HS6.4: Remote sensing of soil moisture

Soil moisture retrieval from Sentinel-1 data using multiple linear regression approach

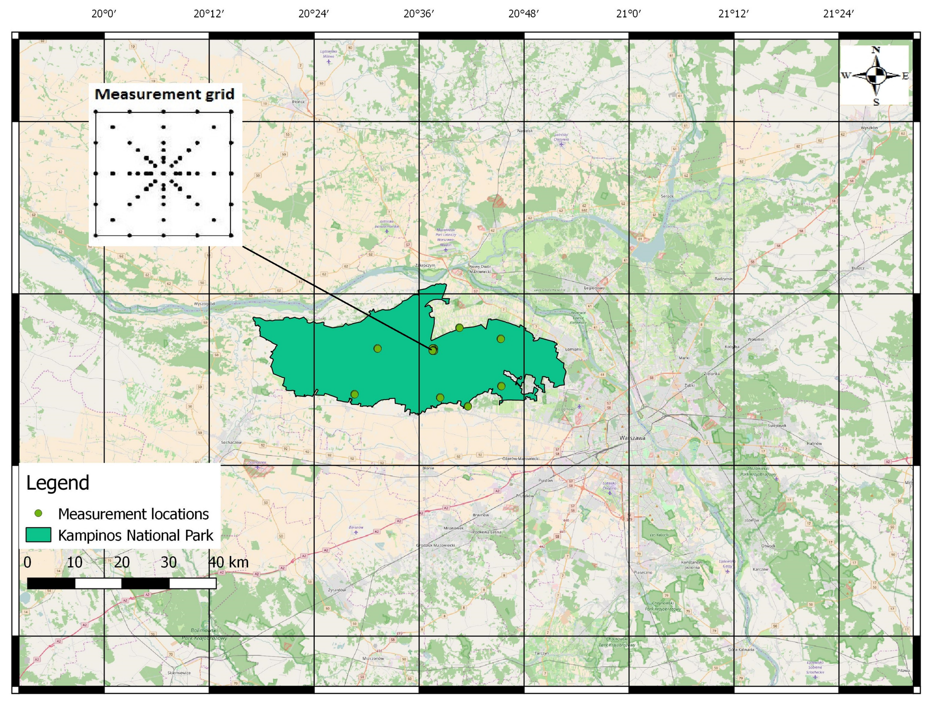
Paweł Grzegorz Gilewski & Mateusz Kędzior & Jarosław Zawadzki

Introduction

Soil moisture (SM) is one of the key variables that rules partitioning of the rainfall to infiltration and surface runoff. Despite its importance, number of missions dedicated to soil moisture measurement is limited. Microwave band - L is best suited for SM purposes, however there are several difficulties related to measurement. As a result, many approaches to retrieve SM content from active C-band measurements have been investigated in the literature. One of such approaches is construction of the multiple linear regression model (MRM). MRMs that apply terrain related indices, could properly predict soil moisture content. Recently, it was also proved that using MRMs, it is possible to obtain SM information using both passive [Al-Yaari et al., 2015] and active satellite sensors [Lievens et al., 2017]. In our previous work [Gilewski et al., 2016], we verified the performance of simple linear-regression model.

Study area

The measurement campaign took place 8-10 April 2015 in **the Kampinos National Park** which is located north-west from Warsaw, Poland. In-situ measurements were collected in 8 locations over **low-** and **high vegetation** areas. According to the literature [Teixeira et al., 2012] the grid thickening to the center was chosen. The data were collected using a time-domain reflectometer (TDR).



Methodology

The proposed method is based on the linear relationship between backscatter and soil moisture [Ulaby et al., 1984]. The high number of ground measurements resulted in having more than one in-situ value per one Sentinel-1 pixel. That was eliminated by applying mean in-situ soil moisture value if the described phenomena occured.

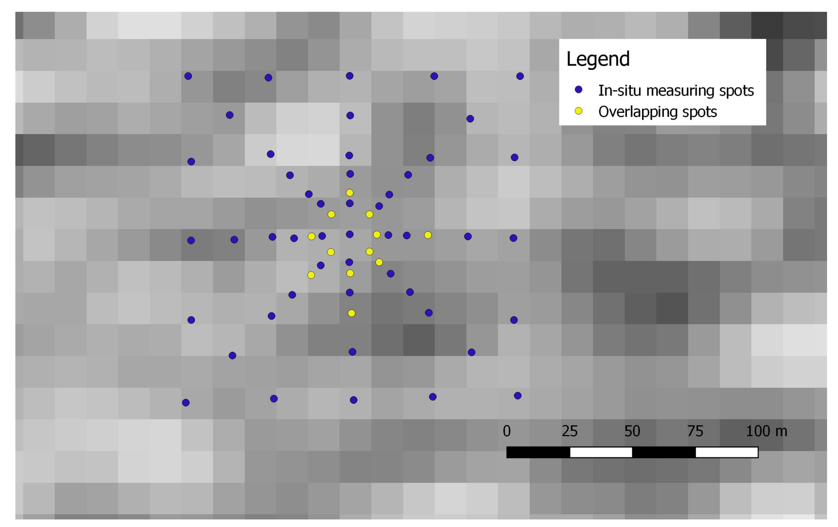


Figure 1: Overlapping spots

The multiple linear regression model was based on the following variables:

- **in-situ soil moisture,**
- **VH/VV Sentinel-1 backscatter.**

For the analyzed period of time Sentinel-1 data were available for 7 and 10 April 2015. Thus the primarly model for soil moisture retrieval was:

$$SM = \beta_0 + \beta_1 \cdot \sigma_1 + \beta_2 \cdot \sigma_2 + \beta_3 \cdot \sigma_4 + \beta_4 \cdot \sigma_4 \quad (1)$$

where: β_0 - intercept; β_1, β_2. β_3, β_4 - model coefficients; σ_1, σ_2, σ_3, σ_4 [dB] - backscatter for available polarizations.

In order to measure the relative quality of the proposed model **the Akaike information criterion (AIC)** and **the Bayesian information criterion (BIC)** were applicated. Both suggested to keep as the dependend variables for the model VH polarization for 7 April and VV polarization for 10 April.

Thus the final equation for Sentinel-1 soil moisture retrieval was following:

$$SM = -3.6524 - 0.9579 \cdot \sigma_1 - 0.5040 \cdot \sigma_2 \quad (2)$$

where: σ_1 - VH polarization for 7 April [dB], σ_2 - VV polarization for 10 April [dB].

Results

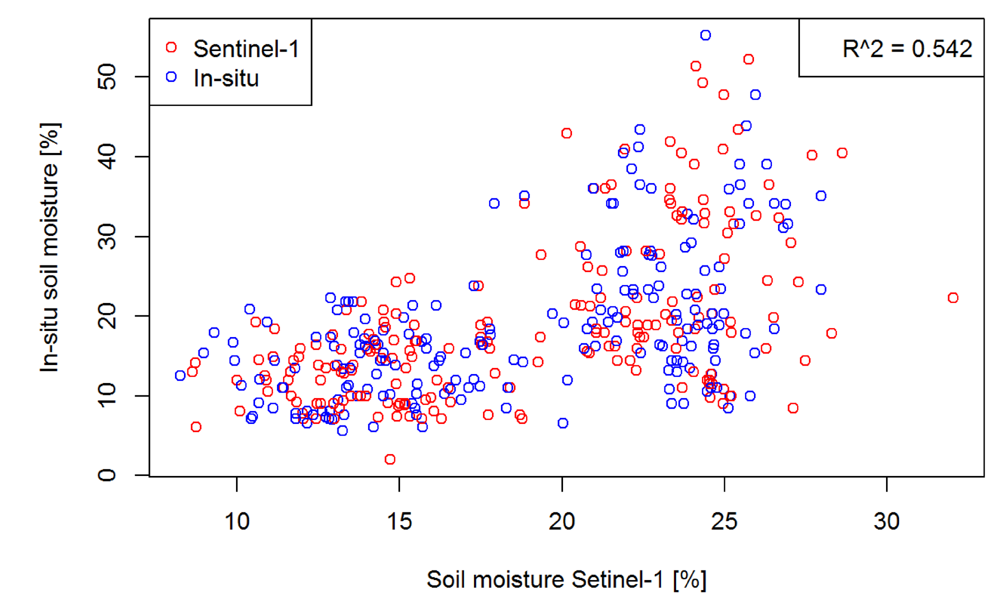


Figure 2: Scatterplot for Sentinel-1 soil moisture retrevials and in-situ measurements

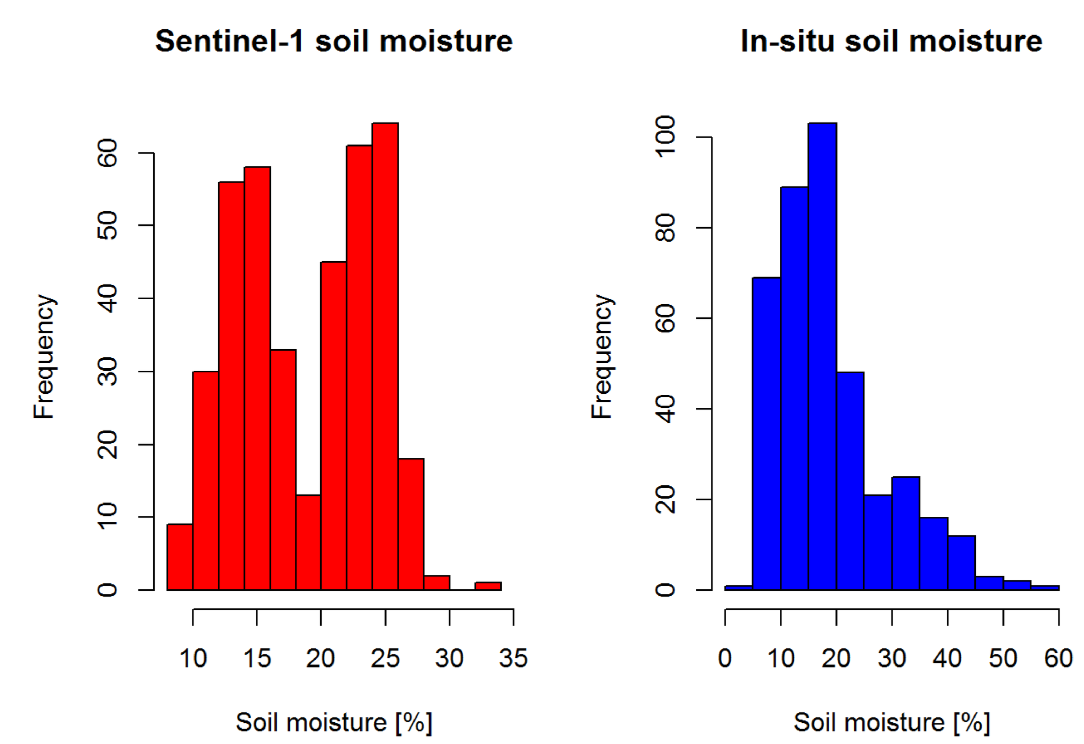


Figure 3: Histograms for soil moisture estimates

Conclusions:

- elimination of overlapping spots significantly improves model accuracy
- MRM gives higher correlation coefficient (0.54) than linear regression (0.51), but most importantly it has better structure of spatial distribution of SM
- the proposed MRM approach for Sentinel-1 soil moisture retrieval is rather applicable up to 40% soil moisture
- further research should apply longer data set to properly test developed MRM model on more homogeneous area

References

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POLITECHNIKA WARSZAWSKA
WARSAW UNIVERSITY OF TECHNOLOGY

Faculty of Building Services, Hydro and Environmental Engineering
WARSAW UNIVERSITY OF TECHNOLOGY

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pawel.gilewski@is.pw.edu.pl, mateusz.kedzior@is.pw.edu.pl