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Natural Hazards and Earth System Sciences
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Discussions

Interactive comment on "Numerical rainfall simulation with different spatial and temporal evenness by using WRF multi-physics ensembles" *by* Jiyang Tian et al.

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Point 1: Cumulus parameterizations are not needed at this spatial resolution (1km, 3km, and even 9km). Therefore, at this point the full paper makes no sense for this reviewer.

Reply: We appreciate the referee for raising the issue which is worthy to be discussed. In general, WRF users tend to have fixed mindset that the cumulus parameterisations (CPs) are invalid with fine horizontal resolutions. As told by the WRF developers, the model is run at CPM mode where the dynamics of atmospheric convection is already treated with sufficient accuracy. This is also pointed out by the anonymous referee #2. However, in reality, the selection of different CPs at fine resolutions does make sub-

stantial differences in numerical rainfall simulation. This can be proved by the results of our study: the use of different CPs with identical settings of the other parameterisations resulted in different simulated rainfall. Many other studies also indicate that CPs have significant effect on the performance of the WRF model at fine resolutions, especially the three CPs (KF, GD and BMJ) discussed in our study (Argüeso et al, 2011; Evans et al, 2012; Pei et al, 2014). Among them, Shepherd et al (2016) explored the sensitivity of hurricane track to four cumulus parameterizations, including KF, BMJ, G-3 and TD, with the nested domains 1.33km, 4km and 12km. Madala et al (2013 and 2014) evaluated the performance of KF, GD and BMJ for the simulation of thunderstorm events, with the resolutions of the three nested domains being 3km, 9km and 27km. Remesan et al (2015) studied the WRF model sensitivity to the choice of parameterisations: 4 nested domains (1km, 3km, 9km and 27km) are used and the cumulus parameterisations of GD, BMJ, KF1 and KF2 are investigated. We do not approve that Referee #1 think the study is "no sense" based only on the unapproved point of CPs. The WRF model is still developing and explorations of the model users help break many boundaries. Like the widely accepted "6h spin-up time", the "1:3 downscaling ratio", and the "6-grid buffering zone", they are all proved not to be unchangeable rules. In order to make the manuscript more convincing, as suggested by Referee #2, we would like to compare the current rainfall simulation results with additional runs by masking CPs. This will be done by adding 4 members of the ensemble in Table 1 (Member 13-16). The references mentioned in the reply are provided as follows: Argüeso D, Hidalgomuñoz J M, Gámizfortis S R, Estebanparra M J, Dudhia J, Castrodiez Y. Evaluation of WRF parameterizations for climate studies over Southern Spain using a multistep regionalization. Journal of Climate, 2011, 24(21):5633-5651. Evans J P, Ekström M, Ji F. Evaluating the performance of a WRF physics ensemble over South-East Australia. Climate Dynamics, 2012, 39(6):1241-1258. Pei L, Moore N, Zhong S, Luo L, Hyndman D W, Heilman W E, Gao Z. WRF Model sensitivity to land surface model and cumulus parameterization under short-term climate extremes over the Southern Great Plains of the United States. Journal of Climate, 2014, 27(20):7703-7724. Shepherd T J, Walsh K J. Sensitivity of hurricane track to cumulus parameterization schemes in the WRF model for three intense tropical cyclones: impact of convective asymmetry. Meteorology and Atmospheric Physics, 2016:1-30. Madala S, Satyanarayana A N V, Tyagi B. Performance evaluation of convective parameterization schemes of WRF-ARW Model in the simulation of premonsoon thunderstorm events over Kharagpur using STORM Data Sets. International Journal of Computer Applications, 2013, 17(15):43-50. Madala S, Satyanarayana A N V, Rao T N. Performance evaluation of PBL and cumulus parameterization schemes of WRF ARW model in simulating severe thunderstorm events over Gadanki MST radar facility - Case study. Atmospheric Research, 2014, 139(6):1-17. Remesan R, Bellerby T, Holman I, Frostick L. WRF model sensitivity to choice of parameterization: a study of the 'York Flood 1999'. Theoretical and Applied Climatology, 2015, 122(1):229-247.

Point 2: The nomenclature is not right. The authors call ensemble N, to the member N of the ensemble.

Reply: Thanks for the suggestion and they will be revised accordingly.

Point 3: Plots showing the domains and orography would be desirable.

Reply: The following figures will be added to show the nested domains and the orography of the two study catchments.

Point 4: What are the differences between semi-humid and semi-arid? The authors state that in both regions annual precipitation is 600mm.

Reply: The dividing line between semi-humid and semi-arid region in China is an annual precipitation of 400mm. The two catchments in this study are located in semi-humid climatic region. The Haihe River basin which embraces the two study catchments covers a vast area of Northern China with both semi-humid and semi-arid climatic conditions. That is why the term "semi-humid and semi-arid" is used. In the revision, it will be clarified clearly.

Point 5: Fig 1, does not show the location of the rain gauges.

Reply: The locations of rain gauges will be added in Fig 1.

Point 6: What is the criterion to choose 0.4 as critical value for Cv?

Reply: This is a good point and readers may also have the same query while reading the paper. In order to learn the spatial and temporal evenness of the rainfall in the two study catchment, both spatial and temporal Cv of the storm events from 1985 to 2015 are all calculated. In reality, rainfall in Northern China is much more uneven than the south and it is impossible to find absolute even rainfall in both space and time. So we chose a threshold of 5%, which is also considered in other statistical analyses in the same area, as the critical value to separate even and uneven rainfall events. With the threshold, we found the two critical values of 0.4 for the spatial Cv and 0.6 for the temporal Cv. That is to say, the storm events with the spatial Cv below 0.4 or with the temporal Cv below 1.0 account for 5% of the total storm events from 1985 to 2015 in the study area. Explanations will be added in the manuscript to clarify this issue.

Point 7: The way of calculating mean observed precipitation could be not appropriated, specially for "uneven" cases. Why not using directly the output of the model at the observation sites?

Reply: In the manuscript, the simulated rainfall from the WRF model is evaluated from three aspects, i.e., the 24h areal rainfall accumulation, the spatial rainfall distribution and the temporal rainfall distribution. Firstly, the mean observed rainfall is used to calculate the accumulated areal rainfall, which is treated as an overall quantity metric. Secondly, the spatial and temporal distributions of the simulated rainfall are evaluated by a two-dimensional verification scheme comprised of 4 categorical indices and 3 continuous indices. At this stage of verification, the model outputs at the observation sites are directly used. In the spatial dimension, the observed and simulated rainfall accumulations at each rain gauge are compared; and in the temporal dimension, the comparison is made on the areal rainfall at each time step. Detailed explanations are provided in the methodology part of Section 3.2.

Point 8: The way of presenting the results should be improved. Figures 6 and 7 do not permit to extract fast conclusions.

Reply: The storm types will be indicated by the members of ensemble, which can help readers find the corresponding event in Figure 3, 4, 6 and 7. If the referee has better suggestion to improve the way of presenting the results, we are pleased to accept it in detail.

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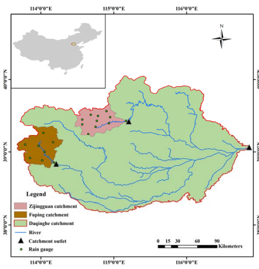

Fig. 1. Figure1

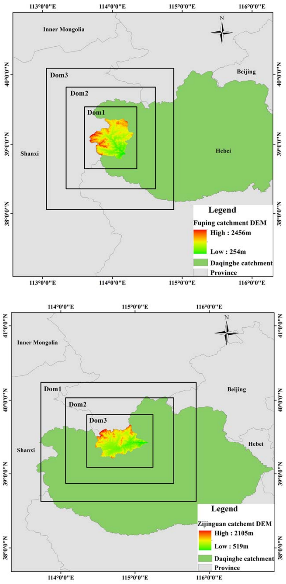

Fig. 2. Domains and orography

Table 1. The constitution of the WRF physical ensemble

Member ID	Microphysics	PBL	Cumulus parameterisation
1	Lin	YSU	KF
2	WSM6	YSU	KF
3	Lin	MYJ	KF
4	WSM6	MYJ	KF
5	Lin	YSU	GD
6	WSM6	YSU	GD
7	Lin	MYJ	GD
8	WSM6	MYJ	GD
9	Lin	YSU	BMJ
10	WSM6	YSU	BMJ
11	Lin	MYJ	BMJ
12	WSM6	MYJ	BMJ
13	***Lin***	***YSU***	/
14	***WSM6***	***YSU***	/
15	***Lin***	***MYJ***	/
16	***WSM6***	***MYJ***	/

Fig. 3. Table1