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

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Revision History

Revision Date	***Changes***	***Author***
9/8/2017	Original Document	Thomas Hearty
10/5/2017	Added dataset description and references	Kevin Bowman

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1.0 Introduction

This document provides basic information for using the 8 Carbon Monitoring System (CMS) datasets listed in Table 1.

Table 1. Datasets in this collection.

Dataset Title	**Short Name/DOI**
Carbon Monitoring System Flux for Fire L4 V1	CMSFluxFire 10.5067/3C1Y3EJB1E7Q
Carbon Monitoring System Flux for Posterior Fire Carbon L4 V1	CMSFluxFirepost 10.5067/N3HM4V0JZVLB
Carbon Monitoring System Flux for Fossil Fuel L4 V1	CMSFluxFossilfuel 10.5067/JC6BC3CPEJXQ
Carbon Monitoring System Flux for Shipping, Aviation, and Chemical Sources L4 V1	CMSFluxMISC 10.5067/RLT7JTCRJ11M
Carbon Monitoring System Flux from the Net Ecosystem Exchange L4 V1	CMSFluxNEE 10.5067/4ACY6GOWQ7BB
Carbon Monitoring System Flux for Ocean Carbon L4 V1	CMSFluxOcean 10.5067/96SSC2AOLE3Z
Carbon Monitoring System Flux for Posterior Total Carbon L4 V1	CMSFluxTotalpost 10.5067/QCBSYYY4CENP
Carbon Monitoring System Flux for Prior Total Carbon L4 V1	CMSFluxTotalprior 10.5067/F0JBNZ5QYWY6

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 2010-2014 are constrained with GOSAT v3.5b whereas total fluxes from 2015-2016 are constrained by OCO-2 v7r.

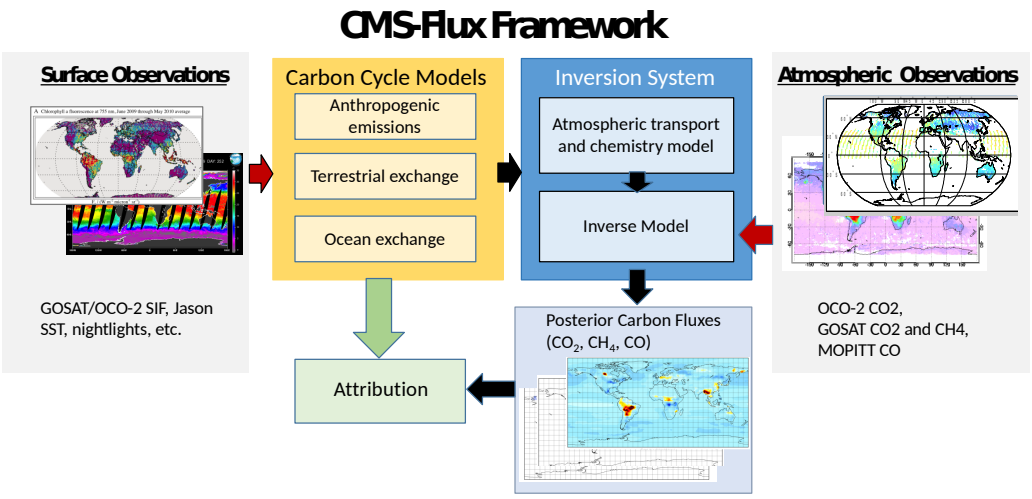

Figure: Carbon Monitoring System Flux (CMS-Flux) Framework. Satellite observations of surface data are integrated into a suite of anthropogenic (FFDAS), ocean (ECCO2-Darwin), and terrestrial (CASA-GFED) carbon cycle models. These are in turn used to compute surface fluxes that drive a chemistry and transport 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	CMSFluxFire_YYYY_v1.nc4
CMSFluxFirepost	CMSFluxFirepost_YYYY_v1.nc4
CMSFluxFossilfuel	CMSFluxFossilfuel_YYYY_v1.nc4
CMSFluxMISC	CMSFluxMISC_v1.nc4
CMSFluxNEE	CMSFluxNEE_YYYY_v1.nc4
CMSFluxOcean	CMSFluxOcean_YYYY_v1.nc4
CMSFluxtotalpost	CMSFluxTotalpost_YYYY_v1.nc4
CMSFluxtotalprior	CMSFluxTotalprior_YYYY_v1.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:
        lon = 72 ;
        lat = 46 ;
        time = 12 ;
variables:
        float lon(lon) ;
                string lon:long_name = "longitude" ;
                string lon:units = "degrees_east" ;
        float lat(lat) ;
                string lat:long_name = "latitude" ;
                string lat:units = "degrees_north" ;
        float time(time) ;
                string time:long_name = "time" ;
                string time:units = "months since 2010-01-01" ;
        float Fire(time, lat, lon) ;
                string Fire:long_name = "Biomass Burning Carbon Emission" ;
                string Fire:units = "kg/km^2/s" ;
        float Area(lat) ;
                string Area:long_name = "surface area per cell" ;
                string Area:units = "km^2" ;
```

CMSFluxFirepost

```
dimensions:
        lon = 72 ;
        lat = 46 ;
        time = 12 ;
variables:
        float lon(lon) ;
                string lon:long_name = "longitude" ;
                string lon:units = "degrees_east" ;
        float lat(lat) ;
                string lat:long_name = "latitude" ;
```

string lat:units = "degrees_north" ;
float time(time) ;
string time:long_name = "time" ;
string time:units = "months since 2010-01-01" ;
float Biomass_Burning(time, lat, lon) ;
string Biomass_Burning:long_name = "Posterior Biomass Burning Emission Carbon Emission" ;
string Biomass_Burning:units = "kg/km^2/s" ;
float Area(lat) ;
string Area:long_name = "surface area per cell" ;
string Area:units = "km^2" ;
float Biomass_Burning_Uncertainty(time, lat, lon) ;
string Biomass_Burning_Uncertainty:long_name = "Posterior Biomass Burning Emission Carbon Emission Uncertainty" ;
string Biomass_Burning_Uncertainty:units = "kg/km^2/s" ;

CMSFluxFossilfuel

dimensions:
lon = 72 ;
lat = 46 ;
time = 8760 ;
variables:
float lon(lon) ;
string lon:long_name = "longitude" ;
string lon:units = "degrees_east" ;
float lat(lat) ;
string lat:long_name = "latitude" ;
string lat:units = "degrees_north" ;
float time(time) ;
string time:long_name = "time" ;
string time:units = "hours since 2010-01-01 00:00:0.0" ;
float FF(time, lat, lon) ;
string FF:long_name = "Fossil fuel Carbon Emission" ;
string FF:units = "kg/km^2/s" ;
float Area(lat) ;
string Area:long_name = "surface area per cell" ;
string Area:units = "km^2" ;

CMSFluxMISC

dimensions:
lon = 72 ;

lat = 46 ;
lev = 47 ;
time = 12 ;
variables:
float lon(lon) ;
string lon:long_name = "longitude" ;
string lon:units = "degrees_east" ;
float lat(lat) ;
string lat:long_name = "latitude" ;
string lat:units = "degrees_north" ;
float lev(lev) ;
string lev:long_name = "GEOS-Chem vertical Level (1: surface)" ;
string lev:units = "none" ;
float time(time) ;
string time:long_name = "time" ;
string time:units = "months since 0-01-01" ;
float Shipping(time, lat, lon) ;
string Shipping:long_name = "Shipping Carbon Emission (ICOADS)" ;
string Shipping:units = "kg/km^2/s" ;
float Area(lat) ;
string Area:long_name = "surface area per cell" ;
string Area:units = "km^2" ;
float Aviation(time, lev, lat, lon) ;
string Aviation:long_name = "Aviation Carbon Emission (GEOSChem)" ;
string Aviation:units = "kg/km^2/s" ;
float ChemicalSources(time, lev, lat, lon) ;
string ChemicalSources:long_name = "Chemical Source Carbon Emission (GEOSChem)" ;
string ChemicalSources:units = "kg/km^2/s" ;

CMSFluxNEE

dimensions:
lon = 72 ;
lat = 46 ;
time = 2920 ;
variables:
float lon(lon) ;
string lon:long_name = "longitude" ;
string lon:units = "degrees_east" ;
float lat(lat) ;
string lat:long_name = "latitude" ;
string lat:units = "degrees_north" ;
float time(time) ;
string time:long_name = "time" ;

string time:units = "hours since 2010-01-01 00:00:0.0" ;
float NEE(time, lat, lon) ;
string NEE:long_name = "Net Ecosystem Exchange (NEE) Carbon Emission" ;
string NEE:units = "kg/km^2/s" ;
float Area(lat) ;
string Area:long_name = "surface area per cell" ;
string Area:units = "km^2" ;

CMSFluxOcean

dimensions:
lon = 72 ;
lat = 46 ;
time = 2920 ;
variables:
float lon(lon) ;
string lon:long_name = "longitude" ;
string lon:units = "degrees_east" ;
float lat(lat) ;
string lat:long_name = "latitude" ;
string lat:units = "degrees_north" ;
float time(time) ;
string time:long_name = "time" ;
string time:units = "hours since 2010-01-01 00:00:0.0" ;
float Ocean(time, lat, lon) ;
string Ocean:long_name = "Ocean-Atmosphere Exchange Carbon Emission" ;
string Ocean:units = "kg/km^2/s" ;
float Area(lat) ;
string Area:long_name = "surface area per cell" ;
string Area:units = "km^2" ;

CMSFluxTotalpost

dimensions:
lon = 72 ;
lat = 46 ;
time = 12 ;
variables:
float lon(lon) ;
string lon:long_name = "longitude" ;
string lon:units = "degrees_east" ;
float lat(lat) ;
string lat:long_name = "latitude" ;
string lat:units = "degrees_north" ;
float time(time) ;
string time:long_name = "time" ;

string time:units = "months since 2010-01-01" ;
float Total_Flux_Posterior(time, lat, lon) ;
string Total_Flux_Posterior:long_name = "Posterior Total Surface-Atmosphere Exchange Carbon Emission" ;
string Total_Flux_Posterior:units = "kg/km^2/s" ;
float Area(lat) ;
string Area:long_name = "surface area per cell" ;
string Area:units = "km^2" ;
float Total_Flux_Posterior_Uncertainty(time, lat, lon) ;
string Total_Flux_Posterior_Uncertainty:long_name = "Posterior Total Surface-Atmosphere Exchange Carbon Emission Uncertainty" ;
string Total_Flux_Posterior_Uncertainty:units = "kg/km^2/s" ;

CMSFluxTotalprior

dimensions:
lon = 72 ;
lat = 46 ;
time = 12 ;
variables:
float lon(lon) ;
string lon:long_name = "longitude" ;
string lon:units = "degrees_east" ;
float lat(lat) ;
string lat:long_name = "latitude" ;
string lat:units = "degrees_north" ;
float time(time) ;
string time:long_name = "time" ;
string time:units = "months since 2010-01-01" ;
float Total_Flux_Prior(time, lat, lon) ;
string Total_Flux_Prior:long_name = "Prior Total Surface-Atmoshere Exchange Carbon Emission" ;
string Total_Flux_Prior:units = "kg/km^2/s" ;
float Area(lat) ;
string Area:long_name = "surface area per cell" ;
string Area:units = "km^2" ;
float Total_Flux_Prior_Uncertainty(time, lat, lon) ;
string Total_Flux_Prior_Uncertainty:long_name = "Prior Total Surface-Atmoshere Exchange Carbon Emission Uncertainty" ;
string Total_Flux_Prior_Uncertainty:units = "kg/km^2/s" ;

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 Data Services

Data services and access methods can be found on the dataset landing page for each product:

http://disc.sci.gsfc.nasa.gov/datacollection/CMSFluxFire_1.html

http://disc.sci.gsfc.nasa.gov/datacollection/CMSFluxFirepost_1.html

http://disc.sci.gsfc.nasa.gov/datacollection/CMSFluxFossilfuel_1.html

http://disc.sci.gsfc.nasa.gov/datacollection/CMSFluxMISC_1.html

http://disc.sci.gsfc.nasa.gov/datacollection/CMSFluxNEE_1.html

http://disc.sci.gsfc.nasa.gov/datacollection/CMSFluxOcean_1.html

http://disc.sci.gsfc.nasa.gov/datacollection/CMSFluxTotalpost_1.html

http://disc.sci.gsfc.nasa.gov/datacollection/CMSFluxTotalprior_1.html

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

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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.