Ionosphere Effects on SAR Performance at UHF and VHF Frequencies

Sassan Saatchi, Ernesto Rodriguez, and Mahta Moghaddam
Jet Propulsion Laboratory
California Institute of Technology
4800 Oak Grove Drive
Pasadena, California 91109

Abstract

Currently, several international space agencies are investigating the use of low frequency spaceborne synthetic aperture radar (SAR) systems for a variety of planetary and earth science applications. At low frequencies such as UHF and VHF, the radar signal penetrates with less attenuation into surface layers and can measure much larger variations of moisture and structure. Forest biomass and soil moisture profile measurements for earth science and subsurface water detection for planetary science are examples of applications already considered for spaceborne UHF and VHF SAR sensors. At these frequencies ionosphere and troposphere spatial and temporal irregularities and fluctuations affect the performance of SAR sensors. These include, the Faraday rotation of the plane of polarization, distortions in azimuth and range resolution due to changes in coherent length of SAR and group delay of propagating waves, and possible pulse broadening as a result of ionospheric dispersion. In this paper, analytical and numerical calculations of the ionosphere effects on the synthetic aperture radar (SAR) performance for UHF and VHF frequencies are reported for earth science applications.

The effect of Faraday rotation on linearly polarized backscatter measurements is addressed by using a backscatter model to simulate the changes in the scattering matrix over natural surfaces such as forest canopies at both UHF and VHF frequencies. The analysis of the model simulations has resulted in an algorithm to estimate the Faraday rotation angle and to recover the true scattering matrix of a polarimetric system. The algorithm is then applied to AIRSAR P-band polarimetric images over tropical and boreal forests to correct for the Faraday rotation effect. The images were spatially distorted by using a simple ionosphere model that simulates the spatial changes of the total electron content (TEC) for a typical spaceborne system. The results show that for polarimetric systems, the effect of the Faraday rotation can be removed and the spatial distribution of the integrated total electron content of ionosphere along the altitude of the earth orbit of the satellite can be estimated. Effects of ionosphere on azimuth and range resolution for both UHF and VHF SAR sensors are discussed.

Keywords: SAR, UHF, VHF, Ionosphere, Faraday Rotation, Polarimetric