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-2

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

Summary

The manuscript explores the impact of convection-permitting climate model data on assessing wine grape productivity. The analysis utilizes observed wine productivity data from two consortia located in Italy. First, the climate data are compared with both meteorological observations and reanalyses to evaluate their quality. Second, single and multiple regression analyses are conducted to investigate the potential of climate-related indices to “predict” wine

productivity. The results show correlations between bioclimatic indices (in particular temperature-based indices) and wine productivity, suggesting their potential use in assessing future changes.

General comments:

The manuscript is well written, data and methods are described adequately; the topic treated adheres to the journal's scope. In my opinion, the manuscript would benefit from a more extensive discussion comparing the findings to previous similar studies or applications of CPM climate data in agriculture. Additionally, providing in-depth comments on the potential impact of this research, particularly its implications for future grape productivity, would underscore the relevance of the study. My general assessment is that the manuscript doesn't have any relevant flaws that prevents its publication. My recommendation is to accept the paper, provided that the specific remarks below are addressed.

English is not my native language and I have no comments on it.

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

TITLE

I suggest modifying the title, e.g., from "Using a convection-permitting climate model to predict wine …" to "Using a convection-permitting climate model to assess/estimate wine grape productivity: two case studies in Italy". In fact, the authors make use of single/multiple regression to explain the variance of wine productivity data and not to predict them.

Thanks for this suggestion, we have modified the title in *"Using a convection-permitting climate model to assess wine grape productivity: two case studies in Italy"* to better fit the content of the paper.

ABSTRACT

General comment

lines 7-9: "Viticulture is tied to climate, it influences the suitability of an area, yield and quality of wine grapes. Therefore, traditional wine-growing regions could be threatened by a changing climate. Italy is at-risk being part of the Mediterranean climatic hotspot and judged in 2022 the second-largest exporter of wine worldwide."I suggest removing this sentence as the opening statement. It is redundant in the Abstract but appropriate for the Introduction section.

The sentence has been removed from the abstract and integrated into the introduction, as follow:

Introduction: "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)."

The Abstract now reads:

Abstract: “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 is 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.”

Specific comments

Line 13: “and both the Regional and the Convection-permitting…” which models? If not detailing them, use the article “a” instead of “the”.

The names of the analysed models are now indicated (CNRM-ALADIN and CNRM-AROME): “[…] the regional climate model CNRM-ALADIN and the km-scale convection-permitting climate model CNRM-AROME.”

Line 14: “The potential of CPMs”, which CPMs? One CPM or multiple CPMs? Remove the “s”

We extensively rephrase the abstract, now this concept is expressed as: “[…] the added value of convection-permitting resolution […]”. Please see the response to the comment to lines 7-9.

line 17: “of CPM, became” remove the comma “,” which currently lies between the subject and the verb.

We thank you the reviewer for spotting the error.

line 17: “of CPM, became” mixed use of present and past. Please change to “becomes”.

We thank you the reviewer for spotting the error.

1. INTRODUCTION

General comment

The Introduction is adequate and presents the state-of-the-art and the innovative approach of the research (from line 50 to the end of the section). As stated previously and for the reasons claimed by the authors in the Introduction (see lines 65-66: “Single and multiple regression approaches are used to determine the extent to which bioclimatic indices can explain changes

in wine grape productivity at the local scale"), I suggest modifying the title by removing the word 'predict' and replacing it with a more generic term such as 'assess' or 'estimate.' In fact, predicting implies providing the accuracy of the predictions, including associated errors and uncertainties, rather than just the R-squared value of the regression.

We agree with the reviewer and have modified the title as suggested.

Specific comments

line 21: I would start the Section with the first sentence of the Abstract, which I found redundant in that context.

The first paragraph of the introduction has been modified, and the redundance fixed:

"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)."

Line 21-22: "Wine-growing has a strong socio-economic impact and is one of the principal agricultural economic activities in Italy, that in 2022…" I would change to "Wine-growing has … in Italy. In 2022…"

Thank you for the suggestion, we have modified as suggested.

line 22: "world's leading wine producer (49.8 million hl)" Can the authors provide any reference to support this statement?

We have added the reference: OIV, 2023: STATE OF THE WORLD VINE AND WINE SECTOR IN 2022.

line 22: "and second" change to "and the second"

Thank you for spotting the error, we have corrected.

line 27: "than the global average (Bernetti et al., 2012;.." Can you provide a more climatic-sound references to support such sentence? Further, these two references could be moved below (i.e., line 28)

Following the Reviewer's suggestion, we have added the following references:

Giorgi, F. (2006). Climate change hot-spots. Geophysical Research Letters, 33(8), 1–4. https://doi.org/10.1029/2006GL025734

Roehrdanz, P. R., & Hannah, L. (2016). Climate Change, California Wine, and Wildlife Habitat. Journal of Wine Economics, 11(1), 69–87. https://doi.org/10.1017/jwe.2014.31

Santillán, D., Garrote, L., Iglesias, A., & Sotes, V. (2020). Climate change risks and adaptation: new indicators for Mediterranean viticulture. Mitigation and Adaptation Strategies for Global Change, 25(5), 881–899. https://doi.org/10.1007/s11027-019-09899-w

line 31: “when frost events are still frequent” I think the word “still” can be removed to streamline the sentence

The sentence has been rephrased in response to a comment from Reviewer#1.

“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: “are expected to experience important shifts in viticulture suitability that can consequently causes a decline in production” “causes” or “cause”? What is the subject? “shifts” or suitability?

The sentence has been rephrased:

“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 causes a decline in production (Adão et al., 2023; Rafique et al., 2023; Sgubin et al., 2023; Tóth and Végvári, 2016).”

Line 36: “developed” change to “computed” or something else

The word has been changed as suggested

line 48: modify “) (“

The sentence was modified to improve readability:

“To valorise the designation of origin and guarantee a defined level of quality (Gori and Alampi Sottini, 2014; Ugaglia et al., 2019), producers are organized in wine consortia (Consorzi di Tutela) according to the EU and national regulations, i.e. Regulation (EU) No 1308/2013.”

line 65: “are used to determine the extent to which” change to “are used to determine to which extent”?

We have changed the sentence as suggested:

“Single and multiple regression approaches are used to determine to which extent bioclimatic indices can explain changes in wine grape productivity at local scale.”

2. Data and Methods

General comment

I think it should be explained better why the authors used Aladin/Arome model outputs rather than SPHERA or other regional CP reanalyses. Can the authors stress the differences in the experimental design of numerical simulations? As stated in the manuscript, Aladin model is fed by ERA-Interim data, whereas SPHERA is fed by ERA5. Which is the difference? SPHERA are started frequently (once a day?) and receive boundary conditions every hour. What about the

Aladin/Arome numerical architecture? The authors should give the audience a taste of the differences without delving into the suggested bibliography.

The major difference between climate models (GCM, RCM or CPM) and any reanalysis dataset is that the latter assimilate observations and accurately reproduce the observed temporal variability, at least for the variables that are assimilated. Clearly the shortcoming of any reanalysis datasets is that cannot be used for climate projections. In our work, we aim to prove that also RCMs, and especially CPMs, can be used for evaluating the impact of climate on viticulture. This would open the path for studying the impact of future climate change on wine productivity.

We have clarified this aspect and we have added further details on SPHERA reanalysis dataset as well as on the climate models. In particular, Section 2.2 "Climate observations and reanalysis data" has been improved with additional information regarding the data employed and a more comprehensive justification for the selection of these specific data sources. Please find the relevant changes reported below:

"In addition to observations, the analysis uses a high-resolution convection-permitting reanalysis product, called SPHERA (High rEsolution ReAnalysis over Italy; Cerenzia et al., 2022; Giordani et al., 2023), produced by ARPAE-SIMC (Agency for Environmental Protection of the Emilia Romagna Region, Italy). Based on the non-hydrostatic limited-area model COSMO (Schättler et al., 2018; Baldauf et al., 2011), SPHERA dynamically downscales the global reanalysis ERA5 (Hersbach et al., 2020) boundary condition, updated every hour, in sequence of 24-h-long integrations. Being a reanalysis product, SPHERA assimilates in situ observations using a continuous nudging approach based on the Newtonian relaxation principle (Stauffer & Seaman, 1990). The quality-checked observational data nudged in SPHERA are wind speed components, pressure, air humidity, and temperature (excluding 2m temperature) derived from ECMWF catalogue, i.e. SYNOP, SHIP, TEMP, PILOT and AIREP. More details on the SPHERA configuration can be found in Cerenzia et al. (2022). This new reanalysis product covers Italy at a horizontal resolution of 2.2 km with a temporal coverage of 26 years (1995-2020). When validated against independent rain gauge observations, SPHERA showed an improved representation of the precipitation field, both at daily and hourly scale, compared to its driver, i.e. ERA5 (Giordani et al. 2023). The performance of SPHERA demonstrates that it can be a valuable resource for improving climate monitoring by providing insights into regional climate change impacts (Giordani et al., 2023). The SPHERA data, provided at hourly time steps, have been aggregated at the daily time scale for the purposes of this study.

In this study, the E-OBS dataset and SPHERA reanalysis are both employed as a reference. This strategy enhances the validation process and evaluate the potential of a reanalysis product to serve as an alternative to observation for the validation of climate models as well as for viticulture studies."

We have also added new information in the Section 2.3 "Climate model data" that now reads:

"The French Centre National de Recherches Météorologiques (CNRM) provides two climate simulations spanning the period 2000-2018. The first simulation, covering the Med-CORDEX domain (Ruti et al. 2016) at 12.5 km resolution, is performed with the RCM CNRM-ALADIN (Nabat et al., 2020), the limited area version of ARPEGE-Climate global model, driven every 6

hours by the ERA-Interim (80 km) reanalysis (Dee et al., 2011). The second one is performed with the CPM CNRM-AROME, driven by the CNRM-ALADIN simulation every hour, and covers with a resolution of 2.5 km the pan-Alpine domain defined within the CORDEX FPS on Convection programme (Lucas-Picher et al., 2023; Coppola et al., 2020). In contrast with any reanalysis datasets (e.g., SPHERA), climate models do not assimilate observations. This has the disadvantage to lead usually to larger biases than reanalysis (at least for variables which are assimilated in the reanalysis), but the advantage that they can be used for climate projections. The main difference between CNRM-ALADIN and CNRM-AROME resides in the parameterisation of deep convection, which may be source of errors and uncertainty (e.g., Prein et al., 2015), active in the former and switch off in the latter. In addition, CNRM-AROME, being a kilometre-scale model, allows a more accurate representation of surface and orographic features. Both models have been extensively evaluated (e.g., Daniel et al. 2019; Nabat et al. 2020, Coppola et al. 2020b; Fumière et al. 2020; Ban et al. 2020; Pichelli et al. 2020). In particular, Caillaud et al. (2021) found that the CNRM-AROME, besides an underestimation of the highest intensities, realistically represents autumn extreme precipitation at both daily and hourly timescale in terms of location, intensity, frequency and interannual variability, while CNRM-ALADIN fails to do so. Both CNRM-ALADIN and CNRM-AROME (hereafter simply called respectively RCM and CPM) provide hourly output, which are aggregated at the daily time scale for the purpose of this study."

Specific comments

Figure 1: In both the digital and hardcopy versions of the manuscript, the geographical locations of the two consortia are difficult to discern from the images. Could the authors provide larger images and/or magnify the map of Italy?

Figure 1 has been modified to improve readability.

Line 102: "at regional level between 1994 and 2000; at national scale while" change to "at the regional level between 1994 and 2000; at the national scale while"

We have modified as suggested.

line 103: "at national scale while from 2000 to 2005" sentence not clear. Perhaps just remove "while"

We have modified as suggested.

line 112: remove the acronym "NMHSs" since it is used only once

We have removed the acronym as suggested.

line 124: "SPHERA reanalysis" change to "The SPHERA reanalysis" or just "SPHERA"

We have modified as suggested.

line 124: SPHERA is validated against a gridded dataset made of independent rain-gauges. ERA5 data are used as a benchmark. Please specify better.

Thank you for comment. We have clarified as follow:

"When validated against independent rain gauge observations, SPHERA showed an improved representation of the precipitation field, both at daily and hourly scales, compared to its driver, i.e. ERA5 (Giordani et al. 2023)."

line 138: "." is missing at the end of the text

Thank you for spotting the error. We have corrected it.

line 163: "but also take" change to "but also takes"

We have modified as suggested.

line 199: "Tests performed to investigate…are not impacted by the resolution chosen for the remapping (not shown)" I think the authors should give more details about the tests performed. At least they should say whether the tests were performed on the remapping strategy (i.e., the algorithm) or on the resolution (i.e., the final grid spacing). Please expand this point and give some details

We modified the sentence as follow:

"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 205: "weighing" please replace with "weighting"

Thank you for spotting the error. We have corrected it.

line 214: "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 disagree; can the authors support this statement by providing evidence?

We agree with the Reviewer that the sentence was confusing, and it has been removed. The whole paragraph has been rephrased:

"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). 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 217: I don't get why E-OBS are used within the parenthesis Line 221: too many "()"

We have corrected it as suggested.

3. Results

General comment

I don't see why many Figures/Tables that are commented in this Section are taken from the Appendix (e.g., lines 255, 258, 261, 265, 267, 277, 298, 306, 316). This doesn't help the readability of the manuscript. I encourage the authors to rethink this section. For example, it should start from line 269 "Figure 2 and Figure 3 show the ten bioclimatic…" and the first sentence "The precipitation and temperature time series of both…" could be moved elsewhere in the manuscript (Discussion or Appendix). Alternatively, some tables/plots shown in the Appendix could be streamlined (e.g., Table A 4 which has many columns and rows) or simply removed and their content moved into the text (e.g., Table A 6, Table A 8). Table 2 is hard/difficult to read. I wonder whether a plot could help its readability. I suggest the authors to reconsider it. If they decide to keep it, I suggest to remove the RMSE column, since it is not commented in the text. Further, it is shown the RMSE% which is more informative since the ranges of bioclimatic indexes are very different.

Following the Reviewer' suggestion, we have rethanked this section.

The first paragraph of this section has been streamlined and now 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. In FRA the variability observed in E-OBS is always reproduced in both climate simulations with RCM being 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 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."

Table 2 has been replaced by Figures 4 and 5, which show the correlation coefficient and the NRMSE for each index of the comparison between the climatic sources used, for FRA and MON respectively.

Moreover, Table A6 and A8 have been aggregated in Table A7 that now contains the Sen's slope of productivity in both FRA and MON consortia. "Table A7: 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)"

Specific comments

line 276: “(Table 2)” remove empty space

Thank you, we have removed them.

line 296: “CNI with model simulations” change to “CNI with model climate simulations” or simply “CNI with climate simulations”, in fact, SPHERA is a model simulation too.

Changed as suggested: “climate model simulations”.

lines 302-306: I would like to see this paragraph in the Discussion section, where it is more pertinent.

We have removed the paragraphs 302-306 and 325-330 from this section as suggested. The concept that was presented here is now addressed in the Discussion section; the relevant paragraph is reported below:

“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 fact, they did not find any statistically significant correlations for LOM or TOS region, where FRA and MON respectively lie, for neither with temperature-based nor precipitation-based indices. At the contrary, in this work the MR can explain up to 64% in FRA with RCM and 45% in MON with the CPM. This indicates that working at a local scale and including a larger variety of bioclimatic indices is crucial to improve the portion of productivity variance explained by the bioclimatic indices.”

lines 325-330: as above

We have modified the paragraph following the Reviewer’s comment. Please refer to the response to the comment on lines 302-306 for further details.

Table 3: Can the authors discuss why, in MON, the variance of E-OBS is 44% for the SR case and 32% for MR? Is it related to the poor quality of E-OBS data (in MON) as argued previously? This happens also for RCM although to a smaller extent (32%→29%). I would like to see a plausible explanation in the Discussion section

The variance in SR is simply calculated as the square of the Spearman correlation between the single bioclimatic index and the observed productivity. The MR uses the k-fold method to select the relevant bioclimatic indices and determine the coefficients to predict the productivity with a formula such as productivity = a1*index1 + a2*index2 + a3*index3 + … We then calculate the variance as the square of the Pearson correlation between the predicted and the observed productivity.

In case only one bioclimatic index is selected, the correlation (and therefore the variance) might be different from the SR method. In fact, with the MR the correlation is calculated between observed productivity and α*Index1 (i.e. the predicted productivity) and not between observed productivity and Index1 as in SR. in addition, the SR and MR method use a slightly different type of correlation, Spearman in the former and Pearson in the latter.

We have added a paragraph in the Data and Methodology section to better explain it, and we have modified the caption of Table 2 to recall the definition.

"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."

We have also clarified in the discussion between SR and MR performance in section 3.2.2: "To note that the decrease in performance from SR to MR method only occurs when only one bio-climatic index is selected in the MR. This could be linked to coefficient included in the MR (i.e. productivity=a1*Index1) or to the different type of correlation used in SR (Spearman) and MR (Pearson)."

And again, in the Discussion and conclusion

"When more than one bioclimatic index is relevant, the multi-regression method outperforms the single regression approach, systematically enhancing the explanatory power of bioclimatic indices regarding productivity variability. Furthermore, the method has the potential to deliver predictors that are fit for purpose."

4. Discussion and conclusion

General comment

I think this section lacks a critical review of the results found in comparison with previous studies. It looks like a summary of the manuscript. If no or few previous studies are found, it should stress the novelty of the study and highlighted the potential and limits of CP model data in assessing productivity.

Further, the main advantage of using CPM data is the removal of any parameterisation to model convection processes. Indeed, it is well known they provide more accurate precipitation estimates than RCM data (e.g., lines 53-55). However, you found that wine productivity is mostly related to temperature-based bioclimatic indexes rather than precipitation-based one. Do the authors have any comment on it?

We are grateful to the Reviewer for drawing attention to the shortcomings of this section, which drove a comprehensive revision and expansion of the part.

In particular, in order to stress the novelty of the work here presented, we have added the following paragraph in the Introduction section:

"Nevertheless, no prior studies have employed CPMs to examine the influence of climate variability and change on viticulture.

The present study presents a novel approach to estimate wine grape productivity at the local scale by using a CPM, showing windows of opportunity for the use of CPMs in the context of ongoing and future climate change."

And in the Discussion and conclusion section:

“This study represents, to the best of the authors' knowledge, the first application of a CPM to investigate the impact of climate variability and change on wine grape productivity, through the use of bioclimatic indices.”

The predominance of the impact of temperature over precipitation on productivity is a fact in viticulture. We have addressed it in the introduction:

“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.”

Furthermore, this aspect is considered in in the Discussion and conclusion section, when the limitations of the CPM in this particular application are discussed:

“When the MR approach is applied, climate models appear to be a useful tool to explain the variability of productivity, improving the results obtained using E-OBS. However, the use of the CPM does not show a clear added value with respect to the RCM, since it performs better in MON, but not in FRA. This could be linked to the fact that temperature is generally the main driver of wine grape production, and the added value of the CPM become more evident when precipitation is a dominant factor, as in MON. 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, on grape productivity might increase and in turn the use of CPM might become crucial.”

Specific comments

line 401: “This could be link” replace with “This could be linked”

Thank you for spotting the error, we have corrected it.

References

line 573: incomplete reference

Thank you for spotting the error, we have corrected it.

Appendix A

Figure A2 provided in poor quality when on hardcopy

The quality of the figure has been improved and it has been moved to the main text in Section 3.1 “Validation of the climate simulations”.