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Global trends in lake surface temperatures observed from space

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The temperatures of lakes and reservoirs worldwide are an excellent indicator of climate variability. Consistent, long-term in situ observations of lake surface temperature are very rare on a global scale, however the existing 30-year archive of thermal infrared imagery can be used to infer accurate and homogeneous time series of water surface temperature and associated trends for lakes and reservoirs worldwide. Here we show research on utilizing the existing archive of spaceborne thermal infrared imagery to generate multi-decadal time series of lake surface temperature for 169 of the largest lakes worldwide. The data used for this purpose includes imagery from the Advanced Very High Resolution Radiometers (AVHRR), the series of (Advanced) Along-Track Scanning Radiometers ((A)ATSR), and the Moderate Resolution Imaging Spectroradiometer (MODIS). Used in combination, these data sets offer a gapless time series of daily to near-daily thermal infrared retrievals since the early 1980s. We first demonstrate using comprehensive in situ data at Lake Tahoe, California/Nevada, that lake water surface temperature can be estimated using these sensors with an accuracy of up to 0.2 °C. We further show that long-term trends obtained from satellite observations agree very closely with those computed from in situ temperature data at the Laurentian Great Lakes. Finally, our main results obtained for 169 inland water bodies worldwide indicate that the surface temperatures of the studied water bodies have been rapidly warming with an average rate of 0.045 $\pm$ 0.011 °C/yr and rates as high as 0.10 $\pm$ 0.01 °C/yr for the period 1985–2009. Worldwide, the data show far greater warming in the mid- and high latitudes of the northern hemisphere than at low latitudes and the southern hemisphere. The research performed within the framework of this study for the first time allows a unique, global-scale, and consistent perspective on the temporal thermal properties of large inland water bodies worldwide, in particular for the vast majority of lakes for which no in situ data is available. This facilitates the construction of continuous surface temperature time series for the last few decades as well as the detection of trends in the lakes' temporal thermal behavior. As such, the results of this study are important with respect to ongoing research on the impact of global climate change on lake ecosystems as well as the interaction between large lakes and regional climate.