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Comment on hess-2022-379

Anonymous Referee #3

Referee comment on "Improving regional climate simulations based on a hybrid data assimilation and machine learning method" by Xinlei He et al., Hydrol. Earth Syst. Sci. Discuss., https://doi.org/10.5194/hess-2022-379-RC3, 2023

This paper takes advantage of the opportunity provided by the abundance of data in the Heihe River basin to illustrate the importance of accurate soil moisture and LAI information for climate modeling in regions with highly heterogeneous land surfaces. The spatial and temporal variations of soil moisture and LAI in the WRF are realistically expressed by data assimilation and machin learning (DA+ML). After assimilating the state variables from observations or satellite remote sensing, both soil moisture content LAI values are increased, which then increases evapotranspriation in the model and futher reduces the air warming bias and dry bias in the simulation. The improved simulation shows more realistic oasis-desert boundary and the wind shield effect within the oasis. Overall, this is an excellent study in terms of capacity building that improves climate modelling through implementing detailed information of land characteristics in a basin with very complex underlying surfaces. Nevertheless, I think this paper can be organized better and some moderate revisions are required..

1. The scientific question to be answered is unclear. If the authors intend to answer a question of general interest, applying satellite data as an input to SM and LAI is understandable because they are globally accessible. However, the application of in situ soil moisture as an input, as done in this study, has no way to expand spatially. If the authors are trying to answer a scientific question specific to the Heihe Basin, the challenges of climate modeling in this basin should be addressed. In either case, it should be stated in the INTRODUCTION in the form of motivation.

2. The structure and presentation of the paper could be imporved. (1) 4.1 should be verification of data assimilation rather than validation of model simulations of LAI and SM. LAI and SM are essentially an input (through ML+DA). Their realistic representaiton in the model verifies the correctness of the implementation in the model, but it does not mean the model's simulation capability. (2) 4.2 For land-air interaction simulations, the key linkage is sensible heat, latent heat (or evapotranspiration), and momentum fluxes, and there is a lack of description of sensible heat and momentum fluxes. (3) 4.3 Specific humidity and air temperature, which has been presented properly. (4) 4.4 Wind speed and

precipitation. This part currently lacks quantitative assessment and the results are not convincing. I am not surprised by this, because the improved representations to SM and LAI are local and there are other errors in the model itself. Therefore, it is very difficult to improve wind speed and precipitation quantitatively. I think it is acceptable to consider this part as sensitivity analysis rather than evaluation. If so, this subsection can be much shorten, e.g., deleting Figures 13b-c and Figures 14-15.

3. Suggest to revise the title. The work of this paper is not a prediction but a simulation; land-air interactions are not presented: it shows the response of the atmosphere to the change of the surface state, but does not present the influence of the atmosphere on the land.

4. L329-332: How mountain winds affect the climate in the oasis and how the cooling/wetting affects the air temperature and humidity aloft should be further clarified. Particularly, the height of 600hPa was chosen too arbitrarily. In the oasis and desert region, the influenced height is far lower than 600hPa. Later, the authors explained the phenomenon of warmer and drier aloft through horizontal advection between oasis and desert, but I guess the enhanced subsidence over the oasis in the WRF(DA-ML) is the cause.

5. In section 4.3, about the simulated wind speed difference between the two cases: when you update LAI, do you update the vegetation height (or roughness length and zero-plain displacement) in the WRF?

Minor comments:

In relevant figures, please indicate where is desert and where is oasis; otherwise, it is hard to understand what you are describing.

L179ï¼□what is “the standardized soil texture”ï¼□

L195-196ï¼□“the WRF model and DA-ML method were coupled and run dynamically and consistently through the cycles of steps one and two.” What is the time interval of the cycles? This is critical information for applications.

L368: what you mean by "divergent wind direction". I can understand the whole sentence neither.

L390: In the upper atmosphere, air masses enhanced the background northerly winds (orange areas)? It is hard to understand.

L391-395, and some similar sentences: it is not the focus of this work to study the ecological effect, which has been discussed in many early studies. Please delete.

L396-397: You have not established the causality among these components.

L415-418: Figure 12 shows downslope wind, so how could it transfer water vapor from the oasis upslope. There are some similar issues (e.g. L424-425). The authors must be more cautious to draw a conclusion.

L 474: "resembled the rainfall, vegetation cover, irrigation event, and shallow groundwater table features." Is it the conclusion of this study?

L476: You have not presented "the simulated seasonal cycles of air temperature". Instead, you only give the seasonal mean!