

Uptake of Ozone-Depleting Halogenated Gases to the Snow-Covered Surface at Niwot Ridge, Colorado

Detlev Helmig



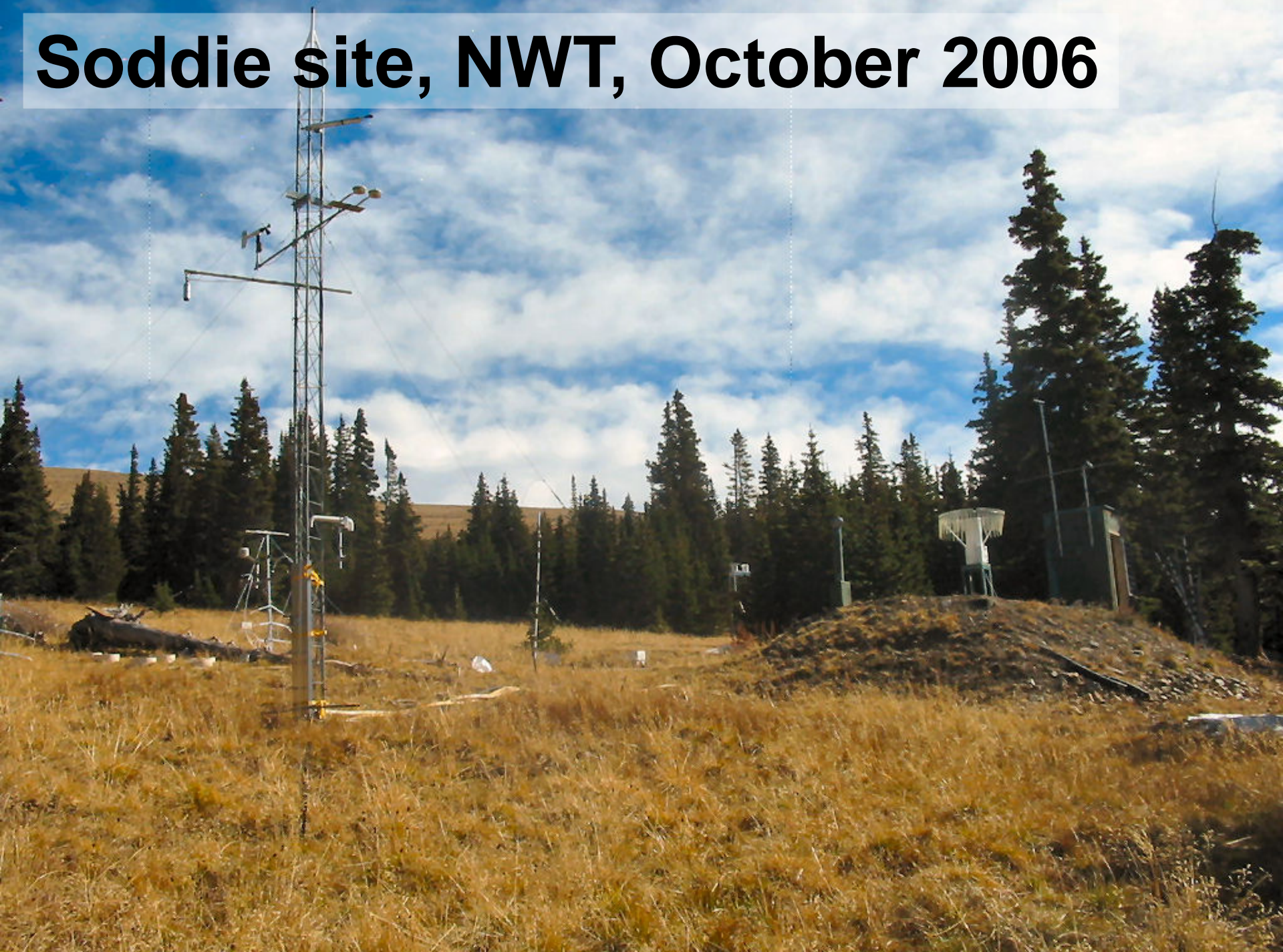
Eric Apel

Donald Blake, Simone Meinardi, Aaron Swanson

Laurens Ganzeveld

Bary Lefer

Soddie site, NWT, October 2006



Snowpack Air Sampling Tower





sampling inlet w/ syringe filter

thermocouple

January 2005





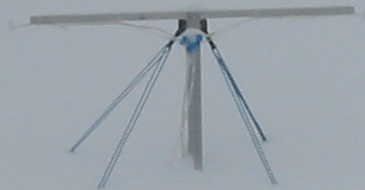


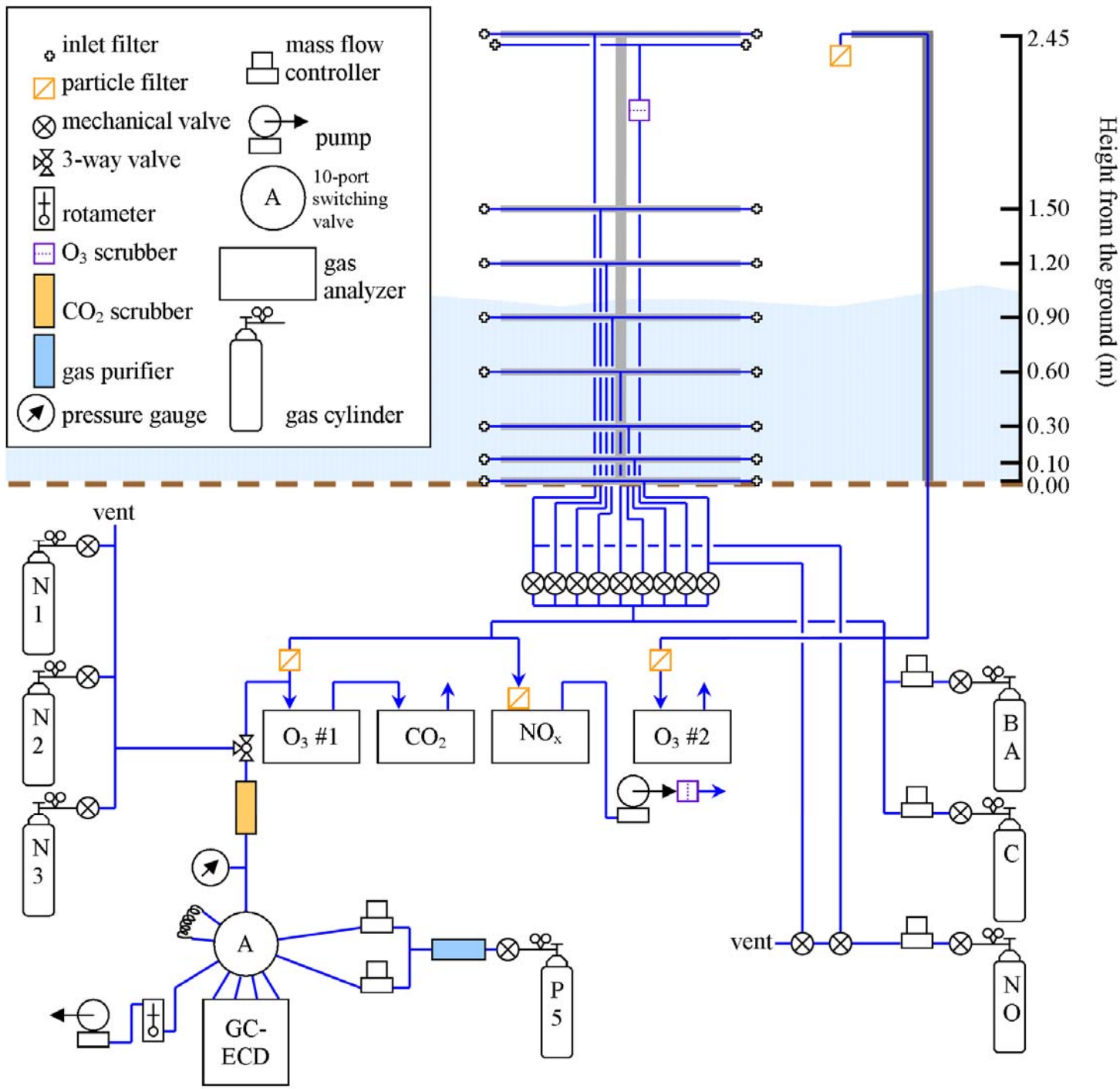
11





205 cm of snow~!





Valves, etc.

CR23X

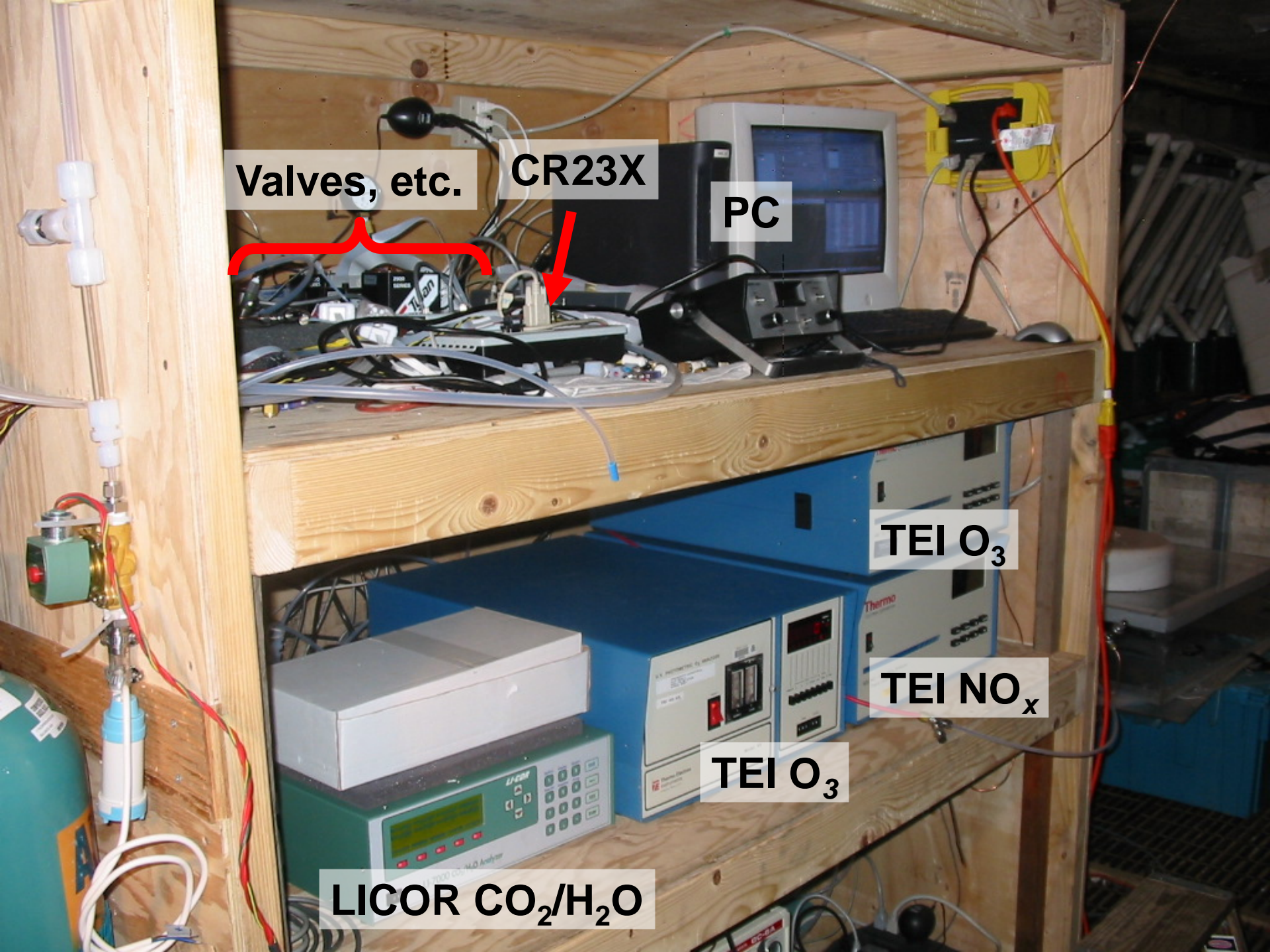
PC

TEI O₃

TEI NO_x

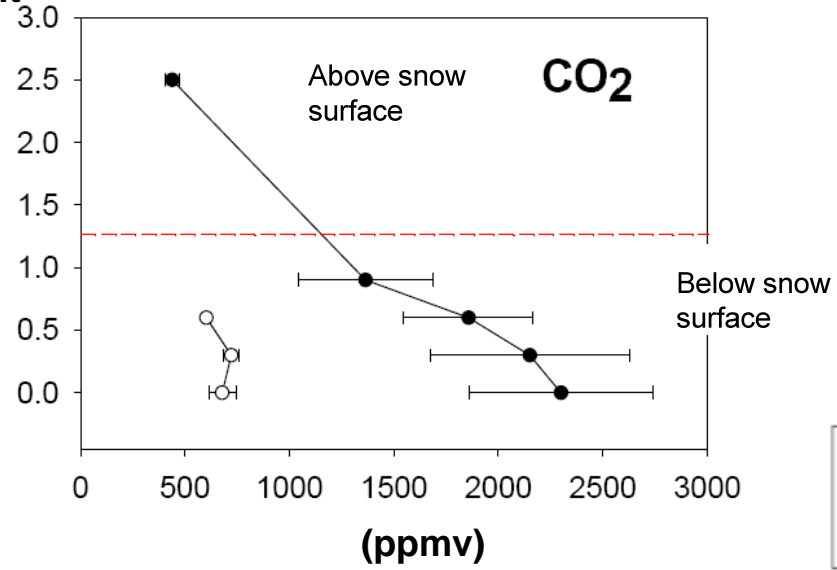
TEI O₃

LICOR CO₂/H₂O



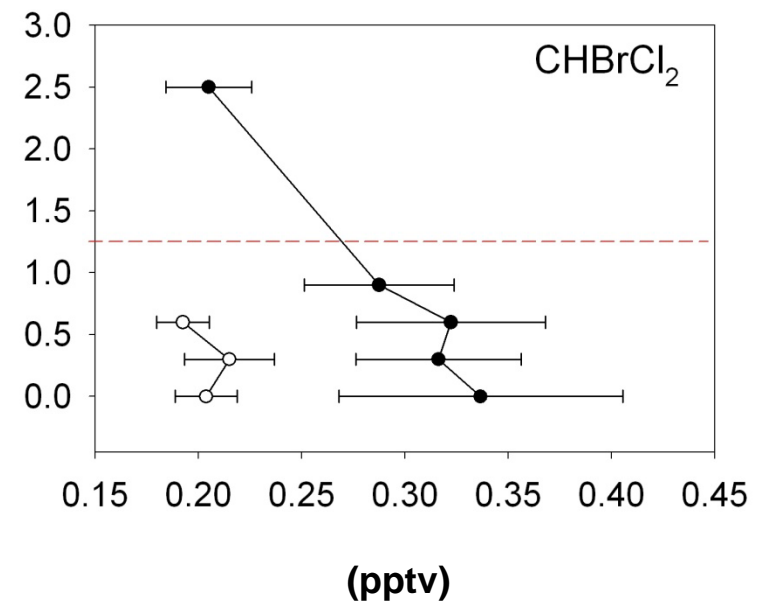
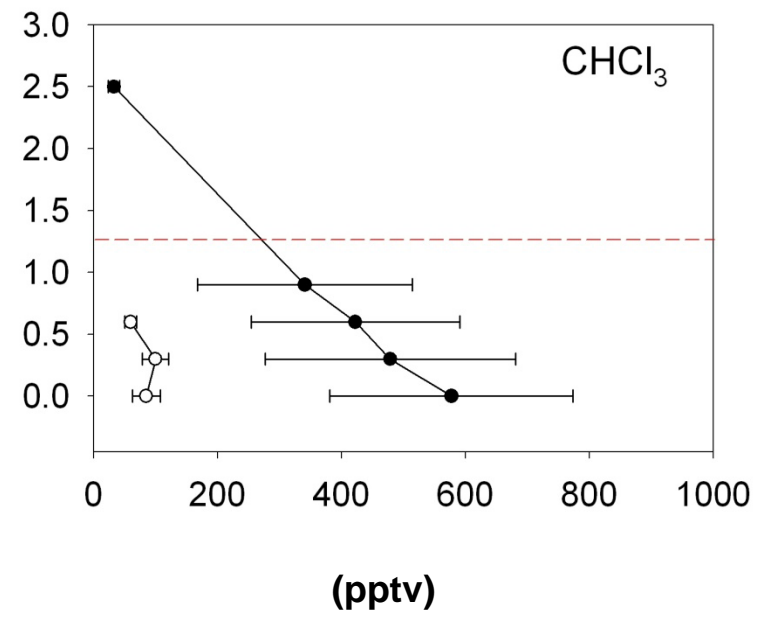
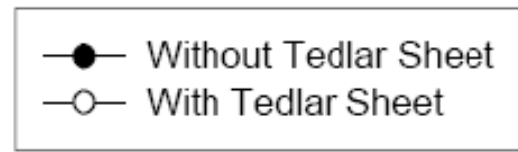


Height

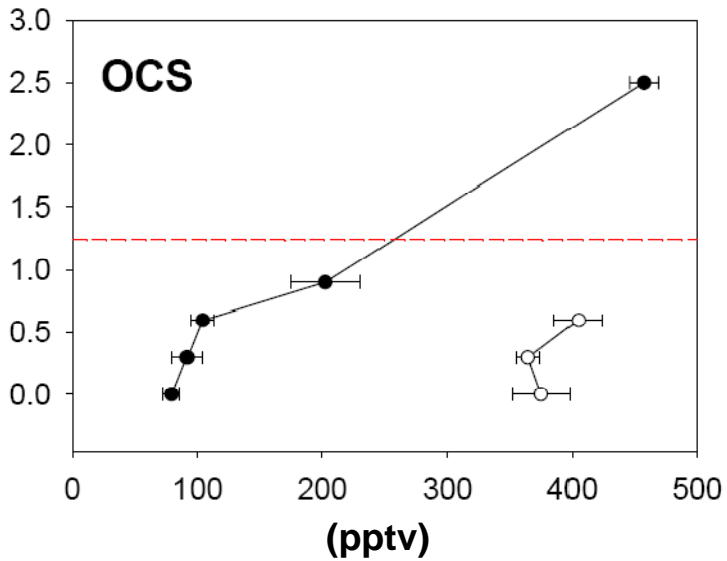
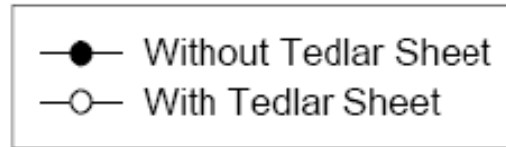
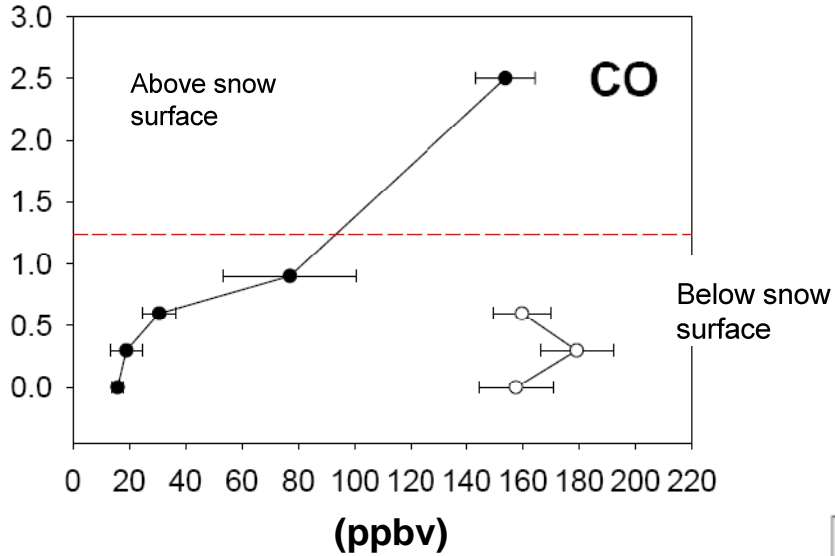


Gases produced

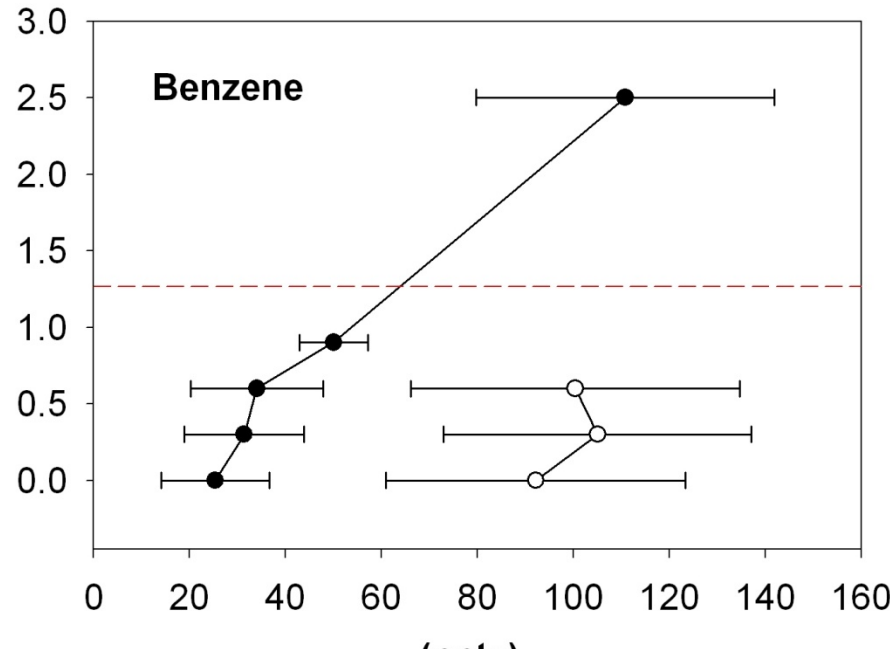
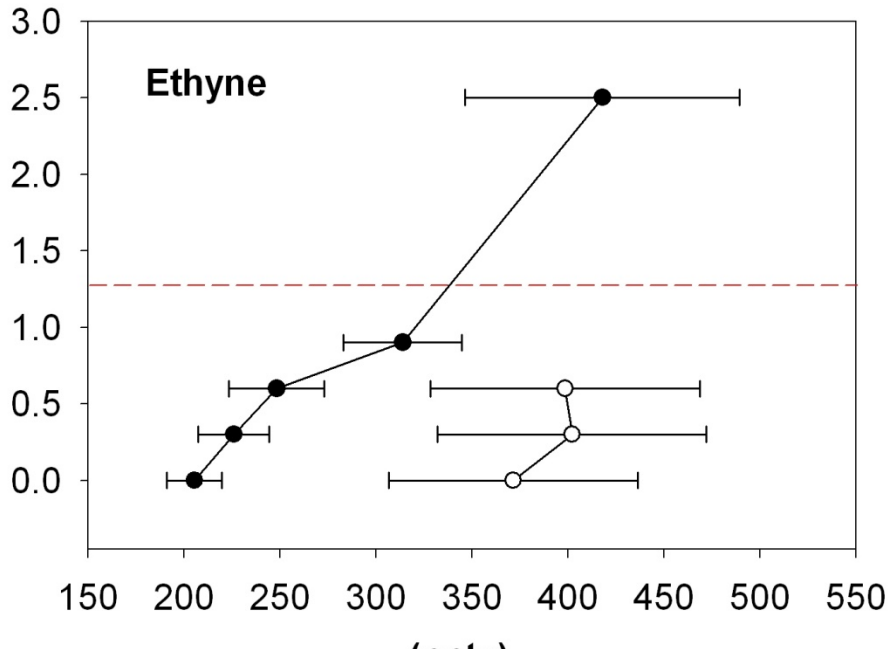
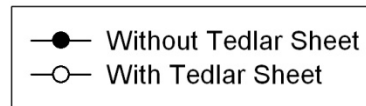
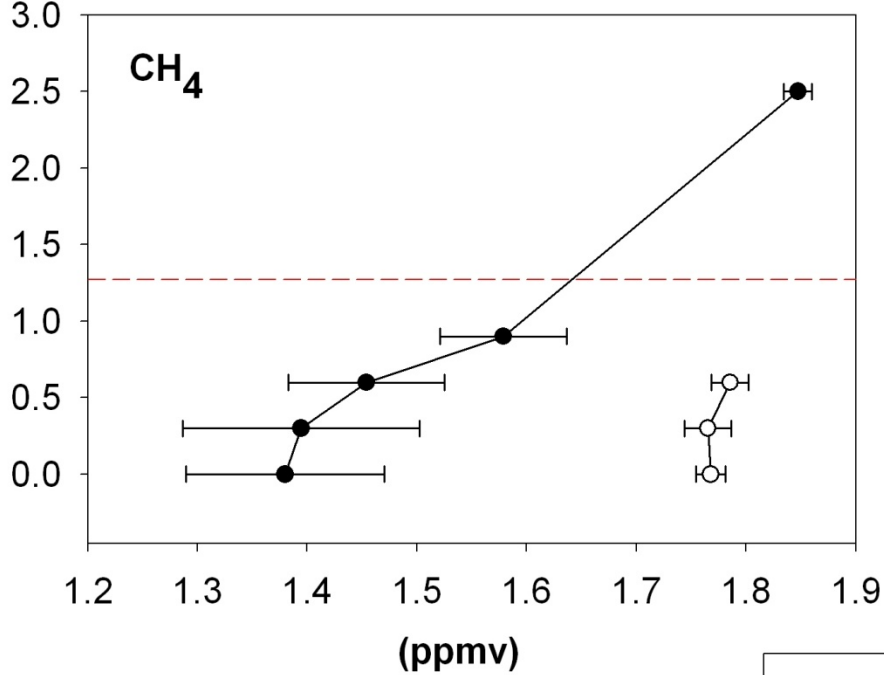
also: NO, N₂O, DMS



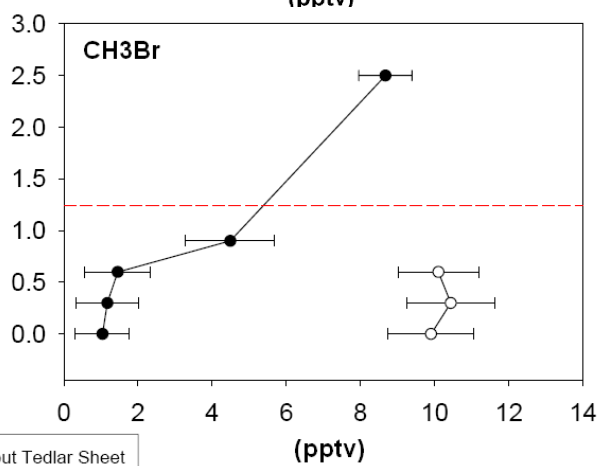
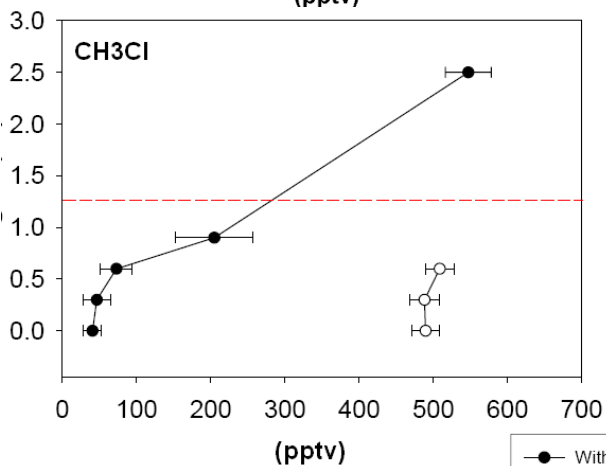
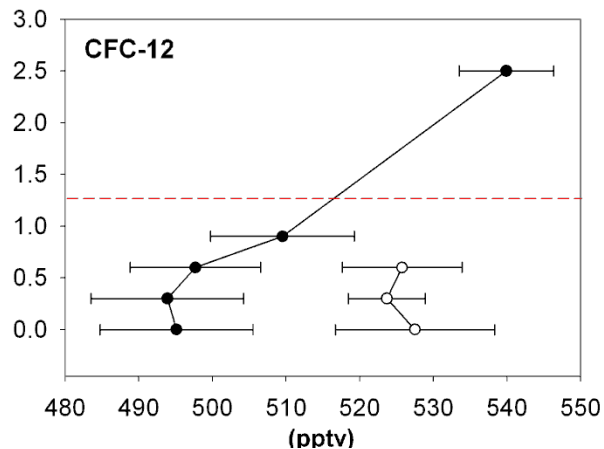
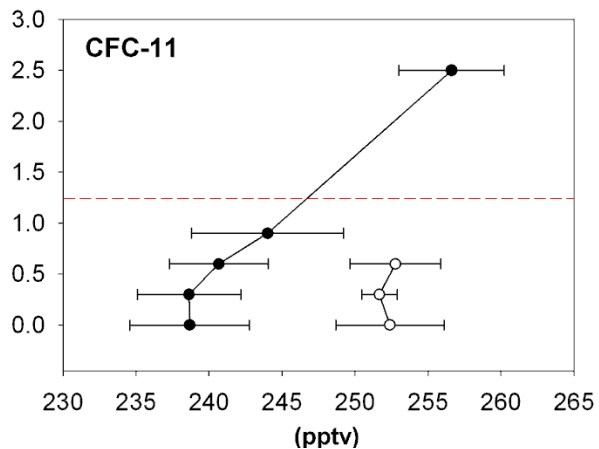
Gases taken up (I)



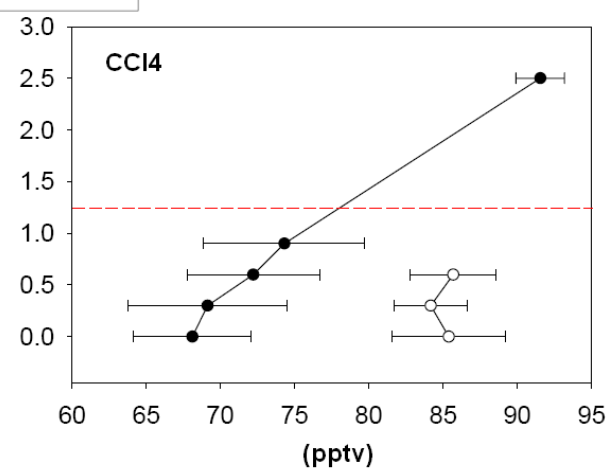
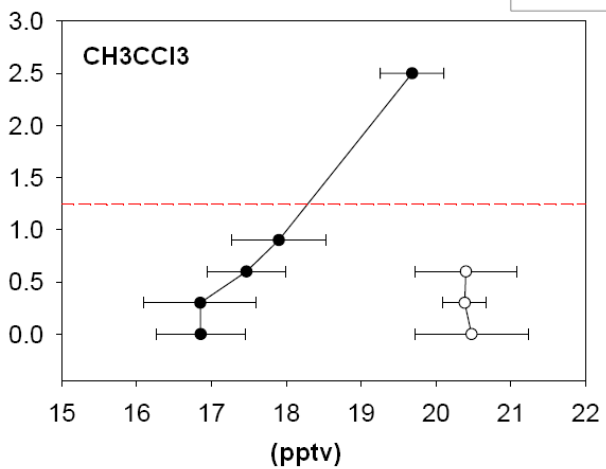
Gases taken up (II)



Gases taken up
(halogenated compounds)



● Without Tedlar Sheet
○ With Tedlar Sheet



Fick's Law Steady-State Diffusion Model

$$F_{CO_2} = -D_{CO_2} \left(\frac{\partial C_{CO_2}}{\partial z} \right)$$

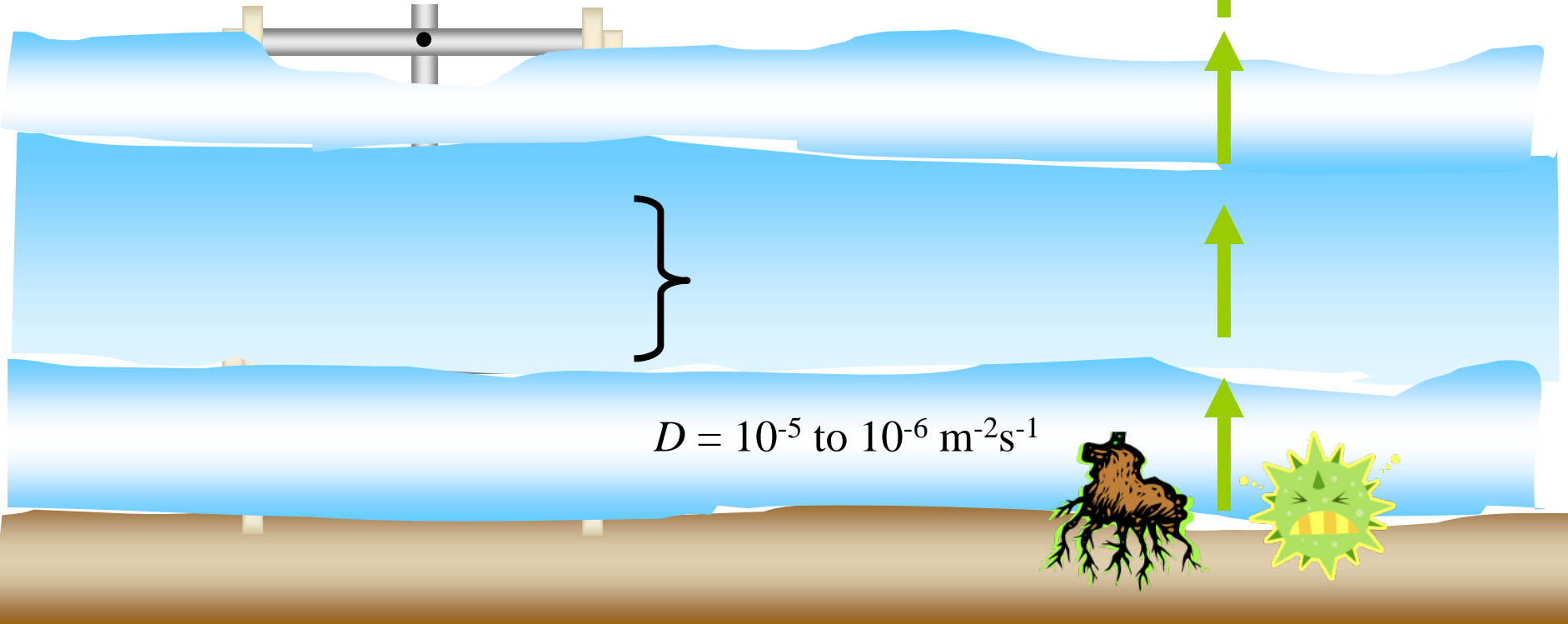
$$D = 10^{-2} \text{ to } 10^0 \text{ m}^2\text{s}^{-1}$$

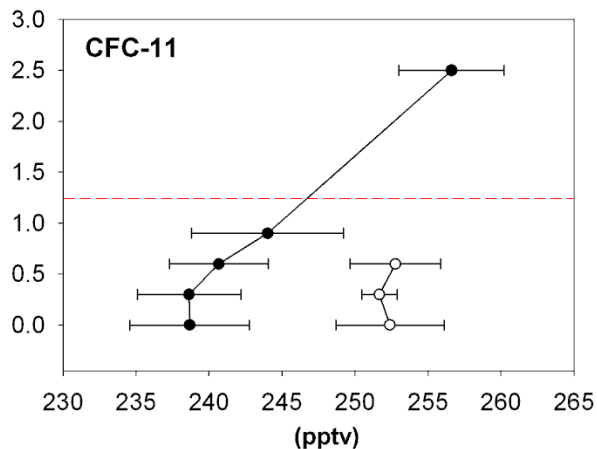
$$D_{CO_2} = \phi \tau D \frac{P_0}{P} \left(\frac{T}{T_0} \right)^\alpha$$

CO₂



$$D = 10^{-5} \text{ to } 10^{-6} \text{ m}^2\text{s}^{-1}$$





“What if...”

Lifetime Estimate

Median ± Standard deviation	Units	Seasonal Snow Only [years]	All Land [years]
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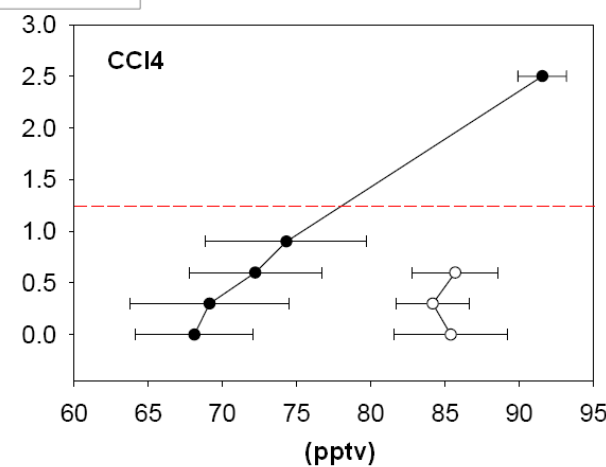
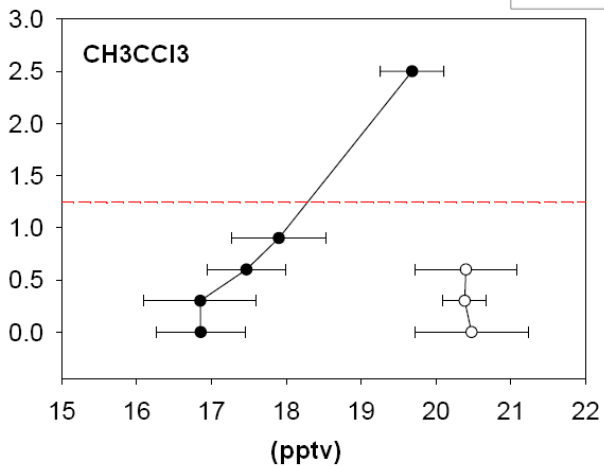
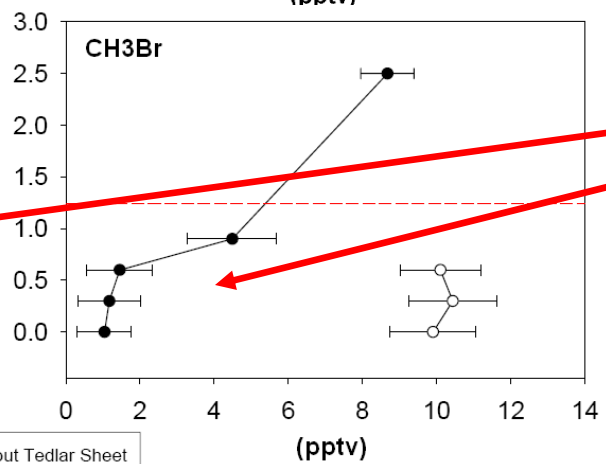
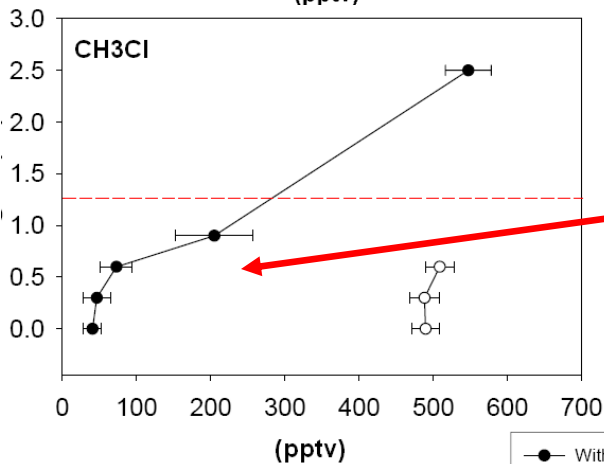
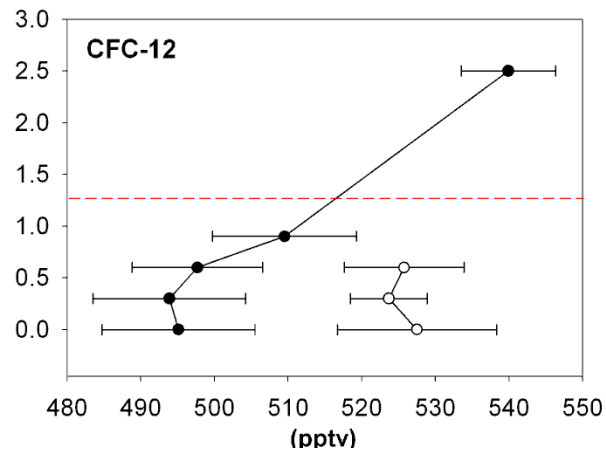
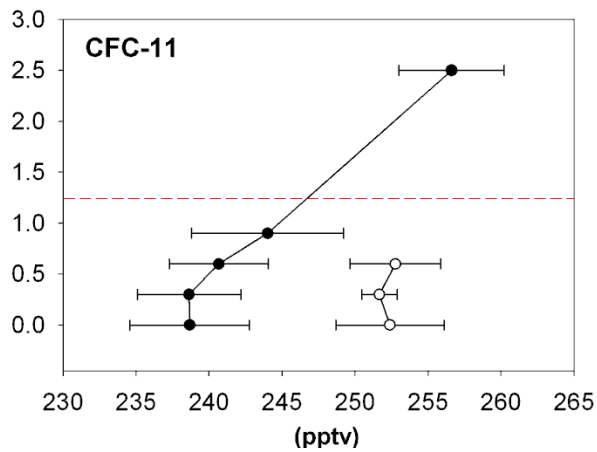
Uptake Flux

CH ₃ Cl	-67 ± 97	10 ⁻¹⁵ mol m ⁻² s ⁻¹	2100	105
CFC-12	-9 ± 8	10 ⁻¹⁵ mol m ⁻² s ⁻¹	15000	750
HCFC-22	-5 ± 5.7	10 ⁻¹⁵ mol m ⁻² s ⁻¹	9300	465
CFC-11	-2 ± 2.5	10 ⁻¹⁵ mol m ⁻² s ⁻¹	41000	2050
CH ₃ Br	-2 ± 1.8	10 ⁻¹⁵ mol m ⁻² s ⁻¹	1300	65
CCl ₄	-1 ± 2.8	10 ⁻¹⁵ mol m ⁻² s ⁻¹	18100	905
1,2-dichloroethane	-499 ± 740	10 ⁻¹⁸ mol m ⁻² s ⁻¹	42000	2100
CFC-113	-427 ± 1373	10 ⁻¹⁸ mol m ⁻² s ⁻¹	49000	2450
MeCCl ₃	-288 ± 306	10 ⁻¹⁸ mol m ⁻² s ⁻¹	18000	900
HCFC-141b	-167 ± 520	10 ⁻¹⁸ mol m ⁻² s ⁻¹	29000	1450
HCFC-142b	-157 ± 251	10 ⁻¹⁸ mol m ⁻² s ⁻¹	25000	1250
CH ₂ Br ₂	-49 ± 114	10 ⁻¹⁸ mol m ⁻² s ⁻¹	4500	225
CHBr ₃	-25 ± 129	10 ⁻¹⁸ mol m ⁻² s ⁻¹	11000	550

Processes ???

1. Microbial activities below snowpack

2. Snow-photochemical destruction ?



Summary

1. Very sensitive Flux Method

2. Wintertime Snow Exchanges are 'there'

-Emission

-Deposition

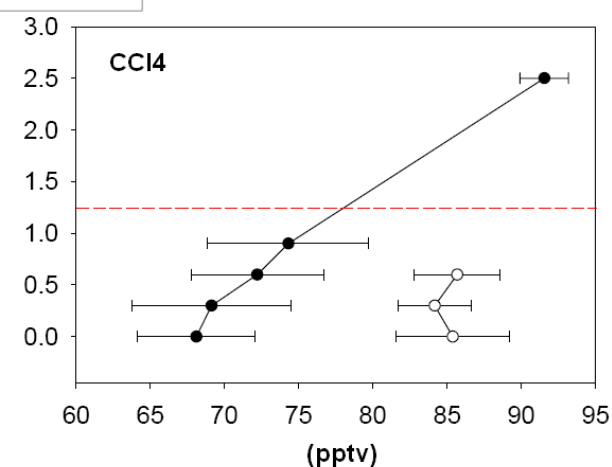
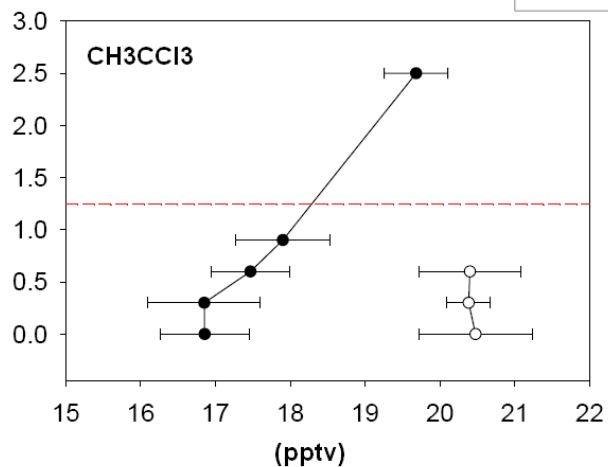
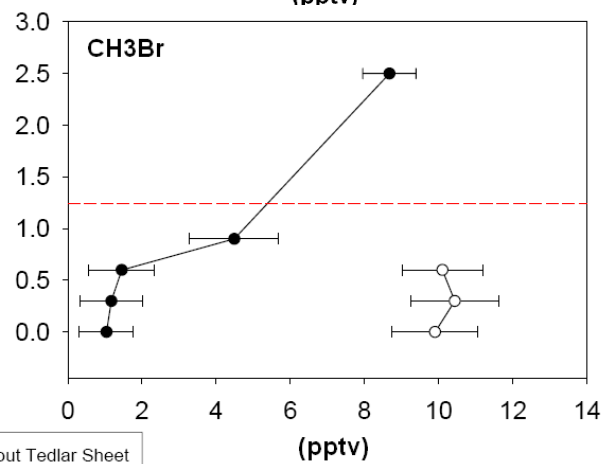
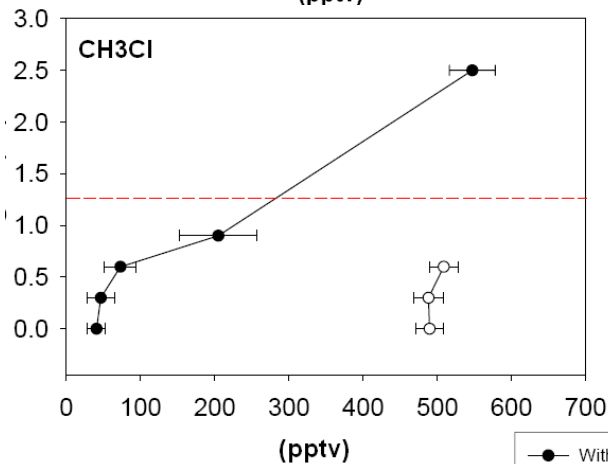
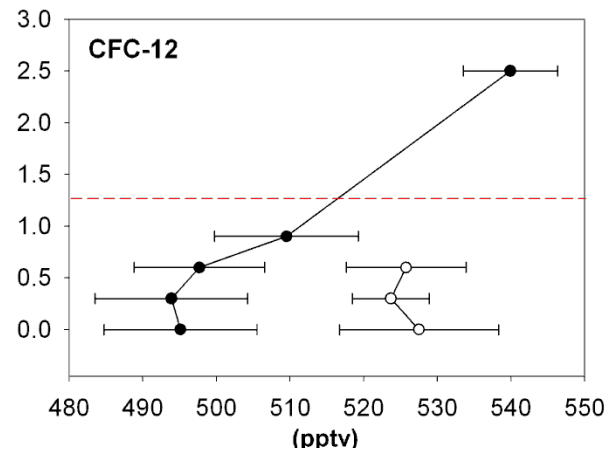
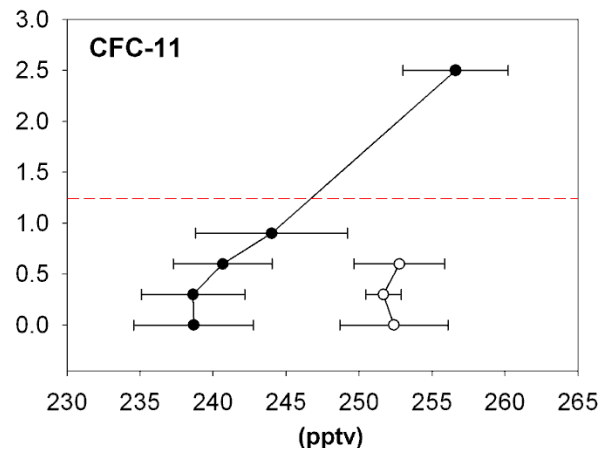
3. Significance?

- Particular Gas

- Snow Cover Regime

- High Elevation Mtns Important

- ???



Biogeochemistry Special Issue "White on Green"

"White on Green: Under-snow microbial processes and trace gas fluxes through snow, Niwot Ridge, Colorado Front Range" by Mark Williams et al.

"Storage and Release of Solutes from a Subalpine Seasonal Snowpack: Soil and Stream Water Response, Niwot Ridge, Colorado" by Mark Williams et al.

"Exponential growth of "snow molds" at sub-zero temperatures: an explanation for high beneath-snow respiration rates and Q10 values" by Steve Schmidt et al.

"Biological and physical influences on the carbon isotope content of CO₂ in a subalpine forest snowpack, Niwot Ridge, Colorado" by David R. Bowling et al.

"Winter and summer nitrous oxide and nitrogen oxides fluxes from a seasonally snow-covered subalpine meadow at Niwot Ridge, Colorado" by Gianluca Filippa et al.

"The trade-off between growth rate and yield in microbial communities and the consequences for under-snow soil respiration in a high elevation coniferous forest" by David Lipson et al.,

"Process-level controls on CO₂ fluxes from a seasonally snow-covered subalpine meadow soil, Niwot Ridge, Colorado" by Daniel Liptzin et al.

"An automated system for continuous measurements of trace gas fluxes through snow: an evaluation of the gas diffusion method at a subalpine forest site, Niwot Ridge, Colorado" by Brian Seok et al.

"Fluxes and Chemistry of Nitrogen Oxides in the Niwot Ridge, Colorado, Snowpack" by Detlev Helmig et al.

"A comparison of water and carbon dioxide exchange at an alpine tundra and subalpine forest site near Niwot Ridge, Colorado" by Peter Blanken et al.

"Release and uptake of volatile inorganic and organic gases through the snowpack at Niwot Ridge, Colorado" by Detlev Helmig et al.

