Tereno Ozcar - Bonn – 26 Sept. 2023

Self-referenced Cosmic-rays Neutron Sensing probes based on contextual muons detection

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TERENO TERRESTRIAL ENVIRONMENTAL OBSERVATORIES

Outline of the presentation

1. The Finapp CRNS network

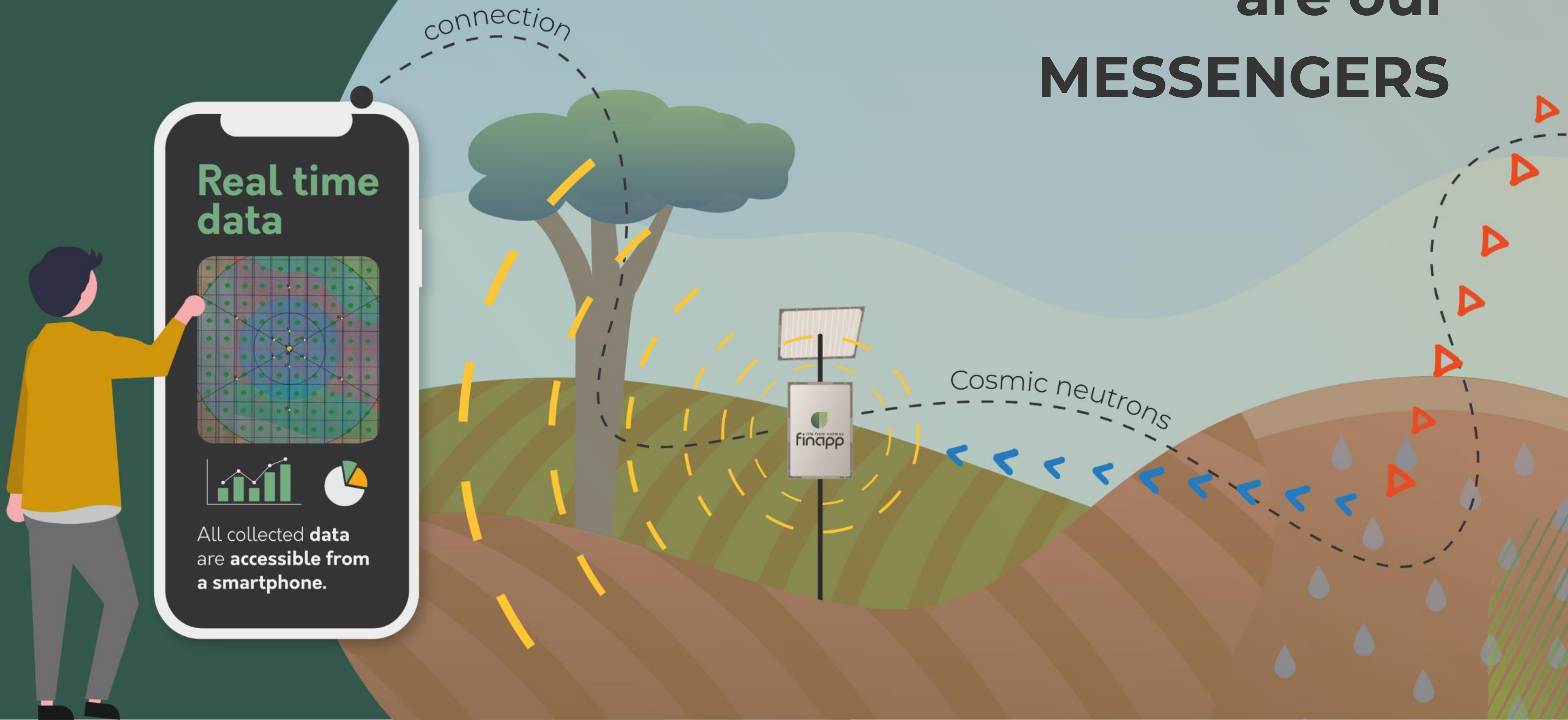
2. Muons detection as a self-referenced incoming correction

3. Muons detection as a site-specific incoming correction

1. Finapp CRNS network

How does **CRNS technology** work?

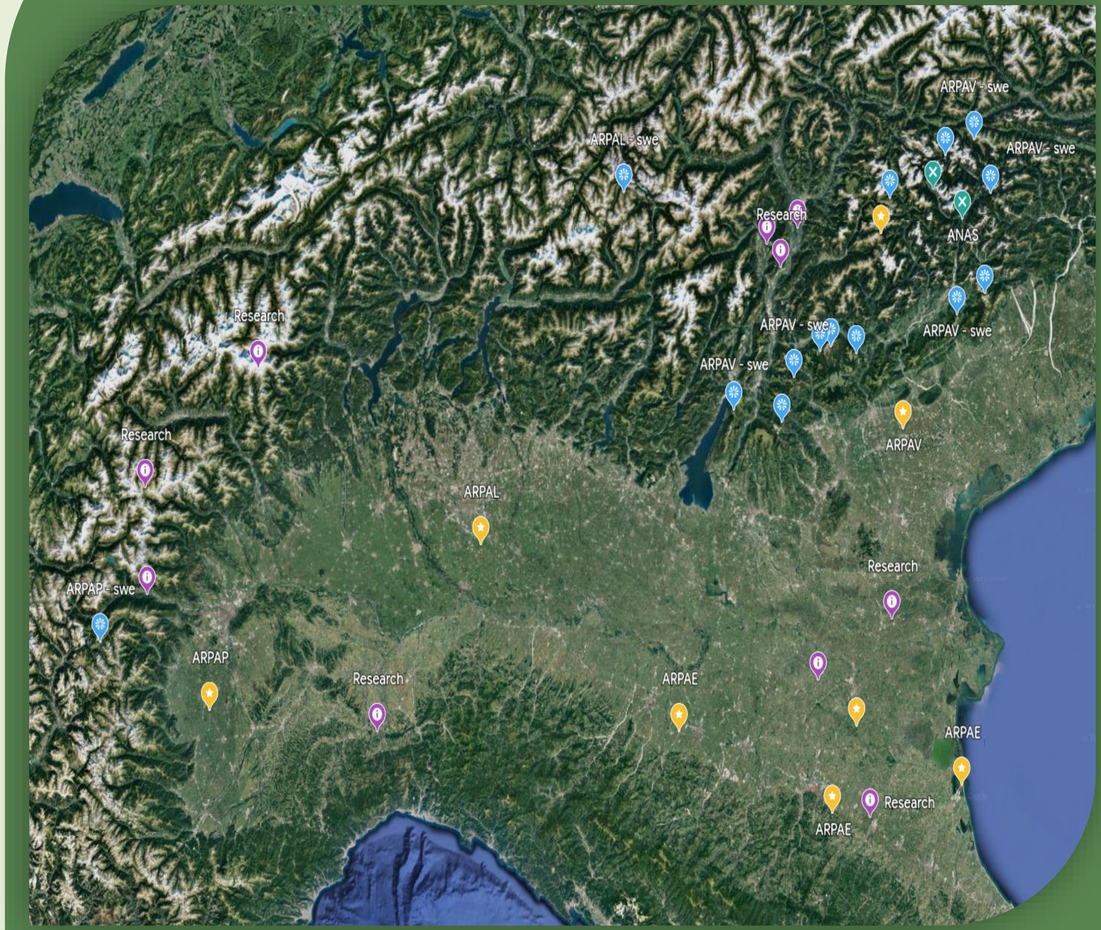
COSMIC NEUTRONS are our MESSENGERS



The growing Italian network

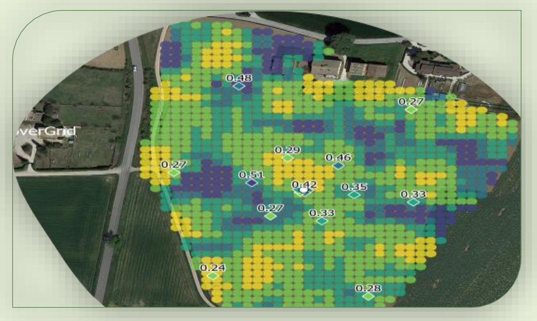
Finapp is the most used CRNS probe in Italy:

- ARPA (regional environmental agencies): 8 Soil Moisture probes + 2 Snow Water Equivalent probes (on field)
- ARPA Veneto: 25 probes for Snow Water Equivalent (partially delivered)
- ANAS (road infrastructures company): 2 probes for landslide early warning experimentation (on field)
- Protezione Civile Veneto (civil protection agency): 6 probes for fire risk early warning (to be delivered)
- Research institutions (POLITO, UNIBO, UNIPD, FEM...): > 10 probes on field for various applications (agriculture, hydrology, glaciology, climate); 5 probes to be delivered to CNR and installed in southern Italy
- Private customers (not shown on map): agriculture applications



Finapp: a range of applications

Precision Farming
Irrigation scheduling



Rover mapping

Snow water equivalent

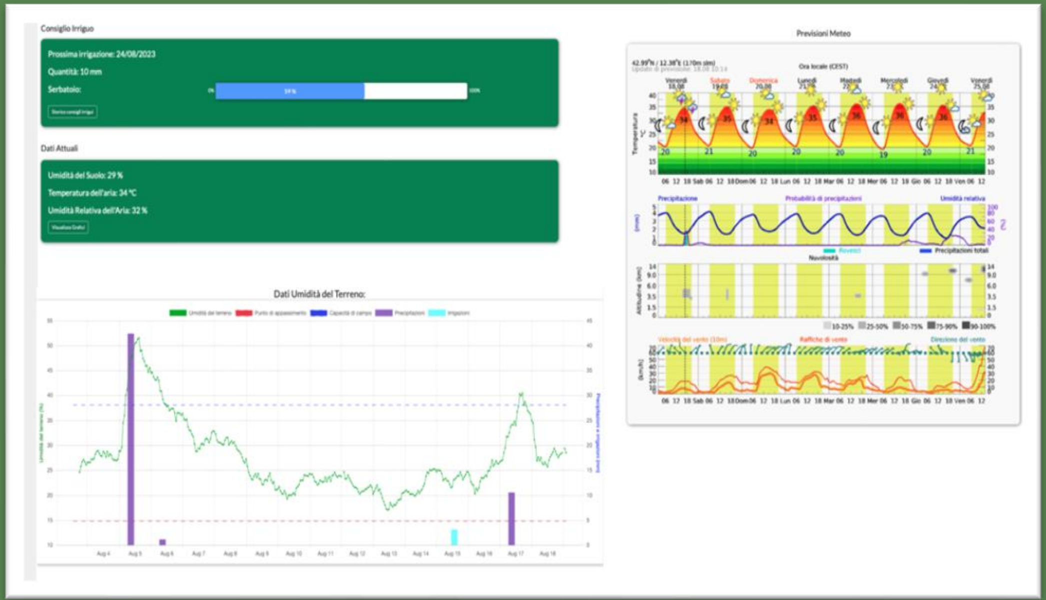
Early warning systems:
floods and landslides

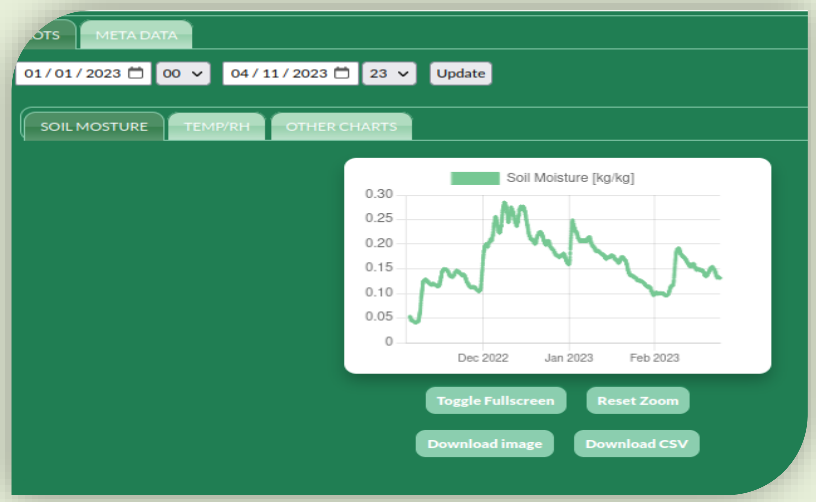
Early warning systems:
wildfire

Water leaks pre-location

Data and user interface

1. Direct data transfer to cloud
2. Plots visualization
3. Downloadable datasets
4. Dedicated services





2. Muons as self-referenced incoming correction

Finapp specialty: muons detection

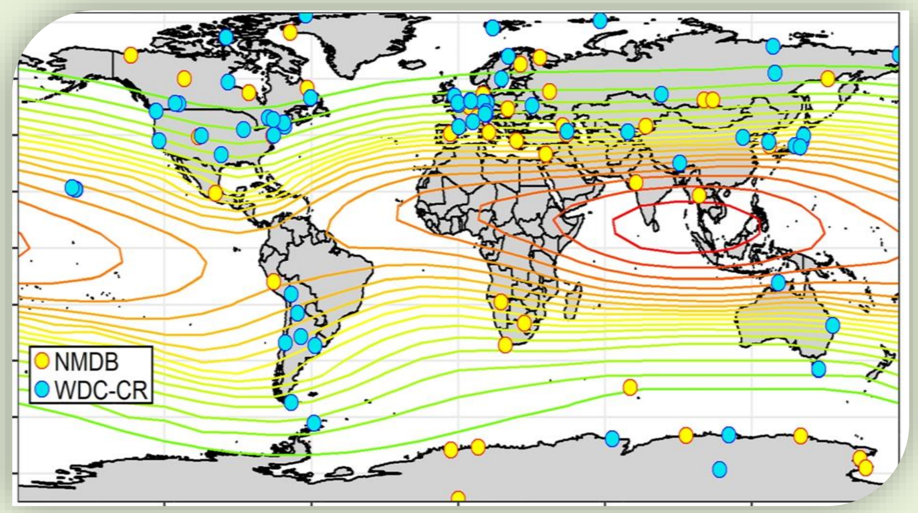
The patented Finapp detector can discriminate and count **neutrons** and **muons**

The incoming correction

How to compensate for the natural variation of cosmic rays flux?

$$\boxed{f_I = I_{ref}/I}$$

The traditional way is refferring to the Neutron Monitor Database (NMDB) global network

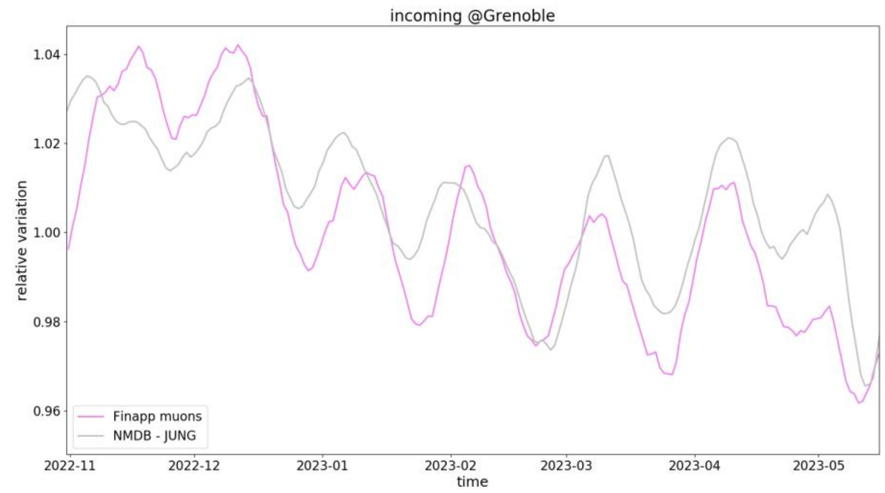


Finapp as a self-referenced probe

<u>Muons flux is correlated to the incoming neutrons flux.</u>

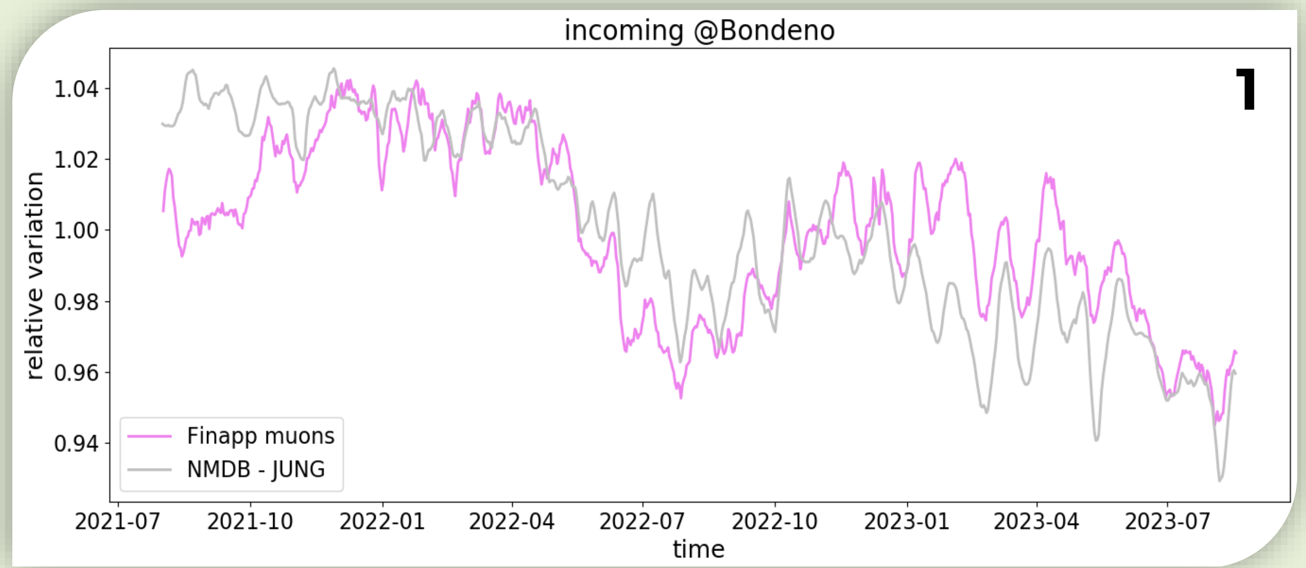
=> Finapp can refer to itself for incoming correction by using the relative variation of the muons flux

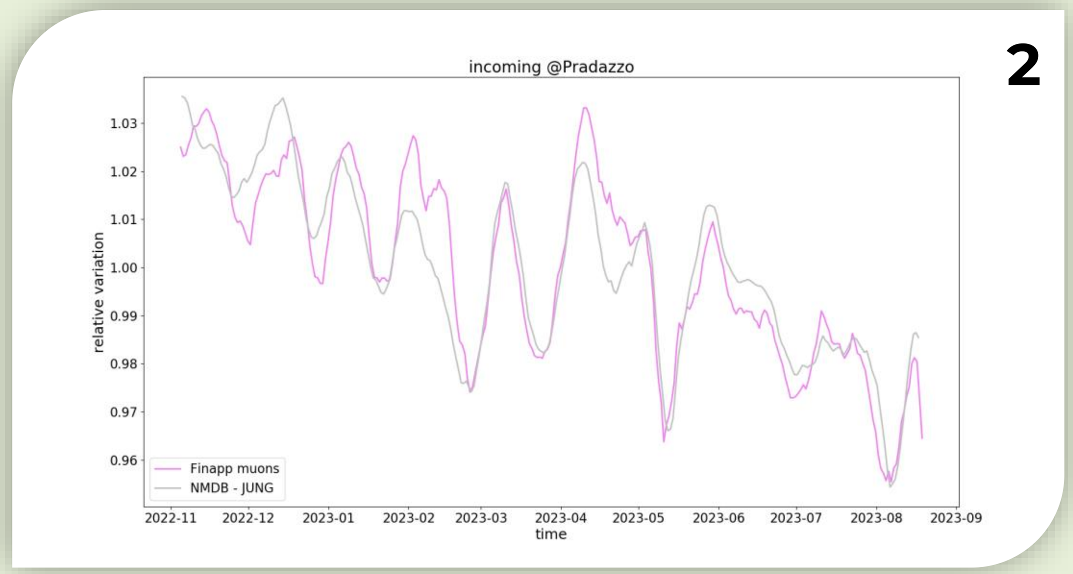
We collected solid evidence of the correlation by comparison to NMDB-JUNG

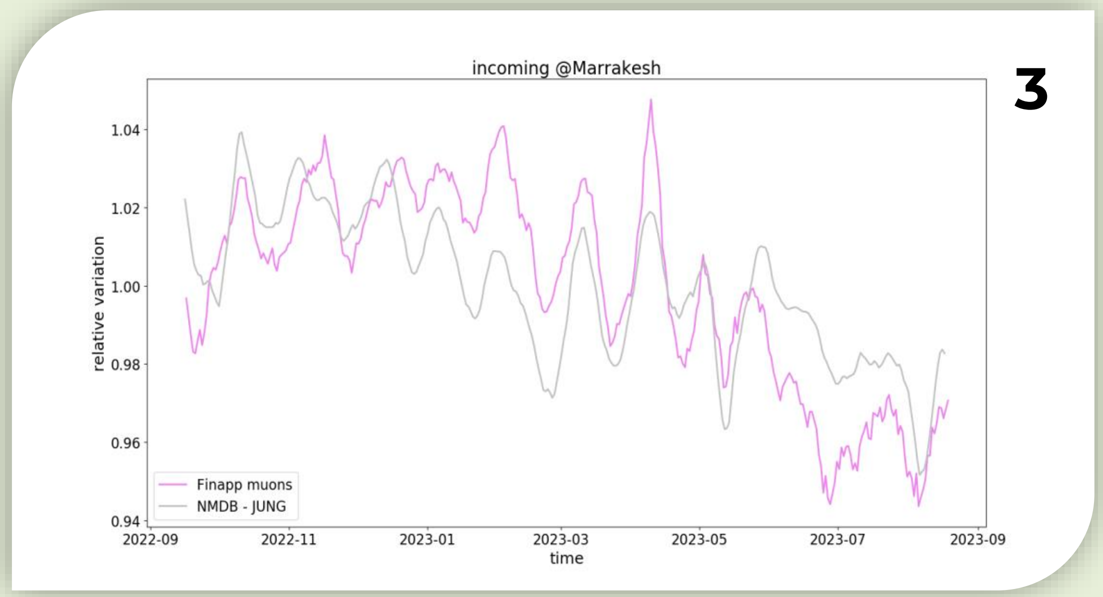


Representative case-studies

1. Bondeno, Italy (2 years long)
2. Cima Pradazzo (2200 m altitude)
3. Marrakesh (Morocco)







3. Muons as <u>site-specific</u> incoming correction

The incoming muons flux is clearly correlated to the incoming neutrons flux.

Yet there are also differences.

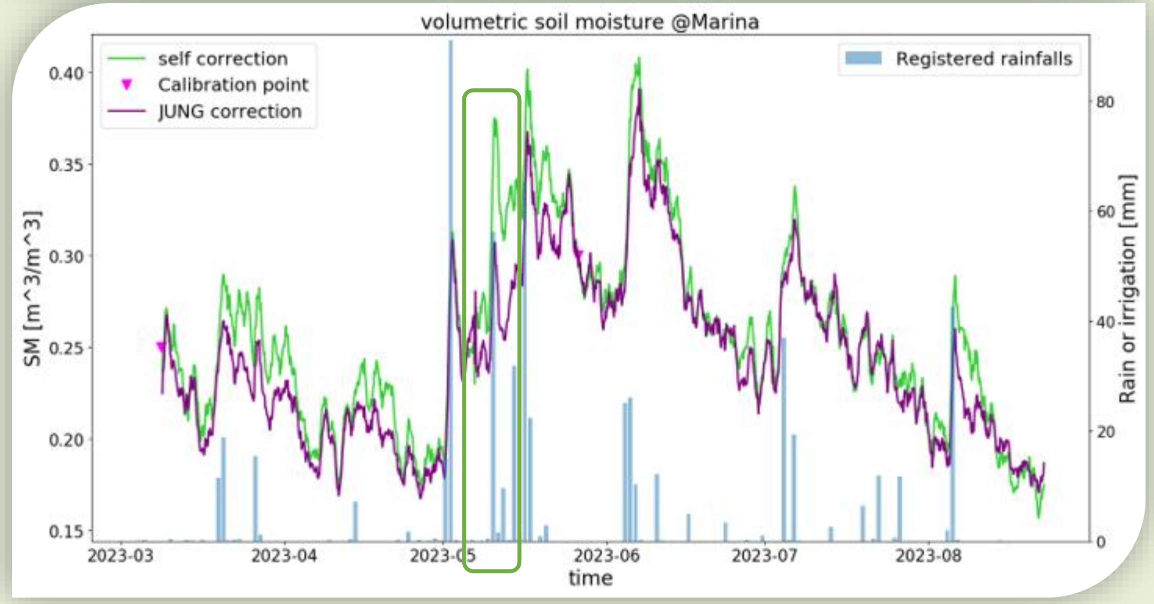
Can we claim they are a true site-specific effect?

Site-specific differences

Sample 1: Marina di Ravenna, May 2023

On this occasion JUNG reported a major drop unmatched by most of our stations.

In our Ravenna site it would suppress the probe response to the floods that hit the Emilia Romagna region on these days.

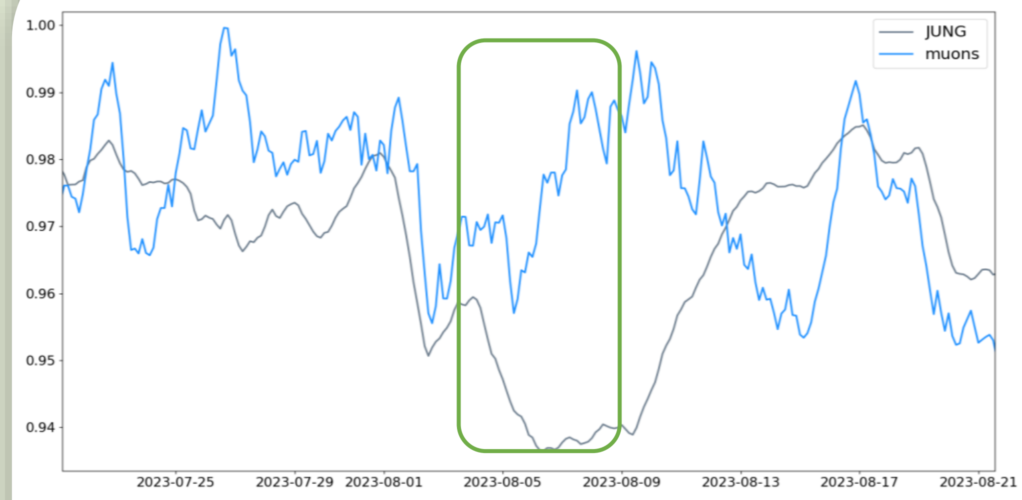


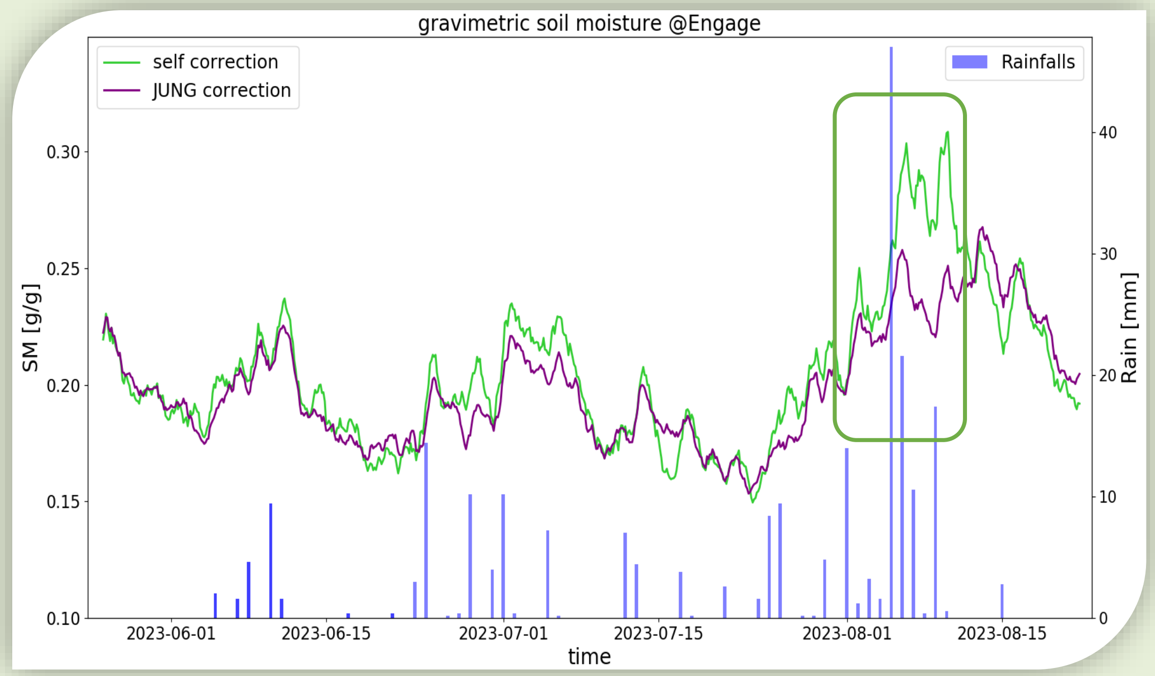
Site-specific differences

Sample 2: Vienna, August 2023

On this occasion JUNG reported a major drop unmatched by most of our stations.

In our Vienna site it would suppress the effect of a significant precipitation.

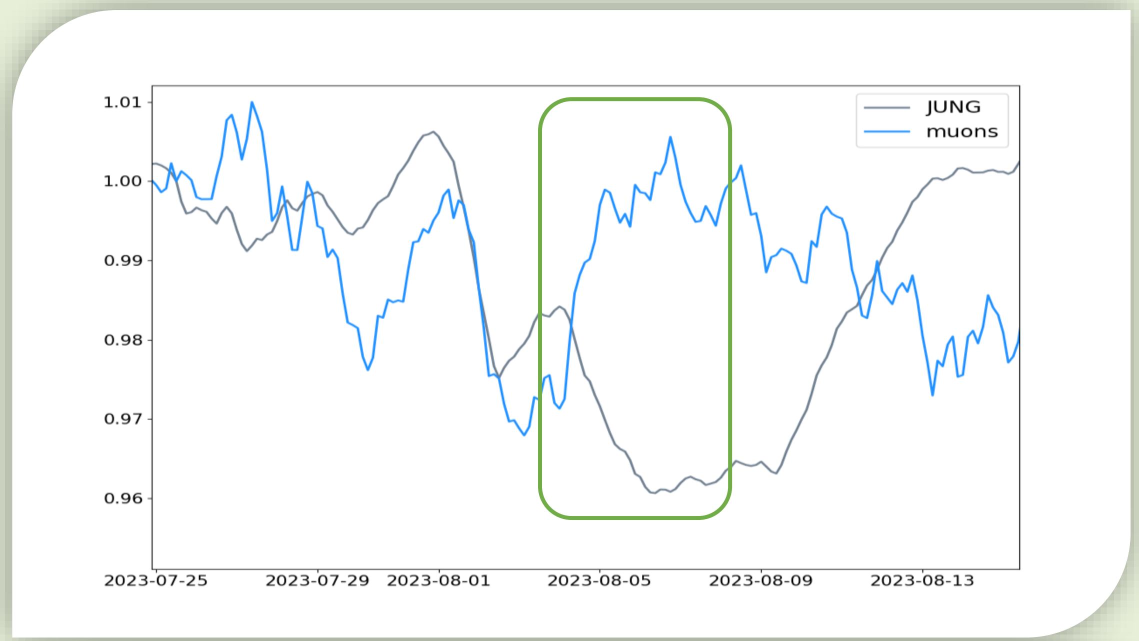


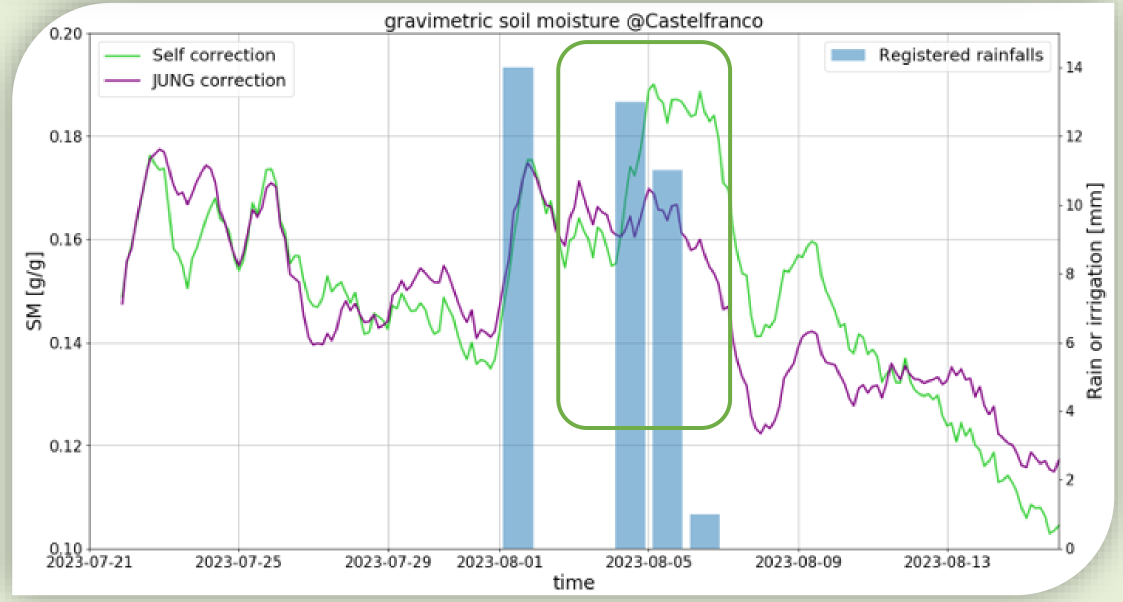


Site-specific differences

Sample 3: Castelfranco Veneto, August 2023

Also here the drop in JUNG counts would suppress the effect of significant precipitations





Conclusion

- Every Finapp station can consistently measure the incoming muons flux

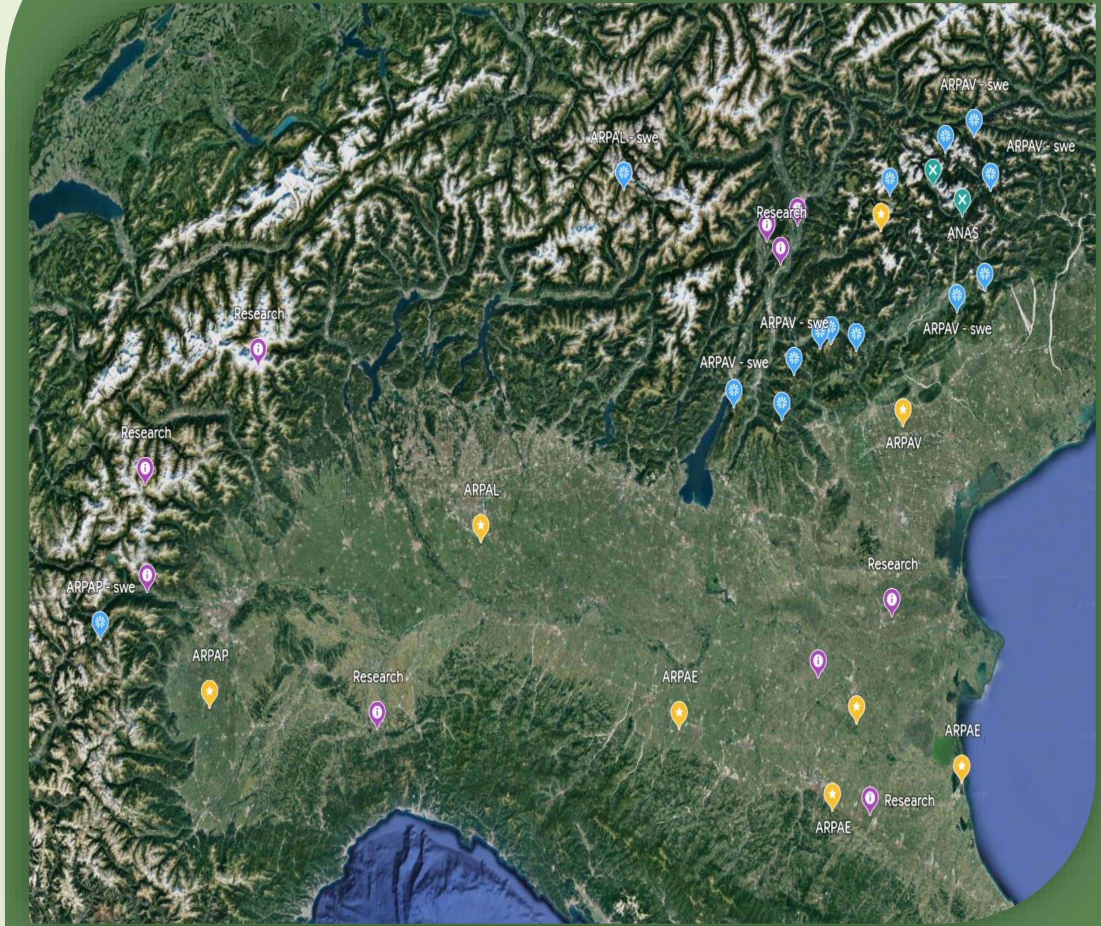
=> **a Finapp network could be used as a cost-effective distributed muons observatory**

- The incoming muons flux is correlated to the incoming neutrons flux while providing a site-specific monitoring

=> **Finapp is a self-referenced CRNS probe**

- Differences with JUNG: possible effects of different energy spectrum, altitude, weather

=> **Targeted experiments may be interesting for the community**



Thank you for your attention!

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