INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
SHORT ABSTRACT OF THESIS

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Thesis Title:
Study of Snow Geophysical Parameters using Advanced Geospatial Techniques: Inferences from Parts of Northeastern Indian Himalayas

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SHORT ABSTRACT

The glacial hazards in high mountain areas are frequent over the globe; recent disasters (Chamoli landslides, floods, forest fires, earthquakes, and landslides) in the Himalayas are evident that caused loss of human lives, infrastructural damages and affecting day-to-day activities. The geophysical properties of snow/glaciers (SGP) are important indicators of the status of the snow/glaciers and related hazards. Important SGPs, such as dielectric constant, density, and liquid water content, play a vital role in avalanche studies, hydrological modeling, and flood monitoring. Since in-situ measurements are challenging and expensive in such difficult terrains, satellite images have proved to be an important source of information for retrieving geophysical parameters. However, the high-altitude regions mostly have cloud cover, which motivates us to explore the potential of microwave remote sensing data in geophysical parameters studies. The study uses multispectral, synthetic aperture radar (SAR), and hyperspectral datasets in conjunction with in-situ measured parameters to develop models/estimate important SGPs, such as dielectric, density, wetness, grain size, snow depth, and snow impurities. Several field investigations were performed using field instruments (Snow Fork and Spectroradiometer) to measure the in-situ parameters and further integrated with the satellite-derived results to evaluate and improve the model performance.

A state-of-the-art models is developed by integrating satellite-derived SGP with in-situ (Rathong Glacier, Sikkim, India) measurements, resulting in a novel inversion model using Sentinel-1-derived Stokes parameters. This model demonstrates a high coefficient of determination ($R^2 > 0.7$) for estimating snow dielectric properties, density, and wetness, with root mean squared errors (RMSE) of 0.26, 0.08 g/cm³, and 0.84, respectively. The snow grain size estimation has been attempted using the PRISMA dataset. Analyzing reflectance spectra at specific wavelengths can infer snow grain size more accurately than multispectral sensors. This study presents the results from the Sikkim Himalayas and shows that a characteristic absorption position around 1.03μm is sensitive to snow grain size. Further, snow depth has been estimated using SAR interferometry (InSAR) techniques. A state-of-the-art methodology has been proposed for snow depth estimation in vegetated areas of Arunachal Pradesh, whose RMSE is less than 10 cm. This research also provides critical insight into studying snow conditions (non-contaminated and contaminated) using satellite remote sensing, which is not limited to visible regions of the electromagnetic spectrum. The methodology employs the harmonic use of Landsat-9 and Sentinel-1 datasets for the parts of Arunachal Pradesh, India. It is evident from the results that SAR backscattering is significantly affected by snow contamination due to changes in the snowpack's physical parameters.