Improving smoke source characterization in chemical transport models by introducing satellite measurements of fire radiative energy.

Charles Ichoku (ESSIC/UMD, NASA/GSFC)

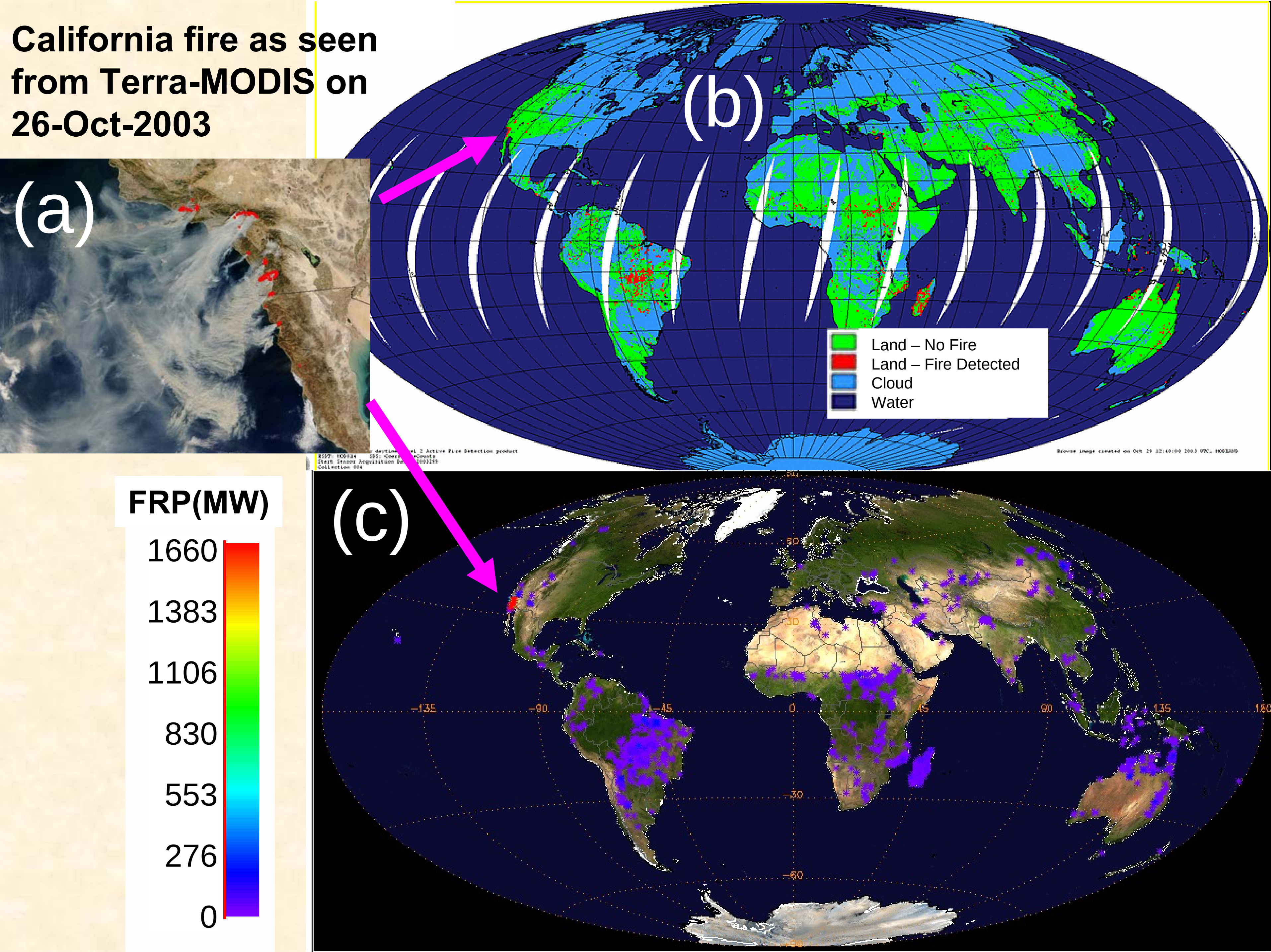
Acknowledgement
Yoram J. Kaufman (NASA/GSFC)
J. Vanderlei Martins
Martin J. Wooster (KCL)
Gareth Roberts (KCL)
Louis Giglio (SSAI, NASA/GSFC)
Thomas Diehl (GEST/UMBC, NASA/GSFC)
Mian Chin (NASA/GSFC)

Presented at the 5th AEROCOM Workshop, Virginia Beach, 17-19 Oct 2006
Session: Emissions II

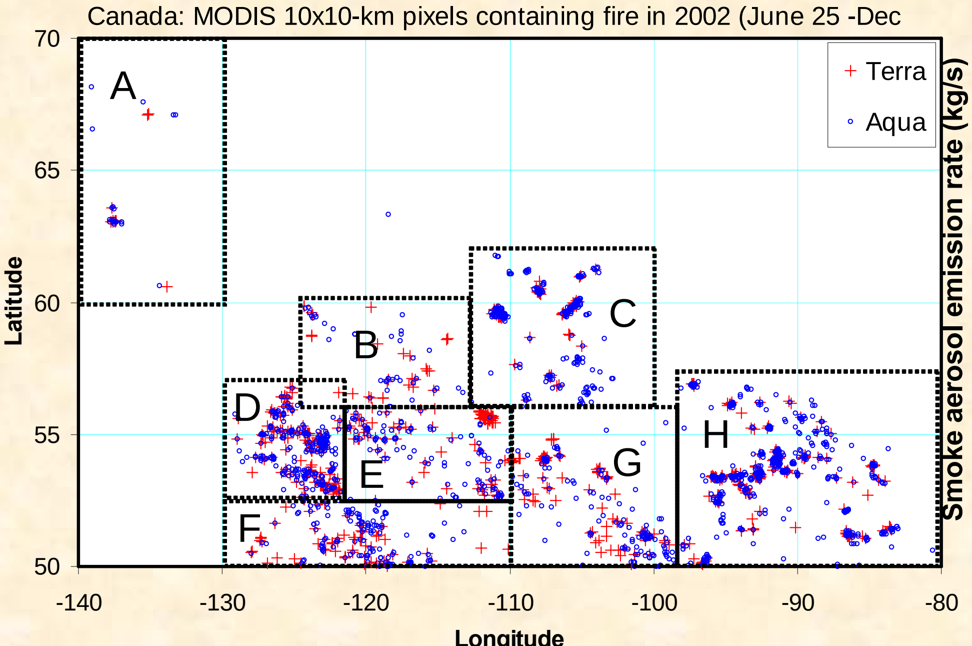
Outline

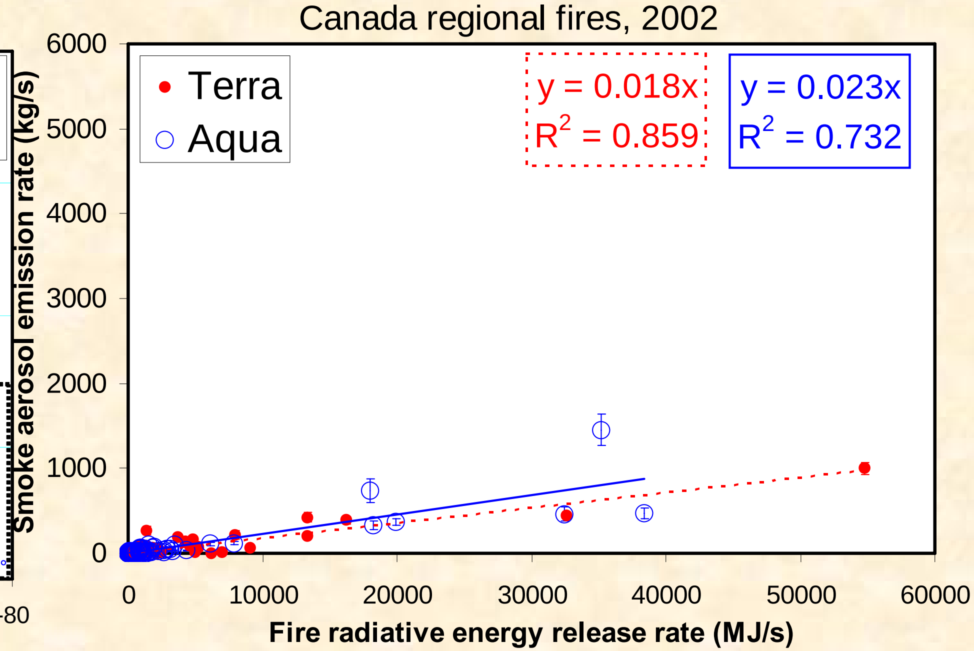
- Fire Radiative Energy (FRE) from Space.
- Estimating Smoke Emission from FRE.
- Estimating Burned Biomass from FRE.
- Application of FRE to Emissions Modeling.

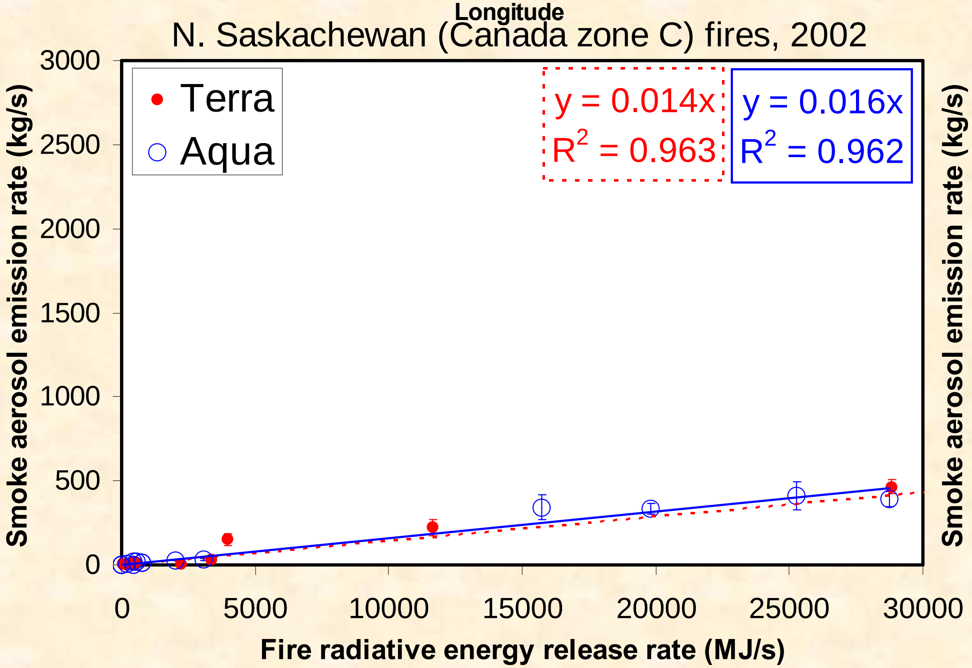
California fire as seen from Terra-MODIS on 26-Oct-2003

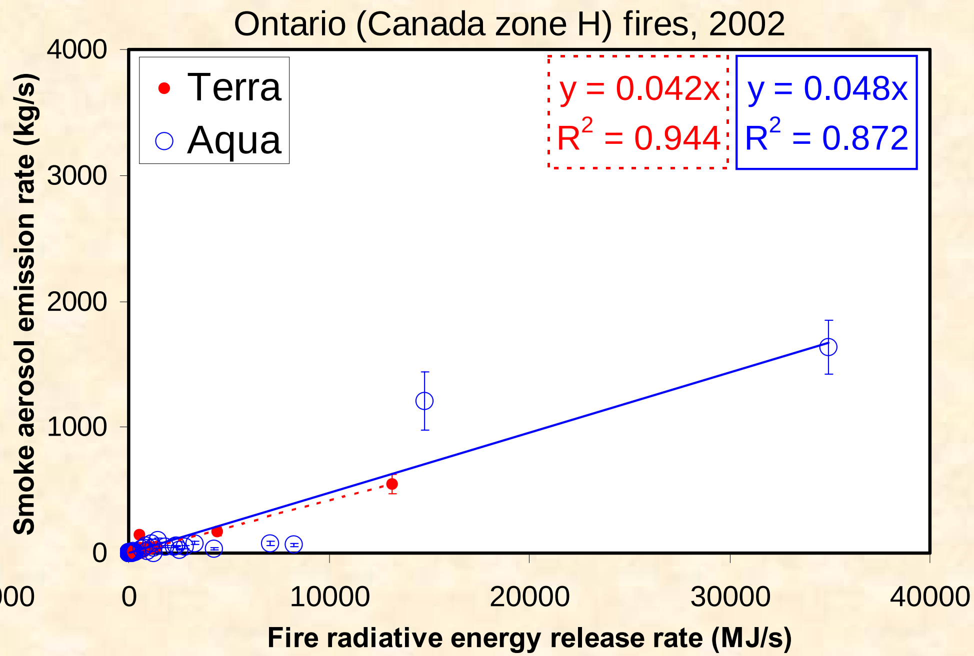


MODIS Fire Emissions: Canada



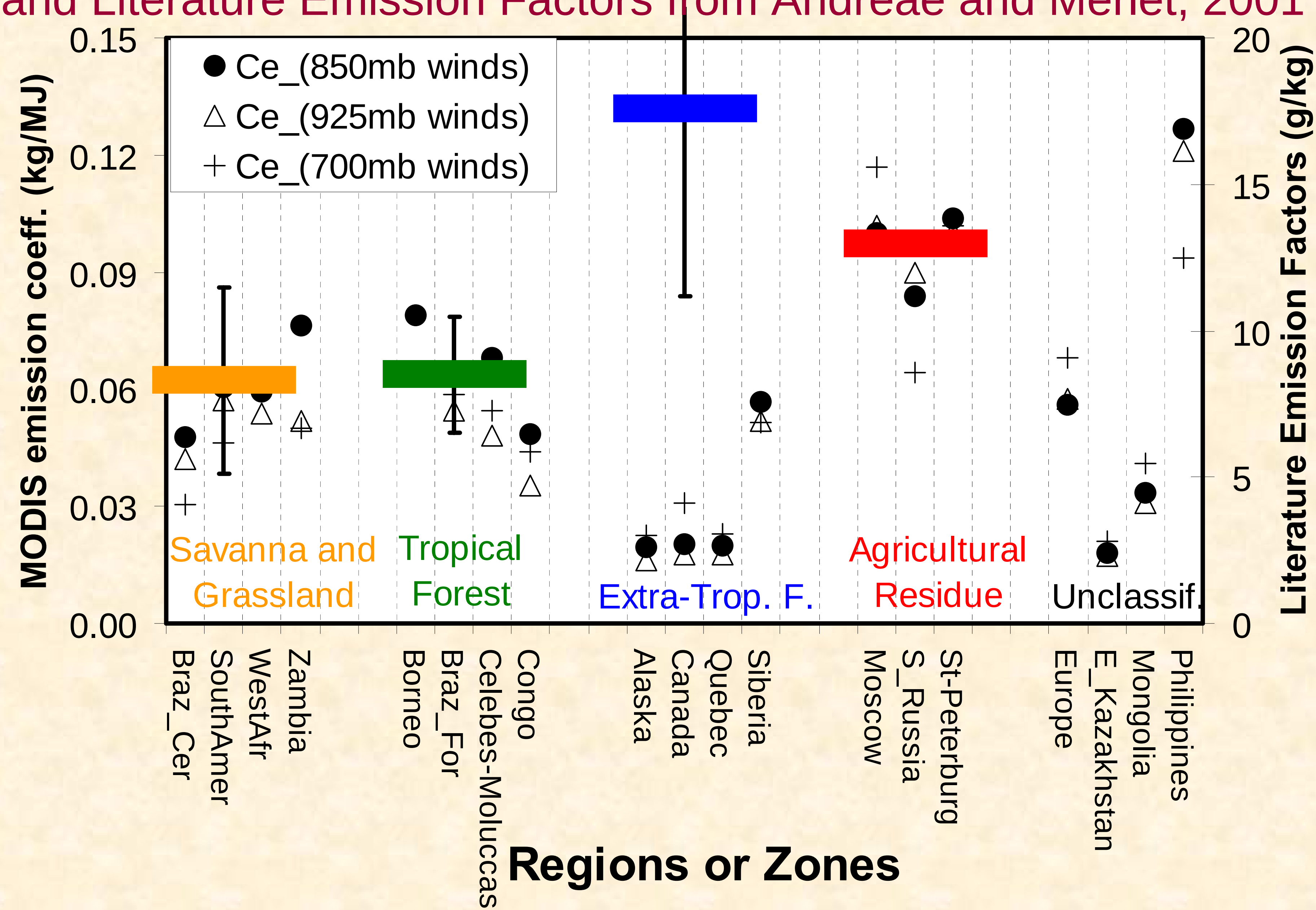






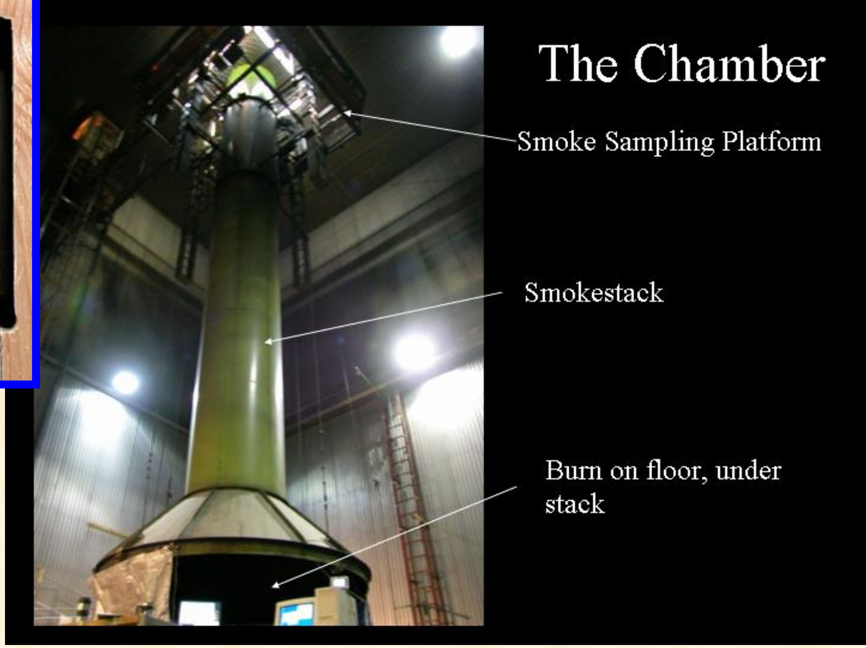
Ichoku and Kaufman, 2005, IEEE-TGARS

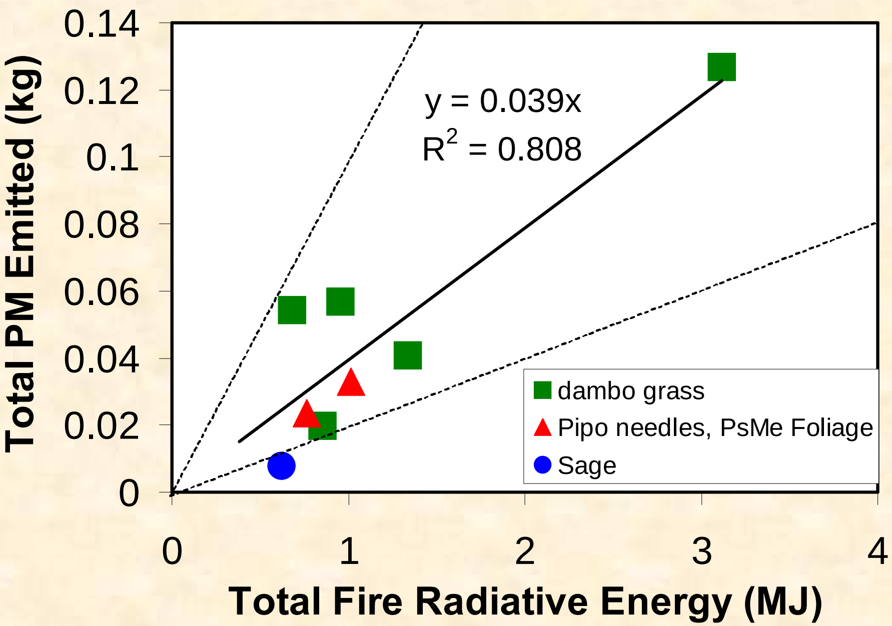
Qualitative Comparison of MODIS-derived Emission Coefficients and Literature Emission Factors from Andreae and Merlet, 2001

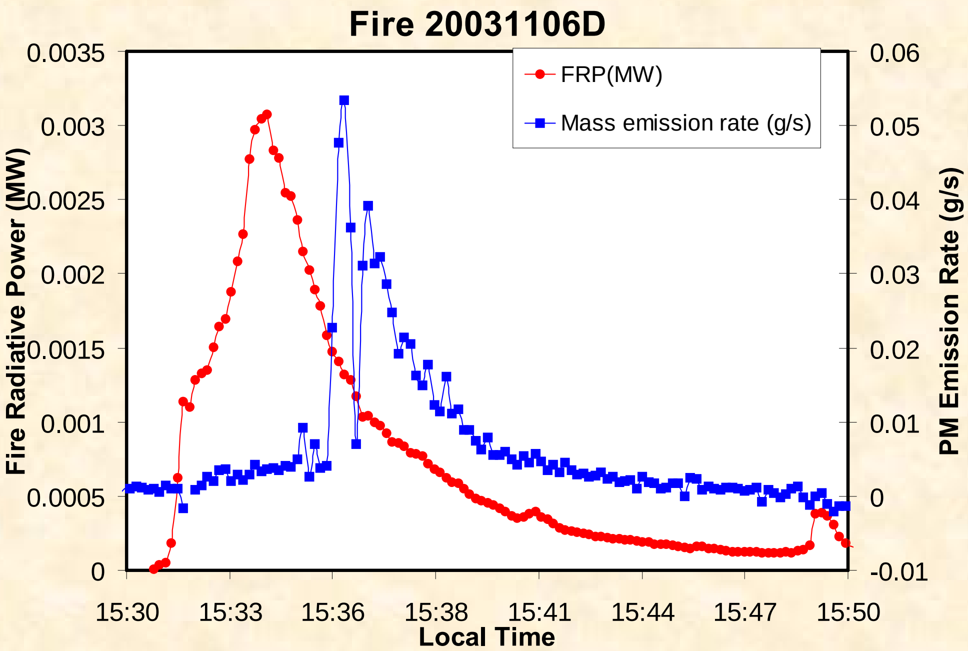


Ichoku and Kaufman, 2005, IEEE-TGARS

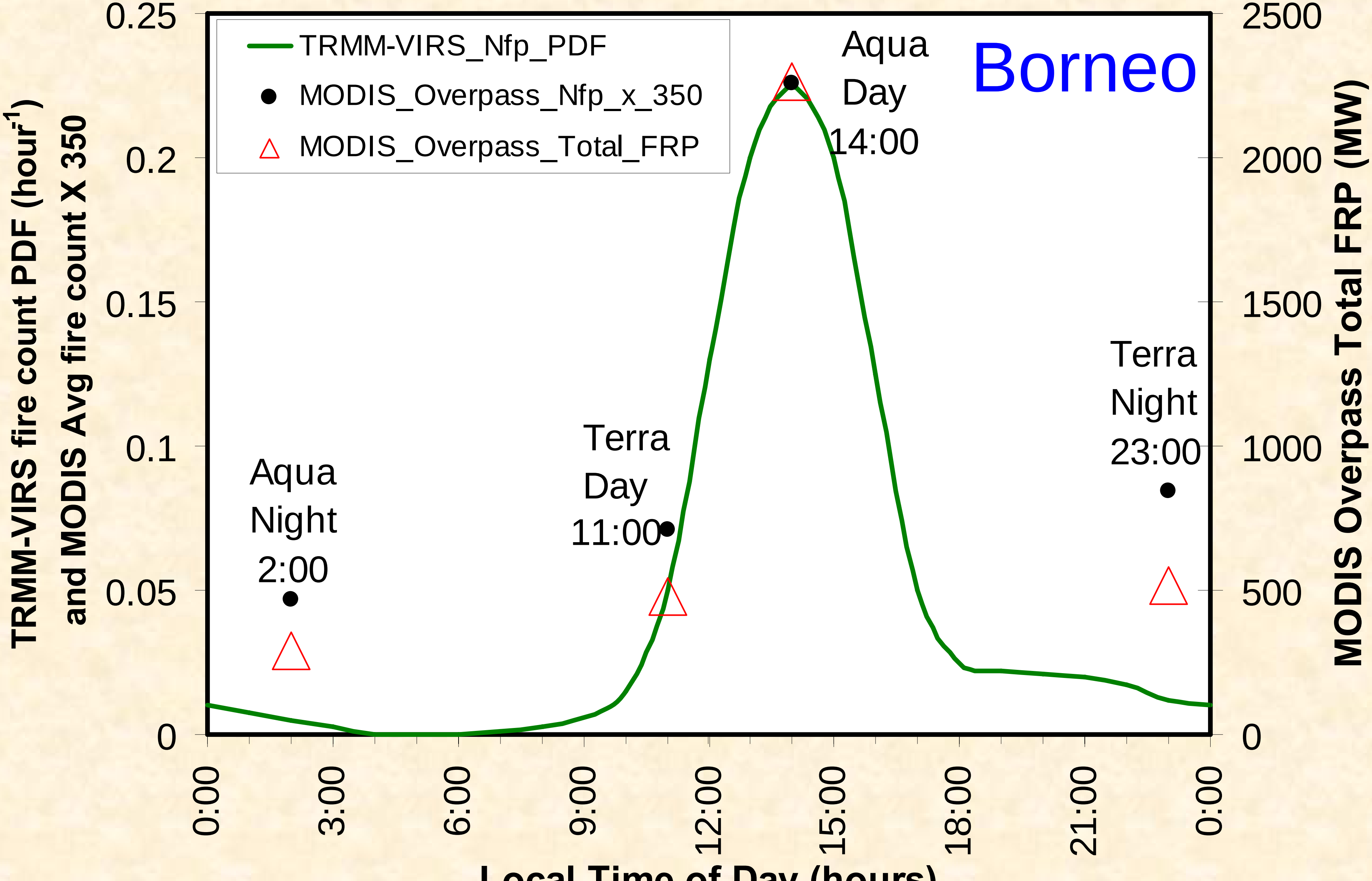
Laboratory measurement of Fire Radiative Energy and emissions during November 2003 controlled burns conducted inside the Burn Chamber of the Fire Sciences Laboratory, USFS, Missoula, Montana





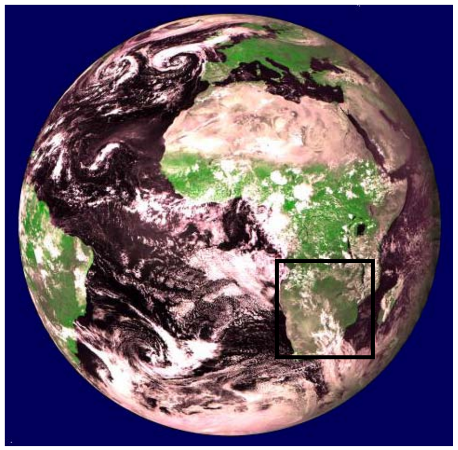


Typical diurnal distribution of fires from TRMM-VIRS (1999-2001) and MODIS 2004 Fire Pixel Counts (Nfp) and Fire Radiative Power (FRP)

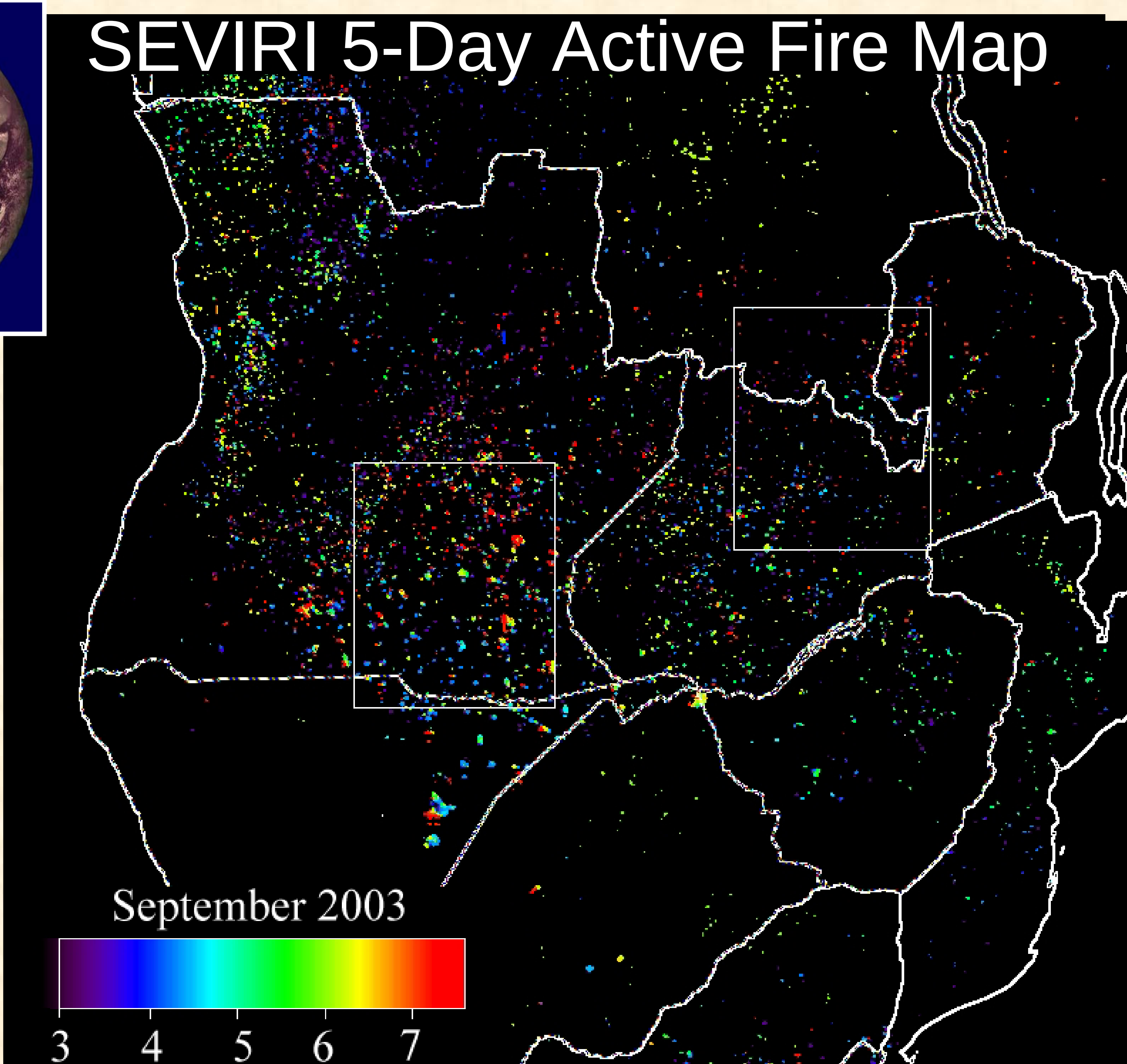


TRMM plot from Giglio et al., 2003, JGR.

SEVIRI 5-Day Active Fire Map

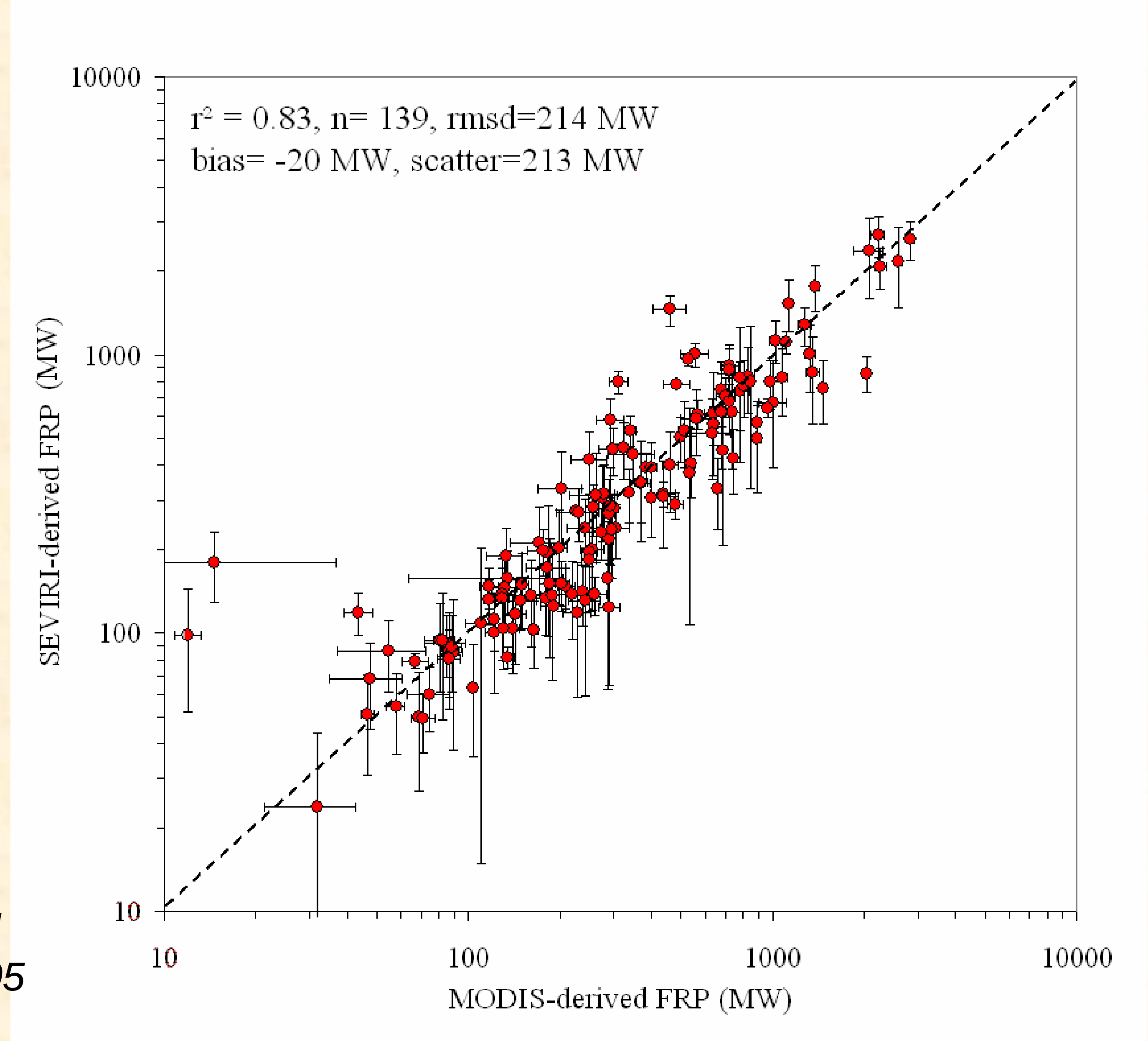


15 mins frequency



Wooster and Roberts, 2005

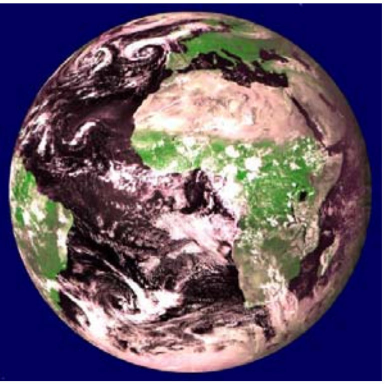
SEVIRI vs. MODIS FRP Comparison



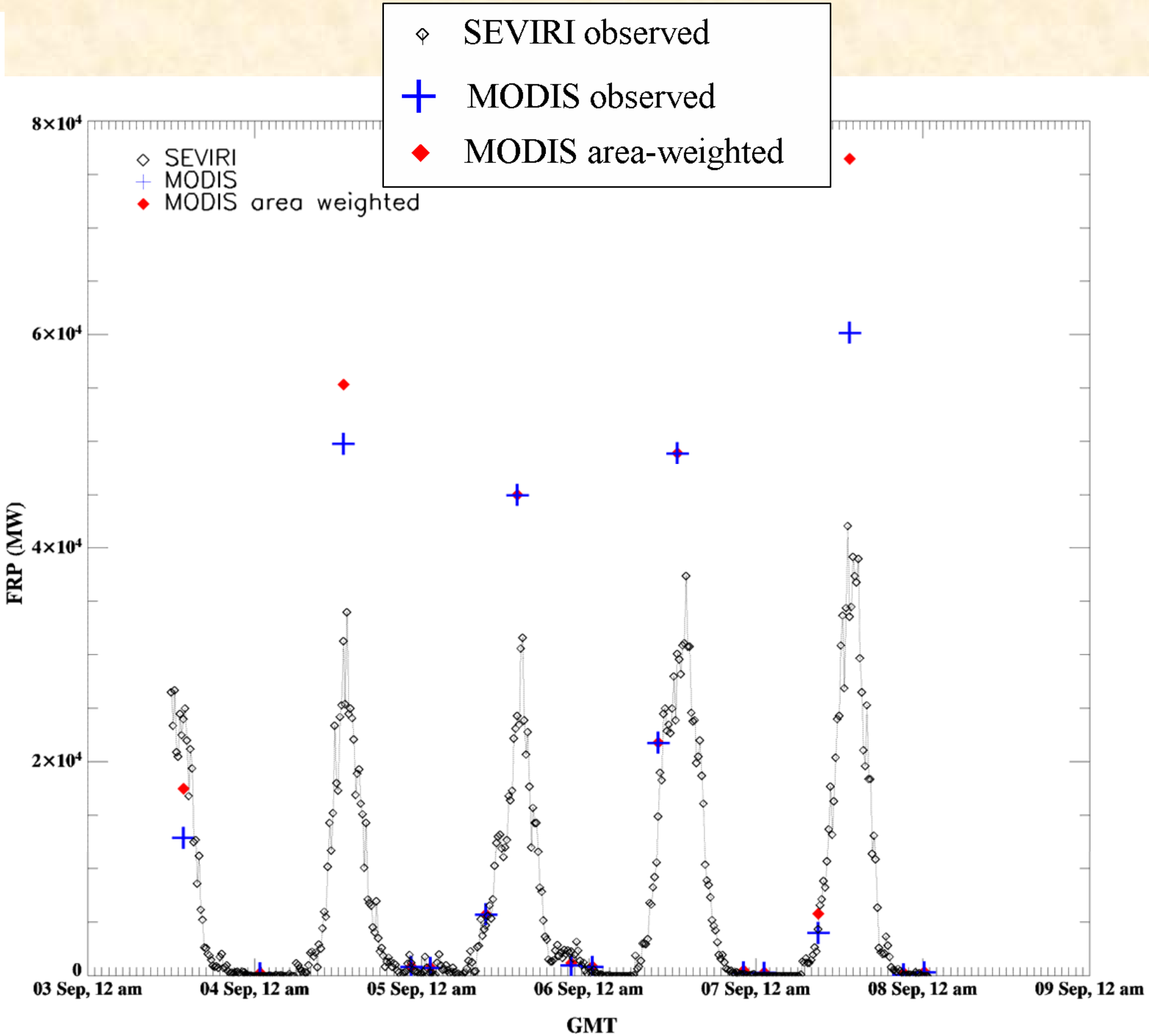
Wooster and Roberts, 2005

Per fire <u>NOT</u> per pixel (due to differences in SEVIRI/MODIS pixel size)

SEVIRI vs. MODIS FRP Time-series

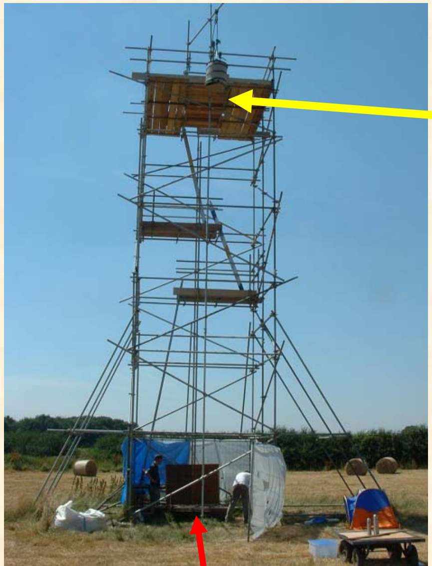


15 mins frequency

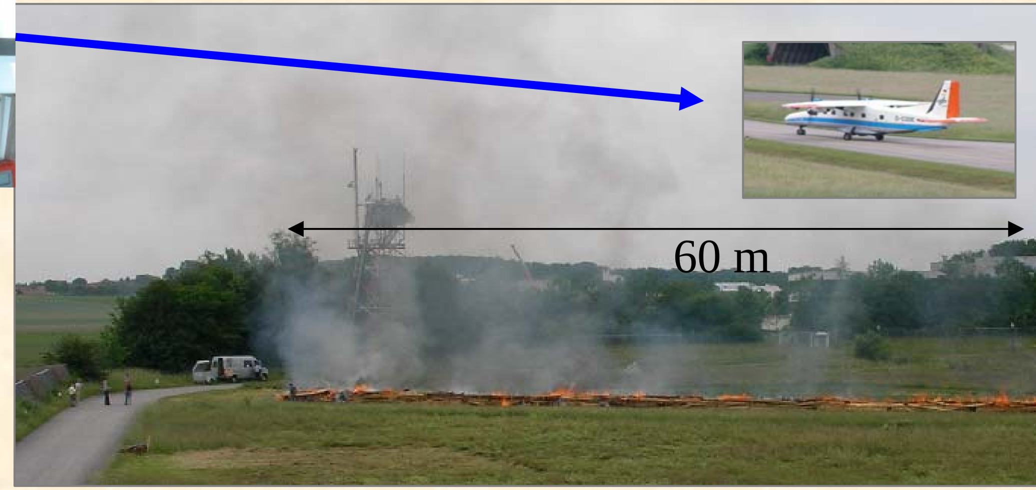


Wooster and Roberts, 2005

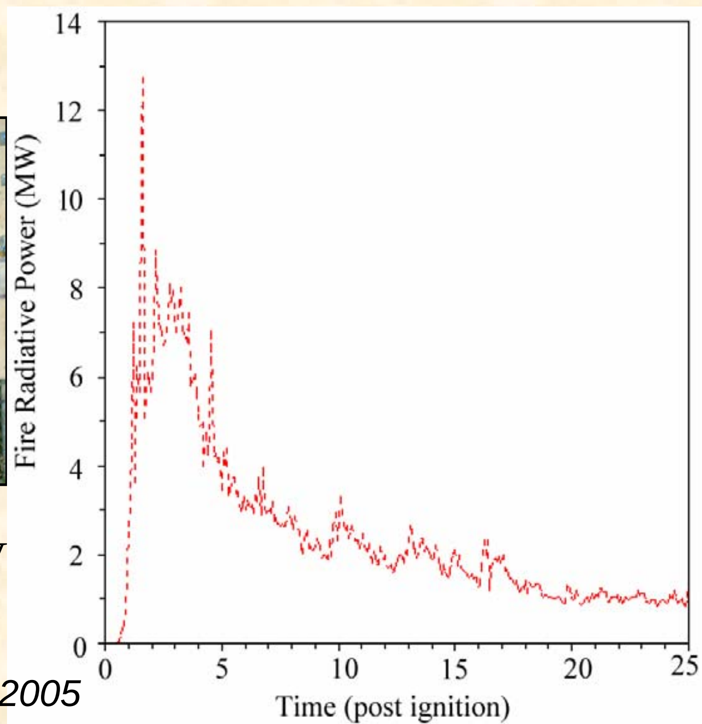
Fire Radiative Energy and Burned Biomass

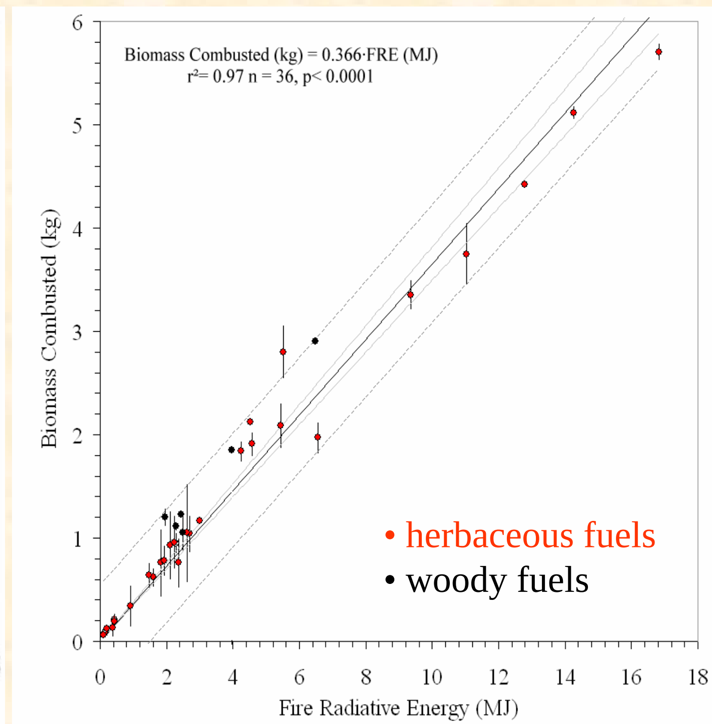


Spectro-
Radiometer
or IR Camera



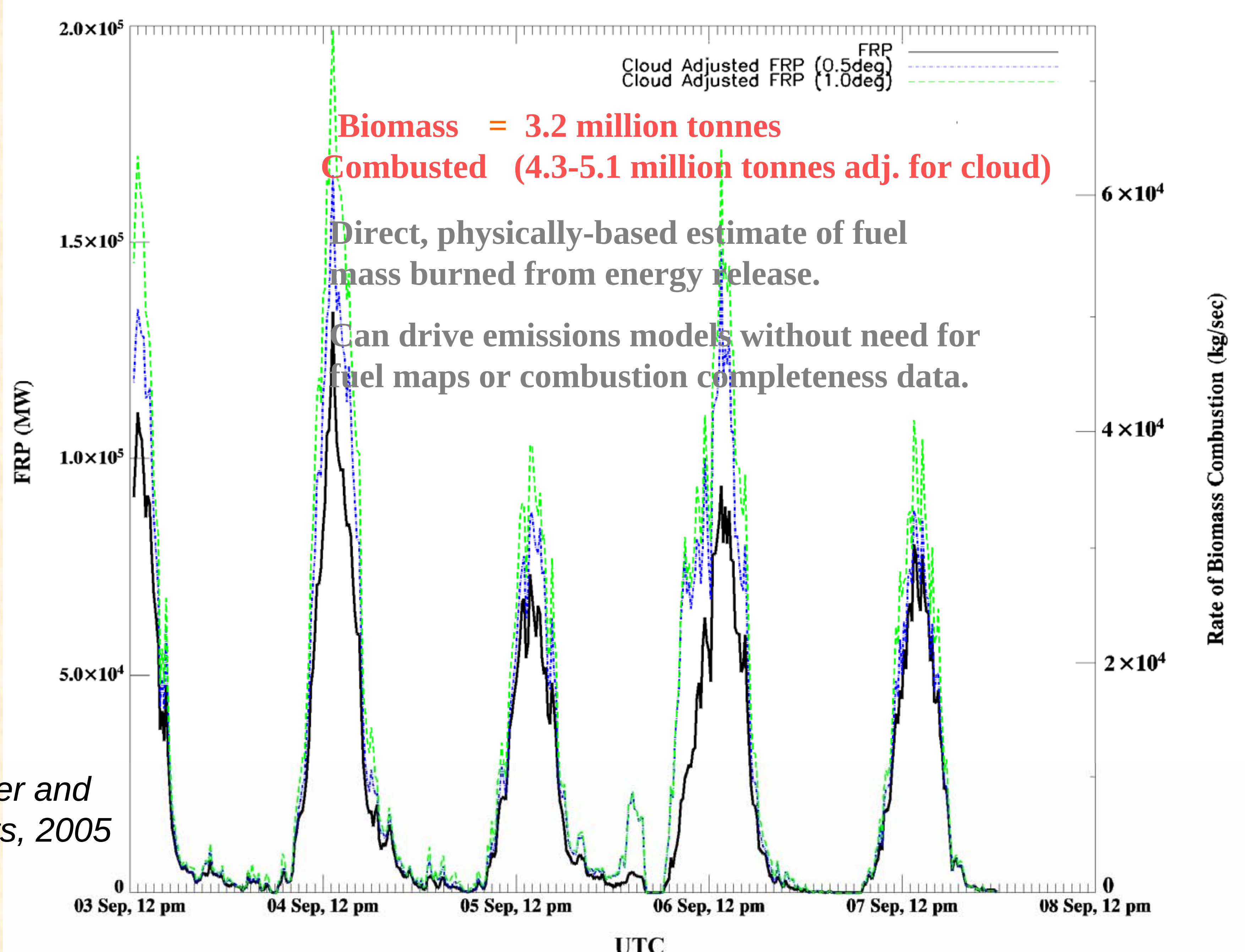
Spectro-radiometer FOV





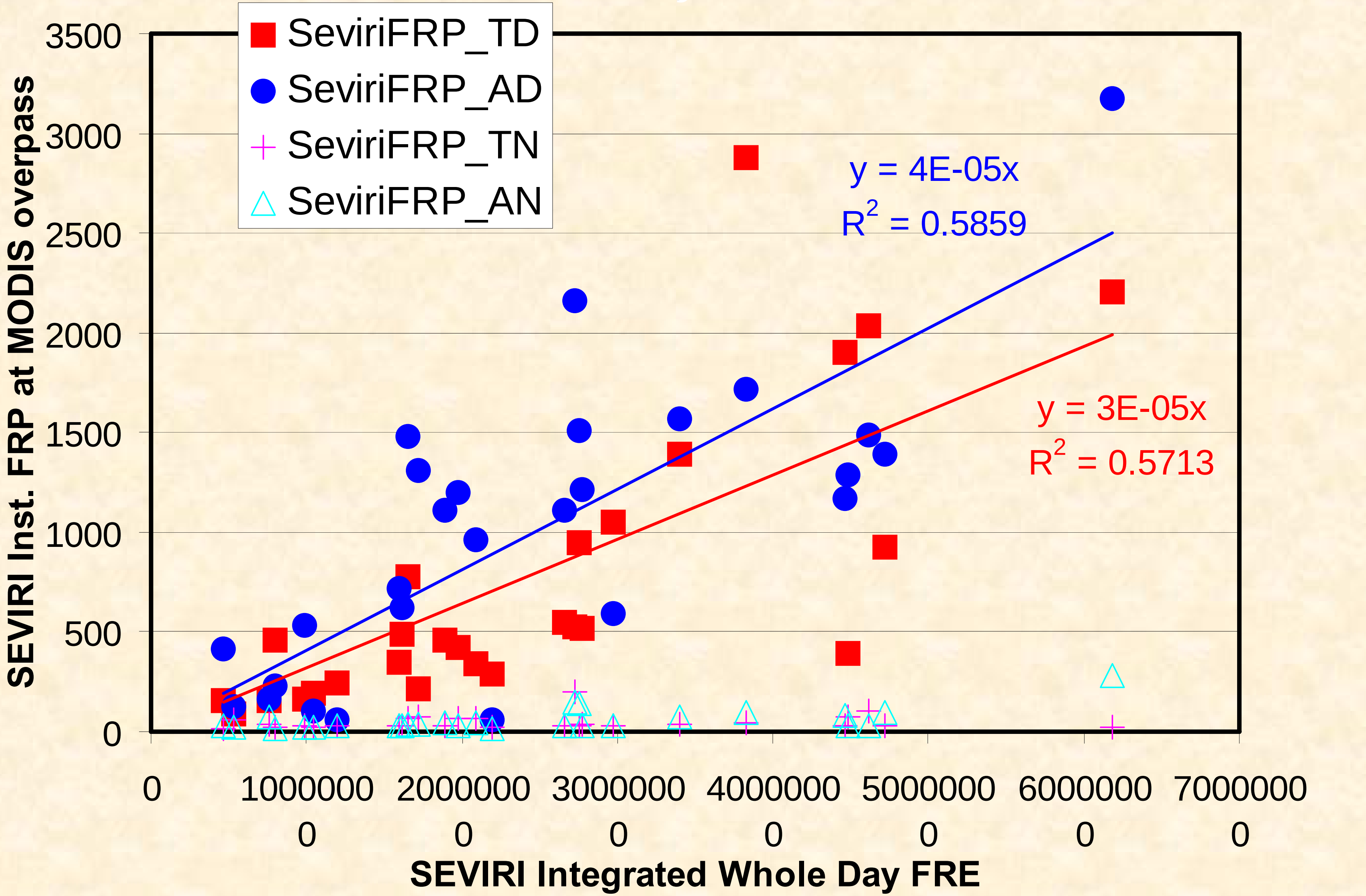
Wooster, 2002, 2003, 2004, 2005

SEVIRI FRP Southern Africa, 3-8 September 2003



Wooster and Roberts, 2005

MODIS diurnal cycle from SEVIRI FRP West Africa, February 2006



Data provided by Martin Wooster and Gareth Roberts

Revising the smoke emissions estimation approach

Traditional Emissions Estimation Approach

Emissions = Emission Factor (EF) × A × B × α × β

A × B × α × β = Biomass Mass (BM)

Where,

A=Area burned

B=Biomass density

α=Above ground biomass proportion

β=Combustion Efficiency

FRE-based smoke emissions estimation approach

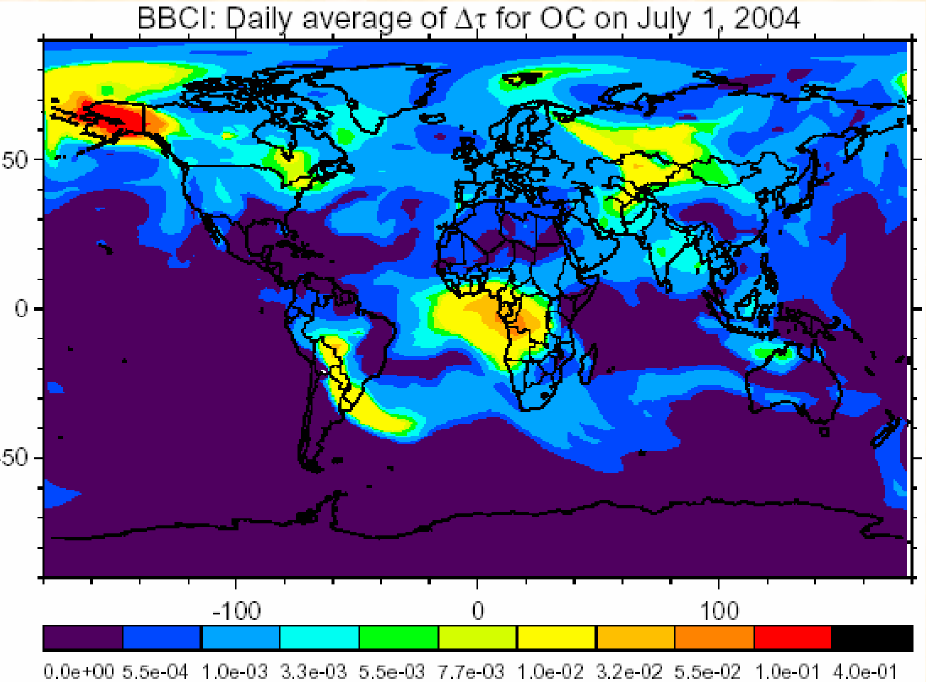
(1) Emissions = Emission Coeff. (Ce) × (FRP or FRE) *[Ichoku]*

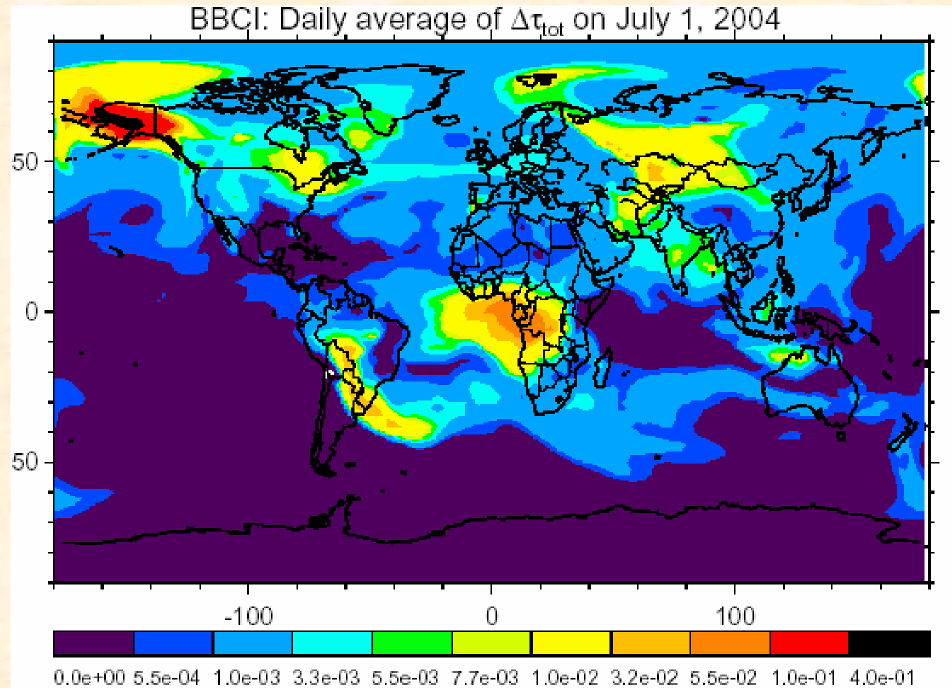
(2) Emissions = EF × BM (from FRE) *[Wooster]*

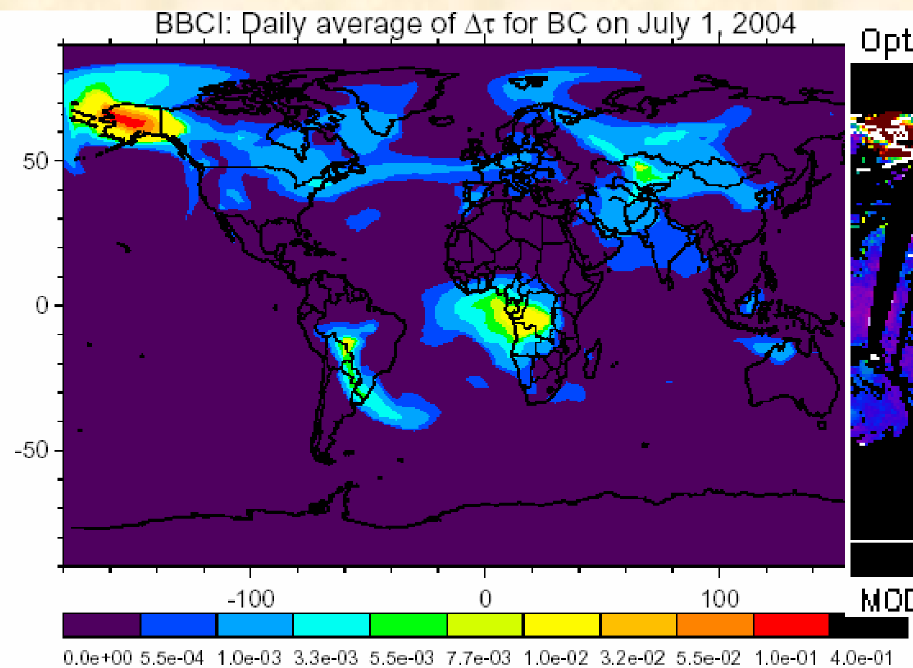
Advantages of MODIS

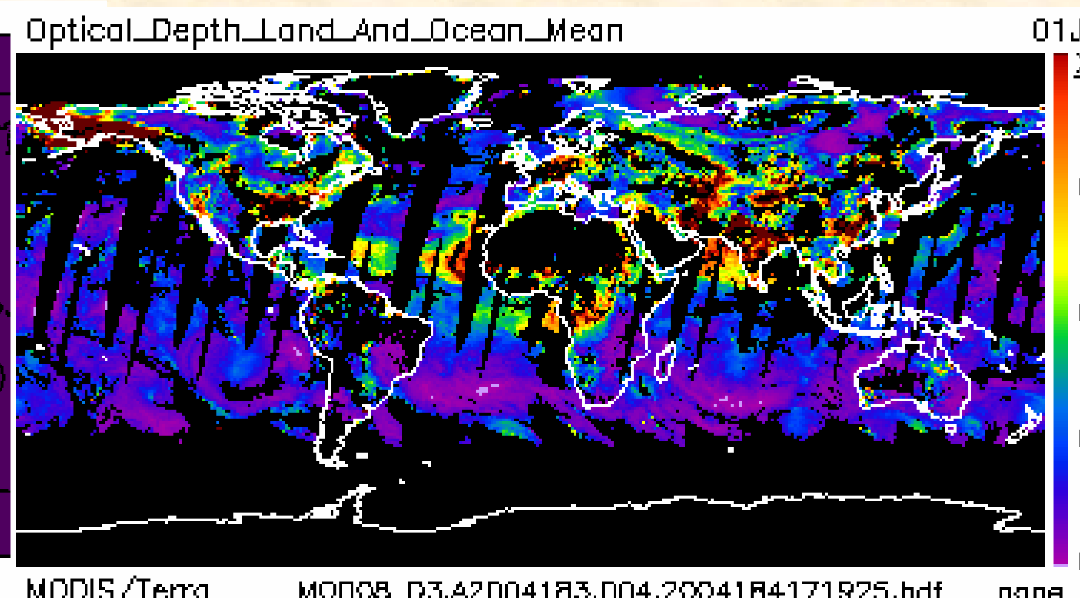
- The only space-borne sensor that measures fire strength (Fire Radiative Power) operationally.
- Covers the globe 4 times daily at strategic times and at 1-km resolution (good for wildfires).
- Products freely available globally and on time.
- Real-time with Direct Broadcast (DB) systems.
- At least 8 DB stations in the US and Over 100 worldwide.
- MODIS-like sensor (VIIRS) on NPOESS will provide continuity.

GOCART simulations of smoke emissions with MODIS Fire Radiative Power









Conclusions

- Fire Radiative Power from satellite is directly related to fire strength, biomass consumption, and emissions.

- It offers great advantages as model input to derive smoke emissions: quantitative, more direct, fewer assumptions, less uncertainty, higher accuracy.

- It enables the generation of emissions at a wide range of spatial scales (local, regional, and global) and temporal scales (real-time, daily monthly, etc.).

- Its applications are varied and far-reaching: emissions inventories for climate studies and real-time application to fire progression and pollutant dispersion forecasting for planning emergencies, alerts, and evacuations.