National Aeronautics and Space Administration Goddard Earth Science Data Information and Services Center (GES DISC)

README Document for the Carbon Monitoring System (CMS) Carbon Flux Data Sets

Prepared By:

Thomas Hearty	Kevin Bowman
GES DISC GSFC Code 610.2	JPL/Caltech

Revision History

Revision Date	*Changes*	*Author*
9/14/2020	Original Document	Thomas Hearty

Goddard Earth Sciences Data and Information Services Center (GES DISC)
http://disc.gsfc.nasa.gov
NASA Goddard Space Flight Center
Code 610.2
Greenbelt, MD 20771 USA

Table of Contents

1.0 Introduction

This document provides basic information for using the 6 Carbon Monitoring System (CMS) datasets listed in Table 1.

Table 1. Datasets in this collection.

Dataset Title	**Short Name: DOI**
Carbon Monitoring System Carbon Flux for Fire L4	CMSFluxFire: 10.5067/HO07ZJEQBMHE
Carbon Monitoring System Carbon Flux for Fossil Fuel Prior L4	CMSFluxFossilFuelPrior: 10.5067/JHP9Q8DBRQCB
Carbon Monitoring System Carbon Flux from the Net Biome Exchange L4	CMSFluxNBE: 10.5067/ZQQ4M53CP6L2
Carbon Monitoring System Carbon Flux from the Net Biome Exchange Prior	CMSFluxNBEPrior: 10.5067/3DVX5KRI8AYL
Carbon Monitoring System Carbon Flux for Ocean Prior L4	CMSFluxOceanPrior: 10.5067/MYWVXT4RWQO3
Carbon Monitoring System Carbon Flux Total L4	CMSFluxTotal: 10.5067/71F2I0PR2ISD

1.1 Description of the Data Sets

These datasets contain global estimates of various components of the carbon cycle constrained by satellite observations through the Carbon Monitoring System Flux (CMS-Flux) carbon cycle data assimilation system as shown in Figure 1. A description of the methodology and technical details of the system can be found in Liu et al. 2014 and Bowman et al. 2017. The total CO_2 flux, which is the net sum of all carbon fluxes, from 2010-2016 are constrained with GOSAT v3.7b whereas total fluxes from 2015-2016 are constrained by OCO-2 v9r.

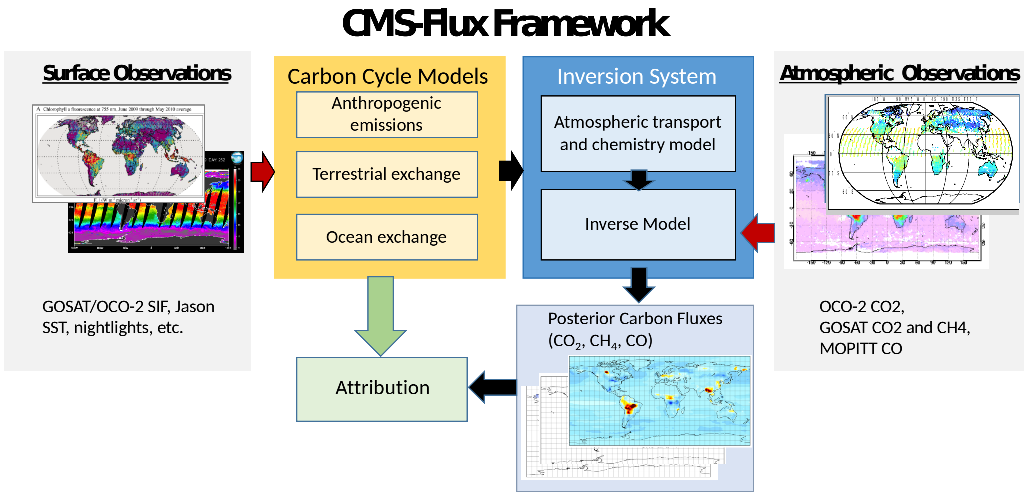

Figure: Carbon Monitoring System Flux (CMS-Flux) Framework. Satellite observations of surface data are integrated into a suite of anthropogenic (FFDAS), ocean (ECCO2-Darwin), and terrestrial (CASA-GFED) carbon cycle models. These are in turn used to compute surface fluxes that drive a chemistry and transport model (GEOS-Chem). Atmospheric observations of CO2, CO, CH4 are ingested into an inverse model that computes posterior estimates of carbon surface fluxes. The combination of fluxes is used to attribute carbon and then reconcile those differences with prior carbon cycle models (from Bowman et al, 2017).

1.2 Carbon Monitoring System (CMS) Description

The NASA Carbon Monitoring System (CMS) is designed to make significant contributions in characterizing, quantifying, understanding, and predicting the evolution of global carbon sources and sinks through improved monitoring of carbon stocks and fluxes. The System will use the full range of NASA satellite observations and modeling/analysis capabilities to establish the accuracy, quantitative uncertainties, and utility of products for supporting national and international policy, regulatory, and management activities. CMS will maintain a global emphasis while providing finer scale regional information, utilizing space-based and surface-based data and will rapidly initiate generation and distribution of products both for user evaluation and to inform near-term policy development and planning.

1.3 Data Disclaimer and Digital Object Identifier (DOI)

The data sets may be acknowledged in publications using the Digitial Object Identifiers listed in Table 1.

2.0 Data Organization

The data in all the files are organized on and equal angle grid in longitude and latitude but they have different spatial resolutions. The files also each contain one year of data.

2.1 File Naming Convention

The filesnames are Described in Table 2 where YYYY should be replaced by the year.

Table 2. CMS Flux File Naming Conventions

Short Name	**Filename patern**
CMSFluxFire	CMS_Flux_Fire_YYYY_v2.nc4

CMSFluxFossilFuelPrior	CMS_Flux_FossilFuelPrior_YYYY_v2.nc4
CMSFluxNBE	CMS_Flux_NBE_YYYY_v2.nc4
CMSFluxNBEPrior	CMS_Flux_NBEPrior_YYYY_v2.nc4
CMSFluxOceanPrior	CMS_Flux_OceanPrior_YYYY_v2.nc4
CMSFluxTotal	CMS_Flux_Total_YYYY_v2.nc4

2.2 File Format and Structure

The files are stored in NetCDF-4 format.

3.0 Data Contents

The dimensions and variables of each of the CMS-Flux products are listed below.

CMSFluxFire

```
dimensions:
	lat = 46 ;
	lon = 72 ;
	time = 12 ;
variables:
	float area(lat, lon) ;
		area:long_name = "Surface area per cell" ;
		area:units = "km^2" ;
	double flux(time, lat, lon) ;
		flux:units = "kg/km^2/s" ;
		flux:missing_value = -999. ;
		flux:long_name = "Posterior Biomass Burning Carbon (C) Flux" ;
	double fluxunc(time, lat, lon) ;
		fluxunc:long_name = "Posterior Biomass Burning Carbon Flux Uncertainty
(standard deviation) (C)" ;
		fluxunc:units = "kg/km^2/s" ;
		fluxunc:missing_value = -999. ;
	double lat(lat) ;
		lat:long_name = "latitude" ;
		lat:units = "degrees_north" ;
	double lon(lon) ;
		lon:long_name = "longitude" ;
		lon:units = "degrees_east" ;
	float seconds_in_month(time) ;
		seconds_in_month:long_name = "Seconds in one month of a non-leap year." ;
		seconds_in_month:units = "seconds" ;
	float time(time) ;
```

```
		time:units = "months since 2010-01-01T00:00:00" ;
		time:long_name = "time" ;
```

CMSFluxFossilFuelPrior

```
dimensions:
	lat = 46 ;
	lon = 72 ;
	time = 12 ;
variables:
	float area(lat, lon) ;
		area:long_name = "Surface area per cell" ;
		area:units = "km^2" ;
	double flux(time, lat, lon) ;
		flux:units = "kg/km^2/s" ;
		flux:missing_value = -999. ;
		flux:long_name = "Prior Fossil Fuel Carbon (C) Flux" ;
	double lat(lat) ;
		lat:long_name = "latitude" ;
		lat:units = "degrees_north" ;
	double lon(lon) ;
		lon:long_name = "longitude" ;
		lon:units = "degrees_east" ;
	float seconds_in_month(time) ;
		seconds_in_month:long_name = "Seconds in one month of a non-leap year." ;
		seconds_in_month:units = "seconds" ;
	float time(time) ;
		time:units = "months since 2010-01-01T00:00:00" ;
		time:long_name = "time" ;
```

CMSFluxNBE

```
dimensions:
	lat = 46 ;
	lon = 72 ;
	time = 12 ;
variables:
	float area(lat, lon) ;
		area:long_name = "Surface area per cell" ;
		area:units = "km^2" ;
	double flux(time, lat, lon) ;
		flux:units = "kg/km^2/s" ;
		flux:missing_value = -999. ;
		flux:long_name = "Posterior Net Biome Carbon Exchange (C) Flux" ;
```

```
	double fluxunc(time, lat, lon) ;
		fluxunc:long_name = "Posterior Net Biome Carbon Exchange Flux Uncertainty (standard deviation) (C)" ;
		fluxunc:units = "kg/km^2/s" ;
		fluxunc:missing_value = -999. ;
	double lat(lat) ;
		lat:long_name = "latitude" ;
		lat:units = "degrees_north" ;
	double lon(lon) ;
		lon:long_name = "longitude" ;
		lon:units = "degrees_east" ;
	float seconds_in_month(time) ;
		seconds_in_month:long_name = "Seconds in one month of a non-leap year." ;
		seconds_in_month:units = "seconds" ;
	float time(time) ;
		time:units = "months since 2010-01-01T00:00:00" ;
		time:long_name = "time" ;
```

CMSFluxNBEPrior

```
dimensions:
	lat = 46 ;
	lon = 72 ;
	time = 12 ;
variables:
	float area(lat, lon) ;
		area:long_name = "Surface area per cell" ;
		area:units = "km^2" ;
	double flux(time, lat, lon) ;
		flux:units = "kg/km^2/s" ;
		flux:missing_value = -999. ;
		flux:long_name = "Prior Net Biome Carbon Exchange (C) Flux" ;
	double lat(lat) ;
		lat:long_name = "latitude" ;
		lat:units = "degrees_north" ;
	double lon(lon) ;
		lon:long_name = "longitude" ;
		lon:units = "degrees_east" ;
	float seconds_in_month(time) ;
		seconds_in_month:long_name = "Seconds in one month of a non-leap year." ;
		seconds_in_month:units = "seconds" ;
	float time(time) ;
		time:units = "months since 2010-01-01T00:00:00" ;
		time:long_name = "time" ;
```

CMSFluxOceanPrior

```
dimensions:
	lat = 46 ;
	lon = 72 ;
	time = 12 ;
variables:
	float area(lat, lon) ;
		area:long_name = "Surface area per cell" ;
		area:units = "km^2" ;
	double flux(time, lat, lon) ;
		flux:units = "kg/km^2/s" ;
		flux:missing_value = -999. ;
		flux:long_name = "Prior Ocean Carbon Exchange (C) Flux" ;
	double lat(lat) ;
		lat:long_name = "latitude" ;
		lat:units = "degrees_north" ;
	double lon(lon) ;
		lon:long_name = "longitude" ;
		lon:units = "degrees_east" ;
	float seconds_in_month(time) ;
		seconds_in_month:long_name = "Seconds in one month of a non-leap year." ;
		seconds_in_month:units = "seconds" ;
	float time(time) ;
		time:units = "months since 2010-01-01T00:00:00" ;
		time:long_name = "time" ;
```

CMSFluxTotal

```
dimensions:
	lat = 46 ;
	lon = 72 ;
	time = 12 ;
variables:
	float area(lat, lon) ;
		area:long_name = "Surface area per cell" ;
		area:units = "km^2" ;
	double flux(time, lat, lon) ;
		flux:units = "kg/km^2/s" ;
		flux:missing_value = -999. ;
```

```
		flux:long_name = "Posterior Total Surface-Atmosphere Exchange Carbon (C) Flux"
;
	double lat(lat) ;
		lat:long_name = "latitude" ;
		lat:units = "degrees_north" ;
	double lon(lon) ;
		lon:long_name = "longitude" ;
		lon:units = "degrees_east" ;
	float seconds_in_month(time) ;
		seconds_in_month:long_name = "Seconds in one month of a non-leap year." ;
		seconds_in_month:units = "seconds" ;
	float time(time) ;
		time:units = "months since 2010-01-01T00:00:00" ;
		time:long_name = "time" ;
```

4.0 Options for Reading the Data

4.1 Programming Languages

The data can be read using major programming languages such as Fortran, C, Java, IDL, Matlab, and Python.

4.2 Command Line Utility

ncdump

The ncdump tool can be used as a simple browser for NetCDF and HDF data files, to display the dimension names and sizes; variable names, types, and shapes; attribute names and values; and optionally, the values of data for all variables or selected variables in a netCDF file. The most common use of ncdump is with the –h option, in which only the header information is displayed.

ncdump [-c|-h] [-v ...] [[-b|-f] [c|f]] [-l len] [-n name] [-d n[,n]] filename
Options/Arguments:
[-c] Coordinate variable data and header information
[-h] Header information only, no data
[-v var1[,...]] Data for variable(s) <var1>,... only data
[-f [c|f]] Full annotations for C or Fortran indices in data
[-l len] Line length maximum in data section (default 80)
[-n name] Name for netCDF (default derived from file name)
[-d n[,n]] Approximate floating-point values with less precision filename File name of input netCDF file

4.3 A tool for simple visualization

Panoply, developed at the Goddard Institute for Space Studies (GISS), is compliant with NetCDF Climate and Forecast (CF) Metadata Convention that is gaining popularity. A strength of the tool is that data can be previewed “remotely” over the network – i.e. user can preview file content of HDF files stored on a remote site, without downloading them. Panoply is available from GISS:
http://www.giss.nasa.gov/tools/panoply/

5.0 Help Desk

If you need assistance or wish to report a problem:
Email: gsfc-help-disc@lists.nasa.gov
Voice: 301-614-5224
Fax: 301-614-5268
Address:
Goddard Earth Sciences Data and Information Services Center NASA Goddard Space Flight Center Code 610.2 Greenbelt, MD 20771 USA

6.0 Acknowledgments

The distribution of this data is funded by the NASA Carbon Monitoring System CMS program.

7.0 References

Liu, J., K. Bowman, M. Lee, D. Henze, N. Bousserez, H. Brix, G. J. Collatz, D. Menemenlis, L. Ott,S. Pawson, D. Jones, and R. Nassar, Carbon monitoring system flux estimation and attribution: impact of ACOS-GOSAT XCO2 sampling on the inference of terrestrial biospheric sources and sinks, Tellus B, 66(0), doi:http://dx.doi.org/10.3402/tellusb.v66.22486, 2014.

Bowman, K. W., J. Liu, A. A. Bloom, N. C. Parazoo, M. Lee, Z. Jiang, D. Menemenlis, M. M. Gierach, G. J. Collatz, K. R. Gurney, and D. Wunch, Global and Brazilian carbon response to El Niño Modoki 2011-2010, Earth and Space Science, 4, doi:10.1002/2016EA000204, 2017.