Lake Water Temperatures For Regional Models

Eileen Maturi[1], Andy Harris[2], Jeehye Han[2], Jacob Carley[3], Geoffrey Manikin[3]
1. NOAA/NESDIS 2. University of Maryland 3. NWS/Modeling and Data Assimilation Branch

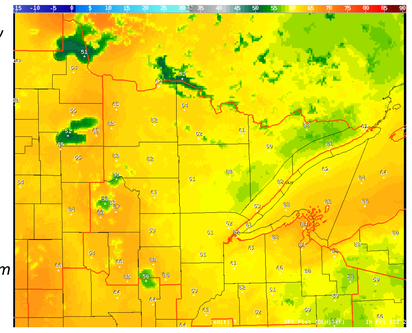
Introduction

As model resolution increases, there is an ongoing need for accurate lake water temperatures. The cumulative effect of multiple lakes is notable, while predicted and analyzed inland water temperatures also form a key aspect of forecasts. However, it is evident that existing information on the model grids is inadequate. The primary reason for this is that the current observing systems are not meeting the needs of either model assimilation or forecasters.

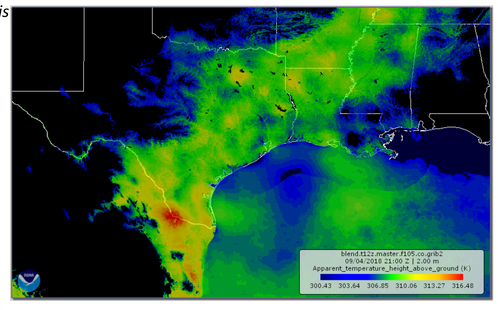
Examples of deficiencies

Sample feedback from forecast offices:

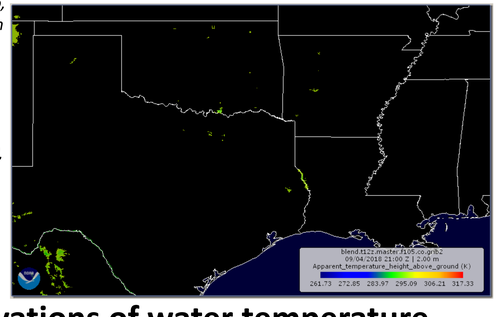
"…Every summer into Fall we have inappropriately low 2 m temperatures in the grids across our many inland lakes. These values are in SuperBlend and get there from a variety of input: The CAMs have them due to the simplistic and poor way water temperatures are assigned to inland lakes. The RTMA/URMA has them since they use the HRRR for a first guess, which suffers from the water temperature assimilation issue, and this then screws up the bias corrected grids… …it can screw up the point and click forecasts the public sees (depending on where they click the temperature can be 10 degrees or more off given that the 2.5 km grid is not sufficiently fine to perfectly outline inland lakes), and can also screw up spot forecasts and require additional editing of those. This effect is most problematic for us during the Summer and early Fall."



"The other item I noticed in making this loop, were the "hot spots" over cities, which one might expect (heat islands), but I also noticed the speckled reflection of the lakes over northeast Texas. Others have noted this in prior posts, but the next image, valid on Sep 4th at 21z, I zoom in on the South for a closer look. Zooming in, one can not only see the too-cold lakes…



…Now, back to the too-cold lakes, which as I said, has already been covered, but since I was in here, I wanted to check the temperatures. So, in the image below, I filtered the Kelvin temperatures to ONLY show Apparent Temperatures 74 degree F or less. Below, you can see all the lakes that show up as 74 degrees or colder (the one along the TX/LA border had some pixels in the upper 60s!). Rest assured, the lake temperatures down here, for the most part, are in the 80s, if not mid 80s this time of year."

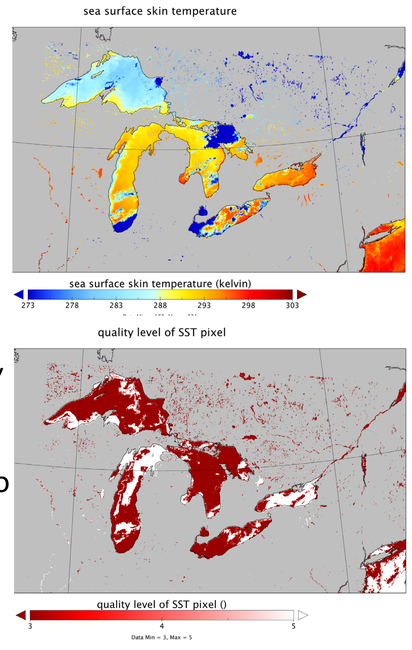


<u>Key priority – obtain good observations of water temperature for lakes in North America</u>

Lake water temperatures from Satellite

Thermal infrared satellite measurements offer the best prospect for observations of lake water temperature on the continental scale. However, there are some issues with the current products. Most of the problems in existing NESDIS satellite-based lake temperature products are due to the simple fact that the processing methodologies for cloud detection and temperature retrieval (Advanced Clear-Sky Processor for Oceans, ACSPO, see Petrenko *et al.*, 2010, 2014) have been optimized for the open ocean, where the atmosphere is usually close to equilibrium with the water surface, and the target is far from the disrupting influence of land.

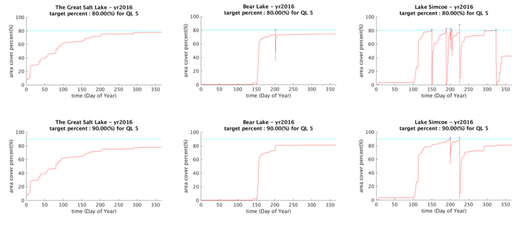
Example of ACSPO water surface temperatures (top) and quality level (bottom) for Gt Lakes region. Quality level <5 not recommended, and values of 3 are considered cloud contaminated. Note that many seemingly valid temperatures are assigned quality level 3, as are virtually all smaller lakes.



The Gt Lakes are as close to ocean as possible in terms of retrieval conditions, and yet there are significant problems. There is a notable tendency to mask cold, clear water. In such cases, the average temperature for data denoted "good" will not be representative.

Implications for temporal coverage

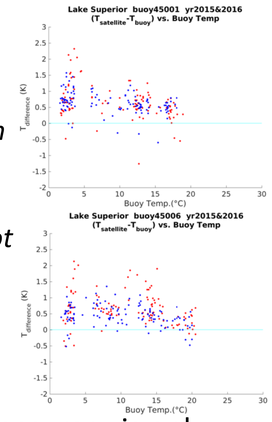
For "smaller" lakes the time it takes to accumulate 80% or 90% coverage can be prohibitive...



Product accuracy

The training of retrieval algorithms to *in situ* observations in the open ocean also leads to increased bias and scatter for lake water temperatures

Example of ACSPO lake water surface temperatures compared to in situ measurements from 2 separate buoys in Lake Superior. Note the trend with temperature which implies a seasonal Dependence that is indeed observed (not shown). These trends in error are quite typical For all the Great Lakes.



While not as critical as the lack of coverage issue, the overall retrieval accuracy is only about ½ as good as that obtained for the open ocean, while the bias is an order of magnitude worse.

The solution

The problems observed stem from the fundamental problem that **conditions for water targets over land**, especially for lakes at different altitudes, are generally **different from those in the open ocean**. Such differences are **seasonal in nature**. For the **coverage issue**, deriving tailored cloud masking thresholds for each lake target is impractical. Thus, use of **fast radiative transfer to derive cloud detection** will enable **localized atmospheric information from NWP** to be utilized to improve the result. Furthermore, we propose the use of a **deterministic physical retrieval** method, Modified Total Least Squares (MTLS, Koner *et al.*, 2015) to obtain lake water temperature from satellite radiances. The key advantage of MTLS is that the regularization of the gain matrix is **calculated dynamically at solution time**, rather than requiring *a priori* error covariances. In the circumstance of somewhat infrequently observed lake targets, this is a significant advantage. The methodology also allows for **incorporation of aerosol information** (Koner & Harris, 2016a) and functions as a final **quality check for residual cloud** (Koner & Harris, 2016b, Koner *et al.*, 2016)

References

Koner, P.K., Harris, A.R., and Maturi, E.M., A Physical Deterministic Inverse Method for Operational Satellite Remote Sensing: An Application for Sea Surface Temperature Retrievals, *IEEE Trans. Geosci. Rem. Sens.*, 53, 5,872-5,888, 2015
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Contact: eileen.maturi@noaa.gov