Does Pulsed Sampling Provide Good Estimates of Atmospheric Concentrations?

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Tracer Experiments

- To understand how the atmosphere transports, disperses, and diffuses materials.
  - Release a small amount of tracer.
  - Sample and measure the concentrations.
  - Combine results with meteorological information.

How is Sampling Done?

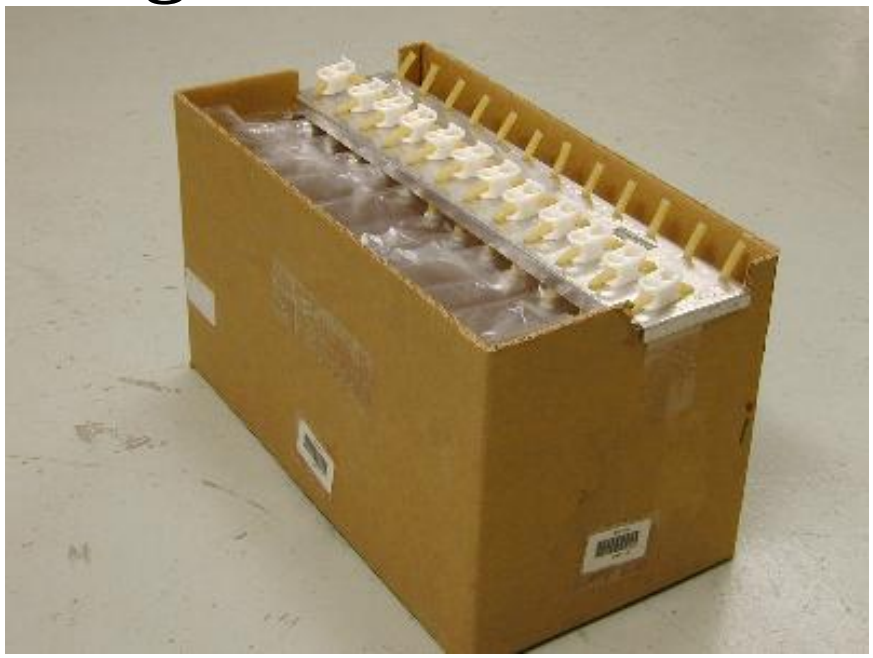
- Programmable Integrating Gas Sampler
  - Collect samples over a period.
  - Sequentially fill 12 bags for the programmed duration.
  - Pumps are “pulsed” for short bursts.

Sampler

- Waxed cardboard box with pumps and controlling electronics.

Cartridge

- Smaller cardboard box containing 12 Tedlar bags.



Sampler + Cartridge Inside Without the Lid

- The cartridge is placed inside the sampler.

Sample + Cartridge With Lid

- The lid is placed on the sampler.

How Are the PIGS Placed?

- PIGS are placed at pre-selected sites.
- Hung 10 feet above ground on poles.

Keeping Track of All Those Samples

- Locations, samplers and cartridges tagged with barcodes.
- Longitude and latitude recorded on a computer.
- Timewands used to track samples.

Timewand

Automated Tracer Gas Analysis System (ATGAS)

Sample Analysis

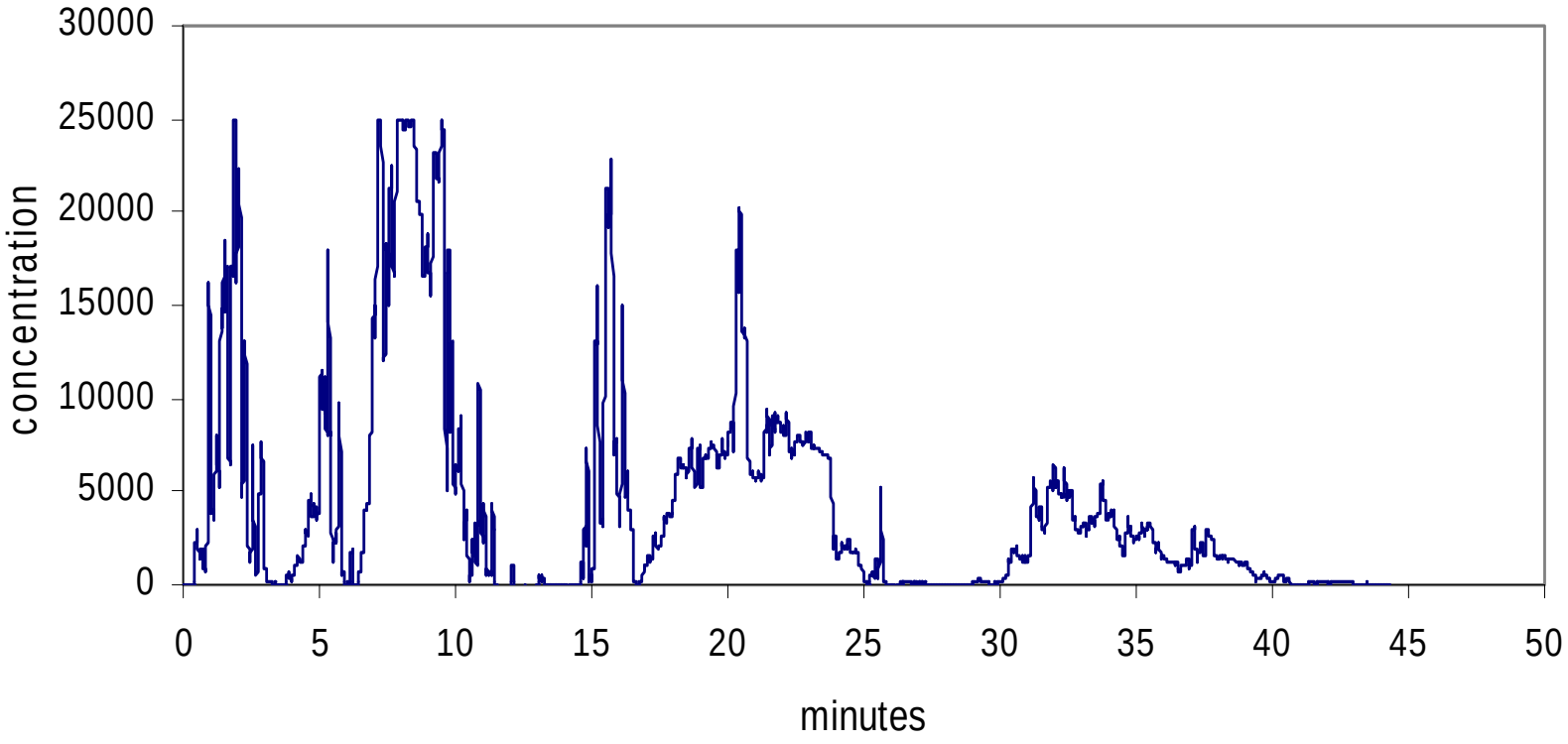
- Cartridges are collected.
- Cartridge barcode is scanned.
- The parameters and test information are included with the analysis results.
- No hand entry.

Trace Gas Analyzer (TGA)

- Continuous analyzer

Does the Sample Created By Filling the Bag Using Pulses Adequately Represent the Average Concentration of the Sampled Tracer?

TGA Plume Plot



Experimental Setup

- PVC pipe suspended horizontally with tubing ports.
- Tracer (SF_6) and ultra pure air injected into one end.
- Flows set with mass flow controllers.
- TGA and PIGS attached to sampling ports.

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Three Tests Were Done

1. Test A: “Worst case” scenario.

2. Test B: “Best case” scenario.

3. Test C: “Random pulse” scenario.

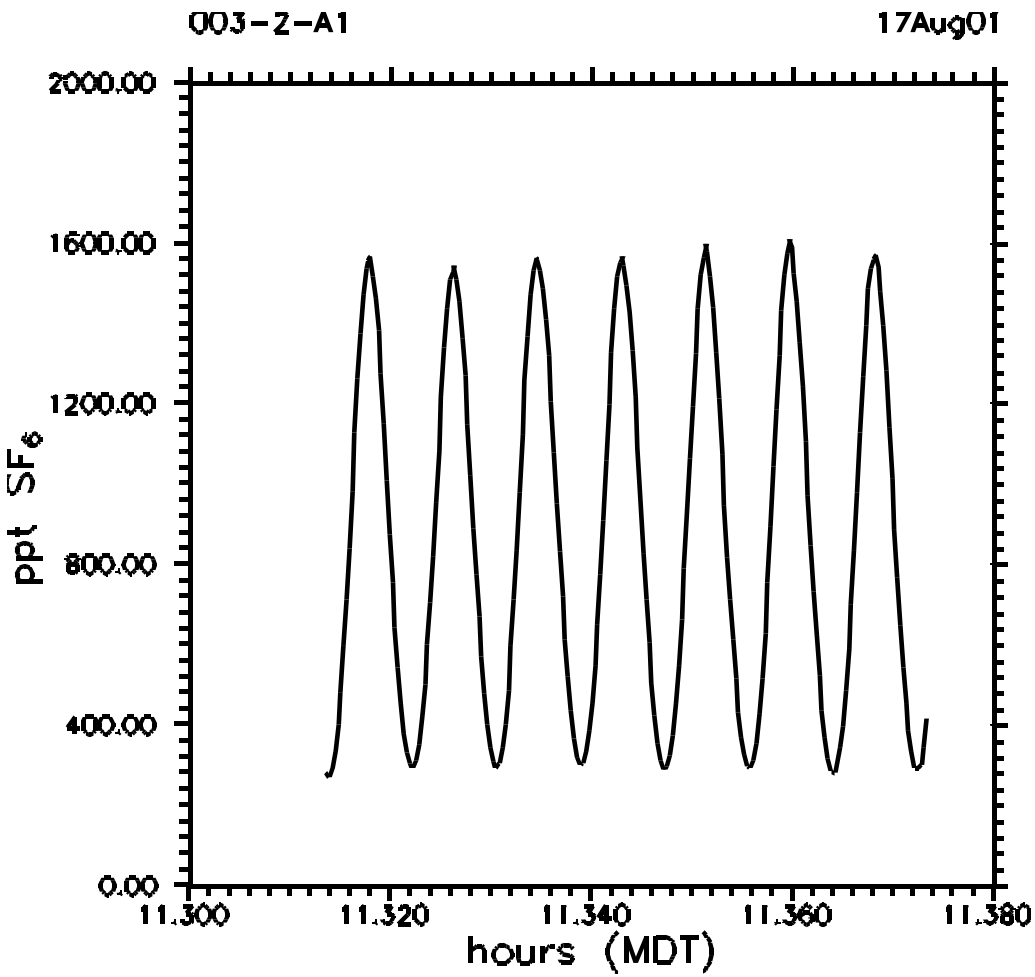
Test A- Worst Case Scenario

- Sampler pulses and SF_6 puffs were the same frequency.
- Samplers in-phase measure higher concentration than out-of-phase.
- Worse than real world because variations were continuous.
- Samplers ran for 50 minutes/bag, pulsing at 30 second intervals.

TGA Monitoring of Tracer

- Two TGAs sampled the gas in the sampling pipe to verify that the concentration puffs were not mixing into a uniform concentration.

TGA Output


003-2-A1
17Aug01
2000.00
1600.00
1200.00
800.00
400.00
0.00
ppt SF6
11.300
11.320
11.340
11.360
11.380
hours (MDT)

Test B- Best Case Scenario

- Same as Test A except sampled almost continuously.
- The difference between Test A and Test B = worst-case effect?

Test C- Random Pulse Scenario

- SF_6 pulsed for 1 second; time between pulses varying randomly.
- Samples pulsed their pumps every 5 seconds.

Results for Each Test

Test	Average Concentration (pptv)	Standard Deviation (pptv)	RSD (%)
A Worst Case	979	155	16
B Best Case	1032	63	6
C Random Pulse	1422	96	7

Worst Case Scenario Produced Greater Imprecision

- Worst Case resulted in the highest RSD of 16%.
- Best Case and Random Pulse had fairly equivalent RSDs of 6% and 7% respectively.

Comparison Between Tests

Test	RPD of Average Concentration (%)	RPD of RSD (%)
Worst Case and Best Cast	8.5	67
Worst Case and Random Pulse	NA	57
Best Case and Random Pulse	NA	11

Random Pulse Mimicked Best Case Very Well

- The RSDs of Best Case and Random Pulse were almost the same.
- The RPD of the RSD between Best Case and Random Pulse was less than the control limit of ± 20%.

Summary

- Not an exhaustive treatment.
- Worst Case 95% confidence intervals were ±32%, only 12% beyond control limits.
- Random Pulse showed no problems.
- Not likely that real world scenarios would cause significant problems.