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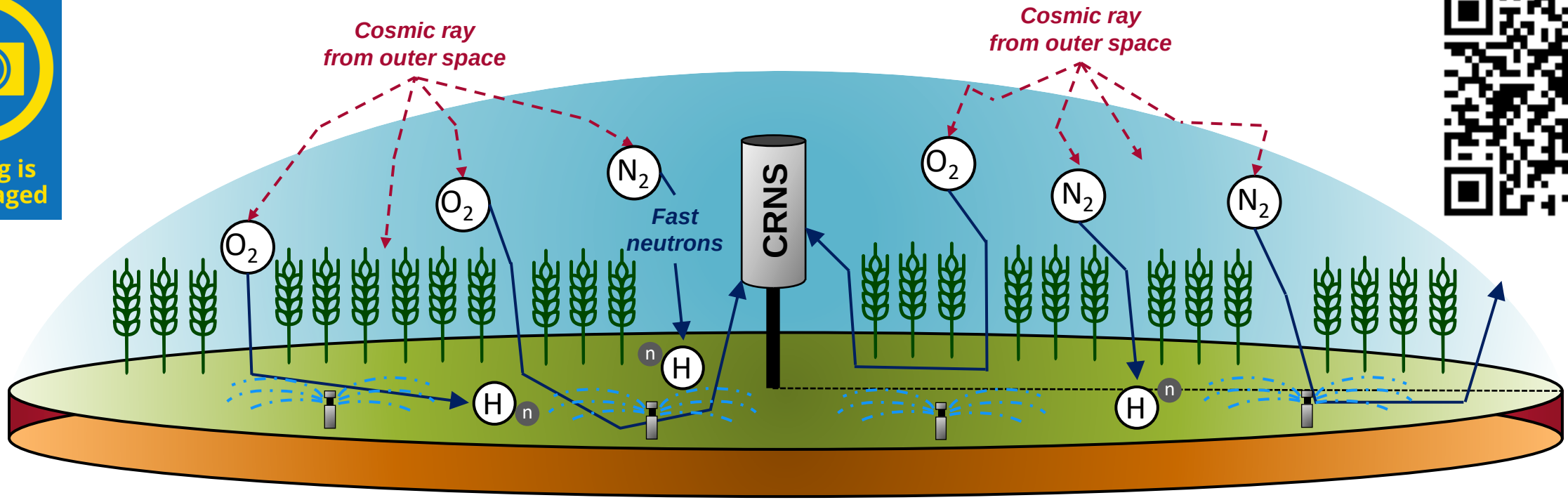

Smart irrigation using novel cosmic ray neutron sensors and land-surface modelling approaches

C. Brogi, O. Dombrowski, H. R. Bogena, V. Pisinaras, M. Köhli, H. J. Hendricks-Franssen,
A. Panagopoulos, K. Babakos, A. Chatzi

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ATLAS AGRICULTURAL INTEROPERABILITY AND ANALYSIS SYSTEM

SWRI Soil and Water Resources Institute
IEYP

Cosmic Sense

Horizon 2020
European Union Funding
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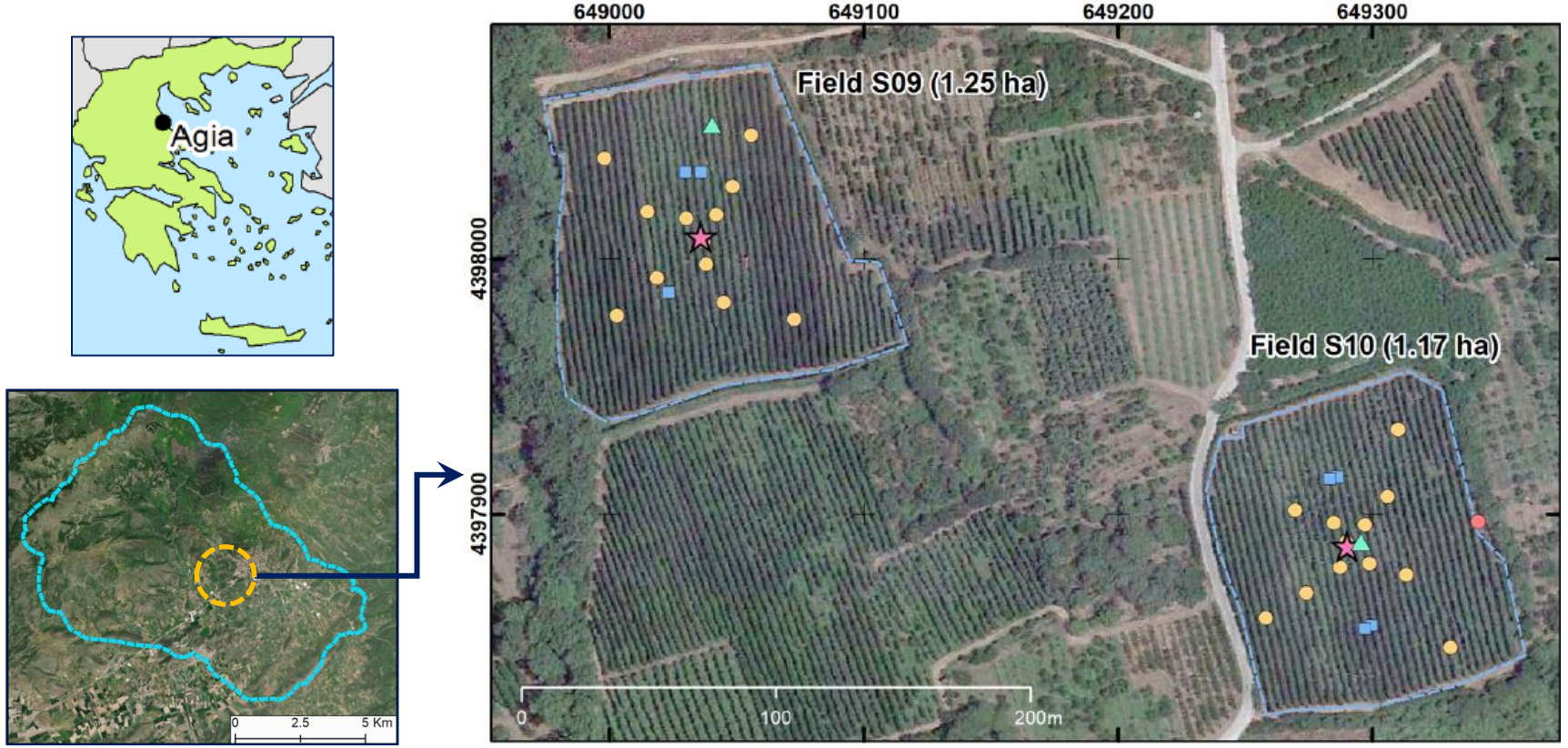
Sensor network in two apple orchards in Greece



The two instrumented pilot fields S09 and S10 and their dimension.

SoilNet (soil moisture, *h*, and temperature)

Atmos41 (climate station)

Water Meters

Cosmic Ray Neutron Sensor

Cosmic Ray neutrons sensor Styx Neutronica GmbH, Heidelberg, Germany

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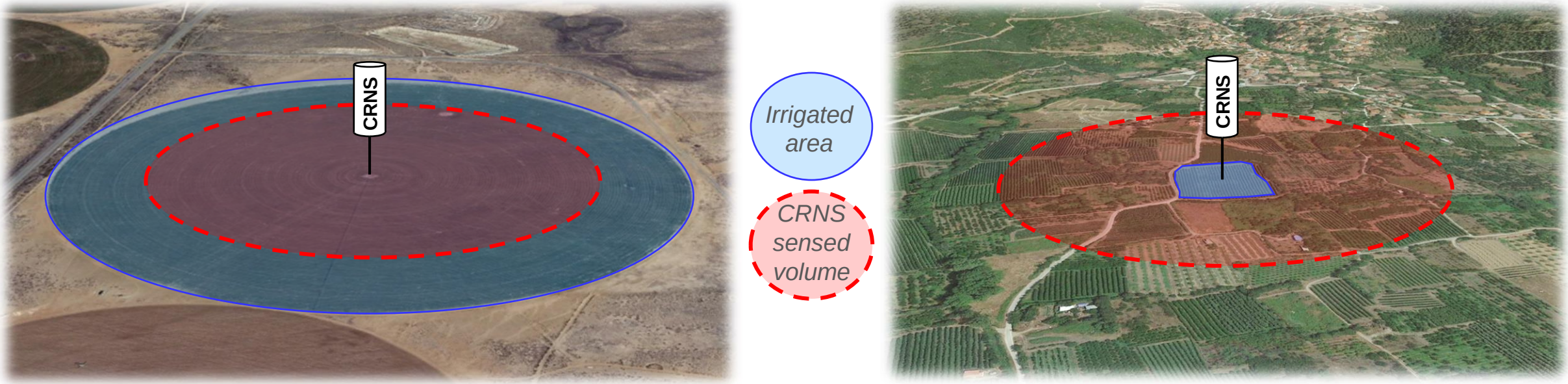
CRNS in soil moisture and irrigation monitoring

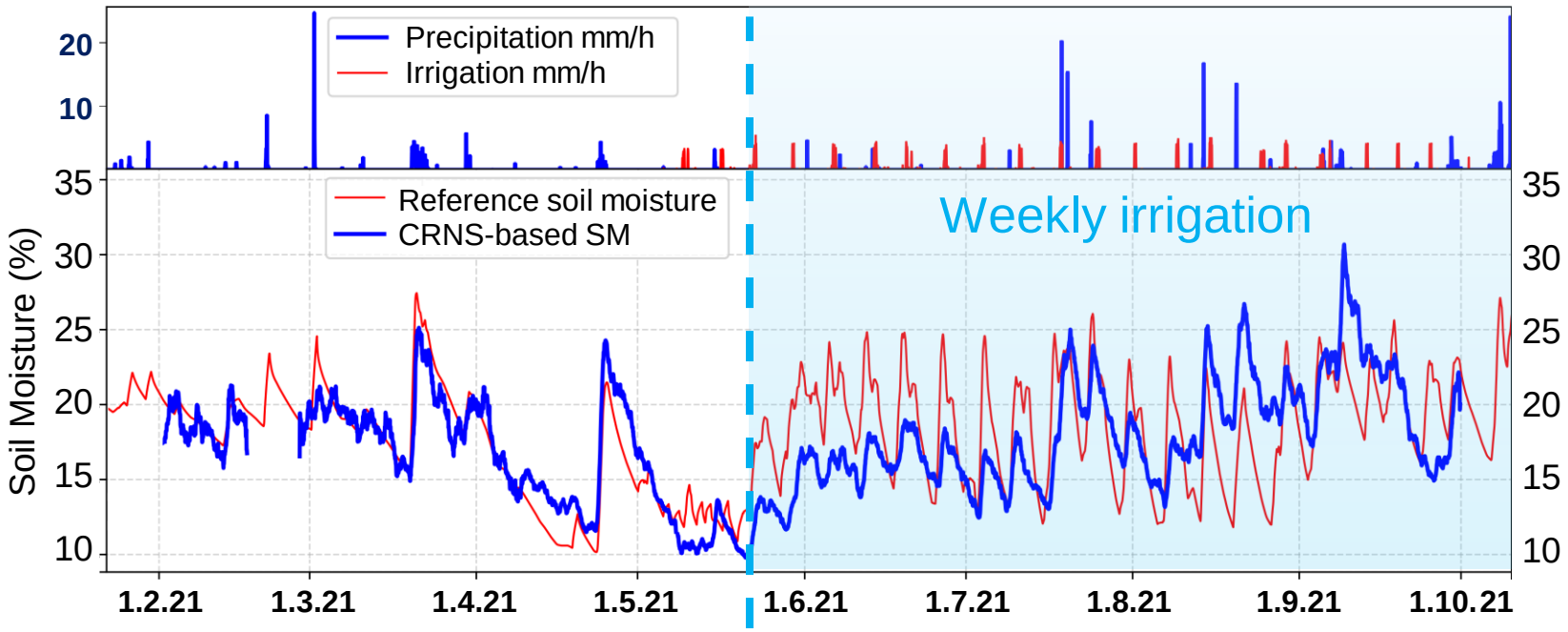
- ✓ Large measured volume (130-240 m radius)
- ✓ One sensor to monitor the entire field
- ✓ No removal during management

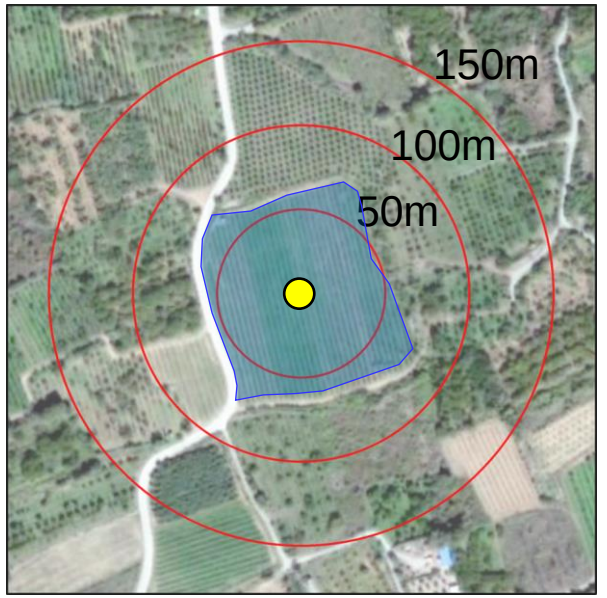
Higher soil moisture = Fewer neutrons detected



The footprint can become a challenge in small irrigated fields

CRNS irrigation monitoring in 2021



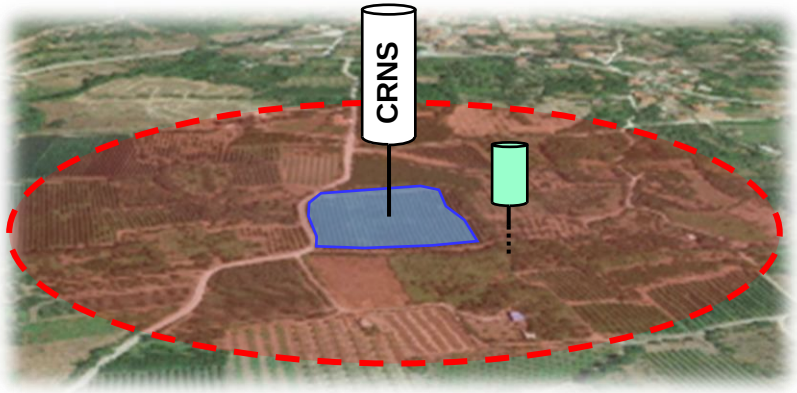


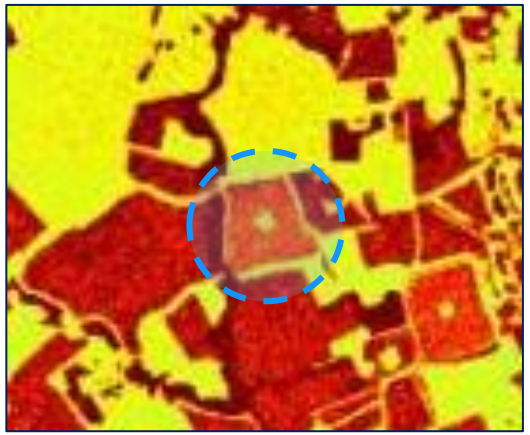
CRNS in field S10 (footprint = 130-240 m)

- Before irrigation, **CRNS**-derived soil moisture matches the **reference data**
- With irrigation, **CRNS** slightly deviates from **reference data**
- **CRNS** is affected by neutrons from outside the irrigated area

Novel CRNS correction (for small irrigated fields)

- Soil moisture measurement outside the irrigated field used to correct CNRS-based soil moisture
- Simulation of neutron transport (URANOS model) to obtain weights of:
  a. Albedo neutrons from inside/outside the field
  b. Non-albedo neutrons (no soil moisture information)
- Obtain synthetic neutron count (N_{in}^{S}) for the irrigated area
- Convert N_{in}^{S} to soil moisture of irrigated area





Simulated neutron density around the irrigated field

sensors MDPI

Article

Monitoring Irrigation in Small Orchards with Cosmic-Ray Neutron Sensors

Cosimo Brogi [1,*], Vassilios Pisinaras [2], Markus Köhli [3], Olga Dombrowski [1], Harrie-Jan Hendricks Franssen [1], Konstantinos Babakos [2], Anna Chatzi [2], Andreas Panagopoulos [2] and Heye Reemt Bogena [1]

URANOS v1.0 – the Ultra Rapid Adaptable Neutron-Only Simulation for Environmental Research

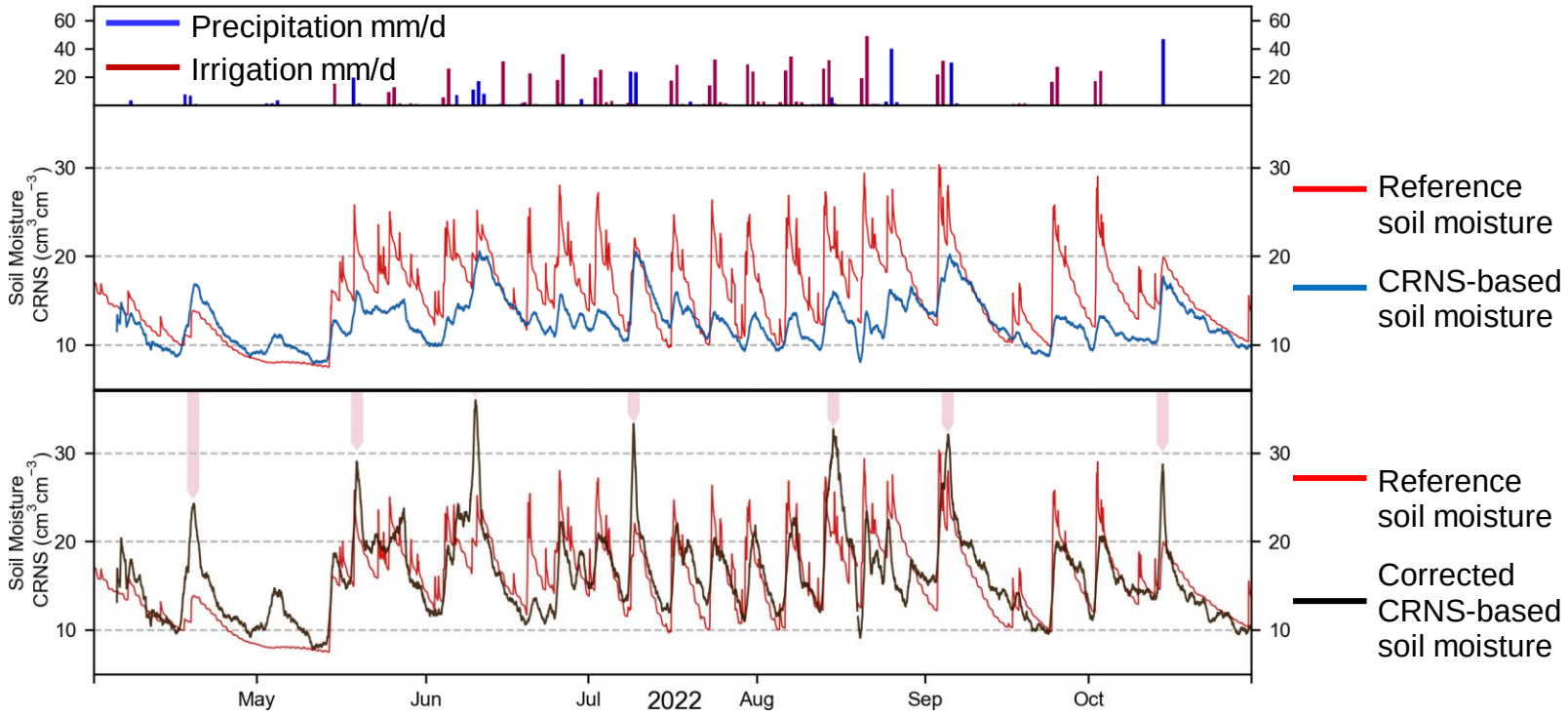
Markus Köhli[1,2], Martin Schrön[3], Steffen Zacharias[3], and Ulrich Schmidt[1]

Geoscientific Model Development EGU

CRNS irrigation monitoring in 2022

Uncorrected

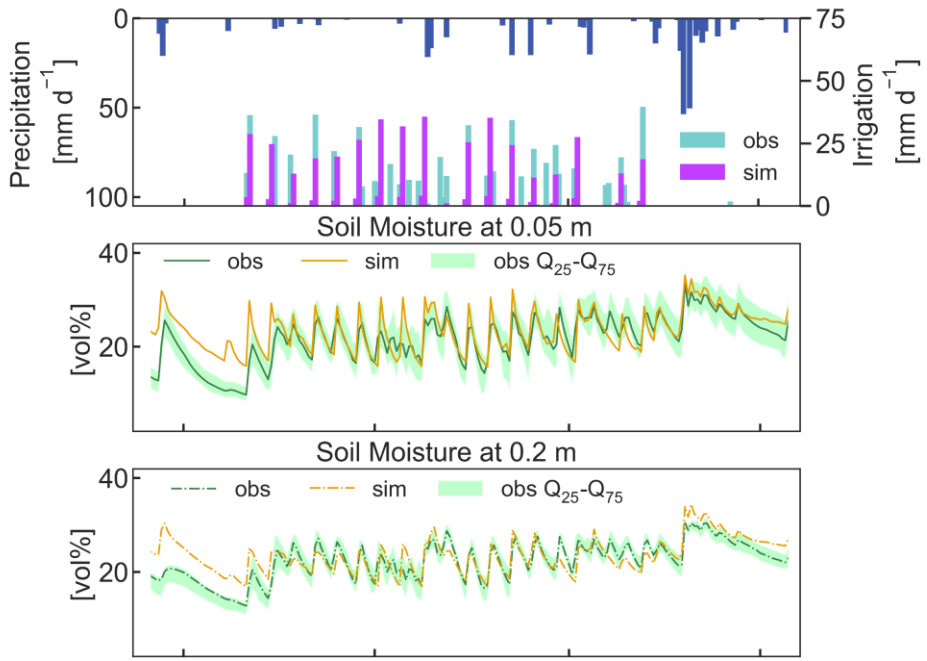
Corrected



- RMSE reduced (0.053 to 0.031) and soil moisture dynamics considerably improved
- Few overestimations caused by supporting sensor position (installed too deeply)

Modelling irrigation with CLM5 (1D)

CLM5 is a land-surface model representing terrestrial processes and the effects of local climate.



Actual and simulated irrigation and soil moisture in orchard S09

- Development of a new apple plant functional type

CLM5-FruitTree: a new sub-model for deciduous fruit trees in the Community Land Model (CLM5)

Olga Dombrowski[1], Cosimo Brogi[1], Harrie-Jan Hendricks Franssen[1], Damiano Zanotelli[2], and Heye Bogena[1]

Geoscientific Model Development

- 10-50% irrigation reduction would not affect yield (Poster: Tsakmakis *et al.* EGU23-5186)

➢ Simulations in the second orchard show soil moisture overestimations, probably due to misrepresentations of soil hydraulic properties

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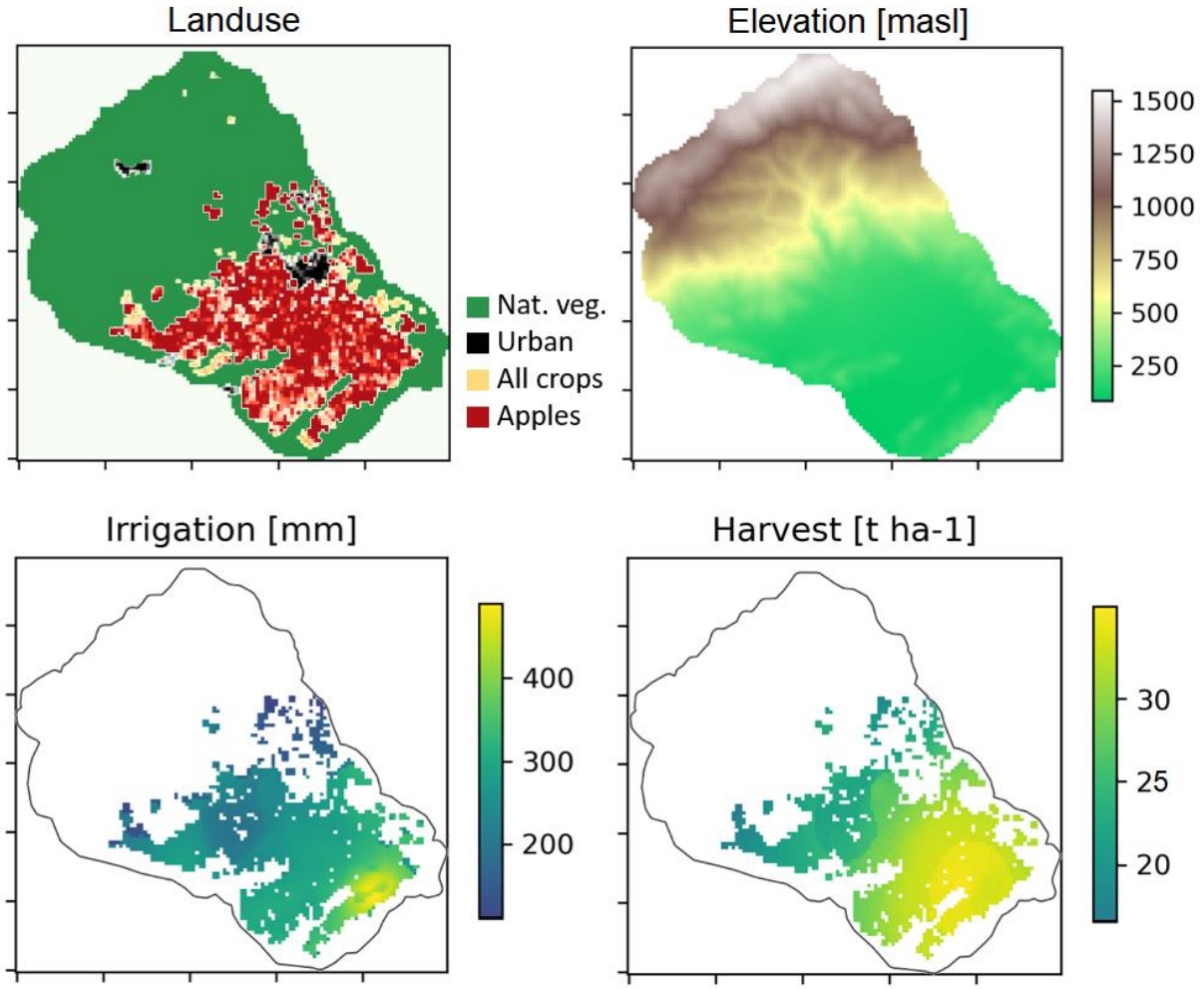
Modelled irrigation at catchment scale (2D CLM5)



Estimate irrigation effects on regional:

- Infiltration/evapotranspiration
- Agricultural productivity
- Water consumption
- Ground water recharge/abstraction

Assess impact of:

- Climate change adaptation strategies
- Regional policy decisions

Conclusions & Outlook

Cosmic-Ray Neutron Sensors can inform irrigation in small fields (~1 ha)

- A correction procedure must be applied
- When corrected, the **CRNS** could replace a dense sensor network
- Need for more studies in different environments to standardize the methods

Instrumented pilot fields are key to refine models and test predictions

- CLM5 can inform irrigation practices, but the representation of small-scale soil moisture dynamics should be further improved
- At the catchment scale, CLM5 can inform on the interaction between irrigation practices and freshwater resources consumption
- Assess the impact irrigation-related policies and their dependency on future climatic scenarios

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Thank you for the attention

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Sharing is encouraged

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Feasibility of irrigation monitoring with cosmic-ray neutron sensors

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