EPA-RCRA* perspectives on:
Environmental Justice & Citizen Scientists (with ITS)
– Temporal

- **Temporal** Variability

    - **Environmental Justice** – many bldgs. <u>screened-out</u> by 'sampling' <u>errors</u> (T)

    - **Citizen Scientist** (with ITS measurements) – can **contribute** to risk decisions (T)

- Theme: *Minimizing the Opportunities for **In**justice* (in exposures)

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Addressing:
Two Basic Tenets of Environmental Justice

- 1) **Equal protection**
  - from 'risky' exposures*
    - e.g., **Temporal** variability

- 2) Equal access to participation
  - meaningful (representation) in risk decisions
    - e.g., Spatial variability

    - Theme: *Minimizing the Opportunities for **In**justice* (in exposures)

*Subject to regulatory (e.g., RCRA) authority for Corrective Action

Data-Quality Assessment Signals Toxic-Site Safety Threats and Environmental Injustices

Kristin Shrader-Frechette and Andrew M. Biondo

[It's all about VI exposures] "All but one of the CBRE/TCC toxic-site redevelopments assessed in this study **violated all 10** of the government-mandated "requirements" for ensuring the temporal, geographical, and technological representativeness of hazardous-site sampling."

"**all** the CBRE/TCC toxic-site redevelopments are **located** in **environmental-justice communities**, neighborhoods with **disproportionate numbers** of **children, minorities, and poor** people.*

"society may need to re-examine how to ensure … public health, environmental justice, and environmental-health equity."

*see Table 9 for statistics on poverty, Latino & children; underlines & bold added here

Equal <u>protection</u> from risks/exposures (T)

1) <u>Initial</u> screening/assessments

- High-quality ('data-rich') evidence collect to-date has shown:

- VI exposures are:
  - <u>Highly variable</u> across **Time**

- Sampling efforts that are <u>not</u> '**data-rich**' are <u>unlikely</u> to be <u>representative</u>:
  - Across **Time**
    - Residential occupants typically breath **continuously** (24/7/365 for ~20 years)
    - Typical sampling <u>represents</u> **<<1%** of that?
  - Opinion – **Not enough** sampling to **consistently** 'find' **average** or **peak** exposures

- <u>Typical VI **sampling**</u>-assessments are **not** <u>providing equal</u> **protection**
    - To all the population 'at risk' for VI exposures (& <u>Inequities/Injustice</u> **are possible**)

Sampling assessments are Not providing Equal protection
A Critique – For a better Future

- Highly skewed distributions (of exposure)
- Flawed sampling objectives
- Too few samples
- Interpretation 'challenges'
- Misclassification/errors – can only <u>under</u>-represent risk – screen out
- Screened-out buildings – not looked at again
- Buildings un-selected/un-sampled – Only looked at, If nearby impacts
- Buildings found w/ 'unacceptable' exposures – mitigated & monitored …
- Could be <u>surrounded by</u> some homes w/ <u>equal</u> **or** <u>higher</u> exposures
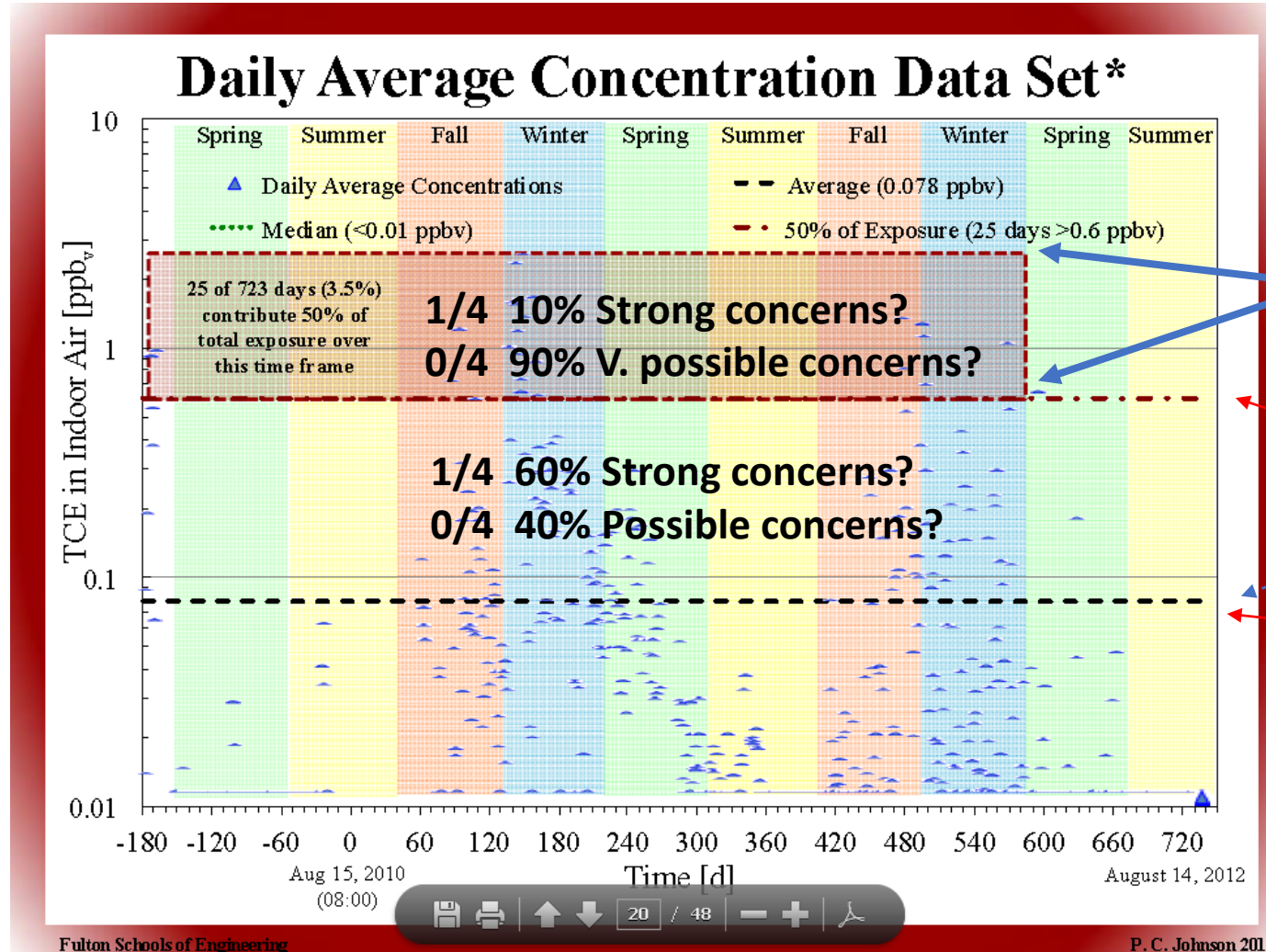
Typically, & in general

Sampling assessments are Not providing Equal protection (Critique 1-4)

- Highly skewed distributions (of exposure)
  - Log distributions (Not Normal distributions)
    - Box & whisker plots = signature of the building's VI 'behavior' (of 5 sites 7 bldgs.)
    - Our sample (7/7) suggests **Many/Most** VI sites appear to be **highly skewed**
- Flawed sampling objectives
  - Can appear – Confirm 'unacceptable' now, or Deny for <u>all</u> past & future
- Too few samples
  - To characterize the full <u>Distribution</u> or even the **Peaks**
- Interpretation 'challenges'
  - <u>Intuitive</u> interpretations of <u>non-normal</u> unknown distributions are <u>impossible</u>;
  - Is 1/4 samples > screen **strong** evidence of VI (not <u>outlier</u> or <u>background</u> source)?

e.g., Indoor air is *variable* & Episodic Peaks can Drive Exposure

25 days (*3.5%*) presents more exposure than the other 698 days

How should we interpret **4 Qtrly samples results where 0/4 samples > screen or 0/4 Winter samples?**

1) **Interpreting** sparse screening-sample results w/o seeing the **distribution** the samples come from can be very difficult & lead to frequently erroneous conclusions & 2) seeing **where the screening level 'falls' in the distribution;** an unknown for VI)

Daily Average Concentration Data Set*

| Spring | Summer | Fall | Winter | Spring | Summer | Fall | Winter | Spring | Summer |

▲ Daily Average Concentrations   – – Average (0.078 ppbv)
•••• Median (<0.01 ppbv)   – • – 50% of Exposure (25 days >0.6 ppbv)

25 of 723 days (3.5%) contribute 50% of total exposure over this time frame

1/4 10% Strong concerns?
0/4 90% V. possible concerns?

1/4 60% Strong concerns?
0/4 40% Possible concerns?

TCE in Indoor Air [ppb$_v$]

10 — 1 — 0.1 — 0.01

-180 -120 -60 0 60 120 180 240 300 360 420 480 540 600 660 720

Aug 15, 2010 (08:00)   Time [d]   August 14, 2012

Fulton Schools of Engineering   P. C. Johnson 2013

Majority of Exposure

Can they mean ***strong*** *&* ***possible*** *concerns?*

~10x higher screening level

Avg. (mean) - Next slide uses **avg.** as screening level for 4 seasonal samples looking for conc. **> mean-screen** & *if* **4 Qtrly samples results were 0/4 >screen?**

Chemical VI (TCE) at 'Sun Devil Manor' (SDM) CVI research house

Dr. Paul Johnson's slide 20/48 - Note audio recording of presentation also available at:
https://iavi.rti.org/attachments/WorkshopsAndConferences/05_Johnson_03-19-13.pdf

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Interpreting the meaning of infrequent samples & their Error 'rates'
Probability of finding 0 out of all of samples with Conc. > screening Levels (in SDM)

		SDM	2W			4Qtr						1W1S				1W
% of data > mean Log norm.	Screen Conc. ug/m3	Std/mean	0/2	≥1	2	0/4	≥1	2	3	4		0/2	≥1	2		0/1	1
___	0.09	0.2	**9%**	91%	51%	**6%**	94%	64%	20%	1%		**28%**	72%	4%		?	
<50%	0.45	1	**34%**	66%	15%	**40%**	60%	14%	1%	0%		**59%**	41%	0%		**> 60%**	< 40% ?
___	4.5	10	**84%**	16%	1%	**90%**	10%	1%	0%	0%		**92%**	8%	0%		?	

a True Mean = 0.09 ppbv [~0.45 ug.m3] for the synthetic data set.
MDL = 0.01 ppbv for the synthetic data. [Note; ~40% ND# not explicitly shown here]
Should we to compare to log-normal distribution % expected?

Now we find 0/4 are most closely assoc. with the <u>majority of exposure</u>

*Re: "1 of __" samples. Do we need guidance on interpretation to ensure equity in decisions?

Sun Devil Manor (SDM), Layton, UT, Reformatted from Holton et al., 2013 in EST
Is this Minimizing Opportunities for Injustice?

(9 out of 10 times)? so **strong** concerns? We can't know what 0/4 samples means until we can see the full distrib.

After some years of struggle, It appears:

- Results of **small sample numbers** from **highly-skewed** distributions are:
- Are almost **Un-interpretable**
  - that is w/o:
- Knowing (at least the shape of*) the **full Distribution,** &
- **Where** the **Screening** level (for exposure concern) **falls**

- We **can't** (find $ to) **sample** chemicals in indoor air **enough** to <u>know</u> the **full distribution** of exposures in **every** <u>building</u> 'at risk' & over time
  - Or even see the **Peaks** (i.e., w/o some continuous guiding factors)
- Gen. Hypothesis: If the distribution is <u>not normal</u>, sample results are <u>worse than they appear</u> to be (i.e., more exposure)

* & a probability table for it

Anyone who has seen *continuously*-measured (real time) radon (Rn) levels in their building

- **Knows:**   Temporal variability

  - Every day (and hour) is different*

  - A building's soil-gas intrusion 'behavior' varies with weather & other environmental & building-operational conditions

  - A random/convenience one-day sample for chemicals (from soil-gas intrusion, VI)
  - does not represent anything more than that one day, not tomorrow, or the next: week, month, year or decade; e.g., Not likely short- or long-term chemical risks

  - A handful of one-day samples for chemicals (from soil-gas intrusion) does not represent much more than a handful of days – **unless** they were *within the **context*** of:

  - **Distribution** of building-specific **measurements;** & if not cVOCs, of at least **soil-gas** intrusion (**rates** & **variability**) e.g., by Rn levels in indoor air

*Rn is a long-term chronic risk, allows integration over time, EPA defined a 90 day sample as a short-term sample. VI is not.

Rn is in ~all Soil Gas, & when **TCE is also there,** they <u>can</u> intrude together;
& Rn is easily measured continuously – forming a bldg.-specific *distribution*

In this SDM data, as presented here, the red (Rn) data and blue (TCE) data show some **rough visual correlation**.

Rn has a **highe**r base/**background** (outdoor air) level, and the conc. varies on a linear scale ~3x

TCE has a **lower** near 0 base/**background** (outdoor air) level and varies on a log scale ~100x

Radon Comparison

Average Daily TCE and Radon in Indoor Air
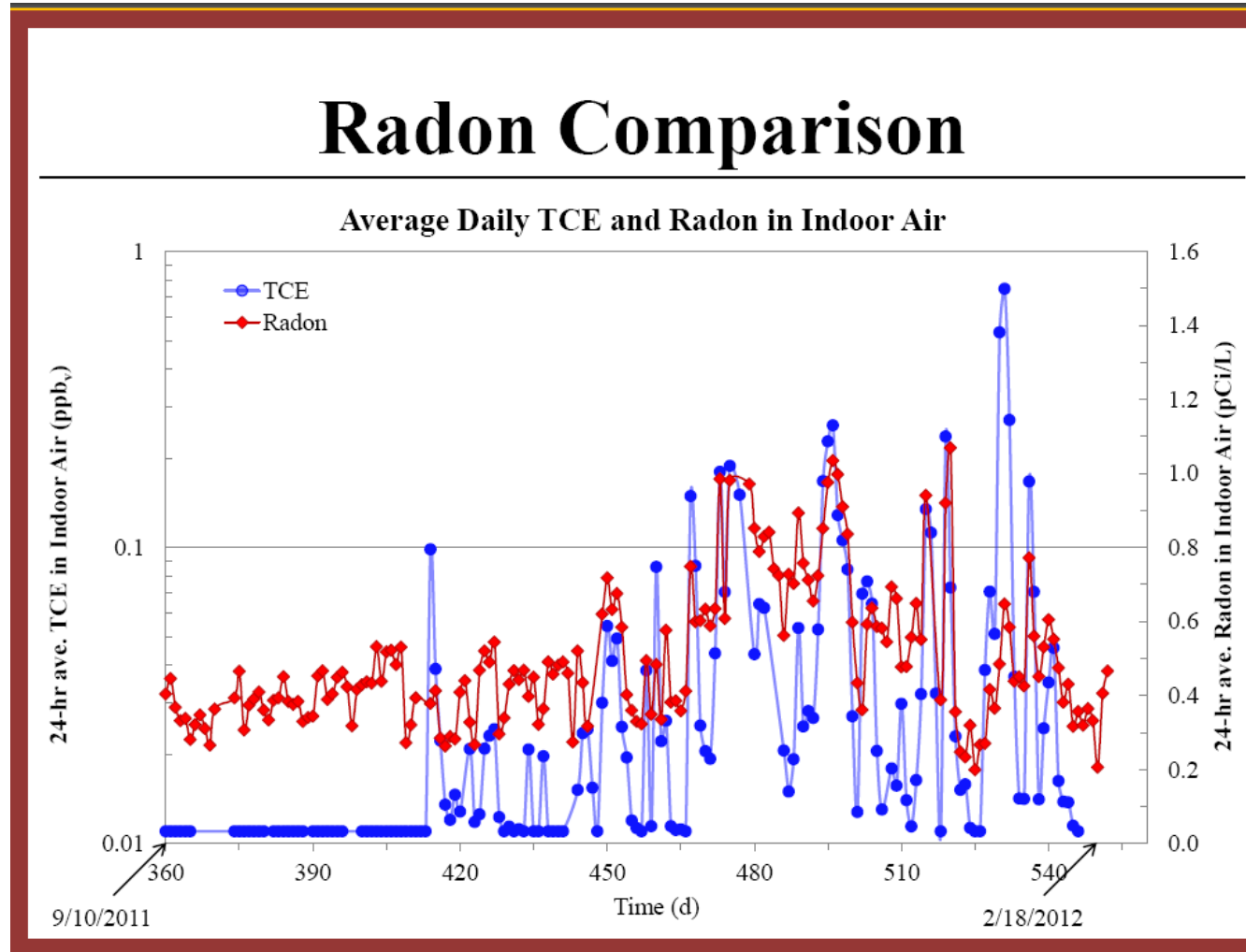
ORD & our team's use of advanced Time Series Regression statistics showed **99%** & **99.9%** correlation in the **direction** of conc. change over time

When <u>Rn conc. goes up</u> (or down) <u>so does TCE</u>, 99.9% at SDM
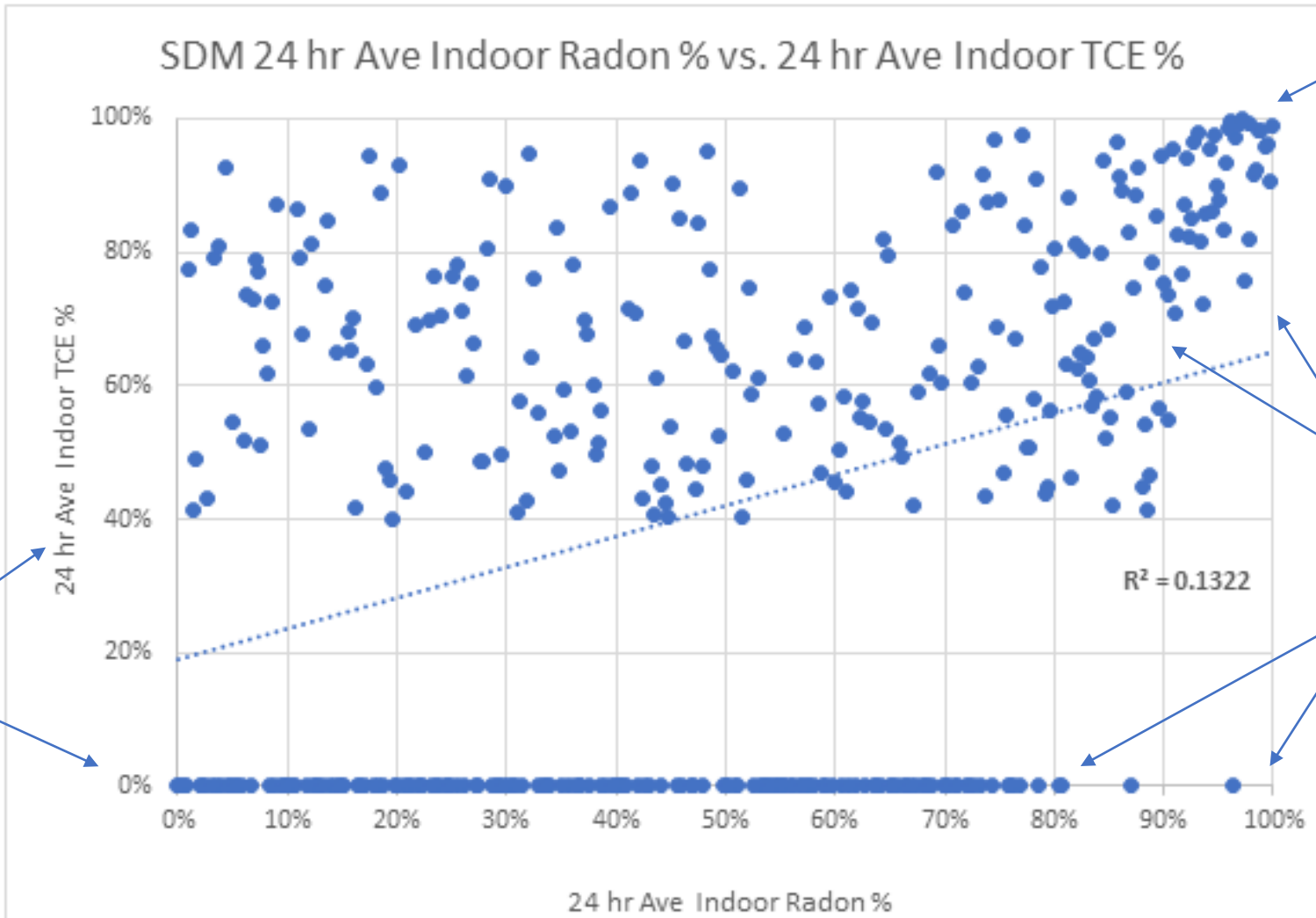
& 99% w/ PCE in EPA's Indianapolis Duplex (EID)

(<u>Not</u> exact <u>magnitude</u>)

Calculated Percentiles (of distributions) – w/o regard to sequence/time

Calculated Percentiles (%iles), including <u>No-Detected</u> (ND) values

~ 40% of the TCE levels are Non Detected

SDM 24 hr Ave Indoor Radon % vs. 24 hr Ave Indoor TCE %

24 hr Ave Indoor TCE %

24 hr Ave Indoor Radon %

$R^2 = 0.1322$

The **highest levels** of Rn & TCE are **most closely associated** – & **that's v. useful!***

When >90th%ile Rn, almost all TCE levels >70th%ile & up to 100th%ile (Highest TCE levels)

At >80th%ile Rn near-lack of ND levels;

Regression line for correlation – **over all**; But we only really care about the highest

Sampling for TCE **when** the **Rn** level is <80th%ile gives a >**40% probability (~1/2)** of finding a **ND TCE value!**
You **need to know** the **building's %ile** of **Radon** conc. **when chem. sample is collected** to **understand** what chemical conc.
found represents. **If sampling when Rn was >80th%, or even better >90th%, you could find much higher TCE levels**

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EPA-RCRA* perspectives on: Environmental Justice & Citizen Scientists (with ITS)
Review & Summary (p. 1)

- **Temporal** Variability – Outline (& <u>Take Home Messages</u>)

  - **Environmental Justice** – many bldgs. <u>screened-out</u> by 'sampling' <u>errors/challenges</u> (T)
    - Due to a combination of <u>in-frequent sampling</u> & <u>challenging Interpretation</u> of sampling results
    - **Infrequent** chemical sampling results are ~**un-interpretable** <u>w/o full distribution if skewed (not norm.)</u>
    - <u>Rn & Chemicals can intrude together</u> in soil gas (i.e., **Peak** conc. are most closely **associated**)
    - Rn intrusion rates & variability is <u>easily measured</u> **continuously**, showing **Peaks** & <u>full Distribution</u>

  - **Citizen Scientist** (with ITS measurements) = <u>our best hope</u> for **frequent** measurements

- Theme: *Minimizing the Opportunities for **In**justice* (in exposures)

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What is Citizen Science

- Involvement of the public in research
- Informs public of environmental health issues

Working Together

- Volunteers help collect data
- Consent to access of private property