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Hydrology and Earth System Sciences
Discussions

Interactive comment on "The value of satellite remote sensing soil moisture data and the DISPATCH algorithm in irrigation fields" *by* Mireia Fontanet et al.

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Dear,

We are grateful to the Editor and Reviewers for the time and effort spent on the review of our manuscript. We provide a detail response to your comments in this document. We believe that our responses and the revisions made to the manuscript fully address the issues raised by the reviewers. This revision has helped us to clarify some aspects of our work. Consequently, the manuscript has been largely improved.

Sincerely,

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Mireia Fontanet on behalf of all co-authors.

Response to reviewer:

GENERAL COMMENTS

1) MAJOR: The text of the manuscript does not read well in many parts. In the specific comments, I added some suggestions for the abstract only. The whole text should be revised avoiding repetitions, improving English writing (but I am not mother-tongue), and taking care to write accurately symbols, equations, acronyms. Being a scientific paper, the structure and the methodology used should be clear to the readerships.

We have completely revised the manuscript to avoid repetitions, clarify some parts of the manuscript and improve English quality.

We have also modified mistakes regarding acronyms and symbols.

Specific comments have been corrected. Please, see the list of specific comments at the end of this document.

2) MAJOR: The authors found that 1-km SMOS soil moisture product is not suitable to detect small scale irrigation, even though theorically the 1-km resolution of the product should be suitable for detecting irrigation in the investigated area. The authors investigated spatial variability of NDVI and LST and found it is much larger (even if not specified in the text) than the extend of in situ soil moisture measurements, therefore the comparison should not be carried out. Moreover, the problem is not related to the spatial variability of NDVI or LST, but to their capability to detect the irrigation signal. Much better should be to carry put a specific analysis with NDVI and LST to assess if they are able to "see" irrigation.

The range of a semivariogram is the distance at which spatial correlation vanishes. This geostatistical property is used here to measure the size of independent image details. This is described at page 9, lines 2-5: "..., the range can ultimately be regarded as the size of independent objects. Since the spatial resolution of an image can be regarded as the size of independent bodies (Atkinson and Curran, 1997; Woodcock and Strahler, 1987), the range of variability in an image relates directly to its resolution". Of course, if the size of independent information content is too large compared to our field site, the satellite image cannot capture the spatial variation occurring at the scale of the field site. This is essentially the same as saying that there is no statistical difference between neighbor pixels. To further demonstrate this point, we can complement the geostatistical analysis with a visual comparison of the NDVI and LST pixel data obtained at a certain distance away from the Foradada pixel.

To do this, we have downloaded the neighbor NDVI and LST pixel data using MOD13A2 and MOD11A1 products with Google Earth Engine website from DOY036 to DOY298 (the same period of time as the execution of the DISPATCH algorithm). Two different pixel values have been extracted for each data set; 1) The Foradada field pixel value, where high values of NDVI and low values of LST are expected during irrigation period; 2) and the variable values of a pixel located 2 km away from the Foradada pixel value in the North-West direction. This pixel represents a dry land with expected lower NDVI and higher LST values compared to Foradada.

Figure 1, shows the temporal evolution of NDVI in both pixels. It can be observed that, during large-scale precipitation, both pixels represent similar conditions as expected, but there is no significant difference between them during local irrigation. If these periods of time are analyzed in detail, spring months, from DOY051 to DOY151, NDVI data from both pixels indicate that crop is growing as a consequence of a general precipitation that affects the full region, while during DOY152 to DOY298, NDVI values decreases because, on the other hand, in North-West pixel there is no irrigation, and on the other hand, the Foradada pixel NDVI data does not detect how crops develop as a consequence of irrigation.

The same case is shown with Fig.2., that represents LST temporal evolution in both pixels. In this case, LST also shows the same dynamics in both pixels even when irrigation is applied. As mentioned before, LST values form Foradada pixel should be

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lower than North-West pixel if local irrigation was detected.

In our opinion, we think that this extra information clarifies the information in the manuscript.

3) MAJOR: Related to point (2), I believe that the problem is the strong dependency of the disggregated SMOS 1-km product to SMOS soil moisture product. SMOS has a spatial resolution of around 40 km, therefore it is not sensitive to small scale irrigation in the area. As the 1-km product is strongly dependent on SMOS, it is simply not suitable for detecting irrigation at a field scale (we obtain similar results in scientific analyses we doing). As mentioned above, the analysis of the NDVI and LST signal by MODIS should be carried out, even though the temporal resolution might be not good due to cloud coverage. I believe that if we want to consider a disaggregated soil moisture product for irrigation detection, a different strategy should be implemented.

We agree with your comment when you say that a different strategy for measuring soil moisture should be implemented, in fact, this is a part of our conclusions in page 11, line 17-18: The results show that the downscaled soil moisture estimations are capable of predicting the variations in soil moisture caused by rainfall events, but fail to predict those soil moisture estimates affected by irrigation at a local scale.

We would like to note that the DISPATCH method uses NDVI and LST information from Terra and Aqua satellite data to downscale soil moisture. The NDVI and LST satellite data is supposed to have a spatial resolution of 1 Km and therefore one should expect these estimates to be affected by local irrigation at the scale of the given field site (and consequently the DISPATCH product). The point here is that we actually see that the DISPATCH product is not affected, which calls for a reanalysis of the spatial resolution of these input variables. In doing this, we do not investigate whether the DISPATCH algorithm is adequate or not (we do not enter into the DISPATCH conceptualization) but we demonstrate that the DISPATCH input variables have smaller resolution than originally postulated. This is just one possible explanation among many others for the

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failure of the DISPATCH algorithm in this case. In the revised manuscript, we will make this discussion clear.

4) MODERATE: As mentioned before, the text should be improved and specifically the structure of the paper. In section 4 “Discussion” the theoretical background of geostatistical analysis is described. It should be moved to the methodology section.

We have also reorganized the manuscript to improve the structure and flow of the manuscript based on the comments raised by the two reviewers. In this context, we have added a sub-section entitled “Spatial resolution analysis” in section 3 (i.e., Materials and Methods). This way, the methods used to estimate the spatial resolution of variables (which where before introduced in the discussion section) were moved to the methods section. We hope this will largely improve the clarity of the manuscript. We have also improved the manuscript in several editing aspects based on the comments raised by the two reviewer: avoiding repetitions, writing symbols, and equations consistently, improve English grammar and clarify confusing aspects about resolution and the use of scales.

SPECIFIC COMMENTS All specific comments that we agree, can be changed at the final version of the manuscript.

Page 1, line 8: Soil moisture data are not really important for climate change studies.

We have deleted “climate change studies” and added “hydro-climate approaches”. Soil moisture measurements are needed in a large number of applications such hydro-climate approaches, watershed water balance and irrigation management.

Page 1, line 10: “with both space and time” is not correct, to be revised.

We have deleted “with both” and we have added “in”. One of the main characteristics of this property is that soil moisture is highly variable in space and time, hindering the estimation of a representative value.

Page 1, line 12: Currently we can obtain soil moisture estimated through 1) in situ observation (fixed stations and field measurements), 2) remote sensing (satellite, aire-planes, drones), and 3) modeling (hydrological and/or climate).

We have modified this sentence. Nowadays, different kinds of methodologies exist for measuring soil moisture; 1) in situ measurements, which can be obtained through fixed stations or field measurements, 2) Remote Sensing, where satellites, air-planes and drones estimate soil moisture, and 3) modeling, representing a hydrological system.

Page 1, line 13-14: “where soil moisture measurements. . .” Which measurements?

We have not found “where soil moisture measurements” in this line, anyway, in this line there is the sentence “where soil moisture sensors”. In this case, we have not modified anything.

Page 1, line 16: Currently we have Setinel-1 that can provide 1-km soil moisture measurements. . . and also new techniques (e.g. CYGNSS)

Even though Setinel-1and other new techniques, such as CYNSS, provide soil moisture at 1 km resolution, we consider that it is not relevant information for abstract, but, we have added this information at the Introduction section: Other satellites, such as Sentinel-1, are able to estimate soil NSSM at 1 km resolution (Hornacek et al., 2012; Mattia et al., 2015; Paloscia et al., 2013). Sentinel-1 provides two kinds of products, the first one is Single Look Complex (SLC) and the second one is Ground Range Detected (GRD). The last one can be used in solving a wide range of problems of the Earth surface monitoring, such as soil moisture, but, it is not a direct measurement, thus data treatment is needed. In this case, GRD product is converted into radar backscatter coefficient and then into dB units to estimate soil moisture. Usually, these transformations are not easy because these kind of measurements have surface roughness and vegetation influence on the signal (Garkusha et al., 2017; Wagner et al., 2010).

Page 1, line 19: Acronyms should be defined (SMOS, NDVI, LST. . .)

It is true and we have added acronyms definitions. The DISaggregation based on

Physical And Theorical CHange (DISPATCH) algorithm downscales soil moisture estimations from 40 km to 1 km resolution using Soil Moisture and Ocean Salinity (SMOS) satellite soil moisture, Normalized Difference Vegetation Index (NDVI) and Land Surface Temperature (LST) from Moderate Resolution Imaging Spectroradiometer (MODIS) sensor estimations.

Page 1, line 27: “reason for why” remove “for” We have deleted “for”

…the variations of the average water content at the site, and this could be a reason why the DISPATCH algorithm is unable to detect soil moisture increments caused by local irrigation.

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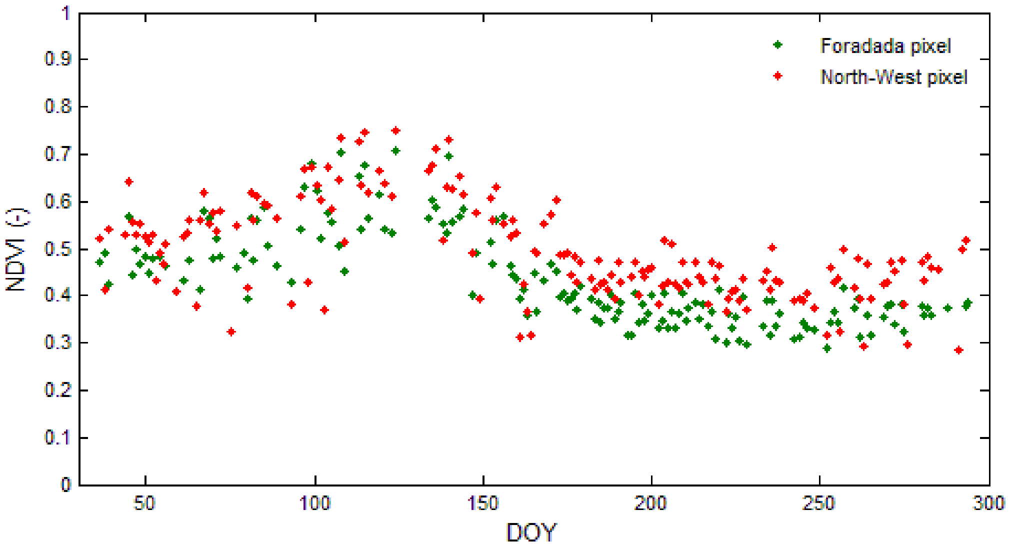

Fig. 1. NDVI data from Foradada pixel and North-West pixel.

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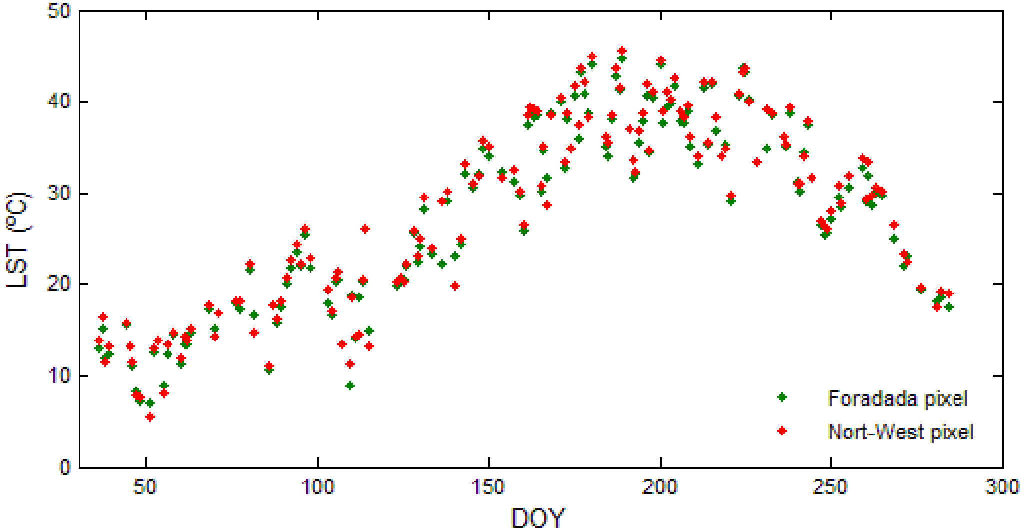

Fig. 2. LST data from Foradada pixel and North-West pixel.

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