Harnessing the potential of EOS-04 SAR data for Himalayan and polar cryospheric studies

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Present study focuses on the utilization of Earth observation satellite-04 (EOS-04) synthetic aperture radar (SAR) data for maintaining the continuity of the first Indian radar imaging satellite (RISAT)-1 SAR derived products along with exploring the potential of capability of the improved sensor over mountain and polar cryospheric region. Backscattering coefficient (σ^0) of various snow and ice features over mountain and polar cryosphere have been analysed to understand the interaction mechanism using C-band SAR data. EOS-04 is able to pick up the spatio-temporal variability of SAR backscatters over accumulation and ablation zone of the glacier due to melt-freeze cycles, and observations were in accordance with variation in elevations over the glacier surface. When analysed for Drang-Drung glacier, wet snow zone was found to be prominently centered around 5500 m elevation zone, having sigma-naught backscatter lower than –10 dB in the ablation months, whereas percolation zone was observed at more than 6000 m elevation with higher sigma-naught backscatter of around –4 dB and above as winter started setting in. EOS-04 also showed the potential to classify various polar ice features based on backscattering signature using HH (H, horizontal) (σ^0), HV (V, vertical) (σ^0) and normalized difference polarization ratio index (NDPRI) respectively. EOS-04 data have been used to implement approaches to retrieve wet snow cover and set up of Weather Research and Forecasting Model Hydrological Modelling System (WRF hydro) model for snow melt runoff studies, interaction mechanism of snow and ice, snow/ice facies extraction, ice shelf monitoring, sea ice properties and sea ice advisory for Indian scientific expedition to Antarctica. Enrichment of EOS-04 data, suitable for cryosphere studies, will be employed to retrieve parameters such as snowpack properties, elevation, ice surface velocities over mountain and polar region, and to further improve comprehensive understanding on regional and global frozen ice dynamics.

Introduction

SNOW and glaciers are important components of the Earth Sciences System, as they regulate global climate and hydrological cycle on the Earth's surface[1]. Earth has experienced global scale changes in its landform due to paleo-climate changes primarily due to natural phenomenon along with anthropogenic activities. The exchange processes in radiative forcing balance can alter the atmospheric temperature by few °C at local and global scales[2], resulting in the melting of glaciers[3]. Cryosphere elements are quite sensitive to such changes in atmospheric temperature, and experience metamorphism. Presence of liquid water in snow and ice crystal may change the dielectric constant and surface roughness significantly. Microwave signal interact with snow and glacier depending on sensor parameters and physical properties of the medium[4–7]. Fresh snow is transparent to radar wavelengths at X, C, S and L band[4] but penetration depth drastically reduces as snow becomes wet in nature. However, synthetic aperture radar (SAR) backscatter is a summative contribution from air/snow interface, volume scattering within snowpack, scattering at the snow/soil interface and volume within underlying surface. The interpretation and analysis of the SAR images rely on the intensity and textural variations which are caused by differences in surface roughness, volume inhomogeneities (both on orders of length scales of the wavelength), and macro-scale ice structures (e.g. ice ridges, leads and floe margins), all of which can vary considerably with the time of the year and prevailing environmental conditions.

Space borne SARs have demonstrated their capability of detecting the extent of wet snow cover in mountainous terrain[8,9]. Imaging C and X-band SARs demonstrated their potential in estimating snow physical parameters of the snowpack[10]. However, it