NOAA NESDIS
CENTER for SATELLITE APPLICATIONS and RESEARCH

The Blended Global Biomass Burning Emissions Product from MODIS and Geostationary Satellites (GBBEPx) Maintenance Manual

Version 1.1

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AUTHORS:

Xiaoyang Zhang (GSCE, South Dakota State University)
Shobha Kondragunta (NOAA/NESDIS/STAR)
Arlindo Da Silva (NASA)
Sarah Lu (IMSG@NOAA/NWS/NCEP)
Hyuncheol Kim (IMSG@NOAA/ARL)
Hanjun Ding (NOAA/OSDPD)
Yufeng Zhu (IMSG @NOAA/OSDPD)
Zhaohui Cheng (NOAA/OSDPD)

APPROVAL SIGNATURES:

_____

Shobha Kondragunta (STAR) Date
Project Lead

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1. PRODUCTS

This is an external user's manual document describing the NOAA GBBEPx product and output files. The GBBEPx product system was developed at the Center for Satellite Applications and Research (STAR). It will be delivered to the Office of Satellite and Product Operations (OSPO) to be run operationally.

The intended users of the External Users Manual (EUM) are end users of the output products and files, and the product verification and validation (V&V) teams. The purpose of the EUM is to provide product users and product testers with information that will enable them to acquire the product, understand its features, and use the data. External users are defined as those users who do not have direct access to the processing system.

1.1. Product Overview

1.1.1. Product Requirements

The GBBEPx is derived based on SPSRB requirement (**SPSRB #: 1009-0013**). The NOAA Environmental Modeling System (NEMS) will serve as the next-generation operational common model infrastructure expected to be running at the NCEP as early as 2015. NEMS is ESMF-based and is designed to enhance the interoperability of the operational model production suite. NEMS will have various components in dynamic, physics, and chemistry and communicated with each other through EMSF framework and its development involved institutions across the NOAA. For operational global forecasting, NCEP is testing the NEMS system with GFS meteorology (NEMS/GFS) and also with NASA-GOCART aerosol module (referred to as NEMS/GFS-GOCART). NEMS/GFS-GOCART with dust only forecasting is tested and expected to be implemented in Q3FY12. With the anticipation of the NEMS will be implemented in the near future, NCEP is developing the GSI capability to ingest the first guess fields from NEMS in the past few years. GSI is now able to perform some NEMS/GFS data assimilations on meteorology fields (referred to as NEMS/GDAS), as well as to ingest the NEMS/GFS-GOCART aerosols fields and MODIS aerosol optical depth observation for aerosol data assimilation developments (referred to as NEMS/GFS-GOCART/DAS). In support of NCEP's model development and subsequent operational deployment, NOAA/NESDIS and NASA have developed biomass burning emission datasets that will be transitioned to operations for NCEP's model applications.

1.1.2. Product Team

The GBBEPx development product team consists of members from STAR and OSPO. The roles and contact information for the different product team members are identified in Table 1-1.

Table 1-1 Product Team Members

Team Member	Division	Role	Contact Info
Shobha Kondragunta	STAR	STAR Product Lead	5825 University Research Ct College Park, MD 20740 Phone: 301-683-2565 Email: Shobha.Kondragunta@noaa.gov
Xiaoyang Zhang	GSCE at SDSU	Algorithm development and programmer	Wecota Hall, Box 506B, Brookings, SD, 57007 Phone: 605-688-6714 Email: Xiaoyang.zhang@sdstate.edu
Sarah Lu	IMSG at NWS	Processing data in NEMS/GFS-GOCART	sarah.lu@noaa.gov
Hyun Kim	ARL	Data comparison	hyun.kim@noaa.gov
Arlindo DeSilva	NASA	QFED development	arlindo.dasilva@nasa.gov
Zhaohui Cheng	OSPO	Product Area Lead (PAL)	5825 University Research Ct College Park, MD 20740 zhaohui.cheng@noaa.gov
Hanjun Ding	OSPO	Product Area Lead (PAL)	5825 University Research Ct College Park, MD 20740 Hanjun.ding@noaa.gov
Yufeng Zhu	OSPO	Implementation of operational code	5825 University Research Ct College Park, MD 20740 yufeng.zhu@noaa.gov

1.1.3. Product Description

The GBBEPx system produces global biomass burning emissions. The product contains daily global biomass burning emissions (PM2.5, BC, CO, CO2, OC, and SO2) blended fire

observations from MODIS and geostationary satellites. It also produces hourly emissions from geostationary satellites. The details of the algorithm used to generate these products are contained in the peer-reviewed articles listed in the section of reference.

1.2. Product History

GBBEPx is a global product of biomass burning emissions extended from North America biomass burning emissions. Previously, the Geostationary Operational Environmental Satellite Biomass Burning Emission Products (GBBEP) are produced from GOES-E and GOES-W fire products since 2008. In these products, biomass burning emissions are estimated using burned area and fuel loadings. Current GBBEPx is the biomass burning emission product by blending fire FRP detected from MODIS and the network consists of two Geostationary Operational Environmental Satellites (GOES) which are operated by the National Oceanic and Atmospheric Administration (NOAA), the Meteosat Second Generation satellites (Meteosat-09) operated by the European Organization for the Exploitation of Meteorological Satellites (EUMETSAT), and the Multi-functional Transport Satellite (MTSAT) operated by the Japan Meteorological Agency (JMA).

1.3. Product Access

GBBEPx output data files will be made available on data distribution server at NCDC in a near real time manner. For access to this server, information about data files, and associated documentation, the PAL should be contacted.

GBBEPx is produced every day. Output files are listed in the Table 1-2 and made available on the near real time data server.

The netCDF files from GBBEPx contain daily biomass burning emissions in a grid cell of 0.25x0.3125 degree, and the netCDF file from GBBEP-Geo contains hourly geostationary-derived emissions at individual fire pixels. Tables 1-3 and 1-4 show the detail content of output biomass burning emissions listed in Table 1-2.

Table 1-2 GBBEPx Output Files

File	Description	Format
GBBEPx.emis_bc.001.yyyymmdd.nc4	Daily BC emissions at 0.25x0.3125 grid and latitude and longitude	netCDF4
GBBEPx.emis_co.001.yyyymmdd.nc4	Daily CO emissions at 0.25x0.3125 grid and latitude and longitude	netCDF4
GBBEPx.emis_co2.001.yyyymmdd.nc4	Daily CO2 emissions at 0.25x0.3125 grid and latitude and longitude	netCDF4
GBBEPx.emis_oc.001.yyyymmdd.nc4	Daily OC emissions at 0.25x0.3125 grid and latitude and longitude	netCDF4
GBBEPx.emis_pm25.001.yyyymmdd.nc4	Daily PM2.5 emissions at 0.25x0.3125 grid and latitude and longitude	netCDF4
GBBEPx.emis_so2.001.yyyymmdd.nc4	Daily SO2 emissions at 0.25x0.3125 grid and latitude and longitude	netCDF4
GBBEPx.emis_pm25.001.yyyymmdd.jpg	Spatial pattern of daily PM2.5	netCDF4
GBBEP_Geo.Hourly_emissions.yyyymmdd.nc4	Emissions from geostationary satellites. The file contains latitude, longitude, fire radiative energy, ecosystem type, dry mass burned, burned area, and the emissions of PM2.5, BC, CO, CO2. OC, and SO2.	netCDF4
GBBEPx.emis_pm25.00.yyyymmdd.jpg	Spatial pattern in Pm2.5 in jpg map	Jpg
ST_PM2.5_yyyymmdd.txt	Statistic data in PM2.5	Txt

Table 1-3 GBBEPx Biomass Burning Emission File

Variable	Type	Description	Dim	Units	Range
PM2.5_emission	Float	PM2.5 emissions	1	kg	0 – 9000000.0
CO_emission	Float	CO emissions	1	kg	0 – 9000000.0
CO2_emission	Float	CO2 emissions	1	kg	0 – 9000000.0
OC_emission	Float	OC emissions	1	kg	0 – 9000000.0
BC_emission	Flaot	BC emissions	1	kg	0 – 9000000.0
SO2_emission	Float	SO2 emissions	1	kg	0 – 9000000.0
Longitude	Float	Longitude	1	Degree	-180 – 180
Latitude	Float	Latitude	1	Degree	-90 – 90

Table 1-4 GBBEP-Geo Biomass Burning Emission File

Variable	Type	Description	Dim	Units	Range
PM2.5_emission	Float	PM2.5 emissions	24	kg	0 – 9000000.0
CO_emission	Float	CO emissions	24	kg	0 – 9000000.0
CO2_emission	Float	CO2 emissions	24	kg	0 – 9000000.0
OC_emission	Float	OC emissions	24	kg	0 – 9000000.0
BC_emission	Flaot	BC emissions	24	kg	0 – 9000000.0
SO2_emission	Float	SO2 emissions	24	kg	0 – 9000000.0
Burned area	Float	Burned area	24	Km^2	0 – 9000000.0
Longitude	Float	Longitude	1	Degree	-180 – 180
Latitude	Float	Latitude	1	Degree	-90 – 90
Ecosystem	Float	USGS ecosystem type	1	None	1 – 110

2. ALGORITHM

The detailed description of GBBEPx algorithm can be found in the peer-reviewed articles listed in reference section and ATBD. A brief overview is provided below.

2.1. Algorithm Overview

The GBBEPx product is to calculate biomass burning emissions (PM2.5, BC, CO, CO2, OC, and SO2) released from wildfires using fire radiative power. Quick Fire Emission Dataset (QFED) extracts FRP from both Terra MODIS and Aqua MODIS in each grid cell and areal proportion of cloud mask. Then FRP value is adjusted using cloud proportion. In each grid cell, the FRP value is separated for tropical forests, extra-tropical forest, cerrado/woody savanna, and grassland/cropland. The biome-based FRP is used to calculate biomass burning emissions from Terra MODIS and Aqua MODIS separately. The outputs are used as input to simulate AOD, which is then used to compare with MODIS AOD in order to get a set of scaling factor for biomass burning emission estimation from Terra MODIS and Aqua MODIS, separately. Finally, the scaling factors are applied to adjust FRP-derived biomass burning emissions. The adjusted values from Terra and Aqua are averaged to product QFED.

GBBEP-Geo is produced from FRP retrieved from a network of multiple geostationary satellites. Specifically, the FRP is retrieved using WF_ABBA V65 (Wildfire Automated Biomass Burning Algorithm) and the network consists of two Geostationary Operational Environmental Satellites (GOES) (GOES-East and GOES-West) which are operated by the National Oceanic and Atmospheric Administration (NOAA), the Meteosat Second Generation satellites (Meteosat-09) operated by the European Organization for the Exploitation of Meteorological Satellites (EUMETSAT), and the Multi-functional Transport Satellite (MTSAT) operated by the Japan Meteorological Agency (JMA). These satellites observe wildfires at an interval of 15-30 minutes. Because of the impacts from sensor saturation, cloud cover, and background surface, the FRP values are generally not continuously observed. The missing observations are simulated by combining the available instantaneous FRP observations within a day and a set of representative climatological diurnal patterns of FRP for various ecosystems. Finally, the simulated diurnal variation in FRP is applied to quantify biomass combustion and emissions in individual fire pixels with a latency of one day. The emissions from GBBEP-Geo are compared with QFED during a year period. This comparison produces a set of scaling factors to continue GBBEP-Geo with QFED. These scaling factors are applied to adjust GBBEP-Geo biomass burning emissions.

The final GBBEPx product is the average of AOD-adjusted GBBEP-Geo and QFED. If the emissions are measured only from one dataset, the estimates are taken as the final results. However, the final product also provides hourly emissions from GBBEP-Geo without any AOD adjustments.

2.2. Input Satellite Data

2.2.1. Fire radiative power from satellite Instruments

GBBEPx produces biomass burring emissions using fire radiative power data detected from polar satellites and geostationary satellites. FRP data are retrieved from a set of geostationary satellites and MODIS data. FRP is theoretically a function of fire size and fire temperature. It is empirically related to the difference of brightness temperature between a fire pixel and ambient background pixels at the middle infrared (MIR) wave band of satellites. Further, FRP is approximated as the difference of MIR spectral radiances between a fire pixel and ambient background pixels in a linear form. The latter approach is adapted by WF_ABBA V65 to detect FRP from a network of geostationary satellite instruments that include SEVIRI on board the Meteosat-9, and Imagers on board both GOES and MTSAT. The WF_ABBA V65 algorithm has been installed in NOAA OSDPD (the Office of Satellite Data Processing and Distribution) to operationally produce fire radiative power from geostationary satellites since late 2009 (http://satepsanone.nesdis.noaa.gov/pub/FIRE/forPo/). The NOAA fire product provides detailed information of WF_ABBA V65 fire detections. It includes the time of fire detection, fire location in latitude and longitude, an instantaneous estimate of FRP, ecosystem type, and a quality flag. The quality flag is defined as: flag 0 - fire pixel detection with good quality, flag 1 - saturated fire pixel, flag 2 - cloud-contaminated fire pixel, flag 3 - high probability fire pixel, flag 4 - medium probability fire pixel, flag 5 - low probability fire pixel. The ecosystem type in the fire product is based on USGS (US Geological Survey) Global Land Cover Characterization (GLCC) dataset.

Polar orbiting fire observations are retrieved from the MODIS instruments on both the NASA Terra and Aqua spacecraft. These data provide a nominal spatial resolution of 1 km. Each MODIS instrument scans a surface location twice a day in low-middle latitudes. The Terra spacecraft cross the equator near 10:30 AM/PM local standard time while Aqua does so near 1:30 AM/PM. MODIS fire FRP and cloud mask data are collected to produce QFED biomass burning emissions.

2.2.2. Pre-Processing Steps

The processing of GBBEPx is to read MODIS fire product and WF_ABBA fire data to estimate biomass burning emissions, separately. These two emission estimates are then

blended to produce global daily biomass burning emissions. The products are formatted in netCDF4.

The GBBEP-Geo_Leo is processed based on the steps listed in the Figure 2-1.

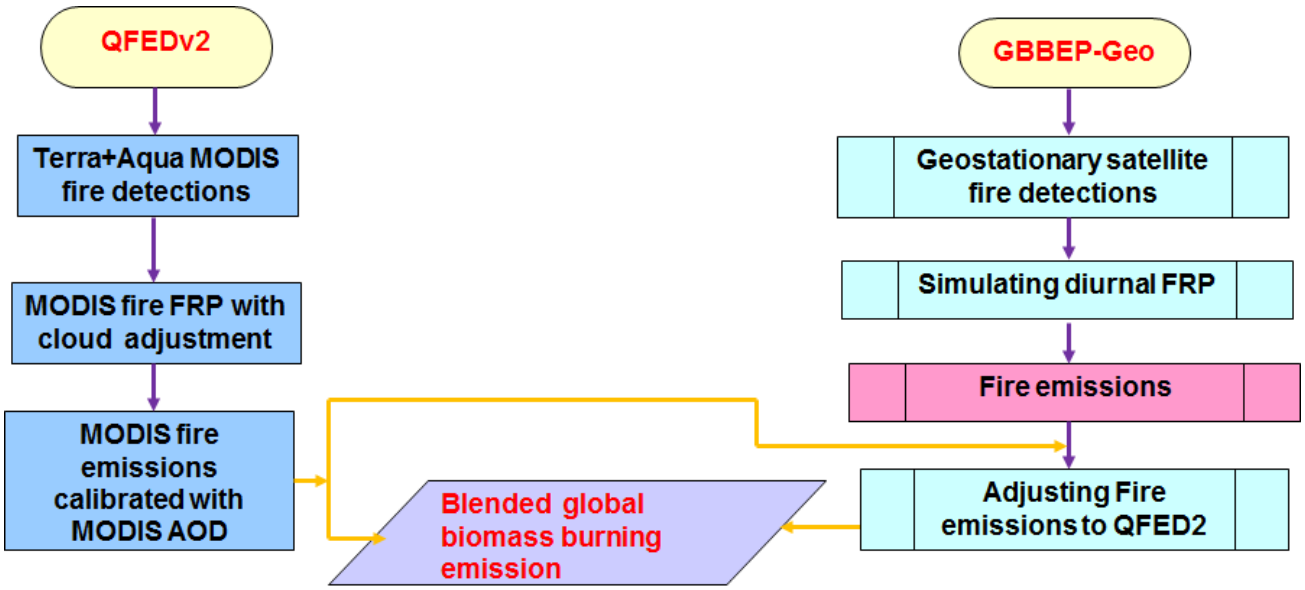

Figure 2-1 GBBEPx Processing Flowchart

2.3. Input Ancillary Data

2.3.1. Emission factors

Emission factor varies with emission species. Thus, a set of emission factors are collected from literature and coded in the codes.

2.3.2. Scaling factors

A set of scaling factors are used to adjust emissions in GBBEP-Geo to be comparable to QFED. GBBEP-Geo and QFED are not directly comparable because they are derived from different satellite sources and approaches. Thus, a set of scaling factors for calibrating GBBEP-Geo are obtained by comparing daily PM2.5 emissions in 2011 between GBBEP-

Geo and QFEDv2. The calibration is performed for North America, South America, Africa, Asia, and Australia, respectively.

2.3.3. Climatological diurnal pattern in FRP for geostationary satellites

Diurnal variation in FRP data for each individual fire pixel is simulated using a climatologic FRP diurnal pattern. The reconstructed diurnal pattern provides estimates of FRP for a large number of instantaneous fires with both poor detections and non-detections from WF_ABBA V65. Climatological diurnal pattern in FRP is established for GBBEP-Geo. The climatologic diurnal pattern at a half hour interval is generated using the average of FRP values with good quality (flag 0) from 2009-2010 for GOES, Meteosat SEVIRI, and MTSAT, respectively. Because FRP variation may depend on view angle, the diurnal climatological pattern is further separated to 0-20 degrees and 20-40 degrees. The latter is for all the observations with view angle larger than 20 degrees. Diurnal variation in FRP data for each individual fire pixel is simulated using a climatological FRP diurnal pattern and timely available WF-ABBA FRP detections. The reconstructed diurnal pattern provides estimates of FRP for a large number of instantaneous fires with either poor detections or non-detections from WF_ABBA V65.

2.3.4. IGBP land cover

A global 1km IGBP land cover type is used to stratify land surface into tropical forests, extra-tropical forest, cerrado/woody savanna, and grassland/cropland. From these land cover type, emissions factors are assigned in QFED.

2.3.5. Template Files

The system uses a number of template files. These are all static files that will only change with a new delivery of the system. They are never modified by the scripts and programs that use them. Scripts will only copy these files to a local directory or create soft links to them

3. REFERENCES

Zhang, X. Kondragunta, S., Ram, J., Schmidt, C., Huang, HC, 2012. Near real time global biomass burning emissions product from geostationary satellite constellation, JOURNAL OF GEOPHYSICAL RESEARCH, VOL. 117, D14201, doi:10.1029/2012JD017459.

Darmenov, A., and da Silva, A. 2013, The Quick Fire Emissions Dataset (QFED) - Documentation of versions 2.1, 2.2 and 2.4, In M. J. Suarez (Editor), *Technical Report Series on Global Modeling and Data Assimilation*, Volume 32.

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