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Comment on acp-2021-402

Anonymous Referee #2

Referee comment on "Effect of rainfall-induced diabatic heating over southern China on the formation of wintertime haze on the North China Plain" by Xiadong An et al., Atmos. Chem. Phys. Discuss., <https://doi.org/10.5194/acp-2021-402-RC2>, 2021

General comments:

The manuscript by *An et al.* investigates the effects of rainfall-related diabatic heating over southern China on the wintertime haze events over northern China plain (NCP). The authors suggest that the NCP haze event is modulated by the Rossby wave train emanating from the North Atlantic and the secondary circulation induced by the heavy rainfall over southern China. Specifically, the authors argued that the diabatic heating associated with the heavy rainfall over southern China leads to descending motions over NCP, which reinforce the anticyclonic anomaly produced by the Rossby wave train and thus favor the formation of haze events.

Overall, the flow of the paper and the figures used to support the arguments are cohesive. However, I am not fully convinced about the role of diabatic heating over southern China in the haze events over NCP. I recommend that the paper be considered for publication after addressing the major comments below.

Major comments:

- The authors found that the NCP haze is modulated by the Rossby wave train emanating from the North Atlantic and the secondary circulation induced by the heavy rainfall over southern China. The diabatic heating associated with the heavy rainfall over southern China leads to descending motions over NCP, which reinforce the anticyclone resulting from the Rossby wave train. I am not fully convinced by this argument because (1) in

observations, it is difficult to disentangle the effect of diabatic heating over southern China on the anticyclone from the Rossby wave train; (2) the LBM simulation doesn't reproduce the observed anticyclonic anomaly over NCP (compare Fig. 9a with Fig. 4b; Fig. 11).

- L131: Could the authors elaborate on the definition of extreme winter rainfall events? Is the definition based on monthly rainfall or daily rainfall averaged over southern China? Why there are 22 rainfall events during 1985-2015 and why the durations of each individual event are different (Tables 1 and 2)?
- L137: When heavy rainfall fell over southern China, the probability for haze to occur over NCP is ~59% (13 out of 22 extreme rainfall events). Although the authors have compared the atmospheric circulations between SR-NH (13 events) and SR-noNH (9 events) events, I feel that the upper-tropospheric Rossby wave trains look very similar (c.f., Fig. 4a and Fig. 14a). Instead, the significance of the Rossby wave train reduces in the SR-noNH events, which might suggest more variabilities in the wave train. Could the authors explicitly show the differences between Fig. 4 and 14?
- While the authors have compared the atmospheric circulations during SR-NH events and SR-noNH events, how many NH events occur without SR? Is the atmospheric circulation during NH-noSR events also controlled by Rossby wave train similar to the one shown in Fig, 4b? This might help illustrate the importance of SR rainfall in observations.

Technical corrections:

- L51-56: I wouldn't call the Eurasian snow cover, ENSO, and Arctic sea ice changes as atmospheric conditions
- L108: add a space between QG and w
- L222: "The NSC simulated by the LBM bears a striking resemblance to the observed spatial pattern of the NSC (Figs. 5 and 10)". Should "Figs. 5" be "Fig. 6"? Also, for the caption of Fig. 10, should be "as Fig. 6" instead of "as Fig. 5".
- L222: Given the substantial differences between Figs. 6 and 10, I personally wouldn't say the NSC simulated by LBM bears a striking resemblance to observation.
- L205: Fig. 9a should be Fig. 8a
- L208: Fig. 9b should be Fig. 8b
- L216: Fig. 10a, may be Fig. 9a
- L218: Fig. 8b, may be Fig. 9b
- Fig. 12: the first and second rows show the diabatic heating and dynamic forcing terms, of which the sign is opposite to the omega. For ease of comparison with the omega shown in the bottom row, I suggest reversing the sign of diabatic heating and dry forcing terms.
- Is the omega shown in Fig. 6 also multiplied by -20 as that in Fig. 10? If not, the magnitude of omega is significantly different in the LBM model and observation.
- L47-49: "Large-scale circulation, and the related external forces derived via exciting the teleconnection pattern, regulate meteorological conditions, reduce dispersion, and facilitate the accumulation of haze pollutants (Zhang et al., 2020)." Please consider rephrasing this sentence.