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Glacier Dynamics and Water Balance in the Qinghai-Tibet Plateau

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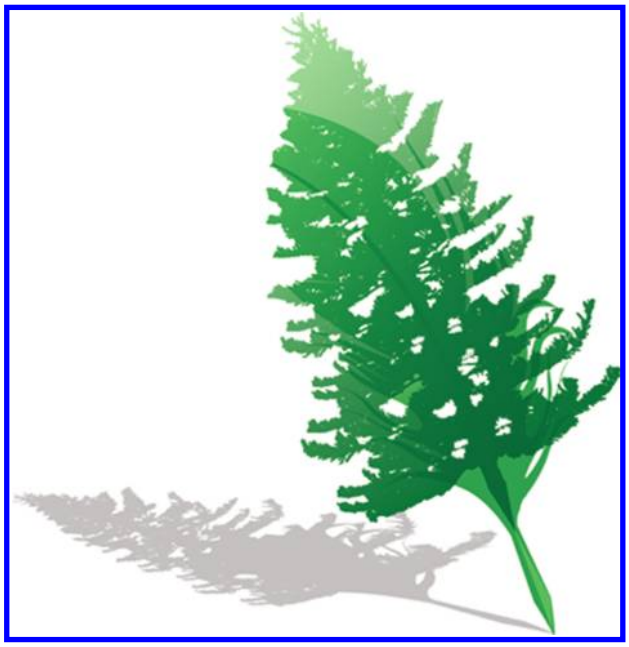

Climate change is among the most important research topics in earth sciences. Many discussions have been focused on glaciers, because they are not only precious fresh water sources which may determine the survival and development of human society, but also sensitive to global warming. Known as the "third polar", the Qinghai-Tibet Plateau is the youngest, highest, most extensive and sensitive plateau on the Earth. It is comprised of a wide range of mountain glaciers, which are the sources of important rivers for adjacent countries, such as China and India. About 1.4 billion people are dependent on the rivers that originate from the Tibetan plateau and Himalayas. [1] Thus, the relationship between glacier melting and water resources available for ecosystem and society has aroused much public concern.

The interaction between glacier dynamics and precipitation in the Qinghai-Tibet Plateau is complex. With global warming, most glaciers in the Qinghai-Tibet Plateau shrank at a rate of about 10.1% from 1970 to 2000. [2] However, all not research results showed similar trends. Glaciers in the Karakoram Mountains were reported to have displayed seasonal and interannual variations but no significant retreat. [3] The development of Glaciers may be attributed to the increasing precipitation in the area. Zhang et al. reported that annual precipitation had increased in some river basins of Tibetan plateau glacier area, including LLi River Basin, the Junggar Interior Basin around the Tianshan Mountains, the Ob River basin around the Altay Mountains, and the Hexi Interior Basin around the Qilian Mountain. [2] Glaciers melting can positively influence precipitation in the short term by increasing evapotranspiration. In the long run, however, with increasing loss of water resources by anthropogenic activities and the drying trend of global climate, the shrinking rate of glaciers will be further accelerated. It was estimated that the shrinkage of the glacier area and volume might reach 30%-67% by 2100. [4] Then a positive feedback loop emerges: glaciers shrinkage → less precipitation → glaciers shrinkage and less river flow.

Another outcome from glaciers melting is the formation of adjacent glacial lakes (Figure 1), causing associated downstream lakes and wetlands to expand in a short time. In the long term, however, it will lead to shrinkage or demise of those lakes and wetlands with a gradual decline in glacial meltwater. The dynamics might surpass the threshold for ecosystem stability in the fragile Qinghai-Tibet Plateau. What makes it more complex is that Qinghai-Tibet Plateau is distributed with vast permafrost soils. The increased permafrost activities period does not increase the utilization of downstream water resources. Instead, seasonal permafrost melting absorbs glacial meltwater and can significant reduce downstream runoff. In short, global climate change has interrupted the water balance of the Plateau lake-river system, which makes the management and utilization of water resources in glacier area a top priority as well as part of long-term plans.

As the protection of fresh water resources from the plateau mountain glaciers becomes more urgent, it is imperative to establish complete ecological and environmental monitoring systems in this area. The distribution of Qinghai-Tibet Plateau glaciers also offers a chance for its water resources protection. Southeastern Tibet includes the eastern section of Himalayas, Hengduan Mt., and Nyainqentanglha Mt., which are featured with a snow-land-ocean-atmosphere system. The glaciers in these areas belong to marine type, which are highly sensitive to global warming and melt at a high speed. In this region, water conservancy facilities should be constructed and more attention should be paid to the protection of newly formed glacial lakes. In western and central Qinghai-Tibet Plateau, the vast area, from West Kalakunlun to Qiangtang plateau area, Altai Mountain,

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Figure 1. Glacial lake near the Tanggula Pass (Altitude 4900 m).

Middle East section of Qilian Mountains, the East Tanggula Mountain and Himalaya, Nyainqentanglha mountains, and West and Karakoram, is covered with continental and subcontinental glaciers that ablate at a low speed. In these areas the policies including investment should be developed to avoid the destruction of the ecosystem and maintain its current status, since it will be extremely difficult to be restored after ecological deterioration. Thus, coordinated development of the population, economy and environment should be investigated and planned carefully, especially keeping water balance in mind: short-term vs long-term, local and region, and economy and environment.

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Notes

The authors declare no competing financial interest.

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