Reply to the comments of referee 1 for Second Revision of HESS-112

Thank you for revising the manuscript. I am still recommending major revisions due to the important comments raised by reviewer #2. Please make sure to carefully reviewer #2's comment and clarify/revise accordingly. Of particular significance is their comment on significance test. Please address it carefully and clearly explain how you are conducting the significance test. The reviewer also found several errors (grammatical etc), so please carefully review for those too.

Major/Specific Comments:

1. **Comments:**

   I appreciate that the authors took the time to send the manuscript for English language editing, but I found a mistake in the first sentence of the paper, and a number of oddities in the first paragraph. While the authors sent this out for editing they should still re-read it for flow and inconsistencies.

   Thank you for your comments. We proofread the manuscript for fluidity and corrected any inconsistencies.

   (a) In the climate system, soil moisture is a crucial variable that influence[s] water balance and surface energy components...

   Line 37: Thank you. Done

   (b) Line 47: "Another potentially useful earth system component that varies slowly is soil moisture" - You've already introduced soil moisture. It seems like you're introducing it again. You actually could just get rid of this sentence.

   Line 47: Thank you for your suggestion. We have deleted this sentence as advised.

   (c) "One important role of anomalies in soil moisture in the coupling of land and atmosphere has been shown in several studies, using numerical climate models (Jaeger and Seneviratne, 2011; Zhang et al., 2011) and observation datasets (Zhang et al., 2008a; Dirmeyer et al., 2006)." What is the important role?

   *Line 53-59 : Thank you. In this revised version, we removed the reference to Jaeger and Seneviratne (2011) which referred on climate extremes (already cited in Part 2) and we added a sentence to illustrate the important role of soil moisture as follows: **The important role of anomalies in soil moisture in the coupling between land and atmosphere has been shown in several studies, using numerical climate models (Zhang et al., 2011) and observation datasets (Zhang et al., 2008a; Dirmeyer et al., 2006). For instance, over East Asia, Zhang et al., (2011) showed that soil moisture is found to have a much stronger impact on daily maximum temperature variability than on daily mean temperature variability, but generally has small effects on daily minimum temperature, except in the***

eastern Tibetan Plateau. They showed that soil moisture has a prominent contribution to precipitation variability in many parts of western China.

(d) However, at local and regional scales, the land-atmosphere coupling studies with AGCM[s]...

*Thank you, done. Please check lines 66-68; **However, at local and regional scales, the land-atmosphere coupling studies with AGCMs, present significant uncertainties (Xue et al. 2010).***

(e) Line 65, define RCMs.

*Thank you, done. Please check lines 67-68 : **The regional climate models (RCMs) have been used to simulate the impact on interannual climate variability of anomalies in soil moisture…***

f) Overall, the results of these studies show that, during summer, the strong impact of the anomalies of soil moisture in land-atmosphere occurred mainly over the transition zones with a climate between wet and dry climate regimes, [in agreement with Koster et al.]

*Thank you for the suggestion. Done lines 73-76: **Overall, the results of these studies showed that, during summer, the strong impact of the anomalies of soil moisture in land-atmosphere occurred mainly over the transition zones with a climate between wet and dry regimes, in agreement with Koster et al. (2004).***

(g) Line 75: This study will focus on the influence of initial soil moisture conditions anomalies. Remove either conditions or anomalies.

*Thank you very much. The sentence has been reword as follows (line 78): **This study will focus on the influence of soil moisture initial conditions on climate mean.***

... Again, I'm not listing all of these instances. The authors need to be more proactive in their read-through of the paper.
Yes, we took the time to go through the document, correcting typos and making it easier to read.

2. **Comments:**
Perhaps I missed it but I'm still confused about the experiment design. Are these ensemble experiments? I.e. does your wet initial soil moisture condition experiment (for example) have ensemble members of precipitation and temperature, or is it just one model run? I just want to make sure I'm understanding this correctly. I might note somewhere that you have 1 realization of precipitation and temperature (or its an ensemble) for each soil moisture initial condition just to make this abundantly clear.

Thank for your comments. In this revised version, we began the section 2.2 (Experiments setup and analysis methodology) as follows (lines 130-145): **The European 20th Century Weather Prediction Center ERA20C soil moisture reanalysis was used to initialize the control experiment, while its domain-wide minimum and maximum values were used to establish the initial dry and wet soil moisture conditions respectively (hereafter dry and wet experiments). We initialized the dry and wet soil moisture initial conditions (in volumetric fraction m3.m-3) respectively at the minimum value (=0.117*10-4) and the maximum value (=0.489).**

We designed three experiments (reference, wet, and dry), each with an ensemble of five (5) simulations starting from June 1st to September 30th. The difference between these three experiments is the change in the initial soil moisture condition (reference initial soil moisture condition, wet initial soil moisture condition, and dry initial soil moisture condition) during the first day of the simulation (June 1st 2001, 2002, 2003, 2004 and 2005) over the West African domain. Then, we selected the two runs most impacted by the wet and dry soil moisture initial conditions in order to exhibit the effects on the climate mean beyond the limits of the impacts of RegCM4 initial soil moisture internal forcing. In the same context, several previous studies have selected two extreme years to investigate the climate models sensitivity to soil moisture initial conditions (Hong et al., 2000; Kim and Hong, 2006) outside Africa.

3. **Comments:**

Are the soil moisture initial conditions soil moisture anomalies? Make sure this language is consistent.

Thank you. We used in the whole manuscript (wet or dry) soil moisture initial conditions. See for example at lines 159, 161, 166,...

4. **Comments:** This comment goes for both hess112 and hess113. I'm not entirely satisfied by your statistical significance test using a t-test. If I'm understanding your experiment design and statistical significance test correctly, this is a two-sample t-test of means - You've compared your control (sample 1) to the sensitivity test (sample 2). Are you doing this for 1 year only, for your entire study period? For a two sample t-test you need to assume the values are independent, and I'm wondering if they truly are independent samples. Both reviewers have made notes about your significance test asking specifically for the sample size used and it has not been adequately provided. Some of these questions might be answered if the authors better explained their significance test procedure.

Thank you very much. The main concern was that we performed the significance test with monthly values leading to samples of small size. We agree that this is a shortcoming.
In this revised version, instead of doing the Student t-test with monthly means, we did it with daily values (from June to September) for each year (2003 and 2004) and thus, with samples of 115 days (without the 7 days spin-up period).

For each year, the Student t-test is used to compare the significance of the difference between a wet or dry sensitivity test (sample 1) and the control (sample 2) in assuming that our two samples are independent and in considering that this method performs well for climate simulations compared to more sophisticated techniques developed to address autocorrelation (Damien et al., 2014).

Damien Decremer, Chul E. Chung, Annica M. L. Ekman & Jenny Brandefelt (2014) Which significance test performs the best in climate simulations?, **Tellus A: Dynamic Meteorology and Oceanography**, 66:1, DOI: 10.3402/tellusa.v66.23139

The t-test is extensively used for analysis in climate sciences; it is fairly robust and easy to use and interpret (Wu et al., 2020; Menedez et al., 2019; Talahashi and Polcher, 2019; Wu et al., 2019; Alvdes et al., 2017):

Menéndez, C. G., Giles, J., Ruscica, R., Zaninelli, P., Coronato, T., Falco, M., ... & Li, L. (2019). Temperature variability and soil–atmosphere interaction in South America simulated by two regional climate models. **Climate Dynamics**, *53*(5), 2919-2930.

Takahashi, H. G., & Polcher, J. (2019). Weakening of rainfall intensity on wet soils over the wet Asian monsoon region using a high-resolution regional climate model. **Progress in Earth and Planetary Science**, *6*(1), 1-18.

Wu, T., Hu, A., Gao, F., Zhang, J., & Meehl, G. A. (2019). New insights into natural variability and anthropogenic forcing of global/regional climate evolution. **Nature, Npj Clim. Atmos. Science**, *2*(1), 1-13. https://doi.org/10.1038/s41612-019-0075-7

Alves, L. M., Marengo, J. A., Fu, R., & Bombardi, R. J. (2017). Sensitivity of Amazon regional climate to deforestation. **American Journal of Climate Change**, *6*(1), 75-98.

Wu, J., Han, Z., Xu, Y., Zhou, B., & Gao, X. (2020). Changes in extreme climate events in China under 1.5 C–4 C global warming targets: Projections using an ensemble of regional climate model simulations. **Journal of Geophysical Research: Atmospheres**, *125*(2), e2019JD031057.

The t-test takes into account, the difference between the means of each sample, the variance (S) and the number of degrees of freedom (n − 1), which depends on the sample size (n). The test statistic is calculated as:

$$t = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{\frac{S_1^2}{n_1} + \frac{S_2^2}{n_2}}}$$

Where $\bar{X}_1$ ($\bar{X}_2$) are the sample means, n_1 (n_2) are the sample sizes and S_1^2 (S_2^2) are the sample variances. The t-test at the 95% confidence level was used to consider statistically significant.

Author's changes in the manuscript: In this revised, we added 2 paragraphs on the Student t-test used in this study as follows (lines 166-179):

For the two years most sensitive to soil moisture initial conditions, the Student t-test is used to compare the significance of the difference between a wet or dry sensitivity test (sample 1) and the control (sample 2) in assuming that our two samples are independent and in considering that this method performs well for climate simulations compared to more sophisticated techniques developed to address autocorrelation (Damien et al., 2014). The Student t-test is extensively used for analysis in climate sciences; it is fairly robust and easy to use and interpret (Menedez et al., 2019; Talahashi and Polcher, 2019). The Student t-test takes into account, the difference between the means of each sample, the variance (S) and the number of degrees of freedom (n − 1), which depends on the sample size (n). The test statistic is calculated as:

$$t = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{\dfrac{S_1^2}{n_1} + \dfrac{S_2^2}{n_2}}}$$

Where $\bar{X}_1$ ($\bar{X}_2$) are the sample means, n_1 (n_2) are the sample sizes and S_1^2(S_2^2) are the sample variances. In this study, the t-test at the 95% confidence level was used to consider statistically significant.

5. **Comments:** Line 440: The strongest precipitation decrease (increase) is found over the central Sahel (over central Sahel) in dry (wet) experiment in JJAS 2003 (JJAS 2004) with maximum change reaching -4% (40%). You don't need that parenthetical reference for the central Sahel twice. In addition, and I think I've noted this in some of my earlier reviews, over-use of this style of writing can be very confusing for long sentences. You could just make this into two sentences instead of using the () style.

Thank for your comment. You are right. We rewrote and corrected the sentence to make it more comprehensive. For long sentences, we make them into two sentences instead of using the () style.

In this revised version the sentences have been changed as follows:

*Lines 298-302: **The strongest precipitation decrease was found over west Sahel for dry experiment for JJAS 2003 with maximum change reaching −4%. While, the strongest precipitation increase was found over the central Sahel for wet experiment in JJAS 2004 with maximum change about 40%.***

*We improved also the lines 360-363 which were with the () style: **In the wet experiments, the strongest latent heat flux increase is found over West Sahel with maximum change reaching 36.49 W.m-2 in JJAS 2004 (Table2). In the dry experiments, the strongest latent heat flux decrease is located over Guinea Coast with maximum change reaching −14.64 W.m-2 in JJAS 2004 (Table2).***

*Lines 425-429: **In the dry experiment, the strongest precipitation decrease is found over the Central Sahel in JJAS 2003 with maximum change reaching −4% while in the wet experiment,***

the strongest precipitation increase is found over the West Sahel in JJAS 2004 with maximum change reaching 40%.

6. **Comments:** It would be good to re-iterate how these results fit into the greater body of literature in your concluding remarks. For example, how this has not been quantified for West Africa, and these are very idealized experiments meant to provide what is essentially a first look or guess of what the impacts of soil moisture initial conditions might be in the region. These results are also likely very specific to RegCM4. The authors could also speculate about further work that could be done given the results of these experiments

Thank for the suggestion. We have improved the conclusions in adding a paragraph on the perspectives as follows (452-460):

This study is the first investigating the impact of soil moisture initial conditions in West Africa. However, this study is based on idealized experiments and very specific to RegCM4. In the future, an investigation using different RCMs in a multi-model framework will contribute to better quantify the impact of soil moisture initial conditions. At shorter timescales, there is a need to understand how the soil moisture initial conditions contribute to the triggering and the maintenance of the mesoscale convective systems which are known to explain large amount of rainfall in the region (Mathon et al., 2002).

Mathon, V., Diedhiou, A., & Laurent, H. (2002). Relationship between easterly waves and mesoscale convective systems over the Sahel. *Geophysical research letters*, *29*(8), 57-1.