Contribution of Glaciers in China and Central Asia to rising global sea level

Liu Shiyin Ding Yongjian Shangguan Donghui Wang Ningliang Zhang Yong Li Jing Han Haidong Wang Jian Xie Changwei Ding Liangfu and Li Gang
Key Laboratory of Cryosphere and Environment, Cold and Arid Regions Environmental and Engineering Research Institute, Chinese Academy of Sciences, Lanzhou 730000

1. INTRODUCTION

Various studies indicated that the melting of global small glaciers has caused sea level rise at a rate of 0.2-0.4 mm/yr. Recent results for Alaskan and Patagonian glaciers indicated that the contribution of these glaciers to sea level rise might be lowly estimated. Does this mean that glaciers in Central Asia, a largest glacierized area in the mid-latitudes, have a greater contribution than the former estimate? Here we present results of glacier changes in China and show how much the wastage of these glaciers contribute to sea level rise.

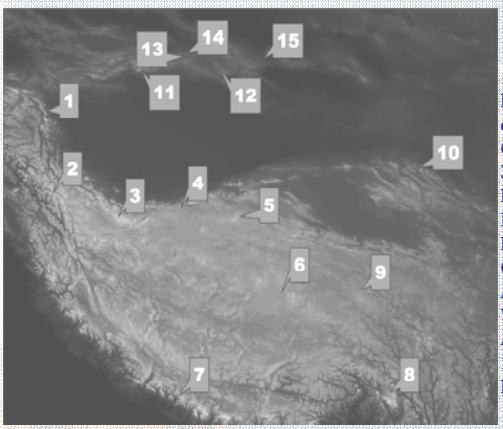
2. GLACIERS IN CHINA AND CENTRAL ASIA

The western China and the surrounding parts in the Central Asia are characterized by the unique high mountains and plateaus as the Himalayas, mountains of Karakorum, Nyainqen Tanglha, Tanggula, Hengduan, Qilian, Tianshan and Altay and the Qinghai-Tibetan Plateau. The high mount peaks of these mountains form the highly glacierized centers. There are 46377 glaciers with a total area of 59425km^2 and the estimated ice volume is 5600km^3 in China. Glaciers in central Asia are about 114,800km^2 in area, nearly 2 times of that in China. Meltwater from these glaciers supplies large rivers like the Yangtze, the Ganges, Tarim and so on, so a key source influencing sea level change.

3. GLACIER CHANGES IN CHINA

Using aerial photos, topographical maps(1/50k or /100k), satellite remotely sensed images, we derived glacier changes since the Little Ice Age Maximum (by referring to fresh end and lateral moraines) and during the last decades in different areas of western China. Changes over 3000 glaciers since LIAM in western China were identified on aerial photos taken in 1968 (44.3% of the photos used), 1963 (20.5%), 1970 (10%) and in late 1950s and early 1980s (26.2%). The LIAM moraines in western China were dated between 1570 and 1800 AD by lichenometry, treering index and ice core records. Here we took the mean date (by addition to the response time of 14 years of the glaciers, for 97% glaciers in China are less than 5km in length) as 1720 AD, and the weighted year for aerial photos is 1967. Ice volumes of the observed glaciers in LIAM and 1967 were estimated by the modified volume~area relation of $V=0.04S^{1.35}$ derived from radar-sounding ice thickness measurements on 23 glaciers in China. The same relation was also used for the volume estimation of glaciers in the recent period. It was found that ice volumes of LIAM glaciers were linearly related to that in 1967 (within 3 groups, <1km^2, 1~5km^2 and >5km^2) and these linear equations were applied for other glaciers without measurements. We calculated that glaciers in China have thinned by 19.3m in average during 1720 and 1967, or 78.1mm/yr.

Glacier changes during the late 1950s and 2001 were derived from topographical maps and satellite images (Landsat TM/ETM$^+$, ASTER). All images were geometrically corrected by referring to the maps (Krosovsky spheroid, Alberts equal area conical projection)). We have extracted changes of 5020 glaciers during the past several decades in different areas of western China (Figure below). The volume changes were calculated by the above-mentioned equation. Of all the monitored glaciers, 82.8% of which were retreating during the mentioned time span. We also found there existed good linear relations between volumes of glaciers in the late 1950s and 2001 for the three size groups. By extrapolation, we estimated that glaciers in China have lost a total ice volume of 278.9km^3, or thickness thinning of 4.7m between 1967 and 2001 or 126.5mm/yr. An accelerated ice mass loss was obvious compared to that since LIAM.



Monitored regions for glacier changes in the last decades: 1: Gaiz River; 2: Yerkant River; 3: Hetian River; 4: Keriya River; 5: Xinqingfeng (XQF) Ice Cap; 6: Geladandong Mountain; 7: Pengqu River; 8: Gangri Gabu range; 9: A'nyêmaqên mountains; 10: Western Qilian Shan; 11: Aksu River; 12: Kaidu River; 13: Kashi River; 14: Sikeshu River; 15: the Urumqi River.

4. CONTRIBUTION TO SEA LEVEL RISE

Due to limited data of glacier changes outside of China in Central Asia, we assumed that glaciers other than that of China experienced the same ice loss rate during the same time intervals. We calculated that glaciers in Central Asia have lost total ice mass of 2215.6 and 493.6km^3 respectively during 1720~1967 and 1967~2001, corresponding to sea level rise of 0.022 and 0.036mm/yr in the two time intervals. The contribution of Central Asian glaciers to rising sea level since LIAM was smaller than that of the early estimates (Meier (1980), Dyurgerov and others (1997), but similar to that of Zuo and Oerlemans (1997) for the late half of 20 century.