Journal: Hydrology and Earth System Sciences

Title: Soil salinity patterns reveal changes in the water cycle of inland river basins in arid zones

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General comments

This paper analyze the changes in soil salinity in the Shiyang River Basin using remote sensing and observation data from 2002 to 2022 and attempt to explore the impacts of the soil salinity changes on water conservancy projects, farmland, irrigation, and climate change. The scope of the study fits well with the journal's theme of the study of the spatial and temporal characteristics of the global water resources.

However, although the title claims that Soil salinity patterns reveal changes in the water cycle, the results section and the subsequent analysis do not justify this claim. The results section only shows the results relating to the evolution (trend of increase or decrease) of the surfaces in the different severity ranges considered, without detailing the specific methodology used to obtain them or the assessment of the accuracy of these results. In the discussion section, it is not put in context with the existing literature and appears to be a continuation of the results. Moreover, the conclusions on the impact on the water cycle are not justified by the results presented. After reviewing the manuscript and based on these comments, I recommend that the manuscript be reconsidered after a **major revision** to address the identified shortcomings.

Specific comments

The introduction section should expand the study of the use of remote sensing in salinity analysis, and coordinate with the new discussion section that will need to be written to compare with previous works in this field. The novelty of the article should be emphasized, especially in the Introduction.

The methodology is described very briefly 162 to 174, within the Data section, but needs to be reorganized and considerably expanded:

- All data sources should be grouped together in a single section, in order to have a better overview of the whole set of data used: satellite images, land use maps, land use maps, etc.
- Line 159 refers to a DEM but does not indicate its source.
- Line 152, please clarify if you are referring to satellite images.
- Line 153, summer images are the least likely to have clouds, but could you indicate why summer images are the best for measuring salinity?.
- Line 155, pre-processing of the image (radiometric correction) is not "improving the image quality", it is a necessary step in the process.
- Line 160, The workflow in figure 2 helps in understanding the steps but should also be explained in the body of the text.
- Line 164, it is mentioned that "In the spectral region, saline soils have higher reflectance than non-saline soils" given the importance of this aspect, it should be expanded and justified with other previous works.
- Line 165 Indicate how many control points have been used for each salinity range studied, detail their spatial location, check if there is a balance in relation to the

irrigation areas studied, etc. It should also be indicated how they have been divided into train-test-validation for accuracy control.

- Line166 indicates that the band combinations of remote sensing imagery most suitable for saline soil extraction have been adjusted. However, no further information is given on how this has been done. This part of the methodology is of vital importance in the results obtained and should be completed extensively. What alternative band combinations have been used? Which are the ones that work best and on what criteria are they based to measure it?
- Line 168 should indicate the supervised classification method that has been used, taking into account the importance of these results in the conclusions that are intended to be drawn in this study, the way in which the accuracy of the classifications has been evaluated should be described in an exhaustive manner.
- The sentence on lines 169 to 174 "In this process, the slope data, image texture features....". It is a very long sentence, and the meaning is not clear, it should be rewritten in a clearer way.
- Line 172, the concept of field sample points appears for the first time, but it is not clear whether they refer to those taken on satellite images or are field work. The location and number of these sample points should also be clarified.
- Line 180 The criteria used to define low, moderate and severe salinity ranges should be explained in detail in the method section. Given that the results of the article show almost exclusively the area classified in each severity range, it is considered of vital importance to explain how these areas have been obtained and how the accuracy of these results has been assessed.

Regarding the results and discussion sections, it seems that the division of the two sections is not clear, especially in the discussion section, as this section shows new results and new figures and does not compare the results obtained with other previous studies. In fact, the discussion section is a continuation of the results, in the entire discussion section only two papers are cited, (Thorslund et al., 2021 and Jägermeyr et al., 2017), which is a clear sign that it is not a discussion per se, but a continuation of the presentation of the results, and what is more, conclusions are observed that are not justified by the results presented.

- The analysis in the Temporal changes in soil salinization section should be rewritten to describe what is observed in the graphs, and it is useful to indicate the figure a, b, c, etc., to which you refer in each case.
- Lines 216 – 217: "*From 2002 to 2022, the overall salinized area of the basin shows an increasing trend, with an average annual growth rate of 1881.9hm2/a*". However, in fig 4a, the grey bar does not so clearly present this growth, in fact, from 2017 to 2022 there is a decrease in overall terms.
- Lines 214 and 218. The results are referred to as heavy salinization, the same nomenclature "severe" should be used.
- Lines 217 to 219:"*shows an increasing trend*", however it is maintained over time until the increase in the last period.
- Trends are analyzed by administrative counties, but the characteristics of each of them are not described: e.g. soil types, cultivated area, natural areas, semi-desertic areas, etc. Why is it analyzed by administrative terms and not for example by cluster of territory with similar characteristics? What are the factors that determine the response of the soil to the increase or decrease in salinity?

- The description of the results in the irrigation districts, line 331 onwards, should be done graphically, and not with the names of the 27 districts because it is very confusing.
- line 257, What do they mean when they talk about *transfer of water for irrigation and the rise in the water table caused by the foreign water*? Figure 5 seems key in the study but appears for the first time at the end.
- There is no relationship between conclusion (3) and the results shown and actually obtained in this document: *the regional salinization problem is more prominent as a result of the rise in the groundwater level around the reservoirs, the evaporation from the irrigation of the agricultural fields, and the evaporation from the downstream ecological water conveyance*. It should be completed and clarified. What data and results analyzed in this work support this conclusion?
- Line 370, in the statement: *The relationship between salinity and irrigation is apparent: over-irrigation increases the concentration of salts in the soil, leading to salinity problems*. It should be clarified and related to which of the irrigation areas studied have over-irrigation and relate this aspect to the specific results obtained for these areas, in order to verify if what is stated is really what is happening in these areas.

As mentioned above, there are conclusions that are not justified by the results presented:

- Lines 381- 383, The following is stated: *Farmland, grassland, and wasteland are at the most significant risk of being converted into saline soils, challenging farmland management*. However, at no point in the article are the different types of crops analyzed by irrigation areas nor are results grouped into these categories of crop types provided.
- The conclusions presented in lines 384 to 394 are not supported by the information and results presented in this work.

Technical corrections

In figure 1:

- I would recommend adding a more general situation map of the country, adapting the legends of the rivers, and clarifying why the lines of the channels are cut; it seems that there is no connection to the hydrological network.
- Fig 1b is within the desert zone, however they look like crop areas.
- Is Fig 1c in 3D? It is not clear what is being represented.

In figure 3:

- In the figure, unnamed counties appear; if they are part of the studied basin area, they should be named. Clarify if they are ignored because the results do not show salinity in these areas.
- It is difficult to follow the presentation of the results showed in this figure in the body of the text.
- The temporal evolution of salinity did not look very good to the naked eye in figures 3a to 3e. In addition to the figures presented, a single figure that represents, for each pixel, the relative temporal evolution throughout the time series (increase or decrease) would help in presenting the results.

In figure 4, taking into account that results are represented with a spatial component, it is recommended to represent these results on a map with their spatial distribution.

The Figure 5 is not cited in the text.

In Figure 6, the results shown are not located correctly in space, it would be helpful to superimpose the scale, north, etc. on the aerial image.

Figure 7, in this figure it seems that there is continuity of the channels and irrigation areas. Is that why they appear cut off in Fig. 1? This figure can be greatly improved, for example with maps of crop types in each area, soil types, etc., with data that provides information on the context of the space studied.

Other minor comments:

- It is detected that a space is missing after the period and it often happens frequently throughout the document (e.g. 136, 142, 150, etc.)
- line 144, It seems that the phrase "Detect more subtleties" is repetitive of the previous one.
- line 217, in units hm^2/a What is the meaning of a? annual?