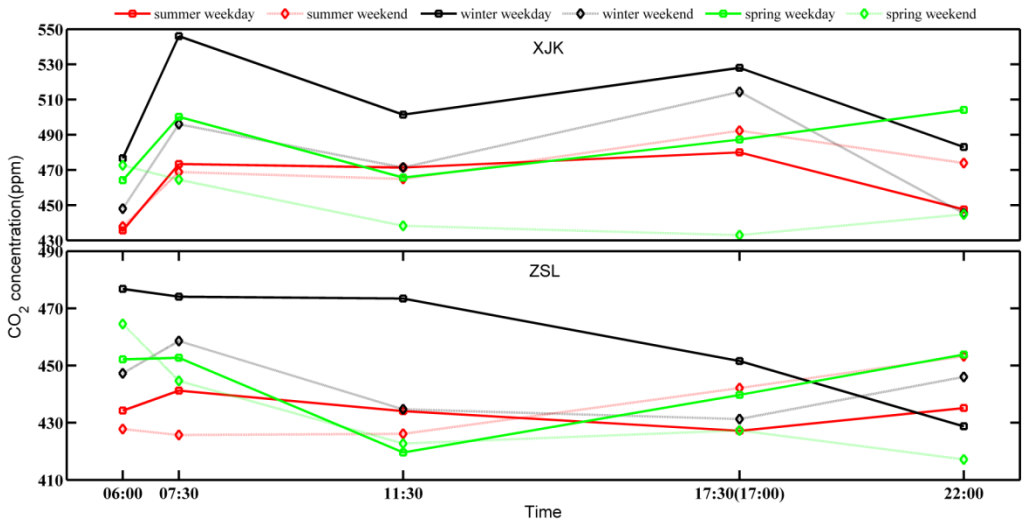
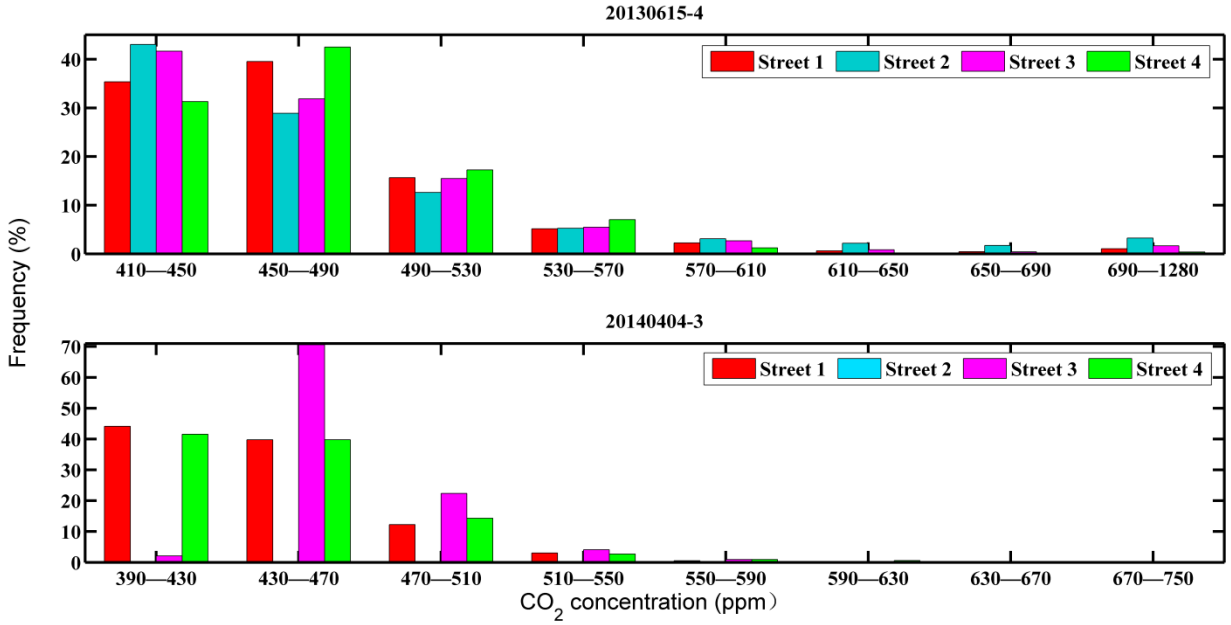


Fig. 4(b). Diurnal variation of CO_2 concentrations(ppm) Of XJK and ZSL in different seasons

Table. 3. Diurnal variation range of XJK and ZSL in different seasons

Season	Diurnal variation range			
	XJK weekday	XJK weekend	ZSL weekday	ZSL weekend
Summer	44.37	54.45	14.07	27.54
Winter	69.38	69.05	48.06	27.28
Spring	39.99	39.70	34.27	47.42

3.2 Impact factor
3.2.1 wind



June 15, 2013 wind:
17:30 – 18:00 86.0°
18:00 – 18:30 91.6°

April 4, 2014 wind:
11:30 – 12:00 86.3°
12:00 – 12:30 81.0°

Fig. 5. Frequency distributions of CO_2 concentrations for each street when the wind from the East.

3.2.2 Vehicle speed

Table. 3. The relationship between vehicle speed(m/s) and CO_2 concentration(ppm) of four streets

Street	Summer		Winter		Spring	
	R^2	P	R^2	P	R^2	P
Street 1	0.31	0.0034	0.21	0.044	0.084	0.22
Street 2	0.30	0.0053	0.40	0.0028	0.15	0.10
Street 3	0.46	0.00017	0.40	0.0029	0.28	0.016
Street 4	0.19	0.025	0.40	0.0029	0.16	0.085
Total	0.28	<0.0001	0.27	<0.0001	0.11	0.0034

Table. 4. The relationship between vehicle speed(m/s) and CO_2 concentration(ppm) of five times

Time	Summer		Winter		Spring	
	R^2	P	R^2	P	R^2	P
6:00	0.089	0.23	0.00017	0.96	0.020	0.60
7:30	0.049	0.36	0.34	0.017	0.26	0.046
11:30	0.24	0.027	0.025	0.56	0.012	0.70
17:30	0.089	0.16	0.11	0.20	0.40	0.0087
22:00	0.074	0.25	0.044	0.44	0.056	0.38

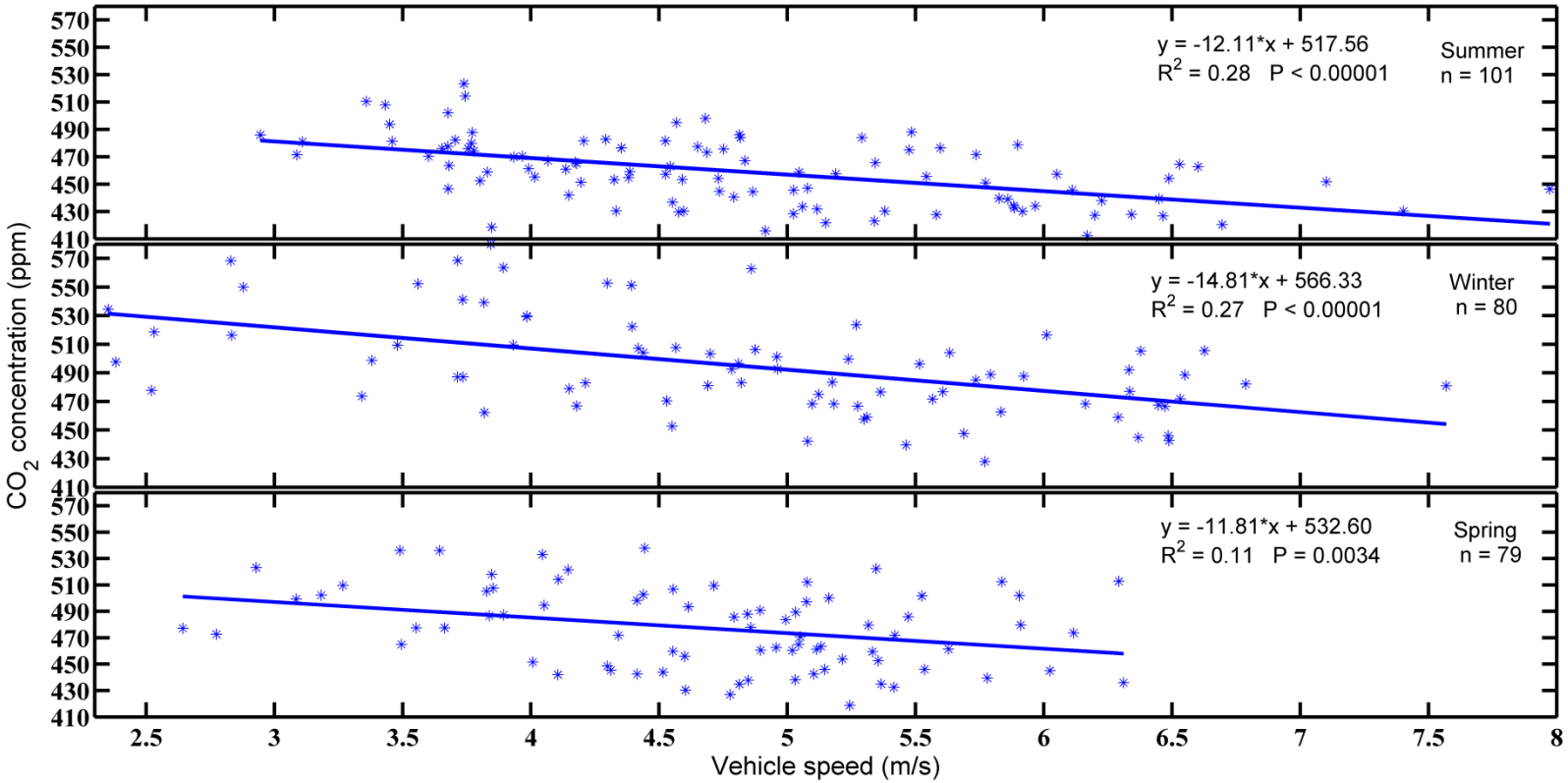


Fig. 6. The relationship between vehicle speed(m/s) and CO_2 concentration(ppm) of three seasons

3.2.3 NDVI

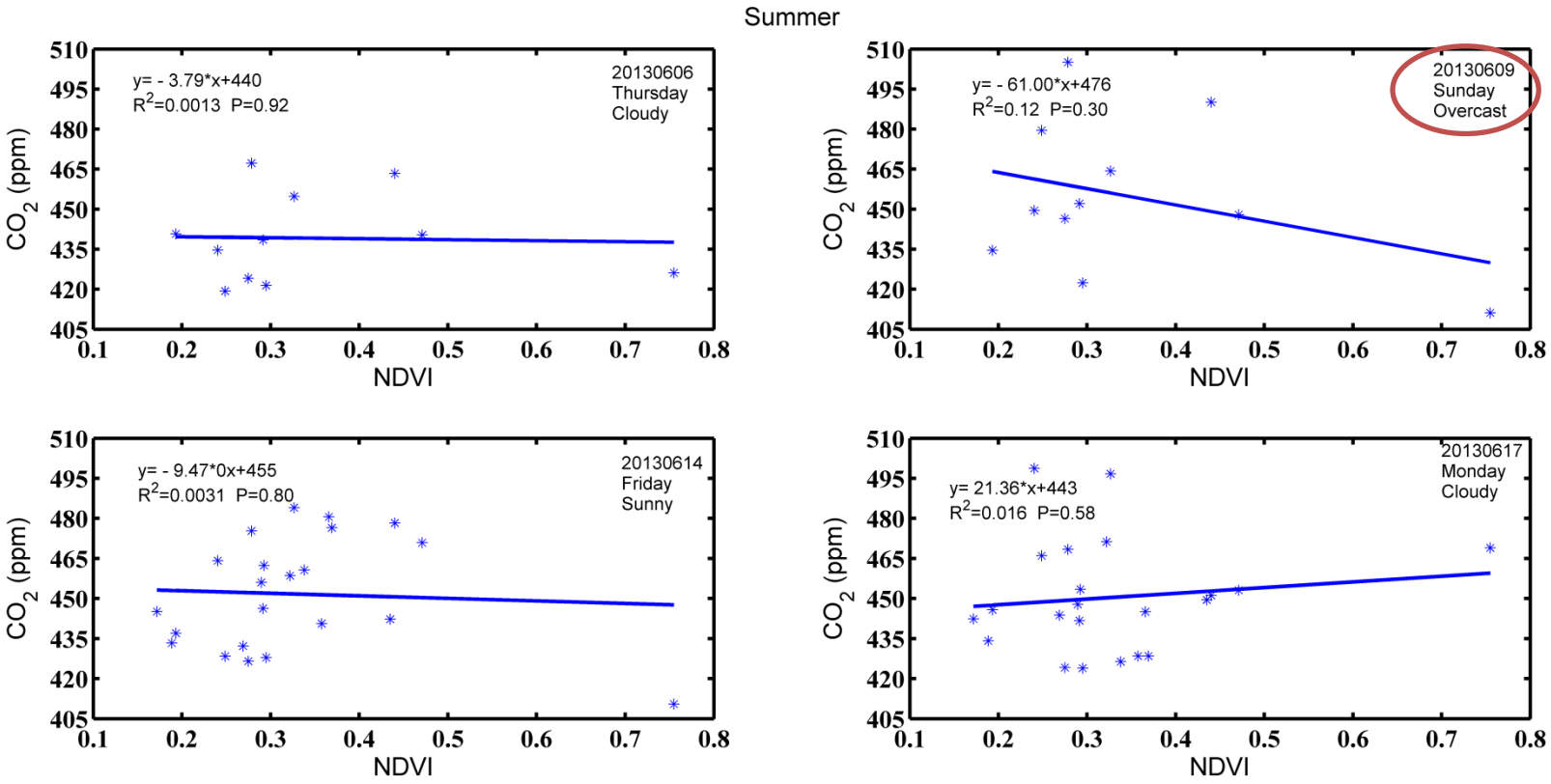


Fig. 7. The relationship between NDVI and CO_2 concentration(ppm) of Summer

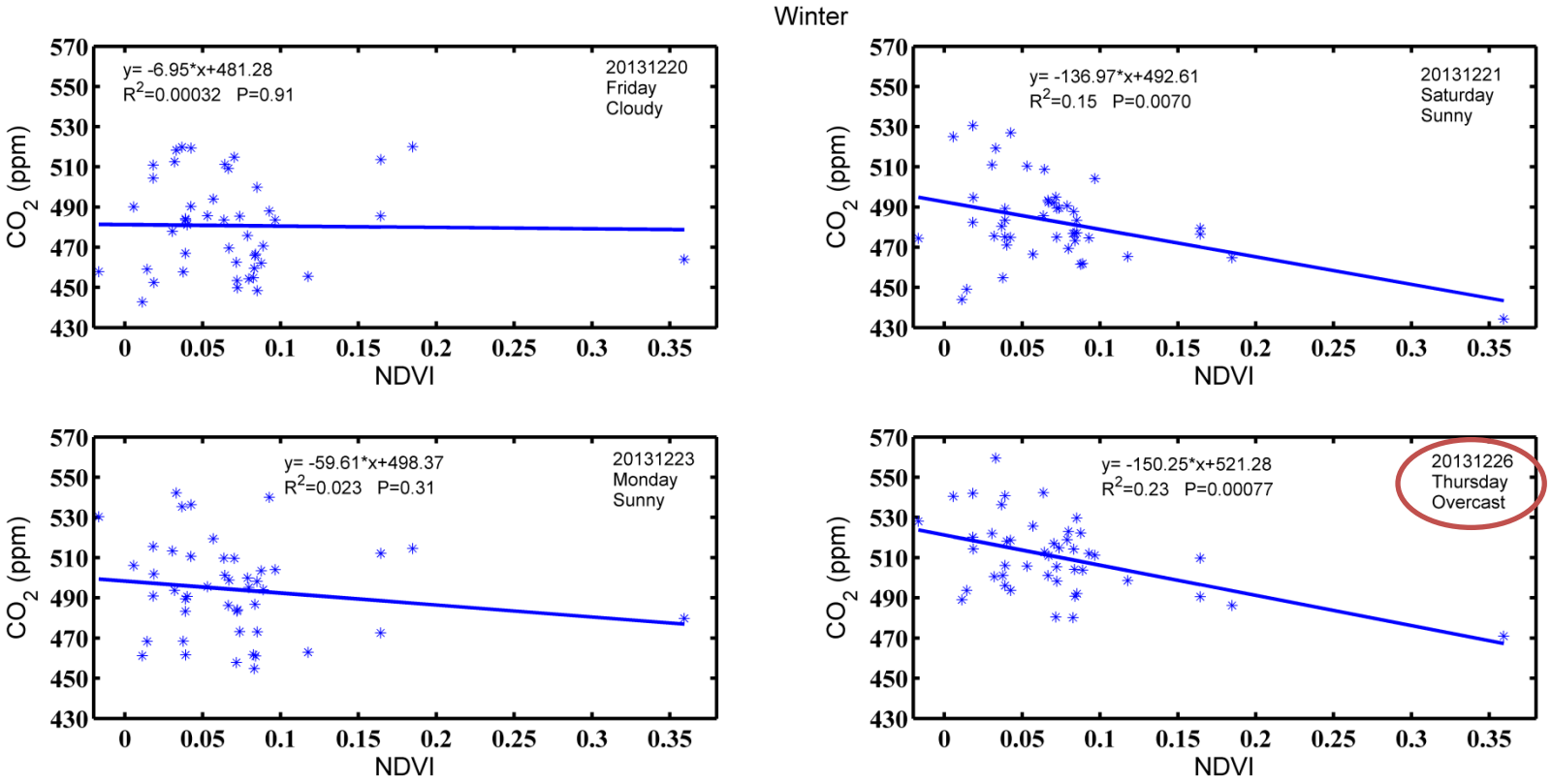


Fig. 8. The relationship between NDVI and CO_2 concentration(ppm) of Winter

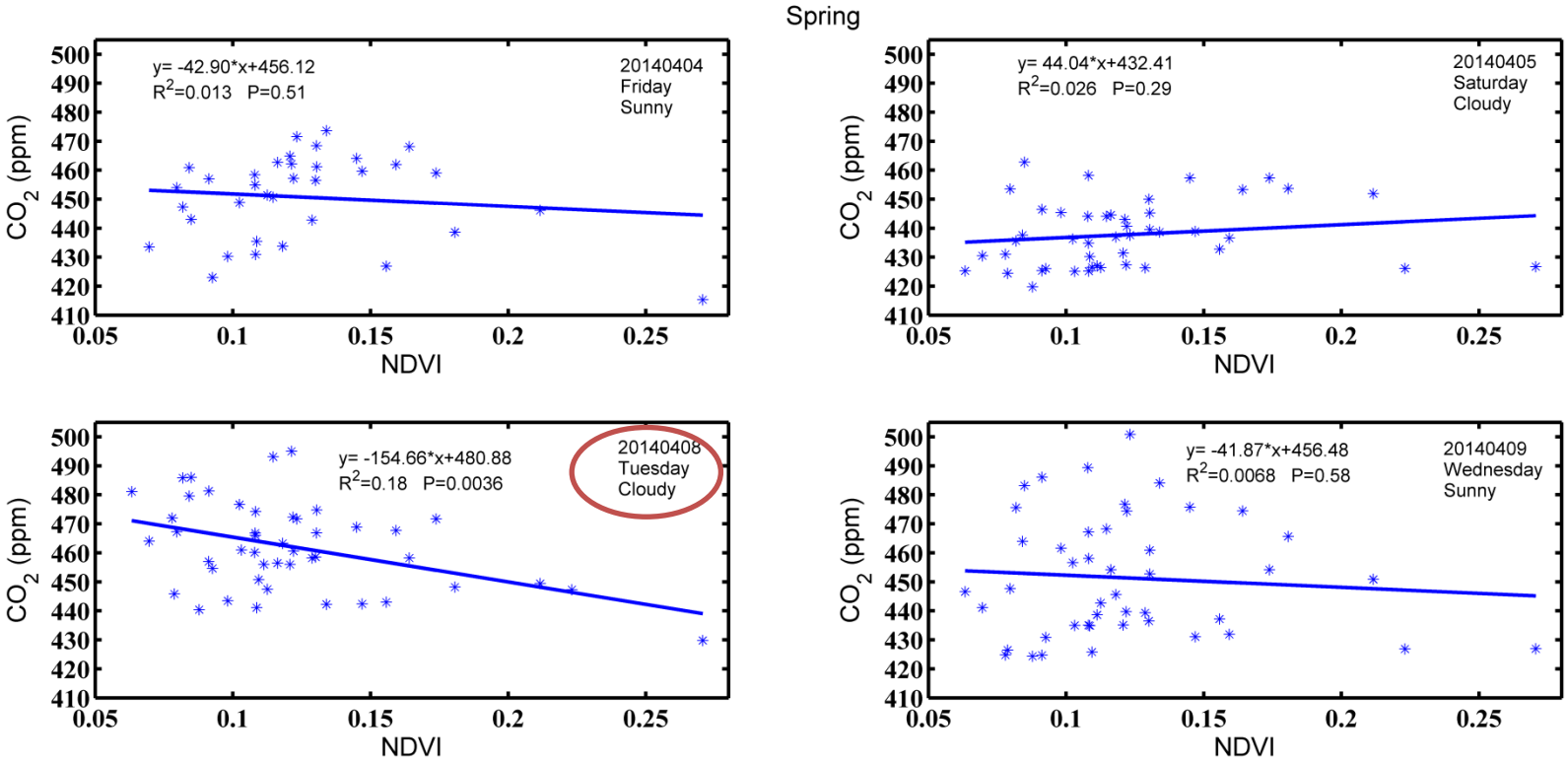


Fig. 9. The relationship between NDVI and CO_2 concentration(ppm) of Spring

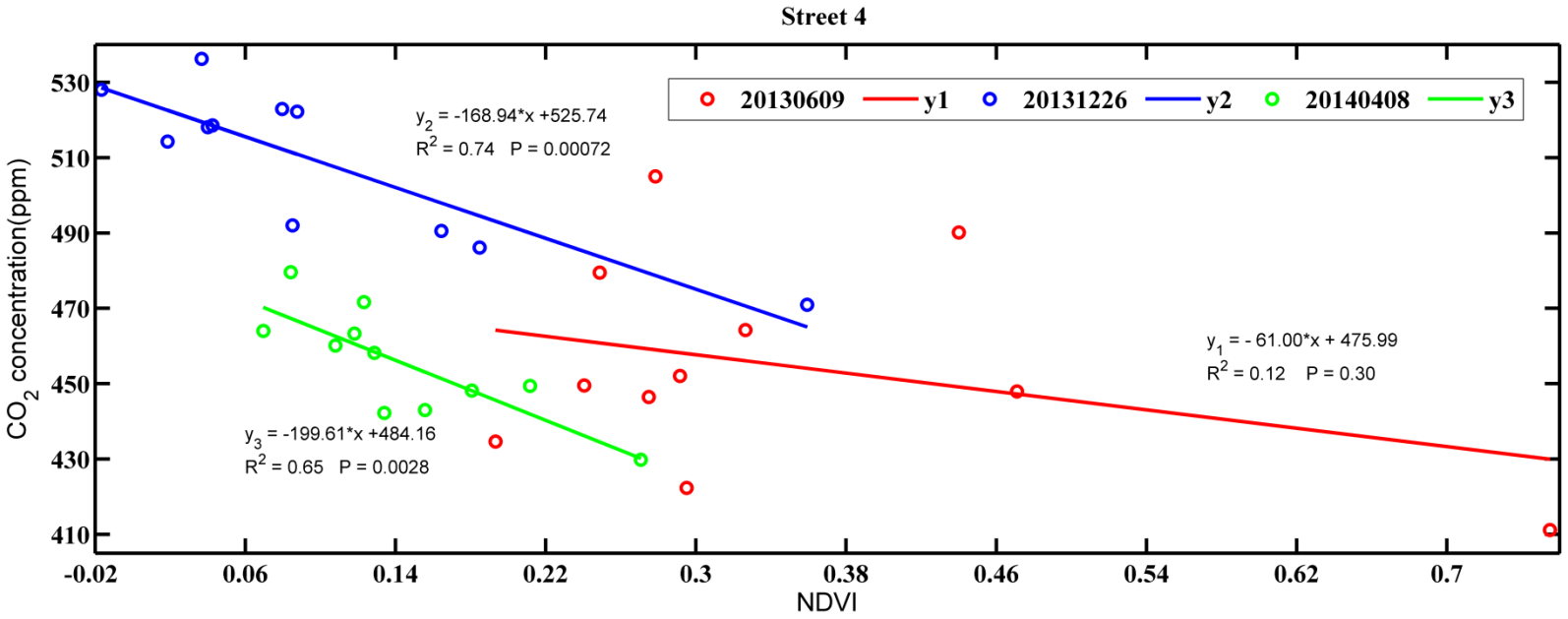


Fig. 10. The relationship between NDVI and CO_2 concentration(ppm) of Street 4 in three seasons

3.2.4 NDVI and vehicle speed

Table. 5. The relationship among NDVI、 vehicle speed(m/s) and CO_2 concentration(ppm) of Winter

Winter （ n=46 ）	With NDVI	With V	With NDVI and V
a	-150.25	-2.04	-148.08
b	/	/	-1.94
c	521.28	523.74	533.53
R^2	0.23	0.072	0.29
P	0.00077	0.071	0.00055

Table. 6. The relationship among NDVI、 vehicle speed(m/s) and CO_2 concentration(ppm) of Spring

Spring（n=46）	With NDVI	With V	With NDVI and V
a	-154.65	-2.46	-151.87
b	/	/	-2.30
c	480.88	474.95	492.61
R^2	0.18	0.052	0.22
P	0.0036	0.13	0.0045

$CO_2 = a*NDVI + c$ $CO_2 = a*V + c$ $CO_2 = a*NDVI + b*V + c$

4. Summary

- In summer, CO_2 concentrations at weekends are higher than that of weekdays. The pattern reverses in the winter and spring. To sum it, Winter mean CO_2 concentrations are the highest, while Summer the lowest.
- During the observation, mean CO_2 concentrations on Street 2 are the lowest; Mean CO_2 concentrations on Street 1 are the highest in Summer, while Street 3 the highest in Winter and Spring.
- During the observation, mean CO_2 concentrations on Street level show obvious double peak on weekdays.

- Diurnal patterns of CO_2 concentrations in XJK and ZSL are different in different seasons.
- CO_2 concentrations have certain relationship with wind, NDVI and vehicle speed.

Thank you