Evaluation of GOES Biomass Burning Emissions using Modeled and Observed Carbon monoxide (CO) during April – May 2007 Florida/Georgia Fires

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Emissions Algorithm

- Conventional
  - Based on burned area, available fuel loading, combustion efficiency, and emissions factors

Emissions (g) = Burned area (ha)*fuel load (kgC/ha)*emissions factors (g/kgC)* fuel consumed (%)

- Inputs
  - MODIS Vegetation Property-based Fuel System (MVPFS) (NASA MODIS) – *NESDIS product*
  - Fire location and size (NOAA GOES) – *NESDIS product*
  - Fuel moisture category factor (NOAA AVHRR) – *NESDIS product*
  - Emissions factors - *Literature*
- Outputs
  - PM2.5, CO, NOx, NMHC, etc. emissions in tons/hour in near real time

Zhang, X and S. Kondragunta, Estimating forest biomass in the USA using generalized allometric models and MODIS land products, *Geophysical Research Letter*, 33, L09402, doi:10.1029/2006GL025879, 2006
Zhang et al., Near real time biomass burning PM2.5 emissions across CONUS using multiple satellites, *Atmospheric Environment*, 2008
Zhang and Kondragunta, Temporal and spatial variability in biomass burning area across the USA using the GOES fire product, *Remote Sensing of Environment*, 2008

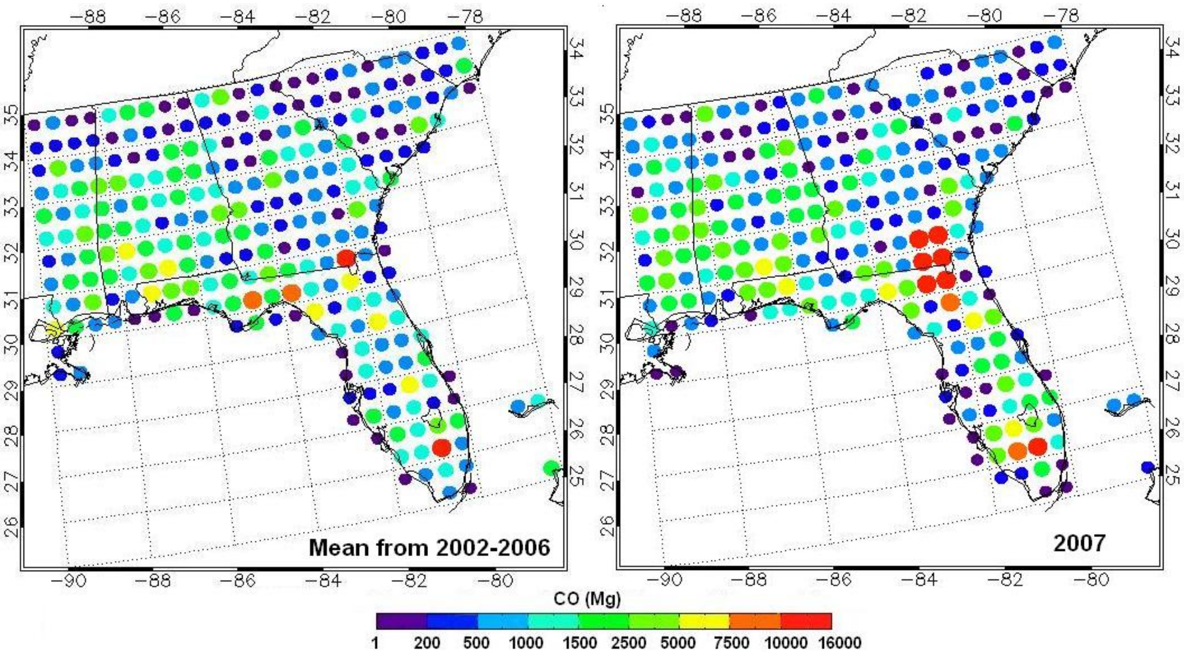
Validation Strategies

- Validation of emissions product (*ground-based or satellite-based*) is difficult
- Approaches
  - Direct *in situ* flux measurements – difficult due to limited or no measurements available
  - Intercomparison with other independent estimates (e.g., EPA 2002 effort)
  - Evaluate inputs that go into the algorithm
  - Use emissions in a 3-D model and compare predicted species concentrations to observed concentrations provided model transport and plume injection height are accurate
    - Use a tracer (e.g., CO) to avoid complications due to chemical loss/production mechanisms

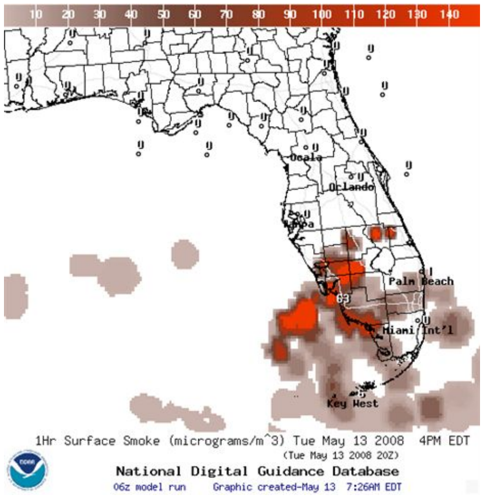
Data

- GOES biomass burning emissions of CO (http://satepsanone.nesdis.noaa.gov/pub/EPA/GBBEP)
  - 4 km resolution at nadir
  - Hourly temporal resolution
  - CONUS only
- AIRS observed CO (http://mirador.gsfc.nasa.gov)
  - 45 km resolution at nadir
  - Twice a day
  - Global
- CMAQ CO simulations
  - 12 km resolution
  - Hourly temporal resolution
  - CONUS only
  - CO emissions distributed uniformly within the boundary layer
- CMAQ and AIRS matchup criteria
  - ± 6km and ± 30 minutes

Biomass Burning Episode



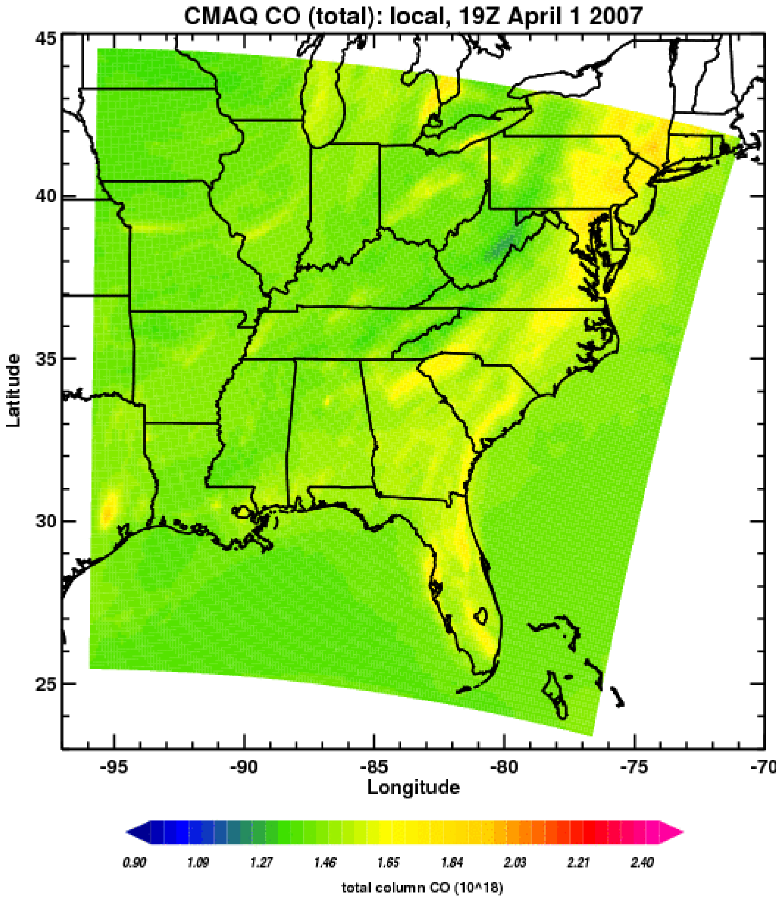
- April – May 2007
  - 125,000 acres of land burned as estimated by GOES-12 Imager
  - Smoke from fires spread far and wide. Areas with violations of PM2.5 standard to flag this as an exceptional event
  - NWS operational HYSPLIT smoke forecast model forecast the smoke dispersion very well

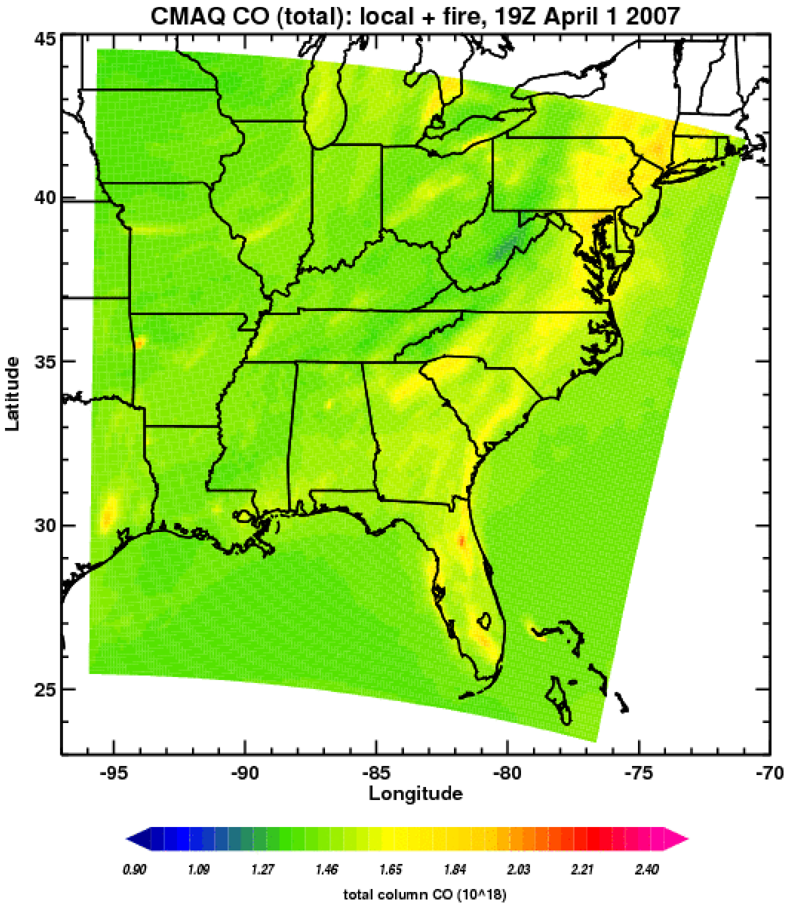


http://www.weather.gov/aq

Without Fire Emissions

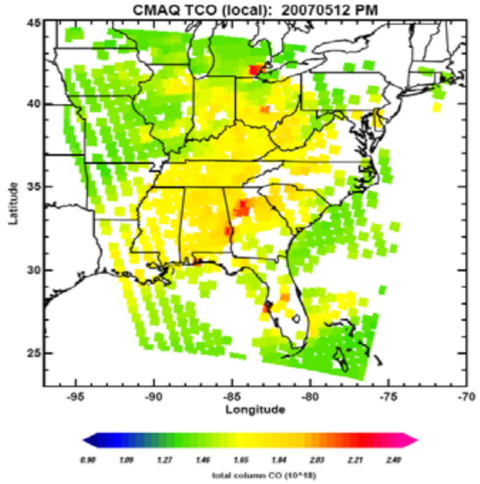
With Fire Emissions

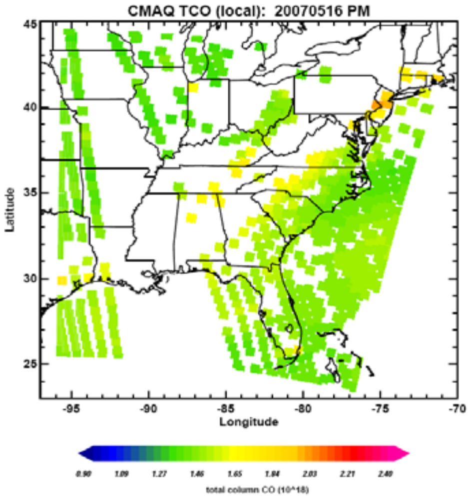


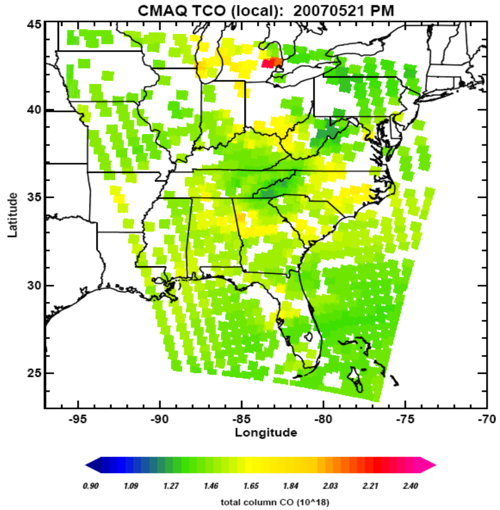


Difference in Total CO (fires – no fires)

CO (CMAQ vs AIRS)

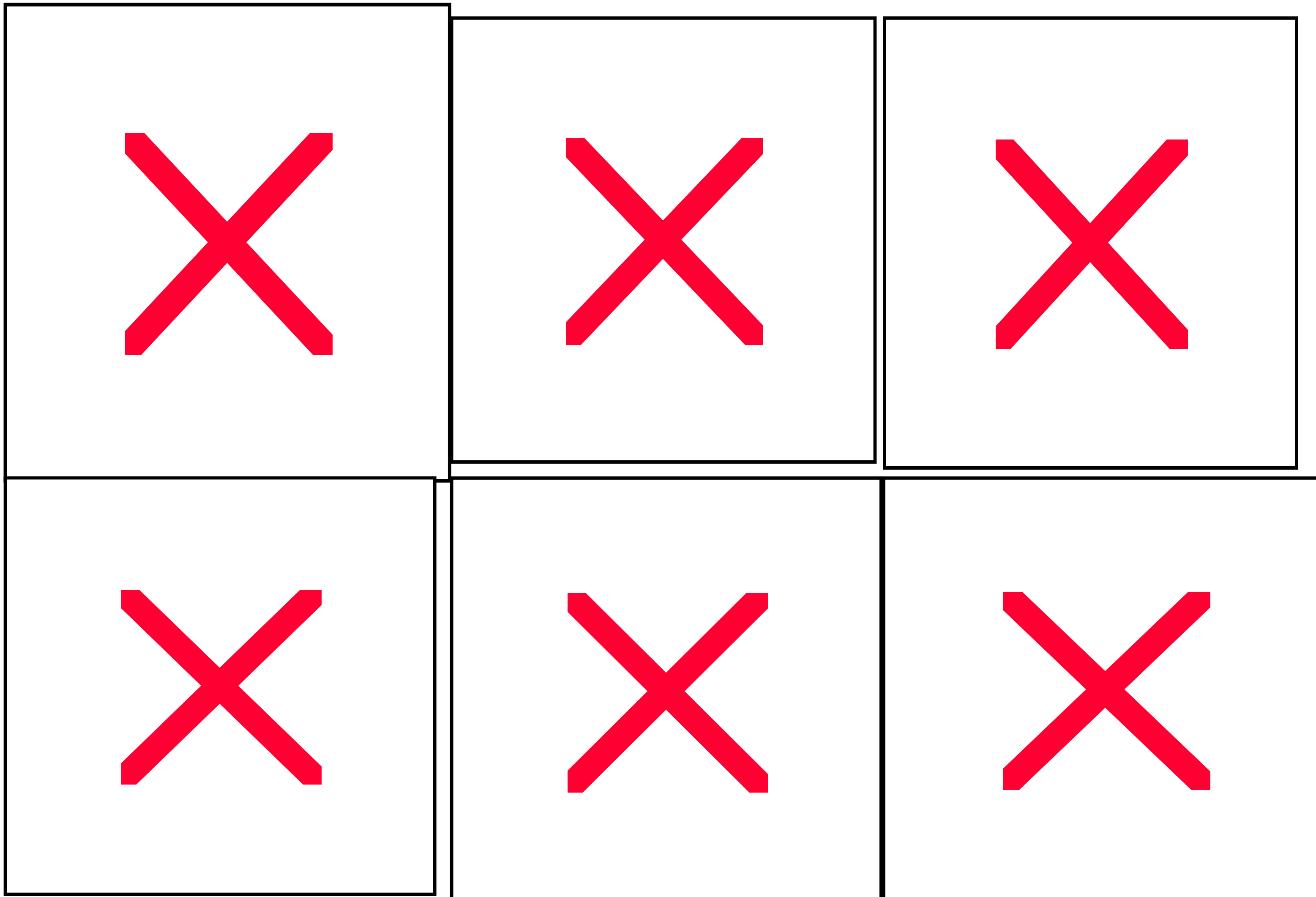




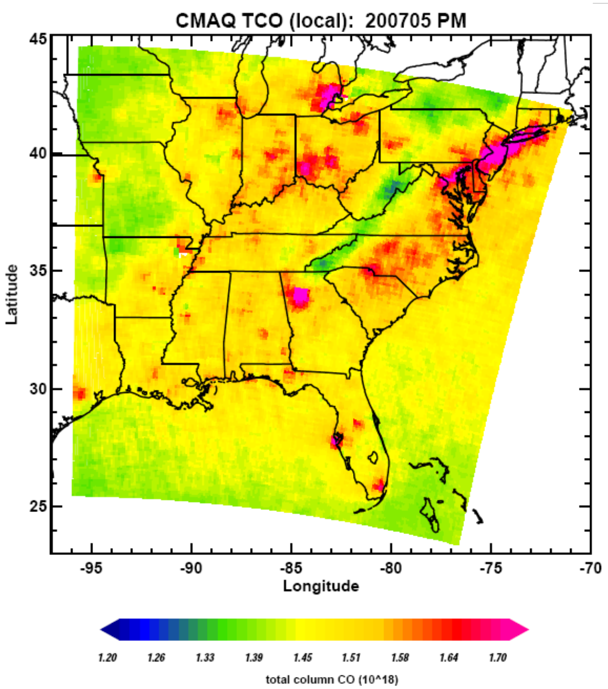


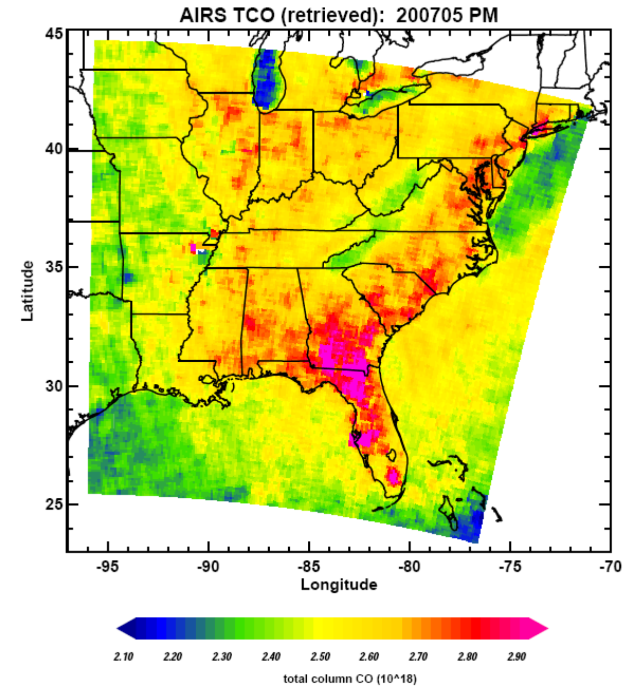
Note AIRS color scale is different

CO (CMAQ with Fire Emissions vs AIRS)



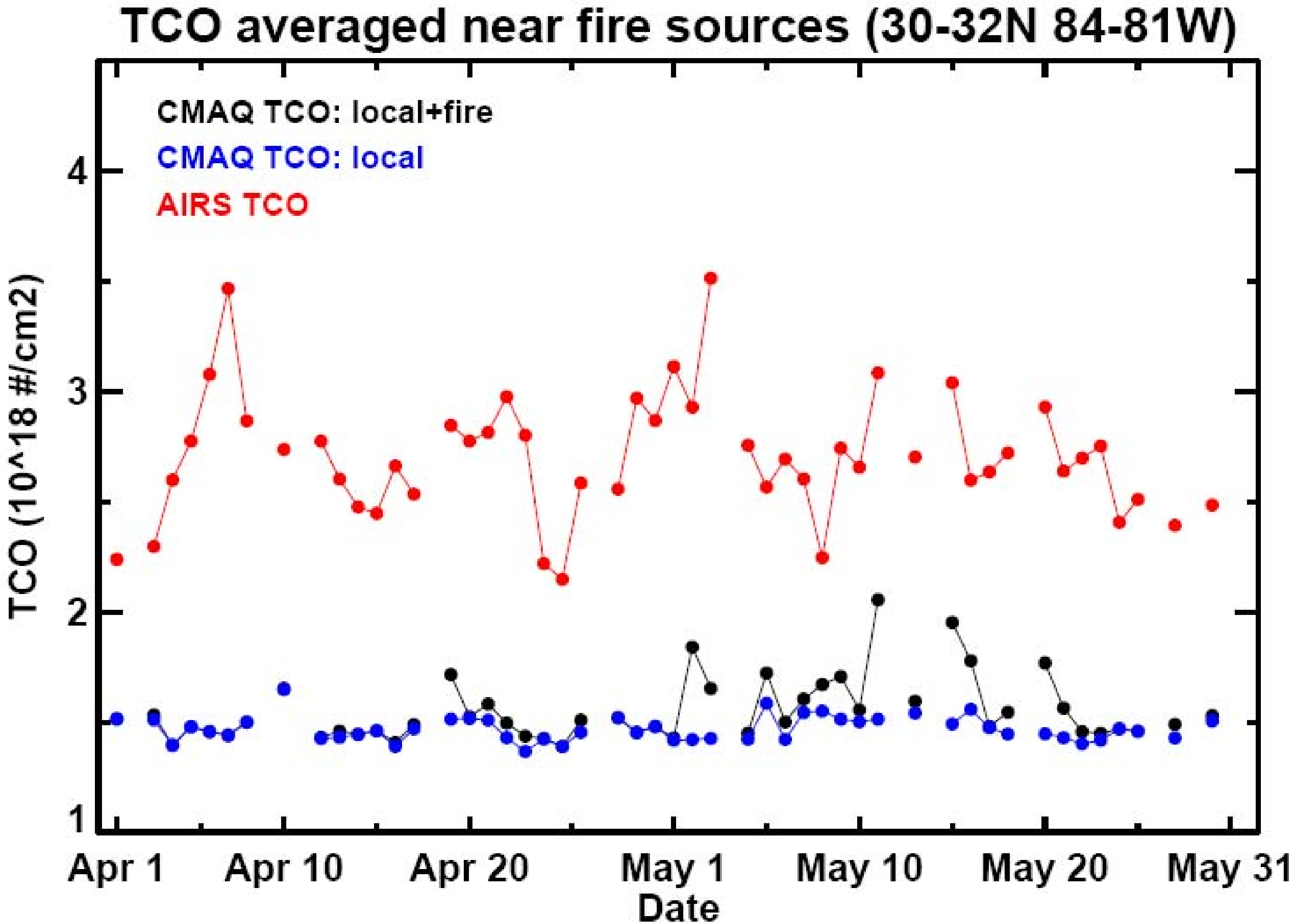
Note AIRS color scale is different

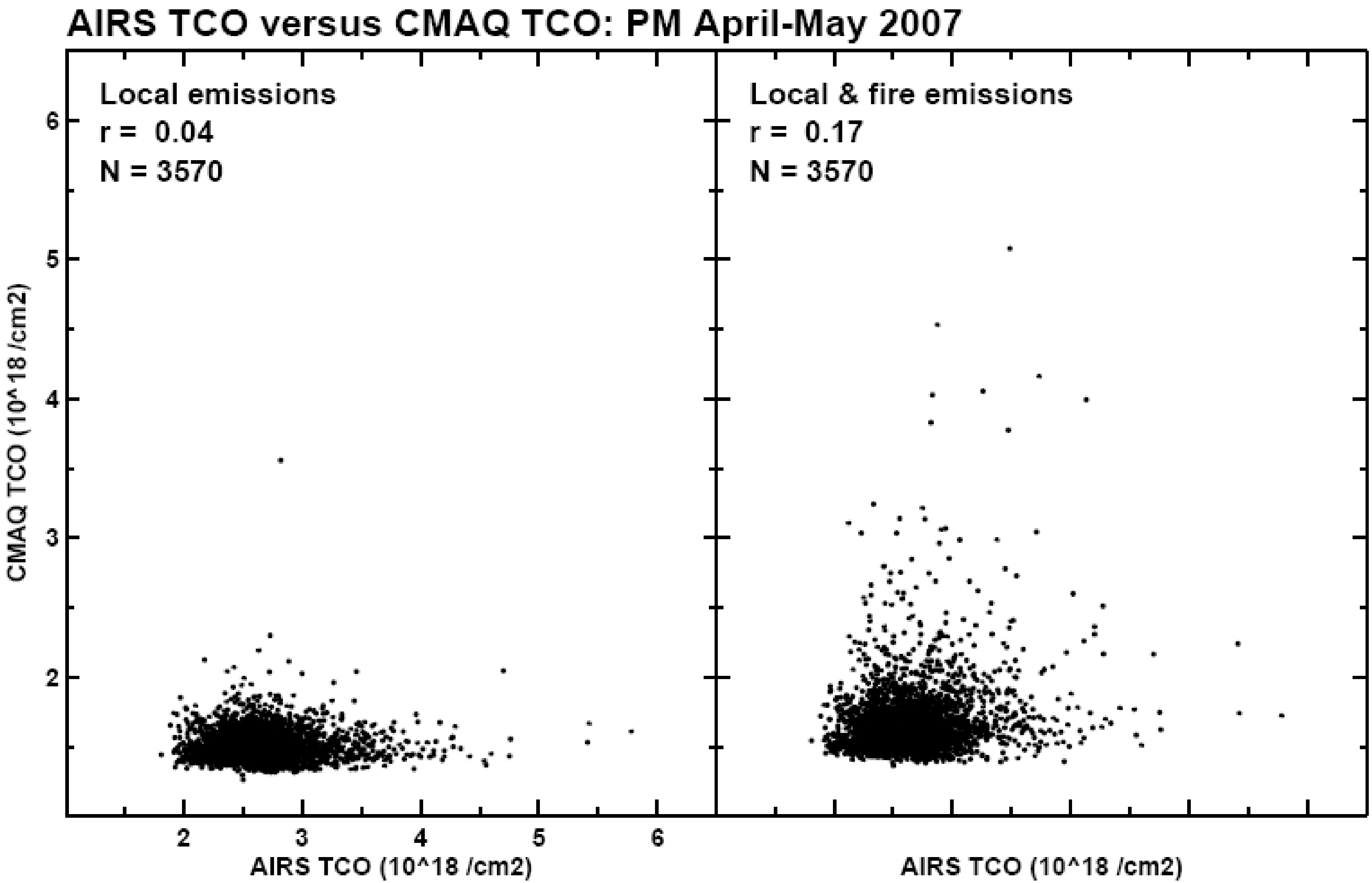


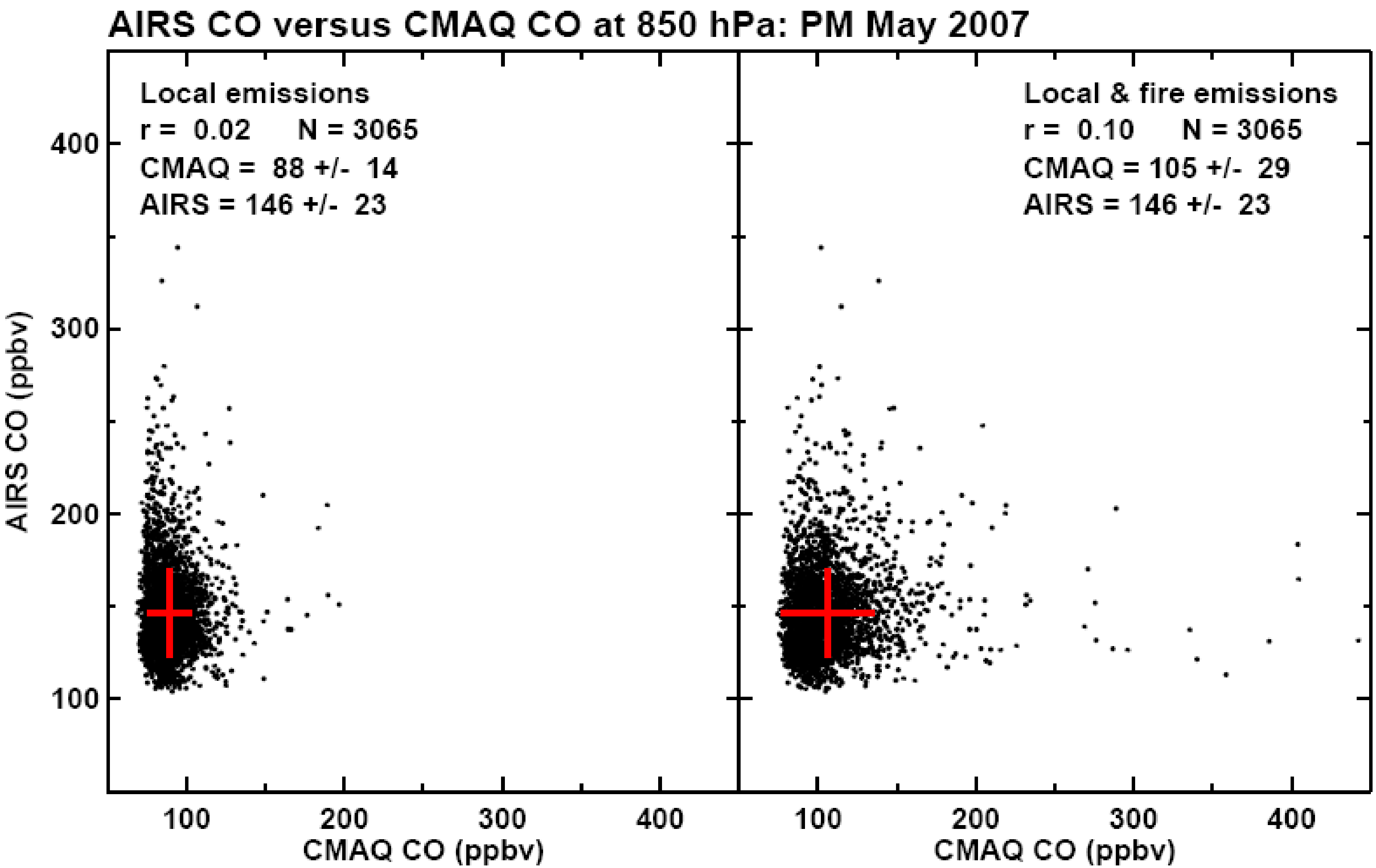


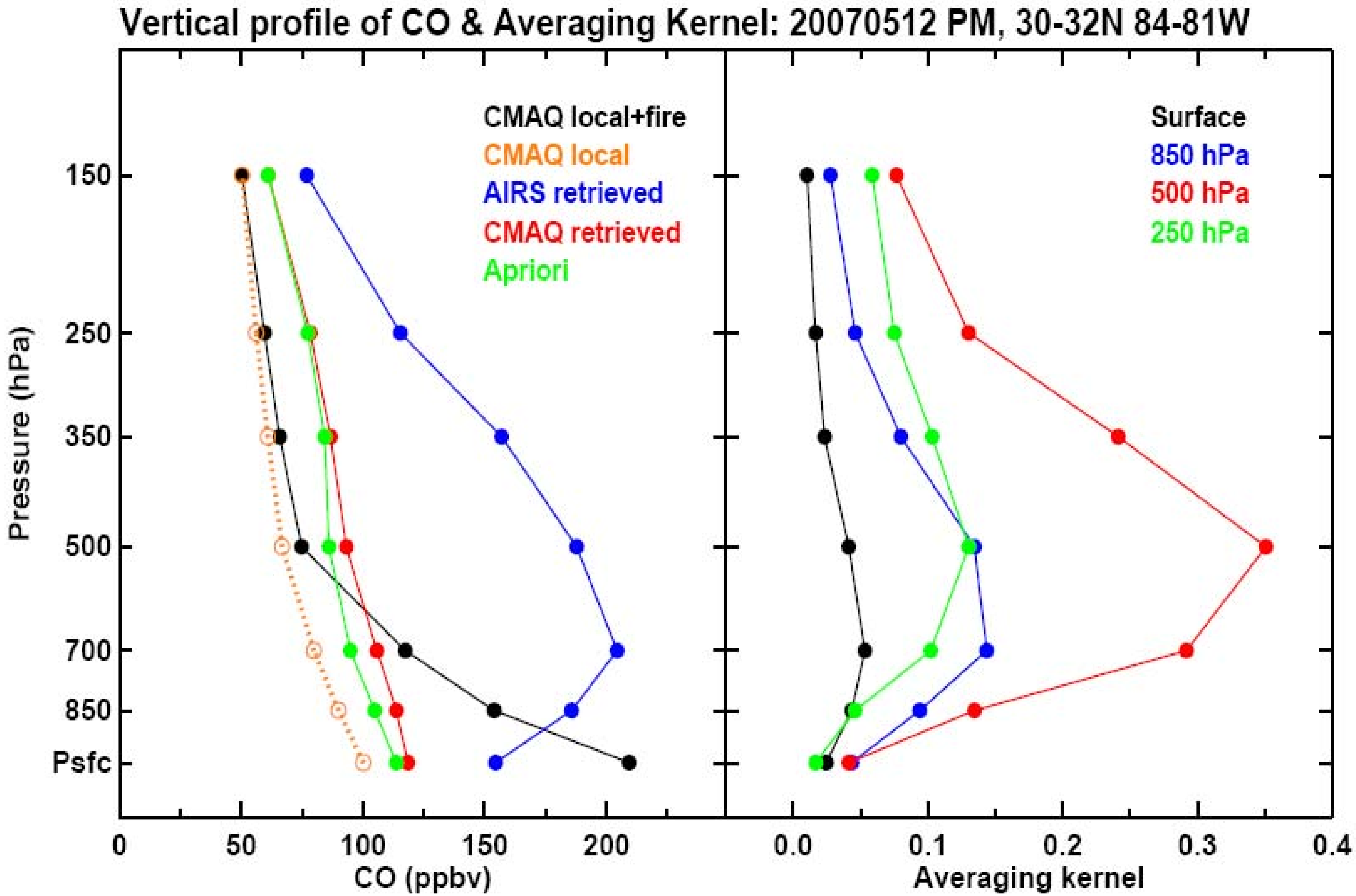
- CMAQ point sources are not discernable in AIRS CO map (e.g., mid-West). Spatial patterns are somewhat similar
- CMAQ with fire emissions captures enhanced CO in Florida. However enhanced CO in AIRS more widespread

Note AIRS color scale is different


TCO averaged near fire sources (30-32N 84-81W)
CMAQ TCO: local+fire
CMAQ TCO: local
AIRS TCO
TCO (10^18 #/cm2)
1
2
3
4
Apr 1
Apr 10
Apr 20
May 1
May 10
May 20
May 31
Date


AIRS TCO versus CMAQ TCO: PM April-May 2007
Local emissions
r = 0.04
N = 3570
Local & fire emissions
r = 0.17
N = 3570
CMAQ TCO (10^18 /cm2)
AIRS TCO (10^18 /cm2)
AIRS TCO (10^18 /cm2)
2
3
4
5
6


AIRS CO versus CMAQ CO at 850 hPa: PM May 2007
Local emissions
r = 0.02 N = 3065
CMAQ = 88 +/- 14
AIRS = 146 +/- 23
Local & fire emissions
r = 0.10 N = 3065
CMAQ = 105 +/- 29
AIRS = 146 +/- 23
AIRS CO (ppbv)
CMAQ CO (ppbv)
CMAQ CO (ppbv)
100
200
300
400



Vertical profile of CO & Averaging Kernel: 20070512 PM, 30-32N 84-81W
CMAQ local+fire
CMAQ local
AIRS retrieved
CMAQ retrieved
Apriori
Surface
850 hPa
500 hPa
250 hPa
Pressure (hPa)
150
250
350
500
700
850
Psfc
0
50
100
150
200
CO (ppbv)
0.0
0.1
0.2
0.3
0.4
Averaging kernel

Conclusions

- For the two month period from April – May 2007:
  - CMAQ CO has a bias of $1.07X10^{18}$ molecules/cm^2 compared to AIRS CO. This bias reduced to $0.97X10^{18}$ molecules/cm^2 when fire emissions were used in CMAQ model
  - Using $2.5X10^{18}$ molecules/cm^2 AIRS CO as a mean value, a bias of $0.97X10^{18}$ molecules/cm^2 indicates that GOES CO emissions are underestimated by 40%
  - Further analysis is needed to fully understand the variability in AIRS CO in early April (long-range transport?) and analyzing only pixel data that are influenced by fire emissions. Why are AIRS CO values always so high? Why are AIRS CO maps not showing hot spots associated with urban/industrial areas?
  - Additional CMAQ simulations will be carried out to test the impact of plume injection height