Development of a Mobile Tracer Correlation Method for Assessment of Air Emissions from Landfills and Other Area Sources

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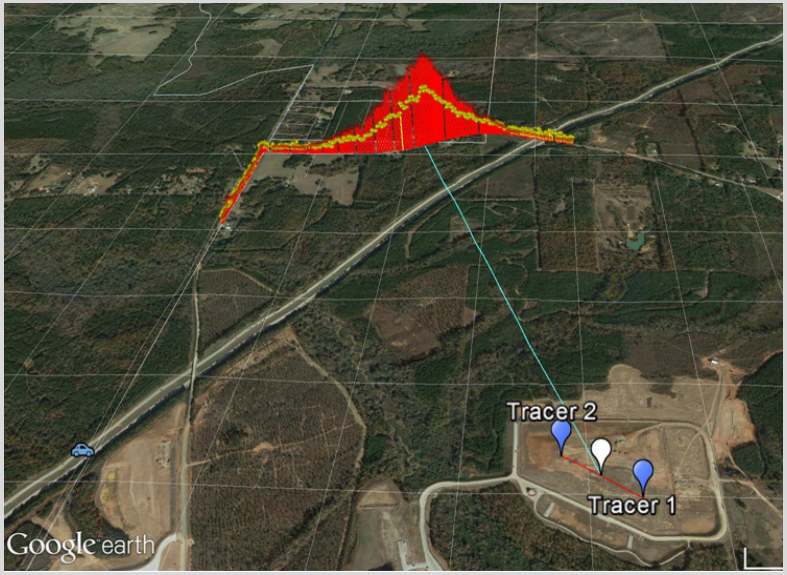

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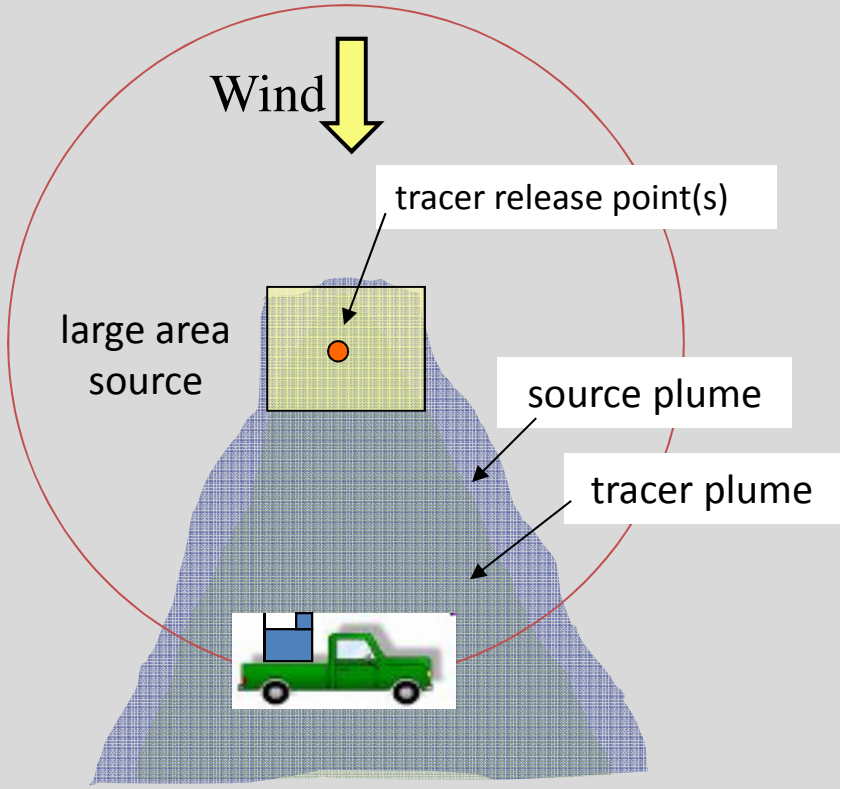
Background

- Large area sources like landfills present many emissions measurement challenges:
  - Large in extent, spatially variable emissions
  - Temporally variable, difficult to model
- Measurement tools such as flux boxes and EPA OTM 10 provide a “picture” of emissions from parts of a landfill
- A technique that provides whole-facility emission measurements is a valuable complementary tool

Background

- Mobile tracer correlation is a simple approach for measuring large area source emissions
- Use mobile monitor to map target source and tracer plumes
- Calculate dilution ratio based on known tracer release rate



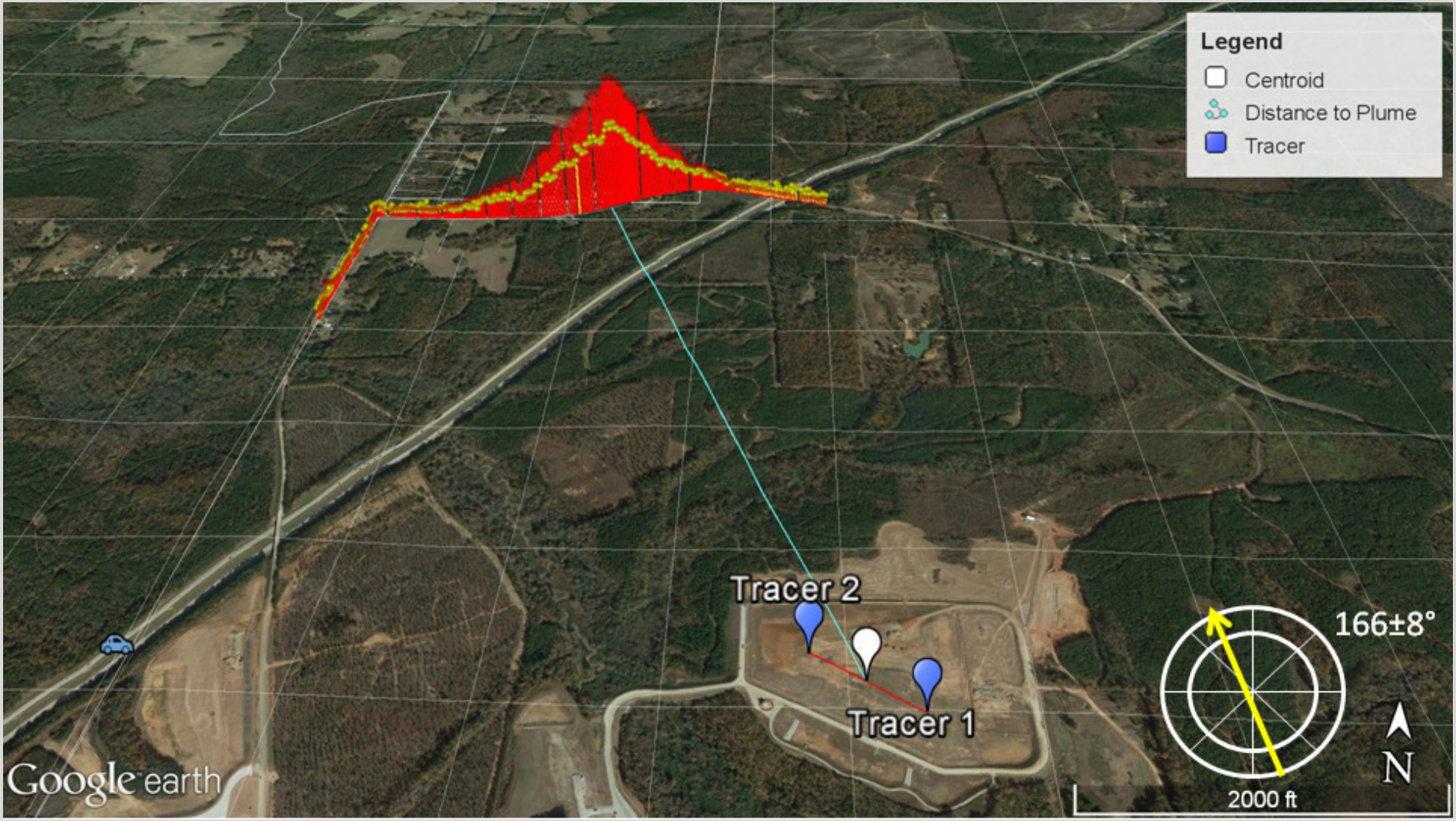
Background

- Mobile tracer correlation has been well-published in the literature using somewhat complex instruments (Quantum cascade lasers and FTIRs)
- Our project explores a more implementable form of the approach that uses high performance but simple to use instruments and a new tracer gas option (acetylene)
- This work supports development of an EPA preliminary method called OTM 33B and is based on real-world testing
- Waste Management and other Landfill companies through EREF are partnering with U.S. EPA to develop OTM 33B

This Talk

- Reviews the tracer correlation approach
  - Tracer setup
  - Equipment
  - Data analysis software
  - Emissions calculations
- Describes the field test sites
- Discusses preliminary method quality indicators (MQIs)
- Describes a few measurement scenarios and summarizes data completeness results

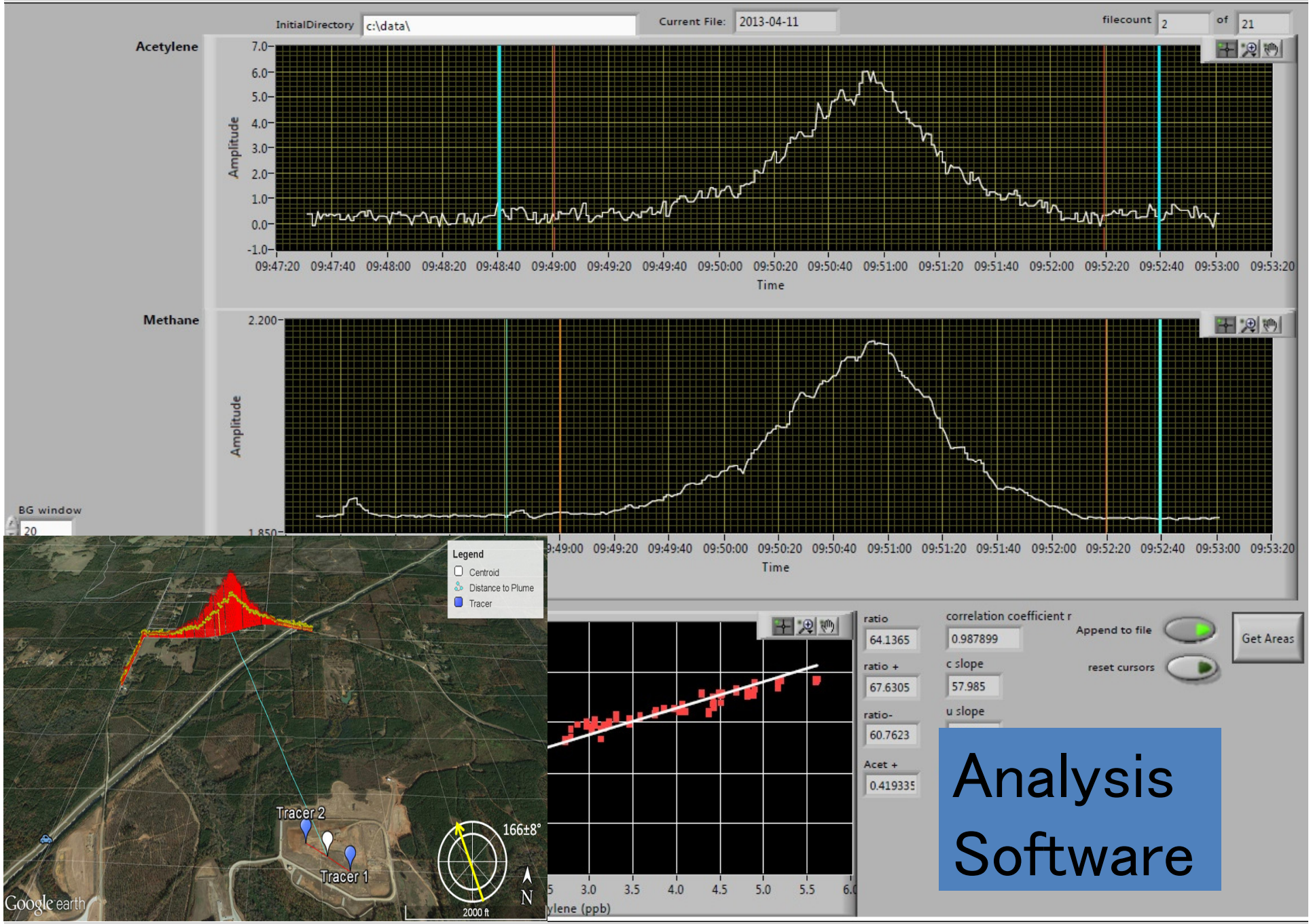
GMAP-REQ-Tracer Correlation (TC)

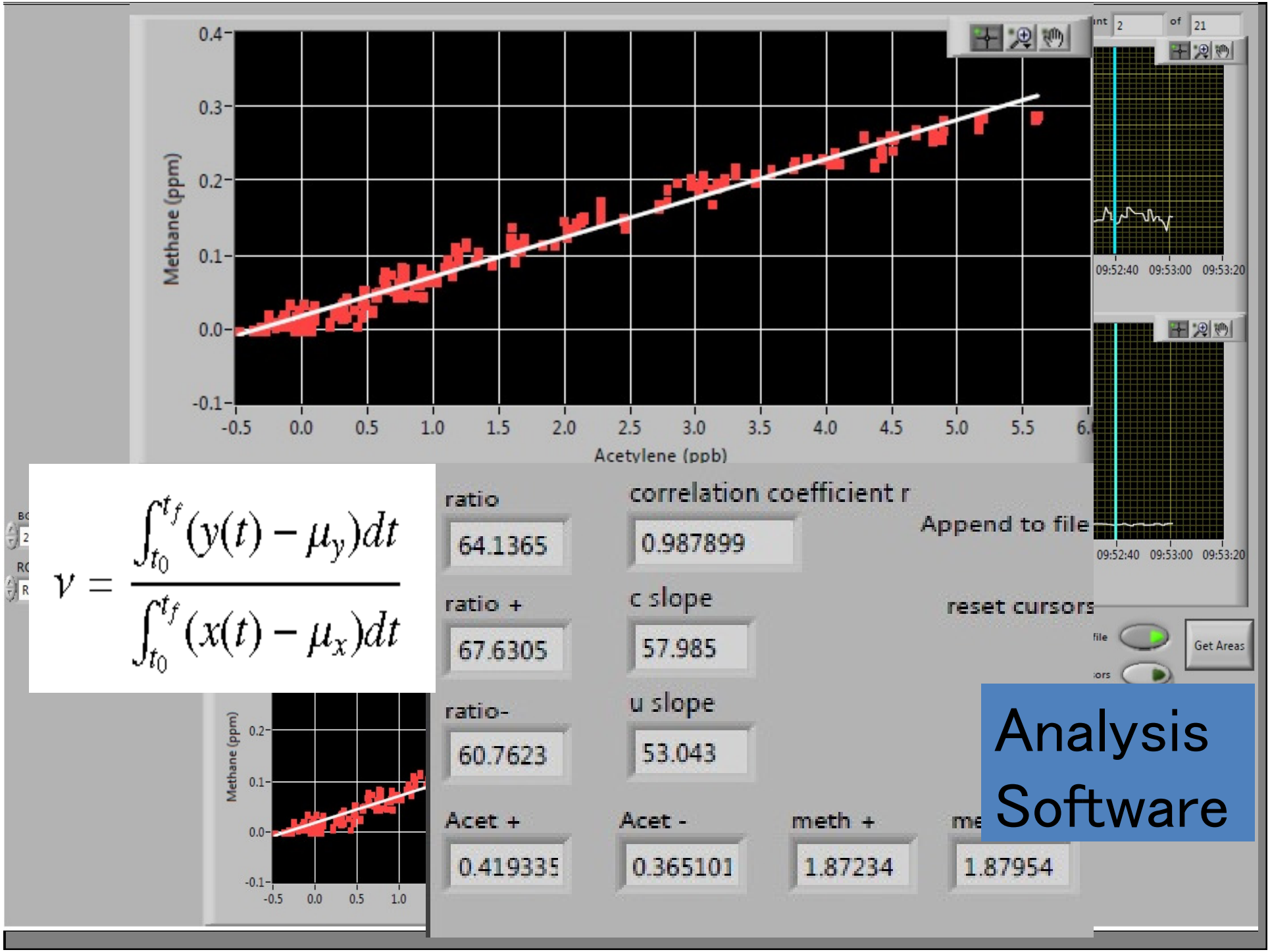


Tracer Setup

geometrical approach
two forms

Equipment (CRDS and C_2H_2)


InitialDirectory
c:\data\
Current File:
2013-04-11
filecount
2
of
21
Acetylene
Amplitude
Time
Methane
Amplitude
Time
BG window
20
Legend
Centroid
Distance to Plume
Tracer
Tracer 2
Tracer 1
166±8°
N
2000 ft
Google earth
ratio
64.1365
ratio +
67.6305
ratio-
60.7623
Acet +
0.419335
correlation coefficient r
0.987899
c slope
57.985
u slope
Append to file
reset cursors
Get Areas
Analysis Software


Methane (ppm)
Acetylene (ppb)
0.4
0.3
0.2
0.1
0.0
-0.1
-0.5
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
5.5
int 2
of 21
09:52:40
09:53:00
09:53:20
$\nu = \frac{\int_{t_0}^{t_f} (y(t) - \mu_y) dt}{\int_{t_0}^{t_f} (x(t) - \mu_x) dt}$
ratio
64.1365
correlation coefficient r
0.987899
Append to file
ratio +
67.6305
c slope
57.985
reset cursors
file
Get Areas
ratio-
60.7623
u slope
53.043
Acet +
0.419335
Acet -
0.365101
meth +
1.87234
1.87954
Analysis Software

EQUATIONS

m – u slope
ν – ratio

$$Q_{\mathrm{CH_4,\,m}} = (m)Q_t \frac{M_{\mathrm{CH_4}}}{M_{\mathrm{C_2H_2}}}$$

$$Q_{\mathrm{CH_4},\nu} = (\nu)Q_t \frac{M_{\mathrm{CH_4}}}{M_{\mathrm{C_2H_2}}}$$

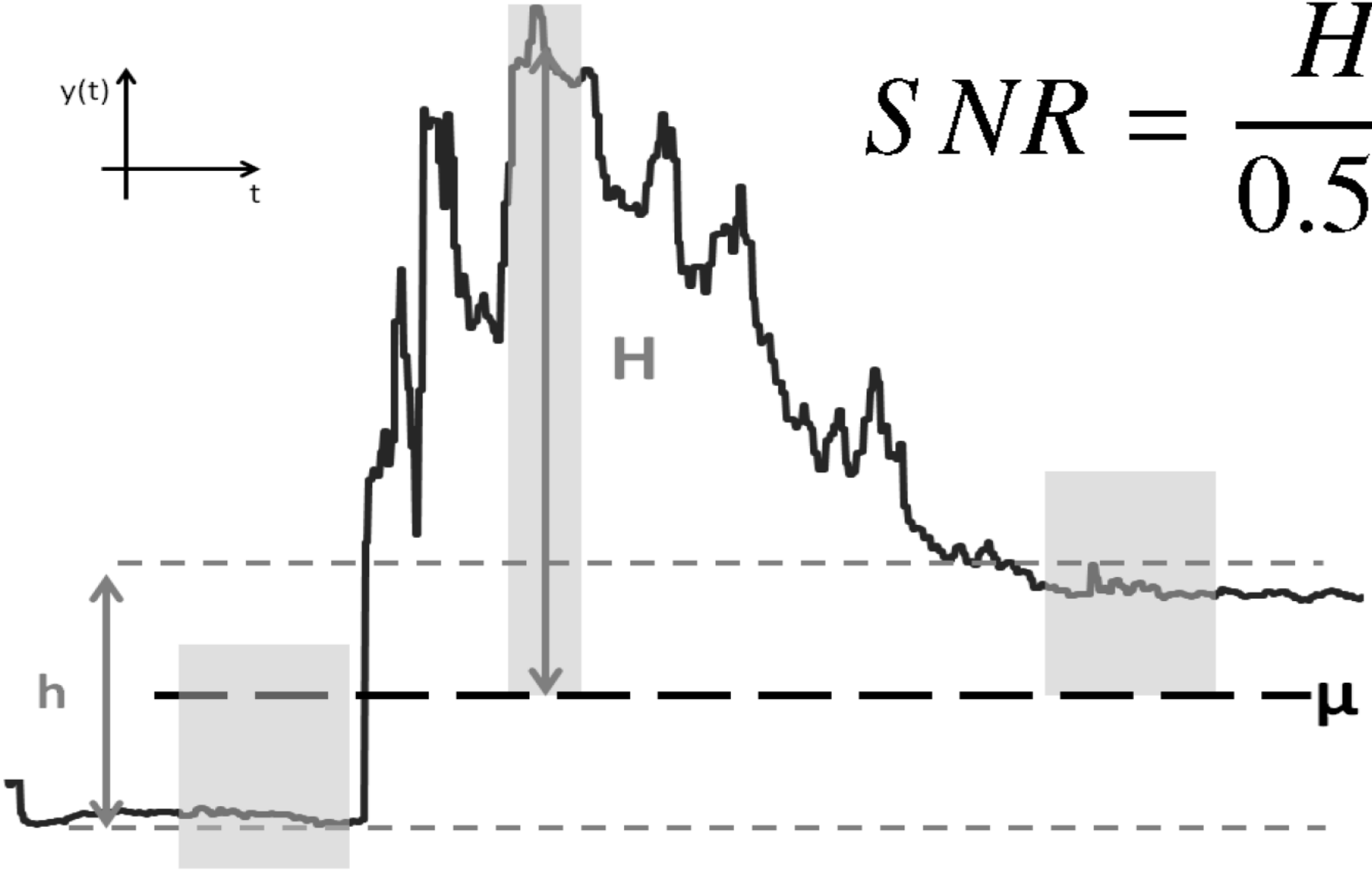
$$ERD = \frac{|Q_{\mathrm{CH4},\nu} - Q_{\mathrm{CH4,m}}|}{.5(Q_{\mathrm{CH4},\nu} + Q_{\mathrm{CH4,m}})}$$

Field sites for testing

Site Code	Location	Year	Studies (days)	Transects	Low/High
CA1	CA	2009	1(1)	26	High
CA2	CA	2009	1(1)	21	High
GA1	GA	2012	1(2)	9	High
GA2	GA	2011-2013	10(35)	443	Low
IL1	IL	2013	3(10)	163	Low
IN1	IN	2010-2011	5(9)	100	High
IN2	IN	2010-2011	6(8)	149	Low
IN3	IN	2009-2012	11(24)	331	High
KS1	KS	2012-2013	6(18)	321	High
KY1	KY	2010	3(5)	58	High
NM1	NM	2011	1(2)	7	Low
OH1	OH	2010	2(4)	41	Low
OH2	OH	2010	1(1)	20	Low
OH3	OH	2010	2(4)	48	High
OH4	OH	2010	3(7)	139	High
15 sites	8 states	5 years	56(131)	1876	-

MQI 1: Signal to Noise Ratio (SNR)

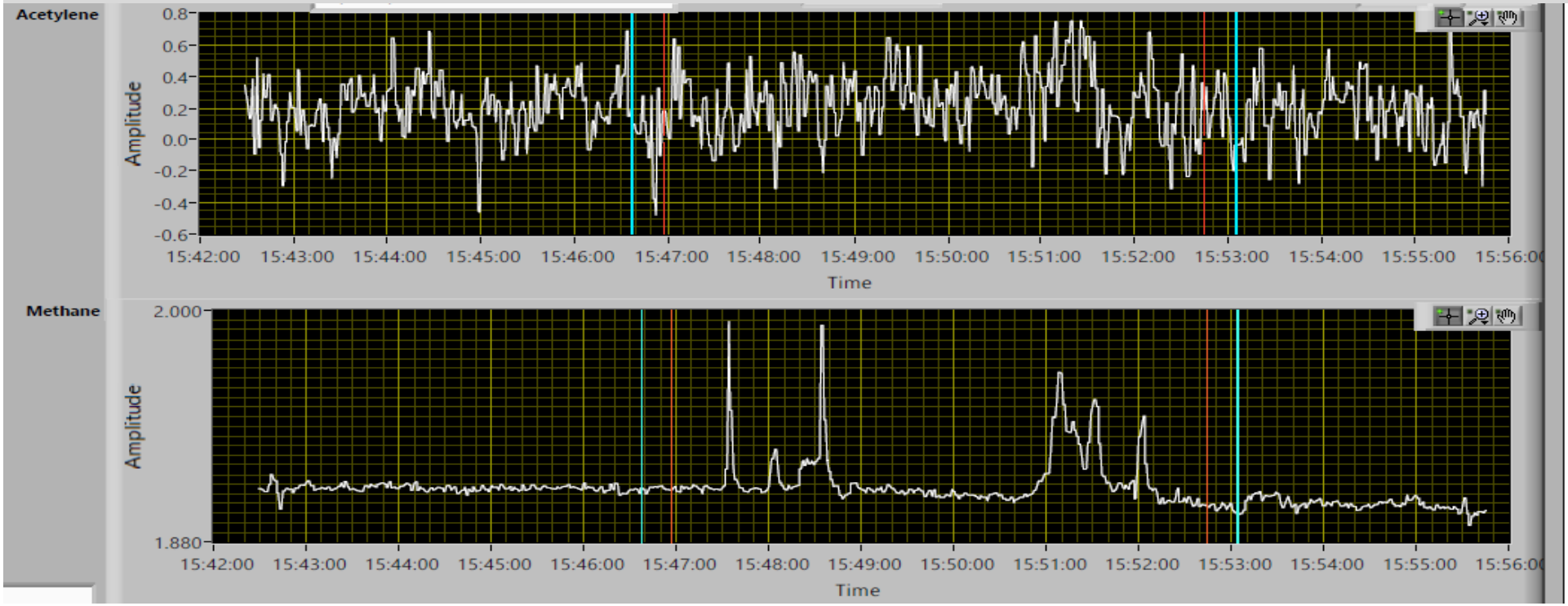
$$SNR = \frac{H}{0.5h}$$



Analysis

- Invalid Data
  - Visual Inspection
  - Signal to Noise Ratio (SNR) < 3
  - Distance < 500 m
  - Before/after tracer release

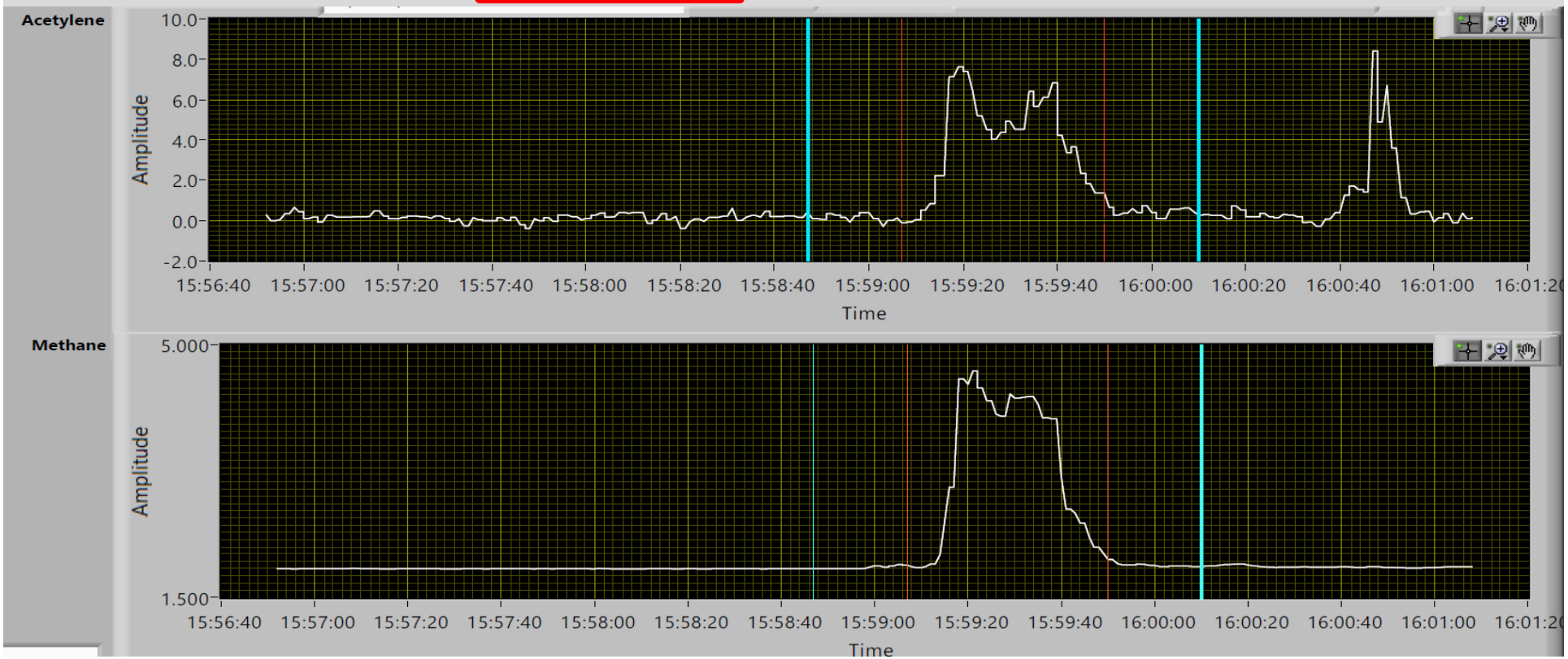
- 1366 transects (73 %)



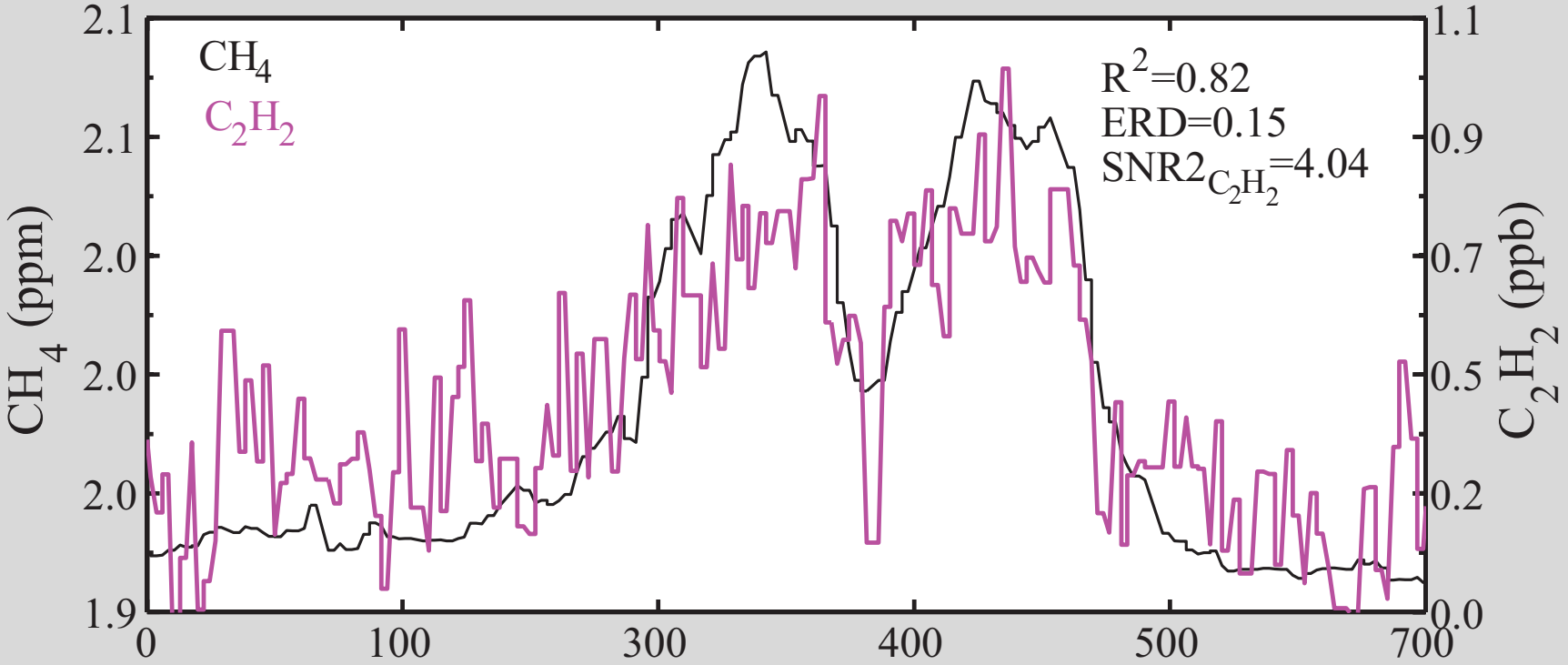
Analysis

- Acceptable Data
  - SNR > 10
  - Emission Rate Difference (ERD) < 20 %
  - R^2 > 80 %

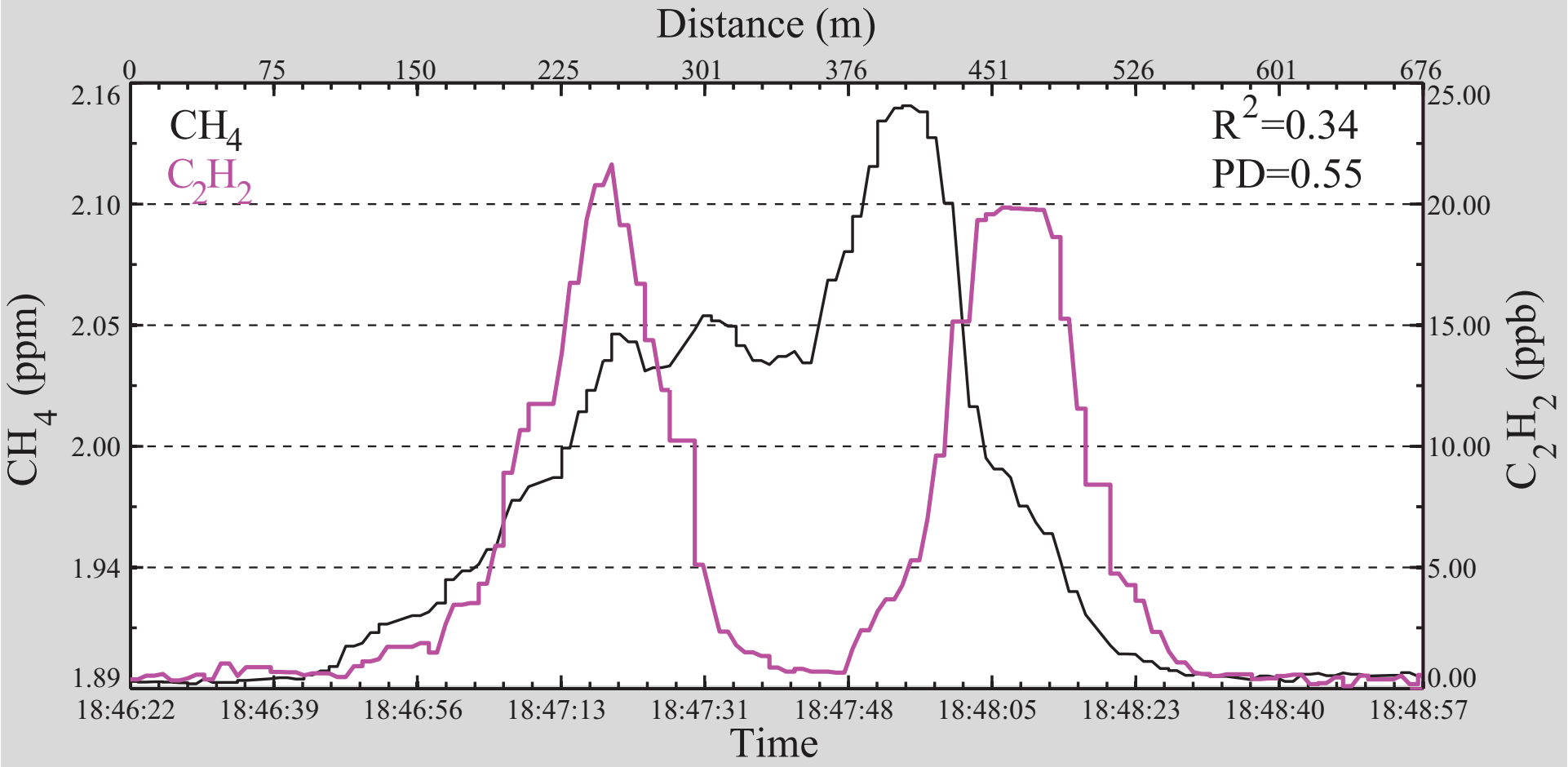
- 456 transects (33 %)
  - SNR – 936 (69 %)
  - ERD – 731 (54 %)
  - R^2 – 751 (55 %)



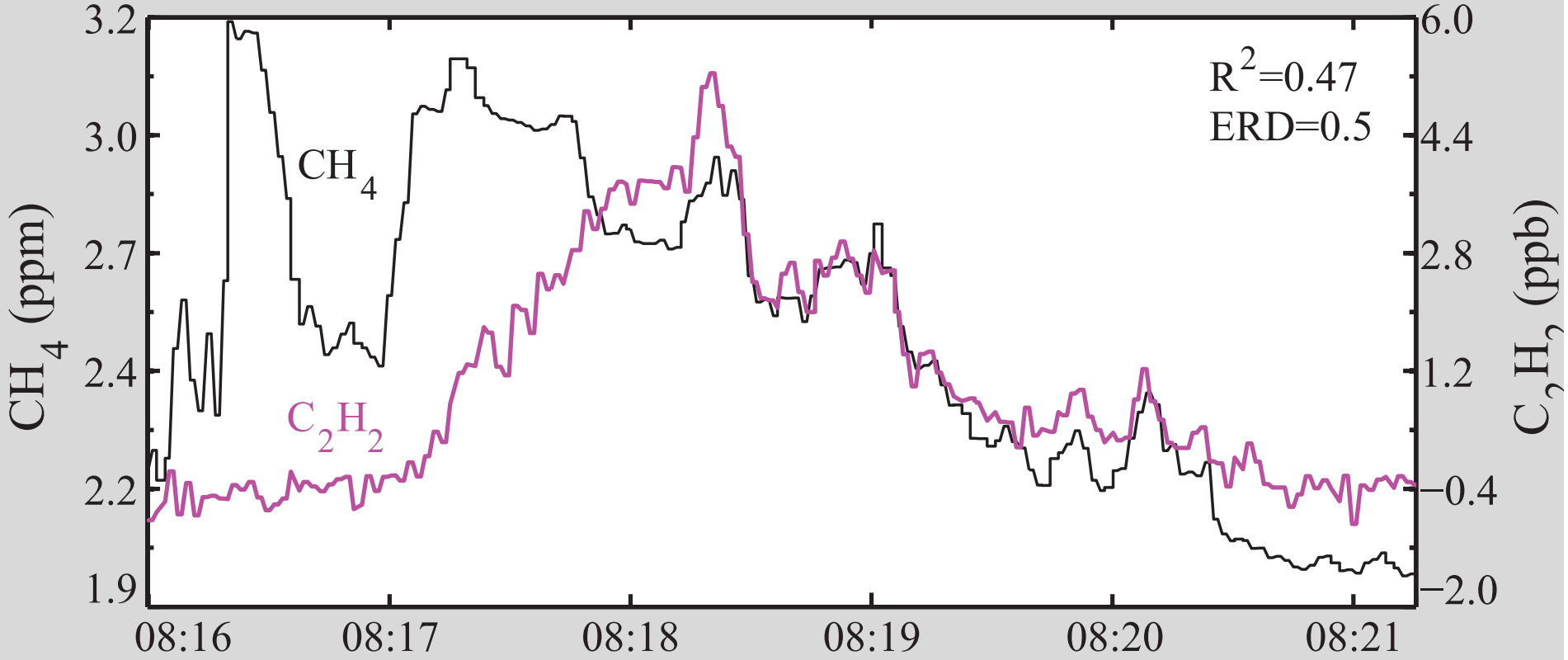
MQI 1: Signal to Noise (SNR)



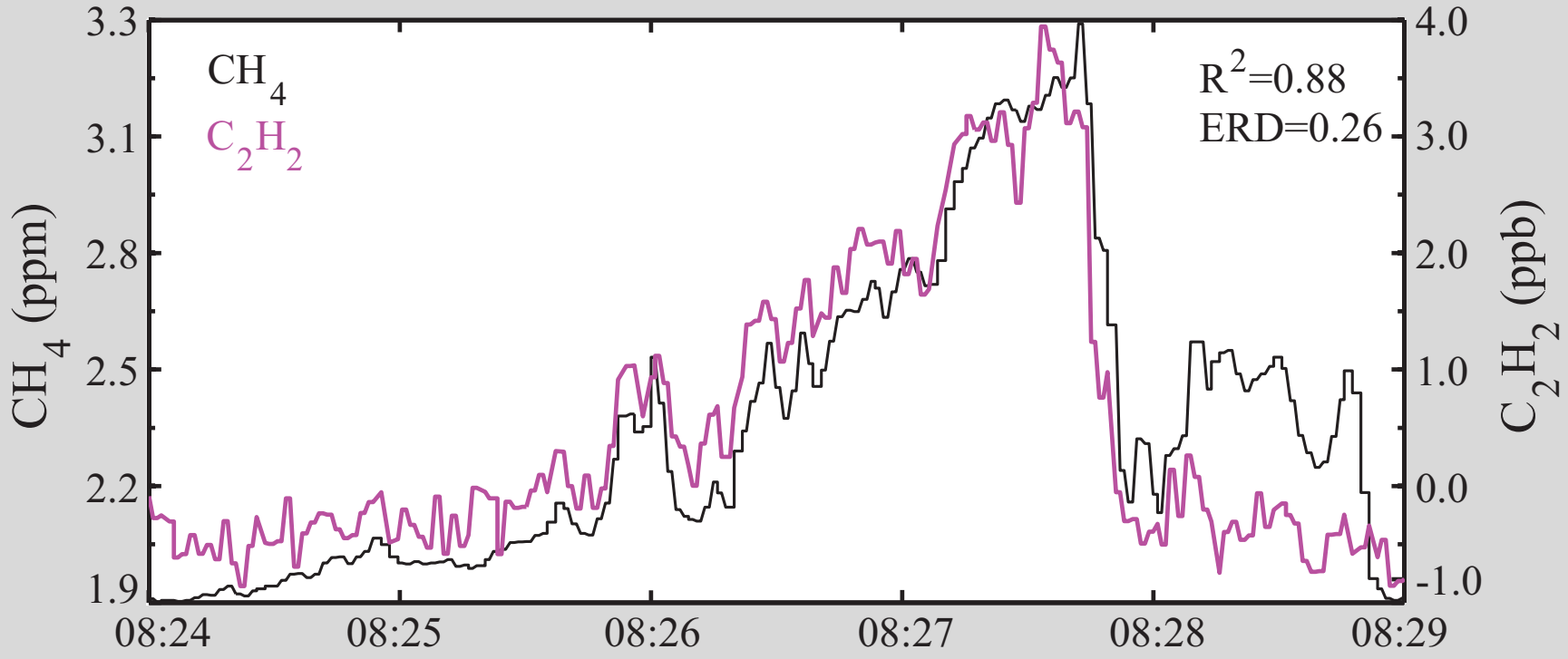
MQI 2: R-Squared

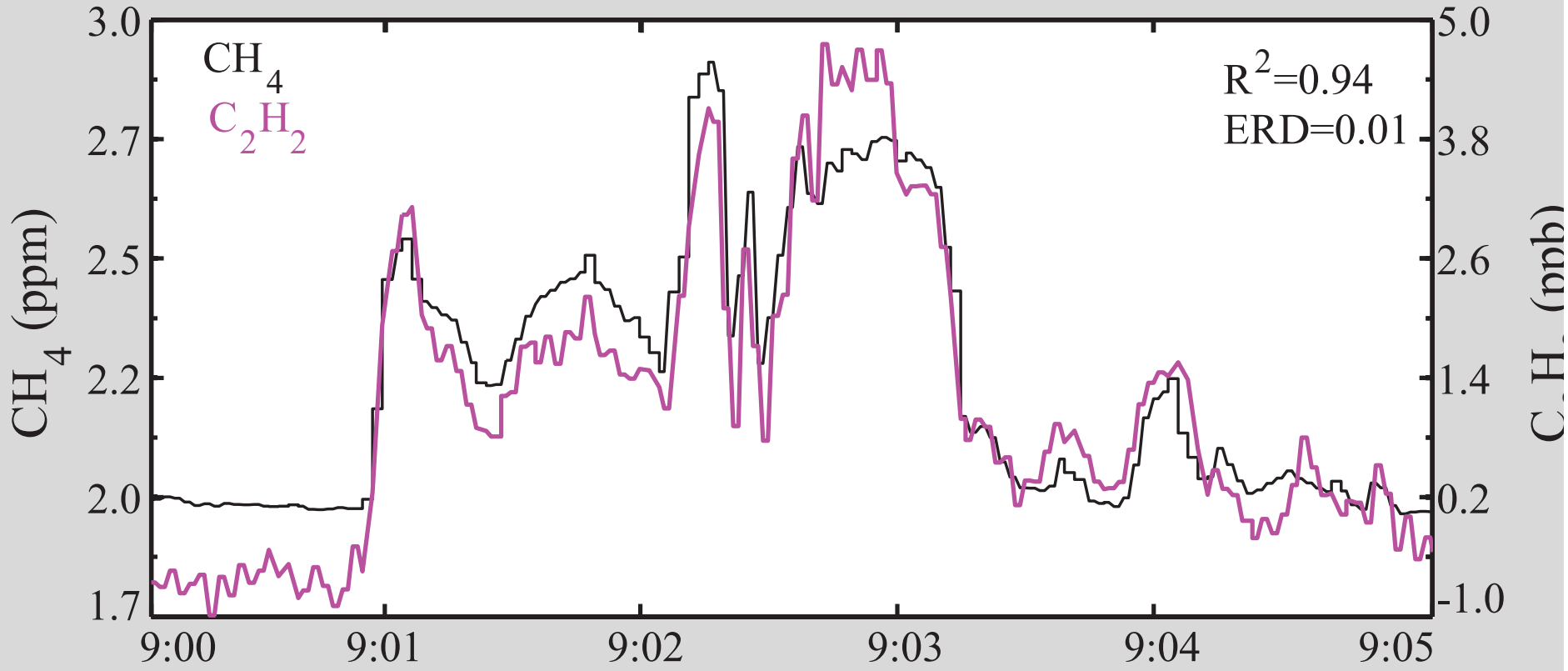


Pooling

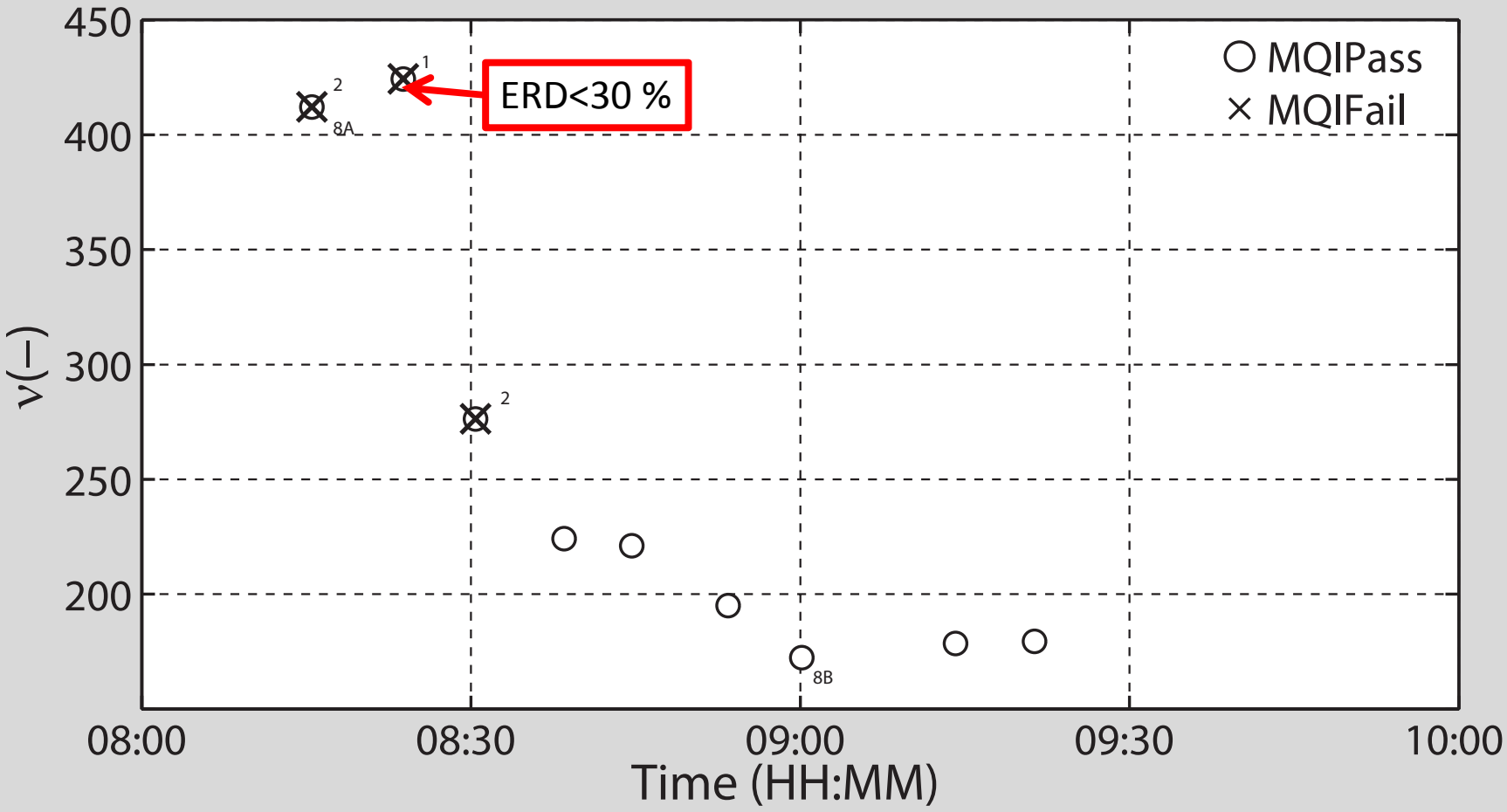

3.2
3.0
2.7
2.4
2.2
1.9
CH4 (ppm)
6.0
4.4
2.8
1.2
−0.4
−2.0
C2H2 (ppb)
CH4
C2H2
R2=0.47
ERD=0.5
08:16
08:17
08:18
08:19
08:20
08:21

MQI 3: Emission Rate Difference

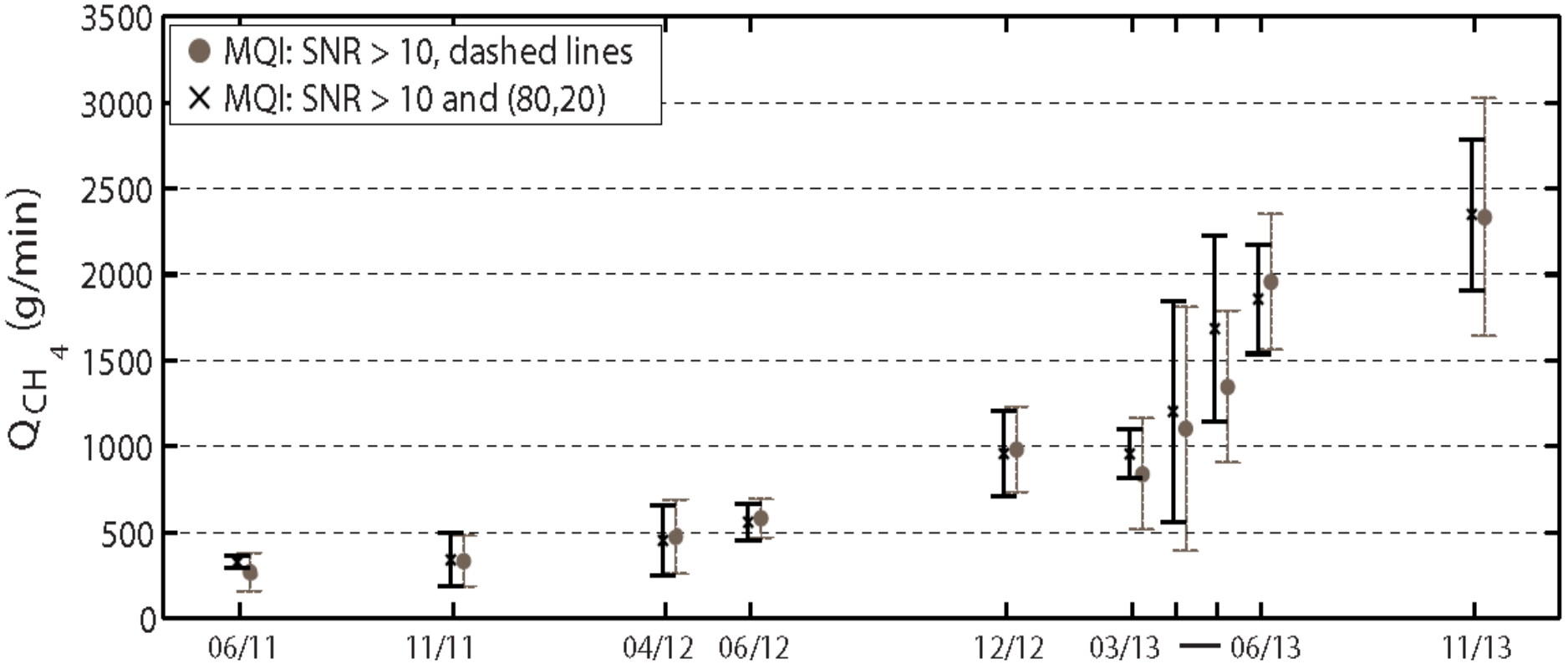



CH4
C2H2
R2=0.94
ERD=0.01
CH4 (ppm)
C2H2 (ppb)
3.0
2.7
2.5
2.2
2.0
1.7
5.0
3.8
2.6
1.4
0.2
-1.0
9:00
9:01
9:02
9:03
9:04
9:05

Results: MQI Effects



Results: GA2 Emissions



Field study data completes rates

- 1366 Valid Transects
  - SNR > 3
  - Distance > 500 meters

- 456 Acceptable Transects using the MQIs:
  - SNR > 10
  - R^2 > 80 %
  - ERD < 20 %

Summary

- A more implementable form of mobile tracer correlation was successfully used to measure methane emissions in 56 real-world field studies in 15 landfills around the U.S.
- General quality assurance metrics including signal to noise ratio (SNR), emissions rate difference (ERD) and plume to tracer correlation (R^2) were developed
- This information will be helpful in development of a standardized mobile tracer correlation method called OTM 33B

Thank You