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Discussions

Interactive comment on "Impact of climate change on groundwater in a confined Mediterranean aquifer" *by* Y. Caballero and B. Ladouche

Anonymous Referee #1

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The article focusses on the evolution of a confined aquifer subjected to human pressure via pumping and climate change. There are actually few articles devoted to such aquifers, although these aquifers are key water resource at local scale. Moreover, the aquifer studied is rather complex: it is not fully confined, and the connection between aquifers, surface and even the sea, together with the effect of groundwater pumping make it difficult to model and thus difficult to project its evolution in the future. Thus, the article presents an interesting topic. Moreover, the article presents in a condensed form an important work, with details on the aquifer characteristics, an assessment in present day that has necessitate the reconstruction of past groundwater abstraction based on the short time observed database, and the projection in a context of climate change. Although some parts of the manuscript can be improved to clarify some points,

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Discussion Paper

I think that a revised version should be suitable for publication in HESS.

1 Detailed comments

1.1 Description of the aquifer, section 2:

The aquifer system although rather complex, is presented as a Quaternary deposit overlaying a Pliocene aquifer; with some connections between these two layers. However, it is not clear from figure 1 if the Pliocene is entirely overlayed by Quaternary deposit, and, later it is explained that part of the Pliocene recharge comes from river infiltration. In such case, it cannot be stated that the Pliocene deposit is a confined aquifer, rather, it is a partially confined aquifer. In such case, it is rather hard to believe that the piezometric levels vary in the same way in the whole aquifer system as stated section 2, and moreover, this statement is contradicted later on since the simulation in section 4.2 is limited to one piezometer instead of two because their recharge have not the same dynamics. Indeed, even if aquifer pressure is transmitted rapidly in the confined part, it is less the case in the unconfined part. Therefore, I suggest to better expressed from which part of the aquifer system are the wells selected figure 2, to distinguish those from the Quaternary aquifer if there are any, and to give an idea if the ones from the Pliocene are mostly confined or not. Moreover, instead to plot the piezometric levels, it'll be more interesting to plot their evolution from their means to improve the comparison of the temporal evolution. Additionally, more details on the two piezometers selected could be provided, for instance, the thickness of the layers above. It would be nice also to add in Figure 1 the available time period of observation for each piezometer, this will help understand the various temporal windows presented in the manuscript (use for instance a bullet with color associated with a duration).

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1.2 Section 3.1

Overall, it is suggested that the general trend in observed decreasing groundwater level is due to increasing pumping. However, decreasing trend could have been observed even with a constant pumping pressure as soon as the groundwater abstraction and discharge are larger than the recharge. So the simple visual comparison between observed time series of the piezometric level and groundwater abstraction cannot be solely used to explain the trend. Moreover, the partition between seasonal and permanent pumping seems obvious to the authors, but has not significance for me. I would instead claim that the mean annual pumping is the main indicator. Indeed, if the seasonal pumping is about the same form year to year, the evolution of the annual pumping is therefore linked to the permanent pumping. But, the distinction between permanent and seasonal pumpings should be better argued. Is it due to the pumping use? drinking water versus irrigation water ? Not sure... It can be understood that a distinction between annual and seasonal cycles should be distinguished from a signal analysis point of view, but not from a physical point of view. So the partition between general approach and wavelet analysis should be better made, and the description of the method should be better explained.

1.3 Subections 3.2 and 3.3

As the objective of the wavelet analysis is solely to reconstruct the pumped volumes, I suggest to merge these two sections.

1.4 Subsection 3.4

Again, here, the subsection is entitled inverse modeling, although the model is also used to estimate the piezometric level, and is used in this way to project the impact

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of climate change. I would suggest better explaining that a conceptual model based on impulse responses is used, and that its parameters are inferred from the period when all the data are available by inverse modelling. Units in the equations should be provided. Moreover, equation 4 relies on variables that are not explained at all: what is Ta(t)? Its name suggests the atmospheric temperature, but this is rather strange. In section 3.5 it is explained that potential evapotranspiration (PET) is used. Is Ta the PET ? What is the time step of the model? Monthly?

1.5 Section 3.5

Why don't you present the results in present day in the next section? It is confusing to have it mixed with climate change.... I suggest having the assessment of the model (now section 4.1) just after section 3.4, and sections 3.5 just before section 4.2.... It is hard to have an idea how adapted the anomaly method is if ones don't get an idea how sensitive the model is to individual rainfall events.

1.6 Section 4.1

Here, it is explained that the model is different for the two piezometers, and that one of the site is affected by river infiltration. Later on, it is explained that it might not be river infiltration but rather irrigation canal. To better understand this part and the contribution of each component, it is important to provide a water balance: how much is the rainfall recharge compare to the river recharge and compare to the groundwater abstraction? If the model is expected to be representative of a wider part of the aquifer and not solely to the piezometers, then, the water balance should be provided. Otherwise, it should be better explain in the title that the focus is made on local wells. Moreover, this will help to understand the weak sensitivity to the change on rainfall. It is difficult to have various time periods: 1974-2011, 1994-2006, 1998-2006, 1990-2018... can't

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you harmonized?

1.7 Section 5

As the aquifers are partly fed by river loss, are they still supposed to be confined? Again, it should be better stated that the aquifers are partly confined. Exchange between upper and lower aquifers are not taken into account and a bit discussed. It seems suggested that water from Quaternary aquifer feeds the Pliocene. Is it correct? Is this connection expected to be stable in a context of exploitation of the aquifers and climate change?

Conceptual partition between permanent and seasonal pumping is here better discussed, with the evidence that the seasonal cycle could in fact include other signal. I think this should be even stated more clearly, since the partition is only linked to the methodology and not to physical process.

Discussion of the pumping in m3 is given, but it is really missing water balance to relate it to the presented results.

2 Minor comments

Previous comments provided numerous typo error, so I make it short. . .

Why not published figure 1 in a color mode?

Figure 14, encapsulated titles should be given for all or none of the subplots. . .

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 12, 10109, 2015.

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