Water level changes in alpine lakes on Tibetan Plateau and its implications for climate impact

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Abstract: The Tibetan Plateau (TP, hereinafter) in central Asia is well known as "the Third Pole" of the earth and "Asian Water Tower". This region contains many alpine lakes and mountainous glaciers and is also the origin of several large Asian rivers, which supply more than one billion people of downstream countries in south-east Asia. During the past decades, climatic changes had substantial influences on the cryospheric regions and radically transformed the lake water environment on the plateau. Using satellite altimetric data, we examine seasonal and abrupt changes in water levels between 2003 and 2009 of 120 alpine lakes on the TP. The cluster analysis method is applied to partition different temporal evolutions of lake water-level and the links between different clusters of lake variations and key climatic variables (temperature (T), "precipitation – evaporation (P – E)" difference, snow depth) are further analyzed. The results show that the seasonal water-level variations performed evident spatio-temporal heterogeneity during the study period. Most lakes over the plateau had significant increases in water-level in warm seasons and declines in cold seasons. Whereas, in the Chiangtang Plateau and northern TP, lakes showed severe negative water budget in warm seasons due to low precipitation and strong evaporations, but showed positive water balance depending on snow meltwater in cold seasons. The abrupt changes in water level for different clusters of lakes are shown to be tightly associated with climatic variables. It is notable that, for most of expanding lakes, the abrupt rising water levels within one or two seasons (inconsistent years for different clusters of lakes) with special climate conditions, such as large "P – T" differences, comprised more than 60% of the total cumulative water-level

increases during the analyzed period, while in normal hydrologic seasons, the water level generally kept minor fluctuations or slight upward tendency. During the study period, the precipitation and evaporation played more important roles in rising water levels for most lakes on TP than glacial meltwater, and the glacial meltwater may contribute to a small proportion of lakes greatly supplied by glaciers and perennial snow cover. In addition, the GRACE-derived terrestrial water storage estimation reveal seasonal and inter-annual water mass variations and redistribution within different clusters of lake basins, in good agreement with seasonal and abrupt lake water-level changes derived from ICESat altimetry measurements and corresponding hydro-climatologic conditions.

Keyword: Tibetan Plateau, lake, water level, climate change, laser altimetry