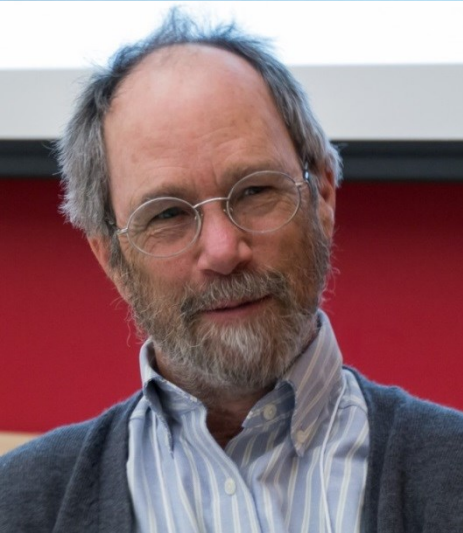


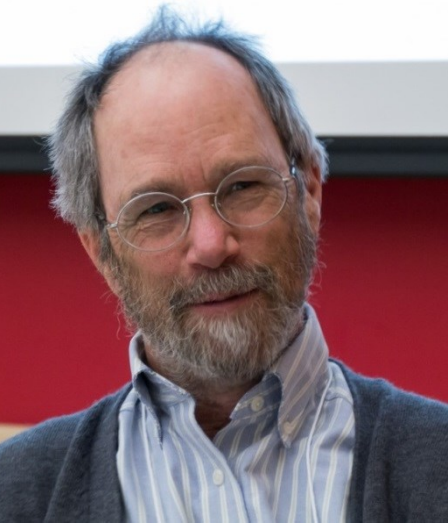
February 27, 2015

ROCIS Stakeholder Meeting

# Low Cost Monitors: Empowerment, Limitations & Potential

*Don Fugler and Michael Taylor*





# Monitoring in Three Easy Steps

Don Fugler

ROCIS Stakeholder Meeting

27 February 2015

# Range of monitoring

- Measurement of air quality can be done with a wide range of instrumentation, occupant disruption, and cost
- All methods and tools have their place
- Entry level: “Gee, is there a problem?”
- Other extreme: professional protocol with calibrated instruments, trained technicians
  - Suitable for publishing in peer-reviewed journals or as evidence in litigation

# How I was taught

- My mentor at CMHC was Jim White who helped develop the Canadarm on the space shuttle
- Very smart man given to epigrams
- Here is what he taught me with regards to research
  - His method equally applies to monitoring and instrumentation

# Jim White's Three Steps

- First: Get the sign right
- Second: Find the order of magnitude
- Third: Measure to the first significant figure
  - and then improve that accuracy depending upon the time and funding you have available

# “Get the sign right”

- Is the effect positive or negative?
- Is the flow in or out?
- Is the temperature colder or warmer?

# “Find the order of magnitude”

- One order of magnitude is ten times the next one
  - e.g. ones, tens, hundreds, thousands, etc.
- Is this a big effect or a small effect?
- Is the pollutant obvious or is it going to take advanced instrumentation to tease out a difference?
- Compare to purchases:
  - Can I buy this with pocket change?
  - Will this empty my wallet?
  - Do I have to re-mortgage my house?

# “Measure to the first significant figure”

- Avoiding a math review, we will say that the first significant figure is the first non-zero digit in a number
- e.g. the number 9 is the first significant figure in all these numbers:
  - 9,000,000
  - 92
  - 0.0093765
- We will not delve into rounding

# What does this have to do with ROCIS?

- Good precepts to have when you are planning a monitoring initiative
- Is required monitoring basic (sign, order of magnitude), somewhat quantitative (first significant figure), or scientific in quality (usually more than one significant figure)?

# Examples

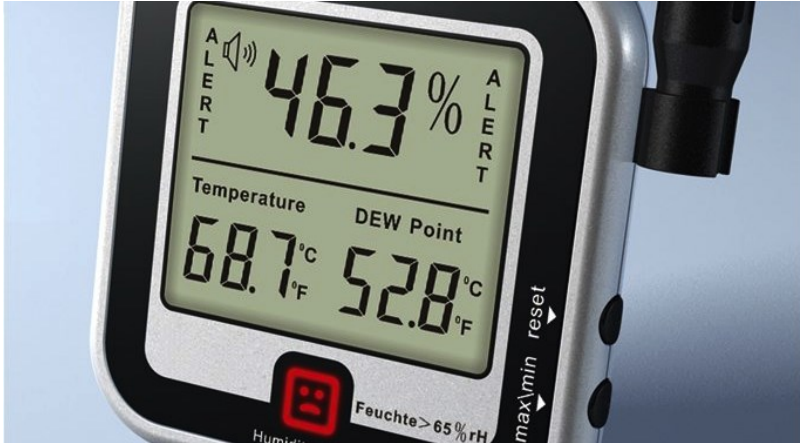
- Relative humidity (RH)
- Radon
- CO<sub>2</sub>
- Flow
- Particles

(all basic instrumentation listed < \$200)

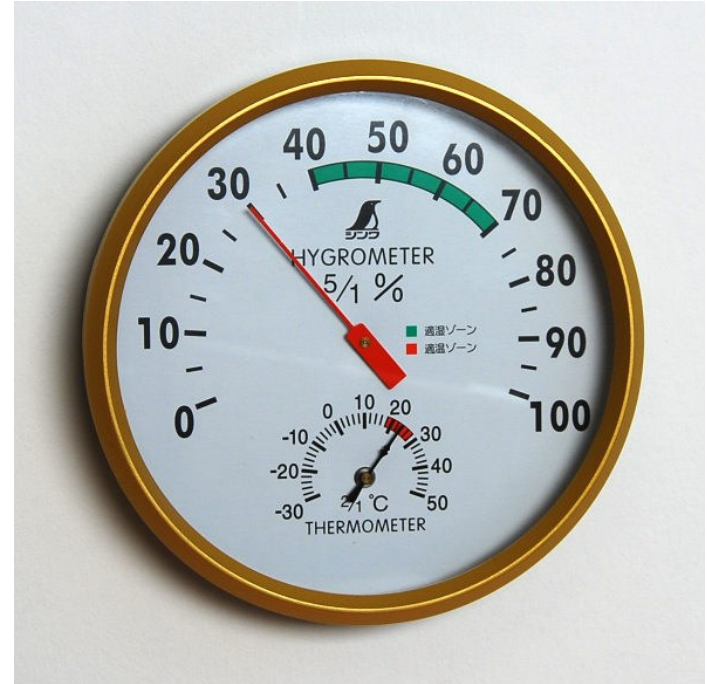
# Relative humidity

- Lots of ways to measure relative humidity

# Relative humidity



Nonwoventools.com



Fine-tools.com



Kestrelmeters.com

# Relative humidity

- Accuracy varies all over the place with inexpensive instrumentation
- Some are read-only
  - Scientific studies would require recording to datalogger

# Relative humidity

- Why measure RH during monitoring?
  - Sign: Does the intervention make the place more humid or drier?
  - Magnitude: Does this house have a moisture problem or not?
  - First SF (or better): Do the interventions in these houses result in lower RH in the sample?
- Question asked determines the instrumentation needed

# Radon

- What would you need to measure radon during monitoring?
  - Order of magnitude: Do we have a radon problem or not
  - First SF: Do our interventions lead to higher radon in these houses or lower
    - Are any houses greater than EPA limit or WHO recommendation?

# Radon measuring devices



Alpha track from Accustarcanada.com



Electret from Radelec.com



Amazon.com/Safety-Siren-Pro

# CO<sub>2</sub>

- CO<sub>2</sub> can be a surrogate for the combined effects of occupant loading/density and house air exchange rate
- Inexpensive measurement devices are available
- Would need laboratory grade devices for scientific research

# CO<sub>2</sub> measurement



Co2meter.com

# CO<sub>2</sub>

- Sign: does this change make the CO<sub>2</sub> level go up or down
- Order of magnitude: Is CO<sub>2</sub> close to outside air or in high concentrations
- First SF and better: What is the increase or decrease in indoor CO<sub>2</sub> caused by the intervention?

# Flow and pressure

- Sign: Is air flowing in or flowing out?
  - Can check by smoke pencil, match, hair on your arm
- Order of magnitude: Various home-built devices that are good for measuring flows in ducts and grilles;  
see: <http://www.homeenergy.org/show/article/id/59>
- Scientific studies require more precise airflow instruments, Duct Blasters, accurate manometers

# Particles

- Sign and Order of magnitude: Inexpensive particle counters are now available. They will indicate roughly whether you have a problem or whether an action will create more particles
- Current health standards reference mass-based measurements done by expensive instrumentation
- At some point, both technologies (mass measurement and particle counts) will likely be part of health criteria

# Particles

- Particle size does matter
  - Differently sized particles will have different entry rates
  - Differently sized particles will have different health impacts (many still being established)
- Particles can carry VOCs (volatile organic compounds) or can be biological in origin (and possibly allergenic or toxic)

# Particles

- Mike Taylor is going to tell you about the Speck monitor from CMU CREATE Lab
- Linda Wigington can relate her experience with indoor and outdoor particle measurement at her house.

# My House: Observations & Exploration from Dylos Air Quality Monitors



Linda Wigington  
lwigington1@outlook.com



# Success!!

## (.5 $\mu\text{m}$ PM)

***Indoor particles are now under control*** (1/10 to 1/20 outside)

- My house is a pretty effective filter
- Reduction of indoor sources (induction stove top/more cleaning)
- Air cleaner used in occupied zone (s)

***The monitor provides useful feedback*** regarding how effective my actions are, and when & what level to operate the air cleaner

In some homes, ***indoor data may be too noisy*** to be useful without a good log of activities, and a relatively committed occupant

***Need to aggregate outdoor data*** – having cloud-based aggregation of outdoor PM could help to explain variations and sources

# Attention to Cooking & Sources



Portable, double-burner  
induction stove top unit  
~\$275.  
(Single burner, lower quality units <\$100)



Care when cooking  
Cover the pan!

Air Quality Chart .5 um – Small Count Reading	
3000 +	= VERY POOR
1050-3000	= POOR
300-1050	= FAIR
150-300	= GOOD
75-150	= VERY GOOD
0-75	= EXCELLENT

.5 um PM Scale on Dyls Montor

# Filter to Clean the Air<sup>1</sup>

Additional 50 - 75% reduction  
“on” vs. “off”

Usually “good” – “very good”  
range with outdoor “poor”  
~2,000 – 10,000 (.5)

## Air Quality Chart .5 um – Small Count Reading

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.5 um PM Scale on Dylos Monitor



\$300 - \$500 depending on size &  
filter; filter lasts ~ 5 years

Potential conflict of interest –  
I sell these units (at cost)

# Making the Invisible Visible



Inside w air cleaner  
on – occupied zone

Inside w no air cleaner  
– unoccupied zone

Outside – front porch

## Air Quality Chart .5 um – Small Count Reading

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### DISPLAY

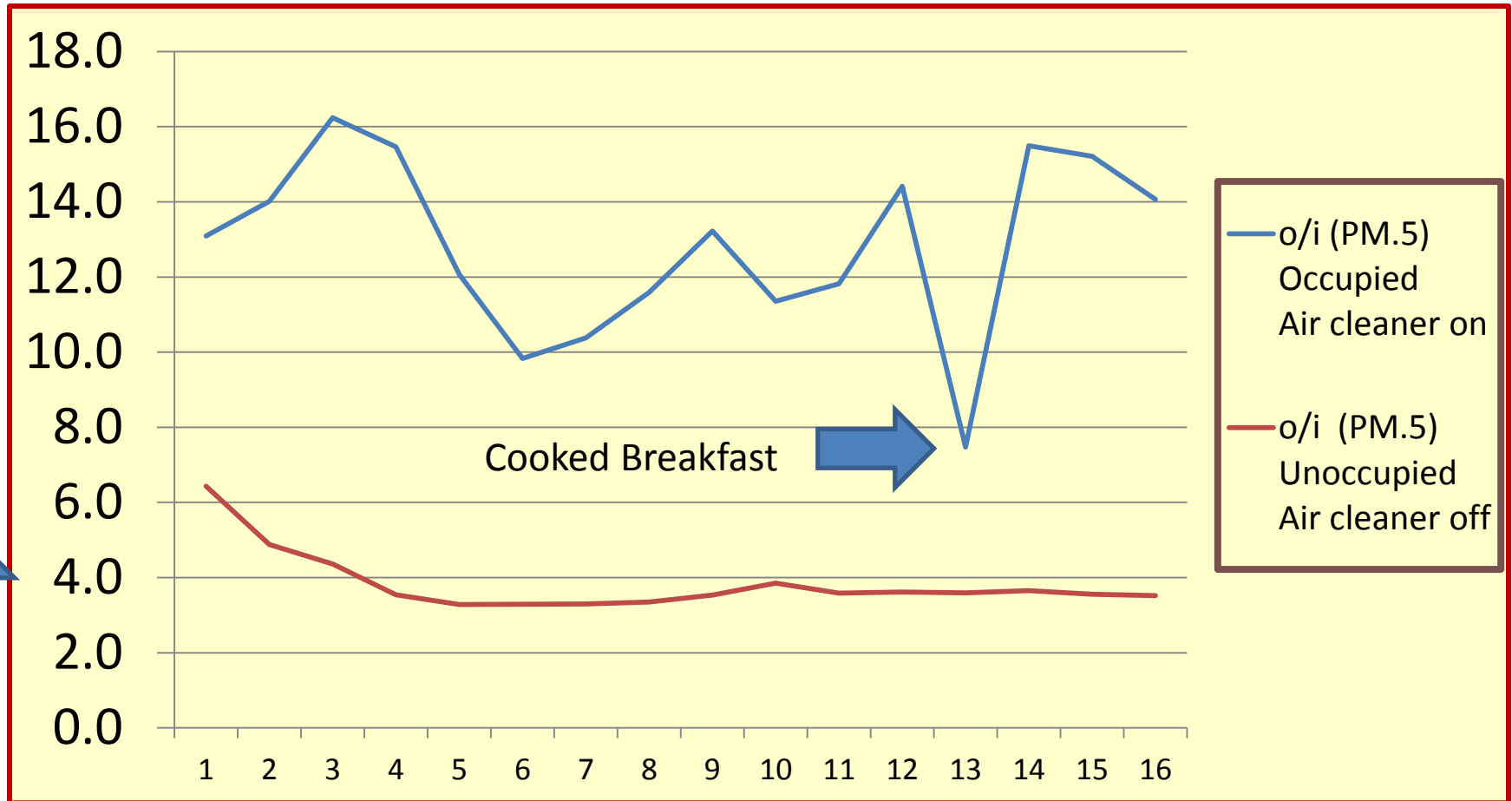
On left: PM.5 um

On right: PM 2.5 um

# Ratio Outdoor to Indoor (o/i) (PM .5)

*More than good enough for occupant feedback*

Same house & time; 2/26/2015; Outdoor 2,000 – 4,000 (PM.5)



Ratio

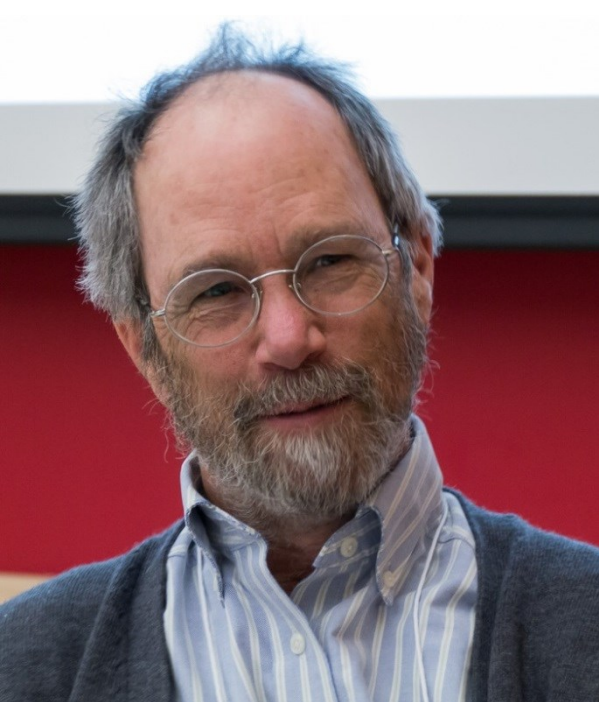
Time (Hourly Avg.)

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# What About Your House or Building??

***What can you learn?? We need to explore:***

- Leakier homes
- Higher occupancy
- Carpets
- No zoning
- Better outdoor air quality
- Other control options



# Back to Don

# Summary

- Any measurement is better than none
  - BUT know the limitations of the devices being used
- Inexpensive instrumentation will generally provide enough information for practical advice
- More expensive instrumentation and trained technicians are usually required for scientific or litigation studies

# Summary

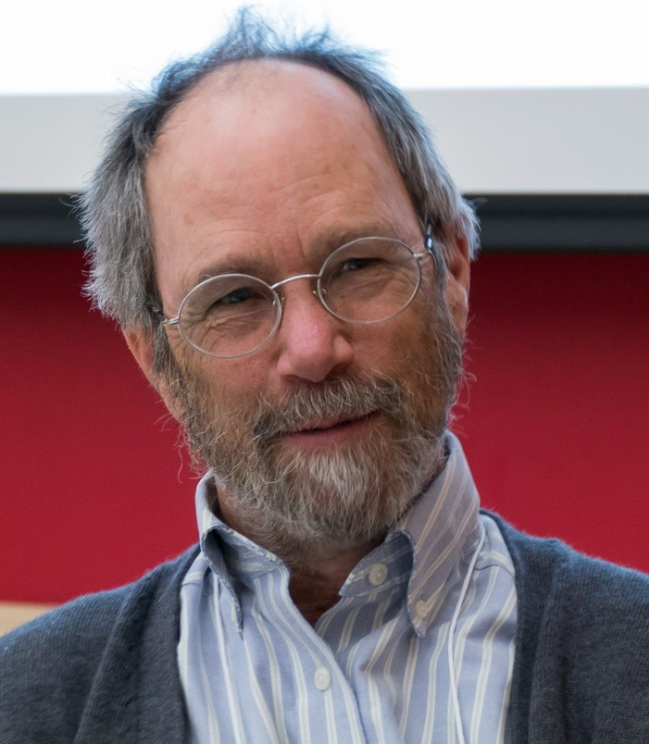
- Multiple benefits of basic monitoring for schools and communities
  - Gives people something to do with their hands (besides texting)
  - Provides real numbers for their individual homes, schools, or outdoor air, upon which they can act
  - Can be a warning in times of high pollutant release
  - Helps build skills and understanding for math, science, environmental assessment, communication
  - Can be shared with or compared to data from others
  - Multiple citizen reports can provide a more comprehensive picture than isolated airport readings

# ROCIS Resources

- ROCIS website ([rocis.org/resources](http://rocis.org/resources)) has lots of good information including:
  - White papers on residential and commercial building pollutants
  - Webinar material by particle experts
  - Presentation slides from meetings and Forum
  - Links to additional sources of information

# Questions/Discussion

## Don Fugler



ROCIS Stakeholder Meeting February 27, 2015

*Thanks to the Heinz Endowments  
for their support of the initiative,  
Reducing Outdoor Contaminants in Indoor Spaces (ROCIS)*

