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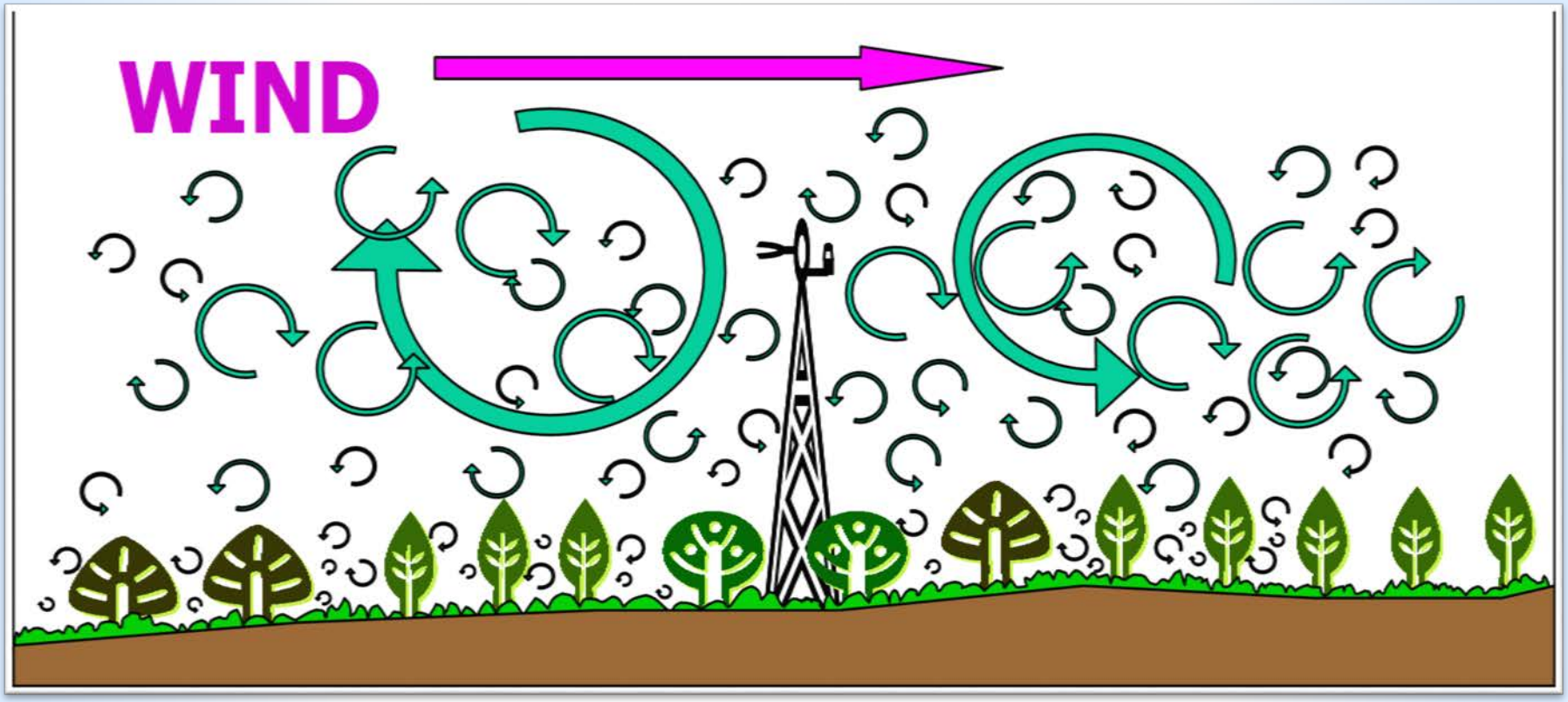
Impact of Changes in Barometric Pressure on Landfill Methane Emission

Outline

- Eddy-covariance method
- Site information
- Result
- Implications

Eddy covariance (EC) method



EC method: the basic

$$Flux = \overline{ws}$$

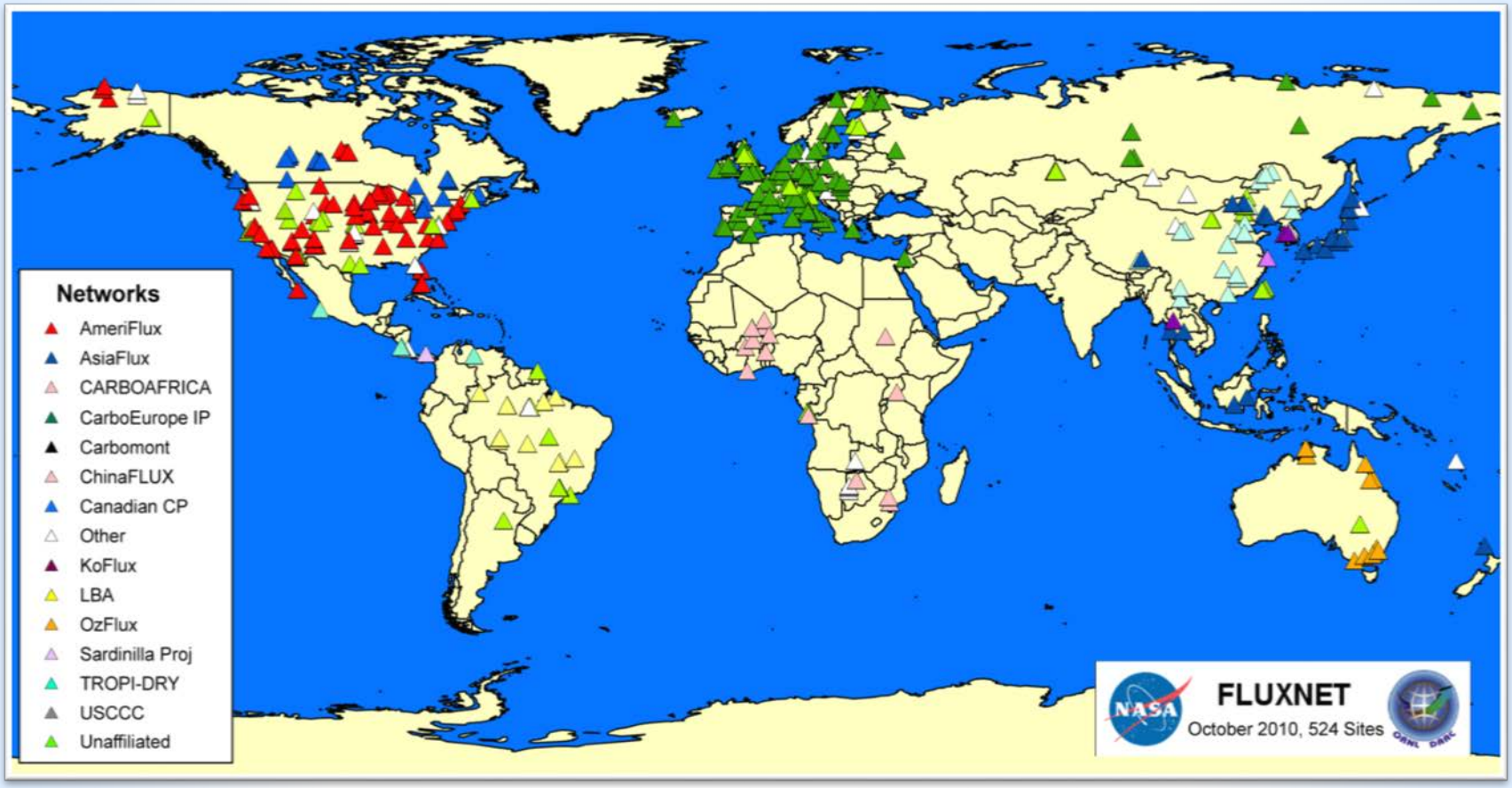
w: vertical wind speed (m s^{-1})

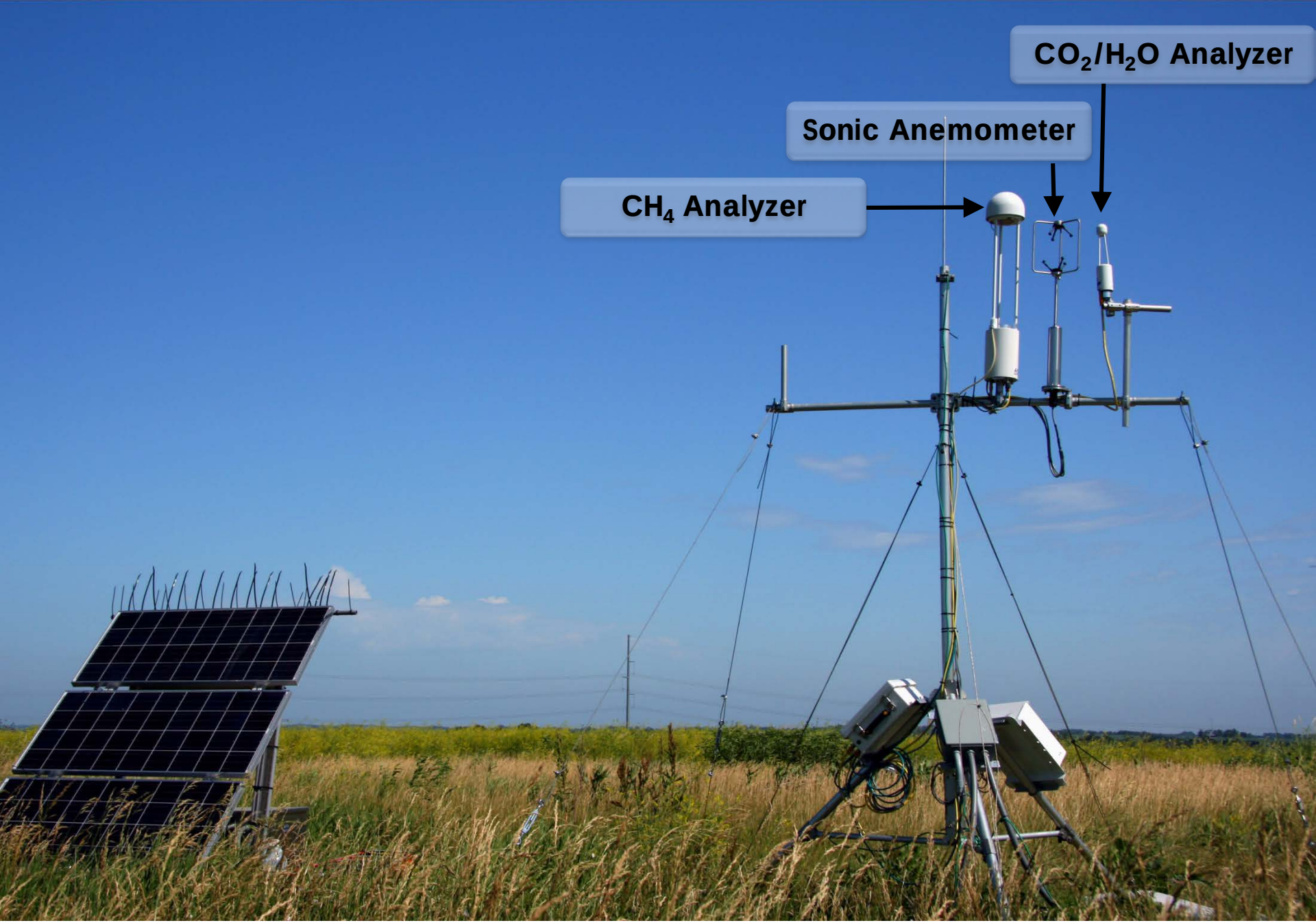
s: gas concentration (mol m^{-3})

Requirements

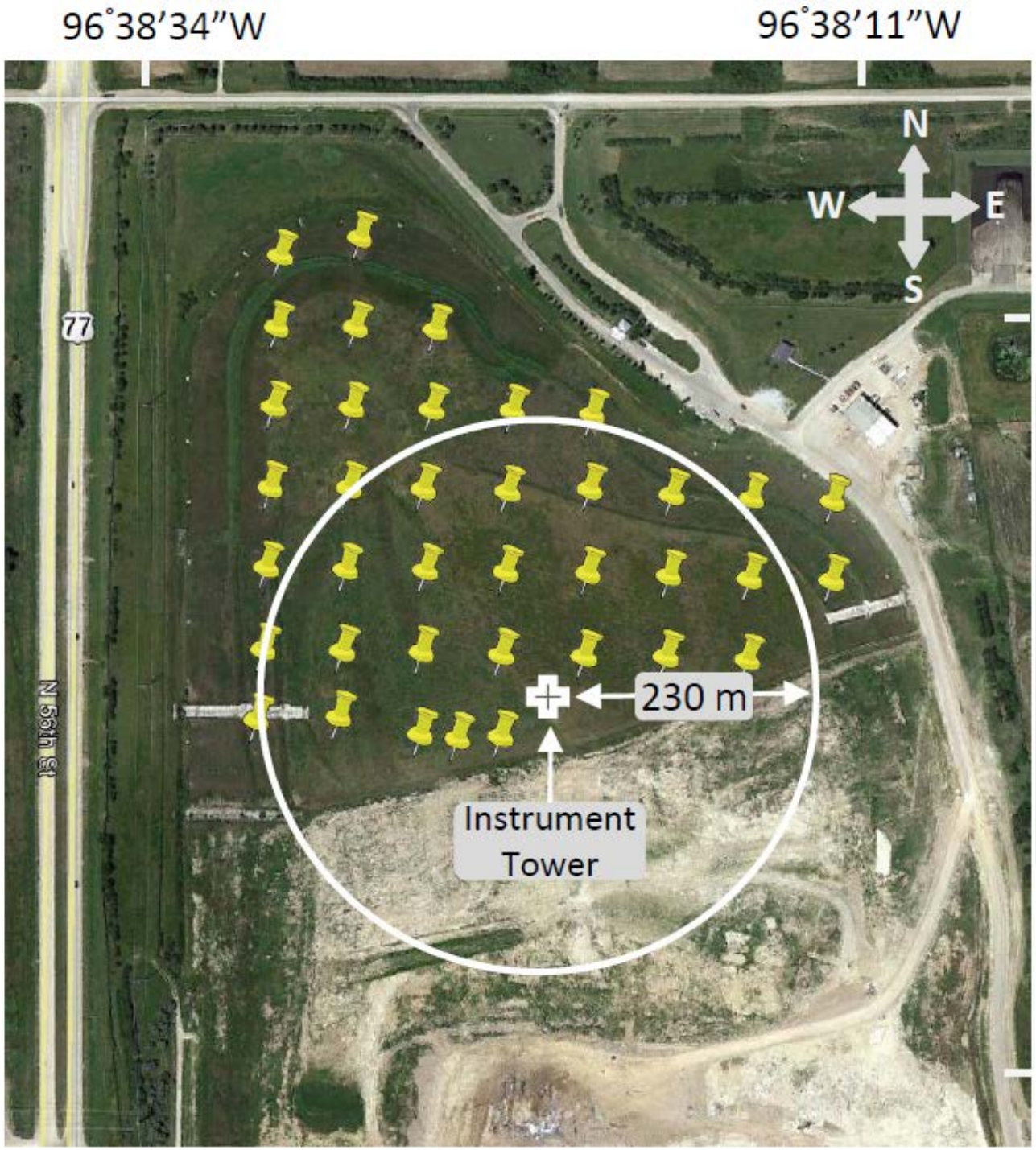
10-Hz sampling rate for gas concentration and wind speed

FLUXNET: CO_2 Flux Network





Field measurement since Jun 1, 2010



Opened

Oct 1988

Estimated closure

2035

Waste in place

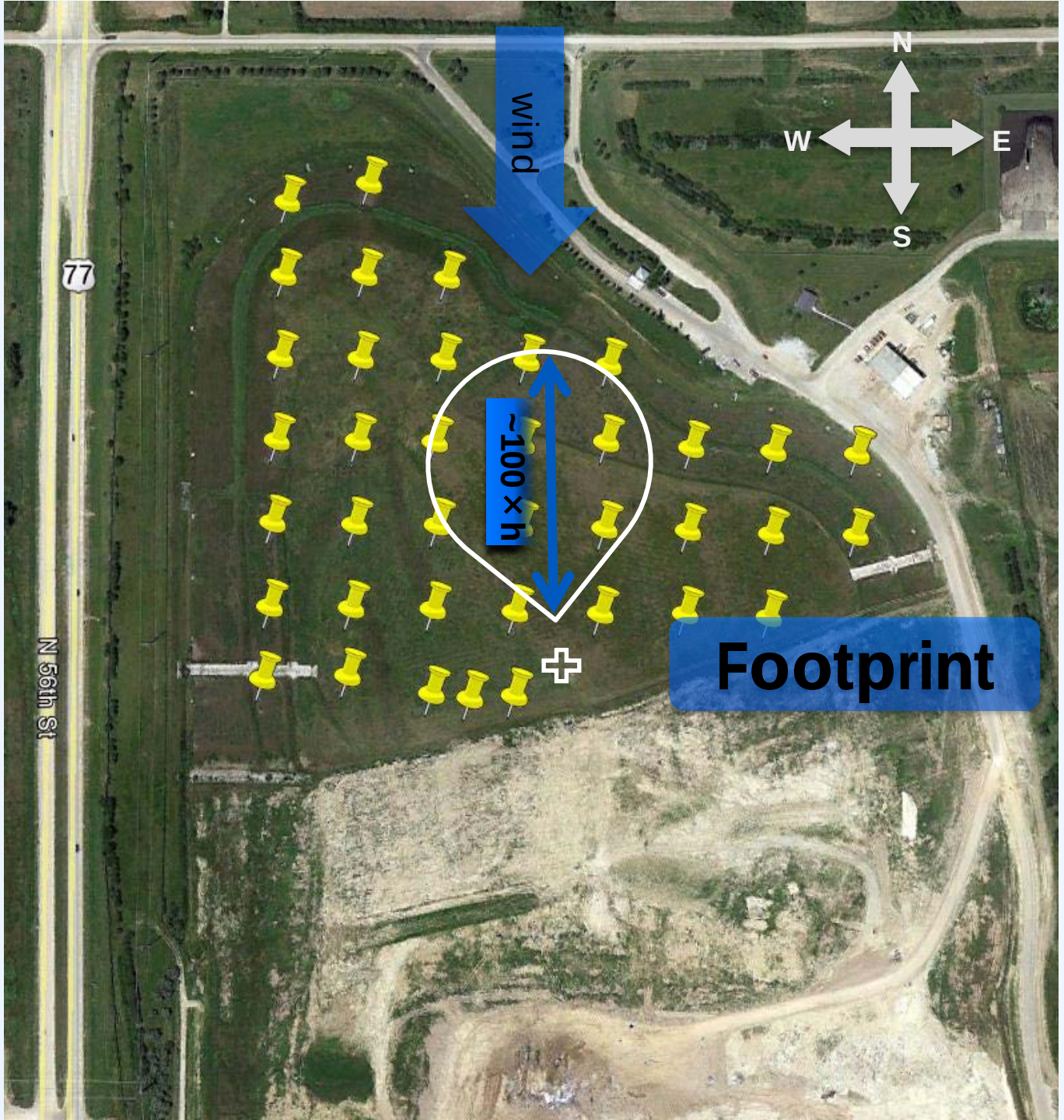
6.1 million ton

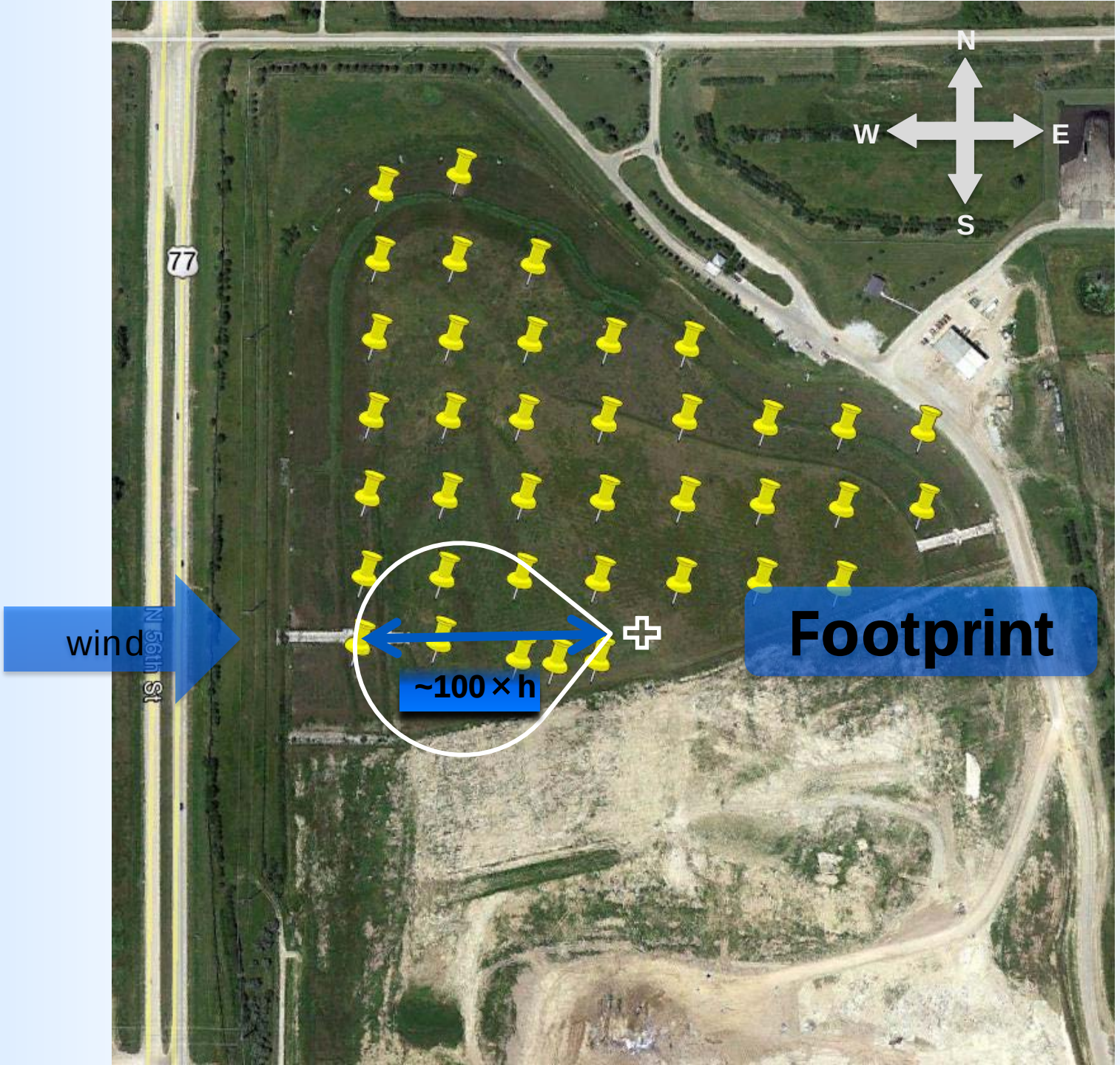
Design capacity

23.6 million cubic yards

Waste depth

60 to130 ft


wind
N
W
E
S
77
N 56th St
~100 × h
Footprint


N
W
E
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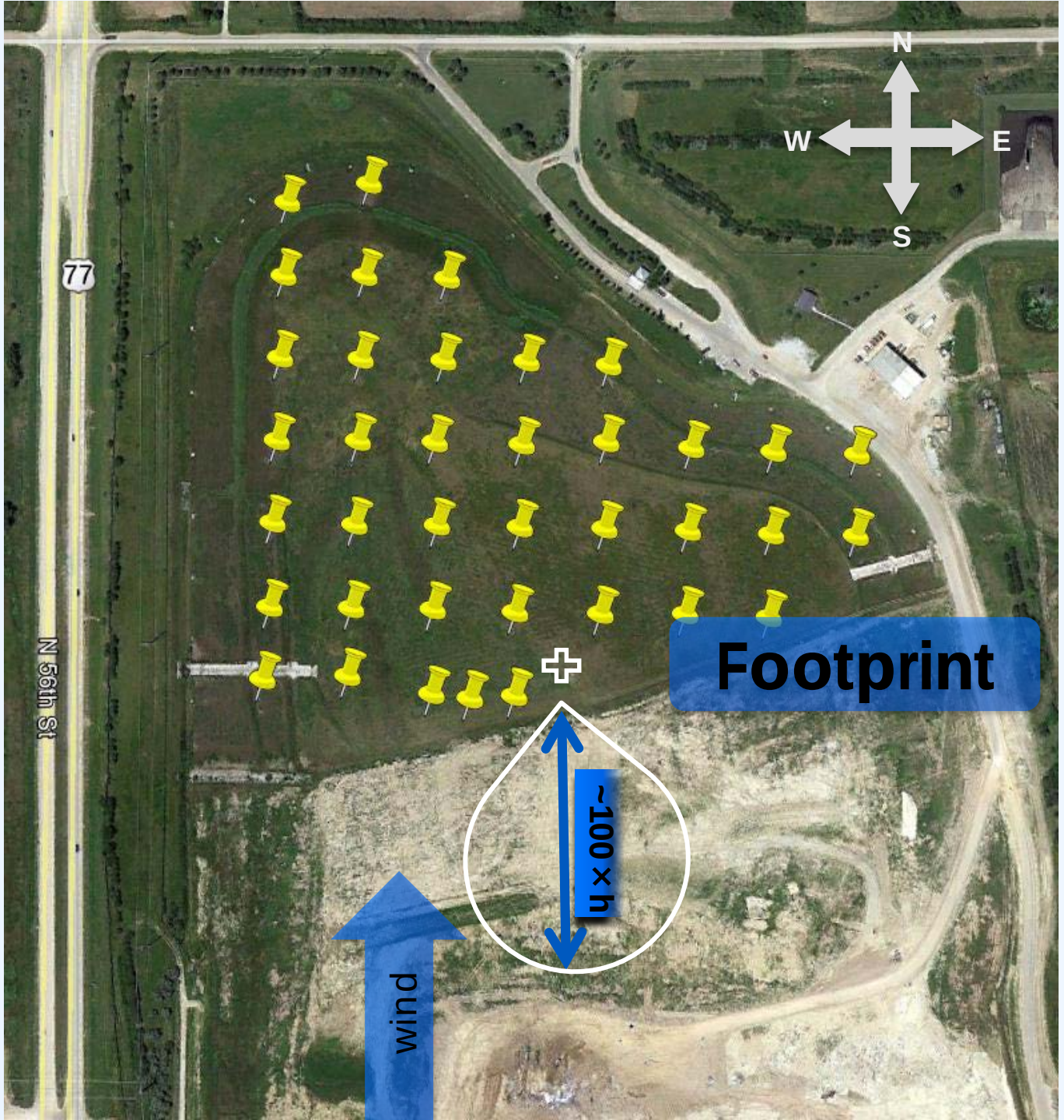
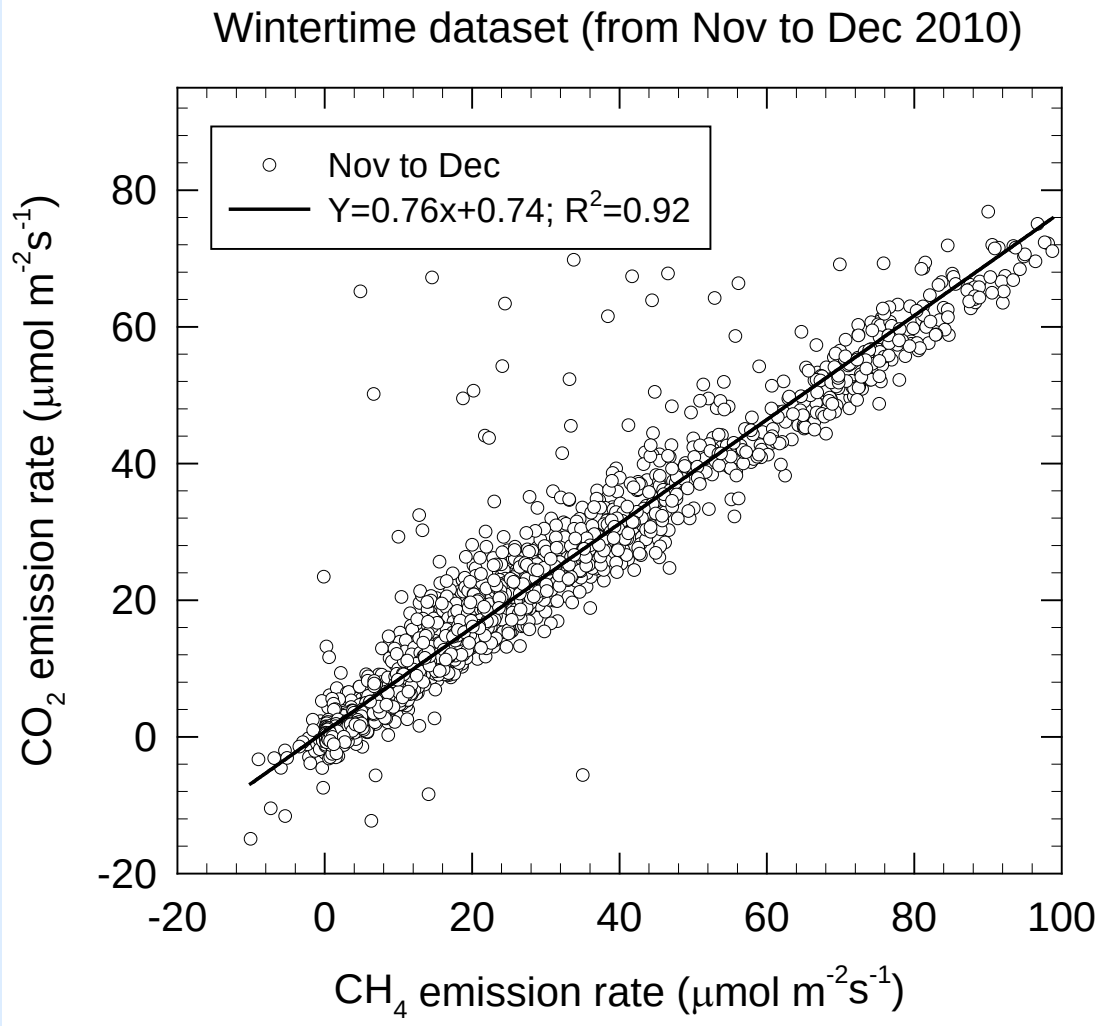
N 56th St
wind
~100 × h
Footprint


N
W
E
S
77
N 56th St
Footprint
~100 x h
wind

CO_2 emission rate vs. CH_4 emission rate

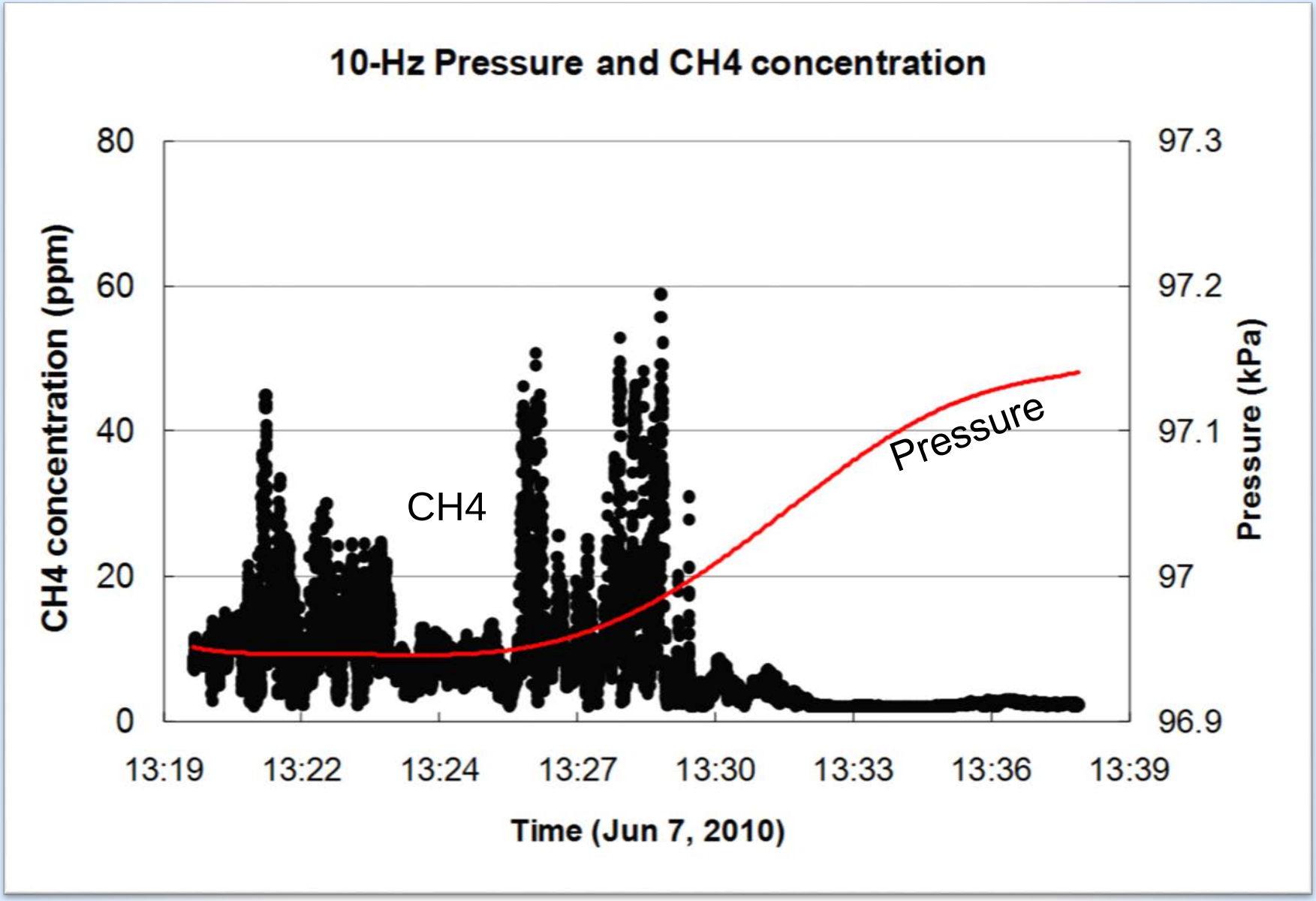


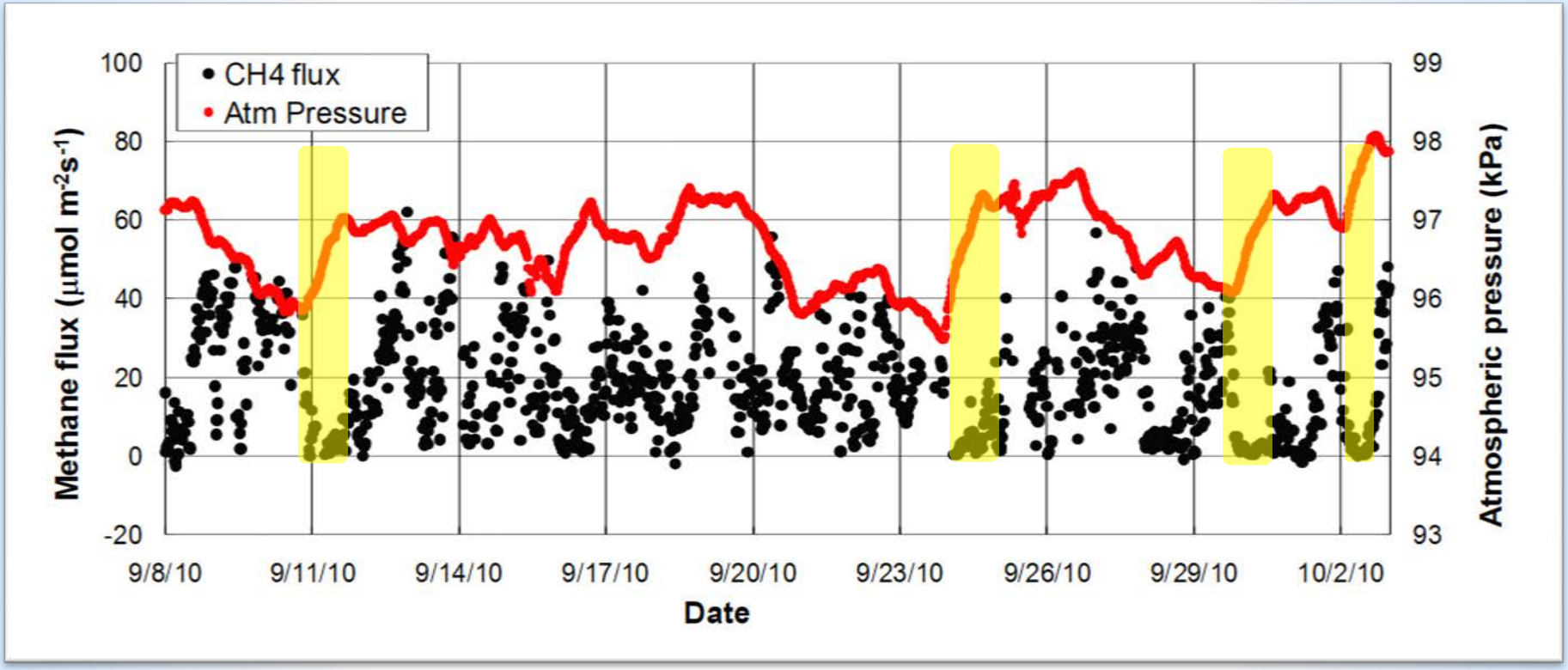
Landfill Gas composition

CO_2 41.3%

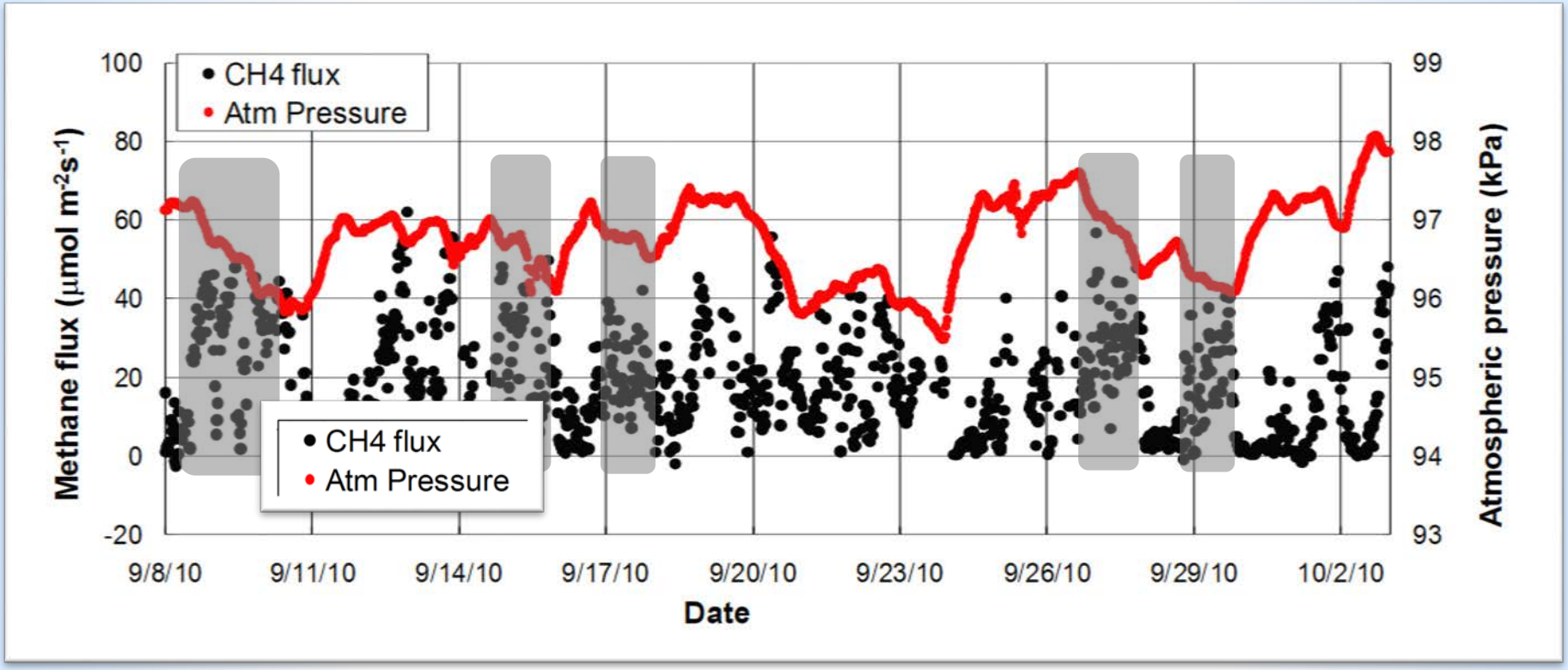
CH_4 54.4%

$[CO_2]/[CH_4]=0.76$

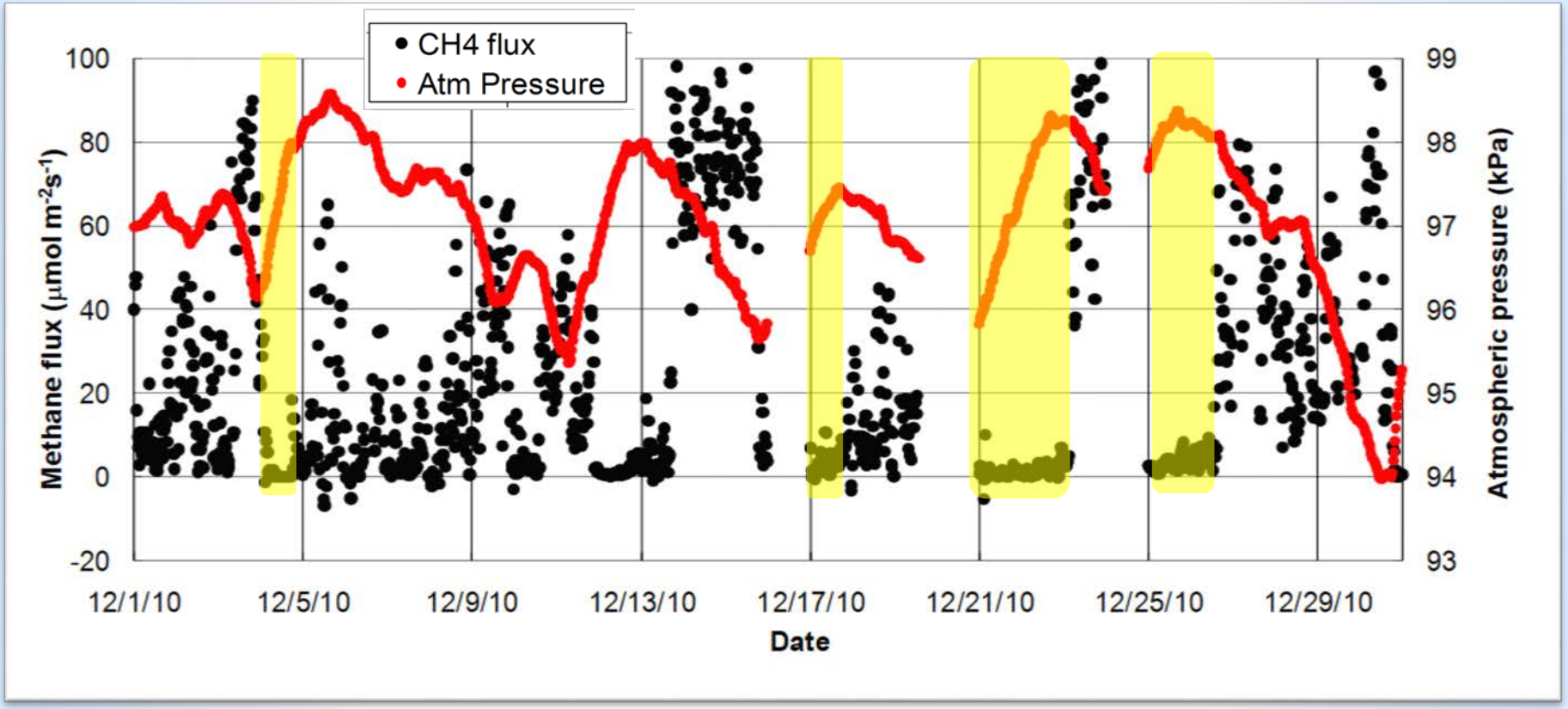

10-Hz Pressure and CH4 concentration
CH4 concentration (ppm)
80
60
40
20
0
97.3
97.2
97.1
97
96.9
Pressure (kPa)
CH4
Pressure
13:19
13:22
13:24
13:27
13:30
13:33
13:36
13:39
Time (Jun 7, 2010)



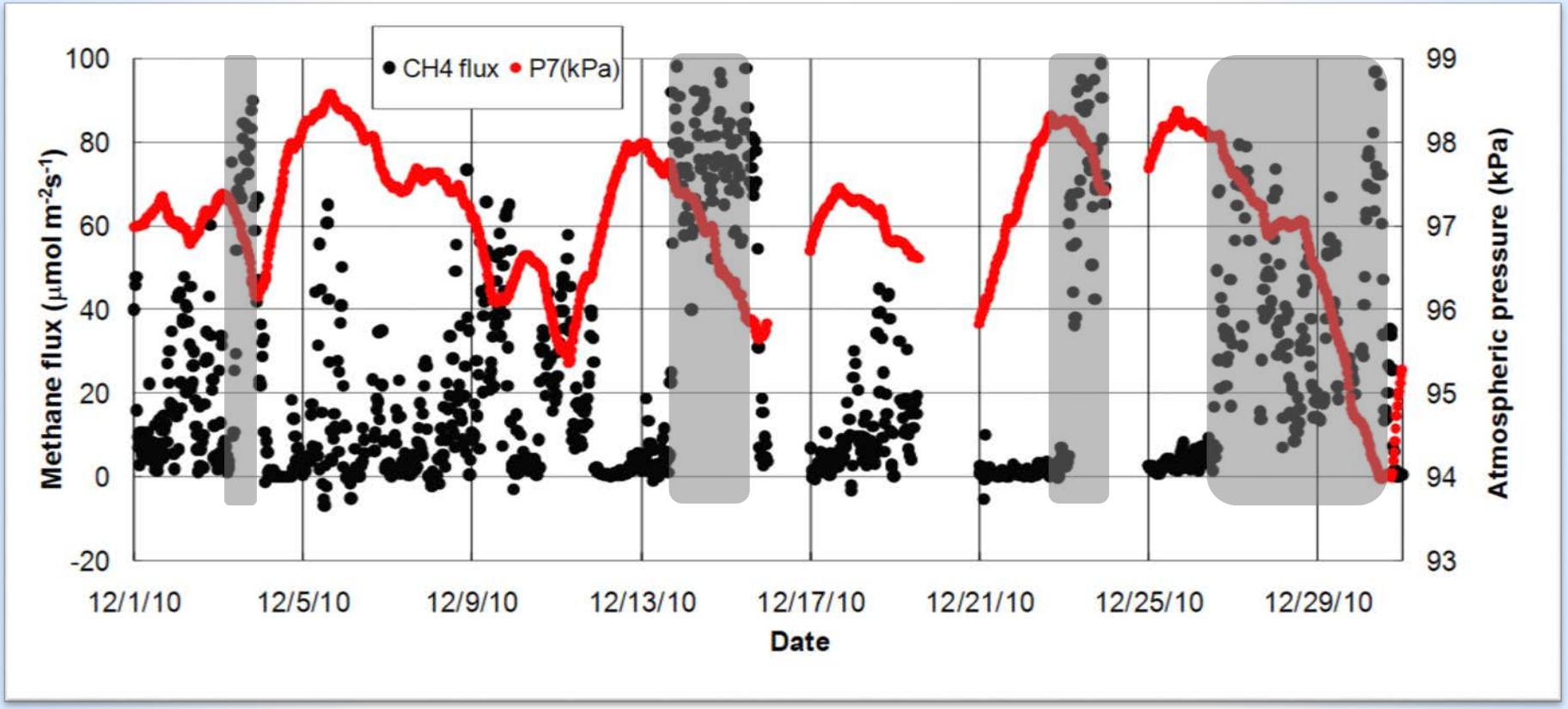
When dP/dt>0, CH_4 emission rate decreases

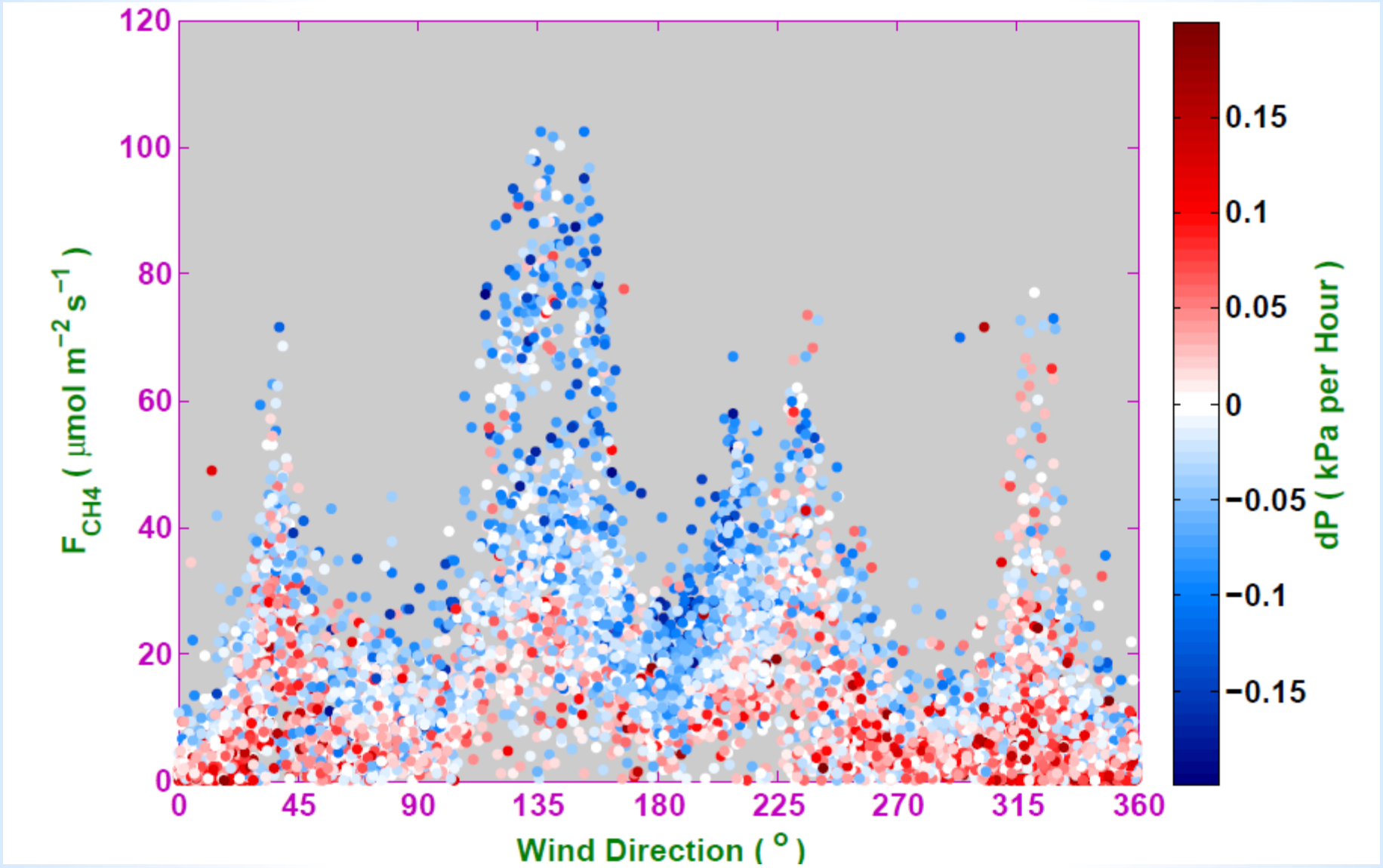


When dP/dt<0, CH_4 emission rate increases



Fast pressure increases can almost stop CH_4 emission.

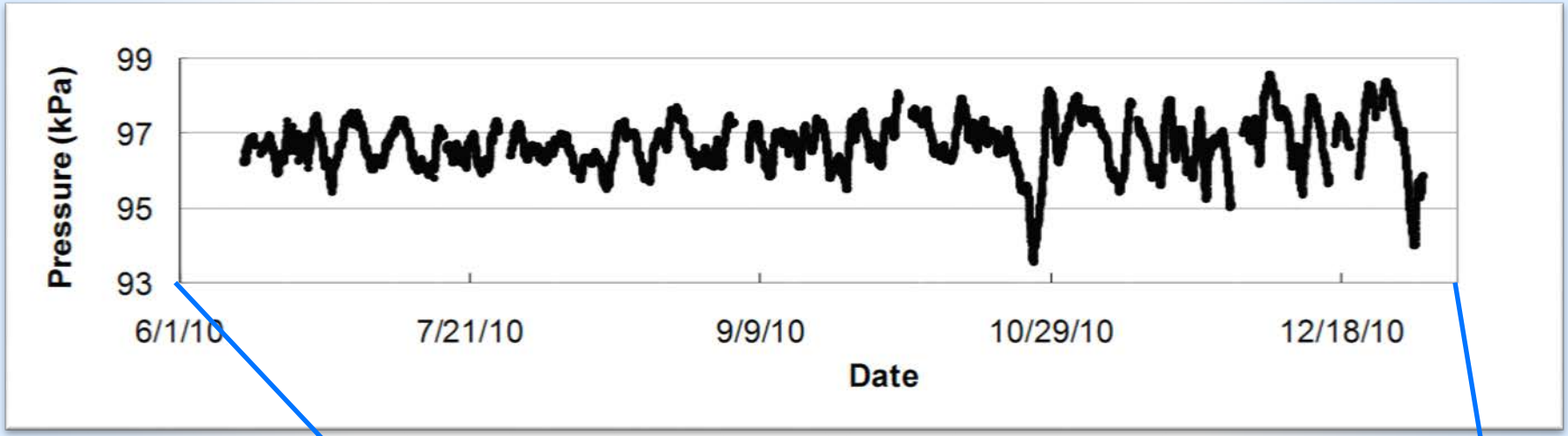

CH4 flux
P7(kPa)
Methane flux (μmol m-2s-1)
Atmospheric pressure (kPa)
100
80
60
40
20
0
-20
99
98
97
96
95
94
93
12/1/10
12/5/10
12/9/10
12/13/10
12/17/10
12/21/10
12/25/10
12/29/10
Date

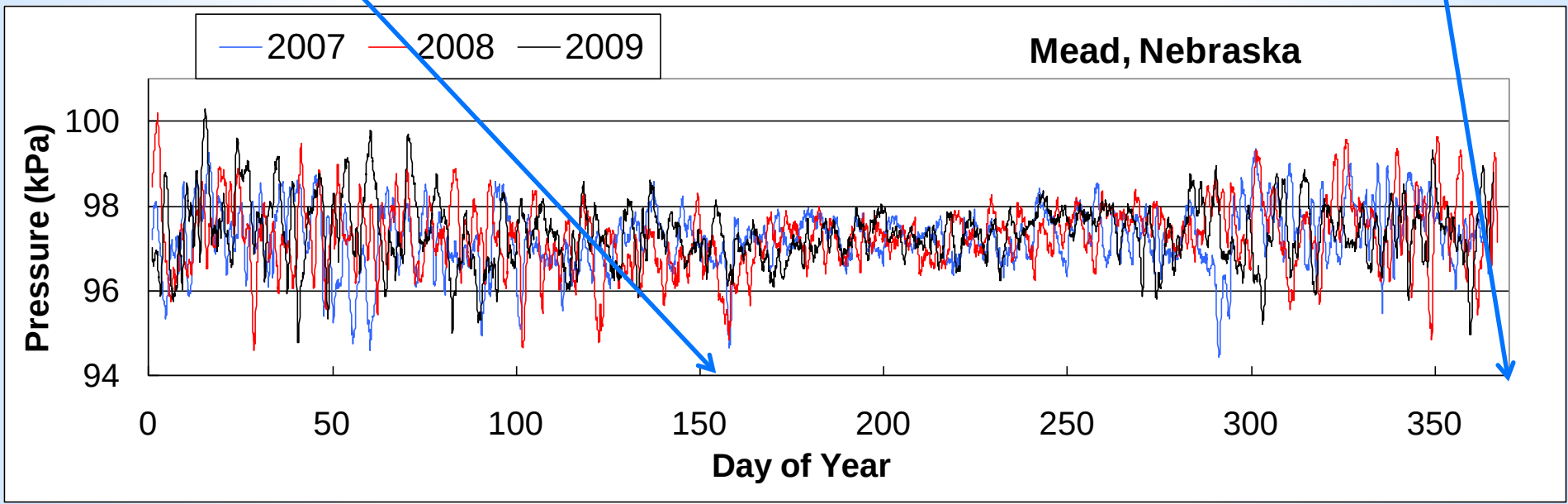

120
100
80
60
40
20
0
F_{CH4} (μmol m^{-2} s^{-1})
0
45
90
135
180
225
270
315
360
Wind Direction (°)
0.15
0.1
0.05
0
−0.05
−0.1
−0.15
dP (kPa per Hour)

What is going?

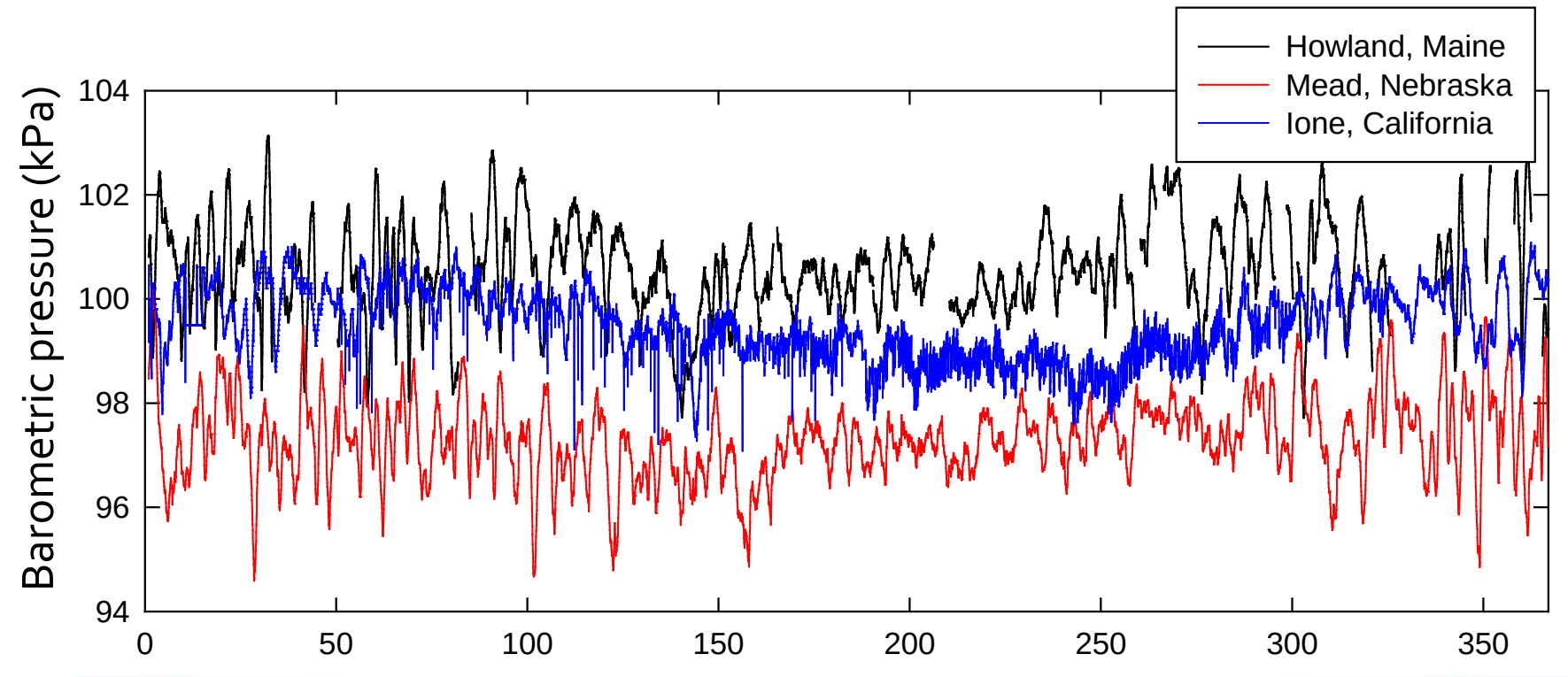
Pressure pumping

Was pressure variation during our field measurement unusual or unique?

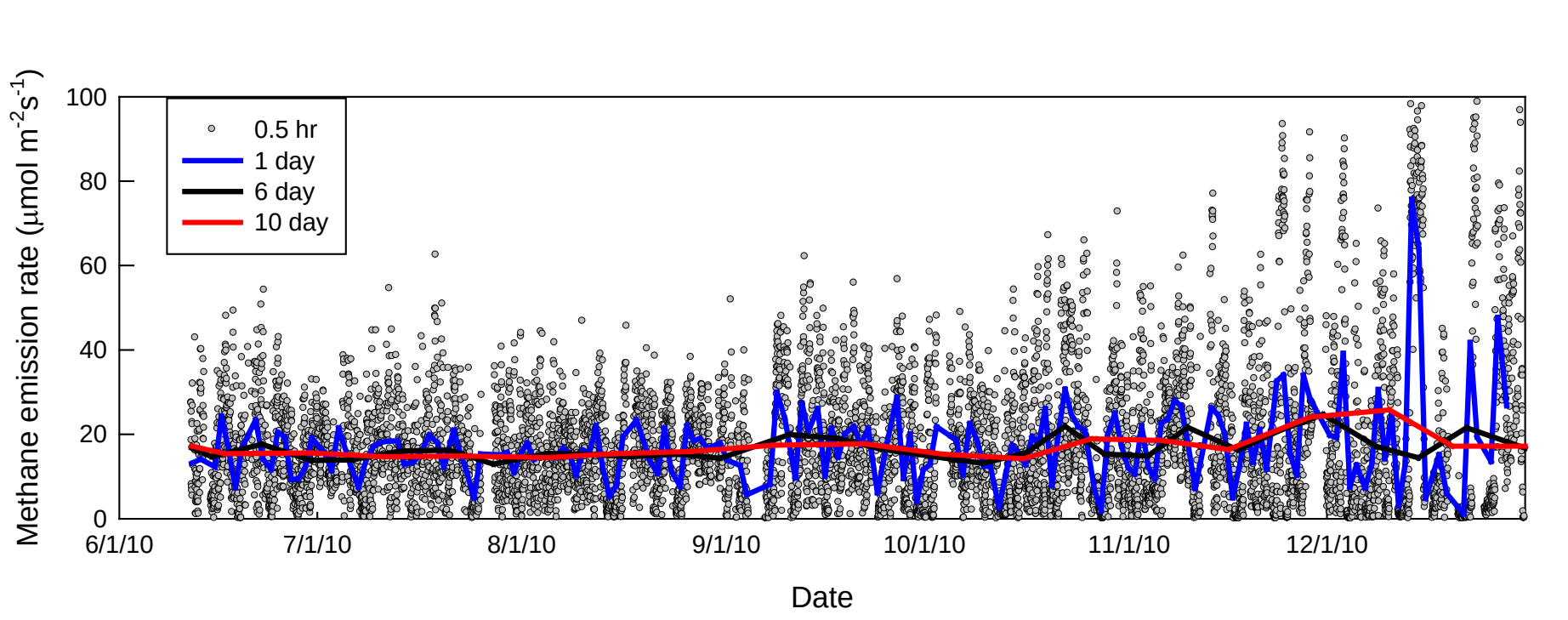




Seasonal barometric pressure variation cross US continent



How many days of continuous measurement do you need?



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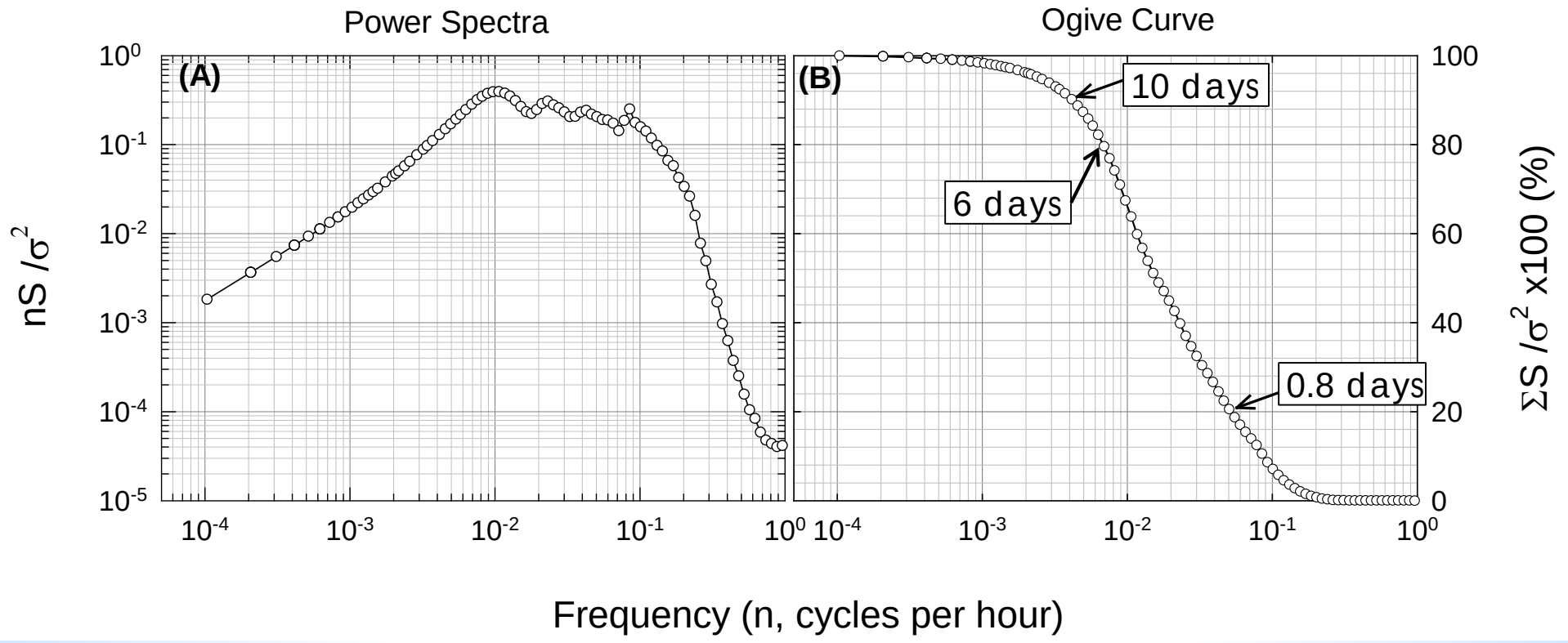


Pressure pumping phenomenon reported in the literature

- Mattson, Likens 1990. Air pressure and methane fluxes, *Nature*, **347**

  "At Mirror Lake, New Hampshire, we observed that sporadic methane bubble releases (ebullition) from the sediments were correlated with changes in local air pressure."

- McQuaid, Mercer 1991. Air pressure and methane fluxes, *Nature*, **351**

  "A similar phenomenon has been known to mining engineers in the UK for more than 250 years."

- Clements and Wilkening 1974. Atmopheric pressure effects on ^{222}Rn transport across the earth-air interface, *J Geophys. Res.,* **79(33)**

  "pressure changes of 1-2% produce changes in the ^{222}Rn flux from 20 to 60%."

Applicable to

Same phenomenon would also occur for gas transport through porous media

Examples;

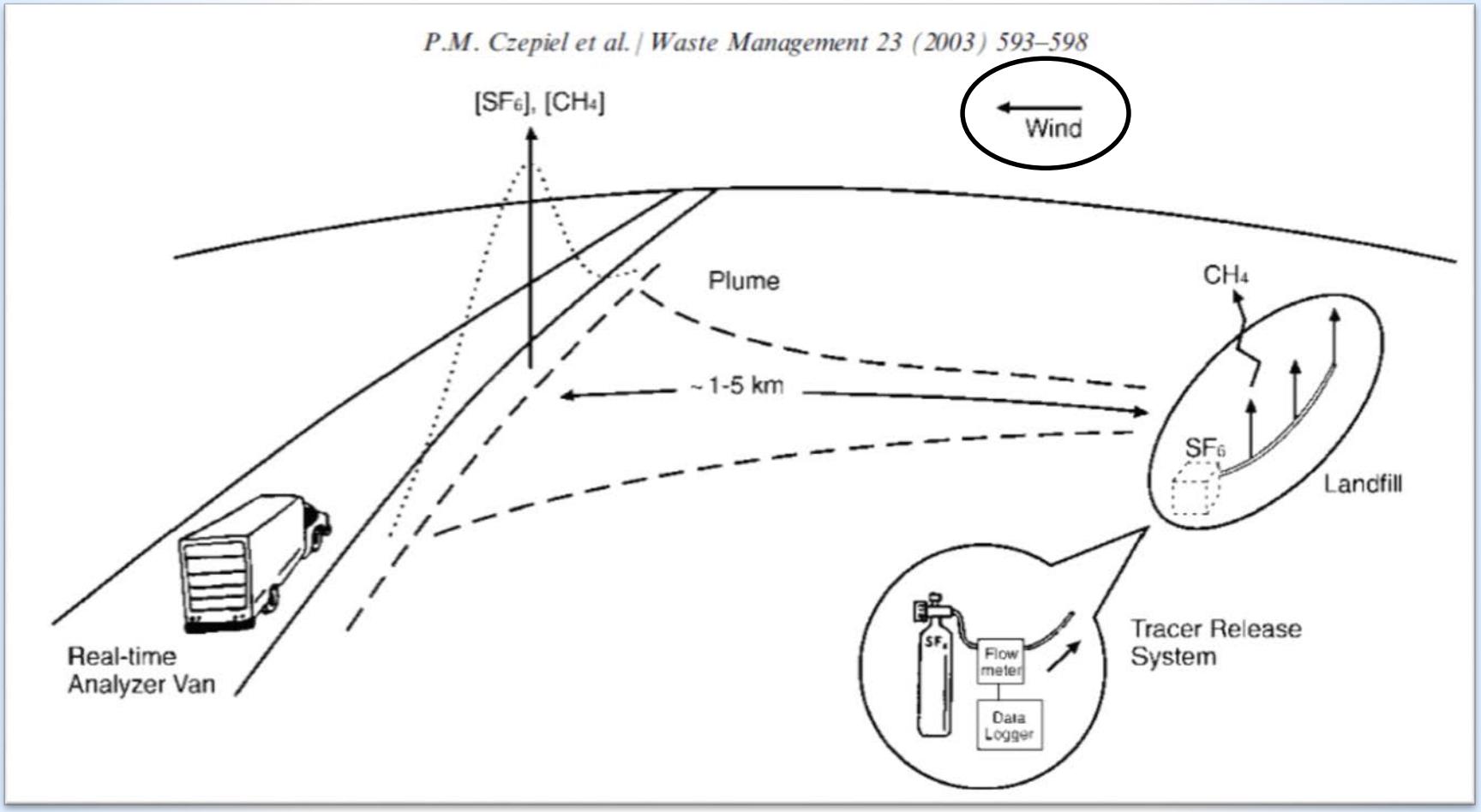
- CH_4 emission at peatland, wetland and rice paddies
- Soil gas movement, soil contaminant transport, radon transport

We Acknowledge

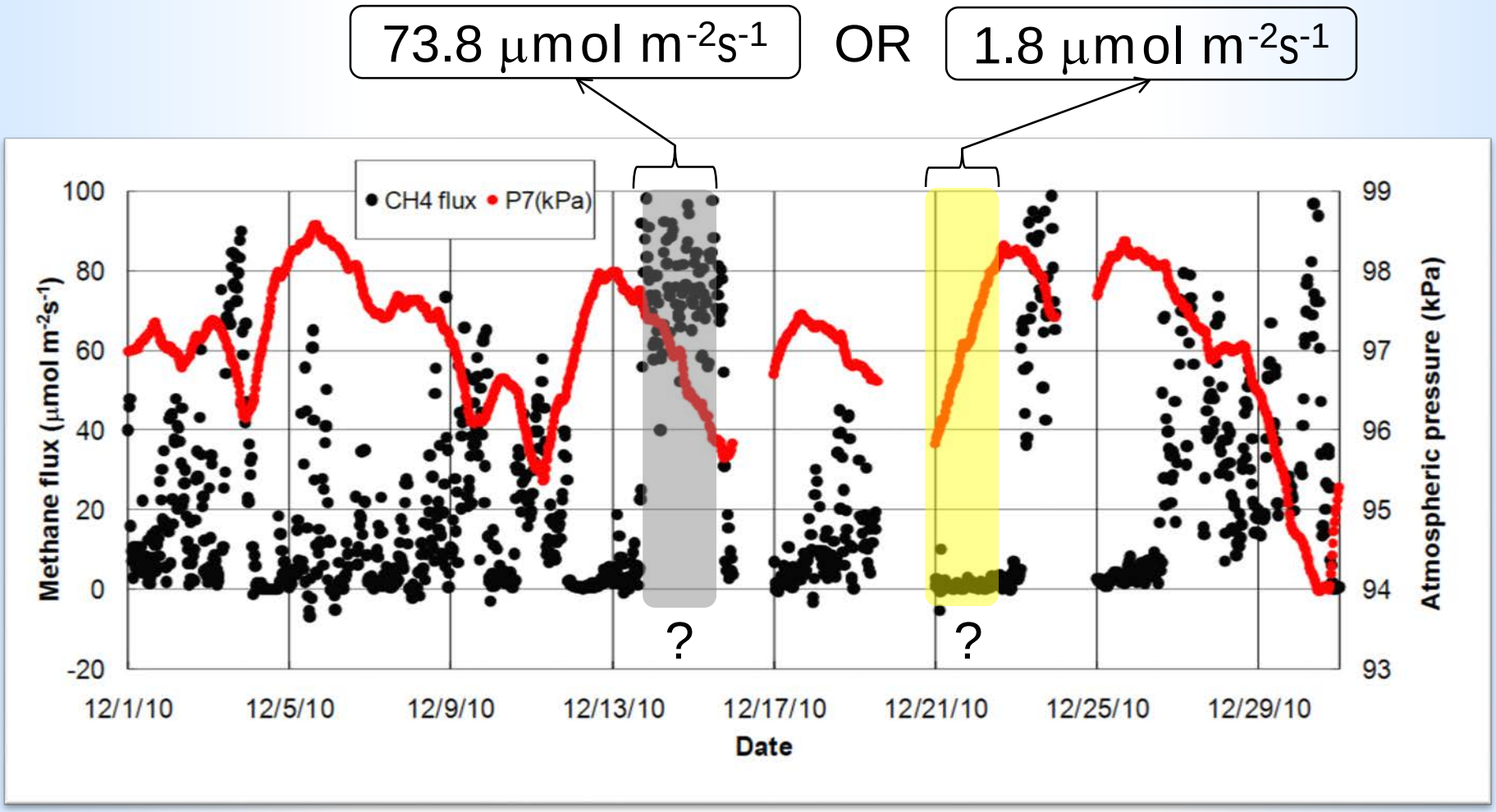
Our results are not applicable to landfills that use active gas collection systems.

Implication I

Plume tracer method: $Q_m = Q_t \times (C_m / C_t)$



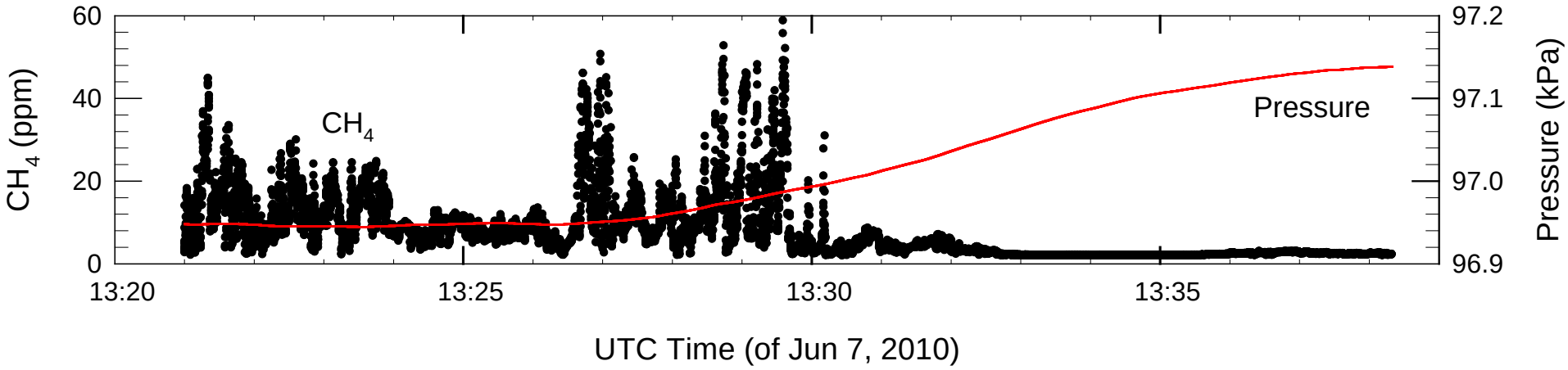
Implication I



Implication II

Gas (esp hazard gas) emission monitoring over porous media should be done on a continuous basis.

Emission may be missed if the measurement is made when the pressure is rising.



Conclusions

1. Strong dependence of landfill CH_4 emissions on changes in barometric pressure
    - Increasing pressure suppresses the emission
    - Decreasing pressure enhances the emission
2. Large day-to-day variation of methane emissions due to changes in barometric pressure.
3. Must have continuous measurements in order to get the total methane emission of landfill.
4. Gas (esp. hazard gas) leak detection over porous media should be done on a continuous basis.

This result was published in 2014

Global Biogeochemical Cycles

RESEARCH ARTICLE
10.1002/2013GB004571

Key Points:
- Landfill methane emissions strongly depend on changes in barometric pressure
- Current methods lead to uncertainty in

Impact of changes in barometric pressure on landfill methane emission

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LI-COR Biosciences

Thank You !