# A Simple Modeling of the Bare Soil Emission at L-Band

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## 1 Introduction

In the framework of the SMOS mission preparation, it was necessary to test the existing land emission models, improve them in case it was necessary to get to a model that was directly applicable to the SMOS data.

The SMOSREX experiment [de Rosnay 2004] was developed to prepare the SMOS mission, the experimental site is located about 30km south of Toulouse (France) in the PIRRENE installation area (43°23'N, 1°17'E, 188m altitude). Weather conditions vary enormously along the year with a dry/warm summer and a wet/cold winter, which provides a very dynamic annual cycle of soil moisture.

Two different surfaces, natural fallow and bare soil, are continuously monitored by the means of multi-spectral remote sensing. Soil instrumentation allows continuous measurements of soil temperature and humidity.

## 2 The LEWIS radiometer

The LEWIS (L-band radiometer for Estimating Water In Soils) radiometer was especially designed for the experience [Lemaitre et al. 2004] and installed on the SMOSREX site. The instrument is mounted over a 15m height structure and continuously making measurements. Our radiometer stands out for its sensitivity (0.1 - 0.2 K) and the fact that it has no rear lobes. It is measuring over the site since 23th January 2003.

**FIG.1 LEWIS**

It measures continuously the fallow under an angle of 40° to its vertical axis and features automatically scans eight times a day to look at both the fallow and the bare soil at different angles.

The site is equipped, as well, with a very complete meteorological station. Soil moisture profiles are obtained by a set of Theta-Probe ML2 at different depths, and the temperature profiles by the mean of PT100 temperature transducers.

## 3 The model

According to the Radiative Transfer Models, the brightness temperature of a bare soil for a given angle $\theta$ and a polarization p can be written as:

$$T_{Bp}(\theta) = (1 - r_p(\theta))T_{eff} \quad (1)$$

where the effective temperature is calculated as, [Wigneron et al. 2001]

$$T_{eff} = T_{Deep} + (T_{Surf} - T_{Deep})(\frac{w_{surf}}{w_0})^b \quad (2)$$

$w_0$ and $b$ where calibrated in our site, and result to be $w_0$ = 0.36, and $b$=0.71

$r_p$ is the reflectivity of a rough surface, and according to [Wang et al. 1983]

$$r_p(\theta) = [(1 - Q)r_{sp}(\theta) + Qr_{sq}(\theta)]exp(-hcos^n(\theta)) \quad (3)$$

where $r_{sp}$ is the reflectivity of a smooth surface. The three parameters to calibrate are n, Q and h.

### 3.1 Influence of roughness at different polarizations

The relationship between LEWIS measured reflectivity and Fresnel reflectivity was studied for each angle and polarization. This relationship gives us a measurement of the influence of roughness.

We have plotted this relationship for each angle at vertical versus horizontal polarization, if roughness had the same influence on both polarizations, points would be on the $y = x$ line, which is not the case as we can see in fig (2).

A different value of n was tried for each polarization. A value of $n_h = n_v + 1$, homogenizes the effect of roughness on both polarizations as can be seen on fig (3).

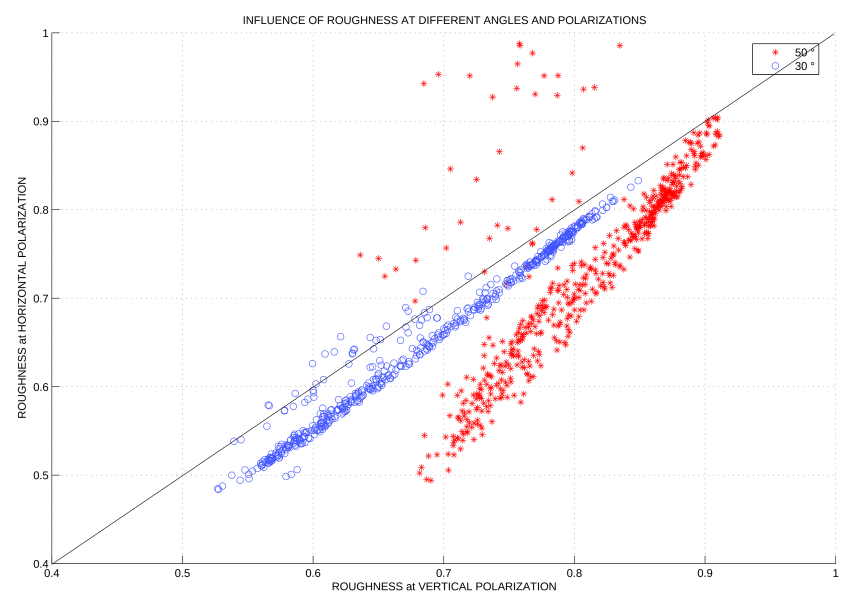

**FIG.2 roughness at different angles and polarizations.**

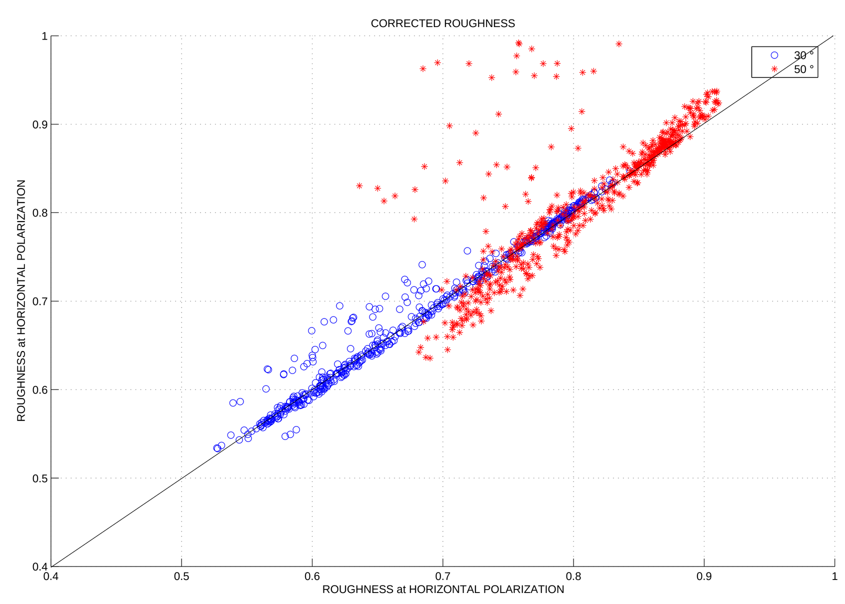

**FIG.3 corrected roughness $n_h = n_v + 1$**

### 3.2 Influence of roughness at different angles

Similar procedure between angles to determine the actual value of each n, was done. A value of $n_v = 1$ and $n_h = 2$ seems to fit better the data.

### 3.3 Roughness dependency on surface soil moisture

We obtain a linear dependency between roughness and surface soil moisture. It showed no dependency on deeper soil moisture or effective temperature, regression can be seen on fig (4).

When the soil reaches its field capacity, roughness reaches its minimum.

For dry soils, we obtain a maximum of roughness, and polarization mixing is being studied.

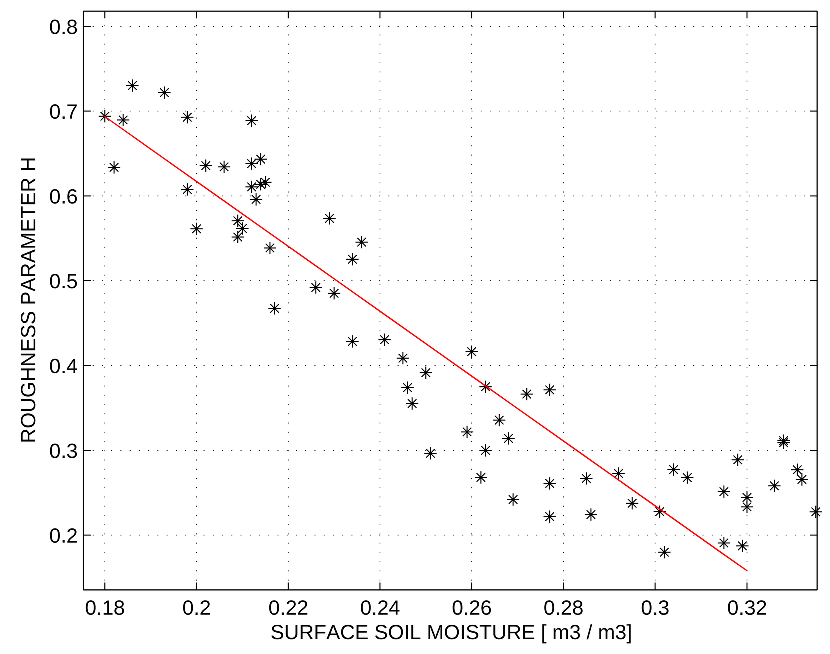


**FIG.4 roughness dependency on SSM.**

## 4 Conclusion

A simple model for the bare soil emission has been implemented, the error between the model and observations is comparable to other much complicated models.

The RMS error between model and measurements on vertical polarization reflectivity is 0.0118 and for horizontal polarization 0.0126.

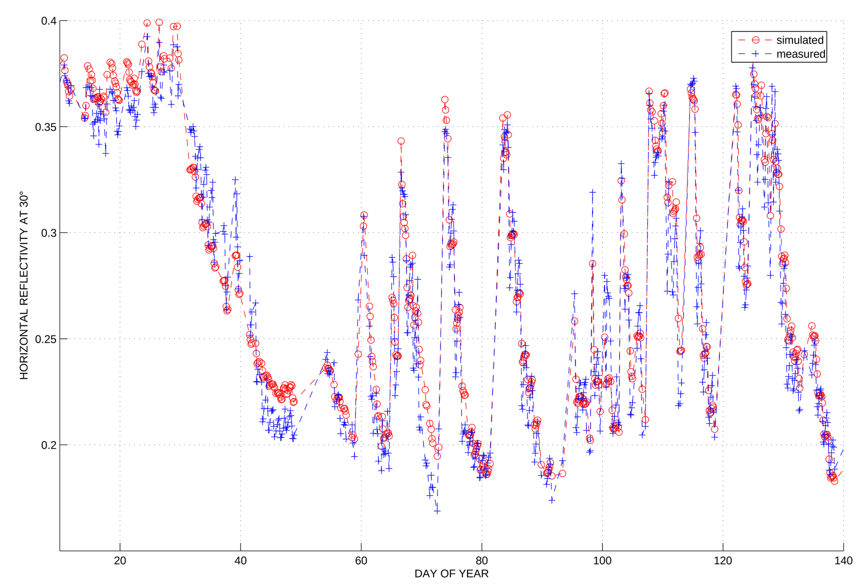

**FIG.5 Reflectivity at 30 $^o$.**

The difference between polarizations was modelized, without introducing new parameters.

Roughness linear dependency on surface soil moisture was found.

Our model does not represent well the signal for very dry soils. Polarization mixing might be considered. Further study is going on, including soil dielectric measurements.

## References

[de Rosnay 2004] de Rosnay, P., 2004: SMOSREX: A Long Term Field Campaign Experiment for Soil Moisture and Land Surface Processes Remote Sensing. *in preparation.*

[Lemaitre et al. 2004] Lemaitre, F., J. Poussiere, Y. Kerr, M. Dejus, R. Durbe, P. de Rosnay, and J. Calvet, 2004: Design and test of the ground based L-band radiometer for estimating water in soils (LEWIS). *IEEE Trans. Geosc. Remote Sens.*, **42**,1666–1676.

[Wang et al. 1983] Wang, J., P. O'Neill, T. Jackson, and E. Engman, 1983: Multifrequency measurements of the effects of soil moisture, soil texture, and surface roughness. *IEEE Trans. Geosc. Remote Sens.*, **21**,44–51.

[Wigneron et al. 2001] Wigneron, J., L. Laguerre, and Y. Kerr, 2001: A simple parameterization of the l-band microwave emission from rough agricultural soils. *IEEE Trans. Geosc. Remote Sens.*, **39**,1697–1707.