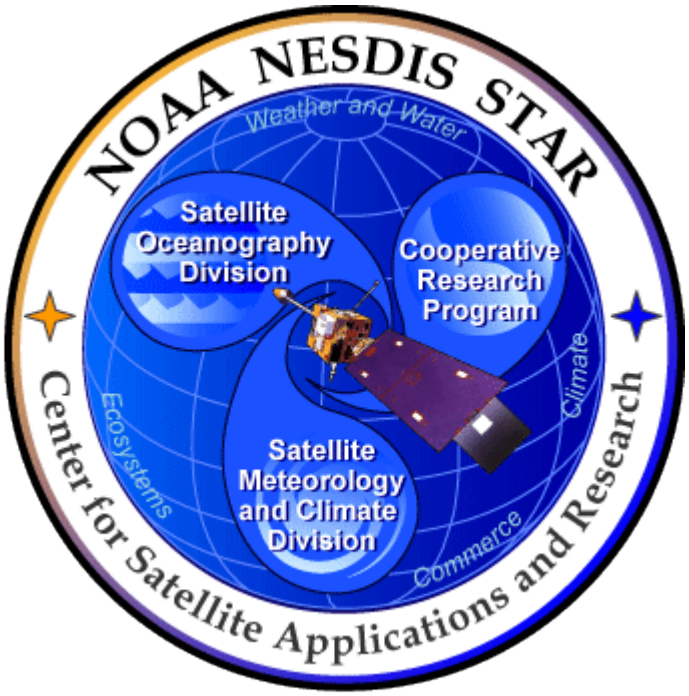

NOAA NESDIS CENTER for SATELLITE APPLICATIONS and RESEARCH

The NOAA Blended Polar Geo Biomass Burning Emissions Product (Blended-BBEP) External Users Manual

Version 1.1

TITLE: BLENDED POLAR GEO BIOMASS BURNING EMISSION PRODUCT EXTERNAL USERS MANUAL VERSION 1.1

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APPROVAL SIGNATURES:

_____ Date

Project Lead

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1. PRODUCTS

This is an external user's manual document describing the NOAA Blended-BBEP product and output files. The Blended-BBEP 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 Blended-BBEP is derived to meet SPSRB requirement (**SPSRB # :** 1009-0013). NWS/NCEP Environmental Model Center is responsible for providing fire weather model guidance to the NWS Incident Meteorologists (IMET) who are deployed at the fire sites. Currently, NCEP NWP models do not account for wild-fire heating or fire burnt area impacts on its land surface model component. A 1.3 km fire weather model nest forecast run is planned for FY11, therefore, burnt area and fire behavior processes should be incorporated in local area fire weather models. Burnt area and fire area information are both needed to initialize the NWP fire weather model. NWS/NCEP is also developing capabilities to provide global aerosol forecasts. The global model needs biomass burning emissions sources (fires) as input. There is a need for timely update of emissions on an hourly basis. NCEP and NESDIS STAR are working towards this development through funding from Joint Center for Satellite Data Assimilation

1.1.2. Product Team

The Blended-BBEP 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	ERT at STAR	Algorithm development and programmer	5825 University Research Ct College Park, MD 20740 Phone: 301-683-2567 Email: Xiaoyang.zhang@noaa.gov
Gilberto Vicebte	OSPO	Product Area Lead (PAL)	5211 Auth Rd, Camp Springs, MD. 20746 Phone: 301- Email: gilberto.vicente@noaa.gov
????	OSPO	Help Desk	????

1.1.3. Product Description

The Blended-BBEP system produces burned area and biomass burning emissions. The details of the algorithm used to generate these products are contained in the peer-reviewed articles listed in the section of “references”.

1.2. Product History

Blended-BBEP is a continuous product of biomass burning emissions, which will be used to replace previous operational product. Previously, the Geostationary Operational Environmental Satellite Biomass Burning Emission Products (GBBEP) are produced from GOES-E and GOES-W fire products separately beginning in 2008. In these products, each emission species is stored in an individual ASCII file. Current Blended-BBEP is produced by blending fires detected from GOES-E, GOES-W, MODIS, and AVHRR. The outputs are written in ASCII and netCDF files which include burned area and all emission species.

1.3. Product Access

Blended-BBEP 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.

The Blended-BBEP is produced every six hours. Output files from Blended-BBEP are listed in the Table 1-2 and made available on the near real time data server. Table 1-3 shows the detail content of output biomass burning emissions listed in Table 1-2.

Table 1-2 Blended-BBEP Output Files

File	Description	Format
biomass_burning_yyyymmdd_hh_hh.nc	Output hourly biomass burning emissions and related attributes	netCDF4
biomed_area_yyyymmdd_hh_hh_12km.grib2	Output cumulated six hour burned area in 12 km grids	GRIB2
burned_area_yyyymmdd_hh_hh_1km.grib2	Output cumulated six hour burned area in 1 km grids	GRIB2
biomass_burning_yyyymmdd_hh_hh.txt	6 hourly emission and related attributes	text
burned_area_yyyymmdd_hh_hh_NA.jpg	Spatial pattern in burned area in jpg map	Jpg
burned_area_yyyymmdd_hh_hh_QA.jpg	Statistic data in burned area	Jpg

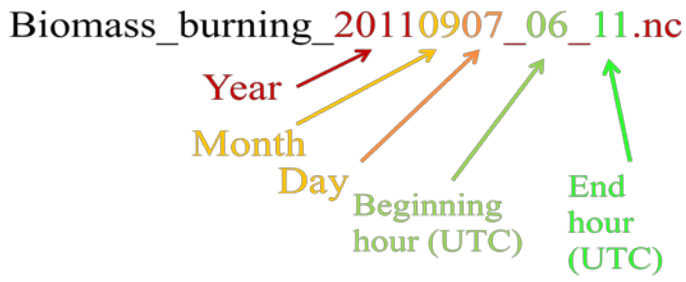
Table 1-3 Blended-BBEP Biomass Burning Emission File

Variable	Type	Description	Dim (hours)	Units	Range
Burned_area (BA)	Float	Hourly burned area	6	Km2	0 – 50.0
PM2.5 emission (PM25	Float	PM2.5 emissions	6	kg	0 – 9000000.0
CO emission (CO)	Float	CO emissions	6	kg	0 – 9000000.0
CH4 emission (CH4)	Float	CH4 emissions	6	kg	0 – 9000000.0
CO2 emission (CO2)	Float	CO2 emissions	6	kg	0 – 9000000.0
TNMHC emission (TNMHC)	Float	TNMHC emissions	6	kg	0 – 9000000.0
NH3 emission (NH3)	Float	NH3 emissions	6	kg	0 – 9000000.0
N2O emission (N2O)	Float	N2O emissions	6	kg	0 – 9000000.0

NOX emission (NOX)	Float	NOX emissions	6	kg	0 – 9000000.0
SO2 emission (SO2)	Float	SO2 emissions	6	kg	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
Fuel_loading	Float	Total fuel loading	1	Mg/km2	1 – 30000
Fire_pixel_size	Float	Pixel size from satellites	1	Km2	1 – 200

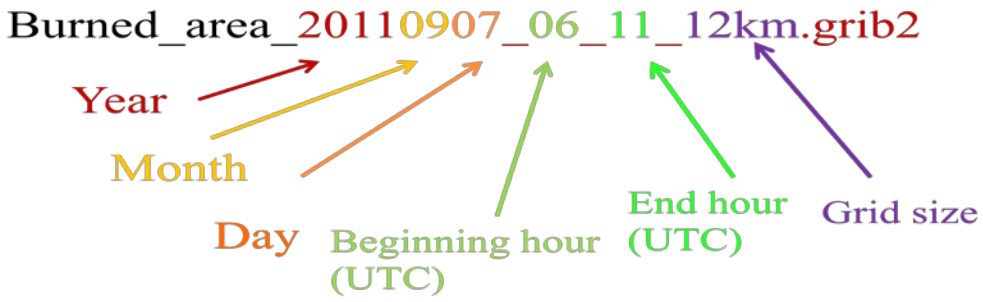
The netCDF file contains hourly biomass burning emissions, burned area, fuel loading, and geolocation. The file name is defined using the following example:

File name:

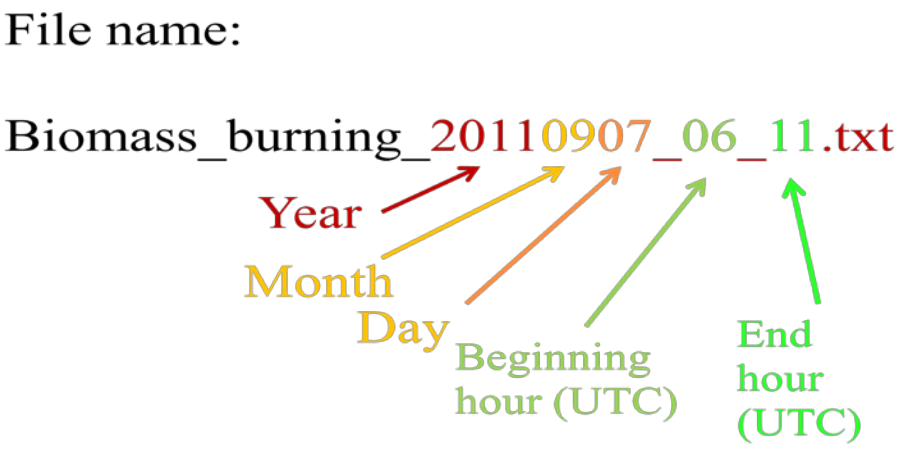


The GRIB2 file contains cumulated burned area during six hours in 12 km grid cells and cumulated burned area during twelve hours in 1km grid cells. The file is named as:

File name:



Biomass burning emissions in ASCII format are named in the format:



In the text file of biomass burning emissions, the first line provides the name of 9 attributes: TotalFirePoints, BeginingYear, BeginingMonth, BegingDay, BegingTime, EndingYear, EndingMonth, EndingDay, EndingTime.
The second line provides the values corresponding to the attributes in the first line.
The third line consists of the names of biomass burning parameters. The details are listed in Table 1-3. The "_h0 _h1 …. _h23" represent the hour in UTC.

Two jpg files are also produced. One is the spatial distribution of burned area and another is the statistics of fire size and burned area to check the quality of burned area.
The spatial pattern of burned area is named as:
burned_area_YYYYMMDD_HH_HH_NA.jpg
The statistics of burned area is named as:
burned_area_YYYYMMDD_HH_HH_QA.jpg

2. ALGORITHM

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

2.1. Algorithm Overview

The Blended-BBEP product is to calculate burned area and emissions (PM2.5, CO, CH4, CO2, TNMHC, NH3, N2O, NOX, and SO2) released from wildfires using fire detections provided in the Hazard Mapping System (HMS). The HMS consolidates automated fire detections from Geostationary Operational Environmental Satellite (GOES) Imager, Advanced Very High Resolution Radiometer (AVHRR), and Moderate Resolution Imaging Spectroradiometer (MODIS) over North America. Wildfire detections from GOES are conducted using the Wildfire Automated Biomass Burning Algorithm (WF_ABBA).

Specifically, WF_ABBA v65 detects instantaneous fires in sub-pixels using 3.9 μm and 10.7 μm infrared bands by assuming that the thermal radiance in a pixel (4 km at nadir) is a linear mixture of radiance from a fire target and background. The algorithm not only identifies fire pixels but also calculates sub-pixel fire size for the pixels with high quality detections. Using WF_ABBA v65, fire products are produced from the GOES-E and GOES-W Imager data in an interval of half hour, respectively.

Polar orbiting fire observations are provided by the MODIS instruments on both the NASA Terra and Aqua spacecraft and the AVHRR on NOAA-15/17/18. These data provide a nominal spatial resolution of 1 km. Each instrument scans a surface location twice a day in low-middle latitudes. Fire hotspots from AVHRR data are retrieved using FIMMA (Fire Identification, Mapping, and Modeling Algorithm). Basically, it uses mid-infrared band (3.55-3.93 μm) to identify all potential fires, uses thermal band (10.3-11.3 μm) to eliminate clouds, has multiple filters for noise in the data, and uses the difference between brightness temperature in mid-infrared band and thermal band to isolate fires from warm background. Similarly, MODIS fire detection is also based on various thresholds.

The HMS system allows satellite analysts to manually integrate fire data from all the above satellite detections. The analysts inspect fires detected from all instruments, delete detections that appear to be false alarms, and add fires that are undetected in the automated algorithms.

The Blended-BBEP algorithm estimates burned area using active fire observations from MODIS, AVHRR, and GOES for each GOES fire pixel. The procedure of this algorithm is briefly described in the following. Instantaneous fire size from the WF-ABBA is only calculated for 'processed' fires (which constitute approximately 20-30% of the total WF-ABBA detected fires). To simulate the fire size for all instantaneous fire observations, climatologic diurnal variation in fire size is employed. The climatologic diurnal variations in fire sizes for various ecosystems are generated using historical WF_ABBA fire size estimates. The ecosystem types are stratified as forest, savanna, shrublands, grasslands, and croplands. Using the climatologic diurnal variation and GOES fire sizes in each individual GOES fire pixel, the diurnal pattern for the given fire pixel is empirically reconstructed. Although without fire size, the MODIS+AVHRR observations improve the quality of time duration of a fire event in a GOES footprint because some small fires may not be instantaneously detected from GOES. The simulated fire sizes are empirically converted to burned areas after compared and validated using the burn scars detected from post-fire Landsat ETM+ (Enhanced Thematic Mapper plus) imagery. In the cases there are only MODIS and AVHRR observations, the burned areas are empirically calculated based on the relationship between fire counts and TM-based burn scars.

Fuel loading is basically divided into live and dead fuel loadings. The live fuel loading consists of canopy (foliage and branch) biomass in forests, shrub biomass, and grass (including crop) biomass, and the dead fuel loading is composed of litter and coarse woody detritus. To determine the fuel loadings for each pixel at a spatial resolution of 1 km, we

developed a MODIS Vegetation Property-based Fuel System (MVPFS) using percent vegetation cover, leaf area index, and land cover types.

Combustion and emission factors are dependent on fuel type and moisture condition. We determine fuel moisture conditions from time series of AVHRR data, which are then related to moisture category factors for estimating the factors of combustions and emissions.

By integrating burned area, fuel loading, and combustion and emission factors, the Blended-BBEP product is produced every 6 hours by acquiring and blending instantaneous fire observations from GOES-W, GOES-E, MODIS, AVHRR during past 24 hours. The processing is fixed in North America (NA) and produces burned area and emissions of PM2.5, CO, CH4, CO2, TNMHC, NH3, N2O, NOX, and SO2 in every hour. The GBBEP-Geo algorithm runs automatically four times a day through a CRONTAB job and makes them available in the ftp site.

2.2. Input Satellite Data

2.2.1. Satellite Instruments for Fire Detections

Blended-BBEP uses data from fire detections from polar satellites and geostationary satellites. Geostationary Imagers on both GOES-East and GOES-West offer observations with a nominal spatial resolution of 4 km at satellite nadir. The GOES-East Imager scans the surface of South America and North America (excluding Alaska) at 15 and 45 minutes in each hour while GOES-West does west part of North America and west coast of South America at 0 and 30 minutes. The WF_ABBA (WildFire Automated Biomass Burning Algorithm) identifies hotspot pixels from the 3.9 μm band. Then, GOES WF_ABBA derives instantaneous fire size and temperature. The GOES fire product contains the time of fire detection, fire location in latitude and longitude, instantaneous subpixel fire size, corresponding ecosystem type, and quality flag. The flag represents the confidence of fire detections with six different levels.

Polar orbiting fire observations are provided by the MODIS instruments on both the NASA Terra and Aqua spacecraft and the AVHRR on NOAA-15/17/18. These data provide a nominal spatial resolution of 1 km. Each instrument scans a surface location twice a day in low-middle latitudes. The Terra and NOAA-17 spacecraft cross the equator near 10:30 AM/PM local standard time (however, the NOAA-17 3.9μm band does not operate during daylight) while Aqua and NOAA-18 do so near 1:30 AM/PM. NOAA-15 provides coverage near 6:00 AM/PM. The instruments on these satellites are used to automatically detect fire hotspots. The HMS system allows satellite analysts to manually integrate fire data from all the above satellite detections. The analysts inspect fires detected from all instruments, delete detections that appear to be false alarms, and add fires that are undetected in the automated algorithms.

Time series of AVHRR data are used to determine fuel moisture conditions. Particularly, Vegetation Condition Index (VCI) In AVHRR is employed as a surrogate to represent the fuel moisture conditions required for calculating the factors of combustions and emissions. The weekly VCI provided in the NOAA AVHRR product is produced from the NOAA Global Area Coverage (GAC) using smoothed weekly NDVI datasets at a spatial resolution of 4 km.

2.2.2. Processing Steps

The processing of Blended-BBEP is to read HMS (MODIS+AVHRR) fire product, GOES WF_ABBA fire data, and AVHRR VCI (vegetation condition index), to simulate burned areas from the active fires, to calculate emissions by integrating simulated burned area and static inputs (fuel loading and emission factors), and to generate output (ASCII, netCDF4, and GRIB2) data of hourly burned area and various emissions in a period of every 6 hours.
The Blended-BBEP is processed based on the steps listed in the Figure 2-1.

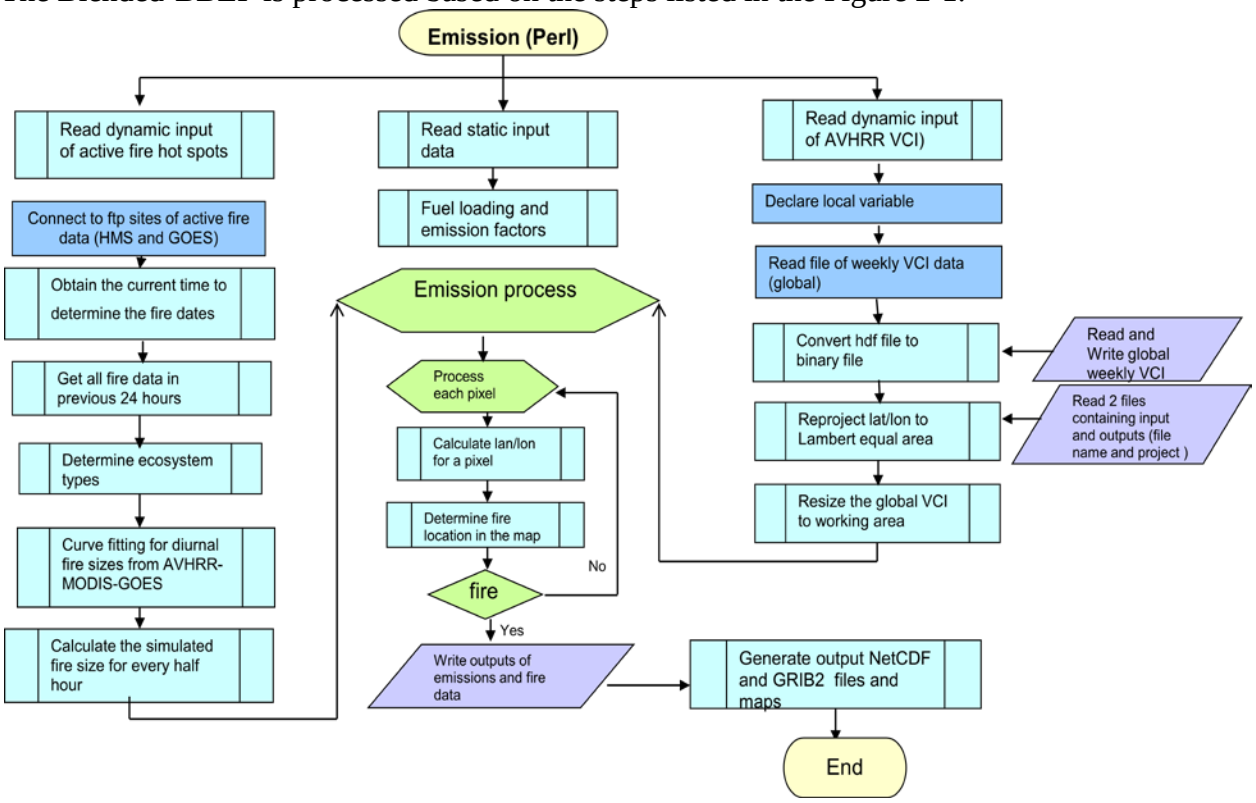


Figure 2-1 Blended-BBEP Processing Flowchart

2.3. Input Ancillary Data

2.3.1. Fuel loading data

There is one fuel loading file: MVPFS_fuel_ave200234_NA_2km. It contains fuel values at a spatial resolution of 2km with Lambert project. It has 3500 columns and 3885 lines and 7 bands. The file size is 190.365MB.

2.3.2. Land cover type

This file contains MODIS land cover type over North America. It has 3500 columns and 3885 lines and 1 band. The file size is 135.975MB.

2.3.3. Geolocation of GOES-E and GOES-W

The latitude and longitude for GOES-E and GOES-W are provided in two separate files. They are "lon_lat_east" (13.6MB) and "lon_lat_west" (18.24MB).

2.3.4. Fuel combustion factor

One file (FEPS_moisture_consumption.txt) contains fuel combustion factor. The factor varies with fuel moisture condition.

2.3.5. Emission factors

Emission factor varies with emission species. Thus, there are a set of ASCII files containing emission factor.

2.3.6. 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

These files include climatologic diurnal pattern of fire size (fittedfiresizeLST.txt) and reprojection parameters (CONvert_VCI_Y_NA_2km.out and CONvert_VCI_Y_NA.in).

2.3.7. Land/water mask

Land/water mask is added in the GRIB2 files. Two type of land/water masks are used, which are at spatial resolutions of 1km and 12km.

3. REFERENCES

Zhang, X. Kondragunta, S., and Quayle, B., 2011. Estimation of biomass burned areas using multiple-satellite-observed active fires. *IEEE Transactions on Geosciences and Remote Sensing*, 10.1109/TGRS.2011.2149535.

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Zhang, X., Kondragunta, S., 2008. Temporal and spatial variability in biomass burned areas across the USA derived from the GOES fire product. *Remote Sensing of Environment*, 112, doi:10.1016/j.rse.2008.02.006.

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