

Reply to anonymous referee 1

We would like to thank the anonymous referee 1 for his truly relevant comments on the manuscript and we are glad he finds this work presents an interest for the hydrogeological community. We agree with most of the comments and we propose an answer for each specific comment hereafter.

Comment:

1. I believe that the manuscript should be divided into two separate papers. In the paper discussed now, only the most important descriptions, results and discussions of three types of statistical analyses performed for only four storylines should be left. However, storyline No. 4 seems unlikely, so its description and results should be moved to the Supplement Material. Similarly, the RCP2.6 path is rather unlikely, so the description of the study and results for this path can also be moved from the main text to the Supplement Material.

- Reply: the referee is right about the manuscript being quite long, which does not help for the clarity of the main messages. However, the authors do not believe that splitting this article into two different articles, a first describing results from all the CPs and a second focusing on the storylines, is relevant as they consider that both sets of analyses are complementary and should not be dealt with separately. This point of view is shared by the EXPLORE2 project community, to which this work is part. However, the authors understand the comment of the referee and propose to mainly focus the analyses on the storylines inside the main text and to provide the analyses from all the CPs in the supplementary material, as the referee suggested. Moreover, the authors propose to improve the readability of the manuscript by reducing some redundant elements to supplementary material.

Comment:

2. A report of studies based on all the available climate projections (CP) can be successfully published in the second paper, in the discussion of which the obtained results can be related to the results for the storylines. Or vice versa - depending on the authors' decision.

- Reply: as mentioned in the response to the first comment of the reviewer, the authors believe that splitting this article to two different articles is not relevant as both sets of analyses are complementary and should not be dealt with separately. The authors propose to focus in the main text on the storylines and to move the analyses from all the CPs to supplementary material. In the main article, the spread on the different CPs will still be first presented on Figure 3, in order to show how relevant are the four storylines.

Comment:

3. The justification for removing descriptions of tests performed for RCP2.6 from the main text are, among others, section 3.2, Fig. 5 and Table 5. This is all unclear and too far removed from the main thrust of this paper, i.e. spatial projection of climate change on a regional scale. Considering the description in the text, it seems possible to move Table 5 to the Supplement.

- Reply: the authors agree with the referee's suggestion. As mentioned in the previous responses, this part will be focus on the storylines and the results from the statistical tests (previously Table 5) will be moved to supplementary material.

Comment:

4. Table 1 should rather be in the Supplement because it is additional information and does not directly concern the main research problem solved by this study.

- Reply: as requested, Table 1 will be moved to supplementary material.

Comment:

5. line 113 – it is unclear what "strong seasonal contrast" means in story No. 3 (Purple) – this should be explained.

- Reply: the sentence was unclear, the seasonal contrast being associated to precipitation. The purple storyline is characterised by “strong seasonal contrast **in precipitation**” with the winter season having large amount of precipitation, while summer season has low amount of precipitation (Marson et al., 2024). This point will be clarify in the main text.

Comment:

6. lines 140-143 - models EROS and HS1D - since these 2 models have not been taken into account in this study, why mention them (it only makes the text harder to follow).

- Reply: as requested, to shorten the text, the mentions and descriptions of the models EROS and HS1D will be removed from the main text.

Comment:

7. Lines 144 – 160 - models EauDyssee and MARTHE - these descriptions are not necessary in the main text and can be moved to the Supplement. Only the sentence in lines 157-159 is important for the main text.

- Reply: the authors are willing to keep a short description of the two hydrogeological software packages in the main is important as this prevents the reader to refer himself to the supplementary material to quickly understand the processes modelled by the Aquifer platform. However, as suggested by the reviewer this part will be reduced and clarified.

Comment:

8.lines 173 -177 - excessive detail - can be moved to the Supplement.

- Reply: as for the description of the hydrogeological software packages, the authors think that moving this part to supplementary material is not necessary as Table 3 will be moved to supplementary material, which will clarify this section without requiring the reader to refer to the supplementary material excessively.

Comment:

9. Table 3 - can be moved to the Supplement because Figure 3 shows the modelled catchments well.

- Reply: as requested and as mentioned as the response to the previous comment, Table 3 will moved to supplementary material.

Comment:

10. lines 193-196 - I don't understand how the SPLI values were calculated. Are they based on frequency percentages? The description should be clearer, because that's the basic element of this research.

- Reply: the referee is right, the description of the SPLI was not clear enough. The calculation of the Standardized Piezometric Level Index is similar to the calculation of the Standardized Precipitation Index (SPI) (McKee et al., 1993). The SPLI is an indicator used in the French Monthly Hydrological Survey published each month. Details about its computation are given in Seguin (2015). Considering a piezometric head time series of N years, the steps are the following:
 - Step 1: the monthly mean time series from the reference data is computed;
 - Step 2: constitution of twelve monthly time series (January to December) over the N year period. For each time series of N values, a non-parametric kernel density estimation (KDE) allows estimating the best probability density function (pdf) fitting the reference histograms. As time series of piezometric heads show a big variety of histogram, the use of a KDE to estimate a pdf fitting the reference histogram is preferred;
 - Step 3: For each month from January to December, the adjusted cumulative density function is deduced, and a projection over the standardized normal distribution allows deducing the SPLI.

This part will be clarified in the main text, section 2.3.1, and Figure 2 will be redrawn to better illustrate the calculation method.

Comment:

11. sections 4.1 and 4.2 - confirm that this manuscript is too burdened with too much information, analysis and discussion. All of these strays too far in different directions from the main topic given in the title. This should be an article about just one specific study - either about the storylines or about the all available CPs , depending on the authors' decision. It is also possible to propose two publications under one common main title, divided into Parts 1 and 2, respectively covering the indicated topics.

- Reply: the referee is right that the manuscript is too long, but as mentioned in the previous responses, the authors do not believe that splitting this article into two different articles is relevant. They propose to focus the main analyses on the storylines and to

provide the analyses on all the CPs from the three RCPs in supplementary material. Ultimately, the discussion will be simplified, clarified and focused on the long-term horizon, which may be sufficient to address the issue raised by the referee about the lack of key messages in the paper and its length.

References:

Marson, P., Corre, L., Soubeyroux, J.-M., Sauquet, E., Robin, Y., Vrac, M., and Dubois, C.: Rapport de synthèse sur les projections climatiques régionalisées, METEO FRANCE, INRAE, Institut Pierre-Simon Laplace, Toulouse, France, 2024.

McKee, T. B., Doesken, N. J., and Kleist, J.: The relationship of drought frequency and duration to time scales, Proceedings of the 8th Conference on Applied Climatology, California, 179–183, 1993.

Seguin, J.-J.: Proposition d'un indicateur piézométrique standardisé pour le Bulletin de Situation Hydrologique 'Nappes,' BRGM, Orléans, France, 2015.