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# Reply to Referee 3 on the manuscript "Role of surface hydrology in determining the seasonal cycle of Indian summer monsoon in a general circulation model"

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Thank you for your valuable feedback and suggestions and your time!

*General comments: This study starts with showing the precipitation bias between model results and observation datasets during the Indian summer monsoon period, combining with analyzing the vertical moisture stability. Furtherly, the sensitive experiments are conducted to indicate that the effect of remote soil moisture over the WCA contribute more to the precipitation bias in June than that of local ones over the GP. However, about description of the moisture circulation in the remote influence is very confused.*

Reply: We will modify the remote forcing section and make it more elaborate and clear.

*Comment: First of all, due to the location of GP, how could the intensifying low-level westerly jet (depicted in Fig.9b) influenced by the negative soil moisture over the WCA bring more moisture to GP in June? The southwest wind cannot reach to GP and the wind interacting area locates in the southern part to GP.*

Reply: In our paper, the Gangetic Plain (22–28 N and 76–88 E) is very close to monsoon core zone. In Figure 9a, where we have shown the difference of precipitation and 850 hPa winds between WCAWET and CNTL (WCAWET-CNTL), the anti-cyclonic nature of 850 hPa winds over GP in WCAWET with respect to CNTL is noticeable. WCAWET experiment has wetter soil moisture condition over WCA compared to CNTL. The point we want to make here is that the moisture influx into GP depends on the cyclonic turning of low level winds, which also depends on the strength of the south-westerly Jet.

Additionally, the figure below shows a weakening of the 850 hPa westerlies over 65-75 E in June in WCAWET run as compared to control.

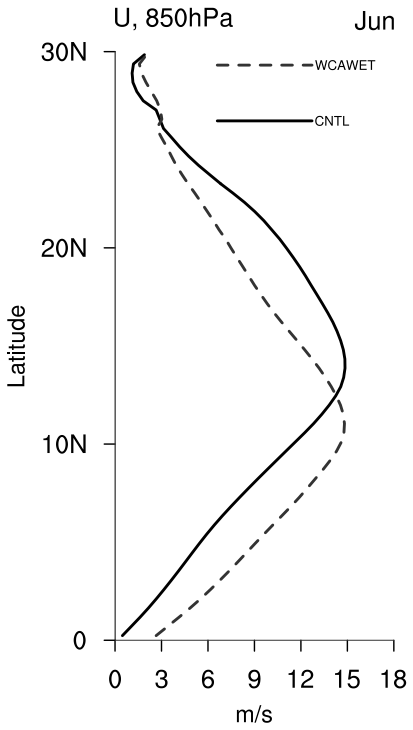


**Figure 1.** Zonal wind at 850 hPa averaged between 65–75 E plotted versus latitude for the month of June for WCAWET and CNTL.

*Comment: In addition, the explanation of the low-level jet in the sensitive experiment of WCAGP_NDG should be specific, so does ITCZ.*

Reply: We will modify appropriately. Sorry for the confusion.

*Comment: Overall, the soil moisture, especially explaining from its induced moisture circulation, cannot be seen that it can improve the prediction of the onset of the Indian summer monsoon in this study. But the results are promising to advance the GCM simulating the Indian summer monsoon precipitation.*

Reply: We tend to disagree here with the reviewer. In this work we do not want to claim that soil moisture nudging improved the prediction of onset. We only want to bring to the attention of readers the improvement in seasonal cycle of precipitation over GP with soil moisture bias correction, especially in early June, that is onset phase of monsoon. But we neither deny the implication that this link between WCA soil moisture anomalies and monsoon onset over India could be of use in improving prediction of onset, but it is surely outside the scope of this study.

Our results show that soil moisture bias in model is responsible for distorted seasonal cycle and sharp rise in precipitation after onset over GP in beginning of June. Towards the end of paper, we demonstrate through WCAGP_NDG experiment, that after soil moisture bias correction over WCA and GP, the seasonal cycle over GP improved, and also the sharp rise in precipitation is not there, and the precipitation gradually increases in June. We do not want to assert through our experiments that onset date is changed through soil moisture bias correction. We only want to highlight the sharp increase in precipitation

in CNTL after onset. We will modify the sentences in manuscript, which could cause such confusion to readers. We are sorry for this confusion in the first draft of manuscript. We will make it more clear.

*Specific comments: 1) Page 6 line 20, " that is an onset is declared if the area averaged rainfall is more that 4 mm day$^{-1}$ for at least five consecutive days after first of June ". This sentence need to be rewrittern.*

Reply: We will rewrite this sentence.

*2) The usage of which and that is not proper, eg. Page 8 line 28 "under extreme conditions, that is very dry surface and completely saturated surface" where" that" should be changed to "which".*

Reply: We will modify appropriately.

*3) Page 9 line 9, 'though this small. . ., but. . .' where but should be removed.*

Reply: We will correct it.

*4) Page 9 line 14, '. . .weakens the circulation. . .'where 'the circulation' is not very clear.*

Reply: By 'the circulation' , we basically mean moisture influx over GP in CNTL. We have pointed out the net moisture advection and net zonal moisture advection terms in previous line. But we will modify this sentence for clarity.

*5) Page 13 line 6, '. . .modulate the onset phase and seasonal cycle of Indian summer monsoon' where 'the onset phase' should be specific.*

Reply: By onset phase we mean early part of June. Major difference in seasonal cycle of precipitation over GP between CNTL and WCAGP_NDG is noticeable (Figure 12d). We will further modify in manuscript for clarity.

*6) About the equations, please give the details of the physical meaning of every alphabet.*

Reply: We will add details. Thank you for your comments.