Sensitivity Analysis of P-Band Interferometric SAR Response to Soil Moisture Profiles and Subsurface Random Media

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In this paper a comprehensive sensitivity analysis of P-band interferometric SAR (InSAR) response to variations in soil moisture profiles and subsurface random media will be presented. In the forward modeling of rough soil surface and subsurface heterogeneity, 3D stabilized extended boundary condition method (SEBCM) and recursive T-matrix method is utilized. Due to the modularity of this forward model, different subsurface features can be simulated separately as scattering matrices and then combined together for computational efficiency. The results of sensitivity analysis are exploited to develop a preliminary soil moisture retrieval algorithm using synthetic InSAR data at P-band.

The realistic soil structure is modeled as a rough soil surface on top of numerous homogeneous layers representing a soil moisture profile, as shown in Figure 1. The soil moisture profiles can be characterized by a constant, linear, quadratic, or even higher-order polynomial function, depending on in-situ information and the number of unknowns allowed in the inverse problem. In this work, the soil moisture profile is assumed to be quadratic, i.e., $m_v(z) = az^2 + bz + c$. Since volume scattering is expected to play an important role in producing significant InSAR phase variation, air voids and buried rocks are included within the soil profile as small spheres with corresponding dielectric constants. Sensitivity analysis is conducted by varying the subsurface features mentioned above under physical assumptions of realistic soil conditions (e.g., soil moisture less than saturated moisture). Figure 2 shows an example of sensitivity of HH P-band InSAR phase to coefficients *b* and *c* under the constraint that *a = -1.5*b -0.05* based on in-situ information. We can see that wetter surface soil (larger *c*) reduces the sensitivity of InSAR phase to coefficient *b* due to higher signal attenuation from the surface and near-surface layers. The information observed from various sensitivity studies will be taken into account when developing a soil moisture retrieval algorithm. Model validation will also be performed once AirMOSS P-band phase-calibrated SAR data becomes available.

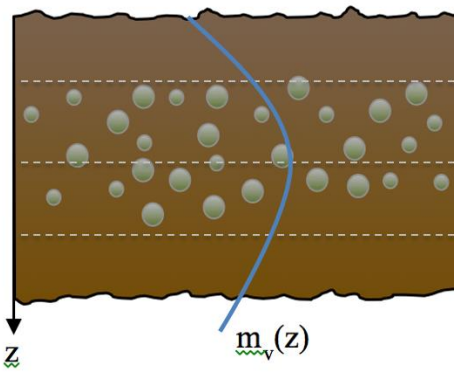

Figure 1. Rough soil surface with moisture profile $m_v(z)$ and random scatterers (grey circles).

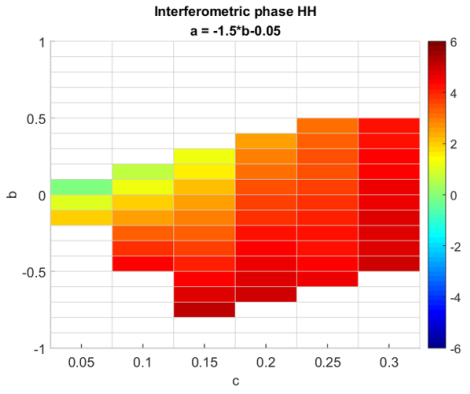

Figure 2. HH P-band InSAR phase of varying coefficients b and c (a = -1.5*b-0.05 is assumed based on in-situ information).