CARVE: L4 Gridded Particle Trajectories for WRF-STILT model, 2012-2016

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Documentation Revision Date: 2022-05-06

Dataset Version: 1.1

Summary

This data set provides Weather Research and Forecasting (WRF) Stochastic Time-Inverted Lagrangian Transport (STILT) model inputs for particle receptors located at positions along Carbon in Arctic Reservoirs Vulnerability Experiment (CARVE) flight paths (2012 - 2015) and various meteorological stations in Alaska and the Canadian Arctic. Each product consists of multiple NetCDF files packaged as a TAR/GZIP file. These data correspond to WRF-STILT model footprint data also generated by the CARVE science team.

There are 72 TAR/GZIP files included in this data set containing WRF-STILT Particle files in NetCDF format.

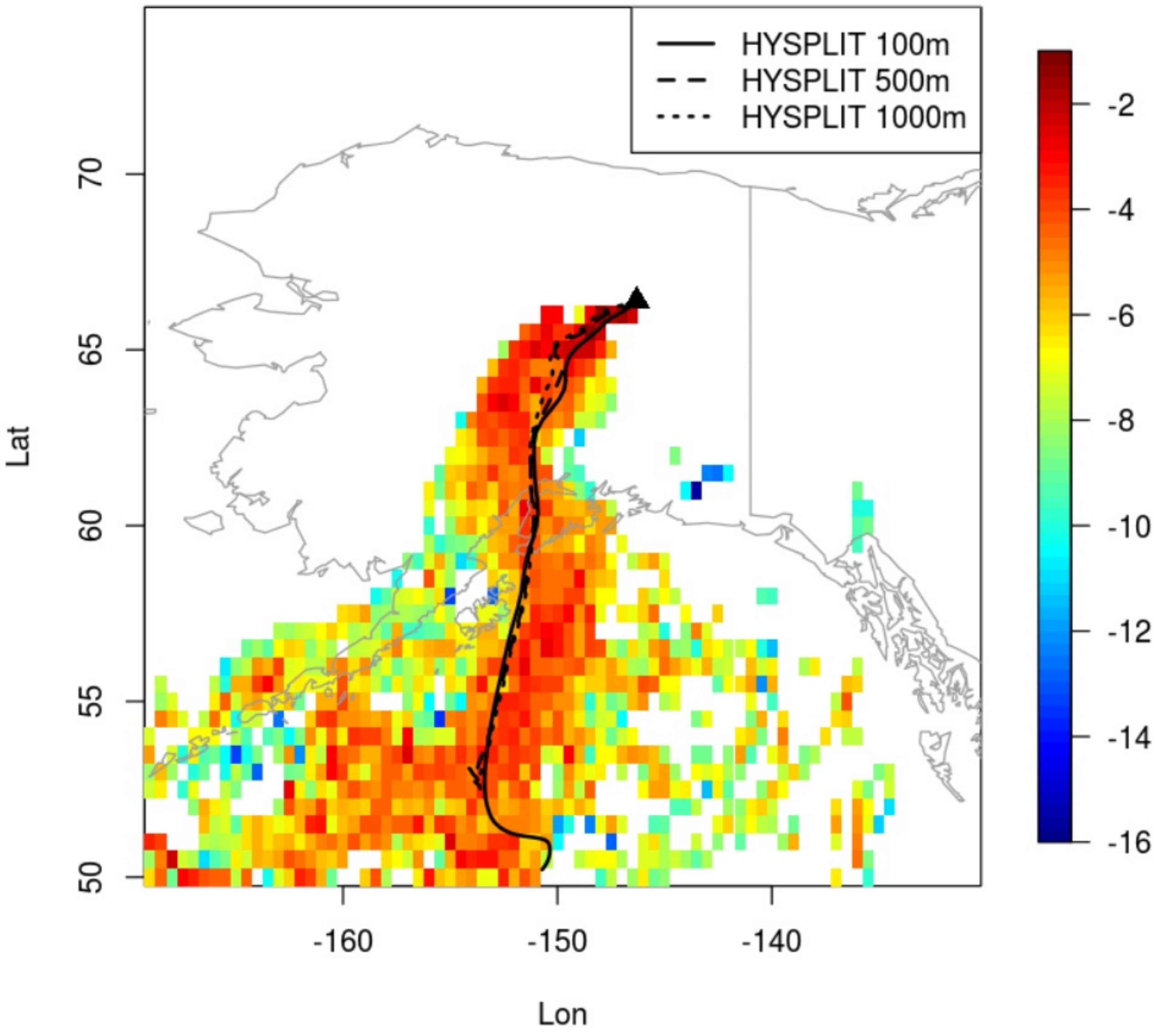

Figure 1. STILT footprints (shaded, units are ppmv / (micromole / m^2 / s)) and HYSPLIT trajectories from receptors located at 100 (solid), 500

(dashed), and 1000 m (dotted black lines) at 19:35 UTC 20 August 2012 (Figure from Henderson et al. 2015).

Citation

CARVE Science Team. 2017. CARVE: L4 Gridded Particle Trajectories for WRF-STILT model, 2012-2016. ORNL DAAC, Oak Ridge, Tennessee, USA. https://doi.org/10.3334/ORNLDAAC/1430

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1. Dataset Overview

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.

Related Data:

These particle files support the CARVE: L4 Gridded Footprints from WRF-STILT model, 2012-2016 data available from ORNL DAAC. The relationship between particle files and footprint files is outlined in the companion file 'carve_wrf-stilt_inventory.csv'.

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

2. Data Characteristics

Spatial Coverage: Campaign flights and station observations within the CARVE domain

Spatial Resolution: 0.25-degree for *foot1* data; 0.1-degree for *footnearfield1* data

Temporal Coverage: 20120101 - 20160428

Temporal Resolution: Hourly

Study Area (coordinates in decimal degrees)

Site	Westernmost Longitude	Easternmost Longitude	Northernmost Latitude	Southernmost Latitude
CARVE Domain	-180	180	90	30

Data File Information

The TAR/GZIP files (*.tar.gz) contain NetCDF files representing gridded footprints from WRF-STILT simulations for one particle receptor location. Each file aggregates particle footprints on a lat/lon/time grid starting at the STILT simulation start time.

Notes about TAR/GZIP files

- If *convect* is present in the filename, STILT was run with convective fluxes active. If *noconvect* is present, or if there is no label, then fluxes are not active (standard for simulations through 2015).
- Simulations for 2012 were run with WRF v3.4.1. Simulations for 2013 were run with both v3.4.1 and v3.5.1. Subsequent years used only v3.5.1.
- *CARVE-CAN* refers to use of the WRF CARVE-CAN domain that was available after 2014.
- Filenames containing *freum** were generated going back 15 days instead of the usual 10.

The first surface influence field, represented by the *foot1* variable in the NetCDF files, provides 10 days of surface influence representing the response of the receptor to a unit surface emission (ppm/nmol m-2 s-1) of CO_2 in each 0.25- x 0.25-degree grid cell within the whole area of coverage (30N to 90N, 180E to 180W) at hourly temporal resolution.

The second surface influence field, represented by the *footnearfield1* variable in the NetCDF files, provides 24 hours of surface influence representing the response of the receptor to a unit surface emission (ppm/nmol m-2 s-1) of CO_2 in each 0.1- x 0.1-degree grid cell within a small region close to the measurement location at hourly temporal resolution.

The WRF-STILT model as run for this project is described further in Henderson et al. (2015). File naming convention for WRF-STILT footprint files is described in Table 1.

Table 1. Naming convention for NetCDF files generated by WRF-STILT.

Example file name: *foot2013x06x25x04x00x65.1330Nx147.4539Wx00003.nc*

Name element	Example value	Units
Year	*2013*	YYYY
Month	*06*	MM
Day	*25*	DD
Hour	*04*	hh (UTC)
Minute	*00*	mm (UTC)
Latitude	*65.1330N*	decimal degrees
Longitude	*127.4539W*	decimal degrees
Height A.G.L.	*00003*	m

For example, the above file contains the modeled particle footprints for June 25, 2013 at 4:00 UTC. The observation was taken at 65.1330N, 127.4539W at 3 m above ground level.

Data Variables

Table 2. Data variables in each NetCDF file. Fill values or missing data were set to -1.0E34 for all variables.

Variable name	Units	Description
checkbasic		basic output from Trajeccheck()
checkbasicnames		names for checkbasic 1D array
checksum		checksum array
checksumdate	days since 2000-01-01 00:00:00 UTC	checksum date
checksumnames		column names for checksum array
endpts		stilt particle location array thinned to retain rows containing trajectory endpts
endptsdate	days since 2000-01-01 00:00:00 UTC	end points date
endptsnames		column names for particle array ‘endpts’
foot1	ppm per (umol m-2 s-1)	gridded STILT footprint
foot1date	days since 2000-01-01 00:00:00 UTC	date of foot1
foot1hr	hours	hours back from STILT start time
foot1lat	degrees_north	degrees latitude of center of grid cells
foot1lon	degrees_east	degrees longitude of center of grid cells
footnearfield1	ppm per (umol m-2 s-1)	gridded STILT footprint
footnearfield1date	days since 2000-01-01 00:00:00 UTC	date for 'footnearfield1'
footnearfield1hr	hours	hours back from STILT start time for 'footnearfield1'

Variable name	Units	Description
footnearfield1lat	degrees_north	degrees latitude of center of grid cells
footnearfield1lon	degrees_east	degrees longitude of center of grid cells
ident		identifier string
nchar		numeric identifier
origagl	meters	original receptor height above ground before rounding for STILT
origlat	degrees_north	original receptor latitude
origlon	degrees_east	original receptor longitude
origutctime	UTC time	original receptor time
origutctimeformat		original receptor time format
part3d		stilt particle location array thinned to retain rows approximately every so many hours
part3ddate	days since 2000-01-01 00:00:00 UTC	date of part3d
part3dnames		column names for particle array ‘part3d’
partfoot		stilt particle location array thinned to retain rows where foot > 0
partfootdate	days since 2000-01-01 00:00:00 UTC	date of partfoot
partfootnames		column names for particle array ‘partfoot’

3. Application and Derivation

WRF-STILT footprints support accurate estimates of CO_2 and CH_4 surface-atmosphere fluxes using CARVE flight and tower observations. Simulated CO2 mole fractions from the PolarVPRM model based on WRF-STILT footprints show strong agreement with tower observations, suggesting that the WRF-STILT model does a good job representing the meteorology of the region (Karion et al., 2016).

4. Quality Assessment

Preliminary analysis in support of CARVE showed good overall agreement between WRF outputs and quality-controlled surface and radiosonde observations.

Analysis of STILT footprints showed realistic seasonal variability and good agreement with tower observations, indicating that WRF-STILT footprints are of high quality and support accurate estimates of CO_2 and CH_4 surface-atmosphere fluxes using CARVE observations (Henderson et al. 2015).

5. Data Acquisition, Materials, and Methods

CARVE Flights

These data represent one part of the data collected by the Carbon in Arctic Reservoirs Vulnerability Experiment (Miller et al, 2012). A C-23 Sherpa aircraft made frequent flights out of Fairbanks, Alaska between March and November over multiple years, observing the spring thaw, summer draw-down, and fall refreeze of the Arctic growing season. Flights concentrate observations on three study domains: the North Slope, the interior, and the Yukon River valley. North Slope flights cover regions of tundra and continuous permafrost and were anchored by flux towers in Barrow, Atqasuk, and Ivotuk. Flights to Prudhoe Bay characterize the CO2 and CH4 emissions from oil and natural gas processing plants. Flights over interior Alaska sample discontinuous permafrost, boreal forests, and wetlands. A complete list of CARVE flights can be found at: https://carve.ornl.gov/flights.html. Flight paths and atmospheric gas concentrations for CARVE surveys can be visualized through the CARVE Flight Data Visualization Tool (http://carve.ornl.gov/visualize).

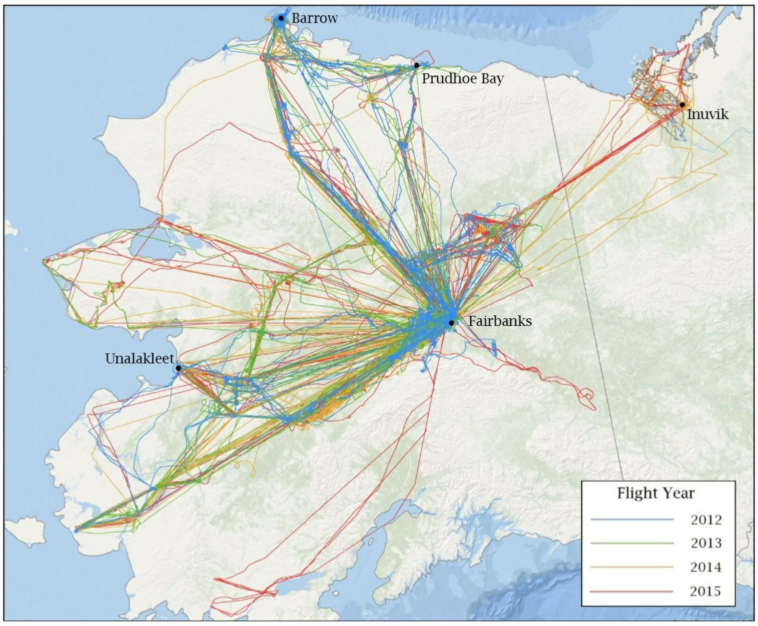

Figure 2. CARVE flights during 2012-2015 delivered measurements over continuous and discontinuous permafrost regimes.

The CARVE aircraft carried a remote sensing and atmospheric sampling payload consisting of the following instruments: a Fourier transform spectrometer (FTS), and an in situ gas analyzer suite (ISGAS) with a gas analyzer and flask sampling system (see https://carve.ornl.gov/documentation.html). All instruments were controlled by a master computer system (Data Acquisition and Distribution System, DADS). DADS also recorded GPS data (Lat, Lon, altitude), aircraft pitch, roll, and yaw, as well as basic meteorological data from onboard instruments.

WRF-STILT Simulations

CARVE aircraft positions and various flux tower locations were treated as receptors in a Stochastic Time-Inverted Lagrangian Transport (STILT) model coupled with meteorology fields from the polar variant of the Weather and Research Forecasting (WRF; Skamarock et al., 2008) model, in order to model the land surface influence on observed atmospheric constituents. The atmospheric model was configured to generate high-quality, high-resolution meteorological fields over Arctic and boreal Alaska.

The WRF-STILT coupled model is described in Nehrkorn et al. (2010).

STILT applies a Lagrangian particle dispersion model backwards in time from a measurement location (the "receptor" location), to create the adjoint of the transport model in the form of a "footprint" field (Nehrkorn et al., 2010; Henderson et al., 2015). The footprint, with units of mixing ratio (ppm --- CO_2; ppb --- CH_4) per (umol m-2 s-1), quantifies the influence of upwind surface fluxes on concentrations measured at the receptor and is computed by counting the number of particles in a surface-influenced volume and the time spent in that volume. This data product includes the particle files only as NetCDF files. The footprint files are also available from ORNL DAAC at CARVE: L4 Gridded Footprints from WRF-STILT model, 2012-2016 .

6. Data Access

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

CARVE: L4 Gridded Particle Trajectories for WRF-STILT model, 2012-2016

Contact for Data Center Access Information:

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

7. References

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8. Dataset Revisions

This dataset was revised on May 6, 2022 to rename 11 data files that contained the plus sign in their filenames. The plus sign in each file was replaced with an underscore. No data vales in the files were changed.