Controls on supraglacial pond formation at the Hinang glacier, Manaslu

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Glacier recession in mountain regions has resulted in increased numbers of glacial lakes, presenting a risk of Glacial Lake Outburst Floods (GLOFs) to downstream communities (Carrivick and Tweed, 2016), whilst providing important water resources in high-mountain regions (Immerzeel et al., 2010). Supraglacial ponds typically form on stagnating and downwasting debris-covered glaciers worldwide (Quincey et al., 2007). Supraglacial debris strongly influences ablation, ice dynamics and glacier response to climate change (Rowan et al., 2015). Reynolds (2000) identified glacial structures and flow dynamics as controls on supraglacial pond shape, but these influences on pond formation and evolution have since lacked further investigation. It is hypothesised here that glacier structural features and weaknesses represent foci for the initiation and development of supraglacial ponds on stagnating glaciers with sustained rates of thinning.

Research was recently undertaken at the Hinang glacier in the Manaslu conservation area of the Nepalese Himalayas to assess the supraglacial ponds and ice cliffs present. The Hinang glacier is located between ~3350 m to 4600 m a.s.l. and is ~12 km long and ~1 km wide. The Hinang glacier is located to the east of Mount Manaslu, the eighth highest mountain in the Nepalese Himalayas and is accessed via the Manaslu trekking circuit. The Hinang glacier is a debris-covered glacier with evidence of supraglacial ponds. Previous research by Robson et al. (2018) on the Hinang glacier showed signs of frontal retreat between 1999 and 2013. The terminus underwent substantial stagnation although much of the upper glacier is comparatively active. The location of the Hinang glacier located in the Manaslu region has therefore been selected to provide significant insight regarding glacier response to climatic change across the Himalayas aiding the debate on the Himalayan debris-cover anomaly (Buri et al., 2016; Pellicciotti et al., 2015), impact on potential water resources and future GLOF risk.

Fieldwork undertaken at the glacier included bathymetric surveys carried out at four supraglacial ponds to produce depth and morphology data regarding the shape of the ponds. At each of the four ponds, Structure from Motion (SfM) models were produced to assess the size and presence of ice cliffs surrounding supraglacial ponds. A time-lapse camera was set up on the northern side of the glacier to monitor changes over the next year including drainage of two of the surveyed ponds. Satellite imagery has been collected to supplement the data collected in the field and provide a glacier-wide analysis.

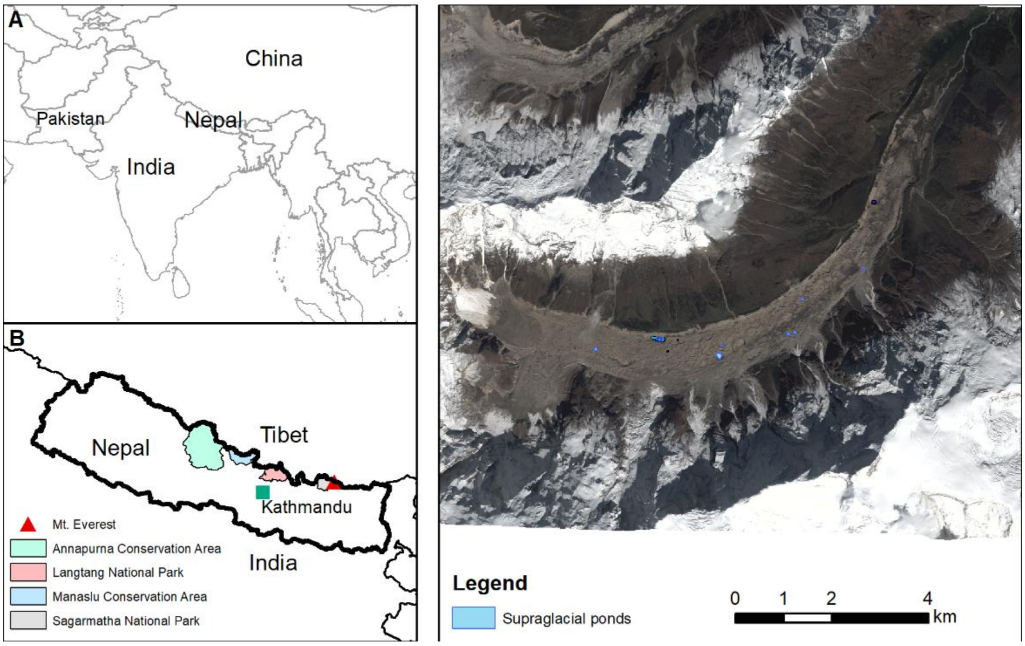

Figure 1 A: Location of Nepal; B: Location of the Manaslu region in Nepal; C: Pleiades image with supraglacial ponds mapped.

Table 1 Initial results from the bathymetric and SfM surveys.

Supraglacial pond	Maximum depth of pond (m)	Maximum height of ice cliff (m)
S1	2.81	~7.14
S2	25.48	~19.79

S3	13.90	~4.37
S4	14.27	~28.02

Further analysis is planned to assess the development of the ponds through historical satellite imagery and to extract elevation data. In addition the effects of the monsoons will be assessed in relation to the development and drainage of supraglacial ponds across the glacier surface.

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