Quantifying Mercury Emissions from Large Point Sources in the Southeastern U.S. during NOMADSS

J. L. Ambrose,[1] L. Gratz,[1] D. A. Jaffe,[1,2] C. A. Cantrell,[3] R. L. Mauldin III,[3] T. Campos,[4] F. Flocke,[4] D. Knapp,[4] and A. Weinheimer[4]

[1]University of Washington, Bothell, WA
[2]University of Washington, Seattle, WA
[3]University of Colorado, Boulder, CO
[4]National Center for Atmospheric Research, Boulder, CO

Southeast Atmosphere Study Data Workshop
Boulder, CO
March 31, 2014

Jaffe Research Group
University of Washington | Bothell

Acknowledgements

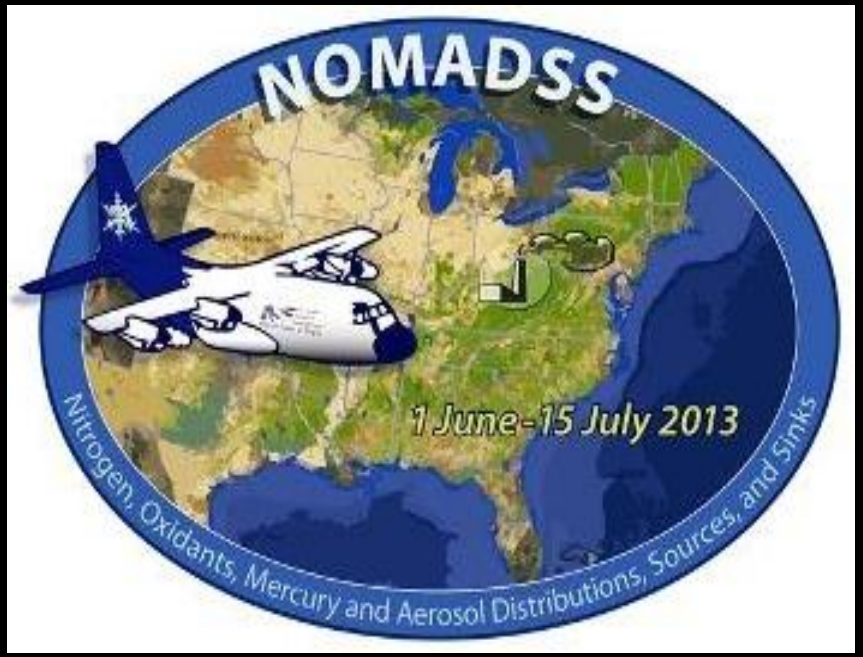
People

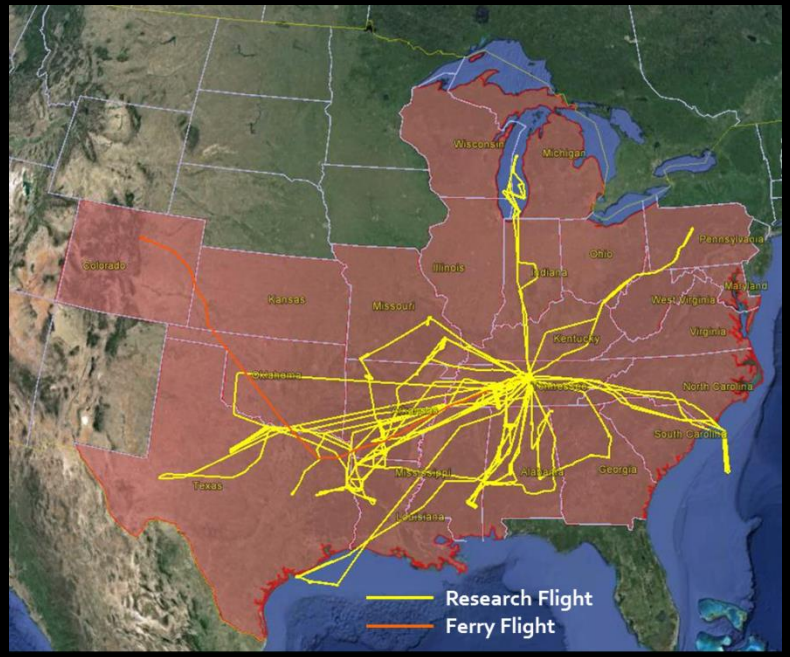
- NOMADSS science team
- NCAR Research Aviation Facility staff

Funding

Some data in this presentation are preliminary.

Nitrogen, Oxidants, Mercury and Aerosol Distributions, Sources and Sinks





NOMADSS Hg science goals

- **Characterize emissions from large U.S. Hg point sources**
  - **coal-fired power plants generate 50% of U.S. anthropogenic emissions**
- **Study regional scale Hg distribution and atmospheric chemistry**

Aircraft Hg Measurements: Detector for Oxidized Hg Species (DOHGS)

- Species measured
  - Total atmospheric Hg (THg)
  - Gaseous Elemental Mercury (GEM)
  - Reactive Mercury (RM) by difference
- Time resolution: 2.5 min
- Mean overall uncertainties
  - THg, GEM: 7–8%
  - RM: ~45 pg/m^3
- RM LOD (3σ): 110 pg/m^3

Supporting Data

C-130 measurements* (technique, investigators)

- SO_2 (UV fluorescence, U. Colorado-Boulder)
  - 10 s data averaged to 2.5 min
- NO, NO_2 (chemiluminescence, NCAR CARI group)
- CO_2 (CRDS, NCAR CARI group)
  - 1 s data averaged to 10 s, 2.5 min

Emissions inventories (EPA)

- EPA National Emissions Inventory (NEI)
- EPA Toxics Release Inventory (TRI)
- EPA Air Markets Program Database (AMPD)

Transport modeling

- NOAA HYSPLIT dispersion model

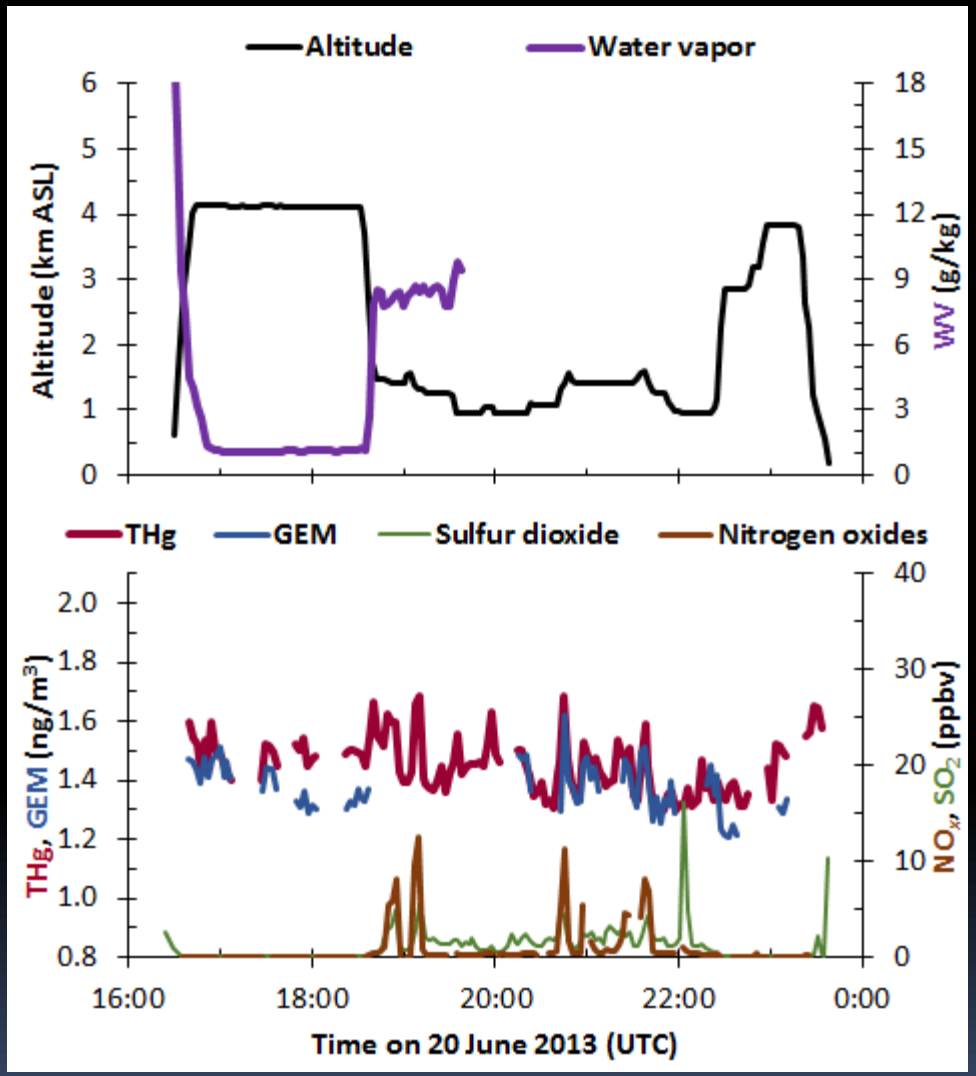
Hg Point Source Analysis Protocol

1. Identify pollution plumes
2. Identify potential sources
3. Calculate plume ERs
4. Calculate source EFs
5. Compare ERs to EFs
6. Attribute source(s) ← SO_2/CO_2
7. Assess inventory accuracy ← THg/CO_2

ER, Enhancement Ratio
EF, Emission Factor

Point Source Survey 1: RF-07 (Ohio River Valley)

C-130 flight track during RF-07

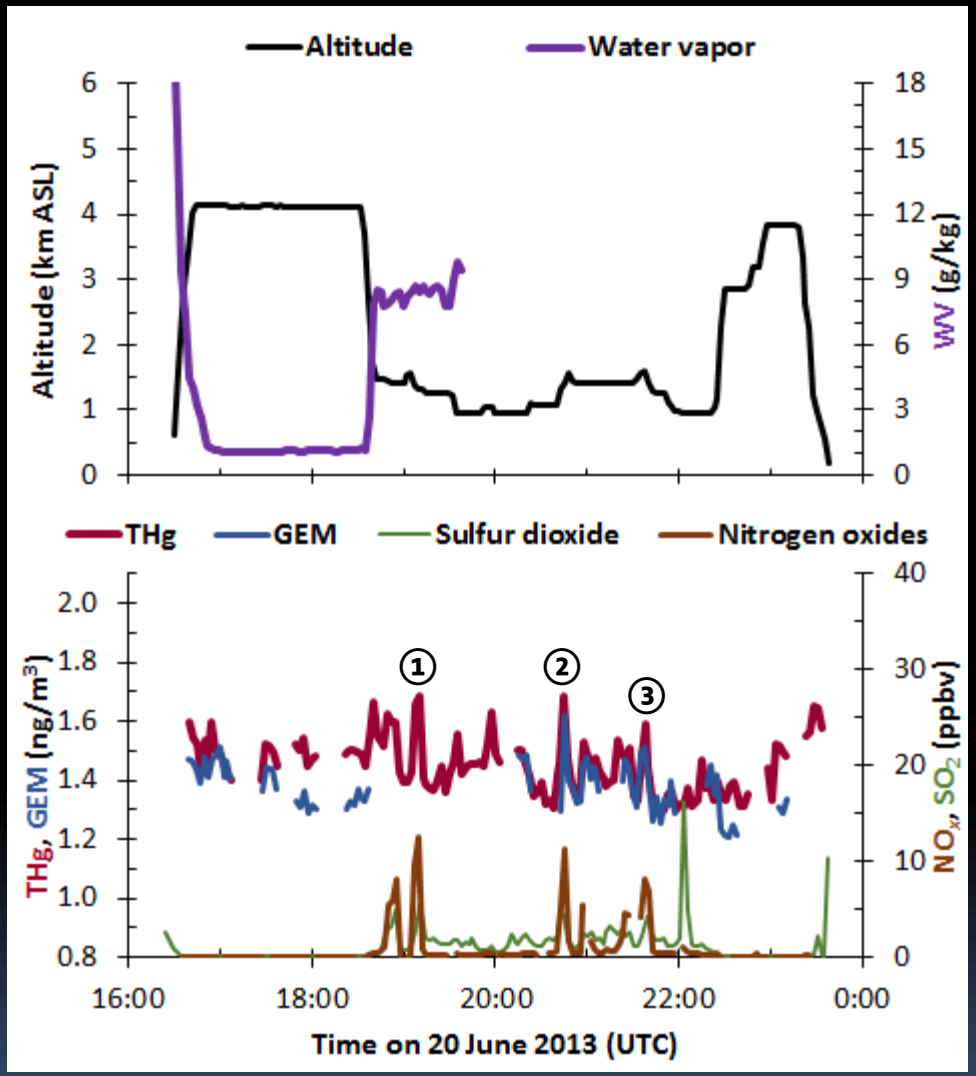


Selected C-130 measurements (2.5 min)

Point Source Survey 1: RF-07 (Ohio River Valley)

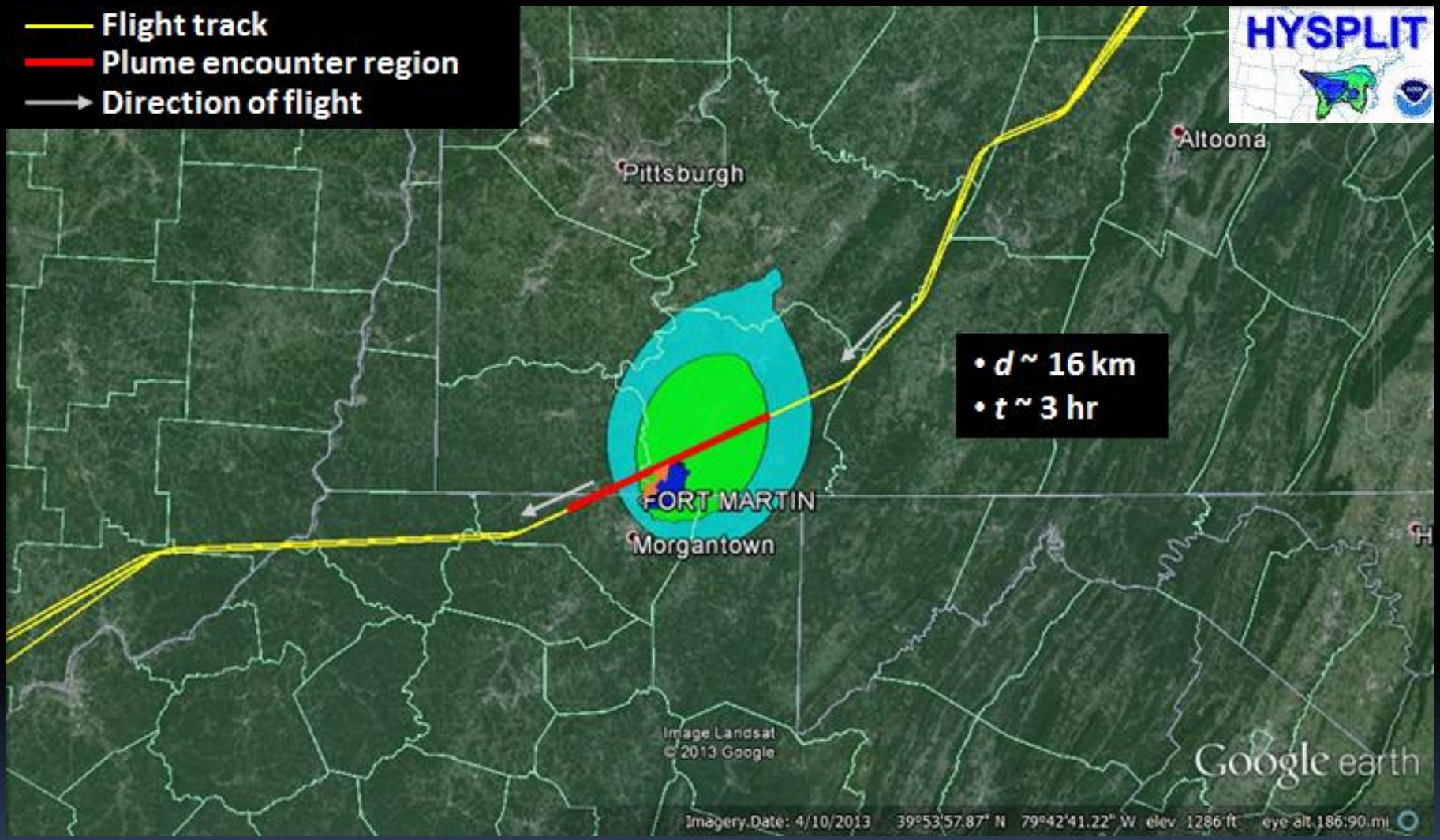
C-130 flight track during RF-07

- Numerous plumes observed



Selected C-130 measurements (2.5 min)

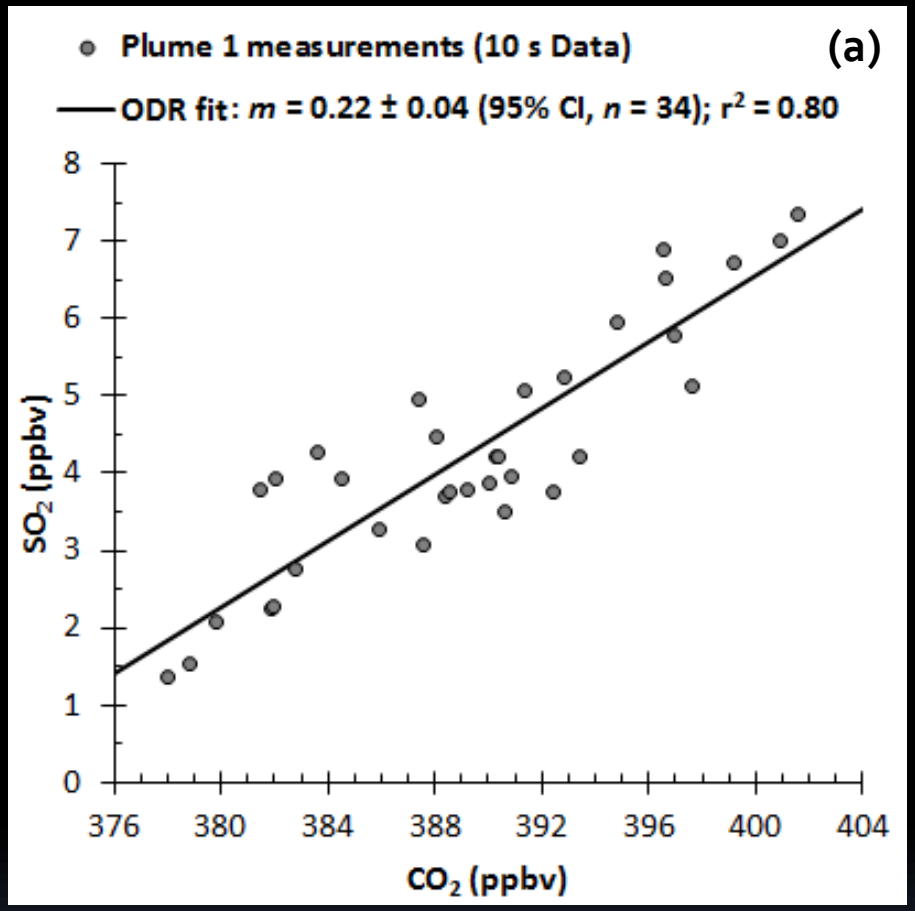
Source Attribution Example: RF-07, Plume 1

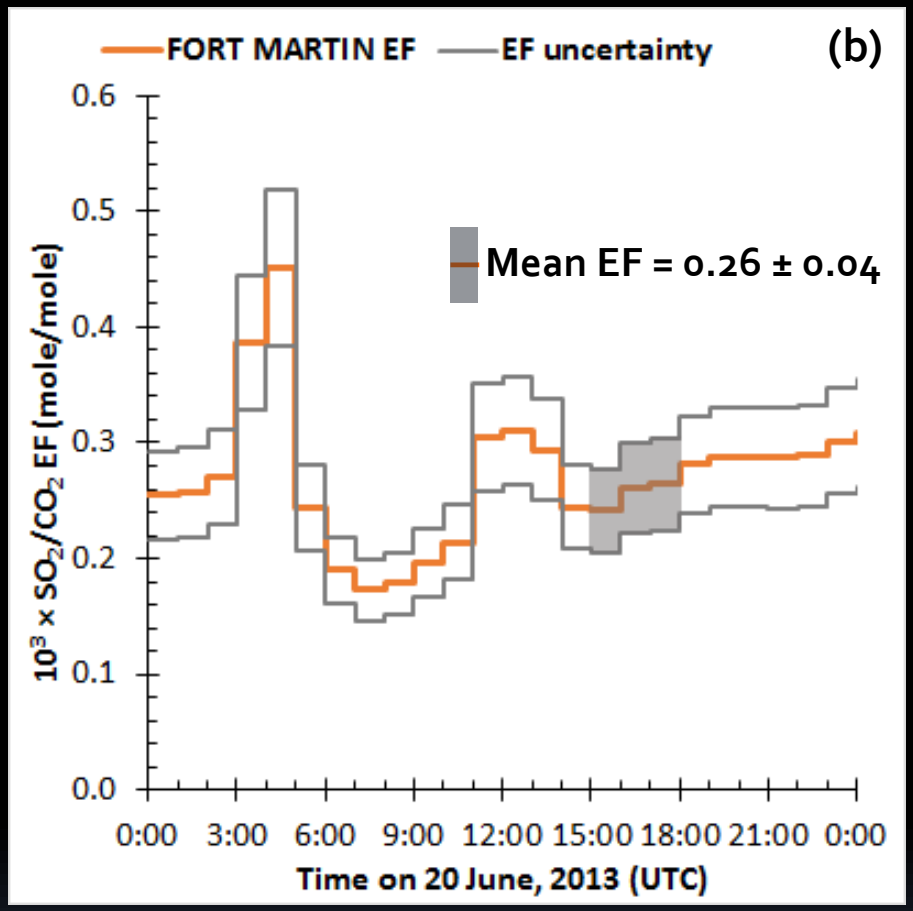


Modeled emissions dispersion from nearby Fort Martin coal-fired power plant

(Data sources: EPA TRI, NEI; http://www.ready.noaa.gov)

Source Attribution Example: RF-07, Plume 1 – *continued*



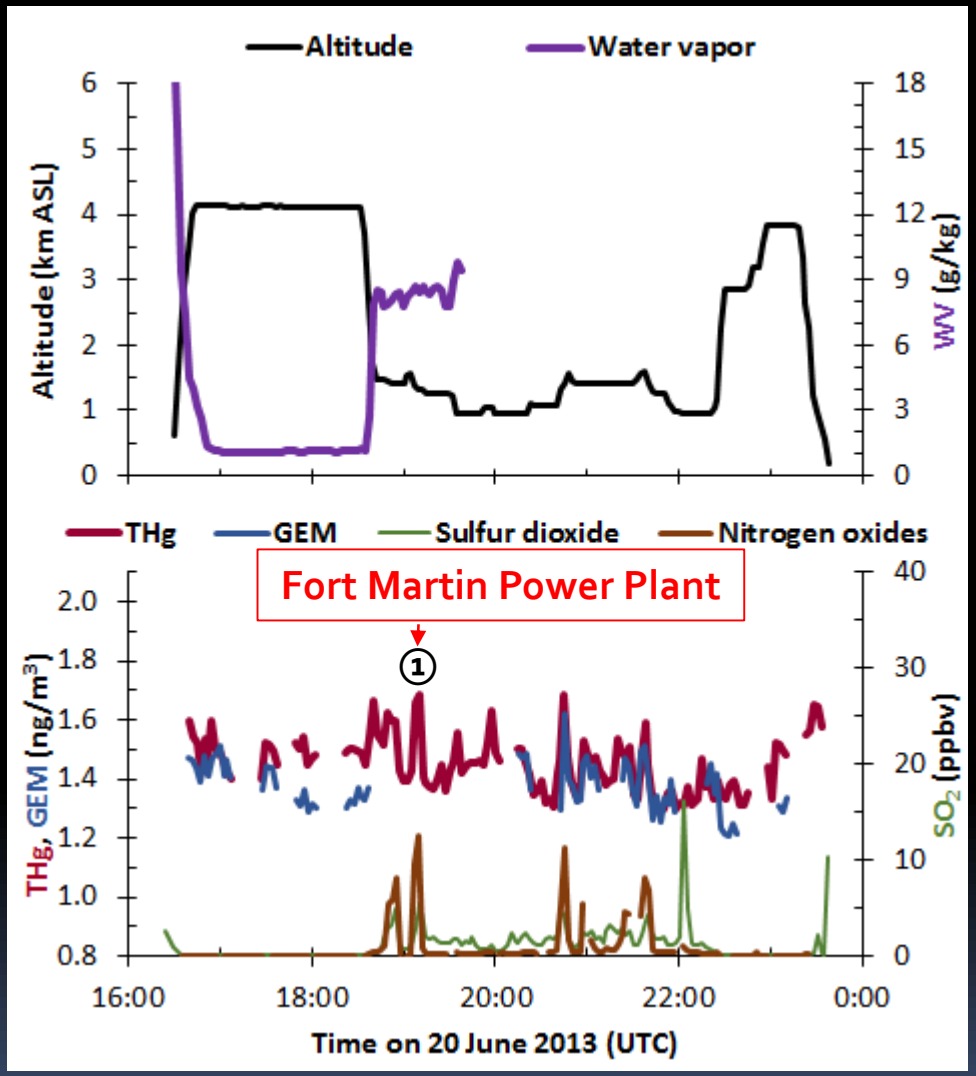


(a) Observed SO_2/CO_2 ER (plume 1) vs. (b) inventory EFs (Ft. Martin Plant)

- Plume 1 SO_2/CO_2 ER matches real-time EF for Fort Martin Power Plant
- Ft. Martin was 2nd largest Hg point source in WV in 2012 (326 lbs)

Source Attribution for RF-07

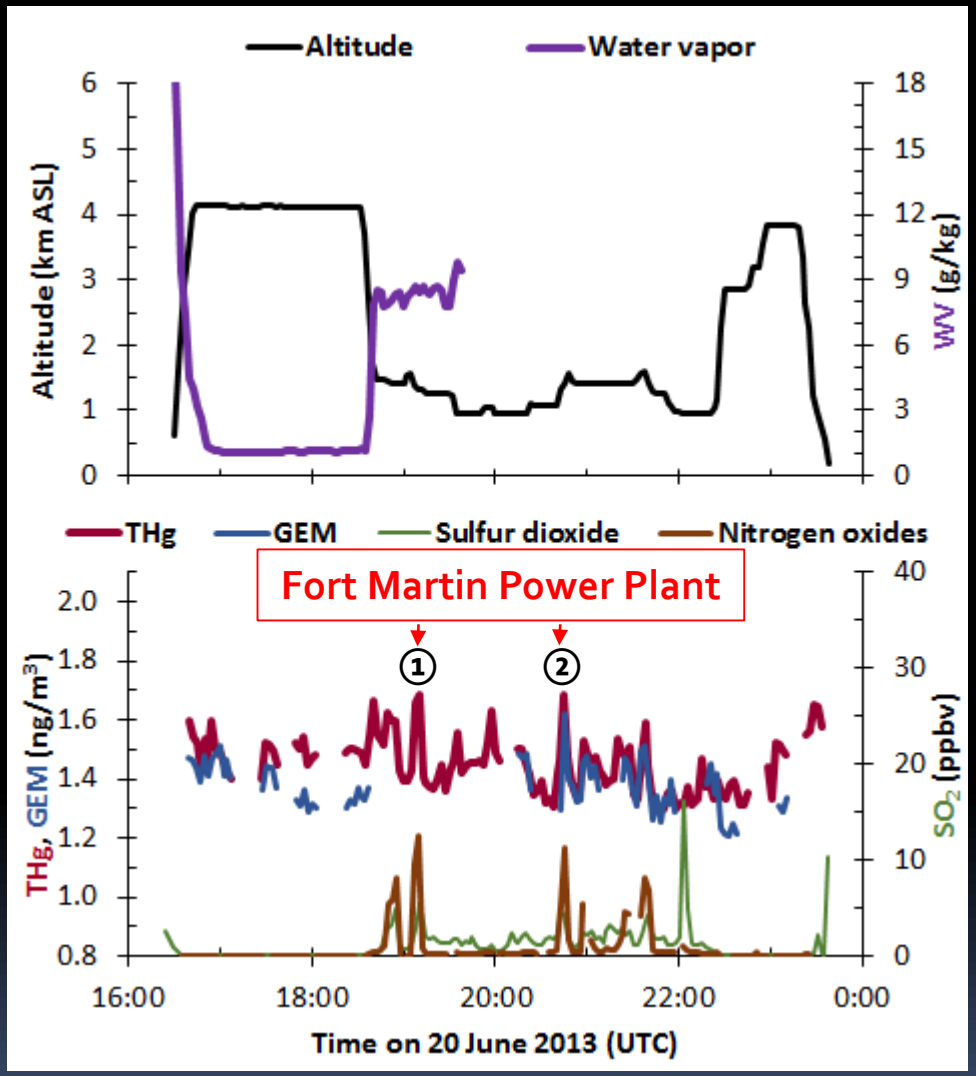
C-130 flight track during RF-07



Selected C-130 measurements (2.5 min)

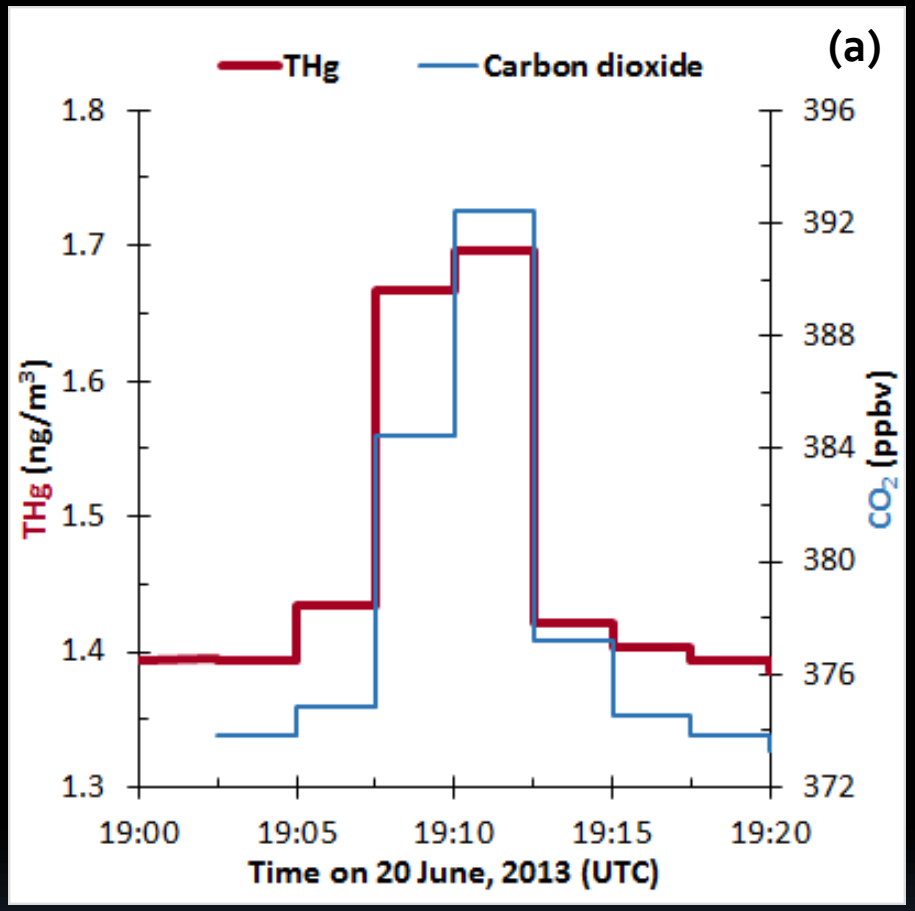
Source Attribution for RF-07 – *continued*

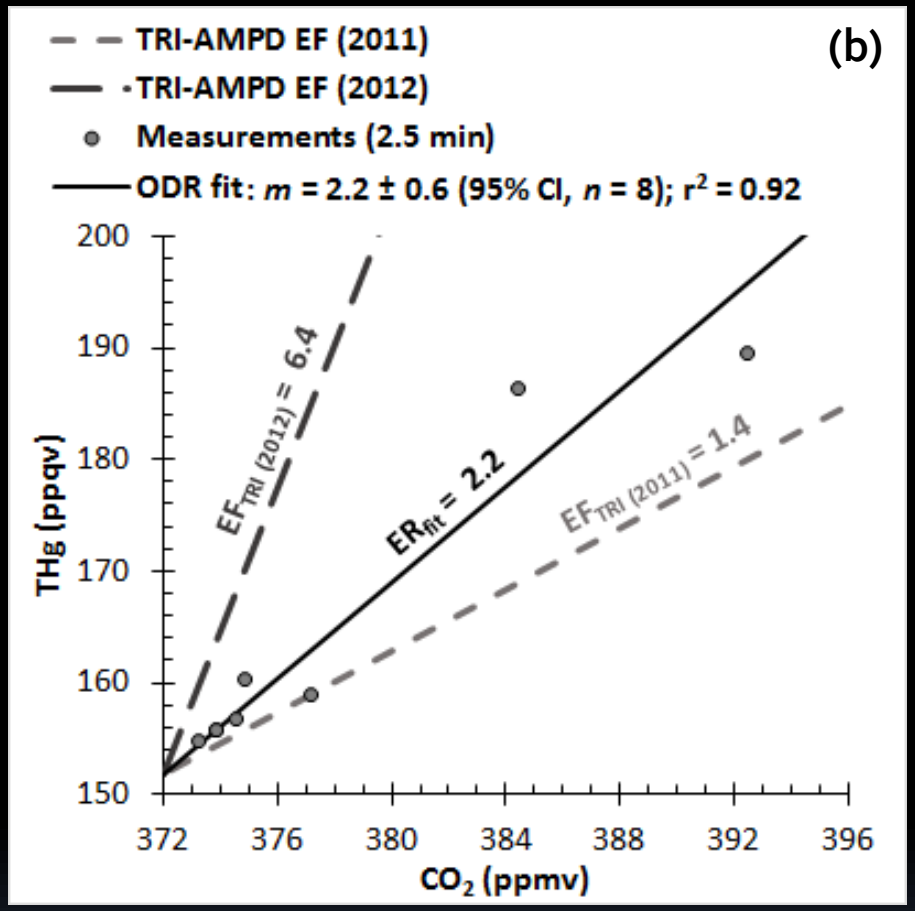
C-130 flight track during RF-07



Selected C-130 measurements (2.5 min)

Inventory Evaluation: Fort Martin Power Plant

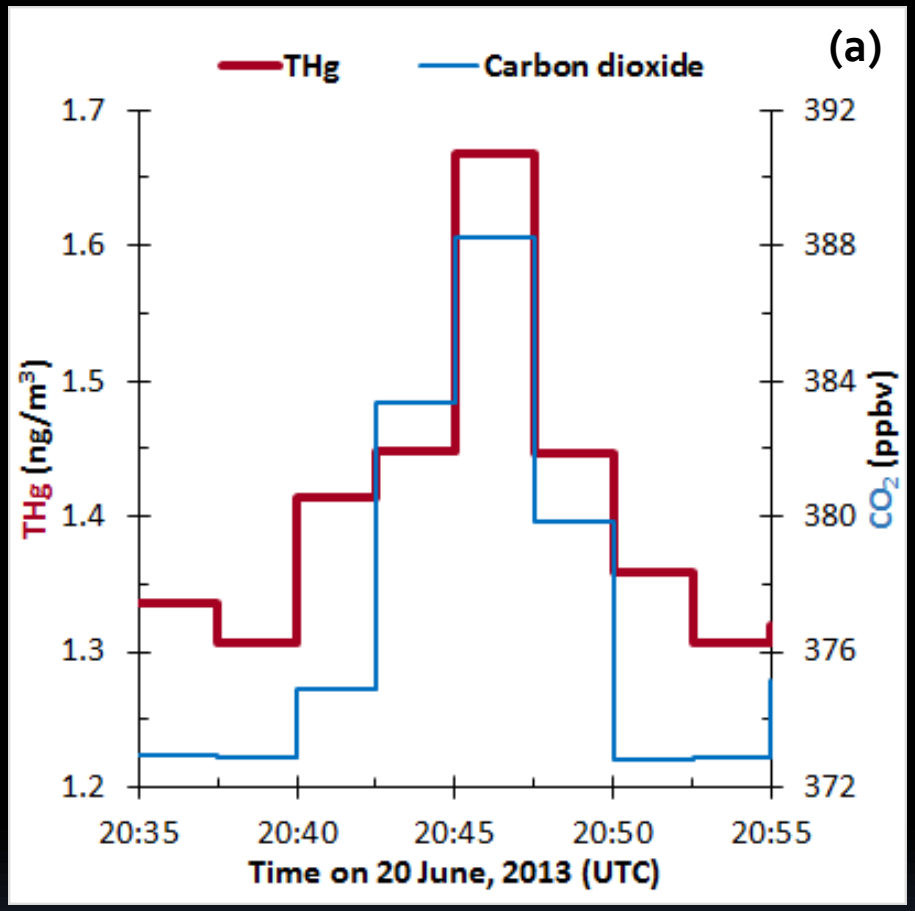


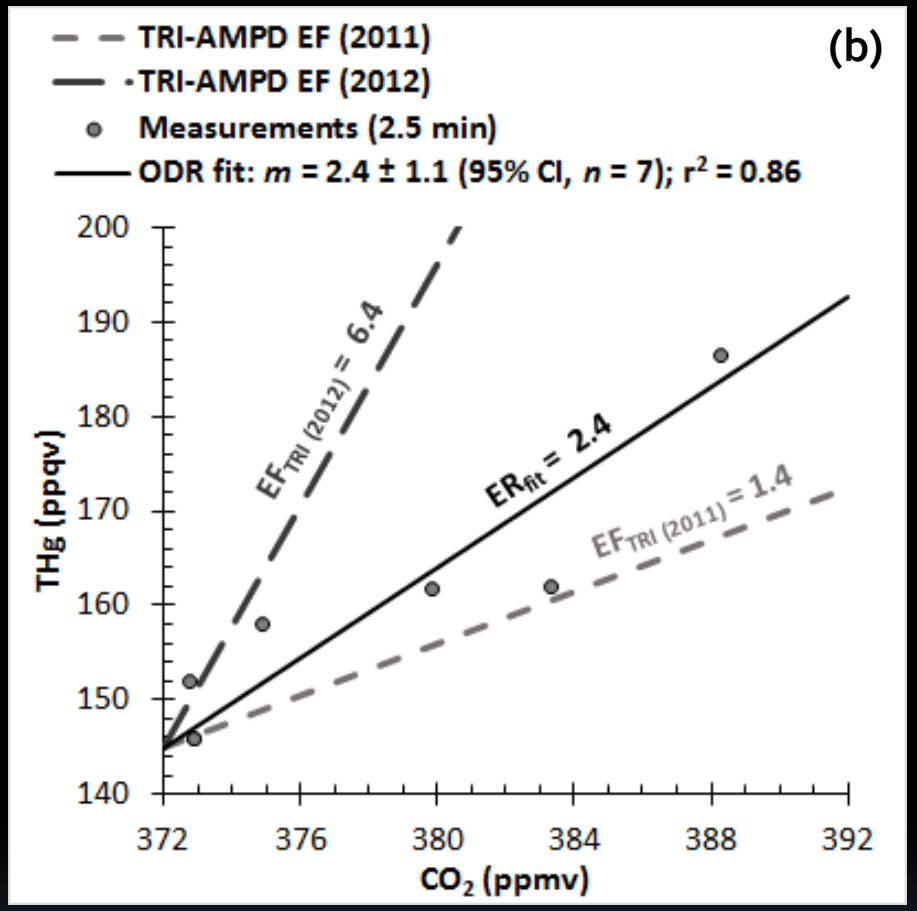


(a) Cross-plume Hg and CO_2 obs. (2.5 min); (b) Fort Martin ER-EF comparison

- Hg/CO_2 ER is ~1/3rd of most recent inventory-based EF
- But, ER is ~60% higher than previous year's EF
- 2013 Hg data are needed to better evaluate inventories

Inventory Evaluation: Fort Martin Power Plant – *cont.*



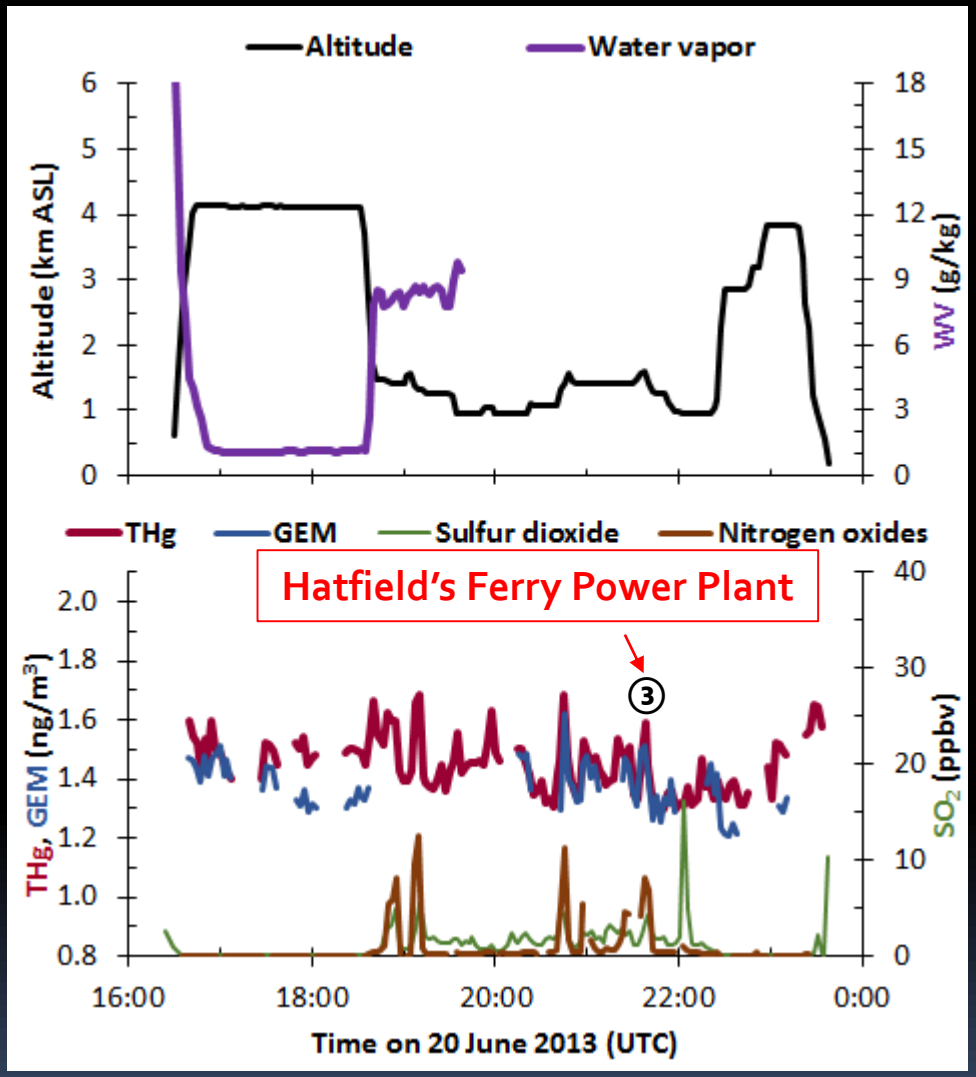


(a) Cross-plume Hg and CO_2 obs. (2.5 min); (b) Fort Martin ER-EF comparison

- Results are consistent with those for first plume crossing
  - Plume 1 ER = 2.2 ± 0.6 ppqv/ppmv
  - Plume 2 ER = 2.4 ± 1.1 ppqv/ppmv

Source Attribution for RF-07 – *continued*

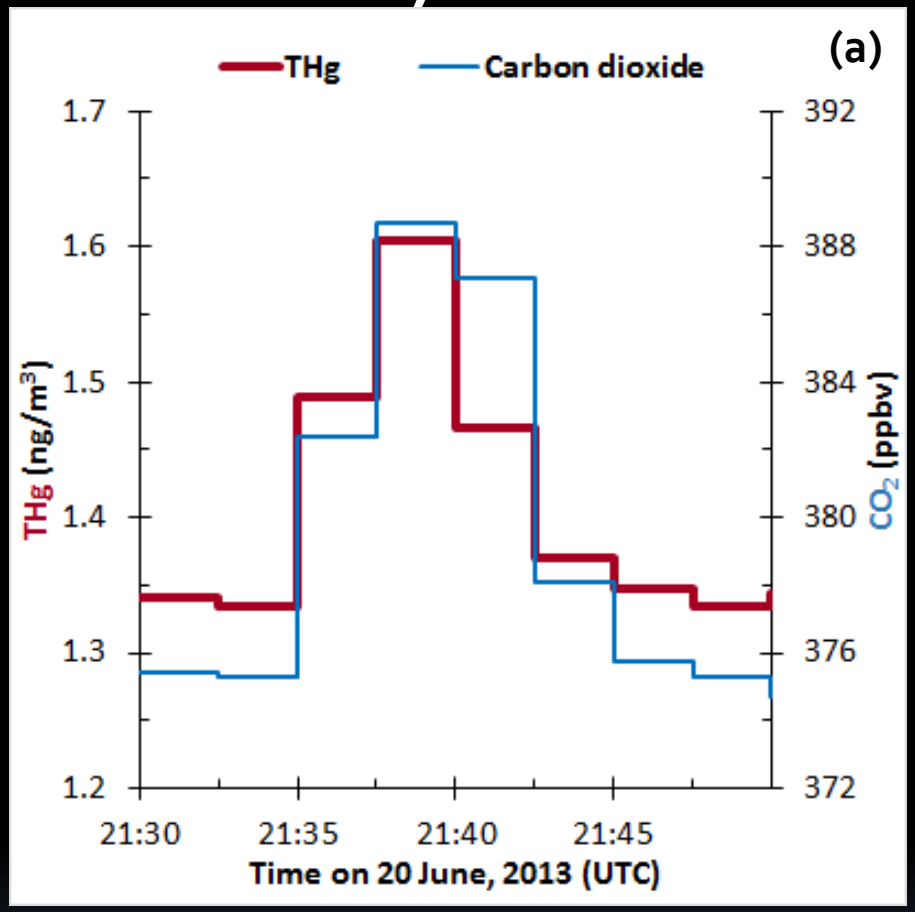
C-130 flight track during RF-07

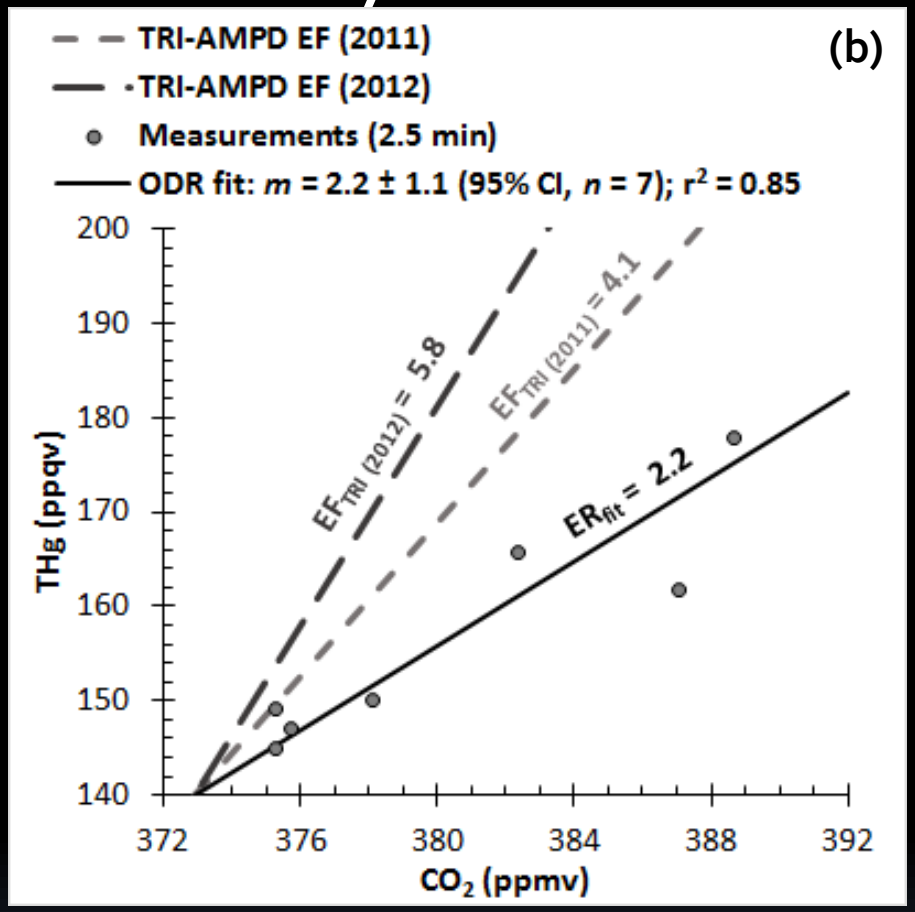


Selected C-130 measurements (2.5 min)

- Hatfield Plant was the largest Hg point source in PA in 2012 (530 lbs)

Inventory Evaluation: Hatfield's Ferry Power Plant

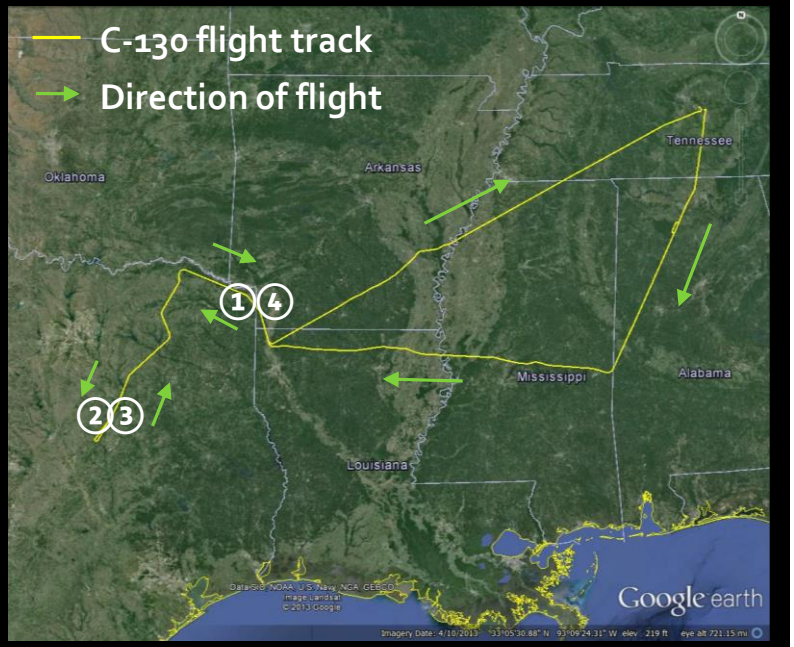




(a) Cross-plume Hg and CO_2 obs. (2.5 min); (b) Hatfield ER-EF comparison

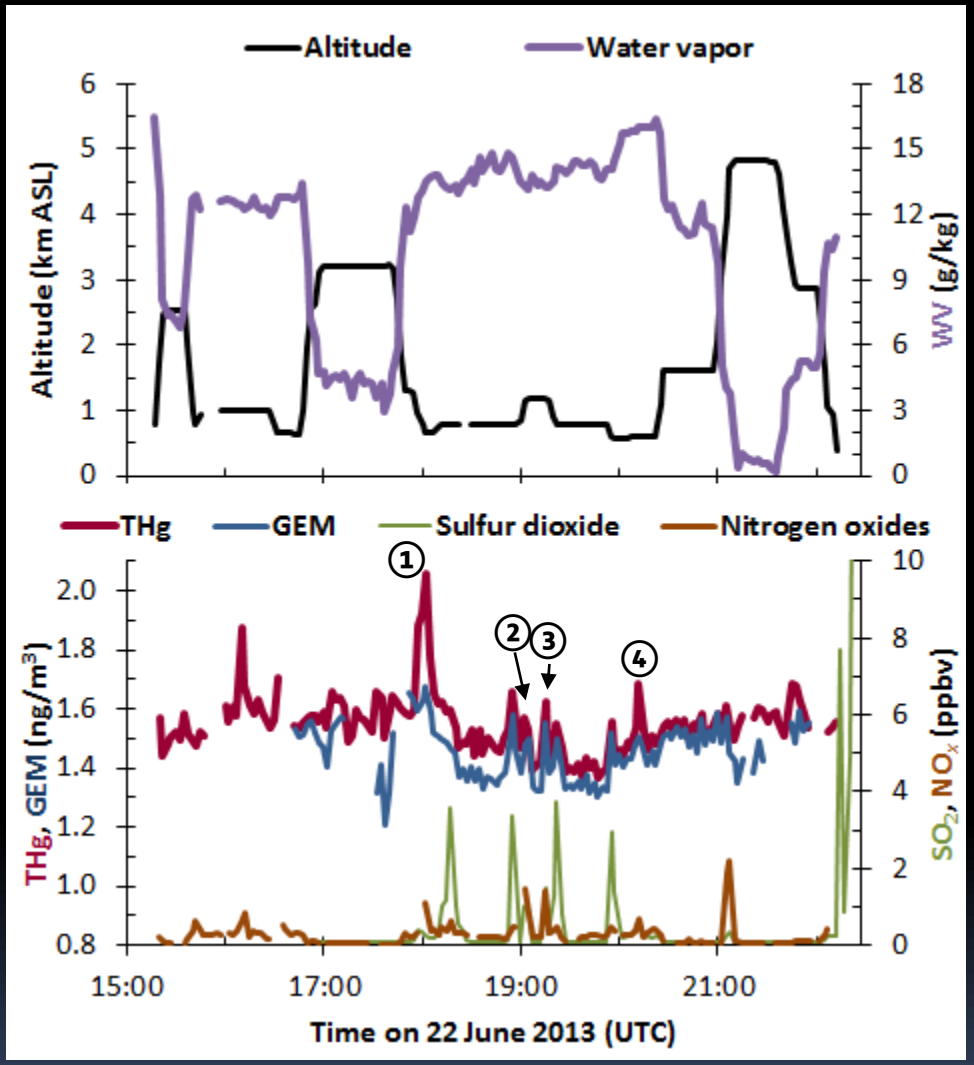
- Hg/CO_2 ER is ~45 to 60% of most recent inventory-based EFs
- 2013 Hg data are needed to better evaluate inventories

Point Source Survey 2: RF-08 (AL and Northeastern TX)



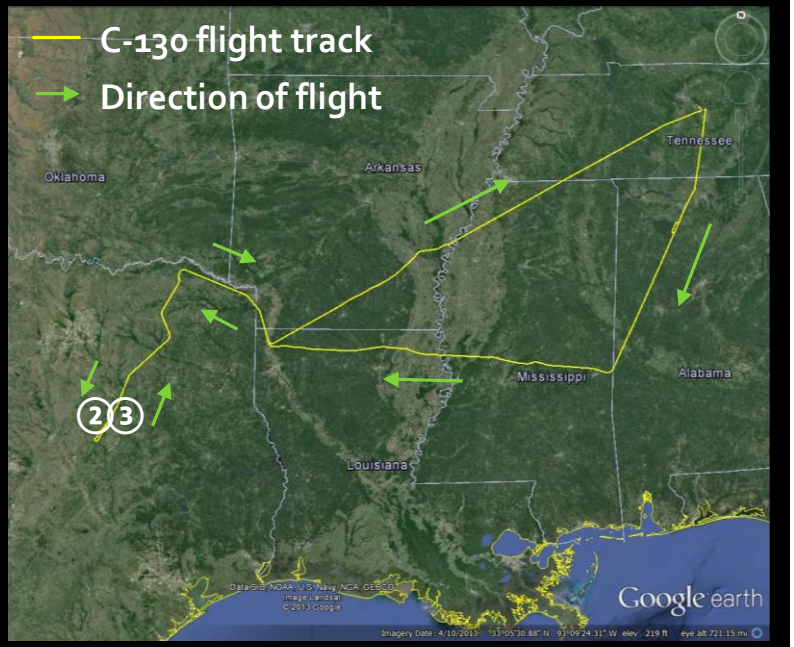
C-130 flight track during RF-08

- Numerous plumes observed

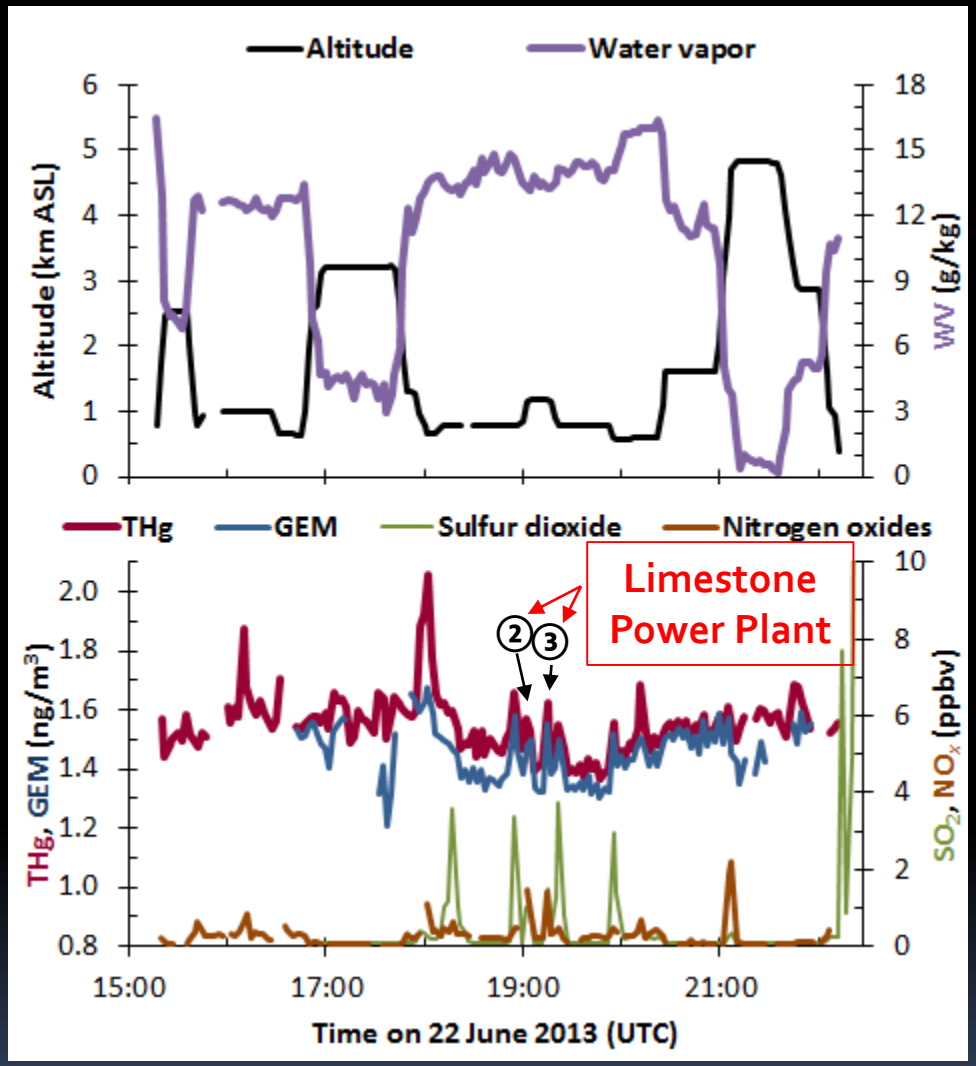


Selected C-130 measurements (2.5 min)

Source Attribution for RF-08



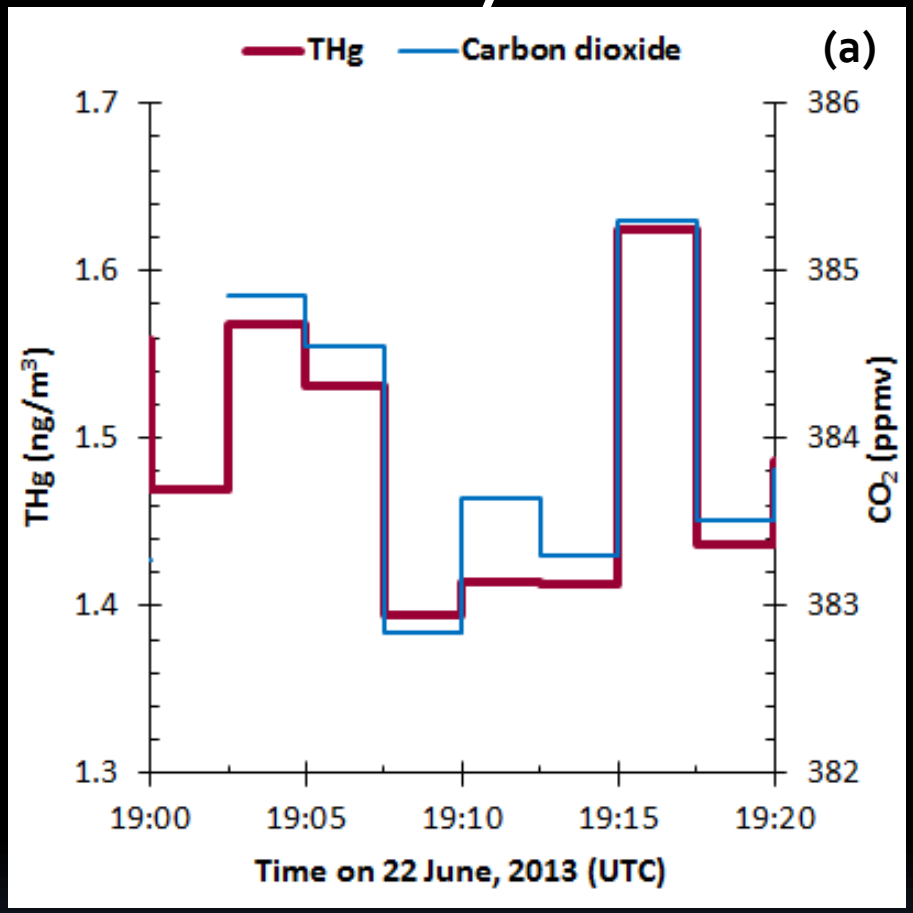
C-130 flight track during RF-08

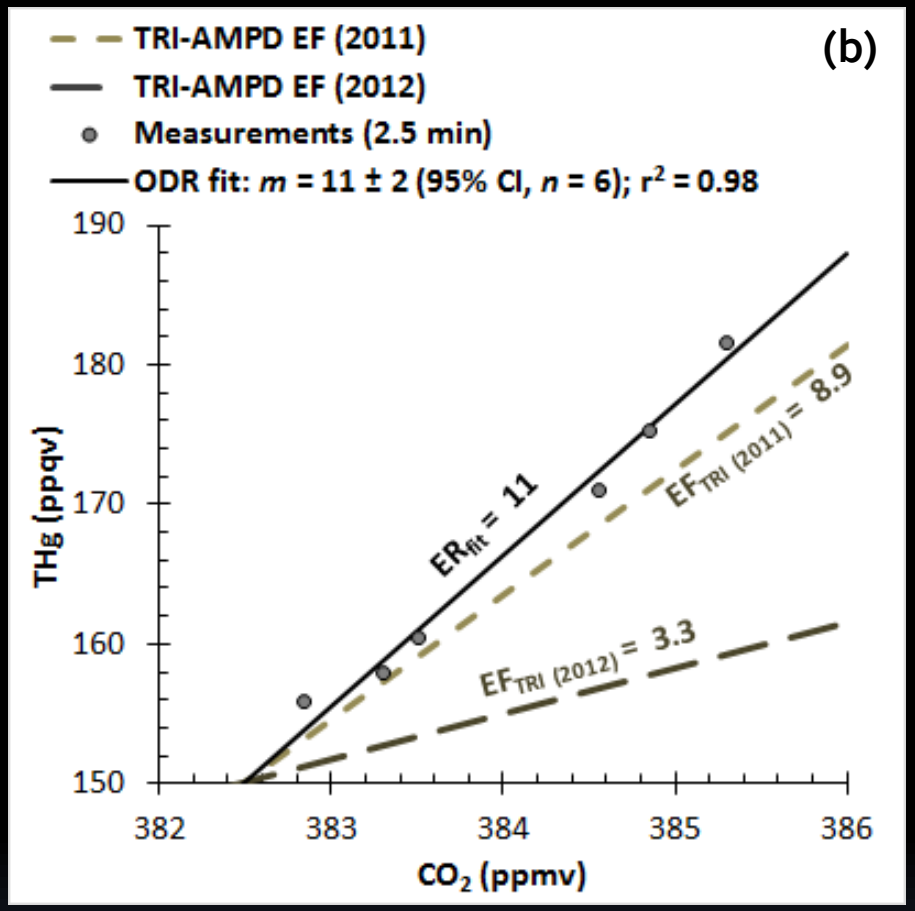


Selected C-130 measurements (2.5 min)

- Limestone Plant was 12th largest Hg point source in TX in 2012 (375 lbs)

Inventory Evaluation: Limestone Power Plant



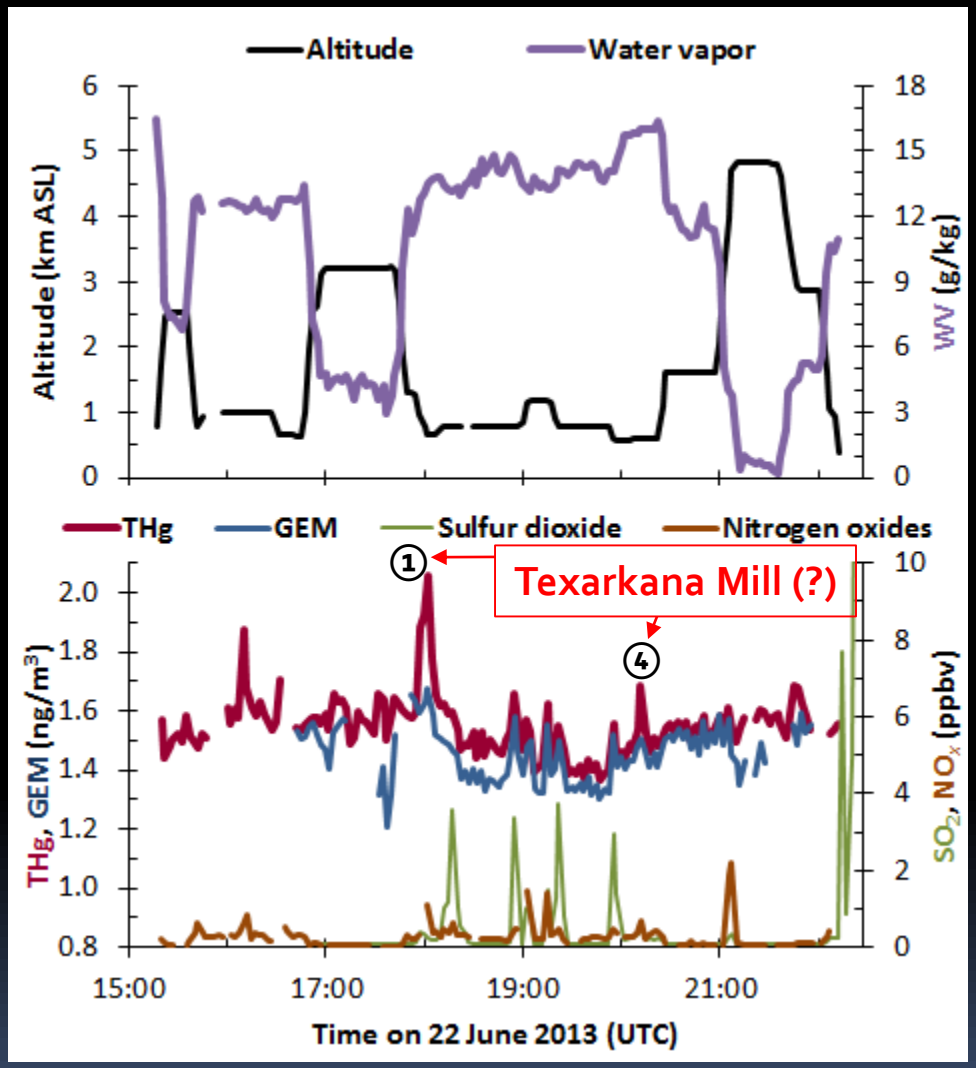


(a) Cross-plume Hg and CO_2 obs. (2.5 min); (b) Limestone ER-EF comparison

- Hg/CO_2 ER is ~3-fold higher than most recent inventory-based EF
  - But, ER is close to previous year's EF
- 2013 Hg data are needed to better evaluate inventories

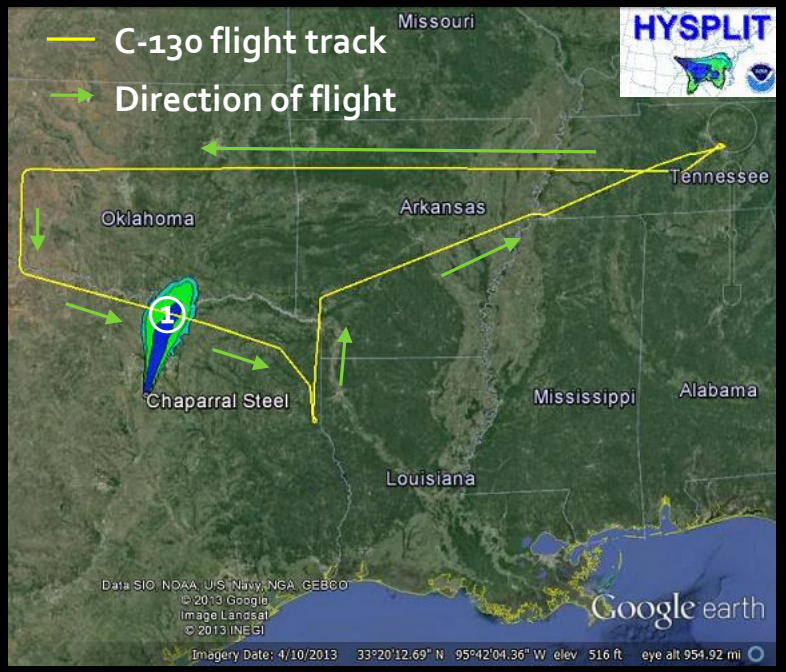
Source Attribution for RF-08 – *continued*

C-130 flight track during RF-08

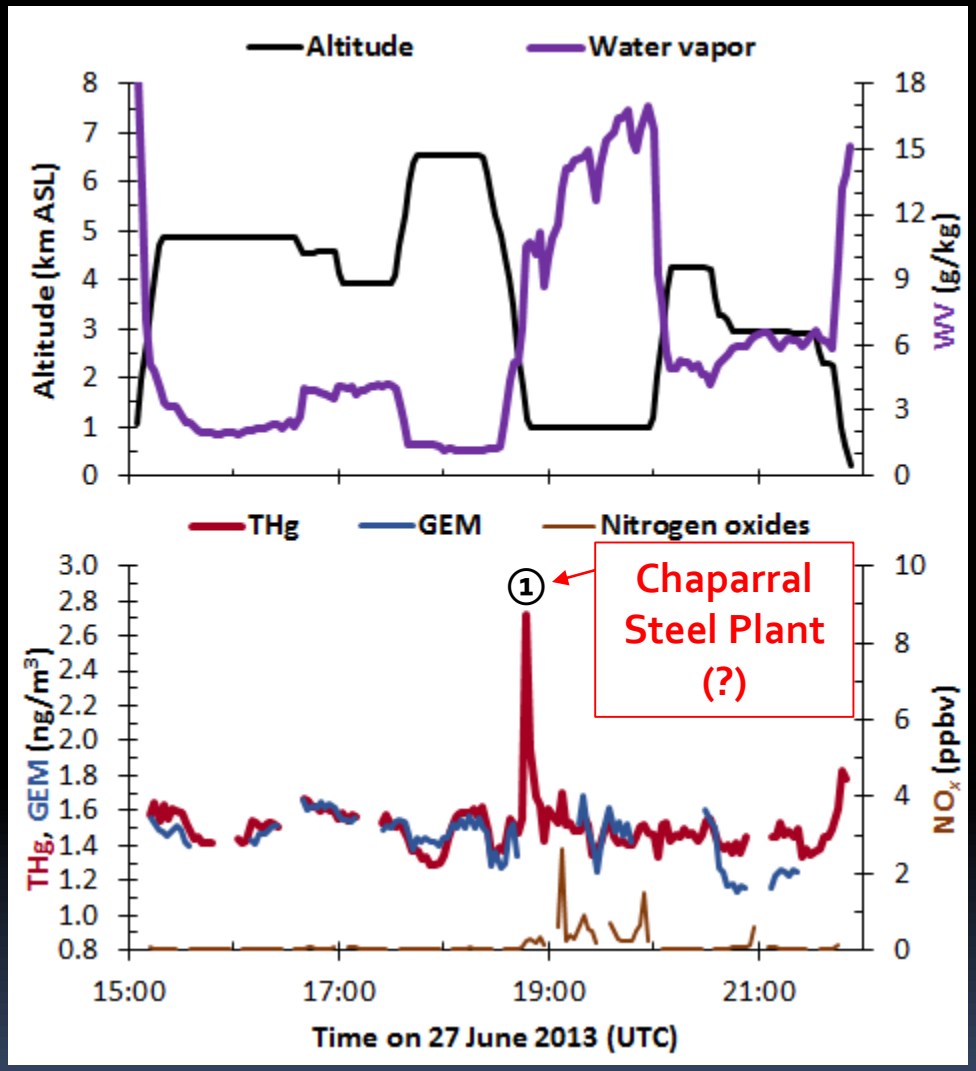


Selected C-130 measurements (2.5 min)

Other Large Non-Power Plant Hg Point Sources



C-130 flight track during RF-10



Selected C-130 measurements (2.5 min)

- Chaparral Steel was 7th largest Hg point source in TX in 2012 (375 lbs)

Conclusions

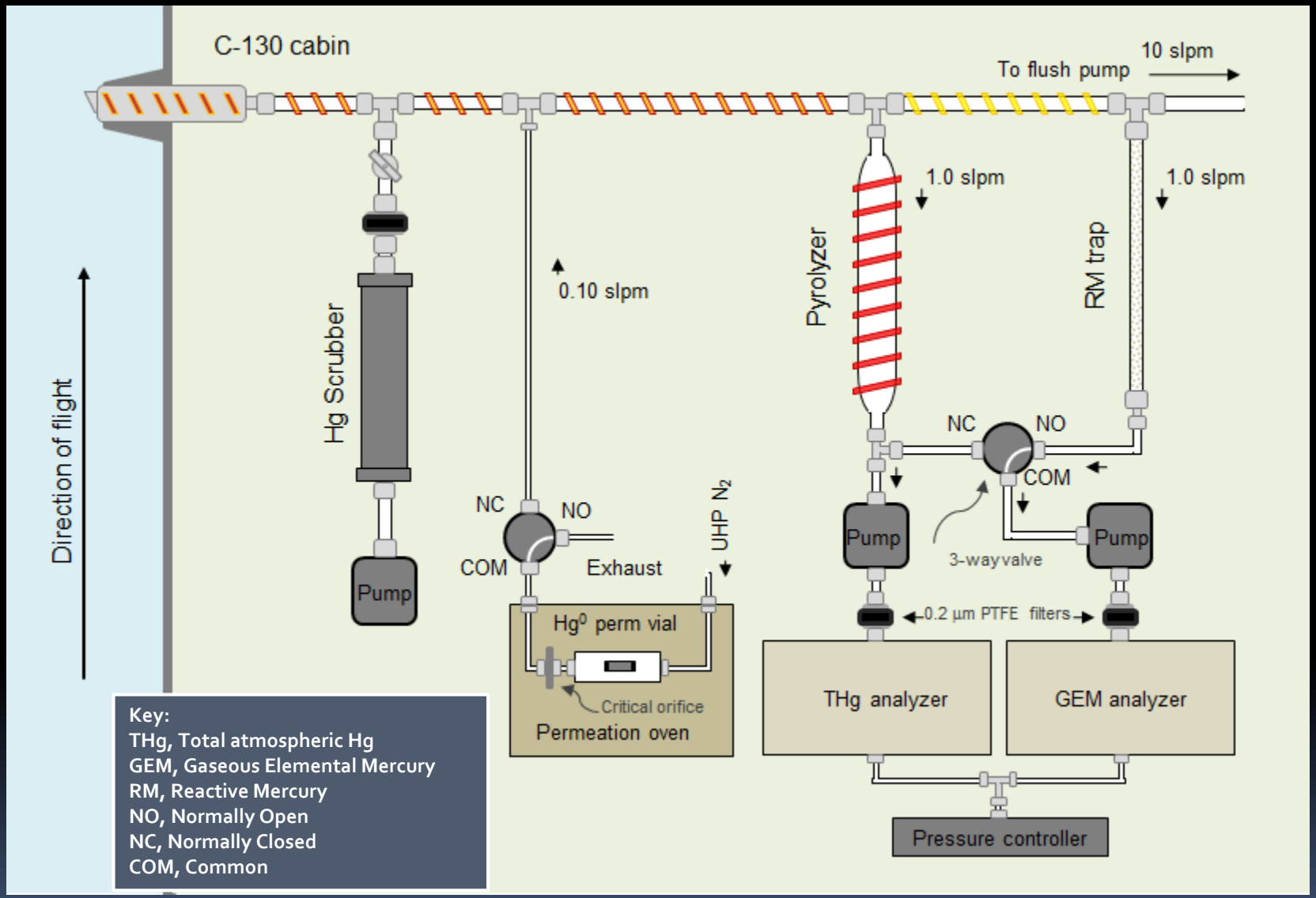
- Sampled numerous Hg-rich plumes in the Southeast during NOMADSS, many are traceable to large coal-fired power plants.
- Developed a method to compare observed ERs with inventory EFs and applied this to several large coal fired power plants.
- Preliminary evaluation indicates the actual Hg emissions may differ significantly from inventory values.

- Will continue to evaluate Hg emission inventories for all sources that we sampled.
- Will revise our analysis using 2013 Hg data when available.

THANK YOU

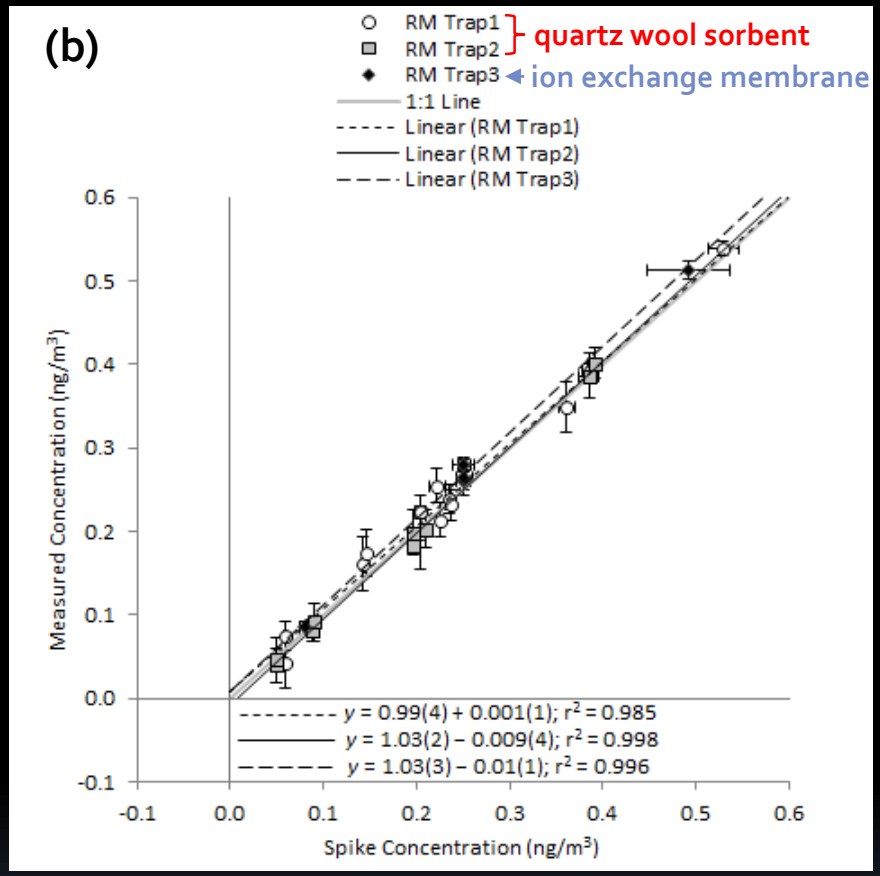
Extra Slides

Instrument Overview – Detector for Oxidized Hg Species



Schematic of the 'UW-DOHGS' as configured on board the C-130

Evaluation of RM Collection Efficiency



(a) Manifold/spiking system; (b) measured vs. expected manifold $HgBr_2$ concentrations

- $HgBr_2$ is used as a surrogate calibration standard for RM