ABoVE: Light-Curve Modelling of Gridded GPP Using MODIS MAIAC and Flux Tower Data

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Summary

This dataset contains gridded estimations of daily ecosystem Gross Primary Production (GPP) in grams of carbon per day at a 1 km2 spatial resolution over Alaska and Canada from 2000-01-01 to 2018-01-01. Daily estimates of GPP were derived from a light-curve model that was fitted and validated over a network of ABoVE domain Ameriflux flux towers then upscaled using MODIS Multi-Angle Implementation of Atmospheric Correction (MAIAC) data to span the extended ABoVE domain. In general, the methods involved three steps; the first step involved collecting and processing mainly carbon-flux site-level data, the second step involved the analysis and correction of site-level MAIAC data, and the final step developed a framework to produce large-scale estimates of GPP. The light-curve parameter model was generated by upscaling from flux tower sub-daily temporal resolution by deconvolving the GPP variable into 3 components: the absorbed photosynthetically active radiation (aPAR), the maximum GPP or maximum photosynthetic capacity (GPPmax), and the photosynthetic limitation or amount of light needed to reach maximum capacity (PPFDmax). GPPmax and PPFDmax were related to satellite reflectance measurements sampled at the daily scale. GPP over the extended ABoVE domain was estimated at a daily resolution from the light-curve parameter model using MODIS MAIAC daily reflectance as input. This framework allows large-scale estimates of phenology and evaluation of ecosystem sensitivity to climate change.

There are 6,576 data files in HDF4 (*.hdf) format and one companion file in Portable Document (*.pdf) format included in this dataset.

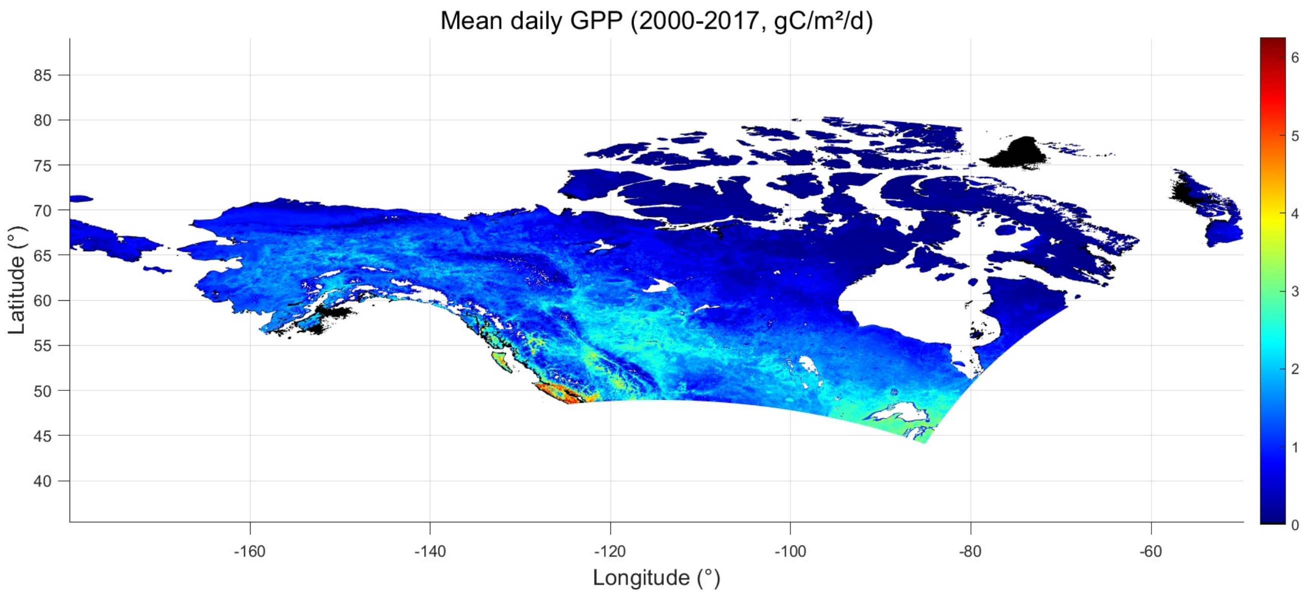

Figure 1. Average daily GPP for 2000-2017 in units of grams of carbon per square meter per day.

Citation

Hmimina, G., R. Yu, R. Wang, K.F. Huemmrich, and J.A. Gamon. 2022. ABoVE: Light-Curve Modelling of Gridded GPP Using MODIS MAIAC and Flux Tower Data. ORNL DAAC, Oak Ridge, Tennessee, USA. https://doi.org/10.3334/ORNLDAAC/2024

Table of Contents

1. Dataset Overview

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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.

Related Datasets

Yu, R., G. Hmimina, K.F. Huemmrich, D.P. Billesbach, A. Lyapustin, Y. Wang, and J.A. Gamon. 2019. ABoVE: Corrected MODIS MAIAC Reflectance at Tower Sites, Alaska and Canada, 2000-2016. ORNL DAAC, Oak Ridge, Tennessee, USA. https://doi.org/10.3334/ORNLDAAC/1700

Acknowledgments

This work was supported by NASA's Arctic-Boreal Vulnerability Experiment (grant NNX15AT78A).

2. Data Characteristics

Spatial Coverage: Alaska, U.S., and Canada

ABoVE Reference Locations

Domain: Extended ABoVE

State/Territory: Alaska, Canada

Spatial Resolution: 1 km^2

Temporal Coverage: 2000-01-01 to 2018-01-01

Temporal Resolution: Daily

Study Area: Latitude and longitude are given in decimal degrees.

Site	Northernmost Latitude	Southernmost Latitude	Easternmost Longitude	Westernmost Longitude
Alaska and Canada	79.74890	50.06044	-73.64067	-172.07817

Data File Information

There are 6,576 data files in HDF4 (*.hdf) format and one companion file in Portable Document (*.pdf) format included in this dataset. The data files are named GPP_**YYYYDDD**.hdf (e.g., GPP_2000001.hdf), where **YYYYDDD** is the four-digit year and three-digit month of the orbit timestamp.

Table 1. File names and descriptions.

File Names	Description
GPP_**YYYYDDD**.hdf	predicted daily GPP (grams of carbon per square meter per day)
MAIAC_GPP_ATBD.pdf	Algorithm Description: Light-curve modelling of GPP across the ABoVE domain using MODIS MAIAC data and a flux tower network

Data File Details

The scale factor varies by file and is provided in the attributes of the variable *GPP*. Each file contains 4800 rows and 3600 columns. The Coordinate Reference System is Albers Conical Equal-Area (WGS-84).

Table 2. Variable names and descriptions.

Variable Name	Units	Description
GPP	gC m^{-2} day^{-1}	GPP predicted using a light-curve model, where GPP = double(x) / scale + offset. The scale and offset values are provided as attributes in each file.

Variable Name	Units	Description
flag		Quality Flags: >0 = land 1 = missing data 2 = valid data

3. Application and Derivation

This dataset provides a daily Gross Primary Productivity (GPP) product spanning the ABoVE Domain and adjacent regions (areas covered by MODIS tiles overlapping the domain). Applications include ecosystem photosynthesis and carbon flux analyses at multiple spatial scales (MODIS pixel to entire Extended ABoVE Domain), GPP phenology, and climate change and disturbance impacts.

4. Quality Assessment

Estimated GPP was compared to independent flux tower derived GPP data over 17 sites selected using a land cover class homogeneity criterion (MODIS pixel composed of at least 75% of the same land cover class as the flux tower). No significant differences in Root Mean Square Error (RMSE) were found between International Geosphere-Biosphere Programme (IGBP; CITE) classes, years, and months. MODIS GPP products showed good agreement with flux tower GPP (R^2=0.831; RMSE=1.11 g m^{-2} d^{-1}). Error estimates can be derived from the relationship between the bootstrapped RMSE and GPP estimates (R^2=0.99; RMSE=0.051 g m^{-2} d^{-1}) using the equation:

$$RMSE = -1.394 * \exp(-0.8105 * GPP) + 1.485$$

5. Data Acquisition, Materials, and Methods

Daily Gross Primary Productivity (GPP) was estimated using a light-curve model. The general approach involved performing a multi-site analysis centered on a network of flux towers across the extended ABoVE domain, then an upscaling of the results using MODIS MAIAC data (Yu et al., 2021) to span the entire extended ABoVE domain. The first step involved collecting and processing site-level data (mainly carbon flux data to be used as a reference). The second step involved the correction and analysis of MODIS MAIAC data at the site level. The final step was to develop a framework to produce large-scale estimates of phenology and ecosystem sensitivity to climate change. The steps are detailed in the companion file MAIAC_GPP_ATBD.pdf.

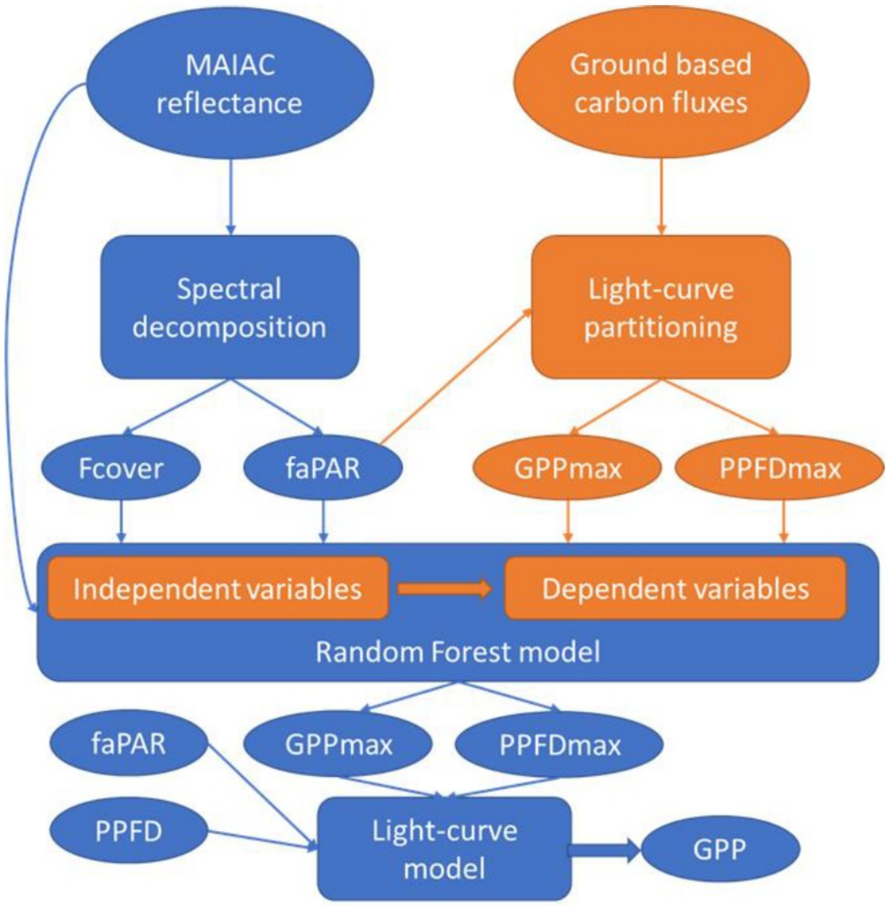

Figure 2. Functional diagram of the tile level GPP model. Blue components are datasets or processes at the tile-level scale, orange components are datasets of processes at the flux-tower level. Source: MAIAC_GPP_ATBD.pdf

Estimates of hourly GPP (in µmol m^{-2} h^{-1}) were derived using the light-curve model described as

$$GPP = GPP_{max} * \mathrm{Erf}((PPFD * faPAR_{vegetation}) / (PPFD_{max} * (1 / \mathrm{erfinv}(0.95))))$$

where GPPmax is the maximum GPP or maximum photosynthetic capacity, Erf(x) is the error function (i.e., the integral of a Gaussian function between -infinity and x), $PPFD_{max}$ is the photosynthetic limitation or amount of light needed to reach maximum capacity, and $faPAR_{vegetation}$ is the fraction of absorbed PAR.

Hourly PPFD estimates were derived from the ERA5-Land dataset (Muñoz Sabater, 2019). faPAR $_{vegetation}$ estimates were derived using a linear spectral decomposition of MODIS MAIAC reflectance data (Yu et al., 2021) and a compiled spectral library (see References). The light-curve parameters GPP_{max} and $PPFD_{max}$ were obtained first at the flux-tower level by fitting the light-curve model onto net ecosystem exchange (NEE), then interpolated across the extended ABoVE Domain using random forest models fitted onto MODIS MAIAC reflectance data. The estimated hourly GPP was then summed up to a daily scale and converted to the units g m^{-2} d^{-1}.

6. Data Access

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

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Contact for Data Center Access Information:

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

7. References

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