Reply to the comments of editor for the manuscript hess-2020-112

Major/Specific Comments:

1. ***Comments:***

I think both reviewers concern regarding choice of only two years for conducting this analysis is valid. I would strongly suggest you to provide a reason for why two years is good enough for these experiments and why you couldn't include more years in the analysis.

Author's response*: Thank you for your comment. We re-run the simulations over 5 years (2001 to 2005) during the months of June to September over our West African domain. We superimposed the 5 years and their climatological average in order to analyze the changes in daily soil moisture over our domain studied (Fig.1). The Fig.1 shows that the weakest and strongest impact of the dry experiments is found for 2003 and 2004 respectively. For a wet year, the impact of drying out soil moisture is quickly erased. While for a dry year the impact of the drying of the soil is accentuated. This meaning that 2003 and 2004 are respectively the wettest and driest years in dry experiment. However, for the wet experiments, the weakest impact is found for 2004, and the strongest impact is found for the years 2001, 2002 and 2004. The wet experiments confirm the result obtained in dry experiments, 2003 and 2004 are wettest and driest years respectively. To conduct our analyzing to estimate the limits of the impact of internal soil moisture forcing on the new dynamical core non-hydrostatic of RegCM4, we have used the two extreme years 2003 and 2004 (resp. the wettest and the driest years) among the 5 years. It is in the same context, several previous studies chosen two extreme years for their sensitivity study of initial soil moisture condition on the models. Hong and al. (2000) use in their study only two years (3 months per year) to investigate the impact of initial soil moisture over the North of America (in the Great Plains) during the two summers, May-June-July (MJJ) 1988 (corresponding to a drought in the Great plains) and MJJ 1993 (correspond to a flooding event). Over Asia, Kim and Hong (2006) in their paper "Impact of Soil Moisture Anomalies on Summer Rainfall over East Asia: A Regional Climate Model Study" used two contrasted years 1997 (below normal precipitation year) and 1998 (above normal precipitation year).*

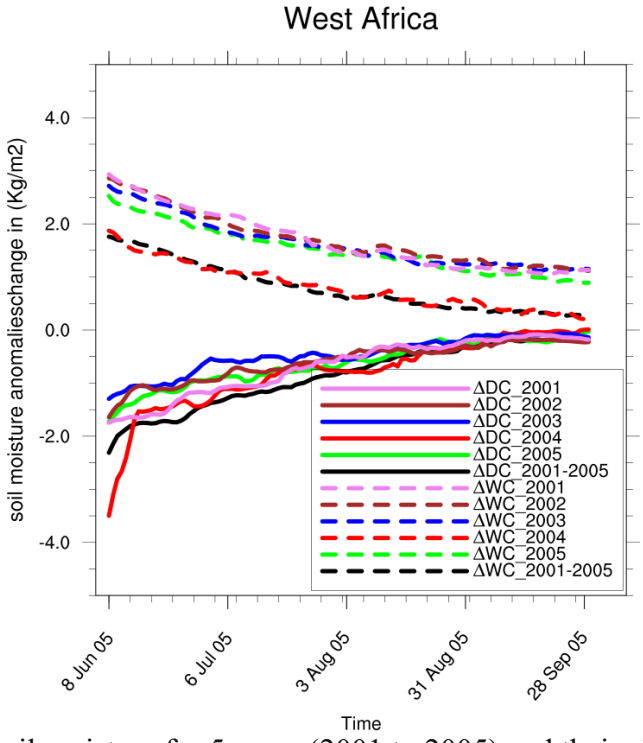


Fig.1: Changes in daily soil moisture for 5 years (2001 to 2005) and their climatological mean during JJAS over West African domain, from dry (ΔDC) and wet (ΔWC) experiments with respect to their corresponding control experiment.

2. ***Comments:***

Reviewer 1's comment #5 on the novelty of this study is also another important comment. I'd strongly advise to respond to this comment with sufficient details and rigor.

Author's response*: Thank you for your comment. There are few papers on the impact of soil moisture in Africa, but they were performed with Global Circulation Model (Koster et al. 2004, Douville et al. 2001, Zhang et al. 2008). While it is known that in the region the interactions between land and atmosphere are very important for convection and rainfall, a regional climate model will contribute to better capture local and regional features. The other novelty of this study is that we use the new dynamical core non-hydrostatic of RegCM4. This has never been done before, while 80% of rainfall in the region is associated with mesoscale convective systems. Moreover, it is the first time that the impact of soil moisture initial conditions on mean and extreme of precipitation and temperature in terms of intensity and duration is investigated over West Africa. Finally, this study provides the quantification of the sensitivity of the RegCM4 model to initial soil moisture conditions, which could allow the evaluation and development of the RegCM4 model in the aim to improve sub-seasonal to seasonal forecast skill. The novelty and contribution of this paper has been added in the revised version of the manuscript (conclusion section).*

3. ***Comments:***

In a number of cases, in your response to reviewer #2, you are referring to manuscript "Please see the manuscript at.." since at this stage I can't see the revised manuscript, I can't decide if your responses are satisfactory or not. Please include any substantial changes made in the manuscript to your response too.

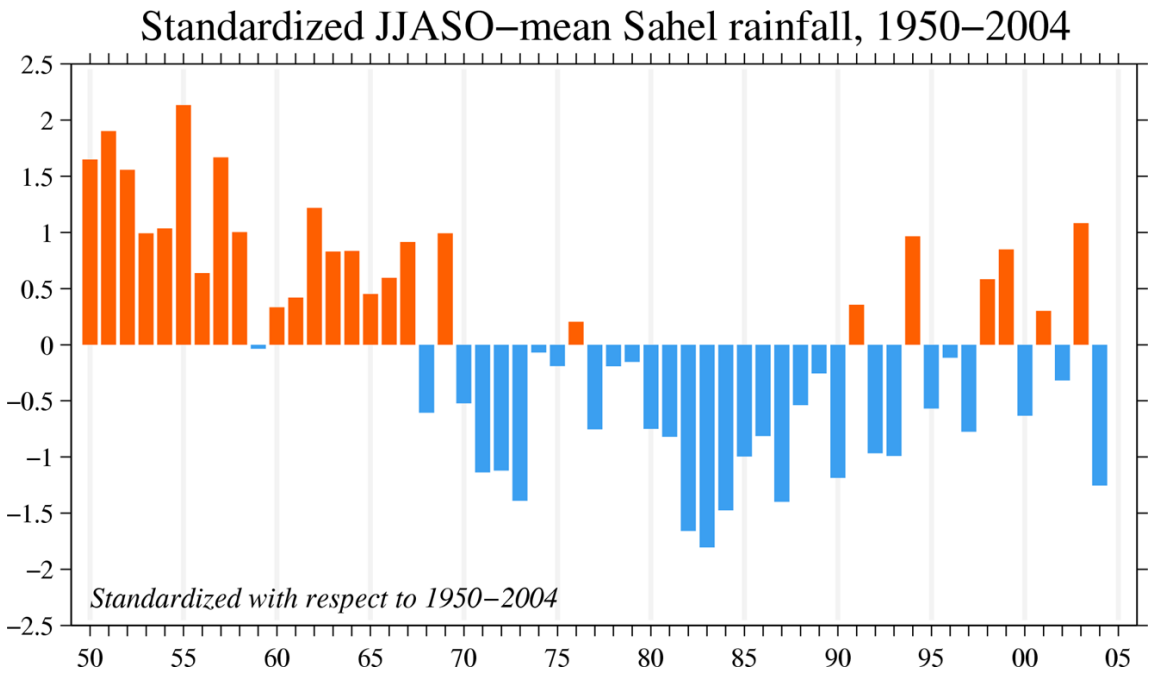
> ***Author's response:*** *Thank you for your comment. Please see the responses to the reviewer#2 below, we included below and where relevant those substantial changes made in the manuscript.*

Reply to the comments of the referee 2 for the manuscript hess-2020-112

1. ***Comments:***

How were the years 2003 and 2004 chosen? Perhaps show a time series of precipitation anomalies in your study region to highlight why you chose 2003 and 2004. “Dry” and “wet” are very subjective terms. Or consider showing observed precipitation and soil moisture anomalies during 2003 and 2004.

> ***Author's response****: Thank you for your comment. Our choice of year stems from a long-term study of rainfall anomalies carried out over the sensitive Sahel zone from 1950 to 2004 (cf fig. below), which shows precipitation anomalies of about ± 1.5 mm of rainfall for the consecutive years 2003 (positive anomalies) and 2004 (negative anomalies). The two contrasted years in West Africa (in 2003 wet year and in 2004 dry year compared to the mean 1950-2004 cf fig. below) have been chosen in the aim to assess the results of the sensitivity study, whatever the year studied.*



Choice of soil moisture data:

2. ***Comments:***

Why initialize soil moisture with ERA 20C, which includes only surface forcings of surface pressure and marine winds only? How well does this dataset compare to satellite-derived observations? ERA 20C isn't really a reanalysis of soil moisture, because the soil moisture doesn't include any observations. If the authors want an observationally-based soil moisture dataset, they could consider a product like GLEAM (Martens et al., 2017; Miralles et al., 2011).

> ***Author's response:*** *Thank you for your comment. The soil moisture initialization data of the RegCM4 climate model consists of three surface soil moisture datasets: ERA20c, ESACCI and CPC. We performed a sensitivity study of RegCM4 to these three different data sets in simulating the mean and extreme climate of West Africa. The sensitivity test showed good performance in quantitative assessment of temperature and rainfall simulations of ERA20C data over the entire domain of West Africa and its sub-regions. This is what justified our choice for ERA20C.*

3. ***Comments:***

> You show the observations for precipitation, perhaps show observations for soil moisture too. You could show ERA20C (which you added) and maybe GLEAM as an independent dataset.
>
> ***Author's response:*** *Thank you for your comment. The aim of this work is to study the impact of soil moisture initial conditions in simulation of the climate mean and extreme over West Africa. Due to discrepancies between the datasets in West African region, we used two observational data for temperature and precipitation to validate our simulation outputs. We do not seek in this study to validate soil moisture data.*

4. ***Comments from referee 1:***

Using global wilting points and field capacity: In the dry and wet runs the authors use

a uniform wilting point and field capacity everywhere. But we expect that both the permanent wilting point and the water holding capacity of the soil differ by location (see, for example Figure 6 of Leenaars et al., 2018). These two values will be radically different in the Sahara Desert and southern Nigeria, for example. The assumptions made here, that wilting point is 0 or that field capacity is 0.489 is likely unrealistic for many locations, and these extreme initial conditions may be affecting the results. The authors need to more completely justify the use of these initial conditions, as opposed to using the maximum and minimum observed values, for example.

Author's response: *Thank you for your comment. We use the minimum and the maximum soil moisture datasets value in our simulation domain. The two values obtained is defined as volumetric fraction ranging from the permanent wilting point (=0.117*10^{-4}) to the field capacity (=0.47). Previous studies on Asia and North America have been conducted in the same way (Hong and Pan (2000); Kim and Hong (2006)).*

Author's changes in manuscript: *We did this following modification in the manuscript at the Section 2.2 Line 157-161 of the manuscript:*
*We initialized the dry and wet soil moisture initial conditions (in volumetric fraction m^{3}.m^{-3}) respectively at the wilting point (=0.117*10^{-4}) and the field capacity (=0.489) derived from ERA20C dataset. The wilting point and the field capacity correspond to the minimum and the maximum values of soil moisture over our simulation domain studied.*

5. ***Comments:***

Effect of methods on the analysis: The fact that the wet year (2003) and the dry year (2004) look the same in most graphs when used as the control seems to indicate that they're either quite similar, or that the values for initial soil moisture are incredibly strong, and are overwhelming everything about the dry vs wet year. Are extreme values of soil moisture like this really useful? If so, the authors need to better justify them. I understand that this is a sensitivity analysis, but the authors need to contextualize how relevant this sensitivity analysis is to the conditions of the real world.

Author's response: *Thank you for your comment. We recognize that sensitivity experiments such as "wet" and "dry" ones conducted in this study were not intended to simulate real climate since such extremes are very rare. This sensitivity study can provide estimates of the limits of the impact of internal forcing of the soil moisture for the new non-hydrostatic dynamical core of RegCM4.*

Author's changes in manuscript: *We did this following modification in the manuscript at the Section 4 Line 503-507:*
We recognize that sensitivity experiments such as "wet" and "dry" ones conducted in this study were not intended to simulate real climate since such extremes are very rare. These kinds of experiments, however, can provide estimates of the limits of the impact of internal forcing of the soil moisture for the new non-hydrostatic dynamical core of RegCM4.

6. ***Comments:***

Starting at soil moisture of 0 is quite extreme. how, for example the local minimum and maximum soil moisture estimated for the region in the target starting month (June) in an observational dataset as comparison. Showing local min/max for each pixel would demonstrate how the initial conditions used compare to what has historically been experienced.

> ***Author's response:*** *Thank you for your comment. Well, that's what we did with our domain of simulation.*
>
> ***Author's changes in manuscript:*** *We did this following modification in the manuscript at Section 2.2 Line 159-161:*
> *The wilting point and the field capacity correspond to the minimum and the maximum values of soil moisture over our studied simulation domains.*

References:

Hong S-Y. and Pan H. L.: Impact of soil moisture anomalies on seasonal, summertime circulation over North America in a regional climate model. J. Geophys. Res., 105 (D24), 29 625–29 634, 2000.

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.