SIMULATION AND MEASUREMENT OF RELIEF EFFECTS ON PASSIVE MICROWAVE RADIATION

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1. INTRODUCTION

The signal of a microwave radiometer observing a land surface is considered to be affected by relief effects [1]. Relief effects on microwave radiation are composed of four factors, which are hill elevations, hill slopes, hill aspects, and hill shadows. Though the importance of terrain reflected on microwave radiation is well understood theoretically, and has widely received proper attention, it has not been adequately explained from field experiment data. This is especially true at lower microwave frequencies, as atmospheric effects can be ignored at the frequency less than 10GHZ [2]. To investigate the potential of passive microwave for observing a hill-scale land, it is necessary to provide a crucial link between passive microwave observations and relief effects on an emitting surface. Accordingly, the objectives of this study are to report on: 1) field-data-supported selection and verification of an appropriate physically based surface emission model for describing relief effects on passive microwave radiation; 2) the generation of a comprehensive brightness-temperature observation data under some of relief factors.

2. SIMULATION ANALYSIS

Used by the advanced integral equation model (AIEM) and Fresnel equations to describe surface emission, relief factors were entered in the calculation of surface emissions [3]. Here hill slopes and aspects were input in AIEM used the flowing relationships

$$\cos\theta l = \cos\alpha\cos\theta + \sin\alpha\sin\theta\cos(\phi-\beta)$$

Where θl is the local incident angle transformed from the global to the local plane of incidence, α is the tilt angle, θ is the observation angle with respect to the surface normal, ϕ is the azimuth angle of the observed view, β is the aspect of tilted surface.

Furthermore the linear polarization is rotated by an angle φ, given by

$$\sin\varphi = \sin(\phi-\beta)\sin\alpha / \sin\theta l$$

The emissivity E_v (θ) and E_h (θ) in rolling terrain can be represented:

$$E_v(\theta) = E_v(\theta_l)\cos^2\varphi + E_h(\theta_l)\sin^2\varphi$$

$$E_h(\theta) = E_v(\theta_l)\sin^2\varphi - E_h(\theta_l)\cos^2\varphi$$

Figure1 left describes the relationship between surface emission and local incident angles affected by hill slopes only. When concerned with polarization rotation, the microwave radiation of tilted surface becomes more complex. From the right figure1, it shows the change of surface emission with the polarization rotation angles.

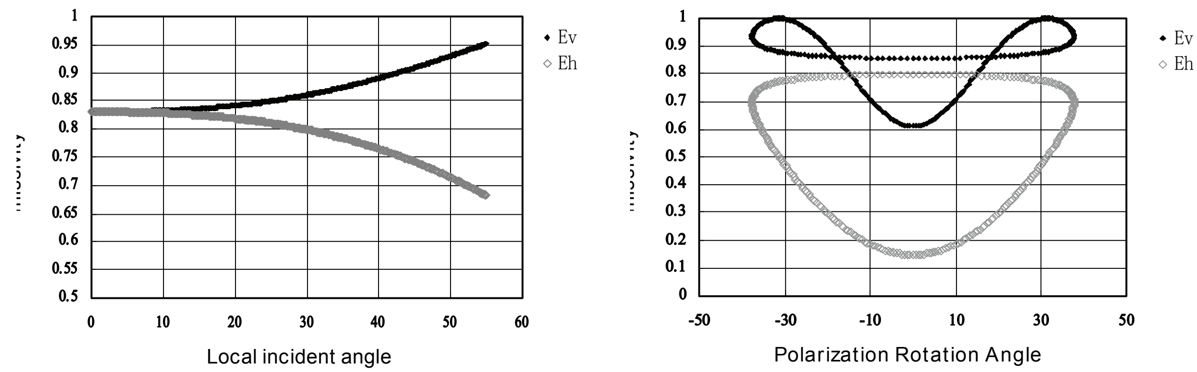

Fig.1. Simulation of local incident angle impact on surface emission at 6.925GHZ frequency by AIEM: Left computed without polarization rotation; Right considered polarization rotation.

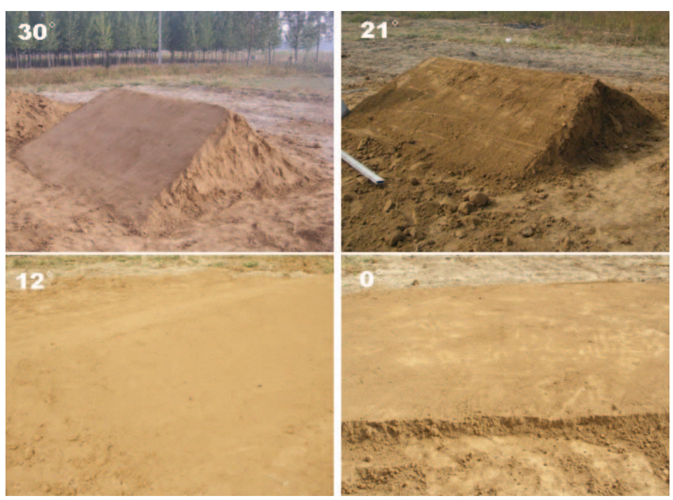

Fig.2. Views of relief landscape of different slopes: 30°, 21°, 10°, and 0° prismy hills

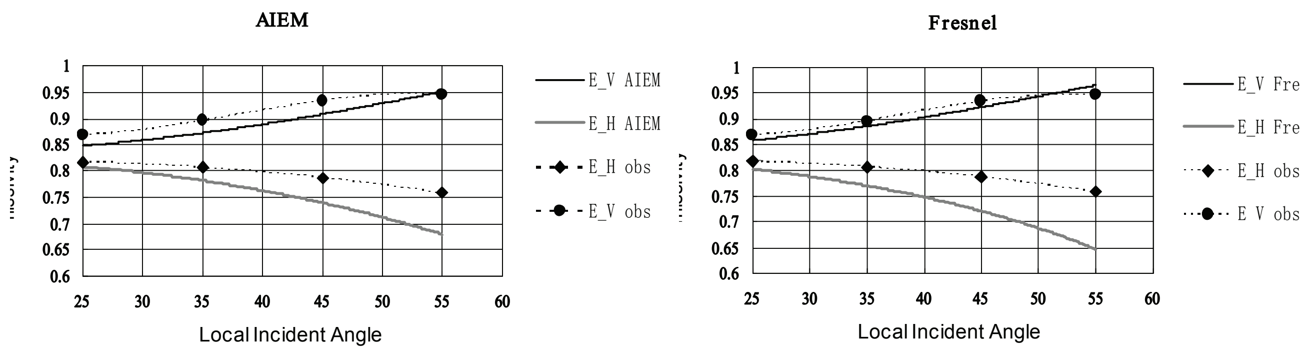

Fig.3. Results of observed data compared with simulation at C band: Left is based on AIEM simulation; Right is based on Fresnel equations.

3. EXPERIMENTAL MEASUREMENTS

To argue relief effects on microwave radiation, we designed a controlled field experiment based on the truck-mounted microwave radiometer, which seeks to improve our understanding of relief effects on microwave radiation at microwave frequencies (C-band). Considering diversification of hill slopes, prismy hills were piled by fluvo-aquic soil as observed landscapes to insure the orientation of the observed surface in a certain view of direction without polarization rotation. Prismy hills was built in different slopes(0° ,10° ,20° ,30°) . When due with variational aspects at each observed facet, we put up a conical hill so that it could obtain surface emission on the impact of polarization rotation. Figure 2 exhibits some of relief landscapes we projected.

4. RESULTS AND DISCUSSION

Brightness temperatures of relief landscapes obtained from the field observation were converted to apparent (effective) emissivity [4]. It is essential to explore whether local incident angles as one of important relief factors have influence with surface emission due to tilt angles. Figure3 shows a comparison of observation and simulation on local incident angles at C band. In the vertical polarization at C band, we note an apparent agreement between the observed and simulated data sets. It is noteworthy that there is more difference in the horizontal polarization than the vertical polarization. Because we made surfaces of relief landscapes as smooth as possible, Fresnel equations introduced contrasted with AIEM model. The result illuminates that local incident angles indeed have an impact on surface emission, which resulted in the difference of brightness temperatures from tilt angles (0° ~ 30°) within 15K to 25K. Meanwhile, the compare also suggested we could describe the tilted surface emission with AIEM, or Fresnel equation if predigest the surface condition as smooth lands.

5. CONCLUTIONS

The approaches we adopted in our study, such as using AIEM, which was developed for modeling random rough flatterrain emission, cause some shortcomings. However, when compared the simulation with our experiment data, we acquired the agreement that relief effects do affect microwave radiation features. Here we regard local incident angles as the principal relief factor which reflects in microwave radiation. We find that hill-scale topography influences microwave radiation in a way that produces bias at microwave brightness temperatures. When AIEM and Fresnel equations simulate the relief effect of local incident angle in the H polarization, there are distinctions between simulation and observation within small tilt angles ($<20^{\circ}$). These results have implications for soil moisture data assimilation and disaggregation of brightness temperature observations to topography [4].

6. REFERENCES

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