PM_{coarse} Monitoring in Texas
2011 Data Comparisons

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Purpose for Monitoring

- PM_{coarse} monitoring was initiated in 2011 to meet EPA NCORE monitoring requirements
- The Met One Beta Attenuation Monitor (BAM) systems for PM_{coarse} measurement were deployed to each of the three Texas NCORE sites to meet this requirement
- TCEQ has also been evaluating the BAM 1020 $PM_{2.5}$ instrument at the Austin Audubon site for potential TEOM $PM_{2.5}$ instrument replacement

Monitoring Locations
NCORE sites dark blue
Dallas Hinton C401
Austin Audubon C38
El Paso
Chamizal C41
Houston
Deer Park C35
NEW MEXICO
UNITED STATES
TEXAS
MEXICO
CHIHUAHUA
COAHUILA
NUEVO LEÓN
TAMAULIPAS
ARKANSAS
LOUISIANA
MISSOURI
Albuquerque
Santa Fe
Amarillo
Lubbock
Oklahoma City
Dallas
Fort Worth
Plano
Austin
Houston
San Antonio
Corpus Christi
Monterrey
Nuevo Laredo
Reynosa
Matamoros
Ciudad Juárez
Chihuahua
Abilene
Waco
Shreveport
Little Rock
Gulf of Mexico
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Inside the PMcoarse Cabinet

Inlets above the PM_{coarse} Cabinet

At Houston Deer Park CAMS 35

Summary of Findings

- Performance of the BAM $PM_{2.5}$ monitors did not meet Federal Equivalent Method (FEM) expectations in 2011
- Major problems with cabinet temperature and relative humidity control were a likely cause of degraded data quality
- BAM PM_{10} measurements were much higher than nearby Federal Reference Method (FRM) Wedding Hi-Volume PM_{10} monitors in El Paso where the cut point is often challenged with heavy loading

Approach

- Minimally edited data were initially compared to collocated and nearby sites, with no rejection of data based on the comparisons
- The final validated data sets were more stringently edited to eliminate the worst outliers based on collocated or nearby data

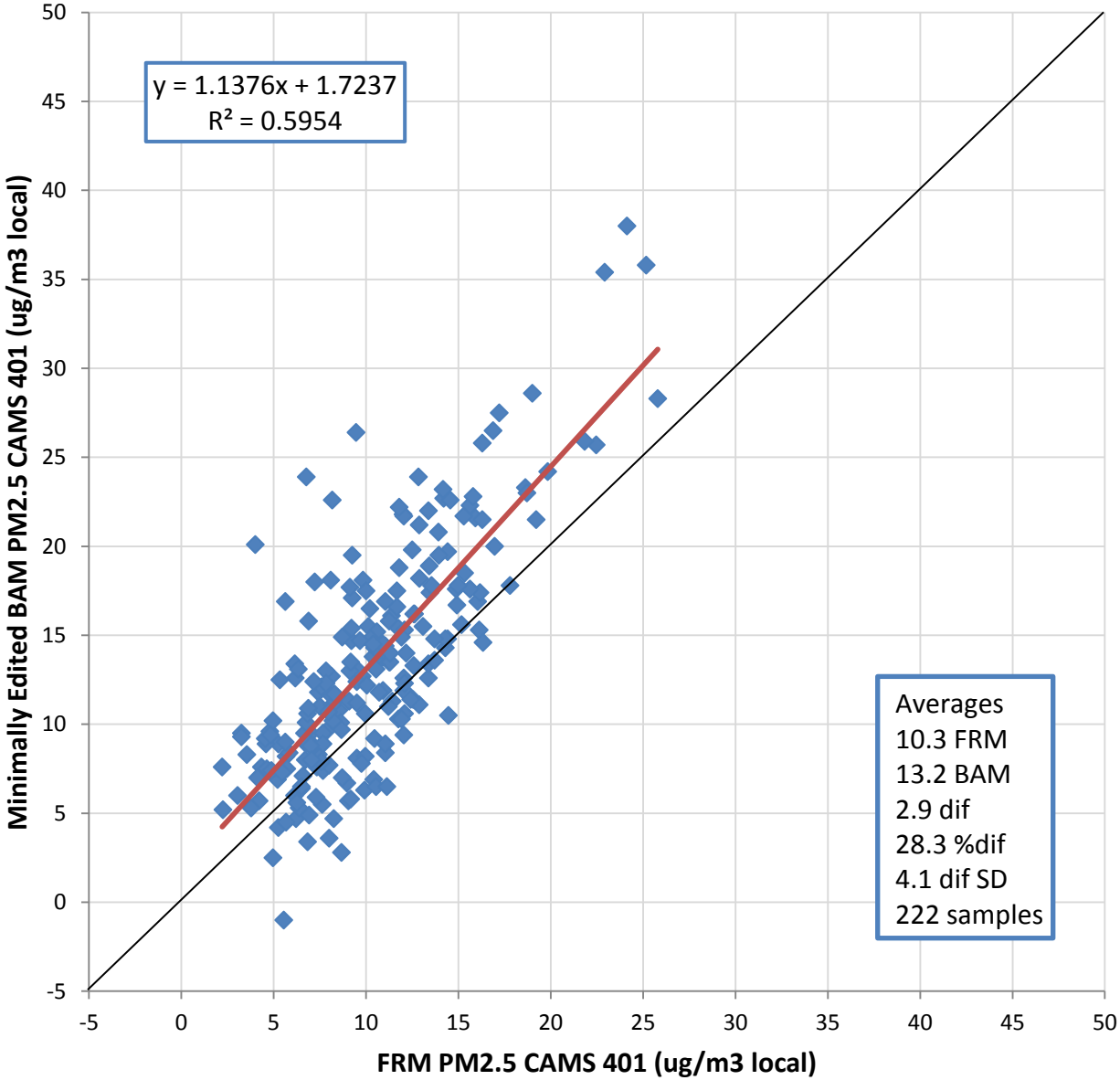
$PM_{2.5}$ BAM vs FRM

Dallas Hinton C401

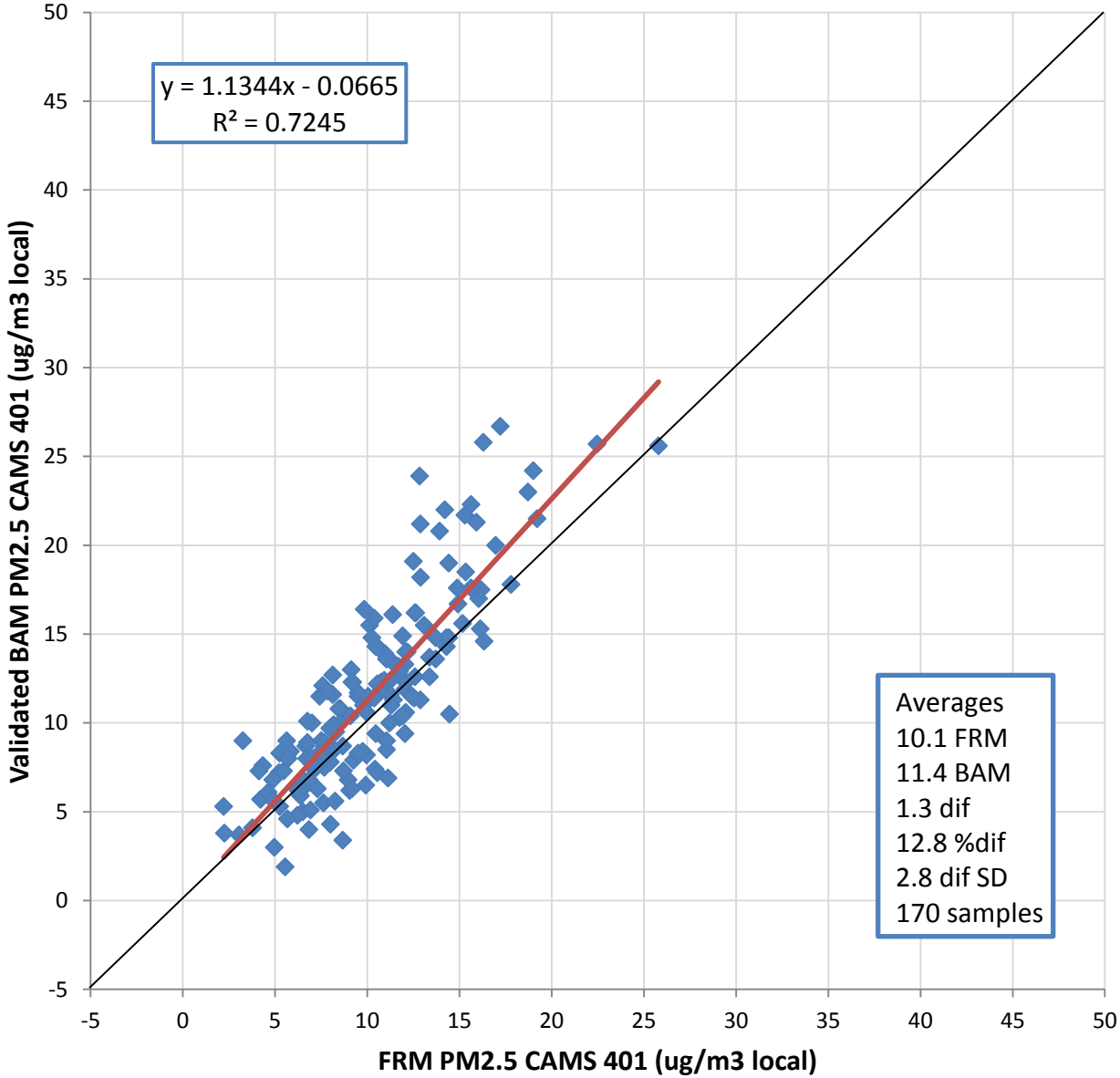
Austin Audubon C38

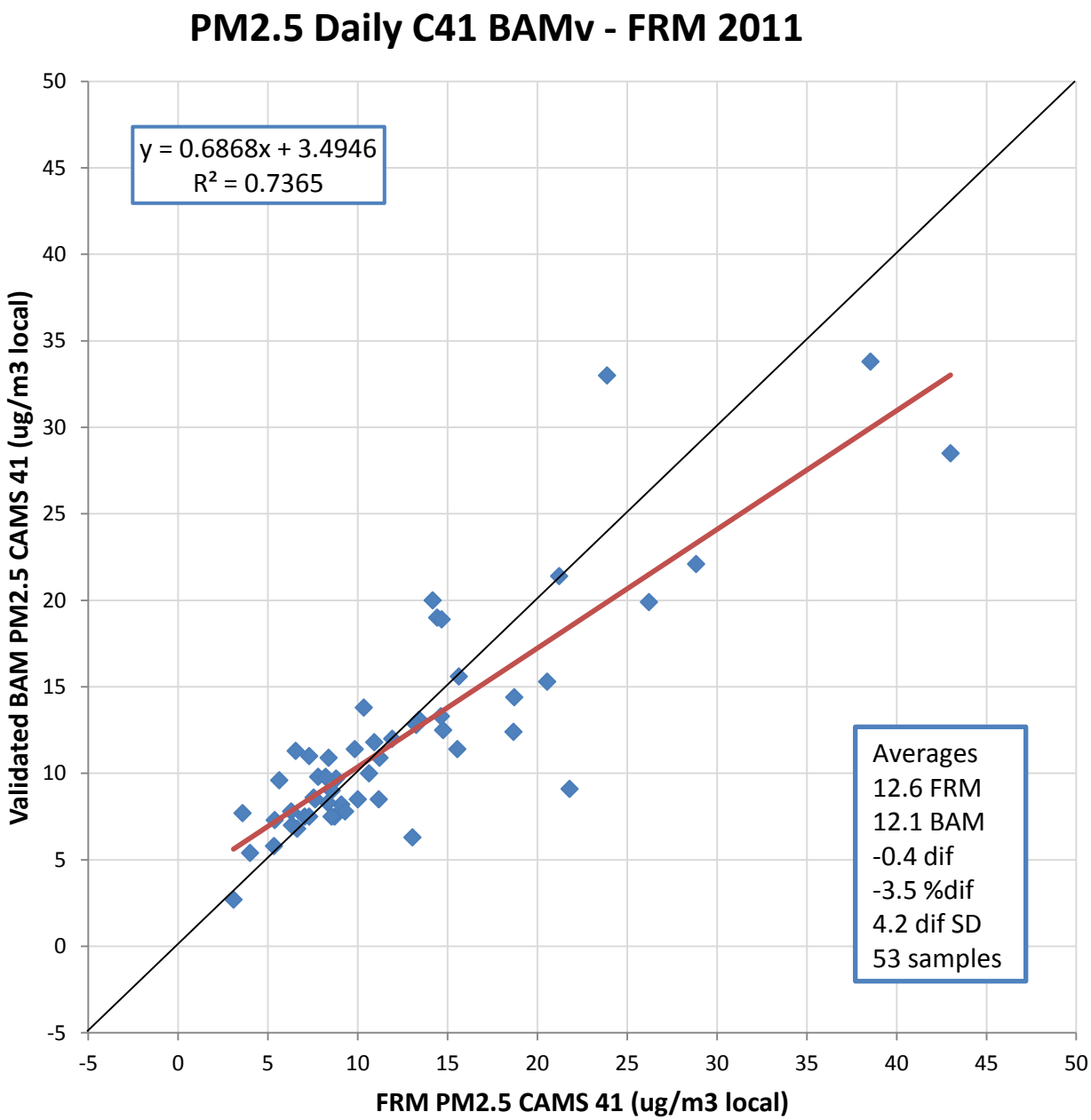
El Paso Chamizal C41

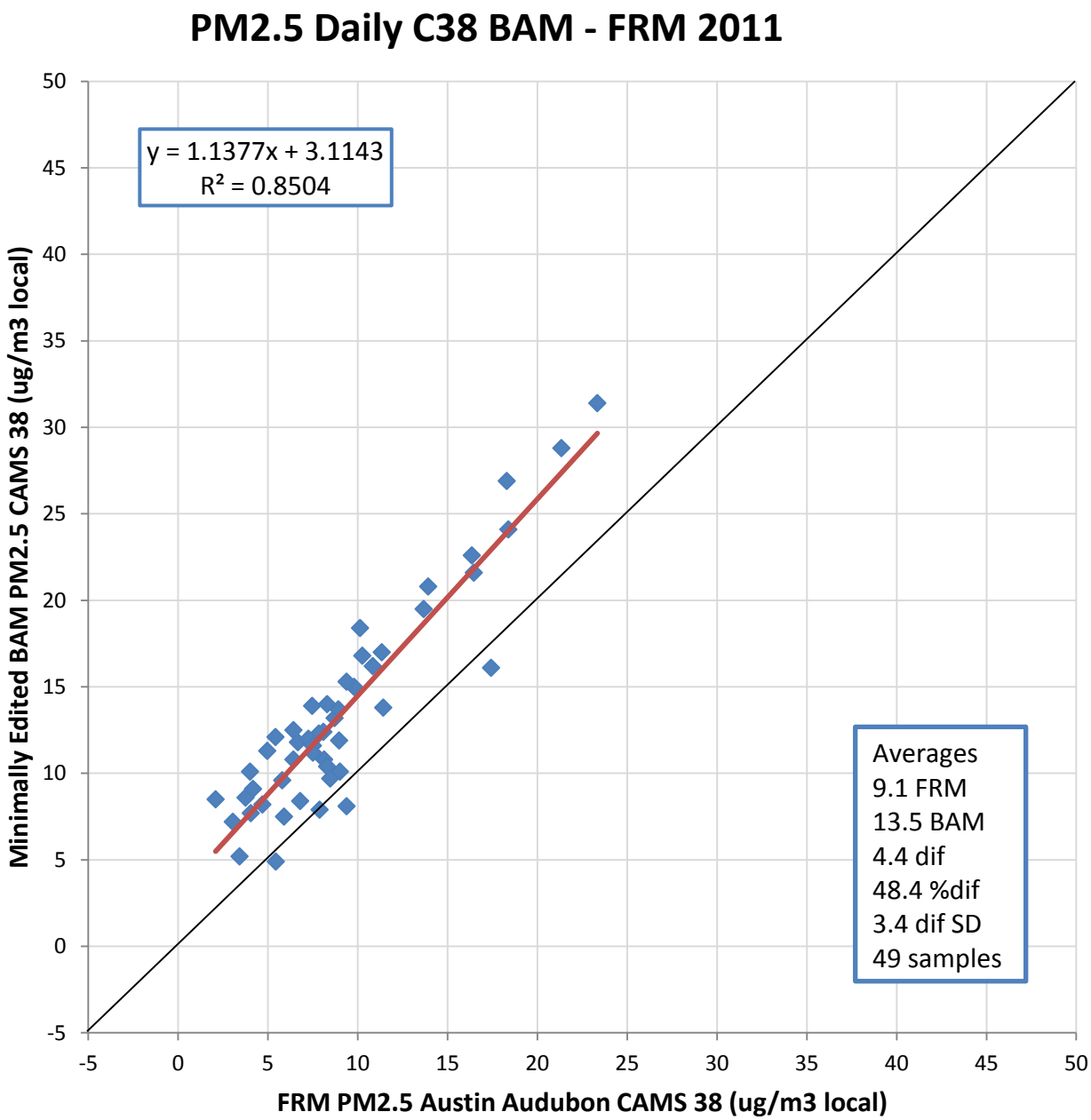
PM2.5 Daily C401 BAM - FRM 2011



PM2.5 Daily C401 BAMv - FRM 2011




PM2.5 Daily C41 BAMv - FRM 2011
y = 0.6868x + 3.4946
R² = 0.7365
Averages
12.6 FRM
12.1 BAM
-0.4 dif
-3.5 %dif
4.2 dif SD
53 samples
Validated BAM PM2.5 CAMS 41 (ug/m3 local)
FRM PM2.5 CAMS 41 (ug/m3 local)
50
45
40
35
30
25
20
15
10
5
0
-5
-5
0
5
10
15
20
25
30
35
40
45
50

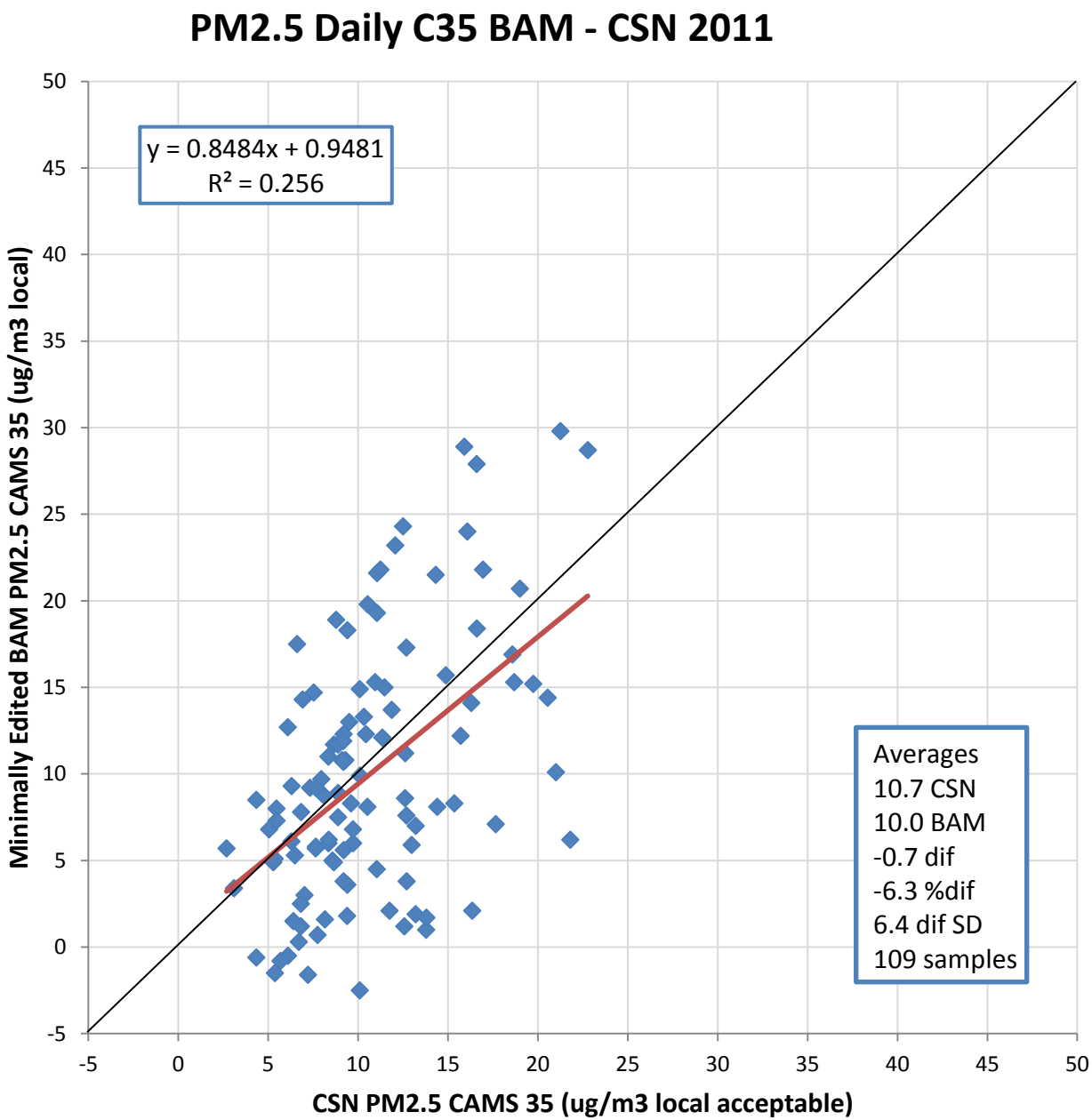

PM2.5 Daily C38 BAM - FRM 2011
y = 1.1377x + 3.1143
R² = 0.8504
Averages
9.1 FRM
13.5 BAM
4.4 dif
48.4 %dif
3.4 dif SD
49 samples
Minimally Edited BAM PM2.5 CAMS 38 (ug/m3 local)
FRM PM2.5 Austin Audubon CAMS 38 (ug/m3 local)
50
45
40
35
30
25
20
15
10
5
0
-5
-5
0
5
10
15
20
25
30
35
40
45
50

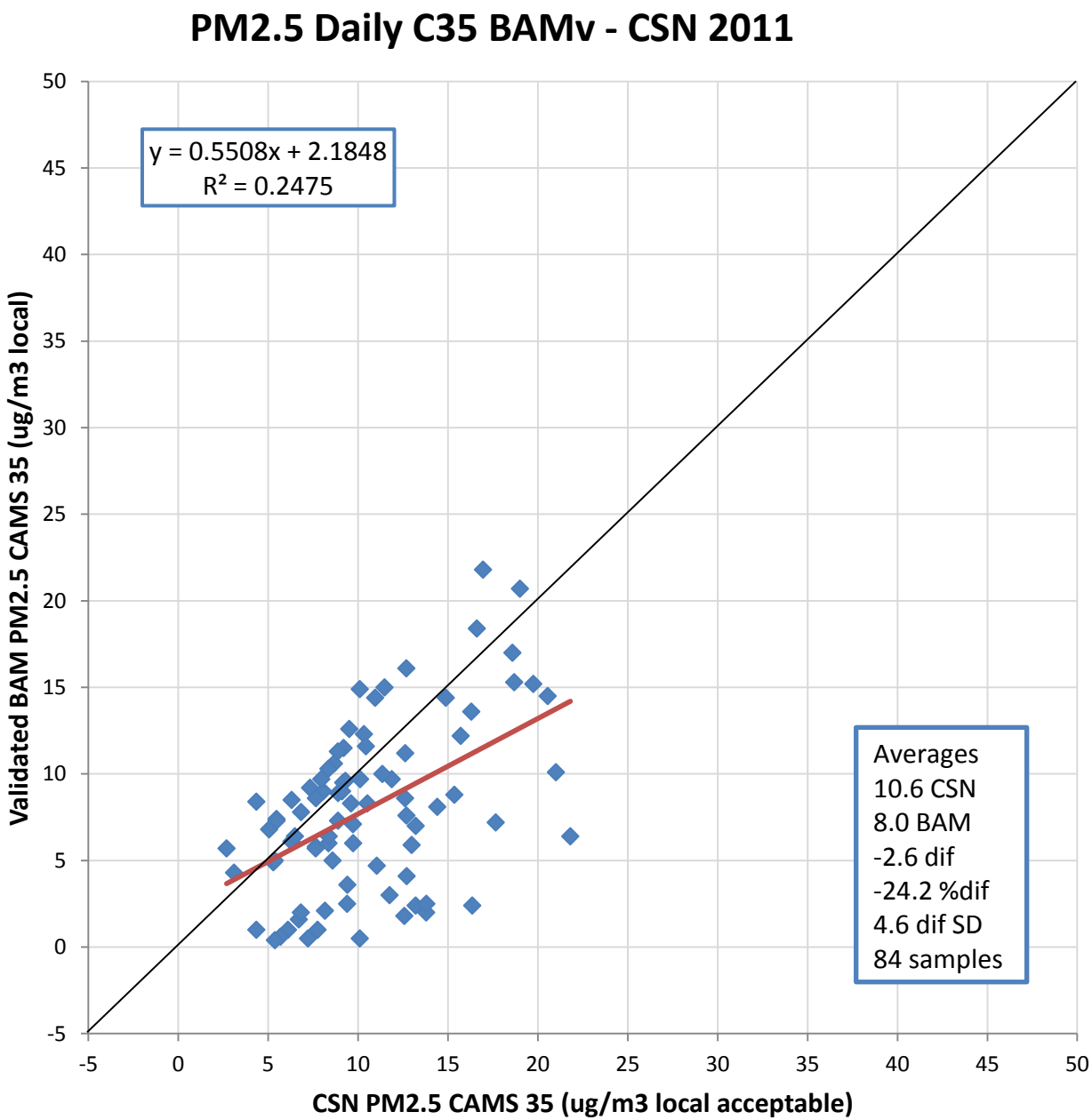
$PM_{2.5}$ BAM vs CSN

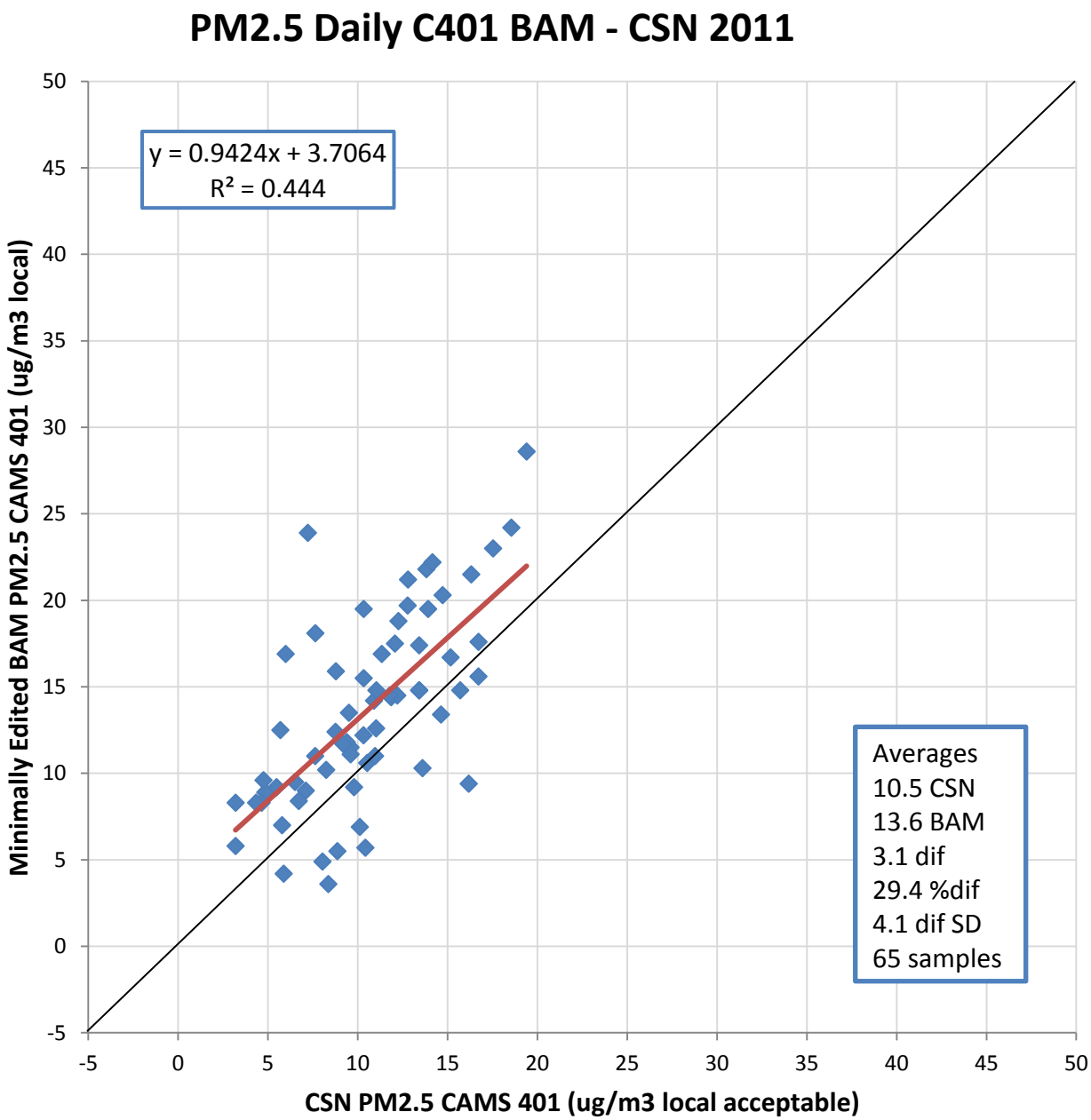
Houston Deer Park C35

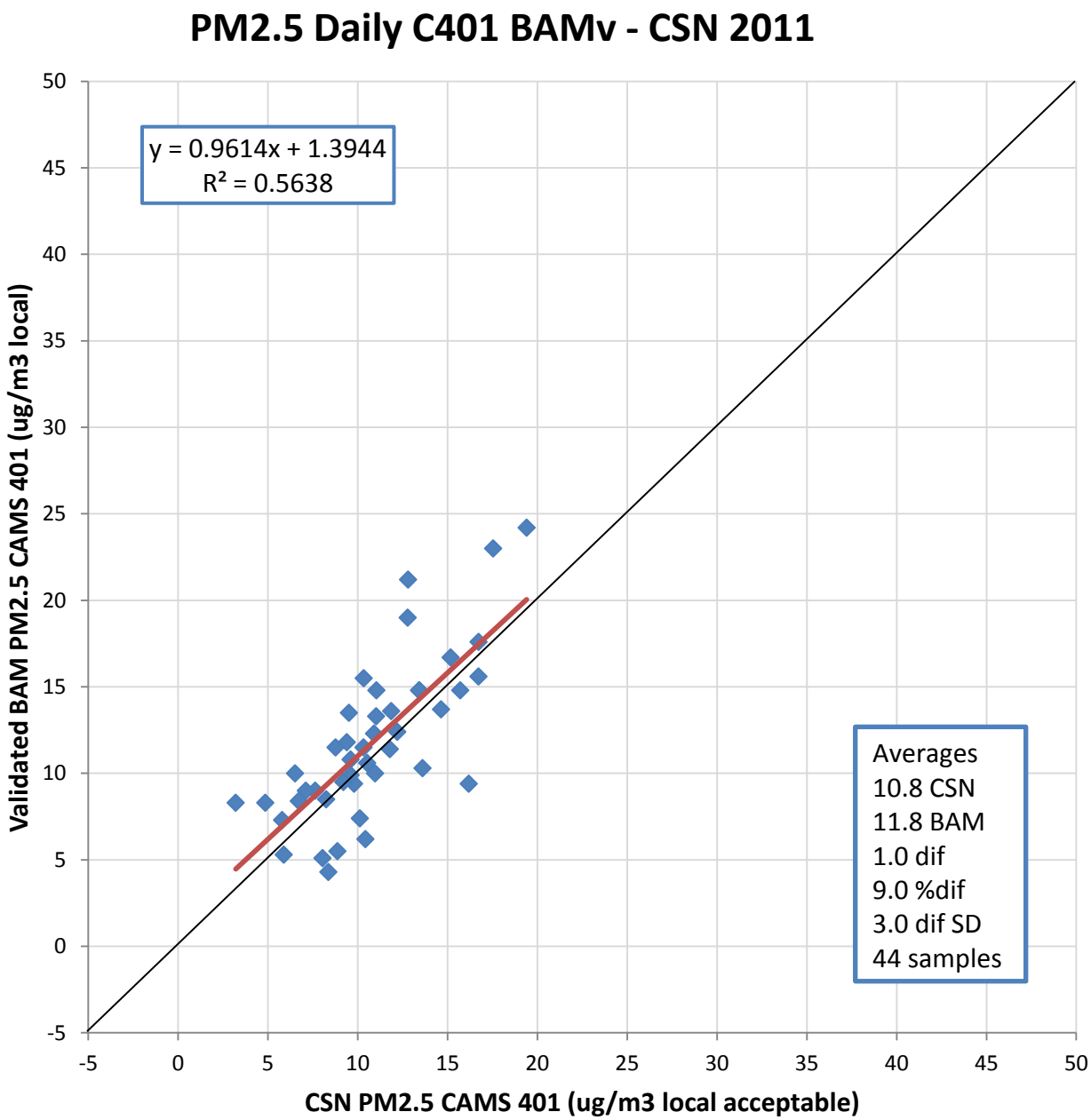
Dallas Hinton C401

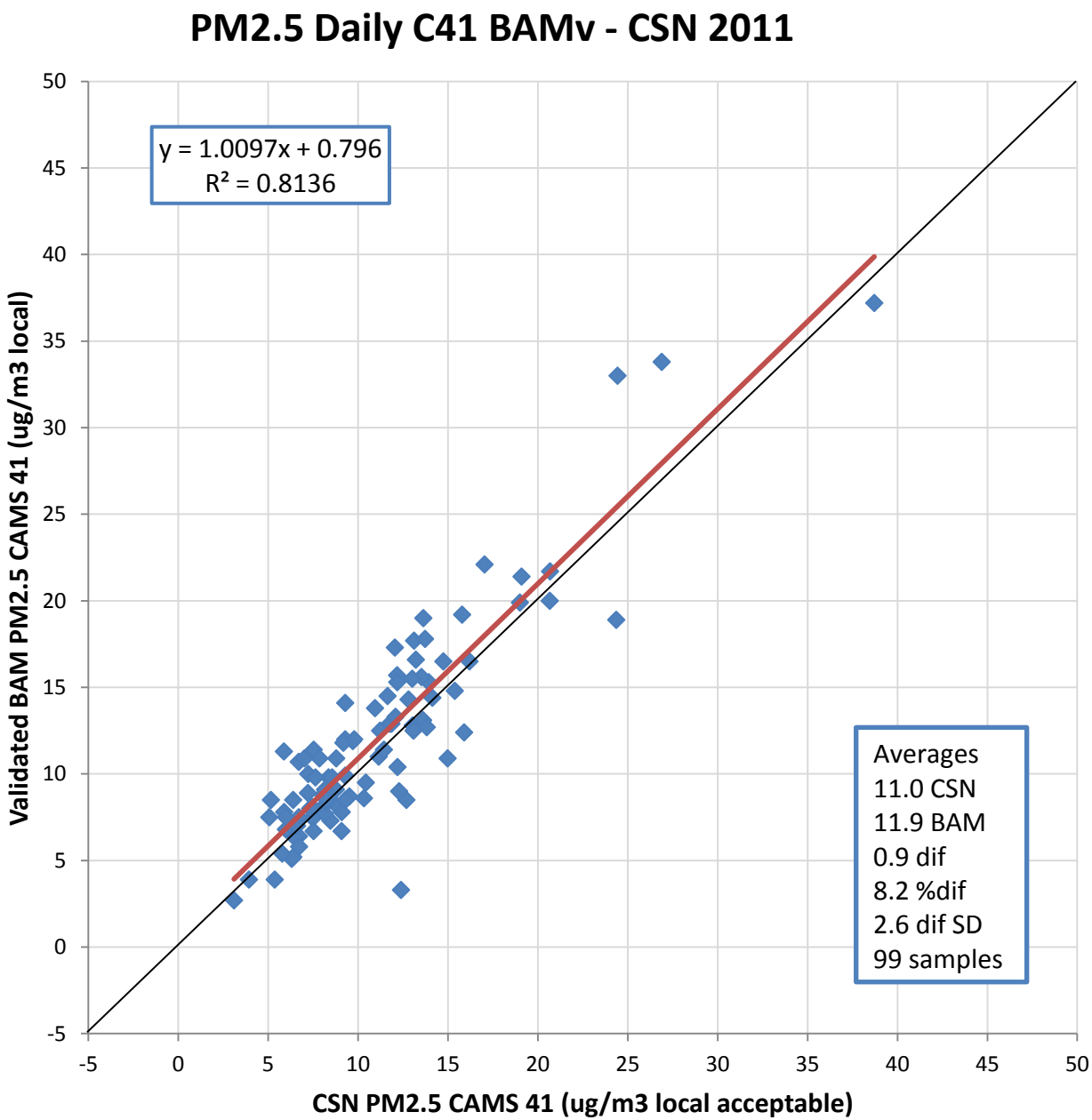
El Paso Chamizal C41


PM2.5 Daily C35 BAM - CSN 2011
y = 0.8484x + 0.9481
R² = 0.256
Averages
10.7 CSN
10.0 BAM
-0.7 dif
-6.3 %dif
6.4 dif SD
109 samples
Minimally Edited BAM PM2.5 CAMS 35 (ug/m3 local)
CSN PM2.5 CAMS 35 (ug/m3 local acceptable)
50
45
40
35
30
25
20
15
10
5
0
-5
-5
0
5
10
15
20
25
30
35
40
45
50


PM2.5 Daily C35 BAMv - CSN 2011
y = 0.5508x + 2.1848
R² = 0.2475
Averages
10.6 CSN
8.0 BAM
-2.6 dif
-24.2 %dif
4.6 dif SD
84 samples
Validated BAM PM2.5 CAMS 35 (ug/m3 local)
CSN PM2.5 CAMS 35 (ug/m3 local acceptable)
50
45
40
35
30
25
20
15
10
5
0
-5
-5
0
5
10
15
20
25
30
35
40
45
50


PM2.5 Daily C401 BAM - CSN 2011
y = 0.9424x + 3.7064
R² = 0.444
Averages
10.5 CSN
13.6 BAM
3.1 dif
29.4 %dif
4.1 dif SD
65 samples
Minimally Edited BAM PM2.5 CAMS 401 (ug/m3 local)
CSN PM2.5 CAMS 401 (ug/m3 local acceptable)
50
45
40
35
30
25
20
15
10
5
0
-5
-5
0
5
10
15
20
25
30
35
40
45
50


PM2.5 Daily C401 BAMv - CSN 2011
y = 0.9614x + 1.3944
R² = 0.5638
Averages
10.8 CSN
11.8 BAM
1.0 dif
9.0 %dif
3.0 dif SD
44 samples
Validated BAM PM2.5 CAMS 401 (ug/m3 local)
CSN PM2.5 CAMS 401 (ug/m3 local acceptable)
50
45
40
35
30
25
20
15
10
5
0
-5
-5
0
5
10
15
20
25
30
35
40
45
50


PM2.5 Daily C41 BAMv - CSN 2011
y = 1.0097x + 0.796
R² = 0.8136
Averages
11.0 CSN
11.9 BAM
0.9 dif
8.2 %dif
2.6 dif SD
99 samples
Validated BAM PM2.5 CAMS 41 (ug/m3 local)
CSN PM2.5 CAMS 41 (ug/m3 local acceptable)
50
45
40
35
30
25
20
15
10
5
0
-5
-5
0
5
10
15
20
25
30
35
40
45
50

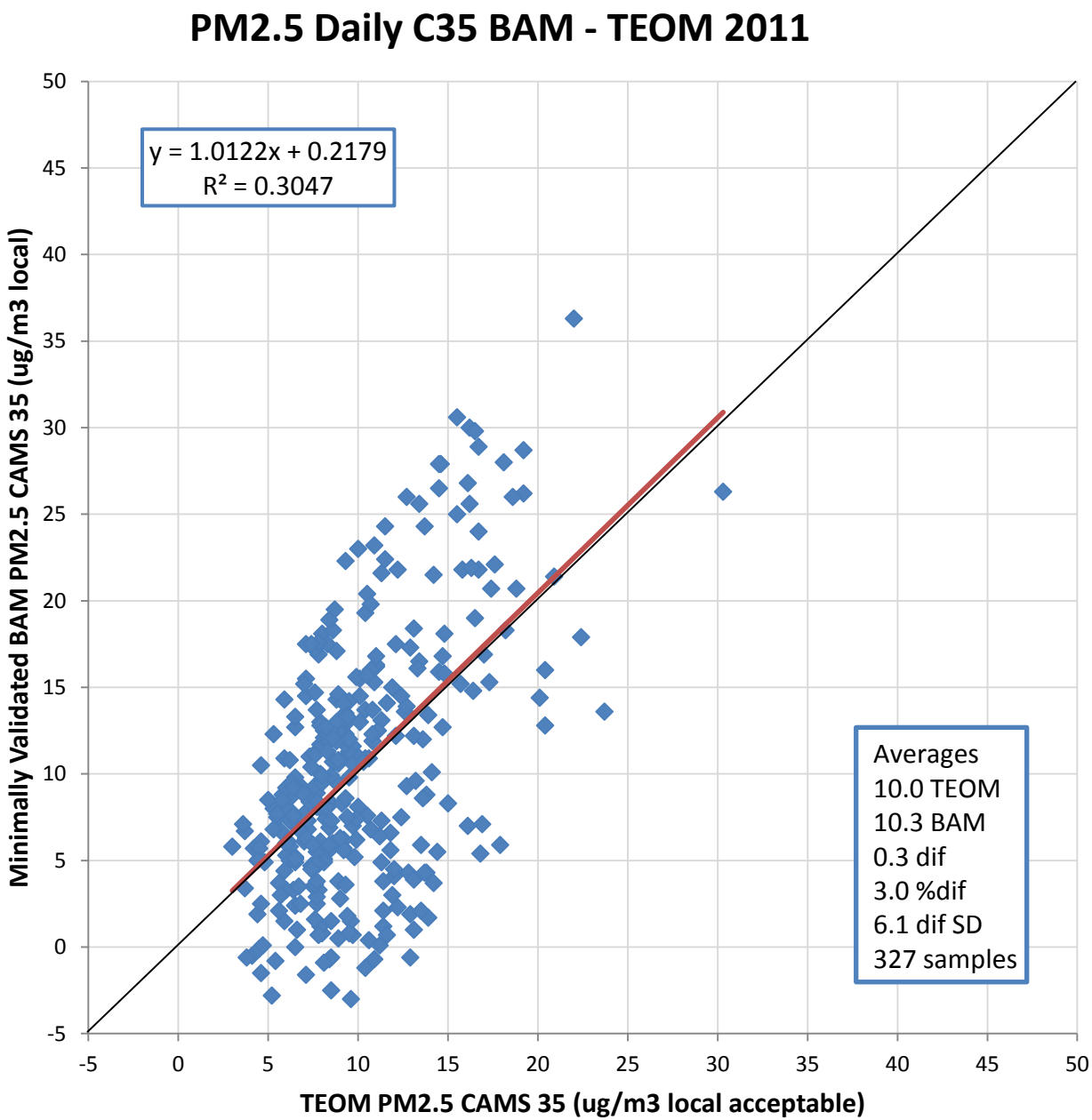
$PM_{2.5}$ BAM vs TEOM

Houston Deer Park C35

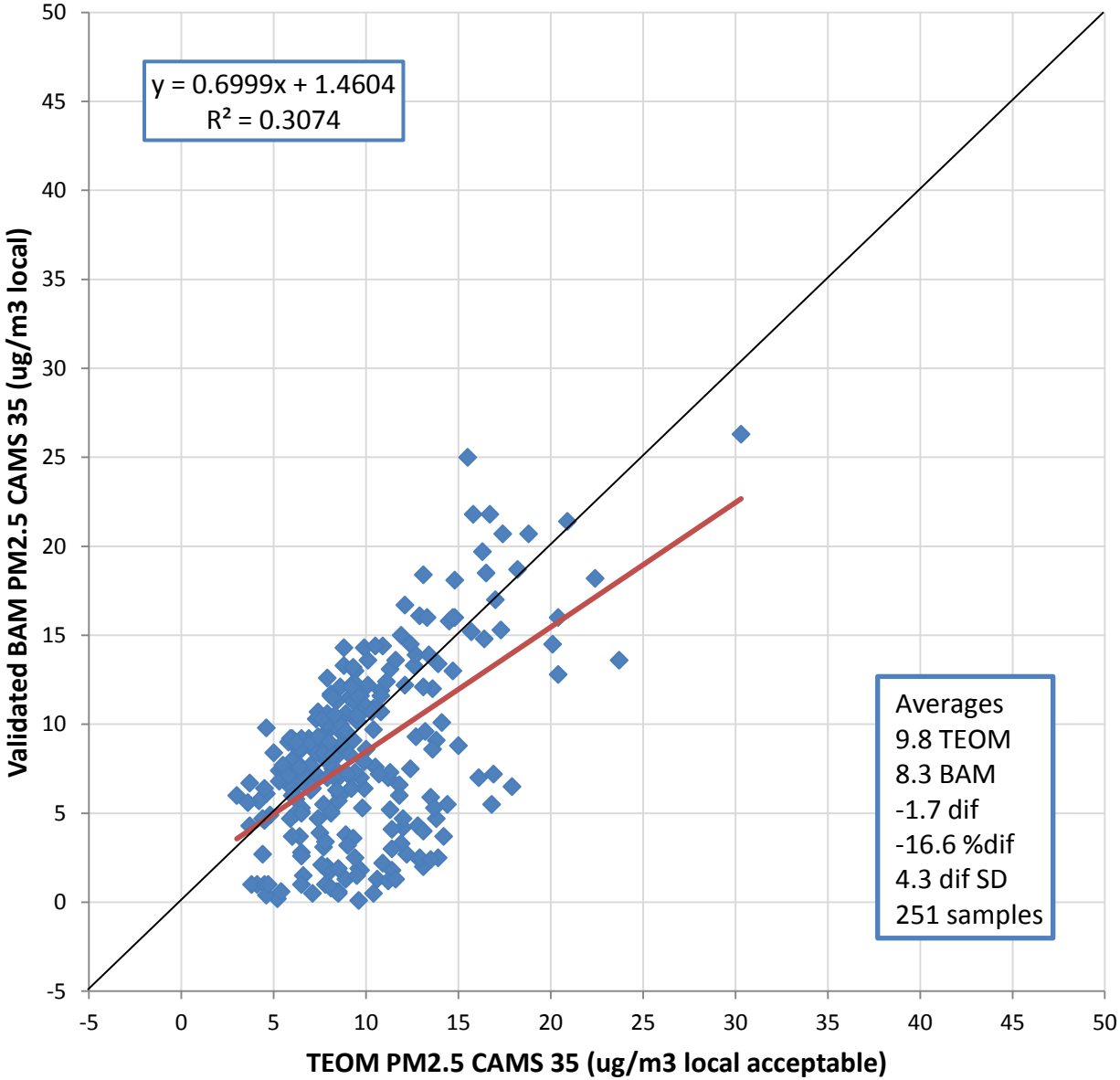
Dallas Hinton C401

Austin Audubon C38

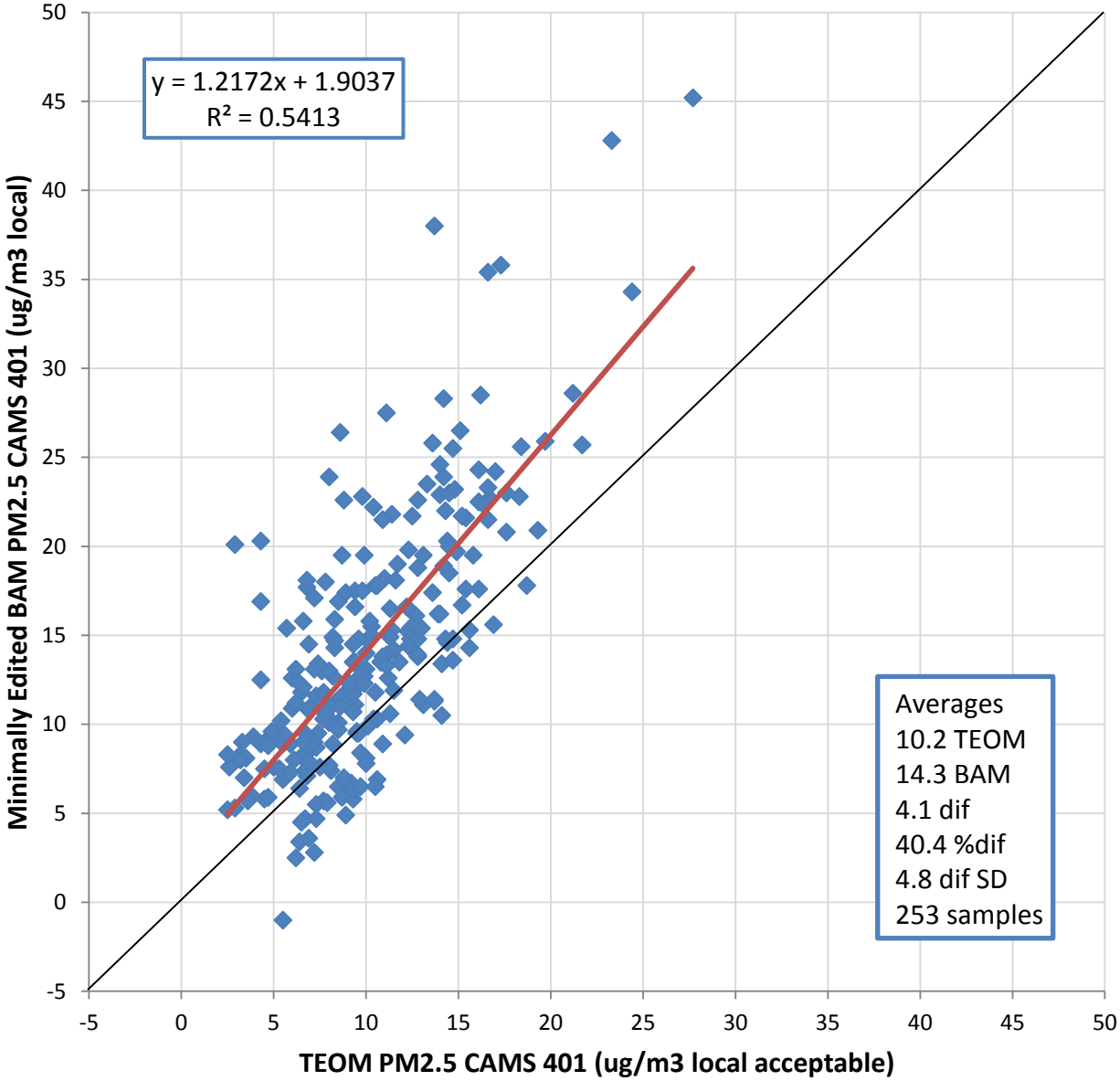
El Paso Chamizal C41


PM2.5 Daily C35 BAM - TEOM 2011
y = 1.0122x + 0.2179
R² = 0.3047
Averages
10.0 TEOM
10.3 BAM
0.3 dif
3.0 %dif
6.1 dif SD
327 samples
Minimally Validated BAM PM2.5 CAMS 35 (ug/m3 local)
TEOM PM2.5 CAMS 35 (ug/m3 local acceptable)
50
45
40
35
30
25
20
15
10
5
0
-5
-5
0
5
10
15
20
25
30
35
40
45
50

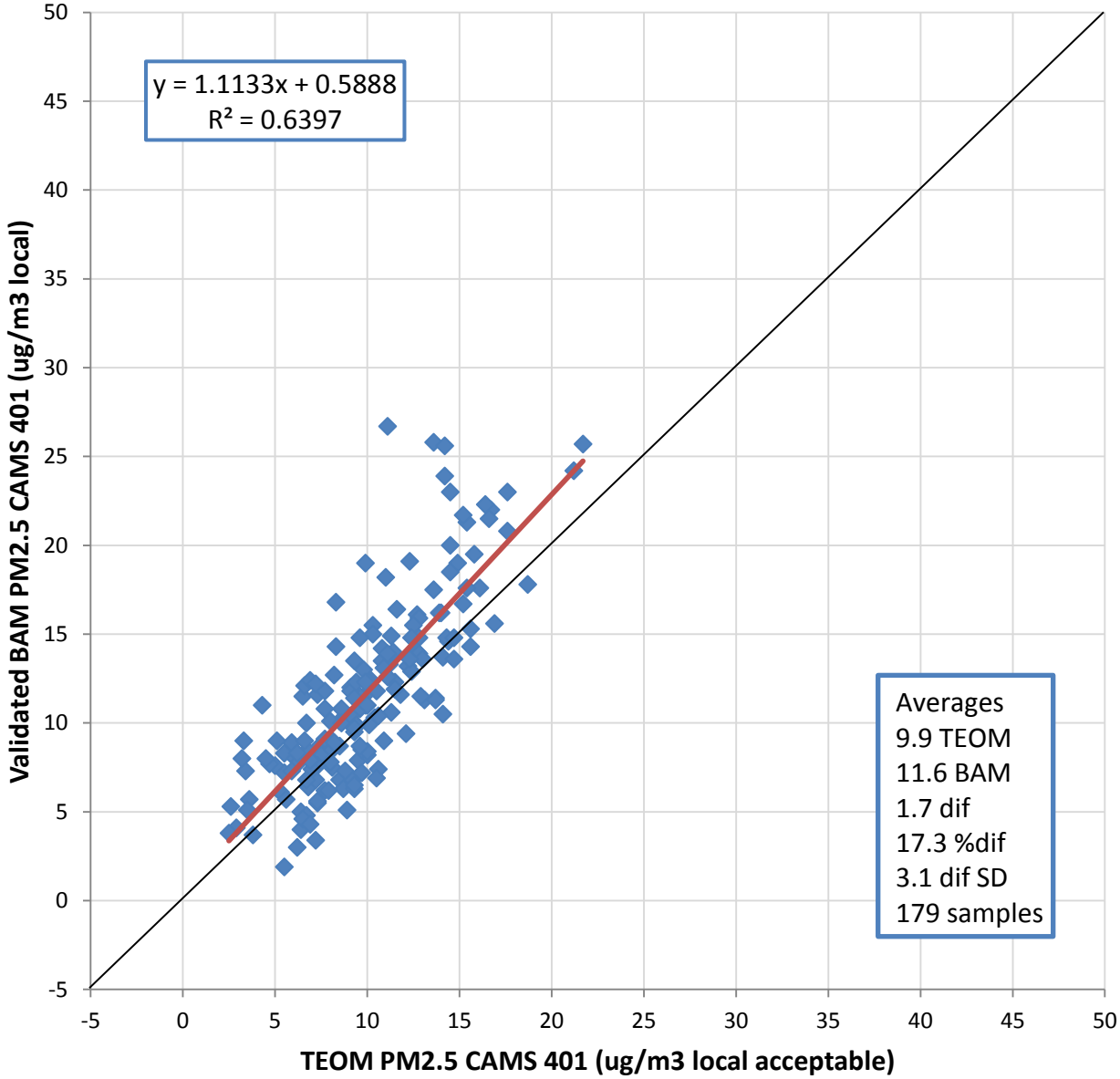
PM2.5 Daily C35 BAMv - TEOM 2011

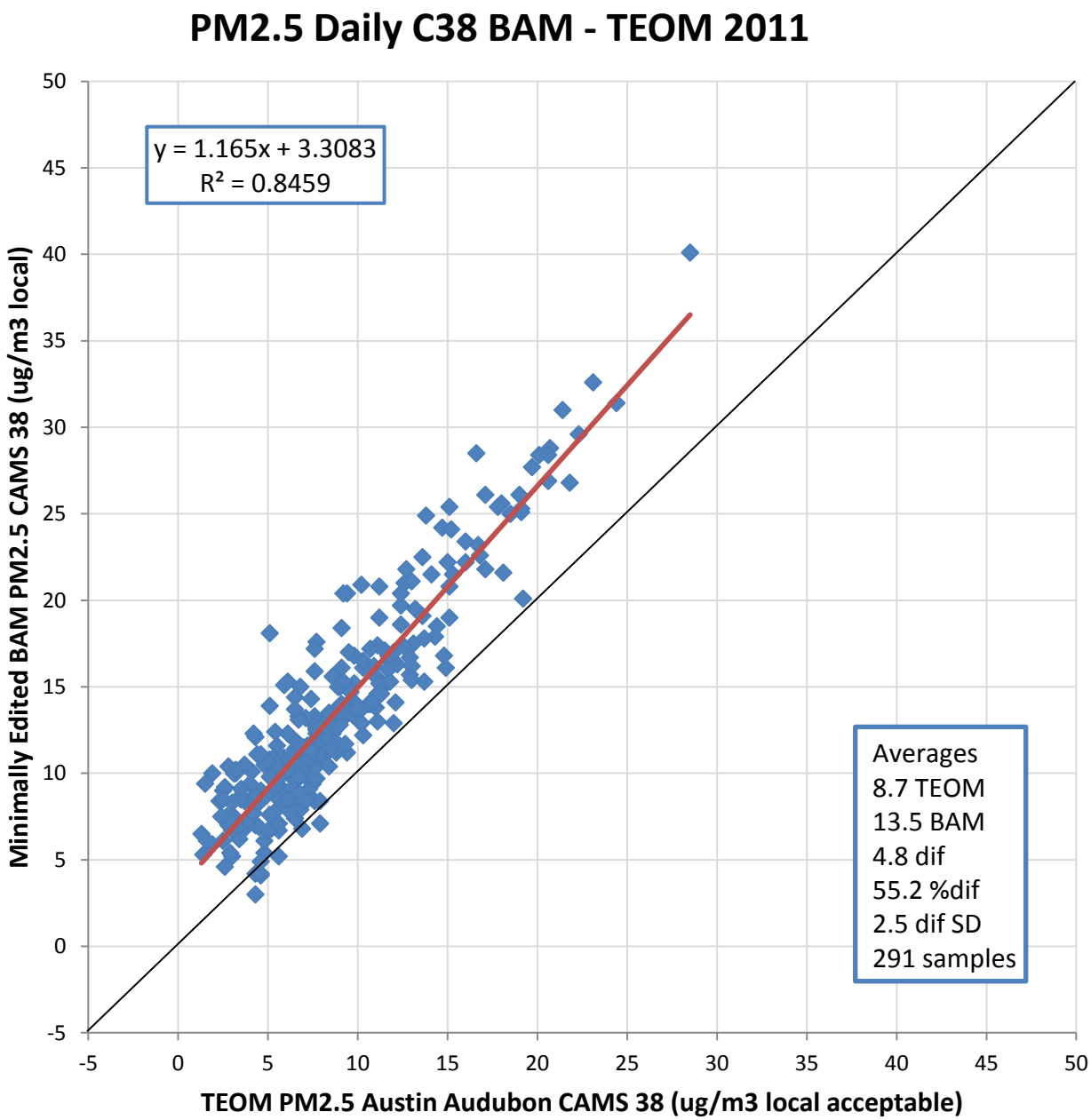


PM2.5 Daily C401 BAM - TEOM 2011

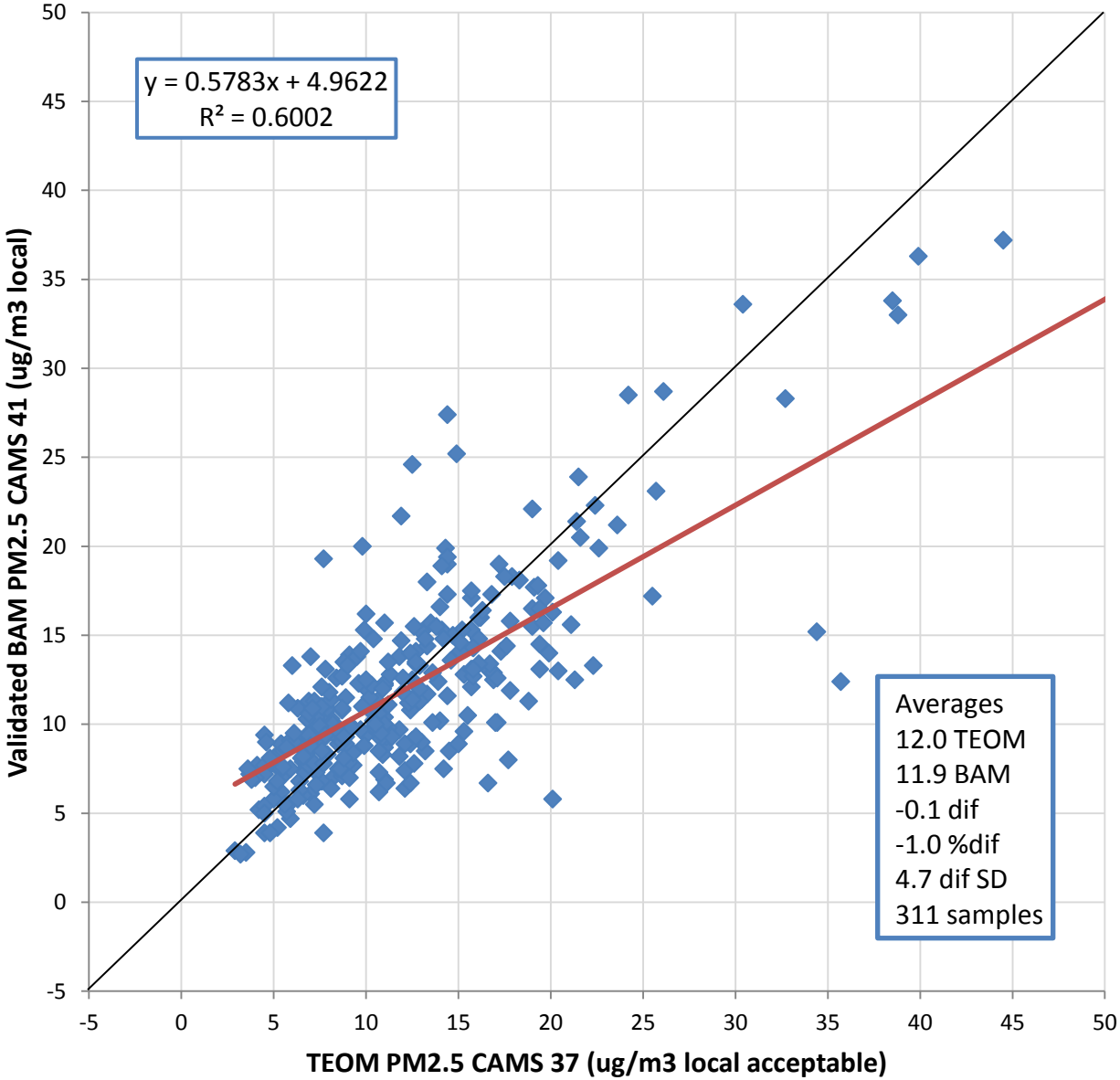


PM2.5 Daily C401 BAMv - TEOM 2011




PM2.5 Daily C38 BAM - TEOM 2011
y = 1.165x + 3.3083
R² = 0.8459
Averages
8.7 TEOM
13.5 BAM
4.8 dif
55.2 %dif
2.5 dif SD
291 samples
Minimally Edited BAM PM2.5 CAMS 38 (ug/m3 local)
TEOM PM2.5 Austin Audubon CAMS 38 (ug/m3 local acceptable)
50
45
40
35
30
25
20
15
10
5
0
-5
-5
0
5
10
15
20
25
30
35
40
45
50

PM2.5 Daily C41 BAMv - C37 TEOM 2011

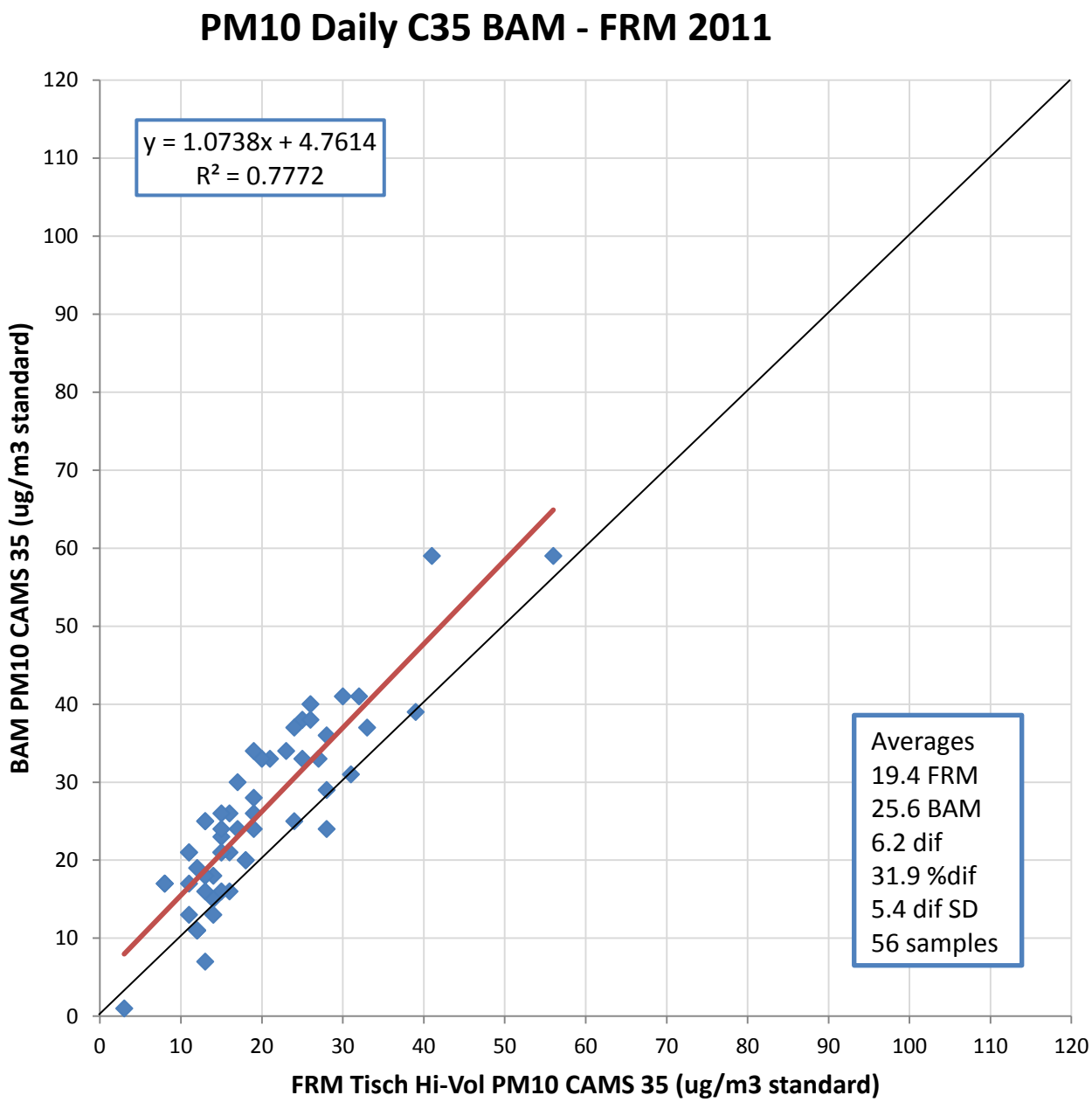


PM_{10} BAM vs FRM

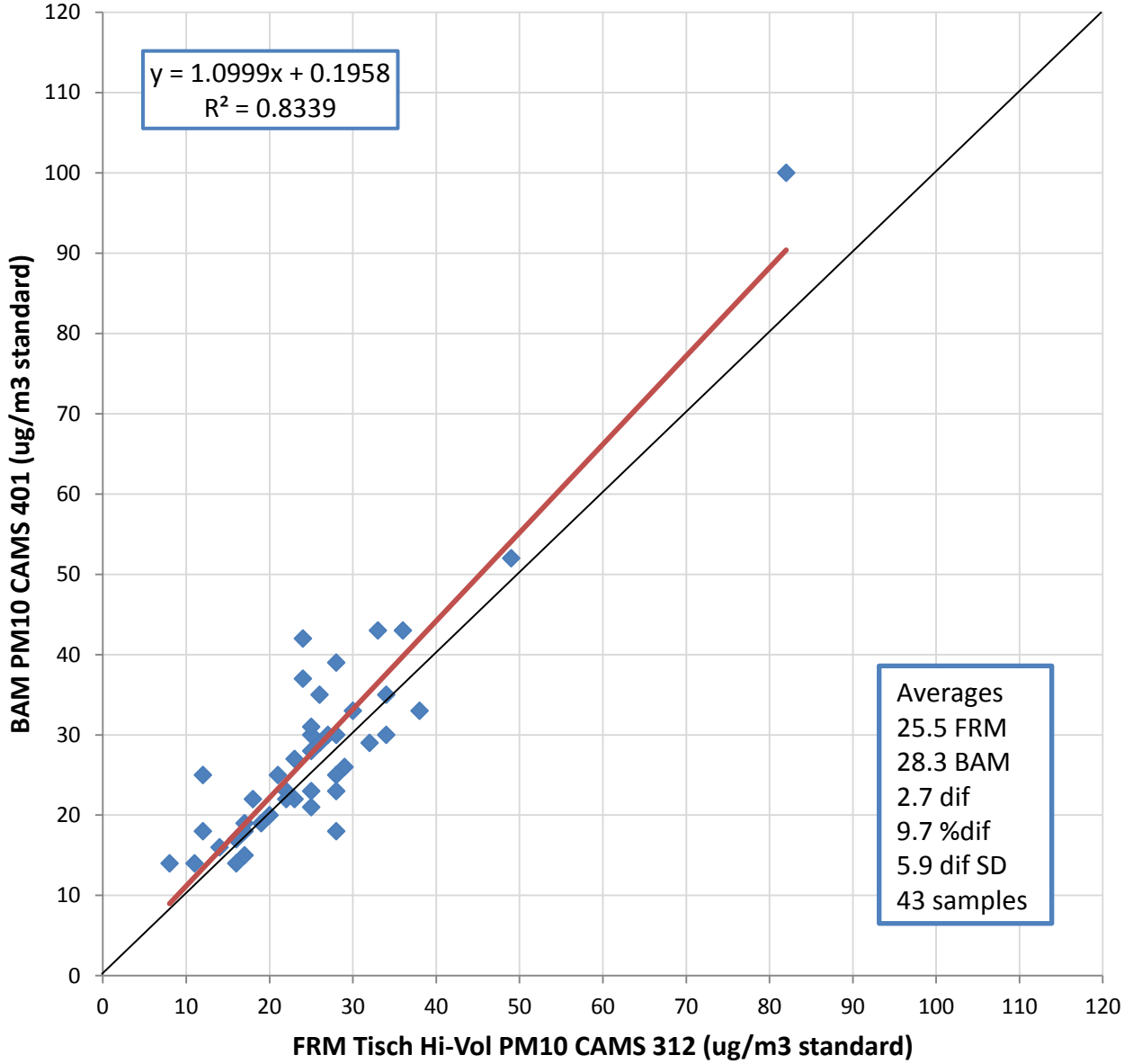
Houston Deer Park C35

Dallas Hinton C401

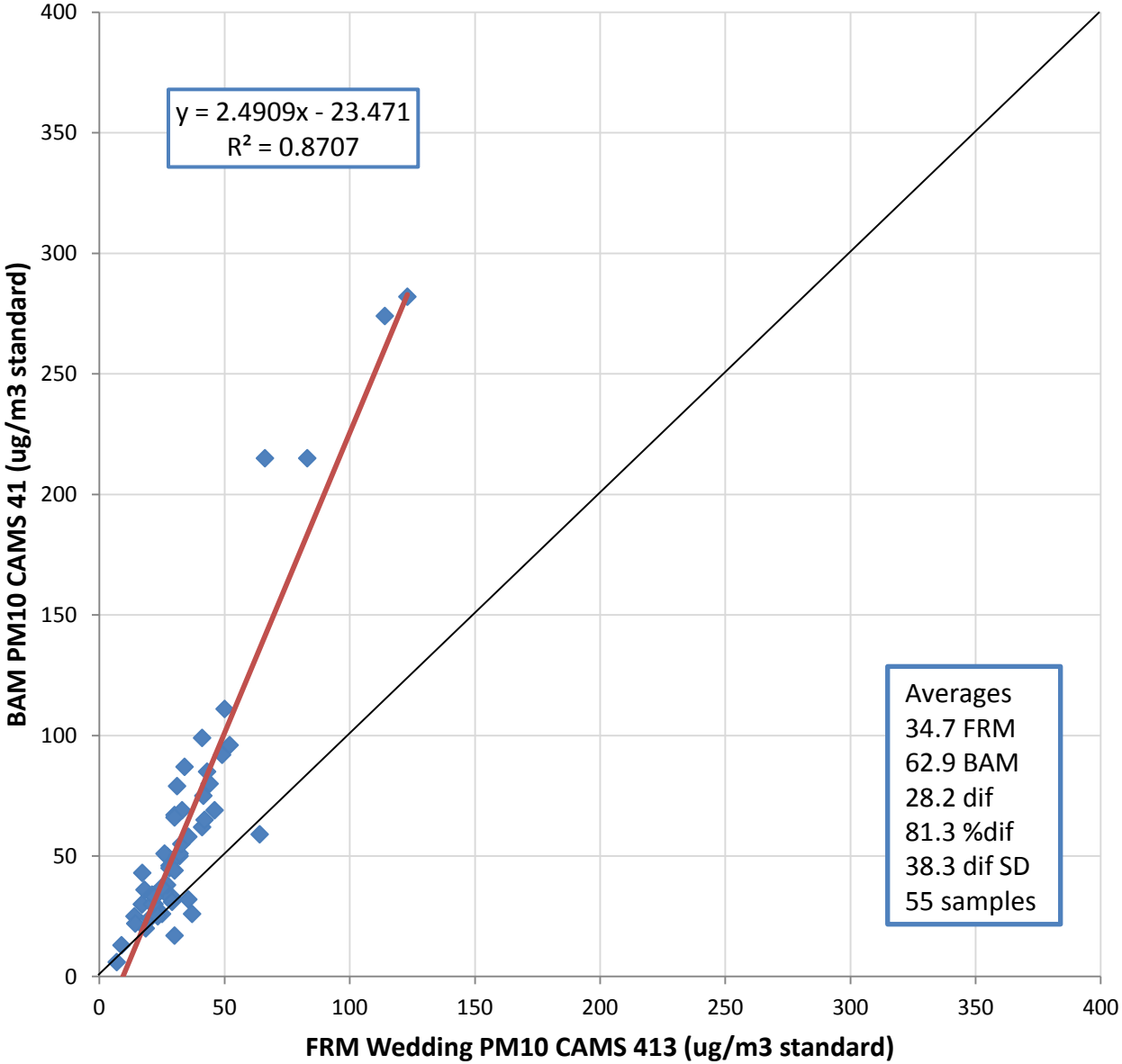
El Paso Chamizal C41


PM10 Daily C35 BAM - FRM 2011
y = 1.0738x + 4.7614
R² = 0.7772
Averages
19.4 FRM
25.6 BAM
6.2 dif
31.9 %dif
5.4 dif SD
56 samples
BAM PM10 CAMS 35 (ug/m3 standard)
FRM Tisch Hi-Vol PM10 CAMS 35 (ug/m3 standard)
0
10
20
30
40
50
60
70
80
90
100
110
120

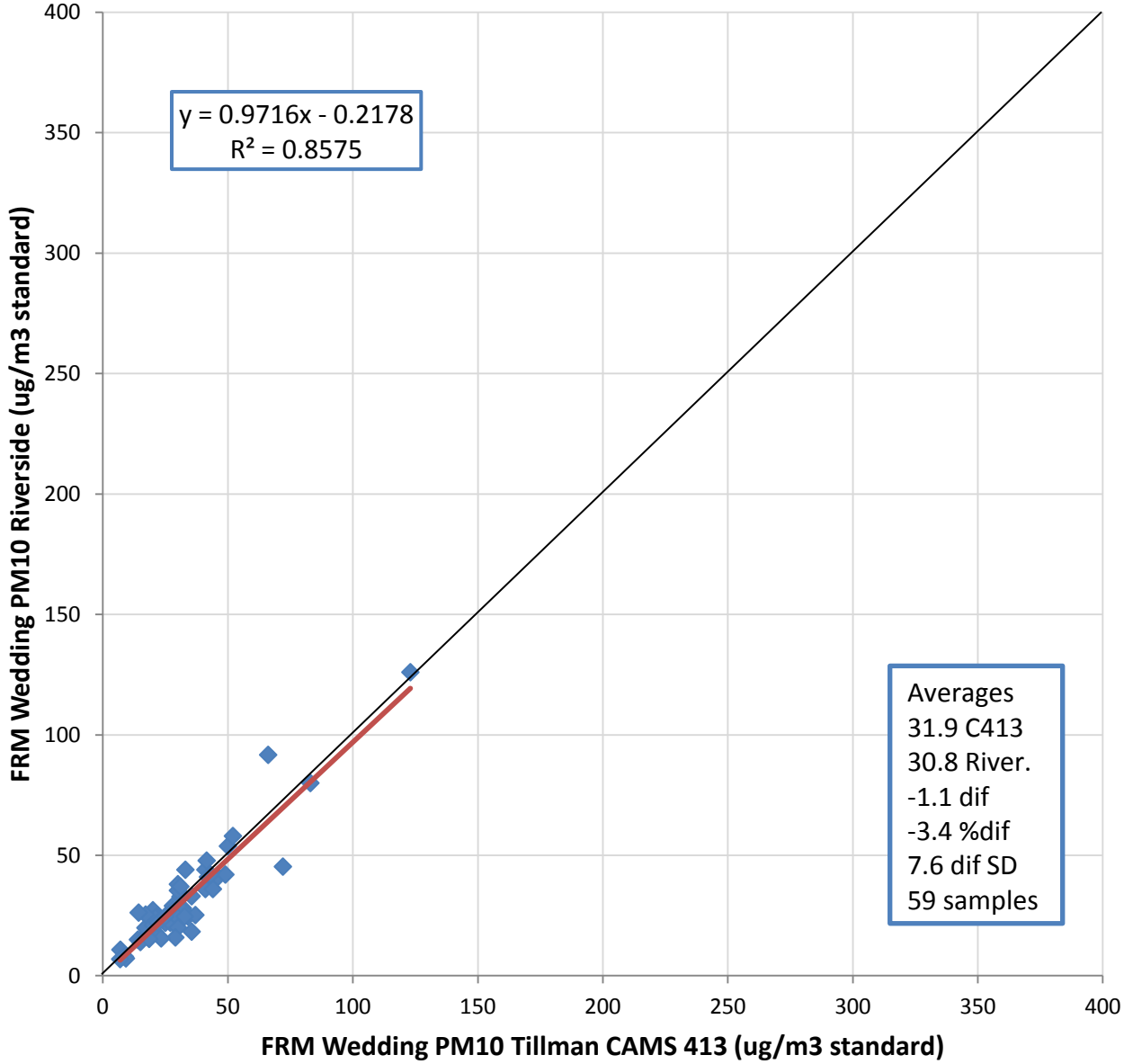
PM10 Daily C401 BAM - C312 FRM 2011



PM10 Daily C41 BAM - C413 FRM 2011

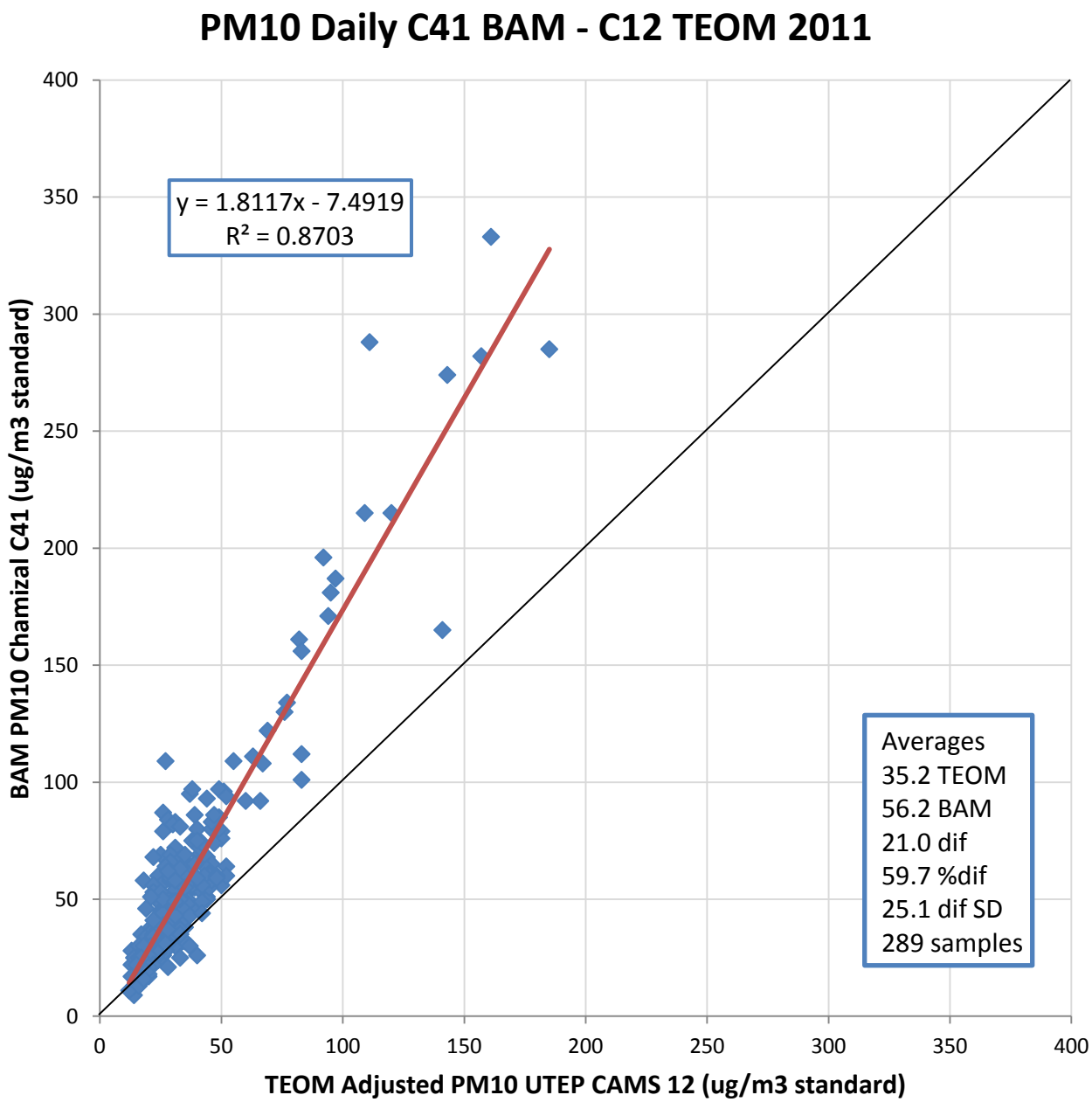


PM10 Daily Riverside FRM - C413 FRM 2011

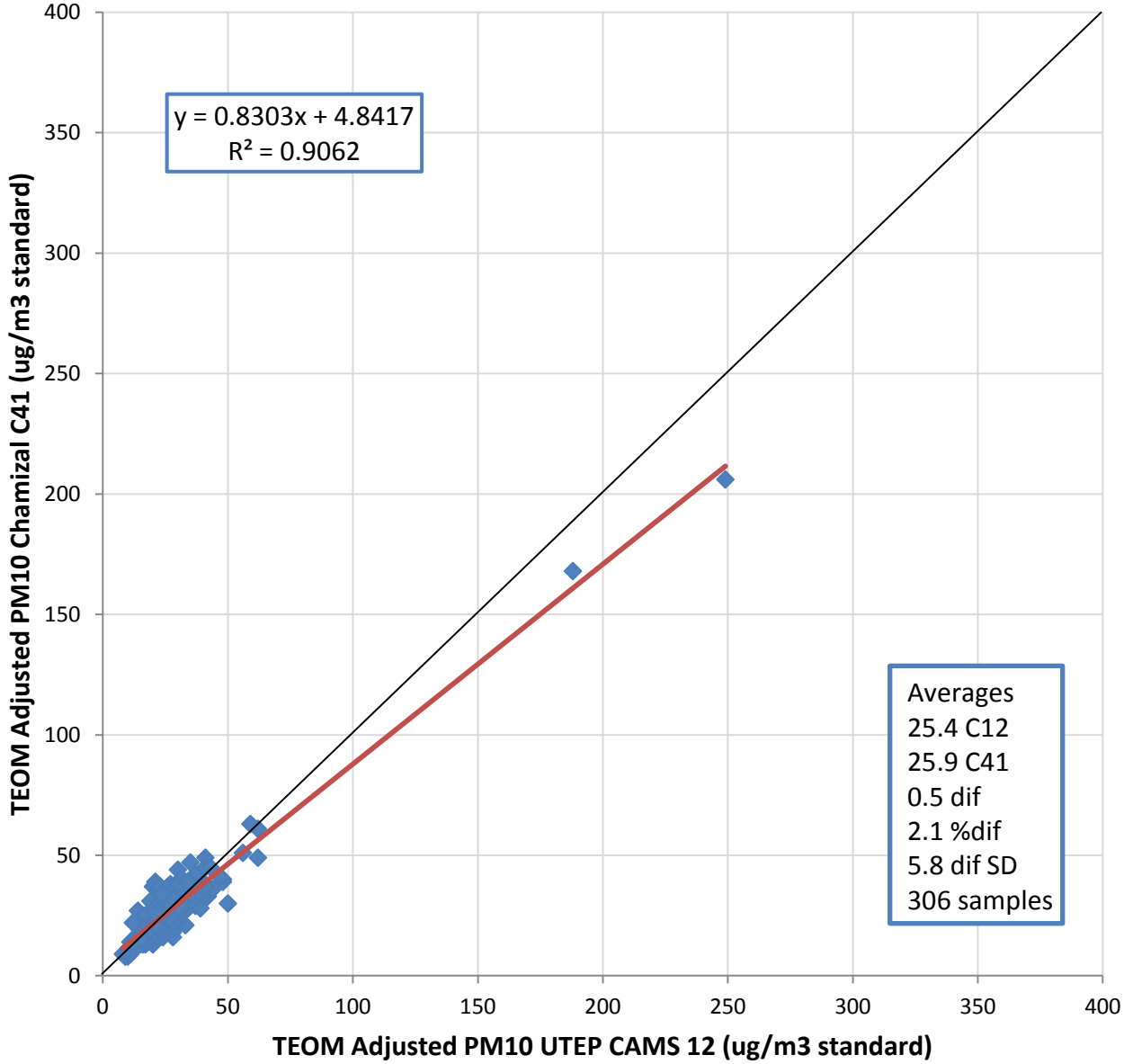


PM_{10} BAM vs TEOM

El Paso Chamizal C41


PM10 Daily C41 BAM - C12 TEOM 2011
y = 1.8117x - 7.4919
R² = 0.8703
Averages
35.2 TEOM
56.2 BAM
21.0 dif
59.7 %dif
25.1 dif SD
289 samples
BAM PM10 Chamizal C41 (ug/m3 standard)
TEOM Adjusted PM10 UTEP CAMS 12 (ug/m3 standard)
0
50
100
150
200
250
300
350
400

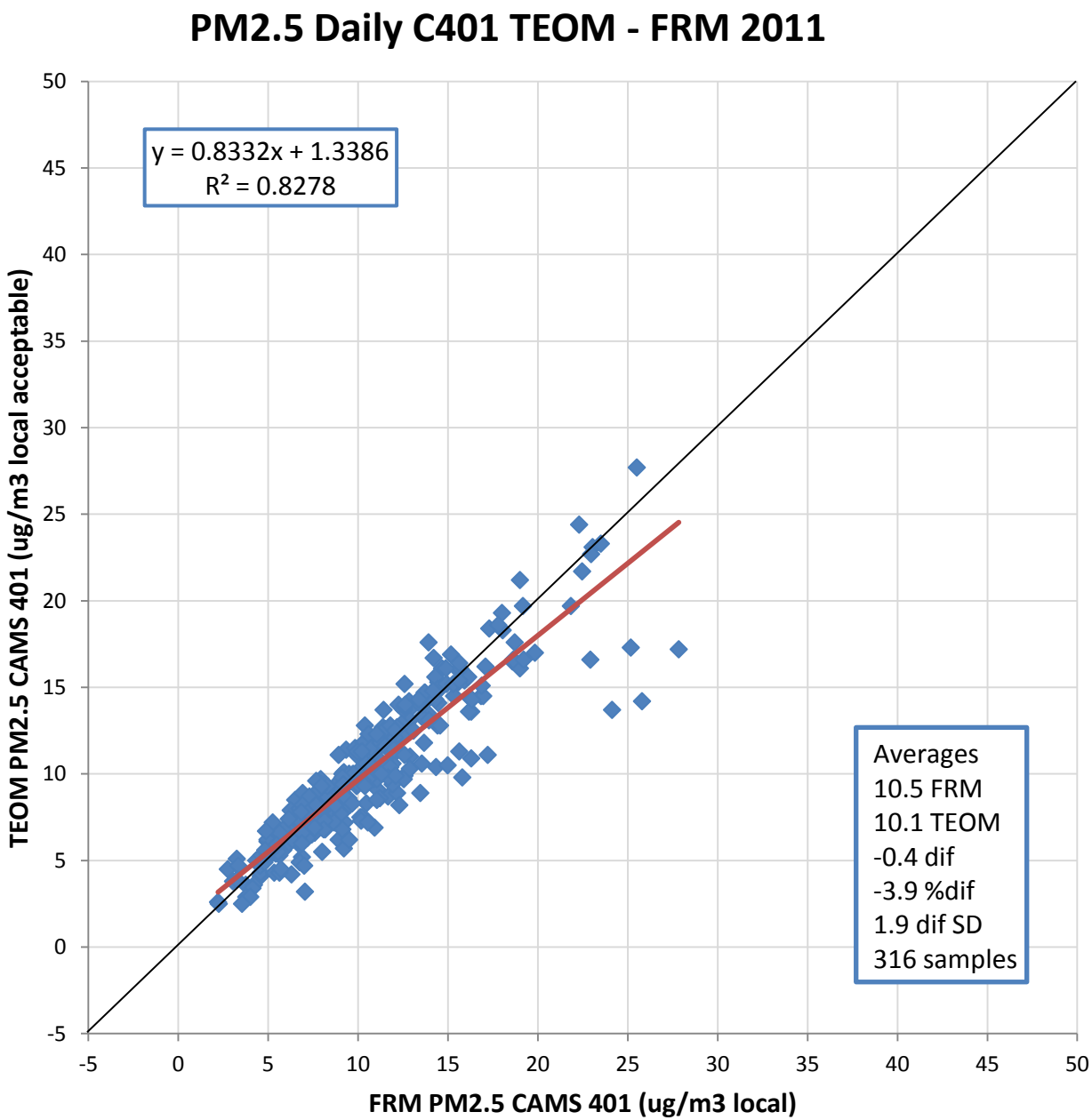
PM10 Daily C41 TEOM - C12 TEOM 2010



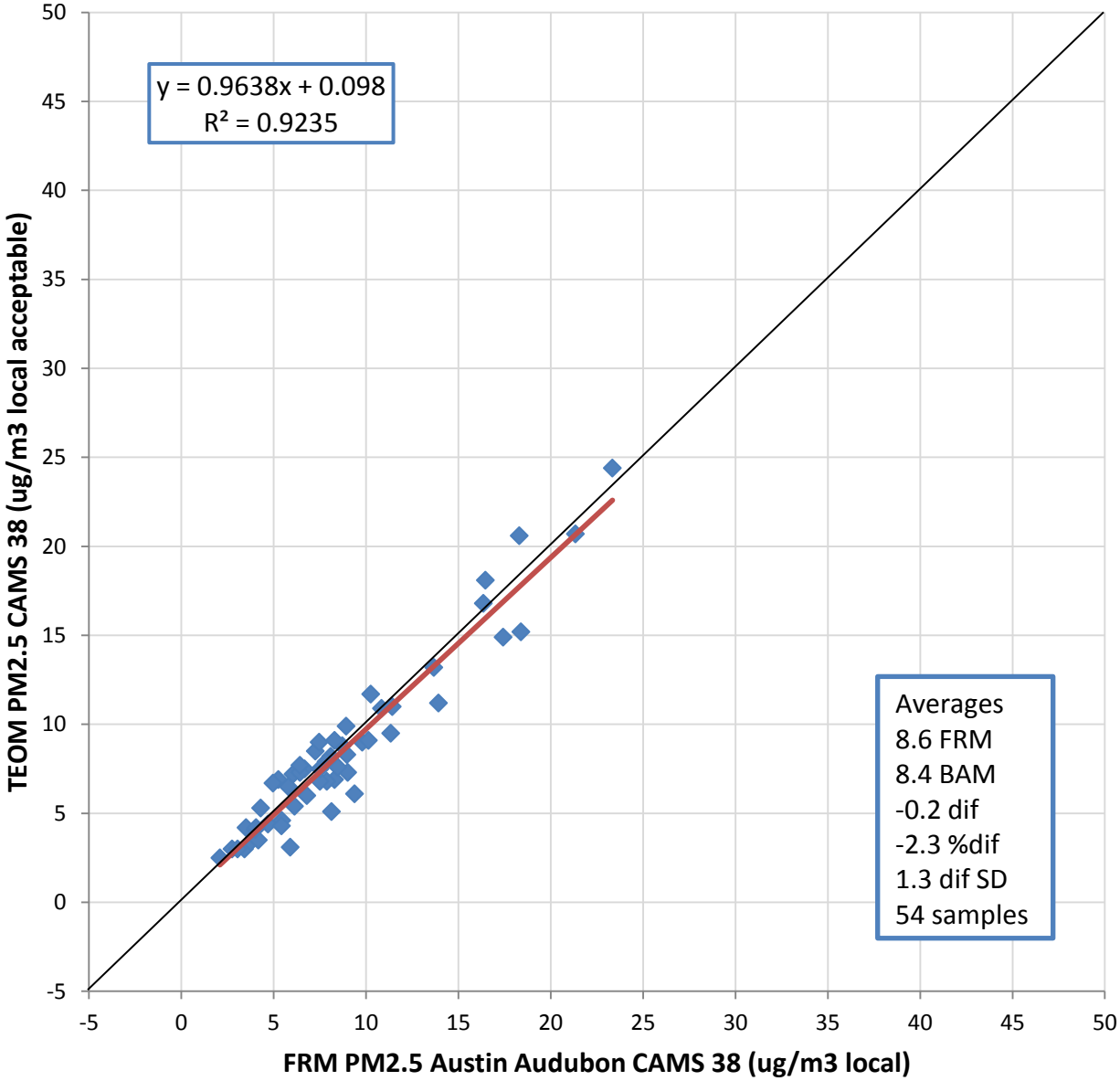
$PM_{2.5}$ TEOM vs FRM

Dallas Hinton C401

Austin Audubon C38


PM2.5 Daily C401 TEOM - FRM 2011
y = 0.8332x + 1.3386
R² = 0.8278
Averages
10.5 FRM
10.1 TEOM
-0.4 dif
-3.9 %dif
1.9 dif SD
316 samples
TEOM PM2.5 CAMS 401 (ug/m3 local acceptable)
FRM PM2.5 CAMS 401 (ug/m3 local)
50
45
40
35
30
25
20
15
10
5
0
-5
-5
0
5
10
15
20
25
30
35
40
45
50

PM2.5 Daily C38 TEOM - FRM 2011

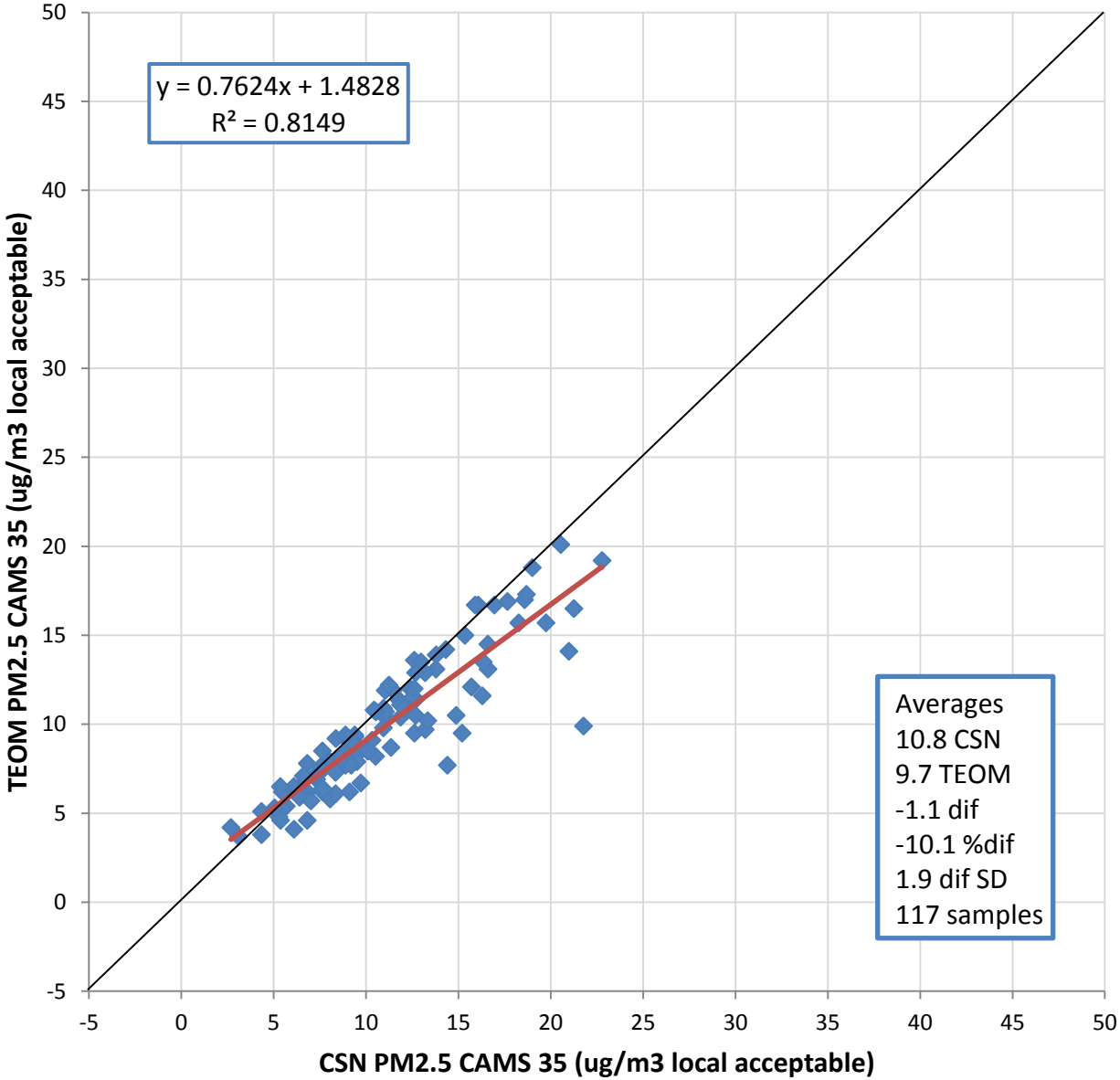


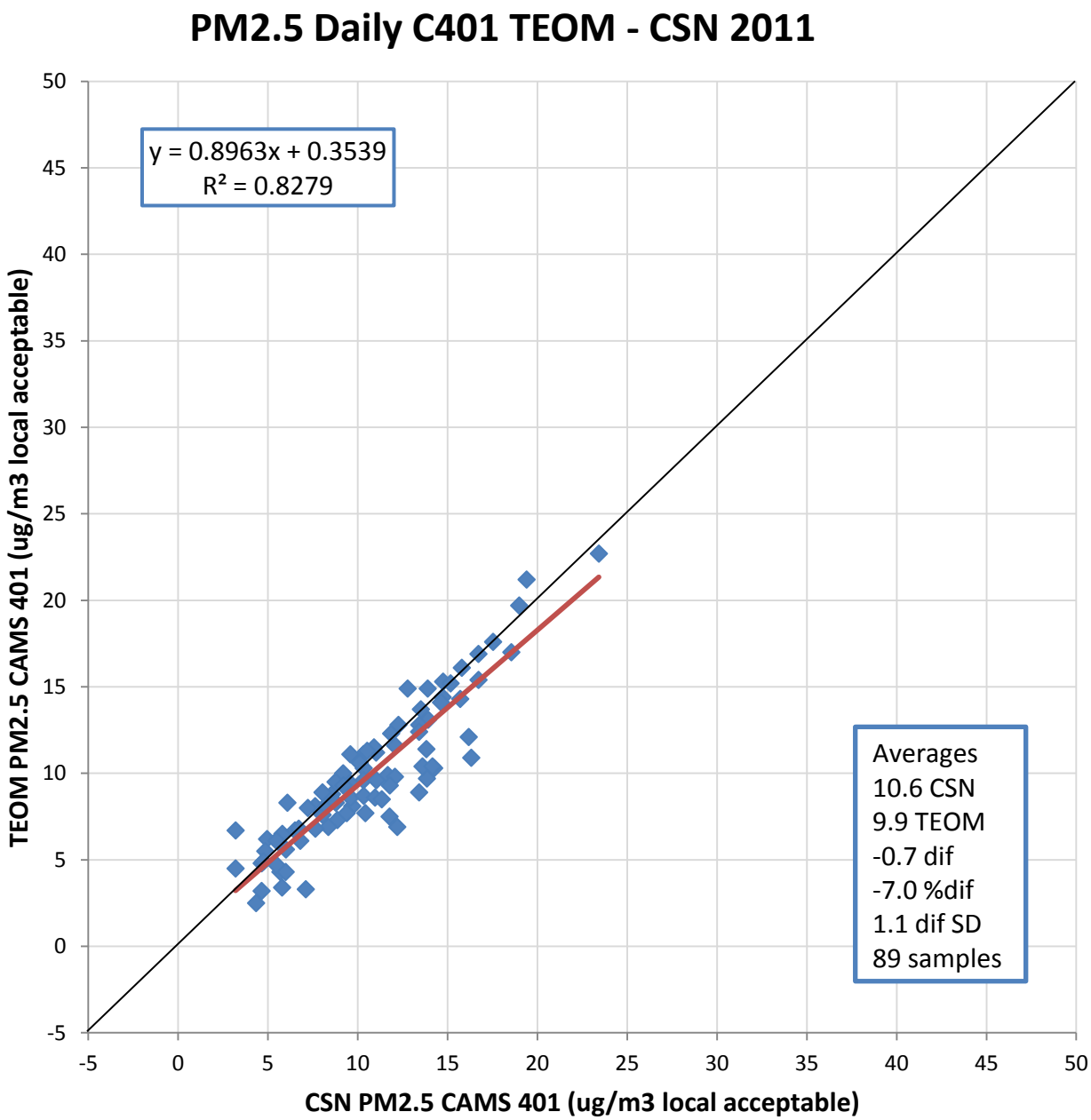
$PM_{2.5}$ TEOM vs CSN

Houston Deer Park C35

Dallas Hinton C401

PM2.5 Daily C35 TEOM - CSN 2011

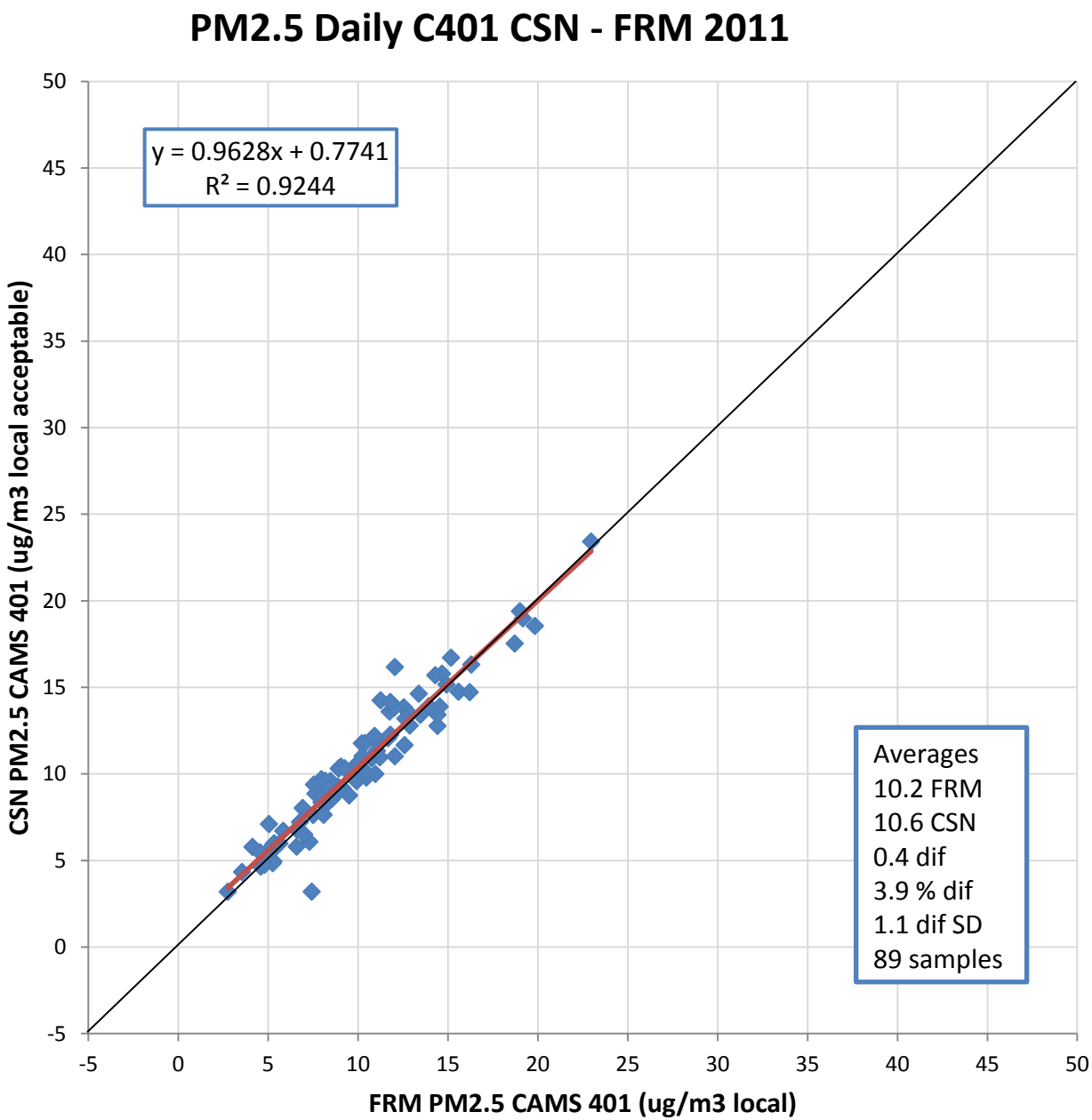



PM2.5 Daily C401 TEOM - CSN 2011
y = 0.8963x + 0.3539
R² = 0.8279
Averages
10.6 CSN
9.9 TEOM
-0.7 dif
-7.0 %dif
1.1 dif SD
89 samples
TEOM PM2.5 CAMS 401 (ug/m3 local acceptable)
CSN PM2.5 CAMS 401 (ug/m3 local acceptable)
50
45
40
35
30
25
20
15
10
5
0
-5
-5
0
5
10
15
20
25
30
35
40
45
50

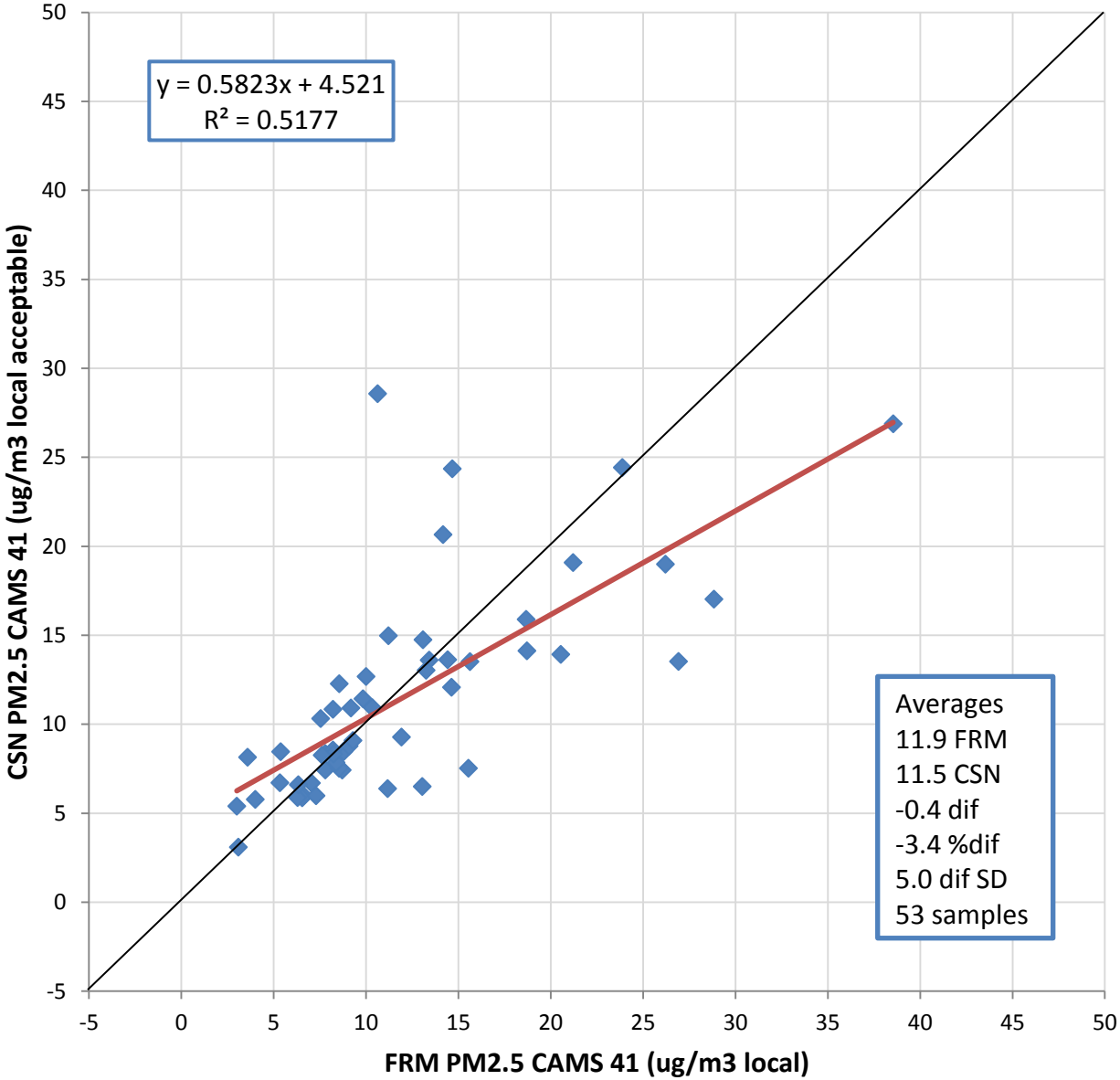
$PM_{2.5}$ CSN vs FRM

Dallas Hinton C401

El Paso Chamizal C41


PM2.5 Daily C401 CSN - FRM 2011
y = 0.9628x + 0.7741
R² = 0.9244
Averages
10.2 FRM
10.6 CSN
0.4 dif
3.9 % dif
1.1 dif SD
89 samples
CSN PM2.5 CAMS 401 (ug/m3 local acceptable)
FRM PM2.5 CAMS 401 (ug/m3 local)
50
45
40
35
30
25
20
15
10
5
0
-5
-5
0
5
10
15
20
25
30
35
40
45
50

PM2.5 Daily C41 CSN - FRM 2011

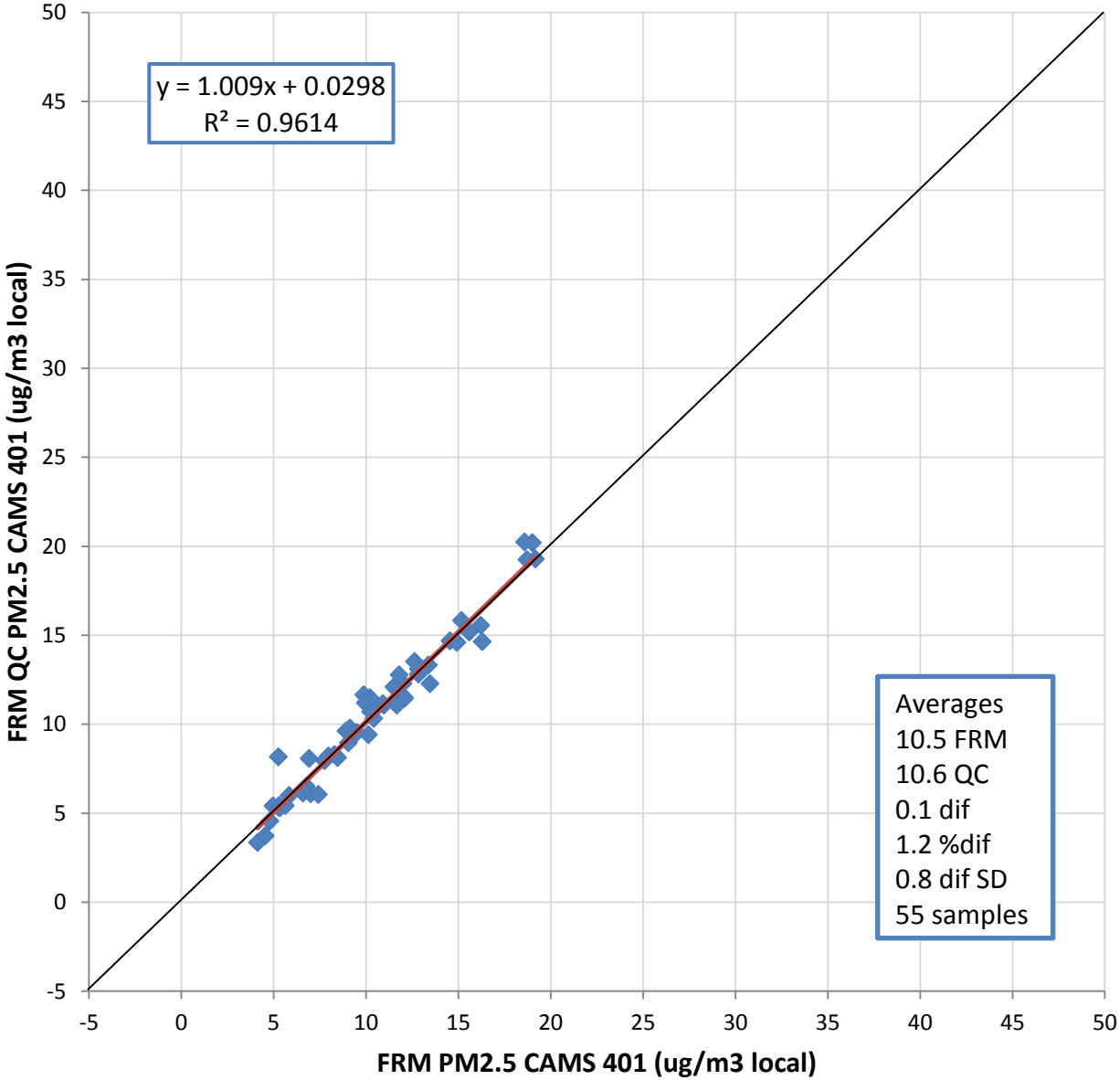


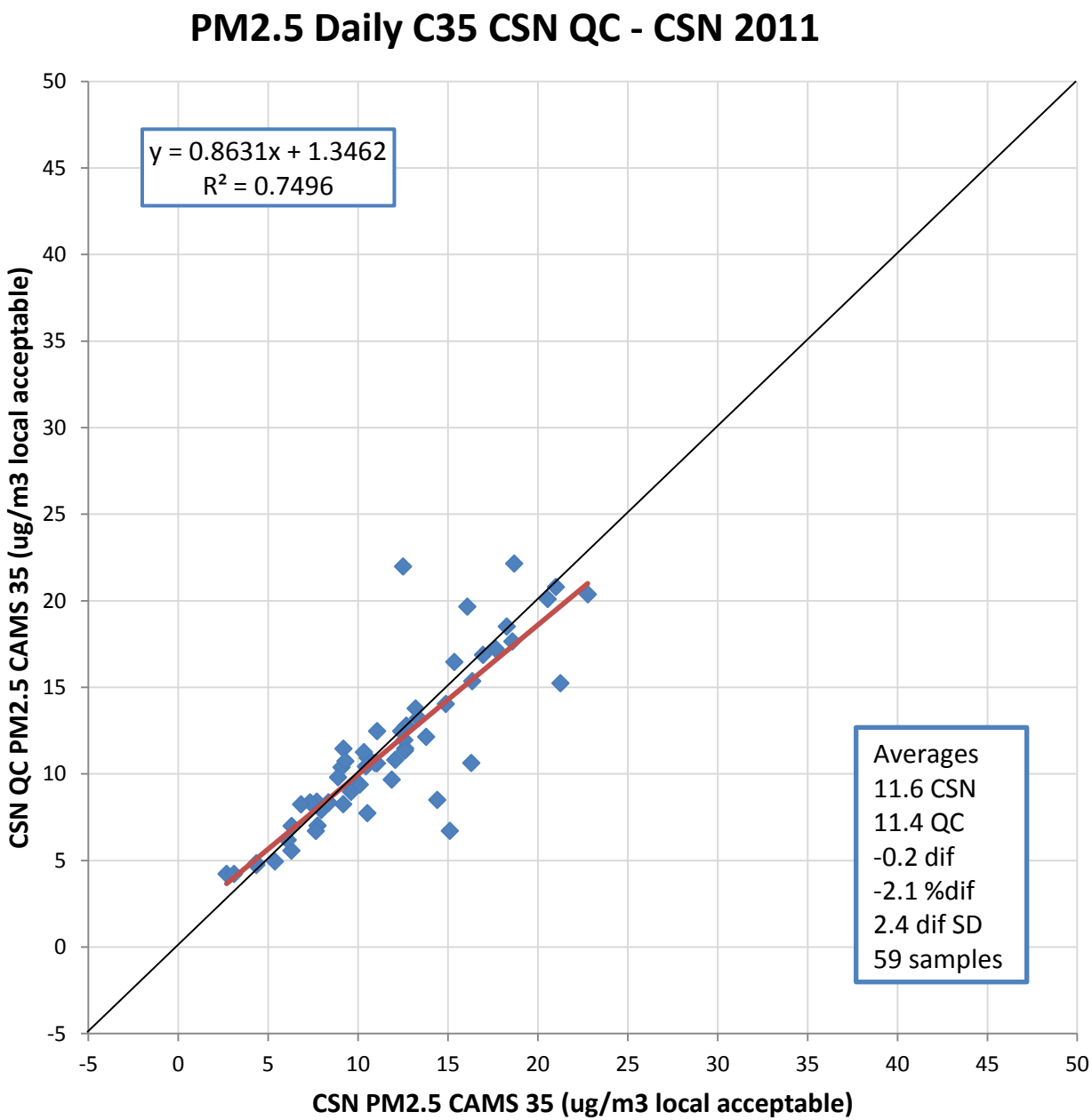
$PM_{2.5}$ QC vs FRM/CSN

Dallas Hinton C401

Houston Deer Park C35

PM2.5 Daily C401 FRM QC - FRM 2011



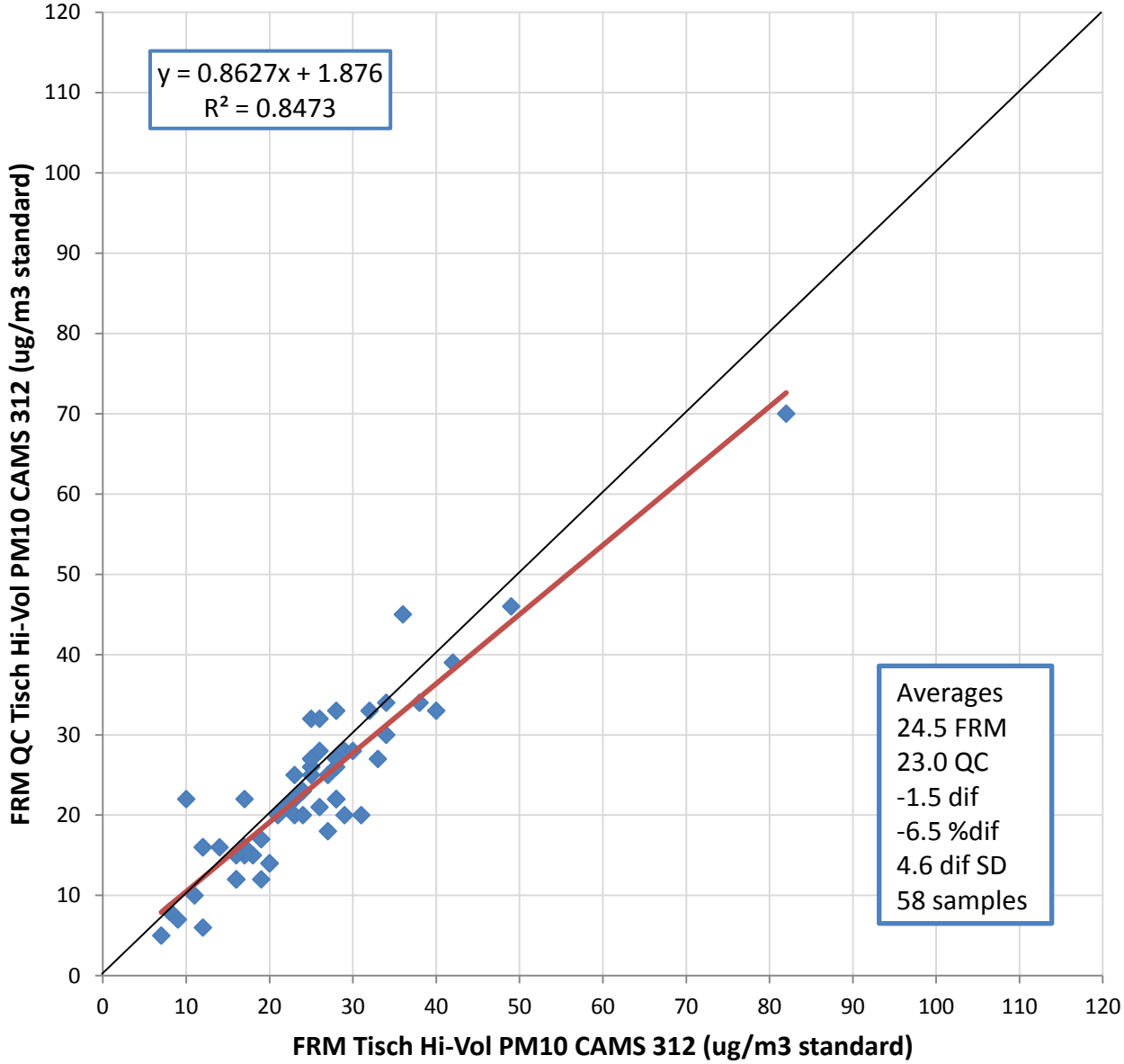

PM2.5 Daily C35 CSN QC - CSN 2011
y = 0.8631x + 1.3462
R² = 0.7496
Averages
11.6 CSN
11.4 QC
-0.2 dif
-2.1 %dif
2.4 dif SD
59 samples
CSN QC PM2.5 CAMS 35 (ug/m3 local acceptable)
CSN PM2.5 CAMS 35 (ug/m3 local acceptable)
50
45
40
35
30
25
20
15
10
5
0
-5
-5
0
5
10
15
20
25
30
35
40
45
50

PM_{10} QC vs FRM

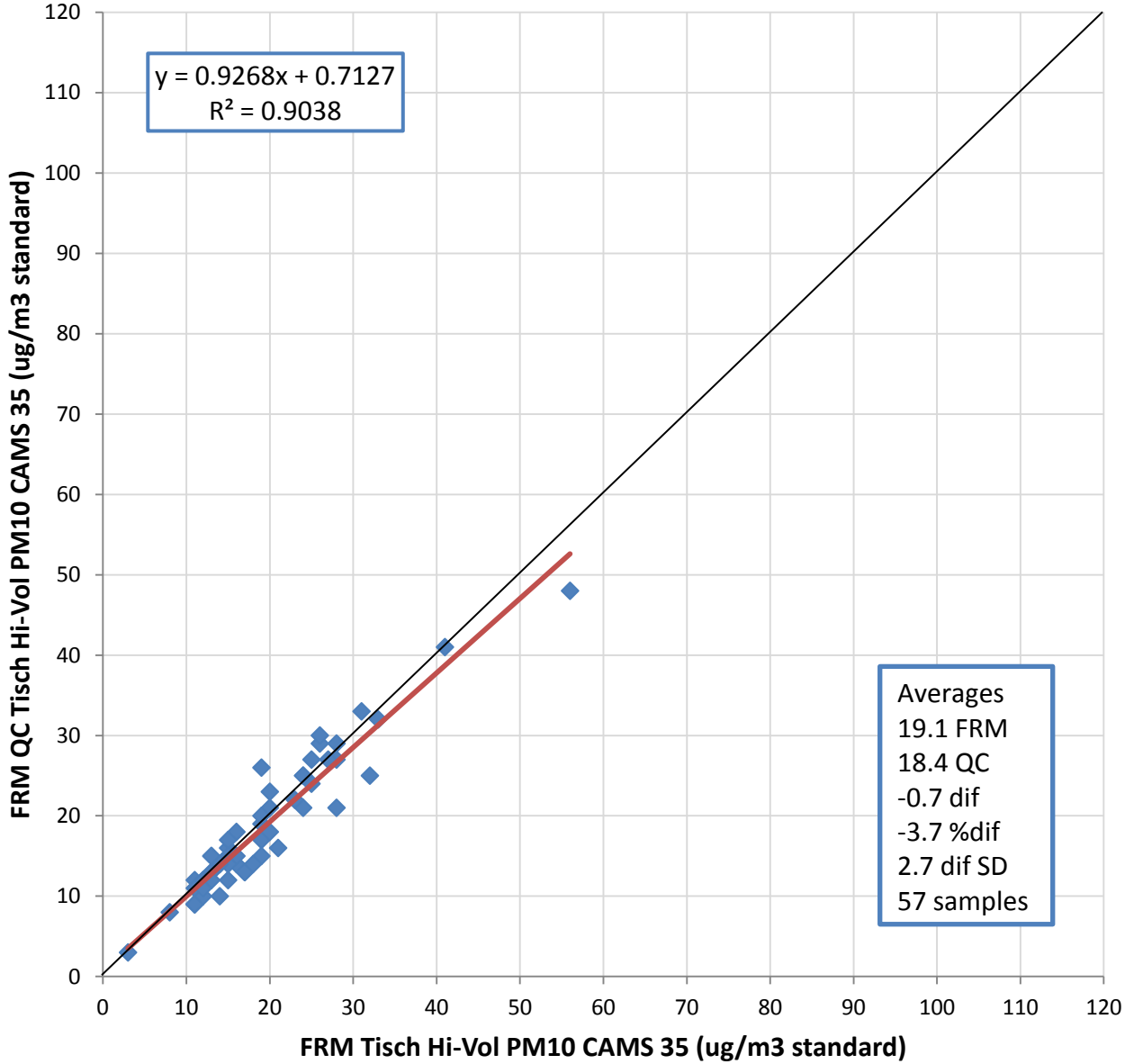
Dallas Convention Center C312

Houston Deer Park C35

PM10 Daily C312 FRM QC - FRM 2011

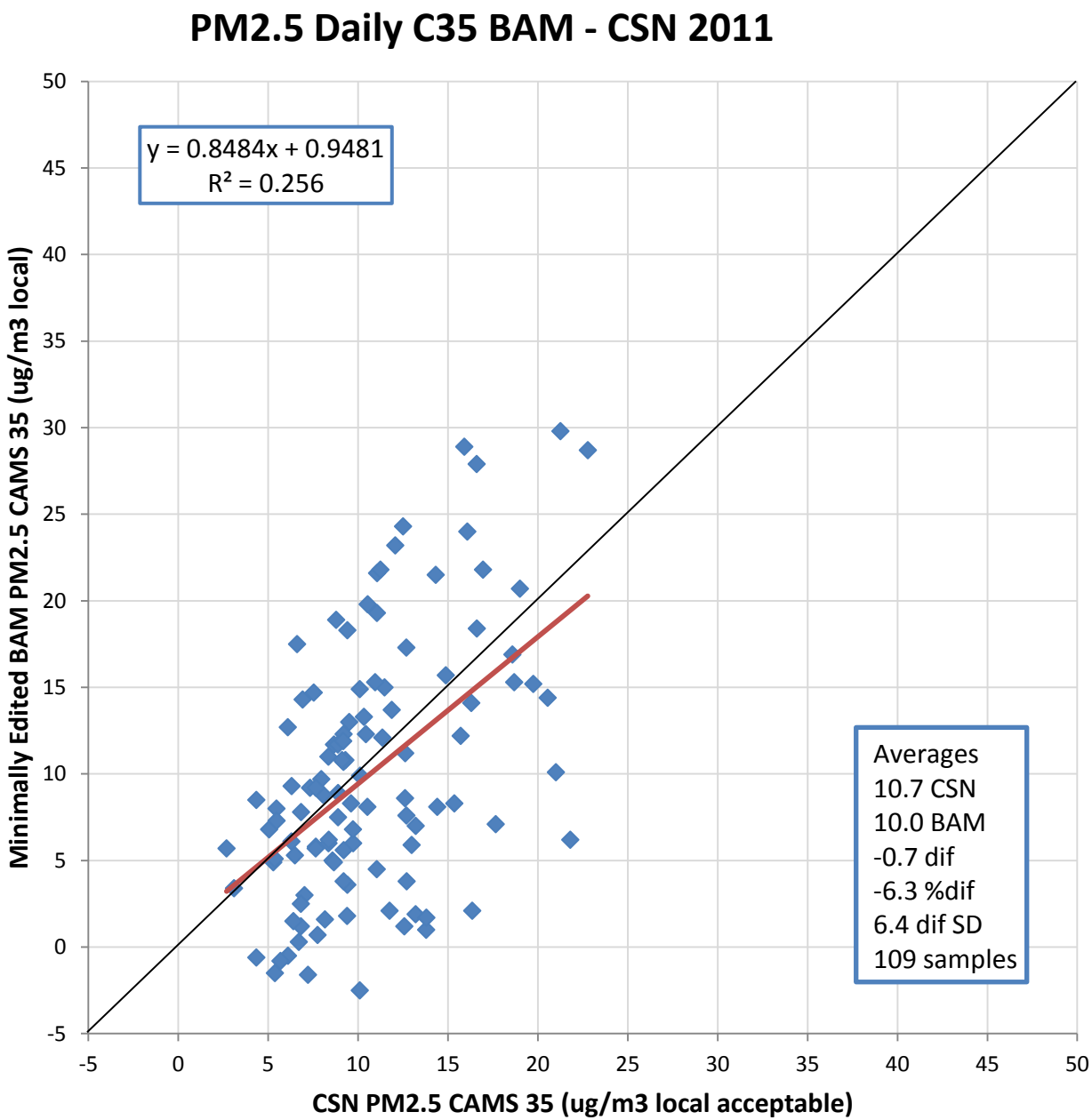


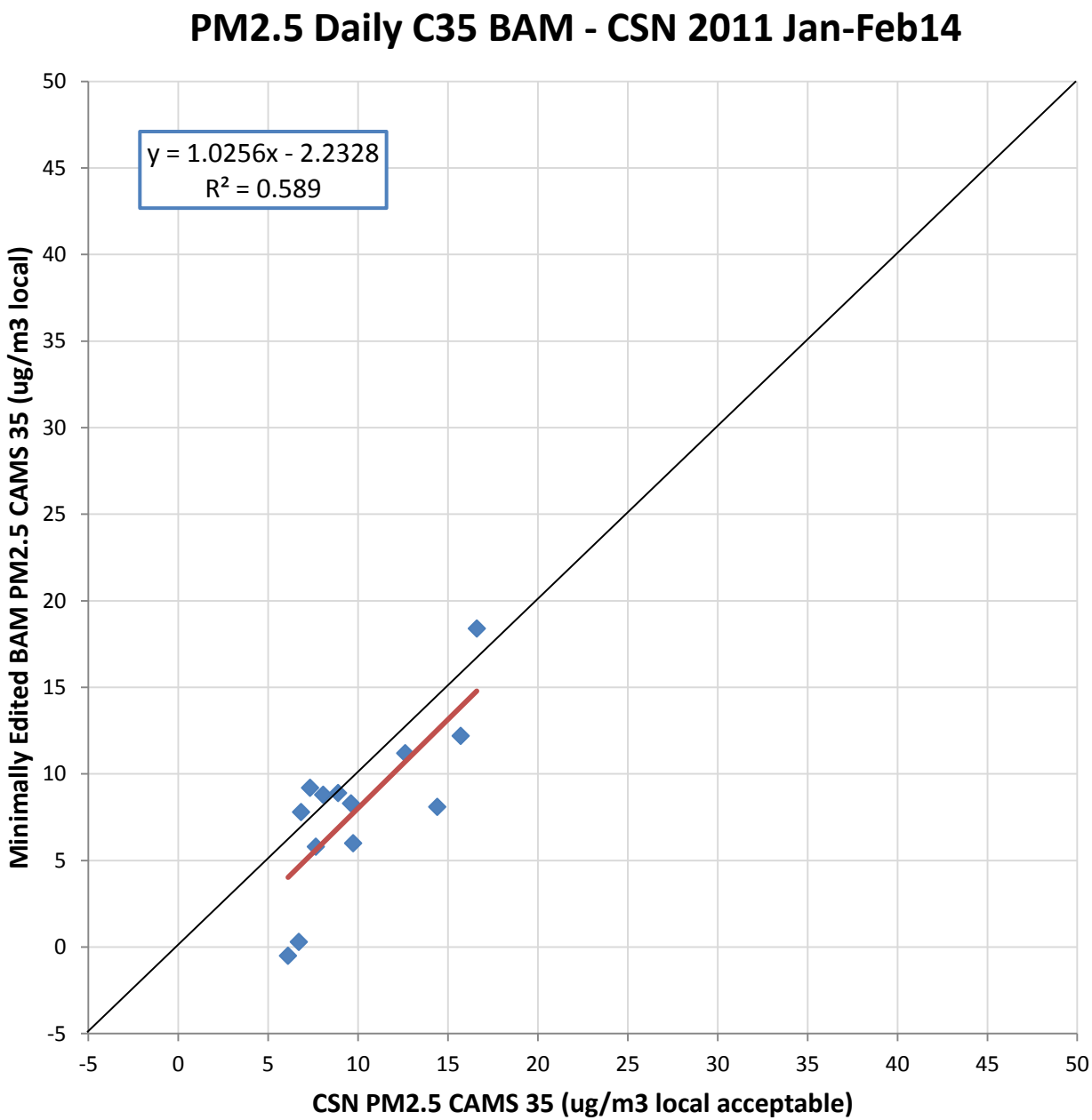
PM10 Daily C35 FRM QC - FRM 2011

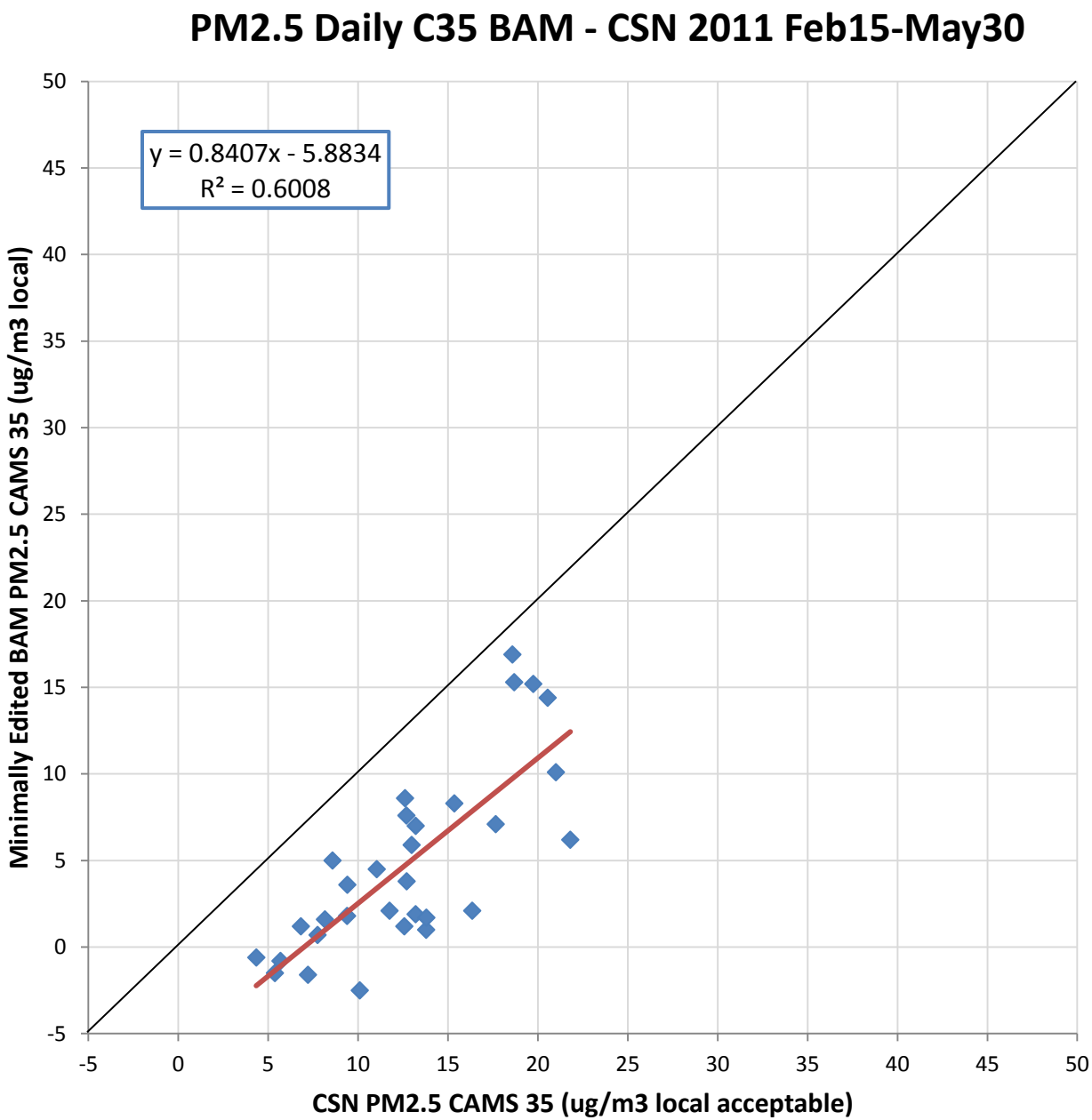


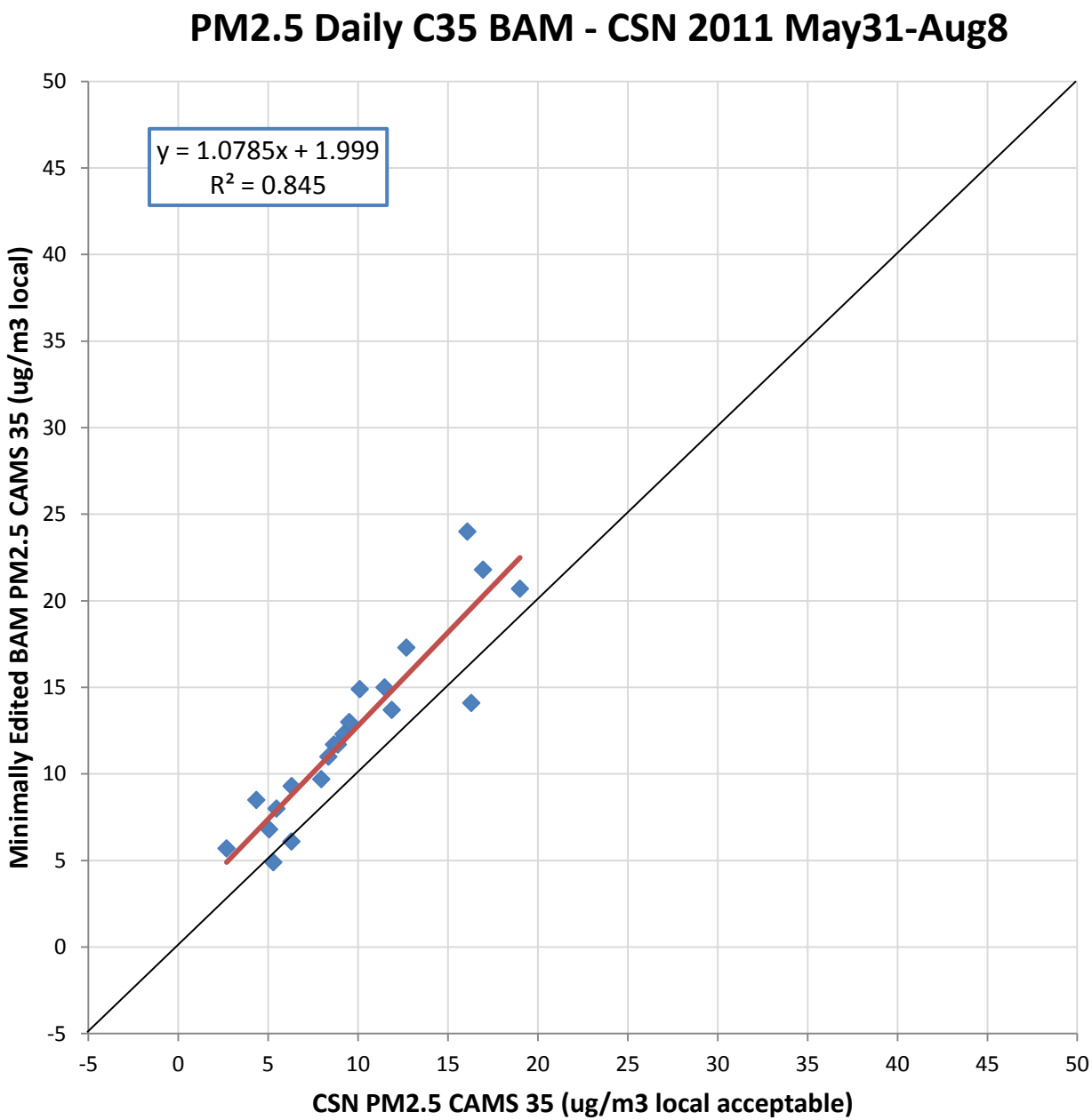
BAM Baseline Drift

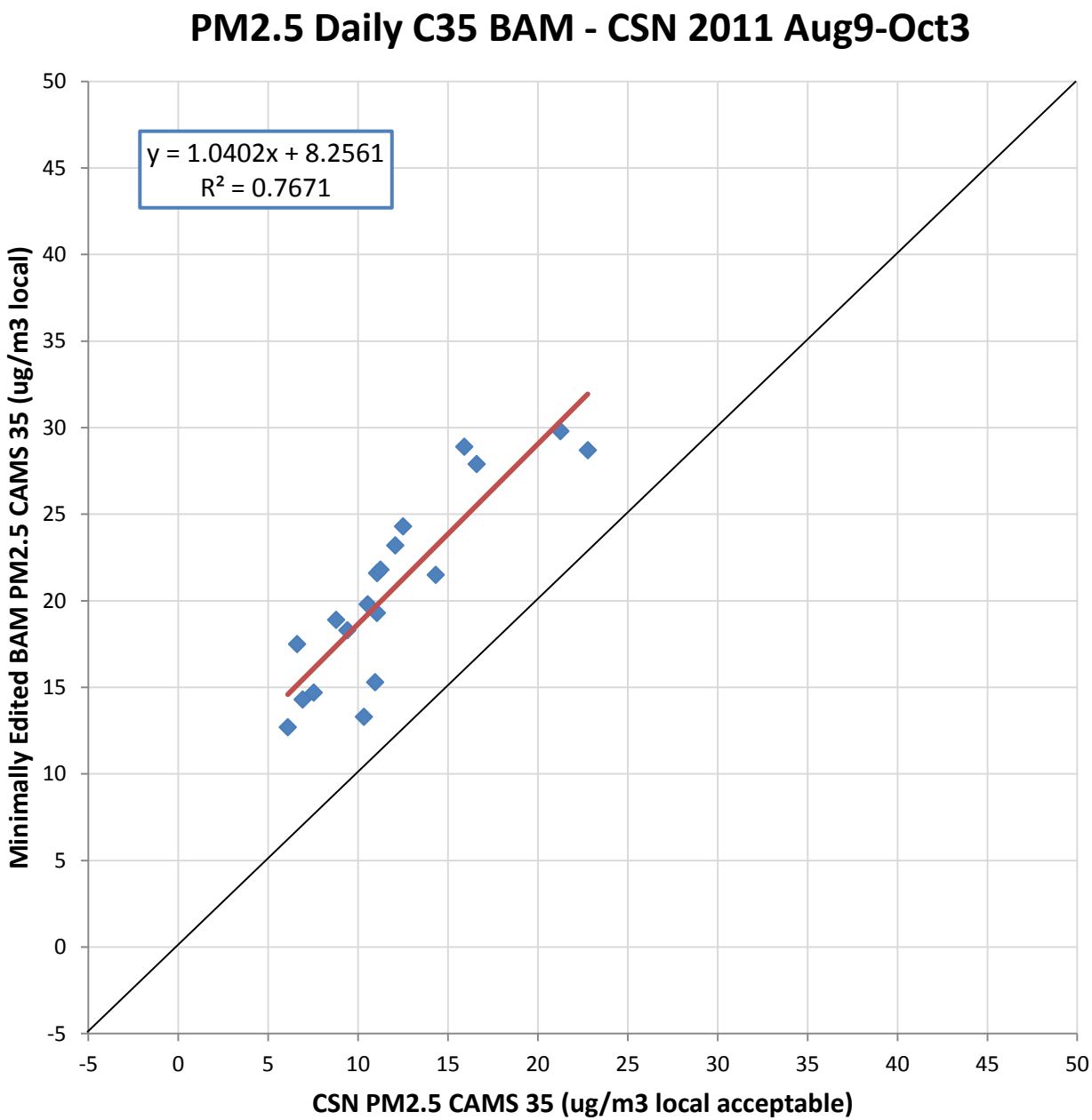
Houston Deer Park C35

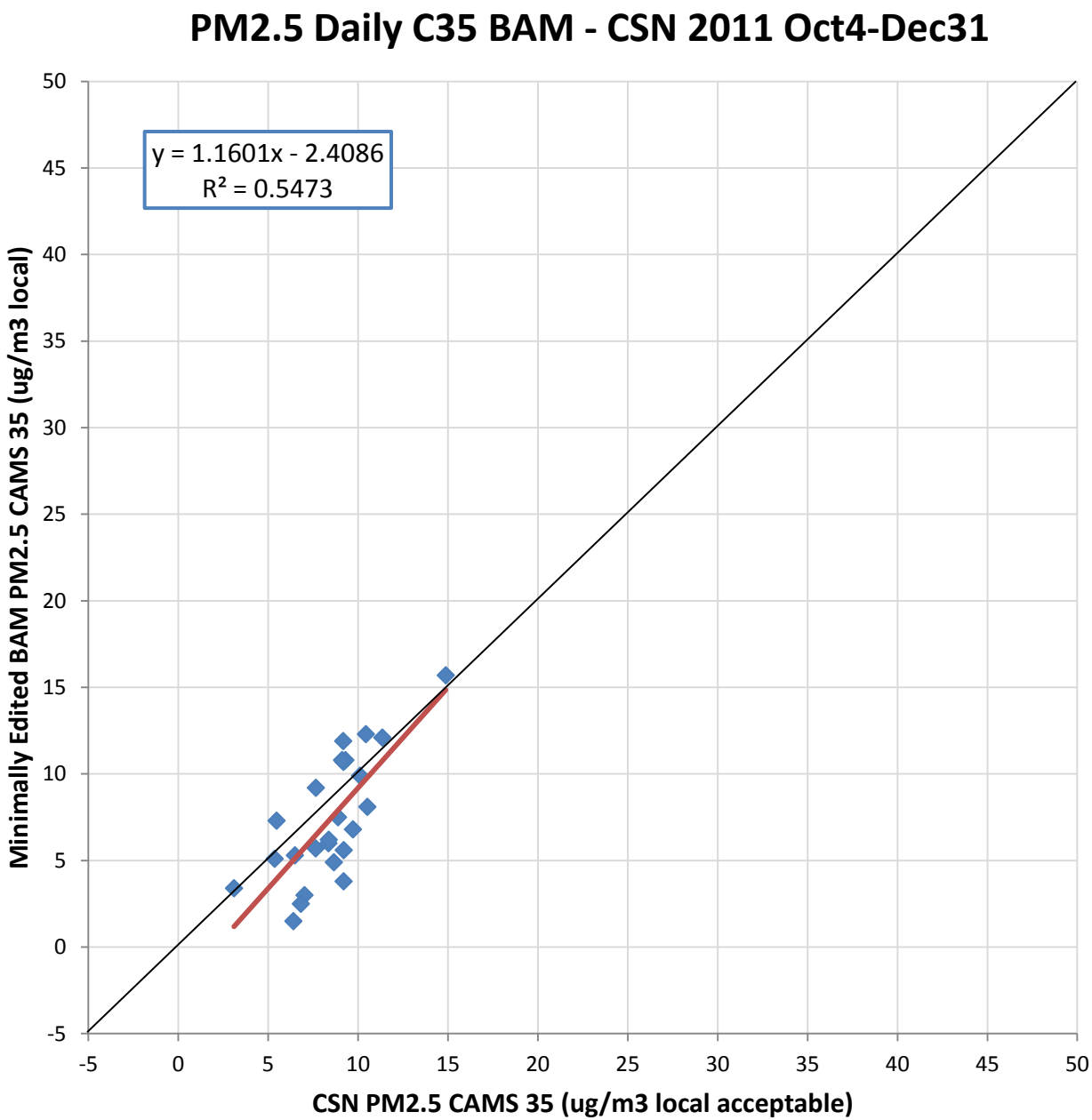

PM2.5 Daily C35 BAM - CSN 2011
y = 0.8484x + 0.9481
R² = 0.256
Averages
10.7 CSN
10.0 BAM
-0.7 dif
-6.3 %dif
6.4 dif SD
109 samples
Minimally Edited BAM PM2.5 CAMS 35 (ug/m3 local)
CSN PM2.5 CAMS 35 (ug/m3 local acceptable)
50
45
40
35
30
25
20
15
10
5
0
-5
-5
0
5
10
15
20
25
30
35
40
45
50


PM2.5 Daily C35 BAM - CSN 2011 Jan-Feb14
y = 1.0256x - 2.2328
R² = 0.589
Minimally Edited BAM PM2.5 CAMS 35 (ug/m3 local)
CSN PM2.5 CAMS 35 (ug/m3 local acceptable)
50
45
40
35
30
25
20
15
10
5
0
-5
-5
0
5
10
15
20
25
30
35
40
45
50


PM2.5 Daily C35 BAM - CSN 2011 Feb15-May30
y = 0.8407x - 5.8834
R² = 0.6008
Minimally Edited BAM PM2.5 CAMS 35 (ug/m3 local)
CSN PM2.5 CAMS 35 (ug/m3 local acceptable)
50
45
40
35
30
25
20
15
10
5
0
-5
-5
0
5
10
15
20
25
30
35
40
45
50


PM2.5 Daily C35 BAM - CSN 2011 May31-Aug8
y = 1.0785x + 1.999
R² = 0.845
Minimally Edited BAM PM2.5 CAMS 35 (ug/m3 local)
CSN PM2.5 CAMS 35 (ug/m3 local acceptable)
50
45
40
35
30
25
20
15
10
5
0
-5
-5
0
5
10
15
20
25
30
35
40
45
50


PM2.5 Daily C35 BAM - CSN 2011 Aug9-Oct3
y = 1.0402x + 8.2561
R² = 0.7671
Minimally Edited BAM PM2.5 CAMS 35 (ug/m3 local)
CSN PM2.5 CAMS 35 (ug/m3 local acceptable)
50
45
40
35
30
25
20
15
10
5
0
-5
-5
0
5
10
15
20
25
30
35
40
45
50

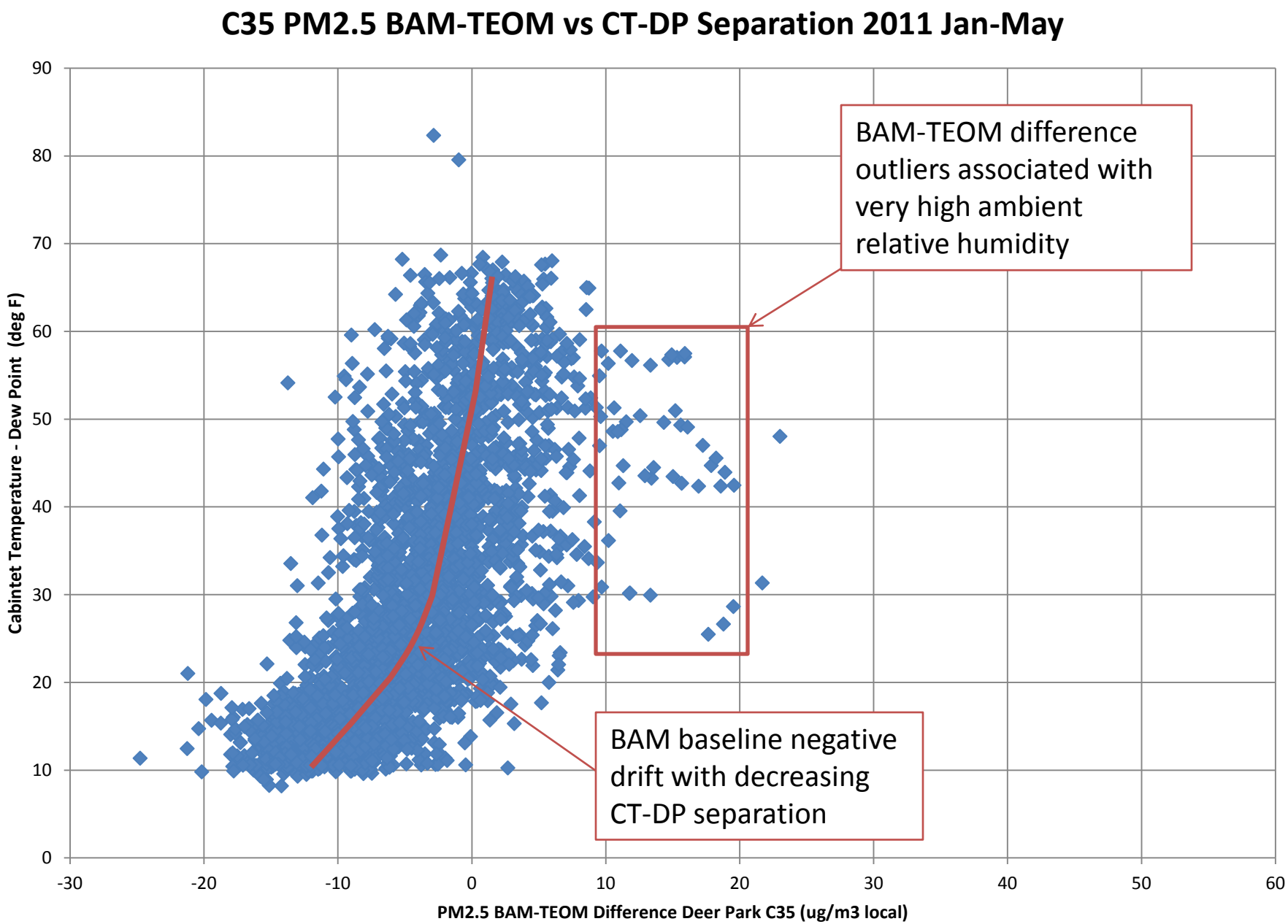

PM2.5 Daily C35 BAM - CSN 2011 Oct4-Dec31
y = 1.1601x - 2.4086
R² = 0.5473
Minimally Edited BAM PM2.5 CAMS 35 (ug/m3 local)
CSN PM2.5 CAMS 35 (ug/m3 local acceptable)
50
45
40
35
30
25
20
15
10
5
0
-5
-5
0
5
10
15
20
25
30
35
40
45
50

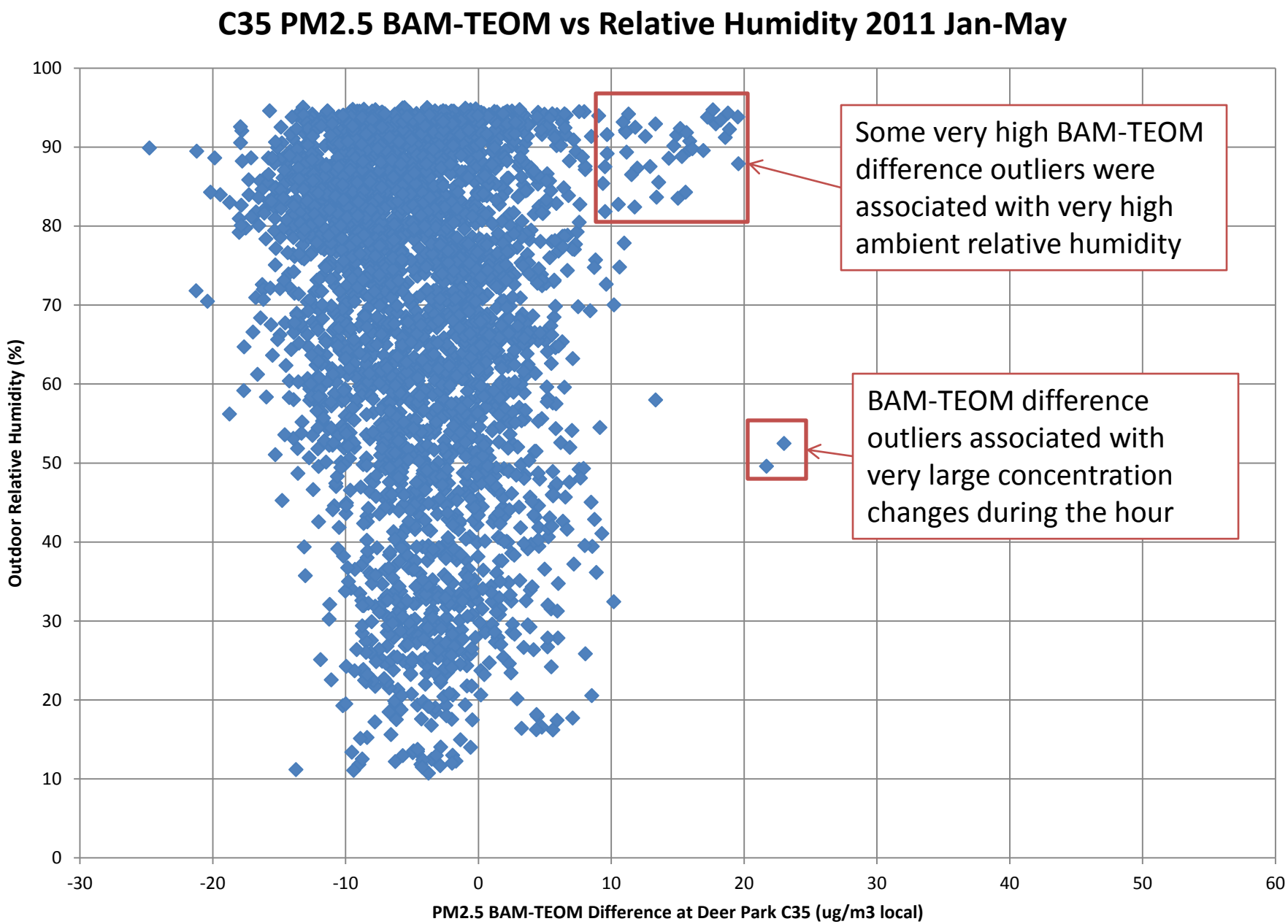
BAM Data Quality Issues

Cabinet Temperature minus Dew Point

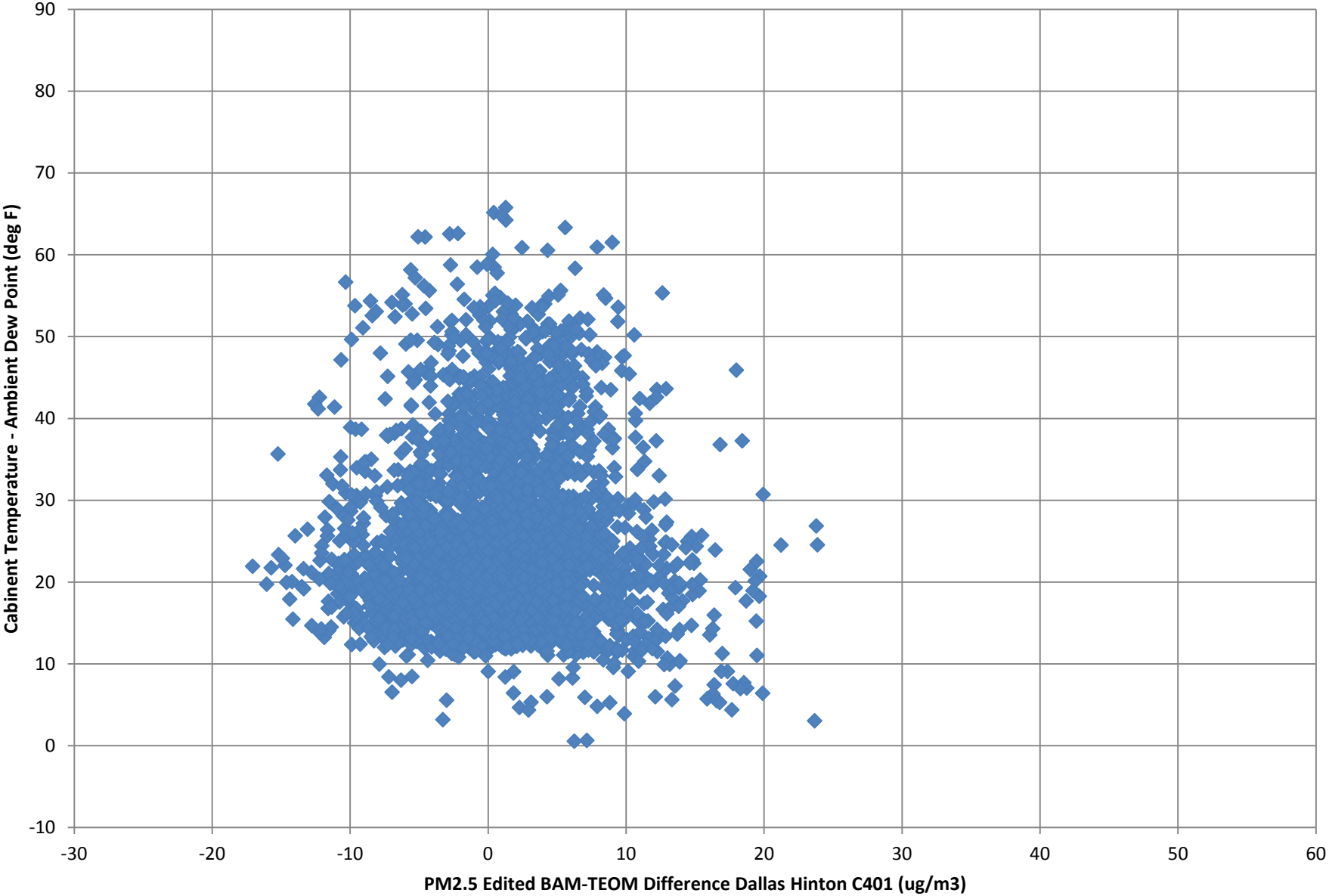
Ambient Relative Humidity

Hourly Data

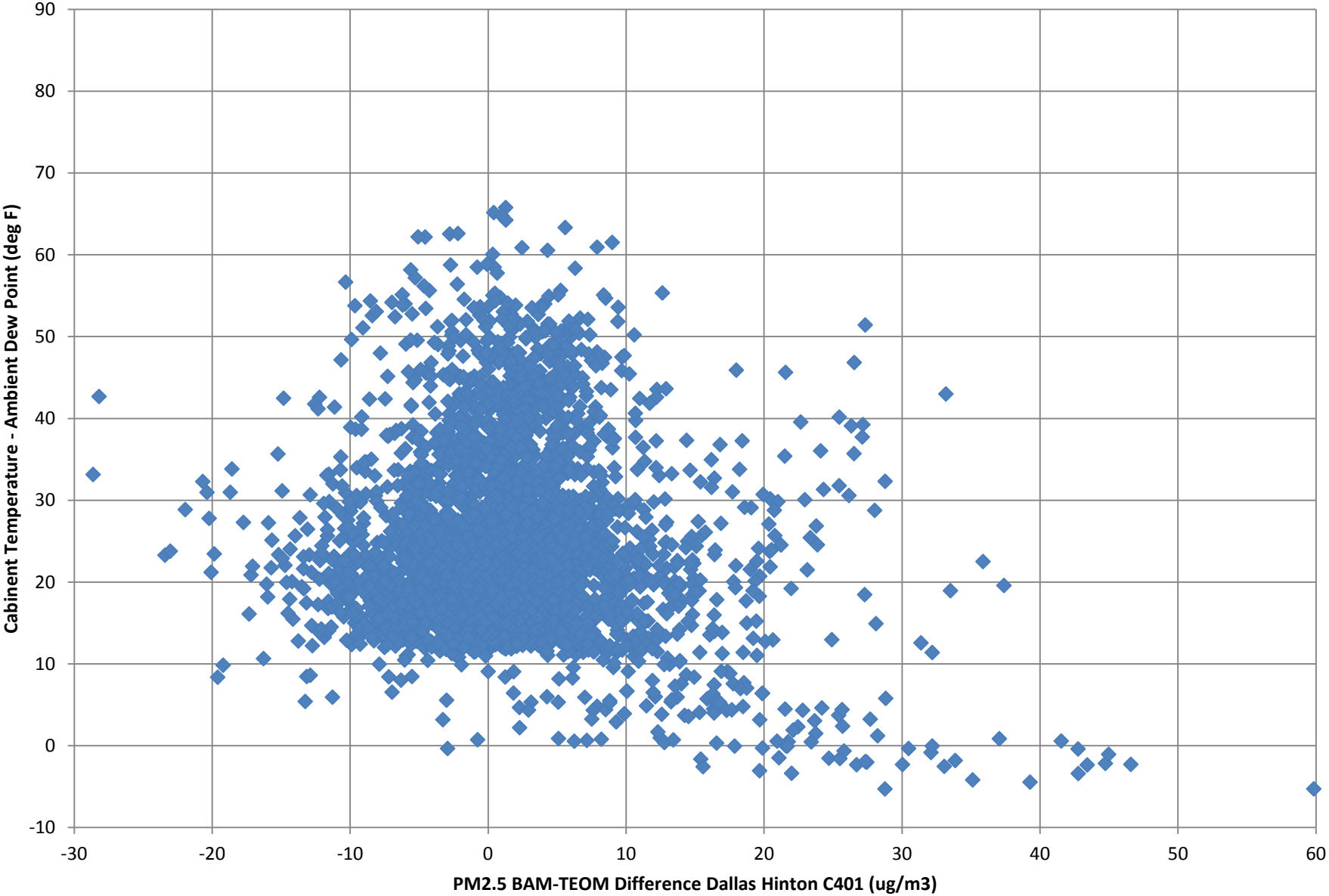

C35 PM2.5 BAM-TEOM vs CT-DP Separation 2011 Jan-May
Cabintet Temperature - Dew Point (deg F)
PM2.5 BAM-TEOM Difference Deer Park C35 (ug/m3 local)
90
80
70
60
50
40
30
20
10
0
-30
-20
-10
0
10
20
30
40
50
60
BAM-TEOM difference outliers associated with very high ambient relative humidity
BAM baseline negative drift with decreasing CT-DP separation


C35 PM2.5 BAM-TEOM vs Relative Humidity 2011 Jan-May
Outdoor Relative Humidity (%)
PM2.5 BAM-TEOM Difference at Deer Park C35 (ug/m3 local)
100
90
80
70
60
50
40
30
20
10
0
-30
-20
-10
0
10
20
30
40
50
60
Some very high BAM-TEOM difference outliers were associated with very high ambient relative humidity
BAM-TEOM difference outliers associated with very large concentration changes during the hour

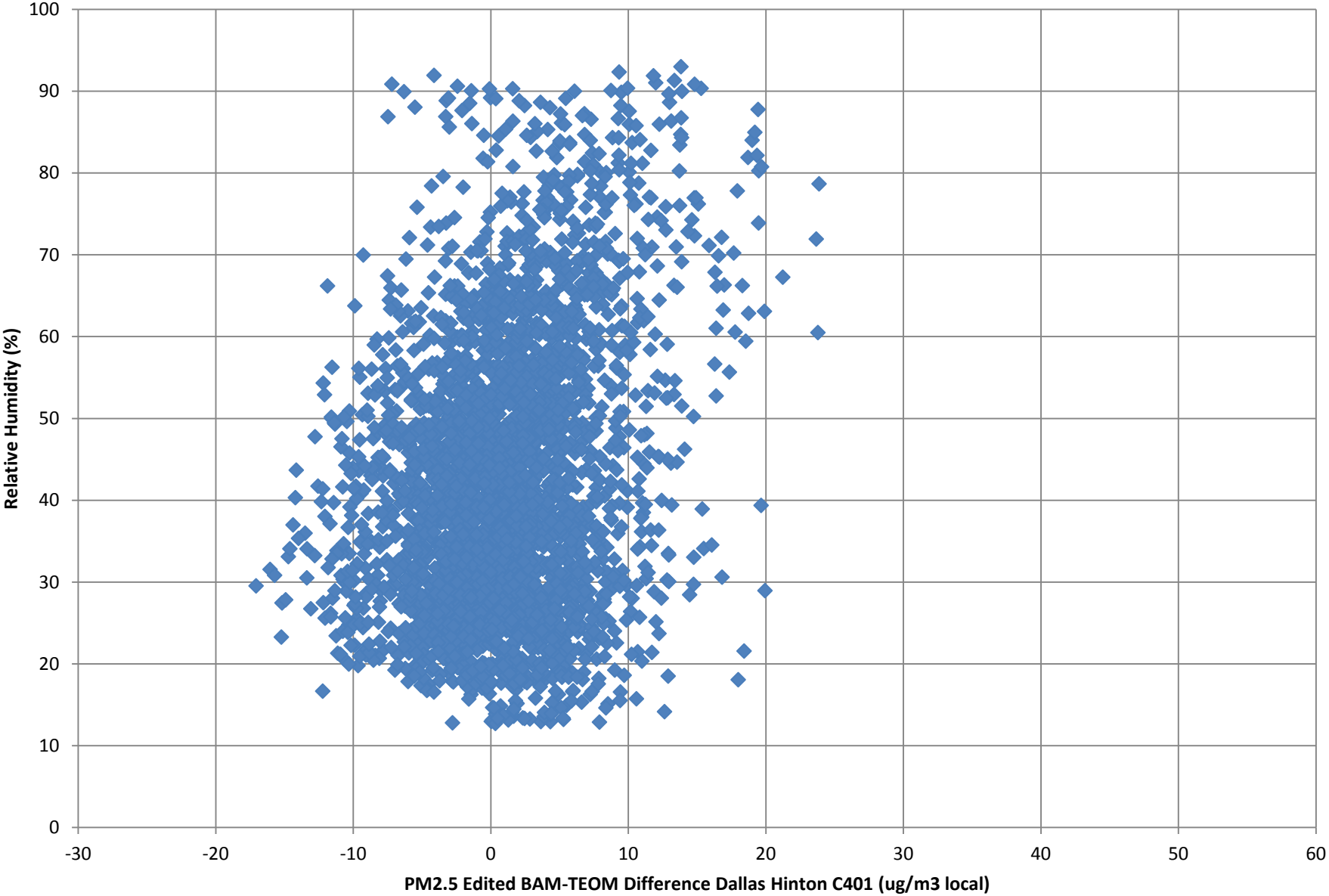
C401 PM2.5 eBAM-TEOM vs CT-DP Separation 2011 Jun16-Nov7



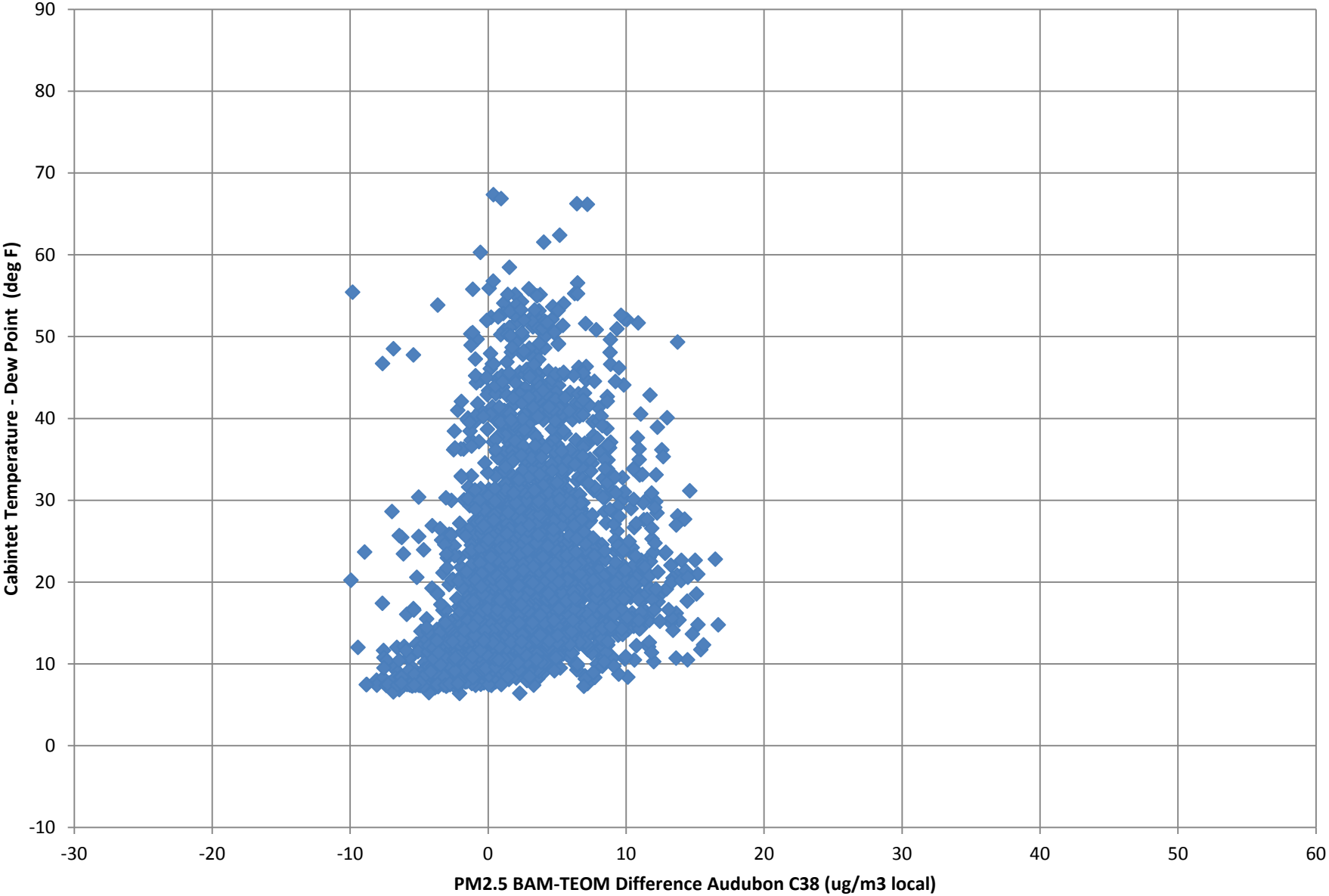
C401 PM2.5 BAM-TEOM vs CT-DP Separation 2011 Jun16-Nov7



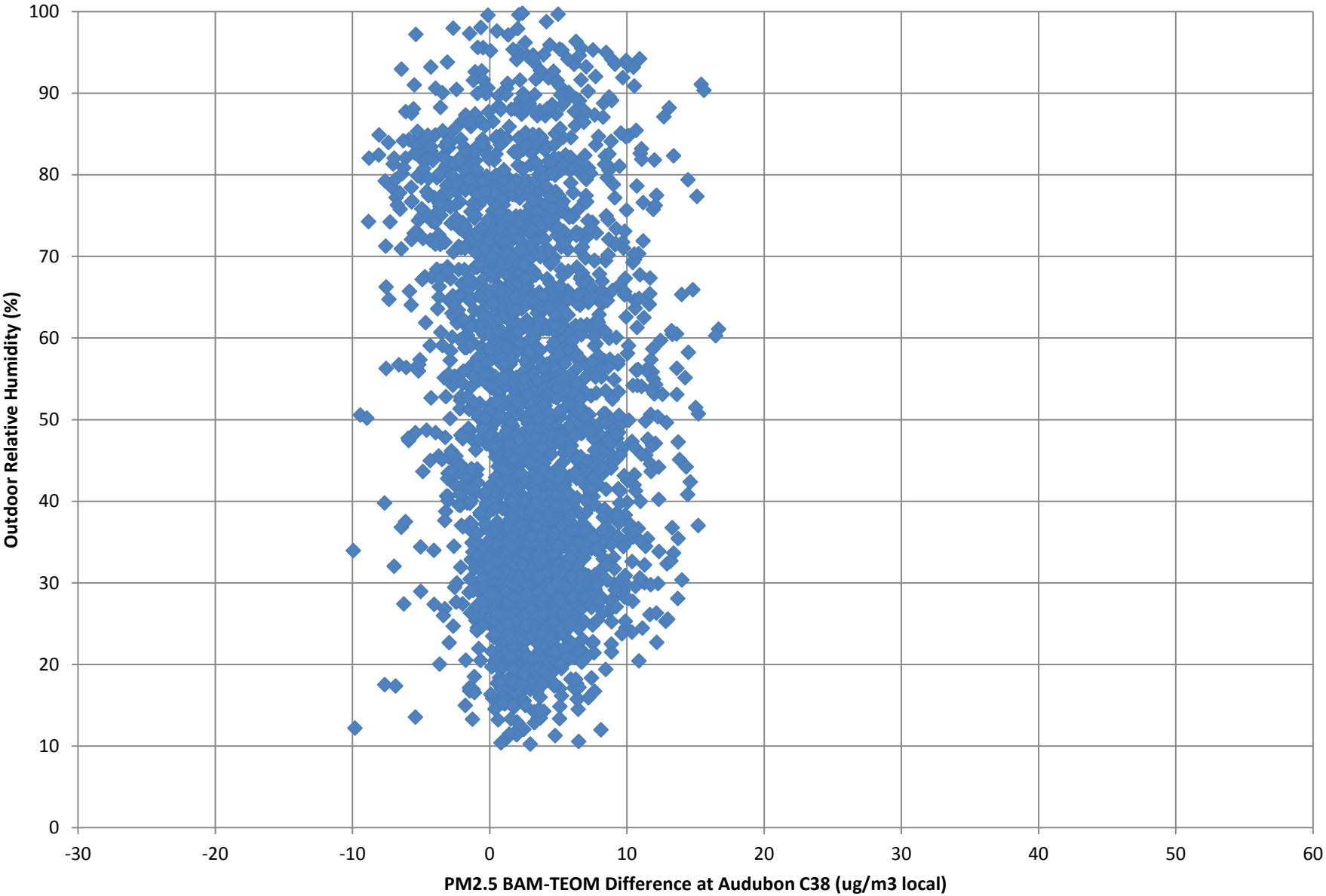
C401 PM2.5 eBAM-TEOM vs Relative Humidity 2011 Jun16-Nov7



C38 PM2.5 BAM-TEOM vs CT-DP Separation 2011 Jul6-Nov4



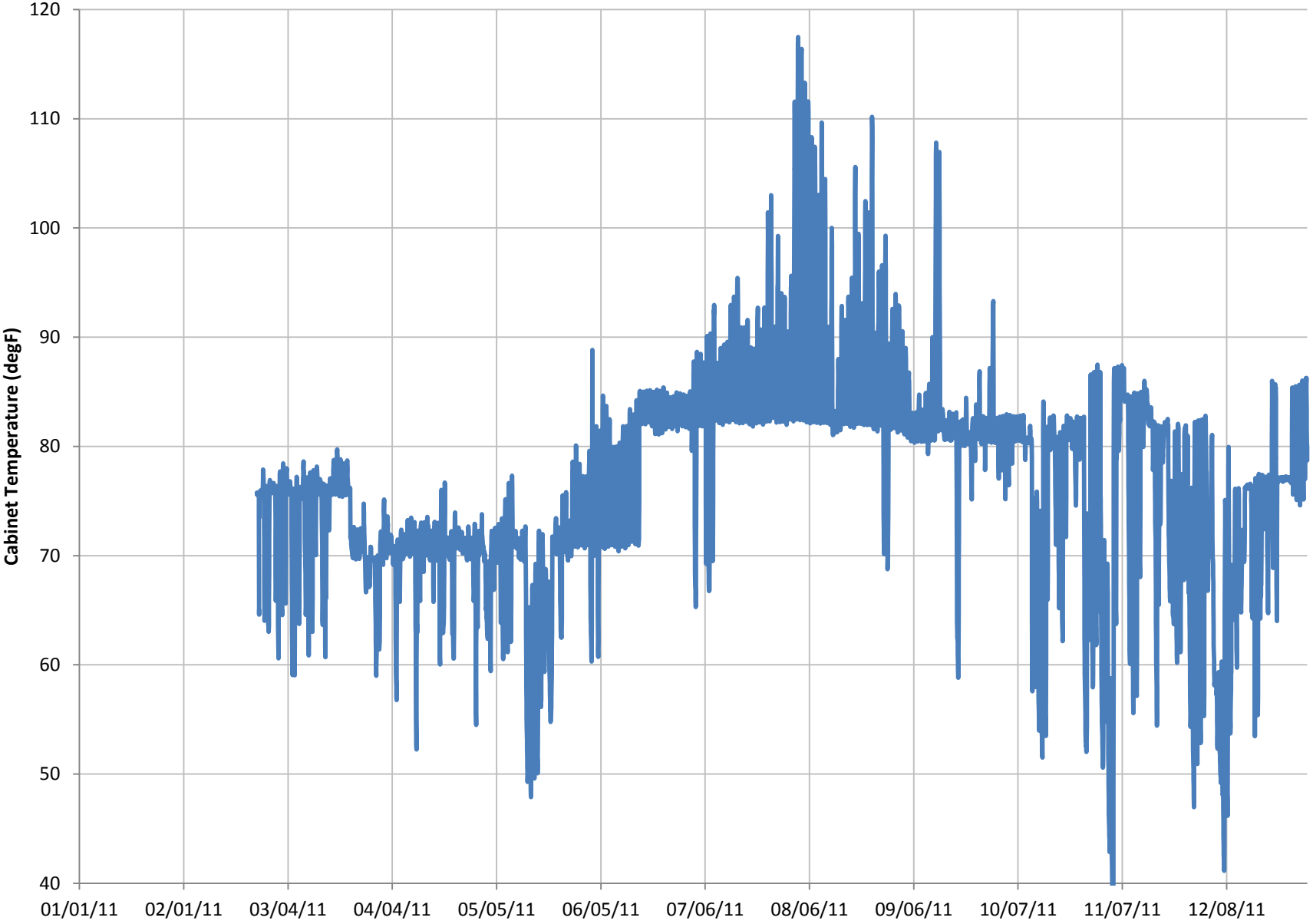
C38 PM2.5 BAM-TEOM vs Relative Humidity 2011 Jul6-Nov4



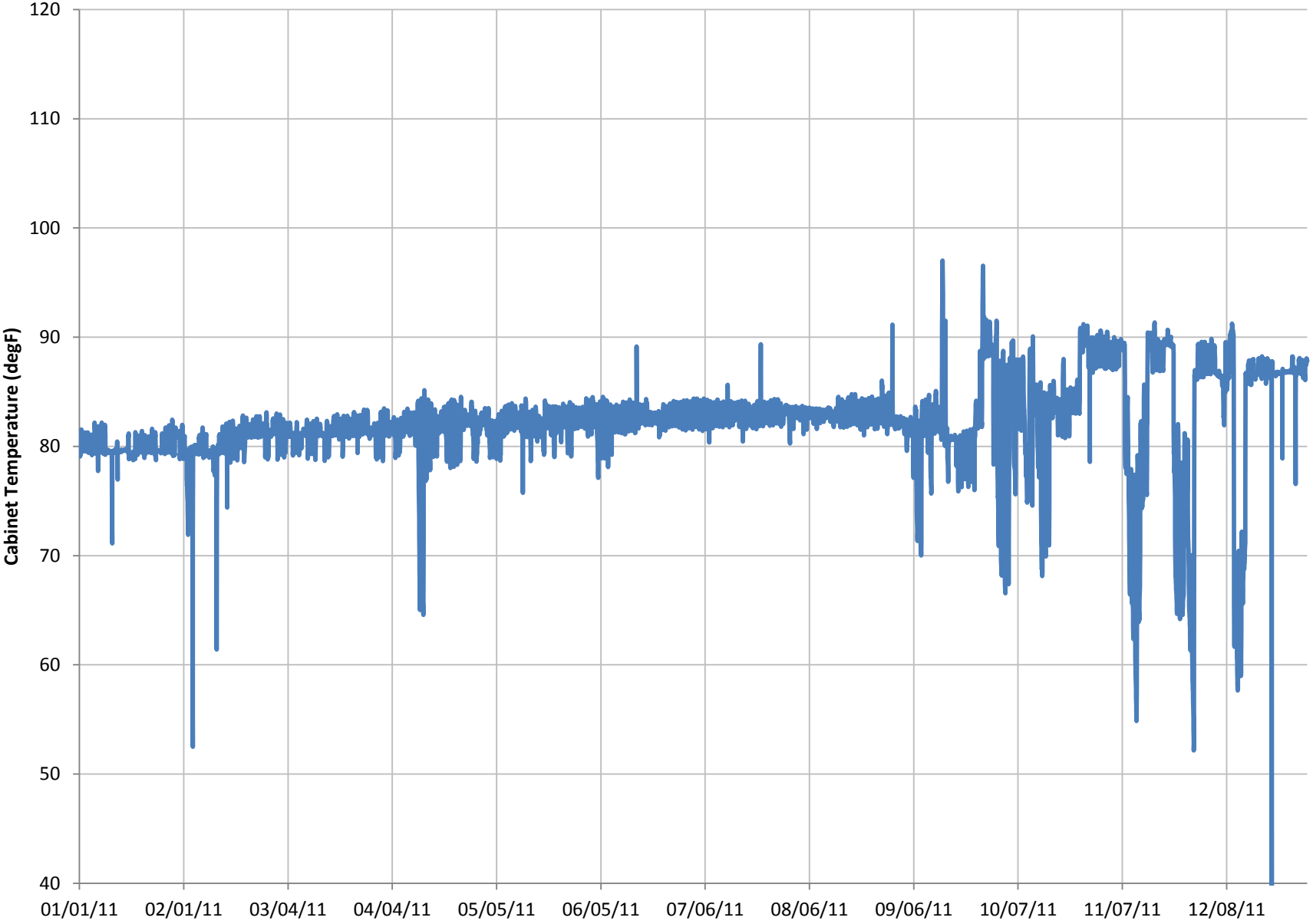
BAM Cabinet Temperature Control Problems

Thermostat Issues

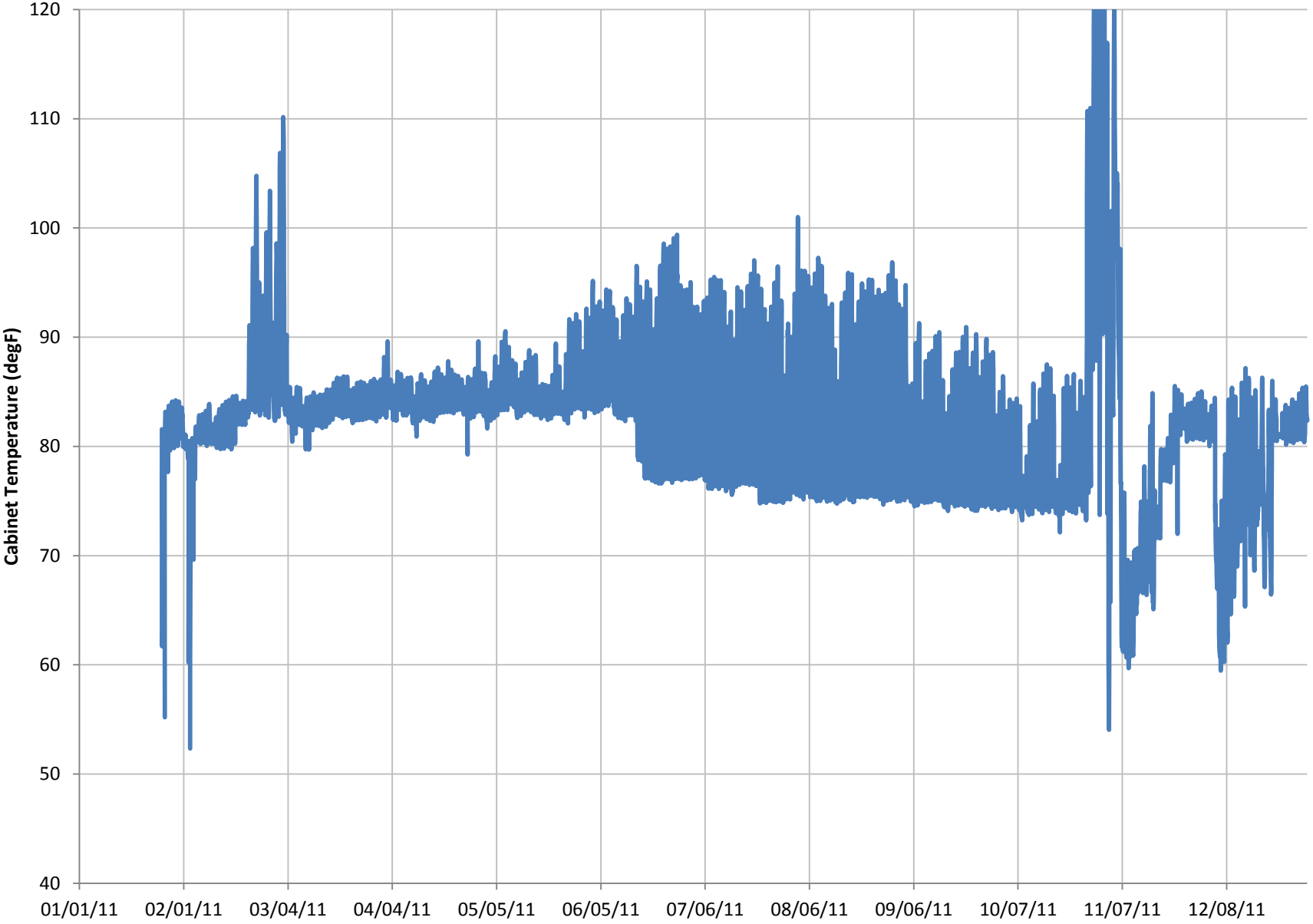
Dallas Hinton C401 Cabinet Temperature



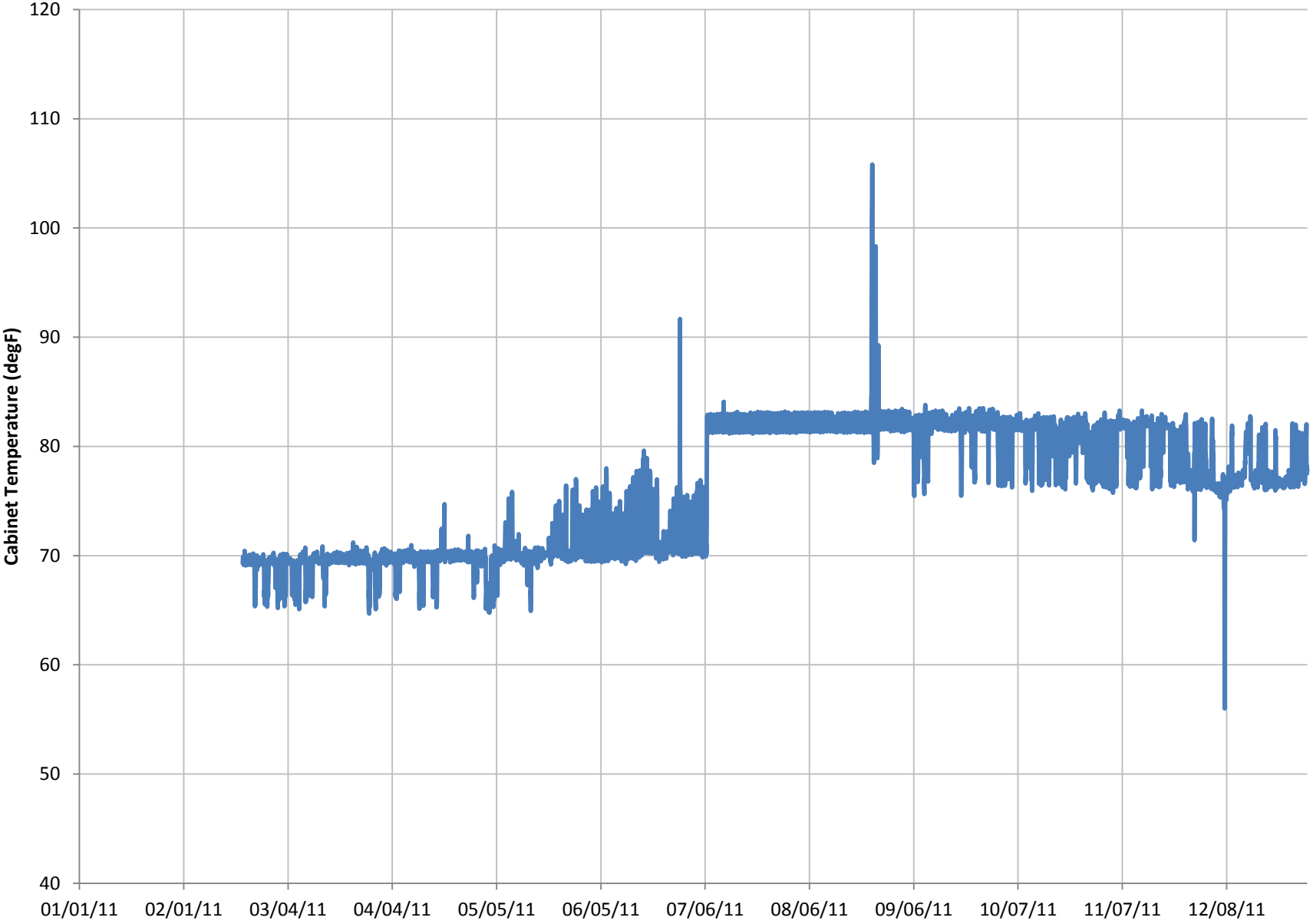
Deer Park C35 Cabinet Temperature 2011



Chamizal C41 BAM Cabinet Temperature



Austin Audubon C38 BAM Cabinet Temperature

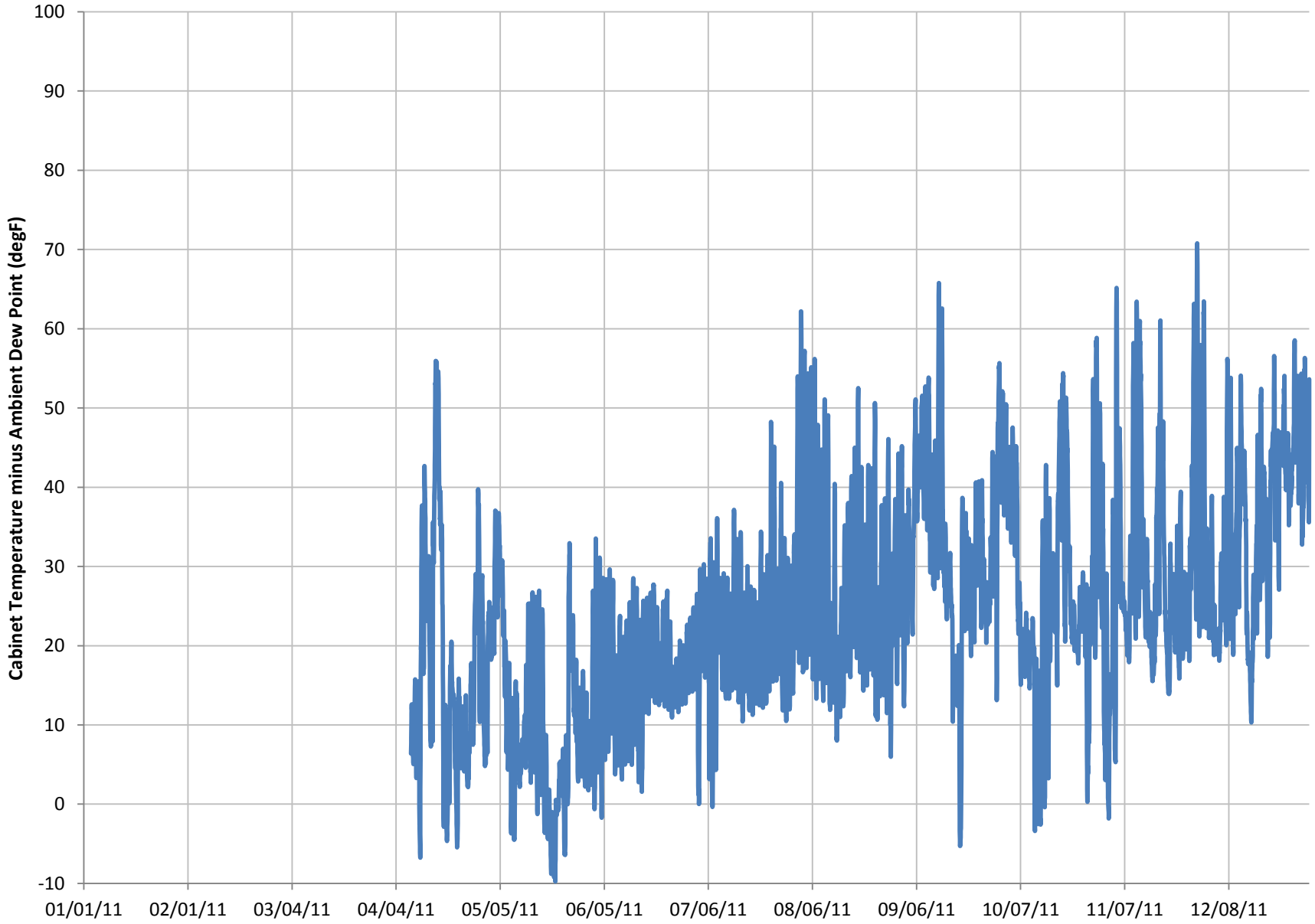


BAM Cabinet Relative Humidity Control Problems

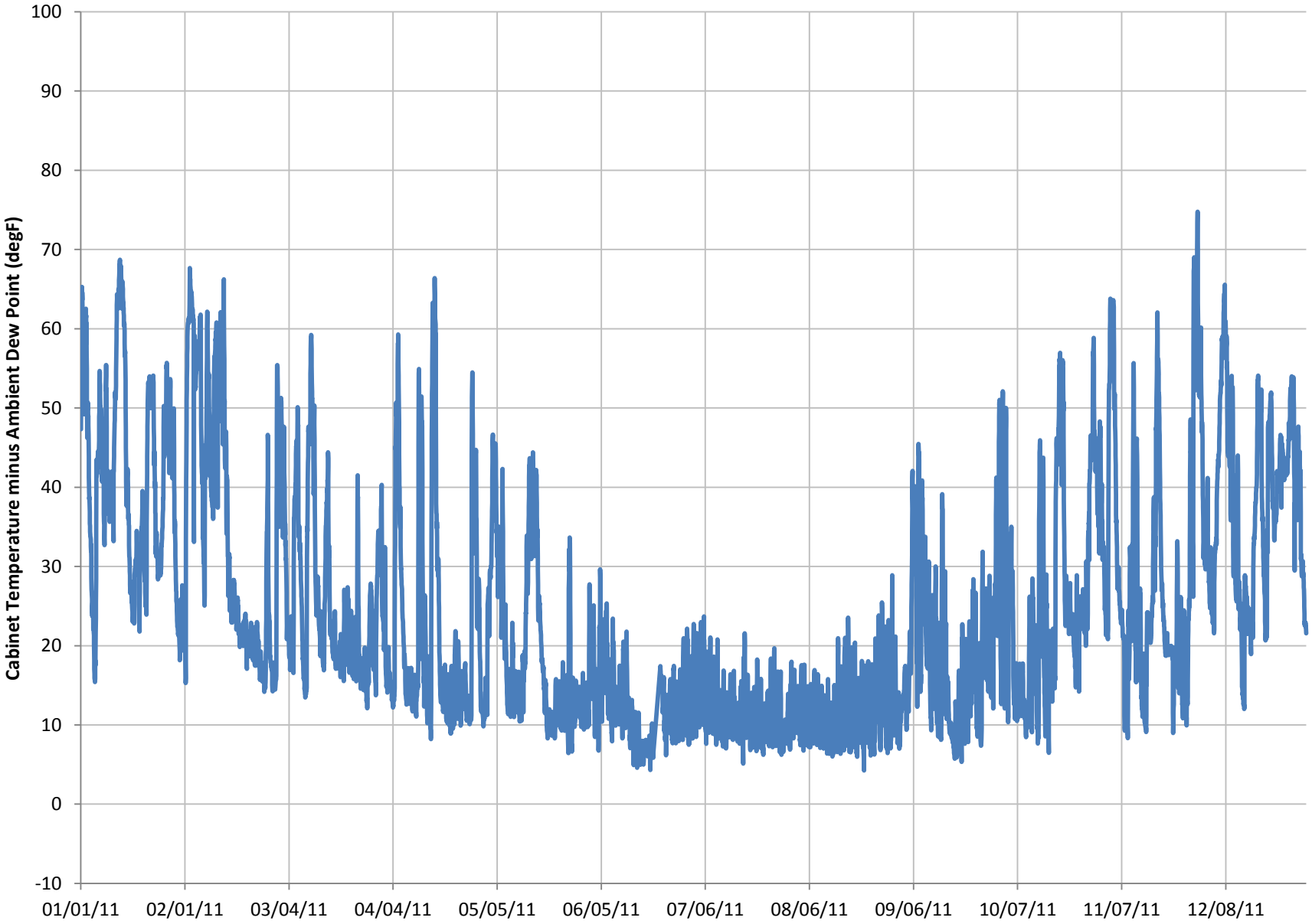
As indicated by cabinet temperature minus ambient dew point

(CT-DP)

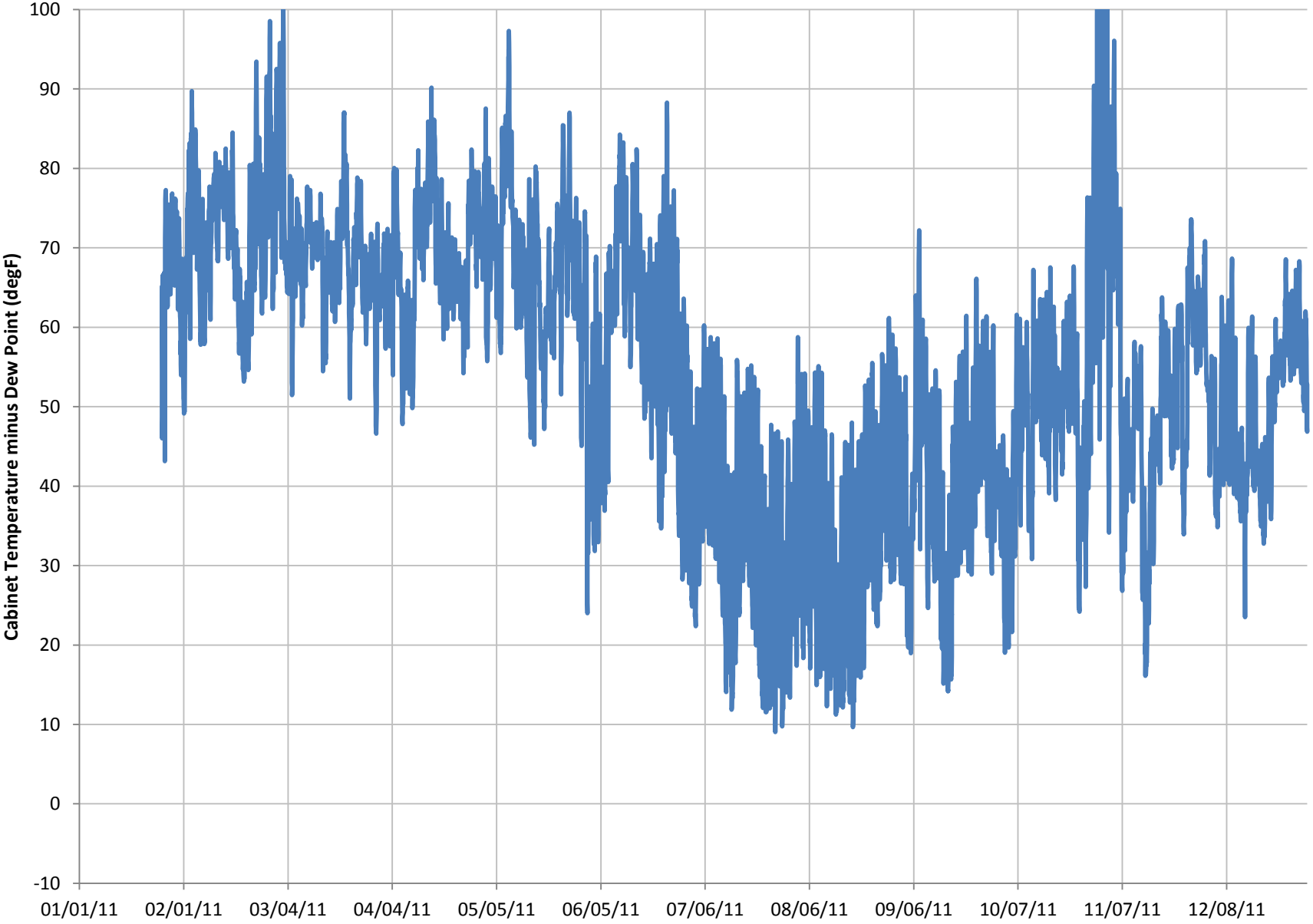
Dallas Hinton C401 Cabinet Temperature minus Dew Point



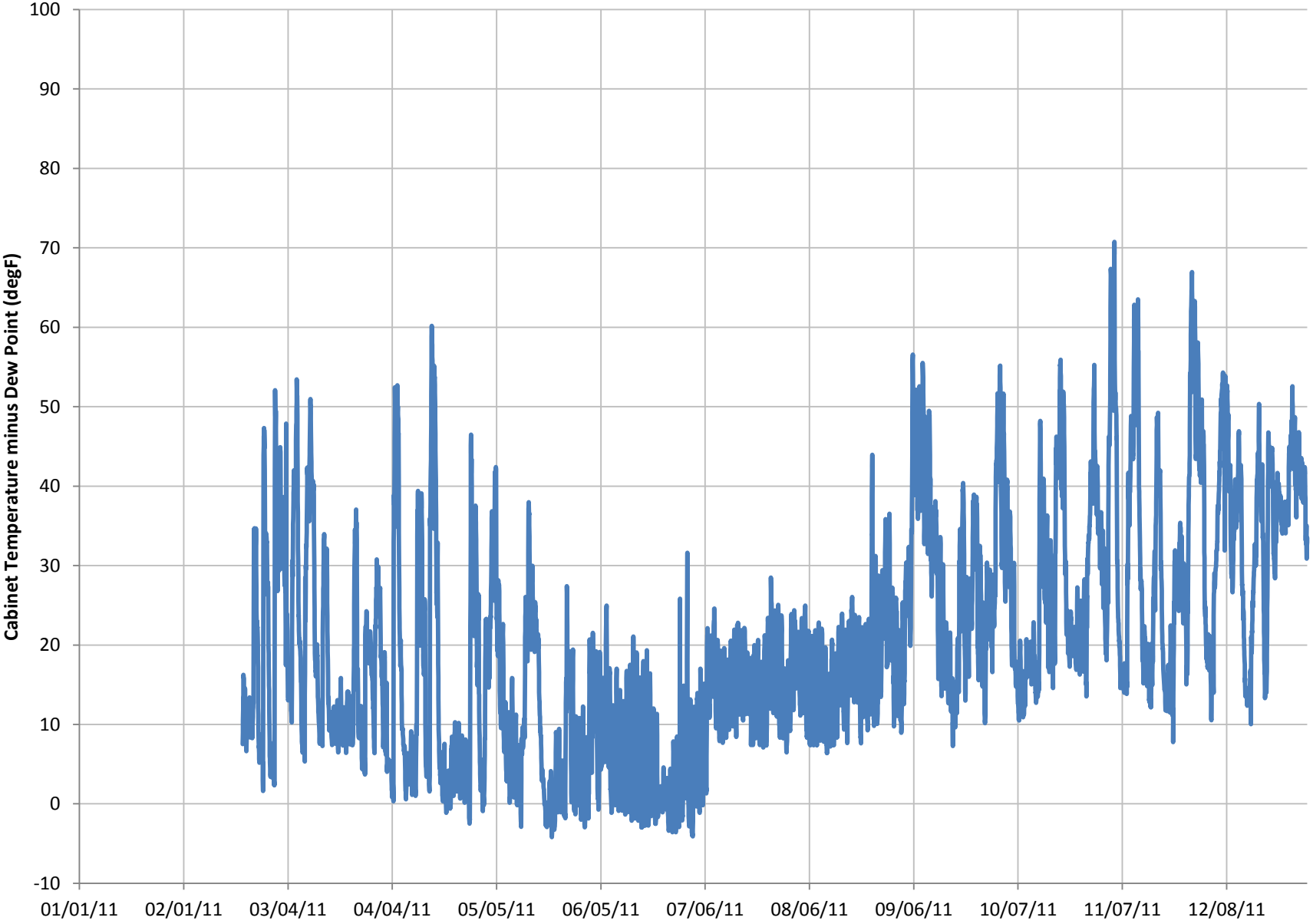
Deer Park C35 Cabinet Temperature minus Dew Point 2011



Chamizal C41 Cabinet Temperature minus Dew Point



Austin Audubon C38 Cabinet Temperature minus Dew Point



Summary of Findings

- Performance of the BAM $PM_{2.5}$ monitors did not meet Federal Equivalent Method (FEM) expectations in 2011
- Major problems with cabinet temperature and relative humidity control were a likely cause of degraded data quality
- BAM PM_{10} measurements were much higher than nearby Federal Reference Method (FRM) Wedding Hi-Volume PM_{10} monitors in El Paso where the cut point is often challenged with heavy loading