Glacier and Glacier Supplied Lake Changes on Mount Qomolangma (Everest) and the Nam Co Basin, Southern Tibet

Shichang Kang[1, 2]*, Feng Chen[1], Tobias Bolch[3,4]

[1]*Institute of Tibetan Plateau Research, Chinese Academy of Sciences (CAS), Beijing 100085, China;*

[2]*State Key Laboratory of Cryospheric Science, Chinese Academy of Sciences, Lanzhou 730000, China;*

[3]*Institut für Kartographie, Technische Universität Dresden, Germany*

[4]*Department of Geography, University of Zurich, Switzerland*

** Corresponding author. Tel.: +86-10-6284 9681; Fax: +86-10-6284 9681*

E-mail address: shichang.kang@itpcas.ac.cn

Meteorological data, topographic maps, remotely sensed data and field observation data on the northern slope of Mt. Qomolangma (Everest) and the Nam Co Basin, southern Tibet, were used to analyze the characteristics of climate change, glacier and lake variations during the past three decades. The annual temperature increased dramatically while the annual precipitation had a slight increase trend in the southern Tibet since 1970. The magnitude of warming in winter was much higher than that in summer. Affected by the climate warming, the glaciers in the southern Tibet were undergoing an overall shrinkage.

Changes in clean ice area, debris-covered glacier area, and supra-glacial lake area in the Rongbuk River Basin (RRB) at the northern slope of Mt. Qomolangma were retrieved using integrated remote sensing data and older topographic data. In 1976, the clean ice covered 139.2 ± 3.48 km^2. From 1976 to 1992 the glacial area has shrunk to 134.2 ± 3.36 km^2 (3.60%), diminished further to 129.0 ±3.23 km^2 by 2003 (3.89%). The overall change in clean ice area in the RRB was 7.45 ±2.5% of the surface area in1976 within 27 years. The rate of clean ice area reduction for the whole basin increased from 0.31 ±0.11 km^2 a^{-1} in the first period (1976-1992) to 0.48 ±0.16 km^2 a^{-1} during the second period (1992-2003). The debris-covered glacier area underwent on average a downwasting of 24.2±15.8 m within nearly 30 years from 1974 to 2003. A stagnant area from the terminus up to 2 km and a clear downwasting area was detected which was in accordance with the field observation. Supra-glacial

lakes were sporadic in 1974 with an area of 0.013 km^2, and then the area increased to 0.079±0.002 km^2 in 1992 and then 0.799±0.02 km^2 in 2003. Glacier shrinkage and the concurrent enlargement of supra-glacial lakes might be caused by increased air temperatures in the region.

During the period of 1970 to 2007, the glacier area reduced 37.1 km^2 accounted for 18.2 % of the whole glacier area in the Nam Co Basin with the annual glacier change ratio of -1.0 km^2/a. The GPS surveying indicated that the terminus of the Zhadang glacier and Lanong glacier had retreated 381.8 m and 489.5 m with the annual change ratio of 10.3 m/a and 13.4 m/a, respectively. In the same period, the area of the Nam Co Lake, which is partially supplied by glacier melt water, increased 72.6 km^2 with an annual increase rate of 2.0 km^2/a. During the three periods of 1970-1991, 1991-2000 and 2000-2007, the average annual increase rate has been growing as 1.1, 2.8, and 3.4 km^2/a, respectively. The water level of the Nam Co Lake has a notable increase during summer season which is coincident with the expanding of lake area.