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Co-funded by
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METROLOGY
PARTNERSHIP



SoMMet

Project SoMMet

Soil Moisture Metrology

Soil moisture Session
→ Wed 27 Sept 09:00

Metrology for multi-scale monitoring of soil moisture

MMC2023, Torino, 26 – 30 September 2023

Miroslav Zboril, María de los Ángeles Millán Callado

Neutron Radiation Department of Physikalisch-Technische Bundesanstalt (PTB)

on behalf of SoMMet Consortium

Soil moisture



$$\theta_g = M_{\text{water}} / M_{\text{soil}}$$

$$\theta_v = V_{\text{water}} / V_{\text{sample}}$$

WMO Guide No. 8

Guide to Instruments and Methods
of Observation
Volume I – Measurement of Meteorological Variables

2018 edition

WEATHER CLIMATE WATER



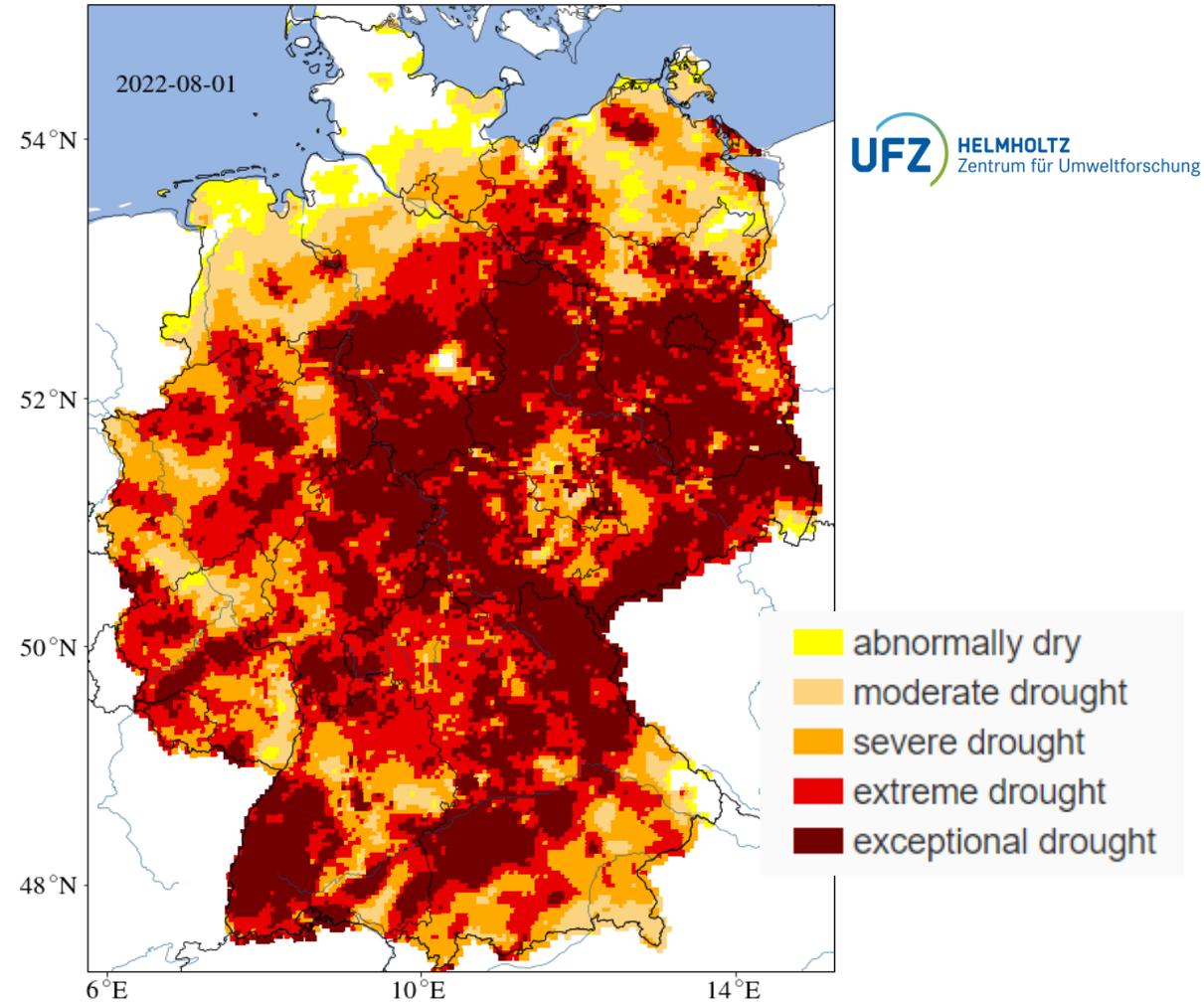
WORLD
METEOROLOGICAL
ORGANIZATION

WMO-No. 8

Soil moisture



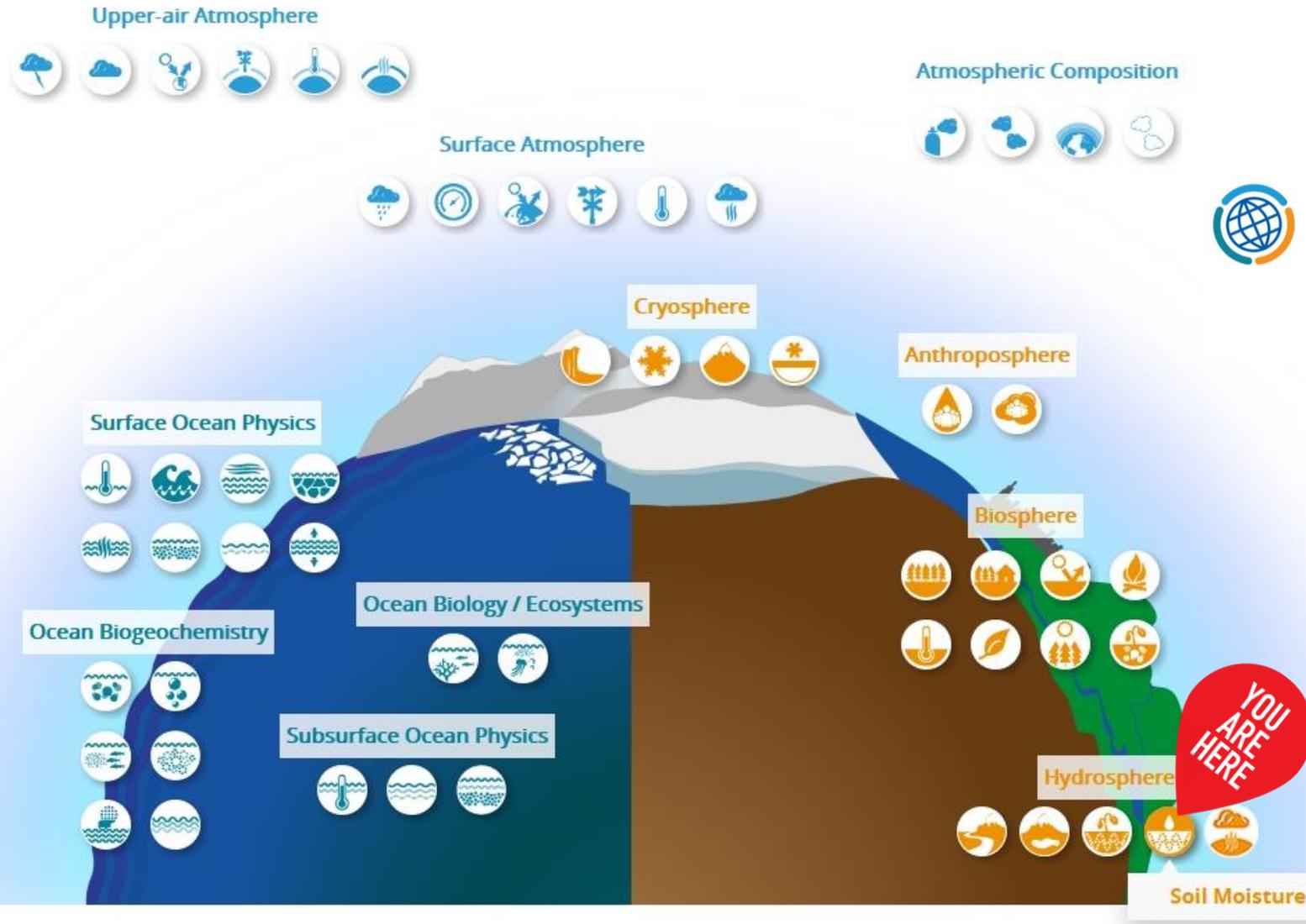
UFZ Drought monitor of Germany



Example: Total soil column 1.8 m, raster of 4 km size

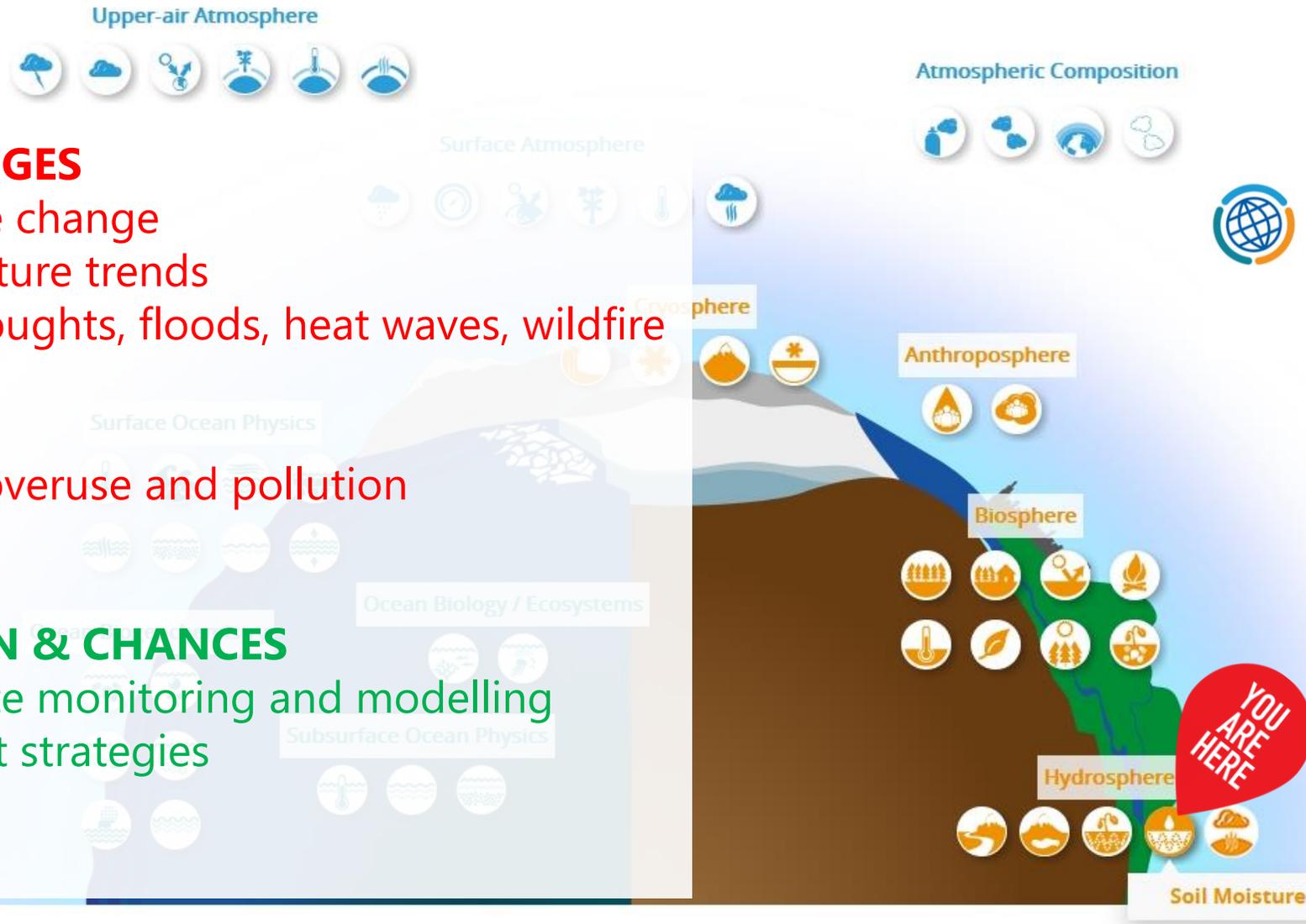
- Soil moisture measurements by DWD German Weather Service
- Simulations via meso-scale hydrological model mHM,

Soil moisture *is* Essential Climate Variable



WMO Global Climate Observing System

Soil moisture *is* Essential Climate Variable



RISKS & CHALLENGES

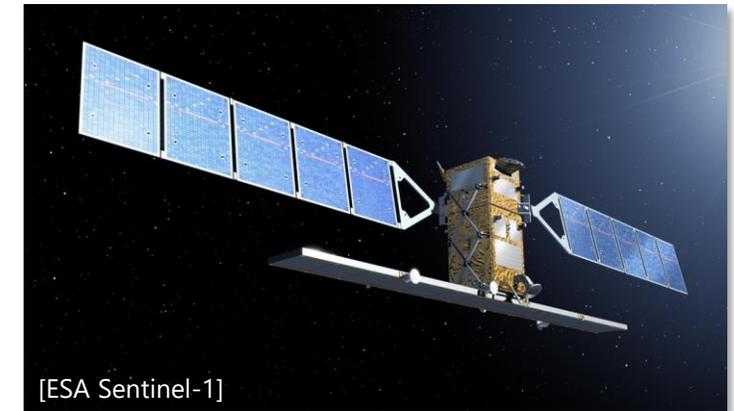
- Progressing climate change
- Changing soil moisture trends
- Extreme events: droughts, floods, heat waves, wildfire
- Water scarcity
- Soil erosion
- Agriculture: water overuse and pollution
- Food security

RISKS MITIGATION & CHANCES

- Weather and climate monitoring and modelling
- Water management strategies
- Precision farming
- Soils as CO₂ sink

Soil moisture – problem of scales

Satellite-based remote sensing



Point-scale sensors



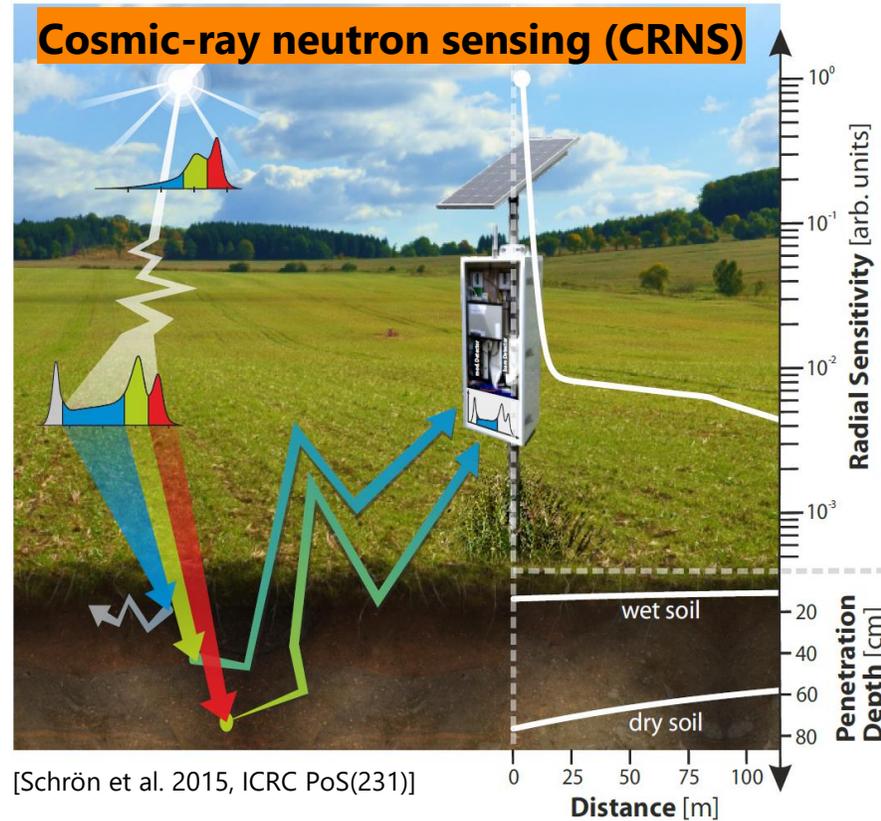
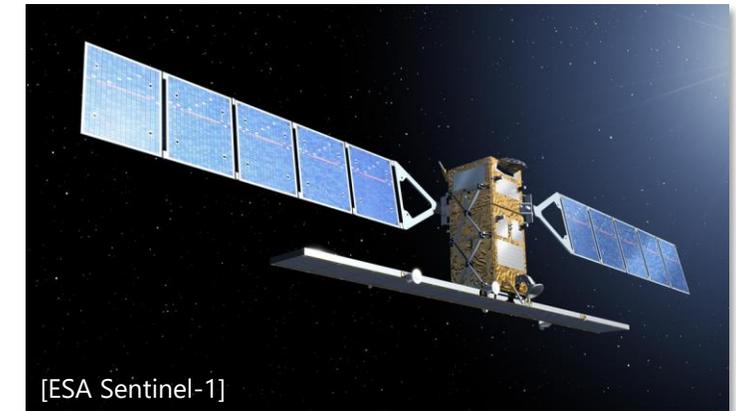
[<https://soilsensor.com>]

$(10^{-1} - 10^1)$ m

Horizontal scale $(10^3 - 10^4)$ m

Our approach

Satellite-based remote sensing



Point-scale sensors



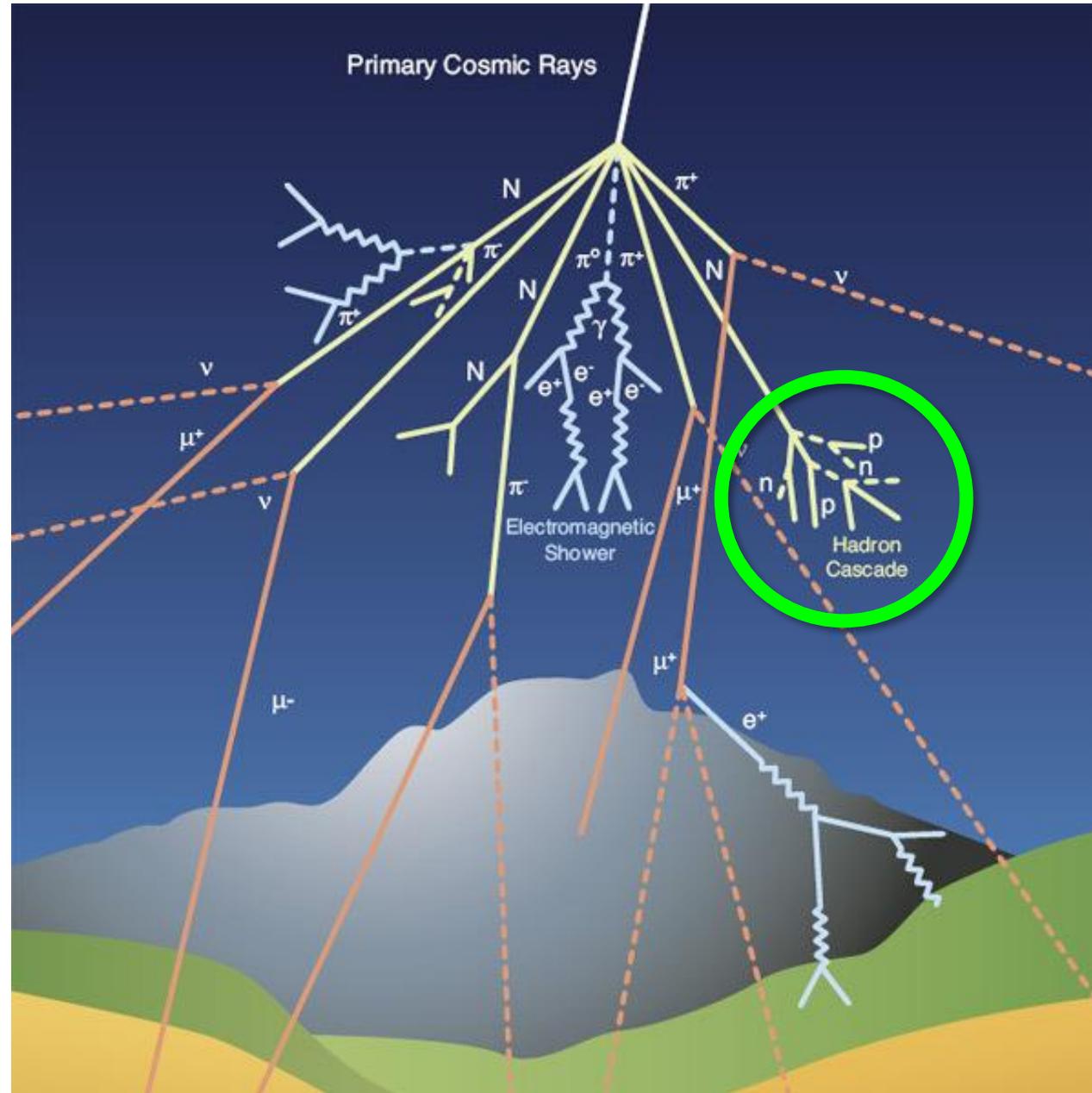
[<https://soilsensor.com>]

$(10^{-1} - 10^1)$ m

$(10^2 - 10^3)$ m

Horizontal scale

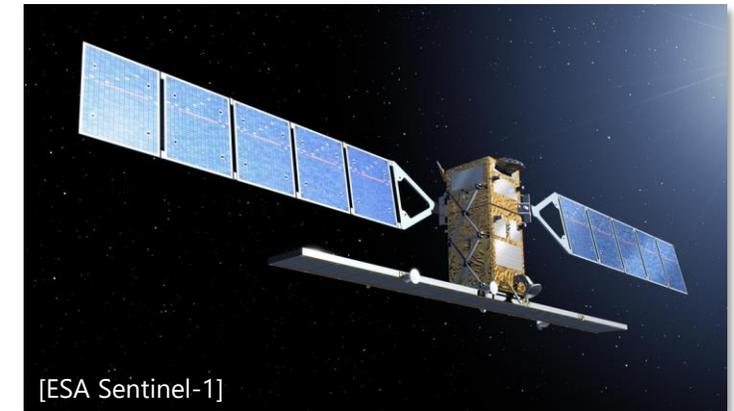
$(10^3 - 10^4)$ m



[CERN]

Our approach

Satellite-based remote sensing

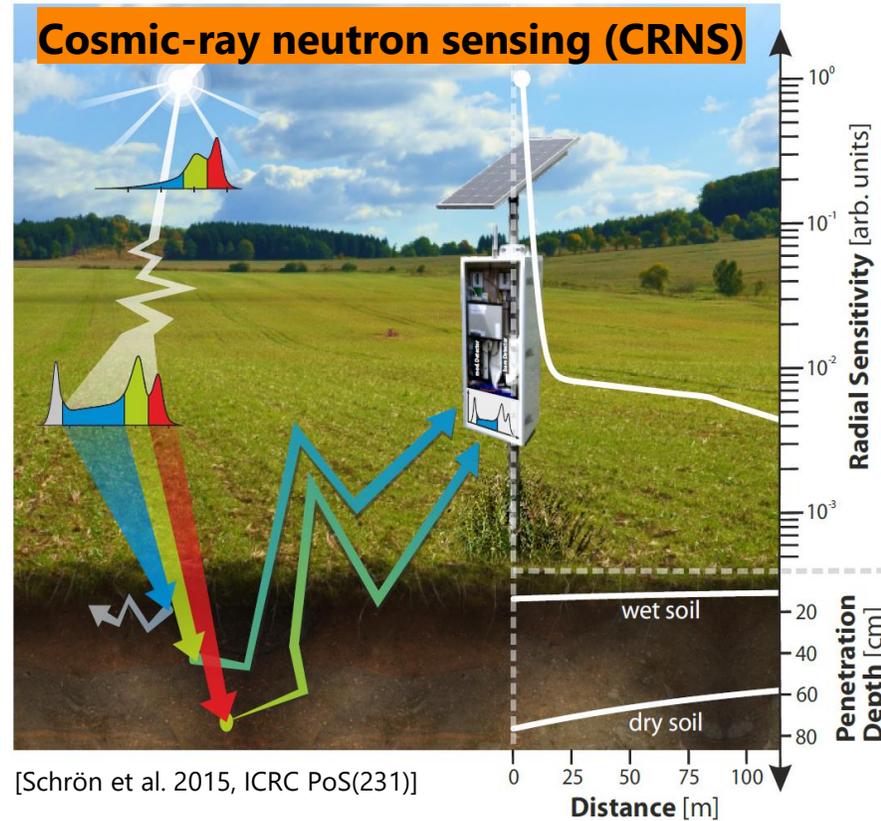


[ESA Sentinel-1]

Point-scale sensors



[<https://soilsensor.com>]



(10⁻¹ – 10¹) m

(10² – 10³) m

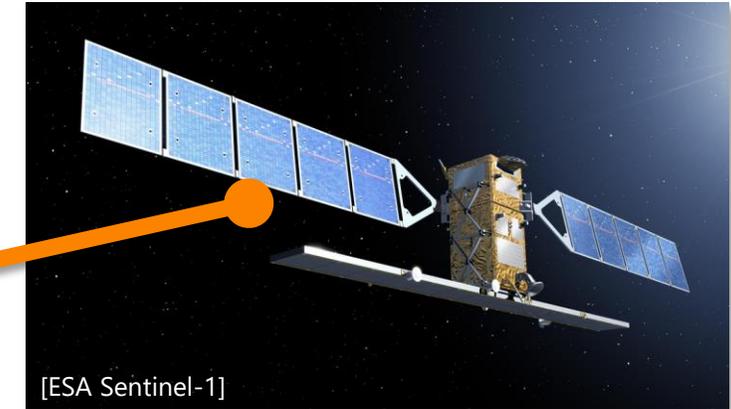
Horizontal scale

(10³ – 10⁴) m

SoMMet: Main goal

Calibration establishes **traceability** which in turn improves **comparability** of different methods across scales.

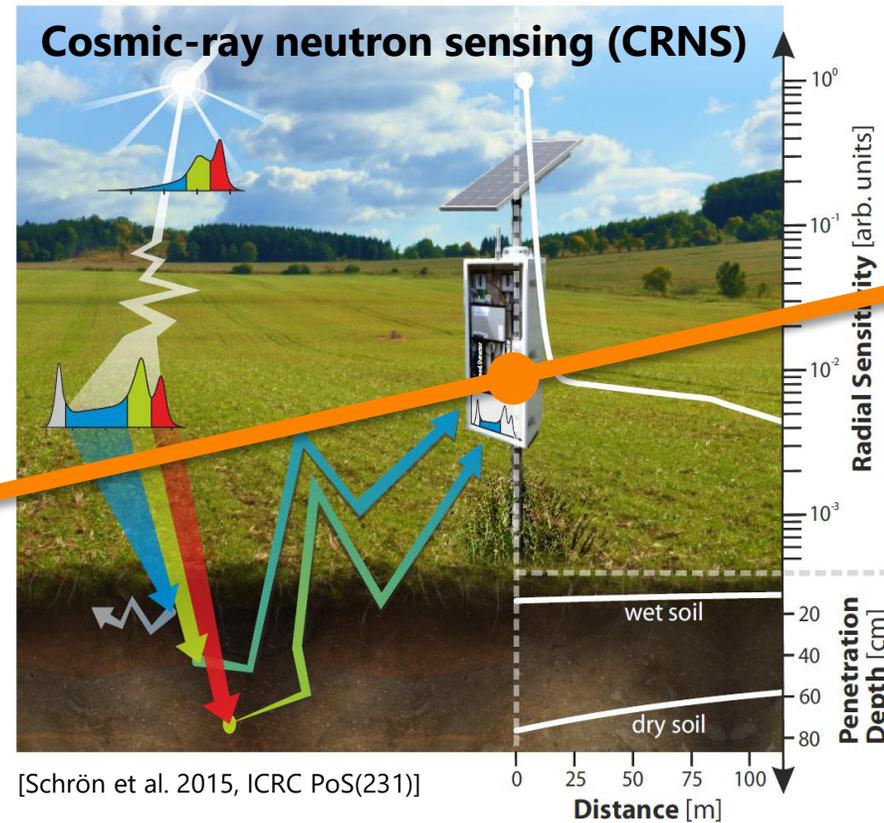
Satellite-based remote sensing



Point-scale sensors



[<https://soilsensor.com>]



- WP1: **Traceability**
- WP2: **Validation**
- WP3: **Harmonization**
- WP4: **Data fusion**
- WP5: **Impact**
- WP6: **Coordination**

$(10^{-1} - 10^1)$ m

$(10^2 - 10^3)$ m

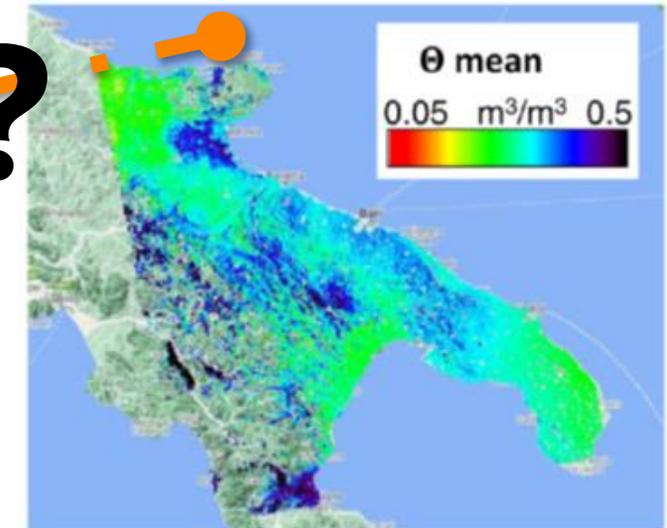
Horizontal scale

$(10^3 - 10^4)$ m

Exemplary datasets

Satellite-based remote sensing

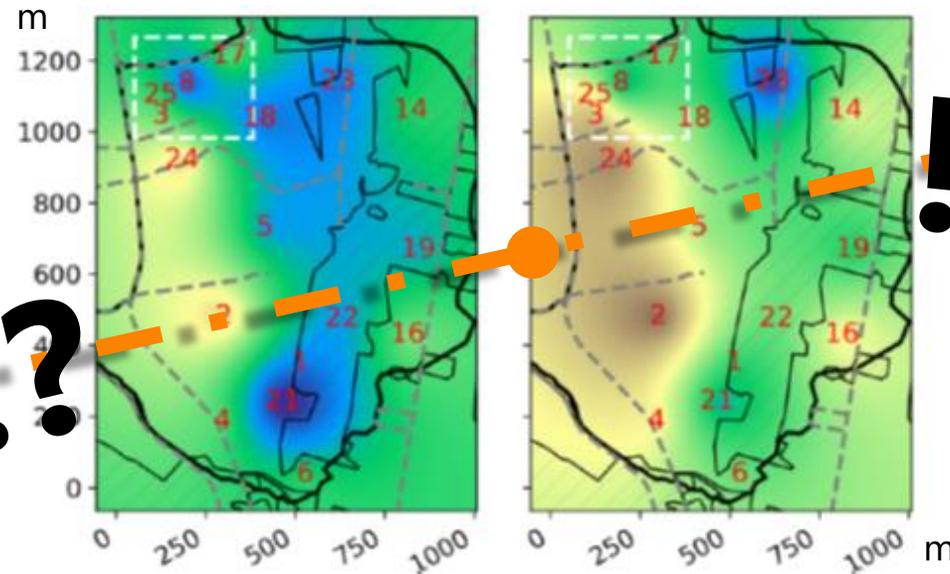
Example: Sentinel-1 surface soil volumetric water content at 1 km spatial resolution



[Balzano et al., Data in Brief 38 (2021) 107345]

Cosmic-ray neutron sensing (CRNS)

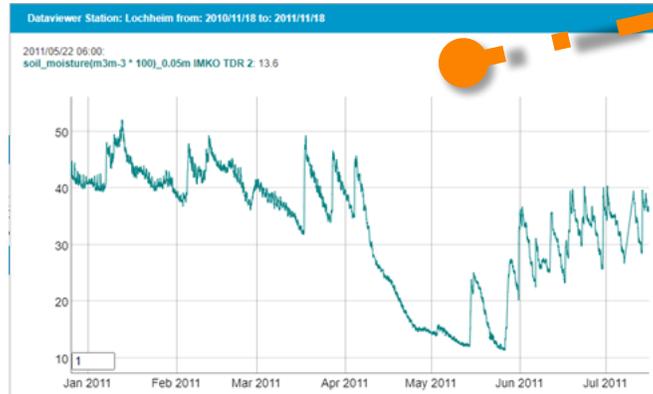
Example: CRNS mapping on catchment scale



[Heistermann et al., HESS 25 (2021) 4807]

Point-scale sensors

Example: Single sensor data series



[International Soil Moisture Network]

!?

$(10^{-1} - 10^1)$ m

$(10^2 - 10^3)$ m

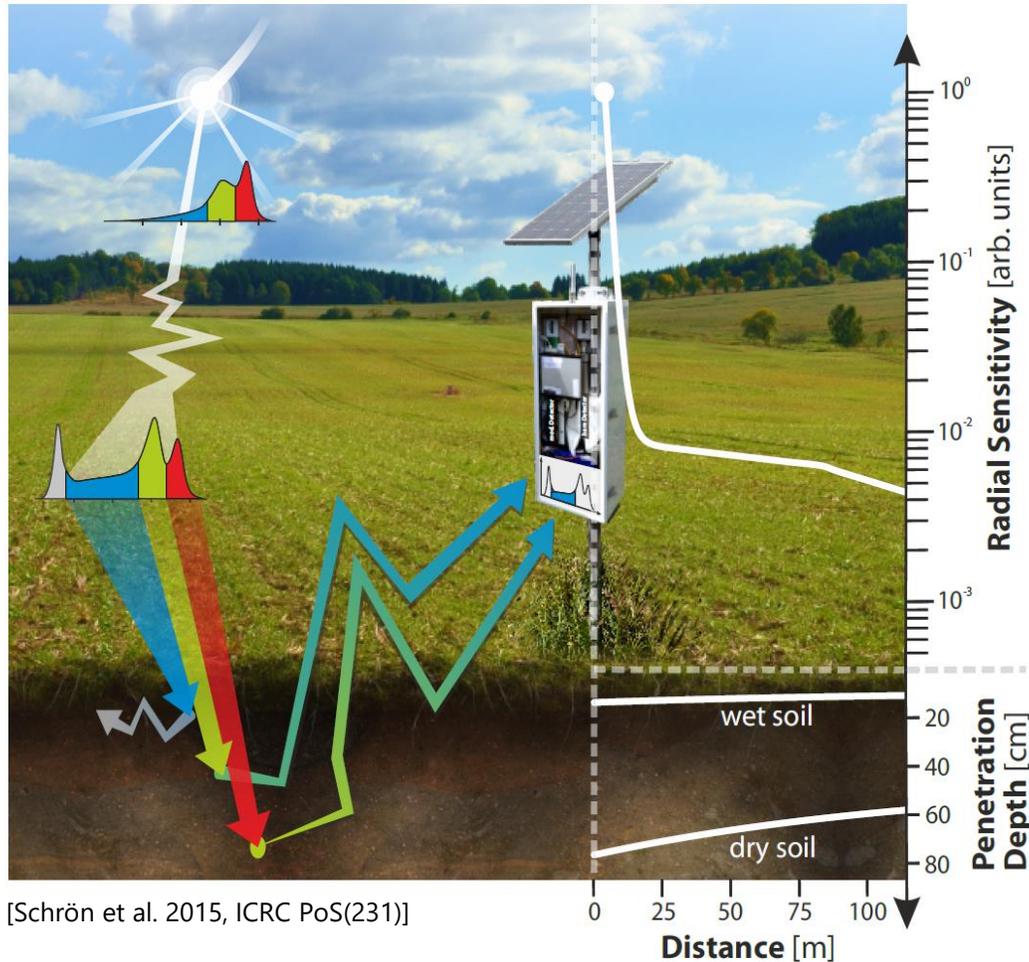
Horizontal scale

$(10^3 - 10^4)$ m

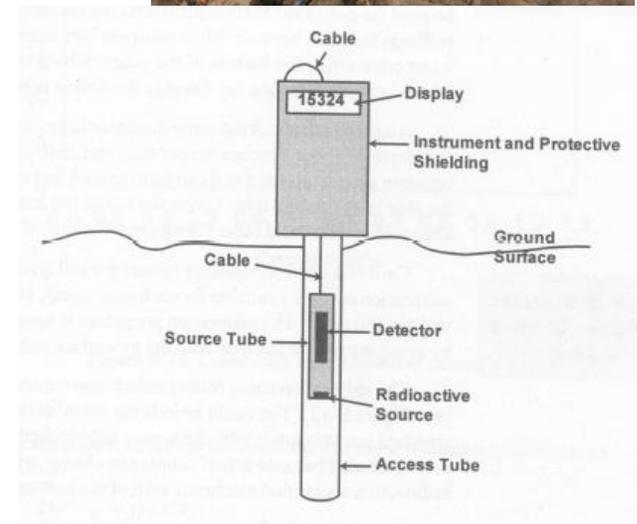
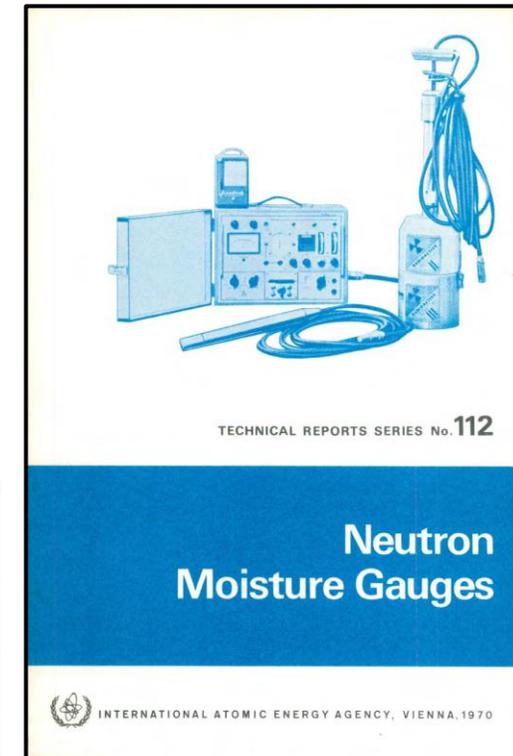
SoMMet: Objectives

- Establishing SI-traceability for point-scale soil moisture sensors
- Establishing SI-traceability for CRNS instruments in laboratories & standardised on-field-calibration practices under outdoor conditions
- New calibrated data from joint comparison campaigns
- Good practice guides for harmonisation and interdisciplinary data fusion practices for soil moisture measurements on lateral scales 10^{-1} m – 10^3 m

CRNS \neq Neutron scattering method



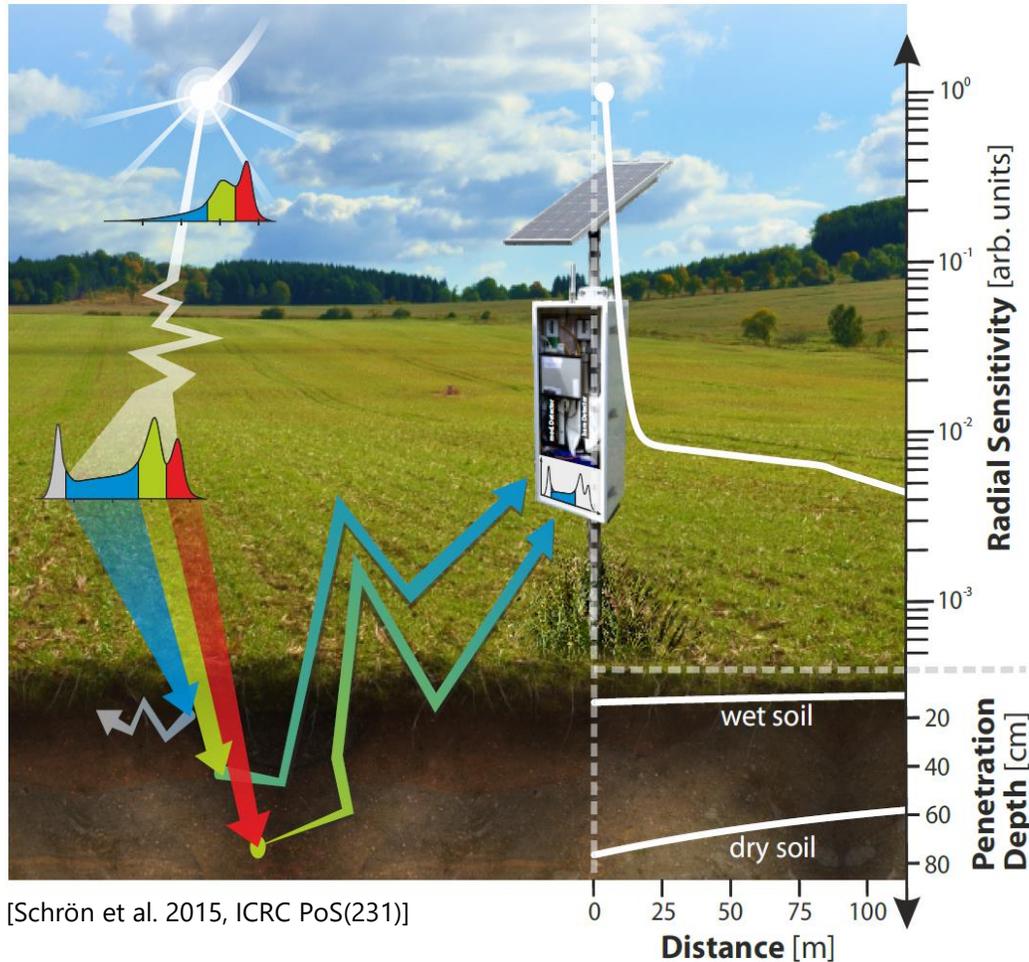
\neq



[Schrön et al. 2015, ICRC PoS(231)]

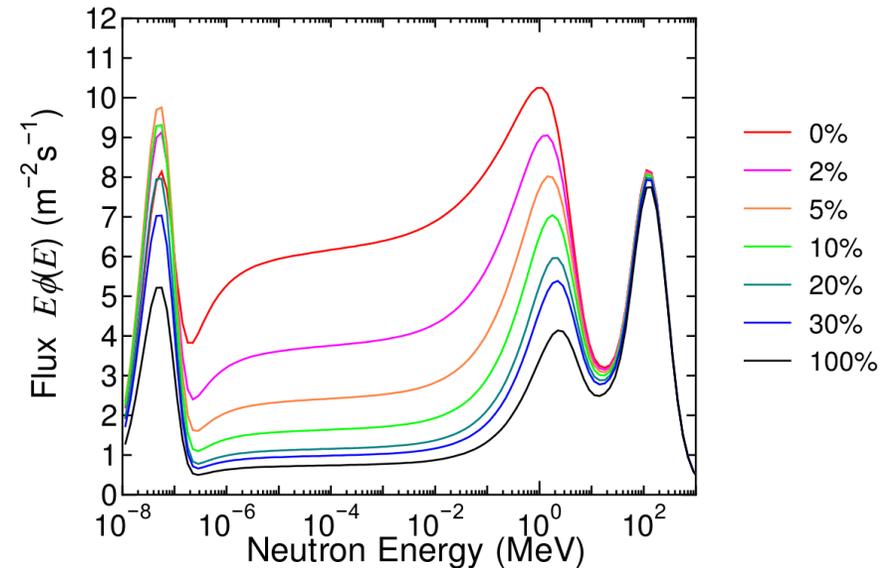
CRNS: Measurement principle

[T. Sato, COSMOS Workshop, 2020]



[Schrön et al. 2015, ICRC PoS(231)]

Consideration of Water Density



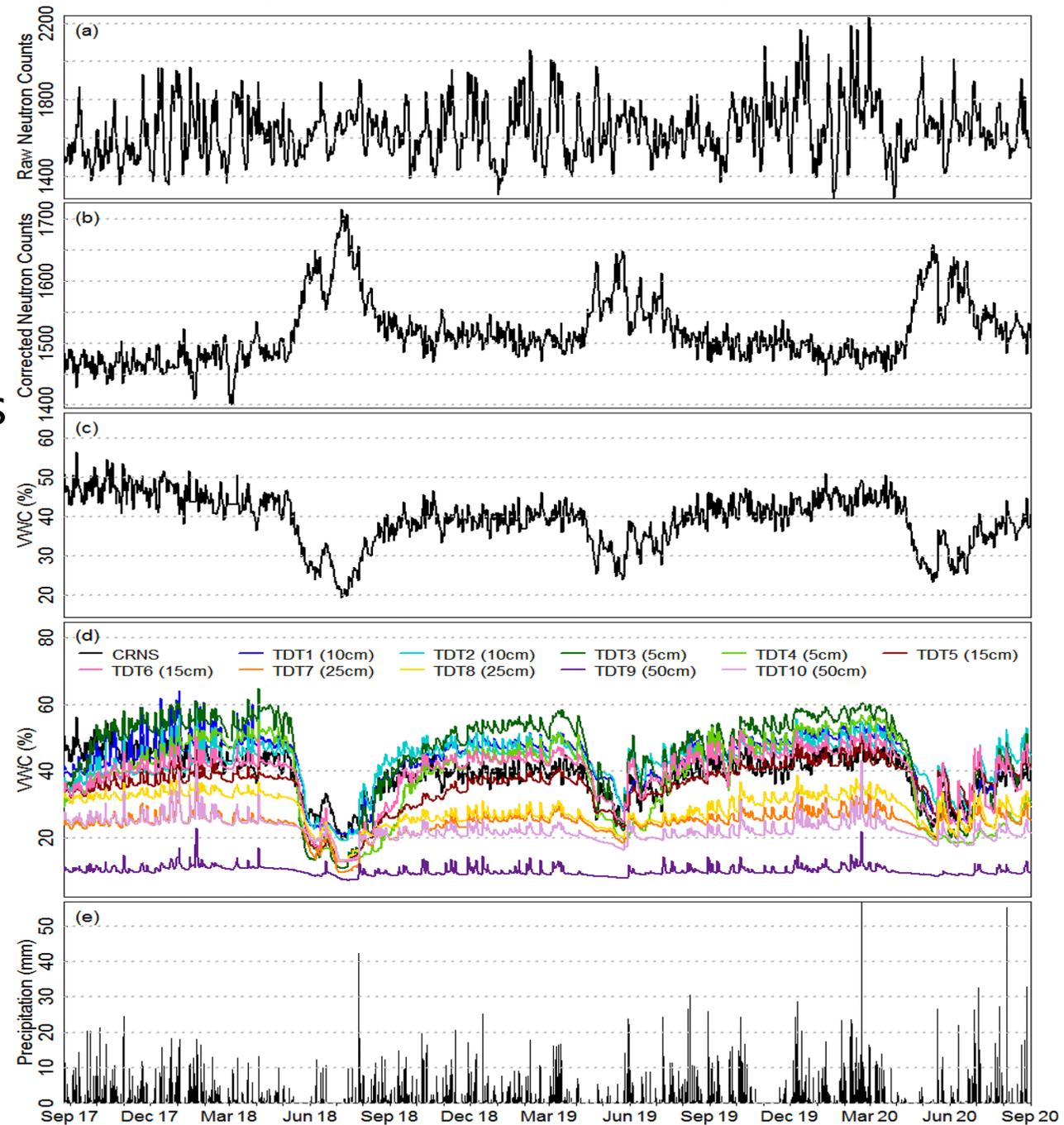
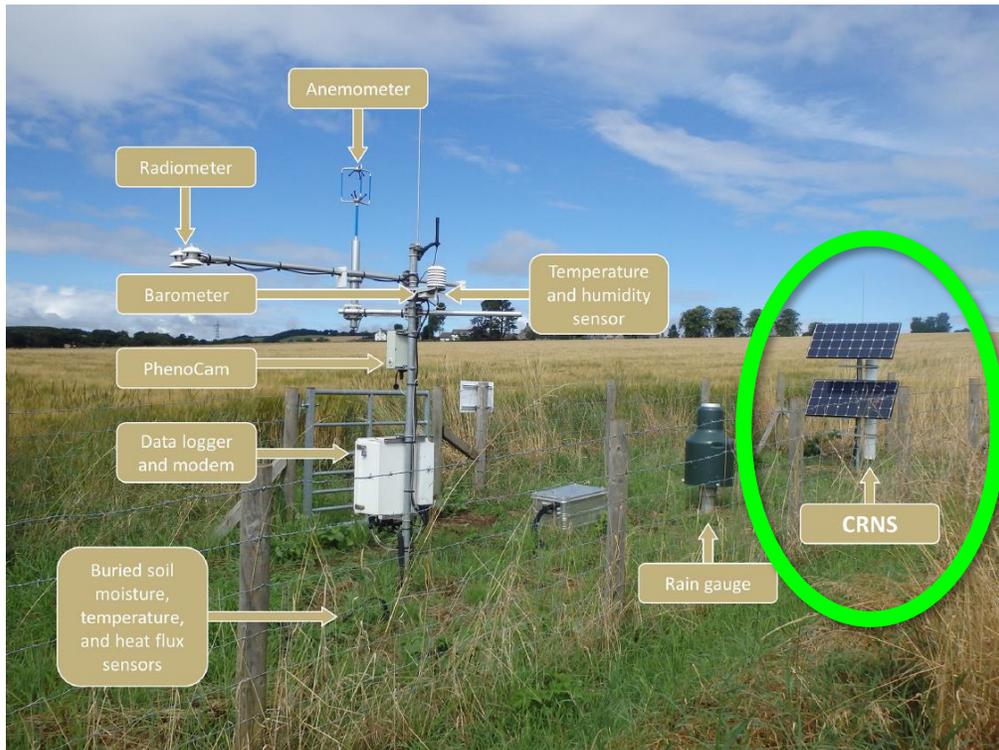
Neutron fluxes calculated by PARMA at Tokyo with different water mass densities

- ✓ Evaporation neutron fluxes decrease with increase of water density
- ✓ Thermal neutron fluxes have peak around water density = 5%

CRNS: Time series

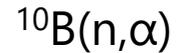
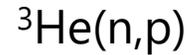
Exemplary 3-years time series of CRNS data and comparison to point-scale soil moisture measurements

[Cooper et al.,
ESSD 13, 1737, 2021]



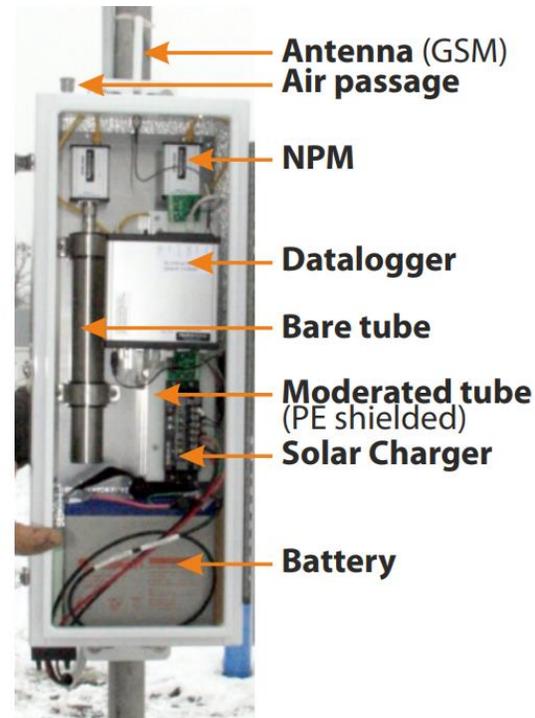
CRNS: Instruments in SoMMet

Selected instruments are based on typical neutron detection reactions:



- **Labs:** Monte Carlo particle transport codes → detector models → characterisation in neutron reference fields
- **Outdoor:** Simultaneous neutron measurements with reference neutron detectors
- **Outdoor:** Studies of systematic effects

Hydroinnova, USA



Finapp, Italy



StyX Neutronica, Germany



SoMMet: Organisation



- European Partnership on Metrology, 2021 Green Deal Call
- 21GRD08 SoMMet: 10.2022 – 09.2025 www.sommet-project.eu
- 18 Funded partners: 9 NMI's/DI's + 9 Research institutions
- Coordinated by Neutron Radiation Department of PTB
- Total budget 2.5 M€

PROJECT PARTNERS

EXPERIMENTAL SITES

3 high-level test field sites



PROJECT PARTNERS:



Coordination, Lead WP6



Lead WP1



Lead WP5

Justervesenet

TÜBITAK



Lead WP2



Lead WP3



Lead WP4



UK Centre for Ecology & Hydrology



HELMHOLTZ Zentrum für Umweltforschung



INSTITUTE OF AGROPHYSICS PAS

SUPPORT & STAKEHOLDERS:



Agenzia Spaziale Italiana



United Nations Educational, Scientific and Cultural Organization



International Centre for Water Resources and Global Change under the auspices of UNESCO

Deutscher Wetterdienst Wetter und Klima aus einer Hand



Norwegian University of Life Sciences



AGRICULTURE & HORTICULTURE DEVELOPMENT BOARD



NORWEGIAN INSTITUTE OF BIOECONOMY RESEARCH



THE UNIVERSITY OF ARIZONA

PROJECT PARTNERS

EXPERIMENTAL SITES

We are very interested to cooperate with you!

- Collaborators
- Stakeholders
- Private companies
- End-users

3 high test f

→ please contact:
Miroslav.Zboril@ptb.de

PROJECT PARTNERS:



Coordination, Lead WP6



Lead WP1



Lead WP5

Justervesenet



Lead WP2



Lead WP3



Lead WP4



SUPPORT & STAKEHOLDERS:



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NIBIO NORWEGIAN INSTITUTE OF BIOECONOMY RESEARCH



Acknowledgment

We acknowledge

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- The funding by the European Union
- The EURAMET Management Support Unit



Kick-off Meeting @PTB, October 2022

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or EURAMET. Neither the European Union nor the granting authority can be held responsible for them.

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