INTERCOMPARISON OF NOAA'S GLOBAL BIOMASS BURNING EMISSIONS PRODUCT (GBBEP) FROM GEOSTATIONARY SATELLITES AND NASA'S QUICK FIRE EMISSIONS DATA (QFED) FROM POLAR-ORBITING SATELLITES

Jessica Ram[1], Xiaoyang Zhang[2], Shobha Kondragunta[3], Ho-Chun Huang[4], and Arlindo da Silva[5]

[1]IMSG at NOAA/NESDIS/STAR [2]ERT at NOAA/NESDIS [3]NOAA/NESDIS [4]IMSG at NOAA/NCEP [5]NASA/GSFC

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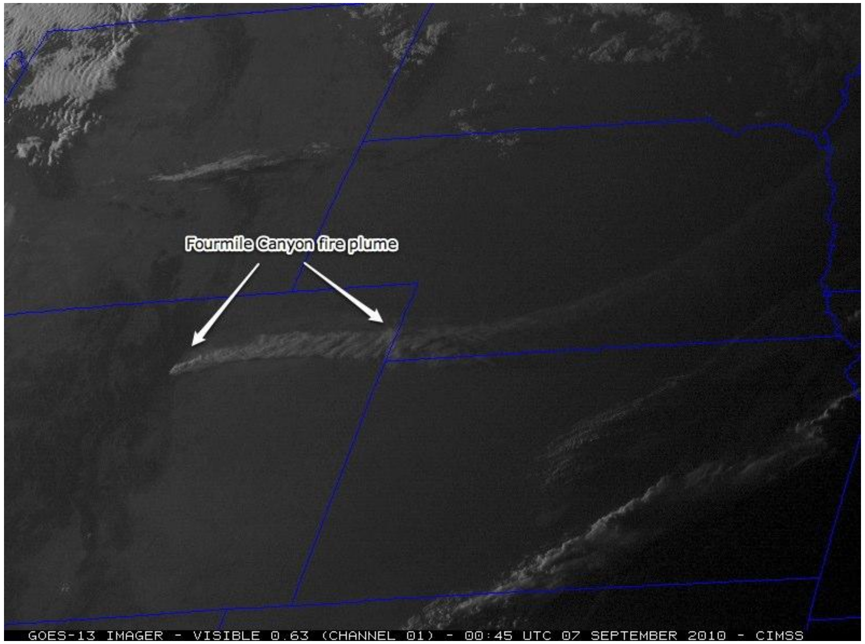
Overview

- Improved representation of biomass burning emissions in numerical air quality models is expected to improve the accuracy of predictions.

- Two sets of satellite-derived emissions are used in this study to demonstrate the impact on models (Ho-Chun Huang's talk) and also compare the datasets. Global emissions are compared using the NCEP Global Forecasting System (GFS) aerosol module, the NASA Goddard Chemistry Aerosol Radiation and Transport (GOCART) model

- Off-line GFS-COGART simulations with a 1° x 1° horizontal resolution and 64 vertical layers during the months of July, August, September 2010
  - AOD
  - Emissions (kg/hr)
  - Black & Organic Carbon Concentrations
    - Surface (μg/m^3)
    - Column (μg/m^2)



Fire in the Fourmile Canyon, CO.
September 7, 2010
(image from CIMSS)

Products

GBBEP

- NESDIS Global Biomass Burning Emissions Product (GBBEP)
- Geostationary
  - GOES-11
  - GOES-13
  - Meteosat-9
  - MTSAT-2 imager
- Based on Fire Radiative Power (FRP)
- Available hourly with a 3-4 km horizontal resolution

Fire products courtesy of Chris Schmidt, UW-Madison

QFED

- NASA's Quick Fire Emission Dataset
- Polar-orbitting
  - Aqua MODIS
  - Terra MODIS
- Based on fire counts and climatological emissions data from Global Fire Emissions Data (GFED)
- Available daily with a 1 km horizontal resolution
- Hourly values can be derived using an empirical fit

QFED data courtesy of NASA

GBBEP Algorithm

Fire Radiative Power [MW]

$$FRP = \frac{A_{sample}\sigma}{c}(L_{3.9\mu m,MIR} - L_{background,MIR})$$

Fire Radiative Energy [MJ]

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

Biomass Combusted [kg]

$$BC = FRE * \beta$$

Emissions [kg]

$$E = BC * EF$$

A = burned area

c = constant

$\sigma = 5.67*10^{-8}$ W m^{-2} K^{-4}

L = radiance

$\beta = 0.368 \pm 0.015$ kg/MJ

EF = emissions factors

- Wooster, M. J., Roberts, G., Perry, G. L. W., and Kaufman, Y. J., 2005, Retrieval of biomass combustion rates and totals from fire radiative power observations: FRP derivation and calibration relationships between biomass consumption and fire radiative energy release, Journal of Geophysical Research,110, D24311, doi:10.1029/2005JD006318.

QFED Algorithm

Grid cell FRP density [W/m^2]

$$\rho_k(j) = c_k * \frac{\sum_i FRP_k(i)}{\sum_i A_k(i)}$$

Total observed grid cell area

$$a_k(j) = \sum_i A_k(i)$$

i = pixel

j = grid cell

k = dataset

c_k = correction factor for biases in different FRP datasets [MODIS = 1, SEVIRI = 2]

A_k = total observed pixel area

Spatially merged, temporally averaged, observed FRP density [W/m^2]

$$\rho = \frac{\sum_k a_k * \rho_k}{\sum_k a_k}$$

s = species

$\alpha = 1.37*10^{-6}$ kg(dry matter)/J (normalized to GFEDv2 fluxes)

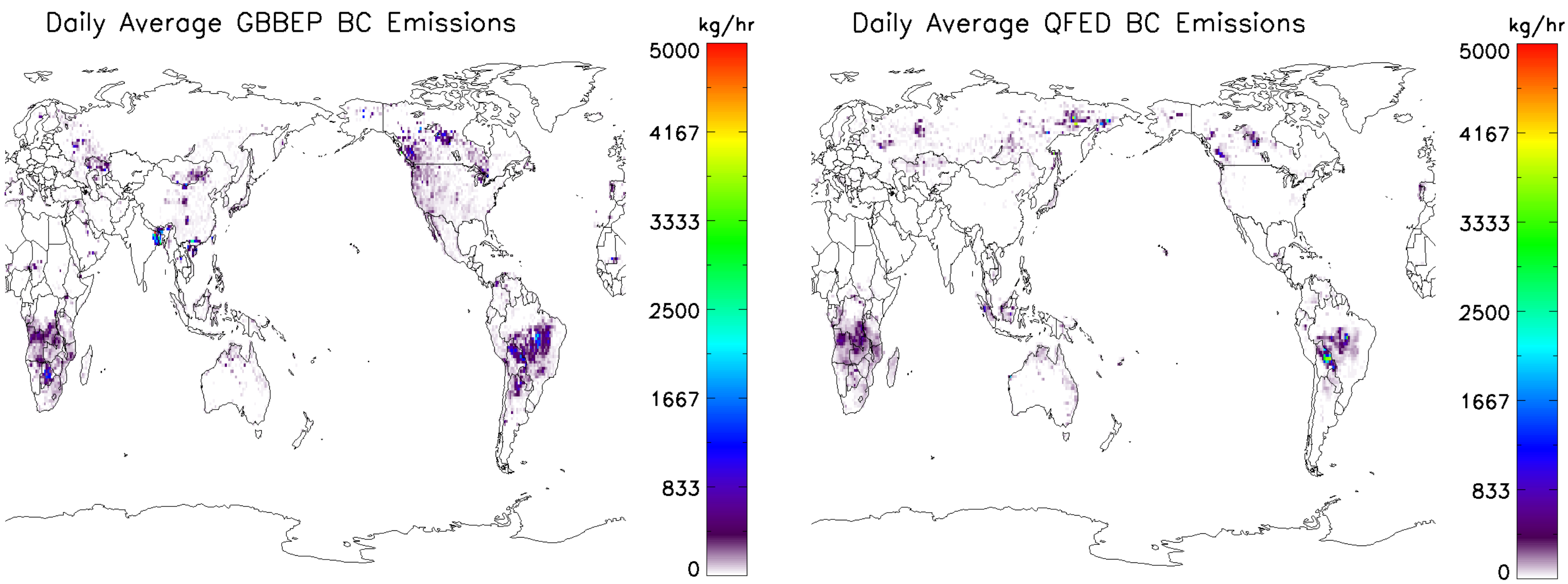
Fire emission flux density [kg/(s*m^2)]

$$f_s = \rho * \alpha * \beta_s$$

β_s = emission factors from GFEDv2 inventory (savanna, tropical forest, other forest)

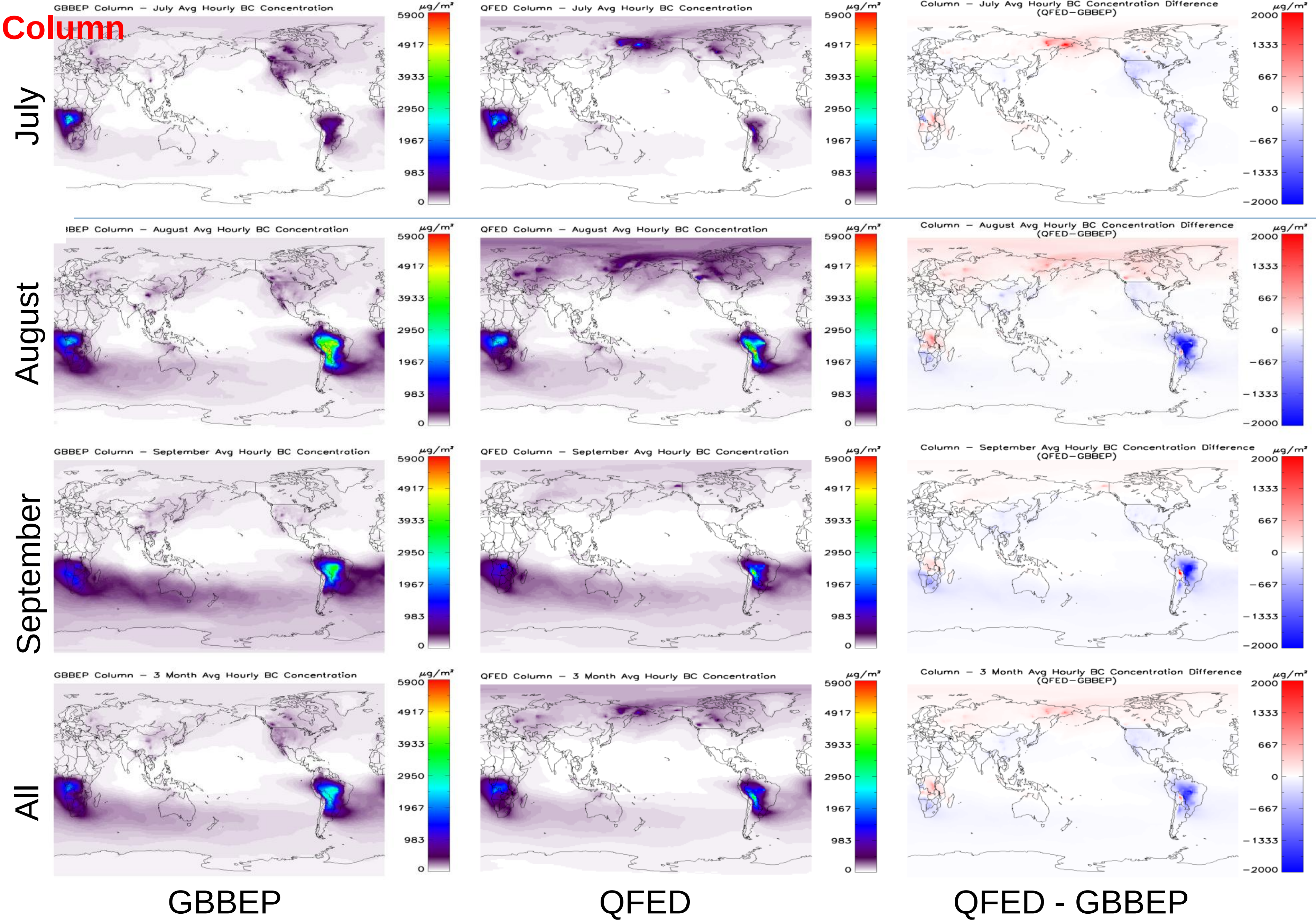
- Kaiser, J. W., J. Flemming, M. G. Schultz, M. Suttie, and M. J. Wooster (2009) The MACC global fire assimilation system: First emission products (GFASv0). ECMWF Tech. Memo. 596. Archived and publicly available at http://ecmwf.int/publications/library/do/references/show?id=89271
- Kaiser, J. W., M. Suttie, J. Flemming, J.-J. Morcrette, O. Boucher, and M. G. Schultz (2009b) Global real- time fire emission estimates based on space-borne fire radiative power observations. AIP Conf. Proc., 1100:645–648. doi:10.1063/1.3117069. Permalink: http://link.aip.org/link/?APCPCS/1100/645/1

Average Emissions

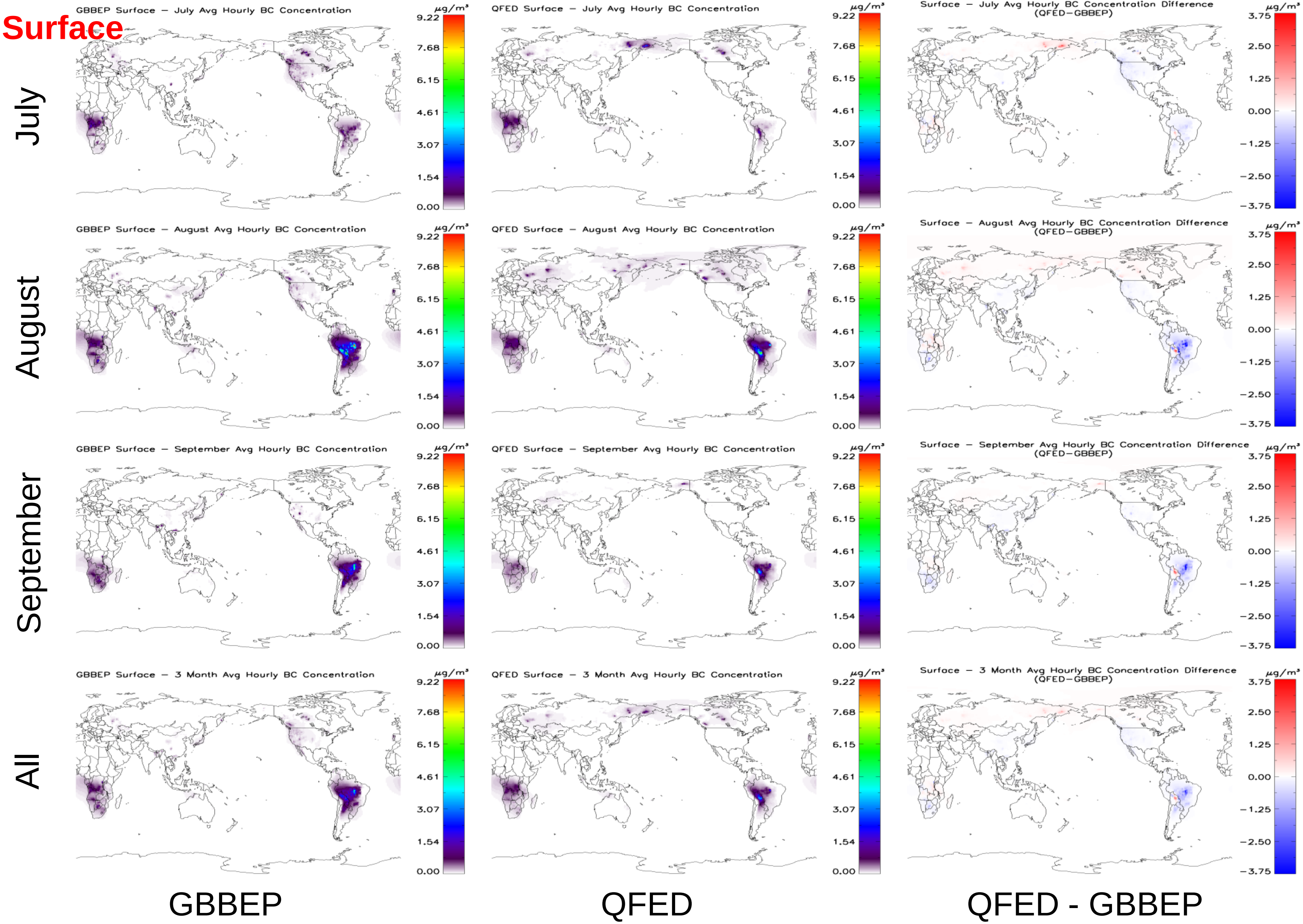


- QFED has smaller area of detected fires
- GBBEP detects less fires over higher latitudes

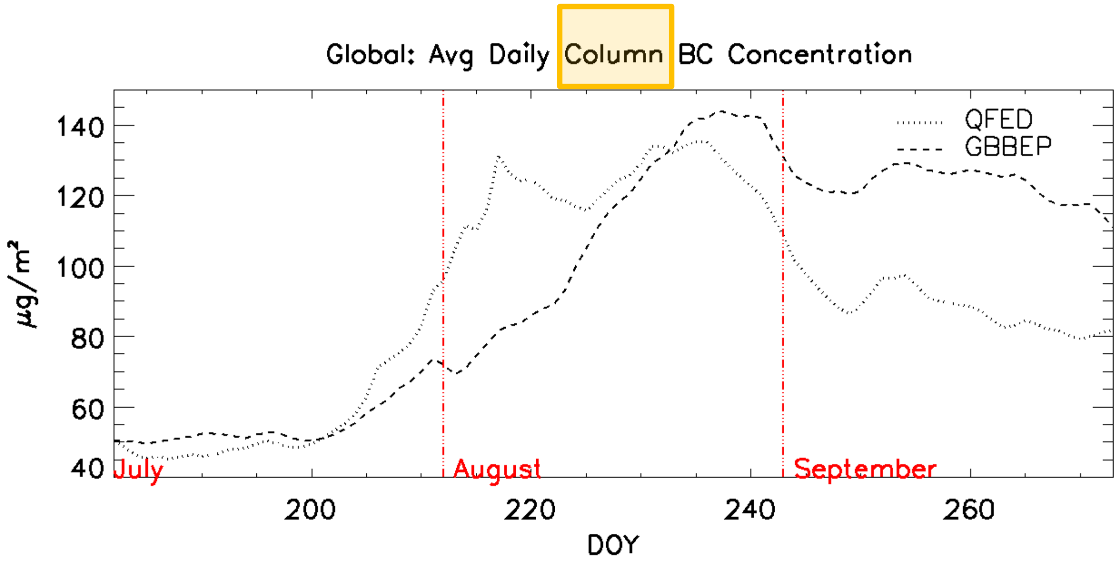
Column

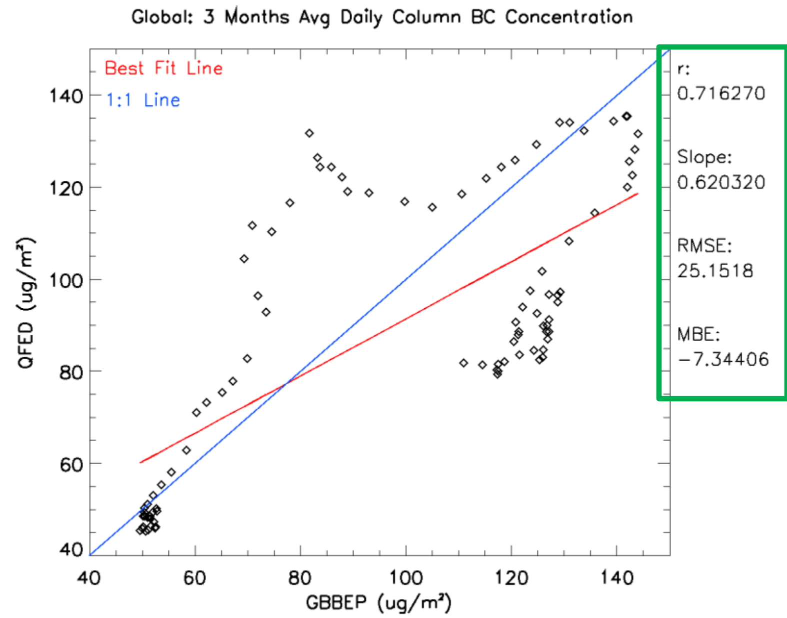


QFED column concentrations are 7.6% less than GBBEP

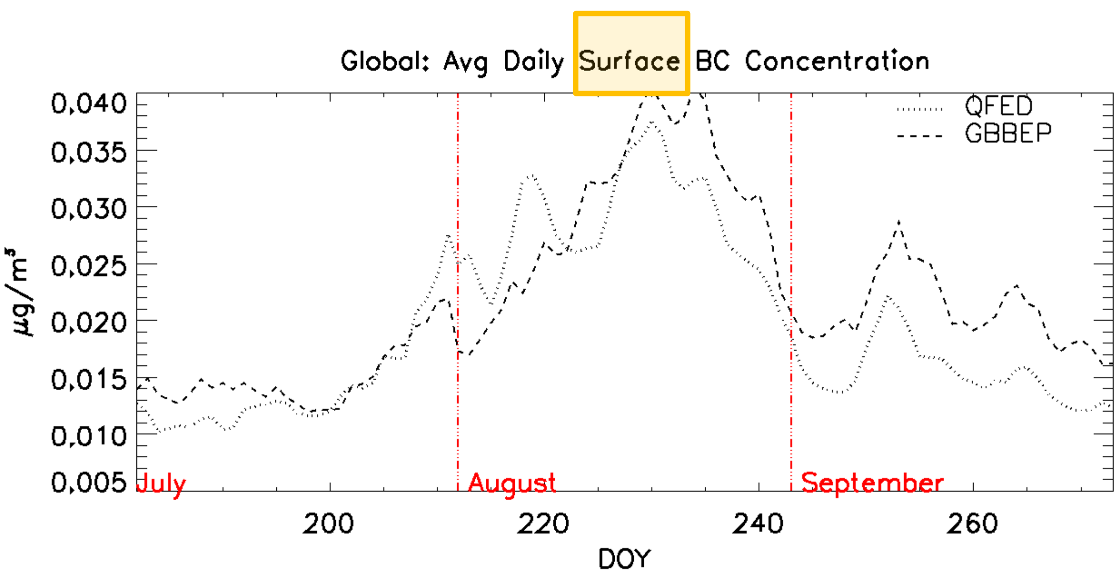


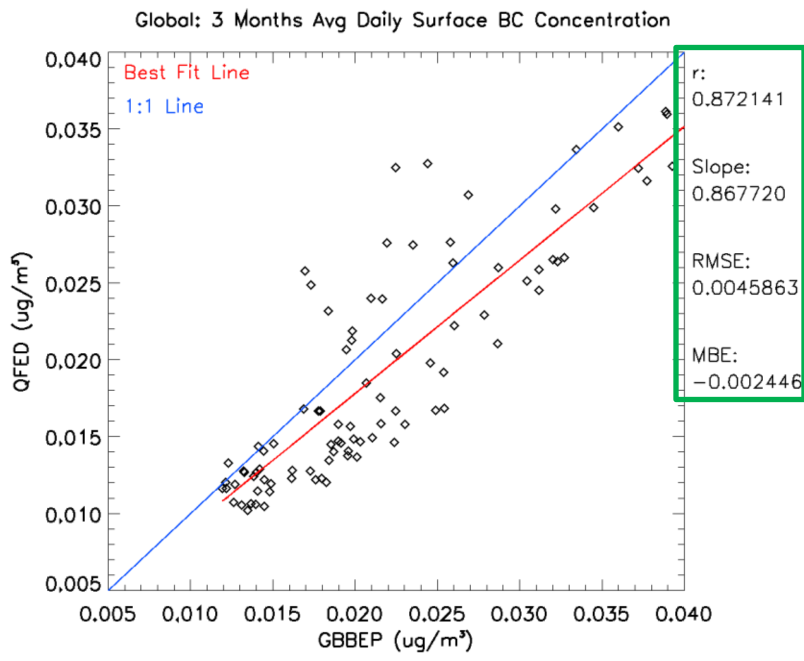
QFED surface concentrations are 11.2% less than GBBEP

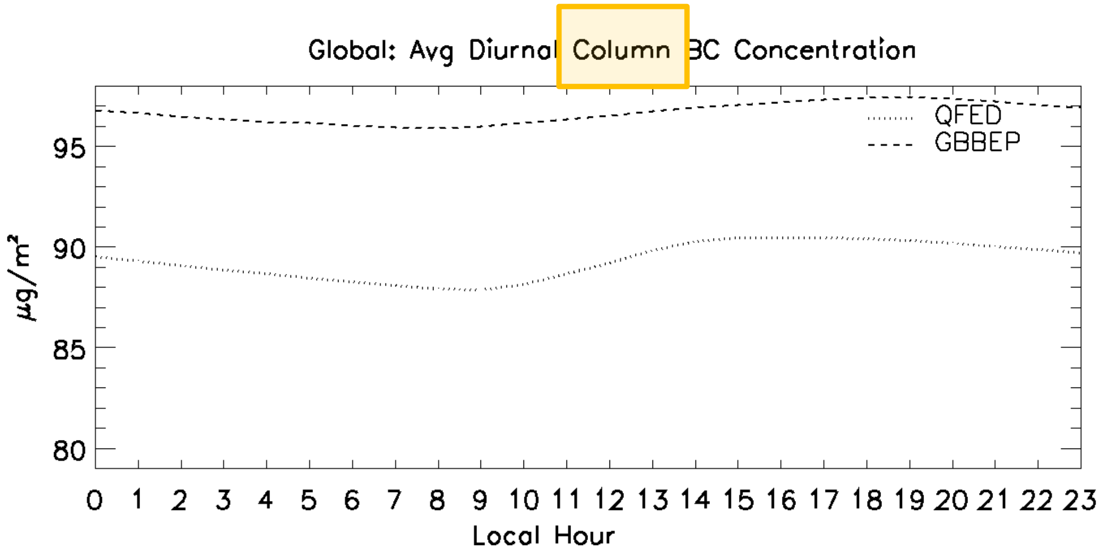


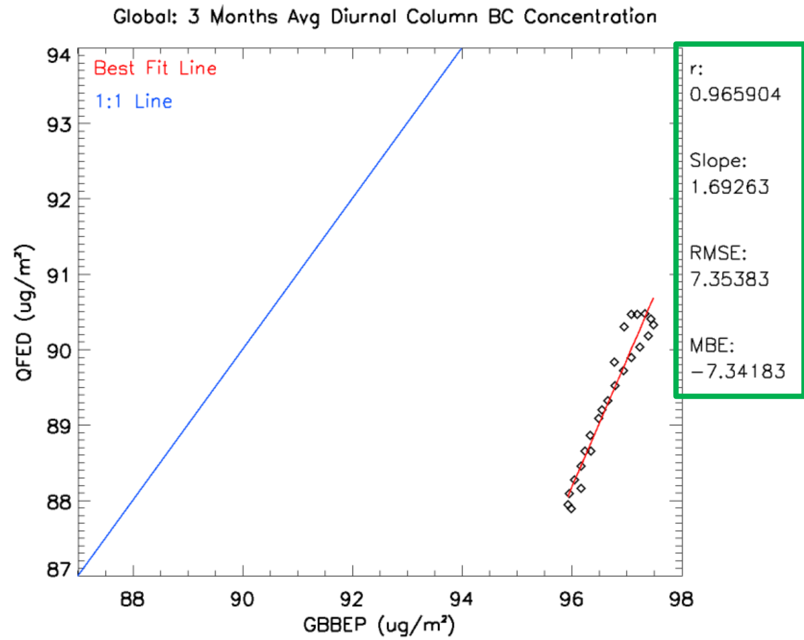


Daily Concentrations

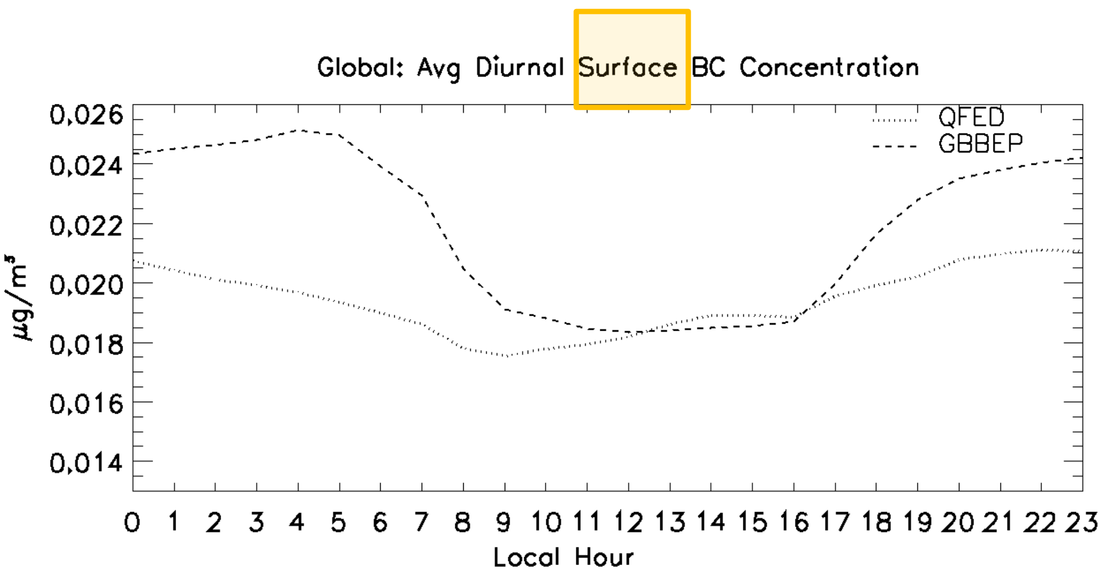


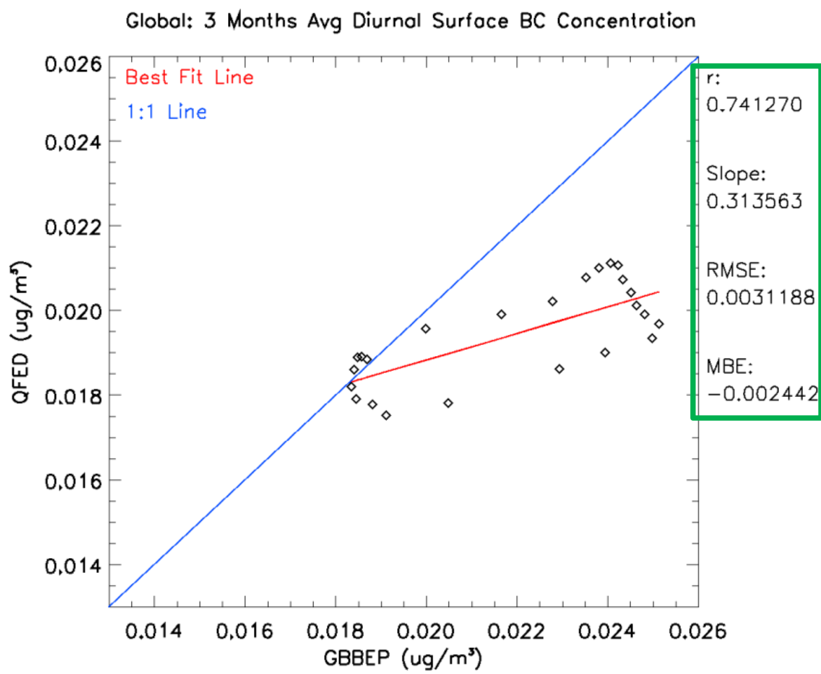






Diurnal Concentrations

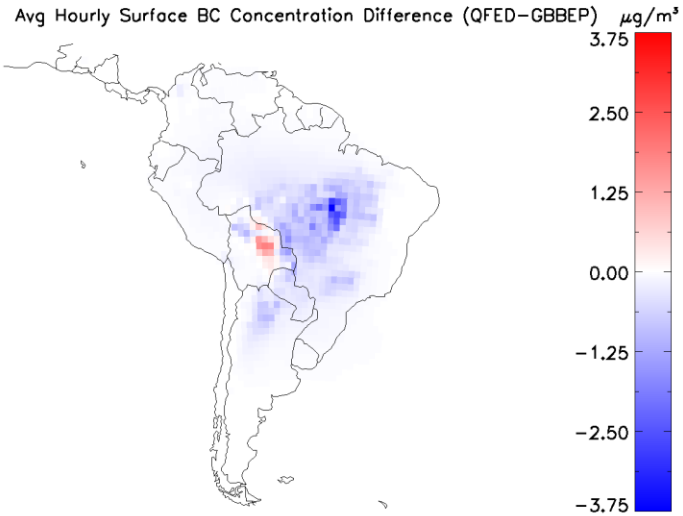


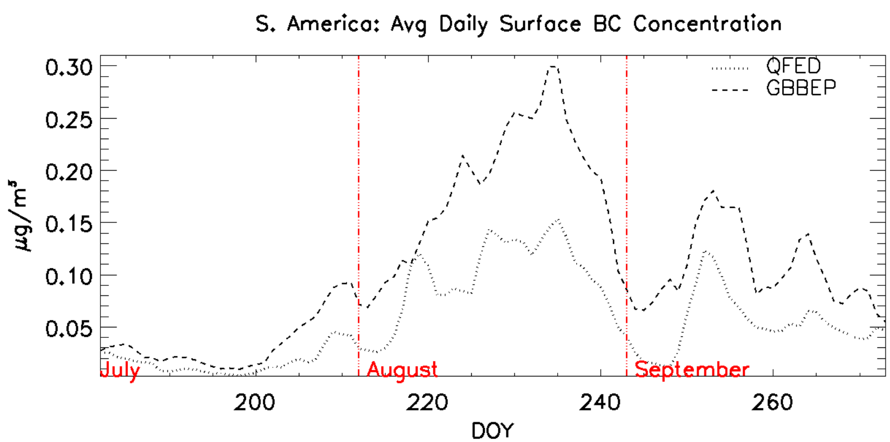


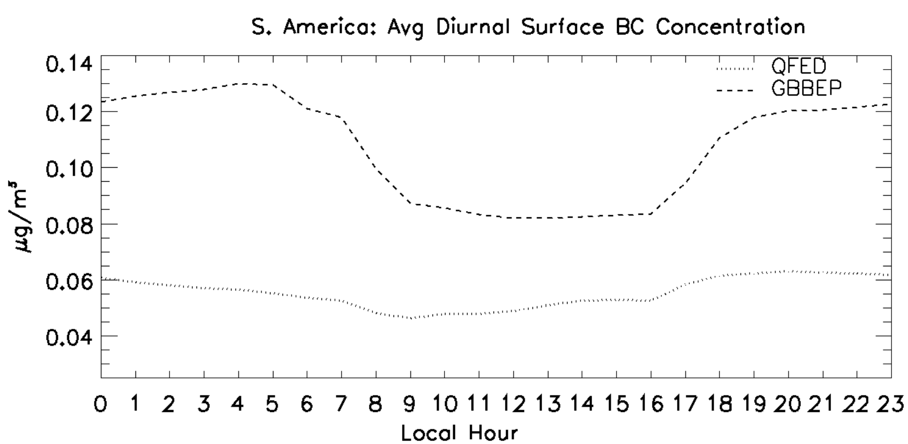
S. America

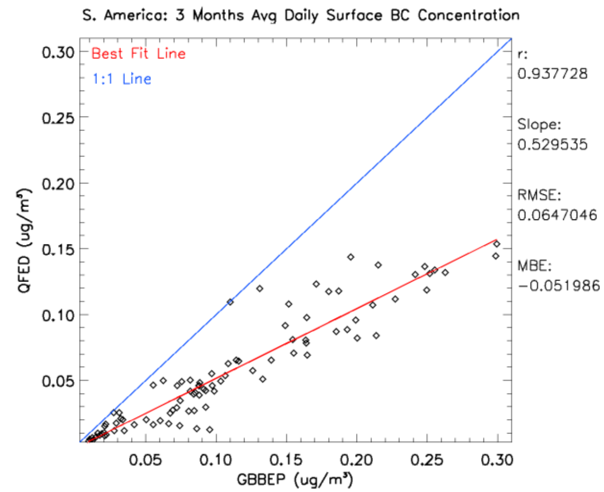
QFED surface concentrations are 48.4% lower than GBBEP

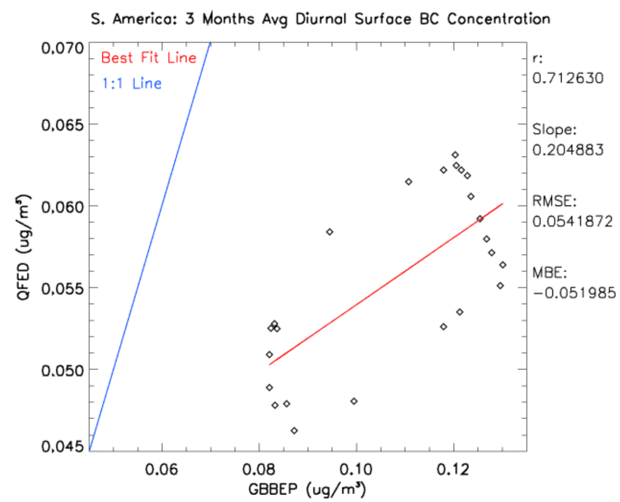
QFED column concentrations are 38.8% lower than GBBEP







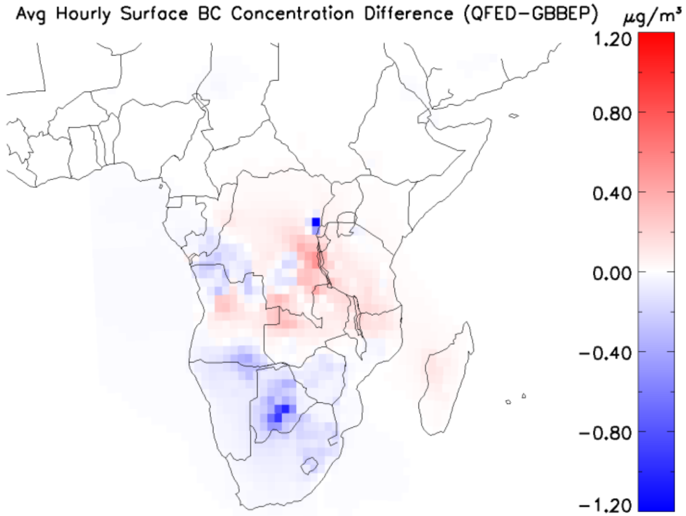


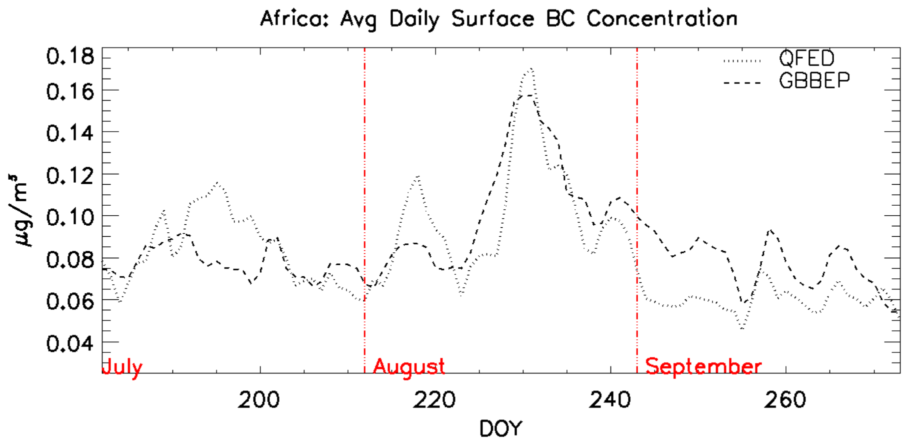


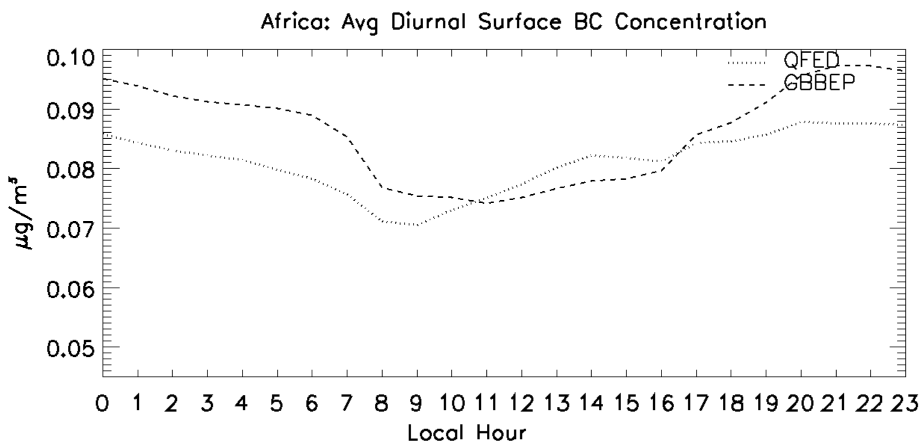
Africa

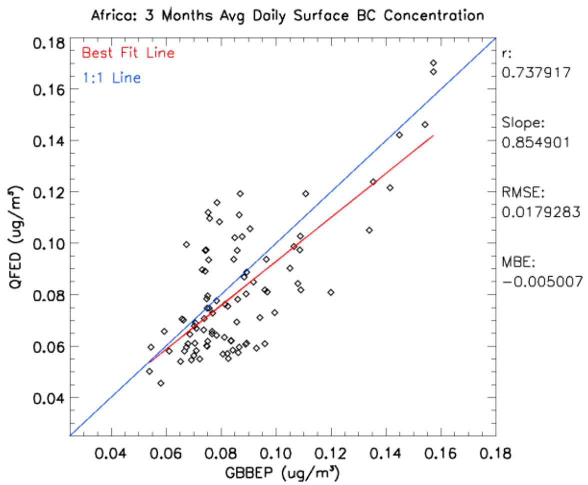
QFED surface concentrations are 5.8% lower than GBBEP

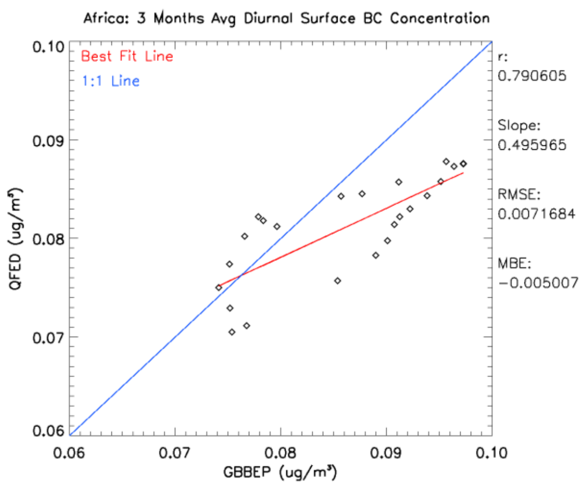
QFED column concentrations are 7.2% lower than GBBEP











Conclusions

- Global emissions from MODIS and multiple geostationary satellites show similar spatial patterns and monthly variations.
- MODIS-based QFED has smaller area of detected fires.
- GBBEP typically has greater emission values overall.
- MODIS-based QFED data has good coverage over high latitudes.

Questions?

NASA image

Diurnal Fits