Office of Satellite and Product Operations
Environmental Processing Satellite Center

Blended Global Biomass Burning Emissions Product from VIIRS Observations
System Maintenance Manual

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Approval Page

Environmental Satellite Processing Center

Blended Global Biomass Burning Emissions Product from VIIRS Observations

System Maintenance Manual

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Changes/Revisions Record

This system maintenance manual is changed as required to reflect system, operational, or organizational changes. Modifications made to this document are recorded in the Changes/Revisions Record below. This record will be maintained throughout the life of the document.

Version Number	Date	Description of Change/Revision	Section/Pages Affected	Changes Made by Name/Title/ Organization
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Preface

This document comprises the National Oceanic and Atmospheric Administration (NOAA) National Environmental Satellite, Data, and Information Service (NESDIS), Office of Satellite and Product Operations (OSPO), publication of this Blended Global Biomass Burning Emissions Product (GBBEPx) from VIIRS Observations System Maintenance Manual. This document reflects current operations for the DOC/NOAA/NESDIS Environmental Satellite Processing Center (ESPC) (NOAA5045) information technology systems. This document describes the established ESPC procedures for GBBEPx system maintenance in accordance with Federal, DOC, NOAA, NESDIS and OSPO requirements.

Future updates and revisions to this document will be produced and controlled by DOC/NOAA/NESDIS for ESPC information technology systems.

The published version of this document can be found at the OSPO SharePoint Products Library.

Table of Contents

List of Tables

List of Figures

Executive Summary

This is a System Maintenance Manual (SMM) document describing the Blended Global Biomass Burning Emissions Product (GBBEPx) Science Algorithm (SA). The intended users of this document are those looking for system related information, such as maintenance personnel or management. The purpose of this manual is to describe the system and what must be done to ensure the system meets all of its organizational goals.

GBBEPx will produce multiple biomass burning emissions files for end users. End users are defined as users who do not have direct access to the processing system. The GBBEPx system currently uses data captured by the VIIRS instrument flying on the JPSS-01/NOAA-20 and JPSS-02/NOAA-21 satellites. Each of the eight biomass burning emission products can be seen in Table 0-1.

Table 0-1 - GBBEPx V5 Output Files

Interface Item	Format	Filename	File Size	Number of Files per Run
Daily Emissions in FV3 C384 Grid	Bin	GBBEPxemis-<burn_emiss>-C<col_num>GT<tile_num>_v<v_num>r<r_num>_blend_s<start_time>_e<end_time>_c<create_time>.bin	600 KB	36
Daily FRP in FV3 C384 Grid	Bin	GBBEPxFRP-<stats>-C<col_num>GT[<tile_num>_v<v_num>r<r_num>_blend_s<start_time>_e<end_time>_c<create_time>.bin	590 KB	30
Daily Emissions in FV3 C96 Grid	Bin	GBBEPxemis-<burn_emiss>-C<col_num>GT<tile_num>_v<v_num>r<r_num>_blend_s<start_time>_e<end_time>_c<create_time>.bin	37 KB	36
Daily FRP in FV3 C96 Grid	Bin	GBBEPxFRP-<stats>-C<col_num>GT[<tile_num>_v<v_num>r<r_num>_blend_s<start_time>_e<end_time>_c<create_time>.bin	37 KB	30
Daily Emissions	NetCDF	GBBEPx-<burn_emiss>-emissions_v<v_num>r<r_num>_blend_s<start_time>_e<end_time>_c<create_time>.nc	200 KB	6
Blended Mean FRP	NetCDF	GBBEPx-MeanFRP_v<v_num>r<r_num>_blend_s<start_time>_e<end_time>_c<create_time>.nc	200 KB	1
Daily Emissions at 0.1 X 0.1 Degree Grid	NetCDF	GBBEPx-all01GRID_v<v_num>r<r_num>_blend_s<start_time>_e<end_time>_c<create_time>.nc	3.9 MB	1
Spatial Pattern of PM2.5 in JPG Map	JPG	GBBEPx-PM25-emissions_v<v_num>r<r_num>_blend_s<start_time>_e<end_time>_c<create_time>.jpg	176 KB	1

Where:

<burn_emiss>	→	indicates the pollutant associated with the file, will be BC, CO, CO2, OC, PM2.5, or SO2
<start_time>	→	the start time of the file in 4-digit year, 2-digit month, 2-digit day, 2-digit hour, 2-digit minute, 3-digit second format
<end_time>	→	the end time of the file in 4-digit year, 2-digit month, 2-digit day, 2-digit hour, 2-digit minute, 3-digit second format
<create_time>	→	the creation time of the file in 4-digit year, 2-digit month, 2-digit day, 2-digit hour, 2-digit minute, 3-digit second format
<v_num>	→	indicates the version number associated with the file
<r_num>	→	indicates the release number associated with the file
<tile_num>	→	indicates the grid tile number associated with the file, this could be 1, 2, 3, 4, 5, or 6
<col_num>	→	indicates the column number associated with the file, this could be either 96 or 384

<stats>	→	indicates the statistic associated with the file, will be one of the following: CloudPerc, FirePerc, MeanFRP, NumSensor, QCAll

All GBBEPx products must be processed once per 24-hour time period. Some GBBEPx requirements are described in Table 0-2.

Table 0-2 - GBBEPx Product Requirements

Product Requirement	Description
Satellites	SNPP[1], JPSS-1/NOAA-20, JPSS-2/NOAA-21
Instrument	VIIRS
Product Accuracy	Emissions: 30%
Horizontal Resolution	Global Daily Products: 0.25 X 0.3125 degree, 0.1 X 0.1 degree, 25 X 25 km (C384 grid), 100 X 100 km (C96 grid)
Latency	Daily
Timeliness	Daily
Geographic Coverage	Global
Update Cycle	24 Hours
Output Formats	NetCDF4, JPG, binary
Data Products	Daily fire emissions of black carbon (BC), carbon dioxide (CO2), carbon monoxide (CO), organic carbon (OC), ammonia (NH3), nitrogen oxides (NOx), Sulfur dioxide (SO2), fine particulate matter (PM2.5); Global grid emission totals, C384 grid emissions, C96 grid emissions, daily mean FRP, fire percent, number of VIIRS observations, quality of FRP observations
Dependencies	VIIRS Enterprise Fire I-Band Product

The GBBEPx product development team consists of members from NESDIS, SDSU, OSGS and OSPO. The roles and contact information for the product team members are identified in Table 0-3.

Table 0-3 - Product Development Team Information

Name	Organization	Role	Contact Information
Walter Wolf	OCS	Product Management Division Chief	walter.wolf@noaa.gov
Shobha Kondragunta	NESDIS	Science Team Lead	shobha.kondragunta@noaa.gov
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Fangjun Li	SDSU	Science Team	fangjun.li@sdstate.edu
Hanjun Ding	OSPO	PAL	hanjun.ding@noaa.gov

[1] SNPP is a backup source of satellite data

Name	Organization	Role	Contact Information
Yufeng Zhu	OSPO	OSPO Team	yufeng.zhu@noaa.gov
Kari St. Laurent	NESDIS	PPM	kari.stlaurent@noaa.gov
Li Bi	NESDIS	PIB	li.bi@noaa.gov
Priyanka Roy	OCS	ASSISTT Management Team	priyanka.roy@noaa.gov
Letitia Soulliard	OCS	ASSISTT Standalone Integration Team Lead	letitia.soulliard@noaa.gov
Shukming Wu	OCS	ASSISTT Standalone Integration Team Lead	shukming.wu@noaa.gov
Ismail Mohamed	OCS	ASSISTT Standalone Integration Team	ismail.mohamed@noaa.gov
Jeremy Greenough	OCS	ASSISTT Standalone Integration Team	jeremy.greenough@noaa.gov
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Hua Xie	OCS	ASSISTT Science QA Team Lead	hua.xie@noaa.gov

All low-level processing code in GBBEPx is written in C, Fortran90 and Perl compiled languages. Low-level code performs all data processing, scientific computation, read/writing, reformatting, and opening/closing of files. All high-level code is written in Python. High-level tasks include file management, system management, making system calls, and error trapping from low-level processing. All scheduled processes are initiated as Python scripts. For a more detailed description of the science algorithm responsible for GBBEPx processing, please refer to the appropriate Algorithm Theoretical Basis Document (ATBD) for the GBBEPx algorithm package (NOAA & SDSU/GSCE, 2024).

The NESDIS Policy on Access and Distribution of Environmental Data and Products is provided at: http://www.ospo.noaa.gov/Organization/About/access.htmlhttp://www.ospo.noaa.gov/Organization/About/access.html

To access GBBEPx data, users need to fill out the Data Access Request Form located on this site and submit it to the PAL with a copy to nesdis.data.access@noaa.gov. This address provides the OSPO Data Access Team a copy of the correspondence. Once the request is approved by OSPO management, the data will be delivered by the Product Distribution and Access (PDA) system. ESPC User Services (SPSDuserservices@noaa.gov) should be contacted for any data accessibility and data distribution problems.

The GBBEPx NetCDF4 format expected output products will be archived at CLASS/NCEI.

1. Introduction

This section provides an overview of the GBBEPx product, algorithm, and interface.

1.1. Product Overview

Global biomass burning emissions products have been requested by NOAA/NWS National Center for Environmental Prediction (NCEP) for enhancement of the Global Forecasting System (GFS) by including biomass burning aerosols. The availability of this information in near-real time is considered critical for both weather and air quality forecasting.

To meet the users' requirements, NESDIS/STAR has developed the Blended Global Biomass Burning Emissions Products (GBBEPx) from VIIRS fire observations onboard JPSS-1/NOAA-20 and JPSS-2/NOAA-21. Each output product file and the corresponding file naming convention are provided in Table 0-1.

1.2. Algorithm Overview

Table 1-1 displays the emissions monitored by the most recent packaged delivery of the GBBEPx system.

Table 1-1 - Emissions Monitored by GBBEPx

Emission Abbreviation	Meaning
BC	Black Carbon
CO	Carbon Monoxide
CO2	Carbon Dioxide
OC	Organic Carbon
PM2.5	Particulate Matter with a diameter less than 2.5 micrometers
SO2	Sulfur Dioxide
NH3	Ammonia
NOx	Nitrogen oxides

There is a linear correlation between fire radiative energy (FRE) and biomass burned for a certain time period (Wooster, 2003). There is no considerable variation in the energy content of dry biomass across different ecosystems and fuel types (Chapin et al., 2002). For a fire event, the actual heat yield is slightly influenced by environmental factors such as slope, fuel arrangement, and wind speed (Whelan, 1995). For each unit mass of dry fuel fully burned, the total amount of energy released can range from 16 to 22 MJ/kg (Lobert and Warnatz, 1993; Whelan, 1995; Trollope et al., 1996; Wooster et al., 2005).

Since FRE cannot be calculated from two VIIRS observations during a single day, the GBBEPx V5 algorithm estimates fire emissions directly from VIIRS fire radiative power (FRP) data. Figure 1-1 and Figure 1-2 provide an overview of the data processing flow necessary to generate the emissions product.

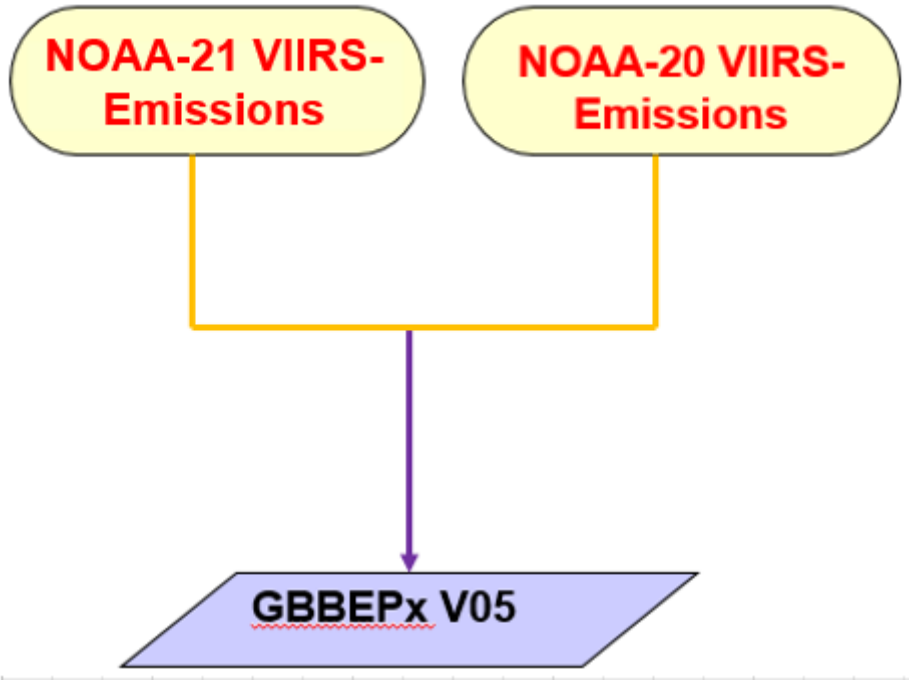

Figure 1-1 - Generation of GBBEPx V5 Products

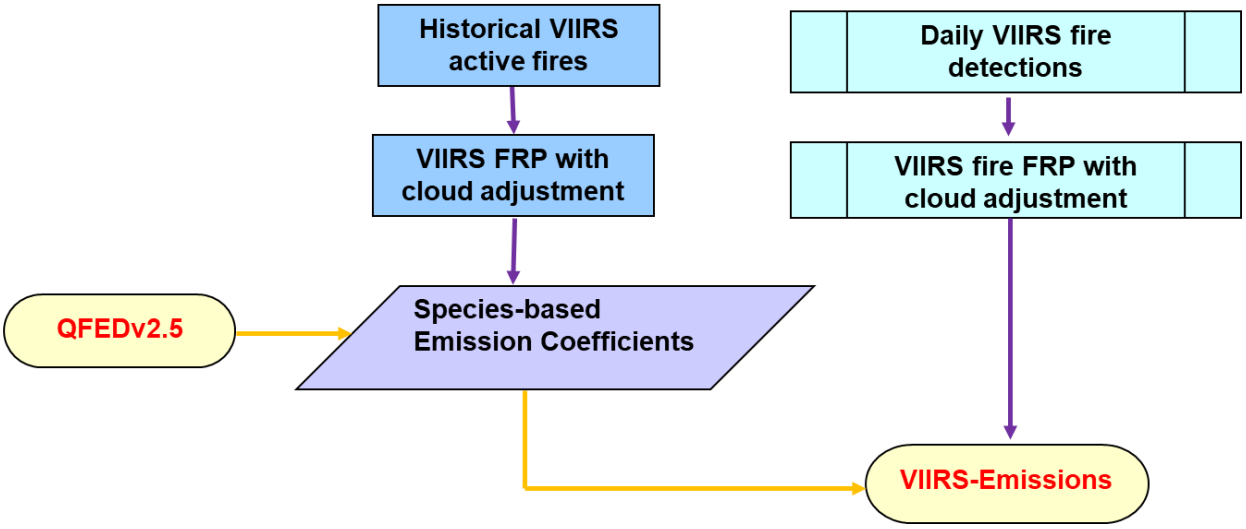

Figure 1-2 - Fire Emissions Estimate from VIIRS I-Band FRP[2]

First, VIIRS FRP data at 375m resolution (at nadir) is obtained from the VIIRS I-band Active Fire EDR product. Once obtained, the FRP observations are stratified based on four biome types: tropical forest, extratropical forest, savanna, and grassland. These biomes apply to all continents except Antarctica (i.e., North America, South America, Europe, Asia, Africa, Australia). In North America and Asia, the extratropical forest is further divided into additional forest biome types, including boreal forest. For each of these biomes, the FRP observations during one day for a single satellite are summed together and regridded to 0.05° grid cells. The areas of cloud-free and cloud cover pixels in each 0.05° grid cell are calculated separately. These calculations are used to adjust FRP because fire detections are generally obstructed in cloud cover pixels. The daily FRP flux within each grid cell is calculated using the cloud-adjusted FRP.

Emissions coefficients are calculated using historical VIIRS fire detection data and associating that data with QFED v2.5 products. The cloud adjusted FRP is summed up for a single day for different ecosystems and continents. Then the cloud adjusted FRP is linearly correlated to the QFED v2.5 emissions. The resulting linear slope is considered to be the emissions coefficients. These coefficients are used to calculate the daily biomass burning emissions from VIIRS fire detections. This process is performed for a single satellite at a time and is separate for each satellite.

1.3. Interfaces Overview

Before reviewing this System Maintenance Manual (SMM), please request the live **master NCCF SMM** (refer to ***System Maintenance Manual - NESDIS Common Cloud Framework (NCCF)***) from the OSPO PALs in Table 1-2. The NCCF system overview is described in the **master NCCF SMM: NCCF Description and Overview (or Document Object: 4,5).**

2 For a single satellite and QFED-based emission coefficients

2. Hardware

This section describes the GBBEPx hardware and system requirements.

2.1. Hardware Description

The hardware is described in the **master NCCF SMM: NCCF Description and Overview (or Document Object: 4,5): Infrastructure**.

2.2. Operating Requirements

The NCCF operating system description can be found in the **master NCCF SMM: Operating System (or Document Object: 64).**

2.3. System Requirements

2.3.1. Storage Requirements

Table 2-1 contains a list of storage requirements for all GBBEPx primary and ancillary input data, intermediate data, and output data. These requirements reflect the current build of GBBEPx. The approximate size listed is for a single file of the given storage item. For the static ancillary data storage item, the size of the whole directory is provided.

Table 2-1 - GBBEPx Storage Requirements

Catalog Item	Storage Item	Approximate Size
Input Satellite Data	EFIRE-VIIRSI	1.09 MB
	GITCO	100 MB
Input Ancillary Data	Dynamic Ancillary Data	N/A
	Static Ancillary Data	914 MB
Output Files	Final Output File	Daily Emissions in FV3 C384 Grid: 600 KB, Daily FRP in FV3 C384 Grid: 590 KB, Daily Emissions in FV3 C96 Grid: 37 KB, Daily FRP in FV3 C96 Grid: 37 KB, Daily Emissions: 200 KB, Blended Mean FRP: 200 KB, Daily Emissions at 0.1 x 0.1 Degree Grid: 3.9 MB, Spatial Pattern of PM2.5 in JPG Map: 176 KB
System Files	Log File	87 KB

2.3.2. Computer Resource Requirements

The following libraries and utilities are required by the GBBEPx algorithm package:

- GNU Fortran / GCC
- HDF5 Fortran Library
- NetCDF4 Fortran Library
- NetCDF4 C Library
- Zlib

Please refer directly to the algorithm package for any version numbers associated with these libraries and utilities.

2.3.3. Communication Needs

The target system for GBBEPx is the NESDIS Common Cloud Framework (NCCF). The communication needs of the system must be sufficient to meet all requirements specified throughout Section **Error! Reference source not found.**.

3. Software

This section describes GBBEPx software. The GBBEPx algorithm directory and source code are listed below.

3.1. Software Description

The GBBEPx algorithm package is composed of one processing unit: the run_gbbepx processing unit. Table 3-1 provides a description of the responsibilities of each processing unit.

Table 3-1 - SFR Processing Unit Description

Processing Unit	Description
run_gbbepx	Daily processing unit, should be run once per day Time triggered Processes data acquired from the 24-hour period comprising the previous day Granules must fall completely within the given processing date Responsible for producing all GBBEPx expected output product files 8 NetCDF4 Files 132 Binary Files 1 JPG File

3.2. Directory Description

This section includes a top level directory tree describing the GBBEPx algorithm package. Please note that this is only a top-level directory tree reflects the directory structure of the algorithm package immediately after it is unpacked in the current working directory. The main software directory is fully expanded to provide additional software information to end users of this document and the expected output files.

```
DATA
|
DOCS
|
gbbepx
├── ancillary_data
|   ├── C401_Grids
|   ├── dap_version.txt
```

```
│   ├── FRP_density_climatology
│   ├── FV3_C384Tiles
│   ├── gl_igbp_new
│   ├── Globalshp
│   ├──
VIIRS_Iband_emissions_scalingFactors_LCs_Boreal_Dec2021_Notes.txt
│   ├── VIIRS_Iband_emissions_scalingFactors.txt
│   ├── VIIRS_Iband_pixelsize.csv
│   ├── VIIRS_Mband_emissions_scalingFactors_2022_Notes.txt
│   ├── VIIRS_Mband_emissions_scalingFactors.txt
│   └── VIIRS_Mband_pixelsize.csv
├── bin
│   ├── agg_FV3C384_writeBN_C96.exe
│   ├── agg_p05CloudFire_2_FV3C384.exe
│   ├── agg_p05CloudFire_2_stdGrid.exe
│   ├── blend_agg_p05EmisFRP_QA_writeNC4_p10.exe
│   ├── blend_agg_p05EmisFRP_QA_writeNC4_p25.exe
│   ├── blend_agg_p05EmisFRP_writeBN_C384.exe
│   ├── blend_FV3CloudFire_QA_writeBN_C384.exe
│   ├── calc_emis_mass_p05.exe
│   ├── cBinary2FortranBinary.exe
│   ├── com_tools.pl
│   ├── execheckSums.chk
│   ├── GBBEP-Geo_QFED_1.pl
│   ├── generate_FV3_GBBEPx_and_FRP.pl
│   ├── gridding_FRP_area_p05.exe
│   ├── readAF.exe
│   ├── readme
│   ├── sp_emission.py
│   ├── VIIRS_JPSS01_emissions.pl
│   └── VIIRS_NDE_emissions.pl
├── build_alg
├── copyOTS
├── installOTS
├── integrator_gbbepx.diff
├── packages
│   ├── aim
│   ├── gbbepx
│   └── __init__.py
├── README.md
├── setEnvLib
│   ├── build_scripts
│   ├── README.md
│   ├── templates
│   └── test
│
```

```
├── setEnv.sh
├── setEnvStaticRuntime.sh
├── source
│   ├── agg_FV3C384_writeBN_C96.c
│   ├── agg_FV3C384_writeBN_C96.o
│   ├── agg_p05CloudFire_2_FV3C384.c
│   ├── agg_p05CloudFire_2_FV3C384.o
│   ├── agg_p05CloudFire_2_stdGrid.c
│   ├── agg_p05CloudFire_2_stdGrid.o
│   ├── blend_agg_p05EmisFRP_QA_writeNC4_p10.c
│   ├── blend_agg_p05EmisFRP_QA_writeNC4_p10.o
│   ├── blend_agg_p05EmisFRP_QA_writeNC4_p25.c
│   ├── blend_agg_p05EmisFRP_QA_writeNC4_p25.o
│   ├── blend_agg_p05EmisFRP_writeBN_C384.c
│   ├── blend_agg_p05EmisFRP_writeBN_C384.o
│   ├── blend_FV3CloudFire_QA_writeBN_C384.c
│   ├── blend_FV3CloudFire_QA_writeBN_C384.o
│   ├── calc_emis_mass_p05.c
│   ├── calc_emis_mass_p05.o
│   ├── cBinary2FortranBinary.f90
│   ├── cBinary2FortranBinary.o
│   ├── err_consts.h
│   ├── error_message.c
│   ├── error_message.h
│   ├── error_message.o
│   ├── error_messaging.f90
│   ├── error_messaging.o
│   ├── error_module.h
│   ├── errormsg_modules.f90
│   ├── errormsg_modules.mod
│   ├── errormsg_modules.o
│   ├── global.h
│   ├── gridding_FRP_area_p05.c
│   ├── gridding_FRP_area_p05.o
│   ├── make_all.bash
│   ├── make_c.mk
│   ├── make_f.mk
│   ├── netcdf_tools.c
│   ├── netcdf_tools.h
│   ├── netcdf_tools.o
│   ├── readAF.c
│   ├── readAF.o
│   └── tools.sh
├── test_alg
└── test_data
```

```
      ├── conda_environment.yml
      └── config_gbbepx.yml
wrapper
├── config
│   ├── application_info.yaml
│   ├── docker_info.yaml
│   └── path.PCF
├── launch.py
├── __pycache__
│   └── util.cpython-39.pyc
├── util.py
└── wrapper.py
```

Table 3-2 contains a brief description of each of the top-level directories.

Table 3-2 - GBBEPx Top Level Directory Tree Description

Directory	Description
DATA	Contains test data associated with the algorithm package; includes input, output, and logs
DOCS	Contains documentation associated with the algorithm package
gbbepx	Contains the science code supporting the algorithm package; Contains Python wrapper scripts and configuration YAML files to launch the Docker container, run the Docker container, and support the application

3.3. Source Code Description

Table 3-3 describes each of the key files present in the source code of the GBBEPx algorithm package. When possible, the descriptions in the table are from the header of each source code file.

Table 3-3 - GBBEPx Source Code Description

File Name	Description
agg_FV3C384_writeBN_C96.c	This script estimates emissions flux in FV3 C96 grids from that in C384 grids
agg_p05CloudFire_2_FV3C384.c	Generation of emission flux in NOAA FV3-C384 grid format based on VIIRS I-band active fire product (NDE_AF) and geolocation product (GITCO)
agg_p05CloudFire_2_stdGrid.c	Calculate FRP (MW) and Area (mk2) at a specific grid level from VIIRS moderate-band active fire product (NDE_AF) and geolocation product (GITCO)
blend_FV3CloudFire_QA_writeBN_C384.c	Generation of mean FRP in NOAA FV3-C384 grid format based on VIIRS FRP
blend_agg_p05EmisFRP_QA_writeNC4_p10.c	This is to generate NetCDF4 for biomass-burning emissions
blend_agg_p05EmisFRP_QA_writeNC4_p25.c	This is to generate NetCDF4 for biomass-burning emissions
blend_agg_p05EmisFRP_writeBN_C384.c	Generation of mean emission flux in NOAA FV3-C384 grid format based on VIIRS emissions fluxes
cBinary2FortranBinary.f90	This module is used to convert c-style binary into fortran-style binary
calc_emis_mass_p05.c	Calculate VIIRS-FRP based, cloud-corrected emission mass at 0.05 degree
err_consts.h	This is a module defining integer byte sizes. It is to be included in all code.

File Name	Description
error_message.c	This function takes a program name, error message, and status. It writes an error message to standard out and then performs the required action based on the program status
error_message.h	N/A
error_messaging.f90	Routine to write out messages if errors occur during processing
error_module.h	This is a module defining error message definitions
errormsg_modules.f90	Module to hold specification kinds, with parameter attributes, for variable declarations
global.h	N/A
gridding_FRP_area_p05.c	Gridding FRP and area of fire-clear water-clear land pixels into 0.05deg based on VIIRS moderate-band active fire product (NDE_AF) and geolocation product (GMTCO)
make_all.bash	N/A
make_c.mk	To build all C binaries
make_f.mk	To build all C binaries
netcdf_tools.c	This is to generate NetCDF4 for biomass-burning emissions
netcdf_tools.h	N/A
readAF.c	Read Lon, Lat, FRP, SampleNumber, DOY information from VIIRS moderate-band active fire product (NDE_AF)
scale_emission.c	Scale the 0.05-deg emission mass and meanFRP for each sensor to make it closer to the QFED product; Blend different sensors at 0.05-degree, then aggregate blended emission to 0.25-deg; Aggregate emission/FRP from 0.05 degree to 0.25-deg, then blend different sensors at 0.25-deg calculate the ratio = 0.25-deg emission blended at 0.25-deg / 0.25-deg emission blended at 0.05-deg then for each 0.05-deg pixel within the 0.25-deg grid, multiple the ratio
tools.sh	N/A

4. Normal Operations

This section describes system control, installation, configuration, operations, and distribution procedures for the GBBEPx product system.

4.1. System Control

The GBBEPx system and processing control files are listed in this section.

4.1.1. System Control Files

4.1.1.1. Application Information YAML File

There must be at least one YAML file present in the algorithm package. This file is responsible for guiding the inner script as it chooses what processing or preprocessing steps will occur, which granule to be processed, and which span of time will be observed. For convenience, all items in the file that have a possibility of variation or are system specific will be located at the top of the YAML file as anchors. These arguments can be seen in Table 4-1.

Table 4-1 - Application Information YAML File Keys

Key	Description of Value
startttime	Processing start date for given run in YYYYMMDDHHMMSS format (e.g., "20221010000000")
stream_logging_level	Logging level for stream
prod_site	Production site for processing
prod_env	Production environment for processing

4.1.2. Processing Control Files

There must be at least one YAML file present in the algorithm package that contains information concerning the setup of the Docker run command. For convenience, all items in the file that have a possibility of variation or are system specific will be located at the top of the YAML file as anchors. These arguments can be seen in Table 4-2.

Table 4-2 - Docker Information YAML File Keys

Key	Description of Value
data_dir	Full path to directory containing data for run
sw_dir	Full path to directory containing GBBEPx source code, static ancillary files, and algorithm scripts
logs_dir	Full path to logging directory
output_dir	Full path to output directory
wrapper_dir	Full path to directory containing Docker wrapper code
application_yaml	Full path to application_yaml
application_pcf	Path to static PCF file used in GBBEPx processing
caseid	Case ID for execution

4.2. Installation

4.2.1. Installation Items

For more information concerning the installation items associated with GBBEPx, please refer to Section **Error! Reference source not found.**.

4.2.2. Compilation Procedures

1. cd Source/
2. Review make_all.bash, make_c.mk, and make_f.mk and be sure all the install, libs ,and include directories are within reach.

3. ./build_alg new
4. This will run clean, make, and install
5. The make will produce *.exe listed under /bin/

4.3. Configuration Procedures

Please refer to the README document included with this delivery package.

See the **master NCCF SMM: Installation Procedures (or Document Object: 77)**

4.3.1. Production Rules

The GBBEPx algorithm is time-triggered once per day and runs using data acquired from the 24-hour period spanning the previous day. Each granule used as input to the GBBEPx algorithm package must lie completely within the given processing date. For example, if the processing date is June 2nd (i.e., 06/02), the GITCO_j01_d20220601_t2359269_e0000511_b54900_c20220602012106179826_oeac_ops.h5 granule should not be used to generate GBBEPx expected output files. Even though the granule's coverage lies partially within the given processing date, it does not fall completely within the given processing date, so it should not be used.

4.4. Operations Procedures

4.4.1. Normal Operations

Please refer to the **master NCCF SMM: Procedures for Normal Operations (or Document Object: 10)**

4.5. Distribution

4.5.1. Data Transfer/Communications

Please refer to the master NCCF SMM: Data Transfer/Communications and Data Preparation (or Document Object 73, 81)

4.5.2. Distribution Restrictions

There are no restrictions on GBBEPx product distribution.

4.5.3. External Product Tools

There are no external product tools provided with the GBBEPx algorithm package. For the NetCDF4 expected output files, end users can utilize their choice of tool to view these files.

5. Monitoring and Maintenance

The GBBEPx monitoring, maintenance, and program backup procedures are discussed below.

5.1. Job Monitoring

5.1.1. Product Monitoring Visualization and Alarms

Product quality is monitored using the NCCF Product Monitoring Tool at

https://nccf.espc.nesdis.noaa.gov/mtool/index.html. Users can use this page to monitor summaries of the GBBEPx product quality based on parameter thresholds determined by the PAL.

The NCCF GBBEPx product webpage at https://www.ospo.noaa.gov/Products/land/gbbepx/ can also be used to view GBBEPx images of select parameters in near real-time. These images are updated daily.

NCCF PG Product Latency and Product Missing Alarms can be found at https://us-east-1.console.aws.amazon.com/cloudwatch/home?region=us-east-1#alarmsV2.

5.2. Product Monitoring

5.2.1. Unit Test Plans

ASSISTT Unit Tests were performed for each of the cases provided below. For each case, sample data was run ensuring input files were identical to those used by the Science Team's run, and then the two sets of files were checked for differences. Only precision differences were noted. Specifically, the following cases were used:

- NOAA-20/SNPP EFIRE-VIIRSI/GITCO data from October 1, 2023
- NOAA-20/NOAA-21 EFIRE-VIIRSI/GITCO data from October 1, 2023

5.2.2. Internal Product Tools

There are no internal product tools associated with the GBBEPx algorithm package.

5.2.3. Performance Statistics

The NCCF product quality monitoring system is used to generate the near real time statistics from the metadata included in the GBBEPx algorithm package's expected output product files. The system also monitors the quality of these products. These performance statistics are kept in the NCCF product quality monitoring database.

5.3. Maintenance

5.3.1. Monitoring

See the **master NCCF SMM: Maintenance Utilities (or Document Object: 84)**

5.3.1.1. Ingest Monitoring

See the **master NCCF SMM: Data Transfer/Communications and Data Preparation (or Document Object: 73 and 81)**

5.3.2. Science Maintenance

If applicable, product quality monitoring is performed by the OSPO product quality monitoring system

and the developers; these personnel should communicate regularly to discuss potential data quality issues and to formulate and schedule updates to the GBBEPx algorithm package code.

5.3.3. Library Maintenance

See the **master NCCF SMM: Library Maintenance (or Document Object: 71)**

5.3.4. Special Maintenance Procedures

See the **master NCCF SMM: Special Maintenance Procedures (or Document Object: 72)**

5.3.5. Maintenance Utilities

See the **master NCCF SMM: Maintenance Utilities (or Document Object: 84)**

5.4. Program Backup Procedures

See the **master NCCF SMM: Data Recovery Procedures and Program Recovery Procedures (or Document Object: 89, 90)**

6. Troubleshooting

This section describes GBBEPx program diagnosis and recovery, as well as application and system shutdown and restart procedures.

6.1. Program Diagnosis and Recovery

See the **master NCCF SMM: Problem Diagnosis and Recovery Procedures (or Document Object: 82)**

6.1.1. Quality Control Output

Each of the NetCDF4 output files generated by the GBBEPx algorithm package will have a quality_information variable. Table 6-1 provides a description of the quality_information variable.

Table 6-1 - GBBEPx Quality Information

Quality Information	Description
total_number_retrievals	Provides the total number of retrievals present within the file
percentage_optimal_retrievals	Provides the percentage of optimal retrievals present within the file
percentage_sub_optimal_retrievals	Provides the percentage of sub-optimal retrievals present within the file
percentage_bad_retrievals	Provides the percentage of bad retrievals present within the file

6.1.2. Error Correction

See the **master NCCF SMM: Error Correction – Warnings and Messages for Systems and Error Codes, Menus and Navigation (or Document Object: 43,44,45)**

6.1.3. Problem Diagnosis and Recovery Procedures

See the **master NCCF SMM: Problem Diagnosis and Recovery Procedures (or Document Object: 82)**

6.1.4. Data Recovery Procedures

See the **master NCCF SMM: Data Recovery Procedures (or Document Object: 89)**

6.1.5. Program Recovery Procedures

6.2. Application Shutdown and Restart

See the **master NCCF SMM: Program Recovery Procedures (or Document Object: 90)**

6.2.1. Application Shutdown Procedures

See the **master NCCF SMM: Application Shutdown Procedures (or Document Object: 94)**

6.2.2. Application Restart Procedures

See the **master NCCF SMM: Application Restart Procedures (or Document Object: 92)**

6.3. System Shutdown and Restart

See the **master NCCF SMM: Reboot Procedures, Restart Procedures and Shutdown Procedures (or Document Object: 83, 93, 95)**

7. Appendix

This appendix includes descriptions of the GBBEPx product data flow, data files, and output and archive data sets.

7.1. Data Flow

Figure 1-1 and Figure 1-2 depict data flow diagrams for the GBBEPx algorithm package.

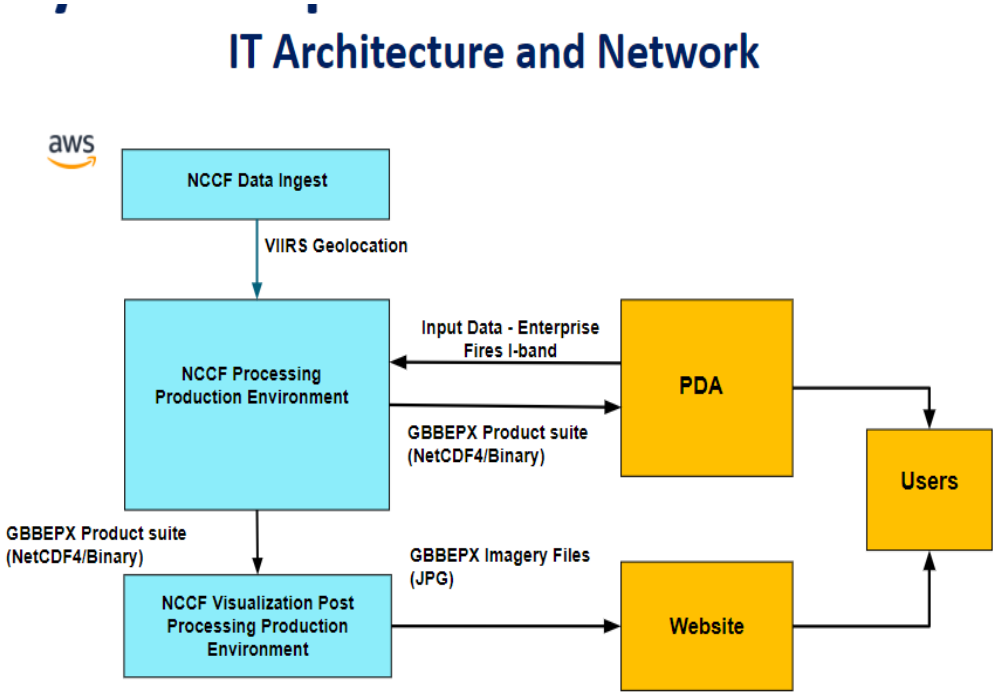

Figure 7-1 - IT Architecture & Network

7.2. Input Data Files

7.2.1. Input Satellite Data

There are two types of satellite input data required by the GBBEPx system. Table 7-1 contains information describing the file name convention associated with these files.

Table 7-1 - GBBEPx Input File Naming Convention

Type of Input	File Naming Convention
Terrain-Corrected I-Band Geolocation (GITCO) HDF5 Files	GITCO_<sat>_d<YYYYMMDD>_t<HHMMSSS>_e<HHMMSSS>_b<NNNNN>_c <YYYYMMDDHHMMSSSssss>_<cccc>_ops.h5

Type of Input	File Naming Convention
VIIRS Enterprise Fire I-Band NetCDF4 Files	EFIRE-VIIRSI_<version>_<sat>_s<YYYYMMDDHHMMSSS>_e<YYYYMMDDHHMMSSS>_c<YYYYMMDDHHMMSSS>.nc

Where:

<YYYYMMDD>	→	the 4-digit year, 2-digit month, 2-digit day associated with the file
<HHMMSSS>	→	the 2-digit hour, 2-digit minute, 3-digit second associated with the file
<version>	→	indicates the Active Fires product version number
<sat>	→	indicates the satellite associated with the file (e.g., j01, j02)
<NNNNN>	→	indicates the orbit number
<cccc>	→	indicates the operational environment associated with the file

For information on the production rules associated with these files, please refer to Section **Error! Reference source not found.**.

7.3. Input Ancillary Data

7.3.1. Static Ancillary Data

All static ancillary data needed during a processing run of the GBBEPx system can be found in the following directory:

<base_dir>/gbbepx/ancillary_data

Within this directory path, <base_dir> refers to the top level installation path for the GBBEPx algorithm package.

These files support the algorithm package's generation of the expected output files by supplying the following information:

- Emission factors
- Scaling factors
- Climatological diurnal pattern in FRP
- Emissions coefficients for VIIRS FRP
- IGBP land cover

7.3.2. Dynamic Ancillary Data

There are no dynamic ancillary data files associated with the GBBEPx processing system.

7.4. Output Data Set Description

Table 0-1 contains information describing each GBBEPx v5 output file.

Table 7-2, Table 7-3, and Table 7-4 display output file and metadata information for the GBBEPx product files.

Table 7-2 - Daily Emissions at 0.1 X 0.1 Degree Grid Output File Description

Variable	Type	Description	Dim	Units	Range
BC	64-bit floating point	BC Biomass Emissions	3	kg s-1 m-2	0.0, 100000.0
CO	64-bit floating point	CO Biomass Emissions	3	kg s-1 m-2	0.0, 100000.0
CO2	64-bit floating point	CO2 Biomass Emissions	3	kg s-1 m-2	0.0, 100000.0
CloudPerc	32-bit integer	Mean Percentage of Clouds	3	Percentage (%)	0, 100
FirePerc	32-bit integer	Wildfire Fraction of Observed Area	3	Percentage (%)	0, 10000
Latitude	32-bit floating point	Latitude	N/A	degrees_north	-90.0, 90.0
Longitude	32-bit floating point	Longitude	N/A	degree_east	-180.0, 180.0
Max_emission	64-bit floating point	Maximum PM2.5 emissions	1	kg s-1 m-2	N/A
Max_emission_col	32-bit integer	The column of maximum PM2.5 emissions, start from (0,0)	1	1	N/A
Max_emission_row	32-bit integer	The row of maximum PM2.5 emissions, start from (0,0)	1	1	N/A
MeanFRP	64-bit floating point	Mean Fire Radiative Power	3	MW	0.0, 100000.0
NH3	64-bit floating point	NH3 Biomass Emissions	3	kg s-1 m-2	0.0, 100000.0
NOx	64-bit floating point	NOx Biomass Emissions	3	kg s-1 m-2	0.0, 100000.0
NumSensor	32-bit integer	Number of Sensors Observed Fires	3	unitless	0, 2

Variable	Type	Description	Dim	Units	Range
OC	64-bit floating point	OC Biomass Emissions	3	kg s-1 m-2	0.0, 100000.0
PM2.5	64-bit floating point	PM2.5 Biomass Emissions	3	kg s-1 m-2	0.0, 100000.0
QCAll	8-bit character	Retrieval quality: 0: high, 1: medium, 2: low, 3: no retrieval	3	1	0, 3
SO2	64-bit floating point	SO2 Biomass Emissions	3	kg s-1 m-2	0.0, 100000.0
Time	32-bit floating point	Time	N/A	N/A	N/A
TotalEmis_region_Africa	64-bit floating point	Region-based total mass of PM2.5 emissions	1	Gg	N/A
TotalEmis_region_Asia	64-bit floating point	Region-based total mass of PM2.5 emissions	1	Gg	N/A
TotalEmis_region_Australia	64-bit floating point	Region-based total mass of PM2.5 emissions	1	Gg	N/A
TotalEmis_region_Europe	64-bit floating point	Region-based total mass of PM2.5 emissions	1	Gg	N/A
TotalEmis_region_NorthAmerica	64-bit floating point	Region-based total mass of PM2.5 emissions	1	Gg	N/A
TotalEmis_region_SouthAmerica	64-bit floating point	Region-based total mass of PM2.5 emissions	1	Gg	N/A
quality_information	8-bit character	total_number_retrievals, percentage_optimal_retrievals, percentage_sub_optimal_retrievals, percentage_bad_retrievals	1	N/A	N/A

Table 7-3 - Daily Emissions at 0.25°×0.3125° Grid Output File Description

Variable	Type	Description	Dim	Units	Range
Latitude	32-bit floating point	Latitude	N/A	degrees_north	-90.0, 90.0
Longitude	32-bit floating point	Longitude	N/A	degrees_east	-180.0, 180.0
Max_emission	64-bit floating point	Maximum emissions	1	kg s-1 m-2	N/A

Variable	Type	Description	Dim	Units	Range
Max_emission_col	32-bit integer	The column of maximum emissions, start from (0,0)	1	1	N/A
Max_emission_row	32-bit integer	The row of maximum emissions, start from (0,0)	1	1	N/A
QCAll	8-bit character	Retrieval quality: 0: high, 1: medium, 2: low, 3: no retrieval	3	1	0, 3
Time	32-bit floating point	Time	N/A	days since 2021-03-29 12:00:00	N/A
TotalEmis_region_Africa	64-bit floating point	Region-based total mass of emissions	1	Gg	N/A
TotalEmis_region_Asia	64-bit floating point	Region-based total mass of emissions	1	Gg	N/A
TotalEmis_region_Australia	64-bit floating point	Region-based total mass of emissions	1	Gg	N/A
TotalEmis_region_Europe	64-bit floating point	Region-based total mass of emissions	1	Gg	N/A
TotalEmis_region_NorthAmerica	64-bit floating point	Region-based total mass of emissions	1	Gg	N/A
TotalEmis_region_SouthAmerica	64-bit floating point	Region-based total mass of emissions	1	Gg	N/A
biomass	64-bit floating point	BC Biomass Emissions	3	kg s-1 m-2	0.0, 100000.0
quality_information	8-bit character	total_number_retrievals, percentage_optimal_retrievals, percentage_sub_optimal_retrievals, percentage_bad_retrievals	1	N/A	N/A

Table 7-4 - Blended MeanFRP at 0.25°×0.3125° Grid Output File Description

Variable	Type	Description	Dim.	Units	Range
CloudPerc	32-bit integer	Mean Percentage of Clouds	3	Percentage (%)	0, 100
FirePerc	32-bit integer	Wildfire Fraction of Observed Area	3	Percentage (%)	0.0, 10000.0
Latitude	32-bit floating point	Latitude	1	degrees_north	-90.0, 90.0
Longitude	32-bit floating point	Longitude	1	degrees_east	-180.0, 180.0

Variable	Type	Description	Dim.	Units	Range
MeanFRP	64-bit floating point	Mean Fire Radiative Power	3	MW	0.0, 100000.0
NumSensor	32-bit integer	Number of Sensors Observed Fires	3	N/A	0, 2
QCAll	8-bit character	Retrieval quality: 0: high, 1: medium, 2: low, 3: no retrieval	3	1	0, 3
Time	32-bit floating point	Time	1	Days since 2022-06-02 12:00:00	N/A
quality_information	8-bit character	total_number_retrievals, percentage_optimal_retrievals, percentage_sub_optimal_retrievals, percentage_bad_retrievals	1	N/A	N/A

Product-monitoring metadata is included with all NetCDF output files associated with the GBBEPx algorithm package. Both collection and geographic level metadata are included in the files. The metadata associated with the NetCDF files can be found in the following in Table 7-5.

Table 7-5 - Daily Emissions at 0.1 X 0.1 Degree Grid, Daily Emissions, Blended MeanFRP Output File Metadata

Name	Description	Type	Array Size
Conventions	Indicates the CF Convention the file complies with	String	Scalar
EastBoundingCoordinate_degree	Provides the East Bounding Coordinates	32-bit floating point	1
NorthBoundingCoordinate_degree	Provides the North Bounding Coordinates	32-bit floating point	1
PRODUCT_ALGORITHM_VERSION	Provides the product algorithm version	String	Scalar
RangeBeginningDate_YYYY_DOY	Provides the beginning date of the range	String	Scalar
RangeBeginningTime_UTC_hour	Provides the beginning time of the range	String	Scalar
RangeEndingDate_YYYY_DOY	Provides the ending date of the range	String	Scalar
RangeEndingTime_UTC_hour	Provides the ending time of the range	String	Scalar
SouthBoundingCoordinate_degree	Provides the South Bounding Coordinates	32-bit floating point	1
TIME_RANGE	Provides the time range	String	Scalar
WestBoundingCoordinate_degree	Provides the West Bounding Coordinates	32-bit floating point	1
_NCProperties	NetCDF and HDF version numbers, will be generated automatically	String	Scalar
cdm_data_type	Description of the geographic category associated with the file	String	Scalar
creator_email	Provides an email address for the algorithm development team	String	Scalar

Name	Description	Type	Array Size
creator_name	Provides the name of the algorithm team responsible for developing the product	String	Scalar
creator_url	Provides a URL to a website associated with the products that end-users can access	String	Scalar
date_created	Provides the UTC time the product file is created in 4-digit year, 2-digit month, 2-digit day, 2-digit minute, 2-digit second format	String	Scalar
day_night_data_flag	Will be set to "day," "night," or "both" depending on sunlight conditions of the observation	String	Scalar
geospatial_lat_max	Indicates the maximum geospatial latitude	64-bit floating point	1
geospatial_lat_min	Indicates the minimum geospatial latitude	64-bit floating point	1
geospatial_lat_resolution	Indicates the geospatial latitude resolution	64-bit floating point	1
geospatial_lat_units	Indicates the unit associated with geospatial latitude	String	Scalar
geospatial_lon_max	Indicates the maximum geospatial longitude	64-bit floating point	1
geospatial_lon_min	Indicates the minimum geospatial longitude	64-bit floating point	1
geospatial_lon_resolution	Indicates the geospatial longitude resolution	64-bit floating point	1
geospatial_lon_units	Indicates the unit associated with geospatial longitude	String	Scalar
history	Provides the algorithm name and version used to create the product file	String	Scalar
id	This attribute should be a unique identifier (e.g., the NetCDF file name or another Unique User Identifier (UUID)) for the product	String	Scalar
institution	Indicates institution responsible for the product file	String	Scalar
instrument	Provides the name of the satellite instrument used to create the product	String	Scalar
keywords	A comma-separated list of key words and/or phrases associated with the product; May be common words or phrases, terms from a controlled vocabulary, or URIs for terms from a controlled vocabulary	String	Scalar
metadata_link	A URL providing a location with more complete metadata or a product information webpage; Can also be the name of the file	String	Scalar
naming_authority	Provides the name of the organization responsible for providing the "id" attribute	String	Scalar
platform	Provides the satellite(s) used to derive the product	String	Scalar
processing_level	Describes the level of processing associated with the product file	String	Scalar

Name	Description	Type	Array Size
production_environment	Describes the processing string that generates the product, will be: "DE" - Development, "UAT" - User Acceptance Test, "OE" - Operational Productions	String	Scalar
production_site	Describes the processing site of the product	String	Scalar
project	Indicates the project responsible for generation of all expected output files	String	Scalar
publisher_email	Provides an email that can be used to contact the person or entity who is responsible for publishing the output files to the proper end users	String	Scalar
publisher_name	Provides the name of the organization responsible for the product's publication	String	Scalar
publisher_url	Provides URL of publisher's website	String	Scalar
source	This attribute lists all major input files as a comma delimited list	String	Scalar
standard_name_vocabulary	Provides the name and version number of the CF standard Name Table used to create the product file	String	Scalar
summary	Provides a brief description of the product	String	Scalar
time_coverage_end	This attribute should be set to the UTC end time of the observation used for the file in 4-digit year, 2-digit month, 2-digit day, 2-digit hour, 2-digit minute, 2-digit second format	String	Scalar
time_coverage_start	This attribute should be set to the UTC start time of the observation used for the file in 4-digit year, 2-digit month, 2-digit day, 2-digit hour, 2-digit minute, 2-digit second format	String	Scalar
title	Indicates the short name of the product	String	Scalar

7.5. Archive Data Description

The GBBEPx NetCDF4 format expected output products will be archived at NCEI.

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9. Acronyms

Acronym	Definition
ASCII	American Standard Code for Information Interchange
ATBD	Algorithm Theoretical Basis Document
BBEP	Biomass burning emission product
CDL	Common Data Language
CDR	Critical Design Review
CLASS	Comprehensive Large Array-data Stewardship System
CPU	Central Processing Unit
DAP	Delivered Algorithm Package
DDS	Data Distribution Server
DHS	Data Handling System
DOD	Department of Defense
EDR	Environmental Data Record
EPL	Enterprise Product Lifecycle
ESPC	Environmental Satellite Processing Center
GB	Gigabyte
HMS	Hazard Mapping System
ICD	Interface Control Document
IDPS	Interface Data Processing Segment
IP	Intermediate Product
IPD	NOAA's Internal Processing Division
IPT	Integrated Product Team
JPSS	Joint Polar Satellite System
NCDC	National Climate Data Center
NCEP	National Center for Environmental Prediction
NESDIS	National Environmental Satellite, Data, and Information Service
netCDF	network Common Data Format version
NOAA	National Oceanic and Atmospheric Administration
NWP	Numerical Weather Prediction
OSDPD	Office of Satellite Data Processing and Distribution
SMCD	Satellite Meteorology and Climate Division
SPSRB	Satellite Products and Services Review Board
STAR	Center for Satellite Applications and Research
SWA	Software Architecture Document
WF_ABBA	Wildfire Automated Biomass Burning Algorithm
VIIRS	Visible Infrared Imaging Radiometer Suite
SNPP	Suomi National Polar-orbiting Partnership