

## Polarimetric Coherent Scattering Model for Radar Remote Sensing of Snowpack



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**Abstract:** Snow is a critical component of the global water cycle, storing freshwater during winter and releasing it through snowmelt to support rivers, reservoirs, agriculture, and communities during warmer months. Radar remote sensing offers a unique capability for monitoring snow over large and inaccessible regions because of its sensitivity to snowpack properties and its ability to operate day or night and under cloud cover.

This work develops a physics-based, fully coherent polarimetric radar model of snow-covered terrain for estimating snow water equivalent (SWE). Realistic three-dimensional snow media are generated using spatial correlation and Lineal-Path functions to capture snow structure and particle connectivity. Electromagnetic scattering from the snowpack is modeled using a recently developed new model known as the Statistical S-matrix Wave Propagation in the Spectral Domain (SSWaP-SD) technique, in which the snowpack is divided into thin layers represented by polarimetric multi-port scattering matrices. These matrices are coherently cascaded to predict forward and backward bistatic scattering from snowpacks of arbitrary thickness. Full-wave MoM/DDA and FEM simulations are used to characterize and validate the snow response. The model is then extended to snow-covered terrain by incorporating scattering from the underlying rough ground. Monte Carlo simulations of the complete snow-ground system show good agreement with measurements, providing a rigorous framework for interpreting radar observations and retrieving SWE.

**Bio:** Professor Kamal Sarabandi is the Fawwaz T. Ulaby Distinguished University Professor of EECS and the Rufus S. Teesdale Endowed Professor of Engineering at The University of Michigan. His research areas of interest include microwave and millimeter-wave radar remote sensing, metamaterials, electromagnetic wave propagation, antenna miniaturization, and bio-electromagnetics. Professor Sarabandi has supervised 68 Ph.D. and numerous Masters students and postdoctoral fellows. He has published a textbook, many book chapters, more than 360 papers in refereed journals, and more than 780 conference papers. He, together with his students, are recipients of 36 paper awards. Dr. Sarabandi served as a member of NASA Advisory

Council for two consecutive terms (2006-2010) and served as the President of the IEEE Geoscience and Remote Sensing Society (2015-2016). He is the past Chair of Commission F of USNC/URSI and serving as member of the AdCom for the IEEE Antennas and Propagation Society. He led numerous NASA projects and served as a member of the Science Team for NASA SMAP mission. He also led a major Center for Microelectronics and Sensors funded by the Army Research Laboratory (2008-2018) and is leading the Center of Excellence in Microwave Sensor Technology. His contributions to the field of electromagnetics have been recognized by many awards including Humboldt Research Award, the IEEE GRSS Distinguished Achievement Award, the IEEE Judith A. Resnik award, the IEEE GRSS Education Award, NASA Group Achievement Award, the 2024 IEEE Electromagnetics Award, and many other awards from the University of Michigan. He is a Life-Fellow of the IEEE, a Fellow of the American Association for the Advancement of Science (AAAS), and a Fellow of the National Academy of Inventors. He received the esteemed recognition of being chosen as one of the inaugural members of the "Legends of Electromagnetics" by the IEEE Antennas and Propagation Society. He was awarded the 2026 IEEE Geoscience and Remote Sensing Honorary Life Membership, one of only eight GRSS members to have received this honor during the Society's 65-year history. Professor Sarabandi is a member of the National Academy of Engineering and a 2024 recipient of the prestigious Ellis Island Medal of Honor. The IEEE Board of Directors announced him as the recipient of the 2025 IEEE Dennis J. Picard Medal for Radar Technologies and Applications.