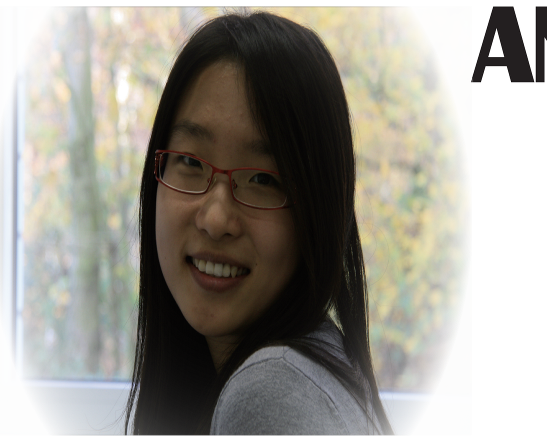

ANALYZING TOPOGRAPHY EFFECTS FOR L-BAND RADIOMETRY USING AN IMPROVED MODEL APPROACH

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Introduction

Effects of topography on passive remote sensing at L-band can be divided into the observation geometry effect on microwave emission and the adjacent effect on microwave radiation scattered by the surrounding elevated terrain. The former was considered by [1] using the classical geometric optics approximation. Mialon et al. [3] and Cuneyt et al. [4] provided an intuitive estimation of the impact of topography, with a parameter relative to topographic features instead of Digital Elevation Model (DEM) by statistical modeling approaches. The latter was calculated by a simplified maximum estimation [1] and a complex ray-trace algorithm [2]. In this study, we pay close attention to the interactive mechanism between topography and microwave radiation by describing microwave radiation characteristics of terrain scenes. An improved microwave radiative transfer model is proposed to simulate relief effects for five different landscapes built up by Gaussian surfaces, and to predict the impact of topography on brightness temperature (T_B), and consequently on soil moisture retrieval at L-band.

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Methdology

To simulate and estimate topographic effects on L-band, a three-step approach is performed. First, we gneerate various landscapes based on Gaussian surfaces ranging from flat terrain to multiple hills within a 35 x 35 km scene. Topography is classified by five levels according to the terrain complexity (i.e. 0 = flat, 1 = a single hill, 2 = double hills, 3 = hills in line, and 4 = hills in circle (Figure 1)). Secondly, we propose a L-band microwave radio transfer model on mountain areas as shown in (1). The up-welling brightness temperature (T_{up}) includes land surface emission in the local frame, scattering radiation (T_{sr}) and sky radiation (T_{sky}). T_{sr} is represented in (2), with θ_H as the horizontal zenith angle of terrain , and R_{d_sur} is the diffuse reflection from surrounding terrain. While receiving radiation from neighborhood, the central terrain reflects the energy back to surrounding terrain again indicated by the diffusion scattering from central terrain (R_{d_cetr}). $E_{P\_sur} \cdot Ts$ is the land emission term from surrounding elevated terrains. Thirdly, we analyze the impact of involved soil moisture and soil temperature on the model, and estimate relief effects on the L-band soil moisture (SM) retrieval. The SM retrieval algorithm at L-band is determined by (3), where R_{P_sp} is spectral reflection for vertical or horizontal polarization, S_D and L_C are surface roughness parameters, S_D/L_C is set to 0.1, and A, B, and C are empirical parameters for L-band.

$$T_{up}= E(\theta_l)_P \cdot T_s+T_{sr}+T_{sky} \quad (1)$$

$$T_{sr}= \cos^2\theta_H \cdot R_{d\_sur}+R_{d\_cetr} \cdot (E_{Psur} \cdot T_s-T_{sky}) \quad (2)$$

$$SM= \{-\ln[(1-T_{up}/T_s)/R_{Psp}]/[A(S_D/L_C)^C]\}^{1/B} \quad (3)$$

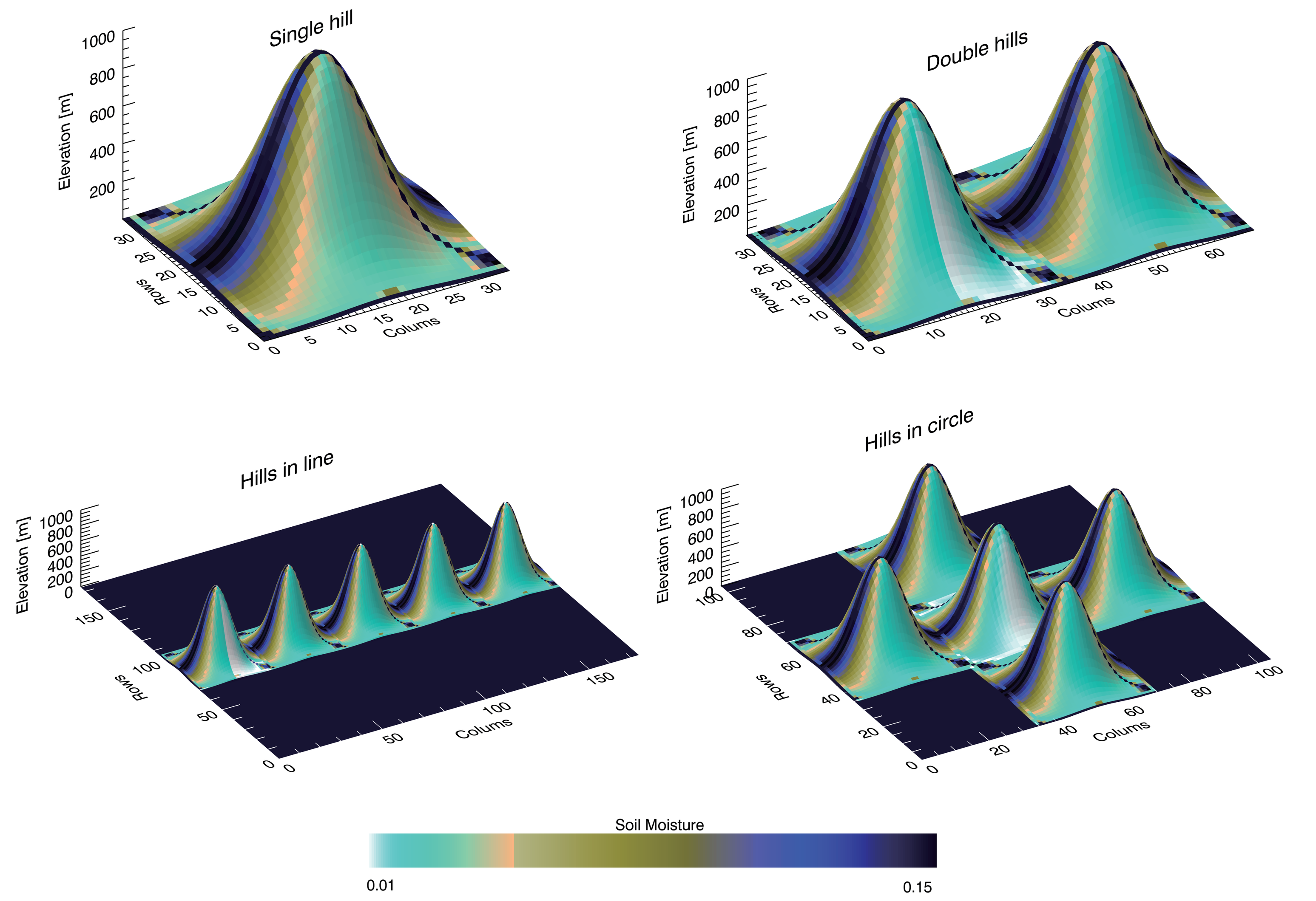

Figure 1. Overview of the terrain complexity and the distribution of retrieved soil moisture [cm³cm⁻³]. All terrains were assumed to be homogeneous in land surface temperature (283 K), observed angle (32.5°), soil texture (35% sand and 13% clay content), and soil moisture (15%). The ratio of flat to hill projection area is maintained constant for all hilly scenes, and therefore, the only variable factor will be topography.

Results

Brightness temperatures of each scenario are plotted under different levels of the terrain complexity in Figure 2. To estimate the impact of the model input parameters on topography, the significance of the assumed soil moisture from low to high to relief effects is revealed in Figure 3. When the soil becomes wetter the deviation of T_B between flat and mountainous terrain is enhanced. In contrast to water content, land surface temperature has a negligible effect with less than 1 K for both polarizations (Figure 4). In Figure 1 the spatial distribution of soil moisture is plotted for various terrain scenes. Additionally, soil moisture retrieval error increases with increasing terrain complexity as shown in Figure 5.

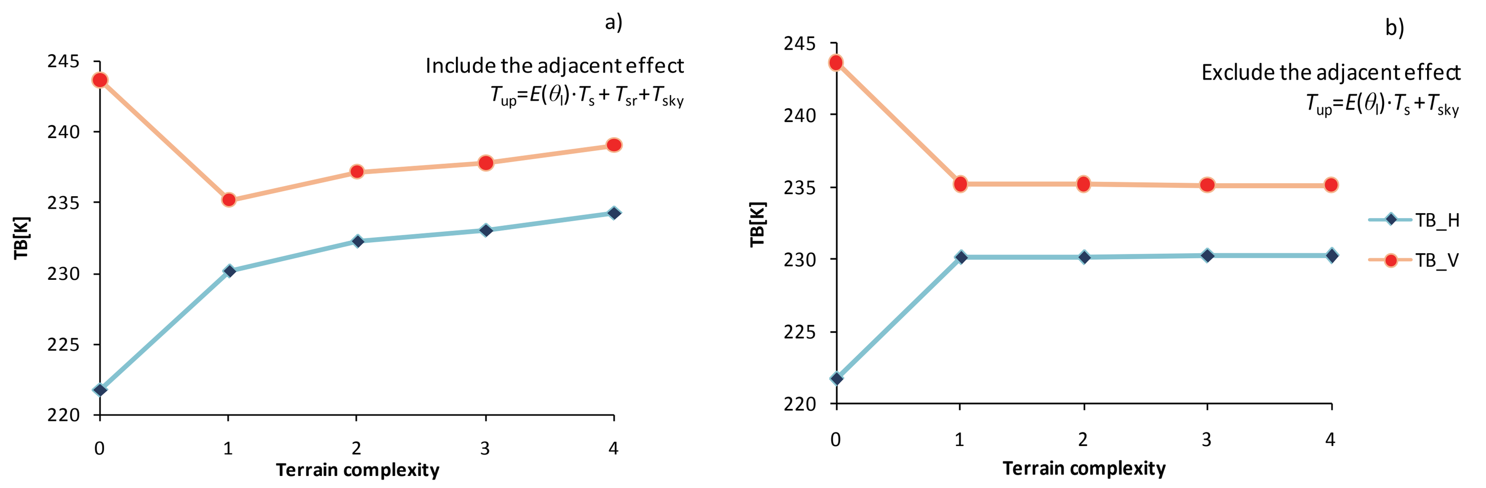

Figure 2. The up-welling T_B simulation for every terrain scene.

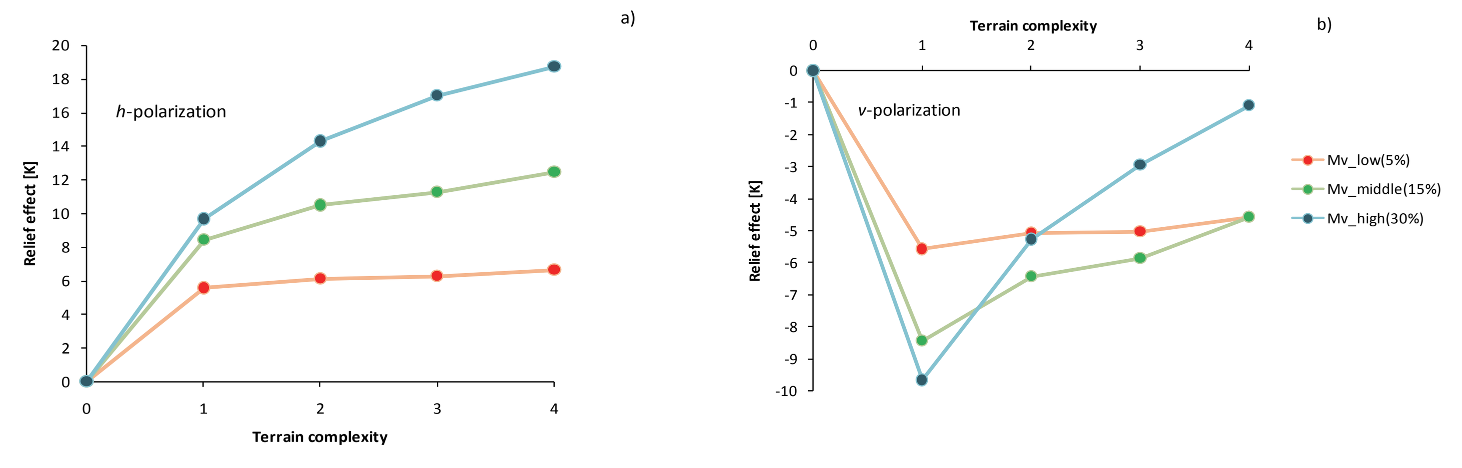

Figure 3. The influence of soil water content on relief effects ($\Delta T_B=T_{B\_flat}-T_{B\_relief}$).

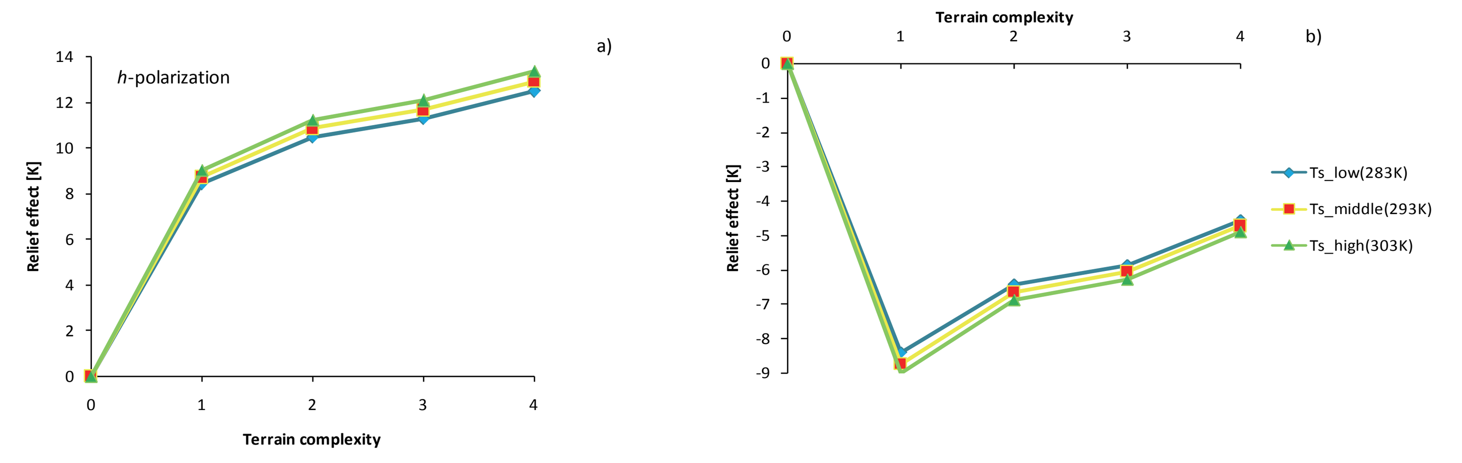

Figure 4. The influence of soil temperature on relief effects ($\Delta T_B=T_{B\_flat}-T_{B\_relief}$).

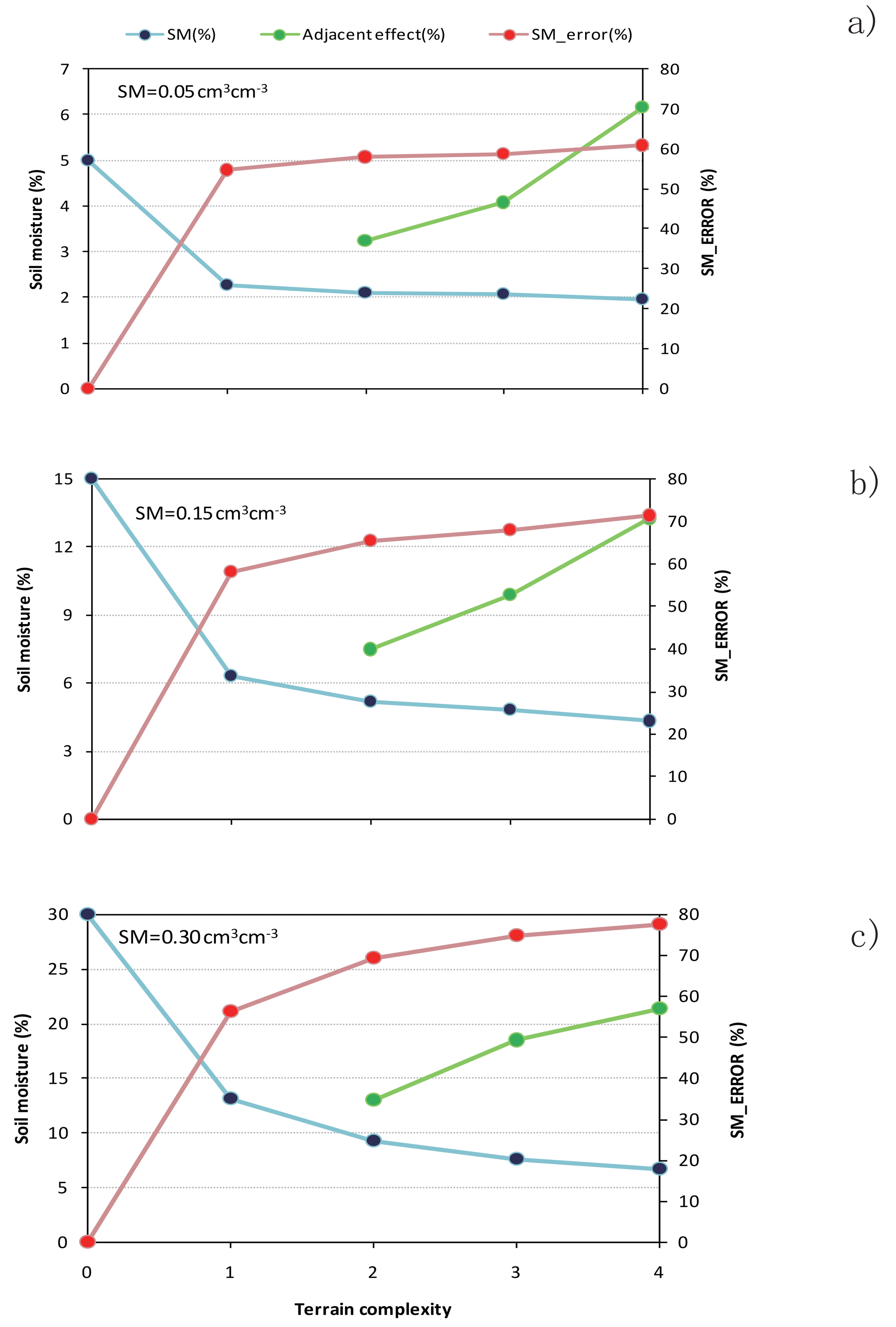

Figure 5. Relief effects on soil moisture retrieval at L band, and SM retrieval error is $SM_{error}=|(SM_{relief}-SM_{flat})/SM_{flat}|\times 100\%$, and the adjacent effect on SM retrieval is calculated by $SM_{error}(n)-SM_{error}(flat)$, n is the terrain complexity (n=2,3,4).

Conclusions

It is imperative to develop microwave radiative transfer models for L-band over mountain areas characterized by low complexity, and practical use. Based on this improved model, the soil moisture retrieval error at L band caused by topography is more than 4%, the maximum permissible error. The results presented indicate the necessity of eliminating relief effects at L-band and our approach provides a potential methodology for topography correction.