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Global trends in lake surface temperatures observed using multi-sensor thermal infrared imagery

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Recent research has shown that the temperature of lakes and other inland water bodies does not only act as a good indicator of climate variability but under certain conditions can even increase more rapidly than the regional air temperature. Further investigation of this phenomenon in particular and of the interaction between lake temperature and climate variability in general requires extensive observations of lake temperature on a global scale. Current in situ records are limited in their spatial and/or temporal coverage and are thus insufficient for this task. However, a nearly 30-year archive of satellite-derived thermal infrared imagery from multiple sensors is available at this point and can be used to fill this data gap.

We describe research on utilizing the existing archive of spaceborne thermal infrared imagery to generate multi-decadal time series of lake surface temperature for 170 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 from 1981 through present. In this contribution we 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 K. We further show that accurate continuous time series of water surface temperature can be derived from the data and that these time series can be used to detect significant trends in the temporal thermal behavior of lakes and other inland water bodies worldwide. Complementing our recent case study for lakes in California and Nevada for which a rapid increase in mean nighttime summertime lake surface temperatures of 0.11 K per year on average was found, we present first results of an extended global study of worldwide trends in lake temperatures, indicating that the majority of lakes studied has been warming significantly over the last few decades. We further discuss distinct regional patterns in these trends and how they relate to spatial patterns in recently observed global air temperature increase.

Using a multi-sensor archive of thermal infrared imagery, 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.