Dear Editor and Reviewer # 1:

Thanks for your careful reviewing and all constructive comments on our manuscript. We have taken all your comments into account and responded positively to qualify our manuscript for a potential publication in the journal. Our responses are written in blue below.

Comment 1:

I was very impressed by such valuable daily SM for more than 20 years over the whole mainland of China. Comparing with quantities of public products retrieved from remote sensing or downscaling into fine resolution, Chinacropland really open a new window for us to provide key parameters on earth observations. Irrigation practices do play more significances on crop production in China, especially for dryland crop. Therefore, no any doubt will be shown on the values of irrigation sub-model. Such novelty imply a potential way for applying irrigation sub-model into other areas and crops in the world. The study is fallen closely within the scope of ESSD. However, the authors should consider my several concerns below before their submission being accepted.

Thank for your positive comments, which really encourage us to improve our study.

(1) I am wondering how they obtain the crop dryland maps. For wheat or maize, it seem to me the location is constant. I need more detailed information to better understand their study.

Response:

Yes, we did remain the ChinaCropland location constant as several publications did similarly (Gervois et al., 2008; Ke et al., 2018). We proposed a new crop phenology-based crop mapping approach to generate a 1 km harvesting area dataset for three staple crops (i.e. rice, wheat, and maize) in China from 2000 to 2015 based on GLASS leaf area index (LAI) products (Luo et al., 2020a, b). Actually, we used the union of the annual harvested area dataset for maize and wheat as the China crop drylands maps.

Reference:

Gervois, S., Ciais, P., de Noblet-Ducoudré, N., Brisson, N., Vuichard, N., and Viovy, N.: Carbon and water balance of European croplands throughout the 20th century: CARBON BALANCE OF EUROPEAN CROPLANDS, Global Biogeochem. Cycles, 22, n/a-n/a,

https://doi.org/10.1029/2007GB003018, 2008.

Ke, X., van Vliet, J., Zhou, T., Verburg, P. H., Zheng, W., and Liu, X.: Direct and indirect loss of natural habitat due to built-up area expansion: A model-based analysis for the city of Wuhan, China, Land Use Policy, 74, 231–239, https://doi.org/10.1016/j.landusepol.2017.12.048, 2018.

Luo, Y., Zhang, Z., Chen, Y., Li, Z., and Tao, F.: ChinaCropPhen1km: a high-resolution crop phenological dataset for three staple crops in China during 2000–2015 based on leaf area index (LAI) products, Earth Syst. Sci. Data, 12, 197–214, https://doi.org/10.5194/essd-12-197-2020, 2020a.

Luo, Y., Zhang, Z., Li, Z., Chen, Y., Zhang, L., Cao, J., and Tao, F.: Identifying the spatiotemporal changes of annual harvesting areas for three staple crops in China by integrating multi-data sources, Environ. Res. Lett., 15, 074003, https://doi.org/10.1088/1748-9326/ab80f0, 2020b.

(2) I do not think RF is a new method to retrieve SM. That is to say, more interesting findings have ascribed from combining irrigation module into SM estimation model. However, the authors have not specified the point. I am looking forward to more information on it, e.g. the accuracy comparison between with irrigation module and without it.

Response: Many thanks for your valuable suggestion. We have compared their accuracy results between with-irrigation module and without-irrigation module as supplemental materials. Please see it in **Table S5**. The improved accuracy results were consistently indicated by all comparisons, e.g. decreases in RMSE, and ubRMSE and increase in R^2.

Table S5 The accuracy comparison between with irrigation module (in bold) and without it.

ChinaCropSM1km	BIAS		R^2		RMSE		ubRMSE	
wheat$_{0-10}$	**−0.0011**	−0.0019	**0.860**	0.801	**0.037**	0.044	**0.037**	0.044
wheat$_{10-20}$	**−0.0002**	−0.0006	**0.895**	0.838	**0.031**	0.039	**0.031**	0.039
maize$_{0-10}$	**0.0009**	0.0007	**0.861**	0.798	**0.036**	0.043	**0.036**	0.043
maize$_{10-20}$	**0.0003**	−0.0001	**0.894**	0.812	**0.029**	0.038	**0.029**	0.038

(3) Deeper and more extent discussions will further expand the reputation and influence of their

study.

Response: Thanks very much for your constructive comment. We have followed you to insert deeper and more extent discussions into our manuscript (Line 307~320 in the revised manuscript).

"The ChinaCropSM dataset are credible and accurate according to the results comparing with the public datasets, however, some limitations are still existed in our study. First, the limited AMS irrigation records may lead to the uncertainty in the irrigation factor predictions. More detailed irrigation information will help to improve irrigation module performances. Second, our method for generating cropland SM is applicable to other regions and crops, but more environmental variables will be increasingly required considering the SM variabilities are complex processes controlled by many factors (Famiglietti et al., 2008; Qin et al., 2013; Guevara and Vargas, 2019), especially for irrigation activities. For example, to characterize more accurately the irrigation activities, many field samples are highly required in both spatial and temporal resolutions. Other auxiliary data on information of crop growth, classification, and managements (e.g. irrigation frequency, amount and method) will benefit to develop our irrigation module and derive SM datasets more accurately. Moreover, advanced algorithms will be potential alternatives for random forest due to its strong dependence on inputs (Breiman, 2001; Rasmussen, 2004). Improving irrigation module should be focused on details such as irrigation amount and frequency, which will significantly help to verify and improve the accuracy of both irrigation and SM predictions.".

(4) Generally, the English writing is Ok. But typo can be observed sometimes, a careful check should be conducted throughout their manuscript.

Response: Thank you for your careful comments. We have modified carefully throughout the revised paper (Line 58, 100, 143, 524).

Line 58: r^2 -> R^2

Line 100: "accumulated precipitation for 10 days" -> "ante-accumulated precipitation over ten days"

Line 143: ~~in China~~

Line 524: "mode" -> "factor"

Dear Editor and Reviewer # 2:

This study provides a longer term soil moisture dataset (ChinaCropSM1km) for crop drylands across mainland of China. ChinaCropSM1km perform better than public product in both higher accuracy and more details (daily, more soil layers) by using machine learning technology. Such soil moisture dataset with higher resolutions is very valuable for the studies on crop model, yield estimation, and climate change impact assessment. Moreover, their methodology is robust, and their interesting results were well interpreted. The irrigation module is a novel way to improve highly moisture estimation. Therefore, I recommend it can be accepted after a minor revision.

We appreciate your insightful comments on our paper. The comments offered have been immensely helpful. We have responded to every question, indicating exactly how we addressed each concern or problem and describing the changes we have made. The revisions have been approved by all authors. The point-to-point responses to your comments are listed below in **blue**.

Comments and suggestions:

Point 1: There is a problem with the resolution. The ground observation data is point measurement data, how to match the resolution of 1km? Please explain this in the manuscript.

Response: Thank you a lot for the insightful suggestion. We have followed you to insert relevant contents into our manuscript (highlighted in "Track Changes", line 140~143, 185~186).

"We use the Extract Values to Points tool to extract the 1km resolution raster information of environmental (i.e. SP, RSD and GI) data to AMS point data, output point data attributes and save it in CSV format to obtain a data set of environmental factors through ArcGIS 10.5.".

"All these point samples are used to develop pointed-SM model, and then applied these pointed-models developed to inversely calculate the gridded-SM by inputting 1km-raster environmental variables.".

Point 2: Section 2.1. The authors pointed out that the study area is dominated by dryland crops (i.e.

wheat and maize) in China, how was the Chinacropland layer defined in Figure 1 according to the annual crop harvested area in mainland China from 2000 to 2015? please describe the details.

Response:

We remain the ChinaCropland location constant as several publications did similarly (Gervois et al., 2008; Ke et al., 2018). We proposed a new crop phenology-based crop mapping approach to generate a 1 km harvesting area dataset for three staple crops (i.e. rice, wheat, and maize) in China from 2000 to 2015 based on GLASS leaf area index (LAI) products (Luo et al., 2020a, b). Actually, we used the union of the annual harvested area dataset for maize and wheat as the China crop drylands maps.

Reference:

Gervois, S., Ciais, P., de Noblet-Ducoudré, N., Brisson, N., Vuichard, N., and Viovy, N.: Carbon and water balance of European croplands throughout the 20th century: CARBON BALANCE OF EUROPEAN CROPLANDS, Global Biogeochem. Cycles, 22, n/a-n/a, https://doi.org/10.1029/2007GB003018, 2008.

Ke, X., van Vliet, J., Zhou, T., Verburg, P. H., Zheng, W., and Liu, X.: Direct and indirect loss of natural habitat due to built-up area expansion: A model-based analysis for the city of Wuhan, China, Land Use Policy, 74, 231–239, https://doi.org/10.1016/j.landusepol.2017.12.048, 2018.

Luo, Y., Zhang, Z., Chen, Y., Li, Z., and Tao, F.: ChinaCropPhen1km: a high-resolution crop phenological dataset for three staple crops in China during 2000–2015 based on leaf area index (LAI) products, Earth Syst. Sci. Data, 12, 197–214, https://doi.org/10.5194/essd-12-197-2020, 2020a.

Luo, Y., Zhang, Z., Li, Z., Chen, Y., Zhang, L., Cao, J., and Tao, F.: Identifying the spatiotemporal changes of annual harvesting areas for three staple crops in China by integrating multi-data sources, Environ. Res. Lett., 15, 074003, https://doi.org/10.1088/1748-9326/ab80f0, 2020b.

Point 3: In (1), the author judges the irrigation factors by comparing the observed soil moisture and the soil moisture evaluation index (SMI) according to the corresponding soil depth and phenology of crops. However, I notice that the SMI in Table 2 is a range, rather than an exact number. Please give reasonable explanation for this.

Response:

Actually, we use the minimum value of the SMI interval (i.e. an exact number threshold) to judge

the irrigation factors considering the spatial differences in irrigated cropland. The irrigation factor (CIR) is assigned by 1 if the actual soil moisture is larger than the irrigation threshold. We used the minimum value to ensure that CIR were taken into account in all zones during forecasting SM. Using the minimum value might misclassify CIR, such as assigning "1" to no irrigation application, but such treatment is a compromise way before more detailed irrigation information is available. Moreover, we explained this limitation in the discussion section.

Point 4: In section 2.3.2, considering the new SM product has been derived by integrating the irrigation module into SM model, it is better to evaluate accuracy of the module (irrigation factor forecasting model) and supply such important information into new edition.

Response: In the Data and methods (Section 2.2.1), the accuracy of irrigation factor forecasting model has been provided in the revised manuscript (Line 214~220).

We evaluated our irrigation factor forecasting model results (**Table S4**) using the receiver operating characteristics (ROC) curve and their Area Under the Curve (AUC) (Fawcett, 2006). Also, we calculated UA (Eq. 7), PA (Eq. 8), and overall accuracy (Eq. 9) based on confusion matrices (**Table S3**) containing the percentages of the four possible outcomes of a model: True Positive (TP), True Negative (TN), False Positive (FP) and False Negative (FN) (Fawcett, 2006).

$$PA = \frac{TP}{TP+FP} \tag{7}$$

$$UA = \frac{TP}{TP+FN} \tag{8}$$

$$Accuracy = \frac{TP+TN}{TP+FP+TN+FN} \tag{9}$$

Reference:

Fawcett, T.: An introduction to ROC analysis, Pattern Recognition Letters, 27, 861–874, https://doi.org/10.1016/j.patrec.2005.10.010, 2006.

Table S3 Confusion matrix table in this study.

		Class	
		Irrigated	Non
Reference	Irrigated	TP	FN
	Non	FP	TN

Table S4 Confusion matrix of irrigated validation based on the test dataset. Prediction categories are columns while reference categories are rows.

ChinaCropSM1km	Class	Irrigated	Non	Total	Accuracy	PA	UA	AUC
wheat$_{0-10}$	Irrigated	1633	395	2028	0.85	0.82	0.81	0.84
	Non	365	2744	3109				
	Total	1998	3139					
wheat$_{10-20}$	Irrigated	1583	446	2029	0.84	0.81	0.78	0.83
	Non	365	2749	3114				
	Total	1948	3195					
maize$_{0-10}$	Irrigated	915	310	1225	0.86	0.85	0.75	0.84
	Non	167	2030	2197				
	Total	1082	2340					
maize$_{10-20}$	Irrigated	875	321	1196	0.86	0.83	0.73	0.83
	Non	175	2052	2227				
	Total	1050	2373					

Point 5: Some typos are found in manuscript, and check manuscript carefully and correct them. e.g. Line143: delete 'in China'.

Response: Thank you for your careful comments. We have modified all typos in the revised paper (Line 58, 100, 143, 524).

Line 58: r^2 -> R^2

Line 100: "accumulated precipitation for 10 days" -> "ante-accumulated precipitation over ten days"

Line 143: ~~in China~~

Line 524: "mode" -> "factor"

Point 6: Figure 2 should be improved. Currently, some labels are too vague to clearly identify.

Response: Many thanks for your advice. We have modified it in the revised paper.

Point 7: Please modify the line widths in Table 2.

Response: Many thanks for your careful check. We have modified it in the revised paper.

Point 8: Line257: insert blank between two words. 'Figure8' -> 'Figure 8'.

Response: Thanks for your careful review. We have modified it in the revised paper. (Line 284).

Point 9: Figure S5 was not used in the main text, please cite it in main text or delete it from supplemental material.

Response: Thanks for your careful review. We have deleted it from supplemental material.

Dear Editor and Reviewer # 3:

We appreciate your insightful comments on our paper. The comments offered have been immensely helpful. We have responded to every question, indicating exactly how we addressed each concern or problem and describing the changes we have made. The revisions have been approved by all authors. The point-to-point responses to your comments are listed below in **blue**.

This is an interesting effort in developing the SM product for crop dryland, which has potential for various applications. The paper is well written and organized. Taking the CIR as a predictor seems to be a useful way to predict SM in crop dryland. However, I have some concerns as following. Please pay more attention on the comments about line 174-175.

Point 1: Why only mapping SM for dryland, not rice?

Response: Rice is commonly grown in southern areas with plenty rainfall or northern areas well equipped by irrigation in China. Therefore, soil moisture is usually over saturated and keeps constant (near 100%) during the whole growing season (Zheng et al., 2000; Alhaj Hamoud et al., 2019). Considering the significant role of SM for maize and wheat planted in dryland across China, we mapped the SM for crop drylands, not including rice.

Reference:
Alhaj Hamoud, Y., Guo, X., Wang, Z., Shaghaleh, H., Chen, S., Hassan, A., and Bakour, A.: Effects of irrigation regime and soil clay content and their interaction on the biological yield, nitrogen uptake and nitrogen-use efficiency of rice grown in southern China, Agricultural Water Management, 213, 934–946, https://doi.org/10.1016/j.agwat.2018.12.017, 2019.

Zheng, X., Wang, M., Wang, Y., Shen, R., Gou, J., Li, J., Jin, J., and Li, L.: Impacts of soil moisture on nitrous oxide emission from croplands: a case study on the rice-based agro-ecosystem in Southeast China, Chemosphere - Global Change Science, 2, 207–224, https://doi.org/10.1016/S1465-9972(99)00056-2, 2000.

Point 2: Line 110-115: there are two sources of FC which one is used?

Response: Field capacity (fc) was obtained from OpenLandMap which included fc under 33kPa at 0cm (b0) and 10 cm (b10) depth. When predict ChinaCropSM$_{0-10cm}$, we used fc under 33kPa at 0cm (b0) depth. When predict ChinaCropSM$_{10-20cm}$, we used fc under 33kPa at 10cm (b10) depth.

Point 3: Line 120: the short name "AMS" is used only one time. Consider full name. In addition, what is R4, R5 and R16?   And it should not be calculated only for AMS but for each cell, as a predictor.

Response: Many thanks for your advice. We have increased the full name of "AMS" in the revised paper.

Yes, R4, R5 and R16 is calculated for each cell, as a predictor. Actually, the R4, R5 and R16 are river network vector data at different levels in China. When training sample data, we calculate the distance for AMS. Additionally, we calculated the distance from each cell to river network vector data when predicting the ChinaCropSM.

Point 4: Line 171: Grammar error. Not a complete sentence.

Response: Thank you for your careful comments. We have modified it (Line 180).

"As for the response variable (Classified Irrigation CIR), it is calculated by irrigation threshold (Table 2) and in situ information, including crop type, phenology and soil depth.".

Point 5: Line 174-175: It should not be random splitting because SM of different time from the same site may be highly correlated. This will give a higher performance for the model. Instead, the splitting should be based on sites, i.e., data from a site should be all in the training set or all in test set. Note that the model is predicting unknown locations based on the observing sites, and the spatial interpolation ability should be evaluated by the site-based splitting.

Response: Thanks very much for your constructive comment.

According to your site-based splitting method, we re-optimized the hyper-parameters of the prediction model to reduce overfitting and evaluated the prediction results. We found the soil moisture predicted by your method agreed well with in situ SM observations (ubRMSE ranges from 0.046–0.057, and R^2 ranges from 0.642–0.761), although the model performance drops slightly (Figure 1).

Similarly, in the case of site-based splitting, all prediction accuracy of SM were consistently improved both for crops and depths with comparison of those without an irrigation module (e.g. R^2 increased by 9–41%, ubRMSE decreased by 21–26%) (Figure 2). Also, we further compared our ChinaCropSM1km with the two popular public global SM products (Table 1). All indexes of our ChinaCropSM were consistently indicated by the higher accuracy.

Different splitting methods during training and testing do affect model performance. Selecting which splitting method to improve the generalization performance is dependent on data. Generally, the larger size of data, the smaller effect of the splitting methods on the results (Birba, 2020). Therefore, the model performances of two splitting methods show no significant differences because of quantities of field observations available in our study. We have followed you to insert deeper and more extent discussions into our manuscript (Line 307~322 in the revised manuscript).

Reference:

Birba, D. E.: A Comparative study of data splitting algorithms for machine learning model selection, 2020.
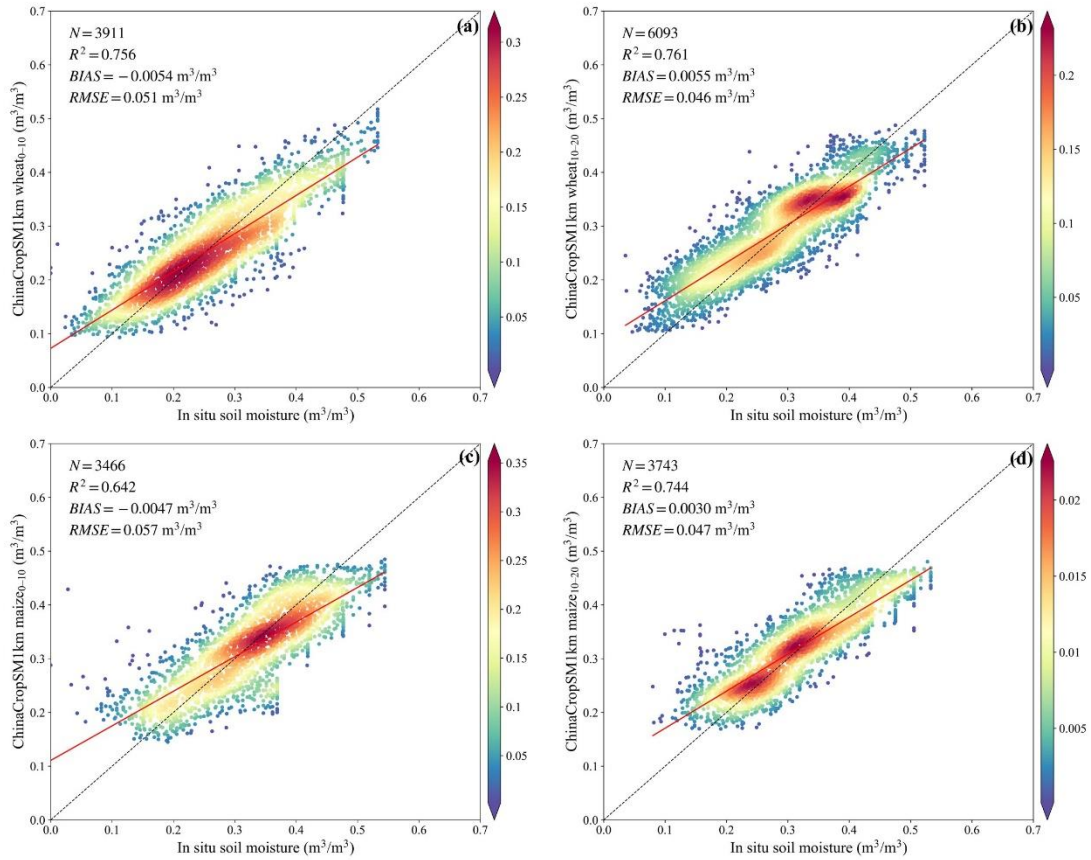
The results are following:

Figure 1 Comparison between the predicted soil moisture (ChinaCropSM1km) and in situ samples by crops and depths (cm) according to site-based splitting.
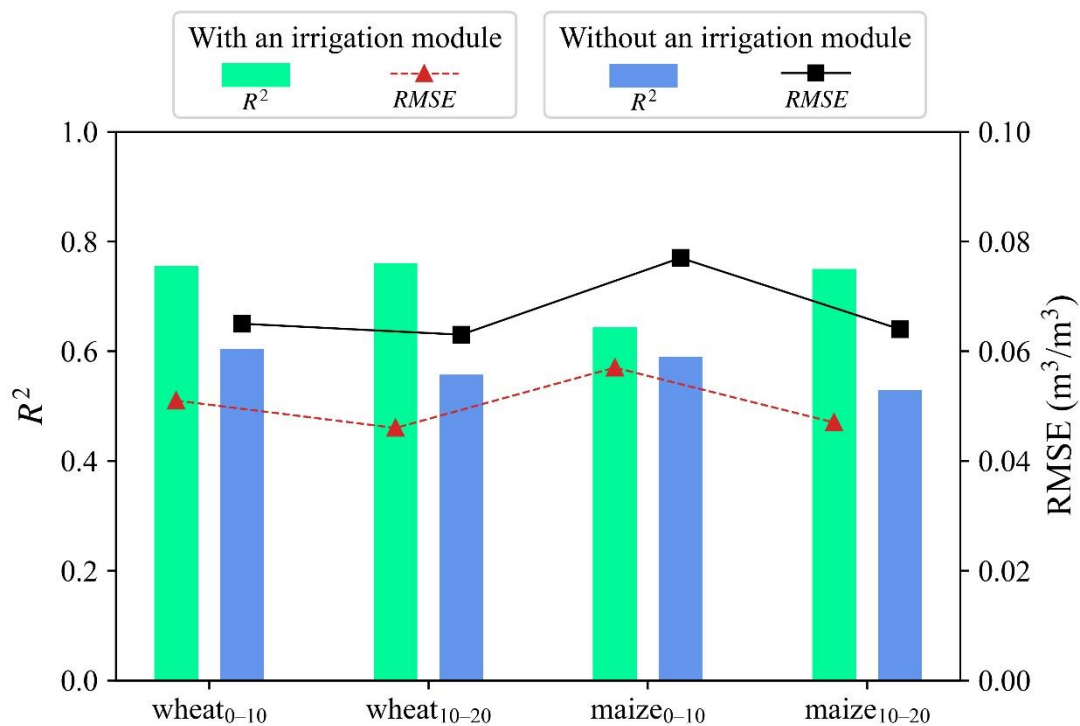
Figure 2 Comparison of soil moisture accuracy between with irrigation and without an irrigation module according to site-based splitting.

Table 1 Summary on means of evaluation indexes of three products (ChinaCropSM1km, RSSSM and ESA CCI SM).

Product	ChinaCropSM	RSSSM	ESA CCI SM
r	0.85	0.52	0.42
RMSE	0.054	0.144	0.120
bias	–0.005	–0.112	–0.066
ubRMSE	0.054	0.092	0.100

Point 6: Line 185: How many times do you run the model to get the importance, as the importance will be different each time. It should take the average importance of dozens of runs like 100.

Response: Yes, we did take the averages of dozens of runs. We ran each training model 50 times to get the importance and averaged the importance outcome.

Point 7: Fig.6 and 7: what are the different boxes stand for?

Response: The boxes in Fig.6 and Fig.7 actually stand for different results, with spatial pattern in Fig.6 and temporal one in Fig. 7. Both patterns were conducted between ChinaCropSM1km and the in situ SM observations.

The horizontal line within each box stands for median, the white dot for mean, the box bottom for first quantile, the top for third quantile, and black dots for outliers.

Point 8: Section 3.5: I do not think this comparison is fare. The evaluation using the test data for Cropland should be used instead of all in situ data because the model used them to establish leading to an independent evaluation.

Response: Actually, we only used the testing data for evaluating, not including all in situ data. We agreed well with you that using all observations will lead to an independent evaluation.