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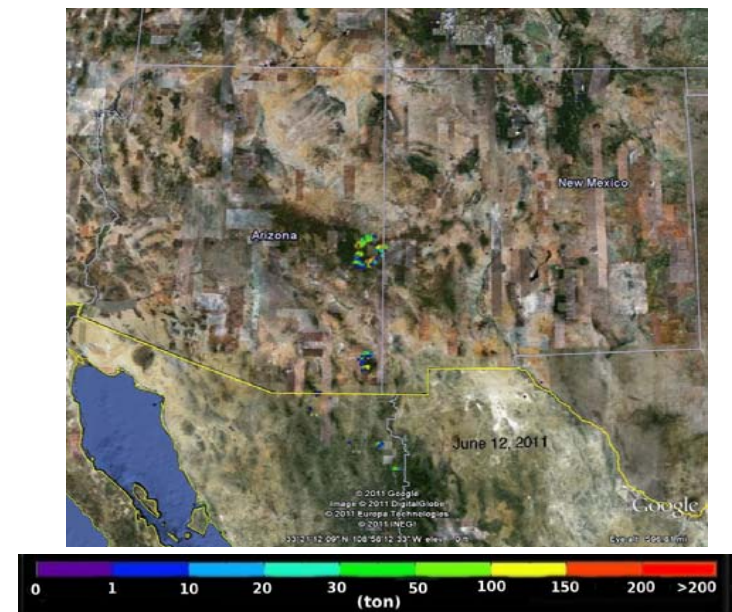
# Global Biomass Burning Emissions from a Constellation of Geostationary Satellites for Global Model Forecast Applications

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with contributions from  
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A. Da Silva (NASA)

Funded by JCSDA and G-PSDI

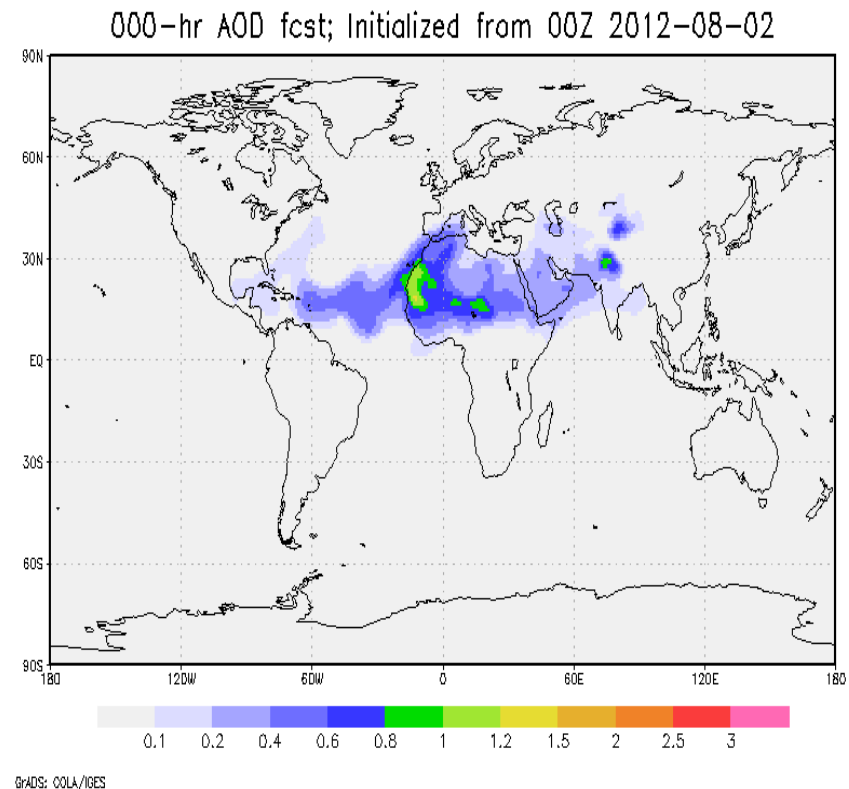




# Background



- 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

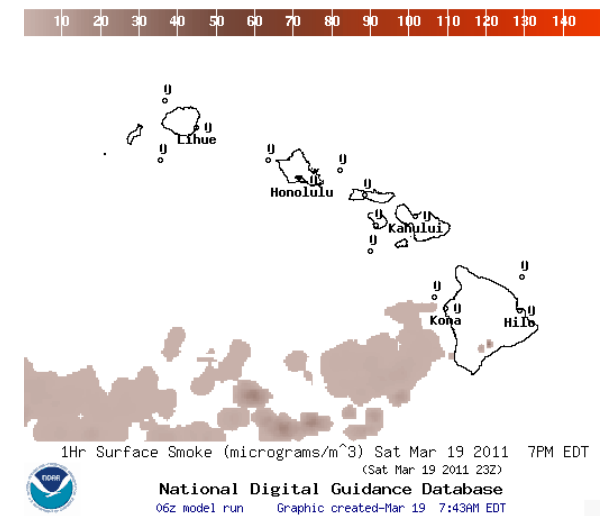
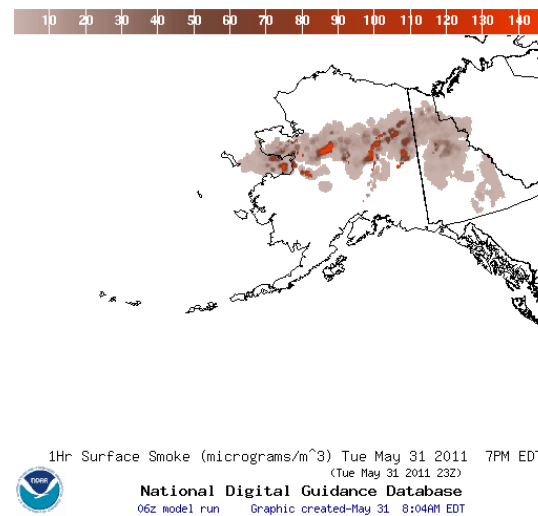
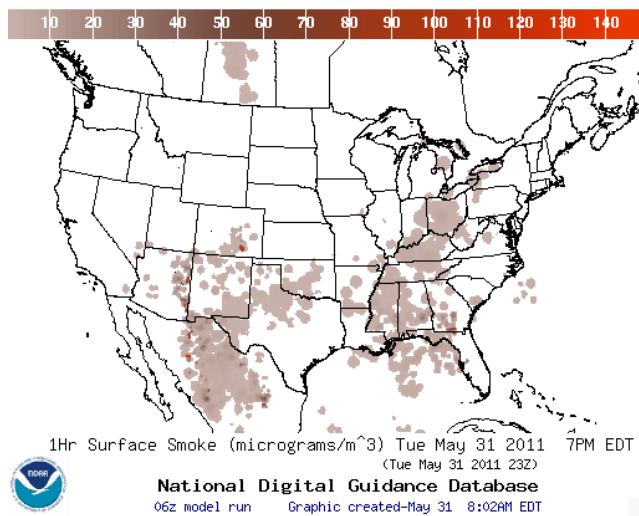


# Background



- 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>





# Biomass Burning Emissions from

4

$$E = A \times M \times C \times F$$

Following Seiler and Crutzen, 1980

$$FRE \times \beta \times F$$

E: biomass burning emissions (kg)  
A: burned area (km<sup>2</sup>)  
M: biomass density/fuel loading (kg.km<sup>-2</sup>)  
C: combustion factor  
F: emission factors  
B: a combustion rate per unit energy

- 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.

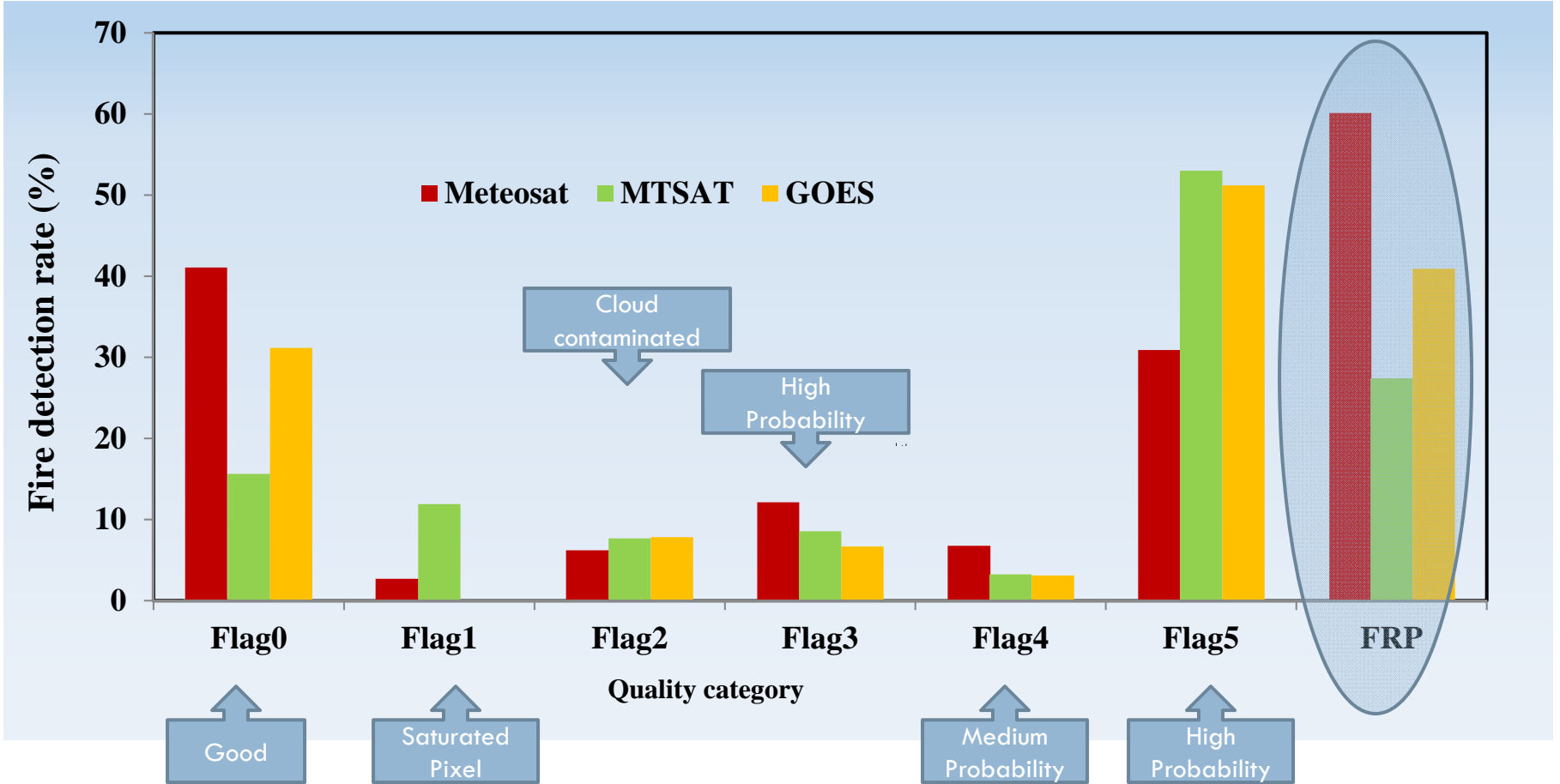


# Input Datasets

Satellite/Sensor	Algorithm Version	Spatial Resolution	Parameters in fire pixels	Temporal Resolution
<b>GOES-E:</b> WF_ABBA fire product <b>Coverage: America</b>	V65	4 km	FRP Latitude Longitude Land cover type	30 min
<b>GOES-W:</b> WF_ABBA fire product <b>Coverage: America</b>	V65	4 km	FRP Latitude Longitude Land cover type	30 min
<b>Metosat SEVIRI:</b> WF_ABBA fire product <b>Coverage: Africa and Europe</b>	V65	3km	FRP Latitude Longitude Land cover type	15 min
<b>MTSAT Imager:</b> WF_ABBA fire product <b>Coverage: Eastern Asia</b>	V65	4 km	FRP Latitude Longitude Land cover type	30 min



# NOES Fire Product Quality Flags

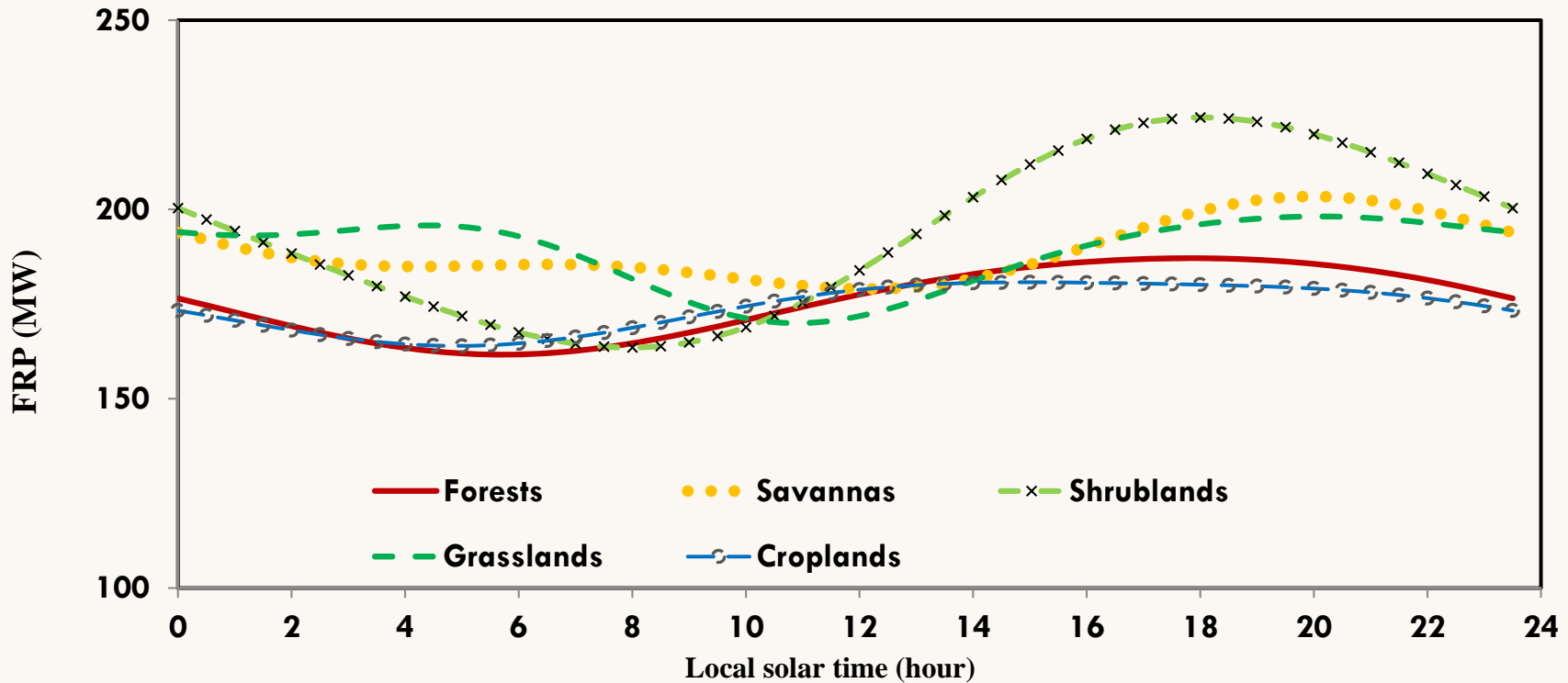




# Diurnal FRP Climatology (2002-2005)



7

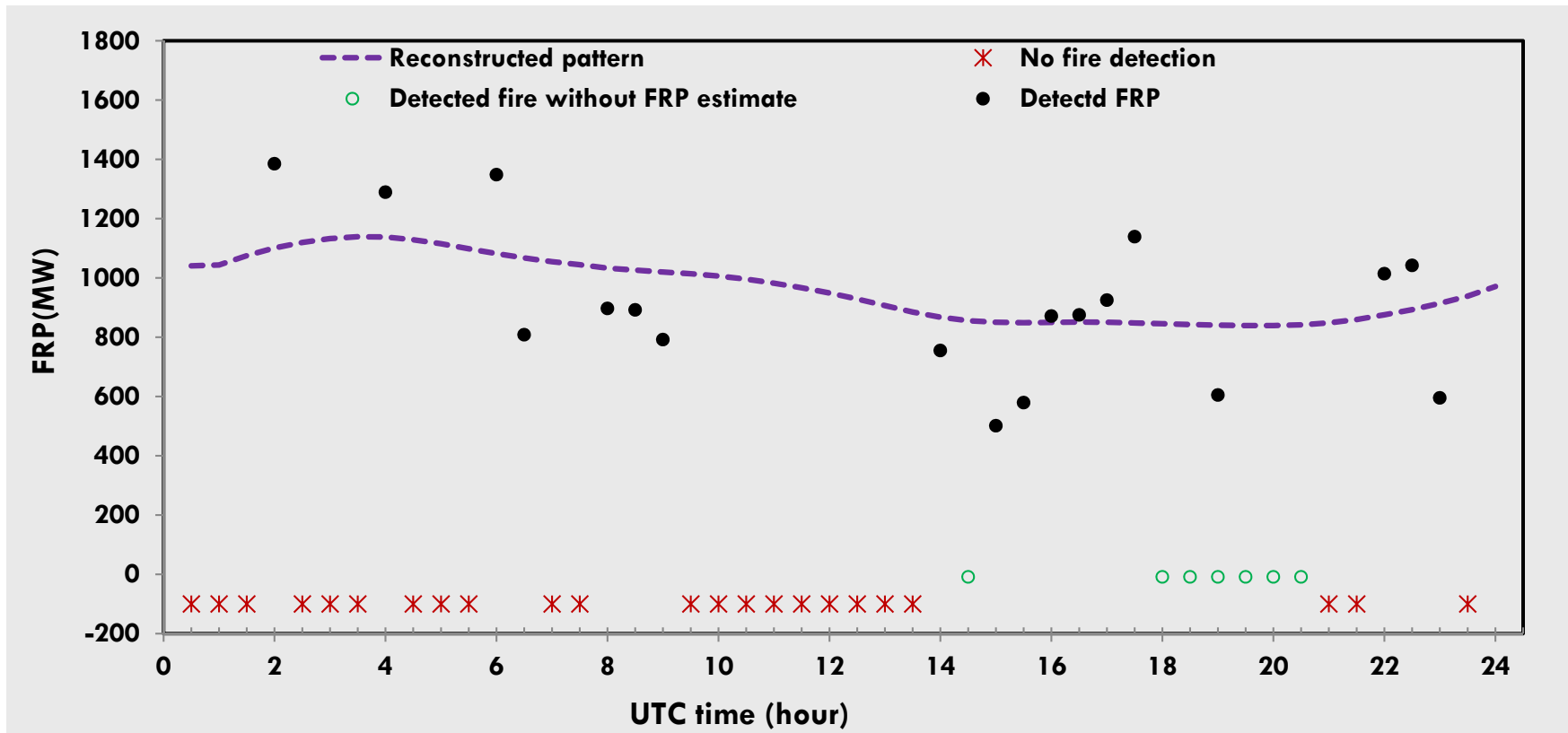




# Construction of Diurnal FRP in Fire Pixel

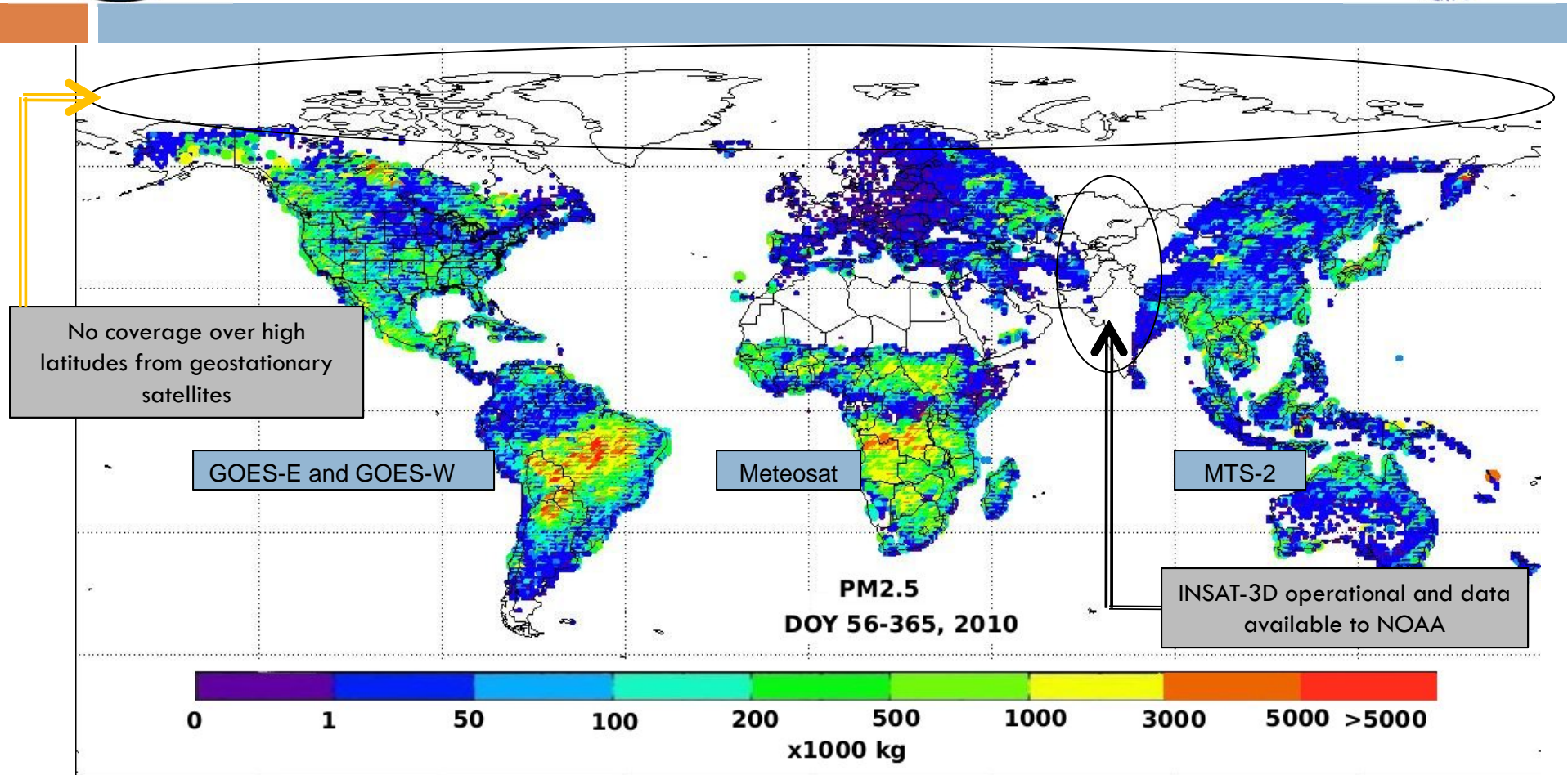


115.4°W , 44.49°N





# Annual Global Biomass Burnin Emissions for 2010





# Product Validation



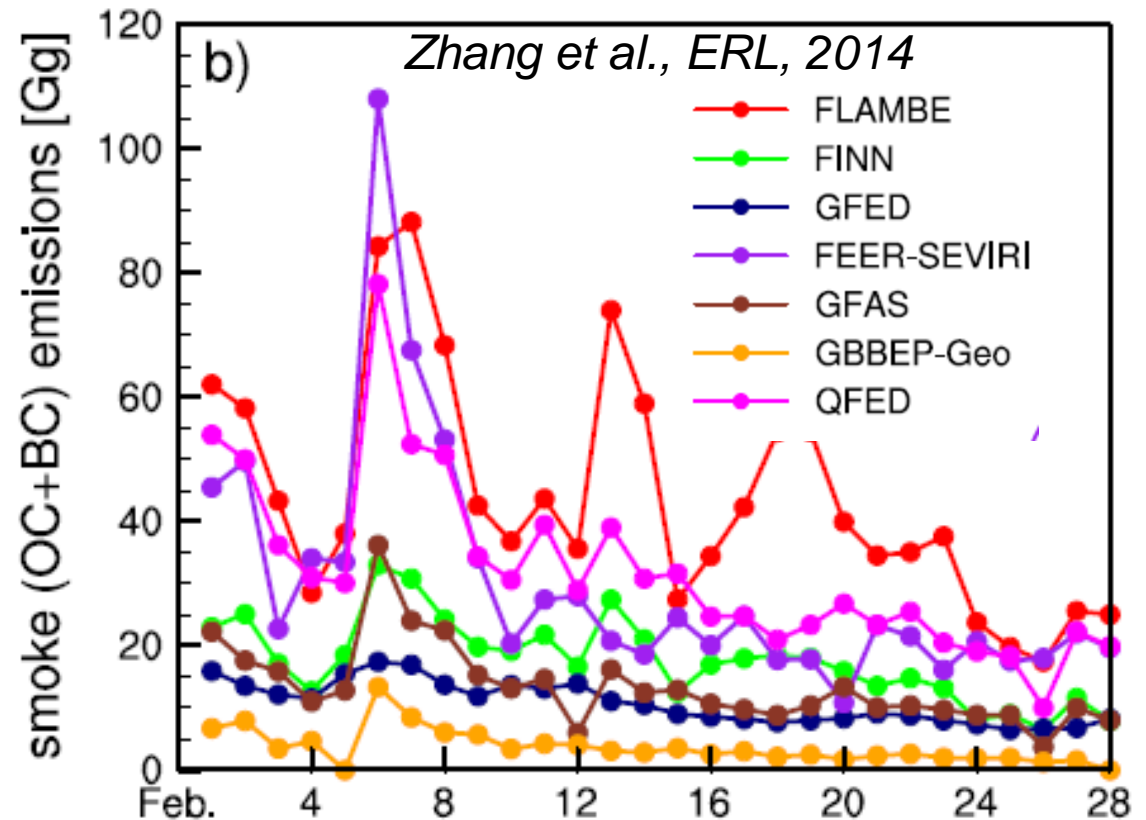
10

## Strengths

- Real time availability
- Diurnal coverage

## Limitations

- Emissions are underestimated
- No data in high latitudes



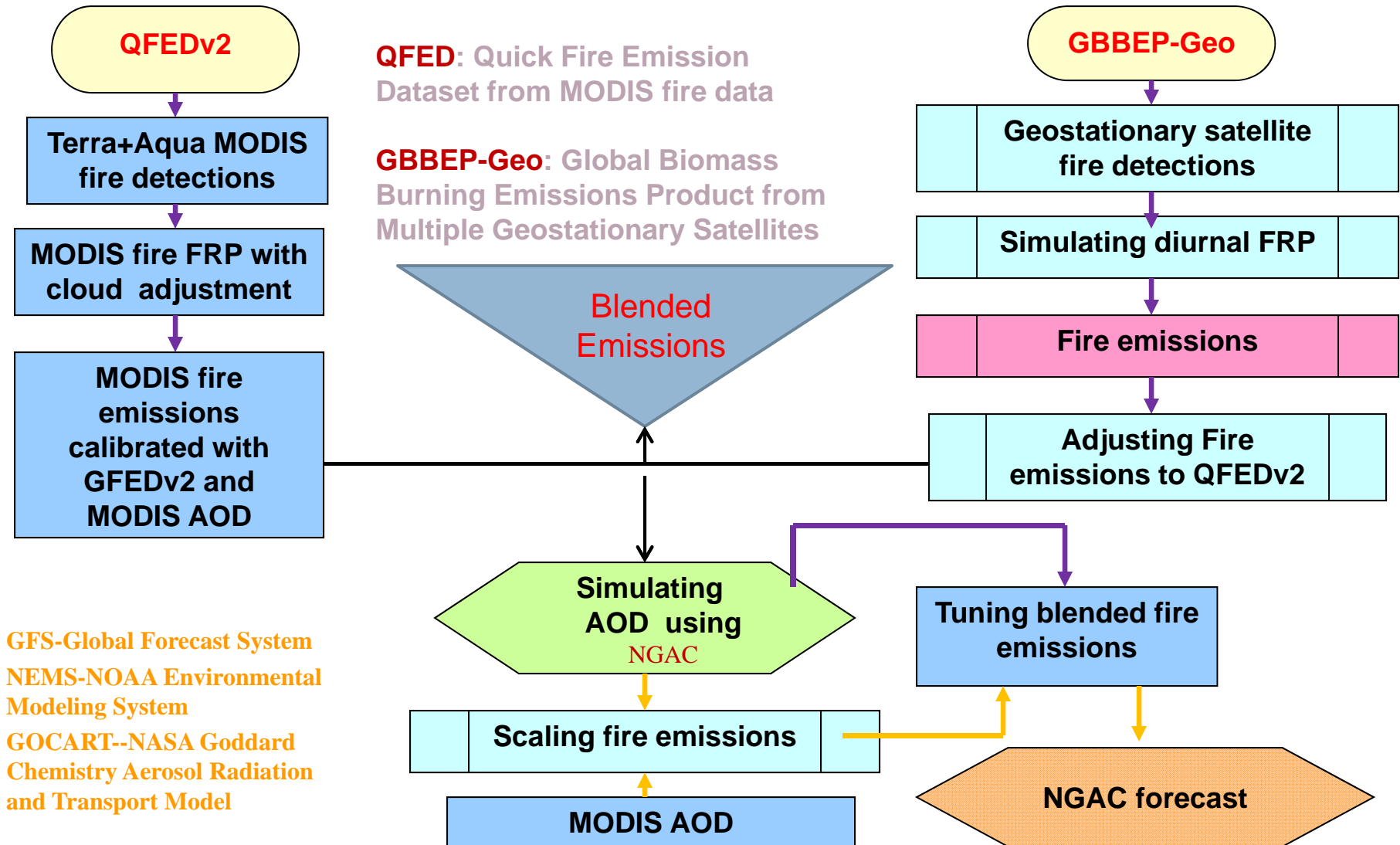
*Note: GBBEP-Geo not scaled/tuned whereas all other products tuned*



# Global Biomass Burning Emissions Product – Extended (GBBEPx)



11



GFS-Global Forecast System  
NEMS-NOAA Environmental Modeling System  
GOCART-NASA Goddard Chemistry Aerosol Radiation and Transport Model

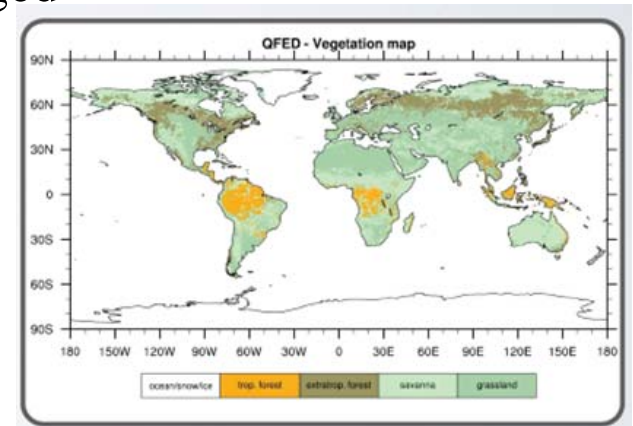


# Quick Fire Emission Dataset (QFED) from MODIS DATA



12

- 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, SO<sub>2</sub>, CO, CO<sub>2</sub>, PM<sub>2.5</sub>





# MODIS Data for QFED Product



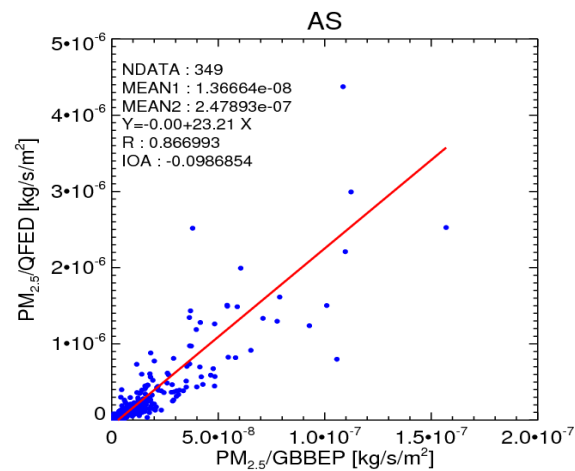
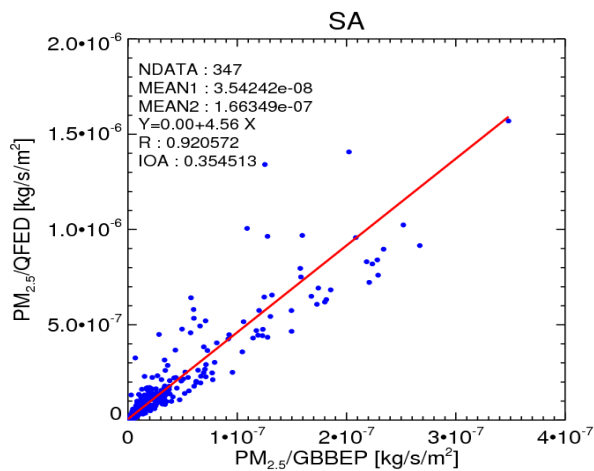
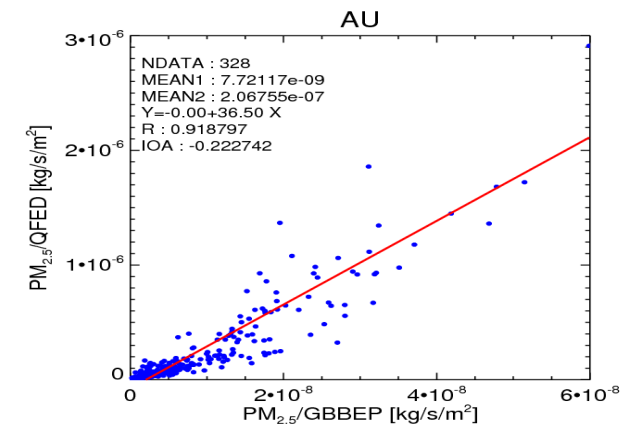
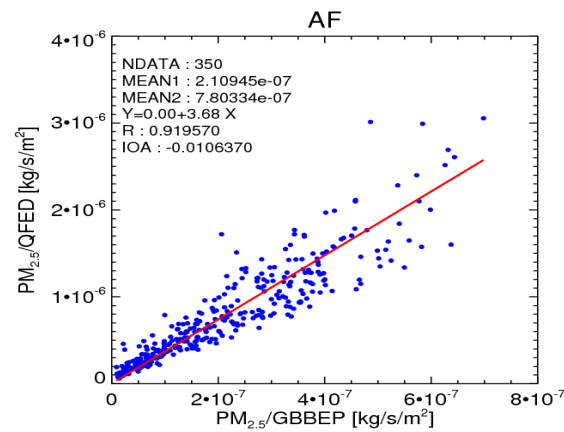
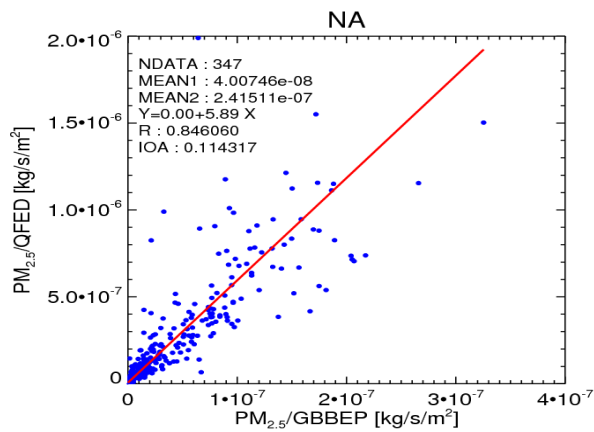
13

Satellite/Sensor	Algorithm Version	Spatial Resolution	Parameters in fire pixels	Temporal Resolution
Terra/MODIS : MOD14- Thermal Anomalies/Fire products	Collection 5	1 km	FRP Latitude Longitude Sample andline	Daily (2 times)
Terra/MODIS: MOD 03 - Geolocation Data Set	Collection 5	1km	Number of fire pixels Cloud pixels Clear land pixels	Daily (2 times)
Aqua/MODIS : MYD14- Thermal Anomalies/Fire products	Collection 5	1 km	FRP Latitude Longitude Sample line	Daily (2 times)
Terra/MODIS: MYD 03 - Geolocation Data Set	Collection 5	1km	Number of fire pixels Cloud pixels Clear land pixels	Daily (2 times)

*NASA ftp site: [nrt1.modaps.eosdis.nasa.gov](http://nrt1.modaps.eosdis.nasa.gov)*

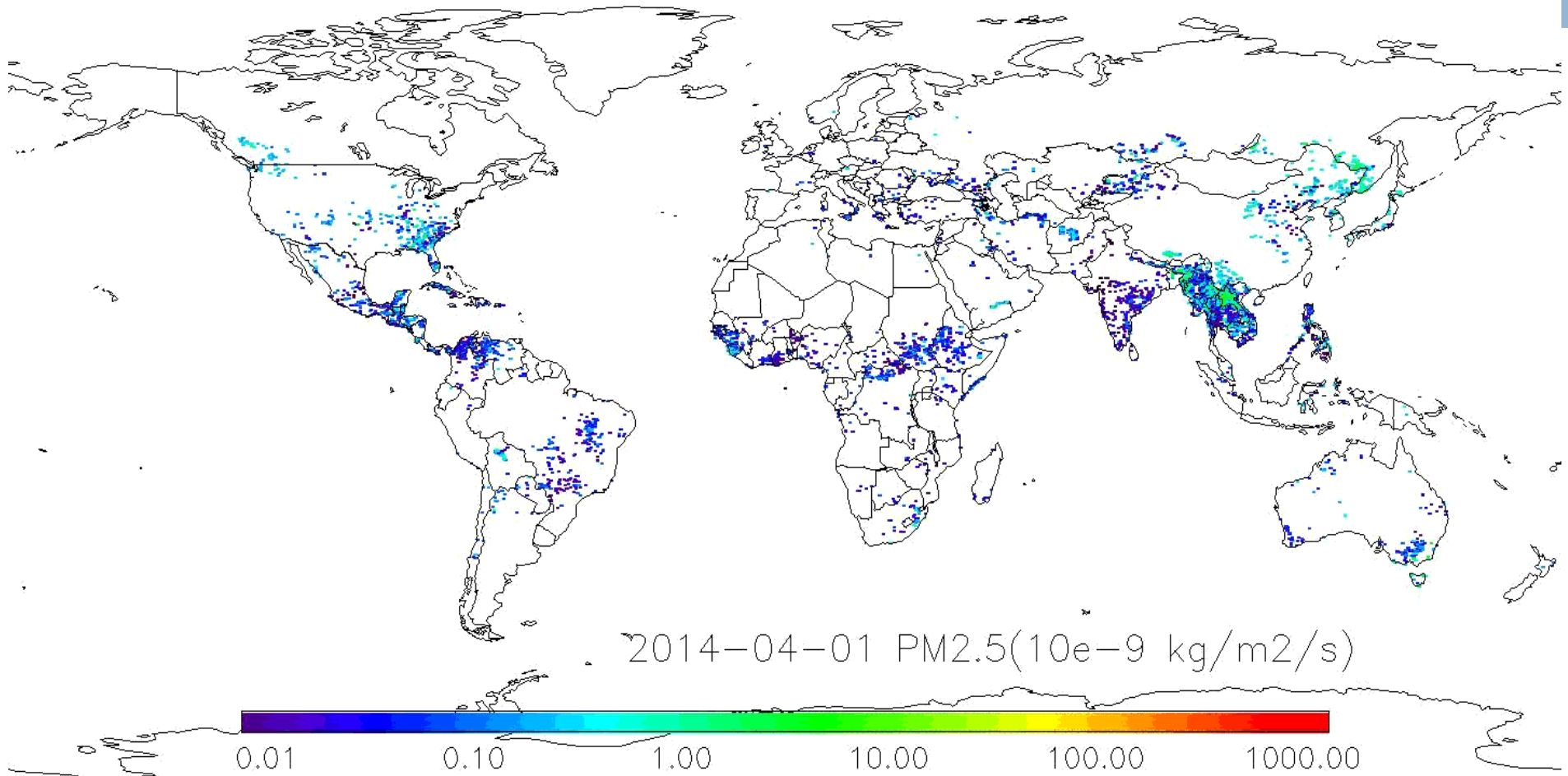


# Scaling Factors for GBBEP-Geo





# Temporal and Spatial Variation in Fire Emissions from GBBEPx



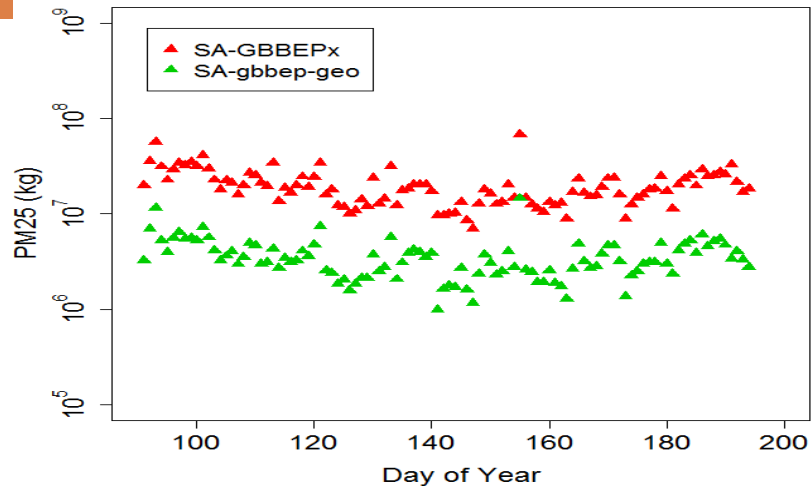
<http://satepsanone.nesdis.noaa.gov/pub/FIRE/GBBEPx/>



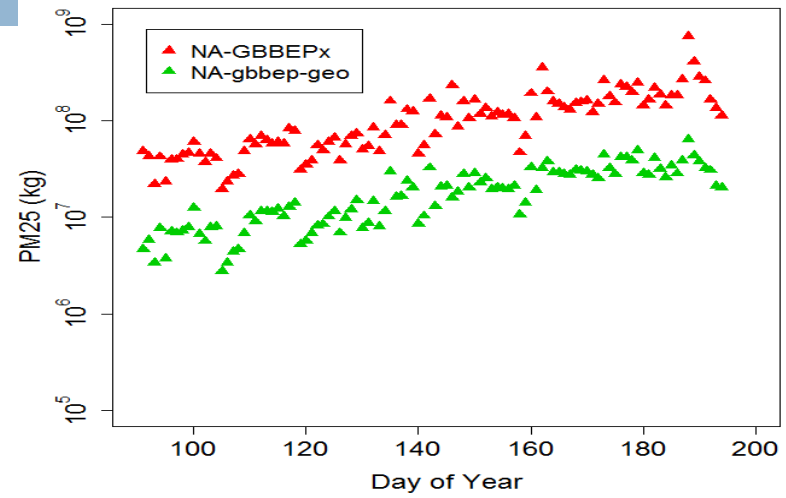
# GBBEP-Geo vs. GBBEPx



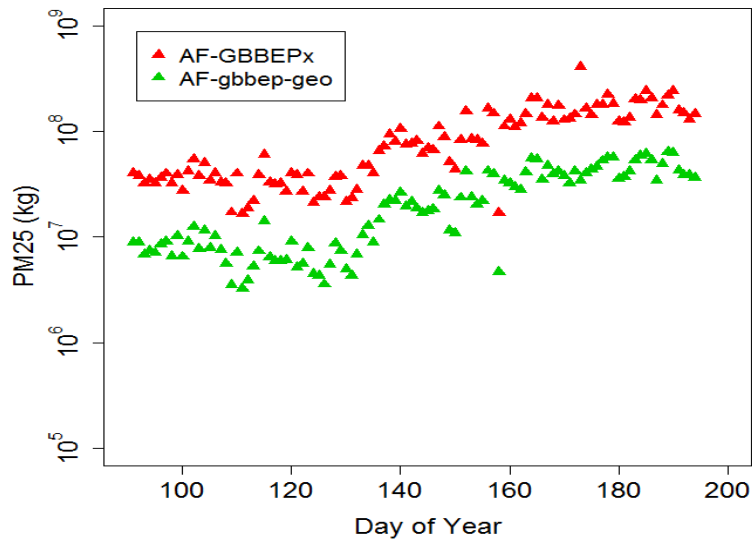
South America PM25 Daily Total emissions



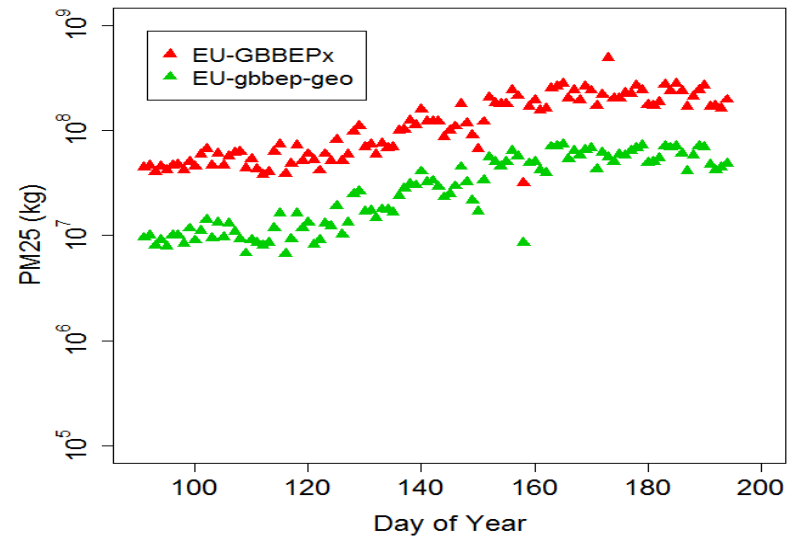
North America PM25 Daily Total emissions



Africa PM25 Daily Total emissions

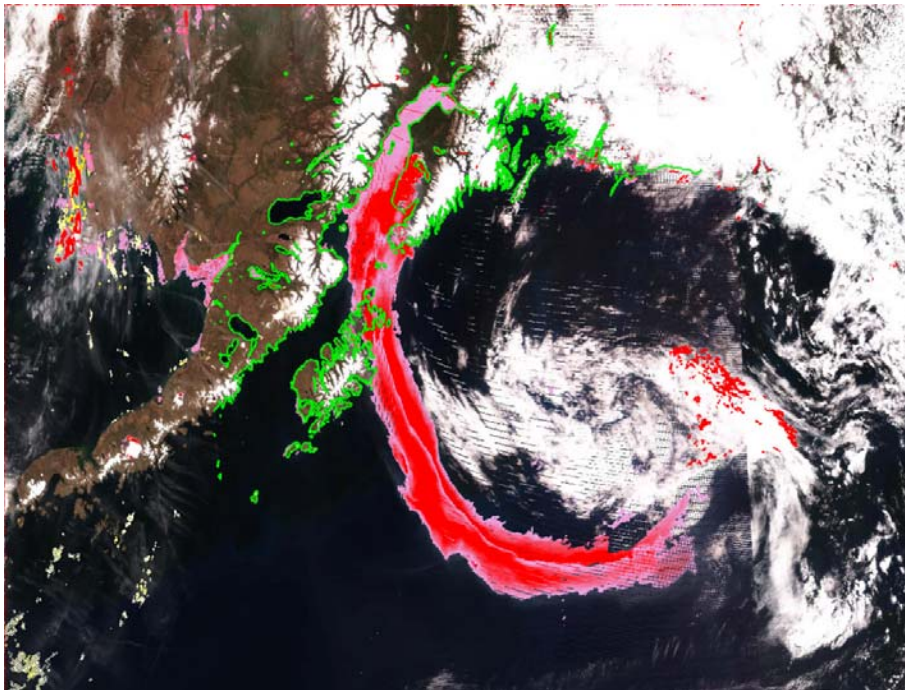


Europe PM25 Daily Total emissions



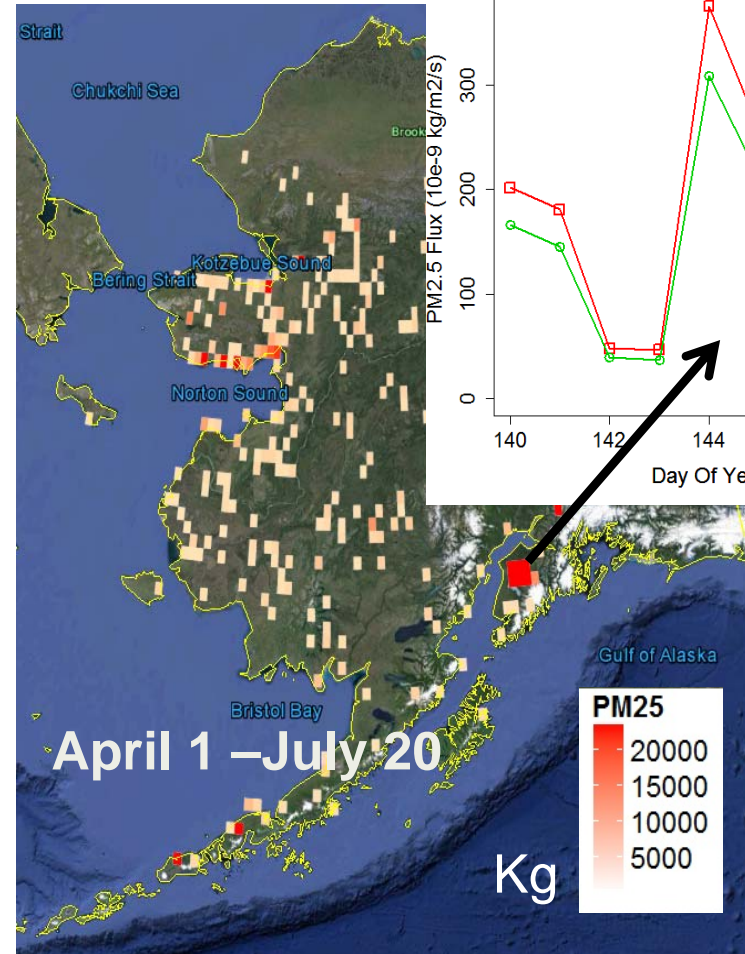


# Biomass Burning Emissions: Funny Fire, Alaska

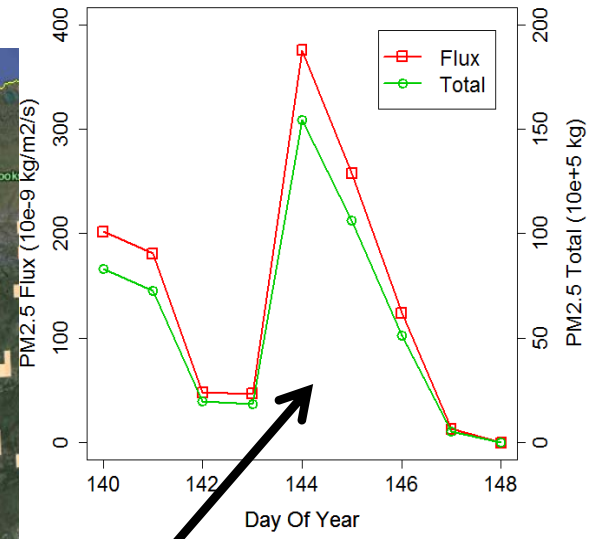


Thick Smoke      Thin Smoke

VIIRS Smoke Detection on  
May 20, 2014



Alaska PM2.5 Emission, May 20, 2014 - May 28, 2014

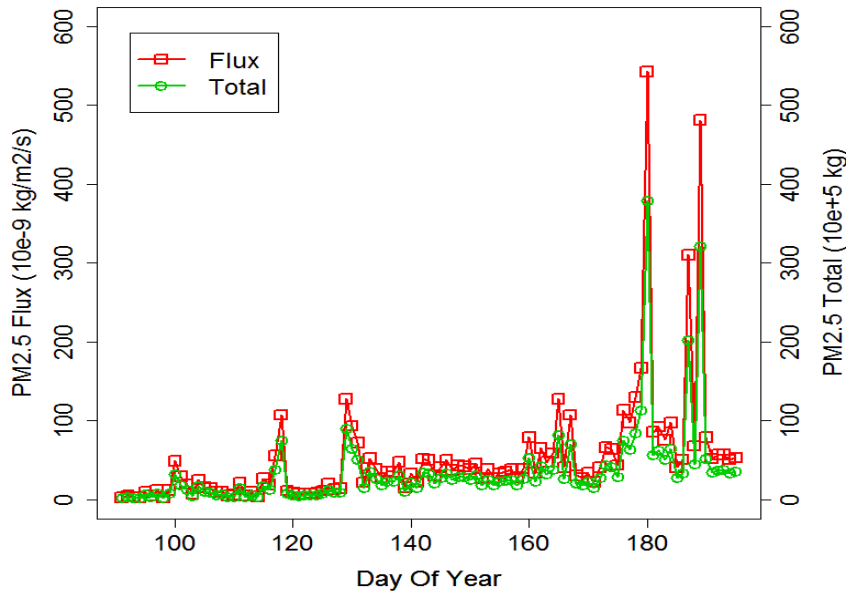




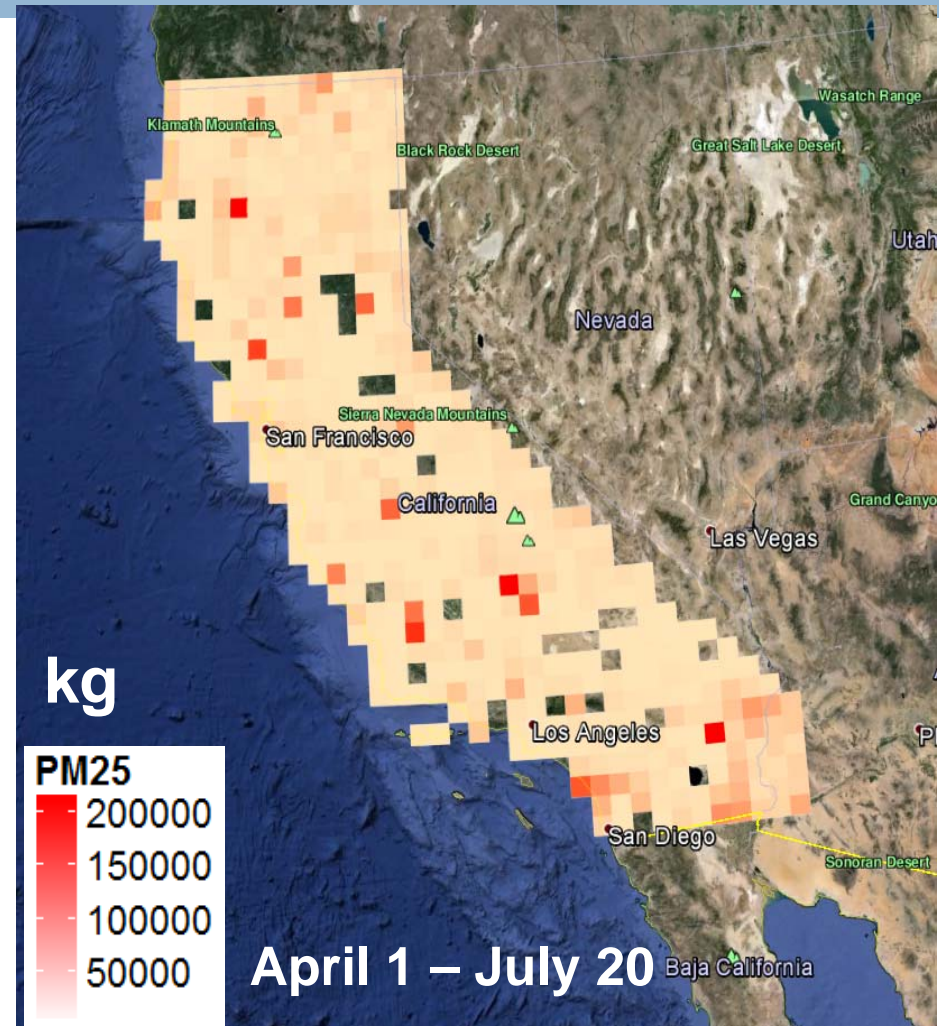
# Biomass Burning Emissions In California



California PM2.5 Emission, Apr 01, 2014 - Jul 20, 2014



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

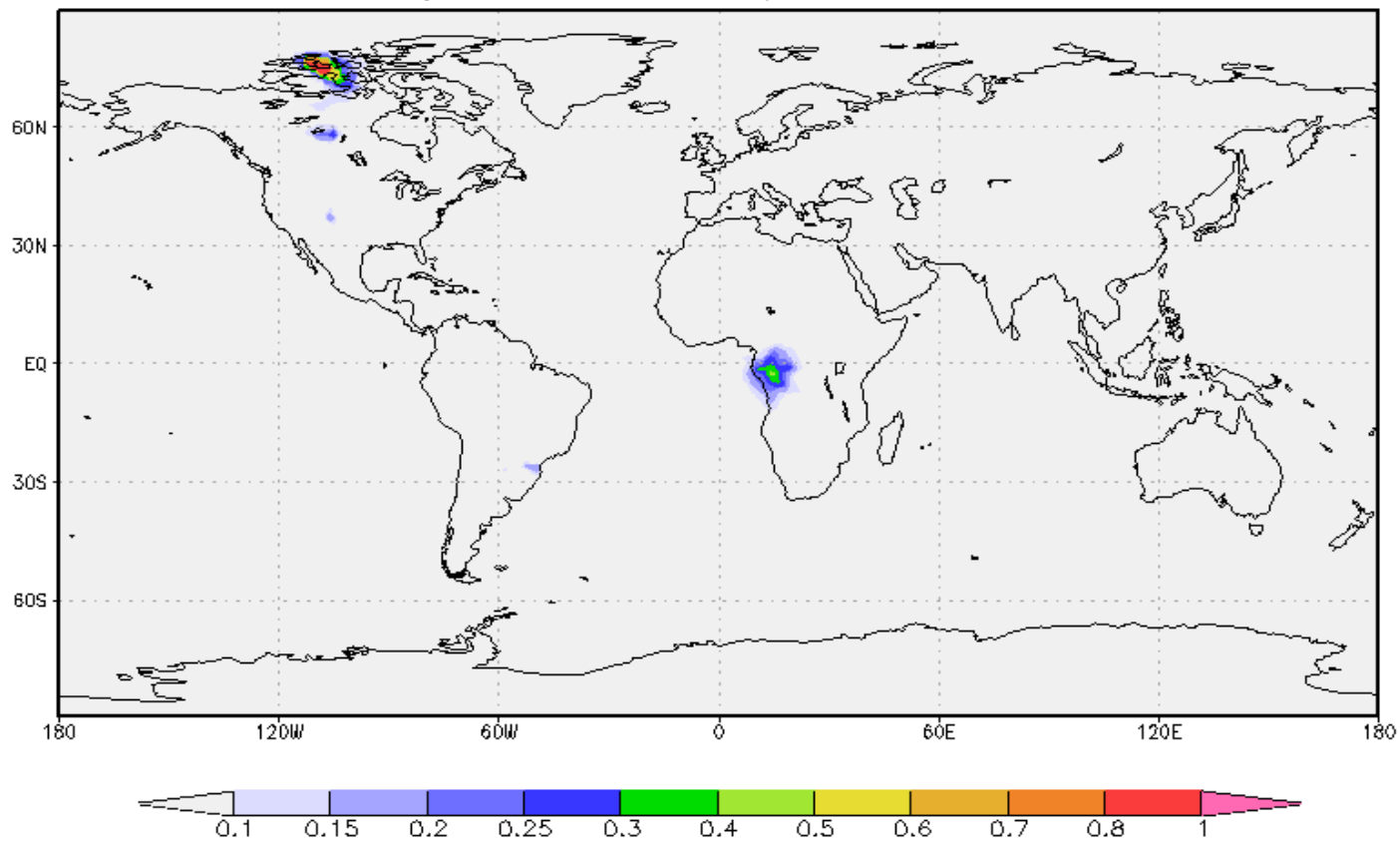




# NGAC Simulations with Biomass Burning Emissions in July 2011



AOD (GBBEP - NOBB); 20110701 00z



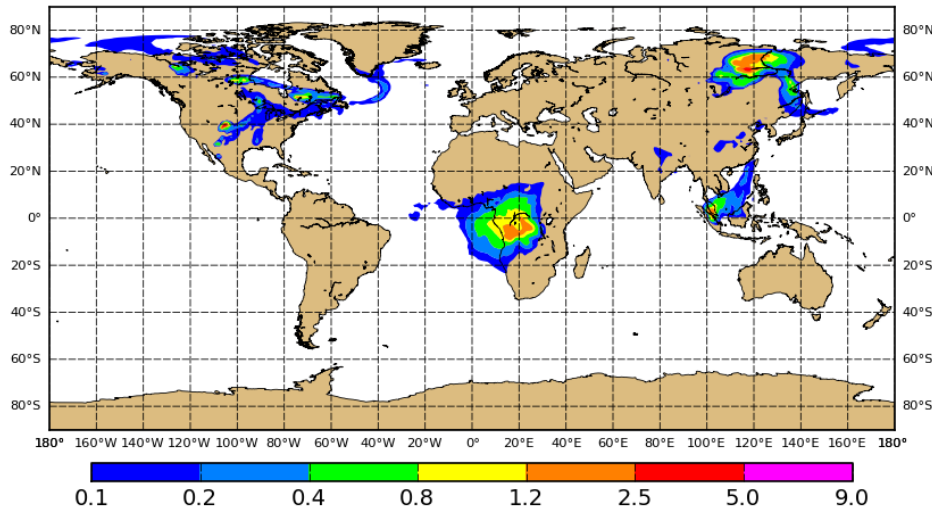


# NGAC Simulations using GBBEPx



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

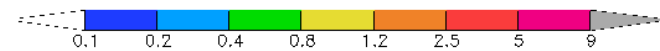
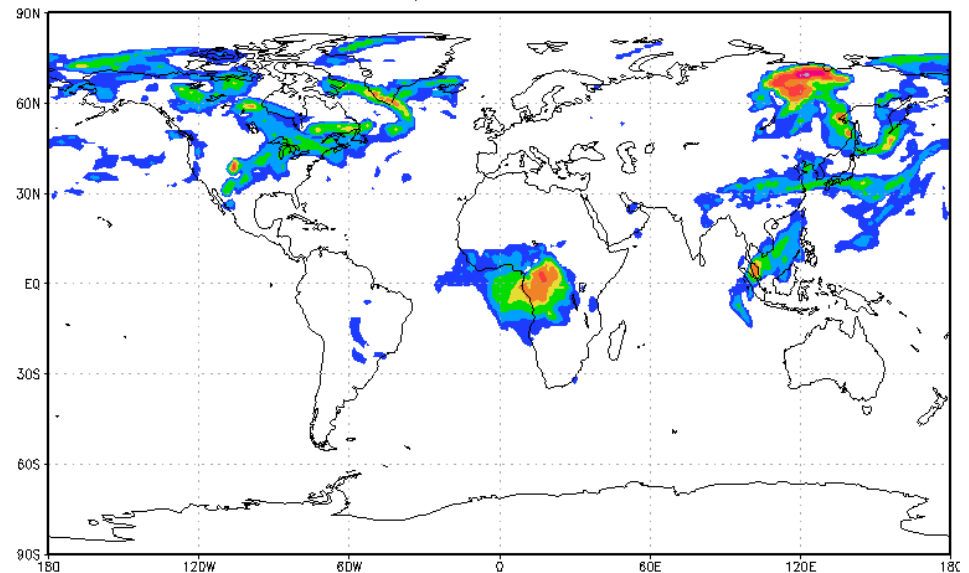
Sunday 23 June 2013 00UTC ICAP Forecast t+024  
Monday 24 June 2013 00UTC Valid Time  
SMOKE Aerosol Optical Depth at 550nm ( nMEM = 4 )



Plots Generated Monday 24 June 2013 16UTC NRL/Monterey Aerosol Modeling

## NGAC

OC AOD; 2013-06-24 00z



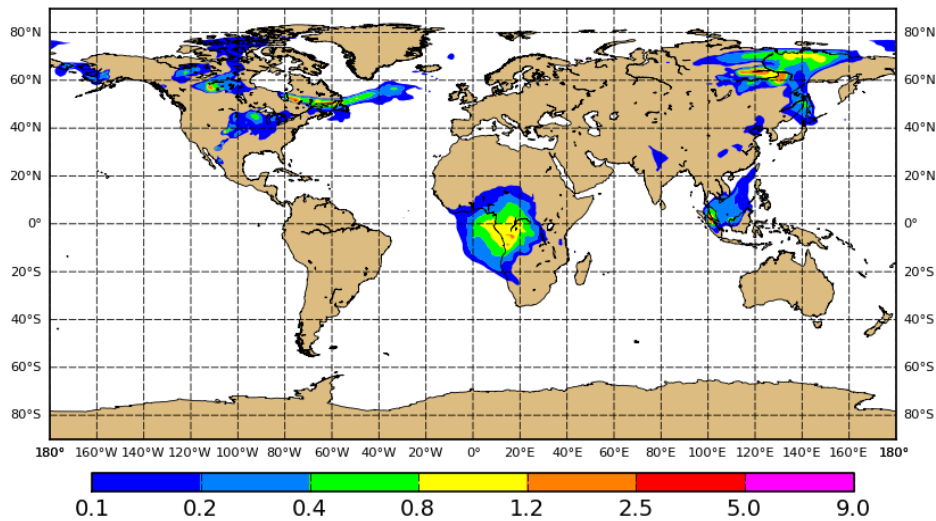


# NGAC Simulations using GBBEPx



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

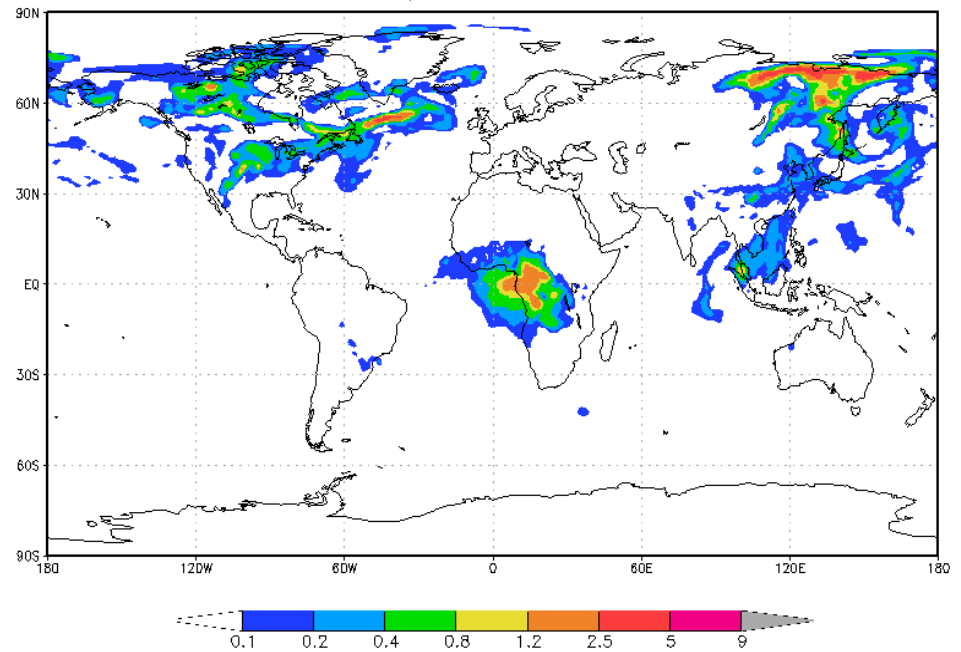
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Tuesday 25 June 2013 00UTC Valid Time  
SMOKE Aerosol Optical Depth at 550nm ( nMEM = 4 )



Plots Generated Tuesday 25 June 2013 16UTC NRL/Monterey Aerosol Modeling

## NGAC

OC AOD; 2013-06-25 00z



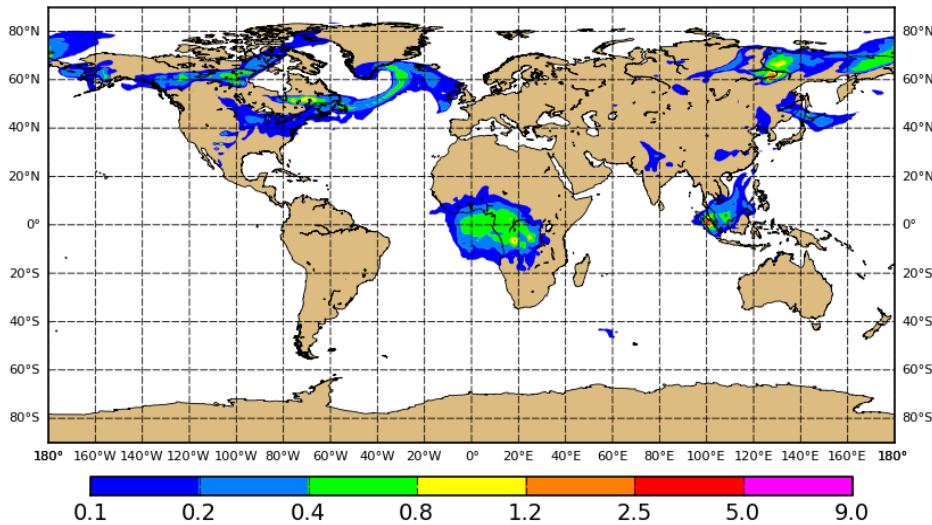


# NGAC Simulations using GBBEPx



## ICAP global ensemble from NRL, ECMWF, GSEC, and JMA

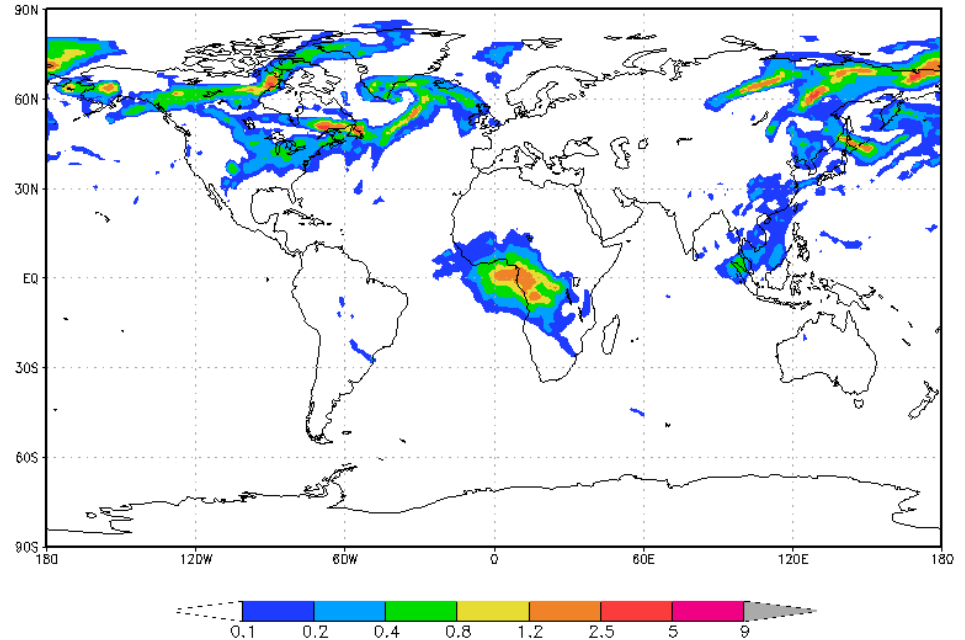
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Wednesday 26 June 2013 00UTC Valid Time  
SMOKE Aerosol Optical Depth at 550nm ( nMEM = 3 )



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

## NGAC

OC AOD; 2013-06-26 00z





# Future Development Plan



23

- 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.