NAEMS

Agricultural Area source emission measurements

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National Air Emissions Monitoring Study (NAEMS)

- Open area and barn source components
  - Open area component
    - 8 farms: sequential rotating measurements: each farm each season for two years
    - 2 farms: continuous measurements for one year
    - Measure NH_3, H_2S emissions routinely
    - Measure volatile organic (Methane..) emissions for only limited period within study

Open Source Measurements

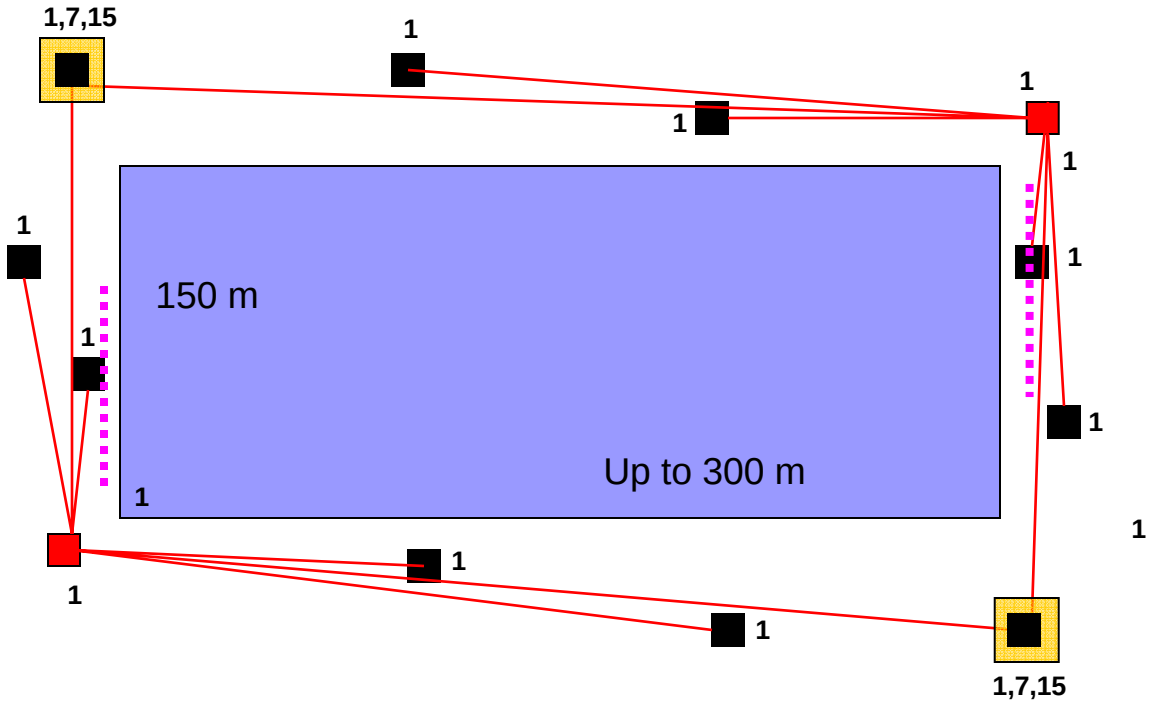
Gas Concentration	Gas Emissions
■ NH_3 ; TDLAS	Radial plume mapping (RPM)
■ H_2S; S-OPS/PF ■ VOCs; S-OPS/PAS	Backward Lagrangian Stochastic (bLS) or Ratiometric

Continuous concentration and meteorological measurements for 8-21 days.

Emissions calculated every ½ hr.

Source: Dr. Rich Grant, Purdue University, April, 2008

Configuration of ideal gas concentration measurement paths



Retro-reflectors

5 cubes for most paths

21 cubes for 750 m paths

All retro's heated, pressure vented

S-OPS

TDLAS reflector

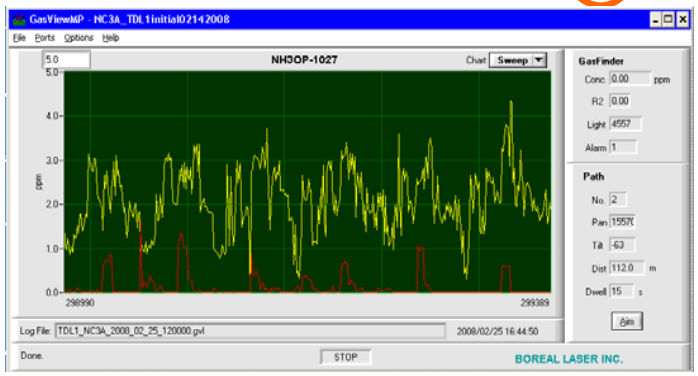
TDLAS

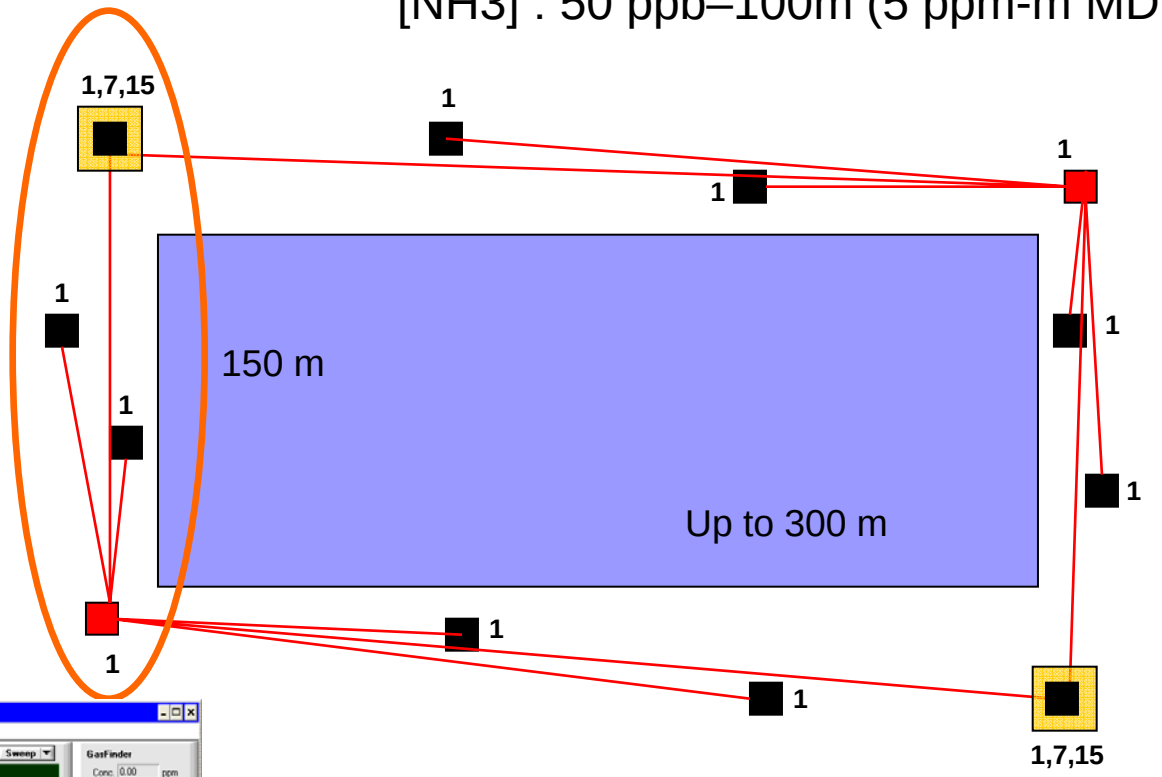
Corner tower

Source: Dr. Rich Grant, Purdue University, April, 2008

NH_3 Measurements: TDLAS

[NH3] : 50 ppb–100m (5 ppm-m MDL)



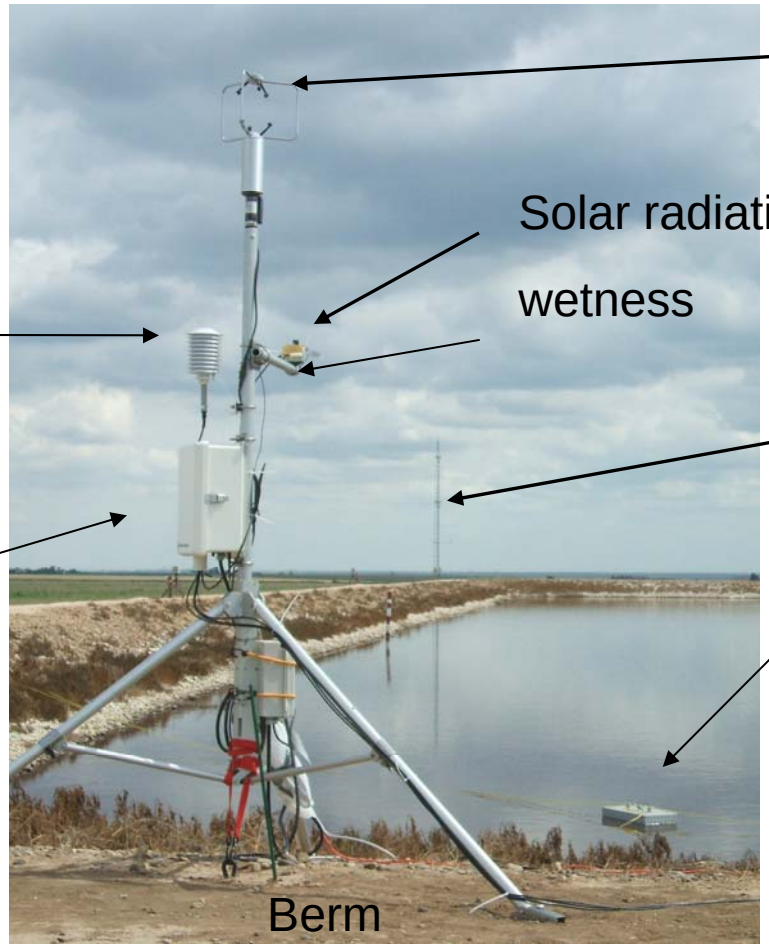


TDLAS reflector

TDLAS

Source: Dr. Rich Grant, Purdue University, April, 2008

Meteorological and lagoon measurements

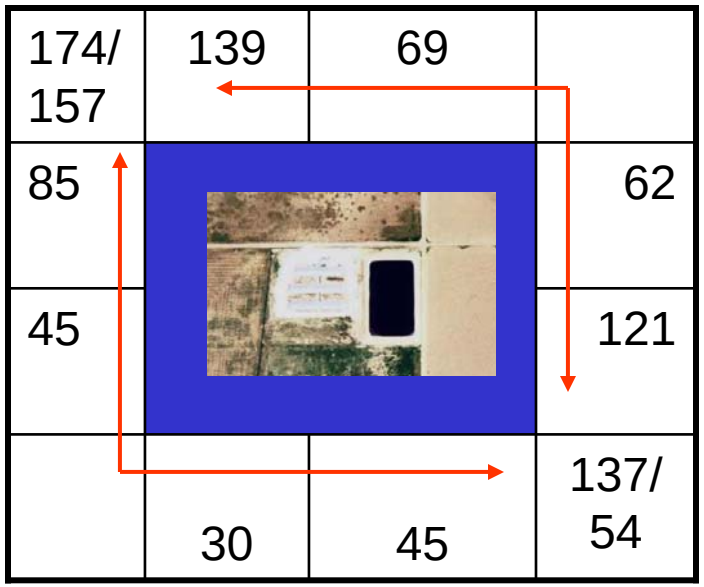


Source: Dr. Rich Grant, Purdue University, April, 2008

Example mean NH_3 PIC (ppm-m)

39	70
73	90
174	157

tower



N

48	46
51	51
137	54

tower

8/10-23/2007

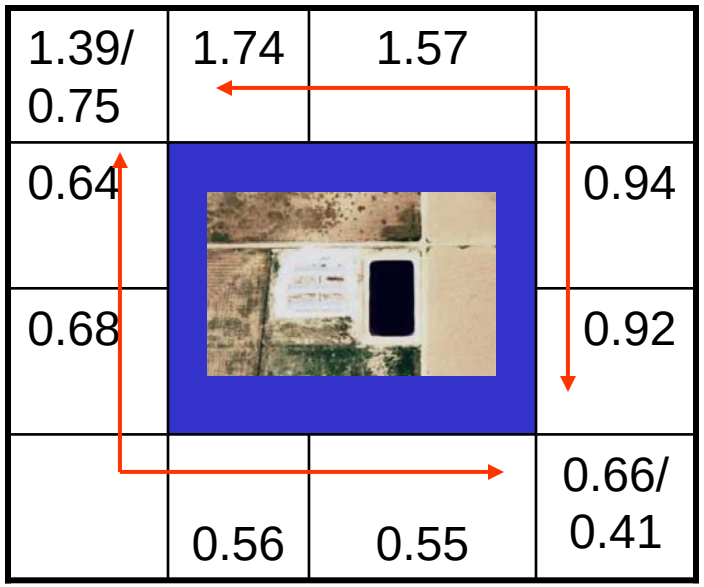
Steady S winds, air temp 20-37°C

Source: Dr. Rich Grant, Purdue University, April, 2008

Example mean NH_3 conc (ppm)

0.31	0.33
0.58	0.43
1.39	0.75

tower



N

0.22	0.35
0.24	0.39
0.66	0.41

tower

Upwind background ~0.3-0.5 ppm

8/10-23/2007

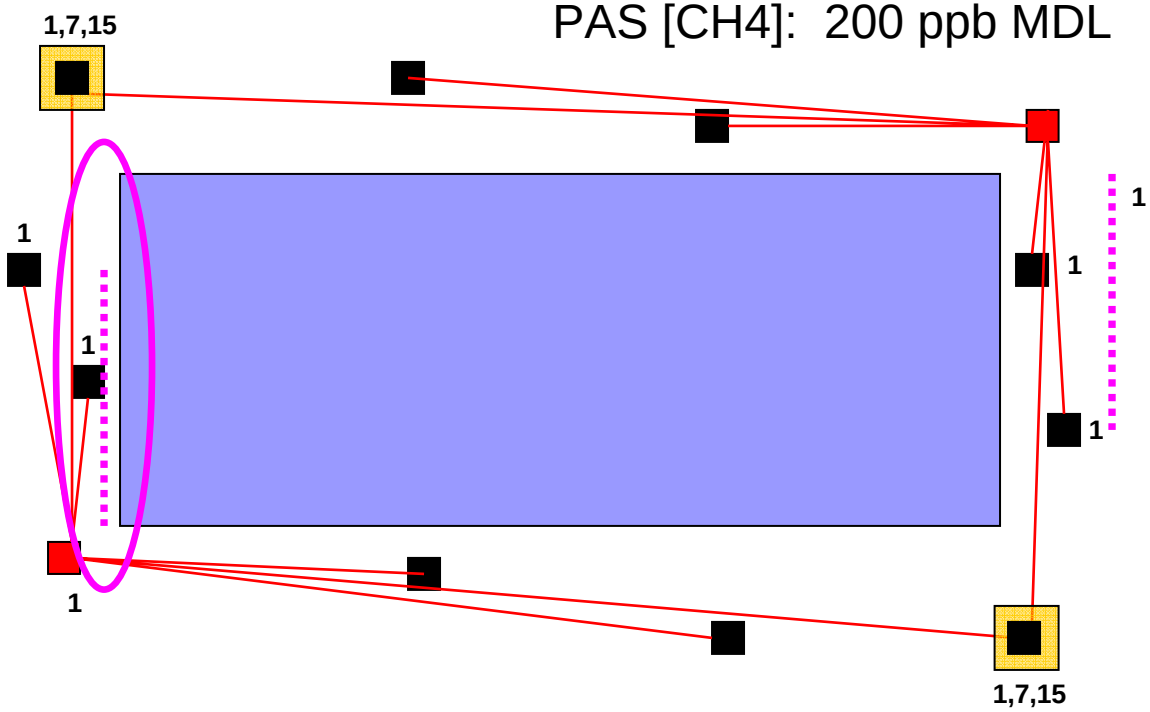
Steady S winds, air temp 20-37^{o}C

Source: Dr. Rich Grant, Purdue University, April, 2008

VOC, H_2S Measurements: S-OPS/GSS

PF [H2S] : 2 ppb MDL
PAS [CH4]: 200 ppb MDL

50 m path



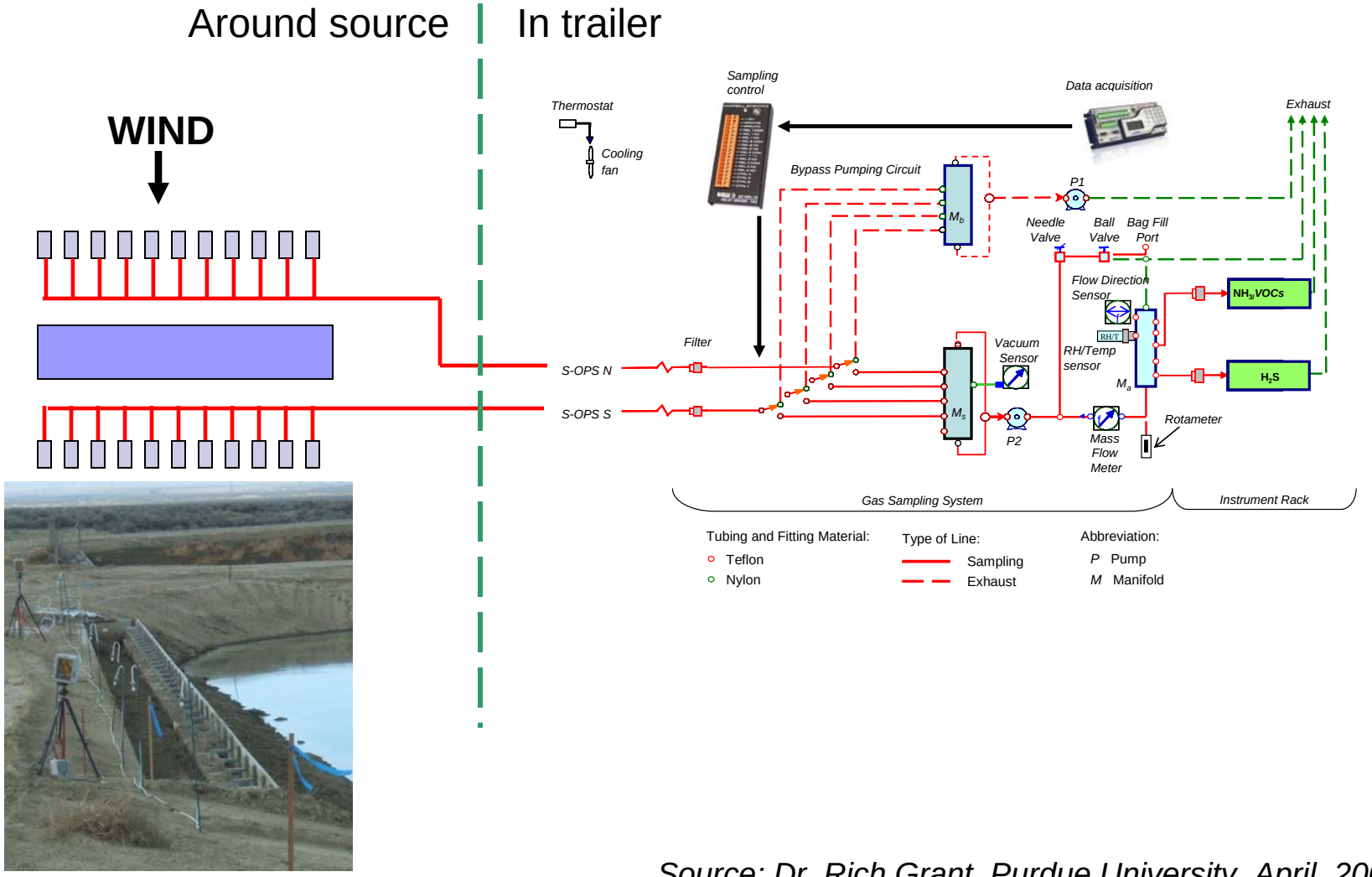
S-OPS

TDLAS reflector

TDLAS

Source: Dr. Rich Grant, Purdue University, April, 2008

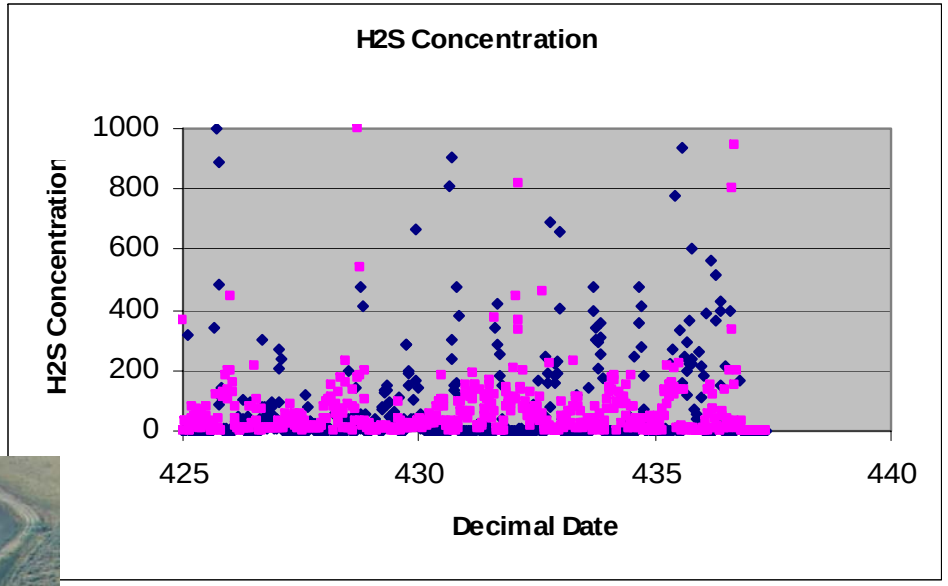
S-OPS/ Gas sampling system



Source: Dr. Rich Grant, Purdue University, April, 2008

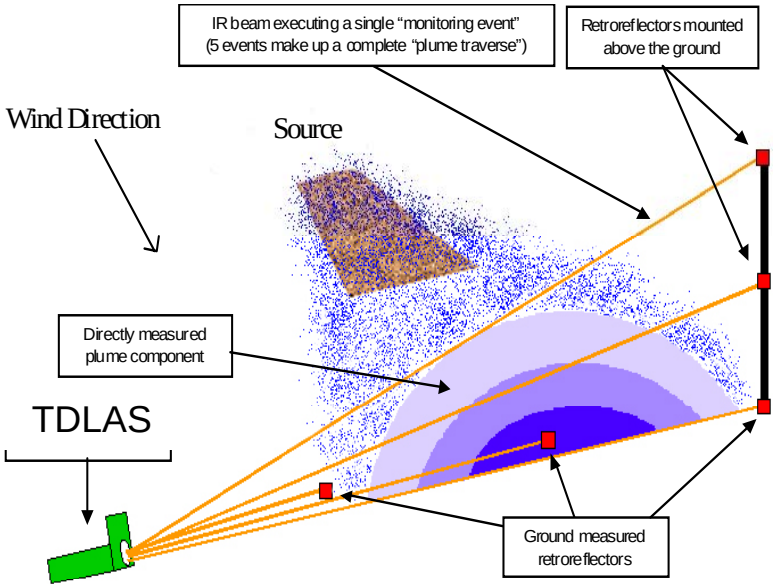
H_2S Measurements

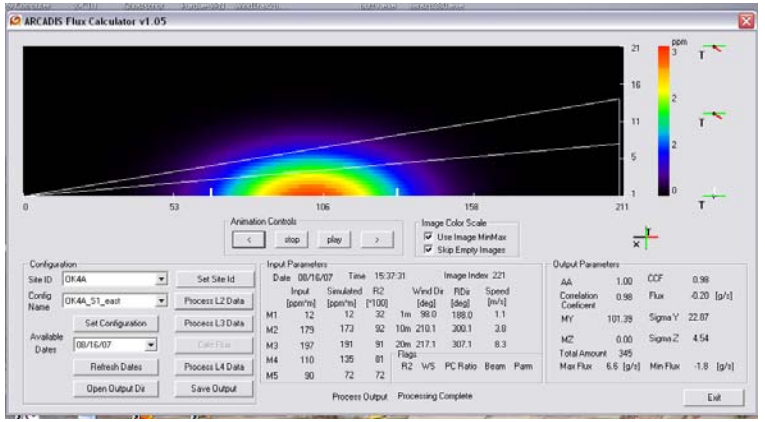
- Uses S-OPS and GSS for upwind/ downwind



Source: Dr. Rich Grant, Purdue University, April, 2008

RPM emissions





If all four sides valid

$$Q = \frac{\sum_{y=0}^{pathlength} \sum_{z=0}^{20m} (C_{y,z})\hat{u}_z}{S}$$

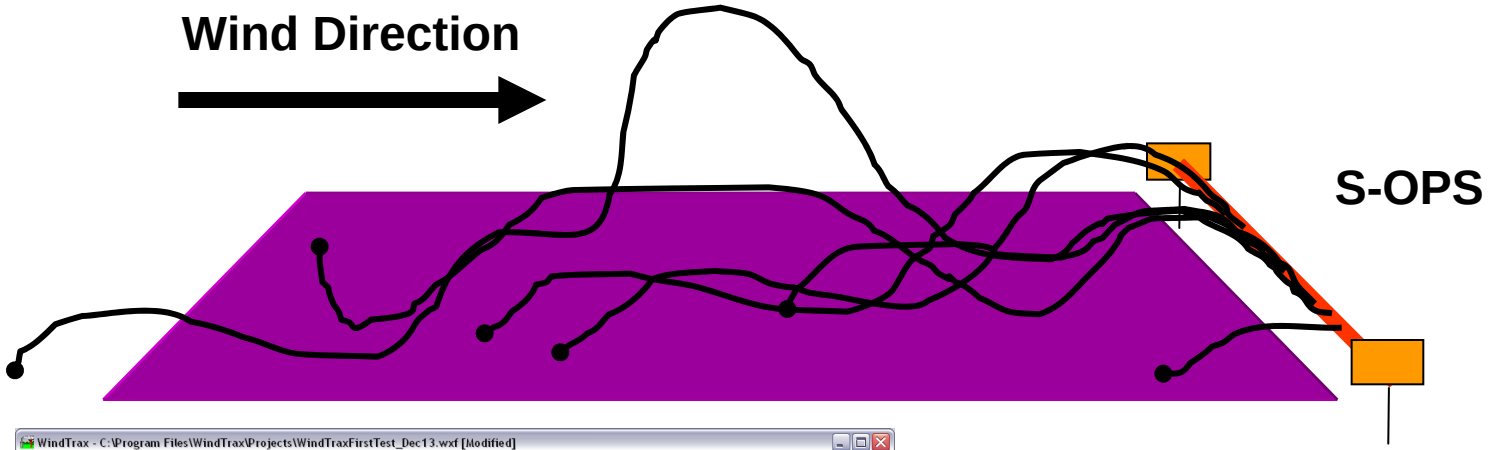
If 2 downwind sides valid and 1 upwind path valid

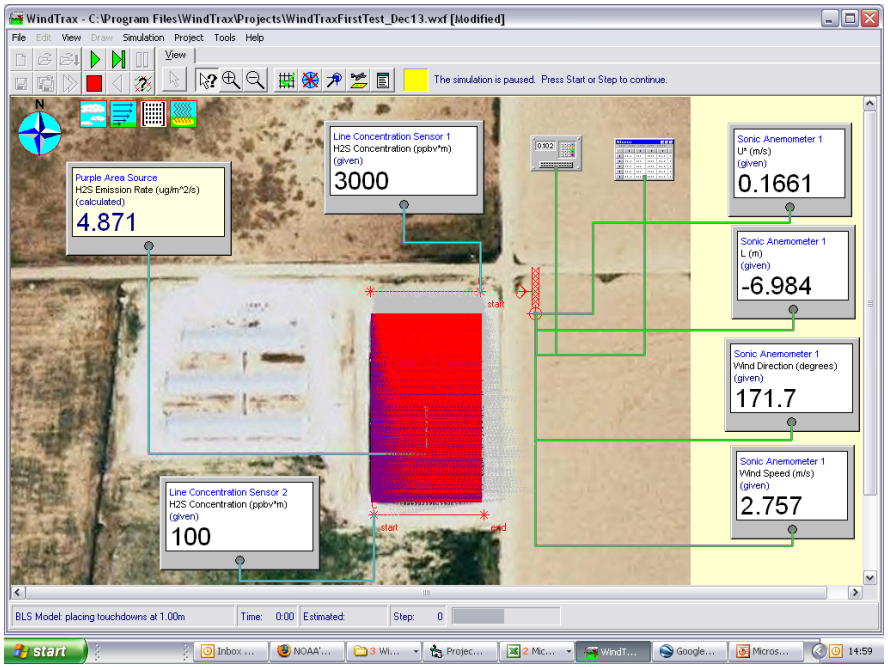
$$Q = \frac{\sum_{y=0}^{pathlength} \sum_{z=0}^{20m} (C_{y,z} - C_{bg})\hat{u}_z}{S}$$

A plume of some area with measured concentration traveling at some speed is the emission from the lagoon

Source: Dr. Rich Grant, Purdue University, April, 2008

bLS emissions

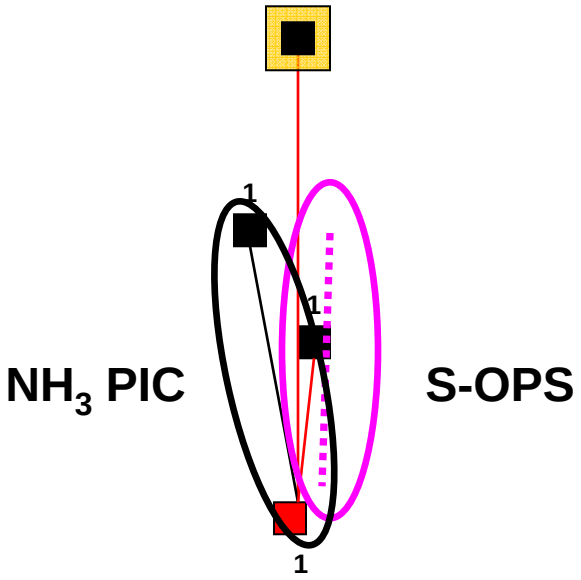




$$Q_{obs} = \frac{(C_{obs} - C_{obs,bg})}{[C_{sim} / Q_{sim}]}$$

Source: Dr. Rich Grant, Purdue University, April, 2008

Ratiometric emissions

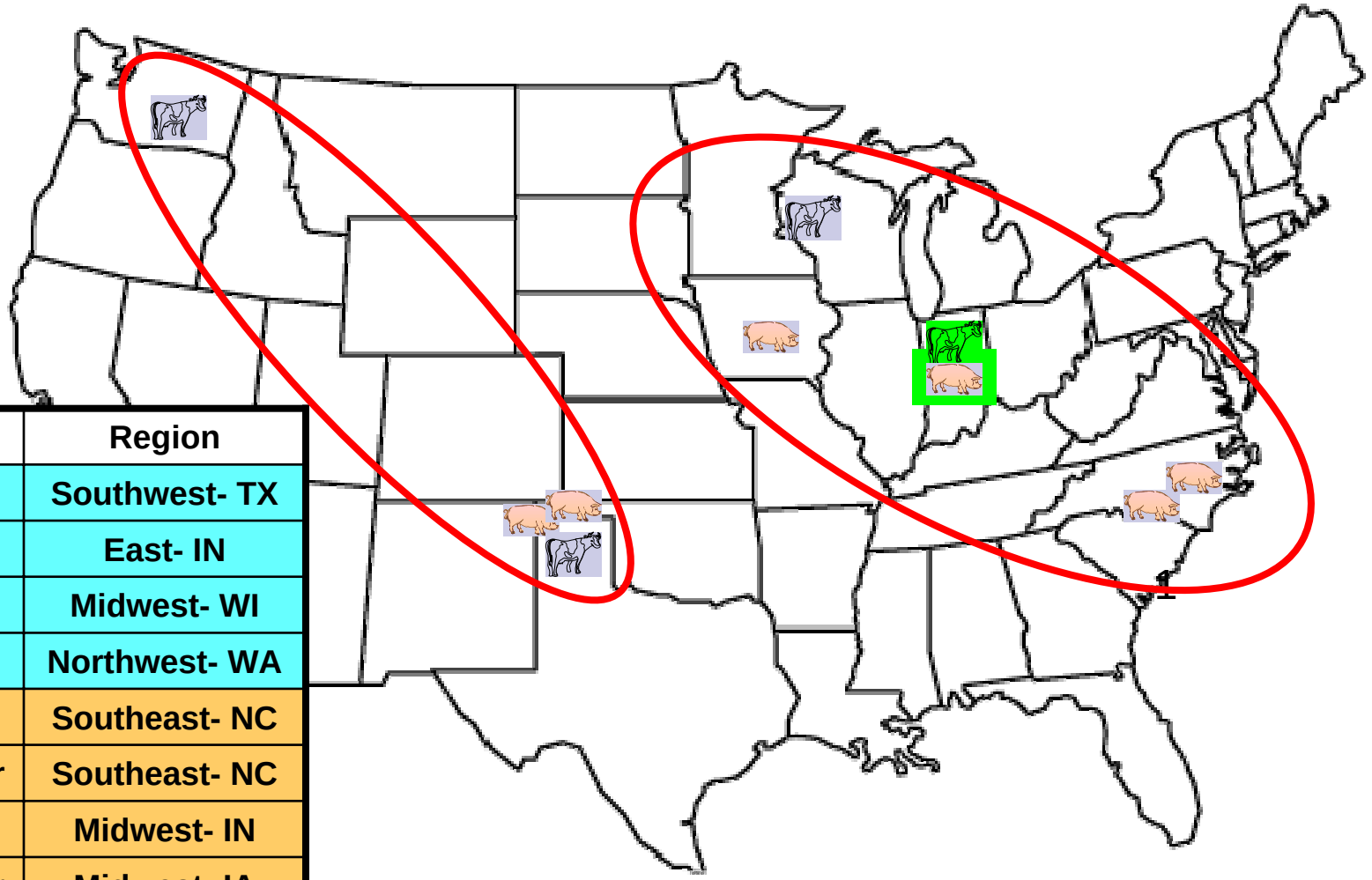


- RPM emissions of NH_3,
- Measured NH_3 of nearby PIC
- Measured concentration of H_2S (or VOC) from S-OPS

$$Q(H_2S) = Q_{RPM}(NH_3)\frac{C_{S-OPS/PFA}(H_2S)}{C_{TDLAS}(NH_3)}$$

Source: Dr. Rich Grant, Purdue University, April, 2008

Measurement sites



Type	Region
Dairy	Southwest- TX
Dairy	East- IN
Dairy	Midwest- WI
Dairy	Northwest- WA
Pork-sow	Southeast- NC
Pork-finisher	Southeast- NC
Pork-sow	Midwest- IN
Pork-finisher	Midwest- IA
Pork-sow	West- OK
Pork-finisher	West- OK

Roving teams visit each area source once each quarter

Source: Dr. Rich Grant, Purdue University, April, 2008

Washington Dairy

Farm description

# animals	Measured Source	Barn manure removal
5600	Lagoon	Flush

Completeness criteria: 7.5d/ season
6 of 8 seasons

Estimated Days of Complete Valid Data

Season	NH_3	H_2S	VOCs
Su 2007			
Fa 2007			
Wi 2007/8			
Sp 2008	9d	9d`	
Su 2008			
Fa 2008			
Wi 2008/9			
Sp 2009			

Source: Dr. Rich Grant, Purdue University, April, 2008

Wisconsin Dairy

Farm description

# animals	Measured Source	Barn manure removal
650	1 & 2 of 3 stage Lagoon	Flush

Completeness criteria: 7.5d/ season
6 of 8 seasons

Estimated Days of Complete Valid Data

Season	NH_3	H_2S	VOCs
Su 2007	0d[1]		
Fa 2007	12d		
Wi 2007/8	3d[2]		
Sp 2008			
Su 2008			
Fa 2008			
Wi 2008/9			
Sp 2009			

1: System development
2: Scanner failure

Source: Dr. Rich Grant, Purdue University, April, 2008

Texas Dairy

Farm description

# animals	Measured Source	Barn manure removal
3400	Corral	Scrape/lagoon

Completeness criteria: 7.5d/ season
6 of 8 seasons

Estimated Days of Complete Valid Data

Season	NH_3	H_2S	VOCs
Su 2007			
Fa 2007	16d[1]		
Wi 2007/8	5d	11d	
Sp 2008	8d	12d	
Su 2008			
Fa 2008			
Wi 2008/9			
Sp 2009			

1: TDLAS stuck shutter and communications failure

Source: Dr. Rich Grant, Purdue University, April, 2008

Indiana Dairy

Farm description

# animals	Measured Source	Barn manure removal
2600	Lagoon	Scrape

Completeness criteria: 7.5d/ season
3 of 4 seasons

Estimated Days of Complete Valid Data

Season	NH_3	H_2S	VOCs
Su 2007			
Fa 2007			
Wi 2007/8			
Sp 2008			
Su 2008			
Fa 2008			
Wi 2008/9			
Sp 2009			

Source: Dr. Rich Grant, Purdue University, April, 2008

Indiana Swine: Sow

Farm description

# animals	Measured Source	Barn manure removal
1400	lagoon	Pull-plug

Completeness criteria: 68d/ season
3 of 4 seasons

Estimated Days of Complete Valid Data

Season	NH_3	H_2S	VOCs
Su 2007	0d[1]		
Fa 2007	34d[2]		
Wi 2007/8	0d[2]	0d	0d
Sp 2008	2d[2]	10d	18d
Su 2008			
Fa 2008			
Wi 2008/9			
Sp 2009			

1: System development
2: TDLAS and scanners often used to replace rotation team equipment returning to factory

Source: Dr. Rich Grant, Purdue University, April, 2008

North Carolina Swine: Sow

Farm description

# animals	Measured Source	Barn manure removal
2000	**lagoon**	**Flush**

Completeness criteria: 7.5d/ season
6 of 8 seasons

Estimated Days of Complete Valid Data

Season	NH_3	H_2S	VOCs
Su 2007			
Fa 2007	0d[1]		
Wi 2007/8	7d[2]	12d	
Sp 2008	11d	10d	
Su 2008			
Fa 2008			
Wi 2008/9			
Sp 2009			

1: Scanner failure
2: TDLAS calibration problem

Source: Dr. Rich Grant, Purdue University, April, 2008

Oklahoma Swine: Sow

Farm description

# animals	Measured Source	Barn manure removal
2784	Lagoon	Pull-plug/flush barns

Completeness criteria: 7.5d/ season
6 of 8 seasons

Estimated Days of Complete Valid Data

Season	NH_3	H_2S	VOCs
Su 2007	9d[1]		
Fa 2007	13d		
Wi 2007/8	10d		
Sp 2008			
Su 2008			
Fa 2008			
Wi 2008/9			
Sp 2009			

1: System development

Source: Dr. Rich Grant, Purdue University, April, 2008

Iowa Swine: finisher

Farm description

# animals	Measured Source	Barn manure removal
3840	**Basin**	**Pull-plug barns**

Completeness criteria: 7.5d/ season
6 of 8 seasons

Estimated Days of Complete Valid Data

Season	NH_3	H_2S	VOCs
Su 2007			
Fa 2007	1d[1]		
Wi 2007/8	17d		
Sp 2008			
Su 2008			
Fa 2008			
Wi 2008/9			
Sp 2009			

1: Retro alignment problem on 1 path

Source: Dr. Rich Grant, Purdue University, April, 2008

North Carolina Swine: finisher

Farm description

# animals	Measured Source	Barn manure removal
8000	**lagoon**	**Flush**

Completeness criteria: 7.5d/ season
6 of 8 seasons

Estimated Days of Complete Valid Data

Season	NH_3	H_2S	VOCs
Su 2007			
Fa 2007	1d[1]		
Wi 2007/8	15d	15d	
Sp 2008	13d	13d	
Su 2008			
Fa 2008			
Wi 2008/9			
Sp 2009			

1: TDLAS shutter stuck

Source: Dr. Rich Grant, Purdue University, April, 2008

Oklahoma Swine: finisher

Farm description

# animals	Measured Source	Barn manure removal
3000	lagoon	Pull-plug/flush barns

Completeness criteria: 7.5d/ season
6 of 8 seasons

Estimated Days of Complete Valid Data

Season	NH_3	H_2S	VOCs
Su 2007			
Fa 2007	3d[1]		
Wi 2007/8	0d[2]	16d	
Sp 2008			
Su 2008			
Fa 2008			
Wi 2008/9			
Sp 2009			

1: TDLAS shutter stuck
2: TDLAS calibration failure

Source: Dr. Rich Grant, Purdue University, April, 2008