Submitted Abstract

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Abstract

Accurate and detailed mapping of glacier features can be efficiently done from high spatial resolution remote sensing images using object-based image analysis (OBIA). OBIA that works on a group of pixels (i.e., objects) offers possibilities for situations where spectral properties are not unique, but where shape and/or neighbourhood relations are distinct. It also provides a means to work collectively on data from varied sources and at different measurement scales and units (using multiscale segmentation) and weigh them based on their importance. However, since the debris covered glacier features exhibit irregular shapes due to complex landforms, the challenges that OBIA can pose are to determine the correct spatial scale, define meaningful context and pattern relations, and classify based on spectral, spatial, contextual, and hierarchical criteria.

In this paper, we have developed an OBIA paradigm which establishes contextual and hierarchical relation among objects for sequential extraction of debris covered glacier features like snow/ice, ice-mixed debris (IMD), supraglacial debris (SGD), periglacial debris (PGD), valley rock, debris cones, supraglacial lakes/ponds including mountain shadows by integrating multispectral, thermal, and slope information into one workflow. We have used remote sensing imagery of Linear Imaging Self-Scanning System (LISS)-IV satellite sensor procured from National Remote Sensing Centre, Hyderabad, India. Ancillary information such as slope derived from ASTER Global DEM v2 and brightness temperature derived from Landsat Thematic Mapper thermal band have also been used to deal with the spectral resemblances between glacier surface (snow/ice + IMD + SGD) and non-glacier surface (PGD + valley rock). As a case study, we have considered the debris covered Gangotri Glacier which is one of the largest glaciers in the Himalayas. Its ablation zone is full of supraglacial lakes/ponds. The OBIA paradigm has been developed in the most widely known OBIA software i.e., eCognition. The novel contributions of this study are precise classification of shadow regions without manual corrections and discrimination of glacier surface features namely, snow/ice, SGD, and SGD without using short-wave infrared band. This study is also first of its kind to map small yet important geomorphological feature of a debris covered glacier i.e., debris cones which are conical-shaped depositions of thick debris sufficient to inhibit the melting of the ice beneath it. The large-scale thematic glacier map has been produced with a high overall accuracy of ≈90%.