The COSMOS Network

A network of cosmic-ray probes distributed throughout the contiguous USA

to provide soil moisture measurements at an intermediate spatial scale (700 m) with arbitrary temporal resolution and corresponding arbitrary precision

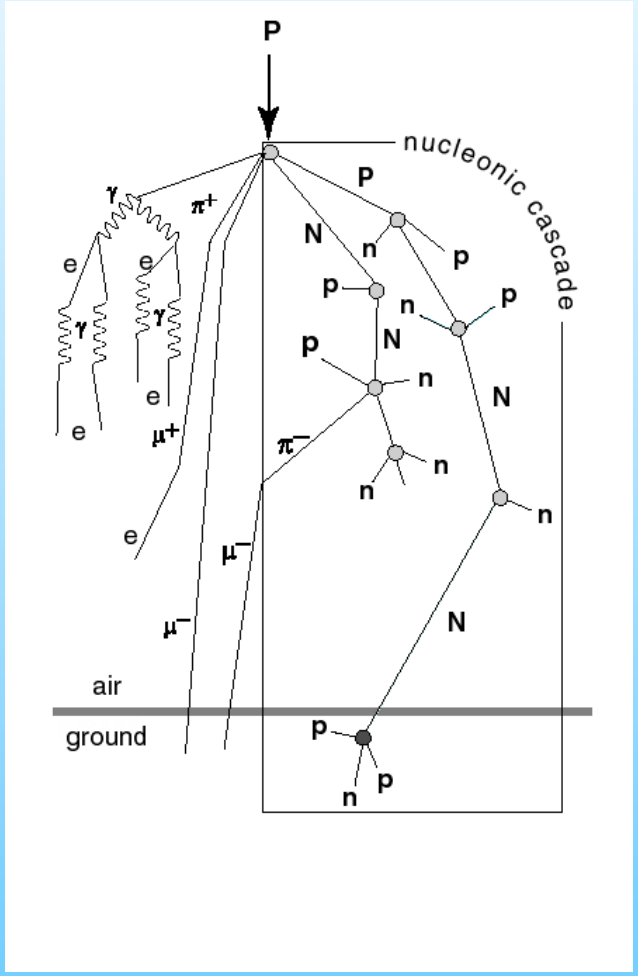
Lead scientist: Marek Zreda

Supporting institution: NSF (University of Arizona)

Status: Pending

Plans: 2009-2013 (phase 1), 2013-2016 (phase 2)

How the cosmic-ray method works

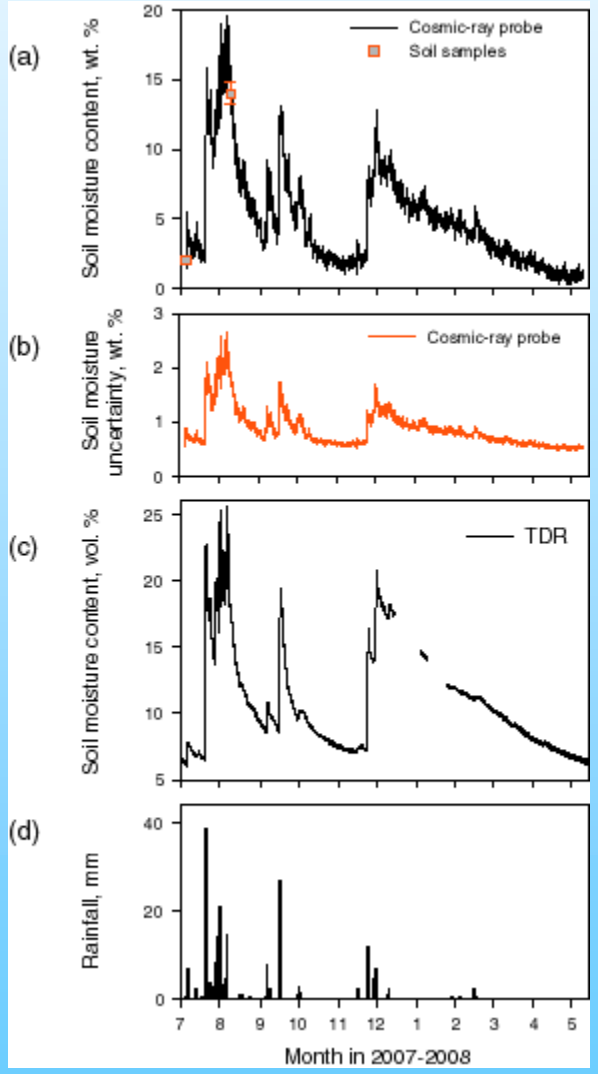


- Primary cosmic rays - mostly protons and alphas
- Interact with magnetic field and with atmospheric nuclei
- Produce secondary particles - cascade
- Which produce fast neutrons in the ground
- These fast neutrons

  - slow down by elastic collisions (H is extremely efficient)

  - and diffuse to the atmosphere, where they mix on the scale of hundreds of meters, and where their intensity is measured

The fast neutron intensity in air above the surface depends on the hydrogen content of the soil.



Cosmic-ray soil moisture probe characteristics

Sensitive primarily to soil moisture content.

Insensitive to soil chemistry, texture, topography.

Non-invasive, no contact measurement (probe above the ground measures neutrons emitted from soil).

Fully automatic measurement and data transfer.

Integrated soil moisture over a footprint of ~700 m.

Integrated soil moisture over a depth 0-70 cm (dry) and 0-12 cm (wet).

→ Deep integration better for LSM to get soil moisture profiles.

Arbitrary precision based on the number of counts (2% easily achievable).

States - both liquid and frozen water measured.

Snow - detectable:

→ Snow-water equivalent measurable (large or small footprint).

Vegetation - not critical to soil moisture determination:

→ Separating canopy or intercepted water may be possible.

Installation and calibration specifics

Installation

Probe is placed above the ground on:

- a pole (see photo) or a tripod;
- a (flux) tower or a tree ;
- the ground (on blocks);
- or any other secure object (e.g., roof).

Avoid locations close to open water bodies.

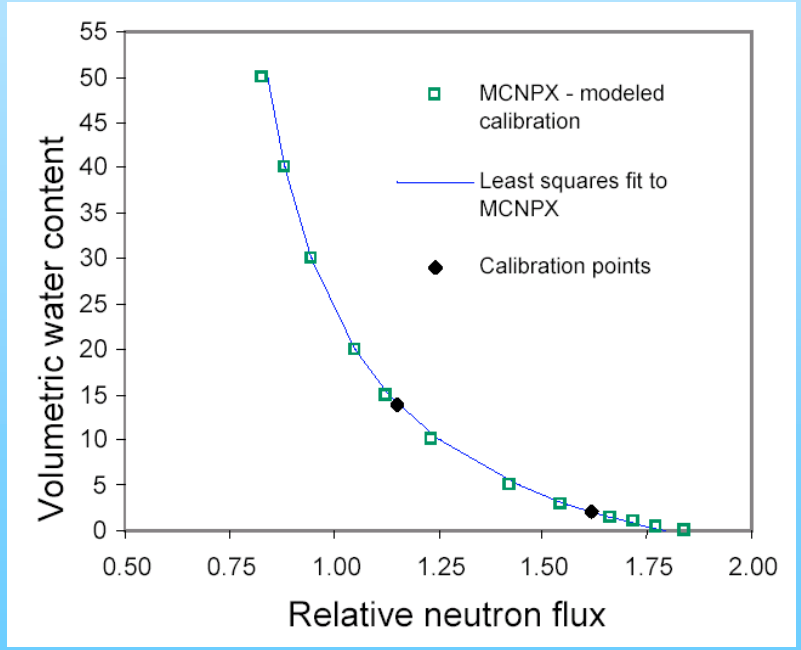
Calibration

Probe is calibrated using multiple soil samples within the cosmic-ray probe footprint and depth:

(1) Determinegravimetric soil moisture content (standard oven drying method).

(2) Determine dry bulk density on the same samples.

(3) Convert gravimetric data to volumetric soil moisture.



Locations, data availability, issues

Locations:

Overall project goal: 500 probes in the contiguous 48 states

Exact locations to be determined (with community input)

Phase 1 (2009-2013): 50 probes

+ possible 58 probes for SMAP and SMOS cal/val

Data availability:

Time-series soil moisture data will be available:

in real-time (sent after each integration period) - uncorrected

in ear-real time - corrected

Available to all, no restrictions

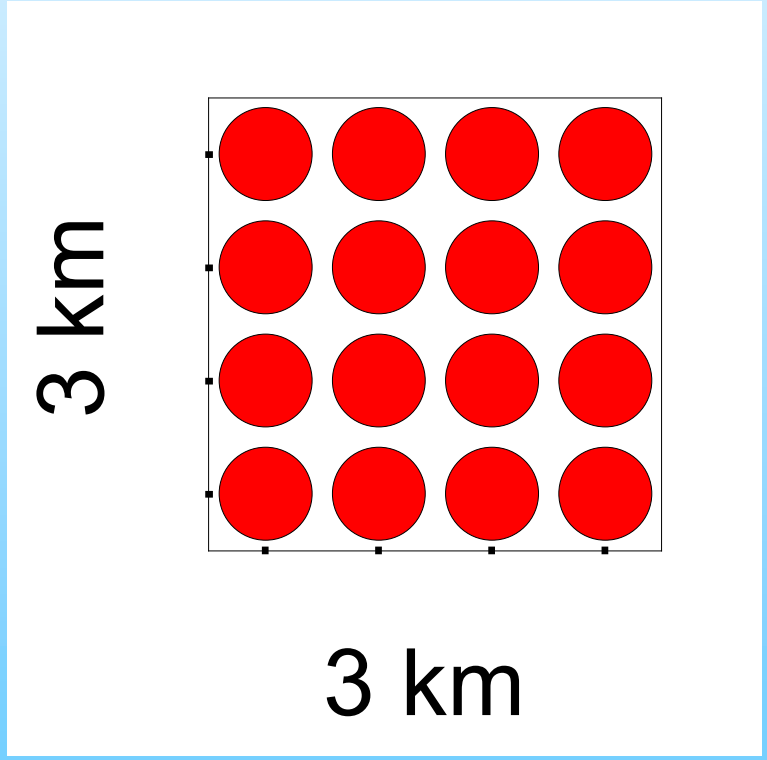
Issues:

Measurement depth 12-70 cm: need LSM to use product with SMAP

Sensitive to the presence of open water bodies closer than ca. 300 m

Cosmic-ray footprint and active pixel size

Active: 3 km by 3 km



Cosmic-ray probe footprint is 700 m (86% of signal).

For pixel size 3 km by 3 km, 16 probes will cover 68% of SMAP pixel area.

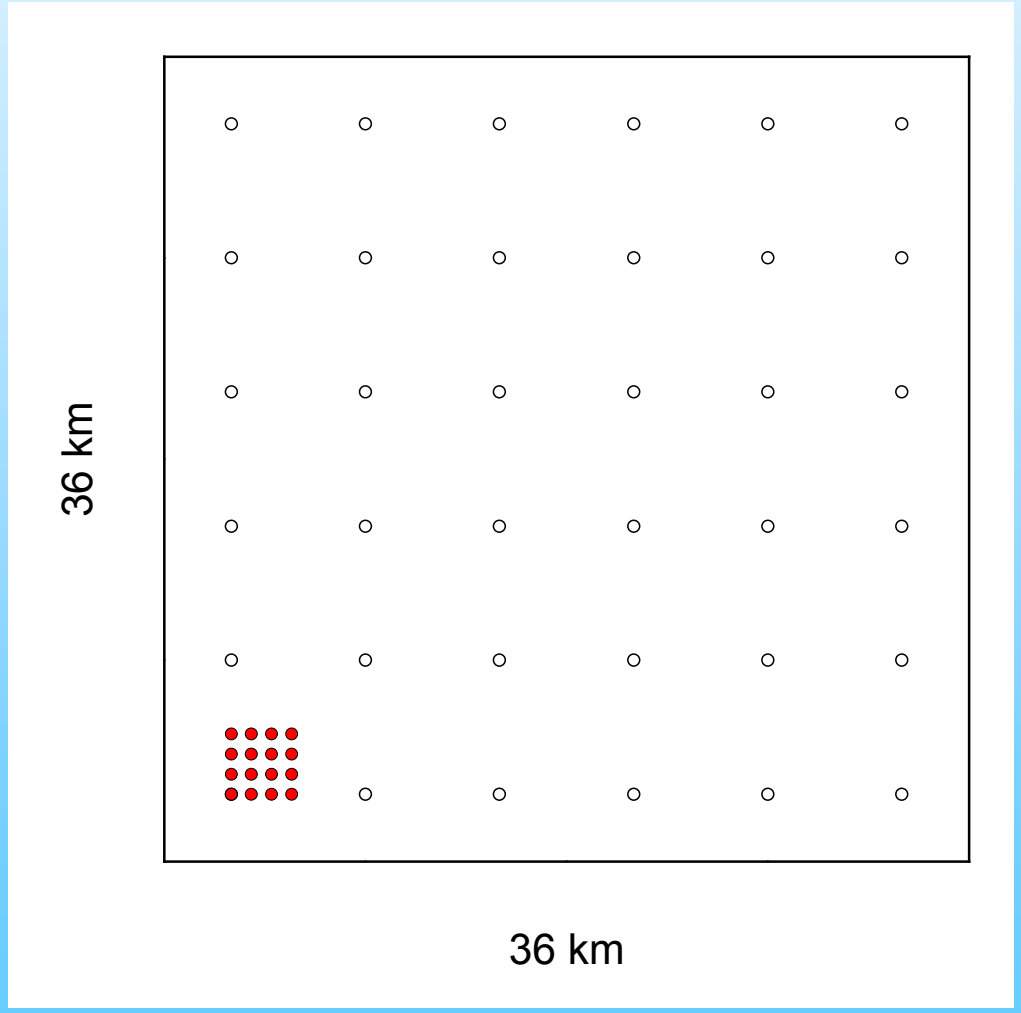
Continuous measurements integrated over arbitrary time are available on line in near-real time.

Other methods can be nested within:

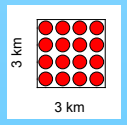
- GPS (10 m footprint),
- TDR (point measurement).

Cosmic-ray soil moisture probe footprint and passive pixel size

Passive, 36 km by 36 km



Active



Need 30+ probes to capture soil moisture variations and obtain representative soil moisture fields within the passive pixel area.

Can use instrumented "active clusters" within the passive pixel area.

Other methods can be nested within:

- GPS (10 m footprint),

- TDR (point measurement).