FLEXPART Influence Functions for ACT-America, 2016-2017

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Documentation Revision Date: 2022-12-29

Dataset Version: 1

Summary

This dataset contains a set of Lagrangian particle dispersion simulations of carbon dioxide concentrations using the FLEXible PARTicle (FLEXPART) model. FLEXPART quantified the source-receptor relationships, so-called "influence functions", in a backward mode. The simulations were constructed for five Atmospheric Carbon and Transport America (ACT-America) deployments over the eastern U.S. that occurred in 2016-2019. Each receptor of the influence function is the 30-second or 10-minute interval along flight tracks, characterized by a box with boundaries between the maximum and minimum latitude/longitude as well as between the maximum and minimum altitudes during the interval. Each receptor box released 5,000 particles and simulated their transport and dispersion backward for 10 or 20 days. The simulations were driven by 27-km meteorology provided by the WRF-Chem simulation or by ERA-Interim data from the European Centre for Medium-Range Weather Forecasts (ECMWF). Background levels of carbon dioxide were obtained from CarbonTracker and OCO-2 v9 MIP. The data are provided in netCDF and FLEXPART binary formats.

This dataset includes a total of 745 files in Zip archive format. Three archives hold background CO_2 values in netCDF format. The remaining archives hold simulation output in netCDF and FLEXPART binary format (n=742 simulations).

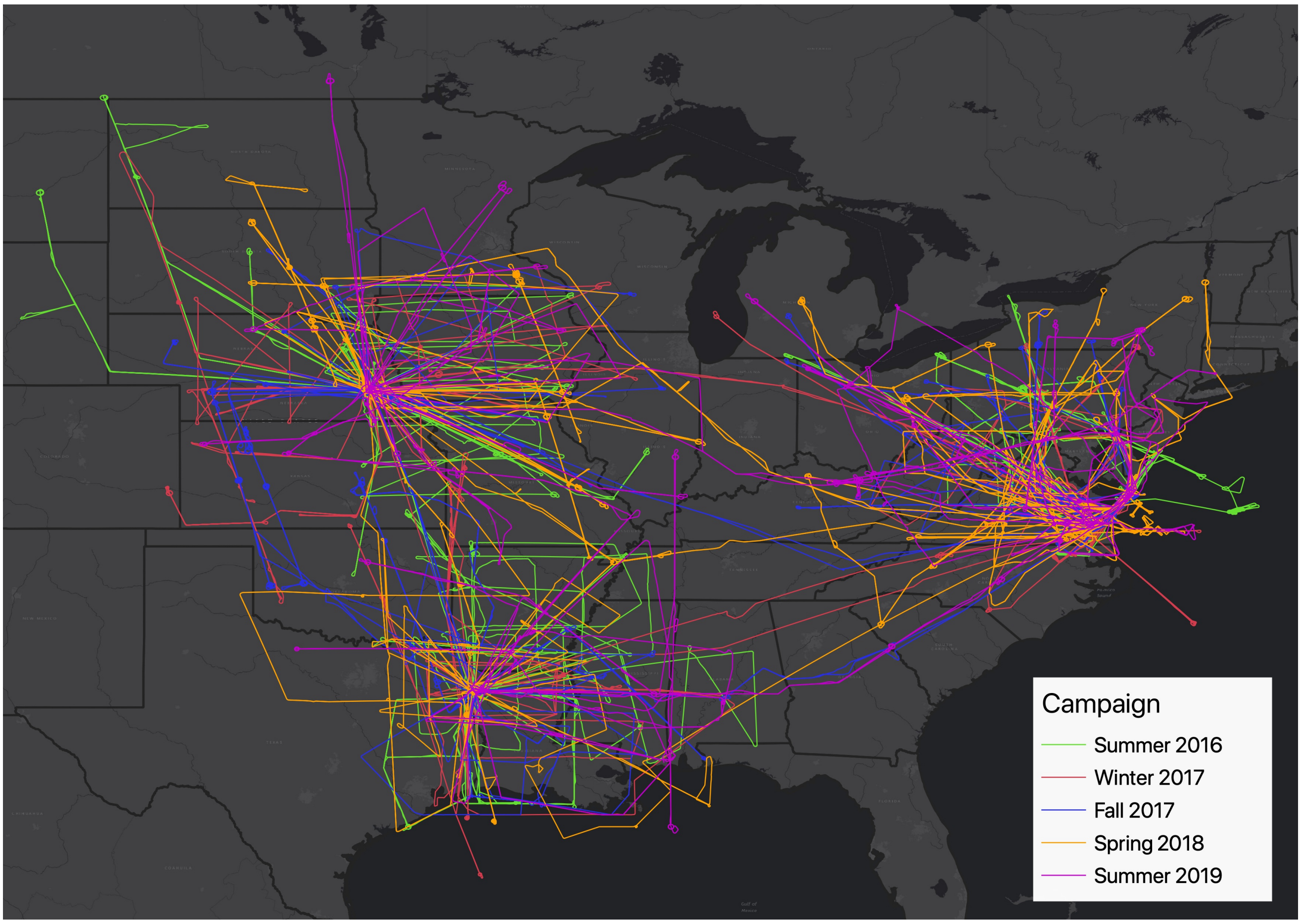

Figure 1. Flight paths for five airborne campaigns of ACT-America that provided receptor locations and CO2 measurements for these FLEXPART simulations. Flights were concentrated on three study areas: the northeast, south-central, and mid-west regions of the United States.

Citation

Cui, Y.Y., A.R. Jacobson, S. Feng, D. Wesloh, Z.R. Barkley, L. Zhang, T. Gerken, K. Keller, D.F. Baker, and K.J. Davis. 2022. FLEXPART Influence Functions for ACT-America, 2016-2017. ORNL DAAC, Oak Ridge, Tennessee, USA. https://doi.org/10.3334/ORNLDAAC/2018

Table of Contents

1. Dataset Overview

This dataset contains a set of Lagrangian particle dispersion simulations of carbon dioxide concentrations using the FLEXible PARTicle (FLEXPART) model. FLEXPART quantified the source-receptor relationships, so-called "influence functions", in a backward mode. The simulations were constructed for five Atmospheric Carbon and Transport America (ACT-America) deployments over the eastern U.S. that occurred in 2016-2017. Each receptor of the influence function is the 30-second or 10-minute interval along flight tracks, characterized by a box with boundaries between the maximum and minimum latitude/longitude as well as between the maximum and minimum altitudes during the interval. Each receptor box released 5,000 particles and simulated their transport and dispersion backward for 10 or 20 days. The simulations were driven by 27-km meteorology provided by the WRF-Chem simulation or by ERA-Interim data from the European Centre for Medium-Range Weather Forecasts (ECMWF). Background levels of carbon dioxide were obtained from CarbonTracker and OCO-2 v9 MIP.

Project: Atmospheric Carbon and Transport - America

The ACT-America, or Atmospheric Carbon and Transport - America, project is a NASA Earth Venture Suborbital-2 mission to study the transport and fluxes of atmospheric carbon dioxide and methane across three regions in the eastern United States. Flight campaigns measured transport of greenhouse gases by continental-scale weather systems. Ground-based measurements of greenhouse gases were also collected. Project goals include better estimates of greenhouse gas sources and sinks which are required for climate management and for prediction of future climate.

Related Dataset

Feng, S., T. Lauvaux, Z.R. Barkley, K.J. Davis, M.P. Butler, A. Deng, B. Gaudet, and D. Stauffer. 2021. ACT-America: WRF-Chem Baseline Simulations for North America, 2016-2019. ORNL DAAC, Oak Ridge, Tennessee, USA. https://doi.org/10.3334/ORNLDAAC/1884

- This dataset employed the WRF-Chem model discussed in the Quality Assurance Section of this document.

Related Publications

Cui, Y. Y., Jacobson, A. R., Feng, S., Wesloh, D., Barkley, Z. R., Zhang, L., et al. (2021). Evaluation of CarbonTracker's inverse estimates of North American net ecosystem exchange of CO2 from different observing systems using ACT-America airborne observations. Journal of Geophysical Research: Atmospheres 126:e2020JD034406. https://doi.org/10.1029/2020JD034406

Cui, Y. Y., Zhang, L., Jacobson, A. R., Johnson, M. S., Philip, S., Baker, D., et al. (2022). Evaluating global atmospheric inversions of terrestrial net ecosystem exchange CO2 over North America on seasonal and sub-continental scales. Geophysical Research Letters 49:e2022GL100147. https://doi.org/10.1029/2022GL100147

Acknowledgement

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2. Data Characteristics

Spatial Coverage: Northern portion of western hemisphere

Spatial Resolution: 27 km as determined by meteorological drivers

Temporal Coverage: 2016-07-01 to 2019-08-01

Temporal Resolution: Hourly during 10-day or 20-day simulation

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

Site	Northernmost Latitude	Southernmost Latitude	Westernmost Longitude	Easternmost Longitude
Western hemisphere	70.10	-10.0	-170.0	5.0

Data File Information

This dataset includes a total of 745 files in Zip archive format.

Three archives hold background CO_2 values used in the simulations in netCDF format:

- WRF-background.zip
- ERA-back10d-rec10min-background.zip,
- ERA-back10d-rec30s-background.zip

The remaining archives hold simulation output in netCDF and FLEXPART binary format (n=742 simulations). The naming convention for these Zip archives is *<Meteorology>***-back***<time>***-res***<temporal resolution>***-***<date>***-***<platform>***.zip**, where

- *<Meteorology>* is the source of meteorological drivers: "WRF" or "ERA"
- *<time>* is the duration of the backwards simulation: 10 days ("10d") or 20 days ("20d")
- *<temporal resolution>* is the averaging period of the receptor data along the ACT-America flight path: 10 minutes ("10min") or 30 seconds ("30s")

- *<date>* is the date of the simulation as YYYYMMDD
- *<platform>* is the NASA aircraft deployed for the flight: B200 ("b200") or C-130 ("c130")

Table 1. File names and descriptions.

<table>
<tr><th>Set</th><th>Filename</th><th>Number of archives</th><th>Format</th><th>Description</th><th>Related Publication</th></tr>
<tr><td rowspan="3">1</td><td>WRF-background.zip</td><td>1</td><td>netCDF</td><td>Background values of CO_2 used for FLEXPART-WRF influence function simulations in Set 1</td><td rowspan="3">Cui et al., (2021)</td></tr>
<tr><td>WRF-back10d-rec30s-<date>-<b200|c130>.zip</td><td>208</td><td>netCDF</td><td>Influence function simulations, backward for 10 days</td></tr>
<tr><td>WRF-back20d-rec30s-<date>-<b200|c130>.zip</td><td>169</td><td>FLEXPART binary</td><td>Influence function simulations, backward for 20 days</td></tr>
<tr><td rowspan="2">2</td><td>ERA-back10d-rec10min-background.zip</td><td>1</td><td>netCDF</td><td>Background values of CO_2 used for FLEXPART-ERA influence function simulations in Set 2 from CarbonTracker CT2019B (Jacobson et al., 2020)</td><td rowspan="2">Cui et al., (2022)</td></tr>
<tr><td>ERA-back10d-rec10min-<date>-<b200|c130>.zip</td><td>162</td><td>FLEXPART binary</td><td>Influence function simulations using 10-min averaged receptor data</td></tr>
<tr><td rowspan="2">3</td><td>ERA-back10d-rec30s-background.zip</td><td>1</td><td>netCDF</td><td>Background values of CO_2 used for FLEXPART-ERA influence function simulations in Set 3 from CarbonTracker 2019B</td><td rowspan="2">See Cui et al., (2022) for methods.</td></tr>
<tr><td>ERA-back10d-rec30s-<date>-<b200|c130>.zip</td><td>203</td><td>FLEXPART binary</td><td>Influence function simulations similar to Set 2 but at higher temporal resolution (using 30-s averaged receptor data)</td></tr>
<tr><td colspan="2">Total:</td><td>745</td><td colspan="3"></td></tr>
</table>

Datafile Details

Each archive holds a collection of files for the backward simulations. The naming convention for these individual files varies among archives but may include the name elements listed above along with these additional elements:

- Date and time as *YYYYMMDD_hhmmss* or *YYYYMMDDhhmmss*
- "CT" or "CT2019B" refer to background CO_2 concentrations from CarbonTracker 2019B (https://gml.noaa.gov/ccgg/carbontracker/)
- "27km" referring to the spatial resolution of the meteorological drivers at 27 km
- NetCDF files have the suffix ".nc" while FLEXPART binary files have not suffix.

The archives holding FLEXPART binary files have additional files in plain text format (e.g., "dates", *.namelist) associated with the simulation runs.

3. Application and Derivation

These data may be used to study the sources and movement of greenhouse gasses and aerosols in the atmosphere as well as net ecosystem exchange of carbon.

4. Quality Assessment

The FLEXPART simulations were compared to WRF-Chem simulations of CO_2 mole fractions along the flight tracks using the same flux inputs, boundary conditions, and meteorological fields. There was close agreement between the FLEXPART and WRF-Chem simulations.

5. Data Acquisition, Materials, and Methods

Lagrangian particle dispersion simulations of carbon dioxide concentrations were created using the FLEXible PARTicle (FLEXPART) model (Brioude et al., 2013). FLEXPART quantified the source-receptor relationships, so-called "influence functions", in a backward mode. The simulations were constructed for five Atmospheric Carbon and Transport–America (ACT-America) deployments over the eastern U.S. that occurred in 2016-2019 (Davis et al., 2018; Figure 1). These ACT-America flights carried calibrated instruments for measuring in-situ atmospheric CO_2 concentrations. The flights were conducted using two NASA aircraft, a B200 and a C-130, which facilitated concurrent sampling at different altitudes.

To provide receptor values for the influence functions, CO_2 measurements were aggregated in 10-minute and 30-second intervals along the flights, excluding take-off and landing portions. Each receptor was characterized by a box with boundaries between the maximum and minimum latitude/longitude as well as between the maximum and minimum altitudes during the aggregation interval. Each receptor box released 1,000 to 5,000 particles, and their transport and dispersion were simulated backward for 10 or 20 days.

Three sets of FLEXPART simulations were conducted (Table 1). In Set 1, simulations were driven by 27-km meteorology provided by the WRF-Chem simulation as described by Feng et al. (2019). Receptor measurements were aggregated to 30-second intervals. Each receptor box released 5,000 particles. The simulation time period was 10 days and 20 days backward from the receptor time. Background values of CO_2 were obtained from CarbonTracker CT2019B (https://gml.noaa.gov/ccgg/carbontracker/; Jacobson et al., 2020).

In Set 2, simulations used FLEXPART version 3.1 (Pisso et al., 2019) driven by meteorology from ERA-interim reanalysis data (Dee et al., 2011). Receptor measurements were aggregated to 10-minute intervals. Each receptor box released 1,000 particles, and the simulation period was 10 days backward from the receptor time. Background values of CO_2 were derived from OCO-2 v9 MIP global optimized CO_2 mole fraction fields (https://gml.noaa.gov/ccgg/OCO2_v9mip). Set 3 employed the same methods as Set 2 except that receptor data were aggregated to 30-second intervals.

Detailed methods for Set 1 are available in Cui et al. (2021). See Cui et al. (2022) for methods used for Set 2 and Set 3.

6. Data Access

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

FLEXPART Influence Functions for ACT-America, 2016-2017

Contact for Data Center Access Information:

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

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