Weather Clim. Dynam. Discuss., referee comment RC2
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Comment on wcd-2021-79

Anonymous Referee #2

Referee comment on "European summer weather linked to North Atlantic freshwater events in preceding years" by Marilena Oltmanns et al., Weather Clim. Dynam. Discuss., https://doi.org/10.5194/wcd-2021-79-RC2, 2022

General comments

The relationship between the Atlantic ocean and the summer climate over Europe is investigated. It is argued that events releasing freshwater into the North Atlantic subpolar gyre are followed by a persistent cooling (warming) over the subpolar (western subtropical) gyre. Such modified SST is linked to warm and dry conditions over western Europe in the next two subsequent summers.

While the overall mechanism seems realistic, the overall presentation of the results is very confusing. I did not understand the link between the SST anomalies analyzed and the freshwater release in the manuscript. Similarly, I was not able to understand many of the analyses presented and the conclusion seems highly speculative. I believe a large amount of work is needed to publish this work in a scientific paper.

Specific comments

- The Arctic sea ice loss is presented in the introduction and is mentioned in the abstract. But can Arctic sea ice loss release freshwater in summer in the right location? After in the manuscript, L93-98, the Greenland ice sheet melting is mentioned, then the authors say that the scope of the paper is not about understanding the origin of the freshwater. I guess that the introduction and abstract need to be reformulated to have a more balanced picture of the processes releasing freshwater during summer.
- In many parts of the manuscript (for instance L59, or legend of Fig. 1), it is argued that a mass balance was used to infer the freshwater release from the SST observation. A reference is given, but can the authors present how this is done. The link between SST and SSS is not obvious and the present paper relies a lot on these previous findings. A presentation of these previous results would improve the manuscript.

- In the interpretation, the authors discuss some sharper SST front between the Gulf Stream and the cold anomaly (L110). The location of the North Atlantic Current is also given by a thick arrow Fig. 3. After, in many parts of the manuscripts (L136-140, or L131) are discussed some shifts of the North Atlantic current. However, the SST anomalies in Fig. 2c show large scale SST anomalies rather than sharp fronts. The North Atlantic current is not well located in Fig. 3. I suggest the authors mention a modification of the SST gradients inducing modification of the lower tropospheric baroclinicity. The investigation of the link with the Gulf stream of North Atlantic current would require showing the mean location of the currents with more accuracy, and I am not sure it is needed to explain the large scale atmospheric response.
- The manuscript is not based on a quantification of the freshwater released but use the NAO time series from July and August as the starting time series. Why not using the freshwater itself from ERA5? Why not using SSS which could be more related to the freshwater flux. The authors argue that the time series of summer NAO and freshwater are correlated but what does it mean? Can the authors at least suggest some hypothesis behind this statistical relationship? What are the correlations and their p-value? Similarly, the authors used other indices for the freshwater release are used when investigating climate model simulations. The choice of these indices is not well justified, and it seems that different processes are assessed when using different time series, and the link with the freshwater release remains unclear.
- The authors chose to subsample their time series so that they have a large relationship between the summer NAO and the SST anomaly in the following winter. In particular, they chose an arbitrary threshold (0.5) and exclude part of the data (one year that seems to be 2014, represented by the yellow point). I do not believe the relationship obtained are representative of the data, as the subsample is somehow selected to have a large relationship. Similarly, later in the manuscript, the time series are again subsampled to build another index in Fig. 8. I am not sure about the interest of doing this.
- How the SST impacts the atmosphere and land surfaces in summer is not well discussed or investigated. The impact of the SST on the baroclinic instability and storm tracks are relevant for winter, but in summer other processes might dominate, such as the impacts of the soil moisture or the impact of tropical Atlantic and the intrusion of moist air from the Mediterranean region. In Figs. 4ab only the few wind vectors are shown over the ocean, and it is difficult to see any shift of the jet stream as argued in L136-145. What are the SLP, geopotential height, zonal wind or streamfunction anomalies? Can the Fig. 4ab be extended to include most of Europe and the Mediterranean region? Similarly, when using model results (section 4.4 and Fig. 6), the SLP or the wind is never shown.
- The authors argue that ‘’the large-scale dipolar circulation anomaly is reproduced by SST-forced simulations, supporting that it is driven by the ocean (Appendix B)’’ L121-122. What do the authors mean by dipolar? Why are the authors present the results in appendix? When looking at the appendix B, another index is used to characterize the freshwater events (why not using the index built on the NAO??), based on SST. Such regression may reflects here the impact of ENSO on the Atlantic ocean, or the impact of tropical Atlantic, and this cannot be interpreted as an impact of the Subpolar Atlantic SST.
- The sea-level anomalies are interesting and show a large band of anti-cyclonic eddies (Fig. 3c). Can the authors discuss these small scale structures? What is the link between the fresh water release and the sea-level anomalies? Maybe a spatial smoothing would be needed to see the large scale structure suggested in the text.
- The authors should try to reduce the number of figures and appendices, or better summarize their results. I found the appendix not always relevant. For instance appendix A does not help to understand the surface mass balance and the link with the salinity shown in the main manuscript.

Technical details and other comments:

L35: is the NAO defined as the first or second rotated EOF of monthly 500-hPa geopotential height?

L40 : why not only use HadISST to avoid discontinuity in the dataset used?

L47: can the authors specify if u is the module of the wind or the zonal wind?

L49-55 : can the author specify the boundary condition used for SST and sea ice, as well as the external forcing (for the two experiments). How are generated the initial conditions?

L55:''we subtracted regionally averaged trends from the air temperatures, both in ERA5 and the model output'' -> I do not understand what are mean regionally averaged trends. How are the regions defined? I believe that it is important that all trends be removed before calculating the regression. Are the SST trends removed as well?

Figure 1 : The regressions shown are regressions of the SST and SSS variation from summer to winter onto the summer NAO. Are the variations calculated from the previous winter (n-1) to summer n? Or from summer n to next winter n? I do not understand why the authors investigate the SST and SSS variations and not the actual SST and SSS anomalies.

Figure 1 : I do not understand what are the SSS results? Are they from SSS observations? Can the authors provide more details on the method used to retrieve the SSS?

Figure 2 : I believe Fig. 2b shows the regression and not the correlation.

L66 : The authors find also warming in the western Atlantic at 30°N. Can the authors explain the link between the freshwater flux in the subpolar gyre and the SST anomalies in the subtropical region? It seems that the atmosphere is forcing a large part of the signal, with the so-called tripole pattern as a response to the NAO (Czaja and Frankignoul, 2002).

L64: ‘’the relationship between the negative summer NAO and the seasonal surface freshening is approximately linear’’ -> Can the authors explain how this was assessed and analyzed in the data?

L74 : I think that directional t-tests are not justified here. Do the authors mean ‘one-tailed test’? The sign of the regression of the variables studied is not obvious and only two-tailed test are needed here. Can the authors explain?

L86-87 : ‘’After evaluating the surface fluxes, wind-driven Ekman transports, Ekman pumping and re-emergence of SST anomalies’’ Can the authors explain better where and how these processes are evaluated?

L89-92: I believe this needs to be better explained. Does the authors assume a perfect density compensation to deduce the SSS? It does not explain how the entrainment below the mixed layer and the re-emergence are evaluated then.

L95 : I do not see a pronounced seasonality of the […] surface freshening in Fig. 1d. Can the authors explain what is the seasonality of the surface freshening and how the anomalies observed reinforce this seasonality?

L93-98 : I would rather link the freshening with P-E, and I do not understand well the hypothesis that runoff from Greenland is dominant here.

Figure 3b : The SLP anomalies are huge. Maybe hPa are Pa?

L110: I do not understand what the authors mean with ‘’ after stronger relative to weaker freshwater events ‘’. What not just say ‘’after the large freshwater events’’?

Figure 3c: the data used for the ADT need to be presented in the method section.

Figure 3c: the thin black arrow shows the flow implied by the ADT anomaly. What does it mean? I am surprised that such flow is not geostrophic... Can the authors explain how the arrows are computed?

L123-125 : ‘’most negative NAO summers are followed by a positive NAO in the subsequent winter’’ -> This statement is not supported by the results presented so far, as

the regressions shown in observation are built using only 8 winters.

L130 : ‘’the northward shift of the North Atlantic Current is obscured by the southern Ekman flow’’ -> Many studies argue that the heat flux is dominant in driving the SST anomalies during the NAO, while the Ekman flow drives weak anomalies (Deser et al., 2010). A more accurate presentation of the terms driving the SST anomalies is required to support this statement.

L133-134 : ‘’an increasingly sharpened SST front all across the eastern boundary of the North Atlantic (Fig. 3d)’’ -> Can the authors describe where are these fronts in the eastern Atlantic in Fig. 3d? The SST in the second winter looks similar to that in the first winter, but weaker.

L141: ‘’it shields the regions to the south from the moist air over the Atlantic’’ I do not understand this statement. Can the authors reformulate?

L146: ‘’the regressions […] are […] characterized by steep slopes and high correlation’’ Note that the correlation is never shown in figures, so that the authors may provide hear some number to support this statement. The authors should note that with 8 points, the threshold for a significant correlation is 0.707 for a p-value at 5%. Therefore high correlation does not necessarily mean a significant relationship. I would remove this comment, and I would only comment the level of statistical significance and not the amplitude of the correlation.

Fig. 4ef and Fig. 5ab, the values for P-E are huge. Can the authors check if the map shows correlation and not regression.

Fig. 5cd: I do not see why the authors show these figures… I would remove them.

L154-157: I do not understand why another index for the freshwater release is used. I do not understand what it is? For instance, L156-157 ‘’we map the SST each summer onto the observed pattern obtained from freshwater event. The mapping is obtained from a least square fit of the SST […] to the SST pattern obtained from the freshwater events (Figs. 6a and 6b)’’. How are the freshwater event defined? Does the author mean that the time series is obtained using a projection onto a spatial pattern over a specified region (that needs to be defined)?

L159-160 ; ‘’we find that the observed and simulated atmospheric response agree qualitatively well’’ Can the authors explain the difference between Fig. 4 and Fig. 6. It seems that the SST anomaly is different in Fig. 6, with a clear SST tripole, with large

impacts on the P-E. It seems that the simulation and models show a feedback between warming over the continent and soil moisture decrease. Did the authors use detrended data? If not, the authors might see here the impacts of global warming over the summer continents.

L173 : ‘’we […] refer to these freshwater events as circulation-driven events’’. The authors argue that explaining the origin of the freshwater anomalies is beyond the scope of the paper. Therefore, I suggest changing the name of these events, otherwise, the authors should justify how the circulation explains the freshwater anomalies.

L182-183: ‘’we exclude events, that are preceded by another strong circulation-driven freshwater event, for which F_C is larger than 0.2’’. Can the authors justify the choice of 0.2 here? Did they test other values?

L184 : ‘’correlation with the SST gradient’’ I do not see any figure of the correlation SST gradient in Fig. 8, but some regression of the SST.

Fig. 10c and 10d :I do not see any level of statistical significance. Does it mean that the SSS or SST in winter is not related to the temperature in summer?

Figure 7: how are the outlier defined in the box plot of Figure 7. I believe that showing the 5% and 95% percentile would be useful, as observation seems to be at the edge of the simulated distribution concerning precipitation minus evaportation. The authors should also note that the observation never lies in the interval defined by the first and third quartiles.

Figure 10a : How is T_summer defined? What region? Is it surface air temperature over land only?

Figure 11: This figure does not add much to the manuscript.

Appendix C: the results are not discussed in the main text. Note sure that the appendix C is needed, the authors may summarize the results by one or two sentence in the main manuscript with ‘’not shown’’.

References

Deser, C., Alexander, M. A., Xie, S. P., & Phillips, A. S. (2010). Sea surface temperature variability: Patterns and mechanisms. *Annual review of marine science*, *2*, 115-143.

Czaja, A., & Frankignoul, C. (2002). Observed impact of Atlantic SST anomalies on the North Atlantic Oscillation. *Journal of Climate*, *15*(6), 606-623.