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Bistatic radar observations of the coherent backscatter opposition effect in dry snow

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In this submission we report on observations of the coherent backscatter opposition effect (CBOE) in seasonal snow layers using bistatic radar, and the possible pathways towards estimation of snow properties from these radar observations.

Bistatic radar refers to a configuration where the transmitter and the receiver are not in the same location. From the point of view of the observed target, there thus exists a non-zero angular separation between directions towards the transmitter and towards the receiver, referred to as the bistatic angle. The coherent backscatter opposition effect (CBOE) is a phenomenon that causes increased backscatter of coherent radiation at small bistatic angles (less than 1 degree) in refractive but non-absorbing disordered media (e.g. snow). It has been previously investigated to characterize surfaces of various water-ice covered Solar System bodies [1], however it has received comparatively little attention in Earth-focused observations, despite the well-known occurrence of significant volume scattering within snow and ice.

Scattering models of CBOE relate the shape of the intensity peak (width, height) to specific parameters of the random medium (grain size, mean free path, reflectivity) [2]. Measurements of the CBOE peak profile are thus a possible pathway towards improving the accuracy of estimates of these parameters, and those closely connected to them, such as the snow water equivalent (SWE).

We report on two separate observations of the CBOE-intensity peak in snow. We carried out ground-based observations using an experimental bistatic Ku-band radar system KAPRI [3], to observe the effect in a winter snow layer on top of the peak Rinerhorn in Davos, Switzerland. We also report on observations of backscatter enhancement in the accumulation zone of Aletsch glacier, using the spaceborne bistatic X-band synthetic aperture radar system TanDEM-X. Applying the aforementioned scattering models to the observations, we can estimate the mean free path of the scattered signal within the snow layer to be 10 cm at Ku-band, and 17 cm at X-band.

We believe that further study of CBOE in the context of Earth-focused observations of snow and ice opens new opportunities for development of quantitative models aiming to derive snow properties from bistatic radar observations.

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