The validity of Freeman-Durden Decomposition of snow-covered sea ice C-Band SAR images

Keegan Shaw • Dept of Geography • University of Calgary

Background

- Arctic Sea ice can moderate and indicate variation in regional climate, support marine ecosystems, provide a platform for local community food access, and affect marine navigation.
- Spaceborne Polarimetric Synthetic Aperture RADAR (SAR) sensors can capture images of vast areas on regular time intervals, even during polar night and cloud cover.
- The usefulness of SAR imagery for observing sea ice is limited by the detailed representation of geophysical, and thermodynamic properties of snow and sea ice (Nghiem et al, 1995).
- Freeman-Durden (FD) decomposition (1998) of Polarimetric SAR has been used to create measurable parameters reflective of physical target properties, thus may be useful for studying snow-covered sea ice. The validity of FD for sea ice imagery has been questioned (Komorov, et al, 2015).

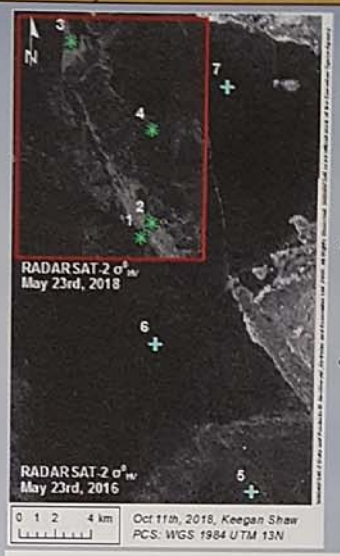
Research Objectives

- Develop a model to predict cross-polarized backscatter (σ^0_{HV}) from volume scatterers (brine inclusions and ice crystals) for late winter snow on sea ice using snow observations taken insitu, a diffuse layer volume scattering model (Fung et al., 2009), and assumptions from FD decomposition.
- Compare simulated σ^0_{HV} with measured σ^0_{HV} from RADARSAT-2 imagery taken late winter.
- Compare measured σ^0_{HV} with roughness derived from mid-winter σ^0_{HH} in RADARSAT-2 imagery (Greater σ^0_{HH} corresponds with rougher ice).

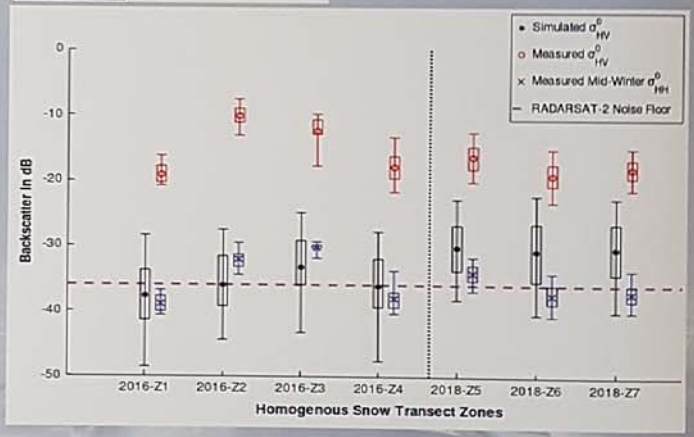
Methods

* Mid-winter σ^0_{HH} used for proxy for roughness (Nghiem et al., 1995)

Analysis and Results



- Measured σ^0_{HV} was greater than expected for zones in 2016 but was less than expected for zones in 2018 based simulated σ^0_{HV}.
- Measured σ^0_{HV} was dependent on roughness derived from mid-winter σ^0_{HH}.
- On smooth sea ice, measured σ^0_{HV} was largely controlled by the noise floor of the RADARSAT-2 sensor.



Summary

- Cross-polarized scattering from late winter sea ice images is likely more related to ice surface roughness, and to the noise floor of the polarimetric sensor then to the volume scattering from a brine-wetted snow pack.
- The assumptions behind the Freeman Durden Decomposition are likely not valid for first year snow-covered sea ice during the late-winter regime. This supports the argument put forward by Komorov et al. (2015).

References & Acknowledgments

Komarov, A. S., Isleifson, D., Barber, D. G., & Shafai, L. (2015). Modeling and Measurement of C-Band Radar Backscatter from Snow-Covered First-Year Sea Ice. IEEE Transactions on Geoscience and Remote Sensing, 53, 4063–4078.

Freeman, A., & Durden, S. L. (1998). A three-component scattering model for polarimetric SAR data. IEEE Transactions on Geoscience and Remote Sensing, 36, 963–973.

Fung, A. K., Chen, K., & Schutzer, D. (2009). Model for Scattering from a Low-Dielectric Layer of Rayleigh Scatterers with Irregular Layer. In Microwave scattering and emission models for users (pp. 359–366). Norwood, MA: 2010 Artech House

Nghiem, S. V., Kwok, R., Yueh, S. H., & Drinkwater, M. R. (1995). Polarimetric signatures of sea ice: 1. Theoretical model. Journal of Geophysical Research, 100, 13665–13681.

I would like to thank the participants of the Arctic-ICE 2016 Field Experiment based out of Cambridge Bay, Nunavut, Canada for their support and hard work in the field program, including Principal Investigators, C.J. Mundy (CEOS, University of Manitoba) and B. Else (University of Calgary). I also appreciate the collegial assistance from V. Nandan, T. Geldsetzer and M. Mahmud. POLAR Knowledge Canada, Cambridge Bay, is also acknowledged for logistical support for field data collection. I acknowledge Canadian NSERC Discovery grants to R. Scharien and J. Yackel towards this work. The Canadian Ice Service support in providing, planning and ordering RADARSAT-2 imagery is appreciated. Supplementary RADARSAT-2 imagery and planning support was provided by the Canadian Space Agency's Science and Operational Applications Research program. RADARSAT-2 Data and Products © MacDonald, Dettwiller and Associates Ltd. 2012. All Rights Reserved. RADARSAT is an official mark of the Canadian Space Agency

Contact Information: Keegan.shaw1@ucalgary.ca