# Tracking four-decade inundation changes with multi-temporal satellite images in China's largest freshwater lake

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Poyang Lake is the largest freshwater lake in China. The lake has undergone remarkable spatio-temporal changes in both short- and long-term scales since 1970s, resulting in significant hydrological, ecological and economic consequences. Remote sensing techniques have advantages for large-scale studies, by offering images at different spatial and spectral resolutions. However, due to technical difficulties, no single satellite sensor can meet the needs for high spatio-temporal resolution required for such monitoring. In this study, using Landsat Thematic Mapper (TM) and Moderate Resolution Imaging Spectroradiometer (MODIS) images collected between 1973 and 2012, we documented and investigated the short- and long-term characteristics of lake inundation based on Normalized Difference Water Index (NDWI). First, we presented a novel downscaling method based on the NDWI statistical regression algorithm to generate small-scale resolution inundation map (30m) from coarse MODIS data (500m). The downscaling is a linear calibration of the NDWI index from MODIS imagery to Landsat imagery, which is based on the assumption that the relationships between fine resolution and coarse resolution are invariable. Second, Tupu analysis method was further performed to explore the spatial-temporal distribution and changing processes of lake inundation based on downscaling inundation maps. Then, a defined water variation rate (WVR) and inundation frequency (IF) indicator was used to reveal seasonal water surface submersion/exposure processes of lake expansion and shrinkage in different zones. Finally, mathematical statistics methods were utilized to explore the possible driving mechanisms of the revealed change patterns with meteorological data and hydrological data. The results show that, there is a high correlation (mean absolute error of 3.95% and an $R^2$ of 0.97) between the MODIS- and Landsat-derived water surface areas in Poyang Lake. Over the past 40 years, a declining trend to a certain extent for the Poyang Lake's area could be detected. The lake surface displayed comparatively low values ($\sim$2000 km2) in wet periods of 1980, 2006, 2009 and 2011, corresponding to severe hydrological droughts in the lake. In addition, the water surface variation in Poyang Lake had a typical seasonal behavior. It mostly followed a unimodal cycle with area peaks appeared in the wet season. The earliest beginning of the inundation cycle was emerged in 2000 and the latest in 2006. In general, the change of lake area is a synthetic result of climate change, land-cover change and construction of dykes. Our findings should be valuable to a comprehensive understanding of Poyang Lake's decadal and seasonal variation, which is critical for flood/drought prevention, land use planning and lake ecological conservation.