SNOW WETNESS RETRIEVAL INVERSION MODEL DEVELOPMENT FOR C-BAND AND X-BAND MULTI-POLARIZATION SAR DATA

G. Singh and G. Venkataraman

Centre of Studies in Resources Engineering, Indian Institute of Technology Bombay
Mumbai (India) – 400076
E-mail: gskaliar@iitb.ac.in

ABSTRACT

This paper is concerning the estimation of snow wetness from multi-polarization SAR data. In this paper, microwave interaction with snow covered terrain and different scattering mechanism from snowpack and their backscattering model for developing inversion algorithm with wet snow conditions are described in order to estimate snow wetness. SAR data processing and field measurement of snow parameters are also discussed. In this study, snow wetness has been measured with a dielectric moisture meter with synchronous satellite passes over the part of snow covered Indian Himalayan region (e.g. Dhundi observatory in Himachal Pradesh, India).

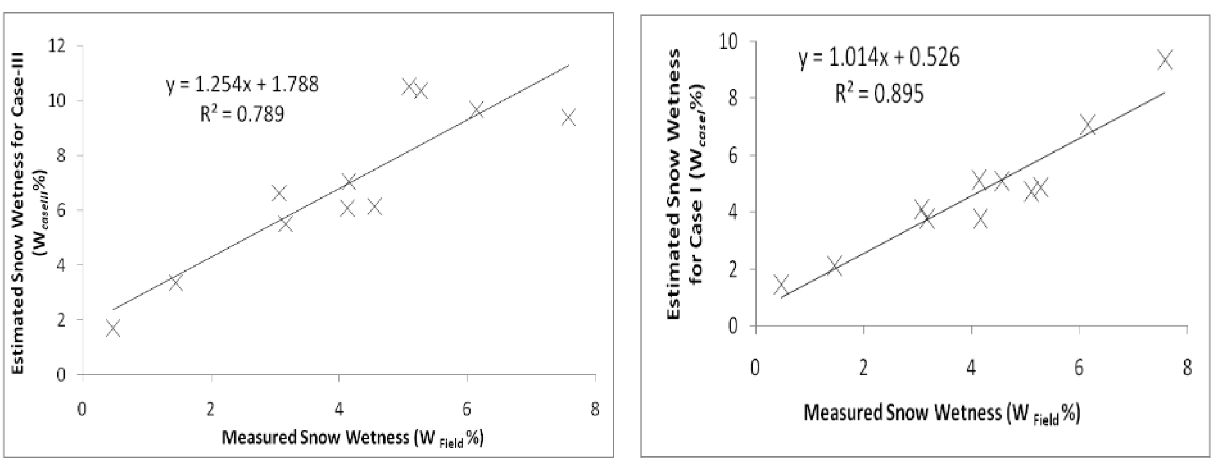
Liquid water content (snow wetness) in the top layer of a snow pack is very critical to forecasting of snow melt run off and avalanche activity. This is a very important parameter, which gives indication about the melting nature of the snow that can lead to other processes. Specifically monitoring spatial and temporal changes of liquid water content in a snow pack is important for hydrological modeling because it identifies that a particular area of the basin can contribute immediately to runoff. Despite the importance of snow wetness, hydrologic models have not used such measurements in analysis or forecasting of snowmelt because the data have not been routinely available [1].

In this study, Integral Equation Method based, inversion model of Shi and Dozier [2] has been modified for retrieval of snow wetness from multi-polarization data at C-band and also a new inversion model for estimating snow wetness from multi-polarization data at C-band and X-band have been developed. These models include two main scattering components (snow volume

backscatter and surface backscatter from air/snow interface) for wet snow. The first order volume scattering and surface scattering models depend on the four unknown functions viz. dielectric constant, incidence angle, volume scattering albedo and root mean square height and surface correlation length. In the case of surface backscattering through simplified nonlinear regression equations and also using best pair of polarization, the unknown can be reduced to only dielectric constant. In the case of volume backscattering, using volume backscattering ratios the unknown can be reduced to only dielectric constant and incident angle. In the final term combining both surface and volume backscatter only two functions namely incident angle and dielectric constant remain. Knowing the incident angle, we can solve snow permittivity which can be directly related to snow wetness.

For modified inversion model at C-band, a reasonable correlation coefficient was observed to be 0.88 (Fig.1a) and standard error was observed 1.16 % by volume. The comparison of advanced synthetic aperture (ASAR) derived snow wetness with the ground measurements shows the average (mean) absolute error as 2.8% by volume. Fig.1 (b) shows the reasonable correlation coefficient as 0.94 for developed inversion model at C-band.

The inversion model for X-band has been developed and implemented on TerraSAR-X data. The absolute error between TerraSAR-X estimated snow wetness and field measured snow wetness was 2.14% by volume (Table1).



(a) (b)

Fig. 1. Comparison of estimated snow wetness of Dhundi Observatory for (a) modified inversion model (b) developed inversion model

Table 1. TerraSAR-X backscattering Coefficient (BSC) and their corresponding measured and estimated snow wetness

BSC HH Pol (dB)	BSC VV Pol (dB)	Incidence angle	Estimated Wetness (% by volume)	Measured Wetness (% by volume)	Absolute Error (% by volume)	Mean Absolute Error (% by volume)
-30.467	-27.421	38.471	1.93331	1.82659	0.10672	
-35.749	-31.597	38.467	8.47552	4.11386	4.36166	
-31.693	-32.049	38.467	8.38762	3.25752	5.1301	
-31.559	-31.319	38.46	7.52352	5.3098	2.21372	
-33.094	-31.069	38.457	7.75647	7.5962	0.16027	
-30.505	-32.465	38.456	6.91743	4.47166	2.44577	
-31.706	-33.705	38.465	9.34362	6.85543	2.48819	
-31.485	-30.913	38.477	6.99517	6.66495	0.33022	
-32.565	-32.624	38.483	9.99406	6.66495	3.32911	2.14
-31.93	-30.432	38.49	6.52339	6.12995	0.39344	
-38.629	-31.435	38.497	7.25422	5.16369	2.09053	
-31.549	-34.192	38.497	9.03886	6.82716	2.2117	
-31.568	-31.39	38.497	7.5753	6.6426	0.9327	
-31.582	-29.766	38.509	5.51102	3.33413	2.17689	
-30.865	-32.916	38.51	7.5753	3.33413	4.24117	
-30.012	-30.115	38.495	5.23549	3.33413	1.90136	
-30.865	-32.916	38.502	7.5753	5.69035	1.88494	

REFERENCES

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[2]. J. Shi and J. Dozier, "Inferring snow wetness using c-band data from SIR-C's polarimetric synthetic aperture radar," IEEE Trans. Geoscience and Remote Sensing, Vol. 33, No. 4, pp. 905-914, 1995.