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An Aggregation Process for Estimation of Snow Depth using Microwave Remote Sensing in Mountain Region

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Spatial distribution of snow amount derived from satellite observations has been previously achieved for flat region. But for mountainous regions, spatial distribution of snow depth has not been addressed because remote sensing instruments are very sensitive to the effect of the terrain slope; and because there is no available data for validation.

This study focuses on the estimation of snow depth using a microwave Radiative Transfer Model (RTM) in mountain region. AMSR-E satellite observations of brightness temperature at 18.7GHz and 36.5GHz frequencies are compared to calculated values of brightness temperature in Lookup Tables (LT) generated by the RTM. The model uses a snow algorithm to derive the snow depth and snow temperature spatial distribution over the target region. The innovative approach is to estimate the brightness temperature for the 18.7GHz and 36.5GHz frequencies taking into account the local incidence angle for each terrain grid in an aggregated process. The lookup tables for brightness temperature of 18.7GHz and 36.5GHz frequencies are generated by inputting the snow depth and snow temperature into the microwave radiative transfer model. The snow algorithm then compares the observed brightness temperature to the calculated brightness temperature in the lookup table, and estimates the corresponding snow depth and temperature for each observed footprint. Furthermore, the snow algorithm can estimate the snow grain size which improves the estimation of snow depths.

The target region for this study is the Puna Tsang River Basin in Bhutan. Because there is no available data for validation, the estimated snow depth spatial distribution by the RTM is evaluated with outputs of snow depth from a hydrological model at this basin. The model Water & Energy Budget based Distributed Hydrological Model with improved Snow physics (WEB-DHM-S), is used to evaluate the RTM model performance. WEB-DHM-S outputs of stream discharge and snow cover area are previously validated with MODIS observed snow cover area; and observed flow discharge from 4 gauge stations. The RTM successfully estimates the seasonal snow depth values and accurately resembles the observed snow cover area.

This new approach for estimating snow amount is applied in mountainous regions for the first time taking into account the local terrain slope and local incidence angle of the radiometer scanner in an aggregated process. It is important to accurately simulate the snow processes in snow-melt dependent basins such as the Himalayan river basins, because their flow regime does not only depend on the precipitation amount.