CARVE: Daily Thaw State of Boreal and Arctic Alaska from AMSR-E and SSM/I, 2003-2014

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Documentation Revision Date: 2018-11-02

Data Set Version: 1.1

Summary

This data set provides daily 10 km resolution maps of the Alaskan and Arctic Boreal land surface state as either frozen, melting, or thawed. These data are generated from passive microwave radiometer observations made from 2003 through 2014 by the Advanced Microwave Scanning Radiometer (AMSR-E) and the Special Sensor Microwave Imager (SSM/I). Data products overlap with science data collections carried out during the Carbon in Arctic Reservoirs Vulnerability Experiment (CARVE).

The data products were generated using a time series singularity classifier that detects discontinuous changes, or edges, in time series data associated with the large changes in surface hydrology occurring during the freezing or thawing of soil or snow. The classifier uses continuous wavelet transform and multi-scale analysis applied to spectral gradient brightness temperatures from frequency channel combinations to identify and differentiate timings of snowmelt, the length of the snow-free season and surface refreeze. Snowmelt is determined from diurnal change in brightness temperature at K_a band observations. Freeze and thaw are determined using the gradient between K- and K_a-band observations as well as C- and X-band observations, when available.

There are 15 yearly files of daily land surface state in NetCDF (*.nc) and 15 companion files (*.zip) of corresponding map images (*.png) included in this data set.

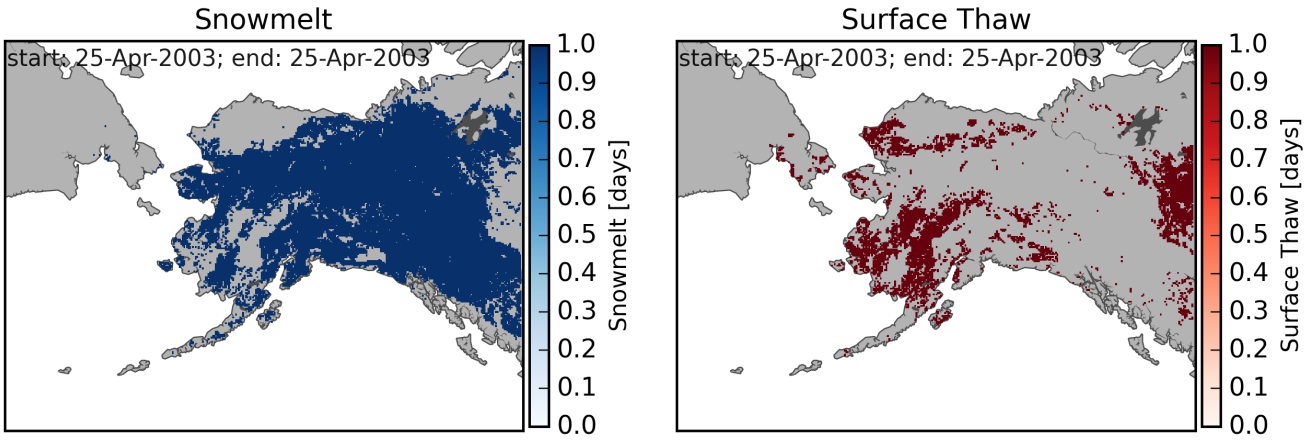

Figure 1. The spring snowmelt and thaw binary maps as measured by the AMSR-E satellite radiometer for 25 April 2003. High-frequency channels indicate snowmelt for the majority of Alaska, apart from the North Slope, as bulk thaw begins in the southwestern marine-forest and tundra.

Citation

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Table of Contents

1. Data Set Overview

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Project: Carbon in Arctic Reservoirs Vulnerability Experiment (CARVE)

The Carbon in Arctic Reservoirs Vulnerability Experiment (CARVE) is a NASA Earth Ventures (EV-1) investigation designed to quantify correlations between atmospheric and surface state variables for Alaskan terrestrial ecosystems through intensive seasonal aircraft campaigns, ground-based observations, and analysis sustained over a 5-year mission. CARVE collected detailed measurements of greenhouse gases on local to regional scales in the Alaskan Arctic and demonstrated new remote sensing and improved modeling capabilities to quantify Arctic carbon fluxes and carbon cycle-climate processes. CARVE science fills a critical gap in Earth science knowledge and satisfies high priority objectives across NASA's Carbon Cycle and Ecosystems, Atmospheric Composition, and Climate Variability & Change focus areas as well as the Air Quality and Ecosystems elements of the Applied Sciences program. CARVE data also complements and enhances the science return from current NASA and non-NASA sensors.

Related Data:

A full list of data products from the CARVE campaign is available at: https://carve.ornl.gov/dataproducts.html

2. Data Characteristics

Spatial Coverage: Alaska

Spatial Resolution: 10 x 10 km

Temporal Coverage:

AMSR-E: 20030101 to 20100101

SSM/I: 20080329 to 20141231

Temporal Resolution: Daily

Study Area (coordinates in decimal degrees)

Site	Westernmost Longitude	Easternmost Longitude	Northernmost Latitude	Southernmost Latitude
Boreal and Arctic Alaska	159.161	-106.952	74.399	47.115

Data File Information

There are 15 files in NetCDF format (*.nc) included in this data set: 8 from the AMSR-E and 7 from the SSM/I. Each file contains daily gridded surface thaw and snowmelt data for one year. Variables in the AMSR-E and SSM/I data files are described in Tables 1 and 2, respectively.

The files are named by sensor and year: carve_ft_*sensor_yyyy*.nc

where *sensor* = either amsre or ssmi; *yyyy* = year. e.g.:

- *carve_ft_amsre_2003.nc*
- *carve_ft_ssmi_2008.nc*

Spatial Reference Information

Projection: Albers Conical Equal Area
False easting: 0.0
False northing: 0.0
Central meridian: -154.0
Standard parallel 1: 55.0
Standard parallel 2: 65.0
Latitude of origin: 50.0
Linear unit: Meter (1.0)
Datum: NAD83

Table 1. Variables in the AMSR-E data files

Variable name	Units	Description
time	days	Days since 1970-01-01
freeze_melt_thaw	0: snow/frozen; 1: snowmelt; 2: snow-free/thawed	Combined diurnal difference snowmelt and freeze/thaw state from spectral slope 36.5V-18.7V GHz
freeze_thaw_hf	0: frozen, 1: thawed	Freeze/thaw state from spectral slope 36.5V-18.7V GHz (X- and C-band algorithm)
freeze_thaw_lf	0: frozen, 1: thawed	Freeze/thaw state from spectral slope 10.7V-6.9V GHz (K_a- and K-band algorithm)
lat	degrees north	latitude coordinate
lon	degrees east	longitude coordinate
snow_melt	0: dry snow/thawed land, 1: snowmelt	Surface state, diurnal difference classifier

Table 2. Variables in the SSM/I data files

Variable name	Units	Description
time	days	Days since 1970-01-01
freeze_melt_thaw	0: snow/frozen; 1: snowmelt; 2: snow-free/thawed	Combined diurnal difference snowmelt and freeze/thaw state from spectral slope 37.0V-19.35V GHz
freeze_thaw	0: frozen, 1: thawed	Freeze/thaw state from spectral slope 37.0V-19.35V GHz (X- and C-band algorithm)
lat	degrees north	latitude coordinate
lon	degrees east	longitude coordinate
snow_melt	0: dry snow/thawed land, 1: snowmelt	Surface state, diurnal difference classifier

Companion Files

There are 5,392 images in *.png format provided as companion files, one image depicting each daily observation. Image files are named by sensor and observation day of the year, i.e., *carve_ft_<sensor>_DDDYYYY.png*. The files are stored in 15 *.zip files by sensor and observation year, i.e., *carve_ft_<sensor>_YYYY.zip* .

3. Application and Derivation

This data set is the product of advancements in the ability to determine soil and snow freeze/thaw timings from microwave frequency observations. These advancements improve upon the ability to predict the response of carbon gas emission to warming through synthesis with in-situ observations.

Arctic permafrost soils are major sources of organic carbon released into the atmosphere as carbon dioxide or methane when thawed. This data set may be used to examine spatial and temporal trends in freeze/thaw dynamics over Alaska and adjacent areas of the Arctic Boreal Zone.

4. Quality Assessment

Uncertainty in the freeze/thaw and snowmelt state is determined for locations coincident with Snow Telemetry (SNOTEL) stations using air temperature and snow depth measurements. These analyses find that the average agreement, expressed using an F1 Score, of the time series singularity classifier is 0.91 for determining frozen and thawed state. For snowmelt, the classifier has an F1 score of 0.50.

5. Data Acquisition, Materials, and Methods

This data set was derived from data gathered from satellite-based microwave radiometers and validated using weather station data from the Snow Telemetry (SNOTEL) station network. Surface water observations were determined from satellite observations of upwelling microwave brightness temperatures from the Advanced Microwave Scanning Radiometer instrument (AMSR-E) between 2003 and 2010 and the Special Sensor Microwave Imager (SSM/I) between 2008 and 2014.

A time series singularity (TSS) classifier was used to detect discontinuous changes, or "edges", in time series data similar to those that occur from the large changes in surface hydrology during the freezing or thawing of soil or snow (McDonald et al 2004). The TSS identifies large, sustained changes in microwave emissivity and models the changes based on the rate of change using multiscale analysis (Steiner and Tedesco, 2014).

The transition from frozen conditions to snowmelt onset dominates brightness temperatures over a range of frequencies during the spring shoulder season (Stiles and Ulaby, 1980). These abrupt changes are clearly observed in X- and C-band observations but are maximum in the K-band. Maximum DAV occurs when liquid water content difference is the greatest and is reduced as more liquid water content in snow persists into the night. The initial increase in DAV is coincident with abrupt increase in both spectral gradient channels. Large diurnal amplitude variations (DAV) in K-band brightness temperature were used to determine the onset and length of snowmelt (Ramage and Isacks, 2002). The DAV signal end indicated snow-off conditions and a thawed landscape.

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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8. Data Set Revisions

Revision Log - 11/02/2018

In the original release of this dataset (2017-09-20), latitudes mapped to the y-dimension were inverted for science variables (freeze_melt_thaw, freeze_thaw_hf, freeze_thaw_lf) in the AMSR-E NetCDF files.

Revised files were published 2018-11-02:
* Affected variables were flipped along the y-dimension.
* Minor changes were made to all NetCDF files to bring into compliance with CF-1.6 conventions.