A COMPARISON STUDY BETWEEN MODIS AND SENTINEL-3 LAND SURFACE TEMPERATURE IN DERIVING HIGH RESOLUTION SOIL MOISTURE ESTIMATES FOR DESERT LOCUST MANAGEMENT

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INTRODUCTION

Amongst the large number of applications that require high resolution (HR) soil moisture (SM), one example is the estimation of the potential habitat of desert locusts. Desert locusts may reach swarm level (dangerous for crops) if, over desert areas, SM is high for long enough, which implies vegetation growth and thus their reproduction. Having information on SM offers an early indication of potential nesting areas, since it precedes vegetation growth. Considering the large extent of the breeding areas and that it is not practical to send survey teams to cover it all, remotely sensed SM estimates are of particular interest. However, current remote sensing SM estimates have a coarse resolution, of tens of kilometers, which is not adequate for an effective prevention management. However, HR SM products can be derived by using downscaling methodologies. Amongst all, DISPATCH is an algorithm that downscales the 40 kilometers SMOS SM data using land surface temperature (LST) and vegetation cover data, along with a self-calibrated evaporation model[1], [2].

OBJECTIVES

A comparison is performed between two LST products and also between the SM products derived using these two distinct LST datasets, over a period spanning July to December 2017. The study area covers the entire North of Africa (40° - 10° N, 20° W - 20° E), with focus on Algeria, Mali, Mauritania and Morocco.

This study is part of the SMELLS (Soil Moisture for dEsert Locust earLy Survey smells.isardsat.com/) project , whose aim is to specifically address the use of SM for preventive management of desert locust[3].

METHODS

DISPATCH uses the following approach to derive HR SM, where SEE stands for Soil Evaporative Efficiency and is defined as the ratio of actual to potential evaporation:

$$SM_{HR} = SM_{LR} + \left(\frac{\partial SM}{\partial SEE}\right)_{LR} * \left(SEE_{HR} - SEE_{LR}\right)$$

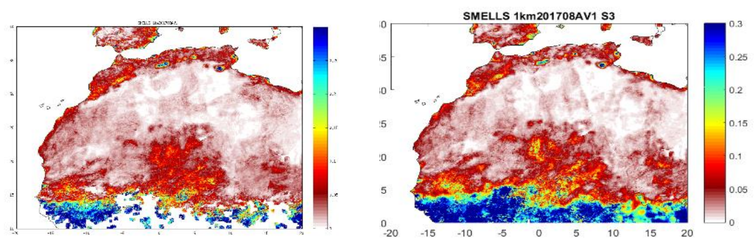
SEE is derived using LST data. Two distinct LST datasets were used: from MODIS (MODerate Imaging Spectroradiometer) and from the Sentinel-3A SLSTR (Sea and Land Surface Temperature Radiometer) sensor. The vegetation cover is derived from MODIS NDVI (Normalized Difference Vegetation Index). SMOS Level 2 SM is used.

The continuous measurements of the in-situ soil moisture data from three AMMA (Analyse Multidisciplinaire de la Mousson Africaine) sites in Niger are used for in situ validation.

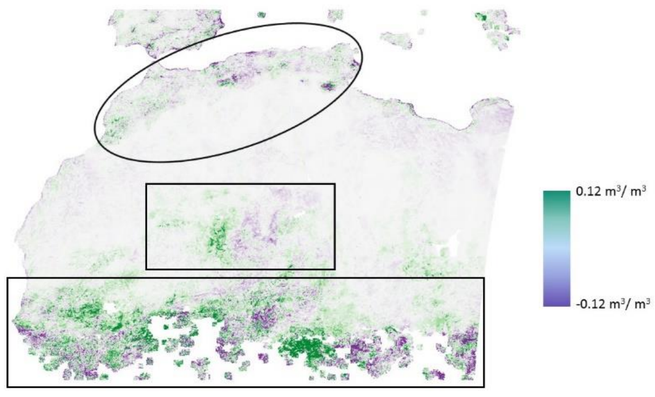
RESULTS

QUALITATIVE ANALYSIS

The introduction of Sentinel-3 LST does not change fundamentally the results. The products follow well seasonality and water bodies such as rivers and lakes can be identified. An improvement can be seen, with a better coverage over the Sahel region for the S3-derived SM, most likely due to a later overpass time in the morning for MODIS.



Difference maps were created to observe where the products differ the most (here an example for the first decade of August).

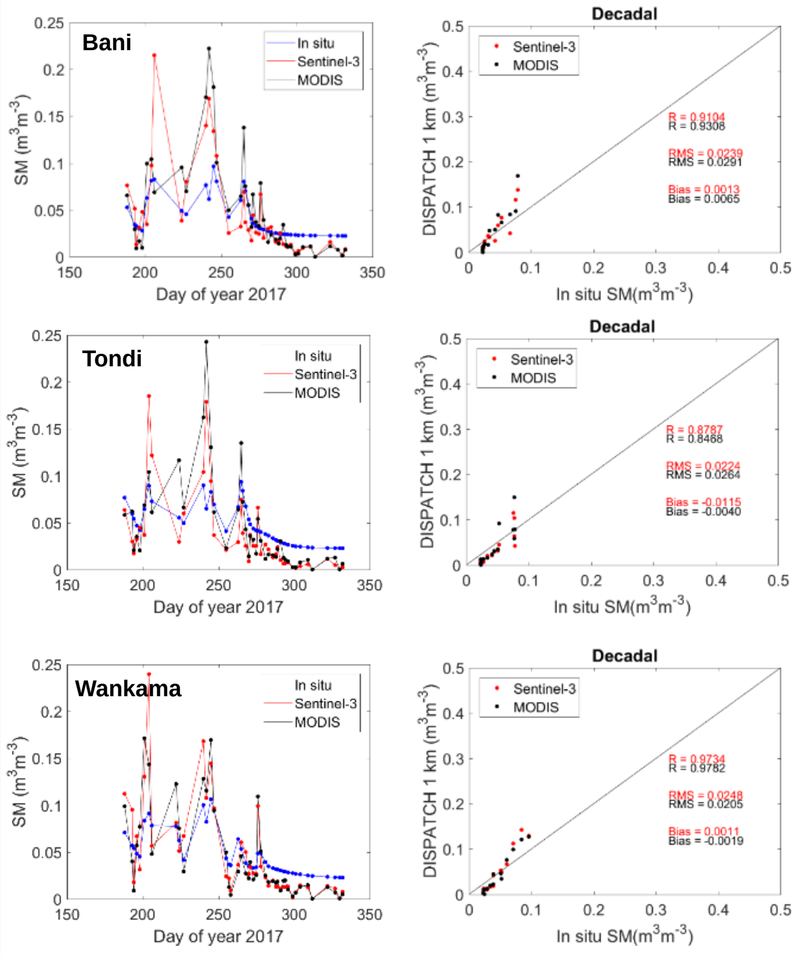


Part of these differences can be explained by:
- different data availability for Sentinel-3/MODIS
- different overpass times

Soil moisture presents the same spatial structures both in S3 and MODIS derived products but because at MODIS overpass times temperatures are more contrasted, this results in high resolution soil moisture maps also being more contrasted.

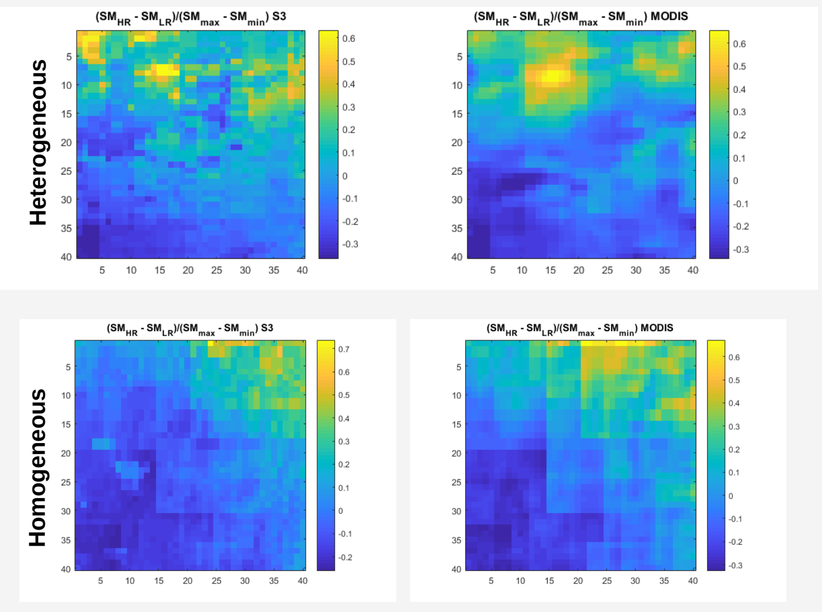
COMPARISON WITH IN SITU DATA

A comparison is performed with in situ data acquired over 3 AMMA stations in Niger: Bani, Tondi and Wankama.



SENSITIVITY ANALYSIS

A sensitivity study was carried out with respect to the S3-derived and MODIS-derived SM products, under two different conditions: heterogeneous and homogeneous. The study area considered in each case was a one 40 km by 40 km SMOS pixel, containing the 1 km by 1 km pixel of interest. The sensitivity analysis consisted in looking at the difference between the high resolution 1 km SM product and the low resolution SMOS SM, divided by the difference between the maximum and minimum SM values found within the scene.



A similar pattern with the same sensitivity scale can be observed, albeit with certain differences: the MODIS-derived SM has a more blurred effect and a border corresponding to larger pixels can be seen encompassing the smaller 1 km by 1 km pixels. This could be due to the atmospheric correction of the MODIS LST, which is done at 5 km.

CONCLUSION

Sentinel-3 LST data was introduced in a downscaling algorithm of SMOS soil moisture. The Sentinel 3-derived products are consistent with MODIS-derived products, following well seasonality and water bodies such as rivers and lakes. Moreover, it provides a better coverage over the Sahel region. Several differences can be noticed, and are partly attributed to different overpass times. The validation performed with measurements from the AMMA sites provide good statistics, with the Sentinel 3-derived SM performing slightly better.

Finally, a sensitivity analysis was performed, which showed that the two SM products generally have a similar pattern with the same sensitivity scale. Some differences were noted, which can be explained by the atmospheric correction of the MODIS LST, which is done at 5 km.

MAJOR REFERENCES

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[3] Escorihuela et al. (2018) *SMOS based high resolution soil moisture estimates for desert locust preventive management*, submitted to Remote Sensing Applications: Society and Environment.

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