MODELLING POLSAR SCATTERING SIGNATURES AT LONG WAVELENGTHS OF GLACIER ICE VOLUMES

Giuseppe Parrella[1], Noora Al-Kahachi[1], Thomas Jagdhuber[1], Irena Hajnsek[1,2], Konstantinos P. Papathanassiou[1]

[1] German Aerospace Center - Microwaves and Radar Institute, Wessling (DE)
[2] ETH Zurich - Institute of Environmental Engineering, Zurich (CH)

ABSTRACT

The crucial role of cryosphere for understanding the global climate change has been widely recognized in recent decades [1]. Glaciers and ice sheets are the main components of the cryosphere and constitute the basic reservoir of fresh water for high-latitudes and many densely populated areas at mid and low latitudes. The need of information on large scale and the inaccessibility of polar regions qualify synthetic aperture radar (SAR) sensors for glaciological applications. At long wavelengths (e.g. P- and L- band), SAR systems are capable to penetrate several tens of meters deep into the ice body. Consequently, they are sensitive to the glacier surface as well as to sub-surface ice structures. However, the complexity of the scattering mechanisms, occurring within the glacier ice volume, turns the interpretation of SAR scattering signatures into a challenge and large uncertainties remain in estimating reliably glacier accumulation rates, ice thickness, subsurface structures and discharge rates. In literature great attention has been given to model-based decomposition techniques of polarimetric SAR (PolSAR) data. The first model-based decomposition for glacier ice was proposed in [2] as an adaptation and extension of the well-known Freeman-Durden model [3]. Despite this approach was able to interpret many effects in the experimental data, it could not explain, for instance, co-polarization phase differences.

The objective of this study is to develop a novel polarimetric model that attempts to explain PolSAR signatures of glacier ice. A new volume scattering component from a cloud of oriented particles will be presented. In particular, air and atmospheric gases inclusions, typically present in ice volumes [4], are modeled as oblate spheroidal particles, mainly horizontally oriented and embedded in a glacier ice background. Since the model has to account for an oriented ice volume, the anisotropic nature of the ice medium has to be incorporated. This phenomenon, neglected in [2], leads to different refraction indices, i.e. differential propagation velocities (phase differences) and losses of the electromagnetic wave along different polarizations [5]. Furthermore, the introduction of additional scattering components (e.g. from the glacier surface) will extend and complete the polarimetric model.

For a first quality assessment, modeled polarimetric signatures are compared to airborne fully polarimetric SAR data at L- and P-band, collected over the Austfonna ice-cap, in Svalbard, Norway, by DLR's E-SAR system within the ICESAR 2007 campaign.

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