# STATISTICAL ERROR FOR THE MOISTURES RETRIEVED WITH THE SMOS RADIOBRIGHTNESS DATA, AS INDUCED BY IMPERFECTNESS OF A DIELECTRIC MODEL USED

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## 1. INTRODUCTION

In connection with the European Space Agency's (ESA) Soil Moisture and Ocean Salinity (SMOS) mission , the problem of soil type impact on the error of soil moistures retrieved by this instrument (L-Band radiometer) has emerged as an especially important issue. To retrieve the moisture from the radiobrightness measured, a specific dielectric model must be applied, which links the radiobrightness to the wave frequency, moisture, and soil type. At present, the Dobson semiempirical dielectric model [1] is employed to take into account soil type in the SMOS algorithms retrieving moisture. Meanwhile, there are the alternative models by Schmugge [2] and Mironov et. al. [3]. These also provide for permittivity values as a function of soil moisture, and soil type, allowing to link radiobrightness measured by SMOS to soil moisture. In this paper we carried out comparative analysis regarding the error of moisture retrieved from radiobrightness measured by SMOS, which is invoked by imperfectness of the three models discussed above. For this purpose, we used the dielectric database of complex permittivities available in the literature [1], [2], [4] at 1.4 GHz for different soil types and varying moistures. A statistical analysis was carried out to obtain the 95% confidence intervals in which a true moisture is confined, provided the value of moisture retrieved by the SMOS algorithm using a specific soil dielectric model is known. [1]

## 2. COMPARATIVE DEVIATIONS OF PERMITTIVITY CALCULATED WITH DIFFERENT DIELECTRIC MODELS

The soil moisture precision target for the SMOS mission is 0.04 $cm^3/cm^3$ and so we must know if the dielectric model used needs to be improved in order to reach this objective. Currently the model developed by Dobson et al

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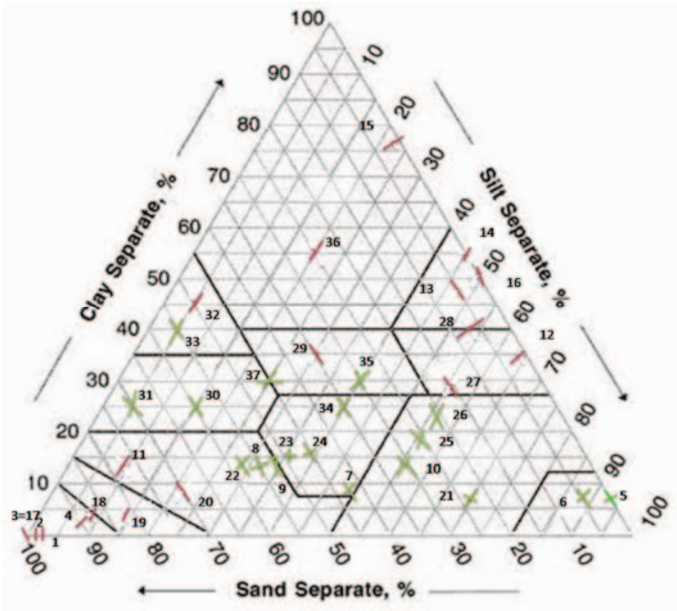


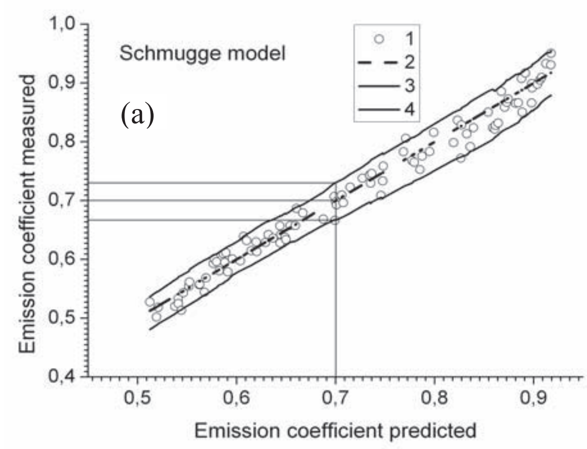

Figure 1. The real part of the permittivity deviations as computed with Schmugge model and Mironov model. The soils for which the deviation exceeds ± 5% marked with a line (minus). Soil moisture (SM) = 10%, T = 293.15ºK.

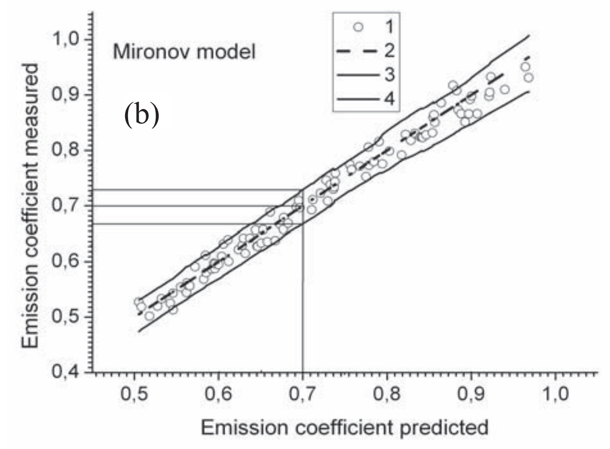
is used in L-band Microwave Emission of the Biosphere model. However the error it introduces has not been studied in depth but it is known that the precision of Dobson model is poor for different types of the soil [5]. While for these soil types, the Mironov model seems to give better results. As a first step, we compared soil permittivities estimated by the three models regarding the soil types as determined by the U.S. Texture Triangle. A reference number was given to each type of soil, as shown on the texture triangle in Fig. 1.

Using the three models, a percentage gap between Dobson, Schmugge and Mironov models was calculated for different values of soil moisture (0-30%). Then we determined the number of texture classes where the gap between the models was important (more than 5% or 10%). The soil types marked with line (minus) had the deviation of dielectric constant predicted by the Schmugge model from those obtained with the Mironov model exceeding 5%. This proves both models to provide for close predictions. While the deviations regarding the Dobson model were shown to exceed 10% for the majority of soil types.

## 3. CONFIDENCE INTERVALS CONFINING A TRUE MOISTURE

To estimate error of the moistures retrieved by SMOS, which is caused by imperfectness of each specific dielectric model discussed above, we formed the dielectric database comprising the dielectric constants and loss factors measured in [1], [2], [4] as a function of moisture and texture. These are three soils (45 measurements) from [2], the three soils (15 measurements) from [1] and 10 soils (34 measurements) from [4].



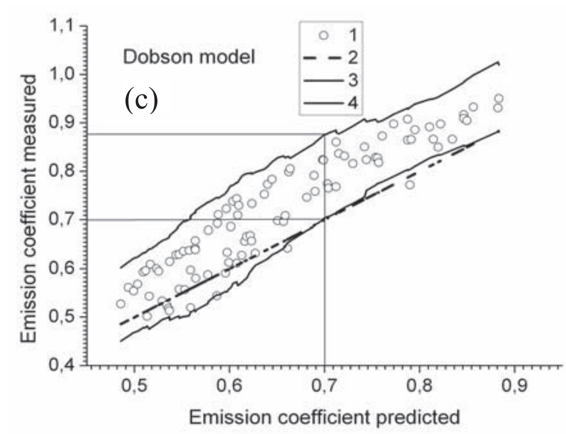
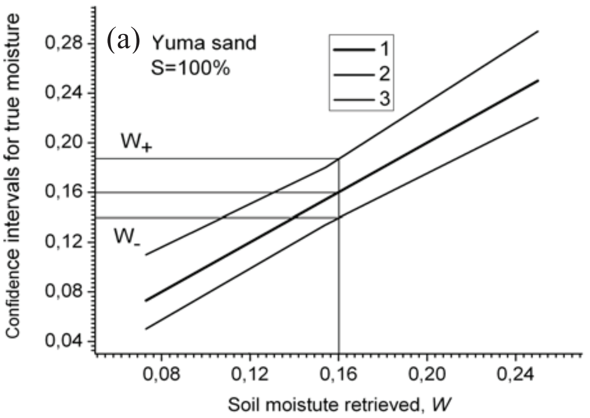




Figure 2. 95% confidence intervals (upper and lower) for a true emission coefficient as a function of the emission coefficient predicted, using the Schmugge (a), Mironov (b), and Dobson (c) models. The lines marked with 2, 3, and 4 represent upper confidence intervals, bisectors, and lower confidence intervals, respectively.

With this database available, the emission coefficients were calculated, using both the predicted and measured values of complex permittivities. As a result, the emission coefficient measured (corresponding to the emission coefficient computed with the measured complex permittivities), is compared with the value of the emission coefficient calculated using the respective dielectric models (emission coefficient predicted).

We considered the emission coefficient corresponding to observations in nadir. In Figs. 2, a, b, c, the emission coefficients measured are given as a function of the predicted ones. The errors were estimated as a relative deviation of the predicted emission coefficient from the upper and lower boundaries of the 95% confidence intervals shown in Figs. 2a, b, c. For the Schmugge model and the Mironov one these were found to be on the same order of 3% to 6%. While the error regarding the Dobson model exceeded the value of 27%, which suggests for the error of soil moistures retrieved with the use of this model to have much greater error then those retrieved using the Schmugge and Mironov models.

Using the results shown in Figs 2a, b, c, we estimated the error of the moisture retrieved in terms of 95% confidence interval moistures, between which a true moisture is confined. In the case of the Mironov model, the results of that estimation are shown in Figs 3a and b, concerning the Yuma Sand and Miller Clay analyzed in [2],



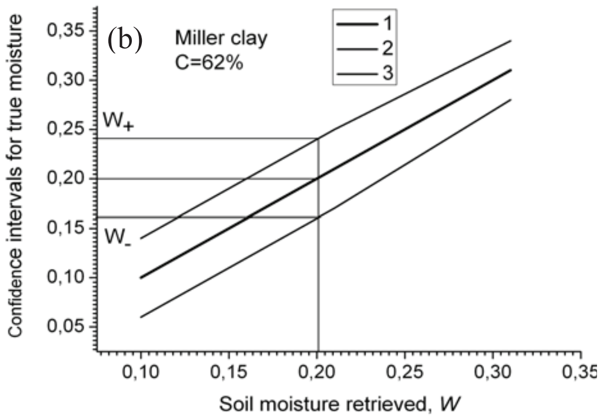




Fig. 3 a, b. 95% confidence intervals (upper, $W_+$, and lower, $W_-$) for a true moisture, $W_{tr}$, to be confined within, that is, $W_- < W_{tr}, < W_+$, as a function of moisture retrieved from radiobrightness observations corresponding to the SMOS mission.

which contain 0 and 62% of clay fraction, respectively. The errors corresponding to the Schmugge model were found to be on the same order as those shown in Figs. 3a, b.

## 4. CONCLUSIONS

As seen from Fig. 3, the error of moisture retrieved from the SMOS observation with the algorithms employing the models developed by Schmugge or Mironov was estimated to be on the average of ±0.02 $cm^3/cm^3$ to ±0.04 $cm^3/cm^3$ which fit the soil moisture precision target for the SMOS mission [5]. While the error regarding the Dobson model was found to substantially exceed that target error.

## 5. REFERENCES

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