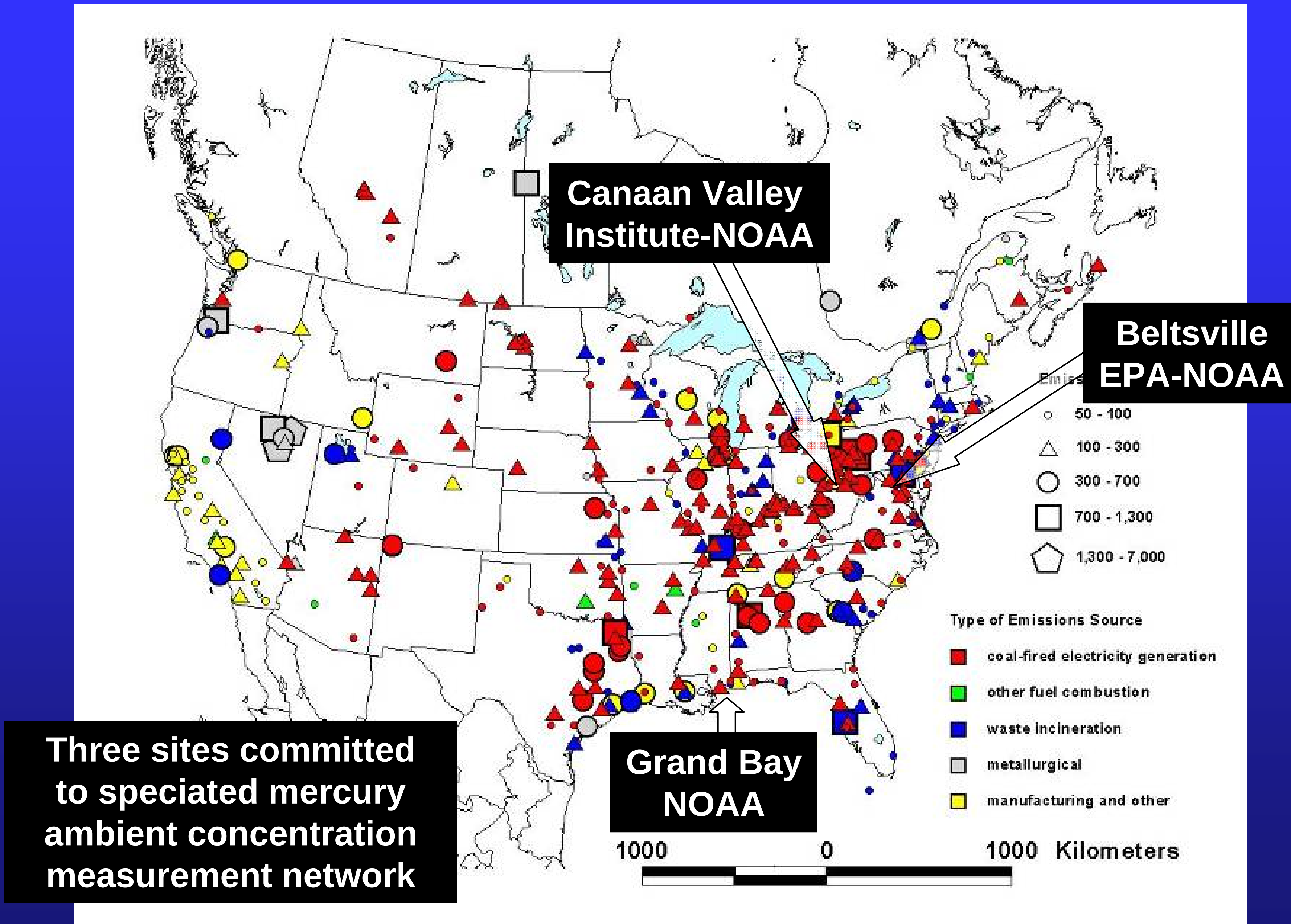
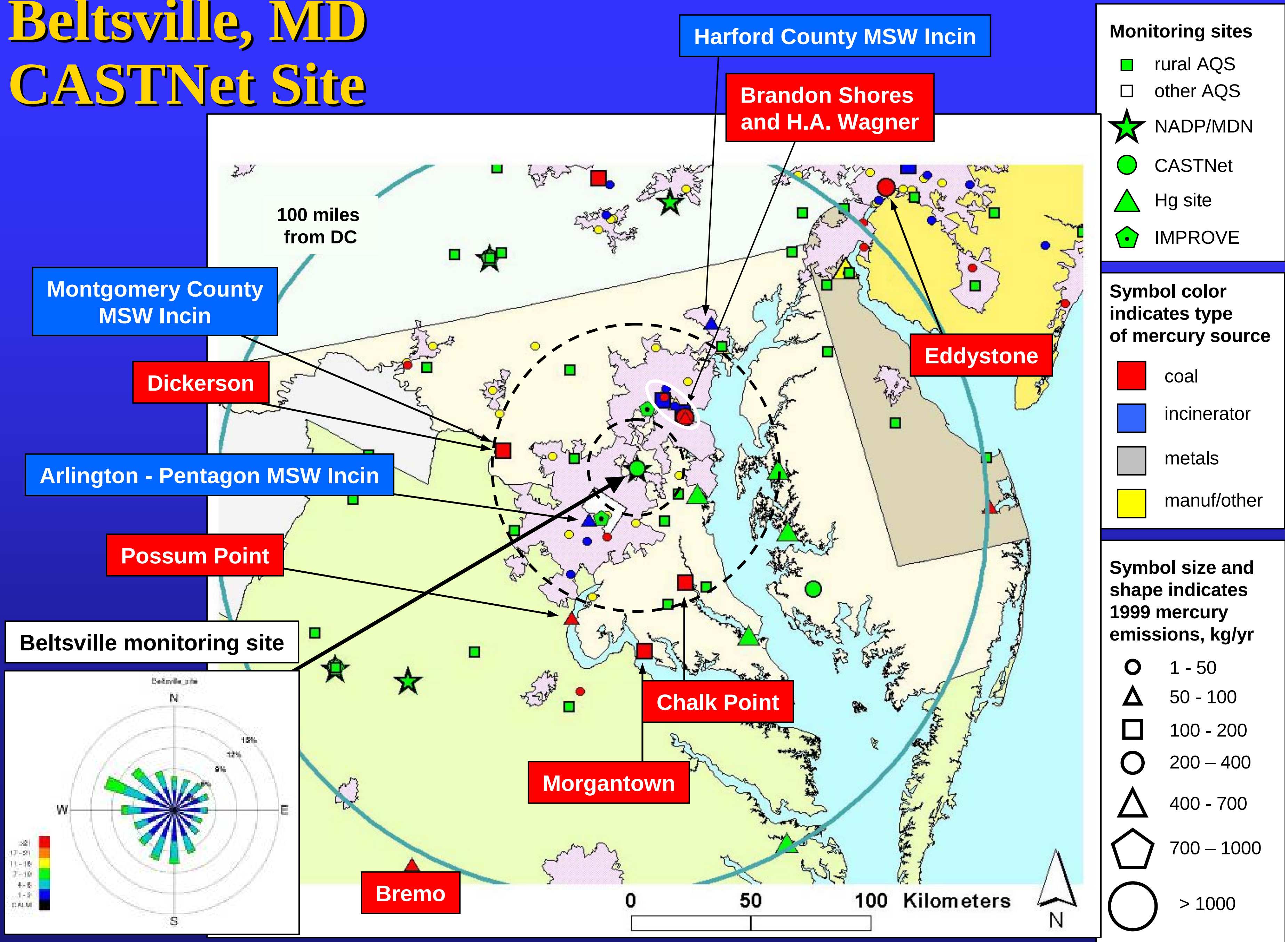
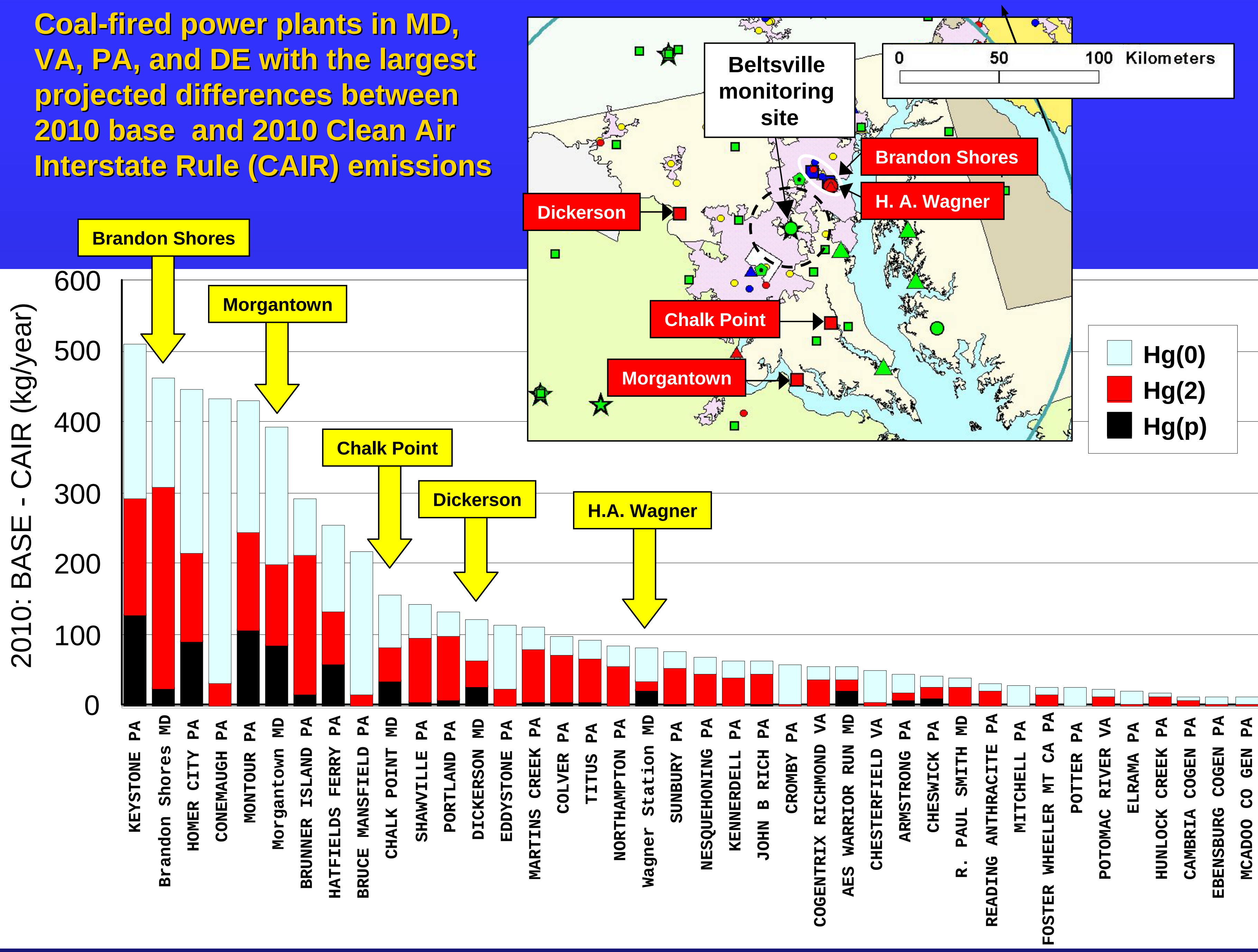
NOAA Collaborative Mercury Sites



Beltsville, MD CASTNet Site



Coal-fired power plants in MD, VA, PA, and DE with the largest projected differences between 2010 base and 2010 Clean Air Interstate Rule (CAIR) emissions



Status of Atmospheric Measurements at Beltsville, MD CASTNet Site

Measurement
Elemental mercury
Fine particulate mercury
Reactive gaseous mercury
Sulfur dioxide
Ozone
Carbon Monoxide
Nitrogen Oxides (NO, NOy)
Wind speed
Wind Direction
Relative Humidity
Temperature
Precipitation
SO_4^{2-}, NO_3^-, NH_4^+, HNO_3, SO_2 (Weekly)
Total mercury in precipitation (weekly)
Major ions in precipitation (weekly)

Tekran Speciation System

- Installed System 1 (NOAA) Nov. 7, 2006
  Height of Inlet: 3.75 m above ground
  0.5 m above trailer

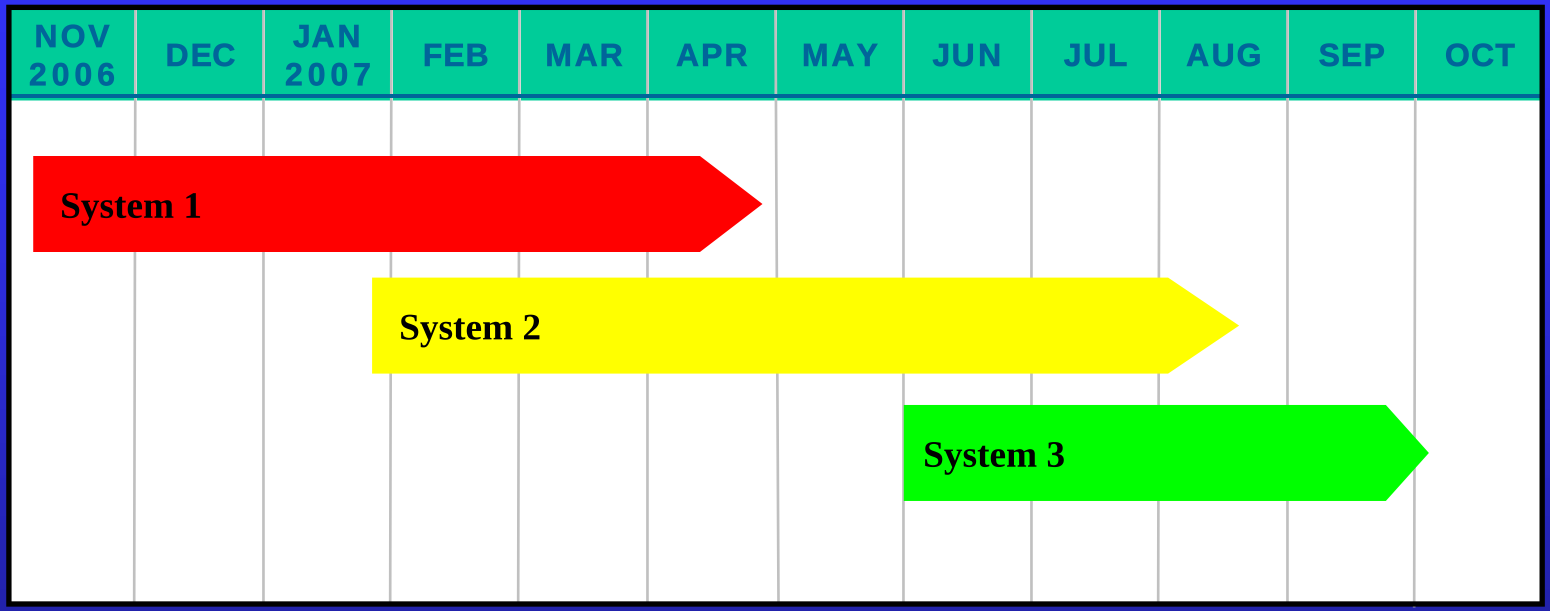
- Installed second system
  (System 2-NOAA) Jan 26, 2007

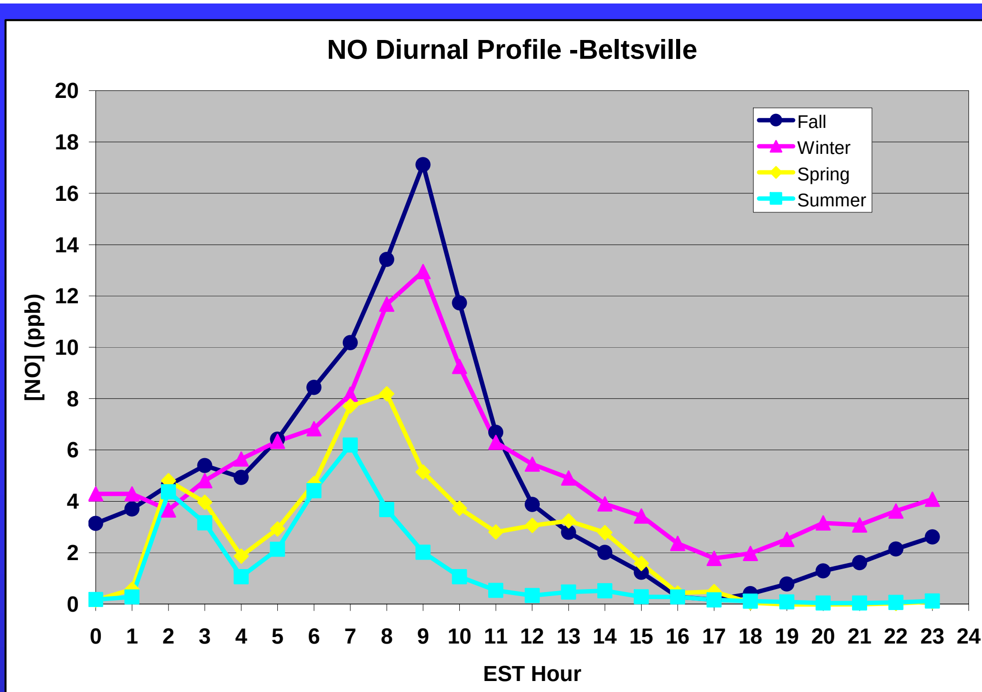
- System 1 removed April 27, 2007

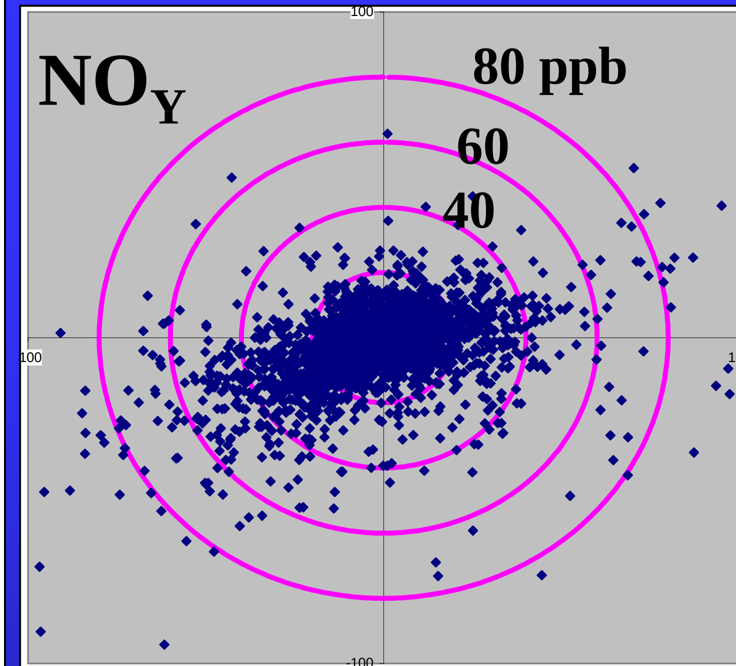
- Install System 3 (EPA) June 1, 2007

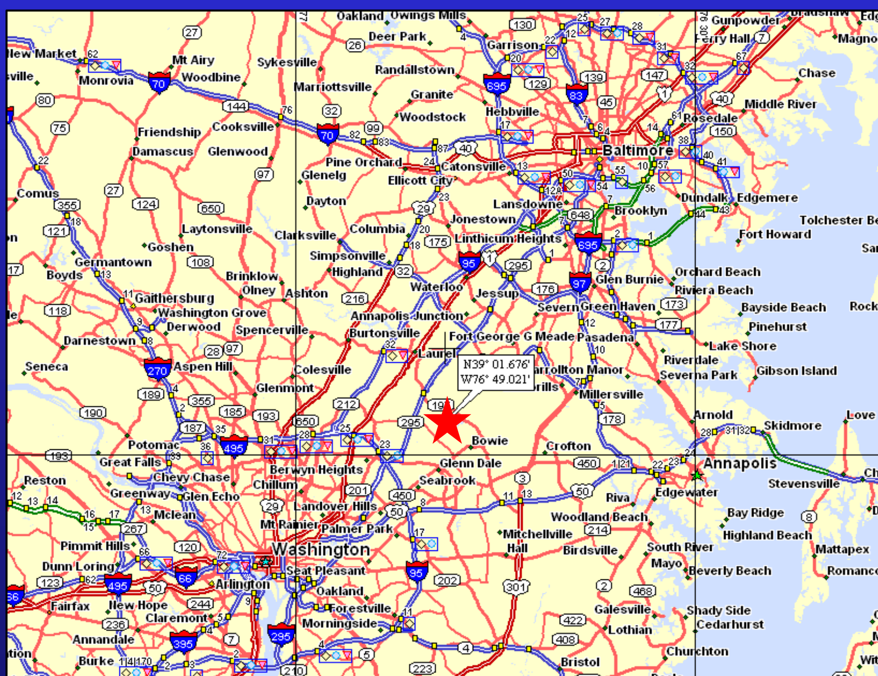
- Remove System 2 August 17, 2007

Tekran Deployment Timeline -Beltsville

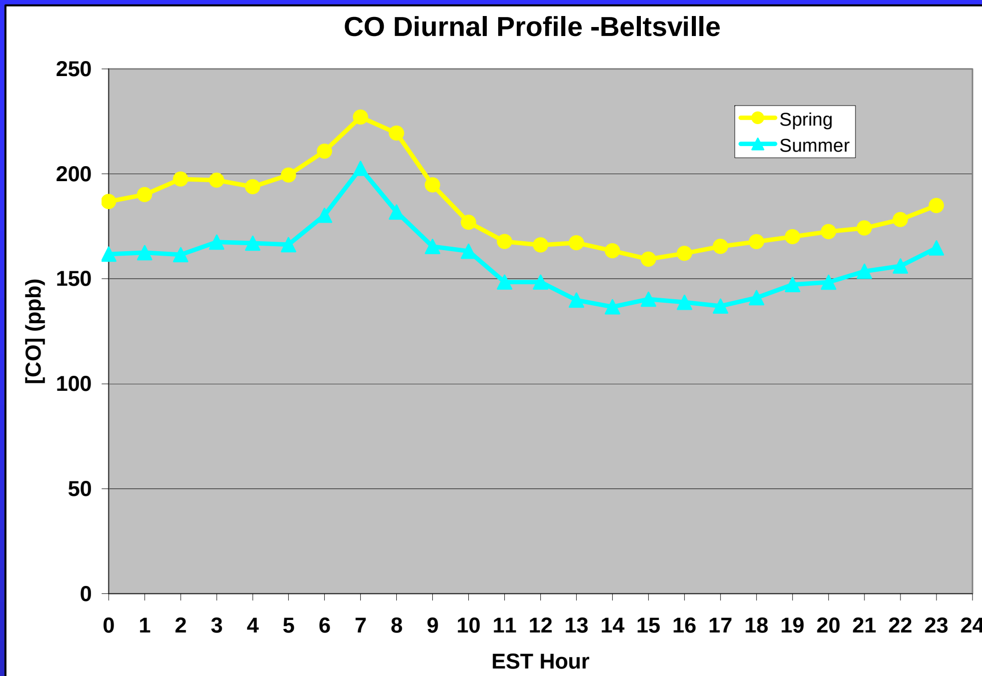


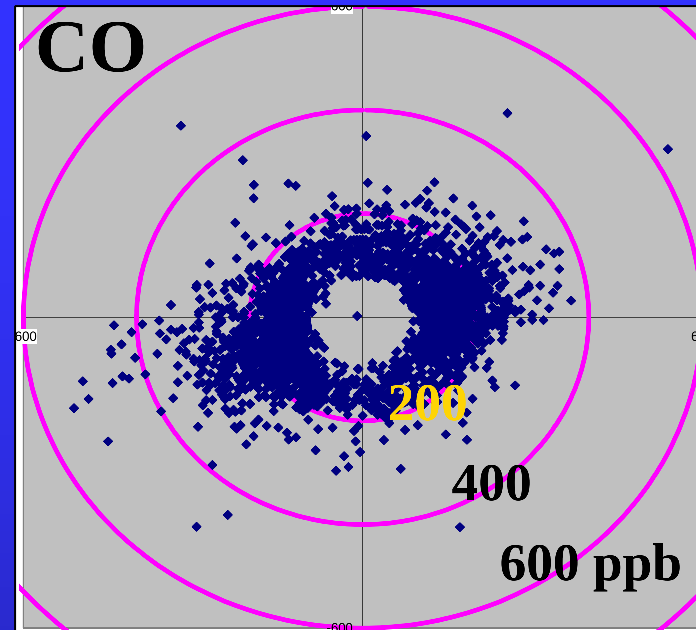


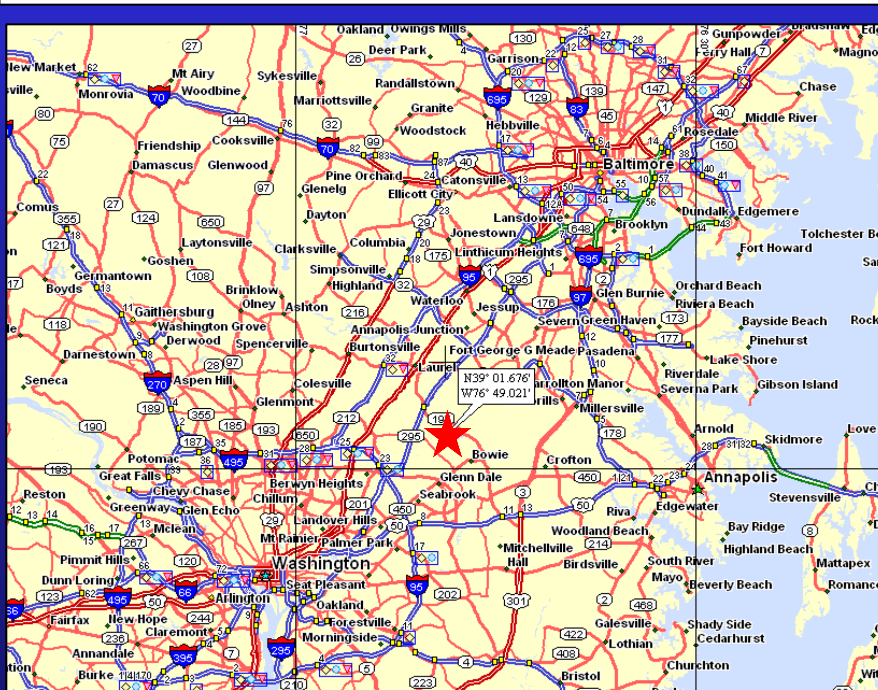




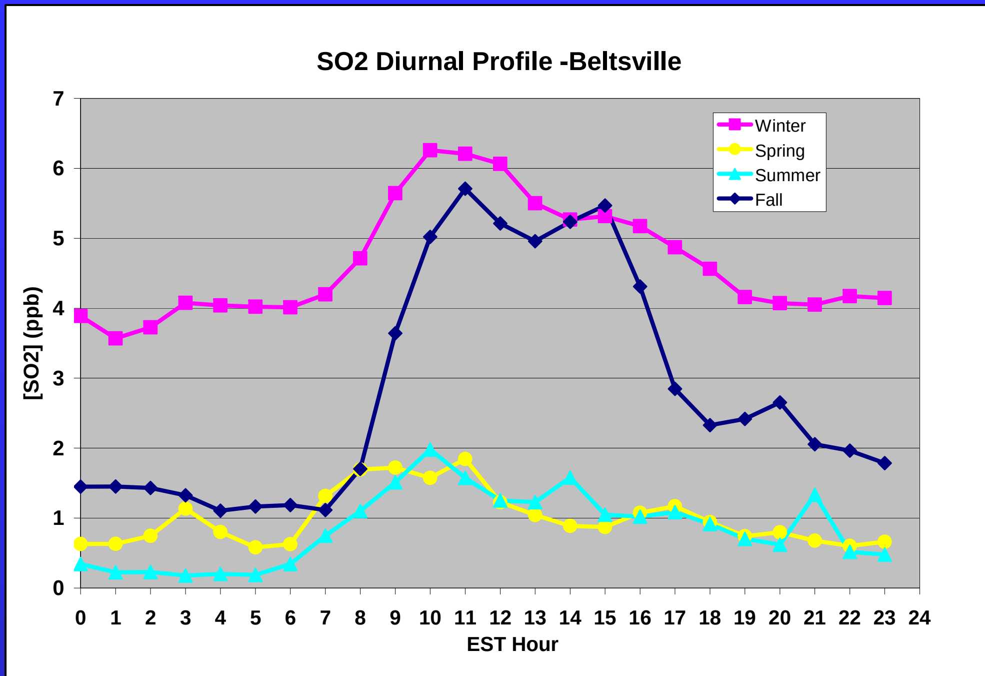
Site is influenced by vehicular traffic in Washington Metropolitan area, particularly pronounced during the morning rush hour. Higher boundary layer in the afternoon/evening dilutes vehicular emissions.

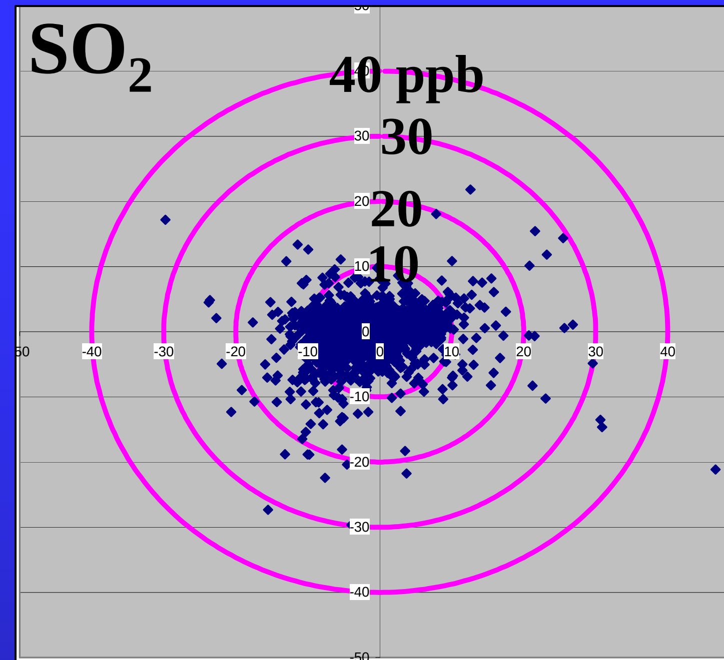


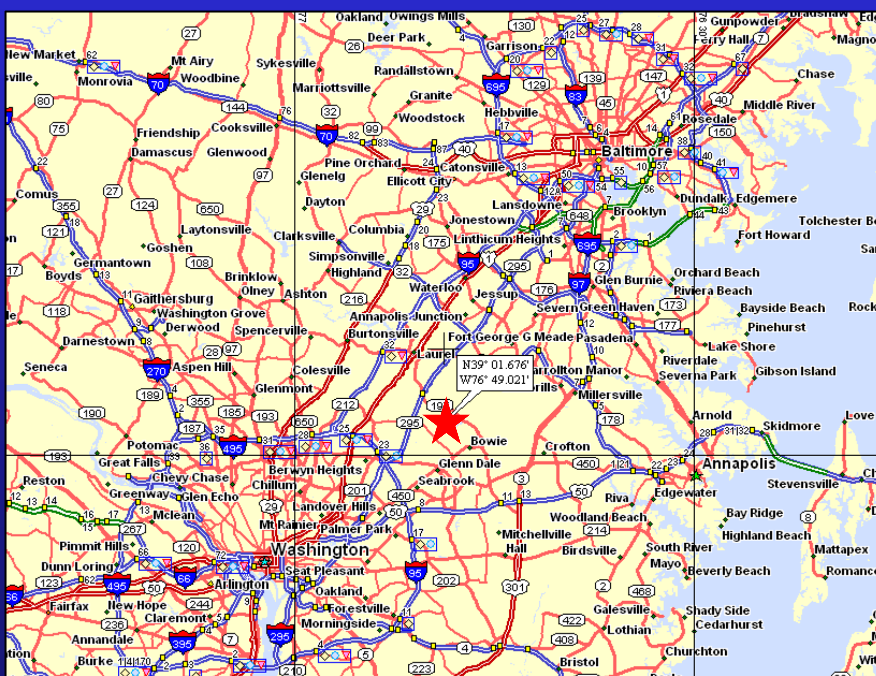




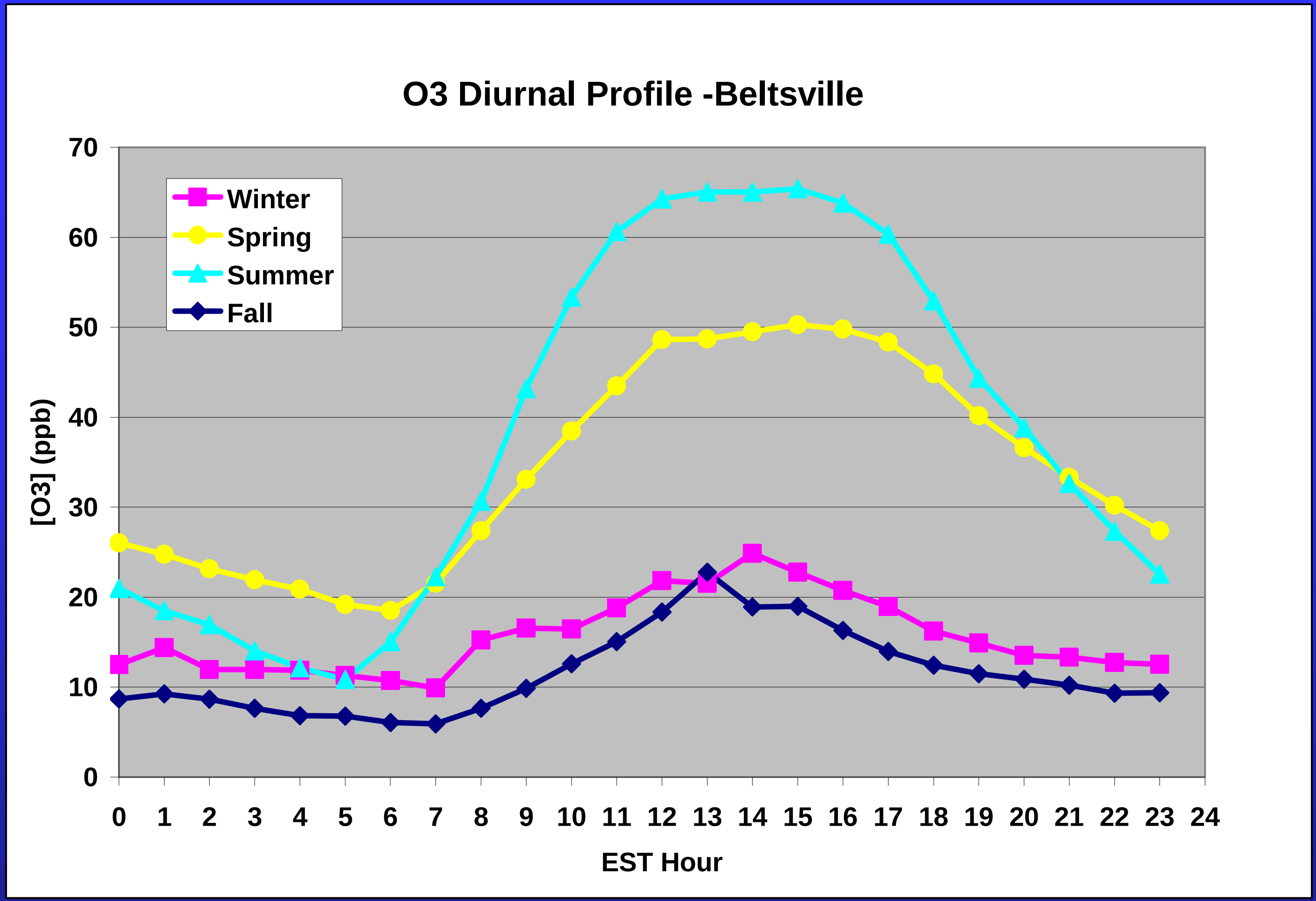
Concentrations of CO at the site also reflect the impact of vehicular emissions, but the efficacy of emission controls in the past decade have reduced the strength of this signal.



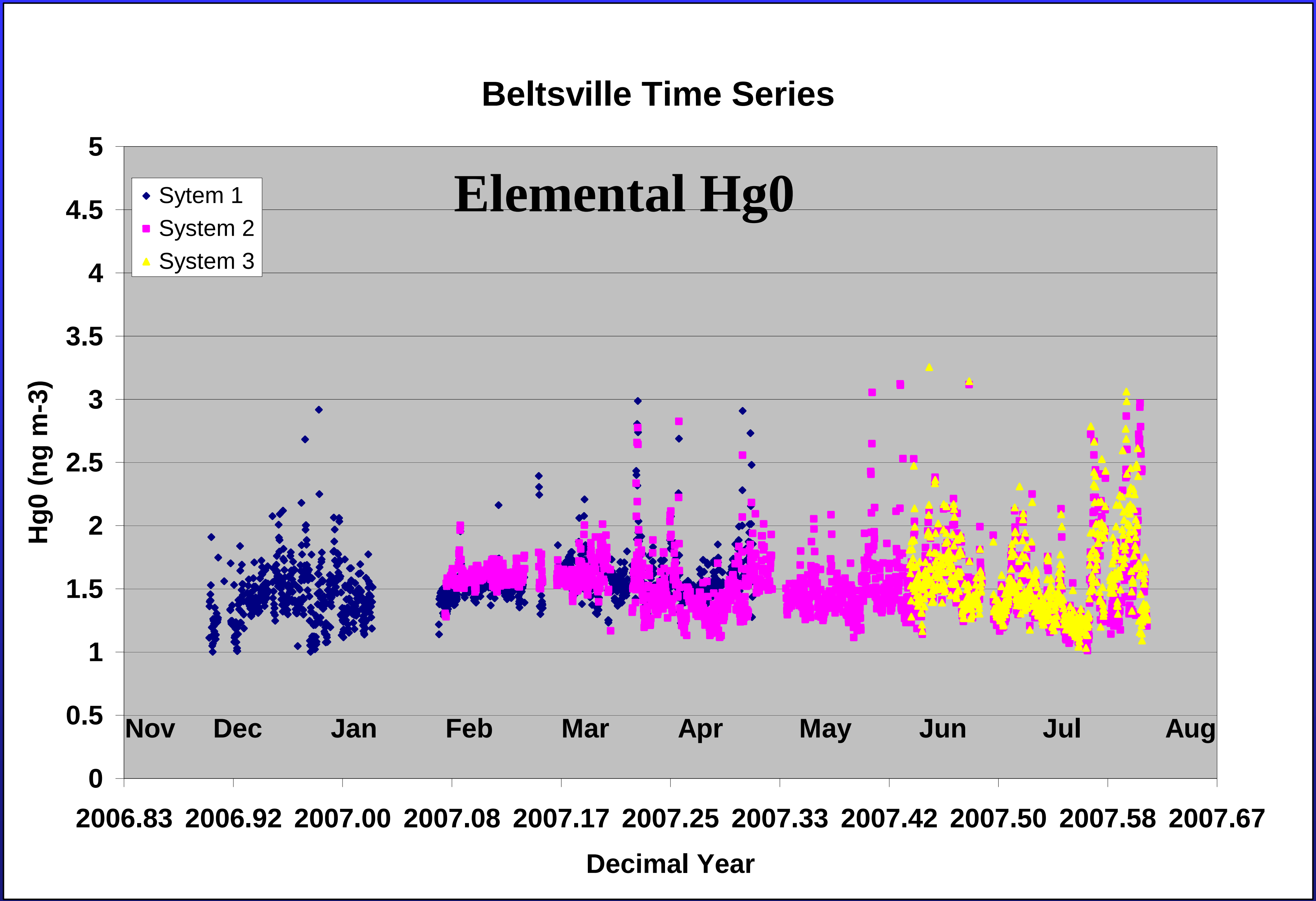




Site is also influenced by point-source emitters in the region. Higher concentrations in Fall and Winter reflect lower boundary layer heights, slower conversion of SO_2 to SO_4^{2-}

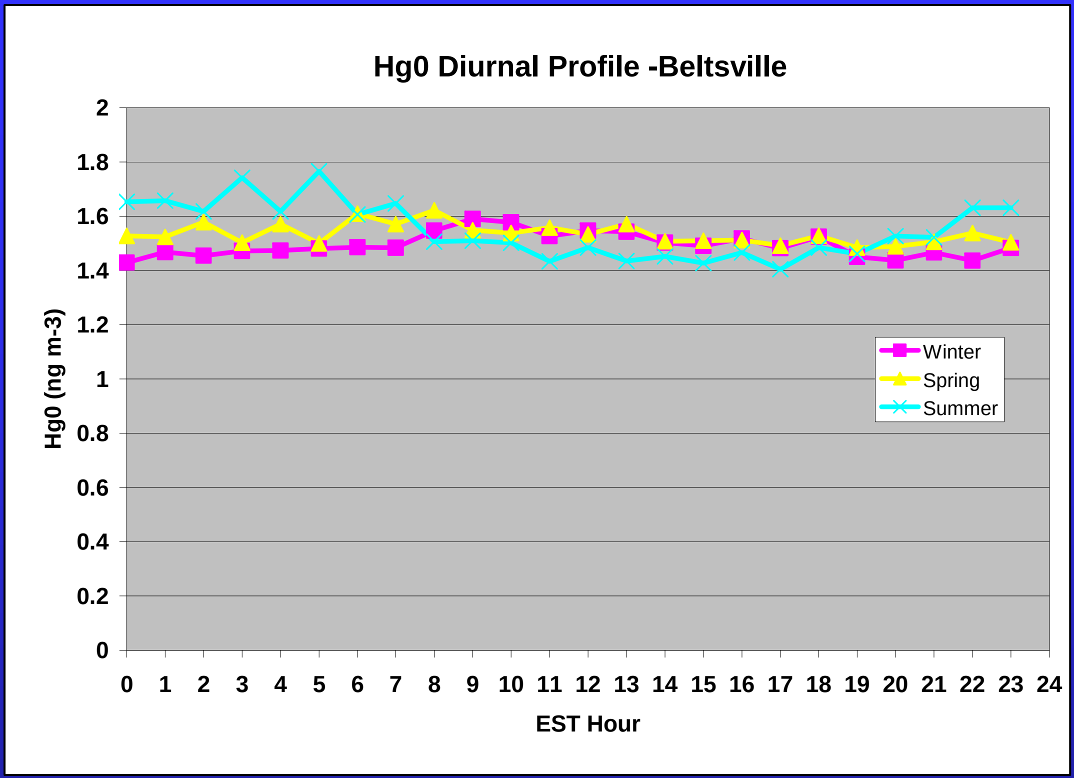


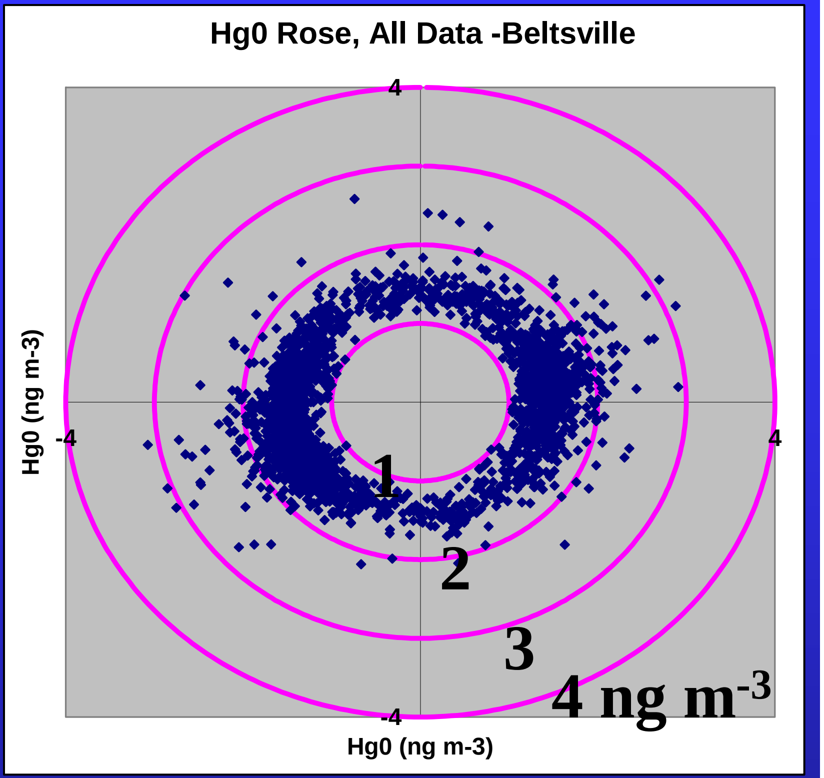
Photochemical ozone generation in the Spring and Summer leads to elevated concentrations in mid-day. Note the later time of boundary layer breakup in Fall and Winter, as evidenced by later onset of daytime increase.



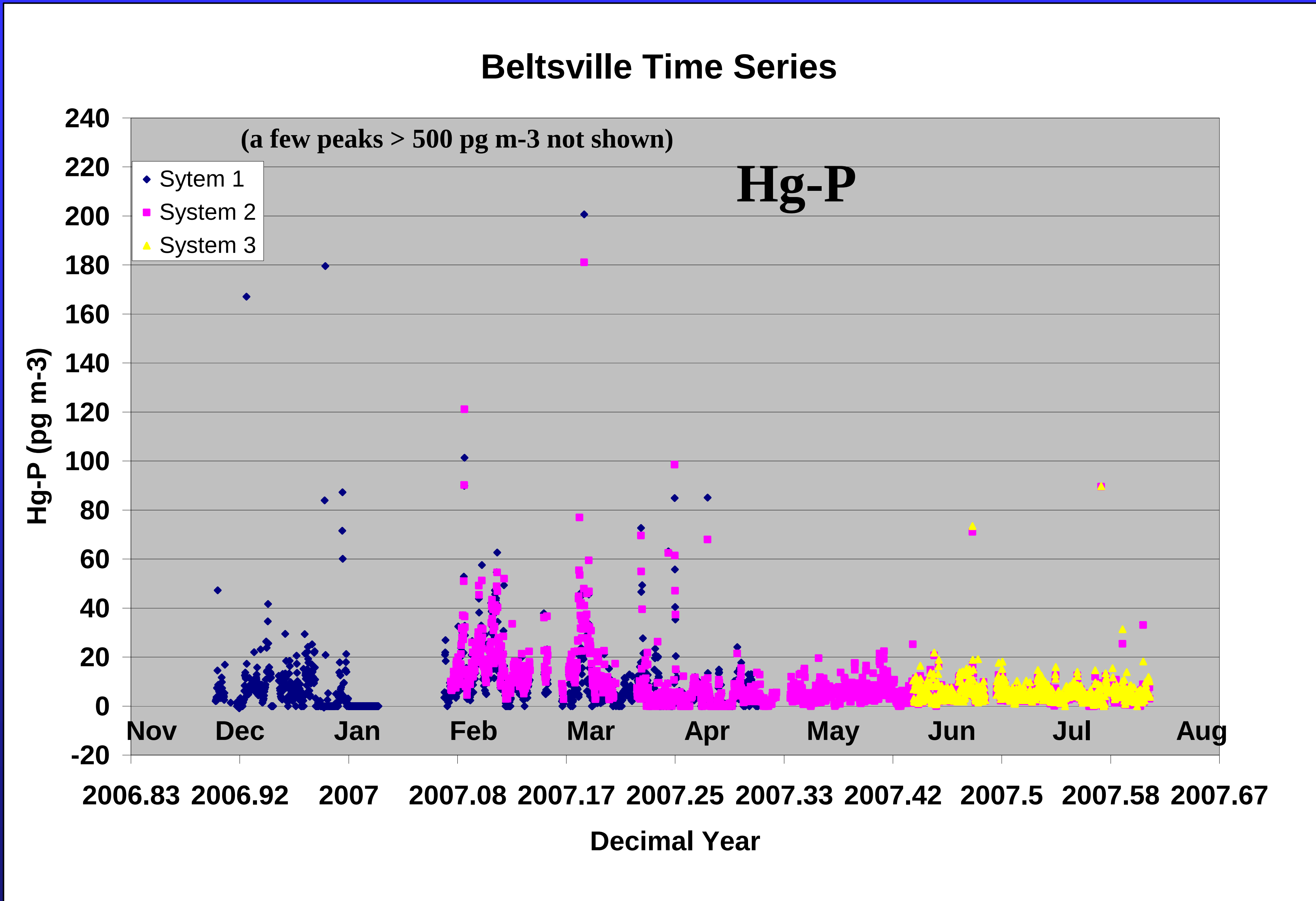
Beltsville Time Series
Elemental Hg0
Sytem 1
System 2
System 3
Hg0 (ng m-3)
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
2006.83
2006.92
2007.00
2007.08
2007.17
2007.25
2007.33
2007.42
2007.50
2007.58
2007.67
Decimal Year

Elemental Mercury (Hg^0) at Beltsville

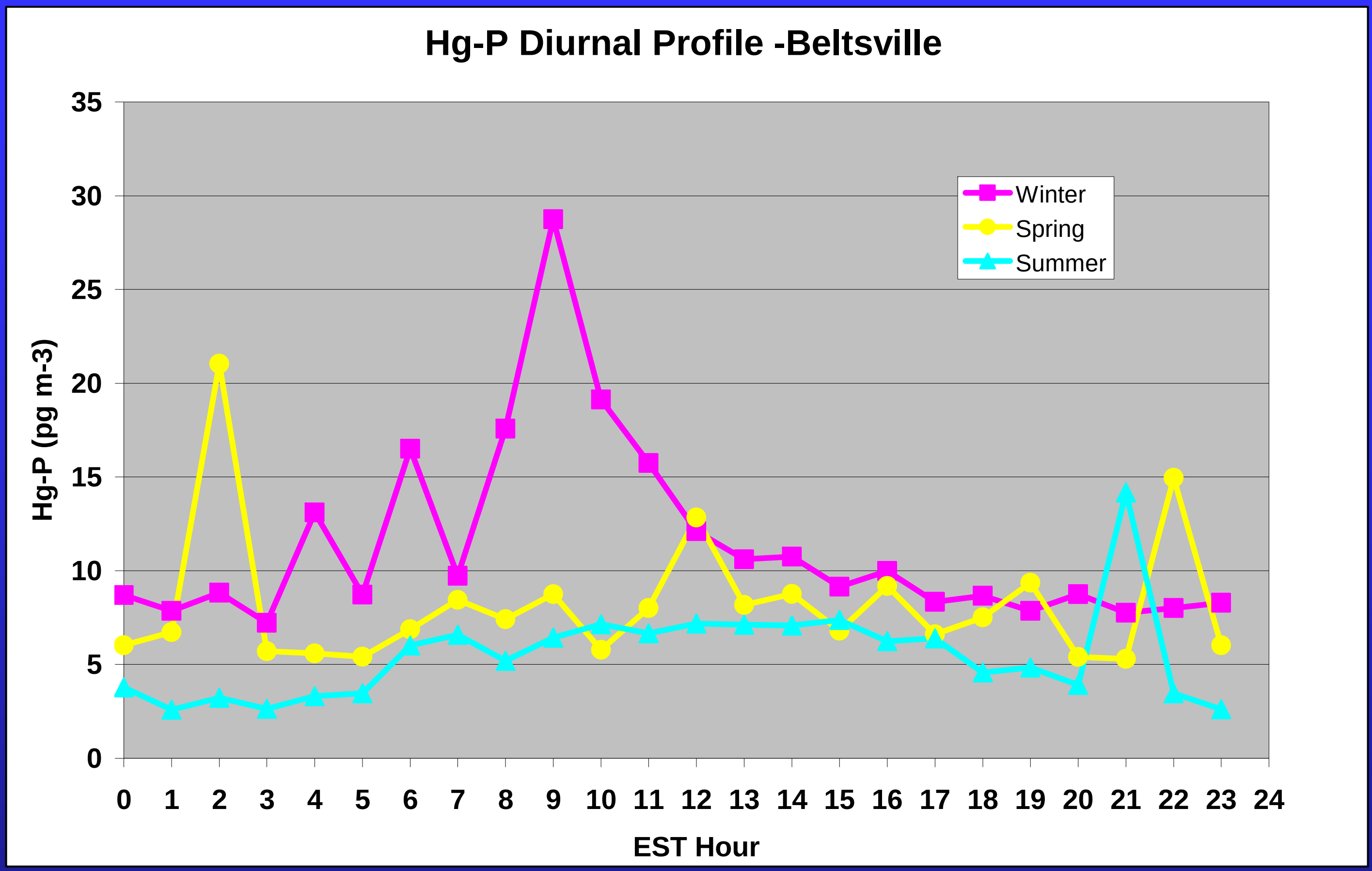




As expected, Hg0 at Beltsville shows no diurnal pattern, little dependence on WD, consistent with a long-lived, ubiquitous, and well mixed trace species. Note that emission source regions match those for SO_2, NO_Y, CO

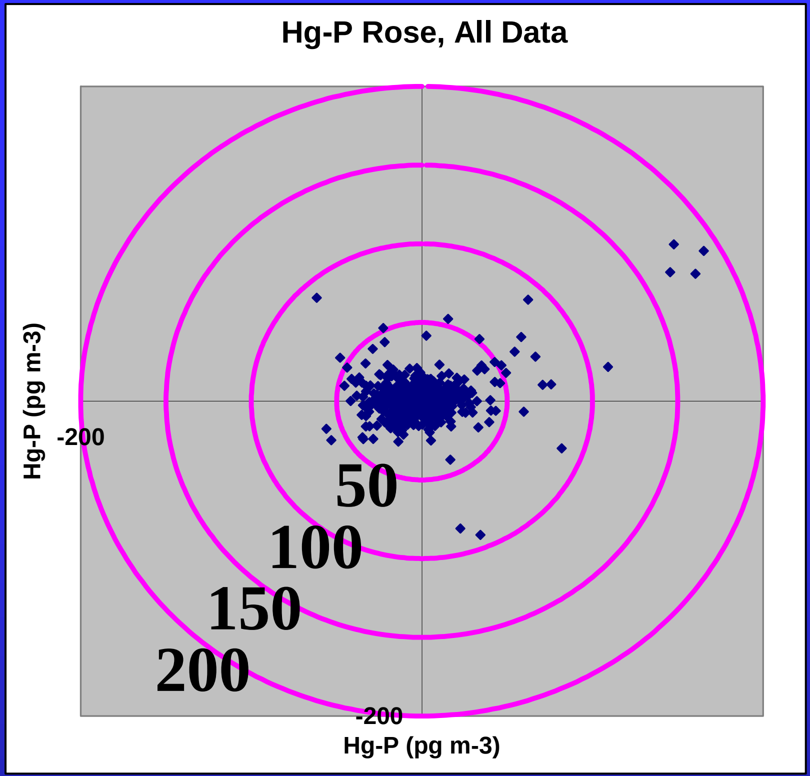

Beltsville Time Series
(a few peaks > 500 pg m-3 not shown)
Hg-P
Sytem 1
System 2
System 3
Hg-P (pg m-3)
240
220
200
180
160
140
120
100
80
60
40
20
0
-20
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
2006.83
2006.92
2007
2007.08
2007.17
2007.25
2007.33
2007.42
2007.5
2007.58
2007.67
Decimal Year

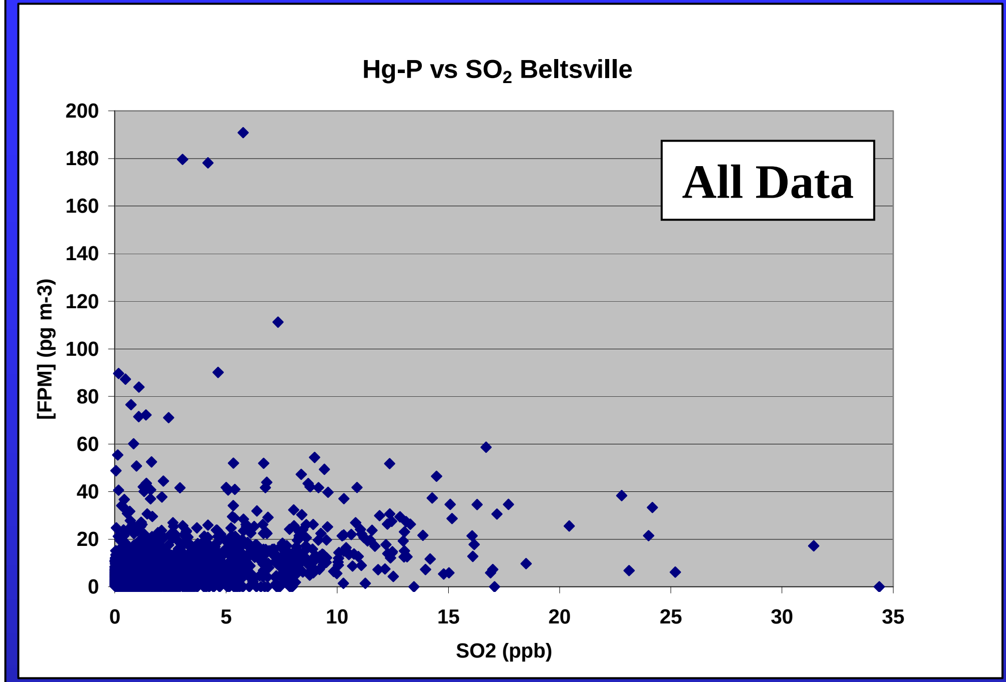
Particulate Mercury (Hg-P)

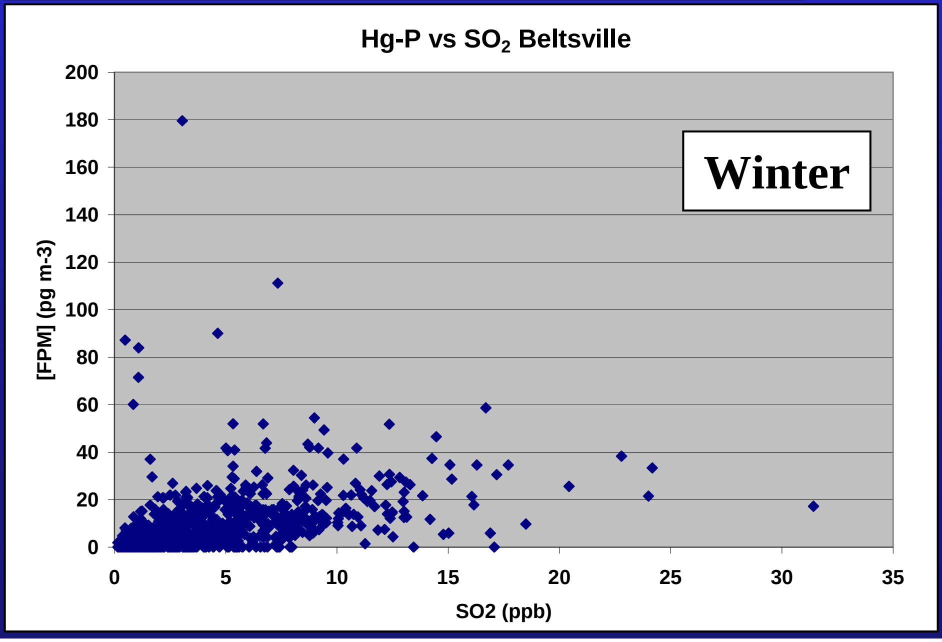


Little diurnal variation in Hg-P concentrations, with some evidence of entrainment of higher concentrations aloft beginning in the morning, after the breakup of the nocturnal inversion. Spikes due to influence of a few high-concentration events.

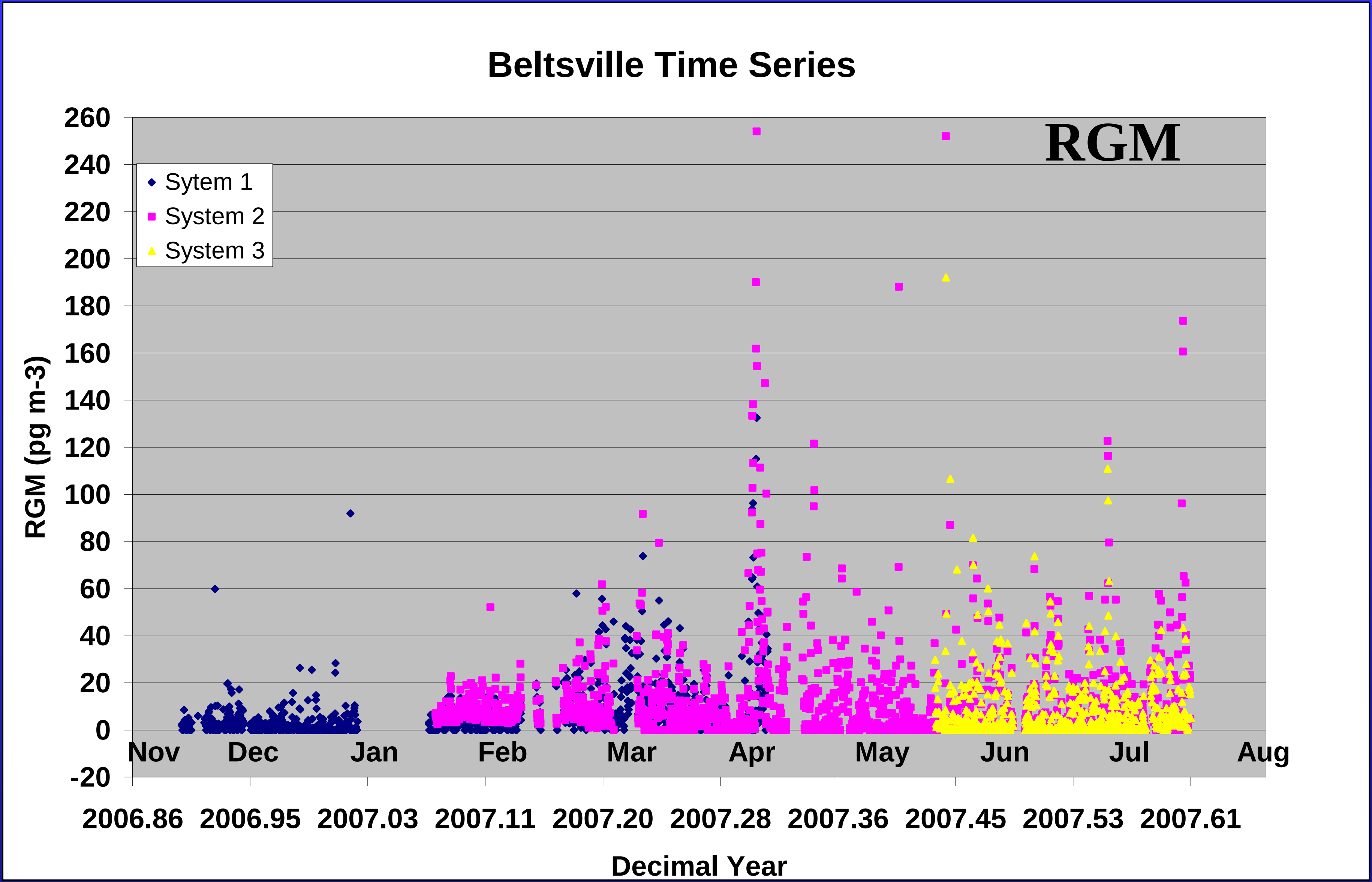
Particulate Mercury (Hg-P)





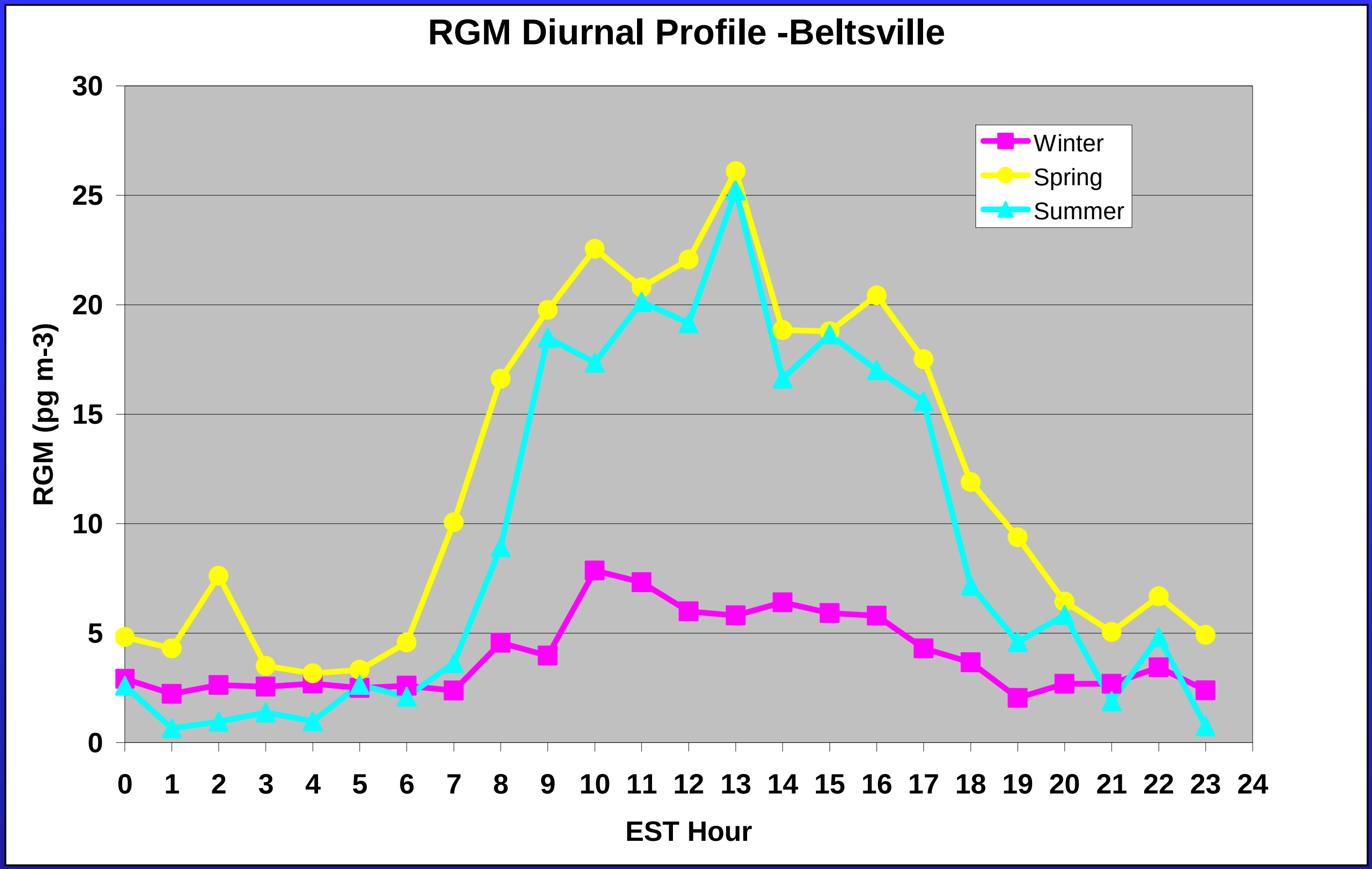


Hg-P concentrations are highest during NE flow, consistent with the distribution of local/regional sources. Concentrations show some association with SO_2, especially in Winter. Power plants emit little Hg-P.

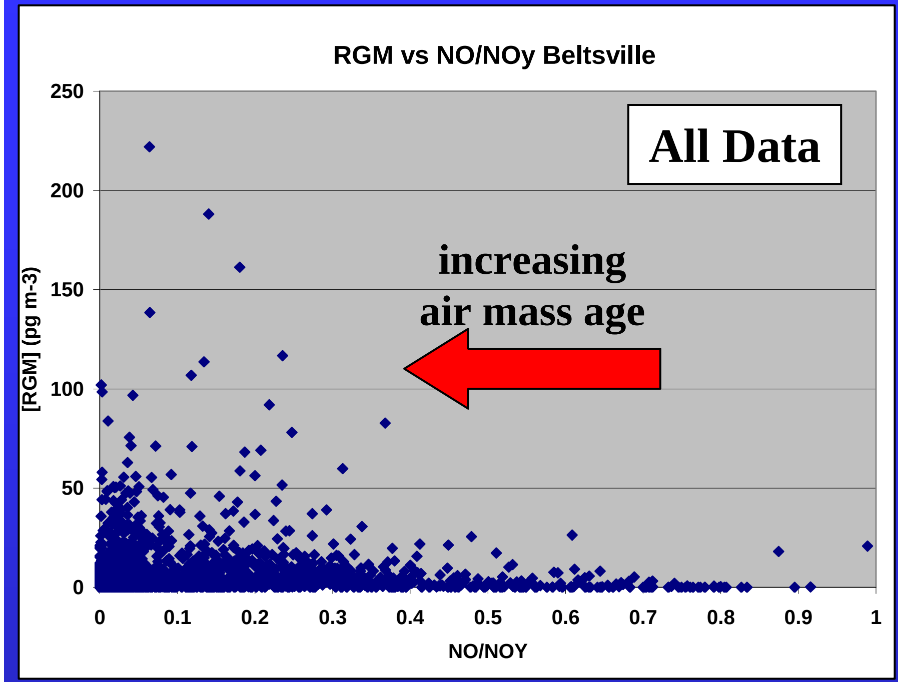


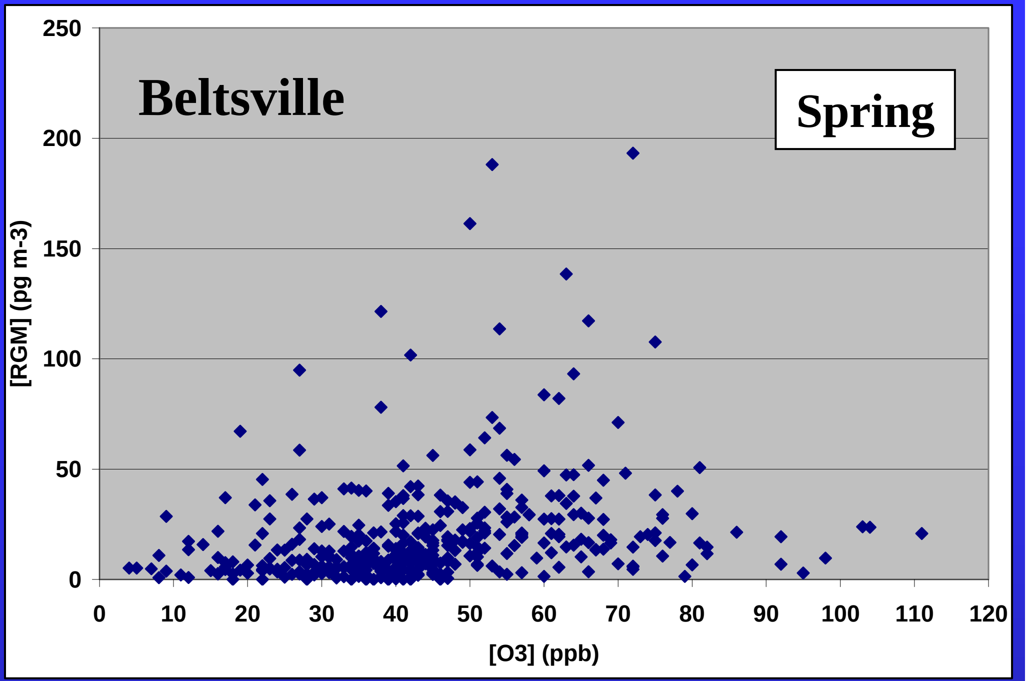
RGM concentrations generally < 20 pg m^{-3}, with more frequent peaks in concentration than was seen for Hg-P

Reactive Gaseous Mercury (RGM)



More pronounced diurnal variation in RGM concentrations, again showing evidence of entrainment of higher concentrations aloft with the breakup of the nocturnal inversion. Large seasonal differences may point to secondary (photochemical) source of RGM as well.

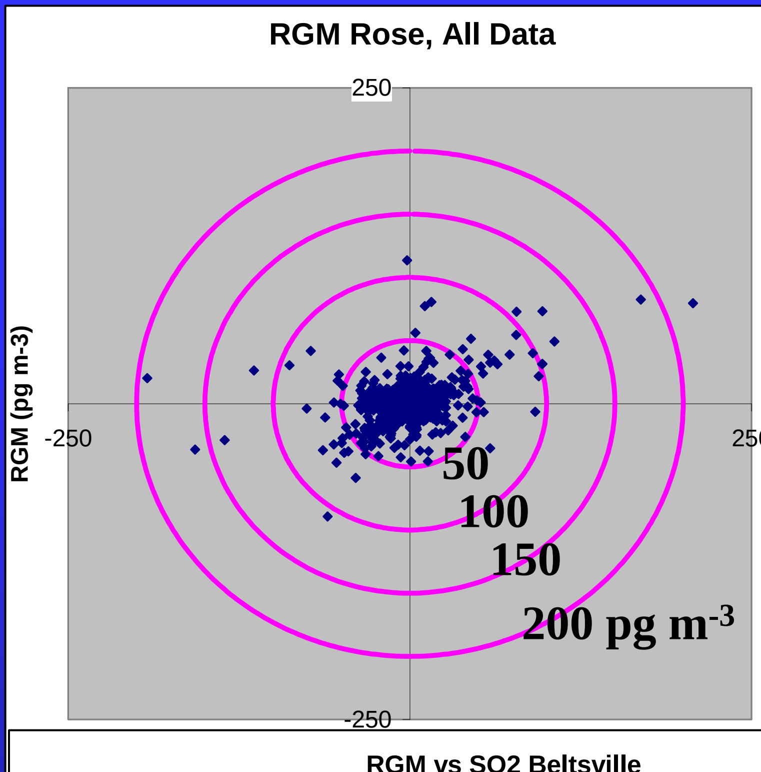




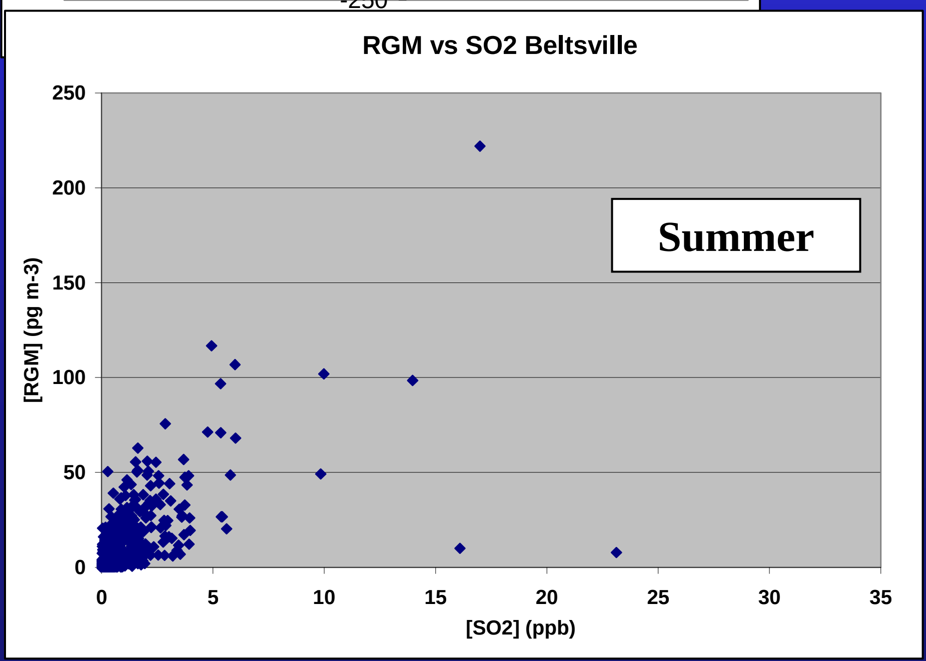
Association of high RGM with high O_3 and aged air masses (low NO/NO_Y ratios) suggests that secondary production of RGM may be occurring.

However, high concentrations of RGM may arise from primary emissions from sources a few hours away – and the air masses are somewhat aged on arrival at the site.

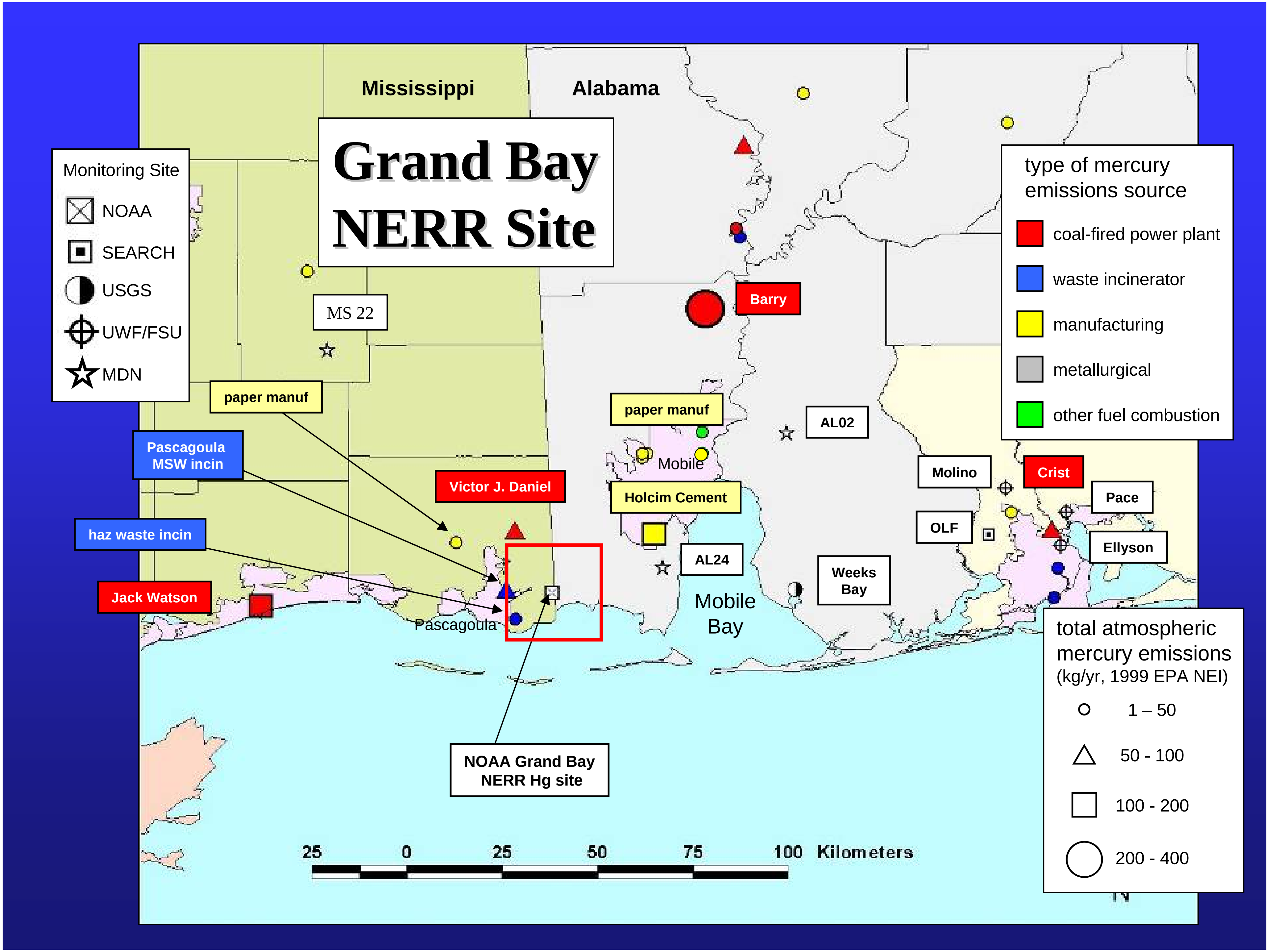
Reactive Gaseous Mercury (RGM)



Directionality of [RGM] shows lobes to the SW and NE, coincident with known local sources of mercury and other primary trace species.



RGM is most closely associated with SO_2 at Beltsville (Summer) suggesting that point-source emissions also play an important role in influencing RGM concentrations at the site


Grand Bay NERR Site
Mississippi
Alabama
Monitoring Site
NOAA
SEARCH
USGS
UWF/FSU
MDN
MS 22
paper manuf
Pascagoula MSW incin
haz waste incin
Jack Watson
Victor J. Daniel
Pascagoula
NOAA Grand Bay NERR Hg site
Barry
paper manuf
Mobile
Holcim Cement
AL02
AL24
Mobile Bay
Weeks Bay
Molino
OLF
Crist
Pace
Ellyson
type of mercury emissions source
coal-fired power plant
waste incinerator
manufacturing
metallurgical
other fuel combustion
total atmospheric mercury emissions (kg/yr, 1999 EPA NEI)
1 – 50
50 - 100
100 - 200
200 - 400
25 0 25 50 75 100 Kilometers

Status of Atmospheric Measurements at Grand Bay NERR, Mississippi

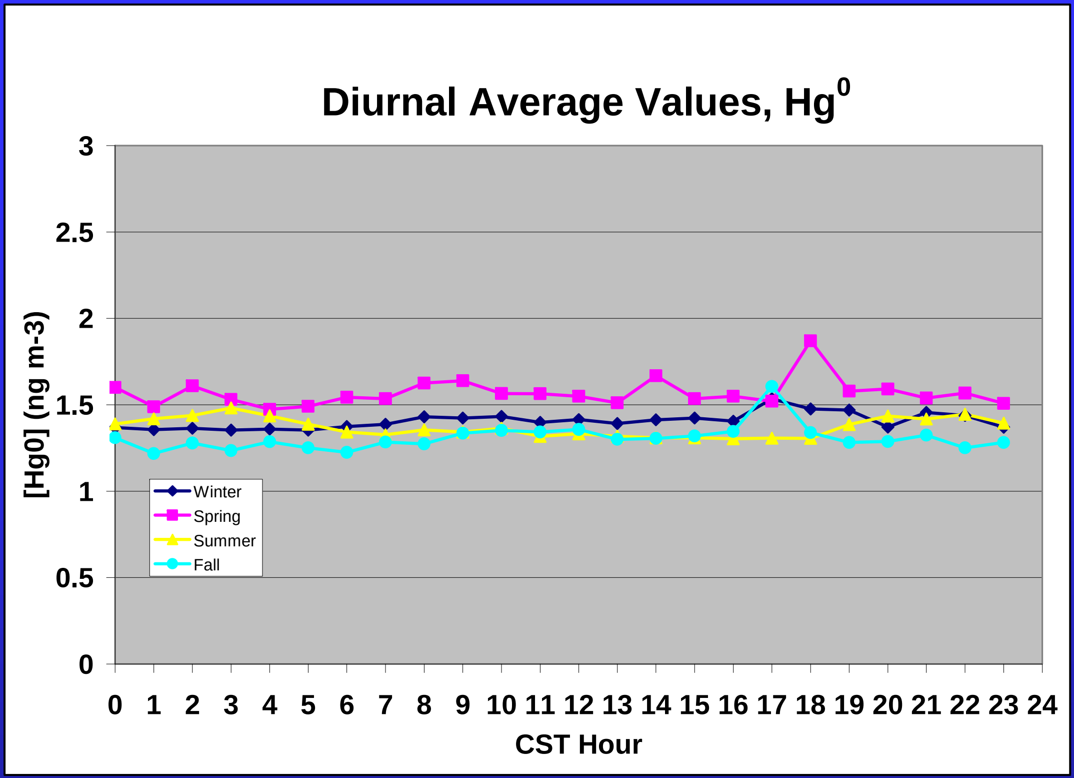
Type of Measurement:
A = concentration in ambient air
B = concentration in precipitation
C = meteorological parameter

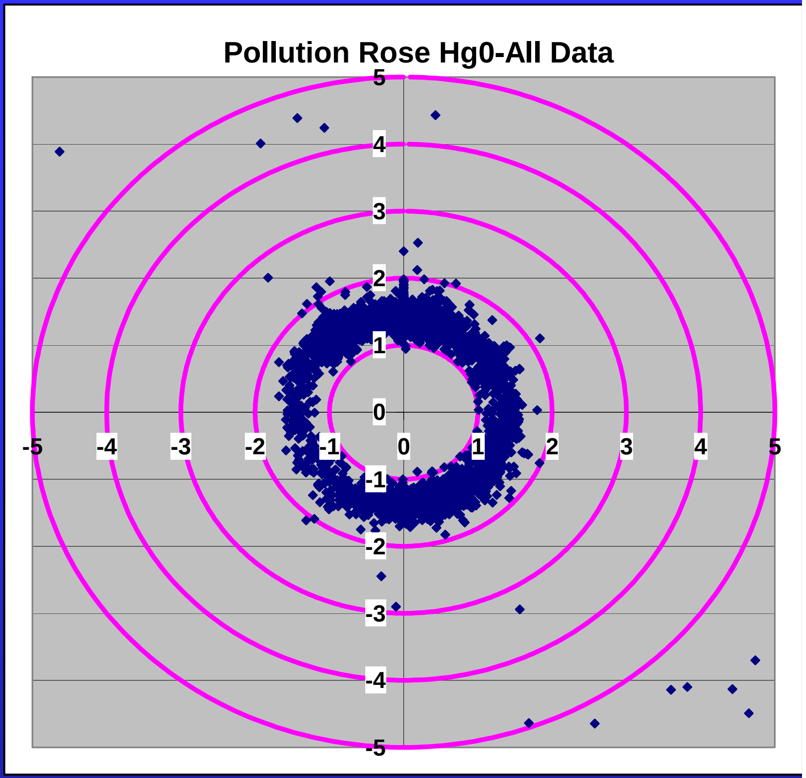
4 m sampling height

Measurement	Type	Start Date
Elemental mercury	A	Sept 2006
Fine particulate mercury	A	Sept 2006
Reactive gaseous mercury	A	Sept 2006
Sulfur dioxide	A	Oct 2006
Ozone	A	Oct 2006
Carbon Monoxide	A	Oct 2006
Nitrogen Oxides (NO, NOy)	A	*
Wind speed	C	Feb 2007
Wind Direction	C	Feb 2007
Relative Humidity	C	Feb 2007
Temperature	C	Feb 2007
Precipitation	C	Feb 2007
Total mercury in precipitation	B	*
Major ions in precipitation	B	*

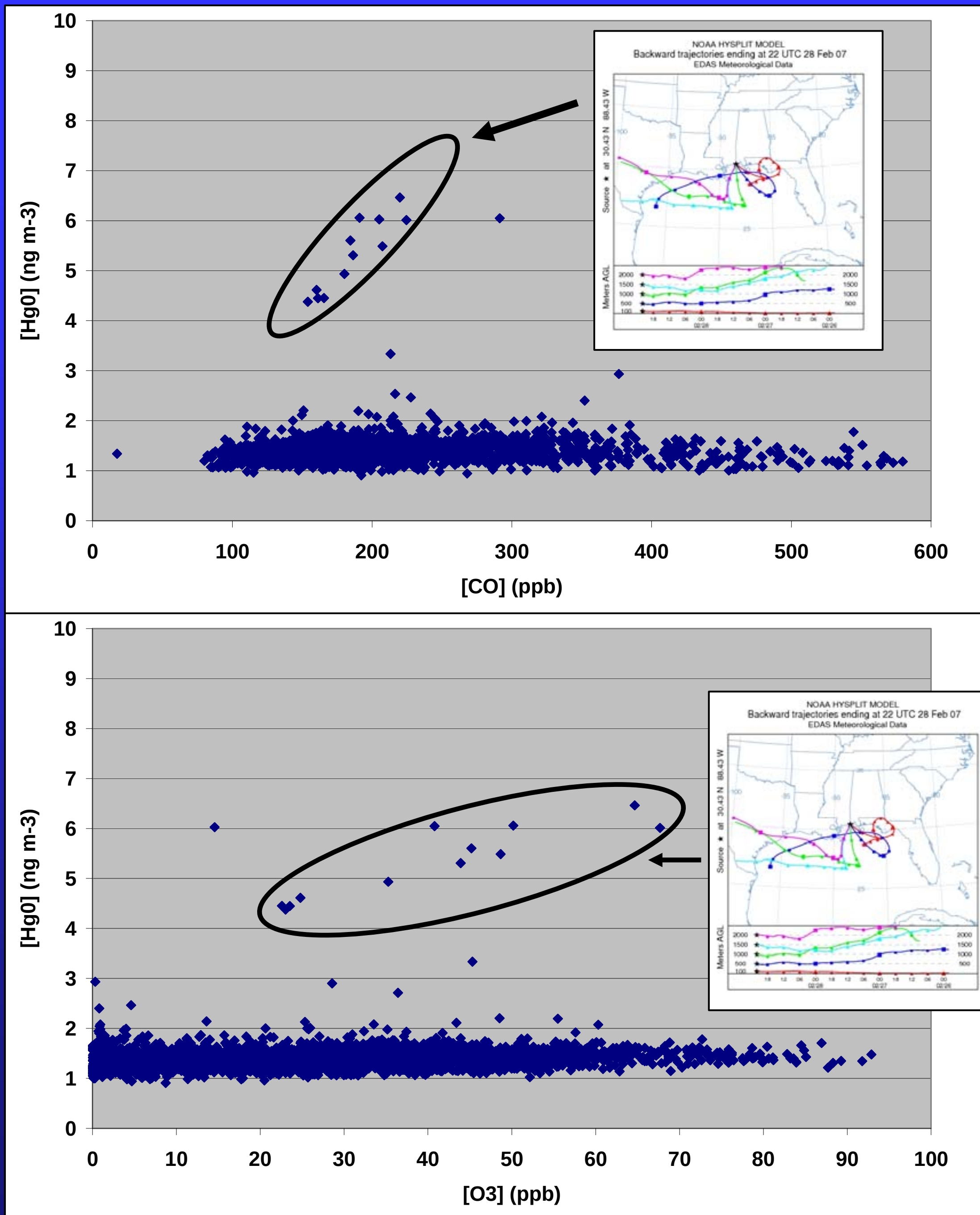
* to be established

Elemental Mercury (Hg^0) at Grand Bay





As expected, with a few exceptions Hg^0 concentrations show little or no diurnal variation or dependence on wind direction

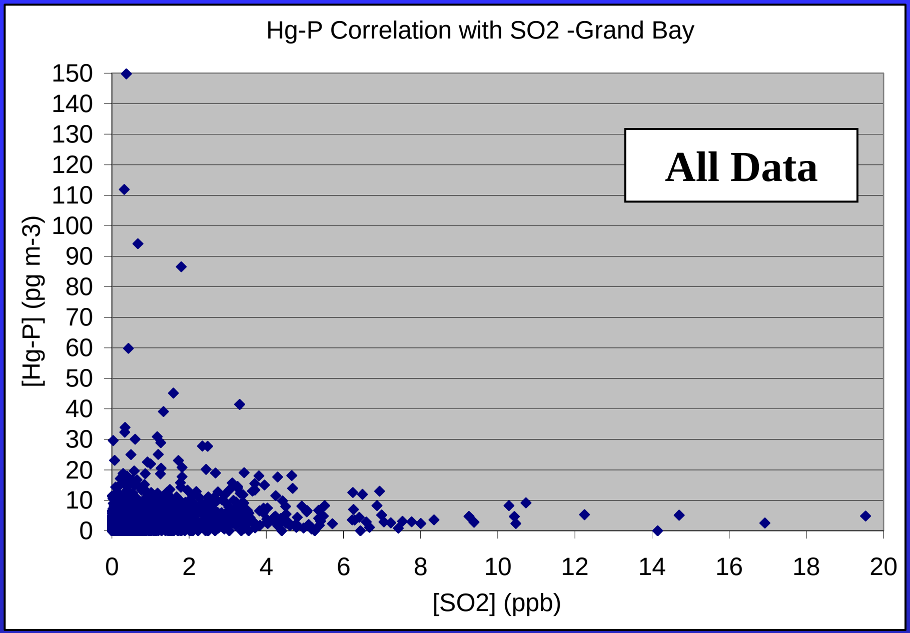


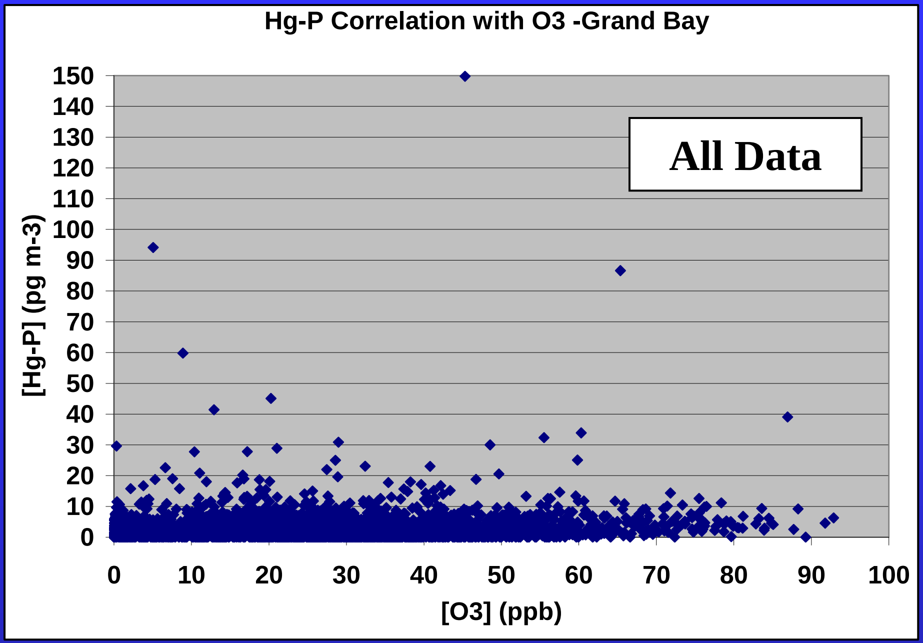
Overnight Event Feb. 28-March 1

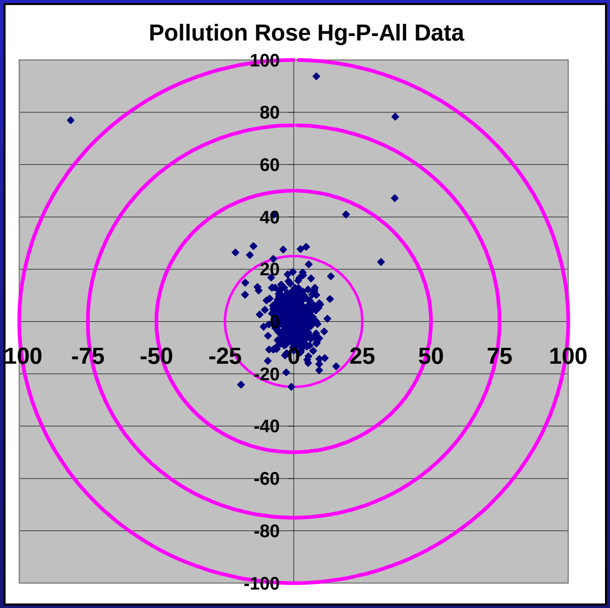
Strong correlation between Hg^0 and CO, O_3.

Suggests combustion (natural sources?) and transport from source regions to West. RGM, Hg-P ca 20 pg m^{-3} during episode

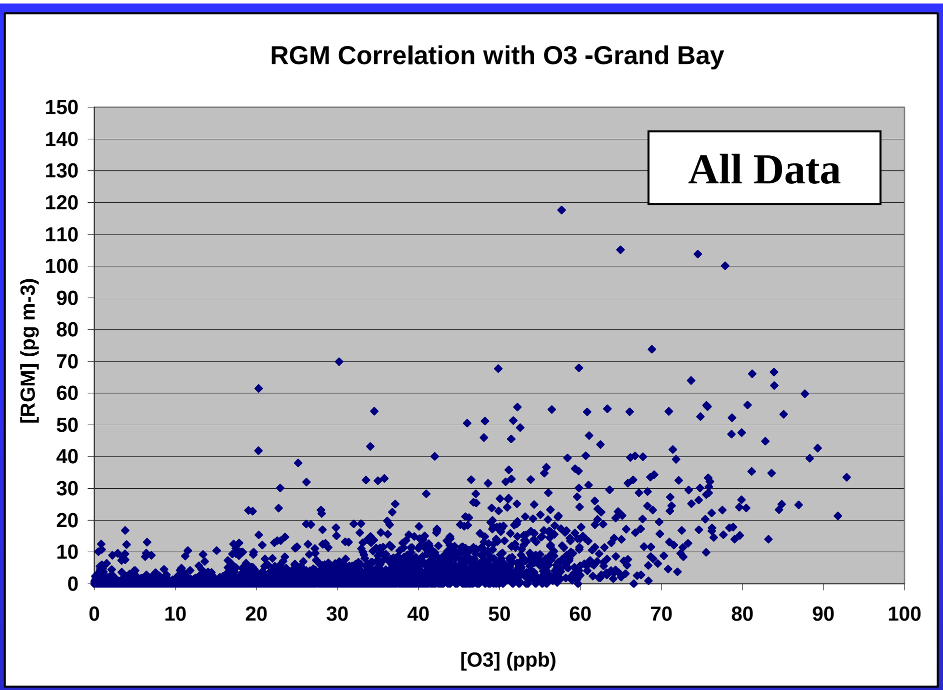
Particulate Mercury (Hg-P)

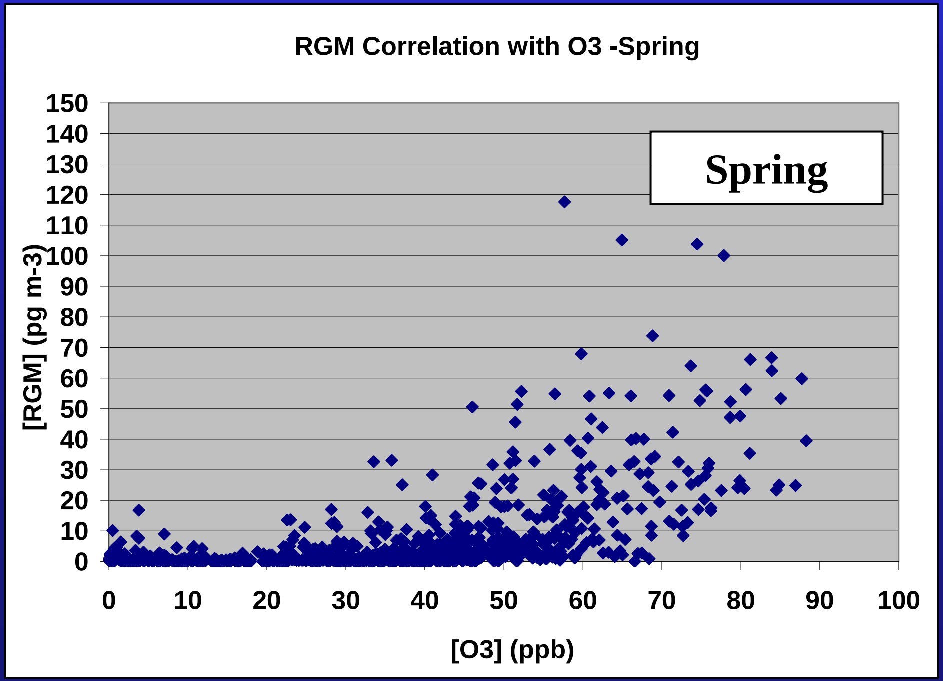




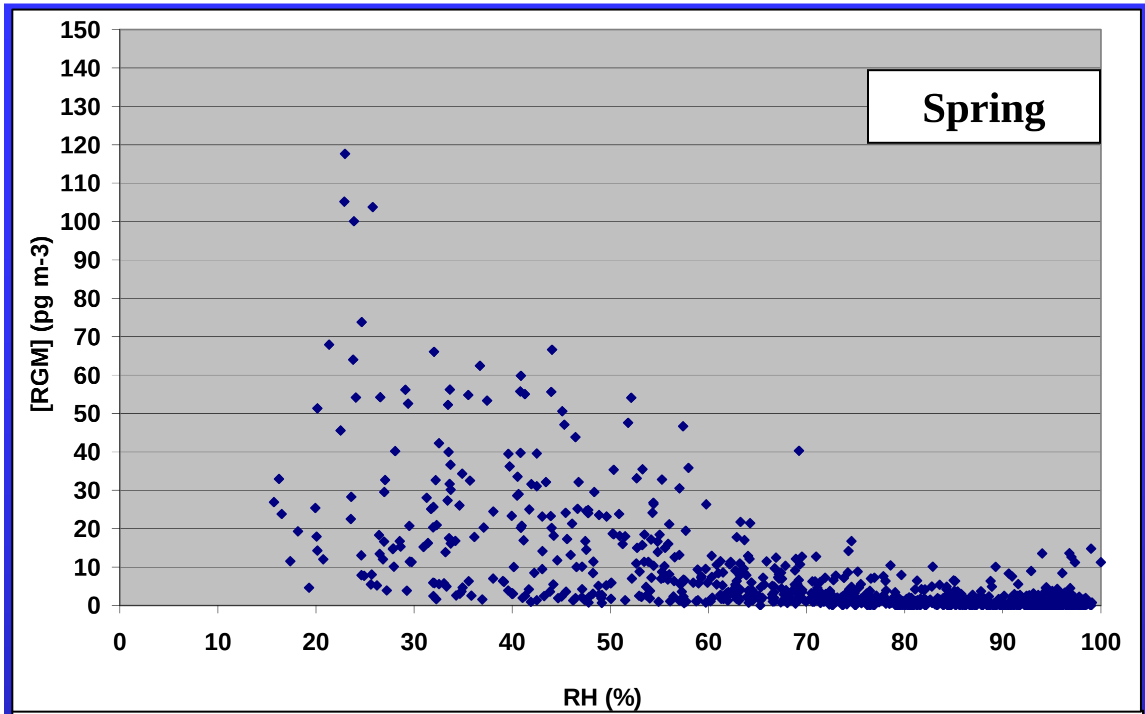


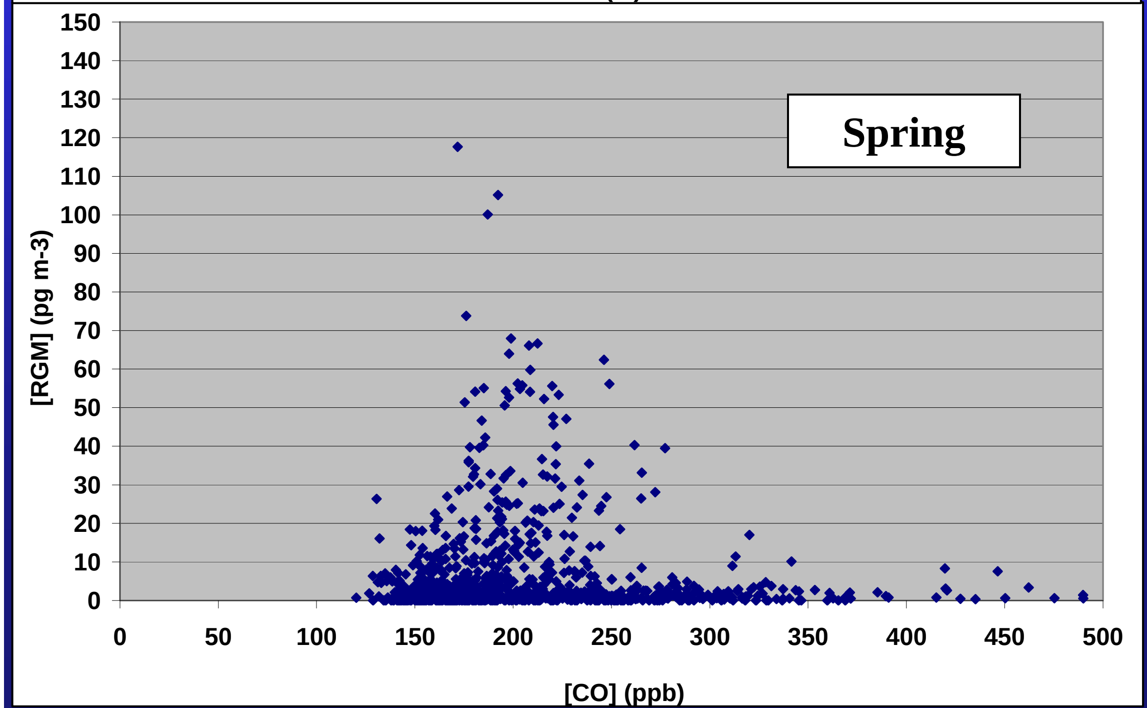
With the exception of a few well-defined transport events, Hg-P displays no consistent relationship with wind direction, and exhibits little or no correlation with other trace species





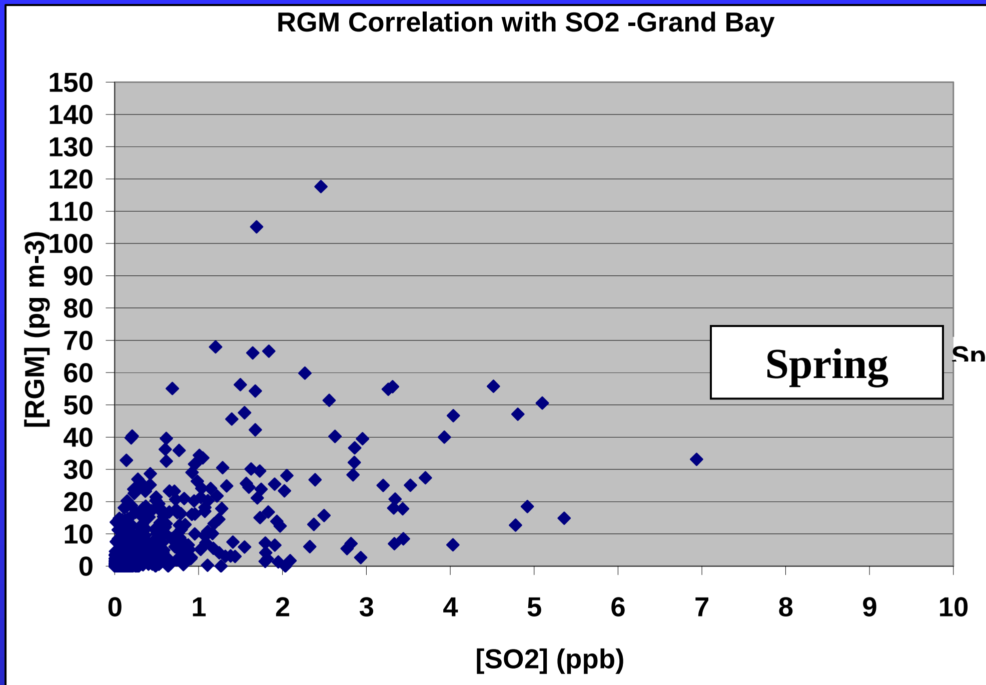
Strongest correlations seen between RGM and O_3, most of which is driven by seasonal dependence –RGM concentrations are highest, relationship with O_3 is strongest in Spring.

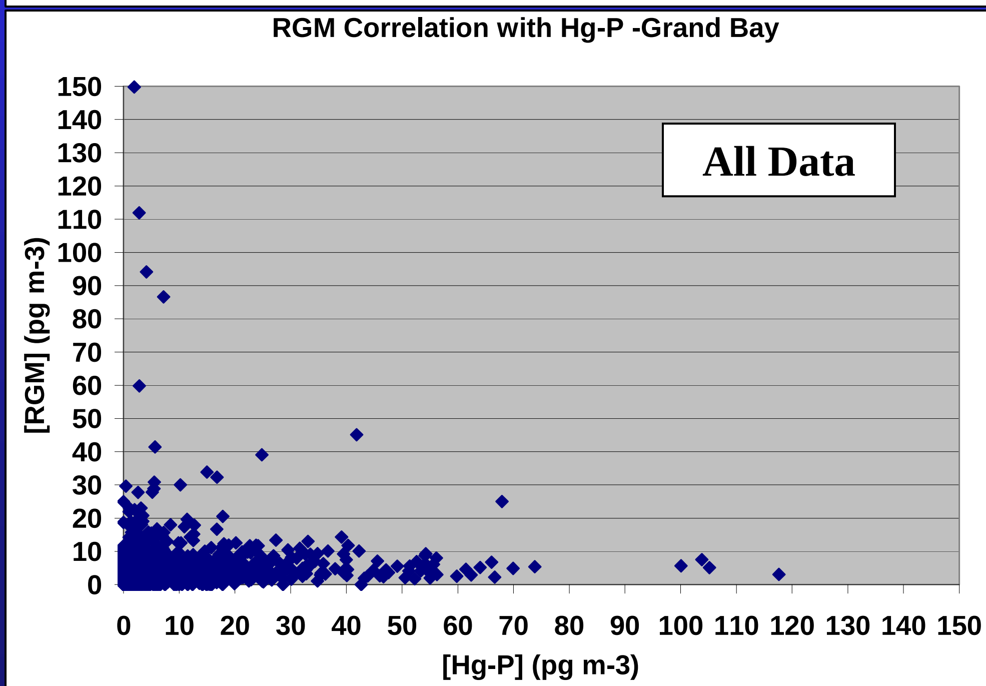




Association of peak RGM with low RH and CO concentrations typical of continental influence suggests highest Spring peaks of RGM are seen in post-frontal activity, with transport from upwind continental sources to the North.

What is the role of downward mixing of upper-tropospheric air, which contains elevated RGM, O_3, and lower CO and RH ?

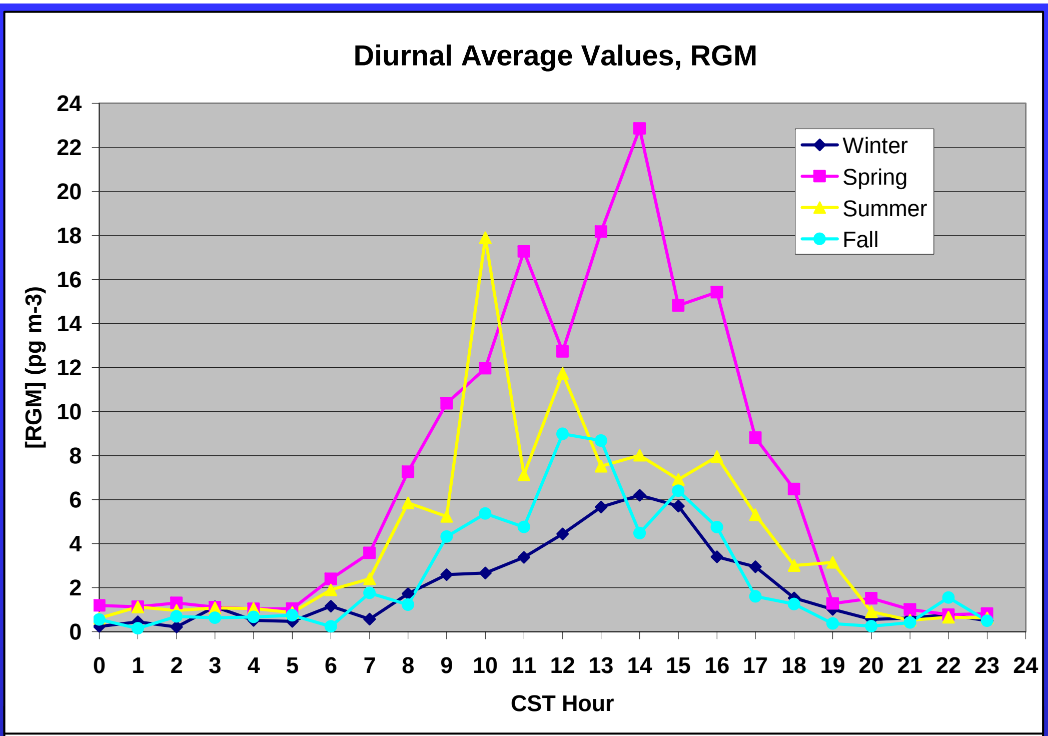


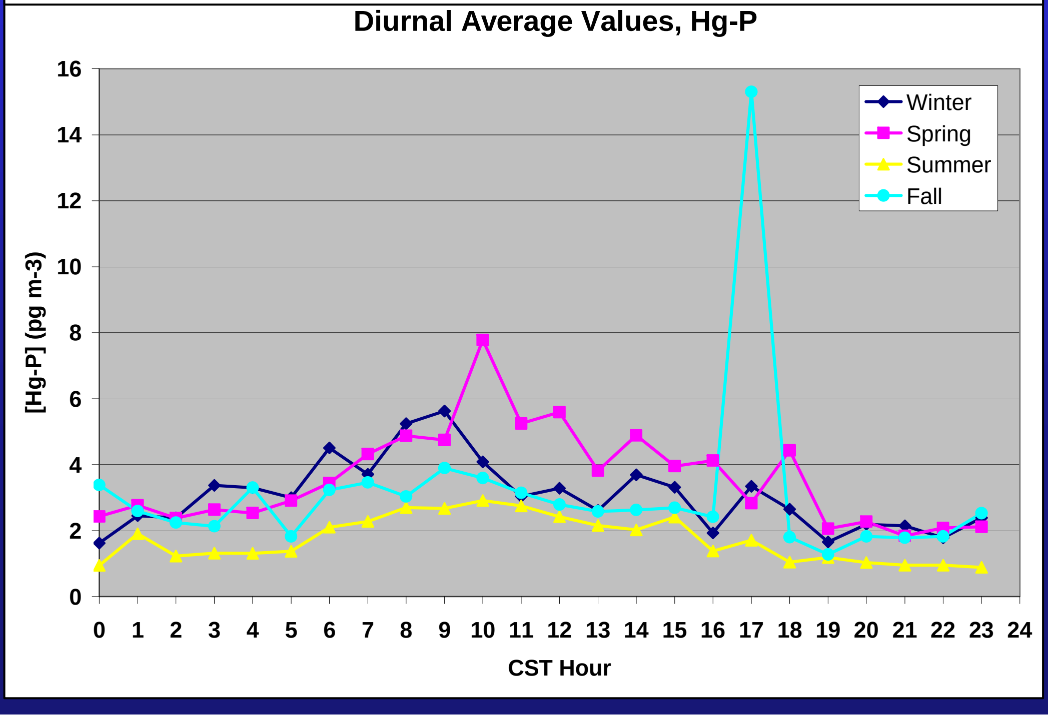


Weaker RGM – SO_2 correlation at Grand Bay than at Beltsville suggests:

- A mix of primary sources with varying emission characteristics
- A mix of primary and secondary sources of RGM
- Different chemical processing and removal rates of SO_2 and RGM during transport

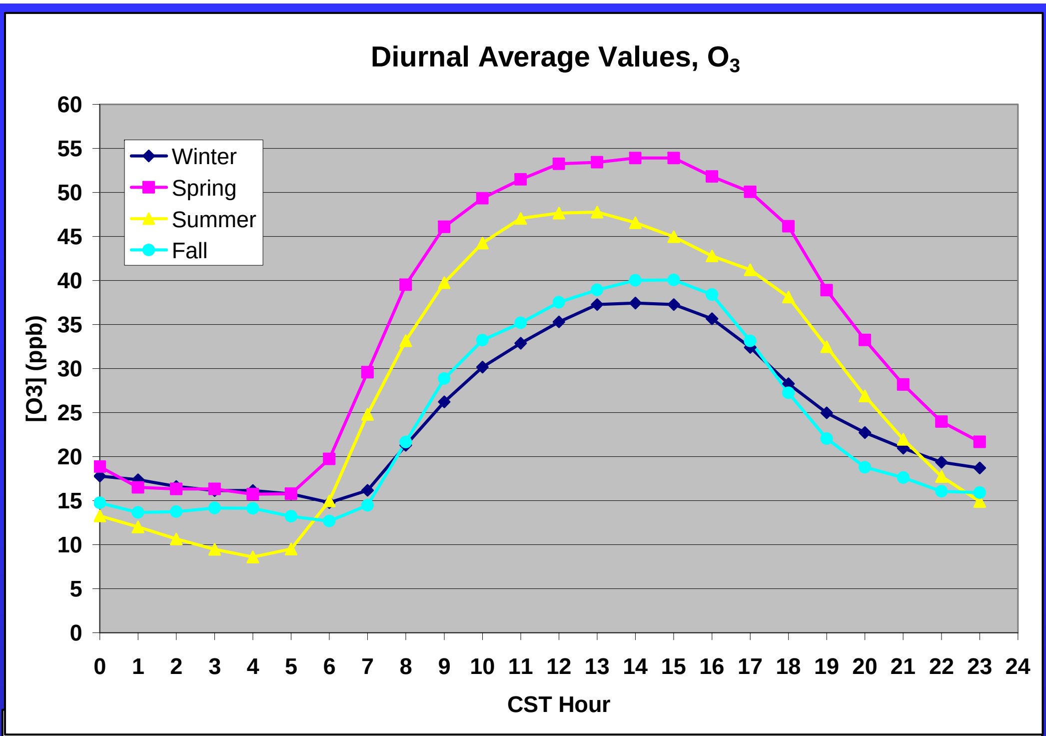
Lack of correlation –RGM and Hg-P suggests different sources and/or removal rates of these species

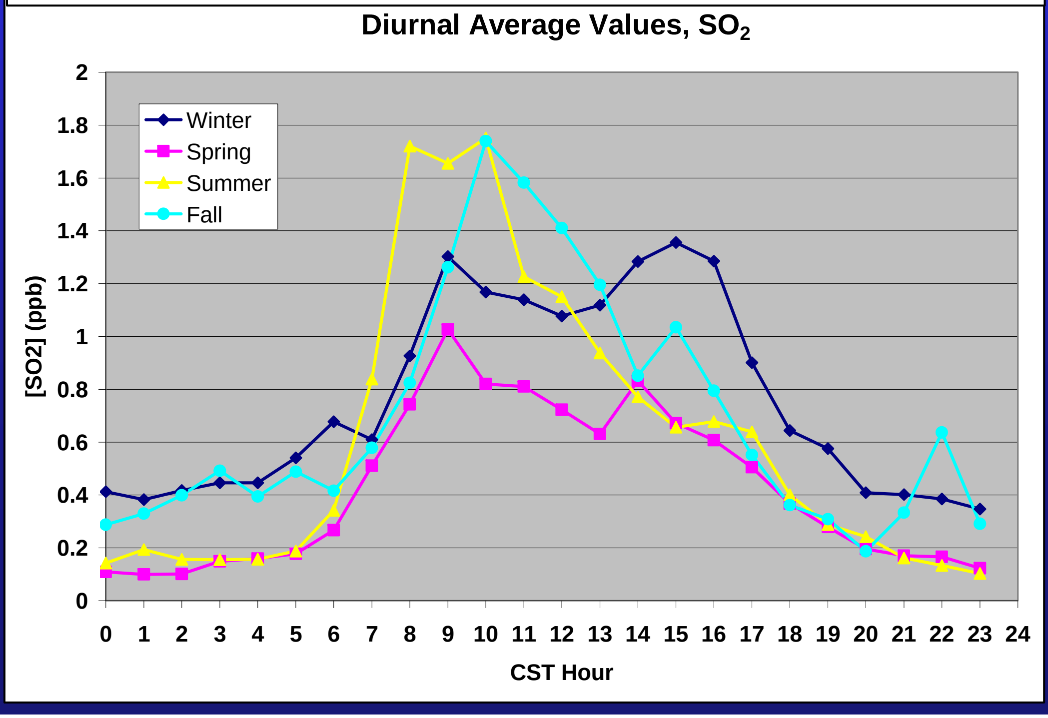




As at Beltsville, significant diurnal patterns seen in RGM, but amplitude of diurnal Hg-P profile is much smaller.

Highest RGM and Hg-P concentrations seen in Spring. At Beltsville, Hg-P peaks in the winter, and Spring-Summer differences between RGM and Hg-P are small





Similarity to O_3 and SO_2 diurnal profiles confirms the importance of downward mixing in the development of the daytime boundary layer, but photochemical (secondary) production of RGM is also possible

Summary and Conclusions – Interpretation of Ambient Measurements

- Beltsville site is semi-urban and is ringed by emission sources of mercury and other primary trace species, with frequent peaks in RGM (less for Hg-P) concentrations due to transport from nearby sources. Grand Bay NERR Site exhibits characteristics of a rural/remote site with low concentrations of all species but occasional transport related episodes of higher concentrations.

- At both sites, RGM exhibits a more pronounced diurnal profile than Hg-P, but both profiles are coincident with O_3 and SO_2 peaks, suggesting downward mixing of an aloft reservoir upon the breakup of the nocturnal boundary layer. In situ production of RGM may also be contributing. RGM peaks in the Spring at Grand Bay, in Spring and Summer at Beltsville. Hg-P is higher in Winter at Beltsville.

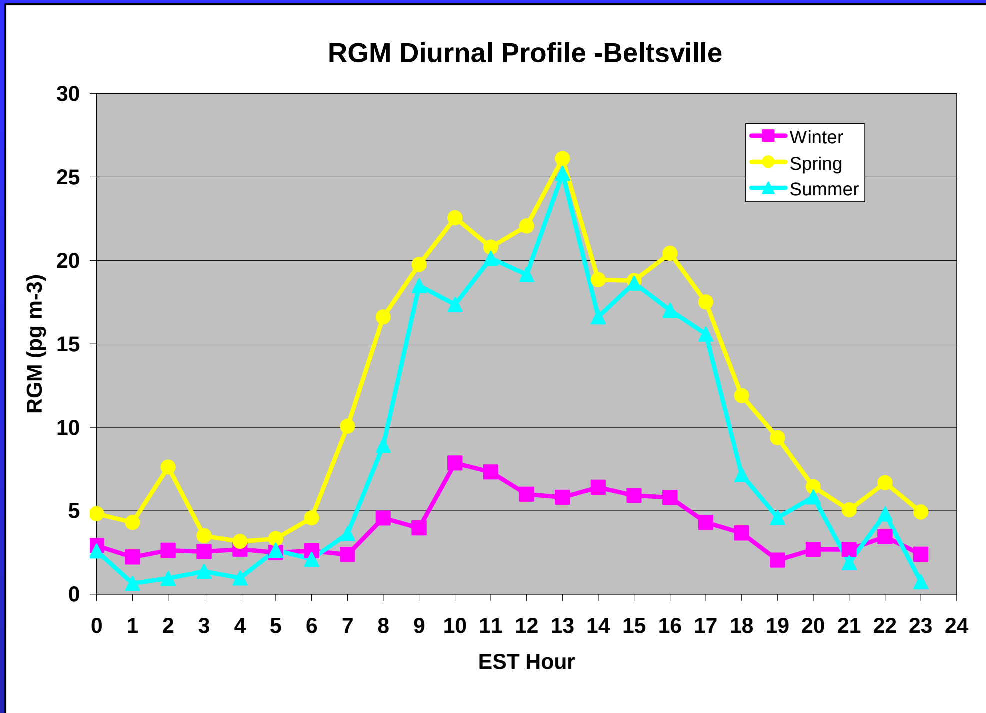
- At Beltsville, RGM correlates most closely with SO_2 in Summer, suggesting the dominance of nearby (primary) emissions. However, RGM is also associated with elevated O_3 and low NO/NOy ratios, suggesting that secondary production may also be important

Summary and Conclusions – Interpretation of Ambient Measurements (continued....)

- At Grand Bay, RGM is associated with O_3 in Springtime, and is associated with dryer air characteristic of continental emissions (CO ca 200 ppb).
- These results suggest RGM is transported from northerly continental sources following cold-frontal penetration in Spring. Reduced frequency of cold frontal passage at the site in Summer leads to lower RGM levels, more sporadic transport to the site from upwind sources.

Deposition Estimates

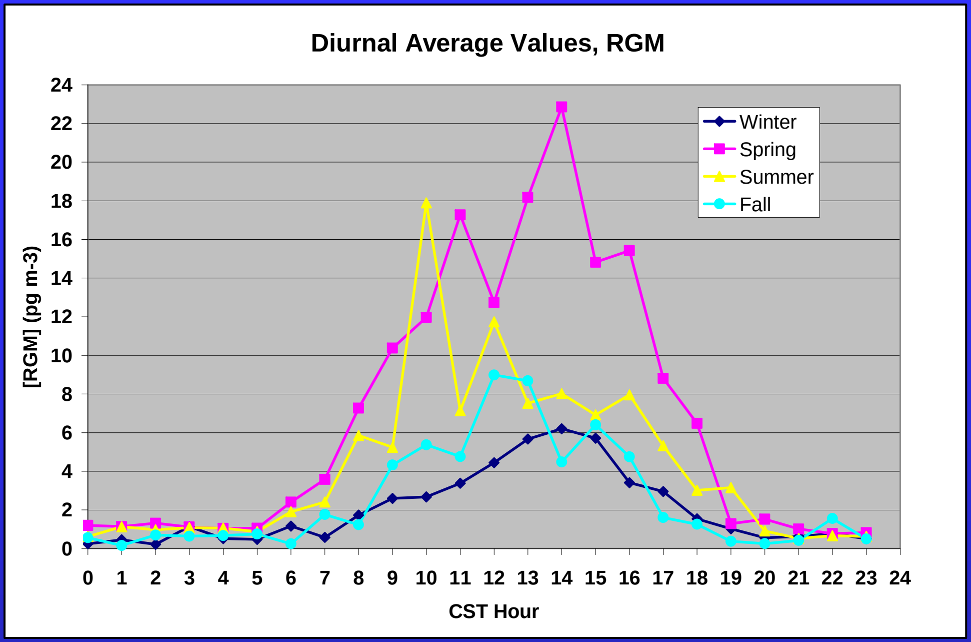
Preliminary Deposition Estimates -Beltsville

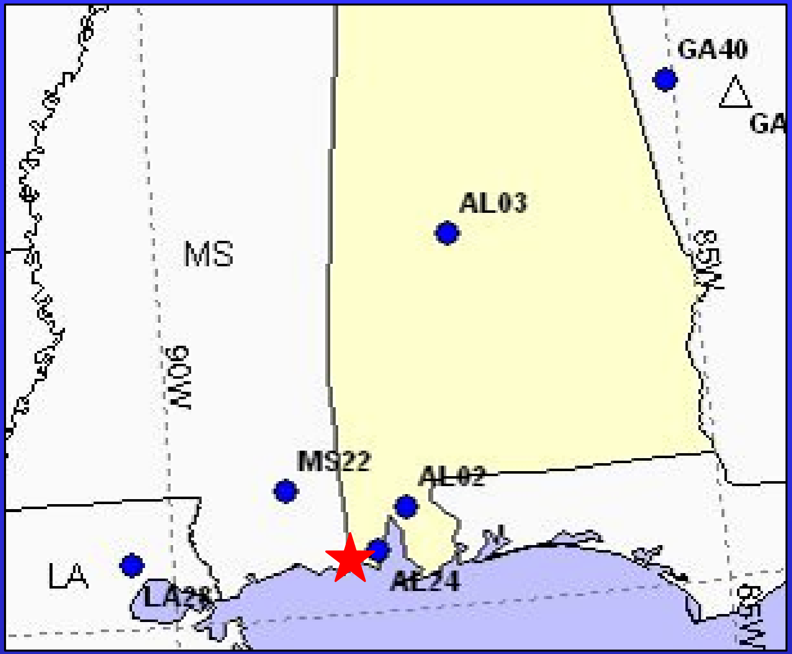


RGM + Hg-P Dry Deposition (ng m^{-2} day^{-1}); assumes V_d = 2.5 cm s^{-1} and 0.3 cm s^{-1} mid day average

	Fall	Winter	Spring	Summer
	Fluxes (ng m^{-2} day^{-1})			
Dry Dep, Beltsville (2006-2007)		7.8	22.3	18.2
Wet Dep, Beltsville (2005-2006)	35.4	13.9	13.0	54.8

Preliminary Deposition Estimates -Grand Bay





RGM + Hg-P Dry Deposition (ng m^{-2} day^{-1});
assumes V_d = 2.5 cm s^{-1} and 0.3 cm s^{-1} mid day average

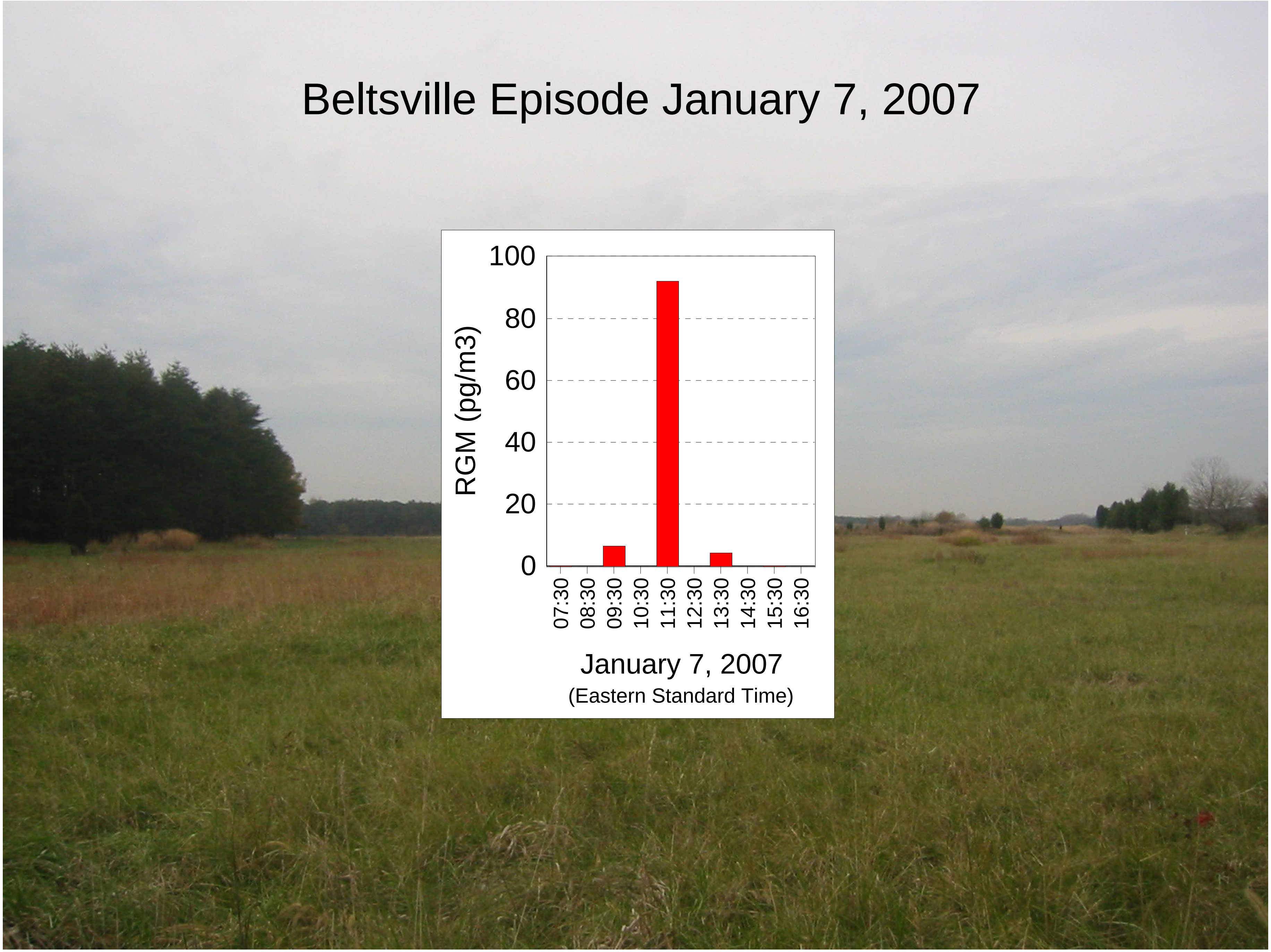
	Fluxes (ng m-2 day-1)			
	Fall	Winter	Spring	Summer
Dry Dep, Grand Bay (2006-2007)	5.4	4.3	14.2	8.6
Wet Dep, AL24 (2005-2006)	13.5	24.8	31.6	34.6
Wet Dep, MS22 (2005-2006)	11.9	28.2	28.5	65.3
Wet Dep, AL02 (2005-2006)	24.7	21.6	31.3	34.6

Summary and Conclusions - Deposition

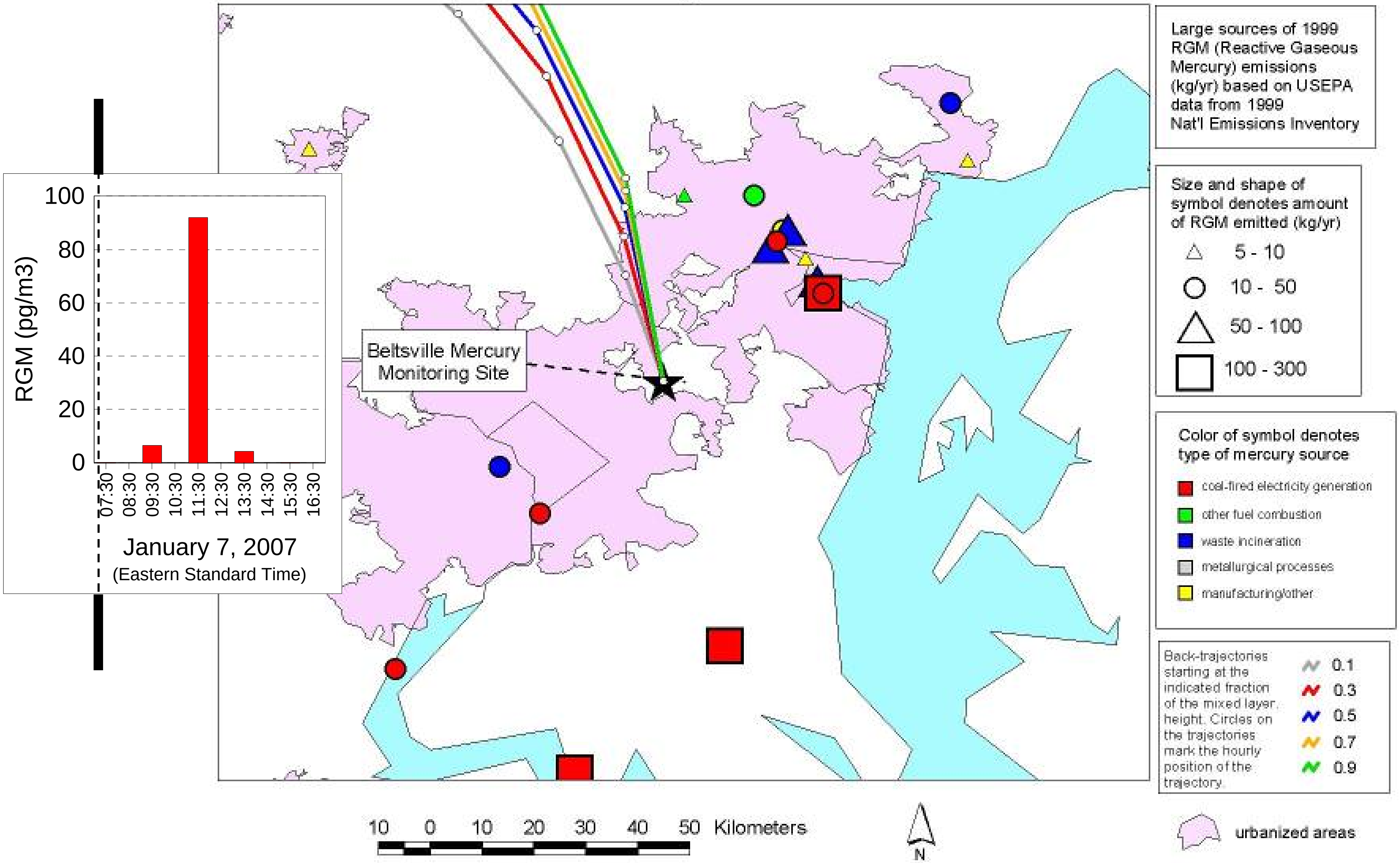
- Preliminary estimates of dry deposition have been made based on measured RGM and Hg-P concentrations. More sophisticated estimates will be made in the future.
- Dry deposition estimates, when compared with nearby MDN deposition records, suggest that dry deposition sometimes dominates at the Beltsville site, depending on season.
- At Grand Bay, wet deposition dominates the removal of reactive mercury species, especially in Winter.
- If substantial Hg exists in the coarse aerosol fraction, however, the reported dry deposition fluxes are under-estimated.

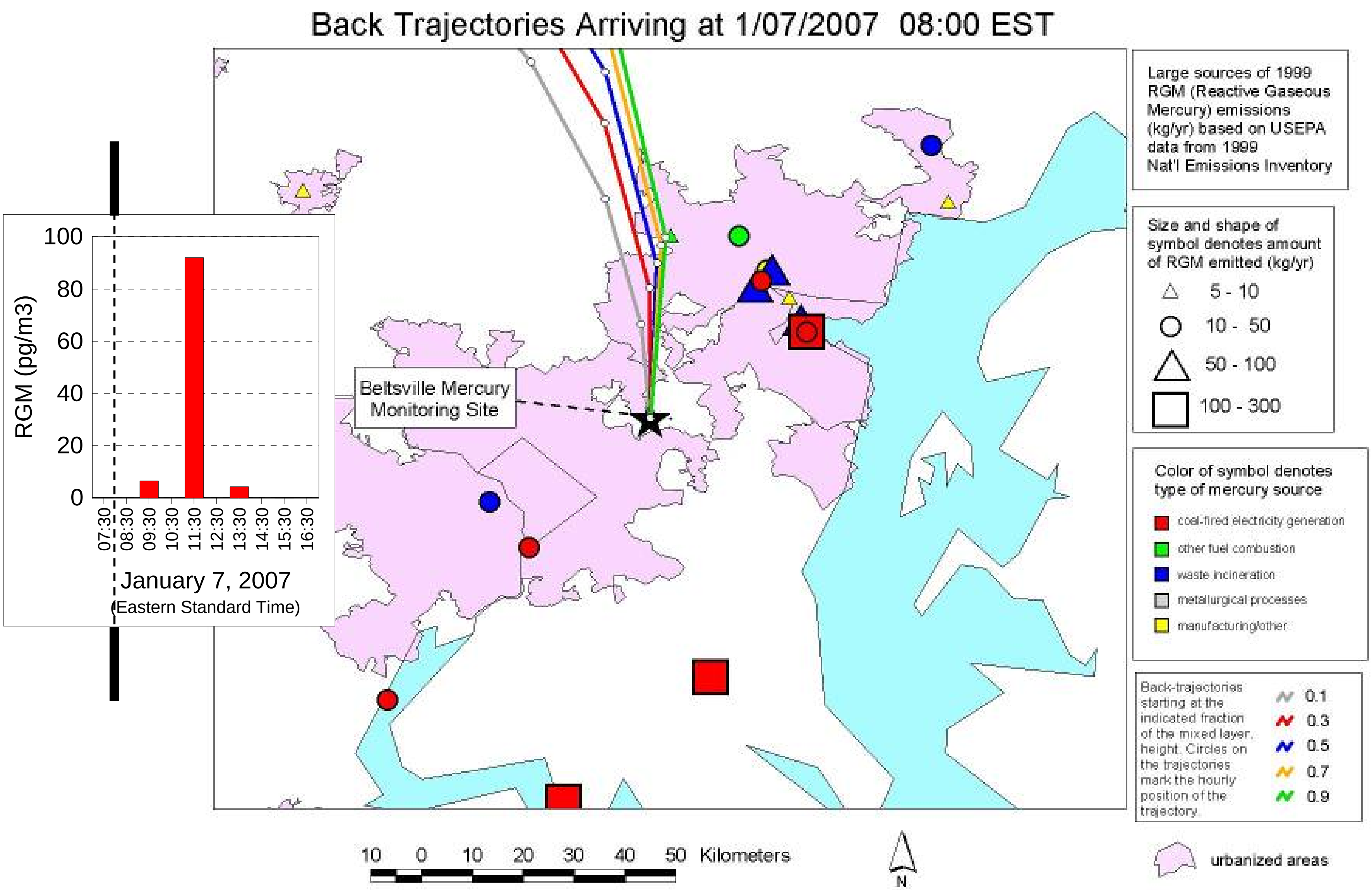
Trajectory Analysis Examples: Beltsville

Beltsville Episode January 7, 2007



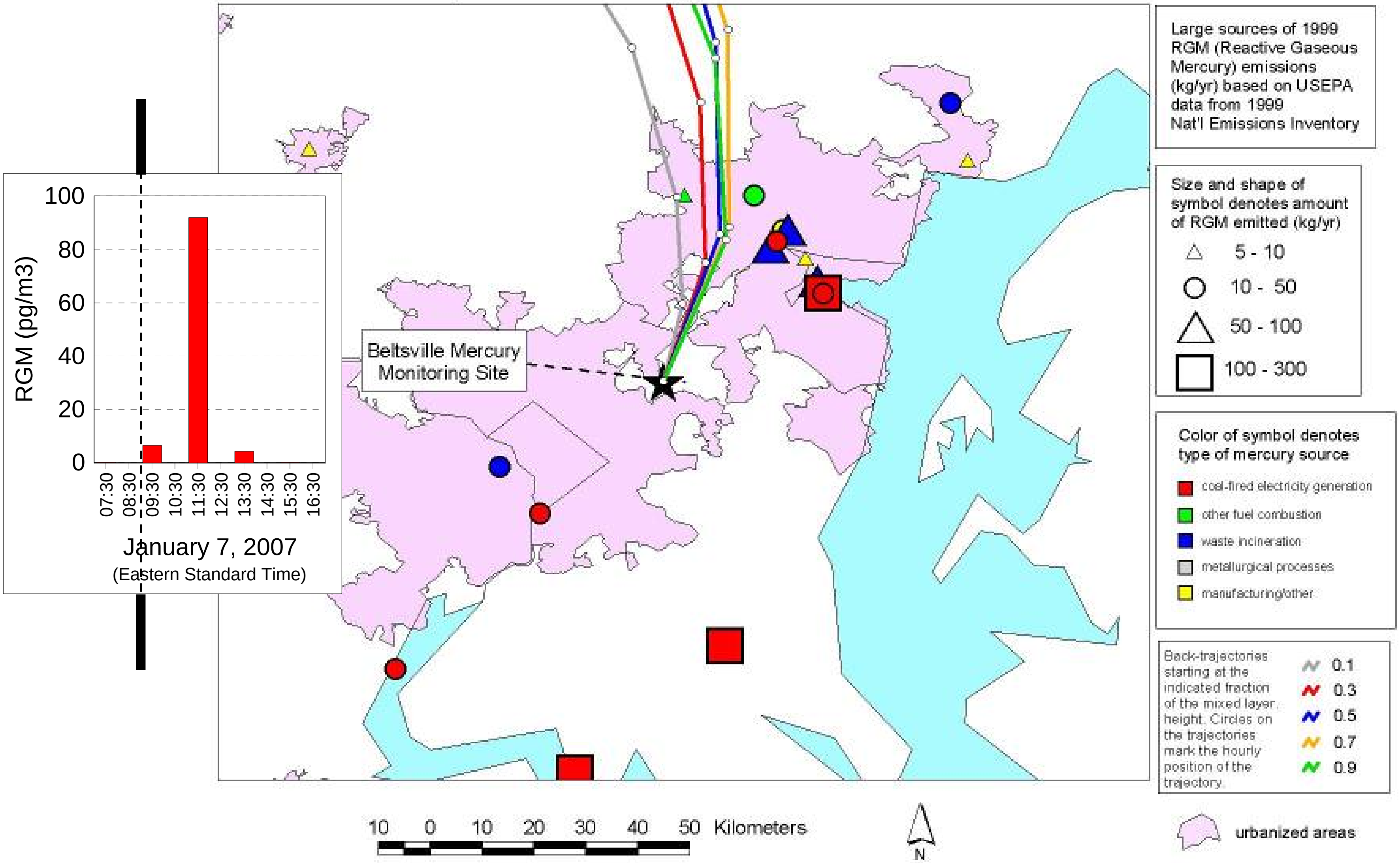
Back Trajectories Arriving at 1/07/2007 07:00 EST

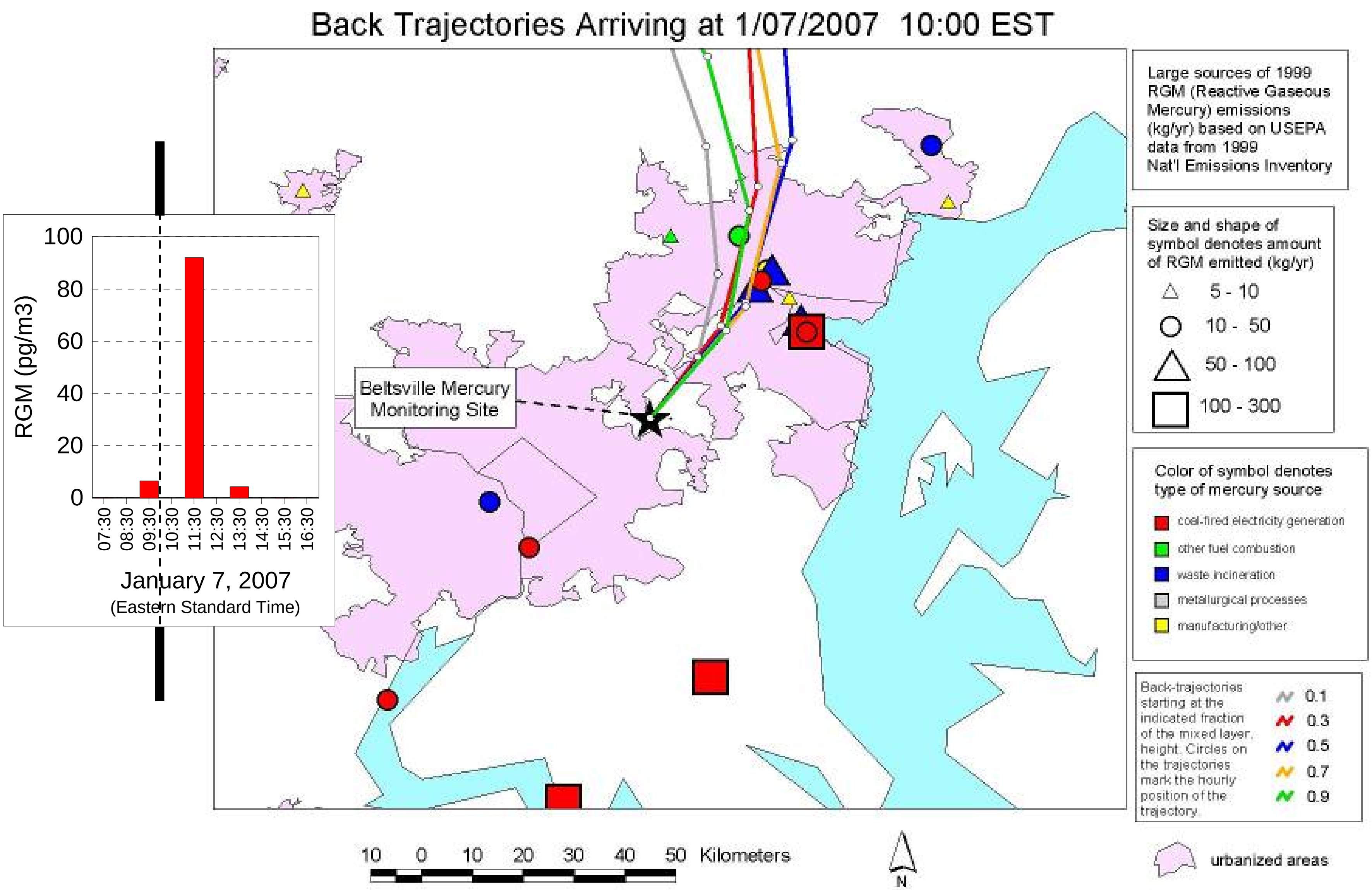




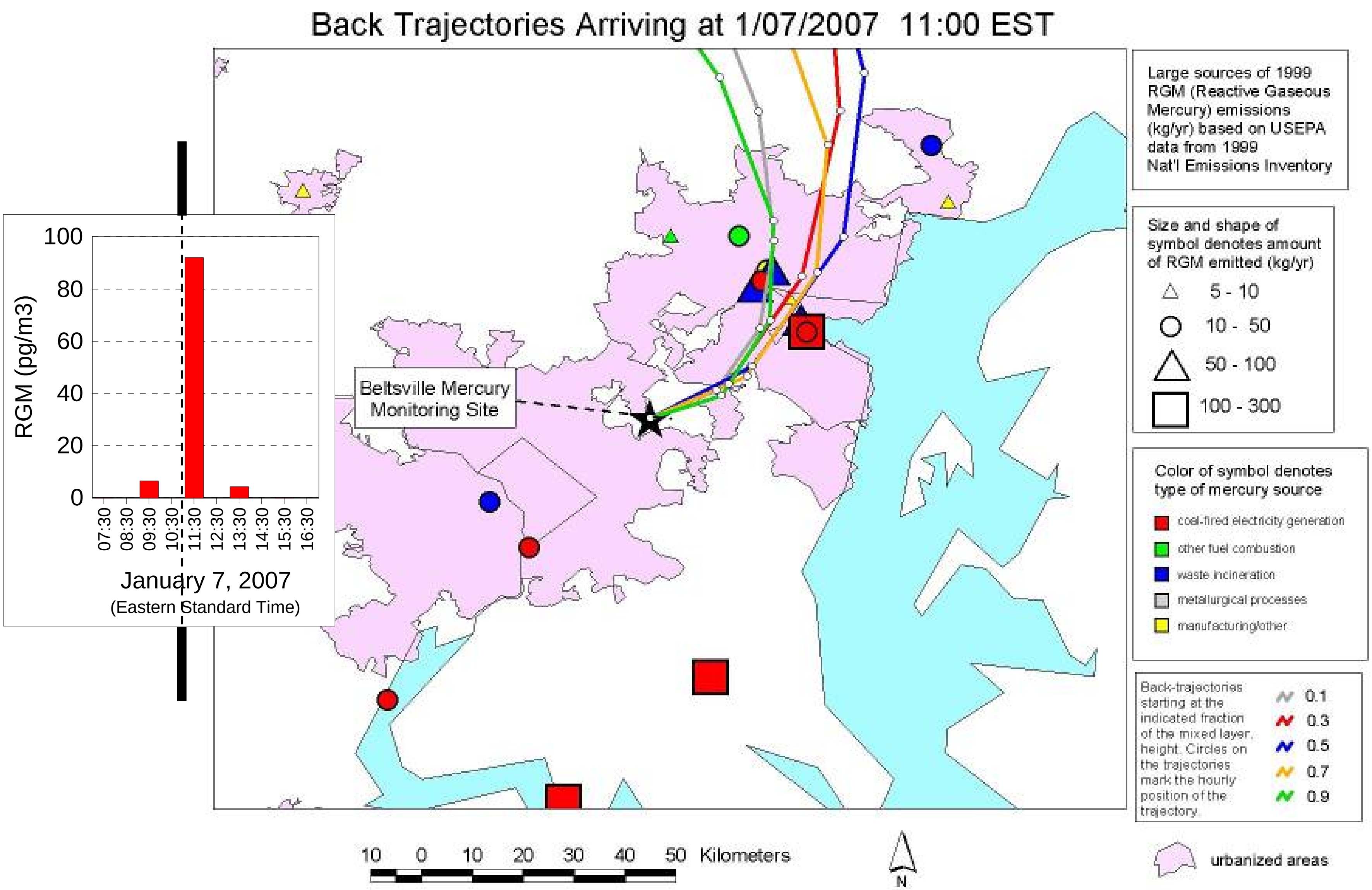
Back Trajectories Arriving at 1/07/2007 08:00 EST
Beltsville Mercury Monitoring Site
RGM (pg/m3)
100
80
60
40
20
0
07:30
08:30
09:30
10:30
11:30
12:30
13:30
14:30
15:30
16:30
January 7, 2007
(Eastern Standard Time)
Large sources of 1999 RGM (Reactive Gaseous Mercury) emissions (kg/yr) based on USEPA data from 1999 Nat'l Emissions Inventory
Size and shape of symbol denotes amount of RGM emitted (kg/yr)
5 - 10
10 - 50
50 - 100
100 - 300
Color of symbol denotes type of mercury source
coal-fired electricity generation
other fuel combustion
waste incineration
metallurgical processes
manufacturing/other
Back-trajectories starting at the indicated fraction of the mixed layer height. Circles on the trajectories mark the hourly position of the trajectory.
0.1
0.3
0.5
0.7
0.9
10 0 10 20 30 40 50 Kilometers
N
urbanized areas

Back Trajectories Arriving at 1/07/2007 09:00 EST



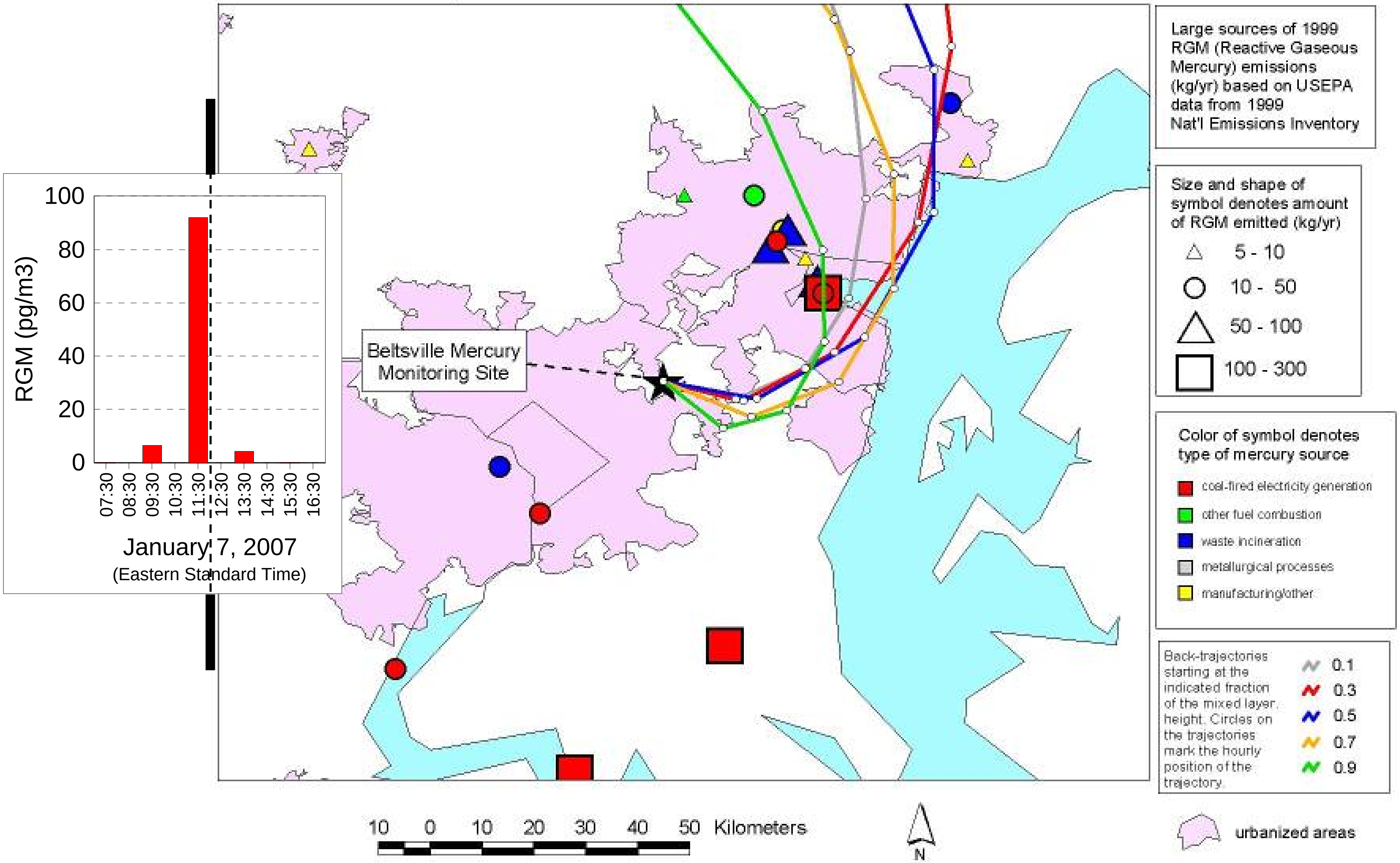


Back Trajectories Arriving at 1/07/2007 10:00 EST
Beltsville Mercury Monitoring Site
RGM (pg/m3)
100
80
60
40
20
0
07:30
08:30
09:30
10:30
11:30
12:30
13:30
14:30
15:30
16:30
January 7, 2007
(Eastern Standard Time)
Large sources of 1999 RGM (Reactive Gaseous Mercury) emissions (kg/yr) based on USEPA data from 1999 Nat'l Emissions Inventory
Size and shape of symbol denotes amount of RGM emitted (kg/yr)
5 - 10
10 - 50
50 - 100
100 - 300
Color of symbol denotes type of mercury source
coal-fired electricity generation
other fuel combustion
waste incineration
metallurgical processes
manufacturing/other
Back-trajectories starting at the indicated fraction of the mixed layer height. Circles on the trajectories mark the hourly position of the trajectory.
0.1
0.3
0.5
0.7
0.9
10 0 10 20 30 40 50 Kilometers
N
urbanized areas

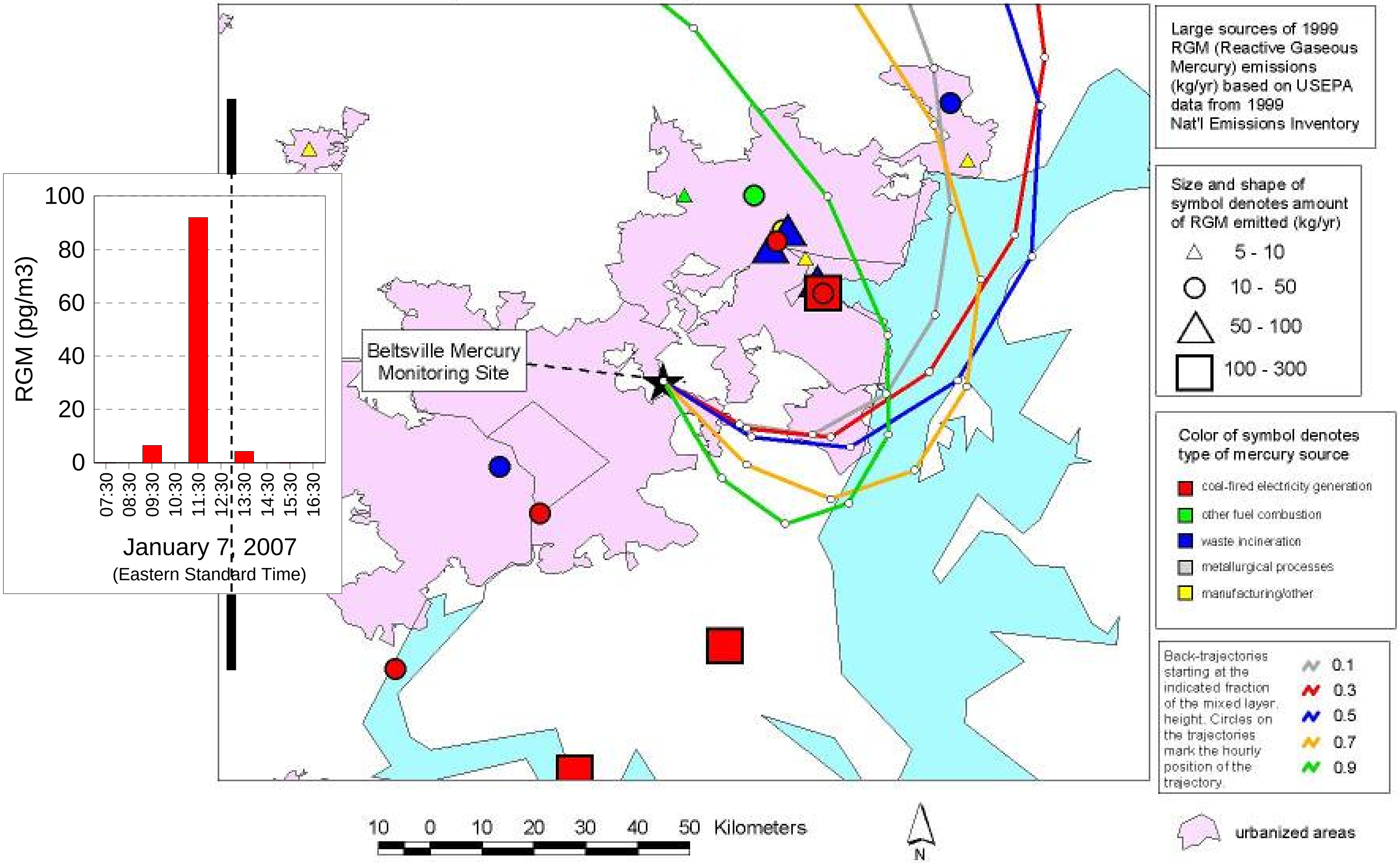


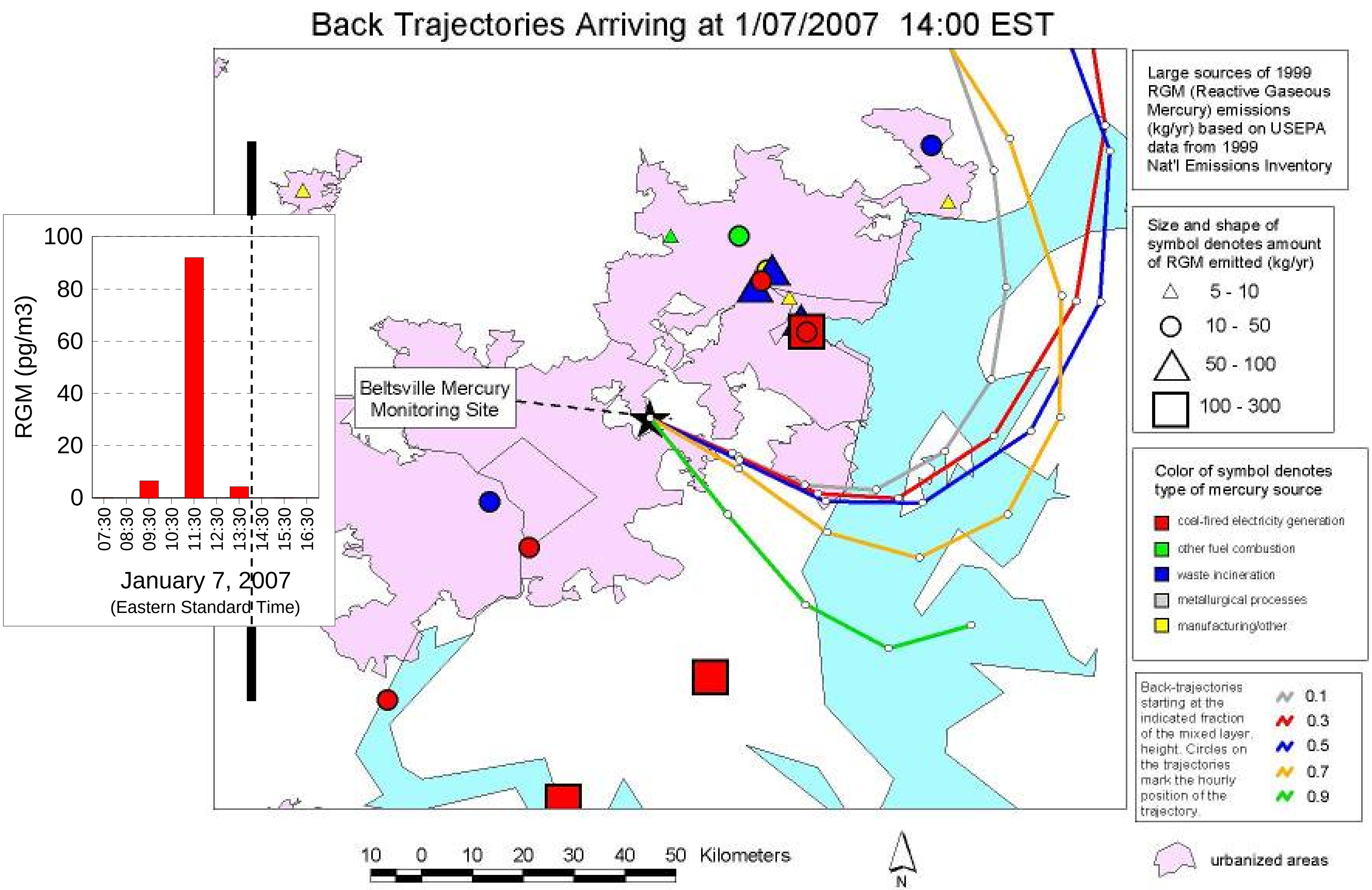
Back Trajectories Arriving at 1/07/2007 11:00 EST
Beltsville Mercury Monitoring Site
RGM (pg/m3)
100
80
60
40
20
0
07:30
08:30
09:30
10:30
11:30
12:30
13:30
14:30
15:30
16:30
January 7, 2007
(Eastern Standard Time)
Large sources of 1999 RGM (Reactive Gaseous Mercury) emissions (kg/yr) based on USEPA data from 1999 Nat'l Emissions Inventory
Size and shape of symbol denotes amount of RGM emitted (kg/yr)
5 - 10
10 - 50
50 - 100
100 - 300
Color of symbol denotes type of mercury source
coal-fired electricity generation
other fuel combustion
waste incineration
metallurgical processes
manufacturing/other
Back-trajectories starting at the indicated fraction of the mixed layer height. Circles on the trajectories mark the hourly position of the trajectory.
0.1
0.3
0.5
0.7
0.9
10 0 10 20 30 40 50 Kilometers
N
urbanized areas

Back Trajectories Arriving at 1/07/2007 12:00 EST

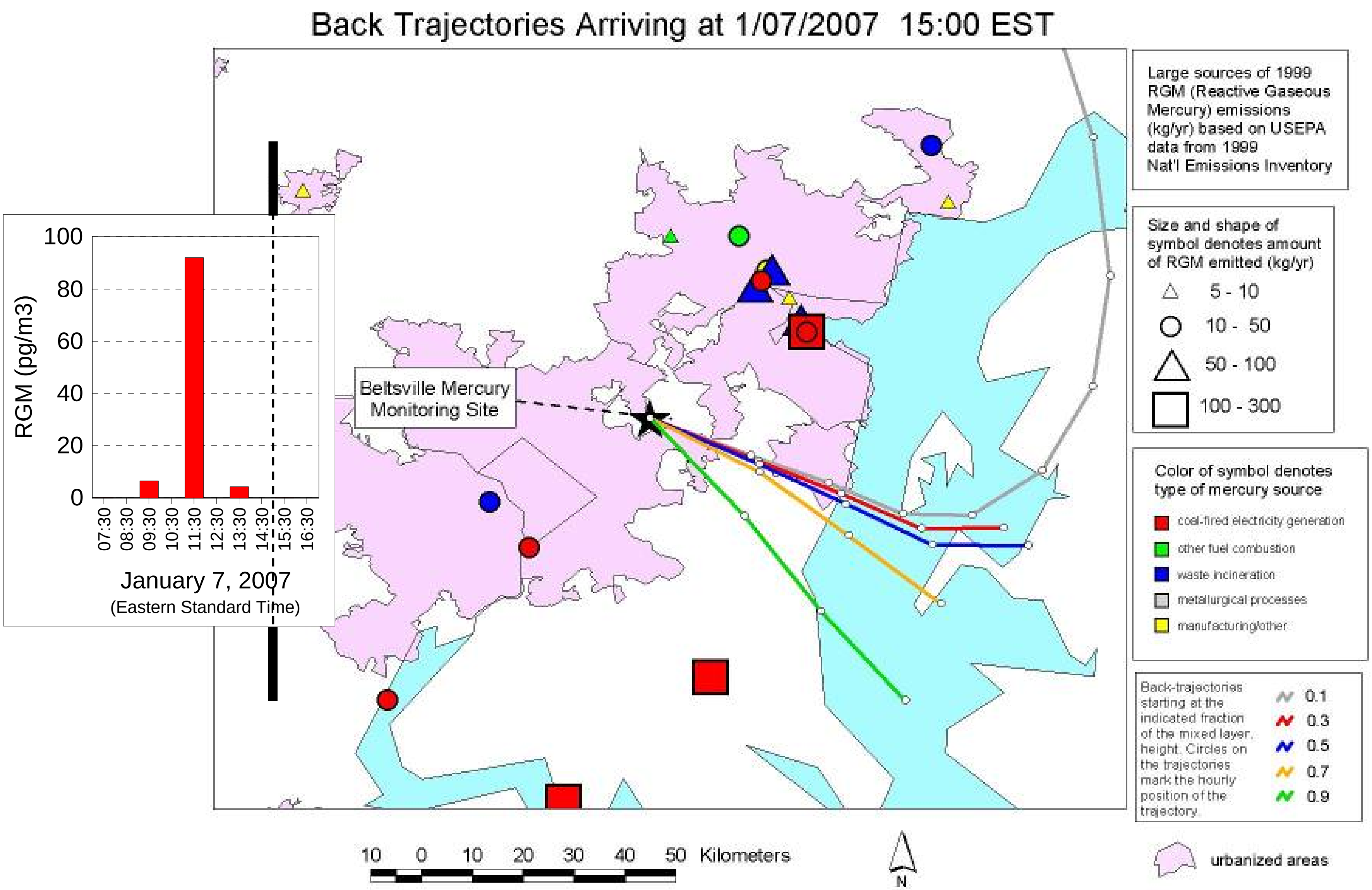


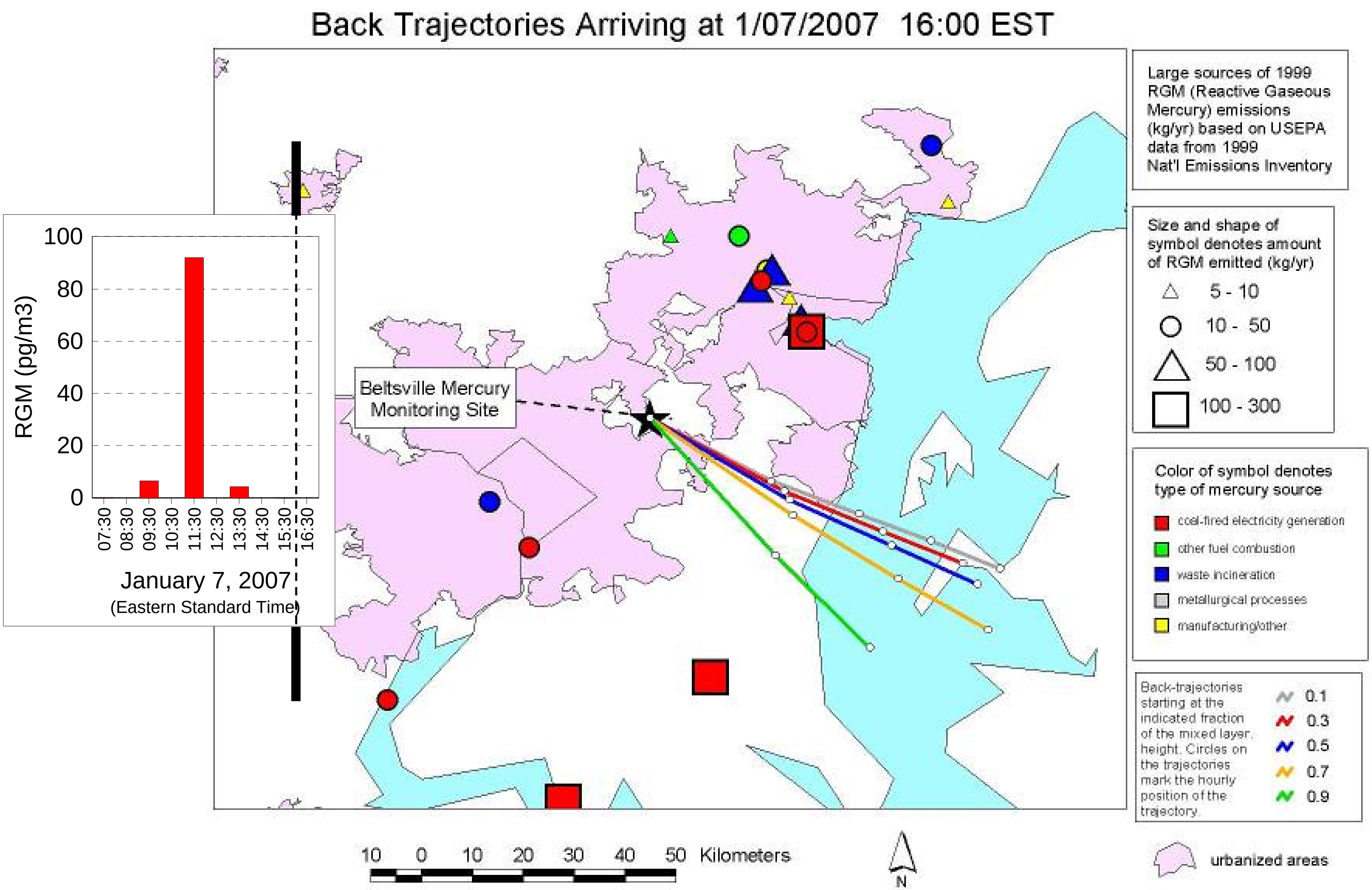
Back Trajectories Arriving at 1/07/2007 13:00 EST





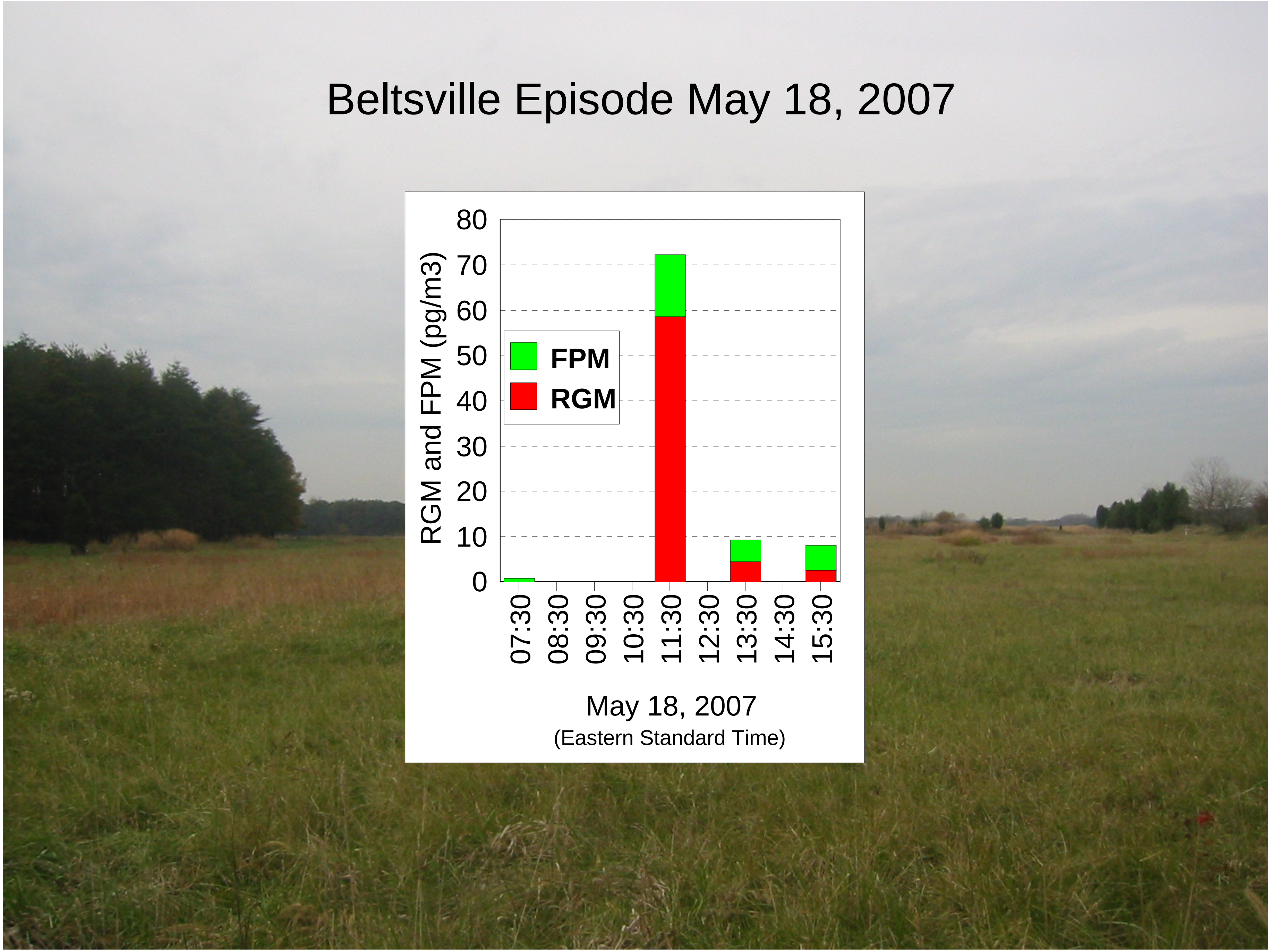
Back Trajectories Arriving at 1/07/2007 14:00 EST
Large sources of 1999 RGM (Reactive Gaseous Mercury) emissions (kg/yr) based on USEPA data from 1999 Nat'l Emissions Inventory
Size and shape of symbol denotes amount of RGM emitted (kg/yr)
5 - 10
10 - 50
50 - 100
100 - 300
Color of symbol denotes type of mercury source
coal-fired electricity generation
other fuel combustion
waste incineration
metallurgical processes
manufacturing/other
Back-trajectories starting at the indicated fraction of the mixed layer height. Circles on the trajectories mark the hourly position of the trajectory.
0.1
0.3
0.5
0.7
0.9
urbanized areas
Beltsville Mercury Monitoring Site
10 0 10 20 30 40 50 Kilometers
N
RGM (pg/m3)
100
80
60
40
20
0
07:30 08:30 09:30 10:30 11:30 12:30 13:30 14:30 15:30 16:30
January 7, 2007
(Eastern Standard Time)


Back Trajectories Arriving at 1/07/2007 15:00 EST
Large sources of 1999 RGM (Reactive Gaseous Mercury) emissions (kg/yr) based on USEPA data from 1999 Nat'l Emissions Inventory
Size and shape of symbol denotes amount of RGM emitted (kg/yr)
5 - 10
10 - 50
50 - 100
100 - 300
Color of symbol denotes type of mercury source
coal-fired electricity generation
other fuel combustion
waste incineration
metallurgical processes
manufacturing/other
Back-trajectories starting at the indicated fraction of the mixed layer height. Circles on the trajectories mark the hourly position of the trajectory.
0.1
0.3
0.5
0.7
0.9
urbanized areas
Beltsville Mercury Monitoring Site
10 0 10 20 30 40 50 Kilometers
N
RGM (pg/m3)
100
80
60
40
20
0
07:30
08:30
09:30
10:30
11:30
12:30
13:30
14:30
15:30
16:30
January 7, 2007
(Eastern Standard Time)

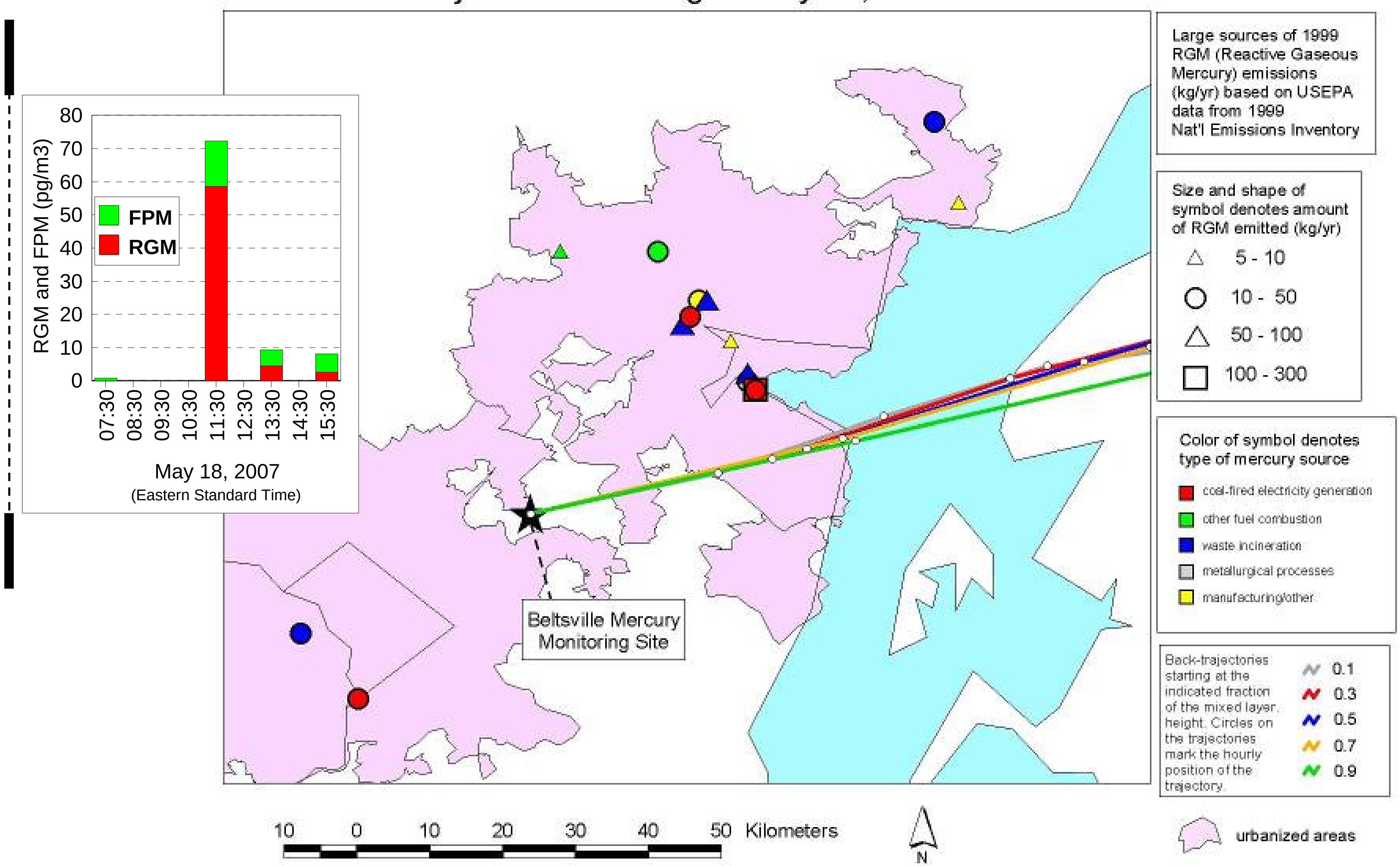


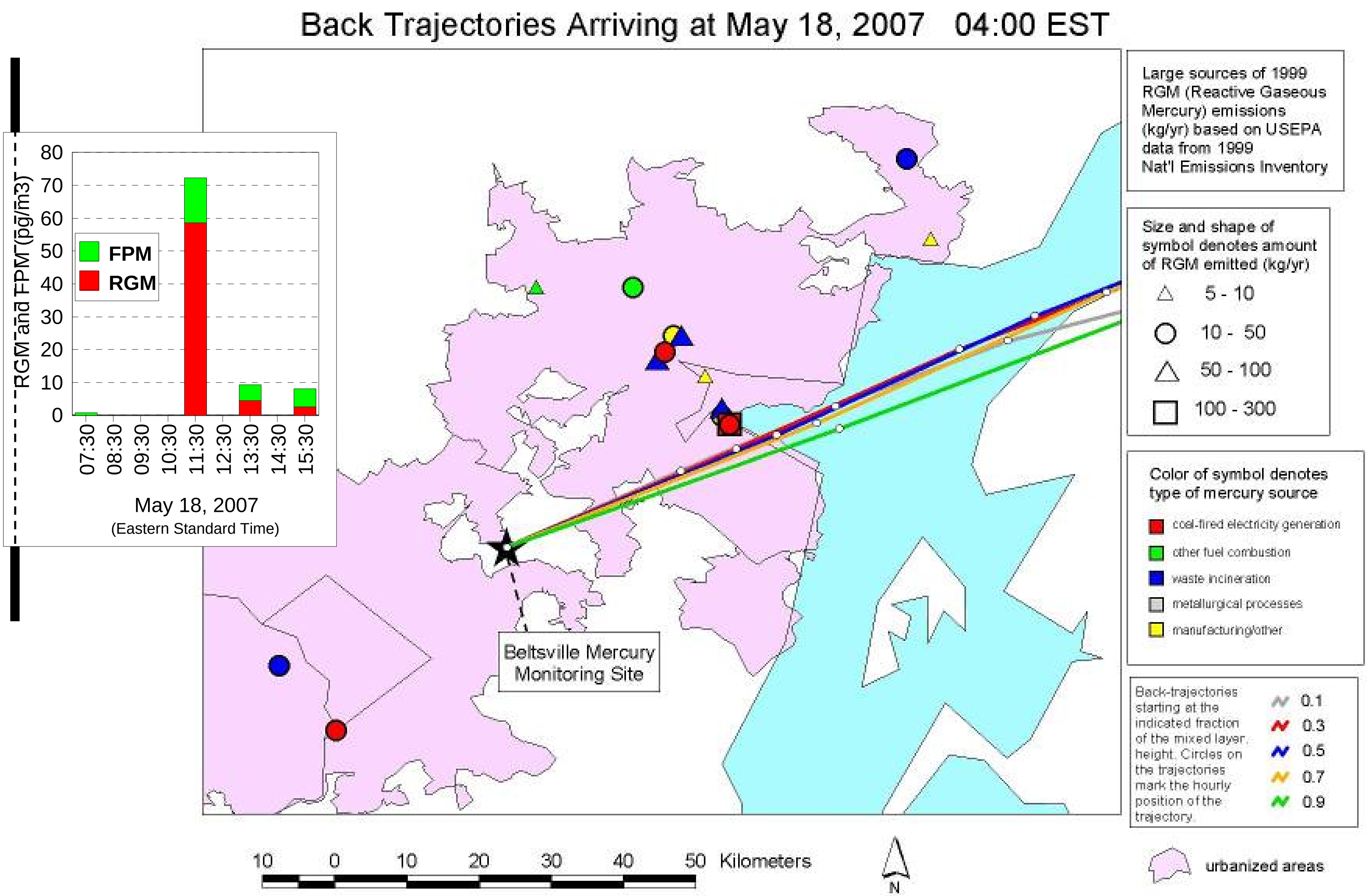
Back Trajectories Arriving at 1/07/2007 16:00 EST
Large sources of 1999 RGM (Reactive Gaseous Mercury) emissions (kg/yr) based on USEPA data from 1999 Nat'l Emissions Inventory
Size and shape of symbol denotes amount of RGM emitted (kg/yr)
5 - 10
10 - 50
50 - 100
100 - 300
Color of symbol denotes type of mercury source
coal-fired electricity generation
other fuel combustion
waste incineration
metallurgical processes
manufacturing/other
Back-trajectories starting at the indicated fraction of the mixed layer height. Circles on the trajectories mark the hourly position of the trajectory.
0.1
0.3
0.5
0.7
0.9
urbanized areas
Beltsville Mercury Monitoring Site
10 0 10 20 30 40 50 Kilometers
N
RGM (pg/m3)
100
80
60
40
20
0
07:30
08:30
09:30
10:30
11:30
12:30
13:30
14:30
15:30
16:30
January 7, 2007
(Eastern Standard Time)

Beltsville Episode May 18, 2007

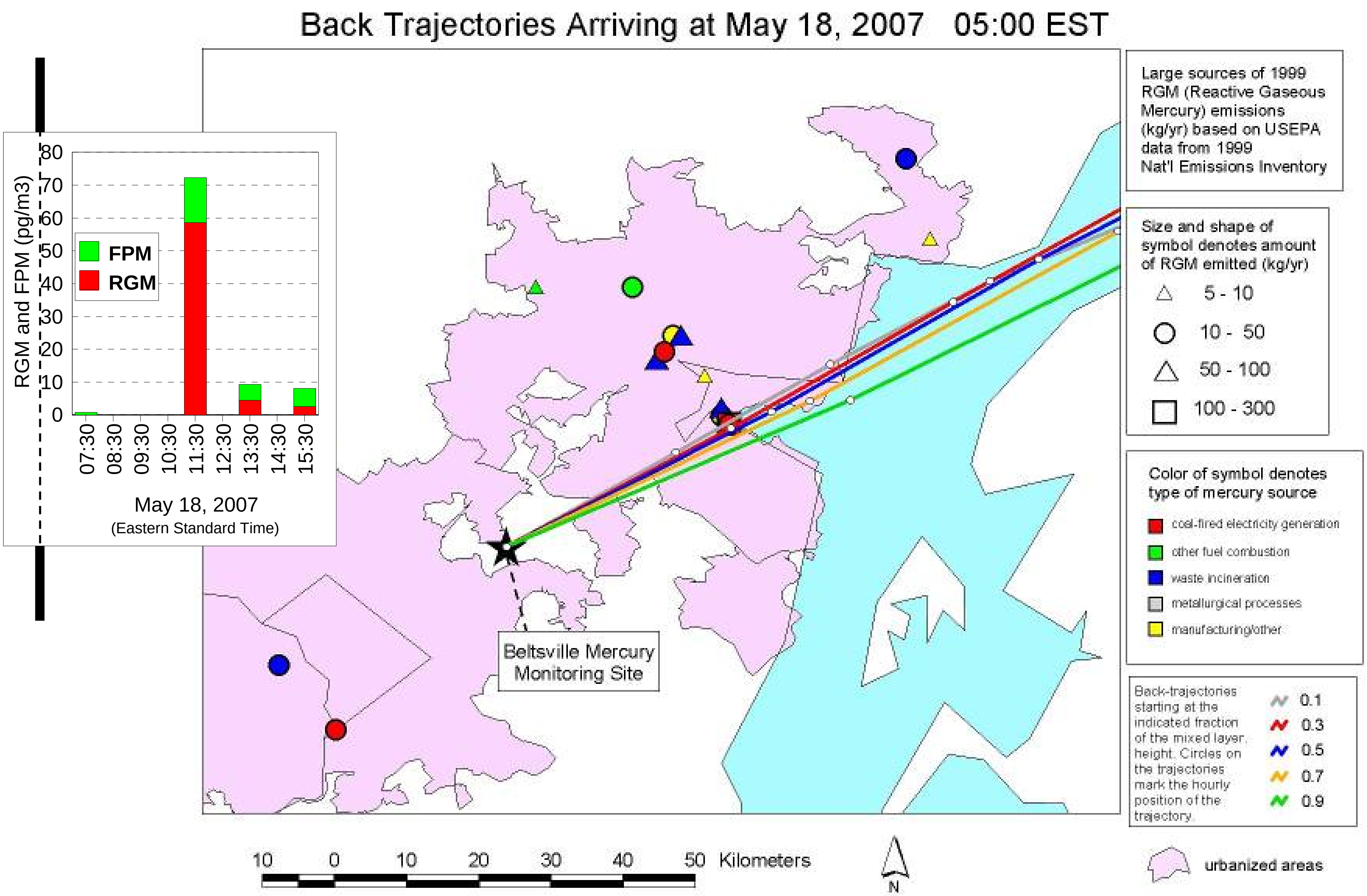


Back Trajectories Arriving at May 18, 2007 03:00 EST

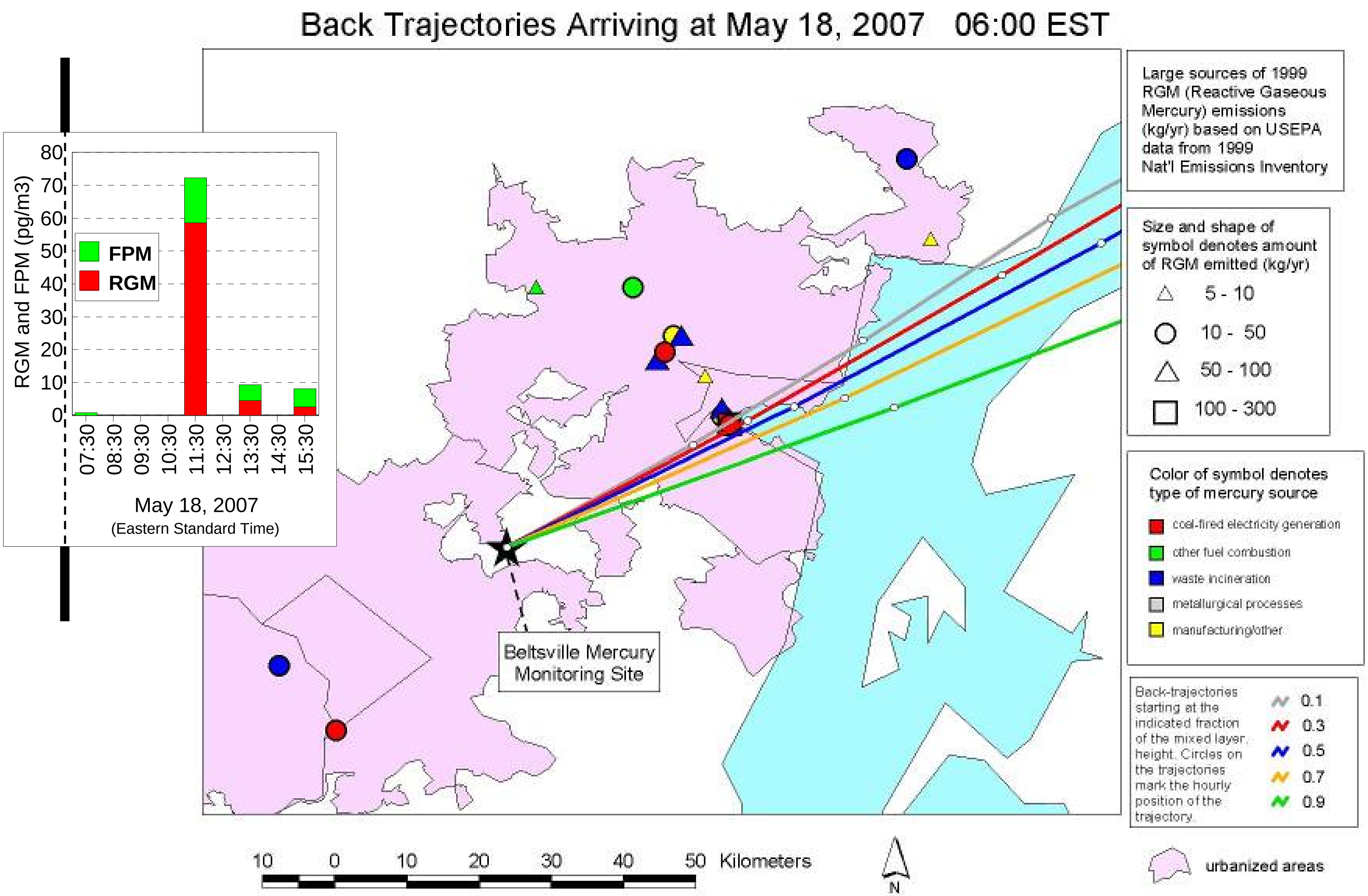




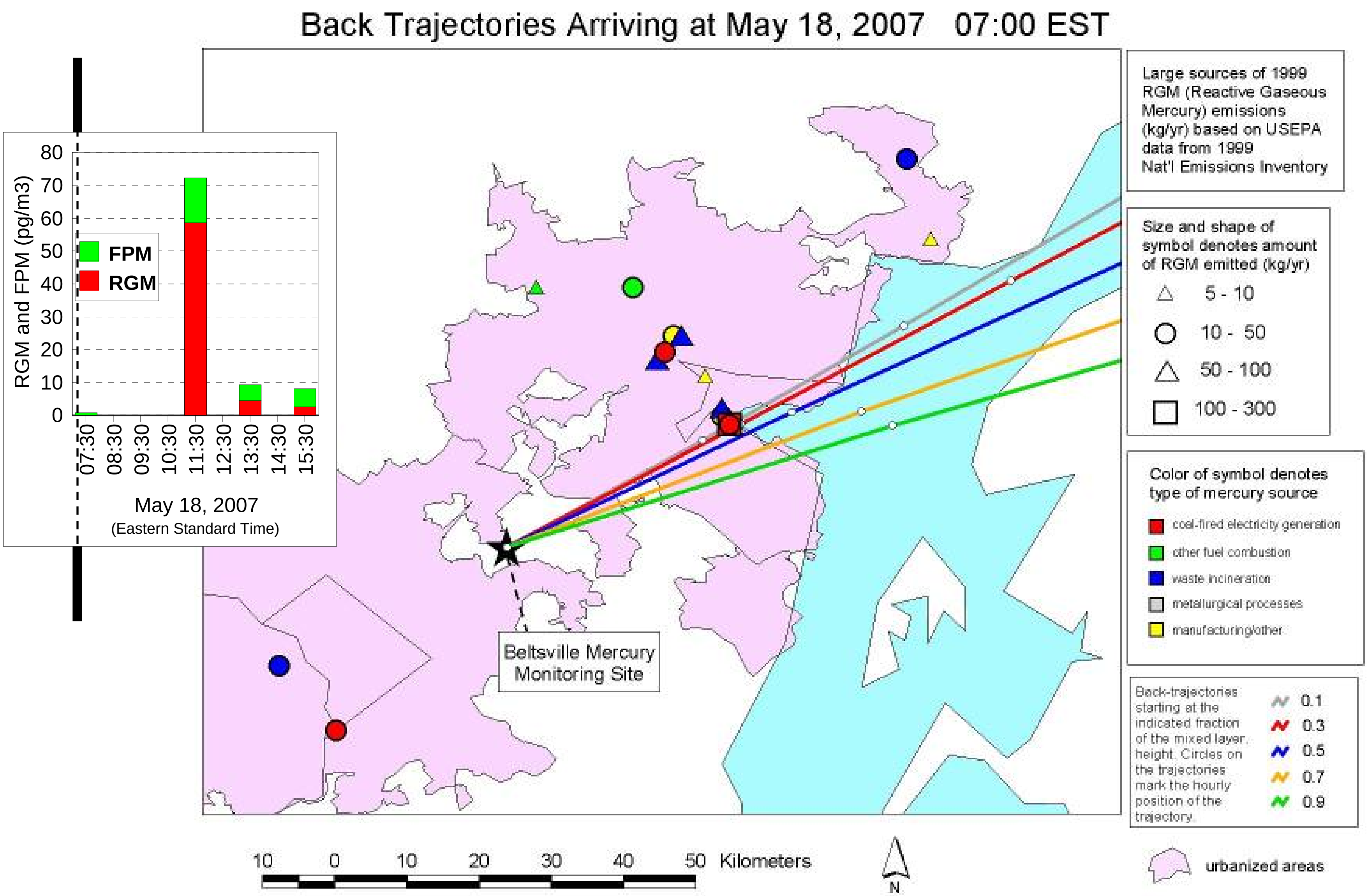
Back Trajectories Arriving at May 18, 2007 04:00 EST
RGM and FPM (pg/m3)
80
70
60
50
40
30
20
10
0
FPM
RGM
07:30
08:30
09:30
10:30
11:30
12:30
13:30
14:30
15:30
May 18, 2007
(Eastern Standard Time)
Beltsville Mercury Monitoring Site
Large sources of 1999 RGM (Reactive Gaseous Mercury) emissions (kg/yr) based on USEPA data from 1999 Nat'l Emissions Inventory
Size and shape of symbol denotes amount of RGM emitted (kg/yr)
5 - 10
10 - 50
50 - 100
100 - 300
Color of symbol denotes type of mercury source
coal-fired electricity generation
other fuel combustion
waste incineration
metallurgical processes
manufacturing/other
Back-trajectories starting at the indicated fraction of the mixed layer height. Circles on the trajectories mark the hourly position of the trajectory.
0.1
0.3
0.5
0.7
0.9
10 0 10 20 30 40 50 Kilometers
N
urbanized areas



Back Trajectories Arriving at May 18, 2007 05:00 EST
RGM and FPM (pg/m3)
80
70
60
50
40
30
20
10
0
FPM
RGM
07:30
08:30
09:30
10:30
11:30
12:30
13:30
14:30
15:30
May 18, 2007
(Eastern Standard Time)
Beltsville Mercury Monitoring Site
Large sources of 1999 RGM (Reactive Gaseous Mercury) emissions (kg/yr) based on USEPA data from 1999 Nat'l Emissions Inventory
Size and shape of symbol denotes amount of RGM emitted (kg/yr)
5 - 10
10 - 50
50 - 100
100 - 300
Color of symbol denotes type of mercury source
coal-fired electricity generation
other fuel combustion
waste incineration
metallurgical processes
manufacturing/other
Back-trajectories starting at the indicated fraction of the mixed layer height. Circles on the trajectories mark the hourly position of the trajectory.
0.1
0.3
0.5
0.7
0.9
10 0 10 20 30 40 50 Kilometers
N
urbanized areas

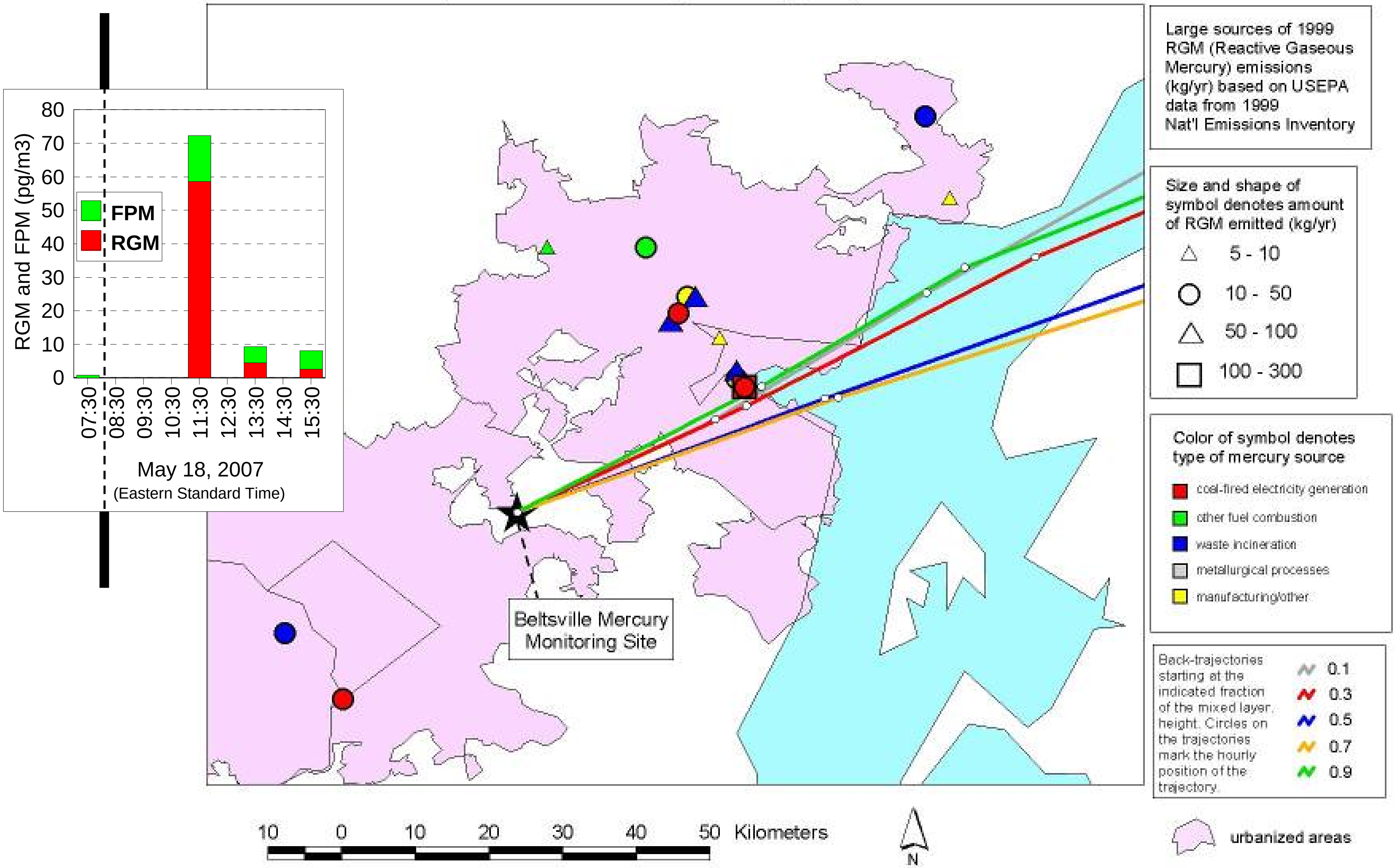


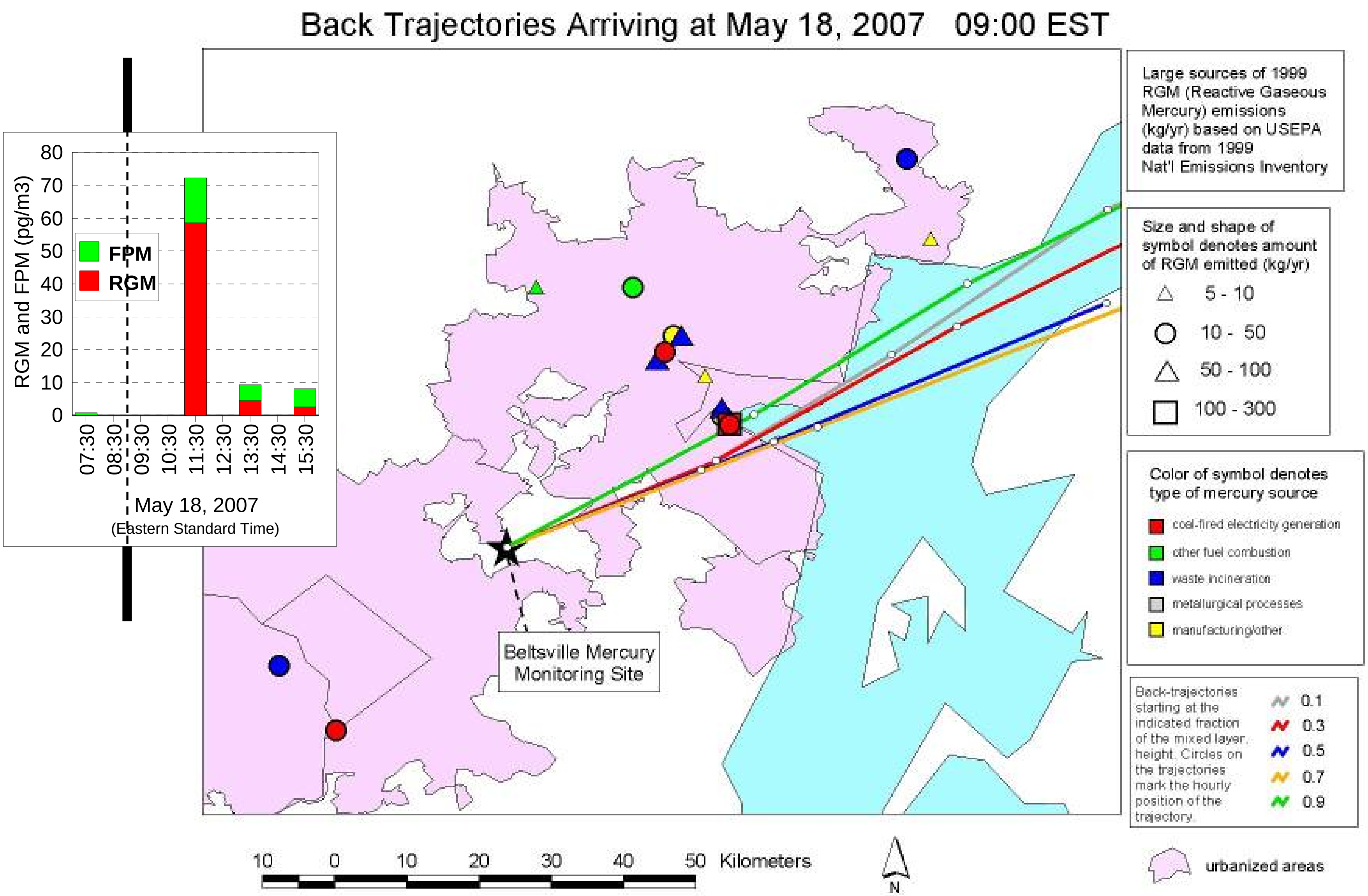
Back Trajectories Arriving at May 18, 2007 06:00 EST
RGM and FPM (pg/m3)
80
70
60
50
40
30
20
10
0
FPM
RGM
07:30
08:30
09:30
10:30
11:30
12:30
13:30
14:30
15:30
May 18, 2007
(Eastern Standard Time)
Beltsville Mercury Monitoring Site
Large sources of 1999 RGM (Reactive Gaseous Mercury) emissions (kg/yr) based on USEPA data from 1999 Nat'l Emissions Inventory
Size and shape of symbol denotes amount of RGM emitted (kg/yr)
5 - 10
10 - 50
50 - 100
100 - 300
Color of symbol denotes type of mercury source
coal-fired electricity generation
other fuel combustion
waste incineration
metallurgical processes
manufacturing/other
Back-trajectories starting at the indicated fraction of the mixed layer height. Circles on the trajectories mark the hourly position of the trajectory.
0.1
0.3
0.5
0.7
0.9
10 0 10 20 30 40 50 Kilometers
N
urbanized areas

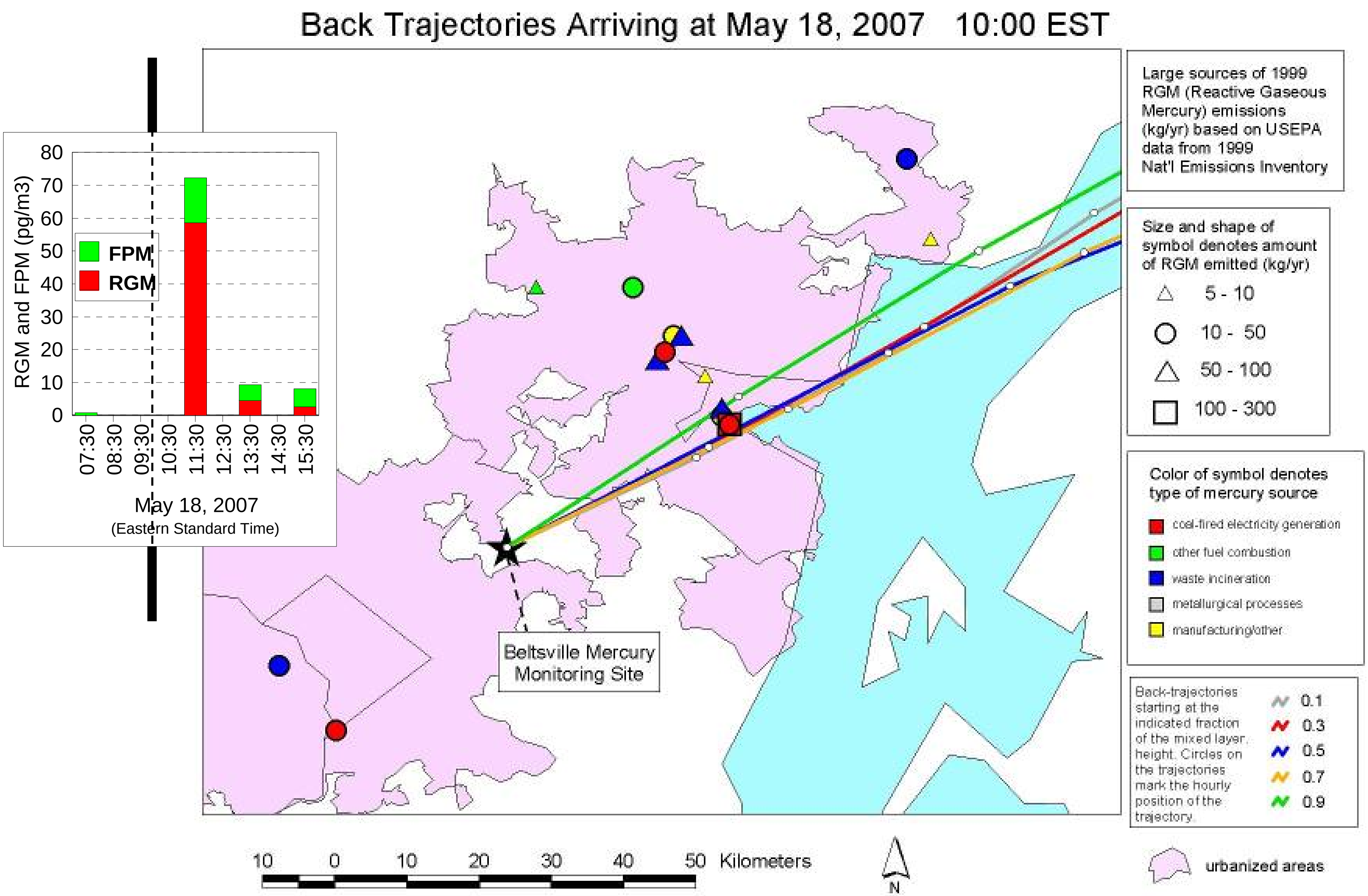


Back Trajectories Arriving at May 18, 2007 07:00 EST
RGM and FPM (pg/m3)
80
70
60
50
40
30
20
10
0
FPM
RGM
07:30
08:30
09:30
10:30
11:30
12:30
13:30
14:30
15:30
May 18, 2007
(Eastern Standard Time)
Beltsville Mercury Monitoring Site
Large sources of 1999 RGM (Reactive Gaseous Mercury) emissions (kg/yr) based on USEPA data from 1999 Nat'l Emissions Inventory
Size and shape of symbol denotes amount of RGM emitted (kg/yr)
5 - 10
10 - 50
50 - 100
100 - 300
Color of symbol denotes type of mercury source
coal-fired electricity generation
other fuel combustion
waste incineration
metallurgical processes
manufacturing/other
Back-trajectories starting at the indicated fraction of the mixed layer height. Circles on the trajectories mark the hourly position of the trajectory.
0.1
0.3
0.5
0.7
0.9
10 0 10 20 30 40 50 Kilometers
N
urbanized areas

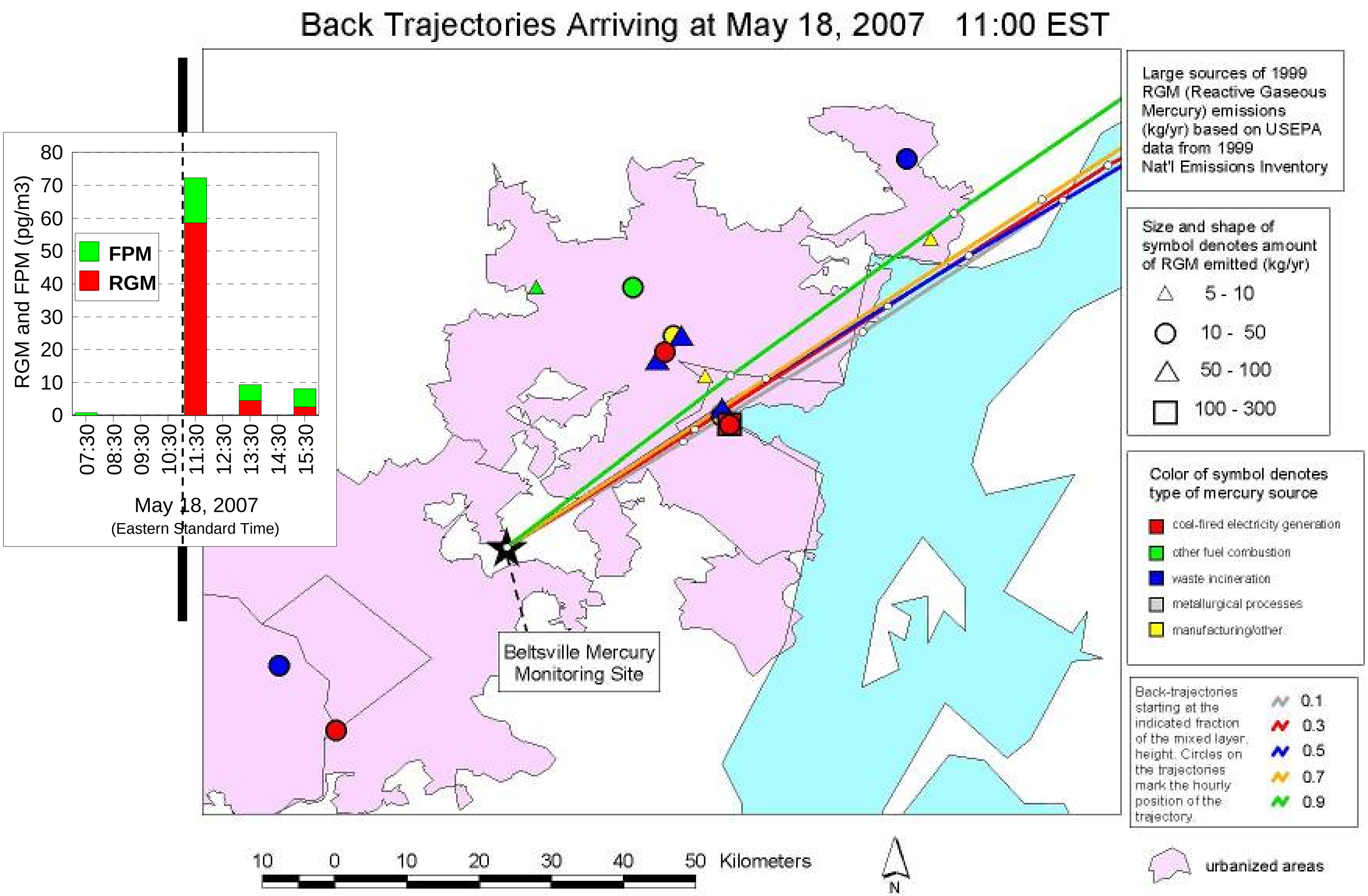
Back Trajectories Arriving at May 18, 2007 08:00 EST




Back Trajectories Arriving at May 18, 2007 09:00 EST
80
70
60
50
40
30
20
10
0
RGM and FPM (pg/m3)
FPM
RGM
07:30
08:30
09:30
10:30
11:30
12:30
13:30
14:30
15:30
May 18, 2007
(Eastern Standard Time)
Beltsville Mercury Monitoring Site
Large sources of 1999 RGM (Reactive Gaseous Mercury) emissions (kg/yr) based on USEPA data from 1999 Nat'l Emissions Inventory
Size and shape of symbol denotes amount of RGM emitted (kg/yr)
5 - 10
10 - 50
50 - 100
100 - 300
Color of symbol denotes type of mercury source
coal-fired electricity generation
other fuel combustion
waste incineration
metallurgical processes
manufacturing/other
Back-trajectories starting at the indicated fraction of the mixed layer height. Circles on the trajectories mark the hourly position of the trajectory.
0.1
0.3
0.5
0.7
0.9
10 0 10 20 30 40 50 Kilometers
N
urbanized areas

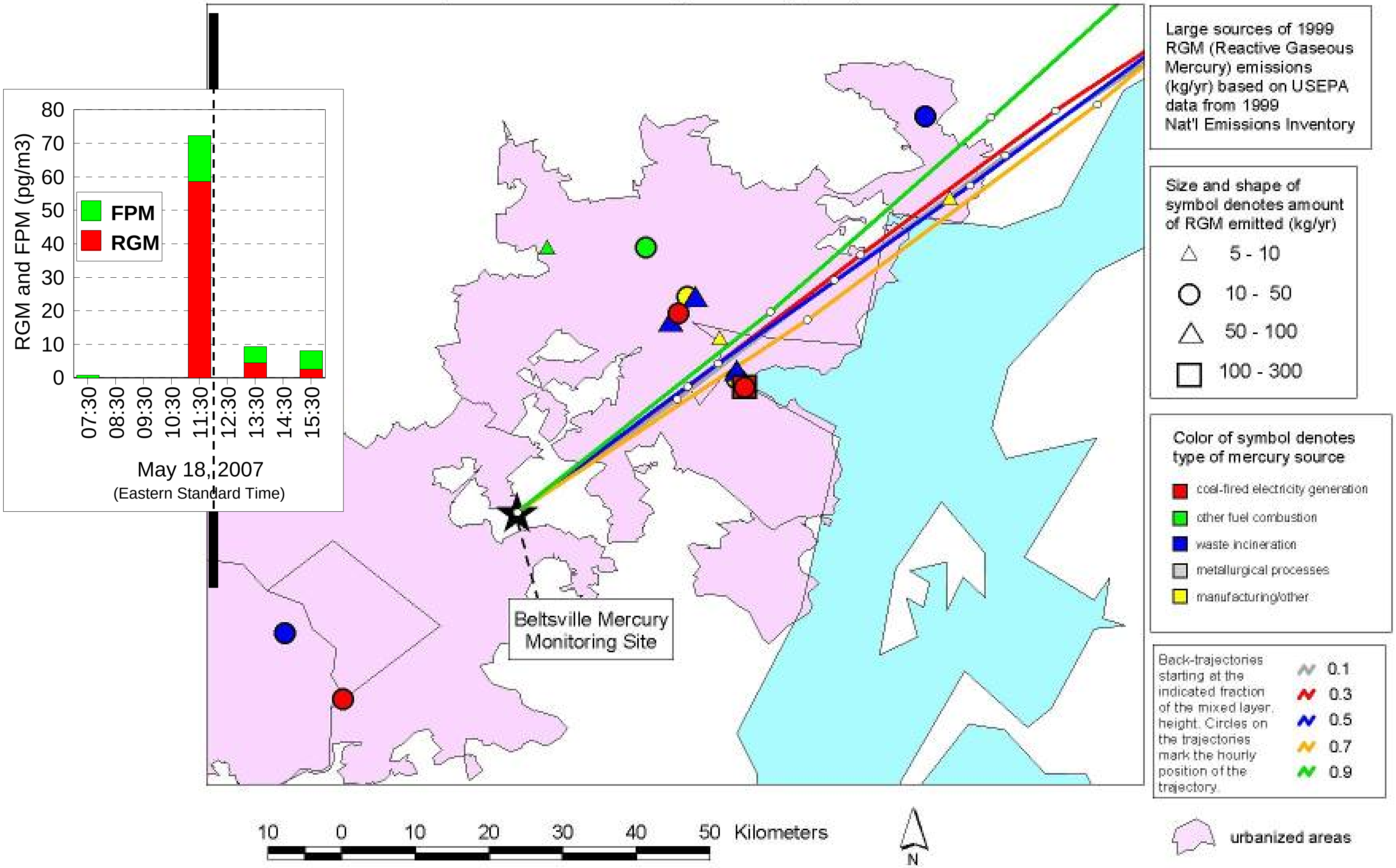


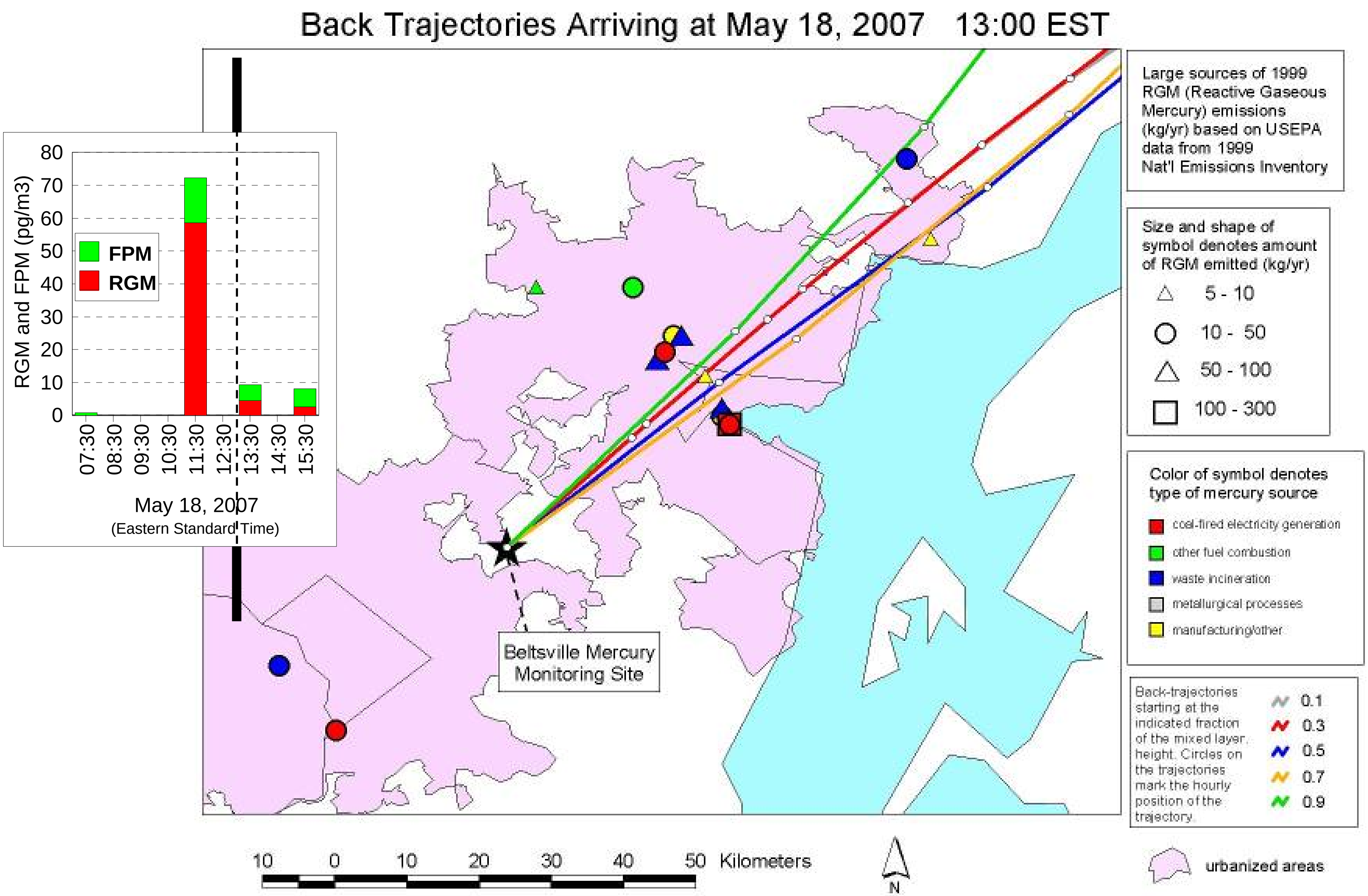
Back Trajectories Arriving at May 18, 2007 10:00 EST
80
70
60
50
40
30
20
10
0
RGM and FPM (pg/m3)
FPM
RGM
07:30
08:30
09:30
10:30
11:30
12:30
13:30
14:30
15:30
May 18, 2007
(Eastern Standard Time)
Beltsville Mercury Monitoring Site
Large sources of 1999 RGM (Reactive Gaseous Mercury) emissions (kg/yr) based on USEPA data from 1999 Nat'l Emissions Inventory
Size and shape of symbol denotes amount of RGM emitted (kg/yr)
5 - 10
10 - 50
50 - 100
100 - 300
Color of symbol denotes type of mercury source
coal-fired electricity generation
other fuel combustion
waste incineration
metallurgical processes
manufacturing/other
Back-trajectories starting at the indicated fraction of the mixed layer height. Circles on the trajectories mark the hourly position of the trajectory.
0.1
0.3
0.5
0.7
0.9
10 0 10 20 30 40 50 Kilometers
N
urbanized areas



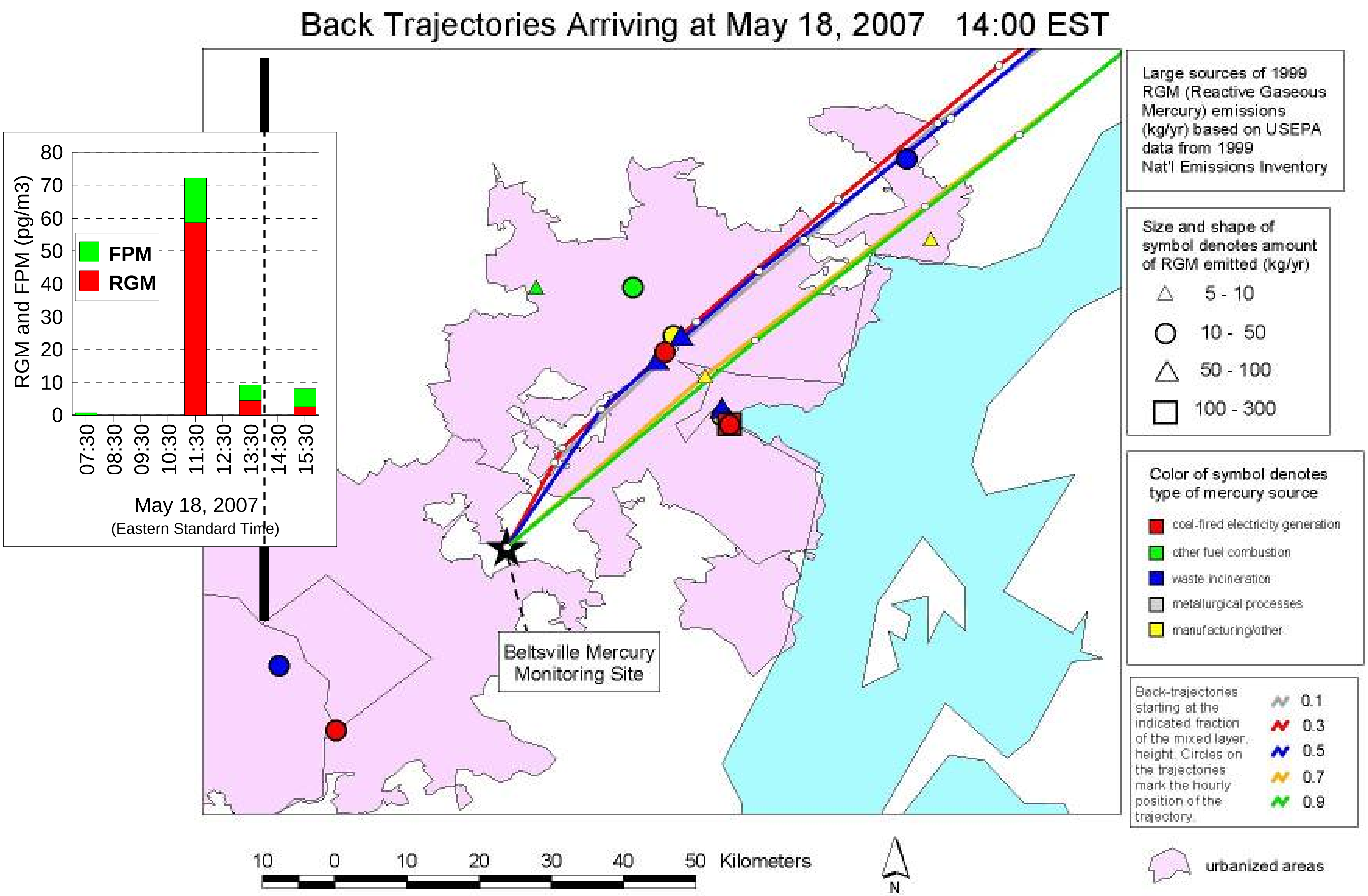
Back Trajectories Arriving at May 18, 2007 11:00 EST
RGM and FPM (pg/m3)
80
70
60
50
40
30
20
10
0
FPM
RGM
07:30
08:30
09:30
10:30
11:30
12:30
13:30
14:30
15:30
May 18, 2007
(Eastern Standard Time)
Beltsville Mercury Monitoring Site
Large sources of 1999 RGM (Reactive Gaseous Mercury) emissions (kg/yr) based on USEPA data from 1999 Nat'l Emissions Inventory
Size and shape of symbol denotes amount of RGM emitted (kg/yr)
5 - 10
10 - 50
50 - 100
100 - 300
Color of symbol denotes type of mercury source
coal-fired electricity generation
other fuel combustion
waste incineration
metallurgical processes
manufacturing/other
Back-trajectories starting at the indicated fraction of the mixed layer height. Circles on the trajectories mark the hourly position of the trajectory.
0.1
0.3
0.5
0.7
0.9
10
0
10
20
30
40
50
Kilometers
N
urbanized areas

Back Trajectories Arriving at May 18, 2007 12:00 EST

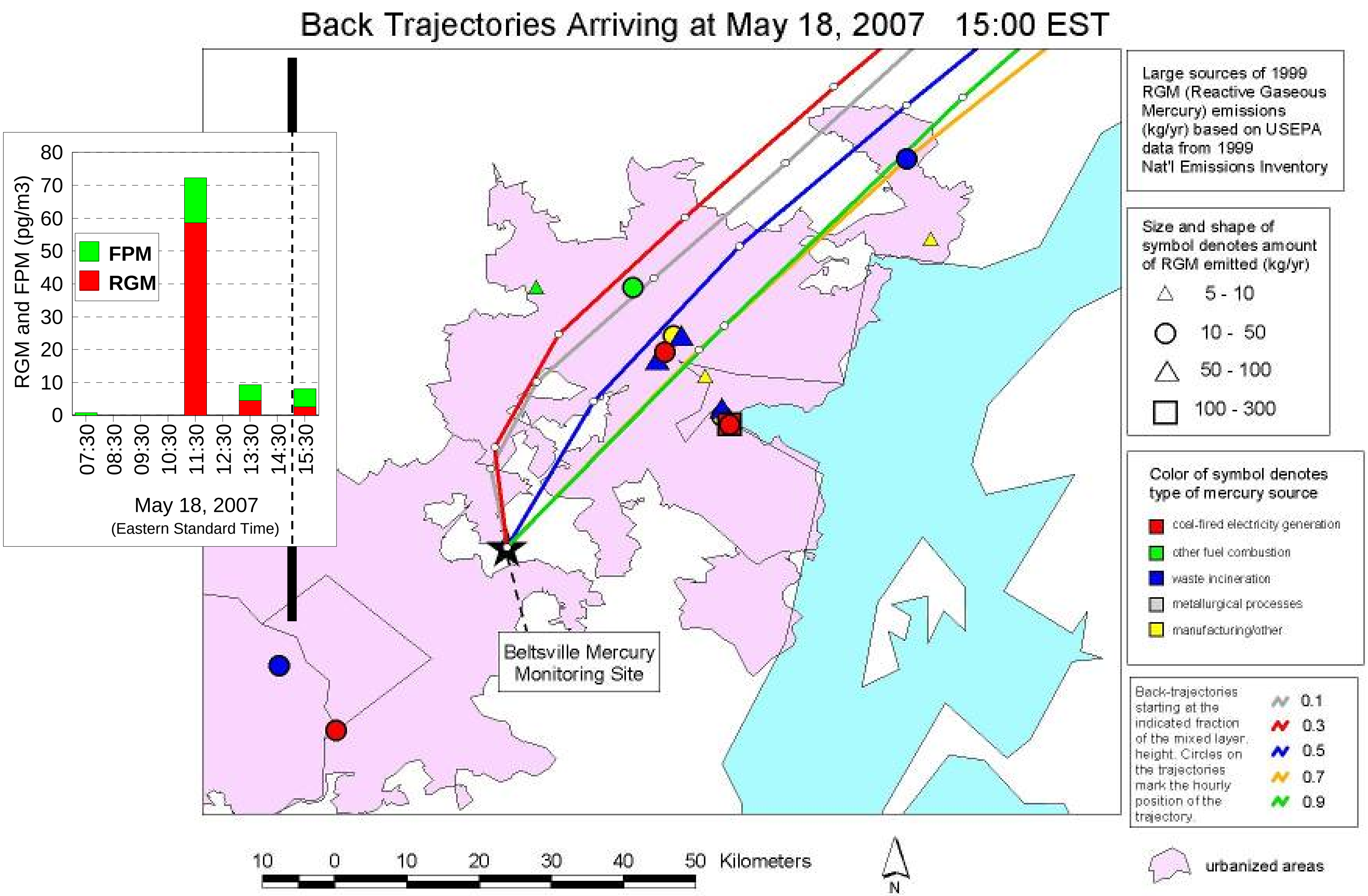




Back Trajectories Arriving at May 18, 2007 13:00 EST
RGM and FPM (pg/m3)
80
70
60
50
40
30
20
10
0
FPM
RGM
07:30
08:30
09:30
10:30
11:30
12:30
13:30
14:30
15:30
May 18, 2007
(Eastern Standard Time)
Beltsville Mercury Monitoring Site
Large sources of 1999 RGM (Reactive Gaseous Mercury) emissions (kg/yr) based on USEPA data from 1999 Nat'l Emissions Inventory
Size and shape of symbol denotes amount of RGM emitted (kg/yr)
5 - 10
10 - 50
50 - 100
100 - 300
Color of symbol denotes type of mercury source
coal-fired electricity generation
other fuel combustion
waste incineration
metallurgical processes
manufacturing/other
Back-trajectories starting at the indicated fraction of the mixed layer height. Circles on the trajectories mark the hourly position of the trajectory.
0.1
0.3
0.5
0.7
0.9
10 0 10 20 30 40 50 Kilometers
N
urbanized areas

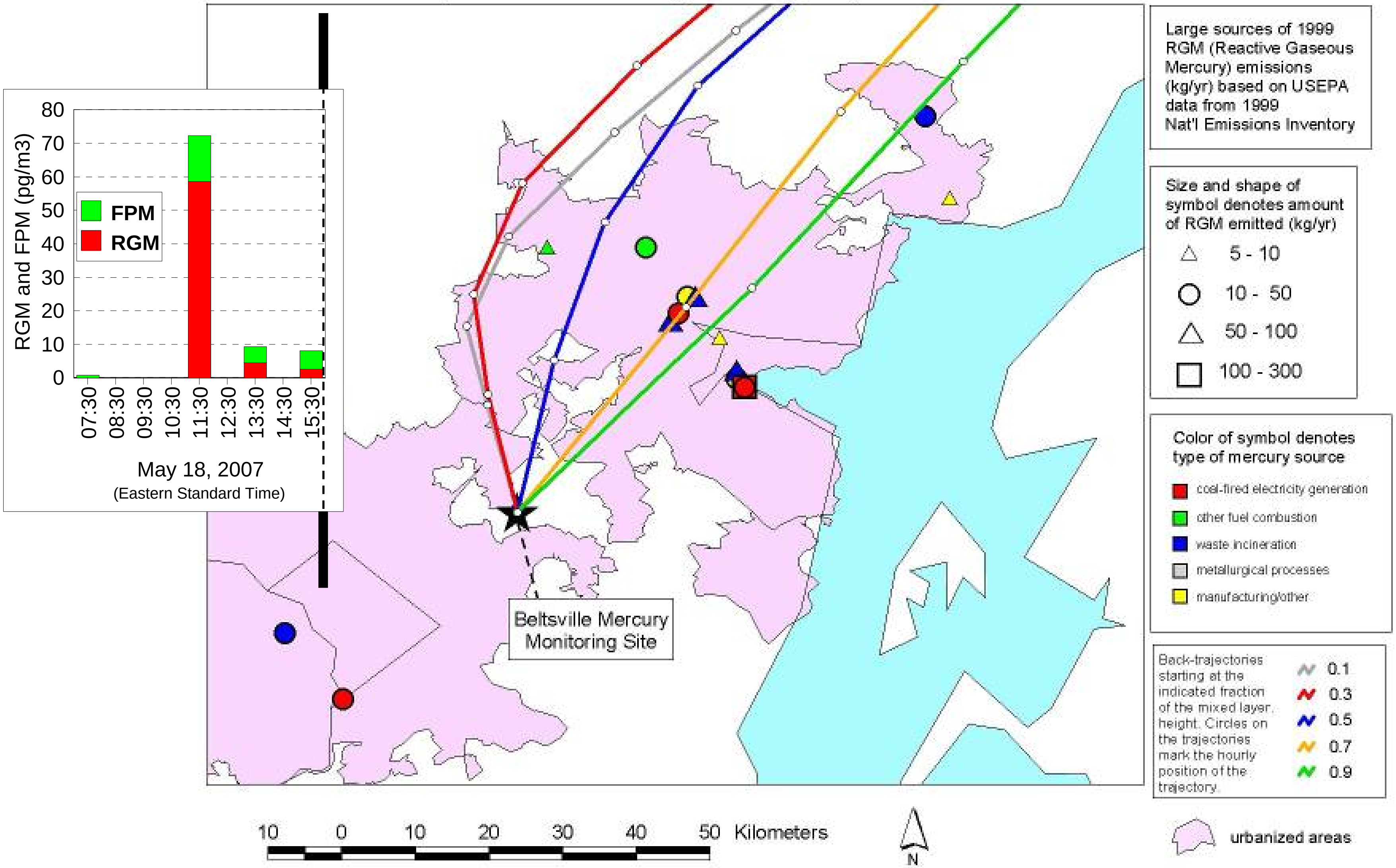


Back Trajectories Arriving at May 18, 2007 14:00 EST
RGM and FPM (pg/m3)
FPM
RGM
80
70
60
50
40
30
20
10
0
07:30
08:30
09:30
10:30
11:30
12:30
13:30
14:30
15:30
May 18, 2007
(Eastern Standard Time)
Beltsville Mercury Monitoring Site
Large sources of 1999 RGM (Reactive Gaseous Mercury) emissions (kg/yr) based on USEPA data from 1999 Nat'l Emissions Inventory
Size and shape of symbol denotes amount of RGM emitted (kg/yr)
5 - 10
10 - 50
50 - 100
100 - 300
Color of symbol denotes type of mercury source
coal-fired electricity generation
other fuel combustion
waste incineration
metallurgical processes
manufacturing/other
Back-trajectories starting at the indicated fraction of the mixed layer height. Circles on the trajectories mark the hourly position of the trajectory.
0.1
0.3
0.5
0.7
0.9
10
0
10
20
30
40
50
Kilometers
N
urbanized areas

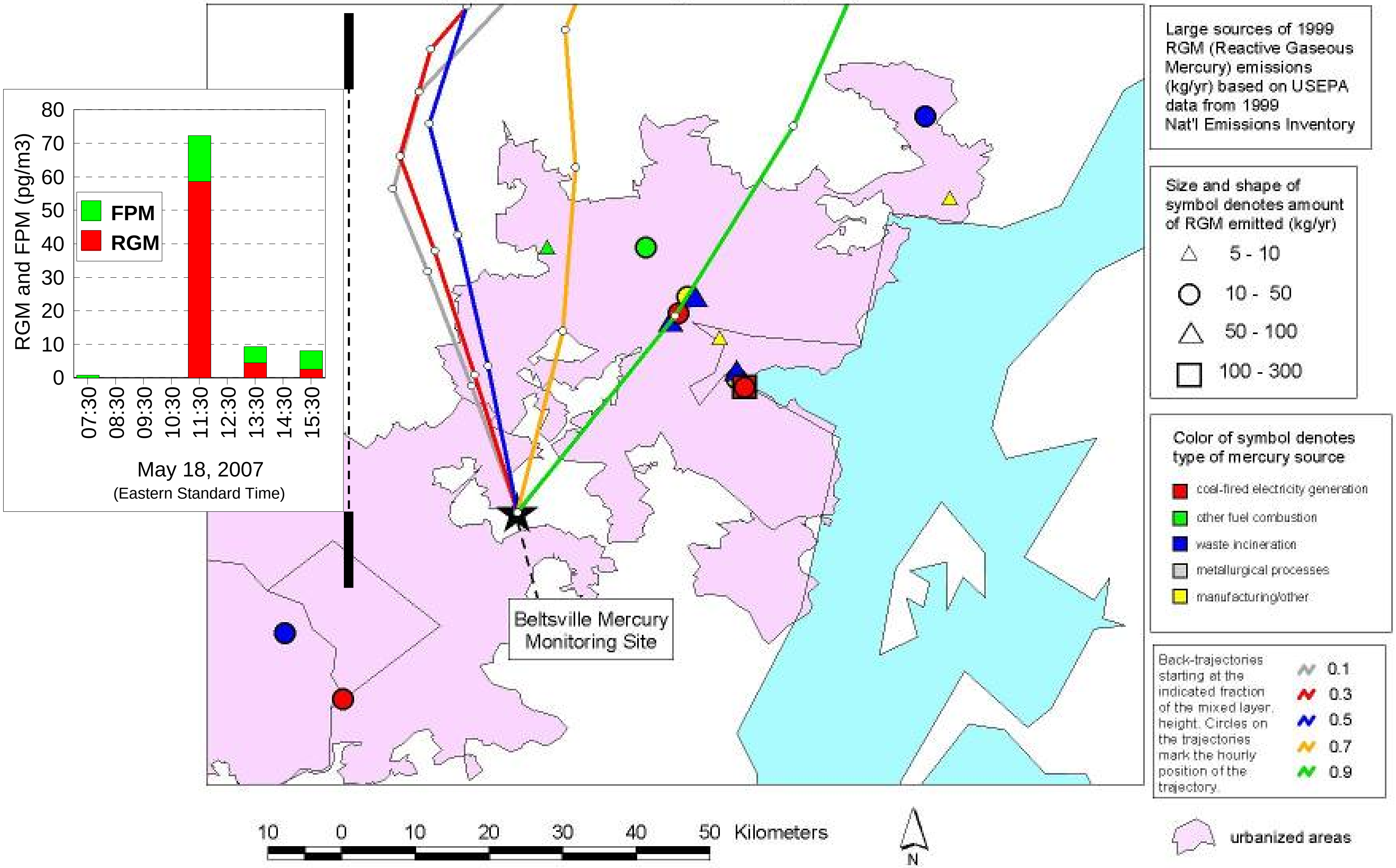


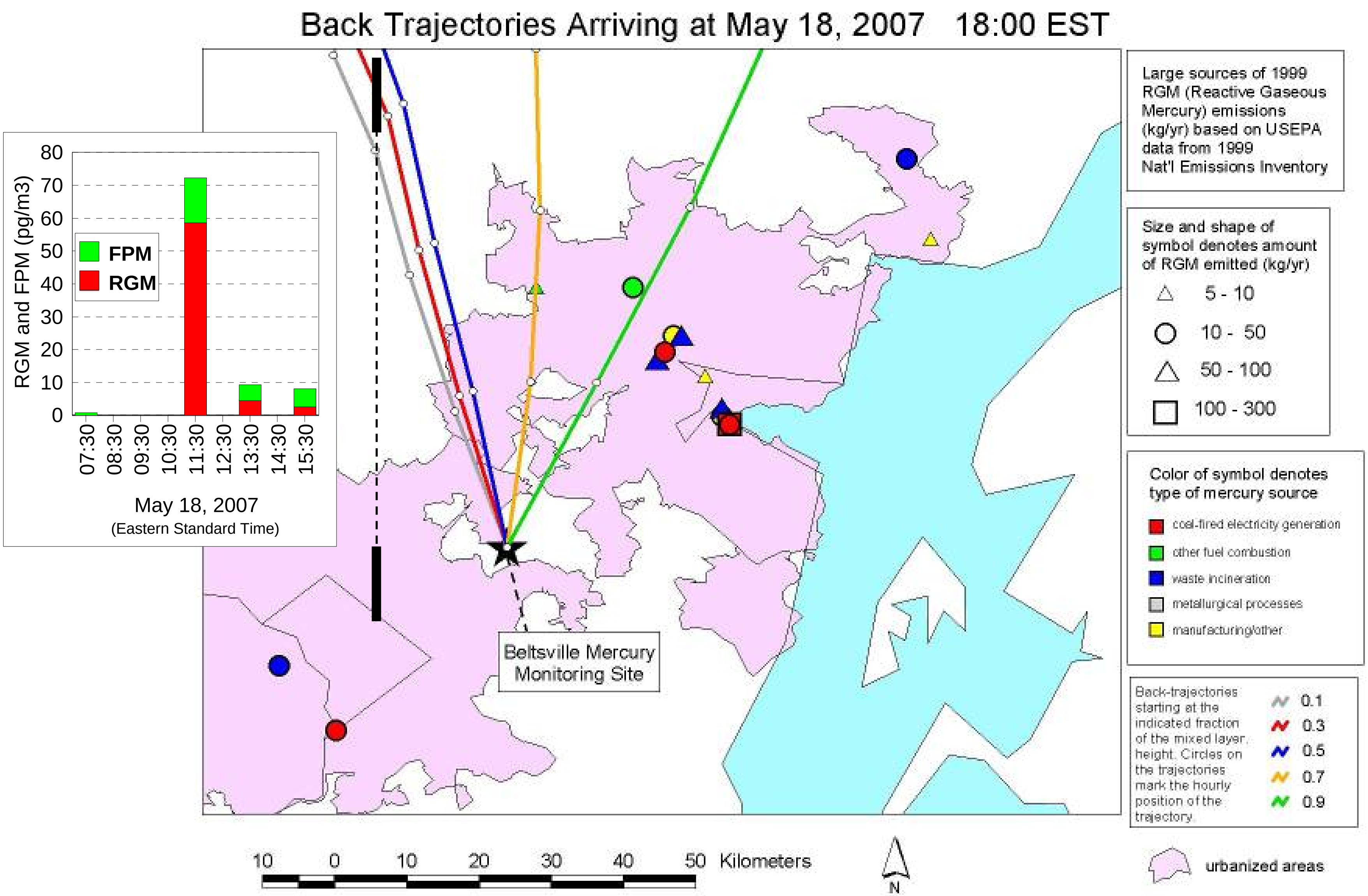
Back Trajectories Arriving at May 18, 2007 15:00 EST
RGM and FPM (pg/m3)
80
70
60
50
40
30
20
10
0
FPM
RGM
07:30
08:30
09:30
10:30
11:30
12:30
13:30
14:30
15:30
May 18, 2007
(Eastern Standard Time)
Beltsville Mercury Monitoring Site
Large sources of 1999 RGM (Reactive Gaseous Mercury) emissions (kg/yr) based on USEPA data from 1999 Nat'l Emissions Inventory
Size and shape of symbol denotes amount of RGM emitted (kg/yr)
5 - 10
10 - 50
50 - 100
100 - 300
Color of symbol denotes type of mercury source
coal-fired electricity generation
other fuel combustion
waste incineration
metallurgical processes
manufacturing/other
Back-trajectories starting at the indicated fraction of the mixed layer height. Circles on the trajectories mark the hourly position of the trajectory.
0.1
0.3
0.5
0.7
0.9
10 0 10 20 30 40 50 Kilometers
N
urbanized areas

Back Trajectories Arriving at May 18, 2007 16:00 EST



Back Trajectories Arriving at May 18, 2007   17:00 EST

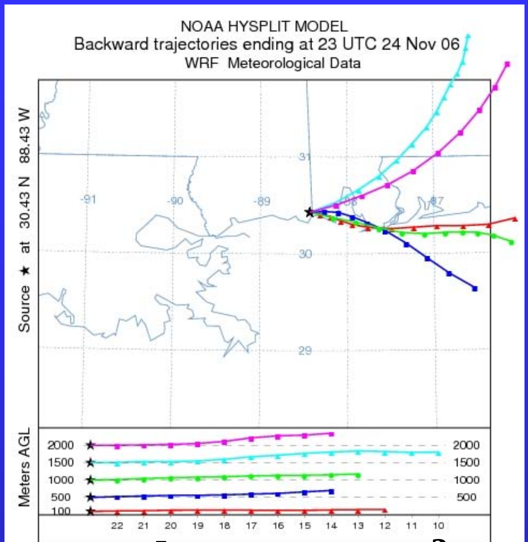




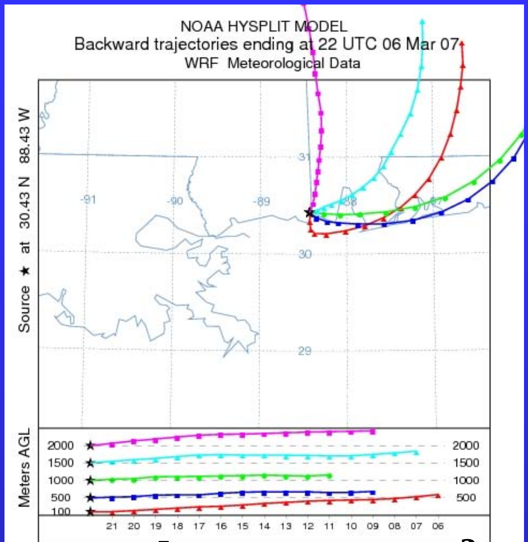
Back Trajectories Arriving at May 18, 2007 18:00 EST
RGM and FPM (pg/m3)
80
70
60
50
40
30
20
10
0
FPM
RGM
07:30
08:30
09:30
10:30
11:30
12:30
13:30
14:30
15:30
May 18, 2007
(Eastern Standard Time)
Beltsville Mercury Monitoring Site
10 0 10 20 30 40 50 Kilometers
N
Large sources of 1999 RGM (Reactive Gaseous Mercury) emissions (kg/yr) based on USEPA data from 1999 Nat'l Emissions Inventory
Size and shape of symbol denotes amount of RGM emitted (kg/yr)
5 - 10
10 - 50
50 - 100
100 - 300
Color of symbol denotes type of mercury source
coal-fired electricity generation
other fuel combustion
waste incineration
metallurgical processes
manufacturing/other
Back-trajectories starting at the indicated fraction of the mixed layer height. Circles on the trajectories mark the hourly position of the trajectory.
0.1
0.3
0.5
0.7
0.9
urbanized areas

Trajectory Analysis
Examples: Grand Bay

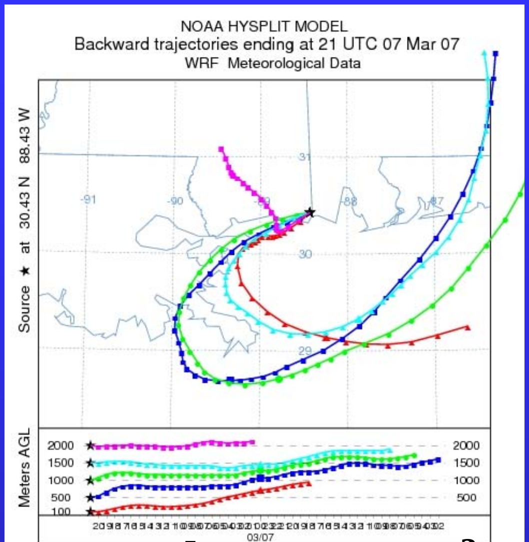
Higher RGM Associated with N-E trajectories



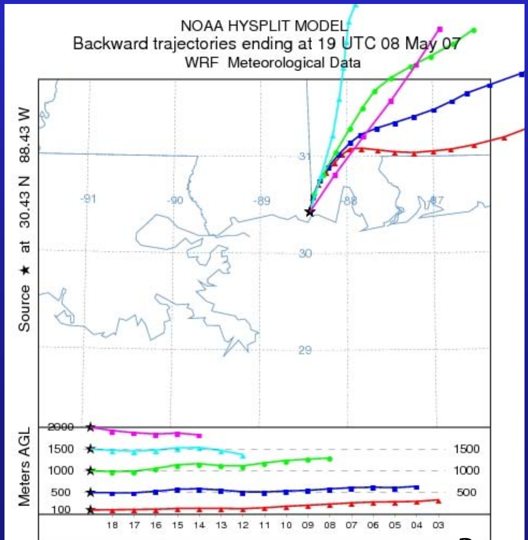
Peak ~ 50 pg m^{-3}



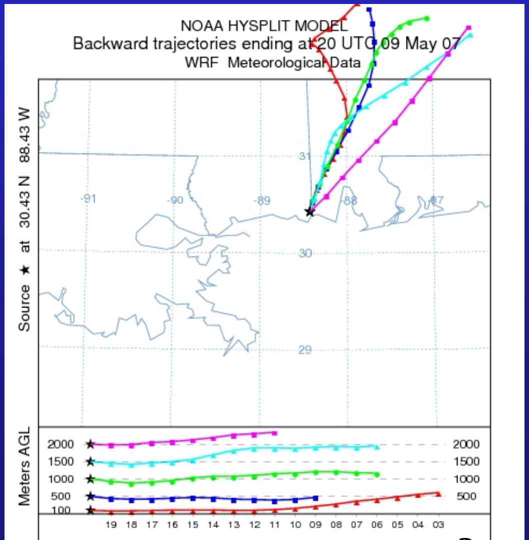
Peak ~ 118 pg m^{-3}



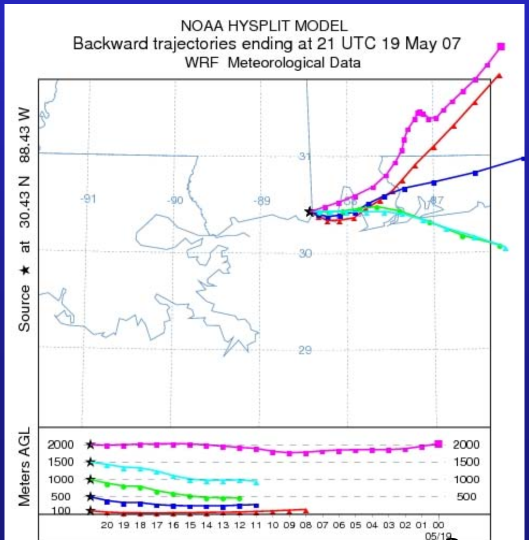
Peak ~ 55 pg m^{-3}



Peak ~ 105 pg m^{-3}

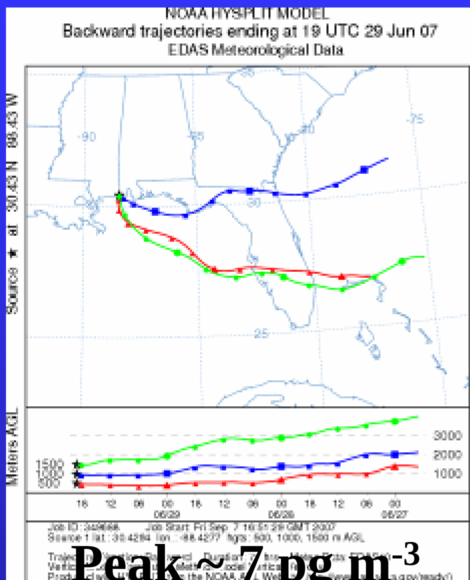


Peak ~ 100 pg m^{-3}

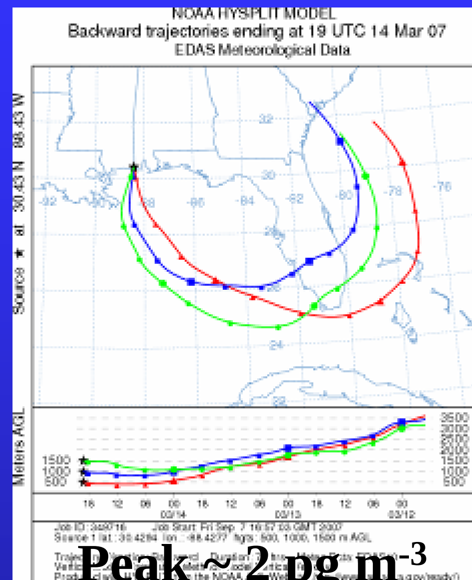


Peak ~ 65 pg m^{-3}

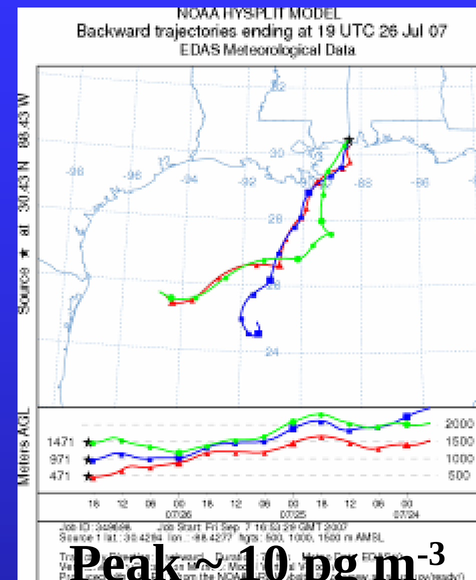
Lower RGM in Maritime trajectories



Peak ~ 7 pg m^{-3}

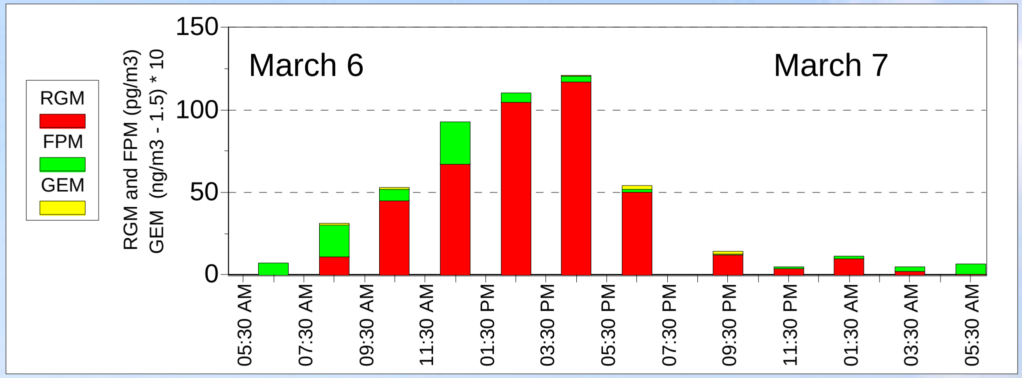


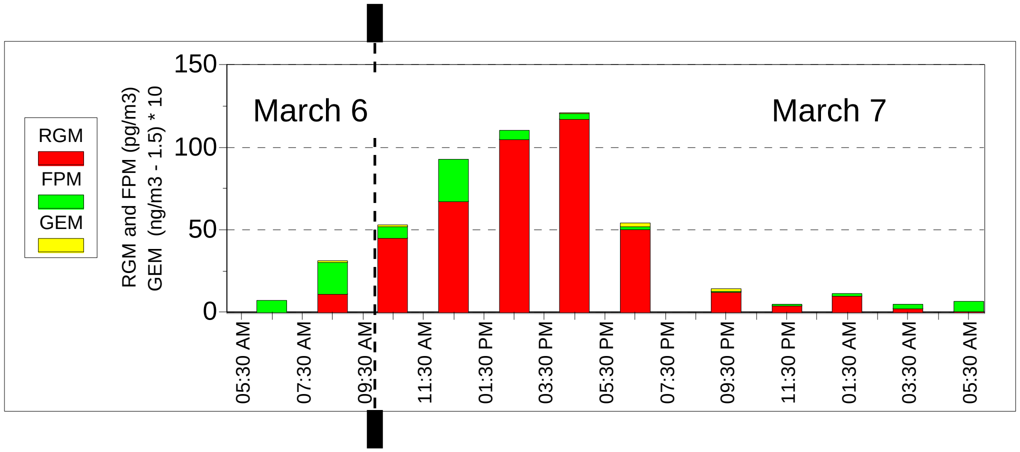
Peak ~ 2 pg m^{-3}

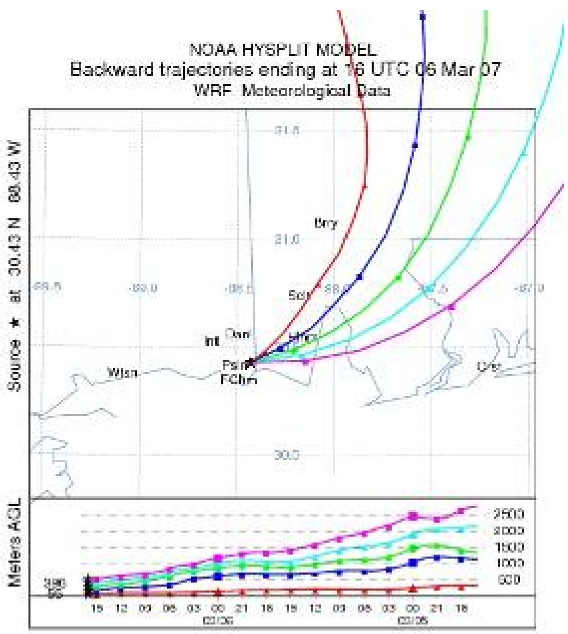


Peak ~ 10 pg m^{-3}

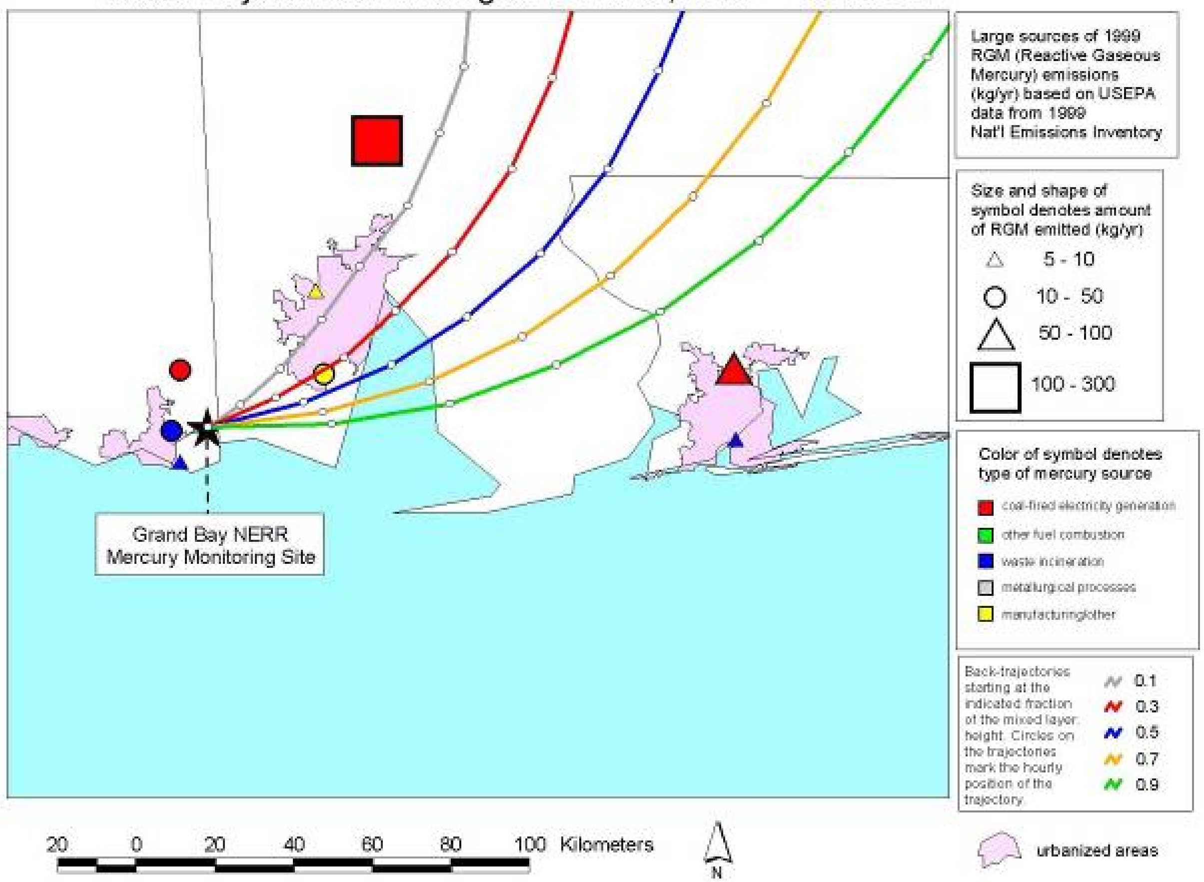
Grand Bay Episode March 6, 2007

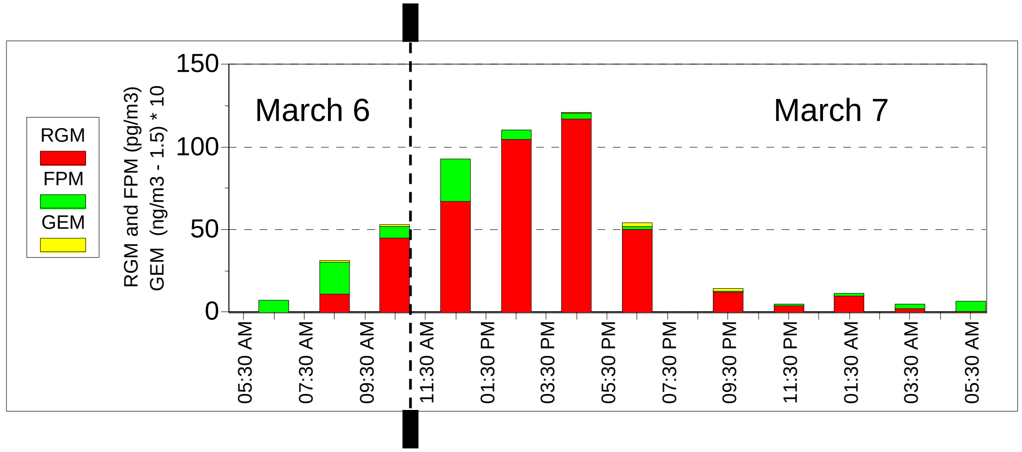


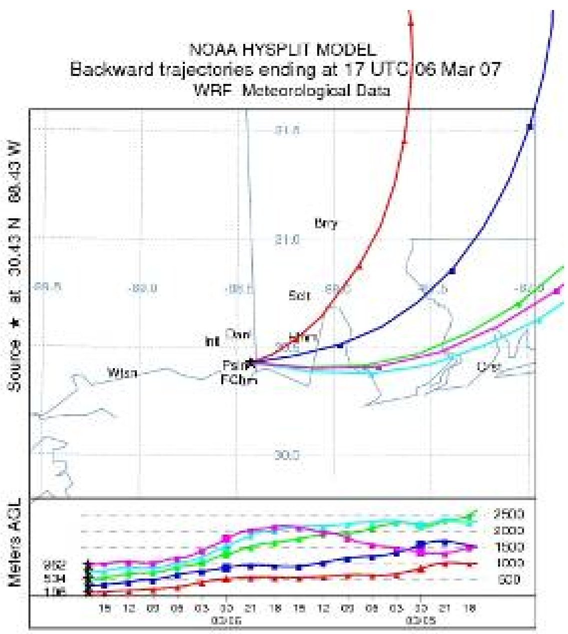


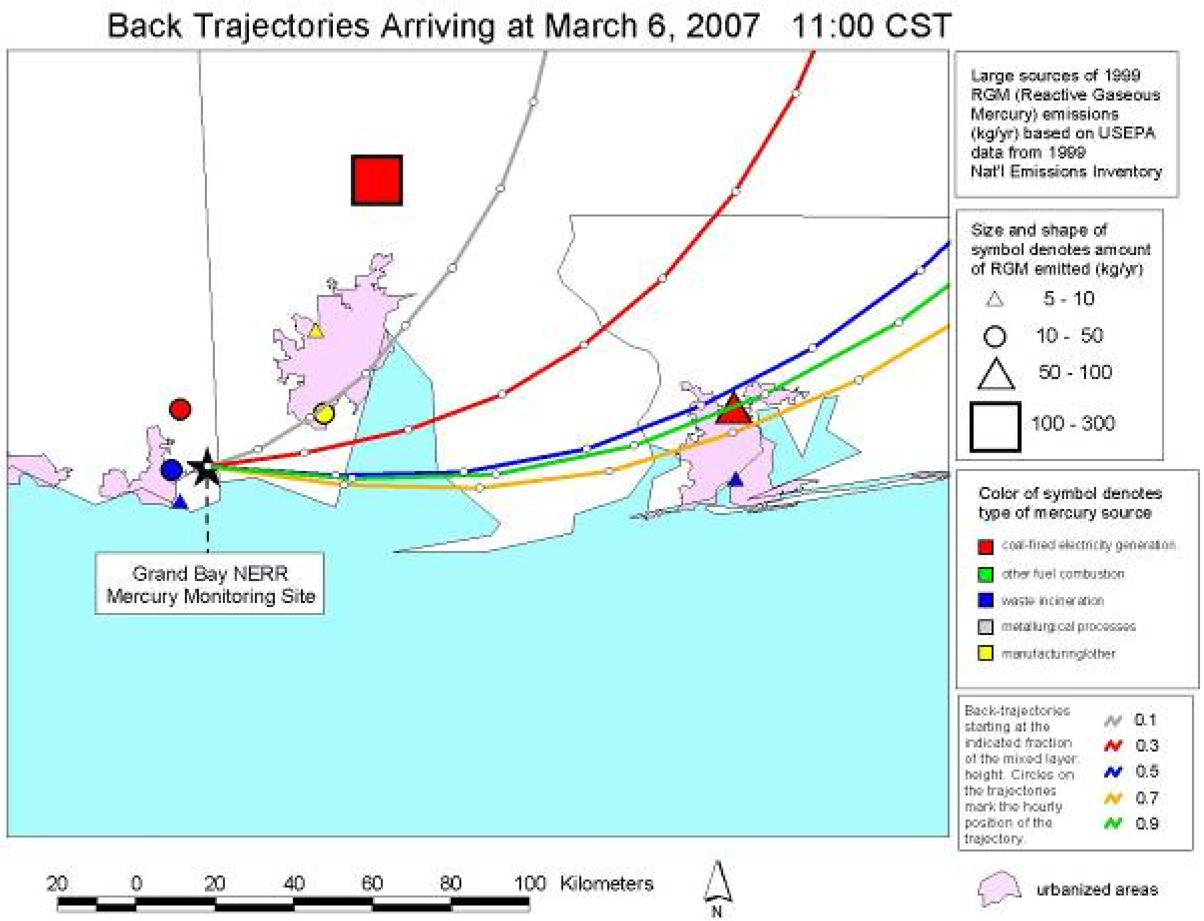


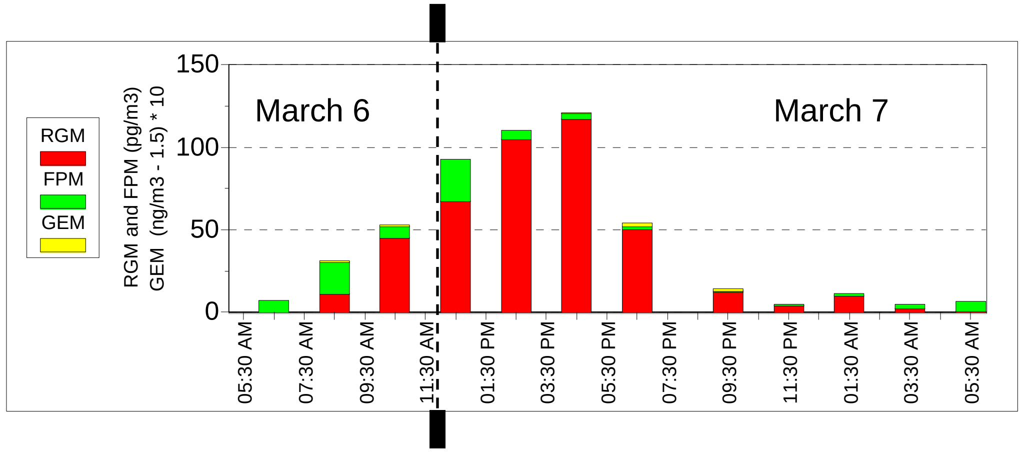
Back Trajectories Arriving at March 6, 2007 10:00 CST

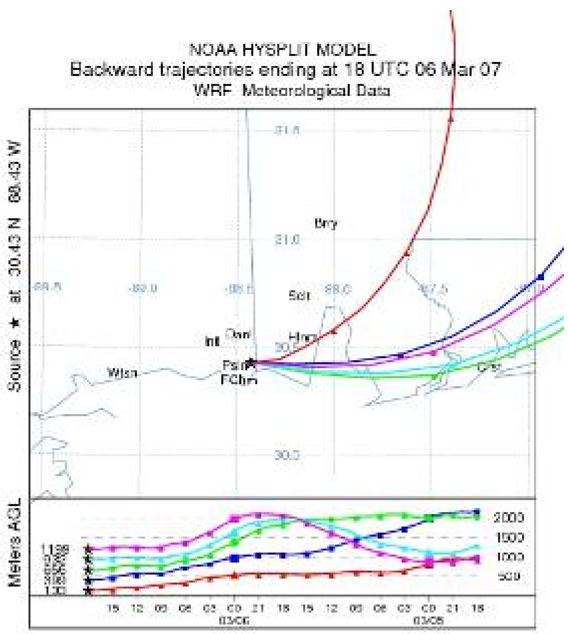



RGM
FPM
GEM
RGM and FPM (pg/m3)
GEM (ng/m3 - 1.5) * 10
150
100
50
0
March 6
March 7
05:30 AM
07:30 AM
09:30 AM
11:30 AM
01:30 PM
03:30 PM
05:30 PM
07:30 PM
09:30 PM
11:30 PM
01:30 AM
03:30 AM
05:30 AM

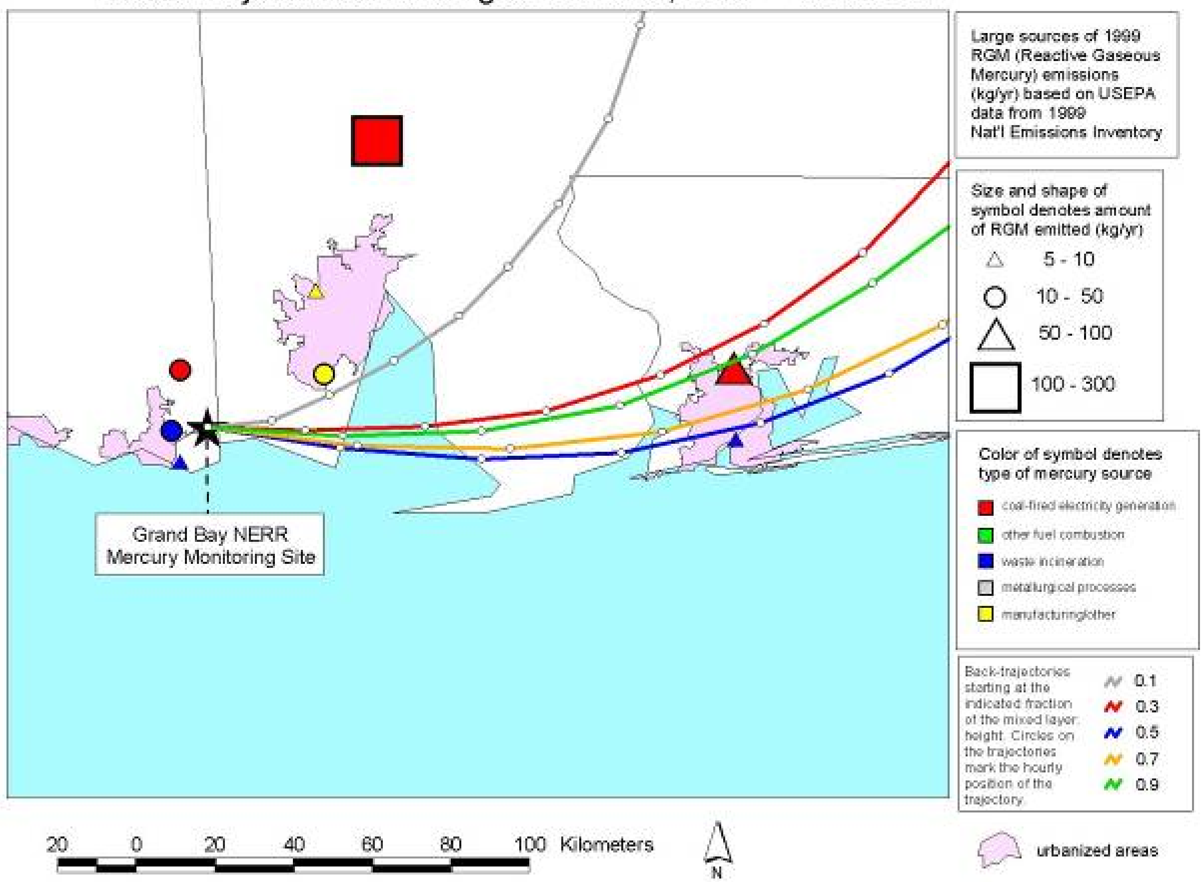

NOAA HYSPLIT MODEL
Backward trajectories ending at 17 UTC 06 Mar 07
WRF Meteorological Data
Source ★ at 30.43 N 88.43 W
Meters AGL
2500
2000
1500
1000
500

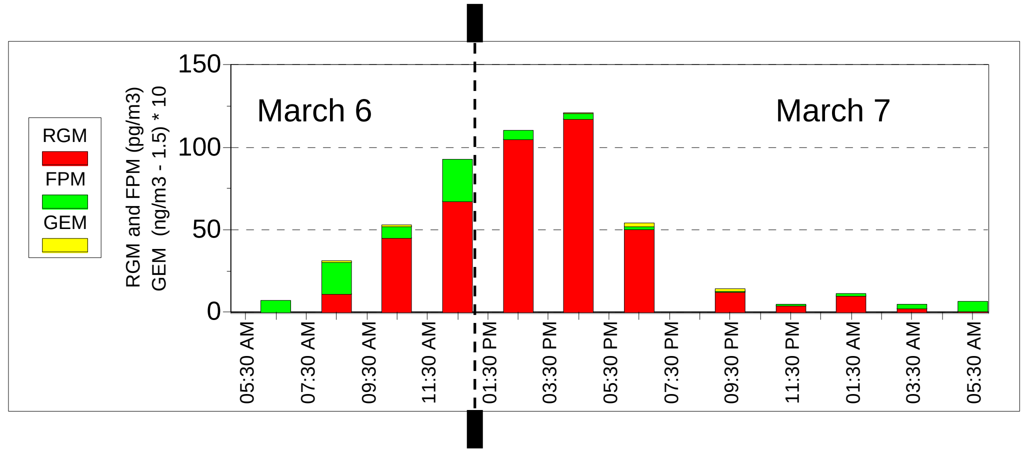

Back Trajectories Arriving at March 6, 2007 11:00 CST
Large sources of 1999 RGM (Reactive Gaseous Mercury) emissions (kg/yr) based on USEPA data from 1999 Nat'l Emissions Inventory
Size and shape of symbol denotes amount of RGM emitted (kg/yr)
5 - 10
10 - 50
50 - 100
100 - 300
Color of symbol denotes type of mercury source
coal-fired electricity generation
other fuel combustion
waste incineration
metallurgical processes
manufacturing/other
Back-trajectories starting at the indicated fraction of the mixed layer height. Circles on the trajectories mark the hourly position of the trajectory
0.1
0.3
0.5
0.7
0.9
Grand Bay NERR
Mercury Monitoring Site
20
0
20
40
60
80
100
Kilometers
N
urbanized areas

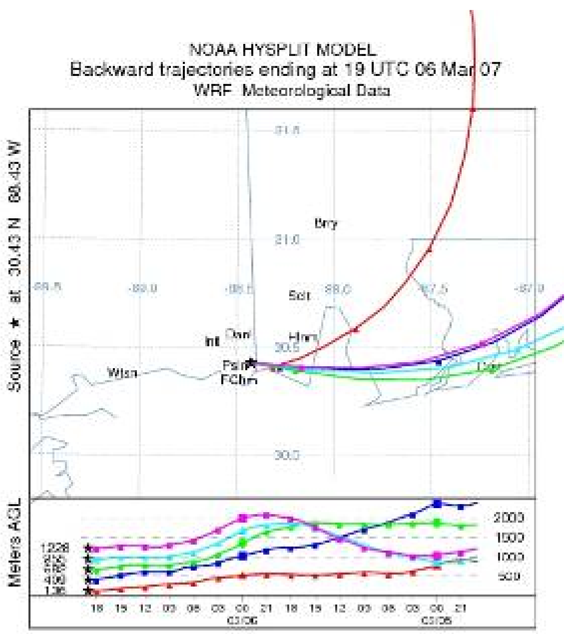


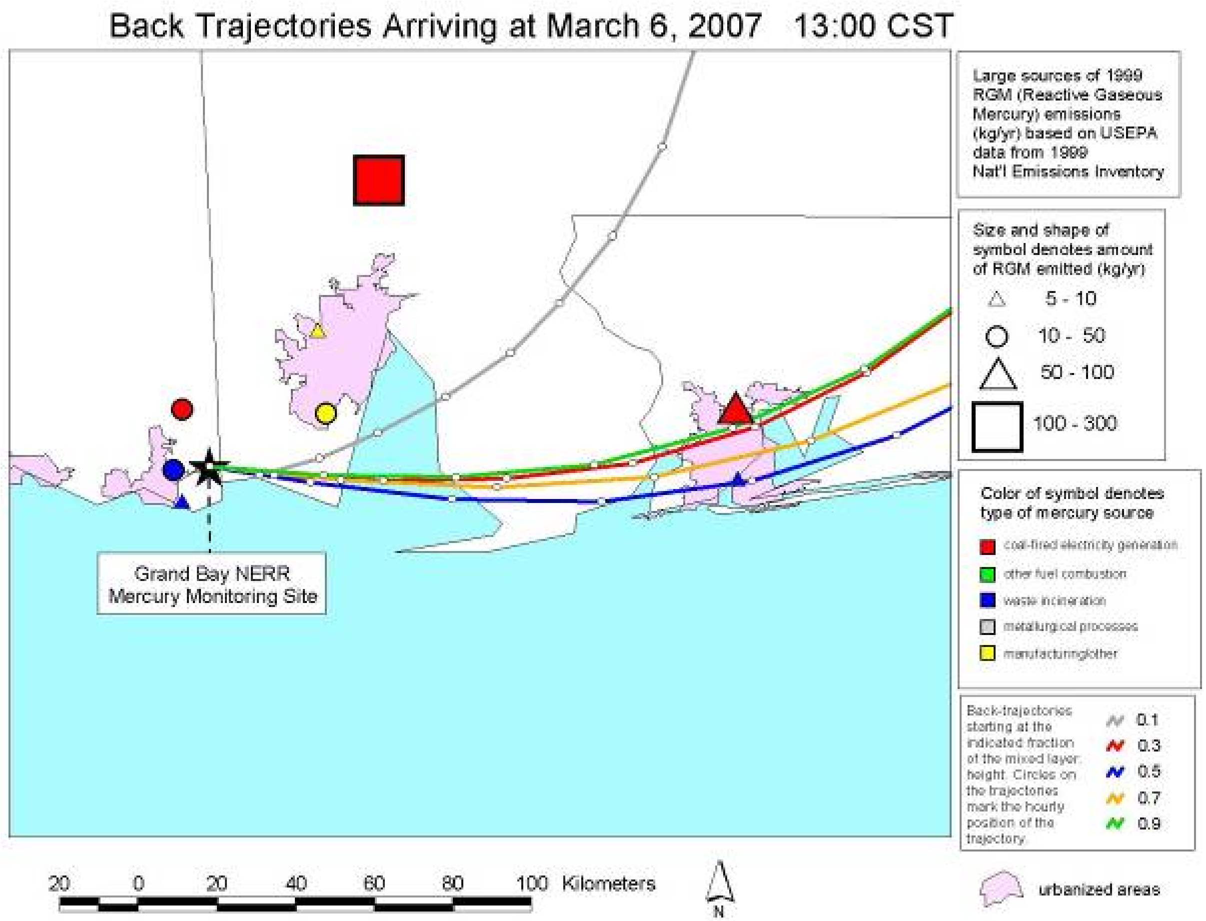


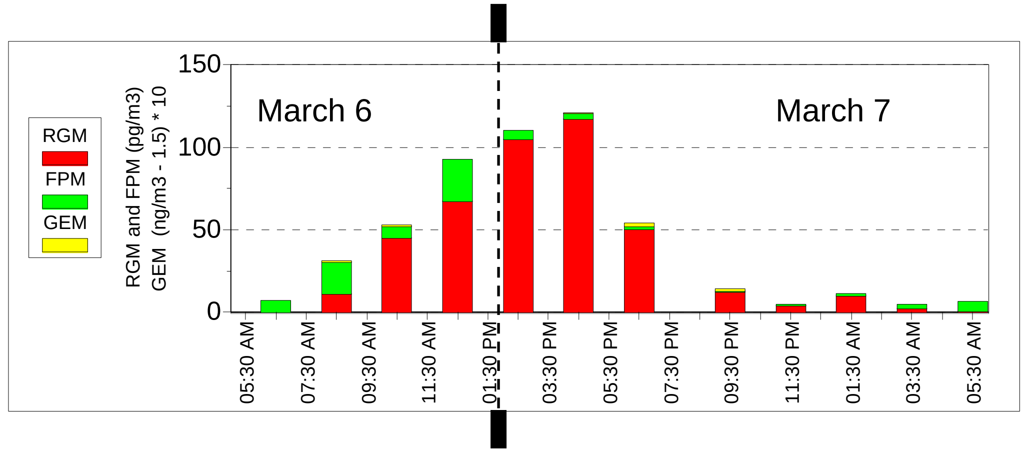
Back Trajectories Arriving at March 6, 2007 12:00 CST

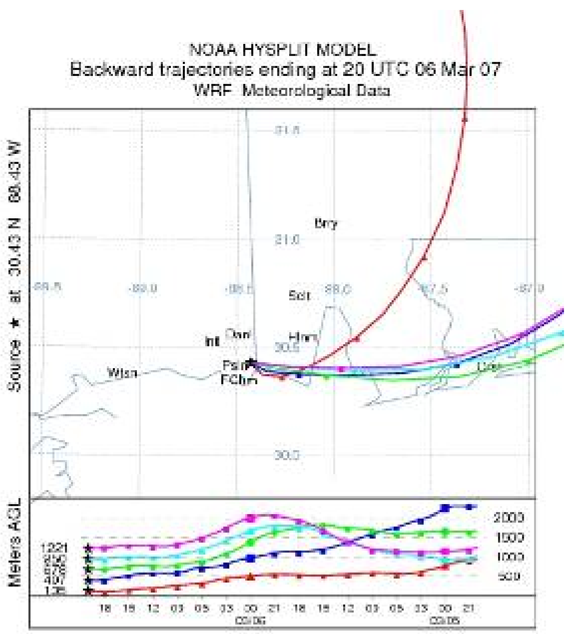



RGM
FPM
GEM
RGM and FPM (pg/m3)
GEM (ng/m3 - 1.5) * 10
March 6
March 7
150
100
50
0
05:30 AM
07:30 AM
09:30 AM
11:30 AM
01:30 PM
03:30 PM
05:30 PM
07:30 PM
09:30 PM
11:30 PM
01:30 AM
03:30 AM
05:30 AM

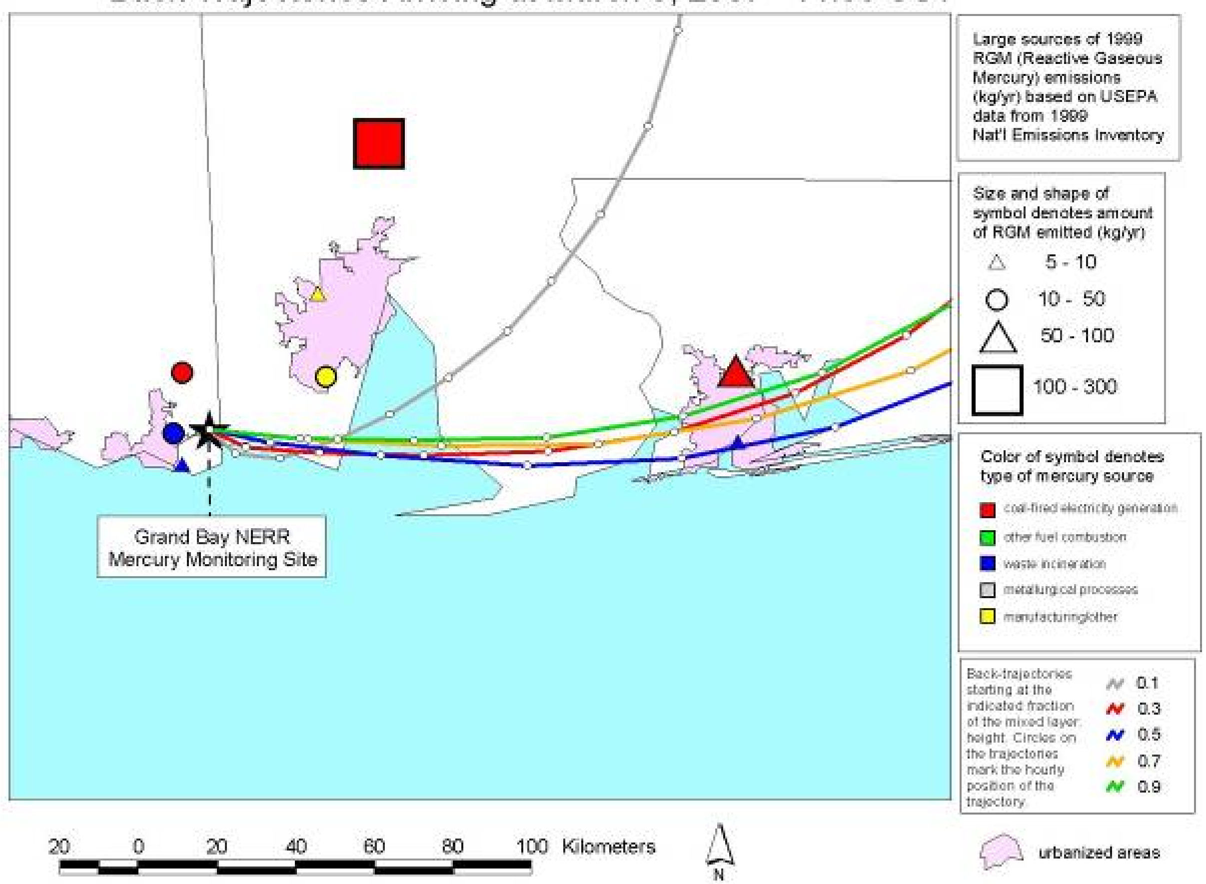

NOAA HYSPLIT MODEL
Backward trajectories ending at 19 UTC 06 Mar 07
WRF Meteorological Data
Source ★ at 30.43 N 88.43 W
Meters AGL
2000
1500
1000
500

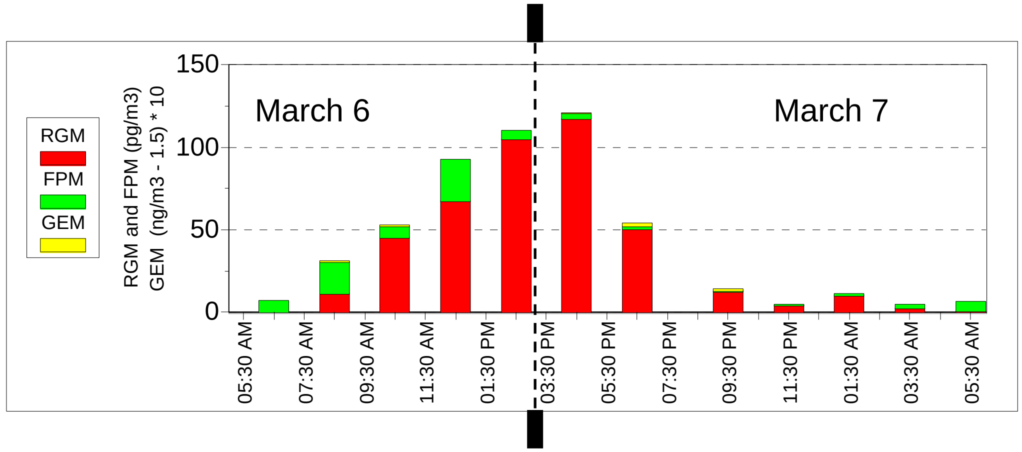

Back Trajectories Arriving at March 6, 2007 13:00 CST
Large sources of 1999 RGM (Reactive Gaseous Mercury) emissions (kg/yr) based on USEPA data from 1999 Nat'l Emissions Inventory
Size and shape of symbol denotes amount of RGM emitted (kg/yr)
5 - 10
10 - 50
50 - 100
100 - 300
Color of symbol denotes type of mercury source
coal-fired electricity generation
other fuel combustion
waste incineration
metallurgical processes
manufacturing/other
Back-trajectories starting at the indicated fraction of the mixed layer height. Circles on the trajectories mark the hourly position of the trajectory
0.1
0.3
0.5
0.7
0.9
Grand Bay NERR
Mercury Monitoring Site
20 0 20 40 60 80 100 Kilometers
N
urbanized areas

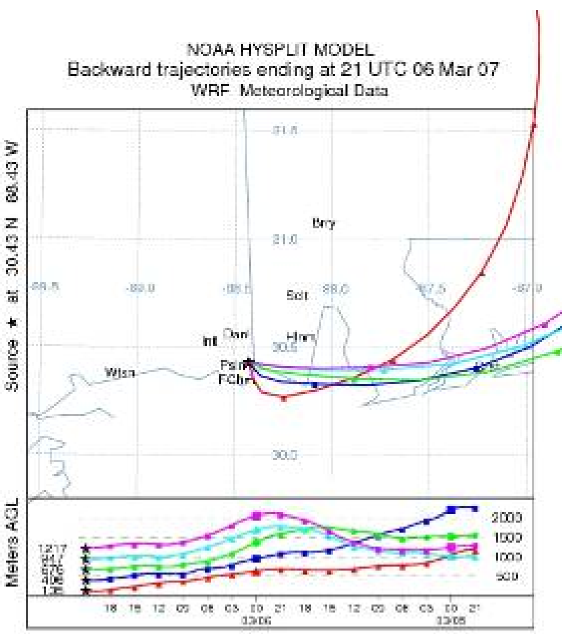




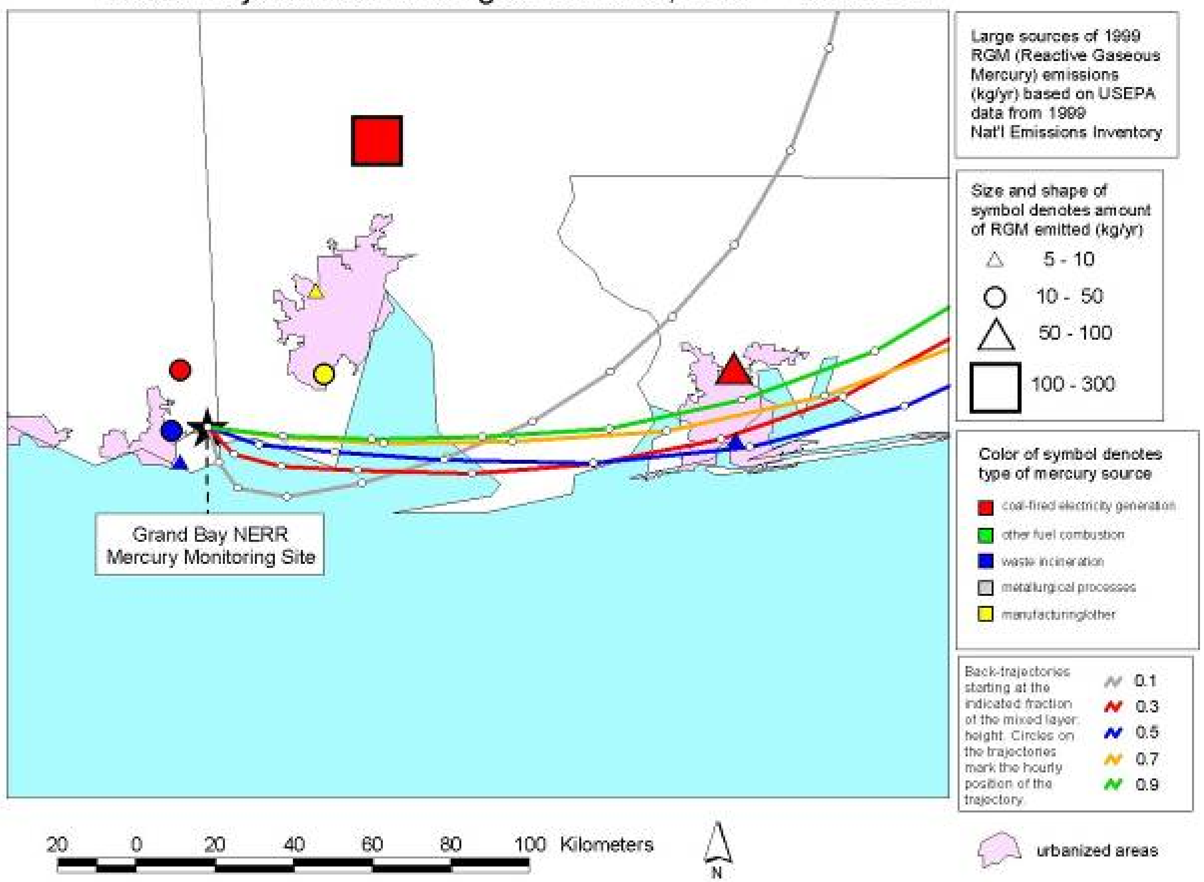
Back Trajectories Arriving at March 6, 2007 14:00 CST

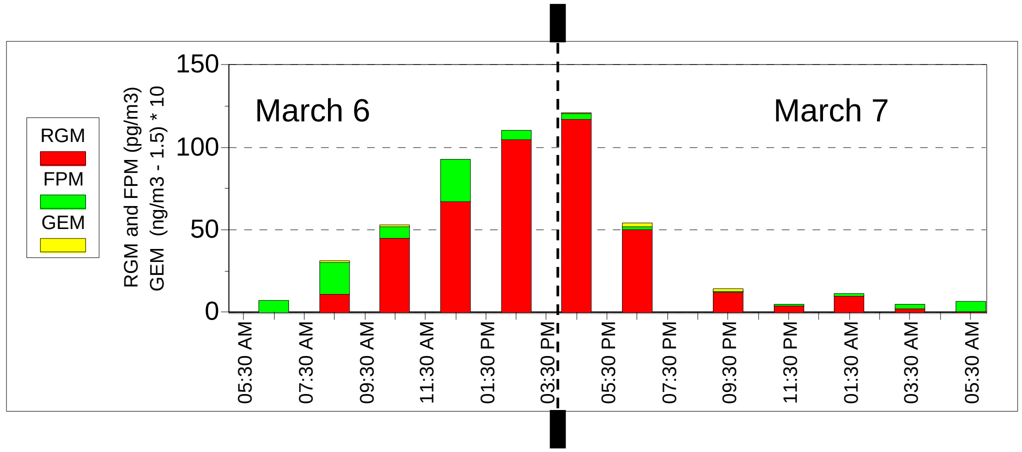




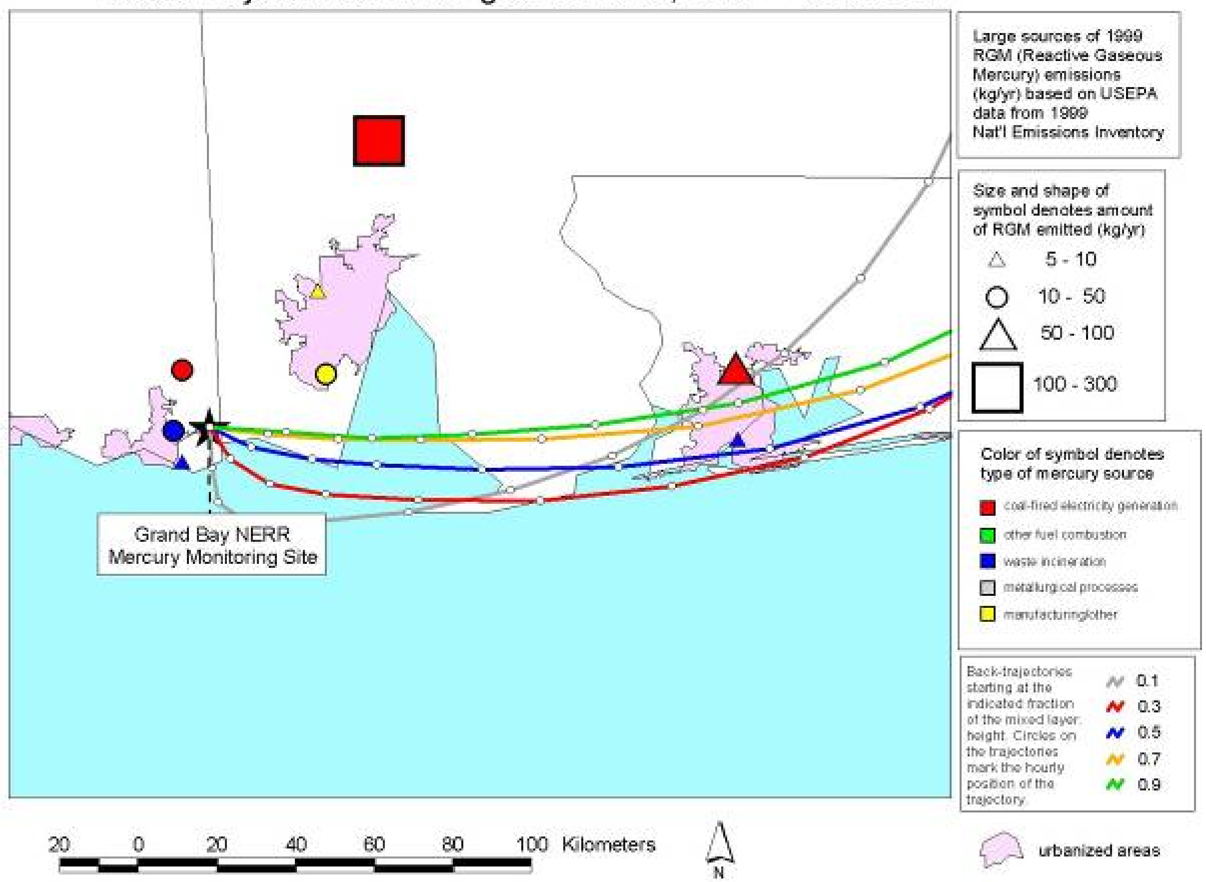


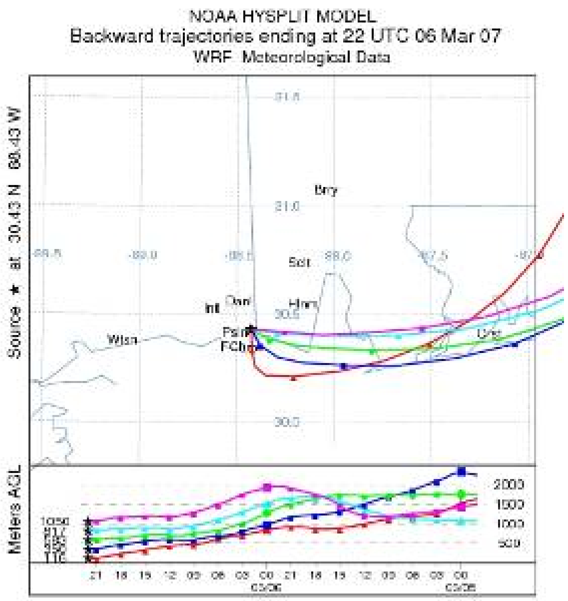
Back Trajectories Arriving at March 6, 2007 15:00 CST

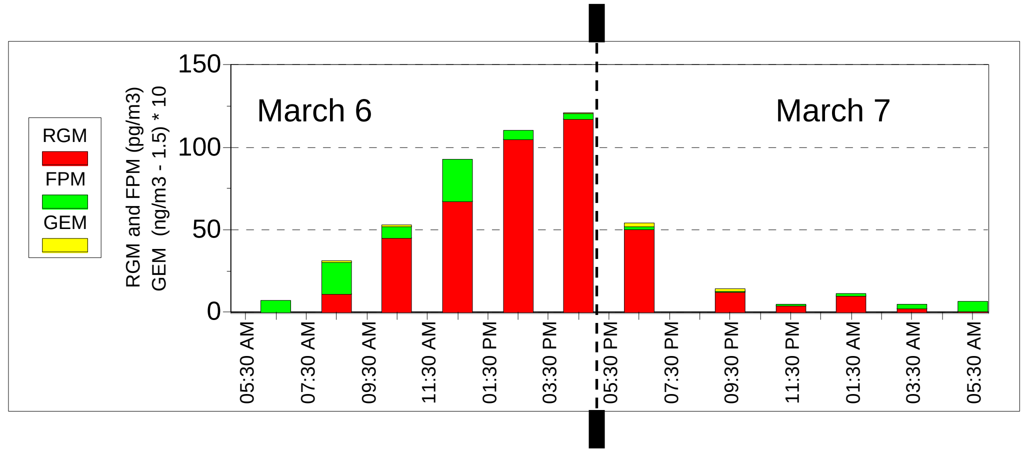




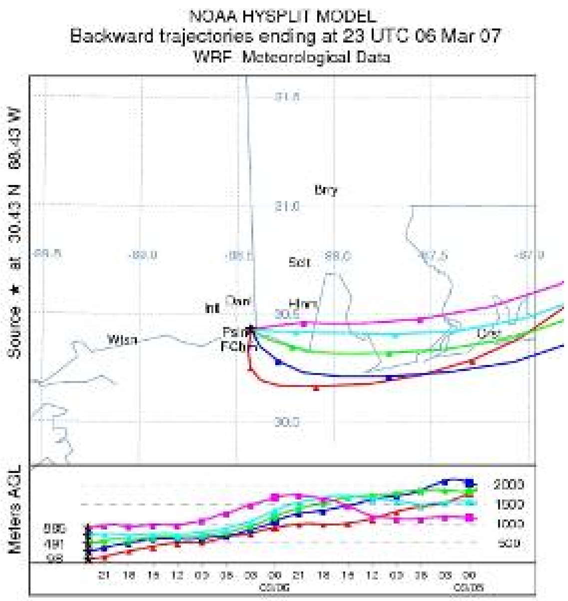
Back Trajectories Arriving at March 6, 2007 16:00 CST



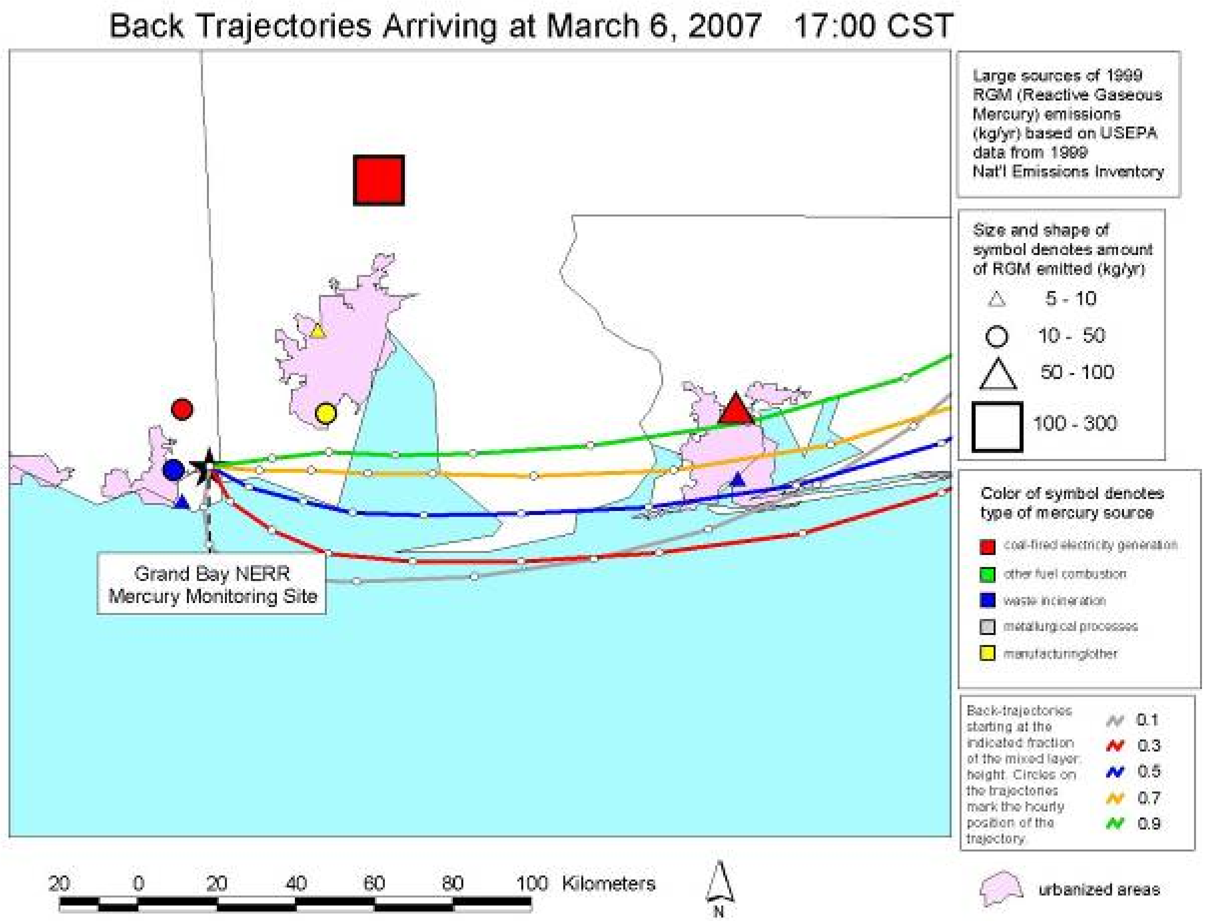




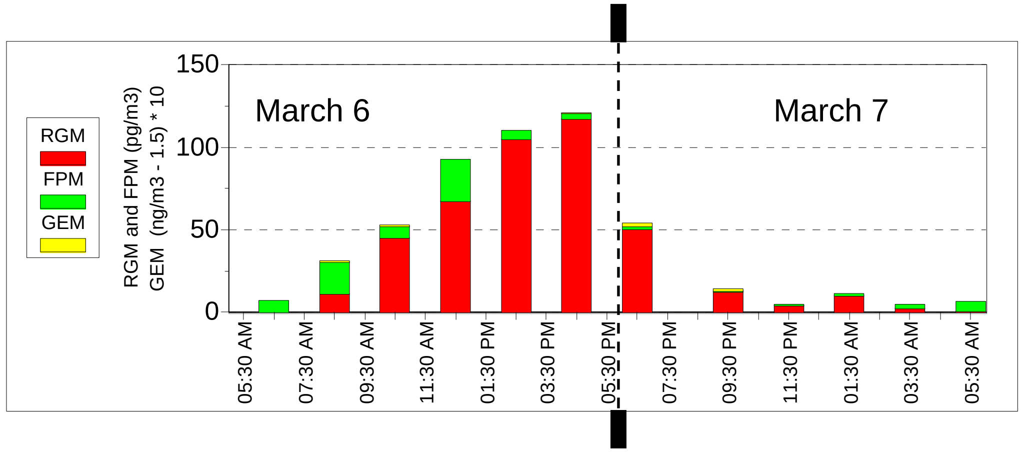
RGM
FPM
GEM
RGM and FPM (pg/m3)
GEM (ng/m3 - 1.5) * 10
150
100
50
0
March 6
March 7
05:30 AM
07:30 AM
09:30 AM
11:30 AM
01:30 PM
03:30 PM
05:30 PM
07:30 PM
09:30 PM
11:30 PM
01:30 AM
03:30 AM
05:30 AM

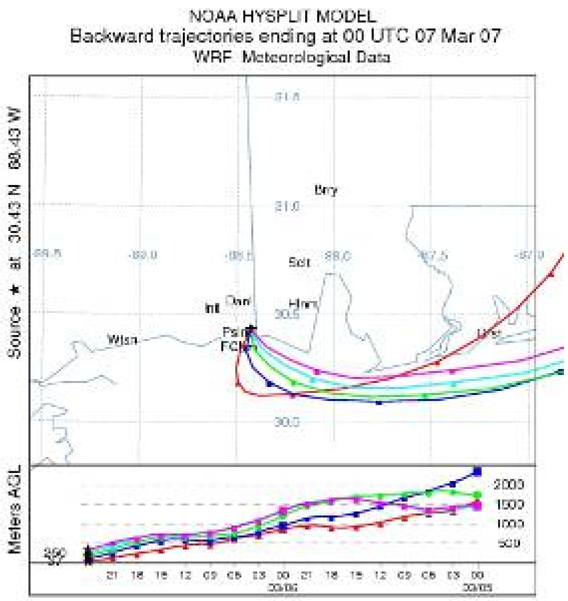


NOAA HYSPLIT MODEL
Backward trajectories ending at 23 UTC 06 Mar 07
WRF Meteorological Data
Source ★ at 30.43 N 88.43 W
Meters AGL
2000
1500
1000
500

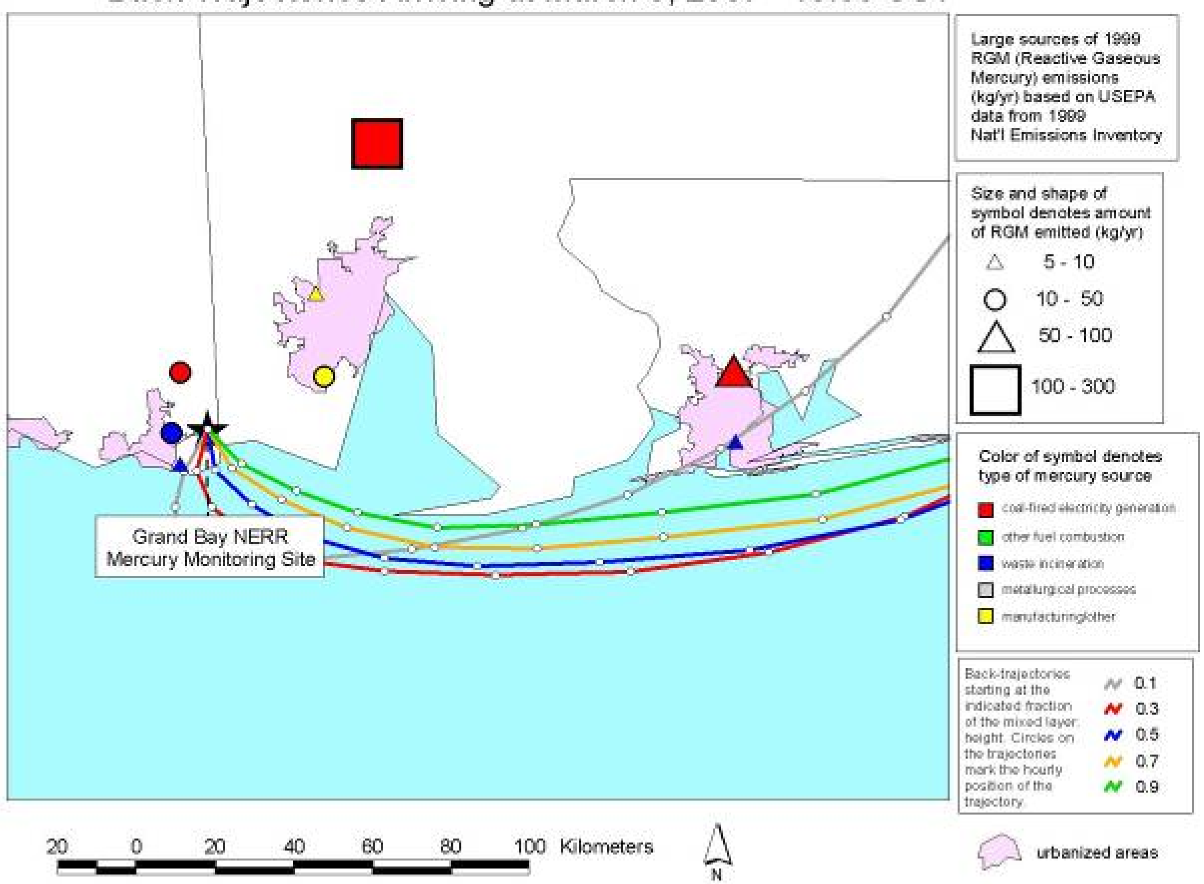


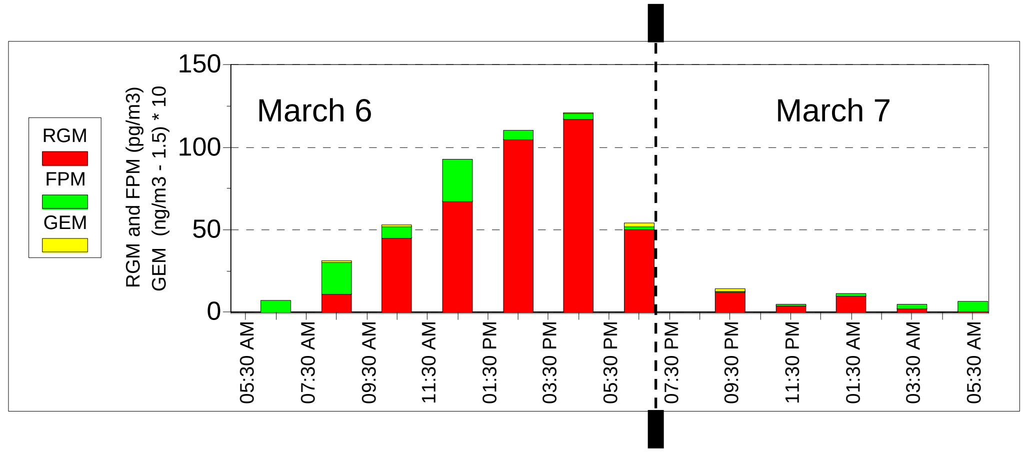
Back Trajectories Arriving at March 6, 2007 17:00 CST
Grand Bay NERR
Mercury Monitoring Site
Large sources of 1999 RGM (Reactive Gaseous Mercury) emissions (kg/yr) based on USEPA data from 1999 Nat'l Emissions Inventory
Size and shape of symbol denotes amount of RGM emitted (kg/yr)
5 - 10
10 - 50
50 - 100
100 - 300
Color of symbol denotes type of mercury source
coal-fired electricity generation
other fuel combustion
waste incineration
metallurgical processes
manufacturing/other
Back-trajectories starting at the indicated fraction of the mixed layer height. Circles on the trajectories mark the hourly position of the trajectory.
0.1
0.3
0.5
0.7
0.9
20
0
20
40
60
80
100 Kilometers
N
urbanized areas

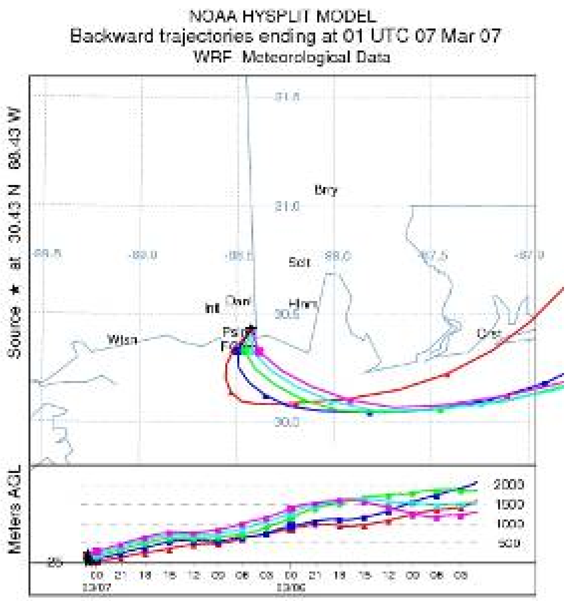




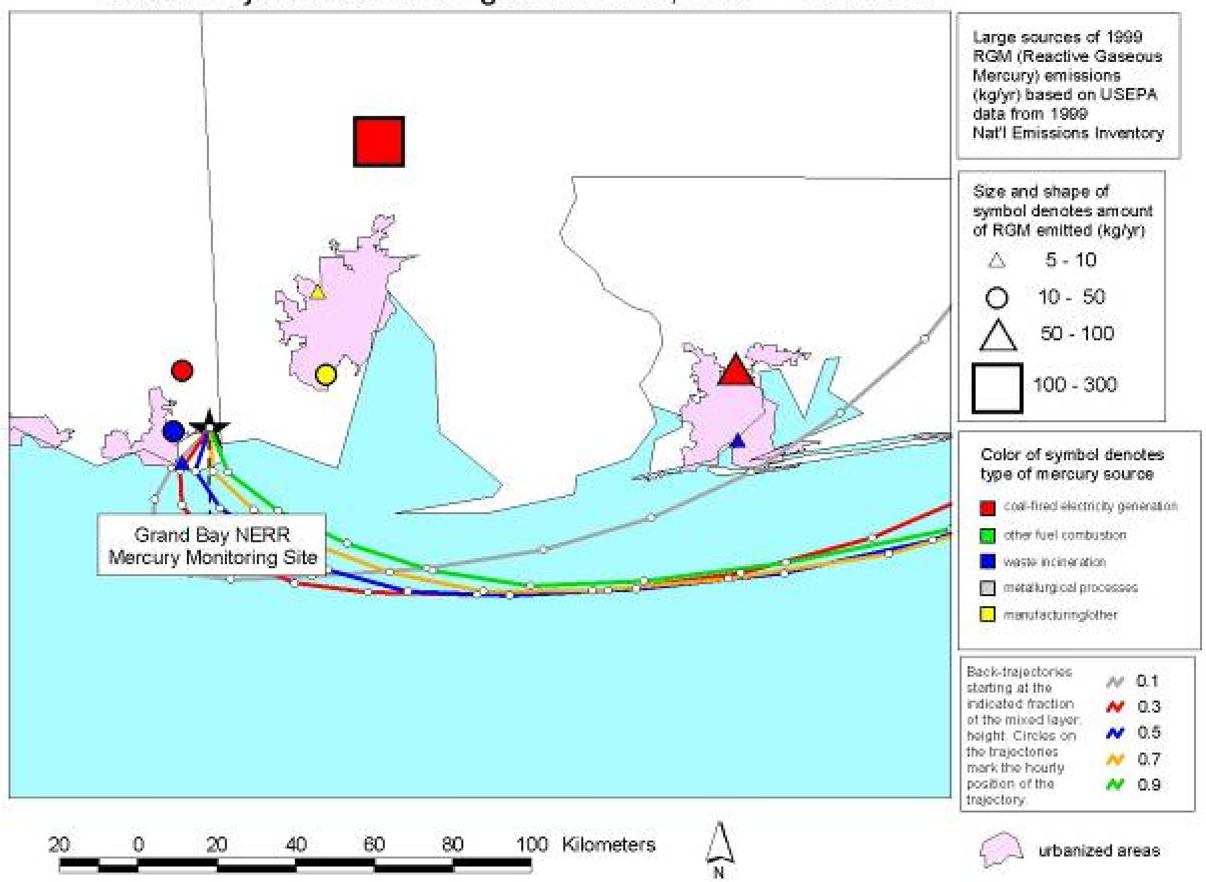
Back Trajectories Arriving at March 6, 2007 18:00 CST

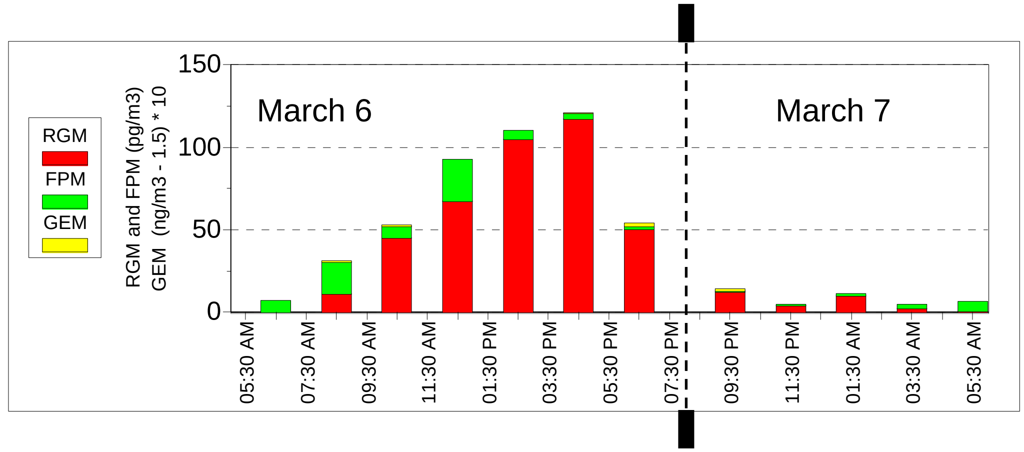


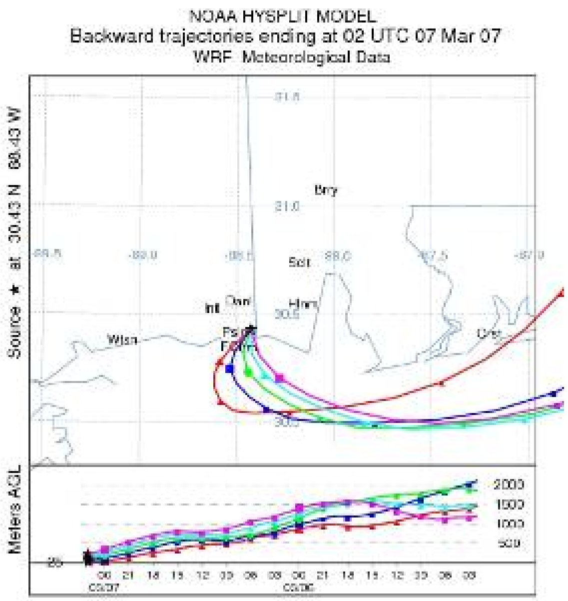




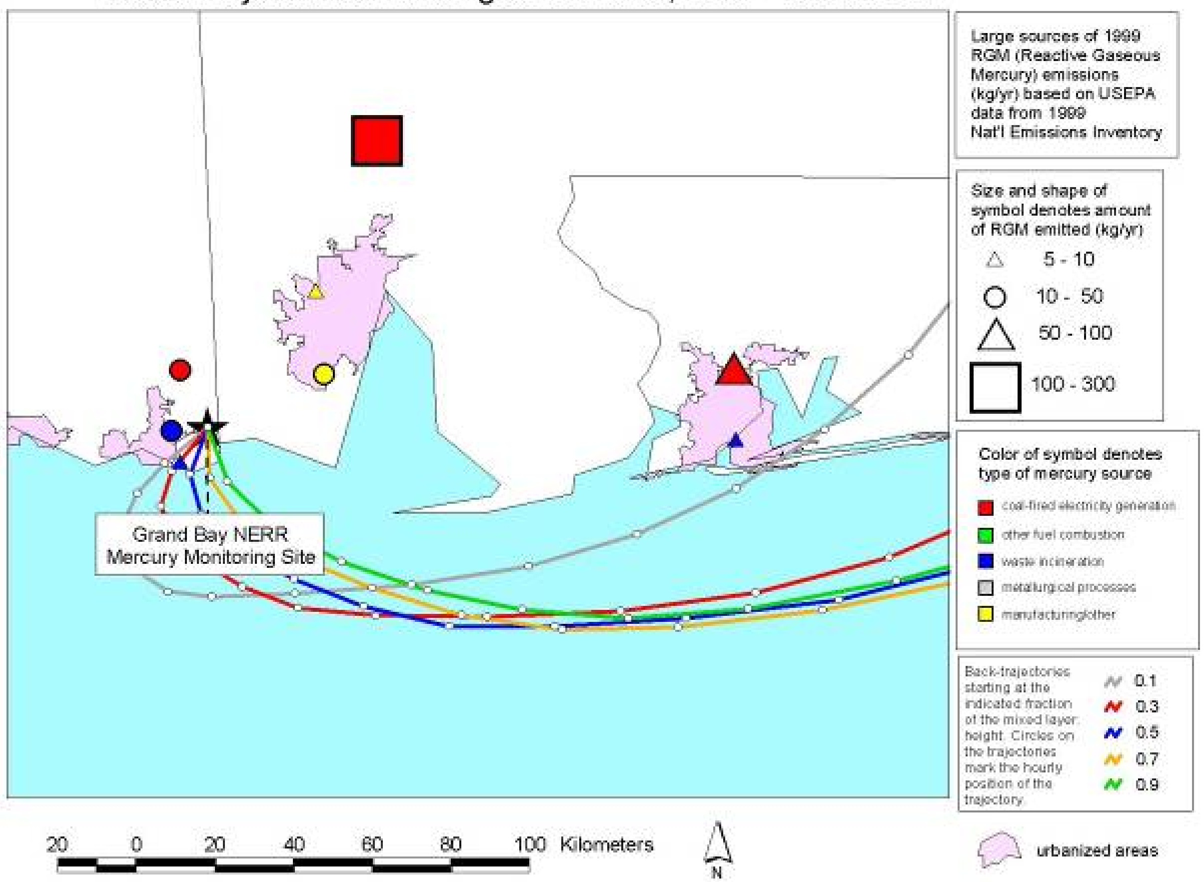
Back Trajectories Arriving at March 6, 2007 19:00 CST

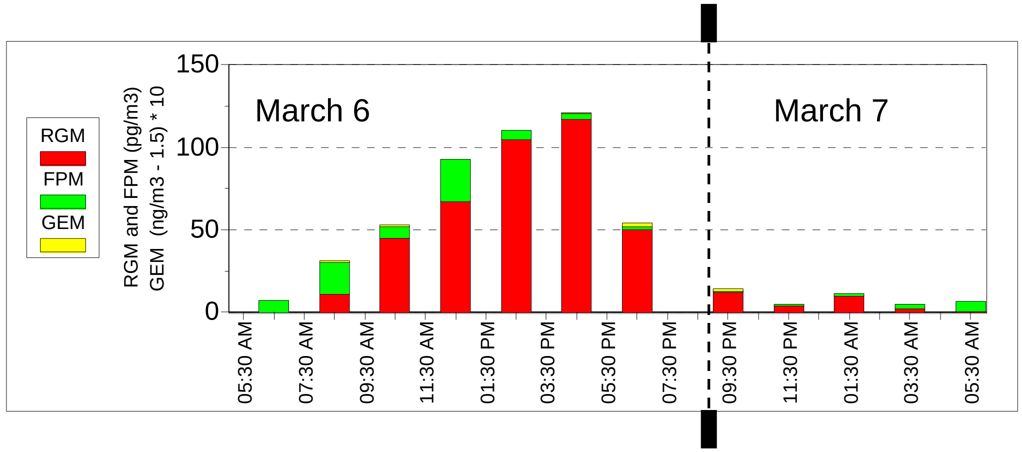


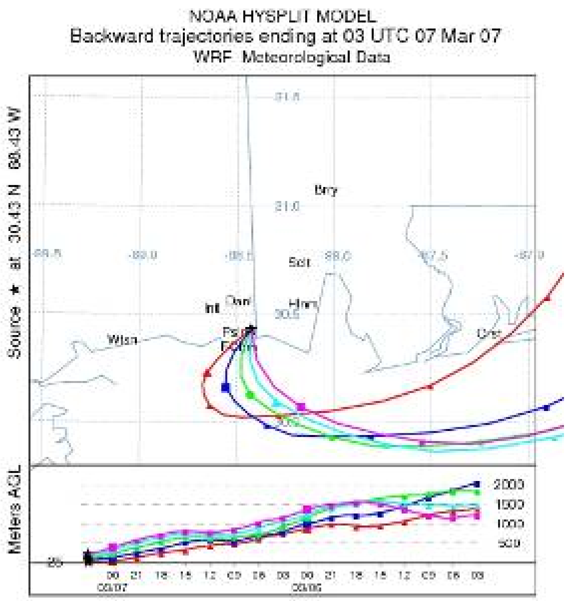




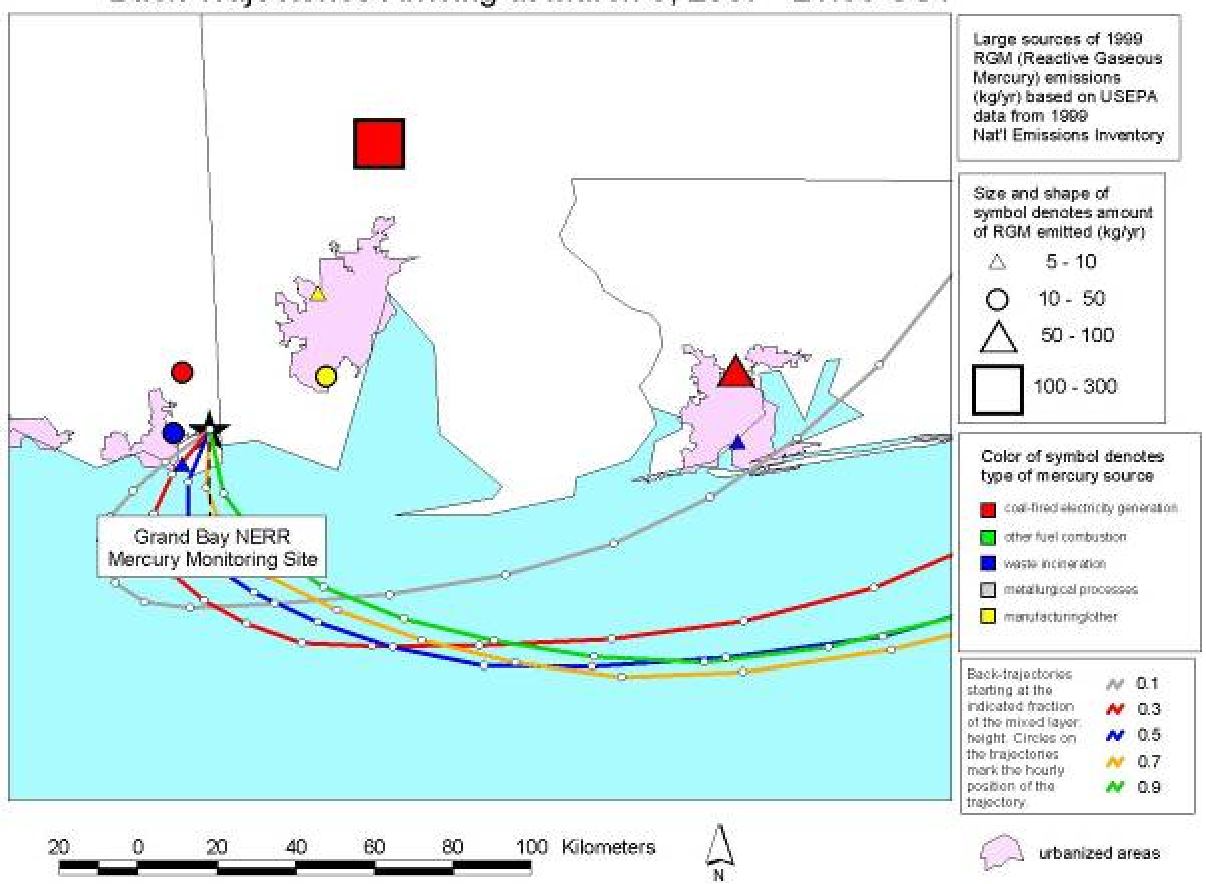
Back Trajectories Arriving at March 6, 2007 20:00 CST

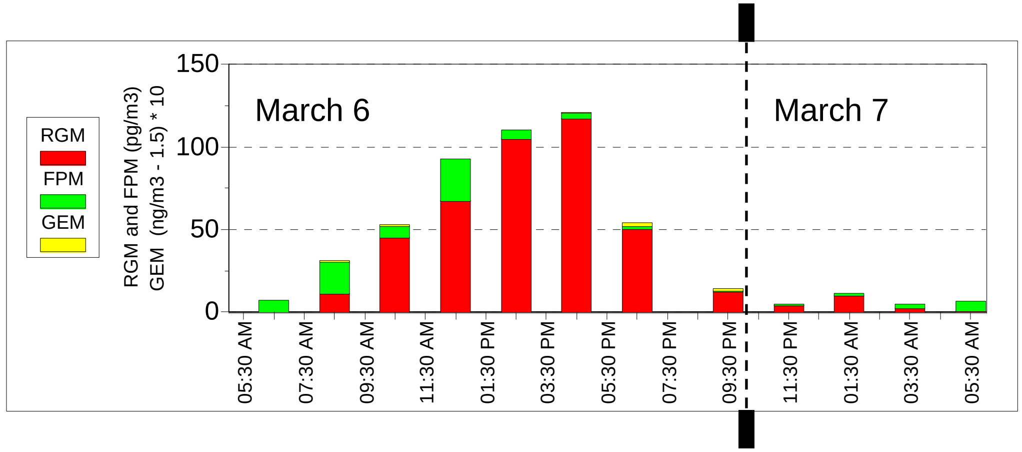


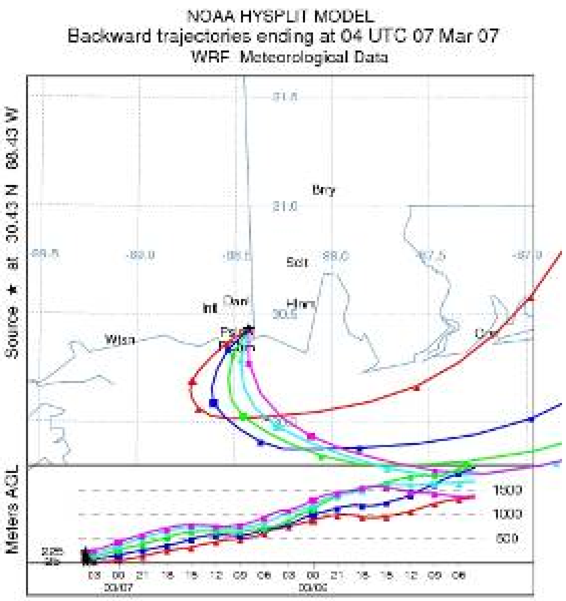




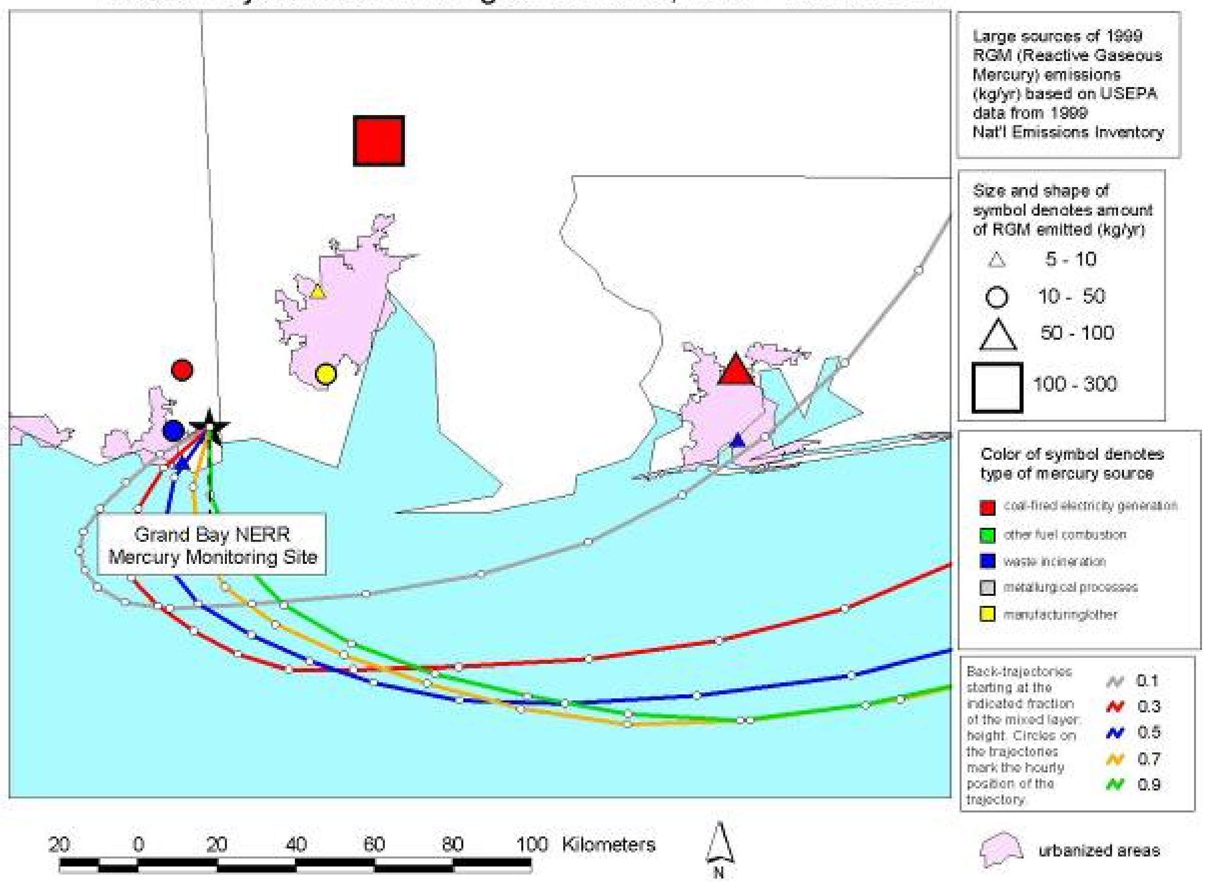
Back Trajectories Arriving at March 6, 2007 21:00 CST

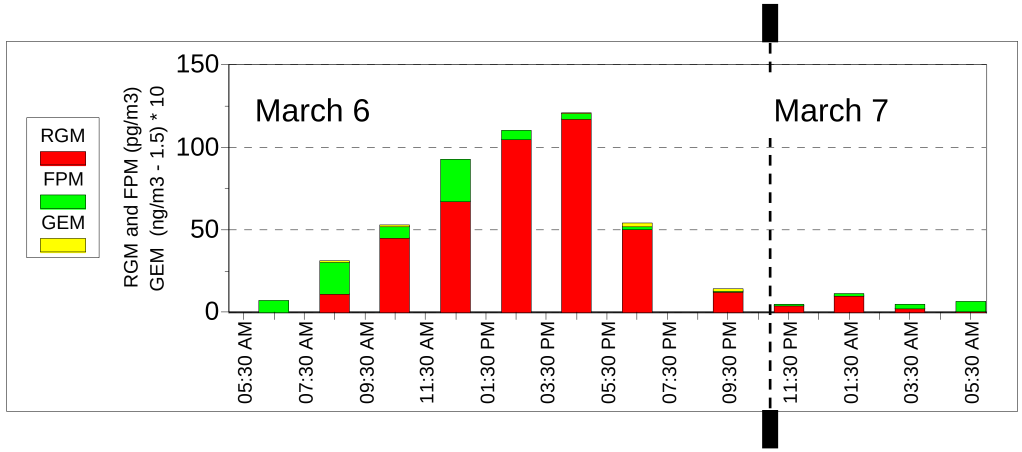


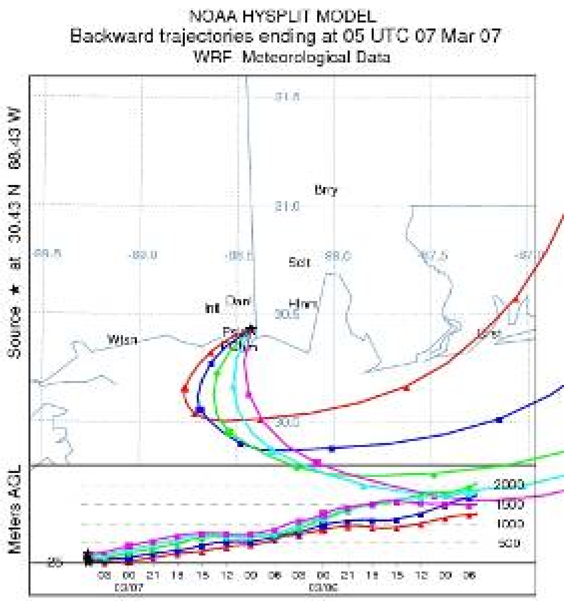


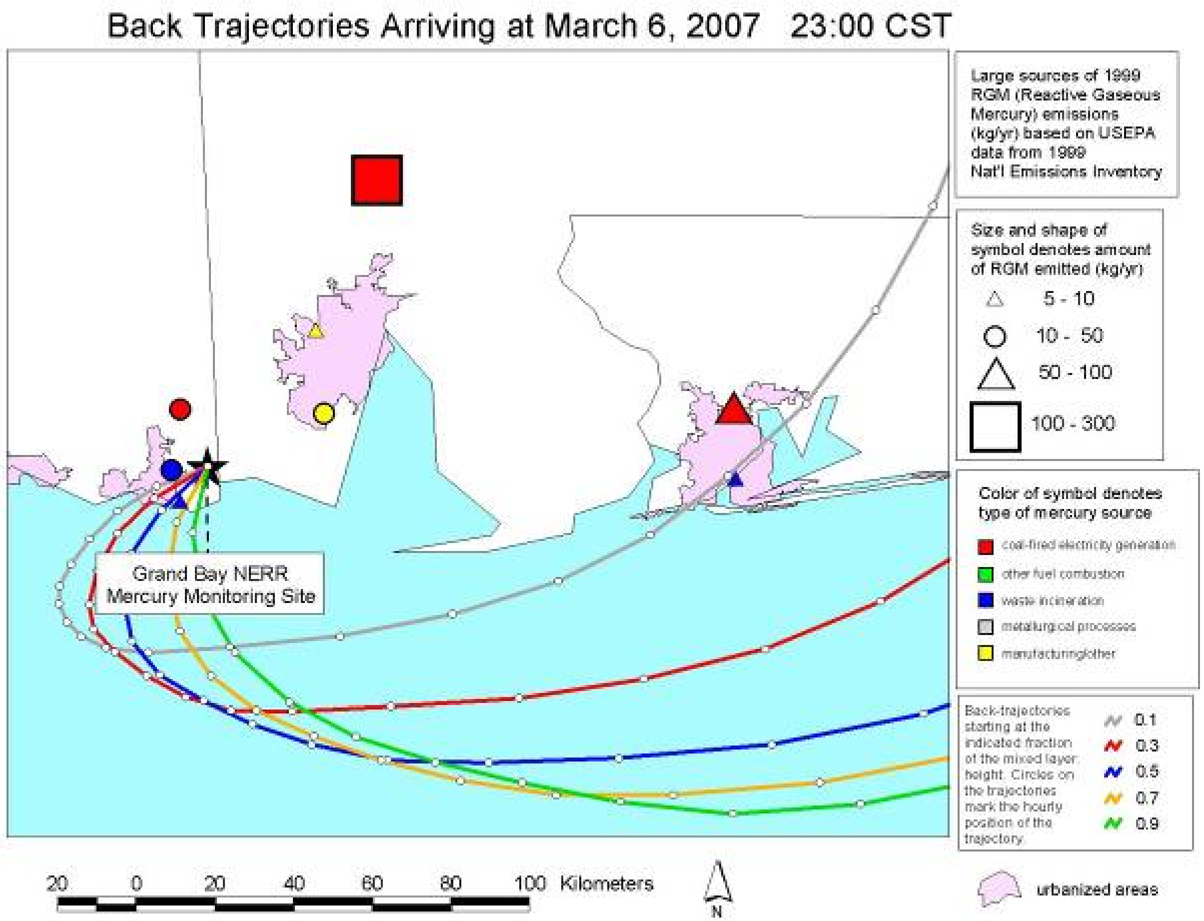


Back Trajectories Arriving at March 6, 2007 22:00 CST

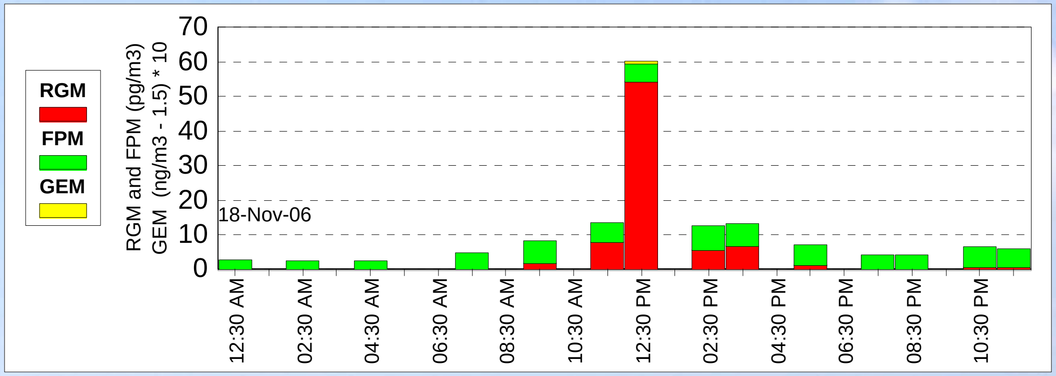


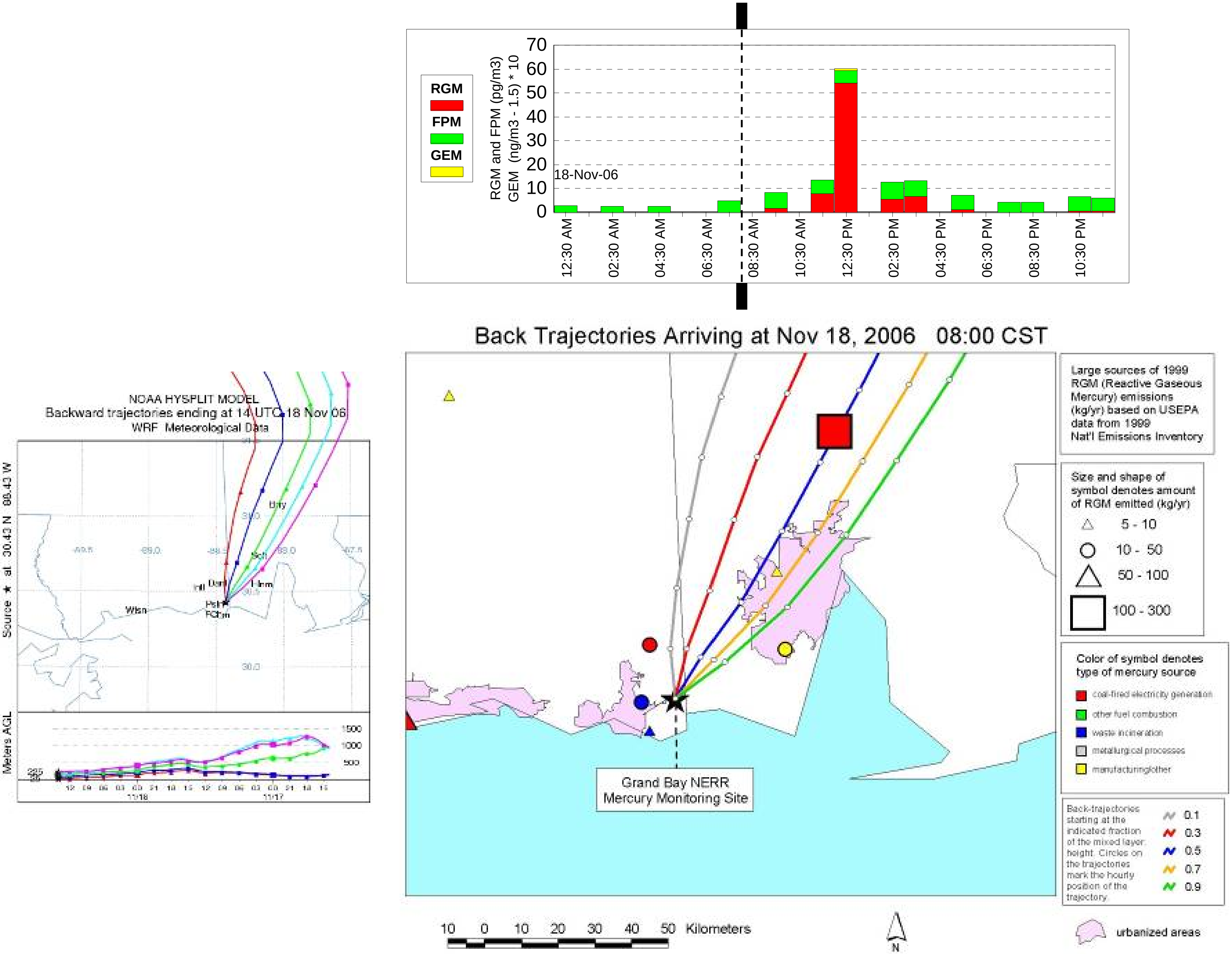

RGM
FPM
GEM
RGM and FPM (pg/m3)
GEM (ng/m3 - 1.5) * 10
150
100
50
0
March 6
March 7
05:30 AM
07:30 AM
09:30 AM
11:30 AM
01:30 PM
03:30 PM
05:30 PM
07:30 PM
09:30 PM
11:30 PM
01:30 AM
03:30 AM
05:30 AM


NOAA HYSPLIT MODEL
Backward trajectories ending at 05 UTC 07 Mar 07
WRF Meteorological Data
Source ★ at 30.43 N 88.43 W
Meters AGL
2000
1500
1000
500

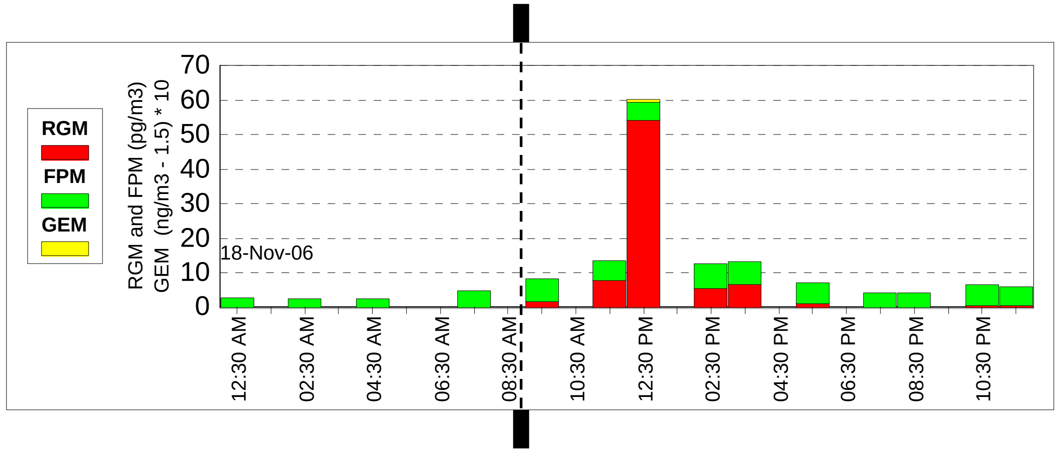

Back Trajectories Arriving at March 6, 2007 23:00 CST
Grand Bay NERR
Mercury Monitoring Site
Large sources of 1999 RGM (Reactive Gaseous Mercury) emissions (kg/yr) based on USEPA data from 1999 Nat'l Emissions Inventory
Size and shape of symbol denotes amount of RGM emitted (kg/yr)
5 - 10
10 - 50
50 - 100
100 - 300
Color of symbol denotes type of mercury source
coal-fired electricity generation
other fuel combustion
waste incineration
metallurgical processes
manufacturing/other
Back-trajectories starting at the indicated fraction of the mixed layer height. Circles on the trajectories mark the hourly position of the trajectory
0.1
0.3
0.5
0.7
0.9
20 0 20 40 60 80 100 Kilometers
N
urbanized areas

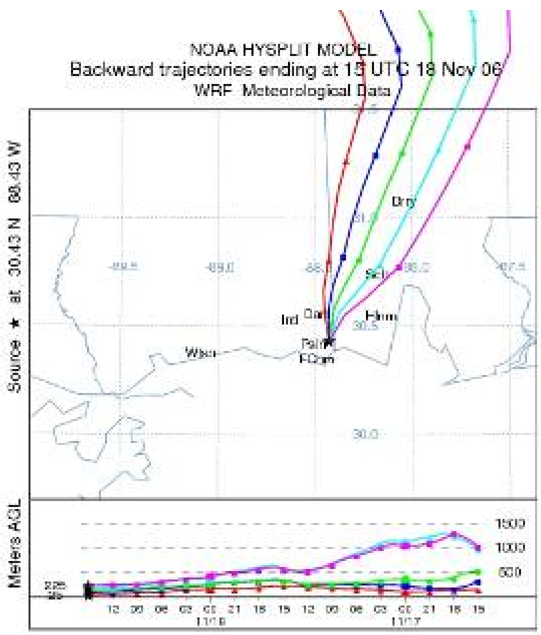
Grand Bay Episode Nov 18, 2006

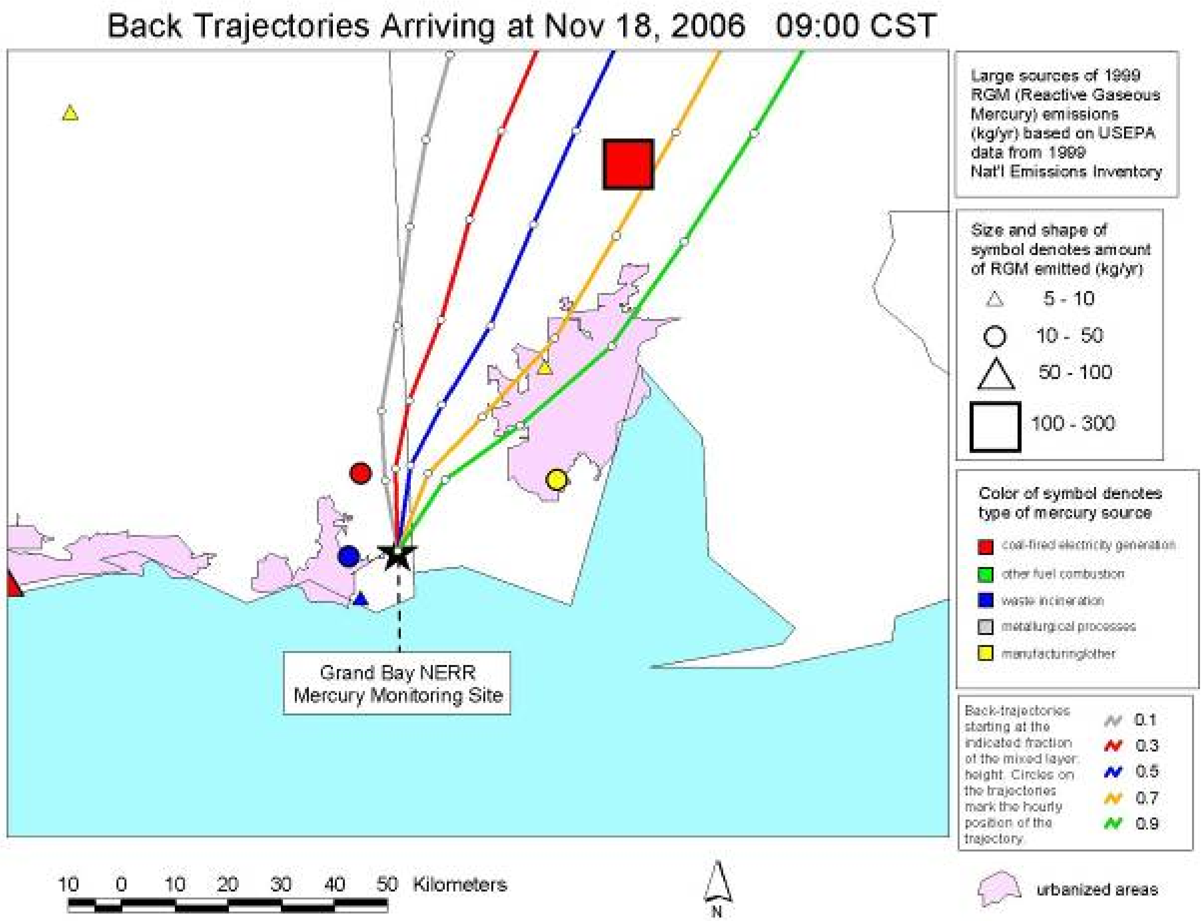


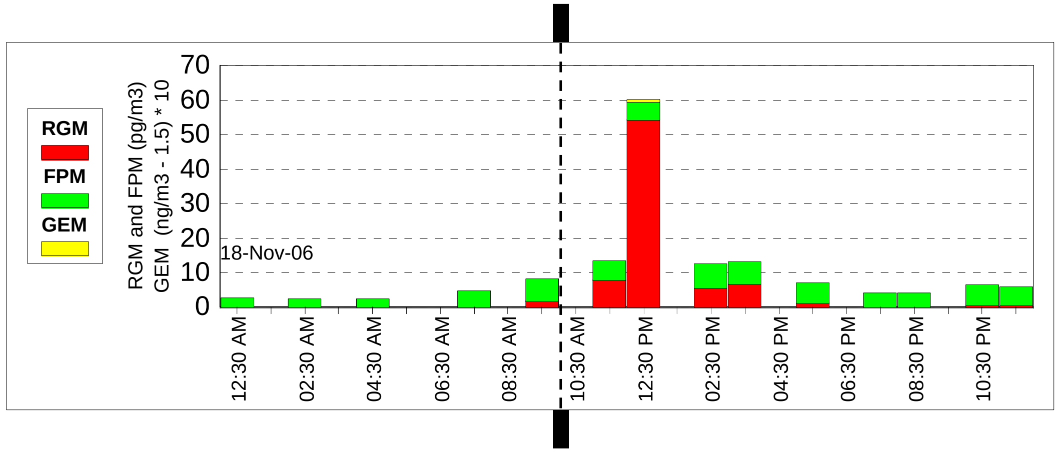


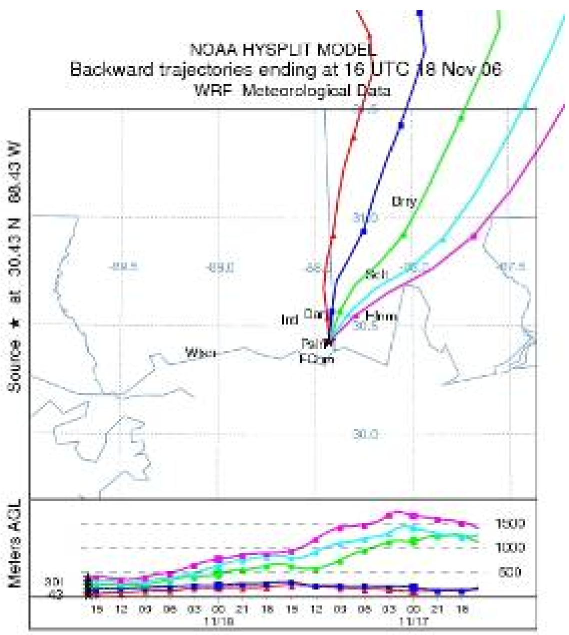
RGM
FPM
GEM
RGM and FPM (pg/m3)
GEM (ng/m3 - 1.5) * 10
70
60
50
40
30
20
10
0
18-Nov-06
12:30 AM
02:30 AM
04:30 AM
06:30 AM
08:30 AM
10:30 AM
12:30 PM
02:30 PM
04:30 PM
06:30 PM
08:30 PM
10:30 PM
NOAA HYSPLIT MODEL
Backward trajectories ending at 14 UTC 18 Nov 06
WRF Meteorological Data
Source ★ at 30.43 N 88.43 W
Meters AGL
1500
1000
500
Back Trajectories Arriving at Nov 18, 2006 08:00 CST
Large sources of 1999 RGM (Reactive Gaseous Mercury) emissions (kg/yr) based on USEPA data from 1999 Nat'l Emissions Inventory
Size and shape of symbol denotes amount of RGM emitted (kg/yr)
5 - 10
10 - 50
50 - 100
100 - 300
Color of symbol denotes type of mercury source
coal-fired electricity generation
other fuel combustion
waste incineration
metallurgical processes
manufacturing/other
Back-trajectories starting at the indicated fraction of the mixed layer height. Circles on the trajectories mark the hourly position of the trajectory
0.1
0.3
0.5
0.7
0.9
Grand Bay NERR
Mercury Monitoring Site
10 0 10 20 30 40 50 Kilometers
N
urbanized areas


RGM
FPM
GEM
RGM and FPM (pg/m3)
GEM (ng/m3 - 1.5) * 10
70
60
50
40
30
20
10
0
18-Nov-06
12:30 AM
02:30 AM
04:30 AM
06:30 AM
08:30 AM
10:30 AM
12:30 PM
02:30 PM
04:30 PM
06:30 PM
08:30 PM
10:30 PM

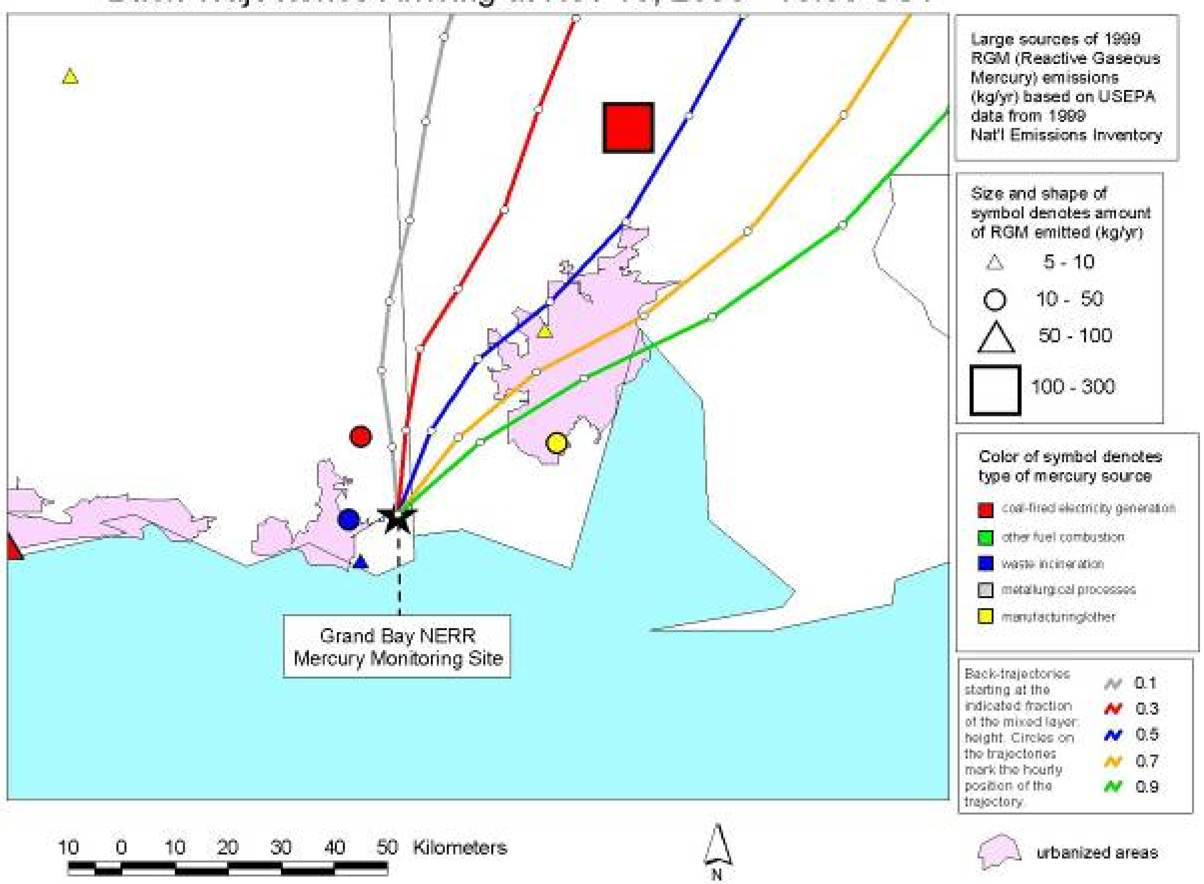

NOAA HYSPLIT MODEL
Backward trajectories ending at 15 UTC 18 Nov 06
WRF Meteorological Data
Source ★ at 30.43 N 88.43 W
Meters AGL
1500
1000
500
30.0

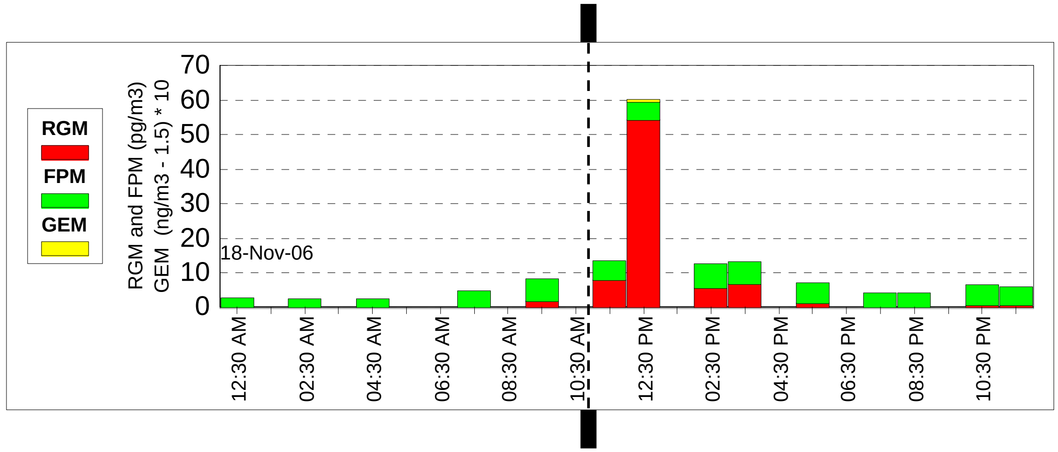

Back Trajectories Arriving at Nov 18, 2006 09:00 CST
Large sources of 1999 RGM (Reactive Gaseous Mercury) emissions (kg/yr) based on USEPA data from 1999 Nat'l Emissions Inventory
Size and shape of symbol denotes amount of RGM emitted (kg/yr)
5 - 10
10 - 50
50 - 100
100 - 300
Color of symbol denotes type of mercury source
coal-fired electricity generation
other fuel combustion
waste incineration
metallurgical processes
manufacturing/other
Back-trajectories starting at the indicated fraction of the mixed layer height. Circles on the trajectories mark the hourly position of the trajectory
0.1
0.3
0.5
0.7
0.9
Grand Bay NERR
Mercury Monitoring Site
10 0 10 20 30 40 50 Kilometers
N
urbanized areas

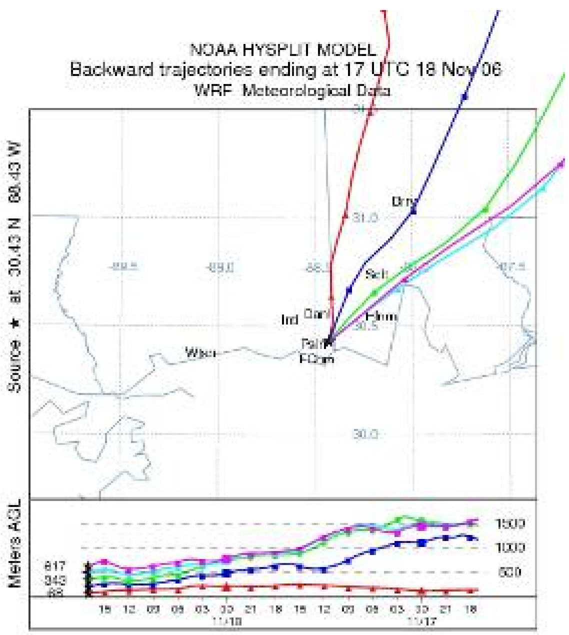




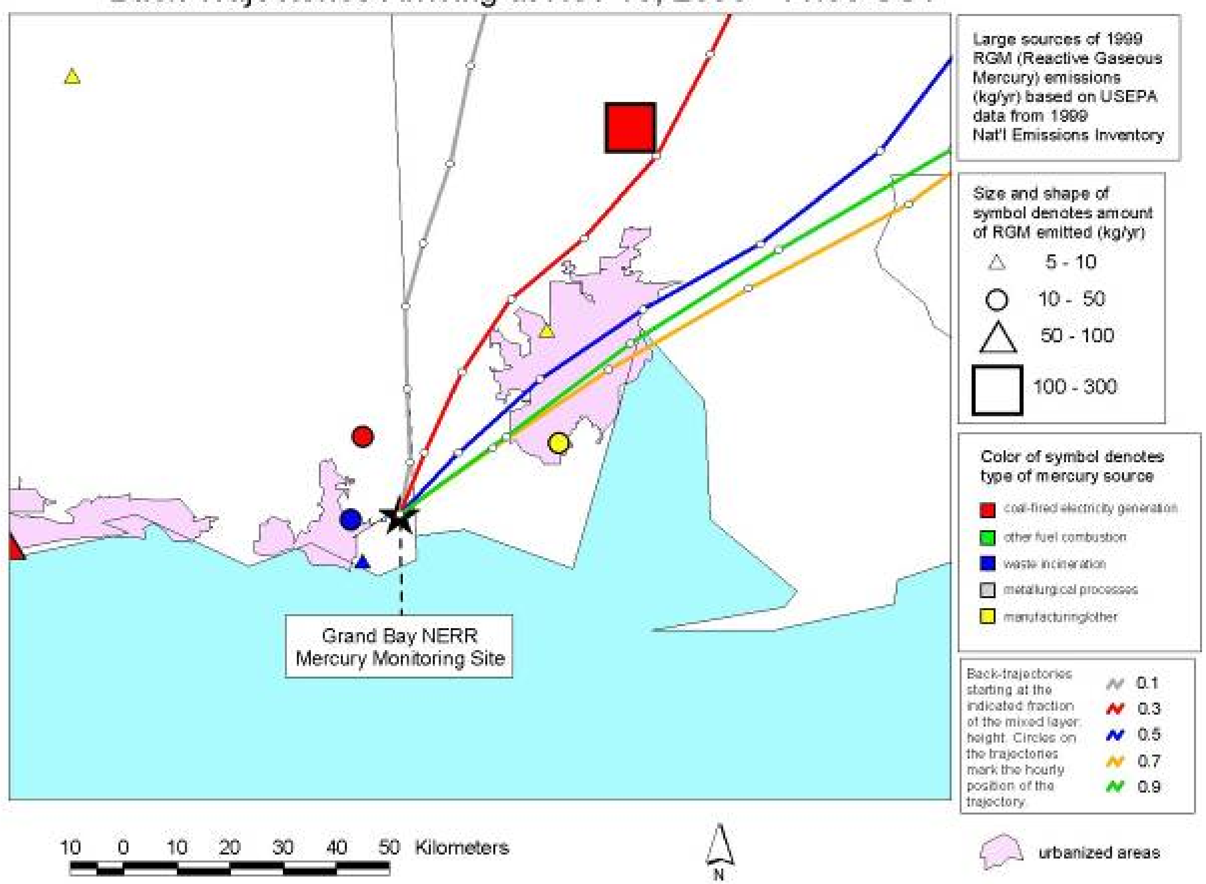
Back Trajectories Arriving at Nov 18, 2006 10:00 CST

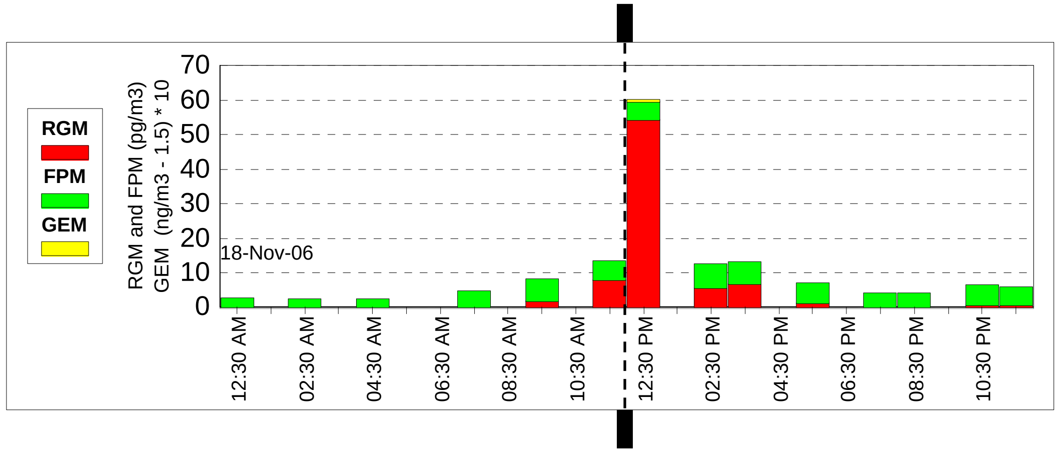


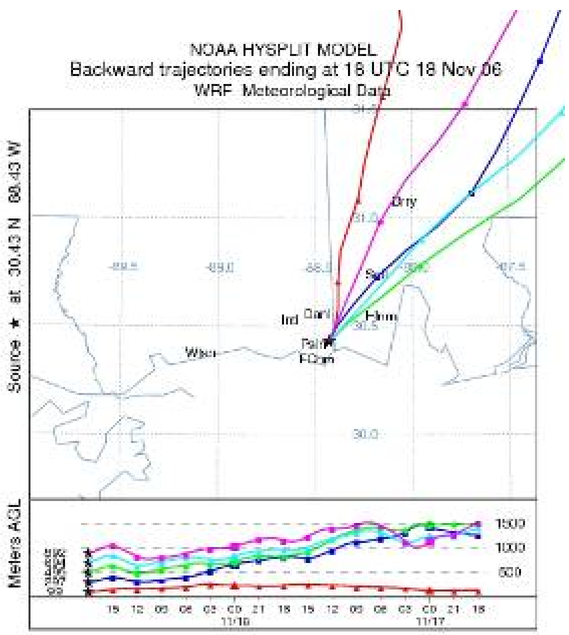


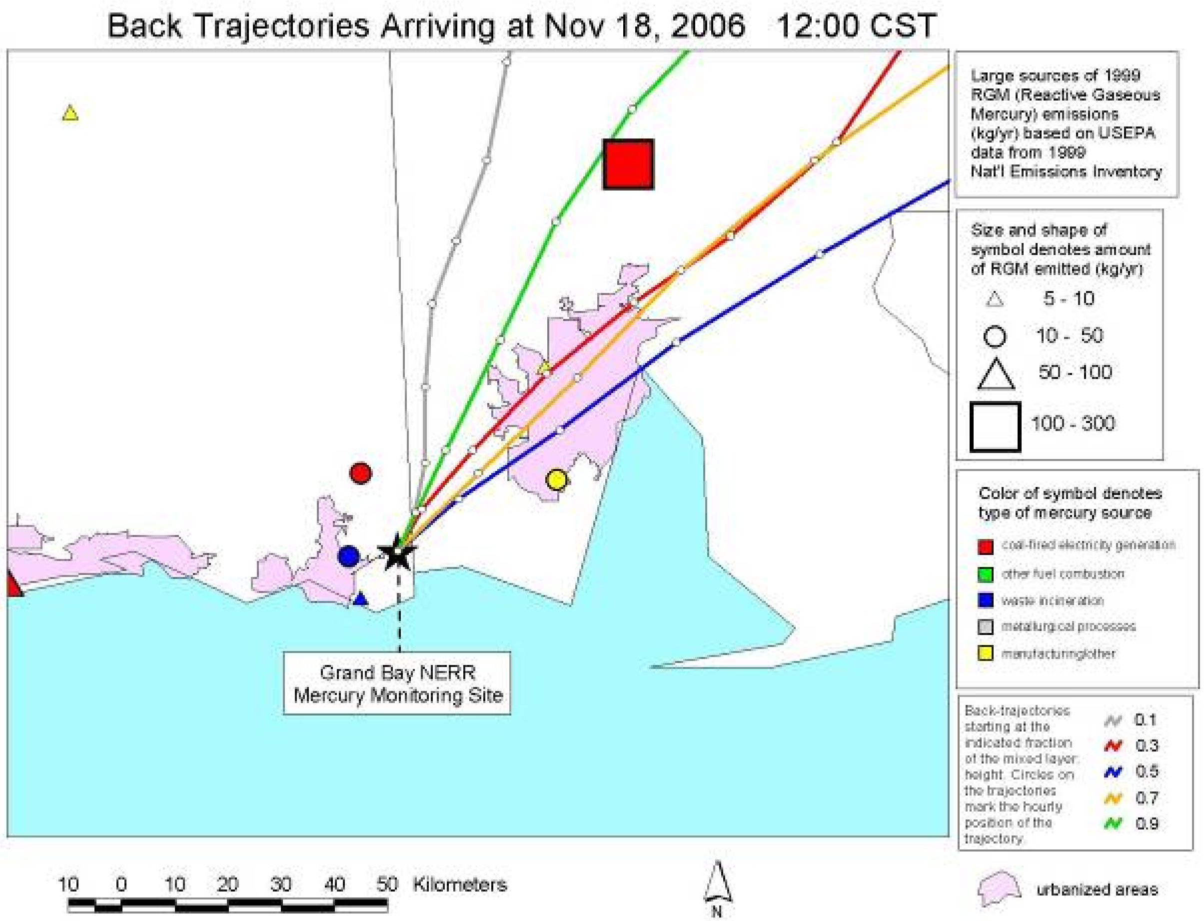


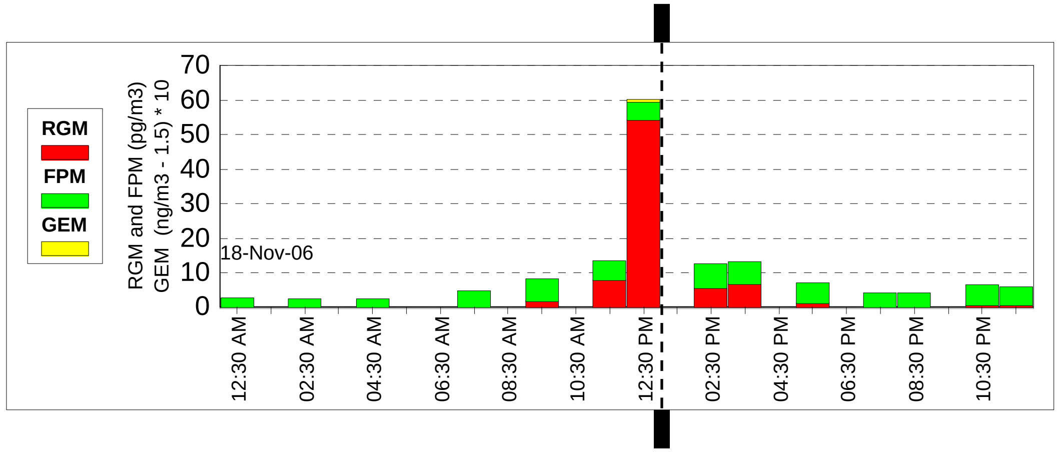
Back Trajectories Arriving at Nov 18, 2006 11:00 CST

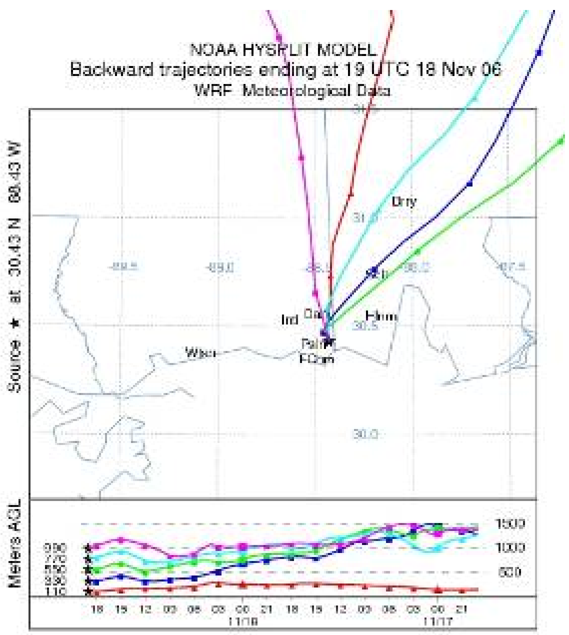



RGM
FPM
GEM
RGM and FPM (pg/m3)
GEM (ng/m3 - 1.5) * 10
70
60
50
40
30
20
10
0
18-Nov-06
12:30 AM
02:30 AM
04:30 AM
06:30 AM
08:30 AM
10:30 AM
12:30 PM
02:30 PM
04:30 PM
06:30 PM
08:30 PM
10:30 PM

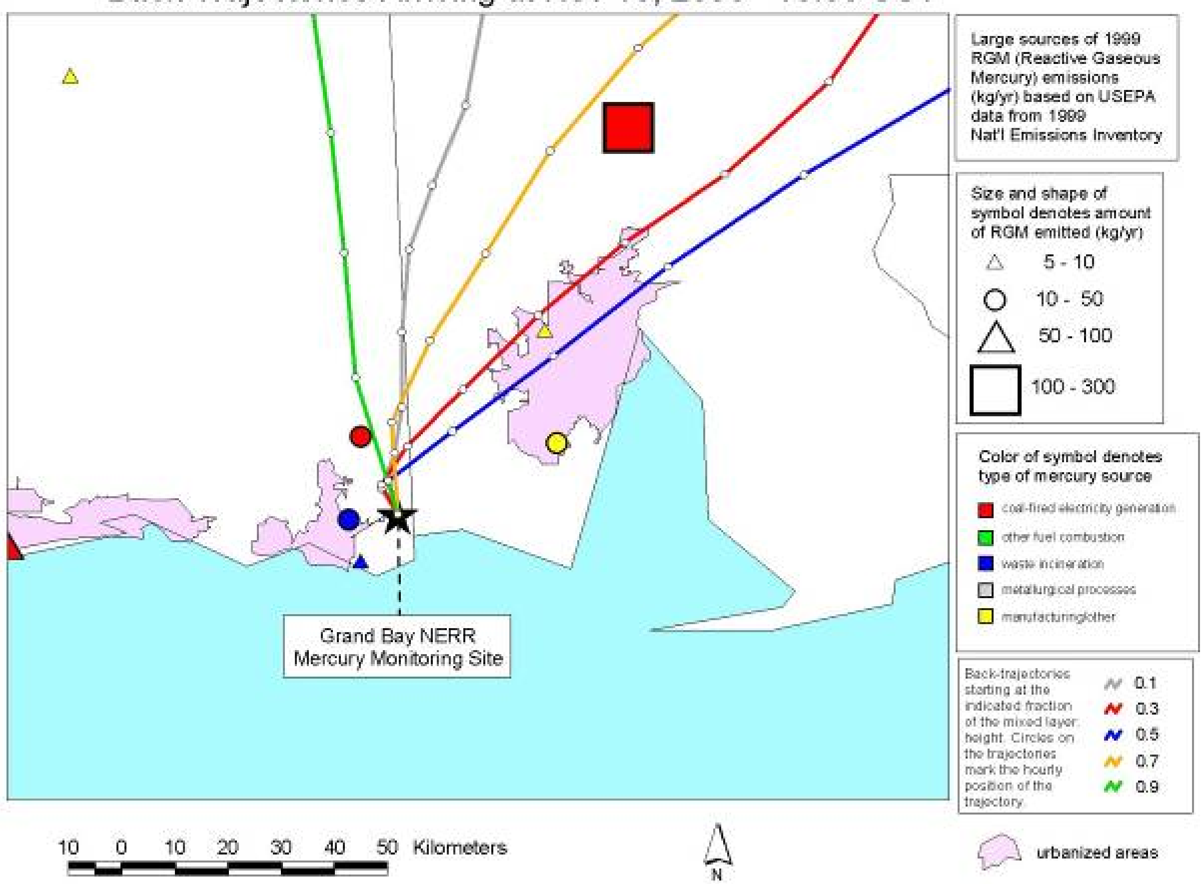

NOAA HYSPLIT MODEL
Backward trajectories ending at 18 UTC 18 Nov 06
WRF Meteorological Data
Source ★ at 30.43 N 88.43 W
Meters AGL
1500
1000
500

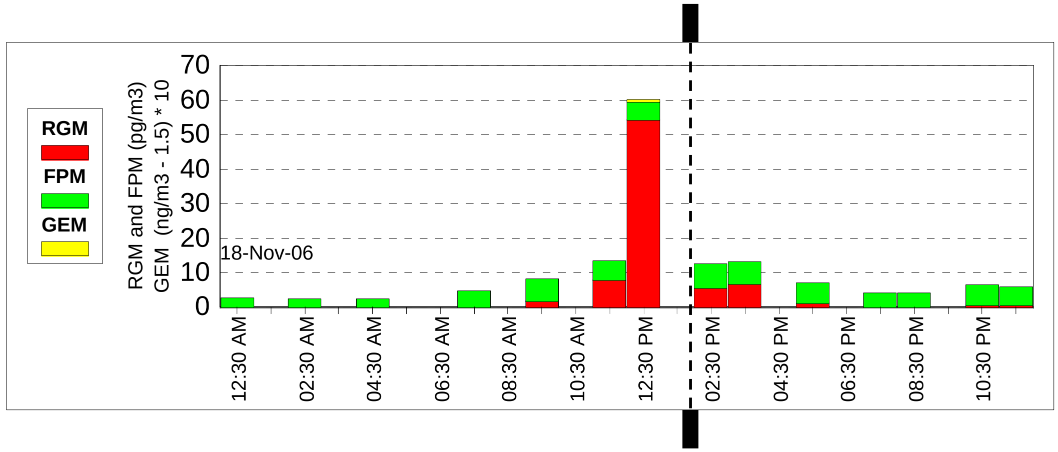

Back Trajectories Arriving at Nov 18, 2006 12:00 CST
Grand Bay NERR
Mercury Monitoring Site
Large sources of 1999 RGM (Reactive Gaseous Mercury) emissions (kg/yr) based on USEPA data from 1999 Nat'l Emissions Inventory
Size and shape of symbol denotes amount of RGM emitted (kg/yr)
5 - 10
10 - 50
50 - 100
100 - 300
Color of symbol denotes type of mercury source
coal-fired electricity generation
other fuel combustion
waste incineration
metallurgical processes
manufacturing/other
Back-trajectories starting at the indicated fraction of the mixed layer height. Circles on the trajectories mark the hourly position of the trajectory
0.1
0.3
0.5
0.7
0.9
10 0 10 20 30 40 50 Kilometers
N
urbanized areas

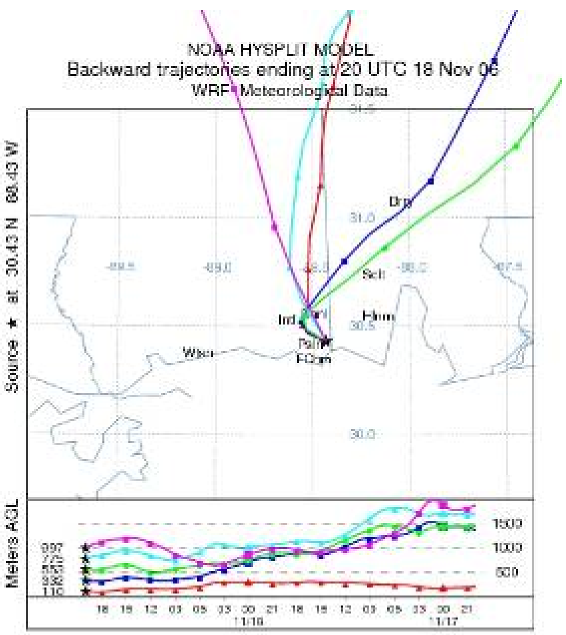


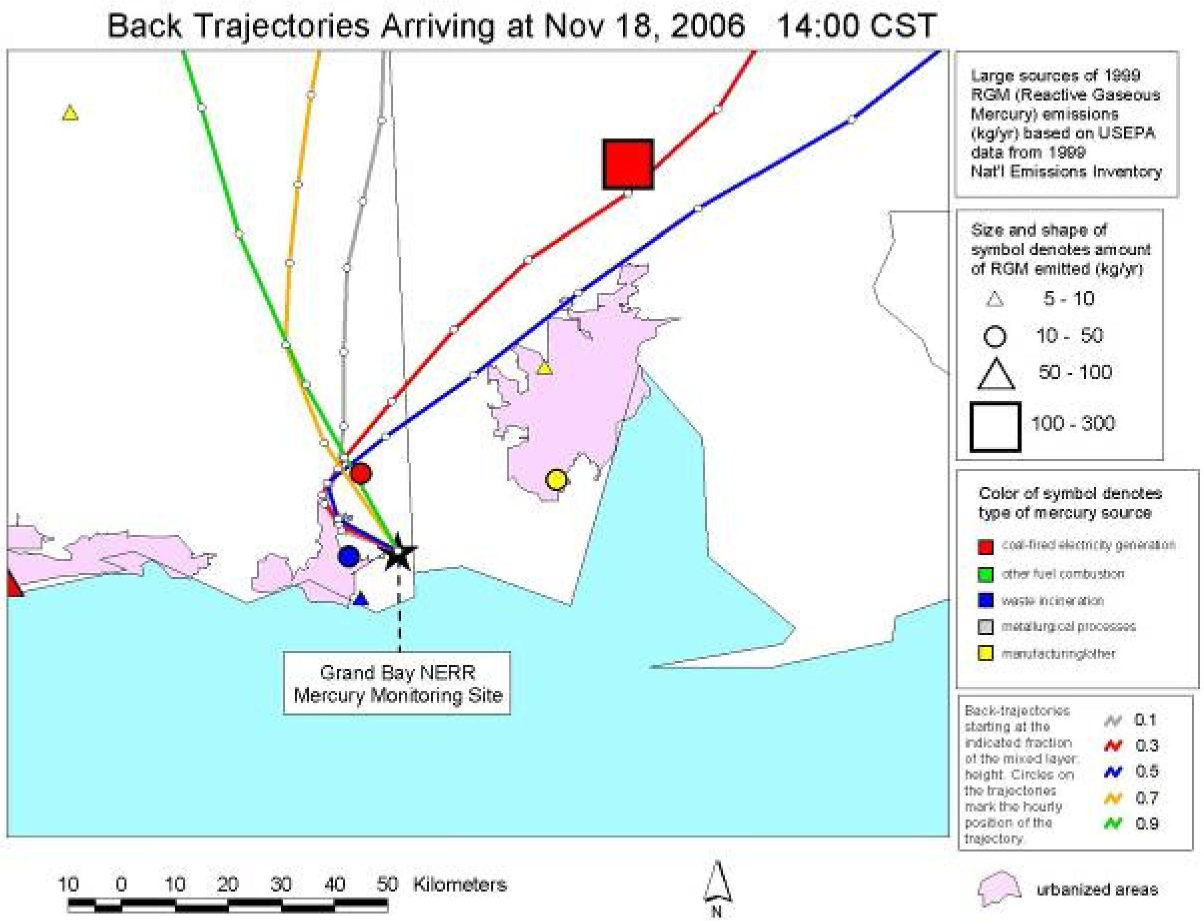


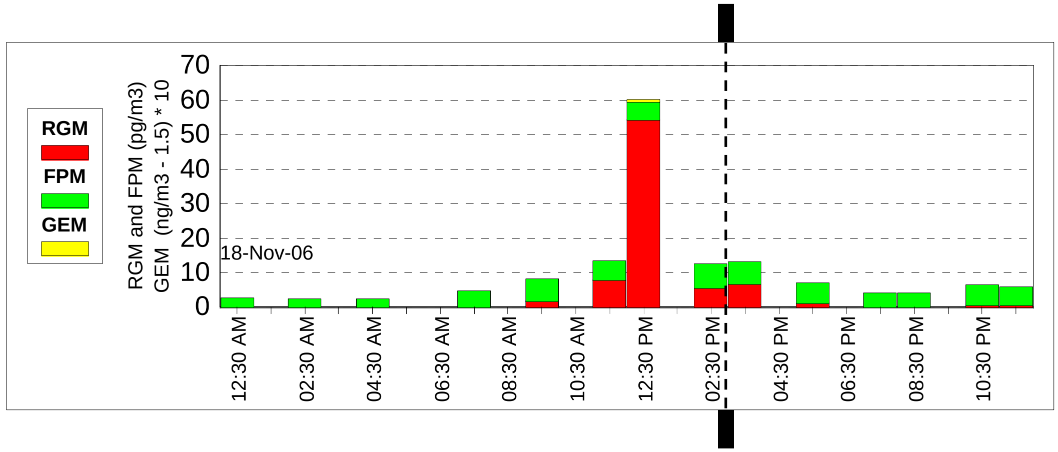
Back Trajectories Arriving at Nov 18, 2006 13:00 CST

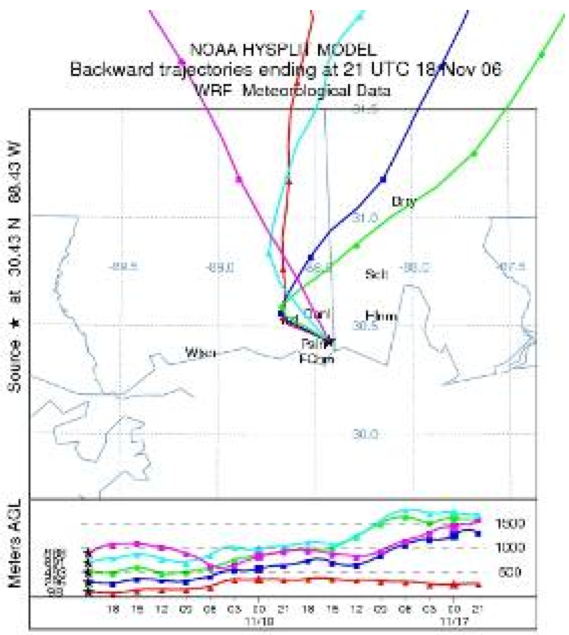



RGM
FPM
GEM
RGM and FPM (pg/m3)
GEM (ng/m3 - 1.5) * 10
18-Nov-06
70
60
50
40
30
20
10
0
12:30 AM
02:30 AM
04:30 AM
06:30 AM
08:30 AM
10:30 AM
12:30 PM
02:30 PM
04:30 PM
06:30 PM
08:30 PM
10:30 PM

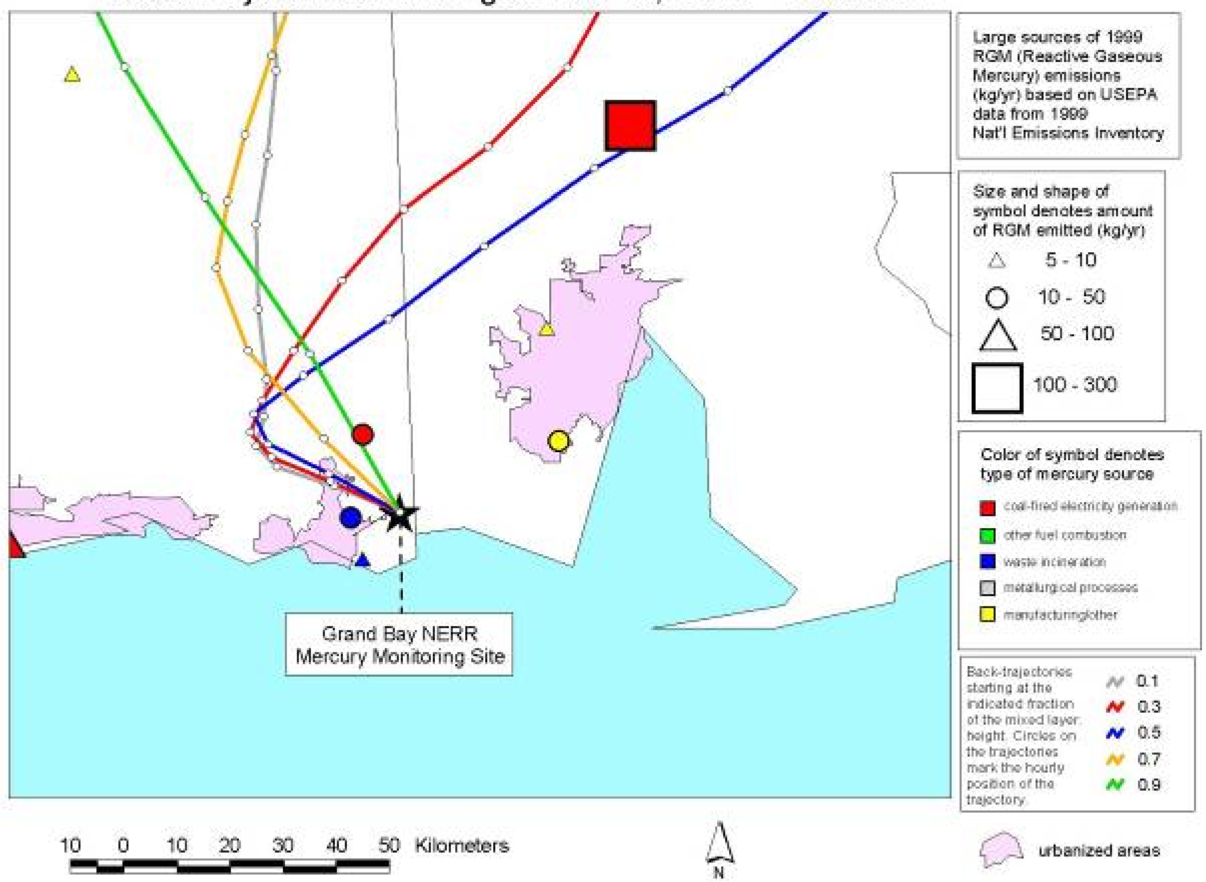

NOAA HYSPLIT MODEL
Backward trajectories ending at 20 UTC 18 Nov 06
WRF Meteorological Data
Source ★ at 30.43 N 88.43 W
Meters AGL
1500
1000
500

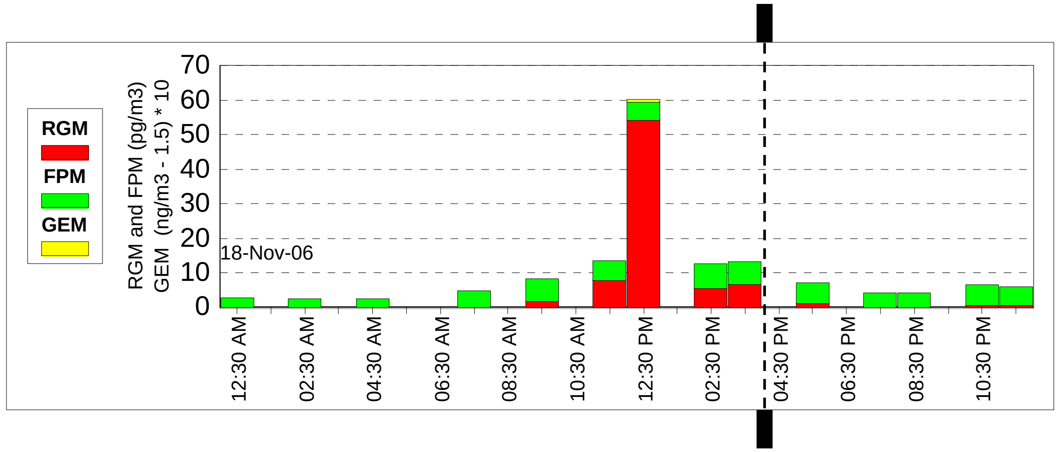

Back Trajectories Arriving at Nov 18, 2006 14:00 CST
Grand Bay NERR
Mercury Monitoring Site
Large sources of 1999 RGM (Reactive Gaseous Mercury) emissions (kg/yr) based on USEPA data from 1999 Nat'l Emissions Inventory
Size and shape of symbol denotes amount of RGM emitted (kg/yr)
5 - 10
10 - 50
50 - 100
100 - 300
Color of symbol denotes type of mercury source
coal-fired electricity generation
other fuel combustion
waste incineration
metallurgical processes
manufacturing/other
Back-trajectories starting at the indicated fraction of the mixed layer height. Circles on the trajectories mark the hourly position of the trajectory
0.1
0.3
0.5
0.7
0.9
10 0 10 20 30 40 50 Kilometers
N
urbanized areas

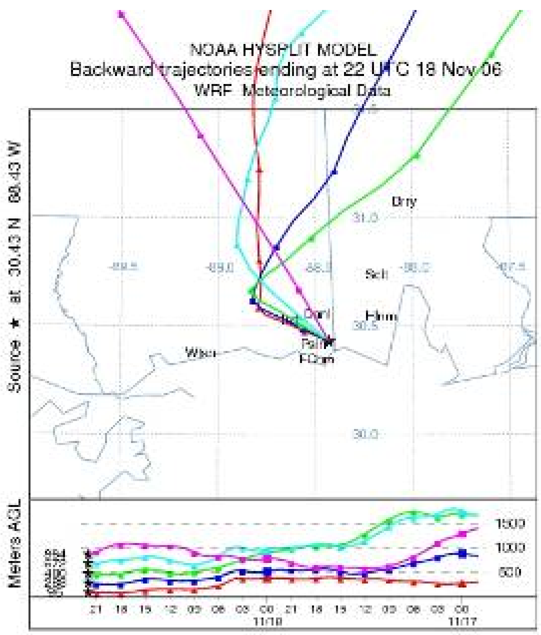


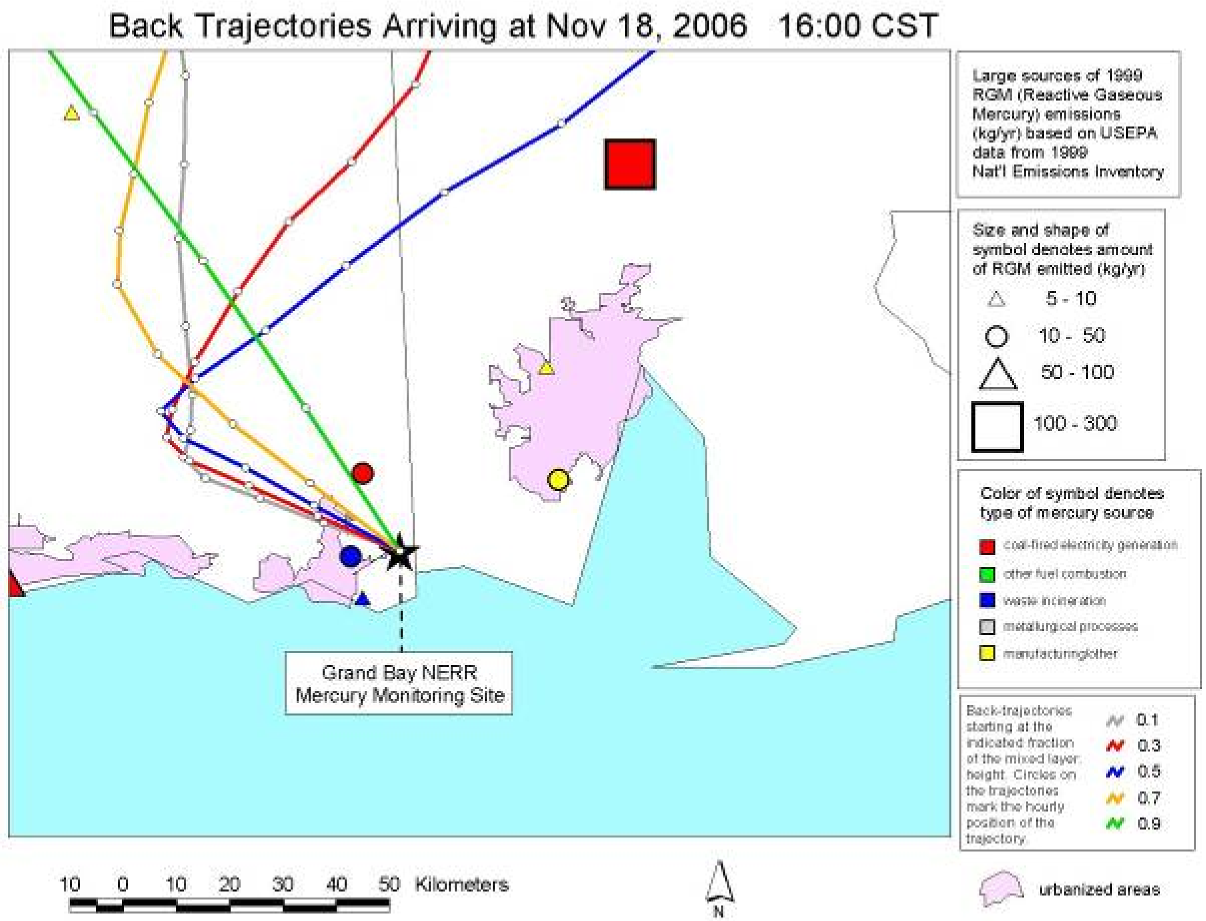


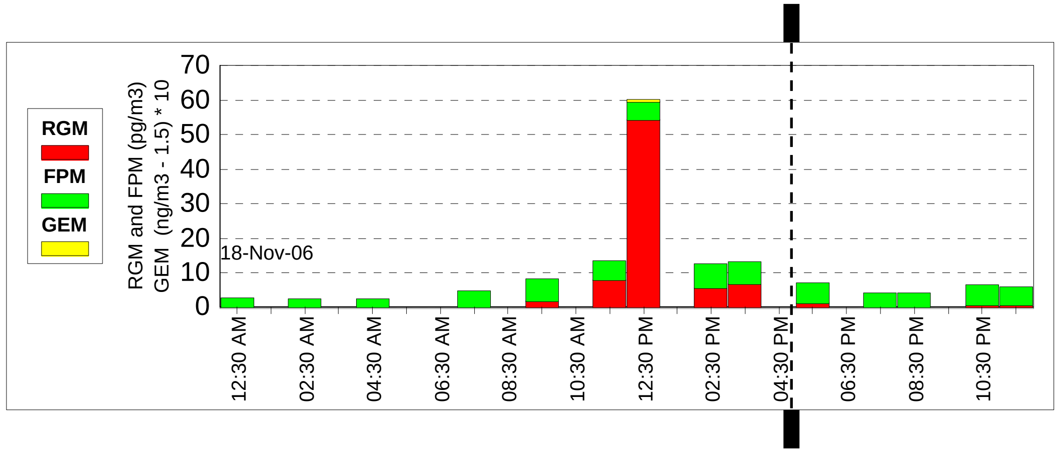
Back Trajectories Arriving at Nov 18, 2006 15:00 CST



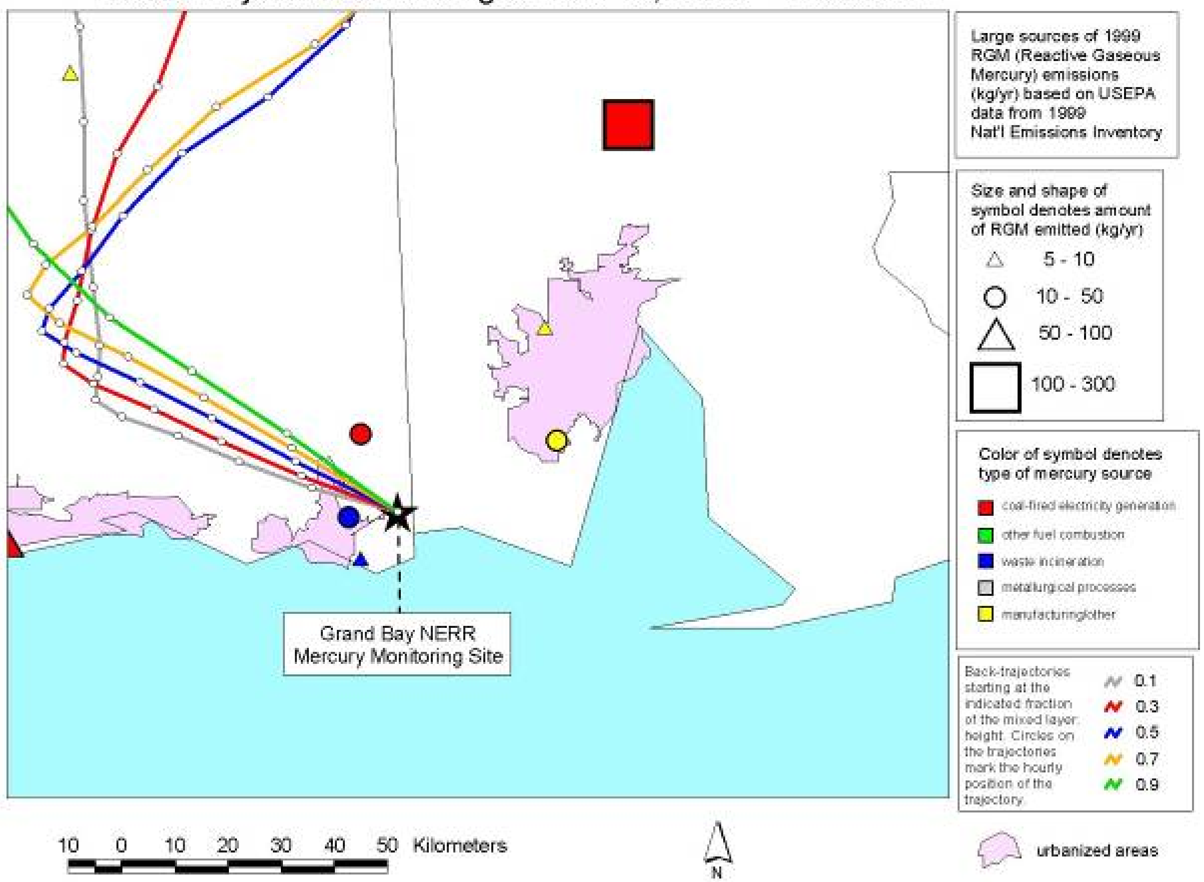

RGM
FPM
GEM
RGM and FPM (pg/m3)
GEM (ng/m3 - 1.5) * 10
70
60
50
40
30
20
10
0
18-Nov-06
12:30 AM
02:30 AM
04:30 AM
06:30 AM
08:30 AM
10:30 AM
12:30 PM
02:30 PM
04:30 PM
06:30 PM
08:30 PM
10:30 PM

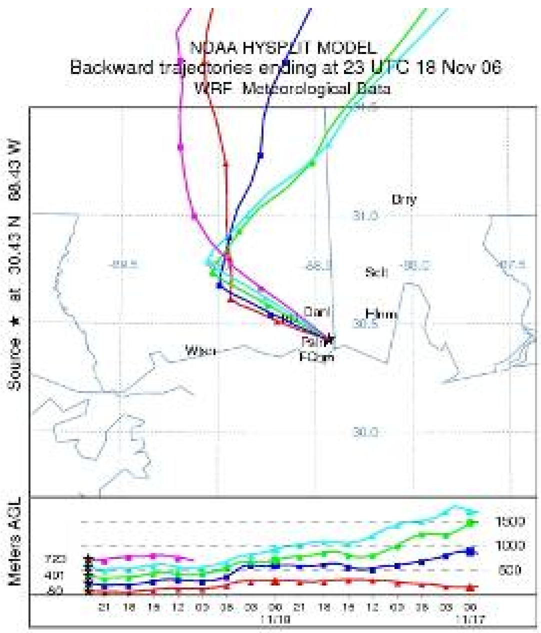

NOAA HYSPLIT MODEL
Backward trajectories ending at 22 UTC 18 Nov 06
WRF Meteorological Data
Source ★ at 30.43 N 88.43 W
Meters AGL
1500
1000
500


Back Trajectories Arriving at Nov 18, 2006 16:00 CST
Large sources of 1999 RGM (Reactive Gaseous Mercury) emissions (kg/yr) based on USEPA data from 1999 Nat'l Emissions Inventory
Size and shape of symbol denotes amount of RGM emitted (kg/yr)
5 - 10
10 - 50
50 - 100
100 - 300
Color of symbol denotes type of mercury source
coal-fired electricity generation
other fuel combustion
waste incineration
metallurgical processes
manufacturing/other
Back-trajectories starting at the indicated fraction of the mixed layer height. Circles on the trajectories mark the hourly position of the trajectory.
0.1
0.3
0.5
0.7
0.9
Grand Bay NERR
Mercury Monitoring Site
10 0 10 20 30 40 50 Kilometers
N
urbanized areas



Back Trajectories Arriving at Nov 18, 2006 17:00 CST





Precision, QA/QC Studies

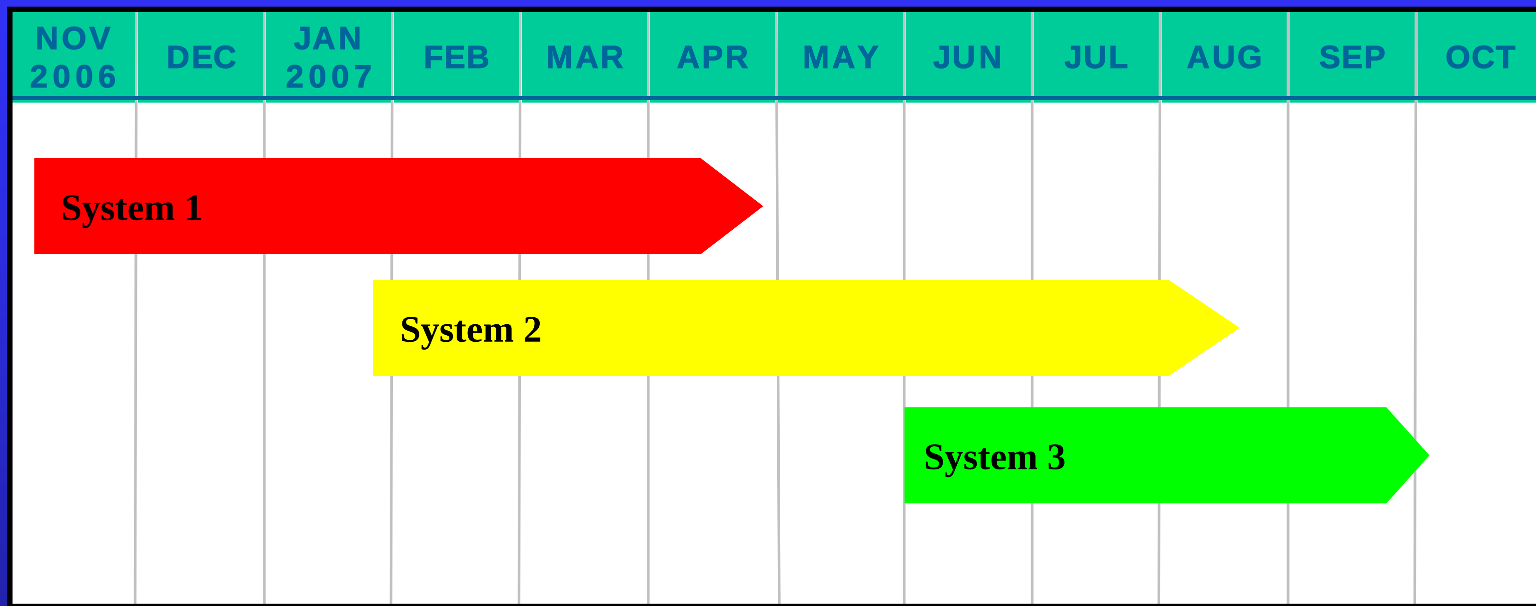
Tekran Speciation System

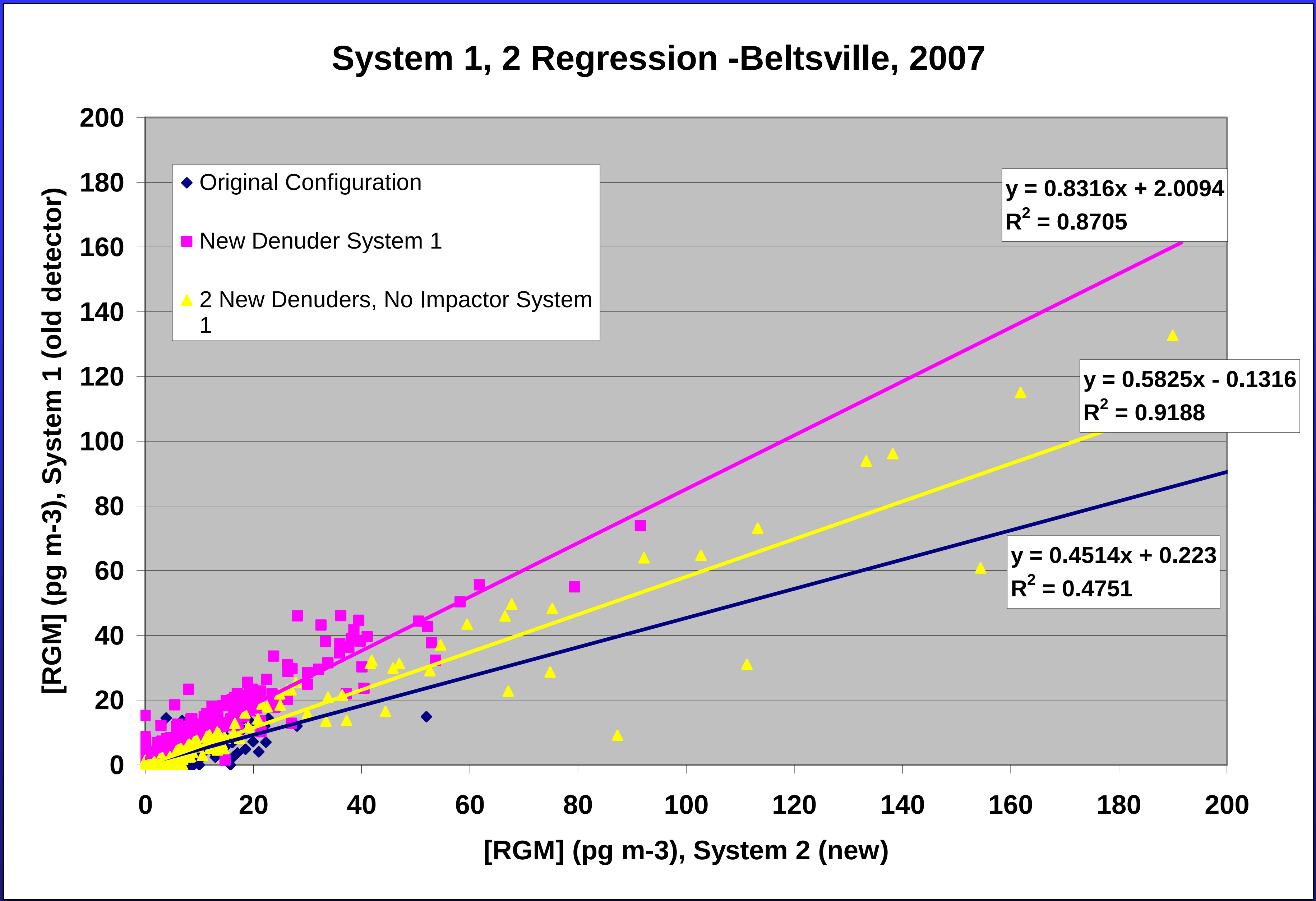
- Installed System 1 (NOAA) Nov. 7, 2006
  Height of Inlet: 3.75 m above ground
  0.5 m above trailer
- Installed second system
  (System 2-NOAA) Jan 26, 2007
- System 1 removed April 27, 2007
- Install System 3 (EPA) June 1, 2007
- Remove System 2 August 17, 2007

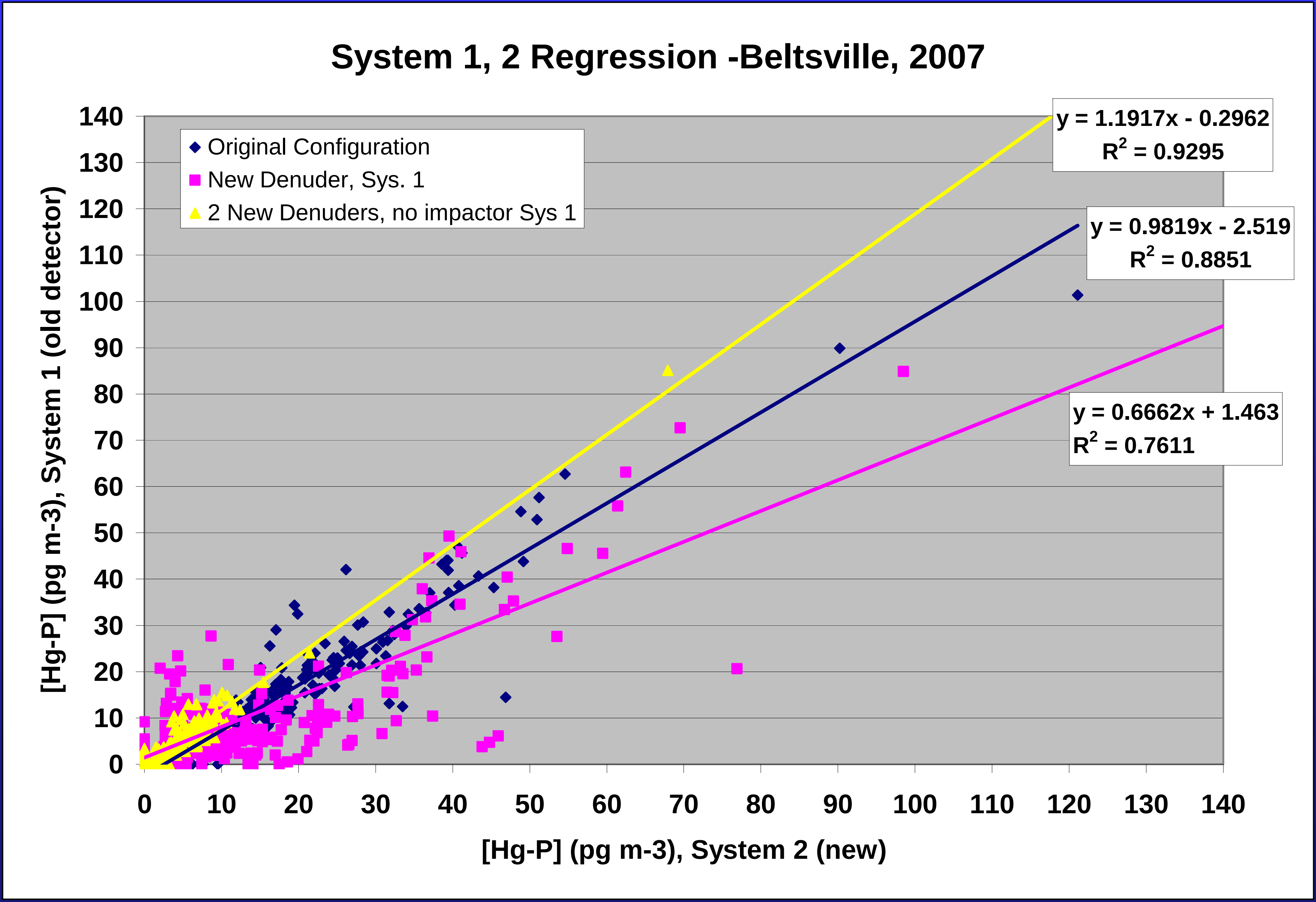
Tekran Speciation Systems QA/QC Studies

- Periodic deployment of duplicate systems
  Jan. 26-Apr. 27, 2007
  June 1-Aug. 17, 2007
- Precision and accuracy of independent systems
- Investigation of aerosol size segregation of Hg-P

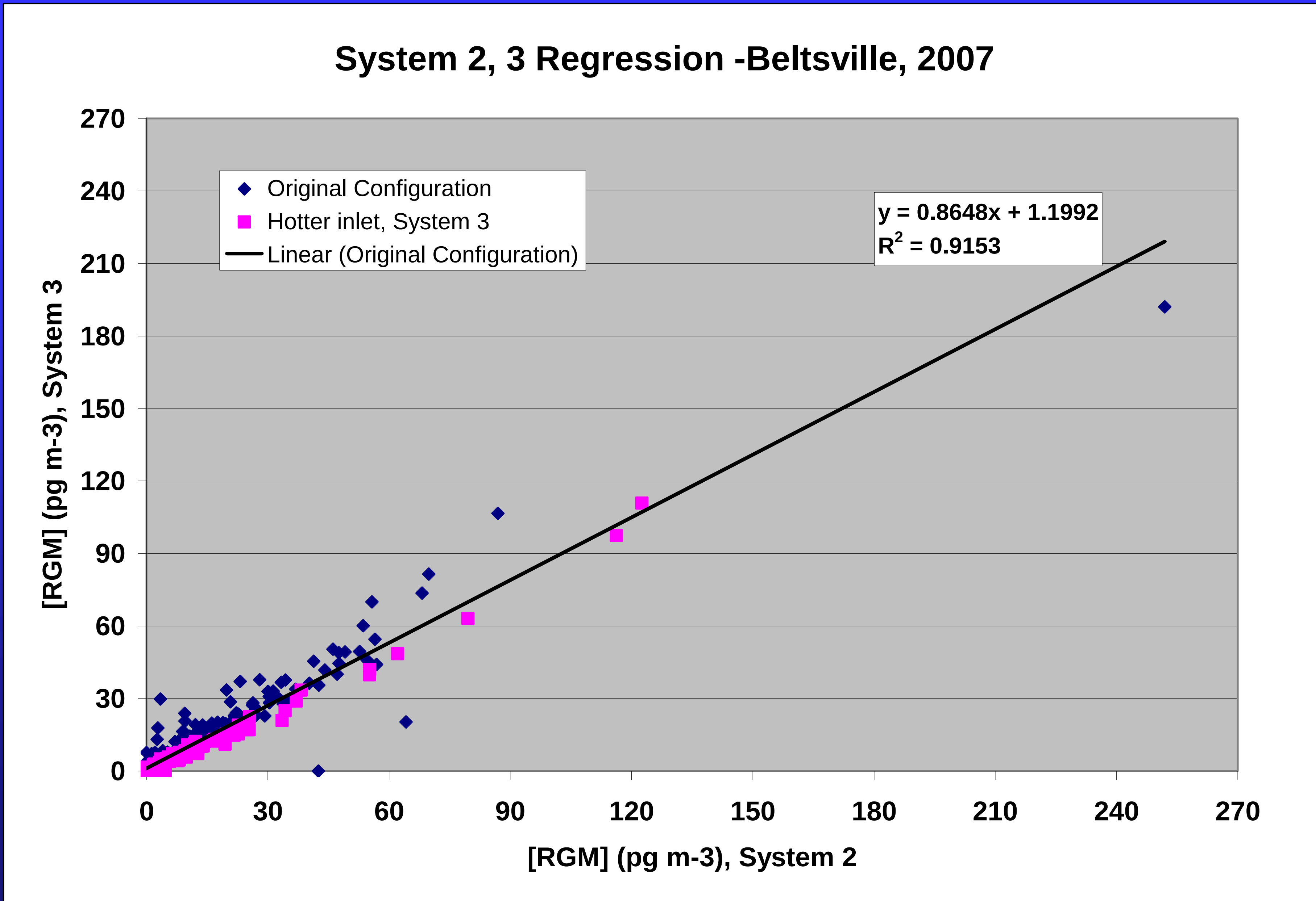
Tekran Deployment Timeline -Beltsville

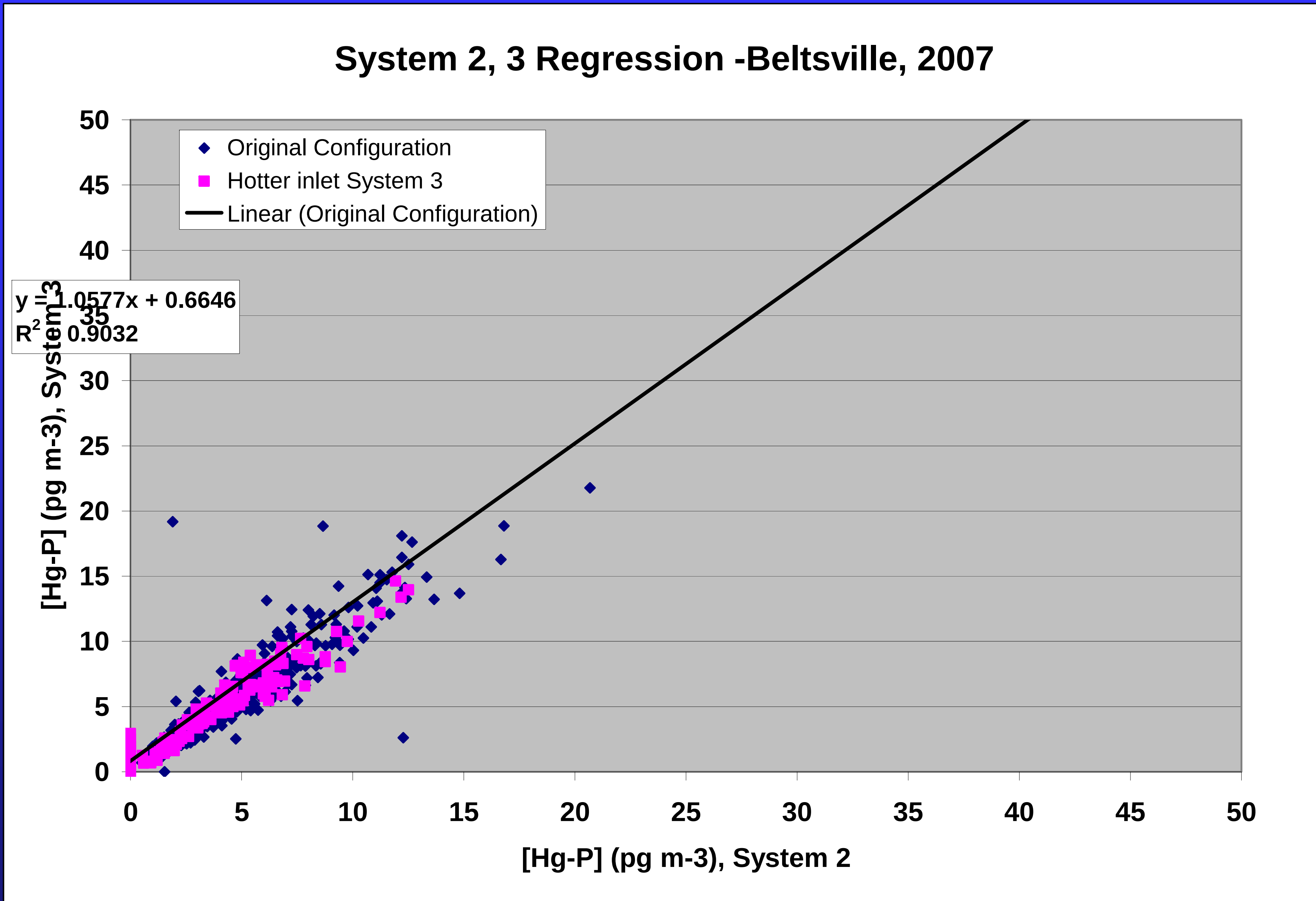



System 1, 2 Regression -Beltsville, 2007
Original Configuration
New Denuder System 1
2 New Denuders, No Impactor System 1
y = 0.8316x + 2.0094
R2 = 0.8705
y = 0.5825x - 0.1316
R2 = 0.9188
y = 0.4514x + 0.223
R2 = 0.4751
[RGM] (pg m-3), System 1 (old detector)
[RGM] (pg m-3), System 2 (new)
0
20
40
60
80
100
120
140
160
180
200



System 1, 2 Regression -Beltsville, 2007
Original Configuration
New Denuder, Sys. 1
2 New Denuders, no impactor Sys 1
y = 1.1917x - 0.2962
R^2 = 0.9295
y = 0.9819x - 2.519
R^2 = 0.8851
y = 0.6662x + 1.463
R^2 = 0.7611
[Hg-P] (pg m-3), System 1 (old detector)
[Hg-P] (pg m-3), System 2 (new)
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140


System 2, 3 Regression -Beltsville, 2007
270
240
210
180
150
120
90
60
30
0
[RGM] (pg m-3), System 3
Original Configuration
Hotter inlet, System 3
Linear (Original Configuration)
y = 0.8648x + 1.1992
R2 = 0.9153
0
30
60
90
120
150
180
210
240
270
[RGM] (pg m-3), System 2



System 2, 3 Regression -Beltsville, 2007
Original Configuration
Hotter inlet System 3
Linear (Original Configuration)
y = 1.0577x + 0.6646
R2 = 0.9032
[Hg-P] (pg m-3), System 3
[Hg-P] (pg m-3), System 2
0
5
10
15
20
25
30
35
40
45
50

Monitoring Sites:
Next Steps

Beltsville

- Addition of 10 m walk up scaffold
- Migration to new shelter?
- Acquisition of second Tekran system

Synchronous sampling –precision, QA/QC studies, etc.

Asynchronous sampling for true continuous measurements

Grand Bay

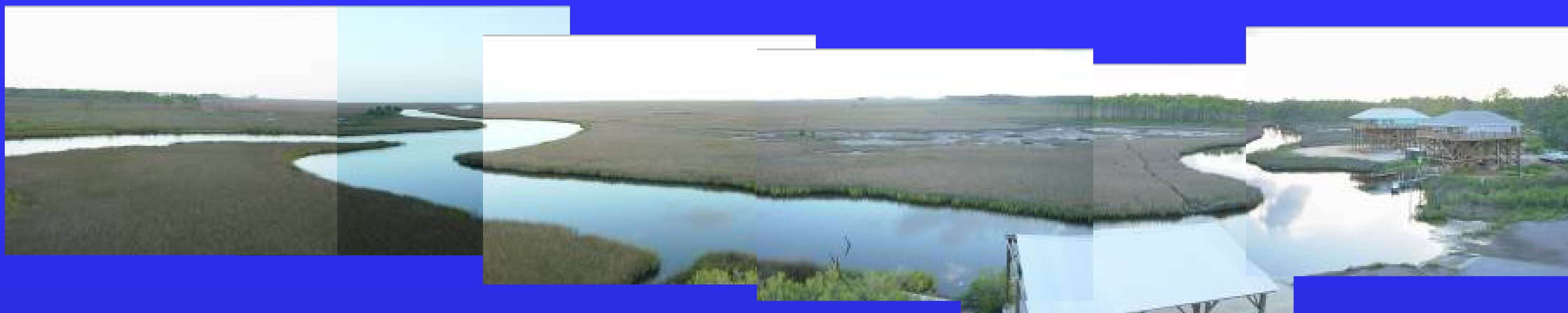
- Migration from old trailer and site to new trailer at permanent site (water's edge, 2 miles distant)
- Addition of 10m walk-up scaffold
- Addition of second Tekran System

  Synchronous sampling –precision, QA/QC studies, investigation of Hg/aerosol size, etc.

  Asynchronous sampling for true continuous measurements

- Addition of NO/NO_Y monitor

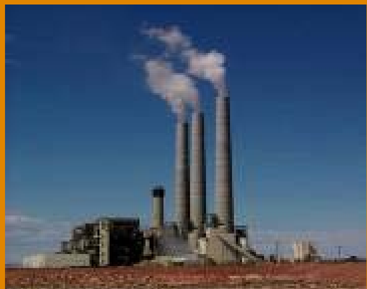
Pictures of Permanent Monitoring Site –Grand Bay

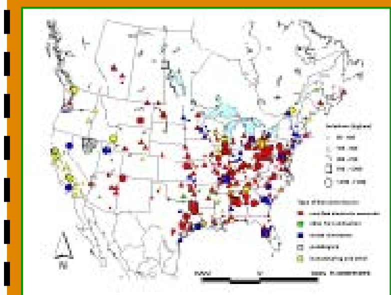


View from top of 10 m tower looking at the southerly (prevailing wind) sampling sector over the U.S. Fish and Wildlife Service Pavilion at Grand Bay NERR

Model Evaluation and Improvement

Emissions Inventories





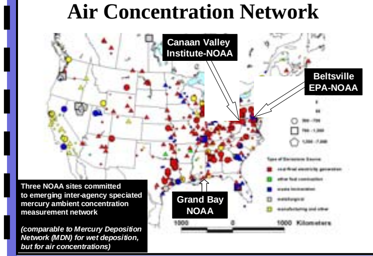
To evaluate and improve atmospheric models, emissions inventories must be:

- Accurate for each individual source (especially for large sources), including variations
- For the same time periods as measurements used for evaluation
- For all forms of mercury

Atmospheric Monitoring

Mercury Deposition Network (MDN)
(wet deposition only)

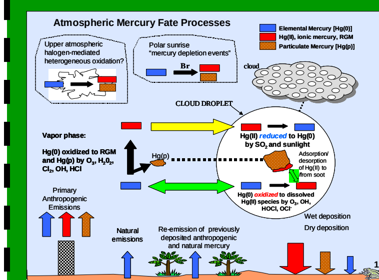
Air Concentration Network

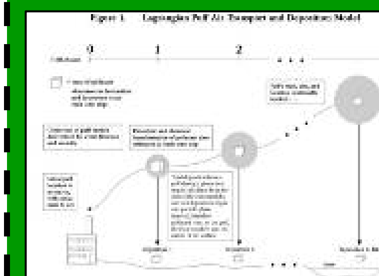


To evaluate and improve atmospheric models, atmospheric monitoring must be:

- For air concentrations (not just wet deposition)
- For all forms of mercury
- For sites impacted by sources (not just background sites)
- At elevations in the atmosphere (not just at ground level)

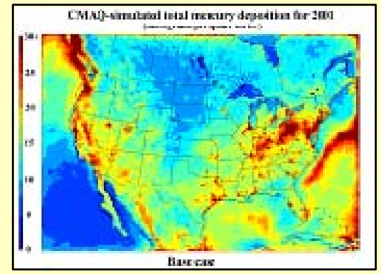
Atmospheric Models



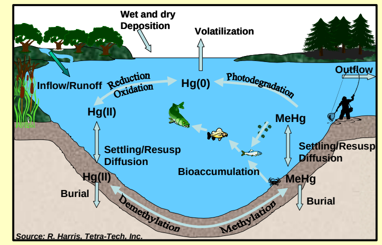


Understanding and Decisions

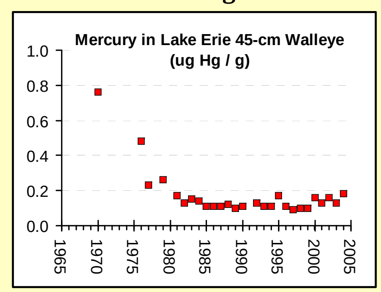
Deposition For Entire Region



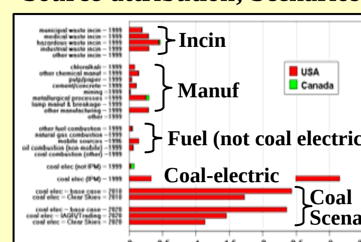
Inputs for Ecosystem Models



Understanding Trends



Source-attribution; Scenarios



Hg Dep to Lake Michigan (g/km2-yr)

<u>Why do we need atmospheric mercury models?</u>

- **to get *comprehensive source attribution* information**
  ...we don't just want to know how much is depositing at any given location, we also want to know where it came from:
  - different source regions (local, regional, national, continental, global)
  - different jurisdictions (different states and provinces)
  - anthropogenic vs. natural emissions
  - different anthropogenic source types (power plants, waste incin., etc)

- **to estimate *deposition over large regions***
  …because deposition fields are highly spatially variable,
  and one can't measure everywhere all the time…

- **to estimate *dry deposition***
  ... presently, dry deposition can only be estimated via models

- **to evaluate *potential consequences* of alternative future emissions scenarios**

Atmospheric models can potentially provide valuable deposition and source-attribution information.

But… models have not been adequately evaluated, so we don't really know very well how good or bad they are…

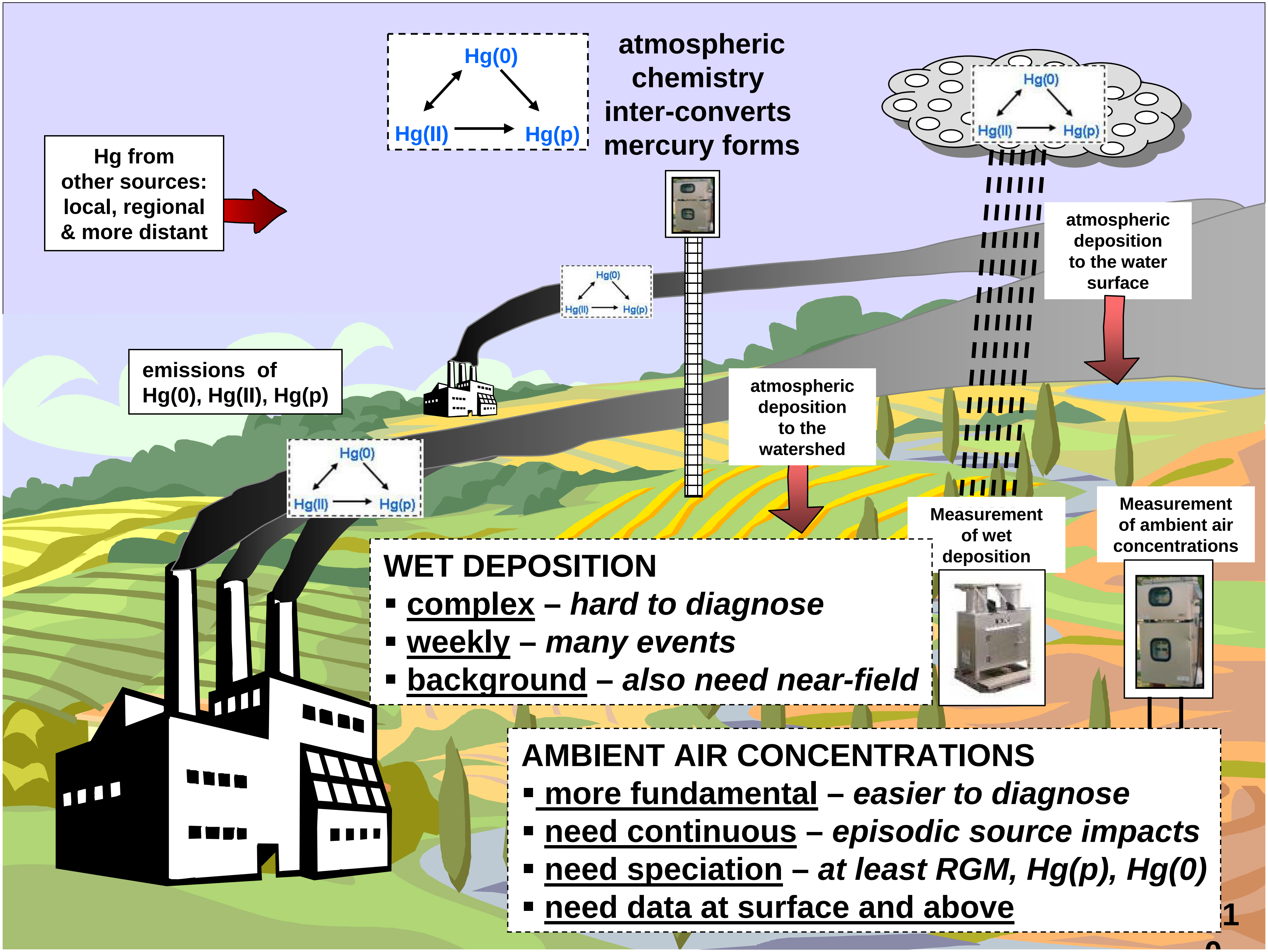
Challenges / critical data needs for model evaluation:

Ambient Monitoring Data

- speciated ambient concentrations at a number of different locations, both source-impacted and remote
  (need RGM and Hg(p), not just total gaseous mercury)
- wet deposition

Emissions inventories

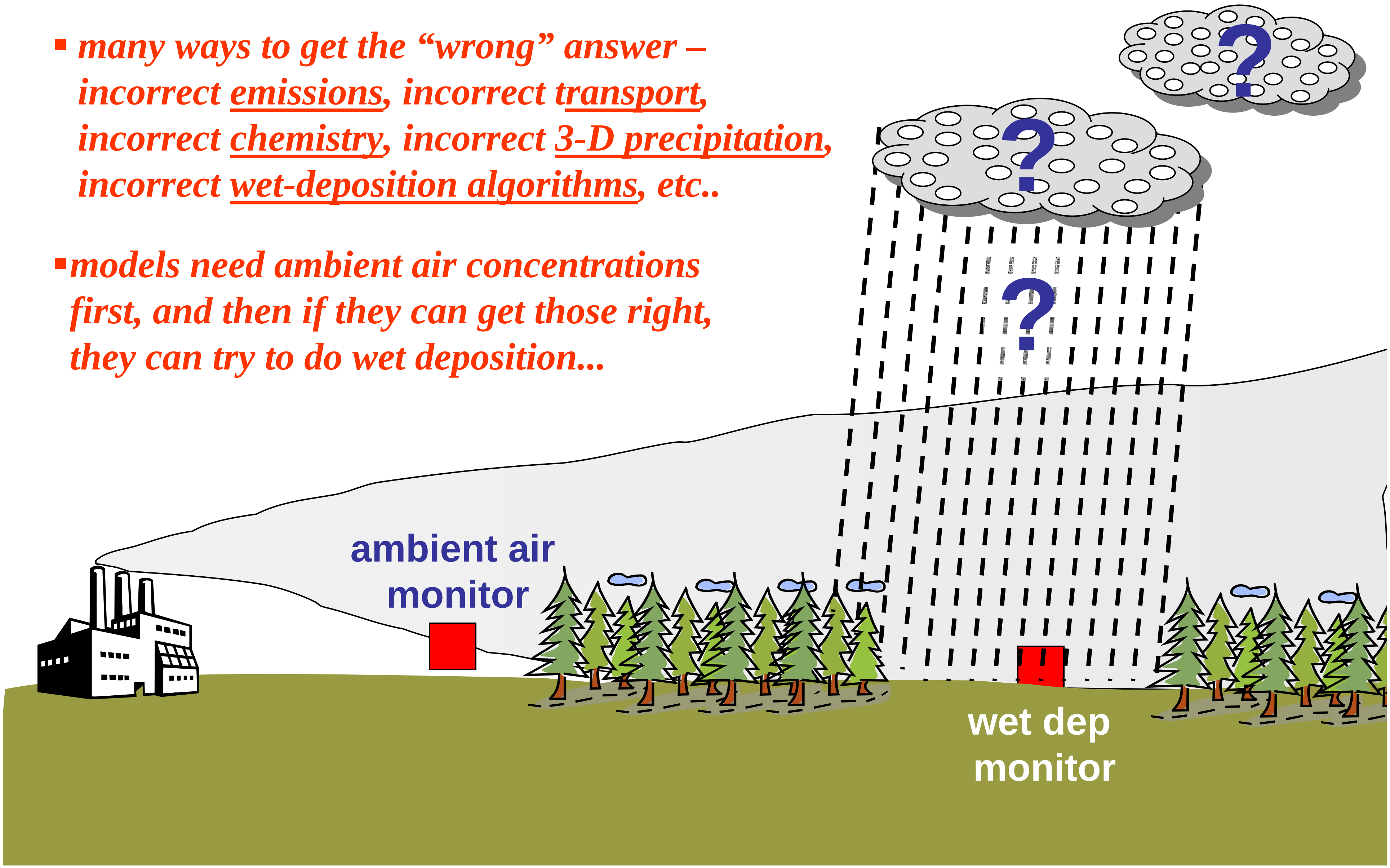
- complete, accurate, speciated
- up-to-date (or at least for the same period as measurements)
- temporal resolution better than annual (e.g., shut-downs, etc)

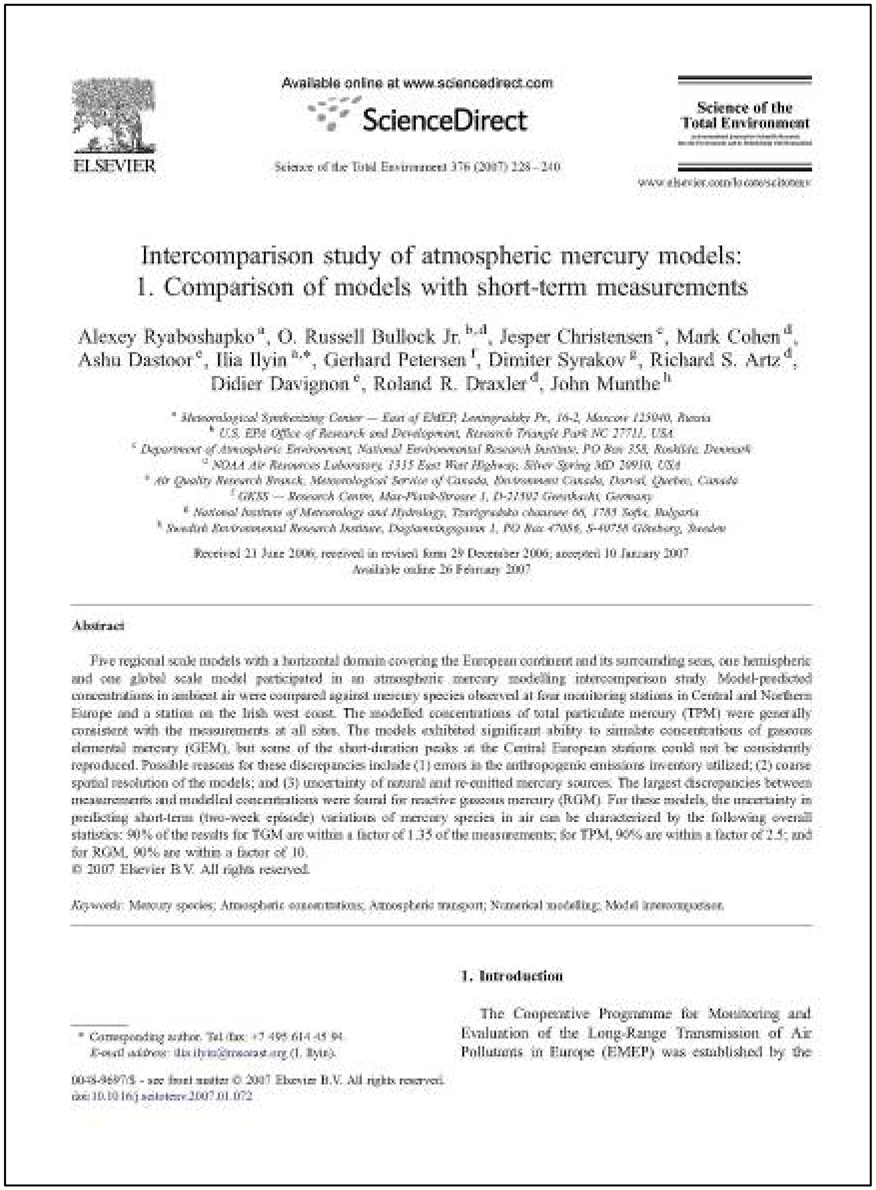

Hg(0)
Hg(II)
Hg(p)
atmospheric chemistry inter-converts mercury forms
Hg from other sources: local, regional & more distant
emissions of Hg(0), Hg(II), Hg(p)
atmospheric deposition to the water surface
atmospheric deposition to the watershed
Measurement of wet deposition
Measurement of ambient air concentrations
WET DEPOSITION
▪ complex – hard to diagnose
▪ weekly – many events
▪ background – also need near-field
AMBIENT AIR CONCENTRATIONS
▪ more fundamental – easier to diagnose
▪ need continuous – episodic source impacts
▪ need speciation – at least RGM, Hg(p), Hg(0)
▪ need data at surface and above
10

Wet deposition is a very complicated multi-stage phenomena... not ideal for atmospheric mercury model evaluation purposes

- ***many ways to get the "wrong" answer – incorrect <u>emissions</u>, incorrect <u>transport</u>, incorrect <u>chemistry</u>, incorrect <u>3-D precipitation</u>, incorrect <u>wet-deposition algorithms</u>, etc..***

- ***models need ambient air concentrations first, and then if they can get those right, they can try to do wet deposition...***





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Intercomparison study of atmospheric mercury models: 1. Comparison of models with short-term measurements

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Abstract

Five regional scale models with a horizontal domain covering the European continent and its surrounding seas, one hemispheric and one global scale model participated in an atmospheric mercury modelling intercomparison study. Model-predicted concentrations in ambient air were compared against mercury species observed at four monitoring stations in Central and Northern Europe and a station on the Irish west coast. The modelled concentrations of total particulate mercury (TPM) were generally consistent with the measurements at all sites. The models exhibited significant ability to simulate concentrations of gaseous elemental mercury (GEM), but some of the short-duration peaks at the Central European stations could not be consistently reproduced. Possible reasons for these discrepancies include (1) errors in the anthropogenic emissions inventory utilized; (2) coarse spatial resolution of the models; and (3) uncertainty of natural and re-emitted mercury sources. The largest discrepancies between measurements and modelled concentrations were found for reactive gaseous mercury (RGM). For these models, the uncertainty in predicting short-term (two-week episode) variations of mercury species in air can be characterized by the following overall statistics: 90% of the results for TGM are within a factor of 1.35 of the measurements; for TPM, 90% are within a factor of 2.5; and for RGM, 90% are within a factor of 10.

Keywords: Mercury species; Atmospheric concentrations; Atmospheric transport; Numerical modelling; Model intercomparison.

1. Introduction

The Cooperative Programme for Monitoring and Evaluation of the Long-Range Transmission of Air Pollutants in Europe (EMEP) was established by the

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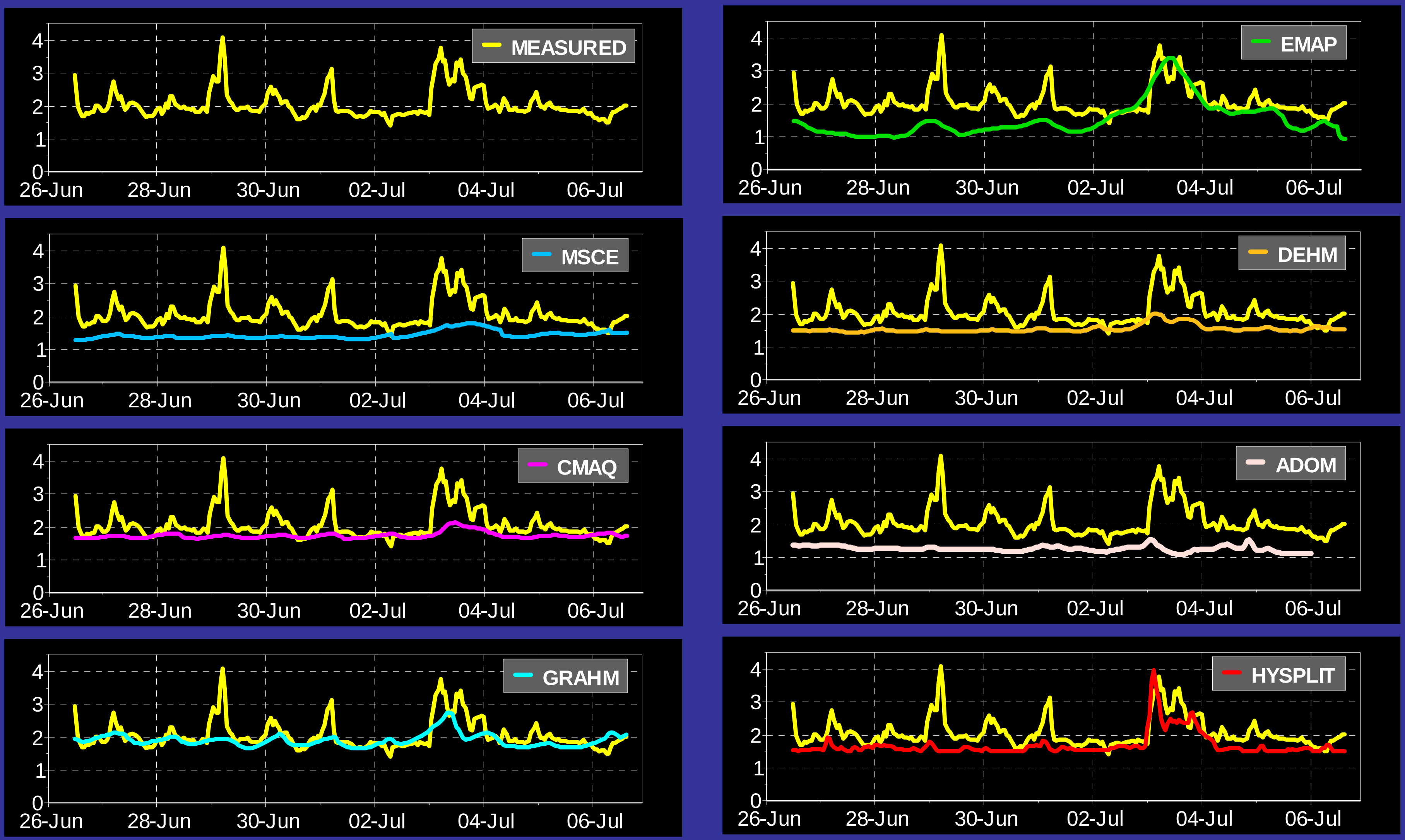
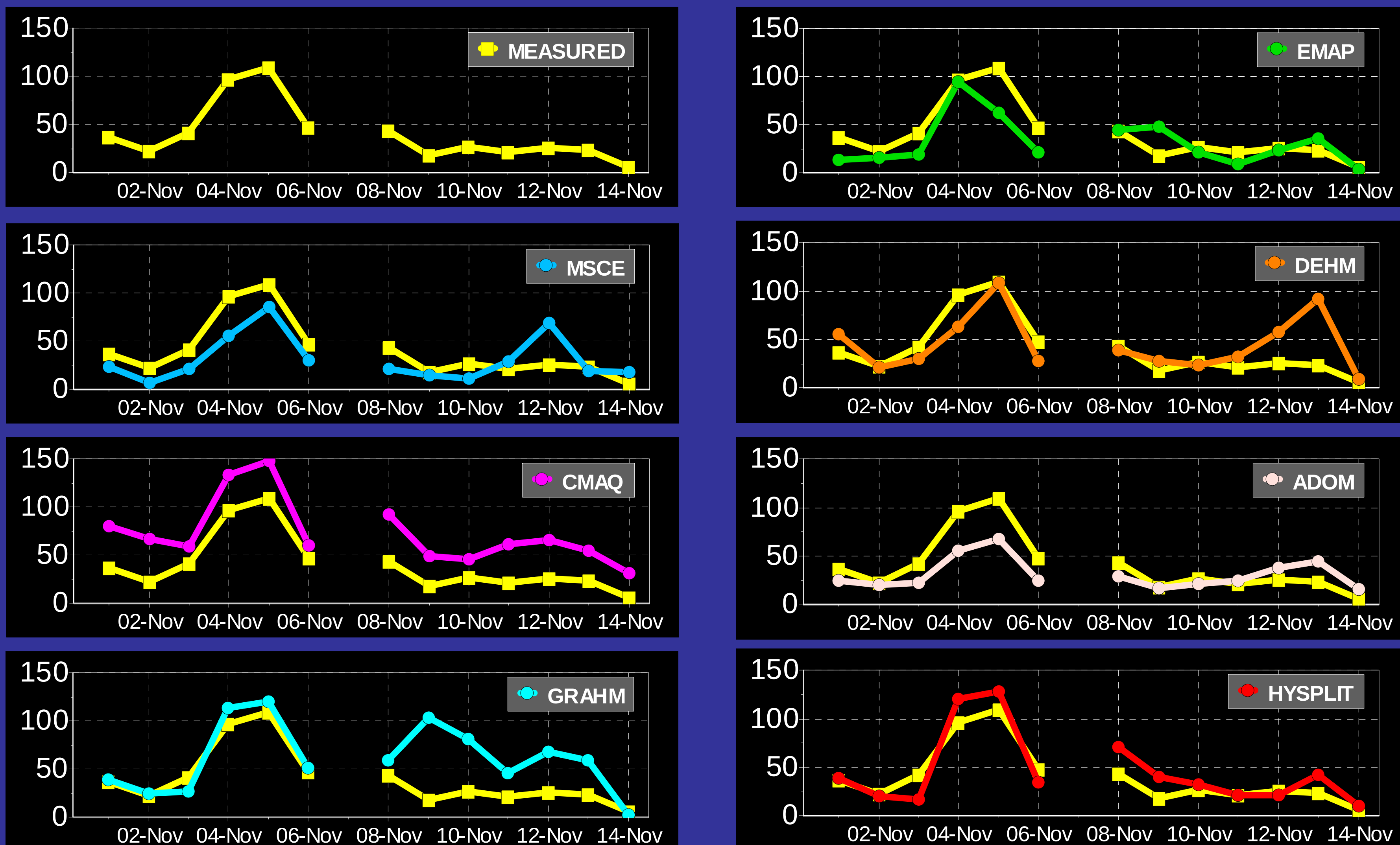
http://www.arl.noaa.gov/data/web/reports/cohen/49_EMEP_paper_2.pdf

Total Gaseous Mercury (ng/m³) at Neuglobsow: June 26 – July 6, 1995



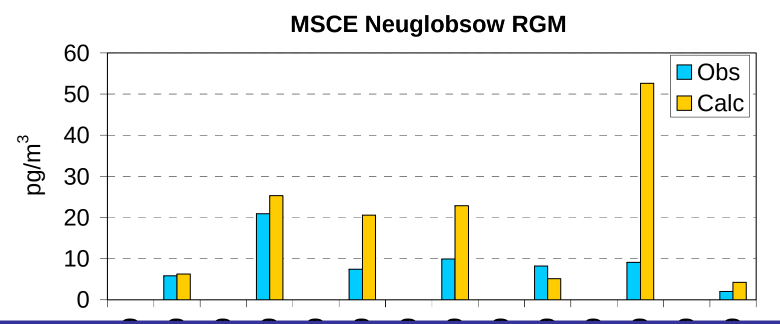
Total *Particulate* Mercury (pg/m³) at Neuglobsow, Nov 1-14, 1999

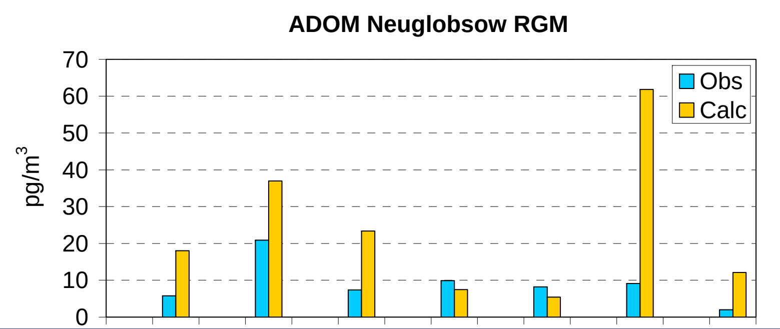


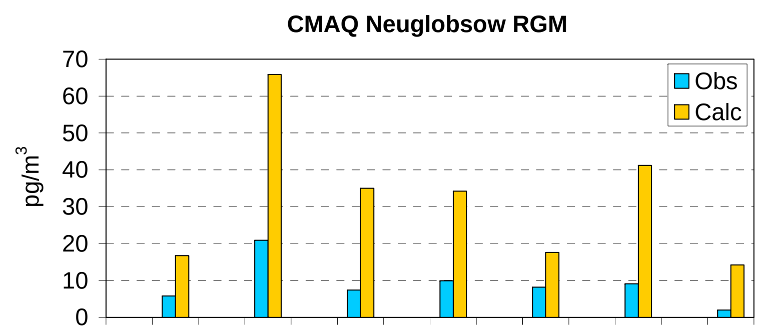
EMEP Intercomparison Study of Numerical Models for

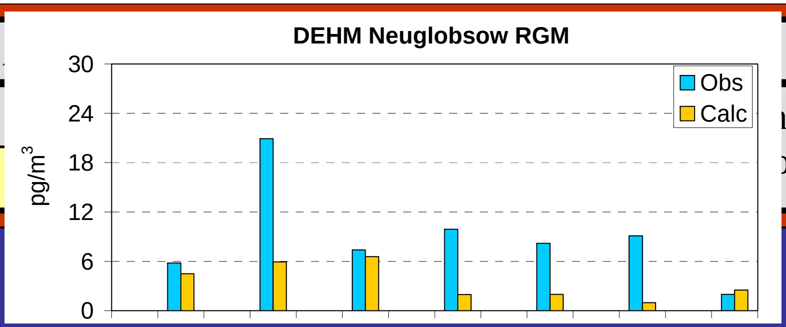
Intro-duction	Stage I	Stage II			clu-ons
	Chemistry	Hg^0	Hg(p)	RGM	

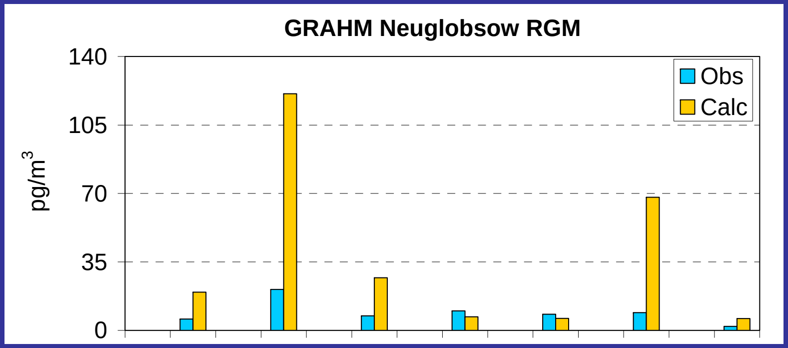
Reactive Gaseous Mercury at Neuglobsow, Nov 1-14, 1999

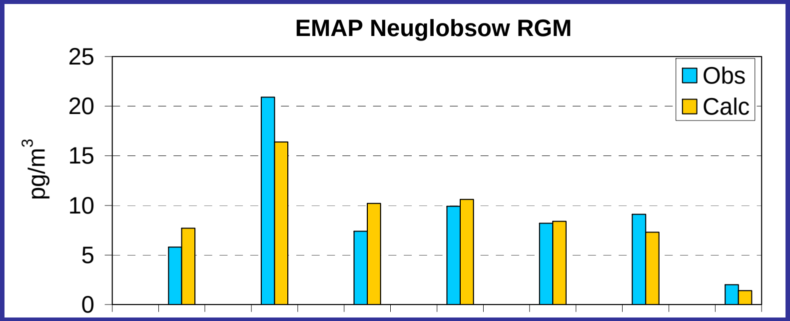


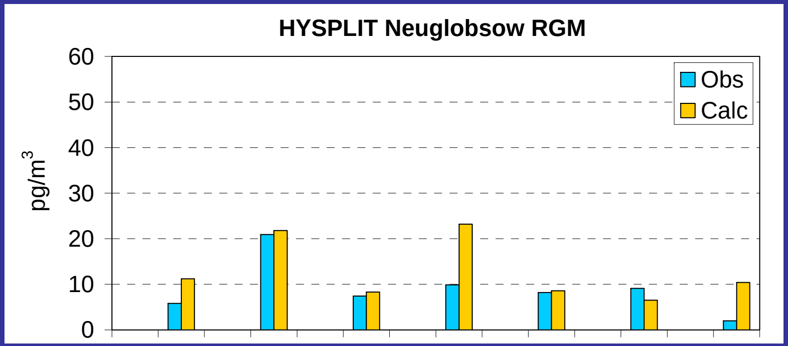












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Intercomparison study of atmospheric mercury models: 2. Modelling results vs. long-term observations and comparison of country deposition budgets

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Abstract

Five regional scale models with a horizontal domain covering the European continent and its surrounding seas, two hemispheric and one global scale model participated in the atmospheric Hg modelling intercomparison study. The models were compared between each other and with available measurements from 11 monitoring stations of the EMEP measurement network. Because only a very limited number of long-term measurement records of Hg were available, significant attention was given to the intercomparison of modelling results. Monthly and annually averaged values of Hg concentrations and depositions as well as items of the Hg deposition budgets for individual European countries were compared. The models demonstrated good agreement (within ±20%) between annual modelled and observed values of gaseous elemental Hg. Modelled values of Hg wet deposition in Western and Central Europe agreed with the observations within ±45%. The probability to predict wet depositions within a factor of 2 with regard to measurements was 50–70% for all the models. The scattering of modelling results for dry depositions of Hg was more significant (up to ±50% at the annual scale and even higher for monthly data). Contribution of dry deposition to the total Hg deposition was estimated at 20–30% with elevated dry deposition fluxes during summer time. The participating models agree in their predictions of transboundary pollution for individual countries within ±60% at the monthly scale and within ±30% at the annual scale. For the cases investigated, all the models predict that the major part of national anthropogenic Hg emissions is transported outside the country territory.

Keywords: Atmospheric mercury; Numerical modelling; Model intercomparison; Transport and deposition; Transboundary pollution; Uncertainty

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http://www.arl.noaa.gov/data/web/reports/cohen/49_EMEP_paper_2.pdf

Overall Summary

- Three long-term monitoring sites – Beltsville, Grand Bay, and CVI -- measuring speciated ambient concentrations of mercury, related trace species, and meteorological parameters form the core of an emerging national ambient mercury measurement network.

- The different sites provide the opportunity to investigate the effects of differences in regional source distribution, atmospheric processes, geographic characteristics, etc. on the fate and transport of atmospheric mercury. However, additional sites are needed to provide a wider range of conditions.

- Ancillary trace gas, aerosol, and meteorological measurements are critically needed to interpret mercury measurements.

- Substantial progress is being made on the development of Standard Operating Procedures (SOP) and Best Measurement Practices (BMP) , as well as QA/QC protocols.

- A draft SOP / BMP document will be discussed and ratified later this week at a meeting in Chicago

Overall Summary... continued

- Initial back-trajectory analysis of peak-measurement events suggest that concentrations at the sites are influenced episodically by local/regional sources.
- Atmospheric mercury models are needed to provide source-attribution information and estimated impacts of alternative future scenarios, but models have not been adequately evaluated due to a lack of speciated ambient concentration data.
- The emerging ambient monitoring network discussed today will provide this critically needed measurement data.
- With these data, models will be able to systematically evaluated -- and improved if necessary -- allowing their results to be used with more confidence.
- Moreover, the datasets will be available on an ongoing basis for ground-truthing model results generated for policy analysis purposes.