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1 Summary

In the manuscript *Changing European Hydroclimate under a Collapsed AMOC in the Community Earth System Model*, eight model simulations are used to assess the impact of the AMOC strength and two different Representative Concentration Pathways (RCP4.5 and RCP8.5) on the European hydroclimate. The authors reconstruct daily potential evapotranspiration rates (PET) from CESM variables stored at monthly frequency. This allows them to diagnose the differences in dry season length and intensity under the different scenarios, as well as determining the dominant terms in the PET equation that are most sensitive to the changing climatic conditions in the eight simulations. The authors find that compared to the pre-industrial conditions (PI), nearly all scenarios show a general reduction in the potential precipitation deficit (PPD) over Europe, resulting in generally drier climate and an increase in drought extremes.

The eight scenarios allow for a comparison between the effects of the AMOC shutdown and the anthropogenic climate change on the European hydroclimate. Under PI conditions with reduced AMOC strength, the precipitation and PET rates decrease, and the latter dominates, resulting in dry conditions. In the RCP8.5 scenarios, the precipitation is reduced as well, but the PET rates increase, and the two effects combine, resulting in more intense and longer dry periods than in the AMOC off scenarios. Lastly, the RCP4.5 simulations provide the most important comparison between the European climate states under increased radiative fluxes with and without collapsed AMOC. These results show how AMOC collapse intensifies the dry conditions in Europe in the warming climate. The RCP4.5 scenario with collapsed AMOC shows significantly longer and more intense dry season in Southern and Central Europe compared to the AMOC on case, as well as significantly increased probability for drought.

The study presents a meaningful and important contribution to understanding the risks associated with the combined effect of climate change and AMOC tipping on the hydroclimate. As such, the article is a relevant addition to the Hydrology and Earth System Sciences (HESS) Journal, both in terms of scientific content and result significance.

2 General comments

The manuscript is well organized and the analysis is conducted to a high standard. Analyzing the PPD and its decomposition into precipitation and PET rates reveals the pathways driving changes in European hydroclimate across scenarios. The changes in precipitation are linked to mean sea-level pressures, and it is shown that the dominant factor affecting the PET is temperature. It is furthermore demonstrated that reconstructing $\mathrm{PET}^{\mathrm{day}}$ is important for understanding the scenario impact, as the $E - P$ signal is weaker than $P - PET$, since evaporation in the model is limited by the precipitation rate.

The reconstruction of $\mathrm{PET}^{\mathrm{day}}$ and $\mathrm{PET}^{\mathrm{month}}$ in Appendix A is well justified and described. However, comparing the RMSE of end-year PPD computed from true and reconstructed PET would be a more meaningful measure of the biases introduced with the upscaling method. Since the CESM PPD biases are significant compared to ERA5, it would be useful to know to which extent the PET reconstruction may be contributing to these biases, if at all.

The communication, especially in the results section, is lacking clarity and should be improved. First of all, the significance of the k-means analysis is unclear. The authors

should state clearly the significance of this analysis and how it fits with the previous results. More importantly, it takes a long time to realize that the focus for the reader should be the difference between the two RCP4.5 scenarios, where the role of the AMOC collapse in contributing to the hydroclimate changes under increased radiative forcing can be identified. This important result drowns in the overly detailed text of the section, and is also not clearly visually indicated on the figures. The manuscript clarity would improve if both the results and the figures were streamlined to better express the focus on the differences between the results from the two RCP4.5 scenarios.

The naming convention for the different scenarios greatly contributes to the lack of clarity and transparency in the text and on the figures. Instead of the cumbersome 'AMOC on ($F_H = 0.18$)', the authors could consider simply writing 'PI_LOW' or 'ON_LOW' to indicate the lower rate of freshwater hosing. It is not crucial for the reader to know the exact F_H value throughout the text. It is also not obvious how the simulations in the manuscript are branched off from the simulations with $F_H = 0.66$ Sv (ll. 65-69). This can be clarified. Additionally, the figure titles and labels are very small, and increasing the font size would improve the ease of understanding.

Lastly, the discussion about model biases is lacking. The assumption that CESM biases with respect to ERA5 stay constant is highly unlikely to hold (ll. 111-113). It would be great if the authors could include more discussion about how the significant CESM biases may affect the results.

3 Minor comments

It is surprising that the Netherlands is chosen as the reference location to show the local changes in PPD. The authors show that the European hydroclimate is profoundly affected by the different scenarios, but choose to visualize the location that is among one of the least impacted. Would it not make sense to show the local differences somewhere where the signal is stronger? This modeling choice should be more clearly justified.

Equations are not correctly punctuated throughout the manuscript.

l. 7: 'depends' → 'depend'

Table 1: Should be m^3s^{-1} not ms^{-1}; 'statistical equilibrium' should be defined somewhere.

l. 18: What is meant by a 'major' climate tipping point? The Armstrong McKay paper uses the term 'global tipping point', and this is rigorously defined. Are you using a different term for a reason, and if so it should be defined.

l. 65: 'indirectly' and 'directly' have opposite meanings; which is it?

l. 88: 'logarthemic' → 'logarithmic'

l. 130: 'the PPD' → 'the negative PPD'

l. 144: 'eigh' → 'eight'

l. 165: 'decreases which' → 'deacreases, which'