Preliminary remarks

As suggested by Anonymous Referee #2, the tittle of the manuscript has been modified in “Using a convection-permitting climate model to assess wine grape productivity: two case studies in Italy” to better reflect the aim of the paper.

In addressing the reviewers’ comments, we decided to modify the structure of the article. Different sections of the article have been moved and streamlined, to account for the suggestions of both reviewers and improve readability and the fluency of the text.

The most relevant changes are reported below:

As suggested by Reviewer #1, the Abstract has been rephrased to enhance its precision and focus.

2. Data and Methodology: Subsection “2.6 Trend Analysis” has been added, and the order of the two subsections, “2.4 Bioclimatic indices” and “2.5 Validation of climate simulations and calculation of bioclimatic indices” has been reversed. Section "2.5 Validation of climate simulations and calculation of bioclimatic indices" has been renamed "2.5 Validation of climate simulations" to better reflect its content. The revised order is now as follows: "2.4 Validation of climate simulations "; "2.5 Bioclimatic indices"; “2.6 Trend Analysis”.

3. Results: Subsection “3.1 Validation of the climate simulations” has been streamlined, Table 2 was replaced by two new figures, Figure 6 and 7, to increase the readability. Figure A2 and A3 showing the time series of mean (TM), maximum Temperature (TX), minimum (TN) temperature and precipitation (P) over FRA and MON area have been moved to the main text before Figures 2 and 3showing the time series of the bioclimatic indices from 2000-2018 averaged on the FRA and MON consortium area.

At last, the “4 Discussion and Conclusion” section has undergone a comprehensive revision and expansion.

Further details are set out in our point-by-point response (in blue), which can be found below.

Response to RC-1

Manuscript number: egusphere-2024-941

Title: Using a convection-permitting climate model to predict wine grape productivity: two case studies in Italy

Authors: Laura T. Massano, Giorgia Fosser, Marco Gaetani, Cécile Caillaud

General comments:

- This study investigates correlations between wine productivity and bioclimatic indices, calculated based on observations, reanalysis data, RCM, and CPM. Temperature and precipitation-based indices explain the changes in wine productivity in two consortia. The simulation output from climate models is validated at a local scale and is expected to predict

productivity using highly correlated indices. It provides a valuable contribution to understanding the variability impact of the climate on viticulture.

For this reason, this work should be published after several improvements are made. The written text should be proof checked. The presentation of the work can be much improved regarding the description of the dataset and interpretation of the results (see comments below).

We thank the Reviewer for taking the time to revise our manuscript and providing constructive comments, which helped in improving the paper. Please find below our point-by-point response, highlighted in blue.

Specific comments:

- The abstract can be sharp and more specific. Please specify "some bioclimate indices" in line 15. It should also include a discussion on two cases, highlighting why it is necessary to use CPM.

Thank you for the comment. We modified the abstract according to the suggestion as follow: "[...]. Temperature and precipitation-based bioclimatic indices are computed using the observational dataset E-OBS, the high-resolution climate reanalysis product SPHERA, the regional climate model CNRM-ALADIN and the km-scale convection-permitting climate model CNRM-AROME. The multi-regression method outperforms the single regression, systematically enhancing the ability of bioclimatic indices to explain productivity variability. The results show that productivity is strongly tied with temperature-based bioclimatic indices in the area of "Consorzio per la tutela del Franciacorta" in northern Italy, while for the "Consorzio del Vino Nobile di Montepulciano" area in central Italy both temperature and precipitation-based indices are relevant. Climate models, providing similar results as E-OBS and SPHERA, appear to be a useful tool to explain productivity variance. In particular, the added value of convection-permitting resolution is evident when precipitation-based indices are considered. [...]"

- a good explanation of frost risks on line 31.

We rephrase the paragraph to clarify:

"Since temperature is the primary driver for the phenological phases (Fraga et al., 2016), a warmer climate may lead to a shorter growing cycle and an earlier onset of phenological phases, which would increase frost-related risk (Lamichhane, 2021; Trought et al., 1999). In fact, budburst is the most vulnerable phase to frost in the vine growing cycle, and an earlier budburst in spring would increase the exposure of the vine to late frost events."

- line 33, please explain "important shifts" in "important shifts in viticulture suitability".

We have clarified by rephrasing the paragraph:

"Furthermore, climate conditions typical of traditional wine-producing regions, such as Douro in Portugal, La Rioja in Spain, Bordeaux in France, and Tuscany in Italy, are expected to shift northwards or at higher altitude, and this modifications in viticulture suitability may consequently cause a decline in production (Adão et al., 2023; Rafique et al., 2023; Sgubin et al., 2023; Tóth and Végvári, 2016)."

- line 64, "the driving RCM simulation" what drives RCM simulation

The RCM simulation is used to drive the CPM simulation and is in turn driven by ERA-Interim reanalysis. This aspect is elaborated in the methodological section. Sentence at line 64 has been rephrased to clarify:

“The CPM performance is validated against climate observations and a km-scale reanalysis product. Furthermore, the added value of the higher resolution is assessed by comparing the CPM to an RCM simulation.”.

- Figure 1 does not show clearly the scale, north direction, and regions (FRA, LOM, MON). The zooming-in parts are not clearly shown in the map.

Thanks for the suggestion, we have replaced the figure with a more informative one.

- line 95, okay, it is a fair assumption

Thank you.

- line 98, "thus contextualise this work within the broader framework of previous studies", what specific framework? is it necessary to mention this?

Thank you for pointing this out. The sentence has been modified and now reads: “To assess the consistency of productivity data between local and regional scales, the productivity at the local scales (FRA and MON) is compared with productivity at regional scale provided by the Italian National Institute of Statistics (ISTAT).”

- line 107, "the Welch's t-test proves that both consortium distributions are part of the regional population", why this test can prove this conclusion here. please simply explain. What are the variables used in the table. please explain and not directly use terms from the code.

The application of the Welch’s t-test is explained in the text:

“In addition, the application of a Welch's t-test, designed to assess whether two samples are extracted from the same population, proves that the productivity distributions of both consortia are consistent with the respective regional productivity distributions (Table A 1 and Figure A 1).”

The header of Table A1 has been modified:

“Table A 1: Results of Welch's t-test applied to regional and consortia productivity data: t statistics (t), reference value for t (tref), degrees of freedom (DoF) for the t-test based on the number of observations computed according to the Welch’s equation for effective degrees of freedom (Welch, 1947) are displayed. Values of t lower than t_{ref} indicate that consortium and regional productivity samples comes from the same population, at 95% level of confidence. In the last column: temporal correlation coefficient (r) computed between consortium and regional productivity data. Asterisks (*) indicate statistically significant correlations (p<=0.05).”

In addition, the headers of Tables A3 and A4 have been improved:

“Table A 3: Results of Welch's t-test applied to mean (TM), maximum (TX) and minimum (TN) temperatures and precipitation (P) from E-OBS, SPHERA, RCM and CPM datasets, for FRA and MON: t statistics (t), reference value for t (tref), degrees of freedom (DoF) for the t-test based

on the number of observations computed according to the Welch's equation for effective degrees of freedom (Welch, 1947) are displayed. Values of t higher than tref indicate that the samples from climate model simulations and the reference datasets come from different populations, at 95% level of confidence. Asterisks (*) indicate the means showing statistically significant differences."

"Table A 4: Results of Welch's t-test applied to the bioclimatic indices from E-OBS, SPHERA, RCM and CPM datasets, for FRA and MON: t statistics (*t*), reference value for *t* (tref), degrees of freedom (DoF) for the t-test based on the number of observations computed according to the Welch's equation for effective degrees of freedom (Welch, 1947) are displayed. Values of t higher than tref indicate that the samples from climate model simulations and the reference datasets come from different populations, at 95% level of confidence. Asterisks (*) indicate the means showing statistically significant differences."

- line 154, "more than 3000 degrees per day", please explain if the unit is correct. Also the same unit used below

We have corrected the text, the unit is degree days

- line 160, please explain the unit

The correct unit is degree days.

- line 173, by "occurrence", do you count the frequency of frost days per year?

No, we don't count the frequency of the frost days. The index indicates the minimum temperature the vines are exposed during the vegetative period. We have rephrased for clarity.

"Minimum temperature during vegetative period (TnVeg), which is the minimum temperature recorded during the vegetative period (1st April to 31st October). This index is important to assess whether the vines are exposed to low temperature or even to spring frosts that pose a significant risk to viticultural practices and production. The damage threshold is fixed at -2 °C (Sgubin et al., 2018)."

- line 200, The remapping strategy is the key to the workflow. Please explain the remapping strategy (average, weighted average, (fraction-) interpolation). How are datasets with different resolutions (OBS: 11 km, reanalysis: 2.2 km, RCM: 12.5 km, CPM: 2.5 km) interpolated onto the same grid? What happens when grids from different datasets do not overlap?

The reviewer is right, the remapping strategy is an important step for the analysis. Because all the analysed datasets have different grids, we remapped all to the coarsest one (E-OBS at ~11 km), using a conservative remapping. The paragraph has been rephrased for clarification:

"To compare datasets with different horizontal resolutions on equal terms (Berg et al. 2013), observations, reanalysis and model simulations are conservatively remapped on a common grid, i.e. the E-OBS regular grid at ~11 km, the coarsest among all. Tests performed to assess the impact of upscaling SPHERA and CPM at a coarser resolution showed no significant changes in the results (not shown)."

- line 200-210, what are the temporal resolutions of the datasets? I expect the value of accumulative variables to depend on the temporal resolution.

The analysis is performed at daily time scale. E-OBS data are provided at daily resolution, while SPHERA, CPM and RCM data, originally at hourly resolution, are aggregated at the daily time scale to match E-OBS data. We clarify this aspect in Sections 2.2 and 2.3.

- the CNI indices looks like an accumulative value, but the suitable class range is within 12 -18 degrees.

The CNI is not an accumulative value but is an average of the minimum air temperatures of September. We rephrased for clarity as: “Cool Night Index (CNI), defined as the average of minimum air temperatures during the month of September”.

- line 121, what do you mean by "common period”.

We have modified the sentence, which now reads “CPM performance is evaluated for the period 2000-2018”, since the previous paragraph clarifies that “The analysis focuses on the 19 years from 2000 to 2018 that is the longest period available for RCM and CPM simulations and shared with E-OBS, SPHERA climate data and FRA and MON productivity data.”

- line 215, "SPHERA and E-OBS time series together provide a range within which the CPM and the RCM time series are expected to fall, similar to a ‘confidence interval’." I understand that observations and reanalysis data are taken as a reference. I don't understand why observations and reanalysis data "provide a range" since observations and reanalysis data are not statistical tests. i don't see why CPM and RCM should fall into this range. Please rephrase.

The sentence was rephased for clarity.

“The comparison between climate model simulations and the reference datasets is carried out by computing the Spearman correlation, the Root Mean Square Error (RMSE) and the Normalised Root Mean Square Error (NRMSE) with respect to the range of values, i.e. the maximum value of the variable considered (y_{max}) minus the minimum value (y_{min}), for the reference datasets (SPHERA and E-OBS).”

- line 233, please rephrase the sentence.

We have rephrased it to clarify the objective of the statistical tools we are using:

“In particular, the Spearman correlation coefficient is used to assess the ability of the climate models in reproducing the climate variability of the reference datasets, while RMSE and NRMSE provides a measure of the climate models biases. Moreover, the statistical significance of the model biases is assessed by applying a Welch’s two-tailed t-test (Welch, 1938), with a 95% level of confidence.”

- line 236, "The best subsets regression technique" what do you mean by subsets regression technique, why it is the best - the multi-regression part can be improved by specifically describing how the bioclimatic data is being processed.

The “best subset selection” refers to the approach described by James et al., 2013 (*James G, Witten D, Hastie T, Tibshirani R. An Introduction to Statistical Learning: With Applications in R. 1st ed. 2013, Corr. 7th printing 2017 edition. Springer; 2013)*. We utilize the "best subset selection" approach when constructing the regression model. This approach aims at identifying the subset of predictors (the bioclimatic indices) that most effectively predicts the

predictand (productivity) by considering all potential combinations of independent variables. The method was already employed in a similar study by Massano et al (2023), showing good results. The method is described in the revised version of the manuscript as follow:

“The best-subset selection approach, implemented by James et al. (2013), is used to optimise the prediction of productivity, as in Massano et al. (2023). This approach seeks the subset of predictors, i.e., the bioclimatic indices in this case, that most accurately predicts the predictand, i.e. the productivity, by examining all feasible predictor combinations and thus selecting the one minimising the error in the prediction. This is achieved by utilising the k-fold cross-validation method. The k-fold cross validation method is employed to identify the optimal model (Kassambara, 2017). This method performs cross-validation by randomly dividing the data into k subsets of approximately equal size, with k typically set to 5 or 10 (here k = 5 is used). One of the folds serves as test set and the remaining as training set.”

- line 249, could you explain "the variance explained by the MR model"? variance of what, what does "explain" the variance mean? you mean the model is able to predict

The MR model is used to predict the observed productivity. Its performance is assessed by computing the correlation between observed productivity and the productivity predicted by the MR model. The variance of observed productivity explained by the predicted productivity is estimated as the determination coefficient, i.e. the squared of the correlation coefficient. The sentence has been modified as follows:

“The so-optimised MR model (productivity = a1*index1 + a2*index2 + a3*index3 + ..., with “indexn” indicating the selected bioclimatic index) is then used to predict the productivity and the Pearson correlation between predicted and observed productivity is calculated.

Following Massano et al. (2023), the comparison between the SR and MR methods is performed in terms of the productivity variance explained by the prediction, estimated by computing the coefficient of determination, i.e. the square of the correlation coefficient.”

- the variance of the productivity data to some degree (percentage). The terms here are vague. This applies to similar terms used later on.

This study is based on the analysis of time series by means of correlation and regression analysis. Therefore, we refer in the manuscript to the variance of the distributions of the analysed time series explained by the statistical models used. This applies to climate variables, bioclimatic indices and productivity data. This has been clarified by improving the description of the methodology.

- line 253- 255, sorry i couldn't understand what you mean here, "evaluate biases"; "could lead to biases"

Section 3.1 has been rearranged and line from 253 to 269 has been streamlined to improve readability. We have clarified that the existing bias in the climatic variables, i.e. temperature and precipitation, could result in biases in the bioclimatic indices (that are based on temperature and precipitation).

Now the first paragraph (that was lines 253-269) reads:

“Prior to the computation of the bioclimatic indices, the precipitation and temperature fields in both consortia (FRA and MON) are analysed to assess the potential biases, which could impact on the temperature and precipitation-based bioclimatic indices. Figure 2 for FRA and Figure 3 for MON show the precipitation (P) and temperature (TM: mean temperature, TX: max temperature and TN: min temperature) time series of E-OBS, SPHERA, RCM and CPM for the period 2000-2018. In general, both RCM and CPM well reproduce SPHERA temporal variability, as also confirmed by the high and significant correlations for all the climate variables in both consortia (Table A 2). Nevertheless, both climate models tend to overestimate mean and maximum temperature while underestimating minimum temperature, as reflected by the statistical differences in mean values (Table A 3). Both climate models, and especially the RCM, underestimate precipitation in FRA, while the CPM tends to overestimate it in MON. Precipitation in MON is slightly overestimated also by the RCM. In FRA In FRA, RCM is closer to E-OBS mean values than CPM (Table A3). However, in MON, E-OBS minimum temperature time series shows a strong decrease of almost 2°C between 2015 and 2018 (Figure 3), which is not observed in any models nor SPHERA. Further investigations revealed that this temperature decline is observed throughout the entire TOS and is inconsistent with other observational records (not shown). This E-OBS misrepresentation of the temperature field has a subsequent effect on the mean and minimum temperature time series (Figure 3), the temporal correlations (Table A 2), and is likely to be reflected in the temperature-based bioclimatic indices in TOS region, and at local scale in MON.”

- line 255- 257, what do you mean "common period", are these variables different from your "ten indices"? if it is the statistics over the whole period, please specify that.

Section 3.1 has been streamlined and this sentence has been removed. Please refer to the response to your comment on lines 253- 255 for further details.

- line 255 - 257, since the validation part is important to show the validity of the climate model, why not put it in the main text?

We agree with the reviewer, and we have modified section 3.1 and included the figures that were previously in supplementary. Please see our response to your comment on lines 253-255.

- line 259, "Further investigations highlighted that this temperature fall affects the entire TOS" what do you mean this temperature fall affects the entire TOS? does this decreasing temperature have an influence on the TOS region? please rephrase, make it clear that the indices in the TOS region are influenced by this.

The sentence has been rephrased. Please refer to the response to your comment on lines 253-255 for further details.

- line 264-269, I suggest moving this part before the underestimated temperature part.

This paragraph has been rearranged. Please refer to the response to your comment on lines 253-255 for further details.

- line 265, "reproduce the same variability", high correlations do not mean "variability". please rephrase.

We mean that high correlations indicate that the variables show high temporal co-variability. The sentence has been rephrased, please refer to the response to the comment on lines 253-255 for further details.

- line 266, Table A3, again What are the variables used in the table. please explain and not directly used the term from the code.

The header of Table A3 has been modified accordingly to the Reviewer's comment on line 107.

- line 268, "The Welch's t-test confirmed that E-OBS is closer in mean value to RCM than CPM simulations." please rephrase.

We have modified the text (please see the response to your comment on lines 253-255) as well as the caption of Table A3 for clarity.

- line 297, i don't understand what you mean by "the long-term component."

The time series analysed in the paper can be decomposed into a long-term (low-frequency) component and an interannual variability (high-frequency) component. In the presence of trends, part of the correlation is associated with the trend. This is now clarified as follow:

"Nevertheless, some of these bioclimatic indices (i.e. BEDD for E-OBS and CNI for CPM) as well as the FRA productivity show significant trends (Table A 5 and Table A 7), thus these significant correlations may depend on the long-term variability (i.e. the trend) rather than on the interannual variability.".

- Table A5, Sen's slope needs explanation to the reader. how is the slope calculated? In Table A6, why is only productivity from FRA shown?

Table A5, A6, A7, A8 have been modified according to the Reviewer's suggestion. The Sen's slope of the climatic variable and bioclimatic indices is now displayed in Tables A5 and A6, for FRA and MON respectively. Table A8 now display the Sen's slope for both FRA and MON productivity (previously presented in Tables A6 and A8).

We have added a sentence in the Data and Method section clarifying the use of Sen's slope: "The Sen's slope estimator calculates the rate of change over time of a variable by taking the median of the slopes of all linear regressions between points pairs (Kh Aswad et al., 2020)."

We have improved the tables' captions by adding the Sen's slope definition presented in the Data and Method section.

"Table A 5: Sen's slope estimator, a statistical measure to evaluate the magnitude of the trend, for FRA area. Asterisk (*) indicate a significant trend (p<=0.05)"

"Table A 6: Sen's slope estimator, a statistical measure to evaluate the magnitude of the trend, for MON area. Asterisk (*) indicate a significant trend (p<=0.05)"

"Table A 7: Sen's slope of the productivity in FRA and MON. Sen's slope is a statistical measure used to calculate the rate of change in a variable over time, based on the Sen's estimator. Asterisk (*) indicate a significant trend (p<=0.05)"

- line 298-299, "RCM presents a statistically significant outcome also for TnRest". This statement seems to be a bit vague.

The sentence has been improved as follows:

“RCM presents a statistically significant and positive correlation also between productivity and TnRest, which does not show trend over the period 2000-2018, suggesting that TnRest variability has a role in controlling productivity at the interannual time scale”.

- line 302, could you specify what resolution you used for "the regional scale", just for the comparison.

The sentence refers to the results by Massano et al. (2023), who applied the same methodology to predict the observed productivity aggregated at the regional scale, using E-OBS data. The sentence has been rephrased and moved to the Discussion section: “[…] These results, which are obtained at the local scale using data from wine consortia, complement and expand the previous study conducted at the regional scale by Massano et al. (2023) using ISTAT productivity data and E-OBS (v26, resolution ~11 km) climate data.”

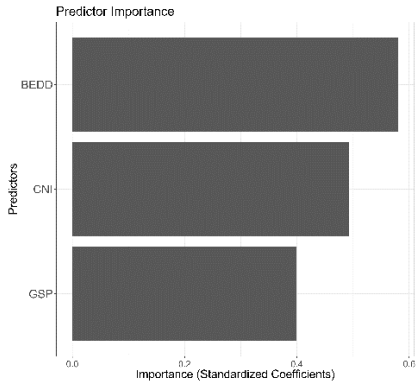
- In FRA (Table 3, line 342), could you explain why MR picks up GSP, a precipitation-based index, in RCM instead of CPM?

We thank the Reviewer for pointing this out, this comment gives us the opportunity to clarify an important aspect of our analysis. We first highlight that the MR is a statistical method that identifies the combination of indices that minimises the error without any consideration of the physical meaning of the selection. GSP from RCM shows high and significant correlation with GSP from CPM and SPHERA, as well as mean values do not show any statistically significant differences. It is surprising indeed that MR picks GSP as a predictor from RCM only. We cannot provide any physical explanation for this behaviour, and we speculate that this is just a statistical artifact, resulting from the selection of an additional predictor, which only adds a residual fraction to the variance of the observed productivity explained by the MR model. To prove this we assess the relative importance of GSP as a predictor by analysing the standardized beta coefficients of the MR in FRA for RCM (Dodge, Y. (2008). The Concise Encyclopedia of Statistics. In The Concise Encyclopedia of Statistics. Springer New York. https://doi.org/10.1007/978-0-387-32833-1). The standardised beta coefficients are expressed in standard deviations, which facilitates comparison of variables. A standardised beta coefficient enables the comparison of the strength of the effect of each individual independent variable on the dependent variable. The greater the absolute value of the beta coefficient, the more pronounced the effect. Table R1 shows that, among the predictors selected by the MR model, GSP exhibits the lowest coefficient, indicating that it had the least impact on the variance of productivity explained by the MR model. The impact on the variance in FRA explained by RCM is estimated by comparing the productivity predicted by the MR model with and without using GSP as a predictor. Results show that including the GSP as a predictor in the MR model produce a correlation coefficient of rho = 0.8 between the observed and predicted yields. When the GSP is omitted, the correlation coefficient slightly decreases to rho = 0.73, a reduction of just 0.07. Furthermore, the model with the GSP accounts for 64% of the variance, while the model without it explains 53%, showing only a modest difference in explanatory power. In conclusion, even though GSP is selected by the MR model for RCM only, it is also the

least relevant predictor. This could explain why it is not selected by the MR model for CPM and SPHERA, despite the high correlation between the series.

Table R1: Standardized coefficients of the MR model for RCM in FRA; the accompanying bar plot presents the coefficients in a visual format, facilitating comparison.

Intercept	0.00000
BEDD	0.58036
CNI	0.49247
GSP	0.39856



We have added the following paragraph in the manuscript:

“The selection of GSP for the RCM is unexpected. Indeed, although GSP from the RCM shows high and significant correlations with both the CPM (not shown) and SPHERA (Figure 6), it is not selected by the MR model for the CPM and SPHERA. The comparison between the standardised beta coefficients (ref. Dodge 2008) of the MR model for RCM in FRA shows that GSP has the least impact on the explained variance of the observed productivity, suggesting that the selection of GSP for the RCM only might be an artifact of the statistical model.”

- line 379, "in a small number of cases". do you mean a small number of indices?

We actually mean “indices”. Modified as follow: “Overall, the single regression exhibits high correlation coefficients, but statistically significant results are only found for a small number of indices at the 95% confidence level”

- It would be beneficial if the authors could include a discussion on future

Following the reviewer’ suggestion, we add a comment on this in the Discussion and Conclusion section.

“Nevertheless, in a changing climate, with precipitation frequency and intensity expected to change (Tramblay and Somot, 2018; Zittis et al., 2021), the relevance of precipitation, along with precipitation-based bioclimatic indices, for grape productivity might increase and in turn the use of CPM might become crucial.”

Technical corrections:

- line 7, "..., it influence the suitability...", please clarify "it" and rephrase the sentence.

The Abstract (line 7 to 19) has been rewritten to enhance its focus and alignment with the paper's aim, following the comments from both reviewers. The new abstract is the following:

“The article explores the potential use of climate models to reproduce wine grape productivity at local scale in Italy. To this end, both single and multiple regression approaches are used to link productivity data provided by two Italian wine consortia with bioclimatic indices. Temperature and precipitation-based bioclimatic indices are computed using the observational dataset E-OBS, the high-resolution climate reanalysis product SPHERA, the regional climate model CNRM-ALADIN and the km-scale convection-permitting climate model CNRM-AROME. The multiple regression method outperforms the single regression, systematically enhancing the ability of bioclimatic indices to explain productivity variability. The results show that productivity is strongly tied with temperature-based bioclimatic indices in the area of “Consorzio per la tutela del Franciacorta” in northern Italy, while for the “Consorzio del Vino Nobile di Montepulciano” area in central Italy both temperature and precipitation-based indices are relevant. Climate models, providing similar results as E-OBS and SPHERA, appear to be a useful tool to explain productivity variance. In particular, the added value of convection-permitting resolution becomes evident when precipitation-based indices are considered. This assessment shows windows of opportunity for using climate models, especially at convection-permitting scale, to investigate future climate change impact on wine production.”

Line 7 to 9 were rephrased and moved to the Introduction section where are more relevant. Now the introduction starts with:

“Viticulture is tied to climate, that influences the suitability of an area, the yield and quality of wine grapes. The wine industry has a significant socio-economic influence and is a key agricultural sector in Italy. In 2022, Italy was the world's leading wine producer (49.8 million hl), and the second largest wine exporter, with a value of 7.8 billion euros (OIV, 2023). Over the coming decades, the wine sector is expected to be affected by climate change, especially in Italy that is part of the Mediterranean climatic hotspot (Tuel and Eltahir, 2020), where the impact of climate change is expected to be more severe than the global average.”

- line 8, "at risk" no hyphen

Thank you we have modified it, please refer to the response to line 7 comment for further details.

- line 12, delete "by"

We have done it, thank you. Please refer to the response to line 7 comment for further details.

- line 16, "..., however, .." split the sentence.

We have modified it, please refer to the response to line 7 comment for further details.

- line 50, remove "the" "the wine consortia"

We have done it, thank you.

- line 53, "Thanks to" informal

Thank you, we have rephrased it.

- line 53, "without the need for parameterisation," this is inaccurate. most of the parameterizations are turned on in CPM models.

Thank you, we have rephrased the sentence: “Due to their high spatial resolution (less than 4 km), CPMs can represent convection explicitly, without using the parameterisation of deep convection, and thus reduce the model uncertainty (Fosser et al., 2024).”

- line 64, "added-value" no hyphen

Thank you, we have modified it.

- line 71, "as well as the hectares devoted to viticulture" can be concise: "planting area"

Thank you, we have rephrased it: “the hectares of vines”.

- line 73, are "LOM" and "TOS" used a lot later in the text, if it is not, you may consider not use these acronyms since there are already many.

Thank you for the suggestions, however we have decided to keep the acronyms because they streamline the text and align with the cited literature (Massano et al., 2023).

Massano, L., Fosser, G., Gaetani, M., & Bois, B. (2023). Assessment of climate impact on grape productivity: A new application for bioclimatic indices in Italy. Science of the Total Environment, 905. https://doi.org/10.1016/j.scitotenv.2023.167134

- line 77, "thanks to" same as the above

Thank you, we have rephrased it.

- line 79, same as the comment in line 73

Thank you for the suggestions, please refer to the response to line 73 comment.

- line 94, "the grape yield", remove "the"

We have modified it. We thank the reviewer for spotting the error.

- line 98, , after e.g. "e.g.,"

We have modified it. We thank the reviewer for spotting the error.

- line 99, "the productivity", remove "the"

We have modified it. We thank the reviewer for spotting the error.

- line 98, remove "the" before productivity

We have modified it. We thank the reviewer for spotting the error.

- line 99, remove "the"

We have modified it. We thank the reviewer for spotting the error.

- line 100, provide data of …

Thank you, we have modified it.

- line 100, "the area devoted to vines" please rephrase this.

Thank you, we have modified it: “vintage area”.

- line 100 -104, missing "the"

Thank you, we have modified it.

- line 103, and at the national scale.

Thank you, we have modified it.

- I will stop commenting on the usage of articles.

Thanks for your comments, we have checked the manuscript for misuses of the articles.

- line 689, with? Do you mean "with"

Yes, we have corrected it.

- line 129, delete "the period"

We have done it, thank you.

- line 218, "RSME" - RMSE, also, explain what it is when you mention it the first time.

We have done it, thank you.

- line 218, "the percentage differences of RMSE with the mean of the reference" this is the normalized RMSE

Thank for pointing that out. We have modified the text and table accordingly. Furthermore, in the revised version of the paper we have opted to normalise the RMSR with respect to the range of values. The normalization method of RMSE is descripted as: “[...] Normalised Root Mean Square Error (NRMSE) with respect to the range of values, i.e. the maximum value of the variable considered (y_{max}) minus the minimum value (y_{min}), for the reference datasets (SPHERA and E-OBS).”

- line 219, remove "the". I will stop commenting on the usage of articles.

Thanks for your comments, we have checked the manuscript for misuses of the articles.

- In all line plots, please change your legends indicating the right datasets (dashed, solid)

We have done it, thank you.

- The ticks and legends are barely visible in the plots of the appendix.

Figures in the appendix have been improved.

- line 295, "for some of the temperature-based indices"

We have modified it.

- line 295, "few cases"

Thank you we have modified it.

- line 346, "in other datasets"

Thank you we have modified it.