

Empirical Modeling of Soil Radon

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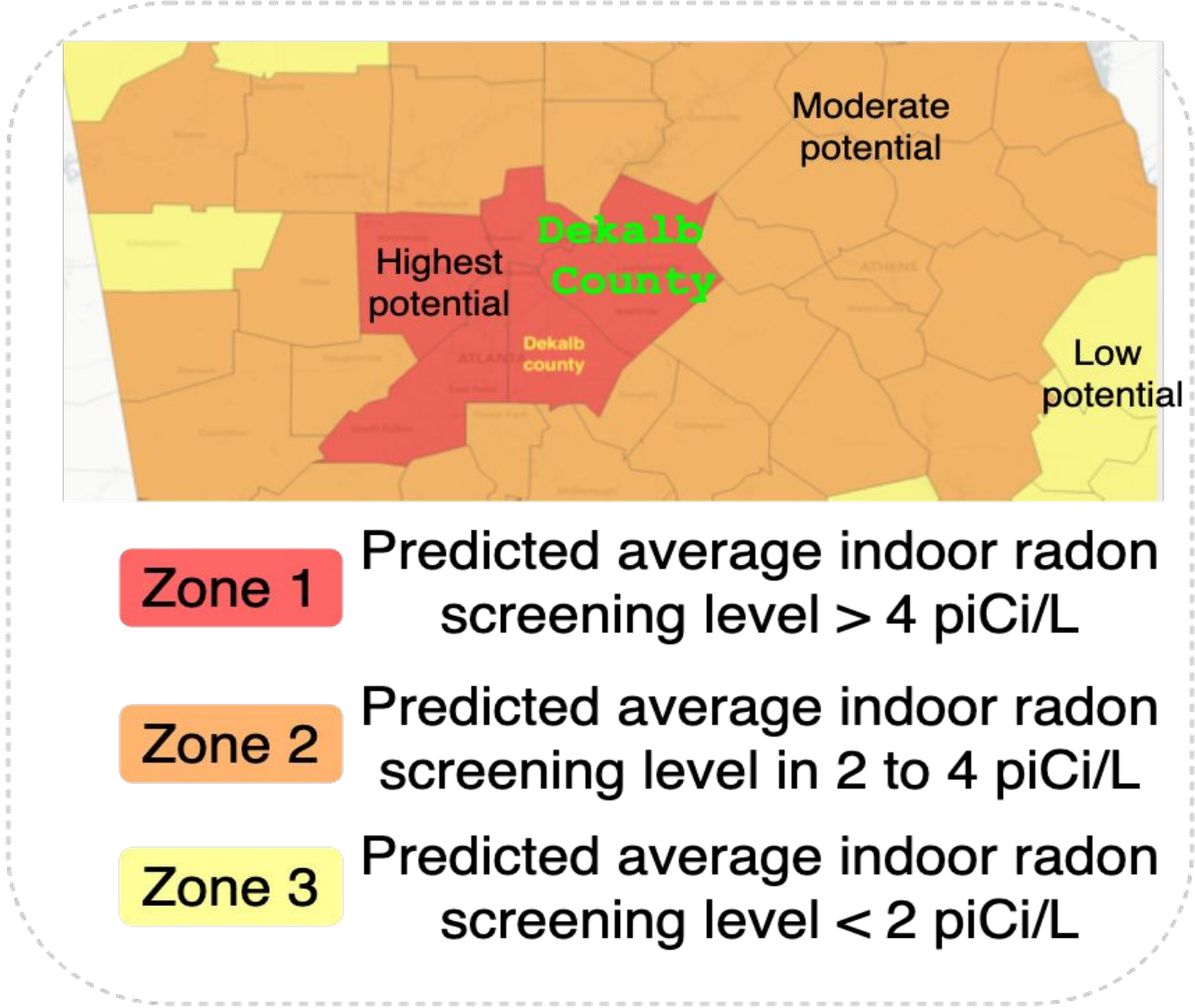
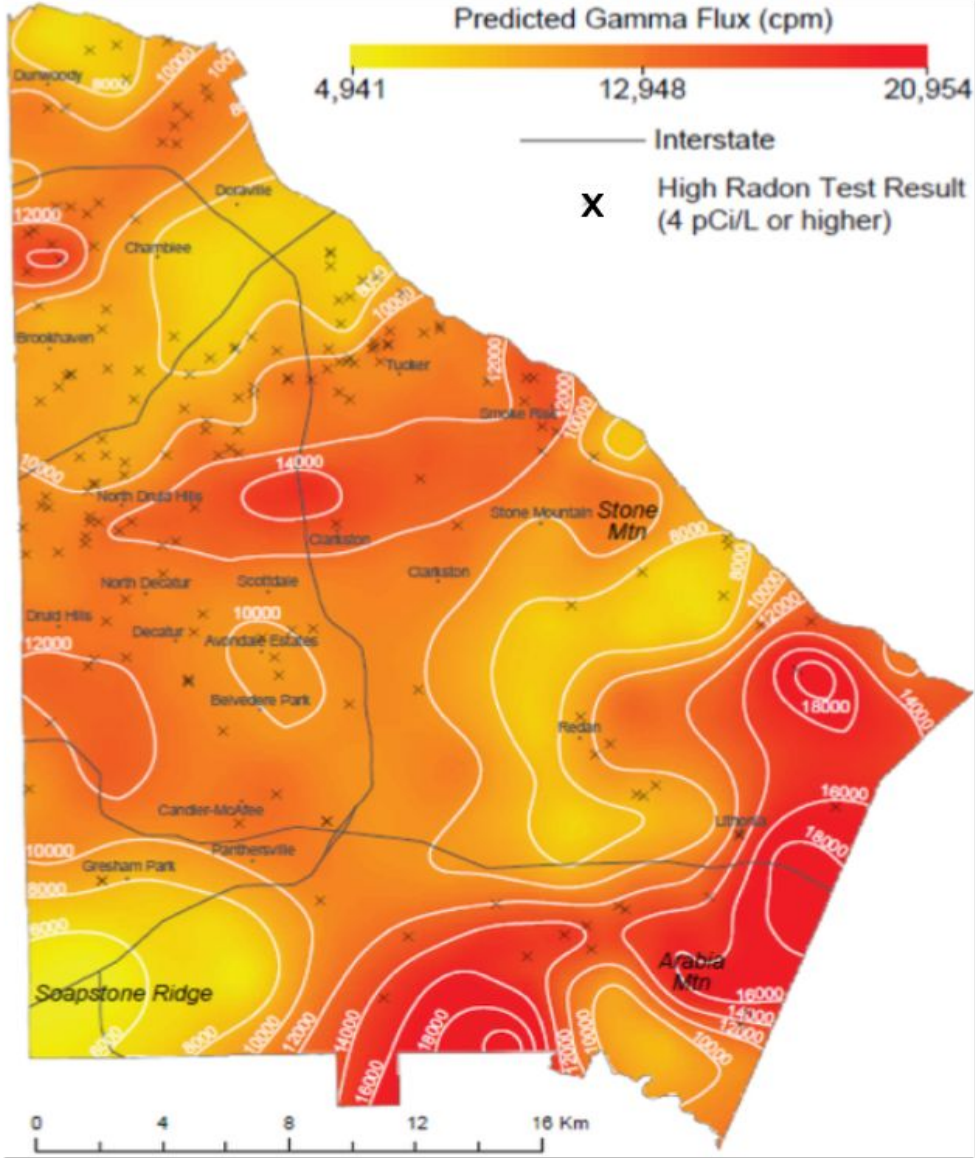
&

Abbaas Nishar, Mayur Aitavadekar, Sumya Tasnim

Drs. Nadine Kabengi, Dajun Dai, Xiaochun He, Pamela Gore and Samantha Andrews

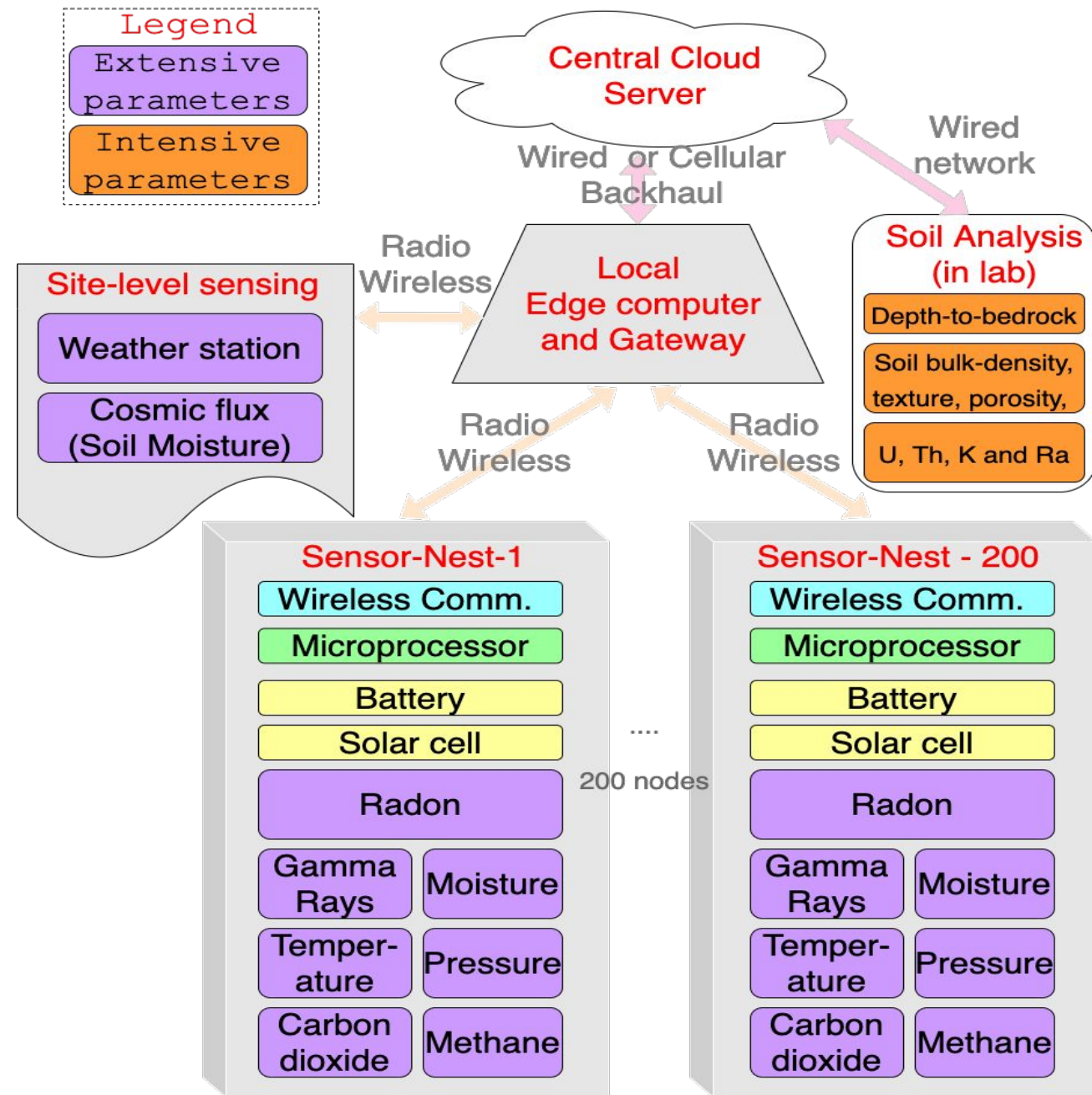


Georgia Dekalb County and Radon

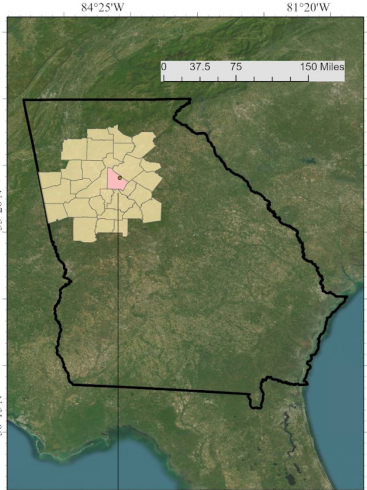


GSU Radon Testbed

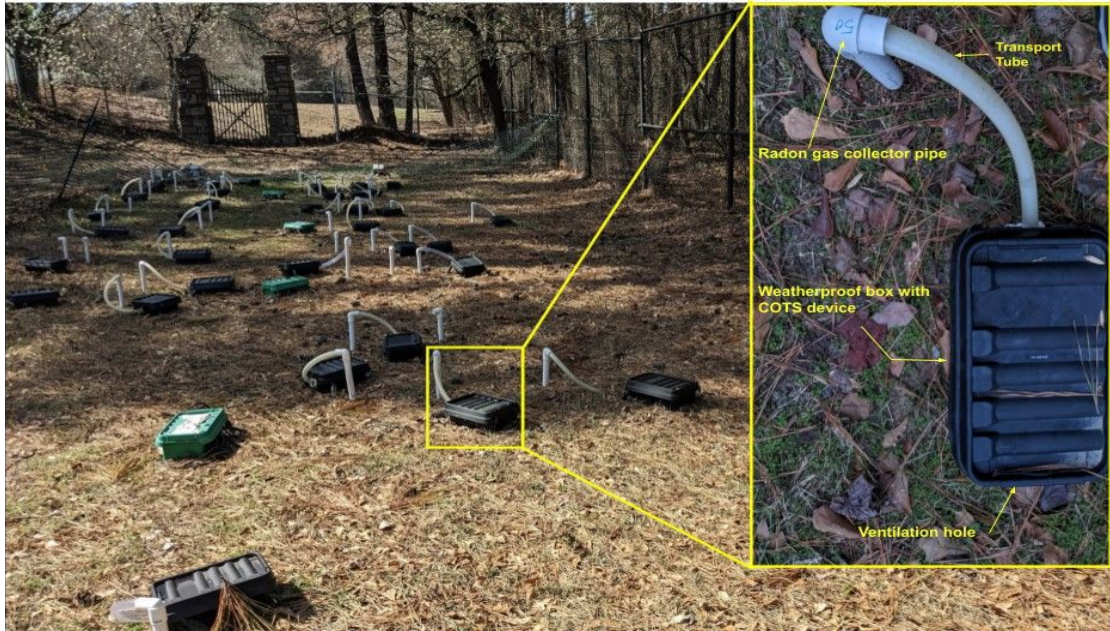
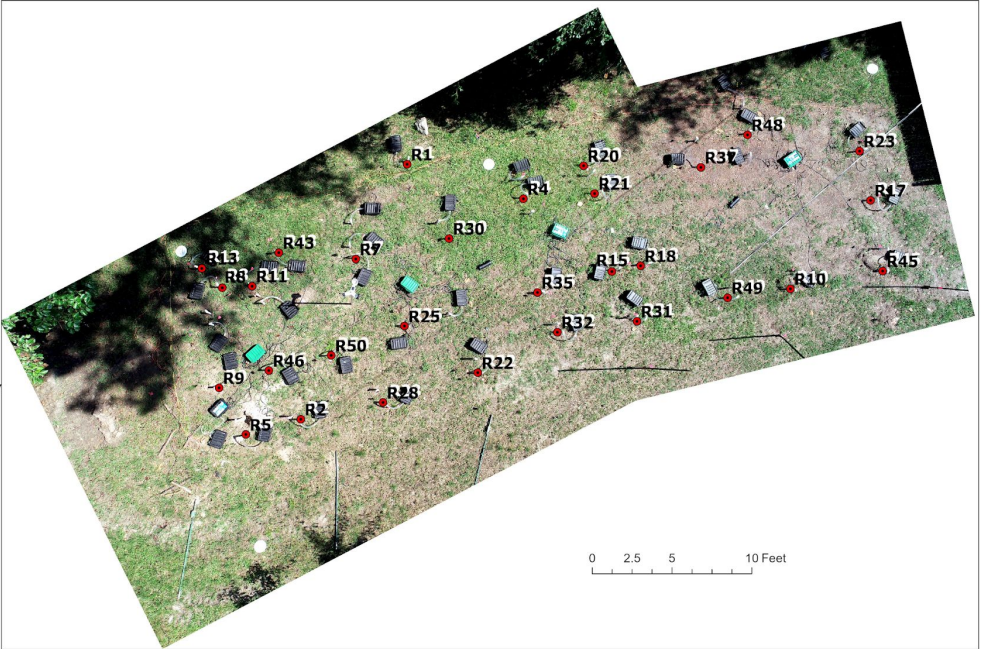
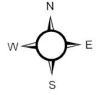
There is no clear understanding of the impact of geological, soil and environmental factors on soil radon generation and penetration, and there is no predictive understanding of the spatio-temporal distribution and variability of radon concentrations in soil



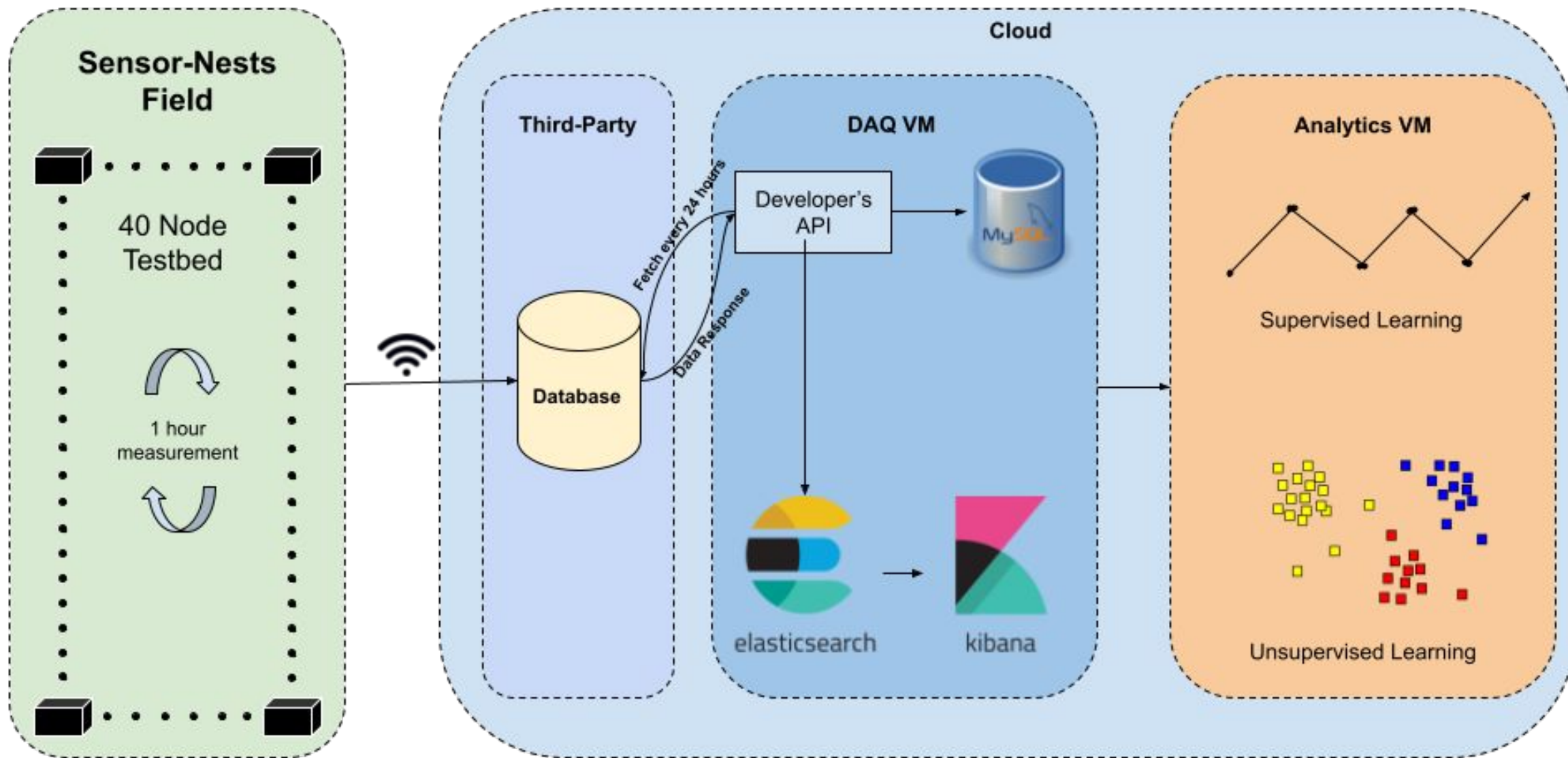
Radon Testbed at Stone Mountain Park, GA



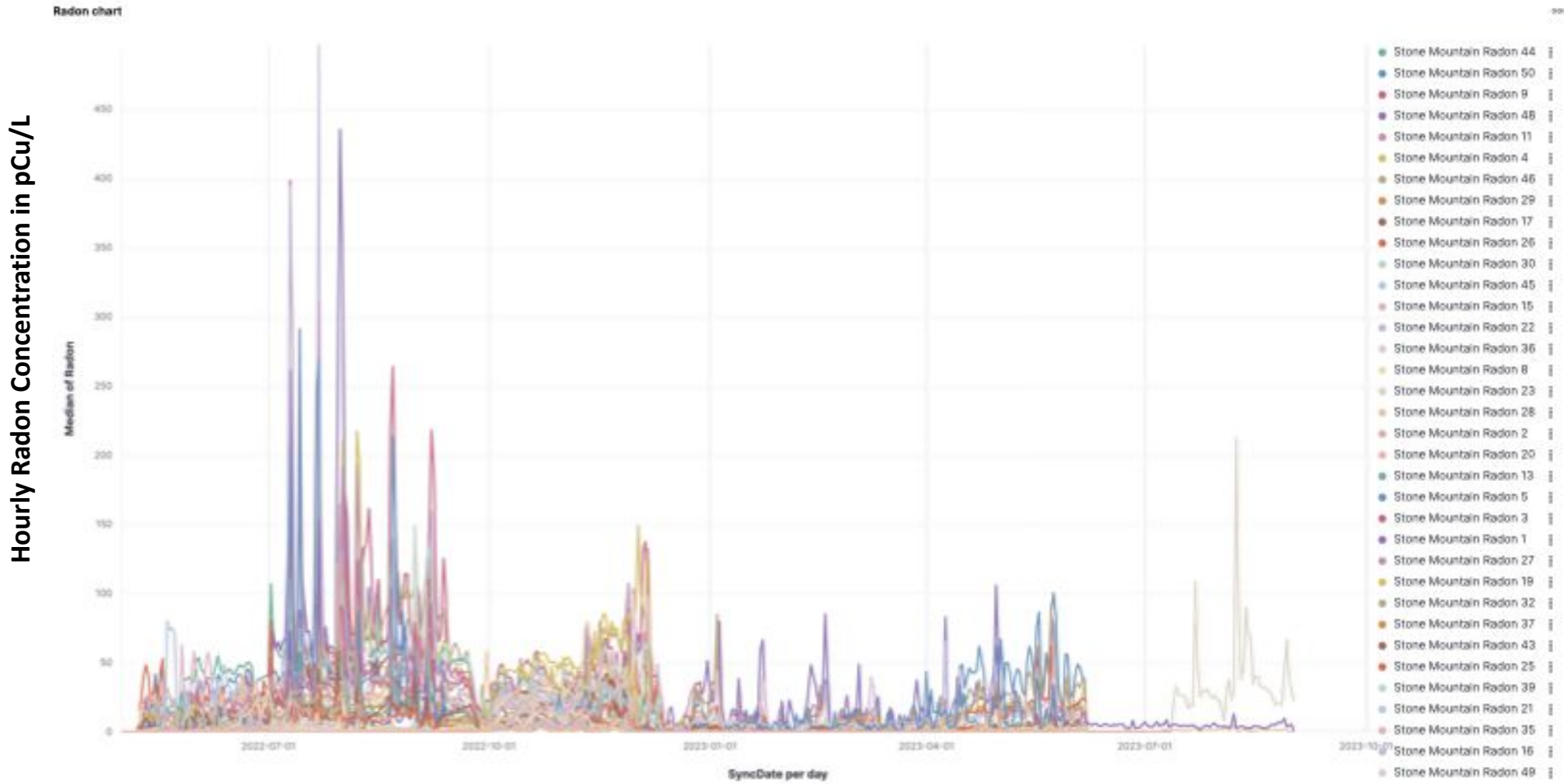
- Sensor Testbed
- Atlanta Region
- Dekalb county
- Georgia State Boundary



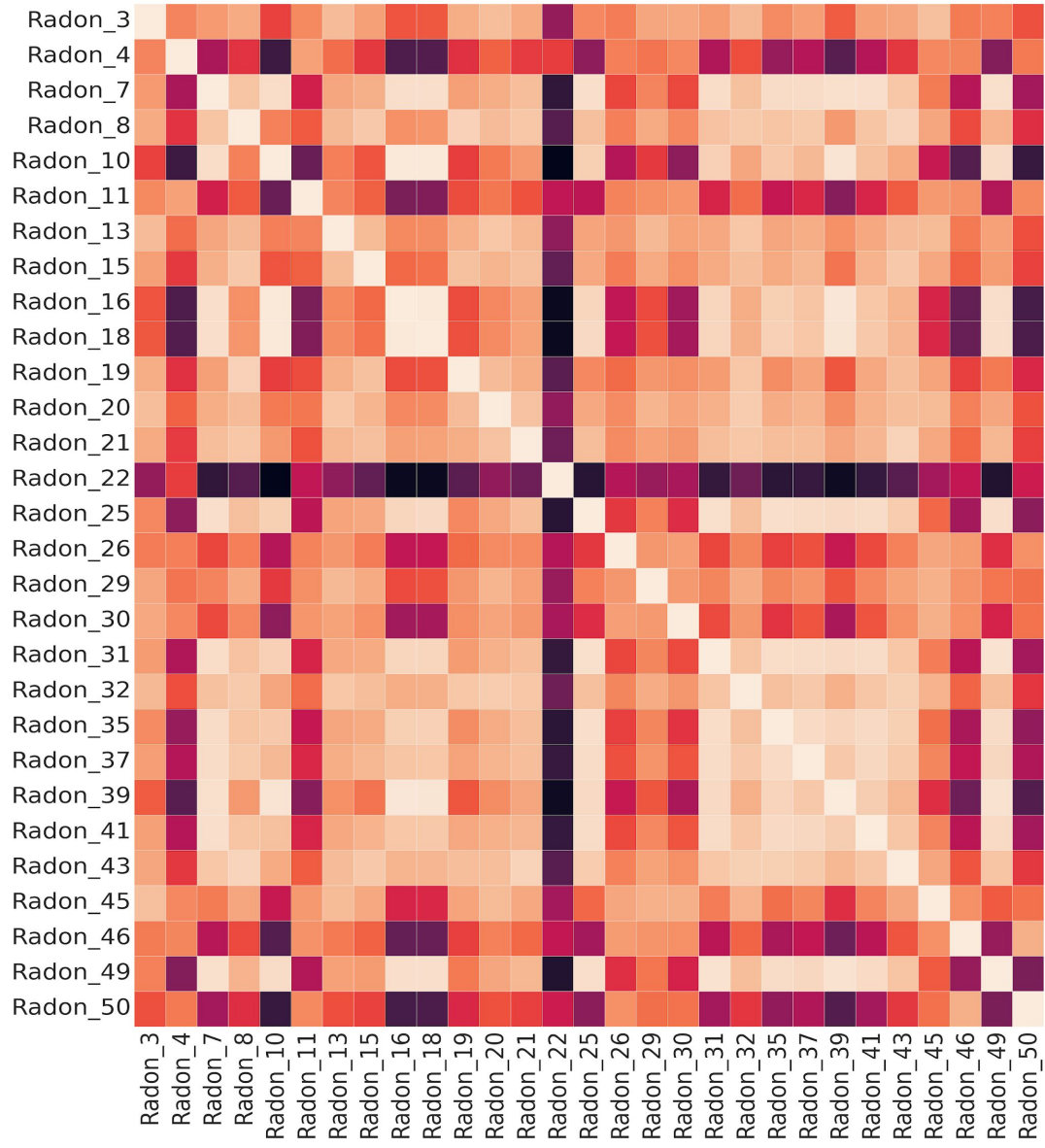
Data Pipeline



Radon Data from Stone Mountain Testbed



Similarity Score analysis

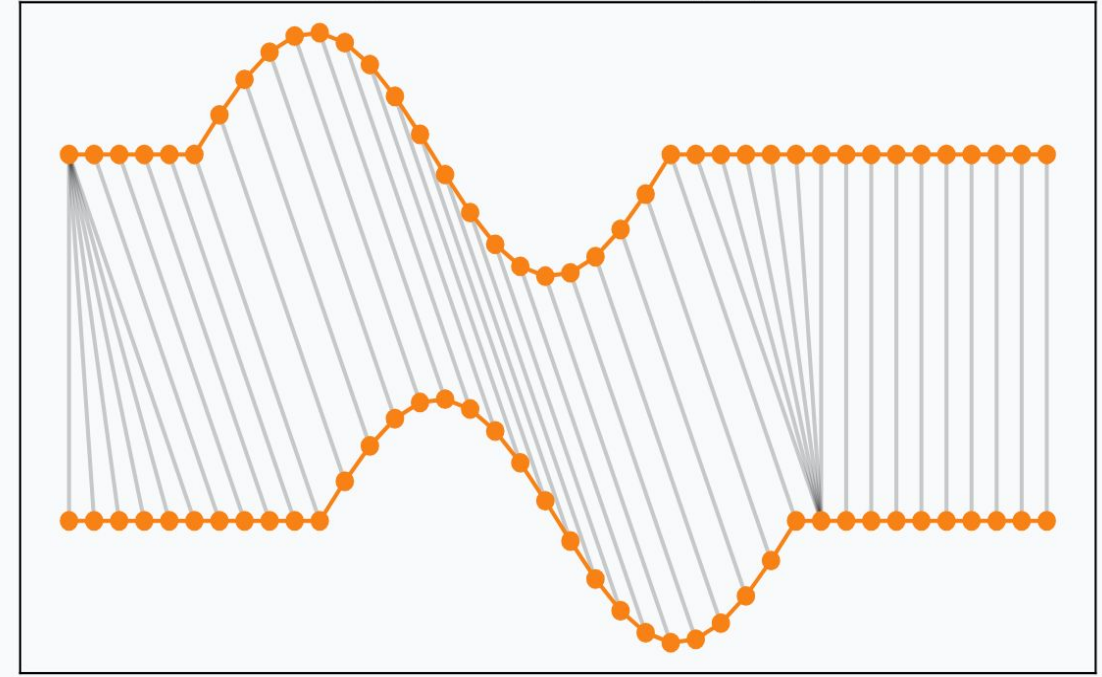


$$S(x, y) = \frac{M - D(x, y)}{M}$$

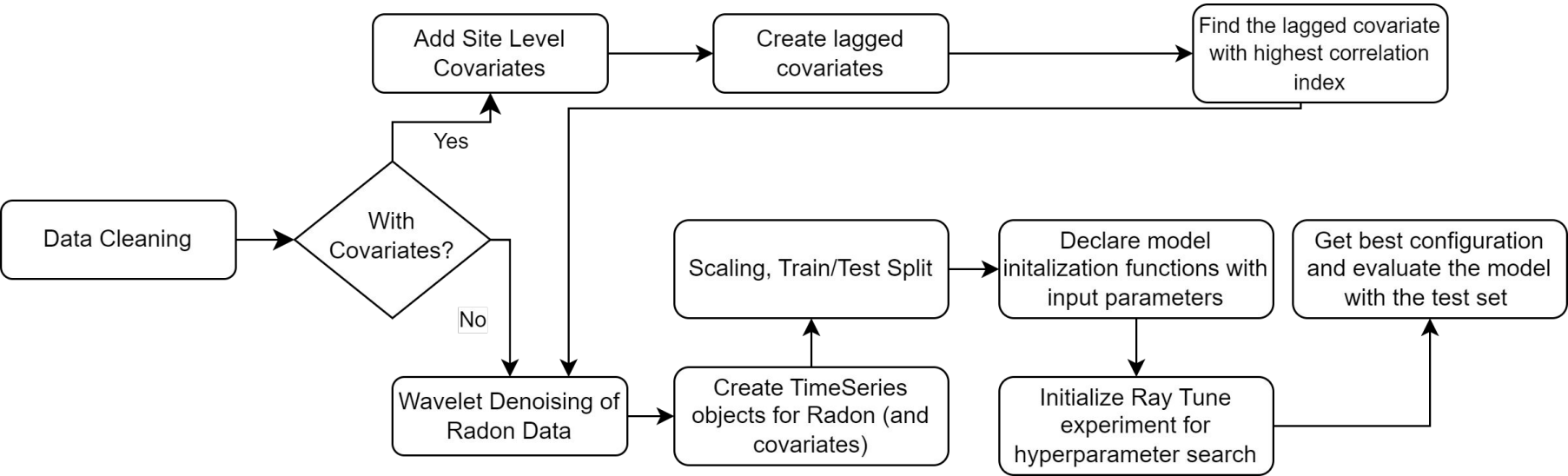
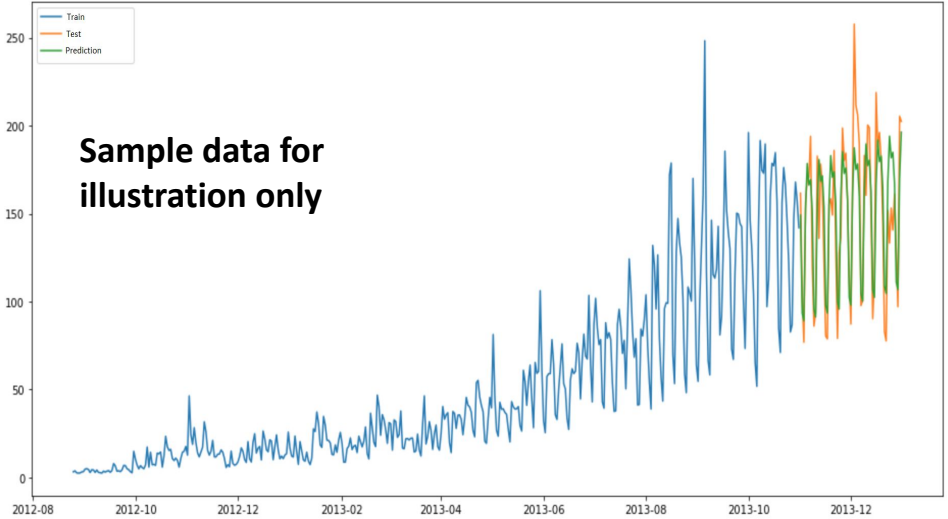
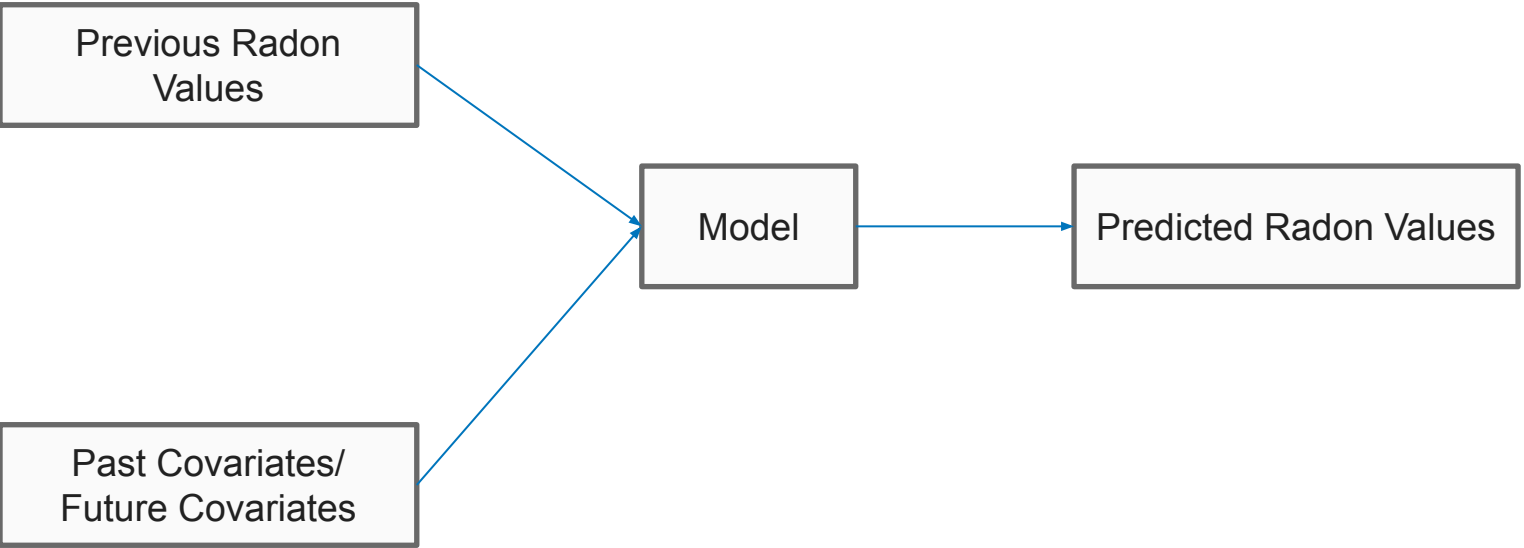
*M is Global Maxima of distance:
D(x, y) is the DTW distance*



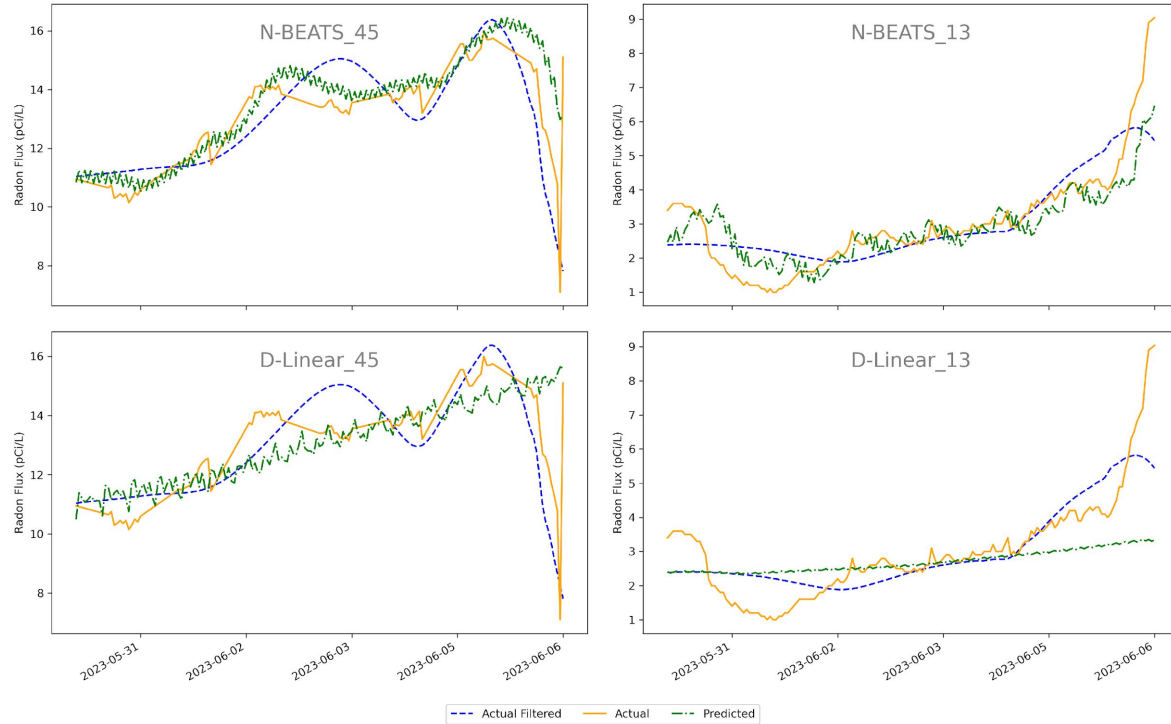
Dynamic Time Warping



Prediction Modeling Analysis



Prediction Modeling- Supervised Learning



	sMAPE	Linear Regression	Xgboost	RNN	Transformer	N-BEATS	N-HiTS	TFT	TCN	N-Linear	D-linear
With Covariates	45	12.08	12.02	7.44	13.04	8.49	16.09	16.73	9.71	22.97	13.17
Without Covariates	13	56.64	24.81	23.84	21.22	16.95	23.6	13.62	19.52	37.33	20.67
With Covariates	45	12.08	12.49	10.60	12.39	17.43	8.51	8.82	7.95	7.30	6.95
Without Covariates	13	52.56	24.80	21.72	24.92	24.21	26.12	25.76	21.05	20.56	19.5

Table 2: sMAPE scores of Radon 45 and 13 for all models

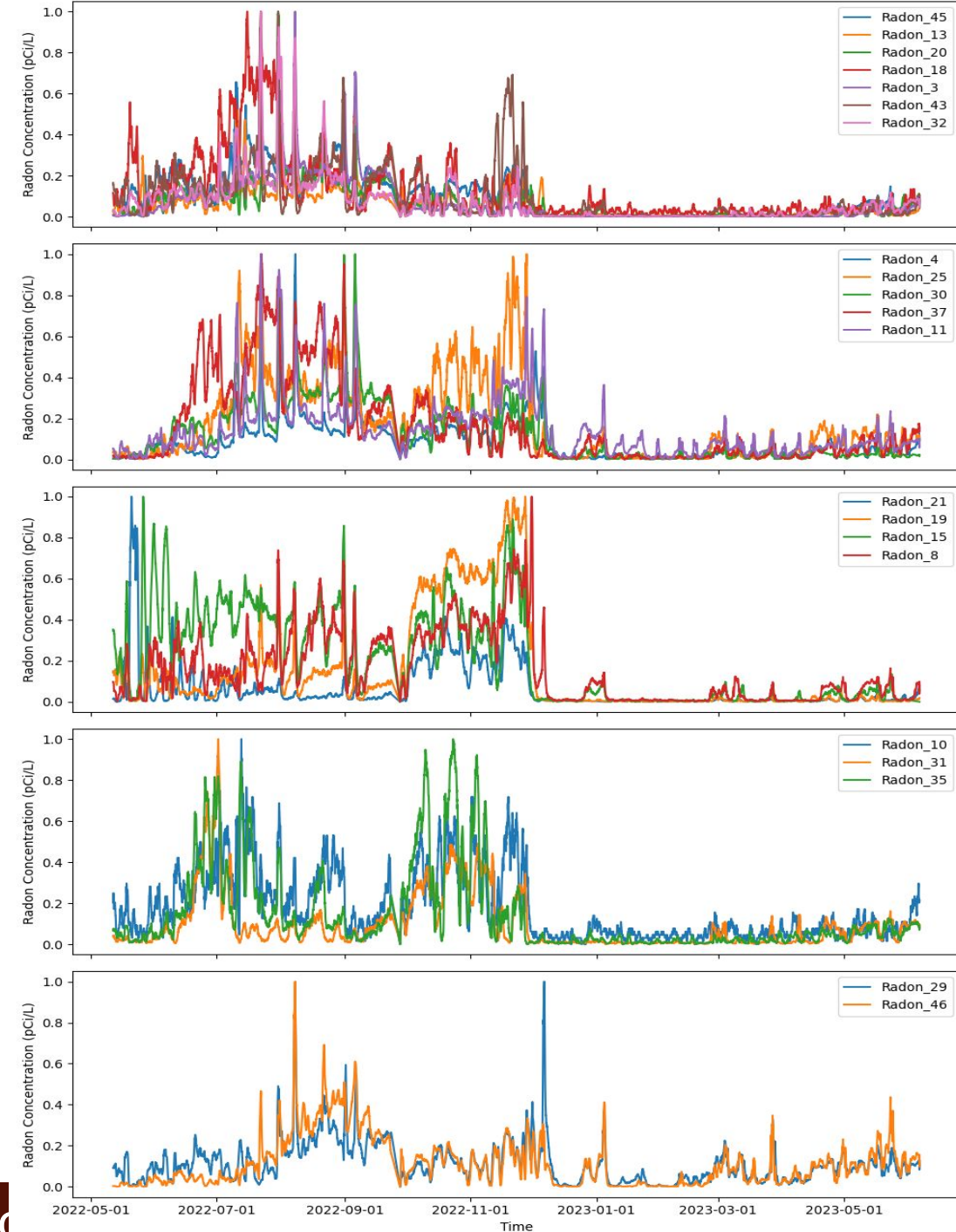
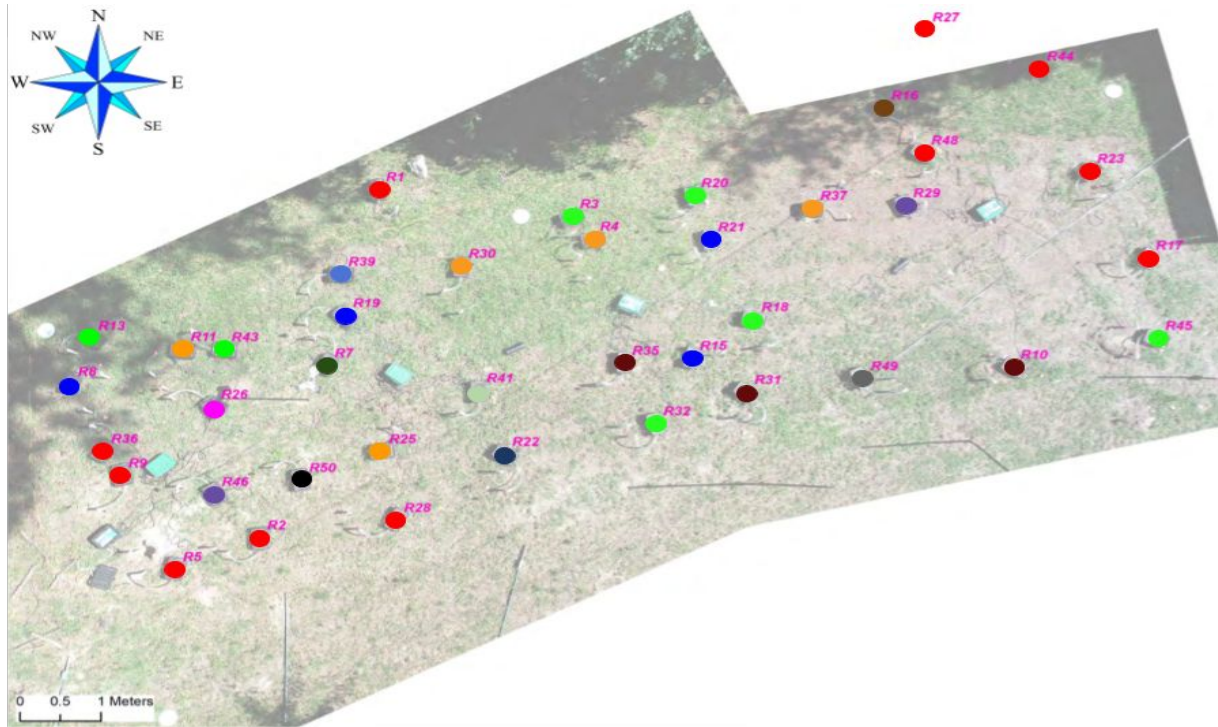
	Avg. sMAPE	Linear Regression	Xgboost	RNN	Transformer	N-BEATS	N-HiTS	TFT	TCN	N-Linear	D-linear
With Covariates	34.36	18.415	15.64	17.13	17.13	12.72	19.845	15.175	14.615	30.15	16.92
Without Covariates	32.32	18.645	16.16	16.16	18.655	20.82	17.315	17.295	14.5	13.935	13.225

Table 3: Avg. sMAPE score for Radon 45 and Radon 13 for all models

Model	μ_{sMAPE}	σ_{sMAPE}
N-BEATS	14.82	16.37
D-Linear	19.44	15.91

Table 4: Mean and Standard Deviation of sMAPE scores for best models

Prediction Modeling- UNSupervised Learning

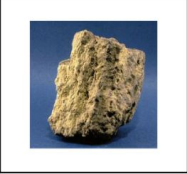


Summary of learnings from the experience so far

- It is challenging to converge on any **best** model for time series prediction of Rn from individual sensor locations – *should there be a controlled experiment study of Radon?*
- The spatial correlation proved that there is no apparent spatial cluster groups we attribute that to different modulators in nature – *should the Radon over the entire area be studied collectively?*

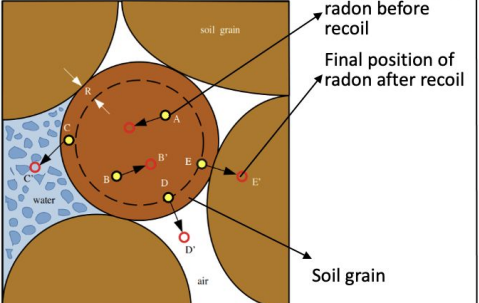
Ongoing Works – Happy to talk offline!

Stage 1



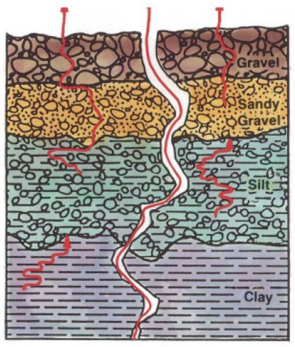
- The decay of radium generates radon with 86 keV energy.
- Key take-away: in our simulation, we need to use information about radon, radium, and uranium.

Stage 2



Schematic representation of radon emanation [1]

Only radon particles in range R can escape the soil grain.
(radon emanation study simulation)



Once radon escapes from soil grain and enters pore space it can migrate towards the surface.
(radon migration study simulation)

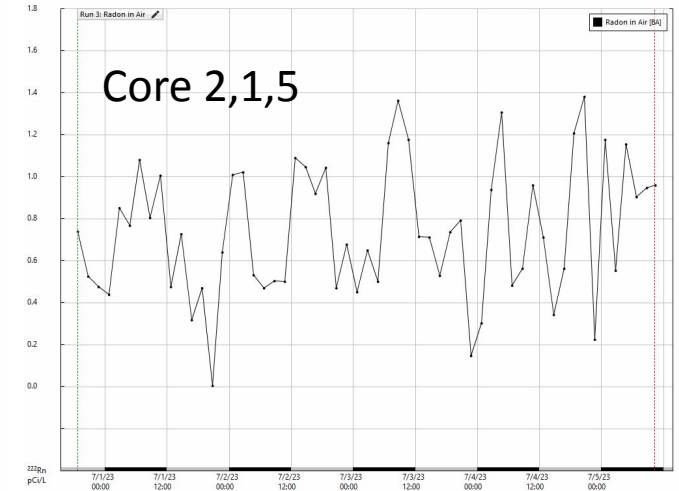
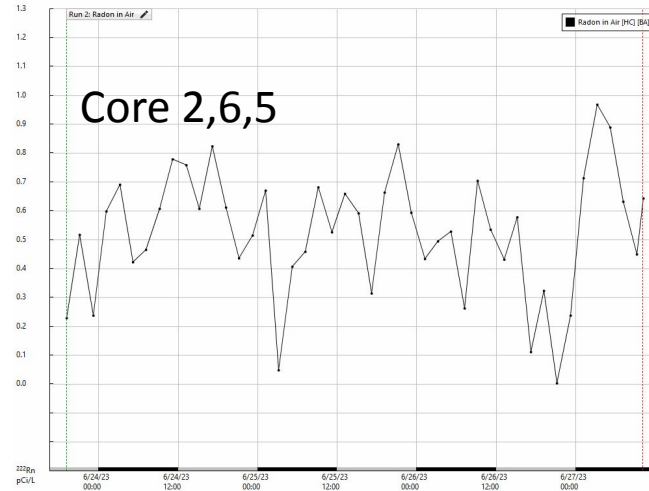
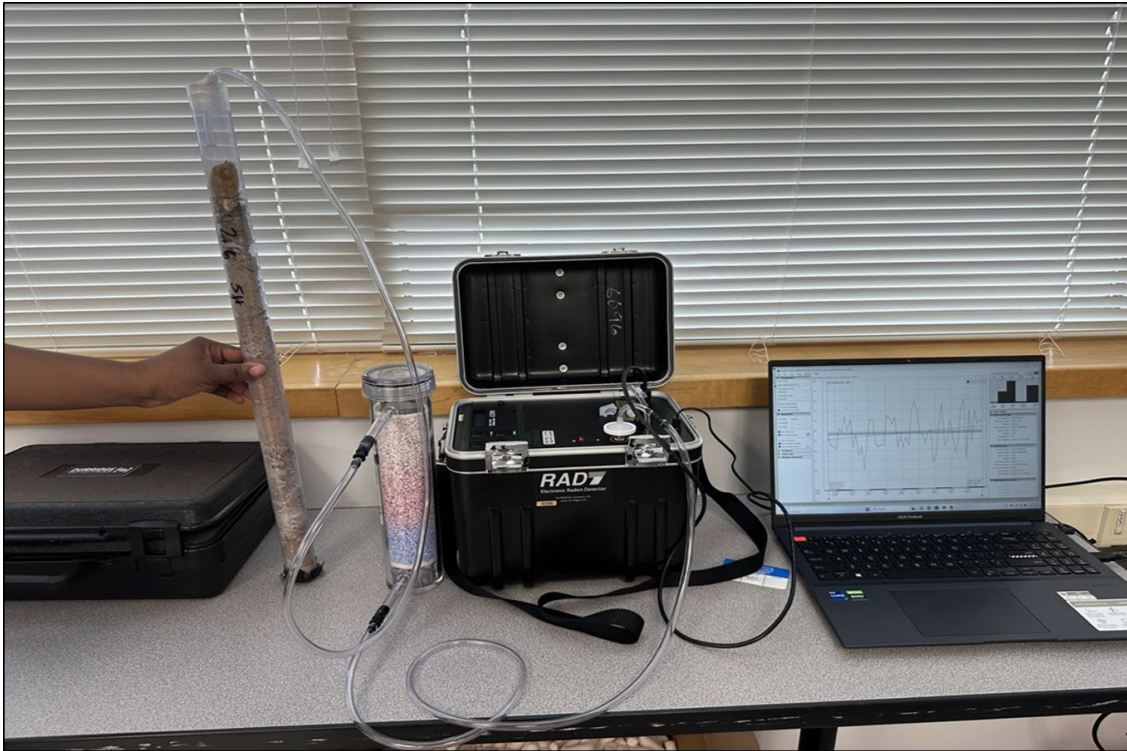
Simulation study of Rn Transport (Propagation) using GEANT4

Controlled Soil-Column Experiment



Education Outreach

Extras



▼ Entire Data Range

File Created By: CAPTURE 6.2.5
File Creation Date: 7/5/23 10:33
Platform: Windows
Avg. Radon In Air: 0.524 ± 0.029 pCi/L
Avg. Air Temp: 26.7°C
Avg. RH: 5.24%
Num. Data Pts: 45
Time Duration: 3 Days, 15 Hrs, 0 Min

▼ Entire Data Range

File Created By: CAPTURE 6.2.5
File Creation Date: 7/5/23 10:27
Platform: Windows
Avg. Radon In Air: 0.737 ± 0.030 pCi/L
Avg. Air Temp: 27.1°C
Avg. RH: 5.14%
Num. Data Pts: 57
Time Duration: 4 Days, 15 Hrs, 40 Min