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Near Real Time Monitoring of Global Biomass Burning Emissions by Integrating Fire Observations from Geostationary Satellites

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Outlines

- Comparison between MODIS FRP and GOES FRP
- Correlation between GOES FRP and biomass combustion
- Global biomass burning emission
- Summary

Estimate of Biomass Burning Emissions Using Fire Radiative Power (FRP)

Method 1 (Fire size and temperature):

FRP (Watts, J/s) : **$FRP = A\,\sigma\,T^4$**

A -- the area burned

σ -- the Stephan-Boltzman Constant (5.67×10^{-8} $Js^{-1}m^{-2}.K^{-4}$)

T -- the temperature of the fire

Method 2 (Radiance, Wooster, 2005):

$$FRP_{MIR} = \frac{A_{samp}\sigma}{a}\left(L_{h,MIR} - L_{bk,MIR}\right)$$

$L_{h,MIR}$, $L_{bk,MIR}$ are the MIR radiance of the active fire and ambient background, respectively.

A_{samp} is the pixel sample area

a is a constant

Biomass Consumption from Fire Radiative Energy (FRE)

$$FRE = \int_{t1}^{t2} FRP dt$$

t1,t2– time of the fire observations

BC = β * FRE

BC—biomass combustion (kg)
β–biomass combustion rate.
FRE–fire radiative energy

FRP Comparison--
FRP Datasets from MODIS and GOES

Time Period: September 14 (257) - October 31 (304), 2009

MODIS fire product (collection 5, pixel size 1km):

MOD14A (Terra)-crossing the equator around 10:30AM and 10:30PM local time

MYD14A (Aqua)-crossing the equator around 1:30AM and 1:30PM local time

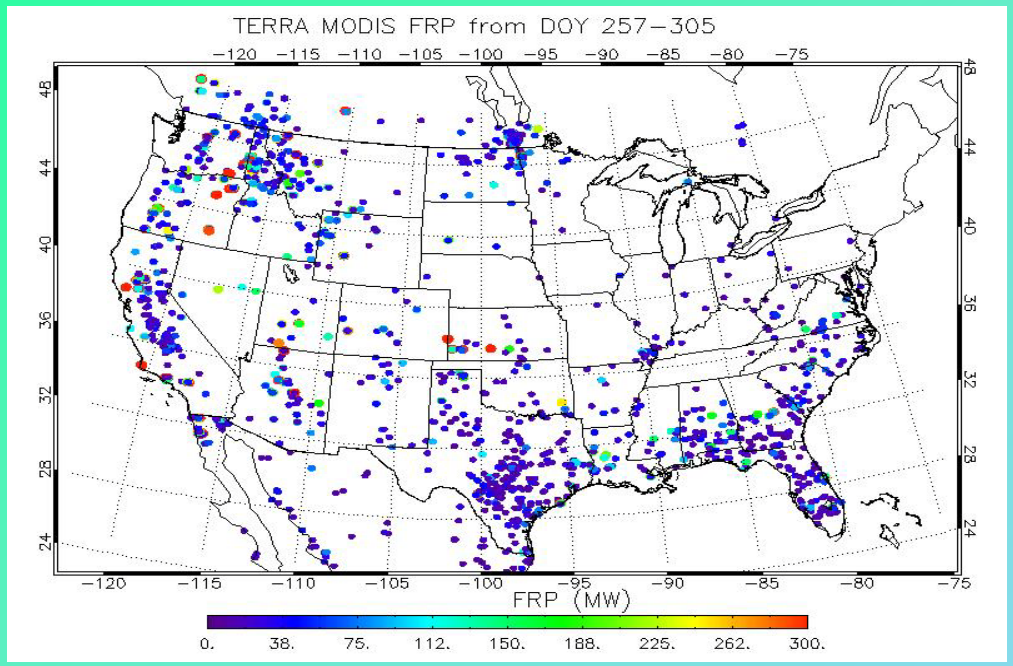
GOES fire product (pixel size 4km at nadir) from WF_ABBA V65:

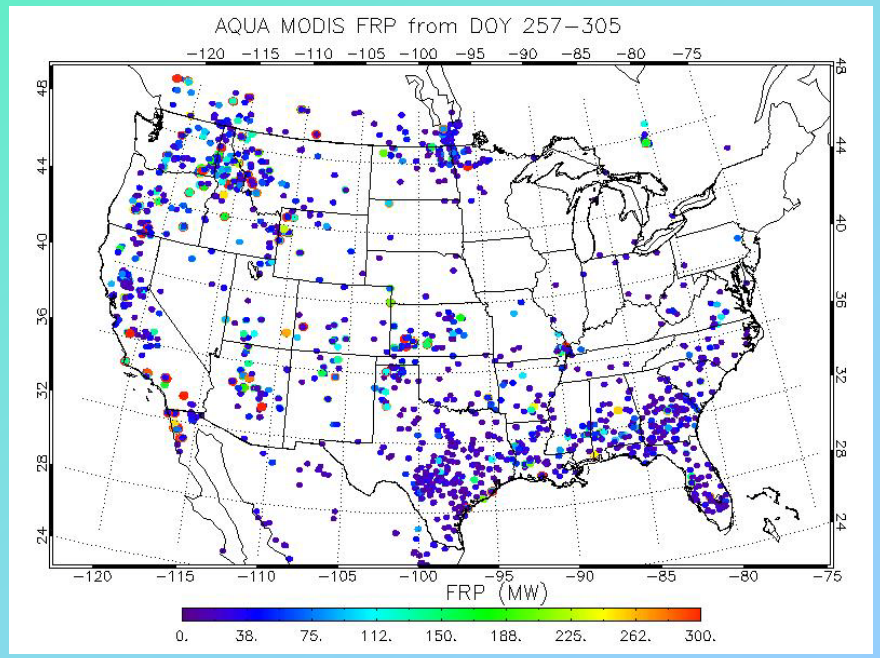
GOES11—observig surface at 0 and 30minutes every hour.

GOES12—observing surface at 15minutes and 45 minutes every hour.

(GOES WF_ABBA v65 dataset is provided by Christopher Schmidt)

Spatial Pattern of Aggregated MODIS FRP across CONUS



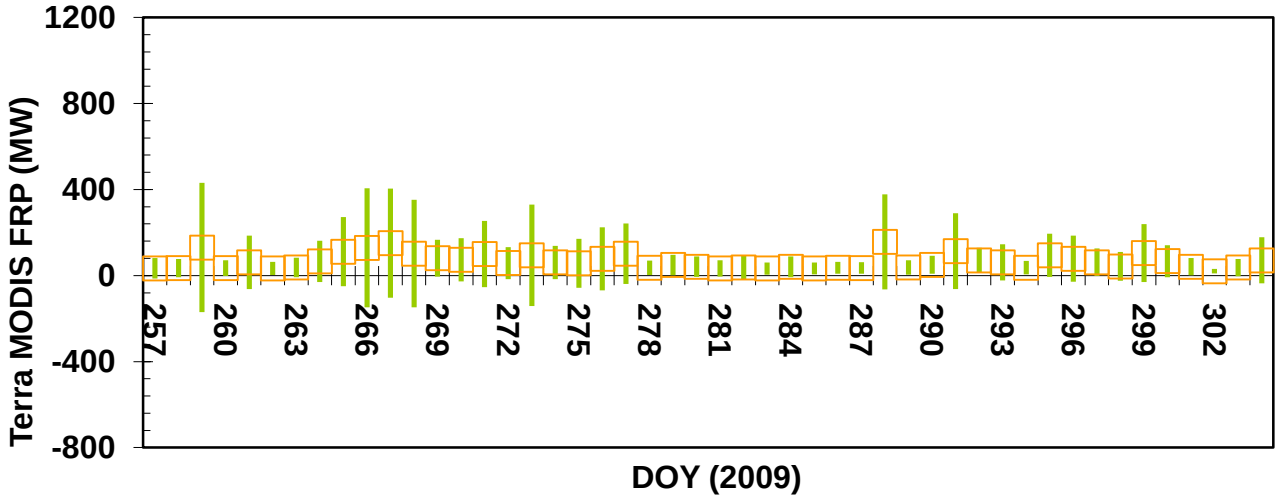


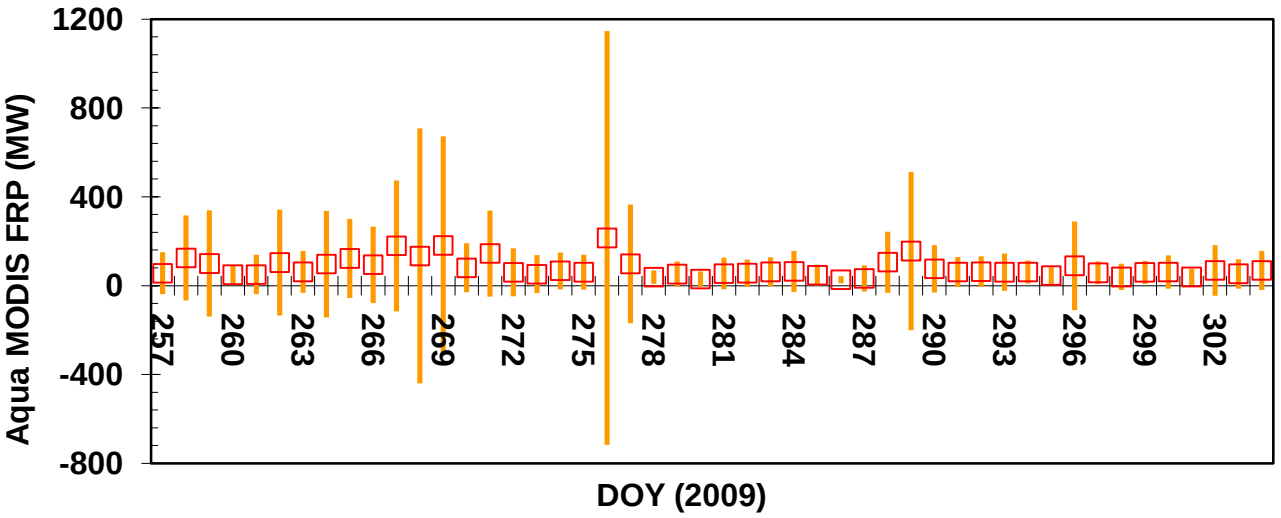
September 14 (257) - October 31 (304), 2009

MODIS FRP Characteristics

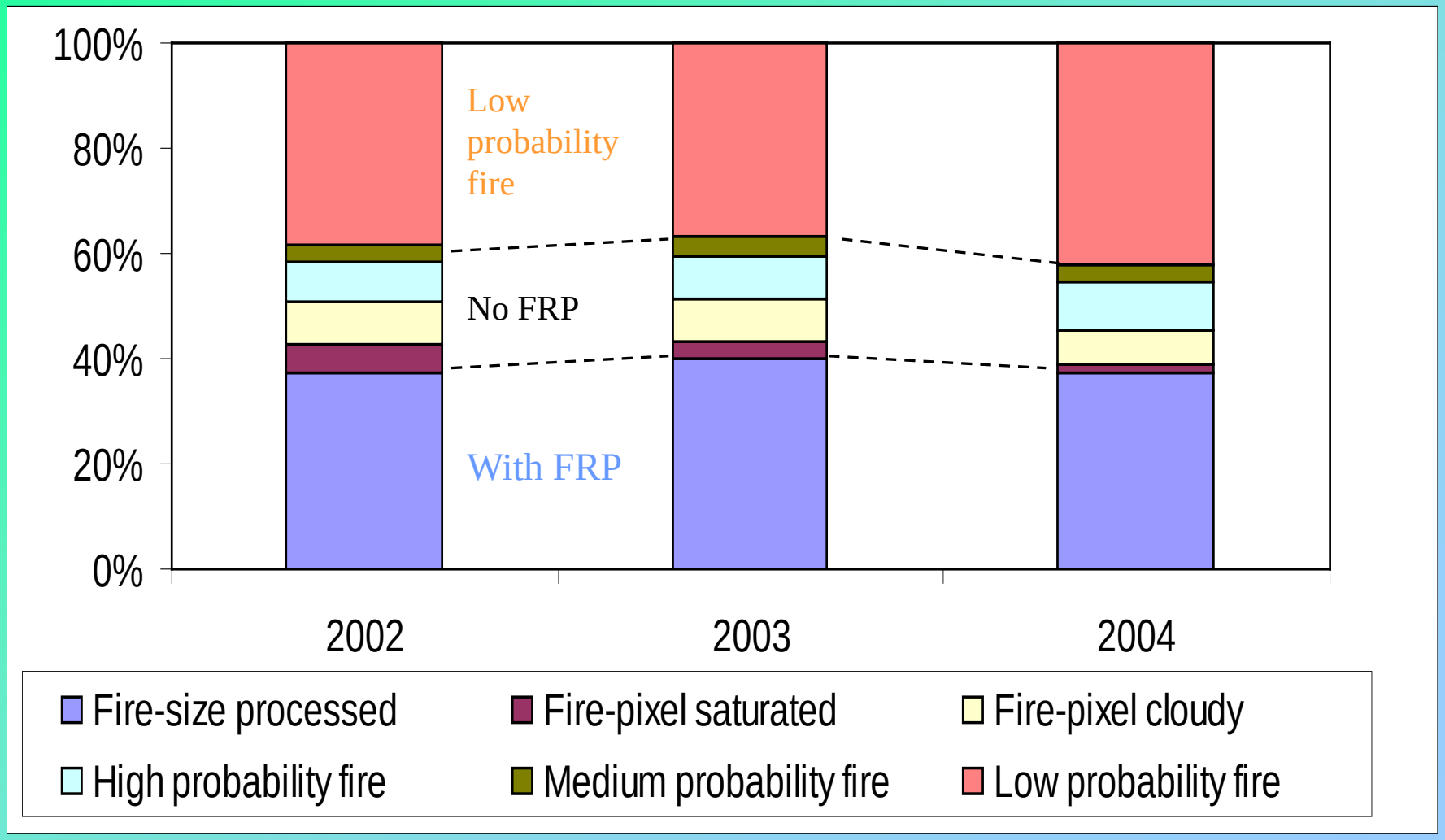
---Daily average FRP across CONUS

- FRP value varies greatly among hot spots.
- Daily average FRP is slightly larger in Aqua MODIS (78.2MW) than in Terra MODIS (65.6 MW)
- Aqua MODIS FRP presents much larger variance comparing with Terra MODIS FRP.
- Aqua MODIS FRP may have extremely large values.

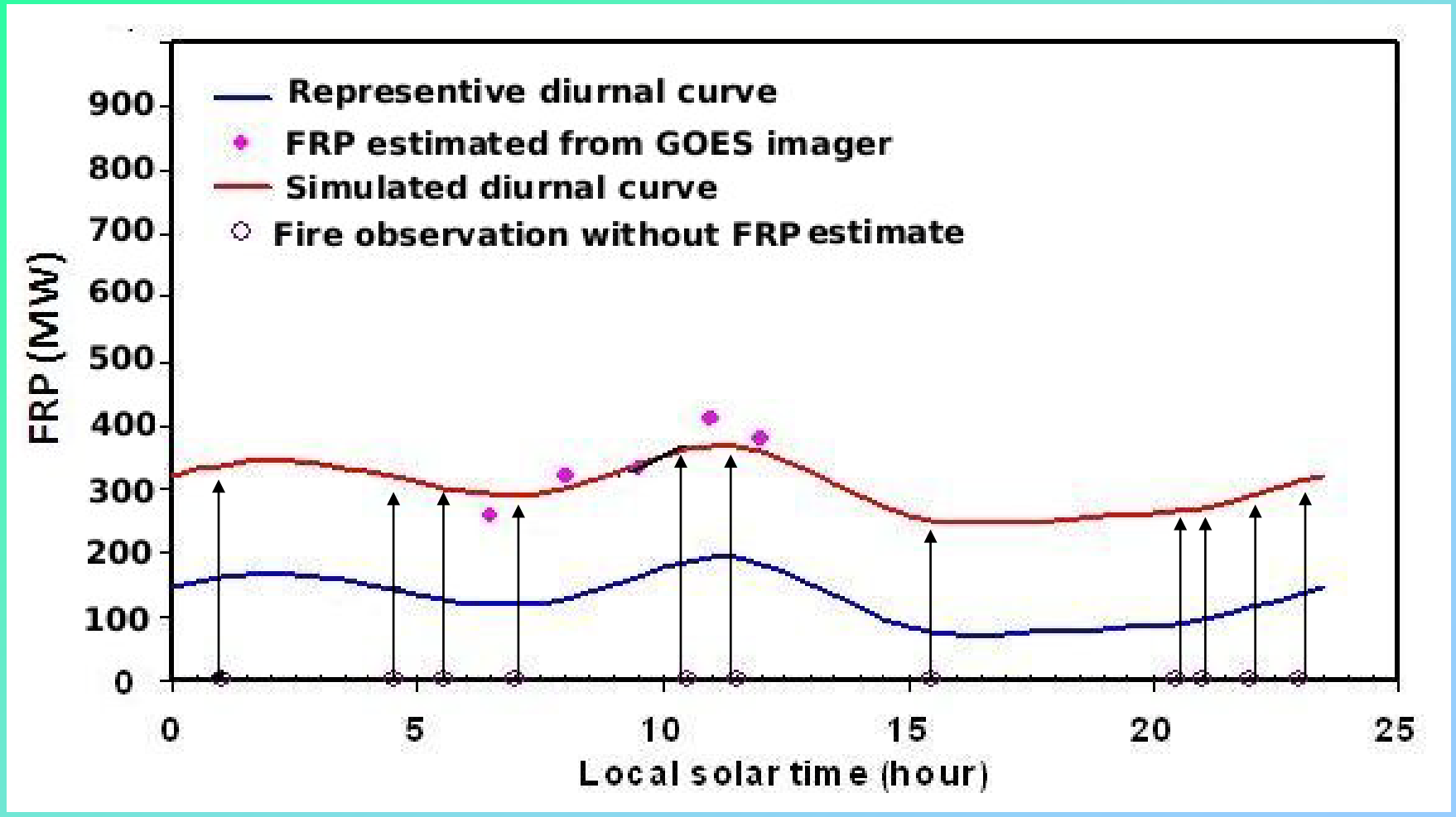




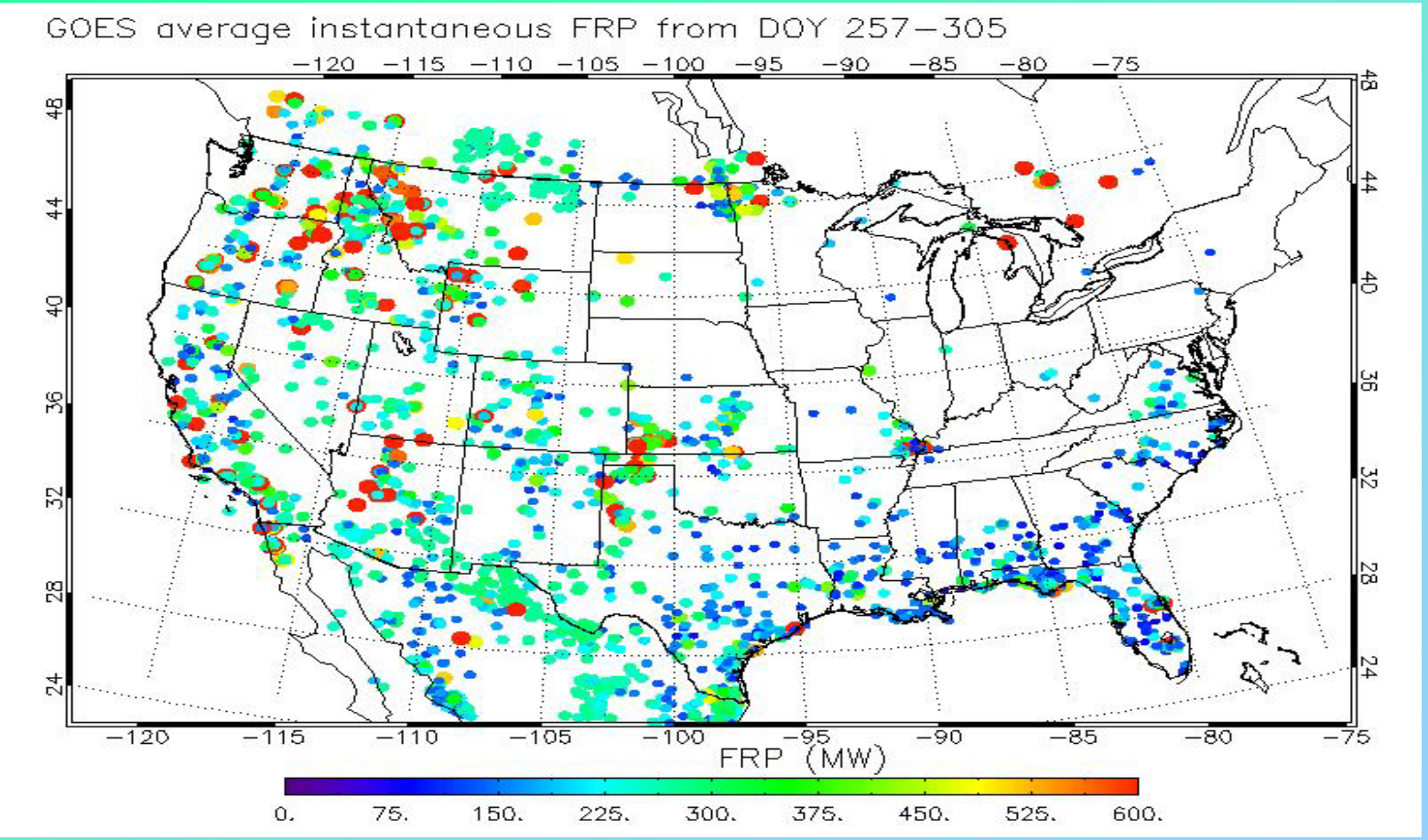
Quality in Fire GOES WF-ABBA Fire Product



Simulating FRP Diurnal Pattern for Individual GOES Fire Pixels

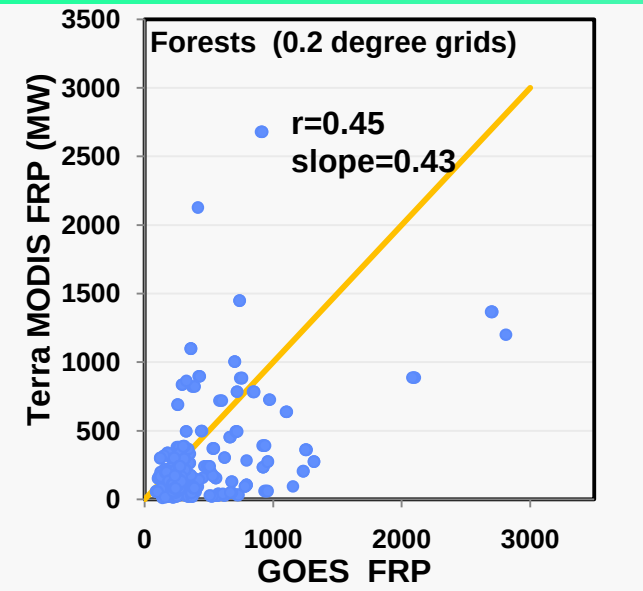


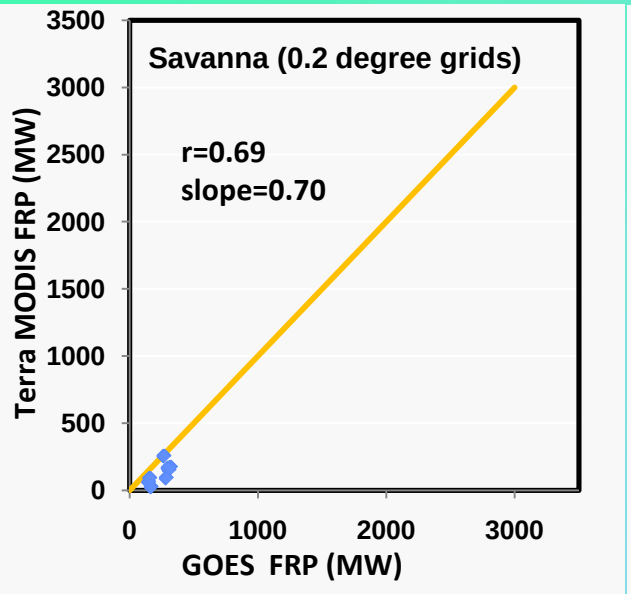
Spatial Pattern of Aggregated GOES FRP across CONUS (September 14 (257) - October 31 (304), 2009)

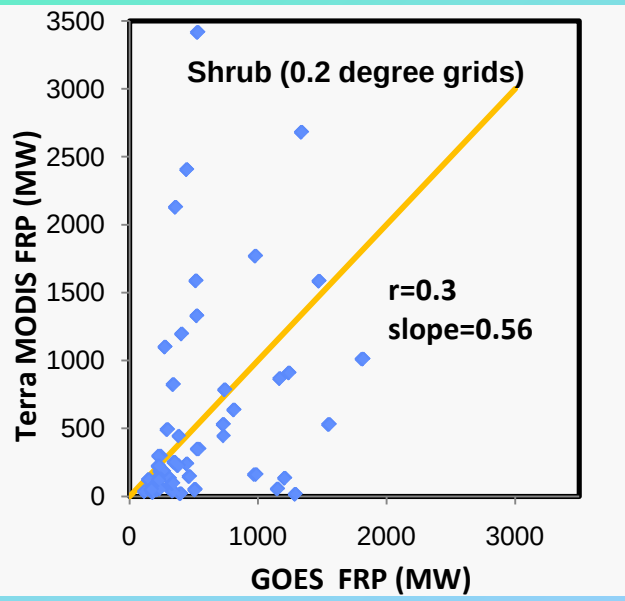


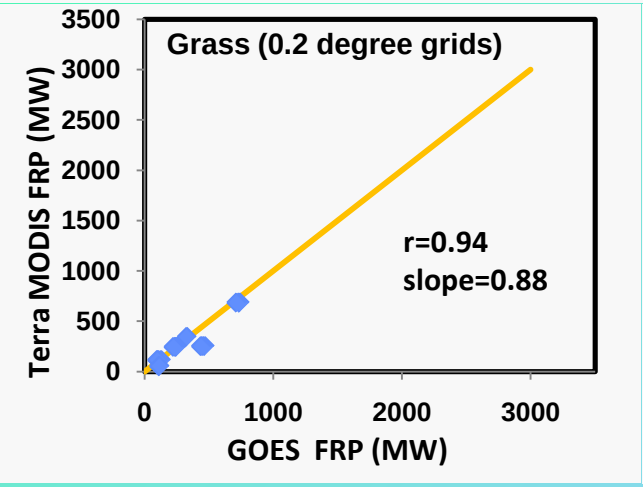
Note: GOES nadir pixel size is ~4km. FRP values in GOES-W and GOES-E are combined in the generation of diurnal pattern

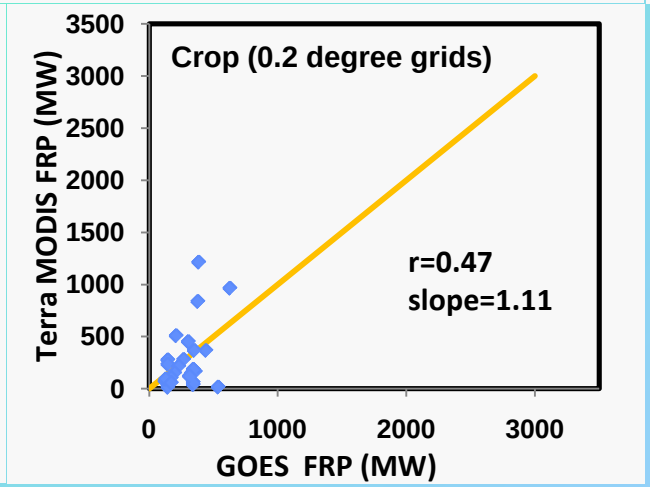
GOES FRP (fitted diurnal pattern) vs. Terra MOIDS FRP in Various Ecosystems











GOES FRP (fitted diurnal pattern) vs. MODIS FRP

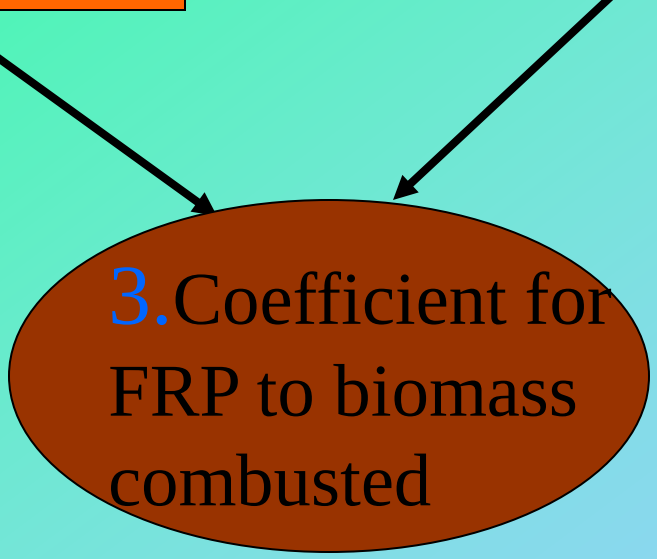
	GOES vs Terra MODIS			GOES vs Aqua MODIS		
Grid size	0.1 degree	0.2 degree	0.5 degree	0.1 degree	0.2 degree	0.5 degree
r	0.35	0.40	0.38	0.30	0.51	0.48
Slope	0.86	0.90	1.38	1.1	1.04	1.09
Samples	161	234	289	191	281	364

Summary: The FPR is significantly correlated to MODIS FRP ($p<0.001$). The samples are scattered but the slope is close to one. GOES FRP is slightly better correlated to Aqua MODIS FRP.

Correlation between GOES FRP and biomass combustion

1. Biomass combustion from TM burn scar

2. FRP from GOES



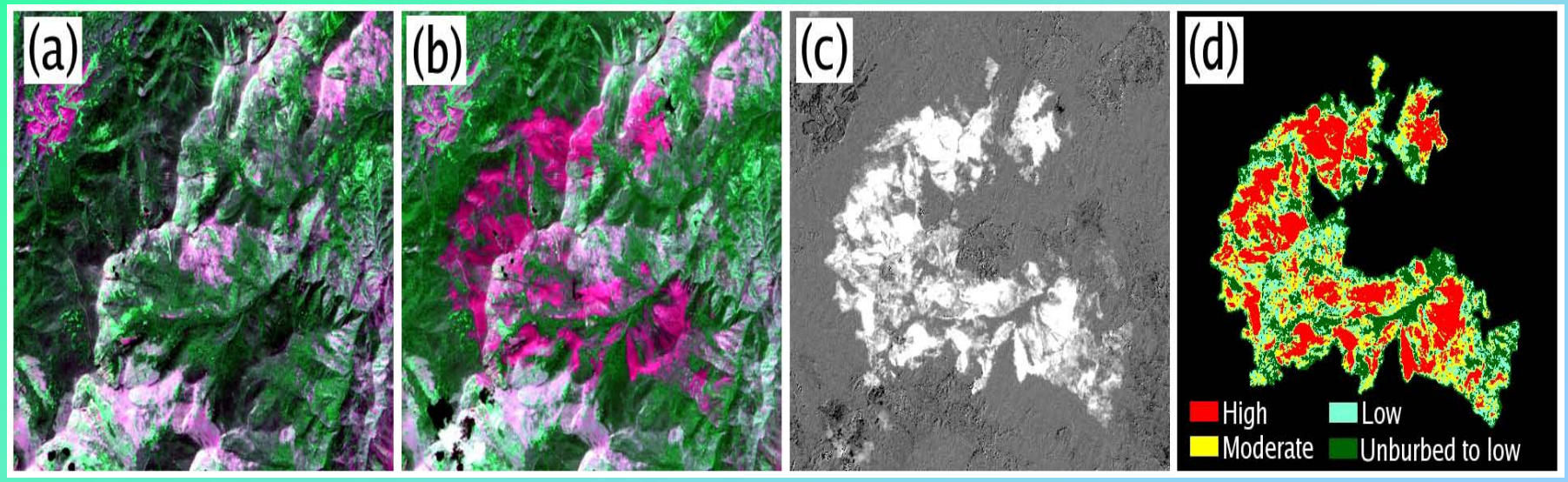
β =f(BC, FRE)

BC—biomass combustion (kg)

β–biomass combustion rate.

FRE–fire radiative energy

Burned Severity from TM Imagery



Biomass Combustion from TM Burn Scar

$$BC = \sum_{l=1}^{J} \sum_{k=1}^{I} A_{kl} M_{kl} C_{kl}$$

l - fuel type (little, coarse woody detritus, foliage, branch, shrub, and grass)

k - burn severity categories (low, middle, and high)

A – area of TM burn scar

M – fuel loading

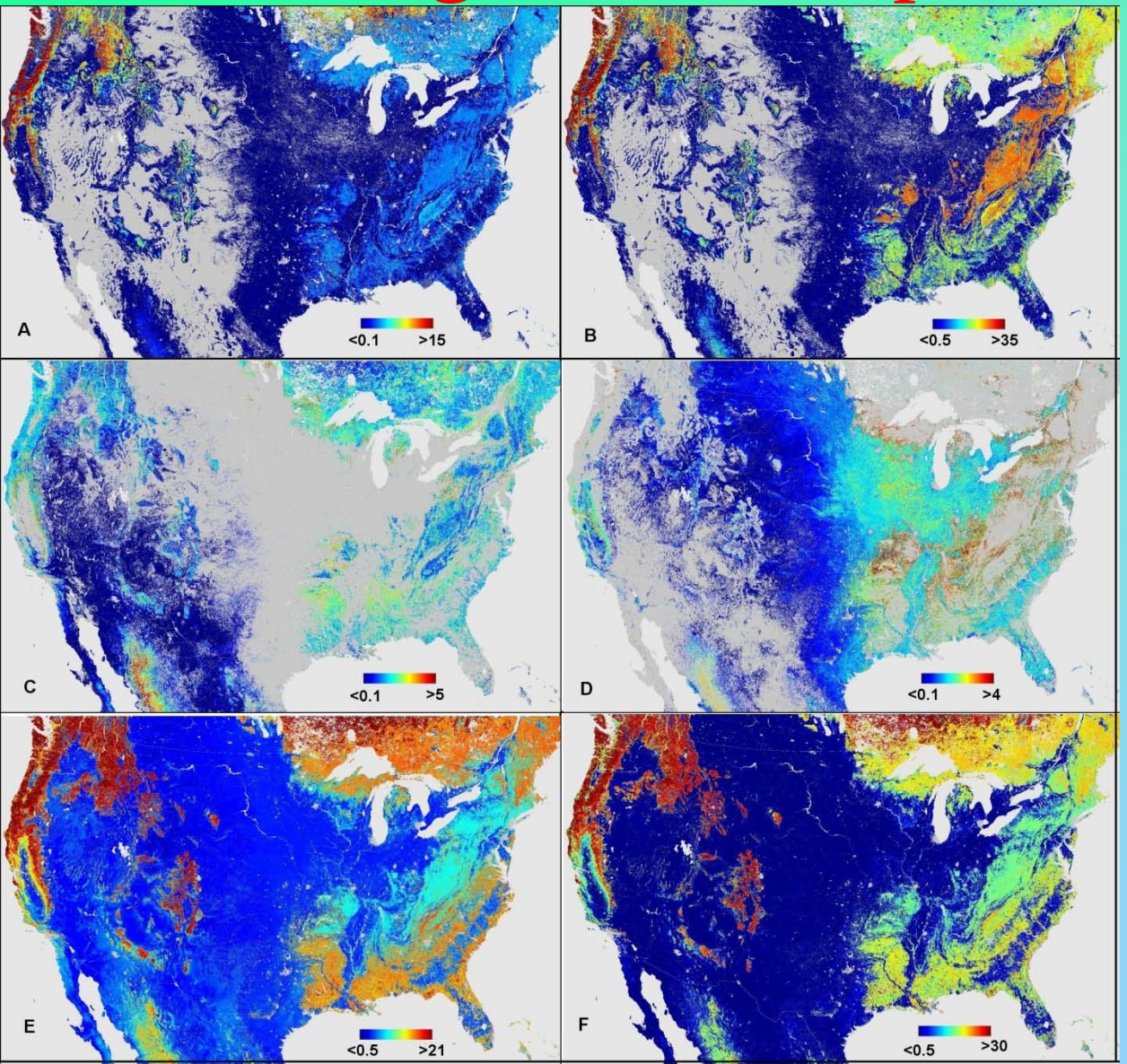
C-- fuel consumption rates (%)

Fuel Consumption Rates in TM-Burn Scar

Fuel consumption rates (%) in different burn severity categories (based on Key and Benson, 2006; Epting et al., 2005; van Wagtendonk et al., 2004)

%	litter	Coarse woody detritus	Herb	Shrub	Crown (Foliage)	Crown (Branch)
Low severity	50	10	30	20	20	10
Middle severity	100	25	70	50	60	30
High severity	100	50	100	80	100	50

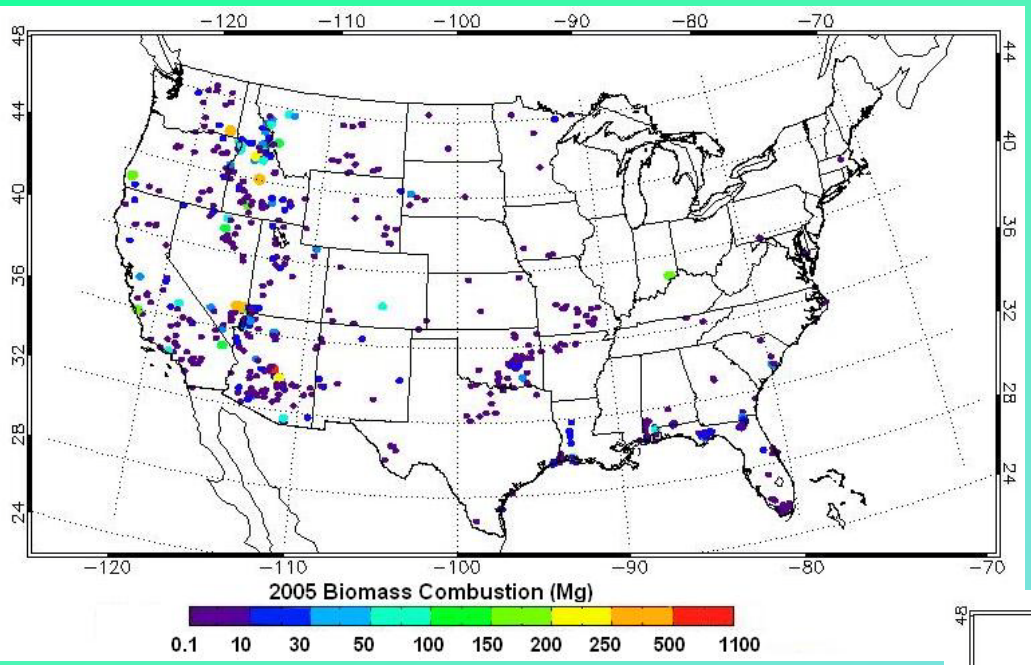
Fuel Loadings Estimated from MODIS Vegetation Properties (1KM)

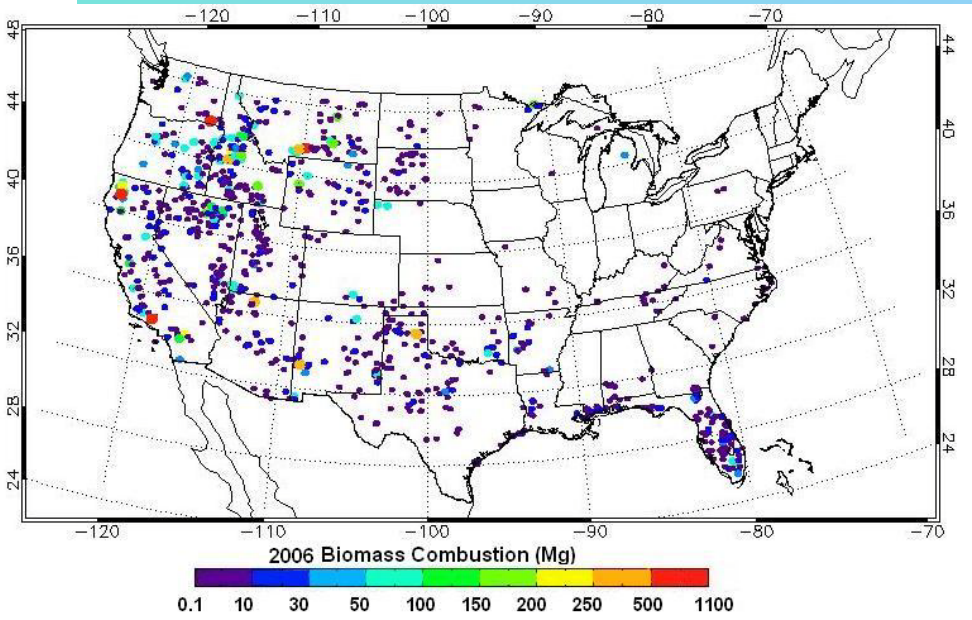


(a) Forest foliage
(b) forest branch
(c) shrub
(d) grass
(e) litter
(f) coarse woody detritus

(ton/ha)

Fire Combustions in Burn Scars



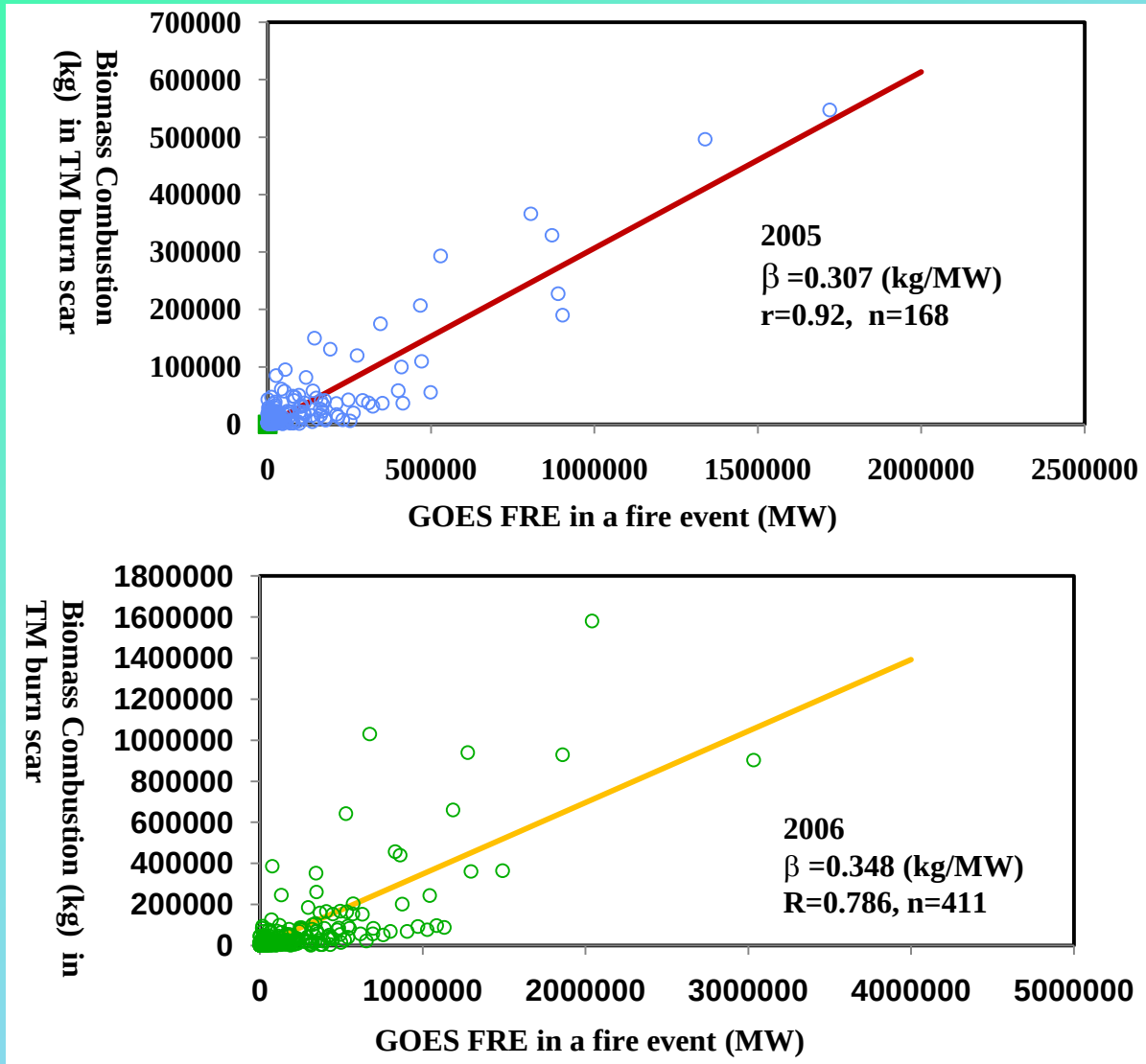


Biomass Combustion Rate (β)

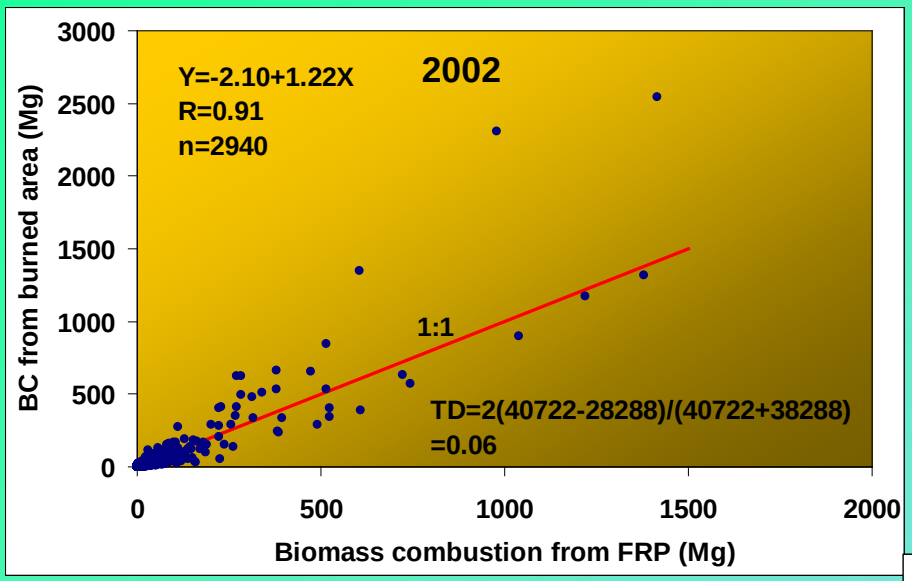
--Determined from GOES FRE and Biomass Combusted in TM Burn Scars

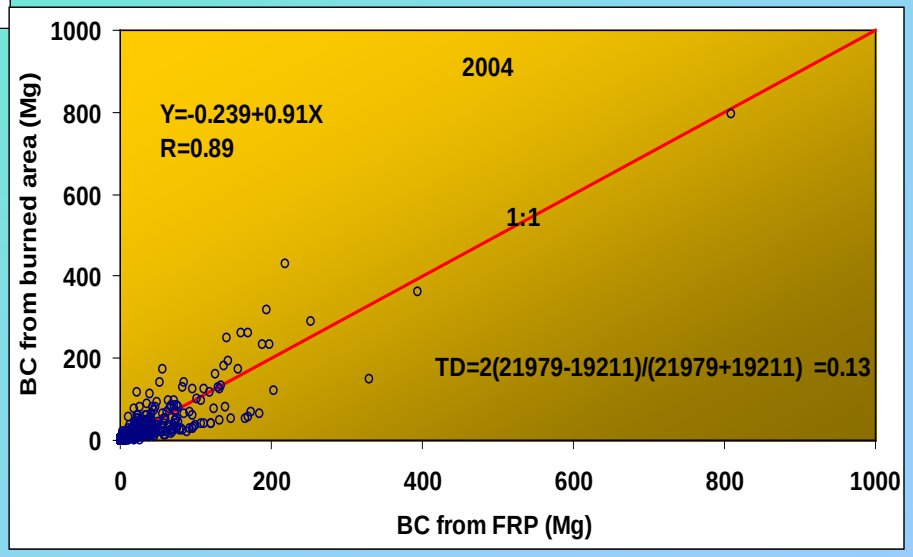
Each pair of sample indicates the GOES FRE and burn-severity-based biomass combustions in each burn scar detected from TM imagery. Thus the relationship between FRE and biomass combustion is established to determine the rate of biomass combustion β for the FRE released.

The β value is 0.368±0.015 kg/MJ (Wooster et al., 2005)



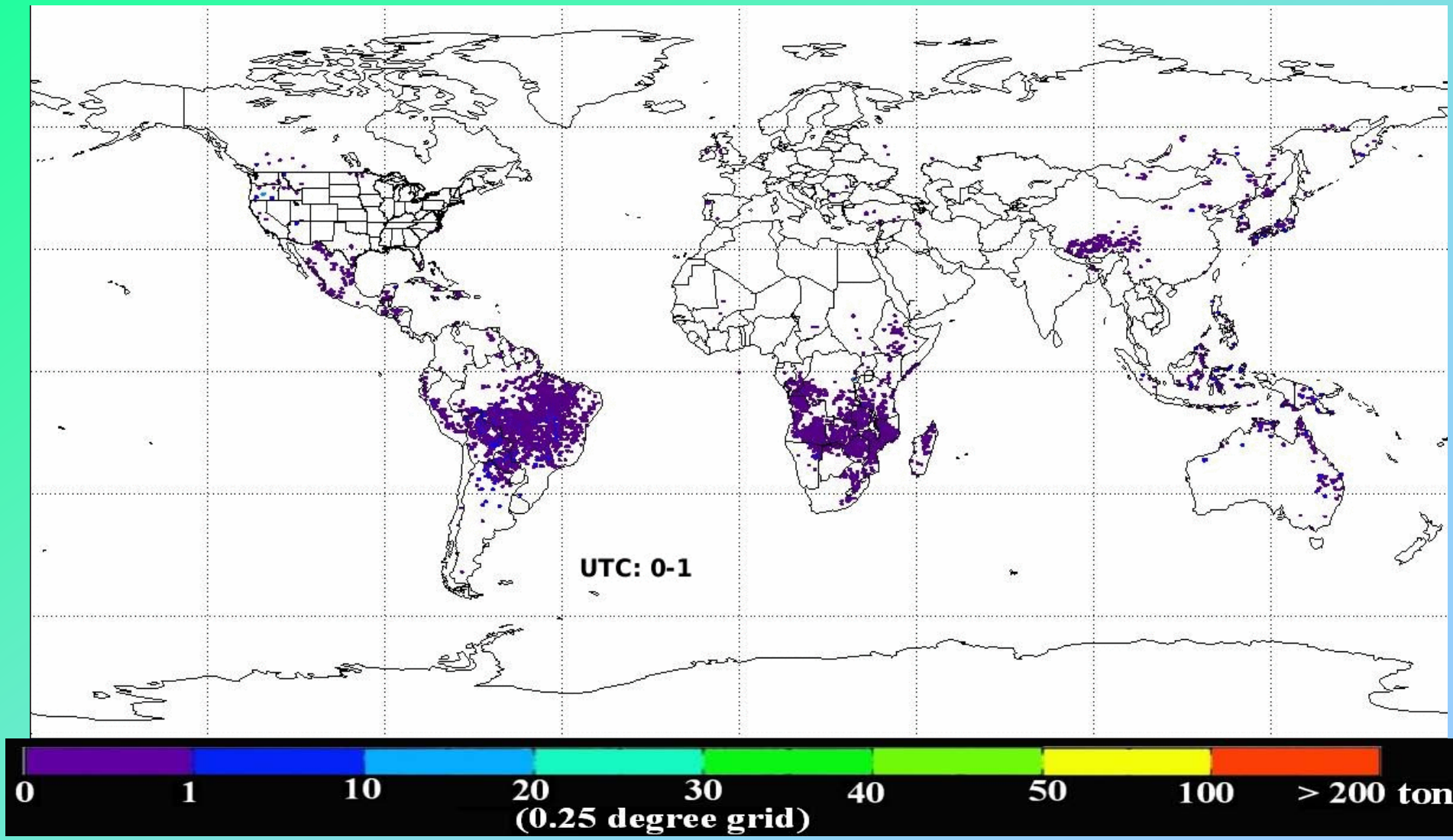
Comparison between Biomass Combustions Derived from Burned Area+Fuel Loadings and FRE (20’ grids)



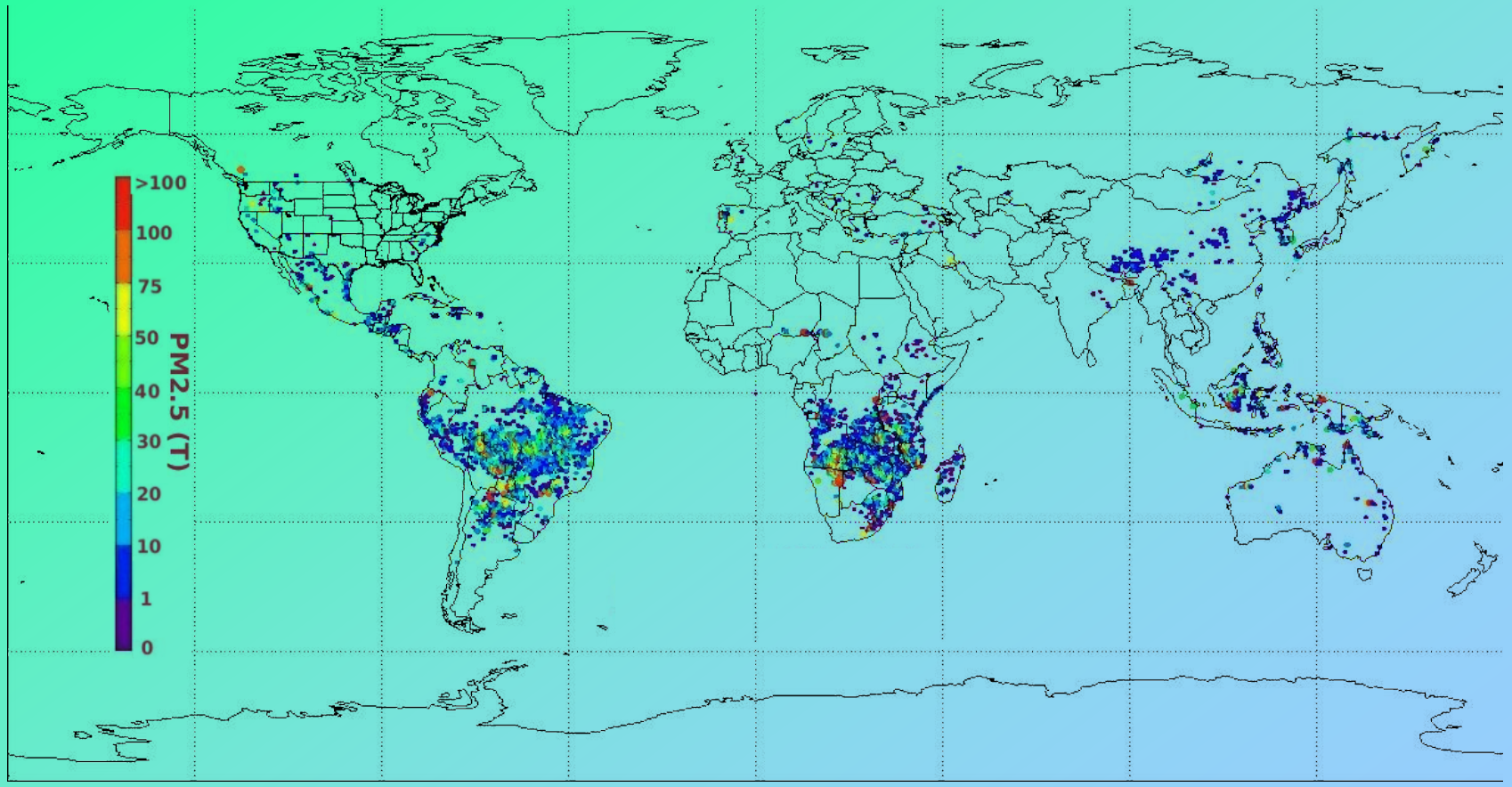


TD-total difference

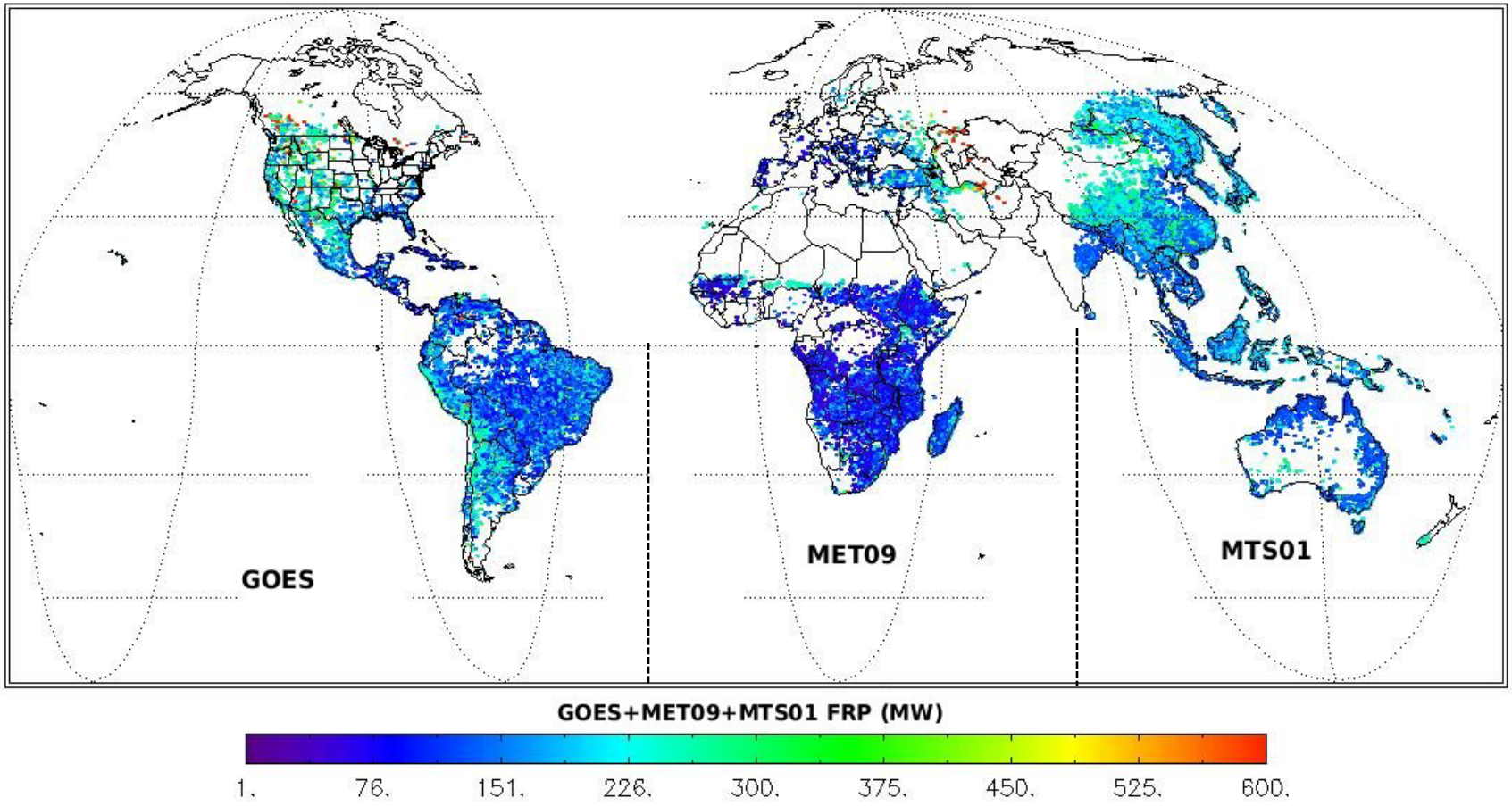
Hourly Biomass Burning Aerosols in Sept. 16, 2009 (animation)



Global PM2.5 Emissions in September 15, 2009

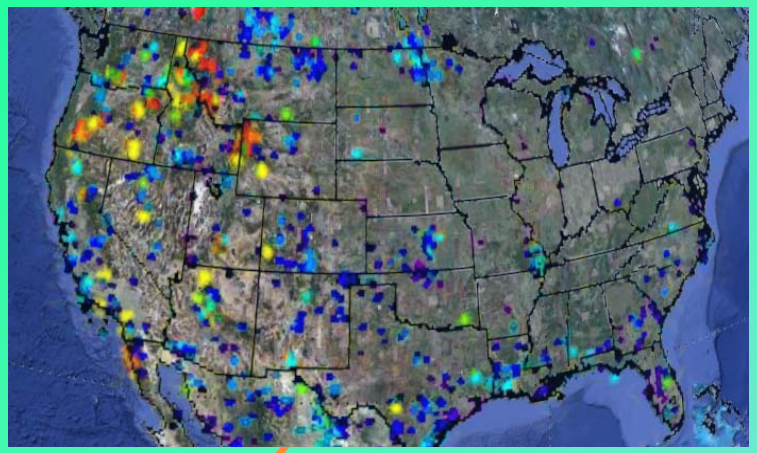


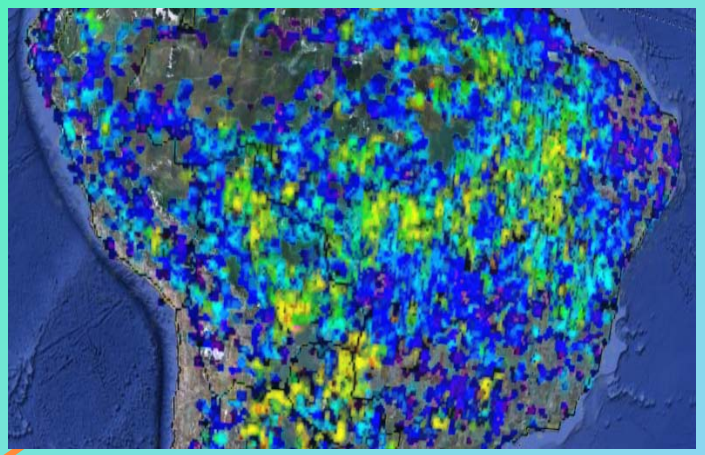
Spatial Pattern of Aggregated GOES+MET09+MTS01 FRP across Globe

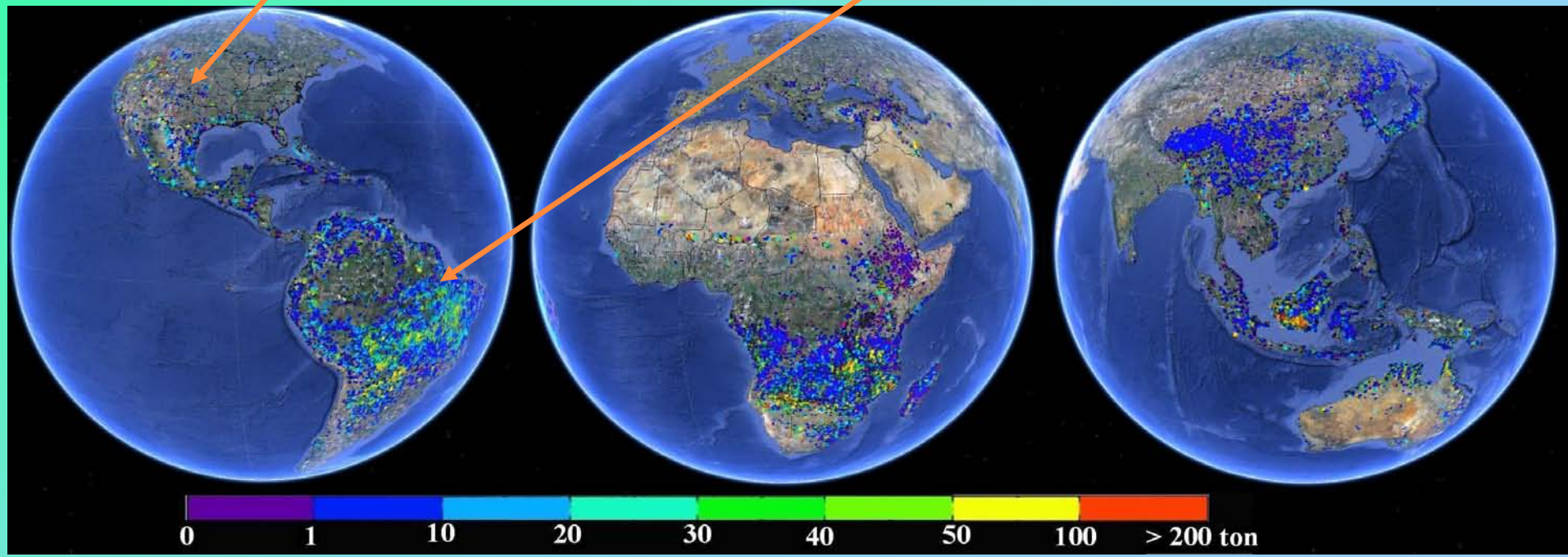


Average from DOY 257-305, 2009

Burning Emissions of Aerosols Calculated from FRP in Sept. 15-30, 2009





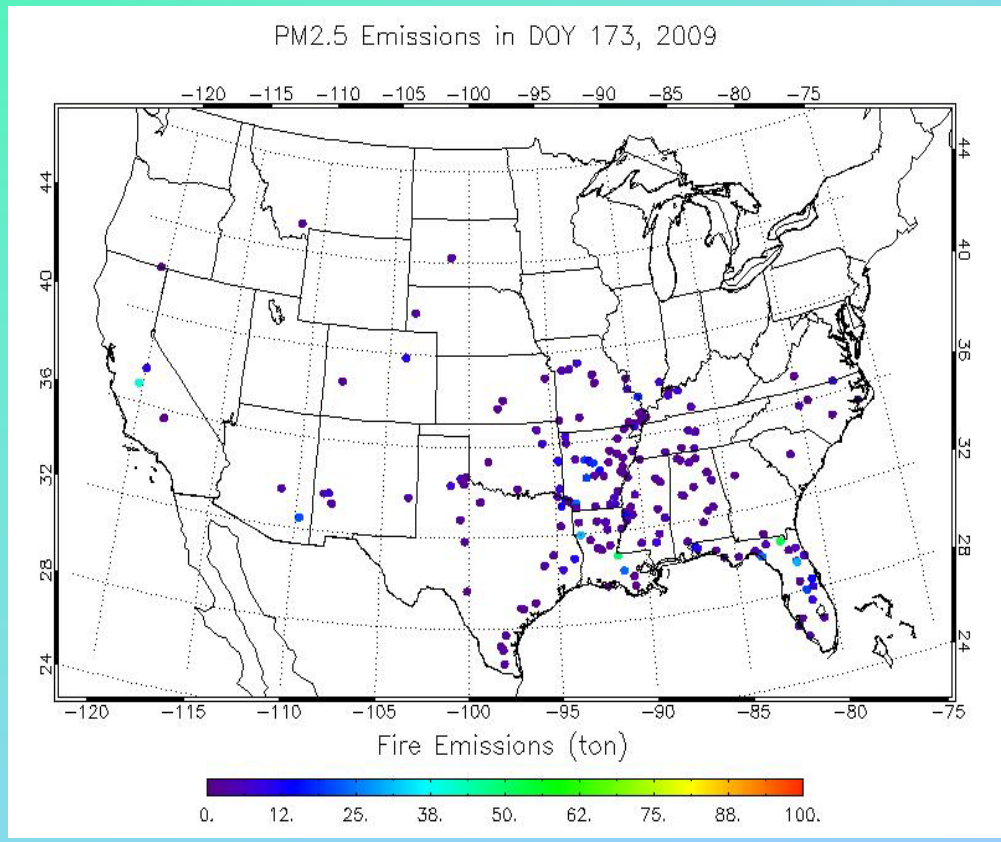


Operational product of Biomass Burning Emissions from GOES-E

- Biomass burning emissions are produced once a day. The output parameters include:

  hourly emissions in PM2.5, CO, CO2, CH4, N2O, NH3, NOX, SO2, TNMHC, separately.

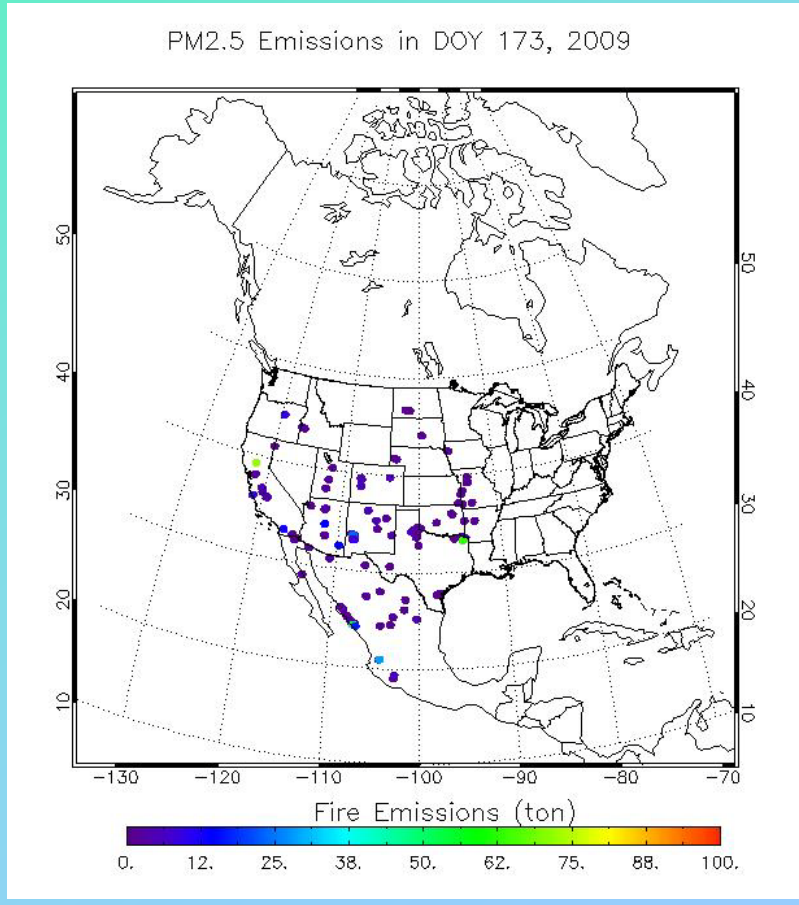
- The emission data are available at
- ftp://satepsanone.nesdis.noaa.gov/EPA/GBBEP/



Operational Biomass Burning Emissions from GOES-W

- Biomass burning emissions derived from GOES-W cover west part of North America. The output has the same format as GOES-E emissions
- The product is available at:

ftp://satepsanone.nesdis.noaa.gov/EPA/GBBEP_W/



Summery

- FRP is relatively simple in the estimates of biomass burning emissions, but how to calculate FRP and to convert to biomass burning needs further investigations.
- Further comparison is needed between the emissions calculated from FRP and the burned-area-fuel-loading model.
- It is currently a big concern about the accurate of emission estimates because reliable ground “truth” is not available for validations.
- Although there are limitations, integrating GOES, MET09, and MTS01 fire detections provides an opportunity to estimate global biomass burning emissions in near real time.


THANK YOU