# A MODEL FOR COHERENT BACKSCATTER FROM DIFFUSE TARGETS

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PolSAR and InSAR investigations have served to highlight an interesting set of natural targets with peculiar behaviors; seemingly at odds with the common understanding of coherent backscatter. While representing extremes in climatology, the mangroves of the Florida Everglades and the frozen lakes of northern Alaska share similarities in the way that microwaves are backscattered. What they share structurally is a diffuse distribution of Mie scatterers over a natural mirror. In the case of the mangroves, that is an intricate set of roots over a water surface, and in the case of the frozen tundra lakes it is a profuse distribution of elongated bubbles over an ice/water interface (Fig.1).

**Figure 1.** Photos showing bubbles in Arctic pond ice (left) and mangrove roots in the Florida Everglades (right).

Both ecosystems can be described as a random volume of scatterers over a surface, yet in both instances, the backscatter processes are highly coherent. In the mangroves, X-, C-, and L-band InSAR has been used to determine water level; yielding surprisingly low temporal decorrelation for vegetated land cover [1-2]. In the case of arctic pond ice, SAR backscatter intensity has been used to map whether there is liquid water under the ice [3-4] and X-band single-pass interferometry can be used to map the bottom surface of pond ice. These behaviors would seem to be indicative of double bounce, yet in both cases, polarimetric decompositions fail to show dominant double bounce behavior (Fig.2). Last, HV backscatter is typically associated with incoherent scattering processes, yet in both of the above cases, a strong coherence is seen in the HV response.

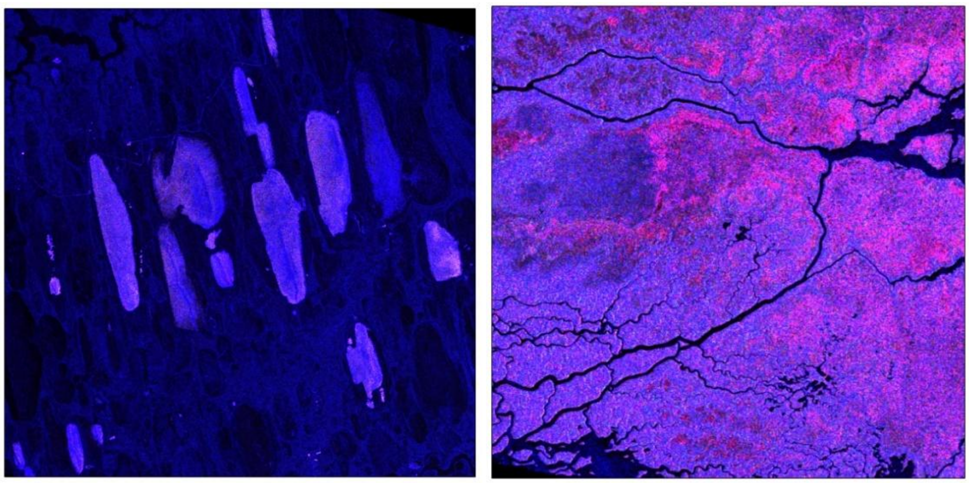

**Figure 2.** Despite the hypothesized double bounce behavior, Pauli decompositions (HH-VV HV HH+VV) of Arctic lakes (left) and mangroves (right) appear to show that surface bounce is the dominant scattering mechanism.

To address these characteristics, a wave propagation model has been developed to describe the co-pol and cross-pol coherent responses, as well as to explain the limitations in current decomposition theory. The approach relies upon coherent Bragg scattering, utilizing some elements from the theory of SAR backscatter from a wind roughened sea surface [5]. In the same way that microwaves "find" the surface wavelets that satisfy the Bragg condition in the ocean wave spectra, microwaves entering the pond ice and mangrove root structure "find" repetitive sets of dihedrals and trihedrals in the diffuse scatterers that satisfy the Bragg condition.

Fig. 3 depicts the product of a model that assumed a random distribution of forward scatterers over a perfect reflecting plane, with the assumption that there has been one scattering event from the random volume. The image portrays those scatterers that contribute the same phase signal (modulo $2\pi$) to a backscattered response. It is clearly seen that the contributing scatterers are those constituting a set of dihedrals with a spacing d, which satisfies the Bragg Equation $\boldsymbol{2d\ sin\theta = \lambda}$. Although harder to visualize, it is proposed that a set of Bragg trihedrals can serve to produce a coherent cross-pol response.

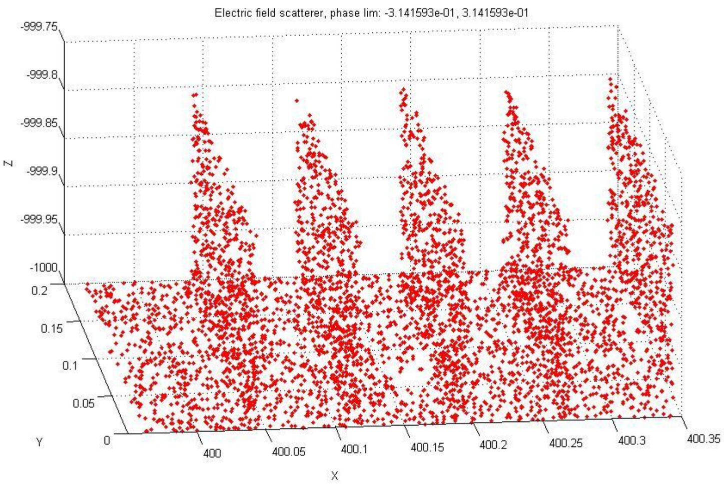


**Figure 3.** Model indicating those scattering points in a random volume over reflective plane that contribute to a single phase backscatter response. Contributing points are seen to represent a Bragg grating composed of dihedrals.

After outlining the unique scattering characteristics of the Arctic frozen ponds and Everglades mangroves, this paper will describe the new model for coherent backscatter from diffuse targets. Diffuse incoherent scattering is always present, but the received backscatter signal will be dominated by those mechanisms that generate a coherent return. Using both conceptual and mathematical treatments, this paper will introduce Bragg dihedrals as the mechanisms for producing coherent co-pol responses and Bragg trihedrals as the mechanisms for producing coherent cross-pol responses. Last, the issue of scattering mechanism decomposition will be presented and recommendations for how these new scattering mechanisms can be identified will be discussed.

## REFERENCES


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