Glacier monitoring and topographic-controlled debris cover extension in mid-eastern Himalaya

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1 Introduction

Glaciers are an eminent source for alpine hydrology and possesses prominent signal for climate change in South Asian region where scientific research are largely meagre. Previous research largely focused on glacier shrinkage and its volumetric melting whereas less attention were paid for debris-covered glacier and its formation in regional domain. To understand the regional features of debris covered glacier, we create a new glacier inventory separating debris and clean parts with high resolution ALOS images. We analyze relation between potential debris supply (PDS) slope and debris-cover to understand reason behind debris cover formation in larger domain.

2 Methodology

2.1 Study Area

Our study domain covers Bhutan, India, China and Nepal (Fig. 1). We divide study area in four major massifs (Langtang, Khumbu, Kan-Sikkim and Bhutan) covering both sides of Himalayan barrier to understand the role of PDS in debris cover formation.

2.2 Data Used

Boundaries of both clean type (C-type) and debris type (D-type) glaciers along with its debris cover part (D-part) were manually delineated by using PRISM and AVNIR-derived ALOS images of 2.5 m and 10 m resolution, respectively, taken between 2006 and 2010.

Debris part and clean part of debris covered glaciers were separated using multiple images of similar date and potential debris supply (PDS) were delineated by following methodology proposed by Nagai et al., 2013. On the other hand, slope distribution and the contour map generated by ASTER GDEM-2 largely helped to distinguish the upper glacier boundary whereas snow fields were separated from glacier surface by interpreting their surface roughness visually from multiple date images.

Fig. 1: Spatial distribution of glaciers both C-type and D-type with their debris part coverage.

Fig 2. Relationship between PDS area and debris part area for all four massifs where solid lines and dash lines implies north and south glaciers, respectively.

We delineated 5301 glaciers covering the area of 5691 km\textsuperscript{2} across mid to eastern Himalayan region where both C-type (area of 1853 km\textsuperscript{2}) and D-type (area of 3839 km\textsuperscript{2}) along with its debris part (971 km\textsuperscript{2}) and clean part (2867 km\textsuperscript{2}) were separated. Among them, large area of D-part (632 km\textsuperscript{2}) has been formed in southern side of the Himalayan barriers than northern side (343 km\textsuperscript{2}). The debris part in southern side of barrier is situated in lower elevation than that in northern side.

Statistical analysis carried out over the entire domain suggests that debris cover (D-part) extension is significantly controlled by the corresponding PDS area (Fig 2) and is more pronounced (with higher correlation value) in southern glaciers across the Himalayan barrier with slight signal of regional differences, for example Bhutan area shows clear difference.

3 Results and Discussion

3.1 Potential Debris Supply

Potential debris supply (PDS) in debris covered domain was calculated by following methodology proposed by Nagai et al., 2013. PDS is the potential area where debris can supply to glacier surface and depends on several factors such as slope, aspect, snow cover and climate condition.

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4 References:


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