The IROE algorithm

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On the basis of experimental results, obtained in past years by IROE Microwave Remote Sensing Group, it has been stated that the brightness temperature (Tb) of microwave emission measured at C-band (6.8 GHz) is able to estimate soil moisture content (SMC) in different conditions of roughness and vegetation biomass, provided that a correction for the presence of vegetation is introduced. An algorithm has been proposed for computing SMC and correcting the effects of vegetation by using the sensitivity of Polarization Index ($PI=Tb_V-Tb_H/Tb_V+Tb_H$) at X-band (10 GHz) to biomass.

The relation between the brightness temperature (Tb) at C-band and the soil moisture of bare soils has the following generic form:

$$SMC = M + N * Tb_C$$

When the soil is covered by vegetation, the slope (N) of the regression line decreases and the intercept (M) may also change. On the other hand, the (PI) at higher frequencies and in particular at X-band is more sensitive to the vegetation biomass, and can discriminate between several levels of Leaf Area Index (LAI) [Paloscia and Pampaloni 1988]. We can therefore assume that PI at X-band could be related to the slope (N) and intercept (M) of the regression line between PI at C-band and SMC, according to equations of the following type:

$$M = a + b * PI_X \quad \text{and} \quad N = a' + b' * PI_X$$

Substituting these relationships in equation (3), we can choose more adequate coefficients for the regression line of SMC retrieval, which becomes:

$$SMC= [a + b * PI_X] – [a'+ b' * PI_X] * Tb_C$$

This procedure can be summarized in the flow-chart of Fig.1.

This algorithm was first tested on microwave data sets collected on agricultural area using IROE airborne radiometers at C and X band. A comparison of SMC retrieved from radiometric measurements with SMC measured on the ground, is shown in Fig. 2, which refers to experimental data collected in the agricultural area of *"Les Alpilles"* in Southern France [Macelloni et al, 2000]. The resulting correlation coefficient is R=0.78 and the standard error of estimate is SE=4.31.

The algorithm was subsequently validated to a larger scale by using satellite data from SMMR. NASDA kindly provided us with a data set of SMMR collected over 79 Russian agro-meteorological stations during a period of about 3 years (from October 1978 to December 1981), together with the corresponding ground-measured values of gravimetric SMC. The latter data, archived by Dr. K. Masuda and Dr. V. Savelin, represented the average value of the first 10-cm layer: they were obtained, with a time interval of 10 days, from April to October. Five SMMR data were picked up within an area around the target station.

From the analysis of these data sets, the slope and the intercept of the regression line $SMC=M+ N*Tb_C$ were related to the corresponding values of PI at X-band (PI_X). In this case, we found that:

$$M= 60.5+7* (PI_X)$$

And

$$N= 0.0008 – 0.2156*Ln(PI_X)$$

The final equation for the retrieval of SMC therefore becomes:

$$SMC = [60.5+7* (PI_X)] + [0.0008 – 0.2156*Ln(PI_X)] *Tb_C$$

The results of this algorithm is shown in the diagram of Fig. 3, where SMC measured on the ground was compared with SMC computed from SMMR data with the algorithm. Although the dispersion of experimental data is rather high, we see that, at least for some ground stations, the algorithm is able to retrieve reasonable data of SMC with R on the order of 0.70 and SE ranging between 3 and 9 [Paloscia et al. 2001]. The main problem of this validation lies on the considerable coarse ground resolution of the SMMR at C-band. The retrieval of SMC can work only in the case of highly homogeneous areas, for which the SMC values measured at the agro-meteorological station can be assumed to be representative of the entire surrounding zone. Other problems were due to the poor calibration accuracy between the two polarization channels.

References

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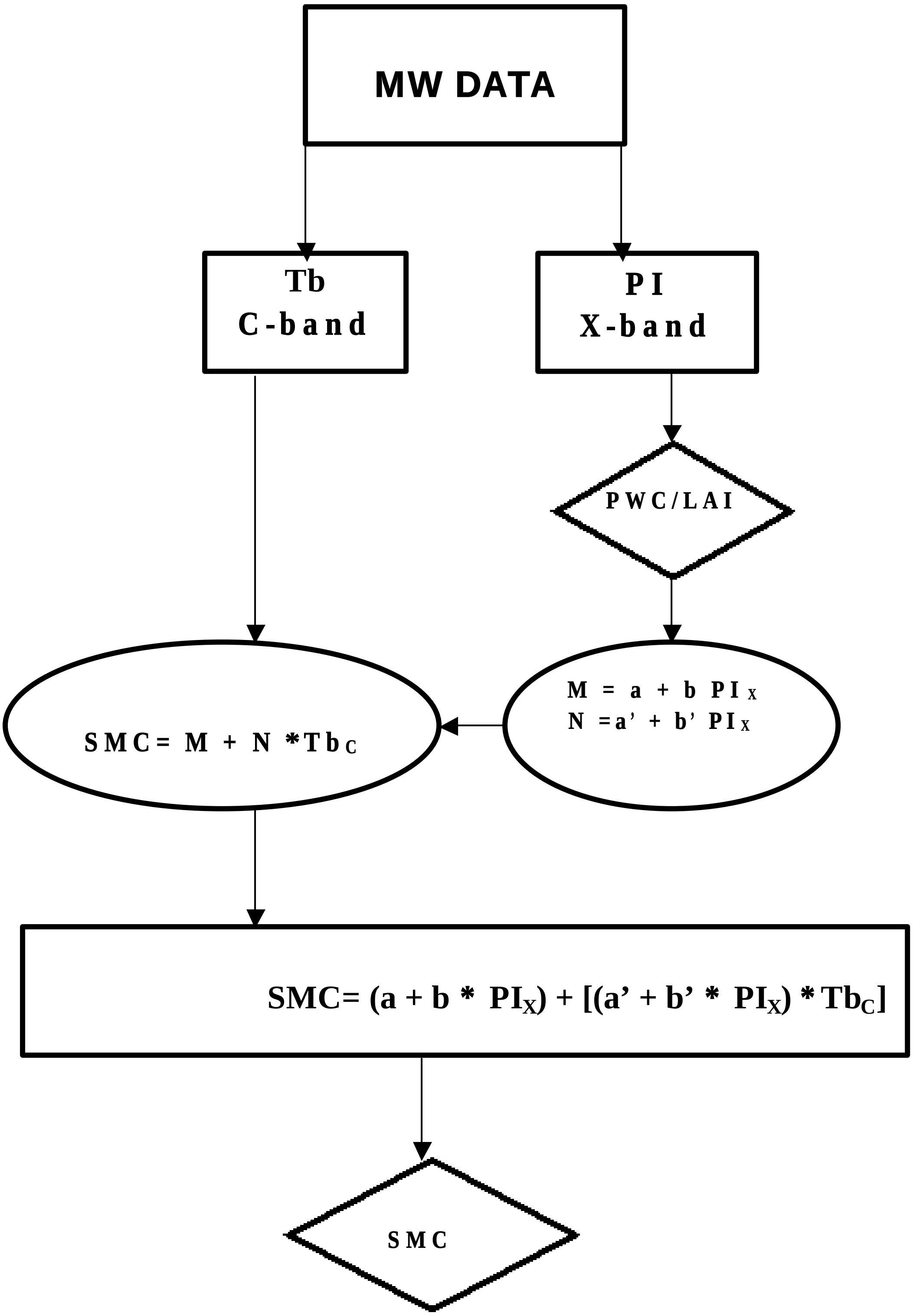

Fig. 1 – The proposed algorithm

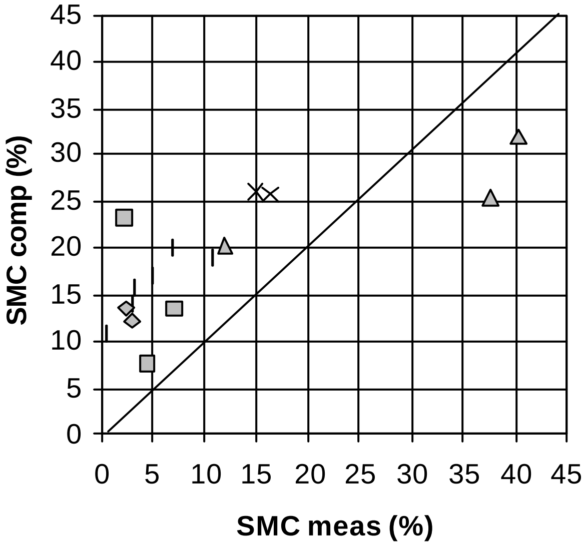

Fig. 2 - SMC % estimated with the algorithm as a function of SMC % of the first 5 cm layer measured on ground. The line represents the 1:1 line. Symbols refer to different crop types: = alfalfa, ▲= bare soil, x = sunflower, ♦ = wheat.

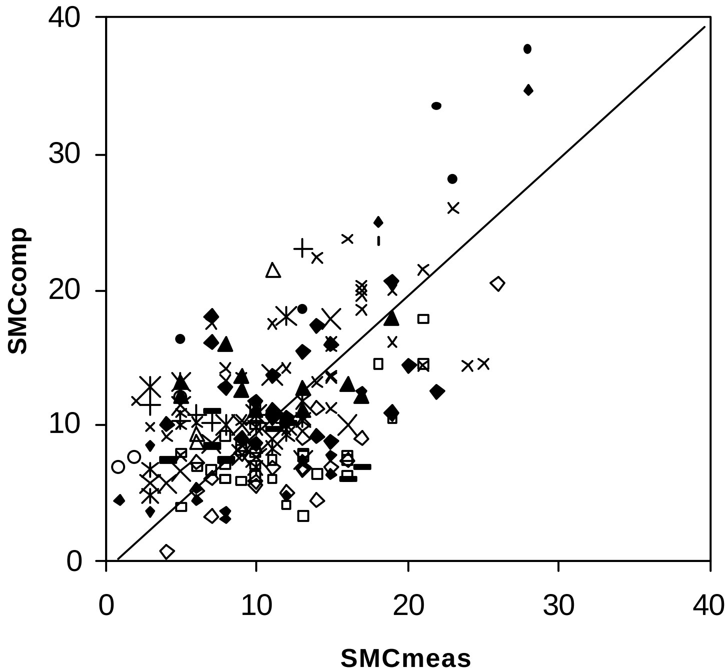

Fig. 3 - SMC% estimated from SMMR data of Tb at C-band vs. SMC% measured on ground. Different symbols refer to different Russian stations.