MICROWAVE CHRACTERISTICS OF CORN AT HIGHER FREQUENCIES BY MODELING AND EXPERIMENTS VALIDATION

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1. INTRODUCTION

In soil moisture retrieval by passive microwave technique at lower frequencies, the τ-ω model is often used. To eliminate vegetation effects at higher frequencies than C-band, a Matrix-Doubling microwave emission model is developed in this paper to study the single scattering albedo and transmissivity of corn with different height at C (6.925GHz), X (10.65GHz) and Ku (18.7GHz) bands. The comparison between the simulated emissivity of corn and the data collected by a truck-mounted microwave radiometer in a field experiment were good. During the experiment, to verify the emission from vegetation layer only, the ground surface of corn field was placed with an Aluminum foil, so as to mask the emission from the ground. A Brightness Temperature database was established by the Matrix-Doubling model, to simulate emission of corn field with different height. The results from the database were then matched to those by τ-ω model at the same parameters by least-square deviation, so as to retrieve the effective single scattering albedo and transmissivity of corn at C, X and Ku-band. The retrieved results were applied by PSR data during SMEX02 campaign, the retrieved soil moisture were close to the *in situ* measurements.

2. THE MODELS

In soil moisture retrieval, τ-ω model is often used, whose Brightness Temperature is:

$$T = T_c(1-\omega)(1-e^{-\tau}) + T_c(1-\omega)(1-e^{-\tau})\gamma_s e^{-\tau} + (1-\gamma_s)T_s e^{-\tau} \quad (1)$$

where ω is single scattering albedo of vegetation, and τ is its opacity, γ_s is surface reflectivity. T_c and T_s is brightness temperature of vegetation and surface, respectively[1]

In this paper, a Matrix-Doubling (thereafter M-D) model was developed[2], the soil surface model IEM in M-D was substituted by AIEM[3] which works well at higher frequencies and large roughness. The M-D model is based on ray-tracing technique, which could account for multiple scattering inside vegetation layer, as well as that between vegetation and soil surface at wider frequencies range.

3. EXPERIMENT AND MODEL VALIDATION

To verify the microwave emission by M-D model, we did a field experiment at QingYuan, Hebei Province of China (N 38°44'53", E 115°28'10") in July 7, 2008, when corn grew to about 80cm. The comparison between model and experiment were good as shown in figure 1. To verify the emission contribution from corn layer only, which is one the terms of M-D model, an Aluminum foil was placed on the ground below the corn, so as to mask the soil emission(Fig. 2.). The comparison is shown in figure 3.

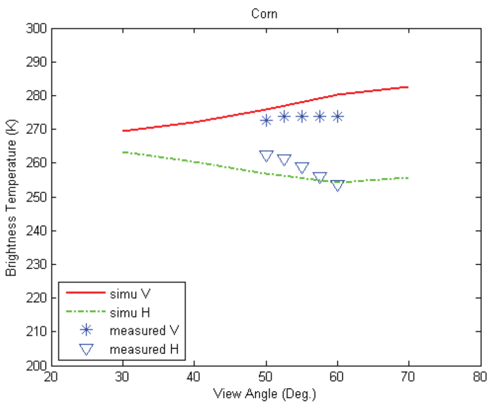


Fig.1. Comparison of simulation and measured Brightness Temperature at 6.925GHz

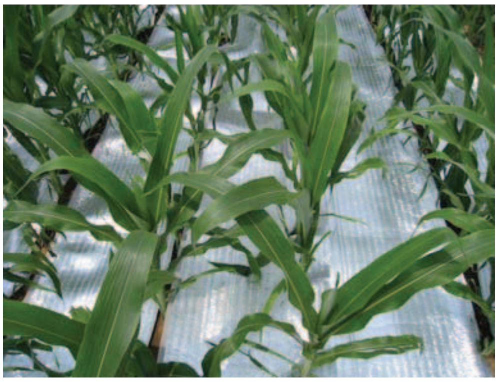


Fig. 2 An aluminum foil was placed on the ground under the corn to mask the soil emission

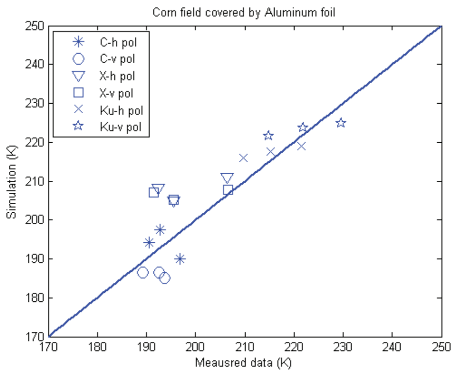


Fig. 3 Comparison of measured data vs. simulation of corn only when ground covered by Aluminum foil

4. ESTIMATION OF SCATTERING AND ATTENUATION

Since M-D model are very complicated, it is difficult to relate soil moisture to microwave emissivity directly. Based on equation (2), we matched the total emission from M-D model with those from τ-ω model at the same conditions by least-square error, so as to get the effective scattering and attenuation characteristics of vegetation at higher frequencies [4]:

$$\sigma = \sqrt{\sum_{1}^{N}(e_{i1} - e_{i2})^2} \qquad (2)$$

where e_{i1} and e_{i2} is emission from M-D model and τ-ω model, respectively. N is the number of simulation. The retrieved results are listed in Table 1.

Table 1(a) Effective single scattering albedo of corn at V pol (50° view angle)

	60cm	80cm	100cm	120cm	140cm	160cm	180cm	200cm
6.925 GHz	0.025	0.060	0.065	0.070	0.070	0.070	0.070	0.070
10.65 GHz	0.055	0.085	0.085	0.085	0.085	0.085	0.080	0.080
18.7 GHz	0.085	0.100	0.095	0.095	0.09	0.085	0.085	0.080

Table 1(b) Transmissivity of corn at V pol (50° view angle)

	60cm	80cm	100cm	120cm	140cm	160cm	180cm	200cm
6.925 GHz	0.81	0.71	0.61	0.53	0.46	0.42	0.33	0.28
10.65 GHz	0.75	0.64	0.51	0.43	0.39	0.31	0.22	0.18
18.7 GHz	0.69	0.56	0.42	0.33	0.25	0.19	0.14	0.10

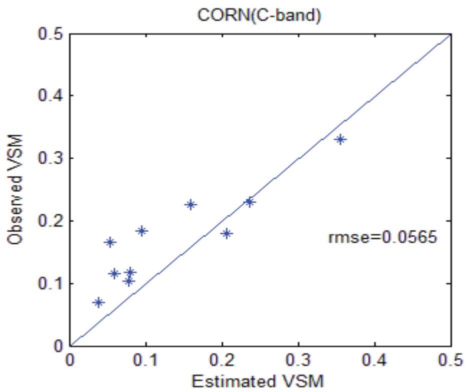
5. APPLICATION OF THE RETRIEVED RESULTS

Results from Table 1 were used by PSR airbone data during SMEX02 campaign. The soil moisture retrieval algorithm are based on Q_p model [5], at WC areas it is represented as:

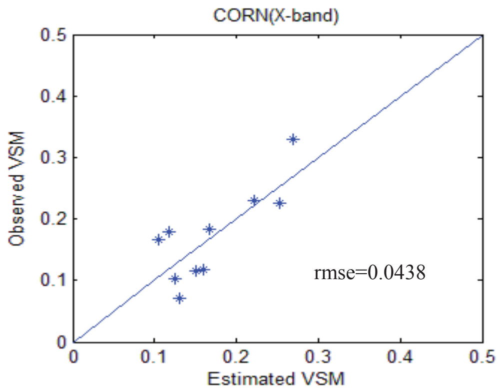
$$M_v(6.925GHz) = 4.576 + 2.315(0.4531e_v + e_h) - 6.643\sqrt{0.4531e_v + e_h} \qquad (3a)$$

$$M_v(10.65GHz) = 4.179 + 2.17(0.4092e_v + e_h) - 6.045\sqrt{0.4092e_v + e_h} \qquad (3b)$$

The retrievals of SMC of corn fields by equation (3) vs. measurements are shown in figure 4, where RMSE at C-band is 0.0565, at X-band is 0.0438.



(Left)Fig. 4a The retrievals of SMC of corn field vs. measurements at X-band



(Right)Fig. 4b The retrievals of SMC of corn field vs. measurements at C-band

6. PRELIMINARY CONCLUSION

The values of single scattering albedo and transmissivity of corn at τ-ω model are extended to C/X/Ku bands in this paper. The method is match results from M-D model to τ-ω model, before the M-D model was verified by an experiment. The single scattering albedo and transmissivity of corn were applied by PSR airbone Brightness Temperature data. The retrieval of SMC at C and X bands by Qp model are very close to the *in situ* measurements.

7. REFERENCE

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RESUME

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