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Polarimetric Calibration of L-band Airborne SAR

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The Polarimetric SAR is useful in understanding the different scattering mechanisms happening on the Earth's surface from different types of targets using the phase and amplitude information from the 4 channel data with the help of different polarimetric decomposition and classification techniques. But the polarimetric distortion in the PolSAR datasets causes the Polarimetric decomposition and classification techniques to produce wrong outputs which result in misinterpreting the scattering phenomenon and the ground targets. The most important error is the overestimation of volume scattering targets like vegetation caused due to the increased magnitude in cross-pol channels due to crosstalk between the co-polarization and cross polarization channels. The crosstalk occurs mainly due to the non-ideal behaviour of the Transmit-Receive Modules (TRM) of the Radar antenna. The band ratios using different channels results in wrong results due to the channel imbalance between different channels caused by unequal antenna gains of the High Power Amplifiers (HPA) in the Transmit system for horizontal and vertical polarizations and also of the Low Noise Amplifiers (LNA) in the receiving system. The minimization of all these polarimetric distortions using polarimetric calibration techniques is very important to carry out the quantitative analysis using PolSAR data, time series analysis and to compare results between different sensors. The Uninhabited Aerial Vehicle Synthetic Aperture Radar (UAVSAR) is the airborne L- band (24 cm wavelength) Quad-Pol SAR system developed by JPL/NASA. The objective of our study was to implement the external calibration of the L-band UAVSAR system using trihedral corner reflectors. The UAVSAR L-band datasets acquired over the Rosamond corner reflector array at California was used for this purpose. The Rosamond calibration array test site at California contains twenty-three trihedral corner reflectors with inner side arm length of 2.4 m and five trihedral corner reflectors with an inner side arm length of 4.8 m. As a thumb rule, to use the trihedral corner reflectors for polarimetric calibration, the inner side arm length of the reflector should be at least ten times the wavelength of the radar which is valid for UAVSAR. Initially the theoretical Radar Cross Section (RCS) (σ_{cr}) expected from the corner reflectors are calculated using the wavelength, azimuth and tilt angles used to align the corner reflectors to the radar. The corner reflector coefficients are then estimated from the pixels corresponding to the corner reflectors in the dataset. The corner reflector coefficient values are used to estimate the observed backscattering coefficient (σ_o), and the deviation between the theoretical RCS and observed backscattering coefficient is calculated. Adjustments are then done to each pixel of the entire dataset to nullify this deviation. This radiometrically calibrated dataset is then processed to estimate the crosstalk and channel imbalance parameters, for this purpose the Polarimetric Distortion Matrix (PDM) is generated which relates the observed scattering matrix, theoretical scattering matrix, crosstalk parameters and channel imbalance parameters. The band ratios between the different polarization channels are utilized to estimate the co-pol & cross-pol channel imbalance parameters. The phase bias between the co-pol channels are estimated by assuming that the theoretical phase bias between the co-pol channels is zero. The crosstalk parameters are estimated by assuming the scattering reciprocity constrain which is valid in the case of monostatic radars. After estimating all the channel imbalance and crosstalk parameters in the Polarimetric Distortion Matrix, the only unknown left in the equation is the theoretical scattering matrix. Matrix inversion approach is used to estimate the theoretical scattering matrix from the Polarimetric Distortion Matrix equation. The theoretical scattering matrix thus obtained is free from crosstalk and channel imbalance errors. The calibration improvement to the dataset is analyzed by carrying out the polarimetric decomposition analysis on both Polarimetrically calibrated and uncalibrated datasets and also by plotting the polarimetric signatures of the trihedral corner reflectors before and after calibration. The polarimetric decomposition analysis shows that the volume scattering component significantly reduced in the calibrated dataset which is an indication of the reduced crosstalk. The double bounce scattering component also increased at the boundaries of the features. The polarimetric signatures of the corner reflector after calibration shows good agreement with the theoretical polarimetric signature of the trihedral corner reflector.