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Interactive comment on "Intermittent turbulence contributes to vertical diffusion of $PM_{2.5}$ in the North China Plain" *by* Wei Wei et al.

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Dear reviewer, Thank you so much for all these recommendations. The manuscript has been refined following your advice. In order to enrich this work, some more detailed information on the methodology is given in a supplement due to space limit. The detailed responses are as follows:

This manuscript investigates the role of intermittent turbulence in alleviating heavy pollution episodes that frequently occur in China. The papers includes a theoretical background and analysis of measurement data related to 2 pollution episodes. While the vast majority of the prior research on air pollution episodes in China has concentrated on the factors favoring the accumulation of pollutants, this paper investigates a phe-

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Discussion paper

nomenon that helps to get rid of high pollution levels. As such, I think that this paper is original enough to warrant publication in ACP. I have a few issues that should, however, be addressed before the publication.

The authors introduce an Intermittent Factor (IF) which they use for explaining the effects of intermittent turbulence on the observations. I have a few comments on this. First, it seems that q is the key variable when determing IF. Therefore, the authors should explain more explicitly what is the exact meaning of q, not just to mention that it is the power exponent of the instantaneous amplitude of something. Second, IF is defined such that it is zero for fully developed turbulence and negative if not. However, the exact value of IF does not tell anything for the reader. Would it be possible to provide some idea how to interprete the value of IF. How small (or large in absolute sence) should IF be for the intermittent turbulence to be important etc?

Response: We all appreciate your constructive comments. A sketch of the arbitrary-order HSA has been given in the manuscript, including the derivative process, equations and a brief comparison with existing methods, (i.e., Fourier analysis and wavelet transform). Due to lack of space, we cannot address the method and the relative parameters fully in the manuscript, so we write a supplement (Figure S1-S6 and the relative illustration) to describe the process of the arbitrary-order HSA. As you pointed out, q is an important parameter in the derivation of scaling exponent function ξ(q) for several reasons. Firstly, q is the moment of the arbitrary-order Hilbert spectrum L_q (ω)=$\int p(\omega$,A)Aˆq dAãĂŮ. If q is taken as 2, the second-order Hilbert spectrum L_2 (ω)=$\int p(\omega$,A)Aˆ2 dAãĂŮ can be an analogical representation of classic Fourier energy spectrum, given that the square of amplitude is equivalent to energy density. Secondly, in the identification of the range of scale invariance, the third-order Hilbert spectrum L_3 (ω)=$\int p(\omega$,A)Aˆ3 dAãĂŮ is taken as the reference. Kolmogorov's initial proposal leads to ζ(q)=q/3 (Kolmogorov, 1941), while the scaling exponent function ζ(q) of intermittent turbulence is nonlinear and concave. Only ζ(3) has no intermittency correction, that is, ζ(3)=1. Finally, the highest moment of ζ(q) considers both computing efficiency and accuracy in the measurements of high-order moments. The higher the order is, the longer the length of sample needs, while the arbitrary-order HSA process of long data will take a lot of time. Therefore, the maximal moment is taken as $q\_max=4$. The details on the method have been elaborated in the supplement. In terms of the values of IF, the magnitude of IF changes from different observation sites based on our past experience. And from Fig. 6 in the manuscript, it can be seen that the absolute values of IF increase with higher levels, which implies that there is no universal criteria for the identification of intermittency using IF. However, we can extract a reference value for these two cases in Tianjin in this study. The following figure (also Fig.7 in the revision) illustrates the relationship between IF and u_* and nocturnal z/L. The absolute IF increases with stronger turbulent strength when stability in the ABL becomes weaker. Hence, a point of intersection can be identified using the fittings from least-squares regression and represent a critical IF value at given level (here 40 m) beyond which the intermittency of turbulence in the ABL is significant. Based on the regression analyses, the cross points correspond to IF values of -0.53 (Case-1) and -0.50 (Case-2), respectively. Hence, in the present study, we adopt -0.5 as a threshold for the strong intermittency in the ABL. Some relative discussion has added to the revision. "Besides, the points of intersection from the least-squares regression in Fig. 7 could denote the threshold beyond which the intermittency of turbulence arises under the mutual influence of dynamic and thermodynamic. The values of IF are -0.52 and -0.50 for Case-1 and Case-2, respectively. Hence, a cut-off value of IF (-0.50) can be identified to manifest the significant intermittency of turbulence. But it should be kept in mind that the absolute values of IF change from different heights and sites and this cut-off value of IF can only be used as a reference in the present study." (page 13 lines 12-16) "For 40 m, a cut-off value of IF (-0.50) indicates the initiation of strong turbulent intermittency in the ABL, while this is not a universal value and the threshold varies with different cases." (page 18 lines 4-6)

Figure 7 in the manuscript. Scatter plot of IF vs. u_* and z/L (night time) for (a) Case-1 and (b) Case-2 at 40 m. The dashed lines are the fittings from least-squares regression and the triangle marks the cross point.

The discussion of Figure 5 in the beginning of page 11 is a bit confusing. The authors state that the difference for CSs is much more obvious. I do not understand this statement. By looking at the figure, the differ curves for TS show more spread than the curves for CS. So what are the authors referring to when discussion about differences? Also, figures 5a-d have the straight line for fully developed turbulence (faint solid black lines). This line should show up more clearly in the figure and it should be said that it is a solid line.

Response: Thank you so much for your detailed comments. Yes, the beginning of page 11 should be “TSs”. We apologize for this slip of the pen and have corrected it in the revision. Please see page 10 lines 3-4: “However, the difference for TSs is much more obvious (in Figs. 5b and 5d), indicating stronger intermittency in the turbulence.” Also, bolder lines for q/3 are used in Fig.5 and the caption has been written as “the black solid line”.

Figure 5 in the manuscript. Hilbert-based scaling exponent function at 40 m during different stages for (a) – (b) Case-1 and (c) – (d) Case-2, where each dashed curve represents the result of 30-min vertical wind speed signal and the black solid line denotes the K41 result q/3. (e) compares vertical wind fluctuation at 40 m between the CS (before 00:00 on 26 January 2017) and TS (after 00:00 on 26 January 2017). The latter shows apparent ‘bursts’ marked by the rectangular frame.

Please check out that all the used mathematical symbols are explained in the text.

Response: Thank you. We have checked through the text and defined all of the mathematical symbols.

A few grammatical issues: Page 1, line 25 should read "particulate matter" Page 14, line 7: . . .we summarize. . .

Response: We are sorry for these mistakes and have been corrected them.

Please also note the supplement to this comment:
https://www.atmos-chem-phys-discuss.net/acp-2018-121/acp-2018-121-AC3-supplement.pdf

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Interactive comment on Atmos. Chem. Phys. Discuss., https://doi.org/10.5194/acp-2018-121, 2018.

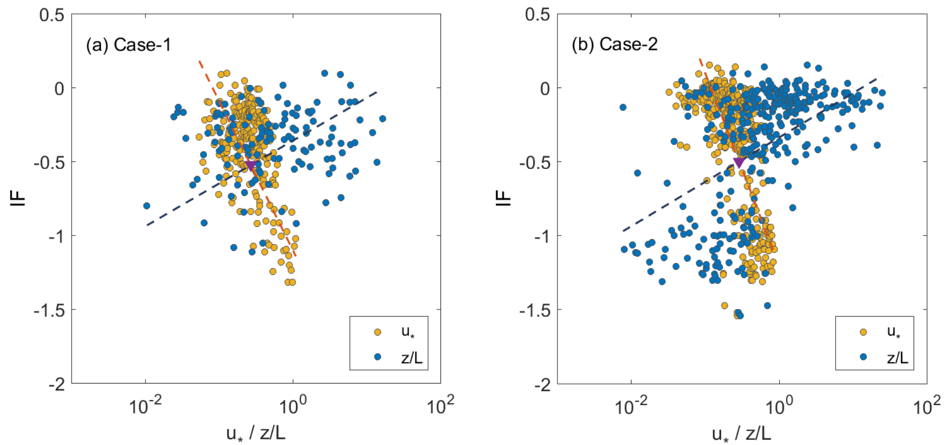

Fig. 1. Figure 7 in the manuscript. Scatter plot of IF vs. u_* and z/L (night time) for (a) Case-1 and (b) Case-2 at 40 m. The dashed lines are the fittings from least-squares regression and the triangle mark

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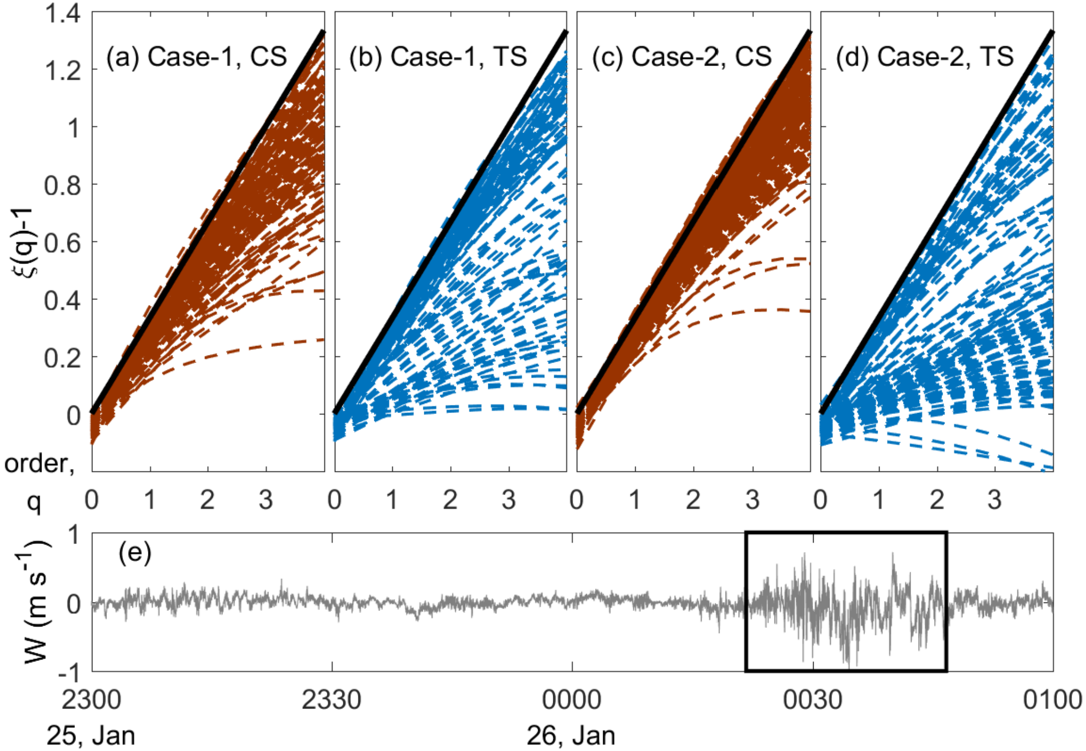

Fig. 2. Figure 5 in the manuscript. Hilbert-based scaling exponent function at 40 m during different stages for (a) – (b) Case-1 and (c) – (d) Case-2, where each dashed curve represents the result of 30-min v