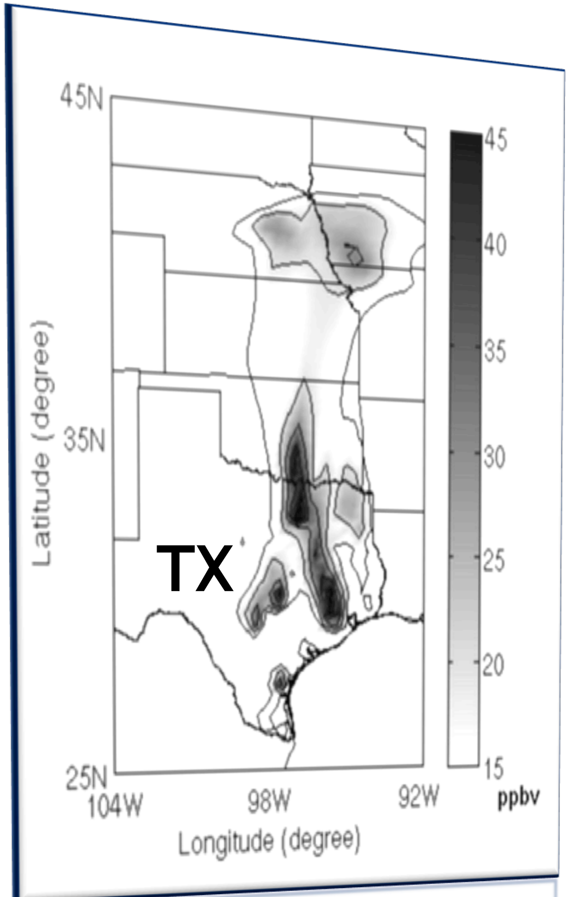

Quantifying regional emissions using WRF-Chem tagged tracers:

Implications for cross-state pollution transport and extreme air quality events

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Acknowledgements : NASA ACMAP

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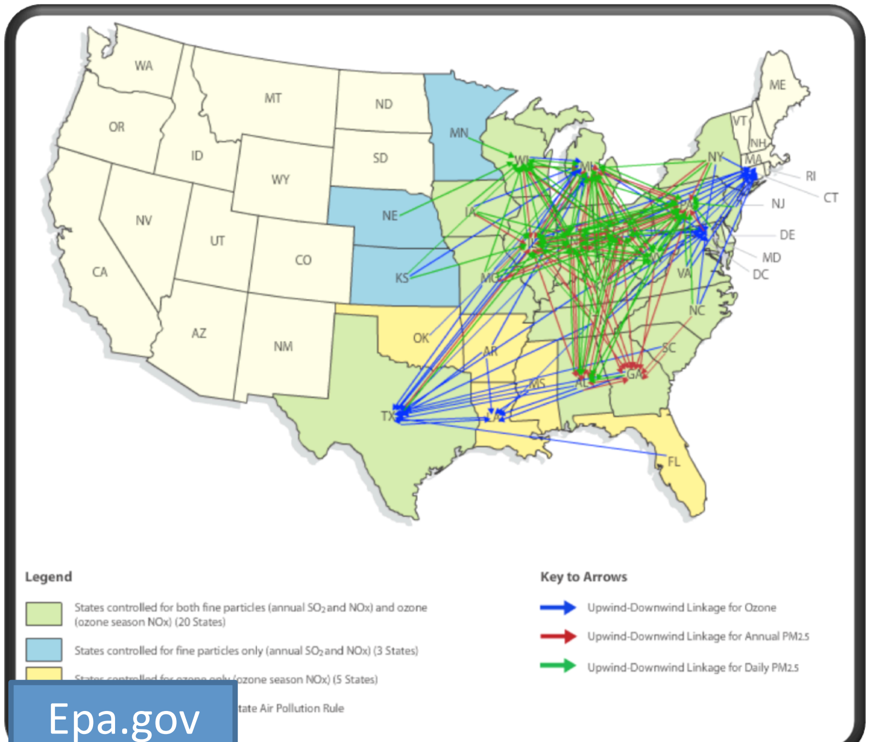
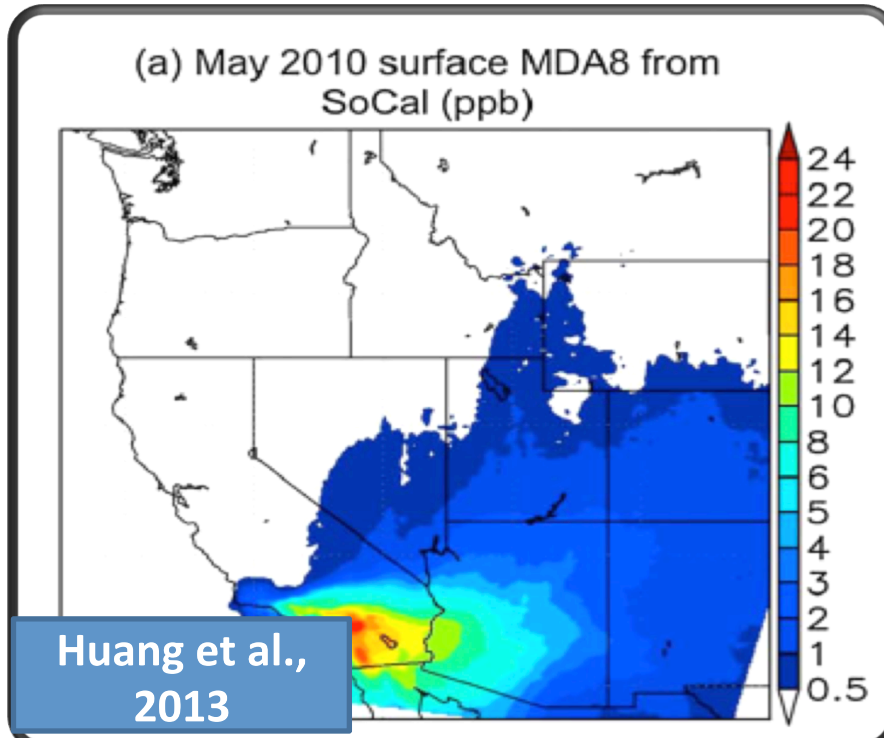
Why state – level emissions?

- Cross-state Air Pollution Rule / Cross – state neighborhood rule by EPA
- Recent studies point to reduction in CO emissions in U.S – However, uncertainties remain, esp for seasonal and inter-annual variations.

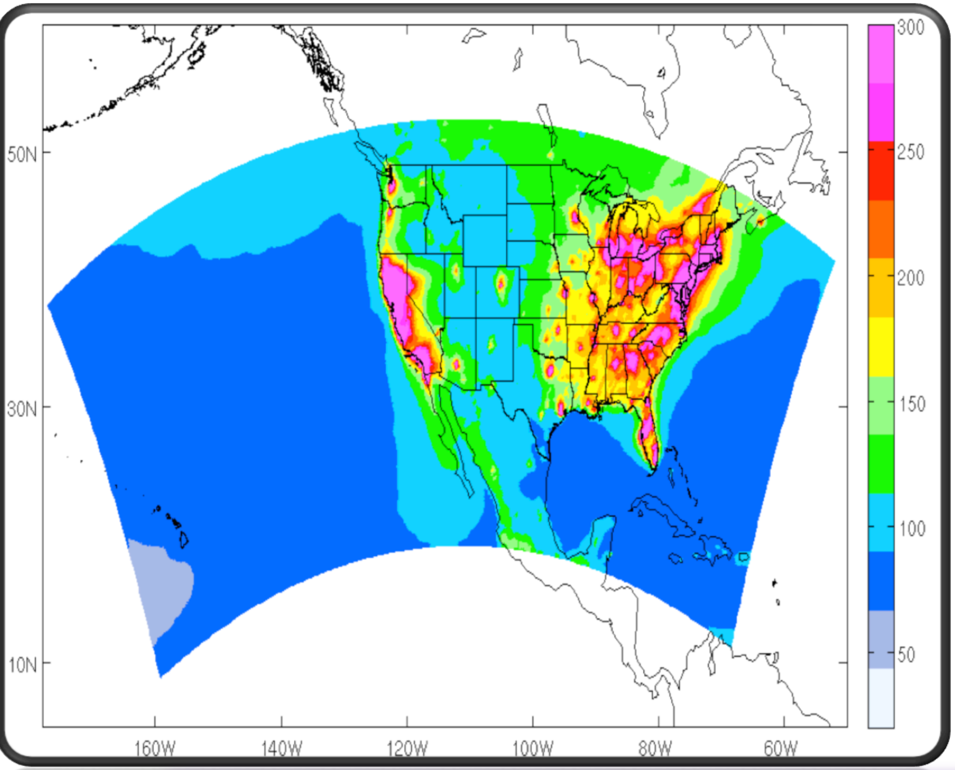


Epa.gov



Huang et al., 2013

WRF V3.4.1 Configuration



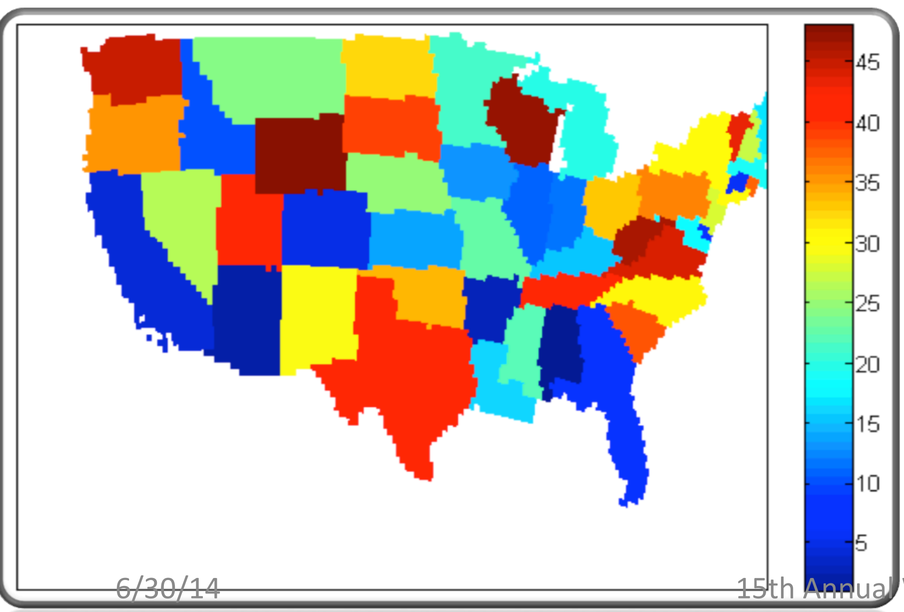
Simulation Period	**2008/06/01 00Z to 2008/07/31 23 Z**
Grid spacing	36 Km x 36 Km
Chemistry spinup	1 June – 15 June
Shortwave and Longwave radiation	Goddard shortwave and RRTM longwave
Boundary Layer scheme	Mellor-Yamada-Janjic (Eta) TKE

- *WRF-Chem MOZCART with sectoral tracers*
- *Initial and boundary conditions for meteorology from NCEP 6-hourly FNL analysis @ 1^{o} resolution.*
- *Emissions : NEI 2005, FINN fire emissions, MEGAN biogenic*
- *Refresh at 18Z every day*

State level emission contributions in WRF-Chem

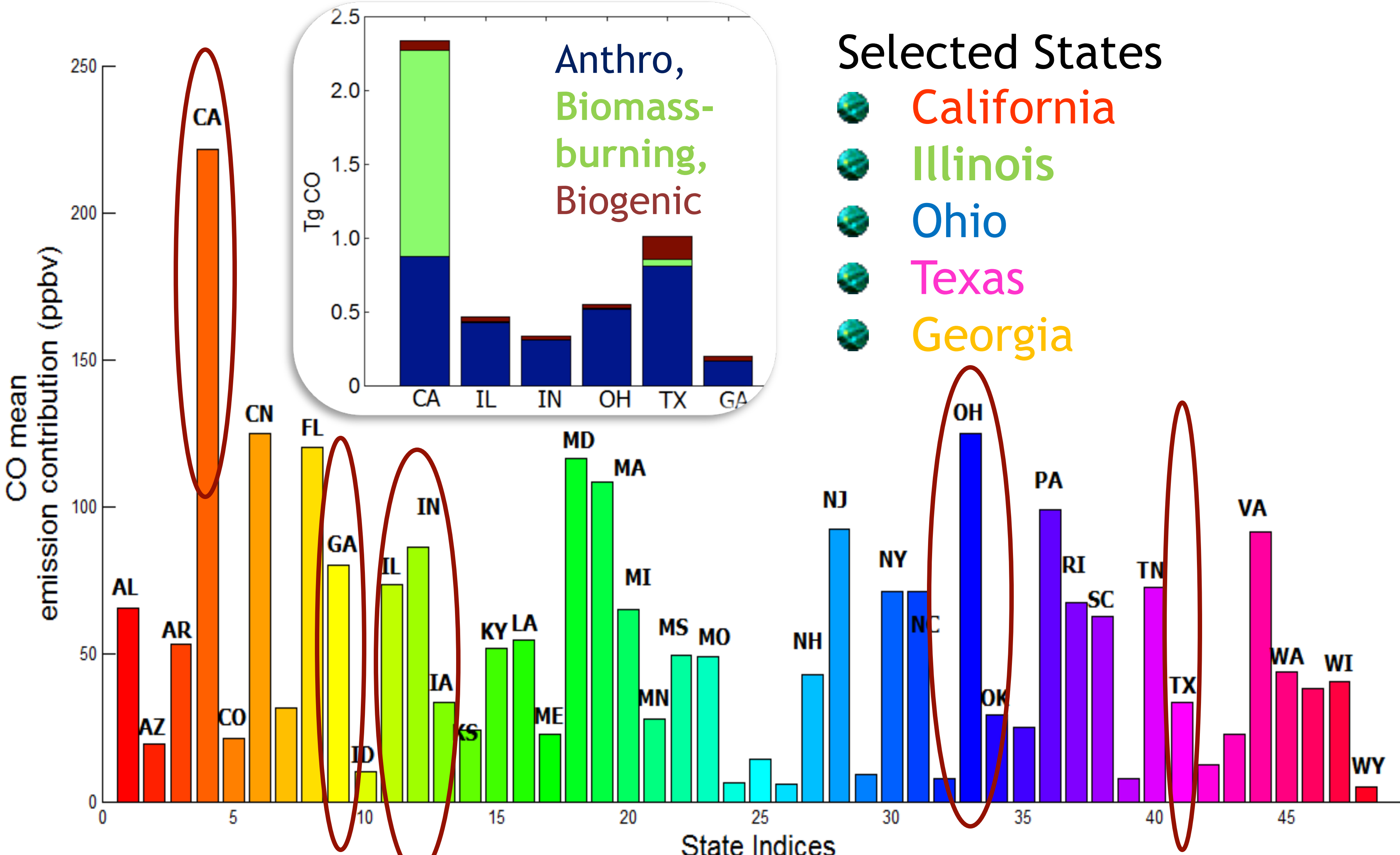
$$\frac{d[CO]}{dt} = \left(\frac{d[CO]}{dt}\right)_{Emission} + \left(\frac{d[CO]}{dt}\right)_{Chemistry} + \left(\frac{d[CO]}{dt}\right)_{Deposition} + \left(\frac{d[CO]}{dt}\right)_{Transport}$$

- Sources for state tracers : Anthropogenic , biomass burning, and biogenic emissions
- Sinks : Dry deposition and OH oxidation



- State Indices developed for 48 states in U.S
- CO Emission contributions from individual states in CONUS are analyzed

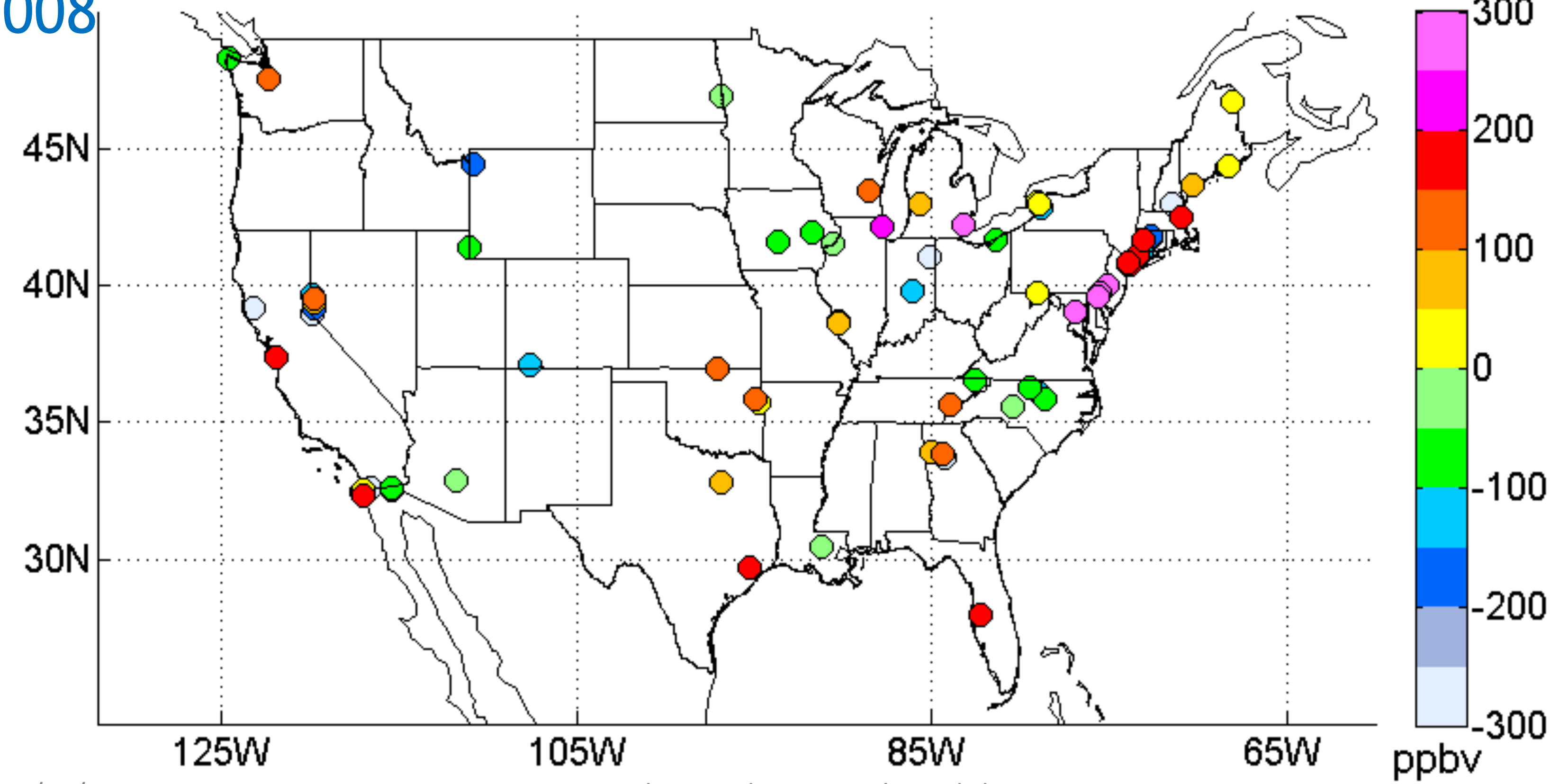
Emission Contributions from CONUS



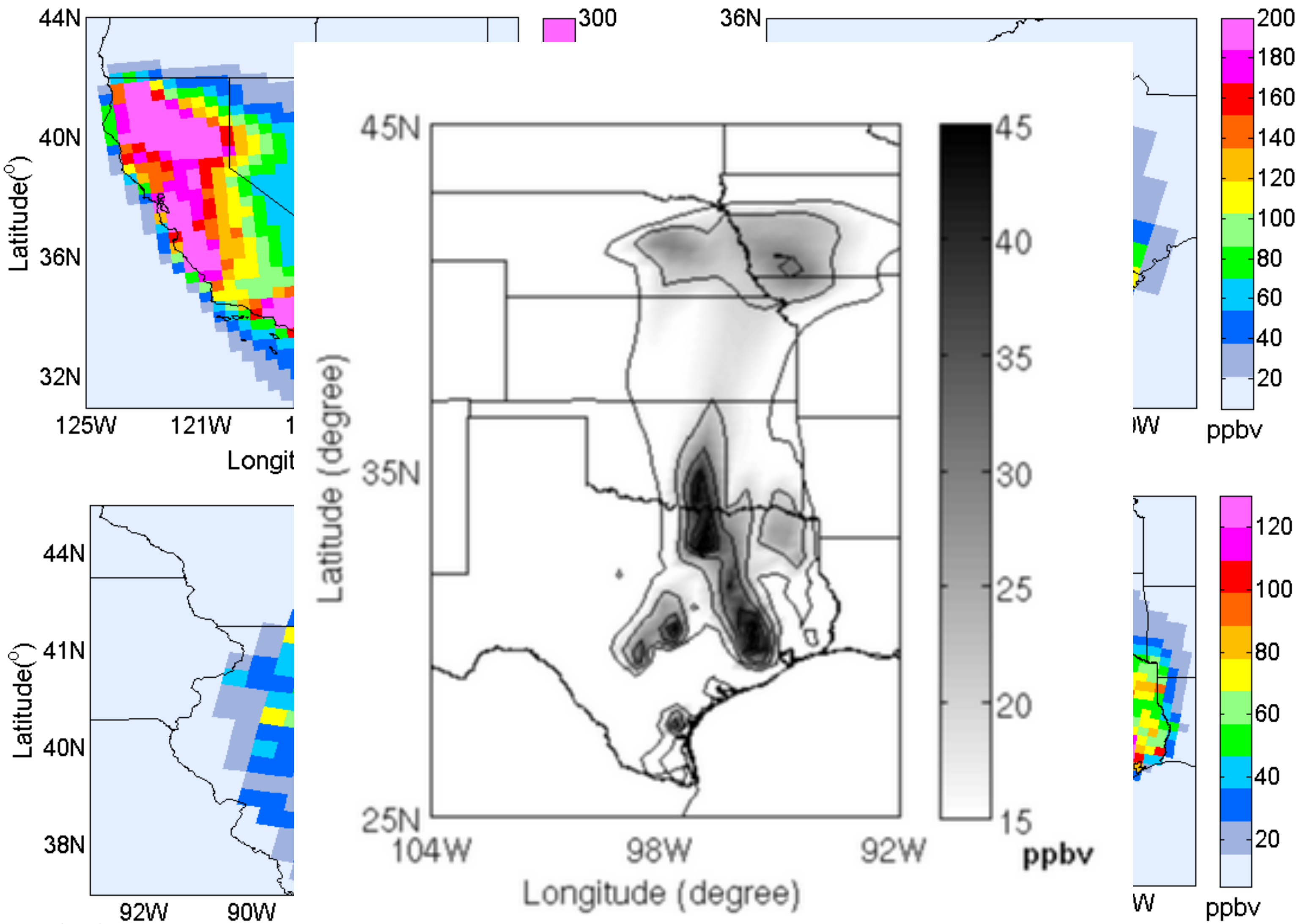
Selected States
- California
- Illinois
- Ohio
- Texas
- Georgia

Mean bias for EPA-AQS high resolution sites

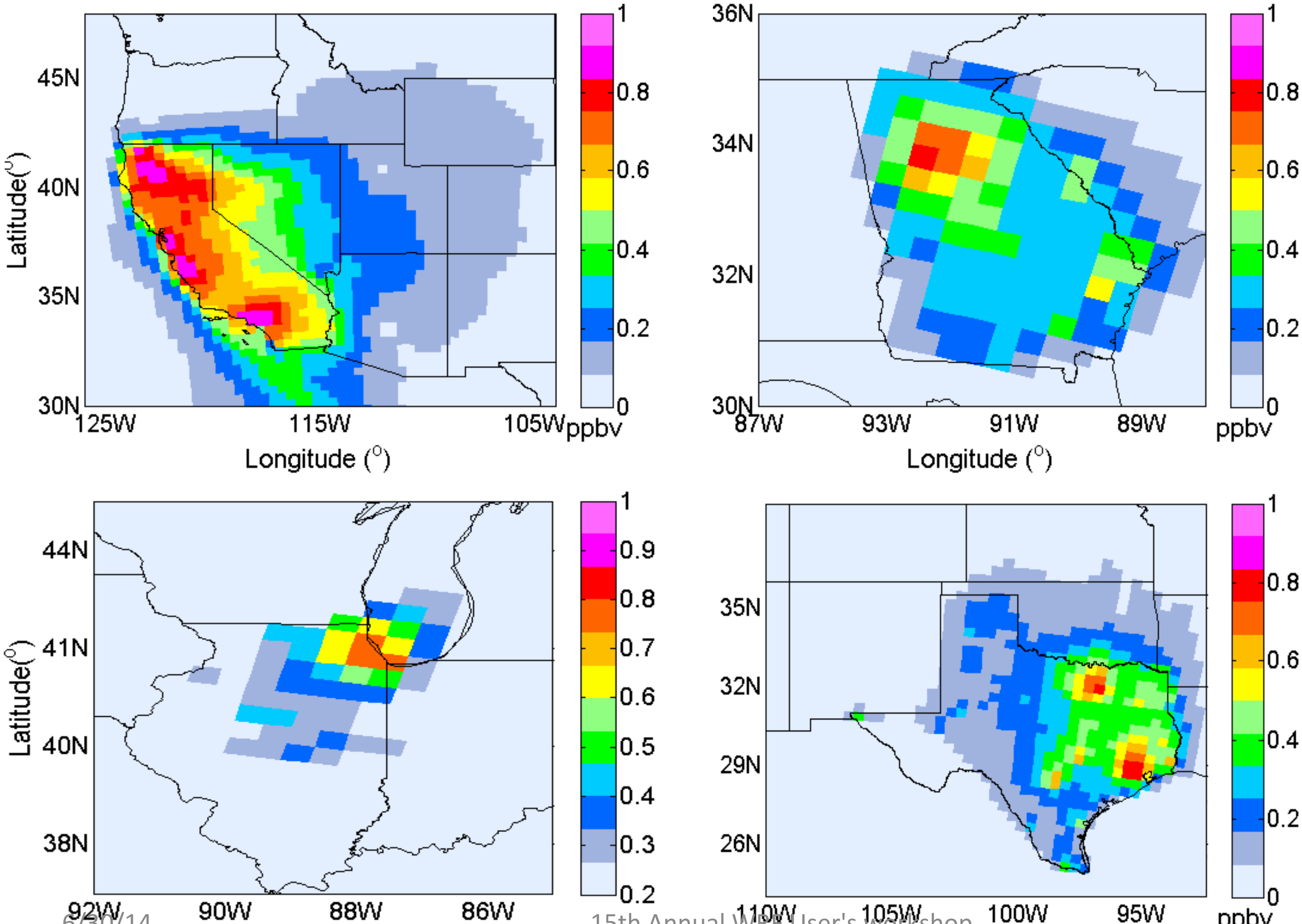
- EPA –AQS sites with CO hourly resolution less than 100 ppbv
- # of high-res EPA-AQS sites : 67 sites for June and July 2008

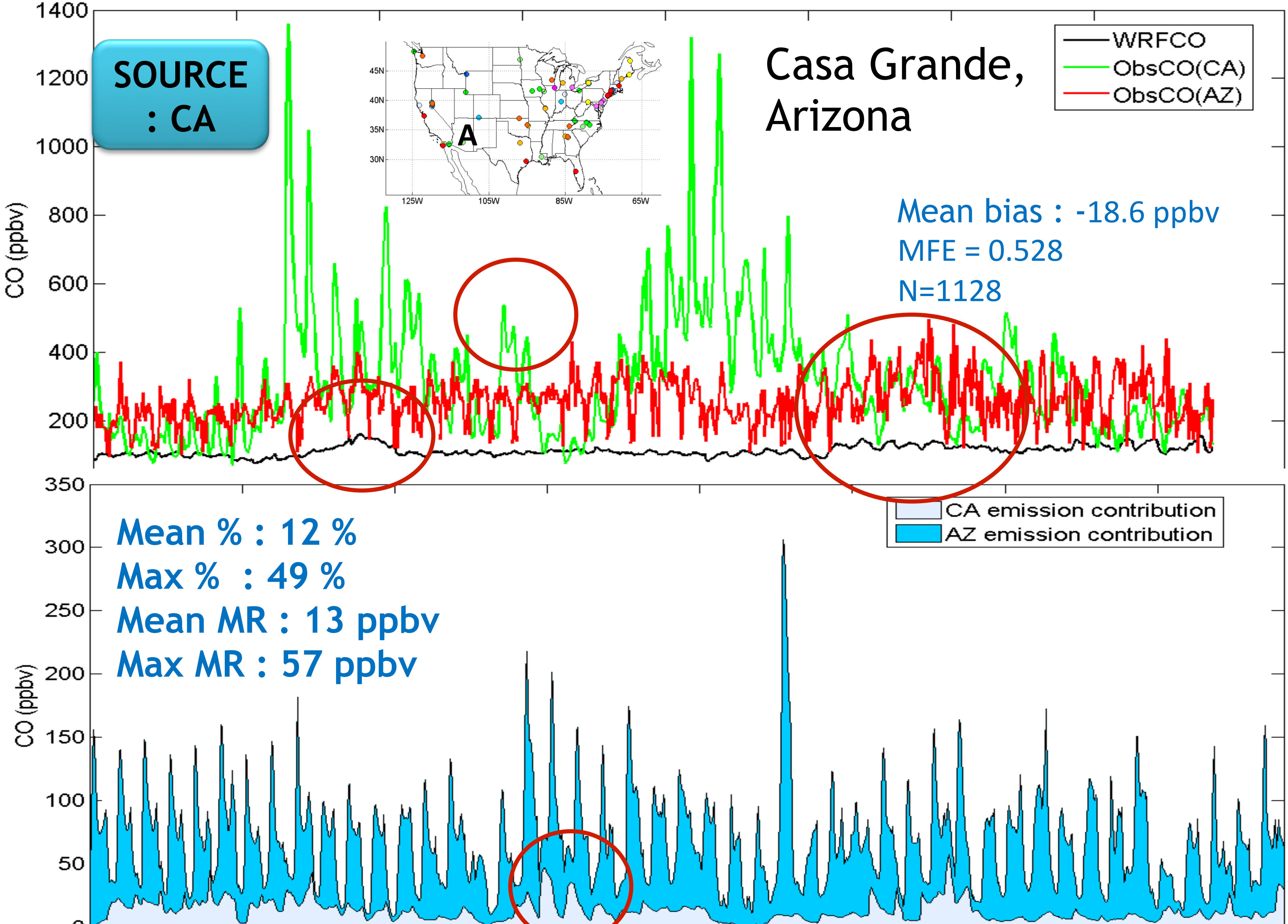


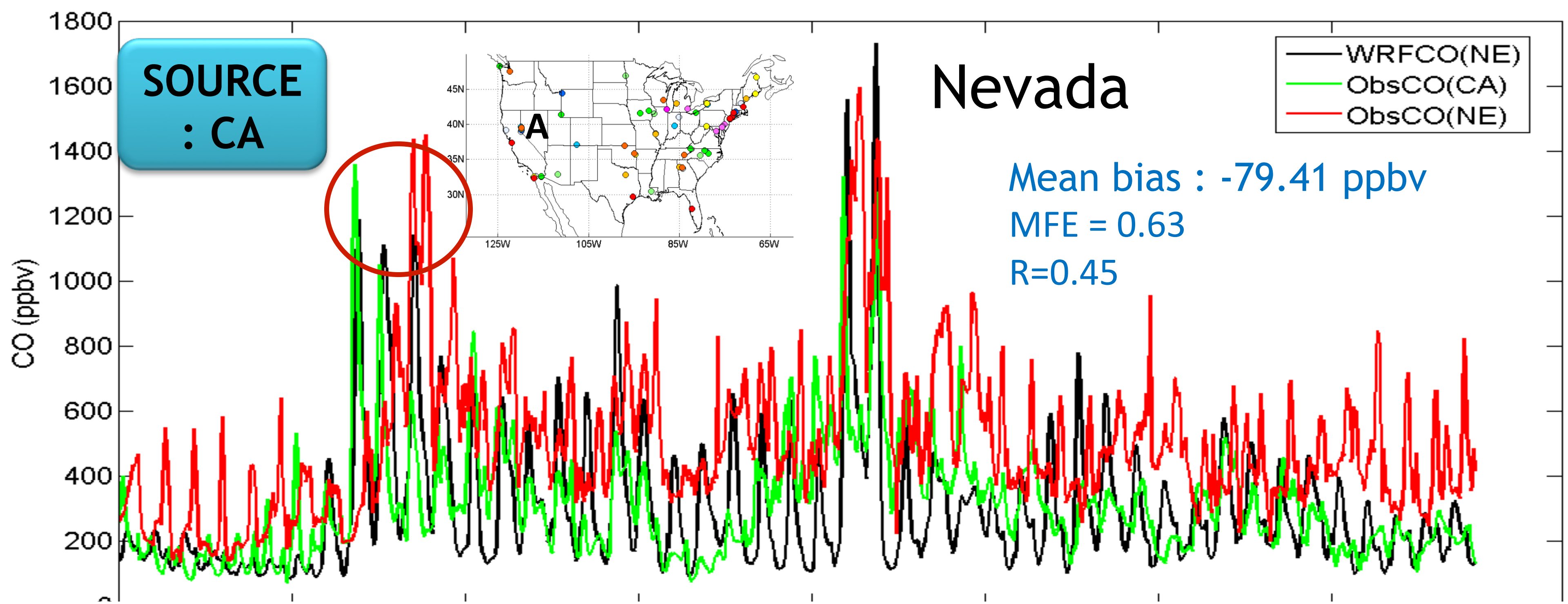
Interstate pollution transport : Mean CO surface mixing ratios



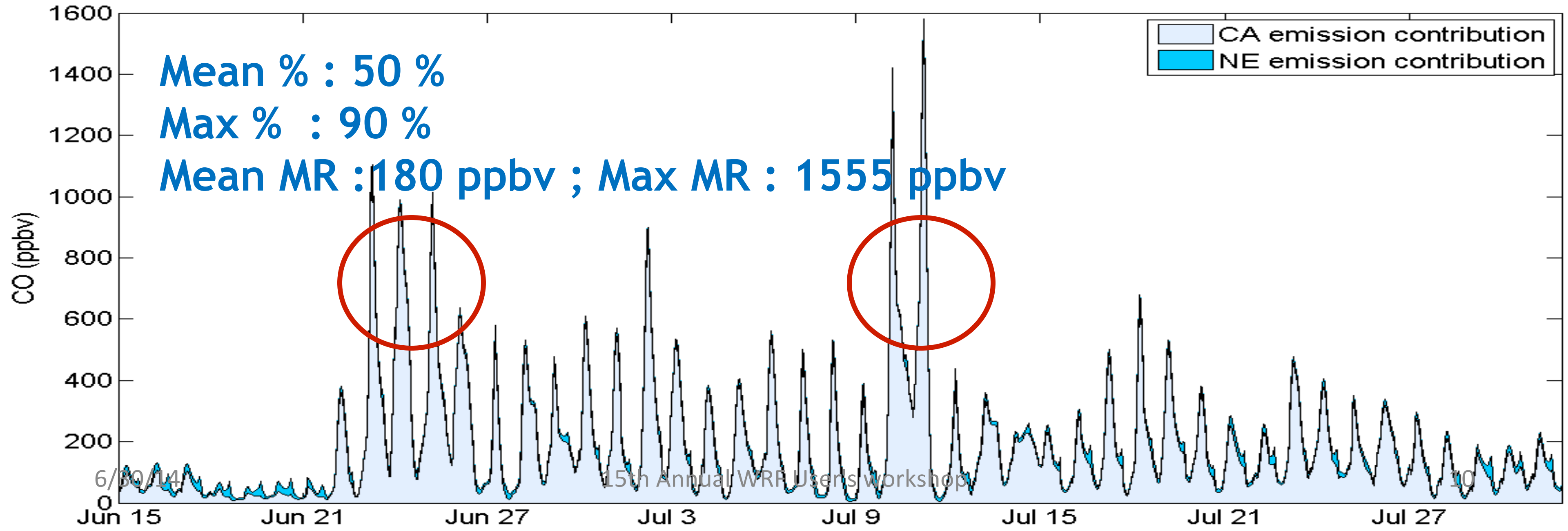
Ratio of CO tracers / total CO



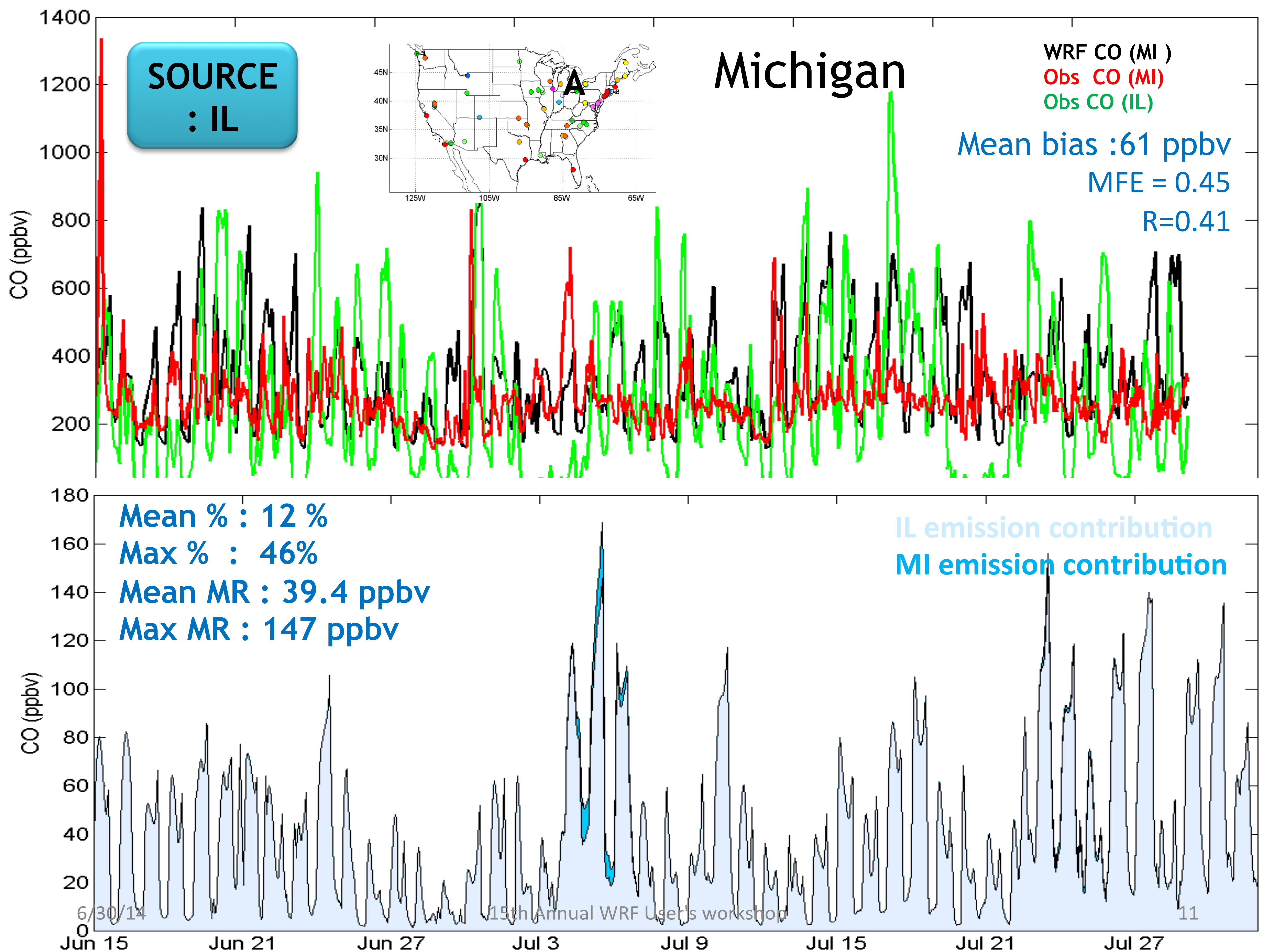

SOURCE : CA
Casa Grande, Arizona
WRFCO
ObsCO(CA)
ObsCO(AZ)
Mean bias : -18.6 ppbv
MFE = 0.528
N=1128
CO (ppbv)
A
CA emission contribution
AZ emission contribution
Mean % : 12 %
Max % : 49 %
Mean MR : 13 ppbv
Max MR : 57 ppbv
Jun 15
Jun 21
Jun 27
Jul 3
Jul 9
Jul 15
Jul 21
Jul 27



SOURCE : CA
Nevada
WRFCO(NE)
ObsCO(CA)
ObsCO(NE)
Mean bias : -79.41 ppbv
MFE = 0.63
R=0.45
A
CO (ppbv)



Mean % : 50 %
Max % : 90 %
Mean MR :180 ppbv ; Max MR : 1555 ppbv
CA emission contribution
NE emission contribution
CO (ppbv)
Jun 15
Jun 21
Jun 27
Jul 3
Jul 9
Jul 15
Jul 21
Jul 27


SOURCE : IL
Michigan
WRF CO (MI)
Obs CO (MI)
Obs CO (IL)
Mean bias :61 ppbv
MFE = 0.45
R=0.41
A
45N
40N
35N
30N
125W
105W
85W
65W
1400
1200
1000
800
600
400
200
CO (ppbv)
Mean % : 12 %
Max % : 46%
Mean MR : 39.4 ppbv
Max MR : 147 ppbv
IL emission contribution
MI emission contribution
180
160
140
120
100
80
60
40
20
0
Jun 15
Jun 21
Jun 27
Jul 3
Jul 9
Jul 15
Jul 21
Jul 27

Interesting neighbors!

SOURCE	RECEPTOR	Mean %	Max %	Mean MR (ppbv)	Max MR (ppbv)
CA	NE	50	90	180	1555
	AZ	12	49	13	57
	WY	12	33	14	51
	CO	10	25	11	31
GA	TN	2.2	22	6	70
	NC	1.7	17	4.43	39.6
IL	MI	12	46	39.4	147
	WI	4.8	51	14	271
	IN	4	31	10.5	101
TX	OK	9.5	35	15	58
	IA	1.7	14	3.3	24
	LA	1.4	16	3	25

Summary

- Cross-state pollution transport is important.
- WRF-Chem MOZCART shows promising results in evaluating the state tracers in non-biomass burning regions.
- TX, CA, IL have significant cross-state air pollution transport.
- CA contributes to more intense pollution in NV, AZ, and CO. Peak contribution in NV increases to more than 90%.
- Emission contributions from TX decreases with distance. However, individual days show that TX emission contribution reaching Iowa with a maximum of 24 ppbv and a mean contribution of 3 ppbv.

Current work

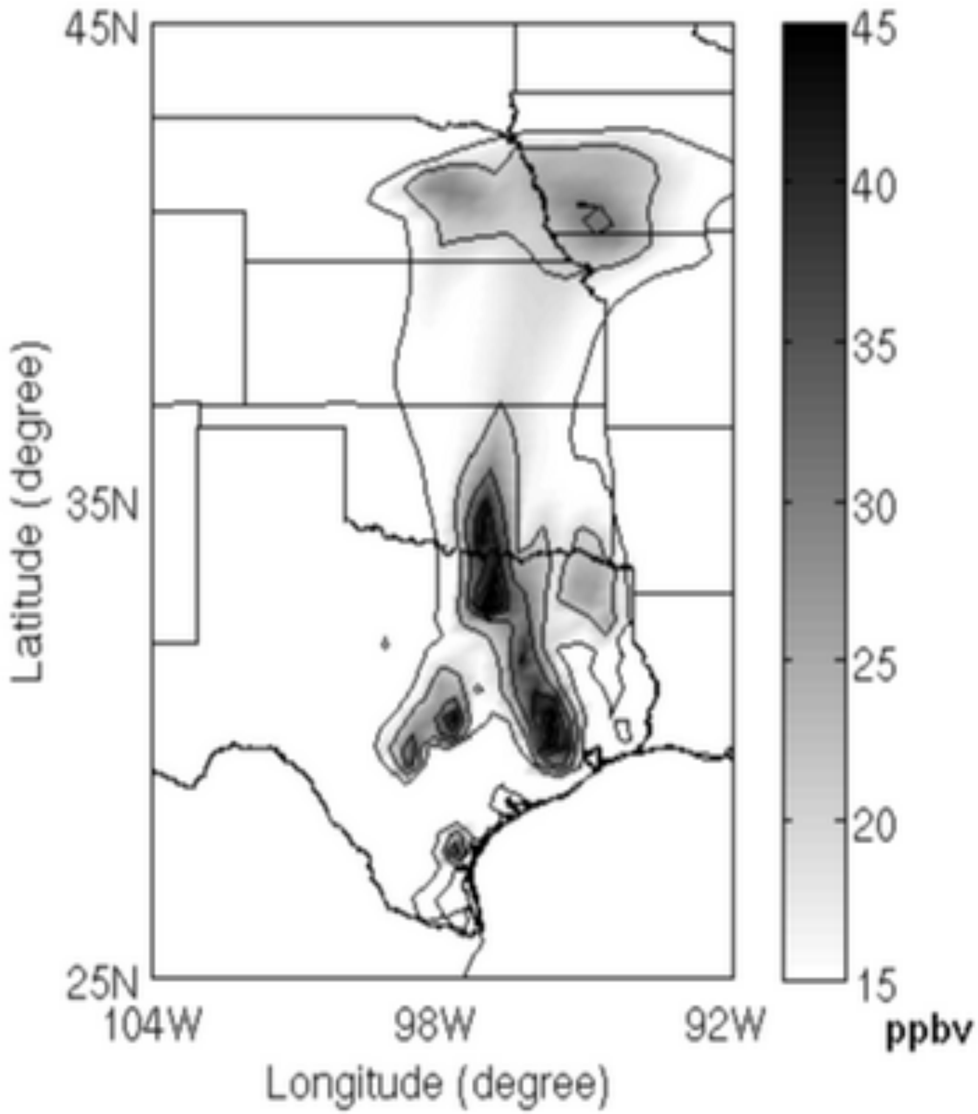
- Time independent inverse modeling experiments for JJA months in 2008 using EPA-AQS high-res sites.

- We will conduct these experiments for 2006,2008,and 2011 to provide top-down estimates of state level emissions for CONUS corresponding to NEI05,NEI08, and NEI11

- Addition of dust tracers similar to CO state tracers to track dust from the South Western United States during dust storms and massive haboobs.

Thank you!

Know your Neighbors!



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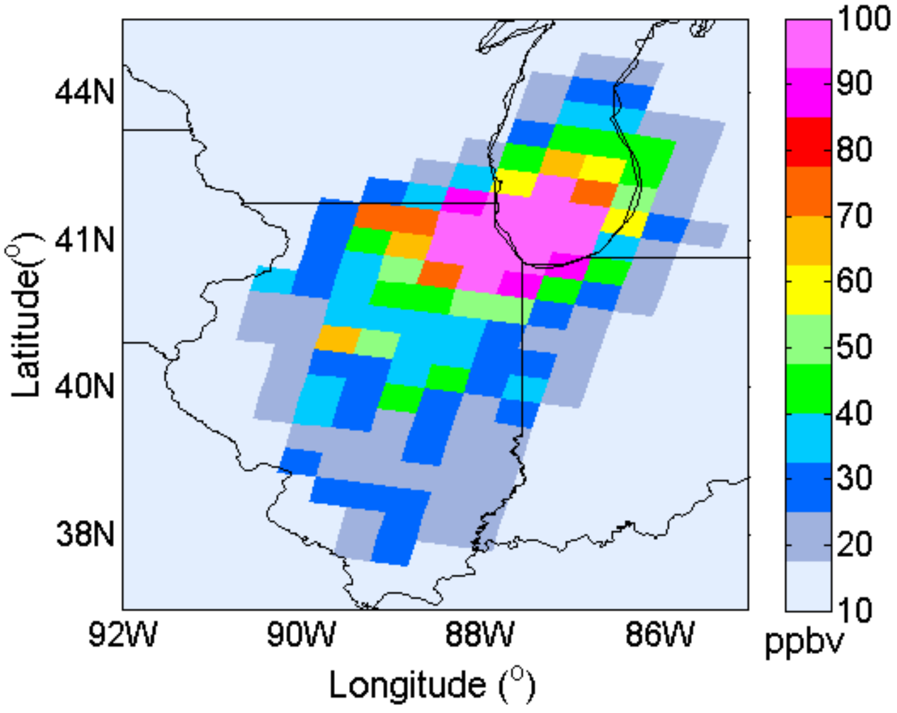
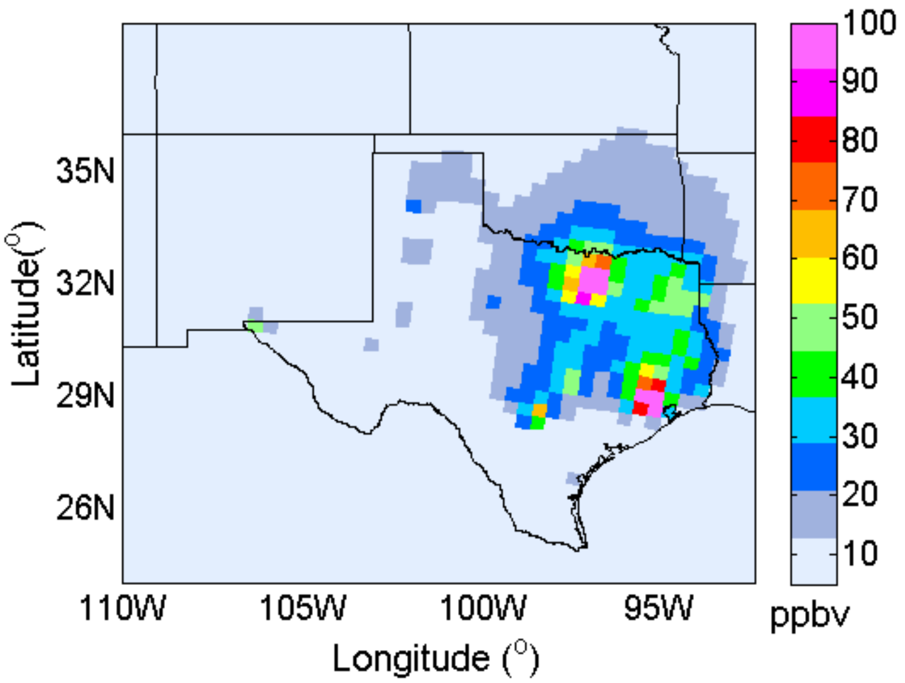
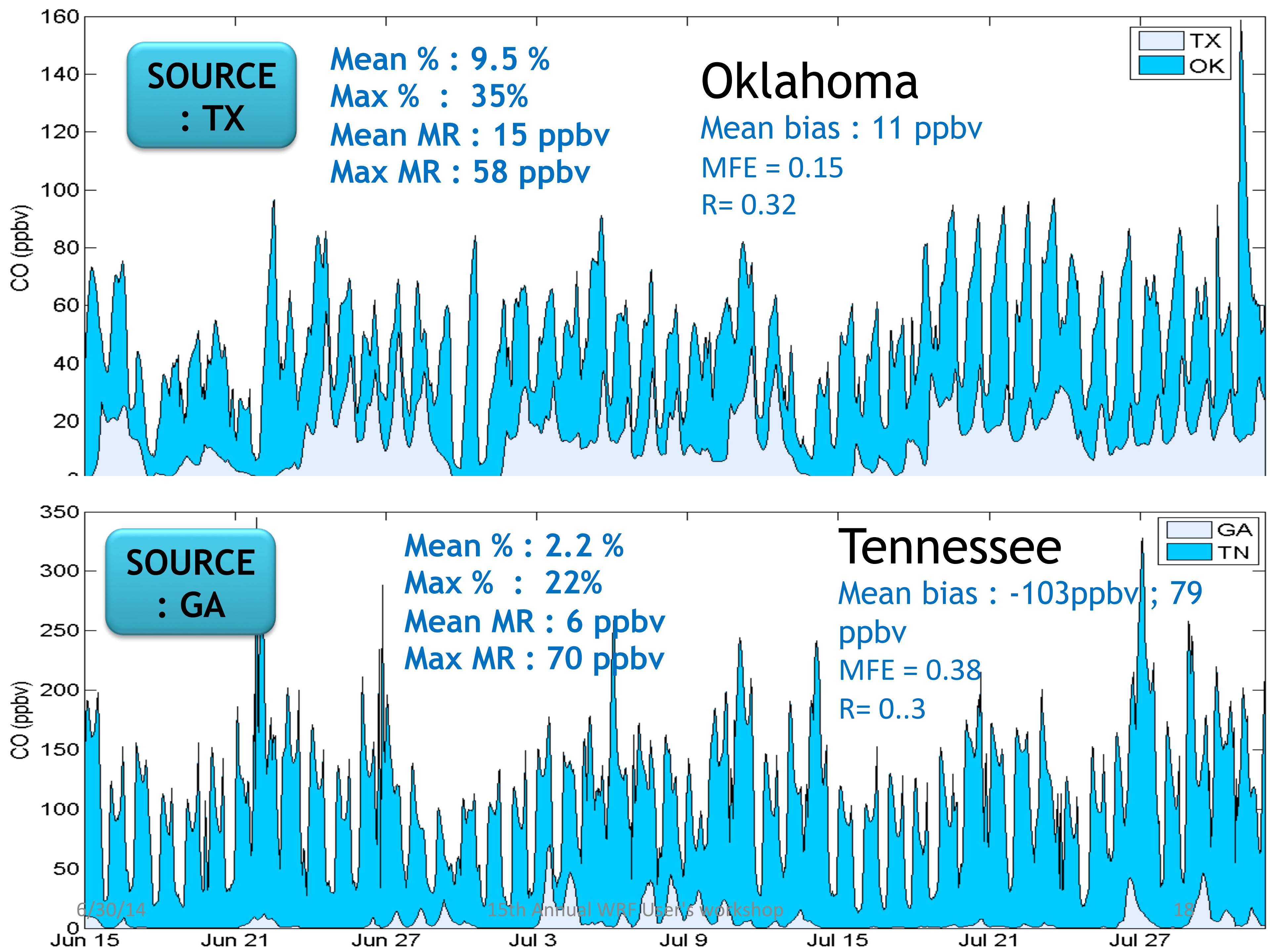
Extra Slides

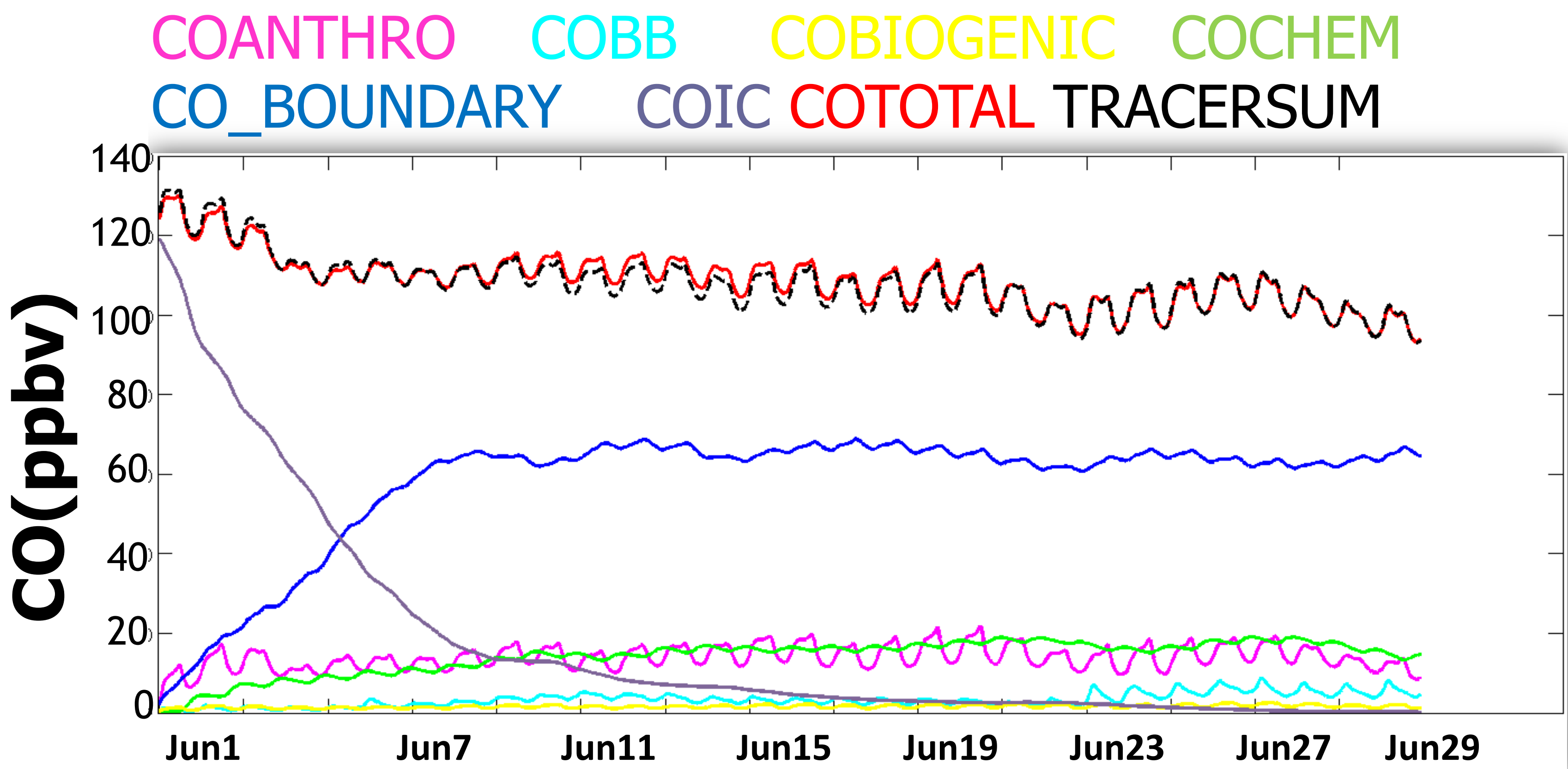
Interstate pollution transport : Mean CO PBL mixing ratios






SOURCE : TX
Mean % : 9.5 %
Max % : 35%
Mean MR : 15 ppbv
Max MR : 58 ppbv
Oklahoma
Mean bias : 11 ppbv
MFE = 0.15
R= 0.32
TX
OK
CO (ppbv)
160
140
120
100
80
60
40
20
SOURCE : GA
Mean % : 2.2 %
Max % : 22%
Mean MR : 6 ppbv
Max MR : 70 ppbv
Tennessee
Mean bias : -103ppbv ; 79 ppbv
MFE = 0.38
R= 0..3
GA
TN
CO (ppbv)
350
300
250
200
150
100
50
0
Jun 15
Jun 21
Jun 27
Jul 3
Jul 9
Jul 15
Jul 21
Jul 27

Tracer spin up



Total runtime : 1 Jun – 31 July, 2008
Chemistry spin-up time : 15 Jun 00Z (0.3% agreement between tracer sum and total CO at the surface)