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Revisiting Bathymetry Dynamics in the Lake Urmia using Extensive Field Data and High-Resolution Satellite Imagery

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Abstract:	Bathymetry mapping for an accurate estimation of stored water volume in drying lakes is a key information for an effective monitoring of their recession or restoration status. Extraction of bathymetry in shallow saline lakes from remote sensing has always been challenging due to the complex influences imposed by the physical properties of substrate and the spatial variability of salinity. In this study, we developed a machine learning-based model to quantify the implicit, non-linear relationship between water depth and surface reflectance by leveraging extensive in-situ data and high-resolution satellite imagery. We trained and tested the learning model in the hyper-saline Lake Urmia (LU), which faced catastrophic drying over the past two decades. To this end, we used Landsat-8 imagery and 32,984 hydrography data points surveyed by the Urmia Lake Restoration Program (ULRP) from 2017 to 2020 during six stages. To enhance the model accuracy, we tuned the model inputs by optimizing the spectral information and clustering in-situ data from stages with similar meteorological conditions into three classes. The results demonstrated the high accuracy of the developed intelligent model as evidenced by R2 = 0.8 ~ 0.9 and RMSE = 7.8 ~ 17.9 cm for the three models. We found that the average water depth in the LU was increased from 0.43 m in September 2018 to 2.00 m in May 2020. In particular, the lake water volume in May 2020 was 3.6 times greater than that in February 2019, which marks a remarkable shift in the LU restoration. Comparison between the bathymetric maps also witnessed considerable salt dissolution taking place across the lake during this period. Finally, we extracted the LU level-area relationship by processing 172 Landsat images between 1984 and 2020, which was validated against the field data surveyed along the lake water boundary in 2019. The results showed that the level-area relationship follows a dual linear relationship separated at the water level of 1271.31 m.
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