Temporal Snowpack density mapping using C-band multi-polarization ASAR data

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ABSTRACT

Generally, Snow can be classified into two broad classes namely wet snow and dry snow. This paper is concerning the estimation of dry snow density from multi-polarisation SAR data. Dry snow is consisting of ice particles and air and contains no liquid water. Snow is a dielectric material and one important property of a dielectric material is its dielectric constant. The real part of dielectric constant of dry snow (ε_{ds}') is a function of the snow density and the real part of dielectric constant of air and ice. The real part of dielectric constant of air is 1.0 and pure ice is 3.15 for frequencies from 1MHz to well above the microwave region. Real part of ice dielectric constant (ε_i') may be considered independent of both temperature (below 0^0) and frequency in the microwave region. However, imaginary part of ice dielectric constant ($\varepsilon_i^{"}$) exhibits strong variation with both parameters. Hence in effect, the real part of dielectric constant of dry snow (ε_{ds}') is governed by snow density (ρ_s) under natural dry snowpack condition. Density of snowpack is an important parameter in snow hydrology. The most appropriate method for estimation of dry snow density is based on determination of dielectric constant at radio frequencies because in the range between 1 MHz and 10 GHz the real part mainly depends on density. Satellite-borne synthetic aperture radars (SAR) are promising for determination of snow pack characteristics like snow dielectric constant [1-2].

Availability of spaceborne sensor dual polarization C-band data of ENVISAT-ASAR can enhance the accuracy in measurement of snow physical parameters as compared to single fixed polarization data measurement. This study shows the capability of C-band SAR data for estimating dry snow density over snow covered rugged terrain in Himalayan region. The study area lies in Beas, Chandra and Bhaga catchments of Himachal state (India). An algorithm for estimating snow density has been developed based on snow volume scattering and snow-ground scattering components. Snow density estimation algorithm requires HH and VV polarization

combination data. The radar backscattering coefficients of both HH and VV polarization and incidence angle are given as input to the developed algorithm. Finally, the algorithm gives the snow dielectric constant which can further be related to snow density using Looyenga's semi empirical formula [3].

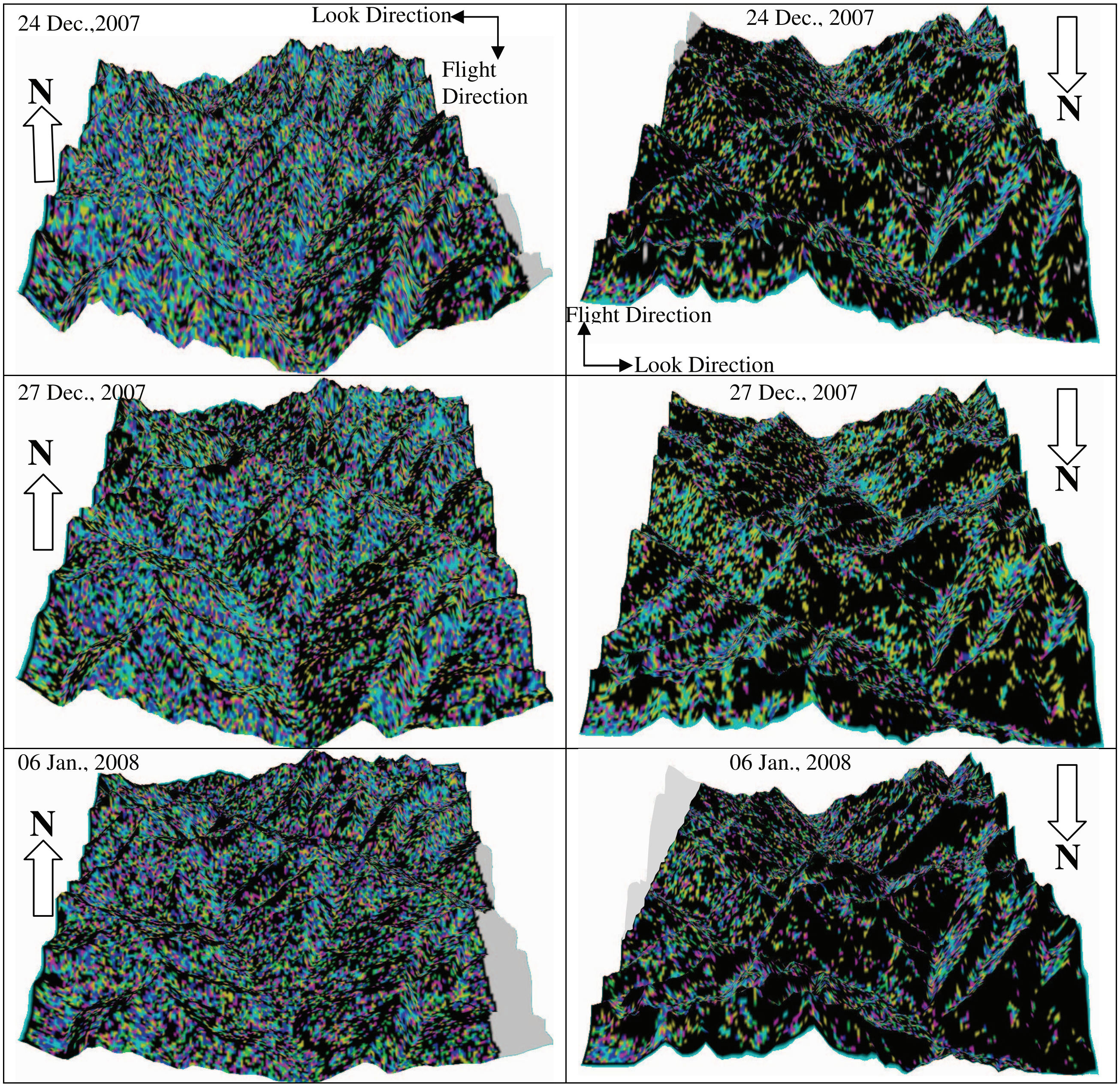

Fig.1 Slope Facing look direction (left) and Image rotated 180^0 for viewing back slope in an image (right) [colors in the maps as follows: Cyan : <100 kg/m^3 , Blue : 100 – 200 kg/m^3 , Yellow : 200 – 300 kg/m^3 , Magenta : 300 – 400 kg/m^3 , Green: 400 – 500 kg/m^3 , Black : Layover/Shadow, Gray: No Data]

Comparison was done between algorithm estimated snow density and field value of snow density in the study region. The mean absolute error between estimated and measured snow density was 24.38 kg/m^3. Finally temporal snowpack density maps (24 Dec.2007, 27 Dec. 2007, 01Jan. 2008, 06 Jan. 2008, 25 Jan.2008, 02 Feb. 2008, 05 Feb. 2008, 10 Feb. 2008, 22 Feb. 2008, 29 Feb 2008) have been prepared using developed inversion algorithm (Fig.1).

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