RC3: 'Comment on hess-2024-82', Anonymous Referee #3, 28 May 2024

Comments of the Referee#3.

Ojeda et al. conducted interdisciplinary studies in Alhama de Aragón and Jaraba in Spain including the analysis of geologic and hydrogeologic conditions, the hydrochemical data, and groundwater modeling. Authors aimed to unravel the source of springs in the study area which would be helpful to the sustainable conservation strategy. Authors do use a lot of different kinds of data and build a likely sounding flow model. I think the results are important to understand the groundwater movement in the study area and this study is a good contribution. However, I don't think the current manuscript is well prepared for publication in HESS. The reasons are as follows:

1. The biggest problem is that the author didn't well leverage the model they built. If the objective is to identify the source of the springs, after you built the well calibrated flow model and did particle tracking using MODPATH based on your flow field, why not analyze the flow paths of the particle tracking results. Then you can easily get what you want and then the modeling work is essentially meaningful.
2. It looks like the authors' idea is that they propose a kind of conceptual model based on geologic and hydrogeologic conditions. Then they build a flow model using modflow. If the calibrated model has a good performance on different hydrologic variables by comparing with observations, then their proposed conceptual model sounds. I really cannot agree such an idea as you didn't correctly use the model and the modeling work lost its intrinsic significance.
3. If the author can utilize the model well, the last part of hydrochemisty is not necessary. You can merge them into your analyzation of your particle tracking results and use these data to validate your particle tracking results. In Lines 859 and 861, it is sad to see 'is assumed' as you still cannot identity the flow paths after si many modeling efforts.
4. So, the 'interdisciplinary studies' are like a documentation of all your work which do not connect each other tightly. The main line is not clear and a lot of descriptive sections just like filed work documentations.

Reply to the comments of the Referee#3:

Thank you very much for these observations that we consider important. The MODPATH was actually used at the time but we thought that in order not to accumulate an excessive number of figures in the article, it was finally not included. But we think it's very good to discuss this topic. So, we include the results in section 4.3.9, where it can be seen that the ages obtained from the flow considering the recharge area of the model are compatible with the results of the tritium isotopes for each spring, since they are of the same order of magnitude. We intended to write the following in the section of the article referring to the model (4.3.9.) and in 4.4. I hope they seem good to you:

We include the entire and updated chapter 4.3.9 where we have included all your comment:

In line 829 we will include the following paragraph:

4.3.9 Transit time estimation

Thanks to mathematical modelling of the hydrothermal aquifer, it has been possible to approximate the effective porosity of the hydrothermal system as well as the Darcy velocity.

In order to carry out this simulation, the Modpath package was used to simulate the path of a contaminant plume along the aquifer. This has allowed us to estimate the time it takes for a pollutant to travel through the aquifer until it emerges at the discharge points.

To achieve this, a contaminant located in the northernmost area of the calcareous outcrops of the Aragonese branch has been introduced, and another contaminant has been introduced in the outcrops of this same formation corresponding to the catchment area of the Deza springs.

We can see in figures 1-A and 1-B the progress of said tracer after 20 years and 80 years. It can be seen in Figure 1-A how after around 20-25 years it comes out through the Deza springs. And in Figure 1-B, how after 80 years. It leaves through the springs of Alhama de Aragón first, and then through Jaraba, having made a similar route concentrated in the deepest and most conductive area, although the peripheral flow that flows into Jaraba makes it slightly longer and older. Let us advance here the ages obtained by tritium from the following section, and although these have a semiquantitative and approximate value, we see that the results obtained by the two methods are of the same order of magnitude. Indeed, it is observed that the simulation shows that the waters of the Deza springs are more modern than those of Alhama and Jaraba, and that the age obtained from the model coincides with the time estimated by tritium from the latest analyses, which is about 20-25 years. In the case of Alhama and Jaraba we observe that the ages obtained by tritium from the most recent analyzes give us an age of more than 61 years, so 80 years could fit.

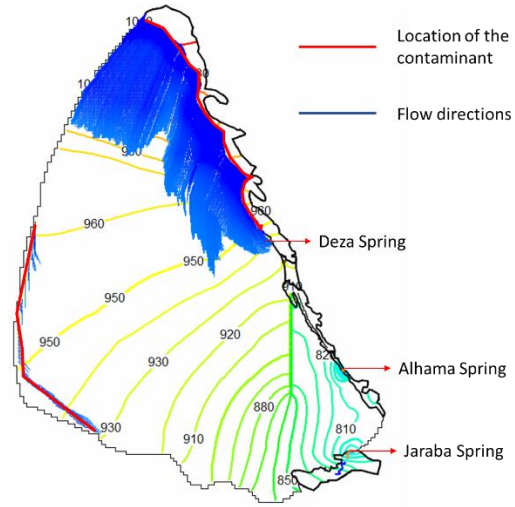


Figure 1-A

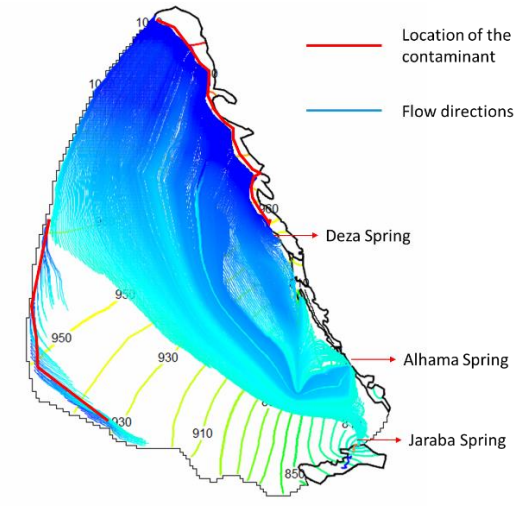


Figure 1-B

Figure 1-A and 1-B. Simulation of the situation of a contaminant introduced in the recharge area of the outcrops of the thermal calcareous aquifer of the feeder (or catchment) basins of the Deza, Alhama de Aragón and Deza springs; Figure 1-A. Simulation of the contaminant plume situation after 20 years. Figure 1-B. Simulation of the contaminant plume situation at 80 years of age.

Finally, we see in Figure 2 the situation of a tracer stain along all the edges of the aquifer and also in the underground divide below the Tertiary after 250 years, with colors that indicate the age of the groundwater (where strong blue corresponds to the youngest ages and red corresponds to the oldest). Perhaps most prominently, in the SE zone of the aquifer, the recharge comes from the Tertiary, which has little influence on the magnitude of the flow and is very old water. On the NE side closest to the Aragonese Branch the flow is hydrodynamically more active and the water more modern.

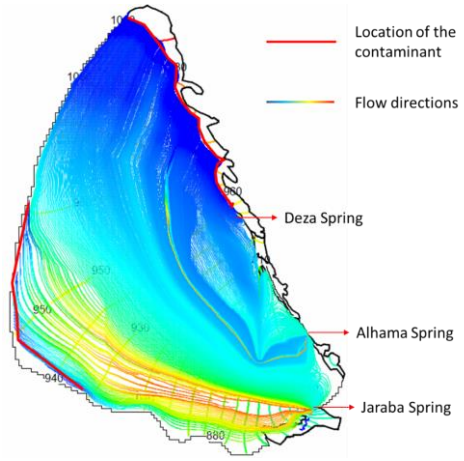


Figure 2. Groundwater age distribution

Please keep in mind that these figures have been made quickly to respond to your comment quickly, the final ones will be better modeled

In addition, we have included in section 4.5. after line 1020, the following paragraph in red.

7. Nor are the values of groundwater age obtained from tritium for Alhama/Jaraba justified because 1015 the flow distances from the centre of gravity of the Sierra del Solorio to these springs (about 25 km) are not so large as to result in ages above 60 years, as occurs in our model with flow lines of 70 km. Neither does it explain the order of increasing age of Deza-San Roquillo-Embid- Alhama/Jaraba, it would have to be the opposite, as the length of the flow lines increases towards Deza. Furthermore, if the flow first passed through Jaraba and ended in Alhama (ITGE-DGA, 1994), the age of the latter 1020 spring would be greater, and yet its age and evolution is totally parallel to that of Jaraba. To validate these results, monitoring contaminant particles using the flow model obtains ages of the same order of magnitude as those obtained using the tritium data. In this way, the hydrochemical aspects acquire all their value when connected to the results of flow modeling.

Comments of the Referee#3.

> Also, there are too many names which are not well introduced in the manuscript, and it is really messy and hard to follow the many descriptive words. For example, the most important 'Alhama de Aragón and Jaraba' even did not appear in your Figure 1.
>
> There are also a lot of small errors everywhere in the manuscript and make it even harder to follow. For example, I don't think the numbers in the caption of Figure 5 are right.

Reply to the comments of the Referee#3:

You are right. These typographical errors have already been corrected, since they have been comments from Referee#1. A general and exhaustive review of the manuscript has been done. Names that did not appear before are added to figure 1.

Comments of the Referee#3.

> There are also a lot of small errors everywhere in the manuscript and make it even harder to follow. For example, I don't think the numbers in the caption of Figure 5 are right.

Reply to the comments of the Referee#3:

A general and exhaustive review of the manuscript has been done in order to avoid typographical errors. Figure 5 has been removed according Referee#2 comment.

Comments of the Referee#3.

Line 781: I don't think Figure 14 is the right figure you want to direct the audience to. Line 814: what is Fig. 16 and Fig. 16.

Reply to the comments of the Referee#3:

Due to the complex model that has been created and given the high number of boundary conditions, we believe that it is essential that Fig. 14 be included. In addition, this figure shows the location of the springs and other important boundary conditions which makes it easier for the reader to understand the model.

Line 814: what is Fig. 16 and Fig. 16: It is a typographic error. It should we said "Table 2 and Fig.15). In addition, a general review of the manuscript is made to check that there are no more typographical errors such as the one indicated.

Comments of the Referee#3.

Fig. 18: I don't think the legend is right. The red and blue points are neither observed values nor the simulated values.

Reply to the comments of the Referee#3:

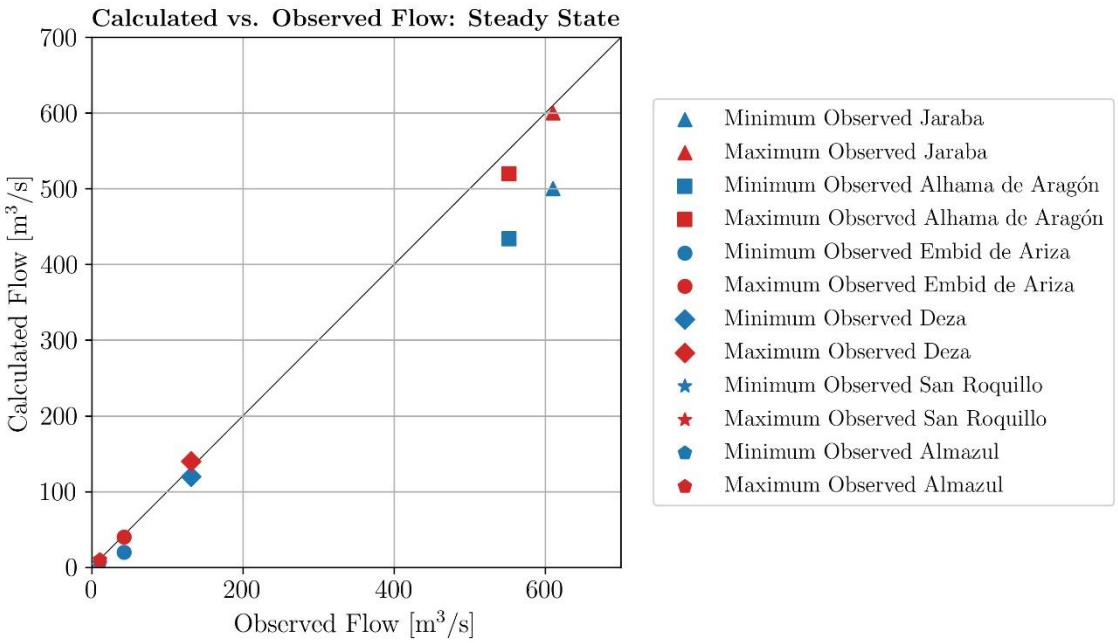
The figure shows the maximum and minimum observed values, as shown in the table 2 and table 3. Please check it. I surrounded in a red square the minimum and maximum observed values concerning table 2.

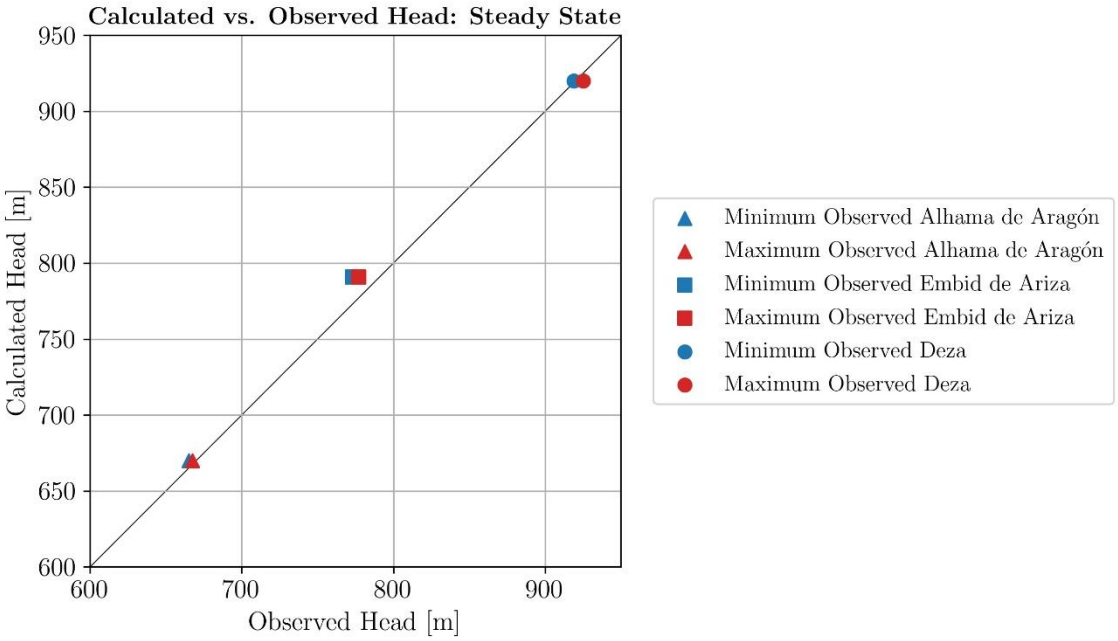
790 **Table 2.** *Calculated vs observed groundwater heads at calibration points.*

Alhama de Aragón piezometer		Embid de Ariza piezometer		Deza piezometer	
Calculated values	Observed values	Calculated values	Observed values	Calculated values	Observed values
670	665 – 667.5	791	777-773	920	919 – 925

As can be seen, the calibration of the observation points is considered acceptable, as the measured and simulated values are very close (Table 2 and Fig. 17.).

In addition, we have changed the figures slightly so that they can be understood better. I show below the updated figures.





Comments of the Referee#3.

Line 827: what does “in order to carry out this simulation” mean? Does ‘this simulation’ mean your modflow model? The modflow model does not necessarily depend on your particle tracking.

Reply to the comments of the Referee#3:

As previously explained, a simulation was carried out with MODPATH, which we include in these answers

Comments of the Referee#3.

Line 946: you have the first half of the parenthesis, so where the second half? There are a lot of such small errors.

Reply to the comments of the Referee#3:

It's a typographical error. The manuscript has been reviewed and will be reviewed again to avoid these types of errors.