ROTATED DIHEDRAL AND VOLUME SCATTERING BEHAVIOR IN CROSS-POLARIMETRIC SAR

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Wetland InSAR is a relatively recent application of the InSAR technology measuring water level changes in wetland and floodplain environments, where vegetation emerges above surface water. It works thanks to double bounce scattering, in which the radar signal backscatters twice, once from the water surface and then by the vegetation, or vice versa first by the vegetation and then by the water surface [1]. The new generation of SAR satellites with high spatial resolution and full quadruple polarization (quad-pol) capabilities provide new insights into double bounce scattering in vegetated environments.

We conducted an InSAR analysis of SAR data acquired over the Everglades in south Florida using Radarsat-2 quad-pol mode acquisition, in order to detect water level changes. For each pair of observations, we calculated four independent interferograms, one for each polarization (HH, HV, VV, and VH). Surprisingly, all four interferograms show very similar fringe patterns (Fig. 1). According to common SAR vegetation scattering theories, cross-pol observations (HV and VH) are assumed to reflect only volume scattering due to the interaction of the radar signal with upper sections of the vegetation. However our cross-pol results, which show water level fringe patterns, reveal that the cross-pol observations also have a double bounce component induced by backscattering from the water surface beneath the vegetation. Thus we suggest that the cross-pol observations reflect also double bounce scattering due to rotated dihedral from the surface. Following previous polarimetric decompositions studies [2-6], we developed a new decomposition that accounts also for cross polarization double bounce in wetlands and other vegetated environments. We use the coherency matrix approach, which deals with

non-reflection symmetric scattering conditions to decompose the cross-pol into the rotated dihedral and volume scattering components. It is necessary to introduce the scattering matrices of a rotated dihedral plane with orientation angle to derive the double bounce cross-pol component. The proposed decomposition method has the capability to separate the double bounce component into two powers from the co- and cross-pol components, which was previously ignored. The results of our decomposition method are shown in Fig. 2 and 3. Our decomposition approach, which explains the cross-pol observations as a combined volume and rotated dihedral surface scattering, also explains why cross-pol interferograms can be indicative of water level changes in wetland environments. However it is important to note that the contribution of the rotated dihedral component varies depending on vegetation type and density and basically diminishes in high, dense vegetation.

Keywords: Polarimetric synthetic aperture radar (POLSAR), Wetland interferometric SAR (InSAR), volume scattering, rotated dihedral scattering, polarimetric decomposition, Everglades.

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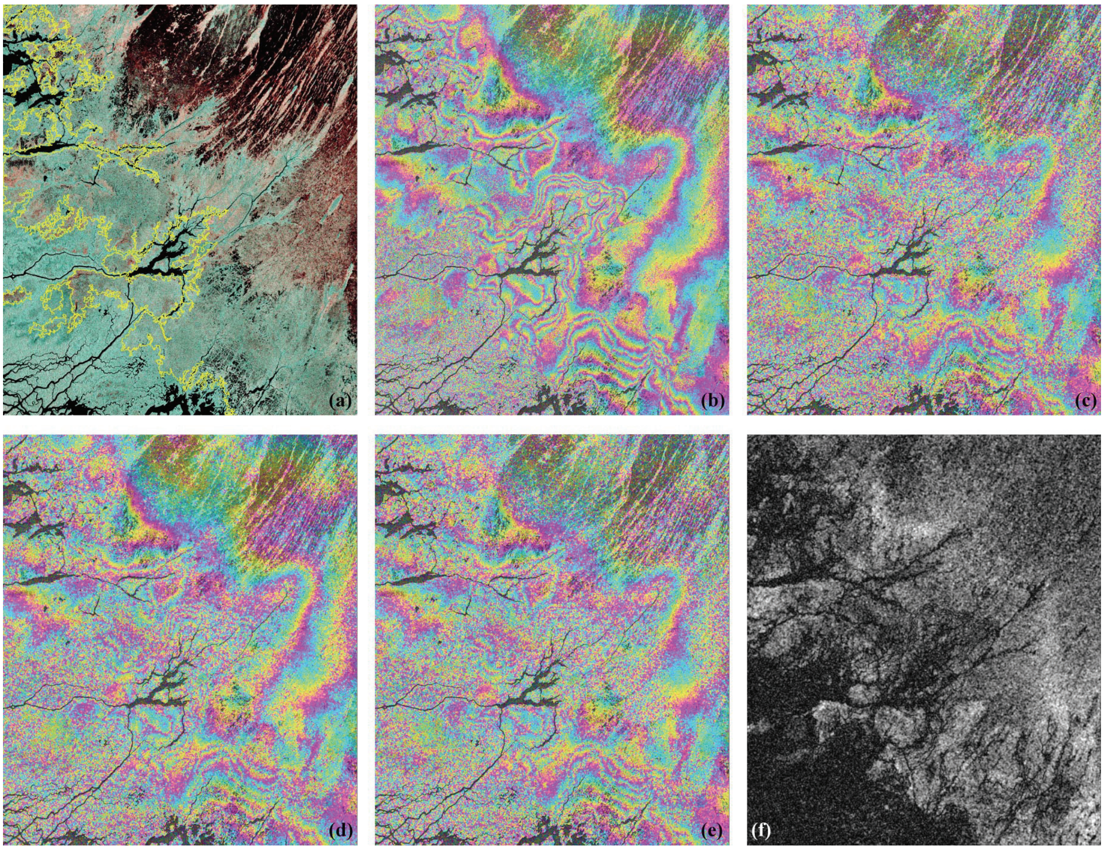

Fig. 1. SAR data and interferograms of the study area. (a) Color composite polarimetric SAR amplitude image of the study area: HH (red), VV (blue), and HV (green). The yellow line shows the boundary between coherent and incoherent areas. (b, c, d, and e) HH, HV, VV, and VH polarization interferograms. (f) Coherence map of HH polarization interferogram.

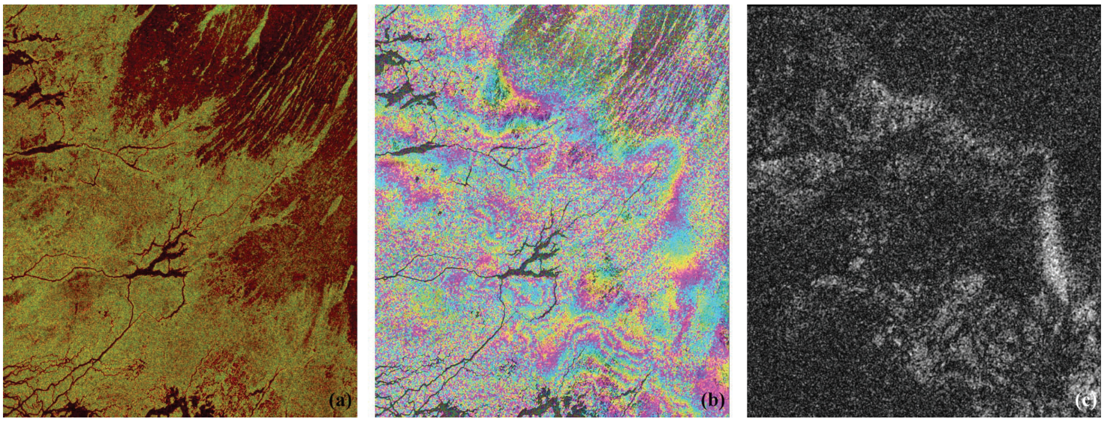

Fig. 2. (a) Color composite image: double bounce scattering from cross-pol (red), volume scattering (red). (b) HV polarization interferogram, and (c) HV polarization interferometric coherence. Generally better coherence is mainly detected where double bounce scattering from cross-pol is dominant, while the coherence is not maintained in volume scattering dominant area.

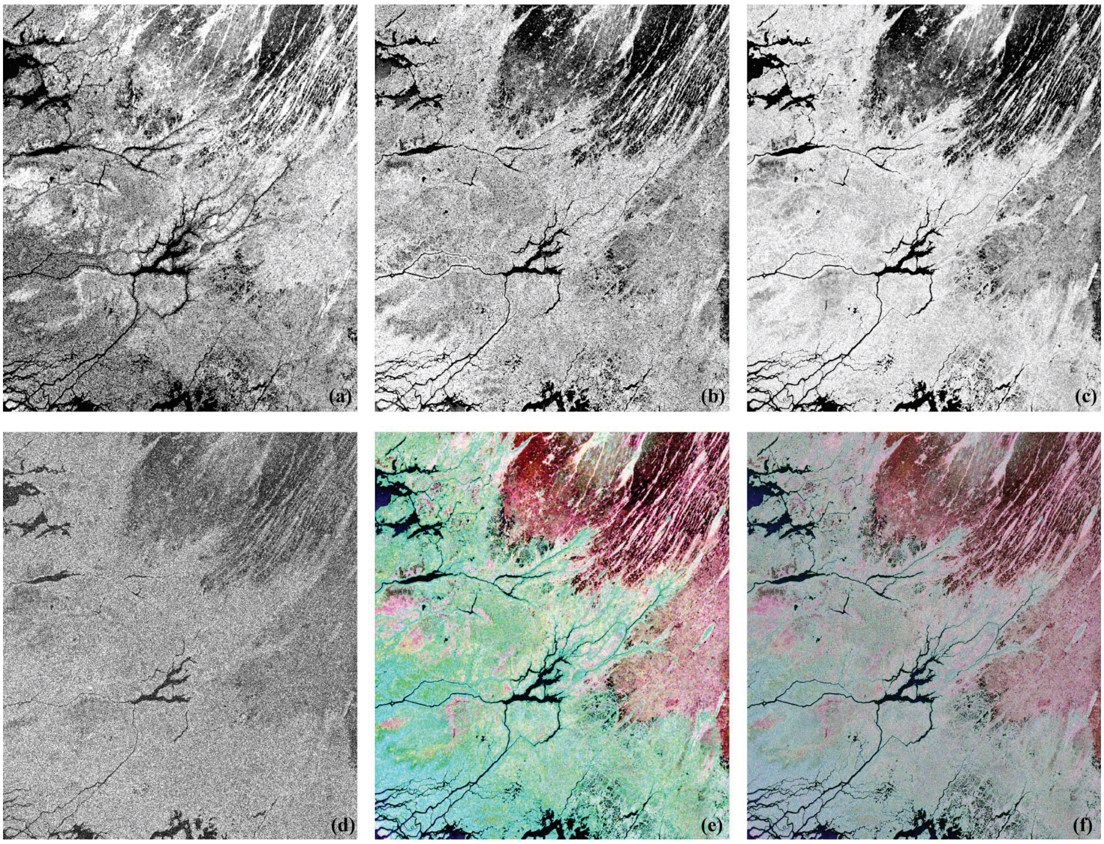

Fig. 2. Decomposed images of the study area. (a) double bounce scattering from the co-pol, (b) single bounce (surface scattering) from co-pol component, (c) volume scattering from co- and cross-pol components, (d) double bounce scattering from the cross-pol, (e) Our decomposition: P_s (surface scattering: blue), P_d (double bounce scattering: red), and P_v (volume scattering: green), and (f) Pauli decomposition color composite image: HH-VV (red), HH+VV (blue), and HV (green). Our results show that the dominant scattering of the freshwater herbaceous area is double bounce and the saltwater mangrove area is dominated by volume scattering (c). The scrub habitat in the transition zone is characterized either double bounce or volume scattering. The surface scattering is limited in the small area of aquatic surface and tall dense vegetated area. The double bounce scattering from the cross-pol is shown mainly mangrove and scrub vegetated area and limited regionally in the herbaceous area (d).