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The Interpretation of a Polarimetric Coherency Matrix with Four Scattering Models Considering Polarimetric Symmetry

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For a multi-look polarimetric synthetic aperture radar (POLSAR) image, each pixel corresponds to a polarimetric coherency matrix. Model-based incoherent polarimetric decomposition is a technique which is widely used to analyze multi-look POLSAR data. Traditional model-based incoherent polarimetric decomposition algorithms have some inherent drawbacks such as negative power components, polarimetric information loss, and non-model-based decomposition results. This study tries to completely interpret a polarimetric coherency matrix by the incoherent sum of four scattering mechanisms. Therefore, the proposed algorithm can be regarded as a new type of model-based incoherent polarimetric decomposition. All the four scattering models are firstly derived with polarimetric symmetry. The four scattering models correspond to surface scattering, double-bounce scattering, volume scattering and helix scattering, respectively. Then a new four-component model-based incoherent decomposition algorithm is found. After extracting the helix scattering component and the maximum possible volume scattering component, the remaining coherency matrix is decomposed into two components with an orientation angle difference of 45°. With the new algorithm, most pixels of a real POLSAR image can be completely decomposed into four components which are exactly consistent with helix scattering, volume scattering, surface scattering, and double-bounce scattering, respectively. Moreover, the proposed decomposition algorithm fully utilizes the polarimetric information, and all scattering component powers are nonnegative. Experiments with E-SAR, RADARSAT-2, and GF-3 data are presented to illustrate the effectiveness of analyzing the scattering mechanisms of real terrain targets with the proposed decomposition algorithm. The proposed decomposition algorithm is also compared with classic four-component model-based incoherent polarimetric decomposition algorithms.