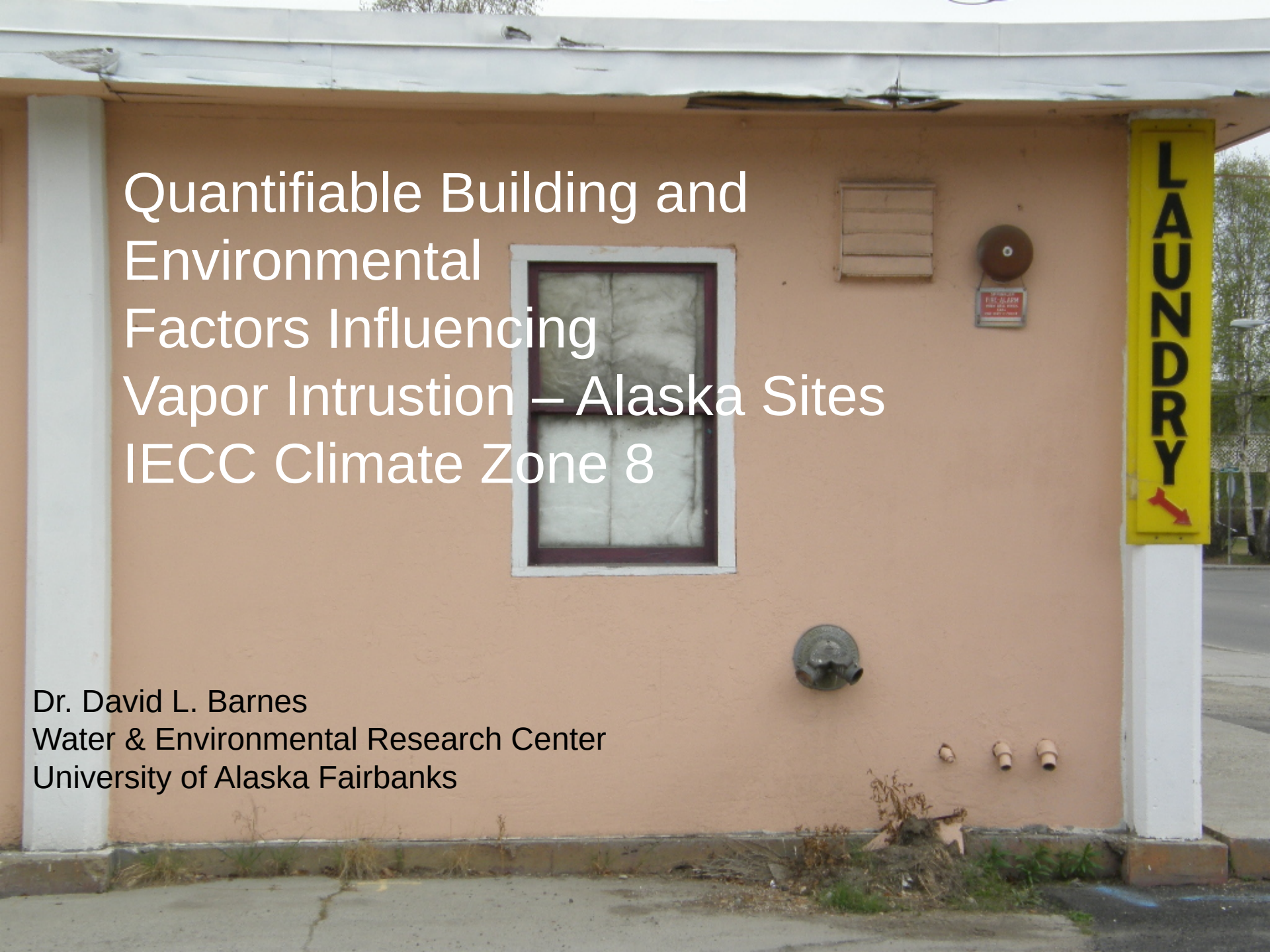

Quantifiable Building and Environmental Factors Influencing Vapor Intrustion – Alaska Sites IECC Climate Zone 8

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Study Sites

Laundromat - Wendell

- Unheated garage
- Slab-on-grade foundation
- Passive ventilation

Book Store – Gaffney

- Heated connected storeroom
- Slab-on-grade foundation
- Unventilated

Study Sites

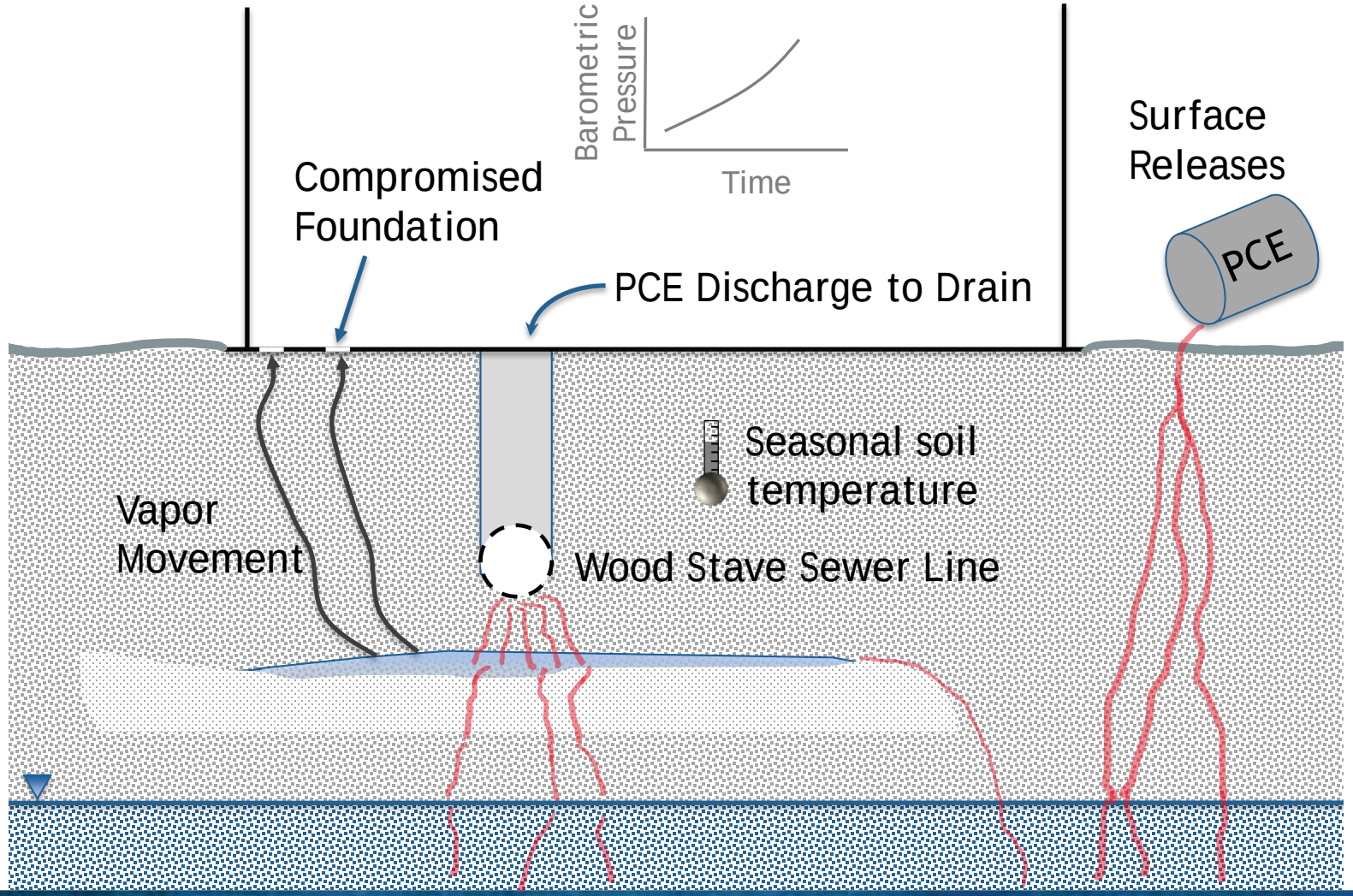
Study Sites

Pathways into Buildings (Wendell)

Study Sites

- Tetrachloroethylene released at both sites
- Climatic zone - Continental subacrtic (Dfc) average January minimum = -28 ^{o}C and average July maximum = 23 ^{o}C
- Seasonal frost depts range between 1 and 3 m.
- Stratigraphy – well stratified layers of unconsolidated coarse sand and gravel interbedded with poorly stratified layers of unconsolidated silt and sandy silt
- Dry cleaning facilities at both locations.
- Releases through leaking wood stave sewer pipe and surface releases.
- Free product and dissolved phase contaminant at both sites

Conceptual Site Model



Monitoring

- Temperature under slab (4 depths)
- Temperature adjacent to slab (4 depths)
- Indoor air temperature
- Barometric pressure
- Water level
- Soil moisture under slab
- Indoor air concentration
- Sub slab soil-gas concentration

Air Sampling Pump

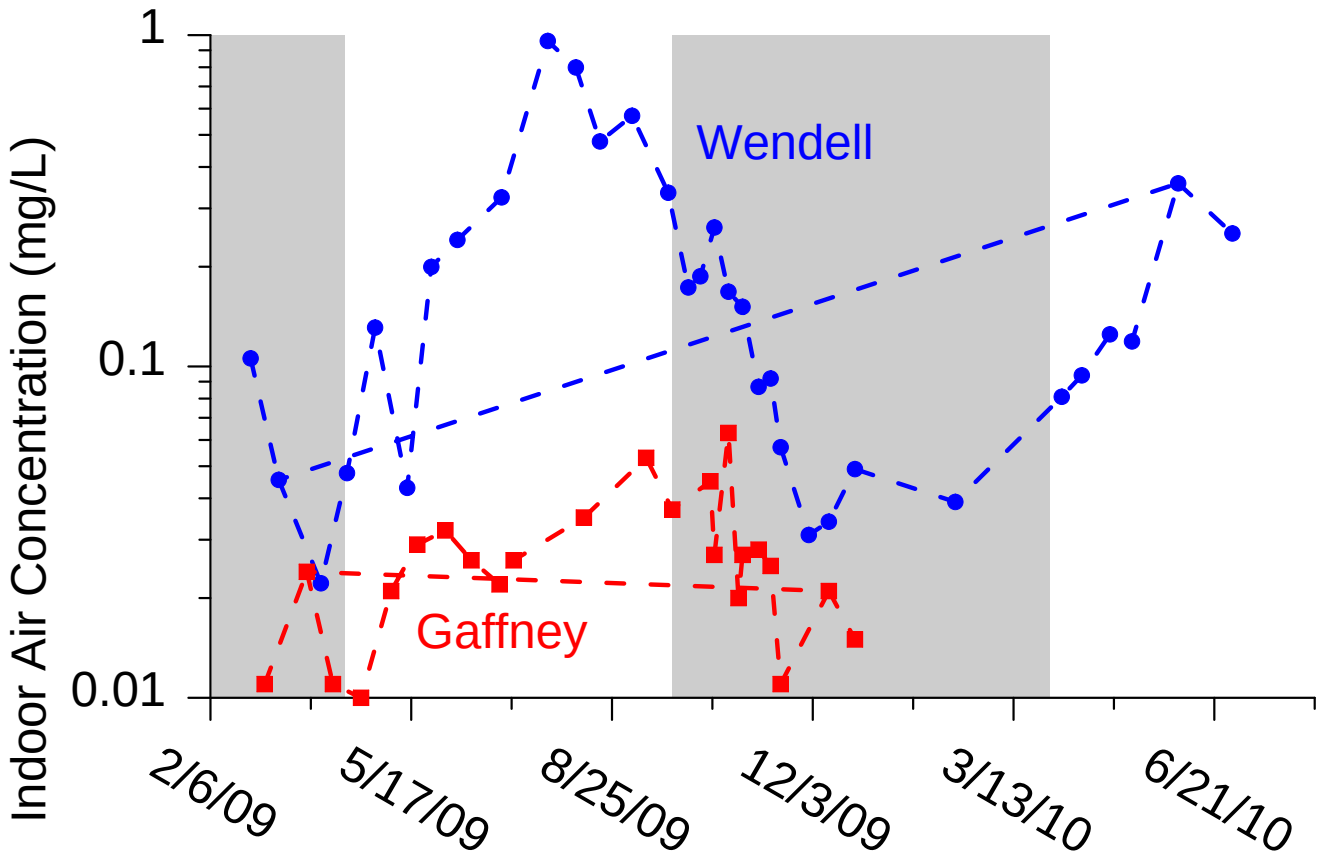
SKC AirChek 2000
Air Sampling Pump

Photo from - http://www.skcinc.com/pumps/210-2000.asp

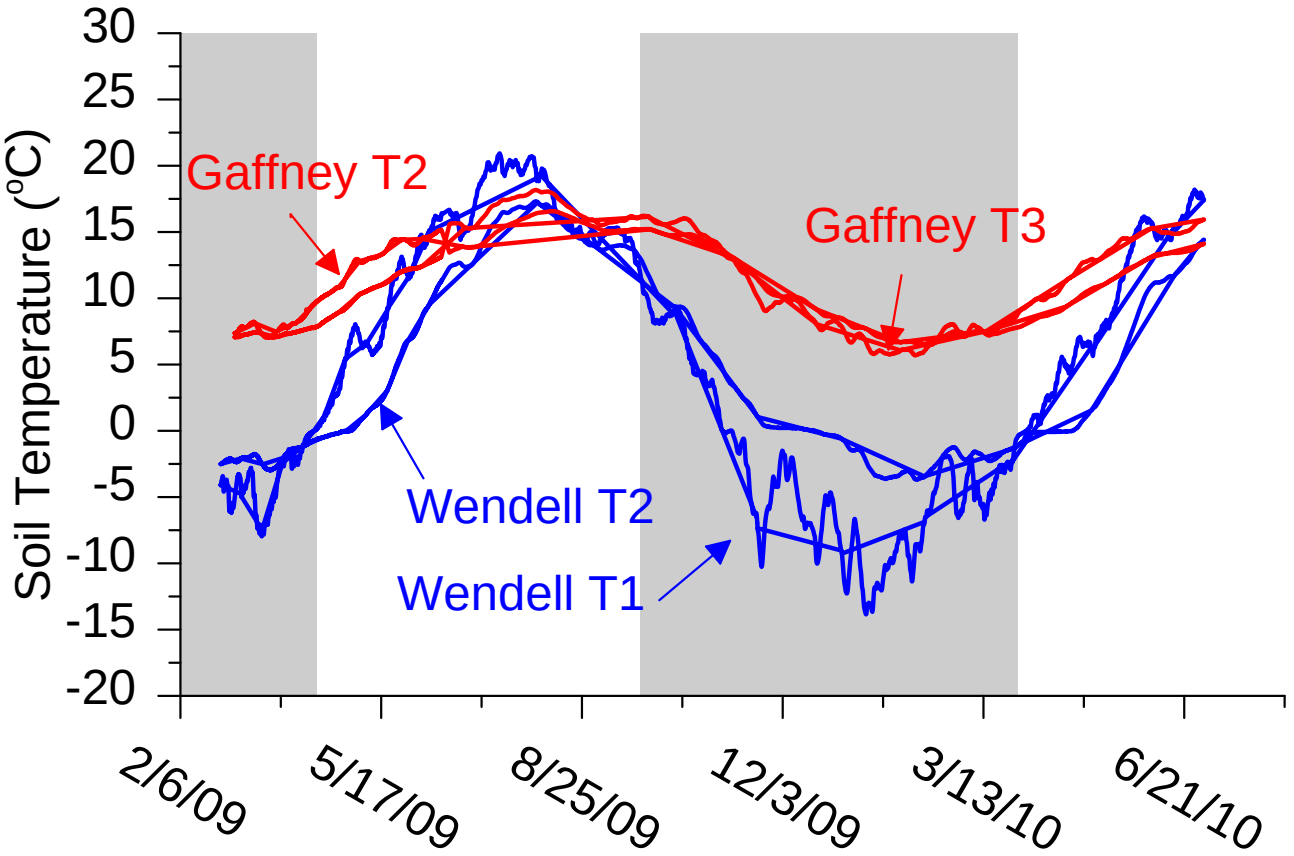
Comparison of Sampling Methods

	Concentration µg/L	
Location	Summa	GAC
Gaffney	16	20
Gaffney	24	29
Gaffney	1.1	1.3
Gaffney	2.5	2.7
Wendell	940	671
Wendell	1300	1520
Wendell	400	684

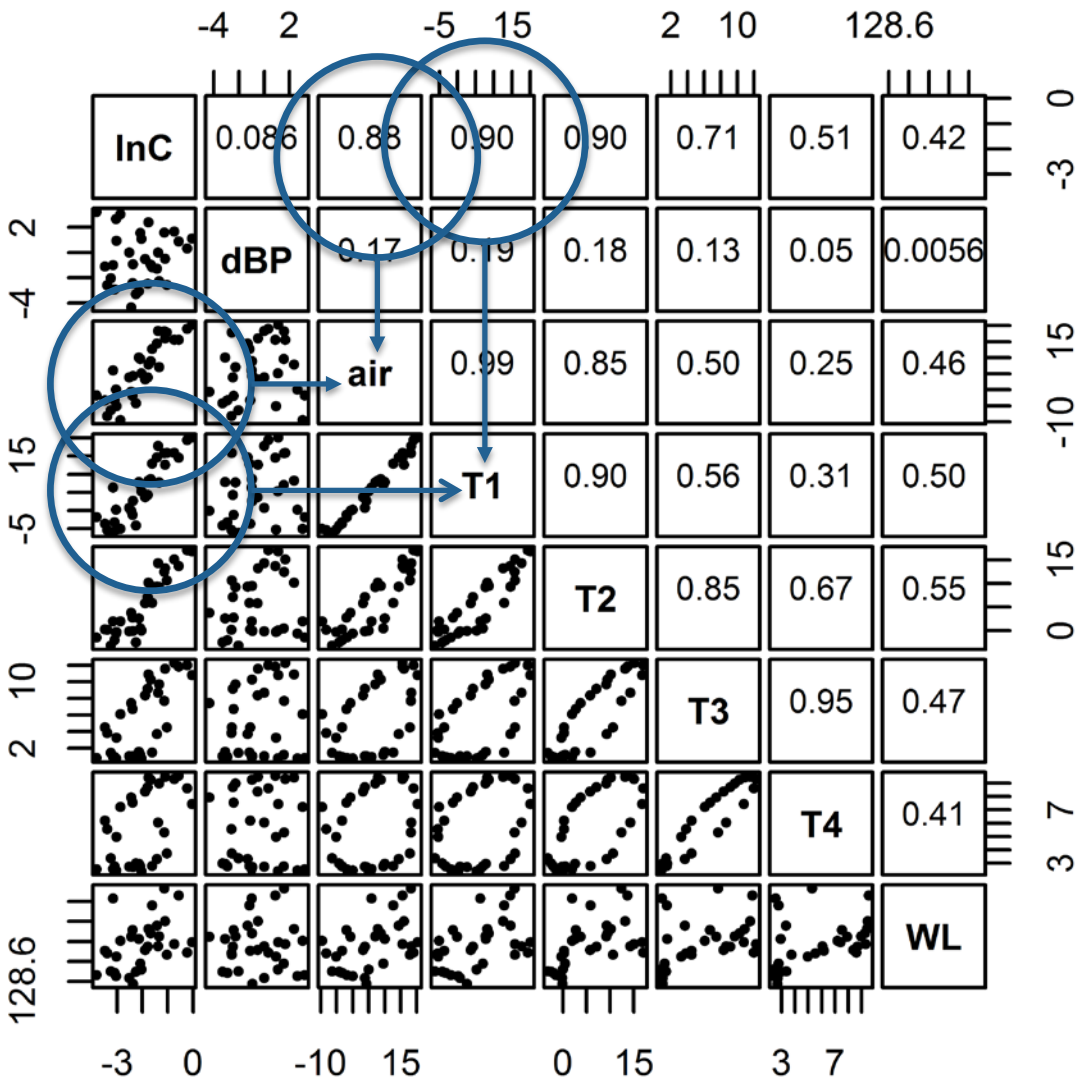
Results – Indoor Air Concentrations



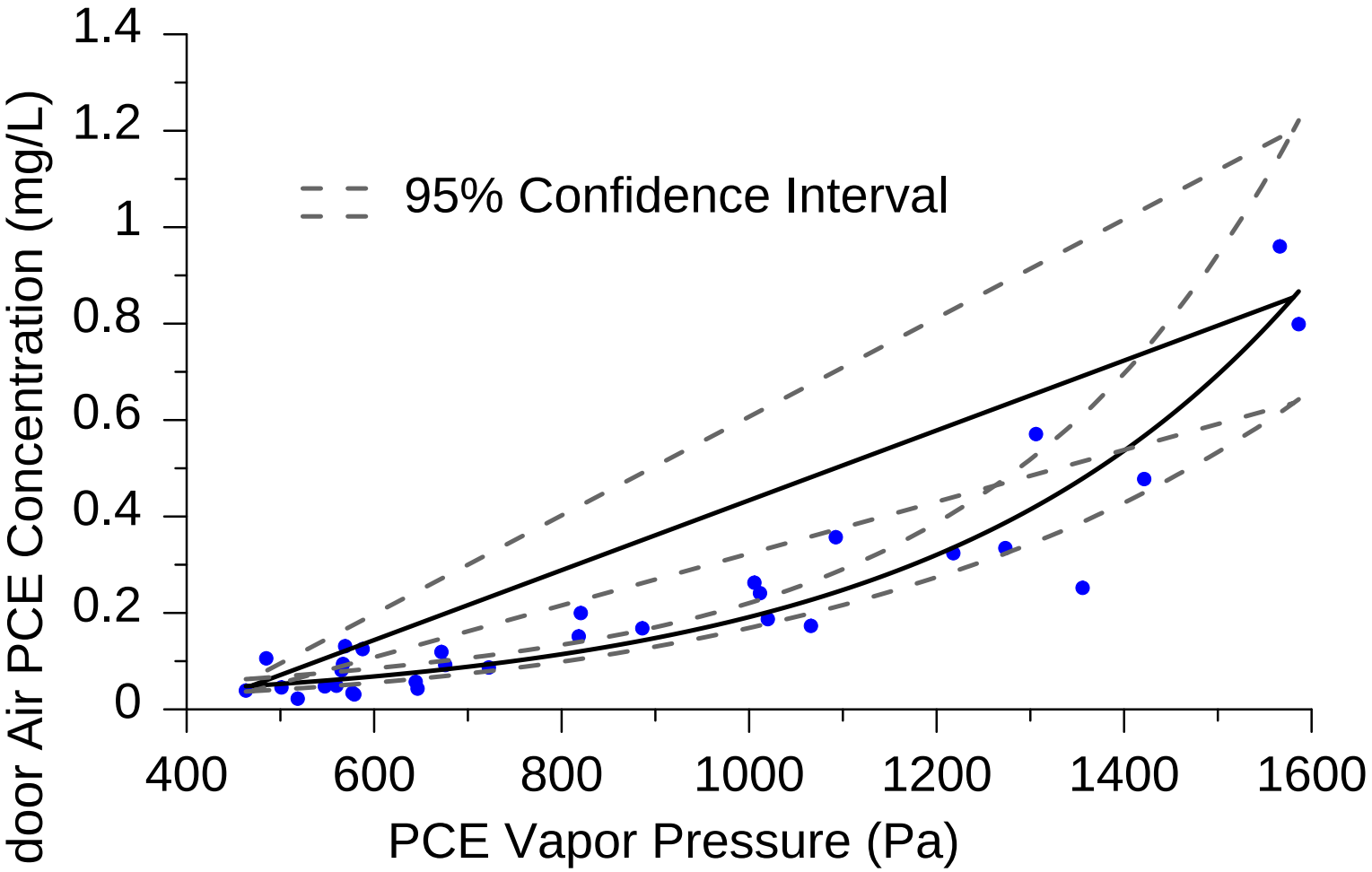
Results – Soil Temperatures



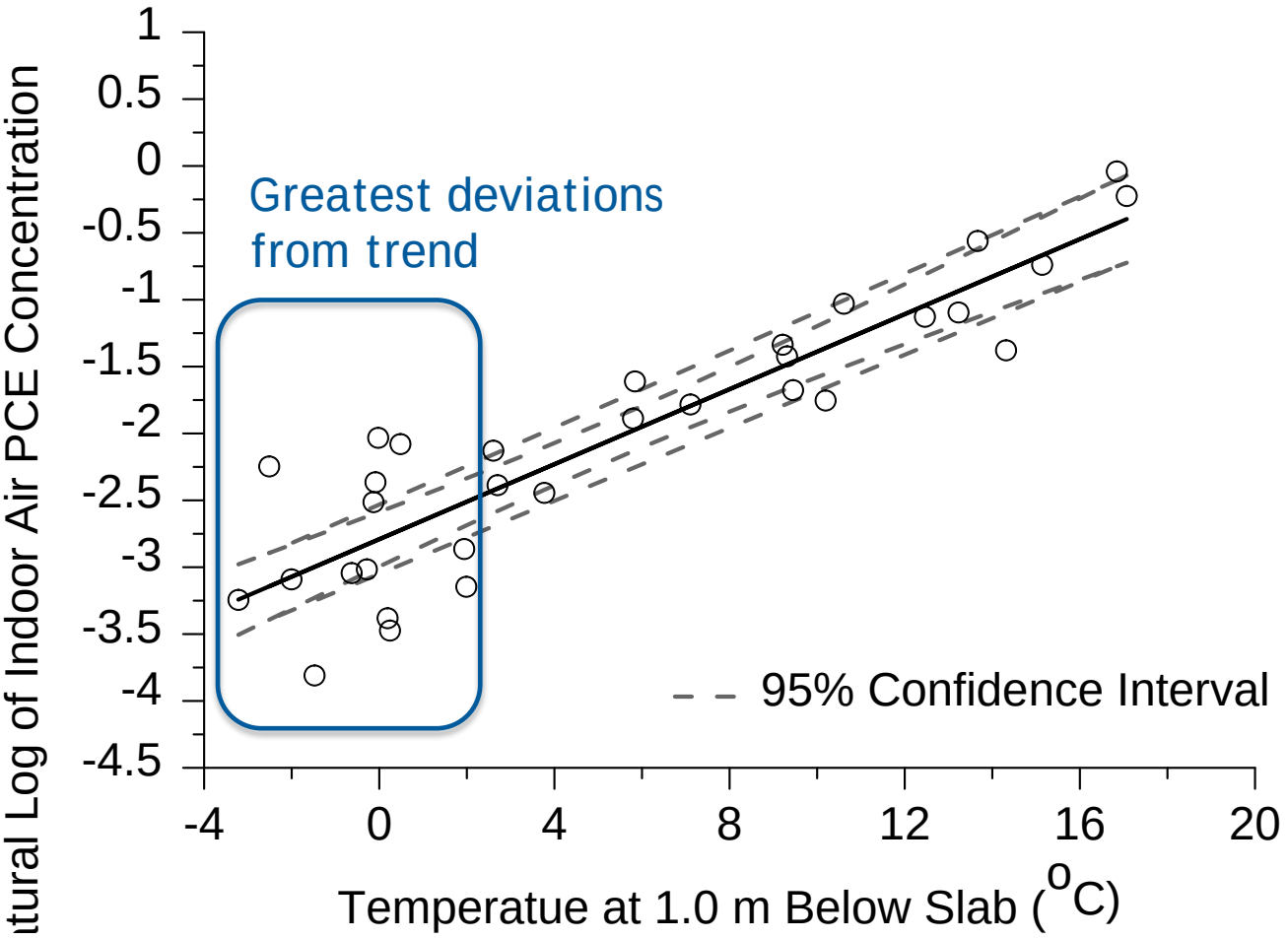
Wendell Site Results - Correlations



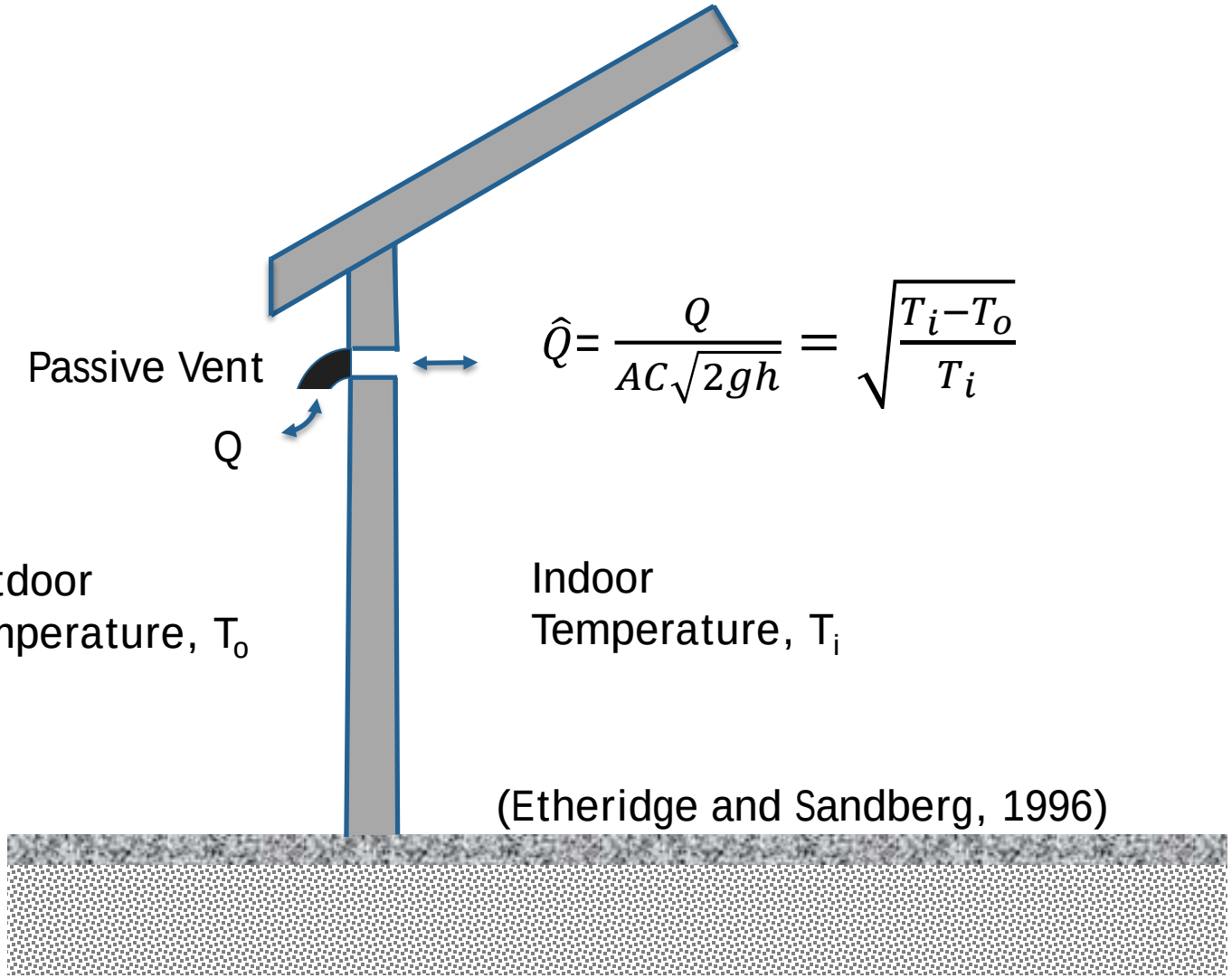
Wendell Site Results – Indoor Air Concentration versus PCE Vapor Pressure



Wendell Site Results – Linear Model

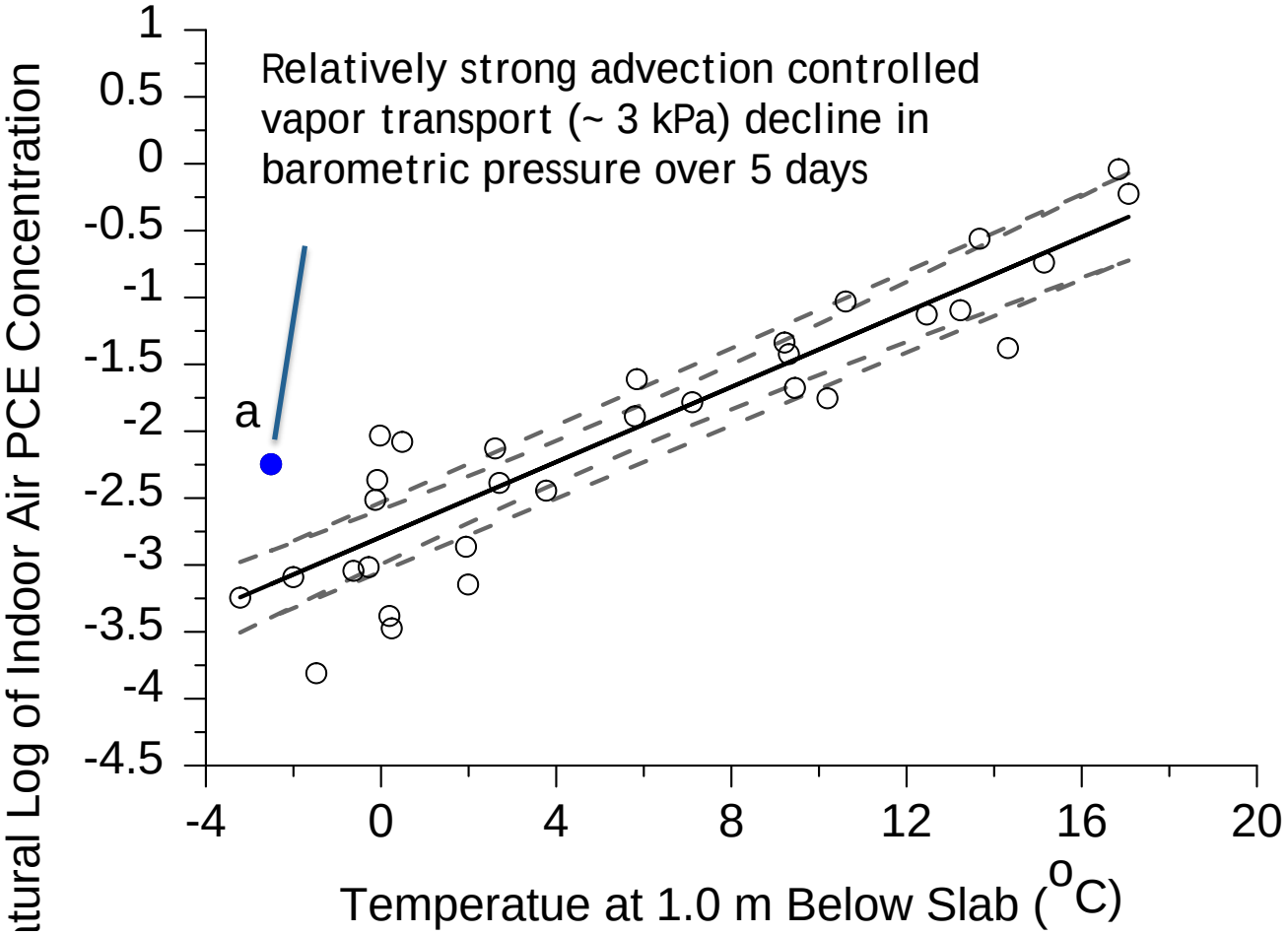


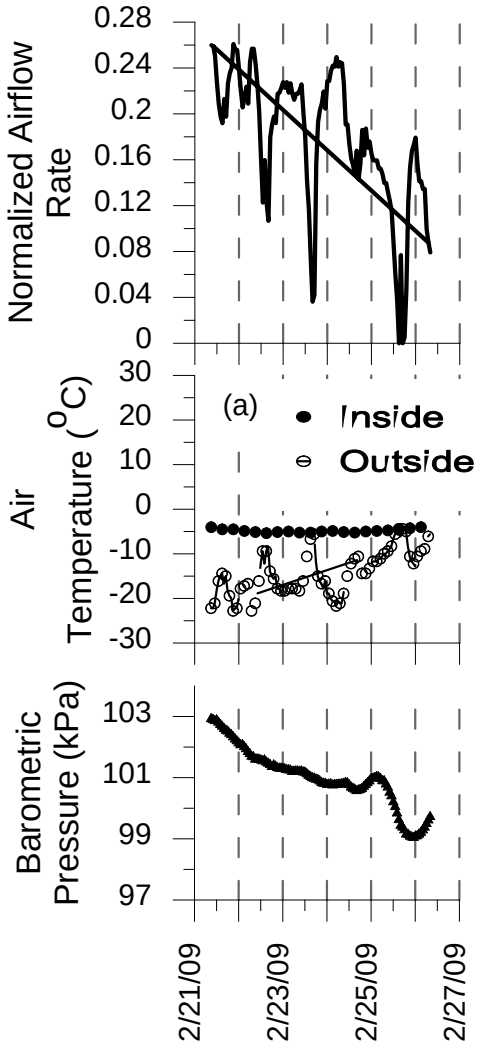
Draft Airflow Rate



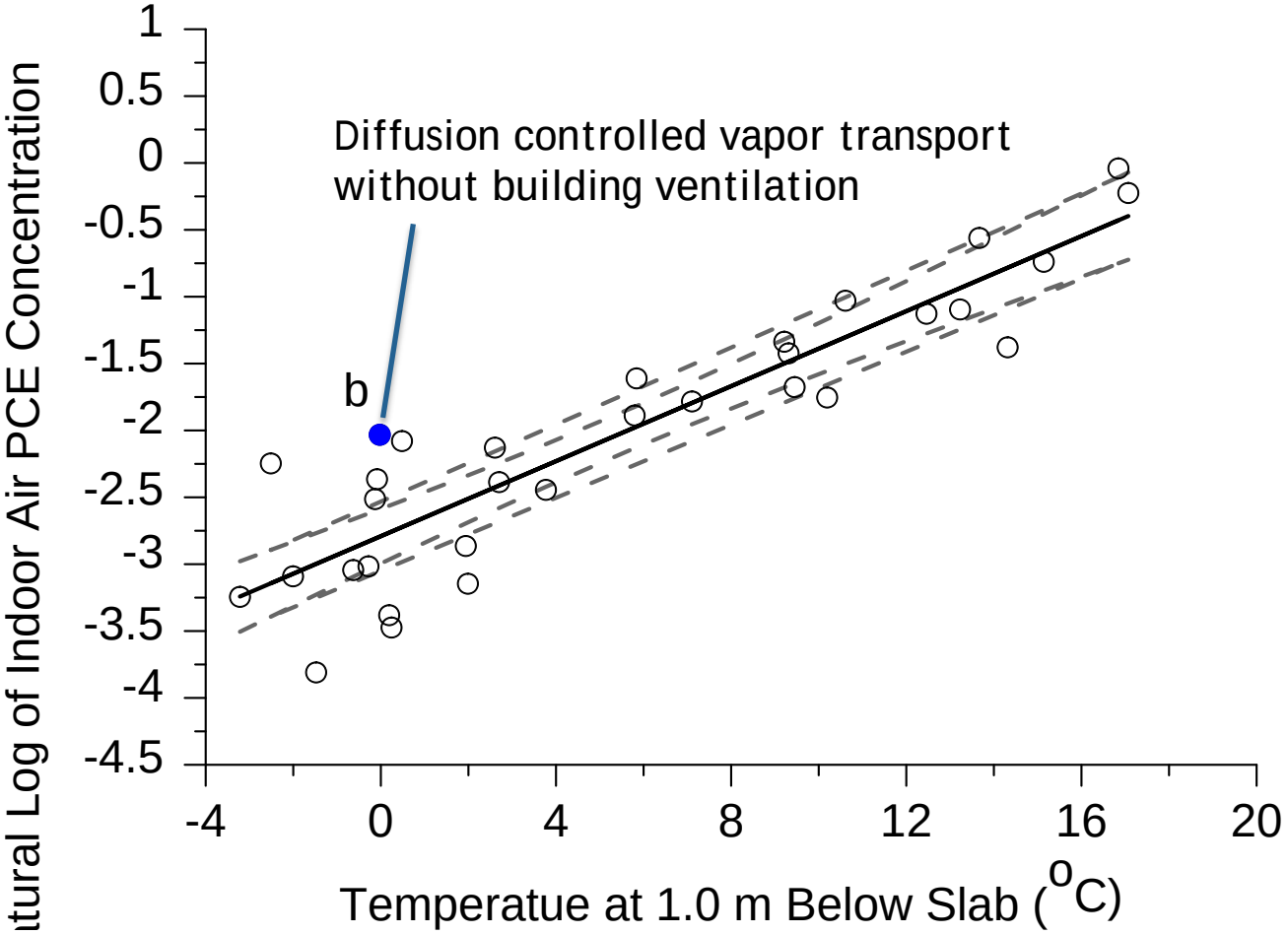
(Etheridge and Sandberg, 1996)

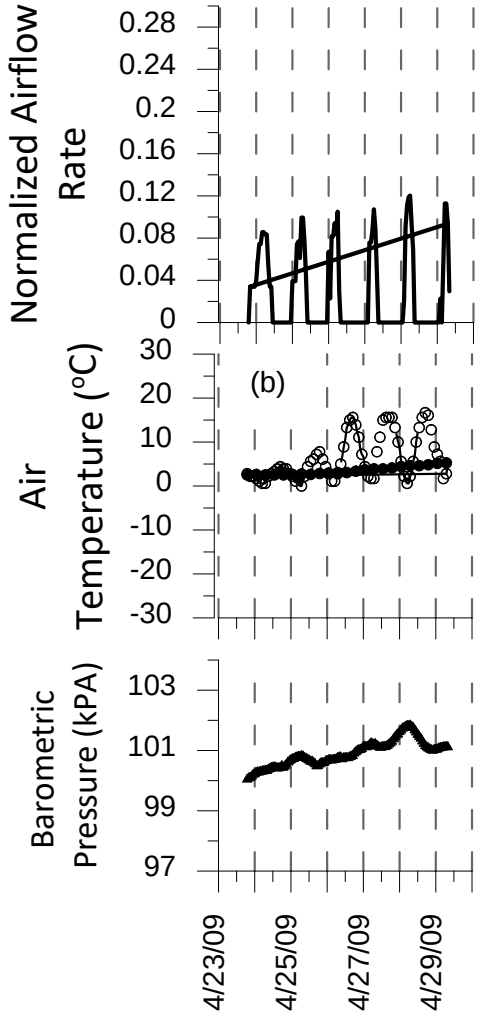
Wendell Site Results – Notable Deviations from Linear Model



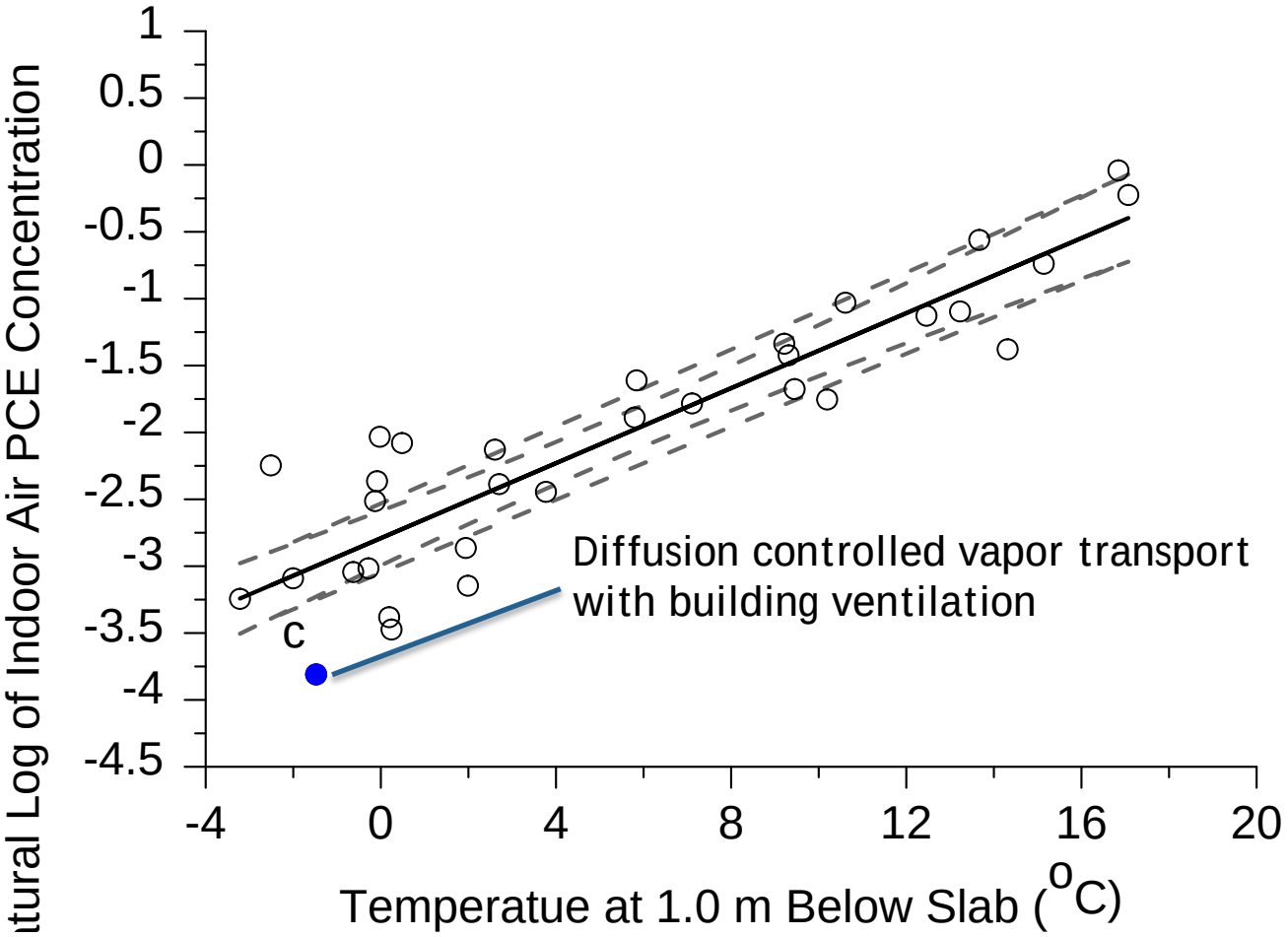


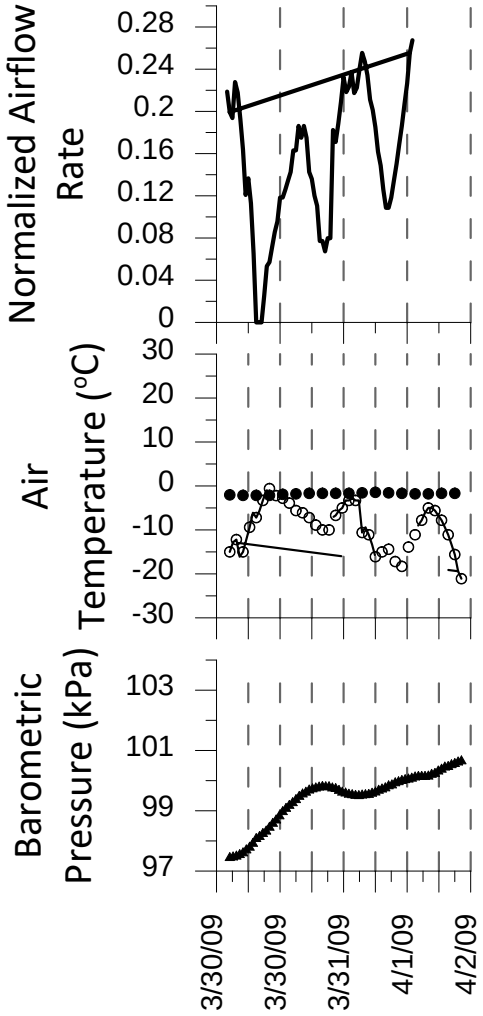
Wendell SiteResults – Notable Deviations from Linear Model



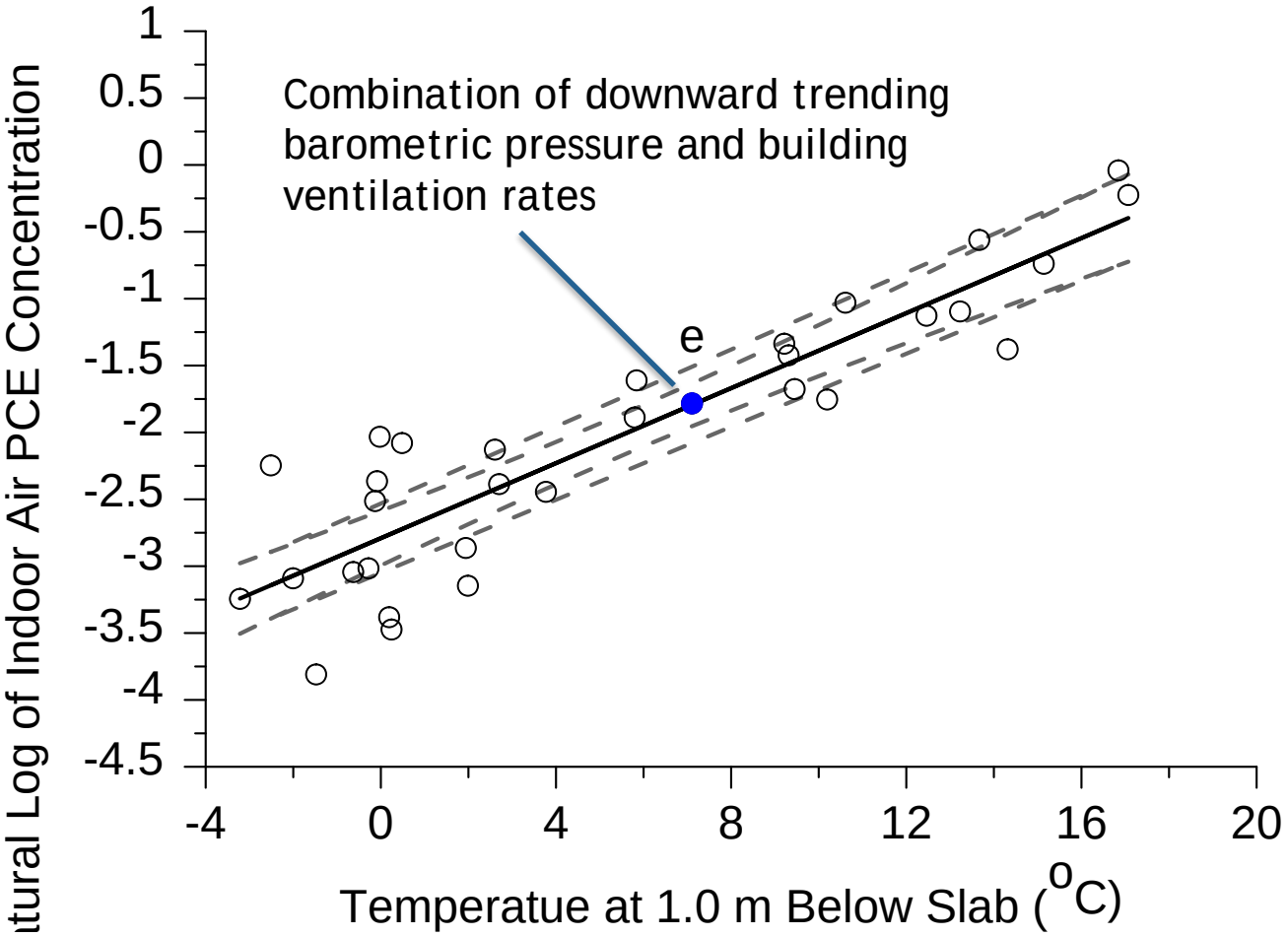


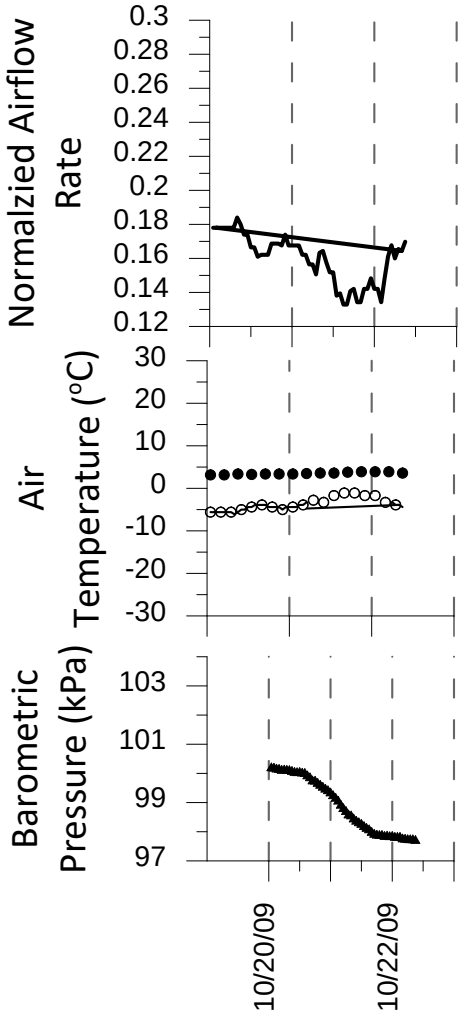
Wendell Site Results – Notable Deviations from Linear Model



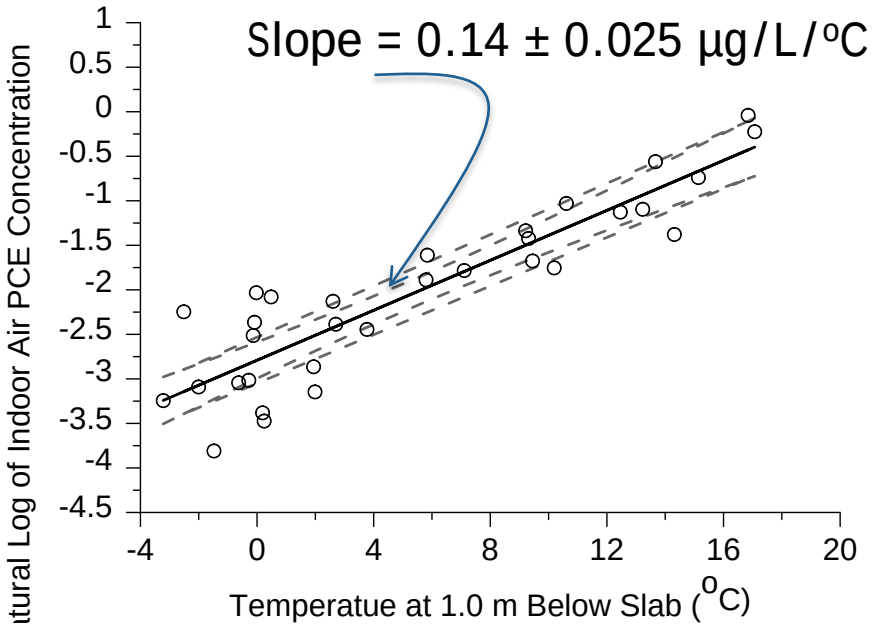


Wendell Site Results – Typical Model Predicted Concentration





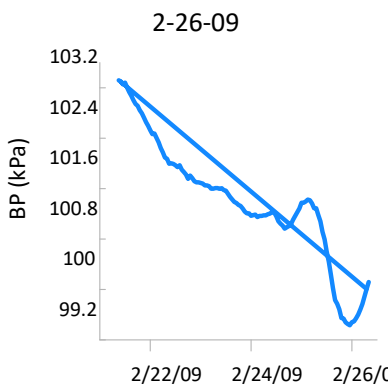
Implications for Monitoring – Soil Temperature

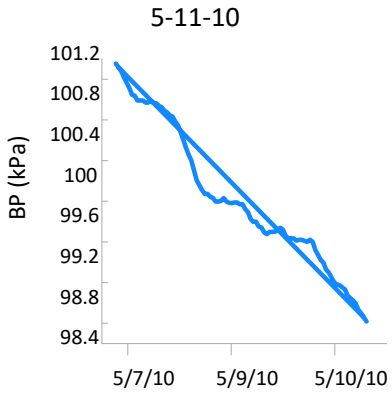


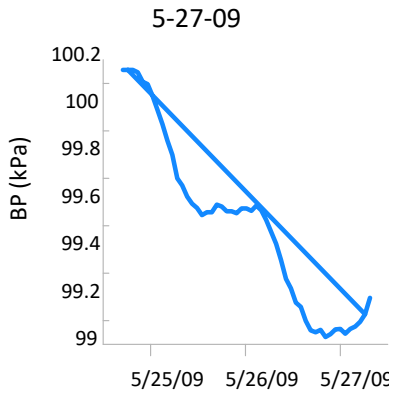
Concept of a "Doubling Temperature"

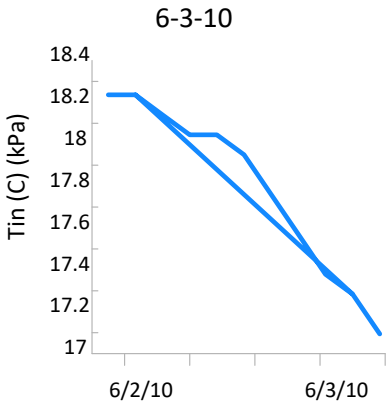
- Statistically similar slopes at Wendell and Gaffney
- The increase in soil temperature required to increase the indoor air concentration by twice what would be measured at lower temperature (borrowed from microbial kinetics)
- $T_d = {\ln(2)}/{slope}$
- T_d = 5.0 °C
- Small change in soil temperature can have large influence on indoor air VOC concentration

Implications for Monitoring – Barometric Pressure Drop









T = -3.2 → -2.2 °C	T = 2.7→ 3.7 °C	T = 5.0→ 6.0 °C	T = 9.5→ 10.6 °C
Max C = 0.11 mg/L	Max C = 0.12 mg/L	Max C = 0.20 mg/L	Max C = 0.36 mg/L
ΔBP = 3.00 kPa	ΔBP = 3.56 kPa	ΔBP = 1.36 kPa	ΔBP = 2.69 kPa
Δt = 4.8 day	Δt = 6.8 day	Δt = 2.9 day	Δt = 2.0 day

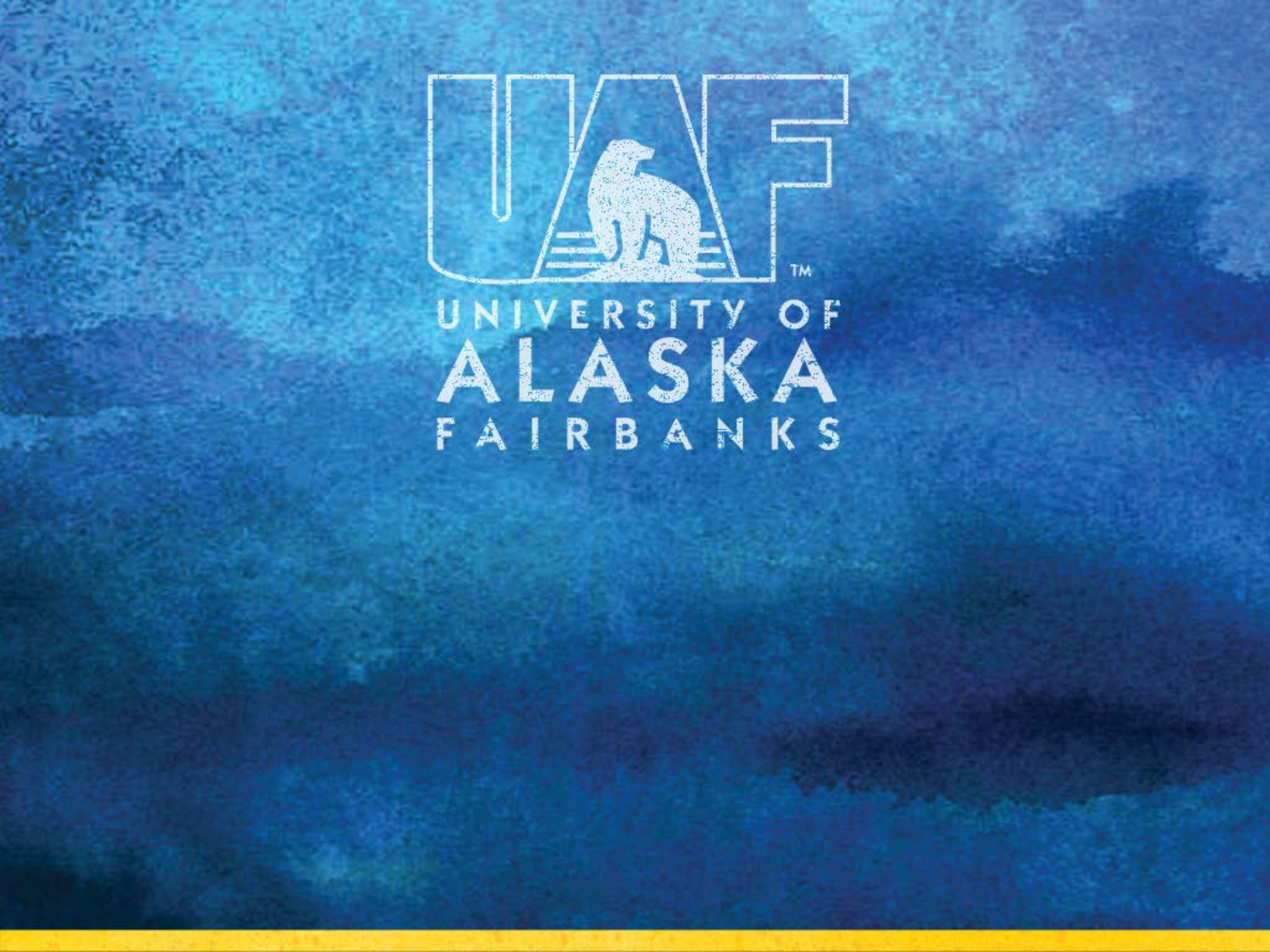
Recommendation – Take indoor air sample after a ~2 kPa decline in barometric pressure

Conclusions

- Soil temperature has a clear and predictable influence on seasonal indoor air VOC concentrations
- Small variations in soil temperature can result in large variations in indoor air VOC concentrations
- Diffusion can result in significant vapor intrusion fluxes
- Recommend sampling indoor air for VOCs after 2 kPa drop in barometric pressure

Noteworthy References

- Johnston, J.E., J.M. Gibson. 2014. Spatiotemporal variability of tetrachloroethylene in residential indoor air due to vapor intrusion: a longitudinal, community-based study. *Journal of Exposure Science and Environmental Epidemiology*, 24: 564-571. – *Shows trends of higher summer indoor air VOC concentrations compared to winter*
- Robinson, A.L., R.G. Sextro. 1995. Direct measurement of soil-gas entry into an experimental basement driven by atmospheric pressure fluctuations. Geophysical Research Letters, 22(14): 1929-1931. – *Shows relationship of soil-gas entry into buildings with barometric pressure trends.*
- Bekele, D., R. Naidu, S. Chadalavada. 2014. Influence of spatial and temporal variability of subsurface soil moisture and temperature on vapour intrusion. Atmospheric Environment, 88: 14-22. – *Shows influence of temperature on vapor migration in subsurface.*
- Barnes, D.L. and M.F. McRae. 2017. The predictable influence of soil temperature and barometric pressure changes on vapor intrusion. *Atmospheric Environment*, 150: 15-23. – *This study*.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