Synergistic Use of SAR and Lidar Data for Terrestrial Ecology Research

Overview of ORNL DAAC data and tools for terrestrial ecology research

Rupesh Shrestha (ORNL DAAC)
Michele Thornton (ORNL DAAC)
Yaxing Wei (ORNL DAAC)

The Oak Ridge National Laboratory Distributed Active Archive Center for Biogeochemical Dynamics operates under an interagency agreement between NASA and the U.S. Department of Energy
About ORNL DAAC

• Mission
  – Assemble, distribute, and provide data services for a comprehensive archive of terrestrial biogeochemistry and ecological dynamics observations and models to facilitate research, education, and decision-making in support of NASA's Earth Science.

https://daac.ornl.gov
ORNL DAAC Products: 1,547
1,532 datasets and 15 models (as of July 2021)
ORNL DAAC Products: Science Themes

- Arctic Ecosystems
- Biomass
- Carbon Cycle
- Land Use and Human Dimensions
- Soils
- Climate
- Fire
- Hydrology and Cryosphere
- Vegetation and Forests
Data Tools and Services at ORNL DAAC

MODIS
Obtain MODIS Land Product subsets for any location, area, and time period globally.

THREDDS
Find, visualize, and subset netCDF datasets.

Spatial Data Access Tool (SDAT)
Visualize and download geospatial datasets in user-selected file formats, extent, projection, and resolution through OGC standards.

Daymet
Get daily meteorological data for any North American location.

Airborne Data Visualizer
View and download in-situ measurements from multiple airborne missions.

Soil Moisture Visualizer
Subset, view, and download harmonized soil moisture data across North America from AirMOSS, SMAP, SoilSCAPE, and other sources.

https://daac.ornl.gov/tools/
Weather and Climatic Variables

• Daymet V4
  - a daily meteorological dataset derived from land surface weather station observations
  - integrating vegetation structure with climatic variables can improve understanding of terrestrial ecosystems

Data Characteristics
Temporal / Spatial Resolution ..... Daily / 1km x 1 km
Years Available ..... 1980 – 2020
Spatial Region ..... North America, Hawaii, Puerto Rico

<table>
<thead>
<tr>
<th>Daymet Data Products</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Variable</strong></td>
</tr>
<tr>
<td>maximum temperature</td>
</tr>
<tr>
<td>minimum temperature</td>
</tr>
<tr>
<td>shortwave radiation</td>
</tr>
<tr>
<td>vapor pressure</td>
</tr>
<tr>
<td>snow water equivalent</td>
</tr>
<tr>
<td>precipitation</td>
</tr>
<tr>
<td>day length</td>
</tr>
</tbody>
</table>

https://daymet.ornl.gov
Daymet V4

- Version 4 – Data Released in December 2020
- Improvements include:
  - improvement to the three-dimensional regression model techniques in the core algorithm
  - reductions in the timing bias of input weather station measurements
  - novel approach to handling high elevation temperature measurement biases


https://daymet.ornl.gov
Daymet Version 4 lower-latency data product

- Daymet V4 lower-latency (LL)
  - Starting in Jan, 2021, Daymet daily data is provided on a monthly cycle
  - Published as a separate, provisional dataset

https://daymet.ornl.gov
Daymet

- Daymet V4 Data Access
  
  https://daymet.ornl.gov
Daymet

- Daymet V4 Data Access
  
  https://daymet.ornl.gov
Daymet/Lidar-SAR Applications in Ecology

- Publications showing synergistic use of Daymet & Lidar/SAR
Topographic LiDAR/SAR Datasets at ORNL DAAC

- Airborne & derived Products
- TLS & related
- Space-borne & related
- SAR Datasets
## Raw LiDAR (Processing Levels ~1-2)

<table>
<thead>
<tr>
<th>Platform</th>
<th>Footprint</th>
<th>Technology</th>
<th>Description</th>
<th>Region</th>
<th>Time Period</th>
</tr>
</thead>
<tbody>
<tr>
<td>Airborne</td>
<td>Large</td>
<td>Full-waveform</td>
<td>BOREAS Scanning Lidar Imager of Canopies by Echo Recovery (SLICER)</td>
<td>Canada</td>
<td>1996</td>
</tr>
<tr>
<td>Terrestrial</td>
<td>Small</td>
<td>Discrete return</td>
<td>ECHIDNA LIDAR Campaigns: Forest Canopy Imagery and Field Data</td>
<td>USA</td>
<td>2007-2009</td>
</tr>
<tr>
<td>Airborne</td>
<td>Small</td>
<td>Discrete return</td>
<td>LiDAR Data for Forested Areas in Paragominas, Para</td>
<td>Brazil</td>
<td>2012-2014</td>
</tr>
<tr>
<td>Airborne</td>
<td>Small</td>
<td>Discrete return</td>
<td>LiDAR and DTM Data from Tapajos National Forest in Para</td>
<td>Brazil</td>
<td>2008</td>
</tr>
<tr>
<td>Airborne</td>
<td>Small</td>
<td>Discrete return</td>
<td>LiDAR and DTM Data from Forested Land Near Manaus, Amazonas</td>
<td>Brazil</td>
<td>2008</td>
</tr>
<tr>
<td>Airborne</td>
<td>Small</td>
<td>Discrete return</td>
<td>LiDAR Data for Forested Sites on Borneo Island, Kalimantan</td>
<td>Indonesia</td>
<td>2014</td>
</tr>
<tr>
<td>Airborne</td>
<td>Small</td>
<td>Discrete return</td>
<td>LiDAR Data for Mangrove Forests in the Zambezi River Delta</td>
<td>Mozambique</td>
<td>2014</td>
</tr>
<tr>
<td>Airborne</td>
<td>Small</td>
<td>Discrete return</td>
<td>LiDAR Data, DEM, and Maximum Vegetation Height Product from Southern Idaho</td>
<td>USA</td>
<td>2014</td>
</tr>
<tr>
<td>TLS</td>
<td>Small</td>
<td>Discrete return</td>
<td>Terrestrial Lidar Scanning Forest-Tundra Ecotone, Brooks Range, Alaska</td>
<td>USA</td>
<td>2008-2018</td>
</tr>
</tbody>
</table>
Derived Products (Processing Levels ~3-4) – Regional & Local

- 30+ data products
- Science variables
  - Aboveground biomass (AGB)
  - Canopy height metrics (CHM)
  - Tree cover (TC)
  - Topographic metrics (TM)
  - Vegetation map (VM)
# Derived Products (Processing Levels ~3-4) - Global

<table>
<thead>
<tr>
<th>Science Variables</th>
<th>Resolution</th>
<th>Description</th>
<th>Time Period</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHM</td>
<td>Site</td>
<td>GLAS LiDAR-derived Global Estimates of Forest Canopy Height</td>
<td>2004-2008</td>
</tr>
<tr>
<td>AGB, CHM</td>
<td>30m</td>
<td>Global Mangrove Distribution, Aboveground Biomass, and Canopy Height</td>
<td>2000-2009</td>
</tr>
<tr>
<td>CHM, TM</td>
<td>1000m</td>
<td>GEDI L3 Gridded Land Surface Metrics</td>
<td>2019-2020</td>
</tr>
<tr>
<td>CHM$</td>
<td>1000m</td>
<td>Global 1km Forest Canopy Height</td>
<td>2011</td>
</tr>
</tbody>
</table>

AGB = aboveground biomass; CHM = canopy height metrics; TC = tree cover; TM = topographic metrics
GLAS LiDAR-derived Global Estimates of Forest Canopy Height, 2004-2008

Dataset: Healey et al., 2015. https://doi.org/10.3334/ORNLDAAC/1271
GEDI L3 Gridded Land Surface Metrics

Dataset: Dubayah et al., 2021. https://doi.org/10.3334/ORNLDAAC/1865
Method: Luthcke et al., 2021.
Global Mangrove Distribution, Aboveground Biomass, and Canopy Height

Dataset: Simrad et al., 2019. https://doi.org/10.3334/ORNLDAAC/1665
Aboveground Biomass Change for Amazon Basin, Mexico, and Pantropical Belt, 2003-2016

Dataset: Baccini et al., 2019. https://doi.org/10.3334/ORNLDAAC/1824
Synergistic Applications: SAR and LiDAR

Fusion of polarimetric synthetic aperture radar interferometry (PolInSAR) and land, vegetation, and ice sensor (LVIS) lidar data for canopy height estimation

**Dataset:** Denbina et al., 2018. https://doi.org/10.3334/ORNLDAAC/1589

**Method:** Denbina et al., 2018. https://doi.org/10.1109/JSTARS.2018.2841388