WRF-STILT Particle Trajectories for Boston, MA, USA, 2013-2014

Get Data

Documentation Revision Date: 2018-05-24

Data Set Version: 1

Summary

This dataset provides Weather Research and Forecasting (WRF) Stochastic Time-Inverted Lagrangian Transport (STILT) particle trajectory data and footprint products for two receptors located in Boston, Massachusetts, USA, for July 2013 - December 2014. Meteorological fields from version 3.6.1 of the Weather Research and Forecasting model are used to drive STILT. 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. The footprint, with units of mixing ratio (ppm) per surface flux (umol m-2 s-1), quantifies the influence of upwind surface fluxes on CO2 and CH4 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. Footprints are provided for the two receptors at two temporal and spatial scales: three days of surface influence over the whole North American coverage area at 1-degree resolution and 24 hours of surface influence within a smaller region close to the measurement locations ('near field') at 0.1-degree resolution.

The WRF-STILT particle trajectories and footprints were used to compute enhancements (over background values) of hourly CO2 values due to regional surface fluxes, over the Boston metropolitan area.

There are 18 monthly data files with this dataset provided as TAR/GZIP files (*.tar.gz). When uncompressed, each monthly file contains 48 files per day (24 hourly files at 2 receptors) in NetCDF (.nc4) format.

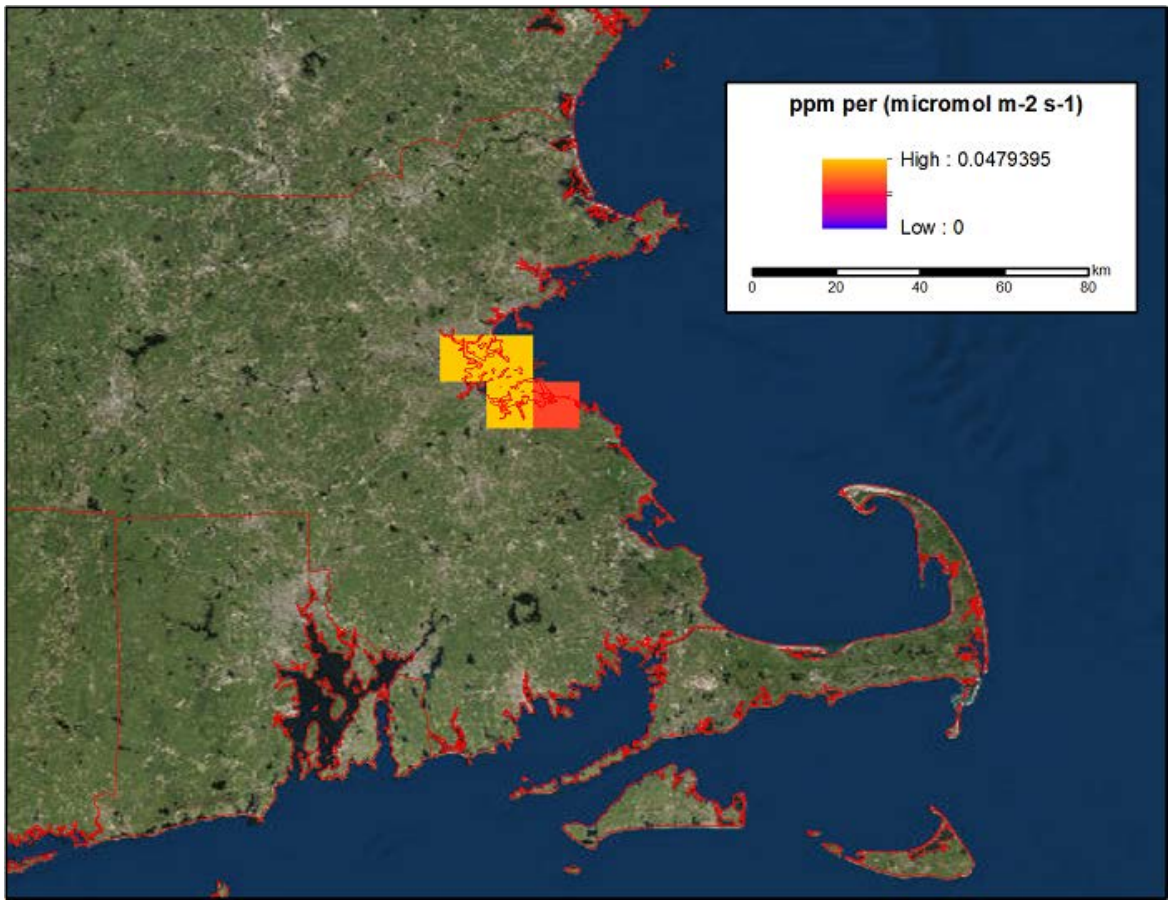

Figure 1. Data from the WRF-STILT model representing the response of a receptor in Boston, Massachusetts to a unit surface emission of CO2 (ppm/umol m-2 s-1).

Citation

Nehrkorn, T., M. Sargent, S.C. Wofsy, and M. Mountain. 2018. WRF-STILT Particle Trajectories for Boston, MA, USA, 2013-2014. ORNL DAAC, Oak Ridge, Tennessee, USA. https://doi.org/10.3334/ORNLDAAC/1596

Table of Contents

1. Data Set Overview

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The WRF-STILT particle trajectories and footprints were used to compute enhancements (over background values) of hourly CO2 values due to regional surface fluxes, over the Boston metropolitan area.

Project: North American Carbon Program (NACP)

The North American Carbon Program (NACP) is a multidisciplinary research program to obtain scientific understanding of North America's carbon sources and sinks and of changes in carbon stocks needed to meet societal concerns and to provide tools for decision makers. The NACP is supported by a number of different federal agencies. The central objective is to measure and understand the sources and sinks of Carbon Dioxide (CO2), Methane (CH4), and Carbon Monoxide (CO) in North America and in adjacent ocean regions.

Related Dataset:

Gridded footprint data on a 1km grid from these model runs are also available as a separate dataset from the ORNL DAAC..

Nehrkorn, T., M. Sargent, S.C. Wofsy, and M. Mountain. 2018. **WRF-STILT Gridded Footprints for Boston, MA, USA, 2013-2014.** ORNL DAAC, Oak Ridge, Tennessee, USA. https://doi.org/10.3334/ORNLDAAC/1572

Acknowledgements:

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2. Data Characteristics

Spatial Coverage: Footprints were calculated for all of North America and for the 'near field' area surrounding Boston, Massachusetts

Spatial Resolution: 1-degree for *foot1* data; 0.1-degree for *footnearfield1* data

Temporal Coverage: 2013-07-01 to 2014-12-31

Temporal Resolution: Hourly

Study Area (coordinates in decimal degrees)

Site	Westernmost Longitude	Easternmost Longitude	Northernmost Latitude	Southernmost Latitude
Boston University (receptor location)	-71.1040	-71.1040	42.3500	42.3500
Copley Square, Boston (receptor location)	-71.084	-71.084	42.347	42.347
Boston region (footnearfield1 variable)	-76.1	-66.1	45.85	38.85

There are 18 monthly data files with this dataset provided as TAR/GZIP files (*.tar.gz). They are named by year and month (for example, **stilt-201310.tar.gz** and **stilt-201410.tar.gz).**

When uncompressed, each of the 18 monthly files contains 48 files per day (24 hourly files at 2 receptors), for a total of 26,304 files, provided in NetCDF (.nc4) format.

The files provide particle trajectories (and lat-lon gridded footprints) from WRF-STILT simulations for one particle receptor location. Each file aggregates the particle data on a lat/lon/time grid starting at the STILT simulation start time.

NetCDF data file naming convention:

The files are named by **year, month, day, hour, minute, latitude, longitude,** and **height A.G.L.** in meters, separated by an **x.**

Example file name: **stilt2014x12x31x23x00x42.3500Nx071.1040Wx00029.nc.** This file contains the modeled particle trajectories for December 31, 2014 at 23:00 UTC. The observation was taken at 42.3500N, 71.1040W at 29 m above ground level, Boston University.

For a description of the naming elements in the example file name, refer to Table 1.

Table 1. Description of elements in the example file name

Name element	Example value	Units
Year	2014	YYYY
Month	12	MM
Day	31	DD
Hour	23	hh (UTC)
Minute	00	mm (UTC)
Latitude	42.3500N	decimal degrees
Longitude	71.1040W	decimal degrees

Height A.G.L.	00029	m

Data Variables

Surface influence fields

The first diagnostic surface influence field, represented by the **foot1** variable in the NetCDF files, provides 3 days of surface influence representing the response of the receptor to a unit surface emission (ppm/umol m-2 s-1) of CO2 in each 1 x 1-degree grid cell within the whole area of coverage (169.5W to 50.5W and 10.5N to 69.5N) at hourly temporal resolution.

The second diagnostic 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/umol m-2 s-1) of CO2 in each 0.1- x 0.1-degree grid cell within a small region close to the measurement location (centered on the receptor location, covering 10 degrees in longitude and 7 degrees in latitude) at hourly temporal resolution.

Data Dictionary

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

Variable	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
endpts		Stilt particle location array thinned to retain rows containing trajectory endpoints
checksumnames		Column names for checksum array
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'
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"
emitwindow	hours, x grid lengths, y grid lengths, z grid lengths	Variables identified by the emitwindownames string array
emitwindownames	various	Describe the emission time and space window of particle releases at receptor

3. Application and Derivation

STILT footprints support accurate estimates of CO2 and CH4 surface-atmosphere fluxes.

4. Quality Assessment

Extensive evaluation of WRF meteorological fields, PBL height, and WRf-STILT simulated enhancements are included in Sargent et al. (2018).

5. Data Acquisition, Materials, and Methods

WRF-STILT Simulations

The Weather Research and Forecasting (WRF; Powers et al., 2017) Stochastic Time-Inverted Lagrangian Transport (STILT) coupled model was used to derive particle trajectory data for two receptors located in Boston, Massachusetts, USA. The receptors were located at Boston University and at Copley Square, Boston.

The WRF-STILT coupled model is described in Nehrkorn et al. (2010). The methods used here are consistent with Henderson et al. (2015). For more information, see Sargent et al. (2018).

Gridded footprint data on a 1km grid from these model runs are also available as a separate dataset from the ORNL DAAC at https://doi.org/10.3334/ORNLDAAC/1572. The footprint data are also provided in this dataset alongside the particle data.

6. Data Access

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

WRF-STILT Particle Trajectories for Boston, MA, USA, 2013-2014

Contact for Data Center Access Information:

- E-mail: uso@daac.ornl.gov
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7. References

Henderson, J.M., J. Eluszkiewicz, M.E. Mountain, T. Nehrkorn, R.Y.-W. Chang, A. Karion, J.B. Miller, C. Sweeney, N. Steiner, S.C. Wofsy, and C.E. Miller. 2015. Atmospheric transport simulations in support of the Carbon in Arctic Reservoirs Vulnerability Experiment (CARVE). Atmos. Chem. Phys. 15:4093-4116. https://doi.org/10.5194/acp-15-4093-2015, 2015

Nehrkorn, T., J. Eluszkiewicz, S.C. Wofsy, J.C. Lin, C. Gerbig, M. Longo, and S. Freitas. 2010. Coupled weather research and forecasting-stochastic time-inverted lagrangian transport (WRF-STILT) model. Meteorol. Atmos. Phys. 107:51-64. doi:10.1007/s00703-010-0068-x

Powers, J.G., J.B. Klemp, W.C. Skamarock, C.A. Davis, J. Dudhia, D.O. Gill, J.L. Coen, D.J. Gochis, R. Ahmadov, S.E. Peckham, G. A. Grell, J. Michalakes, S. Trahan, S.G. Benjamin, C.R. Alexander, G.J. Dimego, W. Wang, C.S. Schwartz, G. S. Romine, Z. Liu, C. Snyder, F. Chen, M.J. Barlage, W. Yu, and M.G. Duda. The Weather Research and Forecasting model: Overview, system efforts, and future directions. Bull. Amer. Meteor. Soc., 98(8):1717 - 1737, 2017. doi:10.1175/BAMS-D-15-00308.1.

Sargent, M., Y. Barrera, T. Nehrkorn, L.R. Hutyra, C. Gately, K. McKain, C. Sweeney, J. Hegarty, B. Hardiman, and S. Wofsy, 2018: Monitoring anthropogenic and biogenic CO2 in the Boston area using atmospheric measurements in an inversion framework, in preparation.