Dear Editors,

We sincerely thank all the Reviewers for reviewing of this paper. The paper has been revised according to the Reviewer comments. We seriously considered these comments and outlined our responds point by point.

We look forward to receiving your opinion.

Yours sincerely,
Lei Liu and Fei Hu

To Reviewer #1

1) I don't know if stratification information is available at the tower site but it would be interesting to see how stratification affects the IN of turbulent CO2 fluxes? Or how do the results vary depending on different stratification classes. Turbulent fluxes are largely affected by the stratification. What about IN of turbulent fluxes?

If no accurate stratification data is available a simple comparison between day and night-time conditions could be a useful extension. During night-time conditions in the atmospheric boundary layers are much more likely to exhibit stable stratification which is a large contrast to the convective day-time boundary layers, particularly in summer.

Response: It can be seen from Fig.6 in the paper that the standard deviation of the fluctuation function is small, so we speculate that the IN of time series used in this paper does not seem to be substantially affected by the stratification. According to the Reviewer’s suggestion, we plotted the fluctuation functions during day-time and night-time conditions (see Fig. R1). The results indeed show that the IN of time series used in this paper would not be substantially affected by the stability stratification.

There may be two reasons to explain Fig. R1. Firstly, the IN is found to be intimately related to the small-scale inertial subrange motions of turbulence (see Sec. 3.1 in the paper). According to the cascade theory of Kolmogorov (1941), the turbulence in the inertial subrange is homogeneous and isotropic, and will not be substantially affected by the anisotropic large-scale motions related to stratification, roughness, and other factors. Cheng et al. (2011) have analyzed the isotropic of turbulence by observations on the Beijing 325-m meteorological tower (data used in our paper is collected on the same tower). They found that the turbulent fluctuations (with scales less than 1 min) are nearly isotropic and large-scale motions (with scales greater than 1 min and less than 10 min) are anisotropic.

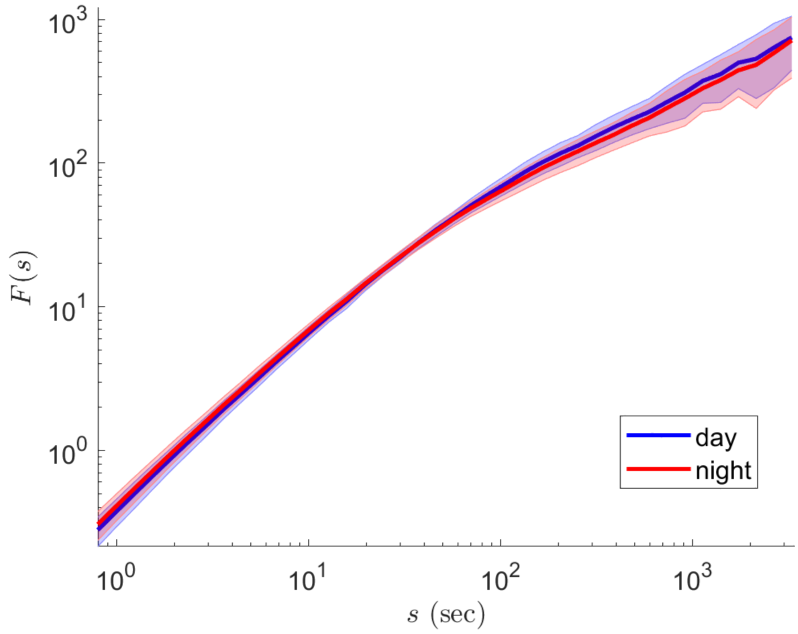

Figure R1. The detrended fluctuation analysis of data during day-time (blue) and night-time (red) conditions.

Secondly, according to Oke et al. (2017), surface heating caused by urban heat islands and large urban roughness, can generate upward heat fluxes at night, and the nocturnal inversion layer is thus elevated on the top of the constant flux layer (i.e., inertial sublayer) of urban boundary layer. According to Cheng et al. (2018), the inertial sublayer height around the 325-m tower is at least 140 m, and the 80-m height is located in the constant flux layer. Thus, the difference between nighttime and daytime stability stratification is not very obvious at 80 m.

As the Reviewer said, the stability stratification usually affects turbulence. However, the stability stratification is more complex in the megacity than in the rural areas. We need collected more boundary-layer data to analyze the stratification effect on the IN. This paper mainly focuses on the nonlinear dynamic characteristics of IN, including what the IN is, how to quantify and simulate it by nonlinear dynamic methods, and its impact on flux measurements. In another paper, we will discuss the boundary-layer meteorological characteristics of IN in details, including the impact of stratification, roughness, and other boundary-layer parameters on IN, when more boundary-layer data are collected and analyzed.

Reference:

Kolmogorov, A. N. (1941), The local structure of turbulence in incompressible viscous fluid for very large Reynolds numbers, Dokl. Akad. Nauk SSSR, 30, 301–305.

Cheng, X. L., Q.-C. Zeng, and F. Hu (2011), Characteristics of gusty wind disturbances and turbulent fluctuations in windy atmospheric boundary layer behind cold fronts, J. Geophys. Res., 116, D06101.

Oke T. R., Mills G., Christen A., and Voogt J. A. (2017) Urban Climate, Cambridge University Press.

Cheng, X. L., Liu, X. M., Liu, Y. J., and Hu, F. (2018) Characteristics of CO2 concentration and flux in the Beijing urban area, J. Geophys. Res., 123, 1785–1801.

2) Generally, and also due to the 2nd comment above, the manuscript would benefit from a short description of the turbulent and typical boundary layer structures of the Beijing downtown urban boundary layer. Is the turbulence usually isotropic? are stable conditions common? etc...

Response: We have added some descriptions of turbulence and typical boundary layer structures of the Beijing downtown. These descriptions are based on the long-term observations of the 325-m tower and have been mentioned in the Response of 1). As the Reviewer said, the added information can indeed help readers better understand the content of this paper. Please see the second paragraph in Sec. 2.3 of the revised paper.

3) Technical comments

Response: We have revised the mistakes or ambiguous statements according to your suggestions. Thank you!