Evaluating the HYSPLIT-Hg Atmospheric Mercury Model Using Ambient Monitoring Data

Mark Cohen[1], Winston Luke[1], Paul Kelley[1], Fantine Ngan[1], Richard Artz[1], Steve Brooks[2], Venkata Bhaskar Rao Dodla[3], Roland Draxler[1], Xinrong Ren[1], David Schmeltz[4], Timothy Sharac[4], Jake Walker[5]

1. NOAA Air Resources Laboratory, Silver Spring MD, USA
2. Canaan Valley Institute, Davis WV, USA
3. Jackson State University, Jackson MS, USA
4. USEPA Clean Air Markets Division, Washington DC, USA
5. Grand Bay National Estuarine Research Reserve, Moss Point MS, USA

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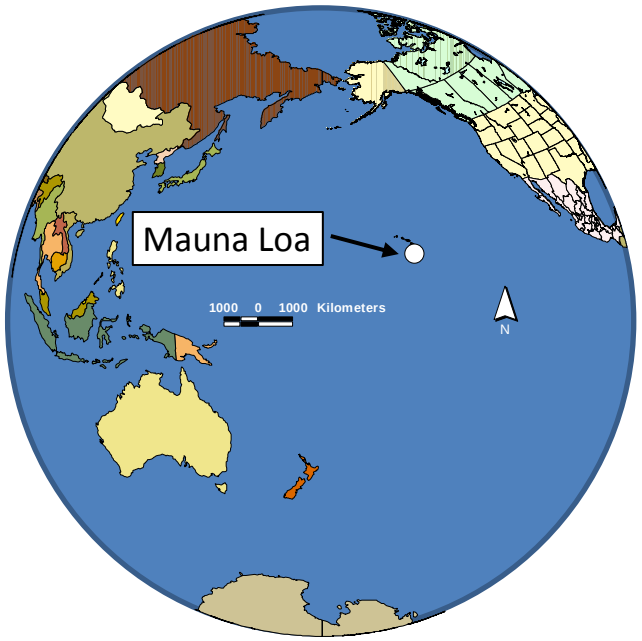
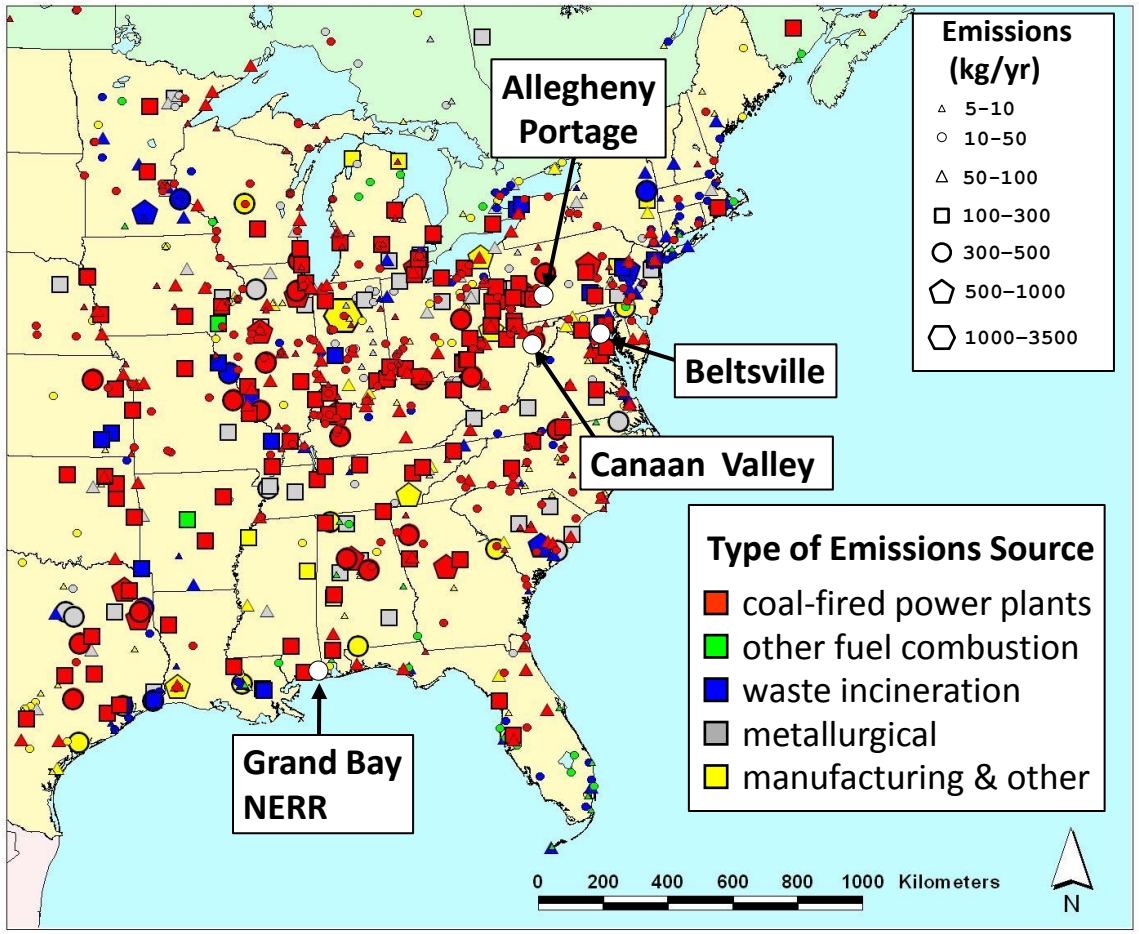
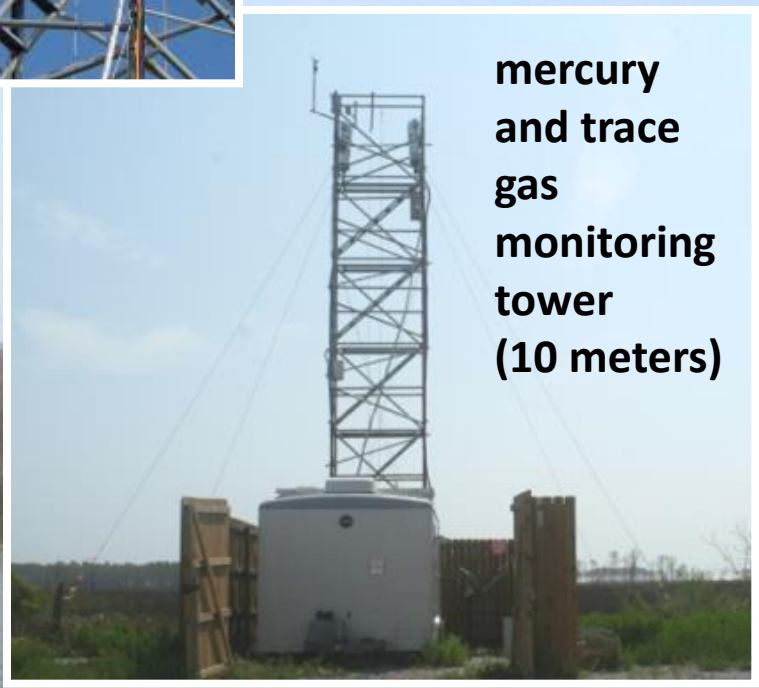
NOAA Air Resources Laboratory: Five Collaborative Speciated Atmospheric Mercury Measurement Sites



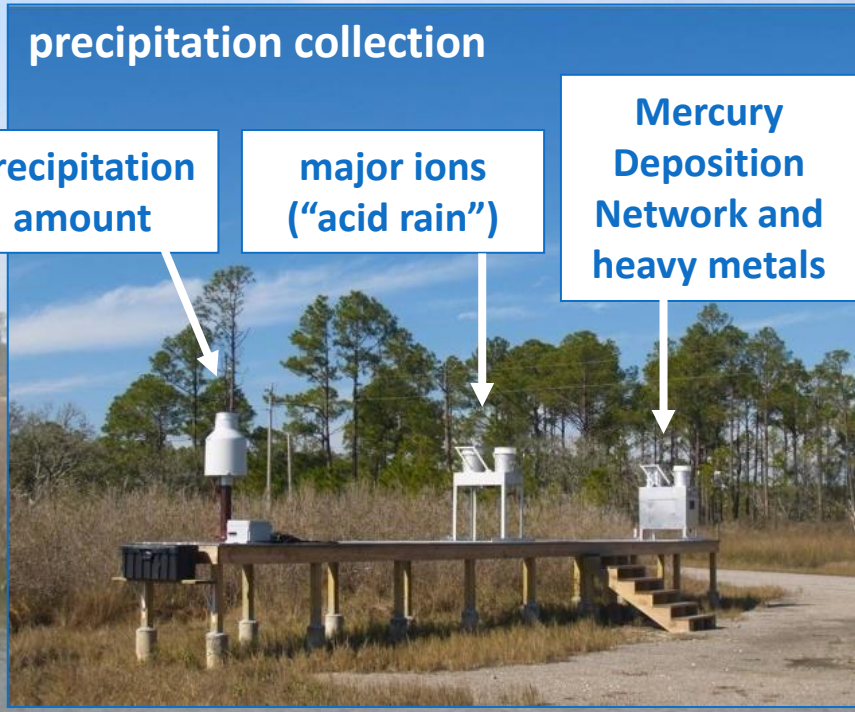


2002 mercury emissions sources based on data from USEPA, Envr. Canada and the CEC

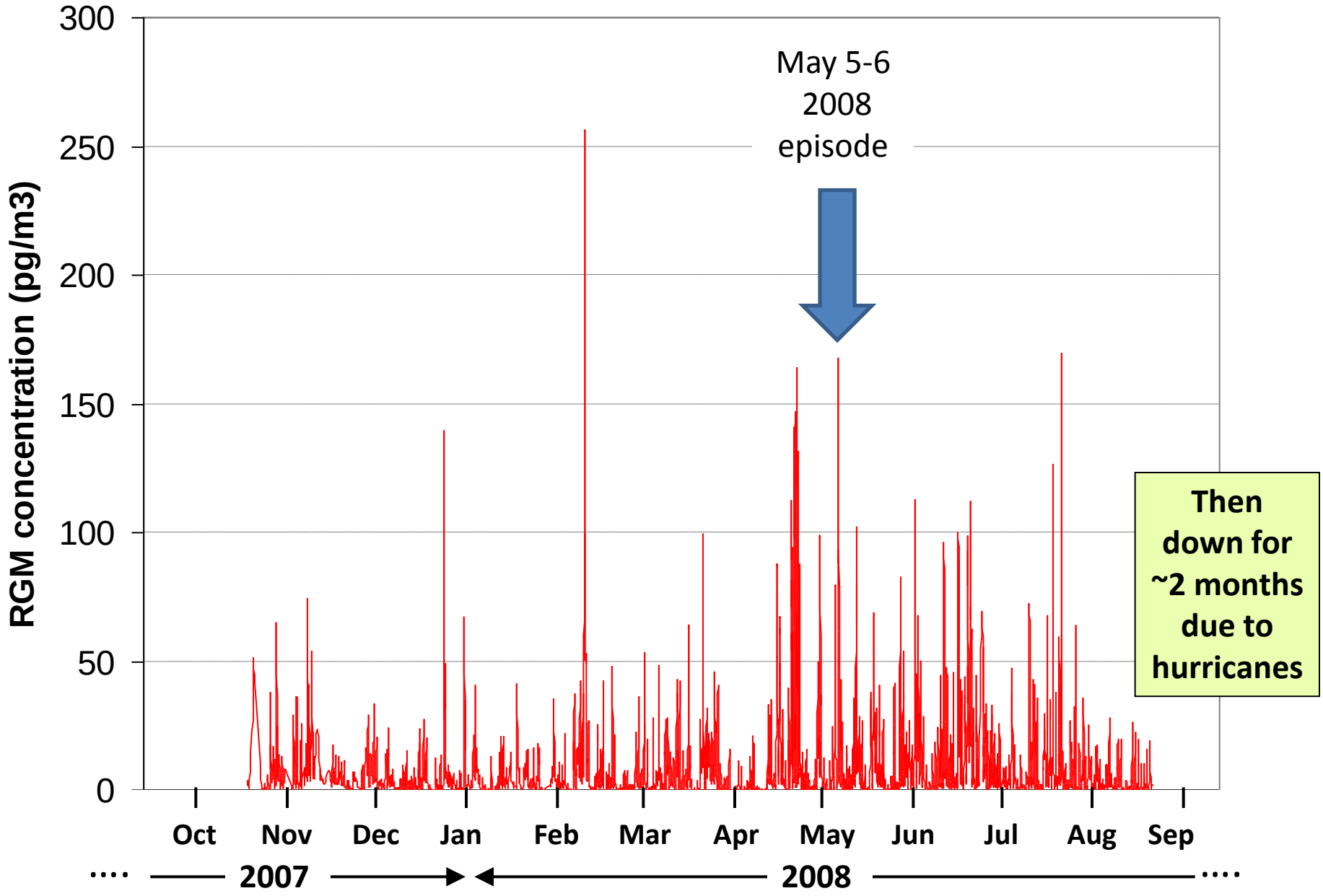
Atmospheric Mercury Monitoring Station at the Grand Bay NERR

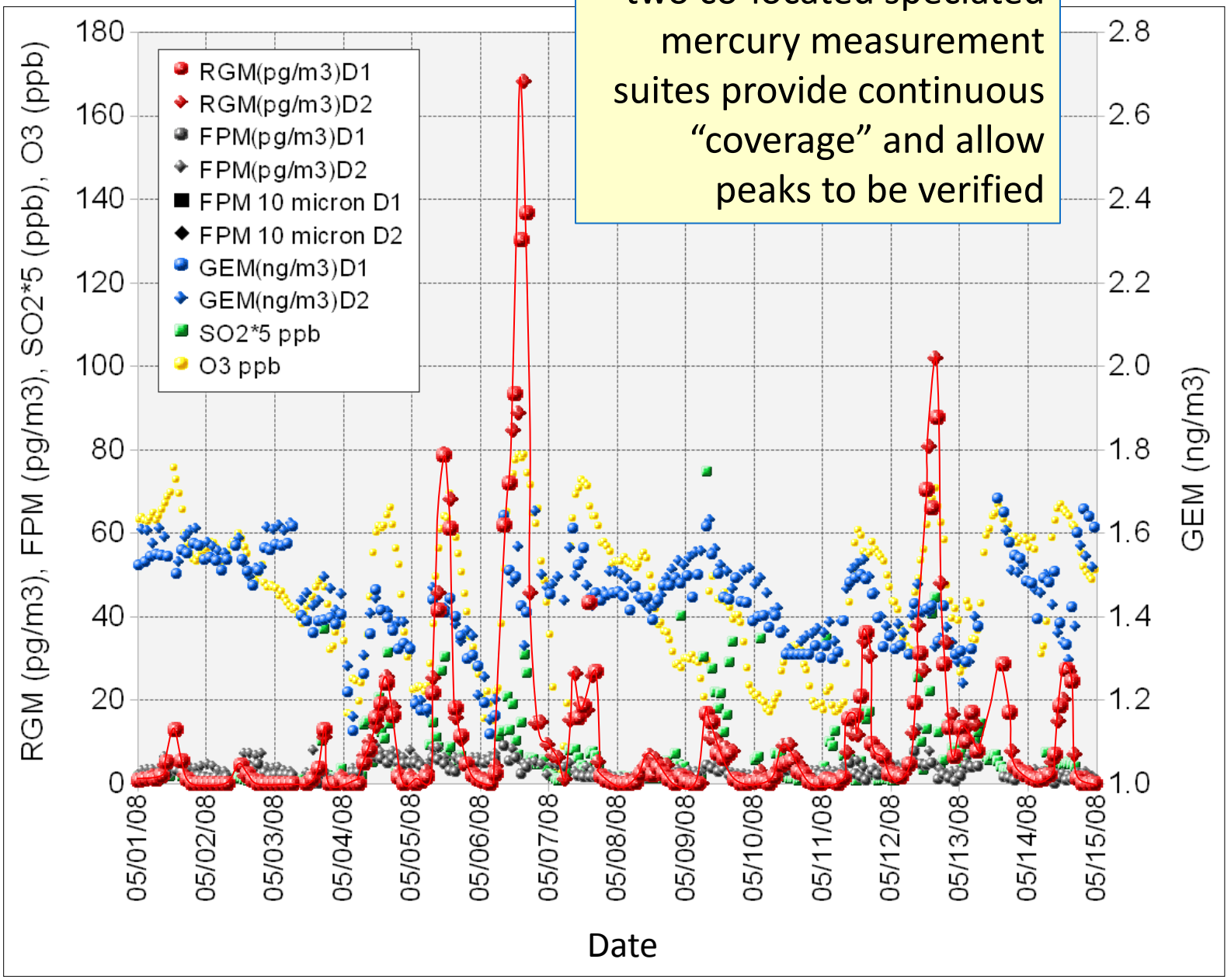


mercury and trace gas monitoring tower (10 meters)



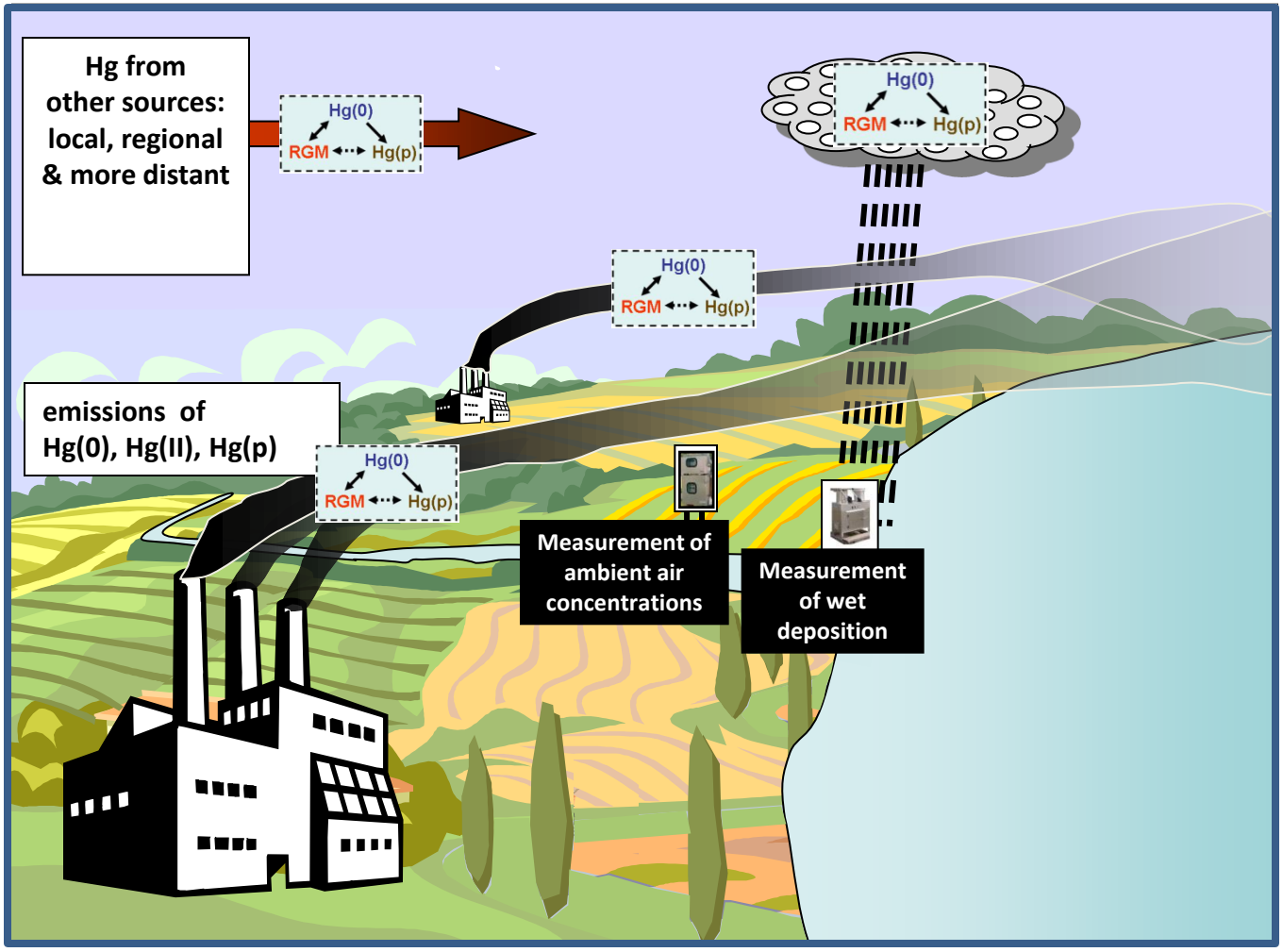
time series of RGM concentrations measured at Grand Bay

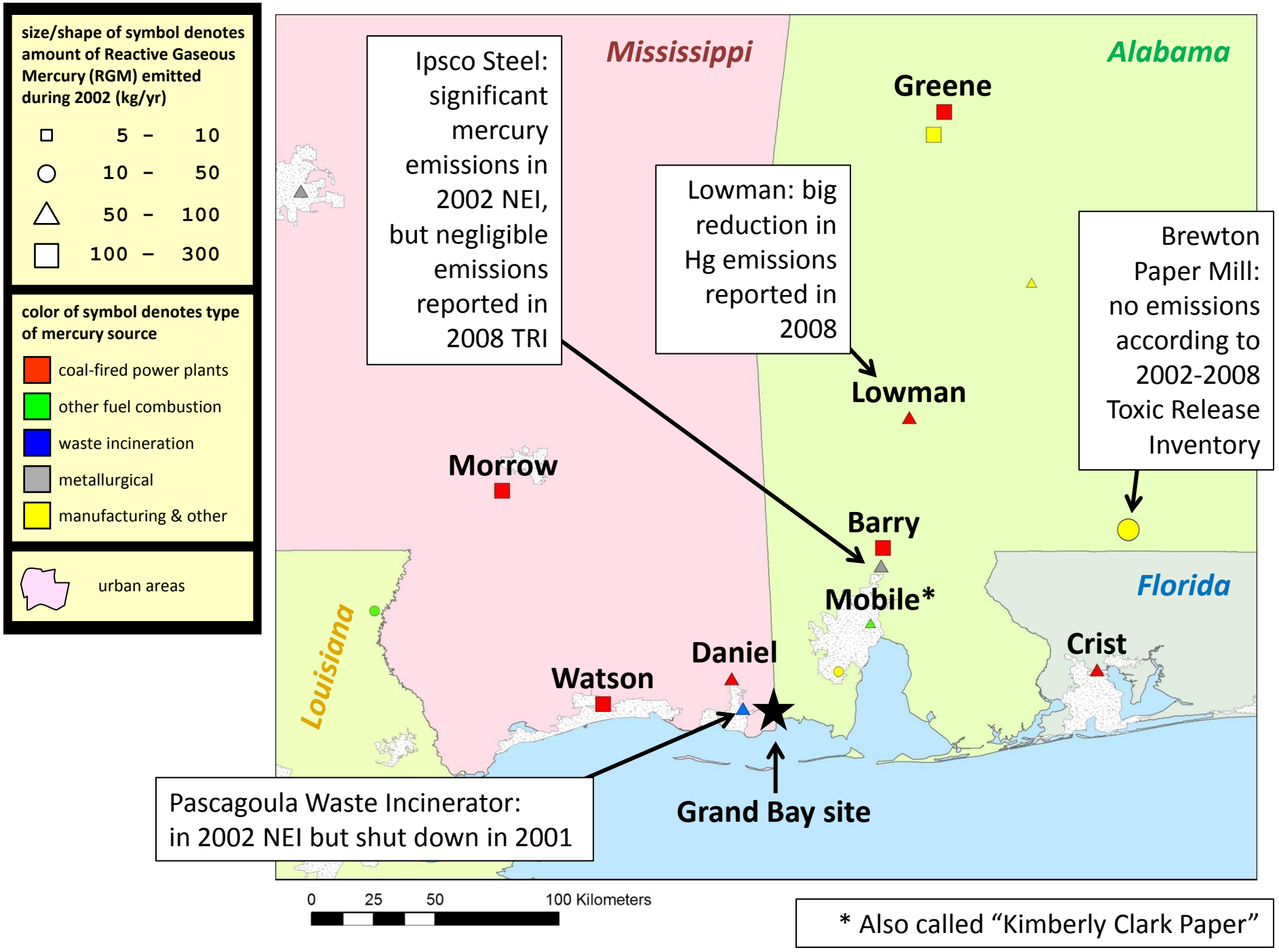



two co-located speciated mercury measurement suites provide continuous "coverage" and allow peaks to be verified
RGM(pg/m3)D1
RGM(pg/m3)D2
FPM(pg/m3)D1
FPM(pg/m3)D2
FPM 10 micron D1
FPM 10 micron D2
GEM(ng/m3)D1
GEM(ng/m3)D2
SO2*5 ppb
O3 ppb
RGM (pg/m3), FPM (pg/m3), SO2*5 (ppb), O3 (ppb)
GEM (ng/m3)
Date
0
20
40
60
80
100
120
140
160
180
1.0
1.2
1.4
1.6
1.8
2.0
2.2
2.4
2.6
2.8
05/01/08
05/02/08
05/03/08
05/04/08
05/05/08
05/06/08
05/07/08
05/08/08
05/09/08
05/10/08
05/11/08
05/12/08
05/13/08
05/14/08
05/15/08

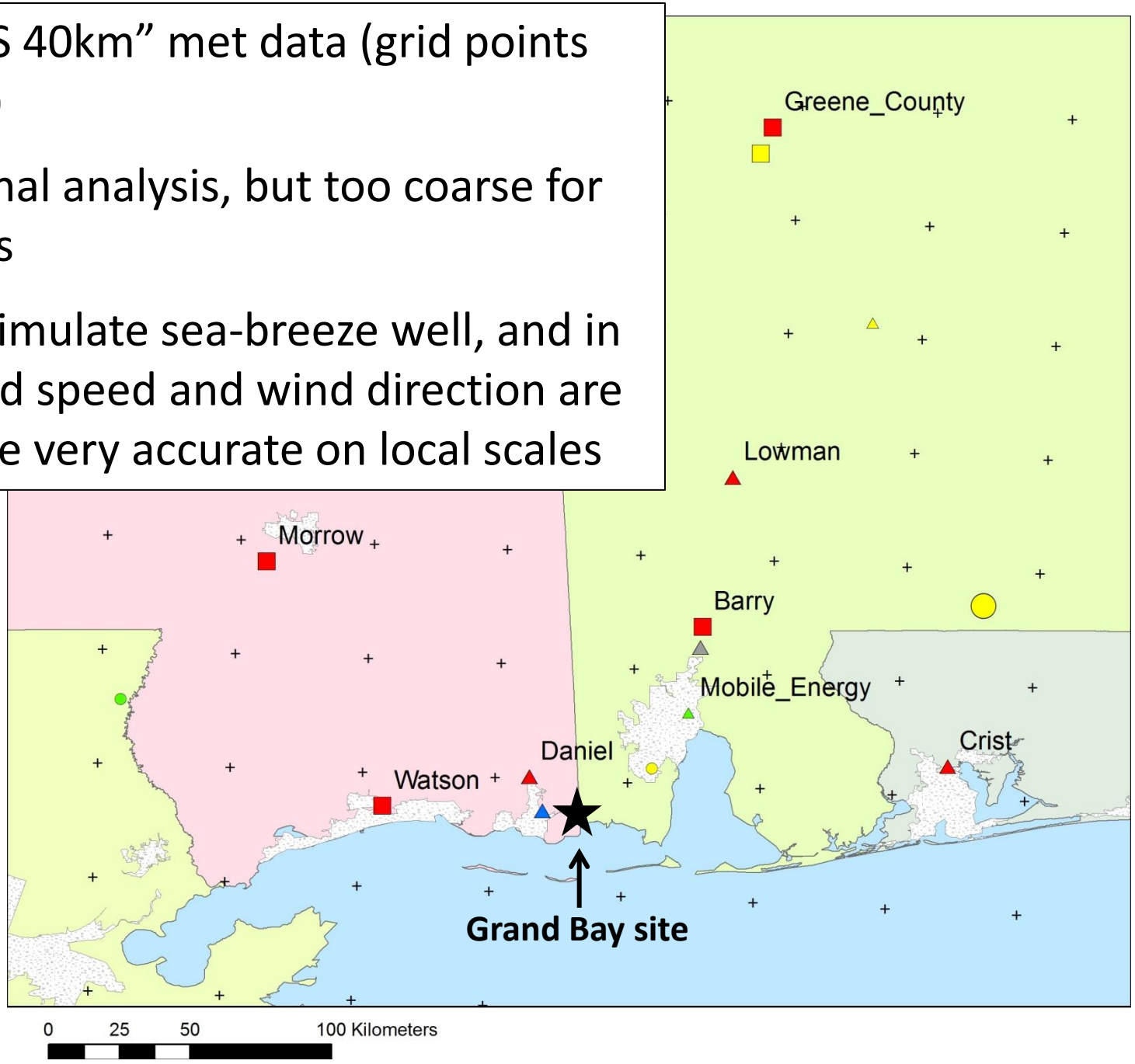
Can we reproduce this episode with an atmospheric mercury model?

- Peaks are important to understand
- Opportunity for model evaluation
- Just one episode of many

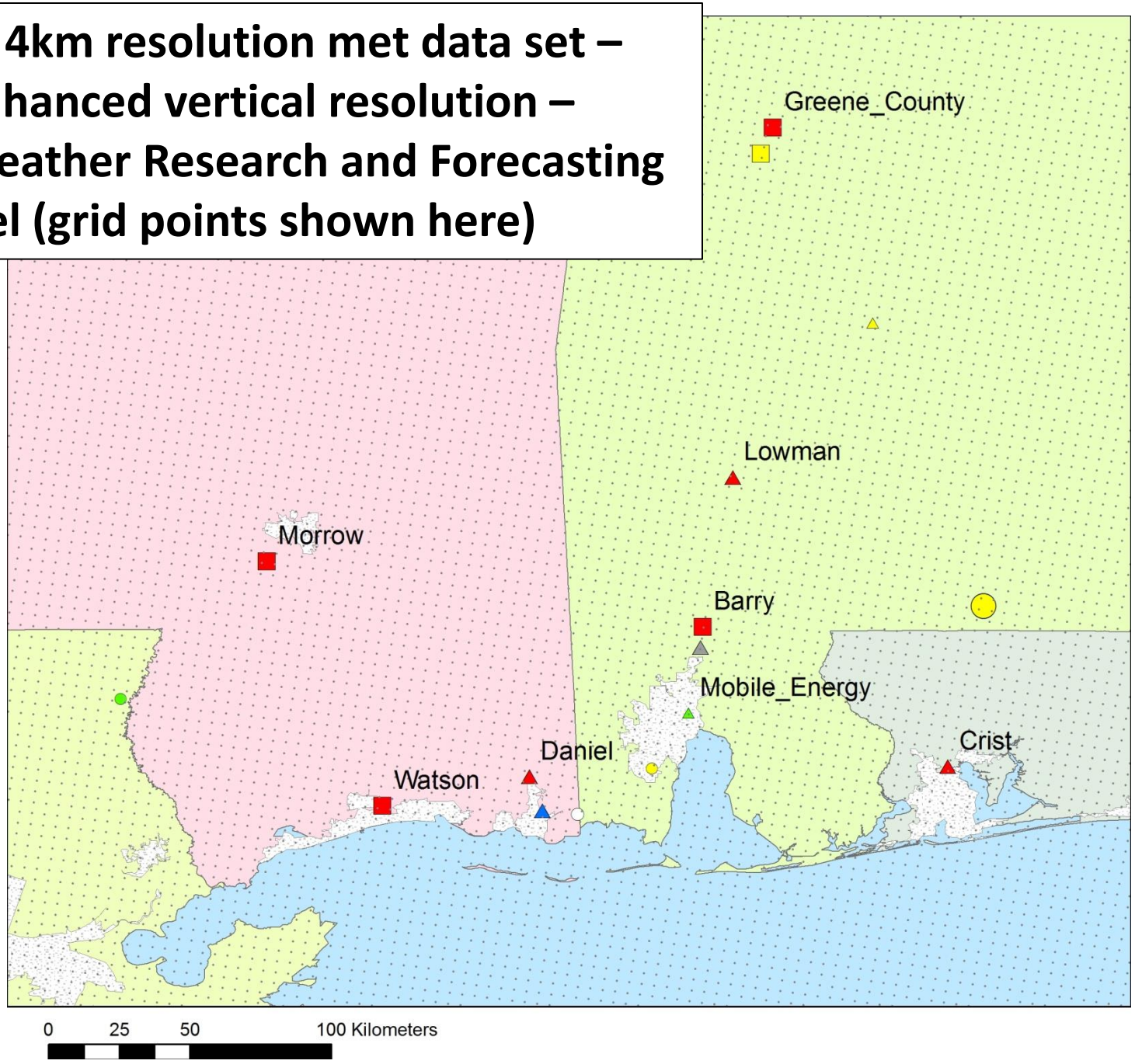


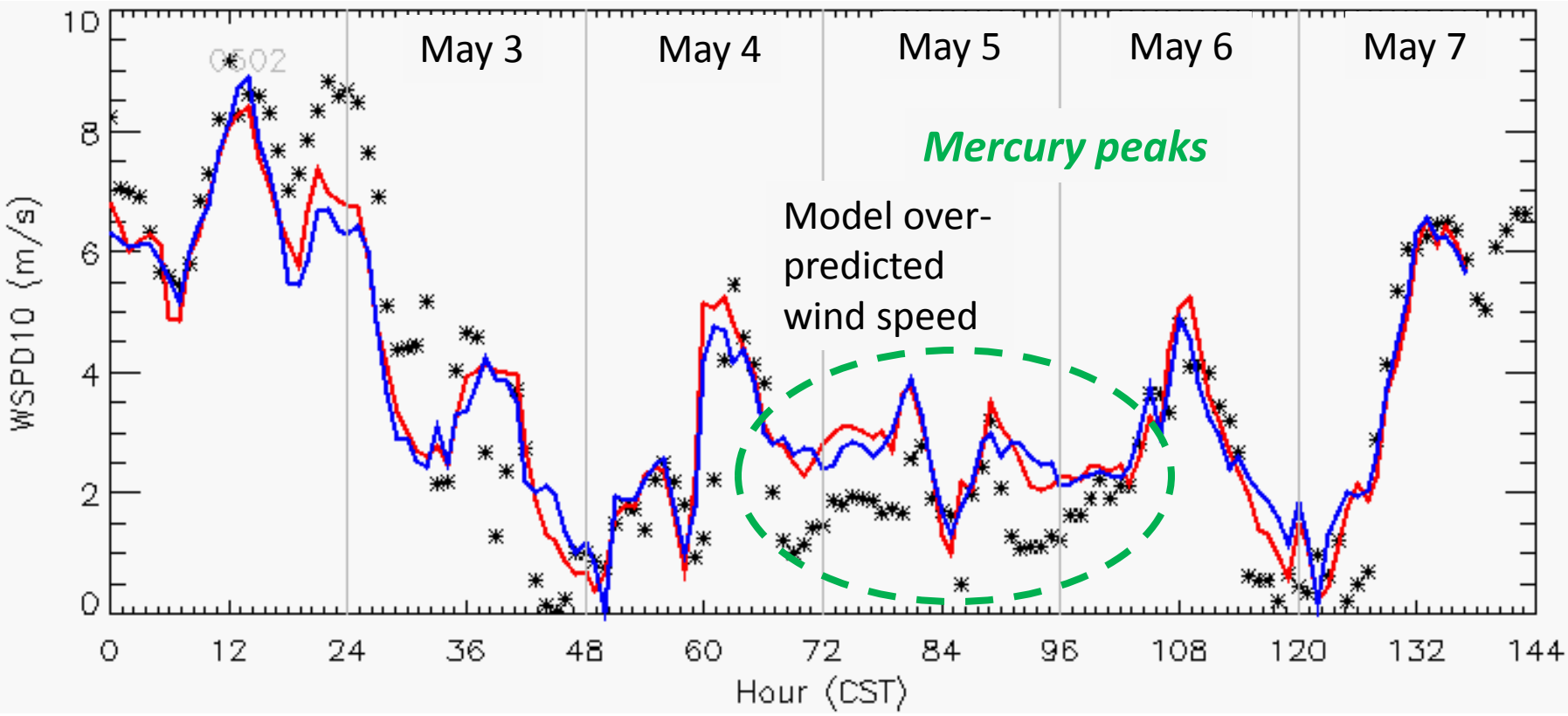

size/shape of symbol denotes amount of Reactive Gaseous Mercury (RGM) emitted during 2002 (kg/yr)
5 – 10
10 – 50
50 – 100
100 – 300
color of symbol denotes type of mercury source
coal-fired power plants
other fuel combustion
waste incineration
metallurgical
manufacturing & other
urban areas
Ipsco Steel: significant mercury emissions in 2002 NEI, but negligible emissions reported in 2008 TRI
Lowman: big reduction in Hg emissions reported in 2008
Brewton Paper Mill: no emissions according to 2002-2008 Toxic Release Inventory
Pascagoula Waste Incinerator: in 2002 NEI but shut down in 2001
Mississippi
Alabama
Florida
Louisiana
Greene
Lowman
Morrow
Barry
Mobile*
Crist
Daniel
Watson
Grand Bay site
0 25 50 100 Kilometers
* Also called “Kimberly Clark Paper”

- NOAA “EDAS 40km” met data (grid points shown here)
- Ok for regional analysis, but too coarse for local analysis
- Unlikely to simulate sea-breeze well, and in general, wind speed and wind direction are unlikely to be very accurate on local scales



We created a 4km resolution met data set – also with enhanced vertical resolution – using the Weather Research and Forecasting (WRF) model (grid points shown here)

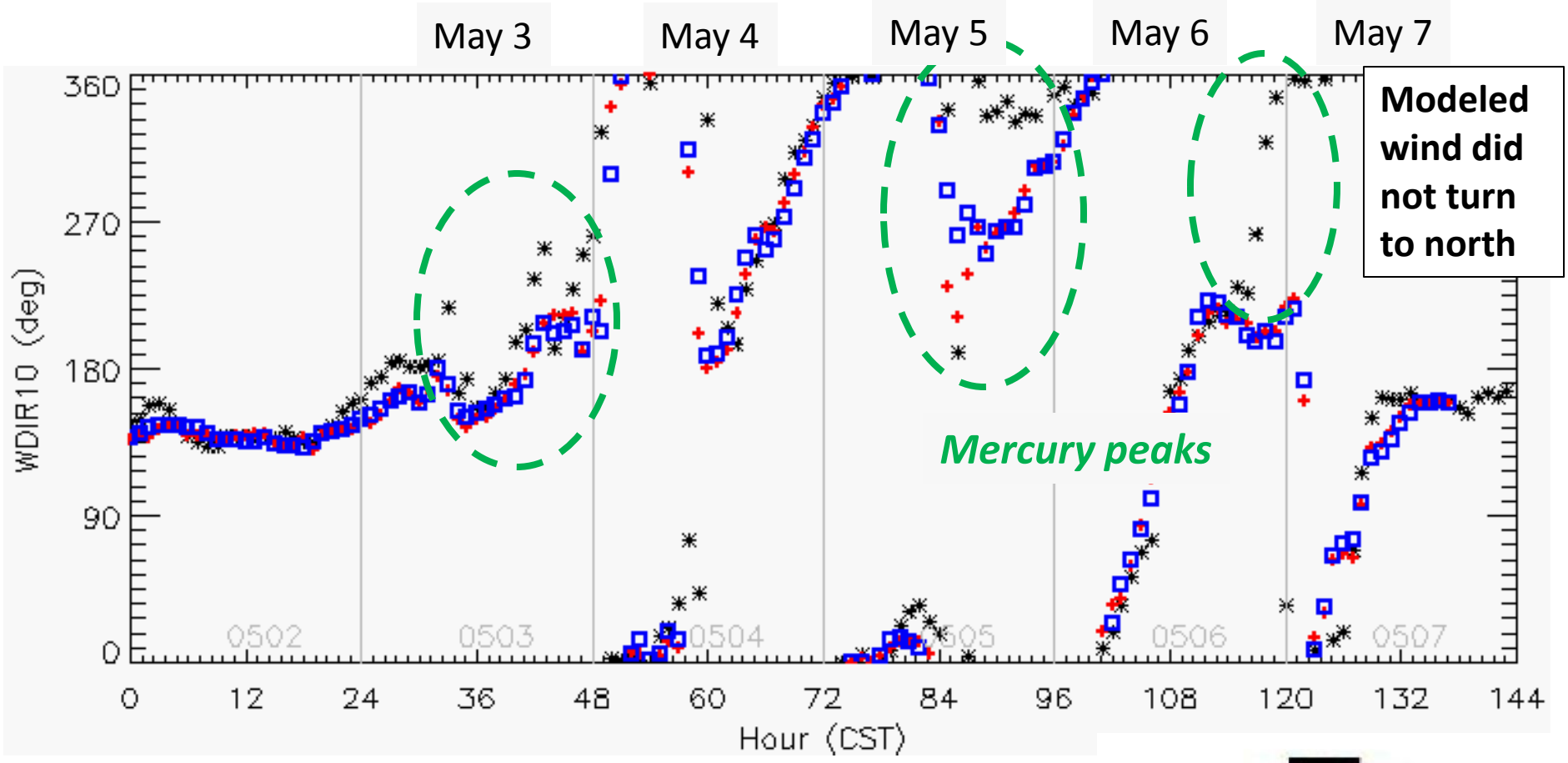




* Measurements at the Grand Bay NERR site

Model: WRF(a) (NOAH Land Surface Model + nudging)

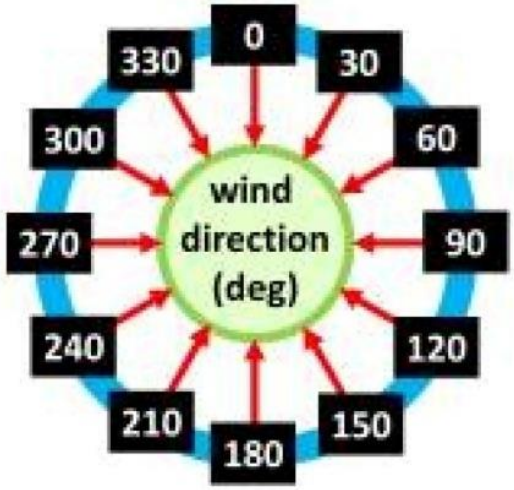
Model: WRF(b) (PX Land Surface Model + nudging)

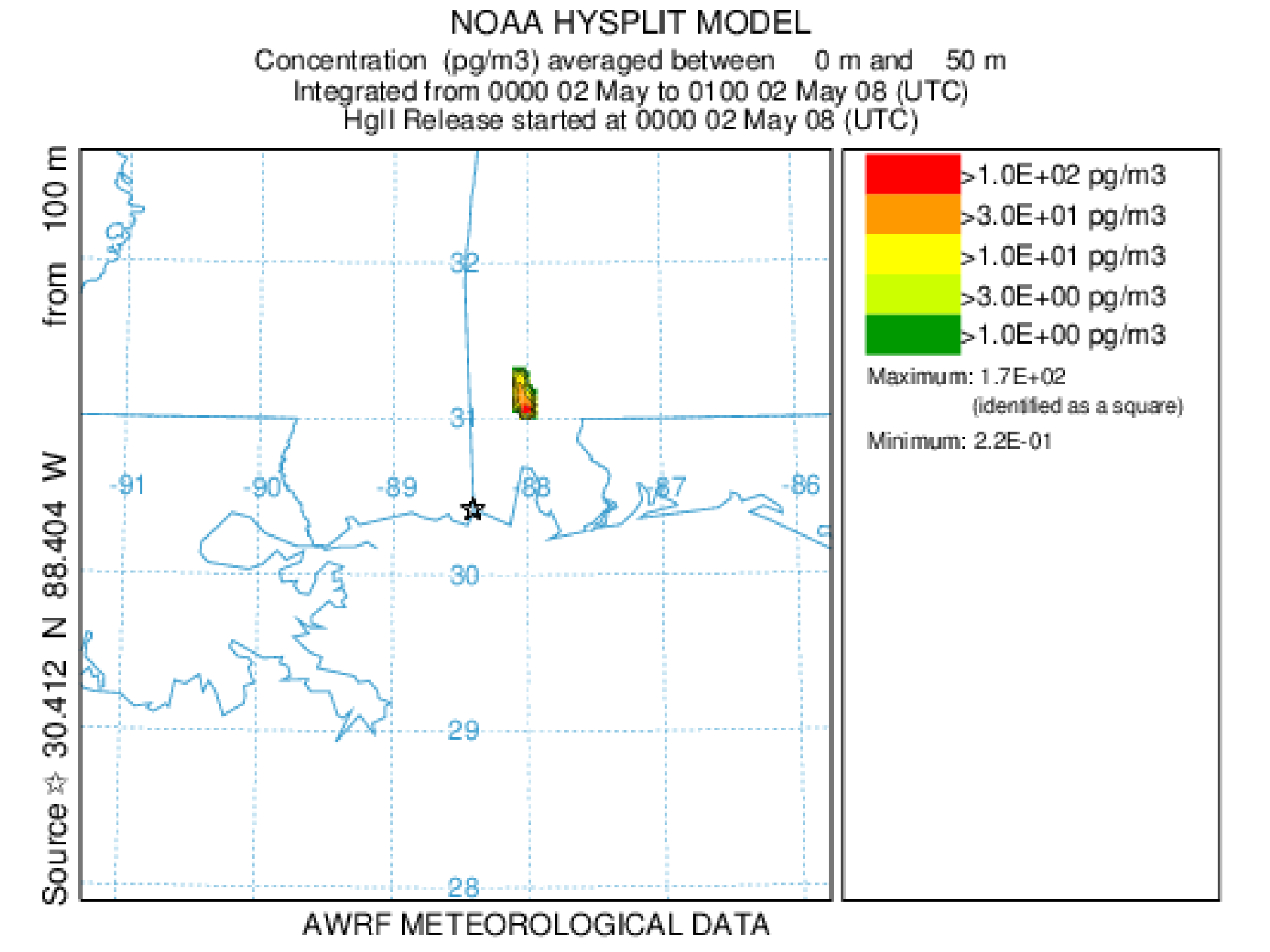


* Measurements at the Grand Bay NERR site

✚ Model: WRF(a)
(NOAH Land Surface Model + nudging)

□ Model: WRF(b)
(PX Land Surface Model + nudging)




NOAA HYSPLIT MODEL
Concentration (pg/m3) averaged between 0 m and 50 m
Integrated from 0000 02 May to 0100 02 May 08 (UTC)
HgII Release started at 0000 02 May 08 (UTC)
from 100 m
Source ☆ 30.412 N 88.404 W
32
31
30
29
28
-91
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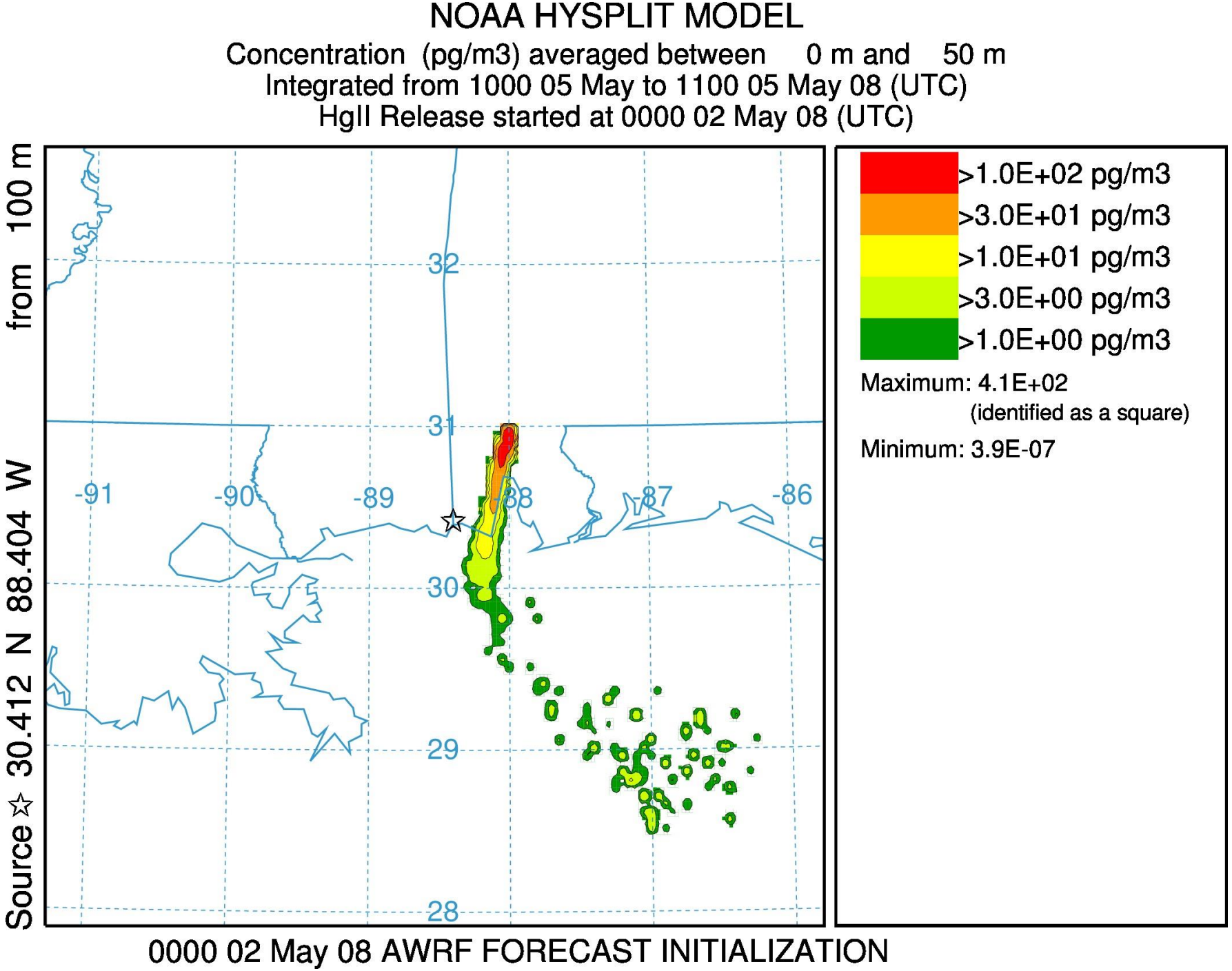
-87
-86
>1.0E+02 pg/m3
>3.0E+01 pg/m3
>1.0E+01 pg/m3
>3.0E+00 pg/m3
>1.0E+00 pg/m3
Maximum: 1.7E+02
(identified as a square)
Minimum: 2.2E-01
AWRF METEOROLOGICAL DATA


NOAA HYSPLIT MODEL
Concentration (pg/m3) averaged between 0 m and 50 m
Integrated from 1000 05 May to 1100 05 May 08 (UTC)
HgII Release started at 0000 02 May 08 (UTC)
from 100 m
Source ☆ 30.412 N 88.404 W
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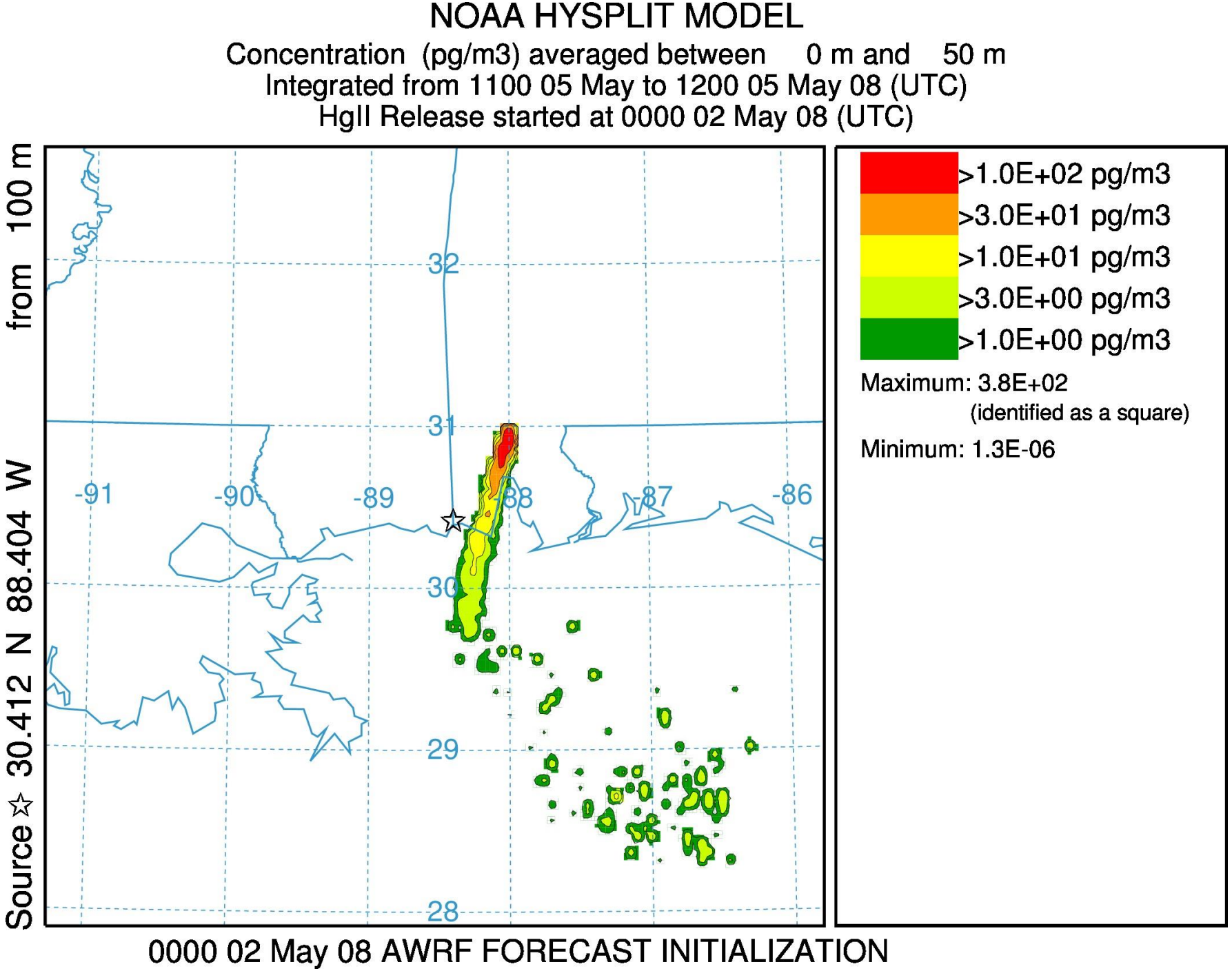
>1.0E+02 pg/m3
>3.0E+01 pg/m3
>1.0E+01 pg/m3
>3.0E+00 pg/m3
>1.0E+00 pg/m3
Maximum: 4.1E+02
(identified as a square)
Minimum: 3.9E-07
0000 02 May 08 AWRF FORECAST INITIALIZATION


NOAA HYSPLIT MODEL
Concentration (pg/m3) averaged between 0 m and 50 m
Integrated from 1100 05 May to 1200 05 May 08 (UTC)
HgII Release started at 0000 02 May 08 (UTC)
from 100 m
Source ☆ 30.412 N 88.404 W
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>1.0E+02 pg/m3
>3.0E+01 pg/m3
>1.0E+01 pg/m3
>3.0E+00 pg/m3
>1.0E+00 pg/m3
Maximum: 3.8E+02
(identified as a square)
Minimum: 1.3E-06
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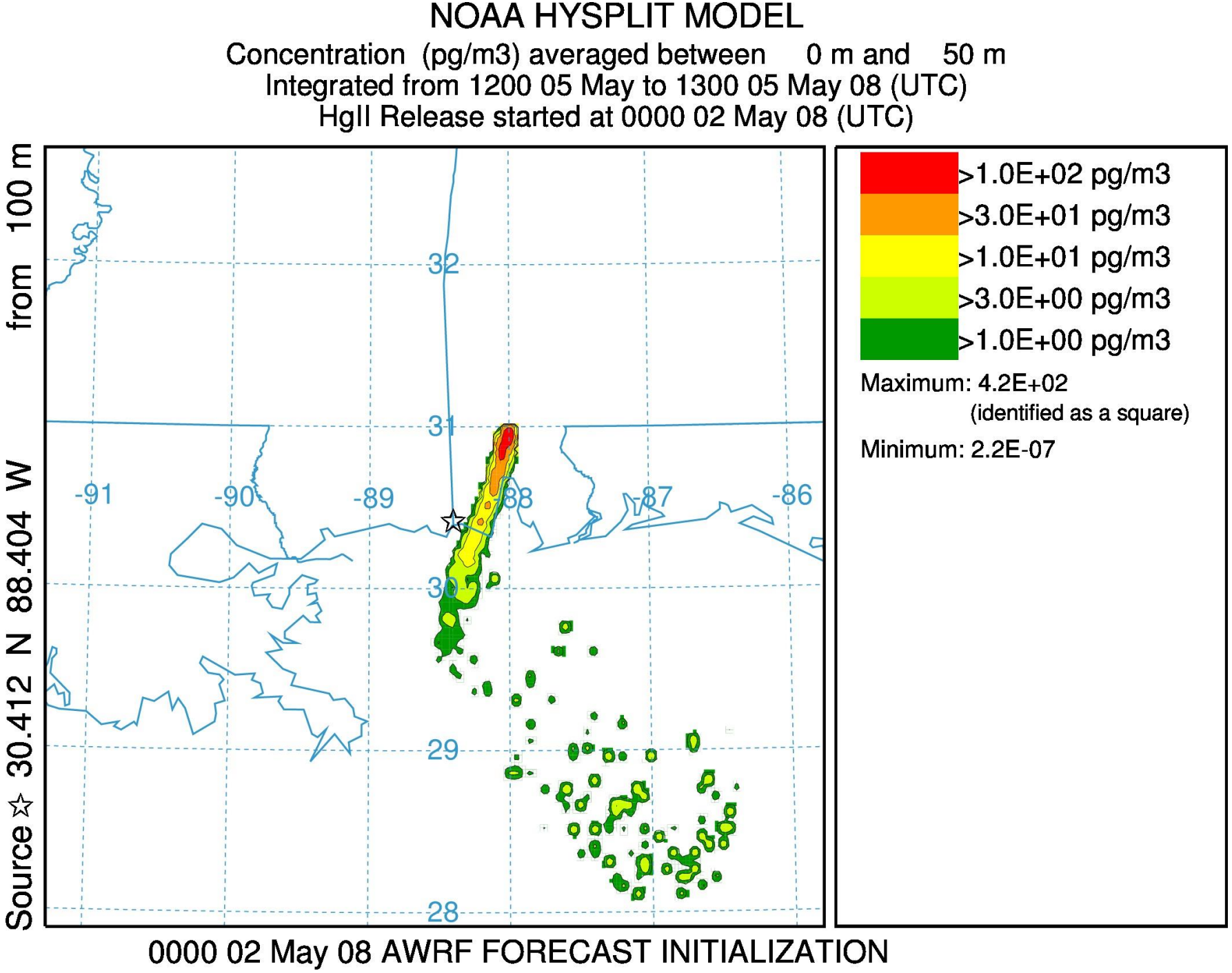
NOAA HYSPLIT MODEL
Concentration (pg/m3) averaged between 0 m and 50 m
Integrated from 1200 05 May to 1300 05 May 08 (UTC)
HgII Release started at 0000 02 May 08 (UTC)
from 100 m
Source ☆ 30.412 N 88.404 W
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>1.0E+02 pg/m3
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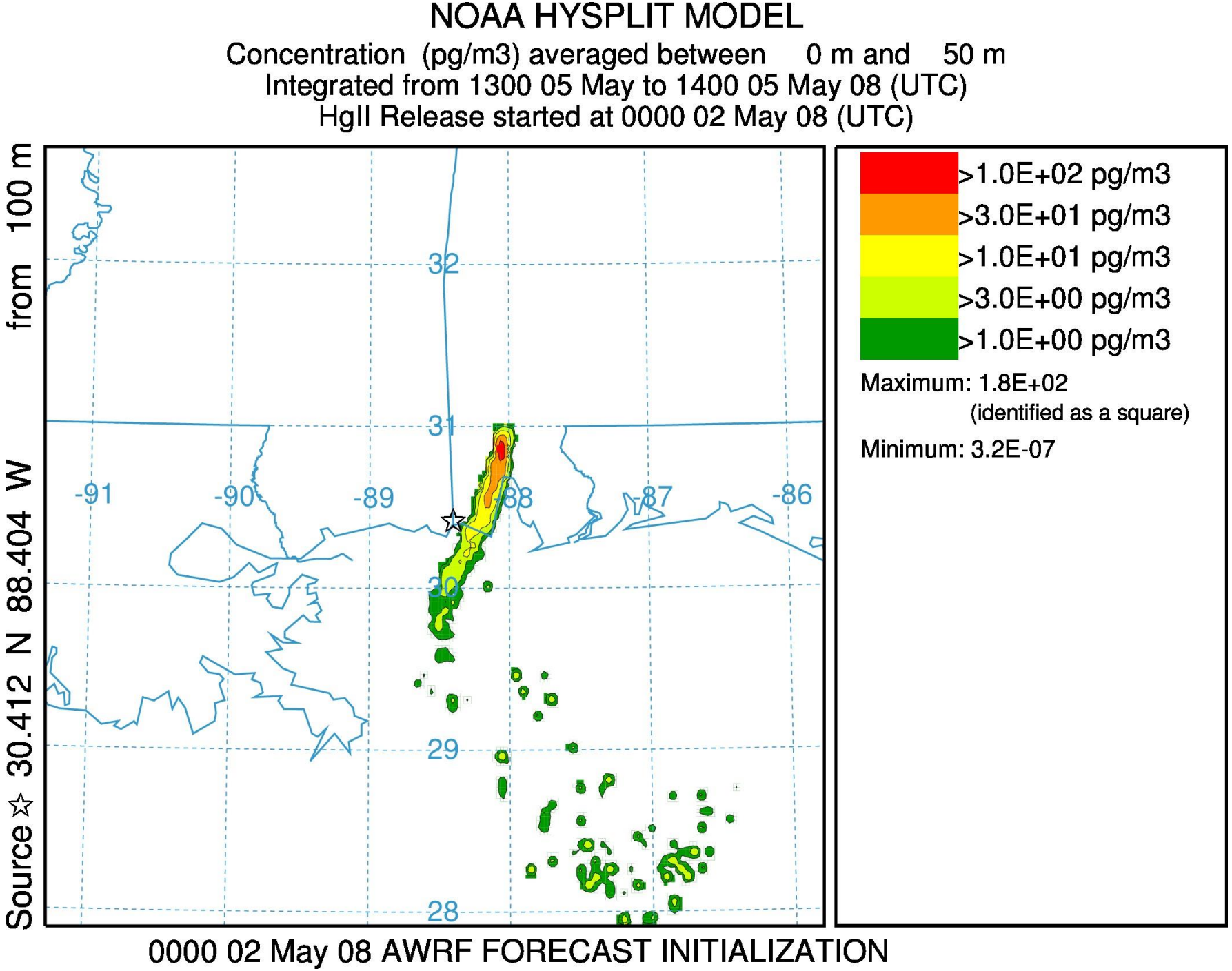
>1.0E+00 pg/m3
Maximum: 4.2E+02
(identified as a square)
Minimum: 2.2E-07
0000 02 May 08 AWRF FORECAST INITIALIZATION


NOAA HYSPLIT MODEL
Concentration (pg/m3) averaged between 0 m and 50 m
Integrated from 1300 05 May to 1400 05 May 08 (UTC)
HgII Release started at 0000 02 May 08 (UTC)
from 100 m
Source ☆ 30.412 N 88.404 W
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>1.0E+02 pg/m3
>3.0E+01 pg/m3
>1.0E+01 pg/m3
>3.0E+00 pg/m3
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Maximum: 1.8E+02
(identified as a square)
Minimum: 3.2E-07
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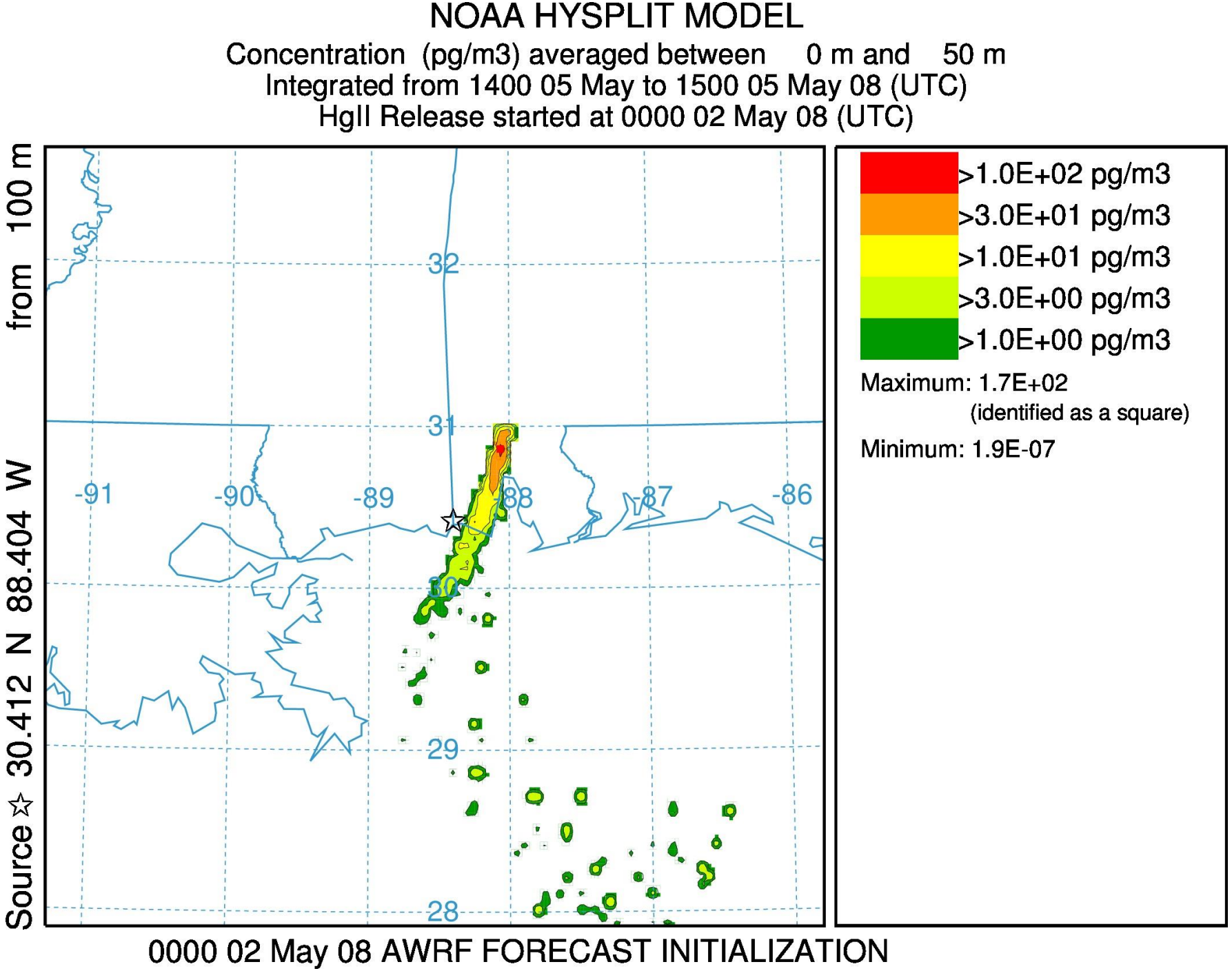
NOAA HYSPLIT MODEL
Concentration (pg/m3) averaged between 0 m and 50 m
Integrated from 1400 05 May to 1500 05 May 08 (UTC)
HgII Release started at 0000 02 May 08 (UTC)
from 100 m
Source ☆ 30.412 N 88.404 W
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>1.0E+02 pg/m3
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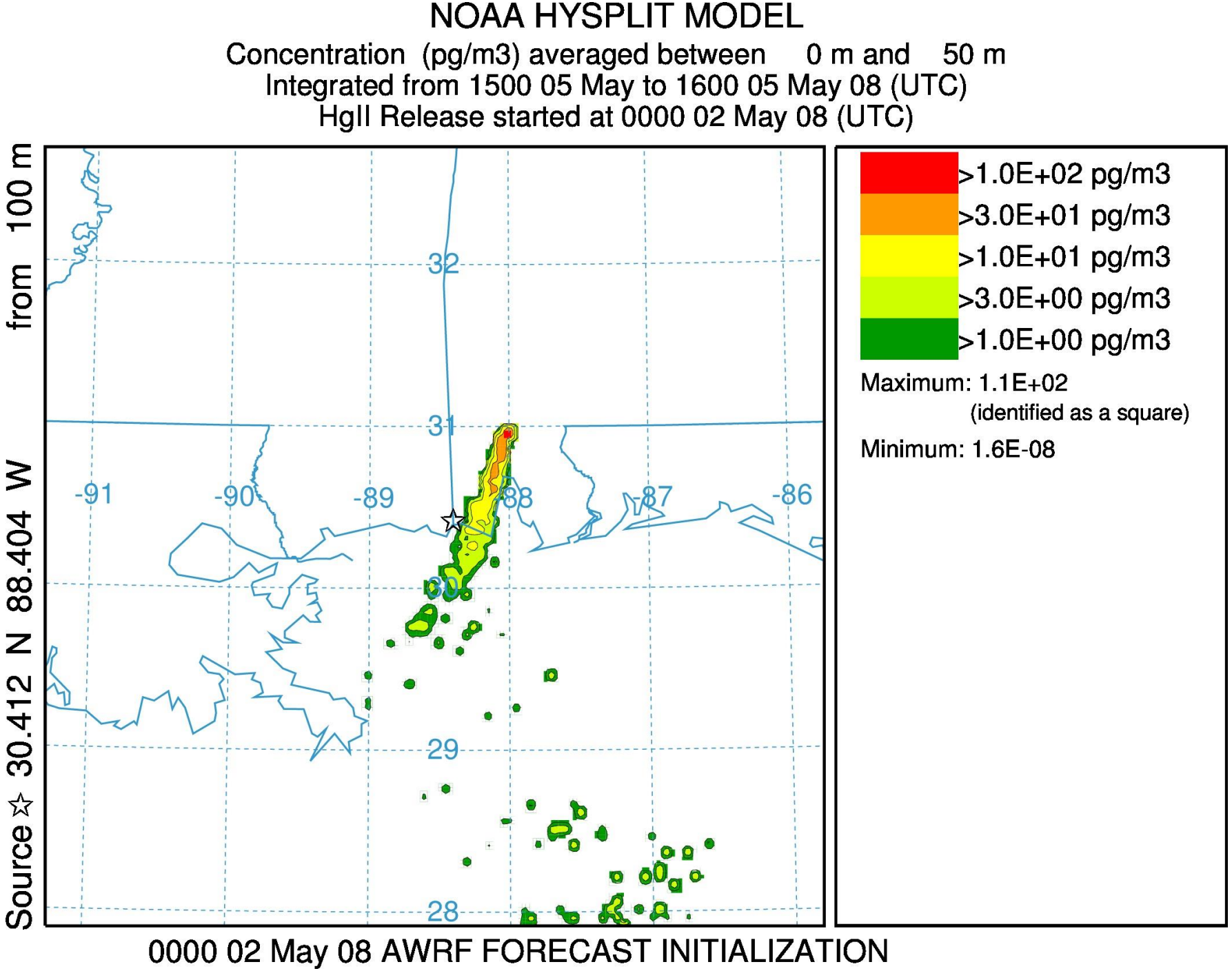
NOAA HYSPLIT MODEL
Concentration (pg/m3) averaged between 0 m and 50 m
Integrated from 1500 05 May to 1600 05 May 08 (UTC)
HgII Release started at 0000 02 May 08 (UTC)
from 100 m
Source ☆ 30.412 N 88.404 W
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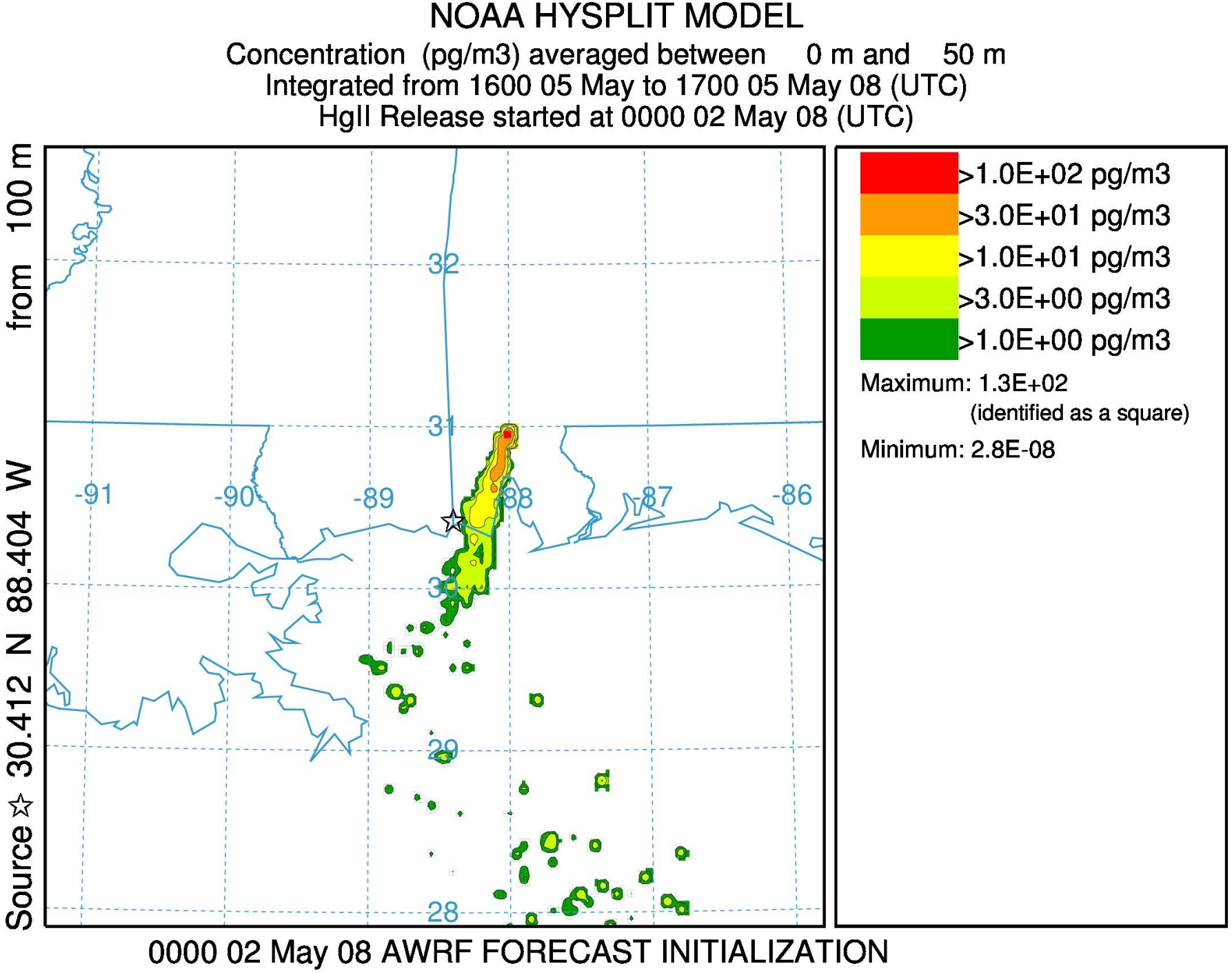
>1.0E+02 pg/m3
>3.0E+01 pg/m3
>1.0E+01 pg/m3
>3.0E+00 pg/m3
>1.0E+00 pg/m3
Maximum: 1.1E+02
(identified as a square)
Minimum: 1.6E-08
0000 02 May 08 AWRF FORECAST INITIALIZATION


NOAA HYSPLIT MODEL
Concentration (pg/m3) averaged between 0 m and 50 m
Integrated from 1600 05 May to 1700 05 May 08 (UTC)
HgII Release started at 0000 02 May 08 (UTC)
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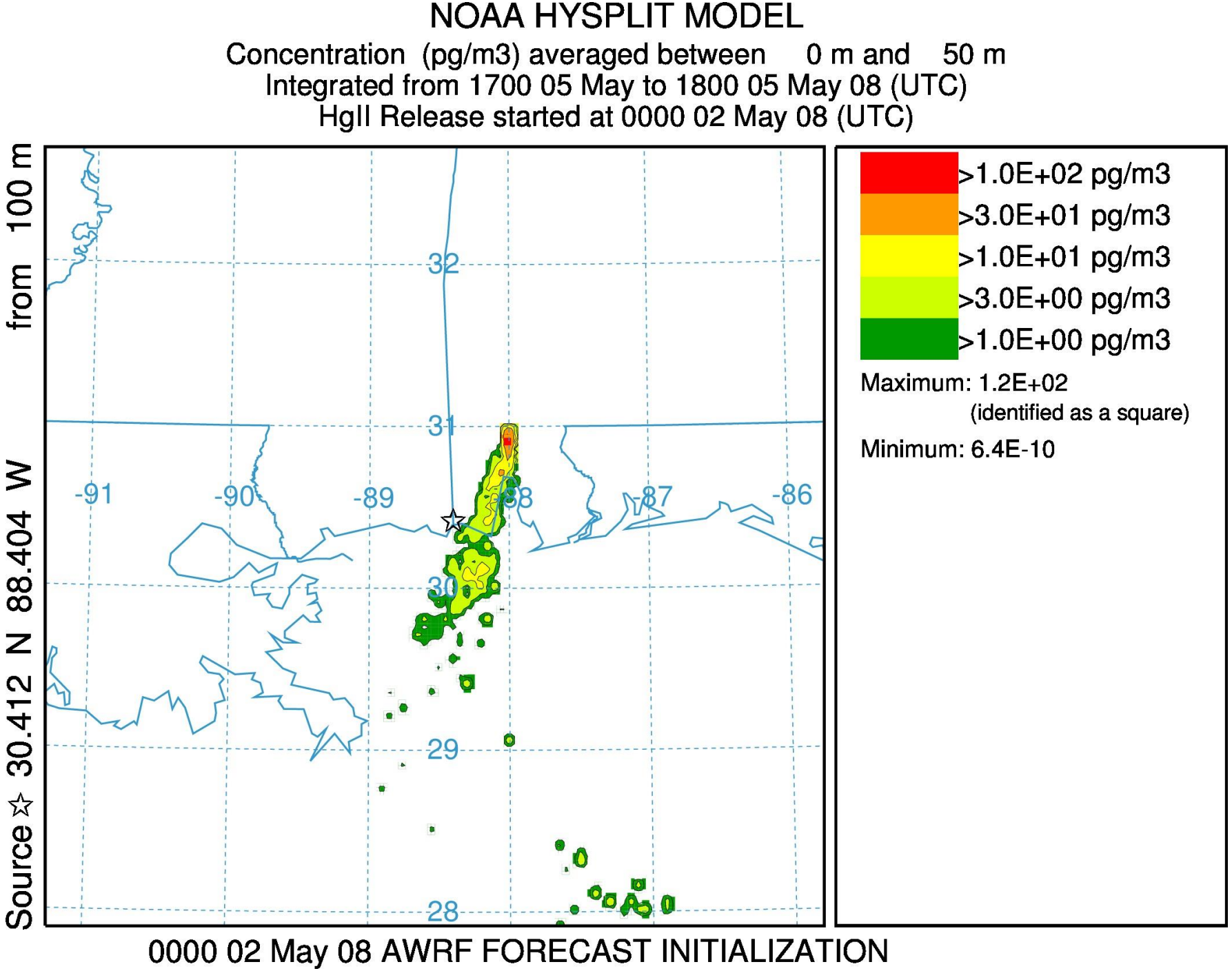
>1.0E+02 pg/m3
>3.0E+01 pg/m3
>1.0E+01 pg/m3
>3.0E+00 pg/m3
>1.0E+00 pg/m3
Maximum: 1.3E+02
(identified as a square)
Minimum: 2.8E-08
0000 02 May 08 AWRF FORECAST INITIALIZATION


NOAA HYSPLIT MODEL
Concentration (pg/m3) averaged between 0 m and 50 m
Integrated from 1700 05 May to 1800 05 May 08 (UTC)
HgII Release started at 0000 02 May 08 (UTC)
from 100 m
Source ☆ 30.412 N 88.404 W
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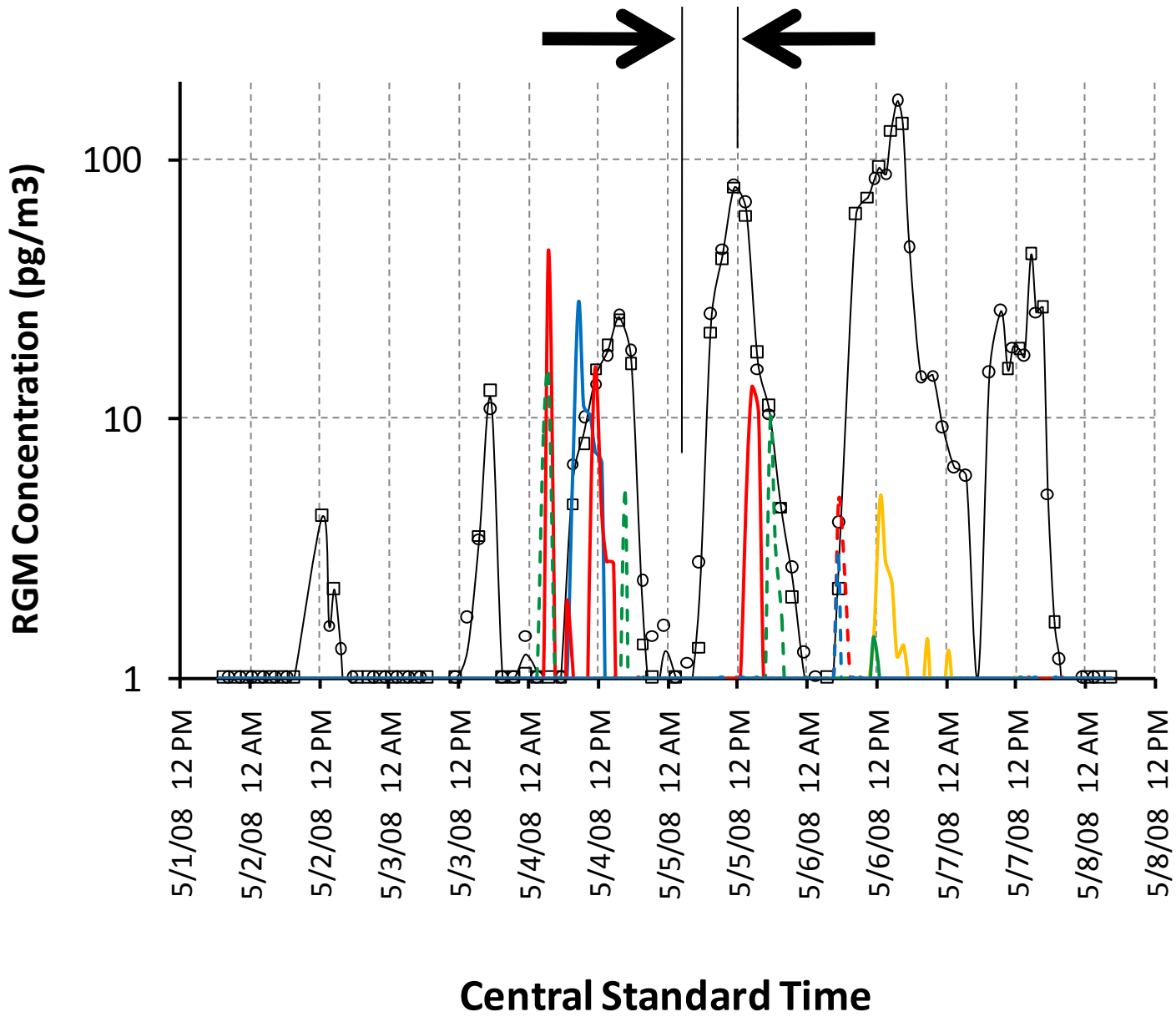
>1.0E+02 pg/m3
>3.0E+01 pg/m3
>1.0E+01 pg/m3
>3.0E+00 pg/m3
>1.0E+00 pg/m3
Maximum: 1.2E+02
(identified as a square)
Minimum: 6.4E-10
0000 02 May 08 AWRF FORECAST INITIALIZATION

This is the period that you just saw – a measured peak, but not a modeled peak (BARRY - blue line)



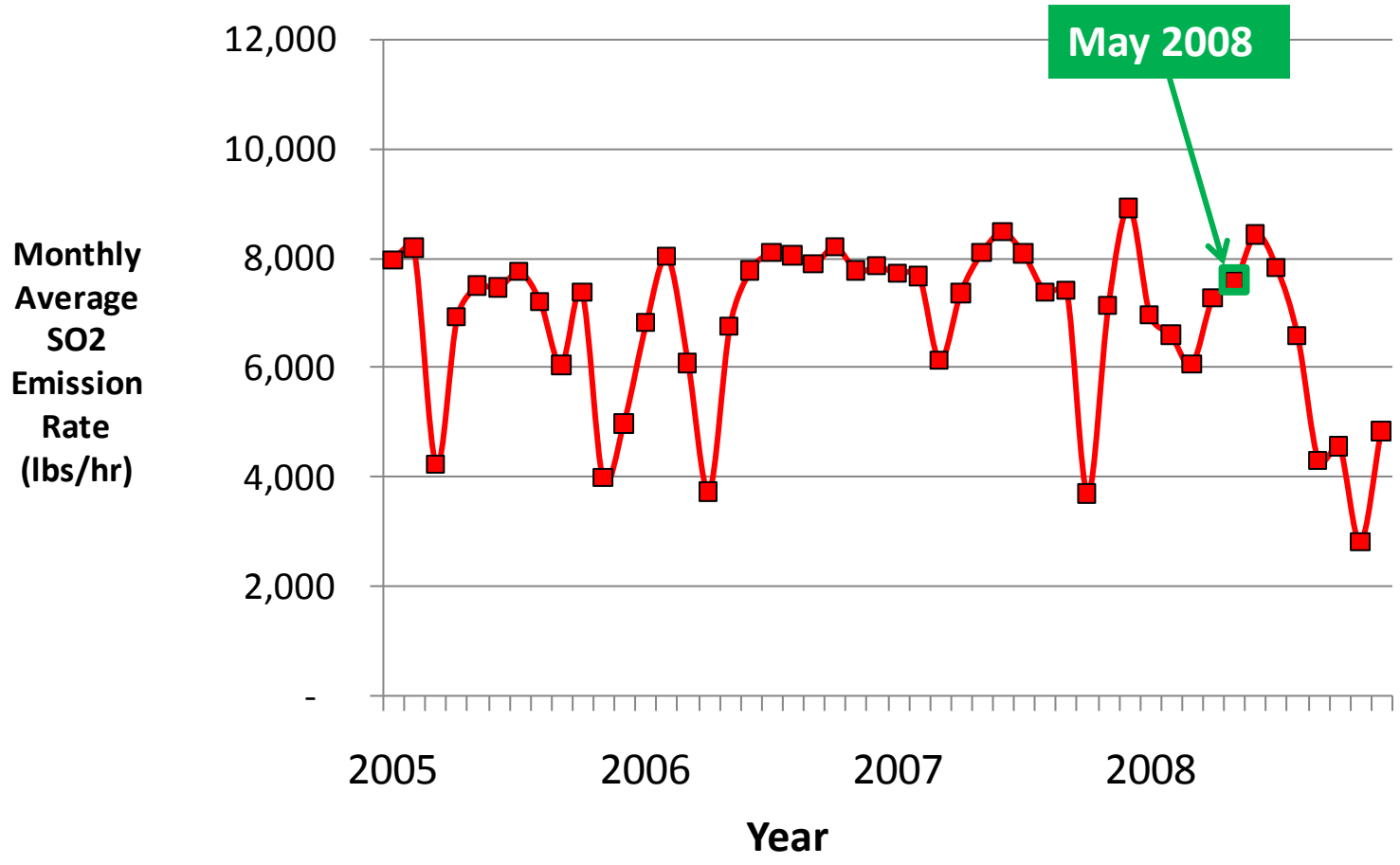
RGM Measurements

#1 #2

One set of model results

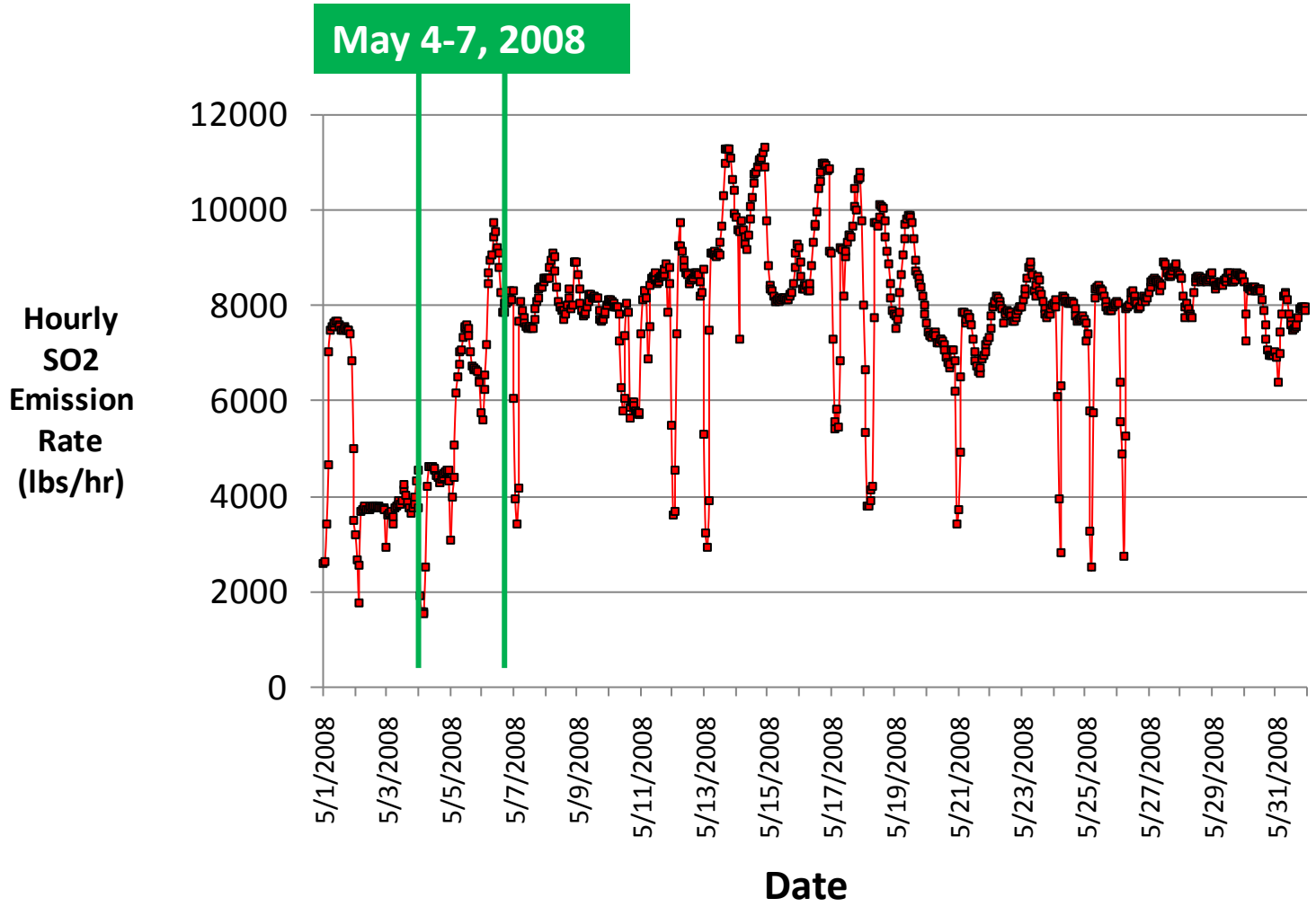
- BARRY
- DANIEL
- CRIST
- GREENE
- LOWMAN
- WATSON
- MOBILE

- We typically assume emissions are constant throughout the year
- May 2008: "typical" month for SO2 emissions at the Daniel plant



Source of data: *USEPA Clean Air Markets Division*

But, hourly SO2 emissions at the Daniel plant were not constant… *and so Hg emissions were also likely variable*



Source of data: *USEPA Clean Air Markets Division*

SOME CONCLUDING THOUGHTS (and questions):

In order to "use" the AMNet data, we need

- **Emissions information with higher temporal resolution (better than annual once every 3 years)**
- **Meteorological data with higher resolution**

…no matter what kind of analyses we are doing

- **Comparing Trends; Trajectories; Dispersion**

Justification for the network depends on being able to use the data meaningfully!

How can we improve this situation?

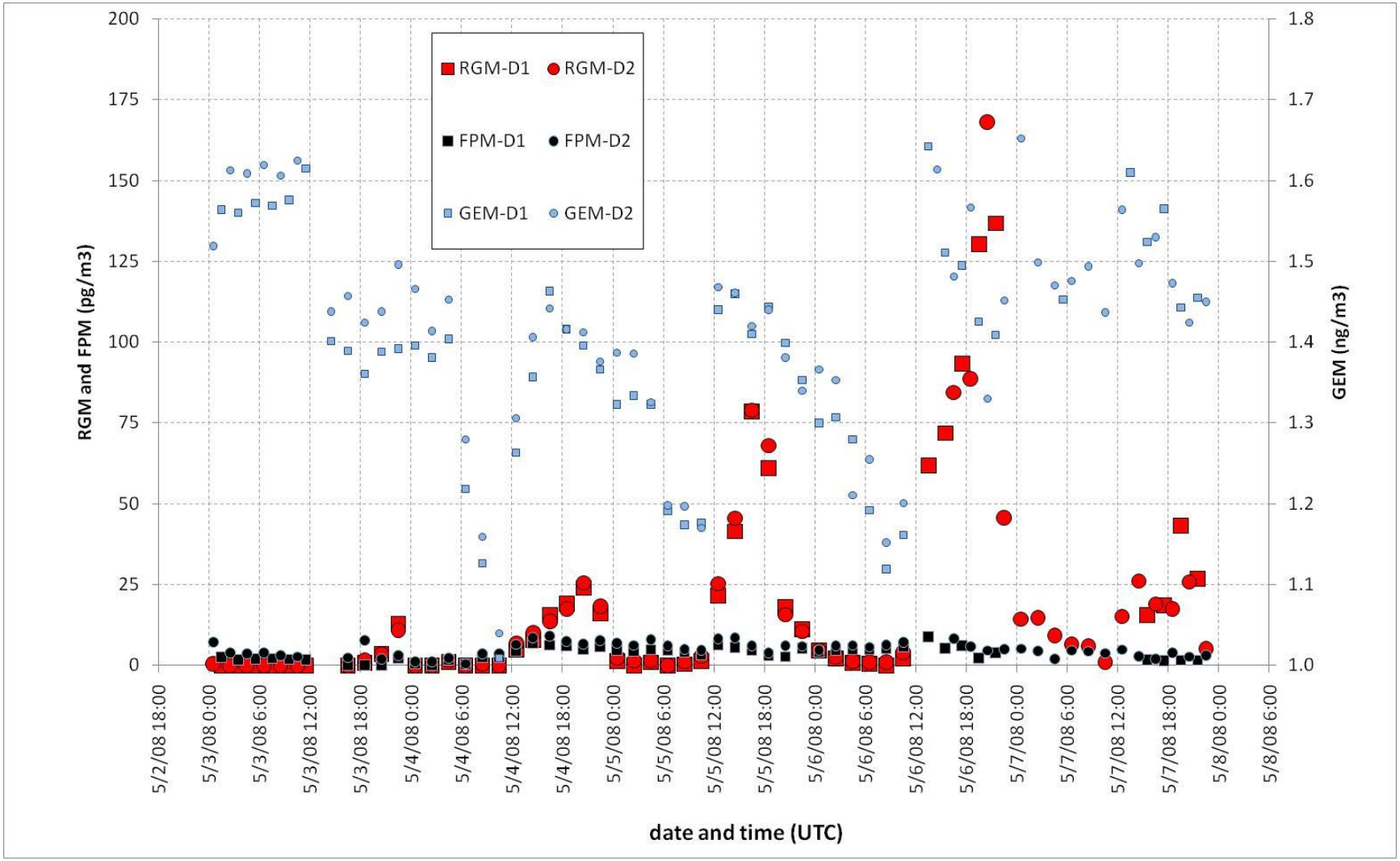
- **This model evaluation exercise will be more fully characterized *for this one episode at this one site***
- **Of course, must look at other episodes, other sites**
- **Variations and uncertainties in meteorology and emissions make local plumes "stochastic"…**
- **Even if a model was "perfect" it would not be generally possible to reproduce a local plume hit at a monitoring site.**
- **What is the best way to evaluate (and improve) models?**


Thanks!

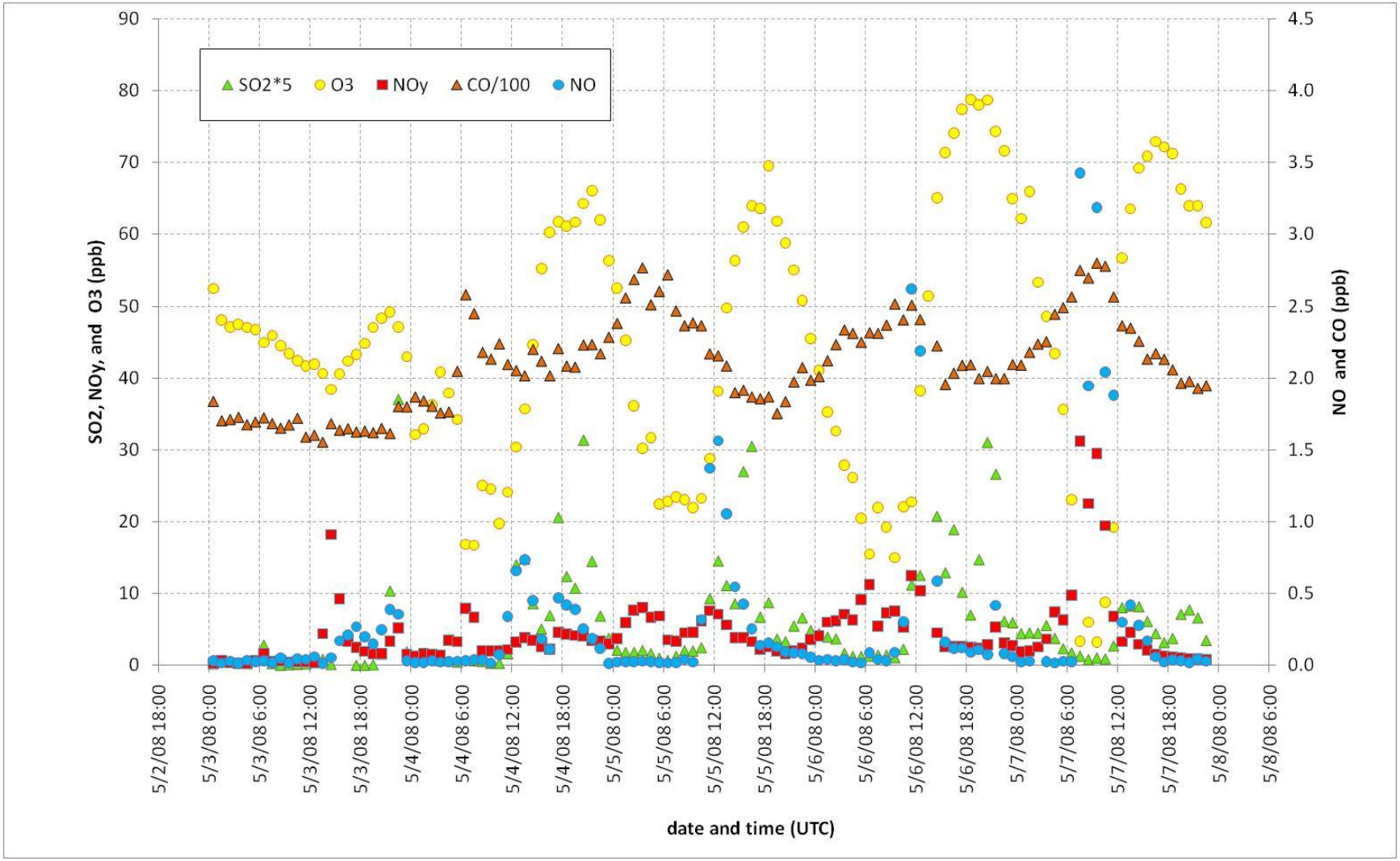
EXTRA SLIDES

Modeling – Comprehensive Fate and Transport Simulations

- Start with an emissions inventory
- Use gridded meteorological data
- Simulate the dispersion, chemical transformation, and wet and dry deposition of mercury emitted to the air
- Source-attribution information needed at the end, so optimize modeling system and approach to allow source-receptor information to be captured
- HYSPLIT-Hg developed over the last ~10 years with specialized algorithms for simulation of atmospheric mercury



(Proposed Alternative) Figure 3. Time series of Reactive Gaseous Mercury (RGM), Fine Particulate Mercury (FPM) and Gaseous Elemental Mercury (GEM) from two co-located instruments (D1 and D2) (top graph) and of SO2, O3, NO, NOy, and CO (bottom graph) measured at the Grand Bay NERR from May 3-8, 2008


SO2*5
O3
NOy
CO/100
NO
SO2, NOy, and O3 (ppb)
NO and CO (ppb)
date and time (UTC)
0
10
20
30
40
50
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90
0.0
0.5
1.0
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2.0
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5/2/08 18:00
5/3/08 0:00
5/3/08 6:00
5/3/08 12:00
5/3/08 18:00
5/4/08 0:00
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