Empirical Modelling of Radon Diffusion Through Lab and Field Studies

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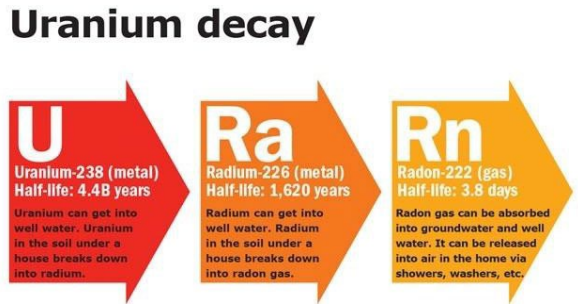
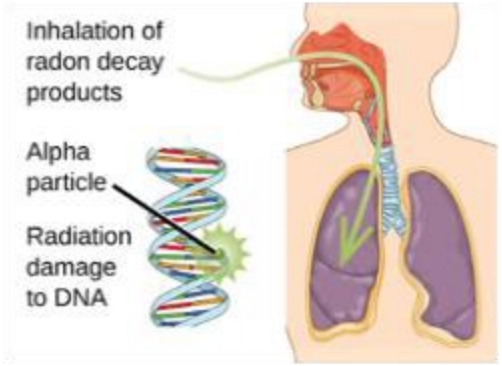
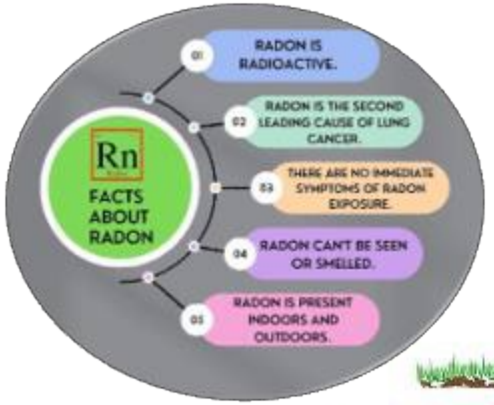
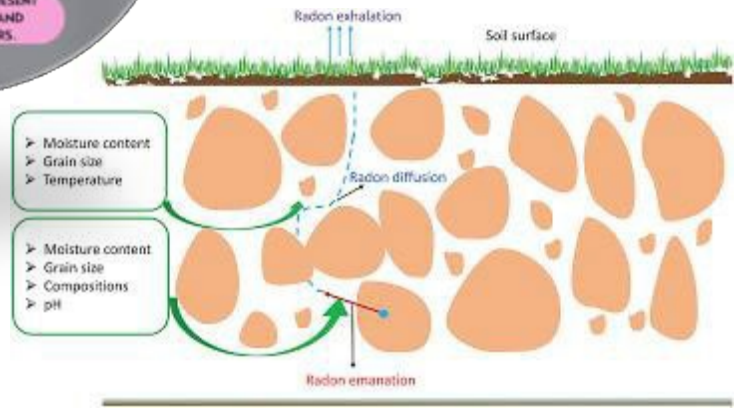
Indoor Environments ™ 2024 - Radon and Vapor Intrusion Symposium

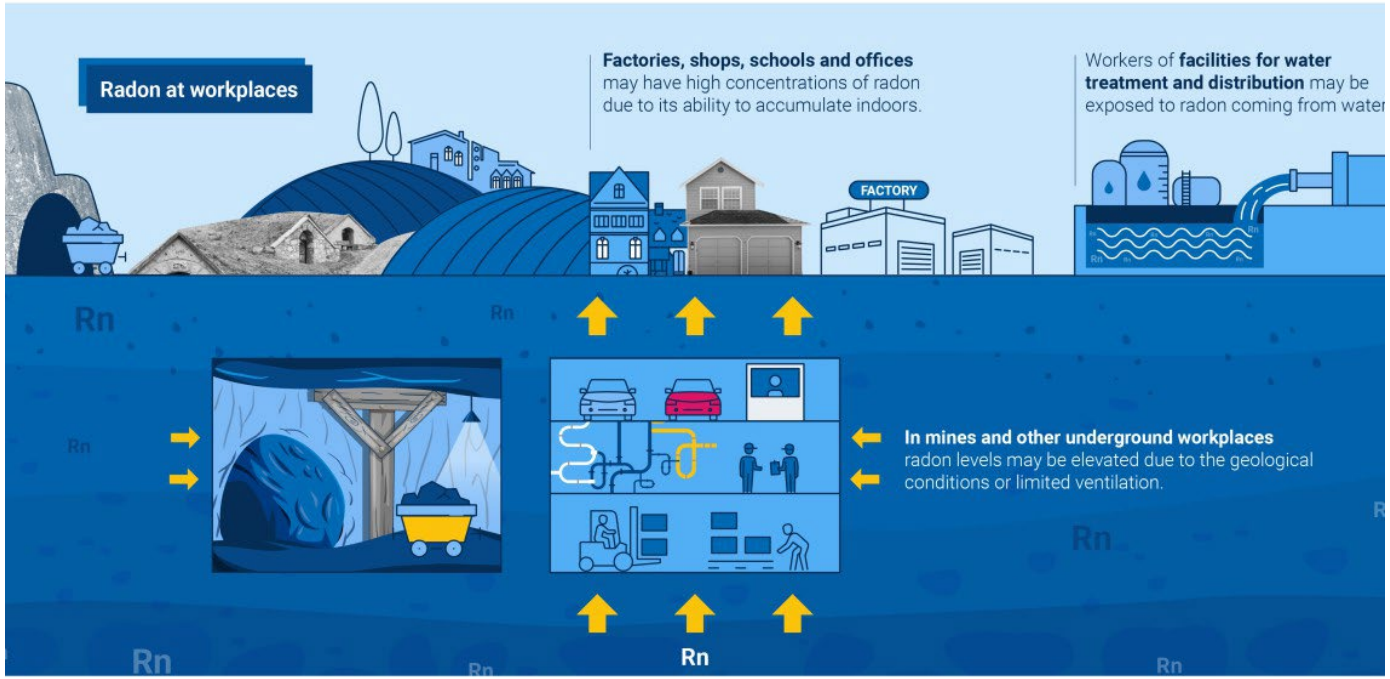
Introduction



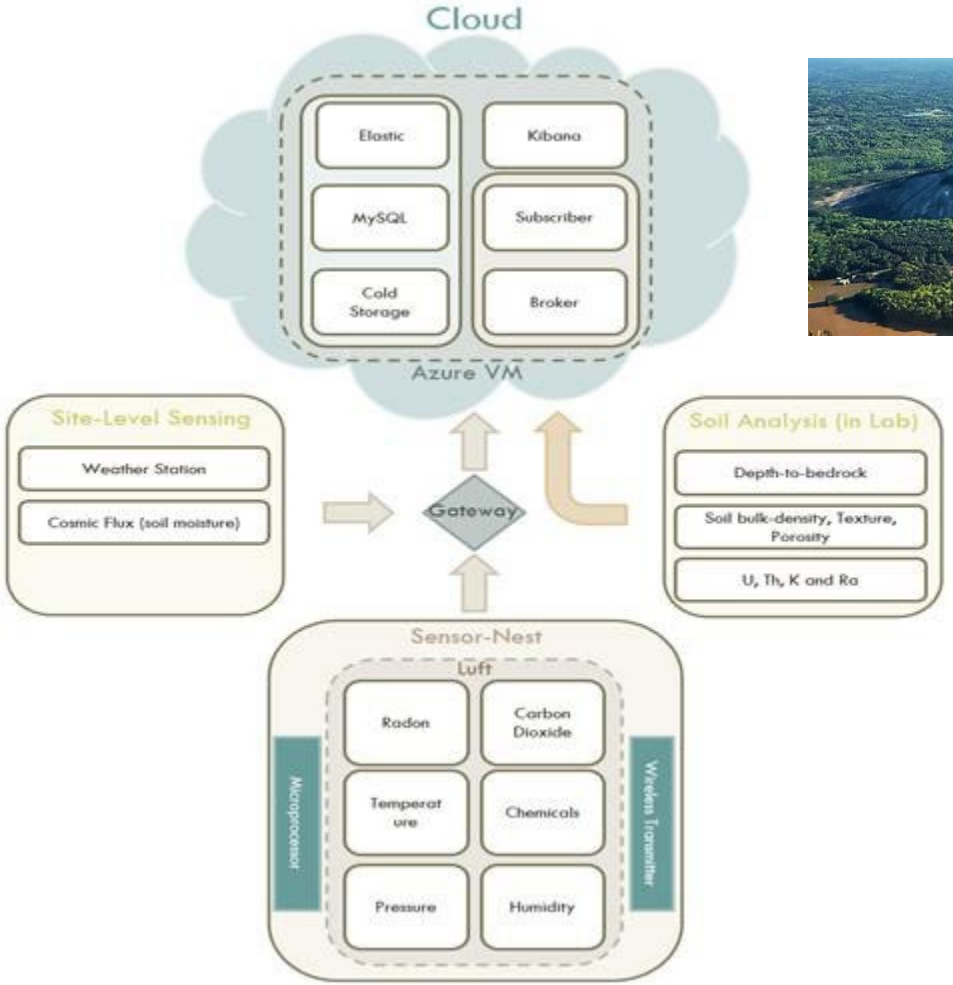








OpenRadon Lab:
Democratizing Soil Radon Modeling & Mapping

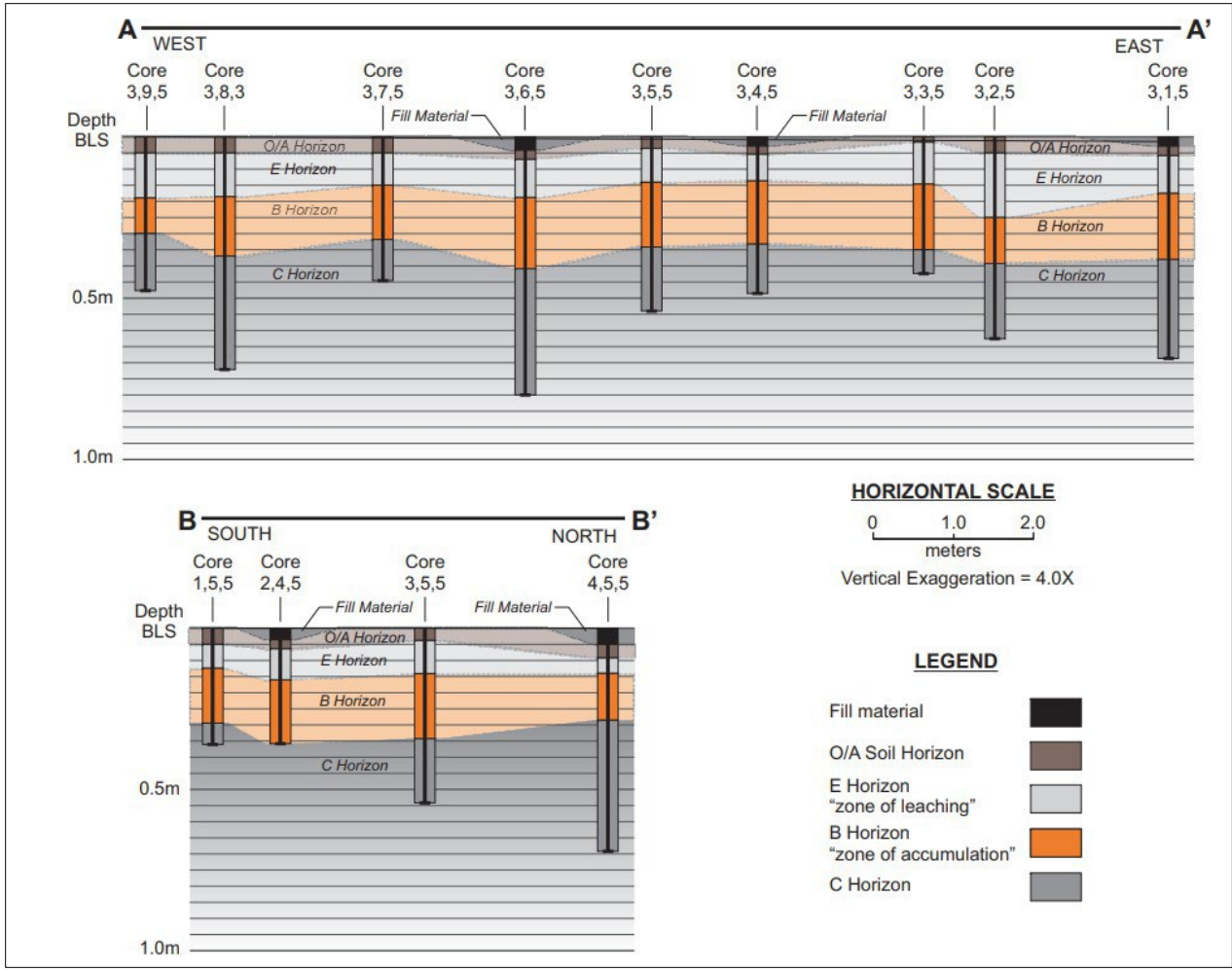


OpenRadon Lab System Architecture

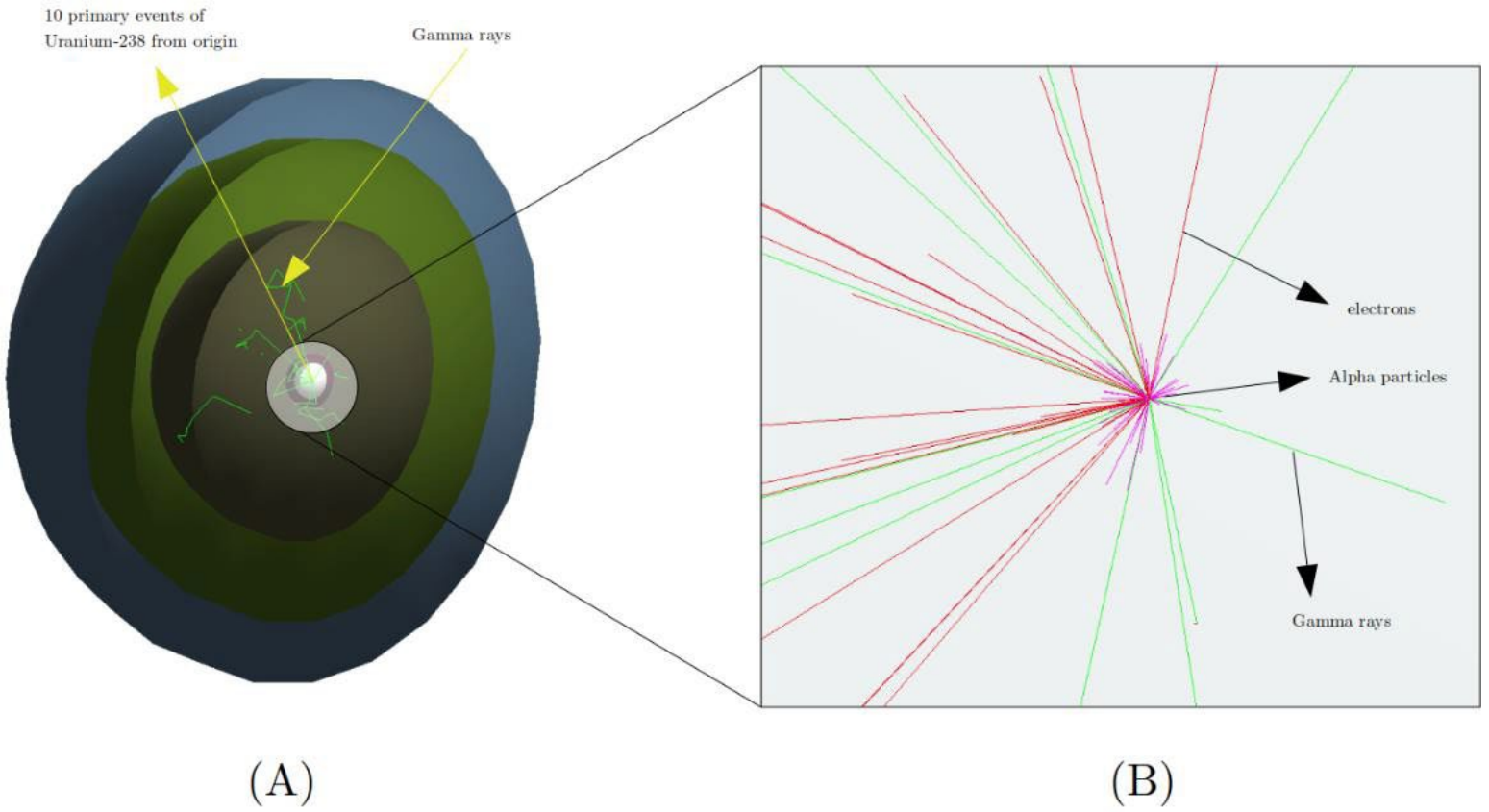
OpenRadon Lab Deployment Stone Mountain, GA
(about 10 miles from downtown Atlanta)

Soil Analysis Summary -- Stone Mountain, GA

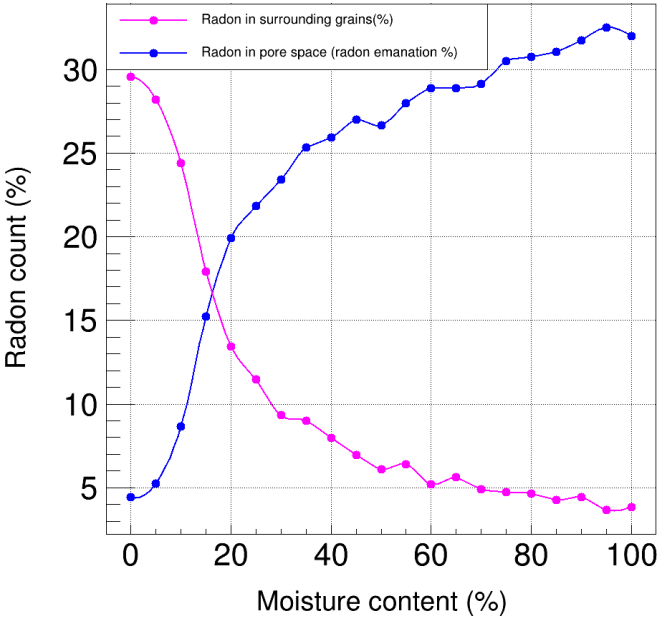
Depth (inches)	Bulk Density (g/cm³)	Soil Moisture (g/cm³)	Porosity	Soil Texture
2 - 6	1.51	0.16	0.43	Sandy loam
10 - 12	0.73	0.13	0.72	Sandy clay loam
23 - 26	1.03	0.02	0.61	Sandy loam
32 - 34	1.06	0.05	0.60	Loam

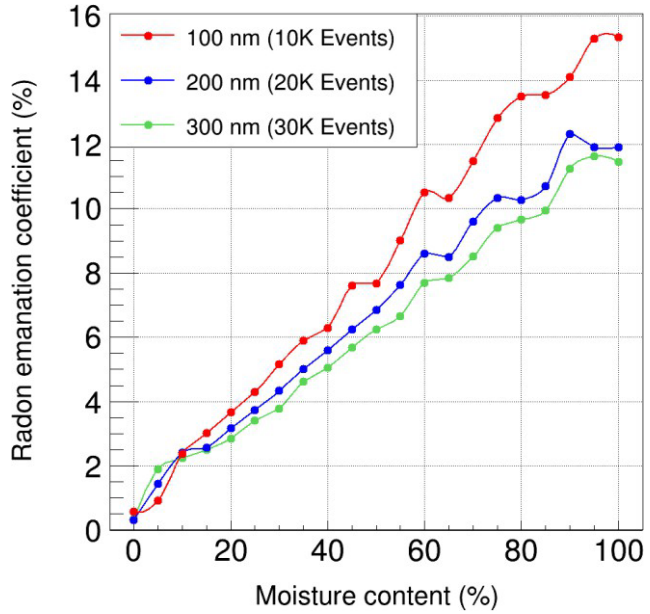


Radon Propagation Study in Soil (Atomic Level)

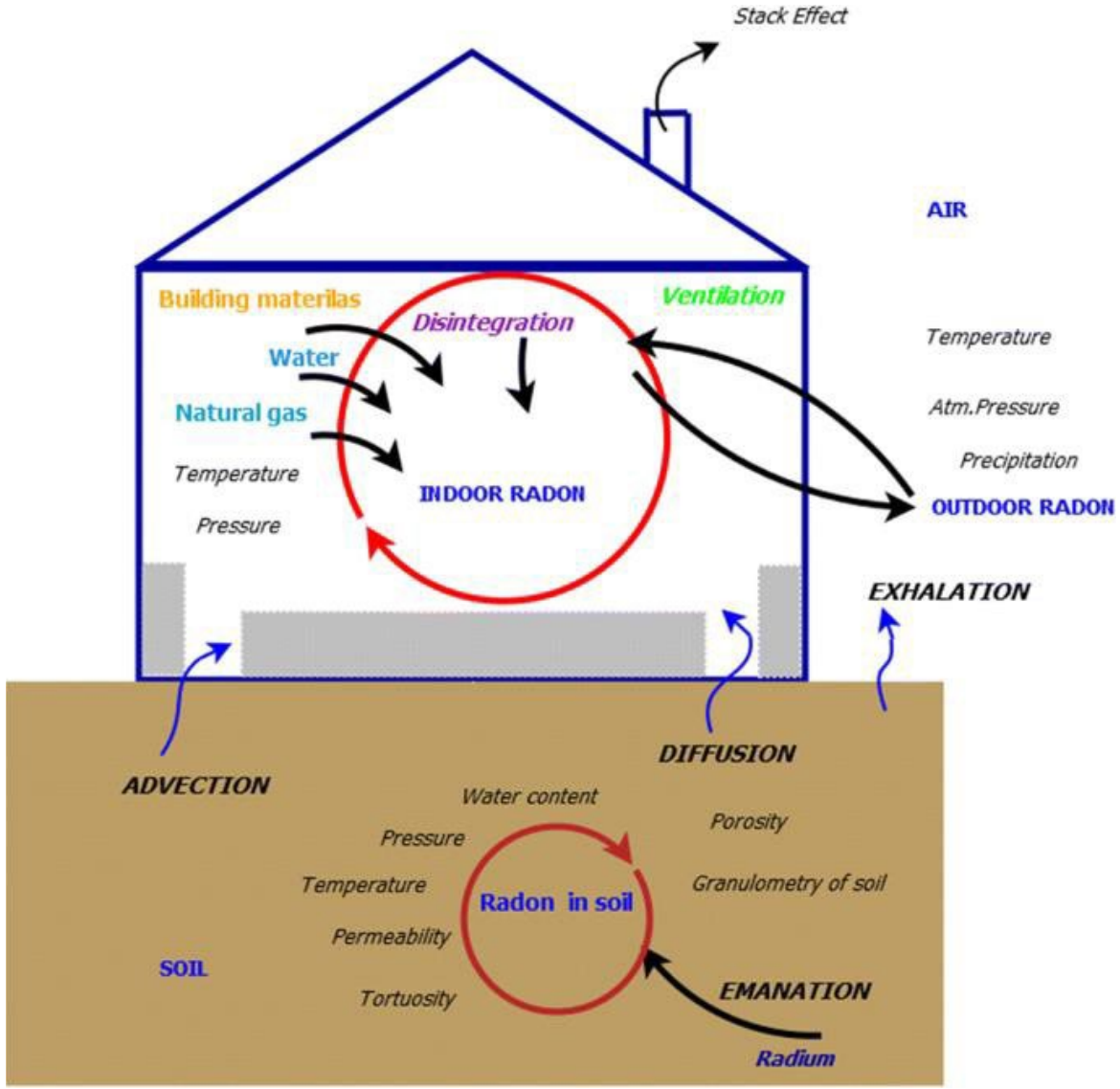


Geant4 Simulation

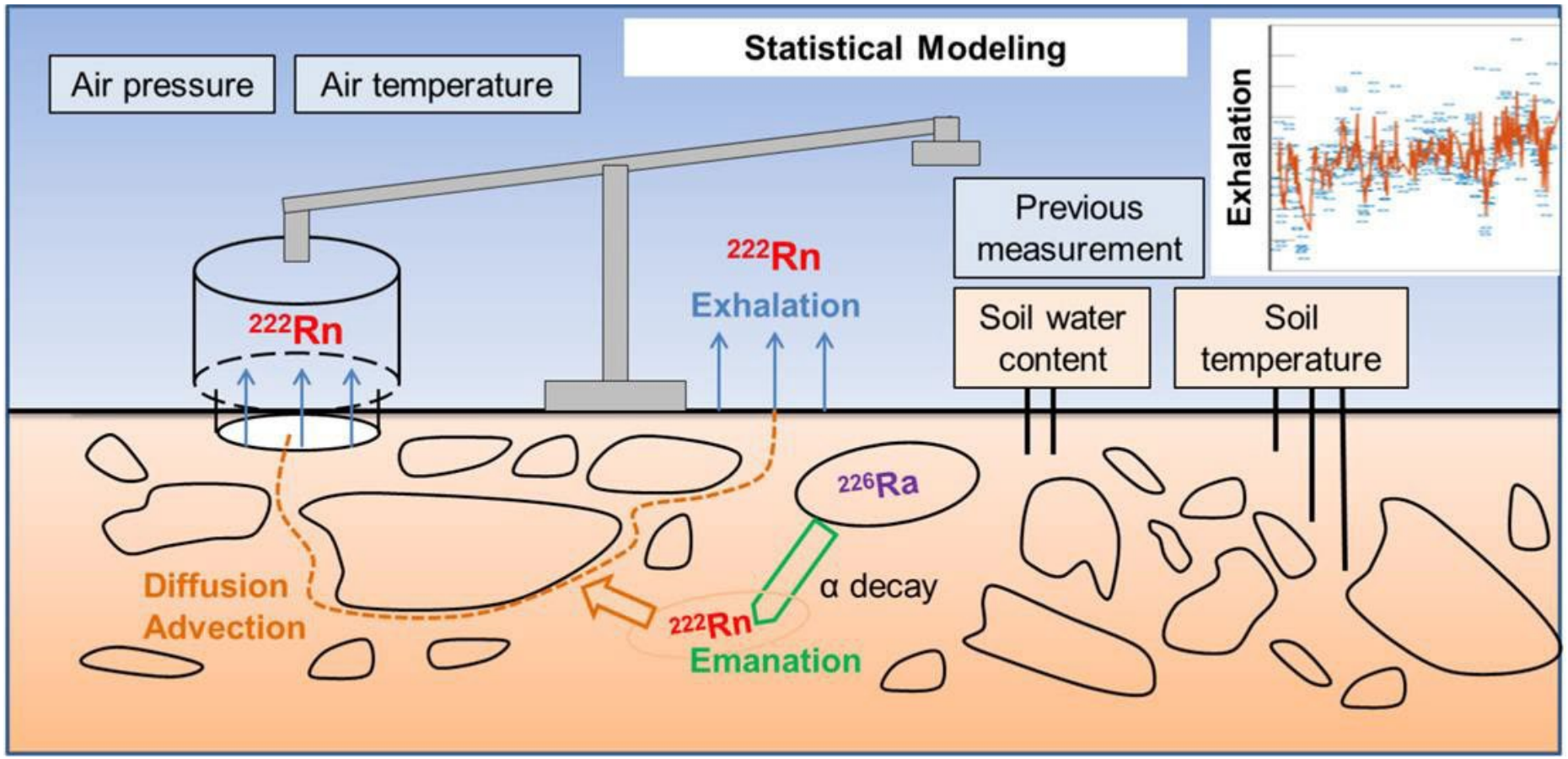




Why Study Radon Diffusion?



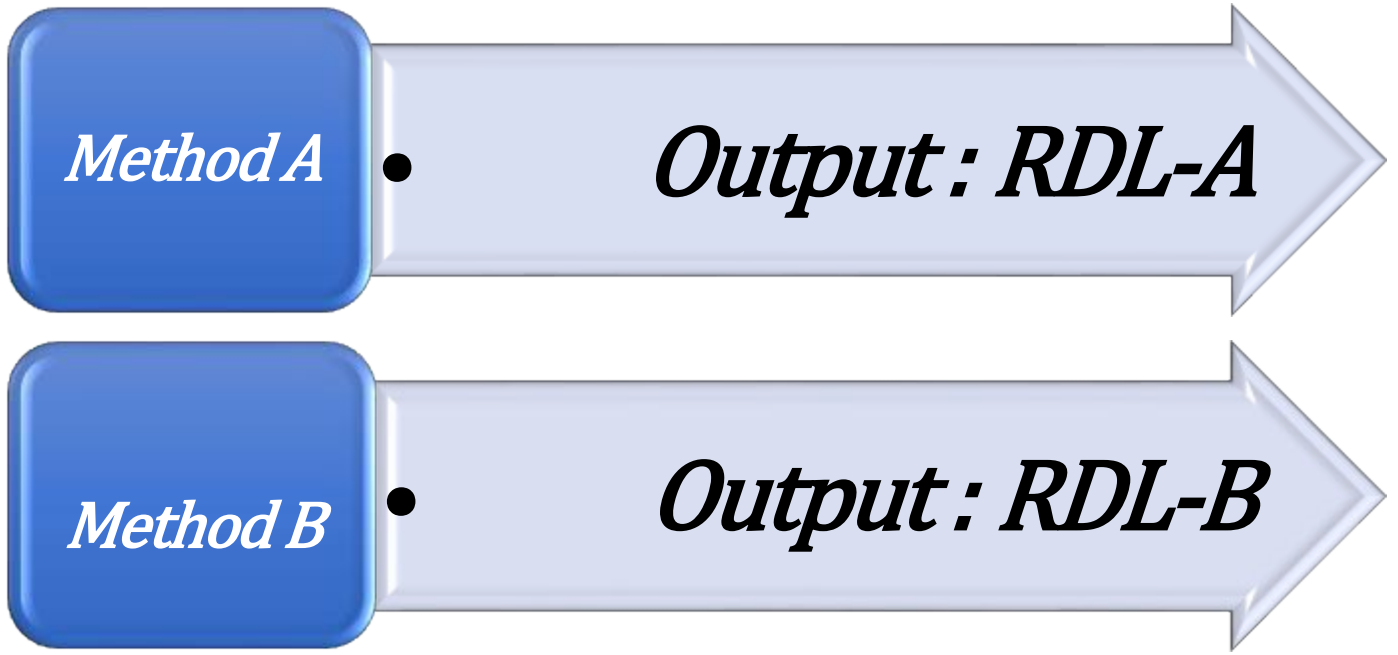
Radon Diffusion Length (RDL)



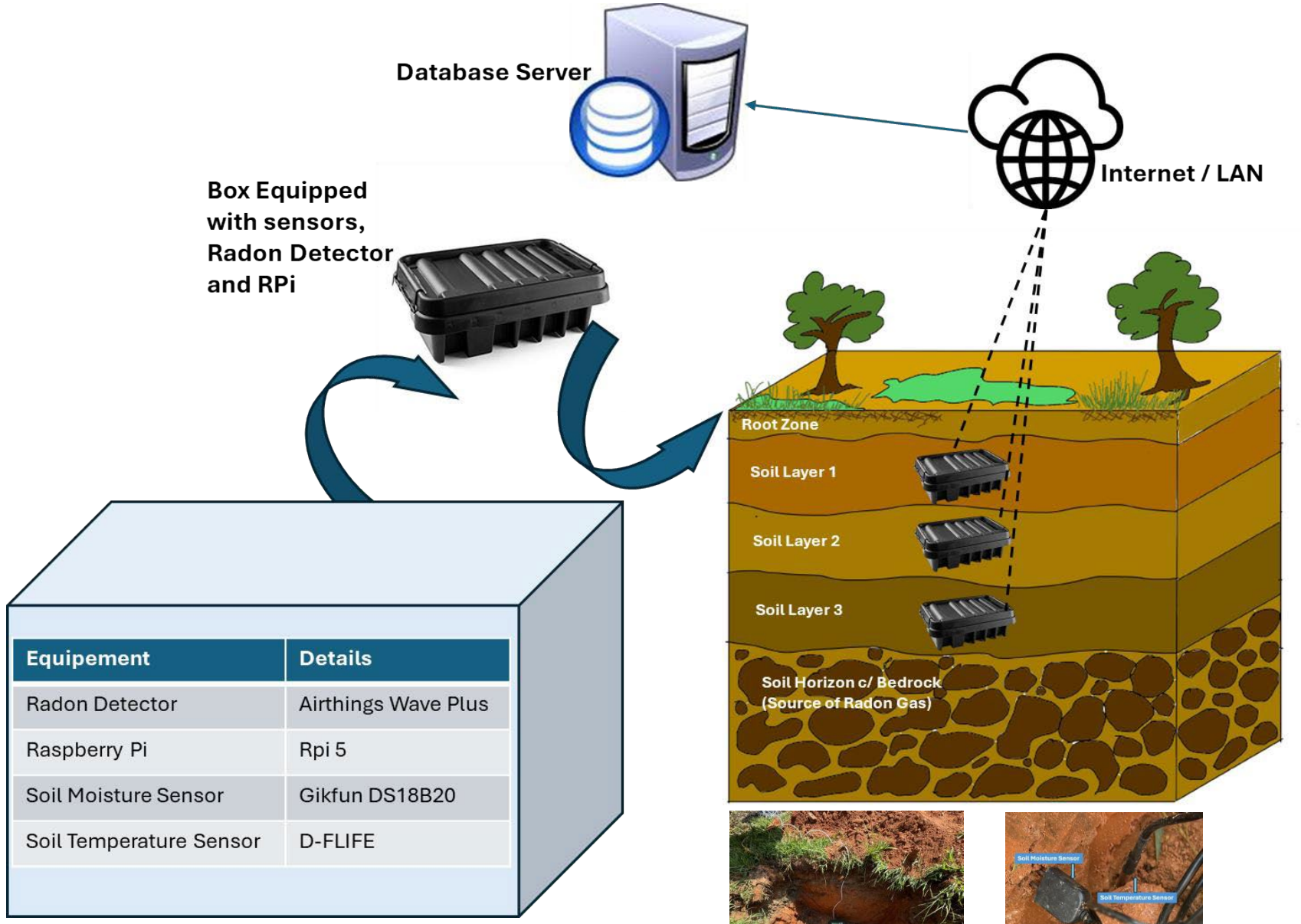
- RDL is the average distance radon can travel before decaying.
- Critical for estimating radon escape from the soil.
- A key parameter in assessing radon exposure risks in soil environments.

Field Validation of Radon Diffusion

- **Method A (Direct Approach):** Estimation based on radon transport principles.
- **Method B (Indirect Approach):** Estimation using environmental data (soil moisture and temperature).

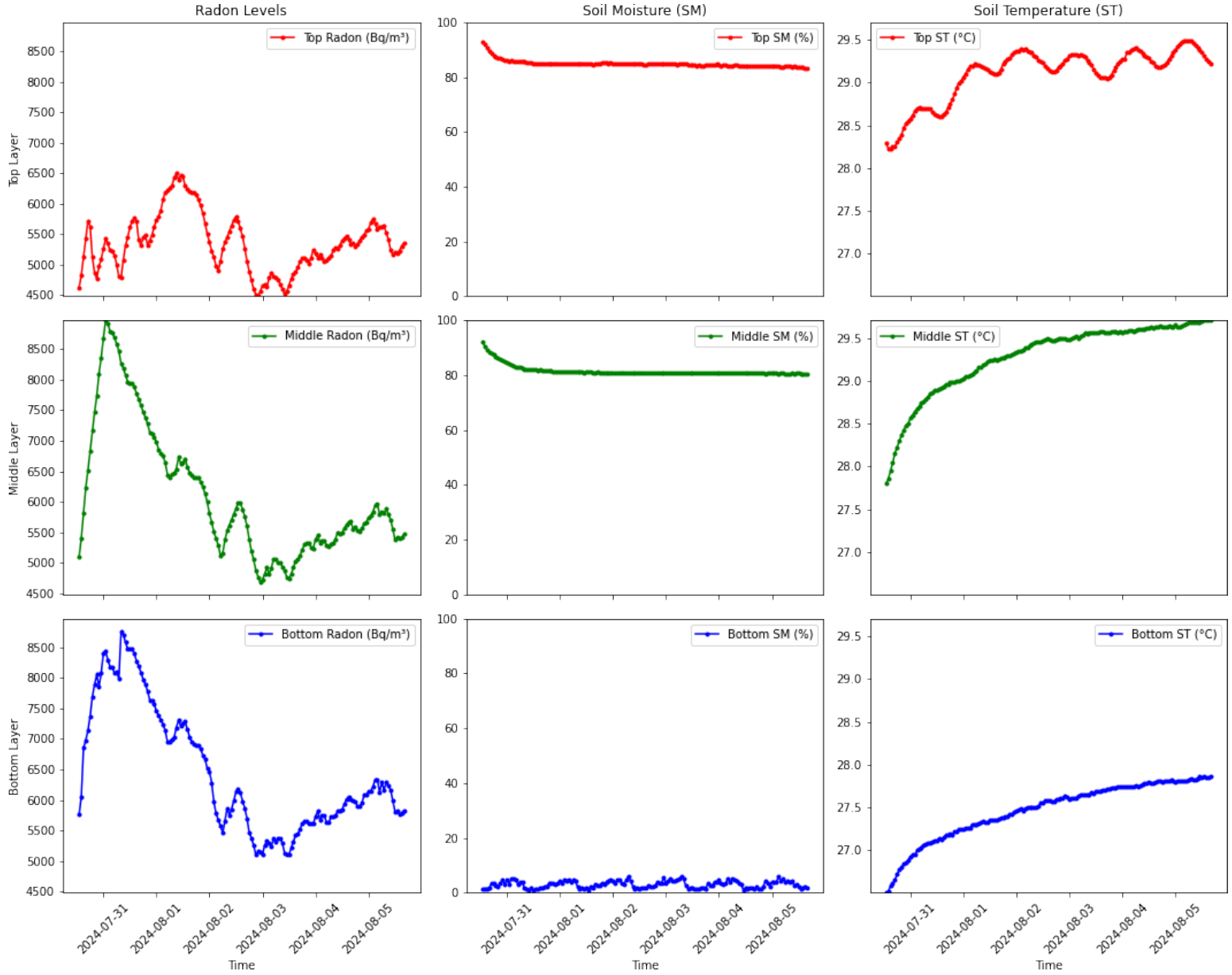


Sensor Network Setup for Real-Time Monitoring of Radon Diffusion Across Soil Layers (Data collection in process)

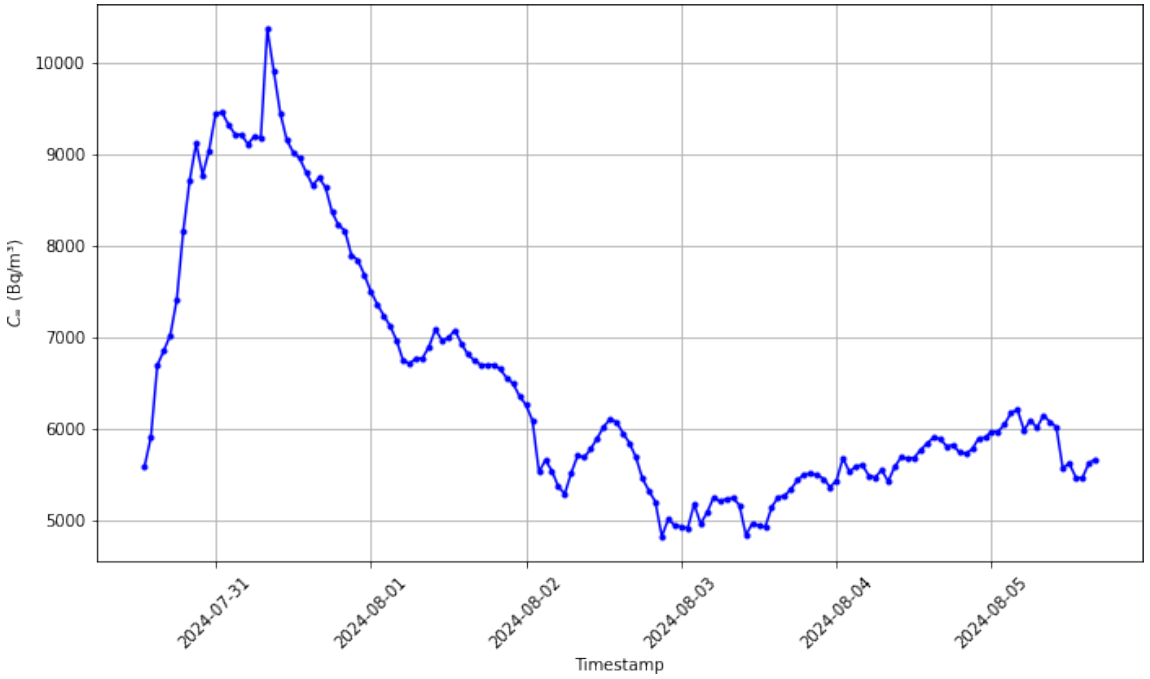


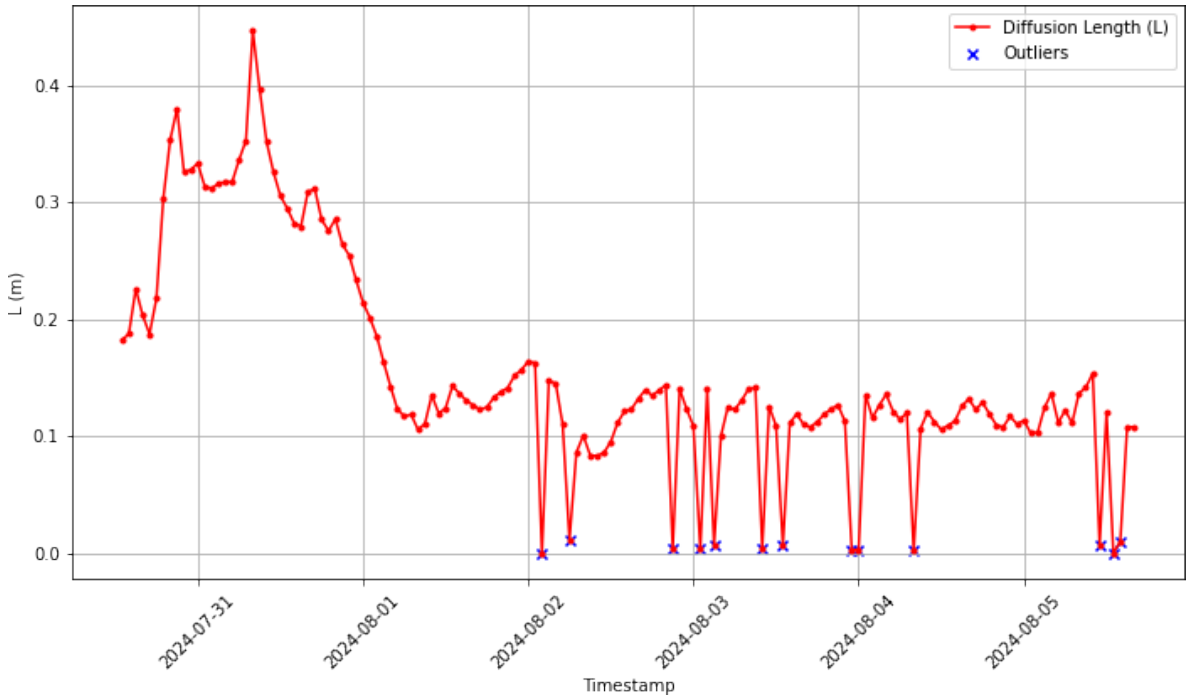
Equipement	Details
Radon Detector	Airthings Wave Plus
Raspberry Pi	Rpi 5
Soil Moisture Sensor	Gikfun DS18B20
Soil Temperature Sensor	D-FLIFE

Hourly Time-Series of Radon, Soil Moisture, and Temperature Across Soil Layers



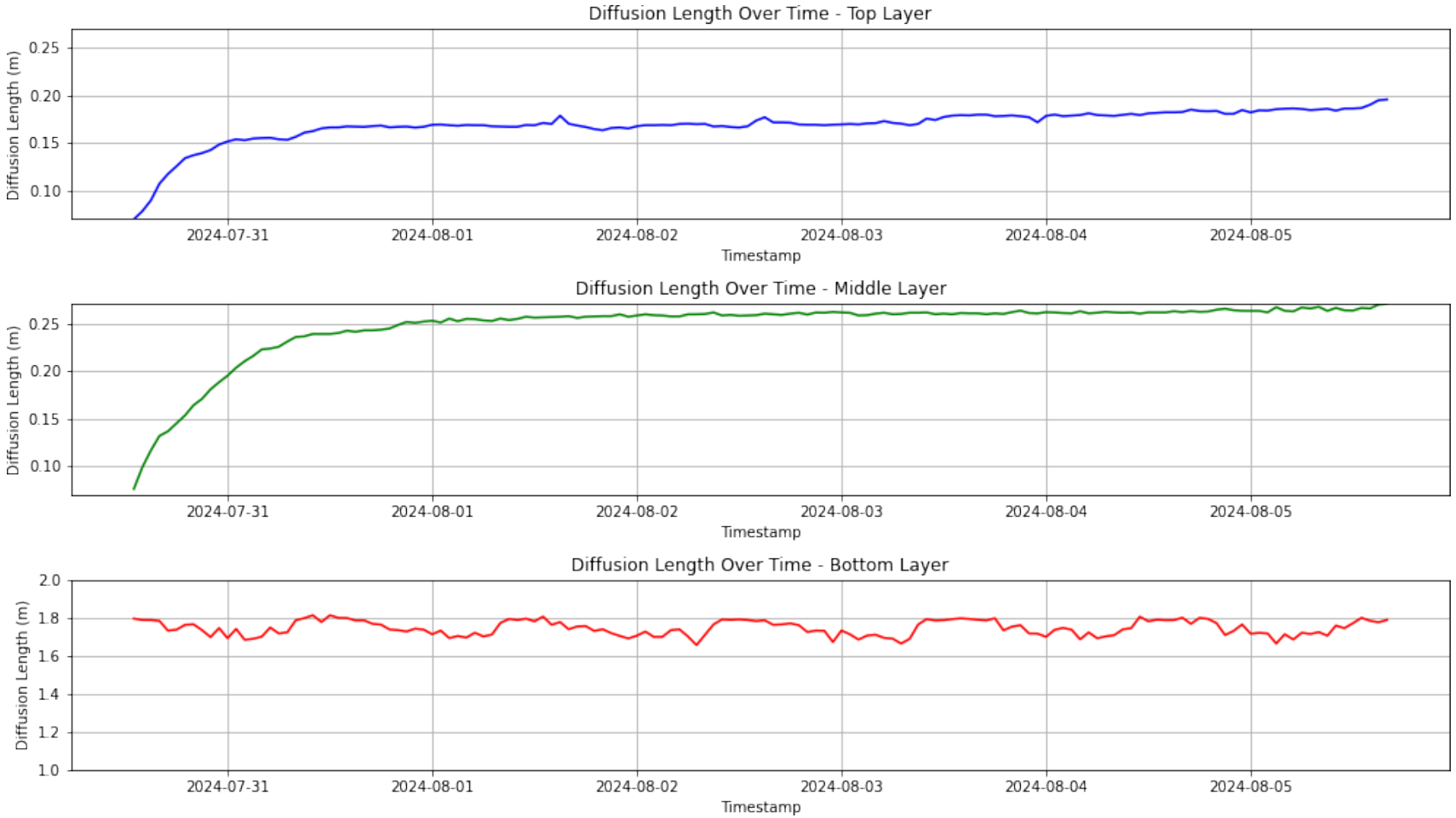
Results: C∞ and Radon Diffusion Length (Method-A)





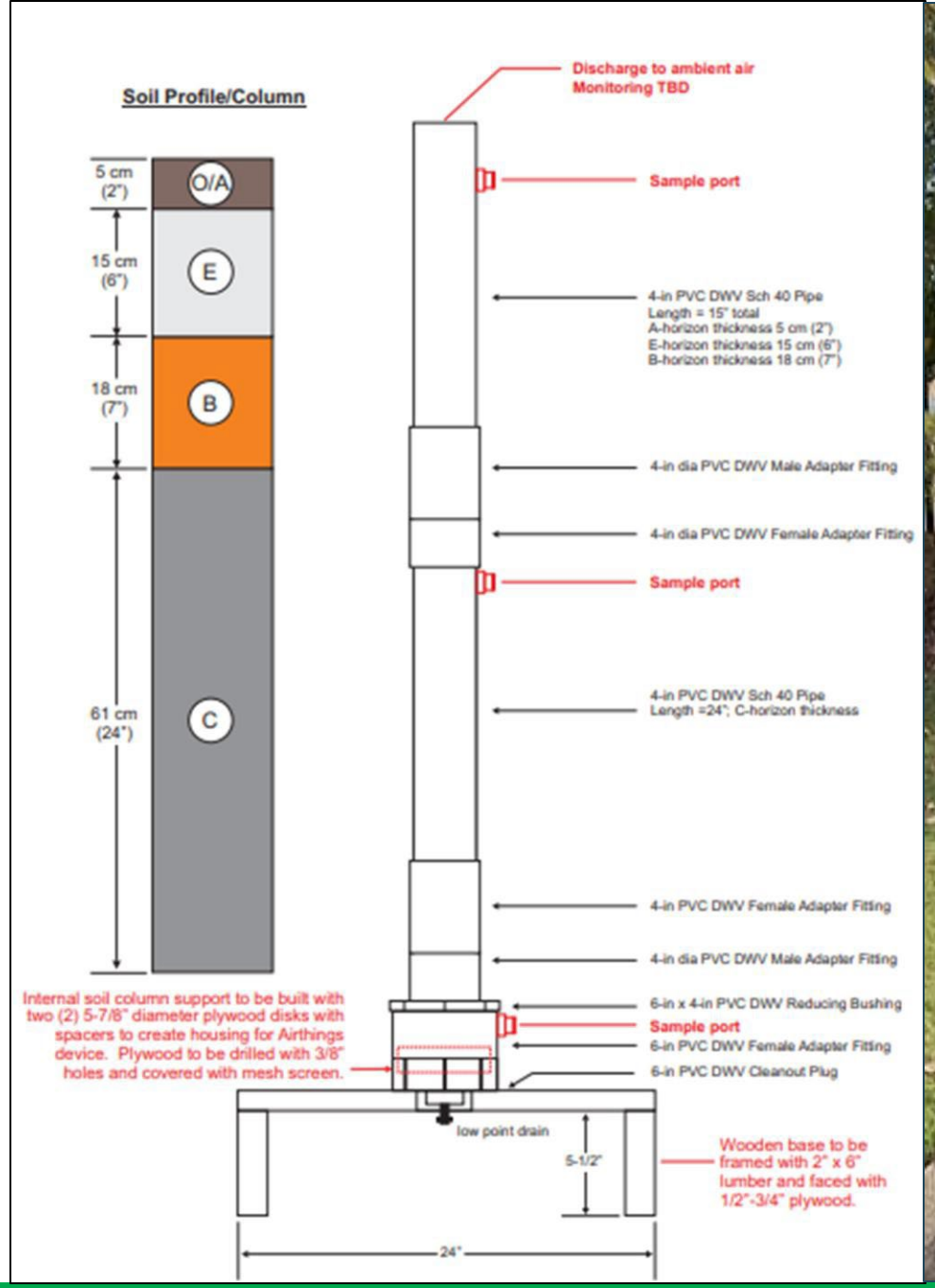
C∞ Method-A (left) and Radon Diffusion Length (RDL-A) computed using Method-A (right) for each hourly data point.

Results: Radon Diffusion Length (Method-B)



Radon Diffusion Length (RDL-B) computed using Method-B for each hourly data points collected at the 1ft (top), 2ft (middle) and 3 ft (bottom) depths.

Radon Transport Dynamics
Lab Soil Column Studies (ongoing)



Summary of learnings thus far..

- **In-situ measurements:** Using sensors and estimation theory can alleviate the burden of soil sampling
- **Radon Emanation:** Radon mobility varies with space, time, and underground geology, including soil structure.
- **Soil moisture:** A key factor in radon diffusion, affecting soil porosity and radon mobility.
- **Method-A (measure Radon gas at different soil depths):** Best for homogeneous soils or early-stage assessments with fewer variables; provides conservative estimates.
- **Method-B (measure moisture and temperature at different soil depths)::** Ideal for detailed studies in complex soils, incorporating real-time moisture and temperature data.
- **Hybrid Approach:** Possibly a safer approach when there are no constraints and need to choose Method-A or B.

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