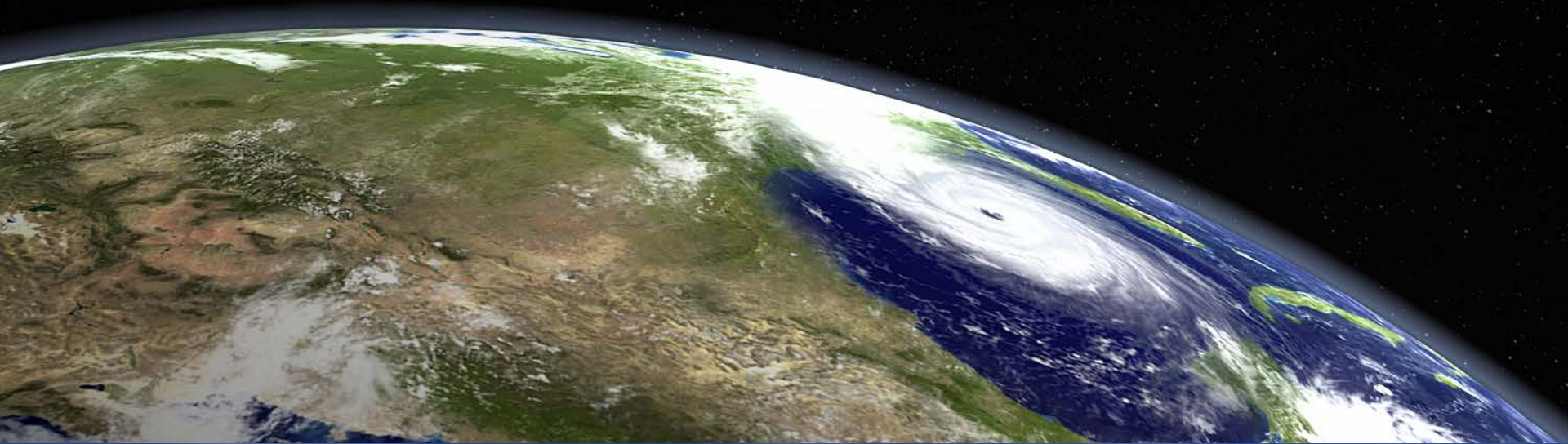


Continuous GHG Monitoring at Local to Statewide Scales

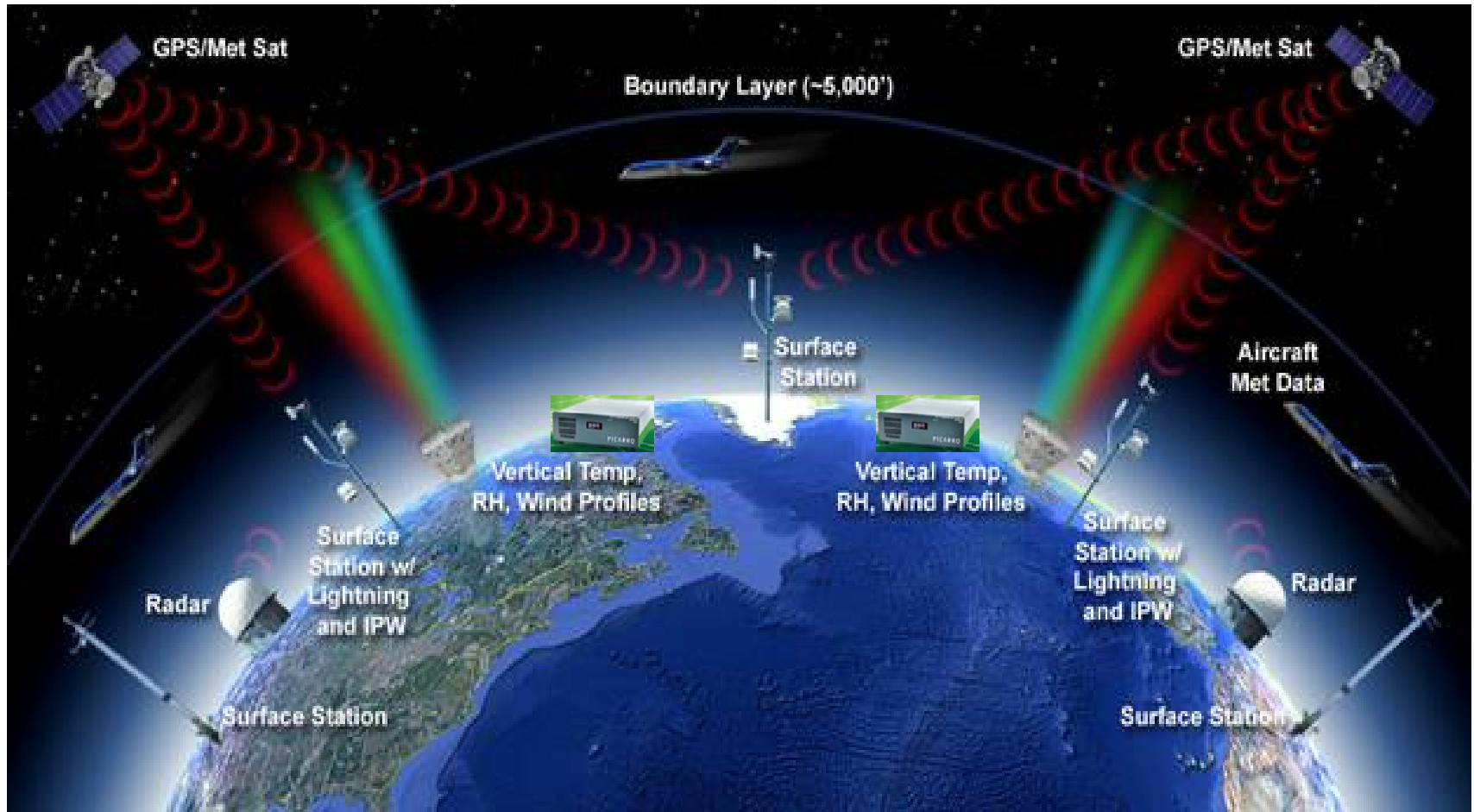


William Callahan, Elena Novakovskaia and Christopher Sloop

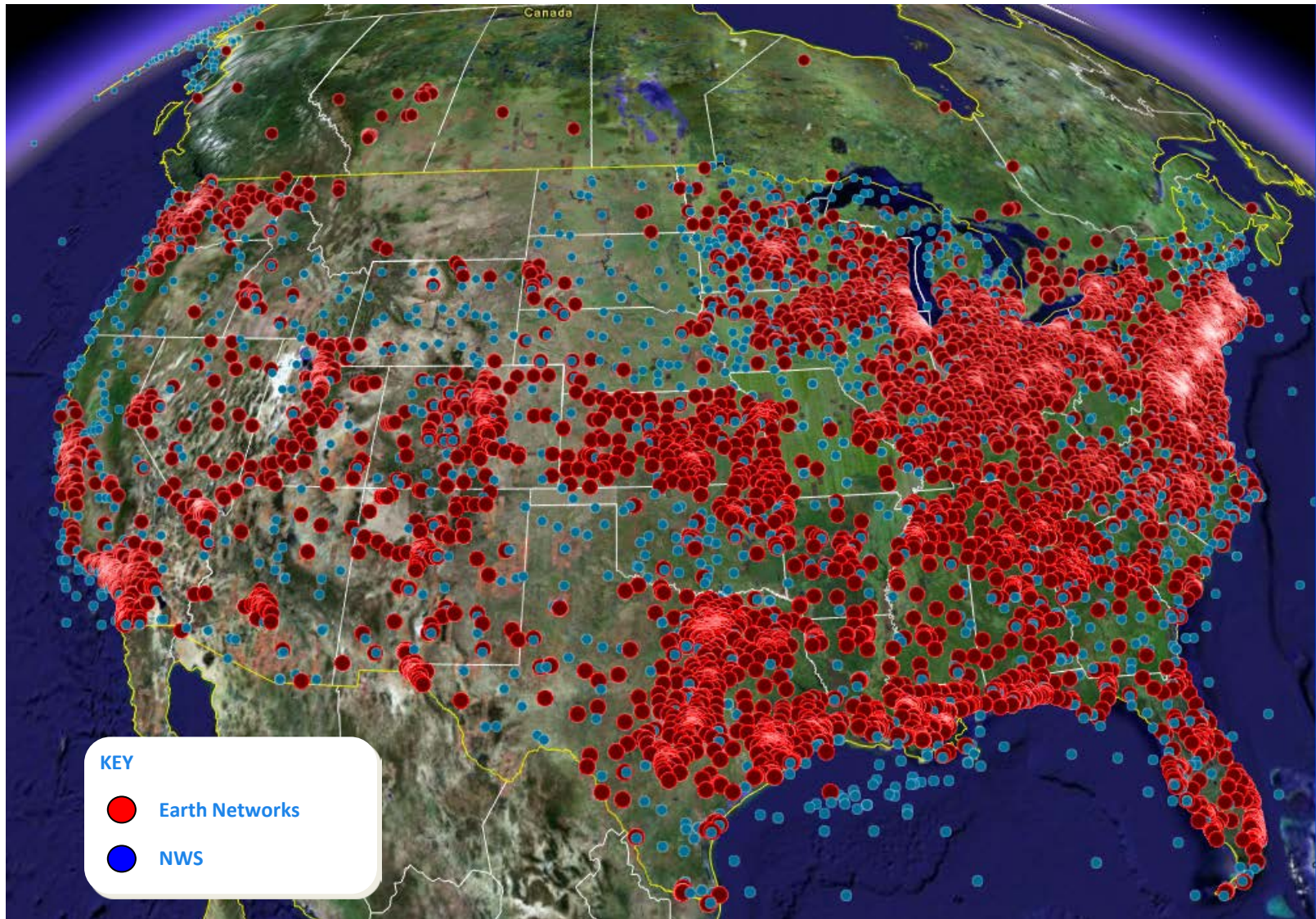
Northeast CO2 Model



Models require a detailed understanding of atmospheric dynamics



Earth Networks Surface Observation Network





KEY

WeatherBug

NWS

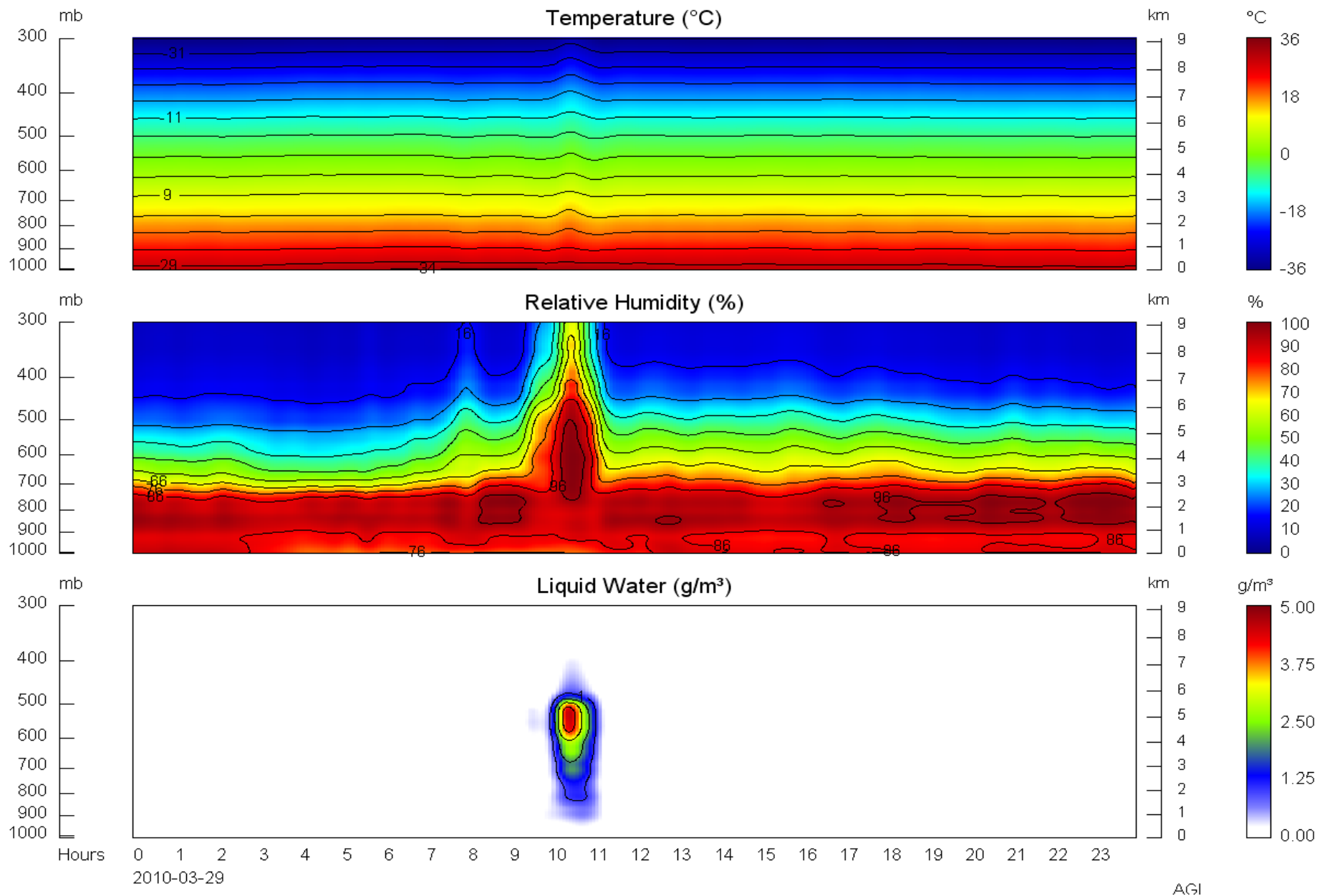


Global Lightning System

Over 600 Sensors Installed and Growing

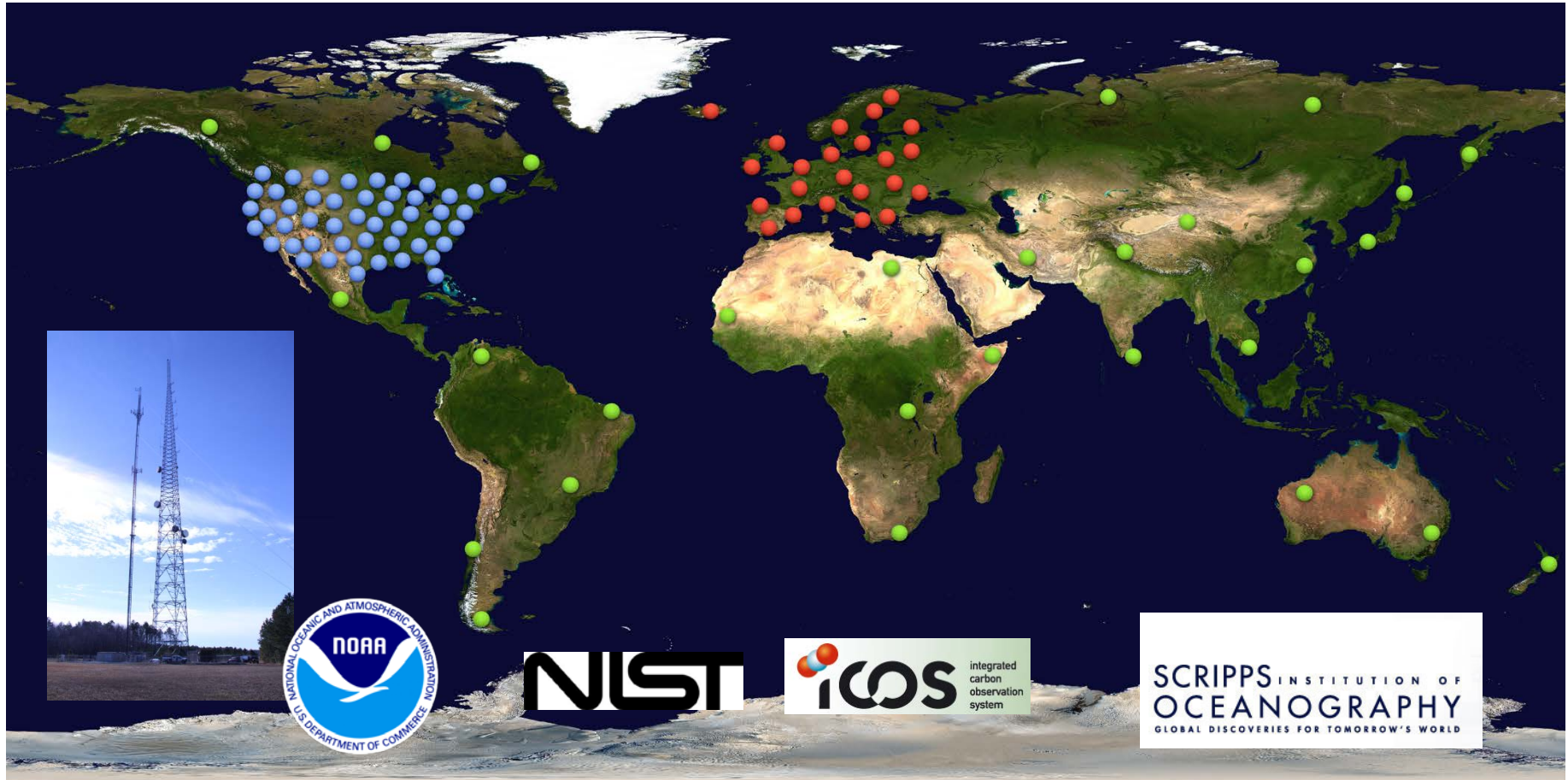






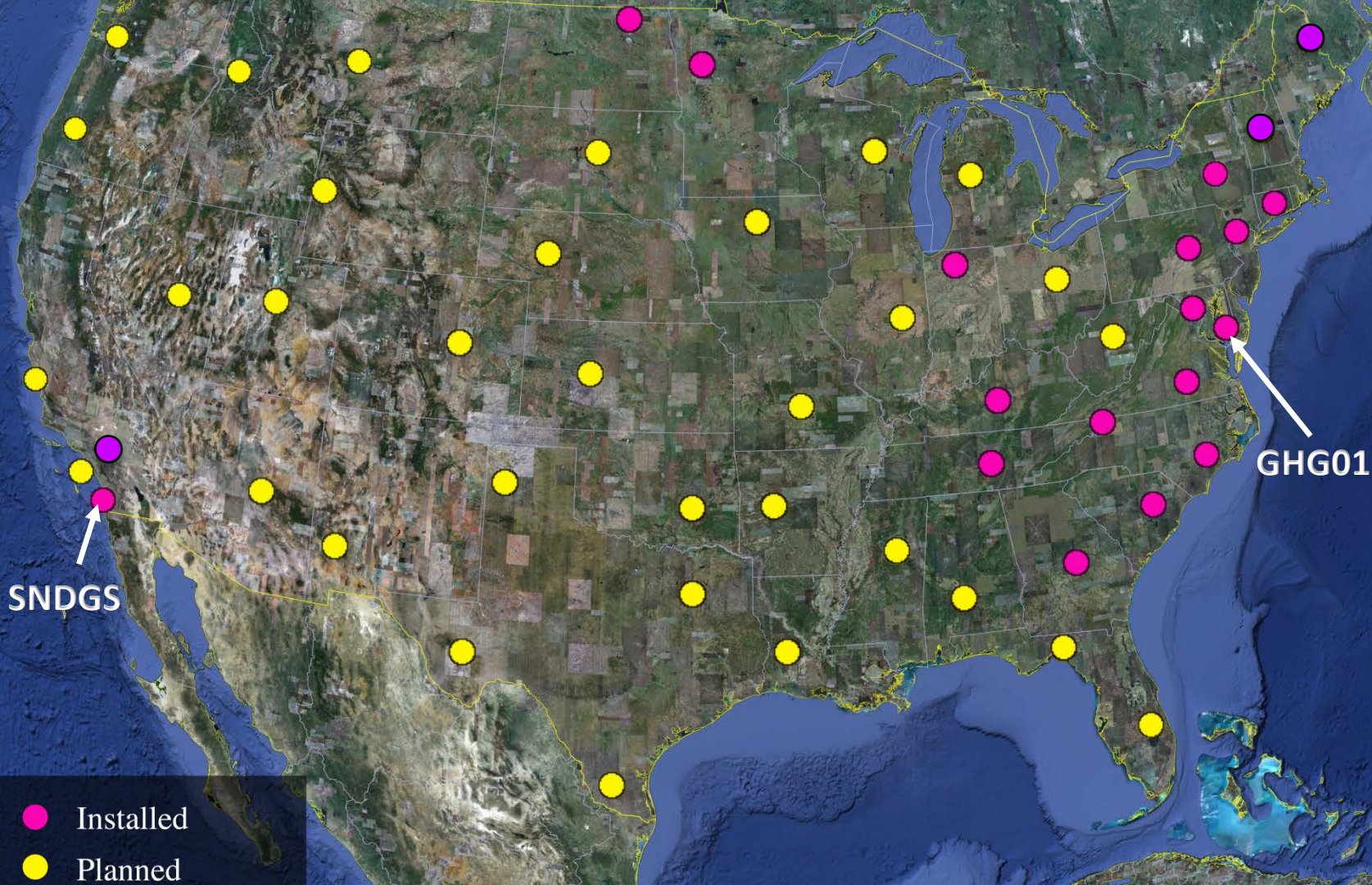
Landward (off-zenith) retrievals 29 Mar 2010

Greenhouse Gas Network Plans



- Install & operate 100 advanced GHG instruments.
- ~50 in U.S., ~25 in Europe, ~25 around remaining continents
- Measure CO₂ (carbon dioxide) & CH₄ (methane)

Earth Networks US Installations as of April 2012



Sampling System

SCRIPPS INSTITUTION OF
OCEANOGRAPHY
GLOBAL DISCOVERIES FOR TOMORROW'S WORLD

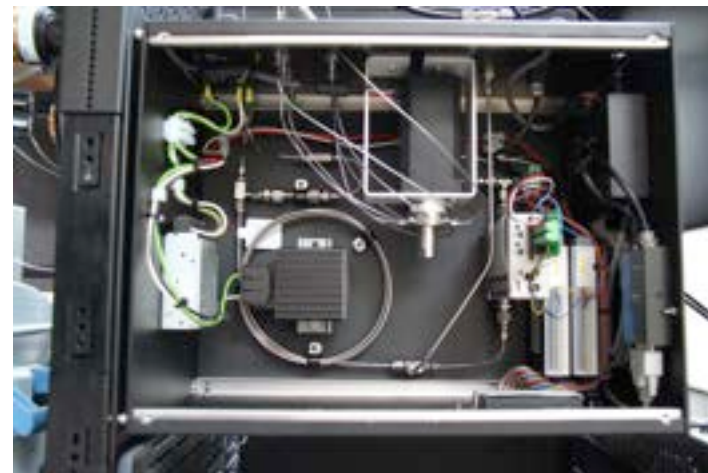
Front View



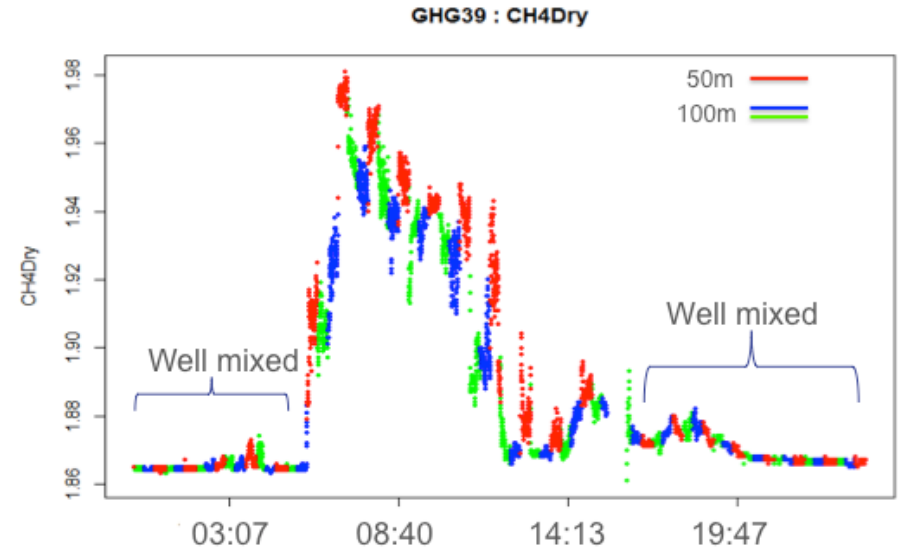
Side View



“Calibration Box”



Typical Tower: Lewisburg, Pennsylvania



Site Data...

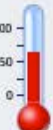
 [Live](#) [Source Map](#) [2D Forecast](#) [3D Forecast](#) [Our Networks](#)

[f Like](#) [f](#) [t](#)

San Diego, CA Earth Networks Site: [SCRIPPS](#)

LIVE WEATHER AND GHG DATA FROM SCRIPPS

Tuesday, January 11, 2011 1:03:46 PM +00:00 GMT -8

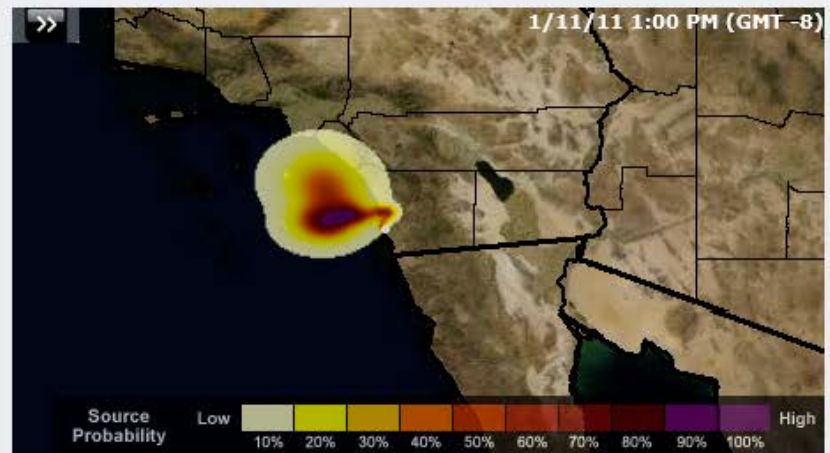
Temp
 **61.2°F**
[Switch to Celsius](#)

	CO ₂ (ppm)	CH ₄ (ppb)
SCRIPPS	417.4	1968
Global Average	386.3	1866

Site Status: Provisional 

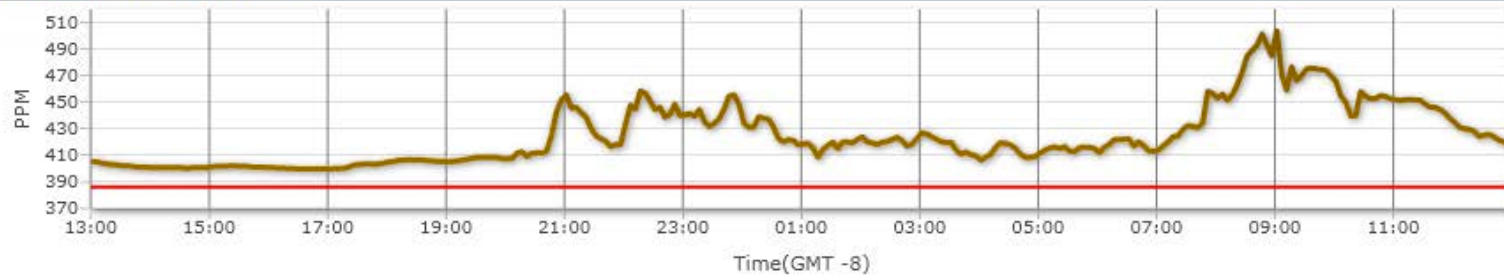


CARBON SOURCE MAP

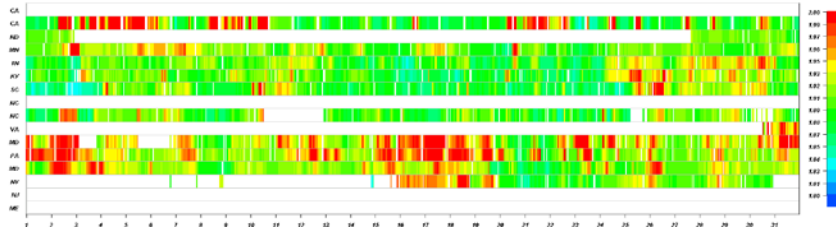


 Time Interval: ☐ 10 Minutes ☐ 30 Minutes ☐ 8 Hours ☒ 24 Hours ☐ 48 Hours ☐ 1 Week

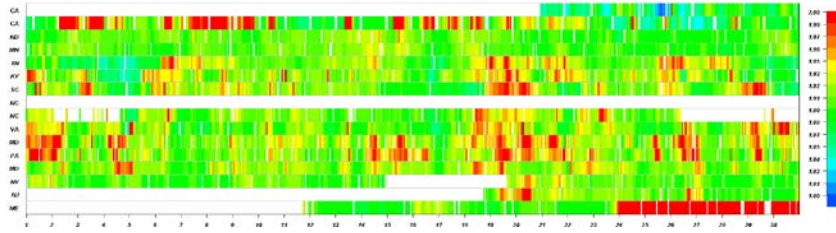
Carbon dioxide (CO₂) Levels



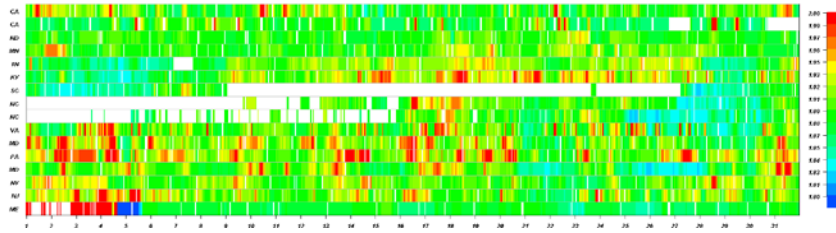
Methane



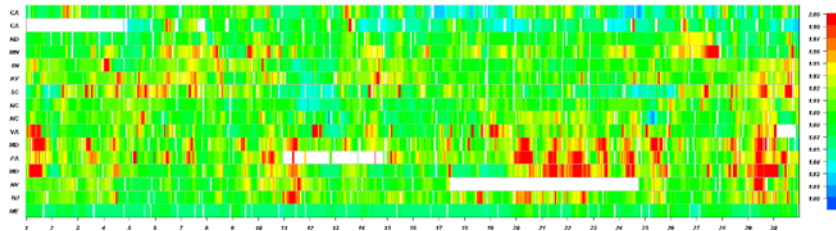
March



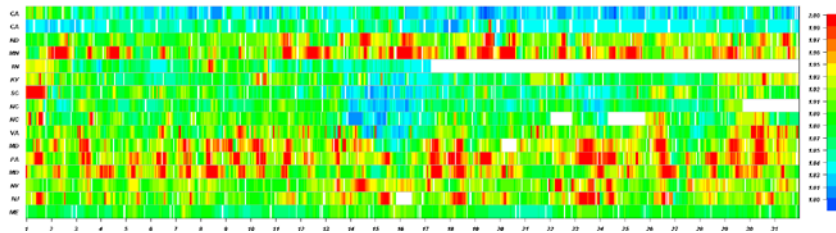
Apríl



May

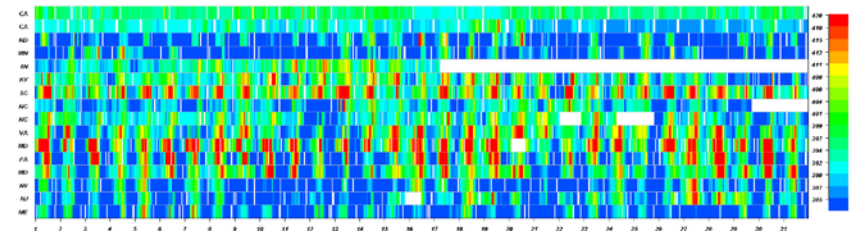
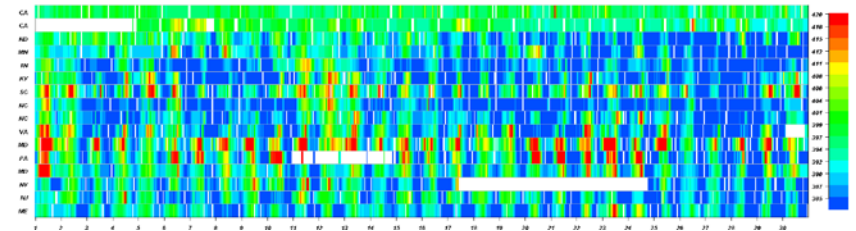
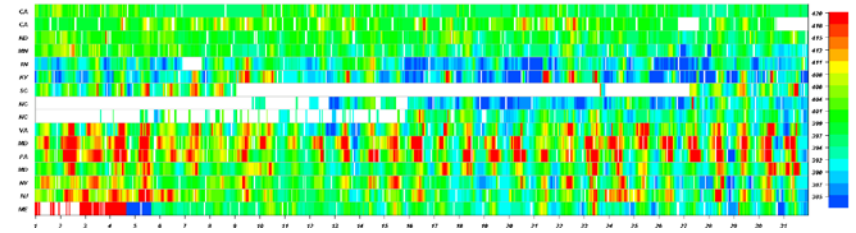
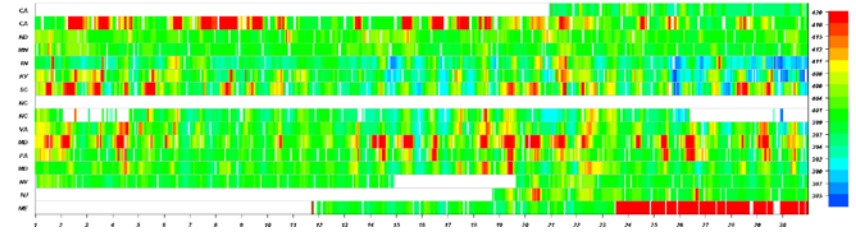
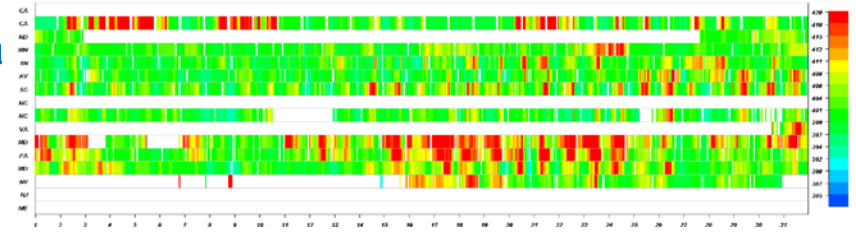


June



July

Carbon Dioxide

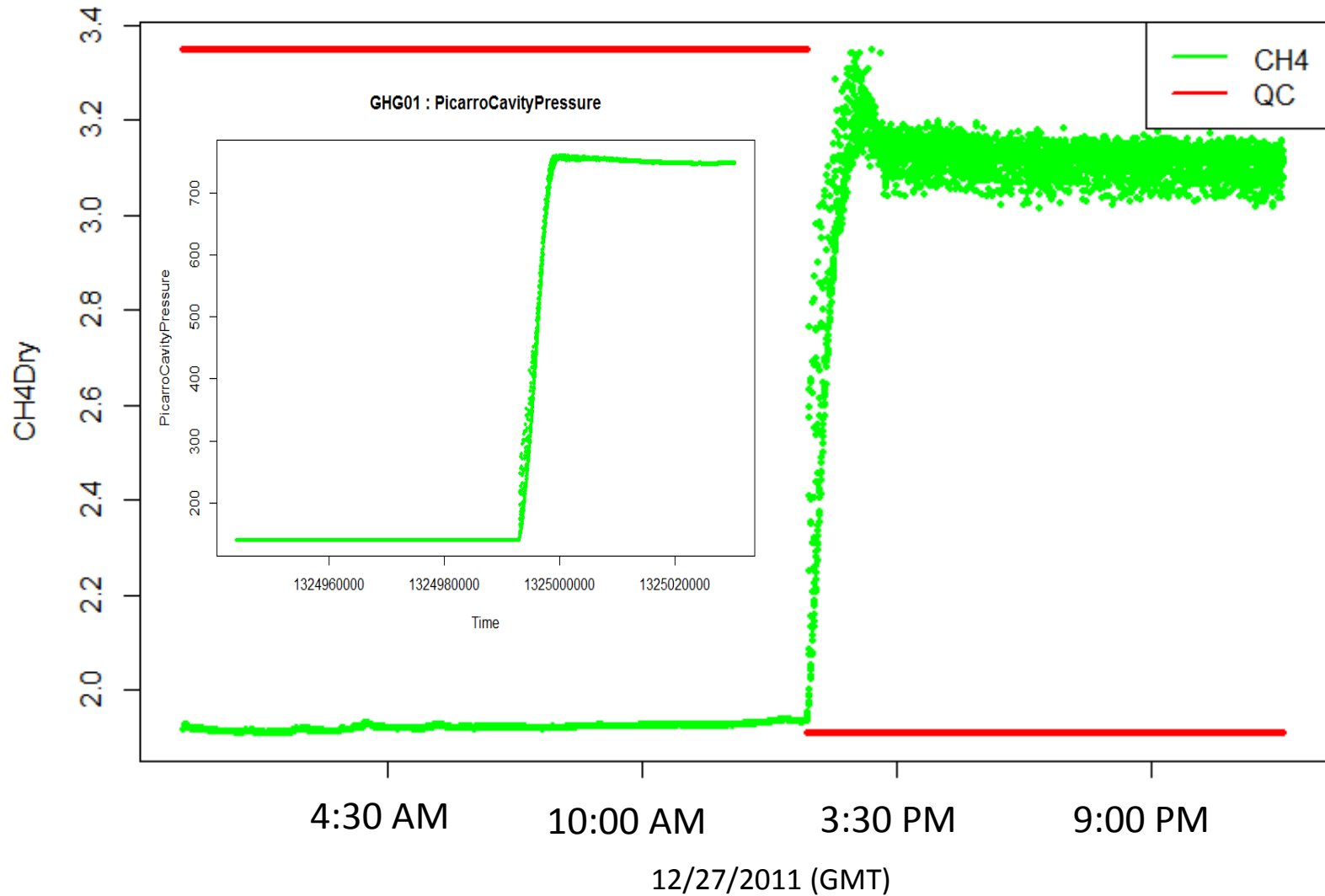


Earth Networks Data Sets

- 
- Level 0 – Raw Atmospheric, Operational and Metadata
 - Level 1 – QC flags included
 - Level 2 – Calibrations applied
 - Level 3 – Filter information included

Data QC

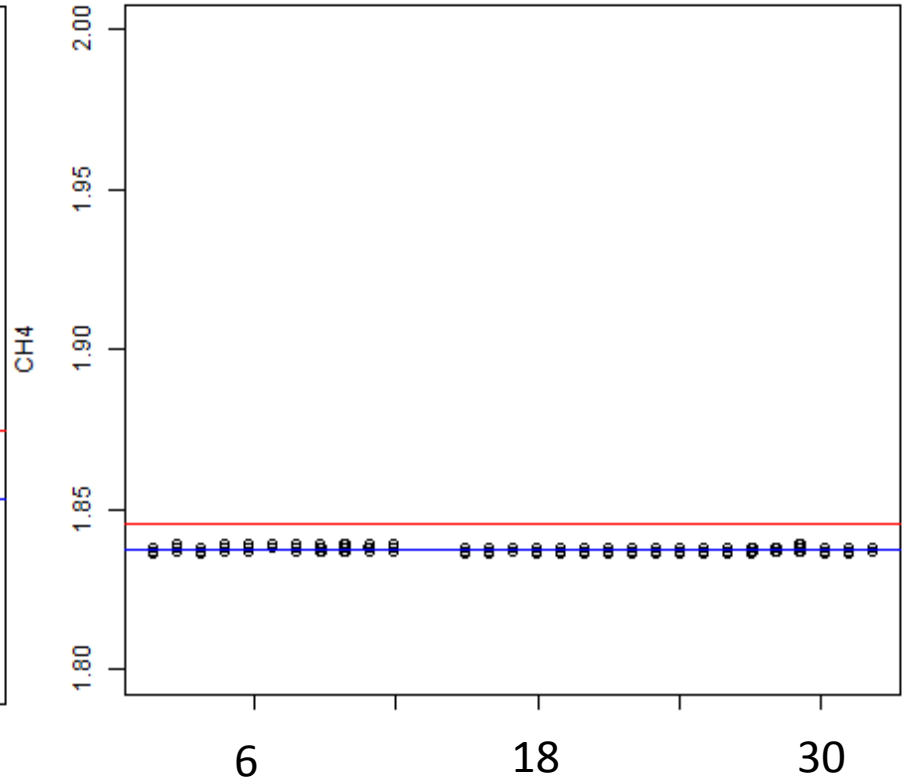
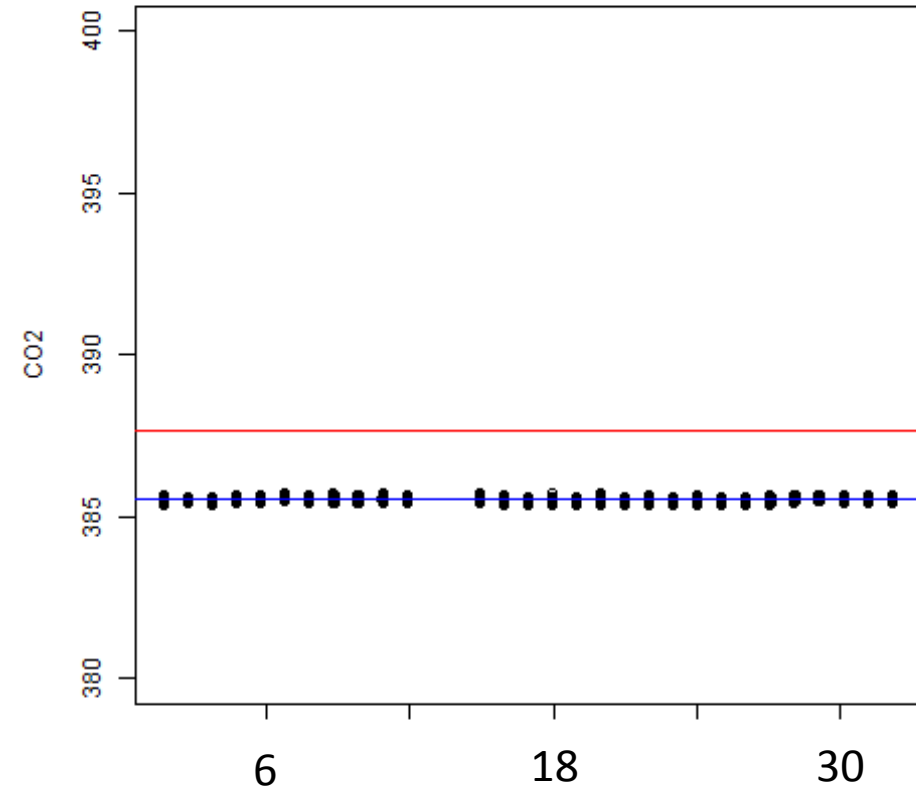
GHG01 : CH4Dry



Calibration

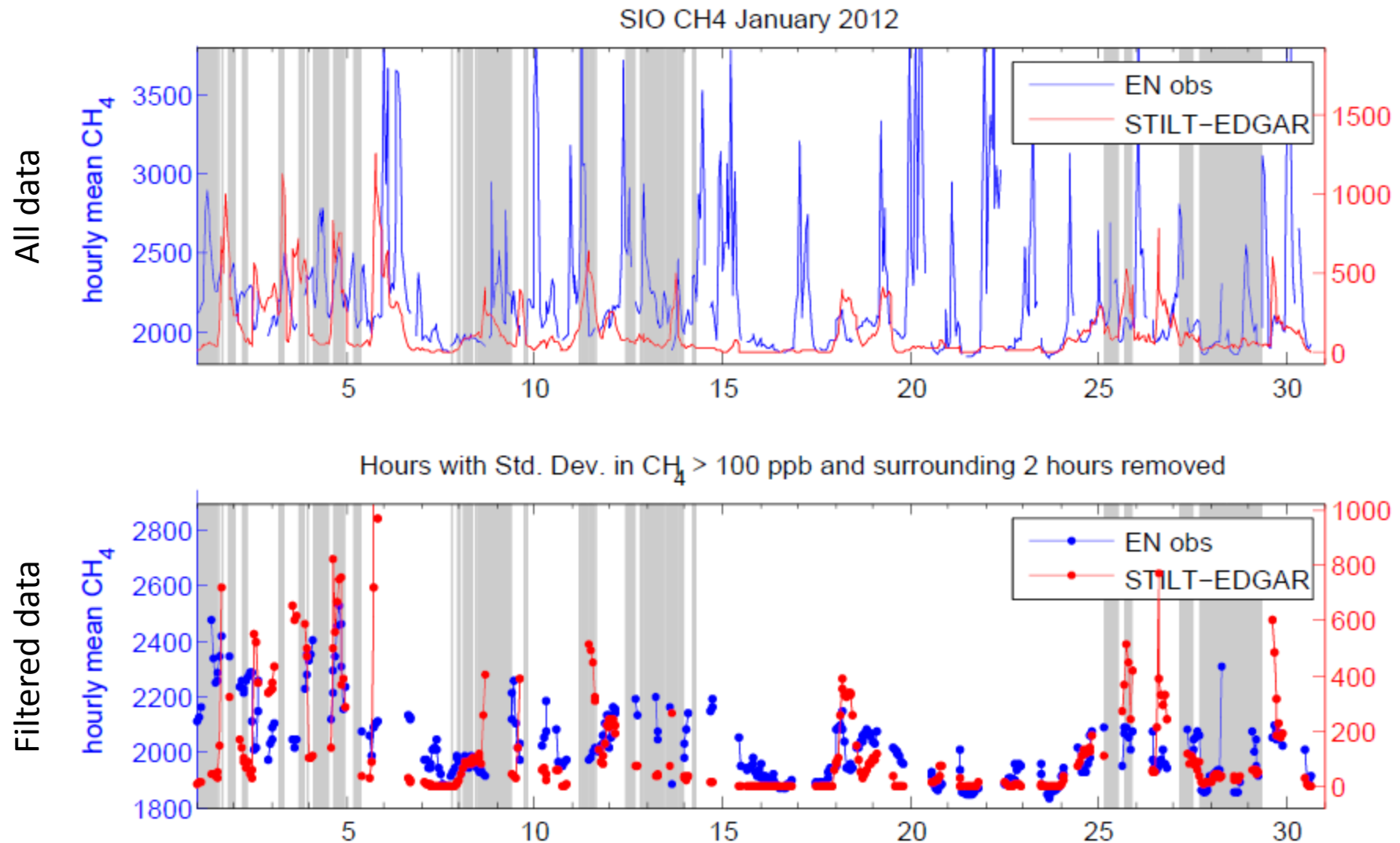
GHG01 : 385.520393803897

GHG01 : 1.83747109549665



March 2012

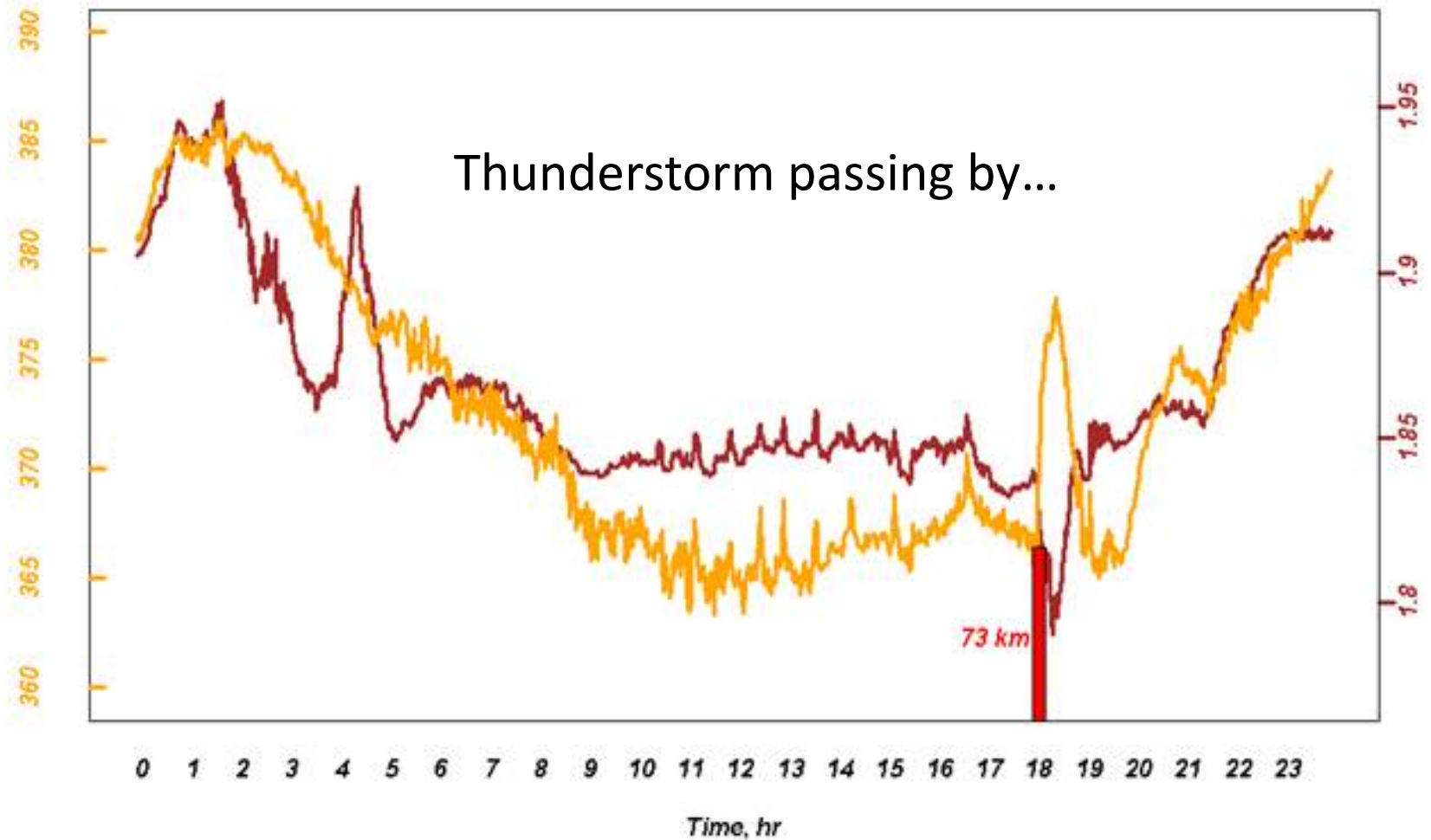
Variance Filter



* Heather Graven, UCSD

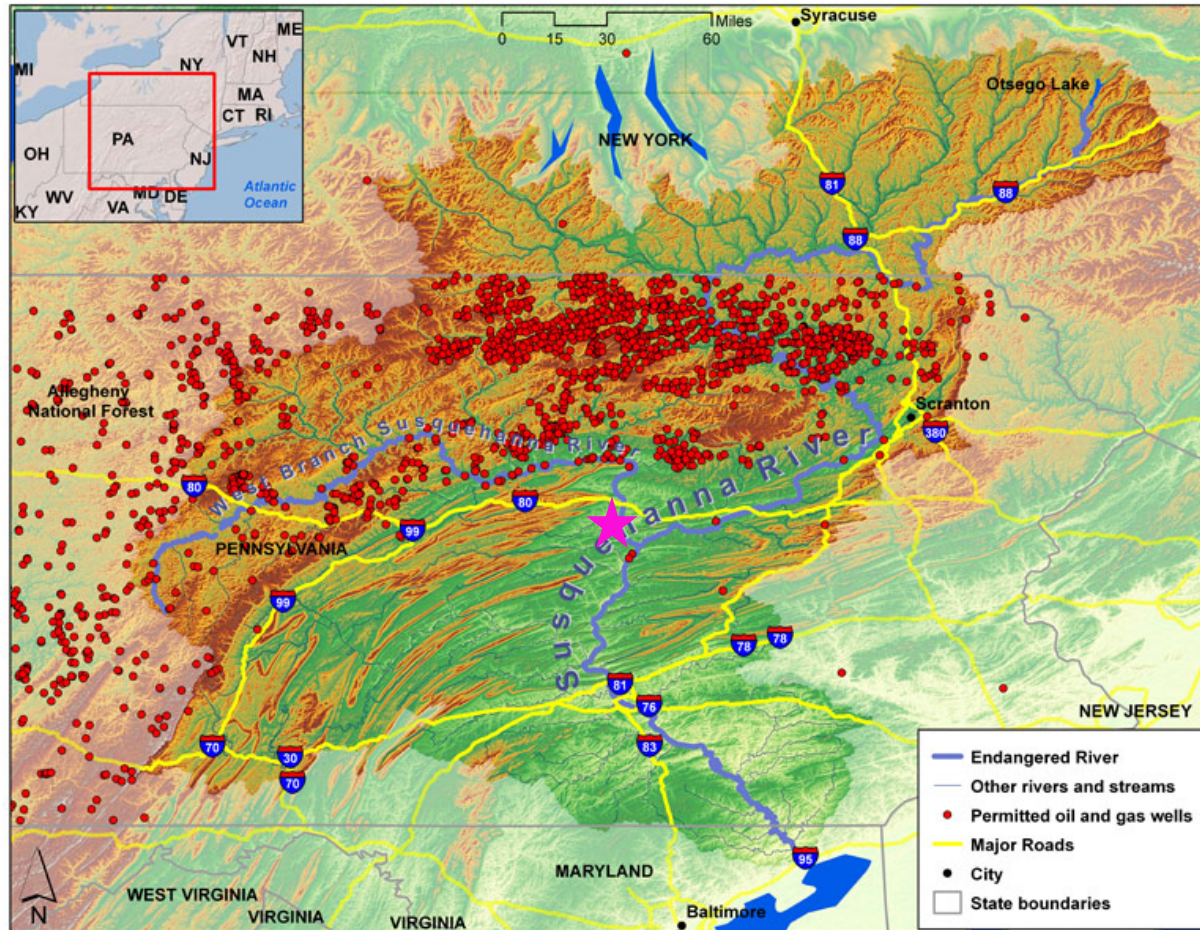
Turbulence Filter

CO₂ [ppm] and CH₄ [ppb] on July 11



Emissions Estimate Example...

Relevance to Gas and Oil Wells in PA



Source:

<http://www.americanrivers.org/our-work/protecting-rivers/endangered-rivers/endangered-susquehanna.html?gclid=CLC1oq-fj68CFUXc4AodTSv0zA>

Inversion Methodology: Region Analysis

Following LBNL's approach (Zhao et al., JGR, 2009):

A priori emission maps from different spatial regions in the domain are linearly scaled by factors λ , to provide *posterior* emissions that are optimally consistent with the tower measurements, C , and background air, C_{BG} , and predicted footprints, $f(x, y, z, t)$. λ_{prior} is the *a priori* scaling factor, typically assumed unity.

$$\hat{\underline{\lambda}} = (\underline{\underline{K}}^T \underline{\underline{S}}_{\varepsilon}^{-1} \underline{\underline{K}} + \underline{\underline{S}}_{prior}^{-1})^{-1} (\underline{\underline{K}}^T \underline{\underline{S}}_{\varepsilon}^{-1} \underline{y} + \underline{\underline{S}}_{prior}^{-1} \underline{\lambda}_{prior})$$

$$\hat{\underline{\underline{S}}}_{\lambda} = (\underline{\underline{K}}^T \underline{\underline{S}}_{\varepsilon}^{-1} \underline{\underline{K}} + \underline{\underline{S}}_{prior}^{-1})^{-1}$$

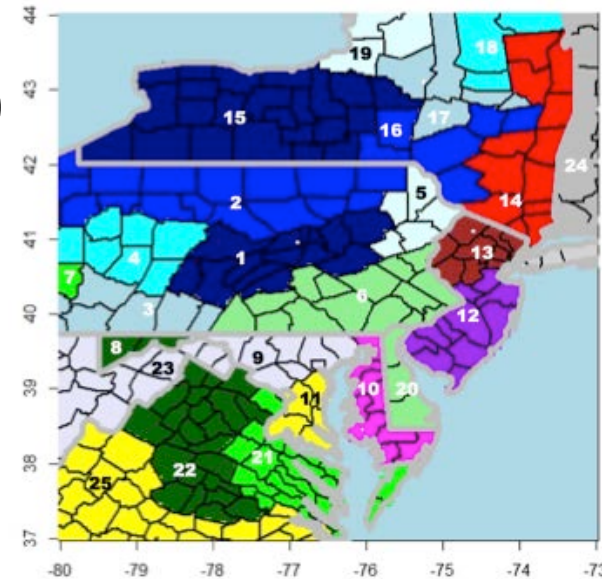
where:

X_r - location of the sensor, t_r - Time of measurement C ,

$$\underline{y} = \underline{C} - \underline{C}_{BG}$$

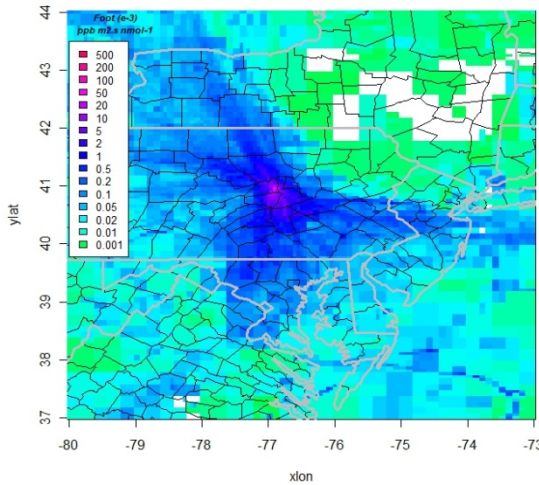
$$\underline{\underline{K}} \underline{\lambda} = \sum_{i,j,m} f(X_r, t_r | x_i, y_j, t_m) \cdot F(x_i, y_j, t_m) \quad \text{- footprint-flux sums over space and time,}$$

$\underline{\underline{S}}_{\varepsilon}$ - measurement error covariance matrix

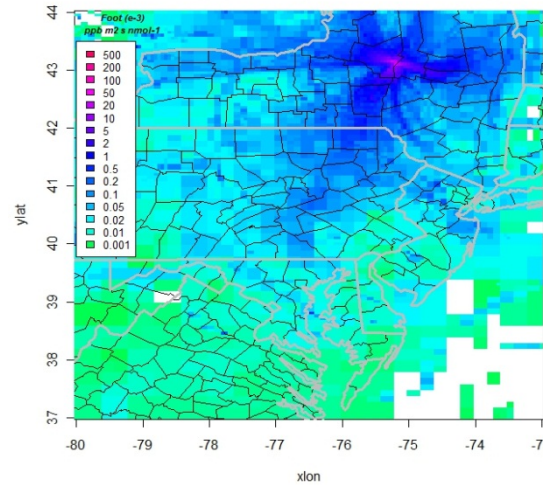


72hr Footprints and Multi-site Analysis

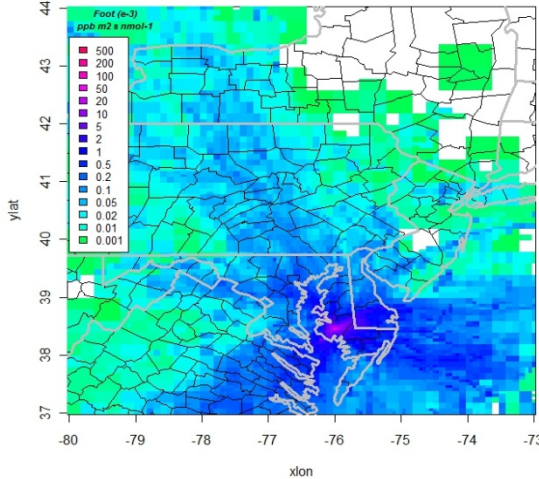
GHG25 - PA



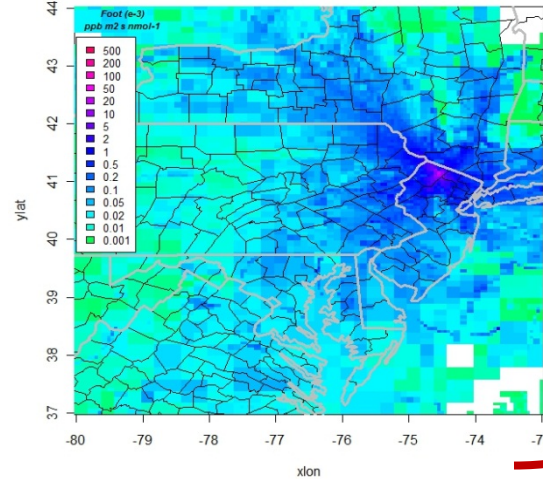
GHG38 - NY



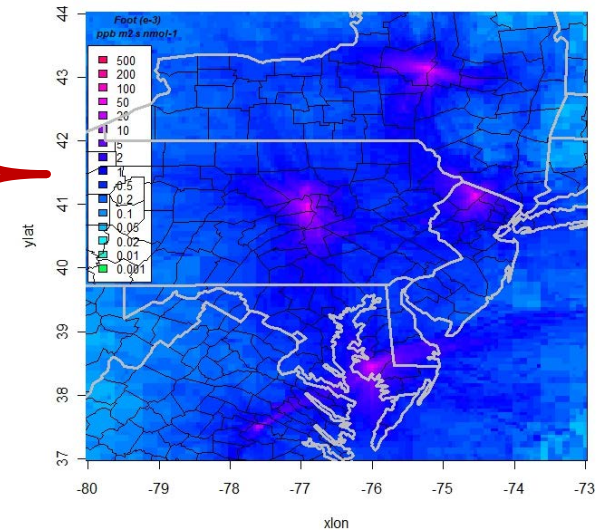
GHG01 - MD



GHG19 - NJ

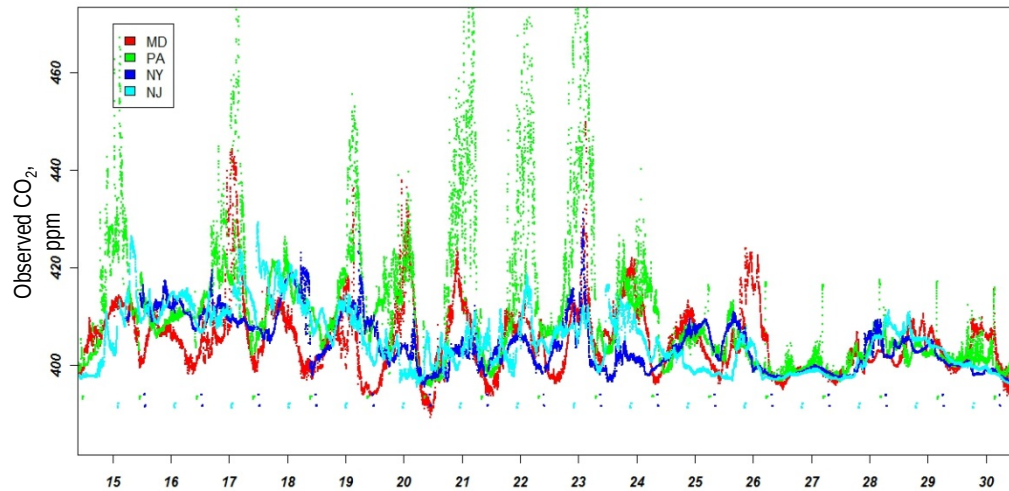


COMBINED
APR - MAY

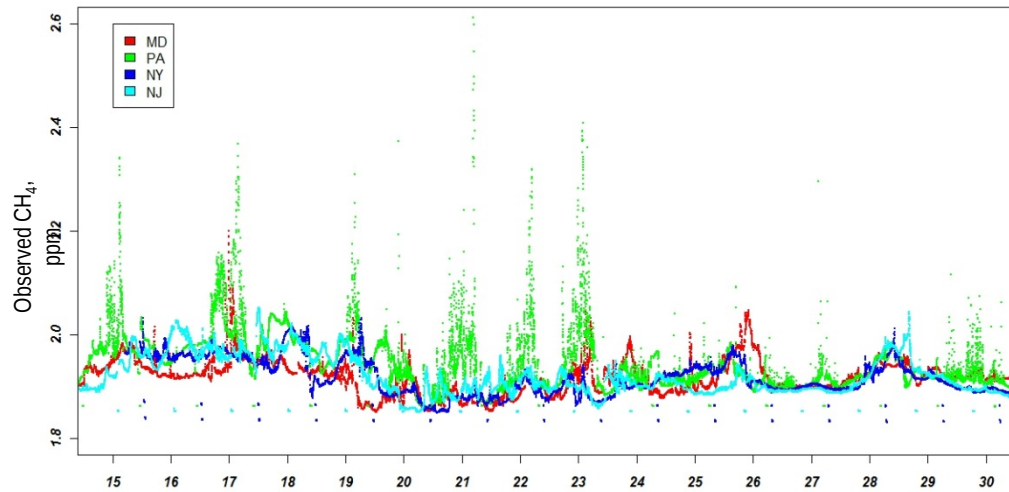


March 2012 monthly averaged 3-day backward footprints for mixing ratio measured at each tower

Recent Northeast Data

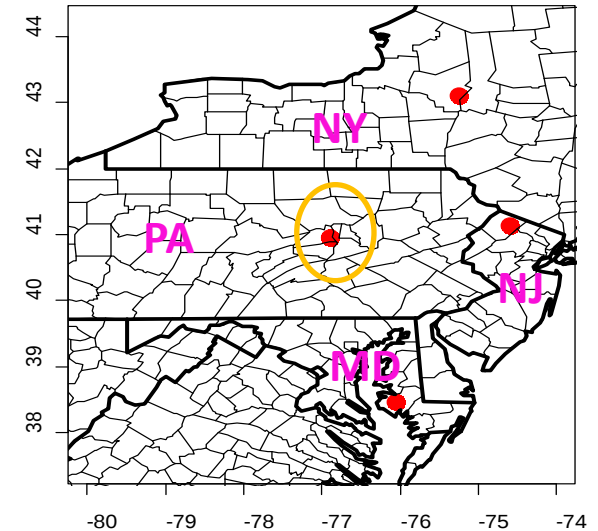


March 2012, UTC

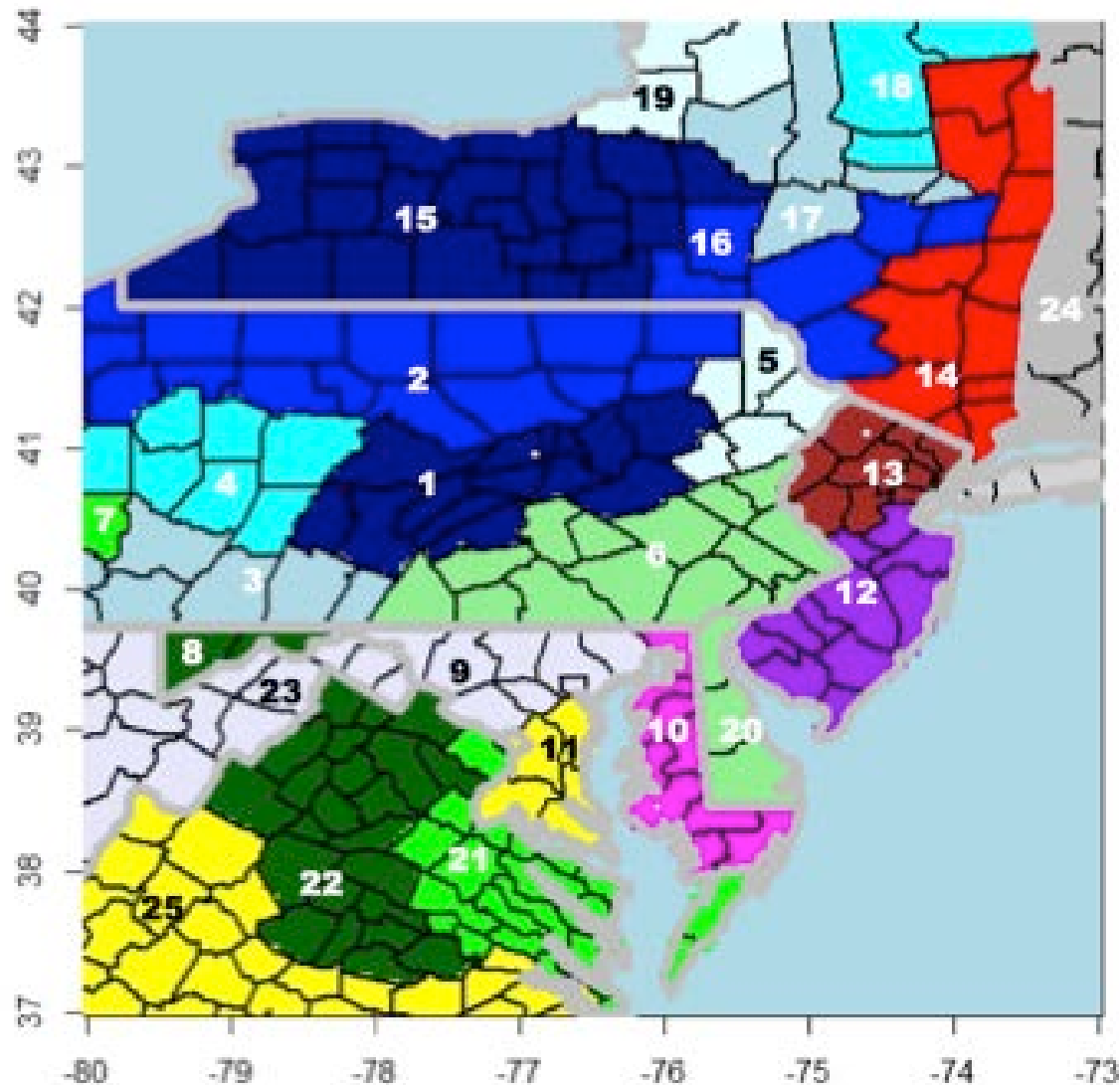


March 2012, UTC

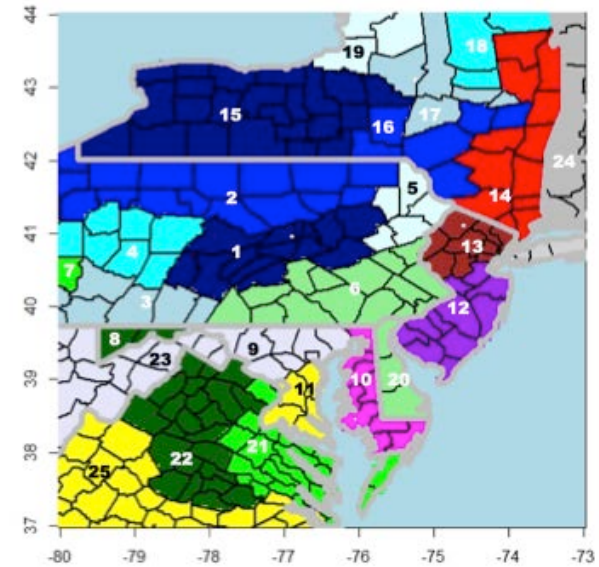
- Timeseries of CO₂ (top) and CH₄ (bottom) at the sites in MD, PA, NY and NJ on March 15-30, 2012 (top of the tower measurements)
- Line of lower points shows calibration data (once per day)



Spatial Regions in the Domain



Initial Inversion Results (Preliminary) April – May Data



Posterior Emissions by Region

Prior Emissions = 1

