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Comment on soil-2021-55

Anonymous Referee #1

Referee comment on "Potential and limits of vegetation indices compared to evaporite mineral indices for soil salinity discrimination and mapping " by Abderrazak Bannari and Abdelgader Abuelgasim, SOIL Discuss., https://doi.org/10.5194/soil-2021-55-RC1, 2021

General comments

This research tests common Landsat 8 OLI multispectral vegetation indices and band ratios based on the SWIR information for soil salinity mapping and tests this at two salt rich, arid environments, one coastal region in Kuwait and a salt pan in Namibia. With the topic of soil salinity mapping a relevant scientific question is addressed in this study. The overall pre-print and is fairly well structured and written, although results and discussion should be separated more clearly. However, relevant concerns relate to the overall research design, the applicability of the methods used, and the novelty of the work presented. Firstly, the sensitivity of spectral vegetation indices is tested for surfaces that are vegetation free. Obviously, the result shows that vegetation indices and soil salinity have no correlation in such a vegetation free environment. For other (at least sparsely vegetated) areas with slightly to moderate saline soils such an approach might be relevant for the (indirect) mapping of soil salinity by the proxy of vegetation vitality/density. The potential and limitation of such a concept would be worth studying, however, at several parts in the pre-print the authors make clear that the objective is to test vegetation indices for salinity mapping of none-vegetated surfaces, which has no theoretical basis at all and a test seems not useful. Considering this study design, the objective on "analyzed the potential and limits of vegetation indices compared to evaporite evaporite mineral indices for soil salinity discrimination and mapping in arid landscapes" cannot be answered fairly. Secondly, the SWIR band index termed SSSI2 is already tested in numerous previous studies with contribution of the author, e.g., Bannari et al. (2008a), Bannari et al. (2017b), El-Battay et al. (2017), Bannari & Al-Ali (2020). In Bannari & Al-Ali (2020) even uses the same Kuwait data that is exploited in this study. The only difference is that the Bannari & Al-Ali (2020) study explores actual Landsat 8 OLI data, whereas in this study the OLI spectra a simulated from laboratory spectra (without explaining the reasoning), which arguably produce results that are not as relevant compared to real spaceborne data. Thirdly, the second SWIR band index termed NDGI seems to be completely misused in the frame of this study. Originally proposed in Milewski et al. (2019) as a narrow band index focusing on the estimation of gypsum content, it is without much explanation adapted as broadband Landsat OLI index for general salinity mapping, although the OLI bands do not even cover the same wavelength. In this "adapted" form the NDGI contains basically the same information than the SSSI2 index (OLI SWIR bands) only in slightly different formula. Finally, the relationship between SWIR indices and specific salt mineralogy is not discussed regarding the impacts to the results and misinterpretations of the surface salinity are the consequence.

In summary, 1) the most relevant part of the proposed methodology (SSSI2 index) is already tested in several studies by the author, 2) vegetation indices are tested for soil salinity detection of vegetation free surfaces and 3) an additional spectral index (narrow band) seems misused. These raised points question the overall relevance and/or novelty of the presented work. From this reviewer's perspective the submission should be rejected mainly as research design is not able to fairly address the research question and the novelty of the remaining results seems minor.

Specific comments

Abstract

Line 14 "The proposed methodology leverages on two complementary parts exploiting simulated and imagery data acquired over two study areas" What is the benefit in simulating Landsat-8 OLI data that are readily available globally? Furthermore, when an image close to the ground sampling date of the field sampling is available (according to Bannari & Al-Ali (2020))

Line 29 "Although the Omongwa [pan] is a natural flat salt playa, the four derived VI's from OLI image are completely unable to detect the slightest grain of salt in the soil" Why should vegetation indices that are parametrizations of the difference between red/infrared bands and "greenness" detect salt that is mostly featureless in the VNIR? This consideration has no basis at all.

Introduction:

Line 41 The first paragraph introduces the problem/ threat of salinization in well written from. However, no link to the study regions is provided. Is salinization a relevant problem for the areas under study? E.g., the Omongwa salt pan is a natural salt pan only with minor anthropogenic impact that is not used for any agriculture that could suffer from the stated problem of salinization.

Line 61-66 Please follow a consistent format for the ion's indication of electrical charge (either always with or without indication).

Line 75 This sentence needs rephrasing, as EC measurements are rather cheap compared to most laboratory soil analysis. Indeed, for larger areas/repeated measurements costs for sampling activities in relevant, but it is not the laboratory method that is expensive.

Line 77 "image processing methods have outperformed ground-based methods" is a very strong claim, as ground based, laboratory measurements they are definitely more accurate compared to remote sensing based retrievals. Suggestions: "more suitable" or "practical"

Line 134 "acquired with diver sensors" Most likely "different sensors" is meant?

Line 137 "Coincidentally, the NDGI is simply the SI-ASTER-4,5 proposed 16 years ago by Al-Khaier (2003)." SI-ASTER-4,5 and the NDGI seem very different. Whereas, the NDGI defined in Milewski et al. (2019) is a band ratio that exploits narrowband reflectances in the SWIR I (1.69 and 1.75 µm), which are both part of the 4^{th} ASTER band (1.6-1.7µm). ASTER band 5 covers the parts of the SWIR II (2.145-2.185 µm) which is not part of the NDGI defined in Milewski et al. (2019).

Line 165 "Cert" typo? Is "Certainly" meant?

Materials and Methods

Line 202 Elaboration is needed on how the "CAM5S radiative transfer code" has been used in the data processing of the laboratory spectra. Normally, radiative transfer is used for atmospheric modelling to convert TOA radiance to surface reflectances (e.g., described later on starting at Line 340), but laboratory spectral measurements are used that are not affected by atmospheric disturbances. The convolution of the spectra to different spectral resolution is usually not linked to "radiative transfer" techniques, but simply done by applying the published relative spectral response factors (e.g., in 1 nm resolution) of the OLI sensor to the laboratory spectra.

Line 337 The SWIR bands of OLI do not cover the wavelength used in the NDGI proposed in Milewski et al. (2019), which exploits narrow spectral bands (10-20 nm) for gypsum detection, specifically the shoulder of the SWIR I absorption at 1690 nm and the center of the absorption feature at 1750 nm. Figure 5 shows very well that the sensitivity of the SWIR-1 Landsat band ends even before the shoulder of the absorption feature. The normalized SWIR I + SWIR II multispectral band ratio used here is commonly known under the name of Normalized Burn Ratio-2 (NBR2) as spectral indices routinely provided by the Landsat mission (https://www.usgs.gov/core-science-systems/nli/landsat/landsat-normalized-burn-ratio-2) and used for over two decades in the field of soil remote sensing (van Deventer et al. 1997).

van Deventer, A.P., Ward, A.D., Gowda, P.H., Lyon, J.G., 1997. Using Thematic Mapper Data to Identify Contrasting Soil Plains and Tillage Practices. American Society for Photogrammetry and Remote Sensing, Photogrammetric Engineering & Remote Sensing Vol. 63 No. 1 pp. 87-93.

Results Analysis

Line 420 The mineralogy of sample “H” cannot be only “a pure salt-sabkha (bright florescent halite)”, as pure halite would be featureless (except water absorption) and the shown spectrum certainly has strong absorption features. This spectrum could contain abundances of bischofite or other MgCl salts (compare spectra of https://10.1016/j.geoderma.2008.03.011 or doi.org/10.3390/rs6042647).

Line 503 “Consequently, undoubtedly VI’s cannot exhibit the spatial patterns variability or provide precise and reliable information about the soil salinity. This finding corroborate those of spectral and CRRS analyses.” This statement is only true for bare soil/sediment surfaces. Obviously, for none-vegetate areas case VI cannot be used to directly map top-soil salinity. But a much more reasonable use for VI is by proxy of salinity by degradation of soil fertility and vegetation vitality. E.g., Zhu et al. (2020, doi.org/10.3390/rs13020250) showed that spectra of agricultural crops do reflect the physiological changes of crops under soil salt stress, and it is feasible to model soil salinity using spectral vegetation indices of the crop canopy (e.g., NDVI with R^2 of 0.78 and RMSE (g/L) of 0.62 TDS). Similarly, a study of Al-Khakani & Yousif (2019, doi.org/10.1088/1742-6596/1234/1/012023) demonstrates an inverse correlation between the soil salinity and NDVI vegetation cover up to R^2 of 0.88 for a larger regional mapping. These examples show that VI can be largely beneficial for salinity mapping and that the usefulness depends on the surface type and specific application.

Figure 7 Why are soils with 0.2-0.3 reflectance in the red band annotated with "bright crust" and soils with 0.6 reflectance as "dark soil"? Are the salt crusts not brighter throughout the VIS compared to none-saline soils?

Line 516 "evaporite minerals indices have the highest power for soil salinity discrimination with R2 517 of 0.71 and 0.72 for NDGI (or SI-ASTER-4,5) and SSSI (Figs. 8e and 8f), respectively. These results are due to the absorption features of salts (gypsum, halite, etc.) in SWIR bands, which are integrated in the equations of the both indices." In this statement an important misunderstanding becomes apparent that leads to a misinterpretation of the actual salinity of the salt pan. The correlation between broadband SWIR indices and general soil salinity is highly dependent on the specific salt mineralogy and its effects on the spectrum. All surfaces that have higher SWIR II absorption than SWIR I would result in a high values of the SI-ASTER-4,5 and SSSI. However, this is not the case for one of the most important/strongest cause of soil salinity at the test site: NaCL (halite), which is almost featureless in the optical range. This important limitation in the applied method needs to be addressed and the interpretation needs to be revised accordingly. For a representation of halite distribution at the Omongwa salt pan see the spectral unmixing result of Milewski et al. (2017).

Line 588 "the SSSI further highlights the main salt crusts present in the pan area that are formed from different mineral sources, including halite, gypsum, calcite, and sepiolite" No, unfortunately the main areas of ~pure halite crust is missed by the SWIR indices. Both indices highlight the presents of gypsum that certainly increases general soil salinity, but not as much as halite. Most concerning, the halite rich areas are mapped as none saline! See comment above. A simple brightness/albedo based spectral index would lead to a more accurate representation of soil salinity, when halite is the major cause.

Line 603 "a total absence of salinity is observed in the center and center-east parts of the pan (black pixels) due to the presence of water which absorbs the signal in the SWIR wavelengths." No, this image acquired at the dry season does not have any surface water present. Please check the Landsat spectra or simply a RGB representation. These areas that appear low in SWIRI-SWIRII indices are the most saline pixels that have a much brighter, but flat spectrum in the SWIR. See attached image of the Landsat OLI scene and exemplary spectra.

Discussion

Line 666 Here, the fact that halite is featureless is mentioned, but is not recognized as a limitation for the applied methods and the results are not discussed according.

Line 676 “While when the EC-Lab values increased also the difference among the salt-affected soil spectra’s increased significantly and progressively in the SWIR”

Line 691 “SWIR-1 and SWIR-2 bands of OLI show the highest potential to discriminate efficiently among different degrees of salinity in the soil.” These statements are valid for some salt minerals, e.g., gypsum or bischofite, but not true at all for other salt minerals, e.g., halite or thenardite. Consequently, SWIR1-SWIR2 indices might produce totally misleading salinity maps for test sites that are for example dominated by halite.

Line 683 As stated in the comment above sample “H” has several features that are not related to halite and spectrally indicate the prancer of a different salt mineral.

Line 693 “of LAI at different densities confirmed the relevance of [..] stress.” This dataset of LAI measurements might be undervalued in the current pre-print status. Instead of calculating vegetation indices for bare soil, the LAI or vegetation indices of the Kuwait imagery (not lab spectra) might show a correlation to the soil salinity measurements, due to reduction in vegetation vitality.

Line 712 Here the higher albedo of the central pan area is actually mentioned, but no contradiction with the results of the SWIR salinity indices is noted or discussed.

Suggested to revise some dramatic wording to more objective language, e.g., Line 559: “Faithful to their mission” or Line 555: “indices are blind”

Please also note the supplement to this comment:
https://soil.copernicus.org/preprints/soil-2021-55/soil-2021-55-RC1-supplement.pdf