A Study on the Parameter Sensitivity Analysis of the L-MEB Model for Passive Microwave Soil Moisture Retrieval

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Abstract: In this paper, a global sensitivity analysis method of the extended Fourier Amplitude Sensitivity Test (eFAST) is used to conduct a parameter sensitivity analysis of the L-band Microwave Emission of Biosphere (L-MEB) model. Sensitivity of all the parameters in the L-MEB model are analyzed, their sensitivity variations with different polarizations and different incidence angles are compared with that of the traditional local sensitivity analysis(LSA) method, and the traditional calibration method through the iteration between the modeled and observed brightness temperature(TB, K) based on the observations of other parameters including soil moisture, vegetation optical depth and so on is also discussed based on the eFAST results. Results indicate that firstly, the parameters of surface soil moisture(SM, cm^3/cm^3) , soil roughness factor(H_R), vegetation optical depth at nadir (τ_{NAD}, being zero and not included for bare soils), and effective soil/vegetation temperature(T_{gc}, ℃) make the four main sensitive factors, with their total sensitivity index(SI) values being up to about 0.6 for vegetation covers and about 0.8 for bare soils. Secondly, some different sensitivity analysis results are found compared with that of the traditional LSA method. For one example, the sensitivity of TB values to SM decreases with incidence angle for H polarization, while it increases slightly with incidence angle for V polarization, which is just opposite that of the LSA method; for another, the H-pol SM sensitivity is always lower than that of the V polarization, which is also contradict with that in the LSA method. All these results should be more explained to help understand the L-MEB model and the eFAST method. Lastly, the reliability of the traditional calibration method by iteration is also discussed to found that the calibration method cannot be applied to vegetation covers especially when the soils are dry, and it may get excellent H_R calibration results for bare soils.

Index Terms— Sensitivity Analysis, L-MEB, Soil Moisture, eFAST

1. Model and Method

◆ L-MEB model

$$TB_{obs,P} = TB_{atm} + (1-\omega_P)(1-\gamma_P)T_V + (1-\omega_P)(1-\gamma_P)T_V r_{GP}\gamma_P + (1-R_{GP})\gamma_P T_S$$

$$r_{GP}(\theta) = \left[(1-Q_R)r^*_{GP}(\theta) + Q_R r^*_{GP}(\theta)\right]\exp(-H_R \cos^{NRP}(\theta))$$

$$\gamma_P = \exp\left(-\tau_P / \cos\theta\right)$$

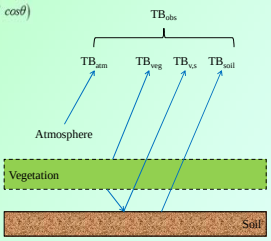

Fig.1 Simplified Radiative Transfer in the L-MEB model

◆ eFAST method

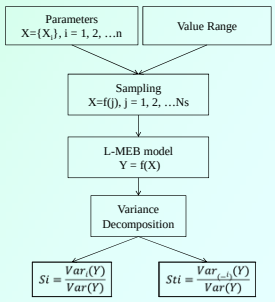

Fig.2 eFAST procedure

◆ Parameters Preparation

Table 1. Parameters' value range in L-MEB Model for Bare Soil Type

	SM	H_R	Tgc	V_clay	N_R
Range	0-0.5	0-1.5	20-50	0-100	-2-2

Table 2. Parameters' value range in the L-MEB Model for Vegetation Cover Type

	SM	H_R	τ_{NAD}	Tgc	V_clay	N_R	tt	ω
Range	0-0.5	0-1.5	0-0.5	20-50	0-100	-2-2	1-10	0-0.1

2. Results

◆ All Parameter Analyzed by eFAST

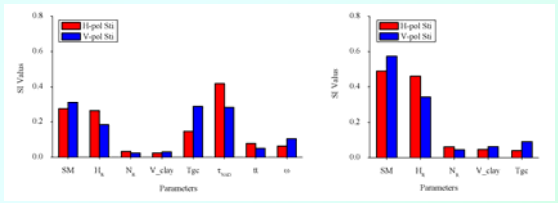

Fig.3 SI Values of all the L-MEB parameters
(a) Vegetation Cover Type and (b) Bare Soil Type

◆ Single Parameter Analyzed by LSA

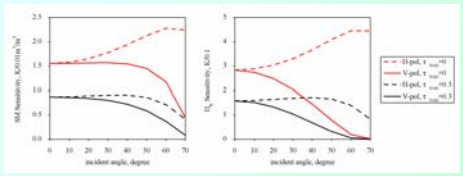

Fig.4 Sensitivity Variations with different incident angles through the traditional LSA method

◆ Sensitivity Index Variation with Different Incident Angles

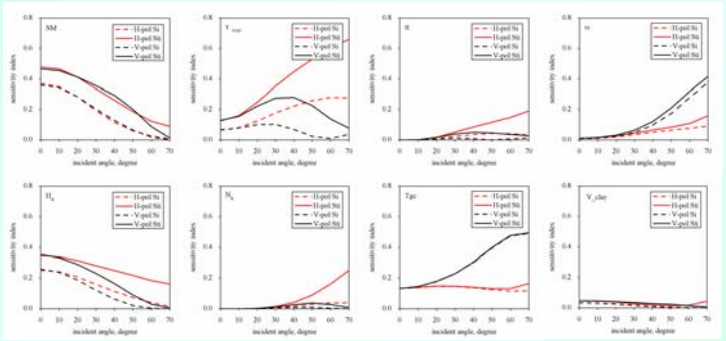

Fig.5 SI Variations with different incident angles for Vegetation Cover Type

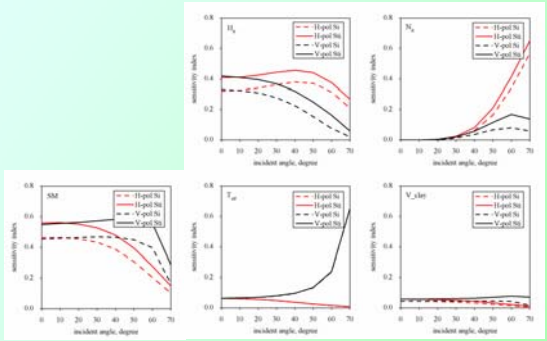

Fig.6 SI Variations with different incident angles for Bare Soil Type

◆ Discussion

The sensitivities of the calibrated parameters vary a lot when SM < 0.2 cm^3/cm^3 for H polarization and SM < 0.3 cm^3/cm^3 for V polarization for vegetation covers, indicating the poor performance of the calibration method by iteration;

The consistently high values of sensitivity index for H_R for bare soils indicating the possible excellent calibration results with the traditional iteration method.

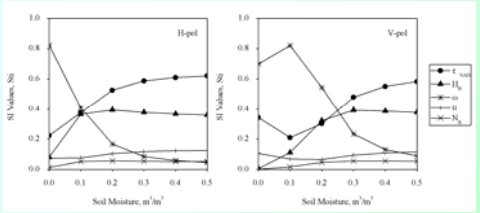

Fig.7 SI Variations of the empirical/semi-empirical parameters to be calibrated
in the L-MEB model for Vegetation Cover Type

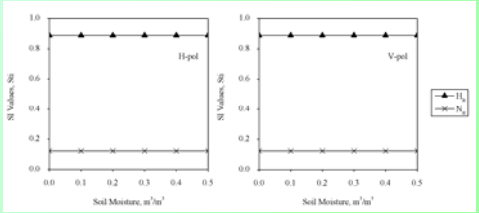

Fig.8 SI Variations of the empirical/semi-empirical parameters to be calibrated
in the L-MEB model for Bare Soil Type

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