We would like to thank the Referee #2 for his/her time and effort in reviewing our manuscript, titled 'An improved Grassberger-Procaccia algorithm for analysis of climate system complexity' (ID: hess-2017-445). Your comments and suggestions are much appreciated. Please see our responses in the following section.

Comment 1. Section 2.1 Algorithm for Computing Correlation Dimension may be reduced as correlation dimension is relatively old.

Response: Thank you for this comment. Section 2.1 introduces the original G-P algorithm. We can point out the problems existing in the traditional algorithm. Furthermore, Section 2.2 is based on Section 2.1. To shorten Section 2.1, we will make following changes: (1) lines 77-78 will be removed ('The dimension of the time series of a variable is indicative of the number of factors governing the underlying dynamical processes'), and (2) lines 97-98 will be changed into: According to the relationship between $D_2(m)$ and m, the saturation value of $D_2(m)$ is defined as the correlation dimension.

Comment 2. Lines 117-119 and Figure 1: Authors compared equations in terms of y =0.5x. What is R square value for both the equations and this also can be taken into consideration while judging superiority of methods.

Response: Thank you for this suggestion. Indeed, adding R square value is better for evaluating the fitting results. We will add R square value in Figure 1 and lines 117-119.

Changes in manuscript:

It can be seen from Fig. 1 that the fitting line (y=0.60 x-0.068; R^2=0.854) obtained from the least squares method is seriously affected by outliers and deviated from the original line y=0.5 x. By contrast, the RANSAC method is able to distinguish the inliers from outliers effectively and results in a satisfactory fitting line (y=0.49 x+0.007; R^2=0.990), demonstrating the advantage of using the RANSAC algorithm for linear fitting.

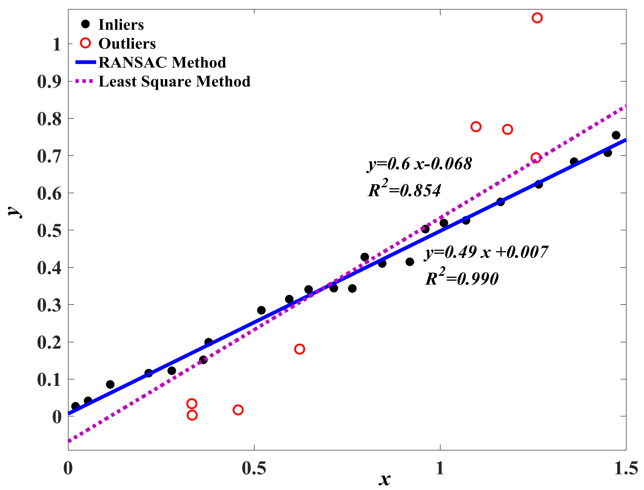

Figure 1: Comparison of the fitted lines obtained from the RANSAC algorithm and the least squares method.

Comment 3. Line 125-140: Detailed information is provided and flow chart is also presented.
Detailed information can be reduced as the flow chart is self explanatory.
Response: Thank you for this comment. According to your suggestion, we will reduce the relevant section as follows.
Changes in manuscript:

The flow chart of the proposed procedures for calculating correlation dimensions is given in Fig. 2, which consists of five major steps. (1) For the time series $x(t)$, the time delay τ is computed by an autocorrelation function (Liebert and Schuster, 1989). Then set the minimum embedding dimension m_{min}=2 and reconstruct the phase space by increasing m to obtain the correlation exponent function $C(r, m)$; (2) The normals of the scatter points on the ln r~ln $C(r, m)$ line are estimated via principal component analysis (Mitra et al., 2004); (3) The K-means clustering technique is performed on the normal set N with K=2 to obtain two different clusters. Set a threshold value T to determine the angle α between the two clusters. If $\alpha>T$, the data set with larger differences in normals is discarded. Then, the K-means clustering technique is repeated on the remaining data set until $\alpha\leq T$; (4) The RANSAC algorithm is used to fit a straight line through the set of remaining scatter points; and (5) The slope of the line obtained from the RANSAC method is computed to acquire the correlation dimension $D_2(m)$ for each m. Finally, the saturation correlation dimension is determined using the plot $D_2(m)$ vs. m.

Comment 4. Figure 8: More discussion will help to understand the figure effectively.
Response: Thank you for this comment. Considering that this is a technical paper, we limited our discussions for the purpose of brevity. We can give more discussion (i.e., the sentences in red color) about this figure.
Changes in manuscript:

The spatial pattern of the correlation dimension for precipitation in the HRB may be largely attributed to the regional flow pathway of moisture fluxes, which is mainly controlled by the East Asian Summer Monsoon (EASM). The HRB is located in a monsoon-dominated region, where the EASM plays a leading role in the regional meteorological system. Chen et al. (2013) showed that EASM had significant impacts on the spatiotemporal distribution of precipitation in East China. Li et al. (2017) further suggested that there was a significant correlation between precipitation and the EASM index in the HRB. Wang et al. (2011) revealed that large-scale atmospheric circulations had close relationships with precipitation patterns in the HRB by analyzing the moisture flux derived from NCAR/NCEP reanalysis data. Influenced by the large-scale atmospheric circulation, precipitation in the middle and southeast parts of the HRB is more sensitive to climate variability due to their locations closer to the ocean. This leads to the decreasing trend of precipitation from southeast to northwest in the HRB, suggesting that the supply of moisture for precipitation in the region mainly comes from the ocean.

Partly owing to the closer geographical proximity to the ocean (Fig. 8), the EASM has a stronger impact on precipitation in the southern and central areas than in the northern part of the HRB. Furthermore, at the north corner of the HRB, the Westerlies primarily affect the hydrometeorological system and thus weaken the impact of the EASM on precipitation (Li et al., 2017). In addition, other factors (e.g., topography, vegetation distribution, and human activity) may also have impacts on regional patterns of climate variables. In particular, the Yan-Taihang mountain located in the northwest HRB obstructs the vapor transport driven by the EASM, resulting in lower spatiotemporal variability in precipitation in the north part of the HRB. As a result, precipitation had higher degrees of complexity in the southern HRB, while its complexity was lower in the mountainous area in the northwest HRB. As to air temperature, the orographic effect in the mountainous area on air temperature might be stronger (Chu et al., 2010b), resulting in the higher complexity of temperature in this area. However, it should be noted that the range of the correlation dimension for air temperature from 1.0 to 2.0 suggests that two primary controls on temperature exist at all stations across the region.

Comment 5. Utility of estimation of correlation dimensions for the future work in HRB can be briefly mentioned.

Response: Thank you for this comment. We will add the limitations and future work of this study in the conclusion section.

Changes in manuscript:

The modified G-P algorithm proposed in this study can be used more objectively to provide a reliable estimate of the number of dominant factors governing the system. This can provide some evidence to simplify the model for representing the climate system. Furthermore, the results of this study can be used for the regionalization in the HRB, which has important significance in prediction in ungaged areas. It should be noted that more studies are still required to verify the present results using other nonlinear techniques, such as Lyapunov exponent (Wolf et al., 1985), and approximate entropy (Pincus, 1995). Besides, the improved G-P algorithm can be employed to analyze the nonlinear dynamics of other hydroclimatic variables, such as streamflow, soil moisture, and groundwater in the HRB and other regions. These results will be studied and reported in future.

References:

Li, F. X., Zhang, S. Y., Chen, D., He, L., and Gu, L. L.: Inter-decadal variability of the east Asian summer monsoon and its impact on hydrologic variables in the Haihe River Basin, China. J. Resour. Ecol., 8(2), 174-184, 2017.

Pincus, S.: Approximate entropy (ApEn) as a complexity measure. Chaos, 1995, 5(1), 110.

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Wolf, A., Swift, J. B., Swinney, H. L.: Determining Lyapunov exponents from a time series. Physica D Nonlinear Phenomena, 1985, 16(3), 285-317.