

Referee #2

Thank you for all the comments and questions. Below, you will find our responses to your comments:

Referee comments	Answers
1) The authors should improve the English throughout the manuscript. For instance, there are many writing issues on the first page alone. The methodology section is also poorly structured. I list specific issues below in the Specific Comments section.	Thank you for the careful revision. We appreciate the addressed observations and questions. We agree that the manuscript required some improvements, especially in the abstract and methods. Therefore, we have solved the specific issues and improved the clarity of the text.
2) The motivation for using convection-permitting experiments is unclear. The authors do not explain why they chose the convection-permitting scale, which is computationally expensive. What added value does this model configuration provide in this study? The analysis of the model output focuses primarily on several near-surface variables. It would be more meaningful to include analysis of precipitation.	Thank you for this observation. We agree that the justification for using convection-permitting resolution was not completely clear in the original manuscript. Our main motivation was the spatial representation of irrigation and the intensity of the impact, which is mentioned in the introduction (first and second paragraphs). The spatial resolution is important across Europe since irrigated areas are highly heterogeneous and localized. Also, as mentioned in Chen & Dirmeyer, 2019, coarse resolution simulations usually aggregate multiple small irrigated areas within individual grid cells, which limits the representation of local irrigation and its impacts. We have added this statement in the revised manuscript. Moreover, we have also clarified this motivation in the model set-up, due to the importance of 3 km resolution for the tile approach in TERRA LSM. Regarding precipitation, we agree that the convection-permitting set-up also benefits the representation of deep convection. Therefore, we have added a section to analyze precipitation. In general, we found no statistically significant results for precipitation when using both the two-sided Student's t-test and the false discovery rate for field significance over the 12 year simulation. However, we found localized precipitation responses in some regions using the two-sided Student's t-test. Therefore, we analyzed these

	results in the manuscript, but we do not consider them evidence of a robust irrigation impact on precipitation. We have added this analysis in section “Impact on precipitation and its interannual variability” and mentioned this also in the conclusions.
3) The model evaluation is based on the ICON-DREAM reanalysis, which also provides the boundary conditions for the irrigation experiments. The authors should consider using other observation-based datasets to assess model performance.	Thank you for this observation. We would like to clarify that ICON-DREAM was not used as the dataset for comparison. Instead, we used ICON-DREAM dataset as the initial and boundary conditions. For the model evaluation, we used quality-controlled observations assimilated into the ICON-DREAM. While 2-meter temperature and relative humidity are assimilated, they do not directly influence the analysis increments fed to the reanalysis system given the fact that those are diagnostic variables (not prognostic ones). Now, in the revised manuscript, we have added text acknowledging that these observations are not fully independent of ICON-DREAM. Moreover, we have added more information about these observations. For instance, they are obtained from the WMO-WIS observation network, consistent with the observational data used in ERA5 (Hersbach et al., 2020), and for the quality-control procedures, ICON-DREAM reanalysis provided the background information to identify potentially erroneous or unrepresentative observations, following approaches commonly used in observational reprocessing (e.g., Copernicus Climate Change Service, 2025; EUMETSAT, 2021). Besides this evaluation, we have evaluated the performance of our simulations against external reference datasets in our recent intercomparison study (Roque et al., 2026, https://doi.org/10.1002/joc.70554). In this paper, 2-m temperature, precipitation and evapotranspiration were evaluated against E-OBS, GPCC and GLEAM, respectively, over the period 2011-2019 for two highly irrigated basins, the Ebro and Po basins. Now, we have added a reference to this evaluation in the revised manuscript.

	- Hersbach H, Bell B, Berrisford P, et al. The ERA5 global reanalysis. Q J R Meteorol Soc. 2020; 146: 1999–2049. https://doi.org/10.1002/qj.3803 - Copernicus Climate Change Service, Climate Data Store, (2025): Comprehensive upper-air observation network from 1901 to present. Copernicus Climate Change Service (C3S) Climate Data Store (CDS). DOI: 10.24381/ba504f7a (Accessed on 24-08-2026) - EUMETSAT (2021): Atmospheric Motion Vectors Climate Data Record Release 2 - MFG and MSG - 0 degree. V. 2. EUMETSAT. (dataset). https://doi.org/10.15770/EUM_SEC_CLM_0020 - European Centre for Medium-Range Weather Forecasts (2021). ERA5T issue in snow depth. https://confluence.ecmwf.int/spaces/CKB/pages/242084340/ERA5T+issue+in+snow+depth. Accessed: 2026-08-24 - Roque, J. L., Lopes, F. D. S., Giles, J. A., Gutknecht, B. D., Schalge, B., Zhang, Y., Ferro, M., Friederichs, P., Goergen, K., Poll, S., and Valmassoi, A. (2026). Intercomparison of a Regional Climate Model Ensemble for Selected European Catchments, International Journal of Climatology, e70 554, https://doi.org/https://doi.org/10.1002/joc.70554
4) The irrigation scheme “integrates irrigation water into grid-scale precipitation before it is passed to the land surface.” This is a typical representation of sprinkler irrigation. It is unclear why the authors chose this irrigation method. Can sprinkler irrigation adequately represent actual irrigation practices across Europe?	Thank you for this observation. We agree that the parameterization and TERRA description were not completely clear about why we selected this method and how TERRA treats irrigation water. TERRA does not represent canopy interactions yet; therefore, even though we add irrigation water to grid-scale precipitation, there are no irrigation water-canopy interactions. As a result, our parameterization closely resembles surface irrigation, which is among the most used methods in southern Europe (Masseroni et al., 2017), including Portugal, Catalonia, and northern Italy.

	Regarding irrigation methods, we are aware of their diversity across different irrigated regions of Europe. We briefly mentioned this in lines 201-203 for the Ebro basin. However, since this is another source of uncertainty, we have revised the conclusions section to add this. Moreover, we have included a description of ICON and TERRA in the methods section.
5) Although the title refers to irrigation impacts “across the European continent,” the analysis focuses only on three subregions: the Alps, the Mediterranean, and Mid-Europe. According to the irrigation map, there are also large irrigated areas in the Iberian Peninsula. Why were these areas not considered?	We agree that the Iberian Peninsula contains highly irrigated regions, such as the Ebro basin. Therefore, we have expanded our results section to include this sub-region. Initially, we focused on three sub-regions to show the irrigation impact across different evapotranspiration regimes (soil moisture-limited or energy-limited) and the exceptional events seen in specific years.
L1: Revise “advancing and becoming more relevant.”	We have revised the sentence and changed it to “Irrigation is an important anthropogenic activity that can impact surface and atmospheric conditions.”
L4: Change “Therefore” to “However.”	Thank you for the observation. We have changed “Therefore” to “However”.
L6: Spell out ICON or remove the acronym.	We have included the whole name and acronym.
L10: It would be better to include a concluding sentence.	Yes, we have added a concluding sentence: “Our results highlight the importance of representing irrigation in climate models across Europe, given its region-specific impact and increasing relevance, especially as the frequency of extreme events such as droughts and heat waves is projected to increase.”
L12: Revise “The role of irrigation in research” to “Research on	We have revised the sentence.

irrigation impacts.”	
L17: “Biases”: biases in what?	We referred to temperature biases. We have added this into the revised manuscript.
L17: Revise “overcome this lack.”	We have revised the sentence to "To overcome this limitation, early research included irrigation into EMS through long-term simulations.”
L72: Why are evaporation sources discussed here?	Thank you for this observation. We agree that only mentioning the evaporation source was not clear enough. We added this sentence to highlight that in our scheme, irrigation water also contributes to evaporation from the land-atmosphere interface. This differs from other irrigation schemes that add water directly to the soil and do not include this evaporation source. We have revised this sentence.
L71: In the Methodology section, the authors should include a section describing the ICON model. Subsections 2.1 and 2.1.x should be at the same hierarchical level.	Thank you for this observation. Based on a previous reply, we have added a section in the methodology to describe ICON and TERRA. We have also corrected the hierarchical level of the subsections.
L173: Revise “Model discussion.”	We have changed the section title to "Model evaluation", so it better describes the content of the section.
L227: Use consistent formatting for the section title.	Thank you for this observation. We have corrected the title's format.
L240: I assume that the model uses negative values to represent upward fluxes. This convention should be clearly explained. The current figures show negative values for changes in LHF, which could be misleading because negative values are typically interpreted as a decrease in LHF.	We agree that the sign convention for LHF and SHF should be clarified. Therefore, we have added a description of this to the results section and explained the interpretation of the corresponding LHF and SHF results.