Global Biomass Burning Emissions from a Constellation of Geostationary Satellites for Global Model Forecast Applications

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Funded by JCSDA and G-PSDI
• NWS/NCEP preparing for near real time global aerosol forecasting including dust, smoke, sulfate, sea salt.

  ➢ Dust operational in September 2011

  ➢ For smoke to be operational, near real time emissions from fires are needed

• Satellite data are a viable option to provide real time fire emissions data to the model.

NOAA Global Forecasting System Aerosol Component (NGAC) Dust Simulations
Background

- NWS operational smoke forecast using HYSPLIT (Hybrid Single Particle Lagrangian Integrated Trajectory) model.
  - Fire hot spots from Hazard Mapping System (HMS)
  - USFS Bluesky emissions algorithm

Operational predictions at http://airquality.weather.gov
Fire Radiative Power (FRP) is theoretically a function of fire size and fire temperature which is closely related to brightness temperature observed from satellite thermal bands (Wooster, 2002).

Fire Radiative Energy (FRE) an integration of FRP over a time interval. It represents the dry fuel mass combusted within a given burned area or a fire pixel.
### Input Datasets

<table>
<thead>
<tr>
<th>Satellite/Sensor</th>
<th>Algorithm Version</th>
<th>Spatial Resolution</th>
<th>Parameters in fire pixels</th>
<th>Temporal Resolution</th>
</tr>
</thead>
<tbody>
<tr>
<td>GOES-E: WF_ABBA fire product Coverage: America</td>
<td>V65</td>
<td>4 km</td>
<td>FRP Latitude Longitude Land cover type</td>
<td>30 min</td>
</tr>
<tr>
<td>GOES-W: WF_ABBA fire product Coverage: America</td>
<td>V65</td>
<td>4 km</td>
<td>FRP Latitude Longitude Land cover type</td>
<td>30 min</td>
</tr>
<tr>
<td>Metosat SEVIRI: WF_ABBA fire product Coverage: Africa and Europe</td>
<td>V65</td>
<td>3 km</td>
<td>FRP Latitude Longitude Land cover type</td>
<td>15 min</td>
</tr>
<tr>
<td>MTSAT Imager: WF_ABBA fire product Coverage: Eastern Asia</td>
<td>V65</td>
<td>4 km</td>
<td>FRP Latitude Longitude Land cover type</td>
<td>30 min</td>
</tr>
</tbody>
</table>
Diurnal FRP Climatology
(2002-2005)
Reconstruction of Diurnal FRP in a Fire Pixel

115.4°W, 44.49°N
Annual Global Biomass Burning Emissions for 2010

Zhang et al., JGR, 2012, DOI: 10.1029/2012JD017459

No coverage over high latitudes from geostationary satellites

GOES-E and GOES-W

Meteosat

MTS-2

INSAT-3D operational and data available to NOAA

PM2.5
DOY 56-365, 2010

0 1 50 100 200 500 1000 3000 5000 >5000 x1000 kg
Product Validation

Strengths

- Real time availability
- Diurnal coverage

Limitations

- Emissions are underestimated
- No data in high latitudes

Note: GBBEP-Geo not scaled/tuned whereas all other products tuned
Global Biomass Burning Emissions Product – Extended (GBBEPx)

**QFEDv2**
- Terra+Aqua MODIS fire detections
- MODIS fire FRP with cloud adjustment
- MODIS fire emissions calibrated with GFEDv2 and MODIS AOD

**QFED**: Quick Fire Emission Dataset from MODIS fire data

**GBBEP-Geo**: Global Biomass Burning Emissions Product from Multiple Geostationary Satellites
- Geostationary satellite fire detections
- Simulating diurnal FRP
- Fire emissions
- Adjusting Fire emissions to QFEDv2
- Tuning blended fire emissions

**Blended Emissions**

**Simulating AOD using NGAC**

**Scaling fire emissions**

**MODIS AOD**

GFS—Global Forecast System
NEMS—NOAA Environmental Modeling System
GOCART—NASA Goddard Chemistry Aerosol Radiation and Transport Model
NGAC forecast
Quick Fire Emission Dataset (QFED) from MODIS DATA

- QFEDv2—Calculated from (1) MODIS FRP for various biome types, (2) combustion factor obtained by comparing with GFED product, and (3) emission factors scaled using scaling factors which are obtained by comparing GFS-GOCART-modeled AOD with MODIS observed AOD.

- Emissions are tuned respectively for Terra MODIS and Aqua MODIS, which are then combined to produce daily global emissions.

- Finally, QFED product at 0.25x0.3125 degree is merged from Terra and Aqua daily fire emissions of BC, OC, SO2, CO, CO2, PM2.5
## MODIS Data for QFED Product

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<tr>
<td>Terra/MODIS: MOD14- Thermal Anomalies/Fire products</td>
<td>Collection 5</td>
<td>1 km</td>
<td>FRP Latitude Longitude Sample and line</td>
<td>Daily (2 times)</td>
</tr>
<tr>
<td>Terra/MODIS: MOD 03 - Geolocation Data Set</td>
<td>Collection 5</td>
<td>1 km</td>
<td>Number of fire pixels Cloud pixels Clear land pixels</td>
<td>Daily (2 times)</td>
</tr>
<tr>
<td>Aqua/MODIS: MYD14- Thermal Anomalies/Fire products</td>
<td>Collection 5</td>
<td>1 km</td>
<td>FRP Latitude Longitude Sample line</td>
<td>Daily (2 times)</td>
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NASA ftp site: nrt1.modaps.eosdis.nasa.gov
Scaling Factors for GBBEP-Geo
Temporal and Spatial Variation in Fire Emissions from GBBEPx

http://satepsanone.nesdis.noaa.gov/pub/FIRE/GBBEPx/
Biomass Burning Emissions: Funny River Fire, Alaska

VIIRS Smoke Detection on May 20, 2014

April 1 – July 20

Biomass Burning Emissions In California

Relevance: According to EPA, 36% of PM2.5 emissions are from fires as of 2011. As control strategies come into play reducing anthropogenic emissions, biomass burning emissions become more important and the detection of fires from satellites...
NGAC Simulations with Biomass Burning Emissions in July 2011

AOD (GBBEP - NOBB); 20110701 00z

[Map showing aerosol optical depth (AOD) with data from GBBEP and NOBB for July 1, 2011]
NGAC Simulations using GBBEPx

ICAP global ensemble from NRL, ECMWF, GSFC, and JMA

Sunday 23 June 2013 00UTC ICAP Forecast t+024
Monday 24 June 2013 00UTC Valid Time
SMOKE Aerosol Optical Depth at 550nm (nMEM = 4)
NGAC Simulations using GBBEPx

ICAP global ensemble from NRL, ECMWF, GSFC, and JMA

Plots Generated Tuesday 25 June 2013 16UTC NRL,Monterey Aerosol Modeling
ICAP global ensemble from NRL, ECMWF, GSFC, and JMA

Plots Generated Wednesday 26 June 2013 16UTC NRL/Monterey Aerosol Modeling
Future Development Plan

- Our work is mainly focused on air quality predictions and monitoring; it is somewhat removed from the work going on under CMS framework and other initiatives such as GOFC-GOLD.
- Bring in VIIRS as a follow-on to MODIS (when FRP is ready and implemented operationally);
- Work with users on the quality of the GBBEPx and improve the product as needed.