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Hydrology and Earth System Sciences Discussions

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Interactive comment on "Simulating the connections of ENSO and the hydrology of the Blue Nile using a climate model of the tropics" *by* M. A. H. Zaroug et al.

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Anonymous Referee #2

Received and published: 29 May 2014 Review of "Simulating the connections of ENSO and the hydrology of the Blue Nile using a climate model of the tropics "by Zaroug et al. first of all, sincere apologies for this belated review. The scope of the paper is interesting in that it uses a regional circulation model to assess the influence of La Nina/El Nino on the precipitation pattern in the Blue Nile region. However, I recommend that this paper undergoes a major revision before it can be accepted for publication.

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Interactive Discussion

Discussion Paper

Main comments 1. The most interesting result of this paper is presented in Figure 8, where you assess how well RegCM4 can capture the difference between LN/EN years. However, as I can read from the figure this is not the case, in fact, the El Nino years are wetter than La Nina, not drier. Your discussion on page 2241 is wrong, since you state the opposite! I would suggest to also add the raw ERA-Interim to this figure, what is the signal of precipitation in this data, and is it different from RegCM4 results? You state something about the ensemble members having variability, what do you mean by that? Also, how was the figure 8 created? Did you take the mean of the difference of each of the ensemble members, or did you compare the difference after averaging (see also below comment? We do not agree with this comment by the reviewer. Figure 8 presents the precipitation difference between La Nina and El Nino years and shows that the model captures quite well the positive anomaly along the Sahel region. The main difference compared to the GPCP data is that over eastern Africa this positive anomaly band is narrower in the model, with negative anomalies to the south, over Kenya and Uganda, not found in the observations. The model also in particular captures the positive anomaly over the northwestern regions of the red box, our area of interest; although to the south it shows a small negative one where the observations show no signal. We have made this analysis more precise in the text. As the reviewer suggested, we also added the same anomaly field from ERA-Interim (also reported in Figure 9 below. It can be seen that in ERA-Interim this anomaly field mostly actually has an opposite sign compared to observations, which indicates that the regional model shows in this regard a better performance than ERA-Interim. This analysis has been added to the revised text.

Fig. 9. ERA Interim JJAS rainfall for (a) 5 La Niña years (88,98, 99, 07 and 08), (b) 5 El Niño years (82, 83, 87, 92 and 02), and (c) The difference between La Niña years and El Niño years.

Appendix A below illustrates for each member the composite of El Nino years and La Nina years and the difference between them. The rainfall difference varies among the

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9 members. From the 9 figures in the appendix (Fig. A1-9), it is evident that the internal variability of the model is high. The 9 members were averaged for each month, and then 5 La Niña years and 5 El Niño years were selected to produce JJAS averages from the monthly means. What we do with the ensemble average is the same as done in the observational analysis. Note that this would give the same results as if we had selected El Nino and La Nina years from each ensemble and then averaged them. The point is that we do the analysis on the ensemble average to remove the noise due to the model internal variability, as is usually done in seasonal prediction exercises. This has been clarified in the text.

2. This follows from the previous comment. Also Fig 11-14 (which needs to be correctly referenced on section 4.3) shows that RegCM4 cannot capture JJA precipitation, since the signal is so much weaker than in observations (Fig 12b compared with 14b). Also Fig 11b compared with Fig 13b shows a very different regression pattern between RegCM4 and observations. How about ERAInterim, which is use as the forcing model? Please add the same analysis for ERAI to fig 11-14 for comparison and deeper analysis of the results. Section 4.3 is correctly referenced. Thank you. Again, we are somewhat in disagreement with the negative view of the reviewer. Overall we feel that RegCM4 does capture the main features of the regression patterns, although obviously some differences with observations can be found. In particular, over Africa RegCM4 captures the negative correlations in JJA over the Sahel region. The main discrepancies with observations occur over the Congo Basin, where however observed precipitation estimates are probably highly questionable due to lack of observing stations. As shown in Figure 8, over Africa ERA-Interim does not capture the ENSO signal, so the correlations are also wrong. Finally note that, for consistency, we removed the analysis of DJF regressions, since the paper focuses only on the summer rainy season.

2. There is no mentioning on how the 9 ensemble members were created, please add this information. Please also state something about the spread of the ensemble, how well does it represent uncertainty/variability? And then, why use ensemble mean in all

the analysis? Surely you will lose a lot of detail taking the average? Why not perform the analysis on the individual members? The difference between the 9 members is in the initial day of the simulation, which varies by one day. The first member starts on January 1 1982, the second on January 2 1982 and so on until the 9th member starts on January 9 1982. (This text was added to the paper). The reason for performing the analysis on the ensemble average is to remove noise associated with the model internal variability. This is commonly done for example in seasonal and ENSO prediction studies (Shukla et al. 2000). Typically, variability can mask forced signals on individual runs, but should be averaged out in ensemble simulations. On the other hand, we did calculate the correlation between Nino 3.4 and the rainfall in the upper catchment of the Blue Nile River for each member of the ensemble as illustrated in Figure 11. The averaging normally dampens the signal, however in this study the averaging of the 9 members gives almost the highest correlation as found in member 7. In addition, all the members except member 6 generally captured the documented negative correlation (Eltahir, 1996; Wang and Eltahir, 1999; Amarasekera et al., 1997; Zaroug et al., 2014). Figure 11 shows indeed the presence of significant model internal variability and one result of our study is that we recommend to perform at least ∼5-6 simulations in order to filter it out. All these considerations have been added to the text.

3. In your discussion on page 22-42 regarding fig 9 and 10, please add correlations with GPCP precipitation as well for comparison. Also, you state that the ensemble mean has a higher correlation than the individual members. This is surprising to me, since an averaging usually dampens the signal. I would suggest to show results from the individual members, even if they are noisy. The correlation between Nino 3.4 and the rainfall in the upper catchment of the Blue Nile was calculated also for the GPCP, CRU and UDEL (Fig. 10). The use of multiple observational datasets in the comparison is required to provide an estimate of related uncertainties (Sylla et al., 2013). The model correlation result is relatively good and within the range of the observational dataset. (This discussion was added to the paper).

Fig. 10. Correlation between rainfall anomalies over the Ethiopian Highlands (Reg-TB ensemble average, GPCP, and CRU) and SST anomalies over the Pacific Ocean in the Nino 3.4 region. As mentioned above, individual correlations are shown in Figure 11. The result that ensemble mean usually outperforms individual simulations is actually quite common in many contexts, from seasonal prediction to climate simulation, although to our knowledge the reason for it is not yet clear.

Fig. 11. Correlation between rainfall anomalies over the Ethiopian Highlands (Reg-TB ensemble average and each individual ensemble member) and SST anomalies over the Pacific Ocean in the Nino 3.4 region.

4. The fact that you have a correlation between SST and precipitation is great, it points to a potential of predictability, but if your model cannot capture this pattern, then you cannot use it for forecasting (see comment 1). It seems to me from the results that El Nino 3.4 SST is a very good indicator of precipitation anomalies, so what is the added value of RegCM4? Can it beat a simple regression model between SST and temperature? If not, then why not? This study represents the first time that the observed negative correlation between SST in the pacific and rainfall over the Nile is reproduced by a physically based model. Whether physical models add value to seasonal prediction compared to simpler statistical models is an open and highly debated issue, which is beyond the purpose of the present work. Here our intention was more simply to assess the performance of the RegCM4 in its tropical band configuration to capture ENSO signals over the Sahel region and the upper Nile River Basin, particularly in view of the fact that the development of this tropical band model is quite recent. Despite the concerns of the reviewer, we feel that the model has shown a reasonable performance in this regard, even better than ERA-Interim. Future applications will further address the model capabilities in climate and seasonal prediction mode.

1. The paper needs to undergo a thorough language review to correct unclear statements and typos. We have thoroughly checked the paper's English language.

Minor comments: 1. P2234, L1-5. Please merge these two sentences. The two sentences were merged "We simulate the observed statistical relationship between ENSO and the rainfall regime of the upper Blue Nile using the tropical-band version of the regional climate model RegCM4 (or Reg-TB) for the 28 year period 1982-2009, an ensemble of 9 simulations is completed to investigate the role of ENSO in the rainfall of the upper Blue Nile catchment."

2. There is no figure or thorough description of the Blue Nile, please consider to add this to the paper. Also mark the study area in figures 2-8 to aid the discussion, at least to fig 7-8. The first paragraph in the introduction describes the Blue Nile River. The study area is now marked in figures 2 to 8 in the paper.

3. P2234, L24. This statement might very well be true, but it needs to be backed up by references. These references were added to support this statement: (Diaz et al., 2001, Holton et al., 1989, Ropelewski and Halpert, 1987)

4. P2236, L6. Please rewrite: "RegCM4 (Giorgi et al., 2012) is an evolution. . .". Rewrite all ""is described by" since they are superfluous. Done, thank you. The first two lines were deleted.

5. In figure 3, I assume you mean T2M in the figure? Yes, I mean Temperature at 2m. The titles of the upper panel and lower panel were changed as shown below, and it's illustrated in the caption of Fig.3.

6. P2242, Section 4.3. The references to the figures in this chapter is not correct. The references to the figures were corrected. Thank you. âĂČ

References

Amarasekera, K. N., Lee, R. F., Williams, E. R., and Eltahir, E. A. B.: ENSO and the natural variability in the flow of tropical rivers, J. of Hydrol., 200, 24-39, 1997. Diaz, H. F., Hoerling, M. P., and Eischeid, J. K. 2001. ENSO variability, teleconnections and climate change. International Journal of Climatology, 21, 1845-1862. Eltahir, E. A. B.:

El Niño and the natural variability in the flow of the Nile River. Water Res., 32, 131-137, 1996. Holton, J. R., Dmowska, R., and Philander, S. G. 1989. El Niño, La Niña, and the southern oscillation, Academic press. Ropelewski, C. F. and Halpert, M. S. Global and regional scale precipitation patterns associated with the El Niño/Southern Oscillation. Monthly Weather Review, 115, 1606-1626, 1987. Sylla, M., Giorgi, F., Coppola, E. & Mariotti, L.: Uncertainties in daily rainfall over Africa: assessment of gridded observation products and evaluation of a regional climate model simulation. International Journal of Climatology, 33, 1805-1817, 2013. Wang, G. and Eltahir, E. A. B.: Use of ENSO information in medium-and long-range forecasting of the Nile floods, J. of Climate, 12, 1726-1737, 1999. Zaroug, M. A. H., Eltahir, E. A. B. and Giorgi, F.: Droughts and floods over the upper catchment of the Blue Nile and their connections to the timing of El Niño and La Niña events. Hydrol. and Earth Syst. Sci., 18, 1239-1249, 2014.

âĂČ Appendix A: Difference between La Nina and El Nino years for each of the 9 members.

Figure âĂŐA.1: The rainfall in North Africa during JJAS of member 1 and for (a) 5 La Niña years (88,98, 99, 07 and 08), (b) 5 El Niño years (82, 83, 87, 92 and 02), and (c) The difference between La Niña years and El Niño years.

Figure âĂŐA.2: The rainfall in North Africa during JJAS of member 2 and for (a) 5 La Niña years (88,98, 99, 07 and 08), (b) 5 El Niño years (82, 83, 87, 92 and 02), and (c) The difference between La Niña years and El Niño years.

Figure âĂŐA.3: The rainfall in North Africa during JJAS of member 3 and for (a) 5 La Niña years (88,98, 99, 07 and 08), (b) 5 El Niño years (82, 83, 87, 92 and 02), and (c) The difference between La Niña years and El Niño years.

Figure âĂŐA.4: The rainfall in North Africa during JJAS of member 4 and for (a) 5 La Niña years (88,98, 99, 07 and 08), (b) 5 El Niño years (82, 83, 87, 92 and 02), and (c) The difference between La Niña years and El Niño years.

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Figure âĂŐA.5: The rainfall in North Africa during JJAS of member 5 and for (a) 5 La Niña years (88,98, 99, 07 and 08), (b) 5 El Niño years (82, 83, 87, 92 and 02), and (c) The difference between La Niña years and El Niño years.

Figure âĂŐA.6: The rainfall in North Africa during JJAS of member 6 and for (a) 5 La Niña years (88,98, 99, 07 and 08), (b) 5 El Niño years (82, 83, 87, 92 and 02), and (c) The difference between La Niña years and El Niño years.

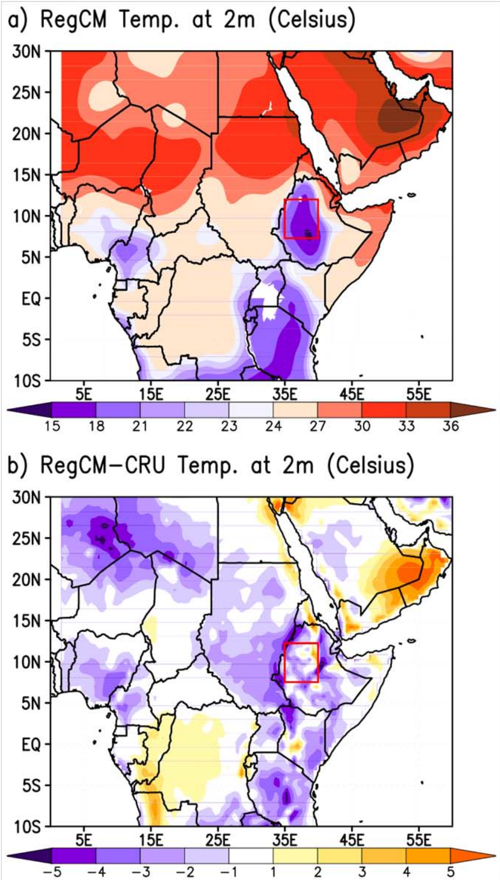
Figure âĂŐA.7: The rainfall in North Africa during JJAS of member 7 and for (a) 5 La Niña years (88,98, 99, 07 and 08), (b) 5 El Niño years (82, 83, 87, 92 and 02), and (c) The difference between La Niña years and El Niño years.

Figure âĂŐA.8: The rainfall in North Africa during JJAS of member 8 and for (a) 5 La Niña years (88,98, 99, 07 and 08), (b) 5 El Niño years (82, 83, 87, 92 and 02), and (c) The difference between La Niña years and El Niño years.

Figure âĂŐA.9: The rainfall in North Africa during JJAS of member 9 and for (a) 5 La Niña years (88,98, 99, 07 and 08), (b) 5 El Niño years (82, 83, 87, 92 and 02), and (c) The difference between La Niña years and El Niño years.

Please also note the supplement to this comment:
http://www.hydrol-earth-syst-sci-discuss.net/11/C3312/2014/hessd-11-C3312-2014-supplement.pdf

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 11, 2233, 2014.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25N
20N
15N
10N
5N
EQ
5S
10S
5E
15E
25E
35E
45E
55E
15
18
21
22
23
24
27
30
33
36
b) RegCM–CRU Temp. at 2m (Celsius)
30N
25N
20N
15N
10N
5N
EQ
5S
10S
5E
15E
25E
35E
45E
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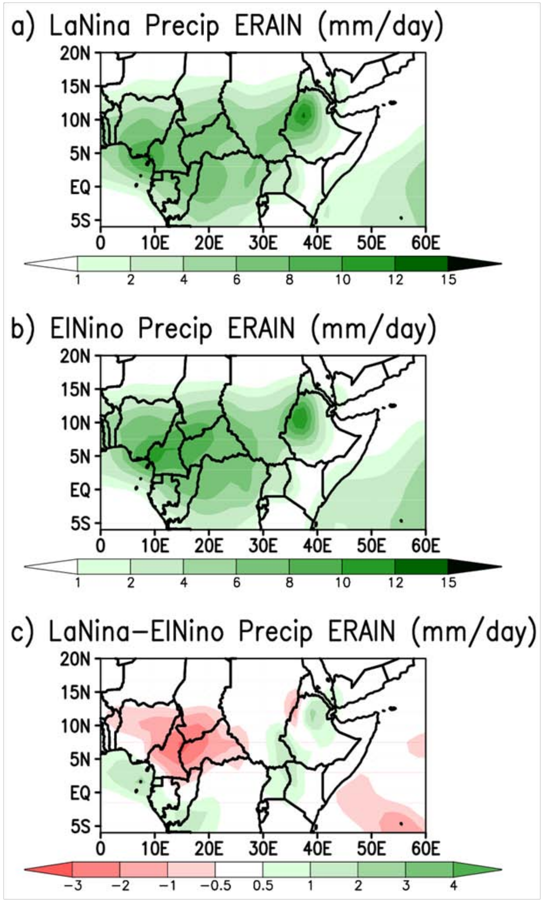
Fig. 1.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15N
10N
5N
EQ
5S
0
10E
20E
30E
40E
50E
60E
1
2
4
6
8
10
12
15
b) ElNino Precip ERAIN (mm/day)
c) LaNina−ElNino Precip ERAIN (mm/day)
−3
−2
−1
−0.5
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1
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4

Fig. 2.

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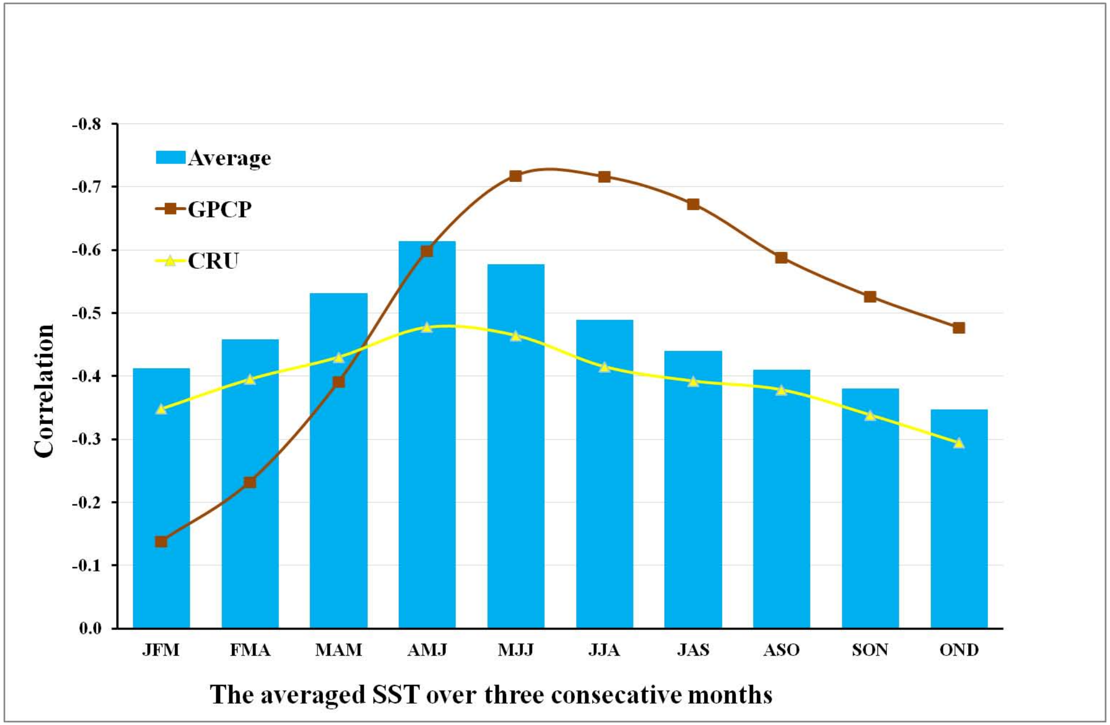

Fig. 3.

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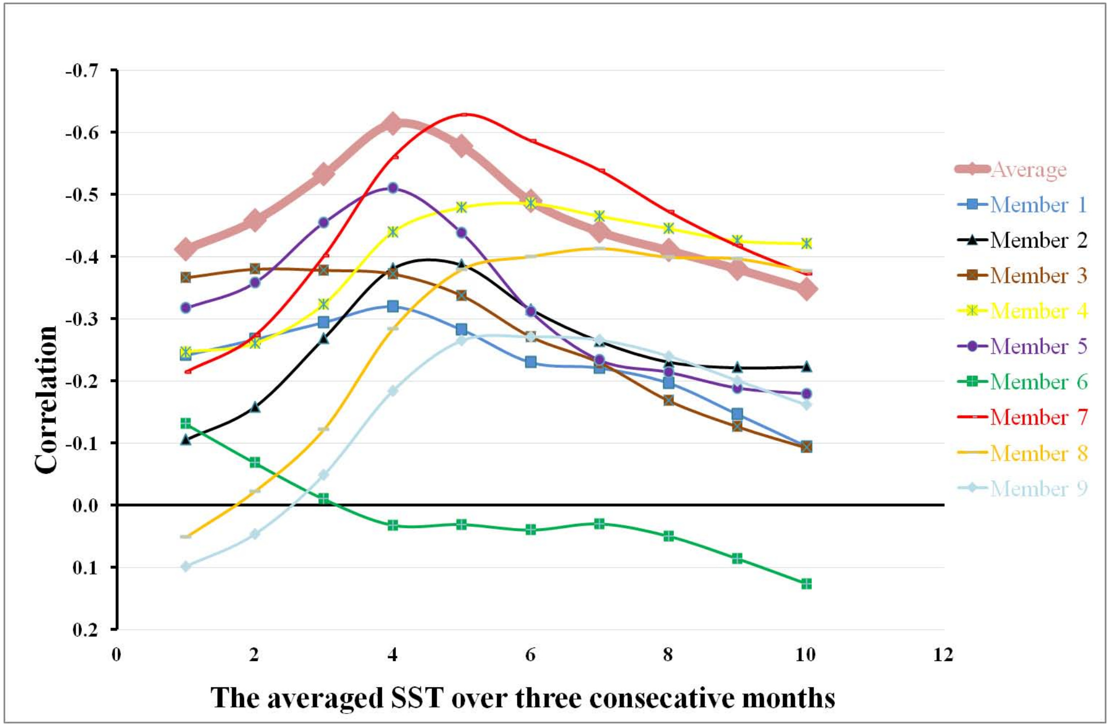

Fig. 4.

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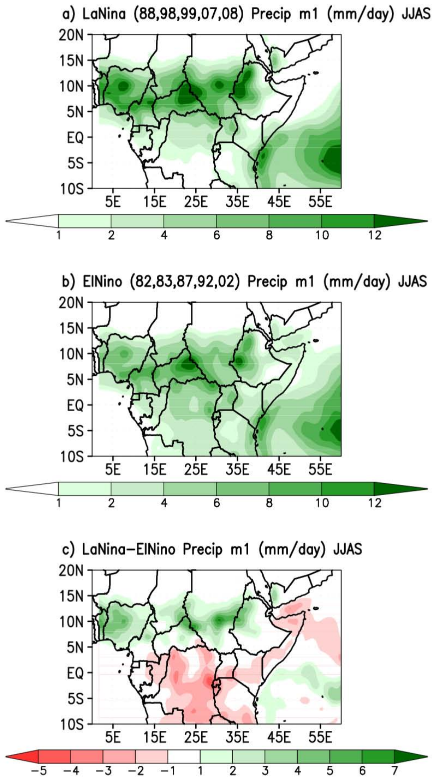

Fig. 5.

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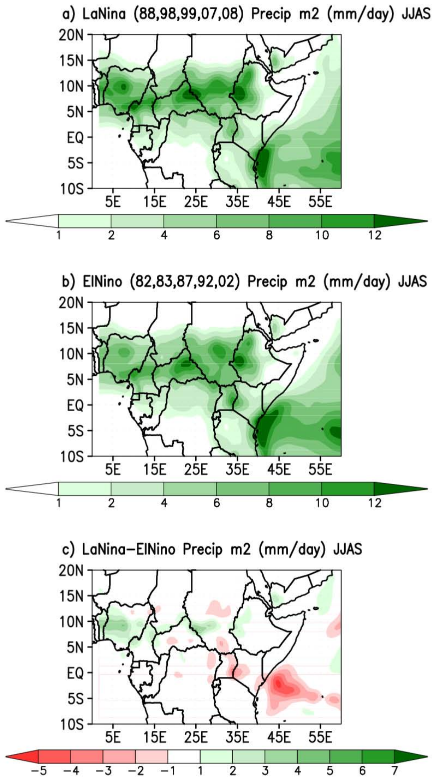

Fig. 6.

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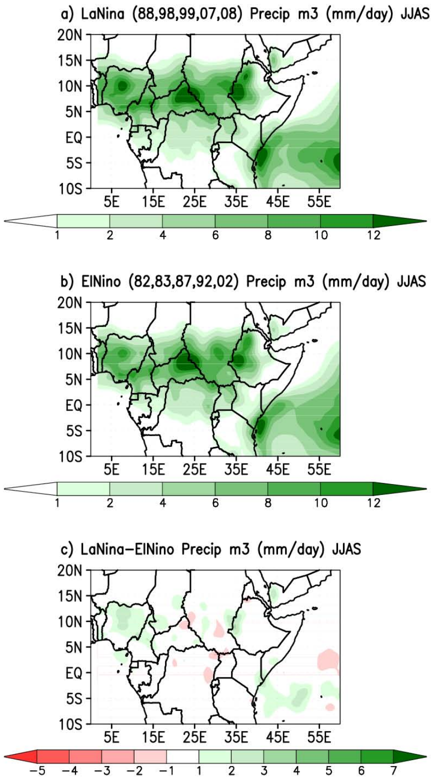

Fig. 7.

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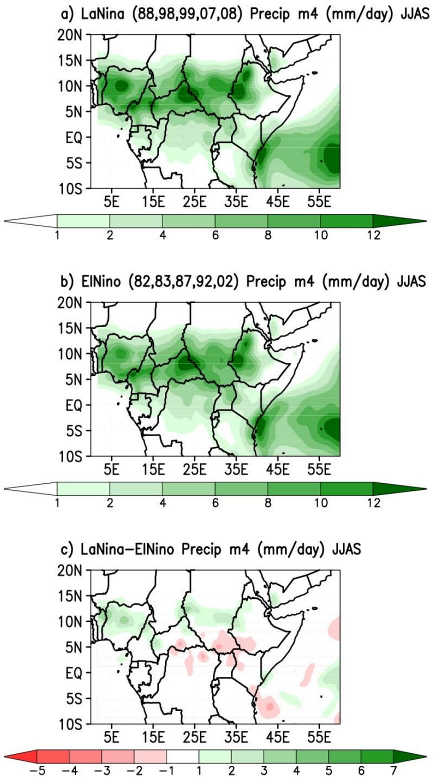

Fig. 8.

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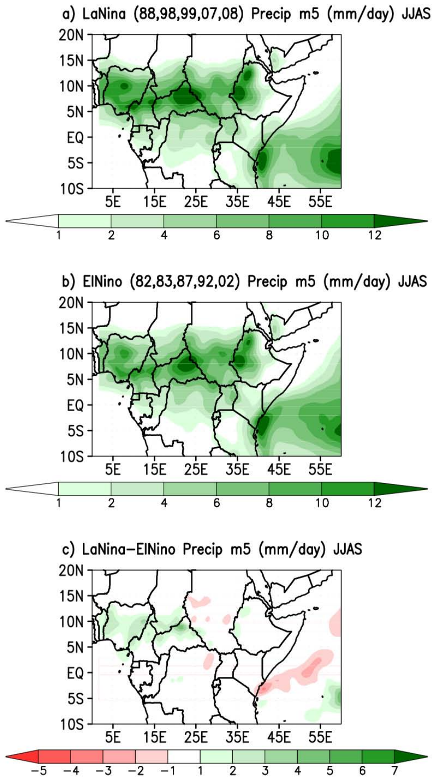

Fig. 9.

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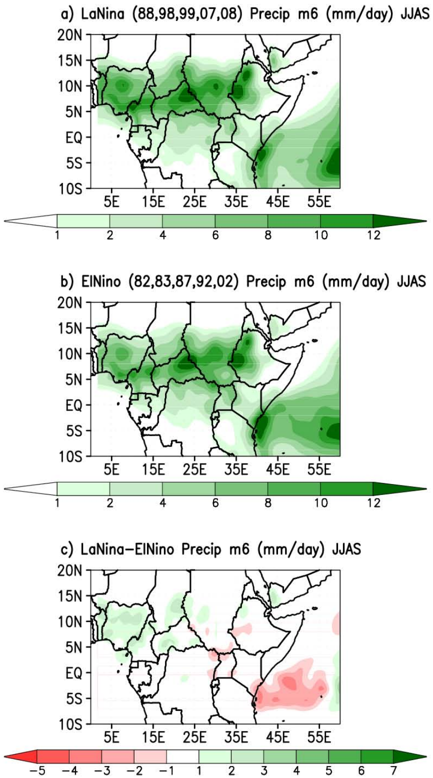

Fig. 10.

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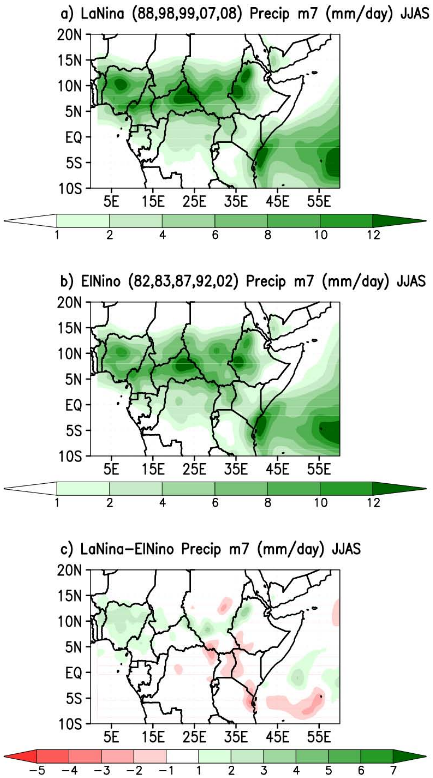

Fig. 11.

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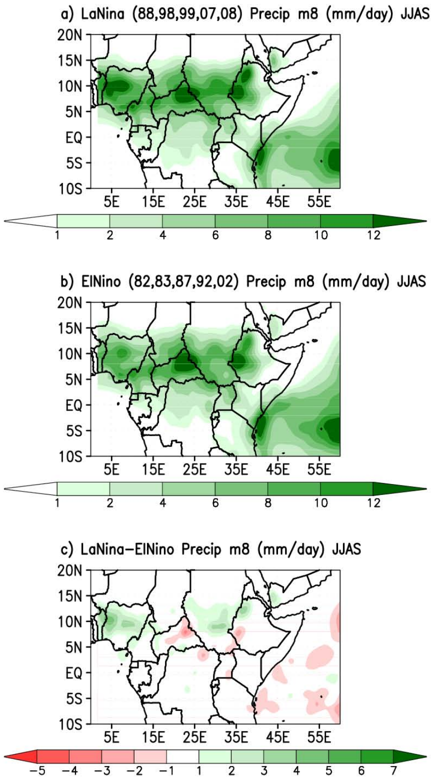

Fig. 12.

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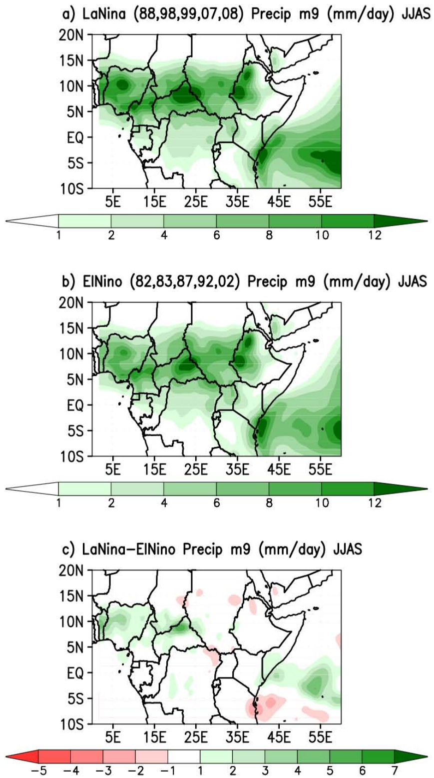
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20N
15N
10N
5N
EQ
5S
10S
5E 15E 25E 35E 45E 55E
1 2 4 6 8 10 12
b) ElNino (82,83,87,92,02) Precip m9 (mm/day) JJAS
20N
15N
10N
5N
EQ
5S
10S
5E 15E 25E 35E 45E 55E
1 2 4 6 8 10 12
c) LaNina–ElNino Precip m9 (mm/day) JJAS
20N
15N
10N
5N
EQ
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5E 15E 25E 35E 45E 55E
−5 −4 −3 −2 −1 1 2 3 4 5 6 7

Fig. 13.