Comments on Manuscript GMD-2024-38

"**Applying double-cropping and interactive irrigation in the North China Plain using WRF4.5**"

by Yuwen Fan, Zhao Yang, Min-Hui Lo, Jina Hur, and Eun-Soon Im

Recommendation: Accept with minor revision.

This study describes the usefulness of the WRF-Crop model in capturing vegetation and irrigation patterns in the North China Plain (NCP), by incorporating double-cropping with interactive irrigation. The authors modified the crop model in terms of the vegetation fraction (FVEG) and the planting/harvesting dates and improved the irrigation model in calculating the irrigation amount. The authors validated their model results in terms of various irrigation and crop growth aspects and concluded that coupling of the enhanced crop and irrigation models significantly improved the performance in estimating crop stages and yields, field biomass, and leaf area index. This manuscript can be a valuable report to the scientific community for better prediction of double cropping and irrigation aspects in NCP; however, some issues need to be clarified or discussed in more detail.

Specific comments:

1. The authors need to specifiy major differences in their methods and results compared with those of Yu et al. (2022).

2. Abstract: Delete the last sentence describing the future research. Just include more details and focus on the current research.

3. Plain Language Summary: This part should have more scientific information, including more details in results and their implications.

4. L 53 & L 78–79: Remove the commas in front of 'but alo'. Note that 'not only ... but also' requires a comma only when two independent clauses are linked. No comma is required in linking nouns or noun phrases.

5. L55: "while others incorporate irrigation with fixed amount (Vira et al., 2019) or dynamically based on daily soil conditions" $\longrightarrow$ Hard to understand: Rewrite. Should 'dynamically' be replaced with 'dynamically varying amount' or something else?

6. L 69: "regionalizing the algorithms" $\longrightarrow$ How can the algorithms be regionalized? In general, one develops new parameterization schemes or improves the existing parameterization schemes and/or tunes/calibrates/optimizes the parameter values in the schemes, making the schemes and/or parameter values work well in a specific region of interest. The authors need to explain more explicityly on 'regionalization of algorithms'.

7. L 71: Include a paragraph that provides examples of 'regionalizing algorithms', e.g., developing new algorithms for a specific region and tuning/calibrating/optimizing parameter values that fits observations well in a specific region. Some examples of developing parameterizatin schemes at regional scales, in chronical order, include

   Bou-Zeid, E., Parlange, M. B., and Meneveau, C.: On the Parameterization of Surface Roughness at Regional Scales. J. Atmos. Sci., 64, 216–227, https://doi.org/10.1175/JAS3826.1, 2007.

   Liu, J., Ding, Y., Zhou, X., Li, Y.: A Parameterization Scheme for Regional Average Runoff over Heterogeneous Land Surface Under Climatic Rainfall Forcing, J. Meteorol. Res., 24, 116-122, 2010.

   Song, W., Tang, H., Sun, X., Xiang, Y., Ma, X., Zhang, H.: Developing a New ParameterizationScheme of Temperature Lapse Ratefor the Hydrological Simulation ina Glacierized Basin Based on Remote Sensing. Remote Sens., 14, 4973, `https://doi.org/10.3390/rs14194973`, 2022.

   Asmus, C., Hoffmann, P., Pietikäinen, J.-P., Böhner, J., and Rechid, D.: Modeling and evaluating the effects of irrigation on land–atmosphere interaction in southwestern Europe with the regional climate model REMO2020–iMOVE using a newly developed parameterization, Geosci. Model Dev., 16, 7311–7337, https://doi.org/10.5194/gmd-16-7311-2023, 2023.

   and some examples of regional parameter estimations, in chronical order, include

Xie, Z., Yuan, F., Duan, Q., Zheng, J., Liang, M., and Chen, F.: Regional Parameter Estimation of the VIC Land Surface Model: Methodology and Application to River Basins in China. J. Hydrometeor., 8, 447–468, https://doi.org/10.1175/JHM568.1, 2007.

Livneh, B., and Lettenmaier, D. P.: Regional parameter estimation for the unified land model, Water Resour. Res., 49, `https://doi.org/10.1029/2012WR012220`, 2013.

Hong, S., Park, S. K., and Yu, X.: Scheme-Based Optimization of Land Surface Model Using a Micro-Genetic Algorithm: Assessment of Its Performance and Usability for Regional Applications, SOLA, 11, 129-133, https://doi.org/10.2151/sola.2015-030, 2015.

Park, S. and Park, S. K.: A micro-genetic algorithm (GA v1.7.1a) for combinatorial optimization of physics parameterizations in the Weather Research and Forecasting model (v4.0.3) for quantitative precipitation forecast in Korea, Geosci. Model Dev., 14, 6241–6255, https://doi.org/10.5194/gmd-14-6241-2021, 2021.

8. L 84: The acronym 'LSM' should be replaced with 'LSMs'.

9. L 89–90: "Noah-Multiparameterization (Noah-MP)" $\longrightarrow$ Give the full original words "Noah land surface model with multiparameterization options (Noah-MP)", and provide a proper reference for it, i.e., Niu et al. (2011).

10. L 92–93: "Weather Research Forecast (WRF)" $\Longrightarrow$ "Weather Research and Forecasting (WRF) model", i.e., provide the correct original words for WRF. And cite a proper reference.

11. Figure 1: Modify the caption to "(a) Annual precipitation (mm/day) and basic geostatic variables applied in this project, including (b) topography (m), (c) cropland fraction (%), and (d) irrigated land fraction (%)."

12. L 120: Provide the proper reference of WRF version 4.3. Please also check if this version number is correct because your title says it is WRF4.5.

13. L 127: "ERA5-Interim" $\longrightarrow$ There is no ERA5-Interim reanalysis data. It should be either "ERA5" or "ERA-Interim". Based on the cited reference, Hersbach et al. (2020), it should be "ERA5".

14. L 143: There exists only one Liu et al. (2016) and only one Zhang et al. (2020) in the References; thus, the authors do not need to put the first names' initials. Replace "X. Liu et al. (2016)" with "Liu et al. (2016)" and "Z. Zhang et al. (2020)" with "Zhang et al. (2020)". Please do it throughout the manuscript.

15. L 175: There exists only one Wu et al. (2018b) in the References; thus, replace "L. Wu et al. (2018b)" with "Wu et al. (2018b)".

16. L 194: "crop growth." $\Longrightarrow$ "crop growth. Equations (1) and (2) below represent the original FVEG equation by Niu et al. (2011) and the adjusted FVEG suggested in this study, respectively:"

17. L 196, Eq. (1): "Niu et al. (2011) FVEG" $\Longrightarrow$ "Original FVEG"

18. L 222–223: Describe explicity 'Yucheng' and 'Shenyang' in Fig. 3a. In Fig. 3a, two red circles may represent these two locations, but the authors needs to put the location names in the map. Most readers around the world are not familiar with the location names.

19. L 225: The double-cropping area is quite large: Would Yucheng be considered to represent well the large area, especially the southern part of the area? Isn't there any station near the southern edge of the area? If another station exists with long-term observation at the southern part of the area, including it will make this study more valuable. Otherwise, add a sentence that Yucheng, located at the northern part of the double-cropping area, can well represent the characteristics of the southern part of the area, with some scientific evidences.

20. L 231: The authors used 'Vcmx25' and 'BIO2LAI' without any definition or explanation. If they are acronyms, please provide the original worrds; otherwise, explain what they are.

21. L 237: "Table S1 provides ... with the supporting scientific references and recalibration procedures." $\Longrightarrow$ "Table S1 provides ... with the supporting scientific references." Then, from Supplementary, please move the 2 paragraphs below "**The recalibration process:**" to the end of Section 2.3.3.

22. Figure 3: In the caption of Fig. 3, explain what the two red circles in Fig. 3a means.

23. Figure 3: Figures 3b-e are never cited in the manucript. The authors need to properly cite each subfigure in the text, probably in the paragraph in L 210–219.

24. L 249: Use consistent tense: "the crop emerges" vs. "the crop matured".

25. L 254: Is there any reason that 'irrigation' should be expressed in capital ("The default Irrigation")?

26. L 267: What does the number '2005' mean? Is it the year 2005?

27. Equations 3 & 4: Define $SMCLIM$ and $SMCAVL$ immediately following the equations.

28. L 264–269: It is recommended to modify this part as below:

    > The default daily irrigation amount is resolved as follows, based on the soil moisture and vegetation fraction which is fixed to be 0.95:
    >
    > $$\int (SMCLIM - SMCAVL) * 0.95 \qquad (3)$$
    >
    > where $SMCLIM$ is $\cdots$ and $SMCAVL$ is $\cdots$. When adopting it to large-scale irrigation, we improve the irrigation amount by replacing the constant 0.95 with $IRRFRA$, i.e., the irrigation land fraction map around 2005 from the Food Agriculture Organization database (Siebert et al., 2013) as follows:
    >
    > $$\int (SMCLIM - SMCAVL) * IRRFRA. \qquad (4)$$

29. L 272–273: Definition of $SMCLIM$ and $SMCAVL$ should appear immediately following Equations 3 & 4.

30. L 284: "which not only comprises irrigation, but also husbandry, forestry, and fishery consumption" $\Longrightarrow$ "which comprises not only irrigation but also husbandry, forestry, and fishery consumption"

31. L 285–287: Figures 4b and 4c are cited before Fig. 4a is cited. It is recommended to switch the order of subfigures in the order that they appear in the explanation.

32. L 296–297: "NCP (i.e., Beijing, Tianjin, Hebei, Shandong, and Henan, follows D. Wu et al., 2018) is coupled" $\Longrightarrow$ "NCP—Beijing, Tianjin, Hebei, Shandong and Henan that follow Wu et al. (2018)—is coupled"

33. L 307: "Figure 4(j)" $\Longrightarrow$ "Figure 4j"

34. L 307–315: Figure 4j is cited before Figure 4i is cited: Switch the order of these two subfigures in Fig. 4.

35. Figure 4, Caption: "(IRRnew), and (i) irrigation range among 10 ensemble members using different initial conditions (j) MAD" $\Longrightarrow$ "(IRRnew), (i) irrigation range among 10 ensemble members using different initial conditions, and (j) MAD"

36. Figure 5 and L 319–329: The authors just compared the results between two models—IRRdef vs. IRRnew. To verify that IRRnew is better, the authos should also show the observations. Although the authors showed that IRRnew had better results than IRRdef in terms of spatial distributions in Fig. 4, the authors should also validate the model results in terms of temporal variations.

37. L 337: "(first two lines in Fig. 6)" $\Longrightarrow$ "(top and middle panels in Fig. 6)"

38. L 338: "we considered the entering the initial reproductive stage as the heading date" $\Longrightarrow$ "we regarded the start of the initial reproductive stage as the heading date"

39. L 340: "is considered as the maturity date" $\Longrightarrow$ "is considered the maturity date" or "is regarded as the maturity date"

40. L 341: "can be considered as rough indicators" $\Longrightarrow$ "can be considered rough indicators" or "can be regarded as rough indicators"

41. L 351: "time Is not" $\Longrightarrow$ "time is not"

42. L 356: "(third row in Fig. 6)" $\Longrightarrow$ "(bottom panels in Fig. 6)"

43. L 365: "each of the following factors, implementation $\cdots$ irrigation, holds" $\Longrightarrow$ "each of the following factors—implementation $\cdots$ irrigation—holds"

44. L 368: "Yucheng and Shenyang station" $\Longrightarrow$ "Yucheng and Shenyang" (We already know that Yucheng and Shenyang are stations.)

45. L 369: "The station-based biomass is adopted for calibration (Fig. 7a-d)." $\Longrightarrow$ "The station-based biomass in a specific year is adopted for calibration in both stations (Figs. 7a-d)."

46. L 369 & 373: "Yucheng station" $\Longrightarrow$ "Yucheng"

47. L 376: "Shenyang Station" $\Longrightarrow$ "Shenyang"

48. L 376: "(Fig. 7b and 7d)" $\Longrightarrow$ "(Figs. 7b and 7d)"

49. L 377: "Fig. 7e-g" $\Longrightarrow$ "Figs. 7e-g"

50. Figure S1: The bottom panels of Fig. S1 show "GWBnew", which is never defined either in the main text or in the Supplementary. Define "GWBnew".

51. Figure 8: The caption can be better described as follows: "Monthly LAI patterns of the satellite observation (OBS), simulation with default crop model only (CROPdef), and simulation with improved crop and improved irrigation (IRRnew) from March (MAR) to October (OCT)."

52. L 417–418: "in the NCP, Shandong, Henan and Hebei, are depicted" $\Longrightarrow$ "in the NCP—Shandong, Henan and Hebei—are depicted"

53. L 418–419: "with horizontal and vertical error bars showing the inter-annual variability of both observation and simulation" $\Longrightarrow$ "with horizontal and vertical error bars showing the inter-annual variability of observation and simulation, respectively" (Please check if this modification gives correct interpretation.)

54. L 419: "Most of the dots especially the red dots, are" $\Longrightarrow$ "Most of the dots, especially the red dots, are"

55. L 421: "the uncertainties associated with the observation and simulation are" $\Longrightarrow$ "the uncertainties associated with the observation and simulation, respectively, are"

56. Figure 9, Caption: "the horizontal and vertical error bars depict the inter-annual variability observed in both the simulations and actual measurements" $\Longrightarrow$ "the horizontal and vertical error bars depict the inter-annual variability observed in the simulations and the actual measurements, respectively"

57. L 430–431: "the model design restricts the simulation of only one crop type per grid" $\Longrightarrow$ "the model design restricts the simulation to only one crop type per grid"

58. L 432 & 433: "the Yucheng Station" $\Longrightarrow$ "Yucheng"

59. L 447: "It is important to acknowledge that the model performance may be less satisfactory in southern NCP." $\longrightarrow$ This may be because the authors did not include an observation station in the southern part of NCP for calibration (see the comment in #19). It will be great if the authors can include one station in the sourthern NCP for calibration and compare the results.

60. L 453–454: This part should not be itemized, i.e., it should be rewritten as

> To enhance our understanding of the irrigation impact on regional climate, our study focuses on simulating irrigated crop growth in the NCP region using the WRF-Crop model. In order to improve the model's capabilities, we have implemented the following enhancements:
>
> - Incorporating $\cdots$
> - Establishing $\cdots$
>
> $\vdots$
>
> - Calibrating $\cdots$

61. L 471: "potential application of it" $\Longrightarrow$ "'potential application of this study" (Please describe 'it' explicitly. Please check if 'it' can be replaced with 'this study'; otherwise, please describe it adequately.)

62. L 472: "adopting it" $\longrightarrow$ Again, describe 'it' explicitly.