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Dramatic and long-term lake level changes in the Qinghai-Tibet Plateau from Cryosat-2 altimeter: validation and augmentation by results from repeat altimeter missions and satellite imagery

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The mean elevation of the Qinghai-Tibet Plateau (QTP) exceeds 4000 m. Lake levels in the QTP are less affected by human activities than elsewhere, and may better reflect the state of contemporary climate change. Here ground-based lake level measurements are rare. Repeat altimeter missions, particularly those from the TOPEX and ERS series of altimetry, have provided long-term lake level observations in the QTP, but their large cross-track distances allow only few lakes to be monitored. In contrast, the Cryosat-2 altimeter, equipped with the new sensor SIRAL (interferometric/ synthetic aperture radar altimeter), provides a much better ranging accuracy and a finer spatial coverage than these repeated missions, and can detect water level changes over a large number of lakes in the QTP. In this study, Cryosat-2 data are used to determine lake level changes over 75˚E-100˚E and 28˚N-37.5˚N, where Cryosat-2 covers 60 lakes and SARAL/ AltiKa covers 32 lakes from 2013 to 2016. Over a lake, Cryosat-2 in different cycles can pass through different spots of the lake, making the numbers of observations non-uniform and requiring corrections for lake slopes. Four cases are investigated to cope with these situations: (1) neglecting inconsistency in data volume and lake slopes (2) considering data volume, (3) considering lake slopes only, and (4) considering both data volume and lake slopes. The CRYOSAT-2 result is then compared with the result from the SARAL to determine the best case. Because Cryosat-2 is available from 2010 to 2016, Jason-2 data are used to fill gaps between the time series of Cryosat-2 and ICESat (2003-2009) to obtain >10 years of lake level series. The Cryosat-2 result shows dramatic lake level rises in Lakes Kusai, Zhuoaihu and Salt in 2011 caused by floods. Landsat satellite imagery assists the determination and interpretation of such rises.