Mountain Intercomparison of Radon Analyzers (MIRA)

S. Montaguti[1], **A. Cavaliere[2]**, P. Cristofanelli[1], C.R. Calidonna[1], L. Malacaria[1], G. Gualtieri[3], A. Zaldei[3], A. Marinoni[1]

1 Istituto di Scienze dell'Atmosfera e del Clima (CNR-ISAC), **2** Istituto di Scienze Polari (CNR-ISP), **3** Istituto di Bioeconomia (CNR-IBE)

IR0000032 – ITINERIS, Italian Integrated Environmental Research Infrastructures System (D.D. n. 130/2022 - CUP B53C22002150006) Funded by EU - Next Generation EU PNRR-Mission 4 "Education and Research" - Component 2: "From research to business" - Investment 3.1: "Fund for the realisation of an integrated system of research and innovation infrastructures"

Finanziato dall'Unione europea NextGenerationEU

Ministero dell'Università e della Ricerca

Italiadomani

About the MIRA project

- Assess reliability and suitability of **Pylon detector** (TEL model) coupled with **Radon Mapper Monitor** (Tecnavia/Mi.am, Italy) for scientific use in mountain environments.
- Test performance with the Radon analyzer under **ITINERIS TNA Access**.
- Conduct intercomparison at **Jungfraujoch station** (3454 m, Switzerland) in July 2025.
- Combine on-site setup with **remote monitoring and real-time data collection**.
- Build on experience from **Mt. Cimone Observatory** (2165 m, Italy), where a similar Pylon detector (TEL model) coupled with a Radon Mapper Monitor has been operating continuously since 2023.

Radon detector at Jungfraujoch (JFJ): The instrument, built at ANSTO (Australia), operate on a two-filter dual-loop principle (Whittlestone and Zahorowski, 1998), where the signal is directly proportional to gaseous ^{222}Rn.

Radon detector of ISAC – CNR: Pylon detector (TEL model) coupled with Radon Mapper Monitor of Tecnavia/Mi.am (Italy).

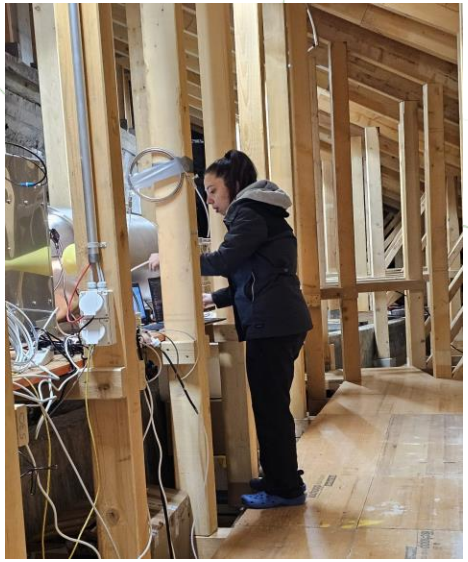
Installation and data acquisition phases

- **VPN** access for secure remote data retrieval and management.
- **Webcam** monitoring system to supervise and track real-time instrument readings.
- Integration of data into the **CNR-ISP mountain hub catalogue**.
- **Data storage and compliance**: all data generated during the campaign will be stored in the ITINERIS HUB repository, ensuring full adherence to **FAIR** principles (Findable, Accessible, Interoperable, Reusable).

⇩

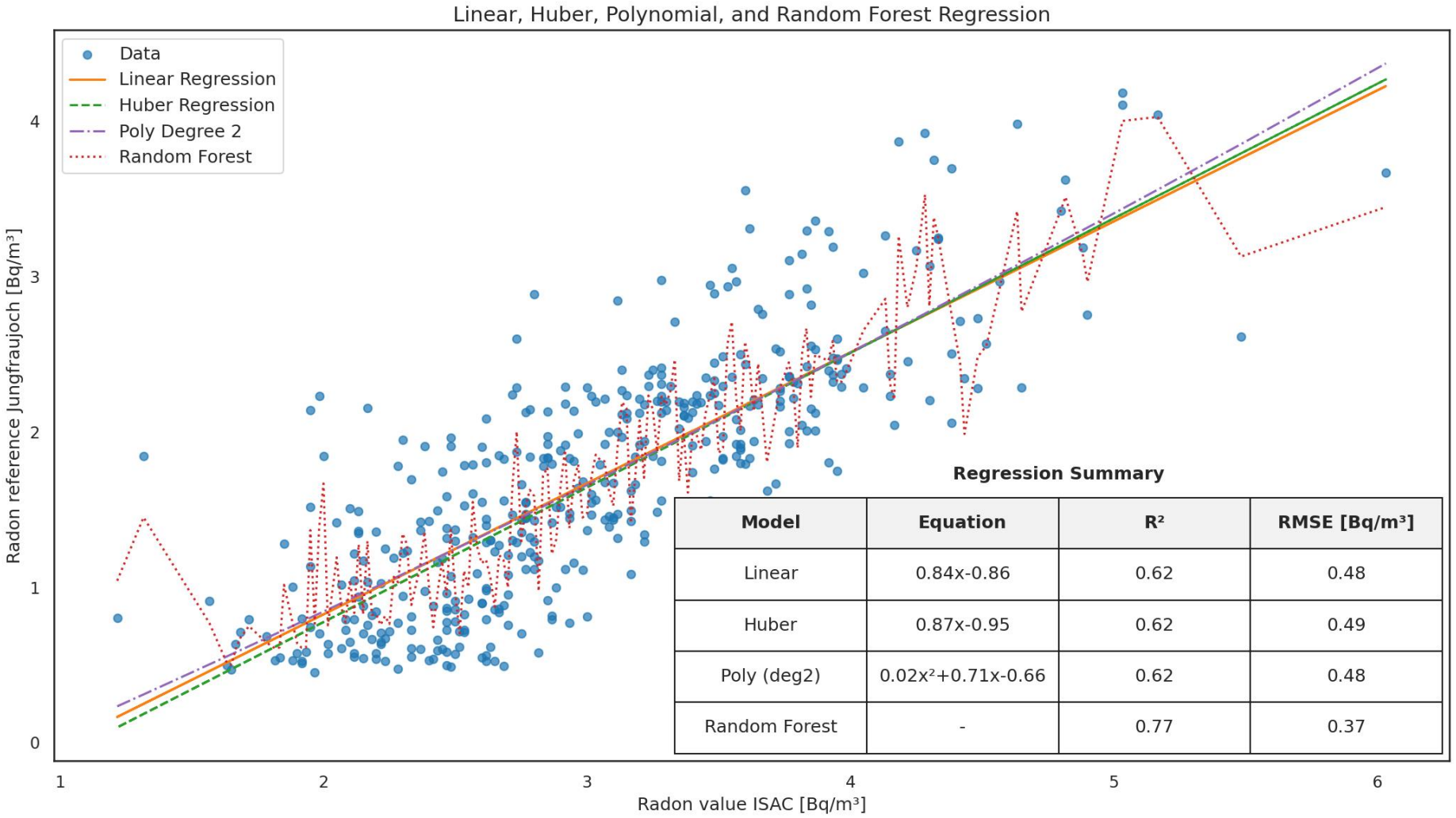
Result: One month of continuous acquisition at 1-minute resolution, with approximately 42,000 measurement points collected (01-07-2025 to 30-07-2025)



Installation and management of the radon measurement campaign: Instrument setup, calibration and connection to data acquisition systems (first two images), preparation and packaging of equipment (third image) and setup the operational monitoring at high altitude (fourth image).

Cross-Site comparison



Regression Summary

Model	Equation	R^2	RMSE [Bq/m³]
Linear	0.84x-0.86	0.62	0.48
Huber	0.87x-0.95	0.62	0.49
Poly (deg2)	$0.02x^2+0.71x-0.66$	0.62	0.48
Random Forest	-	0.77	0.37

Key Insights from the Plot

- All three linear-style regressions (Linear, Huber, Polynomial) produce very similar **$R^2 \approx 0.62$** and RMSE ≈ 0.48–0.49 Bq/m³.
- Random Forest performs better (**$R^2 = 0.77$**, RMSE = 0.37 Bq/m³), capturing more variation and showing less error.
- The scatter of blue points indicates some spread but a **generally positive correlation** between the two radon measurements.

Future perspective

The campaign, conducted in July 2025, combined physical access and remote access for continuous monitoring and real-time data collection, enabling comprehensive instrument performance validation at JFJ. Next step:

- **Comparative Atmospheric Study**: Conduct a detailed analysis of PBL dynamics' influence on the free troposphere at two European mountain sites, leveraging ACTRIS and ICOS RIs frameworks.
- **Calibration & Machine learning integration at Mt. Cimone Observatory**: Apply the calibration coefficients and machine learning models to the Radon detector at Mt. Cimone Observatory (2165 m, Italy) to improve measurement accuracy.
- **Benchmarking Low-Cost Sensors:** Evaluate the performance of commercially available low-cost radon sensors, developed by IBE-CNR (**AIRQino** project), to assess their suitability for environmental monitoring at Mt. Cimone observatory.
- **Polar Campaign:** Continuous radon monitoring in polar regions could reveal how snow cover and seasonal thaw influence soil–atmosphere exchange.



Radon measurement campaign at Alpine and regional observatories: Sphinx Observatory at Jungfraujoch (first image), Aletsch Glacier at Eismeer near Jungfraujoch (second image) and ISAC-CNR Osservatorio Climatico 'O. Vittori' at Mt. Cimone (third image).

Simonetta Montaguti: simonetta.montaguti@cnr.it

Alice Cavaliere: alice.cavaliere@cnr.it

THANKS!

IR0000032 – ITINERIS, Italian Integrated Environmental Research Infrastructures System
(D.D. n. 130/2022 - CUP B53C22002150006) Funded by EU - Next Generation EU PNRR-Mission 4 "Education and Research" - Component 2: "From research to business" - Investment 3.1: "Fund for the realisation of an integrated system of research and innovation infrastructures"

Finanziato dall'Unione europea NextGenerationEU
Ministero dell'Università e della Ricerca
Italiadomani