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An efficient algorithm for detection of seasonal snow cover variations over undulating North Indian Himalayas, India

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Abstract

The detection of rapid snow cover variations over undulating Himalayan mountain ranges may get challenging due to the existence of steep slopes and a diverse range of spatial variability. In this paper, a change detection algorithm is proposed for the detection of seasonal snow cover variations over North Indian Himalayas (NIH). The novelty of the proposed model lies within the applicability of fuzzy classification in change vector analysis (CVA) to identify the mixed pixels, termed as mixels which represent the membership of multiple or partial class-categories. Additionally, this model offers various advantages over existing CVA based algorithms such as (a) ease in selection of threshold value; (b) ease in change determination procedure; and (c) effective utilization of coarse-resolution satellite dataset. The efficacy of the algorithm has been established through a case study in Lahaul and Spiti (Himachal Pradesh), India. This analysis has been done using Moderate-Resolution Imaging Spectroradiometer (MODIS) data for the two-winter periods (i.e. 2009–10 and 2017–18). The accuracy of the proposed algorithm is estimated by the performance-matrix (change-category image) and it has been observed that fuzzy based CVA has achieved better accuracy (85.6%) as compared to conventional improved CVA (ICVA) (71.2%) and post-classification comparison (PCC) (69.6%). The relationships of seasonal snow cover variations with respect to altitudes between two-winter seasons have also been summarized to represent a shift in the duration of ablation and accumulation from 2009 to 2018. Moreover, the snow cover area (SCA) computed from fuzzy based CVA has also been compared with the normalized difference snow index (NDSI) maps for the study period. The applications of the present study may include accurate estimation of the snowmelt runoff, water resource management via continuous snow cover monitoring and mapping.

Keywords: Fuzzy change detection; Change vector analysis (CVA); Post-classification comparison (PCC); Seasonal snow cover variations; Himalayas

1. Introduction

The snow cover acts as a natural resource in hydropower generation, water supply, agriculture growth and smooth running of the hydrological cycle of the earth system (Marty, 2008; Farinotti et al., 2012). On the other hand, unpredicted snow cover variations due to air temperature irregularities lead to natural hazards like snow avalanches or floods and thus, affect the sustainability of human activities (McClung, 2016). Over North Indian Himalayas (NIH), several accidents due to natural hazards have been reported during the past decade (Sati and Gahalaut, 2013; McClung, 2016). Moreover, continuous climate warming impacts the cryosphere in the Indian Himalayas which may lead to considerable consequences for the risk of disasters (Ballesteros-Cánovas et al., 2018). Therefore, accurate monitoring of seasonal snow cover

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