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Remotely sensed open water reservoir and lake evaporation

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Abstract

Estimating open water evaporation is important for understanding water loss from reservoirs and other water bodies. The widely-used PT-JPL evapotranspiration algorithm is used in missions such as ECOSTRESS, Landsat, and MODIS, yet water bodies have been historically masked out. Here, we un-mask water bodies to reveal the remotely sensed open water evaporation retrieval. We retrieve open water evaporation using Landsat at multiple sites, and validate the retrievals with in situ measurements of open water evaporation.

Data Sources

Instantaneous Landsat latent heat data from 2013 to 2019 was compared against in situ eddy covariance flux towers located on lakes and reservoirs across the Continental United States. Of the 10 sites, 3 had consistent, cloud-free imagery that allowed for validation against the ground readings. Altogether, 91 scenes were considered for validation. In Situ data sources and points of contact include Great Lakes Evaporation Network, Open Water Evaporation Network, Justin Huntington and Chris Pearson, and Jacob Collison.

Methodology

Open Water Evaporation

The PT-JPL methodology used to calculate latent heat flux over water is the same as over land but with a modification to the instantaneous ground heat flux calculation. The method, which uses water surface temperature, air temperature, and dew point instead of NDVI is outlined by Abdelrady et al.

Citations

Abdelrady A, Timmermans J, Vekerdy Z, Salama MS. Surface Energy Balance of Fresh and Saline Waters: AquaSEBS. Remote Sensing. 2016; 8(7):583.

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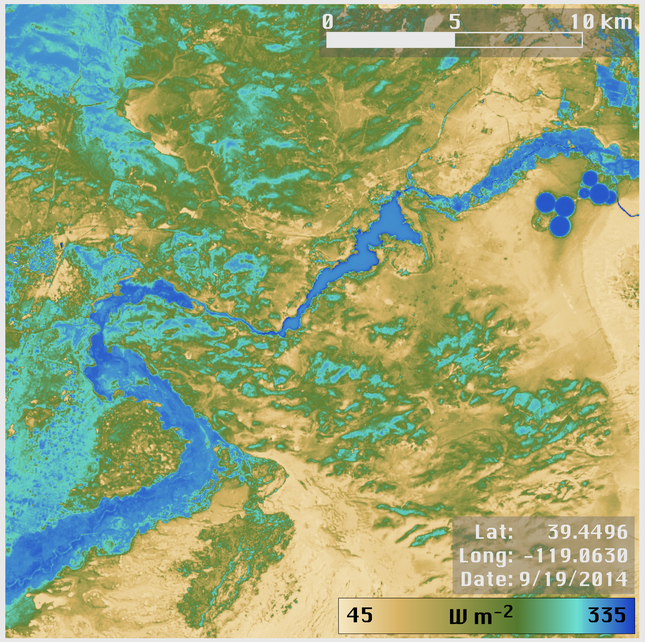
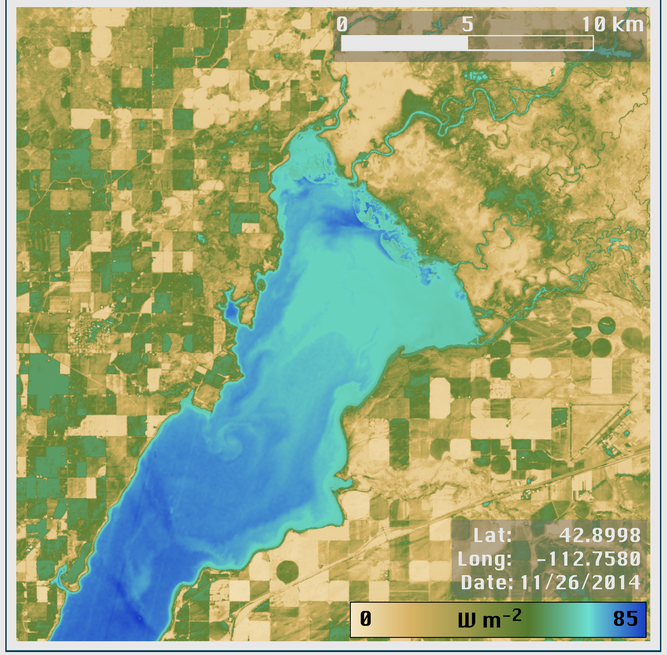
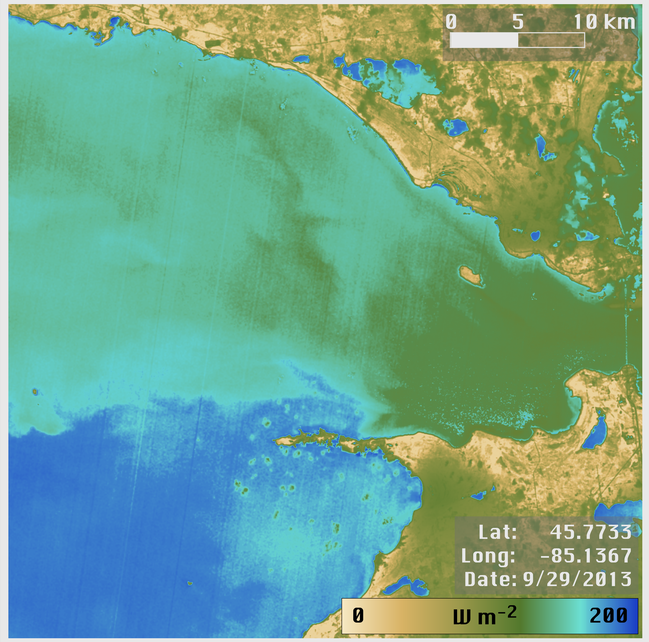
Lahontan Reservoir, NV

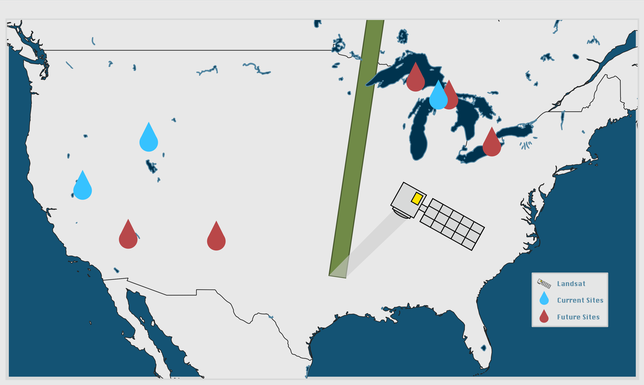


American Falls Reservoir, ID



White Shoal, Lake Michigan





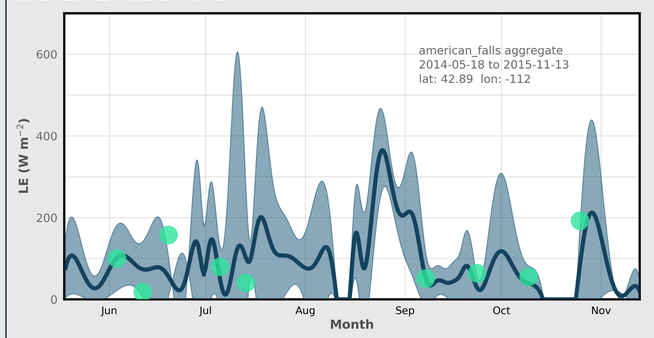
Data Matching

Spatial statistics were extracted from Landsat images at each site. The mean, median, and interquartile ranges were calculated for 5 by 5 pixel subsets. Energy balance closures were applied to sites when possible. After the raw data was processed, the ground data point closest in time to satellite overpass was chosen. Ideal matches of ground data and satellite spatial statistics were used for validation.

Data Filtering

7 sites were excluded from analysis due to lack of satellite imagery or poor quality, cloudy scenes. Furthermore, 4 scenes where satellite LE was zero (the default lower bound) were excluded. This is the extent of the data processing.

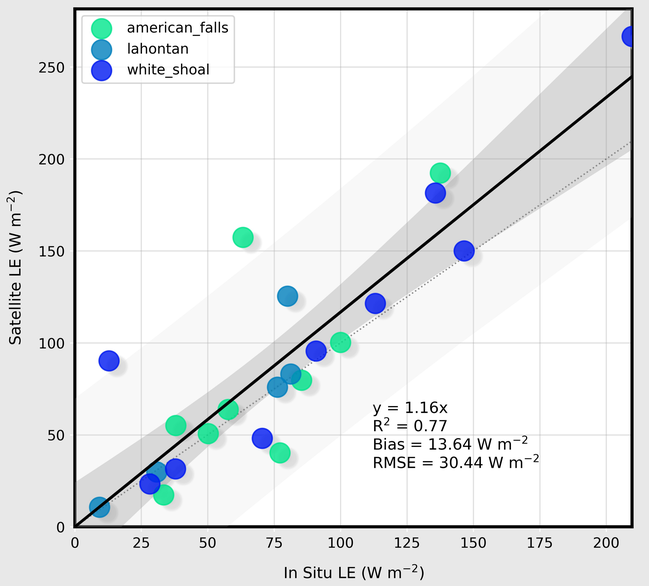
Results



As a preliminary exploration into open water evaporation, the results are very promising. The top left figure shows an example of Landsat data overlayed on an aggregate of daily averages for in situ data at the American Falls Reservoir in Idaho. Given that Landsat is in a solar synchronous orbit, the figure shows a good relationship between readings taken midday (10 a.m.) and the daily average.

Future Work

In order to include more data in the analysis, different satellite and ground sources need to be considered. PT-JPL products that include latent heat flux for reservoirs and lakes are currently in the works for MODIS as well as ECOSTRESS.



The inclusion of the 9 currently available eddy flux sites along with 1 pan evaporation site and any number of currently unknown sites could lead to more consistent and thorough validation.

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