

Validation of high altitude measurements of CO₂ and CH₄ using the AirCore

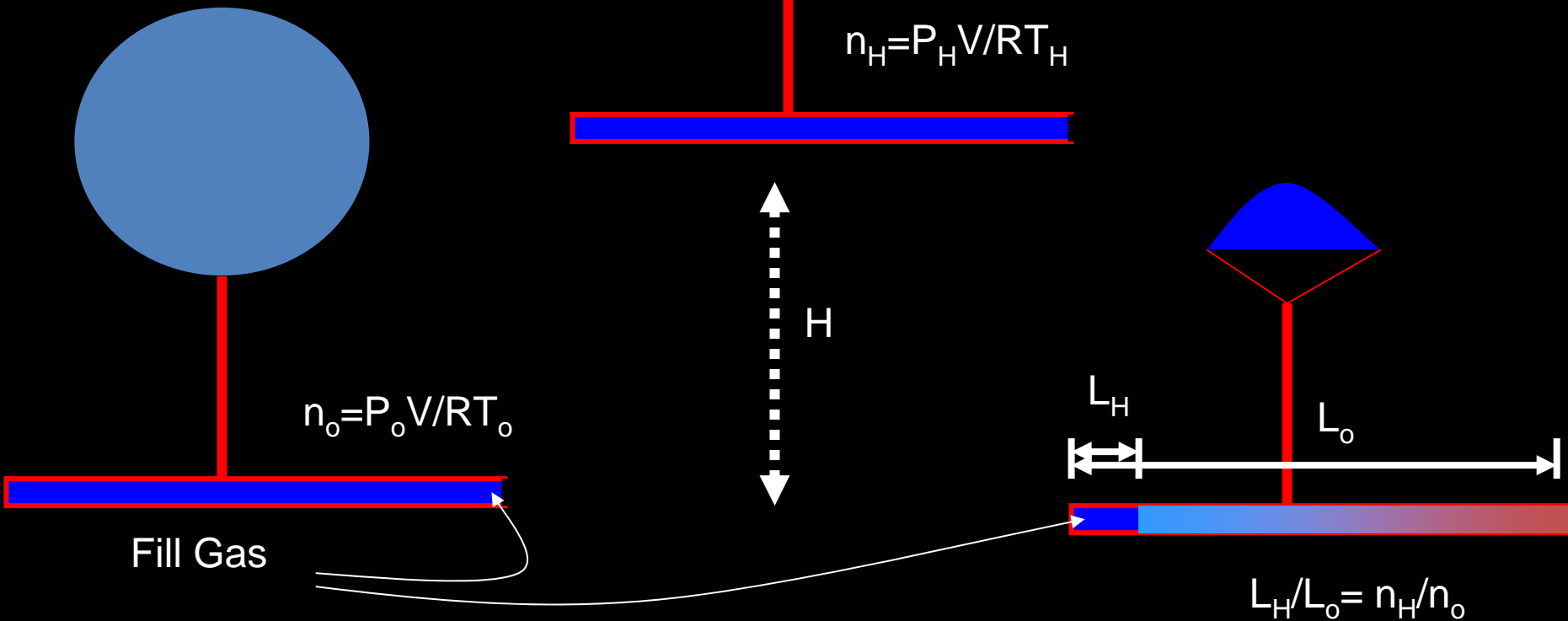
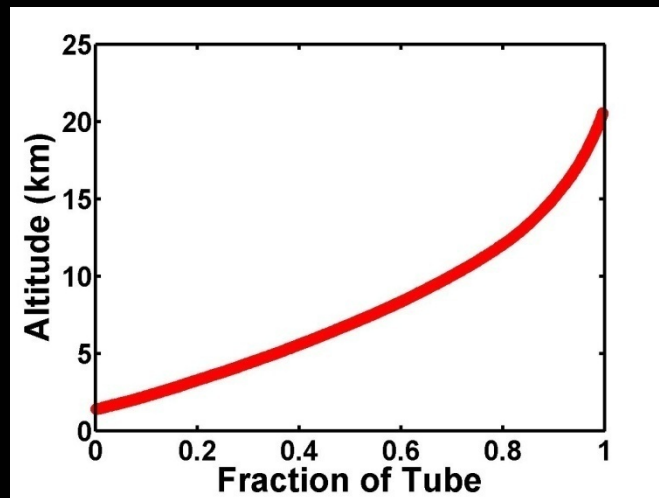
Colm Sweeney
Anna Karion
Tim Newberger
Pieter Tans



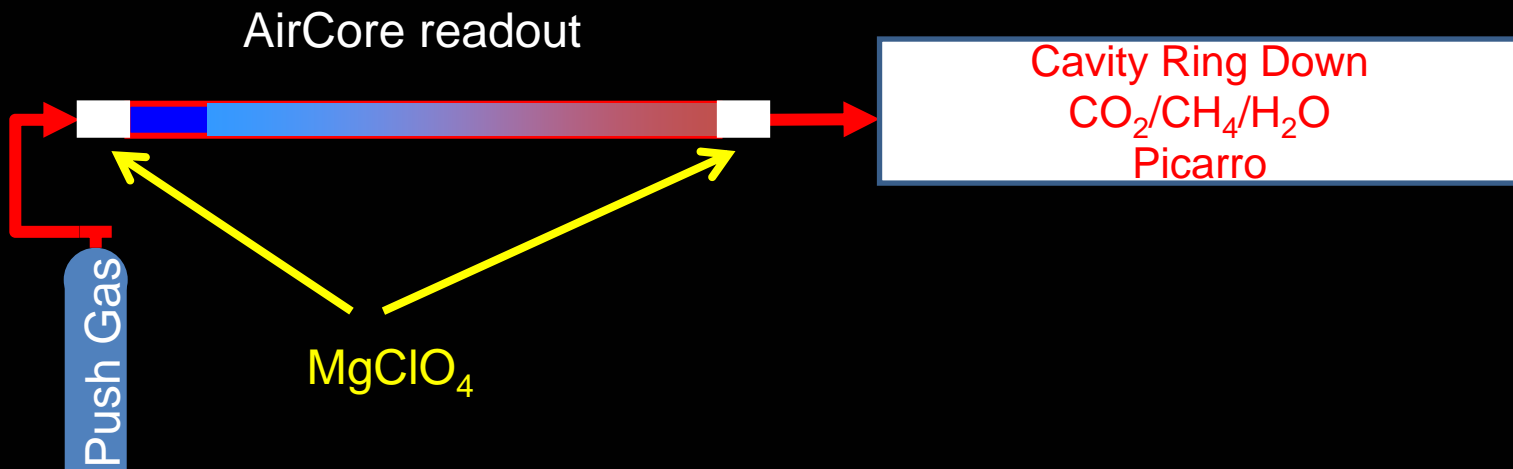
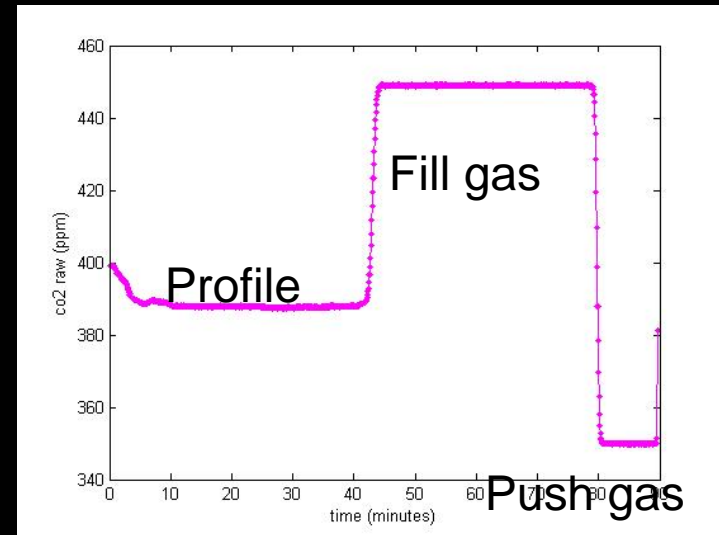
Questions?:
Colm.Sweeney@noaa.gov



AirCore



AirCore analysis



AirCore Validation

Slug Test: Analysis of CH₄/CO₂ successive slugs of air passing through the AirCore

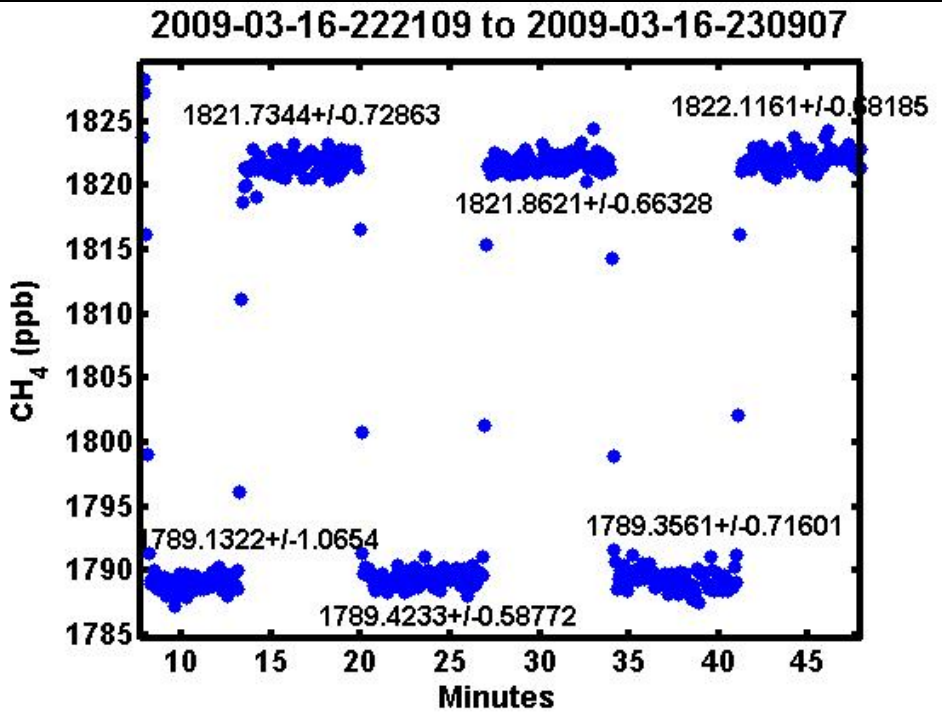
Evacuation Test: Analysis of sample bias under typical pressure conditions.

Storage Tests: Analysis of degradation of CH₄/CO₂ slugs stored in the AirCore

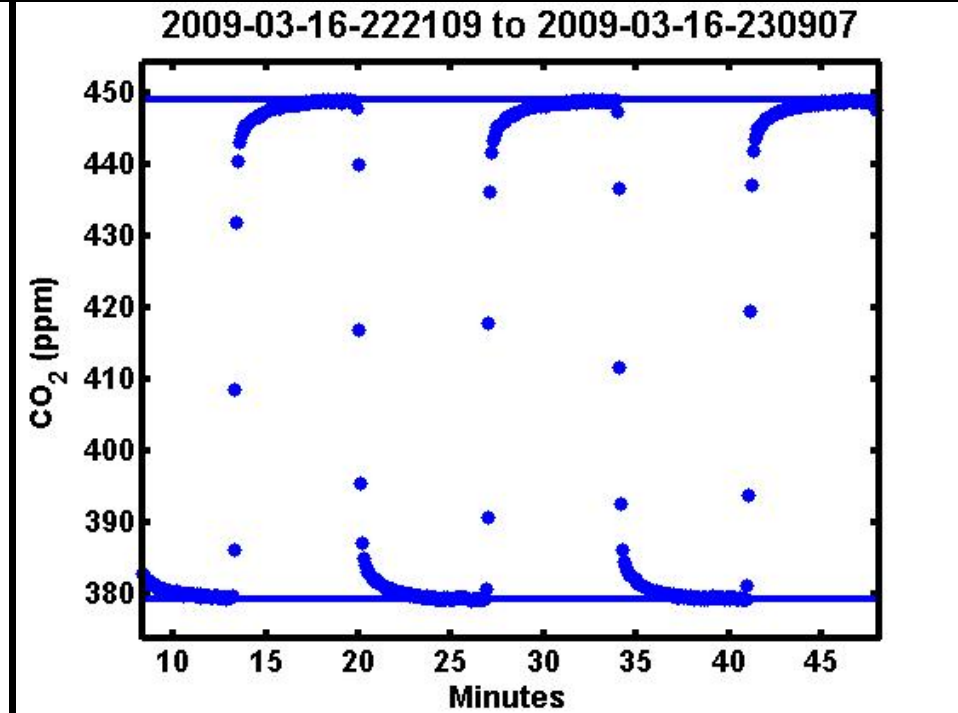
Aircraft Deployment: Comparison of in situ vertical profiles against multiple methods

Balloon Deployment: High altitude measurements

Slug Test - Synflex



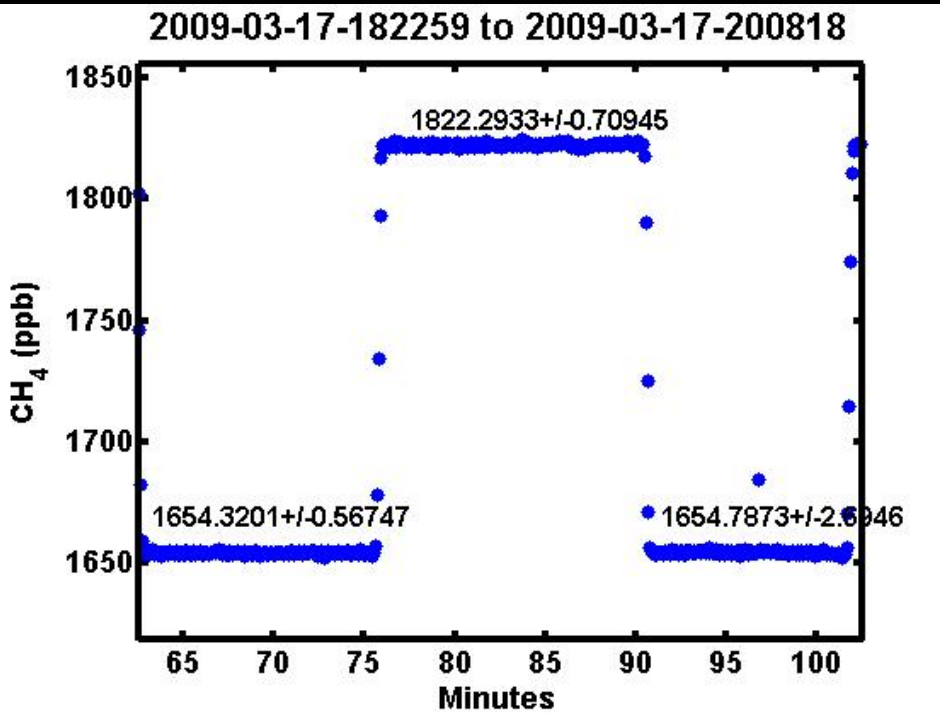
CH₄



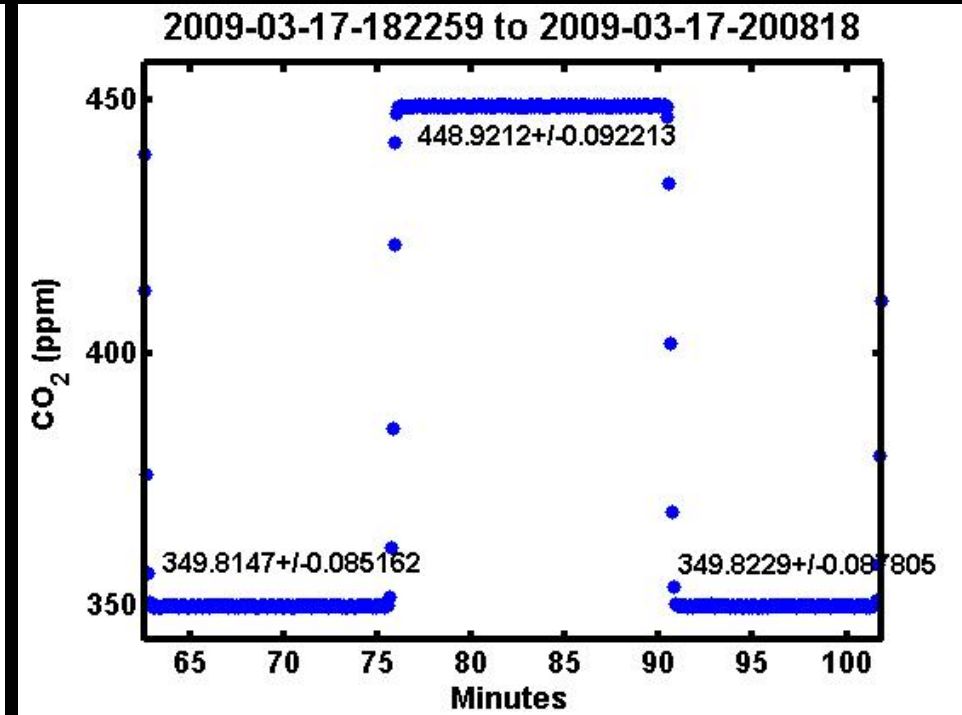
CO₂

CH₄ slugs are unaffected by Synflex but CO₂ slugs are significantly effected – bias and significant equilibration time with tube side wall

Slug Test – Restek/Stainless Steel



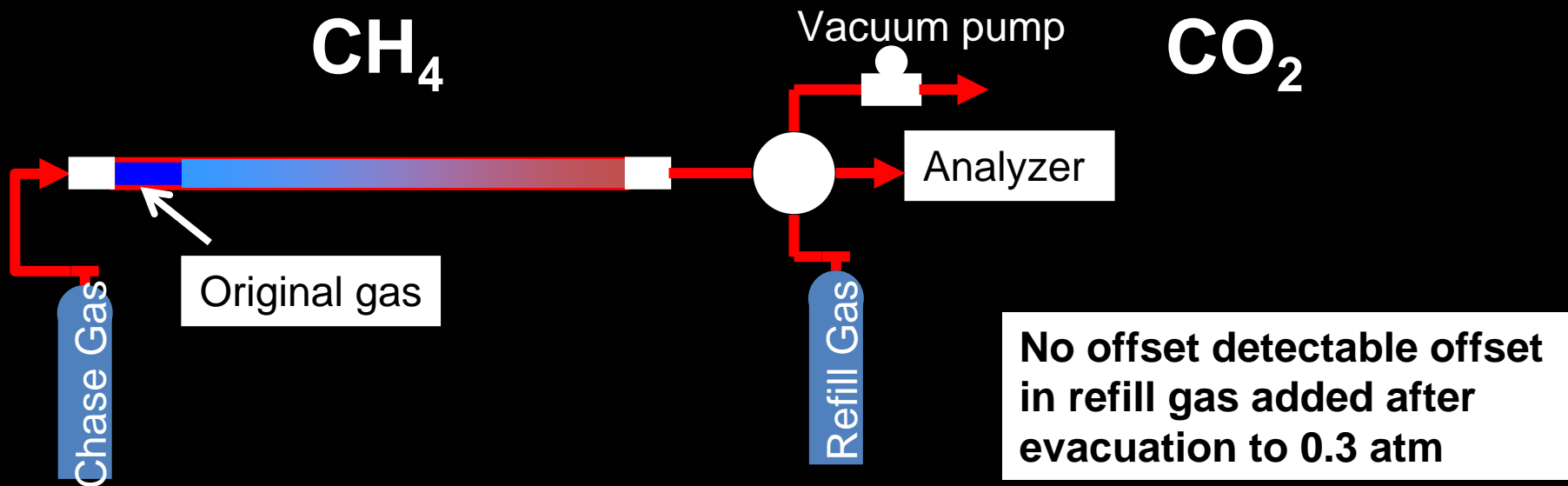
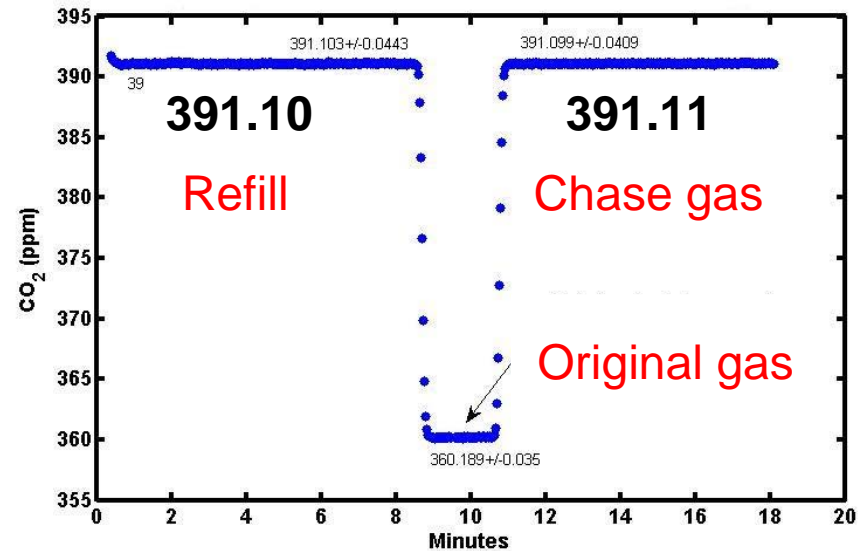
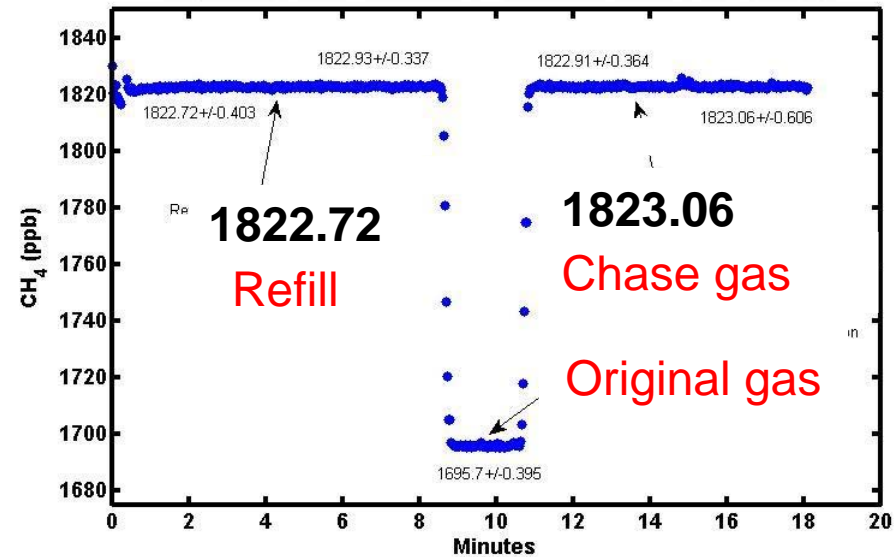
CH₄



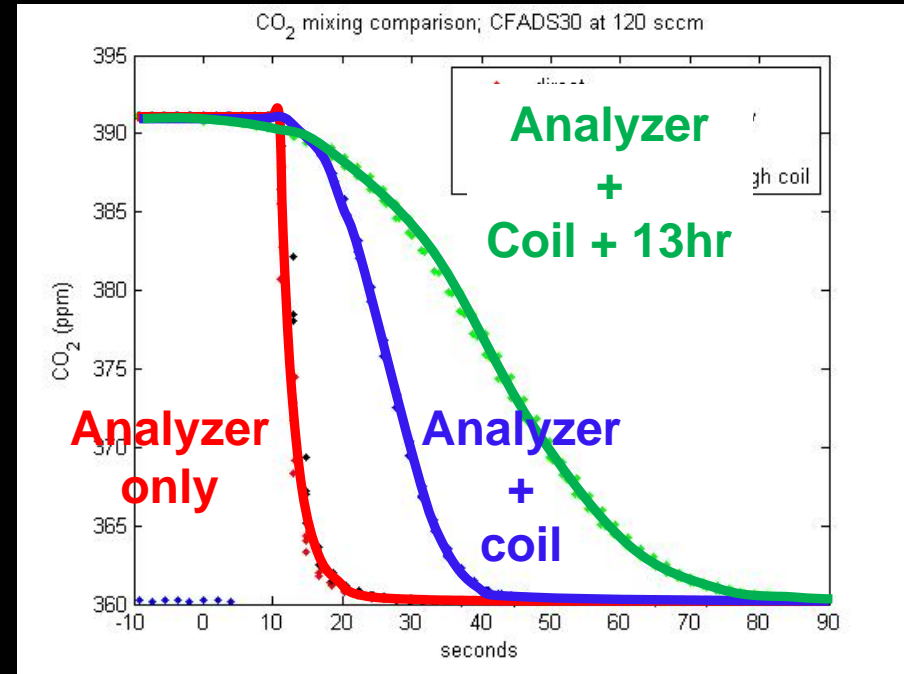
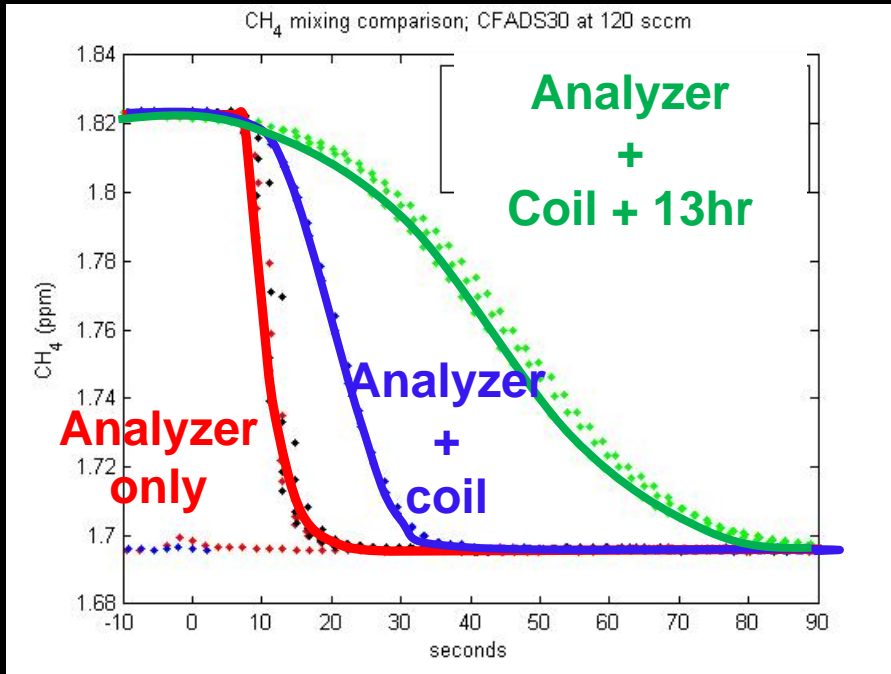
CO₂

Restek treatment shows no bias

Evacuation test



Storage and flow distortion test



CH₄

CO₂

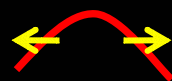
Flowing through coil

Storage



Taylor Dispersion

$$D_{eff} = \left(D + \frac{a^2 \bar{V}^2}{48D} \right)$$

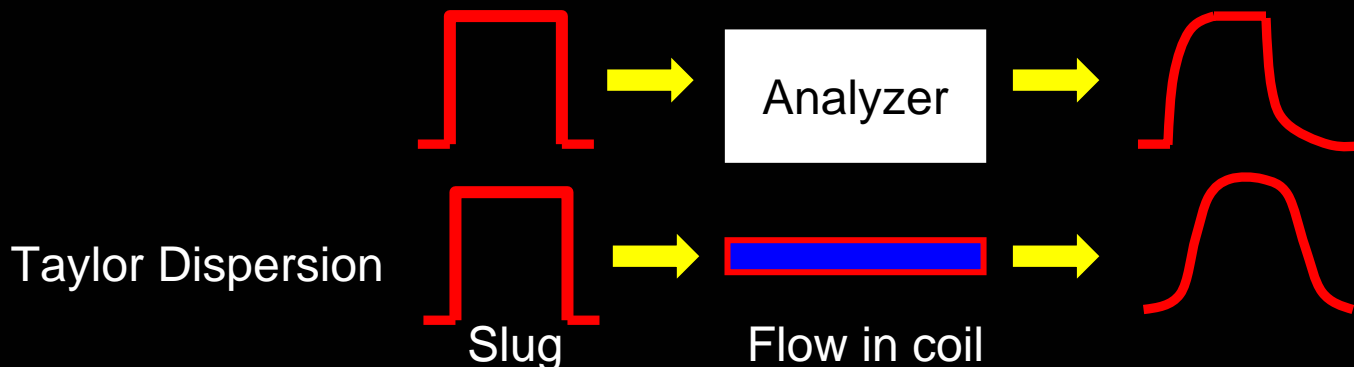
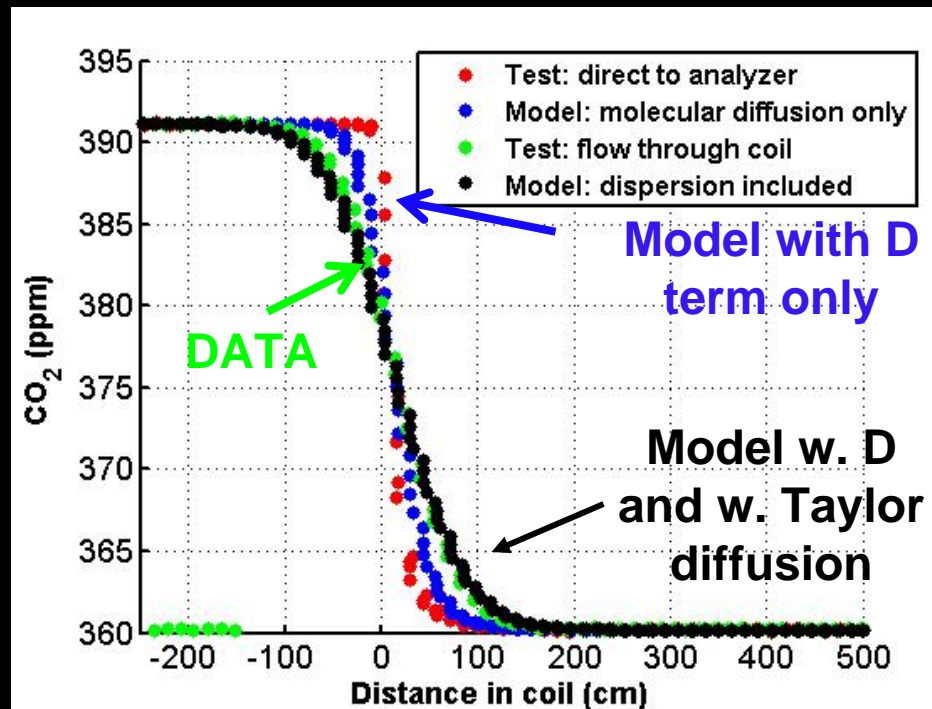


Molecular Diffusion

$$X_{rms} = \sqrt{2Dt}$$

Modeling flow

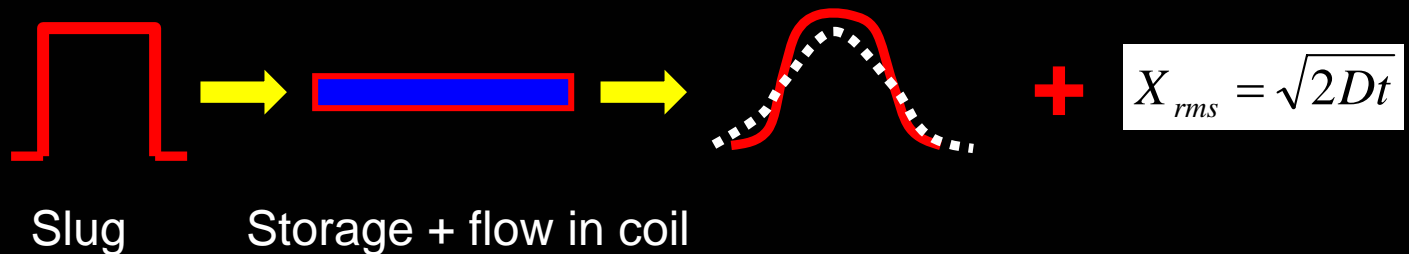
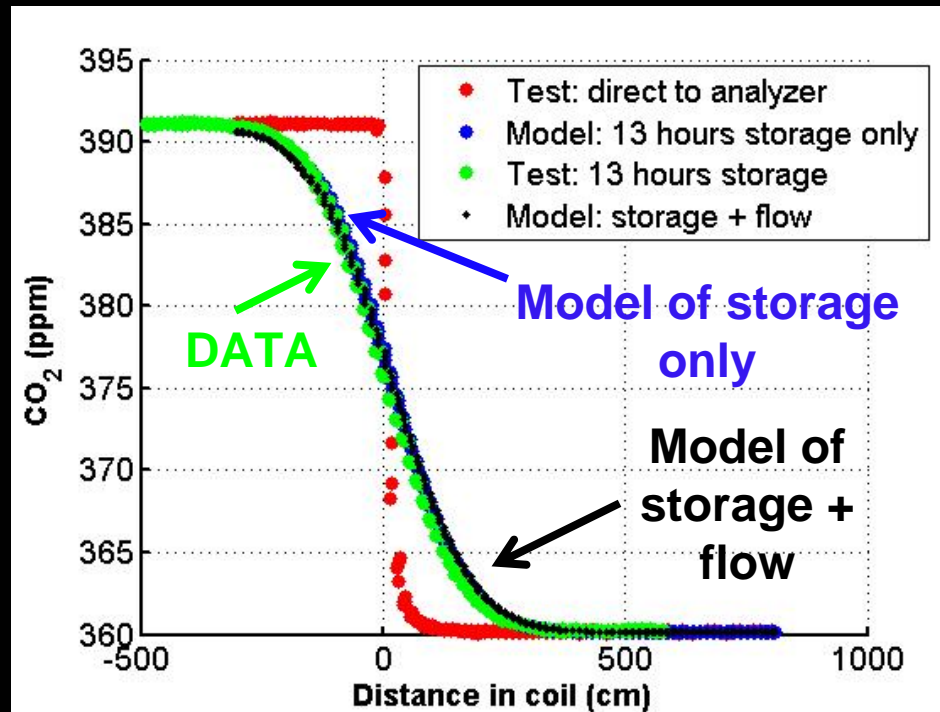
In the short-term the flow dispersion should be considered



$$D_{eff} = \left(D + \frac{a^2 \bar{V}^2}{48D} \right),$$

Modeling storage

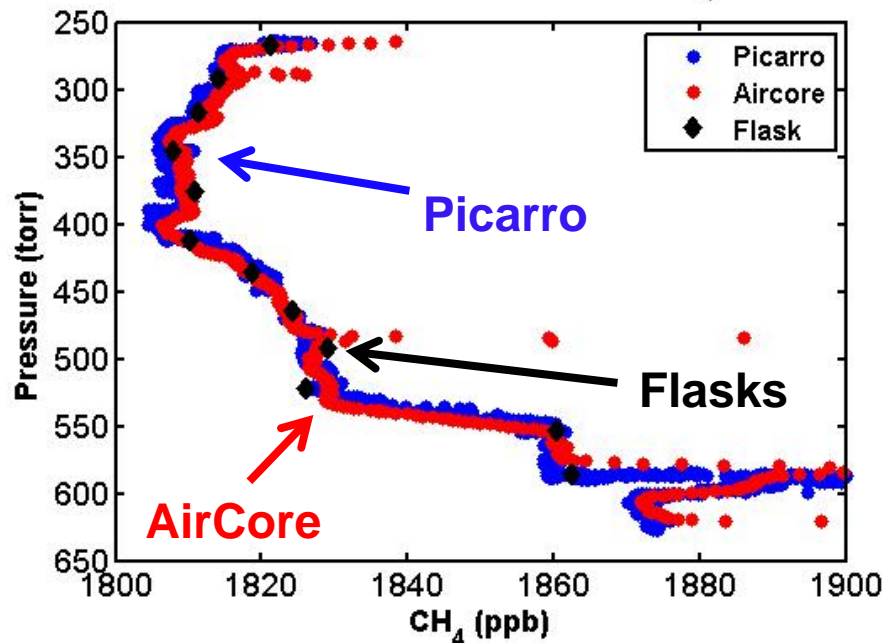
In the long-term the diffusion due to storage is the main factor



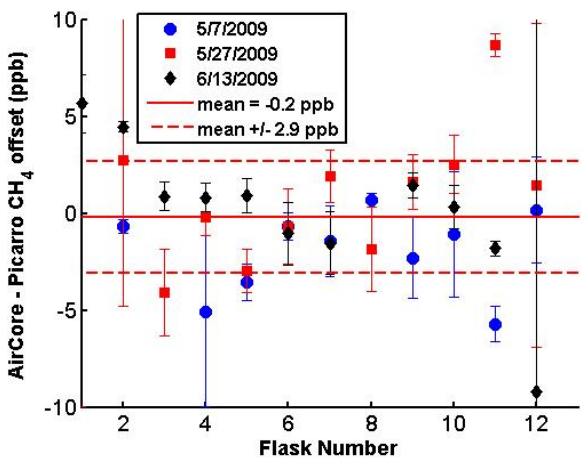
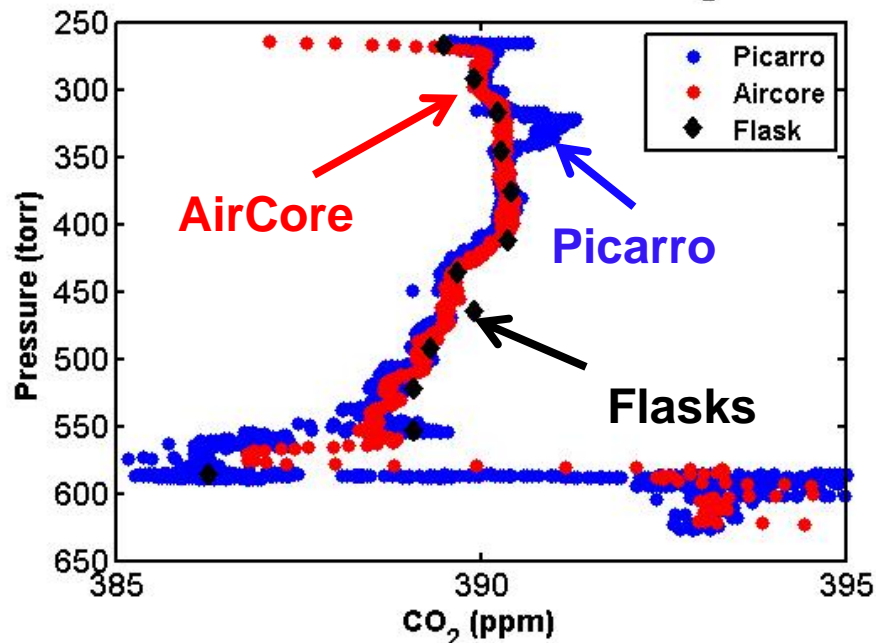
$$D_{CO_2} = 0.14 \text{ cm}^2/\text{s at STP}$$

Aircraft deployment

6/13/2009: Pressure vs. CH₄



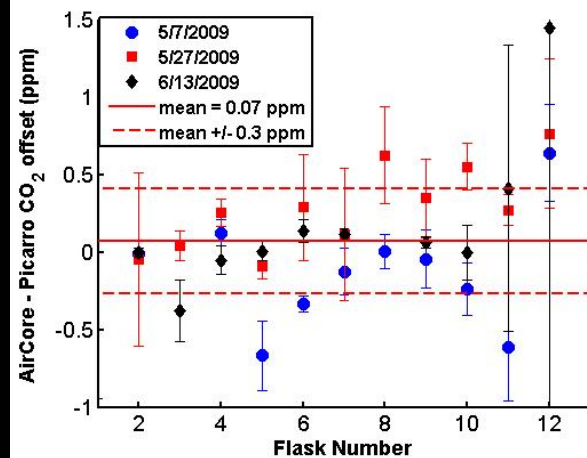
6/13/2009: Pressure vs. CO₂



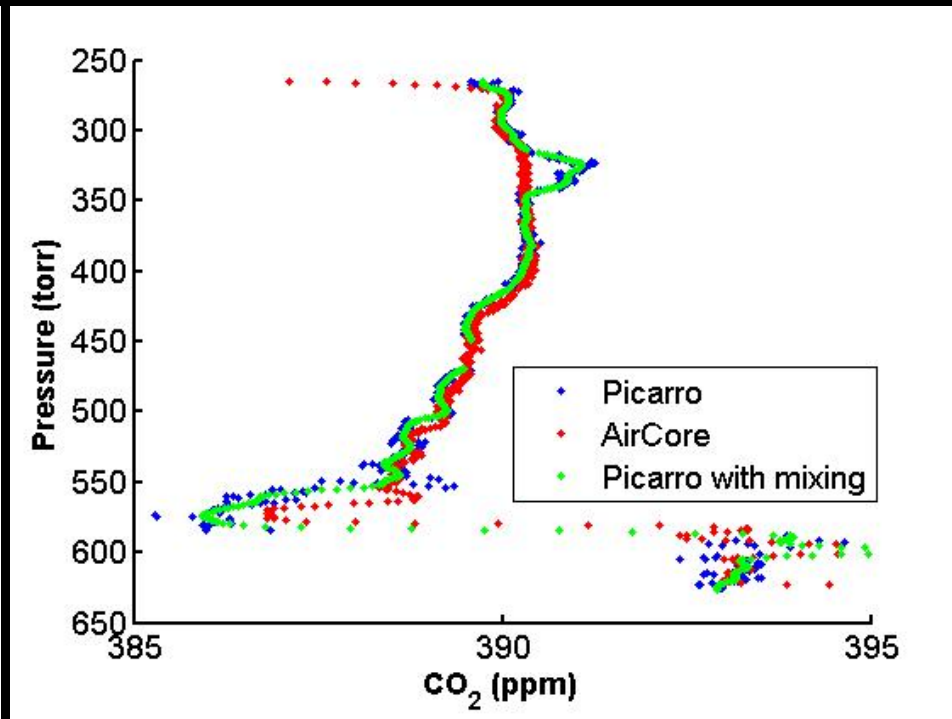
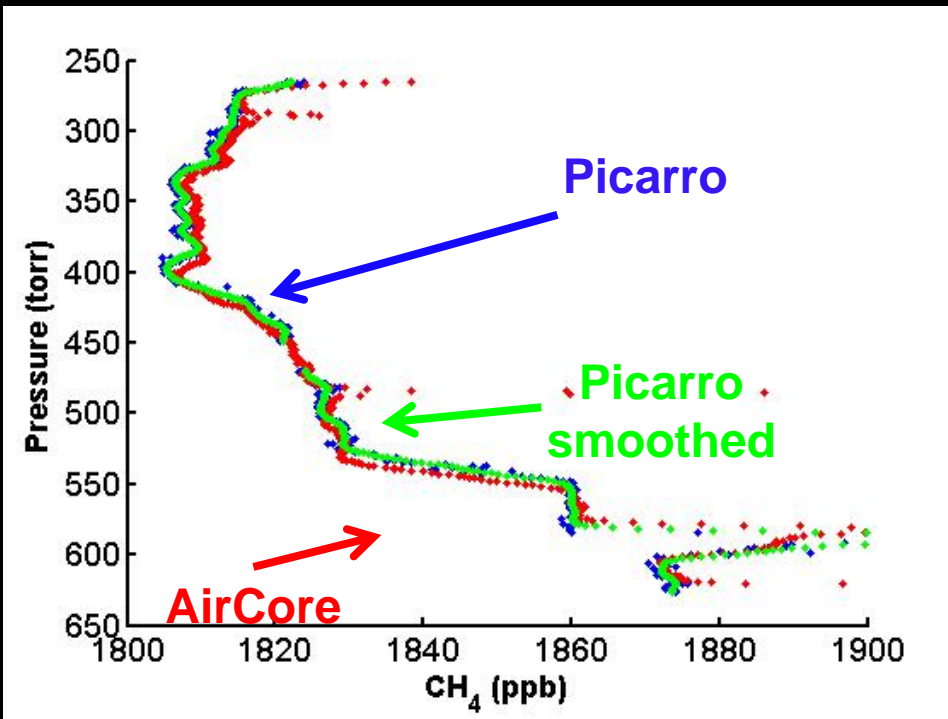
Mean offset

CO₂
(ppm)
-0.07 ± 0.3

CH₄
(ppb)
-0.2 ± 2.9



Vertical Resolution



CH₄

Vertical Resolution

CO₂

Altitude

3 h

9 h

24h

100 m

110 m

150 m

220 m

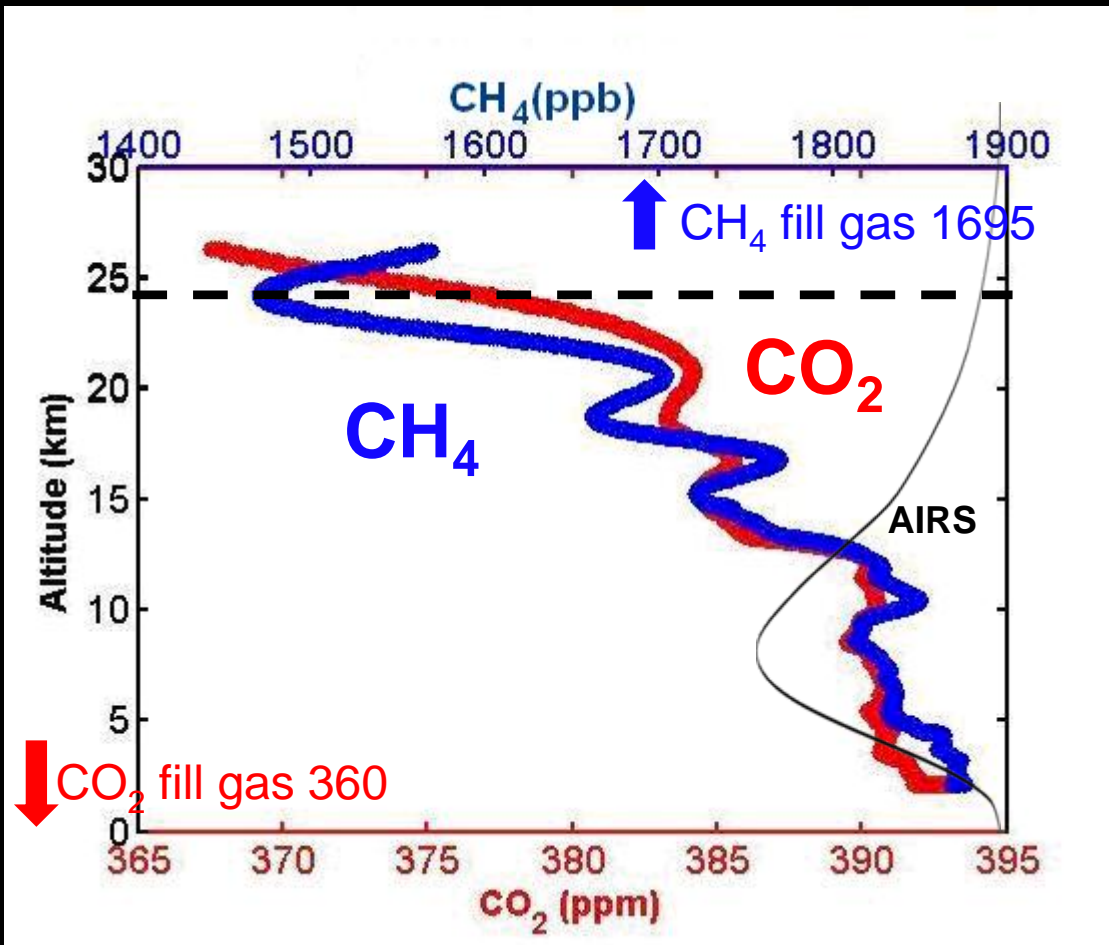
8000 m

260 m

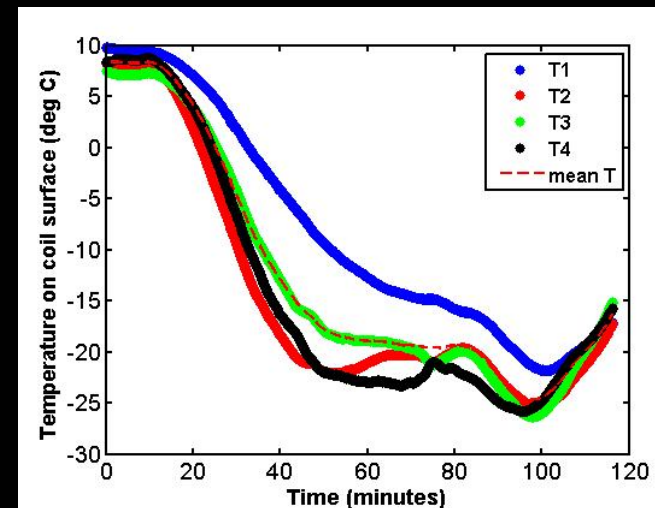
360 m

510 m

Balloon profile

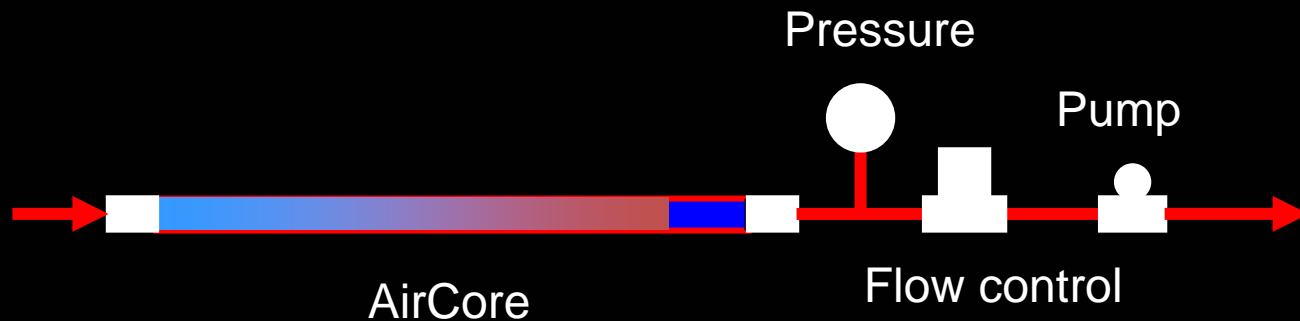


Balloon profiles show large gradients of CH₄ in the troposphere but more work needs to be done to understand the effect of -30 C temperatures



Horizontal Tape Recorder

Samples can be actively pumped into AirCore



- 400 m of 1/8 (0.010 in) inch = ~7 Kg
- After 24 h (3.2 m diffusion) = 125 independent samples
- At 12 cc/min (2.2 L coil) = 3 h of sampling time

Conclusions

- Laboratory repeatability 0.05 ppm CO₂
and 0.4 ppb CH₄
- Aircraft flights show no bias with standard deviation of 0.3 ppm CO₂, 5 ppb CH₄
- Diffusion and flow dispersion predictable
- Future possibilities to be tested:
 - Higher altitudes and low temperatures
 - With pump for level flight
 - Measurement of other gases
 - Alternate tubing type and configuration