REPLY TO THE COMMENTS OF THE REFEREE #2

I appreciate the timing and efforts of the authors in the preparation of this manuscript. There is so much geological and hydrogeological information provided in the paper, and in my opinion, all of them are valuable pieces of information. Overall, the manuscript needs significant improvements, particularly in the writing format. The submitted paper is prepared like a thesis, the number of sub-sections is too much, which makes the paper unreadable. Some of these sub-sections should be merged appropriately. The authors must re-organize the whole paper according to the manuscript format.

Thank you very much for the time and effort spent reviewing this article. We believe that we have taken into account each and every one of the observations made to us.

As recommended, an effort has been made to unify subsections and unnecessary information has been removed where possible.

Secondly, this paper is mainly focused on the improvement of the thermal spring protection area through numerical modeling and interdisciplinary studies, however, when I was reading the manuscript, I felt like reading a regional study, pointing out the importance of a local geothermal system. The paper needs to address what are the new methods to better reveal the protection areas by comparing the existing methodology and approaches. What are interdisciplinary studies currently available (e.g. hydrochemistry and environmental isotopes), or newly used? Are there similar applications in the literature? The novelty of the study (if available) should be emphasized. In my opinion, the authors focused on the modeling phase too much, which shaded other sections.

As a preliminary phase to delimiting the protection areas, the Introduction briefly addresses what interdisciplinary methods exist to identify the recharge areas of springs, and what this article is about. These methods are referred to in our particular case, partly to show that they are not overshadowed by the mathematical model. Classic references and relatively recent examples that have been recommended are cited. And the novelty of the present study is emphasized, which constitutes an example where not only have almost all classical techniques been applied, but other innovative ones have been integrated, such as the existence of widespread paleokarstifications in the thermal aquifer and a mathematical flow model.

Considering these major comments and minor recommendations (added in the pdf file), I recommend a major revision.

Kind regards,
The reviewer.
Major comments

With the intention of facilitating the review process, we have worked hard since receiving the reviewers' comments to update the manuscript with the comments you have sent us.

In any case, we respond one by one to the comments that have been made to us, and we greatly appreciate them.

The introduction must be tidied up. State of the art is not shared, and the aim of the study is not clear.

“As said before, the introduction briefly develops the state of the art on interdisciplinary methods to delimit the recharge areas of springs, as a preliminary phase to the protection areas. Classic references and relatively recent examples that have been recommended are cited.

The objectives are clarified, highlighting the main objective.

Since we cannot attach the manuscript, we paste here part of the introduction that we have updated. The following paragraph will be located after line 65.

“Thus, the first question that must be resolved for the protection zoning of an aquifer system that drains a spring is to find out its catchment area or recharge area. The delimitation of catchment areas requires knowledge of a combination of topographical, geological factors, hydrogeological and hydrological considerations, etc. The geometry of an aquifer is generally defined by stratigraphic, tectonic and topographic elements. Indeed, an aquifer that drains towards a spring is a geological body, characterized by its geometry and internal structure, hydrogeological properties and hydraulic boundary conditions

To understand these characteristics, a variety of research methods can be used, such as hydraulic balances, natural tracers and artificial tracer tests; In karst hydrogeological systems, allogeneic basins should also be taken into account. (Goldscheider and Drew, 2007, Goldscheider, 2010).

Topography has an important influence on groundwater flow patterns and the recharge area of a spring is always situated above the spring level, although flow can also occur below. This level, with flow lines rising from deeper areas of the aquifer towards spring discharges (except in volcanic areas) are the most obvious manifestation of hot groundwater rising to the surface, although the recharge area is always It is located at a higher altitude; We will see this in our case. We will also see in our karst system how the relationship between topography and the dividing lines between neighboring hydrographic basins is not so simple, since the flow of groundwater from the thermal aquifer crosses below the Duero-Ebro dividing line.

Determining the water balance helps quantify the size of the spring catchment area. In general, a water balance not only provides the minimum size of the spring catchment area, but also the transfer from other aquifers or the upward flow of deep groundwater in large-scale regional flow systems. All of this can further complicate or limit the application of water balances, but in our case we have validated it with the application of a flow model.

Natural and artificial tracers can help delineate the spring catchment. Natural tracers include water temperature, which has been underutilized but may have great potential (e.g., Anderson, 2005, discussing it for large sedimentary basins; Wagner et al. (2014) in field experiments). . As will be seen, in our case the correspondence of the depths reached of the flow lines of the system with the different temperatures of the springs associated with each of them is very clear. The chemical composition of water, stable isotopes, and other parameters are also included as natural tracers (for example, and for a low-temperature thermal system: Pasvanoğlu and Çelik (2019). The stable isotopes of the water molecule

(18O and D) are often used to determine the average altitude of the recharge zone, especially useful in mountainous regions. Tritium (3H) can also inform us about the age of groundwater and therefore about the distances necessary to explain them, that is. , the location of the charging area.

The existence of a geothermal system requires, in addition to a heat source, the presence of permeable geological units that form aquifers or reservoirs, as well as adequate water recharge to the system. In this sense, it is essential to know and study the hydrogeological aspects in these geothermal systems (e.g., Cappacionni, et al., 2011, Chandrajit et al., 2013 for isotopic and other techniques). Or in Szocsa et al., 2018, where a multidisciplinary study is also carried out to investigate one of the most important thermal aquifers in Europe.

In this case, the most innovative aspect of our work is that most of the techniques mentioned above have been applied in an integrated manner, from the study of paleokarstification (which justifies the existence of the thermal system as an aquifer), the definition of the geometry of the aquifer through geophysical studies and application of bounded plans, etc. The assimilation of the results of all these interdisciplinary methods have not contradicted each other, but, on the contrary, have allowed the definition of a new conceptual model that has been contrasted by a mathematical groundwater flow model. With this, a new detailed location of the protection areas of the thermal springs of Alhama de Aragon and Jaraba has been achieved."

The majority of the given information in the introduction is related to the site description and should be moved to the Study Area section.

La mayor parte de la información proporcionada en la introducción está relacionada con la descripción del sitio y debe trasladarse a la sección Área de estudio.

This is done, it is moved to the Study Area. . You can check it in the final manuscript where your comment has already been taken into account.

The study area section is too long to read and understand. There is too much (unnecessary) information and details are shared. There are lots of sub-sections, and I recommend merging them into the "Geology" and "Hydrogeology" sub-sections.

Subsections are merged, leaving only Geology and Hydrogeology. It has been shortened somewhat, but it is not easy. . You can check it in the final manuscript where your comment has already been taken into account.

For instance:

"4.3 Simulation of groundwater flow in the thermal aquifer" is enough for a header. Do not divide these sections into sub-pieces (4.3.1/ 4.3.2/ 4.3.3…) Give all the necessary information by summarising. This is what I mean:

4.3.4 Hydrogeological parameters are given in separate sub-sections (4.3.4.1. or 4.3.4.2….) These details do not make the paper better, please decrease the resolution of the details in the paper. Please merge these sub-sections as much as possible.

Subsections are merged as recommended, and summarized to the extent possible. . You can check it in the final manuscript where your comment has already been taken into account.

The results and discussion section includes too much information which should be given in "Model Setup".

We agree with your comment. And we move part to chapter 3.2 as indicated. . You can check it in the final manuscript where your comment has already been taken into account.

Figure 3 is a very well-prepared hydrogeological map, however, Figure 1 and Figure 2 should be merged into 1 figure. Figure 4 (in my opinion) is not necessary and could be removed from the manuscript.

Figures 1 and 2 are merged. Figure 4 is removed as recommended. You can check it in the final manuscript where your comment has already been taken into account.

The sub-section "4.3 Simulation of groundwater flow in the thermal aquifer" should be given in the "3.2 Modelling of hydrothermal system flow" sub-section. Please describe the model before giving the results.

Subsection 4.3 is included in subsection 3.2. just as recommended. It is summarized as much as possible. . You can check it in the final manuscript where your comment has already been taken into account.

You can find my minor details as comment boxes in the pdf document.

All comments included in the attached PDF have been taken into account. . You can check it in the final manuscript where your comment has already been taken into account.

Once again we want to thank you for your dedication and time to give us these comments. It is greatly appreciated