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Estimating dissolved oxygen of Lake Huron at multiple spatiotemporal scales using remote sensing and machine learning

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Dissolved oxygen (DO) effectively indicates the health and self-purification capacity of waterbodies. However, since DO is a non-optically active parameter and has little impact on the spectrum captured by satellite sensors, research on estimating DO by remote sensing at multiple spatiotemporal scales are limited. In this study, the support vector regression models were developed and validated using the remote sensing reflectance derived from both Landsat and Moderate Resolution Imaging Spectroradiometer (MODIS) data and synchronous DO measurements, water temperature and sampling coordinates of Lake Huron (*N* = 206) and three other inland waterbodies (*N* = 282) covering different latitudes. Using the developed models, spatial distributions of the annual and monthly DO since 1984 and the annual monthly DO since 2000 in Lake Huron were reconstructed for the first time. The impacts of five climate factors on DO were analyzed. Results showed that the developed models had good robustness and generalization (average R^2 = 0.91, root mean square percentage error = 2.65%, mean absolute percentage error = 4.21%), and performed better than random forest and multiple linear regression. The monthly DO estimation by Landsat and MODIS data were highly consistent (average R^2 = 0.88). Note that the model performance was limited for samples beyond the range of the training set. From 1984 to 2019, the oxygen loss of Lake Huron was 6.56%. The DO of Lake Huron showed obvious seasonal regularity of decreasing from spring to summer and increasing from summer to autumn. Since 2000, DO of Lake Huron has shown a decreasing trend in the same month of different years. Air temperature, incident shortwave radiation flux density and precipitation were the main climate factors affecting annual DO of Lake Huron. This study demonstrated that Landsat and MODIS data could be used for long-term DO retrieval at multiple spatial and temporal scales. As data-driven models, adding variables related to the target parameter and extending the training set to cover more water quality conditions could effectively improve model performance.