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Interactive comment on "Influence of initial soil moisture in a Regional Climate Model study over West Africa: Part 1: Impact on the climate mean" *by* Brahima Koné et al.

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Reply to the comments of the referee 1 for the manuscript hess-2020-112

We thank the reviewers for the careful review and positive comments which helped to improve the manuscript. Please find our answers to comments in italic as well as suggested text changes in yellow in the revised version.

Introduction of the reviewer The manuscript describes a range of experiments to determine the impact of soil moisture anomalies on the summer (JJAS) climate of West Africa. The experiments include 3 experiments for each JJAS 2003 (a wet year) and

JJAS 2004 (a dry year). The 3 model experiments are a control run using ERA20C initial soil moisture, a dry initial soil moisture state, and a wet initial soil moisture state. The impacts of these varying initial states are discussed for each year, precipitation, temperature, sensible and latent heat, the Bowen ratio, and PBL height. For precipitation, the authors found that (generally) results agree with previous studies and homogeneous impacts are found in the transition zones between wet and dry climate regimes, though the wet experiment impacts precipitation more strongly than dry. However, the results vary regionally, for example the West Sahel and Guinea coast show increased precipitation in both dry and wet experiments. Temperature showed more sensitivity to soil moisture initialization, where dry experiments caused increased warming and vice versa. Wet experiments caused cooling of surface temperatures, smaller sensible heat flux, greater latent heat flux, and a smaller depth of the PBL which was mostly homogeneous over the region. Overall the results may be significant for future studies of soil moisture initialization over West Africa. I think that the manuscript shows merit, and soil moisture initialization remains important for climate prediction - the authors indeed show differences in precipitation and temperature depending on soil moisture initial state; however, I have some concerns about the experiment design. I'm curious about the choice of JJAS 2003 and 2004, and if these two years allow for a robust study of the influence of soil moisture initialization. I have a number of other comments below, but I believe that this paper needs major revisions before acceptance.

Major/Specific Comments: 1. Comments: As noted above, my main concern stems from your year choices. While this results in 6 experiments for comparison, I am not convinced that the results are robust given only a 2 year sample size. Moreover, I'm curious how these years were chosen -are they extreme wet and dry years? How often do years such as these occur? How is "wet" and "dry" defined?

Author's response: Thank you for your comment. The aim of this study is to investigate how soil moisture initialization at the beginning of the rainy season may impact the intraseasonal variability of temperature and precipitation mean and extremes within the subsequent season (June to September). For this purpose, we set up an ensemble of 3 experiments each with simulations starting from June 1st to September 30th. The difference between these 3 experiments is on the change of soil moisture initial condition during the first day of the simulation (June 1st): For each experiment, we applied (i) a reference initial soil moisture condition, (ii) then a wet initial soil moisture condition, and finally (iii) a dry initial soil moisture condition. As previous studies demonstrated that the impact of soil moisture initial condition is no longer than 4 months (120 days; Hong and Pan. (2000); Kim and Hong (2006); Koster et al. (2010); Santanello et al. (2019)), we decided to perform these 3 experiments (wet, dry and reference soil moisture initial conditions) during two contrasted years in West Africa (in 2003 wet year and in 2004 dry year compared to the mean 1950-2004 cf fig. below) in the aim to assess the results of the sensitivity study, whatever the year studied.

The figure below on the anomaly of rainfall in the Sahel from 1950 to 2004 is from http://research.jisao.washington.edu/data/sahel/022208/ and shows differences between wet and dry years. It helps to answer how these years (2003 and 2004) were chosen and how often those years occur. Sahel region as well as the West Africa region experienced a period of wet years in the 50-60s followed by a period of 30 dry years until 90s. Annual rainfalls during the last 30 years are highly variable and although the Sahel has seen a “recovery” in rainfall since the 1980s, cumulative precipitation has not returned to pre-1960s levels.

2. Comments: I’m not sure I understand why you discard the first 7 days as spin-up – perhaps because I’m used to prediction, where those 7 days are included in the forecast and would show large impacts of soil moisture initialization.

Author’s response: Thank you very much. Spin-up is a concern when there is a lack of data or seasonal simulation (Rahman and Lu, 2015). Overestimating the spin-up period would lead to a loss of important information. Likewise, an underestimation will lead to integrate errors in the analysis due to the fact that the model does not reach the dynamical equilibrium between the lateral forcing and the internal physical dynamic of the model. Yes, you're right, Anthes et al. (1989) demonstrated that regional models attain the dynamical equilibrium in 2-3 days spin-up period. However, Kang and al. (2014) by comparing different land surface schemes (BATS and CLM3) and different periods of spin-up to simulate June – July – August precipitations recommended 7 days as spin-up period. In this study, we used CLM4.5 as land surface scheme (Oleson et al., 2013) which has a more complex design. That's why we used 7 days as spin-up period.

3. Comments: Line 152: Is a normal distribution the correct choice here?

Author's response: Use of normal law in probability density functions (PDF) to explore the frequency and severity of climate extremes is not new ((Katz and Brown 1992; Kiktev et al. (2003), Alexander et al. (2006)).

Andronova and Schlesinger (2001) and Knutti et al. (2002) used this method to compute the biases and to represent the uncertainty in physical processes and feedbacks in climate models. Dessai et al (2005) used it to assess the uncertainty in regional climate change projections. Jaeger and Seneviratne (2011) used this method to assess the impact of soil moisture-atmosphere coupling on European climate extremes and trends in a regional climate model.

4. Comments: Line 156 - 157: Given you only have a few experiments, a significance test would be difficult to achieve. Do you feel that you have sufficiently large "n" to address significance? You may have enough grid points to address spatial significance (given that you modify your n due to autocorrelation, but I note in my minor comments that you should include your sample size), but temporally I don't feel the results are robust.

Author's response: Thank you for your comment. The number of our sample size (number of grid points) is 20748 (182x114) covering the entire West Africa region. The statistical significance is performed over these grid points. We test the null hypothesis that the sample means are from the same population (i.e. H0: ave1=ave2) after computing temporal average and p-value at each grid point. We specify a critical significance level for the ttest and test if the means are different at each grid point. We used NCL to perform this significance test.

5. Comments : It seems that in a broad sense your results largely agree with those from Koster et al., etc. which show that the largest impacts occur in transition zones, and you note that this is poorly understood over West Africa. I'd like to see some additional explanation on the impacts of this manuscript to the scientific community - how does this manuscript provide better understanding and what could this better understanding lead to? Basically, your conclusions are more of a summary/rehashing, and I'd like to see more impact full statements.

Author's response: Thank you for your comment. The conclusion has been improved based on comments of reviewers. This paper (part 1) shows that sensitivity to soil moisture initial conditions is stronger with temperature than with precipitation and that the impacts are different depending the sub-regions. Precipitation and Temperature over West Sahel and Guinea Coast sub-regions closer to the Atlantic Ocean react differently to soil moisture initial conditions than over the drier region of Central Sahel.

Minor/Technical Comments:

1. Comments: I noticed a number of grammatical and spelling errors in the manuscript, I suggest having someone read and edit the manuscript specifically for editorial remarks such as these.

Author's response: Thank you for your comment. We did our best to improve the manuscript.

2. Comments: You use a number of parenthetical references such as "impacts of the wet (dry) soil moisture on wet (dry) years etc." - I do not mind these at all, but sometimes the text is very difficult to read when they are used in excess. For example, line 464-468.

Author's response: Thank you for your comment. We reduce this style of writing in the revised version and make it easier to read.

3. Comments from referee 1: Define the lat and lon range of your domain(s).

Author's response: West Africa simulation domain âĂć Number of grid points nlon*nlat = 182x114 = 20748 âĂć Longitude range: 20°W to 19.82°E by 0.22 degrees resolution âĂć Latitude range: 0 to 24.86 N by 0.22 degrees resolution

Author's changes in manuscript: Please see the manuscript at line 105

4. Comments: You make a number of references to differences at the "local" scale - how do these differences impact your results, if at all.

Author's response: Thank you for your comment. The confusion may be due to our English language. We have improved it in this revised version. The PCC gives an overview of the regional coherency of the mean spatial patterns between the model and the observation. However, the PCC needs to be completed with a "local" (or sub-regional) analyses to check where are the main differences and where are the weakest or strongest biases.

5. Comments: Table 1: What is your sample size (how many grid points?)

Author's response: For West Africa, the number of grid points is 17472 (182x96) For Central Sahel, the number of grid points is 2457 (91x27) lon: -9.88 to 9.92 with 0.22-degree resolution lat: 10.12 to 15.84 with 0.22-degree resolution

For Sahel West, the number of grid points is 972 (36x27) lon: -17.8 to -10.1 with 0.22-degree resolution lat: 10.12 to 15.84 with 0.22-degree resolution

For Guinea Coast, the number of grid points =3648 (114x32) lon: -14.94 to 9.92 with 0.22-degree resolution lat: 3.08 to 9.9 with 0.22-degree resolution

Author's changes in manuscript: Please see the manuscript at line 144-146

6. Comments: Fig. 1 and your domains did you only include land points for precipitation and temperature? Author's response: Yes, we computed only over the land grid points.

Author's changes in manuscript: Please see the manuscript at line 161-163

7. Comments: You may want to consider keeping a consistent naming scheme for your experiments - I found it hard to follow at times when you had wet vs. dry years, wet vs. Dry initializations, etc.

Author's response: Thank you for your comment. We agree. What we decided to do in this revised manuscript, is to introduce in the beginning that 2003 and 2004 are respectively wet and dry years and then in the next, we avoid use of "wet or dry years" and focus on wet, dry and control experiments in 2003 and 2004 to refer to soil moisture initial conditions.

Author's changes in manuscript: Please go through the manuscript.

References:

Alexander, L. V., and Coauthors, 2006: Global observed changes in daily climate extremes of temperature and precipitation. J.Geophys. Res., 111, D05109, doi:10.1029/2005JD006290.

Andronova, N. G., and M. E. Schlesinger (2001), Objective estimation of the probability density function for climate sensitivity, J. Geophys. Res.,106(D19), 22,605–22,611.

Anthes, R. A., Kuo, Y. H., Hsie, E. Y., LowâĂŘNam, S., & Bettge, T. W. (1989). Estimation of skill and uncertainty in regional numerical models. Quarterly Journal of the Royal Meteorological Society, 115(488), 763-806.

Dessai, S., X. Lu, and M. Hulme (2005), Limited sensitivity analysis of regional climate change probabilities for the 21st century, J. Geophys. Res., 110, D19108, doi:10.1029/2005JD005919.

Hong S. Y. and Pan H. L.: Impact of soil moisture anomalies on seasonal, summertime

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circulation over North America in a regional climate model. J. Geophys. Res., 105 (D24), 29 625–29 634, 2000.

Jaeger, E. B., & Seneviratne, S. I. (2011). Impact of soil moisture–atmosphere coupling on European climate extremes and trends in a regional climate model. Climate Dynamics, 36(9-10), 1919-1939.

Kang, S., Im, E. S., & Ahn, J. B. (2014). The impact of two landâĂŘsurface schemes on the characteristics of summer precipitation over East Asia from the RegCM4 simulations. International journal of climatology, 34(15), 3986-3997.

Katz, R., and B. Brown, 1992: Extreme events in a changing climate: Variability is more important than averages. Climatic Change, 21, 289–302.

Kiktev, D., D. M. H. Sexton, L. Alexander, and C. K. Folland,2003: Comparison of modeled and observed trends in indices of daily climate extremes. J. Climate, 16, 3560–3571.

Kim J-E., and Hong S-Y.: Impact of Soil Moisture Anomalies on Summer Rainfall over East Asia: A Regional Climate Model Study, Journal of Climate. Vol. 20, 5732–5743, DOI: 10.1175/2006JCLI1358.1, 2006. Knutti, R., T. F. Stocker, F. Joos, and G. K. Plattner (2002), Constraints on radiative forcing and future climate change from observations and climate model ensembles, Nature, 416(6882), 719–723.

Koster, R. D., Mahanama, S. P. P., Yamada, T. J., Balsamo, G., Berg, A. A., Boisserie, M., ... & Guo, Z. (2010). Contribution of land surface initialization to subseasonal forecast skill: First results from a multiâĂŘmodel experiment. Geophysical Research Letters, 37(2). doi:10.1029/2009GL041677.

Rahman, M.M., Lu, M., and Kyi, K. H.: Variability of soil moisture memory for wet and dry basins, J. Hydrol. 523, 107-10118, doi: 10.1016/j.j.jhydrol.2015.01.033, 2015.

Santanello Jr., J. A., P. Lawston, S. Kumar, and E. Dennis, 2019: Understanding the Impacts of Soil Moisture Initial Conditions on NWP in the Context of Land–Atmosphere

Coupling. J. Hydrometeor., 20, 793–819, doi:10.1175/JHM-D-18-0186.1.

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