Review for revised version of "Influence of river runoffs and precipitation on the seasonal and interannual variability of Sea Surface Salinity in East Northern Tropical Atlantic" by Thouvenin-Masson et al.

I appreciate the authors' effort in addressing the issues raised in my previous review. I find the revised manuscript to be improved and much easier to follow, but there are still a few issues that need to be taken care of before publication.

We thank the reviewer for pointing out new inconsistencies and inaccuracies in the text. We have taken his comments into account as listed below. For reasons mentioned in remark D, we had to change the order of the figures (moving Figure 8 to the second position, to place it next to its first citation).

A) While the motivation and goal of the study is given more clearly in the revised version, I think it could be highlighted even more in the abstract and introduction that the focus is on the impact of different precipitation and runoff forcing data sets on the simulation of salinity (rather than the dynamical understanding of salinity variability).

We have revised the abstract and introduction to better highlight this aspect of the paper, as described below.

Abstract:
« The simulated SSS are compared with the Climate Change Initiative (CCI) satellite SSS, in situ SSS from Argo, ships and a coastal mooring, and the GLORYS reanalysis SSS. An analysis of the mixed layer salinity budget is then conducted. » (lines 17 - 19)

Instead of:
"The simulated SSS are compared with the Climate Change Initiative (CCI) SSS, in situ SSS from Argo, ships and a coastal mooring, and the GLORYS reanalysis SSS. The analysis of the salinity balance in the mixed layer is conducted to explore the dynamics influencing the SSS variability."

Introduction:

« These are the goals of this study, in which we aim (i) to differentiate the effects of precipitation from those of river discharges on coastal salinity in the e-NTA region, and (ii) to contrast the effects of different precipitation and runoff datasets on the simulated salinity." (lines 72 - 74)

Instead of:
"This is the aim of this study, in which we aim to differentiate the effects of precipitation from those of river discharges on coastal salinity in the e-NTA region."

« We estimate the seasonal cycle and interannual variation in salinity for each configuration, and intercompare these different configurations. Using a mixed-layer salinity balance, we identify the mechanisms through which river runoffs and precipitation alter the simulated SSS, employing a methodology similar to that of Camara et al. (2015). » (lines 77 - 79)

Instead of:
"We estimate the seasonal cycle and interannual variation in salinity for each configuration, intercompare these different configurations, and identify the physical drivers of SSS using a mixed-layer salinity balance, following a methodology similar to Camara et al. (2015)".

B) I still find it hard to interpret the salt budget curves (Fig. 6) and bring them together with the corresponding text. Please make sure that it is always clear which line you are referring to.
As an example, the salinity anomaly is 2011 is attributed to advection but it looks like the advection term gets large only after the salinity increased.
Also, the negative precipitation anomaly in this case is argued to be compensated by entrainment. In 2018, the entrainment term is huge, much larger than just compensating the atmospheric forcing term, but there the

precipitation anomaly is argued to be important for the salinity anomaly. The advection term is much larger in 2018 than in 2011 but not mentioned to contribute at all.

We have specified in the text which curves we are referring to, and we also refer to Fig 6

For the 2011 anomaly, there is indeed a cumulative effect of overcompensation of freshwater inputs by entrainment, followed by an advection anomaly, and we have clarified this in the text, as follows:

« The fact that the SSS increase also appears in the simulation with climatological precipitation (CROCOprclm), and that the IMERG and ERA5 precipitation anomalies are of opposite signs (Figure 6c), suggests that this anomaly does not result from a precipitation anomaly. Furthermore, the SSS anomaly is also present in the simulation with climatological runoff (CROCOroclm), and the changes in runoff forcing only generate second-order differences in the SSS anomalies (Figure 6b), indicating that the runoff anomaly is not the primary cause of the salinity anomaly. Consequently, the SSS increase must arise mainly from the ocean circulation. The salinity balance (Figure 7a) confirms that a positive anomaly in entrainment in summer (July-August), overcompensating a negative anomaly of atmospheric forcing, triggers the SSS increase, which is reinforced by a positive anomaly of advection in fall-early winter (September-January), in the case of CROCOimerg. » (lines 420 - 427)

Regarding the 2018 salinity anomaly, entrainment compensates for both the freshwater input from precipitation (forcing, yellow curve) and from rivers (included in advection, blue curve), leading to its high value. The discharge anomaly plays a significant role in this case, alongside precipitation, as the ISBA discharge anomaly is particularly pronounced. This point was not sufficiently emphasized in the text, so we have updated it:

« In mid-2018, the SSS anomalies reach ~0.3 pss (Figure 6a). As in 2011, all CROCO simulations, including those with climatological forcing (Figure 6b), reproduce this positive anomaly, which cannot be attributed to one particular forcing anomaly. Analysis of the salinity balance for CROCOimerg (Figure 7g) reveals that the salty anomaly initially results from a strong positive atmospheric forcing anomaly (i.e., rain deficit) in IMERG (Figure 7i), also found in the ERA5 product (Figure 6c). The greater impact of the IMERG precipitation anomaly on CROCOimerg SSS, compared to the impact of the ERA5 precipitation anomaly on CROCOisba SSS (Figure 6a) could be due to a more localized and intense precipitation anomaly in IMERG than in ERA5 (see Figure S.1). This precipitation anomaly is accompanied by a large ISBA runoff negative anomaly (Figure 6c, Figure 7g, black dashed curve), increasing SSS by means of a very large positive advection (Figure 7g, blue curve). This runoff anomaly explains why CROCOprclm (also forced by ISBA, Figure 6b) also simulates the positive SSS anomaly (albeit weaker than in CROCOimerg) without a precipitation anomaly. Because the GLOFAS runoff anomaly has an opposite sign (i.e. larger runoff), the CROCOglofas simulation displays a weaker SSS anomaly than the simulations forced by ISBA runoff (CROCOimerg and CROCOisba; Figure 6b). In the case of CROCOimerg (Figure 7g), the anomaly is due to both a rainfall and a runoff negative anomaly (yellow and blue curves).
In conclusion, the 2018 SSS anomaly is due to the combined effects of precipitation anomalies and river discharges. It is primarily caused by a strong precipitation negative anomaly (observed in both forcing datasets), which is not entirely compensated by entrainment (Figure 7g). This is then accompanied by a river discharge negative (positive) anomaly of ISBA (GloFAS) runoff, thereby accentuating (mitigating) the salinity anomaly through advection. This runoff anomaly explains the CROCOprclm SSS anomaly. The large GloFAS runoff is surprising as it is opposite to the rain deficit over the oceanic region during this period (Figure 6c). » (lines 445 - 463)

C) There seems to have happened a mix-up in Figure 8 - the legends in the figure do not match the corresponding text which makes it rather hard to follow. It's not clear to me whether the text discussing Fig. 7a actually refers to Fig. 7b or whether just the legends in the Figure are wrong. Please correct and carefully check that legends, figure caption and corresponding text align.

We thank the reviewer for pointing this. Panels a and b of Figure 8, and corresponding captions, were swapped in the previous response to the reviews; we have corrected this error.

D) Specific comments:

- title: "…of Sea Surface Salinity in THE…"
- title and elsewhere: The region can be denoted as either "Eastern North Tropical Atlantic" or "Northeastern Tropical Atlantic" but not "East Northern"

We thank the reviewer for his suggestion. The new title is "Influence of river runoffs and precipitation on the seasonal and interannual variability of Sea Surface Salinity in the Eastern North Tropical Atlantic."

- line 13: "of the Intertropical…"

agreed

- line 14: "eastern part of the…"

agreed

- line 31: "The input of these low salinity waters lowers the density of the surface waters"

agreed

- line 48: ENSO has not been defined before

Added definition of ENSO (line 47)

- line 56: Not sure what is meant here. Are the variations expected to "increase by 10 to 28%" maybe?

Yes, we reformulated as proposed

- line 63: "strong" or "pronounced" instead of "thriving"

We replaced « thriving » by « strong »

- line 70/71: I guess this statement is meant for the region that is considered here?!?

Yes, it is. We have reformulated as follows:

« The aforementioned studies demonstrate the usefulness of salinity as a tracer for variations in the water cycle, from the perspective of the seasonal cycle and interannual variability near major rivers. Concerning the impact of freshwater fluxes on the salinity in e-NTA region, only the seasonal variation and their driving physical processes have been studied by Camara et al. (2015) using the Nucleus for European Modelling of the Ocean (NEMO) ocean model. They found that runoffs and precipitations were the main contributors of the freshening in the e-NTA, and that poleward advection of low salinity waters along the coasts was partly compensated by vertical diffusion of salinity. However, to our knowledge, no study has yet focused on interannual variability in this region, nor on the sensitivity of the simulated salinity to the runoffs and precipitation forcing datasets. » (lines 64 - 71)

Instead of:

"Concerning the impact of freshwater fluxes on salinity in e-NTA region, only the seasonal variation and their driving physical processes have been studied by Camara et al. (2015) using the Nucleus for European Modelling of the Ocean (NEMO) ocean model. They found that runoffs and precipitations were the main contributors of the freshening in the e-NTA, and that poleward advection of low salinity waters along the coasts was partly compensated by vertical diffusion of salinity.
The aforementioned studies demonstrate the usefulness of salinity as a tracer for variations in the water cycle, both from the perspective of the seasonal cycle and interannual variability. However, to our knowledge, no study has yet focused on interannual variability."

- line 71: replace the first “aim” with “goal”

We have replaced the first « aim » by « goal ». Thanks.

- Figure 1: Please specify the time period of the average (October to December of which years?) in the caption.

We modified the caption: « CCI satellite SSS (color) averaged over October-November-December of years 2010 to 2019 (over ocean) »

- line 152: either “at the open boundaries” or “as boundary open conditions”

We replaced by « as open boundary conditions »

- line 214: Which monsoon is meant here? Please explain in a bit more detail how this can be seen in Figure 8.

We moved Figure 8 to this paragraph (as Figure 2) to simplify the reading, and we have rephrased:

“GloFAS and ISBA runoffs, after summing the individual outflows for the region studied, have similar climatologies (maximum difference of 1.10^8 m^3/d, see Figure 3b). The simulated river runoffs exhibit strong interannual anomalies in this area (Figure 2). These river runoff anomalies are strongly correlated with African monsoon variations, as shown in Figure 2, where interannual anomalies of modelled runoffs closely mirror the interannual anomalies of precipitations over the watershed, used as forcing in these models. These interannual anomalies can reach 8.10^8 m^3/d, i.e., almost 40 % of the seasonal variation (Figure 3b). They are sometimes of opposite signs between the two products, with differences reaching 1.10^9 m^3/d (Figure 2). These differences and their origins are discussed in section 4. » (lines 214 - 220)”

Instead of:
“GloFAS and ISBA runoffs, after summing the individual outflows for the region studied, have similar climatologies (maximum difference of 1.10^8 m^3/d, see Figure 2b). The simulated river runoffs exhibit strong interannual anomalies in this area (Figure 5c). These river runoff anomalies are highly correlated with monsoon anomalies (Figure 8) and can reach 11 000 m^3s^{-1}, i.e., almost 30 % of the seasonal variation (Figure 2b). These interannual anomalies (see sect. 3.3 below) are sometimes of opposite signs between the two products, with differences reaching 12.10^8 m^3/d (Figure 5c). These differences and their origins are discussed in section 4.”

- line 343: What is meant by “the satellite data are slightly overestimated”?

Satellites near the coast estimate a higher salinity than what is observed in situ on a few measurements. We made it clearer:
« Among the three types of gridded products, satellite observations show the closest alignment with in-situ data, with r^2 values of 0.94 and 0.89 when compared to Argo and TSG data, respectively (Table 2). The observed differences generally remain within 0.2 pss in absolute value (Figure 5b,f), except for a few instances involving in situ measurements taken very close to the coast.» (lines 344 - 347).

Instead of:
“Of the three types of gridded products, satellite observations are the closest to *in situ* data, with r^2 values of 0.94 and 0.89 for comparisons with Argo and TSG data respectively (Table 2). Except for TSG measurements taken very close to the coast where the satellite data are slightly overestimated, the differences observed rarely exceed 0.2 pss in absolute value (Figure 4b,f).”

- Table 2: Does “global” really refer to the whole globe or just the full model domain? If really global is meant, what was used for the comparison with the model output outside of the model domain?

“Global” refers to the full domain, we specified it in the table 2 caption.

- line 453: probably Figure 6g instead of 6c
Yes, this was a typo, we corrected it.