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Interactive comment on "Mapping the suitability of groundwater dependent vegetation in a semi-arid Mediterranean area" *by* Inês Gomes Marques et al.

Anonymous Referee #2

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General comments

The current manuscript provides an interesting insight into the use of mapping and spatial regression to assess the occurrence of groundwater dependent vegetation (GDV). Such maps can subsequently be used to predict the effect of change in any of the explanatory variables, such as climate or groundwater depth, on the spatial distribution of GDV in an area. The paper is well written and structured, and is subdivided into two parts: the first on the building of regression models for predicting GDV occurrence based on actual data, and the second part where a parameter-based index is calculated to construct so-called "suitability maps" for GDV. While I find the first part strong and with high potential of publication by adding a scenario analysis, my main concern lies with the second part. In my opinion this part is less well developed and

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the interpretation of the results is largely straightforward, and to a certain degree incorrect. Interpretation is largely straightforward because of the large bias in weighting of the parameters, where the contribution of soil largely exceeds all other parameters, thus making it essentially a soil map. Additionally, interpretation is to a certain degree incorrect, due to an apparent mistake in the generation of the suitability map, where (inadvertently) a negative weighting was assigned to the aridity index, resulting in the inverse impact of this parameter on the soil map. I would therefore recommend focusing and further elaborating on the regression modelling, as I will specify in my detailed comments below.

Specific comments

Abstract

Line 13-19: The first part of the abstract is more of an introduction. I suggest starting with what was actually done (line 20). Moreover, groundwater depletion will not occur merely as a result of climate change. Finally, as groundwater level seems to have such a low impact in the regression model, the question rises to what extent groundwater depletion will play a role in the spatial distribution of GDV.

Line 48: When referring to climate change impact studies on recharge in Mediterranean areas add the paper of doi.org/10.1007/s10113-012-0377-3, where such a study is being reported.

PART 1: REGRESSION MODELLING

Parameter selection for the regression model

Soil type: the authors only use the first layer of the soil. To understand the importance of capillary rise feeding into the root zone, the texture of deeper soils also needs to be considered. The latter could further affect the role of groundwater depth in the model, as fine soils have a much higher capillary (and water-holding) capacity. In the model, soil type is subdivided into two sub-parameters (2 and 3, Equation 4 and Table 2), but

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this is not further explained. Evidently, this increases the weight of soil type in the regression model.

Groundwater depth: please comment on the reliability of the results in the empty areas (areas without wells or piezometers). Can wells and piezometers be used together, in other words, are all wells installed in unconfined aquifers?

Drainage density: Drainage density was calculated for six river basins. That gives little variation across the area. Is it possible to map drainage density at a higher resolution, e.g. sub-basin scale, or a 10 km grid size? This would increase the importance of this parameter.

Climate: The authors should provide a bit more explanation on the SPEI and particularly the ombrothermic index calculations. Please explain how/where the latter differs significantly from (and is thus not correlated to) the aridity index.

Model development

It is not clear how the parameters were normalized before entering the regression model. How was the soil parameter transformed into a quantitative variable? If all parameters were classified/categorized (as is often done in e.g. factorial regression analysis), this can explain the low influence of the groundwater depth parameter, as there is very little variation (in large part of the area groundwater depth is between 1.5 and 15 m). In this case, I strongly suggest increasing the number of classes for groundwater depth.

Please provide references showing that it is common practice to fit the model on a 5% random subsample. Also explain more lines 264-265.

Results

Overall section 3.2 on environmental conditions mainly consists of an explanation of each of the maps. To support the selection of the five parameters, the authors should provide all the results on correlation and PCA as supplementary material.

The results of the model suggest, as stated by the authors, a low importance of the groundwater depth on explaining the spatial distribution of GDV (eq. 4). However, nothing is said on how this varies locally within in the area. Are there regions where the role of groundwater is larger? Can these regions be identified?

Line 343-344: This requires quite a bit more explanation, but can be easier to follow once the calculation of Ios4 has been better explained in the methods section.

Line 362-364: Please elaborate on this outcome on the Moran index.

In eq. 4 the appearance of Soil type 2 and Soil type 3 is not explained.

The results would become more interesting with:

1) a more local/regional analysis of the explanatory model and the importance of each of the parameters (in particular groundwater depth);

2) an assessment of the use of more/less/different parameters on the final model. It seems the soil type and to a lesser extent the aridity index are the dominating parameters in the regression model. How does a model based solely on these two parameters perform? And what about including a deeper (2nd-3rd layer) soil parameter to account for water holding and capillary rise capacity? Not much can be stated on the importance of soil type for the groundwater storage (as mentioned in line 495) if only the first soil layer is assessed.

3) scenario analysis: what happens if one or more of the parameters (such as climate or groundwater level) change? You do not have to develop climate scenarios, but an assessment of the impact of a relative change in aridity index or groundwater level on the resulting map would be of high added value.

Discussion

Much of the discussion on the modelling approach is more of a summary of the manuscript, particularly lines 425-439. I miss the interpretation of the results obtained by regression modelling, and the this could further be enriched by the discussion of the added results as proposed above.

PART 2: SUITABILITY MAPPING

Suitability map building

The authors decide to attribute the minimum score (in terms of suitability) to areas where groundwater depth is smaller than 1.5 m, considering that vegetation extracting water from shallow depths belongs to another type of GDV. This distinction between shallow and deep groundwater dependent vegetation, which I indeed think is useful (as most vegetation can use water in the first 1.5 m if present) needs to be briefly elaborated upon.

Line 284-286. I do not understand why shallow groundwater flow would be expected at steep slopes. Normally steeper slopes are found in mountainous areas, where groundwater levels are deep.

Results

The main finding here is that "suitability to GDV in the Alentejo region was mainly driven by soil type". That is obvious, as the weight of this parameter is by far the largest in the suitability index (and given by two soil type variables)! The same holds for the observation "The aridity index also showed a strong influence on GDV's suitability", as the weight of the aridity index is highest following that of soil type. I would strongly suggest analysing alternative weights for each parameter (based for instance on the Delphi panel) and evaluating the corresponding sensitivity of the outcome, as well as the degree of success in the validation procedure.

Line 395-396: "high aridity values restricted GDV's suitability in the south". Again, in my view it is exactly the opposite, as a high aridity is classified as class 3, i.e. of high suitability. In the south in fact aridity index is lowest, indicating the highest aridity and therefore higher suitability for GDV.

I think I might have detected a mistake in the resulting map of Figure 7. Where aridity index (AI) values are low, corresponding suitability value is high (Figure B1b), which means that overall suitability should also increase in those areas (towards the south-east). In the map of Figure 7 the values actually decrease in that area, which is contrary to what would be expected and could result from a negative weight being assigned to this parameter (as it also has a negative coefficient in the regression equation). If this is the case, the presentation and interpretation of the results on suitability mapping needs to be redone.

One example of this wrong interpretation is in lines 376-378, where the authors state that the positive impact of the rivers on the GDV suitability “is due to a higher water availability reflected by the values of omborthermic and aridity indexes. In my view it should be the contrary, i.e. due to a lower water availability, indicating a higher suitability for GDV. Moreover, the positive impact is not visible in the map of Figure 7. And why is there a higher groundwater depth near the river? You would expect groundwater levels to be shallowest near the river.

Another example of this is in discussion section, where the authors state that “The lower suitability to this vegetation in the eastern part of the studied area can be explained by less favorable climatic and geological conditions, resulting from the combination of a high aridity index and low water retention at deep soil layers”. It is again the contrary, as the ariditiy index in this (south)eastern area is lower, indicating a higher suitability and therefore higher values on the map of Figure 7. Moreover, it is not clear why the “deep soil” layer is mentioned here now, if only the first soil layer has been analysed.

In Figure 7 please indicate how the values were calculated.

If the authors decide to do the analysis per river basin, they should indicate the river basin boundaries in Figure 1.

Line 382-383: “this high likelihood was hindered by the type of soil present in that area

In terms of soil type in the Tagus basin". That is not true, as the suitability is mostly class 3 in the Tagus river basin.

Line 416-419 belongs to the discussion section, not the results section.

Technical corrections

Overall the text is well written and structured, the main comments above concern the content of the manuscript.

Line 47: decreased precipitation

Line 56: An integrated multidisciplinary methodology

Line 63: do not include

Line 167: listed in Table 1

Line 169: 2.3.1 Slope and soil characterisitcs

Line 205: division of the basin area by the total stream length

Line 244: was evaluated

Line 256: based on the selected variables

Line 277: score from 1 to 3

Line 367: In the GWR model

Line 380: with the exception of

Line 948: Table 2: Groundwater Depth

Line 956: suitable areas for GDV

Figure 1: add catchment limits

Figure 4: change soil colours, or combine

Line 990: what kind of residuals?

Figure 7: consider changing the colour coding

Figure B1: present the maps in the same order as in Figure 4.

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