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Coupling machine learning with high resolution satellite imagery to estimate spatiotemporal changes of salinity in water bodies

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The spatiotemporal dynamics of salinity in hypersaline lakes is strongly dependent on the rate of water flow feeding the lake, evaporation rate, and the phenomena of precipitation and dissolution. Although in-situ observations are most reliable in quantifying water quality variables, the spatiotemporal distribution of such data are typically limited or cannot be readily extrapolated for long-term projections. Alternatively, remotely-sensed imagery has facilitated less expensive and stronger ability to estimate water quality over a wide range of spatiotemporal resolutions. This study introduces a machine learning model that leverages in-situ measurements and high-resolution satellite imagery to estimate the salinity concentration in water bodies. To this end, 123 points were sampled in April and July of 2019 across the Lake Urmia surface covering the wide range of salinity fluctuations. Among the artificial neural networks, ANFIS, and linear regression tools examined to determine the relationship between salinity and surface reflectance, artificial neural networks yielded the best accuracy evidenced by $R^2 = 0.94$ and RMSE = 6.8%. The results show that the seasonal change of salinity is linearly correlated with the volume of water feeding the lake, witnessing that dilution imposes a stronger control on the salinity than bed salt dissolution. The impact of disturbance in the lake circulation due to the causeway is also evident from the sharp changes of salinity around the bridge piers near spring when the mixing of fresh and hypersaline water from the southern and northern parts, respectively, takes place. The results of this study prove the promising potential of machine learning tools fed multi-spectral satellite information to map other water quality metrics than salinity as well.