Retrieving Soil Moisture at a Test Site on the Yamal Peninsula from SMOS Multi-angular Brightness Temperature Observations

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I. Introduction

This paper presents the results of a comparison of soil moisture obtained from the standard algorithms of SMOS, GCOM-W1 with soil moisture retrieved from SMOS multi-angular brightness temperature observations using dielectric model specially developed based on soil samples collected at the test site. As a test site, an area close to Marresale Weather Station (MWS) on the Yamal peninsula was chosen. This test site is located on the coast of the Kara Sea, coordinate of the under satellite point of interest (PoI) is (69.7115N, 66.8197E). This choice is due to the following factors. First, the temperature dependent multi-relaxation spectral dielectric model (TD MRSDM) earlier developed in [1] is based on the soil samples collected at the test site. Second, soil moisture measured in situ, during the nine day mission on August, 2015 from 12 to 20 at the test site is available. Third, daily soil temperature and air temperature (2m above the ground) measured in situ by MWS appeared to be easy available, as well as the SMOS and GCOM-W1 data. For soil moisture retrieval, full polarization brightness temperature product of the Centre Aval de Traitement des Données SMOS (CATDS) [2] was used. Standard soil moisture data was obtained from SMOS L3 SM products, provided by the CATDS and GCOM-W1 L2 SMC products, provided by the Japan Aerospace Exploration Agency (JAXA) [3].

II. Area Of Interest

The weather station Maresale, where the ground meassurents were carried out, is located at the south part of the western coast of the Yamal peninsula. The landscape at the test site is a typical well-drained polygonal tundra, comprised of grasses, moss, lichens, and prostrate dwarf shrubs. Because of a location of the weather station - close to the sea, the test site were chosen more inland. On the Fig. 1 the weather station is marked with a white circle and test site is marked with a square centered at the one of SMOS points.

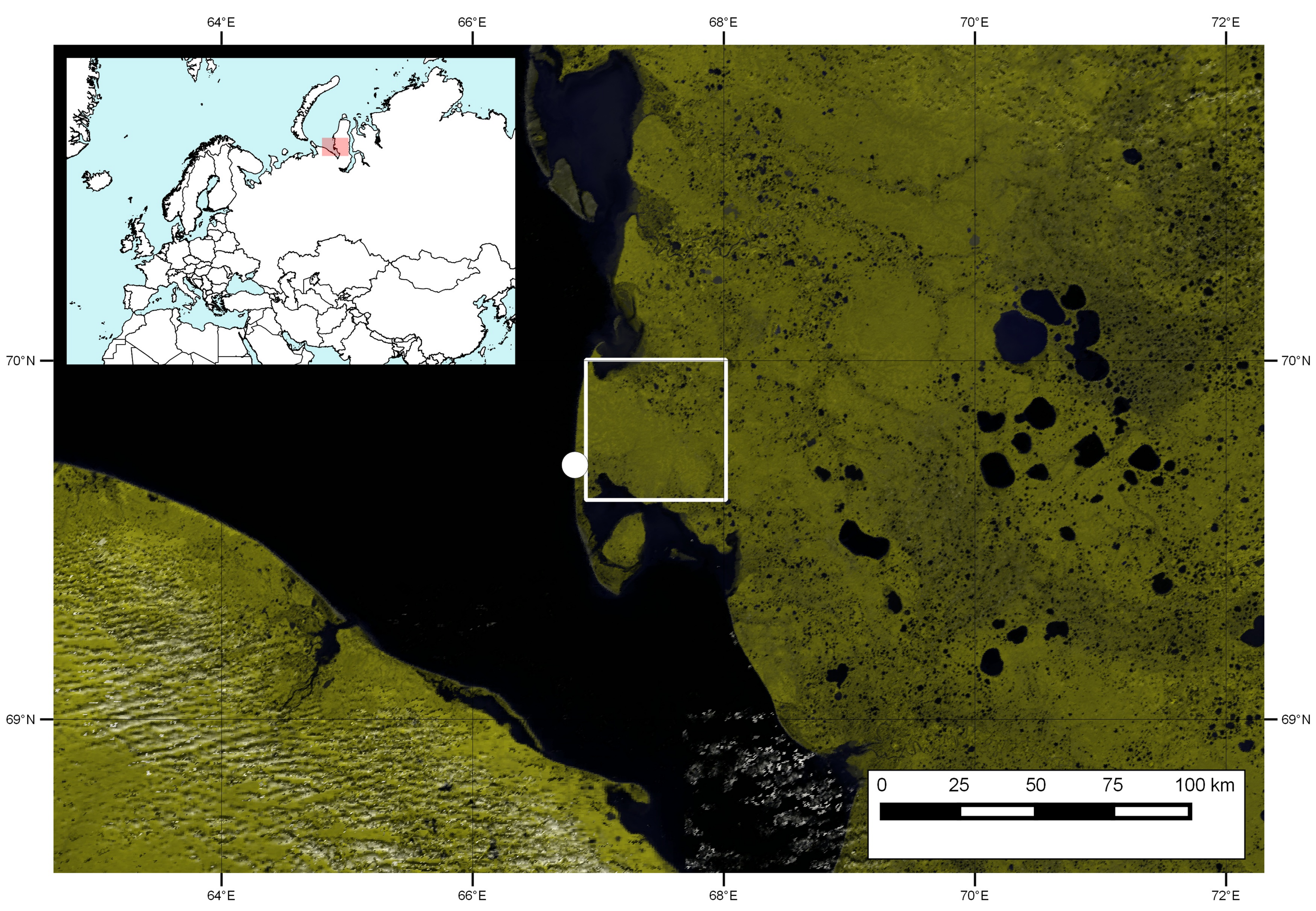

Figure 1. Circle - weather station, square with side of 43km; background - a false-color combination of Bands 2, 2, 1 from MODIS MYD09GQ product acquired September 4, 2015.

III. Methods

Method to retrieve soil moisture is based on solving inverse problem by minimizing norm of the residuals between the observed and predicted values of SMOS brightness temperatures. The calculation of brightness temperatures were performed using semi-empirical model of radiothermal emission [4] Eq. 1, which was modified and takes into account an attenuation of the microwaves in canopy and TD MRSDM for an organic-rich tundra soil [1].

$$T_{B,p}^{th}(\theta) = \left(1 - \left[(1-Q)|R_p(\theta,\varepsilon_s)|^2 + Q|R_p(\theta,\varepsilon_s)|^2\right] e^{-H_r cos^N \theta - 2\tau/cos\theta}\right) .T_s \qquad (1)$$

Before using the retrieving algorithm, radiometric data are first preprocessed. Data are clipped by the area of our interest and then stored in database. This database approach have appeared more comfortable and faster when processing the data at a regional level. As a database management system was chosen PostgreSQL with PostGIS extension (extension for spatial data). The support of PostgreSQL/PostGIS in many of GIS and mathematical softwares as also the advantage.

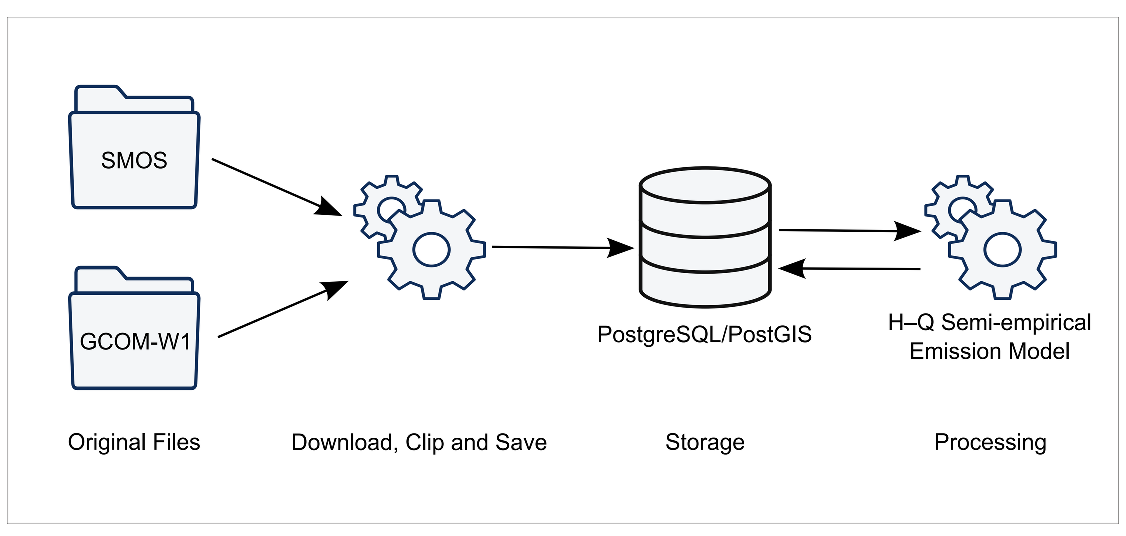

Figure 2. Schema of Processing

IV. Results

As a result, the values of soil moisture obtained from standard SMOS and GCOM-W1 products at the test site was found to be very understated compared to in situ measured soil moisture values. Retrieved values of soil moisture based on our approach with using specific dielectric model much more close to in situ measured soil moisture values. This study shows that for the Arctic soils rich in organic matter, existing soil moisture products of SMOS and GCOM-W1 do not meet the criteria of measurement accuracy of soil moisture. Solve this problem allows the use of a dielectric model specially developed for the typical organic soil collected at the test site.

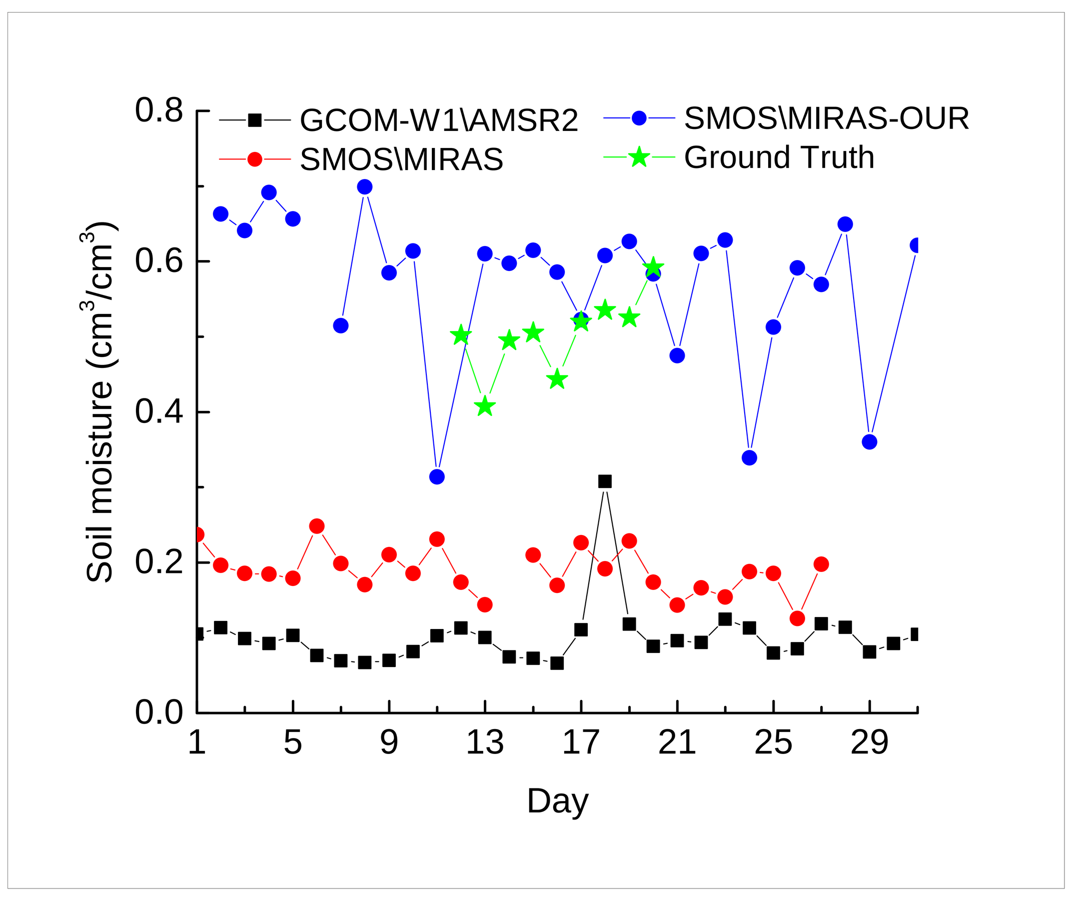

Figure 3. Comperison of soil moisture from SMOS and GCOM-W1 products with ground readings and our results.

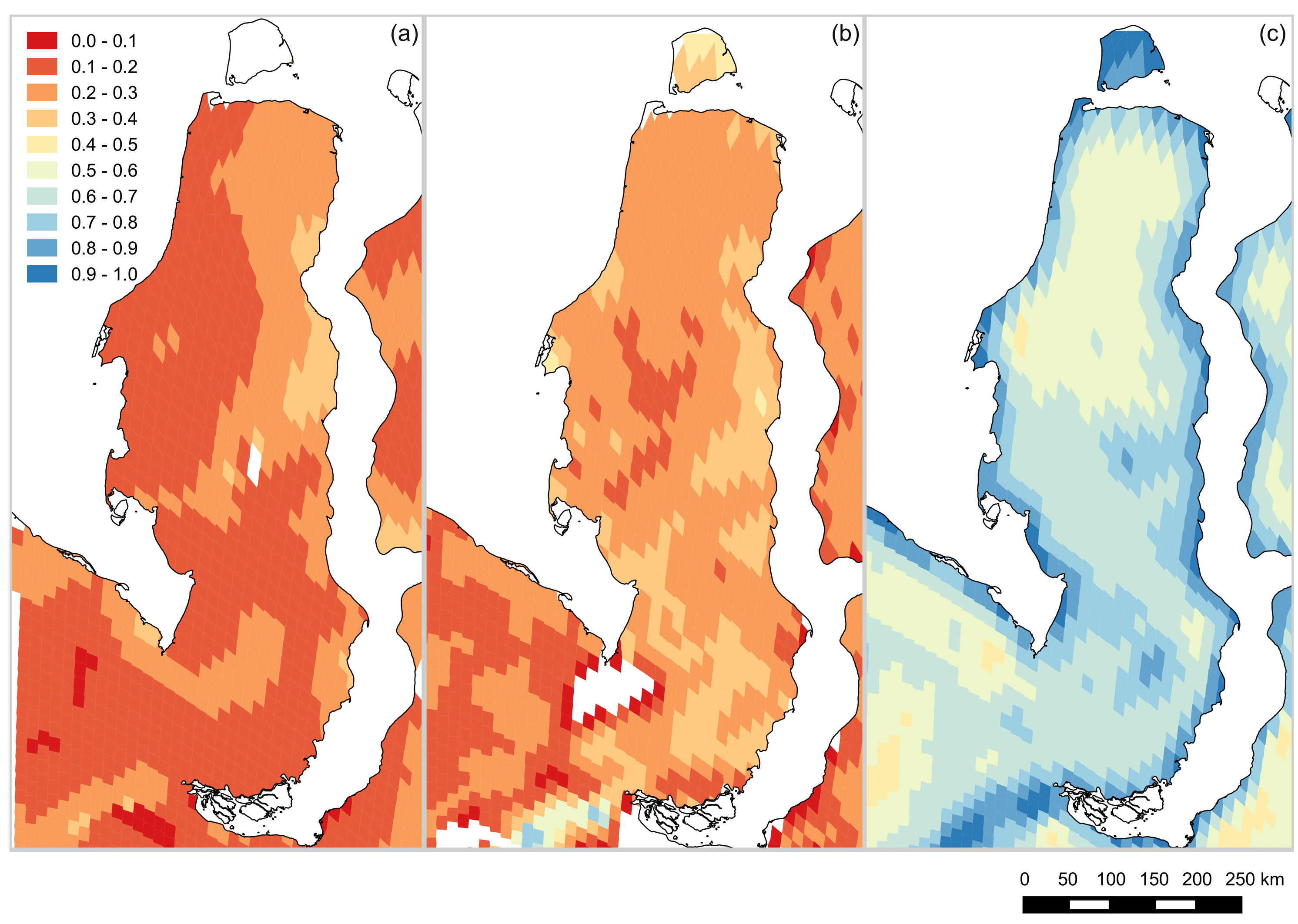

Figure 4. Average soil mositure from 2015-08-12 to 2015-08-20 - (a) GCOM-W1, (b) SMOS and (c) our results.

V. Conclusion

The main goal is to demonstrate, that knowing the type of soil and having the accurate dielectric model, gives better results when estimating soil moisture using brightness temperature.

Therefore a validation of standard soil moisture products of the SMOS and GCOM-W1 is required over the Arctic territory.

References

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