# Lake Bathymetry Maps derived from Landsat and Random Forest Modeling, North Slope, AK

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## Summary

This dataset provides lake bathymetry maps derived from Landsat surface reflectance products for a portion of the North Slope area of Alaska. A random forest regression algorithm was used to generate depths for each point identified as being part of a lake, creating depth prediction files for each Landsat scene available for the study period: 2016-07-01 to 2018-08-31. These products are fitted to the ABoVE standard projection and reference grid to make them easily scalable and geometrically compatible with other products in the ABoVE study domain. The data are provided in cloud-optimized GeoTIFF (COG) format.

There are two data files in cloud-optimized GeoTIFF (COG) format with this dataset.

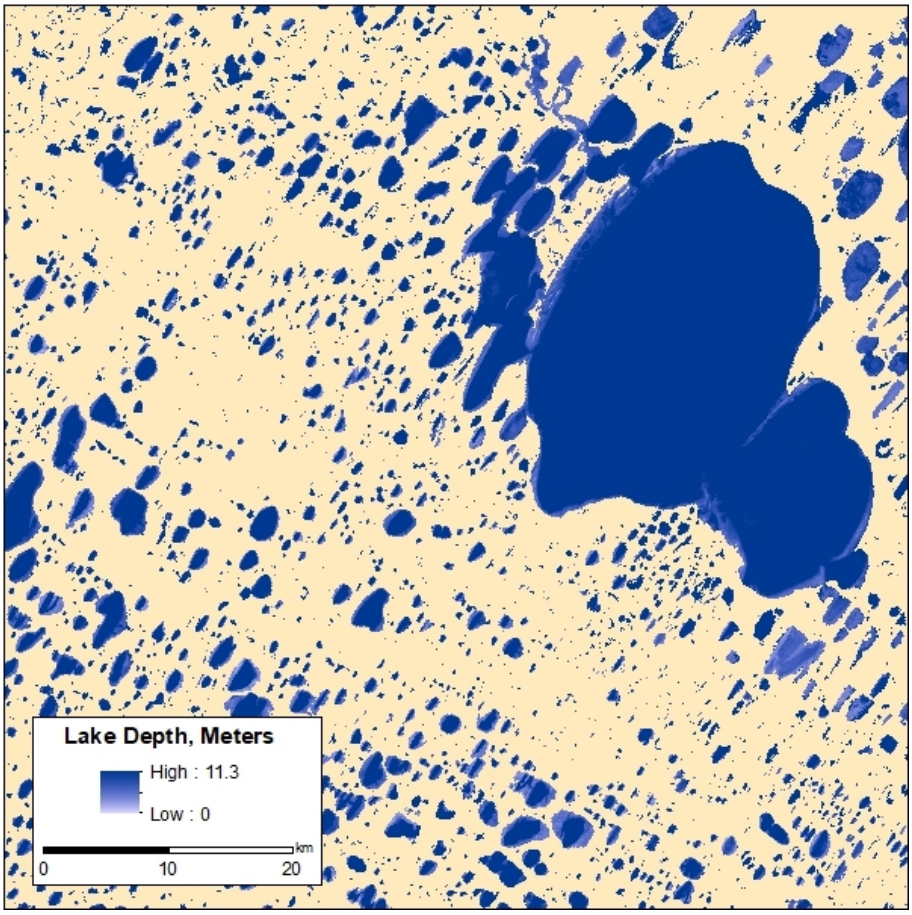


Figure 1. Lake depth from the data file ArcticLakeDepth_Ah01v00_2016-2018.tif.

## Citation

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## 1. Dataset Overview

This dataset provides lake bathymetry maps derived from Landsat surface reflectance products for a portion of the North Slope area of Alaska, split between the ABoVE Ah00v00 and Ah01v00 standard grid tiles. A random forest regression algorithm was used to generate depths for each point identified as being part of a lake, creating depth prediction files for each Landsat scene available for the study period: 2016-07-01 to 2018-08-31. These products are fitted to the ABoVE standard projection and reference grid to make them easily scalable and geometrically compatible with other products in the ABoVE study domain.

**Project:** Arctic-Boreal Vulnerability Experiment

The Arctic-Boreal Vulnerability Experiment (ABoVE) is a NASA Terrestrial Ecology Program field campaign being conducted in Alaska and western Canada, for 8 to 10 years, starting in 2015. Research for ABoVE links field-based, process-level studies with geospatial data products derived from airborne and satellite sensors, providing a foundation for improving the analysis, and modeling capabilities needed to understand and predict ecosystem responses to, and societal implications of, climate change in the Arctic and Boreal regions.

**Acknowledgement**

This study was funded by NASA (grant NNH20ZDA001N).

## 2. Data Characteristics

**Spatial Coverage:** North Slope of Alaska.

ABoVE grid tiles: Ah00v00 and Ah01v00

**Spatial Resolution:** 30 m

**Temporal Coverage:** 2016-07-01 to 2018-08-31

**Study Area:** Coordinates are provided in decimal degrees

| Site | Westernmost Longitude | Easternmost Longitude | Northernmost Latitude | Southernmost Latitude |
|---|---|---|---|---|
| North Slope, Alaska | -177.4690 | -128.1959 | 77.2626 | 56.0894 |

Spatial extents of the median depth prediction files. These correspond to the ABoVE standard grid tiles Ah00v00 and Ah01v00.

| Product | Westernmost longitude | Easternmost longitude | Northernmost latitude | Southernmost latitude |
|---|---|---|---|---|
| ArcticLakeDepth_Ah00v00_y2016-2018_v1.0.tif | -177.4690 | -148.2984 | 69.2779 | 56.0894 |
| ArcticLakeDepth_Ah01v00_y2016-2018_v1.0.tif | -167.8280 | -128.1959 | 77.2626 | 63.4391 |

**Data file information**

There are two data files in cloud-optimized GeoTIFF format with this dataset (Table 1). The files provide lake depth products for lakes in each of two ABoVE domain tiles (Ah00v00, Ah01v00) cropped to fit the boundaries of the North Slope Borough, Alaska. The files contain three bands corresponding to the median depth predictions, normalized median absolute deviation values (NMAD) and count of depth predictions used to derive median depth.

Table 1. Names and descriptions for the bands in each file. Bands correspond to median depth predictions and the ancillary data (nmad and count).

| File name | Band name | Band description | Value Range |
|---|---|---|---|
| ArcticLakeDepth_Ah00v00_y2016-2018_v1.0.tif | Depth_median | Predicted depth for lakes in the ABoVE domain tile Ah00v00. | 0.03 to 8.1 m |
| | Point_nmad | Normalized median absolute deviation values for the median depth predictions in the Ah00v00 ABoVE tile. | 0.0 to 4.3 m |
| | Point_count | Number of depth predictions from which the median depth was calculated in the Ah00v00 ABoVE tile. | 1 to 11 |
| ArcticLakeDepth_Ah01v00_y2016-2018_v1.0.tif | Depth_median | Predicted depth for lakes in the ABoVE domain tile Ah01v00. | 0.2 to 11.2 m |
| | Point_nmad | Normalized median absolute deviation values for the median depth predictions in the Ah01v00 ABoVE tile. | 0.0 to 6.7 m |
| | Point_count | Number of depth predictions from which the median depth was calculated in the Ah01v00 ABoVE tile. | 1 to 16 |

**Properties of the GeoTIFF files**

- Data type: Float32
- No Data Value: -10
- Number of Bands: 3
- Units: lake depth in meters for bands 1-2 and counts for band 3 (Table 1)
- Dimensions: 36000 x 36000 pixels
- Pixel size: 30 m

**Spatial reference properties**

- Projection: Albers Equal Area Conic
- False_Easting: 0.0
- False_Northing: 0.0
- Central_Meridian: -96.0
- Standard_Parallel_1: 50.0
- Standard_Parallel_2: 70.0
- Latitude_Of_Origin: 40.0 Linear Unit: Meter (1.0)
- Geographic coordinate system: GCS_North_American_1983
- Prime Meridian: Greenwich (0.0)
- Datum: NAD 1983
- Spheroid: GRS_1980
- Semimajor Axis: 6378137.0
- Semiminor Axis: 6356752.314140356
- Inverse Flattening: 298.257222101

## 3. Application and Derivation

To reduce the costs associated with direct bathymetry measurements (Liu and Song, 2022), this lake bathymetry map was created from Landsat surface reflectance products using a random forest regression algorithm. These products are fitted to the ABoVE standard projection and reference grid to make them compatible with other products in the ABoVE study domain.

## 4. Quality Assessment

Quality assurance data are provided in the product maps (band names: nmad and count), which should enable the user to assess the quality of the depth measurement. Since the depth measurements do not follow a normal distribution, the normalized median absolute deviation (NMAD) was used as the measure of variability instead of the standard deviation, because NMAD is less affected by potential outliers. The number of predicted depths (count) for each point were retained. The user can combine these measures to assess how well any individual pixel performed.

Validation: The predicted depths were validated against 669 in-situ sonar depth measurements taken by Simpson and Arp (2018) for lakes in the study domain, yielding an $r^2$ value of 0.76. This value represents how closely our predicted depths match actual measurements but does not necessarily indicate the accuracy of the predictions. Accuracy is better assessed by evaluating the ratio between correctly predicted depths and the total number of predictions for a given depth range; this value fell between 82-94%.

The points used for validation each had between 1-16 individual depth predictions (count), and their NMAD fell between 0 and 6.7 m. Only 12.3% of our predictions had a NMAD >2 m, and 53% of our validated predictions had a NMAD <0.5 m. This implies a high degree of agreement between our predictions and the in-situ sonar depth measurements we validated against.

## 5. Data Acquisition, Materials, and Methods

The data encompass the North Slope area of Alaska split up between the ABoVE Ah00v00 and Ah01v00 standard grid tiles. A random forest regression algorithm was used to generate depths for each point identified as being part of a lake, creating depth prediction files for each Landsat scene available for the study period.

The regression model was trained using synthetic training data created for each of 17 lakes using the method published in Stumpf et al. (2003), which produces depth measurements for each pixel based on regression from in situ points (Simpson and Arp., 2018).

The remotely sensed data consist of 308 individual Landsat 8-9 images covering the study area, spanning years 2016 to 2018 during July and August, and including Landsat paths 063-084, and rows 010-013 (Landsat Level-2 Surface Reflectance Science Product, U.S. Geological Survey).

The final bathymetry maps are the result of compositing the individual depth prediction scenes into a single measurement per pixel using the median depth at each point. The resulting maps were clipped to fit the political boundary of North Slope Borough, Alaska.

## 6. Data Access

These data are available through the Oak Ridge National Laboratory (ORNL) Distributed Active Archive Center (DAAC).

Lake Bathymetry Maps derived from Landsat and Random Forest Modeling, North Slope, AK

Contact for Data Center Access Information:

- E-mail: uso@daac.ornl.gov
- Telephone: +1 (865) 241-3952

## 7. References

Liu, K. and C. Song. 2022. Modeling lake bathymetry and water storage from DEM data constrained by limited underwater surveys. Journal of Hydrology 604:127260. https://doi.org/10.1016/j.jhydrol.2021.127260

Simpson, C., and C. Arp. 2018. Sonar depth measurements at lakes on the Inner Arctic Coastal Plain of Alaska, July 2017. Arctic Data

Center. https://doi.org/10.18739/A2SN01440

Stumpf, R.P., K. Holderied, and M. Sinclair. 2003. Determination of water depth with high-resolution satellite imagery over variable bottom types. Limnology and Oceanography 48:547-556. https://doi.org/10.4319/lo.2003.48.1_part_2.0547